Acta Astronautica 66 (2010) 871–882

Contents lists available at ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

59th International Astronautical Congress—Glasgow 2008 Session D2.1.6—Launch vehicles in service or in development, Ariane 5—Program status

Denis Schmitt *, Louis Laurent

ARIANESPACE, Program Department, Boulevard de l'Europe, B.P. 177, 91006EVRY-Courcouronnes Cedex, Essonne, France

ARTICLE INFO

Article history:
Received 15 January 2009
Accepted 13 September 2009
Available online 30 October 2009

Keywords:
Arine 5
Launch system
Exploitation phase

ABSTRACT

While successfully and regularly operating the Ariane 5 ECA launch vehicle since 3 years, Arianespace continues to work to improve its Service & Solutions offer following three main axes: a continuous effort towards the improvement of manufacturing and operational processes, the preparation of a new batch order of launch vehicles to industry, and its participation in the preparation of ESA programs that will be proposed to ESA Council meeting at ministerial level in November 2008. While focusing on Ariane 5 activities, the paper will describe how Arianespace is getting ready to operate the European family of launch vehicles.

1. Recent flights results
   In this first part, the paper will describe the results of the Ariane 5 flights performed over the last 12 months. It will address Ariane 5 ECA flights and also the first Ariane 5 ES flight for the European ATV mission. The major launch campaign and flight events will be presented with subsequent discussions.
2. Ariane 5 program drivers
   After a brief description of the expected launch services demand for the next years, the paper will discuss the Ariane 5 production programs drivers and more specifically:
   - the continuous quality improvement process implemented to ensure regular Ariane 5 operations: configuration stabilization, enlargement of the launcher qualification domain, manufacturing and preparation operations review with the objective to smooth operational processes and control the risks and non-conformance number and
   - the main characteristics of the next batch order in preparation with the European Industry. Arianespace will order 35 launchers delivered ready for launch in the coming years. It takes into account an increased production rate and the industrialisation process implementation.
3. Next steps
   In parallel with the development of Ariane 5 ECA activities, the main challenge for Arianespace for the next years is its transformation as an operator of a family of launchers. The paper will describe the preparation of exploitation of Vega and Soyuz at the Guiana Space Centre (CSG) in synergy with Ariane 5.
   The paper will finally present the Arianespace approach for future European programs expected to be decided for the coming years in Europe.

* Corresponding author. Tel.: +33 1 60 87 61 42; fax: +33 1 60 87 63 27.
E-mail addresses: d.schmitt@arianespace.fr (D. Schmitt), l.laurent@arianespace.fr (L. Laurent).

0094-5765/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.actaastro.2009.09.007

0. Introduction

The last 12 months have been very busy for Arianespace with many Ariane 5 launches. This paper brings synthetic attention to the flight results. There were nine launches between the 14th of August 2007 and the 14th of August 2008, delivering 17 payloads into very accurate orbits, including the first ATV. Ariane 5 is now scoring 28 successful flights in a row, among which 15 are Ariane 5 ECA.

Let us mention that, at the time of writing this paper, the last flight (L542/V185) was not yet analysed and hence will not appear in some results.

With the Ariane 5 ECA workhorse now well on the trail with quality improvement being an objective, Arianespace is preparing the coming PB contract to order a batch of 35 Ariane launchers to the European industry. In parallel, the development of the new launchers of the family, Vega and Soyuz, is progressing impressively.

Arianespace is also considering the coming ESA ministerial council, whose decisions will drive its near as well as long-term future. This is why clear orientations have been determined to be shared by the whole European space industry and agencies.

1. Recent flight results

1.1. Missions overview

V177 flight of the 14th of August 2007 was the last one presented at the last IAC conference (annex 1). Since then, 8 new flights have been carried on, with the last one (V185), on the 14th of August 2008, setting down 15 payloads on their required orbits. These mission configurations are detailed in annex 2. They include the following:

- 5 Ariane 5 ECA in GTO double launch,
- 2 Ariane 5 GS in GTO double launch and
- the first Ariane 5 ES/ATV, which put Jules Verne on the ISS orbit for a very successful automatic docking.

Nearly all satellite operators from various continents have been served with:

- International (Intelsat),
- Europe (Skynet),
- Africa (Arabsat, Rascom)
- South America (Star One),
- Asia (Arabsat, JSAT, Horizons 2 LLC, Superbird, Protostar 1 Ltd., SCC, Turksat, Vinasat),
- Australia (OPTUS) and
- America (SES Americom).

All major platform manufacturers were concerned:

- Astrium (Eurostar 2000, 3000+),
- Thales-AS (Spacebus 3000 et 4000),
- MELCO (DS2000),
- Orbital (STAR 2),
- Lockheed Martin CSS (A2100) and
- SS Loral (FS1300).

1.2. Technical results at stage level

The level 0 flight data evaluation takes place a fortnight after flight. All data are reviewed, analysed to look for possible anomalies and compared with family and prediction. The results are presented to a steering committee where decisions are made concerning the anomalies. The level 1 flight data evaluation consists of mathematical model fitting for all main systems. The following synthesis is based on level 0 evaluations.

The *EAP boosters* have shown very reproducible behaviour. Ignition has always been symmetrical, and the 0.5 s ignition phase stays inside the same narrow envelop. The pressure evolution stays within prediction to within the second. The tail off is also well predicted, with some acceptable scattering in duration inside the family (Figs. 1 and 2).

The welded case configuration has flown twice again, rising to a total of 5 pairs of such EAP experienced in flight. This configuration allows increase in performance and reliability while also reducing cost, and its introduction in production is a success (Fig. 3).

The *EPC* flight has been smooth and within prediction in GS, ES and ECA configurations, the last two being very similar: ignition perfectly inside the thresholds, steady state part without noticeable anomaly, transonic phase buffeting and chugging during shut-down transient inside the family.

Illustration of this reproducibility is given in Fig. 4 with the two main parameters (specific impulse and mixture ratio) compared to the specification.

In yellow are the results of the last flights with Vulcain 2 engine. All of them stay inside 1 sigma of the specification, in coherence with the family, including the ES configuration, which demonstrates the good engine and stage control on such different trajectories.

The *upper stage* also showed, for EPS and ESCA versions, good results in conformance with predictions, without noticeable anomalies. Attitude Control System (SCA in GS and ES versions, SCAR in ECA version), the pressurisation loop and the engine operated normally. As for the EPC, an illustration is given in Fig. 5 for the *ESCA* stage with the two main parameters (Isp and MR) compared to specifications.

In yellow are the results of the last flights with ESCA stage. All of them stay inside 1 sigma of the specification, while improving the family centering.

The *Electrical system* worked perfectly. Let us note only that, on 2 flights, an EAP gyro has been lost at lift-off but without any effect on the flight as they are redundant. This problem has been reproduced on the ground, identified and corrected.

1.3. Technical results at system level

All the system functions worked nominally during these flights. Stage and fairing were separated properly; piloting reacts normally, in particular in the windy conditions experienced in Kourou at the beginning of the year.