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WPP-126

International Workshop on

Innovations for Competitiveness

European Space Agency
Agence spatiale européenne

ESTEC, Noordwijk
19-21 March 1997

WPP-126

International Workshop on

Innovations for Competitiveness

Innovation and Challenge

are Seeds of Progress and of Mankind's Lasting Heritage

Systems Studies Division
ESTEC, Noordwijk
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Post Workshop Issue

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Session 4: Options and Resources

Welcome Address to the Workshop on Innovations for Competitiveness

E. Slachmuylders, Acting Director of ESTEC

Introduction

Good morning, ladies and gentlemen! First, may I welcome you to ESTEC - the Research and Technology Centre of the European Space Agency - and second, welcome to this Workshop on 'Innovations for Competitiveness'. It is a pleasure to host such a prominent group of both space and non-space experts from government organisations and academia as well as industrial companies, who have gathered together to discuss major space-related issues which will affect all our futures.

Before going on to the Workshop itself, let me first give you a little of the background leading up to it.

Background

The theme of this Workshop is very appropriate for today's environment, because the situation regarding space has changed very much in the past few years. Worthy of note are:

- the economic difficulties of the majority of "rich" countries and their desire to reduce public expenditure - including for space activities
- the rapid growth of the commercial space activities, which, combined with the decrease in public funding for space, results in a profound change of the ratio of the level of commercial versus institutional space efforts
- the trend towards the globalization of systems and markets. By their very nature, space systems do not recognize frontiers (earth observation is no doubt the most striking example of this)
- national and regional systems, in telecommunications in particular, are ceding their position more and more to global systems - taking into account the costs of development and the fierce competition at the level of selling services, which has been brought about by deregulation and the liberalization of the telecoms market

Many of these changes have taken place as a consequence of the end of the Cold War, which has made possible the emergence of new international competition, as well as unprecedented cooperation in areas such as manned space flight. In addition, the increasing importance of the civilian market and the desire of the United States to regain its undisputed leadership, that in the civilian space arena was being challenged by its principal rival, Europe, are also contributing to the present situation.

The space sector today is going through a transition period and is gradually settling into a mature scientific and industrial sector where:

- basic technologies exist within industry as well as the competence to use these technologies,
- market forces increasingly determine the developments, which are influenced by many players, and
- public budgets remain constant or even diminish.

Such a situation implies that private investments will more and more become the primary method for financing applications and commercially driven space activities. New rules will therefore come into play, which space agencies will need to support; for instance, new activities may possibly only be carried out when done in cooperation with industrial partners from the non-space field (venture companies, marketing companies, etc) or with operational organisations. Thus the role of space agencies with respect to commercial space applications will change with the agencies providing financial incentives and absorbing risks for the pre-competitive part of new research and developments. The public funding will thus serve more as a catalyst to industry rather than directly financing commercially-driven space activities, although scientific and exploratory activities will still be best undertaken and managed through cooperating supranational agencies. But, in view of the scarcity of public money for space, it is imperative that, also in these exploratory and prospective undertakings, new ways be found to achieve more for less money,.

All this will involve a new set of relationships between space agencies and industry.

In turn, space agencies may become even more involved with the active promotion of emerging and potential applications for space use. It is not only a question of what space can bring to the public or industry at large, but also what can be brought to the space sector by these communities.

To combat the intense competition which is now developing, the European space community must motivate and mobilize itself in order to allow its industry to improve its competitive position. At the heart of the European community, ESA has, by its very mission, a unique and special role to play, particularly regarding the promotion of space applications and the setting up of a true and appropriate European space system. Hence, this Workshop.

The Innovation Workshop

Innovation is vital for the European space sector to increase its efficiency and to become competitive for the global markets. New ventures, enterprises and institutions are created through an innovative process. During their operational life they need to innovate constantly if they want to stay at the competitive edge. Although Europe has an excellent scientific base, it is less successful than its major competitors (the USA and Japan) in converting its competence into new products and competitive services - this is especially true in high technology sectors. It is such thinking that has led to the European Commission's first Action Plan for Innovation in Europe and which is one of the important considerations in the preparation of the 5th Framework Programme of the European Commission .

Although we will undoubtedly hear more about this during the Workshop, it is important to reiterate that ESA too recognizes the need for an innovation culture which combines creativity, entrepreneurship and willingness to take calculated risks, with an acceptance of social, geographical and professional mobility. The innovation mentality needs to take into account education and training and the most effective management and organizational approaches and methods conducive to innovation. What this involves, in particular, is to ensure that research is more closely geared to innovation. In this respect, ESA makes a strong contribution to industry through its technological R&D programmes which integrate innovative activities amongst others. Without such major efforts in R&D the European space sector will lose its competence and its competitiveness. It is with these thoughts in mind that ESA decided to organize this Workshop on Innovations for Competitiveness.

The Workshop is intended to provide a road map, leading via innovation to competitiveness of the European space sector. It should provide a stimulus to the European space capabilities in agencies, universities, industries and the service sector to rationalize and innovate. In the light of a variety of ongoing initiatives in this field at European level, the Workshop will highlight areas of mutual interest for ESA Member States and hopefully open a dialogue with industry and other parties concerned regarding the establishment of a genuine innovation culture. The lessons learned should help the European sector prepare more effectively for the challenges of the coming decade.

As you see from the programme, the Workshop concentrates on both the innovative process and its results. This includes the views of major organizations in the field, the potential opportunities for transforming know-how and technologies into marketable products and services and applications, and the options and resources available for such activities.

I trust you will find the Workshop both stimulating, informative and of real benefit to you and that you will actively take part in the debates and challenges which lie ahead.

Session 1:

A Strategic Overview

Innovation for Competitiveness

Workshop Objectives

A. Atzei (ESA)

1. Introduction

Over the last 20 years Europe has successfully achieved the capability to implement the basic space activities including the frequent and independent access to space, the recognised world excellence in most areas of space science, the space applications in the fields of telecommunication and observation of the Earth and its environment.

Thanks to their unique global capabilities, space means will be a strategic tool for Europe in the next century. In addition to their broad economic potential, space activities will help society to overcome a number of threats to the quality of life on Earth and therefore space initiatives are fundamental to sustain security in all its forms - political, socio-economic, military and ecological in a truly global approach.

At the same time, space initiatives are currently going through a transition period and are gradually settling into a mature industrial and commercial sector where basic technologies exist, where market forces determine major developments, (which are influenced by many global and regional players), and where public budgets remain constant or even diminish. As the applications of "space" broadens continuously, additional European and international players (scientific, administrative, operational) and an ever changing industrial structures continuously emerge.

The economic, cultural, institutional and technical environment of space activities has to adapt to the realities of the worldwide rapidly changing commercial, competitive market as well as to the new development required by emerging public services opportunities.

It is well recognised that without a major effort on Innovation on industrial practices, organisations and R&D the European space sector will stagnate and lose its competence and its competitiveness in comparison to the continuing increased efficiency and initiatives particularly in the US and Japan. This effort should include the setting up of strategic poles and should be guided by strategic initiatives for long-term objectives.

The role of Innovation, its management and implementation is crucial for today's modern societies facing global issues together. Innovation is a two-sided issue: on the one hand it is driven by market requirements and on the other hand it is in turn driving market and new applications (i.e. nanotechnology). In any case, Innovation should also anticipate and prepare for tomorrow's needs.

In the medium term it is expected that space development will be driven by the request for mass production of low cost satellites and by the development of low-cost and more efficient launchers. The scientific missions will continue to motivate major advances in a broad range of frontier technologies, which will constitute the backbone of tomorrow's industrial competitivity.

Europe need a space policy coordinated, comprehensive, realistic and evolutionary which takes into account public, commercial and defence space activities. Space initiatives are assuming a global dimension, leading to international partnership, to a balanced responsibility between the public and private sectors, to international competition and cooperation.

It is with these thoughts in mind that this Workshop has been convened.

2. Purpose and objectives of the Workshop

This Workshop is an initial response to specific recommendations made by ESA Council, European Union and ESA LTPC towards the promotion of competitive and sustainable growth of the European Space sector and the related role of innovation wrt policies, methods, techniques, industrial organisation and financing. This workshop will review and discuss Innovation approaches wrt strategy, processes, products and services elaborated by space agencies, international organisations, industry and research centres in the main sectors of space activities. The workshop will make recommendations for an Action Plan with specific tasks for the various actors of the European space sector and focussing on

- cost/efficiency/benefits
- technology innovation
- development of new applications, markets and financing
- a strategy wrt collaboration, competition, specialisation

In the light of a variety of ongoing initiatives in this field at European level, this workshop will address the key questions:

What do we do?
Why do we do it?
How do we do it?

With the objectives of identifying Europe's space programmes weakness and potentials for improvement. Specifically, the Workshop intends to contribute to improving

- the understanding of trends towards future potential markets and other space applications

- the understanding of the bottleneck factors limiting competitiveness or preventing program implementation.

- the understanding of how Innovation can contribute to the world-wide competitiveness of the European space industry, through the development of an industrial structure appropriate to market requirements and supported by a modern financial base and new financial schemes.

- the coherence, efficiency and prioritisation of the various technology development efforts performed by ESA, EU, its Member States, the space industry and research centres.

A critical outlook will be presented for the major initiatives related to:

- the public service domain, which is primarily of governmental initiative.

- the commercial services domain covering those satellite-based business activities where free market forces determine the developments and where governmental intervention is only at the level of regulatory and legal issues.

- the scientific programmes, fostering basic knowledge as to remain at the forefront of science and technology.

- the manned programme initiatives, serving as a test-bed for technologies and space exploration.

3. New Trends

Private investments are increasingly becoming more important for financing application- and commercially-driven space activities. New relationships are evolving between space agencies and industry, with the agencies providing technical and financial support and sharing risks for the pre-competitive research and development phase and actively promoting emerging and potential applications.

Space is also experiencing a new trend towards a "service-on-demand" type of business emphasizing the early transition of R&D results into practical applications.

The emergence of large commercially-funded space projects requires a novel look at how to fund new space activities. Agencies will increasingly look to industrial support for new initiatives and the space industry itself will increasingly turn to the financial markets in order to help fund new commercial projects.

It is worth noting in this respect that one of the recommendations of the European Commission's "High Level Group on Development and Competitiveness of Space Industries in Europe" concerned the need for improving the available financial instruments in Europe for the development of commercial applications. A comprehensive assessment of the financial instruments available in Europe and their adaptation to the various needs, as well as a comparison with those available to Europe's major competitors was advocated by the Commission.

4. The Challenges of the Commercial Sector

It is significant to notice, that often the "space segment" in the commercial sector is only a smaller part of an overall worldwide business. As an example the world market for fixed communication and broadcasting services for 1996-2005 is estimated to be:

- satellite manufacturing	:	15-20	
- satellite launching	:	11-13	(Billion US$)
- satellite operator revenues	:	20-25	
- ground stations and terminals	:	60-90	
- end-user services	:	150-200	

- The issue of Europe's active participation in the future world navigation system is both fundamental and urgent for the European space industry which was totally absent from this major application segment and only very marginally involved in ground terminals.

- In the area of civil remote sensing, the picture is more mixed, with a reasonable European presence both in the technology domain, and in the operational domain. Studies on possible applications for image processing show great potential in key areas such as agriculture, land use statistics, urbanisation and regional planning, environment monitoring, risk management, coastal monitoring, surface water watching, cartography.

  This multiplication of practical applications affecting a variety of business sectors is leading to a rapid expansion of the user community from its initial user base. It is a fact that also Earth observation technology has great economic and operational potential, but turning that potential into reality is handicapped by a lack of coherent organization in the market place, and the insufficient number of well organized operational services.

Finally, it can be expected that European society will undergo major transformation due to the massive diffusion of digital technology, whose application will challenge European leadership.

5. Road map to Competitiveness

In today's competitive environment there is the need to demonstrate the economic and commercial value of emerging applications of space technology and to identify skills which are necessary to strengthen European industrial competitiveness. Space agencies, industry and research centres should develop research vision and technology strategy targeted to exploring the uncertain dynamics of emerging markets and user communities, anticipating the interaction between socio-economic and technology thrusts.

This requires the capability to perform a high level synthesis of multidisciplinary trends, encompassing applications, science, technology, economics, finance, manufacturing processes and industrial organisation. The above capabilities are essential in the support of the Innovation process, which requires not only creativity but also leadership.

Several efforts and initiatives are in progress to better understand how to make the most out of our creativity and under which conditions and in which sector Europe should compete more efficiently at world level. This ongoing process has highlighted the validity of the following guidelines:

- achievement of economy of scale primarily by mass production of satellite hardware.

- provision of turn-key services, based on strategic and more secure market prospects and featuring profitable services.

- development of high technology products capable of capturing new users, increasing production, decreasing the cost and delivery time, integrating high level of essential information and autonomy (better, faster, cheaper).

- larger investment on payload technologies, driven by global goals rather than by spread objectives.

- introduction of performance-based incentive clauses for timely delivery and quality of products.

- replacement of geographical return rules and other political constraints by strategic partnership, providing longer term probability for survival in a global context.

- in establishing a framework supporting the Innovation process, the major players should elaborate a joint plan with clear assignment of responsibilities. This plan shall include the role of ESA, EU, industry, operators, research centres and universities, user organisations, financial institutions, governmental and public institutions.

- in a more general context, a strategy for improving the European space sector should be elaborated on the basis of innovative elements, such as:

  - product and market-oriented R&D
  - service-oriented partnerships programmes
  - introduction of the leading-edge technologies to visionary programmes
  - consideration of new technical, managerial and financial approaches from outside the space industry
  - adaptation of R&D activities to individual company strategies.
  - a broader involvement of SME's and research centres in the space R&D business and project predevelopment phase.

6. ESA Specific Responsibilities

ESA, as part of its institutional roles, should more efficiently:

* propose strategic objectives for Europe and prepare for the medium and long term.

* foster pilot projects in partnership linking research centres, industry and financial institutions, while making more efficient use of information technologies and supporting networks.

* step up educations of future users and decision makers and broaden the application of existing information data bases.

* formulate quantified research objectives, based on future user requirements, provide appropriate incentive policies, propagate international bench marking and strengthen the ability of SME to transform technical knowledge into application.

* identify with university and research centres potential developments from the technology frontiers (superconductivity, nano-biotechnology, interferometry, nanotechnologies, etc.)

* identify and promote technology development that could enable competitive European small missions and broaden their application

* foster new ideas and concepts for "low cost access to space" systems, tailored to small missions

* identify future applications and their technical needs

* analyse European and global markets and trends (user needs, service cost, financing, ground infrastructure)

* wrt its own programmes, ESA to generate a broader policy framework to instigate and manage national interests and pursue more strongly European interest and European competitivity (especially in the optional programmes originated nationally). This requires also that ESA maintain a high internal expertise and capability to timely adjust European long term space policy.

* elaborate a space policy for Europe, able to take into account the globalisation of economics, the establishment of information and learning society and the acceleration of technical revolution

* fit space to political, social and economic agenda of governments and people

* identify activities to promote cooperation and information exchange between industry, universities and research centres.

* conduct strategic analysis of economics, industrial and socio-cultural issues and promote excellence in education by expanding scientific and technological competence to ensure sufficient talent for leadership.

* foster synergy and cooperation with defence and other civilian terrestrial developments

* assess driving factors and life cycle cost of space exploration and the exploitation of extra-terrestrial resources and ways to measure the benefits from related proposed programmes.

* contribute to the clarification of whether "man in space" can be considered a goal by itself (technological growth serving the biological and cultural evolution of the Human species) and which resources should be planned for this endeavour.

7. Industry Responsibilities

Industry, as part of its role should:

* implement new methods and approaches for providing on time services and products as demanded by the market and at the right affordable price. Those approaches should include a more efficient utilisation of concurrent engineering, advanced computer simulation tools and know-how and lessons learned.

* not only be a valid partner as a supplier, but also an efficient initiator of space-based services, which require capability for strategic marketing prospective, for making initial investments (private co-funds, anchor customer) and a sound business plan demonstrating sufficient profitability.

* analyse the space systems industrial process (global view). Compare with other non-space sectors and identify improvements

* develop life-cycle cost engineering models and validate cost-reduction approaches

* adopt standardised concurrent engineering which can support development and testing of an entire project life cycle.

* establish excellence at the forefront of advancing technologies and make considerable progress in capacity building, also through a more effective synergy with the non-space sector programmes.

* position itself in a global collaboration, as European success will not depend only on succeeding against external competition.

* identify competitors strategy wrt their policies, products, customers, financing and procedures and set targets for objectives and strategic business plans.

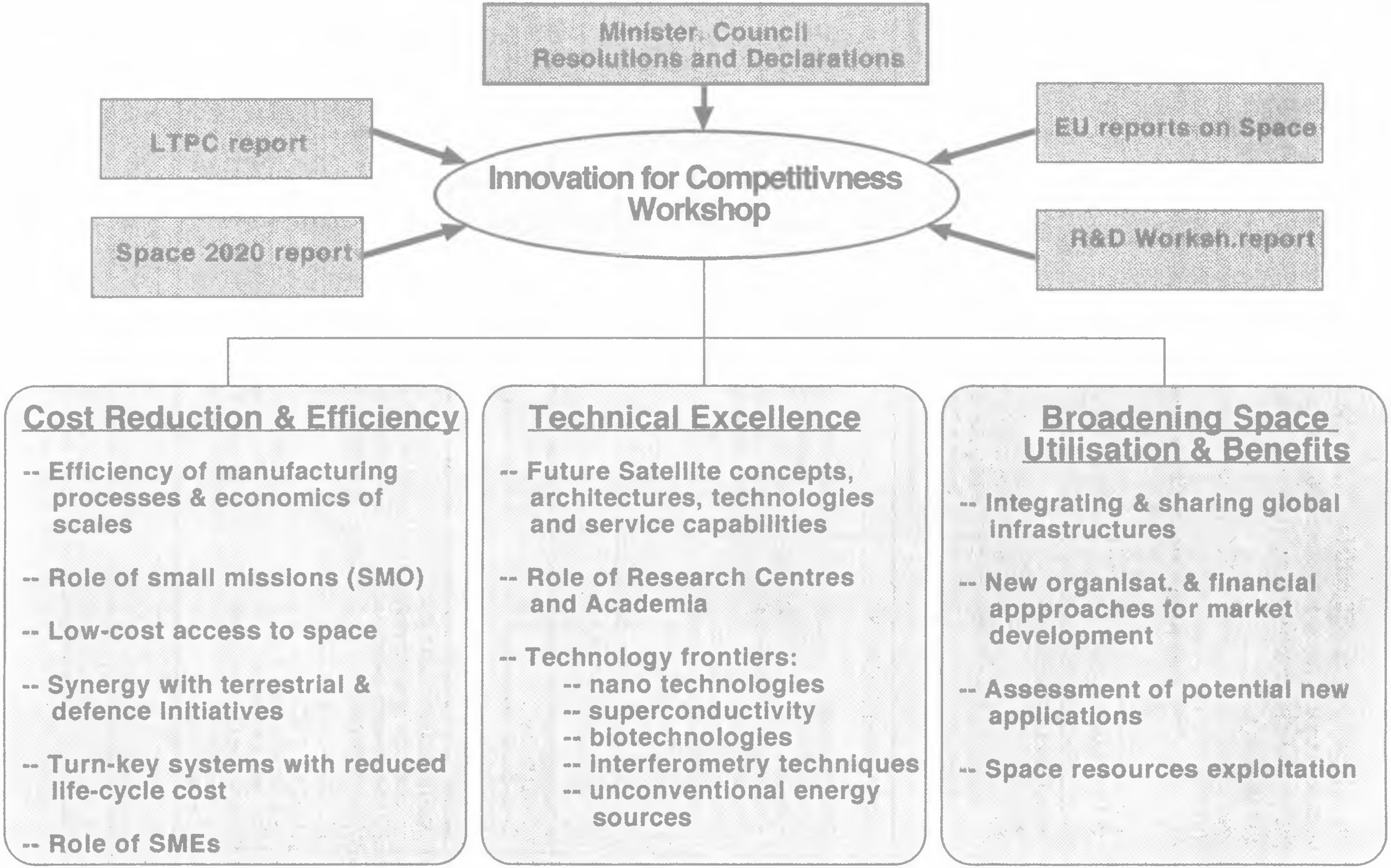
8. Concluding Remarks

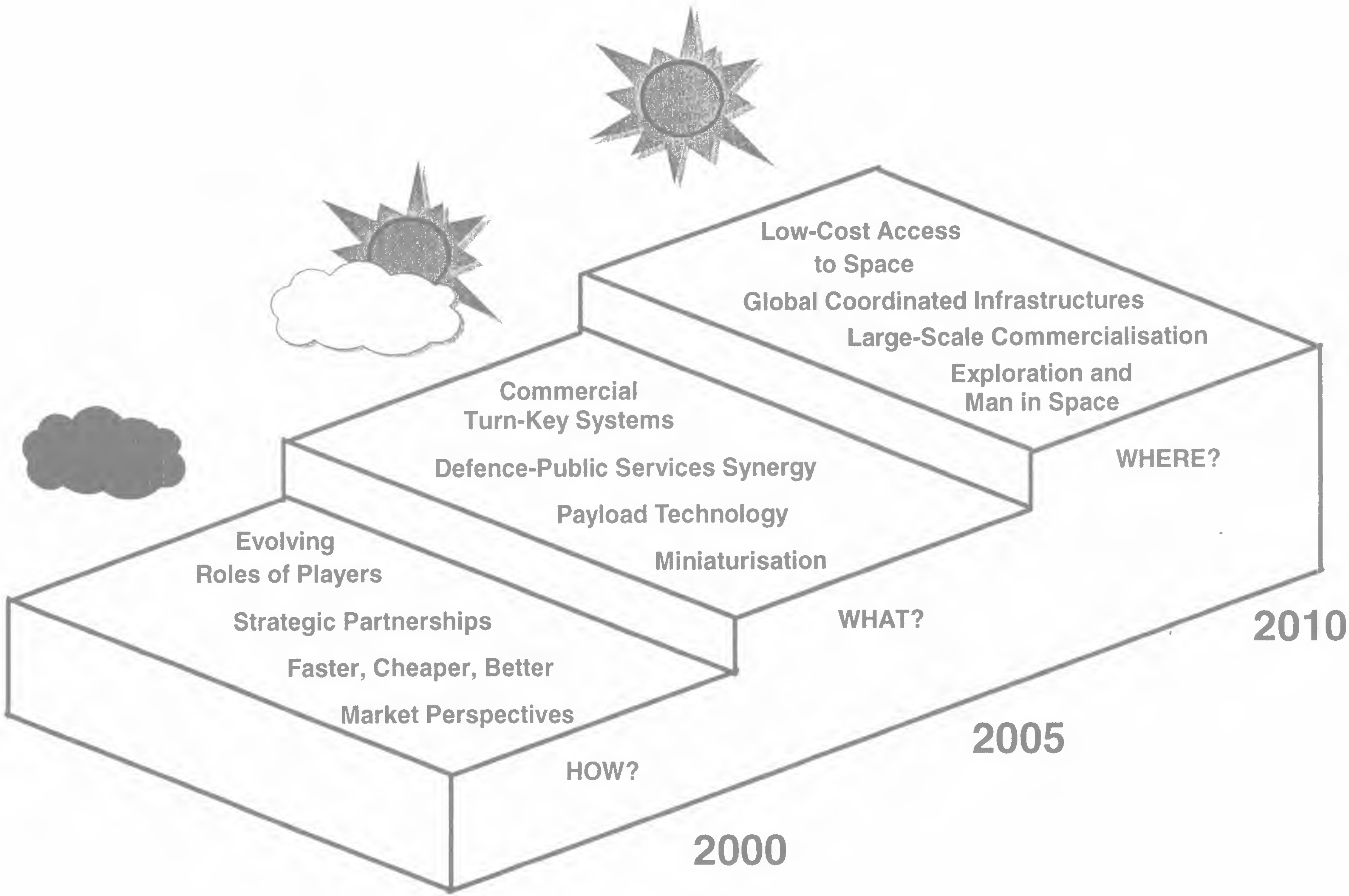
In proposing an action plan as follow-on of this workshop and in defining which policy improvements are possible, the attachment of people to their culture and habits, as well as the organisational and political inertia of the system should not be under valuated. It is essential to gain a good understanding of the reactions from "social/political elements" and to identify less sensitive program choices and pathways to innovation.

This political factor will certainly influence the future agenda of the space sector, with reference to the redefinition of the role and strategies of its players, their R&D policy and the a restructuring of industry according to the need of global end-to-end services.

Programmatic aspects of the space sector and the major drivers

SPACE PROGRAMME TYPE	SERVICE/MISSION CHARACTERISTICS	TECHNICAL DRIVERS
PUBLIC AND APPLICATION SERVICES - Weather - Navigation - Disaster Management	- "Long term service guaranteed" approach (>30 years) necessary - Public infrastructure financing with delegated exploitation	- Satellite constellations - Advanced ground computation and simulation features - Often, available services have to be tied together by appropriate "merging" technologies
COMMERCIAL SERVICES - Mobile telecom - Multi-Media - Broadcasting - Navigation services and traffic management - Global, regional and local application of Earth observation	- Global financial and insurance arrangement dictate schedule for early Return on Investment - Public guarantees expected - Typical 3-4 years from development - Constellation build-up over several years - Constellations from a few to several tens of satellites	- end-to-end turnkey approach - Commercial services will go "fully digital" - Interface with terrestrial means and standards crucial - On-board processing for comms/nav. & E.O. needed for simpler user end. - use of higher frequencies - continuous services - ground stations for constellation control
SCIENCE AND EXPLORATION - Astrophysics + Astronomy - Solar System - Moon/Mars Exploration - Earth Observation - Microgravity	- 10 years cycle typical for large missions - Public funding from R&D budgets - International program setup	- Usually one-of-a kind - Very demanding developments in all technical and scientific fields - Technology push approach - Mission success oriented - Direct man-machine interactivity
SPACE TRANSPORTATION - Improved expandable launchers - Future re-usable systems - Small launchers	- 10 - 20 years of development - Operational flexibility - Guaranteed availability	- improved cryo-propulsion - reusability - low cost
MAN IN SPACE - Space infrastructure - Crew transportation - Logistics, payload support - Maintenance - EVA	- 20 years development time - Public funding for development and operation - "indefinite" system life	- design update during lifetime - maintenance and re-configuration of elements - habitability - very high reliability


Minister. Council
Resolutions and Declarations
LTPC report
Space 2020 report
EU reports on Space
R&D Worksh.report
Innovation for Competitivness
Workshop
Cost Reduction & Efficiency
-- Efficiency of manufacturing processes & economics of scales
-- Role of small missions (SMO)
-- Low-cost access to space
-- Synergy with terrestrial & defence initiatives
-- Turn-key systems with reduced life-cycle cost
-- Role of SMEs
Technical Excellence
-- Future Satellite concepts, architectures, technologies and service capabilities
-- Role of Research Centres and Academia
-- Technology frontiers:
-- nano technologies
-- superconductivity
-- biotechnologies
-- interferometry techniques
-- unconventional energy sources
Broadening Space Utilisation & Benefits
-- Integrating & sharing global infrastructures
-- New organisat. & financial appproaches for market development
-- Assessment of potential new applications
-- Space resources exploitation



Low-Cost Access
to Space
Global Coordinated Infrastructures
Large-Scale Commercialisation
Exploration and
Man in Space
WHERE?
Commercial
Turn-Key Systems
Defence-Public Services Synergy
Payload Technology
Miniaturisation
WHAT?
Evolving
Roles of Players
Strategic Partnerships
Faster, Cheaper, Better
Market Perspectives
HOW?
2000
2005
2010

The Innovation Engine
Powering Competitive Advantage in the 21st Century

Executive Summary

Booz·Allen believes that the next round of competitive positioning will be based on innovation and that a company's innovation capabilities will determine its future growth potential. This creates a special challenge for senior management.

In leading their companies, executives will need to re-orient their thinking about innovation. First, they must shift their strategic perspective from the cost-driven improvements of the 1980s and early 1990s; they must focus instead on the revenue-driven improvements for growth necessary for success going into the next century. Next, they must ask, "What innovation capability could my company develop that would catapult it far ahead of the competition?"

In our experience, the most effective way to improve a company's innovation performance is for it to choose one of four core innovation activities to be its Innovation Engine — and then dramatically improve this capability. Selecting the correct Innovation Engine, measuring it, and strengthening it can raise the performance of the organization's entire set of innovation activities. The results? Greater competitive advantage and overall growth.

This viewpoint summarizes our experience and views on improving innovation performance, based on our work with clients in a variety of industries.

Future viewpoints in the series describe each of the four Innovation Engines and several supporting capabilities.

Innovation Engine

Superior innovation performance requires an Innovation Engine—a specific innovation capability that not only significantly surpasses the competition's but also drives improvement in other supporting innovation capabilities. Building the Innovation Engine improves innovation processes, tools, organizational skills and know-how. The innovation stream consists of four core activities—market understanding, technology management, product planning, and product development. The challenge is to select the right one to be the Innovation Engine, based on a company's strategy, and then develop it to world-class performance.

INNOVATION

Innovation is not a one-time product or service developed in a flash of brilliance. True innovation is a process of building a powerful capability that can be counted on to provide repetitive, sustainable, long-term innovation.

WHAT IS TRUE INNOVATION?

Essentially, innovation is one of a company's two fundamental activity streams (i.e., a group of related activities); the other is the delivery activity stream. The innovation activity stream brings together an understanding of what is needed in the market with what is technologically possible in order to create new products and services.

In the course of our client work, Booz·Allen has found that innovation comprises four core activities: (1) market understanding, (2) technology management, (3) product planning, (4) product development. By focusing on each activity as well as on the strategic and operational management of the innovation process, we are able to help companies identify opportunities for improving their innovation process. A company can then select the activity most suited for serving as its Innovation Engine.

By improving its innovation performance, a company is better able to capture time, cost, or value advantages in the market.

TRUE INNOVATION IS REPETITIVE, SUSTAINABLE, AND LONG-TERM

THE GAP IN INNOVATION LEADERSHIP

Many managers do not know how to lead innovation. Often they are reluctant to deal with the specialized technologies that lead to innovation or the resource base of independent thinkers, because they are not sure they can add value. For example, they will not interfere with a project or process if engineering or R&D says, "Leave us alone or we won't meet our deadlines." As a result, they are caught between wanting to perfect the process and fearing that they will negatively affect progress (and possibly company revenues).

Managing the innovation process requires a clear vision and an orientation toward revenue-generation.

In the 1980s and early 1990s, many executives focused on lowering headcount and improving efficiencies. Although these activities enhanced profitability and cost position, they did not necessarily lead to greater revenues. However, improving a company's innovation capability can lead to higher revenues and even new revenue sources.

Once oriented toward the benefits and importance of innovation, managers should ask, "What capability or capabilities could this company develop that would leapfrog us past our nearest competitor?" The decision about which activity should serve as the company's Innovation Engine will come out of this analysis.

During the late 1960s and throughout the 1970s, the Japanese revolutionized the performance of deliver activity streams. Today, the gap in delivery-stream performance between Japanese companies and non-Japanese competitors has narrowed, although the Japanese have continued to improve and set delivery stream standards.

The next round of competitive positioning will be a battle of capabilities. The companies that win will be those committed to developing a sustained innovation capability. To date, no geographic center or industry group — and few companies — has established innovation as a competitive advantage. Many companies have the resources needed to build the Innovation Engine that will keep them competitive. Now they need to muster the desire and commitment to action.

THE NEXT ROUND OF COMPETITIVE REPOSITIONING WILL BE BASED ON INNOVATION CAPABILITIES

Breaking the Incremental Cycle

Understand that being satisfied with small, predictable changes to products and services can kill a company's dedication to innovation. If an organization has weak innovation capabilities, only incremental advances are possible, except for the occasional technology breakthrough. But a strong innovation capability does not depend on technology breakthroughs; rather, it depends on know-how, process effectiveness, cross-functional linkages, high standards, and performance measurement.

An effective innovation capability with its associated processes does not diminish the role of technology "stars" in an organization. Instead, it systematically captures the stars' contribution. True innovation distinguishes between a sustainable contribution and a rare flash of meteoric brilliance.

Incremental innovation to products and services is the norm, particularly in many large, successful companies. While essential, satisfaction with incremental improvement can paralyze any company, including companies with the largest resource bases in the world.

How does a company think big? Desire is the first step in breaking the incremental cycle. Management must acknowledge that innovation can create advantage, that it can be sustained, and that it is based on developing and applying real innovation capabilities. Innovation advantage is planned, led and developed. It results from real capabilities, high objectives for improvement, and measured performance.

DESIRE IS THE FIRST STEP IN BREAKING
THE INCREMENTAL CYCLE

INVESTING IN THE INNOVATION ENGINE

Executives should ask themselves, "If I could develop one capability to put my company far ahead of my competitors, what would it be?"

Identifying and selecting the right Innovation Engine is perhaps the most important part of the process, because that is where the company will invest its time and energies. Should the Innovation Engine be market understanding? Technology management? Product planning? Product development?

Each company in an industry has a fundamental set of leverage points that is the heart of the Innovation Engine. To enhance competitive performance, management needs to select and build those capabilities that produce innovation advantage. The steps in the process are:

- Make the commitment to achieve superior innovation performance — and to break the incremental cycle.
- Select and build the Innovation Engine.
- Implement best practices throughout the innovation activity stream.
- Measure innovation performance.

Build the Innovation Engine to perform at a very high level; it will power the entire innovation activity stream. When it's in place, the Innovation Engine should drive the organization to meet or exceed current world-performance levels, ultimately improving the company's competitive position.

Selecting the right Innovation Engine is, of course, a critical step. The engine must be company-specific, selected because of its projected competitive value. Projected performance can be quantified; comparing alternative Innovation Engines, based on different potential capabilities, it is critical management responsibility.

For example, one large company picked completely different Innovation Engines in each of its three major businesses. In *power systems*, product planning focused on developing the product architecture capability to match exact equipment designs to customer specifications efficiently and quickly. In *materials*, information technology enabled the sales force, at the point of sale, to specify material composition and production schedule data to exactly meet customer requirements. And in *electronics systems*, a very strong competitive advantage in product development yielded better designs at lower cost.

Building the engine is also a management challenge. Target performance must be measurable, consistent, and distinguished competitively by a significant margin. A program to build the Innovation Engine includes an investment in time and resources — a major corporate undertaking — and must be designed based on expected return.

There are no formulas for selecting the right engine. Alternative capabilities fit different companies in the same industry, based on positioning and resources.

THE SECOND STEP IS TO SELECT AND BUILD A KEY CAPABILITY FOR THE INNOVATION ACTION STREAM — AN INNOVATION ENGINE

Best Practices: Implementing Innovation Learning

Implementing best practices means taking the best process in the innovation activity stream and standardizing them throughout the organization. In best-practice implementation, everyone involved in innovation activities commits to learning from each other, building on each other's strengths, and continuously improving individual and collective performance.

Best-practice implementation means standardizing innovation activity. This includes:

- Standardizing the best, proven innovation business processes within the organization

- Assess innovation performance, usually incorporating cycle and applied time performance

- Holding periodic meetings of designated best-practice groups to review suggested process improvements and adopt best-practices processes

One electronics company used best practices to improve design activities for 25,000 engineers with hundreds of different processes. Engineering management selected the best design process for each technical discipline. Using information technology, the best design process was applied to each project, then cycle time and applied time improvements were made. The company realized a 40 percent engineering productivity improvement in the first year by applying best practices throughout all engineering resources.

Innovation performance cannot be improved without implementation of best practices throughout the organization. This commitment includes the belief that innovation excellence can be led and managed, and that it results from excellent business processes and superior know-how. Outstanding innovation performance isn't the result of accidental breakthroughs; it is the result of people who lead, manage, and build innovation capabilities.

THE THIRD STEP IS TO USE BEST PRACTICES TO IMPROVE INNOVATION EFFECTIVENESS

MEASURING PROGRESS IN INNOVATION

Quantitative measures are essential to evaluating and improving innovation performance. They measure performance of the specific capability that creates the time, cost, or value advantages as well as the performance of the product or service.

Few companies know if their innovation performance is outstanding or weak, because most rarely measure innovation. Very few companies set innovation objectives and measure performance against objectives. Companies that do not measure performance or set increasingly high performance levels actually restrict conceptual freedom and, ultimately, innovation. Without confidence in this ability to innovate, companies have no incentive to set stretch-objectives. Setting low innovation-performance objectives leads to incremental product-performance improvements that do not go beyond what the market expects.

Both the effectiveness of business processes and the depth of know-how for each stage of the innovation activity stream should be measured and benchmarked. Internal measurements and comparisons within large companies can later be supplemented with external comparisons to determine best practices. Periodic measurements provide a sense of accomplishment and record the rate of change.

THE FOURTH STEP IS TO MEASURE INNOVATION CAPABILITIES AND PERFORMANCE

PRODUCT DEVELOPMENT AS AN INNOVATION ENGINE

In many large engineering and manufacturing companies, engineering productivity is the heart of innovation performance. Because of incremental thinking and lack of innovation leadership, many large engineering organizations do poor engineering work and do not understand how to improve. This becomes a vicious cycle. Without an understanding of performance problems, engineering cannot be effectively managed, led or utilized. Low hurdles are set and the organization is unwittingly forced into incremental thinking. Any innovations that do occur are breakthroughs, which are accidental and rare.

One electronics systems company with such problems embarked on a program to develop an Innovation Engine. The company, which had 25,000 engineers, selected product development as its Innovation Engine. It determined that design engineering productivity was a capability that would drive the product development process to set it apart from competitors.

Booz·Allen and the company's senior management developed a program that included:

- Segmentation of conceptual and design engineering
- Implementation of best practices
- Performance measurement
- Capability improvement
- Application management

First, the innovation capability had to be understood. What made a particular circuit design technique better than others? Was it the organization, the methodology, the tools, and the resources used? Best practices were determined and documented via analyses and discussions.

The capability was evaluated by measuring cycle times and applied times. During the first year, periodic measurement showed that the company realized a 40 percent improvement in its design engineering process.

What did this mean for the company? Lower cost because of increased productivity, reduced time-to-market, and enhanced quality and value for the consumer.

ONE COMPANY IMPROVED ENGINEERING PRODUCTIVITY BY 40 PERCENT

EU Innovation Policy developments

Pieter van Nes, European Commission

The paper presents an overview of some of the European Commission's recent activities related to innovation. Following the publication of the Green Paper in 1995 and the adoption of a First Action Plan for Innovation in Europe in 1996, the Commission is currently putting the final touches to the Fifth Framework Programme for Research and Technological Development and Demonstration. This programme is an important instrument for innovation at the European level.

The Green Paper on Innovation[1]

In December 1995, the European Commission published the Green Paper on Innovation. The aim of this document was to stimulate debate on innovation policy at European and national level. Thirteen "Routes of Actions" were proposed in a variety of policy areas related to innovation. The Green Paper was followed by a widespread consultation, involving national conferences in each member state.

The main lessons that emerged from the wide public debate were, firstly, that there is agreement with the Commission's diagnosis of an "innovation deficit" in Europe and, secondly, to remedy this the Commission needs to take action in a number of priority areas.

The First Action Plan for Innovation in Europe[2]

Following the discussions on the Green Paper, the Commission drew up the First Action Plan for Innovation in Europe. It was adopted in November 1996 and provides an initial response to the need to boost innovation. The Action Plan is the starting point for the preparation of a more ambitious, long-term innovation policy for Europe.

The starting point of the Plan is that it is in first instance the responsibility of citizens, of industry and of national, regional and local authorities to act in support of innovation.

At Community level, action is necessary to draw up and enforce the rules of the game, particularly those on competition, intellectual property rights (IPR) and the internal market. This level will also provide the necessary overview, enable the exchanges of experience and best practice to be propagated. Lastly, the Commission should show an example by mobilising its own instruments, above all the Framework Programme for Research and Technological Development and Demonstration, and the Structural Funds.

The Plan identified three key areas for action:

- Foster a genuine innovation culture
- Set up a legal, regulatory and financial framework conducive to innovation
- Gear research more closely to innovation.

Furthermore, the plan sets out a range of actions in these areas, and it specifies the level at which each should be implemented (Community, national, regional and local level).

Two actions within the third area which could be particularly relevant to the space sector are:

- Strengthen the capacity of small and medium-sized enterprises (SMEs) for absorbing technologies and know-how, whatever their origin.
- Prepare to flesh out the Action Plan in various priority sectors and fields of technology.

The text of the Plan itself specifically refers to space technology as a potential area for such action. This implies explicitly that the Commission is looking forward to receiving concrete ideas from industry or from space agencies.

The Action Plan for Innovation is currently being made operational by the Commission. In the medium term, however, the current discussions on the form and content of the Commission's next Framework Programme for Research and Technological Development and Demonstration will mean further developments in Innovation policy.

The Fifth Framework Programme for RTD[3]

In February 1997 the Commission published the second Working Paper on the Fifth Framework Programme. This paper gives a more detailed idea of the possible content of the Programme and of the scientific and technological objectives of the proposed activities within the various programmes. A formal proposal is expected by the end of March.

The Commission proposes organising the Fifth Framework Programme on the basis of six programmes, corresponding to the six priorities identified in the Communication *Inventing Tomorrow*[4]. The first three programmes ("thematic programmes"), related to the implementation of research, technological development and demonstration, are:

- *Unlocking the resources of the living world and the ecosystem*
- *Creating a user-friendly information society*
- *Promoting competitive and sustainable growth*

The last three ("horizontal programmes"), related to promotion of co-operation in RTD with third countries, dissemination and optimisation of RTD results and stimulation of training and mobility of researchers, are:

- *Confirming the international role of European research*
- *Innovation and participation of SMEs*
- *Improving human potential*

The Fifth Framework Programme and Innovation

In the Innovation Action Plan the Commission stated its intention to establish a single, simplified horizontal framework for integrating the "innovation" and the "SME" dimension in the Framework Programme. A horizontal programme on Innovation and SMEs in the Fifth Framework Programme is the result. Indeed, SMEs are important vectors and actors in the innovation process. Providing 66% of employment in the European Union, they should be able to benefit from easy access to advanced technologies, and to the possibilities offered by the Union's research programmes.

Another bottle neck in the European research-development-innovation system is the transfer of research results to market. There is venture capital in Europe, but far less than in the United States for example, and above all, it is seldom used to finance technological innovation. These problems far exceed the scope of the Framework Programme, and they certainly also extend into Europe's space programmes.

In the context of its activities to promote innovation, the Commission will be working to promote the creation of instruments to remedy this weakness. For example, there will be a greater focus on stimulating interfaces between financing institutions and the research projects and on support mechanisms which facilitate the exploitation of results within research projects. Furthermore, the Commission intends to set up a service giving assistance in the areas of IPR and access to finance, and there will also be a strong emphasis on facilitating access to research funding for SMEs.

The European Union and Space[5]

In December 1996 the Commission adopted the Communication entitled: "The European Union and Space: fostering applications, markets and industrial development". As part of the aerospace/defence sector, "space" is certainly not a very typical industrial sector.

Market-oriented applications are a growing, but still not a dominant component of space activity. Their share is about 30% in Europe, against only 10% in the United States. Governments, through their space programmes and a number of other means, have an important impact on this sector and influence the nature of the commercial market. This highlights the importance of a strategic concentration of all European actors involved.

The European Commission leaves no doubt that Europe must preserve and consolidate its large investments in space and that it is ready to use its political and economic dimensions to help European industry in its efforts to adapt to the new order. This can only be successful if it is done in close co-operation with Europe's space organisation ESA, which should remain a central piece of the institutional scheme.

Industry should be free to develop its strategy and choose a path adapted to the European framework. Issues such as industry consolidation, vertical integration and international co-operation are vital to the industry's global competitiveness, and the Commission is willing to assist in the analysis of innovative strategic alliances.

The Fifth Framework Programme and Space

Still, it seems that the main effort for innovation must come from the space industry itself, and the Fifth Framework Programme offers various entries for industry to pick up the challenge. Each of the three vertical programmes has a reference to satellites:

- *Unlocking the resources of the living world and the ecosystem*: proposes work to support the development of generic satellite earth observation technologies for environmental monitoring and resources management;

- *Creating a user-friendly information society*: proposes to promote excellence in the technologies which are the key elements in the spread of the information society throughout Europe, and refers explicitly to mobile and personal communications in particular satellite-based services.

- *Promoting competitive and sustainable growth:* proposes the development of systems for the rational management of transport and refers explicitly to second generation satellite navigation and positioning systems.

With respect to the horizontal programmes, the working paper for the Fifth Framework Programme is also specific that the implementation of the programmes will be carried out closely linked with initiatives and programmes in Member States and through co-operation with other European scientific technological co-operation frameworks and organisations (e.g. ESA).

Conclusions

The actions currently being developed within the context of the Action Plan and the re-focusing of actions under the Fifth Framework Programme for Research and Technological Development together make the European innovation support infrastructure more effective. There are several areas of action where the space industry can play an active role in both.

The Framework Programme and the Action Plan for Innovation provide the context for the European space industry, for ESA and the Commission to seek an optimum exploitation of the human capital, the capabilities and the infrastructure of the European space sector. Innovation in the institutional approach to space can only bear fruit if it is followed by a new industrial approach.

According to the dictionary, the opposite of innovation is "archaism and routine". That is why innovation comes up against so many obstacles and encounters such fierce resistance. It is also why developing and sharing innovation culture is becoming a decisive challenge not only for space, but for European societies in general. The space sector can serve as an example for this process, as a source of innovative approaches.

1 Green Paper on Innovation, COM(95) 688 final

2 First Action Plan for Innovation in Europe, COM(96) 589 final

3 Working Paper on the Fifth Framework Programme, COM(97) 47 final

4 Inventing Tomorrow, COM(96) 332, final

5 The European Union and Space: fostering applications, markets and industrial competitiveness, COM(96) 617 final

The Potential Role of Research Centres and Universities

N. Cabibbo, ENEA, Italy

(See page 349)

Paving the Way: how to support the Innovation Process

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Summary

Based on the experience of the ESA long term forecast initiative, known as "Space 2020", a number of important considerations for the future of the European space sector emerged. The established scenarios focused around the possibilities and constraints for Europe in Space specifically within the changing socio-economic conditions. As key areas have been identified: new competitive space derived products and services, cost reductions in industry and administration, recognition of the valid trends in RTD, and a efficient public administration. To establish these elements of competitiveness for the European space sector, innovations are needed in relevant areas.
The paper tries to extrapolate the findings coming from the European Commission and their "Innovation Programme" and to make them fit to the needs of the space community.
The given conclusions and recommendations could be used as a starting point for further actions.

The Problem

It is one of the great paradoxes of Europe that despite its internationally acknowledged scientific and development excellence, it launches fewer new products, services and applications than its main competitors. In other words, it is innovating less and less well at a time when innovation is becoming a driving force in economic competitiveness. This state of affairs, which is the result of a number of structural obstacles is a serious handicap not only to the European space sector.

Among the obstacles to innovation identified in the Commission's Green Paper are:

* *The relatively low number of researchers and developers compared with the USA and Japan;*
* *Insufficient expenditure on R&D (2% of GDP in the EU as compared with 2.7% in the USA and 2.8% in Japan);*
* *The wide diversity in legislation, regulations, fiscal and social conditions, and heavy administrative procedures which restrict innovation;*
* *The separation between science and industry, education and business, training and employment, commercial sector and agencies, military and civil;*
* *Difficulty in mobilizing private capital;*
* *The need for improved coordination and concentration of efforts;*
* *The presence of linguistic, cultural and legal barriers restricting the movement of persons and ideas.*

As a result of all these drawbacks, innovation is marking time in Europe, which is why ESA wishes, to pave the way for a genuine European strategy to promote innovation within the space sector. It, therefore, invites all the players concerned - Agencies, companies, research centres, etc. - to take part in a wide-ranging debate on the priorities and lines of action which they regard as necessary to remove the obstacles to innovation in Europe. Following these consultations, ESA will evaluate them and possibly draw up an action plan.

What has happened so far

The European Space Agency has been conducting a study over the past 3 years to examine what impact commercial, social, political, cultural and economic issues might have in space activities in the next 25 years or so. This activity, known as "Space 2020", has attempted to provide a programme-independent view of the possibilities and constraints for the European space sector in general, and ESA in particular[1]. It was concluded that the major challenges for the European space sector are likely to stem from the mounting needs for commercial services in the most dynamic parts of the globe.

This new environment for space applications is characterised by:

* *internationalisation and globalization*
* *deregulation and liberalisation*
* *overlaps between civil and military sectors and a*
* *growth potential in developing markets (economies of scale).*

To position the European space sector in this new environment innovations in 4 major areas were considered fundamental:

* *new competitive products and services for the most dynamic market segments*
* *major cost reductions in industry and administration*
* *recognition of the valid trends in RTD, and a*
* *highly efficient public administration to establish a proper frame work (EU, ESA, National agencies).*

With these recommendations ESA and her industrial and scientific partners were very much in line with ongoing initiatives on European level, specifically with the "Innovation Programme" of the European community[2]. Taking due account of these major European trends, a dedicated ESA "innovation working group" prepared the grounds for the workshop on "innovations for competitiveness". Various assessments focused on relevant topics and suggested the workshop structure which centres around four sessions:

* *a strategic overview - definition and evaluation of the innovation process*
* *the players views - strategies proposed by agencies, industry and research centres*
* *opportunities - products, services, synergies, markets and future options and*
* *options and resources - financial and technological possibilities and constraints.*

A new focus

In this context the innovation process should encourage the exchange of information on research and development, and successful commercial use of space related products, services and applications. It also aims to encourage the absorption of new technologies and

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[1] Space 2020, Round Table Synthesis Report, SP-1192, 1995, pp39

[2] The Green Paper on Innovation, ISBN 928268817-8(EN), European Commission

innovation by European space companies, in particular SMEs, and to ensure a continued supply of new information - in areas such as best practice, commercial innovations, and partnerships between European space and non space companies.

The innovation process shall manage a range of activities and services to help companies to exploit new technologies and innovation and, therefore, compete more effectively in today's global market. The innovation process supports services and activities which are focused on five interrelated objectives. These are designed to:

* *ensure the widest possible dissemination of the results of RTD activities under ESA and national space programmes;*
* *achieve optimum exploitation of space potentials by encouraging, with the assistance of the various actors concerned, the conversion of results into innovations;*
* *promote information transfer to and strengthen the sole of SME's;*
* *support the various initiatives launched at national level so as to give them a trans-European dimension;*
* *ensure the continuing development of expertise in innovation transfer.*

An instrument for change

Dissemination and exploitation activities are carried out at the European Community level by the specific research programmes of the Fourth Framework Programme and by the INNOVATION programme. The INNOVATION programme supports activities by providing the specific programmes with specialized skills and infrastructures, in particular the network of Innovation Relay Centres.

It is evident that the activities proposed by the European Space Agency shall take due account of the above initiatives. To select the areas of synergy potentials will be one of the ways to efficiently contribute to increase the European competitive position.

Three important domains

The implementation of a cohesive set of interdependent activities, grouped under three domains, shall help to support the innovation process:

* *dissemination and exploitation of space potentials to customers and users;*
* *support to enterprises (special focus on SME's and research centres);*
* *redefining the financial environment for the dissemination of space products and services.*

The aim of the first domain is to promote the dissemination and exploitation of space potentials across industrial and scientific sectors and national boundaries and, in particular, to publicize space activities and their achievements in order to increase their utilization and to facilitate market readiness in Europe.

Focused on the needs and possibilities of companies, research centres and agencies, this first domain shall be based on a number of measures comprising services of a general nature.

The second domain is targeted primarily at SMEs in the industrial and service sectors (outside the ESA world) which depend on up to date information but do not have sufficient resources to participate in ESA development activities or the direct exploitation of space potentials. Activities covered under this domain include support for innovation, the promotion of cooperation between universities and firms and inter-firm cooperation (SME clusters), the establishment of innovation dissemination networks, the organisation of training sessions, meetings and information about best practice in the management of innovation.

The third and final domain aims to improve the European environment for financing the exploitation, adaptation and dissemination of space products and services. This is to be achieved through encouraging entrepreneurial funding schemes, improving communication between financial circles and promoters of space projects, and management assistance enabling financial intermediaries to evaluate projects and exploit their results[3].

A framework for innovation

Based on the public debate stimulated by the Green Paper on Innovation, which was launched in December 1995, three main areas for action have been identified:

* *fostering an innovation culture: education and training, easier mobility for researchers and engineers,(flexibility in employment contracts)*
* *demonstration of effective approaches to innovation in the space sector, propagation of best management/practices*
* *and organizational methods amongst businesses, and stimulation of innovation in the public sector and in Agencies.*

Establishing a framework conducive to innovation: adaptation and simplification of the legal and regulatory environment, especially with respect to contractual issues, intellectual property rights, and providing easier access to finance for innovative enterprises. Gearing space developments more closely to innovation at both national and Agency level.

As far as action at the Community level is concerned, the Commission proposes to establish within the Fifth Framework a single, simplified horizontal framework for integrating "innovation" and "SME" dimensions[4]. Outside of the Framework Programme, all Community instruments are to be mobilized to support innovation.

Where action shall take place

The research and development area:

* *European space research and development suffers in budgetary terms. (Compared to the US who are at the leading edge in the commercial domain)*
* *Dispersion of European space development efforts leads to duplication of effort and a scattering of resources. Another problem is the gulf between space research and development communities (European space sector) and the commercial market and/or the users of space applications.*

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[3]Innovation: Dissimination and optimisation of the results of research activities, EC, ISBN 92-827-6355-2, 1996

[4] SMEs in the fifth framework programme - a joint EACRO-FEICRO position paper, 1996

* *A substantial effort is needed to improve the use of knowledge and skills, in particular by reorienting employers and workers towards lifelong learning and by focusing on disseminating achieved results.*

The second priority area is that of financing innovation:

* *Greater encouragement is needed for risk capital and capital resources investment in innovative enterprises;*
* *The development of trans-European capital markets for innovative companies needs to be strongly supported;*
* *Conditions of access to long-term loans should be improved;*
* *Contact between technological innovation and financial sectors must be strengthened.*

The third area is the judicial and regulatory environment:

* *Of particular concern is the protection of intellectual property.*

The cost to companies of registering a patent is some six times higher in Europe than in the USA, and many SMEs cannot afford to register their inventions. As regards administrative simplification, the Commission has recently launched the SLIM initiative (simpler legislation for the internal market), which could also be implemented in the innovation sector.

Conclusions and Recommendations

Taking into account the recommendations given by the European commission the below listed conclusions and recommendations could be considered as a first attempt to structure the innovation process for the European space sector.

* **Developing and establishing technology monitoring and foresight**: the main proposal is to encourage the exchanges of experience between countries, companies and research organisations concerning "technology watch". At the same time, regular statistical surveys of space sector innovations should be organized in the ESA Member States;

***Better directing development efforts towards markets and/or application**: at national level, the recommendations are to increase ambitiously the proportion of GDP devoted to space research, development and innovation and to encourage risk taking by enterprises;

***Developing initial and further training**: the main proposals are for the creation of a European system of certification for technical and vocational skills; Furthering the mobility of students and researchers, as well as development engineers;

***Promoting recognition of the benefits of innovation**;

***Improving financing of innovation** (support for venture capital); setting up a fiscal regime beneficial to innovation: eg. Direct access to venture capital, the Green Paper proposes, inter alia, improvements to the accounting and tax treatment of intangible investment (research and training) to bring it into line with the treatment of tangible investment;

***Promoting intellectual and industrial property**: the main actions proposed are to reinforce the legal protection of innovations and to make it more accessible to SMEs and inventors; to reinforce the instruments to combat counterfeiting and copyright infringements; and to step up efforts for the international harmonization of systems for the legal protection of inventions;

***Simplifying administrative procedures**: it is proposed to improve and simplify the business environment (contractual relations, reduce the entrance fee for newcomers), especially with regard to business formation and the growth and transmission of enterprises;

***Developing "economic intelligence" actions**: the Green paper suggests that higher training for future managers, engineers, researchers and senior marketing staff should include familiarization with economic intelligence to encourage sustained awareness of this subject among enterprises. It invites the Member States to create an environment favourable to the emergence of private-sector services offered to enterprises in this field. Economic intelligence can be defined as the coordinated research, processing and distribution for exploitation purposes of information useful to economic operators. It includes the protection of information regarded as sensitive for the company concerned;

***Encouraging innovation in enterprises**: foster cooperation among enterprises and strengthen groupings based on technology or sector in order to realize the potential of local know-how;

***Updating public action for innovation**: to encourage better coordination of public actions and private initiatives in the field of research; to identify, the administrative procedures and rules which are likely to hinder initiatives in the field of innovation; and, at ESA level, to initiate an inter-institutional dialogue on the means of dealing with innovation policies as such.

References:

A.Atzei, K.Pseiner & D.Raitt (1995): Space 2020 - Round Table Synthesis Report; SP-1192, ISBN: 92-9092-267-9, pp.39

K. Pseiner & D. Raitt (1995): The Future Perspectives for Space; FS-SR-95-1, pp.64

A. Atzei, F.Gampe & K.Pseiner (1996): Assessing new applications and testing business opportunities; proceedings of the 47th International Astronautical Congress, October 7-11, 1996/Beijing, China

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Adressing Competitiveness Issues and Partnership with Industry in CNES' Strategic Plan

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The major transformation we are experiencing as the century draws to a close is felt particularly strongly in the space sector, which is by its nature at the confluence of scientific, technological, economic and political concerns. Alongside developments arising from the emergence of a new geopolitical order, such as the International Space Station, or the awareness of global problems, such as space systems devoted to the study of climate change and the environment, we are now witnessing a very large volume of activity connected with the emergence of new growth markets for space applications, such as those catering for the needs of the information society.

In conjunction with the new budget realities and the maturity of new players in the space sector, this transformation has already - and very probably lastingly - affected the behaviour of the major space powers such as the United States and Japan. Alongside their traditional role in large-scale programmes distant from the market, these States are now intervening directly to promote the competitiveness of their space industries as a necessary step towards increasing employment in an innovative, high-technology sector.

For Europe to remain a space power of the first rank, its constituent countries must adjust to these developments. France, which aims to remain one of the driving forces behind European space activities, has a major role to play in this endeavour. To do so, it has entered into a phase of strategic thinking, with a view to defining the actions needed to secure its place in major international programmes, maintain a scientific community of the highest level, ensure the existence of a competitive space industry and meet the growing requirements of space users. A Strategic Plan has been prepared in 1996, and fifty actions have been selected for implementing this plan in 1997. This paper considers the ways in which this plan adresses the issues of competitiveness and relationship between CNES and industry.

Strengthening the competitiveness of French industry

Implementation of a space policy necessarily involves the State in the creation and maintenance of an industrial space potential. In France, through the intermediary of CNES and other bodies, it must concern itself with the profitability of investments, the ability of the industrial sector to meet future requirements and, on a more general level, the problem of coherence between the activities of firms working in the field.

It must however be emphasised that the French space industry was largely built up on the basis of defence programmes, so that when it comes to national industrial policy, CNES can act only as one of the players involved. In addition to the concerns already mentioned, which are moreover shared by all States wishing to become or remain space powers, there is the need to come to terms with the emergence of the market. Although its means of direct intervention are more limited in this area, CNES can develop a partnership with industry to provide it with support in winning new markets.

Achieving maximum efficiency in the State's efforts alongside industry means ensuring that the latter generates profits and can perform the threefold task of:

- Meeting national demand.
- Exporting.
- Increasing the intrinsic competitiveness of space with respect to all

competing options.

CNES can act on two levels to achieve this objective:

- Where the space option replaces an approach based on another technology, CNES must strive to ensure the quality of the service provided, with a constant concern for cost reduction.
- Where space technology responds to a demand that is not yet fully perceived and needs further stimulation, CNES can drive the search for viable economic solutions by acting at the same time on the credibility of the technological solution on offer and on the emergence of the market.

Preserving the diversity of the industrial sector

France has 40% of Europe's industrial space activity, with a very wide variety of firms involved in the sector, ranging from large prime contractors to small and medium-sized businesses. Despite the emergence of a market subject to the rules of private investment, the structure of space activity is still strongly influenced by orders from the public sector and by public policy.

It is in the general interest that CNES should help to strengthen a competitive and innovative industrial sector by maintaining a balance between large prime contractors capable of taking on world competition, equipment suppliers with unique expertise (which the GIFAS is currently responsible for listing and evaluating) sustained by a critical volume of activity, and a network of innovative small and medium-sized businesses creating jobs. Nothing would be more harmful than an excessively vertical structuring of space activities, which, in order to meet the alleged demands of international competition, would do permanent damage to the creative potential afforded by lighter and more flexible structures. As far as it is able, and in coordination with other State bodies, CNES must endeavour to ensure compliance with certain rules of play.

It must also be stressed that space must feed on the development of generic technologies in other fields of industry. It must borrow as well as provide - at least in the same quantity - and obvious economic considerations must draw it closer to existing product lines. The space sector must be resolutely outward-looking, and CNES must therefore take care not to encourage the creation of isolated structures devoted exclusively to space activities.

Ensuring the coherence of industrial activities

It is perfectly legitimate for space firms to seek to win new markets. Nevertheless, the development of space activities must proceed in such a way as to optimise national industrial potential by avoiding dispersal or duplication of expertise, limiting competition, and ensuring the optimum use of public funds.

CNES can harmonise industrial activity by proposing "rules of play", if possible within a European framework, in conjunction with the government authorities responsible. In particular, this requires coordination with the DGA and ESA.

The strong pressure being felt from international initiatives, mainly American and especially in the communications sector, is a further reason for strengthening the coherence of industrial activities. If it appears united and well organised, Europe can cooperate with the United States and avoid a risky direct confrontation based on rivalry. CNES must contribute to the necessary synergy by providing support for French industry in meeting the challenges of the market.

As to the restructuring required if European industrial groupings are to achieve the critical mass needed to face up to world competition, CNES must clearly recommend the further pursuance and consolidation of horizontal and vertical integration. Broadening their range of activities is the best way for industrial groupings to enable the space sector to benefit from the innovations arising in neighbouring areas of technology. Moreover, the incorporation of utilisation functions, such as operator activities, will better equip firms in the space sector to build and fund the commercial systems that will enable them to expand their activities. Industrial groupings will also have to divide their activities judiciously among ESA's Member States in order to meet the legitimate concern for geographical return. This approach will enable the European space industry both to adapt to the rules of European public funding and to meet the challenges of the world market.

A set of simple rules for the partnership of CNES and Industry

In commercial sectors, where market dynamics oblige firms and operators to offer new systems and services, CNES must contribute in accordance with new partnership principles.

These principles could be drawn from a few simple rules:

* Partnership applies in principle to all phases of a project, since CNES has the full range of expertise required from the design phase through to the operational phase.

* Partnership assumes a long-term commitment, until the system that has been developed secures a place on the market.

* Partnership entails a financial risk for each partner, with CNES taking on the risk involved in the development of basic technologies far in advance of subsequent applications.

* Partnership is based on the mutual complementarity of skills combined for the purposes of a joint endeavour, whereby each partner benefits from spin-off in proportion to its participation.

* Partnership must not distort the rules of competition. In the case of a target market fed by public funding, of Basic Technical Research or of a private-sector initiative, the firm selected must be the undisputed leader in the field. CNES may, however, seek to develop a standard in conjunction with a firm selected a~er competitive tendering, as in the case of PROTEUS; in such cases, CNES must promote the development of the space sector by ensuring that the standard is cheap and accessible to all, and by shifting competition to a later stage in the process.

* Partnership must be based on strict rules governing confidentiality and intellectual property rights, so as to safeguard industrial interests.

It has become apparent in the course of developing CNES' strategic plan that the variety of roles assumed by CNES may be a source of confusion. At different times - and in many major fields - a policy-maker or supplier, a driving force for European construction or a defender of national solutions, CNES may seem to lack coherence and clarity in dealings with its partners. The perceived shortcomings in communication between agencies do moreover give rise to inadequate coordination of programme planning and international projects, at a time when the fortunes of the space sector point strongly to the need for synergy.

It is important to restore confidence by establishing regular high-level political and technical exchanges with CNES' partners concerning the environments in which they and we are working, the aims that should be pursued and the ways of achieving them. This is essential if we are to assist our industrial partners in entering new markets.

A wide range of opportunities for working with industry

The strategy developed by CNES must take into account government policies, international and in particular European relations, and forward planning considerations in relation to the evolution of our environment with a view to defining basic lines of action that will lend overall coherence to CNES activities. The far-going changes that we are experiencing, and in particular the new type of relationship with industry which those changes demand of us, require us to formulate a strategy in which CNES' technical capabilities will be called upon to play a key role. It is therefore essential to establish better communications between the establishment's strategic and technical functions. Effective communication of this kind will provide a basis for better exploitation of our capabilities and expertise.

A wide range of opportunities exist for working with industry, in accordance with clearly defined rules of play, and these include:

- Establishing technology development projects.
- Building demonstrators.
- Exploiting basic research.
- Setting up new types of cooperative venture.

If risks are to be shared equitably, industry will of course have to fully assume its particular role wherever production, export and market interests are at stake. CNES for its part should draw on its specific capabilities, its unique expertise built up over years of basic research, pre-project studies and system analysis, tried and tested in the course of many scientific or applications development programmes.

CNES Involvement in the conquest of new markets

It would make little sense, at a time when the market for space applications is undergoing unprecedented growth, for France - which has already invested heavily via CNES and does not to the same extent as some competitors enjoy a large, captive regional market - not to have a significant involvement in the conquest of new markets.

Unlike other agencies and even ESA to some extent, CNES has adopted a « near-to-market » policy by promoting the development of operational applications and establishing the instruments needed to pursue that policy. NASA itself, resituating its relations with the private sector, is now committed to seeking industrial partnerships, its target being to spend 10% of its budget on support for commercial projects managed by the private sector. This sector offers a wealth of partnership opportunities which CNES could exploit by proposing basic research results, innovative concepts, launch and station-keeping of satellite constellations, support for private ventures etc.

This is the fundamental thinking behind a fresh determination on the part of CNES encouraged by most members of the industrial community wishing to draw on its intellectual, technical and financial resources - to assist firms in their efforts to enter new applications markets, in very many cases outside Europe.

Communication is an integral part of the strategy required to achieve this end. Greater attention must therefore be given to the communication function which must, while liaison is maintained with those responsible for developing corporate strategy, ensure that the activities involved form a coherent whole rather than a series of unconnected immediate responses to events.

Promoting and facilitating technology transfer

The French aerospace industry is characterised by a higher ratio of research to production than any other industry in the country, followed by electronics and pharmaceuticals. It is also the area in which this ratio has risen most rapidly, except for the service sector.

The tendency to treat the "space" function in isolation has the dual disadvantage of detracting attention from the potential for technology transfer between CNES and industry, not only in terms of research results but also of brainpower, and of keeping CNES to some extent on the fringes of the progress in generic technologies achieved by the mainstream governmental and industrial aerospace and defence community.

The technologies concerned include high-perforrnance materials, electronic components, sophisticated detection and positioning equipment, advanced mechanical, optical and energy storage systems, so~ware systems, on-board computers etc., which are adapted by CNES to meet the specific constraints of the space environment.

It is important that the initial solutions, once they have been developed and selected by the technical centres, should in return be of benefit to firms which are leaders in their areas of activity or have to meet the needs of demanding users concerned to find appropriate ways of meeting their requirements.

This two-way mechanism for maximising technological potential does not necessarily imply substantial support arrangements. Some streamlined structures have already been set up (one example being NOVESPACE). It does on the other hand call for a determination within CNES to grasp every possible opportunity to respond to the demand from industry for innovative technical solutions. It requires too a genuine acknowledgement that space activity must draw on technologies used in other areas. In some cases this may mean calling in outside expertise rather than opting, often without having attained the critical international dimensions demanded by specific methods, for in-house development. The idea of setting up mixed forward-planning units in some areas merits careful study.

The speed of technological change is leading to the emergence of new concepts which warrant setting up within CNES an amply staffed and well-equipped unit responsible for analysing systems and future missions.

The search for increased overall efficiency

Increasing overall efficiency presupposes stronger links between development activity and Basic Technical Research, advanced technology and the work of French and foreign research institutes. The creation of integrated teams must be encouraged. Drawing together all the necessary capabilities, such teams would provide considerable scope for the delegation of responsibility. A number of constraints would have to be relaxed. An important feature of this carefully controlled process would be the exploitation of feedback, which must be developed and used on a much wider scale.

Another prerequisite for effective project management is the introduction of integrated monitoring systems covering technical, cost and timeline aspects designed to support reporting and synoptic evaluation at all levels. Use of ECSS, the European benchmark for quality and engineering management, adapted to meet the specific demands of individual programmes, must become routine. Real partnership is however possible only if the rules to be followed are clearly defined.

Turning to more technical options, the widest possible use must be made of simulation techniques, not only in system design but also at human resource level, with emphasis on staff training and the creation of appropriate tools. A "paperless" policy must be introduced for all internal and external exchanges of information and this should be backed up by decentralised information management arrangements. Greater use should also be made of standard components and recurrent industrial hardware and soflware products, for which formal user guidance will be necessary. Finally, optimum integration of functions must be sought.

Giving Priority to Basic Technical Research

Finally it is important to emphasize that CNES will be able to play the various roles described in this paper, in support of competitiveness and success of industry in new applications markets, only if it keeps and increases its technical excellence. This means giving a high priority to Basic Technical Research.

BTRis the only link in the chain of CNES activities that meets two fundamental requirements:

- It is the means of sustaining the fundamental knowledge that is indispensable to basic tasks in the space sector.
- It paves the way both for new space application concepts and for the technological developments that will enable them to be put into practice.

As part of CNES's basic task of "developing and directing scientific and technical research in the space research sector", Basic Technical Research is also indispensable.

For these reasons, Basic Technical Research must not be considered as a variable to be used for budget adjustment purposes. On the contrary, it must as far as possible benefit from a steady and significant increase in its budget, so that it can meet clear objectives covering a number of years. It must be organised as a programme in its own right, with an annual planning schedule, and monitored - despite the fact that action is spread over a number of different areas - according to the same rules as a conventional programme. As a group of projects, it must also be evaluated, and the role of the upstream and downstream evaluation boards strengthened accordingly. Finally, it must provide the opportunity to appeal directly to the imagination of all CNES engineers through the issue of internal calls for innovative project proposals.

Basic Technical Research in CNES should put the necessary emphasis on:

<u>• The importance of "system " activities in the choice of major options</u>

Rapid technological development brings to the fore new concepts, such as satellite constellations, which justifies setting up within CNES a body with generous staffing and resources to be responsible for the forward planning of future missions and for systems analysis. Its task will be to revitalise internal expertise by channelling it towards future needs and to inspire the choices made in Basic Technical Research. This will provide the framework for ensuring that guidelines for preparation of the future are conditioned by a deliberate concern for future applications.

• The use of innovatives technologies

The emphasis must be on the use of innovative technologies, especially microtechnologies, where it is recommended that activities be combined in the framework of in-orbit experiment projects, or on exploratory developments. This must be done out in partnership with national centres of expertise in this area, such as the ONERA, INRIA and the relevant CNRS research laboratories. The formation of mixed, not necessarily scientific, groups involving CNES, academic researchers and industry, would be an effective way of increasing the relevance of a purely technical pre-project capability. Basic Technical Research on instruments must also be emphasised, as a factor determining in-orbit mass reduction. Finally, a permanent future Technical watch would make it possible to detect the emergence of technologies elsewhere that could potentially contribute, in the space sector, to significant developments in applications or performance.

• A constant concern for demonstration in orbit

The development of in-orbit demonstrators makes it possible to verify the application of new technologies to the space environment. If properly coordinated with programme launch schedules, it can prove the technical feasibility of their most critical aspects. It also provides a means of training young engineers in project management and increasing their awareness of the potential contribution of new concepts. For all these reasons, Basic Technical Research must systematically include a number of in-orbit demonstration projects, based in particular on a deliberate policy of promoting the use of microsatellites and making full use of the passenger accommodation possibilities afforded by the Ariane launchers.

The importance of a cross-disciplinary approach

One should also stress that excellence in space applications depends on the possession of generic expertise that it is up to CNES to develop. This necessarily requires a cross-disciplinary approach that cannot be classified by discrete topics. It is the case for instance to achieve the following goals:

• Keeping at the top in image and data processing

The quality of observation systems largely depends on mastery of all the technical links in the imaging chain. CNES has developed unique expertise in optics, opto-electronics, optical instruments, micromechanisms, attitude stability and control, "image quality" and information storage. Of all these skills, "image quality" is a recognised field of expertise that is part of French and European acquired assets. These assets must be maintained and enhanced. The same is true of data processing, where the expertise acquired in the course of all the programmes conducted by CNES is directly responsible for the quality of the service provided. The effort needed to develop this know-how must be part of CNES' concern to increase its "downstream" involvement, in close liaison with users in the space sector.

• Taking into account the growing importance of software

Software plays an increasingly important role in space systems. Software programmes are both a functional enhancement factor with considerable potential and a source of vulnerability when their complexity is not properly mastered (as in the case of the Ariane 501 flight). CNES must therefore make a special effort to adapt all the methods developed in other fields to the space sector, so as to ensure the quality of the software. The Ariane 501 failure has also highlighted the need to develop the concept of software architect. It is up to CNES to establish genuine expertise in so~ware systems and in complex systems that are highly software dependent.

• Developing the "tool kits" of the future

Future space applications will rely on new techniques that need to be mastered. Some of them are already known from other fields of expertise such as orbitography, command and control, tele-operations, telescience and systems engineering, and they have to be maintained at a high level of excellence. Others, such as simulation, have yet to be explored or adapted, so that their full potential can be used for space applications. A permanent monitoring capability needs to be developed for this purpose, together with the watch on emerging technologies referred to in connection with Basic Technical Research.

ITALIAN SPACE AGENCY VIEWS AND PERSPECTIVES

G. Rum, S. Di Pippo - Italian Space Agency (ASI)

1. Introduction

The last years have shown a clear trend of public budget shrinking for space activities.
In parallel the commercial market for space products has been subject to an increase in specific areas (Communications - well consolidated -, Earth Observation) but, with few exceptions, the european space companies cannot survive without comprehensive space programs developed by National Agencies and by ESA.
While space research and space exploration will always imply investment of public funding, there is however the stringent need to optimize the overall resources and to clearly pursue, within space programs, a policy that shall allow, beside the accoplishment of their primary objectives, major spin-off's in tecnology and, as the final result, in the capability of the european space companies to find and/or consolidate a preminent place in the commercial market.
Being the space commercial market, at least in Europe, still rather limited the proper approach should be found with respect to a broader perspective and the first consequence is that the "model" Company shall operate in the global, space and non space, market.
Key factors to be considered in order to identify and implement an effective policy are : innovation, tecnology transfer, interaction between industry and the research community, competitiveness.
The main subjects and, at the same time, actors of this process are the SME, but neverthless the "system" Companies can play a very important role by introducing the SME into new domains and also by applying and commercialize their system technology in "terrestrial" applications.
Difficulties of different nature exist today for a Company to enter in the spaces activities. The matter will be briefly touched later in the paper.
The paper, starting from a summary of the relevant policy statements given to ASI by the Italian Government, and passing lesson learned in a specific "test case", identifies a number of recommendations deemed appropriate for implementation in the european scenario.

2. Italian policy lines

ASI was recently given by the Government the main policy criteria for the preparation of the 1998-2002 five years italian National Space Plan.
A number of these criteria are fully applicable to the subject of the Workshop and are summarized hereafter :

a. strategic role of space activities and infrastructure and their economic relevance is recognized ;
b. investments for space programs must have the objective of a balanced growth of scientific, technological and industrial components;
c. a technological program aimed at satisfaction of national needs and capable of increasing the competitiveness of the italian industrial system shall be defined and implemented;

d. coherence among scientific, technological and application programs shall be pursued ;
e. special emphasis shal be given to programs directed to put the conditions for the provision of services in parallel to the promotion for increasing national demand for space services.

The above points, even if of general nature, indicate the full awareness of the strategic nature of the space activities and the determination to pursue, through them, the widening of the market and the competitiveness of its major player, the italian industry.

The 1998-2002 National Space Plan is currently under preparation and will be issued by mid '97 ; it will contain a comprehensive approach to the matter and the specific lines of development.

Today some lines of development can be preliminarly identified and this workshop is considered an important step to exchange respective ideas, with the goal of identifying a common ground, also in view of the forthcoming United Europe.

3. A brief review of the factors involved

It is worth to do a brief review to define the extent of the matter and to make some considerations on the various factors involved.

The key word of the Workshop is competitiveness, that immediately implies the capability for companies to acquire certain portions of the market.

To define an approach one should have clear the objectives : in this case the objective is to have an industrial system, both national and european, to be competitive within Europe and in the worldwide market, both space and non space.

Innovation shall be considered a broad term, because it has various meanings, such as technological innovation, innovation in the "access to space" process, innovation in the way of defining and managing programs. In all cases valuable results can be achieved and the competitiveness is increased, providing a better product at lower or at the same cost.

Technology development in the space field and two-way technology transfer (space to ground applications and viceversa) are two of the main tools to implement the innovation and to maximize its benefits.

Space activities are strategic because they represent the frontier of the human research and exploration and require always, for their continous advance, technological improvement, without whom new missions could not even be thought. Mutual benefits between industry and the scientific Community can only be accrued by enforcing coordination and cross-fertilization.

An other consideration, relevant to the "market", better focuses the matter under review.

While the National Space Agencies and ESA should be the first actors to promote the widening of the space products market, industry, through a number of interfaces they have already in place and under Agency coordination, could be the main driver of the technology transfer. Advance along this lines will allow sensible industrial investments and produce parallel benefits to the overall space activities and to the competitiveness of the industrial system.

4. The ASI's Automation and Robotics space Program : a "test case"

A brief description of the ASI's A&R program, of its approach and developments is considered appropriate as it can be considered a test case to assess the importance of some of the factors mentioned above.

The A&R program was started in 1987 and it was based on the definition and

implementation of a specific mission, supported by coordinated and comprehensive technological developments in specific areas to support and substantiate the feasibility and affordability of the mission itself.
Three main criteria have been applied :

- implement innovation in the "access to space" process, using to the maximum extent the so called COTS (Commercial Off The Shelf) technology ;
- extensively involve non-space companies as subcontractors, enlarging the availability of state-of-the art technologies ;
- give specific attention to potential spin-offs in terrestrial application .

The A&R program is on going and even if it has been subject to some changes due to modifications in the overall reference scenarios and to budgets constraints, its original main goals are kept and the achievements made to date show the applicability and suitability of the above criteria.

Lessons learned :

on the positive side,

a) use of COTS and MIL STD components dramatically reduces cost and development time, while increasing the possibility of "non-space" companies to enter in space activities (ref. to full success of the robotic arm joint and relevant controller test flight on board ESA's EUROMIR 95 mission) ;
b) through a two-way technology transfer, space activities benefit from the involvment of non-space companies, that in turn make advantage of experience and developments made in space programs. Prime responsibility and leadership in specific field(s) of a space company seems to be however mandatory (ref. to Rosetta lander developments assigned to Tecnomare and Rodio as subcontractors of Tecnospazio) ;
c) competitiveness and spin-offs in the terrestrial market can be acquired by non-space companies through well defined participation in space projects (ref. to the use, by COMAU, of force/torque sensors developed under ASI program in terrestrial robots used in the assembly lines of FIAT cars) ;

and, on the negative side,

d) a general non awareness of non space companies of the opportunities offered by space activities for their primary market ;
e) extreme difficulties to enter space activities, both because of mentality and of the extremely heavy "space bureaucracy" (i.e high cost for proposal preparation), in many cases not affordable at all for the SME.

5. Access to space

Access to space still presents some difficulties for Companies : the cost to develop space hardware and bring it in orbit is still high and the life cycle to get results from an experiment in space is too long to cope with the needs and constraints of industrial plans.
Solution of these two problems seems really to be the prerequisite to create the proper conditions for an extensive use of space as an important tool to implement innovation and to improve competitiveness.
Many initiatives are on going (i.e. in the launch systems domain) to offer a cheaper but still reliable access to space and this will certainly contribute to the increase the number of "industrial" users.
Very promising perspectives are also given by the opportunities that will be offered by the International Space Station.
The Space Station can be certainly considered as a multidisciplinary scientific laboratory and

as a technology test bed. In addition it could also dramatically reduce the duration of experiments life cycle thanks to some of its features, such as frequent access, flexibility due to the human presence on board, possibility to bring back experiments. It will allow to shift the focus to the on board testing, instead of on ground qualification.

6. Conclusions and recommendations

Innovation and competitiveness are two essential elements of a much comprhensive scenario, the european idustrial policy, currently on the agenda of the Ministers of ESA Memberstates.

It is anyhow clear that space activities are at the edge of human progress and, as such, are the logical domain in which implement innovation and achieve competitivenss.

The implementation of a clear policy in the european scenario should take in consideration all the main actors, both on governamental and on industrial sides, and should have the final goal of an increased competitiveness of european industry in a rapidly evolving world market, both in terms of competitors and of potential customers.

The following recommendations apply :

- promotion activities to improve the awareness of industry, expecially SME, on the possibilities offered by space activities, including the provision of initial flight opportunities ;
- simplification of the access to space, in terms of lower costs, use of commercial components and less "bureaucracy" ; new generation launchers and extensive use of the Space Station could be important elements to help in this direction ;
- maximization of a two way technology transfer ;
- use of available space technologies for the provision of "space derived" services, also through stimulation of the internal demand ;
- identification of clear technological objectives and their implementation within scientific/exploration programs, finding a suitable balance with associated costs and schedule ;

Pilot projects in different areas, with appropriate participation of space and non space Companies and of research Institutions are considered to be the tool to create the proper conditions to have space considered, for industry, one of the elements of their "core business". These conditions will also allow a broader use of co-financing between Companies and Government Agencies that is the way to optimize the use of the available budget.

Innovation for Competitiveness
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DARA's approach towards more competitiveness in German space business

Klaus G. Saul, DARA GmbH, GERMANY

SUMMARY: The presentation considers

- *goals of DARA,*
- *achievements of Europe in space,*
- *the challenges of globalisation,*
- *perceptions of German space industry,*
- *ESA's industrial policy,*
- *the different roles of industry and DARA,*
- *the notion of technological innovations,*
- *the basic idea of evolutionary innovations,*
- *the innovative path of the German digital Mars cameras and the representative approach towards real-time Earth observation,*
- *comparing the innovative power of enterprises.*

[goals]

Innovations are closely related to science and technology. They are all necessary for

1. technical progress,
2. economic growth,
3. self sustained employment and
4. human welfare in our society;

These are fundamental goals - valid for DARA, too.

[achievements]

In the past 35 years space faring nations have considerably invested into space. Emphasis was put on space related science and relevant technologies. European governments established intergovernmental agencies as ESRO, ELDO and ESA to run common projects. They induced industries and scientists to build up useful technological competence, surpassed only by the United States. The competence of Europe was further enlarged by additional know-how and skill imported by new colleagues trained in the former INTERCOSMOS or other programmes of the communist world. We remember e.g. Sigmund Jähn who the Soviets had made the first European in space, years before ESA-astronaut Ulf Merbold could follow his compatriot.

[the challenge of the globalisation]

Today Europe's space industries are faced with the challenge of globalisation. Increasing demands and global market mechanisms enable considerable economies of scale and drastically reduced production costs per unit. Industries that only produce single units are no longer competitive. Governments trying to subsidise incompetitive industries suffer from financial burdens. New cost levels for innovative services and goods force European governments to redefine their relation to space with respect to

- defence and security issues,
- Europe's transport and space-borne navigation needs,
- space borne tools for implementing new policies for the natural environment,
- agriculture and development aid,
- the progress of basic knowledge including the support of fundamental science and the scientific training and education of Europe's next generation.

[perceptions of German industry]

To really understand the new issues, DARA called together Germany's major space industrialists from

DASA with, among others, experience in the international Globalstar project,
OHB System GmbH with experience in paging systems as Orbcomm,
Siemens AG with global experience in the communications domain,
Bosch Telecom GmbH with good experience in the telecommunication business,
Kayser-Threde GmbH with good experience in optical systems and Earth observation,
Teldix GmbH with global experience in satellite stabilising subsystems,
Alcatel Air Navigation Systems GmbH with experience in the navigation domain,
MAN Technologie AG with good experience in space transport,
Carl Zeiss with long tradition in optical space systems,
Jena-Optronik GmbH with new experience in optical sensors,
Intospace GmbH with competence in low-gravity research.

Having compared the basic data of the world's major space faring nations
{graph # 1 Performance of Space Faring Nations)
{graph # 2 GNP, Space Expenditures & Industrial Sales in the Triad)
the group identified the enormous discrepancy between the public engagement of governments and the economic results for Europe. They discussed the possible reasons for this discrepancy and finally agreed that a major reason was the „suppression of competition“ in Europe.

[philosophy of the ESA convention]

Since this suppression partly is due to present ESA specific mechanisms it is worth to discuss the basic philosophy of the ESA convention. ESA was conceived as an intergovernmental enterprise essentually founded on the three principles:

- the preservation of member states' sovereignity
- a 100% return on each member state's fiscal engagement.
- an augmentation of value through an intra-European competitive sharing of labour in excess of what was achievabable nationally

The founding fathers of ESA knew well from their positive experience with ESRO and negative experience with ELDO that ESA must pursue only programmes for which it can produce an excess of value of at least 20%. This excess - not necessarily be expressed in financial termes - is necessary and sufficient to guarantee the 100% return for each participating member as long as the individual financial return factor does not drop below „0.8“. Consequently the convention requests special measures if the 0.8“ financial return limit is not obtained by one of the members.

[the reality of our days]

Unfortunately ESA no longer adds that excess of value to its programmes. On the contrary: many national delegates declare that there is no more a value-adding at all. Consequently they claim a financial return factor of „1.0“ in order to recover national investments.

With that return coefficient, however, the European space world is in danger of becoming totally regionalised and compartementalised. The situation is extremely counterproductive to competitiveness and to the European space business, in particular. It certainly is not in line with the developments of the European Union and the Common Market. It drives major parts of Europe' space industry out of market.

[ways out]

Recent experience has shown that neither Ministerial Conferences nor Council Working Groups can overcome the dead end in which ESA is captured. The liberation must come from outside. Consequently the German industrialists have looked into the market opportunities as presented by Euroconsult:

{graph #3 Market expectations. 1996 - 2006}

{graph #4 Global Industrial Sales 1994 - 2006}

From the analysis they derived that there is an impressive prospect for economic growth and employment in the space business based on the demands of the upcoming global information society. A corresponding development would allow the German space business to expand by a factor 10 from now to the year 2006

[the role of industry]

However, such an expansion cannot be reached by continuing business as usual. There have to be very serious efforts in particular from industry. Only industry can take necessary initiatives, define market strategies and identify the relevant technological prerequisites.

[the role of DARA]

Space agencies as DARA have to support relevant industrial initiatives as far as technical progress, national economic growth and employment are concerned. They must, however, not interfere with industry's entrepreneurial interests. In particular they must never compensate or substitute for omissions of the industry. They would be totally wrong if they tried to redirect or influence the flow of existing entrepreneural energy.

Nevertheless agencies are in demand when new market opportunities are showing up and new technical grounds for innovative activities of industry are to be broken.

[the importance of innovations]

I should like to emphasise the importance of this approach by discussing the notion of the technical innovation originally introduced by the famous Austrian Joseph Schumpeter:

[the notion of technical innovation]

Technical innovations are the dynamic elements of all competitive markets. Reflections on the actually applied technology and the search for improvements may lead to other solutions eventually offering more advantageous results, better products, a more efficient use of resources, increased performance, enhanced reliability, higher cost-efficiency, more useful procedures etc. etc. The implementation of such superior solutions is often rewarded by some advantages over the competitors. In the resulting "process of creative destruction" the „good" is replaced by the „better". By doing so the overall system releases ballast permanently and can preserve itself flexible, robust and healthy.

[driving forces]

The motivation to look for improvements may be sometimes curiosity or esteem. More often, however, the improvement is associated with an economic advantage or benefit. They may provide the innovator with an exclusive control over the exploitation of an additional source of income.

