Chapter 9
Shifting Priorities: Equipment Relocations
(1989–1990)

In the search for the optimal configuration for Hermes, satisfying requirements such as limited size and mass, cargo capability, aerodynamics, structures and materials all at the same time, led to continued design changes and the addition, deletion and relocation of modules and equipment. Also, the method to rescue a Hermes crew in case of a launch failure still remained to be settled. Here, a potential solution announced itself coming from an empire that was experiencing a complicated and far-reaching evolution of its own.

9.1 Hermes 8M1

By the end of 1988, the 5MX-E configuration had been intended to become the phase C1 baseline, Shape 0.0, which described the concept with its internal layout. At the same time, the aerodynamic concept 8M1 being studied had been defined as Shape 0.0. To avoid confusing, the 5MX-E concept was renamed 8M1-E [1]. At the start of 1989 this new baseline configuration for Hermes had been selected [2]. It would represent the optimal Hermes shape that could be established taking into account all possible requirements. The 0.0 shape (also referred to as the Stage 0 configuration), to be fixed by mid-1989, would be the basis of all further work and was intended to be used as a reference for trade-offs on improved shapes. Shape development was planned to continue until the final shape was established, with Shape 1.0 indentified by July 1989, Shape 2.0 by July 1990, 2.5 by July 1991 and the final Shape 3.0 expected to be set in July 1992 [3]. This schedule would see most activity on Hermes’ shape and configuration performed before the actual start of spaceplane development in Phase 2.
Some major changes had taken place in the design of the HSV. The L5B had been dropped and the HRM added, which in essence incorporated the functions of the earlier propulsion stage. The docking unit was now installed on the roof of the pressurised cabin (see Fig. 9.1).

The Hermes 8M1-E configuration incorporated a fuselage shortened by about 2.7 m and its diameter reduced by 0.7 m, and the wing leading edge was now of ‘gothic’ shape. This ensured that the winglets would remain inside the hypersonic shock wave and realized a relatively large projected area despite the shortening of the fuselage. Nose shape modifications improved thermal behaviour, the transition from laminar to turbulent flow of the boundary layer and yaw stability. Modifications to the winglet shape also helped improve yaw stabilisation (see Table 9.1).

The 8M1-E mass in transfer orbit was 24,640 kg, including a 3-t payload and a mass margin of 2415 kg. Considering a current Ariane 5 capability of 23,700 kg to LEO, the effective payload capacity of this configuration was only 2060 kg.

Hermes nominal mission for the 5MX-E had been reduced from twelve days to a ten-day duration, by optimizing the ascent and phasing until docking, saving one day and deleting one further day of contingency operations. Each saved day represented a mass saving of 75 kg.

HERA would be permanently installed on the MTFF, saving a mass of about 170 kg being carried up and down on each mission (see Fig. 9.2).

A European docking port was baselined in 8M1-E, instead of the US one, yielding an additional 180 kg in saved mass. A further mass reduction measure

![Fig. 9.1 Hermes 5MX-E/8M1-E configuration (© Airbus Defence and Space SAS)]
was to have Hermes supplied with electrical power and energy by the MTFF in
docked mode, resulting in an economy of 260 kg, bringing the total result of mass-
saving measures to about 760 kg.

The travel of the seven aerodynamic control surfaces had been refined; two
elevons, deflecting 20° up, 25° down; two winglet rudders, deflecting 35° out, 5° in;
one body flap, deflecting 27° down and two airbrakes deflecting 50° out.

![MTFF with HERA](image)

**Fig. 9.2** View of the MTFF with the HERA permanently installed on its Resource Module
(© Airbus Defence and Space SAS)

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### Table 9.1 Hermes 8M1-E data

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9.1.1 Hermes Spaceplane (HSP)

The 8M1-E configuration retained the makeup of five main sections of the previous 5M2 layout (see Chap. 5). Added to the nose section were gaseous oxygen and nitrogen bottles and antennas and receivers. The front fuselage now contained the two star sensors and three inertial units, lithium batteries and NH₃ boiler, formerly situated in the rear fuselage.

