ARTEMIS

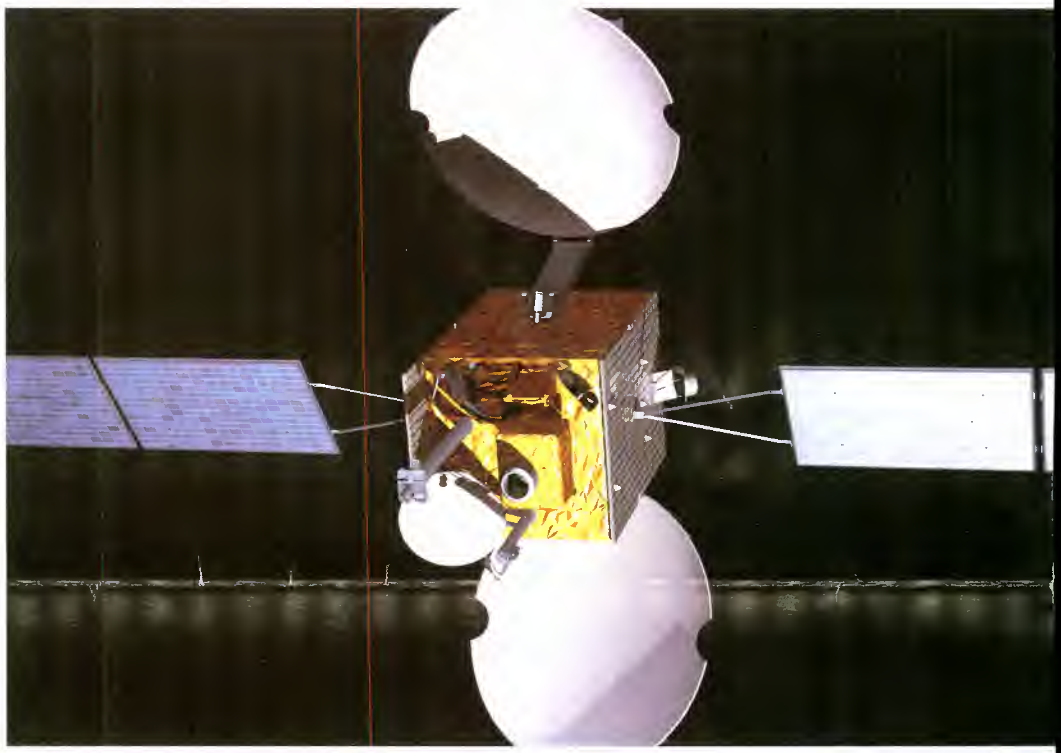
Moving toward a new generation of Communications

The European Space Agency's Artemis spacecraft will herald the start of a new generation of technology and communications services. Artemis - built in Europe by a consortium of companies led by Alenia Aerospazio of Italy for launch by a Japanese H-IIA launcher in late 1999 or early 2000 - is a satellite for testing and operating new telecommunications services.