Nevertheless competitors look for similar success; they will try hard to yield similar rewards. By doing so they may identify other or similar improvements. Consequently the initial path of the first innovator gets parallels. It looses its privacy and exclusivity. What had started as a private path therefore may end as a broad road or highway serving the progress of everybody.

[technical progress]
The finally emerging technical progress is the result of numerous incremental innovations.
Since the technical progress is commonly accessible it is in the end the innovations that enhance the opportunities for economic growth, self sustained employment and human welfare.

[evolutionary innovations]

Most phenomena of space can well be described by Schumpeter's notion. However when he died in 1950 some experience with high-tech innovations in particular in the field of genetic engineering had not yet been made. This new experience lead to a more comprehensive understanding of the innovative process presently addressed with the notion of „evolutionary innovations":

Level of Variation:
{Genes/Innovative Ideas/Hypothesis} **=>Enterprises**
Level of Selection:
{Organisms/Species/Individuals/Products} **=> Markets**
Level of Evolutionary Progress:
{Population/Society} **=>Human Welfare**

{the example of an innovative path}

It took two years to establish a complete Radar Map of the Federal Republic of Germany. Some weeks ago when the map was ready it went to the archives because there was neither a market for such a product nor major interest in the outdated information it contained.
To our understanding Earth observation does not need larger archives. What is needed is a comprehensive geo-coded information system of enormous economic value if it can provide recorded information of any point of the global surface with full actuality.
The requested actuality can easily be achieved by a constellation of satellites similar to that of Teledesic, Globalstar or GPS.
However the limiting factor is cost as well as the availability of a large number of cameras with digital, stereo and hyper-spectral capabilities. The cameras must be light, robust, high performing and made up with components from a low-cost series-production. With regard to the present state of the art this means reductions in weight and costs by a factor of about 10, roughly.
Fortunately Germany has a long tradition in building advanced cameras. It controls most of the requested technologies part of which had been applied in the INTERCOSMOS and other communist programmes. Recent proof was given through the German HRSC and WAOSS contributions to the late Mars-96 mission. An innovative metamorphosis of these cameras towards the type of camera requested, above, has already started.

[Comparing the innovative potential of enterprises]

Indeed, it is difficult to identify and to compare the innovative power of persons or enterprises. The reason is that innovative people don't like to talk about their ideas. From Schumpeter we know: Privacy and exclusivity that is lost to the competitors reduce the innovator's private benefit. But fortunately we can identify the companies that have produced the largest numbers of inventions in the past or achieved international patents registered in at least two countries. Among the first 20 of these companies are 8 Europeans:

Nr. 1	**Siemens**	[6.686 international patents in 1985-91]
Nr. 8	**Bayer**	[3.880 international patents in 1985-91]
Nr. 9	**Bosch**	[3.761 international patents in 1985-91]
Nr. 11	**BASF**	[3.586 international patents in 1985-91]
Nr. 15	**Hoechst**	[2.997 international patents in 1985-91]
Nr. 16	**Philips**	[2.976 international patents in 1985-91]
Nr. 17	**Du Pont**	[2.825 international patents in 1985-91]
Nr. 20	**Ciba-Geigy**	[2.562 international patents in 1985-91]

Unfortunately there is only one company {Nr. 3 Mitsubishi Electric} related to space.

However this listing does not tell too much about the innovative power of the individual enterprises. To better see the innovative power we therefore related the number of employees to the number of patents held by each company. By doing so we learned that the innovative power is much more with smaller and medium sized enterprises than with the larger ones.

Unfortunately I cannot present you the results of an application of that method on the industrial partners of DARA and ESA. However to give you some impression of the diversity and the power which really exists in our countries I should like to present you the data of 10 German enterprises leading in this respect:

Fischerwerke (Fastening techniques; construction tool kits)
2.350 employees; 5.500 patents => 2,34 patents per /employee
Held (Modular presses for producing laminates)
90 employees; 50 patents => 0,56 patents per /employee
Tracto-Technik (Earth-rockets)
211 employees; 100 patents => 0,47 patents per /employee
Herion (pneumatic control)
1.500 employees; 600 patents => 0,40 patents per /employee
RUD Kettenfabrik (Chains for industrial applications)
904 employees; 350 patents => 0,35 patents per /employee
Sachtler (Tripods for cameras)
130 employees; 40 patents => 0,31 patents per /employee
Heidenhain (Electronic length control)
3.190 employees; 800 patents => 0,25 patents per /employee
Reflecta (Positive photographic slide technology)
500 employees; 100 patents => 0,20 patents per /employee
Rittal (switch cases)
4.800 employees; 949 patents =>0,20 patents per /employee
Kiekert (Security systems for cars)
1.670 employees; 300 patents =>0,18 patents per /employee

[conclusion]
From the analysis we learn that the globalisation of space markets and the innovative power of our enterprises allow Germany and other European nations to increase the sales of this very sector by a factor of about 10 from now to the year 2006.
The condition is that we together „creatively destruct“ all counterproductive mechanisms and burocratic hurdles that presently are imposed upon European space activities. We must engage ourselves in the evolution of competitive industries able to innovatively face the global market with new space related products and services.

If by the year 2006 the European space sector contributes a share to the global GNP which is of the same order of magnitude as that already contributed by the European chemical, machine-building, car manufactoring or aeronautics industries our efforts were successful. This is the best we can do for the

- technical progress,
- economic growth,
- self sustained employment and
- human welfare in our society.

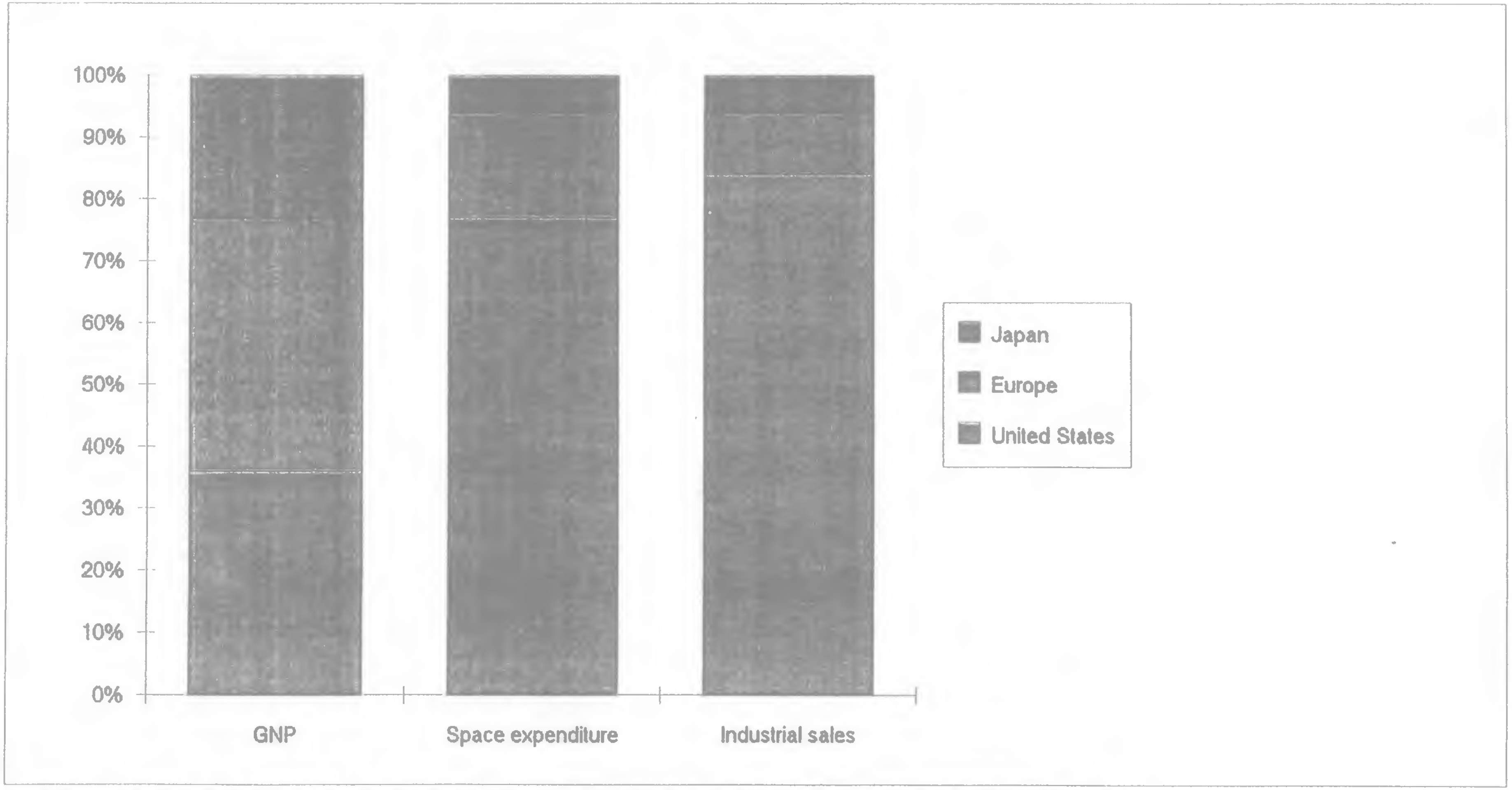
Thank you!

#1 Performance of space faring nations

Nation	Pop.* (mio)	Space exp. (Mio. US-$)*****	relative	Civil***** relative	Defence***** relative	GNP(94) (Mrd US-$)	relative	Employees Space sector	GNP/Pop. (US-$)*
CH	7	118	0,32%	0,32%	0,00%	260	1,26%	400	37.180
DK	5	39	0,11%	0,11%	0,00%	146	0,71%	250	28.110
N	4	41	0,11%	0,11%	0,00%	114	0,55%	260	26.480
S	9	117	0,32%	0,32%	0,00%	206	0,99%	850	23.630
D	82	1.200	3,26%	2,57%	0,68%	2.085	10,07%	5.000	25.580
A	8	40	0,11%	0,11%	0,00%	197	0,95%	320	24.950
F	58	2.640	7,16%	5,02%	2,14%	1.354	6,54%	15.000	23.470
B	10	209	0,57%	0,55%	0,01%	231	1,12%	1.300	22.920
NL	15	171	0,46%	0,46%	0,00%	338	1,63%	600	21.970
I	57	647	1,76%	1,62%	0,13%	1.102	5,33%	5.500	19.270
SF	5	29	0,08%	0,08%	0,00%	96	0,46%	150	18.850
UK	58	487	1,32%	0,80%	0,52%	1.070	5,17%	5.000	18.410
E	39	257	0,70%	0,70%	0,00%	524	2,53%	1.100	13.280
EIR	4	7	0,02%	0,02%	0,00%	48	0,23%	100	13.630
EUROPE:		*16%*	*share of total governmental space expenditure*			*38%*	*share of total GNP*		
US	260	27.090	73,49%	36,42%	37,07%	6.724	32,49%	132.000	25.860
United States		*73%*	*share of total governmental space expenditure*			*32%*	*share of total GNP*		
JAP	125	2.190	5,94%	5,94%	0,00%	4.322	20,88%	10.600	34.630
Japan		*6%*	*share of total governmental space expenditure*			*21%*	*share of total GNP*		
RUS	148	320	0,87%	0,14%	0,73%	393	1,90%	100.000	2.650
CHINA	1.191	500	1,36%	0,49%	0,87%	631	3,05%	100.000	530
INDIA	914	510	1,38%	0,90%	0,49%	283	1,37%	17.000	310
CDN	29	249	0,68%	0,68%	0,00%	569	2,75%	3.500	19.570
Totals	3.028	36.861	100%	57%	43%	20.695	100%	395.430	6.834

Sources
* Der Fischer Weltalmanach 97
** Euroconsult private communication (Nov. 1996)
*** EU Kommission: Öffentliche Haushalte im Frühjahr 1995
**** 1996 European Space Directory, SEVIG Press, Paris
***** NATO (1994) Air & Cosmos/Aviation International Nr 1522 vom 9 Juni 1995
***** Aviation Week & Space Technology (5 Aug. 1996 citing Euroconsult)
****** World Bank Atlas 1995

#2 GNP, Space Expenditure & Industrial Sales in the Triad



	GNP	*Space expenditure*	*Industrial sales*
Japan	23%	6%	6%
Europe	41%	17%	10%
United St.	36%	77%	84%

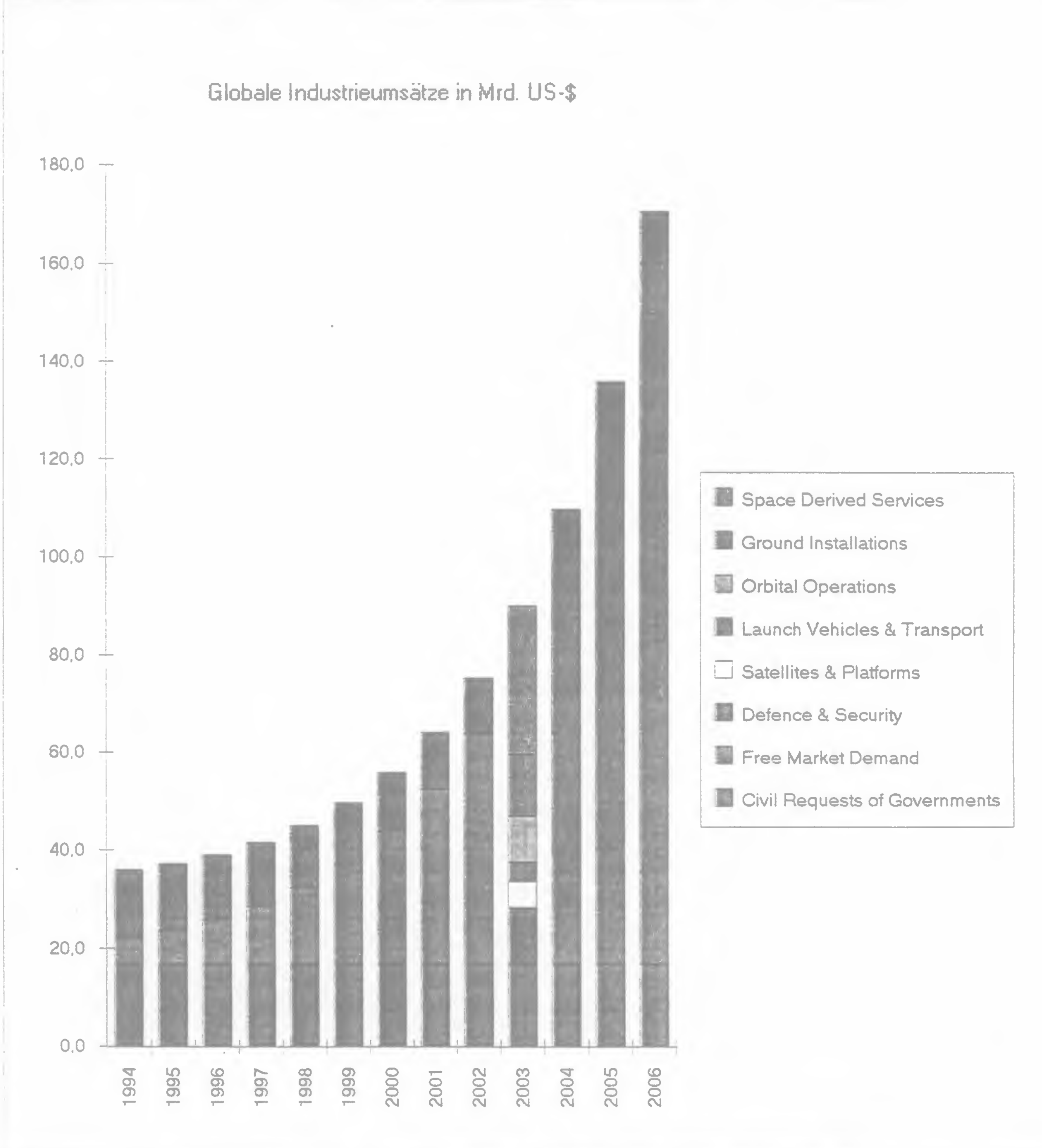
#3 World Space Markets 1996 - 2006

Total Industrial Turnover: DM 700 - 1000 billion

	Telecommunication & TV-Broadcasting	Localisation & Navigation	Earth Observation & Meteorology
Satellites & Platforms *construction & installation*	43 60	(max 1.2 Mrd US$) (min 1 Mrd US$)	14,2 18,7
Launchers & Transport *construction, installation & operation*	33 46	(max 1.2 Mrd US$) (min 1 Mrd US$)	8,8 10,5
Orbital Operations *operations providers*	100 130	(min 0) (max o,5 Mrd US$)	1,8 3
Ground Installations *construction and operation*	130 200	52 75	9,7 13,5
Space Derived Services value adding for consumer *expansion of commercial space applications*	240 330	60 90	22,5 55

Professional Information Services - Multi Media
Entertainment & Comfort Industries
Consumer with Personal Display

#4 Prospective Resources for Space Business until Year 2006



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Civil Requests of Governments	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0	17,0
Free Market Demand	5,0	6,6	8,7	11,6	15,3	20,2	26,8	35,4	46,8		81,8	108,2	143,1
Defence & Security	14,0	13,7	13,3	13,0	12,7	12,4	12,1	11,8	11,5	11,3	11,0	10,7	10,5
Satellites & Platforms										5,4			
Launch Vehicles & Transport										4,0			
Orbital Operations										9,3			
Ground Installations										12,8			
Space Derived Services										30,5			
Totals	36,0	37,3	39,1	41,6	45,0	49,6	55,9	64,2	75,3	90,1	109,8	135,9	170,6

BNSC OBSERVATIONS ON INNOVATIVE APPROACHES TO GREATER COMPETITIVENESS IN SPACE AND GROUND SECTORS

Dr D Leadbeater   British National Space Centre

ABSTRACT

Successful innovative improvements in competitiveness can occur through great leaps in technology and concepts, but more readily occur in more mature markets through bold evolution, application of best practice, attention to customers needs and through professional marketing. A first set of potential lessons is drawn in this paper from UK competitiveness initiatives outside the Space sector.

Across the range of customers for Space from scientists, earth observers to those in the Telecommunications market, potential suppliers must take increasingly greater account of the role to be played by the investor or market maker. The second set of lessons is drawn about the role of technology, the means of demonstration and the role of UK application development programmes in satisfying the needs of markets and stimulating the interests of potential investors.

Conclusions are drawn about the contribution which ESA can bring across the spectrum of activities in Space and a challenge laid down to industry and to all delegations so that the impact of the Agency on the competitiveness of European industry is maximised.

INTRODUCTION

An early casual observer of development in the Satellite Telecommunications market might have concluded that early investment by France and the UK simulated a successful series of technical steps and demonstrations of potential services which led to today's booming commercial market. A later observer might conclude that there was a point during the formation of INTELSAT, EUTELSAT and in SES, when the benefits of market success were clearly visible and the rewards open to industry in return for its own investment sufficiently overriding that there should have been no further requirement for a Government involvement. In my opinion, neither view tells the whole story and they neglect the need to ensure long term access to markets. This can only be achieved through effective deregulation and licensing and some greater equivalence in access to information and technology to overcome market failures in the Space sector.

Recent events in the satellite telecommunications market place show clear evidence of three approaches to innovation in search of greater competitiveness:-

(a) first, the benefits of evolution associated with progressive development of an established product eg digital technology progressively augmenting and replacing analogue for onboard processing - together with consistent application of best practice;

(b) second, the continued emergence of more revolutionary concepts stimulated by the arrival of new technology that is nevertheless accepted by technologically aware investors eg intersatellite networking in LEO constellations;

(c) third, the integration of satellite into a more vitual telecommunications network environment containing a fibre and satellite mix, thereby piggy backing to some extent on the innovative growth of terrestrial telecommunications worldwide.

UK experience outside space in analysising and stimulating competitiveness is well publicised and widely recognised. A series of largely common sense measures built up over many years both in the UK and elsewhere has provided a good basis for measurement, but lets remember that value engineering came well before Value For Money, market driven responses well before supply side reforms and plain old cost reduction long before business process re-engineering. What these have in common however is an evolutionary commitment towards continual appraisal aimed at exploiting the next market opportunity and developing a well matched product. The UK has carried out extensive analysis of the features of competitive companies and these have been widely reported (Ref 1). This analysis nevertheless tends to result in advice that there is no clear formula, but rather a number of factors that need to be applied dependent upon the environment in which a business is operating. Advice is frequently to compare your complete organisation against cooperative competitors in your sectors, to compare with best practice in firms outside your sector who share some of your environmental characteristics and to continually challenge the commonplace in the business.

Application to the Space sector must take account of procurement, industrial policy and technological innovations from ESA, though expectations about what the Agency can achieve must be constrained by its relative sphere of influence. That is in turn constrained by national budgets and industrial self interest in creating market advantage. On-going work within the UK will be outlined which is attempting to measure the extent to which these external lessons can be interpreted for Space, and these include customer supplier awareness, prime contractor to supplier strategic relationships, benchmarking, and plain old entrepreneurial conviction.

LEARNING FROM BEST PRACTICE OUTSIDE SPACE

The BNSC's largest partner Department, Trade and Industry, has placed increasing emphasis and resources in recent years on encouraging UK industry and commerce to improve its competitiveness. It has produced annual White Papers on competitiveness for the last three years, the first of which in 1994 was the first comprehensive Government audit of the UK's competitive position.

The DTI has produced an extensive range of initiatives designed to improve UK business performance. There are too many to detail in a short presentation but I would like to highlight just a few.

A major thrust of the activity has been to encourage companies to seek out best practice, either locally, sectorally or internationally, and examine their own performance against it. The "Inside UK Enterprise" scheme offers companies a programme of visits to other UK companies who have shown themselves to be examples of best practice. Over 25,000 visits have been arranged to date. The objective is to transfer best practice and real life experience from the hosts, who have successfully implemented them, to the visitors, who would like to do so themselves.

The "Inside UK Enterprise" scheme is a part of a wider DTI initiative called "Managing into the 90's" or M90s for short, which has successfully used the format of a travelling roadshow to bring a range of competitiveness topics to a large number of businesses around the UK. Each session of the Roadshow has been interactive with those attending feeding details of their businesses into a computer terminal and responding individually to questions. The software analyses the results and the Presenter adapts the information given to the needs of the audience. At the end those attending are signposted to the best sources in company guidance and given publications catering topics such as Benchmarking; Business Planning; Financial Management; Marketing; Product Development; Purchasing; Production Management; and Quality. This scheme is of course aimed at SMEs, but much that is innovative comes from such companies.

DTI has for the past year been re-shaping its suite of schemes to stimulate industry. Through a process called the "Sectoral Challenge", Trade Associations are being encouraged to bid competitively for initiatives designed specifically by their industry, for their industry. Thus we are moving away from a system whereby Government devised schemes to help companies to one where industry devises its own and seeks Government help to achieve it. A similar change is happening at a local level where business support organisations can bid for funds under a Local Challenge. These processes are in the bidding stage at the moment but the objective of getting Trade Associations to concentrate on and to lead proposals to improve the competitiveness of their sector is a novel approach for the UK.

I mentioned earlier amongst the M90s activities the concept of Benchmarking. This is a way of assessing the performance of a business by objective measurement against the best practice in the sector. DTI has funded, along with the CBI, a self assessment computer package which is independently appraised, and then produces a confidential report back to the company. By identifying the areas of weakness within a business it enables the company to concentrate its efforts on improvement in those areas. It is not a one-off activity - Benchmarking enables companies to continually monitor progress and set higher standards.

Perhaps the best benchmark of all is if a company can be competitive on world markets. Much of the DTI's resources are used in providing a range of assistance to companies who wish to export. This is mirrored and expanded through BNSC's own Export Strategy.

Governments cannot, of course, make companies competitive - it is only they that can make that happen. In the UK BNSC, along with DTI and business organisations, are trying to facilitate in this process.

All of the above is potentially relevant to the European space sector and to ESA, but we need to know more about the supply chain networks to do that effectively.

Supply Chain Relationships: Partnership Sourcing in UK Industry

During the last three years, the Space industry in the UK, and throughout Europe, has been going through a very significant restructuring process. This process continues and is having the effect of decreasing the number of large companies, which can act as Prime contractors, as mergers between those companies take place. This, combined with the will of those large companies to increase the vertical integration of their businesses (as seems to have been the case with their US counterparts), is recognised as a threat to the smaller companies in the value-chain. In the UK, a large proportion of these smaller companies are SME's.

Thus, a key issue within the industry is related to the interface between a prime contractor and its sub-contractors and suppliers. This topic is seen as important by the large companies, who wish to improve their competitiveness by having an efficient supply chain. It is also key to the smaller companies, many of whom have strong concerns about the continuing restructuring of the industry and who seek long-term strategic relationships and access to market beyond that of the UK Prime.

It is important therefore to understand and develop the relationships between companies in the supply chain. Since 1991 DTI, working in conjunction with the Confederation of British Industry (CBI), has been promoting "partnership sourcing" across British industry.

Partnership sourcing has three key objectives:-

(a) to minimise the total value-chain cost, not just unit cost, and improve quality through partner development and joint problem solving;

(b) to ensure continuous improvement, through equal sharing of technical and cost information; and

(c) to ensure information exchange and efficiency, through long-term commitment, inter-organisational exchanges and frequent communication.

The process replaces "power-based purchasing", where companies treat suppliers or customers as adversaries. It focuses rather on co-operation, with both parties in a partnership addressing all aspects of the "cost" of doing business together and not just looking at the "unit price".

The primary aims of the DTI/CBI initiative are therefore to promote the concept of partnership sourcing to British industry, to create awareness and understanding and to facilitate its implementation.

Results from an annual survey conducted across British industry in 1995, show that 97% of respondents had heard of the concept (in 1991, this number was 71%). In addition, a very high proportion (91%) claimed to understand the concept. 80% believe it matters and 74% claim to have actually implemented buyer-supplier partnerships themselves.

To quote one example of partnership sourcing in action, British Airways (BA) helped two suppliers, one specialising in aircraft bearings, the other in aircraft fastenings to set up local distribution centres to provide parts for the airline. The idea was to let each party concentrate on its strengths, thereby becoming increasingly able to compete effectively. A number of specific and significant benefits accrued for BA, including lower direct costs, reduced lead times and reduced administration costs. The suppliers have also benefited from the lower risk that is naturally a part of a long-term agreement.

In a separate example, in the construction industry, Laing Holmes have introduced a scheme to involve suppliers more fully in the needs of the Laing Homes business. Suppliers have been benchmarked vigorously on quality and performance, but are offered in return some security on forward orders as well as being given a chance to contribute to various aspects of Laing's decision making processes. Commitment on both sides was important. Major results have included lead times (again), reduction/elimination of stock and improved packaging methods.

BNSC has therefore recently begun a Programme to investigate the implementation of partnership sourcing within the UK space industry. During the coming year, information will be sought on the number and dept of the supply chain relationships in the UK space industry. We will acquire information on how many suppliers are used by the major companies, how suppliers are chosen (price, quality, location, etc), what is the value in the supply chain, how much multiple sourcing is there, etc. We will also determine information on the geographical nature of the supply chain: how much comes from UK, European, US, Far East, etc. Finally, we will learn about the strategic nature of the relationship: how many supply chain decisions are taken with a long term view, how many are for short term benefits?

Commercial confidentiality will preview full disclosure of results, but the trends should be particularly valuable to ESA and in discussion with other interested parties.

MORE EVOLUTION SOME REVOLUTION

So much for evolution based on best practice, now lets consider larger steps which some call revolution. Iridium, Spaceway, ICO and Teledesic are contrasting development programme at different stages in their approach towards market. They feature to different degrees both evolution and revolution; but no longer raise doubts that the financial market, at least in North America, has the capacity to finance them in expectation of significant profits. The revolution in this case has equally well been applied to the multi billion dollar financing as to the choice of semi-autonomously deployed inter-communicating low earth orbit satellites.

Turning to ESA's role in such future projects, it is possible to argue that ESA has contributed significantly to a series of previous telecommunication missions were it has demonstrated technology and services. At some point however, ESA's contribution to an industry looking for evolutionary development has become more piecemeal and only randomly successful and some would argue that its contribution to more revolutionary aspects has become at best subtle.

Convincing investors that well conceived potential services can be delivered in a more cost effective way by a new concept on new technology but clearly requires commitment by the potential supplier team, early demonstration of the technology and a well structured financing plan that calls upon different players at different stages of development. ESA's role is clearly not in the provision and structuring of finance - there is much more of that tomorrow from other speakers - but it can play a major part in demonstrating and qualifying technology and demonstrating novel services which would not otherwise capture the interest of potential investors. Discussions within the Agency and amongst delegations are concentrating on the impact which ESA could or indeed should have on the competitiveness of European industry. The recent workshop on multimedia services held at ESTEC five weeks ago approached this challenge but its results have yet to show that Agency, delegations and industry understand the full implications of the need for Government to dance with an industrial partner to a tune that is for the first time of industry's choosing. Any role for Government beyond creation of effective regulation and licensing and for ESA beyond identification of enabling technology needs to be fully debated and scoped, before it can become viable and fully effective.

ESA - and certainly ESTEC's - role has been previously to sponsor development of enabling technologies through industry. Parallel attention has been given in recent times - particularly in the UK within the Earth Observation sector - to development of application programmes which attempt to educate new customers to the possibility of innovatively improving the effectiveness of their business through the use of space derived data sources that are being provided initially at Government expense for a variety of scientific, environmental international collaborative and defence purposes. A considerable number of lessons have been learnt from this ongoing exercise and many keypoints are contained in this list (viewgraph).

Returning to the theme of Telecommunications however, the market requirement is a slightly different combination of enabling technology and service demonstration. Tomorrow's presentation from ESYS will show how a low cost demonstrator derived from a mix of ESA, national and industrial funding is providing a basis to demonstrate innovative services in telecommunications and multimedia to a new range of customers. ESA can play a very important part in drawing from the industrial collaborators and/or competitors a view of which technologies are going to be required - be that evolution or revolution - in order not just to deliver next generation services but thereafter to exploit the ten year life of satellites that can intercommunicate with a developing network of low medium and geostationary orbiting satellites and ground networks.

ESA's POTENTIAL CONTRIBUTION TO COMPETITIVENESS THROUGH INNOVATION

In considering the contribution which ESA can make to competitiveness through innovation, this workshop is due to consider the role and aspirations of various players across the full range of Government, customers, suppliers and financiers.

A breakdown of a complete space system from inception to evolutionary development of services over the ten to fifteen year life of a satellite can be illustrative - see figure 1. During a current ongoing discussion about the evolution of ESA's industrial policy and its potential impact on the competitiveness of European industry, industry has asked ESA to take account of its teaming relationships with suppliers in Europe and by implication from elsewhere. In attempting to cut costs, primes in Europe are naturally looking to streamline their supplier chains and determine the best sources worldwide for competitive components and subsystems and thereby produce the most cost effective products. The challenge for ESA is to take a lead in determining the opportunity to create teaming arrangements within ESA pre-development programmes and missions which either build on or competitively replace those which industry has previously developed in international markets. This balance clearly needs to include the contribution which the smaller Member States and smaller companies bring to the overall resource because in many cases it is the accumulation of their overall resource and the exploitation of their very many additional ideas which contribute to the richness of European solutions. ESA can contribute positively to the creation of strategic relationships between companies in Europe and thereby achieve a substantial increase in overall competitiveness but this will require a degree of openness in strategic communication which until recently has barely existed.

BNSC's previously described study looking at the supplier chain relationship between prime subsystem supplier and consultancy contributors across the UK space sector could be a useful trigger for an ESA initiative for and to collect together work from elsewhere. An experienced contractor has been chosen able to bring the full benefit of the non-space analysis to this task and we anticipate substantial briefing to BNSC and UK industry at the end of this year. It is open to discussion whether some of this data could be shared in order to aid creation of strategic relationships between primes, subsystem suppliers and their major long term suppliers of equipment and components. ESA will need to establish whether its procurement teams can adapt to industry's wider needs, and is of course in a good position to simulate the debate about the distribution of current capabilities in Europe and through bilateral discussions to establish a degree of freedom which can be explored to develop those capabilities over time through national direction and through the influence of competition.

Consideration of what ESA can do in practice however must take account of the different aspirations of the Member States. Some clearly wish to play a leading role, some to provide opportunities for their industry inside and outside space to explore new technologies, some to make a collective contribution to the exploration of space while others have broader objectives. Noting the current realities ESA's contribution should be to fashion actions which stimulate that focussing. To stimulate debate, I suggest a mixture of actions and constraints as follows:-

(a) to accept absolutely that re-structuring in industry must be lead by industry at a pace only it should determine;

(b) to act bilaterally to understand the current preferences of Member States and industrial grouping and to understand the extent to which teaming arrangements created under ESA's industrial policy can or cannot influence teaming arrangements formed by industry under standard market pressures;

(c) to identify the components and subsystems which are fundamental to the next generation of services, to the development of those services through system life, to the cost reduction in those services and the achievement of ever greater networking with terrestrial capability;

(d) to pay more attention when identifying technology requirements for future science missions to the extent to which technology choices at the development stage that can lead to spin off into Earth Observation or telecommunication markets. In this respect greater use of small satellite solutions could stimulate a different mix of long term, short term missions in science to the benefit of industry and scientists;

(e) to ensure that contributions to particular activities are subject to a competitiveness checklist; taking the example of the small satellite example following instance might be as follows:-

  (i) does it create new or fragment existing capability;

  (ii) does it help tailor an instrument technology, towards a lower cost (smaller) solution;

  (iii) can it exploit low cost launch by utilising a small away of satellite or a small constellation thereby dividing substantially the cost of a single launch;

  (iv) etc.

(f) ESA small mission opportunity and the PROBA proposal under GSTP provide opportunities to stimulate the mini and small satellite scene. To realise this potential however, we must further develop thinking in this workshop, or subsequently, in terms of competitiveness across involved Member States and elsewhere to ensure that the opportunities are developed to the best advantage;

(g) to further develop the relationship with the European Union in conjunction with its recent communication on space; thereby responding to potential Commission and commercial services in striving to achieve more coherent link between ESA's programme and those under Framework 4/5;

(h) to add substance to its embryonic proposal to achieve a partnership with industry;

(i) by appreciating the impact of National and European Commission negotiations can seek through international bodies such as the WTO to achieve more level playing fields. Press reports as recent as 17 February 1997 indicate actions being taken generally for telecommunications from which space will benefit.

Turning once again to the subject of application demonstration and the extent to which ESA can contribute to this innovative approach to market development we should acknowledge that working with the existing customers to encourage new uses of telecommunications capability is primarily the responsibility of the service supplier and his competitors. Understanding the extent to which market structure imposes barriers between space and terrestrial developments could provide ESA with real opportunities to demonstrate bound breaking solution that allow satellites to benefit from the natural development of telecommunications markets. Developing technology which can stimulate and then demonstrate new services which combine capabilities in telecommunications and Earth Observation - for example in the home and car could again be relevant to ESA where pan national solutions are sought. Lessons learnt from European progress in navigation under ARTES 9 should provide a source of lessons learnt.

UK experience with Earth Observation applications development programmes hss already created a number of lessons learnt which are summarised in this viewgraph.

- willingness of industry to co-fund
- abundance of potential ideas
- conflict about data policy
- under exploited mililtary to civil synergy
- inability to provide tailored solutions to user requirements in terms of revisit time, quality, repeatability specific processing requirements which suggest individual lower cost innovative solutions in the space segment
- resistance by user to commit to a source of space data when the real cost of the infrastructure is unknown to him

These lessons could additionally lead to ESA initiatives into hybrid services using EO and comms information.

RECOMMENDATIONS

1. Member States should consider analysing customer supply chain relationships in their own territories and be prepared to contribute to prime centred and ESA centred analysis of potential supply chains consistent with work in ESA and in international competitive markets.

2. Learning from others is vital both inside and outside the space sector. This can be applied not only to industry but to delegations and particularly to ESA. Considerable experience exists on a variety of forms of comparison and benchmarking which should be applied by the Agency and used to encourage corresponding action in industry.

3. ESA should look more aggressively with programme boards to try and identify cost effective revoluntarily concepts based for example the use dulruted a ways of satellites, or networks intelligent intercommunicating constellations.

4. ESA should be looking to identify technologies which exploit the extended life of todays satellites (five to fifteen year) and can respond to unpredictable further development of space and terrestrial telecommunication networks.

5. There should be greater synergy in military and civil markets in order to combat the undoubted advantage achieved by the US through its much greater defence expenditure, while negotiating to reduce that market effect in international bodies such as WTO.

6 ESA should use a competitiveness checklist along the following lines:-

(i) why shouldn't industry do this alone

(ii) is the opportunity time constrained and are the risk commence cerate with success

(iii) does the programme fragment existing capability

(iv) can added value be achieved in adjacent markets eg mapping, navigation and leisure

(v) do strategic relationship exist or will they be improved

(vi) does industry recognise the opportunity sufficiently to co-fund

(vii) does the proposed contract reward success and penalise failure

Innovations for Competitiveness
Tekes Views

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Technology Development Centre (Tekes)
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1 TEKES

Basic definitions

INNOVATION

- "Successful production, assimilation and exploitation of novelty in the economic and social spheres" (*EC Green Paper on Innovation*)

COMPETITIVENESS

- " Superiority over competitors in one or more elements of the value added chain"

INNOVATIONS FOR COMPETITIVENESS

- What do we do?
- Why do we do it?
- How do we do it?

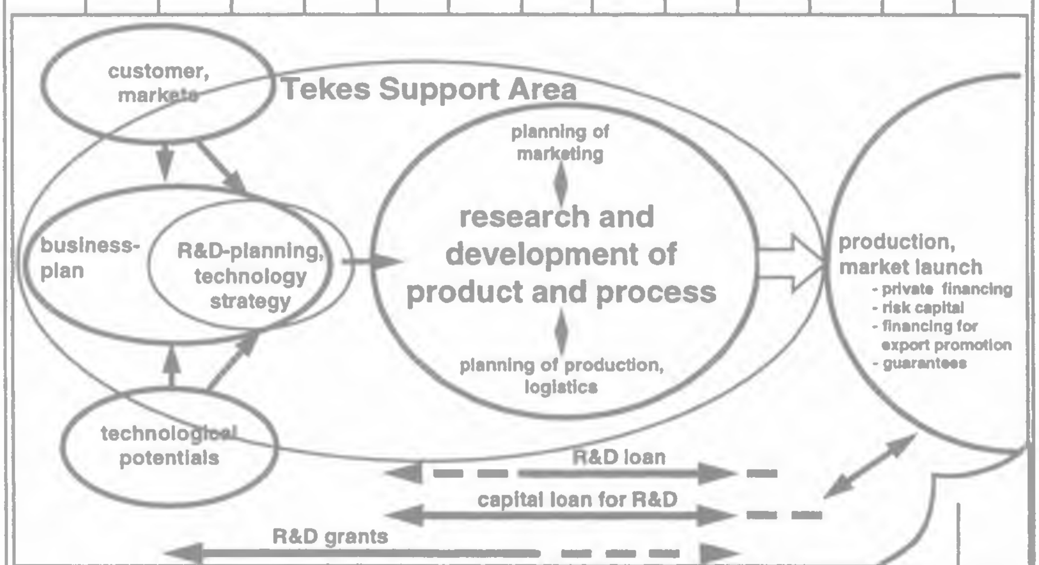
2 TEKES

Tekes mission statement

Tekes primary objective is to promote the <u>technological competitiveness</u> in Finnish industry. Activities should lead to an increase and diversification of industrial production and exports and an improvement of well-being in society.

3

R&D for international business



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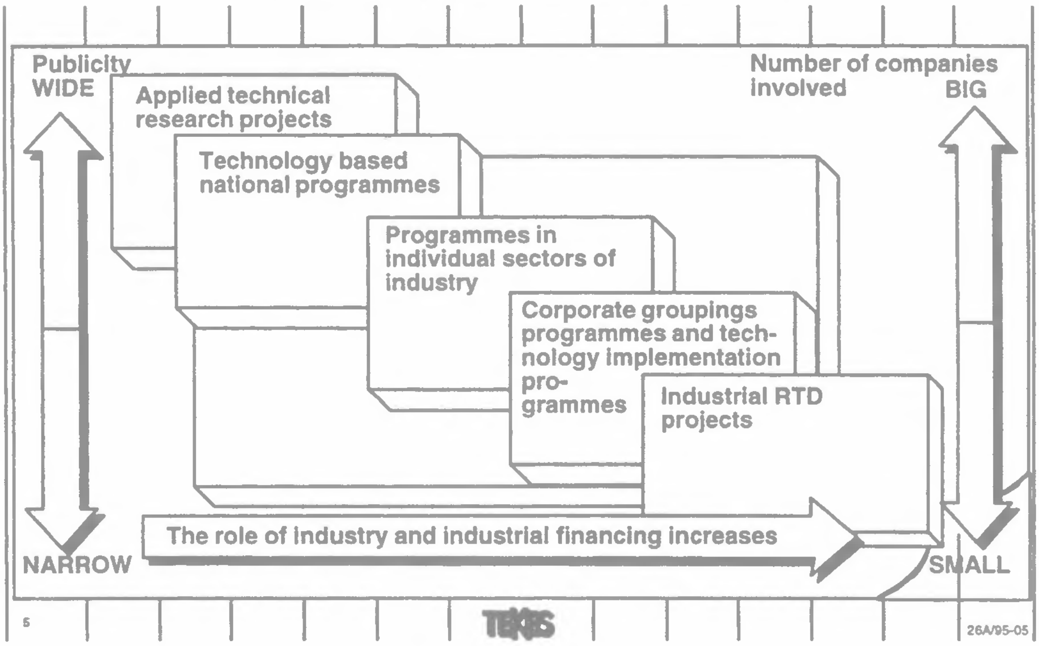
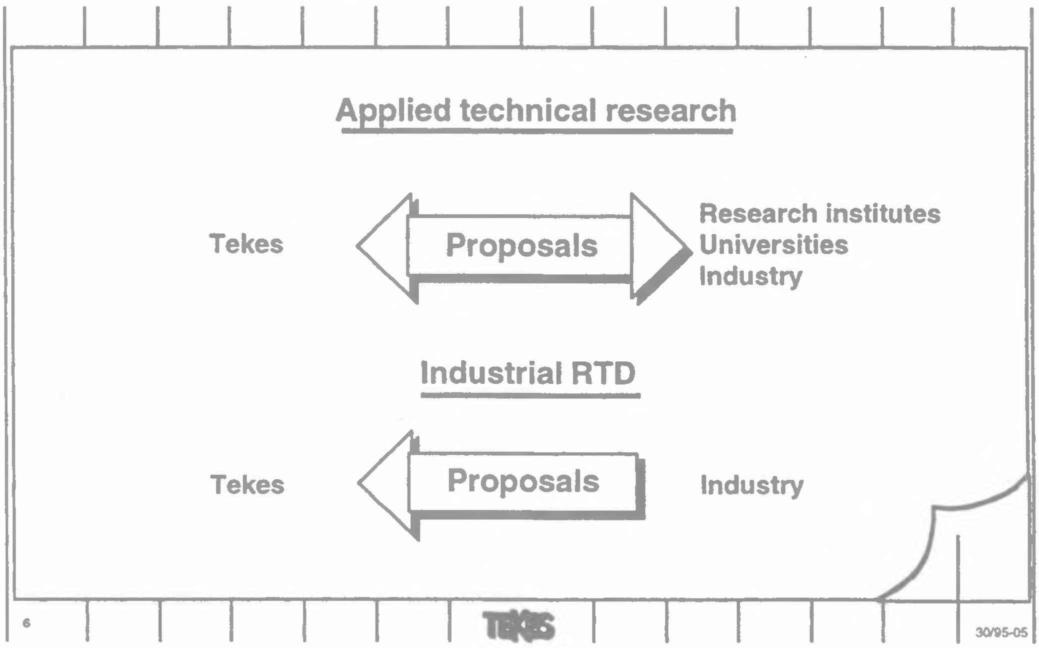
23B/96-10

RTD supported by Tekes



Tekes RTD financing



Tools for fostering innovation and competitiveness

Tekes supported:

1. Technology Programmes
2. Industrial RTD Projects
3. Technology Application Clinics

7 TEKES

Technology Programmes

8 TEKES

The participation of industry is crucial - at every stage

1. **IDENTIFICATION AND EVALUATION**
   → targeting
2. **PLANNING**
   → contents, organization
3. **IMPLEMENTATION**
   → management, running, control, financing
4. **UTILISATION AND EVALUATION**
   → further development of basic technologies, product developments and new innovations

9 TEKES 26B/95-05

Technology programmes

- 52 ongoing programmes in the following technology fields:
  - ↗ information
  - ↗ construction
  - ↗ manufacturing
  - ↗ process
  - ↗ energy
  - ↗ space
- Typical programme duration 3 to 5 years
- From 3 to 100 participating companies per programme
- Programme budgets from 2 to 50 MECU
- Over 30 technology programmes completed in 1991-1995

10 TEKES

Ongoing information and space technology programmes in 1996

	Total budget, mill.	FIM	ECU	
Electronic publishing and printing	1995 - 99	60	11	20 comp.
Machine vision	1992 - 96	115	21	60 comp.
Finnish multimedia programme	1995 - 97	300	54	30 comp.
Adaptive and Intelligent Systems Applications	1994 - 98	100	18	80 comp.
Finn TelSME	1995 - 98	30	5	11 comp.
Remote Sensing	1996 - 2000	40	7	3 comp.
Space 2000 - Space equipment technology programme	1996 - 2000	40	7	8 comp.

11 TEKES 27B/96-03

Aims in funding

Research Projects of Universities and Institutes

- Principal aim
  - ↗ prosperity and development of society through strengthening the foundation of scientific and technological expertise -> raising the level of technological innovation in industry and the capability to produce such innovations
- Supportive aims
  - ↗ impact on environment, energy, health, defence, working conditions, education, science, culture, transport and infrastructure
  - ↗ industrial competitiveness and growth on long-term employment

12 TEKES

Key factors in Research Projects

1. **Development of technological expertise**
   - ↗ level of scientific and technological know-how
   - ↗ extent to which research results improve competitiveness
   - ↗ development of Finnish expertise and infrastructure
   - ↗ prospects for establishing new businesses
2. **Application and exploitation of research results**
   - ↗ nature of the research application
   - ↗ time span and extent of application
   - ↗ implementation programme
   - ↗ influence of commercial strategic views
   - ↗ commitment from the companies involved

13 TEKES

3. **Resources and likelihood of completing the project**
   - ↗ general research strategy and role played by the project
   - ↗ qualitative and quantitative resources of the researchers
   - ↗ quality of the project plan and the application plan
4. **Other factors in the evaluation**
   - ↗ possibility for small and medium-sized firms to benefit from the results and the promotion of new business
   - ↗ international cooperation
   - ↗ utilisation of networks and other research resources
   - ↗ improving the allocation of national resources
   - ↗ important supportive aims

14 TEKES

Industrial RTD Projects

15

TEKES

Aims in funding

Industrial RTD Projects

- Primary objective
  - ↗ promote technological competitiveness
  - ↗ increase and diversification of industrial production and exports and improvement of well-being in society
- Supportive aims
  - ↗ impact of projects on the environment, energy, health, defence, education and transport
  - ↗ growth of industrial competitiveness and volume on long-term employment

16

TEKES

Key factors in industrial RTD projects

1. Technology and its competitive advantage

- developed or applied technological know-how
- basis of the competitive advantage
- level of technology in relation to market/competitors
- impact on the development of the national know-how and infrastructure

2. Expected turnover and exports

- market, customers
- competitors
- realistic targets for turnover, experts and indirect benefits

17 TEKES

3. Resources and the capability of the company of completing the project

- business plan/technology strategy and the role of the project
- company's financial standing and prospects
- human resources, characteristics and commitment
- quality of the project plan
- knowledge of the market and the marketing plans

4. Other factors in the evaluation

- previous involvement with Tekes
- importance of Tekes funding
- utilisation of networks, research + other external resources
- risk evaluation
- important supportive aims

18 TEKES

Technology Application Clinics

19 TEKES

Technology Application Clinics

- Technology Transfer and Diffusion
- Often based on technologies developed in the national technology programmes
- A practical way to implement SME-projects and to offer an access to high-level expertise
- A way to bring SMEs and research organisations together
- Are formed around such new technologies, that can be packaged and will benefit the Finnish industry, but are risky and slowly adopted.

20 TEKES

Technology Application Clinics

- A typical project:

  10 000 - 100 000 FIM (2 000 - 20 000 ECU)

  1 - 3 work months
- Quick and simple procedures
- Client and Tekes share the costs
- A clinic usually exists from 2 to 3 years

21 TEKES

Ongoing clinics

- Noise and vibration
- Machine vision
- Plastic composites
- Laser/EB -welding
- Rapid prototyping
- Useability (machines, software)
- Timber seasoning (for small sawmills)
- Hygiene (food industry etc.)
- Export approval for building materials
- Surface engineering (coating)
- Simulation and modelling of analogue electronics
- Adaptive and intelligent systems
- Computational fluid dynamics

22 TEKES

Tekes funding portfolio and impact

Active project portfolio:
- 1 BECU
- 5 000 projects

1996 project volume:
- 500 MECU

Tekes funding:
- 250 MECU
- 2 000 projects

Business

☆

Export

☆

Employment

☆

Important effects on turnover and export of Finnish industries

23 40/95-05

Evaluation of Tekes funding for industrial R&D

Survey commissioned from the Technical Research Centre of Finland by the Ministry of Trade and Industry (1995):

Summary of projects funded by Tekes in 1990-1993.

- The volume of net sales and exports achieved with Tekes funding is 10-20 times the initial investment.

- Four to five new permanent jobs are created per million Finnish marks invested; there are also significant indirect effects.

- Tekes funding is crucial for the majority of projects; without Tekes funding, a quarter of all projects would never have been realised and two thirds would have been more limited or slower.

24 41/96-10

Small- and Medium-Sized Enterprises (SME's) and small countries in the innovation cycle: Facing the challenge of global competition

Werner CLEMENT and Georg SERENTSCHY

„INNOVATION FOR COMPETITIVENESS" WORKSHOP
ESTEC 19.-21. March 1997

1. INTRODUCTION

SME's are often praised for their flexibility and adaptability thus supporting the overall speed and efficiency of the industrial innovation and production process. On the other hand a global wave of large mergers can be observed especially in the area of the international aerospace and defense industry. What will be the future role of SME's and also SMOPEC's (small open economies) within the constraints of tough global competition and particularly in the space domain? Possible answers to this question may be found somewhere between the following provocative extremes:

Thesis: SME's will disappear because of their economic and political weakness and/or through the ongoing industrial restructuring process.

Anti-Thesis: The large companies will die-out because of the "dinosaurus-effect". Mainly the small and flexible companies will survive.

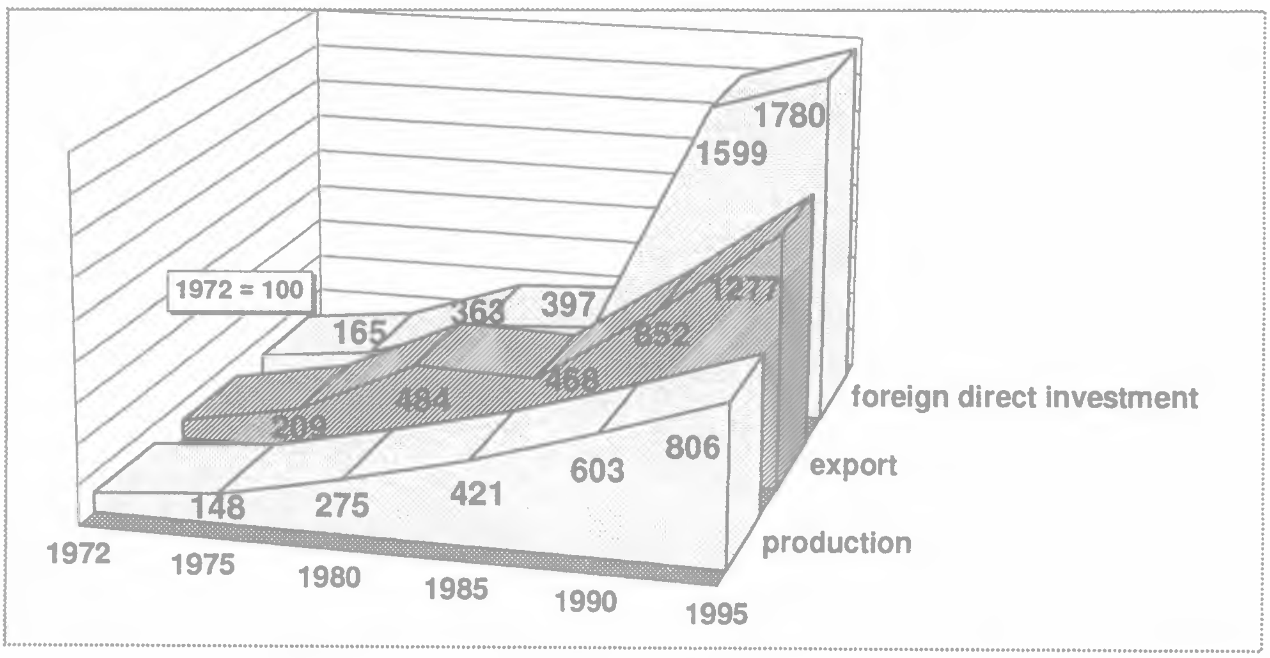
Sin-Thesis: Economy (in general) will benefit significantly from a dynamic interaction between large and small companies. The respective constraints and rules for this interaction have to be defined.

2. COMPETITIVENESS IN A CHANGED GLOBAL ENVIRONMENT

During the last decade international competition underwent profound changes. Traditional trade no longer follows conventional patterns. This has a significant effect on small and medium companies. In order to keep their competitive and innovative potential they should more closely observe the modified structure of global trade.

International economic activities usually are classified in international trade and international production. While trade is following a steady path international production is at present strongly enhanced by foreign direct investment. Due to stronger global competition trade increasingly follows investment - and not vice versa like in the past.

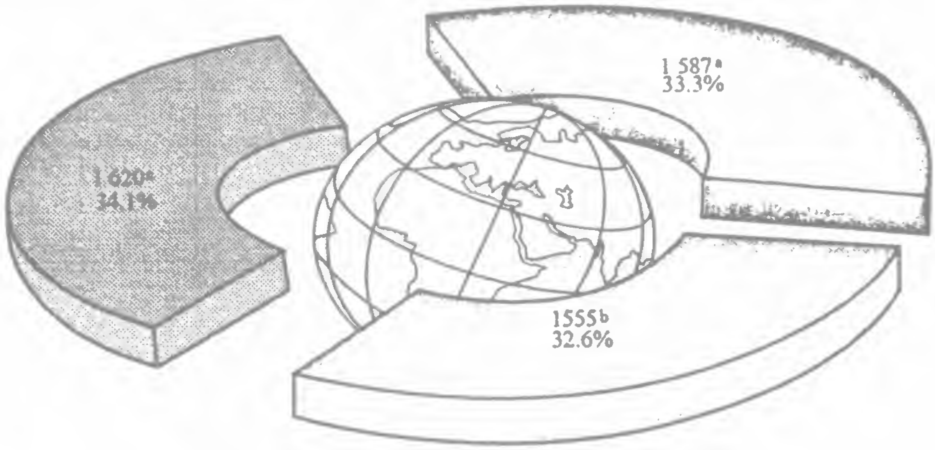
„International Trade and Investment"



Source: IMF, OECD

In addition, trade flows are always less governed by what is assumed as the theory of international (free) trade. It is the dominance of regional trading blocks (fortress Europe, ASEAN...) and Multinational Companies (MNC's) which shape global economic activities.

TNCs in world trade: exports of goods and non-factor services, 1993
(Billions of dollars and percentage)



Intra-firm exports by TNC parent firms and by foreign affiliates.
Exports by TNC parent firms and foreign affiliates to unaffiliated firms.
Exports by all other firms.

Source: UNCTAD, Division on Transnational Corporations and Investment.
[a] Estimated as in table I.13.
[b] Estimated on the basis of the assumption based on the United States data in table IV.6 that arm's length trade by TNCs accounts for 32.6 per cent of world trade.
[c] Derived as the difference between total world exports and estimated exports by TNCs.

This new picture has far reaching consequences for Small and Medium Enterprises (SME's). The preponderance of MNC's is not a "natural" phenomenon. It is the result of deliberate action and strategy triggered by the necessity of stiff competition. Competitive advantages in this new environment can be sought in different ways:
Cost-/price competitiveness is still a major concern despite all the importance of *non-price competitive factors*, like technology, product quality, design, after sales service etc. In a period where technology transfer is eased in an increasing manner, and even leads, strangely enough, to developments like virtual companies, and cost advantages gain importance. However, collective bargaining, fixed exchange rates, harmonisation of environmental standards and bureaucratic procedures make it more difficult to reach cost

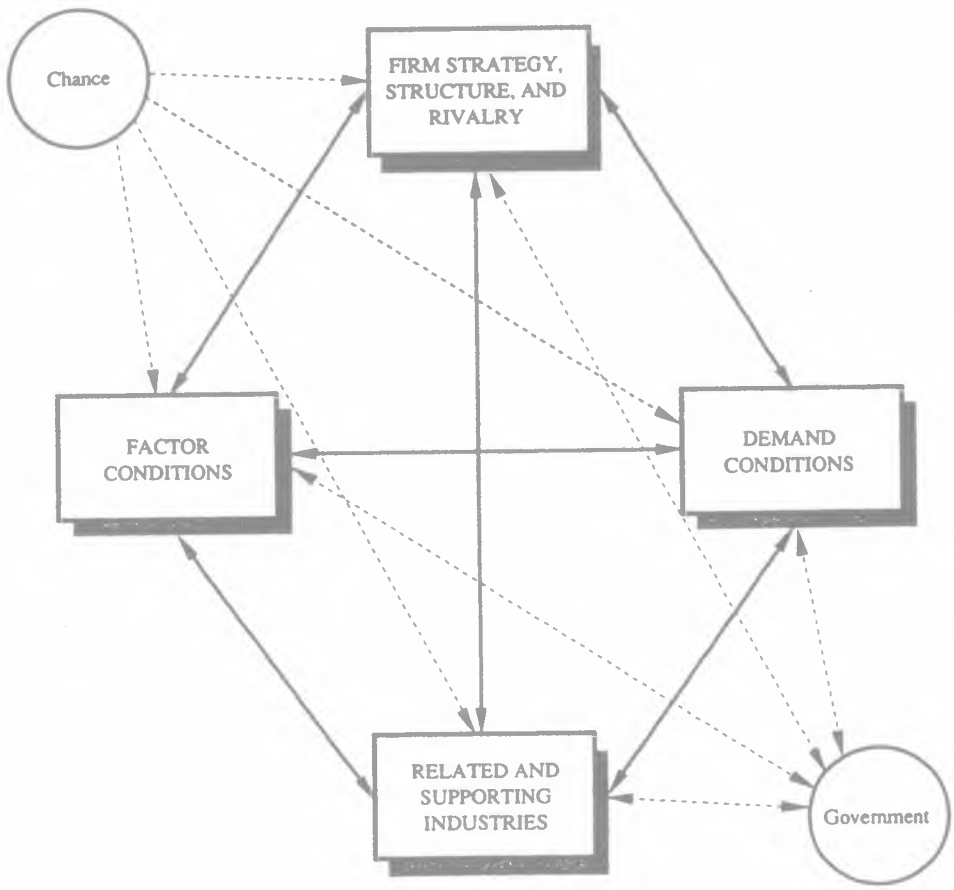
differentials. One major way, however, persists. It is economies of scale. And it is exactly this goal big companies are striving at. This is the basic reason behind concentration.

SME's have problems reaping such economies of scale. More frequently they have not reached their critical size in the relevant market. Therefore, they operate at a relative suboptimal position in their cost-structure. In comparison to big companies there is the risk of losing a foothold in participating in huge R&D programmes or in more disputed markets where the barriers of entry built by the large firms become almost insurmountable. Seeking new strategies is therefore a matter of survival for many SME's. While big is beautiful there may be a second best solution: "Clustering" of business activities has proved to be a promising tool.

3. CLUSTERS - The concept

The term of „cluster" has been introduced in the economic literature by the well-known book of M. Porter in 1990 (earlier, the French concept of „Filières" had a very similar meaning). In his understanding a Cluster can be described by the following determinants:

„National diamond"



The Complete System

Source: Porter, M.E. 1990, p. 127

It is easily understood that this cluster concept is much more than the traditional input/output analysis where only the interfirm linkages are being depicted. The basic philosophy behind a cluster is always the bundling of economic activities in order to gain competitive advantages.

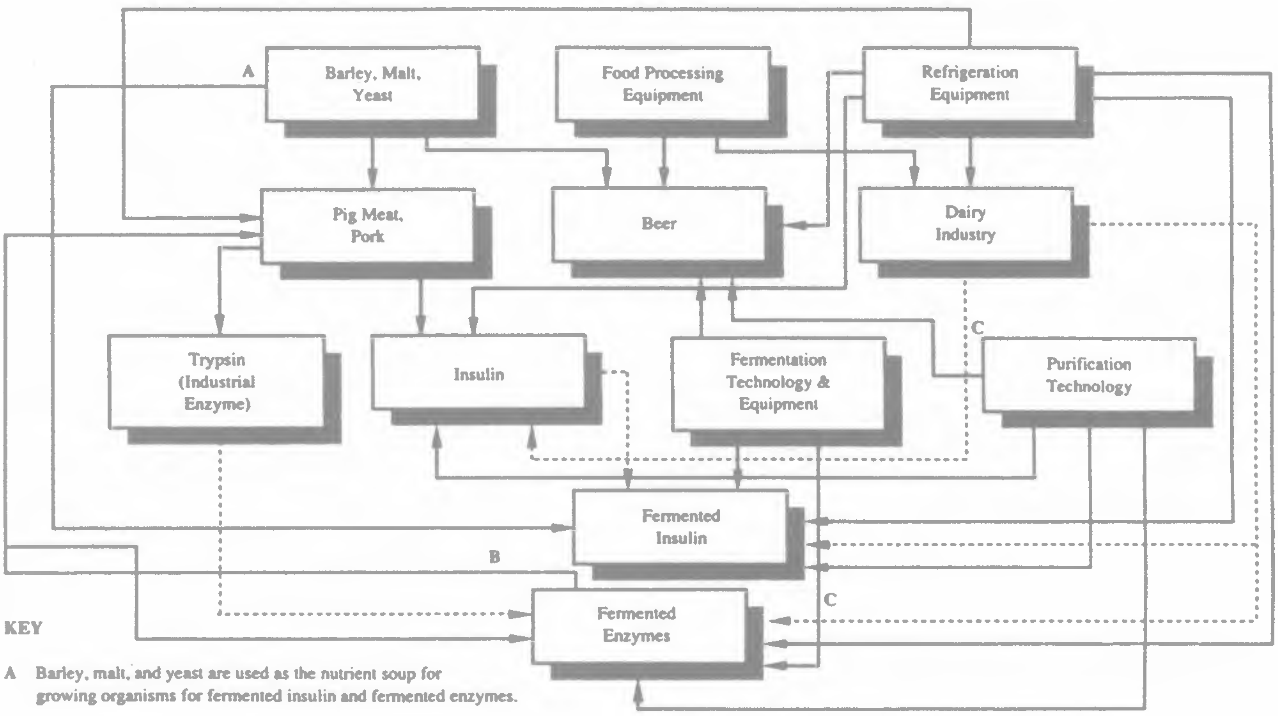
In contrast to traditional analysis of competition the cluster - concept has the following advantages:

- It strives at creating value chains and areas of competence rather than promoting the competitive edge only
- It looks at the whole economic environment and know-how tradition of competencies, trades or even a whole country (think of Dutch flower industry, German engineering or printing, Japanese robotics industry or Italian ceramic tile industry)
- It depicts the influence of science and technology (innovation) across firms, branches and regions
- It evaluates the whole array of innovation-creating factors (R&D, education and training, other forms of intangible investment)
- It looks at the aspiration level of (sophisticated) demand driving suppliers to increasing standards of products and processes
- It determines the competitive advantages of related and supporting industries
- It underlines the links between firms' strategies and government policies.

Although clusters should lead to the detection and promotion of all kinds of national areas of competence irrespective whether these pertain to small or large companies the concept is particularly suitable for conglomerates of SME's linked to strategies for policy-makers. It is also quite adequate of substituting conventional sectoral policies (pursued by almost all industrial countries and the EU) by cross-border policies, i.e. structural policies, R&D policies, educational policies, marketing etc.
It has even led to a new form of economic policy which can be called **„Cluster-oriented Policy"**. Its main characteristics are:

- The process of competence or innovation is, first, observed and, then, fostered across companies and economic sectors. In this way the advantages gained in innovation in one area may be transferred to others. A good example is the Danish agriculture - linked industry reaching from agriculture to the pharmaceutical industry:

Partial Clustering of Competitive Industries in the Danish Economy



KEY

A Barley, malt, and yeast are used as the nutrient soup for growing organisms for fermented insulin and fermented enzymes.

B The initial demand for detergent enzymes comes from slaughter houses.

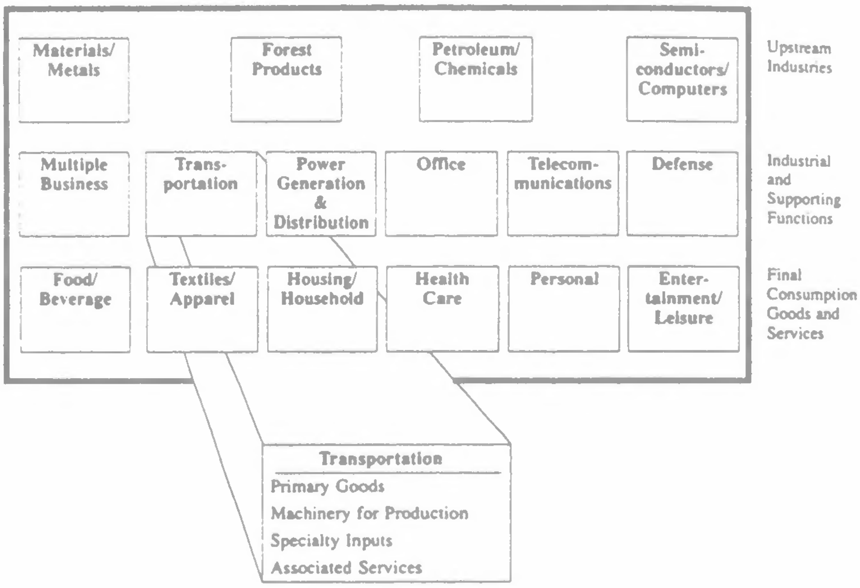
C Insulin and enzyme producers sourced skilled workers from the dairy industry.

Solid line = Supply Relationship
Broken line = Common Technologies or Common Inputs

Source: Porter, M.E., 1990, p. 150

- By extending the concept of the value-added chain through all levels of production it provides an integrated approach to policy-makers and companies benchmarking their quality-level:

„The Cluster Chart"

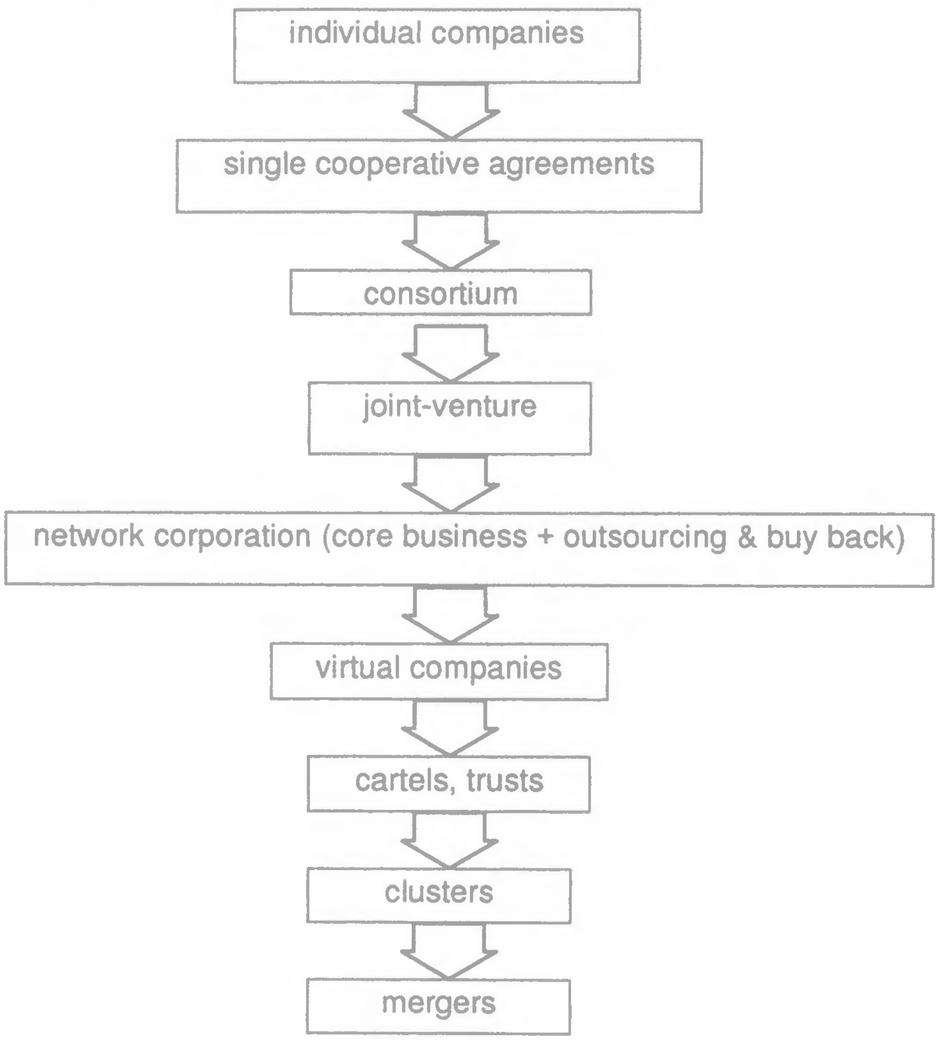


Source: Porter, M.E., 1990, p. 742

- It avoids the misconception and fallacies of „targeting" in economic policy as it aims at balancing competition and structural policy
- By promoting the co-operation and networking in factor improvement, in subcontracting , in the creation of trade marks (or at least an image), in after sales service, marketing and internationalisation it should lead to the all important economies of scale for the SME's in the cluster
- It has to serve as the guideline for more conventional measures of economic policy like regional policy, investment incentives, export promoting measures, procurement policy etc.

- Beyond implementing specific economic instruments a cluster - oriented policy also helps creating a spirit of co-operation. When creating cluster-workshops in Austria the participating firms were struck by detecting how many similar problems were tackled in all isolated way and how much could be gained by co-operation without, however, giving away the ultimate company secrets to the competitors
- In this respect one has to recognise that clusters are a fairly vague term. Actually, co-operation or networking may take many forms:

<u>From the individual company to mergers:</u>



Finally, a warning should be given against a frequent misunderstanding that the dispute is large companies versus clusters. Quite often, large firms are quite happy with the process of building - up a network of smaller companies which have close ties with the leading firm which operate in a way like an icebreaker in research, in production or in marketing. In this model, the leading large firm concentrates on the core competencies and sources out whatever possible. For the clustering SME's this is a kind of a king's road because a basic volume of orders is already secured. Furthermore, cost splitting between the large and small firms is a most welcome result.

4. THE ROLE OF SME's AND SMOPEC's IN THE INNOVATION CYCLE

How can „network-effects" or synergy's be found and developed amongst SME's enabling them to gain a competitive edge over the large companies within certain fields of activities? What can be the role of a small economy in Europe and for the European space programs? These are key-issues for industrial (space) policy in Europe. Some aspects are to be investigated in this paper.

The European Space Industry has undergone a massive restructuring process in the last couple of years which can be characterized by the following:

- Reduction of the number of European Prime Contractors from 10 to currently 4. The „final" number may be 1 or 2
- Existence of approx. 10 „Subcontractors", distributed over Europe
- Dynamic development of the number of Suppliers (200-300) by
  - Mergers amongst them and/or with larger companies
  - Foundation of new (small) supplier-companies by entrepreneurs
  - Changed strategic significance of „Diversification".

The table below shows the measures of industrial concentration of the European Space Industry as per end of 1995 in the large countries and in selected SMOPEC's:

	F	D	I	UK	A	B	CH	DK	FIN	N	NL	S	SP
CR1	24	56	31	46	33	27	33	61	37	34	63	73	40
CR2	45	66	44	64	59	42	55	69	52	48	70	85	52
CR3	57	71	53	67	70	54	62	76	62	58	74	94	64
CR4	63	74	61	70	79	61	68	83	70	67	77	95	70

Measures of Industrial Concentration per country [%] 1993 - 1995

Legend:

CR1....largest contractor
CR2....largest two contractors
CR3....largest three contractors
CR4....largest four contractors

All figures based on EUROSPACE sources (weighted figures)

During the 1980s „Diversification" was on the strategic agenda of many companies thus leading to the introduction of space activities in non-space companies and vice-versa. Now „Concentration on Core-Business" forces many companies to withdraw from their space (or non-space) diversification's. This diversification strategy is based mainly on the idea of „technology-push" which since a couple of years has been more and more replaced by a market-demand-driven approach. Sophisticated technologies developed for the non-commercial space market very often can't be used in a competitive way for commercial non-space applications. This is one of the reasons why so many „classical" diversification programs failed.

Prime Contractors are under extreme competitive pressure by the US- and partly by the Russian and Asian space industry. To increase its price-related competitiveness, European space industry follows more or less without question the „merger-path" of the US industry which is acting as a forerunner. The overall situation for the prime contractors is much more complicated because this industry is closely interlinked with the defense and aircraft sectors which required heavy re-structuring and re-sizing after the end of the Cold War.

The existence of a **Subcontractor** level in the European meaning has been strongly supported by ESA's industrial policy. In particular the rule of „fair geographical distribution" which is an important mean to support the role of small countries in the ESA business is responsible for the existence of this artificial contractual tier (in comparison with a „market-only" regime). Subcontractors are mainly „large" SME's (150-500 employees in the space relevant part) being responsible for an entire sub-system of a spacecraft or launcher.

Suppliers are mostly „small" SME's (<150 employees in the space relevant part) specialized in one or two niches. Their key to success is „non-price competitiveness" such as overall speed, specific know-how and/or technology, tailor-made products, service-orientation etc. Suppliers will survive the huge „merger-wave" if - and only if - they excel in one (or more) of these areas.

For the **European Industrial Space Policy** a significant dilemma can be observed: How to bridge the gap between

- Free market regime to increase industry's competitiveness
- Survival of the SME's to benefit from their specific abilities
- Motivation for small countries to maintain their financial contribution.

It has been considered as a vital effort to adapt these rules to the changing „space world". More flexibility in the application of the fair return rule accompanied by a new rule („fair contribution") can be a solution for this issue. A „Council-Working-Group" has been established by ESA to create a new set of industrial policy rules for the European space industry. No final results from this working group are available for the time being.

In many small countries (NATO-members like B, NL, DK, SP and S, CH) the space industry is very often closely connected with the defense sector. For many years (during the „Cold War") this offered a significant advantage for the relevant companies because of the stable military market and the access to military research funds. In these countries the military sector created the space industry as in the large economies. In Norway, the space industry uses many synergy's with the off-shore industry.

Our investigation in small countries (A, B, DK, SF, NL) demonstrated a strong tendency to align space activities with the relevant national core competencies. This demands space industry and national authorities (in small countries) to support the „escape of space industry from the ivory-tower". The space industry can and should be a part of high-tech clusters in small countries (examples):

- DK: power electronics and software development
- NL: application areas like water, agriculture and forestry
- A: welding technologies for cryogenic applications, acoustics and structural mechanics.

Regarding cross fertilization between the space- and non-space activities we have been informed by a large MNC[1], active in the electronic, power and software sector, about some new examples for successful internal synergy's:

Space Business	Core Business
Network-Management Information System (NMIS) for ESA networks	CONDIS: NMIS for Public Switching Nets and Private Nets (e.g. railways)
Spacecraft Operation SW and Mission Control SW	Control Systems for Electrical Power Distribution Systems
Monitoring Systems for Ground Stations	Automation of Factories
Switching System and Terrestrical Gateway in spaceborn Telecom Systems (e.g. IRIDIUM)	Mobile Telephone (GSM) Switching Systems

Regarding human capital in some countries (A, DK) a very high educational level for engineers has been quoted as a sound basis for space activities. Synergy's with an existing high-tech environment (software engineering, quality management, automotive products or weaponry) are further examples for the networking between space projects and existing industrial/scientific competencies.

Other important constraints for SME's are bidding and teaming conditions and the national support they deserve. Some European countries seem to praise SME's as an „all-singing-all-dancing" mean for innovation and industrial success but in practical terms they support mainly the large enterprises. Other countries' positions seem to oscillate between SME's („we need the entrepreneurs") and large firms („let's create one large company") in an unpredictable manner. This is not to blame politicians and civil servants, but it is about the changing (and often undefined) role of small companies in the marketplace.

To improve the situation for the SME's in the European Space Industry the following key issues are to be pursued by industry and the industrial policy makers on both national and European level:

- Identification of economical, historical and cultural drivers supporting the creation of „CLUSTERS" between SME's enabling them to defeat even large companies in specific areas

[1] MNC ... Multi-National-Company

- Utilization of specific/typical human capital (competence) in an individual small country, serving as a driver for competitive achievements in the space domain
- Identification of specific know-how, product range or industrial tradition in an individual small country which can be used by the national space industry in a synergetic way.

5. CONCLUSIONS AND RECOMMENDATIONS

By applying the CLUSTER-concept on the actual status of the European space industry some fundamental strategic considerations for SME's and SMOPEC's within the constraints of global competition can be presented.

If one takes into account the relation between the two basic figures

- Average yearly turnover of an average SME (approx. 5 MECU), and the
- Minimum efficient project size (3-5 MECU order of magnitude)

it can be seen easily that within the constraints of tough global competition such an average SME cannot survive because of economic instability.

This leads to the following strategic alternatives for SME's:

- Peanuts-Strategy: be happy with „left-over's" from the competition
- Cooperation-Strategy: cooperate with other SME's or with MNC's
- Niches-strategy: offer 'top'-niches and innovative products/services.

Therefore we would strongly support a cooperation strategy for SME's which are not in the position to offer 'top'-niches products. Clustering between these companies, supported by national authorities and the Agency can be a valuable tool for such companies.

SME's will operate as a driver for innovation in the space market, if they focus in particular their activities on „non-price competitiveness" (such as overall speed, specific know-how and/or technology, tailor-made products, service-orientation etc.) in the same way as large companies have to focus both on innovation and economies-of-scale. To this end some improvements should be implemented for ESA's industrial policy such as:

- Fair bidding conditions for SME's supported by a combination/harmonization of national measures (specialization, clustering) and on ESA-level (creation of „Centers of Competence")

- Better harmonization between individual company strategies and the technology programs of ESA
- More continuity for the individual SME within its area of specialization

- No competition of SME's against the upper tier (prime or sub-contractor) in the same area (same product/service)
- Establishment of long-term relations between SME's and their direct customers to support progress on the learning-curve (use competition as a mean for selection and from time to time as a calibration tool)
- Contractual procedures and payment schemes according to industrial standards:
  - Early contractual coverage of contractors by simple and unified contractual and administrative tools
  - Immediate release of relevant down-payments after contractual coverage
  - Rapid and effective processing of invoices to keep SME's in a healthy financial status
  - Financial incentives to enforce the above principles (loss of interest for delayed payments).

In context of the application of a cluster-concept for the SME's of the European Space Industry the following recommendations can be given to overcome the „isolated status" of this business. Clustering between SME's and other SME's or MNC's

- Is aiming at creating value chains and areas of competence rather than promoting the competitive edge in the individual company only
- Includes the whole economic environment and know-how tradition of competencies to support the integration of the space industry
- Takes into account the influence of science and technology (innovation) across the Cluster (firms, branches and regions)
- Is based on the exploitation of the whole array of innovation creating factors (R&D, education and training, other forms of intangible investment)
- Underlines the links between firm's strategies and government policies.

Taking into account the recommendations outlined above, it is proposed that the ongoing effort of the Agency to support the creation of „virtual companies" (Project NOVA) shall be pursued and broadened. As a part of this effort a new program (COBRAS-SAMBA Mission?) could be taken as a show-case for the implementation of these recommendations.

These recommendations are addressed towards both European organizations (ESA, EU, EUMETSAT, EUTELSAT) and national governments. In particular the large countries and companies are requested to support a common European SME-policy.

6. REFERENCE DOCUMENTS

- Fourth Framework Program and the relevance to the SME issue e.g.: "First SME technology Days" Brussels 30. and 31. October 1996. Organized by DG XII to increase the awareness among SME's of the opportunities of the 4th Framework Program.
- CREST, the Community's advisory committee on scientific and technical research, has recently adopted a report on SMEs.
- SMEs in the Fifth Framework Program: Joint FEICRO-EACRO Position Paper. The Federation of European Industrial Cooperative Research Organizations (FEICRO), in cooperation with the European Association of Contract Research Organizations (EACRO) has published its views and recommendations in a position paper.
- Porter, Michael E.: The Competitive Advantage of Nations, London 1990
- UNCTAD: World Investment Report 1995: Transnational Corporations and Competitiveness, Geneva

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RELATIONSHIP BETWEEN SCIENCE AND INDUSTRY : NEW PERSPECTIVES

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Paper to be presented at the workshop on " Innovation for Competitiveness".
ESTEC. March 1997

1. INTRODUCTION

The European Space Agency has been instumental in managing European R&D efforts to endow the Member States with a range of space technologies. In many space related scientific and technological areas, despite a limited global budget that never exceeded one tenth of the US spendings for space, Europe is not lagging behind the United States. Indeed, there are numerous scientific disciplines and technological applications in which Europe excels. However the competitiveness of european countries is challenged by an increasing number of problems:
-The size differential between the United States and Europe at the level of public civil and military budgets is increasing. This is particularly the case for R&D spendings on space applications. The challenge for Europe is to ensure a sufficiently large flow of publicly funded R&D work in all application fields to avoid falling into a position of weakness. The risk is to lag behind at the very moment when these application fields develop into major commercial markets. Even japanese industry, which benefits from its government's interventionist policy, is a potential competitor.
-The nature of the competition in R&D fields has changed. During several decades, all the technological efforts has been driven by agencies that defined the technologies that were needed, funded the creation of scientific and technological competences that were required to be competitive, and organised the process of transfer of technology from space activities to other sectors. Nowadays, with the development of new space applications, such as navigation, mobile telecommunications, or earth observation, this "technology-push" philosophy becomes far less relevant. The absolute need for industrial competitiveness in the world markets cannot be addressed by agencies alone. Key issues in terms of science and technology are beyond the scope of space agencies.
-The nature of the players in the field of space related science and technology has changed. At the beginning of the development of space activities, the "club" of research laboratories, of centres of technology and of industries that were participating in space projects formed a closed community whose objectives and forms of collaboration were strongly influenced by space agencies. As commercial

applications are undergoing a rapid expansion, newcomers are entering in the field, in particular from the user's side. The rapid globalisation of markets offers new opportunities for combining technologies, and new forms of interactions between economic agents. The space community could not survive as a closed world.
-The requirements to space policy have also changed. In terms of scientific and industrial policy, the goal of the agencies was first to stimulate the implementation of competitive competencies in Europe. To a large extent, this mission has been successful. Strong centres of research and technology and leading companies in the space arena have emerged in Europe, thanks to the impulse of space programmes. But the objectives of public policy are now evoluting rapidly: priority is given to a wide diffusion of R&D efforts, in particular to SMEs. These are considered as the best suited places to create jobs.

To remain competitive, Europe is thus obliged to overcome many handicaps in the international arena: Because of the downsizing of government's spendings, Europe cannot expect a substantial increase of publicly funded R&D space projects in the short term. Because of the separation of public from military efforts in Europe, European countries cannot cope with a strong interaction and convergence between civil space budgets and military efforts. Because of the diversity of European countries and cultures, Europe cannot rely in the short term on an homogeneous market that drives economies of scale.
Under these constraints, one of the key solutions for the European space policy is to sharply improve the efficiency of its R&D basis. If European countries cannot expect to significantly increase the size of their R&D budgets, they must endeavour to increase the efficiency of the overall process of innovation related to space in Europe.

The main hypothesis of the present contribution is the following: to increase the efficiency of space R&D efforts in Europe, it is necessary to significantly improve in any domain related to space the relationships between science and industry in Europe. The production of new ideas and the opening up of new opportunities, the diffusion to the economy of knowledge acquired during space projects , the stimulation of SMEs, the efficient interactions between users and suppliers of space products and services, all these objectives require a better relationship between scientists and industrialists. However, any such policy necessitates a deep understanding of the conditions under which the relationships between science and industry emerge and can be made more efficient. That is the reason why a large part of this paper will be theoretical, before coming to practical recomeandations.
In a first part, the paper concentrates on what is considered as the main theoretical consideration: the questioning of the traditional separation between science and industry. Many projects in space (and in other domains as well) are still inspired by this vision which probably leads to major inefficiencies. In a second part, examples of stylised facts and new forms of relationships between science and industry are discussed. The discussion envisages the evolution of bilateral relations (contracts of research, for instance), as well as multilateral forms of cooperation (networks) between research institutions and industrial firms. Finally in a third part, the efficiency of these new forms of cooperation is discussed, from the point of view of a better definition of the role of public policy in R&D. A clear understanding of the

ways public laboratories, centres of research, private laboratories, large firms and SMEs are changing their modes of cooperation and their behaviours in order to increase the efficiency of their innovative efforts is certainly a key issue for the public decision maker. What is at stake is the definition of new principles that will shape future R&D programmes supported by public institutions such as ESA.

2. THE THEORETICAL BACKGROUND

According to a deep-rooted conception in economics the relationships between research and industry used to be explained by a simple dual dichotomy: the distinction between science and technology on the one hand, and between private and public research on the other. Public research ("open science") was supposed to produce scientific results independently of applications, thus contributing to the growing (and free access) stock of knowledge of society. Industry was supposed to try to appropriate and transform scientific results into technological solutions (thanks to private applied research), with the aim to reach useful and profitable applications. This vision relied on the linear model of innovation, that inspired all the policies in the field of science and technology. The main principles that underlined the definition of public programmes in R&D (for example, the principle of precompetitiveness), the policies of transfer of technology, the definition of property rights, were shaped by the linear model of innovation, and by the derived dual dichotomy.

This traditional vision has been recently challenged by the theory as well as by facts. The new theory of innovation in particular the interactive model of innovation, strongly questions the separation between science and industry. At the empirical level, there is nowadays an increasing number of new forms of relationships between research laboratories and industrial firms that leads to a better efficiency of the innovation process.

2.1. The traditional vision

The relationships between science and industry used to be based on two broad distinctions : fundamental research versus applied research, and public research versus private research.

- The separation between fundamental research and applied research is logically deduced from the vision of a linear model of innovation, that supposes a kind of division of work between the two types of research. The role of fundamental research is to increase (through publications of scientific articles, conferences, etc ...) the stock of knowledge of society. The role of applied research is to transform the stock of knowledge of society and shape the technological results obtained (through patents, licenses, copyrights, etc ...) into useful applications.
- The separation between public and private research is related to the fact that science was considered as a public good. Nelson (1959) clearly stated that the knowledge produced by academic research has three essential characteristics: limited appropriability (due to the generality of the knowledge produced),

uncertainty about the results and very slow returns on investments. He indicated that under these conditions, fundamental research has intrinsic properties that discourage private investments. The lack of investment from the private sector means that market forces are unable to attract sufficient funds: It had to be offset by the State which is thus legitimated to finance public research.