The centre fuselage section was the new location for the docking unit, which featured a 0.8 by 1.0-m hatch, housed in the roof. This section was connected to the CEM by a 1.3-m long, 0.8-m diameter tunnel at the front and to the rear by a hatch to the HRM. Two parts made up the center fuselage: a payload bay with cargo racks and an 8-m³ living quarters. Under the payload bay floor, fans of the air conditioning system, water pumps of the thermal control system, a condenser and water separator and three 35 l potable water containers were located.

The rear fuselage section, having lost some of its equipment to the front section, now housed the additional actuators of the airbrakes, hydraulic oil tanks and flight control system boilers. Externally, a deployable airbrake was installed on either side.

9.1.2 Hermes Resource Module (HRM)

This 6.65-m long, 7978-kg adapter structure between the launcher and the spaceplane would be made of carbon-fibre reinforced plastic (CFRP) and interfaced with the HSP using a titanium coupling ring and with the Ariane 5 by means of an aluminum alloy coupling ring. The outer surface was to a large extent covered by 43 m² of fixed radiator panels of the active thermal control system, circulating freon for cooling of the spacecraft.

The forward part of the HRM was an unpressurised section, covering the eight 400-N thrusters of the spaceplane attitude control system mounted on the rear bulkhead of the HSP.

The pressurised part of the HRM was 1.85 m in length with a volume of 13.2 m³ and was connected to the HSP by a 2.46-m long, 0.9-m diameter tunnel. This area shared the functions of payload area and airlock; two EVA suits and associated equipment were located here. A 0.9-m hatch in the left hand side of the HRM exterior wall would provide astronauts with access to open space and the exterior of the spacecraft.

External payload would be carried in the unpressurised rear part of the HRM and removed through a door in the roof, with the help of a hoisting carriage, either using the robotic arm of the space station or by EVA (see Fig. 9.3). Two hydrogen tanks and two oxygen tanks for the Storage and Distribution of Hydrogen and Oxygen
system (SDHO), four nitrogen tanks for the ECLSS, twelve 10-N thrusters and the propulsion module took up the remaining space in the HRM. But this was just one of the many HRM configurations the new module would go through (see Fig. 9.4).
9.1.3 Hermes Propulsion Module (HPM)

The 1820-kg propulsion module consisted of a thrust frame, supporting two 30-kN engines, fed by eight MON and MMH tanks. The engines were pressurised by four helium tanks. Two additional SDHO oxygen tanks, four nitrogen ECLSS tanks and a wastewater tank were also carried on the thrust frame.

Two sets of six bi-propellant 10-N thrusters of the attitude control system were installed on the HRM rear section, while this also contained the high gain antenna, to be deployed after separation from Ariane 5.

9.2 Changes and Concerns

The Hermes concept had by now been subjected to a number of radical changes. Its original weight had been 15 t, now it was put at 21 t. The Ariane 5 boosters went from a propellant load of 190–230 t and that of the central core from 140 to 155 t, while the thrust of the Vulcain cryogenic engine had increased 10% to 110 t. In order too keep down Hermes’ landing weight; the expendable HRM and HPM had been introduced. But the spaceplane would still be limited in the amount of cargo it could return on landing, down to just 580 kg by the beginning on 1989 [4].

Concern about the Hermes budget was continuing. The 1987 The Hague conference had committed $600 million to first stage of the Phase C development program, which would end in 1991.

France was putting up 42.65% of Hermes Phase CI funding, West Germany 26.7%, Italy 12.47%, Belgium 5.86%, and Spain 4.4%. Contributions of the ‘smaller countries’ were: The Netherlands, 2.4%; Switzerland, 1.9%; Austria, 0.5%; Denmark, 0.4%; and Norway, 0.2%. In addition, a non-ESA contribution of 0.45% had been proposed by Canada.