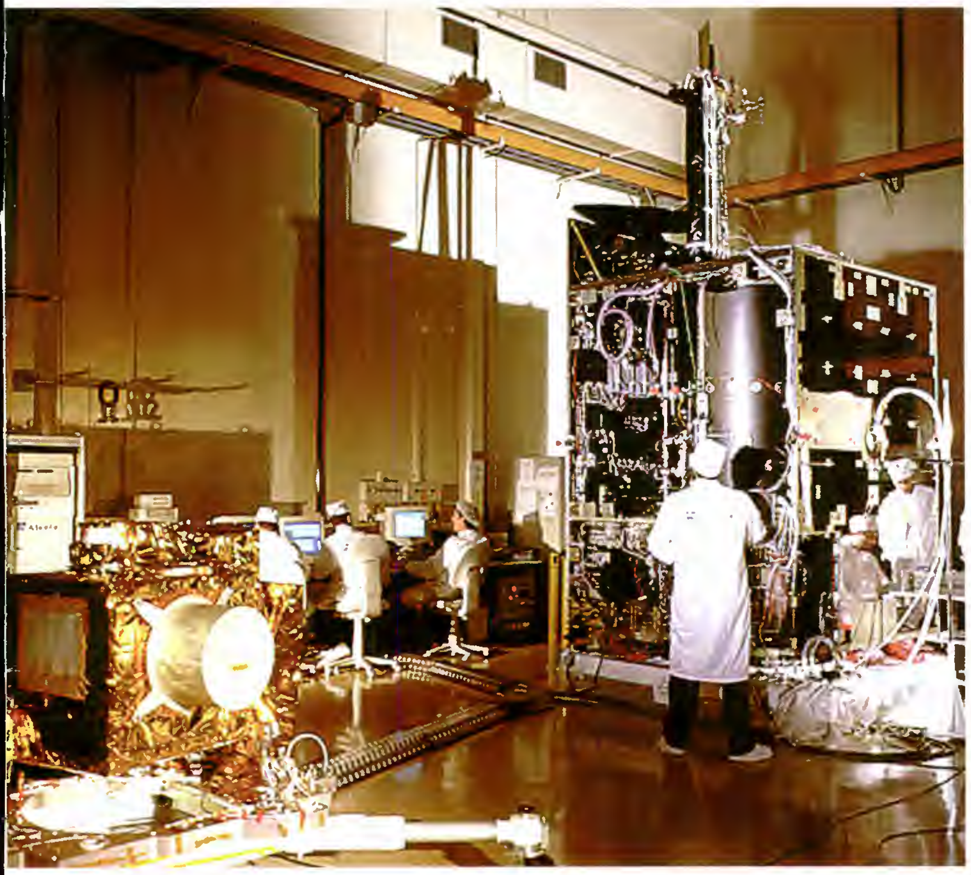
Operating from geostationary orbit some 36 000 km above the Earth, it will have the purpose of demonstrating affordable wide-coverage mobile communications satellite services and testing direct satellite-to-satellite communications, including a revolutionary laser link. Moreover Artemis will carry a navigation transponder as an element of the European satellite navigation system currently being implemented (EGNOS). Once in operation, Artemis will also symbolise a new era of co-operation with Japan and demonstrate Europe's determination to stay at the forefront of satellite communications technology in an expanding world market.

With a planned in-orbit lifetime of ten years, Artemis will impact many areas. Service providers will benefit from the experience gained with operations in mobile communications; satellite manufacturers will expand technological capabilities and competitiveness in the world market; and Europe will be in a stronger position to reap the benefits of its investment in Earth Observation from space because Artemis will help bring data direct to the user where it is needed most.

Communications is also one sector of space activity that has a truly commercial nature and, with Artemis, Europe is setting the scene for the next decade. It is ESA projects like this that provide European industry with a competitive cutting edge in both today's and tomorrow's world markets.



ESA



Alenia Aerospazio

Engineers at work on Artemis in the cleanroom at Alenia

Cutting edge technology for a unique mission

Artemis boasts many innovative technological advances, not the least of which are its ion thrusters which make use of ion propulsion. These will enable the spacecraft to maintain a stable orbital position without carrying large masses of chemical propellant.

A product of Europe's latest, advanced satellite technology, Artemis is designed to perform three specific functions:

- To provide voice and data communications between mobile terminals, mainly for cars, trucks, trains or boats.
- To broadcast accurate navigation information as an element of Europe's EGNOS, a European satellite navigation system designed to augment the US Global Positioning System (GPS) and a similar Russian system known as GLONASS.
- To provide high data rate communications links directly between satellites.

Europe-wide data communications for mobile users, especially in the transport sector, has an important future. The combined use of GPS positioning data and the pan-European mobile communications capabilities of Artemis will offer more efficient transport management.

Artemis' payload for mobile communications works in the L-band and although this means the ground terminal antennas sending signals can be small and simple, the available spectrum in the L-band is a scarce resource. Artemis overcomes this problem in a unique way using state of the art technology. A combination of three spot beams and one wide beam enables bandwidth and power to be configured in a dynamic way so that it always exactly fits the constantly evolving or changing communications traffic. Also, the bandwidth available to every mobile terminal is optimised dynamically so that Artemis can always offer the maximum number of digital voice or data channels.

Artemis will also carry a navigation payload to broadcast GPS and GLONASS compatible navigation signals, together with the correction to be applied to these data. This is an element of EGNOS, a joint programme of ESA, the European Commission and Eurocontrol to set up a regional satellite navigation system for civil users. EGNOS will enhance GPS and GLONASS services and ensure a future role for Europe in this commercial, high-growth sector. Artemis will broadcast the navigation signals it receives from a European master control centre. This data also carries information on the precision, integrity and availability of the GPS and GLONASS systems that ultimately will allow safety-critical users like aircraft or merchant ships to rely solely on satellite navigation.