These theoretical statements were made even clearer when Arrow (1962), in a seminal article, explained why the knowledge produced by fundamental research leads to limited appropriability. He showed that research is generally classed as the production of codified information (scientific papers, theorems, etc ...). The only consideration is production costs: Crculation and reproduction costs, and thus the costs of using information (imitation) are treated as negligible. He suggested that the part the private investor obtains (the private rate of return) is generally too small compared to the benefits reflected in knowledge spillovers appropriated by competitors, users, and consumers. From this, it follows that if basic research should really be let as completely "open" and public, applied research should be protected by strong property rights devised to discourage any "free riding" in the private field.

The consequences of this broad theoretical framework were considerable. They shaped the conception of public intervention in R&D during decades. They justified the role and creation of public laboratories, of centres of research, of public programmes of R&D, of public offices to establish strong property rights, of infrastructures of transfer of technology, etc ... They explained why public efforts in R&D were generally disconnected from applications and why the arguments built upon the existence of spin-offs from public research were so important to justify public money spent on R&D. They suggested that private research being considered as producing codified information could simply be bought on markets, and not necessarily produced internally. They anchored the idea that science and industry are two separate universes. Scientific production was considered as outside the economic sphere, and governed by rules and behavioural norms (reputation effects, peer reviews, etc ...) that are completely different from the norms and behaviours of industry (seeking profits and technical efficiency). In particular, in this prespective the choice of research themes by academics should remain independent of the objectives of industry.

2.2. Questioning the traditional vision

Recently a growing field in the theoretical literature and evidence from empirical facts have strongly reassessed this vision of the separation between science and industry. The main elements of this reconsideration are the following :

- The linearity of the model of innovation has been questioned. The new interactive model of innovation has been proposed by Kline and Rosenberg (1986). It emphasises the importance of interactions and feed-back between basic and applied research as keys to efficiency in a process of innovation. Thus the clear division of work that was stated by the linear model is no more valid. It means that the choice of research themes by academics is not necessarily independent from the preferences of industry, or more generally that the norms and behaviours of the research community are not fully disconnected from those of industial firms. The interactive model of innovation conveys the idea that the quality and the frequencies of interactions between academic laboratories and private firms are a key element in the success on the innovative process. The focus should thus be more on the interfaces between basic, applied and industrial R&D, rather than on the amount of resources allocated to each of these activities.

- The idea that research produces only codified information is also strongly questioned. Dosi (1988), Pavitt (1984) and several other scholars in the field have stated that research does not produce information but knowledge, of which some is coded and some tacit. Tacit knowledge is extremely localised and circulates with high costs and difficulties. Cohen and Levinthal (1990) argued that the degree of spillovers and imitation depends on both the nature of knowledge and the absorptive capacity of firms. All things being equal, the more knowledge is codified, the easier its absorption will be. But, even in the case of codified knowledge, the user or imitator needs certain know-how and technical ability to benefit from the knowledge. To appropriate the results of academic research, even if it is codified, one has to "know the code". From this point of view, to quote Joly and Mangematin (1996) "research activity has two complementary facets : it naturally contributes to the creation of information and knowledge, but it is also a learning process which helps to increase absorptive capacity. Not only are externalities not evenly distributed, they even increase when the knowledge base of firms is similar. In such a context, external research cannot be substituted for internal research; the two are complementary".

These views undermine the concept of science as a public good. The very problem is not so much of being protected by strong property rights, but of having the internal capabilities to access and absorb knowledge produced externally. It opens the possibility to envisage some privatisation of basic research, and to reassess the definition of property rights.

The new vision inspired by the interactive model of innovation and the works on the content of knowledge, plays an important role in the perspective of the development towards a learning economy. As Meyer-Krahmer (1996) mentioned, "the growing degree of internalisation and the acceleration in the rate of diffusion of codified knowledge imply that the capability to absorb the results from basic research persued abroad is becoming increasingly important. A strong position in basic science is important in this context but a stronger emphasis on international comparative advantage may be called for".

From these theoretical bases, one can now look at the implications on the ways research laboratories and industrial firms are interacting in practice.

3. THE NEW FORMS OF INTERACTIONS BETWEEN RESEARCH LABORATORIES AND INDUSTRIAL FIRMS

3.1. New attitudes by research laboratories and by firms

Questioning the hypothesis of the independence of science and industry leads to completely reconsidering the relationships between research laboratories and industrial firms. Such an analysis supposes to investigate, in a first step, the changing attitudes of both actors in the new context.

- For fundamental laboratories, the increasing share of their private financing is a key issue. It implies that research themes will be more and more influenced by applications. Knowledge and scientific theories are supposed to be partly dependent on the context in which they are produced. The scientific themes are not only constructed from the accumulated expertise of researchers, but also from strategies adopted by the laboratories for securing access to resources. Researchers exploit the opportunities offered by industry to complement their public funding : By doing so, they participate in the economic competitiveness of firms. There is a coevolution of research themes and the perspectives of development of industry. This tendency varies from one discipline to the other. But it can be shown that in certain areas, the development of "finalised" research strongly supported by private funds is a growing phenomenon.
- For firms, the works done by Cohen and Levinthal (1989) or Gambardella (1992) clearly show that firms, whatever their size, must invest in basic research to create the capability to recognize, assimilate and exploit knowledge produced elsewere. Investing in basic research allows the firm to gather information from academic contacts. The motivation and aims of firms to improve their links to basic research have been discussed in a recent paper by Hicks (1994). She suggested that originally, the purpose of corporate research laboratories was to develop internal technological resources in order to identify and evaluate external technology. Nowadays, they have a stong tendency to emphasize interactions with external sources of knowledge. Hicks shows that in particular firms in science-based industry do publish an increasing number of scientific articles in academic journals. They are able to do so partly because they perform long term research. They are also able to manage the release of their knowledge, deciding whether to keep information to themselves or to enforce a more open policy. As Meyer-Krahmer (1996) mentioned "They release information in publications for a variety of reasons. Important among these are their need to participate in the barter-governed exchange of scientific and technical knowledge and to send market signals beyond that reflected in prices. Publications signal the existence of tacit knowledge and other unpublishable resources, thus building credibility needed to find partners in knowledge exchange. By signalling the existence of unpublishable resources, papers also allow researchers to search, select and evaluate their tacit knowledge. Thus papers are integral to moving knowledge ; not only they convey formalised information, they point to the unpublishable". Thus, the growing tendency of firms to publish could be interpreted as an attempt to find new accesses to external knowledge, by becoming "members of the club" of academic researchers in a given field. The firm clearly expects a right of access

to the academic tacit knowledge, rather than any specific service or piece of information.

3.2. Contracts and networks

From the understanding of the changing attitudes within research laboratories as well as within firms, it is possible to investigate the ways the relationships between the two entities are evolving. There are two ways to look at this problem : The first one, is to analyse the development of new modes of contracting between research and industry : in this perspective the focus is on the nature of bilateral relationships between the two types of players. The second is to examine the participation of both players in multilateral formal or informal agreements. In that domain, the most advanced literature focuses principally on the evolution of networks of research.

– When looking at bilateral relationships, one can refer to a recent study carried out by Cassier (1992). The author, used a case study of contracts between the Technical University of Compiègne and various industrial partners to explain the new forms of co-ordinating university and industry research contracts. He noted the coexistence of two broad forms of contractual research : One is based on a logic of diffusing the results accumulated by the laboratory, while the other consists of a dynamic process of joint creation on more fundamental themes which are less directly applicable by the firm concerned. As Joly and Mangematin noted: " only a part of industry/university research contracts correspond to a R&D purchase on the market. Certain exchange amount to a subsidy from the firm to the laboratory, with a firm expecting a right of access to the laboratory's network, rather than a specific service. Similarly, firms and public laboratories maintain numerous relations which are not based on commercial exchange but on the rules and norms of reciprocity. The research agreements studied by Cassier correspond to a model of "unified technology research" that allows for two types of outputs : one towards the academic world (e.g. articles, theses), and the other towards the industrial world (e.g. methods, patents). They clearly show that the only existing division is expressed in terms of results from unified technological research". Thus what is behind a research contract is a project of joint-production and mutual dependence between research laboratories and industry. And, if the circulation of some codified pieces of knowledge (either academic articles or industrial patents) are anticipated as one of the results of the collaboration, it clearly appears that this is not by far the only expected output. As we have seen, tacit forms of exchange of knowledge are also expected: firms expect to have access to the laboratory's academic network and to benefit to the laboratory's reputation. To give a precise example of these new forms of contractual relationships between research laboratories and industry, one can quote cases where a laboratory was given by a firm private financial funds to do its own research. The counterpart for the company being the right of priority to access (not to "possess") academic papers to be submitted for publications in journals by the members of the laboratory.

- When considering participation of laboratories and firms to innovative networks, we envisage a growing phenomenon that could be explained through various reasons. The first, is related to the fact that the knowledge exchanged between actors is not a pure form of codified knowledge, even if the amount of codified knowledge is always increasing. In such a context, one should not worry too much about excessive uncontrolled spillovers and risks of excessive imitation, precisely because of significant transaction costs. Imitating is costly and a loose cooperation that allows a certain control of the diffusion of spillovers between agents can be an efficient form, that ensures incentive compatibility between them. Networks offer a way to share knowledge complementarities: what differentiate an agent from another is its specific body of tacit knowledge. Through networks, agents can organize an efficient circulation of codified knowledge through a structure that makes compatible different segments of specific tacit forms of knowledge. Agents accept to increase specialization in a given (tacit) form of knowledge, because they are confident that the other agents will increase their specialization in complementary forms. This reduces the risk of overspecialization.

The second, is that innovative networks between scientific institutions and private firms allow technological learning with a strong collective dimension. Cooperation practices create locally public good in the sense that through a network provided that a sufficient level of trust is established between partners, a collective body of knowledge is progressively built, access to it being theoretically free for participating members. It will be shown that within these types of networks, the presence of a public fundamental laboratory tends to accelerate and reinforce the constitution of the common body of knowledge.

However, at this stage, one of the key questions is the efficiency of all these new modes of cooperation between science and industry. To try to answer this question, we propose to investigate some case studies

4. THE EFFICIENCY OF NETWORKS OF SCIENTIFIC AND INDUSTRIAL INSTITUTIONS IN LARGE EUROPEAN PROJECTS

Over the last three decades, different European organizations (EU, ESA, CERN, etc..) have carried out ambitious R&D programs to stimulate European competitiveness. These programs offer a unique opportunity for different forms of consortiums of research (that include public laboratories, centres of research, private laboratories, large firms as well as SMEs) to collaborate at a competing level. In the perspective of the above discussion, it appears relevant to try to evaluate the efficiency of these networks that involve various types of relationships between academic and industrial institutions.

4.1. The example of the BRITE-EURAM programme

A specific example has been chosen : the evaluation of the BRITE-EURAM programme, proposed by the EU and characterized by the principle of precompetitiveness. The evaluation work has been carried out by BETA in 1992.

To evaluate the efficiency ame generates two kinds of economic effects on the contracting teams – the direct effects and the indirect effects.

- The direct effects are the effects which are directly related to the objectives of the research projects, as they were defined at the beginning of each of these projects. For instance, if the objective is to develop a new product or a new family of products, the sales of such products are considered as direct effects. This rule is not modified in the case of more fundamental research orientated projects : direct effects are related to the application of the new scientific knowledge or the new technologies in the field foreseen at the beginning of the projects ; only the range of possible direct effects may be enlarged in these cases, since the fields of application may be broadly defined.

- The indirect effects are those that go beyond the scope of the objectives of the projects ; they are derived from the use of what has been learned during the execution of the project, in participant's activities which are not directly related to the objectives of the project. Indirect effects have been broken down into four sub-categories : 1) technological effects (transfer of products, transfer of process, transfer of service, patents, etc..) ; 2) commercial effects (network effects, reputation effects, etc ...) ; 3) organization and methods effects (project management, organisational changes, etc..); 4) work factor effects (competence effects, training of new employees, etc...).

A representative sample of 176 contractors has been selected. Then a long face to face interview of all participants of the selected projects was carried out in order to measure real economic effects mainly in terms of sale and cost reductions generated by these participants for their own benefit (the results to be comparable are expressed in terms of added value).

The global results of the evaluation work are the following (see Annex 1): The 176 contractors of the sample received 39.4 MECU (1991). A total of 611 effects have been measured.

The direct effects that have been directly generated to the contractants represent 413.3 MECU at the end of 1993, and 522.5 MECU at the end of 1995. The corresponding ratios "direct effects / EEC fundings" amount to 10.5 and 13.3 respectively.
The indirect effects that have been gnerated amounted to 132.2 MECU at the end of 1993 (ratio : 3.4), and 160.8 MECU at the end of 1995 (ratio : 4.1). These indirect effects can be split into 47.6 % for technological effects, 10.3 % for commercial effects, 11.6 % for organization and methods effects, 30.6 % for workforce effects (competence and training).

The main results for research centers and university laboratories are the following: One should normally only observe indirect effects for these two kinds of organizations because of their status in the program. They are considered as non-profit making organizations and should work at marginal cost. If the universities never sold anything, this was not the case for all the research centers who raised 1 MECU of direct effects.

If the workforce effects (competences plus training) are left aside, one can observe that the rest of indirect effects reaches 9.6 MECU for research centers and 3.3 MECU for universities, mainly through new research contracts from industry, national governments and the EU. The increase in competence and the training effect equal 10.2 MECU for the research centers and 4.3 MECU for the universities. These two figures strongly underestimate the real indirect effects which will be generated in the future. Indeed, the increases in competence are considered by the participants as very important, mainly because of the discovery of new fields of research directly connected to the industry with many future contracts in good perspective, and also because of the fact that the people who have acquired these new competences stay in the laboratory for a very long period (on average, more than 10 years) and hold high hierarchical positions.

The results concerning industrial firms are numerous, but one can focus on a main one: the comparison between big firms and SMEs (see Annex 2). The results indicate that the ratios, either in terms of direct effects or in terms of indirect effects, that have been obtained by big firms are significantly higher than those for SMEs. It means that big firms take naturally high benefits from their participation in research networks. However it does not mean that the performance of SMEs is negligible. They managed to generate a total of direct and indirect effects cooresponding to a ratio of 4.75 (2+2.75). Their only strong position is the amount of commercial indirect effects. They have fully used their membership of a new network to generate effects up to 8.3 MECU, about 19 % of the total effects. Their main weakness is due to their small size both in critical mass of competence and in financial terms. Two signs among many others, extracted from the results, will illustrate this handicap :

- When a firm generates direct effects, it is an indicator of its competence and its ability to transform a research project into a market product. This firm should generate more indirect effects (as it is largely confirmed by the performance of the big firms) and among these indirect effects, a large part should be technological transfers (products or processes). To generate these indirect effects, they do not need large extra investments, but a large spectrum of competences. The SMEs do not have these competences, and as was shown by the results, the champions at generating direct effects are not able to generate even the same amount of indirect effects as the other SMEs (ratio 1.4 versus 3.5).

- The critical lack of financial size is well illustrated by the difference between big firms and SMEs in terms of direct effects (25.3 versus 2.0). For a big firm, in most cases the extra investment necessary to put the product of the research on the market was very small when compared to the total turnover (generally well below 1 %) ; for the SMEs, even for extra investment equal to the amount of money previously invested in the research project (generally in a ratio 1to 1, and not 1 to 10, or 1 to 100, as it is often put forward), the barrier is too high and the technologicallly successful project is abandoned.

In conclusion of this series of results, it should be stressed that the "folk theorem" according to which SMEs are better designed to perform innovation than the big firms, mainly because of their flexibility, shoud be seriously questioned. It has been shown in the study that the best situation to innovate is for a firm to integrate the functions of producer, user, and research-tester, a situation which is almost never observed in the SMEs. In the industrial sectors covered by the BRITE-EURAM programs, the only performing SMEs are the firms which hold a technological and market niche, in a monopoly situation. As soon as a big firm enters the niche, the battle is lost. This was observed in all cases in the sample.

The nature of interactions between academic bodies and industrial firms in the network of contractants revealed significant effects. The presence of a univerity (or even better, a fundamental research institution such as CNRS, Max Plank Society, etc ...) in a consortium has a very positive action on the generation of economic effects, especially for direct effects. On this last point it should be stressed that the main effect of the presence of a university in a consortium is to accelerate the process of generation of indirect economic effects (see Annex 3).

The influence of universities is also observed outside the firms, in the research centers but to a lesser extent. Very strong qualitative differences are also observed in the spread of the indirect effects when universities are or are not associated with firms and research centers. Almost all categories are affected. The presence of universities favours product transfers instead of process transfer, network effects instead of reputation effects, organization effects instead of method effects, and even to a lesser extent, competence instead of training.

In addition, the presence of universities favours all technological effects in general, in particular service transfers, and is unfavorable to the existence of unused patents.

In order to give a precise example of the positive impact of the relationships between research laboratories and industrial firms within a network of contractants, one can mention the case of the domain of applied mathematics. Applied mathematics dealts mainly with mathematical tools for modelization and simulation. It is a generic science which can be applied through very different contexts. No other domain or sector has been as successful. All the direct effects are generated by incremental innovations with the exception of one project which can be qualified as revolutionary because it involves a new material for a new application.

In conclusion, the firms which were the most efficient at generating direct effects, are those who open their consortium to the best fundamental research teams. This conclusion is apparently in contradiction with the prediction of the traditional theories of innovation, in a sense that the impact of the presence of fundamental research teams is not to reach revolutionary innovation but on the contrary incremental innovations. But the efficiency of such networks could be easily understood with the tools developed by the new theories of innovation and generation and distribution of knowledge.

4.2. The case of the ESA programmes.

The case studies done by BETA on the indirect effects of european space programs in 1980 and 1988, are not comparable with the work done on BRITE-EURAM for several reasons. The first one is that the ESA program are essentially "mission oriented" R&D programs, while BRITE-EURAM is a "diffusion oriented program". The direct effects of a mission oriented program is the mission by itself, and BETA for this reason only concentrate on the indirect effects of ESA programs. The second one is that the consortia in the case of ESA programs seldomly contained fundamental research teams. However, despite these differences, significant results were obtained from the observation of consortia:

One of the main findings was that technological learning was made possible through the gradual construction and the upkeep of a critical mass of skills within and among the firms and centers of research of the space programs. There was certainly a highly beneficial learning process that the firms participating to the ESA projects individually appropriated, but it was to a large extent the outcome of the skill network consolidation. What has been shown also is that the network organisation is non-neutral vis-à-vis the nature of technological learning, and so the type of the role one plays in the network (main contractor, equipment supplier, system constructor, etc ...) tends to shape the learning trajectory and related appropriability practices. We can mention on this point a differnce with the results obtained for BRITE-EURAM. It concerns SMEs. SMEs seem to be particularly sensitive to the nature and the form of network they are taking part. Space programs are generally conducted by hierarchical pyramidal networks of contractants. Therefore SMEs acting as equipment suppliers at the base of the pyramid, are developing and producing small components which can be partly or fully reused elsewhere, while beneficiating from technical information related to interface problems, quality requirements, norms, standards; they have opportunity to enhance their tacit knowledge by adding "local" and incremental pieces of information to their already existing knowledge. On the contrary, BRITE-EURAM type of programs are more "open" in the sense that firms have more liberty to propose different types of activities, and can really benefitting from the network of contractants if they have the internal capabilities to absorb new ideas from outside, specifically from academic institutions. This explains why SMEs in BRITE-EURAM, since they have not in general the internal R&D competences that are needed, experience far less economic effects than big firms.

5. POLICY IMPLICATIONS

As far as technology policy is concerned the new innovation "model" implies an altogether different type of intervention for the government when it considers stimulating technology. According to the logic underlying this model the old linear view of a clearly distinct phase of research followed by production and commercialization is basically less and less valid and the stages become much more integrated. The system evolves towards generalized forms of learning by doing. Since the research phase is not clearly distinguishable anymore, no external research can really compensate private insufficiencies. Public intervention should therefore take forms which differ from the one derived from the "former" innovation model. Instead of big technology-push public research programs aimed at substituting for private research the new model asks for a more catalytic type of intervention, i.e. facilitating the conditions of the research learning process. (see Annex 4). The basic idea is to help the technological body of knowledge of the firm reach a critical mass and thus allow for significant research activity. At the inter-firm level the basic idea is to stimulate technological partnerships in order to obtain more extensive cross-fertilization among disciplines, technologies and research programs so that each individual trajectory of specialization becomes less risky to follow (inasmuch as a better adjustment to diversified needs is ensured beforehand and a broader application potential is available). In a competitive scheme of globalization, that is larger planet integration of the market, the risk of over-specialization can be shared in two ways. One is to institutionalize risk-sharing devices among firms and helping to organize common market segmentation and some generic research facilities ; the other is by each using special segments of the fruits of the specialization of the others. In other words some sort of technological integration is needed. It may be more spatial in nature as in chemical industries sites that share common infrastructure devices such as steam power, autonomous electrical power supply and a cheaper access to joint products. It may also be more abstract in nature – sharing knowledge complementarities, or it may include both, as in Silicon Valleys and the like.

6. CONCLUSION AND RECOMMENDATIONS

From the theoretical investigation proposed in this article, the following recommendations can be deduced:

- The reinforcement of relationships between science and industry is a source of

competitiveness for European efforts in space.
- Priority shoud be given to applications. A flow of public R&D remains necessary to promote space applications, but this flow should be carefully oriented to reinforce and encourage concerted efforts between European institutions, industries, research centres, and end-users, particularly at the selection and definition stages of R&D programmes dealing with future applications.
- In a competitive context, Europe can expect to develop a strong comparative advantage in the domain of space applications: many actual or potential applications from space concern domains of public interest: control of pollution, access to water, protection of environment, land monitoring, control of treaties, etc... In these domains, the end users are large cities, regions, coastal areas, etc... There is a need to organise networks of users and suppliers of space services, where european intitutions could provide full funding for pilot and demonstration projects. The efficiency of these networks (open to public as well to private agents) will rely on a good interaction between scientists and industrialists of different disciplines.
- The presence in such networks of public research centres is a key aspect, because these centers are best suited for facilitating the circulation of knowledge between different disciplines, for memorising the knowledge gained, and diffusing it. There is certainly a real opportunity for public research centers (at european or national level) to redefine or extend their mission. As problem solving activities need to integrate an ever increasing body of disciplines to come to efficient solutions, the role of public research centers will become more and more important. What is at stake is the coherence of dispersed efforts, the validation of efficient results, the benchmarking of the best practices, the diffusion of those solutions that proved to be efficient.
- The involvement of SMEs is a key question. The above discusssion showed that there is not much to expect from a direct interaction between fundamental research laboratories and SMEs, at least for the majority of SMEs that have not the internal ability to absorb knowledge from basic research. But there is much to do to improve the technical ability and competiveness of SMEs by facilitating their learning process at the "vicinity" of their technological competences. Several ways are suggested by the above discussion:1)Through a direct interaction with a prime contractor, where SMEs could learn organisational methods, have access to all types of knowledge and information needed for innovation. The risk, however, for a SME in such a context is to have its own knowledge "grasped" by the prime contractor. Within a space program there should be legal incentives to protect SMEs from this risk. For instance, NASA's system of "mentor-protegee"is a good example of what could be implemented through a procurement policy. 2) Through specific interactions with public research centers with which SMEs are used to deal for validation, certification or demonstration purposes. These are the places where SMEs could have access to innovative ideas, generic technologies, etc...3)Through networks of SMEs where some common resources can be shared, in particular the financial services or some commercial activities. But even in such network there is room for a research center to impulse, to diffuse the generic knowledge that is needed, etc..
- With regards to the interactions between large firms and research laboratories, the past tendency was dominated by the principle of separation. The definition of space contracts was not conceived according to principles stimulating a strong interaction between research laboratories and companies. Observation of efficient networks in

R&D projects show that an increasing participation of research laboratories in R&D projects is beneficial to all the members of the network, specifically large companies.

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References

B.E.T.A. (1988), "Study of the Economic Effects of Space Expenditures", ESA Report.

B.E.T.A. (1993), "Economic Evaluation of the Effects of the BRITE-EURAM Programmes on the European Industry", CEE, EUR 15171 EN.

Callon, M. (1994), "Is Science a Public Good ?", *Science Technology and Human Values*, 19(4), pp.395-424.

Cassier, M. (1992), "Les conventions de recherche université-entreprises. Du nouveau dans les services publics de recherche ?", CSI, Paris, 27 pp.

Cohen, W.M. and Levinthal, D.A. (1990), "Absorptive Capacity : A New Perspective on Learning and Innovation", *AdministrativeScience Quarterly*, 35, pp.128-152.

Joly, P.B. and Mangematin, V. (1996), "Profile of Public Laboratories, Industrrial Partnerships and Organization of R&D : The Dynamics of Industrial Relationships in a Large Research Organization", *Research Policy*, 25, pp.901-922.

Meyer-Krahmer, F. and Lundvall, B.A. (1996), "Basic Research and Innovation", BETA Working Paper n°9603.

Kline, S.J. and Rosenberg, N. (1986), "An Overview of Innovation", in Landau, R. and Rosenberg, N. (eds), *The Positive Sum Strategy*, Academy of Engineering Press, pp.275-305

Rosenberg, N. (1990), "Why do Firms do Basic rRsearch (with their own money) ?", *Research Policy*, 19, pp.165-174.

ANNEX 1

Economic effects on the full sample

Parameters	
Number of projects	50
Number of participants (partners)	176
Number of measured economic effects	611
Direct economic effects before January 1994 in MECU 91	413.3
Ratio Direct effects/EEC funding before January 1994	10.5
Direct economic effects before January 1996 in MECU 91	522.5
Ratio Direct effects/EEC funding before January 1996	13.3
Indirect economic effects before January 1994 in MECU 91	132.2
Ratio Indirect effects/EEC funding before January 1994	3.4
Indirect economic effects before January 1996 in MECU 91	160.8
Ratio Indirect effects/EEC funding before January 1996	4.1
Technological indirect effects in MECU 91	76.5 (47.6 %)
Commercial indirect effects in MECU 91	16.5 (10.3 %)
Organisation and method indirect effects in MECU 91	18.6 (11.6 %)
Competence and training indirect effects in MECU 91	49.2 (30.6 %)

ANNEX 2

Comparison between big firms and SMEs

Parameters	Big	SME
Number of firms	75	38
Ratio of direct effects / EEC funding	25.3	2
Total direct effects in MECU 91	503.7	17.9
Ratio of indirect effects / EEC funding	5.45	2.75
Total indirect effects in MECU 91	108.5	24.9
Technological	59 %	17 %
Commercial	5 %	33 %
Organisation and method	14 %	5 %
Competence and training	22 %	44 %

ANNEX 3

The role of universities

Parameters	Research centres	Universities
Number	33	30
Ratio of Direct effects/EEC funding	0.15	0
Total Direct effects in MECU 91	1.0	0
Ratio of Indirect effects/EEC funding	3.0	2.0
Total Indirect effects in MECU 91	19.84	7.62
Technological	28 %	31 %
Commercial	11 %	9 %
Organisation and method	10 %	3 %
Competence and training	51 %	56 %

Parameters	Firms with universities	Firms without	Firms and research centres with universities	Firms and research centres without
Number of partners	49	64	60	86
Total Direct effects in MECU 91	312.1	209.5	312.2	210.4
Ratio Direct effects/EEC funding	24.4	13.0	20.4	10.3
Total Indirect effects before January 94	63.3	43.1	69.3	55.7
Ratio Indirect effects	5.0	2.7	4.5	2.7
Total Indirect effects before January 96	65.1	68.5	71.4	81.8
Ratio Indirect effects	5.1	4.2	4.7	4.0

Parameters	With universities	Without universities
Number of partners	60	86
Total Indirect effects in MECU 91	71.4	81.8
Technological effects	42.1 MECU (59 %)	32.1 MECU (39 %)
- Product transfer	63 %	19 %
- Process transfer	35 %	77 %
- Service transfer	2.5%	0 %
- Patent unused	0 %	4 %
Commercial effects	3.6 MECU (5 %)	12.2 MECU (15 %)
- Network effects	91 %	38 %
- Reputation effects	9 %	62 %
Organisation and method effects	3.5 MECU (5 %)	14.9 MECU (18 %)
- Organisational management	16 %	4 %
- Organisational effects	55 %	22 %
- Method effects	28 %	74 %
Competence and training	22.2 MECU (31 %)	22.7 MECU (28 %)
- Competence	90 %	88 %
- Training	10 %	12 %

ANNEX4

Instruments to improve the links between universities, research institutes and industries - aims, effects and problems

Instruments	*Aims, effects*	*Selected problems*
Institutional arrangements		
contract research institutes	high degree of user-orientation	time horizon of research may be too short-term
cooperative research institutes	high participation of SMEs	for sector specific problems mainly
network approach	establishing effective national and international R&D networks	precondition: a well developed private and public R&D base
Financial incentives		
tax reduction or subsidies for extramural R&D	reinforcing existing internal or extramural R&D	only small effects on initiating R&D cooperation
subsidies for selected R&D cooperation projects	establishing strategic technology fields	diverging interests of research and business systems
Technology transfer by		
transfer units, innovation consultancies	high participation of SMEs; initiating R&D cooperation and start-ups	low acceptance of newly established agencies by industry and host institutions
exchange of persons	increasing mobility of R&D personnel	different career structure in universities and firms

Source: Meyer-Krahmer (1990)

Competitiveness via Innovation and Cooperation

An Industrial view by Eurospace

Past actions of Eurospace in favour of industrial competitiveness. Importance of Research and Technology.

The necessity of innovation for Competitiveness has always been very present in the minds of industry. The consequences of this necessity on the definition and organisation of the ESA programmes are regularly examined in the various Eurospace working groups and our association has presented its position at various occasions.

In the summer of 1994 an overall presentation was made, in Frascati, of the Eurospace's views on ESA's future programmes.
A strong accent was placed in these presentations on the necessity to take commercial programme opportunities explicitly into account in the definition of the programmes of the Agency and in particular the R and T Programmes. An accent was also placed on the necessity of a true partnership between industry and the agency.

In the following months, Eurospace work followed two lines.

The first was the examination of the best way to enhance European industry's competitiveness concerning the most promising commercial activities, namely those in the field of communication and navigation. Workshops were organised and recommendations addressed to ESA and other institutions such as the European Commission, specialised institutions and national space agencies.

The second line was more general. A "Competitiveness Group" was established. This group prepared, in September 1995, recommendations that were addressed to the ESA delegations at the Toulouse Ministerial Conference, which created the Grage Council Working Group on Industrial Policy.

Eurospace members also co-operated in initiatives taken by the European Commission and the Agency.

Prominent Eurospace members were involved in the activities led by the Commission, and in particular in the High Level Group on the Development and Competitiveness of Space industries in Europe, which issued a widely circulated report in January 1996.

Eurospace members also participated in the "2020" Future Prospect Seminar and in the "Workshop on European Space Research and Development" organised at ESTEC respectively in March 1995 and in February 1996, as well as in other, more specific meetings such as the one organised on the ARTES programme in February 1997. The role of Research and Technology to develop the competitiveness of European space industry was also very strongly underlined at the ESA-Industry Workshop of September 1996 on the "Adaptation of ESA's Industrial Policy".

In conclusion of these studies and discussions, Eurospace members took good note of the following factors :

· the first is the decision of ESA to have in the future three categories of R and T activities programmes :
· those preparing future ESA programmes
· those preparing industry to commercial programmes
· those devoted to more long term developments, the application of which is not yet known in detail.

· the second is the consensus in favour of a real partnership between the Agency and Industry.

These are satisfying results, answering in particular the following recommendation made by our Competitiveness Group before the Toulouse Conference :

"European industry needs that the ESA Member States drastically increase and refocus the ESA Budgets for Research and Development Activities ...especially in areas with future commercial perspectives"

However the practical implementation of these principles is only at its beginning and will require a sustained effort in the years to come.

For example, the 1995 Eurospace recommendations asked that continuity for space programmes and budget stability be ensured by a mid-term Frame Plan but that the ESA Director General be authorised to start up "CRASH" programmes to be more reactive to the market pull.
It was realised of course, that the implementation of such recommendations would necessitate a long term effort. Nevertheless it is a disappointment to see that relatively little could be done in this direction unto now.

As a matter of fact, one of the conclusion of the High level meeting held in Paris on 10 October 1996 under the auspices of EC was that the European approach in the most important field of satellite telecommunications was not satisfying and that there was an urgent need for a more forward looking and coherent policy.

Also, one of the 1995 Eurospace recommendations read as follows :

"In order to utilise (its) R and D budget in the most effective manner, Industry asks the ESA executive to institutionalise a formal and comprehensive consultation of the European industry by ESA at least once a year".

This institutionalisation of consultations remains to be done.

To conclude, three lessons can be drawn from the activity of the past years:

· the first that new efforts are really to be made urgently to enhance and increase European industry's competitiveness (and, in the field of communications, the recent agreement at the World Trade Organisation to liberalise communications world-wide in 1998 makes this still more urgent); · the second that the activities of the European Space Agency are more and more to be harmonised with those of the other actors on the scene, and in particular the European Commission, the national space agencies, the entrepreneurs and operators and industry.
· the third, that an effort remains to be made to give more coherence and continuity to the partnership between ESA and industry in the field of Research and Technology.

2. 1997 Eurospace recommendations to ESA.

In the course of 1997, the Eurospace Competitiveness Group prepared new recommendations, addressed to the ESA delegations at the Ministerial Conference of March 1997 in Paris.
These recommendations have been entitled : "The adaptation of ESA's Industrial Policy".
Their text is as follows.

2.1. Text of the Eurospace Recommendations of February 1997

The Adaptation of ESA's Industrial Policy
- Eurospace point of view -
February 1997

I. Need to have ESA programmes and projects, and to increase their efficiency

Eurospace stresses the need for ESA to have programmes and projects, i.e. to carry through the on-going and decided programmes (and projects) as well as to launch new initiatives.

Eurospace emphasizes the need for continuous increases in the competitiveness of European industry in order to defend and improve its position as a major player on the open global market. In order to achieve this goal, it is of prime importance that ESA programmes efficiency be increased as well. The thorough review of its industrial policy and practices is therefore a prerequisite.

If the proposed adaptation of ESA's industrial policy allows a larger subscription of already decided programmes and of new initiatives/programmes/projects to be launched, Eurospace can endorse this new approach provided, with reference to chapter II and III, the European coherence is strengthened, politically and industrially.

So it is up to the Ministers and Delegations to appreciate if the proposed changes put the Member States in a position to enhance their support to ESA and the ESA programmes.

II. Need for a coherent European industrial space policy

The European space industry as a whole (i.e. prime contractors, subsystem and equipment suppliers) is aware that to remain viable it must increase its competence and competitiveness in the global market place.
Therefore, the European industry itself is taking continuously measures in order to reach these goals (reducing costs, production cycles, ...). According to Eurospace, ESA should accompany this endeavour :
1. by refocusing ESA R&T activities (on selected themes defined together with industry through Eurospace) adequately harmonized with other R&T programmes in Europe, and by increasing the funding of these activities.
2. by ensuring a better correlation between ESA R&T activities and ESA programmes.
3. by ensuring a better correlation between ESA R&T activities and the needs of the global market by taking into account inputs coming from industries, users and operators, during the R&T definition process. ESA should encourage and monitor the application of these R&T to the global market.
4. by promoting a specialization policy for implementation at European level, taking into account the specializations already developed in each Member States. Involving equipment and subsystems suppliers in early phases of ESA programmes is one of the best step (mandatory, for most of the Eurospace members) towards the implementation of this specialization policy. 5. by ensuring a better continuity between all ESA programme phases including exploitation.
This approach should stimulate the setting up of long-term agreements between primes, subs and equipment suppliers and it calls for the revamping of ESA procurement practices.

III. Need to refocus and strengthen the role of ESA
To help the European space industry to improve its world-wide competitiveness, ESA, the European public space organization, has to play a larger and different role than before. New debates are opened, new challenges have to be taken up. Therefore, Eurospace recommends to Ministers and Delegations to take into account the above recommandations as well as the following :
1. ESA should foster the use of space for civil public services (such as telemedecine, tele-education, ...).
2. ESA should implement a European ground and flight demonstrator policy. 3. ESA should, together with its international and industrial partners, implement a policy for utilization and operation of the International Space Station (ISS).
4. ESA should take into account the emerging new markets and technologies being developed in Europe in order to ensure the best use of existing European resources and favor dual use of equipment.
5. ESA should enhance and develop its relationship with the numerous European entities directly or indirectly involved in space activities in order to, commercially and politically, reinforce European industries.
6. ESA should propose steps to accompany in the new, quickly developing, space markets, for instance, in helping industry in the creation of new commercial initiatives.

These issues are not the only ones but are just examples given to make Ministers, Delegations and the ESA executive aware that the question of "how to improve the competitiveness of European space industry" is not only linked with geo return or procurement policy rules, but also with today's still pending problems.

2.2. Comments

As can be seen, these new Eurospace recommendations address primarily the necessity to enhance European industrial competitiveness. They also place a strong accent on the efforts that remain to be made in the field of Research and Technology programmes.

In what follows, we present a Eurospace proposal for an action in the very immediate future regarding this last point.

3. Proposed action for the immediate future : Preparation of Space Technology Days

In the next months, one of the objectives of Eurospace is to devote an increased effort on the definition of a R and T programme for ESA, in co-ordination with the other actors mentioned above.

What is envisaged is to start in practice the institutionalised dialogue between industry and the Agency asked for in the September 1995 Eurospace recommendations.

In order to fix a reasonable goal in the not to far-away future, what Eurospace proposes is to organise, in co-operation with ESA, a comprehensive workshop on Space R and T in Europe. The date could be the end of 1997 or the beginning of 1998. The appellation proposed is "the European Space Technology Days".

The purpose of this workshop would be not only to discuss the general orientation of a R and T strategy, but the actual content of ESA's R and T programmes.

The utility of this kind of workshop to establish a R and T programme capable to optimise the satisfaction of all parties involved has been abundantly demonstrated. NASA organises such workshops regularly, as well as several organisations in Europe, such as CNES, to give an example.

In the case of ESA however such workshops are not usual. Contacts between ESA and industry most often take the form of discussions between representatives of the executive and individual companies. Moreover, when ESA programmes proposals are presented publicly to an industrial audience, it is not, generally, to obtain industry's opinion on proposals that are already defined (with the exception of some detail) but to inform the companies of what they can expect in terms of assistance or contracts. In addition, such public presentations usually concern individual disciplines. It is true that in a growing number of programmes (ASTP, GSTP..) the content is defined on the basis of the requests of the companies, as relayed by their delegations. But in this case, the global and long term perspective is often insufficient.

In the view of Eurospace, a more global approach is necessary, in which all disciplines are treated, and issues such as the legal and economic problems as well as the sharing of tasks with other actors than ESA are tackled.

To have a fruitful workshop however, a careful preparation is needed.

This raises no problem for ESA, which is accustomed to prepare regularly a very detailed R and T programme.

For industry however it is less easy to put together a consolidated view of R and T needs at the level of detail that is necessary for such a workshop. In-depth assessments of its needs in R and T are naturally performed by each company in its own field of interest, but such assessments are not usually communicated to other companies and are discussed with the Agency in face to face conversations only.

To prepare European Space Technology Days capable to really help optimising the utilisation of the European resources in R and T, Eurospace thus realises that industry has to engage into a serious preparation effort.

For this reason, the decision has been taken to create a specialised R and T group within Eurospace, with the task of reviewing the various aspects of R and T, and establishing consolidated proposals to be put forward and discussed at the occasion of the European Space Technology Days.

A list of such topics is given below.

The work of the group will involve exclusively the Eurospace members, and it is possible that certain subject will have to be discussed confidentially. However it is not excluded that contacts be established with representatives of ESA or other Agencies on various topics, since such early contacts would not impair the usefulness of the European Space Technology Days, the purpose of which is to review the whole picture of ESA's R and T policy in the presence of all parties interested.

4. Conclusion

The Eurospace proposal to organise, jointly with the European Space Agency, a workshop on space Research and Technology, and to make this workshop a regular event under the appellation of "European Space Technology days" is the result of in-depth reflection.

This proposal is made in a positive spirit. The world is changing fast. The quality of European spacecraft, the success of Arianespace, the contracts obtained by European communication satellite manufacturers on the commercial scene show that the policy followed in the past years to enhance European industry's competitiveness was not without merits. But the market is changing. The ever-increasing rapidity of the technical evolutions, the severity of international competition and the growing disproportion between the governmental support enjoyed by the American and the European companies are factors to which we have to adjust ourselves.

We do not think that the present Eurospace proposal will be considered as a surprise. We rather fear to be reproached that it is coming so late.
But we hope that it will be welcomed by the Agency so that we can jointly engage in the preparation of this workshop without losing more time.

List of the topics proposed for discussion in the Eurospace R and T group, and, subsequently, during the European Space Technology Days.

1. R and T disciplines

Detailed suggestions regarding the usual disciplines that are :

- Telecommunications
- Navigation
- Earth Observation
- Science
- Space Station development (including robotics etc..)
- Space station utilisation and operations
- Activities beyond the space station (e.g. exploitation & exploration of Moon/Mars)
- Launchers

· Propulsion
· Small satellites
· Materials
· Electronic components
· Software development
· Re-entry
· Nanotechnologies
· Simulation
· etc...

will constitute the core of Eurospace's proposals.

2. Legal, funding and organisation problems
Suggestions regarding subjects listed below will constitute the second part of Eurospace's proposals.

· Sharing of tasks with other agencies than ESA
· International relations.
· Activities pertaining to the field of responsibility of the companies/entrepreneurs

Funding problems
· Available resources and optimisation
· The problem of co-funding

Legal problems
· Proprietary rights
· Limitations set by the GATT Agreements and WTO
· Organisation problems
· Continuity between R and T and other ESA programmes
· Specialisation of industry
· Feasibility of crash actions to react to market pull.

etc...

Session 3:

Opportunities

RATIONALIZING REMOTE SENSING INVESTMENT

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ABSTRACT

After a long maturation period, the convergence of advances in various space technologies and of the increasing awareness of the potential benefits of space systems for the common individual's daily life, is finally leading to an era where new space infrastructures will not only allow a considerable broadening of space utilization, but also transform space based services into some of the most basic, even though often invisible tools of tomorrow's society. This paper presents evolutions of space based Earth observation, telecommunications, and navigation systems as well as their innovative integration for economic efficiency and for the development of new services. It shows how these processes together with the development of new organizational and economic frameworks can allow a rationalization of remote sensing investment. Particular new areas of relevance and new applications are highlighted, with a case study focused on the flood insurance business areas and based on the use of the AEROSPATIALE COSME (Center for Operational Services for the Mediterranean Environment) integrated system infrastructure initiative. Finally, recommendations are made to foster the overall rationalization process itself.

1. INTRODUCTION

The question of the return on investment both for the taxpayer and the investors in the deployment of remote sensing space systems is a major concern at several government and industrial levels. While it is usually true that the development of Earth observation space systems, particularly for Earth science is largely an investment in the future, one might assume that a nation, a group of nations, or an industrial consortium would make every effort to reap the benefits of the investment as soon as it becomes possible to do so, in the form of commercial application programs, in the form of a sectorial leadership, or both. In order to plan or justify investments, various assessments of the definition and size of the remote sensing market as well as of its growth rate have been made from different sources, sometimes with a reasonable correlation but always with some substantial uncertainty, not so much in quality as in quantity. In what follows, we first go through a brief review of past and current investments in remote sensing up to the emergence of an awareness and a realization of some benefits. We then show how new concepts in the integration of space and ground infrastructures will allow a rationalization of remote sensing investment by making this investment acceptable and justifiable on several rational grounds. It will appear that while the space element is a strategic element of the information chain and is often the emerged part of the iceberg, most of the activities will be found in the downstream sectors. However a strong position in the space sector is still a powerful asset to sell end-to-end systems and services and to act upon commercial application markets, thus giving a competitive edge. A case study involving all the elements of the chain will be presented followed by recommendations for actions at European level.

2. A VERY BRIEF HISTORY OF INVESTMENT IN REMOTE SENSING

Although remote sensing so to speak can be traced back to the early days of mankind when already the eye, the most sophisticated sensor, gave man the capability to sense from a distance not only fires or animals to be hunted but also the Moon, the Sun and a myriad of stars in the sky, it is only a few centuries ago, with the development of instruments for astronomy, that remote sensing did start to use man-made tools requiring investments of a very substantial amount, often affordable at the time only through royal gifts or subsidies. The twentieth century has seen man develop a capability to bring those sensors further and further away both from the ground and from the observer himself. First with balloons, then with aircraft, then with satellites, remote sensing has relied on more and more sophisticated techniques with often a corresponding increasing need for financial resources. This year marks the 25th anniversary of the launch of LANDSAT 1, which, although following meteorological satellites among civil spaceborne earth observation systems, was nevertheless the first of a new generation of imaging satellites dedicated to Earth resources studies. Most if not all of the evolution of civil space imaging during the last 25 years bears some relationship to the LANDSAT program. The 1984 LANDSAT commercialization act was a bold move to transfer government space technology to private ownership and push government developed technology into the market place. However that experiment failed because the remote sensing market was small and fragmented and because the infrastructure needed to support its growth was non existent. The LANDSAT program investment however had been fruitful in the sense that it had been educative for all those engaging into the development of similar systems such as SPOT, IRS and the armada of privately funded high resolution satellites due to be launched before the year 2000. During the last 25 years Europe, on its side, through ESA and national agencies, has accumulated a solid background in spaceborne Earth Observation with the METEOSAT, SPOT and ERS series both in the space and ground segments, and with the building of a strong experience in the exploitation of such systems. Total investments there have been of the order of several billion dollars. Clearly in terms of direct financial return, the billions of dollars in worldwide investments in the civil remote sensing market during the last 30 years have not yielded direct financial payback anywhere close to expectations. Although an increasing awareness of indirect and non financial benefits as well as ways to realize in the near future some direct financial benefits have emerged recently, projections of data sales for systems such as LANDSAT, SPOT, RADARSAT and the like have all been met at one point or another of their growth curve with less than expected financial return from data sales. After a steady growth during its first years of operation, the SPOT program, itself with a very efficient network worldwide, has hit some form of ceiling at about 200 MF of data sales per year. This must be attributed more to the structure and logistics of the overall remote sensing market chain than to circumstantial events. This whole market from satellites to services is dependent upon the structures and characteristics of downstream products. Up to now customers have been mostly public entities. Because of limited sales, the value added service industry has not been capable to invest to attract new customers and, while promising, the european market for earth observation satellite data is underdeveloped and its expansion requires a considerable european effort. Such an effort is starting to be concentrated in some thematic areas such as:

- Monitoring of land use and resources management
- Monitoring of surface waters
- Monitoring of fishing
- Monitoring of coastal zones
- Monitoring of major risks and natural disasters.

We will see below the components of this effort which are necessary to rationalize remote sensing investment.

3. THE RATIONALIZATION OF REMOTE SENSING INVESTMENT

3.1. Introduction

Past experience has clearly shown that remote sensing data sales cannot economically offset system development and deployment costs. In the next paragraphs, we present innovations in the form of technology, systems synergies or new frameworks which have the potential to trigger the explosion of remote sensing-linked services and markets, not always with a wide visibility, but in any case greatly justifying the investment in remote sensing systems itself.

3.2. Relevant advances in system and technologies

The development of commercial applications of remote sensing will be conditioned by a series of advances in various domains more or less closely related to traditional Earth observation systems (Figure 3.2.1-1). Some of these important advances are indicated below.

3.2.1. Earth Observation Space Systems

New high technology opto-electronic and microwave sensors are pushing performances toward high spatial and spectral resolutions. Such optoelectronic developments include hyperspectral imagers, micro-optics, very high precision lightweight optical pointing devices, ultra lightweight telescope assemblies, miniature densely packet electronics to provide smart and low cost sensors (Ref. 1 and 2). On the microwave side multifrequency, multipolarization, passive and active systems, are emerging using lightweight antennas, compacted electronics, T/R modules and the like. On the satellite platform side, "faster, better and overall cheaper" concepts have emerged based on mini/micro/nano platforms and new system architectures. The use of new materials, stable lightweight structures, new memories, solid state recorders, compact high power/high data rate transmitters and electronics, are leading to fast mass production and an increase in payload/spacecraft mass ratio. This allows one to design at a reasonable price uncontrolled clusters and large networks with highly automated operation. Such developments benefit in particular both from technology developed for military satellites and from commercial off-the-shelf components. Reduction of the cost of a satellite by more than an order of magnitude can then be achieved, making the implementation of a constellation of such "faster, cheaper, better" satellites, for disaster monitoring for instance, both practicable and affordable. The data processing itself, whether on board or on ground is benefiting greatly from advances in fast digital technologies, data compression, neural networks as well as from a wide range of sophisticated software developments related to artificial intelligence. The increase in data product quality (in terms of better spatial, spectral and temporal resolutions) and quantity will have a direct bearing on the economic growth of induced applications.

3.2.2. Navigation and Positioning

The emergence of navigation/positioning constellations is bringing into the Earth observation community a fantastic tool to precisely tag in time and space any event which can be observed from satellite for a very wide variety of situations. While only the american GPS system has attained a high level of operationality today, the Russian GLONASS and the European GNSS projects are aimed at reaching a comparable level of usefulness for the European community and are expected to tie in quite well with the use of Earth observation data, in particular in mapping.

3.2.3. Telecommunications and Ground Infrastructures

Developments in telecommunications and in the Earth observation ground segments (receiving stations, networks, software) are inseparable as far as remote sensing applications are concerned. During the last few years transportable high performance telecom and Earth observation receiving stations and broadband networks have come out, allowing one to have real time on-line access to data and software, large data bases are digital libraries. Operators of broadband satellites are now proposing charging by the megabyte of information, with very competitive rates of only a few cents per megabyte instead of the flat or timed rates. On the ground, networks will be the privileged medium for data, products and services exchange. The INTERNET in particular is both the biggest computer network on Earth, and the world's fastest growing free trade zone, some of its main uses being electronic mail, remote access, file exchange, databases system access and on-line information. It is rapidly growing and has the advantage of being transnational, with even high speed access by satellite now appearing. The resulting increase in data availability and access will have an enormous impact on return on investments for space assets by revolutionizing the exchange of remote sensing imagery products (transfer of large data sets or purchase of images by the pixel). Moreover, the explosive growth over the last few years in the computer software and systems integration industries affects positively the service industry. Sometimes, excessive demand has been problematic, for instance in recent developmental problems with the data management and information system for NASA's EOS project, because it has made it so difficult for the largest contractor on the 2 billion dollar project to retain the software engineers. In addition, such products appear faster than people can get them integrated into their systems, this revolution being inseparable from the revolution in the microprocessors industry. Moreover, the ubiquitous appearance of geographical information systems, as the major consumer of remote sensing data, will pull up remote sensing data sales. The future of GIS itself will be influenced by the enormous communication bandwidth provided by information highways. Concepts of huge virtual "GIS", not restricted to a specific system, data base or location will appear. The creation of such a GIS could be event-driven, for instance during emergency situations such as floods and earthquakes. The GIS could use the most up-to-date information as provided by different organizations.

3.2.5. Other developments

Among other developments having a major impact on the development of remote sensing market is the availability of smaller, cheaper launchers for which the reliability however still remains to be assessed.

3.3. Synergies and the global integration and sharing of infrastructures

3.3.1. Synergies

Synergies, integration and sharing of global infrastructures between EO and other domains will yield innovation in the form of new solutions to existing problems and optimized ones to new problems (Figure 3.3.1-1). Such benefits could occur in the EO fields itself or in other fields. The satellite based US Global Positioning System is now fusing with wireless remote communications to produce tracking and monitoring data. Moreover the fusion of the Internet and low Earth orbit data communications will appear soon.

The quantity and speed of data being transmitted from one Internet address to another will be responsible for the growth of a large number of new industries. Even more, three commercial space technologies are moving forward very rapidly together, GPS, low Earth orbit data communications and commercial remote sensing. Common to all three technologies is the need to deliver information in a cost-effective manner and at the right time. The connection between commercial remote sensing space and "cyberspace" will be the detonator for the explosion of services in remote sensing. Most professions, disciplines, and organizations that have evolved to meet society's needs for all forms of information are affected by the on-going technological revolution in information processing and communication. And the map, as a primary tool for meeting spatial or geographic information needs, is being supplemented and displaced by new computer based tools that have come to be known as geographic information systems. This synergism between automated cartography, GIS and remote sensing has also had a significant impact in accelerating the pace of technological innovation and expanding the market for GIS systems. Researchers have found that map-derived digital data in a GIS can improve the accuracy of interpretation of remotely sensed data while remotely sensed data provides the ability to update map products in a more expeditious manner.

Space based observations do not stand alone in investigations in the Earth sciences and use of space observations in operational applications both require reference to ancillary data sets and in situ data. Although space observations may understandably dominate the cost of conducting an experiment, the other data occupy a coequal importance and must be considered in synergy in the planning of research and applications.

In other instances, neither satellites and conventional aircraft, nor surface measurements are capable of meeting the observational needs. This deficiency has led to the desire for a new technology-high performance unpiloted aircraft (UAV, Drones) to make direct measurements of atmospheric constituents for instance. Such aircraft have been proposed as a means to overcome the limitations of satellite based instruments in deriving accurate vertical profiles of the constituents. On both scientific, applications, and strategic grounds, a coordination of such space, airborne and ground measurements and an integration of the results from all types of experiments are indispensable.

Synergies are also developing between the civil and defence programs. Beside technology transfer or codevelopment (as in the US NOAA-DMSP Convergence program), moves are underway to open to civilian non governmental use at least a portion of the data archives from satellite reconnaissance that were staying secret in the past.

Such synergies and sharing, although unconventional so far, have a very large potential of benefits for the community at large.

3.3.2. End to End Connectivity

The combination of satellite receiving stations, video servers, preprocessors, and high power workstations operating across high bandwidth networks, allows to implement already today trial sites for full end-to-end connectivity for satellite data users (Ref. 3). There is no need necessarily for a hub or central server anymore, as it is natural that distributed storage and server functions will develop. Also, and essentially, that combination opens up for much wider access to remote sensing, as well as other in-situ environmental data, thus ultimately leading to more efficient distribution and exploitation than today, and for a wider range of applications. The first clear advantage of the setting up of networks and video servers is the very wide range of types of data accessible for the potential user. Since the early days of the space era, a tremendous amount of data have been acquired in all areas of Earth observation and space science. A lot of these data are scientific in nature but more and more are being acquired to satisfy clear operational needs. It has become obvious that only a small fraction of those data have been used and the rest sleeps peacefully in archives.

Rendering such data accessible through open access or for-a-charge servers and networks would give them new life while providing some additional return on investment. The second advantage stems from the very short data access time provided by the limitation to the extreme of the human intervention. In particular, it is clear that networks and video servers can function around the clock, which is not only useful for around the clock applications but also to provide data users from the whole planet with ways to access the data, each one at its particular working hours. A third advantage will be to have an end-to-end chain of data, digital all the way, an advantage which will be clearly seen in the area of data manipulation and in particular with the automatic integration in data bases and in geographical information systems of fresh newly acquired data. The last but not least of the advantages is the possibility to influence the price of the data. Indeed instead of being in a situation of low sale of expensive data, networks and video servers could allow a situation of high sales of cheaper data with customized value-added processing set-up either by qualified end users, or by specialist companies. Cheaper data could be obtained not only by having a lower price for a given scene size than one must pay today, but also by providing to the user only the very specific data (location, quality ...) he needs. He will be able to fiddle with the various servers, in time, space and sensor type to optimize his application without paying more than today. This could provide a large increase in data consumption. Finally the development of smaller ground stations and direct broadcast could, through networks and video servers, help larger number of interested parties benefit from what was conceived as a local acquisition for a specific application. Such setups have the potential to eliminate all the problems which slow the expansion of the remote sensing market, by avoiding information channels bottlenecks, delivering needed information in almost real-time and providing a user-friendly way to manipulate and use the data.

3.4. The Emergence of New Applications and Services

Traditionally, application development has been driven by public entities at local, regional, national or international levels, the market for Earth observation products being dominated by governmental needs. Under those conditions, the total investment in governmental Earth observation for research and operational needs vastly exceeds any commercial activity at present and for the near future. However more and more private entities such as multinational companies, large diversified holdings, or small and medium enterprises are engaging in commercial remote sensing. Private companies can enter the market by relaying government entities such as with EOSAT for LANDSAT or the ORBCOMM request to NOAA to leave ARGOS type activities to the private sector. It can also take the form of the creation of a secondary market. For instance weather satellites data have been accepted as a public good primary market because of their need in the protection of people and property. A secondary private market has grown based on these freely available public goods, with the provision of specialized weather forecasts for farmers and enhanced visual presentations seen on TV weather reports (ref. 4). A similar situation can be observed with the primary governmental GPS market giving rise to a geographic information related secondary market where Earth surface characteristics from positioning and remote sensing are the center of interest. Projection of the global GPS market in such applications closely related to remote sensing are for the year 2000 more than 3B$ for road navigation, close to 1B$ for observation, surveillance or monitoring stations and more than 1B$ for cartography and G.I.S. to name some of the main ones. Indeed most Earth data must be position and time-tagged, and data that have been stamped with GPS time and position can easily be entered into map-based GIS data bases. An important remote sensing product is maps. Today's market for maps that use aerial photography and satellite imagery is estimated to be worth 2 billion $ annually globally and growing at a rate of 15 percent per year analysts say. This is the prime market addressed by the Space Imaging System for instance. The satellite imagery should be clear enough to identify buildings, homes, roads and property boundaries, making it useful for the emerging Geographic Information Systems (GIS) market.

Clearly only a small fraction of that currently uses satellite data for the moment however. it is likely that if satellite operators could provide timely, high quality data at reasonable prices, the end-users might switch from aerial photography to satellite imagery. Once such satellite data are available the market is expected to expand substantially with a corresponding return on investment. As an example, the overall market for 1 m resolution images has been projected to be as high as about 8 billion $ in 2000. Beyond that, it is anticipated that more and more new services both indigenous to Earth observation and exogenous in other domains will be pushed by private enterprises. A lot of these new services will be found in real-time monitoring of a wide variety of activities, such as crop health estimated to be linked to trade prices, pollution monitoring, state of ecological systems, transportation traffic management, news gathering, disaster mitigation and management, or international peace keeping to name a few. For European space industry itself, commercial applications are not a dominant element in their turnover today. However they are expected to jump to 38% of their total turnover in 1997 as compared to 29% in 1991 (Ref. 5). A chart showing the positioning of Earth observation related services in the end-to-end market chain is given in Figure 3.4-1.

3.5. New Organisational and Economic Frameworks

3.5.1. Organisational Frameworks

New organisational frameworks can be set up at public or private level to foster the rationalization of remote sensing investment. A public level one of the major organisational challenges is at international level. International arrangements are a powerful way to rationalize remote sensing investment. In the evolution of long distance communications, the nations of the world concluded that their interest, economic as well as thematic, were most efficiently served by the creation of first the International Telecommunications Satellite Organization (INTELSAT), then the INMARSAT and in Europe such entities as EUTELSAT. They have all enjoyed monopolies in their first decades, but are now experiencing competitive pressures. Some have argued that a similar organization, ENVIROSAT, could be created for Earth Observations. This would rely on nations desiring reductions in space investments and being willing to share system costs through multiyear subscriptions. So far two organizations are playing key roles at worldwide scale, the CEOS (Committee on Earth Observation Satellites) and the EO-ICWG (Earth Observations International Coordination Working Group).
Another challenge, at industry level, is the integration of activities of large companies and of SME's in a coherent, synoptic and efficient scheme, taking advantage of each category strength. An example if given below with one set-up of the COSME initiative where sizeable infrastructure set-up by a large company relies on SME's for specific service provision.

3.5.2. Economical Financial Frameworks

The remote sensing market is very fragmented - public sector; international organizations; national administrations, military, agriculture, environment departments...; regional organizations; scientific institutions/private sector: food, transportation, petro-chemical industries... Its supply side - service industry - is still in an embryonic stage and is characterized by a diversity of players including raw and pre-processed data distributors, enhancement and interpretation service

companies, software/hardware companies, GIS, aerospace industrialists diversified in the service industry. Environmental issues have acquired a particularly high political visibility, but being often beyond the means of any single economic group, they require international co-operation.
Offering a remote sensing service that is competitive or, if for public purposes sufficiently useful and cost-efficient, requires that the problem, which is to be solved for the target clients with this service, is understood and accounted for in the way the service is provided. Thus, customer orientation is a must for rationalizing remote sensing investment. The opening up of a new or underdeveloped market for innovative remote sensing services or products requires a careful strategic marketing that integrates analyses of the potential customers' requirements, competing systems and competitors if any, revenue prospects, availability and cost efficiency of required technologies, and cooperation schemes. Additional demonstrations to candidate customers may be required and a sound business plan is obligatory. Such an initiative is costly and may however lead to the conclusion to abandon the project: insufficient profitability, too low return on investment, too long payback period or a general 50 % funding from public sources may not be sufficient.
Therefore a remote sensing project has to integrate the following steps:

- preliminary study phase (understanding of customer needs, field studies, ...)
- planning phase (study affordability of source, identify bottlenecks, defined architecture of planned service, ...)
- financing phase
- implementation phase
- operations, training and services

Concerning the financing concept, there is no general rule or method available which could suit any remote sensing service, but it is obvious that the planned proposed service specialities, the clients financial capabilities, the cultural environment, the available financing sources have to be properly addressed. Key inputs have therefore to be assessed to the needs of financial institutions: service performance (is a measure for the complexity and thus a financial resources demanding information), assessment of the client's price target (very useful, but also very difficult to achieve, to set up price targets and to evaluate the allowed complexity of the service), assessment of the competitors price, if any, identification of public funding sources, identification of private funding sources, search for investors, industrial strategic investment (industry may finance pilot services which are candidates for profitable business).
The above mentioned information will serve to assess the reasonable financial goals of the planned service and create the basis for a first estimate of the prospected revenues coming from the planned service. These preliminary financial goal evaluation will be used to identify an adequate financing concept, i.e. the financing sources and the financing tools. this concept will contribute to the estimation of the service total cost, and of the project profitability (on the basis of a business plan). It will also structure the implementation phase as the flow and the conditions of the financing means will have a significant influence on the realization of the service.
Space project financing are entering a more mature stage even if there are a limited number of transactions. Financial experts say that satellites are generally a good investment, but offer some words of caution as well. For every one good deal, there are two to three that are not good and two or three more potential disasters waiting to happen. For the financial community, the risks to be covered when financing satellites include: Overruns, delays, satellite failure and market risks. In emerging markets, we must add political risks and foreign exchange risks.
On the other hand, equity investors are looking to invest in companies or consortia that can sufficiently address specific corporate strengths and corporate risks. In that appears that, for the financial experts, the most important factor to look at, in a company seeking investments, is how well it knows its customers. "To us, that is the only question", they say, explaining that because

many engineering solutions exist for problems that do not have a market, some investment opportunities are going to be poor prospects.

Remote sensing could fall into this category if the end products offered are too complicated and costly. For government supported programs whether based on national policies or international agreements, government funds both directly or indirectly through WORLD BANK, EBI and similar entities are well proven sources. The funds for private ventures come in two basic forms: debt and equity. While debt primarily takes the shape of loans or bonds (high yield bonds, project financing), lease financing, equity is mainly publicly traded stock or shares of ownership that are privately held, and thus not available for purchase (equity from strategic partners, vendors financing). All of those types of financing have been used in the telecommunication satellite industry, such as high yield bonds for ORBCOMM, leasing financing for GALAXY, or equity from strategic partners and from stock exchange in the case of GLOBALSTAR. However those techniques have been used only recently in the Earth observation business, for the financing of some of the high resolution observation ventures. The Earth observation systems had been indeed almost always government funded. the financial tools described above will give the necessary flexibility to help the emergence of a true remote sensing market.

3.6. European Competitivity in Remote Sensing Applications

The systems, technologies and set-ups described above are for the most innovations. The identified high technologies (mini/micro satellites, state-of-the art payloads), new synergies (Earth observation, Telecom, GPS, ...), production increases and cost reductions (small platforms series, ...), as well as creativity in hardware, software and service design are all innovations resulting in increase in performance and quality and better response time. Services will be more numerous, with better availability, better quality and better tailored to user requirements, and at a better price. These are emerging services where the competitiveness of space equipment and service industries is at stake. Since via satellites any non-European service can overflow the European market within a few months, all efforts should be made to accelerate the rationalization of remote sensing investment. This includes increasing customer fidelity and giving faster turnaround time between problem and solution, ultimately leading to an increase in market size and R.O.I.

4. AN END-TO-END CASE STUDY

4.1. The COSME integrated infrastructure for services

4.1.1. Introduction

What needs to be studied to optimize the decision process in a given application project is not only a single element such as a network, a satellite or an expert system but a full system with all the necessary ingredients intertwined into a single coherently optimized framework. We will thus treat in turn the ground element and then the space element of the set-up being put in place by AEROSPATIALE within its Mediterranean COSME (Center of Operational Services for the Mediterranean Environment) program.

4.1.2. System Aspects and Ground Infrastructure: COSME

More and more the information at the end of the processing chain more than the acquisition sensors or the data processing algorithms and tools themselves have become of interest for decision makers. The very large number of environmental sensors available around and above the Mediterranean has rendered almost impossible the task of finding the optimum data at the right time for the decision maker (Ref. 6).

Moreover it is hard for decision makers to benefit from the deployment of a wealth of new services from small and medium enterprises in the area of data processing, information extraction, or thematic environmental analysis, a potential bounty for them, because of the geographical spread and the considerable time needed to contact, test and be familiar with these service providers. For all these reasons if proved necessary to create a network through which Mediterranean decision makers can access and exchange not only data and informations relevant to their needs but also a service capability to help them solve environmental problems. This is the underlying rationale for the COSME concept developed by AEROSPATIALE and its partners.

COSME is a state-of the art Mediterranean infrastructure based on the most sophisticated information society tools to provide Mediterranean decision makers with the quickest access to the best information and services for the most competitive price. COSME is a highly automated dual ground infrastructure based on both a centralized and a distributed component. The centralized component is the brain of the system, composed of a human part and a Hardware/Software Facility (HSF) part. The decentralized or distributed part of the system relies on the development of small distributed cells (Micro-COSMEs), based on a highly user friendly man-machine interface, spread around the Mediterranean in decision centers. Automatic data and information transfer to Geographical Information Systems (GIS) installed in Micro-COSMEs will be routinely done. COSME development has advanced to the point of various subsystems tests. In particular one can mention the completed realization of an airborne data acquisition campaign to set-up a Mediterranean observation data base, the test of satellite information and image transfer between servers and users, the development of expert systems for optimum information identification and search, expert systems for automatic problem analysis including automatic information extraction and interpretation, decision making strategy set-up as well as remote training to name just a few. It is now in the phase of demonstration projects set-ups with several partners (industries, institutes and university laboratories), one of these projects being in the insurance area as developed below.

4.1.3. The Space Element of COSME

Because of the large population expected in the next decades in the Mediterranean region and the resulting large number of interactions anticipated, some dedicated system has to be considered for the Mediterranean including in particular an Earth observation and a multimedia telecommunication component. COALAS (COAstal and Land Service satellite) is an optical Earth observing system, dedicated primarily to the study of the Mediterranean areas. It is designed for high resolution panchromatic and multispectral observation with no more than 24 hours between request and access to the data. It is based on the use of a PROTEUS minisatellite platform and full reuse of AEROSPATIALE expertise in the development of space sensors such as high resolution cameras and imaging spectrometers (MERIS, VEGETATION, ...).

The whole range of environmental problems which can be tackled by an optical satellite will be addressed by COALAS: in summary one can mention environmental resources inventories, assessment and forecasting, urban monitoring and planning, mapping, coastal processes, pollution control, disaster prevention and assessment, and so on. The COALAS ground segment, designed for optimal real-time data reception and processing is fully embedded in the COSME infrastructure. Dissemination of COALAS data will be made exclusively through digital networks. Operationally as a secondary task, COALAS will be able to observe other parts of the globe if allowed by system management. Moreover, although being designed to be one of the major source of data used by the COSME, COALAS will be completed by the fleet of earth observing satellites provided by other public or private entities as well as by airborne and in-situ sensors. When fully operational COSME will use for telecom segment either available telecom capabilities or the dedicated Mediterranean MEDSAT satellite. All the satellite Earth observation data will be completed by in situ data tagged with precise positioning information and relayed either by messagery or telecom satellites or through ground network using an innovative combination of data sources. The new services available through networks must be accessible to the largest circle of users while being adaptable to the various emerging needs in Euro-mediterranean environmental development. The system will integrate space communications with existing and planned ground networks in the concerned Mediterranean countries. Among the expected benefits of the COSME set-up, one will find all the advantages described above in the implementation of end-to-end connectivity. This will give a major impetus to the development of remote sensing informations and services market. Finally the sharp decrease in information technology cost of acquisition will bring micro-COSME systems within reach of all Mediterranean developing countries.

4.2. The COSMINS programme

4.2.1. Floods and Disasters Insurance

In recent years, losses caused by natural disasters have reached hither to unprecedented magnitudes - a trend which shows no sign of abating. Figure 4.2.1-1 shows the overall losses and the insured losses caused in recent years by catastrophic events (Ref. 7). Some of these floods losses could easily have been much higher. If the dykes in Holland had been breached during the 1995 floods, for example, damage of the order of US$ 50 Billion would have had to be reckoned with. Compared to the overall economic damage caused, the insured losses in the floods listed in Figure 4.2.1-1 turned out to be quite small, due largely to the fact that flood insurance is still not very widespread in many of the markets concerned. There are, however, already a number of markets where there is an enormous insured loss potential from floods. In the UK, for example, a disastrous storm tide could certainly cause an insured loss of more than ten billions US$. The worldwide demand for insurance cover is on the up. For the insurance industry, the flood risk is thus increasingly becoming a subject to be taken seriously. Risk assessment basically means quantifying potential losses to the insured values, if possible coupled with the assessment of corresponding frequencies or probabilities. Risk assessment is vital for both insurers and reinsurers. The direct insurer has to quantify the expected claims burden of the individual objects and perils covered. A test case is being developed using the innovative COSME infrastructure to help manage a real time flood issue in Southern France. In this region, in Nimes in October 88, strong storms led to 10 deaths and 4.1 Billion Francs loss. Vaison-la Romaine, September 92. Sudden flooding led to 46 dead and 3 Billion Francs loss. Summer and Autumn 93, flooding led to 22 dead and 3.9 Billion Francs loss. For the last ten years, floods have accounted for 75% of natural disasters hitting France. More than 9500 small and large cities, that is about 10.000 people have been concerned. By using COSME to organize faster rescue operations, more lives are saved and losses can be reduced.

Between 82 to 95, the overall loss have been of the order of 15 Billions Francs for the French community, a great part of this sum being supported by insurers. In 1992, the insurance industry paid out a record 23 B$ in catastrophe claims.The loss potential for an insured portfolio due to natural hazards is generally much higher than it is for other perils in property insurance. Sound risk assessment is therefore required. With respect to flood insurance, however, adequate tools for assessing the risk (e.g. hazard maps, software tools) are often not available. This is due to two main reasons, Firstly, flood insurance is still not very widespread in most countries. Secondly, adequate flood risk analysis is complex and required a lot of detailed information. Demand for flood insurance cover increases practically everywhere, therefore insurance companies badly need better tools to evaluate their flood exposures. For the time being, flood risk analysis - if considered at all - mostly remain inadequate, because quick and cost-efficient tools are not available yet. Still, the quickly improving performance of today's personal computers and the growing availability of highly sophisticated modelling techniques provide a positive perspective. This, together with loadings for uncertainties and capital cost, provides the basis for rating guidelines or premium tariffs, where risks of comparable characteristics are grouped into categories. The reinsurer - who covers insurance companies instead of individual policyholders - has basically the same situation. He has to know the expected claims burdens resulting from his contracts with direct insurers. Incorrect risk assessment may lead to inadequate premiums, which means bad results and eventually insolvency in the case of a major event. The main problem, is that of quantifying vulnerability and, above all, hazard.

4.2.2. Possible contributions of Remote Sensing and Geomatics to the risk analysis of individual insured objects

Where the individual risk insured has stood in the same place for decades and the quality of the risks and the hazard have not changed (e.g. change of river regime or flood protection measures), insurers may be able to make use of past claims experience and carry out a risk assessment on the basis of statistics. This situation applies only in exceptional cases, however, which is why insurers have to manage in some other way.

For insurers, it would be interesting to have, amongst other things, maps of loaded areas, the number of buildings affected per region, or the proportion of urban areas affected. Geographical information systems are making their appearance in large insurance companies. Operator-friendly scenario programmes for analysing loss accumulations could be produced on PC-based systems at relatively little expense. The insurance industry's requirement for tools for assessing the risk of flooding will continue to increase. For reasons of cost, tools developed by individual companies themselves are likely to be the exception. Effective and timely monitoring of any point on the Earth surface at least once each day from space is an urgent requirement in order to be able to react quickly to mitigate the effects of disasters and reduce the humanitarian and financial burden.

Risk management (before the event): EO data could help to define flood prone areas using precise digital terrain models and stage discharge data. As this work needs expert know-how it cannot be done by insurance companies itself. the risk maps had to be produced somewhere else. Using such risk maps, insurance companies would be able to assess their flood exposure more precisely. However, the benefit depends mainly on the insurance cover available per country and the risk carrier. Where flood cover is not available (e.g. Holland) or where it is offered by the state (e.g. France, USA), benefits for private companies are minimal. In the field of earthquake risk assessment EO might help to improve the know-how about earthquake recurrence, which is important for premium reasons. Again, usually the insurance companies are interested in the results. Other uses like estimation of susceptibility to landslide or drought monitoring are of lesser importance to insurers.

Claims handling (after the event): After a major event thousands of claims are reported to the insurers within a few days. To manage this is quite challenging. It is important to realize in an early state if what happened is of minor or major relevance to the claims handling department. The earlier the severity of a catastrophe is known the more time rests to organize the loss settlement. EO data with useful information about the area affected, delivered within hours after the event, would help insurance companies to improve the loss settlement procedure. Today, reliable loss estimates are usually available within a few days. Also from a financial point of view quick information may be crucial. After a major storm or earthquake event losses for insurance companies may reach tens of billions of $. Insurance companies may be forced to sell assets via the stock market which is expected to react on a catastrophe (e.g. earthquake in Tokyo). Loss prevention or product design are other fields where insurance industry would benefit from EO data. Thus, there are useful fields in insurance industry where EO data is of benefit and the set up of a real time information loop between the COSME and the insurance companies is a typical example of bringing together earth observation systems, telecom networks, and GIS to save numerous lives and millions of dollars. Routine and crisis monitoring of flood zones is being implemented involving COSME's team and insurance partners. Real-time tests of the full operational loop are under preparation. The COSMINS operational goal is a 5 to 10 % reduction of insurance losses, not counting the most important part, lives saved.

5. CONCLUSIONS, OUTLOOK AND RECOMMENDATIONS

It is through the synergy of innovations in Earth observation, telecommunications and navigation domains, whether of a technological, organisational or economic nature, that remote sensing investment will find its payback. This synergy will indeed allow the realization of services with operational performances which cannot be obtained with classical stand-alone Earth observation systems. Nevertheless, such a beneficial synergy might not come up quickly by itself.

Among professional categories usually unfamiliar with remote sensing, awareness of the potential use of remote sensing data has to be developed and **benefits should be strongly publicized.**
Moreover the remote sensing community should **refrain from making unrealizable projections** which might backfire. Simultaneously government entities should not equal value only with commercial value. Consideration must also given to scientific return, technological leadership and overall benefits for the society. It must also be well understood by economists that **a direct cost-benefit analysis is not applicable** in remote sensing because Earth observation data are rarely used alone. Such data can be combined with others in thousands of applications.Competitivity in commercial services will depend on a strong position in the technology and financing of space systems. This will require governmental actions both from space agencies and from political entities to:

- Foster innovations leading to "faster, better, cheaper" space and ground systems for Earth observation, telecommunications and navigation, cost reduction being a must.
- Ensure availability of high performance complementary elements such as small and cheap airborne and launcher capabilities.
- Help coordinate and integrate space, airborne and ground systems maximizing autonomy, end-to-end connectivity and interoperability. Moreover the sharing of global infrastructures at European and Worldwide international scale will increase efficiency and lead to cost reduction
- Develop synergies between civil and defence programs in system development and data sharing.

Finally, governmental **agencies should help the transition to market** and **develop a program of commercial applications.** Space agencies, by mastering all ends of the synergy are in an ideal position to set up such a program which could involve:

- Integration of technologies such as high resolution imaging, telecommunications networks, GPS and GIS; Agencies must take over development efforts and foster pilot projects (Ref. 8).
- Fusion of high resolution optical, infrared and radar capabilities and data to create new products and services.
- Channelling demands from and to civil and defence entities.

The European Union could bring a precious contribution by indicating and evaluating European needs in terms of EO data and relevant services.
When such activities will be in place together with the right organisational, regulatory and financial tools, the scene will clear up and the rationalization of remote sensing investment will cease to be an utopy and give rise to steady earth observation commercial activities and expanding markets in related systems, products and services.

References

1. Micro and nano technology for Space Systems: an initial evaluation, Aerospace Corp., 1993.

2. Microspace Renaissance, M. Gibson, Pasha Public., 1992.

3. Network access and video servers for remote sensing imagery distribution, P. Kamoun, L.F. Pau, Proceedings of Eomark'95, Symposium on the Expansion of the Remote Sensing Market, Paris, March 1995.

4. Earth Observation from Space, History, Promise and Reality, NRC, Washington 1995.

5. L'Union Européenne et l'Espace, promouvoir les applications, les marchés et la compétitivité de l'industrie, European Union, Brussels, Nov. 1996.

6. Space Systems and Information Technology for Sustainable Development in the Mediterranean area, P. Kamoun, EURISY Symposium, Frascati, Oct. 1996.

7. Possible contributions of hydroinformatics to risk analyses in insurance, P. Hausmann, M. Weber, Hydroinformatics 96, Balkema, Rotterdam, 1996.

8. Assessing new applications and testing business opportunities, A. Atzei, F. Gampe, K. Pseiner, IAA-96-IAA.1.3.01, IAF Congress, Oct. 1996, Beijing, CHINA.

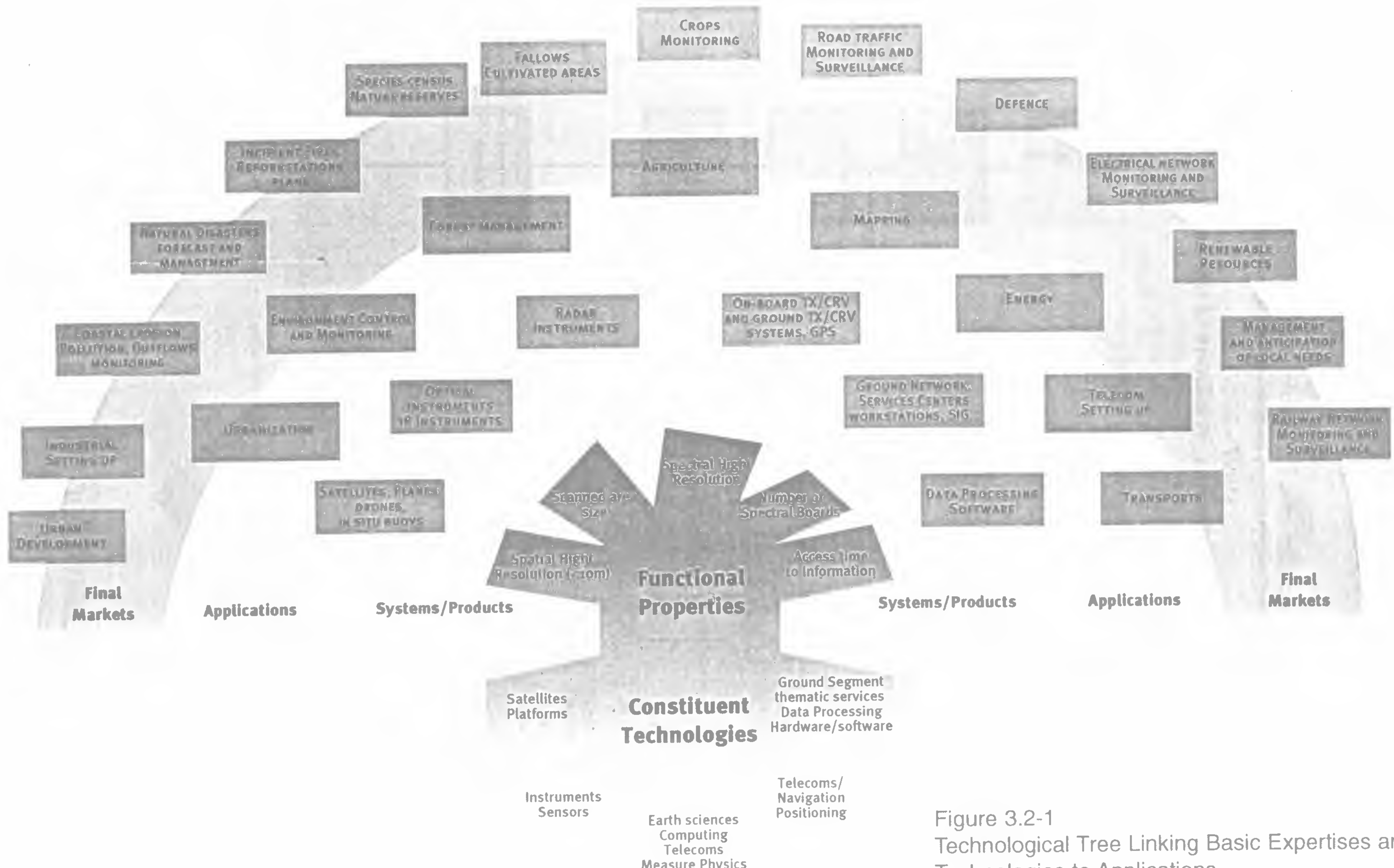
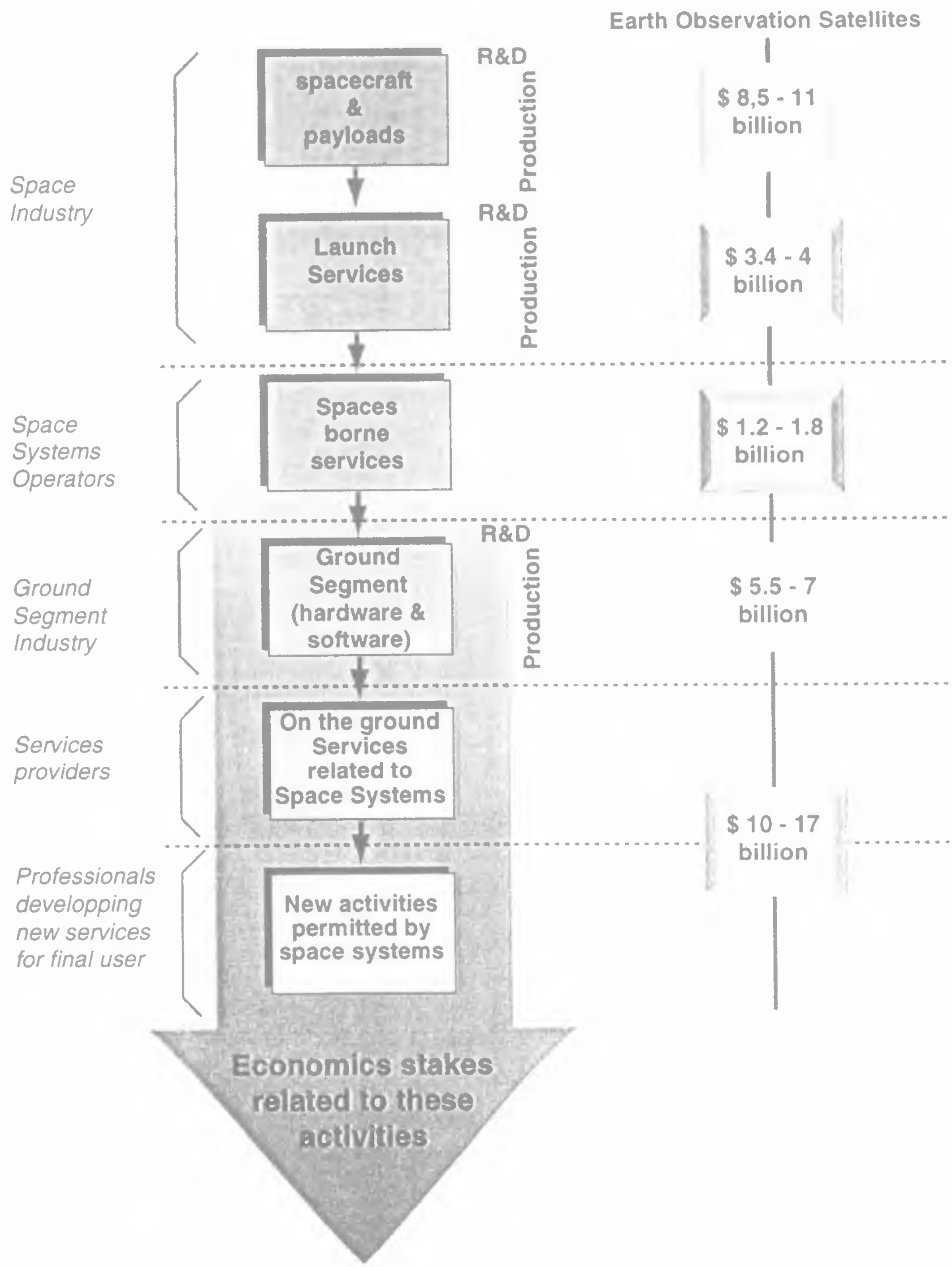


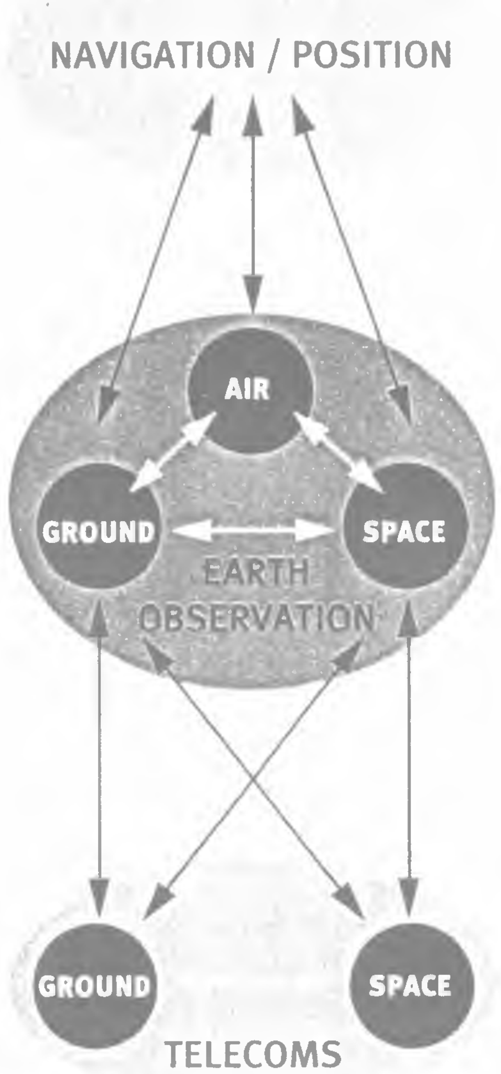
Figure 3.2-1
Technological Tree Linking Basic Expertises and Technologies to Applications

Economics of commercial applications of Earth Observation in the upcoming decade (1997 - 2007) (Worldwide estimates, in billions of US Dollars)



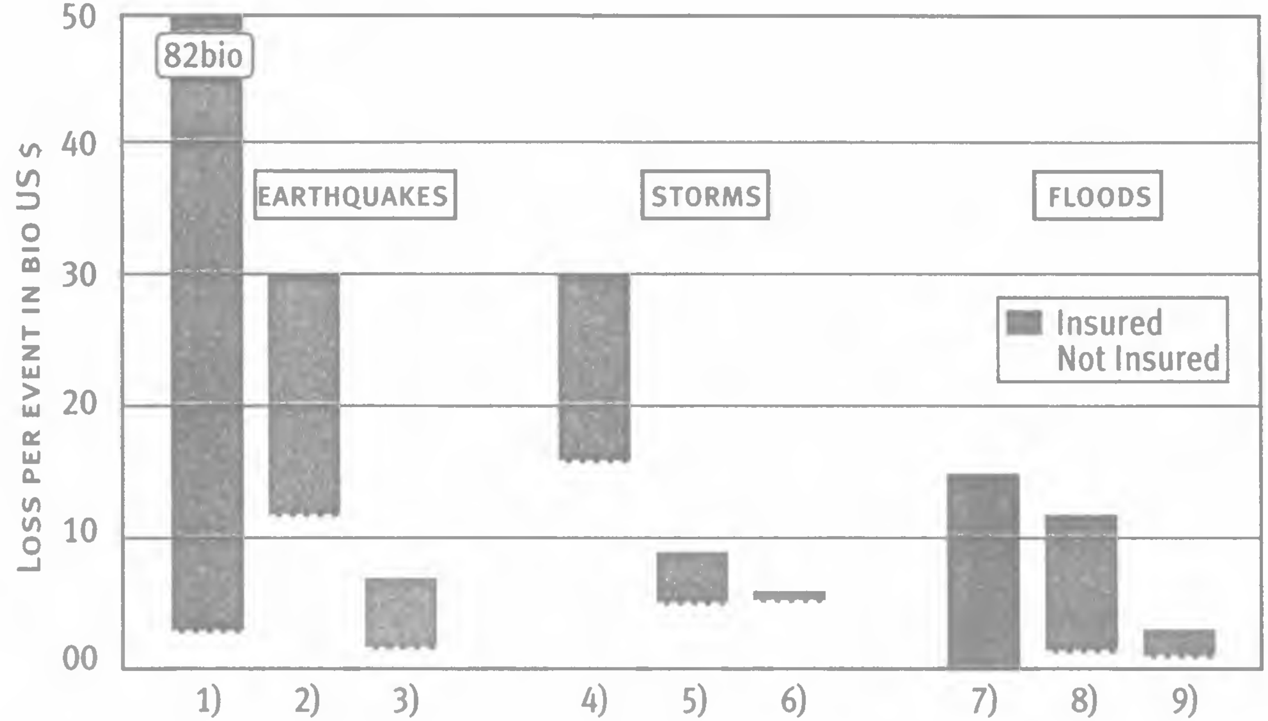
Markets Projections for the Earth Observation Chain

Figure 3.4-1
(Courtesy EUROCONSULT)



Synergies between Earth Observation, Telecom and Navigation Fields

Figure 3.3-1



EARTHQUAKES
1) Kobe (Japan) January 1995
2) Northridge, California (USA) January 1994
3) Loma Prieta, California (USA) October 1989

STORMS
4) Hurricane Andrew (USA) August 1992
5) Hurricane Hugo (Caribbean, USA) September 1989
6) Winterstorm Daria (Europe) January 1990

FLOODS
7) China, July 1991
8) Midwest Flood Mississippi (USA) July 1993
9) N-W Europe, January 1995

Major Losses due to natural disasters in recent years

Figure 4.2.1-1

SATELLITE NAVIGATION: MARKET SUCCESS THROUGH INNOVATION

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ABSTRACT

Innovation is the process of guiding a powerful capability that is proven over time to be sustainable and repeatable. By combining an understanding of what is needed in the market with what is technologically possible, new products and services may be created. Consisting of four major elements, the innovation process needs to harness core capabilities and maximise: customer understanding, product line planning, technology management, and product/process development. By focusing on each element and the strategic and operational management of the innovation process, opportunities for creating innovation, and the capture of new markets, are possible. This paper focuses on the needed core capabilities to successfully implement the Innovation Engine within the satellite navigation arena. By looking at the history of satellite navigation, the current situation, and what the future may hold, capabilities needed to capture time, cost and value advantages in the global market are investigated. The specific sectors reviewed include services and equipment for the space, ground, and user segments of the Global Navigation Satellite System (GNSS).

