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ALDEBARAN: A "SYSTEM" DEMONSTRATOR PROJECT FOR NEW GENERATIONS OF SPACE TRANSPORTATION.

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ABSTRACT

Aldebaran is the name chosen for a "system" demonstrator project which paves the way for one or more next-generation launch vehicle targets and is also specified to be able to realize operational launches. The project takes its name from the brightest star in the Taurus constellation.

The proposed demonstrator comes at a time when it is planned to operate existing European launch vehicles (ARIANE 5, Soyuz, VEGA) until around 2025, with no new generation launcher under development before 2015.

The project is aiming at developing a flight demonstrator by focusing certain activities involved in the preparation of future launch vehicles. The first launch shall take place around 2014. It would represent an intermediate step prior to the development of a new-generation launch vehicle.

The demonstrator shall also be capable of carrying out launch missions for micro- satellites to serve a market niche not covered by existing European launch vehicles. It will be developed in the frame of international co operations.

Several possible Aldebaran concepts are under analyses.

The paper will present the main Functional Performance Specifications of Aldebaran. Some illustrations of possible concepts will be shown.

1. CONTEXT- INTRODUCTION

Aldebaran is the name chosen for a "system" demonstrator project which paves the way for one or more next-generation launch vehicle targets and is also specified to be able to realize operational launches. The project takes its name from the brightest star in the Taurus constellation.

The proposed demonstrator comes at a time when it is planned to operate existing European launch vehicles (ARIANE 5, Soyuz, VEGA) until around 2025, with no new generation launcher under development before 2015.

The project is aiming at developing a flight demonstrator by focusing certain activities involved in the preparation of future launch vehicles or in the preparation of improved operational launch-vehicle. It would represent an intermediate step prior to the associated developments (see figure 1)

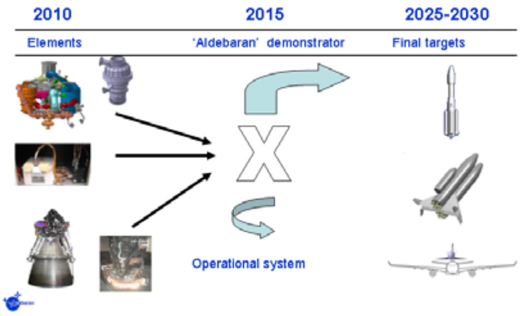


figure1: Aldebaran context.

The demonstrator shall also be capable of carrying out launch missions for micro- satellites to serve a market niche not covered by existing launch vehicles. This "niche" market of micro satellite missions is supposed to be covered by 300kg performance mass objective for a reference 800km Sun Synchronous Orbit mission. The figure 2 below shows how such a launching system will complete the current family of the European systems from the performance point of view.

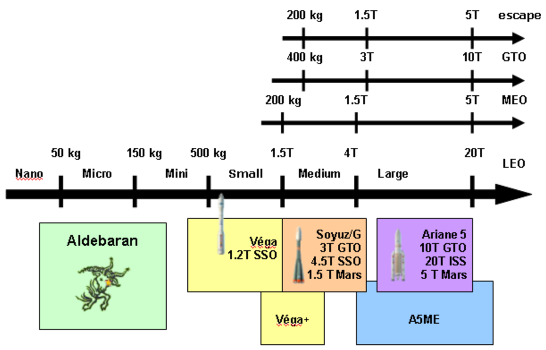


figure 2: The possible place of Aldebaran within the European launch vehicles

The operational version of Aldebaran will also cover the defence launch requirements (responsiveness, confidentiality).

The present paper describes the objectives of the project in terms of performance, schedule, cost, limits and constraints of the launch service. It will also provide some indications about the possible concepts and the chosen technologies.

2. ALDEBARAN ORGANISATION AND GENERAL PLANNING

Aldebaran is co managed by national agencies and institutes (CDTI, DLR and CNES), and is open to possible partners. The phase 0 started early 2008 involving Spanish and French industries and research centres, and involving the DLR institutes of Braunschweig for technologies, and Bremen for system studies. At the end of 2008, 2 or 3 concepts will be selected for the phase A foreseen in 2009. one single concept will finally be retained for the development phases (B/C/D) starting in 2010. the first technological flight is foreseen around 2014.