ARTEMIS

Satellite characteristics

Mass (at launch)	3,100 kg
Power consumption	2.5 kW
Height	4.8 m
Length	25 m (solar array tip to tip)
Width	8.0 m (with antennas deployed)
Launch	end 1999/early 2000
Lifetime	10 years
Orbital Position	21.5° E (and 59° E)

MOBILE PAYLOAD

Coverage	Europe (to Urals), North Africa & Middle East
Frequency Band	1.5 GHz
Voice Channels	400 bi-directional
Mobile Terminal antenna Size	20 cm x 40 cm

DATA RELAY PAYLOAD

User coverage	Approx. 65% of orbit
Feeder/downlink coverage	Western Europe
Inter Orbit Links Capacity S-band (2GHz)	(Forward) up to 1 Mbps (Return) up to 3 Mbps
Ka-Band (23-26 GHz)	(Forward) up to 10 Mbps (Return) 3 channels at 150 Mbps each
Optical (0.8nm)	(Forward) 2 Mbps (Return) 50 Mbps

NAVIGATION PAYLOAD

User coverage	global (specifically Europe)
Mass	25 kg
Power	110 W
Antenna	(downlink) horn antenna (uplink) LLM antenna [2.8m Ø]
Frequency band	(downlink) 1.6 GHz [L-band] (uplink) 14 GHz [Ku-band]

ESA/Eurocontrol/EC

Satellite communications system for trucks

Communications with mobiles

The market in land mobile communications is already growing at a spectacular rate. Not so long ago, mobile systems were mostly used by police forces, ambulance services or taxi companies. Today, mobile phones are in widespread use and the personal communications market is literally exploding - it is estimated that there could be 20 million individual users in Europe by the turn of the century.

In terms of cost, capacity and spectrum efficiency alone, satellite systems cannot compete directly with cellular systems. However, they offer the advantage of wider coverage, which is of particular interest in areas of low population where cellular systems are uneconomic. Also, satellites are more flexible in adapting to changing traffic or service requirements.

ESA is focusing on the development of a pan-European satellite system for land mobiles - cars, trucks and trains. Such systems could capture a tenth of the expanding mobile communications market. Thanks to Artemis, European operators will gain valuable experience prior to the introduction of a commercial service.

ESA has developed two complementary new-generation land mobile payloads, known as EMS (European Land Mobile System) and LLM (L-band Land Mobile). EMS flew on the Italian Space Agency's (ASI) Italsat-F2 satellite in 1995 and the more advanced LLM will fly on Artemis in late 1999 or 2000. Together, they will provide services for mobile terminals throughout Western Europe and neighbouring regions - the Mediterranean Basin, the Middle East and Russia up to the Urals.

EMS can provide 450 two-way voice communications channels between fixed Earth stations and land mobiles anywhere in the coverage zone. LLM, carrying 400 two-way voice channels, offers greater versatility thanks to its three spot beams and wide Eurobeam. To make best use of onboard power and capacity, LLM has been designed with a high degree of flexibility in mind - the allocation of bandwidth, power and frequencies to the four beams can be modified in response to changing traffic patterns.

ESA/Eurocontrol/EC (courtesy of Iberia Airlines)

Pilot at flight controls of commercial aircraft

Who says satellites cannot supply new services?

Imagine your business shipping emergency deliveries throughout Europe. Or products to supermarkets. One of your trucks has a problem on the road. It is vital for your driver to call you and send you a fax but in this out-of-the-way place there are no cellular systems and no call boxes. Your driver – and your goods – are stuck. Relax – help is at hand in the form of space communications technology. Via a handheld terminal in the truck and the latest mobile communications satellites, any vehicle in the fleet can be instantly in touch with you – at affordable rates.

Or imagine another scenario: planning flood rescue operations in Asia. Data from an Earth observation satellite will tell where the damage is worst. Today, the satellite beams its data to a ground station in Asia, where it is stored on magnetic tape and then dispatched to Europe. Tomorrow, a data-relay satellite system will pass this information instantly to where it is needed.

