Chapter 11
Buying Time: The six-month Extension of Phase 1
(1990)

Phase 2 of the Hermes Development Programme was to involve the actual development, final design and construction of the two spaceplanes and the required ground segment. The ESA Council had decided to delay transition to this second phase though by half a year from the end of 1990 to June 1991, at which point the transition to the second phase was expected at an ESA Council of Ministers [1]. Although the required technical definition of Hermes was expected to be achieved by the middle of 1990, arranging industrial contracts and internal preparations were estimated to take the rest of the year (see Chap. 9). As it turned out, just the first half of 1990 proved to be a very busy period, with a more centralised project management put in place through the installation of the ESA-CNES Joint Team. On a less positive note, a difficult decision on the spaceplane’s primary structure was more or less forced on the programme. Despite some undeniable problems in Hermes and in the Columbus and US Space Station programmes (see Chap. 10), the public view of Hermes remained upbeat: Flight International concluded that “Whether or not Freedom goes ahead, with or without full European participation, Hermes is almost certain to fly” [2].

11.1 Extension at a Price

Stretching the Hermes programme would not come without extra costs, though. The delay in the transition from Phase 1 to Phase 2 of six months to June 1st, 1991, necessitated some arrangement to financially bridge the period and make sure industrial teams that had been set up during Phase 1 would remain intact and could continue their work. As the Phase 1 budget had been almost fully been spent or committed, it would become necessary to tap into the Phase 2 budget. The Ariane Programme Board accordingly authorised the Director General to base the credit commitments he had requested to this purpose, amounting to 337 MAU (1989 economic conditions) on the ‘financial sub-envelope’ of Phase
2. A cancellation clause would be included in contracts with industry, limiting the total payments that ESA would be obliged to fulfill in case Phase 2 would not be started to 94.9 MAU [3].

The Director of Space Transportation Systems Jörg Feustel-Büechl explained the political aspect of the six-month delay in deciding on the start of Phase 2 of the Hermes Programme: “Germany may not really be in the position to make such a major decision before the elections, and we did not want Hermes to become a political issue in the middle of an election fight” [4].

The proposal for this financial solution to ease the transition to Phase 2 came in for some criticism. Both the German and French delegations regarded the plan tantamount to an extension of Phase 1, which would require a unanimous decision. But account should be taken of the programme’s dynamics and of the need to keep together the industrial teams. The delegation was of the opinion that there was little reason to put off a decision on the transition to Phase 2, since the degree of technical maturity was sufficient to go ahead. Feustel-Büechl reminded the Programme Board that the need for the transitional phase had been clearly established earlier at the Council in December and in the Programme Board itself. The solution he was recommending in the interest of the programme was the fairest to all parties concerned, he claimed, including industry, whose teams totaling some 1500 people needed to stay intact. Furthermore, the Director General’s proposal to postpone the decision on Phase 2 to June 1991 had been made with regard to national policy considerations, and that was what Council had finally decided to do. As funds allocated to Phase 1 would be mostly used up by the end of 1990, extending this phase turned out to be the only viable option [5].

11.2 Stage 1 Configuration: Hermes 8R1

As Hermes moved into its fourth year as an ESA programme, the vehicle had already gone through various incarnations. In February 1990, the spaceplane was defined in its Stage 1 configuration Hermes as 22 m long: at 13.9 m, the craft was extended by 1.2 m, while the rest was taken up by the HRM. Fuel tanks and thrusters for orbit and attitude control were now divided between these two elements. The vehicle had a span of 9.8 m: the wing was 84 m² in area with a nominal wing load of 190 kg/m² and a maximum of 200 kg/m². The fuselage diameter had been increased by 5% to 2.9 m. Internal changes, including the deletion of the crew escape module, meant that the mass of Hermes decreased from over 23 t to 22 t (see Fig. 11.1).

The payload of 3 t now had a margin of 15%: Hermes would land with a maximum of 1.5 t of cargo in order to stay within the 14.5 t landing mass limit.

The launch profile had also been adapted and now included a direct injection into a 110 by 460-km orbit, inclined at 25.5° by Ariane 5. The MRH would perform a direct injection burn in order to reach the nominal circular 460-km orbit. Hermes’ cargo performance remained very much dependent on its trajectory: reaching the
Soviet Mir space station would require a rendezvous orbit between 51° and 64°. That would reduce the payload to 1 t for a 51° and zero payload to 64°.

Hermes’ cockpit would retain its windows after the thermal gradient on their exterior appeared to be a little less severe than expected during the ascent phase. The deletion of the windows had been considered for both mass and thermal reasons. The side windows had now even been increased in size. CNES had tested a synthetic vision system on a Mirage fighter aircraft, but decided to reject the solution for Hermes in order to provide the two pilots with actual external views on orbit and during landing.

At this time, the Hermes design featured winglets at the end of the wings, but a dorsal fin was still under consideration (see Fig. 11.2). Winglets would offer more control in the hypersonic phase of return to Earth, while the central fin would be more effective during subsonic flight.

