History of Rocketry and Astronautics

Proceedings of the Thirty-Eighth History Symposium of the International Academy of Astronautics

Vancouver, British Columbia, Canada, 2004

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AAS History Series, Volume 35

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 24

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2011

ISSN 0730-3564

ISBN 978-0-87703-567-1 (Hard Cover)
ISBN 978-0-87703-568-8 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 22

The Soviet/Russian Spacesuit History: Part III—The European Connection*

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Introduction

By the mid 1980s the third version of the Orlan spacesuit, Orlan-DMA, was under development for the use on the new Soviet space station Mir. The Orlan-DMA Extra-Vehicular Activity (EVA) spacesuit was a fully autonomous suit system, with many performance features different from the U.S. Extravehicular Mobility Unit (EMU) suit system, for example self don/doff, short prebreathing, in orbit maintenance, and a single suit size for the whole user population. The first operational use was in October 1988 onboard Mir [1,2].

In the same timeframe, in 1986, the European Space Agency (ESA) initiated the development of a (West-)European spacesuit, the European Space Suit System (ESSS), for the Hermes spaceplane missions. The operational scenario envisaged the servicing of the Columbus Man-Tended Free Flyer (MTFF) by the Hermes spaceplane, and this set the overall design requirements for the new spacesuit system ESSS. For the initial feasibility studies and the Phase B work support was acquired from the U.S. EMU project. However based on given performance requirements, the basic concept selected for the start of the ESSS de-

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* Presented at the Thirty-Eighth History Symposium of the International Academy of Astronautics, 4–8 October 2004, Vancouver, British Columbia, Canada. Paper IAC-04-IAA.6.15.3.08.

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velopment (Phase C1) in 1989 differed from the EMU in that a rear-entry concept with a single suit size and a suit pressure of 500 hectopascal (hPa) (for zero-prebreathing) became the adopted baseline. Thus the basic features of the selected concept were similar to those of the Soviet Orlan-DMA spacesuit.

Initial contacts between the Soviet Zvezda Orlan and the ESA Dornier ESSS teams occurred in 1989 and soon Zvezda became a contracted support to the Dornier ESSS team. In 1991 the ESA Minister Conference planned for a closer cooperation with the Russian Space Agency (RKA) for the Hermes program. The possibility to transform the Orlan and ESSS suits into one suit system for Mir, Buran, Hermes, and Columbus, was investigated and found feasible (EVA 2000). When the Hermes program was terminated in 1993 ESA and RKA agreed to jointly continue the development of a new generation spacesuits for the Mir 2 (later International Space Station) program, the EVA Suit 2000, with Zvezda and Dornier as co-primes in a new joint venture (Figure 22–1).

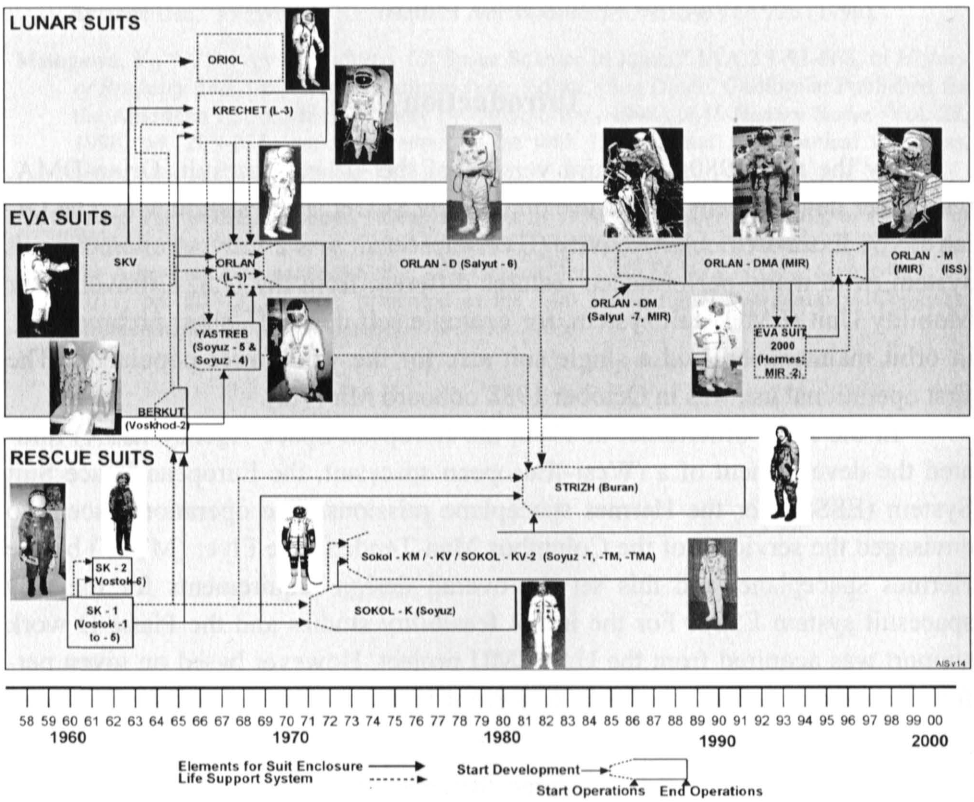

Figure 22–1: Soviet/Russian Spacesuit Family Tree and the EVA Suit 2000 Project. Credit: Archives Skoog and Zvezda.

Orlan-DMA

The Orlan-DMA spacesuit (Figures 22–2 and 22–3) could be used without an electric umbilical connecting the suit with onboard station systems. It was equipped with a special removable unit containing the power supply, radio communications and telemetry system units, and antenna feeder device. The first operational use of Orlan-DMA was in October 1988 [1,2].

