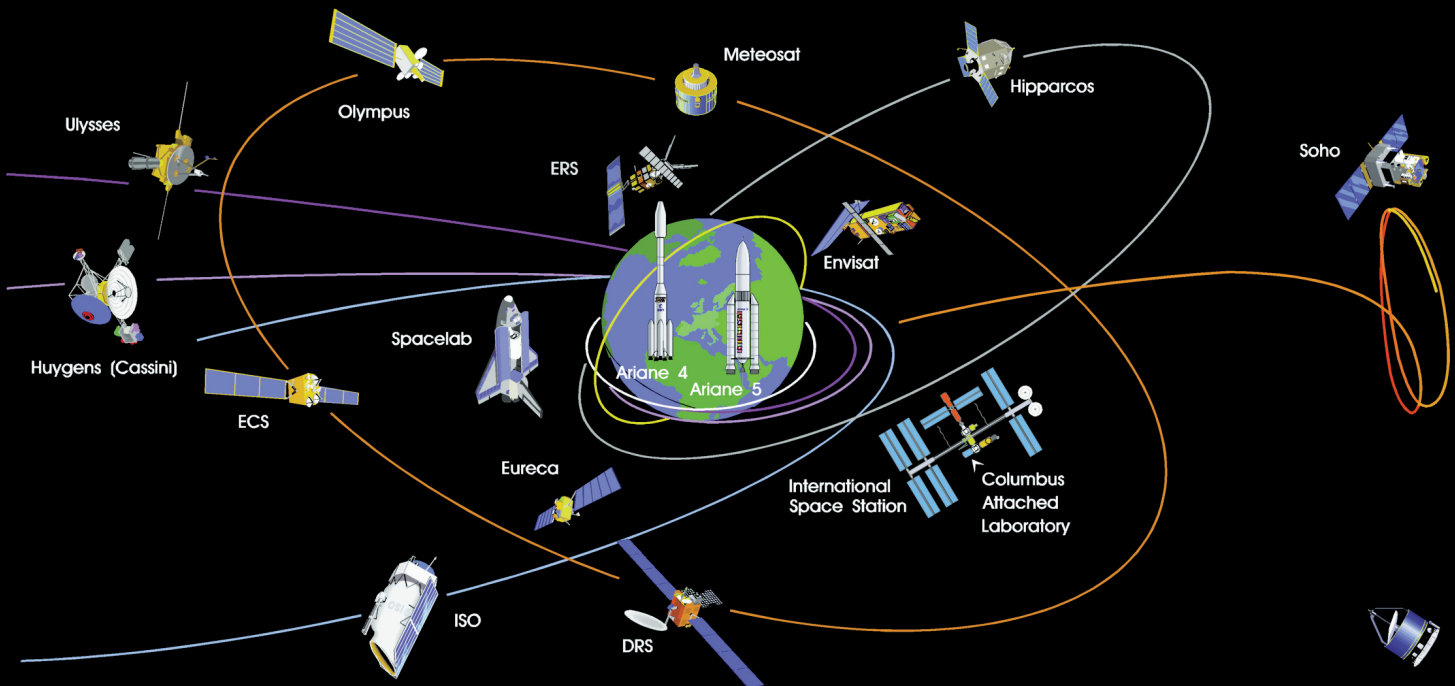
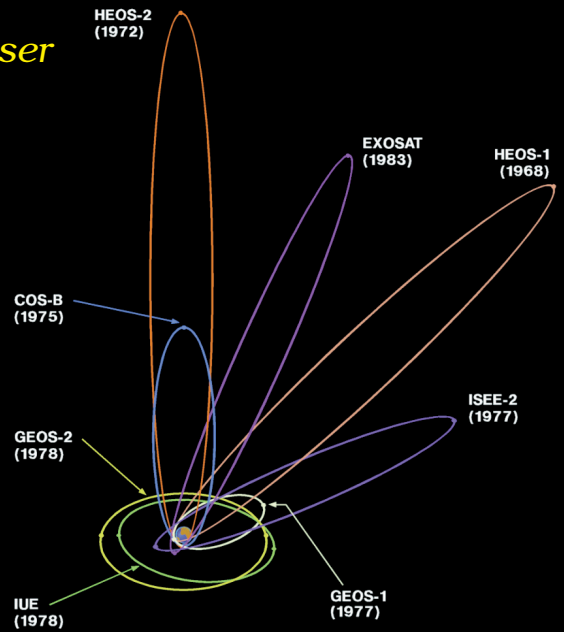
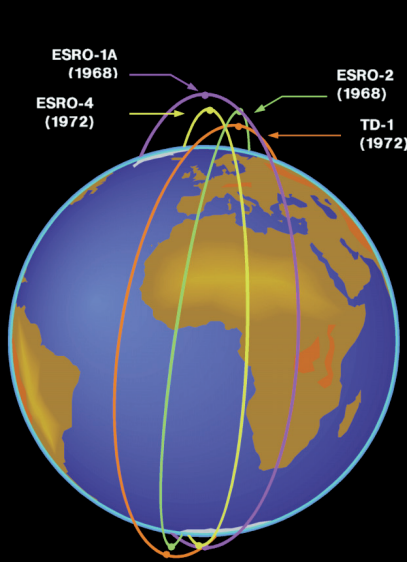


Austria's History in Space

by

Bruno Philipp Besser



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Austria's History in Space

Bruno Philipp Besser

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1 Introduction

“...It must be reserved to historians and other disciplines to portray this with sheer breathtaking speed proceeding conquest of higher altitudes, ultimately of the whole near-Earth space and to comment on its importance and effect on today’s human being. ...”

(from: inauguration speech, Otto M. Burkard, Rector, University of Graz, November 8, 1968)¹

This study aims to summarise the space (related) activities performed over the last few centuries by individuals, small groups of enthusiasts and the Austrian society as a whole. It is by no means complete, but it does attempt to summarise the historical knowledge on the subject scattered across the country and lodged in people’s minds.

The first chapter traces activities starting in the 16th Century, culminating in the early 1920s with the mathematical proof that it is possible to reach space with rockets, to 1955 when Austria regained full sovereignty. The second chapter follows the activities from the time when Austria, after World War II, established herself again in the community of states, to the end of the 1960s. Following the launch of Sputnik, various activities were initiated, both at the administrative level and at the science policy level. The third chapter, starting with the launch of the first hardware developed in Austria as part of the payload of a sounding rocket in Norway, is devoted to the period when Austrian scientists and engineers actively performed space research.

¹ O.M. Burkard, *Der Vorstoß in den interplanetaren Raum. Neue Erkenntnisse. Neue Probleme*, Inaugurationsrede, Karl-Franzens-Universität Graz, 8. November 1968, Verlag Jos. A. Kienreich, Graz, 32 p., 1968.

2 Early Years

Medieval Rocketry by Conrad Haas

One of the earliest and probably most innovative European thinkers in the field of rocketry was *Conrad Haas* (approx. 1509-1569), who served as an artillery guard and commissioned officer in the Artillery Corps of the Imperial Court of Vienna.² He was born in Dornbach (now part of Vienna), but his family originated from Landshut, Bavaria. In about 1529 he moved to Transylvania (“Siebenbürgen”, now part of Romania) and became chief of the artillery camp of the arsenal Hermannstadt (now Sibiu). Between 1529 and 1569 he wrote a manuscript dedicated to rocketry, illustrated with many pioneering drawings (multi-stage rocket principle, rocket with fins, schematic of an early concept of a space station, etc.).

Celestial Mechanics by Johannes Kepler

The general influence of *Johannes Kepler* (1571-1630) on the development of science during the transition from the Middle Ages to Modern Times is worth mentioning. During his time in Austria, initially in the period 1594-1599, he taught mathematics at a protestant school in Graz, and wrote his book “Cosmographic Mystery”. After the Catholic authorities closed the school, he looked for a new position and moved to Prague, to become assistant to *Tycho Brahe*. He returned to Austria in 1612, when he moved to Linz and stayed there for fourteen years. While in Linz he published the “Harmony of the World”, which included his “Third Law”.³

Aurora Borealis Theory by Maximilian Hell

In 1768-1770 *Maximilian Hell* (1720-1792), astronomer and teacher of mathematics, and subsequently astronomer at the observatory of Vienna, travelled to Norway and resided there at the invitation of the Danish king to observe the transit of Venus and a subsequent eclipse. Acquainting himself with the phenomenon of the “northern lights”, he developed a theory for its origin.⁴

Military Rockets by Vinzenz von Augustin

The military rockets developed by Artillery General *Vinzenz von Augustin* (1780-1859), who commanded the Austrian rocket corps from 1814 to 1838, played an important role in Austria’s armed forces in the

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- 2 B.P. Besser, Contributions of Austrian Pioneers to Early European Rocketry, *AIAA Technical Paper 2001-0174*, 9 p., 2001 (short form: Besser, Contributions), pp. 6-7; D. Todericiu, Raketentechnik im 16. Jahrhundert – Bemerkungen zu einer in Sibiu (Hermannstadt) vorhandenen Handschrift des Conrad Haas, *Technikgeschichte*, **34** (02), pp. 97-114, 1967; H. Barth, *Conrad Haas – Leben und Werk in Wort und Bild*, Kriterium Verlag, Bucharest, 104 p., 1983.
 - 3 D. Andrew, “Johannes Kepler 1571-1630”, *Phys. Edu.*, **4** (03), pp. 160-161, 1969; Berthold Sutter, *Johannes Kepler und Graz*, Leykam Verlag, Graz, 459 p., 1975; Karl Sigmund, “Kepler in Eferding”, *Internat. Math. Nachrichten*, **187**, pp. 41-48, 2001.s
 - 4 W. Schröder, *Das Phänomen des Polarlichts. Geschichtsschreibung, Forschungsergebnisse und Probleme*, Wissenschaftliche Buchgesellschaft., Darmstadt, 156 p., 1984, esp. pp. 43, 44, 57 (short form: Schröder, Polarlicht); József Vero, “Maximilian Hell: An auroral study in the 18th century”, *Acta Geodaet. Geoph. Hung.*, **32** (01-02), pp. 235-243, 1997; Konradin Ferrari d’Occhieppo, “Maximilian Hell und Placidus Fixlmiller. Die Begründer der neueren Astronomie in Österreich”, in: *Österreichische Naturforscher, Ärzte und Techniker*, Fritz Knoll (Hrsg.), Verlag der Gesellschaft für Natur und Technik, Wien, 238 p., 1957, pp. 27-31.

19th Century.⁵ The rockets were manufactured in a plant near Wiener Neustadt, and the Augustin war rockets made Austria one of the leading rocket powers in Europe until the abolition of Austria's rocket forces in 1867.

First International Polar Year (1882-1884)

The Austrian-Hungarian North Pole Expedition to the Arctic took place in 1872-1874 under the leadership of *Karl Weyprecht* (1838-1881) and *Julius von Payer* (1841-1915), who had participated previously in the Second German Expedition to the North Pole in 1869-1870. The expedition was made possible through the generous financial support of Count *Johann Nepomuk ("Hanns") Wilczek* (1837-1922). Not only was "Franz-Josef-Land" discovered but several scientific investigations, among them magnetic and northern lights observations, were conducted as well.⁶ Shortly afterwards Karl Weyprecht submitted a proposal to international authorities to organise an "International Polar Year".⁷

In the First International Polar Year (1882-1884) eleven nations sent fourteen expeditions to make special observations, twelve in the northern and two in the southern hemisphere. Austria established a station on Jan Mayen Island east of Greenland and the results were published with financial support from the *Imperial Academy of Sciences, Vienna*.⁸

Discovery of Cosmic Radiation by Viktor Franz Hess

Viktor Franz Hess (recte *Heß*) (1883-1964), born in Deutsch-Feistritz near Graz, studied physics at the University of Graz in 1901-1905, where he finished his doctorate *sub auspiciis Imperatoris* in 1906. He went to Vienna to work at the Institute of Physics, University of Vienna, where he was introduced to the fields of radioactivity and atmospheric electricity by *Franz Serafin Exner* (1849-1926).⁹ In 1910 he started to work at the newly established "Radium Research Institute" (Institut für Radiumforschung) of the *Academy of Sciences*.

During ten balloon ascents, which reached heights up to 1.8 km, made in the period 1911-1913 and almost all of them in Vienna, he registered an increase of ionisation (at 1.5 km the ionisation had the same level as on the ground). From this he concluded that there must be a so far unknown, extremely penetrating radiation, which mainly originates from above and is probably of extraterrestrial origin. He published his finding in six scientific papers and in 1920 he was appointed senior lecturer at the Institute of Physics, University of Graz. Soon afterwards he moved to the United States, where he spent two years working at the US Radium

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- 5 F.H. Winter, Baron Vinzenz von Augustin and his Raketenbatterien: A history of Austrian rocketry in the 19th Century, in: *Essays on the History of Rocketry and Astronautics: Proceedings of the Third through Sixth History Symposium of the International Academy of Astronautics*, R. Cargill Hall (Ed.), NASA Conference Publication 2014, NASA, Washington, D.C., Vol. I, 238 p., 1977, pp. 23-41; F.H. Winter, *The First Golden Age of Rocketry: Congreve and Hale Rockets of the Nineteenth Century*, Smithsonian Institution Press, Washington, D.C., 321 p., 1990, pp. 86-93; W. Nemetz, Die Kriegeraketen im österreichischen Heere, *Mitteilungen Österreichisches Staatsarchiv*, **10**, pp. 257-274, 1957; E. Gabriel, Die österreichische Raketenwaffe im 19. Jahrhundert, *Waffen-Revue*, **8**, pp. 1229-1247, 1973; Hans-Dierk Fricke, *Geschichte der Kriegeraketen und der Raketenartillerie im 19. Jahrhundert*, Bernhard & Graefe Verlag, Bonn, 480 p., 2001, pp. 130-185.
 - 6 G. von Arthaber, Österreichs Anteil an der Polarforschung, *Mitteilungen der Geographischen Gesellschaft, Wien*, **77**, pp. 5-16, 1934; R. Meister, *Geschichte der Akademie der Wissenschaften in Wien 1847-1947*, Verlag Adolf Holzhausens Nfg., Wien, 411 p., 1947, esp. p. 97 (short form: Meister, Geschichte); *Die Österreichische Akademie der Wissenschaften*, brochure, Österreichische Akademie der Wissenschaften (Hrsg.), Wien, 12 p., 1990, esp. pp. 3, 8; the short form **ÖAW** for "**Österreichische Akademie der Wissenschaften**" will be used in the following text; Schröder, *Polarlicht*, *op. cit.*, pp. 97-100.
 - 7 F.W.G. Baker, Auroral studies in the International Polar Years, *Ann. Geophys.*, **1** (04-05), pp. 383-386, 1983.
 - 8 "Kaiserliche Akademie der Wissenschaften Wien"; the name had been changed to "Österreichische Akademie der Wissenschaften" in 1919; Meister, *Geschichte*, *op. cit.*, pp. 120-121; *Die internationale Polarforschung 1882/83. Die Österreichische Polarstation Jan Mayen ausgerüstet durch seine Excellenz Graf Hanns Wilczek, geleitet von k.k. Corvetten-Capitän Emil Edlen von Wohlgemuth. Beobachtungs-Ergebnisse*, 3 vol., Kaiserliche Akademie der Wissenschaften Wien, Wien, 1886.
 - 9 B. Karlik and E. Schmid, *Franz S. Exner und sein Kreis. Ein Beitrag zur Geschichte der Physik in Österreich*, Verlag der ÖAW, Wien, 168 p., 1982.

Corporation, Orange, NY. In 1922 he returned to Graz and was appointed full professor in 1925. In 1931 he was appointed full professor at Innsbruck University and moved there, because he was able to establish a research laboratory at Hafelekar (2300 m above sea level; accessible by cable railway). Two years later, in 1933, he was elected corresponding member of the Austrian Academy of Sciences and in 1936 he shared the Nobel Prize for physics with *Carl D. Anderson* for his discovery of cosmic radiation. In 1937 he was again appointed full professor in Graz as successor to *Hans Benndorf* (1870-1953),¹⁰ moved there, but in spring 1938, due to Austria's forced annexation by Hitler's Germany, he was dismissed from his professorship. He emigrated to the United States, to become professor of physics at Fordham University in New York. He retired with emeritus status in 1956 and died near New York in 1964.¹¹

Period between First World War and 1938

Around 1919 *Franz Ulinski* (1890-1974) proposed a spacecraft propelled by a jet of electrons and published his ideas in a Viennese journal of aeronautics.¹² Two types of energy supply were proposed, one using solar panels for energy generation, the other exploiting disintegration of atoms. His propulsion scheme suffered from some serious problems (spacecraft charging; not useful in strong gravitational fields, etc.) and was out of reach for the technological state of the art at the time. Therefore his ideas were not taken seriously by his contemporaries and fell into oblivion.¹³

In 1923 *Hermann Oberth* (1894-1989)¹⁴ published his ground-breaking booklet "The Rocket into Planetary Space"¹⁵ which initiated large activity in rocketry, especially in Europe. He proved that it is in principle possible to leave the Earth's gravitational field using rockets.¹⁶

He soon found followers for his ideas. One important exponent was *Max Valier* (1895-1930), who started writing about and experimenting with rockets. His most spectacular appearance was at a rocket car demonstration at the AVUS racetrack in Berlin, Germany, in 1928, where the German car factory owner *Fritz von Opel* (1899-1971) piloted a rocket car designed by *Valier*. Another enthusiast was *Franz von Hoeffft* (1882-1954), who in 1926 founded the first space-related society in Western Europe, the *Scientific Society for High Altitude Research* (Wissenschaftliche Gesellschaft für Höhenforschung) in Vienna. Other important Austrians in the rocketry circle were *Guido von Pirquet* (1880-1966), *Hermann Potocnik* (1892-1929), *Friedrich Schmiedl* (1902-1994) and *Eugen Sänger* (1905-1964).¹⁷ *Guido von Pirquet* was a theoretician and his most important contributions were calculations of interplanetary trajectories to Venus and the outer planets. He found the so-called "cosmic paradoxon", declaring that for reaching other planets it is energetically more economic to use a space station in Earth orbit functioning as an intermediate transfer station than to the planets directly from Earth. *Hermann Potocnik's* name is connected with the detailed

10 H. Mache, *Hans Benndorf (Obituary)*, ÖAW Almanach 1953, **103**, pp. 449-465, 1954.

11 S.J. Bauer, "Viktor Franz Hess und die Erforschung der Kosmischen Strahlung: Vom Freiballon zur Weltraumsonde", in: Tradition und Herausforderung. 400 Jahre Universität Graz, Kurt Freisitzer (Hrsg.), Akademische Druck- und Verlagsanstalt, Graz, 737 p., 1985, pp. 319-324; "Victor Franz Hess 1883-1964", in: Robert L. Weber, *Pioneers of science, Nobel Prize winners in Physics*, Institute of Physics, Bristol, 272 p., 1980, pp. 104-105; Rudolf Steinmaurer, "Victor F. Hess, der Entdecker der kosmischen Strahlung, 80 Jahre alt", *Acta Phys. Austriaca*, **17** (02), pp. 111-120, 1963.

12 Besser, *Contributions*, op. cit., p. 6; B.P. Besser, "Guido von Pirquet & Franz A. Ulinski – zwei österreichische Raumfahrtpioniere", in: Tagungsband 4. Tag der Raumfahrtgeschichte, Hermann-Oberth-Raumfahrt-Museum (Hrsg.), Feucht/Nürnberg, pp. 1-4, 2000; Franz Abdon Ulinski, *Das Problem der Welt raumfahrt, Der Flug* (Wien), No. 6-12, pp. 113-124, 1920.

13 B.P. Besser, "Franz Ulinski, an almost forgotten early pioneer of rocketry", *International Academy of Astronautics Technical Paper IAC-02-IAA-2.1.04*, 5 p., 2002, esp. pp. 1-3.

14 H. Barth, *Hermann Oberth: Vater der Raumfahrt*, Bechtle Verlag, München, 407 p., 1991.

15 H. Oberth, *Die Rakete zu den Planetenräumen*, Oldenbourg Verlag, München, 92 p., 1923 (english translation: NASA TT F-9227, Washington, D.C., 1965).

16 H. Oberth was presented the honorary degree *Doctor technicae honoris causa* (short form: Dr. techn. h.c.) in 1985 by the Graz University of Technology in recognition of his ground-breaking ideas.

17 F. Sykora, "Pioniere der Raketentechnik aus Österreich", *Blätter für Technikgeschichte*, **22**, pp. 189-204, 1960; Besser, *Contributions*, op. cit., pp. 2-6; B.P. Besser, "Nine biographical summaries", in: *Austrian Space & Rocket Pioneers*, ESTEC Fine Arts Club (Ed.), brochure, 20 p., 1990; text available at the following homepages: www.asaspace.at/history.htm and www.flight100.org/history/aus.html.

design of a wheel-shaped space station described in his book “The Problem of Space Travel – the Rocket Motor” published in 1929 under his pen name “Noordung”. He also proposed to use it in its geostationary orbit as a relay station for communications.¹⁸ *Friedrich Schmiedl* performed a thorough test series and built solid fuel rockets of his own design. From 1931 onwards he launched several rockets for mail transportation between villages in the alpine regions of Austria. *Eugen Sänger* established a test-bed for rocket engines at the “Technische Hochschule Wien” (Technical College Vienna, now *Vienna University of Technology*) in 1932. He developed and experimented with different designs and structures of combustion chambers. *Eugen Sänger* was also the first academic professional to publish a book on rocketry, “Rocket Flight Engineering” in 1933.¹⁹ In 1936 he was appointed head of the development centre for jet engines in Trauen, Germany, for the German *Research Institution for Aviation* (Deutsche Versuchsanstalt für Luftfahrt). During World War II, together with his wife, *Irene Sänger-Bredt*, they drew up plans for a space plane, called “Silver Bird” (Silbervogel), which should take off and land horizontally.

The aforementioned *Scientific Society for High Altitude Research* was the first focus for space and rocket related discussions in Austria and *Franz von Hoeffft* was president, *Guido von Pirquet* secretary. The meetings took place irregularly either in *von Hoeffft*'s flat or at the Urania Observatory in Vienna. Among other members of the Committee were the geophysicist *Arthur Wagner* (1883-1942)²⁰, the mechanical engineer *Karl Wolf* (1886-1950)²¹ and the physicist *Gerhard Kirsch* (1890-1956)²². However, the aim of constructing rockets for large-scale experiments was not achieved and the group dissolved in 1930.²³

In 1924 *Alfred Wegener* (1880-1930) was appointed professor of Meteorology and Geophysics at the Institute of Physics, University of Graz. In addition to his interest in continental drift and polar research, he conducted several investigations concerning processes in the upper atmosphere, the northern lights, meteors and lunar cratering.²⁴

In recognition of Austria's leading role in the First International Polar Year, Austria was invited to participate in the Second International Polar Year (1932/33). In spite of the financial crisis at the time, the Austrian government provided the required financial resources for three scientists to take part in an expedition, again to Jan Mayen Island to stay there for one year. The main task was to make magnetic measurements and investigations of the aurora.²⁵

The Austrian industrialist *Hugo Hückel* partially financed the rocket experiments of the German *Johannes Winkler* (1897-1947), which culminated in the launch of the first Western European liquid fuel rocket at a parade ground near Dessau, Germany, on 14 March 1931.²⁶

In April 1931 the *Austrian Society for Rocket Engineering* (Österreichische Gesellschaft für Raketentechnik) was founded in Vienna,²⁷ with *Friedrich Krauss*, president of the *Austrian Federation of Inventors*

18 H. Noordung, *Das Problem der Befahrung des Weltraums – der Raketenmotor*, Verlag Richard Carl Schmidt & Co., Berlin, 188 p., 1929 (English translation: NASA SP-4026, Washington, D.C., 1995).

19 E. Sänger, *Raketenflugtechnik*, Oldenbourg Verlag, München, 222 p., 1933 (English translation: NASA TT F-223, Washington, D.C., 1965).

20 H. von Ficker, Arthur Wagner (Obituary), *ÖAW Almanach 1942*, **92**, pp. 210-216, 1943.

21 E. Melan, Karl Wolf (Obituary), *ÖAW Almanach 1950*, **100**, pp. 378-381, 1951.

22 G. Stetter, Gerhard Kirsch (Obituary), *ÖAW Almanach 1956*, **106**, pp. 388-396, 1957.

23 F.H. Winter, *Prelude to the Space Age. The Rocket Societies: 1924-1940*, Smithsonian Institution Press, Washington, D.C., 222 p., 1983, esp. pp. 30-33.

24 W. Kertz, “Alfred Wegener - Reformator der Geowissenschaften”, *Phys. Blätter*, **36** (12), pp. 347-353, 1980; K. Strobach, Zur Geschichte der Geophysik. Alfred Wegener zum 100. Geburtstag, *Naturwissenschaften*, **67** (07), pp. 321-331, 1980; W. Schröder, “Alfred Wegener and the physics of geophysical phenomena in the upper atmosphere”, *Acta Geodaet. Geoph. Hung.*, **35** (01), pp. 87-93, 2000.

25 Meister, Geschichte, *op. cit.*, pp. 177-178; “Vortrag des Leiters der Expedition Dr. Hans Tollner”, *Mitteilungen der Geographischen Gesellschaft, Wien*, **77**, pp. 19-35, 1934.

26 M. Sharpe, “Johannes Winkler: Early investigator in liquid propellants (1897-1947)”, in: *The eagle has returned*, (second part), Ernest A. Steinhoff (Ed.), Science and Technology Series, Vol. 45, American Astronautical Society, Alamo gordo, New Mexico, 440 p., 1977, pp. 255-261, esp. p. 257; Hans und Botho von Römer, Die Flüssigkeitsraketen des Ingenieurs Johannes Winkler, Flugkörper, **2** (09), pp. 292-293, 1960, esp. p. 293.

27 F. Krauss, Die österreichische Gesellschaft für Raketentechnik, *Mitteilungen des Österreichischen Erfinder-Verbandes*, **4** (02), p. 1, Juni 1931.

(Österreichischer Erfinder-Verband), *Hans Pittner*, president of the *Austrian Aeronautical Engineering Association* (Österreichischer Flugtechnischer Verein) and *Guido von Pirquet* as founding members. Also among the members of the board were *Rudolf Zwerina*, *Hermann Stolfa*, and *Franz Kuba*. Members of the group conducted numerous experiments with solid booster rockets for different applications, like meteorological, hail weather²⁸ and signal rockets²⁹ until 1934, when the political situation led to expressed orders forbidding any private possession and use of explosive substances.³⁰ Even the well-known theoretical physicist *Hans Thirring* (1888-1976)³¹ was asked to take part in the discussion about the possibility vs. impossibility of space flight. He expressed his views at a public talk in 1934 and in a subsequent book article.³² He concluded with: “... *but the current generation will not live to see the flight into space*”.³³

In the early period of rocketry between 1918 and 1934, Austrian scientists and engineers contributed many ideas to the concepts of space travel, but could only realise little in Austria, due to the economic crisis in the 1920s and 1930s. Fortunately, several contemporaries and followers were able to implement a number of these ideas and concepts in the international efforts to reach and explore space. One can easily trace back important parts of today’s space applications to the first blueprints, drawings and sketches of these pioneers.

