ESA's SPACE TRANSPORTATION PROGRAMME

J. FEUSTEL-BUECHEL

ESA Headquarters, D/STS, 8-10, rue Mario Nikis, 75738 Paris, France

and

W.WAMSTEKER

ESA IUE Observatory,P.O.Box 50727,28080 Madrid, Spain

1. Introduction

The overall development of ESA's Space Transportation Programme can be perceived in two major phases. The first phase finished with the transfer of the ARIANE 1–4 launch systems to Arianespace for utilisation and commercialization. The second phase was started after the success of the ARIANE launcher programme had created a sound basis for Europe's space industry in the evolving commercial space transportation market. This has lead to the definition of a second phase of the launcher development program which is expected to fulfil the needs for transport into space for many years to come. The wide objectives of the program makes it not only suitable for commercial applications but can also be expected to cover the launching needs for future Space Astrophysics missions.

Market studies of the future commercial space transportation needs show growing satellite masses and an increased worldwide competition. Europe therefore needs a powerful launcher with improved cost-effectiveness and improved reliability for geostationary missions. On the other hand the discussion about the optimum launcher, spacecraft size and orbits for Astronomy missions, as well as for Space Science missions in general, is still a matter under debate, as explained by Dyson elsewhere in these Proceedings. The experience obtained with IUE and EXOSAT -Observatory satellites which, due to their general user nature, do not have a rigidly preplanned observing program - seem to suggest that, at least for operational motives, high orbits appear preferable for such satellites. This is especially true as compared to the operational and planning difficulties foreseen with the recently launched Hubble Space Telescope, which is in low earth orbit (LEO). Of course, for firmly pre-scheduled observatories with a predetermined Science program, such as COBE and HIPPARCOS, this choice may not be obvious.

At this time, the ESA countries also plan for a European manned in-orbit infrastructure which will enable them to use the benefits that can be expected from manned space stations in low earth orbits. This requires a recoverable and reusable transportation system that launches man and equipment and returns them safely to Earth.

ARIANE 5 and HERMES are a unique and forward-looking combination which fulfils both tasks in an effective way. ARIANE 5 allows cost-effective lifting of heavier payloads to geostationary orbit and, at the same time, opens up the possibility of transporting European space station elements into their various low earth orbits.

Y. Kondo (ed.), Observatories in Earth Orbit and Beyond, 333–338.

TABLE I
Ariane 5 Performance Characteristics

	Ariane 44L	Ariane 5
Single launch payload into GTO	4200 kg	6800 kg
Dual Launch into GTO	3800 kg	5900 kg
Payload int polar orbit, unmanned mission	6000 kg	12000 kg
LEO (550 km @ 28.5 degrees), unmanned mission	7000 kg	18000 kg
LEO (500 km @ 28.5 degrees), manned mission	n.a.	21000 kg
Design Reliability, unmanned missions	90%	98%
Design Safety, manned mission	n.a.	99.9%
Recurrent Cost per launch into GTO	100%	90%
Relative launch cost into GTO	100%	55%

The HERMES spaceplane, launched by ARIANE 5, enables Europe to master the technology required for manned space flight. In addition, HERMES is capable of transporting crew, equipment and payload to the European space station elements. This gives a greatly increased in-orbit experimental capacity which enables Europe to participate effectively in the utilisation of the manned space infrastructure.

2. The ARIANE 4 Launcher

The current version of the European launch system is the three stage Ariane, with the modular ARIANE 4 being the workhorse for the 90's. The ARIANE is commercialized by Arianespace, an organization composed all European industries, participating in its developement and based in France. Of the 38 ARIANE launches (August 1990) 33 were successful. The main characteristics of the Ariane 4 are given in Table I. The recent developments in the open launch market and the need for small and cheap launches has generated a development oriented towards additional capabilities in the form of multiple satellite launches in the 400-800 kg range as well as piggyback mode of operation fro up to six satellites of masses no larger than 50 kg each. This mode was first successfully deployed on the V35 launch which brought into orbit not only the SPOT satellite but also deployed six mini-satellites in a Sun-synchronous orbit.

3. The ARIANE 5 Programme

3.1. Objectives

For ARIANE 5, a number of ambitious goals have been set. These are summarized and compared to the most powerful version of Ariane 4 (AR 44L) in Table I, while Figure 1 shows the overall design together with the main technical data.

