ARIANE UTILIZATION

FOR SECONDARY PAYLOADS

BY

*G.G. Reibaldi and M. Trischberger,
In-Orbit Technology Demonstration Programme
European Space Agency/ESTEC
Noordwijk, Holland

G. Melchior
Ariane Department,
European Space Agency/HQ
Paris, France

J. Breton,
Ariane Customer Service
Arianespace
Evry, France

ABSTRACT

In preparing for the future, the European Space Agency (ESA) has identified a growing shortage of flight opportunities for secondary payloads. This was most directly felt in the execution of the In-Orbit Technology Demonstration Programme (TDP), which is aimed at the demonstration of new technologies in orbit, before their application in projects, thereby reducing the overall risk.

The TDP took a lead in investigating the possibility of using the European heavy lift launcher Ariane-IV as a low cost secondary payload carrier, not only for technological, but also for scientific and educational experiments. The secondary payloads were in the form of attached platforms, and small satellites.

This paper gives a detailed account of the efforts, which resulted in firm plans to establish a secondary payload capability on the Ariane-IV. Also, an overview of the technical implementation is given.

* Member AIAA
Fellow BIS

INTRODUCTION

In Europe there is an increasing need of flight opportunities for secondary payloads in the technology, microgravity, telecommunications and scientific area. The USA offers secondary payloads concepts, usually Shuttle based (Hitchhiker-G, GAS). Although both are ideal experiment carriers, the availability will be limited for some time to come. In the Soviet Union and China, the secondary payload concept is well established, but less available to western users (ref 8). In view of the limited possibilities, ESA investigated alternative secondary payload concepts.

New ESA programmes will require for their advanced space technologies in-orbit testing to complete the development cycle (ref 2,3). In the 1990's it is expected that in-orbit technology testing will be a more common means of technology development and verification, contributing to both making new technologies available earlier, and to reduce the risks associated with their application in the programmes under development.

In Europe space transportation is a commercial enterprise, operated by Arianespace. Presently, Arianespace performs regular launches, approximately every second month, of the heavy lift Ariane-IV vehicle, normally carrying two communication satellites into geosynchronous transfer orbit (GTO). Less frequently, about once a year, a single satellite launch into a polar, sun synchronous orbit (SSO) is performed. On both types of flights, often mass remains unused, in some cases as much as 200Kg. This led to the possibility of introducing a secondary payload capability.

Obvious secondary payload candidates are the light or micro satellites. There is renewed interest in those systems due to their low cost and improved efficiency. Small satellites, as conceived by ESA, are in the mass range of 20 to 40Kg. Many universities and research centers around the world are actively involved in their development.

While the small satellites satisfy the needs of modest experiments, there are still larger experiments to accommodate. ESA felt that an alternative carrier concept, similar to the Shuttle based Hitchhiker-G is certainly necessary.

ESA and Arianespace have concrete plans to offer regular secondary payload flights on commercial Ariane-IV launches for small satellites and platforms to carry more demanding experiments.

After a detailed analysis it appeared that the dual satellite GTO launch is the ideal basis for the Ariane Technology Experiment Carrier (ARTEP), while the single satellite SSO launch is more appropriate for the launch of piggyback small satellites. The system to launch the small satellites named Ariane Structure for Auxiliary Payloads (ASAP).

THE ARIANE LAUNCH VEHICLE

The Ariane is a family of European launch vehicles, introduced after successful qualification flights in 1979/80. Since then, the vehicle was continuously improved and upgraded (Ariane-II/III). The Ariane-IV is the latest and most versatile member of the launcher family (see figure 1). The maiden flight took successfully place on the 15 June 1988. The launcher is now operational. The different versions of the Ariane-IV allow masses from 1900 kg to 4200 kg to be launched into GTO, or up to 6000Kg into SSO (ref.1). Due to the wide performance range of the Ariane-IV it is the standard European launch vehicle of the 90's and replaces the older models.