Of the $600 million (510 MAU), $365 million (310 MAU) had already been committed by ESA, which awarded contracts to prime contractor Aerospatiale and industrial prime contractor for aeronautics, Dassault. Aerospatiale was responsible for the airframe, workspace installations, and onboard software: Dassault for thermal protection and the flight control system. The other lead contractors were Matra (functional electronics), ANT (telemetry and communications), MBB (propulsion), Dornier support system), ETCA (electrical power), and Aeritalia (thermal control). These contractors were expected to spend some $210 million (180 MAU) on key technology development issues, particularly thermal protection.

Should everything go according to plan, ESA was to decide in 1991 whether to commit its members to the Phase C2 development programme, at a cost of $3300 million (2800 MAU). To go for Phase C3 leading to operational flights by Hermes, would require allocating a further $15 million (13 MAU).

The fate of Hermes could be sealed earlier than 1991, however, as ESA planned a review of all aspects of the programme and its estimated costs in September 1989.
According to ESA Director General Reimar Lüst (see Fig. 9.5), the Hermes Programme was ESA’s “most technically demanding,” with some key issues yet to be decided: the spaceplane’s weight, the required new materials technologies, and the type of crew escape system. “As long as the programme stays within financial and technical limits, the committed member states are bound by those commitments. If the price escalates, however, each member state has the right to back out.” “If Hermes gets the go-ahead, it has to fly. This cannot be dictated by costs,” Lüst was quoted as saying in August 1989 [5].

9.3 A Proposed Delay to Starting Phase 2

In the final weeks of 1989, the Ariane Programme Board recommended to the ESA Council to postpone a decision on the transition to Phase 2 of the project from the end of 1990 to June 1991. It was expected that the necessary technical definition status would be reached by mid-1990, but it would take the rest of that year to obtain, evaluate and negotiate the corresponding industrial offers, according to the estimation of the Board. The postponement would facilitate time for discussions at the Programme Board and for the internal preparation procedure in the delegations. It was the first in a series of delays for various technical and financial reasons that would beset the rest of the Hermes programme.

Nevertheless, the Programme Board still felt at this point that the Hermes Programme was in good shape, according to the official minutes of its meetings. With two major reviews just behind it, it was felt a ‘fair system baseline status’ and a ‘fair interface definition’ were available for Hermes-Columbus and Hermes-DRS, and that the same was just around the corner for Hermes-Ariane and Hermes-Space Station and the maturity of their external interfaces.
9.3.1 Phase 1: The Story So Far

The first 2 years of Phase 1 activities had achieved major progress in the most critical technologies, such as the selection of the fuel cell operating concept, the start of APU development, final choice of multi-layer insulation technology, the selection of the hot (thermal protection) structures and the comparative evaluation of a large number of samples from various firms of the composite structure materials, in preparation for a final choice to be made in February 1990.

Aerodynamic tools, used to define the spaceplane Shape 0.0, had been verified and improved and development facilities, in particular the wind tunnels were mostly operational, such as the improved Simoun plasma facility, while work had started on the Scirocco, HEG and F4 shock wave facilities.

The ‘stage 0’ configuration had been validated and although the reviews recommended verification and confirmation of a number of technical choices, it remained unchanged in its main features (see Fig. 9.6).

Decisions on the crew escape solution (cabin or ejection seats) and on orbit injection (use of the HPM or direct injection by Ariane), on forward visibility, on the transfer of some of the equipment inside the HRM to the spaceplane itself and those related to the cold structure and thermal protection, were expected to be taken between December 1989 and February 1990.

The definition of HERA had started at the end of 1988, following the ‘relocatable’ concept selected with the spaceplane configuration. The robotic arm had been

Fig. 9.6 Hermes Stage 0 configuration (© Airbus Defence and Space SAS)
submitted for review, due to end in December 1989. Both the EVA and IVA definition had started a bit late, but were also ready for review in early 1990.

It was expected that by the end of the first quarter of 1990, the spaceplane Stage 1 baseline would be established. That would serve as basis for detailed subsystem analysis, the updating of the internal layout and a reassessment of the mass budget. By that time, Dassault was expected to have completed its evaluation of aerodynamic options and to have defined the Shape 1 baseline.