1.0 INTRODUCTION & BACKGROUND

1.1 Satellite Navigation Market Summary

Satellite navigation promises to produce a market opportunity of between 25-35 Billion ECUs over the next 20 years according to some industry estimates. Depending on how the market is classified, this estimate may be drastically understated. These markets include equipment and services sectors which will enter all facets of life, to the point where satellite navigation will become a utility, much like the power generation and telecommunications sectors are today. Applications of satellite navigation signals will cover a wide spectrum of usage's from traditional safety of life operations (e.g., aircraft and maritime navigation) to unforeseen, little thought of, services such as power grid synchronisation, telecommunications, and time standardisation. In the future, every time a person turns on a light switch, makes a telephone call, or moves from one place to another, their lives will be impacted by satellite navigation.

Currently this market is dominated by US manufacturers and service companies. This is mainly due to the early development of the United State's Department of Defense Global Positioning System (GPS). The know-how in satellite vehicle development, production, launch and control, coupled with a powerful innovation process in the user equipment sector, has produced significant global market leadership for US companies. Originally some technology transfer from the military environment to the commercial sector occurred; however, it is the civilian developments today which are leading to new and innovative products and services as the "consumerisation" of satellite navigation occurs.

In the future, this dominance will continue if other market players do not successfully develop better, more desirable, and innovative products and services. In order to overcome current industry leaders, significant effort is necessary on several fronts including: Government and intergovernmental agencies, industry, and research establishments. These organisations must develop the core capabilities needed to succeed in this growing and dynamic market. Through the implementation of Innovation Engines within the various organisations, new markets can be identified, developed, and captured; whilst, removing institutional barriers to market entry.

1.2 What is Innovation?

Innovation is the process of guiding a powerful capability that is proven over time to be sustainable and repeatable. By combining an understanding of what is needed in the market with what is technologically possible, new products and services may be created. Consisting of four major elements, the innovation process needs to harness core capabilities and maximise: customer understanding, technology management, product line planning, and product/process development. By focusing on each element and the strategic and operational management of the innovation process, opportunities for creating innovation, and the capture of new markets, are possible.

Core capabilities to successfully implement an Innovation Engine within a sector of the satellite navigation business needs to be identified by organisations wishing to succeed in this market. By looking at the history of satellite navigation, the current situation, and what the future may hold, capabilities needed to capture time, cost and value advantages in the global market can be identified, developed, and implemented. This applies equally to government and former government research organisations, policy making organisations, industry, and academia. Leadership through the development of Innovation Engines within core industry sectors must be the focus of key decision makers and decision influencers, else suffer the consequences of limited growth, shrinking markets, and/or obsolescence & obscurity.

1.3 Paper Contents

The rest of this paper looks at the history of satellite navigation, the current situation, and what the future may hold. Based upon this brief review capabilities needed to capture time, cost and value advantages in the global market are investigated. Services and equipment for the space, ground, and user segments of the future Global Navigation Satellite System (GNSS) are then briefly investigated versus the core capabilities needed to succeed in this market.

2.0 An Innovation Engine for Satellite Navigation

By investigating past and current successful endeavours in satellite navigation, and/or disciplines with similarly complex, yet diverse markets (e.g., mobile telecoms markets), core capabilities can be identified which led to these successes. Considering these historic success factors, coupled with an evaluation of near and mid term user needs, technology trends, and potential market forces (regulatory changes, standards promulgation, population growth, wealth creation/economic growth, etc.) future core capabilities for success can be identified. It is these core capabilities which will form the basis for the future Innovation Engine paradigms within the satellite navigation arena.

3.0 The Past & Present - Who Succeeded, Who Did Not & Why

Recent history shows us that certain major initiatives within the satellite navigation arena have been successful, whilst others have not fared so well. Within markets and disciplines of similar complexity and broad potential user base, fledgling examples also exist, such as hand-held satellite telephony. This section addresses a limited set of successful and not so successful ventures, and attempts to identify potential macro-causes for the positive or not-so-positive results by way of core capabilities and success factors.

3.1 Successes and Some Which Were Not

In the recent past, several good examples of successful, and not so successful, satellite navigation and communications ventures exist which help to identify keys to success within the arena. Successful recent offerings include the United States Global Positioning System (GPS), the Inmarsat-3 Navigation Payloads, and the fledgling satellite telephony communications systems of ICO and Iridium. Not so successful ventures within the business include the Russian Global Orbiting Navigation Satellite System (GLONASS), early ESA initiatives in satellite navigation such as NavSat, and the Inmarsat International Satellite Navigation System (ISNS). These are shown below in Exhibit 1.

SUCCESSFUL	NOT SO SUCCESSFUL
• GPS	• GLONASS
• Inmarsat 3 Nav Payloads	• ESA NavSat
• ICO & Iridium	• ISNS

Exhibit 1. Successful & Not So Successful Ventures

Each of the above ventures have been successful, or not, due to the implementation, or lack of implementation, of certain key capabilities. In addition, the impact of government leadership on these ventures cannot be ignored. These core capabilities, and leadership are discussed further below. We note that it is not an exhaustive list, but they are, in our estimation, the keys to success within the satellite navigation business.

3.2 Core Capabilities & Success Factors

Successful (and not so successful) satellite navigation ventures, such as those noted above, generally reflect several key success factors. These success factors include institutional leadership and the development of core capabilities. After an analysis of the previous abbreviated list of satellite navigation ventures, it was obvious that several specific aspects helped to make, or break, these ventures. Exhibit 2 below depicts these core capabilities and institutional leadership characteristics.

INSTITUTIONAL LEADERSHIP	CORE CAPABILITIES
• Clear Vision	• Market & User Understanding
• Accountability	• Product Planning
• Financial Committment	• Product Development
• Strong Technology Management	• Leveraged the Extended Enterprise

EXHIBIT 2. CORE CAPABILITIES AND LEADERSHIP WHICH PROMOTE INNOVATION WITHIN THE SATELLITE NAVIGATION INDUSTRY

3.3 INSTITUTIONAL LEADERSHIP

Primarily, satellite navigation is a combination of a military force enhancement system and a safety of life service (aviation and maritime operations). As a secondary bonus, satellite navigation brings great utility to other non-safety of life users such as land mobile, environmental monitoring, remote sensing, telecommunications, power generation & distribution, surveying, etc..

It is due to the safety and security nature of satellite navigation that the role of governments and inter-governmental organisations become so influential unlike other commercial markets (e.g., automotive, chemicals, and computing). The one aspect which becomes obvious when evaluating successful and not so successful ventures in the satellite navigation industry is the key role of *Institutional Leadership*. The US GPS programme was the product of *clear vision* of needs and programme dimension, *financial commitment* in the long term, strong *technology management*, and probably just as important, *accountability* within the government structure.

3.3.1 Clear Vision

The US GPS programme and the Inmarsat-3 navigation payload development were supported from the top of the respective organisations, on down through the ranks. A clear vision and strategy was present, with milestones, evaluation criteria, and top level decision maker visibility and interest. The ISNS and GLONASS constellations also had clear vision as well, but fell down on other institutional leadership aspects.

3.3.2 Technology Management

The successful projects above have benefited from solid technology selection and the nurturing of core technologies which will form the basis for successive projects, products, and process improvements. The focus on mid-term technologies needed for future innovation and development of successive generations of equipment have also played a key role. GPS and ICO/Iridium are good examples of solid technology management. The initial management of the ISNS project also showed strong technology management. However, it is the opinion that less than desirable technology management has landed GLONASS in a difficult position for future market capture.

3.3.3 Financial Commitment

One of the core issues of any large government expenditure is how solid is the financial commitment to implement the product or service. Susceptible to the vagaries of parliamentary positioning, and decision maker support in cyclical budget processes, large multi-year programmes must have strong financial commitment from all stakeholders, decision influencers, and decision makers. By way of strong user advocacy, continual project evaluation with clear go-no go criteria, coupled with economic analysis, financial commitment can be nurtured. GPS almost lost its way in this area, but recovered. ISNS never recovered from the lack of "parliamentary" support by way of the Inmarsat Council decision to not fund ISNS. GLONASS is now suffering from a perceived lack of financial resources to maintain a healthy 24 satellite constellation in the face of a worsening domestic economy.

3.3.4 Accountability

Without a strong individual leader, who is accountable for the development and implementation of a new system, then there is a distinct danger of project failure. ISNS, GPS, GLONASS, and ICO/Iridium all have clear chains of accountability and responsibility. Current models of European satellite navigation development do not bode well for the implementation of a truly accountable body for the implementation of the system. An initial GNSS Office has been established, but currently responsibility is shared between three bodies, with three different national memberships, three different constitutions, three different funding structures, and three different regulatory frameworks. This is not a recipe for success. It is noted however, that under the auspices of the European Commission, steps are being taken to establish a central body for the nurturing of European Satellite Navigation which may remedy this problem.

3.4 CORE CAPABILITIES

3.4.1 Market & User Understanding

A market and user needs understanding is a key and critical component of success within the satellite navigation arena. What are the client needs and experiences in all aspects of operation? Is there a continual requirements capture process implemented and are users consulted on a regular basis on performance? Are techniques to overcome organisational and institutional barriers being overcome to create a more market-oriented culture? These are the questions which successful programmes continually ask, and act upon. ICO, Iridium, GPS and the Inmarsat-3 programmes all perform such analysis. ISNS had planned to do this on a regular basis, but it is the perception that GLONASS does not perform such market oriented self evaluation and external analysis.

3.4.2 Product Planning

The essence of effective product planning is the development of a flexible "product" architecture; whereby one can successfully manage diverse product requirements, capture the power of "line" extensions, deliver new "lines", and create and manage a "portfolio" of new ideas. Applied to satellite navigation, this means the creation of an architecture which does not preclude users on either end of the scale from "low fidelity" to "high fidelity". Multiple levels of service, potential cost recovery techniques, augmentability, etc., should all play a role. GPS, GLONASS, and ISNS, had such a structure. The Inmarsat-3 also has a similar capability, but as an augmentation to GPS and GLONASS, it serves a good example of the effectiveness of the "product planning" (including governmental policy decisions) of GPS and GLONASS which did not preclude its implementation.

3.4.3 Product Development

Product development is another key capability reflected in successful programmes. By the identification, implementation, and institutional-isation of best practices by governments, industry, and academic organisations involved within the satellite navigation sector, successful products, and services will make it "to market" quicker, at lower cost, and with higher quality. However, this requires a commitment to learn from each other's strengths, and to implement and continually improve one's processes. Certainly ISNS, ICO, Iridium, and GPS have implemented, or were planning to implement best practices within certain realms and domains of activity. It is our impression that GLONASS is not, at this time, and hence its tenuous position within the field today.

3.4.4 Leveraging the Extended Enterprise

Another key success factor perceived from the example programmes is the effective leveraging of the extended enterprise within the field of satellite navigation. Whether this is at the macro-level between government sponsors and contractors, or at a lower level, between contractors and suppliers. Certainly players within the GPS arena have utilised the extended enterprise model in the upfront, joint and integrated development of new and innovative products which leveraged each others strengths to ensure value-creation opportunities were available. Also, the macro-extended enterprise between government and contractors have created success such as the improvements in GPS satellites. On a commercial basis, the linkage of ICO or Iridium with its suppliers, also serves as a very good example of leveraging the extended enterprise.

3.5 DETAILED CAPABILITIES - COMPETITIVE ADVANTAGE

The successes described above were attributed to the implementation of certain leadership characteristics and innovative processes and capabilities. However, it is from these activities where core capabilities within the satellite navigation arena must be derived. Within the historical context of the example projects chosen, several detailed core capabilities have been identified which led to key successes. These are as defined below in Exhibit 3.

DETAILED CAPABILITIES - COMPETITIVE ADVANTAGE	
• Networks/Communications	• Timing Systems
• Computing/Electronics	• Large Software Systems
• Launch Vehicles	• Space Hardware
• Testing/Certification	• Systems Integration

EXHIBIT 3. DETAILED CAPABILITIES WHICH PROMOTE COMPETITIVE ADVANTAGE

4.0 THE FUTURE - AMBIGUITY, CAPABILITIES, AND FUTURE MARKETS

The future of satellite navigation is not clear, and in fact it is quite murky. Competing satellite architectures, economic rivalry between the US and Europe, very large needed investments, political uncertainty, unclear lines of authority and responsibility for systems develop, and true financial commitment contribute to the barrier surrounding a future system. The presence of a strong US policy to promote GPS as a de facto world standard also creates market uncertainty as to where potential future systems are heading, if any where at all. But recent strong statements by governments, and inter-governmental bodies have confirmed that something will occur within the sector. What is to be determined. So the question arises, what is a company, organisation, or governmental body to do, so as to position for mid- and far term future markets? The answer is the development of core capabilities and competencies, which will thereby position one for what ever specific product may "pop-out" of the murky future.

4.1 Capabilities Needed

It is our belief that the core capabilities and institutional leadership characteristics which led to historic success, will also lead to future success. With emphasis on the following, governments, industry, and others may be in a position to succeed in near-, mid-, and far-term markets.

- Institutional Leadership
    - ◊ Clear Vision
    - ◊ Accountability
    - ◊ Financial Commitment
    - ◊ Strong Technology Management
- User & Market Understanding
- Product Planning
- Product Development
- Leveraging the Extended Enterprise

4.2 Potential Market Opportunities

In addition to the core capabilities and characteristics needed to be developed, specific potential products, systems, services, and technology are addressed. This list is not exhaustive, nor is it large. It is only indicative of potential types of product opportunities.

4.2.1 Major System Opportunities

Major potential systems opportunities in the next 20 years are envisaged to be:

- Up to 2005:
  - ◊ Additional Regional Geostationary Satellite Augmentations
- Post 2005:
  - ◊ European Navigation Satellite System (ENSS)
  - ◊ Asia Pacific Navigation Satellite System (APNSS)
  - ◊ North American "Soft-Fail" Navigation System
  - ◊ Combined Communication-Navigation Global Systems

4.2.2 Segment/Services Opportunities

Within any major system, three basic segments exist which will offer future opportunities. These segments are the space, ground, and user segments. Additionally, services will also arise which are generated by the presence of the various segments. The following is a partial list of potential market opportunities. It is noted that these opportunities will exist on a multi-regional basis, where requirements may vary significantly, thereby adding complexity, and potential value, to the overall global market.

- Space Segment
  - ◊ Launch Vehicles
  - ◊ Launch Support Equipment
  - ◊ Satellites and related onboard equipment & software
  - ◊ Equipment necessary to build, test, and certify these equipments
- Ground Segment
  - ◊ Communication Equipment
  - ◊ Land Earth Station Antennas
  - ◊ Computing Equipment
  - ◊ Specialised Software
  - ◊ High performance monitoring sensors
- User Segment
  - ◊ Receiver terminals & software
  - ◊ Peripheral Devices
  - ◊ Communications Equipment
- Services & Institutional Actions
  - ◊ Certification
  - ◊ Standardisation
  - ◊ Systems Services & Traditional Service Provision
  - ◊ Mapping and Location Databases

4.2.3 Technology Opportunities

Core technology opportunities also are identified which relate to the above segments, more or less directly. These technologies, to name a few, include:

- Timing standards,
- Communications/Navigation Integration,
- Electronic miniaturisation (especially Inertial Reference Systems),
- Multi-function user terminals (e.g., integration of GSM, Navigation, Computing, & Databases), and
- New advanced signal processing systems and methodologies.

5.0 RECOMMENDATIONS

Within European several initial actions have already been taken which are a good start to creating the Innovation Engine in satellite navigation, both at a governmental level, and within industry. For example:

- The formation of a GNSS co-ordination office in Brussels with the approval of the European Tripartite Group (ETG),
- Certification research by Eurocontrol,
- ESA research on key GNSS-2 signal structures,
- The Drafting of a European GNSS Action Plan by the European Commission and a panel of industry experts, and
- The development of the European Radionavigation Plan which is setting European-wide radionavigation policy.

5.1 INSTITUTIONAL LEADERSHIP & CORE CAPABILITIES

The following are recommendations as related to Institutional Leadership and Core Capabilities which we feel are necessary to create Satellite Navigation related Innovation Engines within Europe. We feel the following actions are necessary as a matter of urgency to enable market capture and growth within the European arena:

Consolidation of Market Players to Capture Efficiencies. North American aerospace manufacturers have undergone radical consolidation since 1989 resulting in extremely large and powerful entities capable of bundling products and services on a scale previously un-imaginable. Such product diversity and size, properly managed, creates a force difficult to compete with on the open market. Europe needs to consolidate in a similar manner to be competitive on a global scale.

Vision Setting & Accountability. The creation of a single vision and a very clear, and fully accountable organisational structure with responsibility for European wide implementation of satellite navigation is required. The start of this is seen in the EC's GNSS Action Plan and the new GNSS Office.

Procurement Reform. In order to effectively procure a European-wide system, procurement reform is necessary which will allow such wide scale powers necessary to perform a full and open competition, managed centrally, and efficiently, without the requirement for "industrial return" mandates for contributing nations.

Financial Commitment. The implementation of a multi-year funding arrangement, which has a sizeable financial commitment attached, is necessary to show the world, and the market players, that Europe is serious about navigation by satellites, and intends to be a world player. A commitment in the range of 1 BECU (+) is envisaged to be necessary to achieve this objective.

User and Market Knowledge. Continue and expand projects which will ensure the continual capture of user requirements (e.g., the ERNP development process) and feedback on services provided. Additionally, continue the development of market understanding activities, such as market studies, and cost benefit analysis.

Technology Management. The effective implementation of a strong Technology Management function at a European-wide level is deemed necessary. Additionally, industrial development of Technology Management Innovative Engines within specific industrial players is deemed to be a high priority if Europe wishes to be a world market leader in satellite navigation in the future.

Managing/Leveraging the Extended Enterprise. Institutional leaders need to embrace and promote the extended government-industry, extended enterprise to better bring products to market in a quicker, lower cost, and higher quality fashion, than is currently possible with today's institutional structure.

5.2 Detailed Capabilities Development

The following are detailed technological and systems related capabilities development recommendations. Again, these are not considered exhaustive, but are provided to reflect a representative listing of potential needed actions.

5.2.1 Short Term

- Fully digitised GPS/GLONASS receivers
- Modular receiver designs to flexibly accommodate GPS, GLONASS, WAAS, EGNOS, MTSAT, etc.
- Integrated GPS/GSM/differential corrections
- Low cost active antenna technology
- Expanded services (e.g., road tolling, cargo tracking, etc.)
- Safety critical certifiable space-based payloads
- Regional augmentation expansion eastward

5.2.2 Long Term

- C-Band receiver technology
- High stability time standards (e.g., space-rated hydrogen masers)
- Phased array antennas
- GNSS based train control
- "IRS on a chip" integrated with the "GPS on a chip"

Innovations for competitiveness

Positioning Europe in the multimedia revolution

ESTEC
March 20, 1997
M Dillon

EUROPEAN ESYS SYSTEMS

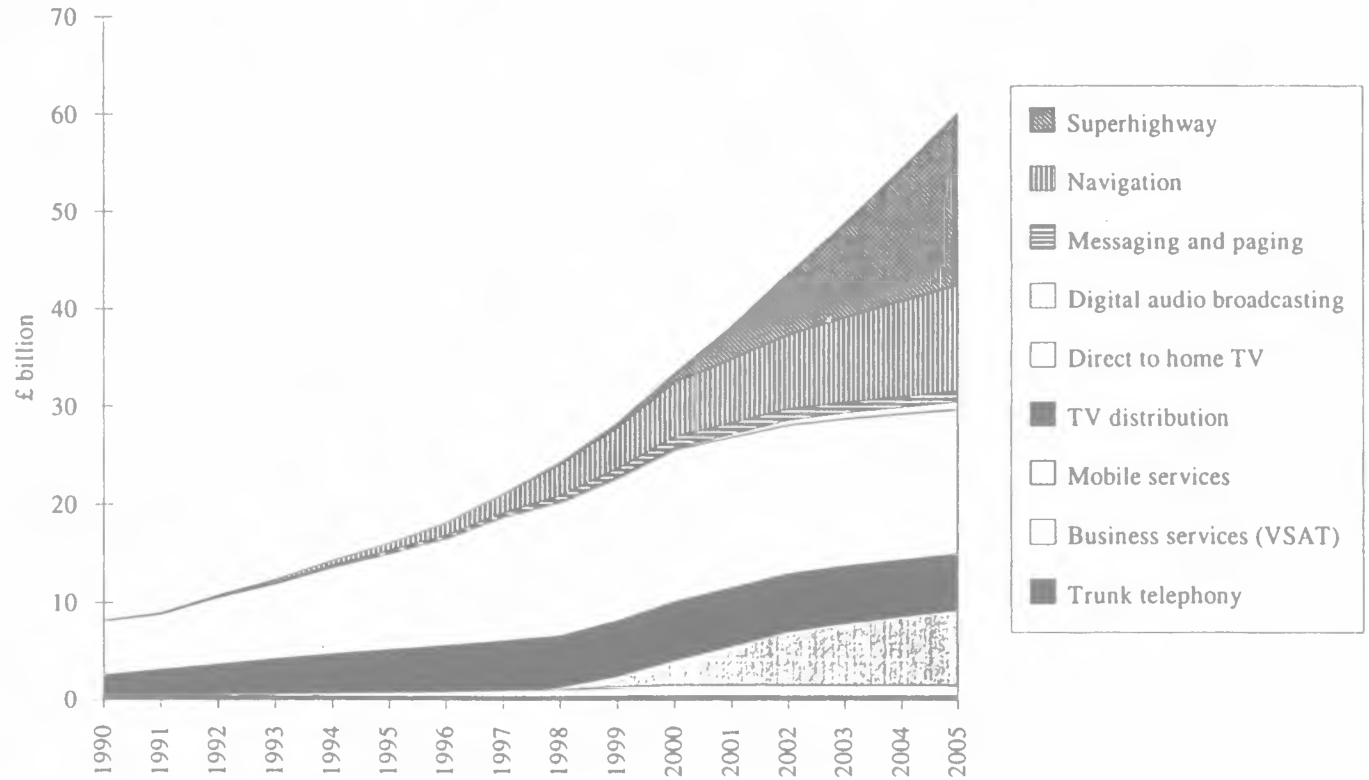
Triggers of opportunity

- **Trends**
  - Worldwide pressure for deregulation
  - Move from analogue to digital for broadcasting standards
  - Change in worldwide Military landscape
  - Acceptance of the Global Information Infrastructure or "Superhighway"
  - Increasing integration of "multimedia" applications
  - User awareness of the potential of multimedia technology
- **Technologies**
  - Low cost on board processing technology enabling "bandwidth on demand"
  - Low cost processing and storage technology using open standards (eg DVB)
  - Low cost software tools that are genuinely easy to use

Opportunities abound, exploitation is the problem

EUROPEAN ESYS SYSTEMS

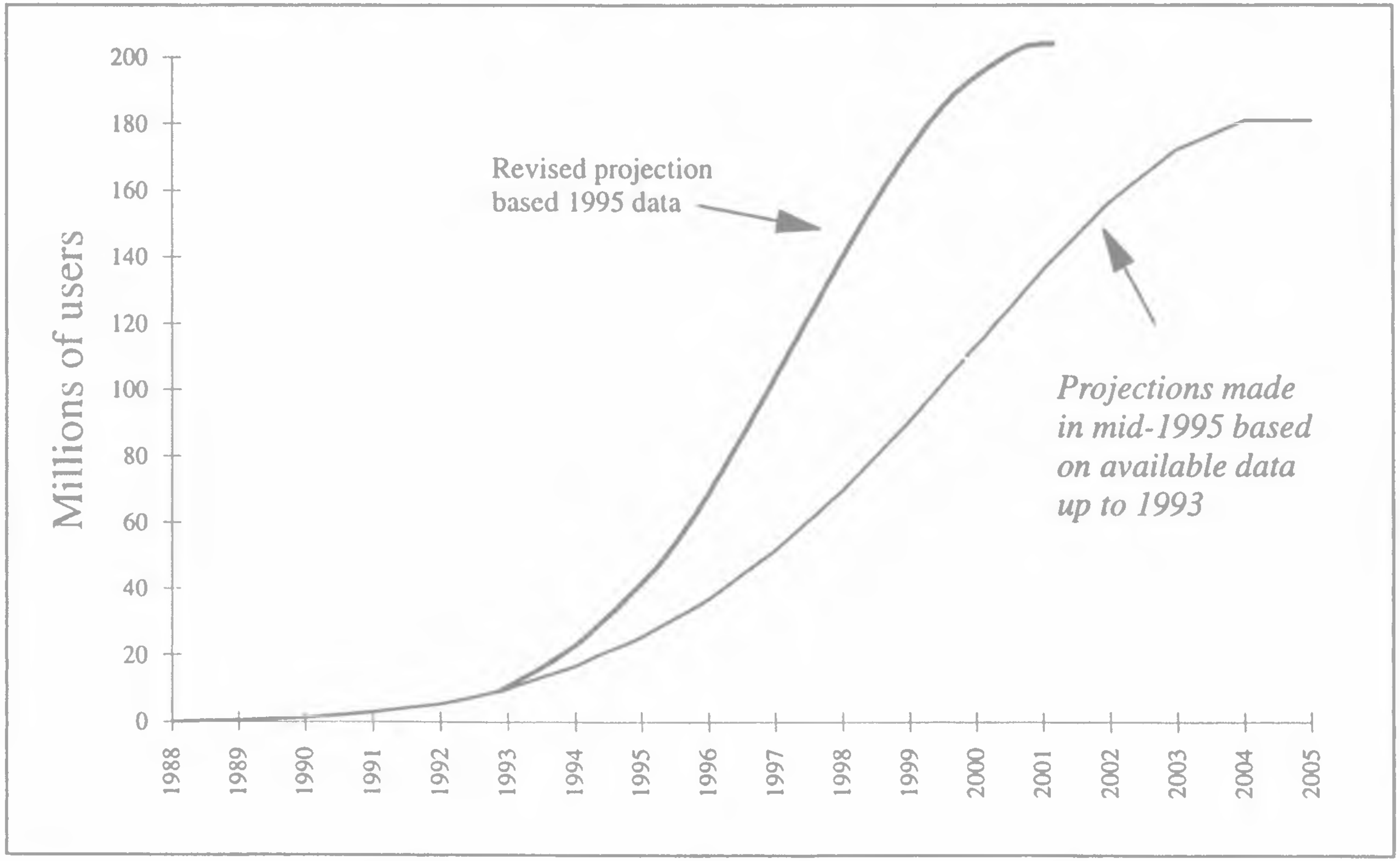
Market for satellite multimedia products/services



Enormous market, sustained growth, cannot be ignored

EUROPEAN ESYS SYSTEMS

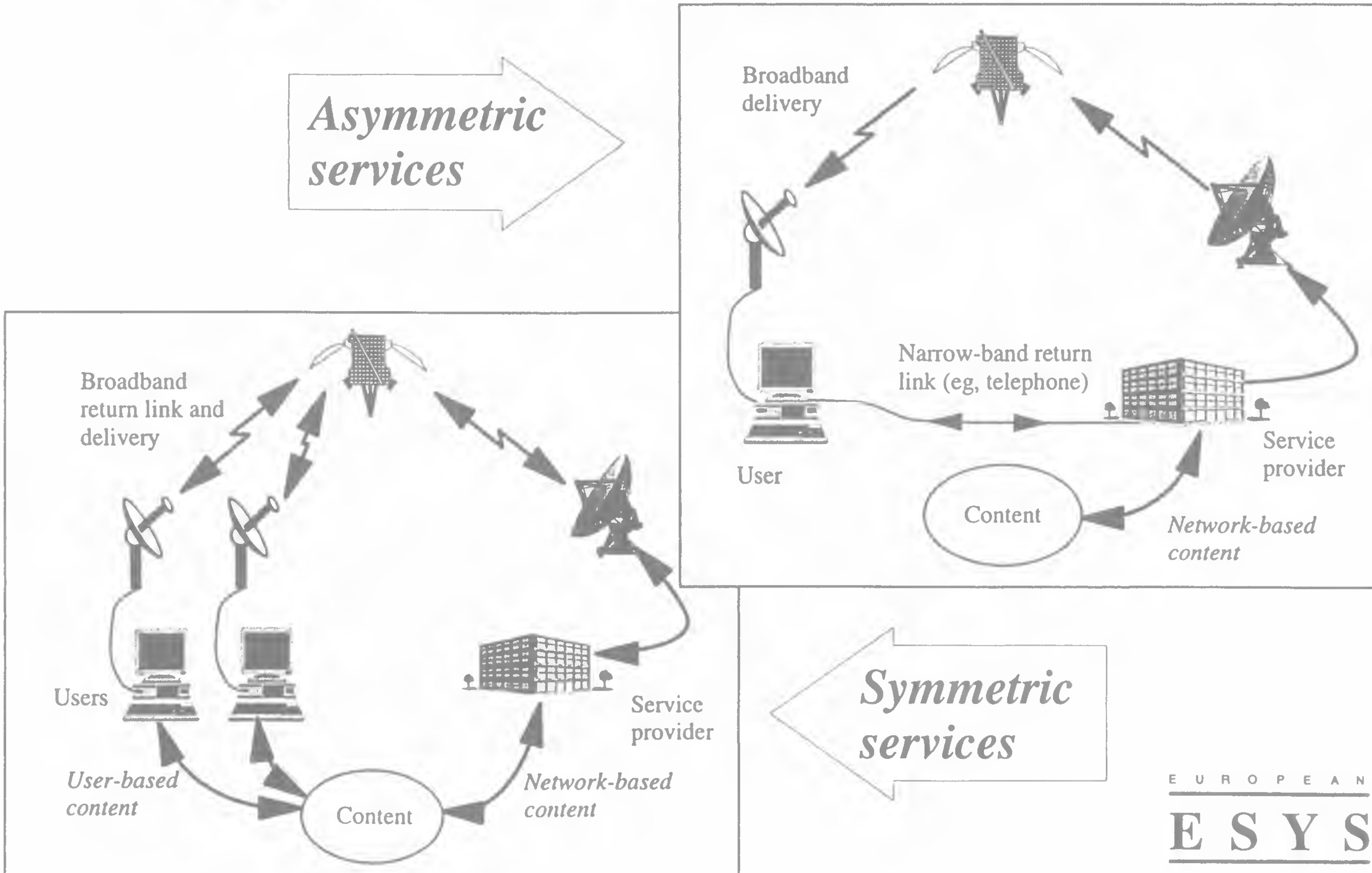
Growth of internet subscriptions



Internet is extremely slow - yet demand is growing at 50-100% annually !!

EUROPEAN ESYS SYSTEMS

Types of interactive satellite services



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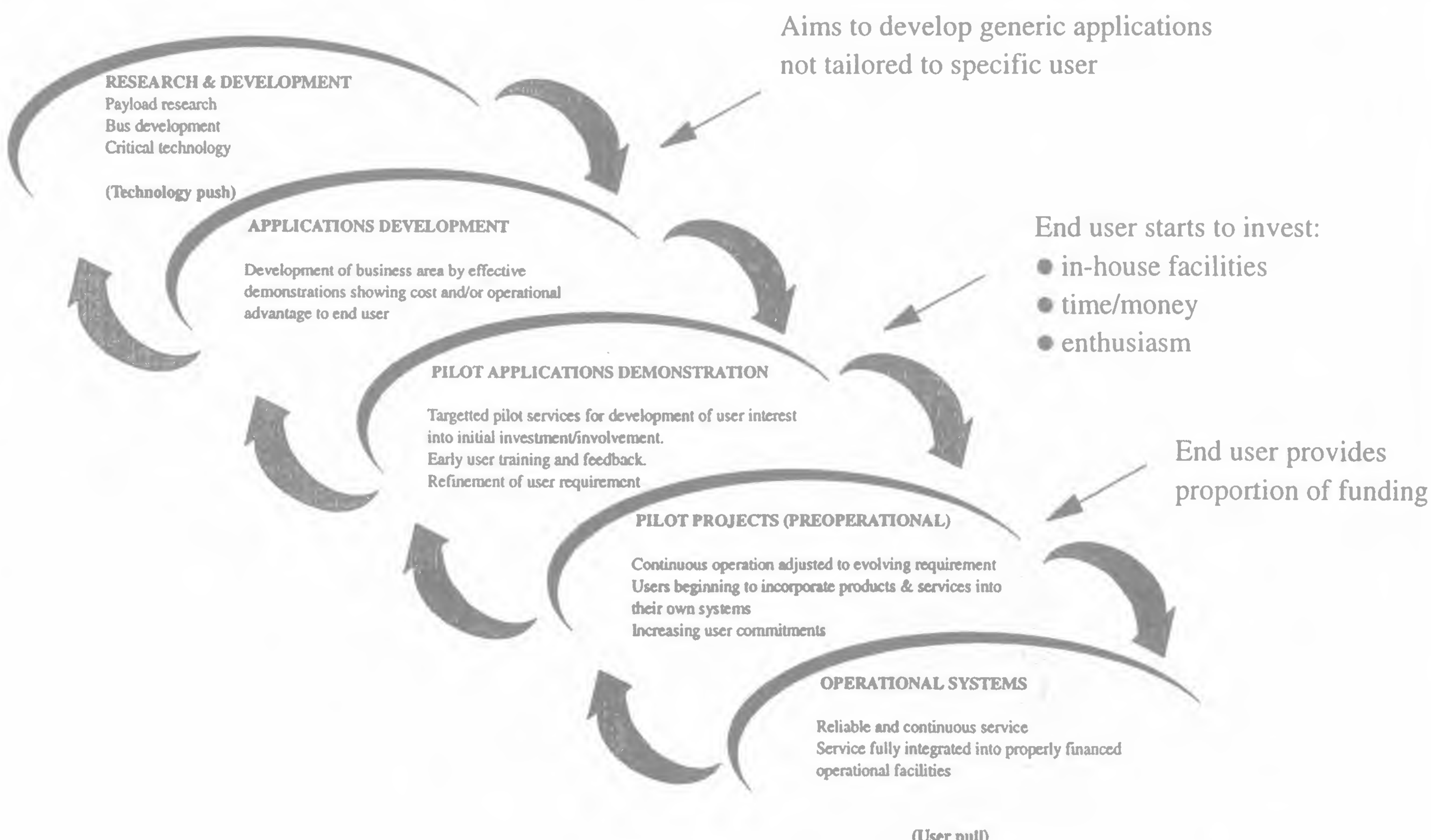


Business development model

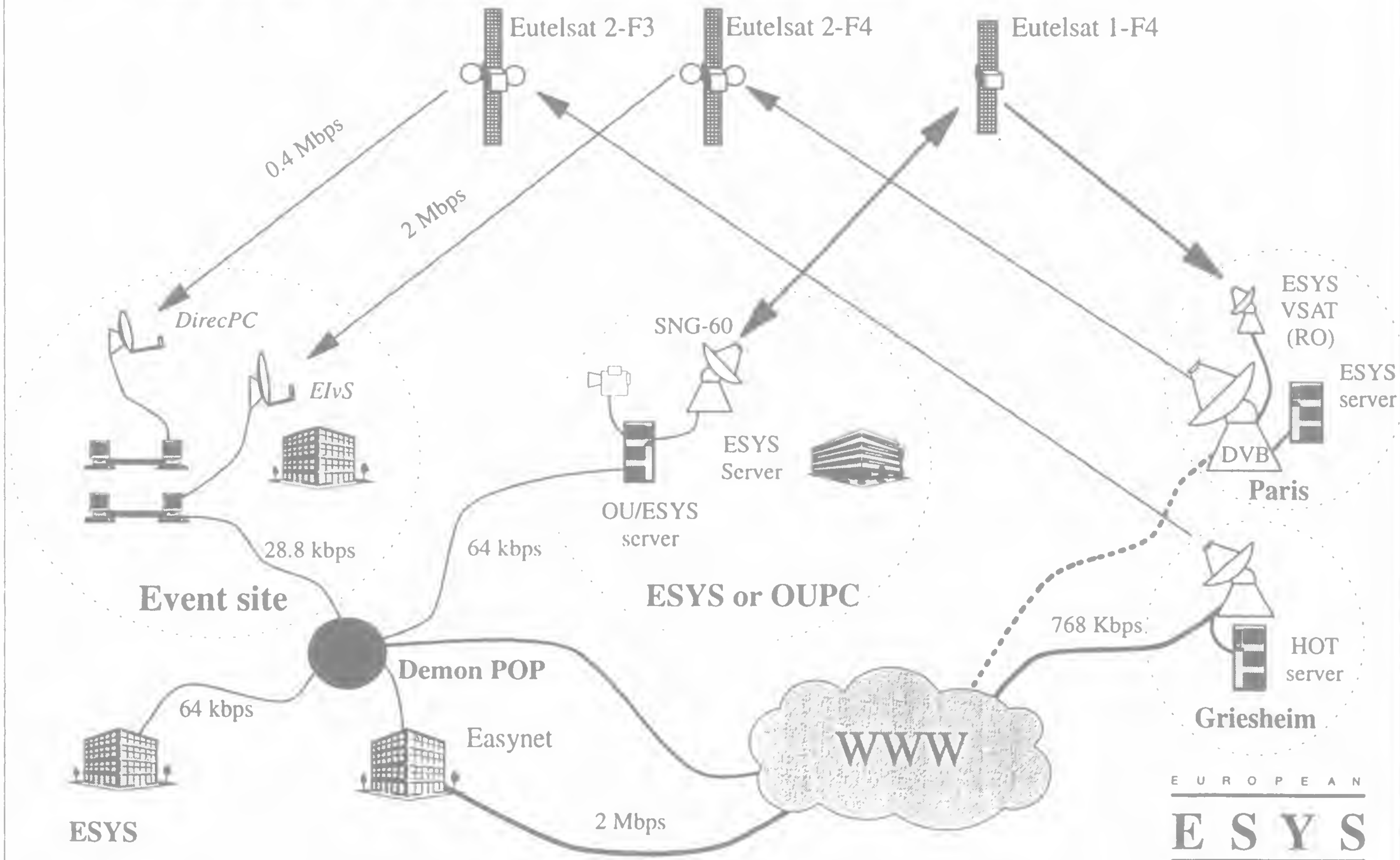
EUROPEAN ESYS SYSTEMS

Examples of multimedia activities in ESYS

Jan 94	Onboard processing study
Jan 95	Satcom market assessment
Jan 96	Role of satellites in Superhighway
May 96	Finance for satellite ventures
Oct 96	Artes 4 Demonstrator
Nov 96	Conveyancing demonstration project
TBC	Estate agents network trial
TBC	Seismic survey service
TBC	Education/Health demonstrators
TBC	Tourism service

EUROPEAN ESYS SYSTEMS

ARTES4 Demonstrator Architecture



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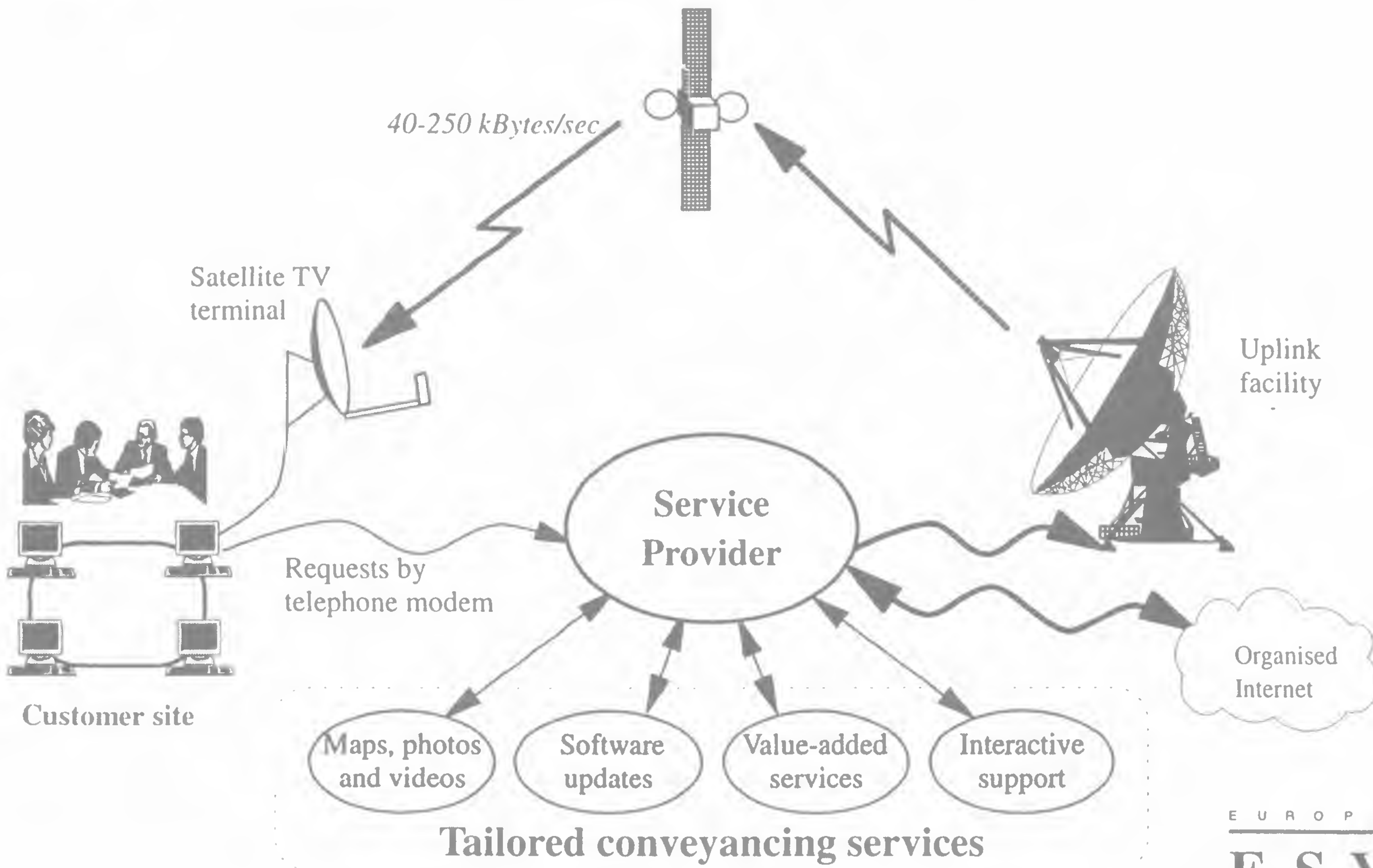
Potential operational conveyancing service



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Characteristics of the multimedia market place

- Driven by the availability of low cost products and services to mass markets
- Major scale of investment required if Europe is to establish a competitive position
- Extremely fast moving technology base at the user end of system, short time to market for products is essential, short shelf life for some products
- Requires a genuine mix of partners and players including:
    - visionaries and system integrators
    - application specialists
    - content providers
    - service providers
    - product manufacturers
- Favours vertical integration for system and service providers with multi source for content provision

Requires large company strength with small company speed

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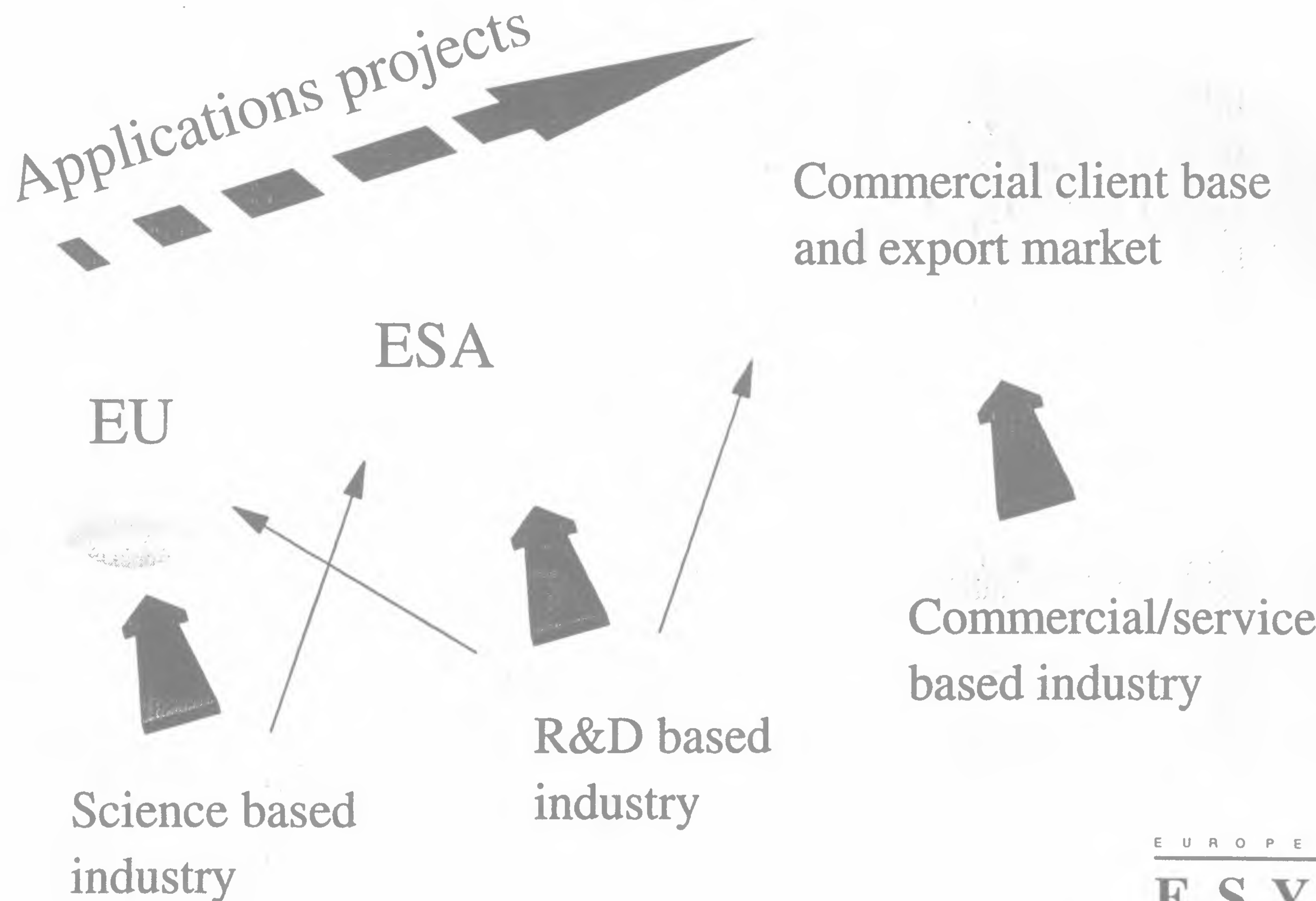
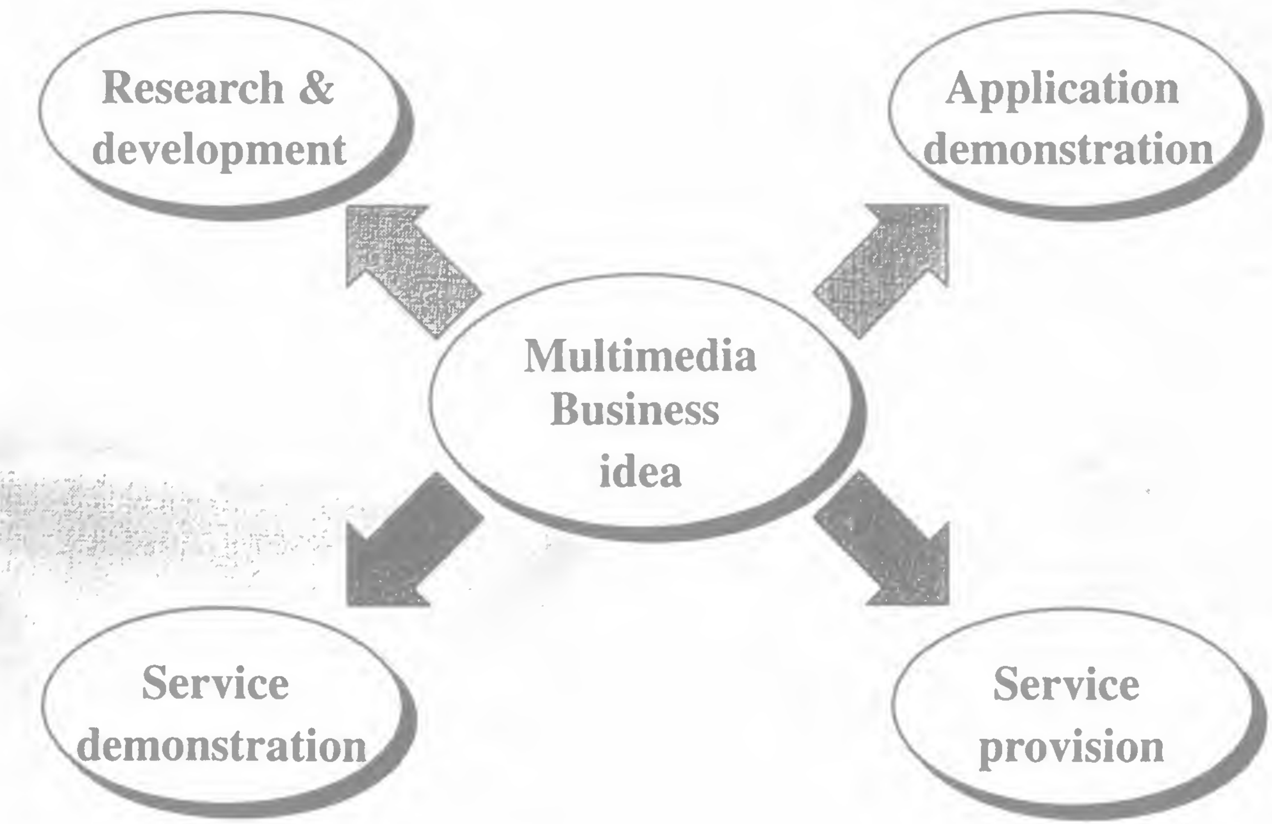

Applications projects
Commercial client base and export market
ESA
EU
Commercial/service based industry
R&D based industry
Science based industry

Multimedia management approach



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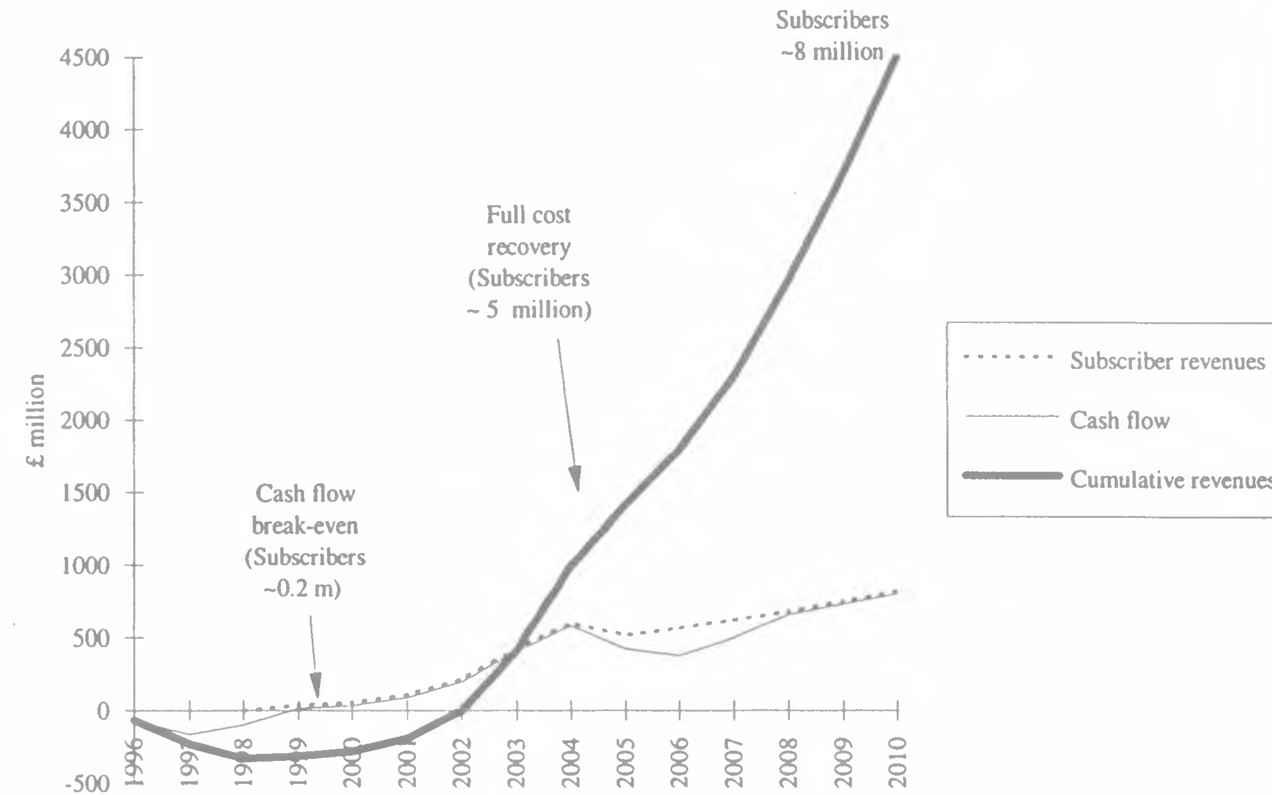
Economics of digital audio broadcasting

Assumptions

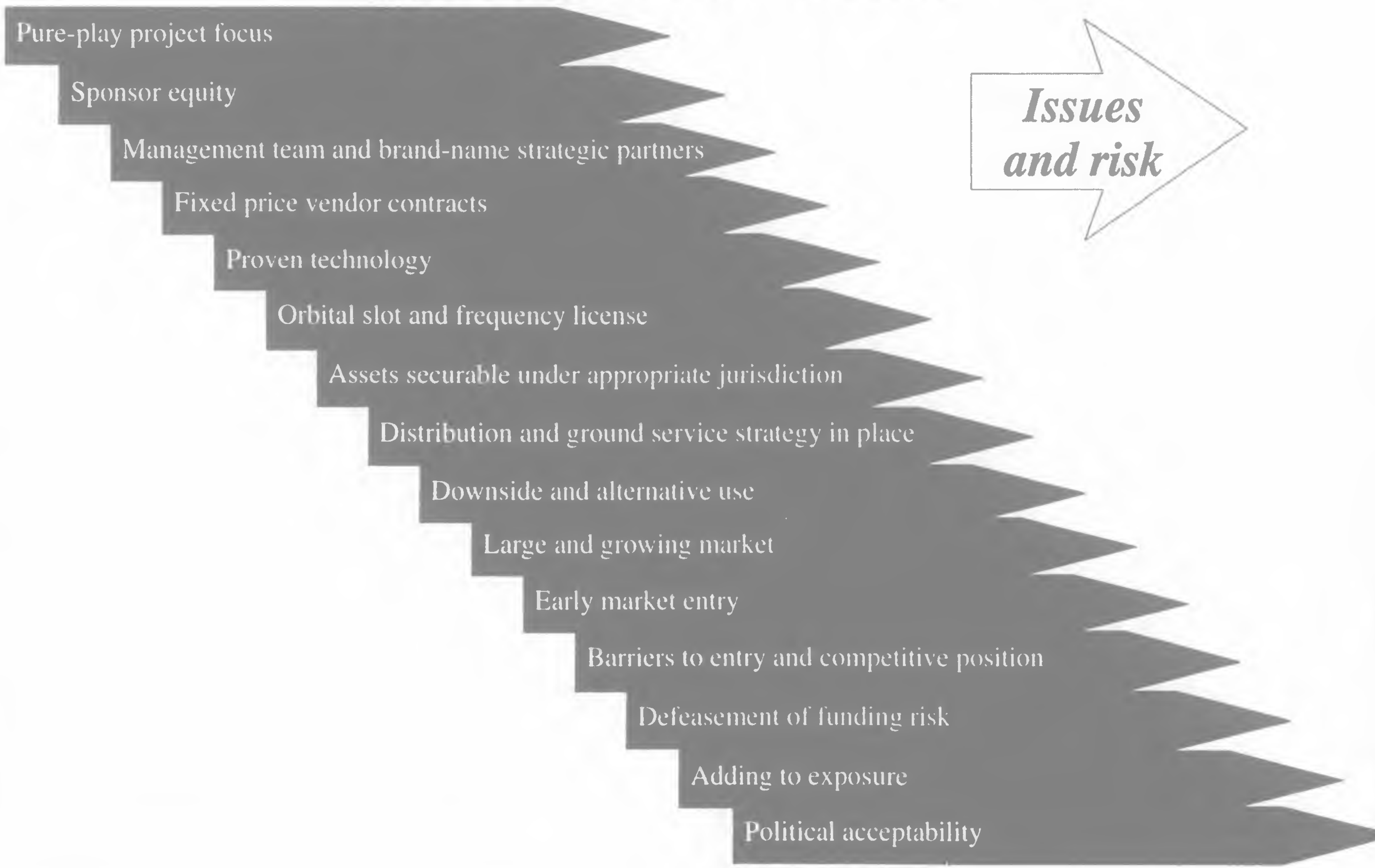
- Based on CD Radio
- £300m start-up
- 2 GEO satellites, 1 spare
- £7/month subscription
- No transponder leasing
- No advertising
- £100 radio price



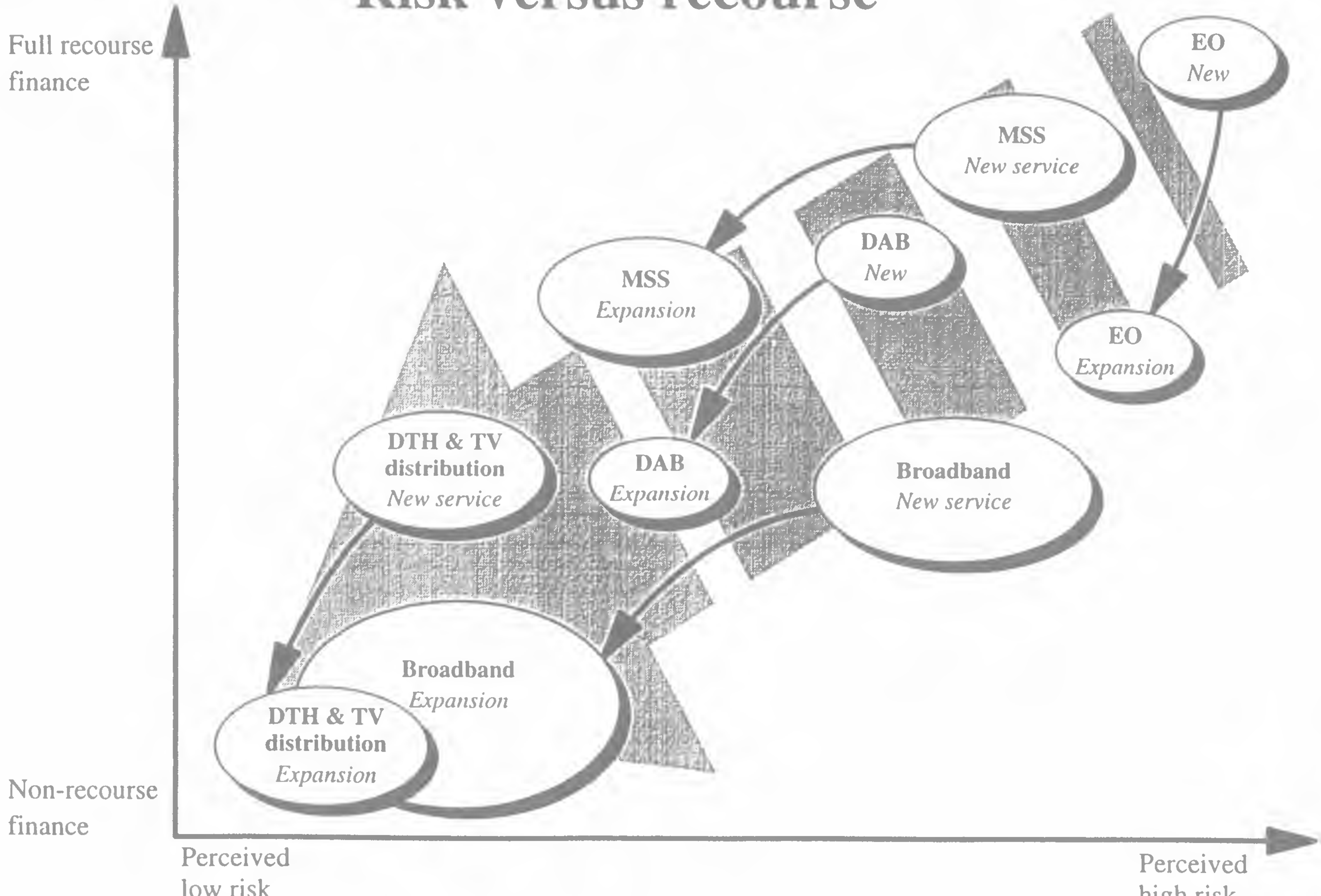
Payback time is the crucial issue in financing

EUROPEAN ESYS SYSTEMS

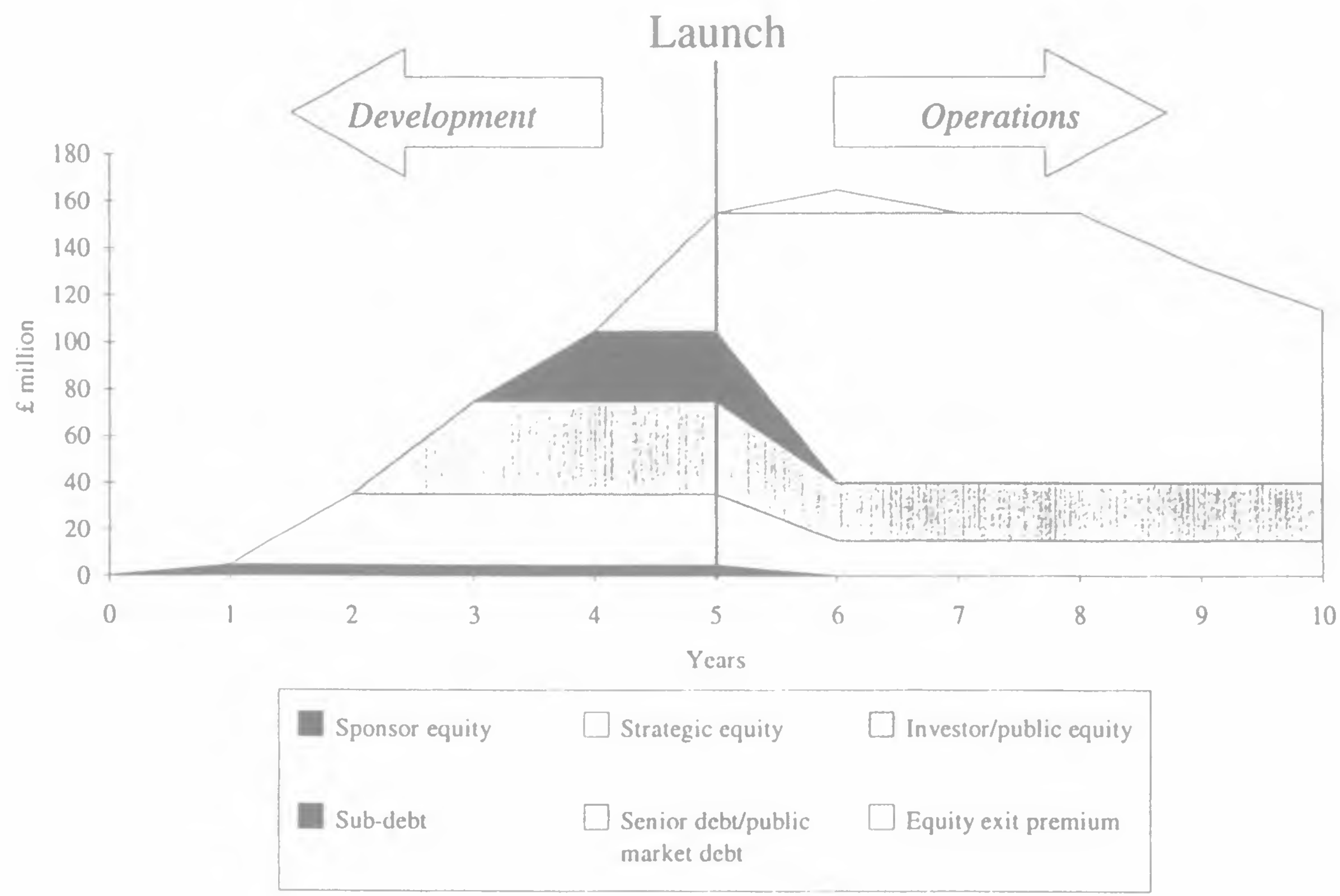
Typical investor check list



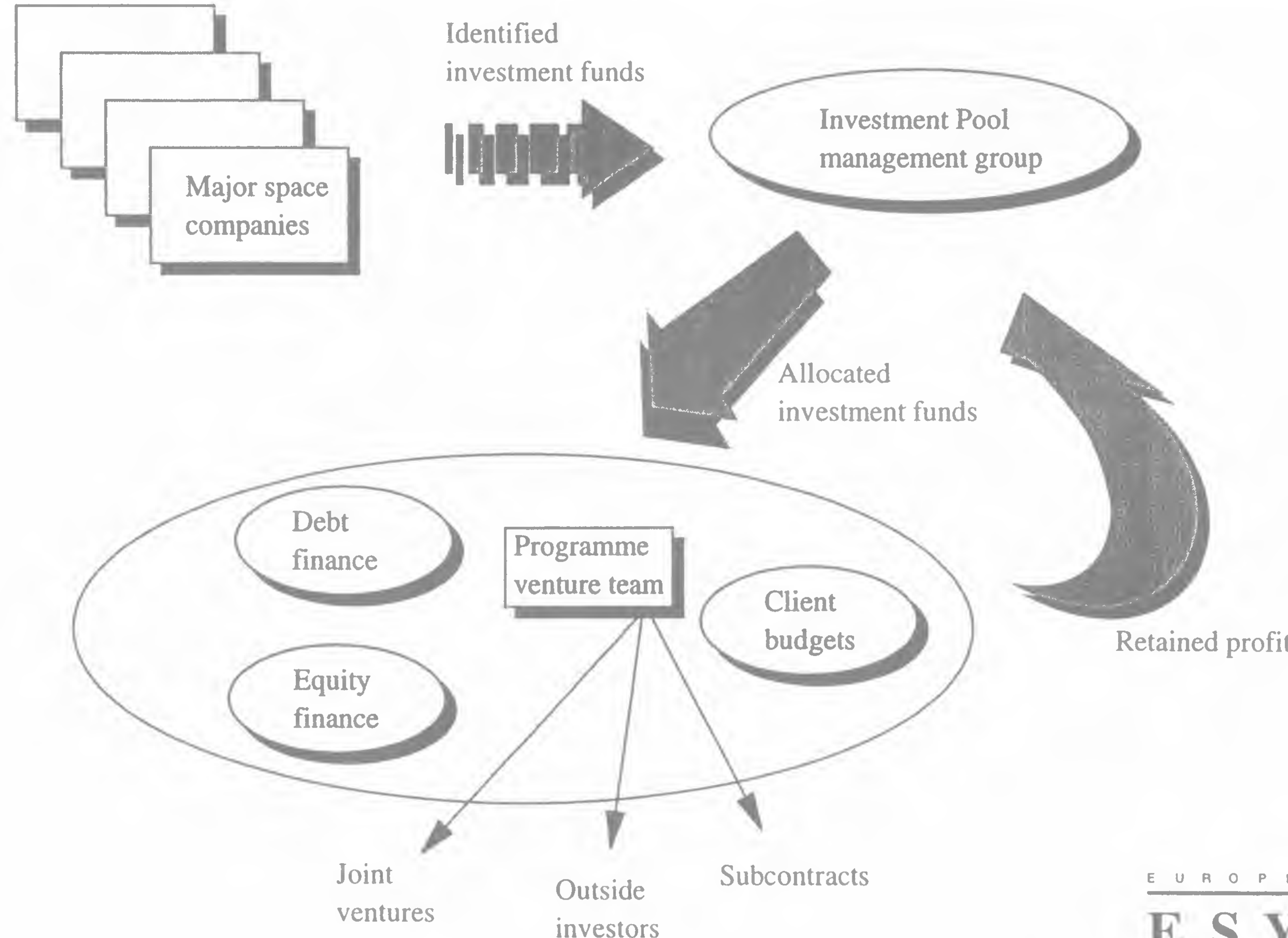
Risk versus recourse



Example financing profile



EUROPEAN ESYS SYSTEMS



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Guidelines for investment pool (IP)

- Major space companies identify 3-5% of turnover as "potential investment funds"
- Commitment limited to minimum contribution to cover costs of IP management group over a 3-5 year period
- Programme proposals made to IP management group by members or outside interest groups and funds assigned as "optional programmes"
- Selection on strictly commercial basis with profit motive as higher priority than industrial return
- IP management group performance measured by commercial return over 5 year period
- Programme structures tailored to particular commercial requirement (joint venture, new company, or normal contracting route)

Enables action now, does not require complete restructuring of industry in this time of opportunity

EUROPEAN ESYS SYSTEMS

Summary

- Europe needs a major multimedia programme to provide a focus for the development of the satcom multimedia market
- The long term consolidation will take time, we need mechanisms to combine our strengths (ideas, innovation, multimedia content) and sidestep our weaknesses (financial, organisational)
- We must maintain our commitment to long term development of critical technology to avoid problems downstream
- Flexible financial instruments are essential if we are to compete in the international market place
- Partnerships between content providers, service providers and product manufacturers are the key to success

We should play with the best to stay with the best, international partnerships will bring exports

EUROPEAN ESYS SYSTEMS

AN INNOVATIVE SATELLITE TELECOMMUNICATIONS PROJECT: NAHUELSAT IN SOUTH AMERICA.

Daimler-Benz Aerospace AG- Space Communications Operations and Services, Ottobrunn, Germany.

With the launch of Nahuel 1A, the satellite-based communications system Nahuel will become fully operational; this system has been initiated by Daimler-Benz Aerospace (Dasa, Munich) and licensed by the Argentine government. The first satellite, tailored to the specific needs of Latin America, will replace the „second hand" satellites used for the former interim system in space. Dornier Satellitensysteme GmbH, Friedrichshafen, a member of the Daimler-Benz Group, is the prime contractor for the delivery of the satellite system to NahuelSat, the satellite operation company.

In addition to Argentina, Nahuel will also serve Brazil, Uruguay, Chile and Paraguay and the Spanish-speaking nations - as well as the southern parts of the United States - with transmission capacities in the modern and high-performance portion of the Ku band. This allows direct-to-home TV reception and distribution, business data communication and telephone connections, with the exception of public switching systems.

As early as May 1993, a new communications age was initiated in South America by granting the license for the implementation of the private, commercial satellite communications system Nahuel by the Argentine Comisión Nacional de Telecomunicaciones (CNT). The license was granted for a term of 24 years beginning with the launch of the system and is valid for two orbital positions. The number of orbital positions may be increased in the future.

Buenos Aires-based NahuelSat S.A. was set up for satellite system operation, a company led by Dasa (Germany) and comprising Aerospatiale (France) and Alenia (Italy) as partners. Further shareholders are international and national banks, telecommunications companies and a large U.S. satellite operator.

NAHUEL - THE HISTORY

A modern and well-developed communications infrastructure is one of the keys to economic prosperity. Therefore, in the summer of 1992, the Argentine government, represented by CNT, issued an international invitation to bid for the operating license of a satellite communications systems.

The Daimler-Benz Group recognised the chances and opportunities for the commercial operation of such a communications satellite system. In conjunction with its industrial partners, Dasa made a license offer against strong international competition. The Argentine authorities were convinced by **the business concept** and the competence of the partners in the consortium. Thus, on December 16, 1992, the Dasa-led Nahuel consortium received the provisional, and on February 5, 1993, the definitive award for the license agreement by CNT. The contract was signed in Buenos Aires on May 27, 1993. The activity resulting from this license award was related to the build-up of a satellite operations business in South America, including all issues related to market-driven technical definition, financial engineering, personnel recruitment and operations.

NAHUEL - THE MARKET-DRIVEN ADVANTAGES

Satellite-based communications systems can quickly be installed, even in remote regions. The demand for transmission capacities can be covered flexibly and thus cost-effectively. Systems such as Nahuel are independent of terrestrial projects and particularly interesting for development areas like South America. On the other side the big challenge of a market-driven project in a developing market had to be faced.

Nahuel offers services in the Ku band, which transmits at higher frequencies (12/18 Gigahertz) than the C band (4/8 GHz). Compared to the widely used C band in South America, the Ku band provided by Nahuel offers several decisive advantages:

- Ground stations do not interfere with satellite transmission, whereas terrestrial transmitters often interfere with the C band in metropolitan areas.

- The procurement costs of the ground receive and transmit systems (VSATs = Very Small Aperture Terminals) for the Ku band are only a quarter of that for the C band.

- The parabolic dishes are at least three times smaller (approx. 1-2 meters in diameter for data transmission and approx. 60 centimeters for direct-to-home TV reception).

- By virtue of less costly electronics components, maintenance and repair costs of the ground systems are markedly lower.

The advantages of Ku-band are not just limited to the ground. In geostationary orbit, the satellites can be deployed closer together thus utilising the available space in this orbit more effectively.

The availability of C-Band capacity through other, competing satellite systems (Intelsat, Panamsat) drove the technical decision to concentrate on the Ku-band frequency, until1993 unavailable in South America. With three coverage areas, Nahuel 1 is able to provide service to all of South America and the southern part of the USA.

Service began in July 1993 with an „interim“ satellite, the Anik C1 procured from Telesat, Canada by a company associated to NahuelSat S.A. This early introduction of a new service before the „definitive“ satellite could be implemented was a key innovative aspect of the business.

NAHUEL - THE BUSINESS ORGANISATION

Since the end of December 1993, NahuelSat has been in existence as a stock corporation under the Argentine law (S.A.). After the set-up phase, and supported by the three foundation partners, the equity capital was raised to 100 million U.S. dollars in December 1995 by accepting further shareholders. The additionally required project funds were provided by the International Finance Corporation (the commercial arm of the World Bank) and a number of European banks led by the Dresdner Bank. The financial structure was engineered by Dasa.

In the meantime, NahuelSat has concluded cooperation agreements with other South American satellite operators, such as Embratel/Telebras (Brazil) and Telecomm Mexico, for strengthening and expanding its market position.

NAHUEL - THE SATELLITES

As of June 1993, NahuelSat has exclusively offered Ku-band capacity with an „interim“ satellite system, through an agreement with the company „Paracom Satellites“. NahuelSat's first satellite, Nahuel 1, was launched on January 30., 1997 and shall be formally transferred to NahuelSat S.A. in the first days of March 1997.

NahuelSat awarded the contract for satellite in-orbit delivery to Dornier Satellitensysteme (DSS), which is to act as the prime contractor. In addition to the satellite and the related ground station, the contract volume also includes launch service organisation and insurance and financing services.

Nahuel, which is based on the so-called Spacebus 2000 platform, weighs 1,790 kilograms, is 2.5 high and has a span (extended solar panels) of 22.4 meters. It is provided with 18 transponders, each having a bandwidth of 54 Mhz. In this way it will be possible to broadcast 36 analog TV programs simultaneously and as many as 180 digital TV programs or to establish 18,000 connections to telephones or small ground stations.

Dornier Satellitensysteme was the system responsible for the In-Orbit-delivery of the satellite system, including the ground segment.

Aerospatiale was commissioned by DSS with the satellite construction.

Dornier Satellitensysteme was responsible for the delivery of the following subsystems:

- attitude and orbit control,

- solar array,
- antennas and
- propulsion subsystem.

Alenia Aerospazio received the contract for the construction of the Nahuel ground station and was responsible for transponder manufacturing and payload integration for Nahuel 1. The control station is located in Benavidez, in the proximity of the Argentine capital, and was approved for operation in November 1996. 30 Argentine technicians have been trained in satellite operation, a nucleus of them in Europe, by Aerospatiale, Alenia Aerospazio and the DLR. The station is designed for the operation of three satellites.

Arianespace has been responsible for the satellite launch. Nahuel 1 was to be injected into its geostationary position by an Ariane 44L booster on January 30., 1997.

A typically European project in a global marketplace.

Nahuel 1A will be in service for twelve years. By late 1997/early 1998, it is planned to launch Nahuel 2 to expand the Nahuel system in order to meet the growing demand for satellite communications capacity in this region.

Dasa regards the commercial implementation of space products as a future-oriented opportunity to be seized and expanded. Within this strategy, the Nahuel project is a significant milestone. Further projects, in South America and in other regions are in preparation.

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Fostering Synergies between Civil & Military Satellite Applications: New Approaches to Promote Innovation & Increase Competitiveness

by

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Building Confidence in the Middle East:
A Remote Sensing Resource Atlas

presented at the

Innovation for Competitiveness
Workshop

European Space Agency (ESA)

European Space Research and Technology Centre (ESTEC)

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ABSTRACT

The present article argues that today's revolutionary challenge in innovating satellite applications is not necessarily in identifying only new key and state-of-the-art technologies. It ventures to contend that such a challenge is also in changing the way satellite applications are perceived and used at the present time. This paper asserts that there is a need to reach out to new end-users, not considering them just as new markets, but instead as part of a new *culture* towards the use of satellite applications. Using the example of international security, this article demonstrates that it is necessary to provide dedicated mobile communication, positioning, and imagery to help joint-multi-country operations and confidence-building measures. It further contends that it is necessary to create an innovative strategy to carry remote sensing-sensing into primary and secondary schools and universities, as well as other potential end-user fora. The article concludes with recommendations on how to create such a strategy by providing innovative ways of co-operation, while at the same time instigating higher levels of competitiveness which are conducive to further development in satellite applications.

I. INTRODUCTION

There has always been a degree of synergies between civil and military uses of space applications since the beginning of the space era. Of course, these synergies have increased with time, and at the present international environment is more conducive than ever to foster the identification of new dimensions for synergies between civil and military applications. Innovation and competitiveness, which have always been key words in the private space industry, are driving forces which have led to increasing development in space applications, primarily, in terms of new equipment and systems.

It is therefore not surprising that intensive efforts has been devoted to the identification of new key and state-of-the-art satellite[1] technologies over the years. This trend is justified on several grounds, specially given the need to ever improve equipments and systems. Yet, it is equally important that these efforts are coupled with a strong strategy to reach out to new end-users in terms of increased numbers (vertical increase) and new categories of users (horizontal increase). It appears, however, that today's use of satellite applications and the perception of their usefulness and access could be greatly improved.

The most fascinating quest towards the innovation of satellite activities appears therefore to be more related to end-use products and their users themselves rather than with respect to new equipment. While a vertical increase in the number of users could increase the demand to maintain and provide more existing systems, a horizontal increase in the number of user categories could lead to new services and thus widen the horizon of applications, equipment and systems. Both increases complement each other and are essential to further development in the space sector. They should consist of a specific strategy which would provide an objective for increased competitiveness and thus boost innovation.

The pursuit of such a strategy would require interested parties to have an innovative look in new areas of relevance in terms of end-users and their needs. This approach does not mean that there is a need to reach out to new end-users considering them simply as new markets. Rather, it implies that it is essential to develop a new *culture* towards the use of satellite applications. Promising present and upcoming initiatives of high future potentials involve the synergy with industrial, scientific and traditionally defence-applications. For example, potential applications in the field of international security involve the creation of dedicated mobile communication, positioning, and imagery to assist in joint-multi-country operations and confidence-building measures.

On another level, an innovative strategy based on a new *culture* of the use of satellite applications should also cover institutions which have not, traditionally, being using these

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[1] Although this is true with respect to many space applications, this article is limited to a discussion of only three areas of satellite services: mobile communication, positioning, and remote sensing.

services. Notably, primary and secondary schools where a large reservoir of future engineers, medical doctors, teachers, and a role set of other professions, could be familiarized with different satellite applications in their early years of schooling. This implies the space industry's and other partners' intense effort to deeper penetrate the social fabric with improved and original satellite services.

The benefits that this type of innovation can bring to the space industry are multifarious and at least two areas should be mentioned. One is that such a strategy would provide a vehicle of integration between users and the space industry, thus allowing for a better understanding of *what is needed by end-users* and *what can be provided by the industry*. Second, this new *culture* could further promote a shift in emphasis of the origin of innovation from an industry-based approach to an end-user needs-based one. (This argument is based on the premises that end-users can greatly contribute to stimulating innovation.) Such a shift would undoubtedly boost competitiveness.

Hence, a number of recommendations are made on how to create such a strategy by providing innovative means of co-operation, while at the same time instigating higher levels of competitiveness which are conducive to further development in space applications.

II. Select Areas to Improve The Synergy between Civil and Military Satellite Applications

The introduction of mobile communication in the civil sector is greatly changing the nature of business and private communications. Indeed, mobile communication has become one of the major revolutions in satellite technologies in the last decade of this century. However, this revolution has not yet been fully integrated into military structures. Mobile communication on the foot-soldier level of armed forces has traditionally been, and still is, carried out through radio equipment. Few countries have incorporated this new medium of communication in their standard equipment. In contrast, geopositioning devices have had a somewhat different history from that of mobile communications, where positioning devices have been used in armed forces for precise location of target and other objectives.

Nonetheless, the commercialization of positioning systems has allowed some armed forces to use like devices such as in peace operations. Yet at present, not every military contingent in a peace operation is equipped with such devices. Likewise, some military contingents are equipped with communication and/or positioning devices which do not permit interoperability, thus creating situations whereby groups of soldiers and civilian peace-keepers are unaware of each others situations and locations—although they may be only a few kilometres away from each other just behind a mountain.

Thus, the integration of mobile communication and geopositioning in one single device is therefore an area that could find concrete applicatibility both for military and civil use. This is technically not an unsolvable problem. For example, portable two-way communication and positioning devices already exist, such as the "911" American system. Small portable devices fit at the level of the foot-soldier, which are capable of working with different satellite systems, would highly improve the performance of armies and at the same time allow different military contingents and civil servants from various countries and organizations to communicate with themselves and find their locations more easily. Naturally, other users outside peace-keeping and military communities would find such devices quite useful. Increasing access to such devices seem therefore to be a formidable marketing challenge, particularly given that such devices would have to be affordable for many different categories of users. Here is an area that an innovative product can stimulate competitiveness among manufactures in the industry.

Another issue of importance is remote sensing. In the past, satellite imagery served governmental and particularly military purposes. With military support, satellite technology progressed and became increasingly sophisticated. Today this type of advanced satellite technology is also available in the public sector and has many non-military applications. For instance, high-resolution satellite images are used in urban development, environmental management, and in damage assessments of natural disasters. Yet, currently, many potential users still do not have access to satellite imagery. Other examples are that a great number of geographers still generate their maps through time consuming and tedious manual methods; and the majority of students and teachers, even in industrialized countries, still incomplete inaccurate maps in their computers.

At least three reasons could be attributed to this phenomenon. One is that there is the notion that in many sectors, satellite imagery is still linked with spying on a country. It is hence very difficult to bring remote sensing into some activities, where the refusal of using such means is decided upon political, security, military, and even ethical grounds. A recent example was the failure to include satellite technology as an integral part of the International Monitoring System (IMS) for the verification of the 1996 Comprehensive Test-Ban Treaty (CTBT). While not being an intrusive means of verification, the stigma of National Technical Means (NTMs) of verification was nevertheless a strong technological initiative for some countries to accept as a legitimate means of multilateral verification, particularly, since it could provide evidence of potential post violations, but also prior to a nuclear text. Additionally, the fear of potentially high costs related to satellite means, has also been very present in the minds of negotiators.

A second reason is the lack of knowledge of the utility of satellite imagery. Many potential users have no idea that they could use imagery to improve both the efficiency and accuracy of their work. There is a general lack of information of the validity of satellite imagery as a useful tool in various disciplines. A third reason is affordability. In some cases, satellite services are still too expensive for many potential users. In others, however, there is simply the fear that satellite imagery would be too costly, and no real effort would be made to conceive projects which consider satellite means, particularly in comparing it to other technologies. These and other reasons prevent a large number of potential users from accessing satellite services.