An improved thruster layout was proposed for the attitude control of the Hermes-Columbus composite. A further study of the positioning of thrusters for spaceplane pitch and yaw control during re-entry showed the need to install them in pods at the rear of the vehicle [6].
The next major step in Hermes’ aerodynamic evolution would be the establishment of Shape 1, which was to be defined by the end of March 1990, followed by new aero-thermodynamic tests (see Fig. 11.3). Concerning the Thermal Protection...
System, a final choice still was to be made between adhesively fixed thermal-protection tiles or bolted-on shingles. These would be made of silicon carbide, quartz and silica fibres, depending on heat levels experienced during the Mach 25 re-entry. The leading edges, heated to 1600 °C and the nose cap which would reach 1900 °C, would be protected by carbon-carbon composites.

A new definition review would follow in October, establishing a further improved configuration: Shape 2, to be tested in June–July of 1991. Achieving the final Shape 3 was planned for the end of 1992 or the beginning of 1993, with a critical definition review taking place in the 1993–1994 timeframe.

Subsonic glide tests of the spaceplane, released from an Airbus A310 were planned for the 1995/1996 timeframe, piloted by the crew that ESA would select for the first space flight. An initial intake of a selection comprising six to ten new astronauts would build up to 30 in the mid-1990s. The temporary addition of jet engines on one of the flight models performing the atmospheric flight tests was being studied [7].

In preparation for Ariane 5 operations, Vulcain engine tests were planned for April 90; first flight 501 in 1995, 502 in 1995, 503 with H01 in 1998.

After eight and a half years of development, Hermes’ first automatic flight H001 would be launched at the beginning of 1998 on the third Ariane 5 qualification flight 503. The first manned mission H02 with a crew of three astronauts would follow at the beginning of 1999. The second manned flight H03, which in principle would be the first operational flight, would occur by the end of 1999, on a servicing mission to the MTFF. Both Hermes orbiters should be operational in 2000 [1, 2, 8].

Fig. 11.3 Hermes’ subsonic glide tests would validate results from low-speed wind tunnel tests (© RUAG Switzerland)
In mid-1990, changes were afoot in the management of the Hermes Programme. At agency level, ESA and CNES were setting up a joint team to bring together all technical and management staff to form a single unit, based in Toulouse. At the same time, ESA requested industry to set up a central company, acting as a single industrial interface for the new joint agency team to interact with [9].

### 11.3 The ESA-CNES Joint Team

In an effort to streamline the management structure of the Hermes Programme, a single team that would include members from both ESA and CNES, functioning at the same level was being set up. At the 103rd Ariane Programme Board meeting, the creation of the ESA-CNES Integrated Team was first discussed. This joint management system’s goal was to rationalise relations and thus increase efficiency: preventing duplication and friction between the two original teams. The composition of the team was yet to be finalised but would aim for a balance between ESA and CNES staff. The team would consist of about 150 members and be headed by a CNES employee: it was to be Michel Courtois, who had been heading the Hermes Project Team at the French space agency. ESA’s Jean-Jacques Capart would be his deputy. At the time, 86 CNES employees and 26 ESA staff members were working on the project in the Toulouse project office: the ESA team would have to be expanded. ESA would retain the responsibility for placing contracts with industry and the Hermes programme would continue to call on the assistance of ESTEC and other ESA establishments.

The German delegation insisted on an equal representation of ESA and CNES in the new team and that the decision of responsibilities between them be perfectly balanced. Furthermore, in its view, an ESA staff member should head the team, making clear to the ‘outside world’ that ESA had the sole responsibility for the programme [10].

Courtois’ appointment would later lead to questions in the Programme Board. The fact that this Director of the Hermes Programme and Manned Spaceflight at CNES would also head the new integrated team and therefore serve simultaneously under both an ESA and a CNES contract was frowned upon by a fair number of delegations. They objected to this ‘double hat’, arguing that the Programme Director should be answerable to ESA only [11]. The questions and objections did not, however, stop Courtois from taking up his new position.

The Director Generals of ESA and CNES signed an agreement between the two agencies on the setting up of the Joint Team for the management of the Hermes Development Programme on April 10th, 1990. On July 4th, relevant texts containing detailed administrative arrangements for the implementation were signed and the ESA-CNES Joint Team started work in their Toulouse office on 1 August 1990 [12]. The team was to submit its first programme report on Hermes to the ESA Council by the end of June 1991. A final date and whether this would be a Ministerial Council meeting remained to be established at this time [13].
A further move to simplify the Hermes project concentrated on the industrial side. An enlarged but integrated prime contractor would be in place by late November 1990. Deutsche Aerospace and Aeritalia were joining Aerospatiale and Dassault, in preparation of a merger of the four industrials into a limited company to be called EuroHermespace. The double restructuring would resolve existing authority struggles between the teams and reaffirm the European character of the Hermes programme. It would also appease German and Italian wishes to be more clearly associated with the contractorship alongside the French companies, dominating the industrial aspect [13].