Regarding the ground segment, although less critical in character than the spaceplane, there was good progress to report too. It was intended for a preliminary development plan, supported by a cost model to be available by mid-1990.

For the flight operations segment, including among others the HFCC and telecom facilities, a good overall architecture was in place, although the detailed industrial definition was expected to start behind schedule.

The training facilities (flight simulator and Hermes Training Aircraft) were on track to being defined in sufficient detail and the requirements for the launch and landing facilities would be well established by early 1990. Outstanding decisions on integration, checkout and maintenance facilities were scheduled to be taken in the first quarter of 1990 as well.

The formal issue of requests for quotes for Phase 2 was planned for March 1990 at this time. While the Programme Board would prepare the final decision, negotiations of the industrial offers would continue in order to place Phase 2 contracts soon after the next Council meeting, which was planned for June 1991 at this point [6].

Late January 1990 saw two major choices coming up for the Hermes project, both of which were to have substantial design consequences. A decision on the choice of an escape system was required and the deletion of the Hermes Propulsion Module was proposed. These themes were the result of recommendations made after completion of the RDP-A.

9.4 Crew Escape

The options for an escape system included the ejectable cabin, which had been under study for some time already and ejection seats, the alternative proposed more recently (see Chap. 23). The Crew Escape Module was considered in two versions: the Type A, in which the entire front section would separate from the plane, and Type B, featuring the ejection of the upper front section only.

The main advantages of the cabin choice were considered to be:

- crewmembers share a single system
- a cabin is easier to locate that individuals
- ejection takes place in a very short time
- a cabin protects against the environment and a possible explosion after ejection
- no action by crew required
The disadvantages were summarised as:

- aerodynamic instability
- uncertain ability to pilot cabin during and after ejection
- difficulty of designing an effective shock absorbing system for landing
- impact on spaceplane design: Centre of Gravity
- scale effects and the need for full-scale testing
- unknowns in development, qualification and costs
- type A cabin: risk of jettisoning lateral boosters
- type B cabin: mass penalty

This extensive set of difficulties prevented any selection of cabin design having been made despite more than three years of work on the subject. Besides, the lack of any experience in this field within Europe made things even more difficult, apart from the difficulty of mobilizing sizeable, highly qualified industrial teams, with the aim to develop a system that would hopefully never be used, was specific to Hermes without any other foreseeable application.

Based on ejection seats, three types of crew rescue system were considered:

- encapsulated seats with a protective shield that closes on ejection, usable over the whole of the solid booster flight range up to Mach 6
- classical ejection seats as used in military aircraft
- improved ejection seats from the Soviet Buran programme, providing a flight range up to Mach 3 by using a modified IVA suit

The pros of an ejection seat solution were: development risks and tests were well known (for systems up to Mach 3), little impact on choice of spaceplane configuration and seats could be used even from a vehicle undergoing extreme angular velocities. On the down side were the limited range of use, close dependence between seat and IVA suit, internal accommodation difficulties (especially with encapsulated seats), difficult sea recovery of dispersed crew, the requirement of each crewmember needing their own survival equipment and the sequencing of successive ejections (within 1–1.5 seconds), needing additional study.

A specific problem to be solved in case of using ejection seats was that they would be required to move away from the spaceplane at high speed in order to avoid passing through the exhaust of the boosters or be exposed to the effects of a launcher explosion.

Analysis showed there to be little difference in the comparative effectiveness of the cabin and ejection seat systems and that the reliability of 0.999 aimed for, would be hard to achieve. Nevertheless, ESA and CNES decided to adhere to that number, not to retain the ejectable cabin alternative and to adopt the Buran-type Mach 3 ejection seats as the Hermes crew escape means.

In view of the analysis of the options, the opinions of astronauts connected with the programme, HESAC and ESA and CNES quality authorities, the two agencies decided that the difficulties of developing and qualifying the cabin favoured the ejection seat choice. Additionally, there were the considerations of the impact on the reliability of the spaceplane itself (a smaller mass margin would be available for
other spaceplane safety measures), worries about costs and deadlines and uncertainty about the configuration of the cabin, highlighted by Aerospatiale’s recently expressed wish to revert to the type B cabin.