From 1938 to the End of the Second World War

The forced annexation of Austria by Hitler’s Germany that eradicated the country from the map of Europe and stripped it of its independence, goes a long way towards explaining why sources about activities in rocketry and space research, which were immediately subjected to German control for this unfortunate period, are rather scarce. Furthermore Austria’s scientific community suffered heavily from politically and racially motivated purges that also forced tens of thousands of Austrians into emigration, amongst them some of the best talents active in space-related fields, whose work, however, continued abroad both during and after the war.³⁴ A mixed fate was also met by specialists remaining behind. Some, such as *Friedrich Schmiedl*, refused to be drawn into the German war effort and he “*destroyed nearly all his research notes and photographs of rocket launches and proceedings, for fear they might be used by the military*”.³⁵ Some of the others were already too old to be forced to serve in the German army, although a limited number of specialists served in various capacities in fields related to military rocket development, among them *Eugen Sänger*, his fellow student *Helmut von Zborowski* (1905-1969),³⁶ *Franz Ulinski* and *Hermann Oberth*. *Helmut von Zborowski* moved to Munich, Germany, in 1934 to work at the “*Bayrische Motoren Werke* (BMW)” plant for aircraft engines. Later he joined *Eugen Sänger* in Trauen and after getting acquainted with the technology of liquid rocket engines, he again worked for the BMW flight engine company till the end of the war, finally as head of the research institute.³⁷

Franz Ulinski worked at the “*Siebel-Flugzeugwerke AG*” (Siebel Aircraft Company) in Halle/Saale, Germany, first as a test engineer at the aircraft production plant, later as design engineer for rocket propelled

28 R. Zwerina, Nächste Anwendungsgebiete des Raketenprinzips, *Der Flug* (Wien), 5 (11/12), pp. 6-7, 1931 + 6 (01), pp. 9-10, 1932 + 6 (02), pp. 6-7, 1932.

29 E. Doleza L, Vom Feuerwerk zum Weltraumschiff, *Frohes Schaffen*, 10, pp. 71-80, 1933.

30 B.P. Besser, “Pioneers from other German speaking countries - Austria”, *International Academy of Astronautics Technical Paper IAC-03-IAA-2.4.b.02*, 6 p., 2003.

31 B. Kromp and Gabriele Kerber, “Hans Thirring (1888-1976) – ein Leben für Physik und Frieden”, in: *Heimat großer Söhne... Exemplarische Leistungen österreichischer Naturforscher, Techniker und Mediziner*, Helmut Grössing und Gerhard Heindl (Hrsg.), Verlag Peter Lang, Frankfurt am Main, 274 p., 1997, pp. 151-167.

32 H. Thirring, “Kann man in den Weltraum fliegen?”, in: *Alte Probleme – Neue Lösungen in den exakten Wissenschaften*, Franz Deuticke Verlag, Leipzig und Wien, 118 p., 1934, pp. 29-55.

33 *ibid.*, p. 54.

34 e.g., Viktor Franz Hess, Hermann Bondi, Thomas Gold, Fred Singer, Erwin Schmerling, George Low, Paul Winternitz, etc.

35 F. Schmiedl, “Early postal rockets in Austria: A memoir”, in: *Essays on the History of Rocketry and Astronautics: Proceedings of the Third through Sixth History Symposium of the International Academy of Astronautics*, R. Cargill Hall (Ed.), NASA CP-2014, NASA, Washington, D.C., Vol. II, 460 p., 1977, pp. 107-112, esp. p. 112.

36 R. Engel and K. von Gersdorff, “Helmut Graf von Zborowski”, in: *DGLR-Kurzbiographien aus der Luft- und Raumfahrt*, supplement to *Luft- und Raumfahrt*, 04/83, 2 p., 1983.

37 H. Zborowski, “BMW-Developments”, in: *History of German guided missiles development*, Theodor Benecke and August W. Quick (Eds.), Verlag E. Appelhans & Co., Brunswick, Germany, pp. 297-324, 1957.

aircraft prototypes. *Hermann Oberth* on the other hand was first invited in 1938 to work on a research assignment at the “Technische Hochschule Wien”, where he installed a rocket test bed in Felixdorf near Vienna. In 1940 he was transferred to the “Technische Hochschule Dresden” to solve certain problems of the turbo pump, which were destined for the “V2” (“Vergeltungswaffe”, vengeance weapon)³⁸. But when *Hermann Oberth* found out that the turbo pump had already been realised by the engineers working in Peenemünde, he was very disappointed and wanted to leave for his home in Transylvania. But as bearer of official secrets he was no longer allowed to leave the country and was recruited for the research institute at Peenemünde, led by General *Walter Dornberger* (1895-1980).³⁹ One of *Oberth*’s former students during his Berlin years, *Wernher von Braun* (1912-1977),⁴⁰ was its technical director.⁴¹

A number of other Austrians may have been working, perhaps not all of them voluntarily, at rocket research institutes and aircraft plants in Germany during the war but no systematic research on their fate has been conducted up to now. But the country that had also lost its name and was now known as “Ostmark” or “Alpen- und Donau-Reichsgaue”⁴² attracted increasing German interest as an alternative location for military industries as the war continued and as Allied air raids on weapons production facilities in Germany proper became more and more effective. Thus, at the end of March 1943, the “Rax-Werke”, a locomotive and railcar factory in Wiener Neustadt, was proposed as the third site besides Peenemünde and Friedrichshafen to produce the A4 (V2) rockets,⁴³ although this idea was not implemented until the end of the war. From 1943 forced labour held at some of the most infamous concentration camps was also used to excavate an underground site for a rocket development facility in Austria. In late October 1943 Nazi authorities approved the complete removal of guided missile development from Peenemünde to the “Zement” tunnels in Ebensee, where they also ordered the building of a subsidiary of the infamous Mauthausen concentration camp in which thousands of unfortunate prisoners, subjected to heavy labour under inhuman conditions later lost their lives.⁴⁴ An additional rocket test centre of the German Navy was installed and run at Toplitzsee, Styria, from 1944 to 1945.⁴⁵ Only sparse information (scattered in incoherent publications) is available about the participation, as ancillary industries, of Austrian industrial undertakings or plants in the German rocket developments.⁴⁶

After the Second World War to the End of the Occupation (1945 to 1955)

Due to the difficult economic situation after the war⁴⁷ and partly due to the occupation and division of the Austrian territory among the four Allies⁴⁸, everyday life could only “normalise” gradually by 1947.

38 another name used for the “V2” was “A4” (“Aggregat 4”)

39 W. Dornberger, V-2, Viking, New York, 281 p., 1954; Jürgen Lange, “Walter Dornberger – Zum 100. Geburtstag”, Luft- und Raumfahrt, 04/95, pp. 30-31, 1995.

40 E. Stuhlinger and F.I. Ordway, Wernher von Braun. Aufbruch in den Weltraum. Die Biographie, Bechtle Verlag, Esslingen, 509 p., 1992; Ernst Stuhlinger and Frederick I. Ordway III, Wernher von Braun: Crusader for space. An illustrated memoir, Krieger Publ., Malabar, FL, 168 p., 1995 and Wernher von Braun: Crusader for space. A biographical memoir, Krieger Publ., Malabar, FL, 392 p., 1994; Johannes Weyer, Wernher von Braun, Rowohlt Taschenbuch Verlag, Reinbek bei Hamburg, 1999; 2nd printing, RoRoRo Monographie, 160 p., 2000.

41 M.J. Neufeld, The rocket and the Reich. Peenemünde and the coming of the ballistic missile era, The Free Press, New York, 368 p., 1995 (short form: Neufeld, Rocket); Dennis Pizskiewicz, The Nazi rocketeers: Dreams of space and crimes of war, Praeger Publishers, Westport, CT, 266 p., 1995.

42 name of Austrian territory during the annexation.

43 Neufeld, Rocket, *op. cit.*, p. 174.

44 *ibid.*, pp. 204-207; Florian Freund, Arbeitslager Zement: Das Konzentrationslager Ebensee und die Raketenrüstung, Reihe: Industrie, Zwangsarbeit und Konzentrationslager in Österreich, Bd. 2, Verlag für Gesellschaftskritik, Wien, 486 p., 1989.

45 E. Baumann, Die Raketenversuchsstation Toplitzsee 1944-1945, Marine-Rundschau, **85** (05), pp. 300-302, 1988.

46 S. Karner, *Kärntens Wirtschaft 1938-1945. Unter besonderer Berücksichtigung der Rüstungsindustrie*, Phil. Diss., Klagenfurt, 1976, and “Wissenschaftliche Veröffentlichungen der Landeshauptstadt Klagenfurt”, Bd. 2, Klagenfurt, 384 p., 1976.

47 F. Weber, Österreichs Wirtschaft in der Rekonstruktionsperiode nach 1945, *Zeitgeschichte*, **14**, pp. 267-298, 1986/87, esp. pp. 270-282.

48 M. Rauchensteiner, *Der Sonderfall. Die Besatzungszeit in Österreich 1945 bis 1955*, Heeresgeschichtliches Museum / Militärwissenschaftliches Institut, Wien (Hrsg.), Styria-Reprint, Graz, 416 p., 1995.

The first professional activities in a space related field after the war started in the Institute of Meteorology and Geophysics, University of Graz. *Otto Burkard*, a disciple of *Hans Benndorf* (1870-1953)⁴⁹, who was working during the war at a geomagnetic observation station at Tromsø, Norway, built an ionosonde to measure the electron density profiles of the electrically conductive upper layers of the atmosphere. The supply of electronic components of the equipment was organised through the British forces. In 1947 *Otto Burkard* became provisional head of the Institute of Meteorology and Geophysics, University of Graz and in 1949 he was finally appointed head.⁵⁰ In 1951 the ionospheric observatory in Graz was fully automated (responsible scientist: *Valentin Mostetschnig*) to provide hourly measurements and in 1955 the equipment was updated to take part in the International Geophysical Year. (IGY, July 1957 to December 1958) measurement campaign.⁵¹

Ferdinand Cap, then working as an assistant professor at the University of Vienna, tried to file a patent in 1947 on the utilisation of nuclear fission energy for rocket propulsion, which was suppressed by the Allied Forces.⁵² In 1948 an anthology of rocket and space related articles was published in Vienna. Among the contributors were *Guido von Pirquet*, *Friedrich Schmiedl*, *Erich Dolezal* (1902-1990) and *Ferdinand Cap*.⁵³

Ferdinand Cap,⁵⁴ after taking a position as assistant professor at the Institute of Theoretical Physics at the University Innsbruck, gathered some colleagues (*Hans Joachim Rückert*⁵⁵, *Karl Wolfgang Scheiber*⁵⁶) and founded the Austrian Society for Space Research⁵⁷ at the end of 1949. *Ferdinand Cap* was elected president, *Hans Joachim Rückert* vice president, and they together with *Friedrich Schmiedl* represented the society at the 1st International Astronautical Congress (IAC) held in Paris in autumn 1950.⁵⁸ Additional branches of the society were established in Vienna, Graz and Linz. The society was aimed at the consolidation of all scientists, engineers, economists and laymen interested in practical astronomy, space flight and related sciences. The first common project was to work out different ideas in the subject area “space stations”, as agreed on at the Paris meeting.⁵⁹ The society was active in publishing several popular articles about space related subjects in the Austrian journal “Natur und Technik” (Nature and Technology) during the following years. Shortly afterwards *Friedrich Hecht* (1903-1980),⁶⁰ an analytical chemist at the University of Vienna, joined the board of directors. He was specifically interested in chemical problems related to space research,⁶¹ and his expertise was in radiochemical analysis techniques. He was founder and a vital member of the “Viennese school of meteorite and cosmic research”, which was the first group in Austria to investigate moon samples in the beginning of the 1970s.

49 H. Mache, Hans Benndorf (Obituary), *ÖAW Almanach 1953*, **103**, pp. 449-465, 1954.

50 O.M. Burkard, Aus der Werkstatt des Forschers, *Österreichische Hochschulzeitung*, **15** (17), p. 3, 1963.

51 O.M. Burkard, Die Ionosphärenstation an der Universität Graz, *Mitteilungen des Naturwissenschaftlichen Vereins für Steiermark*, **86**, pp. 22-25, 1956; Valentin Mostetschnig, “Die Ionosonde an der Universität Graz – Technische Veränderungen seit ihrer Entwicklung vor etwa 30 Jahren”, in: *Gratulationsschrift anlässlich des 70. Geburtstages von o. Univ.-Prof. Dr. O. Burkard*, Institut für Meteorologie und Geophysik der Universität Graz (Hrsg.), Graz, 1978, pp. 20-30.

52 F. Cap, *Österreichische Weltraumaktivitäten 1945-1989*, typewritten manuscript, 5 p., unpublished, not dated (ca. 1989), p. 1 (short form: CAP, Weltraumaktivitäten).

53 *Weltraumfahrt – Utopie?*, Gesellschaft für Natur und Technik (Hrsg.), Verlagsbuchhandlung Natur und Technik, Wien, 52 p., 1948.

54 for more information see: <http://th-physik.uibk.ac.at/plasma/personal/fc/fcresume.html> .

55 H.J. Rückert, worked during World War II at Peenemünde, and later for Messerschmitt GmbH, Kematen, Tyrol.

56 K.W. Scheiber, Austrian science fiction author, living in Tyrol.

57 Österreichische Gesellschaft für Weltraumforschung

58 *IAF. The First 50 Years. The Spirit of Astronautics*, Hervé Moulin (Editor), International Astronautical Federation, Paris, 191 p., 2001, p. 14-15 (short form: *IAF. The First 50 Years*); “Start in den Weltraum. Zum ersten internationalen astronautischen Kongreß”, *Natur und Technik*, **4**, pp. 295-298, 1950.

59 “Gründung der Österreichischen Gesellschaft für Weltraumforschung”, *Weltraumfahrt*, **1** (06), p. 149, 1950; CAP, *Weltraumaktivitäten*, *op. cit.*, p. 1.

60 H. Malissa, Friedrich Hecht (Obituary), *ÖAW Almanach 1982*, **132**, pp. 299-300, 1983.

61 F. Hecht, Chemische Probleme der Weltraumfluges, *Weltraumfahrt*, **3** (01), pp. 3-9, 1953.

3 Years of Preparation

After ten years of occupation by the victorious powers the Austrian State Treaty (Staatsvertrag) was signed by the signatory powers on 15 May 1955 and soon thereafter all foreign troops pulled out of Austria.⁶² The treaty in its Article 13 prohibited Austria from “possessing, constructing or experimenting with any self-propelled or guided missile or torpedoes, or apparatus connected with their discharge or control”. During the occupation period several talented, freshly graduated scientists and engineers took the opportunity given by the military forces of the occupying powers to emigrate and start a professional career outside Austria.⁶³

Austria and the International Astronautical Federation (IAF)

At the 1st IAC (International Astronautical Congress) in Paris the assembled delegates from the astronautical societies of seven countries tabled a six-point resolution to create an international astronautical organisation. *Eugen Sänger* was chairman of a Provisional Committee and the British Interplanetary Society (BIS) was made responsible for coordinating all further material related to the IAF concept.⁶⁴ At the 2nd IAC meeting, convened in September 1951 in London, heads of the delegations signed the agreement on the foundation of the International Astronautical Federation (IAF). But the draft constitution, prepared by the BIS incorporating the proposals agreed at Paris and in subsequent correspondence, was not adopted due to unresolved problems regarding proposed voting procedures. It was agreed for this to be re-submitted at the next Congress, which was to be an annual event in future, to be held in Stuttgart, Germany, in the autumn of 1952. Eugen Sänger was unanimously elected as its first president.

At the 3rd IAC meeting in Stuttgart the revised Constitution was adopted and *Eugen Sänger* was re-elected for a second term. At the 4th Congress in Zurich, Switzerland, a resolution was adopted that the IAF should publish a journal of astronautics. In addition, the decision was taken to hold the 5th Congress in Innsbruck, to be hosted by the Austrian Society for Space Research, being one of the IAF founding societies, and *Friedrich Hecht* was elected Vice President. At this 5th IAC, from 27 August 1954 at the University Innsbruck,⁶⁵ a resolution was implemented concerning an IAF journal and “*Astronautica Acta*”, the official journal of the IAF, was subsequently published for the first time. *Friedrich Hecht* was named Editor-in-Chief, a position he kept for several years.

Austria served again as host country for IAF Congresses, namely for the 23rd IAC from 15-18 October 1972 in Vienna, the 37th IAC from 4-11 October 1986 again in Innsbruck, and the 44th IAC from 16-22 October 1993 in Graz.⁶⁶ At the Congress 1986 in Innsbruck, *Johannes Ortner*, the managing director of the Austrian Space Agency (ASA), was elected President of the IAF for the term 1987 to 1988.⁶⁷

Austria and the International Geophysical Year (IGY)

After attaining full sovereignty Austria made steps to integrate herself into the international community. Already during the time of occupation Austria applied for membership of the United Nations, but was vetoed in the Security Council.⁶⁸ On 15 December 1955 Austria joined the United Nations.⁶⁹ Another important step

62 Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, the United States of America, France – Austria, State Treaty for the re-establishment of an independent and democratic Austria, *American Journal of International Law, Supplement*, **49**, pp. 162-194, 1955.

63 Private communication, Siegfried J. Bauer, 2001; to name only a few in space related sciences: Willi Nordberg, Siegfried J. Bauer, Friedrich Vonbun, Rudolf Stampfl, Rudolf Hanel, Heinrich Kosmal, Karl Kordes, etc.

64 *IAF. The First 50 Years, op. cit.*, p. 16; Leslie R. Shepherd, The International Astronautical Federation, *Acta Astronautica*, **32**, pp. 159-163, 1994.

65 *IAF. The First 50 Years, op. cit.*, p. 26-27.

66 *ibid.*, pp. 88-89, pp. 130-131, and pp. 152-153.

67 “Johannes Ortner, Austria, 1987-1988”, *ibid.*, p. 132-133, “Ortner Johannes”, in: *Who is Who in Österreich*, Who is Who, Verlag für Personenzyklopädien AG, Zug, Switzerland, 2001, p. 1302.

68 “Die Welt, Europa mitgestalten”, in: Portisch, Österreich II, pp. 24-26.

69 B. Kreisky, Österreich zehn Jahre Mitglied der Vereinten Nationen: Festrede, *Die Vereinten Nationen und Österreich*, **15** (01), pp. 5-6, 1966.

on the way to Austria's integration into the community of western European states, following several very difficult years⁷⁰, was its decision to join the Council of Europe. Austria signed the agreement relating to international law on 16 April 1956.⁷¹

The International Council of Scientific Unions (ICSU), in which Austria was represented by the Austrian Academy of Sciences (Österreichische Akademie der Wissenschaften) since 1949,⁷² followed a suggestion by the American National Academy of Sciences member *Lloyd Berkner* to propose in 1952 a comprehensive series of global geophysical observations for the period July 1957-December 1958,⁷³ which was declared to be the "International Geophysical Year (IGY)", following the "International Polar Years" of 1882-1883 and 1932-1933.⁷⁴ Already at its meeting on 8 May 1952 the "Section of Mathematical-Natural Sciences"⁷⁵ of the Austrian Academy of Sciences decided to join the existing Committees for Atmospheric Electricity (since 1901) and the Committee for Earthquakes (since 1895) to form a new Committee for Geophysics under the chairman *Karl Mader* (1890-1965).⁷⁶ Its duty was to prepare and realise the Austrian collaboration in and contributions to the IGY.⁷⁷ Among the members of the Committee were the meteorologists *Heinrich Ficker* (1881-1957),⁷⁸ *Ferdinand Steinhauser* (1905-1991),⁷⁹ and *Otto Burkard*. During 1953 and 1954 *Karl Mader* visited the ionospheric observatory in Graz several times, to arrange for the measurements to be conducted during the IGY. Just before the start of the IGY, on the occasion of the Annual Assembly of the Austrian Academy of Sciences in the middle of May 1957, the Secretary of the Mathematical-Natural Sciences Section, *Fritz Regler*, reported that the Austrian Federal Ministry for Education had allocated an increased share of its budget for the acquisition of equipment during the period 1955 to 1957.⁸⁰ The institutions involved in the measurements for the IGY were the "Central Institute for Meteorology and Geodynamics",⁸¹ Vienna, with stations all over Austria providing mainly meteorological and geophysical parameters, and several observers from the University of Innsbruck, mainly concerned with cosmic rays, the elevation of the astronomical pole and glaciological measurements. In addition to the ionospheric observatory in Graz, the solar observatory at Kanzelhöhe near Villach, the Austrian Hydrographical Service and the precision time service of the "Federal Office for Metrology and Surveying"⁸² took an active part in the campaign.⁸³

Austria and the United Nations

Austria acquired membership in the United Nations in December 1955 and,⁸⁴ favoured by its status as an European neutral soon became an active player in the organisation and its various bodies. Among the offices entrusted to its representatives was the chair of a new Committee on the Peaceful Uses of Outer Space (COPUOS) that was the successor of an earlier 18 member *ad hoc* committee of the same name established

70 F. Weiss, Die schwierige Balance. Österreich und die Anfänge der westeuropäischen Integration 1947-1957, *Vierteljahrshefte für Zeitgeschichte*, **42**, pp. 71-94, 1994.

71 *Österreich und der Europarat*, Republik Österreich (Hrsg.), Parlamentsdirektion, Wien, 47 p., 1975, esp. pp. 9-10.

72 "6. Delegationen", in: Ludmilla Krestan, *Die Mitglieder und Institutionen der Akademie*, ÖAW (Hrsg.), Böhlau Verlag, Wien, 222 p., 1972, pp. 147-152, (short form: Krestan, Mitglieder), esp. p. 151; *ÖAW Almanach 1949*, **99**, p. 137, 1950.

73 L.V. Berkner, The International Geophysical Year, *Proceedings of the IRE*, **47** (2), 133-136, 1959.

74 M.I Nicolet, Historical aspects of the IGY, *EOS (American Geophysical Union Transactions)*, **64**, pp. 369-370, 1983; James A. Van Allen, Genesis of the International Geophysical Year, *EOS (American Geophysical Union Transactions)*, **64**, p. 977, 1983.

75 Mathematisch-Naturwissenschaftliche Klasse, Österreichische Akademie der Wissenschaften.

76 K. Ledersteger, Karl Mader (Obituary), *ÖAW Almanach 1969*, **119**, pp. 300-303, 1970.

77 "Geophysikalische Kommission bei der Österr. Ak. d. Wiss.", *ÖAW Almanach 1953*, **103**, p. 148, 1954; Heinrich Ficker, Geophysikalische Kommission (Bericht), *ibid.*, pp. 286-287.

78 F. Steinhauser, Heinrich Ficker (Obituary), *ÖAW Almanach 1957*, **107**, pp. 390-402, 1958.

79 F. Weber, Ferdinand Steinhauser (Obituary), *ÖAW Almanach 1991/92*, **142**, pp. 353-373, 1993.

80 F. Regler, "Bericht des Sekretärs", *ÖAW Almanach 1955*, **107**, p. 232, 1958.

81 Zentralanstalt für Meteorologie und Geodynamik (ZAMG).

82 Bundesamt für Eich- und Vermessungswesen (BEV).

83 K. Mader, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1957*, **107**, pp. 318-322, 1958; Karl Mader, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1958*, **108**, pp. 326-332, 1959; Karl Mader, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1959*, **109**, pp. 332-338, 1960; "The geographical distribution of the IGY stations", *Annals of the International Geophysical Year*, **8**, pp. XIV-XVI and 1 ff., 1959.

84 K. Zemanek, Neutral Austria in the United Nations, *International Organisation*, **15**, pp. 408-422, 1961.

by General Assembly Resolution 1348 (XIII) 1958. In its permanent form it was authorised by General Assembly Resolution 1721 (XVI) 1961⁸⁵ which gave it a number of important responsibilities in the field of Outer Space, an area where rivalries between the two major space powers of the time, the USSR and the USA could already be felt. Helping the Committee to perform its role and contributing to find constructive solutions to many of the challenges faced by the international community in this field allowed Austria to keep this chairmanship for more than 35 years (1961-1996).⁸⁶ The longest serving chairman was *Peter Jankowitsch*, who held this post, which he first acquired as Permanent Representative to the UN in New York in 1972, for 19 years.

Austrian delegates coordinated work both in the Committee and its two Subcommittees for Legal and Scientific/Technical Affairs, helping to draft, *inter alia*, the annual resolutions of the General Assembly adopted to guide the work of the Committee and its sub-bodies. Austria also chaired for many years various informal groups of countries, such as the so-called group of “like minded countries” constituted to promote the work of the Committee.

Contributions of a particularly important kind were made by Austrian delegates to the formulation of the early space treaties. Examples include the 1963 treaty banning nuclear weapons tests in the atmosphere, in outer space and under water⁸⁷ and the 1967 treaty on principles governing the activities of states in the exploration and use of outer space. Much important work for the formulation of the test ban treaty was performed by a working group of the Scientific/Technical Subcommittee established in May 1963 in Geneva and chaired by the Austrian delegate, *Ferdinand Cap*. Similar work was performed by other Austrian legal and technical experts in formulating further treaties and sets of principles adopted by COPUOS over the years. In that respect *Peter Hohenfellner*, who later also chaired COPUOS, was successful in helping to achieve the adoption of a difficult set of principles concerning the use of nuclear power sources in space.

Austria was also instrumental, supported by many other COPUOS member countries, in bringing about UN General Assembly Resolutions that authorised the convening of three major conferences on the exploration and peaceful uses of Outer Space. As a tribute to the special role played by Austria in COPUOS all three conferences were held in Vienna in 1968, 1982 and most recently 1999.⁸⁸ The first two conferences were chaired by the then Foreign Ministers of Austria (*Kurt Waldheim*⁸⁹ and *Willibald Pahr*⁹⁰), UNISPACE III being an exception as it was called as a special session of the Committee held therefore under its current chair. All three conferences provided important new initiatives to the work of COPUOS, extending its scope of work and helping to provide benefits of space use and exploration to a growing number of nations, in particular developing countries. UNISPACE III adopted “The Space Millenium Vienna Declaration on Space and Human Development”.

While COPUOS usually met in New York and Geneva (Legal Subcommittee), meetings outside headquarters were first held in Vienna (1977 and 1984) and in Graz (1991).⁹¹ In 1993 the Secretary General of the United Nations moved the UN Office for Outer Space Affairs (UN-OOSA) from New York to Vienna, thus adding

85 “International Space Cooperation” in: *International Cooperation and Competition in Civilian Space Activities*, US Congress, Office of Technology Assessment, OTA-ISC-239, Washington, D.C., 1985, pp. 33-61, esp. pp. 45-46.