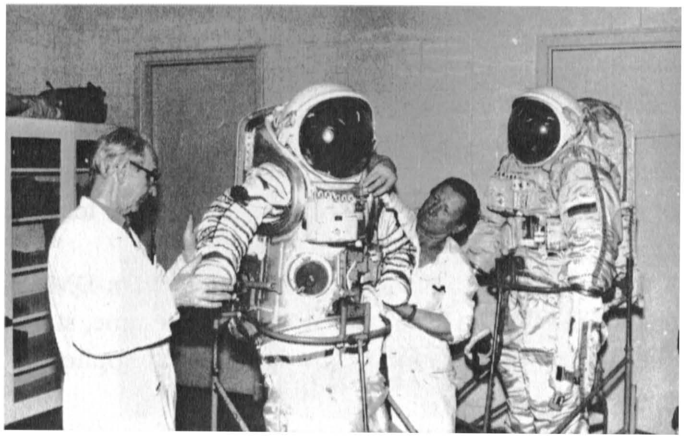

Figure 22–2: The Orlan-DMA assembly shop. Credit: Archive Zvezda.

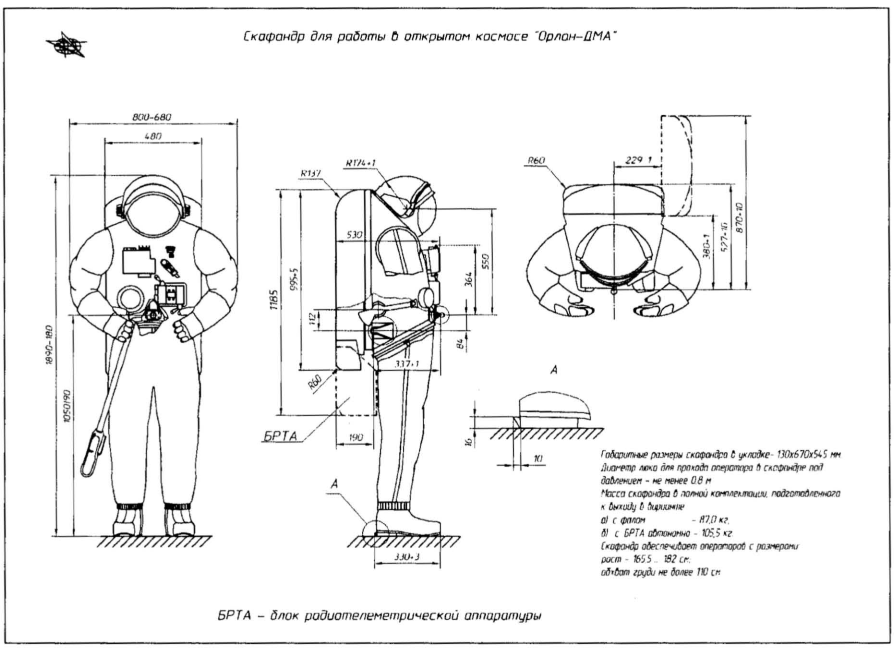

Figure 22–3: Orlan-DMA main dimensions. Credit: Archive Zvezda.

Certain significant changes were introduced into the Orlan-DMA suit design. To begin with, the rigid part of the suit enclosure was improved. Its lower part provided for attachment of leg enclosures via a special removable flange, which made it possible to replace suit soft parts in case they were damaged or worn out. At the same time, the internal volume of the body was slightly decreased and the design of the front lock (made in the form of a "pin") for spacesuit restraint changed. Suit pressure gloves were improved and the utilization of pressure cuffs, which retain the suit pressure for some time in case of damage of gloves, was provided for. Other improvements and changes included installation of the new contaminant control cartridge (absorbing CO_2 and harmful impurities) of increased capacity (with an increase in duration of suit the autonomous operation mode up to six hours), modification of the fan (a new electric motor was used) and headset (with improved characteristics of electric acoustic means), and introduction of an additional safety tether. The Orlan-DMA total mass was 105 kilograms (kg).

In 1987 the decision was made to also use the Orlan-DMA in the Buran program (instead of the Orlan-D spacesuit). At the same time, start was given to activities on the further modification of the spacesuit as applied to the planned Mir-2 orbiting station.

Activities on the development of a completely self-contained spacesuit system were carried out within the "Suit-UPMK System" project [the Russian acronym УПМК stands for the cosmonaut travel and maneuvering system] in line with the government resolution dated 25 September 1985, and the government directive dated 31 October 1985. Therefore, the Orlan-DMA suit was fitted with elements for harmonization with the cosmonaut travel and maneuvering system (identified as the 21KS system) and flight tests of the 21KS system were successfully carried out on the Mir station in 1990 (Figure 22–4).

European Spacesuit System

The ambitious European plans for future manned space systems in the mid 1980s covered numerous elements for short- and long-term stay in orbit. The Columbus program included an Attached Pressurized Module (APM) docked to the International Space Station (ISS), a Man-Tended Free-Flyer (MTFF) as an autonomous mini-space station and platforms.

The Hermes spaceplane with a crew of three was intended for resupply and repair of platforms and the Columbus MTFF. In this context the ESSS was required to perform MTFF servicing and repair, to support the Hermes vehicle in safety critical operations, and to perform external servicing and contingency operations (Figure 22–5). Planned delivery of ESSS was set for 1998.

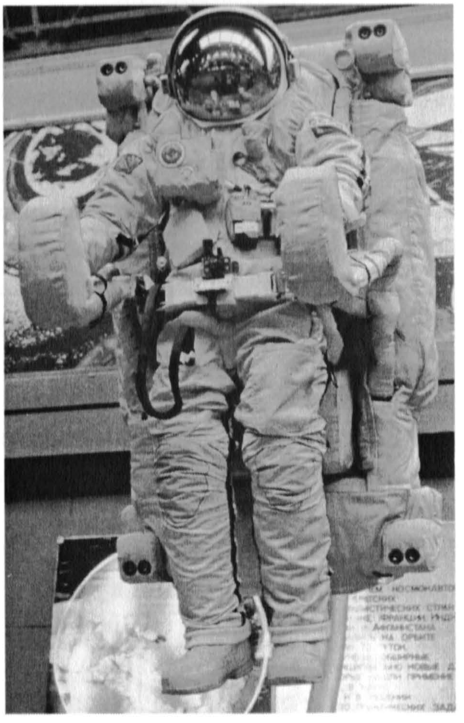

Figure 22–4: Orlan-DMA suit with the 21KS unit. Credit: Archive Skoog.