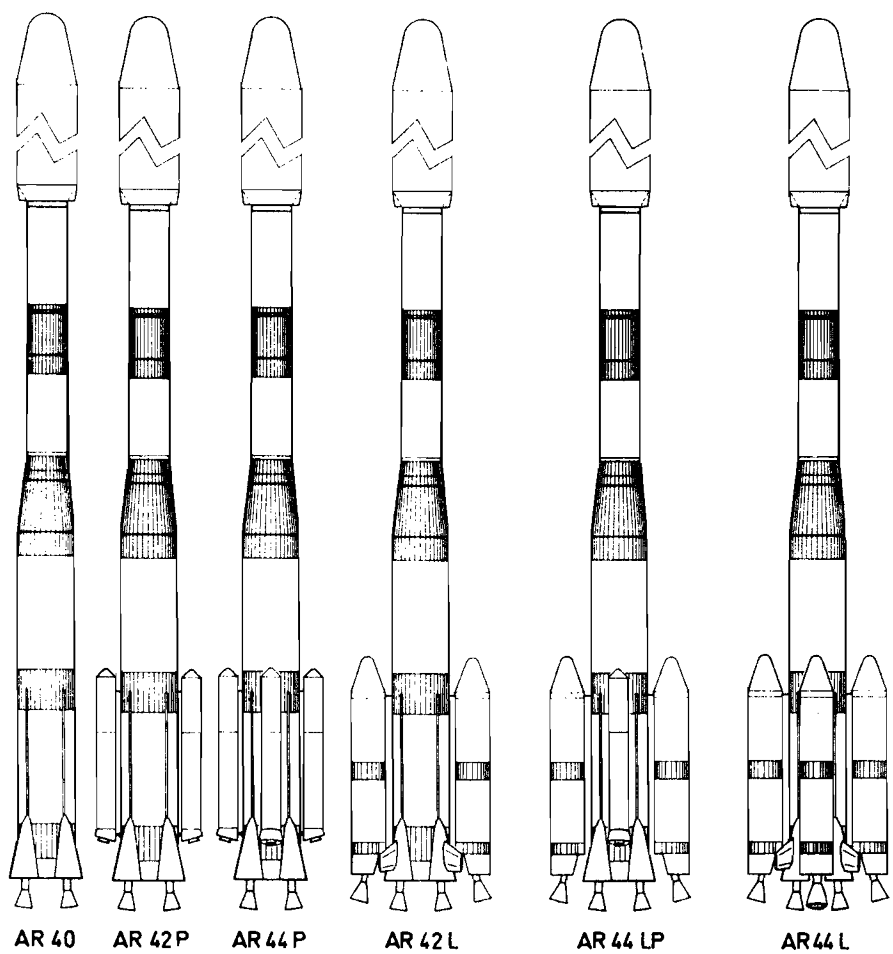

Figure 1: Ariane-IV Configurations

ARIANE TECHNOLOGY EXPERIMENT PLATFORM (ARTEP)

ARTEP is a low cost, free flying platform to perform experiments in GTO. Although designed to carry technology experiments it may also be applied to other disciplines provided that recovery is not required, and that the short mission duration of up to 10 days is acceptable.

The low cost of ARTEP is achieved by a reduced mission duration, by avoiding costly redundancy, and by low launch costs. Another major saving is achieved on the ARTEP system itself, as well as the payloads due to the inherently lower safety requirements of the unmanned Ariane launcher.

Depending on the mass margin of a particular Ariane flight, ARTEP can carry up to 100Kg of payload. It also provides to the payload with a downlink capacity of 100M-bit per day, and a total energy of 5KWh.

The ARTEP concept is only compatible with the Ariane-IV dual satellite GTO launch configuration. This is based on the peculiar spacecraft separation sequence of this type of launch (see figure 2). Phase E is the interesting event for ARTEP. At that stage the combined structure of the SPELDA top and conical adapter of the upper satellite is jettisoned, while the launcher is in a 3-axis stabilized mode.