86 Dr. F. Matsch (1961 – 1965); Dr. Kurt Waldheim (1965 – 1968); Dr. Heinrich Haymerle (1968 – 1970); Dr. K. Waldheim (1970 – 1972); Dr. P. Jankowitsch (1972 – 1990); Dr. P. Hohenfellner (1990 – 1996).

87 CAP, Weltraumaktivitäten, *op. cit.*, p. 3; Bundesgesetzblatt 199/1964 (Federal Law Gazette, short form in German: BGBl.).

88 BGBl. 239/1968; “Die Eröffnung der Weltraumkonferenz”, *Die Vereinten Nationen und Österreich*, **17** (07/08), p. 20; Renato A. Urquiola, Die Konferenz der Vereinten Nationen über die Erforschung und friedliche Nutzung des Weltraums, *Die Vereinten Nationen und Österreich*, **17** (09/10), p. 15, 1968; “Zweite Konferenz der Vereinten Nationen über die Erforschung und friedliche Nutzung des Weltraums (UNISPACE 82)”, *Die Vereinten Nationen und Österreich*, **32** (01/02), p. 19, 1983; Christian Pinter, Sputnik zum Angreifen. Die Weltraumkonferenz UNISPACE landet in Wien. Mit einer interessanten Begleitausstellung, *Wiener Zeitung, Extra*, 16-17.07.1999, p. 13.

89 Kurt Waldheim was elected General Secretary of the UN for two terms (1971-1976, 1976-1981); for biographical details see <http://www.un.org/Overview/SG/sg4bio.html> and <http://www.aeiou.at/aeiou.encyclp.w/w098837.htm>.

90 <http://www.aeiou.at/aeiou.encyclp.p/p029141.htm>.

91 BGBl. 371/1977; BGBl. 354/1991.

an important element to a city that since 1979 had been made one of the permanent Headquarters of the United Nations next to New York and Geneva. According to UN rules all meetings of COPUOS and its two Subcommittees, now comprising 65 members⁹², have since been held in Vienna.

Different scientific symposia have been organised by the United Nations Office for Outer Space Affairs and ESA, hosted and co-sponsored by the Government of Austria, the State of Styria and the City of Graz, and held in Vienna and Graz in the 1990s.

Austria and Space Law

The earliest publications on space law date back to the early 1920s.⁹³ But it was not until 1932 that the world's first monograph on the entire field was published in Germany.⁹⁴ *Vladimir Mandl* (1899-1941) living in Plzen (Pilsen), Czechoslovakia, elaborated in the book on the law of outer space as an independent legal branch governed by principles from the law of the sea and the law of the air. In the second part of his book he opposed the then common idea of sovereignty in outer space.⁹⁵ For several reasons, mainly the absence of an appropriate translation, *Vladimir Mandl's* book was not well known to European lawyers before 1950. For a detailed historical survey on space law, the reader is referred to the comprehensive review on the subject.⁹⁶

In 1958 the IAF created a Permanent Committee on Space Law, which was replaced in 1960 by the International Institute of Space Law (IISL). The purposes and objectives of the IISL include the cooperation with international and national institutions to foster space law development and studies of legal and social science aspects of space exploration. Since 1958 IISL holds annual colloquia on space law. Austria is represented in the IISL Board of Directors by two Honorary Directors, *Peter Jankowitsch* and *Ernst Fasan*. *Fasan* also served as president of the Austrian Society for Space Research and was one of the first to promote space law activities in Austria during the 1960s.⁹⁷

The following five treaties have been adopted by the United Nations and Austria became party to them:

- 1 Treaty on principles governing the activities of states in the exploration and use of outer space, including the Moon and other celestial bodies [Resolution 2222 (XXI), entered into force 10 October 1967; 98 ratifications and 27 signatures (as of May, 2001)]⁹⁸
- 2 Agreement on the rescue of astronauts, the return of astronauts and the return of objects launched into outer space [Resolution 2345 (XXII), entered into force on 3 December 1968; 88 ratifications and 25 signatures (as of May, 2001)]⁹⁹
- 3 Convention on international liability for damage caused by space objects [Resolution 2777 (XXVI), entered into force on 1 September 1972; 82 ratifications and 25 signatures (as of May 2001)]¹⁰⁰
- 4 Convention on registration of objects launched into outer space [Resolution 3225 (XXIX), entered into force on September 15, 1976; 44 ratifications and 4 signatures (as of May 2001)]¹⁰¹

92 Information provided by UN Office for Outer Space Affairs, Vienna, October 2002.

93 S. Doyle, Original contributions to concepts of space law, *J. British Interplanetary Society*, 34, 337-347, 1981.

94 V. Mandl, *Das Weltraum-Recht: Ein Problem der Raumfahrt*, Verlag J. Bensheimer, Mannheim, 48 p., 1932.

95 V. Kopal, "Vladimir Mandl: Founding writer on space law", in: *First steps toward space, Proceedings of the first and second history symposium of the International Academy of Astronautics*, Frederick C. Durant III and George S. James (Eds.), Smithsonian Annals of Flight, No. 10, Smithsonian Institution Press, Washington, D.C., 307 p., 1974, pp. 87-90, esp. pp. 87-88.

96 S.E. Doyle, *Origins of international space law and the International Institute of Space Law of the International Astronautical Federation*, Univelt Inc., San Diego, CA, 135 p., 2002.

97 E. Fasan and F. Gross, Das Recht des Weltraumes, *Österreichische Juristen-Zeitung*, 16 (05), pp. 113-117, 1961; Ernst Fasan, *Weltraumrecht*, Krauskopf-Flugwelt-Verlag, Mainz, 234 p., 1964; Ernst Fasan, "Das Recht Österreichs", in: Marietta Benkő, *Handbuch des Weltraumrechts*, Karl-Heinz Böckstiegel (Hrsg.), Carl Heymanns Verlag, Köln, 893 p., 1991, pp. 851-860.

98 BGBl. 103/1968; field of validity: BGBl. 127/1973, 145/1986, 380/1989.

99 BGBl. 110/1970; field of validity: BGBl. 148/1971, 593/1973, 231/1976, 458/1983, 260/1986.

100 BGBl. 162/1980; field of validity: BGBl. 459/1983, 400/1989.

101 BGBl. 163/1980; field of validity: BGBl. 324/1985, 166/1994.

- 5 Agreement governing the activities of states on the Moon and other celestial bodies [Resolution 34/68, entered into force on 11 July 1984; 10 ratifications and 5 signatures (as of May 2001)]¹⁰²

In addition, the following five declarations have been adopted:

- 1 Declaration of legal principles governing the activities of states in the exploration and uses of outer space [General Assembly resolution 1962 (XVIII) of 13 December 1963]
- 2 Principles governing the use by states of artificial Earth satellites for international direct television broadcasting [General Assembly resolution 37/92 of 10 December 1982]
- 3 Principles relating to remote sensing of the Earth from outer space [General Assembly resolution 41/65) of 3 December 1986]
- 4 Principles relevant to the use of nuclear power sources in outer space [General Assembly resolution 47/68 of 14 December 1992]
- 5 Declaration on international cooperation in the exploration and use of outer space for the benefit and in the interest of all states, taking into particular account the needs of developing countries [General Assembly resolution 51/122 of 13 December 1996].

For a review of current issues on space law the reader is referred to an Austrian standard work on public international law¹⁰³ and a report on the possibilities of future space law developments in Austria.¹⁰⁴ The Institute of International Public Law and International Relations, University of Vienna (scientists involved: *Karl Zemanek*¹⁰⁵ and *Gerhard Hafner*) is one of the most active space law research groups in Austria. Following a suggestion of the European Centre for Space Law, Austria established a National Point of Contact (*Christian Brünner*,¹⁰⁶ University of Graz) in spring 2001, with sub-points at the University of Salzburg, the University of Vienna and the University of Economics, Vienna.¹⁰⁷

The Austrian government became party to several additional agreements to promote its space activities, including:

multi-national

- Convention to join the European Space Agency as an associate member on 1 April 1981 [BGBl. 242/1976, BGBl. 243/1976, BGBl. 257/1978]
- Agreement between the Republic of Austria and the European Space Agency concerning the accession of the Republic of Austria to the convention of the European Space Agency and related terms and conditions [effective 1 January 1987; BGBl. 95/1985].

bilateral

- Agreement between Austria and the Union of Socialist Soviet Republics about the common Austrian-Soviet spaceflight [effective March 1989; BGBl. 133/1988].

102 BGBl. 268/1984.

103 G. Hafner, "Räumliche Regime und Nutzungen über die und jenseits der Staatsgrenzen", in: *Österreichisches Handbuch des Völkerrechts*, Hanspeter Neuhold, Waldemar Hummer, Christoph Schreuer (Hrsg.), Manzsche Verlags- und Universitätsbuchhandlung, Wien, 564 p., 3. Aufl., 1997, pp. 358-405, esp. "4. Der Weltraum", pp. 399-405.

104 L. Summerer, *Vermittlung Österreichischer Expertise im Bereich Weltraumrecht*, unpublished manuscript, 74 p., March 2001; provided by the author, September 2002.

105 "Völkerrecht zwischen normativem Anspruch und politischer Realität. Festschrift für Karl Zemanek zum 65. Geburtstag", Konrad Ginther, Gerhard Hafner, Winfried Lang, Hanspeter Neuhold, Lilly Sucharipa-Behrmann (Hrsg.), Duncker & Humblot, Berlin, 504 p., 1994; Karl Zemanek, The United Nations and the Law of Outer Space, *Yearbook of World Affairs*, **19**, pp. 199-222, 1965.

106 W. Mantl, "Christian Brünner: Erneuerer der Verwaltungslehre in Österreich", in: *Hochschulrecht Hochschulmanagement Hochschulpolitik*, Gerhard Schnedl und Silvia Ulrich (Hrsg.), Böhlau Verlag, Wien, 258 p., 2003, pp. 17-27.

107 C. Brünner, Weltraumrecht in Österreich: ein Neustart, *Space Law Newsletter Austria*, Edition **1/2002**, p.1, 2002.

Austria and COPERS

Activities for the re-integration of Austria into international scientific organisations were started in 1955 and culminated in the membership of Austria in CERN¹⁰⁸ (European Organisation for Nuclear Research) effective 1 July 1959.¹⁰⁹

In early 1961 eleven European countries (Austria, Belgium, Germany, France, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom) teamed up to establish a Commission, abbreviated as COPERS,¹¹⁰ to found a European Space Research Organisation (ESRO). *Ferdinand Cap* and *Friedrich Hecht*, at the invitation of the British Ministry of Supply, London, took part in a preparatory conference held in Strasbourg, France.¹¹¹ *Ferdinand Cap* and *Franz Ceska* (Austrian Embassy in Paris) participated as Austrian delegates to COPERS.

Additionally, *Ferdinand Cap* served as chairman of a COPERS subcommittee on patent issues and economic aspects of spin-offs of space technology, and *Ferdinand Steinhauser* was nominated member of the subcommittee of meteorology.¹¹² In 1963 COPERS, following a proposal of *Ferdinand Cap*, organised a summer school on space research for graduate students in Alpbach, Tyrol.

In 1964 ESRO¹¹³ was created to develop space platforms (satellites and interplanetary probes), and ELDO (European Space Launcher Development Organisation)¹¹⁴ to develop a European launcher. Austria subsequently held only observer status in ESRO and did not join ELDO at all.¹¹⁵ The reason was that no agreement on Austria's financial contributions could be reached, while joining ELDO contravened Austria's State Treaty.

Some Austrians (among them *Johannes Ortner* and *Wolfgang Lothaller*) started their professional career within COPERS. Even though Austria did not attain full membership of ESRO, they continued their work within this European organisation. In the beginning of the 1970s they returned to Austria and worked for an organisational structure to support space activities in Austria.

Austria and COSPAR

After the launch of the first Earth satellite in 1957, the International Council of Scientific Unions (ICSU) established its Committee on Space Research (COSPAR) during an international meeting in 1958. COSPAR's objectives are to promote scientific research in space on an international level, with emphasis on the exchange of results, information and opinions, and to provide a forum, open to all scientists, for the discussion of problems that may affect scientific space research.¹¹⁶

COSPAR played an important role as a bridge between East and West for cooperation in space during its first years of existence. COSPAR has two kinds of members: National Scientific Institutions representing 42 countries and 12 International Scientific Unions (status 2002).

108 Centre Européen de la Recherche Nucléaire.

109 "Geschichte des österreichischen CERN-Beitrittes", in: *25 Jahre Experimentelle Hochenergiephysik in Österreich*, Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften (Hrsg.), Verlag Paul Sappl, Kufstein, 40 p., 1984, esp. p. 11.

110 Commission Préparatoire Européenne pour la Recherche Spatiale (European Preparatory Commission for Space Research).

111 private communication, Ferdinand Cap, April 2003.

112 F. Steinhauser, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1963*, **113**, p. 358, 1964.

113 H. Bondi and J. Ortner, ESRO and its programme, *Physics and Technology*, **1** (01), 2-8, 1969.

114 S.B. Johnson, A failure to communicate: The demise of ELDO, *History of Technology*, **22**, 1-23, 2000.

115 J. Krige and A. Russo (with the assistance of L. Sebesta), *Europe in Space 1960-1973*, N. Longdon and B. Battrick (Eds.), ESA SP-1172, European Space Agency, Noordwijk, 142 p., 1994, esp. p. 20, 27; John Krige and Arturo Russo, "Chapter 2: The early activities of the COPERS and setting up of ESRO", in: *A history of the European Space Agency 1958-1987, Vol. 1 - ESRO and ELDO, 1958-1973*, John Krige and Arturo Russo (with contributions by Michelangelo de Maria and Lorenza Sebesta), R.A. Harris (Ed.), ESA SP-1235, European Space Agency, Noordwijk, 462 p., 2000; esp. p. 66.

116 "COSPAR, Committee on Space Research", information brochure of COSPAR Headquarters, Paris, 8 p., 2002.

At the COSPAR General Assembly in Florence in 1961, Austria was invited to collaborate in space research by establishing an observatory for satellite tracking.¹¹⁷ The Geophysical Commission established a Sub-Commission for Space Research on 13 December 1962 to coordinate the work and serve as the Austrian National Committee of COSPAR. Austria joined COSPAR in 1963 and the Austrian Academy of Sciences was named the institutional member.¹¹⁸ This sub-commission was transformed into an independent Commission for Space Research on 10 October 1968.¹¹⁹

At the COSPAR Assembly in Mar del Plata, Argentina, in May 1965, an invitation was made to hold the 9th COSPAR General Assembly 1966 in Vienna, and COSPAR agreed to it.¹²⁰

The annual Academy public lecture series of 1966 was devoted to space research and served as preparation for the COSPAR Assembly.¹²¹ The 9th General Assembly took place in the conference facilities of the Hofburg from 10 to 19 May 1966. The Academy organised three public evening lectures, one about the US space program, one about the Soviet lunar research programme and the third as a discussion with the US and Soviet delegates to COSPAR.¹²²

COSPAR General Assemblies were again hosted in Austria in 1978 in Innsbruck (21st General Assembly), and 1984 in Graz (25th General Assembly).

Starting in 1988, COSPAR has awarded the “William Nordberg Medal”, named after Austrian born *Willi Nordberg* (1930-1976), a disciple of *Otto Burkard*, “father” of the system of Landsat remote sensing satellites,¹²³ to scientists who have made a distinguished contribution to the application of space science in a field covered by COSPAR.¹²⁴

Austrian Astronautical Society

In May 1962 the Austrian Astronautical Society¹²⁵ was established, emerging from a student group of enthusiasts interested in rocketry in existence since 1957. The main purpose of the Society was firstly to perform launches of solid fuel model rockets, and then to advance into a programme for liquid fuel rockets after 1963.¹²⁶ For this purpose the Society rented an air-raid shelter from the Austrian army at Sollenau proving ground in Felixdorf near Vienna. The ÖGFT organised annual assemblies with public lectures of invited national and international specialists. They also published a monthly newsletter to inform the members about ongoing activities. The Society was renamed in 1967, after the Austrian Society for Space Research had been dissolved.¹²⁷ Additionally, the Austrian Astronautical Society took the seat of the dissolved Society as member of International Astronautical Federation in 1967 till 1972.¹²⁸ The society was active in the dissemination of results of space research activities to the public, organised the 23rd IAF Congress 1972 in Vienna, but was dissolved at the end of 1972.

117 F. Steinhauser, Radiowissenschaftliche Kommission (Bericht), *ÖAW Almanach 1962*, **112**, p. 306, 1963.

118 “6. Delegationen”, in: *Krestan, Mitglieder, op. cit.*, esp. p. 147; Ferdinand Steinhauser, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1964*, **114**, pp. 227-229, 1965, esp. p. 228.

119 F. Steinhauser, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1963*, **113**, pp. 355-358, 1964, esp. p. 358.

120 F. Steinhauser, Geophysikalische Kommission (Bericht), *ÖAW Almanach 1966*, **116**, pp. 239-241, 1967, esp. p. 241.

121 “Öffentliche Vorträge der Akademie”, in: *Krestan, Mitglieder, op. cit.*, p. 201; “Öffentliche Vorträge”, *ÖAW Almanach 1966*, **116**, p. 410, 1967.

122 E. Schmid, “Eröffnungsansprache des Präsidenten”, *ÖAW Almanach 1966*, **116**, p. 122, 1967; “COSPAR-Tagung in Wien”, *ÖAW Almanach 1966*, **116**, pp. 412-413, 1967.

123 N.M. Short, Paul D. Lozman Jr., Stanley C. Freden, and William A. Finch Jr., *Mission to Earth: Landsat views the world*, NASA **SP-360**, Washington, D.C., 459 p., 1976, esp. p. III.

124 *40 Years of COSPAR*, G. Haerendel, S. Grzedzielski, G. Cavallo, B. Battrick (Eds.), ESA BR-135, Noordwijk, The Netherlands, 189 p., 1998, esp. p. 161.

125 Österreichische Gesellschaft für Flugkörpertechnik (ÖGFT) .

126 “ÖGFT 1964”, *ÖGFT Nachrichten*, 01/64, p. 1, 04.05.1964.

127 Österreichische Gesellschaft für Weltraumforschung und Flugkörpertechnik (ÖGFT).

128 “Die ÖGFT wurde Mitglied der Internationalen Astronautischen Föderation”, *ÖGFT Nachrichten*, 08/67, p. 3, Oktober 1967.

Scientific space related activities in the 1960s

Another consequence of the increased interest in radiophysical measurements triggered by the IGY was the foundation, on 13 February 1958, of the Radio Science Committee in the Academy of Sciences, to perform the duties related to URSI (Union Radio-Scientifique Internationale).¹²⁹ *Ferdinand Steinhauser* was appointed chairman, and *Otto Burkard*¹³⁰ and *Josef Fuchs* (1904-1989)¹³¹ served as Austrian delegates to the URSI General Assembly in 1960, where a survey of Austrian investigations in radio science was presented.¹³² In this connection it is important to mention that during a subsequent meeting of the Committee, when the delegates reported on the URSI General Assembly, “possibilities for participation of Austria in the area of space sciences” were discussed.¹³³

On 10 December 1987 the Academy dissolved the Radio Science Committee and established an Austrian National Committee for URSI.¹³⁴ As mentioned earlier, scientific activities related to outer space were mainly coordinated by the Sub-Commission for Space Research of the Geophysical Commission of the Austrian Academy of Sciences.

During the 1960s the following institutes were engaged in space related research:¹³⁵

- *Central Institute for Meteorology and Geodynamics* in Vienna: processing and use of weather satellite images for weather forecasting (*Ferdinand Steinhauser*).
- *Ionospheric Observatory of the Institute of Meteorology and Geophysics, University of Graz*: making ionogram measurements for ionospheric total electron content calculations (*Otto Burkard, Reinhart Leitinger*).
- *Institute of Astronomy, University of Vienna*: making measurements of absolute heights on the lunar surface (*Josef Hopmann* (1890-1975)).
- *Institute of Geodesy, Graz University of Technology*: performing theoretical-mathematical investigations of satellite networks and making optical observations of geodetic satellites (*Karl Rinner*).
- *Institute of Mechanical Engineering, Vienna University of Technology*: theoretical investigations of the factors influencing satellite orbits (*Heinz Parkus*).
- *Institute of Theoretical Physics, University of Innsbruck*: conducting numerical computations of satellite orbits using Lie series and investigation on plasma flow and plasma instabilities (*Ferdinand Cap*).
- *Institute of Analytical Chemistry, University of Vienna*: analysing meteorites with neutron activation and electron beam microscopy methods (*Friedrich Hecht, Wolfgang Kiesel*).
- *Institute of High-Frequency-Techniques, Vienna University of Technology*: satellite and wave propagation studies (*Herbert König, Kurt Richter, Willibald Riedler*).
- *Institute of Theoretical Physics, Graz University of Technology*: theoretical research in Very Low Frequency wave propagation in the ionosphere (*Ernst Ledinegg*).

129 K. Mader, Geophysikalische Kommission (Bericht), *ÖAW Almanach* 1958, **108**, p. 331, 1959; *ÖAW Almanach* 1959, **109**, p. 158 and p. 324, 1960.

130 O.M. Burkard, Aus der Werkstatt des Forschers, *Österreichische Hochschulzeitung*, **15** (17), p. 3, 1963.

131 Professor at the Institute of Astronomy, University of Innsbruck; Hermann Mucke, “Univ.-Prof. Dr. Josef Fuchs zum Gedenken”, *Sternbote*, **32**, 100-102, 1989.

132 F. Steinhauser, Radiowissenschaftliche Kommission (Bericht), *ÖAW Almanach* 1960, **110**, p. 300, 1961.

133 F. Steinhauser, Radiowissenschaftliche Kommission (Bericht), *ÖAW Almanach* 1961, **111**, pp. 322-323, 1962.

134 “Österreichisches Nationalkomitee für URSI”, *ÖAW Almanach* 1987/88, **138**, p. 256, 1988.

135 “Space Research Activities in Austria 1966/67”, presented to COSPAR by Ferdinand Steinhauser, 4 p., not dated (provided by the *Archive of the Austrian Academy of Sciences*, Vienna, file “Ferdinand Steinhauser”, folder “Diverses”); “Space Research Activities in Austria 1968/69”, presented to COSPAR by Ferdinand Steinhauser, 4 p., not dated (provided by the *Archive of the Austrian Academy of Sciences*, Vienna, file “math.-nat. Klasse, COSPAR”, folder “Nr. 6, Berichte über Space Activities in Austria 1968/69 u. 1973/74”).

In addition to the scientific activities, the efforts of the Soviet Union and the United States in their manned space programmes led to increased interest in space activities of the Austrian public. In preparation for the live television transmission of the Apollo 11 Moon landing on 20 July 1969, the Austrian Broadcasting Corporation (ORF, Österreichischer Rundfunk) invited Austrian experts to supervise the coverage. Among those there were *Ferdinand Cap*, *Herbert Pichler*, a medical doctor interested in space flight,¹³⁶ *Willibald Riedler* and *Michael Higatsberger*.¹³⁷ Reporters in charge were *Hugo Portisch* together with *Peter Nidetzky* and *Othmar Urban*.¹³⁸

136 H.J. Pichler, “Österreicher in der Weltraumwissenschaft”, in *Austria Externa. Unser zehntes Bundesland*, Notring-Jahrbuch, 242 p., 1968, pp. 192-197; Herbert J. PICHLER, *Die Mondlandung. Der Menschheit größtes Abenteuer*, Verlag Fritz Molden, Wien, 405 p., 1969.

137 “*Michael J. Higatsberger*”, *Classics of World Science*, Vol. 2, Stepan S. Moskaliuk (Ed.), Walter Thirring International Institute for Mathematical Physics, Astrophysics and Nuclear Investigations (TIMPANI), Kiev, Ukraine, 263 p., 1999; “Michael Higatsberger” at <http://www.aeiou.at/aeiou.encyclop.h/h570103.htm> .

138 “Der Flug zum Mond”, in: Hugo PORTISCH, *Österreich II. Jahre des Aufbruchs. Jahre des Umbruchs*, Verlag Kremayr & Scheriau, Wien, 448 p., 1996, (short form: PORTISCH, Österreich II), p. 325.

4 Active Years

Institute of Meteorology and Geophysics, University of Graz

As pointed out in previous chapters, *Otto Burkard*, after being appointed chair of the Institute in 1949, started to build up the ionospheric observatory, which started full automatic operation in 1951 and contributed successfully to the investigations undertaken during Austria's participation in the International Geophysical Year. The activities of the institute expanded during the 1960s to include ionogram measurements, and they used satellites for total electron contents calculations (*Valentin Mostetschnig*, *Reinhard Leitinger*). The first satellite beacon observations began in 1964.

Institute of Geodesy, Graz University of Technology

Karl Rinner (1912-1991)¹³⁹ was appointed full professor at the Graz University of Technology in 1959 after serving as director of the German Geodetic Research Institute, Munich. The launch of the first balloon-like satellites (ANNA, ECHO, PAGEOS) in the 1960s opened the first possibilities to bridge continental distances by photographic measurements of the satellites against the stellar background. In 1967 the first camera was installed at Graz-Lustbühel, being part of the first global network, which gave an accuracy of 5 m over a distance of 5000 km. This activity was the starting point of satellite geodesy in Graz, which later led to the establishment of the geodetic fundamental station Graz-Lustbühel, at present one of the most accurate worldwide.¹⁴⁰

In 1990 *Hans Sünnkel* was appointed successor as full professor to *Karl Rinner* at the Institute of Geodesy.

Institute of Communications and Wave Propagation, Graz University of Technology

On 1 September 1968, *Willibald Riedler* was appointed full professor at this newly established Institute (short: INW¹⁴¹) in Graz, after having served as a research scientist at the Geophysical Observatory in Kiruna, Sweden.¹⁴² *Willibald Riedler* held the position as head of the Institute until his retirement in 2000, when *Otto Koudelka* succeeded him as head of the institute. In 2002 *Otto Koudelka* was appointed professor at the Institute. When *Willibald Riedler* started work in Graz in March 1969, he was invited by the Norwegian Research Council to fly instruments on sounding rockets. The only condition was that the instruments had to be developed and tested before October 1969 and to provide the necessary instrumentation for the rocket trajectory determination. After the problems with financing of the travel for tests and the launch in Norway were settled, the first Austrian instrument on board a sounding rocket was launched on 26 November 1969 from Andenes on the island of Andøya near Tromsø, Norway. This was the first time that flight hardware developed in Austria flew into space. This also initiated several cooperative projects involving balloons and

139 H. Detter und N. Rozsenich, "Meeresgeodäsie und Erdgezeiten, Karl Rinner, der große Universalgeodät", in: *Aufbruch in die Internationalität, Exemplarische Forschungsleistungen in Österreich (1975-1985)*, H. Detter, R. Kneucker, P. Markl, H. Nowotny, N. Rozsenich, H. Tuppy (Hrsg.), Reinhard Schurawitzki (Redaktion), Edition S, Wien, 272 p., 1989, pp. 149-153 + 244; Helmut Moritz, Karl Rinner (Obituary), *ÖAW Almanach 1991/92*, **142**, pp. 345-352, 1993.