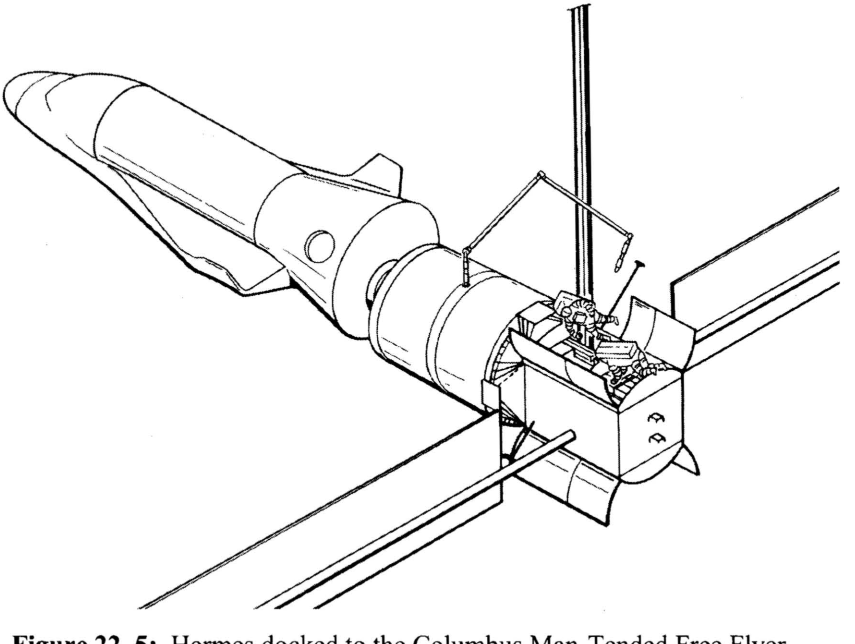

Figure 22–5: Hermes docked to the Columbus Man-Tended Free Flyer. Credit: Archive Skoog.

The two initial ESA feasibility studies from May 1986 until March 1987 were contracted to Dornier System GmbH and BAe in parallel. Dornier teamed with Aviation Marcel Dassault-BA and Aérospatiale in France, Nord-Micro in Germany, and Microtechnica in Italy, and had for this study consultancy from Hamilton Standard, the U.S. spacesuit manufacturer. BAe selected as European partners Matra in France, Sener in Spain, and Normalair-Garrett in the United Kingdom, with McDonnell-Douglas as U.S. consultant. The major findings of the Dornier study for a spacesuit in the Columbus–Hermes scenario were [1]:

- The EVA spacesuit concept was based on a six-hour plus one-hour contingency operation duration by two astronauts. The spacesuit enclosure was to be of a hybrid type with hard upper torso and backdoor entry.
- This suit configuration would allow for a design pressure of 500 hPa, which in combination with a Hermes reduced cabin pressure (700 hPa) would permit a zero prebreathe operation of the spacesuit.
- The life support system was of a non-regenerative closed loop design with CO_2 removal by LiOH and thermal control by means of a condensing heat exchanger and sublimator. Metabolic cooling was achieved by a liquid (water) cooling garment and a gas ventilation network with tubing built into the suit enclosure. The oxygen atmosphere was provided from high pressure tanks. The life support system was integrated in an unpressurized backpack.
- Advanced monitoring and control system, providing partially hands free operation at a work site by means of a chest-pack display with operational data.

These results were driven by the Hermes operational concept with a crew of three astronauts requiring for an EVA:

- unassisted spacesuit donning and doffing,
- shortest possible preparation time for EVA, and
- a maximum of operational flexibility and crew safety.

The spacesuit development started in 1986 with the only relevant experience in Europe being aviation pressure suits and life support system development for the Spacelab Laboratory Module flown with the U.S. Space Shuttle. Thus in case of Dornier the longstanding working relations with Hamilton Standard in the United States for life support systems was of great value in particular as Hamilton Standard also was the prime contractor for the Shuttle spacesuit system EMU. Hamilton Standard supported the Dornier spacesuit team in system engineering, and intensive training was performed in 1987–1988.

Despite this the ESSS concept defined for the start of the Phase C1 in 1989 (Figures 22–6 and 22–7) differed from the U.S. EMU in particular as to the rear-entry concept, the higher suit mobility, and the higher suit pressure. All this was mainly because of the Hermes requirements, and in this respect the ESSS had great similarities with the Zvezda Orlan system, although the knowledge of this system was mainly from the open literature. It shall be pointed out that Dassault had first contacts with Zvezda, when supporting the second French flight of Jean-Loup Chrétien in 1988. During this flight Chrétien performed an EVA with an Orlan-DMA suit from the Mir station and thus was the only European cosmonaut/astronaut with EVA flight experience when the ESSS project started. His experience was also used in the ESSS when dealing with suit and EVA operations. On the other hand the life support system and backpack concept showed great similarities with the unpressurised EMU backpack design.

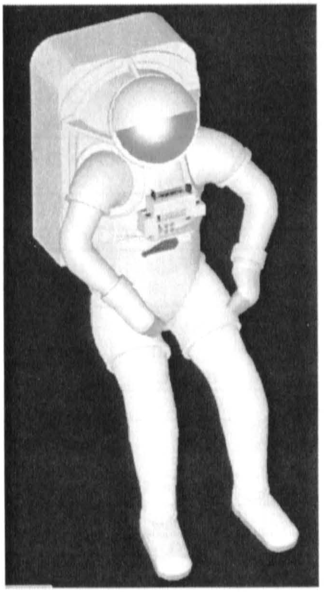

Figure 22–6: Autonomous ESSS. Credit: Archive Skoog.