In addition to an adapted management of the programme, an improved review approach was adopted. It resulted in a next major review: the System Concept Review (SCR), which was scheduled for November 1990 [7].

11.4 Hermes Primary Structure Material

One of the features highlighted at the beginning of the project was that Hermes would have a state-of-the-art composite primary structure. As requested by the RDP-A however, the trade-off between composites and metallic structures was reopened and Dassault considered several options, the requirements on the structure itself and impacts at system level, particularly in thermal control and protection [14].

The analysis of composites was based on demonstration samples made with bismaleimide (BMI) and polymide (PI) temperature resistant composites, while the metallic alloys selected for comparison were aluminium 2219 and 2024 of the type used in the construction of the US Shuttle orbiter. The overall properties, mass, maintenance and lifespan, the complexity of development, manufacture and repair, technical credibility and flexibility of the resulting structure concept were assessed [14].

As the ESA-CNES Joint Team got down to work, a major decision had been taken by CNES. The French space agency had decided to forego the use of titanium alloy or carbon composites in the ‘cold structure’ of Hermes and selected aluminium as the material of preference (see Fig. 11.4). That would be easier to manufacture and aerospace industry was more familiar with this material. It would also provide better safety margins, easier manufacture, and shorter development [2]. Moreover, the composite materials had proven to be more susceptible to moisture and less thermally conductible than aluminium.

Drawbacks of this choice were an increase in the mass of the spaceplane of 250 kg and a reduced temperature range: a composite structure could withstand temperatures up to 200–240 °C while aluminium would be limited to 180 °C.

The choice to switch materials for the primary structure had a very down-to-Earth reason: European industry had essentially failed in their efforts to produce sample structures made of non-metal materials. The seven firms participating in the production of samples experienced difficulties in handling and processing the
As Joint Team head Michel Courtois put it: “Resin-based composites have been completely abandoned because nobody knows how to make them.” Additionally, production costs of the composite structures were estimated to be 70–80% more expensive than the metallic alternative. The choice for the conventional aluminium was rather embarrassing, as it did not make good on the announced objectives of advanced materials to be used Hermes or new skills and knowledge to be gained by the European aerospace industry. It was one of the first cracks to appear in the image of Hermes as an innovative project.

The choice for aluminium also meant the spaceplane’s TPS would have to be beefed up in order to withstand the increased heating of the main structure. A choice remained to be made between tiles and shingles, screwed on the metal structure through an insulating layer of an aluminium fabric coated with a reflective layer of gold or platinum [8].

Apart from the apparent inability of European industry to come up with a composite material for Hermes primary structure, it struggled with another item: the fuel cell. Fuel cell technology proved to be less mature than the structures needed to build the spaceplane. Initially, parallel definition studies were performed by Siemens and Varta from Germany and Belgian Elenco with the Dutch DSM. Dornier, Aerospatiale and ESA/CNES carried out a technical evaluation, supported by a panel of fuel cell technology experts. Additionally, Aerospatiale had requested Dornier to provide an overall development cost quote for the three suppliers. Only a single offer from Siemens was received, but this was found to be unsatisfactory in
the areas of cost, schedule and industrial organisation. Siemens was to continue working towards a planned 1991 test of a technology demonstration model, in cooperation with Elenco, Ecta and DSM [15].

11.5 Ejection Seats

Hermes astronauts would rely on individual ejection seats, which would take an astronaut to a distance of 500 m from the launcher within two seconds. The seats could be used up till Mach 3 and an altitude of 24 km during launch, and from 30 km down after re-entry. The seats would be able to evacuate the crew for a 84-second period during the 120 seconds that the twin large solid-fuel boosters would be burning.

The earlier alternative of the escape module would have permitted ejection up to much later in the launch sequence: at Mach 7 and an altitude of 50 km. Its feasibility had however proven both difficult and prohibitive in cost: around 300 MAU. By comparison, the trio of ejection seats was estimated to cost 100 MAU.

Each seat would weigh 180–200 kg and would launch through an ejectable hatch in the roof of the cabin. At ejection, the astronaut would be automatically secured into his chair by straps pulling in his chest, arms and legs in order to prevent injury to the extremities by dynamic pressure. The astronauts would wear special suits, protecting them from shock waves, thermal flux and thin air.

As envisaged at this time, the seats would be derived from those developed for crew of the Soviet shuttle Buran. Although it would not be possible for ESA to buy Soviet ejection seats outright, but it would a possibility to acquire the technology developed by the USSR. To this end, CNES entrusted Dassault to set up l’Association des Vols Habités (AVH: association for manned flights) in cooperation with Soviet industrials Energia, Molnia, and Zvezda, to be lead by Jean-Loup Chretien [8].

Up to this point, Martin Baker could still have provided the ejection seats, although not participating in Hermes, but it seemed the Soviet deal was highest in popularity [1]. In the mean time, Dornier was instructed to terminate work on their IVA suits as ESA had decided a single system approach for IVA suits and ejection seats [6].