140 K. Rinner, Bericht über die bisherigen Arbeiten der Beobachtungsstation für geodätische Satelliten auf dem Lustbühel bei Graz, *Mitteilungen der geodätischen Institute der Technischen Hochschule in Graz*, **9**, pp. 43-95, 1971; "Geodesia Universalis. Festschrift Karl Rinner zum 70. Geburtstag", *Mitteilungen der geodätischen Institute der Technischen Hochschule in Graz*, **40**, 382 p., 1982.

141 Institut für Nachrichtentechnik und Wellenausbreitung (short: INW)

142 K. Friedrich, Willibald Riedler emeritiert – ein Rückblick auf das Leben und Wirken eines großen Österreicher, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 519-523, 2000, esp. p. 519; Helmut Detter und Norbert Rozsenich, "Sonden zur Erkundung des Weltraums - Produkte von Physik und Nachrichtentechnik. Willibald Riedler und die Arbeit am Institut für Nachrichtentechnik und Wellenausbreitung der Technischen Universität Graz", in: *Aufbruch in die Internationalität, Exemplarische Forschungsleistungen in Österreich (1975-1985)*, H. Detter, R. Kneucker, P. Markl, H. Nowotny, N. Rozsenich, H. Tuppy (Hrsg.), Reinhard Schurawitzki (Redaktion), Edition S, Wien, 272 p., 1989, pp. 154-160+242-243.

sounding rockets in the 1970s and 1980s (responsible scientist: *Martin Friedrich*).¹⁴³ The scientific activities of the institute during the subsequent years are described and spread out over the next several sections.

Space Research Institute, Austrian Academy of Sciences¹⁴⁴

The earliest source mentioning the idea of establishing a Space Research Institute in Austria was an article by *Otto Burkard* in a journal for Austrian Universities in 1962. After describing space research activities in Italy and Belgium, *Otto Burkard* came to the conclusion that it would be necessary and even possible for Austria to participate in space research activities. As the ultimate goal he described the establishment of a space research institute.¹⁴⁵

It was not until May 1968 that the Austrian Federal Ministry for Foreign Affairs established a committee to investigate the “requirements and possibilities of an Austrian participation in space flight activities” in view of the “World Space Congress” (later named UNISPACE) held in Vienna in August 1968. The committee was headed by *Klaus Oswatitsch* (1910-1993)¹⁴⁶ (professor at the Institute of Aero- and Hydrodynamics, Vienna University of Technology; chairman of the board of trustees of the Austrian Astronautical Society), the other members being *Erwin Plöckinger* (1922-1994)¹⁴⁷ (research director, Böhler Corporation) and *Heinrich Rasworschegg* (1903-1978)¹⁴⁸ (director, Waagner-Biro Corporation).

In autumn of 1968 the committee report was presented and the establishment of an *Austrian Institute of Space Flight* (Institut für Weltraumflug) was recommended but never realised, its main tasks being to:¹⁴⁹

- 1 serve as an international contact point by representing Austria in international organisations, and as a national contact point through the organisation of meetings, lectures and the supply of information material;
- 2 provide, administer and disseminate relevant technical and scientific literature;
- 3 offer advice to state and private authorities in all questions of space technology;
- 4 create prospective fields for industrial development through promotion of relevant research;
- 5 educate scientific and technological staff.

Almost simultaneously with the publication of this report, the Austrian Academy of Sciences transformed the existing Sub-Commission for Space Research into an independent Commission for Space Research with the former chairman, *Ferdinand Steinhauser*, remaining as chairman of the newly established commission.

In the spring of 1969 an “Advisory Commission for Space Research Related Questions” was established through a decision of the Council of Ministers, which discussed the report during its meetings in the autumn of 1969.¹⁵⁰

On 7 November 1969, the *Working Group for Space Research* (Arbeitsgemeinschaft für Weltraumforschung) was founded in Graz. Its aim was to coordinate all possibilities for participating in research projects on the subject.

143 K. Friedrich, “Willibald Riedler emeritiert – ein Rückblick auf das Leben und Wirken eines großen Österreicher”, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 519-523, 2000, esp. p. 520 (short form: Friedrich, E&I).

144 The short form *Space Research Institute* will be used hereafter.

145 O. Burkard, Weltraumforschung in Österreich?, *Österreichische Hochschulzeitung*, **14** (08), p. 5, 1962.

146 A.E. Kluwick, “Klaus Oswatitsch 1910-1993”, in: *Memorial Tributes, Volume 7*, National Academy of Engineering of the United States of America (Ed.), National Academy Press, Washington, D.C., 243 p., 1994, pp. 170-174.

147 F. Jeglitsch, Erwin Plöckinger (Obituary), *ÖAW Almanach 1994/95*, **145**, pp. 433-442, 1995.

148 K. Rabus, Heinrich Rasworschegg †, *Österreichische Ingenieur- und Architekten- Zeitschrift*, **123**, pp. 65-66, 1978.

149 Private communication, Otto Burkard, July 2002.

150 O. R., Grünes Licht für Weltraumforschung?, *ÖGFT Nachrichten*, 8 (04-07), pp. 3-4+10, 1971.

The founding members were:¹⁵¹

- *Willibald Riedler* (Institute of Communications and Wave Propagation, Graz University of Technology)
- *Otto Burkard* (Institute of Meteorology and Geophysics, University of Graz)
- *Karl Rinner* (Institute of Geodesy, Graz University of Technology)
- *Paul Gilli* (Institute of Steam Technology and Heat Engineering, Graz University of Technology)
- *Hans List* (1896-1996) (Institution of Combustion Engines, AVL Corporation, Graz)¹⁵²

In late 1969 *Willibald Riedler* met with *Kurt Waldheim*, the then Federal Minister of Foreign Affairs, former chairman of the UN Committee on the Peaceful Uses of Outer Space (COPUOS), who subsequently initiated a meeting between *Willibald Riedler* and *Alois Mock*, Federal Minister for Education, on the topic of future Austrian space related activities, which was instrumental in establishing the Space Research Institute of ÖAW.¹⁵³

At the end of March 1970 the Working Group submitted an “exposé” about the foundation of a Space Research Institute of the Austrian Academy of Sciences to *Erich Schmid*, then vice president of the Academy in Vienna. In the subsequent meeting of the Mathematical-Natural Sciences Section of the Academy, and in the subsequent plenary of the Academy on 24 April 1970, the Academy decided to recommend to the Federal Ministry for Education the foundation of a Space Research Institute associated with the Austrian Academy of Sciences. The institute should have its headquarters in Graz and two departments, one in Graz and one in Vienna.¹⁵⁴

After the establishment of the Federal Ministry for Science and Research in mid 1970, headed by *Hertha Firnberg* as Minister, the Austrian scientific scenario changed considerably.¹⁵⁵ Space research found a strong supporter in *Hertha Firnberg*.

In 1971 several meetings of the advisory committee took place at the newly founded ministry. The Academy appointed a “task force” (Proponentenkomitee) for the realisation of the Space Research Institute, discussing the working programme and the utilisation of the allocated funds with officials of the ministry. The following experts showed interest in conducting research within the institute: *Otto Burkard*, *Willibald Riedler* and *Karl Rinner* from Graz, *Herbert König* (1908-1985)¹⁵⁶ and *Roman Sexl* (1939-1986)¹⁵⁷ from Vienna, and *Ferdinand Cap* from Innsbruck. The Institute was to be directed by the task force.¹⁵⁸

In 1972 the Institute comprised the following experts:

- *Otto Burkard* (ionospheric research with satellites)
- *Ferdinand Cap* (plasma physics)
- *Friedrich Hecht* (meteorite research)
- *Herbert König* (optical communications)
- *Heinz Parkus* (1909-1982) (space mechanics)¹⁵⁹

151 K. Rinner, On the activity of the section geodesy at the Observatory Graz-Lustbühel, *Acta Geodaet. Geoph. Mont. Hung.*, **23** (01), pp. 27-43, 1988, esp. pp. 27-28; *Memorandum “Arbeitsgemeinschaft für Weltraumforschung”*, dated 07.11.1969; provided to the author by Willibald Riedler, October 2002.

152 R. Pischinger, Hans List (Obituary), *ÖAW Almanach 1996/97*, **147**, pp. 335-344, 1998.

153 Friedrich, E&I, *op. cit.*, p. 520.

154 F. Steinhauser, Kommission für Weltraumforschung (Bericht), *ÖAW Almanach 1970*, **120**, pp. 211-212, 1971.

155 W. Frühauf, “Über die Gründung des Bundesministeriums für Wissenschaft und Forschung”, in: *Wissenschaft und Weltbild, Festschrift für Hertha Firnberg*, Wolf Frühauf (Hrsg.), Europa Verlag, Wien, 628 p., 1975, pp. 235-260.

156 J. Pötzl, Herbert König (Obituary), *ÖAW Almanach 1985*, **135**, pp. 317-322, 1986.

157 G. Marx, “Roman Uli Sexl (1939-1986)”, *Eur. J. Phys.*, **8** (01), pp. 58-59, 1987; Walter KRANZER, “Univ.-Prof. Dr. Roman Sexl †”, *Wissenschaftliche Nachrichten*, no. 73, p. 37, 1987.

158 F. Steinhauser, Kommission für Weltraumforschung (Bericht), *ÖAW Almanach 1971*, **121**, pp. 226-228, 1972.

159 F. Ziegler, Heinz Parkus (Obituary), *ÖAW Almanach 1982*, **132**, pp. 293-298, 1983.

- *Willibald Riedler* (experimental space research)
- *Karl Rinner* (satellite geodesy)
- *Roman Sexl* (gravitation and relativistic physics)

Space research and technology was one of main topics discussed at a national symposium about the future of science and technology in Austria organised by the Federal Ministry for Science and Research in the autumn of 1972, with strong participation of Austrian expatriate scientists and domestic scientists.¹⁶⁰ After the academy had changed its organisational structure as well as the structure of the boards of its institutes, it decided in May 1975 to focus on three working groups effective from 1 January 1976.¹⁶¹ These working groups (all located in Graz) had been renamed departments of the Institute (Department for Physics of Near-Earth Space, Department for Experimental Space Research, Department for Satellite Geodesy) and some additional funds were provided to finish the work of the closed working groups in 1976.

In the plenary meeting of the Academy in June 1975, *Otto Burkard* was appointed managing director of the institute (deputy: *Willibald Riedler*) (after he had served as chairman of the task force for several years). In 1982 *Siegfried J. Bauer*¹⁶² succeeded *Otto Burkard* as head of the Department for Physics of Near-Earth Space and in 1984 *Willibald Riedler* succeeded *Otto Burkard* as managing director (1984-1998: deputy *Siegfried J. Bauer*; 1999-2000: deputy *Hans Sünkel*). *Hans Sünkel*¹⁶³ succeeded *Karl Rinner* in 1990 as head of the Department for Satellite Geodesy. The function of head of the Department for Physics of Near-Earth Space was taken over by *Helmut Rucker* after the retirement of *Siegfried J. Bauer* in 1999. After *Willibald Riedler*'s retirement at the end of 2000 *Hans Sünkel* was promoted to managing director (deputy: *Helmut Rucker*) for the period ending 2003, and *Wolfgang Baumjohann* was appointed head of the Department of Experimental Space Research in 2001. The scientific and financial policy was supervised by a board (Kuratorium), the chairmen of which were: (1975-1983) *Karl Lintner*, (1984-1986) *Ferdinand Steinhauser*, (1987-1988) *Johannes "Hans" Pötzl*, (since 1989) *Fritz Paschke*.

In addition to the budget allocated by the Academy, the Institute acquired substantial funding for the research undertaken through special research projects "space research" initially founded by the *Austrian Rectors' Conference* (Österreichische Rektorenkonferenz) and "Communications and Physics-Related Space Research"¹⁶⁴ from the *Austrian Science Foundation* (Fonds zur Förderung wissenschaftlicher Forschung) during the years 1978-1983, which allowed the realisation of medium-term activities. *Fritz Paschke* was instrumental in his capacity as vice-president (1974-1982) in implementing this special research project.

In 1979 the Federal Ministry for Science and Research initiated an Austrian programme "collaboration with the Soviet Union in the field of space research" (later "Soviet Union" renamed to "CIS")¹⁶⁵ and extended it in 1985 through a programme "space research – national programmes".¹⁶⁶ These programmes promoted basic research in space physics and technology and allowed for participation in space projects with the Soviet Union (Russia) and the European Space Agency (ESA) or other states on a bilateral basis. The main "customer" over the years was the Space Research Institute. Several institutes of the Universities in Vienna,

160 A. Thiel, "Space Research and Technology. A view of its past and evaluation of its future", in: *Die Zukunft von Wissenschaft und Technik in Österreich*. (Berichte, Diskussionen, Empfehlungen des Symposiums aus Anlaß des Nationalfeiertages 1972, veranstaltet von der österreichischen Bundesregierung), Europa Verlag, Wien, 446 p., 1973, pp. 183-191.

161 Prof. Hecht's working group had been already re-allocated earlier to the Commission for Geophysics.

162 "*Siegfried J. Bauer*", *Classics of World Science*, Vol. 7, Stepan S. Moskaliuk (Ed.), Walter Thirring International Institute for Mathematical Physics, Astrophysics and Nuclear Investigations (TIMPANI), Kiev, Ukraine, 296 p., 2003.

163 "Im Jahre 1998 neugewählte Akademiemitglieder", *ÖAW Almanach 1997/98*, **148**, p. 114, 1998.

164 "Nachrichtentechnische und Physikalische Weltraumforschung", Schwerpunkt 20; referenced in: *Weltraumforschung: Konzept einer Beteiligung*, Bundesministerium für Wissenschaft und Forschung (Hrsg.), Wien, 162 p., 1982 (short form: *Weltraumforschung: Konzept*), esp. p. 77.

165 Zusammenarbeit mit der UdSSR auf dem Gebiet der Weltraumforschung (later renamed to "GUS" [short form of "Gemeinschaft Unabhängiger Staaten"]) German equivalent to "CIS - Commonwealth of Independent States").

166 Weltraumforschung - Nationale Programme

Graz and Innsbruck, and the *Austrian Research Centre* in Seibersdorf (Österreichisches Forschungszentrum Seibersdorf) were also able to obtain moderate funding.¹⁶⁷

In 1999 the funding of the two programmes was discontinued, but a substantial part of the funding was transferred to the budget of the Academy of Sciences for its Space Research Institute.

Scientific cooperation with space research institutes of other Eastern European countries (*inter alia* Hungary, German Democratic Republic, Poland and Bulgaria) led to very successful collaboration in building the hardware for several experiments on balloon, rocket campaigns and subsequently satellites (other scientists and engineers involved: *Konrad Schwingenschuh*, *Klaus Torkar*). As a result of the continued efforts by *Willibald Riedler*, dating back to 1977,¹⁶⁸ Austria also got involved in space related activities in collaboration with China. A chain of magnetometers, called CHIMAG, developed at the Space Research Institute, to investigate geomagnetic activity in response to the solar wind – magnetosphere interaction, was set up in China. The original plan to fly Austrian instruments on two Chinese magnetospheric spacecraft could not be realised, but finally the mission developed into a Chinese/ESA space mission and the Space Research Institute contributes significantly (see section: **Projects in the 1990s and Beyond**).

Since its foundation in 1970, the employees of the Institute in Graz had been subtenants either of the University, University of Technology, Observatory Lustbühel (after 1976) and later also in different locations of the Styrian research organisation “Joanneum Research”. From 1996 to 2000 the Institute was scattered at seven locations in Graz. To remedy this unsatisfactory situation, the Municipal Council of Graz (under the chairmanship of its Mayor *Alfred Stingl* and the responsible town councillors *Ruth Feldgrill-Zankel* and *Alfred Edler*), took the lead after preparatory work by *Willibald Riedler*. They unanimously dedicated and donated a site to the Academy, in the south-east of Graz in 1990, to build a home for the Space Research Institute. Finally in 1996 the Academy (President *Werner Welzig*; Secretary General *Herbert Mang*), after discussions lasting almost a decade, decided to build a research centre in Graz,¹⁶⁹ where its two Graz-based institutes, the Space Research Institute and the Institute of Biophysics and X-ray Structure Research, as well as several Commissions of the Historical-Philosophical Section, found accommodation. In 1997 the Space Research Institute had grown to be the largest institute of the Academy (heads of administration office of the natural sciences section: (until 1991) *Rudolf Mück*; (1992-1995) *Alfred Vogel*, (1995-1996) *Bruno Besser*, (since 1996) *Gerhard Schadler*), as measured by the number of staff members (about 70 people in 2003). The different groups in Graz moved into the new building called “ÖAW Forschungszentrum Graz” (Austrian Academy of Sciences Research Centre Graz) in the autumn of 2000.¹⁷⁰

Austrian Space Agency (ASA)

Soon after the establishment of the Federal Ministry for Science and Research in 1970, Minister *Hertha Firnberg* invited representatives from the Federal Ministry for Foreign Affairs and the Vienna University of Technology to prepare the establishment of an agency to coordinate Austrian space activities on behalf of the Austrian government.¹⁷¹

167 G. Schrammel, “Die Internationalen Forschungsprogramme der Österreichischen Akademie der Wissenschaften”, in: *Akademie der Wissenschaften. Entwicklung einer österreichischen Forschungsinstitution*, Otto Hittmair und Herbert Hunger (Hrsg.), Verlag der Österreichischen Akademie der Wissenschaften, 269 p., Wien, 1997, pp. 145-148, esp. p. 148.

168 “Bericht des Vizepräsidenten Erich Schmid über den Besuch einer österreichischen Wissenschaftlerdelegation in China”, *ÖAW Almanach 1977*, **127**, pp. 666-667, 1978; “Bericht über eine Vortrags- und Studienreise nach China, 18. bis 31. Oktober 1981”, *ASSA-Informationsdienst/Weltraumfragen*, 01/1982, Wien, 18 p., Jänner 1982, pp. 16-17; Willibald Riedler was presented the honorary degree *Professor* at the Center for Space and Applied Research of the Chinese Academy of Sciences in 1996.

169 H. Mang, “Bericht des Generalsekretärs”, *ÖAW Almanach 1995/96*, **146**, pp. 249-258, 1996, esp. pp. 255-256.

170 *ÖAW Forschungszentrum Graz*, Österreichische Akademie der Wissenschaften (Hrsg.), brochure, 47 p., Graz, 2000.

171 Ministry for Science and Research (Dr. Wilhelm Frank), Ministry for Foreign Affairs (Dr. Paul Hartig), Vienna University of Technology (Prof. Klaus Oswatitsch).

On 12 July 1972 the Austrian Space Agency¹⁷² was founded, with *Otto Zellhofer* as its first managing director and with the following aims and tasks:¹⁷³

- Coordination of projects in space research and technology.
- Establishment and maintenance of contacts with foreign space agencies.
- Advising the Austrian government on space related matters (research, technology and applications) in line with Austrian interests and requirements, taking into account the international development in the field.
- Processing and distribution of data and information to all interested parties.
- Public relations activities.
- Organisation of lectures and conferences.
- Promotion of training and education of skilled students.

The first chairman of the Board of ASA was *Wilhelm Grimburg*, Director General of the Research Department of the Federal Ministry for Science and Research. His chairmanship lasted from 1972 to 1985. The members of the Board were representatives from the following Ministries: Foreign Affairs, Finance, Transport and Science & Research. Furthermore, the Austrian Academy of Sciences and the Federal Economic Chamber were represented on the Board. Thus, ASA was an intermediary between the Federal authorities, industry and scientific institutions. In addition, an Advisory Board was constituted composed of about 50 members from research organisations and industry (chairman: *Willibald Riedler*).¹⁷⁴

In January 1974 *Johannes Ortner* was nominated as Managing Director of ASA after having worked in COPERS and later in ESRO since 1962. He was in charge of the agency until his retirement in May 1998.

One of the first tasks of ASA was to promote the interest of Austrian industry in participating in ESRO – and after 1975 in ESA – activities and programmes. Visits were made by ASA to about 25 Austrian companies working in the fields of electrical & electronics engineering, mechanical engineering, metallurgy, telecommunications and optical engineering. It was realised that the involvement of Austrian industrial companies in space-related activities at the time was almost negligible.

The only company having experience as a supplier of space-proven hardware was “Plansee AG”, founded by *Paul Schwarzkopf* (1886-1970) in 1921, and a world leading firm in metallurgy.¹⁷⁵ At first the interest of Austrian companies was rather limited. The only company expressing immediate interest to work on projects in the framework of ESA programmes was the “Österreichische Klimatechnik GmbH (ÖKG)”. With the assistance of ASA this company received the first hardware contract for an ESA project, namely the design and development of the Spacelab-1 viewport adapter (see section on **Spacelab-1**).

This successful contract was essential for stimulating interest in other Austrian industrial companies to seek collaboration with ESA. Thus, with the assistance of ASA work started in the fields of telecommunications and Earth observation.

In 1976 the Austrian government decided, in reaction to the oil crisis of the early seventies and the subsequent increased interest in renewable energy sources, such as solar and wind energy, to start a thorough research programme in this field. Thus, following a wish of the Minister *Hertha Firnberg*, the Austrian Space Agency (ASA) was transformed into the Austrian Solar and Space Agency (ASSA).¹⁷⁶ A division for Solar Energy was established which commenced work on 1 January 1977.

172 Österreichische Gesellschaft für Weltraumfragen Ges. m.b.H.

173 “Geschäftsbericht, Annual Report, 1974/1975, der Österreichischen Gesellschaft für Weltraumfragen Ges. m.b.H., Austrian Space Agency (ASA)”, Wien, 22 p., 1976, esp. p. 1.

174 *ibid.*, pp. 19-22.

175 “Paul Schwarzkopf”, in: Heinz Jankowsky, *Österreichs große Erfinder: ihr Leben, ihre Arbeiten, ihre Schicksale*, Verlag Styria, Graz, 240 p., 2000, pp. 167-172; Portisch, *Österreich II, op. cit.*, p. 324.

176 Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H.

Thus, the agency was charged with the following additional tasks:¹⁷⁷

- Distribution of information and performing public relations activities with the aim of introducing the utilisation of solar energy in Austria
- Coordination and supervision of solar energy test stations of the Federal Ministry for Science and Research
- Cooperation with the International Energy Agency (IEA) on research projects in the field of solar energy

In addition to the Austrian government, two Austrian oil companies, namely Shell Austria and the ÖMV¹⁷⁸ became paying associates of ASSA as well as an Austrian bank (Giro-Zentrale).

In October 1976 ASSA became an institutional member of the IAF succeeding the dissolved Austrian Astronautical Society.¹⁷⁹

Austria's participation in the Spacelab-1 programme enabled the country to have access to the ESA RECON computer information system. ASSA was charged by the Ministry to make this most advanced information service available to Austrian universities, research centres and industry.

In 1976 the RECON system not only included space technology data (about 1.2 million references with an annual increase of about 80.000 reports), but also references to all areas of science and modern technology covering about 5 million references in total. Financial support by the Federal Ministry for Science and Research was granted to universities to use this automated information and documentation system.¹⁸⁰ In 1979 ASSA was given access to the RECON successor QUEST and the systems DIALOG and ORBIT.¹⁸¹

Between 1977 and 1987 ASSA published a regular information bulletin called "ASSA Informationsdienst/Weltraumfragen" to inform the public about recent developments in the national and international space community.

Several bilateral agreements with space agencies and/or institutions responsible for space activities were concluded by ASA/ASSA. These included the following:

- A cooperative agreement was concluded (and later a Memorandum of Understanding) with the Royal Norwegian Council for Scientific and Industrial Research (NTNFR) to provide a framework for the existing cooperation in the field of ionospheric investigations by balloons and sounding rockets (Institute of Communications and Wave Propagation, Graz University of Technology).
- Correspondence with the "Eidgenössisches Departement des Inneren" of Switzerland¹⁸² led in 1974 to an agreement, which enabled the cooperation of the Institute of Analytical Chemistry, University of Vienna and the Institute of Physics, University of Bern, Switzerland, on the analysis of lunar samples (obtained by NASA).
- An agreement was signed in 1976 with the CNES (Centre National d'Etudes Spatiales), France.
- In 1975 a cooperative agreement was signed with the Swedish Board for Space Activities.

177 "Tätigkeitsbericht, Report on Activities, 1976/1977, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 31 p., 1978, p. 6.

178 Österreichische Mineralölverwaltung AG (Austrian Mineral Oil Administration Corporation).

179 "Space activity in Austria 1975/76", presented to COSPAR by Ferdinand Steinhauser, 4 p., 1976.

180 "Geschäftsbericht, Annual Report, 1974/1975, der Österreichischen Gesellschaft für Weltraumfragen Ges. m.b.H., Austrian Space Agency (ASA)", Wien, 22 p., 1976, pp. 12-13; "Tätigkeitsbericht, Report on Activities, 1976/1977, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 31 p., 1978, pp. 26-30; Eva Maria Müller, Informationssysteme. Situation in Österreich und Dienstleistungen der ASSA, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA) (Hrsg.), 30 p., Wien, not dated.

181 "Tätigkeitsbericht, Report on Activities, 1978/1979, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 40 p., 1980, pp. 32-34.

182 "Swiss Federal Ministry of the Interior".

- At the beginning of 1979 an arrangement was signed with the “Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR)”.
- In 1983 an exchange of letters with the National Aeronautics and Space Administration (NASA) was signed. However under the circumstances there were not sufficient financial resources available to participate in NASA missions on scientific collaboration.

These agreements served as basis for collaborative projects between Austrian and foreign scientific and technical institutions.

The activities of ASSA were instrumental in the preparation of Austria’s membership in ESA. These included both the promotion of increased participation of Austrian industrial companies and research groups in individual ESA programmes, as well as lobbying efforts within the Austrian government. It was essential to demonstrate to ESA, as well as to the Austrian government, that the Austrian industry and research institutions had reached the potential for, and were able to efficiently perform, design and development tasks for ESA projects in line with the level of contributions provided to ESA by the Austrian government.

Thus, Austria was granted associate membership of ESA in January 1981 and full membership in January 1987. Staff members of ASA represented the Austrian interests in various ESA Committees (*Johannes Ortner* and *Wolfgang Lothaller* held the chairmanships of ESA Programme Boards and *Erwin Mondre* was a member of several committees). ASSA/ASA provided the secretary’s office for the “Advisory Committee for Space Research and Technology of the Austrian Government” (see section **Austria and ESA**).