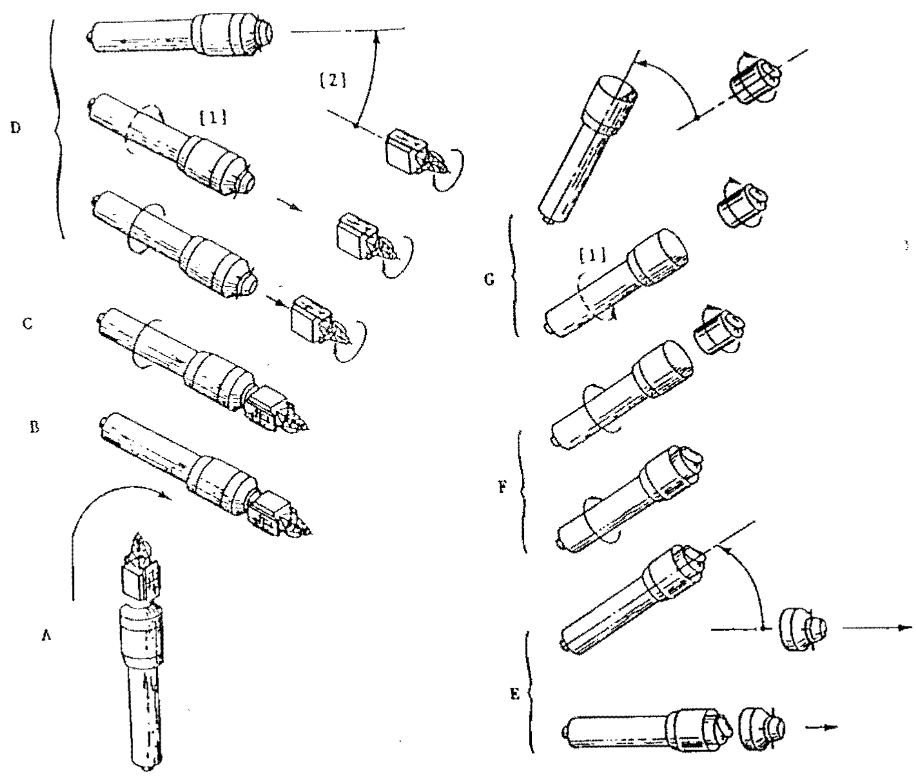

Figure 2: Ariane-IV Payload Separation Sequence

The structure of ARTEP is a simple ring of 160mm height and 2000mm diameter. A doughnut shaped mounting surface is attached to the inside. Either end of the ring is equipped with a flange that permits it to be inserted between the SPELDA top and the conical adapter. This is the only permitted interface to the launcher. The effect of the center of gravity shift on the launcher is under investigation, but is believed to be negligible.

Since ARTEP is bolted to the launcher structure, it is ejected together at phase E. It remains joined throughout the ARTEP operation (see figure 3).

Apart from the payload and the structure, the following subsystems are part of ARTEP:

- Activation and Power subsystem
- Communication subsystem
- Data Handling subsystem
- Attitude Measurement and Control subsystem

Power on ARTEP is provided by a set of LiSO2 battery packs (3-6), each providing a nominal energy of 1200Wh. The actual number of packs for a flight depend on the mission requirements. The first two packs are reserved for the ARTEP system. Since no electrical interface with the launcher is permitted, 5 redundant barometric switches activate a simple delay time during the ascent phase. When the time delay is elapsed, the nominal ARTEP operations begin.