The apparent imminent deal on the ejection seats led to some raised eyebrows in the April 18–19 Programme Board meeting. Countering views that to rely on the Soviet Union for ejection seats, Europe was taking the risk of loosing its independence, Jörg Feustel-Büechl replied that Europe could not reasonably refuse to cooperate with the Soviet Union if doing so would speed up the development of the seats and economise along the way. He also expressed surprise at “this procrastination about ejectable seats when, earlier in the meeting, delegations had been complaining about the persisting uncertainties regarding the spaceplane’s configuration”, reiterating he was solely guided by concern for the crew’s safety [5].
During the same meeting, the Spanish delegation raised the issue of Dassault, which had given the impression in statements to the press that contracts on the ejection seats with the Soviet Union had already been signed. This had ignored the role of ESA’s Industrial Policy Committee who had the sole authority to choose prime contractors. The Italian delegation was of the opinion that Dassault’s reported statements gave reason to doubt the objectivity of the Dassault studies on the best way to produce the seats in question. In reply, Feustel-Büechl made clear Dassault had already been reprimanded for its untimely statements to the press [5].

11.6 Refinement of the HRM

The HRM remained the focus of the search for increased reliability and reduction of developmental and operational costs. The possibility of transferring further equipment back from the HRM to the spaceplane continued to be carefully studied. One option was to do just that with the radiator. Reverting back to the earlier 5M1 configuration, the radiators could be installed on the spaceplane, which would also mean the return of doors on the fuselage. Although this option reduced recurrent cost by 1 to 2 MAU, it also increased the spaceplane mass by 1000 kg at landing. It also added a significant safety hazard, as the doors would need to be closed before re-entry. The radiator could, alternatively, be installed on the conical outer surface of the HRM, protected during launch by an ejectable thermal cover. The third possibility was to have radiators both on the HRM body and on the inside of deployable doors. This version appeared to be the most attractive one and was retained in the baseline design (see Fig. 11.5).

Whatever distribution of subsystems would be chosen, it was clear that the every HRM to be built would be tailored to the requirements of each individual mission. This was aimed at cutting costs, increasing flexibility and speeding up the final design of the spaceplane. The HRM would be available in three basic types [16] (see Fig. 11.6):

- MTFF support mission, duration of 12 days, EVA capability and robotic arm installed
- independent 30-day mission
- docking mission with Soviet Mir station; additional engines would facilitate the plane change to a 51°-orbit.

A permanent feature of all HRMs would be a common docking tunnel leading to a docking port through the centre of the module [2]. The robotic arm would be wrapped around docking unit during launch and would be installed and left behind on the MTFF [8] (see Fig. 11.7). Most of the critical flight equipment, such as the nitrogen propulsion tanks and hydrogen-oxygen tanks of the fuel cell system had meanwhile been put back into the spaceplane itself [14].
11.7 ESA’s Justification for Hermes

With Hermes experiencing its first period of difficulties, with the six-month delay, abandonment of the composite main structure and issues concerning crew rescue systems, Feustel-Büechl made a point of recalling the three political reasons for developing Hermes, speaking to *Flight International* magazine in March 1990. Hermes would enable Europe to master manned spaceflight, to be autonomous in space and to be accepted as an equal partner in international co-operation, according to Feustel-Büechl. The programme should lead to co-operative European development of aeronautical and space industries.
The spaceplane would be “... the symbol of what Europe can achieve as a common goal,” Feustel-Büechl said that operational justifications are that Hermes was not a stand-alone project but closely connected with Ariane 5 and Columbus; it would give a manned capability to Ariane 5 and, in addition to its primary mission to service the Columbus free-flier, Hermes would be capable of performing other missions, including a flight to the Soviet Mir space station.

Hermes would provide Europe with three technological plusses: acquisition of expertise in the key technologies of winged re-entry and aerothermodynamics; expertise in all aspects of manned spaceflight, including launch safety, life support, in-orbit servicing and spacewalks; and a stepping stone to development of future manned transportation systems such as Sänger.

“Hermes can extend Europe’s existing experience-in manned spaceflight operations and uses existing technology, namely a more conventional rocket, Ariane 5,” said Feustel-Büechl. “Going straight to Sänger or another system relying on new ascent technology using supersonic-hypersonic aircraft-like lower stages is too risky and too expensive.”

Only a winged vehicle could provide operational flexibility, crew comfort and safety and sufficient growth potential, Feustel-Büechl believed. A capsule had several disadvantages, such as limited landing opportunities, no mission or orbital flexibility, and limited crew and payload. A capsule was not appropriate for
extended orbital stays, had limited payload flexibility and “would not necessarily be less complex than Hermes,” Feustel-Büechl noted. Re-entry in a capsule would impose high g-loads on the crew and would involve considerable safety risks. He also considered the capsule approach to be a technological dead end [2].

