AIAA 92-3306

Solid Propulsion Systems For Small Launchers Derived From Ariane 5

Mr. Eric Dautriat,
CNES, Evry, France,
Mr. André Truchot,
Société Européenne de Propulsion, Bordeaux, France,
and
Mr. Gilles Vigier,
Aerospatiale, Les Mureaux, France

AIAA/SAE/ASME/ASEE
28th Joint Propulsion Conference
July 6-8, 1992 / Nashville, TN

SOLID PROPULSION SYSTEMS FOR SMALL LAUNCHERS DERIVED FROM ARIANE 5

E. Dautriat (CNES Evry, France)
A. Truchot (SEP Bordeaux, France)
G. Vigier (Aerospatiale Les Mureaux, France)

AIAA/ASME/SAE/ASEE
28th Joint Propulsion Conference
Nashville, TN/July 1992

ABSTRACT

The first launch of Ariane 5 is planned for 1995. New versions offering increased payload capabilities are currently investigated. Derivatives of Ariane 5 with lower payload capabilities are also considered in order to offer a launch service adapted to the whole market.

These derivatives consist of a family of launchers called Ariane 5 Launcher Derivatives (ALD). This family is composed of two launchers :

- ALD-S for polar orbiting satellites up to 4,000 kg (8,800 lb)

- ALD-P for small satellites up to 1,000 kg (2,200 lb).

These launchers will complete the Ariane family in 1998 at the end of Ariane 4 production. They will take advantage of the investment, the demonstrated reliability and the industrial experience that will be gained from Ariane 5 development. In production phase, ALD will benefit also from the Ariane 5 production rate based on component commonality.

The launchers will require two new solid rocket motors of 85 and 30 metric tons of propellant. These motors will be derived from the Ariane 5 solid rocket booster (230 metric tons of propellant). They will allow a rapid and low cost development, reduce production cost, simplify launch pad operations and provide high reliability.

INTRODUCTION

Ariane 5 development is currently underway. The first launch is planned for 1995. With the same philosophy as that of Ariane 1 to 4 family, derivatives of Ariane 5 are considered, with higher payload capabilities (such as Ariane 5 MK 2 and Ariane 5 Heavy Lift) but also with lower payload capabilities.

This paper presents a new generation of medium and small launchers derived from Ariane 5, adapted to polar orbiting satellites up to 4,000 kg (8,800 lb), and the solid rocket motors, that will be used for these launchers

RATIONALE FOR A NEW FAMILY OF LAUNCHERS

Ariane 5 can put into GTO a total mass of 6,800 kg (15,000 lb) with a single payload configuration or 5,900 kg (13,000 lb) with a dual payload configuration. With this increased payload capability compared to the existing Ariane 4, Ariane 5 will be very competitive for commercial missions into geostationary orbit. These missions represent currently the most important segment of the launch market with applications in the field of telecommunication, television, etc... Based on the needs that have been identified, 5 missions per year of Ariane 5 into GTO are currently planned.

The missions into low earth orbits are currently increasing for civil and military applications : earth observation with optical or radar system, meteorological, environmental and scientific missions.

An analysis of the market indicates that a great number of these missions are done into sun synchronous orbit (SSO) with payload mass in the range of 3,000 to 4,000 kg (6,600 to 8,800 lb). An evaluation in 1992 of the needs at the end of the century leads to a number of missions per year comprised between 1.5 and 2.5 (European market only). the same evaluation made in 1987 gave 0.5 mission per year.

Ariane 5 can launch more than 10 metric tons into SSO and presents overcapacity for this class of playload for which single launch is generally the rule for technical reasons (launch window, impact on spacecraft design) or for programmatic reason.

Ariane 4 could satisfy the need from a technical point of view. However the maintaining of Ariane 4 production facilities after 1998 will become uneconomical for 2 or 3 launches per year. Based on this launch rate a specific launcher derived from Ariane 5, using motors or equipment developped for this launcher, becomes very attractive; it will reduced initial investment and also production cost based on component commonality.