After Austria had joined ESA as a full member in 1987, ASSA’s tasks related to solar and wind energy were transferred to the Austrian Research Centre Seibersdorf (ARCS). Space activities attracted renewed and increased interest and ASSA was re-transformed into the Austrian Space Agency (ASA), again concentrating its activities fully on space-related subjects (as was the case prior to 1977).¹⁸³

At that time the Austrian oil companies left the agency as associates, but in subsequent years other private paying associate partners joined the Austrian Space Agency, namely:

- City of Graz
- Federal Economic Chamber
- ARC Seibersdorf Research
- Joanneum Research Forschungsgesellschaft mbH
- Geospace
- Austrian Aerospace GmbH
- Siemens AG Österreich
- Magna Steyr Fahrzeugtechnik AG & CoKG
- Plansee AG

ASA prepared on behalf of the Federal Ministry for Science and Research various publications on the Austrian space activities, e.g. “Austria in Space” (1993 & 1996), describing innovative projects and technologies in science and industry. Furthermore, a brochure on “The Austrian Space Policy” was published in 1997.

ASA was also actively involved or participated in the organisation of several international space conferences in Austria, i.e.

- Second World Space Congress of the United Nations, UNISPACE II in Vienna in 1982.
- COSPAR (Committee of Space Research) Meeting in Graz in 1984.

183 “Tätigkeitsbericht, Report on Activities, 1987/88, Österreichische Gesellschaft für Weltraumfragen Ges. m.b.H, Austrian Space Agency (ASA)”, Wien, 56 p., 1989, pp. 9-10.

- 37th International Astronautical Congress in Innsbruck in 1986, when Johannes Ortner was elected President of IAF for the period 1987-1988.
- 44th International Astronautical Congress (IAF) in Graz in 1993.
- Third World Space Congress of the United Nations, UNISPACE III in Vienna in 1999.

Staff members of ASA also assisted the Austrian delegation of the Federal Ministry of Foreign Affairs in the annual meetings of the UN Committee for the Peaceful Uses of Outer Space (COPUOS).

Following the retirement of *Wilhelm Grimburg* in 1985, the chairmanship of the supervisory council of ASSA/ASA was entrusted to *Otto Zellhofer*, who was responsible for all space activities in the Federal Ministry for Science and Research.¹⁸⁴ During the period of his chairmanship (until his retirement in 1998) ASA significantly improved the quality of design and research contracts received from ESA. Furthermore, important bilateral space activities with other ESA member states and with Russia were greatly enhanced.

In 1998 *Klaus Pseiner* was appointed Managing Director of ASA, having worked at “Österreichische Raumfahrt- und Systemtechnik GmbH”¹⁸⁵ and nine years at the European Space Technology Centre (ESTEC). At the same time Ambassador *Peter Jankowitsch* took over the chairmanship of the Board. After an evaluation of Austria’s industrial space activities in 1999,¹⁸⁶ the last few years were focused on designing the *National Austrian Space Plan* (Österreichischer Weltraumplan), in collaboration with partners in the Austrian scientific and technological communities and in industry, which was published in 2001. In 2002 ASA took over additional tasks, namely the responsibility for technological developments in the field of aeronautical activities, and development of the nano-technology sector. Subsequently, ASA became instrumental for the implementation of the Austrian space and aeronautic policies.

Lustbühel Observatory, Graz

When the astronomer *Karl Stumpff* (1885-1970) was offered the chair in the Institute of Astronomy at the University of Graz and agreed to serve as its director in 1942, he inherited an outdated small refractor in a tower at the university in the city. He tried to convince the local authorities to build an observatory in a suitable place, a hill on the outskirts of Graz, a place called Lustbühel.¹⁸⁷ In 1943 the council of Graz leased a site near the “Lustbühel Castle” to build the University Astronomical Observatory, but it was not until 1956 that the federal government purchased the land. In the meantime the home-built astronomical telescopes and a satellite camera were housed in cabins. In 1969 the interest of several institutes, the Institute of Astronomy (head: *Hermann Haupt*), and the Institute of Meteorology and Geophysics (both University of Graz), the Institute of Geodesy and the Institute of Communications and Wave Propagation (both Graz University of Technology), made it possible to extend the area through an additional purchase of land to a size of about 1.8 hectares. In 1971 a draft of the spatial and functional programme was prepared and after the decision to build this observatory (June 1972), the construction work started in 1974 and was completed in December 1976, when the move took place.¹⁸⁸

In addition to the four above mentioned institutes, the Lustbühel Observatory still serves as home for some researchers of the Space Research Institute which acts as an interdisciplinary link between the institutes.

In 1976 an experimental satellite ground station was established. It has been utilised for the study of the influence of the atmosphere on satellite wave propagation at frequencies above 10 GHz. In 1980 the station was extended as a transmit-and-receive station for the STELLA¹⁸⁹ and SATINE data transmission

184 “Austria in Space” (interview, Dipl.-Ing. Otto Zellhofer), *Austria Innovativ*, 02/1997, pp. 8-10, 1997.

185 Austrian Space System Technology.

186 G. Tichy and H. Posch, *Die strategische Neuordnung der österreichischen Raumfahrtaktivitäten*, Gutachten für das Bundesministerium für Wissenschaft und Forschung, 69 p., 1999 (short form: Tichy and Posch, Neuordnung).

187 T. Schmidt-Kaler, “Karl Stumpff. 17. Mai 1895 bis 10. November 1970”, *Die Sterne*, **72**, pp. 134-152, 1996, esp. p. 139.

188 *Observatorium Lustbühel Graz. Schwerpunkt österreichischer Weltraumforschung*, Astronomisches Institut Universität Graz (Hrsg.), brochure, Graz, 40 p., 1976.

189 O. Koudelka, B. Mulkeen, W. Riedler, J.O. Scanlan, P. Auer, A. Gierlinger, Results of the Dublin-Graz experiment, STELLA Final Report, EUR 9090, CEC/CERN/ESA, Brussels, 1984, pp. A.6.1-A.6.7.

experiments by ESA, the EU and CERN. Since then it has been continuously upgraded and used for the study of advanced satellite communication systems in the framework of ESA and EU programmes.¹⁹⁰

The original instrumentation is no longer in operation and has been replaced by more recent equipment. A laser system for Satellite Laser Ranging was installed in the western dome and has operated since 1982.¹⁹¹ In 1976 the Institute of Communications and Wave Propagation transferred the caesium frequency standard for ultra-high precision time-keeping, which it had acquired in 1972, to the observatory and operated it until 1999 (since 1985 in close cooperation with the Space Research Institute) (responsible scientist: *Dieter Kirchner*), when operation was temporarily stopped due to financial difficulties. In 2002 it was re-activated for two-way satellite time transfer experiments. The timekeeping station served two purposes: it supported all measurements carried out at the observatory with the required precise time and frequency information, and secondly, the installation was used to conduct studies of the performance of novel and more precise time-comparison and world-wide time transfer methods.¹⁹² Additionally the institute operated several antennas for telecommunications research at Lustbühel. Starting in 1986 the Space Research Institute performed decameter range radio observations of both Jupiter and the Sun.

Spacelab-1

In August 1975, an agreement enabled Austria's participation in the design and operation of the manned space laboratory Spacelab-1,¹⁹³ a joint project of ESA and NASA.¹⁹⁴ Three experiments from Austria qualified for the programme:¹⁹⁵

- Experiment 1 ES 019 B: Magnetic field – vector measurements
Principal investigator: *Willibald Riedler*, Institute of Communications and Wave Propagation, Graz University of Technology.
- Experiment 1 ES 305: Vacuum brazing
Principal investigator: *Roland Stickler*, Institute of Physical Chemistry, University of Vienna.
- Experiment 1 ES 313: Solidification of near monotectic ZnPb alloys
Principal investigator: *Hellmut Fischmeister*, Institute of Metal and Material Science, University of Mining and Metallurgy Leoben.

The magnetometer experiment was made possible after the German “Max-Planck-Institut für Aeronomie” (Lindau) had to withdraw from its commitment to build the magnetometer for its experiment 1 ES 019 A: *Low energy electron flux and its reaction to active experimentation on Spacelab*. The Space Research Institute was able to fill the gap and developed this experiment in cooperation with the Institute in Lindau and mastered the task superbly (responsible scientist: *Rudolf Schmidt*). This started a series of very successful projects at the Space Research Institute on the development of magnetometers for space missions.

Austria's contribution represented about 0.8 % of the total programme costs, but the expected return in relation to contracts for the Austrian industry made the project interesting for Austria. ASSA was able to successfully engage industrial interest, even to the extent that part of the contribution to ESA was obtained

190 O. Koudelka and M. Hine, Higher Speed Services, *Computer Networks and ISDN Systems*, **16** (1-2), pp. 129-134, 1988.

191 K. Rinner, Geodetic work and projects at the observatory of Graz-Lustbühel, *Acta Geodaet. Geophys. et Montanist. Acad. Sci. Hung.*, **14** (01-02), 17-29, 1979; Karl Rinner, Über die Tätigkeit der geodätischen Abteilung des Observatoriums Graz-Lustbühel, *Österreichische Zeitschrift für Vermessungswesen und Photogrammetrie*, **73** (01), 46-50, 1985.

192 D. Kirchner, “Precision timekeeping at the Observatory Lustbühel, Graz, Austria”, in: *Proceedings of the 37th Annual Symposium on Frequency Control*, IEEE Ultrasonics, Ferroelectrics and Frequency Control Society, Philadelphia, 529 p., 1983, pp. 67-77, esp. pp. 67-68.

193 W. Büdeler und S. Karamanolis, *Spacelab: Europas Labor im Weltraum*, Goldmann Verlag, München, 285 p., 1976.

194 BGBl. 242/1976, BGBl. 243/1976, BGBl. 257/1978 .

195 *First SPACELAB payload. Directory of European investigators*, ESA, Paris, 57 p., 1978, esp. p. 10, 38, 40; “SPACELAB-1: Jungfernflug des Europäischen Weltraumlaboratoriums”, *ASSA-Informationsdienst/Weltraumfragen*, 05/1983, Wien, 52 p., November 1983, pp. 31, 34.

from industry. The largest individual contracts given to Austrian industry were those for the construction and production of the Spacelab-1 viewport.¹⁹⁶

The mission was successfully carried out from 28 November to 8 December 1983. The European space laboratory Spacelab went out of service in 1998. In 15 years of service, it accomplished 22 missions over a total of 231 days in space with 720 scientific experiments conducted.¹⁹⁷

Austria's cooperation with the Soviet Union

Austria signed an "Agreement about cultural and scientific collaboration with the Soviet Union" as early as 22 March 1968.¹⁹⁸ The earliest contacts with the Soviet Union in the field of space research were initiated mainly through personal contacts of *Willibald Riedler* with Soviet scientists (from IZMIRAN¹⁹⁹, Troitsk, and the Polar Geophysical Institute, Apatity and Murmansk, of the Soviet Academy of Sciences). Some of them were involved in joint balloon campaigns carried out since 1971 from Esrange in Kiruna, Sweden. In 1973 the Austrian Academy of Sciences signed its first agreement on scientific collaboration with the Academy of Sciences of the Soviet Union.²⁰⁰ The SAMBO²⁰¹ campaigns included the Soviet Union as a key partner and concentrated on winter launches during the eastward stratospheric wind period, also using telemetry stations in Northern Russia.²⁰² After 1976, campaigns were organised on a bilateral basis between Austria and the Soviet Union. Austrian instruments also flew on Soviet sounding rockets, notably *Gruziya-60-Spurt*, launched from Kapustin Yar near Volgograd.

At the COSPAR General Assembly of 1976 in Innsbruck, *Roald Z. Sagdeev*,²⁰³ then director of the Space Research Institute (IKI)²⁰⁴ of the Soviet Academy of Sciences,²⁰⁵ was invited by *Willibald Riedler* to visit the Space Research Institute and the Institute of Wave Propagation and Communications, Graz University of Technology. On this visit to Graz *Sagdeev* was accompanied by two cosmonauts and after discussions *Sagdeev* invited these Institutes to collaborate on the *Venera 13* and *14* missions to Venus by flying magnetometers onboard these spacecraft. The invitation to participate in Soviet space missions was on a "no exchange of funds" basis. Because the *Venera* probes were scheduled for launch at the end of 1981, the only way to succeed in time with the delivery of the instruments was to adapt the magnetometer for the Spacelab-1 mission, which was under development at that time.²⁰⁶ The success of the measurements of the magnetic field in interplanetary space and near Venus (March 1982) led to an invitation to provide completely newly designed magnetometers for the Soviet *Vega 1* and *2* missions²⁰⁷ to Venus and Halley's

196 "Tätigkeitsbericht, Report on Activities, 1980/1981, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 37 p., 1982, p. 18.

197 U. Lieske-Wessendorf, Weltraumveteran Spacelab startet in den zweiten Frühling, Aerospace (A publication of DaimlerChrysler Aerospace AG), 02/99, pp. 72-75, 1999.

198 BGBl. 319/1969 .

199 IZMIRAN, English short form of: ? ?????? ?????? ? ?????????, ????????? ? ?????????????????? ?????????? ? ?????? ? ?? ???? ????????? ?????????????????? ?????????? (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation of the Academy of Sciences of the USSR).

200 "Abkommen über wissenschaftliche Zusammenarbeit zwischen der Akademie der Wissenschaften der UdSSR und der Österreichischen Akademie der Wissenschaften" (Agreement on the scientific collaboration between the Academy of Sciences of the USSR and the Austrian Academy of Sciences), dated and effective 23 February 1973; (provided by the Foreign Relations Department of the Academy, January 2003).

201 Simultaneous Auroral Multi-Balloon Observations, successor organisation to SPARMO (Solar Particle and Radiation Monitoring Organization); L. D. De Feiter, Introduction, Space Sci. Rev., **13**, pp. 197-198, 1972.

202 W. Riedler, Balloon research and cooperative programmes, Adv. Space Res., **3** (07), 103-110, 1983, esp. p. 104.

203 R. Sagdeev was presented the honorary degree Doctor technicae honoris causa (short form: Dr. techn. h.c.) by the Graz University of Technology on the same day as Hermann Oberth in 1985.

204 ? ?????? ? ?????????? ? ?????????? (Institute of Space Research, short: IKI).

205 R.Z. Sagdeev, The making of a Soviet scientist: My adventures in nuclear fusion and space from Stalin to Star Wars, Susan Eisenhower (Ed.), John Wiley & Sons, New York, 339 p., 1994.

206 R. Schmidt, Venus, Mars, Saturn und Halley – wissenschaftliche Instrumente aus Graz in den Tiefen des Welt- raums, Elektrotechnik und Informationstechnik, **117** (09), pp. 586-591, 2000, esp. pp. 587-588.

207 Transliterated short form of the Russian ??????-????? (Venus-Halley).

Comet . Unexpected difficulties consisted in avoiding infringement of the CoCom²⁰⁸ regulations for export of strategic and military goods/material and technologies to proscribed destinations, even if the components in question were permanently and inaccessibly integrated in the Austrian scientific instruments.

On 2 November 1982 the Austrian Academy of Sciences signed its second “Agreement on scientific collaboration” with the Soviet Academy of Sciences.²⁰⁹ The magnetometers on Vega 1 and 2 worked flawlessly during the cruise and fly-by phases and the measurements revealed completely new facts about the plasma environments of Venus and Halley’s Comet (responsible scientists: *Konrad Schwingenschuh, Herbert Lichtenegger*). The next Soviet mission, in which the Institute was invited to supply scientific instruments (magnetometers and electronic components), was Phobos to planet Mars in 1988/89.²¹⁰

Following intensive contacts since 1977, Graz University of Technology, at the initiative of *Willibald Riedler*, signed a partnership agreement with the Polytechnical Institute of Leningrad on 25 February 1985. This included an annex incorporating the Department of Magnetospheric Physics at the Institute of Physics, State University Leningrad (group of *Mikhail I. Pudovkin*).²¹¹ This started a very successful scientific collaboration, the so-called “Graz-St. Petersburg reconnection group”, on different topics related to the Earth’s magnetosphere, between the Space Research Institute (scientists involved: *Martin Heyn, Helfried Biernat, Richard P. Rijnbeek, Bruno Besser, Johannes Fritzer*) and the Department in Leningrad (since 1990 St. Petersburg) (scientists involved: inter alia *Mikhail I. Pudovkin, Vladimir S. Semenov, Igor V. Kubyskin, Valentina V. Lebedeva, Andrei V. Runov, Arcadi V. Usmanov, Svetlana A. Zaitseva* (1934-2003)).²¹²

In an official treaty on cultural and scientific collaboration between the Austrian Federal government and the government of the Soviet Union, common space research activities were specifically highlighted.²¹³ The subsequent collaboration within the Soviet (later Russian)-Austrian project *AustroMir*, with the aim of flying an Austrian cosmonaut (astronaut) to the space station *Mir*, and later collaborative space-related research activities, are described in the section **AustroMir**.

Main Scientific Activities in the 1970s and 1980s²¹⁴

Space Research Institute, Austrian Academy of Sciences, Graz

The Department for Experimental Space Research investigated, in close cooperation with the Institute of Communications and Wave Propagation, Graz University of Technology, the upper-atmosphere/ionosphere of the Earth using balloons and sounding-rocket measurements. Later, it performed theoretical studies of non-linear magnetic field line reconnection and investigations of planetary and interplanetary fields. It developed magnetometers for the Soviet space probes *Venera 13* and *14* (1981-82) and the European *Spacelab-1* mission. In 1986 Austrian-Soviet magnetometers were carried by the Soviet space probes *Vega 1*

208 CoCom – Coordinating Committee for Multilateral Strategic Export Controls, founded 1950.

209 “Abkommen über wissenschaftliche Zusammenarbeit zwischen der Akademie der Wissenschaften der UdSSR und der Österreichischen Akademie der Wissenschaften” (Agreement on the scientific collaboration between the Academy of Sciences of the USSR and the Austrian Academy of Sciences), dated November 2, 1982, effective January 1, 1983; (provided by the Foreign Relations Department of the Academy, January 2003).

210 K. Schwingenschuh, Die Untersuchung planetarer und interplanetarer Magnetfelder, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 592-600, 2000, esp. pp. 587-588; *Field, particle and wave experiments on cometary missions (Proceedings of an International Workshop held at Graz, Austria, October 21-23, 1985)*, Konrad Schwingenschuh and Willibald Riedler (Eds.), Verlag der Österreichischen Akademie der Wissenschaften, Wien, 299 p., 1986.

211 “Partnerschaftsvertrag zwischen Technischer Universität Graz und dem Polytechnischen Institut Leningrad”, (partnership agreement between the Graz University of Technology and the Polytechnical Institute Leningrad), dated February 1985 (provided by the *Foreign Relations Department, Graz University of Technology*, January 2003).

212 B.P. Besser, *Die Schriften der mathematisch-naturwissenschaftlichen Klasse 1971-1996*, Dokumentation zur Österreichischen Akademie der Wissenschaften, Bd. IV, Verlag der Österreichischen Akademie der Wissenschaften, Wien, 535 p., 1998, esp. pp. 337-338, 345-349.

213 BGBl. 429/1987 .

214 the following information (if not otherwise stated) has been taken from the annual (later bi-annual) *National Reports to COSPAR* spanning the time period from 1970 to 1989. Activities in communications and remote sensing studies are discussed in the next chapter.

and 2 to investigate Halley's Comet and measured for the first time the magnetic field close to a comet. In 1988 further developed magnetometers were carried onboard the Soviet Phobos spacecraft to investigate the Martian environment.

The Department for Physics of Near-Earth Space made theoretical investigations of the solar wind interaction with bodies in the solar system (comets) (responsible scientist: *Norbert Kömle*) and planets (terrestrial and Jovian magnetosphere). Members of the department also studied the physics of planetary ionospheres (Venus, Mars) and moons (Titan). A radio observation station was established at Lustbühel Observatory for the study of the radio emissions from Jupiter and the Sun in the decameter range (responsible engineer: *Valentin Mostetschnig*). This started operation in 1986.

The Department for Satellite Geodesy operated Austria's only geodetic observatory, making Doppler measurements of satellite passages (responsible scientist: *Peter Pešec*). Studies of the Earth's gravitational field and its temporal changes were made with a laser ranging system installed at Lustbühel Observatory (responsible engineer: *Georg Kirchner*).

Institute of Communications and Wave Propagation (INW), Graz University of Technology

As mentioned earlier, in 1969 the newly founded institute started to conduct experimental research on the Earth's ionosphere and magnetosphere with sounding rockets. These rockets carried Faraday rotation experiments and slant-range receivers, to measure plasma density profiles and particle fluxes of the D- and E-regions in the ionosphere. These are still being performed (many in cooperation with the Space Research Institute) (responsible scientists and engineers: *Martin Friedrich, Klaus Torkar*).²¹⁵ Numerous balloon payloads, containing scintillators, photometers, Geiger-Müller counters and electric field probes have been flown from Kiruna, in cooperation with German, Swedish, French and Soviet groups, to investigate magnetospheric substorms and other high-latitude phenomena (responsible scientists and engineers: *Gerhard Kremser, Herwig Slamanig*).²¹⁶ The extensive activities in communications research performed by the institute are mentioned in the section on **Satellite Communication Studies**.

Institute of Meteorology and Geophysics, University of Graz

The institute performed differential Doppler and Faraday rotation measurements using various satellites to examine the ionosphere and for total electron content studies. Since 1975 it also made theoretical investigations, in collaboration with the Space Research Institute, of the behaviour of the solar wind, the magnetopause and the interaction between the solar wind and the geomagnetic field. In 1981 *Siegfried J. Bauer* succeeded *Otto Burkard* as head of the Institute and the aeronomy of planets and moons was introduced as an additional research topic. After the retirement of *Siegfried J. Bauer* in 1998 *Reinhard Leitinger* was appointed head of the institute. In 2003 *Gottfried Kirchengast* was appointed professor.

Institute of Geodesy, Graz University of Technology

The institute analysed photographs and, since the completion of the Lustbühel Observatory in mid 1976, Doppler measurements of satellite passages. During 1978 and 1982 a laser system for Satellite Laser Ranging was installed at the Observatory and operated thereafter. The data contributed to the establishment and maintenance of a global reference system, and were also used to determine the Earth's rotation and gravity field parameters.

Institute of Applied System Technology (IAS), Forschungszentrum Graz

The institute focused on the study and development of novel satellite communication systems and the improvement of the efficiency and data integrity by advanced modulation, coding and multiple-access

215 M. Friedrich und H. Slamanig, Raketen und Ballone zur Erforschung der Hochatmosphäre und Ionosphäre, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 573-581, 2000.

216 *ibid.*, pp. 577-579; W. Riedler and J. Ortner, "Sounding rocket and balloon programmes in Austria and related activities", in: *Sixth ESA Symposium on European rocket and balloon programmes and related research*, W. R. Burke (Ed.), ESA SP-183, Noordwijk, 479 p., 1982, pp. 25-28.

techniques. These activities were carried out mainly under ESA contracts and in close cooperation with INW.²¹⁷

Central Institute for Meteorology and Geodynamics, Vienna

The institute performed scientific investigations of meteorological sounding rocket data and, together with the Civil Aviation Weather Service, processed cloud-pictures from weather satellites for specific weather analyses.

Institute of Theoretical Physics, University Innsbruck

The institute conducted theoretical and experimental research in plasma physics, especially connected with plasma instabilities, turbulence, magnetohydrodynamics and theoretical modelling of the magnetopause. Additionally calculations of satellite trajectories and navigation were carried out under NASA contracts. Later on, it investigated problems related to the physics of planetary magnetospheres and the solar wind (scientists involved: *Manfred Leubner, Elmar Märk*).

Institute of Theoretical Physics, University of Vienna

The institute investigated the directional characteristics of the infrared radiation emitted by the lunar surface, and performed research in black hole physics and the influence of strong gravitational fields on quantum phenomena (head of group: *Roman Sexl*).

Institute of Analytical Chemistry, University of Vienna

The institute focused its research on the analysis of iron and stone meteorites, and also investigated moon samples at the start of the 1970s (scientists involved: *Friedrich Hecht, Wolfgang Kiesel, Christian Köberl*).

Institute of Mechanical Engineering, Vienna University of Technology

The institute investigated the dynamics and stability of satellites with long deformable booms (scientists involved: *Heinz Parkus, Hans Peter Rossmann, Hans Troger*).

Institute of High-Frequency-Techniques, Vienna University of Technology (later renamed to: Institute of Communications and Radio-Frequency Engineering)

The institute developed S-band receivers for satellite ground stations, and investigated laser radar systems, in particular CO₂ lasers for communications research (head of group: *Herbert König*; later: *Walter Leeb*).

Division of Mineralogy and Petrology, Museum of Natural History, Vienna

Starting in 1974/75, research has been conducted on chondrite meteorites and moon rocks by applying transmitted and reflected light microscopy and electron microprobe techniques. For planetological studies of Earth rock selections from an island in the Red Sea have been analysed (head of group: *Gero Kurat*).

Institute of Meteorology and Geophysics, University Innsbruck

Starting in 1976/77 climate studies in the Alps, especially related to glaciers, have been performed by remote sensing techniques. Of special interest was the surface albedo in Central Europe and its annual modulation by snow and ice cover and the interference of hydrologically relevant data from microwave, infrared and visible imagery (scientists involved: *Hans-Jürgen Bolle, Helmut Rott*).

Institute of Metallurgy and Material Testing, University of Mining and Metallurgy Leoben

Since 1976/77 the Institute investigated the solidification of monotectic Zn-Pb alloys under zero gravity (see also section on **Spacelab-1**).

Institute of Material Sciences, University of Vienna

Since 1976/77 the main field of space related interest was the physics and technology of brazing operations under zero gravity (see also section on **Spacelab-1**).

217 O. Koudelka and W. Riedler, Integrating Local Area Networks by Satellites, *Space Communications Journal*, pp. 3-11, 1994; C.D. Hughes, O. Koudelka, C. Garrido, M. Tomlinson, J. Hörle, A Microterminal Satellite Data Communications System, *IEE Electronics & Communication Engineering Journal*, **3** (06), pp. 243-251, 1991.

Institute of Astronomy, University of Vienna

The institute took part in satellite-based spectroscopic observations of stars and in the 1980s used data from the International Ultraviolet Explorer (IUE) satellite (scientist involved: *Michael Barylak, Werner Weiss*) and, in the late 1990s, the ESA Infrared Space Observatory (ISO) (scientists involved: *Josef Hron, Franz Kerschbaum, Werner Weiss*).

Institute of Industrial Electronics, Vienna University of Technology (renamed to: *Institute of Electrical Engineering and Electronics*; later renamed to: *Institute of Photonics*)

A working group of the institute (head of group: *Johannes Mitterauer*) has, since 1975, developed (under contracts with ESTEC) micro-structured liquid metal electron and ion sources (caesium and indium) to be used for ion engines and thrusters for space applications.

Satellite Communication Studies

*Institute of Communications and Wave Propagation (INW), Graz University of Technology*²¹⁸
Institute of Applied System Technology (IAS), Joanneum Research

The following research topics were investigated in close collaboration with the IAS, established in 1978.