The aim is to make the total recurrent cost of using Ariane 5 for a dual launch into GTO at least 10% lower than that of an Ariane 44L vehicle, assuming eight

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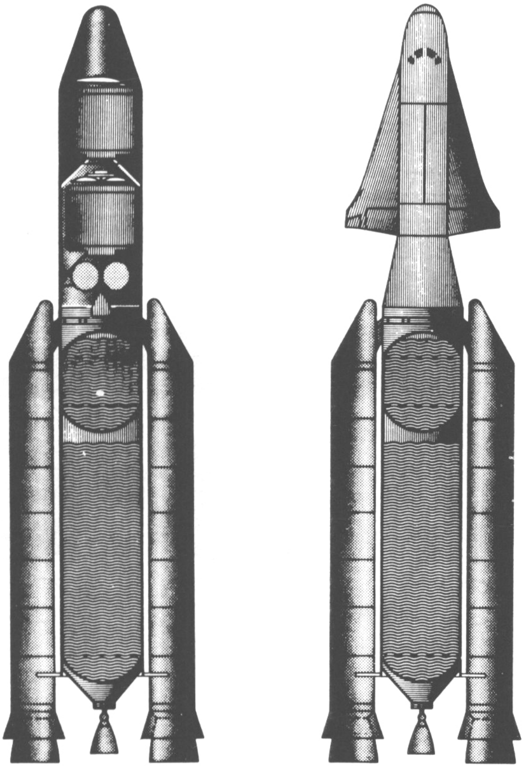

Fig. 1. Ariane-5 and Hermes, the future modular European Launching System

launches a year including four into GTO. On the basis of this target, Ariane 5 should provide a reduction of some 45% in the specific cost (cost per kilogram in orbit) compared with Ariane 44L. The production facilities, the design and development, which are an integral part of Ariane 5 programme, will support the production of 10 launchers a year. The new ELA-3 launch complex in Kourou (French Guyana) will also support this launch rate.

3.2. The ARIANE 5 Launch Vehicle

In order to be able to perform such large variety of different missions with only one launcher, ARIANE 5 is made up of a standard lower composite and mission specific upper composites. For unmanned missions in the ARIANE-5 programme, a variety of payload fairings with 5.4 m diameter and lengths up to 21.7 m will be developed (see Figure 2). The launcher's powered flight will have two main phases. The lower-composite flight will be virtually identical for all missions. It begins with ignition of the HM60 Vulcan engine on the ground; once the proper functioning of this has been checked, the main P230 solid boosters will be fired to reach liftoff. At P230 burnout, these are jettisoned and the H150 core stage continues to supply

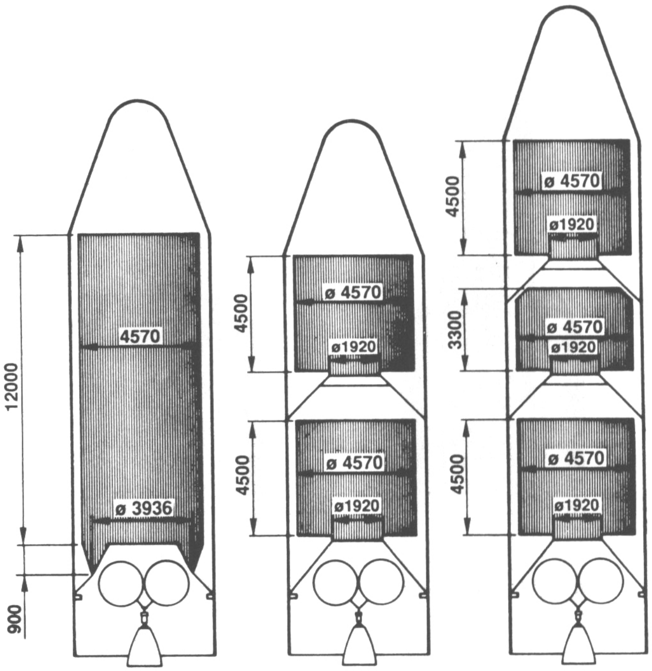

Fig. 2. The various fairings Ariane-5 and their performance characteristics.

the thrust needed for powered flight.

3.3. Schedule of the ARIANE 5 Development Programme

The development of Ariane 5 was started in 1984 with a preparatory phase which primarily concerned the critical cryogenic engine HM60 pre-development, the solid boosters and the overall launcher aspects. This part of the programme was concluded by end 1987. The development programme started early in 1988 and two development launches (501 and 502) for GTO missions are foreseen in early and late 1995. After these qualification launches, the start of the commercial programme is envisaged for 1996. A third development launch (503) in the Ariane 5 programme with an unmanned automatic Hermes is foreseen for mid 1998. These three test flights, intended to validate the in-flight functioning of the entire Ariane 5 vehicle, the functioning of the launch base and associated tracking facilities, are planned as follows:

– Flight A 501: The launch of a dual payload into GTO with the upper section consisting of a short fairing. This corresponds to the dimensioning of a commercial mission in terms of mission duration.
– Flight A 502: The launch of a single payload into a not yet chosen orbit, with the upper section consisting of a long fairing.