11.8 Problems Discussed in the Programme Board

The Ariane Programme Board convened for its 103rd meeting at the ESA headquarters in Paris on the 12th and 13th of February 1990. The delegations from ESA member states met on a more or less monthly basis to discuss, be informed and take decisions on the development of the Hermes spaceplane programme.

Some of the delegations expressed surprise at the fact that a number of technical decisions, on the choice of escape system and the change in the material for the cold structure, had apparently already been taken by the executive, as status reports and technical notes seemed to show. There were objections from some of the delegations that this had happened without consultation with or approval by the Board, as was required. A decision on using Buran-type ejection seats would call for an amendment of the Hermes Programme Declaration, something that would require a unanimous vote by the programme participants.

Delegations declared there could be no question of the Executive going ahead with the ejection seat decision until it had provided delegations with additional information. The board had as yet done no more than decide that studies should continue on these seats. Also the change in structure material to aluminium could not be made without the Board being better informed of the reasons for the change.

The German delegation thought one reason for the problems voiced by delegations was the fragmentation of decisions concerning changes to the spaceplane configuration (see Fig. 11.8) and regretted that delegations had not been invited to the recent second Hermes Industrial Day. The Spanish delegation remarked it was in the interests of all parties for the Executive and the delegations to continue to maintain good relations so the decisions needed on Phase 2 could be taken in a climate of mutual understanding and trust. As the discussion went on, it appeared that the decision not to continue the escape cabin option had come from German industry, while the recommendation of the Buran-type ejection seat had been strongly supported by the European astronauts.

Finally, it was agreed that the Executive should pursue its comparison of the three options for the escape system and draw up a technical document with conclusions of the various groups of experts that had studied the options. The Executive should submit those detailed technical evaluations to the delegations in good time for them to be studied.

Delegations had also expressed worry about the non-existent margin in the design mass budget at this point in the development. The array of technical changes that were now anticipated had resulted in the virtual absence of any mass margin in the design of the spaceplane.
The Executive had pointed out here that Hermes would remain operational until 2015 and that an improved version of Ariane 5 would clearly become available in the meantime. The spaceplane would obviously have to be designed to accommodate the launcher’s growth potential. However, it was the aim to arrive at a 15% mass margin in the case of the spaceplane and at 10% for the margin of the resource module [14].

Fig. 11.8 By 1990 Hermes had already undergone major evolutionary steps (© Airbus Defence and Space SAS)
Meanwhile, the Industrial Policy committee had been discussing the delay to Phase 2. Feustel-Büechl thought that the cost of the development work was not the only element requiring clarification. The industries involved would only start moving things forward once they had received the invitations to tender. Postponing approval until June would mean firms would not be able to get down to work until September. They would then need a good six months to put their proposal together, which would make it impossible to make the Council deadline for moving to Phase 2 by June 1991.

In the end, the Committee voted and approved the procurement proposal, emphasising the need to be better informed on developments, echoing similar sentiments expressed in the Ariane Programme Board [17].

Unease within the Programme Board continued during their next meeting in April. The Italian delegation by now had a dim view of the Executive’s promises regarding the improvement of Italy’s return position by the end of Phase 1. It was no longer prepared to be content with promises and would not be able to support the Executive’s approach unless it had guarantees of its industrial return and until the uncertainty still surrounding the spaceplane’s configuration had been cleared up. The Director of Space Transportation Systems remarked that the Executive had made clear during bilateral talks with the Italian authorities that it would not be possible to achieve an ideal return for Italy under Phase 1 alone [5]. Italy would continue to lament their industrial return results throughout the rest of the programme.

### 11.9 Hermes 8P8

Entering the second half of 1990, the Hermes configuration had evolved yet another step. The new 8P8 HSV configuration measured 18.6 m in total length, 12.7 m taken up by the HSP and 5.9 m by the HRM (see Fig. 11.9).

A number of important technical choices had been made: an aluminium main structure instead of a composite, a delta wing with winglets, windows and ejection seats for the crew and a thermal protection system using a new concept of ceramic shingles. The belly and half of the forward section of the fuselage would be covered with carbon-silicon carbide tiles, as would ailerons, air brakes and winglets. Nose cap and leading edge would be made out of carbon-carbon. The upper side of the vehicle was to be covered by a multilayer ceramic fabric.

In the concept for the thermal protection of the spaceplane, Dassault had arrived at a strongly improved shingle concept and assembly technology, as a result from a trade-off between the baseline fibre-reinforced ceramic shingles and the silica tile solution used in the US Shuttle and Soviet Buran [14].

Still to be refined at the time were the aerodynamic shape, the belly profile, the position of elevons and air brakes and both the area and angle of the winglets.

Feasibility of the fuels cells was still to be established; given the problems industry was encountering in achieving the necessary technology, buying them from the US was being considered [18].
Hermes now weighed 22 t and was capable of transporting a 3-t payload at into a 90-km transfer orbit injection, reaching a speed of 8 km/s after 600 s of boosted flight on Ariane 5. The HRM thrusters would burn 1 t of fuel in order to reach the Columbus free-flyer or the Freedom space station for rendezvous and docking.