In 1973 Austria joined the satellite communication network Intelsat, founded in 1964. In the beginning of the 1970s the institute set up a ground-based very low frequency (VLF) receiving station in Graz, and in 1974 a 11.4 GHz radiometer for sky noise measurements along hypothetical Earth-satellite links was installed at the institute through the first ESRO contract ever with an Austrian institution. This started a series of successful investigations of wave propagation transmission impairment by tropospheric weather phenomena.²¹⁹ The expertise gained in the field of satellite wave propagation and site diversity investigation with radiometers led the institutes into weather radar research. As part of this undertaking they planned and constructed a weather radar facility for precipitation studies, which was installed at the “Hilmwarte” tower in Graz in 1986/87 and has been operational since then (responsible engineer: *Walter Randeu*). To design and build this advanced radar system was a major technical achievement and led the way to contributing major work to the Austrian as well as the Central European weather radar network.²²⁰

Research in terrestrial and satellite wave propagation in the frequency range above 10 GHz started at the Lustbühel Observatory in the mid-1970s, and led to studies on satellite communication systems and their applications. Due to the official Austrian participation in the communications research programme of ESA²²¹, the satellite ground station Lustbühel, the ground communication station Aflenz of the Austrian Postal and Telegraph Authority (Österreichische Post- und Telegraphenverwaltung), and the Austrian Broadcasting Corporation (ORF, Österreichischer Rundfunk) took part in the OTS (Orbital Test Satellite) telecommunications programme from 1978 to 1983.²²² In the early 1990s the institutes took part in the ESA OLYMPUS satellite programme studying advanced modulation, coding and multiple-access schemes. In the application area a satellite multi-point video conferencing system was developed, which was successfully

218 W. Riedler, Die Nachrichtentechnik im Weltraumzeitalter, *Österreichische Ingenieur-Zeitschrift*, **16** (02), pp. 65-76, 1973; W. Riedler, “Current problems in satellite transmission research”, in: *Satellite Transmissions. Proceedings of an International Symposium held in Graz*, ESA SP-245, Noordwijk, 201 p., 1985, pp. 5-11.

219 W. Riedler, Wellenausbreitungsprobleme in Zusammenhang mit Satelliten, *Elektrotechnik und Maschinenbau*, **97** (11), pp. 519-528, 1980.

220 W.L. Randeu und W. Riedler, Entwicklung eines Wetterradars für die Untersuchung der Mikrowellenausbreitungsbedingungen in der Troposphäre, *ASSA-Informationdienst/Weltraumfragen*, 02/1985, Wien, 68 p., Dezember 1985, esp. p. 2.; W.L. Randeu, Radar und Radiometer - wichtige Hilfsmittel für die Wellenausbreitungsforschung, Niederschlagsmessung und Naturgefahrenfrüherkennung, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 541-559, 2000, esp. pp. 543-544.

221 BGBl. 265/1979.

222 W. Lothaller, *Nachrichtensatellitentechnik. Grundlagen, Systeme und Projekte*, Bundesministerium für Wissenschaft und Forschung (Hrsg.), 277 p., Wien, 1985.

utilised for space mission support during AustroMir, Mir-92 and Euromir-94/95.²²³ High-speed satellite communication systems have been studied and developed since 1985, which have found applications in telemedicine and tele-science.

In 2000 *Otto Koudelka* succeeded *Willibald Riedler* as head of the Institute of Communications and Wave Propagation of Graz University of Technology and in 2002 as head of the Institute of Applied Systems Technology, Joanneum Research, positions *Willibald Riedler* had held since 1968 and 1978, respectively. Many of the activities in telecommunications as well as remote sensing are carried out in the framework of Joanneum Research (present directors: *Edmund Müller* and *Bernhard Pelzl*) (see also section **Remote Sensing Activities**).

Institute of Communications and Radio-Frequency Engineering, Vienna University of Technology

The main research topics investigated were electro-optical modulation for space-borne CO₂ laser communication, systems for space-borne optical communications, phased-array optical antennas for space platforms and Lidars (**L**ight **D**etection and **R**anging). Most of the research of the group (head: *Walter Leeb*) has been performed in frame of Austria's subscription to ESA's optional programmes.

Remote Sensing Activities

Remote sensing applications played an important role during the preparation for the Spacelab-1 utilisation studies.²²⁴ In 1979 a study group was set up to coordinate the Austrian activities with delegates from 17 Austrian institutions.²²⁵ ASSA acted as the National Point of Contact for the distribution of the remote sensing satellite data in the ESA Earthnet Programme.

Austrian industry received contracts for mechanical ground support equipment, the active microwave instrument and the construction of an electronic test and simulation unit for the radar altimeter of the first European Remote Sensing satellite (ERS-1).²²⁶

In 1995, to accommodate the increasing importance of remote sensing, the Federal Ministry of Science, Research and the Arts established a research "focal emphasis" to facilitate the Austrian activities in remote sensing of the environment and started promotion of activities aiming at the application of remote sensing for practical purposes.²²⁷

Studies in remote sensing have been performed mainly by the following institutions:

Institute of Applied Geodesy and Photogrammetry, Department of Remote Sensing, Image Processing and Cartography, Graz University of Technology

The institute processed images of satellite data, based on synergetic use of map and image data, in the framework of a geographic information system (heads of group: *Franz W. Leberl*, *Gerhard Brandstätter*, *Mathias Schardt*; scientists involved: *Robert Kostka*, *Viktor Kaufmann*).

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- 223 O. Koudelka und W. Riedler, Österreichische Beiträge zu internationalen Projekten der Satellitenkommunikation, *Elektrotechnik und Informationstechnik*, **105** (04), pp. 189-194, 1988, esp. pp. 191-192; O. Koudelka, Satellitenkommunikationssysteme und ihre Anwendung, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 560-566, 2000, esp. p. 561; O. Koudelka and W. Riedler, VIDEOMIR – Video Conference Support During the AUSTROMIR and MIR-92 Missions, in: *Proceedings of Satellite Symposium 4: Columbus Eight (COSY-8) Utilisation of Earth Orbiting Laboratories*, ESA ISY-4, Noordwijk, 1992, pp. 105-110.
- 224 "Geschäftsbericht, Annual Report, 1974/1975, der Österreichischen Gesellschaft für Weltraumfragen Ges. m.b.H., Austrian Space Agency (ASA)", Wien, 22 p., 1976, p. 4.
- 225 "Tätigkeitsbericht, Report on Activities, 1978/1979, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 40 p., 1980, p. 30.
- 226 "Tätigkeitsbericht, Report on Activities, 1986, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 57 p., 1987, pp. 38-38.
- 227 O. Zellhofer, Informationsveranstaltung "Erdbeobachtung für Umweltfragen", Vorwort, *Österreichische Zeitschrift für Vermessung und Geoinformation*, **84** (01), p. 5, 1996; W.L. Reiter, MISSION-Anwendungen der Fernerkundung in Österreich, Vorwort, *Österreichische Zeitschrift für Vermessung und Geoinformation*, **86** (03), p. 131, 1998; W.L. Reiter, "Vorwort", *Österreichische Zeitschrift für Vermessung und Geoinformation*, **89** (03), p. 141, 2001.

Institute of Photogrammetry and Remote Sensing, Vienna University of Technology

The institute focused on applying remote sensing and image-processing methods to satellite imagery, *inter alia* the Metric Camera on Spacelab-1 (head of group: *Karl Kraus*; scientist involved: *Rainer Kalliany*).

Institute of Meteorology and Geophysics, University Innsbruck

The institute used remote sensing data for hydrology and cryospheric research, mainly glaciological studies (head of group: *Helmut Rott*).

Institute of Image Processing and Computer Graphics, Joanneum Research, Graz

Since 1980 the institute performed research in the field of remote sensing within a wide range of applications (heads of group: *Franz W. Leberl, Manfred F. Buchroithner, Albert Niel, Mathias Schardt*).

Institute of Fundamentals and Theoretical Electrical Engineering, Graz University of Technology

The institute developed a side-looking airborne radar (head of group: *Kurt Richter*).

Space Research Institute, Department of Satellite Geodesy, Graz

The department used ERS-1 and subsequent remote sensing satellites' altimeter data and orbit-determinations to test the accuracy of height transfer between Austrian and Italian stations.

Institute for Computer Graphics and Vision, Graz University of Technology

The main research activities of the workgroup in the institute are in processing synthetic aperture radar imagery (head of institute: *Franz W. Leberl*; head of group: *Rainer Kalliany*).

Austrian Research Centres Seibersdorf Research GmbH

A working group (head: *Gerhard Triebnig*) started to analyse human risks in connection with laser safety for future space lidars (**Light Detection and Ranging**).

Austria and the European Space Agency (ESA)

In addition to technical and scientific reasons for approaching ESA²²⁸ there were also some weighty political motives for Austria's interest in the new European space organisation. From an early moment on Austria had decided to engage to the fullest extent possible in efforts towards European economic integration. It had therefore joined OEEC²²⁹ – predecessor of today's OECD²³⁰ – and later became a founding member of EFTA²³¹ together with a number of other Western European democracies that for one reason or another found it impossible or impracticable to join the early EEC.²³² While working to develop an even closer relationship with the EEC, later the European Community (since 1967), Austria was also keen to participate in other fora of European integration. It was therefore attracted by the type of European cooperation that ESA member countries practised by pooling their technical, industrial and scientific resources in order to establish a European presence in Outer Space.

For Austria, and also for other non-EEC members at the time, membership in ESA could therefore be seen as a step on the road towards fuller participation in the ongoing process of European economic integration. This was made clear to ESA members and may also have helped to overcome some initial hesitations or doubts concerning Austria's eventual membership in the organisation.

228 For a comprehensive review of the history of ESA and its predecessors the reader is referred to: J. Krige and A. Russo (with contributions by M. De Maria and L. Sebesta), *A History of the European Space Agency 1958-1987, Volume 1: The Story of ESRO and ELDO, 1958-1973*, R.A. Harris (Ed.), ESA SP-1235, Vol. 1, European Space Agency, Noordwijk, 462 p., 2000; J. Krige, A. Russo and L. Sebesta, *A History of the European Space Agency 1958-1987, Volume 2: The Story of ESA, 1973-1987*, R.A. Harris (Ed.), ESA SP-1235, Vol. 2, European Space Agency, Noordwijk, 703 p., 2000.

229 OEEC – Organisation for European Economic Cooperation, established in 1948, with Austria as a founding member.

230 OECD – Organisation for Economic Co-operation and Development, superseded OEEC in 1961.

231 EFTA – European Free Trade Association, established in 1960, with Austria as founding member.

232 EEC – European Economic Community, established 1958.

Even though Austria was a founding member of COPERS, it did not become a full member of ESRO at its foundation in 1964, and there was no way to collaborate within its programmes. ESRO representatives, including *Johannes Ortner*, were invited in 1972 to present the organisation to an Interministerial Commission in Austria. Austria's reaction was in general positive and the government set up the Austrian Space Agency in 1972 to manage the build-up of potential and capacities for a possible Austrian participation in Europe's space programme.

As a result of increased interest of Austrian institutions and the preparatory work done by ASA, participation in ESA programmes became desirable. Possibilities for participation were discussed with the Director General of ESA, *Roy Gibson* and this resulted in the Spacelab-1 agreement (see section **Spacelab-1**). The Director General also made it possible for Austria to send delegates as observers to the ESA Council, the Scientific Programme Committee (SPC), the Programme Board for Communications and Meteorology, and to the International Relations Advisory Group.²³³

In May 1975, Austria's associate membership in ESA was recommended to the ministry, but it was not until October 1977 that Austria stated that it was prepared to commence final negotiations to become an associate member, after ratification of the ESA Convention by all Member States. On 17 October 1979, after intensive negotiations between ESA and the Austrian government, the Federal Republic of Austria signed an agreement with ESA to define the conditions governing the association with the agency for five years. This allowed Austria to be represented in the ESA Council and other ESA bodies. It also gave Austrian experts the opportunity to collaborate in ESA working groups and mission definition studies. Moreover, Austria could send observers to various other programme boards and participate in optional programmes, the educational and study programme.

After the ratification procedure by the Austrian Parliament, completed in December 1980, the agreement entered into force in April 1981.²³⁴ In November 1981, a team was formed to work out a concept for Austria's future participation in space research. It consisted of representatives from government, academia and industry, and was chaired by *Willibald Riedler*. This concept described the status of science and industry, and future possibilities. It served as a basis for decision-making and it set priorities and gave recommendations. The results of the working team discussions were published in a report.²³⁵

The main recommendations were (excerpt only):²³⁶

- Build a national space research programme with special emphasis on the following topics: experimental and relevant theoretical work for investigating the solar system; satellite geodesy; remote sensing; communication satellites.
- Concentrate and intensify research with high priority in fields where investments had already been made in the past.
- Priority support for industry-related research and transfer of know-how from academia to industry.
- Expansion of the Space Research Institute of the Austrian Academy of Sciences.
- Consider becoming a full member of ESA after termination of the agreement between the association and ESA in March 1986.

Additionally, the Federal Ministry for Science and Research called for expert opinions, and as a result of the good experience of industry and scientific institutions in the past during the participation in ESA programmes, it intensified negotiations with ESA in 1985. In December 1986 an "Advisory Committee for Space Research and Technology of the Austrian Government"²³⁷ was established with members of four Ministries (Science and Research, Foreign Affairs, Economy and Transport, and Finance), the Federal Economic Chamber, the Austrian Academy of Sciences, the Conference of University Rectors and ASSA.

233 "Geschäftsbericht, Annual Report, 1974/1975, der Österreichischen Gesellschaft für Weltraumfragen Ges. m.b.H., Austrian Space Agency (ASA)", Wien, 22 p., 1976, pp. 5-6.

234 BGBl. 93/1981; changes in: BGBl. 150/1985.

235 Weltraumforschung: Konzept, *op. cit.* .

236 *ibid.*, pp. 110-113.

237 Council of Ministers, "Zahl 70.205/88-25/86"; private communication, Otto Zellhofer, November 2002.

The committee was asked to work out a long-term strategy for Austria's participation in space projects, to recommend participation in specific optional ESA programmes and the science programme, and to evaluate the national space programme.²³⁸

After discussions concerning the size of the "entrance fee" to be paid, the ESA Council unanimously adopted the text, and the agreement was signed by the Federal Minister of Science and Research *Heinz Fischer* in December 1985 at ESA headquarters in Paris, France. The association agreement, signed originally for 5 years, was extended until Austria became a full member on 1 January 1987.²³⁹ After joining ESA as a full member in 1987, Austria benefited from full access to the entire scientific and technological know-how related to the projects signed up for. Several scientists, such as *Siegfried J. Bauer*, *Konrad Schwingenschuh*, *Werner Weiss* and *Wolfgang Baumjohann* (since 2002), were elected members of ESA scientific advisory groups. In 1984 *Siegfried J. Bauer* was appointed as the first Austrian, while the country was still an associate member, a member and later chairman of the Solar System Working Group (SSWG) and thus a member of the Space Science Advisory Committee (SSAC). And later chair of the Planetary Science Team in the long-range Space Science *Horizon 2000* planning effort.

AustroMir

Based on the positive experiences during the intense bilateral collaboration, gained over almost two decades of space research, the Soviet Chairman of the Council of Ministers (*Nikolaj I. Ryshkov*), during his official visit to Austria in July 1987, extended an invitation for an Austrian cosmonaut to perform Austrian scientific experiments for a period of about one week onboard the Soviet (Russian) space station Mir. The Austrian government accepted the offer in March 1988, and after intensive negotiations an official contract was signed in October 1988.²⁴⁰ This was followed by a detailed working agreement between Licensintorg, representing Glavkosmos, and the Austrian Federal Ministry for Science and Research in November 1988.²⁴¹

The flight was to be performed on a commercial basis in October 1991 as a joint undertaking with equal rights of both partners to the scientific outcome. Subsequently, *Otto Zellhofer* was nominated Austrian representative of the AustroMir project (project management jointly with *Ulrike Unterer* (until March 1992) and *Christian Wild* (since March 1992); financial responsibility: *Helmut Schacher*, *Eleonore Heid*), *Willibald Riedler* was designated the scientific director for AustroMir and the ministry entrusted the Institute of Applied Systems Technology (IAS) (head: *Willibald Riedler*) of Joanneum Research (directors: *Berghold Baier* and *Rainer Uranschek*) in Graz to coordinate and manage the project (technical manager: *Christian Feichtinger*; organisational manager: *Bruno Josseck*).²⁴² Already in spring 1988 a public announcement of flight opportunity for payloads was issued opening a new field to Austrian research activities in space. A second public announcement asked for applications as cosmonaut candidate.

From the 34 proposals received, a total of 15 scientific experiments were selected by a joint Austro-Soviet committee, nine from the field of space medicine, one from physiology-signal processing, two from physics/material sciences, one from remote sensing, one mission support and one amateur radio project. Additionally, one project in multimedia art (Prof. *Richard Kriesche*) was designated.

238 "Tätigkeitsbericht, Report on Activities, 1986, Österreichische Gesellschaft für Sonnenenergie und Weltraumfragen Ges. m.b.H., Austrian Solar and Space Agency (ASSA)", Wien, 57 p., 1987, pp. 49-50.

239 BGBl. 150/1985; BGBl. 95/1987.

240 BGBl. 113/1989.

241 W. Riedler, "The joint Austro-Soviet space project AUSTROMIR-91", in: *Proceedings of Satellite Symposium 4: Columbus Eight (COSY-8) Utilisation of Earth Orbiting Laboratories*, ESA ISY-4, Noordwijk, 1992, pp. 93-96 short form: Riedler, AUSTROMIR-91); W. Riedler, The joint Austro-Soviet space project AUSTROMIR-91, *Space Technology*, **13** (02), pp. 175-180, 1993.

242 U. Unterer, F. Viehböck und O. Zellhofer, "W. Riedler und AUSTROMIR – Der Sprung Österreichs in die bemannte Raumfahrt", *Elektrotechnik und Informationstechnik*, **117** (09), pp. 537-540, 2000; C. Feichtinger, B. Josseck, et al., "Technical management and test procedures for AUSTROMIR-91", in: *Proceedings of Satellite Symposium 4: Columbus Eight (COSY-8) Utilisation of Earth Orbiting Laboratories*, ESA ISY-4, Noordwijk, 1992, pp. 111-115.

The experiments selected were:²⁴³

- **MONIMIR**: measurement of arm, eye and head movements; investigation of the influence of weightlessness on postural and positional reflexes (project responsibility: *Meinrad Berger; Franz Gerstenbrand; Massud Mossaheb*).
- **MOTOMIR**: investigating the functioning of arm and leg muscles under weightlessness and muscle fatigue under stress (project responsibility: *Norbert Bachl*).
- **DOSIMIR**: simultaneous measurement of particle beams and electromagnetic ionising radiation on board the space station (project responsibility: *Norbert Vana*).
- **PULSTRANS**: investigating changes in the blood circulation and the distribution of the bloodstream during the space flight (project responsibility: *Maximilian Moser; Thomas Kenner*).
- **COGIMIR**: investigation of the brain functions according to neurophysiological criteria before, during and after the space flight (project responsibility: *Thomas Benke; Franz Gerstenbrand*).
- **MIKROVIB**: investigating the influence of weightlessness on microvibrations as measured in the arm (project responsibility: *Eugen Galasch; Thomas Kenner*).
- **BODYFLUIDS**: investigating the effects of bloodstream changes on hormone systems; measuring the quantity and properties of the fluid which is thereby exchanged between blood and tissue (project responsibility: *Helmut Hinghofer-Szalkay; Thomas Kenner*).
- **OPTOVERT**: investigating the effects of the lack of gravity as counterforce to optical information and possible changes in vertical orientation (project responsibility: *Christian Müller; Luder Deecke*).
- **MIRGEN**: investigation of genetic changes in lymphocytes, their possible repair and immunological effects (project responsibility: *Helga Tuschl*).
- **AUDIMIR**: measuring acoustic localisation error and the significance of acoustic orientation in conditions of weightlessness (project responsibility: *Alexander Persterer*).
- **LOGION**: test of ion-emitters, used to prevent electrostatic charging of space vehicles (project responsibility: *Friedrich Rüdener; Willibald Riedler; Klaus Torkar*).
- **MIGMAS-A**: testing a scanning ion microscope for material analysis under space conditions (project responsibility: *Willibald Riedler, Friedrich Rüdener; Robert Finsterbusch*).
- **FEM**: Earth survey measurements from Mir in combination with other air and surface measurements (project responsibility: *Rainer Kalliany; Karl Kraus*).
- **DATAMIR**: computer system for collecting and recording data from the scientific experiments on board the space station (project responsibility: *Manfred Steller; Willibald Riedler*).
- **AREMIR**: construction of radio apparatus for contact between the cosmonauts and school pupils and amateur radio enthusiasts in Austria and the Soviet Union (project responsibility: *Gustav Paier, Nicolas Valavanoglou; Willibald Riedler*).

Meinrad Berger was also named coordinator of medical experiments for AustroMir.

After a thorough investigation of the physical and mental suitability of the 198 cosmonaut candidates, (by medical and psychological experts, *Walter Bein, Joachim Huber* and *Christian Nemetz* of the Army Hospital Vienna) seven candidates were initially selected and finally two emerged: *Franz Viehböck*, an electrical engineer, and *Clemens Lothaller*, a physician.²⁴⁴ In January 1990 both started their training at “Star City” (Zvezdny Gorodok) on the outskirts of Moscow.

243 Riedler, AUSTROMIR-91, *op. cit.*, pp. 94-95.

244 F. Viehböck and C. Lothaller, *AUSTROMIR. Der österreichische Schritt ins Raumzeitalter*, Edition Tau, Bad Sauerbrunn, 217 p., 1991.

The short time frame for preparation, and the tight financial constraints, made AustroMir a demanding project. Fortunately, it was realised with help, dedication and commitment from the Soviet (Russian) side, which had a strong interest in the scientific findings of the experiments.

On the Austrian side, institutions from about 20 University departments in Vienna, Graz and Innsbruck, the Austrian Research Centre Seibersdorf and the Space Research Institute of the Austrian Academy of Sciences participated.²⁴⁵

In anticipation of the forthcoming event, a large scientific and technological fair was organised in October 1990 at the Austria Centre Vienna, highlighting achievements of the Soviet Union, in particular but not exclusively in the field of space technology. As a special attraction an accessible full-scale model of the space station Mir was on display.²⁴⁶

The flight of the (finally selected) Austrian cosmonaut *Franz Viehböck* with his two fellow cosmonauts *Alexandr A. Volkov* (Russia) and *Toktar O. Aubakirov* (Kazakhstan) to the Mir space station took place on 2 October and lasted until 10 October 1991. It received a great deal of public attention in Austria. *Franz Viehböck* was able to carry out all experiments and returned safely to Earth.²⁴⁷

The evaluation of the various medical experiments provided deep insight into differences in the way biological mechanisms act in microgravity conditions and led to several follow-on activities in the medical/biological sciences.²⁴⁸ But physical/material sciences and technology development also benefited from the knowledge and experience gained during the project, and several spin-off and follow-up projects were carried out. The most important were: the use of the digital videoconferencing system used during the AustroMir project for the German Mir-92, ESA's Euromir-94 and Euromir-95 missions as a communication tool between the station and different ground stations²⁴⁹ and the repeated use of the scanning ion microscope, which remained on Mir after AustroMir. These activities led to the development of a space-tested ion microprobe mass spectrometer for use on Mir or the Russian module of the International Space Station.²⁵⁰

In 1991 the *Austrian Society for Aerospace Medicine & Life Sciences in Space (ASM)* was established to pursue the following aims:²⁵¹

- Plan, coordinate and implement scientific research in the field of aerospace medicine and space life sciences on a national and international level.
- Foster interdisciplinary research approaches.
- Adapt instrumentation and methods employed in space medical research to terrestrial applications for medical diagnosis, therapy, prevention and rehabilitation.
- Issue publications and provide information to the general public concerning aerospace medicine and space life sciences.

245 *AUSTROMIR Handbuch*, Bundesministerium für Wissenschaft und Forschung (Hrsg.), W. Riedler (Redaktion), Graz, 216 p., August 1991.

246 *Wissenschaft und Technik der UdSSR auf der internationalen Wissenschaftsmesse WORLD TECH VIENNA*, promotional brochure, Wien, October 1990, 40 p; *Komm zu MIR. Eine Begegnung der besonderen Art. Die Weltraumstation MIR landet in Wien*, exhibitors catalog, World Tech Vienna, October 1990, 48 p.

247 *Projekt AUSTROMIR 91*, Bundesministerium für Wissenschaft und Forschung (Hrsg.), W. Riedler (Redaktion), Graz, 228 p., 1992.

248 "Austrian Report to COSPAR, 1992", COSPAR Committee of the Austrian Academy of Sciences (Hrsg.), 59 p., 1992, esp. pp. 39-54.

249 O. Koudelka, Satellitenkommunikationssysteme und ihre Anwendung, *Elektrotechnik und Informationstechnik*, **117** (09), pp. 560-566, 2000, esp. p. 563; A. Fellenberg, "Euromir. Die Mission", *Raumfahrt in Europa*, 12/1994, pp. 20-25, 1994.

250 "Space Research in Austria 1996-1997. Report to COSPAR 1998", National Committee for COSPAR of the Austrian Academy of Sciences (Hrsg.), 65 p., 1998, esp. pp. 51-52.

251 "Space Research in Austria 1994-1995. Report to COSPAR 1998", National Committee for COSPAR of the Austrian Academy of Sciences (Hrsg.), 59 p., 1996, esp. p. 43.

ASM has subsequently flown modified and improved versions of medical and life science experiments from the AustroMir project within the scope of the “Russian Longterm Flight Project (RLF)” and its follow-on phases in collaboration with its Russian partner institution.²⁵²

Involvement of Austria’s Industry in Space Activities²⁵³

Industry’s involvement in space-related activities was boosted by Austria’s participation in the Spacelab-1 programme in 1974/75. Investing in production equipment for space-related products or components constituted a high risk for Austrian industry, mainly due to the nonrecurring nature of the production process. Nevertheless the advantages of gaining access to the latest technology outweighed the uncertainties and some Austrian companies entered the competition.

