

Foreword and Acknowledgements

After the publication of the 4th edition at the end of 2001, I continued updating of my documentation work as a retiree at home – not for any 5th edition – but rather for eventual electronic update versions of the book.

The website documentation of the “**history**,” i.e. the 1st chapter of the book, presents a considerable update of the version published in the 4th edition [enlargement from 150 to 634 (Jan. 8, 2007), to 635 (Apr. 11, 2007), to 642 (July 4, 2007), to 649 (Oct. 1, 2007), to 677 (Feb. 7, 2008), to 682 (April 4, 2008) to 703 (July 1, 2008) to 732 (Oct. 2, 2008), to 742 (Jan. 4, 2009), to 756 (April 2, 2009), to 768 (July 1, 2009), to 800 (Oct. 1, 2009), to 815 (January 2, 2010), to 825 (April 1, 2010), to 841 (July 1, 2010) to 857 (Oct. 1, 2010), to 883 (January 1, 2011), to 896 (April 1, 2011), to 905 (July 4, 2011) to 915 (Oct. 13, 2011), to 928 (Jan. 02, 2012), to 956 (July 25, 2012), to 971 (Oct. 16, 2012), to 979 (Jan. 3. 2013), to 992 (April 02, 2013), to 1002 (July 01, 2013), to 1017 (Oct. 1, 2013), to 1033 (Jan. 2, 2014).

The intent is to provide the reader with context information and historic background on some topics of technology introduction in spaceflight. The **thematic approach** led also to multiple mentioning of instruments, missions, observation techniques and/or technologies in various contexts of the documentation. Hopefully to a better overview and understanding of the subject matter. The history is told in a very condensed (almost abstract) fashion to keep it manageable to all involved.

In spite of all efforts – I am quite aware of the fact that my history is incomplete and a bit lopsided in favor of the western spacefaring nations. In particular, it does not reflect properly the accomplishments of the Soviet/Russian space program in the field of Earth observation. This is definitely not intended. The unavailability (and/or non–existence) of documentation on the Russian space program with regard to sensor developments is the prime reason for this deficit. My requests for reviews, for critical comments and for background information on particular topics were only of very limited success. The language barrier, the secrecy of the past political system, the heritage of a military–dominated space program, and the working habits of the Russian research community are at the root of the problem. The nature of any reliable history depends, however, on access to multiple information sources for checks and cross checks for verification.

A further intent of this electronic version of the history is to get in contact with the reader community. A feedback could certainly help to eliminate some errors and to update those topics in obvious need of correction/elaboration. However, experience with the first electronic version in the first 3–month period resulted in a total return of two e–mails (out of over 6000 website contacts).

I am aware of the fact that the history alone contains more than two thousand references. Many of them are simply URL (Uniform Resource Locator) labels of the Internet and as such rather unreliable sources. They may be changed or deleted by the provider – making them eventually inaccessible to the reader. The situation reflects actually the fast–changing environment of today. Sometimes this is the only access available to me (I always try to get published references). I am also aware of the vast amount of acronyms used in the text. Well, this is the way things are conveyed today among the people involved. For this reason, I have added Appendix B “Acronyms and Abbreviations” that should provide a fairly reliable look–up source in case of need. Frequent use of the history should give the reader a certain degree of familiarity with the acronyms and the language of the global survey. In addition, a “**Glossary**” (100+ pages) has been added as of April 11, 2005.

In November 2003, I was very fortunate in receiving an offer of financial support from ESA/ESRIN (Gunther Kohlhammer). The objective is to continue updating of my extensive documentation database in Earth observation and to place the mission and instrument descriptions successively onto the Earth Observation Portal of ESA/ESRIN (whenever the infor-

mation is sufficiently stable and verified). I am grateful for these new developments and hope to be of service to the reader community.

In July 2009, the “Current Table of Contents” was retired and will not be updated anymore. The reason: I am encountering lately problems in file handling on my desktop. I suspect, these problems are due to the fact of different format widths that I am using for publishing a book – and for publishing the project files for the eoPortal (and the generation of a new Table of Contents requires the standard book format in the current version).