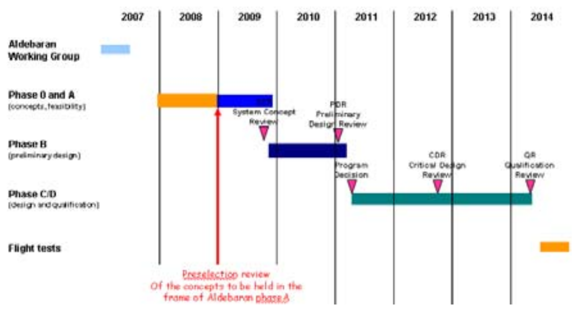


figure 3: the Aldebaran main planning.

3. THE FUNCTIONS AND THE OBJECTIVES OF ALDEBARAN

3.1 The main functions and the objectives

The first objective is to Co-build a system demonstrator project involving different possible partners.

The Aldebaran demonstrator combines a new launch concept, new technology and new techniques to build an operational system based on a flexible organisational structure.

A "new" technique or technology is defined as any improvement made to the launch system (launch vehicle, ground, operations, etc.) or the related development or operating activities that improves both,

- the management during the development phase including the coordination between different actors

- the service provided to the customer:

  reliability/safety/availability,

  operational flexibility (mission, operations, responsiveness),

  operating cost,

  flight environment,

  customer services.

Aldebaran project is the support for the development of new technologies to improve customer service

The technology developed shall be potentially applicable to future launch vehicles destined to take over from those of today (Ariane 5, Soyuz and Vega) around 2025-2030. they also can be applicable to improve the current launch vehicles. With this in mind, key innovative technologies shall be identified and listed. The identified technologies or concepts shall then be classified and their possible integration into a launch vehicle studied to demonstrate their potential.

Aldebaran will naturally develop the industrial skills and the competencies of research centres relating to future launch vehicles .

It shall pool as many technologies and/or techniques applicable to future launchers as possible. For the purposes of this project, pooling means that the demonstrator shall be capable of bringing together activities conducted outside (self-financing, other programmes) or inside the Aldebaran project, according to appropriate framework agreements between partners.

It will also provide for the dual use (civil, security and defence) with launch capabilities, taking its requirements into account right from the design stage. The design work will be improved so as to take the specific requirements of the dual use into account: guaranteed access to space, confidential treatment of the user customer's mission, responsiveness, independence, availability, cost, reliability and operational flexibility.

3.2 The functional constraints

The Aldebaran project shall benefit from technology developed under other programmes and, conversely, it shall be consistent with and complementary to other programmes, particularly those of the European Space Agency.

For a maximum efficiency, optimum use shall be made of technology, equipment, sub-systems and innovative systems developed as part of existing and future european and other international programmes. In exchange, every effort shall be made to ensure that other programmes benefit from the technical progress and achievements of the Aldebaran project.

It shall minimise environmental impact and anticipate changes in the regulatory framework.

Clean propellants shall be used wherever possible. Implementation activities shall meet safety requirements and compliance with the European standard on space debris shall be imposed.

The operational version of Aldebaran will offer a launch service offer aimed at small-satellite operators.

This offer shall outperform the competition in terms of cost, mass, orbit, availability, responsiveness and reliability.

The project will use of new methodologies of collaborative and shared work, using opportunities of networks, software bases engineering environment, numerical simulation

3.3 General constraints of the Aldebaran project.

The measure of the project's success shall be reflected in: innovation rate, improved launch system, successful partnership and organisation on a co-development basis.

The development cost shall be below 400 million €. It covers all design, construction, test, investment and qualification tests relating to the Aldebaran demonstrator and operational system, starting at the start of phase B and finishing after the first technological flight.

The development cost shall include the cost of activities related to the launch vehicle, the ground-based facilities, and the development or adaptation of the carrier vehicle if an airborne launch vehicle is selected.

A project margin strategy shall be set up from the start of the project (performance, safety factor, uncertainties, costs, etc.).