Sailor pointing to latitude readout

ESA/Eurocontrol/EC (courtesy of Raytheon Marine Europe)

ARTEMIS


NASDA

Launch of H-II rocket

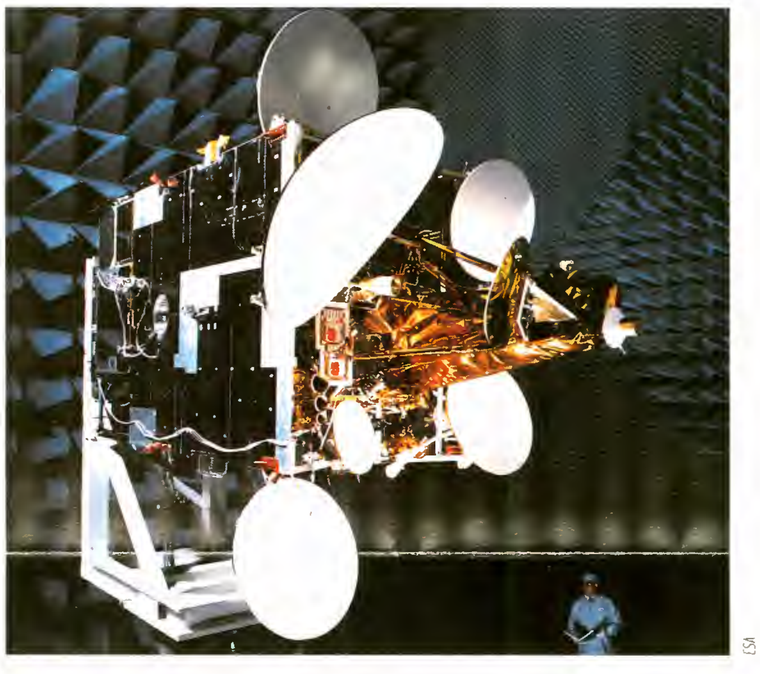
Launch

The launch of Artemis onboard the first flight of the Japanese H-IIA rocket will herald a new era of ESA/NASDA co-operation. ESA will in turn provide NASDA a share of Artemis' in-orbit capacity. NASDA's Optical Inter-Orbit Communications Engineering Test Satellite, (OICETS), and numerous Earth observation missions are examples of future Artemis users.

The Japanese H-IIA is an improved version of the existing H-II launcher and will be able to deliver two tons of payload into geostationary orbit. Its design is based on a first stage liquid hydrogen/liquid oxygen engine providing 110 tons of thrust, and two solid rocket boosters providing 230 tons of thrust each. The second stage, based on a liquid hydrogen/liquid oxygen engine, provides 14 tons of thrust.

Compatibility studies between Artemis and H-IIA started in 1996. The environmental levels foreseen for H-IIA are similar to those of Ariane-5 for which Artemis was originally designed.

Lift-off will occur from the Tanegashima launch complex on the Southern tip of Japan. About 100 seconds later, 50 kilometres to the east south-east, the solid rocket boosters separate. Thirty minutes after lift-off the launcher will pass over the equator and as it approaches the Marquise Islands, eject Artemis into space. From here, Artemis will travel out on its own, using an internal motor to reach geostationary orbit.


ESA

ESA's Olympus telecoms satellite

Artemis

The ESA pedigree

ESA launched its first communications satellite, OTS, back in 1978. This paved the way for the ECS and MARECS series of satellites operated by Eutelsat and Inmarsat.

OTS was the first ever Ku-band satellite with three-axis stabilisation and this concept has since become the standard for communications satellites world-wide, with some 30 satellites built in Europe alone being derived from the original OTS design.

ESA's second technology demonstration mission, Olympus, began in 1989. Its four advanced payloads helped push back the frontiers of new telecommunications services such as direct-to-home TV business networks, narrowcasting and videoconferencing.


NASDA

Japan's Tanegashima launch base

Radio links and lasers in space

ESA has already demonstrated direct satellite-to-satellite radio communications in a trial that ran from August 1992 to June 1993. A data-relay link between the EURECA platform in low-Earth orbit carrying more than ten scientific experiments and the Olympus satellite in geostationary orbit gave researchers up to 60 minutes of uninterrupted communications.

Building on this experiment, Artemis will carry a much more advanced radio data-relay payload and a revolutionary laser data-relay payload called SILEX (Semi-conductor Inter-satellite Link Experiment). Using laser communications, potentially very high data rates can be achieved via small terminals on low Earth orbit satellites. Initially, SILEX will receive remote sensing data from the French SPOT-4 satellite, beaming it to user ground stations in Europe. Fully bi-directional, SILEX can also relay commands from the control centre of a low Earth orbiting spacecraft via Artemis.