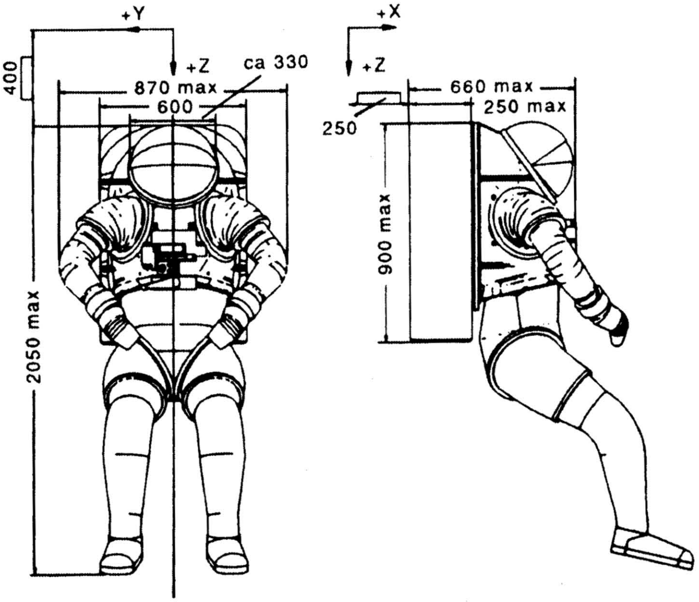

Figure 22–7: ESSS spacesuit overall dimensions. Credit: Archive Skoog.

The ESSS design concept progressed through the predevelopment phase (C1) performed during 1989–1991 as a part of the overall Hermes development program.

The initial Phase C1 configuration was based on the three years of predefinition and conceptual design activities performed both on system and subsystem level but without any previous accompanying technology or other hardware related activities. However, the need for technology investigations and breadboard testing had been identified during the predefinition phase and thus half of the financial budget for the Phase C1 was allocated to the bread-boarding of the most critical parts of the spacesuit. In some cases (that is, glove, sublimator, and CO_2 removal) the purpose was of a more enabling type to build up a know-how already existent in the United States and the former Soviet Union. But in other areas (that is, rolling convolute shoulder, seals and bearings, and voice communication) the selected design concept for the European spacesuit required new technologies previously not implemented in other suit designs. The ESSS design was based on general requirements (Table 22–1) as detailed in the ESA EVA requirements document (ESA-RQ-EVA-001; 27.02.1989), later changed to the EVA design requirements document (H-S-2BA-001-ESA, Issue 1, 30.11.1989) in the Hermes documentation system.

	Orlan-DMA	**ESSS**	**EVA 2000**	**EVA Suit 2000**	**Orlan-M**
Beginning of Operations (alt. planned)	1988	(1998)	(2000)	(2000–2004)	1997 Mir 2001 ISS
Number of EVAs	10	30	35 (ground) 25 (in-orbit)	30 (in four years)	12–15
Total Operational Time per Sortie (hrs)	9	7	7	7	9
Autonomous Operation in One Sortie (hrs)	6 + 1	6 + 1	6 + 1	7	6 + 1
Life Time (years)	4	15	15 (ground) 5–7 (in-orbit)	4 in orbit 15 with maint.	4
Wet Mass (kg)	105	(~ 125)	(121.7)	(< 125)	≤ 112
Heat Removal, Average (W)	300	300	300	300	300
Max (W)	600	962 *	580	950 *	600
Power Consumption (W)	42	(~ 120)	(69)	(~ 130)	54
Suit Pressure, Primary (hPa)	400	500	420	420	400
Emergency (hPa)	220	270	270	< 420	270
Anthropometric Range (cm)	164–185	165–185	165–187, 5	165–185	164–190
Maintenance	In-orbit	Ground	Ground. Alt. in-orbit	In-orbit. Ground (each four years)	In-orbit
Place of Operations (alt. planned)	Mir, (Almaz, Buran)	(Hermes, Columbus MTFF)	(Hermes, Buran, Mir-2, EMSI)	(Mir-2)	Mir, ISS

* Including equipment cooling.

Table 22–1: Performance requirements of the Russian and Russian–European spacesuits.

With this multitude of tasks in the ESSS Phase C1 a large project team with some 30 European companies were involved from the very beginning in 1989. Around the time of the start of Phase C1 the first official contacts with RD&PE Zvezda took place in 1989, and in 1990 Zvezda was subcontracted by Dornier for system engineering support in general and suit enclosure issues in particular.

Figure 22–8: ESSS Suit Demonstrator (Dassault). Credit: Archive Skoog.

In 1991 an ESSS demonstrator (Figure 22–8) was manufactured and tested. It included a representative hard upper torso closed by a door simulator and a simple hemispherical bubble for the helmet. The right arm was the assembly of the shoulder, the elbow, and the glove breadboards. The left arm was simplified but included a sliding cord shoulder joint, a representative elbow, and a simplified glove. The lower torso was simplified and without any bearings. The main results from the ergonomic testing confirmed the design of arms and torso, mobility required, and the donning/doffing concept.

EVA 2000

In the Russian space program of 1992 the relevant extravehicular activities from the Mir station were performed by the Orlan-DMA semi-rigid suit, the origin of which reached back to the 1970s and had since undergone several modifications to cover for the needs of EVAs on Salyut and Mir. The latest modification dated back to 1988, when the suit was modified to guarantee a completely self-contained operation from Mir. Thus the Russian spacesuit specialists were at this time considering the development of a new suit to meet the future demands of Buran and the Mir-2 station being under construction.

With an increasing complexity and prolonged schedule of the autonomous Columbus–Hermes scenario new ways were sought of to save a program, which was becoming unaffordable. In the meantime the initial ESSS operation in the Columbus–Hermes scenario had been shifted to the time frame 2002–2004. A similar situation of a space program under severe financial constraints had also emerged in the new Russian Federation. The ESA Minister Conference of 1991 in Munich decided on a closer cooperation with the Russian Federation in particular as for the Hermes program.