The same launcher can be adapted also to smaller

payload by suppressing the first stage. This market segment of smaller payload is not fully identified at present due to the lack of launcher. It is therefore difficult to justify the investment in a specific launcher. It is however possible to satisfy the need with a version or a spin-off of a launcher justified for existing needs.

ARIANE 5 LAUNCHER DERIVATIVES (ALD)

These derivatives of Ariane 5 consist of a launcher with two versions; the configurations of these versions are presented in figure 1.

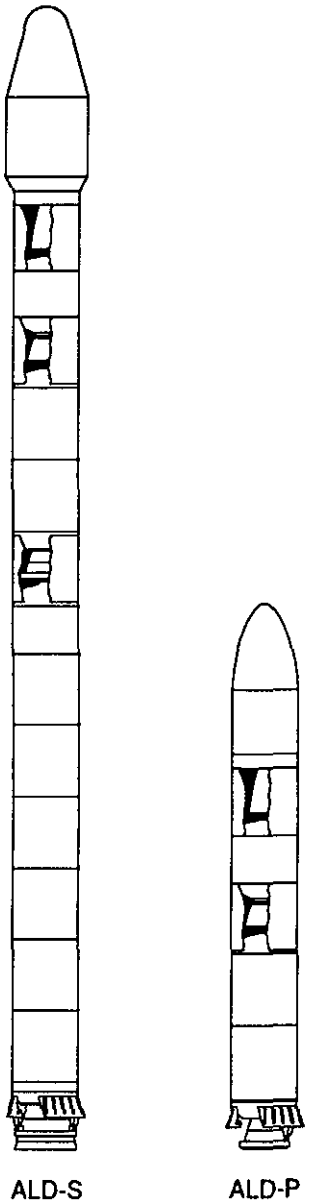

FIGURE 1 : CONFIGURATIONS
OF ARIANE 5 LAUNCHER DERIVATIVES

ALD-S

The ALD-S is adapted to polar orbiting satellites up to 4,000 kg (8,800 lb). The launcher is made up of four stages. The first stage is identical to the Ariane 5 booster (230 metric tons of solid propellant). The second and third stages use respectively 85 tons (P85) and 30 tons (P30) of solid propellant. The liquid upper stage, derived from the Ariane 5 upper stage L9, uses 5 tons of storable propellant. ALD-S will use the existing Ariane 4 fairing with a diameter of 4 m (12 ft).

ALD-P

The ALD-P is adapted to smaller satellites up to 1,000 kg in polar orbit. The configuration is identical to the ALD-S without the first stage. A new fairing with a diameter of 3 m (9 ft) will be developed with a dual payload device.

ALD launchers will be operated from the Ariane 5 launch pad (ELA 3). A specific building will be created in order to assemble ALD launchers. The existing railway system will be adapted to transport the launcher on the launch pad.

These two versions of launcher will complete the Ariane 5 family in 1998 at the end of Ariane 4 production. They will offer with Ariane 5 a complete and competitive launch service adapted to the whole market for payload from 1 metric ton to 20 metric tons.

ALD LAUNCHERS PERFORMANCE

The objectives of performance for ALD launchers are :

ALD-S :
4,000 kg (8,800 lb) into SSO (800 km/98.6°)

ALD-P :
1,000 kg (2,200 lb) into circular LEO (1 000 km/90°)

These performances include the adaptor and the separation system between the payload and the launcher. The performances of ALD launchers into circular LEO are presented in figure 2 and 3.

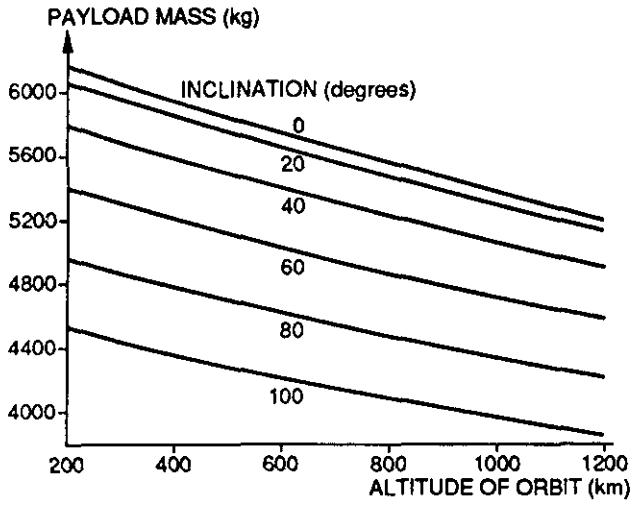

FIGURE 2 : ALD-S LEO CAPABILITY (CIRCULAR ORBIT)