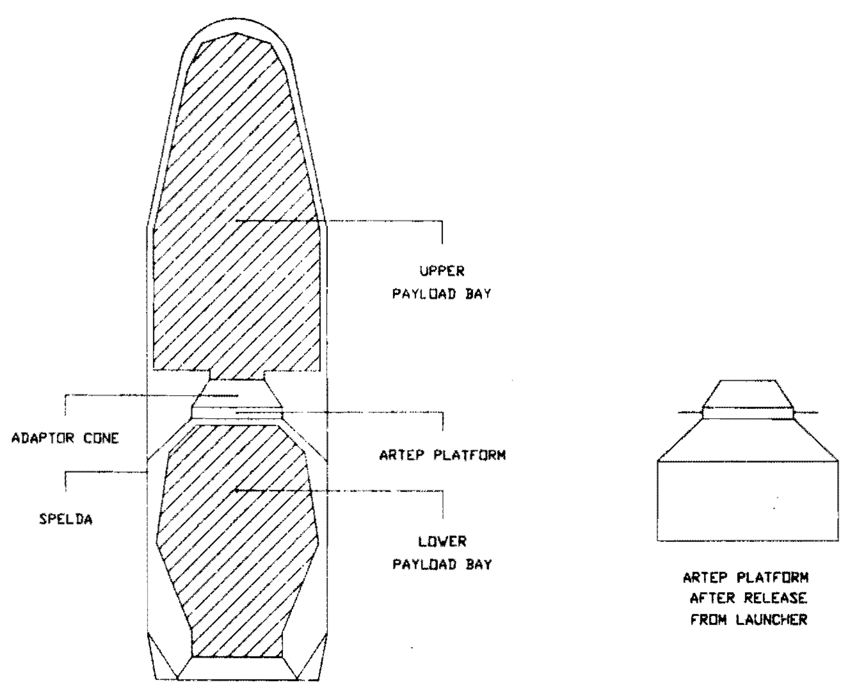

Figure 3: ARTEP Flight Configuration

The communication system operates in the 140MHz band, and consists of a transmitter, a receiver and an omnidirectional antenna, mounted on the outside of the ring. The RF transmitter power is 6W. The receiver is always switched on, while the transmitter is only powered when communication with the ground is required.

The Data Handling subsystem (DHS) comprises an on-board computer, a mass memory of 72M-bit capacity, and a housekeeping unit. The DHS is designed as a packet switching system, allowing completely asynchronous payload operation. Packets may be up or downlinked when ARTEP is close enough to earth. During the time of no radio contact, the packets are queued in the mass memory. The housekeeping unit provides simple on/off commands, and a number of low speed measurement channels.

Figure 4 shows the nominal orbit and attitude of ARTEP. The Attitude Measurement and Control subsystem (AMCS) is optional since some payloads may not require defined pointing. ARTEP operates in the elliptic GTO in a 3-axis stabilized mode. The +Z-axis is always pointing to the polar star. Normally, the AMCS maintains the +Y-axis earth pointed. During the perigee passage (190Km) ARTEP is reoriented so that the +X-axis points into the direction of the flight, since this configuration is aerodynamically stable. The AMCS system consists of a sun/earth sensor and a wide angle CCD camera as a star sensor, and a cold gas (nitrogen) control system.