The past two years of close cooperation with Zvezda led Dornier/DASA to jointly propose to ESA a study to analyze a possible single European/Russian spacesuit development to cover future needs, as the two envisaged concepts had a lot in common. In early 1992 ESA and the newly created Russian Space Agency (RKA) agreed to initiate a requirements analysis and conceptual design study to determine the feasibility of a joint spacesuit development, the EVA 2000 (Figure 22–9). The feasibility study was conducted in 1992 by Dornier/DASA and RD&PE Zvezda, with Dassault and Laben as subcontractors, as a joint ESA/RKA undertaking. If found feasible the new suit would replace the Hermes EVA suit ESSS and the Mir Orlan-DMA and be used for the first time in the Mir-2 orbital station at the turn of the century.

Merging the ESA and RKA future mission scenarios resulted in a large scenario of space planes (Buran and Hermes), space stations (Mir-2 and EMSI) and platforms (Figure 22–10), encompassing both short duration (ground-based) flights and long duration (space-based) ones, with a minimum of changes in the suit concepts for the two applications. The EVA 2000 spacesuit design had to be compatible with both the ESA EDRD (EVA design requirements document, H-S-2BA-001-ESA) and the RF requirements for Mir and Buran. The overall EVA 2000 requirements specification (Table 22–1) as defined in the course of the study shows except for varying mission duration:

- a lower suit pressure (420 hPa) compared with the original Hermes requirements (500 hPa) and slightly higher than for Orlan-DMA (400 hPa),
- an emergency hatch diameter of 0.8 meters (m), and
- a new crew population representing European and Russian male and female cosmonauts.

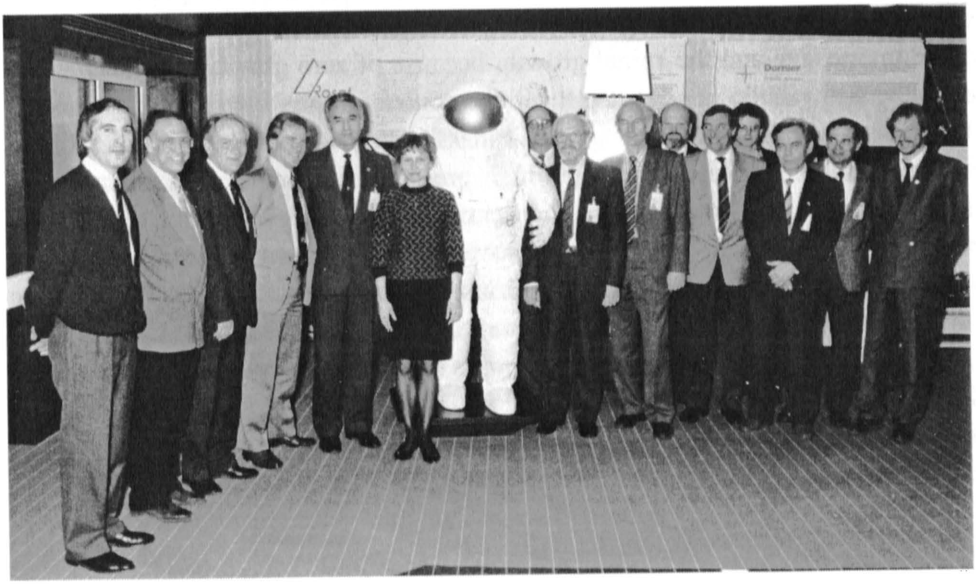

Figure 22–9: The European-Russian EVA 2000 team on 14 April 1992 at the EVA 2000 Study Kick-off at Dornier in Friedrichshafen. Credit: Archive Skoog.

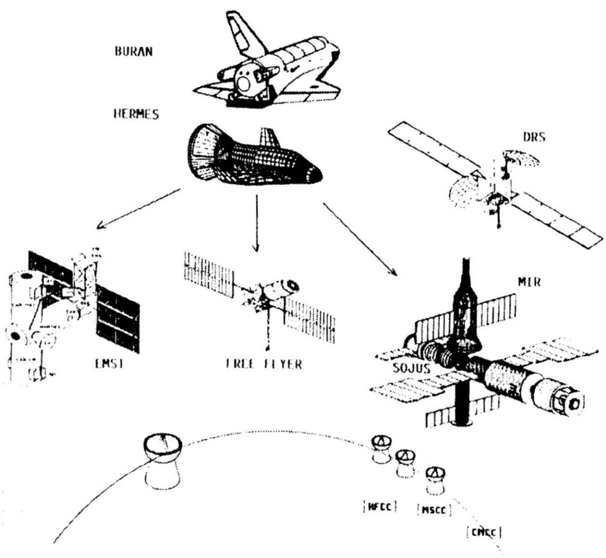

Figure 22–10: EVA 2000 mission scenario. Credit: Archive Skoog.

Compared with the ESSS design the EVA 2000 concept suit enclosure (Figure 22–11) could do without the rolling convolute shoulder joint and the hip and thigh bearings because of the lower suit pressure. The removal of the rolling convolute joint was also necessary in order to meet the emergency hatch requirement for the given anthropometric range. Instead a calf bearing was introduced to maintain leg mobility. Sizing adjustments for the crew population was achieved by means of axial lacing adjustments of the limbs. The hard upper torso came in one size and the spinal growth, because of zero gravity, was accommodated by the waist joint adjustment and the conical shape of the shoulder flanges. These changes also reduced the overall mass to below given requirement. In the backpack the electrical and oxygen high pressure equipment were contained in unpressurized compartments and the ventilation and gas regeneration (CO_2 removal, sublimator, and sensors) and the water cooling equipment in a pressurized part, this being more in line with the Orlan-DMA concept than the ESSS, where all life support and electrical equipment was located in the unpressurized backpack. The EVA 2000 spacesuit system mass (without spacesuit/mothercraft interface unit) was 121.7 kg and the overall power consumption was estimated at 69 watts (W).