The objectives in terms of launch cost are as follows (excluding satellite preparation):

50 kg	€2,5 million EC08
150 kg	€5 million EC08
300 kg	€7 million EC08

The launch campaign shall last less than five days from the arrival of the launch vehicle on the launch site and the actual launch.

All ground means shall be transportable in order to avoid heavy infrastructure.

In the case of an air launched system, a dual source must be possible for the air carrier

4. THE TECHNICAL REQUIREMENTS

4.1 performance and missions of the operational derivative

The design mission is defined for a SSO 800 km:

Three performance targets may be studied (total injected mass above mounting plan) for the design mission :

PT1 : 50 kg

PT2 : 150 kg

PT3 : 300 kg

All the LEO missions (inclination ranging from 0° to 180°, altitude ranging from 200 km and 2000 km) should be achievable.

Depending on the chosen architecture and technologies, the possible Aldebaran concepts, may cover all the three targets (ie modular concepts), or they may focus on one performance target. The evaluation of each concept will integrate the capacity to cover all the targets.

The previous reference mission and performance targets are derived from a market study performed by Euroconsult for the short and long terms. One can see in the next figure an abstract of the global study focusing on the short term period for micro satellite market.

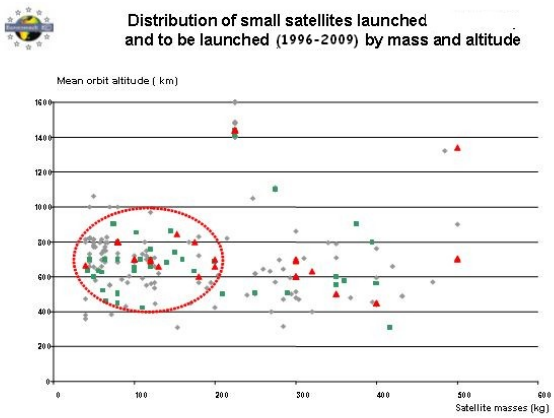


Figure 4: past and short term micro-mini satellites market

4.2 payload launch conditions

Aldebaran will allow a single payload injection under nominal mission conditions.

The launch vehicle shall be designed to carry a payload (including the payload adapter) with the following dimensions, depending on the performance target :

PT1 : 0.6mx0.6mx0.6m

PT2 : 0.8mx0.8mx1m

PT3 :1mx1mx1.2m

Such data will probably change taking into account more accurate informations coming from the potential customers of the Aldebaran launch system.

Concerning the pre-flight payload packaging and environment: The ALDEBARAN operational launch system, that will be defined in a later stage of the program, shall provide the satellite customer with services at least equal to those provided by competing systems.

4.3 Dependability

Reliability: by design, the predicted reliability of the operational launch system shall be at least **0.99** (from the first irreversible operation until satellite injection).

If all or some of the vehicle can be reused, the probability of recovering the vehicle intact on the ground must be more than **0.99**.

Safety rules will be compliant with the applicable regulation.

Launch system availability : the availability of the launch system (aircraft, launch vehicle and launch pad, downstream stations) shall be at least **0.9** excluding weather conditions.

4.4 Upgrade potential

Efforts shall be made to upgrade system performance beyond 300 kg.

5. THE SELECTION CRITERIA

The figure below recall the selection steps for Aldebaran concepts between the phase 0 and the phase B.

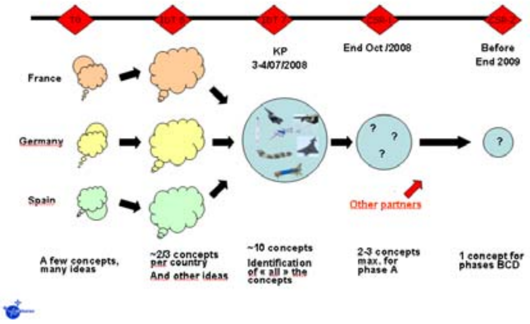


figure 5: selection steps for Aldebaran concepts

The Aldebaran concept shall be based on the following selection criteria:

Innovation: the proposed demonstrator shall represent a genuine "system" innovation, offering a significant gain for new-generation launch vehicles in terms of one or more of the following competitive factors :

reliability/safety,

availability,

operational flexibility (mission, operations, responsiveness),

operating cost,

flight environment,

customer services.