The ejection seat choice represented a reasonable compromise between the desirable and the possible, in the opinion of the agencies. Existing know-how in the field would ensure a successful development, which should emphasise the consequences to the design of the spaceplane and IVA suits, the impact on crew location and recovery after ejection, the impact on physiological criteria of astronaut selection and definition of interfaces between the CSG safety organisation and the crew.

ESA and CNES made some additional recommendations in support of their choice of the ejection seat system. The dependability of the spaceplane itself should be increased to the maximum attainable and a mass reserve should be put aside for more reliable or more robust choices could be made on system, sub-system and technology levels. Toughening up of the spaceplane structure should be considered in order to make it capable of resisting the pressure shocks and thermal fluxes of a Challenger-type accident. And possibilities of protecting the crew outside the flight ranges where the ejection seats could safeguard the crew should be explored.

Regarding the Ariane launcher, the agencies was recommended to incorporate alarm systems in development testing as soon as possible and to analyse operation in ‘degraded mode’ that would increase the possibility of saving the crew. For example, when a problem would arise in the Ariane 5 central stage during the launch phase not covered by the ejection seats, the stage could be put in ‘safe mode’, and the spaceplane ejected at burnout of the boosters. Additionally, the predicted operation of the solid boosters compared to the results of firing tests should be thoroughly analysed.

ESA and CNES emphasised that success in achieving a ejection seat-based escape system demanded that the prime contractor for the seat, the prime contractor for the IVA suit and the leader for the escape system be selected solely on the basis of proven experience and competence [7]. Here, a potential choice for the Soviet manufacturer Zvezda was obvious: their long-time experience in both spacesuit and ejection seats had met in the development of the Strizh spacesuit and K-36RB ejection seat, fully integrated and forming a united escape system, planned to be used on the Buran spaceplane. It would be ideal for Hermes (see Chap. 23).

## 9.5 Deletion of the Hermes Propulsion Module

The RDP-A had recommended reconsidering the justification of the HPM, the propulsion stage that had begun life as the L5B at the time of the programme file in June 1987, and was renamed HPM with the introduction of the HRM in September 1988. The stage was intended to inject the Hermes spaceplane into its transfer orbit after separation from the Ariane 5 central stage. A study into the HPM
had started soon after the RDP-A, in both CNES and Aerospatiale, and results were presented already in December of 1989.

The HPM had been introduced mainly to shorten the H150 propulsive phase and make sure this stage would fall back into the Atlantic Ocean: in other words, to prevent the H150 impacting populated areas. The main disadvantage of having the HPM however, was its impact on the complexity and interfaces of the overall Hermes launch configuration. The HPM, with two large protruding engine nozzles required a longer skirt to ensure sufficient clearance with the top of the H150 stage. It also necessitated an additional pyrotechnic separation interface, complicating the HRM design, in particular regarding the docking unit and manipulator arm stowage. These factors reduced the overall mission reliability. The HPM also represented a significant 30–40% of the recurring cost of the HRM/HPM combination and it complicated integration on the ground and the accessibility of the HRM payload area. Finally, the difference in specific impulse of the bi-propellant HPM compared to the cryogenic H150 and the low mass of the main stage near the end of the propulsive phase did not improve the overall Ariane 5 launch performance.

Deleting the HPM would become possible by storing an additional five tons of fuel in the H150 to become a H155, which would be able to perform direct injection of Hermes. It would allow shortening of the HRM, resulting in better access of the docking port, increase the overall mission success probability and significantly reduce recurring costs. In this new launcher configuration, Ariane 5 would put around 21,800 kg into orbit, instead of the 23,000 kg of the former design.

To ensure the prevention of fallback of the H155 in populated area’s, deorbitation retrorockets would be employed of the type foreseen for unmanned Ariane 5 missions: the central stage would then impact the Pacific Ocean.