The “Österreichische Klimatechnik GmbH (ÖKG)”, being asked to produce the Spacelab-1 viewport adapter, was the first company that worked with an ESA-contract. The decision to put an Austrian company in charge of this contract had been a political one. Without the help of ESA and the German government and engineers hired from the UK to help with the production of the adapter, this contract would not have been fulfilled, because the Austrian expertise in this field at the time was rather limited. Despite the fact that procurement of the contract was a huge success, the return coefficient of the Spacelab-1 programme only reached about 0.46. Austria participated with 0.8 % of the total programme costs, of which the Federal government contributed 5/8 of the sum and 1/8 each was provided by the Federal Economic Chamber, the “ÖIAG”,²⁵⁴ and the “Vereinigte Metallwerke Ranshofen-Bernsdorf AG”.²⁵⁵ The development and construction of a transport container including accessories for the transport of fully integrated pallet-bridges (instrument platforms) was also carried out by ÖKG. A follow-on contract for mechanical ground support equipment (MGSE) for the planned **I**nternational **S**olar **P**olar **M**ission (ISPM) had already been negotiated. In 1983 ÖKG went bankrupt and the “space group” continued its activities within the “Vereinigte Metallwerke Ranshofen-Bernsdorf Aktiengesellschaft”. Later this group - together with the German company “Dornier System GmbH” - founded the firm “Österreichische Raumfahrt- und Systemtechnik GmbH”, abbreviated to “ORS”.²⁵⁶

In 1982/83 the firm ‘Elin-Union Aktiengesellschaft’, based in Weiz, Styria, was awarded a contract to supply parts of the electrical ground support equipment for the ESA telecommunications programme “L-Sat”. In 1984/85 in the framework of the Austrian participation in the Columbus Preparatory Programme, contracts to the firms “Elin-Union AG” and “ORS” were issued for supplying parts for the resource module and the platform. In spring 1985 a contract was awarded to the Vienna-based firm “Schrack Elektronik AG”, in collaboration with the Institute of Communications and Radio-Frequency Engineering, Vienna University of Technology, for the industrial development of a CO₂-laser modulator, in the framework of the **A**dvanced **S**ystems and **T**echnology **P**rogramme (ASTP), nationally funded by the “Microelectronics” programme of the Federal Ministry of Science and Research. Contributions to the Olympus programme led to a commercial spin-off contract, “ORS” won a contract for MGSE for the national Italian communication satellite project Italsat (built by “Alenia Spazio” for the Italian Space Agency; launched in January 1991 by an Ariane launcher). Contracts in respect of the Earth Observation Programme were issued in 1984/85 to “ORS” for parts of MGSE and support equipment for the active microwave experiment on ERS-1 (Earth Remote Sensing Satellite) and to “Schrack Elektronik AG” for the construction of an electric test and simulation unit for the ERS-1 radar altimeter.

The participation of Austrian industry in space-related activities during Austria’s associate membership in ESA (1981-1986) and the success during this period fostered several other industrial activities in the field.

252 *ibid.*, pp. 43-49; *10 Years Space Biomedical Research and Development in Austria*, Helmut G. Hinghofer-Szalkay (Ed.), Facultas Verlag, Wien, 157 p., 2001.

253 Contributions of Austrian industry increased steadily during the years and so only a subjective list can be presented in this chapter; within the different programmes several contracts for system studies were issued to Austrian research institutions; they are not mentioned in this chapter; information was compiled from material provided by ASA and different brochures of Austrian companies engaged in space activities.

254 Österreichische Industrieverwaltungs-AG, Austrian Industry Management Corporation.

255 Short: “VMW”; United Metal Works Ranshofen-Bernsdorf.

256 Austrian Space System Technology.

Finally, with an eye on the promising prospects for technology and innovation, Austria became a full member of ESA in 1987.

Austria's participation in the ESA optional programmes, especially the ones for Earth Observation, Telecommunications and Space Transportation prepared the ground for additional industrial activities in these areas. During the first few years of Austria's membership in ESA the development of a laser test bed, the construction of CDMA (Code Division Multiple Access) terminals and a Neodymium-YAG laser modulator by "Schrack Elektronik AG", as well as the development of software for the analysis of microwave propagation data by a group within "Siemens AG Österreich" are all worth mentioning. Even though Austria did not participate in the Ariane-1 to Ariane-4 Programme and the Ariane-5 Preparatory Programme, Austria signed up to a 0.4 % contribution to the Ariane-5 Development Programme in 1988. This opened the way for the participation of special branches of the companies "Steyr-Daimler-Puch Fahrzeugtechnik AG & CoKG" (head of group: *Hans Peter Gryksa*), renamed several times after its buyout in 1999, now "Magna Steyr Fahrzeugtechnik AG & CoKG, Engineering/Space Technology" (head of group: *Werner Gryksa*), and "Andritz AG", part of the publicly listed "Andritz Group", a global market leader in the supply of customised plants, systems, and services for the pulp and paper industry, the steel industry, and other specialised industries, in various projects as component suppliers for solid- as well as liquid-fuel rocket boosters. Within these programmes several smaller companies established themselves as manufacturers of components and assemblies for Ariane-5. Additionally, Austria's participation in the AustroMir project at the end of the 1980s gave rise to the foundation of subsidiary companies, especially in fields of aerospace medicine management.

Shortly after Austria joined ESA a working group of interested firms and institutions was set up within the Federal Economic Chamber. From this precursor in the beginning of 1991 several Austrian space-engineering companies built up the Austrospace Association (chairman from 1991-97: *Georg Serentschy*; vice chairman from 1991-97: *Mario Rohrer*), an umbrella organisation, to unveil their products and services to the public and policy makers (chairman from 1998 to present: *Oskar Beckmann*; vice chairman from 1998 to present: *Max Kowatsch*).²⁵⁷ About two dozen of these companies working in space-related fields benefited from Austria's involvement in ESA, especially in the optional programmes Austria signed up to, and so Austria's industry was able to contribute successfully to many different ESA space missions.

In the Earth Observation Programme, "Schrack Elektronik AG", later renamed to "Schrack Aerospace GmbH", was involved in the manufacturing and testing of a radiometer instrument and the development of a return signal simulator for a radar altimeter of ERS-1 and ERS-2. For Envisat (**E**nvironmental Monitoring **S**atellite) the company developed a centralised electronics unit for a microwave radiometer instrument and a return signal simulator for an advanced radar altimeter.

The firm "ORS", its main important field being traditionally MGSE for satellites, participated in the science programmes ISO (Infrared Space Observatory) by providing major parts of its sunshield, MGSE for SOHO (**S**olar and **H**eliospheric **O**bservatory) and Cluster (a mission consisting of four satellites to explore near-Earth space), and the de-spinning mechanism, thermal protection and parts for scientific instruments of the Huygens entry probe (ESA-part of the NASA/ESA mission Cassini/Huygens to investigate the Saturnian system and especially its moon Titan).

In the Earth Observation Programmes several firms, like "GEOSPACE Beckel" and "GeoVille", as well as research institutes of the Vienna University of Technology, the University of Graz and "Joanneum Research", participated in several studies on different topics.

In 1997 "Schrack Aerospace GmbH" and "ORS" merged and became the company "Austrian Aerospace". It focused on mechanics and thermal hardware as well as electronics, and is the most active industrial company on the Austrian space scene. Since 1997 it contributed *inter alia* to the telescope sunshield and the mirror doors of XMM-Newton (X-ray space observatory), to thermal hardware for the Integral (Gamma Ray Observatory), and the pyro-release electronics unit of the Meteosat (2nd generation) mission. Recently, the firm contributed significantly to the thermal isolation of the Mars Express spacecraft (ESA mission to Mars) and the electronics for a scientific instrument of the Rosetta (ESA mission to a comet) mission. Since 1998

257 "Austrian space technologies", brochure, Austrian Federal Economic Section – Industrial Section, Vienna, 48 p., 1995.

Austrian Aerospace was involved also in the Metop programme, constituting with its three satellites, launched sequentially beginning in 2005, the space segment of Eumetsat's system of polar orbiting satellites, providing hardware and software for structural elements, thermal isolation, electrical test, mechanical ground support equipment and digital signal processing units.

In the Telecommunications Programmes ASTP-4, Artemis and ARTES, the main contributing Austrian companies, besides research institutions like "Joanneum Research", Graz University of Technology and University of Salzburg (head of group: *Horst Clausen*), were "Siemens AG Österreich" and "Austrian Aerospace".

Within ESA's General Support Technology Programme (GSTP) the firm Plansee AG (head of group: *Klaus Rissbacher*) was able to develop advanced high temperature powder metallurgy materials for application in combustion chambers of rocket motors and thermal protection systems for re-entry.

One particular interesting ESA programme Austria participated in since 1991 was Prodex²⁵⁸, with its main objectives being to improve the relations between scientific and industrial circles, and to provide funding for the industrial development of scientific experiments proposed by institutes or universities. Two very successful examples within this programme were the development of the ACP (Aerosol Collector and Pyrolyser) instrument for the Huygens probe and the MIDAS (Micro-Imaging Dust Analysis System) for the Rosetta spacecraft, both proposed by the Space Research Institute.²⁵⁹

Additionally, Austria can benefit from its space activities through technology transfer by either creating new markets for industry or offering innovative solutions to other sectors.²⁶⁰ The Austrian Research Centres Seibersdorf Research GmbH (ARCS) was able to reach ESA-accreditation as a certified laboratory for the characterisation and qualification of materials and technologies for use in outer space.

Austria's industrial space activities were evaluated in 1999,²⁶¹ and thereafter an updated *National Austrian Space Plan* (Österreichischer Weltraumplan) was worked out in detail with partners in science and research institutions and published in 2001.

Projects in the 1990s and Beyond

In 1991 the International Union of Geodesy and Geophysics (IUGG) held its 20th General Assembly in Vienna. *Siegfried J. Bauer* gave the space-related Union Lecture on "Ionosphere: The edge of space". The IUGG, founded in 1919, is one of more than 25 scientific unions adhering to the International Council for Science (ICSU) and coordinates activities among seven semi-autonomous international scientific associations in different fields of geophysics.²⁶² At the meeting in Vienna the delegates elected *Helmut Moritz*, professor of physical geodesy at Graz University of Technology, to be the IUGG President for 1991-95.²⁶³

258 **PRO**gramme de **D**éveloppement d'**EX**périences Scientifiques

259 W. Riedler *et al.*, "Co-operation between science and industry – An essential impulse for research in Austria", in: *Academic and Industrial Cooperation in Space Research. Proceedings of an International Conference held in Vienna, Austria, 4-6 November 1998*, D. Danesy (Ed.), ESA SP-432, Noordwijk, 219 p., 1998, pp. 97-103

260 *Preparing for the Future*, 10 (02), 2000 (published by ESA).

261 Tichy and Posch, Neuordnung, *op. cit.*;

262 *International Union of Geodesy and Geophysics*, brochure, IUGG, 12 p., not dated, <http://www.iugg.org/brochure.pdf>

263 Biographical information (dated 2001),

see: <http://www2.rz.hu-berlin.de/leibniz-sozietaet/vorgestellt/2001/moritz.htm>

Cooperation within ESA Programmes²⁶⁴

Cassini/Huygens

The joint NASA/ESA mission launched on a Titan IVB/Centaur rocket in 1997 will explore the Saturn system starting in 2004. The ESA Huygens atmospheric probe carries two instruments with major Austrian participation in their development, the ACP (Aerosol Collector and Pyrolyser) and HASI (Huygens Atmospheric Structure Instrument). Both will perform measurements during the probe's descent into the atmosphere of Saturn's moon Titan. ACP will analyse the chemical composition of droplets and aerosols, and HASI will measure several standard and electrical atmospheric parameters. ACP has been designed and manufactured by Joanneum Research and Austrian Aerospace. Additional scientific support is provided by the Space Research Institute to the RPWS (Radio and Plasma Wave Science) experiment onboard Cassini, and GCMS (Gas Chromatograph and Mass Spectrometer) onboard Huygens.

Cluster

The four ESA magnetospheric probes launched by two Russian rockets in 2000 carry instruments developed by and with the Department of Experimental Space Research of the Space Research Institute in Graz, namely the Active Satellite Potential Control (ASPOC) and the Fluxgate-Magnetometer (FGM) electronics. ASPOC is an instrument to actively control the potential of the probes by injecting ions into the satellite's neighbourhood, and was developed in close cooperation with the Austrian Research Centres Seibersdorf Research GmbH. The instruments had previously been mounted on the ill-fated first set of Cluster satellites, when the Ariane-5 rocket exploded shortly after launch during its first test flight in 1996.

Rosetta

The mission originally scheduled for launch in January 2003 (launch postponed due to Ariane-5 problems) will carry several instruments developed by and with the Space Research Institute. The main contribution is the experiment MIDAS (Micro-Imaging Dust Analysis System), a system for dust collecting and an "Atomic Force Microscope", contributions to COSIMA (COmetary Secondary Ion MAass spectrometer), and the magnetometer RPC-MAG onboard the orbiter, as well as contributions to the MUPUS (MULTI-PURpose Sensor), "penetrator system", and ROMAP (ROsetta Lander MAgnetometer and Plasma monitor) on the lander. The mission is now targeted at comet Churyumov-Gerasimenko, whose activity will be studied from a low orbit over a long time period.

Mars Express

This mission is targeted at the investigation of the near Mars environment, specially it is going to search for subsurface water by means of radar measurements. The Space Research Institute is involved in the determination of the reception properties of the radar antenna system and the dielectric properties of martian soil. The launch took place in mid 2003 (project manager: *Rudolf Schmidt*).

GOCE

This mission will investigate the Earth's gravity field with unprecedented precision. The goal will be reached by a combination of satellite tracking and gravity gradiometry in a very low orbit. The detailed knowledge obtained will contribute to a variety of investigations of geodynamical processes in the oceans and the Earth's interior. The Institute of Geodesy of Graz University of Technology in collaboration with the Space Research Institute is participating in the mission.

Venus Express

Based on the experience gained over the last twenty years in the design and operation of magnetometers, the Space Research Institute will make a significant contribution to this recently approved ESA mission.

Doublestar

The two spacecraft are going to complement the Cluster measurements, one by investigating the equatorial region, and the other in a polar orbit. The Space Research Institute is providing a potential control instrument

²⁶⁴ Because the Austrian scientific space activities increased steadily during the past twenty years the following list constitutes only a subjective selection.

for the equatorial and magnetometers onboard the polar and equatorial spacecraft of this Chinese/ESA mission.

Bilateral projects

In continuation of the extraordinarily successful collaboration with the Soviet Union during the 1980s, Austria participated in several follow-on Russian missions:

Mars-96

The Space Research Institute, the Institute of Communications and Wave Propagation, Graz University of Technology as well as the Institute of Astronomy, University of Vienna were involved in this Russian mission to Mars. A malfunction of the propulsion system terminated the mission shortly after launch in 1996.

Interball

The Space Research Institute developed instruments for the potential control of the Russian probe, which performed very well during the mission. The know-how gained during the measurement phases contributed to the design in subsequent instrument developments.

Mir

For experiments performed at the Russian space station, the Space Research Institute provided a magnetometer for the study of the station's magnetic environment. This topic is becoming more and more important in view of the envisaged operational use of the International Space Station (ISS) in the near future.

Other bilateral space missions:

Sounding Rocket Campaigns

In continuation of its activities, the Institute of Communications and Wave Propagation, Graz University of Technology, participated in several sounding rocket campaigns, from the Swedish base Esrange (1991 and 1993) and from Andøya, Norway, Alcântara, Brazil (1994) and in the McWave campaign (2002 and 2003) from Scandinavian ranges. The topics under investigation were, *inter alia* noctilucent clouds, aerosols and the dynamics of the mesosphere, respectively.

Geotail

The primary purpose of this Japanese mission launched in July 1992 was to study the structure and dynamics of the tail region of the Earth's magnetosphere. The Austrian Research Centres Seibersdorf Research GmbH contributed to the electric field instrument by supplying the liquid metal ion sources for controlling the satellite potential.

Equator-S

The Space Research Institute contributed a Potential Control Device (PCD) to this German low-cost mission designed to study the Earth's equatorial magnetosphere, to reduce the spacecraft potentials, to allow plasma particle measurements to very low energies. PCD was identical to the ASPOC instrument developed for Cluster. The spacecraft was launched into orbit in December 1997.

Deep Space 1

The Space Research Institute contributed to the fluxgate magnetometers on board NASA's satellite mission to an asteroid, launched in October 1998. The mission was the first to utilise ion propulsion and an autonomous navigation system in interplanetary space.

Corot

The Institute of Astronomy, University of Vienna, is contributing hardware, which is being developed in collaboration with the Space Research Institute, to this French space mission dedicated to stellar seismology and the study of extra-solar planets. The launch is scheduled for the end of 2005.

Themis

The Space Research Institute is contributing to the magnetometers for the NASA medium class Explorer mission consisting of five small satellites carrying identical suites of electric, magnetic, and particle detectors

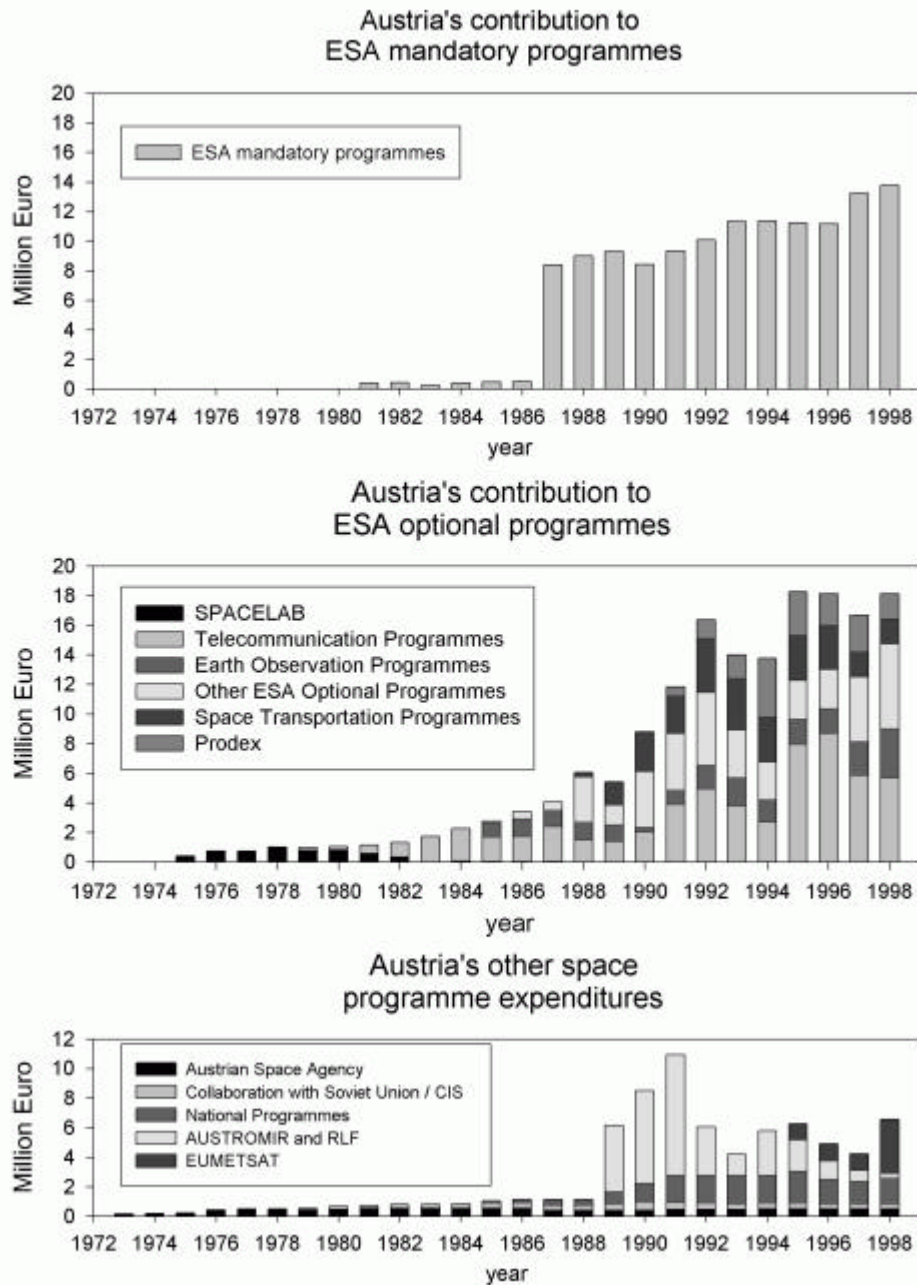
that will be used to determine the cause of global reconfigurations of the Earth's magnetosphere. The launch is scheduled for 2007.

Appendix A: Chronological List of Important Events

16th century	Powder rockets by Conrad Haas
17th century	Activities of Johannes Kepler
18th century	Northern light theory of Maximilian Hell
first half of 19th century	Military rocket development by Vinzenz von Augustin
1872-74	Austro-Hungarian North Polar Expedition
1882-83	First International Polar Year
1911-13	Discovery of cosmic radiation by Viktor Franz Hess
1919	Proposal of an electron rocket by Franz Ulinski
1923	Publication of Hermann Oberth's book "Rocket into Interplanetary Space"
1924	Alfred Wegener accepts professorship in Graz
1926	Scientific Society for High-Altitude Research founded in Vienna
1931	Austrian Society for Rocket Engineering founded in Vienna
1932/33	Second International Polar Year
1946	Installation of ionospheric observatory at Institute of Meteorology and Geophysics, University of Graz
1949	Austrian Society for Space Research founded in Innsbruck
1951	Austrian Society for Space Research is founding member of International Astronautical Federation
1954	5 th International Astronautical Congress held in Innsbruck
1957/58	Austria participates in International Geophysical Year
1961	Austria joins COPERS
1963	Austria joins COSPAR
1966	9 th COSPAR General Assembly held in Vienna
August 1968	UNISPACE-1 conference held in Vienna
1969	Institute of Communications and Wave Propagation at Graz University of Technology established
26 November 1969	First scientific instruments built in Austria are launched onboard a sounding rocket from Andenes, Norway
24 April 1970	Space Research Institute, Austrian Academy of Sciences established
1972	23 rd International Astronautical Congress held in Vienna International Symposium on Satellite and Terrestrial Triangulation held in Graz
1972	Austrian Space Agency founded
1975	First Space Summer School held at Alpbach, Tyrol
1976	Austria's participation in Spacelab-1 codified
December 1976	Observatory Lustbühel put into service
1978	21 st COSPAR General Assembly held in Innsbruck
April 1981	Austria joins ESA as an associate member
March 1982	Venera 13 and 14 near Venus with Austrian magnetometers onboard
August 1982	UNISPACE-II conference held in Vienna
1982	First "Austrian Space Plan" published by the Federal Ministry of Science and Research
December 1983	Spacelab-1 in orbit with three Austrian instruments onboard
1984	25 th COSPAR General Assembly held in Graz
March 1986	Vega 1 and 2 flyby of Comet Halley with two Austrian-Soviet magnetometers onboard
1986	37 th International Astronautical Congress held in Innsbruck
1986	Start-up of decametric radio observations at Observatory Lustbühel
1 January 1987	Austria becomes a full member of ESA
March 1987	ESA Council in Vienna
February-March 1989	Phobos 2 in Mars orbit with Austrian magnetometer onboard
July 1987	Invitation by the Soviet Union to fly Austrian experiments and cosmonaut to space station Mir; project "AustroMir"
1991	20 th IUGG General Assembly held in Vienna
2 to 10 October 1991	Franz Viehböck is first Austrian in Space
1993	44 th International Astronautical Congress held in Graz
1996	International Space University (ISU) Summer Session held in Vienna
1999	UNISPACE-III conference held in Vienna
2001	First inter-university postgraduate lecture course on space sciences
2002	Austrian National Space Plan

Appendix B: Austria's Space Budget

The expenditures given in the graphs do not include the expenses of the Federal Ministries for the ordinary budget of research institutes involved in Austria's space research.



Appendix C: Short Biographies of Key Players

Siegfried J. Bauer (*1930), Em. O. Univ.-Prof., Dr. phil.

1948–53 studied physics, geophysics and meteorology at the University of Graz; dissertation in ionospheric physics with Otto Burkard. Soon after graduation in 1953 emigration to the United States where he first worked on a moon radar at a military research centre in New Jersey. From 1961–81 NASA Goddard Space Flight Centre in Maryland, at last as associate director of space science. From 1981–98 chair of meteorology and geophysics at the University of Graz and department head and deputy director of the Space Research Institute of the Austrian Academy of Sciences in Graz; 1985–90 Dean of the School of Natural Sciences, University of Graz. Interdisciplinary scientist and Co-Investigator of numerous instruments of several space missions (recently: Pioneer Venus, Mars Observer, Mars Global Surveyor, NOZOMI, Cassini/Huygens). NASA Medal for Exceptional Scientific Achievement (1974), Full Member, Austrian Academy of Sciences (1983), member of International Academy of Astronautics (1986) and Academia Europaea (1992). Retired in 1998.

Wolfgang Baumjohann (*1950), Prof., Dr. rer. nat.

1969–75 studied physics at the University of Münster, Germany; in 1975 Diploma in Physics; in 1981 Dr. rer. nat. 1975–83 research scientist at Institute of Geophysics, University of Münster, 1983–2000 scientist, Heisenberg Fellow and later senior scientist at Max-Planck-Institute of Extraterrestrial Physics, Garching, Germany. Since 1993 teaching space physics at University of Munich. Since 2001 head of the Department of Experimental Space Research, Space Research Institute, Graz. Since 2002 Austrian delegate to the ESA Science Programme Committee. Principal Investigator and/or Co-Investigator of numerous instruments on space missions (recently: Cluster, Themis, Doublestar, Venus Express). Member of the International Academy of Astronautics (2002); Fellow of the American Geophysical Union (2003). 2002–04 Member ESA Solar System Working Group.

Oskar Beckmann (*1942), Dipl.-Ing.

1961–66 studied electrical engineering at the Vienna University of Technology and graduated in 1966. In 1967 he joined the R&D division of Siemens Austria. In 1979 he became managing director of Siemens Cable TV Companies in St. Pölten and Ma. Enzersdorf. 1985–93 head of Digital Signal Processing department. Since 1993 director of the Space Business Unit of Siemens. Member of the supervisory board of ASA and president of the association Austrospace.

Otto Burkard (*1908), Em. O. Univ.-Prof., Dr. phil.

Studied physics at the University of Graz; dissertation in the field of atmospheric electricity with Hans Benndorf; graduated in 1933. 1934–38 assistant at the Institute of Physics, Graz University of Technology. 1938–42 teacher of physics, mathematics and radio engineering at a Technical College in Graz. 1942–45 work at a radio observation station in Tromsø, Norway. In 1947 Burkard became provisional head of the Institute of Meteorology and Geophysics, University of Graz, and finally in 1949 he was appointed head and served in this capacity until his retirement in 1981. 1969/70 Rector of the University of Graz. 1975–84 managing director of the Space Research Institute of the Austrian Academy of Sciences in Graz. Full Member of the Austrian Academy of Sciences (1969).

Ferdinand Cap (*1924), Em. O. Univ.-Prof., Dr. phil.

Studied physics, mathematics and chemistry at the University of Vienna and graduated (“sub ausp. pres.”) in 1946. 1945–48 assistant professor at the Institute of Theoretical Physics, University of Vienna. 1948–49 worked in Swiss industry and at ETH Zürich. 1949–60 assistant professor at Institute of Theoretical Physics, University Innsbruck. Founding member of the International Astronautical Federation (IAF). 1960–88 full professor at the Institute of Theoretical Physics, University Innsbruck. Frequent guest professor at several US and other foreign Universities (South Africa, India, Japan) and guest researcher at NASA centres. Recipient of Rutherford Medal of the USSR Academy of Sciences (1974); Honorary Member of the National Academy of Sciences of India (Rajasthan). Retired in 1988.