Scope: the demonstrator and the related technology shall have the widest possible scope (multiple end "targets").

Pooling: The demonstrator shall "pool" as many activities as possible and reuse all or some of the various French, European and cooperative programmes in existence.

For example, a concept that reuses equipment or technology developed within the context of European programmes will be considered as a "pooling" concept.

Operational aspects of demonstrator:

4.a: minimum effort shall be required to obtain a derived operational system.

4.b: characteristics shall be as well adapted as possible to the proposed niche market (in terms of cost, performance, availability, etc.).

Minimum demonstrator development cost

Minimum development risks (technical, delays, financial, political, organisational):

technical risks (concepts, technology, upgrade potential, performance margins),

risk of delays,

organisational risks (cooperation, etc.),

financial risks.

The figure 6 summarizes the selection criteria:

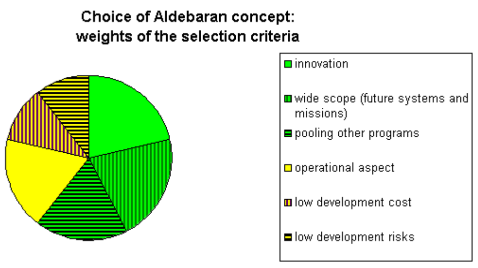


figure 6: Aldebaran concept selection criteria

6. ALDEBARAN PROGRESS STATUS

The partners involved in the Aldebaran project are currently:

-For Germany: DLR institutes and organisations (Bremen, Braunschweig, Cologne).

-For Spain: CDTI (Madrid), EADS_CASA (Madrid), GTD (Barcelone), DEIMOS (Tres Cantos), SENER (Tres Cantos), Aernnova (Madrid), GMV (Tres Cantos), CESA (Getafe), University of Madrid.

-For France: CNES (Evry), EADS_Astrium_ST (Les Mureaux), SAFRAN_Snecma moteurs (Vernon), SAFRAN_Snecma propulsion solide (Le Haillan), SNPE (Saint-Médard), ONERA (Chatillon), Bertin (Montigny-le-Bretonneux).

The Aldebaran phase 0 started early 2008 with a brainstorming concerning all possible concepts and all interesting technologies compliant with the functional file described in the previous paragraphs. The different classes of concepts:

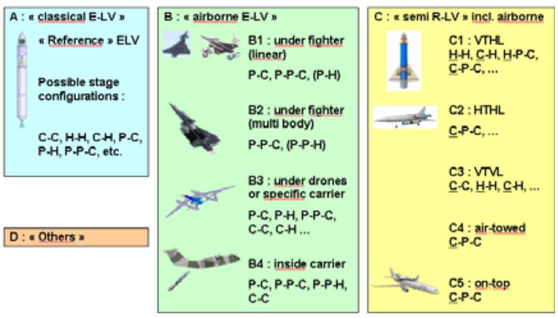


Figure 7: general view of the possible concepts for Aldebaran.

Airborne solutions are being studied intensively (ref [5], [3]). The main advantages are the following:

- L/V reduced mass and cost
- no launch pad: reduction of fixed cost
- launch from many location
- launch preparation possible at satellite customer

The air carrier may be considered as a stage “0” of a launch vehicle, and the impact of such solutions can be shown on the graph below. One can see that a subsonique aircraft with the ability to separate the launch vehicle at MACH 0.8, 10km altitude and with a path angle of 40 degrees, permits to save about 40% of a launch vehicle initial mass compared to a “standard” ground lift-off launching system having the same mass performance.