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– Flight A 503: Launch of the unmanned Hermes spaceplane into a circular 500 km low earth orbit, inclined at 28.5.

Milestones in the Ariane 5 development programme are:

System concept review: late 1987
Preliminary design review of launcher stage and elements: 1987 to 1990
Ground qualification of launcher stage and elements: 1993 to 1994
End of system test in Europe: 1993
ELA 3 available: 1992
First test flight: early 1995
End of development for launcher of automatic payloads: 1995
First operational flight: early 1996
First unmanned Hermes mission: 1998
End of development: 1998.

The cost of the total Ariane 5 development programme is estimated by ESA at 4114 Million AU (1986), which consist of 618 MAU for the nearly completed preparatory programme and 3496 MAU for the actual development phase.

4. The HERMES Programme

4.1. Objectives

The development of the spaceplane HERMES will take into account the following major requirements:

Primary mission: servicing of the Columbus Free-Flying laboratory
Mission duration: 11 days in the normal servicing mode for the Columbus
Maximum flight rate: 3 mission per year
In-orbit mass: 21000 kg (orbit 500 km @ 28.5 deg. inclination) Crew: 3 astronauts
Cargo capability: 3000 kg upload; 1500 kg download; 18 m^3 total cargo volume
Service life: 15 years or 30 orbital missions.
In order to achieve three flights per year, two spaceplanes will be built.

4.2. Schedule of the HERMES Development Programme

The HERMES development programme is two-phased. The first phase, which will be concluded by the end of 1990, is to reduce the risks associated with the development of such a novel spaceplane. The reduction of the technological risks is one of the major goals of phase 1. Besides this the consolidation of the definition of the Hermes System and its equipment in order to allow reliable definition of the content, schedule and cost of Phase-2 is another important goal.

The second phase of development programme, culminating in the second flight of a Hermes spaceplane in early 1999, covers the Hermes System's development and qualification for subsequent operational utilisation. The initial qualification will be achieved by means of two orbital qualification flights. The first (H01) will be unmanned, and the second (H02) will include the crew.

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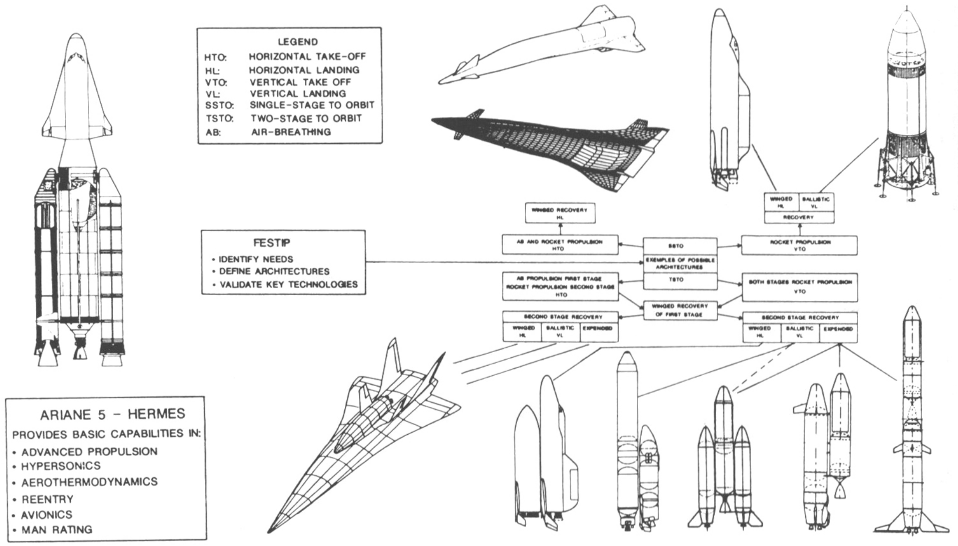

Fig. 3. Possible configuration of future space transportation systems based on the experience gained with ARIANE-5 and HERMES

5. Beyond ARIANE 5 and HERMES

Ariane 5 and Hermes will provide Europe with the basic technologies, expertise, industrial structure and management experience required for the subsequent development of future Space Transportation Systems. Many options are discussed today (see Figure 3). Which ones will eventually be chosen can not be predicted at present, but continuous studies are required if Europe is to derive a continuing and expanding benefit from the large effort it is now undertaking with Ariane 5 and Hermes.

6. Conclusion

It is clear that the developments planned for the ESA STS represent an ambitious programme mainly driven by the forward look needs of the communications, industrial and space sciences communities. The good performance in the Ariane 4 programme with a 90% success rate suggests that we might look forward to a launch system which will in the future also be capable to support the various requirements of a vigourous Space Astrophysics programme. One foresees a sufficiently modular launch capability to support both major Space observatories as well as the smaller type missions which are an fundamental part of the overall needs of Astrophysics from space.