Another early user of the optical payload of Artemis will be the Japanese satellite OICETS (Optical Inter-Orbit Communications Engineering Test Satellite) which is scheduled for launch in 2000.

The radio data-relay payload SKDR (S/Ka-band Data Relay) features the use of two frequencies for relaying data at low, medium or high rates – again both ways. The first users of SKDR include ESA's environmental Envisat-1 satellite to be launched in 1999 and the Japanese ADEOS-2 Earth observation mission.

The ESA-Japan agreement on the launch and utilisation of Artemis, signed in April 1997, and the fact that Artemis and the Japanese Data Relay System are technically compatible, lead to the possibility that the two systems could constitute a network with global coverage, thus creating an alternative to the US TDRS (Tracking and Data Relay Satellite system).

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ARTEMIS

Direct Inter-satellite Data Transmission

One of the most exciting and challenging aspects of Artemis is the testing of communications between satellites. Artemis will provide a practical demonstration of the reception of data from other satellites in orbit and their onward transmission to users in Europe.

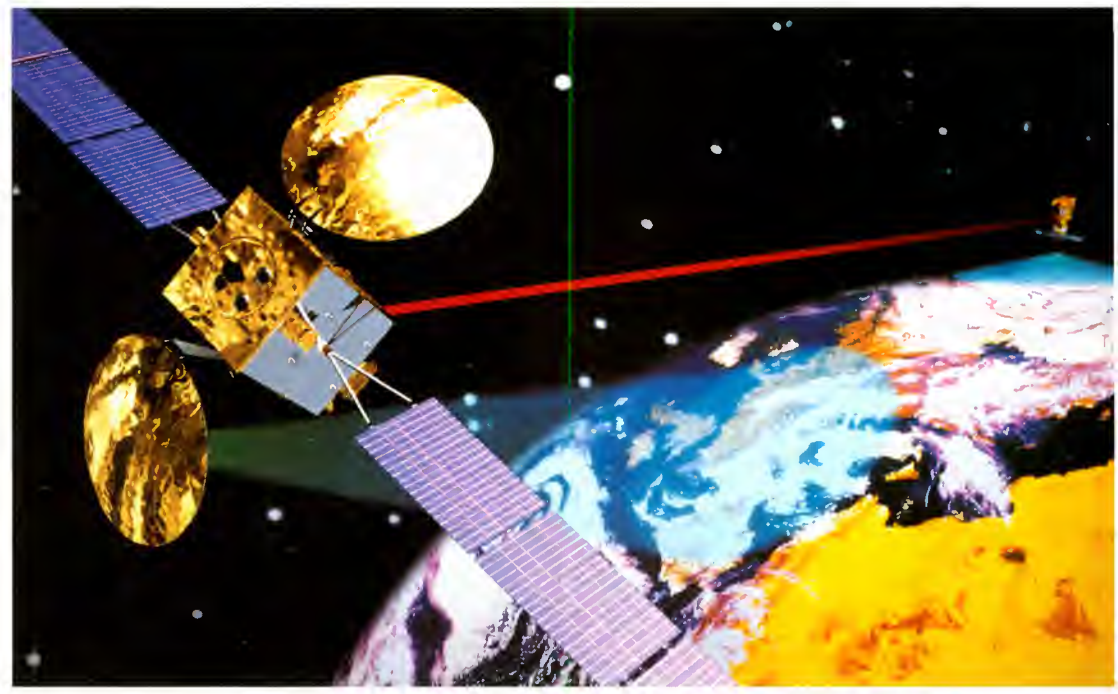
Earth observation satellites cannot send their data to just one Earth station because they fly at such low altitudes, typically at about 800 km. This means that as they scan the Earth's surface, they 'disappear' over the horizon after only a few minutes. Data must therefore be stored in on-board memories - which are far from failsafe - or else transmitted to a large number of distributed Earth stations, which are costly to operate.

On the other hand, Artemis - from its vantage point 36 000 km above the Earth - will be in constant communication with satellites in low-Earth orbit for long periods of each orbit, and can beam data from those satellites directly to users across Europe.