The development of new synergies between what was traditionally military purpose applications and civil uses is therefore not necessarily based only on a need to develop new technologies, but rather on the creation of a new *culture* of *who* could use satellite applications and *what* they would serve for. One way of developing this new *culture* is therefore by clearly demonstrating the availability of imagery that exists in the market and its usefulness. For example, it is important to show how such issues like water supply, population density and distribution, agricultural development, urban and inter-urban infrastructure, and archaeology, can be illustrated with satellite imagery. But it is also important to show how this same data can increase awareness of the political and military situations worldwide. This could provide an important resource for specialists studying both political and military situations as much as it could serve the study of non-military features of the world at universities and lower level school systems.

In addition, a new *culture* towards the use of satellite imagery also calls for a new approach to explain the usefulness of this tool for potential end-uses. These objectives introduce and highlight another aspect of satellite imagery which is the educational value that it carries. Hence, there is a very important link between education and the sciences, especially since the students of today will be the decision makers of tomorrow.

Any strategy or plan dealing with innovation processes of the use of satellite applications must also address the issue of cost. While the sale of end-products are expected to pay for equipment investment, system's maintenance and running bills, there is a clear need today to rationalize the approach to image sales. More flexibility to the use of images could help the increase in the number and categories of end-users. For example, worldwide databases could be conceived whereby end-users would be able to join capitals and share the same data. This could permit low budget projets to acquire satellite images while respecting copy right law. Another financial means of facilitating access to data could consist of networking and improving existing satellite image grants which some image distribution companies, such as the Canadian Radar Satellite company (RADASAT) offers. Some of these initiatives could be undertaken by end-users themselves; others would require the support of satellite and other industries, even governments. It must be understood that although there will always exist competition between (and among) the space industries, reaching out to new users both in vertical and horizontal access to space applications is beneficial to the industry in its entirety; hence, the need to join forces in the pursuit of such efforts.

III. Innovative Approaches

A number of initiatives fostering further synergies between civil and military applications are under way. In terms of international security, for instance, an organized and annotated collection of satellite images could raise interest and awareness among diplomats, scholars and the general public. Efforts are made to increase the ability of the international community to act in preventive action decisions. Other specific areas of emphasis is an increase in the ability to respond to a number of situations such as in the case of peace operations (peace-keeping deployment, peace-building, refugee assistance, de-mining and other humanitarian aid operations), as well as in post-conflict social and economic reconstruction.

The United Nations is an organization that needs to have its own means of accessing digital data to handled imagery and mapping. A Canadian proposal called Rapid Mapping Project (RAMP) is aimed at precisely this objective.[2] RAMP is directed at providing the United Nations Cartographic Division with state-of-the-art software, an enhanced infrastructure, systems training, technology transfer, and application assistance to meet cartographic requirements.[3] In this spirit, the Cartographic Division is reportedly co-ordinating a project to map Guatemala's land administration requirements using satellite imagery, particularly with RADARSAT images. In another area, such as peace-building, a new Canadian project is being prepared where multi-temporal RADARSAT imagery of the Golan Heights would be used to demonstrate transparency and confidence-building potentials.[4] The idea is to compare 3 to 4 data sets of the area looking for changes over a period of time. Non-intrusive monitoring methods stand a good chance of serving international security on a broader sense.

Regarding the role of UNIDIR, the Institute is undertaking some projects related to all three satellite applications mentioned above. UNIDIR is planing to participate, during the month of June 1997, in a joint Argentina/Uruguay peace-keeping training exercise (CEIBO OPERATION) involving over 800 soldiers and civilians. The operation, which shall take place in Frey Bentos, Rio Negro at the border between Argentina and Uruguay, will provide UNIDIR with the opportunity to distribute 7 books from its *Disarmament and Conflict Resolution* Project to some 200 soldiers and civilians participating in the event. This literature, which consists of analyses of various United Nations Peace Operations, will be used as background material for both the operation and a three-day seminar organized after the operation is completed. A second objective in this co-operation will be to foster a quest in identifying areas where new dedicated peace operations-related devices could be conceived for joint operations, in particular, dedicated integrated geopositioning and two-way mobile communication packages. Special attention will be given to the understanding of how such devices could be conceived in light of specific needs. A third objective will be that of studying the ways in which satellite images (optical and radar), could serve peace

[2] For more information on this Canadian initiative, please refer to Jeffrey Tracey, Trade Commissioner, Market Intelligence Division Space, Geomatics and Advanced Manufacturing Technologies, Department of Foreign Affairs and International Trade, Ottawa. Letter to the author, 20 December 1996.

[3] RAMP Demonstration Project, EOP3 Project Proposal.

[4] Letter to the author by Jeffrey Tracey, *op. Cit.*

operations. The focus here will also be placed on the use of satellite cartography for both the foot soldier and the command staff. A number of recommendations are expected to result from the seminar, of which the results will be brought to the attention of diplomats, academics, and special industries.

Another related UNIDIR project involves the use of satellite images with respect to issues concerning the Middle East Peace Talks within the framework of its project on Confidence-Building Measures in the Middle East. Governments, non-governmental organizations and research institutes are currently trying to introduce innovative ideas which could further the official track of these talks. After the 1991 Madrid Conference, five working groups composed of representatives from a number of Middle Eastern and other States, addressed issues of environment, water resources, refugees, economic development, and arms control and regional security. UNIDIR has launched, in close cooperation with the Institute of Global Mapping and Research (IGM) in Salzburg, Austria, the preparation of an atlas of the region. This Atlas will contain an innovative combination of selected satellite imagery as an explanatory tool of exceptional clarity for addressing (a) the multiple and complex factors in Middle East security and (b) a blend of military and non-military proper issues. All of this with special emphasis on confidence and security-building measures.[5] One innovative feature of this Atlas is that a complete package will include a teacher's guide to facilitate its use in the classroom. UNIDIR is aiming to reach a large audience from the primary school level onwards, including study groups. The following discussion contains a more detailed explanation of the project.

1. THE MIDDLE EAST ATLAS: AN EXAMPLE

The Atlas will be divided into four sections. The first section will introduce the concept of confidence- building in the Middle East, the region involved, and the remote sensing technology utilized. The second section will describe the security issues that exist in the Middle East. This part of the Atlas will illustrate the military potential and strategic depth of the region, various regional organizations, States involved in peace-talks, and bilateral and multilateral agreements. The images will range from 5 kilometres to 2 metres in resolution. Third, the section will focus on the non-military aspects of the region. The geography, population, transportation, natural resources, economies and cultural heritage will be described with images and texts by experts in these fields. Finally, the last section will present Egypt, Iran, Iraq, Israel, Jordan, Lebanon, Saudi Arabia, Syria and Turkey, detailing their political, social, economic and military structures.

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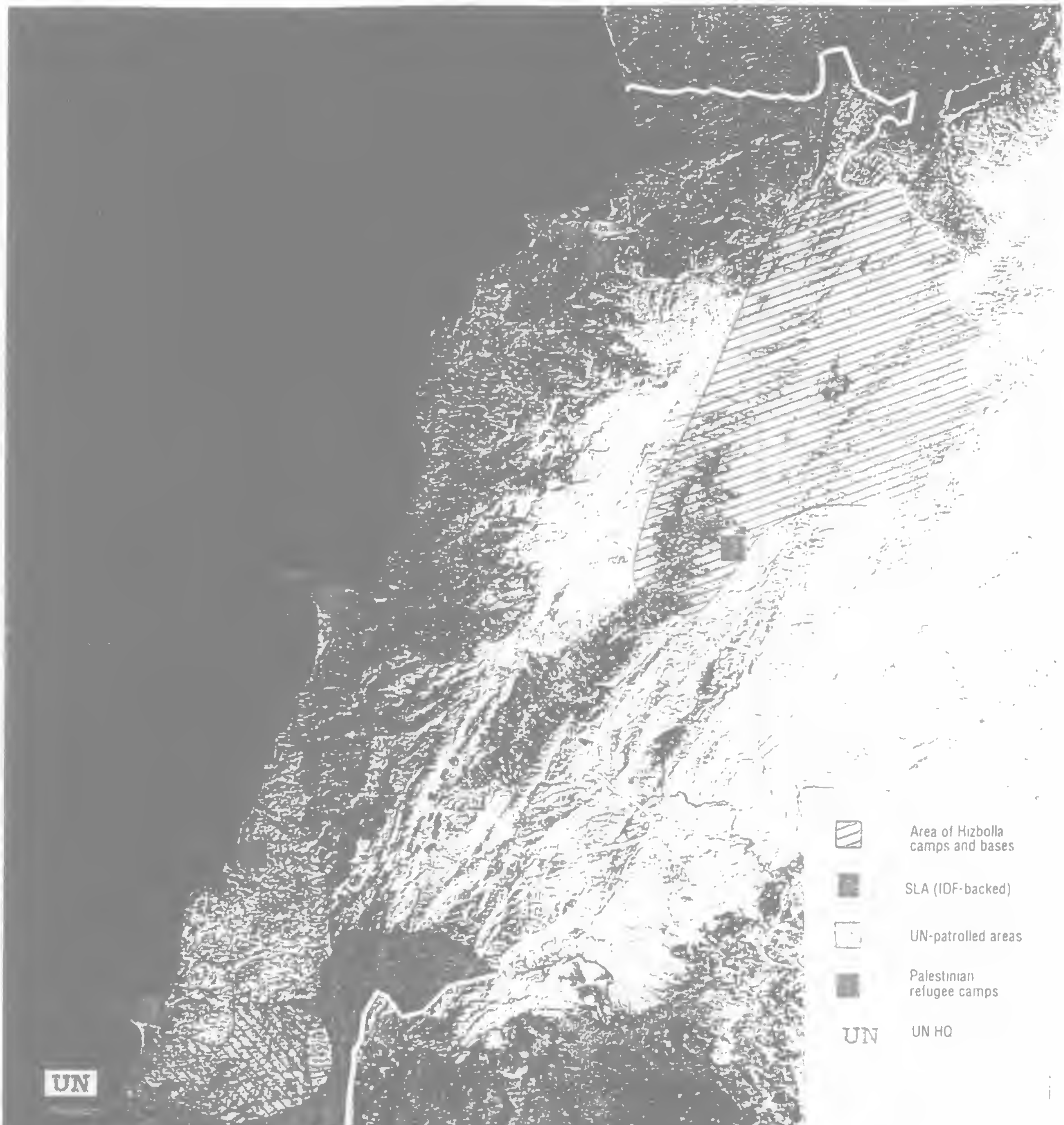
[5] The discretion of the Middle East Atlas in this section was extracted from "Satellite Imagery Serving Peace: The Case of the Middle East: A Preview of UNIDIR's *Confidence Building in the Middle East: A Remote Sensing Resource Atlas*", by Nicole PINTER-KRAINER, UNIDIR *NewsLetter*, n. 96/32, UNIDIR. Nicole Pinter-Krainer is Assistant Editor of *Confidence Building in the Middle East: A Remote Sensing Resource Atlas.*

The utility of satellite images is far-reaching and gives the Atlas its innovative and distinct character. Figures 1 to 4 (following the text) illustrate how satellite images can clarify the analysis of regional conflicts. A view from outer space allows a broader look at the region, highlighting factors which may play a role in peace-talks and which otherwise may not be recognized.

Figure 1 illustrates the utility of satellite imagery for understanding the complex situation in Lebanon. The image shows Lebanon and its borders to the States of Israel and the Syrian Arab Republic. The area of the Hizbolla camps and bases is marked in the northeastern part of Lebanon, stretching from the border with the Syrian Arab Republic southwards through the mountainous landscape, into the Brekaa Valley in the central-eastern part of the country. Within this area of the Hizbolla camps and bases there is a Palestinian refugee camp in Ba'albek. Other Palestinian refugee camps are situated in major cities, such as Tripoli, Beirut, Sidon and Tyre. The area of the Southern Lebanese Army (SLA), which is supported by the Israeli Defense Force (IDF), extends from the Mediterranean Sea along the border with the State of Israel northwards, along the frontier with the Syrian Arab Republic up to the level of Mount Hermon.

Conflict Areas

Lebanon



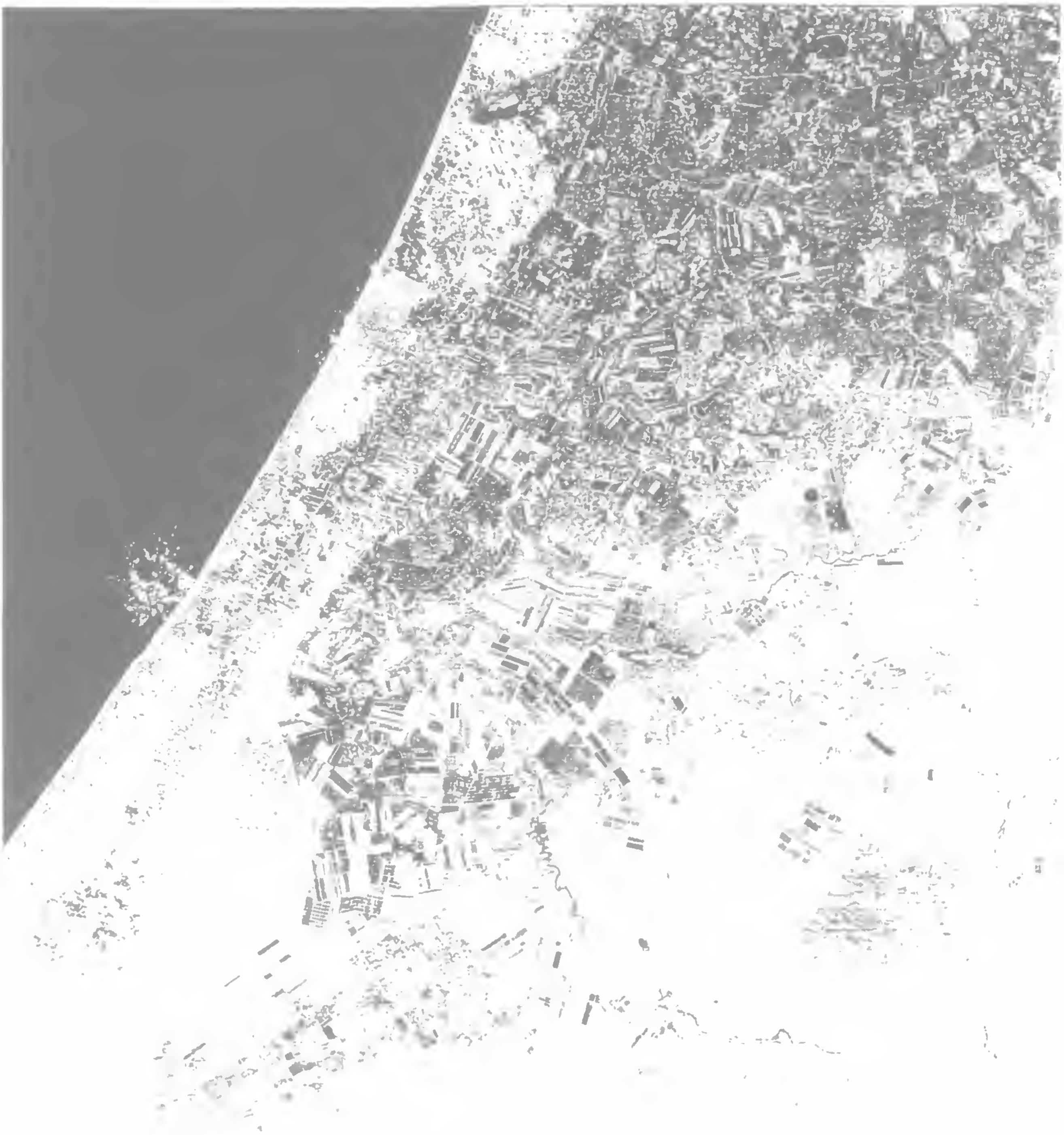
It is remarkable that the two United Nations' patrolled areas both overlap with the section controlled by the IDF-backed SLA. In fact, the northern part of the United Nations area of operation at the border with the Syrian Arab Republic is controlled by the SLA. Also within the SLA-controlled area is the UN headquarters, located in Naquoura. Figure 1 shows the difficulties that the UN forces, namely the United Nations Interim Force in Lebanon (UNIFIL), have to face in Southern Lebanon. UNIFIL was set up in March 1978 with the mandate to confirm the withdrawal of Israeli forces from Southern Lebanon, to restore international peace and security, and to assist the government of Lebanon in ensuring the return of its effective authority in the area. This image illustrates that it has not been possible for UNIFIL to completely carry out its full original mandate and that southern Lebanon remains a region of tension.

Figure 2 shows the Gaza Strip along the coast of the Mediterranean Sea and Israel. In the Gaza Strip, Israeli settlements and refugee camps are visible. Palestinian towns and villages can be seen in the southern part of the Gaza Strip as light grey areas. In the northern part of the Gaza Strip, a light grey concentration of buildings which make up the city of Gaza can be distinguished. The clear division between the Gaza Strip and Israel is the 1950 Armistice Line. This image shows the remarkable difference in size between the areas of cultivation in the Gaza Strip and the ones in Israel. The image illustrates how agriculture is more developed in Israel than in the Gaza Strip. This raises questions about the availability of water for the two areas, especially in the management of fresh water reservoirs, which has had obvious implications in the peace-talks.

Figure 3 demonstrates how population distribution is directly linked to land use and gives a quick glance at settlement throughout Syria. The main population settlements are situated in the northern districts of the Syrian Arab Republic. The northern part of the country is rich in water bodies and, therefore, irrigation and cultivation are easier. The Aleppo district has the largest population. The central part of the Syrian Arab Republic is characterized by desert and steppe and therefore the population density is less than in the north. The south is rich in an intensively cultivated land and is provided with water from the Yarmouk River. The population is relatively small in that area. The distribution of population and land use indicates the importance of the southwestern part of the Syrian Arab Republic, especially Damascus, in terms of Syria's perception of security threats. It is important to note that the population of the country is heavily concentrated in the north, even though the southern region has significant natural resources.

Conflict Areas

Gaza strip and neighbourhood



Syrian Arab Republic

Population - Land use

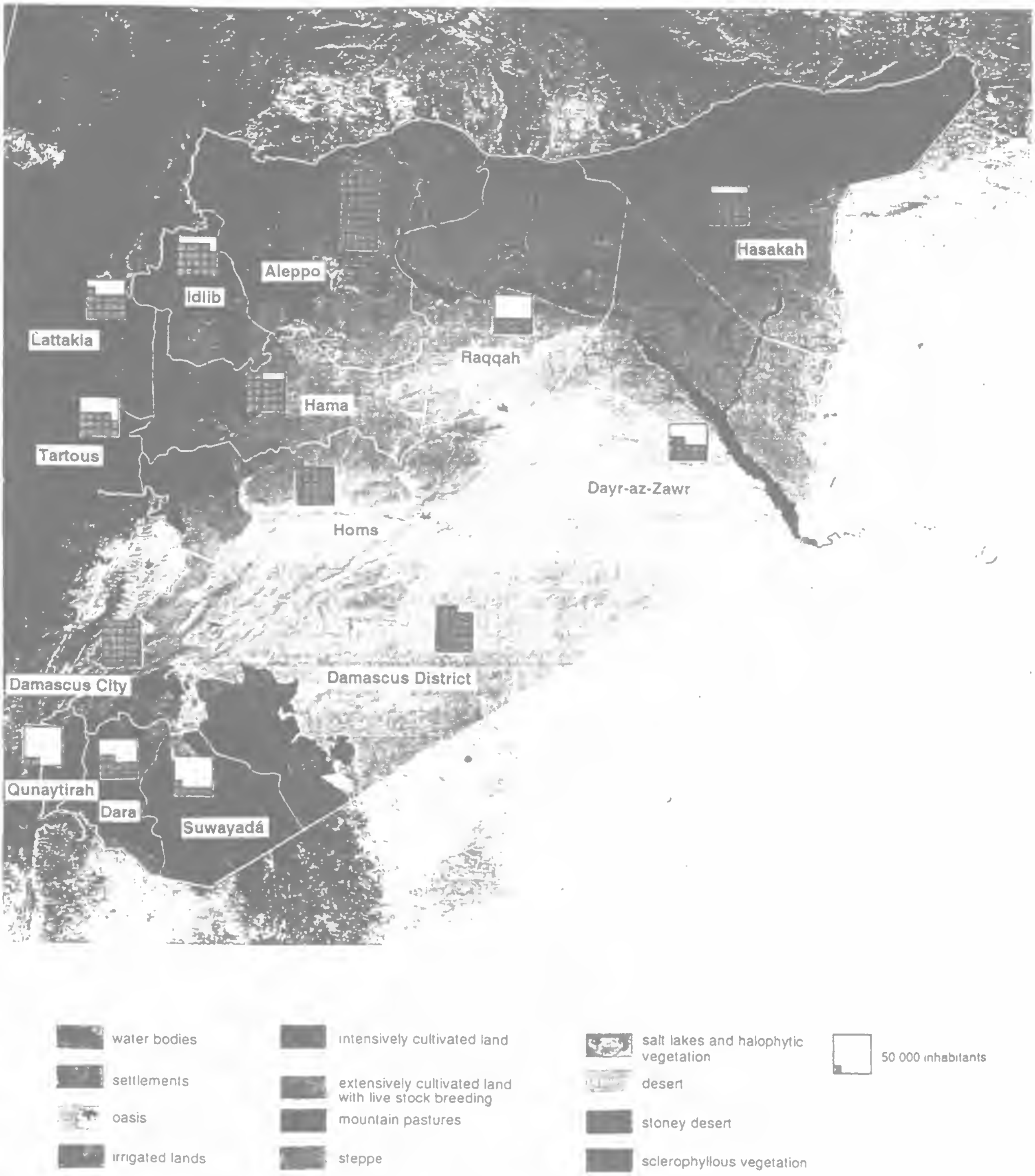


Figure 4, which focuses on the development of the urban environment of Syria, is one of the close-up satellite images from the Atlas. The image shows settlement patterns and infrastructure in Damascus. Other close-up images will concentrate on the areas of Gaza and Jericho. Such satellite imagery could provide a useful tool for planning future development of territories under Palestinian authority.

The Atlas will be produced as a large-format (approx. 27 x 35 cm) book in two bilingual editions (English/German and French/Arabic). A CD-ROM will contain the same images as the bound version of the Atlas, and the reader will be able to focus on particular areas of interest and paste the images into other applications.

The Guide which will be made available along with the Atlas, will present this educational product with the approach of defining terms and suggesting how to use the texts and images. It should comprise of different sections defining how to use the Atlas in the classroom, how to organize and lead discussions in these fora, as well as how to define the level of participants in light of their scholarly backgrounds. The descriptions will also include general explanations of how to interpret satellite images, depicting what can be seen and interpreted from the image, but also defining what is not present, which can also be useful in the overall assessment of situations. A series of questions about the use of imagery and their improved understanding of both military and non-military dimensions of the Middle East Peace Process will also be included. The main focus here will be the tutoring of teachers who have no prior knowledge to the imagery or to the peace-process and the preparation of a course with the Atlas. In addition, an annotated bibliography shall also be included in each section of the Guide.

2. Reaching-out to New Partners

A few national and international institutions such as the satellite industry, governments, and United Nations organs and specialized agencies have an important and central role to play in helping innovation in this field. UNIDIR is aware of this predicament and has started a comprehensive plan of action to inform these different institutions and convince them of the potential innovation in civil/military synergies for satellite applications. Presentations have been made at a few satellite companies. The American Earth Observation Satellite company (EOSAT) is one of UNIDIR's partners in this venture. Given their close association, EOSAT may well bring the Indian satellite industry to co-operate with UNIDIR. The French Earth Observation Satellite company (SPOT Image) has been contacted and may co-operate with UNIDIR. The Canadian RADARSAT company is informed of UNIDIR's projects and has asked to co-operate via the Canadian Ministry of Foreign Affairs. Presentations at space agencies meetings, such as the French Space Agency (CNRS) and the European Space Agency (ESA) are of extreme value since we also have a change to learn more about the concerns of these potential partners. On the industry side, GEOSPACE in Austria has been our main co-operating partner. Other presentations have been made at research institutions such as the security information service ACESS and major networking organizations such as National Geography (NG) and the American Society for Photogrammetry and Remote Sensing (ASPRS).

Urban Environment

Damaskus 1:50 000

Within the framework of the United Nations, UNIDIR has made a presentation at the meeting on *Space Futures and Human Security*, organized by the Albach, Austria on 27-30 January 1997. This meeting gave the opportunity to discuss issues including the quest to specific means of enhancing the active participation of developing countries space in security-related space activities and defining possible co-operative measures to develop new confidence-building measures. Of particular importance was also the fact that this meeting, which was organized by the United Nations Office for Outer Space Affairs in Vienna, addressed issues which will likely be in the agenda of the III United Nations Space (UNSPACE III) conference. The idea that innovation and competitiveness has to be addressed in more detail by suppliers and recipients of satellite technologies, was therefore essential to UNIDIR. This was due particularly to the importance that UNSPACE conferences have in delineating recommendations of major future investments in the area of space applications.

A closer contact of UNIDIR with the space industry is expected to take place at the II Bremen Congress and Exhibition, 14-17 May 1997. It shall provide an opportunity to explore the use of satellite remote sensing and other applications for this and other security related purposes such as in United Nations humanitarian assistance (e.g., with the large movement of refugees, joint mobile communication and positioning in peace operations, etc...). The conference shall also provide an opportunity for a dialogue between users of satellite imagery and the space industry, where user's needs should be clearly presented and evaluated by technology providers. In this context, UNIDIR and the Secretariat of International Decade for Natural Disaster Reduction (IDNDR) shall join forces to identify synergies in their respective projects and needs, so as to optimize United Nations resources, project implementation, and results.

Moreover, UNIDIR also expects that the United Nations Educational, Scientific, and Cultural Organization (UNESCO) can play a role in assisting with the dissemination of the Atlas, but also in providing an open door to a network of potential end-users and institutions worldwide. UNESCO is an ideal platform through which the idea of reaching both pupils, teachers, and their work material could be implemented. Preliminary contacts have already taken place between UNIDIR and UNESCO, and other meetings should follow in the course of 1997.

V. Conclusions: Preparing for the Next Millennium

The idea of hosting a meeting on innovation and competitiveness is both *timely* and *appropriate*. It is *timely* because the end of the century nears, making it is timely to think of innovative programmes which can provide a new vision of development in space applications for the future. The last few years of this century represent therefore a window of opportunity which is unique: taking advantage of this opportunity is not a matter of choice, but of obligation. Hosting this meeting is also *appropriate* because it allows for a critical review of principal achievements in the already 40 years of human development of space applications. It also provides a forum to set priorities which will make tomorrow's space industry more competitive. There is a clear need to undertake such exercises; to analyse the possibilities and constraints of the space industry; and to ascertain which other institutions could join forces to face future challenges in space development.

However, it seems that the space sector, more than any other industry or institution, must first act in developing and implementing a strategy which will foster a new meaning to the use of satellite applications. There can be no half measures, no inhibited initiatives, but comprehensive and determined actions. A firm commitment based on a plan of action for 10-15 years should be developed consisting of identifiable and feasible steps. Several recommendations could be made in this regard, some of which lay the basic foundation for future change:

- ***INCREASING KNOWLEDGE OF THE PRESENT SITUATION:***
  - Undertake a study on the knowledge of end-users related to:
    - what is available today and what shall be in the market on the horizon of the next century, as well as how to use satellite products;
    - what constraints are there in accessing satellite applications and what are the most appropriate means of circumventing them;
  - Identify problem-areas for the use of satellite applications, particularly in regards to synergies between civil and military applications;
  - Identify potential new uses of satellite applications emphasizing educational matters.

- ***MAJOR LONG-TERM OBJECTIVES:***
  - Integrate satellite applications in the preparation of books from primary schools onward;
  - Prepare teachers in using satellite applications;
  - Demystify misperceptions related to the use of satellite applications for security-related purposes, specially regarding peace and other international security operations;
  - Launch a periodical (annually or biannually) meeting in different countries aimed at explaining to the general public what satellite applications can bring to different areas of human development;
  - Create an industry *clearing house* tasked to assist schools, university, international and non-governmental organizations and other institutions on strategic issues related to the assimilation of satellite applications into their work programmes;
  - Support the development of World-Wide-Web database projects using satellite images in view of facilitating synergies between them.

- ***STRUCTURAL AND PROGRAMMATIC ISSUES:***

- •• Build-up on existing structures which associate space industries, experts, and other related potential partners to contribute resources in structuring a *Special Industry-Wide Task Force* to implement such recommendations;
- •• Develop a time-table projecting objectives and targets allowing a momentum to be developed, with building blocks of a five year period which would allow major goals to be accomplished;
- •• Schedule periodical comparative studies aimed at ascertaining the successes and failures of different initiatives.

- ***CONCERNING FINANCIAL ASPECTS:***

  - •• Apply more flexible rules to the use of data, notably supporting joint efforts sharing costs, products, and services;
  - •• Establish major end-user endowments, networked with existing projects, for support of innovative initiatives which further the use of satellite applications with the view of reaching-out to new end-users, particularly at primary and secondary schools;
  - •• Create scholarships for students and teachers who undertake further uses of satellite applications in a scholarly environment;
  - •• Create a worldwide competition aimed at stimulating new ways of using satellite applications;

- ***POTENTIAL PARTNERS:***

The nature of ESA, as a multi state agency, legitimizes it as an organization to pilot such a reorientation towards the focus of a new *culture* of the use of satellite applications. However, such a comprehensive action-oriented agenda cannot be carried-out by ESA alone. It would have to count with the assistance of other institutions such as, *inter alia*:

- •• The space industry as a whole;
- •• National space-related governmental institutions;
- •• National non-space-related governmental institutions involved with educational and other related matters;
- •• Regional institutions such as the European Union;
- •• International and regional organizations such as the United Nations and its specialized agencies, as well as regional security structures.

Ironically, despite the magnitude of such a plan of action, the greatest investment will probably not be of a financial nature, but certainly in terms of changing people's frames of mind and attitudes. There would be a large demand for creativity; an ever growing need for adaptation of new forms of thinking into existing, and sometimes outdated, ways of working. Equally important would be to dare to convince new partners who would otherwise never think of joining forces with the space industry. Considerable determination will be needed to *stay in the course.*

It is worth noting, however, that there is no alternative in sight. On the one hand, maintaining the *status quo* implies widening the gap between a growing untapped end-users potential, while on the other, another growing reservoir of useful satellite applications. Failing to find ways to bridge this gap is a waste of human and material resources that *cannot*, and *must not*, be part of the next 40 years of space development. In contrast, the above strategy to promote innovation and increase competitiveness can provide the space industry with a new vision to enter the next millennium with a strong determination to foster synergies between civil and military space applications.

Broadening Space Utilization through Space Resources Exploitation: The Survival Mode - Why Extraterrestrial Resources Are Necessary

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Abstract

Space activities can only be sustained by changing their orientation from that of a scientific pastime to that of an integral element of the main human activities for addressing major issues such as those related to hosting ten billion people on this planet. There can be no doubt that space can provide the direct resources necessary to this end, that their exploitation is technologically possible, that several strategies to acquire them can be found in the astronautical literature, and that refusing to use space fully will lead to a world with a mortality-aided population stabilization. After summarizing these facts, the paper begins an quantitative assessment of the global needs in the near-21st-century, discussing aggregate metabolic requirements, power generation capabilities, and how well founded is the conventional wisdom that Earth will not needs materials imports before a long time. It is recommended that the ESA support an interdisciplinary research network on the near-term use of extraterrestrial resources.

1. Introduction

1.1 Stalled Space

Space activities can only decline, unless their programs again begin to address the direct needs of society: there lays the true "new applications" specialized agencies have been searching for so long. Such a change of orientation is both necessary and possible - even in the present times, when the predominant ideology highlights the policy of scarcity as the only possible: because, just as humans do metabolize more than information, so does space hold more than immaterial data and events. Thus, space activities would no longer be undertaken as a pastime - however, clever and profitable for some of the participants - but would be integrated in the main current of human activities ***because they serve to address immediate human problems:*** The "old" space players would be in position to take advantage of this broadened and strengthened field of enterprise, but this would be only a spin-off of the main purpose. The intention of the work behind this presentation was to:

- summarize humanity's present and future needs
- show the historical roots for the use of the resources of space
- survey relevant activities in Europe
- discuss needs for, and benefits of, the development of space resources.

While time and resources have not sufficed to cover the whole spectrum of issues, mechanisms to extend the work done up to done will be discussed.

1.2 Economy, Technology, Space

The 10-billion-people world is upon us because, as the saying goes, "the mothers of the next five billions are already walking on this planet." Nor is it in any way useful to haggle about the last digit: maybe, in thirty years, the world population will be of only (!) 9 billions; or maybe it will have reached 11 billions: the situation will be marginally better in the first case, even worse in the second one, but in no way radically different.

Thus, the authentic concern of any human being enjoying a condition that allows him to think about the future, technological innovation, and industrial competitiveness ought to be directed at contributing somehow to the resolution of the largest and unprecedented challenge with which this demographic fact confronts our species. Two elementary pointers to the fact that it is indeed a challenge: today, with roughly half the population, we already observe a growing number of crisis signals -- environmental, economic, political. And, today but for a rather tiny minority, people live in miserable conditions.

Given that space does not figure in the world's plans to master our collective future, which are the projects advanced instead? A rhetorical question, since we all know that the predominant "solution" it the one inspired, entertained, and propagated by the ecozist ideology. How many times has it been repeated, as a mantra, that "a fraction of 1/p of the world population consumes m/n part of the world's resource R"? This statement is made to attribute guilt and to condition the addressees towards accepting the ideologically correct solution: a just redistribution. Yet, that statement by itself proves the infeasibility of the solution: were perfect redistribution implemented (an impossible undertaking in an imperfect world), then all people would have access to R in a quantity of (p.m)/n times that currently available to the privileged (1/p) population fraction. For instance, let us take m=3, n=4, p=5, and thus say that 20% uses 3/4 of the energy: all redistribution could achieve is to force everybody to attempt to live with 26.7% of the mean power level used in the industrialized nations. Furthermore, the riddle is compounded by the population growth, that would force the per capita level down to 16%, and by the fact that - the production level having been assumed constant - any environmental problems that exist would continue unabated (in the example above, the anthropocentric energy use would have actually increased by some 4%). That ecozis are unable to perform even such a simple assessment is a testament to their intellectual integrity.

The only alternative mentioned as "credible" is magic. Clearly, the "redistribution" sacrifice would not be easily accepted. That is why the ecozis and their supporters put much emphasis on the role greed (for power) and stupidity (through waste) play in exacerbating the environmental menaces. Any person who has been in repeated (direct or intellectual) contact with "leaders" - be they in the form of, industrial managers, administration bureaucrats, or politicians - has no reason to doubt how large a role such factors do play in the world's destiny. In facts, they are so widespread that they must be part of nature of our species: therefore - entertaining the thought that said nature, that came to us through a few million years' history, can be changed within what essentially corresponds to a generation - is akin to believing in magic.

The other sort of magical faith is the one that has people thinking that "We have been through that before, and we come out all right" and that "Malthus has been proved wrong once, he will be proved wrong again." Unfortunately, "we" have never been through a crisis like the current one, which differs from any previous one in a qualitative (in addition to quantitative) way. Never before have human problems reached so far or gotten so near to the planetary boundaries. On the other hand, Prometheans do not reject the principle of accessing the resources of space (s.e.g. Bernasconi, 1994): but, apparently, they have been so blinded by the virtual-economy optimism to have lost sight of both the true problem and the extent of the solutions it requires.

Of course, many other illusions are possible, the most simple one consisting in negating the actuality of the problem and arguing that the Earth will never have to support 10 billion people since wars and famines will have greatly reduced the human numbers beforehand. This is indeed possible: but this possibility is part of the problem and not of the solution! And accepting the suppression of a few billions persons as simply an element of a process is so contemptible that it reaches the limits of absurdity. Indeed, most people cannot accept it: and the guilt such "rational analyses" burden them with, actually makes them an easier prey for the ecozist argumentation. The pauperizing and liberticide aspects of the "redistribution" thesis are instinctively associated with the retribution for having potentially attempted to survive under such conditions.

1.3 Broadening Space Utilization

It has been pointed out (s.e.g. Ehricke, 1976; Sheffield, 1986) that at the center of the current crises is the fact that most humans still look at planet Earth as if it were the whole Universe; as we wrote in introducing the Space Option Concept (Bernasconi & Woods, 1993): "While most people do acknowledge - at least on the intellectual level - that the Universe is extremely large, they assume that the relevance of this same Universe for the human affairs is nil." This mind set is far from being alien to contemporary scientists, as pointed out by Lamberti (1989): the opposition by some paleontologists and biologists to the Alvarez hypothesis for the Cretaceous extinction wave can be explained in part by the "unnaturalness" of an asteroid's impact within the Earth's environment: yet, "impacts do happen!"

Table 1 collects a few facts about space: it should not be misunderstood as an advocate's roadmap for the direct acquisition and immediate control of all those potential resources (a sound civilization probably won't need them) nor misconstrued as a believer's statement that all of them can be accessed in the near time (which wouldn't be necessary anyway). It is but a rough instrument for reassessing our perspectives. In this sense, it ought to make clear that the lack of use of the resources of space is also due to the fact that we are looking in the wrong place: low Earth orbits are not only very poor of matter, but also relative deserts in term of power and space! The geocentric perspective extends its damages even through this feeble attempt at using space.

The fascination with the "virtual world" (and this author does spend hours every day connected with Internet) seems to have induce oblivion in many minds to the fact that next century's ten billion humans will continue to require (as all other animal species) real food and living space, as well as they will need real garments, shelters, heating means, and real other commodities. Therefore, any program that undertakes to use the resources of space in providing for any of those real needs will be authentically innovative.

Even within the present-day space community this misconception is widespread, and space is seen as a sort of "extended atmosphere" convenient for parking a few information systems (navigation, communication, meteorology and remote sensing, - s.e.g. Anon, 1997) or as an "astronomy field lab" for collecting science data. Thus, the fact that the Universe does include a few real environments beside those on this planet apparently continues to escape even to those persons that draw daily profit from activities therein.

Table 1: How High the Moon? Perspective on the Resources of Space

Parameter	Earth's Biosphere	Low Earth Orbit	Translunar Space	Geolunar Space	Solar System
Defining distance	10 km	1000 km	400,000 km	$1.5\ 10^6$ km	$6\ 10^9$ km
Volume [10^9 km^3]	5.1	594	$268\ 10^6$	$14.1\ 10^9$	$904\ 10^{18}$
Relative volume	1	116	$52.6\ 10^6$	$2.76\ 10^9$	$177\ 10^{18}$
Solar power flow [TW]	12,800	59,145	$688\ 10^6$	$9.68\ 10^9$	$96.8\ 10^{12}$
Relative Power	1	4.62	53,750	756,250	$7.56\ 10^9$
Matter [10^9 t]	388	~0	7,361,550	~8,000,000	$>2\ 10^{15}$
Rel. Matter Amount	1	0	18,973	~20,000	$>5\ 10^{12}$
Category	Past & Present Arena	Partly in Use	Accessible Arena	Accessible Arena	Future Human Arena

3

2. Historical Background

2.1 Space Resources Utilization

Summaries of the origins and the evolution of the major ideas with regard to human use of space resources, not only in relation with exploration but especially with regard to the Space Option Concept, have been given elsewhere (s.e.g. Bernasconi & Woods, 1993; Hempsell, 1994). Here, only some quotes will be used for showing how deep these roots are. During the 1960s, projected activities in space were a firm component of future-oriented thinking including, e.g., tourism. Thus, Kuhrt (1966) presented a table of 2001 tourist information, reproduced in Fig. 1 (of course, $1250 in 1966 were worth something, about CHF16,000 current): suffice to say that thirty years ago, even the best-tempered skeptics were convinced that space would be widely used and traveled early in the coming century.

DESTINATION	ROUND-TRIP TICKET COST	PASSENGERS PER TRIP	TOTAL TRIP TIME
EARTH ORBIT	$ 1,250	200	24 HR
LUNAR SURFACE	10,000	35	6 DAYS
VENUS	32,000	20	18 MONTHS
MARS	35,000	20	24 MONTHS
MARS EXPRESS	70,000	20	11 MONTHS

Fig. 1: "FY 2001 space tourism information" (from Kuhrt, 1966).

As it has been remarked elsewhere (Bernasconi & Woods, 1993), nobody has expressed better than Krafft Ehricke the rationale, the strategy, and the rewards of a human astronautical program. Fig. 2 (taken from Ehricke, 1966b) illustrates the scope of what could have had such a program: an orbital hospital and the utilization of lunar resources were projected for the mid-1980s, roughly paralleling exploratory missions to Venus and Mars. It may be worth reminding that in those years Ehricke was heavily involved in developing methodologies for space programs planning (s.e.g., Ehricke, 1966a). The analysis of the development logic for using space for the benefit of humanity proceeded apace and ten year later was summarized in a two-dimensional structure reproduced in Fig. 3: the original legend states: "Considerations for a possible 'exploitation' of the Red Planet proceed from a progressive growth of the Martian industry, that closely parallels the technological advances."

Fig. 2 shows that we have wasted a quarter of century, i.e. that the conventional way to do space has frozen development to their early-1970s potential; note, e.g., that even the only "legitimate" program - scientific research - has been stymied to a 1980 condition (since Voyager never flew and its substitute - Viking - was the last major planetary effort, clearly no "advanced planetary probes" nor "outer solar system Voyagers" have been realized, nor have asteroid and comet missions been very numerous) or, more optimistically, to mid-1980s.

Finally, only five of the fifteen fields in Fig. 3 have been covered, only for the Moon, a situation that has remained unchanged for twenty-five years. Even such capabilities are no longer available off-the-shelf. Not a single factual step has been taken towards the utilization of planetary resources.

It could be comforting if such lack of progress could be ascribed to the availability of superior choices elsewhere or to the technical impossibility of the objectives traced so long ago; even better, if we could indeed afford to be lazy because those resources are not needed. Unfortunately, this is not true. And Ehricke (1977) went beyond the simple analysis of technical strategies, studying the consequences of not acquiring the capabilities of the extraterrestrial imperative (Fig. 4), and showing how the choice to corral humanity within a single planet would lead to a "mortality-aided" adaptation of the population to available resources.

The most concrete proposal on the path of human expansion into space and for the use of space resources has centered around the provision of power via a space (solar) power satellite (S(S)PS) system, concept that has been presented as a coherent approach with the use of lunar materials by O'Neill (1975). Nonetheless, a number a misconceptions seem to have collected around the SPS idea. The first is, of cause, that an SPS would call for a very large cargo traffic out of

Earth, has discussed in the reference design of the NASA/ DOE study and evaluation program at the end of the 1970s. This excessive focusing on the reference design may be connected with the "mission" philosophy ingrained in the Agencies' thinking: anyway, by now it has been established that a very large fraction (e.g., more than 99% according to DuBose and co-workers, 1986) of the materials for the SPS can be of lunar origin and any sensible discussion ought to proceed from there.

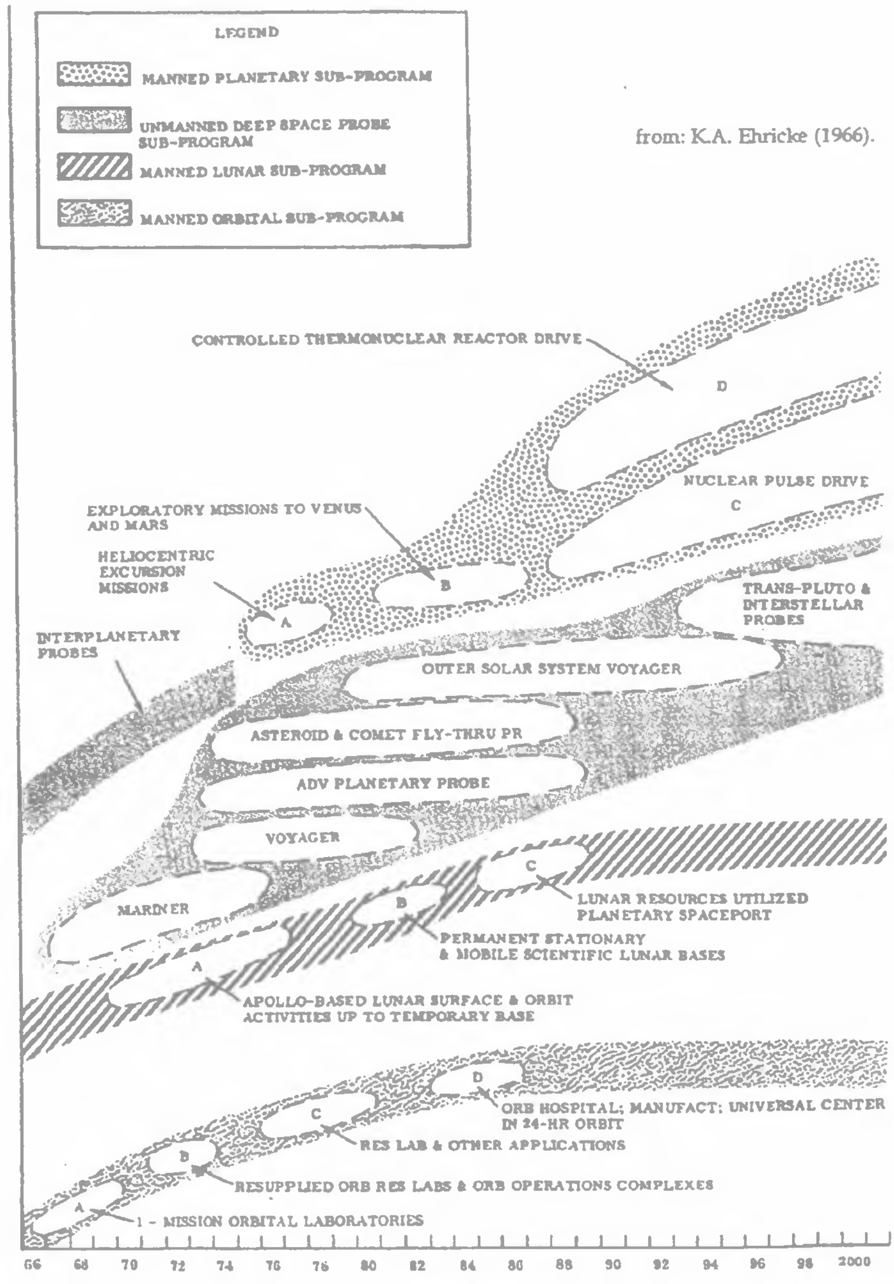

Fig. 2: "Overview of the evolution of space flight to FY 2001" (from Ehricke, 1966b).

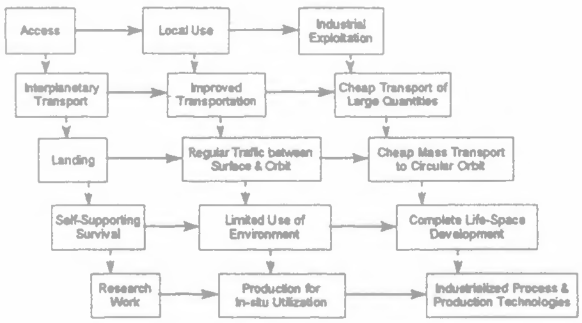

Fig. 3: Considerations for a possible "exploitation" of planetary resources (after Ehricke, 1976).

As second misunderstanding is behind the critique that energy is the only valuable product that can be obtained from space industrialization etc. Not only this is, strictly speaking, false but energy tends to dominate the discourse about using extraterrestrial resources simply as a consequence of its actual economic and social predominance: on the terrestrial end too, much more effort goes in the discussion about, and the fight for, obtaining sufficient, secure, and environmentally compatible means for power generation. Any enterprise for providing power from space would have as direct consequences the creation of an infrastructure enabling additional products to be obtained from space and the substitution of ground installations with space-based plants, to take advantage of the proximity to the power stations. This movement would yield a set of new "negative" or "anti-"products, i.e. the removal from the biosphere of pollution and the decrease of the Earth-side power requirements.

A gradual strategy has been outlined by Ehricke (1980), referring to the near-term space contributions to the energy supply as "assist opportunities" articulated among:

- conservation assistance (communication satellites: teleconferencing, telecommuting -- ">1983"; space processing: large-crystal rectifiers (lower transmission losses), high-temperature turbine blades (higher Carnot efficiency), homogeneous carbides & metal oxides (longer-life components) -- ">1985")
- fossil option support (Earth observation systems: topographic mapping -- ">1984")
- nuclear option support (space NWD -- ">1985")
- space light (orbiting reflector systems for illumination, "Lunetta" -- ">1986")

As the dates given in parentheses show, the power of inaction has been very effective also in years more recent than the 1960s! In parallel with the above activities, the development and test of various electromagnetic power transmission methods was to make possible to obtain increasing amounts of power from space after 2000; "Soletta" orbital reflectors for support ground-based photovoltaic power stations were seen to come on line during the 1990s.

Several authors (Woodcock, 1972; Ehricke, 1980) have underlined the particular significance of nuclear wastes disposal in space, particularly with respect to the economic attractiveness of such operations. It can therefore tempting to argue that innovative, energy-assist actions begin with nuclear waste disposal: the needed technological element for this is a reliable, lower-cost transportation system. In parallel, space light applications are established, through development of (i) solar sail systems (large structures, reflector membranes, attitude/ orbit determination & control), then (ii) Lunetta systems (increase in power handled, Earthwards applications), (iii) Soletta systems (further increase in size and power). There is however no reason that these activities cannot be paralleled by space power systems developments, consisting of (i) technology demonstrators, (ii) powersats for inter-orbit power supply (0.1-0.5 MW), followed by (iii) operational demonstrators (1 - 5 MW).

Key to any further progress is, however, the establishment of lunar development and engineering research facilities.

2.2 European Activities

While a fair amount of focused investigations on the utilization of space resources has been undertaken in the U.S. and, more recently, in Japan, the field has been largely neglected in Europe. Only very few activities are based here:

- the Center for Space Industrialization Research (Lisbon, Portugal)
- the "Olivier Pocé" research group (Amboise, France)
- The OURS Foundation Space Option Concept work (Embrach, Switzerland).

Some consistent work has been done at the University level, in particular at Bremen, Germany (Prof. U. Apel), and at of Bristol, U.K. (C.M. Hempsell). A number of research episodes have occurred in the past, again especially in Germany and in the U.K., or with ESA support; here one may mention:

- lunar exploitation aspects (Dr. Parkinson, Dr. Sheppard, Lyonnet du Moutier) lunox production (DLR)
- nuclear waste disposal (Dornier; TUM)
- space power systems development, issues, energy analyses (ESTEC, TUB, Eurospace, TUM, SEE); strategic options (Parkinson, Martin); GSEK - the general system energy concept (BMFT/ ERNO)
- space tourism (Ashford, Dr. Collins, Dr. Koelle)

Some other studies touched at least incidentally on the potential of space resources, e.g.: the EMSI study (under ERNO leadership), the DLR SAPHIR study, and the LSPC work (that has acknowledged their relationship to global problems). None of the above is an on-going activity, however. Finally, it ought to be mentioned that a limited number of activities are undertaken by international organizations, e.g. by:

- the IAA Committee on Economics in Space Operations (with direct interests on new uses of space and extraterrestrial resources)
- the IAA Committee on Space Activities and Society (addresses global issues, also beyond mere techno-economic considerations, and strategic planning)
- the IAF Power Committee (a general technology body, but gives some attention to SPS)
- the IAA Committee on Space Policy (covers only some aspects, as part of the discussion of the rationale for future space activities).

However, these activities are largely limited to conferences and are global in scope, thus contributing but little to furthering the discourse in the European context.

3. Assessment of Needs

3.1 Population & Food

Food is second basic resource (after drinking water) mandatorily needed by all human beings: while there are uncertainties over the *exact* energy intake necessary for each person, and even wider disputes around the ideal breakdown of that intake among various nutritional categories, a starting point is given by the FAO recommendations. Converting those values into equivalent average power, one arrives to about 0.13 kW/person (corresponding to 11.2 MJ/day or to less than 2700 of the old Calories). Since about 80% of the human nutriment is of vegetable origin (Czihak, Langer, & Ziegler, 1976), the equivalent power consumed by 10 billion people is of 1.3 TW, of which:

- 1.04 TW from vegetables
- 0.26 TW from animals.

The production and power levels in the biosphere are summarized in Table 3, while Table 4 details the equivalent power flows for the primary producers (photosynthetic plants), the primary consumers (herbivores), secondary consumers (predatory carnivores), and the tertiary consumers (second-order carnivores).

Finally, Table 5 joins these data to those of the human metabolic needs indicating the large role mere human feeding is assuming in the economy of the biosphere. The values have been obtained under following assumptions: (a) alimentarily usable fraction of the gross production, 50%, for all trophic planes; (b) 80% of the animal-origin food stuff from herbivores, the balance (or 4% of the total intake) from first-order carnivores. Those percentages are to be considered optimistic (i.e. low) figures for a number of reasons: (i) the ecological efficiency between trophic planes is generally lower than the values used here (which are those of the classic Silver Springs (Fl.) ecosystem); (ii) human corpses are usually not made available to carnivores of second or higher order, fact that increases the sequestration of the corresponding nutritional power; finally, (iii) neither losses, waste, or spoilage have been assumed in the calculation.

Table 3: Biosphere Production

	Surface 10^6 km^2	Primary Biomass Production 10^9 t/a	Bound Organic Carbon 10^9 t/a	Equiv. Power TW
Land	149	108	50	68
Oceans	361	55	25	34
Total	510	165	75	102

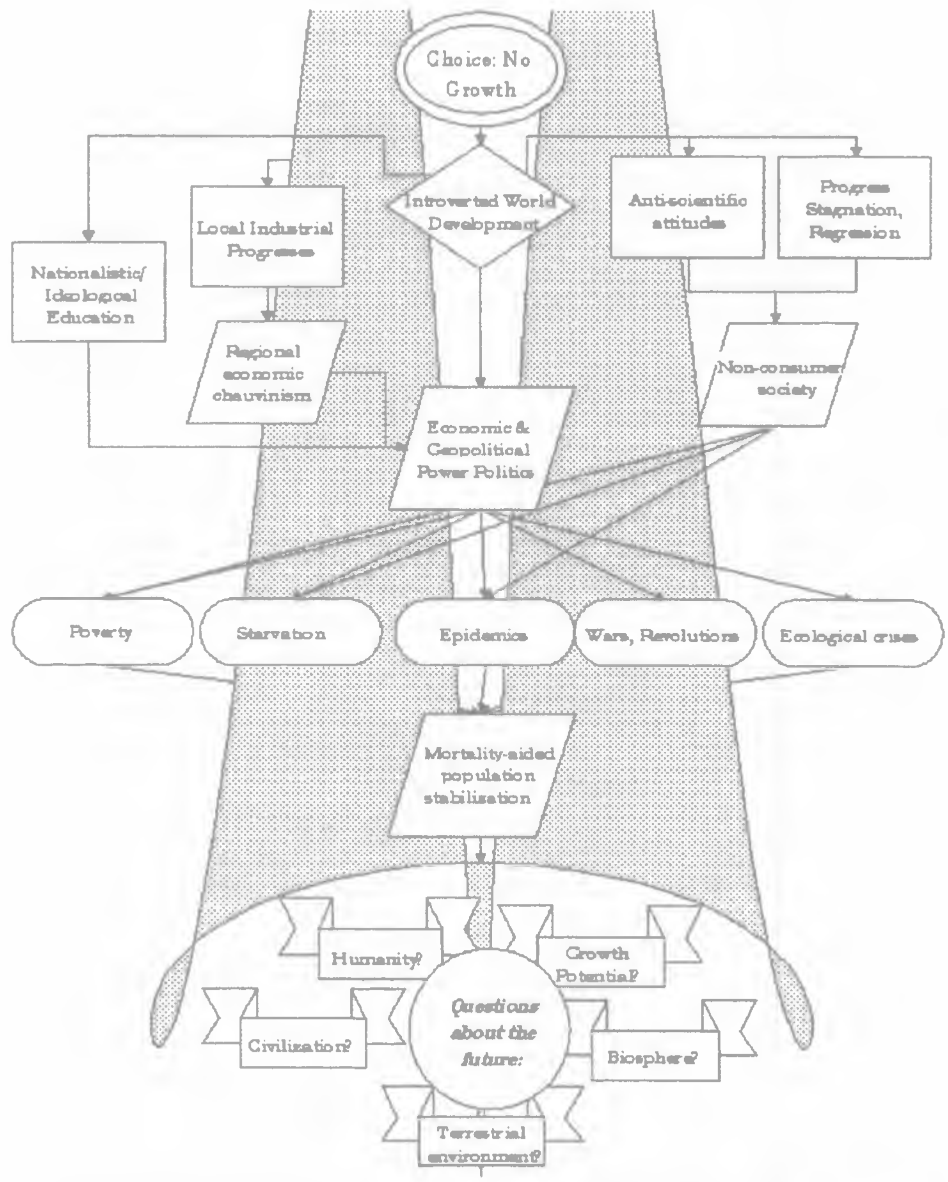

Fig. 4: Questions about the future raised by the no-growth choice (after Ehricke, 1977).

Table 4: Ecological Efficiency & Consumers Production

	Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Ecological efficiency	-	16%	11%	5.3%
Land ecosystems	68 TW	10.9 TW	1.24 TW	0.07 TW
Oceanic ecosystems	34 TW	5.5 TW	0.62 TW	0.03 TW
Biosphere Total	102 TW	16.4 TW	1.86 TW	0.10 TW

Table 5: Relative Human Collective Metabolic Power Fluxes

Supply of	Primary Consumers	Secondary Consumers	Tertiary Consumers	Primary Producers
Land ecosystem	3.1%	3.8%	8.4%	15.2%
Biosphere Total	2.0%	2.5%	5.6%	10.1%

Cornucopians and friends like to argue with positive historical trends to downplay the need for acquiring the resources of space. For instance, Smil (1987) points to the unbroken trend for higher specific wheat yields: the best result has been achieved in the Netherlands, where the 1980 value was around 6 t/ha: 0.6 kg/m^2. With an energy content of roughly 15 MJ/kg, this means some 0.285 W/m^2 for feeding humans; further, if one assumes that the grains mass 50% of the biomass and knowing that the photosynthesis' efficiency is of 1%, the Dutch field arrives at a power extraction of 57 W/m^2.

Can we improve on this? The Earth surface (5.1 10^{14} m^{2}) receives some 102,000 TW of solar power, i.e. an average of 200 W/m^2: a factor of 3.5 would thus be - theoretically - possible, without speaking of a further factor of 2 if one could transform the whole plant into edible parts; this last step, requiring as it does a massive change in the plant's characteristics, would calls for the application of genetic engineering techniques. Such techniques are not available today, and are currently strongly opposed just by the ecozist ideologists. The Dutch power-extraction rate, if sustained over the whole surface of the planet, would yield food equivalent to 145 TW/a -- an impressive figure indeed, since the actual overall biomass production is about half that. The conclusion is therefore that all the hard-working Dutch farmers have achieved over the space of a century is a factor-of-two improvement over the nature's *average*, for a specific crop and under highly controlled conditions. The progress is put under a more realistic light if one observes that the worldwide historical value (i.e. pre-1960) is roughly an order of magnitude lower, i.e. some 20% of the "natural" power extraction. And, with due respect, what has been done was the easy part.

Looking at the issue from yet another angle, if the whole Earth's surface under cultivation were made as productive as the netherlandian fields, to feed with grains the omnivore primates of our own species, we would have to claim at least 3% of the total land surface; at least 6% would be necessary for a more balanced diet for ten billion people. In fact, such an amount of agricultural land is available today showing how far we still are from such perfection.

But we have not argued that space must be acquired for food production (not yet). Power for non-metabolic uses is far more significant. And a very significant power investment is the one needed to obtain food: Table 6 is adapted from the extensive historical analysis of Smil (1990). It can be seen how the agricultural technology has been important for supporting an increasing population density: but one can also see how large the energy subsidy has become in modern times, and that currently amounts to more than half the recommended nutritional energy level.

It is only through this energy subsidy that the Malthusian predictions have not come to pass (Fig. 5); "without energy subsidies the perpetuation of average 1900 yields on a slowly rising cultivated area could support less than 2.5 billion people by 1985; return to the overwhelming solar farming of the late nineteenth century would result in halving the world's population" (Smil 1990). More to the point, the impossibility to provide such subsidies would cause the elimination of 75% of the human population during the next thirty years.

Table 6: Energy in Food Provision
(after Smil, 1990)

Society Form	Energy Input [GJ/ha]	Food Harvest [GJ/ha]	Population Density [person/km^2]	Power [W/person]
Foraging	.001	.005	0.01	320
Pastoralism	.01	.04	1	32
Shifting agriculture	1	17	42	77
Traditional farming	1.3	23	545	8
Modern agriculture	33	65	1550	68

Thus the subsidy (equivalent to 380 GW, or 65 W/person) would have to increase to more than 630 GW to support the expected world population -- under the assumption of a *constant* per capita investment. However, since it does not seem likely that the agricultural land surface can be increased by 70% (and that within a thirty-odd years) and given that the power subsidy per person has been multiplied by eight while the population supported per unit surface increased three-fold (Table 6), it can be inferred that the actual subsidy may be even four times larger, and reach 2.5 TW. At such a stage, the energy subsidy for food provisioning would have grown larger that the food's energy content, justifying a posteriori the earlier, inchoate dreams of synthetizing food industrially, as a more efficient means to support a large population. What such reflections clearly fail to substantiate is that the person-specific energy use in the next century can fall back to preindustrial times, and that power rationing is a better strategy than the acquisition of new power sources.

Food - Conclusions

In conclusion, even ten billion humans ought to find it rather easy to provide enough food for themselves (Table 5), but they have to become conscious that the impact on the "natural world" will assuredly be very large, given that a single species is sequestering a very minimum of a tenth of the whole biosphere's resources for itself. And those are indeed optimistic figures since, in contrast with other animals, humans require fuel for cooking their food, for heating and for lighting their dwellings; furthermore, they need shoes and garments, and their shelters also require non-negligible biomass investments. That only a fairly advanced technological base can provide for these needs by substituting materials other than of biological origin is made obvious by the consideration that the use of such resources for these purposes was predominant throughout the world until early in this last century.

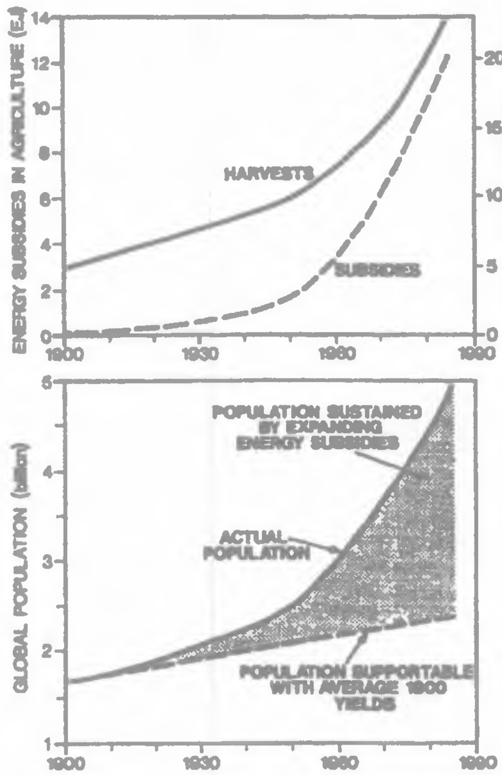

Fig. 5: Importance of agricultural energy subsidies to support the human population (from Smil, 1990)

Some may find comfort in the fact that the above order-of-magnitude analysis shows that some 100 billion humans could be fed by the Earth's biosphere, possible even 25% more is they could be transformed into herbivores, but clearly not the author. There does not seen to be any rationale for piling 10 billion people onto this planet and keeping them there in captivity - ten times greater numbers would definitely be an abomination - but the simple fact is that soon there will be that many, and provisions have to be made for this fact. (Discussion of the economy of cannibalism is left for a later paper, but it does not seem a method with a significant potential for solving the issue.)

The preservation of biodiversity is in conflict with an Earth-dependent human population in the billion range: if one refers to Tables 3 and 6, one can see that the "natural" human world population seems to be of about 2 million, increasing by two orders of magnitude by the adoption of a pastural economy. The introduction of agricultural technology begins a growing interference with the environment, which is made always larger the higher the yield must become in what has been a positive feedback between productivity and population. (Today, that feedback seems broken in that the population growth occurs faster that the agricultural technology can enable it.)

Space food production will *not* yet be *a necessity* in the 21st century: but clearly, any concrete (i.e. not merely informational) support from outside the biosphere will be beneficial in reducing both the need for agricultural land and in removing from the biosphere the effects of the associated energy subsidies that may be four times as large as the metabolic power yield in form of food.

3.2 Energy for Growth?

Energy *use* directed to the benefits of the user (i.e. in an entropy-decreasing fashion) is the most intimate characteristic of *life*. It must, therefore, tax the understanding of many that nowadays a sort of holy war is been waged to reduce human energy usage. The survival of man, and in particular the survival of billions of persons now abroad on this planet, is strictly dependent from exosomatic implements that today are collectively referred to as "technology." While these implements are, clearly, not alive, it is just as clear that their function is (largely) entropy-decreasing, and that therefore they require energy to serve their purposes. Thus, energy is so central among the needs of humanity that at times it may appear as if an excessive attention is given to this issue, both in the general discussion and in the context of the space resources research: but materials may be replaced, substituted or recycled, energy can only be substituted by another form of energy, and it cannot be recycled.

Ten billion people need 70 - 140 TW of thermal power or equivalent, i.e. around 0.1% of the total incoming solar radiation, a flux level that on a local scale seems to be enough to trigger major weather phenomena (Rasool, 1994). The *net* power used could be reduced through electrification -- but this can only mean something if the power station is located outside the biosphere! Were this the case, we would need to import only 25 - 35 TW of electricity, requiring rectenna surfaces in the range of 0.025-0.07% of the Earth surface. Under those transparent rectennae, between 2.8-7.8% of the world's vegetable food could be grown. And this demonstrates, once again, the efficiency and the small impact of the Space Option for supplying the power needed in the near future.

Indeed, many authors have fallen in this trap, to consider the environmental impact of power generating systems from a mere global thermal perspective, reasoning that to reject 0.1% more power a body like Earth needs only to increase its average temperature by 0.1°C. That average temperatures, however, do not mean too much, is demonstrated by the role that the vegetation cover can (and does) play in modulating the weather: again, these modulations are quite tiny on a global scale, but can be extremely significant on a biospheric, and even more human scale.

At its heart, the argument for power from space is quite straightforward:

I) No other source can provide the amplitude and the duration of power supply needed by the

21st-century humanity with sufficient margin to deal with uncertainties of demand and supply (s.e.g., Criswell, 1984, 1994).

II) Most of those sources that come near to cover the projected demands are associated with heavy, and therefore hardly acceptable on an overpopulated planet, direct environmental disturbances: under this category fall, e.g., coal and nuclear power.

III) Those sources that may come near to cover projected demands with reduced environmental impacts are burdened with the need for large energy investments for their realization; also, their energy payback is modest. Ground-based photovoltaics are the banner case here; OTEC (ocean thermal energy conversion) suffers of similar issues. The best renewable energy source is hydropower, both because of relatively slight environmental damage and of excellent payback rates: hydropower is far from coming anywhere near the needed power generation requirements, however.

IV) Given that all power sources impose a thermal burden on the biosphere, space-based systems have the smallest one. Previous analyses have shown (Bernasconi, 1994) that all major power generation processes but space power and hydropower release into the biosphere more than twice the amount of useful energy they yield.

V) There is no factual basis to expect that the per capita power usage can decrease radically (i.e. by a factor of two or more) without causing widespread impoverishment. Often, much is made of historical trends showing an increasing efficiency in the use of energy to generate wealth, in the form of GNP units. This sort of functions usually tend to an asymptotic behaviour after a while, and the data presented by their supporters show that this correlation is not an exception: it appears that said asymptote is only some 30% below the current value. Given that one of the more reasonable criticism to GNP as a measure of national wealth is that it includes acritically the "hot air" turnover of speculative finances &c, one has to wonder how much of the recent data are in truth artifacts resulting from such phenomena. Furthermore, some economic growth (however modest) seems to be necessary: but a 0.8% annual GNP increase would fully suffice to compensate the motion down to the asymptote in terms of per capita energy usage.

(VI) If the above fact were to be neglected and an energy-use "redistribution" program attempted (and even if such an action were materially successful), the environmental burden would continue unabated, and would actually increase with the increase of world population.

The literature about the role of space industrialization and extraterrestrial resources in providing the energy flow necessary for a sensible standard of living into the next century is already fairly extensive and growing: it covers not only systems directly delivering power to Earth, but also ranges from offering "assistance" to ground-based power generation systems to producing or extracting high-enthalpy "fuels" to beginning to assess the potential impact of this part of the Space Option on the global socio-political developments and on the environment.

Power - Conclusions

The least that can be said is that space power generation offers the best possibility to obtain energy for human use in sufficient quantities, with the least environmental impact: actually, it will reduce the pollution levels, as industrial activities increasingly move nearer to the power stations, and therefore out of the biosphere. Energy-related space activities can truly contribute to the solution of the current and coming environmental crises and of the dilemma to obtain sufficient power while minimizing the negative social impacts of any restrictive policy: they can achieve this without having to change human nature, without the development of new technologies, and without invoking magics.

3.3 Materials

A chestnut more than thirty-years old states that nothing material is worth enough to be brought from space to Earth. An answer to this argument was given by Wheaton (1966): terrestrial resources may be easier to reach, but they are already owned by someone. When the world will be confronted with scarcity, the risk of conflicts for those limited resources will rapidly increase. The standard Cornucopian reply to this is that scarcity shall not arise because it never has in the past; of cause, ecozist philosophy asserts we have to make do with less.

An often-quoted paper on the subject of the future availability of nonrenewable materials is that by Goeller & Zucker (1984). However, that paper draws conclusions that are largely not substantiated by the data. Of sixty-six elements surveyed, Goeller & Zucker (1984) assess that twenty-nine will be depleted by more than 100% in 2100, and only fourteen by less than 10%. Extended resources are then invoked, and for four elements the depletion rate is estimated to fall below 10%; for no less than fifteen elements, however, the depletion remains greater than 100% or is simply not updated. In summary, in only about 29% of the cases, the situation seems unproblematic (<10% depletion), in 48% it may well be critical (>10%), and for 23% of the elements it will impossible (>100% depletion). This forces the authors to state "many important elements will be in inadequate supply" -- how can one then conclude ny affirming that "shortages will be at most only transient events and ... [the] population will not be ... impoverished by the lack of materials"?

How sensible the consideration of extraterrestrial resources has become is further evidenced by the type of "extended resources" that are successful in avoiding depletion for fifteen elements: in all cases, low-grade ores or seafloor nodules are invoked. Mining such materials is within the biosphere is sure to be associated with large environmental risks, with correspondingly high costs. Goeller & Zucker (1984) further estimated that about $100 billion/year would have to be invested over the next century, to make their predictions reality. Since many of the necessary processes have to be acquired in any case, clearly this market size enables some learning curves in space mining, particularly once it is understood that shortages can thus be truly eliminated and environmental burdens are removed from the biosphere.

4. Recommendations: A European core activity

In Europe, research work about the acquisition and utilization of extraterrestrial resources has been left to the initiative of a few pioneers, exposed to an extremely harsh cultural environment. Lulled by their socio-economic achievements, European are not simply indifferent or skeptical about this theme, they actually often resist its discussion. Since a serious research program has to go beyond the standardized definition of technology and missions, and be instead authentically interdisciplinary, the chances that such a program arises are next to zero.

Within the framework of activities for furthering innovations in space and the continental competitiveness in general, it is strongly recommended that ESA initiates a gradual program on the utilization of extraterrestrial resources. The first step would be to enable active researchers to build a network for outlining a consistent set of activities and initiatives. True interdisciplinary work means that the network participants ought to include futures researchers, economists, sociologists, and other specialties besides conventional space institutes.

Such an activity, even if seen from a mainstream perspective as "long-term," is surely no less remote from industrial and social returns than most of the science initiatives currently undertaken.

5. Conclusions

The daily preoccupation of a large fraction of humanity are still centered on food and shelter; even in the industrialized countries, resources scarcity and environmental damages are issues of increasing concerns. In the coming ten-billion-people world these problems will be magnified to dangerous levels, unless timely action is taken to eliminate the "need for scarcity," and this is only possible by opening the human economic arena into space, by accessing an using extraterrestrial resources.

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References

Anon (1997). Preliminary Program for the ESA International Workshop on Innovations for Competitiveness. ESTEC flyer.

Marco C. Bernasconi (1994a). The Space Option & Our Future: Some Considerations on the Thermal Burden. Paper presented at the BIS *Symposium on Space Industrialization as a Response to Global Threats*, London (UK), 23 June.

Marco C. Bernasconi (1994b). Humanity Facing the Future: A Role for Astronautics? Paper *IAA-94-IAA.8.1.708*.

Marco C. Bernasconi and Arthur R. Woods (1993). Implementing the Space Option: Elaboration and Dissemination of a New Rationale for Space / Part II: The Space Option. Paper *IAA.8.1-93-764b*.

D.R. Criswell (1984). Cislunar Industrialization & Higher Human Options. Paper *IAF-84-313*.

D.R. Criswell (1994). Net Growth in the Two-Planet Economy. Paper *IAA-94-IAA.8.1.704*.

G. Czihak, H. Langer, & H. Ziegler, Eds. (1976). Biologie - Ein Lehrbuch. 4th edition (1990), Springer-Verlag, Berlin/ Heidelberg, p. 823.

Paul DuBose, Dani Eder, Scott Finfrock & alii (1986). Solar Power Satellite Built of Lunar Materials. *Space Power* 6[01], 1-98.

K.A. Ehricke (1966a). Future Missions. *Annals NY Academy of Sciences* **140**, 496-585.

K.A. Ehricke (1966b). Solar Transportation. *AAS Space Technology Series* **10** (1967), 156-249.

K.A. Ehricke (1976). The Exploitation of the Red Planet. In: E. Stuhlinger, Ed. Project Viking - The Conquest of Mars (in German). Kiepenheuer & Witsch, Cologne (Germany), 131-153.

K.A. Ehricke (1977). The Extraterrestrial Imperative. (Unpublished)

K.A. Ehricke (1980). The Extraterrestrial Imperative - Part 3: New Earth-Space Energy Metabolism. *JBIS* **33**, 379-390.

R. Flindt (1983). Biology in Numbers (in German).

H.E. Goeller & A. Zucker (1984). Infinite Resources: The Ultimate Strategy. *Science* **223**, 456-462.

C.M. Hempsell (1994). A Comparison of Modelling Techniques for Long Term Space Infrastructure Planning. Paper *IAA-94-IAA.8.1.705*.

W.A. Kuhrt (1966). Propulsion. *AAS Space Technology Series* **10** (1967), 22-38.

C. Lamberti (1989). But Asteroids Do Impact! (in Italian). *L'astronomia* XI[84], 23.

G.K. O'Neill (1975). Space Colonies & Energy Supply to the Earth. *Science* **190**, 943-947.

J. Rasool (1994). Earth Observation from the Moon. Paper presented at the *International Lunar Workshop*, Beatenberg (Switzerland), 31 May-3 June.

C. Sheffield (1986). On Timeline Singularities, Space, & Human History. *Far Frontiers* **VII**, 2-19.

V. Smil (1987). Energy - Food - Environment. Clarendon Press, Oxford (UK).

V. Smil (1990). General Energetics. Wiley, New York / Chichester.

E.P. Wheaton (1966), Space Commerce. *AAS Space Technology Series* **10** (1967), 340-358.

G.R. Woodcock (1972). On the Economics of Space Utilization. *Raumfahrtforschung* 17[03] (1973), 135-146.

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ADVANCED SPACE APPLICATIONS: HOW CREDIBLE?

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ABSTRACT

Space exploration is such a demanding enterprise that international cooperation seems to be the only viable approach to open up the path to human expansion in our solar system.

In fact, space is rich in knowledge and resources to be discovered and utilized for the benefit of mankind, but organic and global plans have to be conceived taking into account a wide range of aspects, from the identification of the mission goals to the definition of the overall mission architecture, and from the establishment of coherent development plans to the critical evaluation of programmatic aspects.

In recent years, many discussions and analyses of the subject have been performed by the major spacefaring countries, and appealing mission scenarios have been presented.

Why does it seem to be so difficult to move from the analysis to the implementation of the proposed missions? What are the stoppers? What do we lack?

This paper will try to present a critical analysis of the major factors to be considered when planning for space resource exploration and exploitation, trying to identify the critical areas for further study and research.

When planning for ambitious future space missions, the different space agencies, in addition to budget constraints, have to cope with conflicts of interest driven by more commercial space applications that offer more immediate economic return like new transportation systems, advanced communication satellites, and Earth observation.

To sustain and motivate credible space exploration scenarios, a new cooperative approach will have to be developed, promoting the coordination level between the potential partners in front of the research plan elaboration by the individual agencies.

The International Mars Exploration Working Group (IMEWG) and the International Lunar Exploration Working Group (ILEWG) constitute an initial step in this direction.

1.0 INTRODUCTION

The historical events of recent years have not only deeply influenced the international geopolitical scene, but they have also contributed somehow to revealing a common need to reconsider and readdress mankind's most ambitious goals.

Among the major challenges, the long-term expansion of space activities requires a critical review and reflection of the space activities already realized or currently planned, and an in-depth analysis of the drivers that have sustained them up to now.

The space frontier, in fact, has always attracted humankind. Our drive to explore came first from our need to understand our surroundings better, then from the challenge to go beyond them.

Now is time to conceive organic and global plans to sustain and motivate a long-term expansion of space activities that can support a sustainable development of humanity on the Earth and beyond it.

Besides the answers to fundamental questions about the origin and evolution of the universe and the interest to understand our environment better, space can offer a variety of resources that can be of benefit on Earth:

- communication platforms can improve global-messaging capability
- remote observations can provide a global picture of our planet's health
- orbiting facilities can offer powerful laboratory conditions in the field of microgravity research
- asteroids and planets store an incredible amount of valuable materials that could be used for the benefit of Earth and to support space operations, scaling down the high transportation cost for delivery of materials out of the Earth's gravity pull,
- solar power satellites could be one of the answers to the increasing power demand
- extra-terrestrial sites could offer an "extended home" for the expansion of humankind in the solar system.

How credible do these ambitious goals appear to the general public? How far are these space applications justified in the eyes of the common people? What is the technological leap required to meet them? How affordable are these goals in terms of cost and reliability? How competitive can "space solutions" be in answering human demands w.r.t. "terrestrial solutions"?

2.0 CURRENT PLANS FOR SPACE EXPLORATION

In recent years, different plans have been conceived by the space community to extend the range of the long-term presence of humans in space [1, 2, 3].

Despite the many unknowns related to world-wide economic restrictions, specific initiatives have been undertaken to evaluate potential long-term goals for space programmes.

Like the other spacefaring nations, Europe has been working on the identification of different scenarios that could move human steps in this direction, investigating the possible role it could play in an international enterprise [4, 5].

The strategy commonly proposed for both Moon and Mars missions foresees a multistep approach, from precursor robotic missions for scientific and technical data collection to a first settlement phase aimed at checking the feasibility of local resource exploitation. The character and the evolution of this phase depends heavily on the selected scenario. During the subsequent consolidation phase, a continuous human presence on the Moon and Mars can be foreseen, completing the learning process of living and working effectively on another world.

The Moon Exploration/Utilization Programme presented by ESA at the first International Lunar Workshop in Beatenberg, Switzerland, in 1994, and reconfirmed at the second Workshop in Kyoto, Japan, in October 1996 as a credible approach to pursue a possible International Moon Programme, represents an attempt to reconcile long-term vision and short-term constraints (Fig.1).

Phase I Lunar Resource Explorer	Chemical inventory of the Moon including water, carbon High resolution mapping of the surface. Insitu investigation of the polar region. Technology development for later phases	Polar Orbiter Satellite & Orbiter and polar lander
Phase II Permanent robotic presence	Telepresence (including poles and farside), remote chemical analysis, geophysical observation and survey, assessment of the environment, install pilot radio astronomy instrument, active seismology, resource exploration	Rover system with unlimited range and lifetime (possible supply of new experiments serviced by rover)
Phase III First use of lunar resources and environment	Oxygen production, investigation construction techniques, investigate life support, first biological experiments including eco-systems, install large astronomical instrument (VLFA)	Materialab Biolab VLFA
Phase IV First human outpost	Build-up lunar outpost, install scientific laboratory, install sub-mm interferometer, geological investigation, improve outpost capabilities	Initial human mission (most likely at high latitude)

Figure 1 - Moon Exploration / Utilization Programme

The rationale behind the specific phases is that space exploration must be progressive and compliant with the available resources, starting with small, low-cost, automated missions and progressing to more complex, permanent robotic infrastructures, eventually in support to manned missions [6, 7].

Due to the demanding nature of these missions from a technological and programmatic point of view, each mission should also have a self-standing value in the organic, evolving plan with clear long-term objectives, and it should constitute a competitive plus for the involved partners.

The precursor robotic missions will mainly satisfy the scientific character of space exploration missions, providing the knowledge required for the subsequent applications. Commercial Moon base scenarios are centered on the promising utilization of in-situ resources.

A great deal of interest has focused on a process for generating Liquid Lunar Oxygen from native resources because of the potential market it could have as a propellant.

Another promising long-term market could derive from the utilization of Helium-3 in Earth fusion reactors as a commerical viable alternative to the use of fossil fuels to satisfy the world's increasing energy demand.

Moreover, lunar materials could be used to provide up to 90% of a Solar Power Satellite, with a big saving of transportation costs (Figure 2). In fact, according to the NASA/DOE reference system, a 5GW Solar Power Satellite will weight about 100,000 tons. Even if substantial improvements in solar cell production and in large space structures could reduce the overall mass, the assembly in orbit of a Solar Power Satellite would require more than a tenfold increase of the world's launch transportation capabilities.

As for the exploration of Mars, in 1993 many of the world's space agencies created an International Mars Exploration Working Group (IMEWG) to provide a forum for the coordination of future Mars exploration missions and to examine the possibilities for an International Mars Network Mission as the next step beyond the 1996 launch opportunity.

The proposed mission scenario (see Figure 3) addresses the key scientific objectives at Mars and it is consistent with the strengths, interests and constraints of all the participating agencies [8].

After the 1996 missions planned at that time, of which unfortunately only the Mars Pathfinder is still in place, the Japanese Planet-B orbiter mission and a Russian-launched mission consisting of a US orbiter and a Russian descent module containing a rover and a French/Russian balloon were slated for 1998.

An International Mars Network Mission was planned for 2003 for the delivery of a scientific network of surface stations.

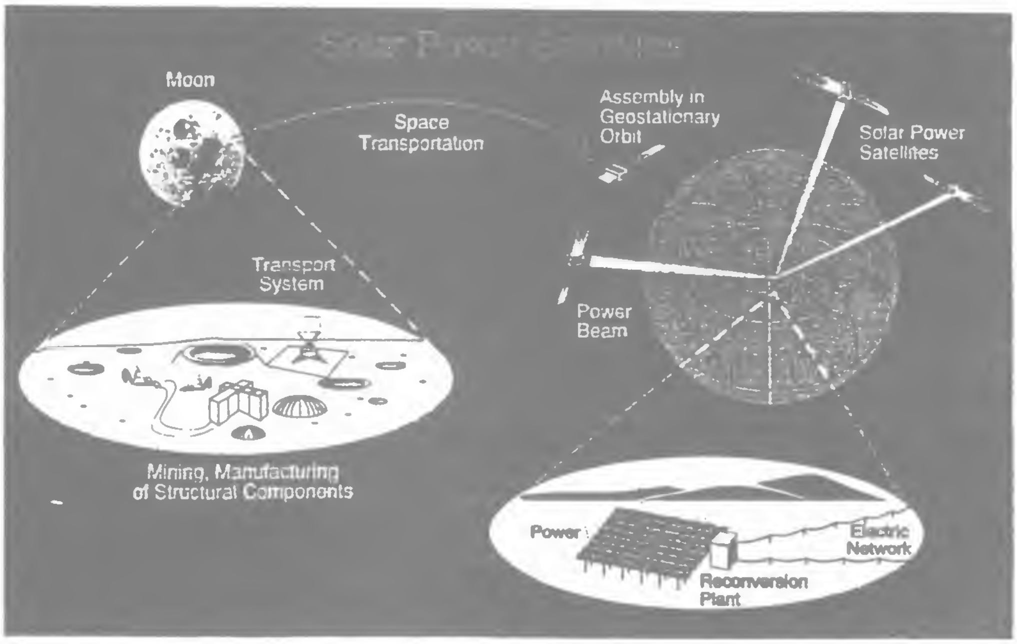

Figure 2 - Lunar Matarial Solar Power Satellite Concept

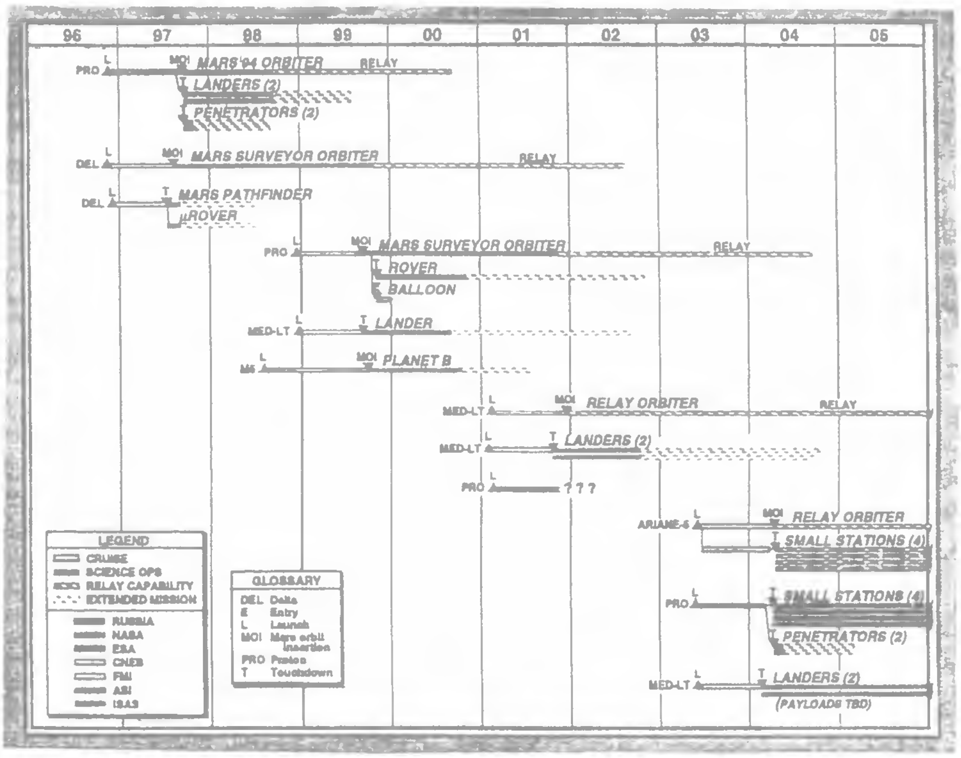

Figure 3 - IMEWG Mars Exploration Scenario

3.0 STRATEGY HIGHLIGHTS

The obvious reason behind the difficulty to realize advanced space applications is the fact that the economic return is not so evident (the payback has to be seen on a long-term basis). In fact, the implementation of the plans outlined in the previous section requires an enormous commitment in terms of the economic investment and long-term political will.

Moreover, it will challenge, at the highest level, both the human and the technical resources that will be employed.

A credible strategy to sustain this type of missions will have to take into account the following key features [9].

- <u>International Cooperation</u>

International cooperation pushed to the highest possible level is considered of utmost relevance for the feasibility and success of advanced space missions.
It is felt that, due to the magnitude and complexity of the proposed scenarios, the effort of a single country could lead, at best, to a delayed, down-scale mission profile.

Additionally, the available resources and infrastructures would not be exploited in the best way and a duplication of effort in some areas or inadequate coverage of other fields could be a risk.

A coordinated, worldwide approach appears to be the best practicable way to keep the costs at a reasonable level for the involved partners, maximizing the intervention of up-to-date technology. Of course, this type of solution requires high level political decisions and mediating structures to create a suitable framework for an effective cooperation [10].