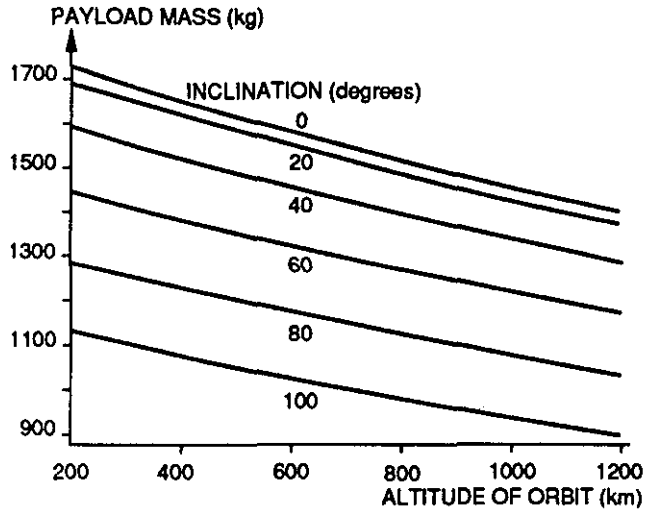

FIGURE 3 : ALD-P LEO CAPABILITY(CIRCULAR ORBIT)

	ALD-S		ALD-P	
	Time (s)	Altitude (km)	Time (s)	Altitude (km)
Takeoff	0	0	0	0
Separation 1/2	120	35	120	38
Separation 2/3	240	70	240	100
Separation 3/4	350	110	/	/
Fairing jettison	420	/	230	120
Iinjection	920	210	790	230
Circularization	2900	800	2900	100

TABLE 1 : MAIN CHARACTERISTCS OF THE TRAJECTOIRIES

FLIGHT SEQUENCE

A typical flight sequence of the ALD-S is presented in figure 4. The flight sequence of the ALD-P is similar. the main characteristics of the trajectories are summurized in table 1.