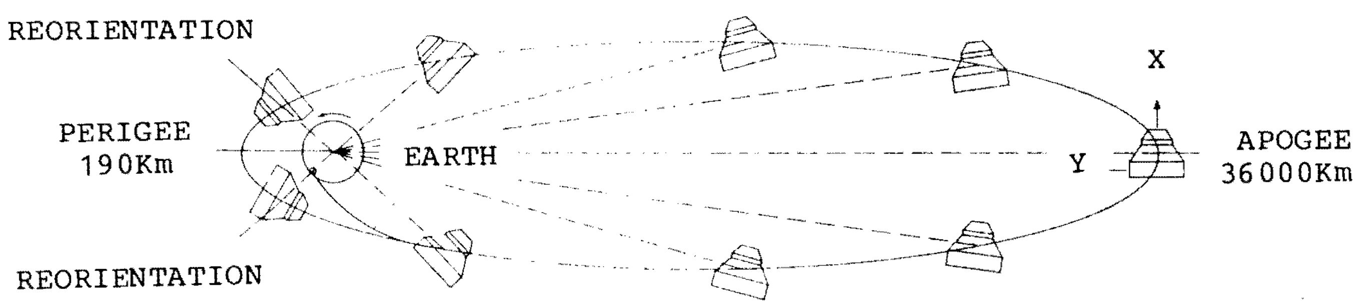

Figure 4: ARTEP Nominal Orbit and Attitude

The ARTEP ground system is very simple. It is assembled from industry standard equipment. The ground antenna is mounted on an elevation/azimuth mount, which maintains tracking. Downlink data is recorded on a digital tape recorder. Commands may be sent when ARTEP is in range of the ground station. The station is located on the Kourou Space Center (French Guiana). This provides optimal communication conditions.

In order to prove the ARTEP concept a first demonstration flight called PATHFINDER is scheduled to be launched in the course of 1989.

The objectives of the PATHFINDER flight are the following:

a) Learn about the technical issues related to the mounting of the platform on the Ariane-IV.

b) Carry out a demonstration of the on board systems.

c) Validation of pre and post launch operations, including ground operations.

d) Carry out a scientific experiment (mapping of radiation levels typical of the GTO orbit for future payload design).

The baseline for the PATHFINDER is, in functional terms, as close as possible to ARTEP. The most significant difference is that it contains no attitude control subsystem.

ARIANE STRUCTURE FOR AUXILIARY PAYLOADS (ASAP)

The ASAP structure allows to launch multiple small satellites, with a maximum mass of 40 kg each. A dedicated structure has been designed, which is compatible with single satellite SSO launches.

The chosen concept consist of an external plate mounted to the standard 1920 mm bolted interface between the internal cone of the Vehicle Equipment Bay and the Payload adaptor (see figure 5). This angular plate, externally located with respect to the support structure, offers the spacecraft a large mounting surface (external diameter 2900 mm - internal diameter 2100 mm). It is a metallic honeycomb structure faced with aluminium alloy skins, 40 mm thick, assembled to 4 metallic sectors secured to the 1920 mm interface. Rods link the extremity of the plate to the 2624 mm third stage interface and stiffen this structure.

It allows the installation of payloads weighing up to 40 kg, their numbers depend on the performance margin and the flight configuration of the foreseen launch. It is defined after study of the possible passengers. The volume of each payload, including its own separation system, will be contained within a cubic envelope of about 350x350x600 mm.

The first flight configuration will carry six satellites:

- 2 University of Surrey Satellites, UoSAT (D and E) (Ref. 5)
- 4 Microsat satellites from the U.S. Amsat amateur organization.

They will be carried as piggyback along with the primary payload of France's Spot2 Earth resource platform. Target date for the ASAP mission is June 1989.