- <u>Up-front Coordination</u>

Given the need for international cooperation, the current trend is to look for collaboration after the research plans have been elaborated by the individual agencies.

The problem here arises from an intrinsic conflict of interests that the different space agencies have to cope with to harmonize ambitious future space mission budget requirements with more commercial space applications that can offer more imediate economic return like new transportation systems, advanced communication satellites, and Earth observation.

To avoid duplication of efforts and to favour complementary contributions by the different countries to a common scenario, the coordination between the different agencies should be moved one level up, in front of the research plan elaboration by the individual agencies.

This "innovative" approach would not kill the entrepreneurial spirit among the involved counterparts, but it would rather work in favour of "competitiveness" in the effort that each country / agency / industry will have to make to be seen as an appealing partner.

- <u>Industry and Government</u>

Current trends indicate that a successful industrial policy for civil space business must include the creation of commercial opportunities for space activities in parallel with increased emphasis on international coordination and cooperation [11].

The present roles of space agency and industry will have to show a higher flexibility to adapt to changing space market requirements. Increasing efficiency and decreasing cost and development time in space project management are mandatory.

Private industry is expected to diversify its capabilities so as to anticipate and meet the upcoming market demands. An increasing direct involvement in space mission operations is already emerging.

- <u>Technological Development</u>

Space exploration / exploitation missions require assessment of complete systems that are much more demanding than the smaller components of satellites orbiting around Earth.

The development of enabling technologies is the key to the implementation of these missions and their projected availability must be confronted with the mission scenario requirements [9]. Critical areas that should be analyzed and developed further include:

- transportation and propulsion
- electronic / mechanical / thermal systems
- in-orbit assembly and operations
- robotics and automation
- life support and human-related aspects
- simulation.

Low cost and higher reliability for access to space is the key issue (Figure 4).

Advanced space applications will require massive transportation to low Earth orbit, where large structures will be assembled, for example for solar power satellites or for a manned Mars spaceship.

Careful analyses indicate that the recurring cost and the reliability for launch into low Earth orbit should increase by a factor of 10, to reach a cost per kg below $1000 and a reliability higher than 99% by the beginning of the next century [11].

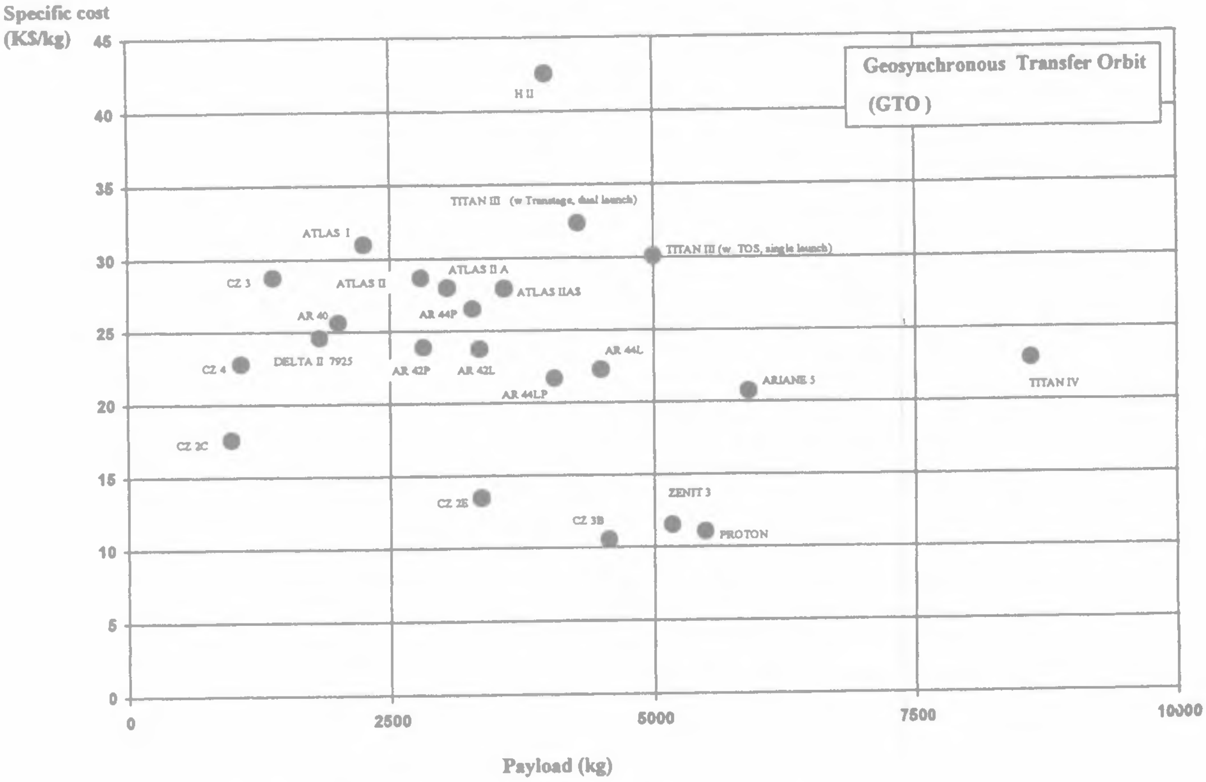

Figure 4 - Current Launch Costs for Medium-Large Launchers

Future reusable launchers will likely be operative during the first decades of the next century. Different concepts have been analyzed (Figure 5) and on-going activities include the development of the VentureStar / X-33 demonstrator to validate the required technology whose launch is foreseen by 1999.

Orbiting Transfer Vehicles and landers will have to be developed for crew and cargo transportation between low Earth Orbit and Moon/Mars surfaces.

As for propulsion, near-term technology options include proposals for hybrid propulsion systems and optimization of launch positions through the use of mobile launch platforms, propelled launch platforms and aircraft assisted launches.

Air-breathing propulsion does not seem to be a credible short-term alternative to chemical propulsion.

As already mentioned, lunar Oxygen might be used to refuel transfer vehicles between Moon and LEO, and it might be also utilized for a mission to Mars unless advanced nuclear propulsion systems are adopted to shorten the overall mission duration.

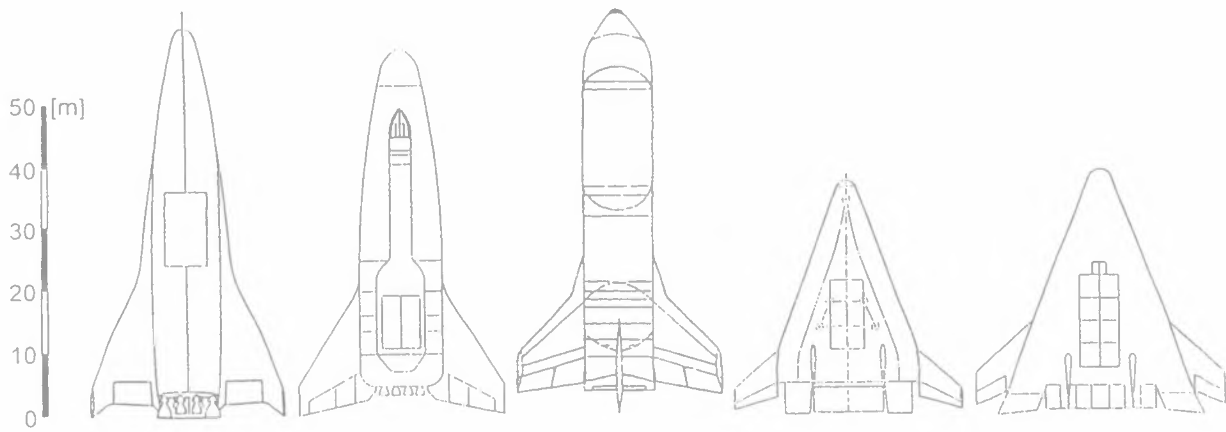

Figure 5 - Vertical Take-Off / Horizontal Landing Single-Stage-To-Orbit Concepts [12]

The areas of Micro-Electro-Mechanical systems and nano-technology may have considerable potential for future space applications [11]. Combined with autonomous spacecraft operations and increased system modularity, these promising technologies may contribute to a significant reduction in development time and mission costs.
Suitable thermal control systems will have to be developed to cope with the extreme temperature conditions encountered on the lunar and Martian surface and, later on, on Mercury.

Highly dependent on the launch system capability and on the availability of an orbiting infrastructure support, in-orbit assembly operations require further study and development in areas like autonomous rendez-vous and docking, manipulator arm, joining processes, control of large structures, internal and external maintenance.

As previously stressed, robotic exploration missions will open up the path to human expansion in the solar system. Teleoperations and telepresence, together with virtual reality and expert systems, must be regarded as highly critical technologies.

Exhaustive simulation programmes are required to enable a better understanding of the complex nature of space exploration missions. Environmental conditions, communication delay, crew training, and crew interpersonal aspects can benefit from simulations to be conducted both on-ground and in-space.

- <u>The Human Being is the Focal Point</u>

Whatever the scenario selected, the human expansion beyond LEO and, eventually, settlement on other worlds, is the ultimate goal that puts the human being in a central, unique position.

A substantial part of the research effort will have to be dedicated to the assessment and solution of the human-related problems. In this perspective, human needs are considered a guideline for any proposed initiative that points to an eventual human involvement.

All these aspects will assume a dimension well beyond the present capabilities, because of the "very far from Earth" conditions encountered in space.

Areas ranging from physiological to psychosocial aspects, and from health management to life support, deserve through consideration. Human factors assume a particular global character because of the special "symbiosis" that will take place between humans and machines.

- <u>Public Support / Involvement</u>

The most urgent short-term policy goal should address an honest promotion of space activities to recapture the support of the general public [11].

In fact, the enthusiasm that used to keep people glued to the television at the time of the Apollo missions in no longer there, nor is the political competition that at that time fed the conquest of space.

Nowadays, space is too often considered very far from the daily interests of common people, too expensive, too inaccessible, and only the privilege for a small elite of specialists.

It is important to undertake a campaign to inform the public about the real possibilities that space can offer in the form of services for the benefit of humanity, filling the gap between "space problems" and "Earth problems".

Access to space must be available not just to a small community but to a larger group of users, by means of services from space, products from space, public accessibility to scientific data via Internet.

Public attention might be caught by the realization of a small lunar landing mission with interactive capabilities on Earth like the one proposed by Lunacorp, or of a small solar power satellite demonstrator.

Entertainment and education programmes should take advantage of virtual reality and teleoperations capabilities to stimulate the interests of the new generation.

4.0 CONCLUSIONS

A critical analysis of the credibility of future space applications must be performed in the light of the current international geopolitical scene and of mankind's interests and needs.
In general, the following recommendations may be made:

- collaboration plans to undertake major space initiatives that can benefit from international cooperation should imply up-front coordination activities among the partners to harmonize the objective capabilities, interests and constraints of the involved counterparts, without forcing already conceived independent missions to fit a common scenario

- international cooperation schemes should properly define the different partners' responsibilities / contributions on the basis of an honest competitiveness

- mission objectives should be clearly identified so as to define the required overall mission architecture

- coherent development plans should be established in the light of the identified critical technologies

- increased transportation capabilities must be pursued as the key issue for access to space

- synergies among different existing space programmes should be maximized with the final objective of cost reduction

- public awareness and support must be recaptured by means of services from space for the benefit of an enlarged community

- besides the economic and technical aspects, a critical role is played by the human related aspects that require extensive research and simulation activities to prepare humans to live and work in a **far-from-Earth** environment.

REFERENCES

[1] "The NASA Mars Conference", D.B.Reiber, Science and Technology Series, Vol.71, 1988

[2] "Report of the 90-Day Study on Human Exploration of the Moon and Mars", NASA, November 1989

[3] "Mission to the Moon", ESA SP-1150, June 1992

[4] "Definition of Long-Term Scenario", ESA SYSTEMSI Study, TN1000, June 1992

[5] INTERMARSNET - Report on the Phase A Study", ESA Publ.Ref. D/SCI(96)2, April 1996

[6] "A Moon Programme: the European View", ESA BR-101, May 1994

[7] "Towards a World Strategy for the Exploration and Utilization of Our Natural Satellite", ESA SP-1170, 1st International Lunar Workshop, Beatenberg, Switzerland, 31 May - 3 June 1994

[8] "Together to Mars", ESA BR-105, July 1994

[9] E.Vallerani, M.A.Perino, "The Critical Path to the Moon and Mars", IAF-94-Q.1.324, Jerusalem, 9-14 October, 1994

[10] E.Sadeh et al., "Modeling International Cooperation for Space Exploration", *Space Policy*, **12** (3), August 1996

[11] P.Edin et al., "Project Space Vision" Final Report, October 1995

[12] FESTIP Programme, Progress Meeting #7 Handout, Ottobrun, Germany, December 1996

Innovative Approaches towards Low Cost Access to Space

by

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Abstract

Launch costs are seen as a major hindrance to achieving affordable access to Space, not only as a cost item in their own right but also in the way that they drive satellite costs also. This paper discusses the requirements for low cost access to Space, and then a number of different approaches that are being studied to deal with the problem, including small satellite launching and various forms of reusable or semi-reusable vehicles. The costs of developing new systems appears to be a significant hurdle to the introduction of innovative systems. In addition there is an intimate relationship between the launch system and the market that it serves.

1. INTRODUCTION

The cost of access to Space has driven the development of Space activities. Successful activities in Space have focussed on high value products - communications, Earth observation, national security and so forth. Progressively science missions in Space have tended towards fundamental science with widespead support throughout the science community. Man in Space activities are seen as "prestige" demonstrations - to quote President Kennedy "we do this not because it is easy, but because it is difficult..." However, the continuing high costs of access to Space have meant not only that new opportunities have (for the most part) not appeared, but that there are increasing demands for reduced costs even in the areas that are successful.

There is a link between the costs of Space hardware and the costs of access to Space. In the simplest case - say a commercial communications satellite - there are ways of saving mass by at the penalty of increasing the cost of the satellite. If these cost increases are less than the reduced launch costs achieved - perhaps by using a smaller launcher, or a shared dual launch - then the technology will be used, until satellite costs and launch costs are in an approximate balance. Different considerations apply to manned Space activities, or to certain science missions, but the effect is always in the same direction.

The argument above depends on the cost per kilogram of the launch, but in other areas it is the actual cost that is critical. Recently attention has been focussed on the potentials of small, cheap satellites. By using small, integrated teams, and perhaps with less obsession about risk when the project cost is smaller, it has been possible to produce satellites with costs at 5 MECU or below. Such satellites are of considerable interest, not only for NASA's "smaller, cheaper, faster" programmes, but for new countries and organizations who would like to enter Space activities but cannot afford high costs. No launch vehicle exists which will currently launch satellites of this size (perhaps 200 kg) for costs which are at all comparable. Thus the cost of the launcher becomes the dominant feature in deciding the viability of the total system. Occasional "free rides" or cheap "piggy backs" are available, but these hardly provide the basis for a continuing industry. Small satellite launcher proposals are springing up like daffodils in the Spring, but it is not clear whether any of these will provide the answer that is required.

At the larger end of the market, there has been a lot of discussion about the potential for reducing launch costs through the use of reusable launch vehicles. Originally the Space Shuttle was intended to be the first of these, and the problems associated with the Space Shuttle have tended to make politicians cautious about embarking on another programme. But there are now experimental investigations and talk of "demonstrator" vehicles in the USA (X-33), Europe (FESTIP) and Russia (Oryol). We need to understand where these might lead as well.

2. SMALL SATELLITES

2.1. The Current Scene

The cost per kilogram of launching a satellite into a low Earth, low inclination orbit is shown in Fig. 1. The data is taken from the AIAA Reference Guide to Space Launch Systems (1991) and may be dated. A number of US systems have recently revised their prices down to achieve a more competitive position, particularly with regard to *Ariane*. All the vehicles are expendable vehicles - the Shuttle is no longer available for commercial hire, but if it were the cost would be about 35 $M/t. What is clear is that the specific costs fall with the increasing capacity of the launcher. Such small launch vehicles as are available may be cheaper than their larger cousins, but not per kilogram delivered into orbit.

The logical conclusion of Fig. 1 would be to gather all the satellites for the year together and launch them on a single *Saturn V*!

Unfortunately this is not realistic. Not only would the risk be too high, but the satellites are all intended for different destinations. However, riding on a large vehicle is a possibility. *Arianespace* offers piggy-back rides on *Ariane 4*, and is funding the development of ASAP-5 at MMS (Fig. 2) for *Ariane 5*. The problem with this is that you

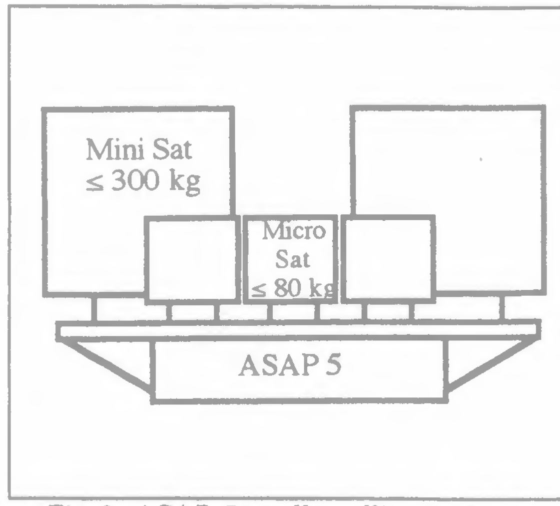

Fig. 2: ASAP-5 small satellite carrier for Ariane 5

have to go to the same orbit as the main payload - generally GTO. The growth markets may well be in sun synchronous polar orbit at up to 700 km altitude, or intermediate altitude "constellation" orbits for the next generation of communications systems. Transfer from GTO to these orbits may be possible, but only at the expense of propulsion mass, which reduces the useful mass delivered into the destination orbit.

2.2. Small Launch Vehicles

The apparent demand for the dedicated launch of small satellites into particular orbits has

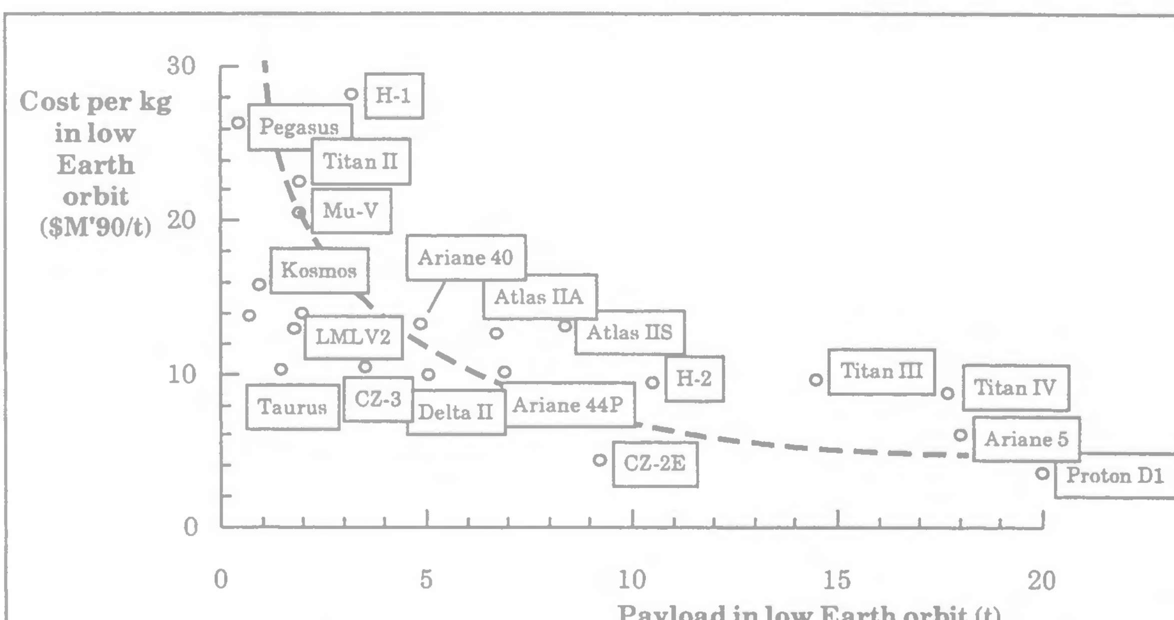

Fig. 1: Specific launch costs for current launch vehicles

raised interest in providing launch services in this region. One system (*Pegasus*) is flying, and another (*LMLV*) is close to commercial operations. Pegasus costs about $ 18 M per launch, LMLV is priced about $ 24 M. (There are variants of both, both in capability and price, so none of the costs quoted here should be taken as definitive.) The technology involved in such vehicles is not demanding. After all, this is where most of us came in with *Scout* in the US, *Diamant* in France, *Black Arrow* in the UK. In principal such launch vehicles can be built from existing solid motors. Furthermore, the costs of the components looks attractive.

Fig. 3 shows a (large-ish) small launch vehicle (VEGA-K4) studied in a recent ESA contract by the author in collaboration with BPD, capable of placing up to 1000 kg into a 1000 km polar orbit. The vehicle consists of three solid

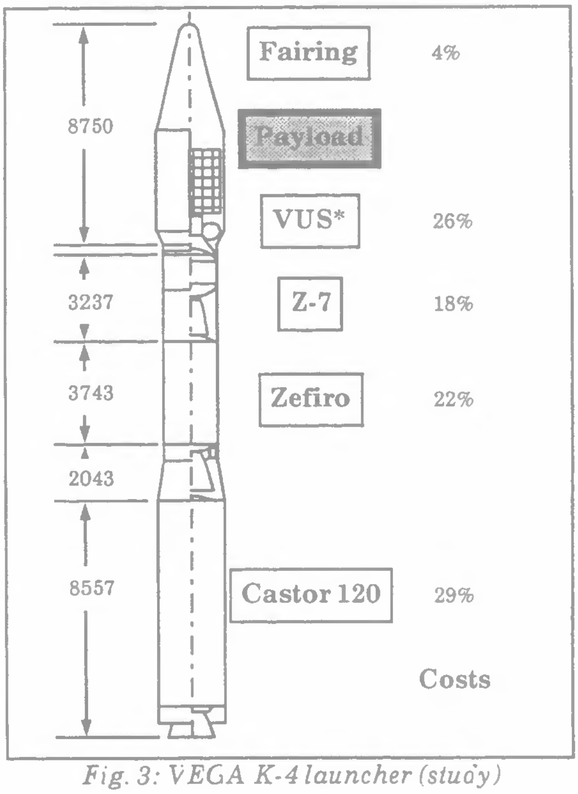

Fig. 3: VEGA K-4 launcher (study)

motor stages, and a final liquid "Vernier Upper Stage" which places the satellite in its destination orbit, and corrects for the errors due to the uncontrolled elements in the solid stages' burns. Also shown in Fig. 3 are a distribution of the hardware cost elements for the vehicle, adding to about 15 MECU, which would appear to make the vehicle very competitive with a launcher like LMLV-2.

This study illustrates one problem that faces the small launcher designer in optimizing the system. Three options were available for the Vernier Upper Stage, a monopropellant hydrazine system, a conventional bipropellant system, and a "dual mode" system using N_2O_4 and N_2H_4. The optimization is shown in Fig. 4.

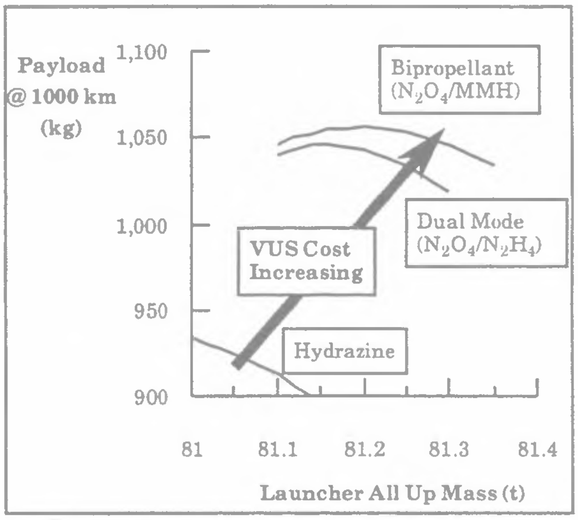

Fig. 4: Performance Optimization of VUS

The hydrazine system is the cheapest, but gives 10% less payload than the other systems. A conventional bipropellant system is the most expensive, but gives the highest payload. And the dual mode system gives the best cost per kilogram. However, it is not clear which represents the "best choice." That decision must (like all other aspects of the vehicle) depend on an assessment of whether the extra 100 kg of payload is worth the extra cost. What is the true market demand? And this question cannot be answered until the launch vehicle has been offered, for in a real sense the vehicle creates the market for its services.

The costs quoted in Fig. 3 do not include everything, however. To the hardware costs must be added:

- the cost of launch site operations
- the cost of launch insurance
- the recovery of development costs

Launch preparations and launch operations for a vehicle of this size can be expected to add another 15 - 20% to the hardware costs. Launch insurance will depend on the reliability of the vehicle, which as yet is undetermined. Solid motor reliabilities vary from about 0.3% (for the Castor II motors on Delta) to 2% (Shuttle SRBs). The vehicle shown in Fig. 3 might have a reliability ofg about 94.5%, giving an insurance cost (currently) of about 16%.

Finally, we have the problem of recovering the development costs. A commercial small launcher development will be conducted on more stringent lines than "traditional" launchers like *Ariane 5*. Use of existing hardware must be used to keep costs low. However, development costs may still be in the range 150 - 250 MECU. And the developer will expect not only to recover the development costs, but to have to pay interest on the money involved. Fig. 5 shows the costs per flight of recovering development costs over 10 years at a flight rate of 3 or 4 flights per year. At 150

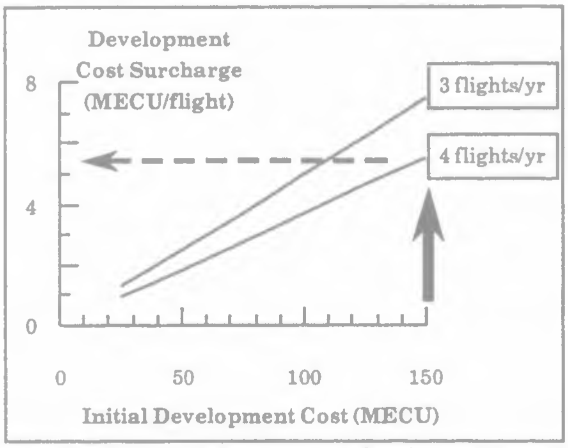

Fig. 5: The cost of recovering development costs

MECU for development, and assuming four launches per year, the recovery of the development costs adds 30% to the per flight cost.

This situation is synthesized in Fig. 6. Now the hardware costs are only slightly more than half of the total flight costs for the launcher. This is not unique to the small launcher. As we shall see, a similar problem applies to producing reusable launch vehicles.

Could we further reduce the costs of small launch vehicles? Part of the hardware cost lies simply in the number of stages the vehicle shown in Fig. 2 has. If we reduced the number of stages to two, and used a higher performance liquid upper stage to substitute for the upper solid stage(s) and the VUS it might be possible to improve on the costs. But the cost of liquid systems tends to be higher than the cost of solid stages, and we have to produce our launcher out of existing hardware - otherwise the cost of development will price us out of the market. There may be room for some cost

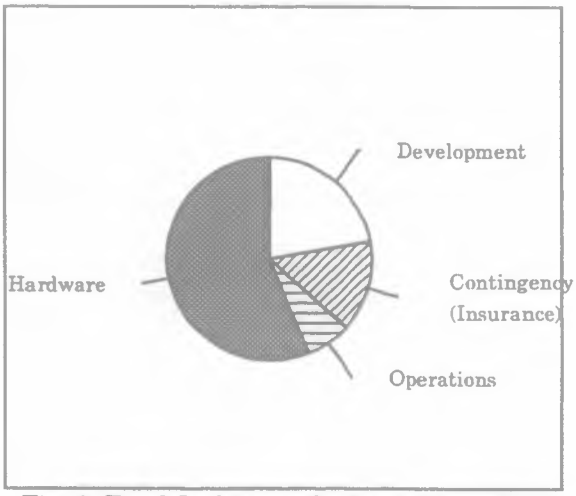

Fig. 6: Total flight costs for a small launcher

improvements, but it seems unlikely that a small, expendable launcher will easily reach the 5 MECU price that the satellite manufacturers are quoting.

3. REUSABLE LAUNCH VEHICLES

Now let us turn to reusable launch vehicles. Reusable launch vehicles (RLVs) are not built from existing hardware. They involve new technologies, and the development costs are expected to be high - perhaps in the order of 10 *billion* ECU. In addition, the cost invested in individual vehicles is expected to be high - certainly several hundred MECU. The pay-off is in a low recurring cost If we can solve the maintenance and operations difficulties that have plagued the Shuttle, and if we can avoid throwing away hardware on each flight, then it ought to be possible to get the recurring flight cost down to the order of 10 MECU.

Since I showed a typical expendable small launcher in Fig. 2, Fig. 7 shows a "typical" RLV - a rocket powered, vertical take-off, winged, single stage to orbit vehicle.

Fig. 8 shows an estimate for the distribution of life cycle costs for this vehicle - development, production of an operating fleet, and operations. The "contingency (insurance) costs" not only cover the cost of losing the vehicle and its cargo, but also the recovery programme that is needed when a disaster occurs, the loss of business involved, and the less disastrous but far more probable case of insurance against launch aborts when the vehicle fails to make orbit.g

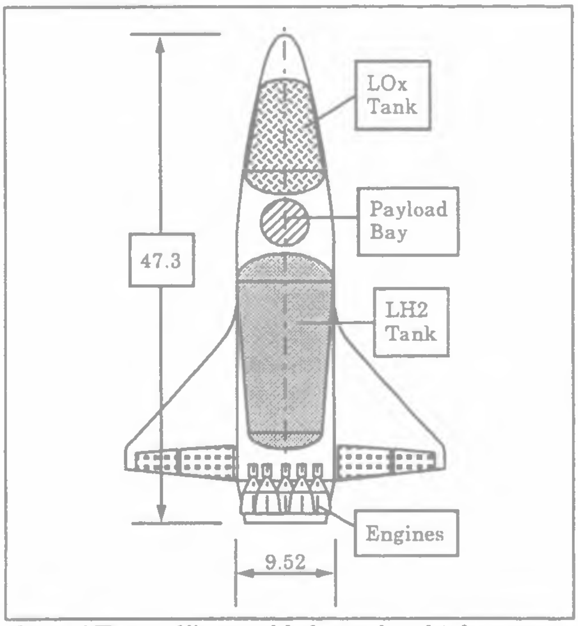

Fig.7:'T}pical" reusable launch vehicle conc€pt

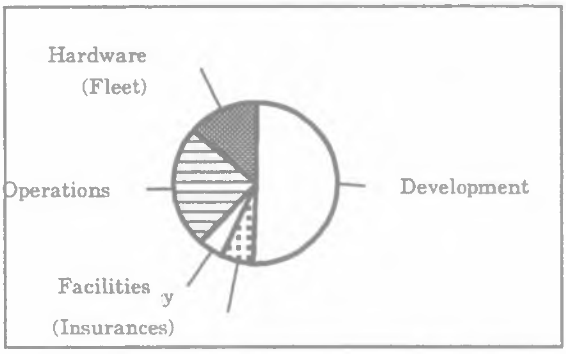

Fig. 8: Total lifetime cost distribution for a reusable launch vehicle

The fact that an RLV can perform aborted launches without losing the vehicle or the cargo is one significant reason why we would expect an improvement from a truly reusable system. It is not expected that equipment reliability would be significantly improved from existing launcher systems. It might even start a little worse, but the fact (except for the first time) the equipment has a history so that we know what worked and have fixed what did not, ought to improve equipment performance. However, the critical factor in the reliability of a reusable vehicle is that if equipment fails we are not committed to continuing the launch until the failure becomes a catastrophe, but instead we shut that item down and return as quickly as possible to the launch site. Launch aborts are expected to be about as common as vehicle losses are now, but vehicle losses will become very small indeed.

It is worth comparing Fig. 8 with Fig. 4. The development costs have risen from about 20% of the total to just over half. Hardware costs on the other hand have fallen from about 60% to about 15%. Operations costs, which now include the on-orbit, recovery and reconditioning costs as well as the launch, account for about 25% of the total.

Clearly development costs are the critical feature in RLV design. Current expendable launchers have had the development costs largely written off. This situation cannot continue indefinitely with each new generation of launch vehicles. RLVs, with low operating costs, offer the possibility of reducing launch prices and paying back development costs at the same time.

The US has a large internal market. I.Bekey has estimated that if a future RLV were given guaranteed access to that national market (NASA and the USAF) for five years, a commercially developed vehicle could pay back its development costs in as little as five years, while at the same time reducing total launcher expenditure by 30%. This is the theory behind the X-33 programme.

Europe is not in this fortunate position. To achieve the same price reduction and commercial return, a European RLV would have to amortize its costs over about 20 years, and interest on this investment would put a greater burden on the commercial developer. However, Europe has one potential opportunity to size the vehicle for a smaller payload size, which would give smaller vehicle costs and potentially be more attractive to the commercial customer.

The development cost for an RLV depends on its size. Fig. 9 shows a parametric cost estimating relation which looks to be appropriate for "winged launch vehicles." Reducing the inert mass of the RLV will bring down the associated costs, but they stay in the billions of ECU.

One way of bringing the RLV size down is to use a two stage vehicle. Unfortunately the development of two, smaller RLVs costs more than one. There are ways out of this. One was proposed in the An-225/HoToL concept, where the RLV is launched from an existing, airborne platform. This approximately halves the mass of the RLV.g

Another possibility is to use the same vehicle for both stages. This "Siamese" concept (Fig. 10) has essentially identical vehicles for both Orbiter and Booster. At launch the Booster provides propellant for both vehicles, separating at about Mach 3.5 to fly back to the launch site. However, the Orbiter can take off under its own power, allowing most of the development testing to be performed with just one vehicle. If the inert mass of the Orbiter can be kept sufficiently low, it might be possible to reach orbit with a minimal payload, leaving the two stage version to launch heavier payloads. The "Siamese" vehicle represents a very interesting fall back position from a vertical launched, single stage to orbit vehicle.

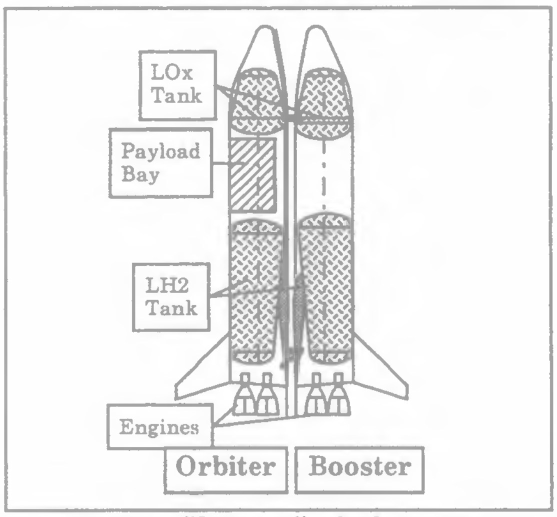

Fig. 10: "Siamese" vehicle concept

4. SEMI-REUSABLE VEHICLES

An RLV is only expected to be able to deliver payloads into a low Earth orbit - perhaps 250 km altitude. Most satellites fly in higher orbits, and therefore would require some additional propulsion to reach their final destination. Given this, then we need to ask, "does the RLV have to reach orbit at all." At least for satellite delivery, the RLV could fly a sub-orbital ballistic trajectory, and eject an expendable upper stage with the payload, which would continue to its destination orbit.

A semi-reusable vehicle would not have as good operating economics as a true RLV. The target flight cost for a true RLV is in the region of 10 MECU. An upper stage would inevitably add 2 - 3 MECU to this. However, there might be savings on development costs.

Both the US X-33 programme and the European FESTIP programme (and probably the Russian Oryol programme as well) envisage the need for an experimental "flight demonstrator" in advance of a fully commercial RLV. Experimental vehicles cost much less than a full-size, complete RLV programme. Converting the "flight demonstrator" into a small, semi-reusable system once it had completed its main purpose might allow a very economical approach to small satellite launches. Indeed, it might be possible to "write off" the reusable booster

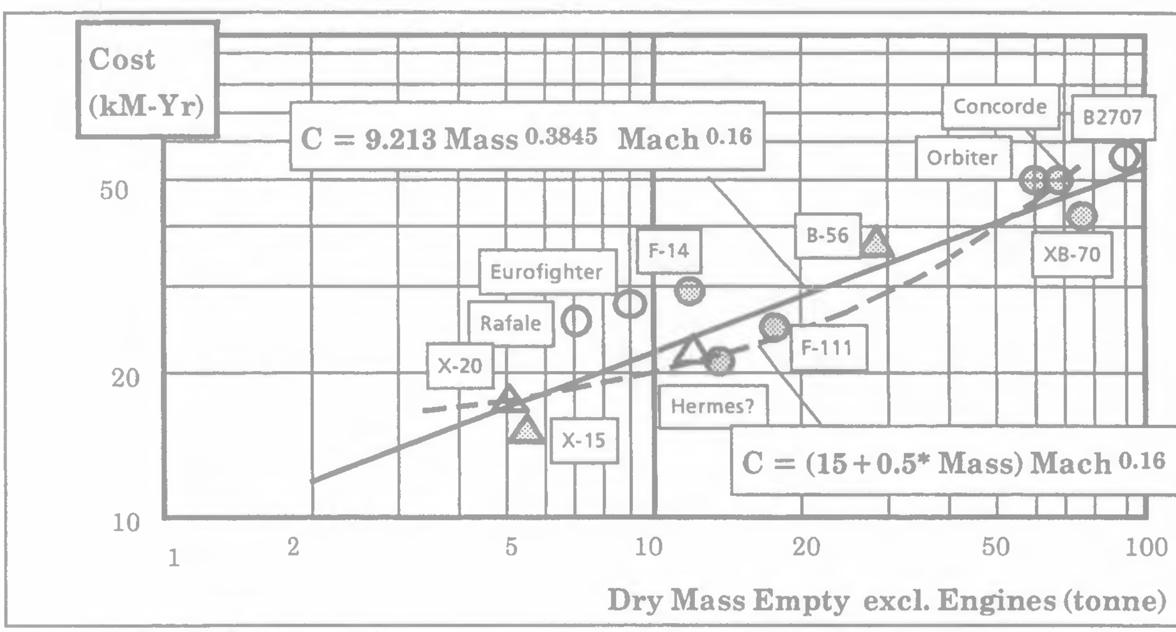

Fig. 9: Parametric Cost Estimating Relationship for Winged Launch Vehicles

development costs as part of the "flight demonstration" programme.

To service small polar satellites of up to 500 kg, the RLV "booster" ought to be capable of achieving about Mach 18 with a 1.5 t payload. An air launched vehicle capable of this would have an all-up mass in the region of 50 t. The recurring flight cost might be as low as 6 MECU, which is the region believed to be required to expand the minisatellite market.

5. SPACELINES

Unless we use an experimental vehicle as an operational RLV, with all the hazards that implies, the principal problem facing the development of such vehicles is the development cost. Running into billions of ECU, these costs are comparable with the cost of developing a large airliner. The reason that large airliners can be developed as commercial projects, and RLVs cannot (at least not yet) is the size of the market. An airliner manufacturer sells more airliners than an RLV manufacturer. And airliner transport costs are (relatively) cheap because there is a huge market.

One solution might be to sell the same vehicle to competing "spacelines". The specialist spacelines could concentrate on generating efficiencies and new markets, and the huge cost of development would be shared. Competition would help keep prices down.

Clearly this is a situation which we are familiar with from airlines, but a very different situation from that which has applied to launch services. The difference has been that with expendable launch vehicles, the hardware cost has been the largest part of the total, and the manufacturer has been intimately involved in it. With RLVs this no longer has to be the case.

Indeed, with a multinational development of an RLV we can immediately see that there might well be more than one customer. And not every customer would want to make commercial profits from the operation. Some - like the military - might simply want capability. Once we stop talking of fleet sizes of 3 or 4, and start talking of production runs of 12 or more, economies in production and support become possible.

We are a long way from competing Spacelines today, but ultimately they may be the key to low cost access to Space.

6. CONCLUSIONS

There are a variety of different ideas being attempted today to reduce the cost of access to Space, from small launch vehicles tailored to the "minisat" market to large, fully reusable systems that offer to be what the Shuttle failed to provide. Simply to list all the options and suggestions would double the size of this paper. And each has technical advantages and problems.

However, the key issue with all launch vehicle schemes is cost. New vehicles cost much more money to develop than satellites, and in the absence of a friendly government to subsidize these large development costs, the problem of minimizing the development costs and then recovering that in the launch price dominates all decisions. Successful commercial launch vehicle developments have built on existing systems rather than attempting radical solutions. And even government funding may not help, for the historical record is that every new launcher funded by government has been funded for political and not economic ends.

Reduced cost access to Space is possible, but it is not a technological breakthrough that is required.

The Enduring Realities of Space Economics

A. Hansson
Coordinator for the establishment of CISIR

"Postmodern despair is afterall a theory: it is not an essential construct inscribed into our being"
Philip K. Lawrence,
Knowledge and Power. The changing role of European Intellectuals
Avebury, 1996.

1 Introduction

It is generally accepted that physical power needs follow a cyclic pattern of around 56 years [1] and references therein. Hence, the next peak demand will be in 2025. At the same time there are now more than twice as many humans alive as there were 30 years ago when space, in the form of the Apollo project, constituted the future, both for the media and public. The pressures of this rapid population growth are not new, except in scale. Last year at the British Association in Birmingham, the then President, Sir Ronald Oxburgh concluded "I myself have no doubt therefore that the real challenge of the 21st century will be to find a way of coping with these unprecendented pressures without resort to military conflict" [2].
In preparation for the establishment of the Center for International Space Industrialization we have been involved in informal discussions on how space activities can make it possible for developing countries to share sufficiently in prosperity in order to acquire a real stake in maintaining our physical environment. The problem is one of appreciating the difference between recycled materials and what we call "new" introductions over the natural geolical or biological cycles. With increasing computing power, I will suggest that the next political issue outside those related to medecine will be how to set up a recycling industrial society with the aid of space assets.
It has been argued that the environmental problems are being solved but this does not take into account the need to provide economic support for the developing part of the world and the fact that the physical circulation is global and not dependent on the level of GDP. Furthermore, if the conditions are desperate, a significant movement of people, as occurs in China in the direction of the coast line, is possible but this time forming a streaming towards Europe...
At the same time it can be argued that even with increasing advertising it is getting more difficult to sell consumer goods to consumers who lack money to pay for them. In short, the developed economy is saturating in its present form. There is an alternative. Already in 1984, Newt Gingrich later speaker of the House of Representatives 1995, stated in Window of Opportunity: "If we make

an intensive effort to develop space, we will create millions of jobs on Earth while creating thousands of jobs in space, while at the same time ensuring a solid balance of payments in foreign trade by producing goods and services others want but cannot produce for themselves". The concept of Space power suggested by Glaser in 1968 was based on large planar arrays of solar cells placed in geostationary orbit (GEO). Many forms of this system have been suggested, including re-transmission via space, but all are very large, namely, of the order of kilometers and tens of thousands of tons.
During the 1980's a laser alternative appeared. Here 500 MegaWatt, not 5 GigaWatt, in a compact system, was aimed for. The question was whether a relatively small power generation could be commercially attractive and ideas started to appear such as supporting Earth based solar cells, etc. However, one clear market would be space itself, that is, power for microgravity manufacture, large assembly and so on.
For this to happen, considerations like present aeronautics will have to be established in the launch industry.

2 Aeronautics vs Astronautics

In 1903, the year of the Wright brothers, Wilbur and Orville's 'Flyer' at Kitty Hawk, Tsilkowsky proved not only that it was possible to leave Earth, but also that the most economical fuel was liquid hydrogen and liquid oxygen.
Hermann Orbeth's *The Rocket into Interplanetary Space* was published in 1923 and in 1926, Robbet Goddard's first rocket travelled 55 m.
By the end of the 1950's, technology was sufficiently advanced for the first orbital launch, in the form of Sputnik I, which took place in 1957, and was followed by the first human in space, namely, Yuri Gagarin in 1961.
Meanwhile, aeronautics was poised to overtake ships as the passenger carrier over the Atlantic. This was the result of a 50 year development which started in the 1920's, when a number of airlines operated round the world, with the main finance coming from mail and high specific value goods. Already in 1919, 5000 passengers were carried. The limiting factor was that the equipment, being either directly ex-military or based on military technology, did not make for economic payloads and was not very reliable, making maintenance costs were high.
In 1934 Douglas introduced the DC-2 as a precursor to the revolutionary DC-3. The DC-3 was a commercial airliner, reliable, and based on the existing engineering. With the DC-3, operators made a profit carrying humans, following Henry Ford 's conclusion a decade before, that passengers were the key to the development of air transport.
Progress continued and in 1939 western airliners carried 2.5 million passengers without any of the airports we now regard as indispensible. Airports started to appear in the 1940's and by 1945 passenger traffic reached 9 million people.

These numbers increased to 300 million per year in the 1970's when air cargo began to grow rapidly with the introduction of high capacity aircrafts.
By this time, the USA Apollo programme and its technological and operational spin-offs, had fulfilled many of the initial ambitions of the pioneers of the space age, with earth satellites, people on the Moon and in Earth orbital stations. But two important differences existed: the scale should have been larger and the transportation should have been a synthesis of aviation and rocketry. Even today, each space mission is a handcrafted entity, with assembly and quality testing at the launch site, where as many of the parameters as possible, are monitored. And, since 2-5 % will go wrong during take off, it is necessary to be able to destroy the transport instantly. This sort of situation, in the end of the 20th century, is a discredit to astronautics as a practical subject.
How can this situation be changed?
As much as 90 % of the weight of the Saturn rocket, used in the Apollo programme, was fuel, stored in its first three stages and jettisoned before the rocket left Earth orbit. Thus, a return to Apollo-like engineering is not the answer. There are at present two modern myths. The first states that the use of solid or low-technology liquid propulsion expendable launchers can achieve very low launch costs. The truth is that any launch vehicle designed to meet the required level of reliability will have a very expensive development programme, irrespective of its technology. This, in combination with an increased size due to low technology obliterates the potential again.
The second myth states that only with the use of very advanced material, exotic propulsion and hypersonic aerodynamics can a vehicle fly as single stage to orbit. The truth is that hybrid engines, together with the available materials and a systems engineering approach to the problem, yields a viable solution. This is the ultimate rocket hiding inside an aircraft and we call it: SKYLON.
SKYLON could do for space what the DC3 did for aeronautics. SKYLON is designed to accept 4.6 m diameter payloads, standard cargo containers and, in its second generation, it can carry 60 passengers. It can be fueled by liquid oxygen and hydrogen under no vent conditions at the runway, with a 2 hours hold before propellants reprocessing. In short, it can be introduced from existing launch sites. Later, as happened in aeronautics, dedicated spaceports, on the equator, will reduce costs to handle cargo.
As every terrestrial transport depends on fuel logistics, so will it be for space and, if economic transport can be established, the main cargo to orbit in the mid 21st century will be propellants.
With progress as described in 2069, 100 years after the first Apollo Moon landing, we could have substantial industrial sites on the Moon to support Earth's population without inflicting on the Earth's biosphere. Lunar liquid oxygen would be used, but hydrogen is still likely to have come from Earth. The equatorial spaceports could each handle 140 flights per day, with perhaps approximately one million people per year in each direction. Cargo could reach 400,000 tonnes per

year, half of which to the Moon and the other half for deep space missions. The trade flow to Earth would have increased up to a billion tonnes a year, including refined metals and finished industrial products. In fact, only the industrialisation of space resources will be able to meet the demands from the 2/3 of the Earth's population who are moving up in material standards, while still leaving the Earth fit for inhabitation.
The fact that the engineering of a space plane is more demanding than a present aircraft does not mean that its operation is more complex, or that we should not introduce it out of fear of its possible military potential. Its potential to form a leap into a sustainable future for the Earth's population is far greater. The only thing that is lacking now is a political assent for such accelerating space transport.
It is worth to remember Tsiolkowsky's words from 1929: 'Most people consider astronautics a heretical idea and refuse to entertain it at all. Others are skeptical, regarding it as an absolute impossibility, while others are too credulous, considering it a simple matter, easily accomplished. But the first inevitable failures will discourage and repel the fainthearted and destroy the confidence of the public".

3 Recommendations for ESA

Paul Krugman, MIT has argued that competitiveness does only apply to companies not to nations or organisations such as ESA. Provided that competitiveness is defined in a sensible way, however, there is much that can be learned from the concept. One reason is that in a commercial environment you have two fundamental options: to oppose a competitor or to 'buy in' into their activity. It is often claimed that the latter is the situation of the European space industry. I do not think this is correct. Afterall Europe has the longest technological tradition in the world and it is difficult for me to understand why any leader would like to give up this activity. This is however what appears to be the case for launchers. Here the establishment is desperately attempting to rescue Arianne 5 as a big launcher. There is nothing gained here by going over the policy adopted by CNES mastering of the ESA class, in the mid 1980. However, two points should be made. 1) a new upper stage for Arianne 4 might have been the most realistic route together with engineering development of single-stage-to-orbit systems. 2) Like B. de Montluc, I believe that "without a launcher, you have no autonomy and hence no independent access to space" [3]. In contrast, however, any new launcher must be designed to increase the market and hence be international like the aircraft production. Hermes showed that not even the French political finesse can solve fundamental engineering issues as could the US $ for Dyna-Soar's (X-20) bending moments. This ESA strategy has made the present situation worse. The end of the Cold War allows the USA to introduce 'black project' technologies making it possible to introduce new hardware testbeds for space science, while

ESA cannot afford to respond to the American challenges to its lead in space science. Hence, I would not be surprised if by 2025 all space scientists in Europe will fly on USA spacecrafts. Perhaps our cost-cutting EU leadership would welcome this but I would not and neither would American scientists since it would remove a partner/competitor to NASA. So what can be done to keep ESA at the space frontier in the future?

The answer is concentration of resources. The present structure is too expensive and lacks an overall EU policy. In more detail I would suggest the following:

- Create an EU pool of advanced engineering combining support from EU, ESA, CERN and defence.
- Create and EU space transportation policy unit
- Introduce prime contractors for each space mission. Limit ESA's role(s) to get academic needs translated into requirements and to set budgets for the platform and sensor for scientific missions.
- Make an in-principle offer to the USA to establish a totally commercial space access system with open budgeting.
- Fund a demonstrator for SSTO, similar in timescale to NASA's X-33 and X-37.
- Fund a demonstrator for Gigabit satellite transfer and open it for global bidding.
- Investigate the feasibility of establishing a market for bandwidth capacity futures trading.
- Set up an oceanographic body, similar to EUMETSAT and give them both the right to select industrial primes for their projects.
- Set up a body to investigate the case for space resources with representatives from Asia, Africa, America, etc, as well as insurance.
- Establish, together with CERN, a program in advanced propulsion, especially on anti-proton catalysed fusion and in pulsed nuclear fusion in general.
- Invite architects and construction companies in ESA states to follow the example of Japan and design service facilities in Earth orbit, such as hotels, old people's homes (note that the reduced load in microgravity makes the heart more efficient and consequently releases less adrenaline for a given workload and leads to less damage [4] and will help if there is no need to return to 1 G) and so on, which are possible with aircraft-like access to space.

4 Final comments on G.O.D for space

As was pointed out by, amongst others, Wroe Alderson and Churchman, all philosophy that includes human purpose needs a G.O.D. which is 'guarantor of decisions' or 'guarantor of destiny'. Churchman, working under contract for NASA, demonstrated that Apollo could not be justified by cost-benefit analysis [5] and hence that we need a purpose.

Cecil Rhodes is claimed to have said "I would annex the planets if I could!" but

such expansionism sounds dated even if it worked for many of the space pioneers. Tsiolkovsky appears to have given space settlers greater wisdom: a spacestation free of greed and envy. The late Carl Sagan urged us to accept being inconsequential dust. This latter view contributed to demolish the pride in ourselves and in our tools, both physical and conceptual, in the same way as the earthquake in Lisbon demolished the idea of a benevolent Nature. If we are no more important to the future than ants are for our political history why do anything at all?
The Space Age advocacy may sound naive, but rejecting it without study would be a grave mistake. In short, I would argue that it raises the question of the morality of our work, but in a more optimistic way than the present post-modernistic end of everything. Elsewhere, I have developed the concept of 'technolibération' [6] against the technocratic social model which resulted from the events of October 4, 1957 and has lasted to the break up of the USSR in 1991. Thus, 'the big picture' or the raison d'être for space exploration has returned. With the public rejection in the USA following its collapse in the USSR, the tecnocratic fall is also generating problems for the European state which came to summon it for its rebirth, i.e. Gaullist France [3]. Since it would appear that the technocratic organisation needs a war, we, space advocates, should not be saddened by its demise. Instead of political control of technology, with its associated oversell of quick results, we should set out to build a commercially viable transport to space, not based on 'gifts' from military missiles and competition between national technocracies, but on competition by expanding access to space for all.

References

[1] B. Cordell, *Space Policy*, February 96, pp 45-57

[2] Presidential address 1996.

[3] B. de Montluc, *Space Policy*, Watersheds in the modern world: the space viewpoint 245-264, quote p. 255.

[4] W.J. Rowe, *Hunters and gatherers in the space age*, in preparation.

[5] Churchman Systems Approach and its Enemies, New York, 1979.

[6] A. Hansson, Technolibération (in preparation).

Session 4:

Options and Resources

Unterberg Harris - Specialty Investment Banking

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Investment Banking

- Concentrate on companies that exhibit rapid growth and have an established presence in markets where we have industry expertise.

Software and Internet / Info Services
Client/Server Computing
Networking
Outsourcing
Satellite Communications
Semiconductors Capital Equipment

Staffing Services
Business Services
Health Care Services

Space & Satellite Practice

- First U.S. Investment Bank with dedicated Satellite Industry Coverage.
- ‘96 - Participated in over $1.3 billion Public and Private Space & Satellite Related Equity Financing.
- Only Annual Satellite Investment Conference on Wall Street.
  - Hughes Space & Communications
  - Loral Space & Communications
  - Globalstar Telecommunications Ltd.
  - Echostar Communications Corporation
  - PanAmSat
  - Orion Network Systems, Inc..

Satellite Services: Coverage List

- **Direct Broadcast Satellite/Direct-To-Home**
  - DirecTV   Tee-Comm Electronics/Alphastar   Echostar Communications
  - USSB   TCI Satellite   A Sky B
- **Mobile Satellite Services**
  - Globalstar   American Mobiles Satellite   Iridium
  - ICO-P   Odyssey
- **Little LEOs**
  - Leo-One   Orbcomm
  - Final Analysis   CTA
- **Digital Audio Radio Service (DARS)**
  - CD Radio, Inc.   Digital Satellite Broadcasting
  - American Mobile Radio   Primosphere
- **Fixed Satellite Services**
  - SKYNET   Orion   PanAmSat
- **Space & Communications**
  - Hughes Space Comm   Loral Space & Communications

Macro Investment Theme

Satellites:

Instant Telecommunications Infrastructure

The Most Efficient Telecommunications Infrastructure

Recommendation Criteria

1. Top-down by Category

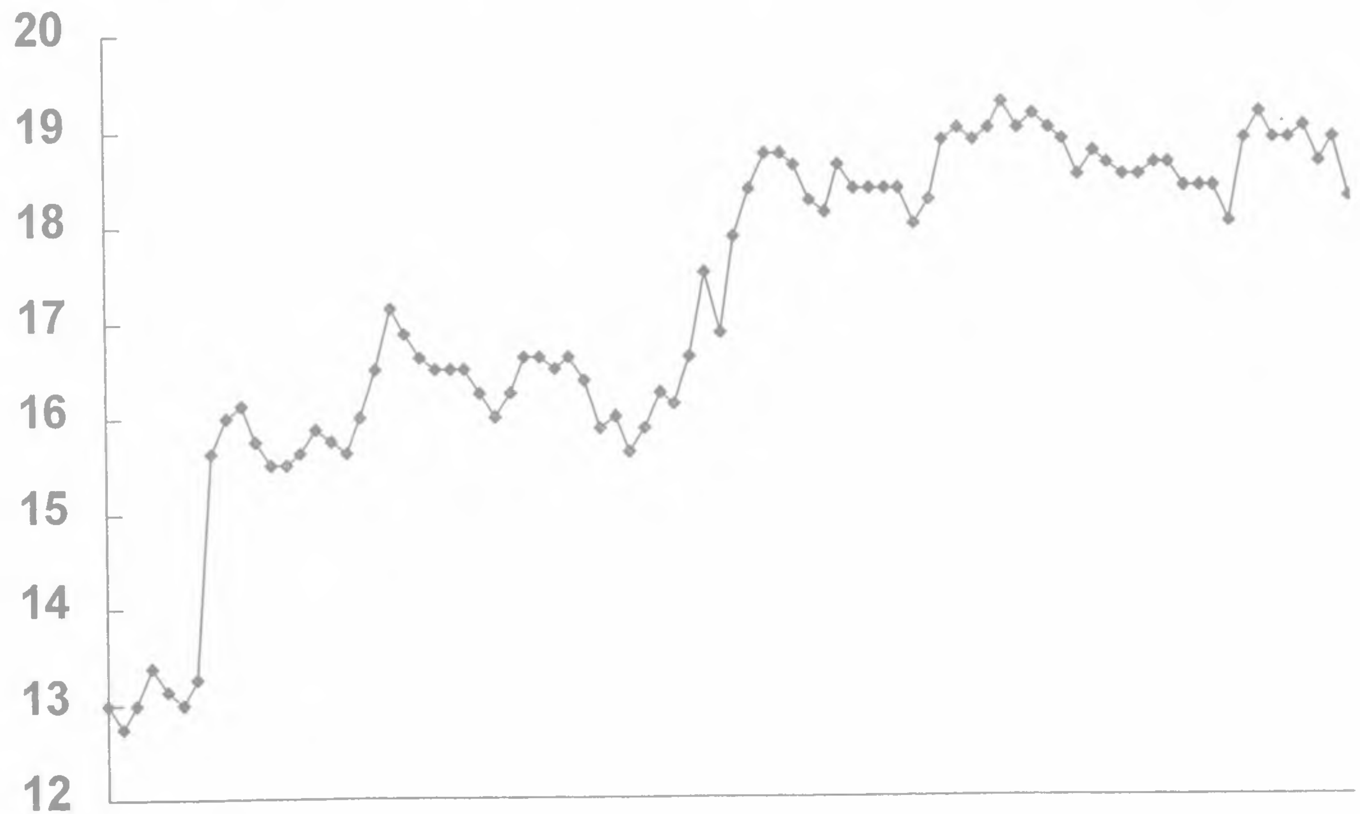
2. Bottom-up within Category

Bottom-up Fundamental Criteria

1. Management
2. Management
3. Management
4. Strategy
5. Company/Financial Performance

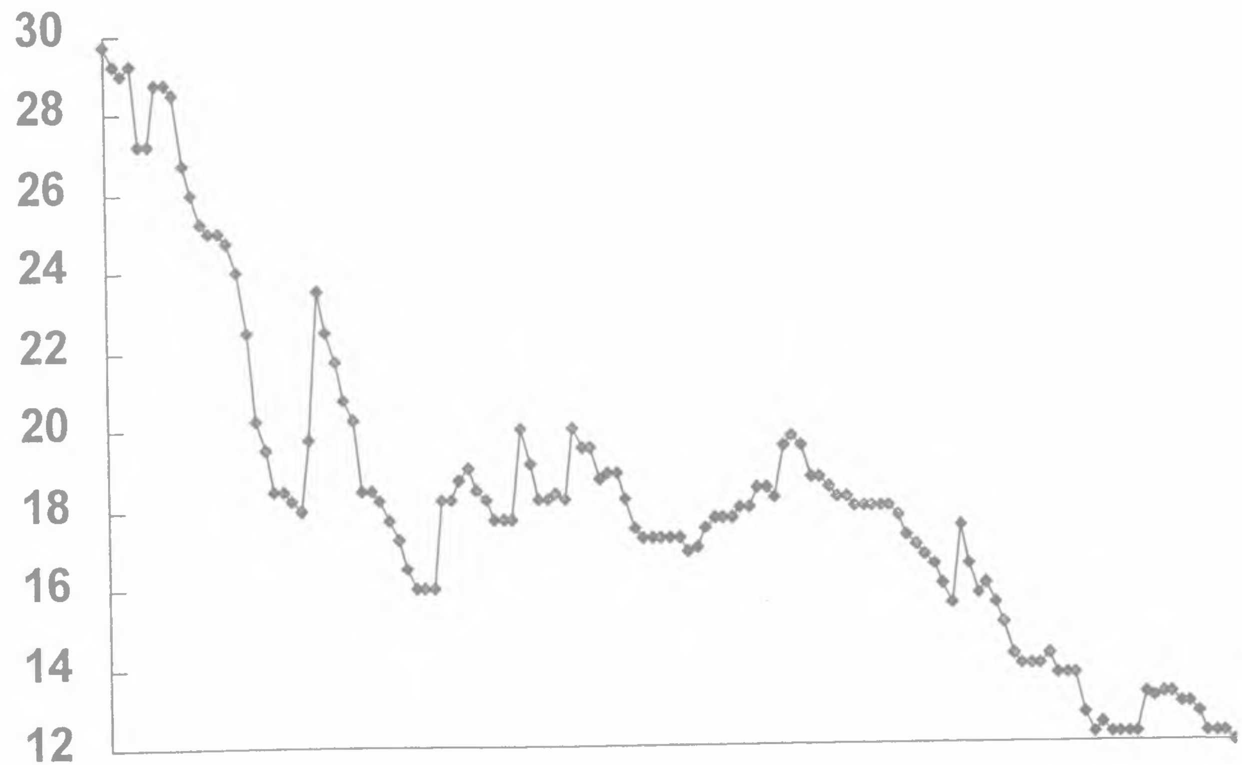
Strong Management: Increased Shareholder Value

Loral Space & Communications: NYSE- LOR



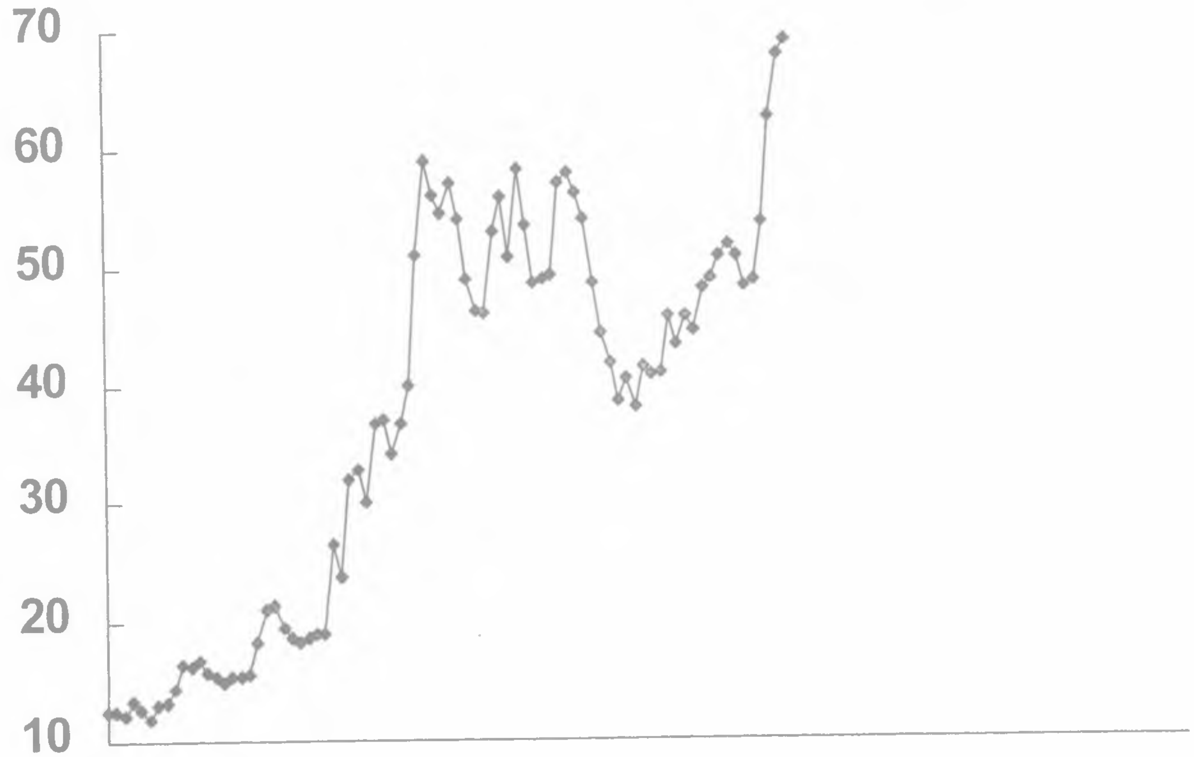
Management's Poor Performance: New Management

American Mobile Satellite Corp: NASDAQ- SKYC



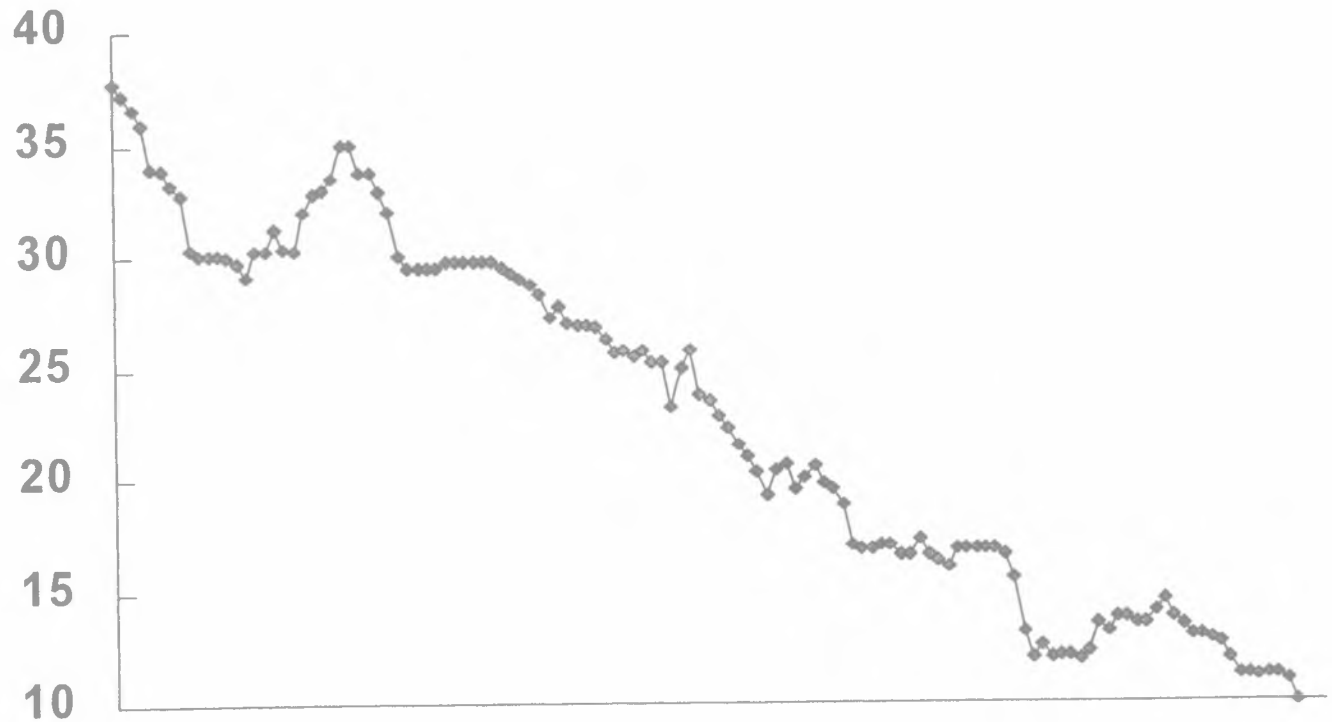
Solid Strategy: More Likely to Succeed

Globalstar Telecommunications LTD: NASDAQ-GSTRF



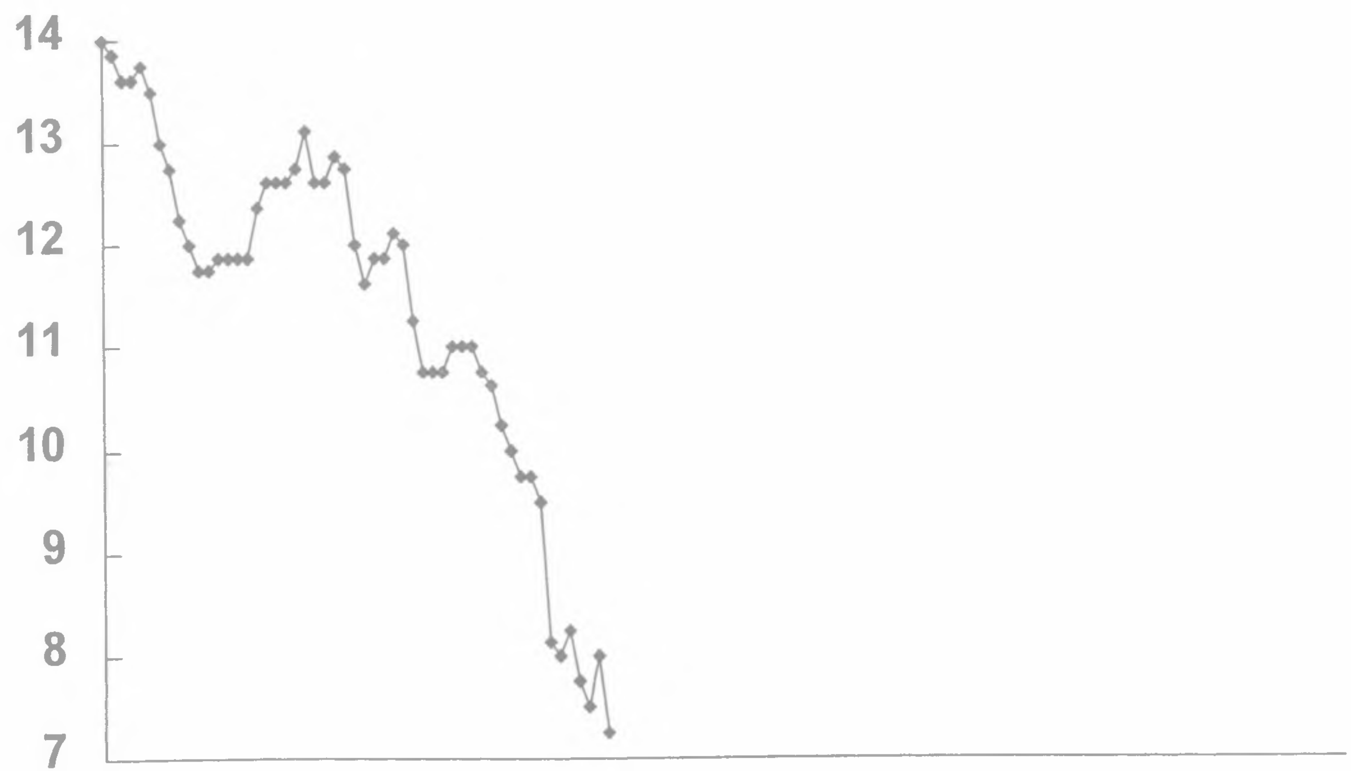
Poor Strategy: Success Unlikely

United States Satellite Broadcasting: NASDAQ-USSB



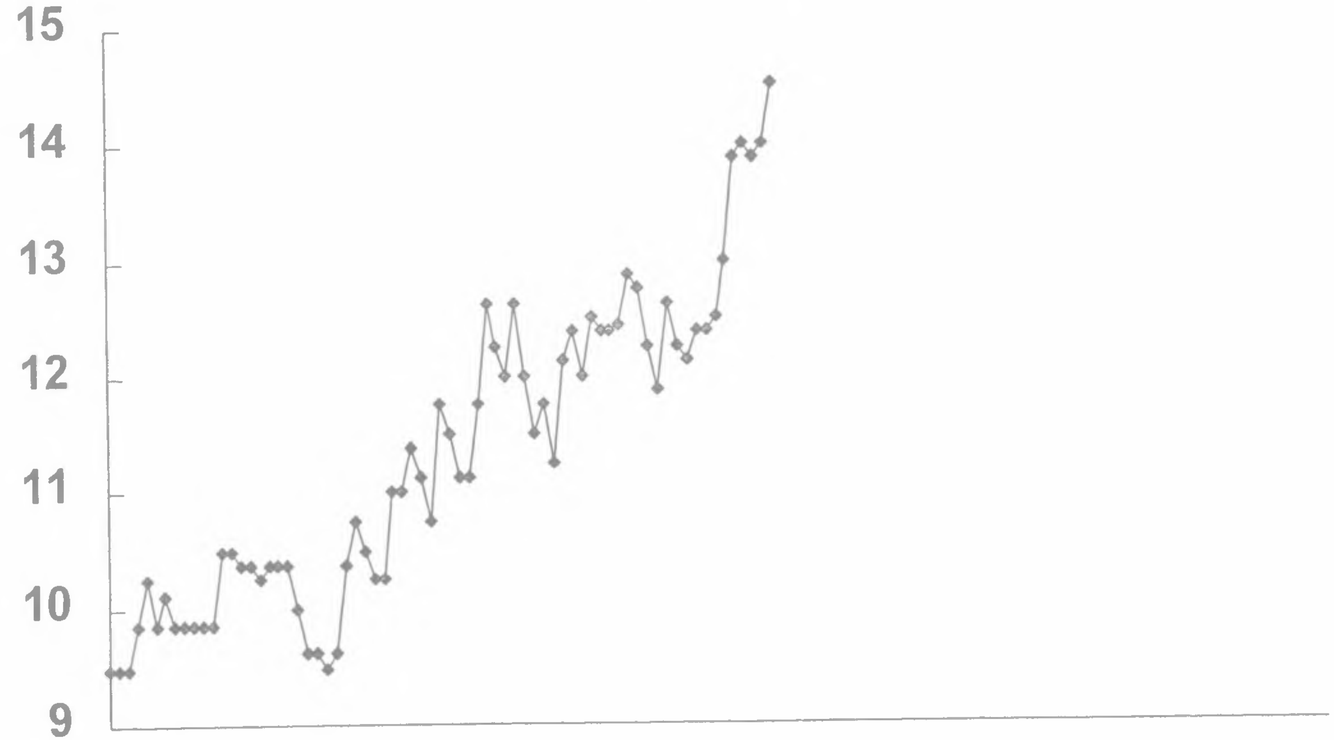
When Not Fulfilling Expectations: Investors Lose Confidence

Orion Network Systems, Inc.: NASDAQ-ONSI



When Fulfilling Expectations: Investors Regain Confidence

Orion Network Systems, Inc.: NASDAQ- ONSI



Valuation Criteria

- Most Satellite Companies in Early Stage with Immature Revenue and Earnings History.
- Communications Services Typically Valued Using Discounted Cash Flow Method.
- Other Considerations Include Orbital Locations, Spectrum
- Multiples typically a function of Management, Expected Growth, Leverage on Assets

Unterberg Harris, Second Annual

Satellite Communications Conference

New York City, April 9 1997

Loral Space & Communications	Bernard L. Schwartz, Chairman & CEO
Hughes Space & Communications	Steve Dorfman, President & CE0
American Mobile Satellite Corp.	Gary Parsons, President & CEO
CD Radio Inc.	David Margolese, Chairman & CEO
Echostar Communications Corp.	Charles Ergen, Chairman & CEO
Federal Communications Commission	Donald Gips, Int’l Bureau Chief
Globalstar Telecommunications Ltd.	Bernard L. Schwartz, Chairman & CEO
Orion Network Systems	W. Neil Bauer, President & CEO
PanAmSat	Lourdes Seralegui, Executive V.P.
TVN Entertainment	Stuart Levin, Chairman & CEO
ViaSat	Mark Dankberg, President & CEO
WSI Systems, Inc.	David Hershberg, Chairman & CEO

Contractual Innovation

M. Jourdain, Matra Marconi Space, France

(See page 361)

VENTURE CAPITAL & SPACE? - YES!

by
Jörg Kreisel & Klaus Nathusius
GENES GmbH Venture Services

ABSTRACT

This contribution to the workshop wants the space community to become aware of venture capital and its capabilities as an appropriate instrument towards commercialization. While billions of dollars equity get invested in tens of thousands of young and mostly technology-oriented companies each year, the space community is still struggeling with fairly unsuccessful commercialization efforts. Two major reasons have caused this dilemma: lack of interaction and communication with the business world and missing skills among the players in the space community to push the desired development to realize a reasonable number of fully commercial activities. Being in the international venture capital business for nearly twenty years, and being familiar with the space sector, GENES after intensive analyses has decided to develop in co-operaton with relevant players space-related venture capital to support a real commercialization process in space. But the experiences made so far have shown, necessary homework has to be conducted as well as visible commitments have to be made by the space community first. This paper puts a mirror on space and spotlights the major factors from a venture capital investors perspective. Then two activity lines to involve venture capital in space will be proposed, which are: a focused educational approach to generate and ensure the ability to understand and communicate business, furthermore the setting-up of a specially tailored international venture capital fund for space. The overall goal of such activities is to relieve the budgets on longterm, and to create jobs by generating sustainable businesses which will profit space, the investors and the economy.

CONTENT

1. INTRODUCTION & BACKGROUND

Who we are

GENES is an independent international Venture Capital firm founded in 1978 by Dr. Klaus Nathusius as one of the first groups in the business in Germany. So far GENES has managed four international Venture Capital funds with an overall volume of US$ 100 mill.. GENES is the German partner of Euroventures, the European network of venture capital funds in each major European country. Klaus Nathusius has served as chairman of the European Venture Capital Association (EVCA). GENES is internationally oriented and has raised reasonable portions of its funds outside of Europe, primarily from institutional investors in the US. Since the involvement of Jörg Kreisel in 1994, who is aerospace engineer by training and gained experiences and connectivity in the space business on international level, the group has decided to set a new focus on space commercialization. The GENES team of partners consists of further experts with technical and scientific background. The space-related objective is to involve specialized venture capital to identify, acquire, fund, develop and monitor selected high-technology enterprises and fully exploit their commercial potential in building highly profitable, financially-sustainable businesses with international growth. Encouraged by an excellent transnational network in the space sector, in the financial community, in industry as well as in R&D and many years of experiences in generating, financing, coaching and monitoring young companies GENES is eager to further develop activities for space commercialization in co-operation with the relevant players.

Our Message in the context of "Innovations for Competitiveness"

The scientific and technological potential of the space sector is obviously tremendous and its skilled manpower base is quite unique. Global downsizing in the nineties and worldwide shrinking space budgets have brought up an intensified discussion on space commercialization. Especially since the space industry as well as R&D-bodies suffer from such budget cuts or fewer governmental and agency contracts, the need for entering new markets and more interactions with the privat sector industry have become priorities. This makes sense, because the entrepreneurs and institutions in businesses exploiting the technology derivatives of space endeavors know that space is one of the most exiting commercial growth sectors today. But what is the situation?

Others think similar:

SpaceVest: "High-tech - scary, complicated, risky. Space - the most high-tech of the high-tech, pie in the sky, the purview of governments, not really a business". This is often the institutional investor´s perception. Decades of building a mystique for space have removed it from the mainstream and created an attitude of unreality and futurism. Exitement with the technology and its potential have created business approaches unrelated to the hard facts of originating and running a business for profit. That, after all, is the bottom line to an investor. And it is irrelevant whether it is exiting, or trendy, or visionary. Investors need the opportunity to get what they want: value. That is value in terms of profit, rapid payback, return on investment. That is not easy or simple. It takes being smarter, better, wiser. It takes education, hard work, and homework. It means rethinking the business - not the project - to maximize growth, strengthen management, and find new markets. That is, what an individually tailored venture capital fund for space will be all about. It will bring smart capital!- It will not consult, but will help to manage. It will not be passive, it will be pro-active. It will not work alone, it will build teams and help to build companies. The space industry represents one of those rare windows into multiple markets and multiple opportunities. Its broad applications potential has been proven over thirty years of generating technology and business advancements for society. This legacy is enhanced for the future by an economic environment in transition and by public sector initiatives specifially designed to maximize the utilization of space technology for commercial gain. The importance of commercial space activities was formally recognized in the mid-1980s. Noumerous government initiatives enhancing growth and technology commercialization are underway since then. Such as, directives for governments procurement of space-related services rather than products, more recent administration efforts to assist small business development, and the establishment of space business in numerous countries. The smaller to medium sized firms in the industry have generally been on the forefront of commercial innovation in the space industry. Typically possessing advantageous cost structures and commercially-oriented market behavior, they are positioned to compete effectively in many unique growth niches. Given the substantial size of the industry worldwide, it is possible for small and medium-sized competitors to experience ample growth without inviting significant competitive response. The need for efficiency improvements and cost controls is causing a rechanneling of resources. The massive space technology reservoir built up from decades of heavy spending is now available at its end to be turned into commercial endeavors. This transition will accelerate the overall growth of the space and space-related industry, making it an even more diverse and vibrant sector of the world economy. Investments from the traditional financial services industry to support this growth has generally been minimal. Recognition of the growth potential of the space industry has been overshadowed by a typical macroeconomic outlook or misunderstanding of its diverse application. Reticence to examine the opportunities in the industry has resulted from unfamiliarity with the nuances and risks of the industry. Further the need for transaction economies of scale brought on by the conglomeration of financial institutions has made it increasingly difficult for small to medium-sized companies, regardless of industry affiliation, to develop strong acceptance in the financial community.

KPMG: Lack of capital for commercial space ventures is indicative of the financial market´s mistrust and unfamiliarity with the industry. Companies requiring external financing must overcome this hurdle by understanding the type of financing required, how best to structure the deal, available resources, and concerns within the financial community. Investors must also understand the market environment and risks to adequately asses a potential deal.

Lance B. Bush: "Researcher culture to support innovation for competitiveness": The well performed investigation of the researcher culture in space conducted by Lance B. Bush, a "commercializer" at NASA LRC, resulted in what many business people knew already: Even in organizations that are recognized for their technology transfer efforts the culture to support a more widespread technology transfer mission may not necessarily exist. NASA which has long prided itself on its spin-offs, even going so far as to publish a yearly magazine highlighting its technology transfers entitled "Spin-Off", may not necessarily have the culture to strongly support an increased technology commercialization mandate. The most important finding of the survey is that the researchers do not want to be accountable or responsible for performing technology transfer. Although 95% of them agreed that technology transfer should be part of the NASA mission, only 64% agreed that it is their respsonsibility, 43% agreed that it should be part of their performance plan and appraisal, and 31% agreed that it should be a consideration during their promotion process. The researchers perceived and real lack of knowledge concerning technology transfer is also troublesome. Only 36% felt they were adequately prepared to perform technology transfer. When asked to identify mechanisms of technology transfer the largest response by them was through publications (43%). In contrast, only 12% identified memorandums of agreements and 6% identified patents. These findings cause concern since this study and many previous ones have identified championing by the researcher as a crucial component of successful technology transfer. The maxim of "publish or perish" still exists in many space laboratories. Until the reward system is changed the number of researchers with interest and ability to perform technology transfer or commercialization may remain at its current level. Technology transfer education and training of the researchers is recommended to overcome this possible hurdle to commercialization success.

2. VENTURE CAPITAL IN BRIEF

2.1 What Is Venture Capital an How Does It Work?

Venture Capital is "capital plus", "involved capital" or "smart capital". That means equity for technology-oriented growth companies plus active support or "value adding". Such pro-active finance is typically provided by venture capital funds that build a portfolio of companies. The money can come from sources like institutional investors (as pensions funds, insurance companies or banks etc.), industrial investors or private individuals. The venture funds take equity positions in the companies which are often realized in syndicates with other venture capitalists. The objective is a real partnership which enables the entrepreneurs to successfully grow their companies and to generate superior returns for the investors. The higher the risks involved, the higher the chances for the investors. The intermediaries are the fund managers adding value to the companies by an active coaching and by providing expertise, connectivity and everything necessary to reach the common goal. A pro of such construction is, that the fund managers have a natural interest in being successful, since they usually participate in the funds performance. When the time has come to realize the investments typically three ways of exiting are available. These are the preferred floatation (initial public offering), trade sale - to another company - or buy-back by the company or the management. Venture capital creates a win-win structure.

2.2 The World´s Equity Finance Business

Equity plays a key role for the successful development of young technology-oriented companies, because of the involved risks, and uncertainties due to external influences as market dynamics, suppliers, capital costs and so on. Already during the last century wealthy people and a few private banks acknowledged this matter by starting first equity finance activities. Earlier this century groups as the Rockefeller or the Whitney family started institutionalized efforts when they set up their own venture capital firms and funds. Others followed until in the 50s the US Small Business Administration through the SBIC-Program finally kicked-off an avalanche of venture capital firms entering the business. This has led into developments as Silicon Valley south of San Francisco or Route 128 around Boston, where thousands of innovative companies where founded and venture-backed, and partly still dominate the world market. Today we have primarily venture capital funds and business angels driving this business on the young companies side, which has become especially over the last decades an industry itself. Who are the players?:

- bank-related funds
- industry-related funds
- independent **Venture Capital Funds**
- *Business Angels*

The venture capital business has developed fast since the early 80s and has spread all over the world meanwhile. The US are still this industry's capital, but evolving activities can be observed in Europe and Asia as well, supported by a global tendency that more money has become available for such alternative investments. This process was definitely encouraged by outstanding successes which were achieved (**average IRRs of VC-funds in the US in 1995 of 35% and close to 200 public offerings of venture-backed companies**). Today there is an estimated number of more than **2,750** private equity players in business, that raised only in 1995 app. **US$ 45 bill.**.

where	how many	capital raised in 1995
USA	1,400	US$ 28.4 bill.
Europe	600	US$ 5.5 bill.
Asia	550	US$ 6.7 bill.
elsewhere	200	US$ 4.4 bill.
total	2,750	US$ 45.0 bill.

Number of private equity players (by Granville Private Equity Funds)

2.3 The Economic Impact of Venture Capital in Europe

European venture capital funds in 1995 have invested more than US$ 6.7 bill. They held stakes in more than 25,000 companies. 46% of the money invested went into buy-outs and 41% into expansions, while only 6% (US$ 400 mill.) was placed in start-ups and as seed capital. The stage distribution by percentage of number of investments was 53% for expansion, 21% for buy outs, and 19% (4.750 companies) for start-ups and seed.

A survey on the impact of venture capital on investee companies and on the European economy, was recently conducted by the European Venture Capital Association EVCA in co-operation with Coopers & Lybrand Corporate Finance. The followig study results derived from a representative selection of 2,200 companies in 12 European countries and were compared to the performances (job creation, investment, exports and other key economic factors) of the top 500 European companies:

◊ **Venture-backed companies are present in all sectors, they are young and medium-sized:** Operating in a wide range of industries, nearly half of the survey companies were founded in the 1990s and 74% are small and medium-sized (10-499 employees) with an average turnover of US$ 45 mill. Approximately 40% are planning a listing (going public) on the national stock exchange markets.

◊ **Venture-backed companies stimulate the economy**

⇒ Despite difficult economic conditions: "They are fast-growing": over the period 1991-1995 they experienced exceptional growth rates outperforming those of the top 500 European companies. On average sales revenue rose by 35% annually, twice as fast as the top European companies.

⇒ "They create jobs": staff numbers increased by an average of 15% per year over the same period and only by 2% for the top European companies.

⇒ "They invest heavily": investment in plant, property and capital equipment grew by an average of 25% annually. In 1995, R&D expenditure represented on average 8.6% of total sales compared to 1.3% for the top European companies.

⇒ "They develop internationally": on average, their exports rose by 30% per year strengthening international competitiveness.

◊ **Venture capital investors are active partners providing both: financial and non-financial support**

⇒ "They provide equity to support fast growth": on average, they held 46% of the total equity of their investee companies and nearly 40% had majority stakes. Moreover one investee company in three benefited from more than one venture capital investment round.