Flying without the HPM would thus pose no problem for Hermes to reach the MTFF. For higher inclination missions of up to 56° to the Mir station however, a mission-specific propulsion kit could be used [8]. A mission to the Soviet orbital outpost had been the topic of discussions between ESA and the Russians for some time.

### 9.6 A Fourth Crewmember?

Apart from the studies of different configuration on the basis of establishing an optimal architecture incorporating all required hardware, Hermes’ configuration was influenced by operational considerations. The spaceplane’s prime function would be to service the MTFF, involving a substantial amount of cargo transfer. More in-depth studies were indicating that up to 230 man-hours might be needed for such a mission as opposed to the 120 man-hours allocated earlier in the reference Hermes servicing mission lasting ten days.

To alleviate this situation, two alternatives were studied: a three-day mission extension or enlarging the crew to a size of four. A mission extension would
increase food and hygiene requirements and those of life support, energy and attitude control. The addition of a fourth crewmember (reverting to the original Hermes crew size) turned out to have bigger consequences. It would complicate crew rescue, involving either a larger escape module or an extra ejection seat both adding mass. An on-pad evacuation, which would be more complicated as a result of the room taken up by the fourth astronaut and his seat in the small cabin, and it would take longer. On the whole, the extra crewmember would require Hermes to be between 1.1 and 1.5 m longer and 460 kg heavier. Consequently, the mission extension alternative was given preference over the increase in crew size [9, 10].

9.7 Eight Hermes Models

Amidst the changes occurring in the Hermes concept, a clearer planning was developed regarding the models that would help define and test the definitive configuration of the spaceplane and the assembly and testing of the flight models. It had now been established that eight models would be built, including the operational vehicles [11].

9.7.1 MA1 (Maquette d’Aménagement: Layout Model)

This model was aimed at determining the general options for electrical and fluid line routing, checking of mechanical interference between subsystems, evaluation of accessibility and the definition of requirements for ground integration, flight preparation, ground maintenance, safety studies and the confirmation of layout specifications of subsystems and allocated volumes. The mostly wooden, full-scale model would represent both the spaceplane (HSV) and resource module (HRM) with some areas deemed unnecessary not modeled. Primary and secondary structures would be represented, with doors and hatches having the required clearance and all equipment representative in volume and removable. The cabin’s mechanical features were designed to be used for general ergonomic study of livability, access and evacuation.

The mockup would be mobile and was to be used between June 1990 and June 1991. From July 1991, the model would be refurbished and used for the development of detailed ergonomics and instrument illumination. The MA1 would be located at Aerospatiale Building B03 in Blagnac. Eventually, this model would become the only one on which construction was actually started, with the spaceplane nose section and aft segment completed before termination of the programme.
9.7.2 MA2

This model would allow to establish detailed layout definitions for fixed and mobile mountings, electrical harnesses and lines, assembly procedures for spaceplane sections and the definition of assembly tools, and freeze interface specifications. The essentially metallic, full-scale model would be positioned horizontally and have some areas only partially modeled or not represented. MA2 would be a realistic representation of the complete spaceplane layout, with equipment being represented by models provided by the sub-system manufacturers, accurate in geometry as well as mechanical and electrical/fluidic interfaces. The model would be sufficiently precise and detailed to validate general choices and facilitate checking accessibility, installation and disassembly.

The model would be operational between January 1992 and June 1993 and would be update according to developments and preserved until the first subsonic flights. The MA2 would be housed at Aerospatiale in Blagnac, in the BIHE (Batiment d’Integration Hermes en Europe: Hermes Integration Facilities in Europe).

9.7.3 BIS (Banc d’intégration Système: System Integration Bench)

The BIS would primarily be a means of testing subsystem integration, aimed at performing subsystem inter-compatibility tests.

This model would facilitate validation of equipment interconnections, development of monitoring software and self-testing, development of communications among subsystems and with external systems, verifying the ‘lois de pilotage’, measurement of software performance margins and development of hardware and software changes.