The online service of the eoPortal was not available in the timeframe March 27 to July 24, 2012. In this period, ESA upgraded its system hardware and software and modernized the access schemes. Throughout this period, I was able to continue my documentation work, submitting over 130 files with updates and to add some new missions.

Gilching, January 02, 2014

Herbert J. Kramer

Acknowledgments after the 4th edition (2002):

I would like to thank the following individuals for their cooperation in providing information, their expertise/reviews, or for general support services – – making possible this update of my documentation. Naturally, this includes all topics of the documentation and not just the history. There is no particular order to the following list except that the individuals are grouped to institutional affiliations. I do value this cooperation of volunteers very much.

R. Keith Raney, Nicholas P. Paschalidis, Richard F. Conde, Peter Sharer, Eric Hoffman, Ralph L. McNutt Jr., all of JHU/APL, Laurel, MD, USA; David L. Glackin, David B. Kunkel, William H. Ailor, John S. Bohlon, all of The Aerospace Corporation, El Segundo, CA, USA; Christoph R. Englert, Michael Zedd, Peter Gaiser, Mike Hurley, NRL (Naval Research Laboratory), Washington, D.C., USA; Dean Roemmich, UCSD, San Diego, CA, USA; Evan H. Webb, Claire L. Parkinson, Dennis Chesters, Charles H. Jackman, Richard D. McPeters, Michael L. Kaiser, Brent Warner, Gilbert Mark Flaming, David J. Bundas, Murzy D. Jhabvala, Rafael F. Rincon, all of NASA/GSFC, Greenbelt, MD, USA; Francis M. Reininger, Brian D. Pollard, Robert Sherwood, Eastwood Im, Bjorn H. Lambrigtsen, Thomas P. Yunck, Roger S. Helizon, David Crisp, Michael Eastwood, Andrew Carmain, Amit Sen, Neil F. Chamberlain, all of NASA/JPL, Pasadena, CA, USA; Dean B. Eppler and Stephen A. Voels, SAIC/ISS Payloads Office, NASA/JSC, Houston, TX, USA; Joseph W. Skiles of NASA/ARC, Moffett Field, CA, USA; J. Puschell, Raytheon Electronic Systems, Santa Barbara Remote Sensing, Goleta, CA, USA; Rachel Leach, Design_Net Engineering, Lakewood, CO, USA; Andrew J. Davis, SRL (Space Radiation Laboratory), CalTech, Pasadena, CA, USA;

Tye Brady, Charles Stark Draper Laboratory, Cambridge, MA, USA; Christopher Jekeli of Ohio State University (OSU), Columbus, OH, USA; Jennifer Gebelein, Florida International University, Miami, FL, USA; Peter Melvin of B–Gravity Inc., MD, USA (formerly of NRL, Washington, DC); Erik Henrikson, Arizona State University (ASU) Tempe, AZ; Ronald I. Phelps, NPS (Naval Postgraduate School), Monterey, CA, USA; Terrance Yee, Microsat Systems Inc., Littleton, CO, USA; Raid Suleiman, SAO (Harvard–Smithsonian

Astrophysical Observatory), Cambridge, MA, USA; Thomas U. Kampe, BATC (Ball Aerospace & Technology Corporation), Boulder, CO, USA; Scott Bailey, Geophysical Institute, University of Alaska, Fairbanks, AK, USA; Neal Hurlburt, Karel Schrijver, LMSAL (Lockheed Martin Solar & Astrophysics Laboratory), Palo Alto, CA, USA; David A. Williamson, The Circle Mountain Co., Tempe, AZ, USA; Robert E. Murphy, IPO (Integrated Program Office), Silver Spring, MD, USA; Robert Haring, Hamilton Sundstrand, Pomona, CA, USA; Timothy J. Schmit, NOAA/NESDIS, Madison, WI, USA; Michael Keidar, Christopher Ruf, University of Michigan, Ann Arbor, MI, USA; Vassilis Angelopoulos, UCB/SSL (University of California, Berkeley/Space Sciences Laboratory), Berkeley, CA, USA; Charles P. Herring, DigitalGlobe Inc., Longmont, CO, USA; Michael Cai, LANL (Los Alamos National Laboratory), Los Alamos, NM, USA; Gregg Parent, Christopher O'Connors, OSO (Office of Satellite Operations), NOAA/NESDIS, Suitland, MD, USA; Marcin D. Pilinski, Xinlin Li, of the University of Colorado, Boulder, CO, USA; Andrew Klesh, University of Michigan, Ann Arbor, MI, USA; Erik Stromberg, USU/SDL (Utah State University/Space Dynamics Laboratory), Logan, Utah, USA; Donald M. Boroson, MIT/LL (Massachusetts Institute of Technology / Lincoln Laboratory), Lexington MA, USA;