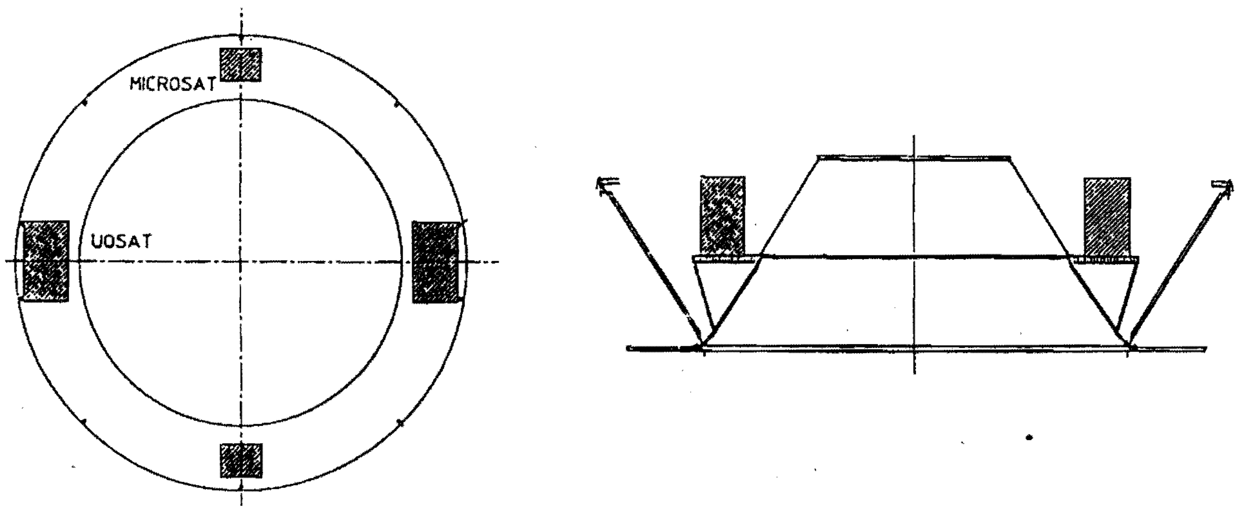

Figure 5: ASAP Mechanical Concept

MARKET SURVEY

A key element in the development of the Ariane utilization for secondary payload is the low cost for the users and therefore an attractive pricing policy. For the utilization of the Ariane Technology Platform a major user will be the next phase of the ESA's In-Orbit Technology Demonstration Programme. The programme will start in 1989 and continue through the 1990's, as envisaged in the European Long Term Space Plan, with a steadily increasing number of in-orbit tests being conducted each year. A wide range of technology experiments are planned to fly on ARTEP, ranging from simple to complex. Those experiments, still to be approved, could be fuel cell components, tethered systems technologies, electric propulsion and many others. Material in orbit testing will also play a important role.

In the scientific disciplines concerned with plasma physics, particle detectors and solar physics, studies could be carried out on board of ARTEP, as well as microgravity and life science experiments not requiring recovery. Late access, however, is not possible. Microgravity and fluid physics experiments such as marangoni convection, liquid columns, and others could be accommodated. Life science experiments on dynamic aspects of biological systems could also be carried out.

Other important categories of users of the ARTEP will be universities and research centers. Those organizations require flight opportunity for educational purposes. In fact several universities in Europe are equipped to build space experiments.

For the utilization of the ARTEP a large potential market exist and up to two flights per year are expected to be carried out.

For small satellites, several private companies such as Surrey Satellites Technology Limited, Globesat Inc., Microsat Inc., as well as universities in Europe such as Technical Universities, Berlin (Ref. 6), Toulouse and others will make use of the ASAP. Up to one flight every year is expected for ASAP, carrying two to six satellites.

Manifesting procedures for Ariane secondary payloads have not yet been finalized but it is evident that given the modularity of the two approaches, ARTEP and ASAP, a queuing system will be established with a six to eight months notification period prior to launch.

CONCLUSIONS

There is an increasing demand for secondary payload flight opportunities in Europe. But, unlike in the USA, the Soviet Union, and China, no such opportunities existed in Europe. Therefore, the European Space Agency, together with Arianespace, developed a consistent strategy to use the Ariane-IV for this purpose, with plans to extend the approach to the Ariane V when it will be available in 1995.

To support secondary payloads, two carriers have been defined; the attached payload carrier ARTEP, and the launch platform for small satellite ASAP. Both concepts will have their first flight in 1989. PATHFINDER, the reduced ARTEP version will either fly on V33 (May '89) or V37 (Nov. '89); ASAP carrying 6 satellites, two UoSAT's and four Microsat's will be flown on V34 (June '89).

ESA and Arianespace will, by end of 1989, have introduced a completely new approach to the launch of low cost secondary payloads using Ariane. It is expected that this will contribute substantially to the European and world needs in this sector that is at the moment striving for flight opportunities.

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