Returning to Earth after completing its mission, the spaceplane would start re-entry starts at Mach 25 at 120 km altitude, landing at 400 km/h on a 3-km strip. The vehicle would weigh 15 t on landing, including 1.5 t of cargo.

The internal layout had been simplified: the crew cabin of 14.4 m$^3$ now connected directly with the pressurized cargo hold that offered 10.7 m$^3$ of additional living space (see Fig. 11.10). A tunnel provided access to the volume 25.4 m$^3$ inside the HRM. The module contained tanks for fuel and gases: air, nitrogen, oxygen and hydrogen, part of the cargo and the EVA suits. These suits would return to Earth upon completion of the mission, secured to the floor of the life/cargo area of the cabin.

The 9 m-long HERA manipulator arm would be folded around the docking unit in the rear of the module. Thermal radiators and separation engines were mounted on the exterior [18]. The mass of the spaceplane upon entering the transfer orbit was put at 19,591 kg without margin. The Centre of Gravity was still 30 cm off the desired location. To correct this, additional work on the internal accommodation of equipment and aerodynamic shape was necessary [7].

![Artist impression of the Hermes 8P8 configuration (© CNES-ESA/Illustration David Ducros)](image.jpg)

**Fig. 11.9** Artist impression of the Hermes 8P8 configuration (© CNES-ESA/Illustration David Ducros)
Nevertheless, the Director of the Hermes Joint Team Michel Courtois stated that “The configuration is now consolidated and technical feasibility of the shuttle is confirmed” [18].

By the summer of 1990, expectations were for the final Hermes configuration to be established by the end of the year in order to prepare for the development starting at the beginning of July 1991. Definition of the spaceplane should subsequently be reached by the end of 1992 and a critical design review was foreseen in 1994. The first functional model of Hermes should be available at the start of 1994 with the static and thermal test models by mid-year. The two flight models should be ready for delivery in mid-1995 and mid-1996. The atmospheric subsonic test flights at Istres would commence in 1996. Hermes’ first, unmanned flight in mid-1998 would be the final preparation for the first mission carrying a crew in 1999. Hermes second manned launch would follow in the same year [18].

The two annual flights planned for the operational phase would not be possible from the start of the programme. Four Hermes missions would be required for spaceplane qualification and operations validation. On the first two flights, the basic performances of the vehicle, including nominal re-entry capabilities would be qualified [7]. Four manned missions during two years were expected to bring the necessary experience, such as with orbital rendezvous before moving on to the Hermes operational phase. This was expected to start around the end of 2000 at the earliest and would run from 2000 to 2015, giving a total program length of 30 years, only half of it spent performing operational flights [18].
The spaceplane’s integration sequence remained to be settled. For the first missions, the spaceplane and the module were to be integrated in Europe. For the operational phase they could be integrated separately; the HRM in Germany and the spaceplane in Toulouse, with final integration at the launch site in Kourou. “There will be only a single final assembly and integration site for Hermes, in Toulouse!” the head of the ESA/CNES Joint Team Michel Courtois had declared. This was against Germany’s wishes, which was lobbying for a second integration site in Germany, responsible for the full final assembly of one of the two Hermes flight models [18].

11.10 The Shape of Things to Come

Dassault and Aerospatiale were in the process of performing continuing aerodynamic studies based on calculations of the performance of a series of shape designs, in order to establish the preliminary Hermes 1.0 shape.

An excerpt from one of the numerous reports on Hermes shapes studied illustrates the extent of the work performed in 1990 on the alternatives that were considered for the spaceplane’s shape 1.0 [19].

**Shape 255/8P5**
The results obtained on this shape show that the adequacy of the center of gravity location with the aerodynamic limits is fulfilled neither for the subsonic regime nor for the hypersonic one.

**Shape 272/8P12**
Results linked to the subsonic behaviour are better than on shape 255/8P5 nevertheless they are still over the limit. Hypersonic results show that this problem is even worse than for shape 255/8P5. Consequently, this shape is not a good candidate for the Hermes 1.0/8R1 definition.

The idea is to increase the wing surface at the rear without moving the fuselage in order to minimize the center of gravity shift (see Fig. 11.11).

**Shape 273/8P21.** has thus been created. It is derived from a 255/8P5 shape by shifting the winglets backwards.

By comparing results to the one obtained on the 255/8P5 shape, one can say that the subsonic problem has been improved, but that it is still over the limits. Contrary to shape 255/8P5, the longitudinal hypersonic behaviour is satisfactory (see Fig. 11.12).

The major remaining problem is the subsonic one. By including the results from the ‘parallel studies’, a new shape has been created:

**Shape 282/8P13.** is derived from a 0.0/8M1 type shape by shifting backwards the winglets) following the direction of the leading edge’ as well as the elevons and the body/flap.