Dieter Sundermann, Friedrich E. Jochim, Alberto Moreira, Renate Weist, Bernd Kirchner, Horst H. Schwarzer, Claus Broja, Rolf Werninghaus, Marian Werner, Hauke S. Fiedler, Gerhard Krieger, Sabine Thiemann, Frank Klefenz, Franz Pätzold, Jens Hammesfahr, Wolfgang Bärwald, Peter Haschberger, Hannelore Krumbholz, Mihai Datcu, Boris Zhukov, Eberhard Gill, Oliver Montenbruck, Rainer Krenn, Reinhard Schuster, Christian Arbing, Johannes Schulz–Stellenfleth, Michael Bartusch, Andreas Müller, Rolf Meyer, Eckehard Lorenz, Hartmut Runge, Wolfgang Schall, Peter Reinartz, Achim Roth, Michael Wendler, Thomas König, Gunter Schreier, Wilfried Kruse, Stefan Buckreuss, Birgit Schättler, Michael Eineder, Sylvia Wohofsky, Manfred Schroeder, Harald Mehl, Miquel Garcia–Fernandez, Wolfgang Balzer, Thomas Rupp, Simone D'Amico, Marwan Younis, Markus Markgraf, Gottfried Schwarz, Achim Dreher, Robert Axmann, Christian Fuchs, Saika Aida, Armin Wedler, Christian Stephan, Dirk Giggenbach, Peter Gege, all of DLR, Germany;

Hendrik Lübberstedt, Fritz Merkle, Danela Sell, and Ingo Engeln of OHB–System, Bremen, Germany; Joachim H. G. Ender, FGAN, Wachtberg, Germany; Gunter Schreier, Ursula Benz, Markus Heynen, Definiens Imaging GmbH, Munich, Germany; Frithjof Barner, Euromap, Neustrelitz, Germany; Winfried Posselt, Rainer Killinger, Michael Mittnacht, Thomas Usbeck, Eveline Gottzein, Christopher T. F. Kühl, Wolfgang Pitz, Walter Fichter, Peter Hill, Werner Hupfer, all of EADS Astrium GmbH, Germany; Helmut Weber, Westcomp Systems, Gilching, Germany; Ursula Weisgerber, Springer Verlag, Berlin, Germany; Christoph Reigber, Rolf König, Franz–Heinrich Massmann, Markus Rothacher, Frank Flechtner, all of GFZ, Potsdam, Germany; Silvia Scheithauer, University of Bremen (ZARM), Bremen, Germany; Urs Mall of MPAe (Max–Planck–Institut für Aeronomie), Katlenburg–Lindau, Germany; Reinhold Spang, FZJ (Forschungszentrum) Jülich, Germany; Herbert Mosebach of Kayser–Threde GmbH, Munich, Germany; Georg Grillmayer, Sebastian Walz, of IRS (Institut für Raumfahrtsysteme) at the University of Stuttgart, Germany; Hanno Ertel, University of Stuttgart, Germany; Klaus Schilling, Julius Maximilians University, Würzburg, Germany; Joern Pflingstgraeff, Technical University of Braunschweig, Germany; Udo Renner, Stephan Roemer, Hakan Kayal, and Martin Herfort, TUB (Technical University of Berlin), Germany; Abelardo Perez Albinana, EUMETSAT, Darmstadt, Germany; Joern Pflingstgraeff, Mareike Krause, ERIG e. V. (Experimental–Raumfahrt–Interessen–Gemeinschaft), Braunschweig, Germany; Stephan Stoltz, Astro– und Feinwerktechnik Adlershof GmbH, Berlin, Germany;