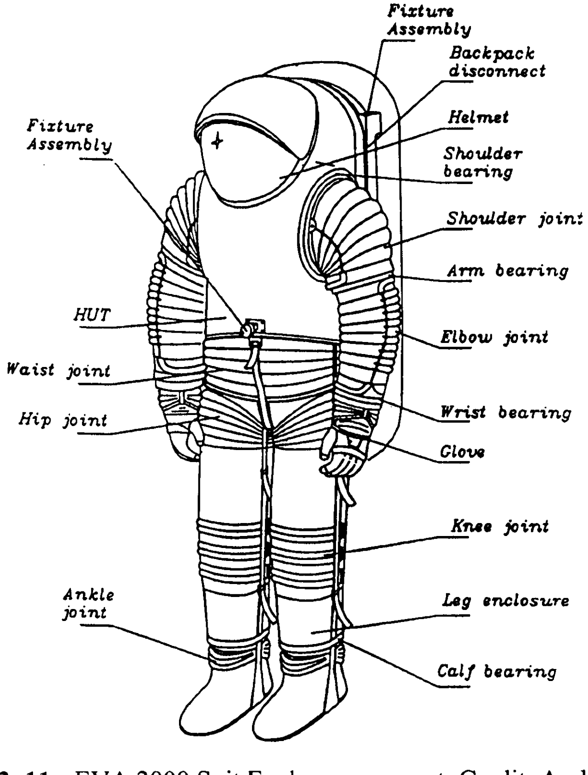

Figure 22–11: EVA 2000 Suit Enclosure concept. Credit: Archive Skoog.

The short duration/ground-based concept envisaged the use of replaceable LiOH cartridges for CO_2 removal, non-rechargeable batteries, and replaceable oxygen tanks. To cover the long-term duration/space-based concept a metal oxide CO_2 removal system, rechargeable lithium batteries, and oxygen tanks were part of the design. For this concept up-front technology advancements with respect to metal oxide CO_2 removal, sublimator/heat exchanger with regenerative heat accumulation capability, and rechargeable lithium batteries would have to be pursued.

The EVA 2000 feasibility study proved the technical viability of a possible joint European/Russian spacesuit concept taking both the Russian operational experience and the advanced technology of the European industry into consideration. The need for development and training facilities was also investigated and an optimized use of available Russian facilities proposed. The study was accompanied by a programmatic evaluation of the joint undertaking and a formal industrial proposal for the EVA 2000 as a joint European/Russian spacesuit development for the next generation piloted missions to start around the turn of the century.

With the decisions of the ESA Minister Conference in Granada in late 1992 and the results of the ESA/RKA negotiations on the future cooperation for a spacesuit development completed in early 1993 the EVA 2000 concept was by late 1993 turned in to a preliminary development contract with new mission requirements. The joint development was to be performed by a European/Russian industrial team under the new project name EVA Suit 2000, which in Europe then replaced the ESSS work, which was transferred with all its hardware into the EVA Suit 2000 project.

EVA Suit 2000

At the Granada meeting the Columbus Man-Tended Free-Flyer (MTFF) was abandoned and in early 1993 after the NASA redesign of the ISS the Columbus Polar Platform was transferred to the ESA Earth Observation program. For the remaining Columbus Attached Pressurized Module (APM) a bridging phase started in April 1993 to support the NASA space station redesign activities. The bridging phase ended in late 1993 with the definition of a new baseline now called Columbus Orbital Facility (COF), COF now being the only remaining element of the Columbus program. In the meantime the Russian Buran program had also been terminated.

Therefore when the joint ESA/RKA spacesuit project EVA Suit 2000 started by late 1993 the intended use of the suit was onboard the Mir-2 station, as no European elements for EVA servicing existed anymore. In December 1993 the Russian Federation joined the International Space Station program as a full partner and as a consequence the elements under development for Mir-2 were reoriented to the Russian segment of the ISS and Mir-2 was abandoned.

As for the EVA Suit 2000 system jointly defined and initiated by ESA and RKA it was concluded that [3]:

- the system could efficiently become a joint development with products and work packages being shared between European and Russian industry under joint management of ESA and RKA, each funding its own activities;
- the RKA determined that they needed such an advanced suit for the assembly phase of their part of the ISS, causing a need date on orbit of April 1998;
- with only a single station to be serviced, the possibility of a common suit was studied. The result of these discussions was an agreement between the nominated representatives of ESA, RKA and NASA (and the respective industrial prime contractors) that the ESA/RKA EVA Suit 2000 would be the baseline suit for the Russian contribution to the station, and could be the basis for a future inter-operable system.

The above quoted ESA, RKA, NASA agreement was signed by all parties in a meeting at RKA in Moscow on 10 February 1994 (Figure 22–12). That agreement was followed by the industry/agency proposal for an EVA spacesuit interoperability capability [4].

Figure 22–12: The ESA, RKA, NASA and industry meeting at RKA in Moscow on 10 February 1994. Credit: Archive Skoog.

The EVA Suit 2000 development program was split into two parts. Part 1 covered the first two years with the detailed definition studies and predevelopment activities including a successful completion of the Preliminary Design Review (PDR). Baseline for the work was the joint ESA/RKA EVA System Requirements Document (HS-RQ-EV-001-ESA/RKA) and the preliminary concept established in the EVA 2000 study. Zvezda and Dornier/DASA acted as co-primes, with a number of European companies involved as subcontractors. Responsible for the suit enclosure subsystem was SABCA in Belgium, the avionics subsystem Laben in Italy, and the power subsystem Signaal in The Netherlands. Zvezda was in addition to the system co-prime activities also responsible for the life support subsystem and to deliver suit enclosure soft parts.

The system requirements were the same as for the EVA 2000, except that the mission scenario was soon narrowed down to the space-based configuration. In a space-based scenario the suit would typically remain onboard the space station for about four years supporting up to 30 sorties, then to be retrieved for ground maintenance including replacement of life-limited items and afterward redelivered into orbit for a total useful life of 10 years. Further was the anthropometric range reduced to a maximum 185 centimeters (cm) with other requirements remaining unchanged. By summer 1993 Zvezda had already completed the manufacturing of a suit model with the new flat pattern shoulder and the arm bearing for ergonomic testing. This prototype (Figure 22–13) was based on Orlan-DMA suit enclosure components as far as possible. One major change was the shape of the hard upper torso. To facilitate a better entry in zero gravity and to increase the waist mobility, the separation plane of the hard upper torso was slightly inclined upward in the front and the rear-entry door was moved up about 5 cm. This prototype helped verify the new shape for improved mobility, which was then to be implemented in the EVA Suit 2000 configuration.