Results on this shape show an improvement of the longitudinal behaviour in general. The main control points are satisfied for this shape. Shape 282/8P13 can thus be a good candidate for the 1.0/8R1 shape (see Fig. 11.13).
Subsonic studies were performed on shapes 264 through 272, 275 and 277, while derivatives of shape 255, shapes 256 through 263 addressed issues such as the addition of the pods containing thrusters added to the rear fuselage, the shape of the body flap, increase in the fuselage length, forward shift in the canopy location, landing speed, Ariane 5 pilotability and length of the vehicle’s nose.

Shape 280 suppressed the body flap and 281 featured an increased elevon size, leading to the 282 shape, which satisfied all aerodynamic and thermal requirements.
of that particular design loop. Shape 282 thus became a candidate for the 1.0 shape, only to be upset by new uncertainties surfacing on the Ariane 5 pilotability criterion. An adapted shape 288 was defined, featuring a reduced area. Minor local modifications to this shape resulted in shape 294, which was subsequently to become the final 1.0 shape (see Fig. 11.14).
11.11 A Visit to Moscow

Following initial contacts between ESA and European industry and representatives of the Soviet space programme at the Paris Air Show in June 1989 (see Chap. 23), ESA and Glavkosmos had a first and informal meeting in Paris, on November 6, 1989. Glavkosmos was the Soviet coordinating agency for international space cooperation, which had started operations in 1985. A formal visit of an ESA delegation to Glavkosmos in Moscow followed from March 22nd to 24th, 1990, with the participation of CNES officials. The main objectives of the visit were limited to the Hermes programme and covered a possible Hermes mission to Mir, possible cooperation in the area of technology and procedures and rules for relations between Glavkosmos and ESA, and between industries on both sides. The ESA party visited facilities of the firms Energia, Zvezda and Molniya as well as the Gagarin Cosmonaut Training Centre and the TsUP mission control centre.

The visit resulted in the decision to propose an ESA-Glavkosmos working group as foreseen in the framework agreement between ESA and the USSR. The principle of a ‘mutually beneficial’ Hermes mission to Mir was established; definition of this mission and interface requirements would be the first task of the working group (see Fig. 11.15). The delegation was also briefed on the Mir-2 station, a new and sizable space complex which was planned to be operational by the time Hermes would perform its first missions. The Russian delegation expressed their interest to support the Hermes programme with their experience, facilities and astronaut

![Image](https://example.com/image.png)

**Fig. 11.15** Impression of Hermes docked to the Soviet Mir space station (© CNES-ESA/ Illustration David Ducros)
training infrastructure. ESA expressed its preference for cooperative activities that would be of technical interest to both parties [6]. A follow-on meeting involving Soviet representatives on potential cooperation with ESA on a mission to Mir and related aspects took place in Paris from June 5th to 7th [7].

11.12 Industry Receives Contracts

Twelve countries were participating in the Hermes programme, with France (45%), West Germany (27%) and Italy (12.1%) being the leading shareholders. These countries were to commit themselves to Hermes Phase 2 after examining the results of Phase 1 in order “to be sure that the objectives can be met within the budget and are in coherence with Ariane 5 and Columbus programmes,” as Feustel-Büchel put it. The decision would be made at ministerial level and requiring double two-thirds majority, which means by at least two-thirds of the participating twelve countries representing at least two-thirds of the financial contribution. In return for their commitment to Hermes, each participating state would be entitled to a ‘geographical return’ of at least 90%. In other words, “... at least 90% of the financial contribution of each country shall return to that state in the form of industrial and research contracts.” This objective had already been achieved by France and Germany. By March 1990, the industrial work performed on Hermes represented 1500 man-years per year in 300 companies and organisations [2].

The overall airframe subsystem responsibility was transferred from the prime contractors Aerospatiale and Dassault to the German MBB with specific associated structure integration responsibilities. The unpressurised, load-carrying part of the Hermes fuselage would be negotiated with Sonaca of Belgium for the front section and Spanish Casa for the central and rear part, including the external access hatch. The German firm Dornier would take care of the pressurised part of the fuselage, with its complex shape and many interfaces. Considering the commonality with advanced welding techniques used in Spacelab and Columbus, the large cylindrical payload and life area vessel would be built by Italy’s Aeritalia.

The work package for the wings, excluding the warm structure of winglets and elevons, would go to Aeritalia as well. MBB and Austria’s Contraves (who were to build Hermes’ cargo bay doors in an earlier stage) were recommended to build the Resource Module in- and external structure, with Contraves concentrating on the outer surface.

The docking adapter and two associated hatches would be built by the Spanish company SENER (see Fig. 11.16). Landing gear doors would be produced by the Germany’s MAN while Fokker from the Netherlands would make the deployable radiators and associated structure; they were earlier earmarked to produce the structure of the now cancelled Hermes Propulsion Module.