Noboru Kazuki, Mitsutoshi Hase of RESTEC, Tokyo, Japan; Shin–ichi Sobue, Takeshi Sasaki, Yuuichi Fujiwara, Shin–ichiro Sakai, Akihiko Kuze, Takashi Hamazaki, Yutaka Kameko, Nobuto Yoshioka, Keizo Nakagawa, Royota Yoshida, all of JAXA (formerly NAS-

DA), Japan; Shigeki Uchiyama, Nihon University, Tokyo, Japan; Akira Meguro, NTT (Nippon Telegraph and Telephone) Corporation, Kanagawa, Japan; Yuya Nakamura, Shinichi Nakasuka of ISSL (Intelligent Space Systems Laboratory), at the University of Tokyo, Japan; Saburo Matunaga, Katsutoshi Imai, Hiroki Ashida, Tokyo Institute of Technology (TITech), Tokyo, Japan; Nobuhiro Takahashi, Morio Toyoshima of NICT (National Institute of Information and Communications Technology), Tokyo, Japan; Yoshihide Aoyanagi of HIT (Hokkaido Institute of Technology), Sapporo, Hokkaido, Japan; Kazuya Yoshida of Tohoku University, Sendai, Japan; Mengü Cho of KIT (Kyushu Institute of Technology), Fukuoka, Japan;

Igor V. Cherny, Space Observations Center of Roskosmos, Moscow, Russia; Stanislav I. Klimov, Boris S. Zhukov, IKI (Space Research Center), Moscow, Russia; Sergey A. Pulnits, IZMIRAN (Institute for Terrestrial Magnetism, Ionosphere and Propagation of Radiowaves), Troitsk, Russia; Vitaly, NTS OMZ (Research Centre for Earth Operative Monitoring), Moscow; Inessa A. Glazkova, Khrunichev State Research and Production Center, Moscow, Russia; Yury D. Kotov MEPhI (Moscow Engineering Physics Institute, State University), Moscow, Russia; Boris A. Khrenov, Vladimir M. Sakhparonov, SINP (D. V. Skobel'syn Institute of Nuclear Physics) at the Lomonosov Moscow State University (MSU), Moscow, Russia;

Philippe Armbruster, Andrea E. Marini, Peter de Maagt, Josep Roselló Guasch, Pierre Fabry, Manfred Zink, Leopold Summerer, Martin Endemann, Marie De Cock, Wolfgang Leibrandt, Jean–Loup Bézy, Rory van Haarlem, Giuseppe D. Racca, Petri V. E. Piironen, Roger Haagsmans, Michael Fehringer, Davide A. Nicolini, Leny Ouvehand, Gianfranco Spinella, all of ESA/ESTEC, Noordwijk, The Netherlands; Gunther Kohlhammer, Jolyon Martin, Maurice Klein–Gebbinck, Michele Betti, Marco Trovatiello, Stephen Briggs, Sveinung Loekken, all of ESA/ESRIN, Frascati, Italy; Pieter Van den Braembussche, Verhaert Design & Development, Krubek, Belgium; E. Renotte, Centre Spatial de Liege, Angleur, Belgium;

Urs Frei, University of Zürich–Irchel, Zürich, Switzerland; Aleksandar Duric, IAP (Institute of Applied Physics) of the University of Bern, Switzerland; Muriel Richard, EPFL, Lausanne, Switzerland;

Elmo Schreder and Morten Bisgaard of AAU (Aalborg University), Aalborg, Denmark; Peter Stauning, DMI (Danish Meteorological Institute), Copenhagen, Denmark; Nils Olsen, DNSC (Danish National Space Center), Copenhagen, Denmark; Stefan Lundin, Fredrik von Scheele, Sten Berge, SSC (Swedish Space Corporation), Solna, Sweden; Olle Norberg, Walter Puccio, David McCann, IRF (Swedish Institute of Space Physics), Kiruna, Sweden; Fredrik Bruhn, Jan Schulte, ÅAC Microtec, Uppsala, Sweden; Jan Tommy Gravdahl, Norwegian University of Science and Technology (NTNU), Trondheim, Norway; Mikko Kantanen, MilliLab, Espoo, Finland; Abe R. Bonnema, Jasper Bouwmeester, TU Delft (Delft University of Technology), Delft, The Netherlands;