The EVA Suit 2000 overall configuration (Figure 22–14 and Table 22–1) also incorporated a backpack with all life support equipment, needing maintenance, inside the pressurized upper part (LSS), and batteries and communication equipment in a lower (APS) unpressurized compartment (similar to the Orlan-DMA configuration). Following the space-based philosophy the onboard support equipment provided all specific functions necessary only during airlock operations. Oxygen, power, and cooling water were recharged, and the metal oxide carbon dioxide removal cartridges regenerated by the onboard support equipment. In case the mothercraft would not provide regeneration or recharging provisions the suit design provided the flexibility to replace these components on-orbit with non-rechargeable ones.

The Backpack Mockup (Figure 22–15) and the Suit Enclosure Ergonomic Model (Figure 22–16) manufacturing were completed in September 1994 and extensive testing of the Ergonomic Model with the Backpack took place in November–December 1994 at SABCA in Belgium. The Backpack Mockup served the purpose of an integration and maintenance checkout model at Zvezda, and was then shipped to Dornier and SABCA for use in some of the tests with the ergonomic model.

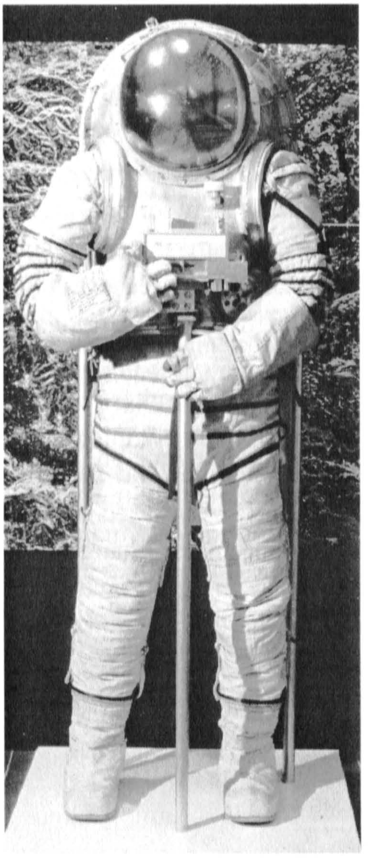

Figure 22–13: Initial Zvezda prototype for arms and rear entry testing. Credit: Archive Skoog.

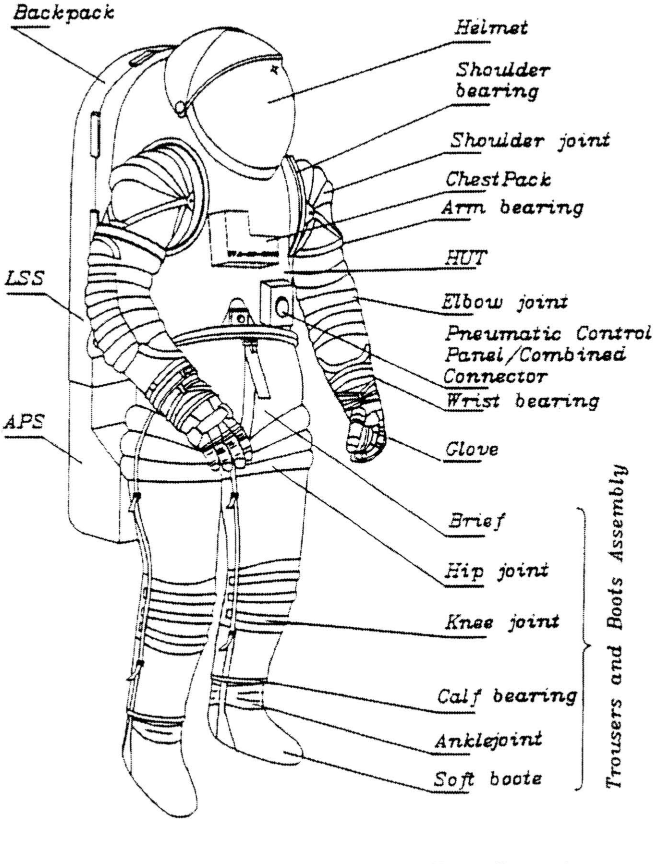

Figure 22–14: EVA Suit 2000 overall configuration. Credit: Archive Skoog.

The Ergonomic Model consisted of an upper torso fabricated out of a composite material and a metal rear door from SABCA; a polycarbonate helmet from Contraves in Switzerland; arms, gloves, and trousers manufactured by Zvezda; and a chest-pack manufactured by Dornier. The Zvezda soft parts were adapted from Orlan-DMA parts with EVA Suit 2000 bearings. The tests performed at 400 hPa suit pressure were, for example, donning/doffing evaluation, sizing, mobility assessment, reach envelope definition, range of vision definition, comfort, and control panel and door closure handling, and these verified the design objectives.

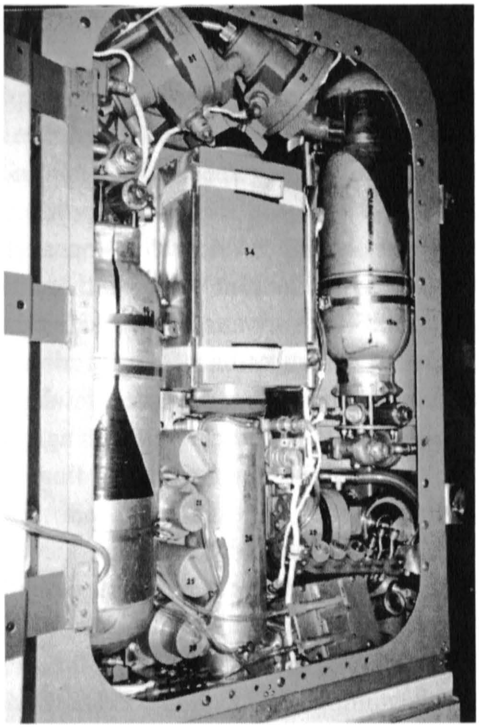

Figure 22–15: Backpack mockup. Credit: Archive Skoog.