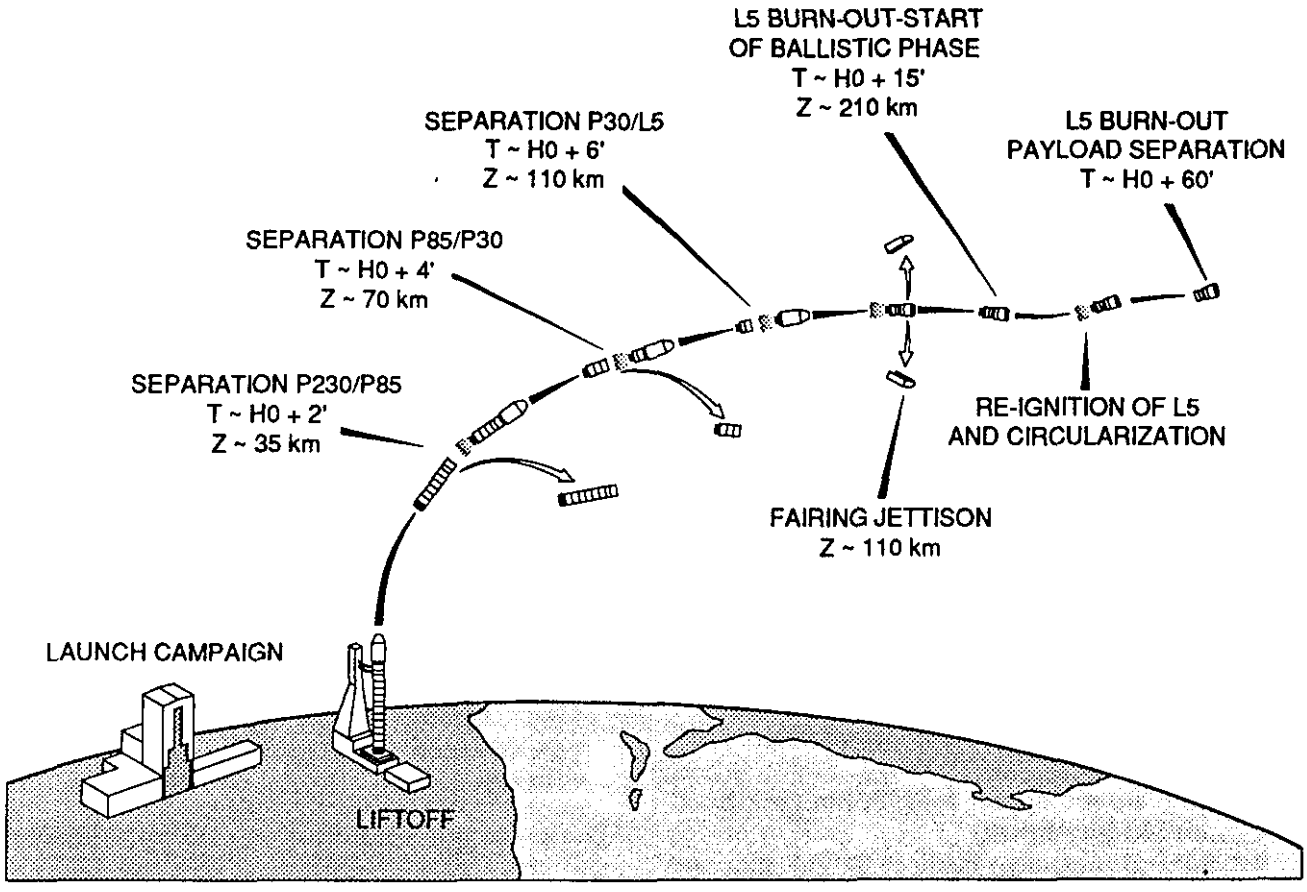

FIGURE 4 : TYPICAL FLIGHT SEQUENCE OF THE ALD-S

ALD PROPULSION SYSTEM

GENERAL

The ALD launchers will require two new solid rocket motors of 85 metric tons and 30 metric tons of propellant (respectively P85 and P30). These motors will be derived from the Ariane 5 booster. They will allow a rapid and low cost development, provide competitive production cost, reduce launch pad operations and give high reliability to the launcher. Table 2 presents the main characteristics of the ALD solid rocket motors : P230, P85 and P30.

	P 230	P 85	P 30
Dimensions			
Length	30m (98 ft)	10.3m (33.8 ft)	4.5m (14.8 ft)
Diameter	3.0m (9.8 ft)	3.0m (9.8 ft)	3.0m (9.8 ft)
Mass			
Propellant mass	230,000 kg (506 klb)	85,000 kg (187 klb)	30,000 kg (66 klb)
Gross mass	265,000 kg (583 klb)	* 87,000 kg (192 klb)	* 37,000 kg (82 klb)
Structure			
Type	7 cylindrical sections	2 cylindrical sections	monocoque
Material	steel (D6AC)	steel (D6AC)	composite
Propellant			
Type	HTPB (86% solid)	HTPB (86% solid)	HTPB (86% solid)
Configuration	3 segments	monolitic	monolitic
Nozzle			
Type	movable Sepcarb throat	movable Sepcarb throat	movable Sepcarb throat
Materials	Phenolic insulators	Phenolic insulators	Phenolic insulators

* : Excluding stage equipment (skirts, actuators, ...)

TABLE 2 : ALD SOLID ROCKET MOTORS CHARACTERISTICS

P230

The first stage of the ALD-S launcher is identical to the existing Ariane 5 P230 solid booster. Stage equipement will be adapted to the different configuration of the launcher compared to Ariane 5 : the forward skirt will be cylindrical, lateral attachment systems will be removed.

The booster includes the following subsystem (see figure 5)

- A metallic motor case with seven cylindrical sections and two domes,
- A thermal protection made of EPDM silica and EPDM Kevlar® rubber,
- A propellant grain segmented in three segments,
- A movable nozzle hinged with a flexible bearing.