Ernst Fas an (* 1926), Dr. iur.

After returning from war captivity in 1947 he studied law at the University of Vienna and graduated in 1950. After court practice he established his own law firm at Neunkirchen, Lower Austria in 1955. Served as examiner for judge aspirants at appellate court. Founding member of the International Institute of Space Law (IISL) in 1960; member of the board and secretary, now Honorary Director. Retired in 1994. Member of the International Academy of Astronautics.

Wilhelm Grimburg (* 1923), Sektionschef, Dr. iur.

After military service studied law at the University of Vienna and graduated in 1950. After court practice he worked from 1952 to 1960 at the “Finanzprokuratur” and from 1960 to 1970 at the “Österreichische Industrieverwaltungs-AG”. In October 1970 he entered into the office of the Federal Chancellor and from 1971 to 1984 he was head of the research section of the newly established Federal Ministry for Science and Research. Retired in 1984.

Werner Gryksa (*1956), Dipl.-Ing., Dr.

1979–84 studied aeronautical and aerospace engineering at the Technical University Munich and graduated in 1984. 1984–91 various positions at Max-Planck-Institute for Extraterrestrial Physics, Garching, DLR Oberpfaffenhofen, NASA, DASA and ESA/ESTEC. 1989(1992)–98 managing director of CASE Aerospace Consulting and CAW Electronics in Germany. Since 1998 managing director of the space technology division of Steyr Daimler Puch, renamed in 1999 to Magna International Developments Austria and in 2002 to Magna Steyr Fahrzeugtechnik, in Graz.

Peter Jankowitsch (*1933), Botschafter, Diplom-Übersetzer, Dr. iur.

Graduated from Vienna University (1956) and Hague Academy of International Law (1959). Joined Austrian Foreign Service in 1957 and served in Vienna, London and Dakar, where, as *Chargé d’Affaires en pied*, he established the first Austrian diplomatic mission in French-speaking Africa. 1970 Director of Cabinet of Federal Chancellor Bruno Kreisky. As Permanent Representative of Austria to the United Nations (New York) from 1972 member of the UN Security Council (1973/74). From 1972 (until 1991) Chair of COPUOS, 1982 acting head of Austrian delegation to UNISPACE 82. As Ambassador of Austria to OCDE (Paris) from 1978 prepared Austria’s first association agreement with ESA. Elected to Austrian Parliament in 1983 and appointed Federal Minister for Foreign Affairs 1986. 1990–92 served as Secretary of State for Europe and Development Cooperation in a second cabinet function. In Parliament (until 1993) co-chaired first Joint Committee between the Austrian and the European Parliament. 1993–98 Ambassador to OECD and ESA, member, *inter alia* of ESA’s Long Term Space Policy Committee. 1998 Chair, Supervisory Board of Austrian Space Agency. Elected Member of International Academy of Astronautics (1998), serving *inter alia* as member of Board of Trustees. 1999 President Austrian National Committee for UNISPACE 99, heading also UNISPACE Technical Forum. Honorary Member of Board, International Institute for Space Law. Received *inter alia* Allan D. Emil Memorial Award for International Cooperation in Astronautics (1981) and Social Sciences Award IAA 2001.

Otto Koudelka (*1954), Univ.-Prof., Dipl.-Ing., Dr. techn.

1974–80 studied electrical engineering at the Graz University of Technology. 1980–82 scientist at Institute of Applied Systems Technology, Forschungszentrum Graz. 1982–93 assistant at Institute of Communications and Wave Propagation, Graz University of Technology. 1986 graduation to “Dr. techn.”. 1993–99 lecturer at Institute of Communications and Wave Propagation, Graz University of Technology. 1999 visiting professor at Department of Electrical Engineering and Computer Science, University of Kansas, USA. 2000-02 associate professor at Institute of Communications and Wave Propagation, Graz University of Technology. Since 2002 full professor at Institute of Communications and Wave Propagation, Graz University of Technology and head of Institute of Applied Systems Technology, Joanneum Research, Graz.

Max Kowatsch (*1953), Ao. Univ.-Prof., Dipl.-Ing., Dr. techn.

1971–78 studied electrical engineering at the Vienna University of Technology and graduated in 1978. 1978–85 assistant at Institute of Electrical Engineering and Electronics, Vienna University of

Technology. 1981 graduation to Dr. techn.. 1985–87 lecturer at Institute of Electrical Engineering and Electronics, Vienna University of Technology. 1987-97 head of engineering department at Schrack Aerospace. 1997–2000 technical director of Austrian Aerospace. Since 2000 managing director of Austrian Aerospace.

Clemens Lothaller(*1963), Dr. med. univ.

Studied medicine at the University of Vienna and graduated in 1987. In 1988 he applied for participation in the Austrian “AustroMir” mission as cosmonaut to the Soviet space station Mir. After two years of training, together with the second Austrian cosmonaut candidate, the electrical engineer Franz Viehböck, he was selected as backup for Soyuz TM-13 to the space station Mir. Afterwards he returned to work as a physician at an Austrian hospital.

Wolfgang Lothaller(*1936), Dipl.-Ing., Dr. techn..

1954–59 studied technical physics at Vienna University of Technology and graduated in 1959. 1959–64 he worked for Philips, Eindhoven, and from 1964 to 1974 first for COPERS, later ESRO, at the Space Technical Centre (later renamed to ESTEC), Noordwijk, The Netherlands. 1974–2002 he worked in ASA, responsible for telecommunications, industrial policy and navigation. He served as Austrian representative and chairman in several ESA committees. He lectured on satellite communication at Graz University of Technology. Retired in 2002.

Johannes Ortner(*1933), Prof., Dr. phil.

1951–57 studied electrical engineering and physics at the Vienna University of Technology and meteorology and geophysics at the University of Vienna where he graduated in 1960. 1957–62 physicist at the geophysical observatory of the Swedish Royal Academy of Sciences at Kiruna, 1962–73 worked at ESRO in Paris, 1965–68 assistant director for scientific projects at Space Science Department of ESTEC, during 1968–73 as assistant director for programme planning in Paris. 1974–98 managing director of the Austrian Space Agency (ASA), Vienna. Served as chairman and member in several ESA committees. Retired in 1998. 1986–88 president of the International Astronautical Federation (IAF). Since 1988 member and since 1998 chairman of the board of trustees of the International Space University (ISU), Strasbourg, France. Member of the International Academy of Astronautics.

Fritz Paschke(*1929), Em. O. Univ.-Prof., Dipl.-Ing., Dr. techn., Dr. h.c.

1947-49 studied electrical engineering at Graz University of Technology and in 1950-53 at Vienna University of Technology, graduated in 1953. Worked as assistant to Prof. Herbert König at the Institute of High-Frequency-Techniques, Vienna University of Technology, where he obtained his technical doctorate in 1955. 1955-61 worked at Radio Corporation of America, Princeton, NJ. 1961-66 chief engineer of Electron Tube Division of Siemens AG in Munich, Germany. In 1965 he was named full professor and held the chair of General Electronics at Vienna University of Technology until his retirement in 1997. 1970-71 Dean of the Faculty of Mechanical and Electrical Engineering, 1972-75 Rector of Vienna University of Technology. 1974-82 Vice President of the Austrian Science Foundation. In 1973 elected to Corresponding Member, and in 1978 to Full Member of the Austrian Academy of Sciences. 1985-90 President of the Society for Microelectronics (GMe). Since 1989 Chairman of the Board of the Space Research Institute.

Klaus Pseiner(*1956), Dr. nat. techn.

1976–83 studied biology (ecology) at the University of Vienna and graduated in 1983. In 1985 he worked for “Dornier GmbH”, Germany on projects in the field of satellite remote sensing. 1985–89 he worked as marketing manager at “Österreichische Raumfahrt- und Systemtechnik Ges. m.b.H”, Vienna. 1989–98 he worked at ESTEC/Systems Technology Department, The Netherlands, responsible for strategic planning and new initiatives within the Technology Directorate of ESA. Since 1998 he is managing director of the Austrian Space Agency (ASA) located in Vienna. Corresponding Member of the International Academy of Astronautics.

Willibald Riedler (*1932), Em. O. Univ.-Prof., Dipl.-Ing., Dr. techn., Dr. phil., Dr.-Ing. e.h., Prof. h.c. (Peking)
 1950–56 studied electrical engineering at the Vienna University of Technology, graduated in 1956. Worked as an assistant to Prof. Herbert König at the Institute of High-Frequency-Techniques, Vienna University of Technology, from 1956 to 1962. In 1961 he graduated with distinction to Dr. techn. and moved 1962 to Sweden, where he was research scientist at the Geophysical Observatory of the Royal Swedish Academy in Kiruna. In 1966 he finished his study of Meteorology and Geophysics, graduating as Dr. phil. with distinction at the University of Vienna (supervisor: Ferdinand Steinhauser), and was named “Scientific Director” for sounding rocket campaigns of ESRO at its ESRANGE facility in Kiruna. In 1968 he was named full professor at the newly founded Institute of Communications and Wave Propagation, Graz University of Technology, where he served in this capacity until his retirement in 2001. 1973–75 Dean of the School of Mechanical and Electrical Engineering. 1975–77 Rector of the Graz University of Technology. 1978–2002 head of the Institute of Applied Systems Technology of “Forschungszentrum Graz”, which became later “Forschungsgesellschaft Joanneum” and is now “Joanneum Research”, the Styrian Governmental Research Organisation. 1984–2000 managing director of the Space Research Institute of the Austrian Academy of Sciences in Graz. In 1979 elected to Corresponding Member, and in 1993 to Full Member of the Austrian Academy of Sciences. Principal Investigator and/or Co-Investigator of numerous instruments on space missions (Spacelab-1, Venera 13 and 14, Vega 1 and 2, Phobos 1 and 2, Interball, Mars-96, Equator-S, Cluster, Cassini/Huygens, Rosetta). Member of the International Academy of Astronautics; for many years ESA SPC member; 2001–03 chairman of ESA Space Weather Working Team.

Mario Rohracher (*1951), Dipl.-Ing.

1969–78 studied physics and electrical engineering at the Vienna University of Technology and graduated in 1978. 1978–88 various industrial positions in the fields of military electronics and space technology. 1988–97 managing director of Schrack Aerospace. Served as vice chairman (1991–96) and chairman (1997) of AUSTROSPACE, the association of Austrian space companies. 1992–97 member of the industrial policy committee of EUROSPACE, the European space industry association. 1998–2001 managing director of AOEM, the Austrian automotive suppliers association. Since 2001 board member of Eybl International.

Helmut Rucker (*1948), Ao. Univ.-Prof., Mag. rer. nat., Dr. phil.

1968–74 studied mathematics, physics and geophysics at the University of Graz; subsequently research scientist at the Space Research Institute, Austrian Academy of Sciences. 1982/83 research tenureship at NASA Goddard Space Flight Center. 1986 development of the radio station at Observatory Lustbühel and development of the European radio network in the decameter range. Co-investigator of the Interball AKR-X and Cassini RPWS experiments. Since 1999 head of the Department of Extraterrestrial Physics, Space Research Institute. 2001–03 deputy director of the Space Research Institute. Since 2001 head of the postgraduate University Course of Space Science.

Eva-Maria Schmitzer (*1955), Ministerialrat, Mag. rer. soc. oec.

Studied business and administration at Vienna University of Economics and Business Administration and graduated in 1981. 1982–84 she worked in the Federal Chancellery, Economics Department. 1984–87 she worked in the Federal Ministry of Public Economy and Transport in the National Economic Affairs and Structural Policy Division. 1987–90 she worked in the Federal Chancellery again. 1990–97 head of Department for Technology Policy, Federal Ministry of Science and Transport. Since 1998 she is head of Department for Space Research and International Technology Affairs, Federal Ministry of Transport, Innovation and Technology and Austrian representative on the ESA Council.

Georg Serentschy (*1949), Dr. phil.

1969–78 studied physics and mathematics at the Vienna University and graduated in 1978. 1978–83 various industrial positions in the fields of software development, industrial robotics and solar energy. 1983–96 Managing Director of ORS (Österreichische Raumfahrt- und Systemtechnik GmbH), 1997–2002 Director at Arthur D. Little International, main focus on telecoms market, 2000–2002 Managing Director of Arthur D. Little's Austrian subsidiary, since 25. Nov. 2002 Head of RTR, the Austria Regulatory Authority for Telecommunication and Broadcasting.

Hans Sünkel(*1948), O. Univ.-Prof., Dipl.-Ing., Dr. techn.

1968–73 studied geodesy at the University of Technology, Graz and graduated in 1973 with distinction. 1973–83 he worked on his dissertation with Prof. Helmut Moritz and as assistant at the Institute of Physical Geodesy and graduated in 1976 with distinction. 1978–79 Research Associate at Ohio State University, Columbus, USA. 1983 he was appointed full professor for mathematical and numerical geodesy at Graz University of Technology. Since 1990 he is head of the Department for Satellite Geodesy at the Space Research Institute. 1992 he was elected to corresponding member and 1998 to full member of the Austrian Academy of Sciences. Since 2001 he is managing director of the Space Research Institute in Graz and vice-rector for research at the Graz University of Technology. In 2003 he was elected Rector of the Graz University of Technology.

Franz Viehböck (*1960), Dipl.-Ing.

Studied electrical engineering at the Vienna University of Technology and after graduation worked there as an assistant. In 1988 he applied for participation in the Austrian AustroMir mission as cosmonaut in the Soviet space station Mir. After two years of training, together with the second Austrian cosmonaut candidate, the physician Clemens Lothaller, he was selected to fly with Soyuz TM-13 to the space station Mir, October 2-10, 1991. After the successful flight he worked for the Austrian Federal Ministry for Science and Research for two more years. Subsequently he worked for different companies in the US and Europe in the field of space technology. Corresponding Member of the International Academy of Astronautics.

Werner Weiss (*1943), Univ.-Prof., Dipl.-Ing., Dr. techn.

1971 graduation with distinction in physics at the Vienna University of Technology. 1968–79 assistant at the Institute for Experimental Physics (Vienna University of Technology); then the Nuclear Institute of the Austrian Universities, finally at the Institute of Astronomy, University of Vienna. 1979–88 assistant professor; 1982/83 research scientists at the Institute for Astronomy, University of Hawaii, USA; since 1988 associate professor at the University of Vienna; 1990–93 member of the PRISMA Science Working Team, ESA; 1995–98 member of the ESA Astronomy Working Group; since 1992 member of the Austrian COSPAR Committee, Co-Investigator of Corot experiment and member of MOST Science Team; since 2000 member of the Scientific Organizing Committee of IAU Commission 45; since 2000 chairman of the IAU Working Group of Ap and Related Stars of Commission 24.

Otto Zellhofer (*1935), Sektionschef, Dipl.-Ing.

1954–61 studied technical physics at the Vienna University of Technology and graduated to Dipl.-Ing. in 1961. 1961–69 worked at Bundesversuchs- und Forschungsanstalt Arsenal, Vienna, in the field of nuclear energy technology. 1969–71 worked at the Federal Ministry of Building and Technology. 1971–96 worked at the Federal Ministry for Science and Research in various capacities, focused on industrial research, finally as head of the Department for Research in Geosciences, Resources, Energy and Space. 1972–74 managing director of the Austrian Space Agency (ASA). 1974–98 member of supervisory council of ASA, since 1985 chairman. 1982–96 Austrian delegate to ESA Council (1993–96 Vice-Chairman). Retired in 1996.

Appendix D: Scientists, Engineers and Administrators not included in Appendix C ²⁶⁵

Bruno Besser , Dipl.-Ing., Mag., Dr.	
Helfried Biernat , Ao. Univ.-Prof., Mag., Dr.	
Georg Kirchner , Dipl.-Ing., Dr.	
Norbert Kömle , Dr.	Space Research Institute,
Herbert Lichtenegger , Dr.	Austrian Academy of Sciences, Graz
Peter Pešec , Dr.	
Konrad Schwingenschuh , Dr.	
Herwig Slamanig , Dipl.-Ing.	
Manfred Steller , Dipl.-Ing., Dr.	
Klaus Torkar , Univ.-Doz., Dipl.-Ing., Dr.	

Martin Friedrich , Univ.-Prof., Dipl.-Ing., Dr.	
Bruno Josseck , Dipl.-Ing.	Institute of Communications and Wave Propagation,
Dieter Kirchner , Univ.-Prof., Dipl.-Ing., Dr.	Graz University of Technology
Walter Randeu , Univ.-Prof., Dipl.-Ing., Dr.	
Nicolas Valavanoglou , Dipl.-Ing.	

Martin Heyn , Ao. Univ.-Prof., Dipl.-Ing., Dr.	Institute of Theoretical Physics,
	Graz University of Technology

Gottfried Kirchengast , Univ.-Prof., Mag., Dr.	Institute of Geophysics, Astrophysics
Reinhard Leitinger , Ao. Univ.-Prof., Dr.	and Meteorology, University of Graz

Helmut Hinghofer-Szalkay , Univ.-Prof., Dr.	Institute of Physiology, University of Graz

Rainer Kalliany , Dipl.-Ing.	Institute for Computer Graphics and Vision,
Franz W. Leberl , O. Univ.-Prof., Dipl.-Ing., Dr.	Graz University of Technology

Viktor Kaufmann , Dipl.-Ing., Dr.	Institute of Geodesy,
Robert Kostka , Ao. Univ.-Prof., Dipl.-Ing., Dr.	Graz University of Technology
Mathias Schardt , Univ.-Prof., Dipl.-Forstwirt, Dr.	

Albert Niel , Dipl.-Ing., Dr.	Institute of Image Processing and Computer
Mathias Schardt , Univ.-Prof., Dipl.-Forstwirt, Dr.	Graphics, Joanneum Research, Graz

Christian Brünner , O. Univ.-Prof., Dr.	Institute of Austrian, European and Comparative
	Public International Law, Political Science and
	Administrative Law, University of Graz

Franz Kerschbaum , Ao. Univ.-Prof., Dr.	Institute of Astronomy, University of Vienna

-
- Norbert Bachl**, O. Univ.-Prof., Dr. Institute of Sport Sciences, University of Vienna
-
- Gerhard Hafner**, Univ.-Prof., Dr. Institute of International Public Law and International Relations, University of Vienna
-
- Wolfgang Kiesel**, O. Univ. Prof., Dr. Institute of Geochemistry, University of Vienna
Christian Köberl, Ao. Univ.-Prof., Dr.
-
- Karl Kraus**, O. Univ.-Prof., Dipl.-Ing., Dr. Institute of Photogrammetry and Remote Sensing
Vienna University of Technology
-
- Gero Kurat**, Univ.-Prof., Dr. Museum of Natural History, Vienna
-
- Walter Leeb**, Univ.-Prof., Dipl.-Ing., Dr. Institute of Communications and Radio-Frequency Engineering, Vienna University of Technology
-
- Erwin Mondre**, Dr. Austrian Space Agency, Vienna
Harald Posch
-
- Hans Troger**, O. Univ.-Prof., Dipl.-Ing., Dr. Institute of Mechanics, Vienna University of Technology
Hans Peter Rossmanith, Ao. Univ.-Prof., Dr.
-
- Norbert Vana**, Univ.-Prof., Dipl.-Ing., Dr. Atomic Institute of the Austrian Universities, Vienna
-
- Manfred Leubner**, Univ.-Prof., Dr. Institute of Theoretical Physics, University Innsbruck
-
- Helmut Rott**, Univ.-Prof., Dr. Institute of Meteorology and Geophysics University Innsbruck
-
- Horst Clausen**, O. Univ.-Prof., Dr. Institute of Computer Sciences, University of Salzburg
-
- Friedrich Rüdenuer**, Univ.-Prof., Dr. Austrian Research Centres
Gerhard Triebnig, Dipl.-Ing., Dr. Seibersdorf Research GmbH, Seibersdorf
-
- Edmund Müller**, Mag. Joanneum Research, Graz
Bernhard Pelzl, Hon.-Prof., Dr.
-

Lothar Beckel , Univ.-Doz., Dr.	GEOSPACE Beckel Satellitenbilddaten GmbH, Salzburg

Klaus Rissbacher , Mag.	Plansee AG, Reutte

Andrea Kleinsasser , Mag.	Federal Ministry of Transport, Innovation and Technology, Vienna

Ulrike Unterer , Mag., Dr.	Federal Ministry for Economics and Labour, Vienna

Liane Lippsky	Federal Ministry for Education, Science and Culture, Vienna

Manfred Buchroithner , Prof., Ing., Dipl.-Geol., Dr.	Institute of Cartography, Technische Universität Dresden

Michael Barylak , Dr.	ESA Headquarters, Paris, France

Christian Feichtinger , Dipl.-Ing., Dr.	ESA, Moscow Office, Russia

Rudolf Schmidt , Univ.-Doz., Dr.	ESTEC, Noordwijk, The Netherlands

Gerhard Schadler , Dipl.-Ing., Dr. Alfred Vogel , Dipl.-Ing, Dr., MBA (IMD)	Austrian Academy of Sciences, Vienna

Appendix E: Summer School Alpbach

The idea to organise Summer Courses in Alpbach for European students was born in 1963 when the first Summer Course was organised by Johannes Ortner within the framework of COPERS. The idea proved successful and was therefore adopted by ESRO, which organised another Summer Course in Alpbach in 1965, and continued to hold sessions in different member states of ESRO thereafter.

ASA decided in 1975 to create a periodic Summer School in Alpbach to train Austrian specialists in different subjects of space research. The aim of the Summer School is to offer advanced training and working experience to European graduates as well as post-graduate students (scientists and engineers) on subjects which are not usually part of the academic curricula.

The first Summer School was jointly organised and financed by ESA, Germany and Switzerland, but later also with France and finally with all member states of ESA. The Summer School Alpbach is special as it features both lectures and workshops. The participants are given the opportunity to extend and strengthen their knowledge, and to put it into practice during workshops, in which case studies or representative space projects are conducted. The teams are guided by experts, who act as tutors for the workshops. The lecturers also participate in the workshops and thus establish a close relationship with the students in providing assistance in the definition of the mission to be designed. The results of each workshop team are presented to a review panel by the students at the end of the Summer School. Joint evening dinners (with after dinner speeches on interesting subjects) are organised for lecturers, tutors, students and accompanying persons to provide a stimulating atmosphere for informal discussions.

The Summer School is organised by the Austrian Federal Ministry of Transport, Innovation and Technology and the Austrian Space Agency (ASA), and co-sponsored by the European Space Agency (ESA) and the national space authorities of its member states on a “no exchange of funds” basis. This means that each participating country finances its own students and lecturers, ASA, chairing the Programme Committee and providing in addition the infrastructure of the Summer School.

Topics of Alpbach Summer School Courses:

- 1963: Introduction to Solar-Terrestrial Relations
- 1965: Electromagnetic Radiation in Space
- 1975: Remote Sensing of the Earth
- 1976: Practical Application of Remote Sensing
- 1977: Satellite Meteorology
- 1978: Manned Space Activities
- 1979: Space Astronomy and Astrophysics
- 1980: Research under Microgravity
- 1981: The Solar System and its Exploration
- 1983: Remote Sensing
- 1984: Utilisation of Platforms in Space (Summer School was cancelled)
- 1986: Space Astronomy and Solar System Exploration
- 1987: Space Science and Fundamental Physics
- 1989: Remote Sensing and the Earth's Environment
- 1991: Global Environment: Processes and Monitoring from Space
- 1992: Infrared Astronomy and Cosmology

1993: Comparative Planetology

1994: Solar Terrestrial Relations

1995: Horizon 2000 Plus

1996: Mission to the Moon (Science of and from the Moon)

1997: Fundamental Physics in Space

1998: Our Solid and Liquid Planet

1999: Mars

2000: Extragalactic Astronomy and Cosmology from Space

2001: Satellite Navigation Systems for Science and Application

2002: Space Weather: Physics, Impacts & Predictions

2003: Working and Living in Space: From ISS to Moon and Mars

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Dr. Herbert Lichtenegger, Dipl.-Ing. Hans Eichelberger, Dr. Peter Pešec, Dipl.-Ing. Dr. Manfred Steller, Dipl.-Ing. Herwig Slamanig, Prof. Dr. Wolfgang Baumjohann, Prof. Dr. Hans Sünkel, Prof. Dr. Helmut Rucker (all at Space Research Institute, ÖAW, Graz), Prof. Dr. Martin Friedrich (Institute of Communications and Wave Propagation, Graz University of Technology), Dr. Johannes Fritzer, Prof. Dr. Siegfried J. Bauer (both at Institute of Geophysics, Astrophysics and Meteorology, University of Graz), Dr. Viktor Kaufmann (Institute of Geodesy, Graz University of Technology), Prof. Dr. Ferdinand Cap, Dr. Ernst Fasan, and Prof. Dr. Otto Burkard are thanked for their critical and attentive reading of earlier versions of the manuscript.

Author's biography

Bruno Besser (*1962), Dipl.-Ing., Mag. rer. nat., Dr. rer. nat.

1982–88 studied geophysics at the University of Graz and graduated in 1988 (“Mag. rer. nat”). 1989–92 worked on his dissertation in space plasma physics at the Institute of Meteorology and Geophysics, University of Graz, graduated in 1992. 1990–92 worked as project scientist in the Department for Physics of Near-Earth Space, Space Research Institute, at the Observatory Lustbühel, Graz. 1992–95 worked as project scientist in the Department of Experimental Space Research, Space Research Institute. 1995–96 head of Administration Office, Section of Mathematical-Natural Sciences, Austrian Academy of Sciences in Vienna. 1996–to present: he works as senior scientist in the Department of Experimental Space Research, Space Research Institute, Graz, in the field of magnetospheric and planetary ionospheric physics. He graduated in electrical engineering at Graz University of Technology in 2001 (“Dipl.-Ing.”) with a master thesis on Lidar technology applications for atmospheric and environmental monitoring. Currently he works on wave propagation problems in the atmosphere of Saturn’s moon Titan. Since 1994 he also conducts research in space history, focusing on early 20th Century rocketry in Middle Europe.

Contact address

Bruno Besser
Institut für Weltraumforschung
Österreichische Akademie der Wissenschaften
Schmiedlstraße 6
A-8042 Graz
Austria
Tel.: +43 - (0) 316 4120 571
Fax.: +43 - (0) 316 4120 590
Email: bruno.besser@oeaw.ac.at

or

Bruno Besser
vulgo Juschitz/po domace Južic
Ratschitschach/Racice 8
A-9100 Völkermarkt
Austria
Tel.: +43 - (0) 664 2746554

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Contact: ESA Publications Division
c/o ESTEC, PO Box 299, 2200 AG Noordwijk, The Netherlands
Tel. (31) 71 565 3400 - Fax (31) 71 565 5433