Figure 22–16: Ergonomic Model testing, at SABCA in November 1994. Credit: Archive Skoog.

By the autumn of 1994 not only the technical design concept was completed but also all necessary programmatic activities to start the full Phase C/D. A second ergonomic model testing was planned to take place at Zvezda with limbs fully correspondent to the EVA Suit 2000 design, but the final termination of the EVA Suit 2000 and a European spacesuit at the end of 1994 prevented these tests.

During the negotiations on the EVA and European Robotic Arm (ERA) projects between ESA and RKA in 1993 it emerged that Russia needed, as a result of its participation in the ISS, an advanced Data Management System (DMS) for its ISS module. A detailed investigation of the Russian requirements showed that the European Data Management System under development within the Columbus program would suit Russian needs, and it was agreed that Europe would deliver a DMS to Russia as a further item, leaving no financial room for both the EVA Suit 2000 and ERA programs.

The ESA Manned Space Program Board on its meeting 14–15 September 1994 approved the ERA project and directed a closeout of the EVA activities. The final contractual closeout meeting took place at Dornier/DASA in Friedrichshafen in December 1994.

So instead of entering into the full Phase C/D by 1995, the project was fully stopped at the end of 1994 after the first phase of the ergonomic model testing. A full set of documentation corresponding to the requirements for the System Requirements Review was delivered to ESA. All produced hardware for bread-boarding, including the ergonomic model, was transferred to ESA/ESTEC.

The work done jointly in the EVA Suit 2000 Phase 1 was later used by Zvezda and RKA to modify the Orlan-DMA suit into the Orlan-M for the ISS. The industrial initiative for EVA spacesuits interoperability also suffered the withdrawal of the Europeans from the EVA spacesuit development. When the EVA Suit 2000 activities were in question in 1994 the U.S. ISS EMU development continued, and when the European activities were finally terminated the U.S. work was too advanced to be influenced by any potential joint effort with Russia. Currently two different EVA spacesuit systems (U.S. EMU and Russian Orlan-M) are used on the ISS.

Orlan-M

When the joint U.S.–Russian Statement on Space Cooperation (Gore-Chernomyrdin Commission) about participation of Russia in the ISS program was signed in 1993 the EVA Suit 2000 was planned to be used in the Russian segment of the International Space Station. However, late in 1994, when ESA initiated the termination of the EVA Suit 2000 project because of financial constraints Zvezda renewed activities on the earlier started modification of the Orlan-type suit but now applicable to the ISS program. Certain ideas worked out by the Zvezda/Dornier team in the EVA Suit 2000 project were materialized in the new spacesuit modification. With the beginning of activities on the Mir–Shuttle program and, subsequently, on the ISS program with planned utilization of the Russian EVA suits by international crews, Zvezda made the decision in 1995 to significantly modify the Orlan-DMA suits of the coming lot, to be manufactured for the Mir station, and add the M letter to the suit name.

With new requirements and operations experience from the Mir station taken into account, the following changes were introduced in the Orlan-M spacesuit design by the beginning of operations on the ISS: the increased spacesuit body dimensions and enclosure height adjustment envelope, additional visor improving the upper field of view (Figure 22–17), protective visor to prevent helmet visor fogging, elbow and ankle pressure bearings, pressure glove of improved mobility and strength, wrist pressure disconnect of improved reliability, water cooling garment of improved performance characteristics, improved snap hook for safety tethers, safety tether of variable length widening the cosmonaut operating envelope, backup pump, modified fan, modified radio set, CO_2 absorption cartridge of increased capacity, et cetera.

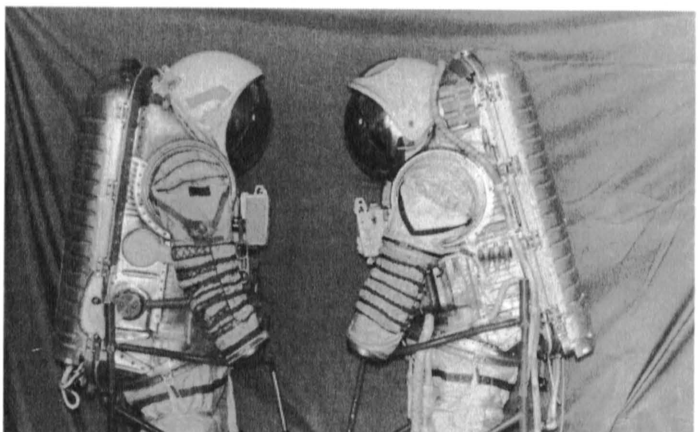

Figure 22–17: External configuration and backpack differences between Orlan-DMA (left) and Orlan-M (right). Credit: Archive Zvezda.

Orlan-M was first used onboard Mir in 1997 to 2000, and then on ISS from 2001. By mid August 2004 12 EVAs had been performed successfully from the Russian part of the ISS.

Conclusions

The EVA Suit 2000 Russian/European spacesuit project was the first genuine attempt to create an international EVA system to serve future missions on ISS. Based on 20 years of Orlan spacesuit development and operations for Salyut and Mir, and the advancement in microelectronics and data handling a new suit design for the 21st century had been created and verified by early testing.

A mature overall technical, management, and programmatic concept was available for the start of the development and manufacture (Phase C/D) of this new-generation spacesuit, when economical and political priorities led to the termination of the EVA Suit 2000 by the end of 1994. At this time a fully integrated Russian–West European industrial team under co-prime of Zvezda and DASA was effectively in operation under the joint leadership of the two space agencies RKA and ESA. Some of the advancements proposed for EVA Suit 2000 were later to be realized by Zvezda in the new Russian ISS spacesuit Orlan-M.

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