The propellant grain is made of three segment :

- A forward segment of 20 metric tons of propellant casted in one cylindrical section and the forward dome.

This forward segment includes a star shape in order to provide

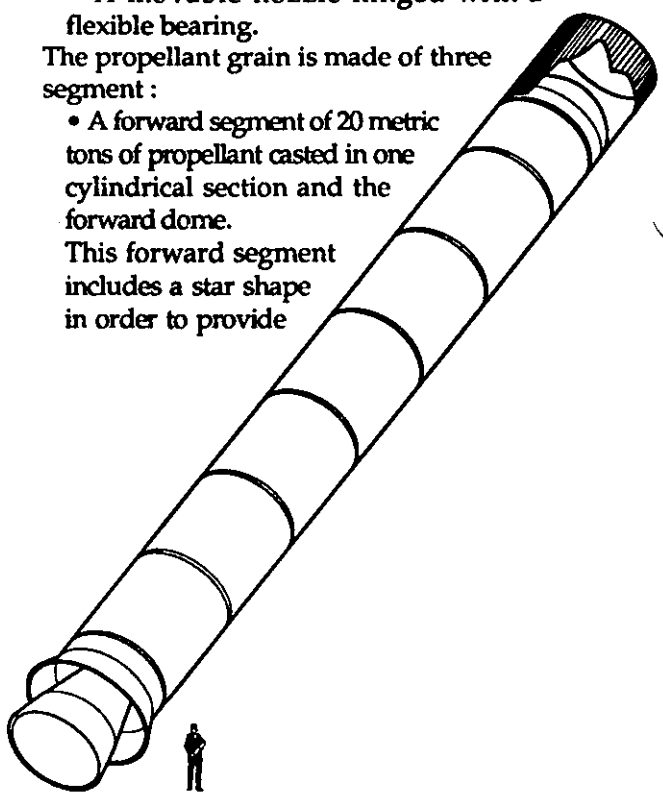

FIGURE 5 : P230 STAGE

the required thrust-vs-time curve.

- A central segment of 105 metric tons casted in three cylindrical sections.
- An aft segment of 105 metric tons casted in three cylindrical sections and the aft dome.

The different segments are assembled with clevis-tang and double seal system. The igniter and nozzle are also assembled with a double seal system.
The propellant uses an HTPB binder (14 percent) with 86 percent of solids (18 percent of aluminum). The nozzle uses performant materials and design (flexseal, carbon-carbon throat, phenolic liner and insulator)

P85

The second stage of the ALD-S, presented in figure 6, uses 85 metric tons of propellant. The design of the P85 has been driven to have the most simple and conservative design and to have a maximum commonality with the P230 in order to improve reliability and minimize cost. Common items include :

- Case material,
- Propellant formulation,
- Insulation and liner materials,
- Flexseal concept,...

The motor case consists of two cylindrical sections and two domes identical to P230 booster case elements. The propellant grain will have a monolitic design with a star shape. The thrust-vs-time curve will be optimized for the ALD-P mission

(use as a first stage). This constraint will have little impact on the ALD-S performance.

The nozzle will be a down scaled version of the Ariane 5 booster nozzle. The nozzle actuation system will use the same actuators and hydraulic power system as the large cryogenic engine actuation system of Ariane 5 (Vulcain engine).

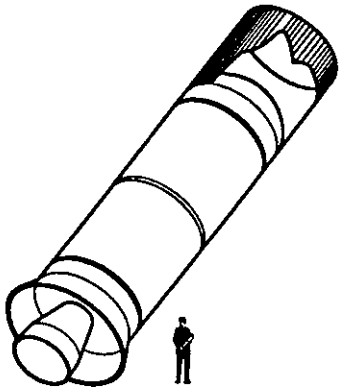

FIGURE 6 : P85 STAGE

P30

The performances of ALD launchers are very sensitive to the mass fraction of the upper stage P30. For this reason, a higher level of technology has been selected for some components :

- The motor case will be filament wound with a carbon reinforcement,
- The nozzle will use an advanced design with a composite flexseal.