As the selection of materials and the configuration of the spaceplane progressed, corresponding industrial responsibilities were revised. A maximum of only two firms per airframe section would now be retained in an attempt to simplify the industrial structure [20].
German claims for a second integration site for a Hermes flight model never gained a favourable response from ESA. The space agency always claimed increased complexity, added expenses and a duplication of efforts. In the words of ESA Director for Space Transportation Systems Feustel-Büchel: “Although we want Hermes to be a real European effort and to give a good representation to all the major players, we don’t want to have duplication. ESA therefore always refused to consider Germany as the integration site for the No. 2 Hermes. […] The Germans should have a participation in the Hermes integration effort, but this should not lead to a duplication of tasks” [21]. The fact that German industry was given responsibility to build the main structure of the HRM an for the full integration of the module can be regarded as ‘compensation’ for never having received the coveted Hermes integration site.

### 11.12.1 Request for Proposals

ESA issued requests for proposals (RFP’s) to industry for development and production of Hermes in mid-1991 in preparation for the expected decision at
government level by member states to proceed with $5400 million (5200 MAU) program [22].

The decision on the RFP’s had not been a smooth one. Member countries’ delegation participating in the Industrial Policy Committee had had doubts about the commitment in the light of the recent technical changes to Hermes. Some had indicated to need more time to better assess the effects of these changes and gain a better picture of the spaceplane configuration, the management structure and industrial return.

The Executive had explained that the aim of the procurement proposal was simply to give industry an opportunity to detail the cost of the development work. All programmes had their moment of truth, as he put it and for Hermes that moment had now arrived. Deferring a decision would just push costs up. Although the Executive understood that delegations were overawed by the high cost of the programme, it was the price Europe would have to pay to have a spaceplane [23].

Increases in the costs of the industrial proposal for development, to be presented next November, could not be excluded, but many of the costs of Hermes elements development were known. Moreover, if certain elements turned out too expensive, they could be simplified or slightly delayed. However, unlike what was happening in the Freedom and Columbus orbital station projects, it would not be possible to delete elements in order to reduce the cost of industrial development of Hermes [13].

### 11.13 A Prophetic Prediction

A seminar held in early June identified the criticality of the period 1991–1994. This period of the development schedule was expected to be of major importance to meeting the launch dates as announced in the programme declaration, even when taking the maximum reasonable risks in paralleling development and integration activities [24].

Through to the third Hermes mission, the first one to service the free-flier, the Hermes programme was budgeted at 4534 MAU, of which 105 MAU was spent in the preparatory programme, 530 MAU on Phase 1 development from 1988 to mid-1991 and 3900 MAU would be spent on Phase 2 between mid-1991 and 1999. The scale of the technology effort was illustrated by the comparative spending of 32 MAU, 230 MAU and 420 MAU in the preparatory, Phase 1 and Phase 2 programmes respectively. Overall spending was expected to peak at 565 MAU in 1994–1995, with a relatively modest 39 MAU required in 1999, when the programme would see its realization [13, 25].

The decision to engage in full development would have to be based on the coherence of Hermes with the other elements of the future European transport system and space infrastructure (Ariane 5 and Columbus) and a demonstration of the technical feasibility of the spaceplane within the financial envelope that had been approved in 1987.
It would be a tall order. And as the announced ‘critical’ period neared, a piece of very recent history had begun to influence the course of the Hermes programme. It would eventually turn into a major factor in the eventual outcome of Europe’s ambitious plans.

References

3. ESA-PB-ARIANE(90)14, 4 April 1990, HAEU ESA-14421
4. ESA Delays Development Decision For Hermes Manned Spaceplane, Aviation Week & Space Technology, 26 February 1990, p 25
5. ESA/PB-ARIANE/MIN/104, 19 April 1990, HAEU ESA-14401
6. ESA PB-ARIANE(90)19, April 1990, HAEU ESA-14426
7. ESA/PB-ARIANE(90)32, 11 July 1990, HAEU ESA-14439
8. La definition d’Hermes sera achevée fin mars, Air & Cosmos, 10 February 1990, p 49
10. ESA/PB-ARIANE/MIN/103, 12 March 1990, HAEU ESA-14400
11. ESA/PB-ARIANE/MIN/107, 22 August 1990, HAEU ESA-14404
12. ESA/C(90)71, 3 October 1990, HAEU ESA-13884
14. ESA/PB-ARIANE(90)14, 8 March 1990, HAEU ESA-14422
15. ESA/IPC(90)67, 31 May 1990, HAEU ESA-14047
17. ESA/IPC/MIN/113, 15 March 1990, HAEU ESA-14026
19. Justification of the choice of shape 1.0, Dassault H-BT-1-1003-AMD, 14 September 1990
20. ESA/IPC(90)67, 31 May 1990, HAEU ESA-14047
23. ESA/IPC/MIN/113, 15 March 1990, HAEU ESA-14026
24. ESA/PB-ARIANE(90)32, 11 July 1990, HAEU ESA-14439