⇒ "They provide guidance and expertise": the major non-financial contributions, according to the managers of investee companies, were offering advice on financial and strategic matters and acting as a sounding board for ideas. They assist by providing market information, by recruiting management, help to develop market strategies etc.

⇒ "Their contribution is highly regarded": over 80% of the investee companies´managers believed their company would not have existed or would have grown less rapidly without venture capital.

The venture capital business in Europe is still not comparable to what it is like in the US, but related to the federal structure of Europe, the just recently and still slow developing exit channels (liquid stock exchange markets) and hesitative investment culture, IRRs of an average of 15% annually (mainly caused by successes in management buy-outs) show, that also here is a professional industry in place.

2.4 What makes Venture Capital Tick?

The secret about the success of venture capital financing can be derived from the decision criteria used in the investment process. Venture capitalists focus their investment decisions on the following core points:

- Management
- Market
- Product
- Return

Management

The management teams of companies looking for equity finance are the prime criterium. Business success is sensed and created by individuals with an extreme success- and profit-orientation and an excellent background in the relevant markets. They typically - at least in high-tech - come in teams with complimentary experiences and skills. Therefore these teams do not solely consist of scientists and engineers, but also (and often primarily) include people from the industry with backgrounds in:

- General Management
- Marketing and Sales
- Controlling and Finance

For technology transfer projects in space this means: pick the team members among the **best of the industry**, from the **target industry** and use them as the core of the entrepreneurial team. They must be seen as the compliment to the scientific and engineering heads from the space development organisation (inventor team). Such team composition will ensure business success through their market- and profit-orientation and by using proven instruments for market entry and penetration on the basis of a sound financial structure. Venture capitalists have the ability to sense the success-potential of entrepreneurial teams. They often are also involved in building such teams.

Market

Venture capital investments are not made to realize ongoing returns from dividends or interest payments. They solely aim at **capital gains**. Capital gains are achieved by bying stocks of companies low and selling them high within a timeframe of tyically 3 to 5 years. This goal can only be achieved with growing companies:

- Growing in Size
- Growing in Profits and/or
- Growing in Values

Such growth can typically be realized in emerging and growing markets or in markets that go through a period of rapid restructuring. These are the target markets for venture capital investments. Space-related projects should therefore aim at markets with convincing growth or restructuring potential and neglect stable industries and niche markets.

Product

Venture Capital investments are tyically made in products/services with unique features. Therefore investee companies need to be on the leading edge of technological development on a global scale. The reasoning is again based on the capital gains-orientation of venture capital investing: only pioneering situations offer the kind of potential, which is necessary for rapid growth and expansion of sales and profit.

Space-related projects score best on this criterium. Space projects are by their nature on the forefront of technical development and more and more meet with efforts of similar ambitions from space organisations in other parts of the world. This is the breading ground for technical and - hopefully - market breakthroughs!

Return

Venture Capital is a very "capitalistic" way of financing, since it is driven by its profit-motive. Managers of venture capital funds raise the fund capital primarily from institutional (banks, pension funds, insurance companies, endowments, etc.) and industrial sources. These fund investors conduct an asset allocation process in order to direct their money to the best investment classes. Venture capital belongs to the asset class "alternative investments", which is characterized by high risk, but also high potential for returns. Typical returns per annum realized in venture capital are 15 to 30%. These returns differ by country, fund vintage and stage of development of target companies.

In making investment decisions the venture capitalist has to pick those companies which offer appropriate return potential. In the case of space-related high-tech projects the aim would be to realize on an annual basis 30 to 40% IRR (internal rate of return). This high number is caused by the high risk involved, because it has to compensate those portfolio companies which fail or are underperforming.

2.5. Venture Capital vs. Bank Financing

Equity vs. Debt

Banks of the "universal bank" type typically supply companies with debt capital and in return ask for:

- interest payments
- guarantees and
- "good standing".

Early stage and high-tech companies normally can not meet these criteria, because they often are still in the product development process and therefore lack the ability to pay interest (out of what?) or to offer guarantees or other collateral. This is why innovation loans or similar programs for many young, high-tech companies are not an appropriate way of financing. Venture capital is based on the partnership idea: the venture capitalist becomes a shareholder of the company, invests by buying stock and follows parallel interests with the entrepreneurs (equity-oriented). Interest payments and guarantees are not part of the contractual agreements. In contrast the partners to such agreements base the capital infusion on the business plan and a joint understanding about the strategy of the company.

Value Adding

Venture capital is often defined as a value adding exercise. The senior partners of the venture capital management company are typically experienced business men, who have been involved in young, fast-growing companies before. They often focus their investment criteria on certain industries or technical areas in which they have developed special expertise and a personal network. Per senior partner of a venture capital group 5 to 6 investee companies are usually assigned for constant monitoring. This limited number ensures, that the senior partner can spent sufficient time with the investee companies in order to add those personalized ressources (experiences, early stage know-how, connectivity etc.) which young companies mostly do not possess.

Motivation of Senior Partners

The senior partners of a venture capital management group are highly motivated to aid the development of their portfolio companies, because they have the chance to make a lot of money for themselves alongside with the members of the entrepreneurial team. It is usual in the venture capital business to offer a "carried interest" to the senior partners. This is in most cases a 20% participation in realized capital gains, which are distributed among the partners as soon as investors have received their money (plus often a certain additional amount = "hurdle") back. This type of success-based compensation ensures the ongoing personal interest of the senior partner in charge in the positive development of the investee company.

Exiting

Venture capital is highly interested to ensure an exit out of the investment within the typical time frame of 3 to 5 years. Up to this point the investment is illiquid, respectively not creating liquidity for the venture capital fund. The profit for investors is made at the end of the stockholding period by selling the stock.Three different routes are available:

Exit Route	Profit Potential
IPO (initial public offering)	high
Trade Sale	good
Sale to Management Team	low

Because of the high profit potential in using the stock market for an IPO the availability of a public market for young, growing companies (like NASDAQ) is essential. Latest developments in Europe (EASDAQ, AIM and NM-markets) show the positive trend in what used to be non-existing.

Optimal Financing Structures

The modern approach to business finance links the type of financing to the development stage of the company. It is obvious from the above mentioned criteria that venture capital financing is a more appropriate means of financing of young high-tech companies because of:

- the parallel interest of the investors and the entrepreneurs
- the illiquid nature of venture capital during the phase of rapid growth
- the "money plus" or value adding strategy of an involved venture capital investor
- the high motivation of the senior partners of the venture management group and
- the high profit potential for the venture capital investor and the management team within a medium-term time frame.

While debt financing often hinders and strangels young growing companies, venture capital is tuned into the needs of this type of business. Therefore: **Of course, this applies to most of the space-related young companies as well.**

3. THE SPACE SECTOR FROM A VENTURE CAPITAL INVESTORS PERSPECTIVE

The following is a reflection of insights by the venture capital business and other players in the finance industry regarding opportunities for commercial space ventures. Spin-offs in the past have been primarily "fallouts". Successful commercial applications as miniaturization of computerchips, structural analysis software, medical technology, grooved roads etc. are almost forgotten, but have generated multiple paybacks. The space community never made significant profits out of those. Industries interests in technology focus on processes rather than products and on cost-savings not necessarily new jobs. Another opportunity for the space industry is to do it by itself. Activities like the ESA-T.E.S.T.-catalogue are nice and useful pieces of the mosaic, but the picture is big and needs a special kind of people-driven selling of space-related know-how, technologies and products.

3.1 Status

The summarized challenges and problems listed below, reflect the space sectors image seen from a business point of view - let´s say among the financial community and non-space commercial players - and should encourage policy- and decision-makers in commercialization to help bypass these hindering obstacles.

Pros

- sound technological and scientific base
- excellent infrastructure, laboratories etc.
- skilled manpower base

- international, interdisciplinary, intercultural
- willingness to commercialize (has become policy)
- good image (know-how) and positive flair
- investment/business opportunities

Cons

- historically single sourcing/public budgets
- no market orientation
- not profit-driven
- lack of adequate management skills
- obsolete financial expertise
- missing entrepreneurial spirit
- bureaucratic processes/red tape
- "Island Syndrom" (mentally egocentric and selfsufficient)
- ignore time windows/timing aspects
- weak ability to turn ideas into concepts and business plans
- too slow when transition from R&D into applications is urgent
- few MBOs of challenging projects
- seldomly new companies are founded as independent entities
- no significant good examples yet
- what is wrong about making a lot of money?
- narrow connectivity

3.2 Current Venture-Backed and Space-Related Activities

Despite tremendous business opportunities (at least theoretically) there are due to the situation stated before only few venture-backed activities visible so far. Here some examples:

- The most advanced approach is the US$ 50 mill. SpaceVest Fund in Washington D.C. launched in 1995 and exclusively financing space-related companies. To date the portfolio consists of 10 companies and is developing well.
- Spacehab, founded in 1984 benefited from Polyventures´ venture capital investment in 1987 and became profitable in 1994 (1995 profit: US$ 15.8 mill.) before going public in December 1995.
- A small German venture capital fund originated a spin-off from RWTH Aachen, a potential future supplier of the Ariane V launcher (tank parts).
- GENES involved university-based space specialists (structural mechanics) in a prototyp development program of one of its portfolio companies in the automotive sector. This company has achieved to become category A supplier for Volkswagen and Audi and is now supported by know-how derived from the hypersonic program developing fully composite-substituted cardan shafts and driving axles.

These cases are highly appreciated! **It is possible to benefit from venture capital in space, but many more examples have to come up in order to really dynamize the commercialization process.**

4. HOW TO INVOLVE VENTURE CAPITAL IN SPACE

4.1. Requirements (Conclusions)

To meet the expectations of a venture capital investor respectively the senior partners of a venture capital management group requires essential homework for the space community and the teams involved:

- implement business development approaches to foster competitiveness
- allow communication with non-space industries and financial community
- adequate promotion of space in these areas
- learn the outside-world's language and culture
- understand business concepts and market development
- learn how to build a company
- learn about finance, at least the basics
- responsibility and risk-taking
- generate professional business plans
- remain from arrogance regarding external expertise - allow help!
- show visible committments to space commercialization
- become business-like to get accepted
- change attitude from an agency standpoint to an entrepreneurial approach

In other industries the financial market regulates and meets the demand of funding automatically, because all involved players are familiar with the game. Not so with space! Therefore a supporting financial instrument has to be provided to successfully start this process. On a longterm basis such initial kick will be followed by immitating approaches and continiously help to become innovative and competitive in terms of business.

4.2. Pilot Projects (Recommendations)

Two major activities to be realized in parallel should be considered as pilot projects to accelerate the commercialization process.

Education to change the culture and promote necessary attitudes and skills

- entrepreneurship institute
- workshops and seminars
- case studies, benchmarking, venture clinics,....
- assessment of competing proposals
- coached trips to the hot spots to meet with the big shots

International Venture Capital Fund for Space

Because of the nature of the space sector being still incompatible with common structures in non-space businesses and the financial community, an insightful and specially tailored capital facility for space should be developed. Such instrument would preferably be an international venture capital fund aiming at meeting commercial innovations, competitiveness and technology transfer. This fund could be designed as follows:

Mission:
- smart equity to stimulate commercial space activities by building sustainable businesses

Investment focus by activity:
- space core activities
- space spin-offs (technology transfer and other terrestrial applications, MBOs etc.)
- fund-of-funds function

Investment focus by geography:
- ESA member countries
- USA & Canada
- selected others worldwide

Limited partners (investors):
- commitment by the space community (lead investment app. 40%) from space agencies, national ministries, EU, and the space industry
- institutional investors
- industrial investors
- subsidies and supporting programs

Fund characteristics:
- target size: min. US$ 100 mill.
- portfolio size/number of investments: 15 to 20 within 3 years
- liquidation after 10 years
- type of finance: early-stage, expansion, MBOs, LBOs
- experienced fund management with background in space and excellent connectivity

Realization:
- concept definition and placement document 1997
- lead investment by spring 1998
- first closing mid 1998
- begin of operation in 1998

This instrument would combine various advantages compensating current lacks in space. Firstly, adequate finance could be provided accompanied by value adding and coaching. Secondly, core activities as well as transfer opportunities could be financed. The size of deals can reach reasonable sizes by involving investment syndicates or leveraging. Thirdly, the fund-of-funds approach allows cross-boarder and cross-industry relationships and provides connectivity, new markets and insights on alternative methods and procedures. Another important side effect would be the transition within the space community towards competitiveness in new markets (and budgets could be relieved, too).

Financing for space ventures

Leo Hellinga

representing
ING Lease International Equipment Finance

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ING Group

- Full subsidiary of ING Group (Aa2/AA- rated)
- Consists of ING Bank, ING Insurance and ING Barings
- ING Group largest financial institution in the Netherlands (Bancassurance)
- Presence in more than 50 countries worldwide
- Some figures
  - USD 240 bln in Total Assets in 1995
  - over 50.000 employees
  - Net Profit 1995: USD 1.6 bln.

ING Lease International Equipment Finance

ING Lease

- Balance sheet total '95: USD 6.2 bln.
- 995 Employees.
- European Network with offices in the Netherlands, Italy, Spain, Poland, UK, France, Germany, Belgium, Ireland.
- General Leasing, Specialist leasing, Big Ticket Leasing.

ING Lease International Equipment Finance

Expertise ING Lease IEF

- Key Asset Based Financings areas:
  - Containers
  - Rolling stock
  - Telecom/Space
  - Aviation

- Tax driven products

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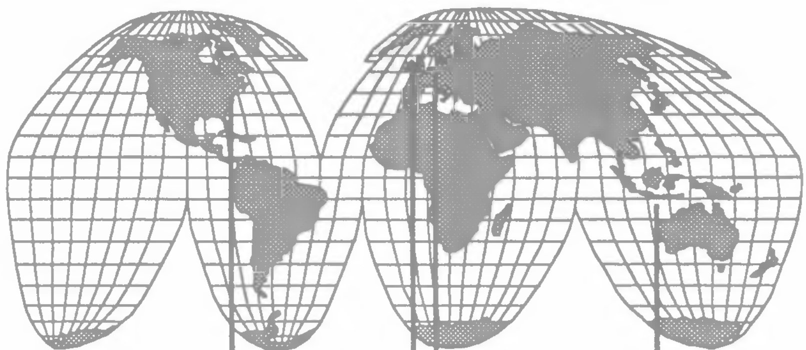
Global Coverage



Satellite Finance Categories

- Corporate Finance - Lending
  - Tax leasing
- Asset Based Finance - Lending
  - Operat. Leases
- Project Finance
- Vendor Finance

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Recent examples

■Corporate Finance	Sea Launch/ Iridium/SeS Astra
■Asset Based	GM Hughes
■Project Finance	APT/ACeS
■Vendor Finance	Arianespace

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When is finance available

- Commercial viability
- Assessment based on:
  - Credit risk assesment
  - Project risk assessment
- Crucial is TIMING

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Categorisation (I)
Credit Risk

- Financial substance of operator/lender
- Country
- Market addressed
- Technology used
- Shareholders
- Market position

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Categorisation (II)
Project Risk

- Regulatory risk
- Market risk
- Asset value/Remarketing risk
- Completion risk (construction/in-orbit)
- Technical risk (launch/in-orbit)
- Political/country risk

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Sources of Finance

- The public (equity/bonds)
- Institutional investors
- Financial institutions as strategic and financial investors
- Banks
- Leasing companies
- Vendors
- Export Credit agencies
- Multilateral institutions

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When to Refinance

- Cost of financing comes down by phase:
  - construction: No cash flow: Risk capital and project financing. Insurance key.
  - In-orbit: Cash Flow: cheaper forms of (non) recourse debt available as well as tax deals.
- and Financial substance.

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Main Roles of ING

- Lender/Underwriter
- Arranger (debt, equity and tax deals)
- (Single) Investor
- Sourcer of Tax Investors
- Advisor (financing and business plan)
- Credit Enhancer

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ING and satellite Tax Based Leasing

- US Leveraged Lease (domestic)
- C-FSC (US cross-border structure)
- Off-balance sheet loan (US)

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Success factors

- Experience in satellite/transponder financing markets
- Ability to arrange and (fully) underwrite deals
- Offer wide range of products
- Knowledge of clients' (local) market
- Flexibility and responsiveness to clients' needs
- Short (institutional) turn around time

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Driving the Evolution of Manned Space Systems

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International Workshop 'Innovation for Competitiveness'

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DRIVING THE EVOLUTION OF MANNED SPACE SYSTEMS

S. Gazey [1] (D), Dasa RI

ABSTRACT

Innovation is in most cases the result of long term strategies and visions. Innovation processes follow innovative strategies and organizations developing technologies, processes and products in preparation for the long term "visionary" goals.

The International Space Station (ISS) will be operational in five years from now. It will be the largest high-tech enterprise ever built by mankind in international cooperation at a multibillion dollars budget. The ISS will open new dimensions of diverse science utilization possibilities, space applications, space technology developments and space systems operations with a high potential for innovative terrestrial and space applications.

The ISS, as a manned system, and future manned or automatic platforms will not only contribute to solutions of our global problems, but also open new opportunities for manned space flight ventures such as space tourism and moon colonization.

This paper will describe such evolutionary scenarios of the ISS and future manned systems and discuss their potential as orbital media for innovation.

[1] *Dipl.-Ing., Vice President Orbital Systems*

1. INTRODUCTION

Since Yuri Gagarin's orbital flight in 1961 in the Soviet Wostok Capsule, a dramatic development of Manned Space Systems has taken place. Crewed landing on the moon, Skylab and Salyut as the first orbital stations, the Space Shuttle regular flights and the permanently manned Russian orbiting station MIR, demonstrating manned long duration on orbit capability up to one year, is the exciting road map of manned space technology achievements.

With the International Space Station (ISS) Programme this technology will not only be consolidated, but also further advanced.
The permanent crew presence on board, the regular crew exchange and logistic flights to the station and back, and the long term operation and utilization of the ISS will add an impressive record to the scale of experience and strongly increase the maturity of manned space flight systems through their frequent operation in international cooperation. This precious experience will form the basis for future manned space ventures.

However, the space sector has to develop innovative strategies, organizations, products and processes to master the upcoming and future tasks under constantly declining budgets and severe political constraints to make future manned space missions of the next century affordable.

With the International Space Station programme, we are given the chance to develop innovative ideas and approaches. Lets take it!

2. THE EVOLUTION OF MANNED SYSTEMS

2.1 The International Space Station - The Orbital Medium for Innovation

Manned space systems will be dominated in the next two decades by the International Space Station (ISS) programme.

The ISS build up will commence end of 1997, and will be operational in 2002. It will consist of an orbital infrastructure of multiple habitation and laboratory modules, exposed facilities and power generating solar arrays mounted to a truss structure.

The ISS (Fig. 2.1-1) orbital infrastructure will be permanently manned by up to 6 astronauts and will be serviced by diverse launching and logistics systems provided by the international partners USA, Russia, Japan, Canada and Europe.

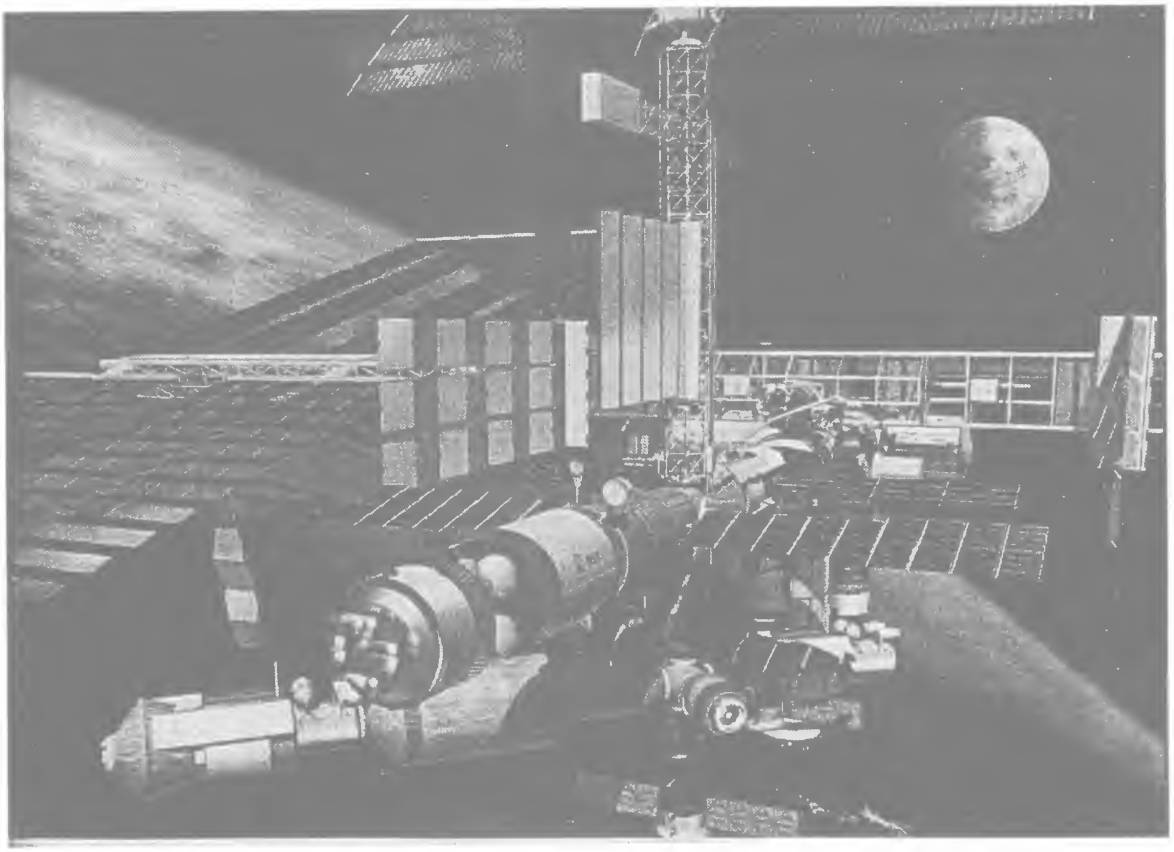

Fig. 2.1-1: International Space Station

The ISS will be the largest high-tech enterprise ever built by mankind in international cooperation at a multibillion dollars budget, and will comprise the world's leading space nations' human flight capabilities and technologies.

When assembly of the ISS is complete, it will be operated and utilized over a period of at least 10 -15 years, involving a multiple of transportation systems, international crew members, ground infrastructures, thousands of engineers, scientists and technicians all over the world. Hence, in its entirety the ISS provides academia and industry a medium for innovation and a unique opportunity for in-orbit research and technology demonstration.

The ISS will open new dimensions of space technology development and of space system operations with a high spin-off potential for innovative space and terrestrial applications, and will push new set-ups in agency / industry responsibility sharing. It will provide unique laboratory capabilities with multi-disciplinary facilities, space exposed platforms, attached payloads and small ISS co-orbiting free-flyer, using the ISS as a servicing base for basic and applied research in a variety of scientific disciplines, i.e. material science, life sciences, space science, earth observation and space technology [5].

The operation and servicing of the station itself will cover multiple state-of-the-art and advanced systems to ensure safe operation and maximum utilization.

The ISS will serve as a testbed for new technologies, using the internal facilities, external platforms and structures, and taking advantage of the availability of crew members for IVA or EVA operations. Human presence at the station will not only allow for extended research and technology development, but also for crew intervention to improve and potentially correct operational and experimental performance.

Examples for technology developments using the ISS and its servicing elements as a testbed for in orbit testing and demonstration are:

- Internal / external servicing robots
- Advanced failure tolerant computers
- Enhanced failure detection, isolation and recovery capable guidance, navigation and control systems (FDIR)
- Micro / Nano technologies
- Inspection and repair procedures and tools
- Crew training tools
- Fully closed loop life support systems.

2.1.1. ISS ENHANCEMENTS / EXTENSIONS

The current design of the International Space Station is the result of a lengthy optimization process between different, and sometimes contradictory, requirements and objectives. This fact provides the opportunity to the space community to come up with ideas and concepts to enhance and / or extend the ISS capabilities over its long lifetime [1].

Such concepts already exist and more will be expected in the future. In October 1995, NASA initiated the AETD Program with the objective to:

- Enhance utilization
- Improve operations and performances
- Reduce life cycle costs
- Reduce risk.

The AETD defines in detail the requirements to enhance the ISS Mission, covering IVA, EVA, Robotic Systems, Power, Logistics, Flight control, Crew and Training, Experiment Accommodations, Life Support, Vehicle Risk and Habitability.
All involved AETD parties at agencies and institutes, and also in industry are requested to contribute to the AETD by submitting their proposals [6].

Proposals will be evaluated on a semi-annual basis and prioritized: Those technologies that support ISS goals and have greater payback for the ISS mission will be selected. Projects will then be initiated consistent with budget and cargo space and weight allocations. In the following some prominent examples of ISS enhancements and / or extensions:

a) Space Station Servicing

Daimler-Benz Aerospace, supported by Rockwell Aerospace and RSC Energia, have proposed the ISS-Inspector Project within the NASA AETD Programme. Inspector - as its name suggests - will be capable of externally implementing inspection of the ISS by means of remote diagnosis and control, hence reducing operational costs and risk prior to assembly or repair operations through EVA. The Inspector will provide visible lighting and video imaging of the ISS at any location, but could also carry infrared cameras and sensors to measure the surrounding environment of the ISS.
The ISS-Inspector is the successor of the MIR-Inspector, which is a prototype vehicle being delivered by the Russian Progress Vehicle to the MIR Station in mid 1997. The vehicle is a free flyer remotely controlled from a laptop type monitoring and control station.

The ISS Inspector will form the basis of future evolution of servicing vehicles at the ISS or the next generation Space Station. By adding robotic and manipulative capabilities, the free flying vehicle would form a so-called Robonaut, which would autonomously execute servicing and repair activities at the Space Station, such as close inspection, including docking at any location, supporting astronauts EVA (e.g. tool caddy) or simple manipulation tasks like precise lighting or cutting [3].

Within the Inspector evolution (Fig. 2.1-2), the "Visitor" co-orbiting platform will provide the capability for payload operations away from the station, but serviced and exchanged at the Station Servicing Platform.The Platform will have automatic soft docking, refuelling, and charging capability.

The servicing platform at the European module (COF) could serve as a permanent servicing base for small multi-purpose platforms and satellites.

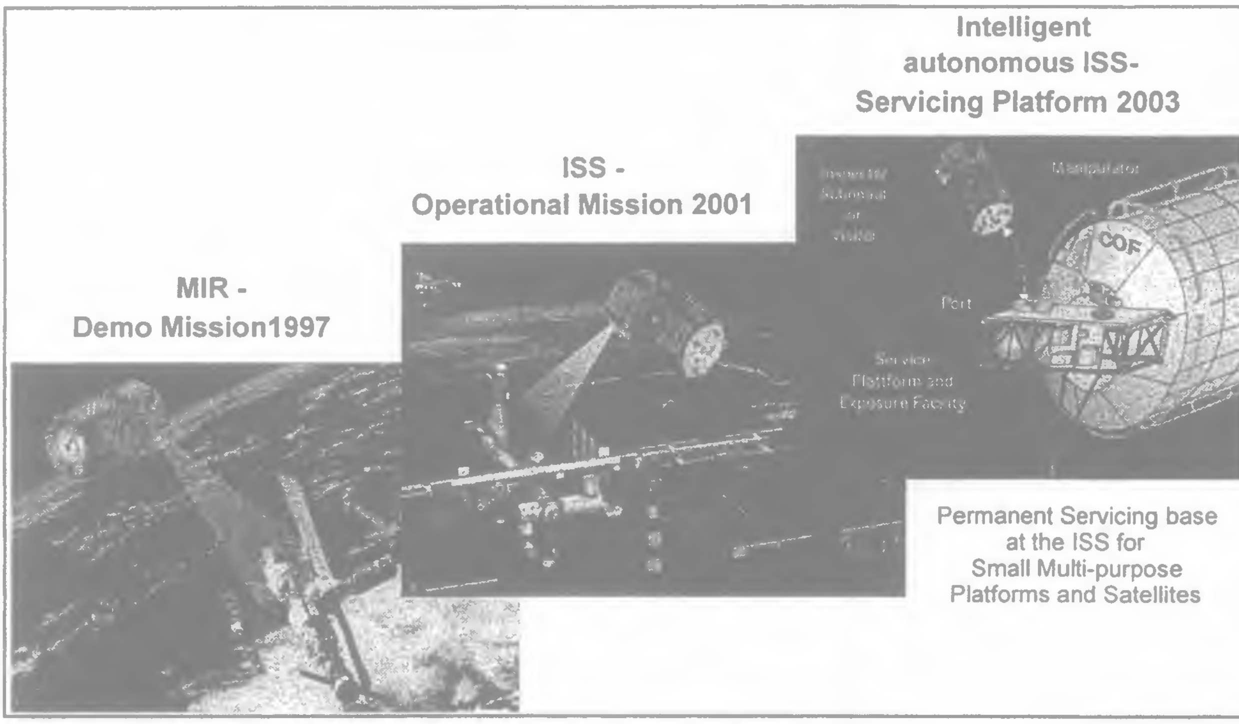

Fig. 2.1-2: The Inspector Evolution

b) Space Station Download

To satisfy the users community need for regular and quick return of small and sensitive samples from the Space Station, the SPARC (Small Payload Return Capsule) project has been proposed by Dasa [2].

SPARC is a semi ballistic capsule using a tether system for deorbitation and a parafoil system for a precise and soft landing (Fig. 2.1-3), no specific landing site is required.

The unsymmetric capsule shape allows a moderate L/D ratio, resulting in an appropriate cross range capability and low reentry G-loads during atmospheric reentry.

SPARC vehicles will be transported to the Space Station by the Space Shuttle or other vehicles, parked at the station and utilized when needed.

All SPARC subsystems are of existing, qualified technologies and include many off-the-shelf equipments. The operational concept demonstration seems to be the only challenging part of this proposal.

The SPARC technical and operational approach, combined with a private industry or combined agency/private financing - provided the service need is demonstrated - could offer an important enhancement of the ISS download transportation capability.

Fig. 2.1-3 SPARC

c) Data Communication Terminal

The COF direct communication link to Europe (DRS Terminal) has been deleted from the baseline for cost "saving reasons". As such a direct communication link is considered essential and would enhance the COF attractiveness to the user community, Dasa is interested and prepared to invest in cooperation with further partners, the development and production of the Data & Communication Terminal and provide the system free of charge to ESA, assuming ESA commits to adequate utilization charges, which would guarantee a return of investment within an acceptable period.

The business would be established on the basis of a balanced benefit/risk situation for both parties. Such an approach would not impact the MSP development budget and would occupy only a fraction of the exploitation budget to cover the users' standard needs. Any special users' requirements for data or communications link could be charged to the user directly.

The proposed DCT would consist of:

- Forward link communication by a Ka-band receiver to command on-board payload from European ground station.
- Return link communication of high rate data streams from on-board system and payload to ground by a Ka-band transmitter (65 M bit/s).
- Closed loop tracking of the Relay satellite (TDRSS or Artemis) or of the ground station by terminal internal control.
- +/-180° azimuth/elevation antenna pointing capability and mast deployment/retraction capability.

d) Industrialized Operation and Utilization

The operation and utilization of the ISS with its complex space and ground infrastructure within the international community cannot be executed in the traditional way as practiced in the past, if cost effectiveness and optimal performance at limited budgets are to be achieved. The space community, agencies and industry, should develop innovative approaches based on its own experience and that of other operators, i.e. commercial satellites and airplane operators using off-the-shelf products and advanced management, simulation and verification tools [8]. Major industrial participants of the ISS programme, Alenia Aerospazio (Italy), Boeing Company (USA), Daimler-Benz Aerospace (Germany), Mitsubishi Heavy Industries (Japan) and Spar Aerospace (Canada) have recently formed a team, which is prepared to take over responsibility for operation and utilization of the Space Station as an international industrial operator (RSC-Energia, Russia, will soon be joining the team as well).

This International Operation and Utilization team will offer their customers, the agencies, an end-to-end service, achieving the goals of low cost operations to maximize the ISS utilization. The team is also jointly developing strategies, processes and products with own investments to prepare for such an innovative approach.

2.1.2 EVOLUTION OF MANNED SPACE SYSTEM CAPABILITIES

Like any technology development, manned or unmanned space systems capabilities will follow an evolutionary process. As a general trend, it aims at a new quality of system capabilities, applying advanced technologies, and includes in the medium and long-term, among others, the following issues:

- Increase of automatic systems with a higher degree of intelligence for pre-planned routine work, keeping crew activity to a minimum. Crew interaction will, however, still be necessary for un-planned and more sophisticated actions
- Implementation of failure tolerant systems to further increase safety and reliability
- Increase of system performance and decrease of operational costs
- Reduction of turn-around times for logistics material and user data
- Improvement of user data links in terms of higher data rates or data compression
- Implementation of in-orbit serviceable systems (e.g. maintenance and repair).

The ISS or its successor needs to be extended to function as a transportation node and as an operations centre, as soon as moon missions in the exploitation phase require heavy traffic between Earth and moon. In future, planetary missions may also benefit from the existence of a LEO space port, where large and heavy systems could be assembled, tested, launched, maintained, repaired or parked. For all these functions, suitable capabilities - assembly facilities, maintenance shelter, fuel storage area, etc. - must be provided at such extended or next generation space station.

2.2 Moon Exploration, Exploitation and Colonization

In the field of Manned Space Systems, the first two decades of the next century will be governed by the Space Station exploitation and the development of advanced and cost effective manned and unmanned transportation systems. During this period, international teams will be preparing the next global manned venture of space fairing nations to the moon, followed later by crewed expeditions to Mars.

After a period of unmanned exploratory missions, which may be "realized" in the short term, a lunar man-tended outpost will be created. The moon, which is the closest and easiest celestial body in space to be reached, could form a "natural" space station as recommended by ESA's long-term space policy committee in their report "Rendezvous with the New Millennium" [4].

Several Space Agencies have issued long-term plans for exploration and exploitation of the moon.
The USA, the only nation that has performed manned visits to the moon so far, is envisaging low cost unmanned missions to the moon with the Lunar Prospector Programme.

ESA presented its new lunar strategy in 1994 at the International Lunar Workshop, consisting of a 4-Phase Plan, addressing specifically the benefits of "Science of, on and from the moon" and the exploitation of the moon's resources.

The proposed phased approach consists of :

I. Lunar explorers
II. Permanent robotic presence
III. First exploitation of the lunar resources and environment
IV. First human outpost.

The technologies developed in Europe for the ISS, and experience and skills gained, will form a solid basis for future moon missions (Fig. 2.2-1).

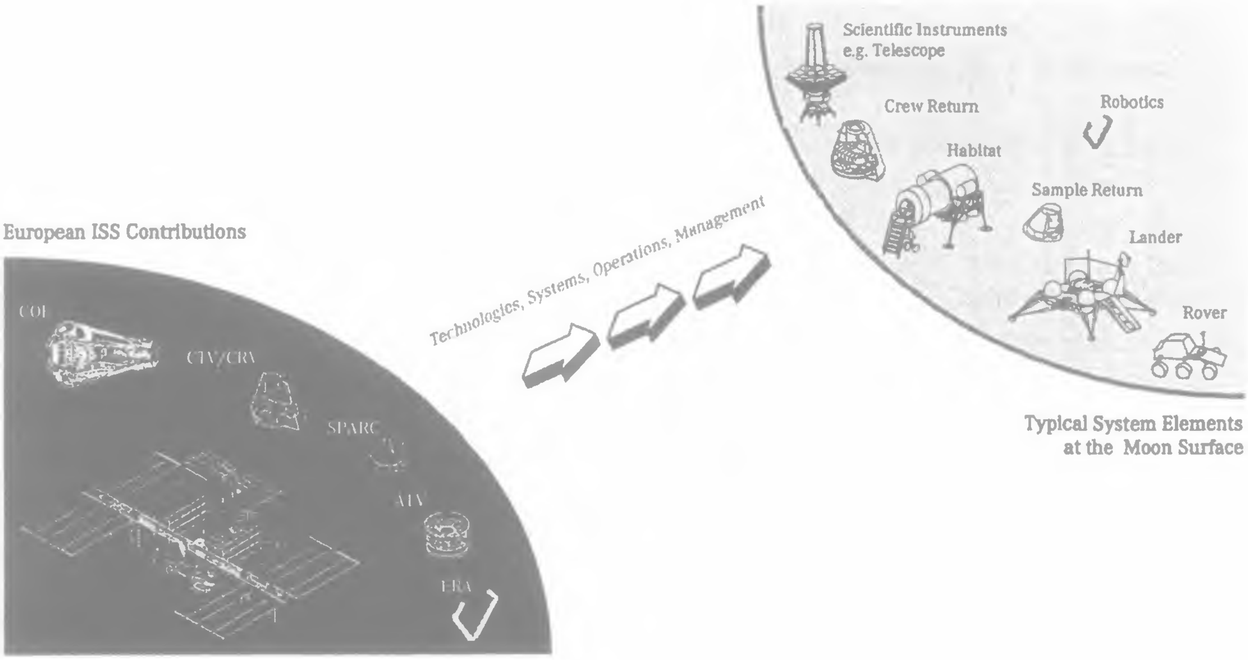

Fig. 2.2-1 Manned Systems Evolution from Space Station to Lunar Surface

In 1996, Japan announced its basic policy for space development, which states that for the Moon in particular, Japan shall continue to accumulate knowledge and pursue a course of comprehensive lunar exploration.

In line with this principle, NASDA and the Institute of Space and Astronautical Science of Japan (ISAS) jointly initiated the Selenological and Engineering Explorer (SELENE) Project. The "Second International Lunar Workshop" to promote world cooperation in lunar exploration and development took place in Kyoto, Japan in October 1996.

The Workshop covered the scientific objectives of moon exploration, the utilization of Lunar environment and resources and proposed a lunar infrastructure for a human-tended base to be established and related technologies be acquired on a worldwide basis.

2.2.1 The ELSPEX Proposal

The Chairman of the Long-term Space Policy Commission (LSPC), Peter Creola, proposed the innovative project ELSPEX - European Lunar South Pole Expedition - for an unmanned exploratory mission to the South Pole of the Moon in the year 2000. The ELSPEX consists of an Orbiter and a Lander Vehicle to be launched by Ariane 4 'free of charge'.

The mission starts with an orbit phase of at least two months to obtain the required knowledge for landing, i.e. topography and gravitation. Then the lander will separate and land on the rim of a small crater located on the south pole and will search for possible frozen volatile, such as water, in the permanently shaded bottom of this south pole crater. The lander will also explore the largest (2500 km!), and probably oldest, lunar crater, the Aitken Basin.

In addition to a scientific payload, mass is allocated to the 'Millennium Challenge' for winning the 'Lunar Southpole Trophy'. A contest will lead to the selection of a few micro rovers or other mobility devices (harpoons or other innovative means), challenged to approach the actual South Lunar Pole, which lies inside the 20 km diameter and 3000 m deep crater, and to find out what is in there! The orbiting satellite will continue its lunar observation mission.

A detailed concept definition of ELSPEX (Fig. 2.2-2) was performed by experts from ESTEC, ESOC and industry, chaired by the former astronaut, Wubbo Ockels, at the Alpbach Summer School in June 1996 [7].

With ELSPEX, Europe could play an important role in Moon exploration, possibly identifying a unique and favourable location for a future human outpost, and would mark the entry of Europe into the third millennium.

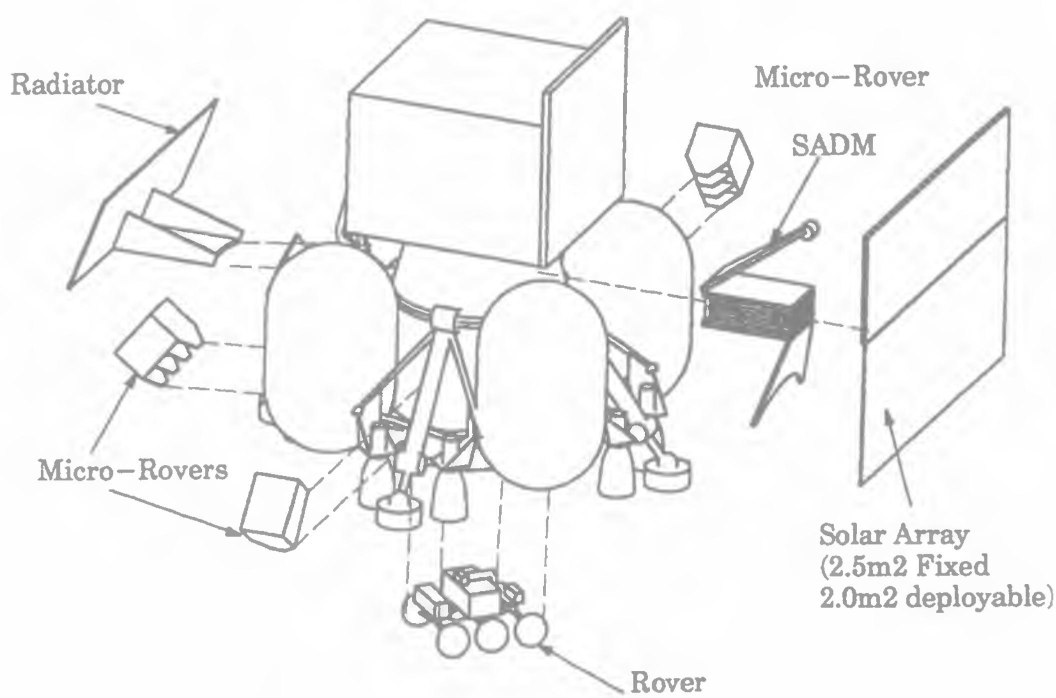

Fig. 2.2-2 ELSPEX Lander

2.2.2 Human Outpost

Complementary to ELSPEX, further lunar exploration missions need to be undertaken to acquire detailed knowledge of the lunar surface and to demonstrate key technologies. This will be followed by the man-tended moon exploitation, facilities installation and possibly resources production, i.e. oxygen using on-site materials to support extended stays by humans on the moon. Finally, larger sized habitats supporting extended stays installed on the lunar surface will represent a first human outpost. Such an outpost would, besides its scientific task, initiate extraction / production of resources in large quantities; with significant industrial exports of lunar resources forming the basis for colonization pacemaker missions, demonstrating possibilities for permanent human settlement on the moon.

With the establishment of a permanent moon base, together with production facilities, the moon will be utilized for missions on and from the moon for human exploration of the universe (Fig. 2.2-3).

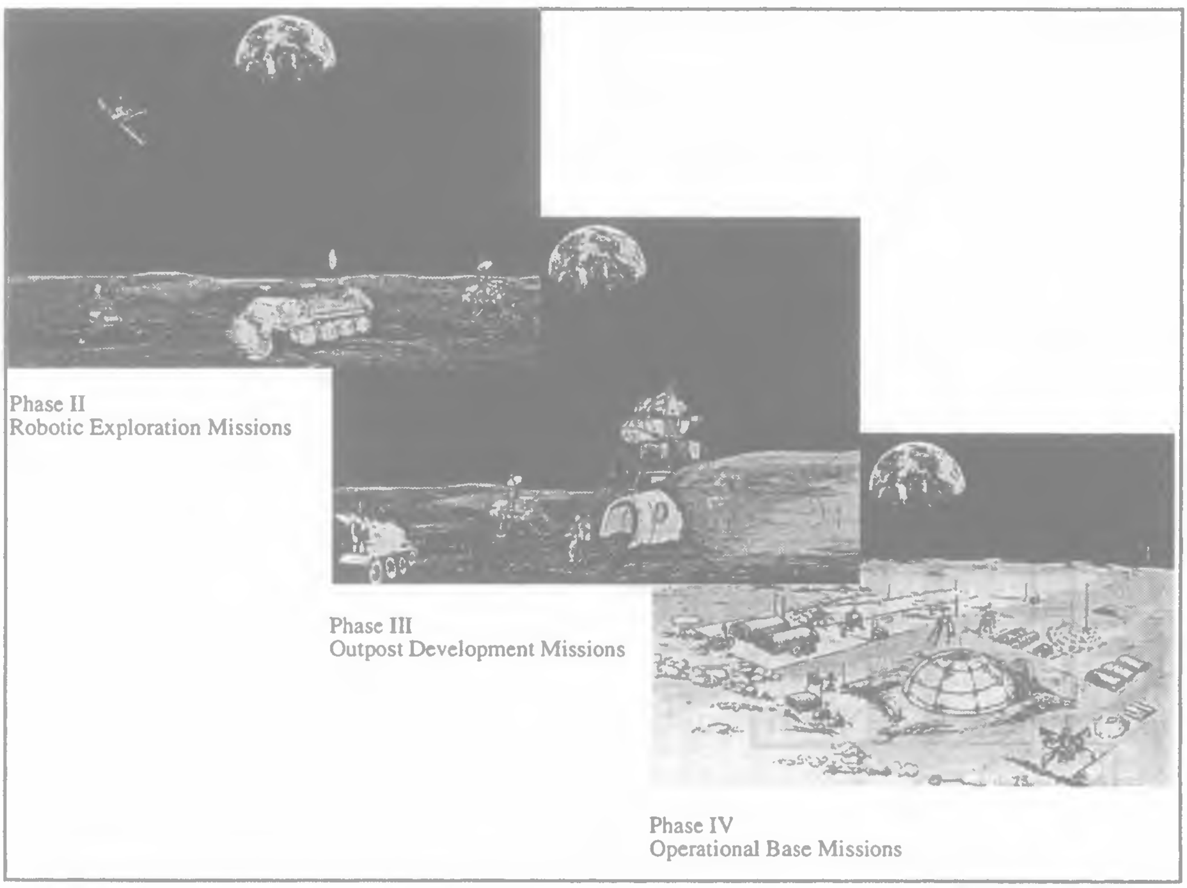

Fig. 2.2-3: Evolution of Moon Base Architecture (Phase II through IV of ESA)

2.3 Space Tourism

In terms of space technology, we have been able to take people into space and return them back to Earth since the early 1960s. Humans have already visited our nearest neighbour planet, the moon, and have frequently orbited Earth for durations of more than a year. The available means to perform these tasks have been gradually improved over the past 35 years, but manned space flight is still a long way from being a routine operation and involves significantly higher risks than comparable high-tech operations, such as commercial air flight or off-shore activities.

Manned space flight will evolve into a routine and safe operation during the forthcoming decades, due to frequent flights to and from the Space Station during the construction and exploitation phases.

Ongoing technology development (X-33, RLV) and future developments will lead to drastic reduction of launch costs.

The above-mentioned facts, plus the growing worldwide demand by individuals to fly into space, as indicated by recent market research, strongly supports the vision of space tourism towards realization. Space Tourism may start with parabolic flights and the stay of selected individuals on the ISS evolving into regular orbital flights to an orbital hotel.
In the long-term, space tourism could evolve into a new opportunity to expand present space activities into new frontiers. Many proposals and publications have been issued discussing the principle feasibility and forecasting a considerable future market. This seems to be not unrealistic when one considers the current global market of terrestrial tourism.

In 1995, the Japanese Rocket Society proposed a tourist space vehicle (Fig. 2.3-1). The system is designed for 50 passengers with panorama windows and facilities to exercise under zero gravity conditions.

Fig. 2.3-1: Capsule Type Tourist Vehicle

Shimizu Corporation has proposed an orbital hotel to accommodate space tourists for durations of up to a few weeks.
At a 'round-trip' ticket price of approx. US $ 20,000, the space tourists will orbit Earth twice at a 200 km circular orbit over a period of three hours.

3. CONCLUSION

Manned Space flight, although a relatively young technology (less than 40 years), has already presented an exciting curriculum vitae to mankind.

Mankind will continue to follow his inherent driving force for exploration, not only to satisfy his curiosity, but also to advance technology developments for daily life, to explore space and planets, and to secure his life on earth.

However, all this demands innovative ideas and approaches to make things affordable.

The ISS, with its capacity, multiple capabilities and international environment, will provide scientists and engineers an excellent medium and opportunity for innovative approaches in research and technology development in cooperation with a world space community.

Abbreviations

AETD	- Advanced Engineering and Technology Development
COF	- Columbus Orbital Facility
DCT	- Data Communication Terminal
DRS	- Data Relay Satellite
ELSPEX	- European Lunar South Pole Expedition
ESA	- European Space Agency
ESOC	- European Space Operation Center
ESTEC	- European Space Research & Technology Center
EVA	- Extra Vehicular Activities
FDIR	- Failure Detection, Isolation & Recovery
ISAS	- Institute of Space & Astronautical Science
ISS	- International Space Station
IVA	- Intra Vehicular Activities
LEO	- Low Earth Orbit
LSPC	- Long-term Space Policy Commission
MSP	- Manned Space Program
NASDA	- National Aeronautics & Space Development Agency
RLV	- Recoverable Launch Vehicle
SELENE	- Selenological & Engineering Explorer
SPARC	- Small Payload Return Capsule
TDRSS	- Tracking & Data Relay Satellite System

References

[1] Gazey, S. / Riedel, U., Dasa-RI
Long-term Development of the Orbital Infrastructure,
DGLR, May 1996

[2] SPARC Final Report,
TN-SPARC-001-Dasa, April 1996

[3] Kerstein, L. / Steinsiek, F., Dasa-RI
The Advanced Serviceable Robotics Free-Flyer Operations at the ISS
IAF-96.T.3.08

[4] Long-term Space Policy Committee,
Rendezvous with the New Millenium
ESA, SP-1187

[5] Gazey, S., Dasa-RI
Die Internationale Raumstation und ihre Bedeutung für Forschung und Gesellschaft,
Technologiemotor Luft u. Raumfahrt
Hannover, März, 1996

[6] Space Station Requirements for Advanced Engineering and Technology Development (AETD), NASA, SSP 50198

[7] Ockels, W.J., ESA
ELSPEX, Alsbach Summer School 1996

[8] Gazey, S. / Boeck, J., Dasa-RI
Industries Preparation and Contribution to Europes's Role in ISS Operations
IAF-96-T.1.07

THE TRENDS TOWARDS MINIATURISATION

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ABSTRACT

Whereas the first industrial revolution was featured by a quest for the "big" and the "impressive" (large ships, large machine tools, large industrial plants), the trend of the Information Technology society is towards the "small" and "efficient". Everything should be portable, personal, friendly, energy saving, clean, but, at the same time, should perform increasingly well and be cheap.
The main factor of this technological revolution is microelectronics. However, mechatronics, a discipline that aims at integrating harmoniously the microelectronic and the mechanical components of a system, also has a profound impact on miniaturisation.
In this paper the authors provide an introduction and background to the field of miniaturisation; point out that this area is strategic for innovation and for industrial competitiveness; and mantain that a concerted effort is needed to exploit the opportunities it offers. The authors conclude that, since the space sector can receive major benefits from miniaturisation - and at the same time generate important fall outs for many industrial sectors - it should also be an active player in the field.

1. INTRODUCTION

The main objective of science is to explore new areas and to find new frontiers for knowledge. History demonstrates that new frontiers explored by science, and the exploitation of these frontiers by technology, have provided the basis for industrial development. Finding new frontiers for the 21st century will guarantee the continued development of science and technology and, in turn, industry, in the coming century.
Today the domain of science is so widespread that it is very difficult (and risky) to predict the new frontiers that are most likely to generate significant industrial development. Recently Prof. Yoshio Tsukio, of the University of Tokyo, suggested three frontiers as the ones that Japan should pursue for promoting industrial growth in the next century: the "*Cyberspace*" (or the realm of Information Technology); the "*Innerspace*" (or the brain functions); and the "*Microspace*" (or miniaturisation) [1]. In fact, there is a wide and growing consensus, also outside Japan, that miniaturisation technologies are not only a new frontier for science and research, but also a tremendous opportunity for application and thus for industrial innovation and competitiveness.
The first industrial revolution of the 18th century was featured by a quest for the "big" and the "impressive" (large ships, large machine tools, large industrial plants), the trend of the present Information Technology society is towards the "small" and "efficient". Everything should be portable, personal, friendly, energy saving, clean, but, at the same time, perform increasingly well and be cheap.

The trend towards miniaturization has been driven by the advent of microelectronics: silicon technology has allowed the development of integrated circuits capable of processing information at a rate that was inconceivable just a few tens years ago, and - most important - at progressively low cost and high reliability, and with smaller dimensions. Silicon-based microsensors for measuring a large range of physical and chemical variables, and incorporating a progressively larger amount of signal preprocessing capabilities became also available soon. Besides determining the computer revolution, silicon technology had another important - and extremely pervasive - technological impact: it changed drastically the way in which virtually all existing products are designed and fabricated; and opened up the possibility to develop totally new products. This second revolution is the one of "*mechatronics*". Mechatronics is the integration of mechanisms, sensors, actuators and embedded electronics for signal processing and control. It allows to obtain products that work better because their mechanisms and functions are controlled better, and that are smaller, because the microelectronic components are smaller (and more performant). Consumer electronics, automotive, industrial automation and health care are clear examples of industrially important sectors being deeply affected by the "*mechatronics revolution*".

Probably, the main reason why mechatronics is not so popular outside Japan (in the United States, even today virtually no universities are offering courses in mechatronics), and in the western countries did not receive much attention as a strategic field for innovation and industrial competitiveness (though, of course, its concepts and technologies are widely exploited by western industry) is cultural. In essence, mechatronics is system design, but requires interdisciplinary "thinking" and the "*harmonious*" integration of different disciplines and technologies since the design phase of the system. This approach is culturally very familiar to the Japanese (who, in fact, invented the term "mechatronics" back in the sixties, and consistently encouraged and promoted its development both in academy and in industry), whereas it is quite hostile to the western tradition which tends to emphasise competition, rather than collaboration, between different theses and disciplines, even in science and technology.

Mechatronics allows to achieve increased functionality for the same dimension of a system, or to reduce its size for the same functionality. As examples of this capability, we can consider widely popular consumer products, such as the camcorder (whose size decreased so much in the last few years that image stabilizers are often included in the palm-size camcorders to compensate for undesired oscillations); or the compact camera, whose size remained the same for practical reasons but whose functions increased dramatically. The new frontier of mechatronics is already here, and is the one of "*micromechatronics*", which aims at pursuing both results, that is to increase the functionality of a system to the highest possible level and, at the same time, to decrease its size to the smallest possible level.

2. THE "SCIENCE TRACK" TO MINIATURISATION: NANOTECHNOLOGY AND MOLECULAR ELECTRONICS

A strategic analysis of the overall field of miniaturisation should involve different viewpoints, since miniaturisation includes so many facets that simplified schemes are certainly reductive. For the sake of clarity and synthesis, however, here we propose some simplification (that obviously implies some approximation) in the analysis. In general, we can say that the field of miniaturisation can be addressed from two points of view: the one of basic science, and the one of engineering and technology. According to the viewpoint of science, the new frontier of the "nanospace" is a natural research domain for such disciplines as solid state physics, biophysics and molecular biology. This field is often named as "nanotechnology" and its dimensional range is comprised between 100 nm and 0.1 nm (approximately the size of the atom). The scientific goal is to observe and eventually manipulate individual atoms to build nanostructures. A strong scientific competition is already started between the U.S., Japan and Europe, driven primarily by national agencies and research institutes, and watched with some attention by large industries (mostly in the area of microelectronics). In Japan, large-scale government support has been put together, with the Ministry of International Trade and Industry (MITI), pledging as much as $225 million in a 10 years project on nanotechnology (comprising two subprojects: the Atomic Technology Project, and the Quantum Functional Devices Project) [2]. The strategic goal of this project is to lay the groundwork for the age of the terabit chip technology, an innovation that would assure substantial competitive advantage to the microelectronics industry which will posses it.

A different approach mantains that conventional microelectronic technology and semiconductor materials will be unable to overcome the intrinsic limitations posed by inorganic materials, because the ensuing quantum size and thermal effects will make such devices unreliable. According to this approach, the hope of breaking the barrier of miniaturisation lies in the utilization of organic materials, in the exploitation of their chemistry as well as physics, and in the design of radically different computer architectures [3]. One of the ultimate dreams of this field of research is the fabrication of carbon-based devices for computational purposes, i.e. the construction of an organic molecular computer or a biocomputer. Molecular electronics is inherently multidisciplinary and interdisciplinary in nature, so that it emerged as a serious endeavour, from the initial dream of some prophetical advocates in the early seventies, only in recent years and thanks to cuncurrent advances made in several disciplines such as material science, biotechnology, condensed matter physics, surface science, nanolithography, neuroscience, cognitive science, neural network and computer science. The emerging research on molecular electronics is addressing a number of important issues, including the following: the design and development of nanometer scale components; the development of suitable techniques by which the "molecular electronic engineer" can assemble the individual components in proper locations so as to implement the desired functions and ultimately fabricate "molecular machines"; the synthesis of organic molecules and biomolecules; the elucidation of the role of protein engineering; the analysis of biological information processing; the molecular implementation of neural networks; the exploitation of the common infrastructure for molecular electronics, biosensor and molecular actuator technology; interfacing problems; and molecular self-assembly and self-repair.

Presently, a number of countries, including Japan and the U.K., have formulated coherent national programs to target research in molecular electronics with growing participation of industry, which is attracted by the strong innovation potential of this field and by the wide anticipated impact on industrial application.

3. THE "ENGINEERING TRACK" TO MINIATURISATION: MICROMECHATRONICS

Nanotechnology and molecular electronics represent a sort of bottom-up approach to miniaturisation: basic science (and related technologies) looking for application. Mechatronics provides a top-down perspective to miniaturisation, with a trend which is driven primarily by engineering and industrial needs.

A micromechatronic system can be defined as one integrating miniature precision mechanisms, motors, sensors, signal processing circuitry and embedded control. Micromechanisms and microactuators are perhaps the most critical among such components. In fact, the progress of microelectronics has already allowed the development of microsensors, integrated circuits and microcontrollers with small size, low cost, high reliability and high performance which are ideally suitable for micromechatronics. On the other hand, micromechatronic systems requires mechanical parts, such as mechanisms and actuators, precisely fabricated and very small in size (a few millimeters), which are not available easily. An important problem to address for the development of micromechatronic systems is the proper design of micromechanisms. Unfortunately, the physics of the microworld - and especially the one of mechanisms with size comprised between a few microns and a few hundreds microns - is not well known; thus research efforts are needed to develop new theories for "*microengineering*".

A second important problem is how to fabricate microcomponents for micromechanisms. Traditional precision mechanics technologies are not suitable to manufacture microparts. Therefore, new fabrication technologies are required.

A third important problem of micromechatronics, relates to the assembling of micromechanisms, which requires the accurate handling of microparts. This is a difficult task, however, especially because of the presence of strong adhesion forces between the parts and/or between the part and the tool. Dedicated instrumentation and tools are required for micropositioning and microassembly.

In order to identify possible strategic actions required to exploit the strong innovation potential of this field, some considerations on its evolution are useful.

Miniaturisation in technology is the result of two parallel lines of technical evolution, originating, respectively, from *microelectronics* and from *precision mechanics*. The first line of evolution, leading directly to the field known today as micro system technology, or *MST*, (a term used mostly in Europe), or micro electromechanical systems, or *MEMS* (a term used mostly in the USA and Japan), can be traced back to the microelectronics "revolution" and on the development of planar silicon technology. The main feature of this evolution was the *integration of components and functions* on silicon. The elective technology for MST & MEMS is silicon. Conceptually, these devices are silicon chips that integrate more functions and have the capability of processing not only information but also "matter". The perspective market of microsystems is very large, since they could be the new and better components that the market is waiting for in many application fields.

Many initiatives have been undertaken by different national and international organizations to promote and focus research on MST and MEMS. Particularly important

is the NNUN (The National Nanofabrication Users Network) of the National Science Foundation in the U.S. The NNUN is an integrated partnership of user facilities with a mission to provide opportunities for researchers and with the commitment to education, training and technical outreach, with services available to universities, industries and government laboratories. In Europe, the main coordinating actor in the field of MST (which adds to national programs in almost all countries of the Union and of East Europe) are NEXUS (the Network of Excellence in Multifunctional Microsystems) and EUROPRACTICE. Both programs aim at providing coordination of research efforts, dissemination of information on MST, technological assistance to industry towards exploitation of MST in existing and new products, and training.
The second line of evolution of miniaturisation originates from the field of "traditional" machine design and *precision mechanics*. Miniaturisation of size and integration of functions gradually led to the development of the field of micromechatronics, and to the design and fabrication of complete machines and systems, whose market potential is also enormous. This approach has been promoted very much in Japan, where MITI has identified the field of *micro machine technology* has a one strategic for industrial development and has promoted a 10-year Large Scale Project with the participation of more than 26 large companies. In the Japanese vision micromachines are real three-dimensional machines, designed according to appropriate machine design rules valid in the micro domain, and fabricated using suitable technologies (precision and ultraprecision machining, silicon micromachining; non conventional technologies, such as microstereolitography and many others). Future micromachines could be produced in large quantities, but they could even be fabricated in very small quantities (maybe assembled manually) and yet be sold remuneratively. (An example is an instrumented medical catheter or an endoscopy system).
In the authors' opinion there is no contradiction and thus there should be no competition between the two approaches just described. On the contrary, the development of silicon-based microsystems is very important and beneficial for micromechatronic systems, whose size could be decreased, functions enhanced and cost reduced by the integration of better microsystems. Furthermore the diffusion of micromechatronic systems and micromachines could represent an important market opportunity for MST and MEMS. (Just like happens for current mechatronic and micromechatronic systems, which are hungry "consumers" of microelectronic components).
In conclusion, the industrial opportunities deriving from innovation in the field of miniaturisation are twofold: one large opportunity is for more "intelligent" microelectronics-based *components and subsystems* ("MST" or "MEMS"); a second large opportunity is for more complex *micromechatronic systems* (the "micro machines").
Some of the considerations presented in this Section have been discussed extensively by the authors in [4][5].

4. PERSPECTIVES OF MINIATURISATION FOR THE SPACE SECTOR

Miniaturisation could open new scenarios for spatial missions which are made possible not only by the reduction of overall dimensions of space systems but also by the complete redesign of existing systems and components based on mechatronic concepts.

The main motivations for miniaturisation in space are the reduction of mission cost and the increase of performance and reliability of space systems. Micromechatronic technologies have the potential for revolutionising the way we design, build, assemble and test space systems. For example, micro- and nano-technologies enable the manufacturing of all kinds of components for miniature systems or microsystems, such as sensors, pumps, valves, and channels. The integration of these components into a complete micromechatronic system drastically decreases the total system volume and mass. Microfabrication technologies enable not only the fabrication of microsystems and components which may substitute current ones, but even the miniaturisation of the whole satellite. By exploiting microfabrication technologies, it is already possible to fabricate "micro" and "nano" satellites (mass about 50 Kg) and to equip them with the instrumentation required for many space experiments. The miniaturisation of components and subsystems, the consequent reduction of mass, power consumption, volume and cost, and the possibility of integration, may allow the development of sort of "satellite clouds" consisting of a very large number of smaller, cheaper and faster satellites.

5. CONCLUSION

The trend towards miniaturisation is leading to the development of extremely innovative instruments, components, subsystems and systems, whose ultimate impact on industrial applications could be very strong, perhaps comparable to the one determined by the microelectronics revolution. In fact, miniaturisation could truly be one of the strategic innovations fueling industrial development in the next century.

Concerted efforts are needed to address the many scientific and technical issues still open in this field and to define common strategies, mutually beneficial for the main actors. (An action in this direction has already been taken by Japan, which, beginning 1995, promoted the series of "World Micromachine Summits", with participation of official delegations from all industrialized countries).

The space sector is facing the opportunity of taking advantage of the coming miniaturisation revolution. More efforts are needed and justified in the space domain in order to: a) exploit available research results to improve existing space systems; b) promote new research efforts focused towards the specific needs of the space sector.

REFERENCES

[1] Y. Tsukio, "Micromachine which Develops the New Industrial Age", Keynote Lecture at the Second International Micromachine Symposium, Tokyo, Japan, October 31, 1996.

[2] R. Crawford; "Japan Starts a Big Push Towards the Small Scale", Science, pp. 1304-1305, 30 November 1991.

[3] F.T. Hong, "Molecular Electronics: Science and Technology for the Future", IEEE Engineering in Medicine and Biology Magazine, pp. 25-32, February/March 1994.

[[4] P. Dario, M.C. Carrozza, B. Allotta, E. Guglielmelli, "Micromechatronics in Medicine", IEEE/ASME Transactions on Mechatronics, pp. 137-148, Vol. 1, No. 2, June 1996.

[4] P. Dario, M.C. Carrozza, L. Lencioni, A. Menciassi, "Perspectives of Micromechatronic Technologies for Space Applications", Final Report for ESA/ESTEC, January 1997.

« BETTER, FASTER, CHEAPER, LESSONS LEARNED »

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Abstract

Faster, Better, Cheaper approaches emerged few years ago from different initiatives involving Universities, small user's groups, commercial ventures, National organizations in the US and lastly National Space Agencies in most of the major Space Countries.

They enlarge the field of space missions through innovations at least in three different areas : Mission concept and operation, Development methodologies, Technologies.

The most innovative programmes to date exhibit a lot of promises but also major weaknesses such as vulnerability to single human error or limitations in low cost launch opportunities. This is probably why the worldwide initiatives for small science or earth observation missions are commonly based on relatively conventional multimission minisatellite platforms.
Large or medium space companies have started development for such platforms through scaling down their practices, rules and products from larger satellites. Small organizations are also developing products with similar capabilities through scaling up their practices rules and products from microsatellites. Some comparisons can already be made between both processes.

Faster, Better, Cheaper approaches make space affordable for more and more countries, organizations and users.

Foreword : In this paper the presentation of SSTL approach and the comparisons are based on the information exchanged during the SMO study (see Ref [2]), but only reflect the MMS synthesis.

1. Introduction

The evolution towards small satellites has often been presented during the last years as the major way of progress *[See f.e. Ref. 1]* and many small launchers are currently emerging. But at the same time Geostationary satellites are still growing and after a period of uncertainty about the adequation of ARIANE 5 to the future market, many launcher manufacturers are running to offer capabilities even larger than the initial AR 5.

A rationale for the growth in size of commercial GEO satellites and for the decrease in size of LEO earth observation satellites can be found in economical terms. But other rationales support the emergence of small satellites so that different classes of systems and missions can be recognized in that field.

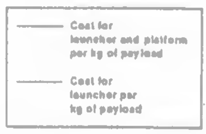
The most significant trend in the so called « Better, Faster, Cheaper approaches » is currently the increase in number of national programmes in Science and Earth Observation, based on multimission small satellite platforms, using derivatives of conventional practices in the space community and of mastered technologies. It is anticipated that the commercial applications of the Earth Observation will call for numerous satellites in the near future.

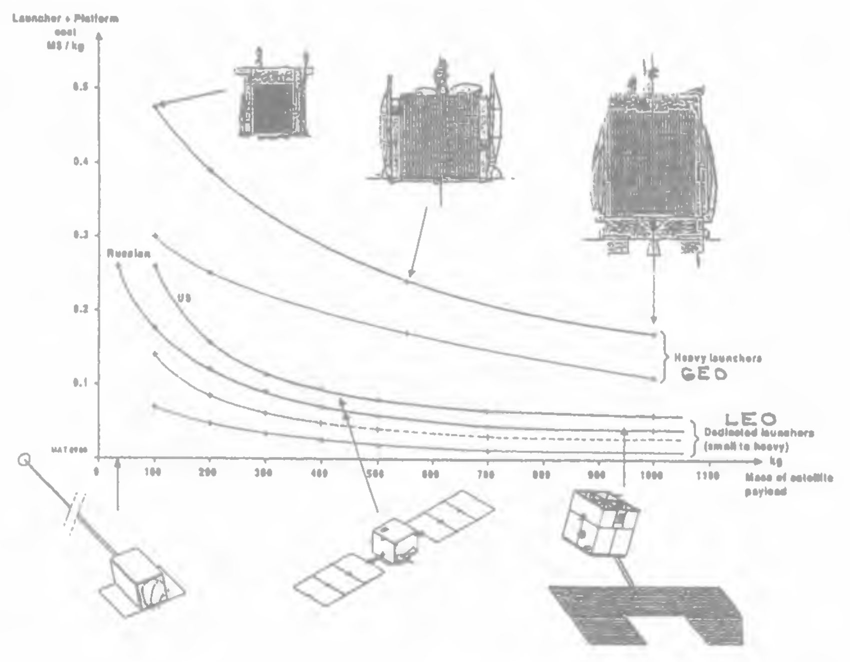
Other trends, highlighted by the most impressive programmes to date, such as the US CLEMENTINE, still present severe weaknesses or limitation, but they bring the major innovations and help space to diversify missions, actors and technologies.

2. Rationales for the evolution of the size of operational satellites

When looking at recurring satellites and launch costs, there is a strong rationale to group multiple payloads on single platforms. *Figure (1)* shows how the launcher and platform cost per kg of payload in orbit decreases with the size of the payload itself. Very significant for GEO Telecommunication satellites, the cost and its variation are much lower for LEO satellites. The rationale is reinforced in the case of GEO satellites by the limitation in the number of orbital locations and by the future need for on-board switching. The rationale is also complemented in some extent in the case of observation satellites, by the customer wishes to get simultaneous observations from different instruments.

Figure 1 : The whole cost for placing satellite payload in orbit





Due to the relatively large market and production, GEO telecommunication satellites now succeed in using recurring platforms, and payloads with similar interfaces. The development is well mastered and needs short duration (24 months or less) even for very big satellites. The above economical rationale fully applies, as demonstrated by the space major Telecommunication organizations which generally increase the size of their satellites from one generation to the next one.

Due to the non commercial market situation, LEO satellites are still mainly non recurring and many missions are in the exploratory phase. When answering customer wishes to get simultaneous measurements through large collections of payloads (with very heterogeneous interfaces), onto single platforms, a large non recurring work has to be done to master the payload interfaces, and a complex platform has to be developed to provide all the required resources at the same time. As the satellite becomes expensive, careful management P.A and test are required, a long development phase is necessary, and conservative, out of date technologies (at launch date) are used.

The recurring cost shown on *Figure (1)* must be added together with an additional non recurring cost which is undoubtly growing more than linearly with the payload size. Then, as a consequence :

- Going towards large non recurring satellites in LEO with multiple and different payloads is clearly not a favoured trend from an economical point of view.
- Going towards small satellites has also an economical limitation, partly due to the high launch cost per kg when small launchers are used. (Sharing larger launchers for multiple satellites is still uneasy due to the variety of orbits and the low traffic to LEO). Other limitations appear in that direction such as : the size of the individual payloads themselves, the rationalisation of the development between different small satellites, the customer satisfaction from mission aspects, and the available technology and its price.

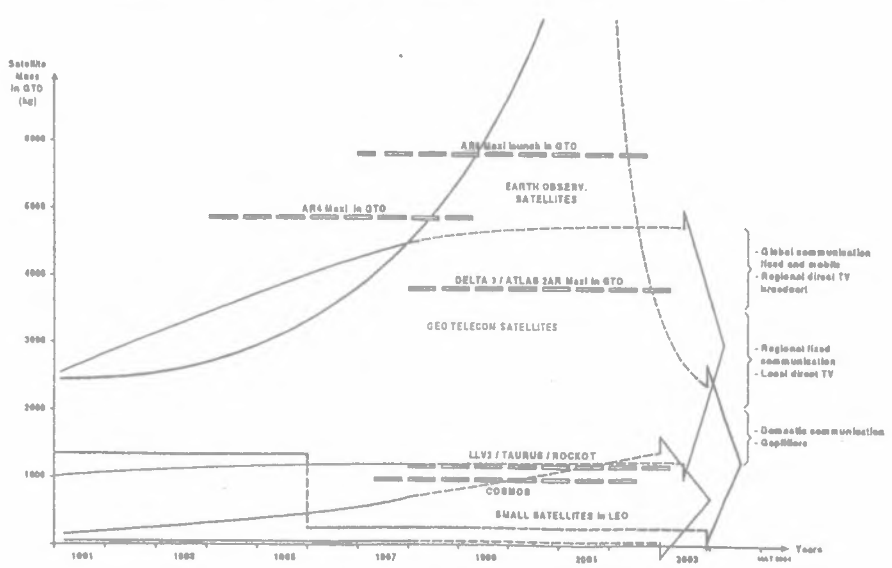
Such analysis suggests that non recurring systems (new mission concepts, new satellites or instruments, new players / actors, new technologies...) should favour the use of small satellites while recurring ones should answer a case by case optimization which favours large satellites in GEO and a diversity of satellite sizes in LEO.

Accounting for the today situation, a favoured range for satellites supporting operational, still mainly not fully recurring LEO missions is from 400 to 1000 kg.

The expected trends in satellite size are summarized *in Figure (2)*.

As an illustration of such trends : recommendation has recently been made within the National Reconnaissance Office in the US, to move for operational Earth Observation from the 10 t class satellites down to a 2 t class.

Figure 2. Small satellites versus large ones (Global trends)



3. Fields of innovations supporting the Better, Faster, Cheaper approaches

Apart from the satellite size aspect, the Better Faster Cheaper approaches are supported by innovations, fully complementary to each other in, at least, the three following fields :

- Mission concept and operations : The large increase in spacecraft autonomy through powerful on board electronics and software, and the important support provided by new space infrastructures such as GPS or by open services such as NORAD, pave the way for a large increase in number of satellites and « operators ». As a result, single small satellites can be developed to support very specific uses (AMSAT, UoSAT series...). Concepts based on two, or few satellites are becoming fully viable for missions requiring differential measurement (in situ measurement, optical or radar interferometry...), or for global redundancy at whole satellite level. At the extreme, use of large constellations in non GEO orbits releases from the rigid limitation of the GEO satellites (time delay, elevation above the horizon...).
  Useful space is becoming a full instantaneous 3D domain where network of satellites can provide diversified and interconnected infrastructure.

- Development methodology : As the background for space systems becomes larger, better structured, integrated in tools and facilities, better known from people..., and as the heritage of space equipments enlarges, satellite development teams can be much smaller and much more efficient. Small groups of individuals can manage all the aspects of satellites and missions and can share together large motivation and enthusiasm. Unified Development and Test bed facilities can be efficiently used.
  Innovations in Small Satellite development methodology have been addressed in several ESA studies and in the SMO Initiative study *(Ref. 2)*.

- Technology : Progress in technologies enables a continuous evolution towards smaller space systems for given missions. Many different ways of looking to the earth can now be explored with instruments of reasonable size such as hyperspectro-imager, active optical sensor, multi frequency and multi polarisation synthetic aperture radar, optical interferometry... Very diversified concepts of solar system exploration can be implemented for observation of planets, asteroids and comets, or even for in situ measurement through landing, sample return... Several fundamental physic experiments in space are feasible.
  Digital electronics and software are at the heart of major evolutions but the current breakthroughs in propulsion will also support major innovations in the near term.
  For instance, propulsion featuring high specific impulse (> 1000 sec) and thrust in the 0.1 to 1 N range will increase orbit or trajectory mobility, paving the way for :
    . lower launch cost based on new scenarios for launches and final orbit injection,
    . new mission concepts based on forced orbits or trajectories, or large orbit changes along the lifetime according to successive mission objectives,
    . (in the longer term) new generation of satellites involving rendez-vous with other satellites or with orbital facilities for close power transmission, repair, deorbiting...
    . new deontology for space such as cleaning of orbits after use.

Many other technologies are supporting, in some extent, the mission concept evolution, such as high efficiency solar cells, solar flux concentrators, aspheric optics, shape memory material, APS detectors...
The New Millenium Program in the US is starting to demonstrate many innovations in space mission based on efficient utilization of advanced technologies. *See Ref [3].*

4. Some limitations in current « Faster, Better, Cheaper » approaches

Apart from the microsatellites which generally avoid the use of the most critical technologies such as propulsion and mechanisms, a significant number of Faster Better Cheaper programmes (including satellites and launchers) have encountered problems during launches or operations.
As a consequence, the most revolutionary practices in the Faster Better Cheaper programmes are not (yet) applicable to all types of systems. In particular much more conservatism is necessary when developing fully operational (mission oriented) systems.
Another limitation of the small satellites for operational missions comes from the relatively high cost of small launchers (per kg of payload).
Those aspects are briefly discussed hereafter :

- Lack of robustness to single human error

The very impressive missions like the US Delta Clipper Experimental (DC X A) or the US Clementine have pushed beyond the limit, the confidence in « small, highly motivated team ».
DC X A was destroyed during landing due to a lack of connection of a pneumatic brake line. No double check was performed.
CLEMENTINE was lost after the Moon mission when the software ordered wrong thruster operations for the transfer towards an asteroid. Insufficient redundancy and check was used in the validation and operation process.

Those two missions appeared as fully successful at some stage but then suffered from a complete failure.
In order to get recurring successes with space systems, many of the lessons learned during 40 years by the space community still applied. In particular the single human check, even for simple operations, is a major source of failure.

- Vulnerability to critical technologies or manoeuvers

Whatever the scale of a space system, major drawbacks can still appear at a high occurrence rate, with critical technologies : propulsion, mechanisms, pyroelectric devices, software, or with critical manoeuvers such as separation from the launcher...
This is well illustrated by problems with :

. pyroelectric devices on HETE, SACB, SSTL FASAT α,
. software on ORBCOM 1 and 2, US CLEMENTINE,
. separation from launcher or mechanisms on : ALEXIS, MARS PATHFINDER...
. propulsion and launcher in general on : CONESTOGA, LLV1, PEGASUS...

When small satellites or systems need critical technologies or devices, the expertises developed along years by the space community is still mandatory.

. <u>High launch cost per kg of satellite</u>.

Many expectations have been placed in the beginning of the 1990's in the development of very low cost small launchers. Few of the developments have been successful and their eventual cost is much higher than expected initially. *Fig. 3* shows how the launch cost per kg increases for single mini satellites launches when the satellite mass decreases below typically 400 kg. Both US and Russian type launcher costs are provided.

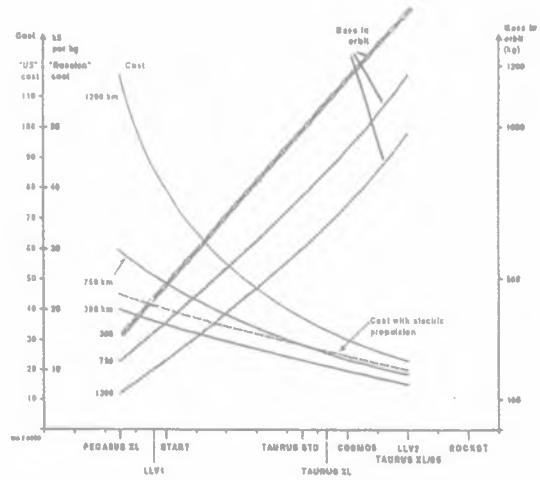


Figure 3 : Launch cost per kg in LEO

5. Major classes of small satellites

Different classes of small satellites are identified today with their specific feature and application (the nano satellites class is not considered because it will not become significant before at least 10 years).

. <u>Micro or small mini satellites</u>.

Microsatellites have been developed mainly by Universities to give their students a good experience with complete, simple and low cost space missions. They make a large use of advanced commercial electronics.

ARIANE 4 has been very important for the development of micro satellites in the 50 kg range. ARIANE 5 could do much more in opening the way for launches of satellites up to 80 or even 100 kg at marginal cost or up to 300 kg satellites at very competitive cost. Since the launch opportunities will be mainly for Geostationary Transfer Orbit, a specific manoeuver has been proposed, using a possible inclination change at apogee (or at increased altitude) with electric propulsion and a transfer for GTO to LEO with aerobraking *(see Ref. 4)*.

The 100 kg class mini satellite, even on GTO orbits, open very interesting test and experiment opportunities for the next 10 years and still raise a particular interest in some Universities. Agencies and industries are also interested, as demonstrated with the PROBA mission, for investigations in the fields of technology, environmental science or even solar system exploration.

Many micro satellites platforms will be developed and many experiments or small scientific missions will be proposed using one or a fleet of 6 up to or 8 satellites launched together by AR5.

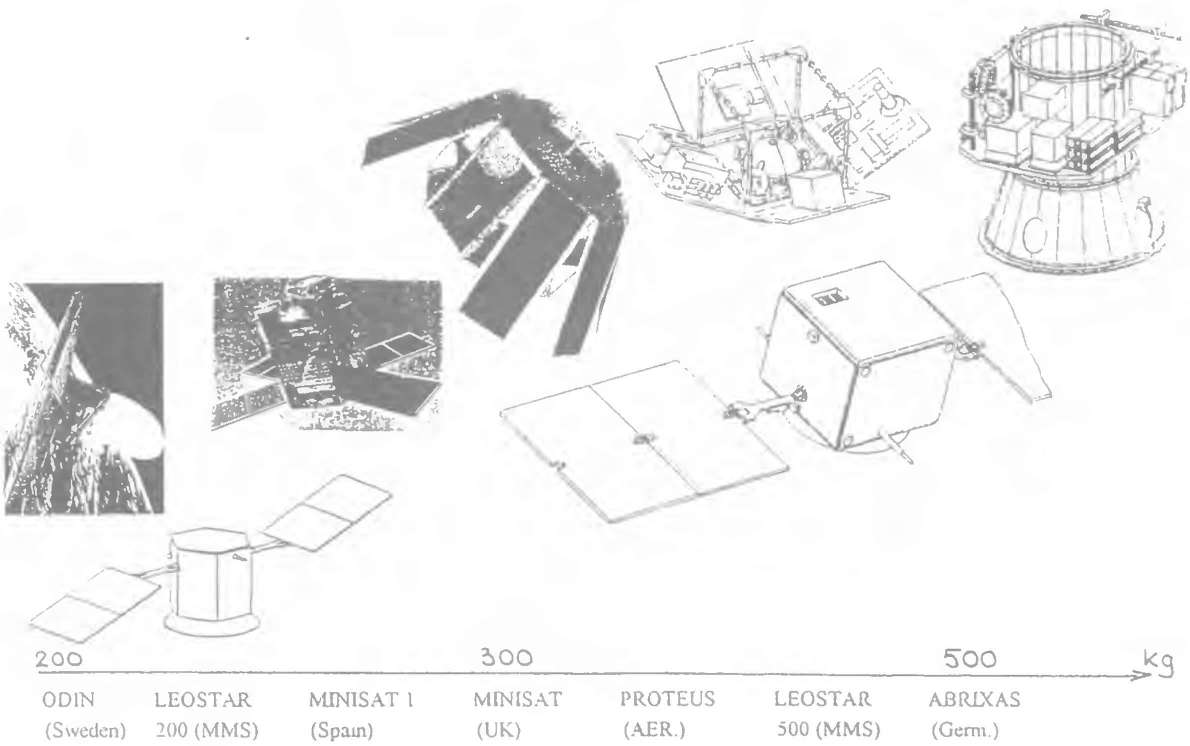
. <u>Minisatellites built around Multimission platforms for scientific observation in low earth orbits</u>.

Limited scale platforms developed with technologies and practices featuring limited innovations from larger spacecraft are appropriate for many earth or space scientific observations or even for fundamental physics experiments. A large interest in several European countries has already been shown for such missions and for the corresponding platforms *(See Figure 4 and Ref 2)*. Space emerging countries are also looking at such type of minisatellites as a point of entry in the space business.

The structure and thermal control parts of the satellites in that class generally need specific adaptation to each mission as shown in the SMEX programme in the US, but at least the avionics is a multimission part of the platforms.

The MMS LEOSTAR platform answers needs in that class of minisatellites and offers through different adaptations accomodation for payloads from 200 kg / 150 W to 500 kg / 450 W.

Figure 4 : Some European small platforms existing or under development



As shown in the SMO Initiative Study *(Ref 2)*, the typical duration for the customization of a multimission platform, the integration of a typical scientific payload and the launch preparation is 18 to 20 months. *(See Figure 5)*. The typical cost for those activities including Core platform and adaptation, Assembly integration and tests, and Ground Control Segment is 20 MAU for a 500 kg minisatellite. The launch cost to access a 700 km heliosynchronous orbit is around 8 MAU with a Russian launcher and 17 MAU with a US dedicated launcher.

. Minisatellites for high resolution earth observation missions.

Based on platforms of similar type as above, but with specific adaptations (accurate earth pointing, microvibration free control systems, high propulsion capability, easy earth sensing instrument accomodation, high autonomy and on-board processing capability), pre-operational or operational earth observation missions will represent a major class of small satellites. Since those satellites will support, at some stages, commercial business, they must feature very low recurring cost, reliable technology, and easy operations.

A major interest is shown for this class of minisatellites by the space companies involved in earth observation.

Demonstration minisatellites such as the US CLARK and LEWIS pave the way for the application of innovative technologies.

. Miniprobes for space exploration missions

The probes developed for space exploration have to be optimized according to each mission objective (asteroid fly-by, asteroid landing, asteroid sample return, etc) Advanced technologies can be used for the major functions such as (communication, autonomy, navigation, propulsion, data compression...). The New Millenium Deep Space 1 mission will demonstrate the capability of electric propulsion to shorten a comet mission duration. Launched in 1998, DS1 will encounter two comets, one in 1999 at 0.4 AU from the sun and the other one in 2000 at 2.6 AU. DS 1 will also validate : advanced solar array, autonomous navigation, 3D stack computer as the flight Computer and Miniature imaging camera spectrometer.

Fleets of miniprobes could be sent simultaneously with a common launcher and a common data relay for some types of investigation.

. Constellation of microsatellites for telecommunication (paging)

Some potential service providers are contemplating commercial use of very small satellites (microsats) in constellation for short messages, mainly machine to machine transmission (ORBCOM, STARSYS). They benefit from what has been demonstrated by small groups (AMSAT), Agencies (ARPA) or Universities.

. Constellation of small satellites (mini or larger) for telecommunication (mobile phone, data transmission)

Some well established service providers together with space organizations develop spectacular visions based on satellite constellations for large commercial telecommunication business, each satellite size falling in the mini or medium categories. The constellation will generally use specific mechanical and structure systems to get low recurring cost for manufacturing, assembly, testing and launch. Reuse of avionics from satellite with similar functions is generally considered since it brings more confidence for a critical sub-assembly and low or no cost penalty for assembly and testing.

6. Small or large industries for small satellite business

Small satellites have been introduced initially by organizations which were not at the heart of the space activities. OSC, CTA, SPECTRUM ASTRO, SSTL... have been known from space community at the same time as small satellites and small launchers. Many people concluded that small systems need small organizations to be developed efficiently.

But when the specific advantage of small satellites started to be recognized, some large organizations (NASA and Industries) started to move in that direction through scaling down their own products.

In the micro satellite field, the first export opportunities have been won by very small space organizations, but in the minisatellite field, only large industries such as (TRW, MMS, SPAR...) have been competing for the initial export business. Today, the minisatellite business is a target for both types of organizations.

. Strength and interest of large industries for small satellites

Several large companies consider now that some classes of mini satellites are fully synergetic with their other products, particularly when the field of application is shared.

When entering the small satellite field, large industries can take advantage of (their) :

. Large background and expertises, efficient tools and facilities and large experience with space systems,

. Very capable and experienced personnel : system engineers who can be especially selected for small satellite development and Experts who can be called for specific support,

. Worldwide network for marketing actions and for procurement of low cost technologies,

. Large manufacturing, integration and test capabilities,

. Technological and financial background to support the export or commercial actions.

Their labour rate is often presented as a major weakness but this is mainly due to an artificial sharing of cost overhead (amortization of non used large facilities) which can be corrected.

Many large or medium space industries are currently developing minisatellites platform. In a first step, relatively conventional technologies and approaches are used. In a second step, when the application is better identified, advanced technologies will be implemented.

. The major strengthes of small industries in the small satellite field.

Because they do not have to protect a core market based on conservative or even zerofault approaches, small organizations have a large freedom in taking risk or in doing innovations in the small satellite field. They can explore new ways of doing space systems and use relatively unproven technologies as soon as they take a research approach where the objective is to have a reasonable (high enough) ratio of success. The non conservative approaches particularly well apply to the specific case of microsatellites in LEO which was not specifically investigated by the space community.

The flexibility in the interface with the customer is a second advantage of small organizations. They can easily integrate customer people in their team to help them learning about space practice or to develop the product which best fits with real customer needs without formal and rigid specification of those needs.