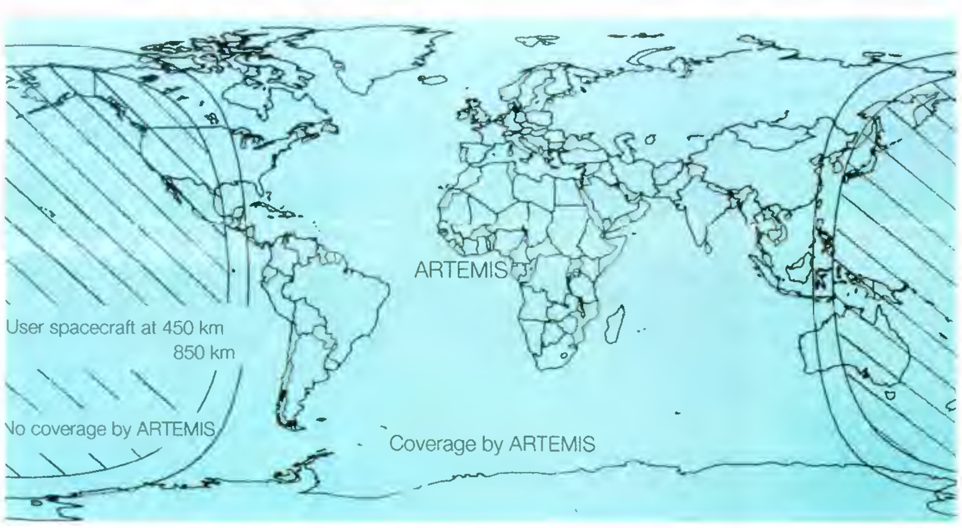
For example, the SPOT-4 spacecraft's telemetry and remote sensing data will be received in Aussaguel near Toulouse, France close to the operations control and image processing centres, while Envisat data will be received directly at the ESRIN processing centre, in Frascati, Italy.

The Artemis data relay payload provides feeder links between Artemis and the ground, and inter-orbit links between Artemis and spacecraft in LEO. The feeder links operate at 20/30 GHz, while the inter-orbit links can operate at S-band (2 GHz), Ka-band (23/26 GHz) and optical frequencies.

The feeder link, S-band and Ka-band payload elements jointly comprise the SKDR (S/Ka-band Data Relay) payload while the optical payload element is called SILEX (Semi-conductor Inter-satellite Link Experiment). SILEX is a world first. Developed by ESA, this technology is of prime interest for future constellations of communications satellites in low-Earth orbit that will need inter-satellite communications links. Laser beam communication offers very high data rates, less power consumption and interference, and lightweight terminals compared to conventional radio beams.



Artist's impression of a data-relay link between Artemis and an Earth observation satellite



Map of Artemis coverage

GLOSSARY

SADA	(Solar Array Drive Assembly)
MGSE	(Mechanical Ground Support Equipment)
EGSE	(Electrical Ground Support Equipment)
TT&C	(Telemetry, Tracking and Command)
IOL	(Inter Orbit Link)
IAPS	(Inter Orbit Antenna Pointing System)
UPS	(Unified Propulsion System)
IPS	(Ion Propulsion System)
RITA	(Radiofrequency Ion Thruster Assembly)
EITA	(Electro-bombardment Ion Thruster Assembly)
ICDS	(Integrated Control and Data handling System)

Industrial organisation and contractors

Prime contractor	*Alenia Aerospazio (I)*
ICDS	*Alenia Aerospazio (I) DASA (D)*
Thermal Control	*Alenia Aerospazio (I)*
Structure	*Casa (E)*
Power subsystem	*Fiar (I)*
Solar Array	*Fokker (NL)*
SADA	*MMS (UK)*
Batteries	*Saft (F)*
UPS	*BPD (I)*
IPS	*DASA (D)*
- RITA	"
- EITA	*MMS (UK)*

LLM Payload	*Alenia Aerospazio (I)*
SKDR Payload	" "
- IAPS/IOL Antenna	" "
- Forward Repeater	*Alcatel Espace (F)*
- Return Repeater	*Bosch Telecom (D)*
- TT&C & Common	*Alenia Aerospazio (I)*
OPALE/SILEX	*MMS (F)*
System MGSE	*ORS (A)*
System EGSE	*Laben (I)*
Parts Procurement	*TOP-REL (I)*
Ground Segment	*ALTEL consortium (I)*