Christian Jayles, Nadia Karouche, Eric Boussarie, Gérard Gave, Michel Le Du, Olivier VanderMarq, Philippe Escudier, Inès Gaudel, Francois Buisson, Frédéric Tavera, Valerio Cipolla, Laurence Houpert, all of CNES, Toulouse, France; Eric Caubet, Alexandre Houpert, Alcatel Space Industries, Toulouse, France; Jean–Luc Lamard, Alcatel Space, Cannes la Bocca, France; Patrice Damilano, Ange Defendini, Xavier Sembely, Francois Faure, Hervé Lambert, all of EADS Astrium SAS, Toulouse, France; Jean–Pierre Marque of ONERA (Office National d'Etudes et de Recherches Aéropatiales), Châtillon, France; Elisabeth Blanc of CEA (Commissariat Energie Atomique), Bruyères le Chatel, France; Guillaume Huby, Geosys S. A. Balma, Cedex, France; Pascal Michel, Astrium Services, Toulouse, France;

Arnold Schoonwinkel, Stellenbosch University, Stellenbosch, South Africa; Martin Jacobs, Gert–Jan van Rooyen, SunSpace and Information Systems (Pty) Ltd., Stellenbosch, South

Africa; Andrew B. Collier, University of KwaZulu–Natal, Durban, South Africa; Timo R. Bretschneider, Nanyang Technological University (NTU), Singapore; Ahmad Sabirin Arshad, Ismail Maszlan, Yushida Mohd Yunus, all of ATSB [Astronautic Technology (M) Sdn. Bhd.] Kuala Lumpur, Malaysia; Jeff Kingwell, CSIRO (Commonwealth Science and Industrial Research Organization), Canberra, Australia;

Carlos de Oliveira Lino, Luiz A. Bueno, Janio Kono, INPE, Saõ José dos Campos, Brazil; F. Raul Colomb, Ida Nollmann, Sandra Torrusi, CONAE (Comisión Nacional de Actividades Espaciales), Buenos Aires, Argentina; Karen Gold Anisfeld, ImageSat International N. V., Tel Aviv, Israel; Fred Ortenberg, Technion, Haifa, Israel;

Yunlong Lin, Huixian Sun, Yaohai Dong, Shengwei Zhang, all of CAS/CSSAR (Center for Space Science and Applied Research), Beijing, China; Chaohua Dong, CMA/NSMC (China Meteorological Administration/National Satellite Meteorological Center), Beijing, China; Xiaolong Dong, NMRSL (National Microwave Remote Sensing Laboratory), Beijing, China; Mingsen Lin, SOA (State Ocean Administration), Beijing, China; Guo Hua-dong, IRSA (Institute of Remote Sensing Applications), Beijing, China; Lili Wang, DFH Satellite Co. Ltd. (DFHSat), Beijing, China; An–Ming Wu, NSPO (National Space Program Office), Hsin–Chu City, Taiwan; Ching–Jyh Shieh, NSC (National Science Council), Taipei, Taiwan;

Killugudi S. Jayaraman (Space News Correspondent) India; V. Jayaraman, S. Krishnamurthy, Rajeev Kumar Jaiswal, B. R. Guruprasad, Mukund Rao, D. V. A. Raghava Murthy, all of ISRO/ISAC (Indian Space Research Organization/ISRO Satellite Center), Bangalore, India; Ramesh P. Singh, Indian Institute of Technology, Kanpur, India; Tapan Misra, Nilesh M. Desai, A. S. Kiran Kumar, ISRO/SAC (Space Research Center), Ahmedabad, India;

Kyungin Kang, Tae–Seong Jang, Myeong–Ryong Nam, KAIST/SaTReC (Korean Advanced Institute of Science and Technology/Satellite Technology Research Center), Daejeon, Korea; Wonkyu Park, Ee Eul Kim, Byunjin Kim, of SaTReCi (SaTReC Initiative Co. Ltd.), Daejeon, Korea; Eun–Sup Sim, Seung–Hun Lee, KARI (Korea Aerospace Research Institute), Daejeon, Korea;