These technologies have already been demonstrated in the frame of military programs in France. Except these technologies, the other components of the P30 will use common technologies with the Ariane 5 booster : propellant formulation, internal thermal protection rubber, nozzle liners and insulators, etc...

The P30 is presented in figure 7 and the main characteristics are given in table 2.

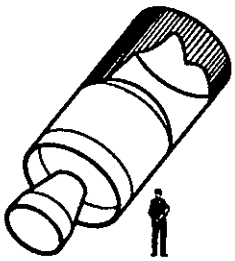

FIGURE 7 : P30 STAGE

ALD DEVELOPMENT

ALD launchers have been designed in order to have the maximum commonality with Ariane 5. They will use existing components or subassemblies if possible, identical materials and similar technologies. These principles will permit the production of ALD in the same facilities as those used for Ariane 5. The advantages of this approach are :

1) Reduce initial investment,
2) Use of Ariane 5 industrial experience,
3) Lower production cost,
4) Guarantee long term availability.

This will result in a rapid and low cost development and also in a competitive cost per pound to orbit.

Tables 3 presents a preliminary development schedule of the ALD launchers. 1992 and 1993 are dedicated to preliminary studies in order to optimize the launcher configuration and the propulsion system. With a start at the beginning of 1994, the first launch of ALD can be planned for mid-1998.

These two launchers will complete Ariane family in 1998 at the end of Ariane 4 production; they will offer with Ariane 5 a complete and competitive launch service adapted to the whole market from 1 metric tons to 20 metric tons.

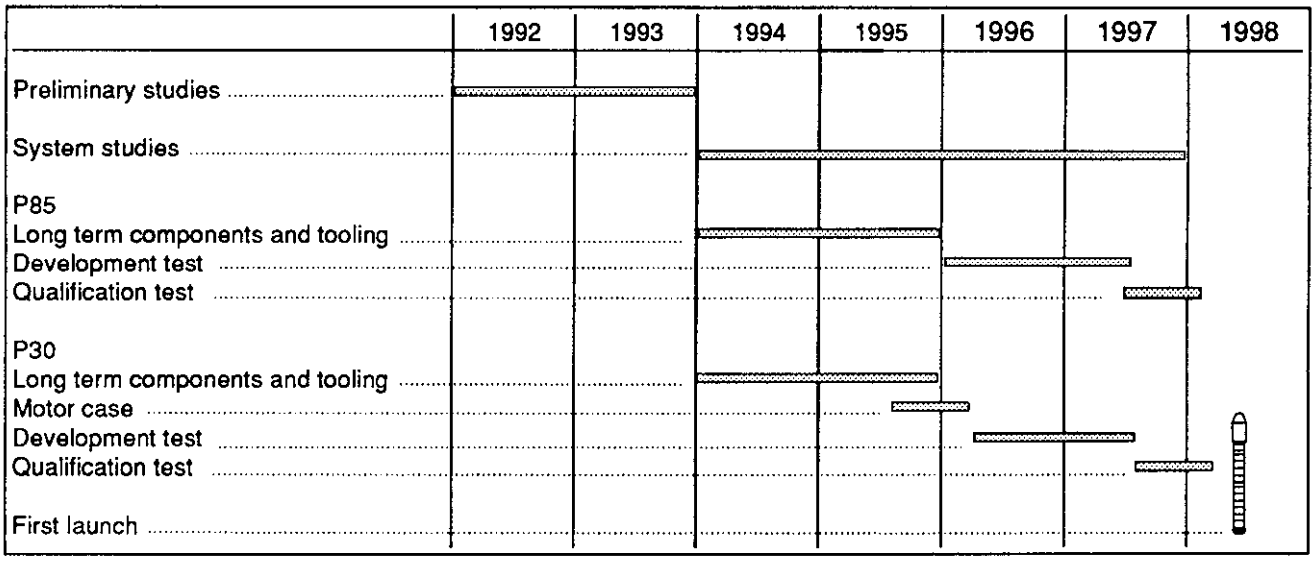

TABLE 3 : ALD LAUNCHERS DEVELOPMENT SCHEDULE