The full commitment of the top management of small companies to their success in small satellite business also brings specific advantage.

. The particular case of SSTL. The initial SSTL motivation was to open a field of research activities for the Surrey University and to find their own way in that field. The microsatellite approaches were not developed in the world when SSTL launched their first satellite in 1981. Since then, SSTL has produced a series of satellites which look similar but which, in most cases, include a significant innovation from one model to the next one. Finding customers for new spacecraft is a way to finance new research and applications.

SSTL had, in the past, no expectation to develop a business or to be the dominant player for a particular product. In the last years, they decided to explore other satellite and mission aspects which include, for instance, propulsion and orbital transfer, higher orbits than LEO (including moon orbits)...

Finding their own way in space means for SSTL, doing as much as possible internally, with internal Product Assurance Rules and Procedures... It also means avoiding any excessive formalization of the reviews with Customers, or any constraints on work segmentation or work sharing, or even any external standard which would not be recognized as useful for the particular work.

Key features of the SSTL procurement approaches are :

. Use of commercial components based on adequate technology, after functional testing but with only limited radiation test,

. Call for external procurement, only when necessary and, in that case, use of well mastered technologies, outside their critical domain to get lower cost and risk even at the expense of some performance (The low cost criteria essentially applies to the procurement, not to the added internal cost).

. Optimize the whole space system, as far as possible, to minimize the cost and the risks with subcontracted elements.

The performance objective for SSTL satellites is expressed as typical expected value not 3σ absolute specification. The performance assessment is done globally from component to satellite without any stratification involving unnecessary specification and undue margin.
The redundancy is selected through pragmatic consideration of mass and cost without systematic rule.

The SSTL's satellites already launched essentially demonstrate innovation in electronics and software with limited complexity. SSTL had to face some difficulties with one of their first satellites from which they improved their products. When their FASAT α got pyroelectric problems with the separation system after launch, they recognized the need for global testing in realistic configuration. For their current minisat, which will be launched end of 97 or beginning 98, SSTL has defined a much larger set of rules and methods.

. <u>Moves towards minisatellites in SSTL's and large European companies</u>

The conventional approaches developed in large European industries are largely based on the necessity to share the work for large satellites and to develop technical specialities and area of excellence in different countries. As a consequence, industries have learnt how to work together, with the support of standard, rules, common langages and common tools. SSTL has been avoiding most of those constraints because they had very specific objectives.
But the European cooperation has also imposed very numerous interfaces which sometimes result in poor industrial efficiency. Small satellites as well as large commercial spacecraft cannot be done efficiently with too large sharing of work and too many interfaces. This is why large companies are adjusting their approaches to enter the small satellite field as they have done, with different criteria, for large commercial spacecraft. They are challenging the many rules developed within Europe to select the useful ones for the application to simpler satellites.
On the other side, SSTL has been moving from no rule, towards the just necessary specific ones. They have a limited staff and try to keep in mind the rationale for each rule. They obviously had much more to explore when addressing the minisat case in non LEO.

In the minisat field, the technologies used respectively by SSTL and the large companies for electronics are still different because one refers to commercial community (f.e : use of a car electronic bus for SSTL) while the others refer to the space one. For other technologies such as propulsion and solar arrays, reaction wheels... similar sources of products are used, (although with different accomodation), and the final performances and characteristics can be compared in many aspects *(See Figure 5)*.

Figure 5 : SSTL and MMS Platform main characteristics

	MMS LEOSTAR 200	MMS LEOSTAR 500	SSTL MINISAT
Size	Pegasus compatible	LLV, COSMOS, TAURUS, ROCKOT	Ariane 5 ASAP ROCKOT
Mass (kg)	200	250	150
Power (Primary)	300 mean	600 W mean	150 mean
Battery	24 or 40 Ah - 30 V		20 Ah - 28 V
On-board Computer and Data Bus	3 x 1750 Computer : Versatility for data transfer		80 C 186-386 with network
Data Storage	2 Gbits		3 to 6 Gbits
Attitude	0.02 to 0.05° rms		0.1° 3 axis
Propulsion	Up to 250 m/sec		Up to 250 m/sec
Attitude and orbit determination	Differential GPS + Star sensors + Inertial Reference		Differential GPS + Star Sensor
Attitude control	Reaction wheels + Magnetic torquers		Reaction wheels + Magnetic torquers
TM/TC	S band 650 Kbps		S band, UHF and VHF
Lifetime	> 5 years		-

7. How the better faster cheaper approaches help changing the whole space programmes and practices

The lessons learned from Better Faster Cheaper approaches and the psychological changes they have introduced in the space field, greatly help the space community to move when appropriate, from very large national or international space programmes (which bring their dramatic obligation of success), towards smaller missions. The psychological focus on the largest achievements : « largest is best » has been mitigated by another focus « small is beautiful » and the « performance over cost ratio » criteria is better used.

The clear demonstration that individual satellites can be managed, launched and operated at low cost and risk, has paved the way for missions involving constellation of satellites.

Better Faster Cheaper missions accelerate the test and demonstration of new services in the telecommunication or earth observation fields, and thus prepare the ground for future (small or large) operational systems.

The Better Faster Cheaper missions also accelerate the demonstration of efficiency of new technologies and ease their adoption by large space systems through providing evidence of right functioning in orbit.

As a whole, they support for the benefit of all types of programmes, a diversification of missions types and concepts, a faster introduction of new operational missions, and a rapid utilization of low cost or efficient technologies.

More limited are the impacts of lessons learned with small satellites onto development practices for large systems. Development approaches for the large multimission platforms and satellites in the commercial telecommunication field are specially optimized and in a large extent they are now used as models for the small multimission platforms and satellites.

8. Conclusions

Better Faster Cheaper approaches have considerably enlarged the ways through which space missions can be implemented. They are supported by true innovations in mission concepts, system development and technologies. They have released Space Agencies from the psychological focus on « Largest is Best » and then from the obligation to build large systems for prestige.

But, as shown in the geostationary telecommunication field, small satellites and small launchers are not the best answer for all types of space missions. Furthermore, most of the impressive small launcher and satellite programmes, already developed, suffered from significant weaknesses such as vulnerability to a single human failure.

Several classes of Better Faster Cheaper missions are emerging with, in particular, the development of initiatives based on multimission minisatellite platforms for science and earth observation. Large or medium space companies are very active in this field and work to scale down the conventional rules elaborated along years by the space communities.

Small companies like SSTL have been exploring for many years a centralized approach to develop microsatellites based essentially on efficient use of commercial electronic and software. Recently, SSTL has been moving towards the minisat field where they use more space technology such as propulsion, but still with internally defined rules.

Many similarities can be seen at the end between the performances and characteristics of minisat platforms from SSTL and large space companies.

All Space activities benefit from the Faster Better Cheaper approaches which provide the right tool for testing technologies and introducing new mission concepts.

References

[1] *The Past, Present and Future of small satellites* - Tenth Annual AIAA / Utah Conference, Logan - 17.09.1996 - W. David Thompson, President, Spectrum Astro, Inc

[2] *Small Mission Opportunities Initiative Study* - Final Report - Executive Summary
ESA Contract n° 95 197.01
Report prepared by MMS with SSTL, OHB and NSC/KONGSBERG - October 1996

[3] *Solar System Exploration and Earth Observation in the New Millennium* - C. Elachi, JPL
3rd International Symposium - Small Satellites Systems and Services, Annecy - 26-28.06.1996

[4] *Une nouvelle conception de la la Politique Spatiale* - September/October 1996 - Edition Dunod
Prof. J. Blamont - Nouvelle Revue Aéronautique et Astronautique

[5] *In orbit capabilities and development programme University of Surrey, Small Satellite Systems*
M. Allery, Prof. M. Sweeting, J. Ward
3rd International Symposium Small Satellites Systems and Services, Annecy - 24-28.06.1996

SYNERGIES IN R&D PROGRAMMES

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1. INTRODUCTION

Since the last few years the European Space Agency carries on an activity, known as "Space 2020" in order to achieve a clear view of the potential scenarios for the European space sector development in the next some 20 years in collaboration with specialists and experts.

This study has conducted, so far, to a clear understanding that the space sector is living a transition period to reach both the scientific and industrial maturity where advanced technologies and the competence to use those constitute the state - of- the -art within industry. In this context, a precise role is played by the market which pushes the developments while public budget diminish. However, the transition action can be appropriately concluded only if specific synergies are successfully activated.

Synergy between military and civilian research and development programmes and activities, both for space and non space applications, including those relevant to research centres, universities and industries, is considered as determinant element in the definition of the future of the European space sector. This synergy would create new systems and products better satisfying the user needs by reducing also the gap between the technological push and market pull.

In this paper, some significant aspects of the possible and useful synergies are considered by highlighting the need of the right mechanism of dissemination of scientific results and how to make them a market success.

Recent technological advances will be also considered to give some indication of new directions towards the innovation for competitiveness.

2. SYNERGIES IN R&D PROGRAMMES

SMALLER, FASTER and CHEAPER are the watchwords in the space sector, but not only in it, to avoid cuts in missions or goals of the space programmes. These guidelines are on the basis of the decision of NASA programme managers who are slashing the workforce and developing new spacecrafts smaller than the Galileo one, having in mind also the reduction of ground controllers.

Such an ambitious objective can only be the result of a well organised synergy among the different partners involved in the programme. Basically it should be first defined the right mechanism to disseminate and exploit the results of the scientific activities transferring them into manufacturing processes, and, then, developed the specific programme with the participation of all the partners.

An example is offered by the NASA programme called "New Millenium" [1] devoted to a new experimental spacecraft smaller and less dependent on ground controllers than the existing ones. To this aim NASA selected over 20 industry and university partners so giving a clear evidence to be convinced of the synergic need in the development of the space programmes.

Another significant example is the precompetitive Consortium on wide-band all - optical networks [2] formed by the American Telephone and Telegraph Company (AT&T), Digital Equipment Corporation (DEC) and Massachussetts Institute of Technology (MIT). The Consortium has the long term goal of developing a national "*infostructure*" capable to provide flexible transport, common conventions and common servers, and, then, to sustain the research and development of technology, architecture and applications in a test bed using state - of - the - art components.

Moreover, the market is today characterised by a global industrial competition which can be now considered as a race with no finish line where potential capability of getting a leading position is strictly related to the possibility to be competitive. In fact, till the mid 1980s U.S. manufacturing industries demonstrated to have lost ground with respect to Europe and Japan, but, starting from that time, they became the most competitive in the world where an ever- intensifying global competition can be easily detected, having clearly in mind the need of continually pursuing the competitiveness as a matter of survival .

Flexible manufacturing, which includes a wide range of techniques such as modelling, virtual design, prototyping, soft tooling and others, is the real secret of that success. Flexible manufacturing, in conjunction with the appropriate synergies and mechanisms of technology transfer, can assure some competitive factors including reduced cost, reduced development time, reliability and quality.

A complete integration of the product and process development involving all the interested subjects is also required to be absolutely competitive in the sense of optimizing design, technological processes and manufacture. In the United States some aerospace and automotive builders have used this technique to reduce the product cost and production cycle time up to 50 percent.

However, full exploitation of this technique requires a number of technological advances mainly for evaluating process options, improving the software to facilitate circulation and interchange of information among producers, suppliers and customers, which means also the need of adequate investment in new technologies.

Synergies among different partners, flexbile manufacturing and concurrent engineering are the way to become competitive.

3. TECHNOLOGY TRANSFER

Simply speaking, technology transfer is the movement of ideas, concepts and processes from one group to another. This implies conversion of university students to engineers, movement of military technology into civilian markets, transformation of scientific results of research laboratory into products or merging the know-how of a number of companies sharing a common technological final objective . [3]

In this definition an important role is played by inventors and investors in a technology transfer process, and some hazards should be considered in order to recognize and avoid themselves. Among the various risks we can identify those due to :

- ◊ global competitiveness
- ◊ fast moving of the technology to the market
- ◊ lack of industrial policy which determines the gap between new technology and useful products.

As for the global competitiveness we can observe that in Europe and Japan has been developed the concept of government-assisted technology transfer and several technology developers are government partnerships, using taxpayers' money to support research and development programmes both in public institutions and private companies. In the United States, federal laboratories were engaged in military and space research and as early as 1960s NASA began to transfer the results of its space research to private companies. The autority of the federal laboratories ends when a technology is developed and used for the specific project or mission. After that the industry can use it for commercialization. In any case, it is quite easy to identify in Europe, Japan or United States an excellence in discovery and basic research but poor expertise, in all those countries, in applying new technologies to the market and this is also due to the market fast pulling.

Drop out of the gap between technology and products requires specific attention to be paid to patents. Patent issues are important to the dissemination of ideas and measures to smooth the patent process in Europe to allow an easier and faster dissemination of new technologies and ideas should be pointed out.

Innovation in the space sector can be characterised either by new technologies transferred from other sectors to the space one or by new technologies developed specifically for the space sector itself. The last situation would be favoured for achieving the capability of exploiting new market which can satisfy the social demand and industrial competitiveness. To this aim we recognize that information is essential to innovation and, therefore, to competitiveness: new technologies or ideas should have the appropriate and fast circulation so that can reach and be undestood in places different from those where new concepts have been generated.

In Europe we can clearly distinguish a general form of poor information mainly due to the attempt of "personally" exploiting possible competitive advantages frequently resulting in that most people working at generating company do not get knowledge of the new ideas. In this context, the short-medium term goal should be the widest use of the innovative technologies mainly in SMEs through the creation of an appropriate service network capable to realize the technology transfer with the partecipation of all the interested regional and national institutions.

To this aim, specific programmes should be developed in order to improve the quality and effectiveness of the services supporting the innovative technology transfer in the industry area, and to allow SMEs to absorb and utilize new technologies. To do this some strategic action are required :

◊ realization of transnational networks of operators to transfer and disseminate new technologies, including research centres, universities, scientific parks and industries;

◊ all the actions able to reduce the distance between demand and supply an= d promote the knowledge and diffusion of new technologies;

◊ definition of the technology transfer mechanism and use of new technologies in SMEs;

◊ pilot projects demonstrating the mechanisms of technology transfer and developing specific expertise;

◊ procedures to optimize the management of the technological resources in industry.

All these action should be accompanied by the right financial support to turn new technologies to better account both from ESA and European Union sides with a simplified protection policy of the intellectual property, and of the formalities and requirements of the patent process.

However, the successful techonology transfer relies on a fundamental ingredient : people. New ideas and new technologies are developed continously; what distinguishes a successful one is strictly related to people able to drive it and their methods of transferring technologies. We would just remind that all people are ignorant, only on different subjects.

Business and marketing experts agree on the folloning major factors determining the successful technology transfer :

◊ Management

Proliferation of "technology management firms" can be observed around the world. Research centres, universities and companies should have a technology-transfer officer or on outside agent to realize the transfer.

◊ Sustainable patents

It has been observed that a strong intellectual property makes partners, while a weak intellectual property makes competitors.

◊ Quality investors

Investors should have at least two reasons to successfully achieve new technologies : one is the monetary gain, the other should be related to other industrial interests.

◊ Clusters

New technology existing in clusters is more likely to succed because companies located close to technology generators can use that new technology more aggressively.

4. RECENT TECHNOLOGICAL ADVANCES

An attempt of coordinating a number of research groups has been made starting from a very good cooperation between Politecnico di Bari and a small enterprise, TER in Italy. Researchers who are not currently active in the space sector and researchers who are involved in space-related domains have been asked to contribute. The topics covered by these groups have been assessed with the intention of establishing their interest to ESA and industries working in the space sector.

Topics considered are relevant to the following areas:

- ◊ optoelectronics
- ◊ microsystems
- ◊ biotechnology
- ◊ superconductivity
- ◊ unconventional power sources
- ◊ softcomputing techniques

Authors provided a paper covering the state of - the - art and future trends relevant to the topical area they are involved in. Particular attention has been paid to technological aspects, in an interdisciplinary view, of competitiveness and innovation for space applications.

4.1 *Optoelectronics*

In the last few years, serious effort both theoretical and experimental in the optoelectronics field have been spent for the development of guided-wave active and passive optical components, such as laser diodes, electro-optics and acousto-optic modulators, photodetectors and so on, in order to fabricate integrated optical devices and circuits for signal processing applications. The main reason of such interest is due to some advantages those devices show with respect to the corresponding electronic processors.

Guided-wave devices are expected to positively impact the space sector technology due to their intrinsic characteristics such as high efficiency, low losses, low power cousumption and small size. Some of these benefits appear to be more consolidated on terrestrial systems, some others are appealing for space based systems.

Further relevant improvement can be achieved in terms of down-link reduction and on -board data processing. Examples of guided-wave devices having high potential impact in the space applications, and, particularly, in Earth observation and telecommunications are discussed in [4] [5] [6] [7]. Although those devices have been proposed a few years ago, they can still be considered innovative in the space sector. However, some effort should be spent to space qualify them and optimize their cost- performance figures.

In Ref. [8] new miniature active cavity laser gyroscopes and accelerometers are investigated. These devices should be extremely useful in stabilising and measuring the movements of personnel and apparatus in space. Two different layouts of gyroscopes using ring lasers are proposed. The configuration of both active sensing systems suggested by the author are new and appear sufficiently attractive for their use in space, but considerable development is required to identify the basic elements of competitiveness and, then, to convert those ideas into commercial products.

Recently [9] a technological process to produce high-quality sol-gel silica glass thim films has been developed for fabrication of low-cost integrated optics and optoelectronics devices by eliminating several time consuming and equipment intensive steps. This new process allows to produce coating films to be used in a wide range of applications such as optical absorption and coloring, reflecting films, antireflection, fluorescence, and so on. Much study is needed to evaluate the performance of the corresponding devices in relation with the requirements of space applications.

On-board optical processing requires small, light and reliable components to have small volume, light and reliable systems incorporating them. Short period gratings are included in those components to be used in sensors, optical interconnects and laser modules for the control of emission properties [10]. A waveguide grating can be used for stabilizing the optical frequency of a semiconductor laser, stabilizing the polarization of a microchip Nd:YAG laser, electrooptically sweeping the optical frequency of semiconductor and microchip lasers, improving the wave-front of high power semiconductor and microchip lasers. At the present stage no specific application can be envisaged other than that relevant to the use of high power and microchip lasers for communication system between satellites in the space segment.

Comunication and remote-sensing systems in the next future will be operating into millimetre-wave regions with wavelenghts in the range 100 G Hz - 1 T Hz. Conventional sources and detectors at those frequencies show poor performance and new sources, detectors and low-dispersion transmission lines for ultra-high frequencies are under investigation. Besides the work on single components, some engineering work researchers are now doing to integrate several functions on a single chip, what is very important in space applications where mechanical stability and payload minimisation are severe requirements. Recently a number of researchers have begun to introduce nonlinearity into quasi-optical methods of accessing those frequencices, in the hope of exploiting some effects such as self-phase modulation, parametric amplification, travelling-wave interactions and so on. In Ref.[11] some of these new techniques are presented showing as they are expected to produce an increasing impact on the future development of millimetre-wave systems.

A very promising acousto-optic processor is described in [12] for compensation of interstellar dispersion influence in the observations of the radio emission from pulsars. Thr processor which is based on an acousto - optic spectrum analyser brings a significant touch of innovation with a considerable increase of the number of channels (up to 1000), a reduction of the complexity, cost and size with respect to the traditional ones.

Fiber optics space applications are reported in Ref. [13]. They include launch rockets, space shuttle vehicles, space platforms and satellites, for telecommunications systems, sensors and signal processing. Among the various advantages we mention the frequency baudwidth of optical fibres which can accomodate the redundancy when required, the very high number of information channels, the low weight of the optical fibres and high electromagnetic compatibility. For the future a further decrease of the cost of using fibres in large systems is expected. The losses in the fibres are no more the major concern as they were because the attenuation of fibre optic signals has been remarkably reduced. Both coupler and connector losses should continue to decrease. Smart sensors will be more and more used in aerospace applications.

4.2 *Microsystems*

Space applications have been recently proposed for the microsystems [14]. They can be considered as cost effective, miniaturized and multifunctional devices. Miniaturization and cost are two important parameters which can lead to significant advantages such as more compactness and the possibility of developing micro- or nano satellite concept. Among the various microsystems that can be used in space we include: microsensors, magnetometers, miniaturized lasers, new solid state radiation detectors, and low-temperature microbolometers. However, the real introduction of microsystems in space requires new system architectures which cannot be envisaged nowadays. It will take some years depending on the development of microsystems for ground applications, and on the feasibility of micro- or nano satellites. Nevertheless, microsystems will certainly introduce both technical and economical advantages in space applications where they have to be considered at system level and not only at component level, although it is not possible to have now a clear vision of the future since microsystems are thought just as a miniaturization of existing devices.

A semi-active technology based on shunted piezoelectric ceramics, showing much larger energy dissipation than viscoelastic materials and compensation of the drift of mechanical properties with the temperature, has been recently proposed. For the first time it has been applied to a middle size space structure with very encouraging results [15]. An efficient noise/vibration control systems to reduce the orbiter lift-off excitation will have, in the next future, the advantage of optimally designing satellite structures for on-orbit operating conditions rather than for lift-off load factors.

4.3 *Biotechnology*

In Ref. [16] the most important biotechnologies in space are reviewed, and innovation and competitiveness with earth-bound technologies are assessed. In particular, electrophoresis, electrofusion of cells, protein crystallisation, bioprocessing of cells, closed ecological life support system and hazardous biological operations, are described. Except for protein crystallisation, the results of the research programmes have not yet been transferred to the market, although the findings are very promising. The link between basic and applied research and commercialization of the results should be established.

The engineering of living tissue is another very interesting research area in biotechnology, which has the purpose of either repairing, replacing; maintaining, or enhancing the function of a particular tissue. The importance of the tissue engineering stands in the contribution it is asked to the overall reduction in health care costs and improvement in the quality of life of patients. At this stage tissue engineering is moving from an art form to a technology based on science and engineering. To this aim, studies under microgravity conditions can give a remarkable contribution [17]. The areas where microgravity studies could significantly contribute include: cell function, construct architecture, mass transport phenomena, and bioreactor fluid dynamics. Also, those studies are expected to help the growth of ground-based technologies.

Silicon, the well known material, is the only one used in space simultaneously as substrate, heat transfer system, radiation shield, substrate for optical devices, substrate for electronic components, and for functional connection with nanoscale miniaturized biomimetic systems for information processing and nano actuator elements [18]. According to the development of nanobiotechnology over the past years, the interest in space and life applications could lead to first miniaturization as innovative technology within the next decade. What we expect to achieve with this technology includes molecular control of 3-dimensional arrangement of genetic machines, controlled modification of the primary histone structure, and pharmaceutical based gene therapy.

4.4 *Softcomputing techniques*

The necessity to find new computational techniques, in order to overcome the limits of the classical information theory in case of problems with high quantity of data to be processed in near real-time, has brought in these latest years to the development of innovative techniques, so called of soft computing [19].

Where it is not possible to catalogue the data in an univocal way, that is in cases where the single data meaning, and thus its catalogation, depends on the related data, the fuzzy logics have been developed. The so called genetic algoryihms have been developed where it was necessary to develop codes for the solution of complex optimization problems.

All these kinds of algorithms are partly applicatrd in space activities, and it is demonstrate since many years during "Aerosense" - the SPIE Annual International Symposium on Aerospace, etc., where there is a section dedicated to the application of these techniques.

Fig. 1
Original File: MacroPhoto 1450x960x24 bit

Fig. 2
Macro Photo Chaotic Processed:
Compression Ratio 42.1:1 - PSNR=42 dB

But the youngest, and also the less known and most promising, among these techniques is that one connected to the Chaos theory [20], until todat limited from the general problem of the characterization of a chaotic dynamics and its attractor, related with the impossibility of a series expansion of simple (non fractal) elements.

In ref [20] it is shown the possibility to stabilize and synchronize a chaotic dynamical system. This was obtained essentially applying the axiom of *dynamic successor* to a recursive parameter adaptation: in this way it is introduced a new modality called *dynamic quantization* with respect to the usual ones called *static* (scalar or vectorial) *quantization*. The main novelties of this implementation are essentially related to the loss of the a-priori hypothesis of a statistical model valid for every image to compress; this loss implies a *mutual rearrangement* of the statistical model and the topology of the input image. Moreover this mutual rearrangement is performed in *real time*.. The superiority in terms of memory allocation and computation time with respect to classical *monotone* algorithms has been shown. In this situation it is possible to apply the chaos theory, for instance, to the problem of data compression, lossy and lossless.

The possible application to *lossless* data compression of this algorithm is related to the possibility of using a modified version of the algorithm to the extraction of recurrences and/or *pseudo*-recurrences in a generic string of symbols.

About lossy data compression the same algorithm can show computational advantages in terms of time and compression factor if used as a sort di non-stationary or non-monotone *windowing* system able to perform an optimal partitioning of the input so to decrease its entropy. It is known that some simple trick like compressing the differences between adiacent pixels of an image can give better results than applying the compression to the original signal. In this sense an optimal windowing system able to follow and to model the non-stationarity of wathever signal can improve the performance of any compression system.

The algorithm described in ref. [20], whom results are reported in figures 1, 2, 3, and 4 and table 1, is a good candidate since it is able to model an highly unstable system like a chaotic one.

Algorithm Type	SAR PRI Image	
	Compression Ratio	PSNR (dB)
Mid	5.8	59.5
High	8.8	50.5
Ultra	19.9	44.5

Table 1
Chaotic Compression on SAR PRI Image results for different algorithm type

The potentiality of the dynamic extension of the algorithms has been only preliminary and very partially explored. Notwithstanding this the results are very encouraging since the prototype gives better results than the standard (JPEG, wavelets and fractal) image compression techniques.

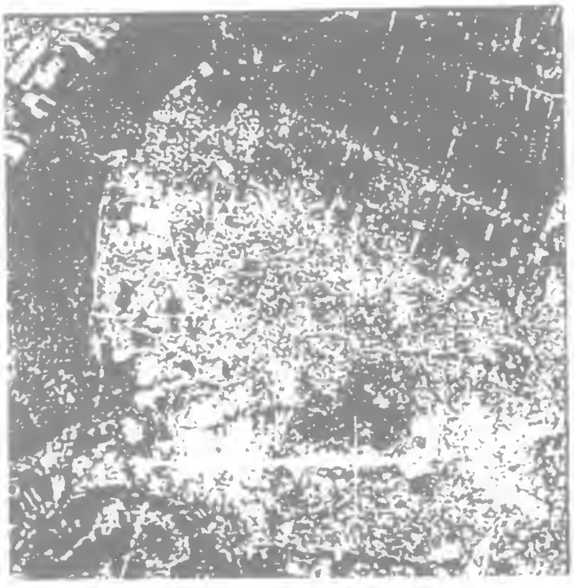

Fig. 3
SAR PRI- Original File: 1024x1024x8 bit

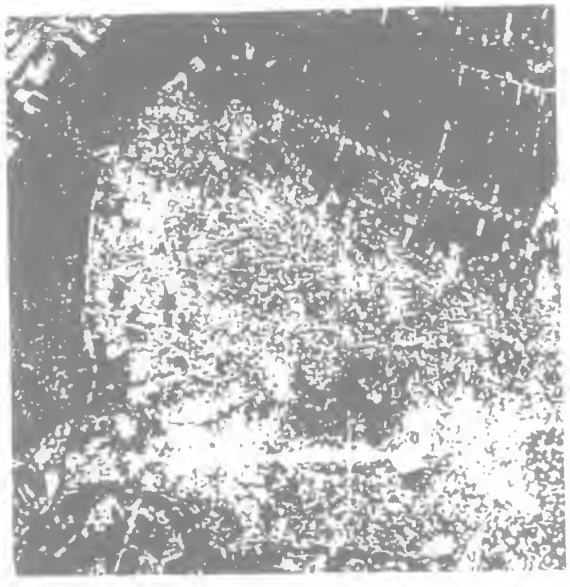

Fig. 4
SAR PRI Chaotic Processed:
Compression Ratio 19.8:1 PSNR=44.5 dB

The data reported in the paper [20] stress that under condition of symmetry between the time of compression with respect to the de-compression one, chaotic compression still obtains low time of computing with high quality level for the de-compressed images.

This kind of opportunity is typically of the new technologies innovation: still remaining the actual infrastructure they are able to realize a complete different quality of the actual services or, in other words, to give a competitive advantage to that subject able to develop and manage the same new technology.

5. CONCLUSIONS AND RECOMMENDATIONS

Innovation is the soul of the economic progress. To develop innovation, consistent immaterial investments need which involve an different stages of the education and scientific research. Other factors responsible for the low-level of innovation in Europe with respect to United States and Japan are related to poor budget for research and development in industry, not yet established and generalised cooperation between universities and industries, still existing significant gap between universities and market, not efficient student and researcher mobility and inadequacy of the financial support to the SMEs in the sense that only 7% of the European venture capital is devoted to specific projects, as the basis of innovation.

To improve the situation the mechanisms of diffusion of innovation and cooperation in Europe should be strengthened.

The real force of a Nation is based on the capability of pushing the development of the scientific research, which is the fundamental element of innovation, which in turn constitutes the basis of competitiveness.

To assure the proper development of the scientific research, a close connection to the education must be established, and, then both education and research should be in some way market-oriented without continuing to mould young people on obsolete sectors in the universities. This clarifies the hauling role of the universities to attain the appropriate technological level in the production . Moreover, it should be noticed that, while it is well clear that education is pertaining to university, research to university and research centres, it is not clear where development should be allocated. This is certainly one important reason of most of failures. Development constitutes the intermediary able to cancel the gap between the research activity and manufacturing. The development activity is surely allocated in medium-large industries, where it is also possible to verify the existence of significant research activity, but it results almost impossible to observe that activity in small enterprises, where one should recognize an expertise of dialoguing simultaneously with both research and production people. Small enterprises specialized in such activity could be of great benefit to innovation and competitiveness. So, we have three big areas, each one with a main subject: the research area (universities and big public institutions), the production area (both SME and big manufacturing firms) and the development or technological innovation area (small and medium engineering companies operating at system level associated to research centres).

Maybe al ESA level this might mean, from one hand to tend to create networks between engineering SME and research centres, from another hand to show outside to these networks, and to the other hand assuming that these networks will also develop the A and B phases of a project or a mission. And this leads straight on to the need of synergies among the different partners each of them playing his own role. Moreover, application of emerging technologies could derive serious benefits if networks including universities, research centres and industries are created for specific projects.

However the education, research and development traiad needes to be sustained by an adequate financing system. Venture capital financing and the right support to the applied research could be instruments of the right industrial politics.

REFERENCES

[1] D. Dooling, "Aerospace & Military", IEEE Spectrum, Vol.33, N.1, Jan. 1996, 87-91;

[2] S.B. Alexander et al., "A precompetitive consortium on wide-band all-optical networks", IEEE Journ. of Lightwave Technology, Vol.11, N.5/6, May/June 1993, 714-735;

[3] S.W. Weiss, "Technology transfer refines photonics", Photon. Spect., March 1996, 74-83;

[4] M.N. Armenise et al., "Design and simulation of an on-board lithium niobate integrated optical preprocessor", IEE Proc., Vol.137, Pt.J, N.6, Dec.1990, 347-356;

[5] M.N. Armenise et al., "Design and simulation of a GaAs acousto-otpic correlator for real time processing", Optical Computing and Processing, Vol.2, N.2, 1992, 79-83;

[6] M.N. Armenise et al., "Novel guided-wave electro-optic processor for synthetic aperture radar imaging", Optical Engineering, Vol.33, N.6, June 1994, 1854-1862;

[7] M.N. Armenise et al., "Lithium niobate guided-wave beam former for steering phased-array antennas", Applied Optics, Vol.33, N.6, Sept.1994, 6194-6209;

[8] P.J.R. Laybourn, "Integrated optoelectronics applications in space", this Workshop;

[9] S. Iraj Najafi et al., "Sol-gel integrated optics and optoelectronic devices", this Workshop;

[10] O. Parriaux, "Short period gratings for space applications", this Workshop;

[11] J.M. Arnold, "Nonlinear optoelectronic and quasi-optical devices for millimetre-wave applications", this Workshop;

[12] V. Proklov et al., "A some prospective acousto-optic implementations in radioastronomy", this Workshop;

[13] O. Soares, "Fibre optics components and sensors in aerospace applications", this Workshop;

[14] S. Valette, "What microsystems for space", this Workshop;

[15] B.J. Brevart et al., "Semi-active vibration damping of satellite equipment during lift-off", this Workshop

[16] A. Cogoli et al., "Biotechnology in space", this Workshop;

[17] R.M. Nerem et al., "Microgravity tissue engineering", this Workshop;

[18] S. Santoli, "Nanobiotechnology: an emerging source of innovation for competitive space strategies", this Workshop;

[19] T. Yamakawa, "Introduction to Soft Computing", this Workshop;

[20] A.L. Perrone and G. Basti, "Computability and Chaotic Systems: a perspective for applications", this Workshop

TECHNOLOGY EXCELLENCE AND COST REDUCTION: NON-COMPETING GOALS

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ABSTRACT

Technology excellence versus cost-reduction. These appear to be opposing criteria but in fact can go hand-in-glove and are essential goals for those wishing to succeed in today's increasingly competitive environment.

ESA is no exception to the rule. As it looks to the need for rationalisation and reductions in infrastructure and procurement costs, ESA is fully aware that, to maintain competitiveness in the world market, the European space effort must also continue the upward path of technology innovation, and increased reliability and performance.

The situation is not new. Many precedents exist where organisations, even whole industries, have re-shaped their infrastructures and working practices to produce improved, more reliable, products more efficiently and at reduced costs. Methods vary, and many would not be appropriate to the unique ESA scenario. This paper will however propose some options for ESA's consideration, citing examples from UK and US defence procurement procedures, and elsewhere, where innovative approaches have produced good returns.

1. INTRODUCTION

As ESA and the European Space Industry seek to adapt to fast developing events in the global space market, there is a recognition that costs must be reduced across the range of research development and production activities. In some quarters this may be interpreted as a need to compromise on the quality and qualification of space technology. This however need not - indeed must not be the case. Recent history, not least that of the Japanese and European car industries, shows that technology excellence and cost-reduction do indeed go hand-in-glove and are essential goals for companies/ organisations wishing to succeed in today's increasingly competitive environment.

In other sectors, with perhaps closer synergies with the ESA/space industry model, other measures have been taken to both spread and reduce technology acquisition and development costs with some success. The role and operating method of the Defence Evaluation and Research Agency (DERA) within the UK defence procurement infrastructure is a case in point and useful parallels with ESA may be drawn. Finally procurement methods themselves in other sectors have undertaken fundamental reviews in recent years with a view to more economical equipment acquisition. Some pointers may be relevant to ESA's situation and again the UK defence equipment procurement system provides interesting study material.

This paper sets out to examine the concepts of both technology excellence and cost reduction and by reference to experience in other sectors, to identify possible mechanisms whereby ESA and the European Space Industry can compete and succeed in the global space market.

2. THE BUSINESS SUCCESS

The experience of the automobile and aircraft industries show that there can be no compromise on the correct business approach if success - even survival - is to be assured. Figure 1 shows the interaction between drivers and solutions in the prevailing business environment in those sectors and it can be clearly seen that technology excellence in conjunction with cost reduction are complementary elements of the solution for success.

DRIVERS

Future Competitiveness Quality		Profit & Current Competitiveness		Market Opportunities		Survival / Return to investors
⇩		⇩		⇩		⇩
Pursue Technology Excellence	+	Reduce Costs	+	Satisfy Market	=	Commercial Prosperity

ORGANISATION SOLUTIONS

Figure 1 Business Success Model

It is not difficult to map the way individual companies in the automobile and aerospace markets have responded to the challenge to implement solutions to the market drivers with varying degrees of success. In a truly competitive, free market environment the way ahead for the European Space Industry would be simply to learn from appropriate measures taken in these areas. The European Space scene is however fundamentally different in one respect - there is no true equivalent of ESA in either the car or civil aircraft industries to guide research effort and inject governmental cash. To gain some clues as to the way ahead for ESA it is therefore worth examining other possible role models. The Defence Evaluation and Research Agency (DERA) in the UK has some parallels, albeit on a one-nation scale, and is well-known to the authors. Some aspects of its evolution to a fund-holding profit making agency are therefore presented in this paper for consideration.

3. TECHNOLOGY ISSUES

3.1 Technical Excellence

It is worthwhile briefly examining the term 'technology excellence' before evaluating how it may be maintained (or improved upon) in the future at reduced cost.

Let us first take an example from the automobile industry. At first sight most people a few years ago when asked to give an example of technology excellence would point to Rolls Royce or Mercedes (two of the most expensive manufacturers). However, technology excellence can never be the "best regardless of cost": there must be an element of "fit for purpose" and "value for money". Thus, there will always be an attempt to define an optimum compromise between quality, performance and cost - the "surface" of the plot at Figure 2 - as a statement of the current State-of-the-Art. In fact, in well established competitive markets, the products would typically lie on one such surface at any given time. The thrust for technology excellence shows as a pushing-out of the surface with time to a next generation State-of-the-Art .

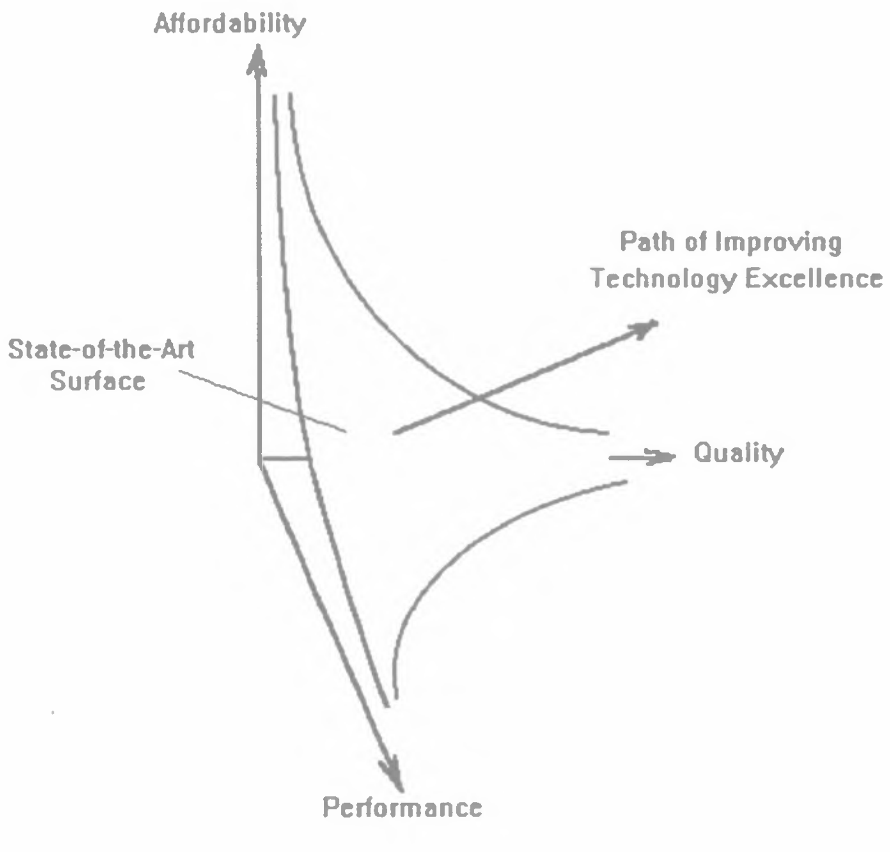

Figure 2 Technology Excellence & State-of-the-Art

In practice this is an approach to technology excellence that car manufacturers have increasingly taken on board in recent years - and one that has been proved by public acclaim, so much so that the answer to the question nowadays "which car most represents technology excellence?", is more likely to be BMW/SAAB or Lexus.

In practice therefore there may be further room for improvement in the way space companies, particularly in consortia projects, approach the design process to place more emphasis on activities that both reduce overall costs and increase overall excellence. Whilst the global car/civil aviation industry provides an imperfect model for ESA in many ways, however elements of its improved approach in recent years which may be relevant and worthy of study in more detail are:

- design for production / value engineering
- common baseline designs with "configurability" to meet individual requirements
- design optimisation at system rather than sub-system level
- wider use of common interface and envelope specifications to obtain interchangeability / ease of building
- design integration using multi-function systems

An outstanding example of the way 'technology excellence' addresses multiple goals comes from the civil aviation industry. Compared with traditional solutions the 'one piece' undercarriage dating back to early Cessna models (see photo) combines performance, with low parts count, hence ease and low cost of produceability, low weight, less drag, low maintenance, together with ease of adaptation to other aircraft.

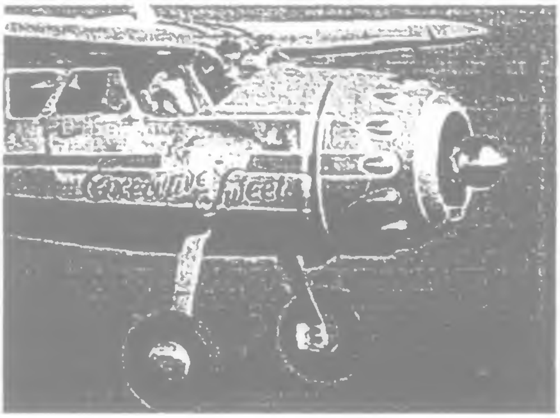

Figure 3 Cessna Undercarriage - Technology Excellence

3.2 Technology Research

A large proportion of technology cost is wrapped up in fundamental research and development and it is here where savings can best be achieved. In the past the space community itself has been the primary driver for many of its component technologies, not only for launch and control systems but in the areas of sensors, materials, data handling, communication, analytical software, simulation, teleoperation, power generation and many more. Now many other industries are also doing their own fundamental research in these areas and driving boundaries forward. There is already evidence of duplication of basic research effort across sectors (for example in the area of knowledge based systems) which, in the case of non-competing industries, must be unnecessary and reduced.

JRA with MHA undertook a study for ESA in 1996[1] which identified many areas of terrestrial research which have relevance to ESA's future technological goals and these would benefit from being investigated in detail. JRA also undertook a related study for BNSC in 1995 which identified UK research establishments with the capacity to address future space technology goals[2]. Industries singled out as having particular synergy with space were nuclear, medical, defence and aerospace and offshore.

In a recent space/technology transfer workshop facilitated by JRA[3], for example, JRA were promoting space-based work in Nuclear Magnetic Imaging (NMI) for application in measuring component flows in pipelines, only to find that the Offshore Sector had been addressing this research area for some years and seemed at a more advanced stage in some aspects of its application.

Looking for role models for ESA in this area both Canada and the USA sponsor co-operative research between space and non-space sectors to a greater extent than is done in the European environment. The STEAR program (Strategic Technologies for Automation and Robotics) was set up by the Canadian Space Agency to encourage the wider participation of Canadian companies, universities and research organisations in the development of the Mobile Servicing System (MSS) for the International Space Station. The STEAR program demonstrated another advantage of the promotion of cross-sector initiatives - the attraction of investment support from other government/funding agencies not directly related to space.

The US Co-operative Research and Development Agreement (CRDA) approach is to encourage government/industry collaboration by allowing a research centre to contribute people, equipment

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[1] JRA Report "Identification of Terrestrial Technologies for Use in Space"

[2] JRA Report "Study to Match UK Research Expertise to ESA's Future Technology Needs"

[3] "Space Technologies for the Offshore Sector "- Aberdeen 4 December 1996

and facilities - but no money. The collaborating party does the same but may reimburse the research centre for some service rendered.

In the UK DERA, working in the area of defence research, is actively seeking industrial tie-ups of this kind at the instigation of the Ministry of Defence (MOD), who are keen to defray costs of fundamental defence research. Demonstration of the lateral thinking involved in pursuing these goals is displayed in these examples of joint programmes with DERA involvement currently underway:

- Investigation of 3D sonar (seismic) simulation modelling - with offshore sector (Applications: submarine detection and oil reservoir mapping)
- Investigation of sonar array design with offshore exploration companies (Applications: submarine detection and oil reservoir mapping)
- Data collection, prioritisation and visual presentation (MMI) with the financial sector (Applications: Glass cockpits and financial workstations)

The overall concept suggested here is a closer alignment, at the ESA (ESTEC) level, with other industrial research organisations to take a commercial advantage of the synergies between basic generic technologies that are becoming more apparent as advanced technology penetrates deeper into all industrial fields, indeed every aspect of daily life. Also as the Canadian model shows to possibly take advantage of collaboration with other funding sources at the early stages of research. Early targets for synergistic moves could perhaps be miniaturisation, electronic packaging and smart materials.

The JRA study report on Terrestrial Technologies for Space suggested an extension and formalisation of the technology monitoring function currently undertaken now at individual desk level by ESTEC engineers and scientists. The EU has recently instigated a Technology Watch Network[4] (which JRA has been requested to join as an associate) and this model may well be worth studying to see whether it could provide similar benefits for the European Space Community.

There are other initiatives ESA could take to position itself at the centre of research into key technology areas of common interest. ESA could promote the wider establishment of its own "Centres of Excellence" in a few key areas and actively encourage co-operation with other industrial sectors. DERA in the UK has done this to good effect with the Structural Materials Centre, whose aims are at Figure 4. As a supplementary move the investment in and co-location of high-value infrastructure and test facilities at these centres would further attract the interest of key research groups in that area from across the industrial spectrum.

[4] European Science & Technology Observatory (ESTO) sponsored by EC JRC Institute for Prospective Technological Studies

- To achieve greater leverage from defence research and to contribute to wealth creation
- To maintain for industry and the MOD customer a leading edge awareness of relevant technologies world-wide
- To provide a critical mass, cross-fertilisation and combinations of expertise that individual companies cannot maintain internally
- To produce a flow of technical staff to and from industry and academia that provides cost effective knowledge, skills and technology transfer

Figure 4 Aims of the DERA Structural Materials Centre

3.3 Technology Spin-Off

Potential benefits from terrestrial technology are not only to be associated with the identification of advanced new technologies for adaptation / joint development for space use. There are indications that closer involvement in the continuing development of spin-off space technologies (achieved through the ESA TT Programme or elsewhere) by other sectors could bring greater returns than the satisfaction of technology twice-used and modest royalties. At least ESA could perhaps obtain advantage from the technology receiver taking the technology to a new level of performance and reap the benefits from further spin-in. At best ESA could play a pivotal role in the widespread application of innovative technology - accruing commercial returns either directly or to its industrial agents. An example of the first mechanism in operation is the polymer artificial nose developed with considerable support from ESA, by Manchester University, and commercialised by AromaScan (which is now a FTSE 100 listed company with many industrial clients). The instrument eventually flown on Euromir undoubtedly benefited from both phases of investment - ESA and commercial.

It is not so easy to quote current examples of the latter case, however CERN would no doubt have benefited from a continued pivotal role and commercial interest in the spread of the World Wide Web. Also judging from the success of the commercialised version of ESA Software Standards (PSS-05), ESA may have recouped considerable benefit by more widely exploiting its expertise in the development of software engineering procedures and tools - an ideal area for a Centre of Excellence perhaps.

Looking forward, several current technologies may fall into this category of those having significant spin-off promise and include the potential medical spin-off of passive microwave spectroscopy at terraherz levels, or the further development of the Multi Channel Plate (MCP) and Charge Coupled Device (CCD) technologies pioneered for space science programmes.

4. COST REDUCTION

It can be seen that the concepts addressed above, if carried through, actually give the opportunity to advance the cause of technology excellence whilst offering the potential for significant overall cost reductions, or cost amortisation, in the medium/long term. In the remainder of this paper we propose other courses of action aimed more at the procurement process itself but still with the potential for reducing costs without diminishing technical excellence or overall performance and reliability goals. Practical examples are quoted where implementation of the concept has had beneficial effects in other sectors.

4.1 "Alignment with Industry"

"Alignment with Industry" was a UK Ministry of Defence initiative of the early 1980's aimed at reducing procurement costs of defence equipment. Key features of this initiative included:

- alignment of equipment functional and performance goals where possible with equipment already under consideration by industry or for other programmes. (In this case this usually meant harmonising defence and commercial applications as far as possible).

- issuing requirements in the form of Cardinal Points Specifications stating key performance and functional goals whilst leaving considerable flexibility in interpretation. (An adapted existing equipment can be much more cost-effective than developing a new one).

- encouraging industry to undertake wider 'trade studies', ie to offer alternative approaches whereby (say) small performance criteria could be relaxed in return for significant cost savings.

- negotiation of tight commercial fixed price contracts, following competition, flowing down significant responsibility, and accountability, to the Prime Contractor.

The initiative was considered a success and continues today. Indeed it has been extended in the UK to encompass Private Finance Initiatives (PFI), where commercial concerns are encouraged to take on more of the risk and financial burden in return for a greater stake in the longer term returns. Typical PFI initiatives involve joint ownership, and operation of, training facilities or major Service (RAF, RN, Army) engineering support facilities.

The significance of wider adoption of the above for ESA is clear. There would be further encouragement for closer co-ordination of national and international programmes and closer co-ordination of ESA-stimulated and strictly commercial programmes. The causes of modular spacecraft designs, common buses, multi-use or configurable sub-systems etc would also all be advanced with considerable potential for cost savings in the medium term.

4.2 Qualification Rethink

One of the spin-offs of the CPS approach in the UK has been the rethinking of equipment qualification procedures and the approach to qualification. Acceptance of existing, adapted, or common designs - one of the beneficial possibilities of the CPS system - means that sub-systems may have been qualified to different criteria or qualified only at system level. The significance is that in these instances, qualification criteria, rather than being written in, by rote, at the design stage and implemented regardless of detailed relevance, are often evaluated on a case by case basis and decisions taken accordingly.

Savings in the defence field have proved to be considerable - particularly in the area of costly flight trials, and it can be seen that more critical imposition of qualification standards could hasten the disappearance of the (possibly apocryphal) space-qualified ashtray (costing 3000 dollars) or the rejection and (expensive) redesign of the cadmium plated payload release spring (to be discarded within 30 minutes of launch) for failing outgassing criteria.

Needless to say, this policy and the general move to cost-cutting in the UK (and US) defence procurement have led to detailed reconsideration of other areas of the procurement process. One such is the specification of High-Rel (Mil Spec) electronic components where significant reductions in costs (30% in production costs of one missile quoted) have been achieved. Whilst the space environment obviously imposes additional limitations on electronic components the potential here is considerable and ESA's initiatives in this area are applauded.

4.3 Reliability Rethink

Many spacecraft designs are driven towards particular configurations by "desirable" but onerous requirements. Many designs end up as chains of prime plus back-up equipment to meet the reliability and no-single-point failure criteria. Such designs are costly, limiting of performance, mass-inefficient, and expensive to launch.

Yet there are alternatives which meet the main raison d'être of these requirements - fault-tolerant designs, or multiple cheap lightweight devices to replace an expensive prime/redundant pair. For example, as an alternative to highly accurate, costly earth sensors, a multiple light-weight cheap array of earth-pointing infrared sensors may achieve the same reliability and even promote useful life beyond the time the "maximum spec" can no longer be achieved.

4.4 Programme Management Rethink

The requirements of spacecraft as traditionally procured, are aligned to a pass/fail concept for every requirement. This is particularly true in the Product Assurance area where controls are such as to cause a review every time a criterion is not met.

The needs of today for much shorter timescales (particularly in commercial spacecraft procurements) mean that decision making must speed up. If achieved, this itself should save on costs. There are a number ways to do this:

- Use of information technology for remote conferencing where collective decision making is unavoidable.

- Use of risk as a local decision criterion. It is often the case that a requirement breached in one area is compensated by a well-within-spec parameter elsewhere. Treating acceptance thresholds collectively rather than individually is one way forward. Tracking residual risks (accepted) is the means of watching over the project from the cost, schedule, performance and quality viewpoints.

- Use of Corporate Memory Knowledge Management databases as a means of avoiding mistakes of the past and providing support for immediate, informed decisions, that would otherwise be delayed or be of questionable validity. The presence of Select-From inventories of available technology in such databases may also speed up design decision making.

5. CONCLUSIONS AND RECOMMENDATIONS

Cost Reduction and Technology Excellence are equally essential and do go hand-in-glove.

ESA can take a lead in the drive to obtain more affordable spacecraft and technology and the following initiatives are recommended:

a. Continue to promote the pursuit of technology excellence through the support of design related initiatives pioneered in the automobile/aircraft industry

b. Foster closer relations with innovative technology developers in other sectors (Centres of Excellence) to take advantage of relevant developed technology and economies of scale through joint programmes

c. Continue to promote active spin-off of space technology to encourage commercial and practical involvement in its development in other applications and the possibility of value-added spin back

d. Consider adopting the Cardinal Points Specification approach to equipment procurement where relevant - aligning buying specifications with the needs of the contractors to exploit commercially the products they develop

e. Encourage Risk-Based Decision-Making

f. Invest in Corporate Memory Systems to improve quality and speed of decisions; avoid mistakes

g. Consider adoption of, or alignment with, a more formalised Technology Watch mechanism.

STRATOSPHERIC PLATFORMS: RE - DIMENSIONING SPACE?

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Abstract

Space sector is witnessing a fast transition from a phase focused on technology to an approach in which, having gained confidence on the maturity of the basic technologies, the driving factors, in the selection of the missions and of the means to accomplish them, are the value of the mission in application terms and the cost/benefit ratio of the proposed alternatives.
In this frame, the use of stratospheric platforms is being considered for a variety of applications, in the areas of telecommunications, earth observation and science.
While the concept is not new, its practical implementation had to wait for significant technology advances, mainly in the fields of materials and propulsion, which seem in the capabilities of today's technology.
Stratospheric platforms have their own peculiarities (e.g.: stationariety, lower altitudes versus spacecraft, etc.) which may provide advantages to the provision of specific services or may enable the practical implementation of entirely new services.
Of course, the question is arising of the impact of these newcomers on the world of services provided by satellites.
Indeed, to answer this question several aspects have to be analyzed, in order to single out the elements to be introduced in a sound cost/effectiveness evaluation for specific applications.
It can be anticipated that, rather than redimensioning the role of satellites, the introduction of stratospheric platforms has to be seen as complementary to space based platforms, therefore they are going to enrich the scenario of possible tools to satisfy operational needs, which may be beneficial also to the satellites themselves.
It is the purpose of this paper to provide the elements for discussion and the views of the authors on the resulting evolutionary scenario.

1. INTRODUCTION

The concept of Stratospheric Platforms is not new, indeed it dates back to the 70's, when two possible implementation approaches where considered and investigated, namely:

- the engine powered gliders or high altitude RPV
- the aerostats or "blimps".

Gliders and aerostats differ both in terms of technical performances (e.g. payload mass) and of operational characteristics (e.g. mobility or, more in general, serviced area).

Even if a number of very interesting and totally new applications were envisages based on the introduction of aerostats, it had to be realized that the unavailability, in the 70's, of suitable superlight materials and propulsion technologies was conditioning their feasibility, therefore research activities were focused on the gliders approach.

The two main technology drivers affecting the feasibility of self-standing stratospheric platforms, or aerostats, are those related to the structural mass and to the control of position and attitude.
The relevant technologies, which have significantly advanced since the 70's, are those of hyperlight materials and of electrical propulsion, which allows the implementation of high efficiency and reliable propulsion systems able to assure the needed stabilization of position and attitude of the platform.
Furthermore, a significant contribution comes from the fall-out of the space technologies, mainly in the areas of the electrical power generation and storage and of miniaturization and reliability of electronics.
A suitable integration of the best practices, know-how and technologies in the fields of aeronautics and space will be the key factor for success of aerostatic platforms, or, more generally, of the stratospheric platforms.
In fact those platforms can be periodically retrieved and then subjected to maintenance and /or refurbishment actions.
This possibility renders those platforms highly different from the usual spacecraft, in the sense that a different quality level for the components and different production techniques may be applied, resulting in significant cost saving.

It is not the purpose of this paper to deeply analyze the technical feasibility of the stratospheric platforms, this evaluation being in fact in progress at various levels (agencies, industries); it is rather its objective to give elements to discuss about the question:
assuming the stratospheric platforms feasibility as achieved, are they redimensioning the role of satellites?
The answer to this question depends on the services which can be provided by those new platforms and on the cost/effectiveness evaluation of the alternatives.
This is the approach followed in the next section.

2. GLIDERS OR AEROSTATS ?

Aerostats and Gliders have their peculiarities which render them more or less suitable for the various applications.
The major characteristics of the two carriers are the following:

Gliders (or RPV) :
- limited payload mass
- greater mobility with respect to aerostats, leading to a wider operational flexibility
- limited endurance, leading to short duration missions

Aerostats:
- greater payload mass with respect to RPV (order of 0.5 to 1.5 tons and 5 to 20 kw of DC power)
- stationary (or near-stationariety), with the possibility of a slow repositioning
- greater endurance with respect to RPV (order of years, if needed)

In terms of possible applications the above characteristics indicate that: gliders are suitable for observation missions of specific targets, but have very limited applicability in the area of telecommunications; aerostats are suitable for missions over limited areas, as, in particular, surveillance, wide band telecommunications between fixed and mobile users, collection from DCPS and distribution of data, audio and video broadcasting, air traffic control.
It seems that, with the exception of the missions requiring mobility (like those dedicated to tactical purposes), aerostats have a wider spectrum of possible applications and significant economical advantages as a consequence of the longer mission duration and of the higher payload mass capability versus RPVs, it is therefore worthwhile to go a little bit deeper into their characteristics and application areas.

The major characteristics of aerostats are:

- Operational advantages:

- simple and transportable ground support infrastructures
- capability to perform autonomous missions or to complement the missions of other systems
- fast deployment and, if needed, retrieval

- Problem areas:

- safety issues
- legal problems, depending on applications
- interference with airlanes during ascent and descent phases

- Technology drivers.

- high endurance propulsion systems
- superlightweight materials
- efficient power generation/storage system.

3. REDIMENSIONING THE ROLE OF SATELLITES ?

There are a number of interesting points that suggest to consider the stratospheric platforms in the cost/benefit analysis of alternatives to satellites for a given mission or service.

In fact the stratospheric platforms:

- do not need launchers or specific launch sites
- do no require expensive deployment operations
- can be maintained
- can follow the technology evolution of payloads, by substitution
- can be specialized by service areas
- can be specialized by service type
- can carry multifunction payloads
- can be geographically repositioned

On the other hand it has to be considered that aerostats do have limitations in the extension of the service area . From typical operational altitudes, around 22 km , an aerostat can see an Earth circle with a maximum radius of 530 km, though, in practice,the useful coverage for sites seen from the aerostat (or looking at the aerostat) with a minimum elevation angle of 5° is a circle with about 230 km radius.

Satellites,wether they are injected in LEO, ICOs or GEO do inherently have a much wider service coverage.

This simple consideration helps in understanding where is the application boundary between aerostats and satellites.
In telecoms, satellites will hardly be replaced by aerostats when the main system drivers concern the provision of links between widely spaced apart points on Earth, as in the case of intercontinental or international telecoms, though in the latter case a string of aerostats possibly interlinked could be conceided to establish two way international links: but then the system costs may render the solution less attractive than a single satellite system.
For regional/national telecommunications, aerostats may instead represent a real challenge, being well matched to the territorial extension, specially in case of small to medium size countries.

Aerostats and satellite may cooperate, in future, to implement a hyeverchical data distribution system worldwide, wherein satellites would carry data over long intercontinental or international distances, and national aerostats can function as intelligent teleports in charge of collecting/redistributing the outgoing/incoming traffic, besides serving as nodes for the locally generated and locally destined traffic.

In Earth observation, satellites cannot certainly be replaced by aerostats for mission aiming at the collection of data at world level for building statistical data bases.
Besides, the use of certain sensor types is tied to the motion of the platform; which aerostats do not have.
On the other hand, aerostats may become good competitors to satellites (and, incidentally, to other observation means) in solving a number of national (or local) needs, both in the civil and non-civil fields. From this viewpoint, aerostats with their technical and operational specificities, can be seen as a natural and logical complement to remote sensing satellites, in that thay would fill a market niche which is badly or not at all served by satellites even if flown in costellations,as it is the case of natural disasters management.

4. CONCLUDING REMARKS

As mentioned in the previous sections, the technical and economical evaluations are presently in progress and it is considered premature to provide a definitive answer to the question posed.
In fact, at the end the answer can only be given in terms of cost/effectiveness ratio among various alternatives to provide a given service.
Nevertheless some concluding remarkes can be drawn:

- stratospheric platforms seem to represent credible competitors to the satellites in those applications characterized by relatively small geographical extension and/or short deployment time
- even in those cases the deployment of stratospheric platforms, while are taking over some functions/services previously assigned to satellites, can introduce new functions to the satellite themselves, e.g. to connect and control several platforms displaced over large territories both for telecommunications and remote sensing applications.

The Potential Role of Research Centres and Universities

Prof. Nicola Cabibbo
(ENEA- Italia)

The framework of industry and commerce is nowadays characterised by the catchword "globalization": any product, or parts of it can be produced anywhere, and will be produced where it is more convenient to do so. In this situation the competitive position of the European economies is strongly linked to their capability of generating technological innovations to counterbalance the lower labour costs of newly industrialised countries, or the dynamic tecnhology of the US or Japan. In order to obtain and defend a competitive edge, European enterprises must be able to introduce products which are new, or have superior qualities - product innovation - or to improve the methods of production to reduce costs of standard products - process innovation. This is true not only in the so called "high tech" sectors, but also, and perhaps more so, in the more mature ones, which are more open to a wider competition, and are less easily protected by the patent system.

Research has a central role to play in making innovation possible. Conceptually the research system is mostly upstream of the productive system of a country, and the efficiency and excellence of the former is essential to the efficiency and innovation rate in the latter. Research should then be considered as an important external determinant to the development of the productive system, on a par with other determinants, such as the communication, transport and financial infrastructures. The existence of a strict link between the economic competitiveness of a Country and the strength of its Research structure is in fact one of the key concepts of the White Book by J. Delors.

Economic competitiveness of a Country and the strength of its Research structure is in fact one of the key concepts of the White Book by J. Delors.

An economicistic approach to the role of Research was clearly outlined by Romer in 1986, and is at present developed in many schools of economic research, and I recall here the work by Wassily Leontieff and his collaborators on the application of the input-output method to the analysis of scientific knowledge, or nearer home, the recent work by Martino Lo Cascio on the influence of technological innovation in determining the "terms of trade" in international commerce.

While normally one is keen to recognise economies which are internal to the production process, such as, for instance the economies of scale, the economies derived by the research activity are to a large extent external, both in the sense that a firm can profit from the knowledge generated by public funded research, and in that a firm which invests in research can more easily profit from the knowledge generated both in the public sector and in other enterprises.

Knowledge generated through research activities can be considered as an intermediate input into the process cycle. While it is difficult to appropriate knowledge as such, the final outputs of the R&D process can more easily become exclusive and be defended.

These arguments lead us to a series of provisional conclusions:

1) Productivity of labour is strictly related to the innovation capability. Innovation is essential to counterbalance the higher labour costs of western style economies.

2) The competitiveness, and therefore the productivity of an economic system depend from the rate of generation and diffusion of product and process innovation.

3) The rate of innovation in an economic system requires the existence of a reservoir of technical-scientific knowledge to which the single enterprises can have access.

4) Technical-scientific knowledge, even if diffused, has a definite economic value as an external factor in productive activities.

The origin of external economies in productive activities due to a strong research system depends from a complex system of interactions, arising from technological spill-overs, both vertical and horizontal and the development, in research activities, of key technologies. Important factors are good user-producer relations, the existence of complementary assets, and the emergence of compatibility standards between the different innovative technologies and between these and the traditional ones. This was incidentally one of the weak points of the otherwise strong technical-scientific system of the former Soviet Union.

A widely established view regards the scientific enterprise as a-localised, the scientist as "citizen of the world". This may in some sense be true, but technological innovation, the economic fruit of research is to a large extent enjoyed locally - consider the extreme example of the Silicon Valley phenomenon.

The importance of the local factor in the relation between research and innovation is closely tied to the time factor. In innovation, and especially in product innovation, time is essential. The pace of innovation is quickening, especially in user oriented products. Physical vicinity between the research centres and industry favours the rapid interchange of information through a multiplicity of channels, both formal ones, such as seminars, industrial associate programs, and, perhaps more important, informal ones. Vicinity favours the exchange of personnel, both on a temporary and permanent basis, with the related transfer of know-how from the research to the industrial sectors, and from enterprise to enterprise, as well as the acquisition of specialised advice on advanced subjects.

Innovation requires the concurrence of a multiplicity of different contributions, both under the form of scientific knowledge, and under the more diffused form of know-how, i.e. that technical-scientific expertise in applying knowledge to the solution of particular problems. The required contributions must be gained from a variety of sources, including other firms, research institutions, university departments. Only in rare cases innovation can be nurtured within the boundaries of a single enterprise, or through knowledge acquired on the market. This is particularly true of small and middle enterprises, at present the leaders in the generation of new employment in the industrial sector.

An essential factor in determining the usefulness of research, considered as a product, i.e. as an input to the production process, is its quality, a property which is not readily defined, but is well understood in the scientific world. Quality (capital Q) has recently become a catchword in industry, but is a concept which dates back to the tradition of the great artisans of the middle ages and of the Italian renaissance. It has to do with (apparently) unreasonable attention to detail, to an exact appreciation of the properties of materials, be it the graining of wood, or the texture of stone surfaces. Quality is then in some sense a synonym of perfect mastery of the medium of production, an essential element of artistic expression. Quality in science is not far from this artistic ideal, since it has to do with originality and creativity arising from a perfect mastering of the art. i.e. of knowledge and its uses.

In view of this, the classical distinction of fundamental - as opposed to applied - research is misguided. One should rather distinguish between Quality research and research which is devoid of Quality. and therefore of value. This is the view accepted by the best scientific circles, represented, for instance by prestigious scientific journals such as Nature or Science, which publish results which could be classified as "applied" side by side with more "fundamental" ones, in both cases judged for their originality, accuracy and depth. The distinction between applied and fundamental science is relatively recent, probably arising from the exceptional scientific breakthroughs of physics which in the first half of this century left the possibility of immediate applications behind. In fact, applications had to wait the full development of our understanding of the structure of matter based of quantum mechanics. The present situation is different, and advances in chemistry, in the physics of materials and in molecular biology are again very often directly applicable to industrial innovation.

Apparently different is the case of branches of research which are devoted to the understanding the structure of very small details of the structure of matter, in particular the structure of elementary constituents of the atomic nucleus, or with the structure of our Universe. The following considerations also apply to very long term research programs such as that on the practical application of nuclear fusion for energy production. The immediate practical interest of these endeavours is not obviously apparent, and one might be tempted, in difficult times, to "rationalise" the effort by drastically reducing the amount of money invested in them. We must resist this temptation. First of all, the investment in these long-term endeavours, although in absolute terms non negligible, amounts to only few percent of the total investment in scientific research; before curtailing the effort in these fields which traditionally represent a point of excellence in European research one should first have a critical analysis of the other fields which represent more than 95% of the total expense in research. A small gain in the latter would be have a higher impact than a large cut in the former.

Long term research has in fact important short term advantages for the industrial sector: a large portion of the technologies which are considered to be critical in modern industry have found their first application, and continue to be developed in the framework of frontier research projects, including High energy physics, space research, nuclear fusion. Through their continued request for advanced instrumentation, these fields have been instrumental in the development of new materials, superconductivity, robotics, high performance computing, digital electronics. Even if the results of frontier research, e.g. new properties of neutrinos, or the nature of Jove's atmosphere, are not directly applicable to industrial innovation, obtaining these results requires the development of new instrumentation which pushes the envelope of technology.

It is interesting to consider the experience of CERN, the European laboratory for High Energy Physics. About half of the CERN budget is devoted to the development of new instrumentation, including accelerators, particle detectors, computer software and hardware. The excellence of the technical developments carried on at CERN is witnessed by two Nobel Prizes in Physics won for technological work done there: one to Simon Van Der Meer for the development of the proton antiproton collider used to discover the W and Z particles, the other to George Charpak for the development of multiwire imaging detectors. Technological developments at CERN lead to important spin-offs to the industrial world. The most recent example is the development of the World Wide Web, invented at CERN as a link between the members of multi-national research teams, and has become the most popular interactive service in Internet. I would like to quote the following passages from CERN documentation, naturally obtained through WWW:

> "CERN encourages technical collaborations with industrial firms in fields of mutual interest. These technologies are in most cases linked to the core capabilities of the Laboratory. Depending on the case, such collaborations can take the form of common development contracts, licensing of know-how and designs or consultancy. Substantial technology transfer does also occur in the course of procurement contracts.
>
> CERN does not conduct an active patent policy. Collaborating industrial partners are however allowed to file patents on the results of joint R&D work and may benefit from exclusive rights provided that CERN keeps free access. In case of commercial exploitation, CERN will request a royalty.
>
> CERN's experience is that the best applications result from "market pull" rather than "technology push". CERN therefore attempts to inform industry about the technological opportunities arising from its activities through a variety of diffusion channels. The World Wide Web (WWW) is one of them."

What is true of CERN is, with the necessary consideration to the difference in size, true of other centres of research in European countries. As an example, most of the know-how in cryogeny and low temperature physics in Italy originates from the group in charge of developing liquid hydrogen targets and a liquid helium bubble chambers to be used with the Frascati Synchrotron in the early sixties. High Energy Physics research at Frascati, originally the responsibility of ENEA, has been in the mean time transferred to INFN, but the cryogeny group remained with ENEA, and has been involved in the design of super conducting cables for tokamak fusion machines, including ITER, and also does work for ESA on spaceborn cryogeny. Members of this group have over the years seeded low temperature Physics groups at CNR. and in the Universities of Rome and Padua.

A different example of the spin-off from frontier research to industry comes from the Ape project of INFN, which aims a designing low cost parallel computers to simulate the behaviour of quarks, the ultimate components of nuclear matter. This project, started in 1984 is now in its third stage, aimed at a teraflop machine. The project itself was made possible by the vast store of knowledge, both at the hardware and the software level, available in INFN experimental groups. The machines were produced in collaboration with Laben, an affiliate of Alenia Spazio which then acquired from INFN the licence to market the machines under the name Quadrics. They have found important applications in a number of fields. At ENEA, for instance, we use Quadrics machines for climate simulation. for the study of combustion processes and for image treatment. Alenia Spazio has developed their use for real-time processing of SAR images.

I would like to discuss briefly the present role of ENEA, an institution whose mission was until the late 80's the development of nuclear energy. Like sister organisations in other countries, ENEA had to redirect its activities, and find new ways of using its scientific and technological capabilities. The logical structure of our programs are shown in fig. 1 according to what we call the hydraulic model. At the left we have research activities and the development of new applications. The focus for this research is given by grand challenge and long term programs (at the top of the figure) including fusion energy, climate change, super computing. The research activity feeds into scientific-technical know-how (in the center) which are then used for services (lower rectangle) and for transfer of technology to industry (right rectangle). Our services range from the management of the Italian Antarctic Base to technical services offered to national and local administration and to industrial firms. Some of these are directly related to space programs, e.g. the vibration testing of payloads. The technology transfer actions are mainly aimed at small and middle enterprises, with a particular attention to "mature sectors" of the economy: ceramics, textiles, furniture. These sectors, to remain competitive, need continuos innovation, but often lack the know-how required for the introduction of new technologies, especially with respect to product innovation.

Although in a certain sense it is the right part of the figure which represent our usefulness to society and the industrial sector, the left and top parts, research and long term programs, are essential in guaranteeing the quality and continued value of these services.

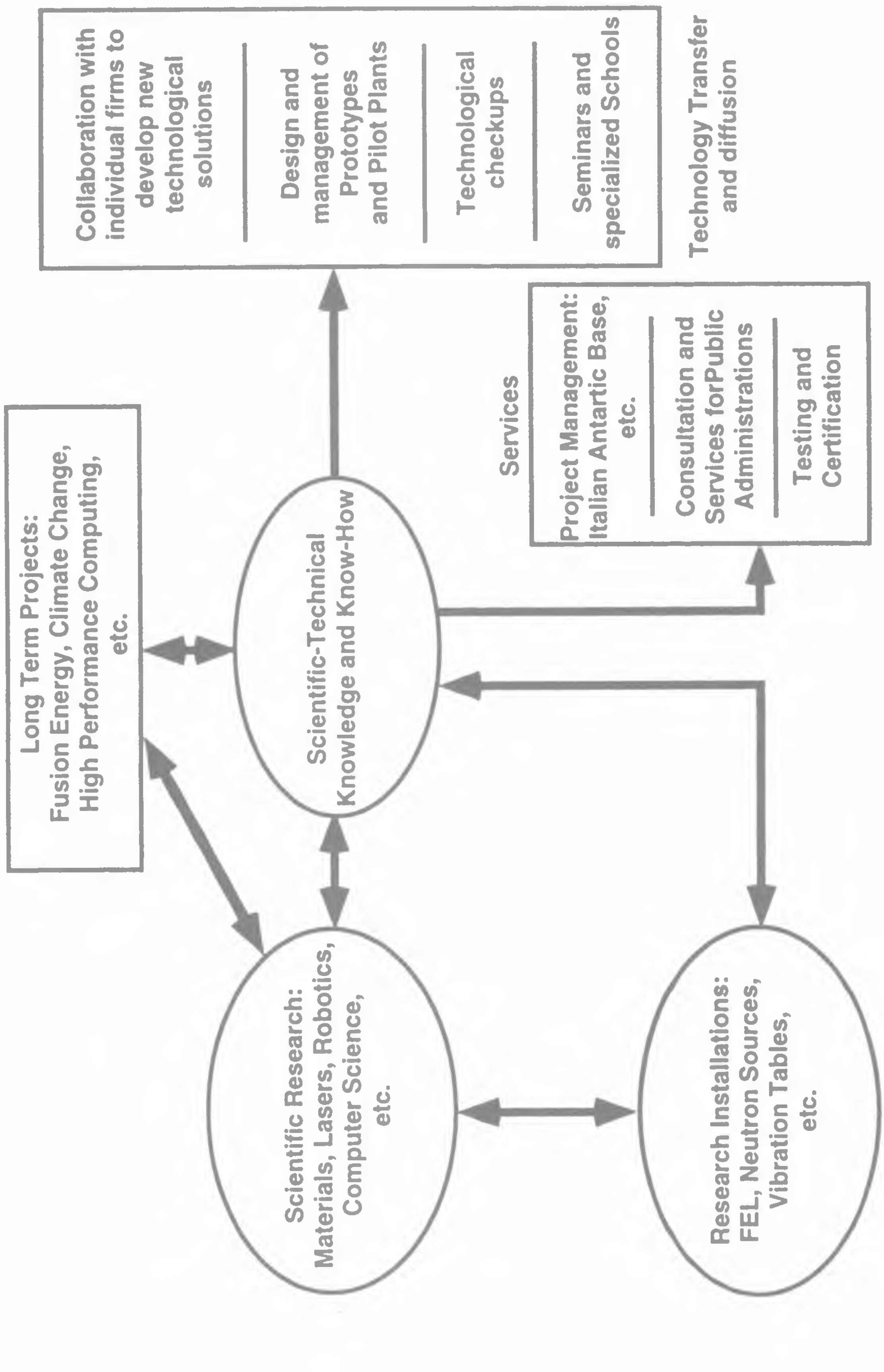
Conclusions

I would like to end this presentation with some considerations:

First of all, if research is (also) a product, which should be considered on a par with others in a global market, one would need a "showcase" to display the different research products, where industrial operators can look for what they need for their process or product innovation. In the case of space industry, it would be interesting to open this showcase also to research developed outside of the space sector.

In general the research sector is still lacking the capability of correctly marketing their products, and the industrial sector is often incapable to clearly express its needs. In order to improve the situation, and strengthen the links between universities and research organisation on the one side, and the industrial sector on the other, a lot of work is needed in the two camps. Initiatives of the EU Commission, especially in the Framework programs, which draw together industrial firms and research organisations over definite programs, and across national borders, are a good step in this direction.

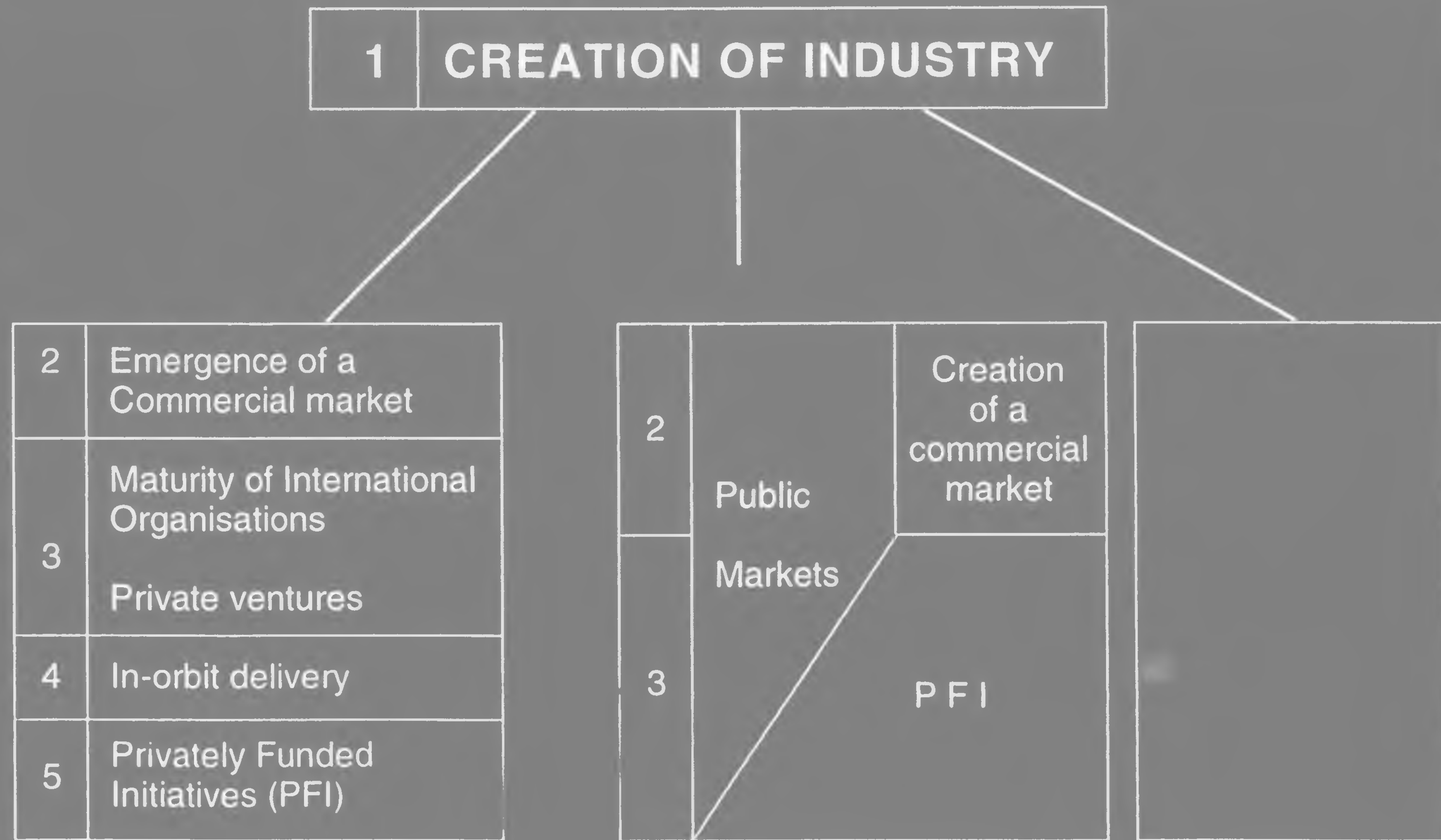
The central problem is finally the level of innovation spirit in industry, without which the best research establishment would not bear fruit. The story of WWW is in this sense paradigmatic. It is well known that WWW led to the rise of new firms, and that one of them (Netscape) has now a market value which is higher of the cost of LHC, the future collider machine which is being built at CERN. Over that cost the European governments have pondered for many years before approving the construction. The small detail: Netscape is a US firm, not an European one. But according to an old German proverb, the Devil is in the detail.


Long Term Projects:
Fusion Energy, Climate Change,
High Performance Computing,
etc.
Scientific-Technical
Knowledge and Know-How
Collaboration with
individual firms to
develop new
technological
solutions
Design and
management of
Prototypes
and Pilot Plants
Technological
checkups
Seminars and
specialized Schools
Technology Transfer
and diffusion
Services
Project Management:
Italian Antartic Base,
etc.
Consultation and
Services forPublic
Administrations
Testing and
Certification
Scientific Research:
Materials, Lasers, Robotics,
Computer Science,
etc.
Research Installations:
FEL, Neutron Sources,
Vibration Tables,
etc.

CONTRACTUAL APPROACHES AND INNOVATION

P. JOURDAN, Marketing Director

MATRA MARCONI SPACE


1
CREATION OF INDUSTRY
2
Emergence of a Commercial market
3
Maturity of International Organisations
Private ventures
4
In-orbit delivery
5
Privately Funded Initiatives (PFI)
2
3
Public
Markets
Creation of a commercial market
P F I

CREATION OF INDUSTRY

ESA MISSIONS :

—> Development of space programmes and technologies

—> Development of an European Space Industry

NO MARKET OUTSIDE INSTITUTIONAL MARKET

PARTNERSHIP FOR SUCCESS : THE KEY ELEMENT IN THE RELATIONSHIP BETWEEN AGENCIES AND INDUSTRY WAS THE TECHNICAL ACHIEVEMENT

A STRUCTURED AND EFFICIENT SPACE INDUSTRY WITH PRIMES, SUB-SYSTEMS AND EQUIPMENT SUPPLIERS WAS CREATED AND WELL ADAPTED TO THE PURPOSE

TELECOMMUNICATIONS

	Creation of Industry	TECHNOLOGY PUSH
2	Emergence of a Commercial market	TECHNOLOGY PUSH
3	Maturity of International Organisations	PHASING OUT OF AGENCIES' LEADERSHIP
3	Private ventures	MARKET PULL
4	In-orbit delivery	MARKET PULL
5	Privately Funded Initiatives (PFI)	MARKET PULL

TELECOMMUNICATIONS

Creation of Industry	**Emergence of a Commercial market**	Maturity of International Organisations New customers	In-orbit delivery	Private Funded Initiatives (PFI)

FIRST MARKET SEGMENTATION : EUTELSAT, INMARSAT, INTELSAT

SPACE TECHNOLOGY DEVELOPMENT COORDINATED BY AGENCIES (ESA, COMSAT)

THE PARTNERSHIP AGENCIES / INTERNATIONAL ORGANISATIONS / INDUSTRY HAS BEEN VERY SUCCESSFUL (OTS, ECS, MARECS, ...) AND HAS REINFORCED THE ROLE OF SATELLITE AND PAYLOAD MANUFACTURERS

TELECOMMUNICATIONS

Creation of Industry	Emergence of a Commercial market	Maturity of International Organisations New customers	In-orbit delivery	Private Funded Initiatives (PFI)

DIRECT PROCUREMENT FROM INTERNATIONAL ORGANISATIONS
NEW COMMERCIAL ENTRANTS

IMPACT ON :

- Agencies which role was diminished
- Industry which had to face international competition

—> VERTICAL INTEGRATION OF INDUSTRY AND INCREASED ADDED VALUE

—> FIRST EFFORTS OF SEARCH FOR COMPETITIVENESS

TELECOMMUNICATIONS

Creation of Industry	Emergence of a Commercial market	Maturity of International Organisations New customers	In-orbit delivery	Private Funded Initiatives (PFI)

MATURITY OF INDUSTRY
INCREASE IN THE RESPONSIBILITY OF INDUSTRY : MORE RISKS WITH IN-ORBIT DELIVERY

PRIME TO ANTICIPATE THE EVOLUTION OF THE PRODUCT AND GIVE VISIBILITY TO TECHNOLOGY MAKERS AND EQUIPMENT SUPPLIERS (CONFIDENTIALITY ISSUE)

RELATIONSHIP PRIMES - EQUIPMENT SUPPLIERS SHALL DEVELOP INTO WIN-WIN LONG TERM AGREEMENTS TO BE WORKED WITH AGENCIES :

- Prime : Shared investment and guarantee to access at market price products
- Equipment supplier : Return on investment by long term procurement guarantee

FOR STANDARD PRODUCTS, OPEN COMPETITION CAN BE MAINTAINED
—> INDUSTRY NEEDS AGENCIES' SUPPORT FOR TECHNOLOGY AND PRODUCT DEVELOPMENT
POSSIBLE FINANCIAL PARTICIPATION OF INDUSTRY WHEN R & D WELL FOCUSSED ON THEIR NEEDS

TELECOMMUNICATIONS

Creation of Industry → Emergence of a Commercial market → Maturity of International Organisations New customers → In-orbit delivery → Private Funded Initiatives (PFI)

DEREGULATED WORLD —> BOOM OF INITIATIVES

THE PREVIOUS DISTINCTION BETWEEN SATELLITE SUPPLIERS, CARRIER AND OPERATOR IS EVOLVING

MARKETS ARE POTENTIALLY ENORMOUS ; INVESTMENTS REQUIRED AS WELL

NEED FOR INDUSTRY TO ADAPT TO NEW APPROACHES (MARKET NEEDS, TECHNICAL, FINANCIAL, ...)

AGENCIES NEEDED TO SUPPORT LARGE RANGE OF TECHNOLOGIES AND TO FULLY QUALIFY PRODUCTS ON SHORT NOTICE (ON-BOARD PROCESSING, OPTICAL LINK)

—> PRIVATE INITIATIVE TO BE UNDERTAKEN BY INDUSTRY WITH POLITICAL AND TECHNOLOGICAL SUPPORT BY EUROPE

EARTH OBSERVATION

Creation of Industry	Public Markets Creation of a commercial market	Private Funded Initiatives (PFI)

INSTITUTIONAL MARKET FOLLOWS A LOGIC OF ITS OWN WITH WELL KNOWN CONSTRAINTS LIKE DECREASING BUDGETS

THE COMMERCIAL MARKET IS JUST EMERGING AND NOT YET STRUCTURED AGENCIES AND INDUSTRY MUST CO-OPERATE TO DEVELOP MARKET SEGMENTS TOGETHER WITH WELL-SUITED SPACE PRODUCTS

INITIAL STEP OF THE TWO-STEP APPROACH

- Agencies "support" the market development
- Development of technologies adapted to future market needs
- User awareness

PHASE OF PRE-COMMERCIAL SERVICE

EARTH OBSERVATION

Creation of Industry	Public Markets Creation of a commercial market	Private Funded Initiatives (PFI)

SECOND STEP OF THE TWO-STEP APPROACH :

- Industry takes over when the market is mature enough
- Some public financing remains necessary

PUBLIC CUSTOMERS CAN BE SERVED BY PRIVATE ORGANISATIONS

AGENCIES ROLE IS STILL TWO FOLD :

- Development of new technologies, to improve the system for the commercial market (similar to the Telecom market)
- Promotion, development of new markets

CONCLUSION

THE AGENCIES AND IN PARTICULAR ESA HAD A PROMINENT ROLE IN ESTABLISHING EUROPEAN SPACE INDUSTRY

THE NATURAL EVOLUTION FOR SPACE INDUSTRY IS TO COMPETE ON THE COMMERCIAL MARKET, DOMINATED BY US INDUSTRY WHICH BENEFIT FROM HUGE R & D SUPPORT AND INTERNAL MARKET

THE ROLE OF THE AGENCIES REMAINS ESSENTIAL TO HELP INDUSTRY TO ACQUIRE AND QUALIFY THE KEY TECHNOLOGIES & PRODUCTS WITH A SHORT CYCLE TIME.
AS A CONSEQUENCE, THE AGENCIES, R & D PLANS SHALL BE ADAPTED

IT IS ALSO ESSENTIAL FOR POLITICAL SUPPORT

- In Telecommunications to ensure a level playing field (OMC) and support the industry needs in ITU (Orbital Slots ; Frequency Allocation)
- In Earth Observation to develop the market (agreement with E.U.; two step approach)
- In Navigation, to ensure presence of european industry in future generations

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