Michael A. Cutter, David J. Purl, Sira Electro–Optics Ltd., Chislehurst, Kent, UK; Martin Unwin, Jeremy Crisp, Audrey Nice, Susan Jason, Alex da Silva Curiel, Fred G. Kennedy III, Philip Davies, Craig Underwood, Chris Jackson, David M. Gibbon, Andrew Cawthorne, Philip E. Davies, Pierre Oosthuizen, Martin N. Sweeting, Adam M. Baker, all of SSTL (Surrey Satellite Technology Ltd.), Guildford Surrey, UK; David M. Simpson, Jaime Reed, Thomas Studdard, EADS Astrium Ltd., Portsmouth, UK; Hazel J. McAndrews, QinetiQ, Farnborough, UK; Jacqueline E. Russell, Imperial College, London, UK; Nigel Morris, Brian P. Moyna of RAL (Rutherford Appleton Laboratory), Chilton, Oxfordshire, UK; Peter Smith, Marotta UK Ltd. Cheltenham, UK; Lloyd Wood, Cisco Systems Global Defense, Space and Security, London, UK; David Spilling, SEA (Systems Engineering and Assessment Ltd.), Bristol, UK; Gordon Petrie, University of Glasgow, Glasgow, UK; May Bound, Chris Mortimore, Infoterra Ltd., Farnborough, UK;

Lyne Rainville, Daniel Schulten, MDA (MacDonald–Dettwiler & Associates, Ltd.), Richmond, B.C. Canada; Robert E. Zee, UTIAS/SFL (University of Toronto, Institute for Aerospace Studies/Space Flight Laboratory), Toronto, Ontario, Canada; Graham Gibbs, Yuri V. Kim, Alfred Ng, CSA (Canadian Space Agency), St–Hubert, Quebec, Canada; James V. King, CRCC (Communications Research Centre Canada), Ottawa, Canada; Marc–Andre Soucy, ABB Bomem Inc., Québec, QC, Canada; Ian C. McDade, York University, Toronto, ON, Canada; Robert D. Richards, Optech Inc., Toronto, Canada; Peter F. Bernath, University of Waterloo, Waterloo, Ontario, Canada;

Valter Tamilia, Paolo Valle, AlcatelAlenia Space, Rome, Italy; Vittorio de Cosmo, ASI (Agenzia Spaziale Italiana), Rome, Italy; Gelsomina Pappalardo, Aldo Amodeo, CNR/

IMAA (Institute of Methodologies for Environmental Analysis), Potenza, Italy; Massimiliano Spelat, Politecnico di Torino, Torino, Italy; Paolo Tortora, University of Bologna, Forlì, Italy; Filippo Graziani, Chantal Cappelletti, University of Rome, “La Sapienza,” Rome, Italy; Daniele Titomanlio, of Techno System Development, Naples, Italy; Mariana Gousheva, Space Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria; Gokhan Yuksel, Middle East Technical University, Ankara, Turkey; Baris Gencay, of TUBITAK–UZAY (Space Technologies Research Institute), Ankara, Turkey; Mehmet Fevzi Ünal, Alim Rüstem Aslan, ITU (Istanbul Technical University), Istanbul, Turkey;

Manuela Unterberger of the Graz University of Technology (TU Graz), Graz, Austria; Werner Balogh of UNOOSA (United Nations Office for Outer Space Affairs), Vienna, Austria; Cesar Martinez Fernandez, Fany Sarmiento Ares, Ignacio Arruego Rodríguez, all of INTA (Instituto Nacional de Tecnica Aeroespacial), Madrid, Spain.

Salem Al Marri of EIAST (Emirates Institution for Advanced Science and Technology), Dubai, UAE (United Arab Emirates); Oleg Lapshinov, SSRE CONECS, Lviv, Ukraine, Alexander Makarov, Yuzhnoye Design Office (SDO), Dnepropetrovsk, Ukraine; Alexander Mostovoy, International Cooperation Office of KGS (Kazakhstan Gharysh Sapary), Astana, Kazakhstan.