BIS would consist of three main assemblies:

- Hermes subsystems: assembled without structural spaceplane elements on a support frames mimicking the layout of the spacecraft
- Real-time Data Center: a simulator, capable of generating all required parameters for full BIS operation
- Interface assembly between the simulator and subsystems

BIS was expected to be used between June 1993 and April 1995. It would subsequently be used to develop hardware and software modifications, to be verified before being incorporated into the identification model. The BIS would be housed at the BIHE.
9.7.4 MI (Maquette d’Identification: Engineering Model)

The model would enable verifying the procedures and means of section and equipment assembly, verifying and/or establishing procedures, software and materials necessary for the integration and the operational use of the spacecraft, verifying the subsystem interfaces, qualifying the space plane for the electromagnetic environment, and provide a functional reference.

This model’s components would be identical to the flight models’ in structural, electrical and fluidic aspects. The equipment used is function of the test phase (development, qualification or operational use). The wiring and lines would be standard flight hardware. The structure would be representative of the spaceplane’s with regards to volume and metallic content and the aerodynamic Shape 1.0. Thermal protection materials would be simulated in certain areas, but would be identical in electrical property. The MI configuration was to be maintained to reflect all most recent changes except in aerodynamics. Its base would be the BIHE, and be used between May 1994 and June 1997.

9.7.5 MST (Maquette Structurel et Thermique: Structural and Thermal Model)

The model would come in sections to allow full-scale test of parts, representative of the aerodynamic Shape 1.0. Doors, hatches, and the landing gear would be flight hardware, qualified after testing.

The cabin would be fully functional but not fitted with thermal protection, which would be simulated in both mass and installation. The hot structures would be simulated using structures of identical shape and electrical conductivity. Lines, wiring and interior would be flight hardware, with some equipment partly represented by thermal models. For electromagnetic testing, individual parts would be joined together to obtain a full model.

The MST would be tested according to the availability of different test facilities. Testing on sections was planned to be performed between May 1994 and April 1995, while electromagnetic tests of the assembled model were scheduled between March 1995 and September 1996. After these tests, the MST would be used for the first trials of the Hermes Carrier Aircraft (HCA).

9.7.6 CES (Cellule d’Essais Statiques: Static Test Airframe)

The CES was to be a complete primary structure that would include those parts of the secondary structure, which contributed to the rigidity of the vehicle. It would copy the actual aerodynamic Hermes shape and feature mobile control surfaces and
either real or simulated hot structures. It was planned to be used between November 1994 and November 1995 and would be located at Aerospatiale in Blagnac.

9.7.7 AV01 (Avion: Flight Model 1 (FM1))

Before performing orbital flights, the flight models would be used to check the behavior of the spaceplanes under actual flight conditions.

Spaceplane AV01 would enable refining results from the Approach and Landing Tests (ALT) and HCA test flights.

9.7.8 AV02 (Avion: Flight Model 1 (FM2))

The second spaceplane AV02 would verify the behavior under various climatic conditions (such as rain) and facing electromagnetic disturbances.

9.8 Second Hermes Industrial Day

More than 300 firms and organisations participated in the second Hermes Industrial Day, hosted in Munich on 1 February 1990. ESA, CNES and Aerospatiale presented and explained recent progress made in the system definition. The first one had been organized in November 1988 and a third one was planned to follow in a year’s time in Italy.

On this occasion, ESA announced it had decided to delay the start of Phase 2 of the Hermes and Columbus programmes by 6 months; their development would now begin on July 1st, 1991. Jörg Feustel-Büechl, ESA’s Space Transportation Director, summarized the reasons for the delay as technical issues, political reasons connected with the forthcoming German elections in the fall of 1990 and the state of affairs regarding cooperation with NASA in the Space Station programme.

The delay was no reason for ESA to adapt the schedule for the Columbus module: its launch aboard a Shuttle was still foreseen for 1996, as were Ariane 5 launches of Polar Platform 1 in 1997 and the MTFF in 1998. By now, the new official designation for the free flyer was Columbus Free Flying Laboratory (CFFL). However, the term was not widely adopted and MTFF would still be used most widely. NASA maintained a 1998 launch date for Columbus, a delay that ESA refused to accept; something the ESA Director General had discussed before the US Congress at the end of January.

The Hermes schedule did change as a result of the announced delay, however. And also as a result of an agreement finally reached between ESA and CNES regarding the launch dates of the first spaceplane missions. Up till then, CNES had

pencilled in Hermes’ initial flights a year earlier than ESA; the first, unmanned launch was now set for 1998, followed by its first crewed mission in 1999. But reports in the press by this time were citing observers not realistically expecting a Hermes first flight until after the turn of the century [12].

A number of hurdles still remained to be taken in 1990 in order to start the final development phase. The final Hermes configuration, ‘Shape 1’, was to be defined at the end of March, with a request for proposals to industry to be issued in April. By July, technical and financial proposals should reach ESA.

In the mean time, CNES had published a revised Hermes program file, establishing the feasibility of the project, its compatibility with Columbus and Ariane 5. Containing detailed cost and schedule planning of both development and operations, the new file would be submitted to ESA in June. This file, together with industry proposals, would form the basis on which Phase 2 of the Hermes programme would be decided. A similar scenario was foreseen for Columbus, with both the laboratory and the spaceplane up for a decision by the ministerial conference planned for July 1991.

The Hermes budget was currently capped at 4534 MAU; the preparatory phase 1986–1987 had cost 104.6 MAU, while the provision for Phase 1 had been set at 530 MAU. The major part of the expenses was to be committed in Phase 2: nearly 3900 MAU was budgeted up to 1999. A peak expenditure of 525–526 MAU per year was expected in the 1994–1997 timeframe, coming later than those of Columbus and Ariane 5.

Being facultative programmes, Hermes and Columbus would need to be decided by a dual two-thirds majority; namely, two-thirds of participating states representing at least two thirds of the contributions covering the overall financial program envelope. For Hermes, France (43.5 %) and Germany (27 %) together already represent more than two-thirds of the contributions. But it would be mandatory that at least six other countries followed to meet the quota of participants and engage in development. In principle, Germany would not be in a position to block the development of the shuttle by itself, despite its important contribution, any more than any other participating country could, due to the dominant contribution of France. It would be a desirable situation for all stakeholders to be in agreement to build Hermes and the same would be true regarding Columbus. This concerned France, Germany and Italy in particular, since they were providing most of the Hermes contributions: 82.6 % for Hermes, 76.8 % for Columbus and 81.7 % for Ariane 5. Including the contributions of Spain and Belgium brought the contributions for these programs by only the five major participants to over 90 %.

At this point, Feustel-Büechl considered the availability of budget to be the main problem for Hermes’ development. For 1990, France and Germany had announced a reduction of their contributions to Hermes and Ariane 5 by around 50 and 80 MAU respectively. An important ‘test’ would be a decision on financing additional Phase 1 activities, coming up in June 1991.

Another delicate point influencing the evolution of Hermes was the political-industrial rivalry between France and Germany. The Bavarian Finance Minister, Gérold Tandler, when welcoming the participants to the industry day, stressed that
Germany’s substantial participation in Hermes ‘should assure an appropriate part of industrial and technological work, vital to the next generation of space vehicles’. The minister also insisted on the necessity of Europeanising to a maximum extent the organisational structures of major European space programmes, in particular Hermes. ESA’s Feustel-Büechl also believed it was necessary to make Hermes more of a European effort and expressed the wish that Aerospatiale and Dassault would give German industry a larger role in the management and direction of the programme, either through Deutsche Hermes GmbH or Deutsche Aerospace (DASA).

And then there were the next German elections, scheduled for the following fall, which could also influence Hermes’ fate. The new governments position on the spaceplane, representing the second largest contributor to the programme, could be of decisive importance to its progress [13].

One more issue having an impact on Hermes and the entire In orbit Infrastructure planned by ESA for that matter, were the circumstances surrounding the Freedom Space Station, under development by NASA. The project was not going along smoothly, suffering from both technical and political difficulties. Most disturbing to ESA were recent expressions of an interest to use the large facility by the US military. With ESA dedicated solely to the civilian use of space, this had the potential of becoming a major problem.

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