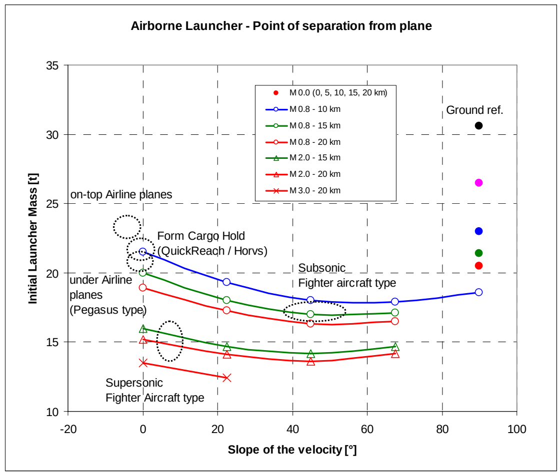


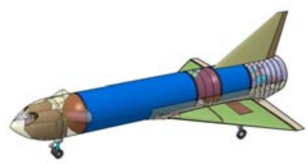
Figure 8: launch vehicle initial mass for lift-off or separation (airborne) conditions versus: altitude, MACH number and path angle.

Among the major constraints of the airborne systems, especially under an existing aircraft, are the mass and geometry limitations. On an other hand, these later constraints will impose drastic efforts in the frame technological innovations in order to find acceptable solutions for avionics, structures and propulsion systems.

Figure 9: preliminary drawings of envisaged airborne solution under military aircrafts.

"Classical" launching system solutions (expendable vertically launch from ground) correspond to an other studied class of concepts for Aldebaran. Such solutions may appear less flexible compared to airborne concepts. But an interesting option consists in working with mobile ground facilities. And a major advantage concerns the possible performance growth potential of such concepts.

Partially reusable launch systems are also studied. The idea is to reuse a 1st cryogenic stage with or without wings, the recovery mode being part of the trade-off. Most of the studies are related to a classical vertical lift-off. The return phase in the case of a winged concept might involve an air breathing propulsion solution derived from the standard turbojet propulsion systems. A trade-off on the possible turbojet engines is ongoing. Alternatives such as the innovative in-air-capturing solution proposed by DLR [6], will also be analysed (figure 10).



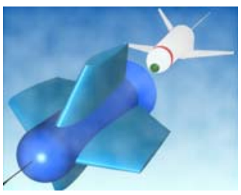


Figure10: Air capturing device proposed by DLR

For the propulsion of the 1st stage flight, among the envisaged possibilities, there is the Vinci cryogenic engine developed by SAFRAN_Snecma. An interesting option for final orbit injection, currently studied at DLR, could be a cryogenic kick-stage with advanced effusion cooled ceramic combustion chamber [7].

Other possible concepts are studied for Aldebaran (solutions based upon an electromagnetic accelerator [8]…).

Concerning the innovative technologies or the advanced technical solutions for the future launch vehicle which will be tested in the frame of Aldebaran demonstrator. The considerable work already done within projects such as "Flex: design-to-experiment oriented" (cf [2]) will be used. Of course, our space research programs will provide the major orientations to follow. But in addition, it is also asked all the partners, to check the possible space application of certain technologies applied in other domains such as aeronautics, automobile…

For the time being, one can list some of the main topics considered, depending on the chosen Aldebaran concept:

- advanced avionics (all concepts: A,B;C…)
- reusable subsystems: propulsion, thermal protection (cf ref [1]… (concept C).
- composite tanks technologies for cryo-technical propellants (all concepts: A,B,C…).
- advanced solid propellants (concept: B).
- new liquid propellant solutions (all concepts, cf ref [4] for a methane engine demonstrator)

All the analysed technologies are evaluated in term of:

- Technology readiness level (TRL): present status and necessary efforts to reach TRL 5-6 around 2010 (phase B of Aldebaran).
- Added value for future launch systems.

- Involvement of the different partners of Aldebaran.

In addition, the necessary components and sub-systems demonstrator tests are evaluated. Some of these tests will begin during the phase A.

These phase A of Aldebaran will start early 2009 on 2 or 3 concepts which will be selected end 2008.

7. CONCLUSION

Aldebaran is a cooperative flight demonstrator as a part of activities to prepare either the main evolutions of the European launch systems, or the new generation of launchers (2025 and beyond). Aldebaran is also a launching system adapted to mini-satellites (performance, cost). It shall also be adapted to the defence requirements. Aldebaran is currently in phase "0" involving German, Spanish and French partners, working on the possible concepts and the innovative technologies. The phase "0" is currently ending with the selection of 2 or concepts.
The phase A of the project will be held in 2009 on these later concepts. The first technological flight will take place around 2015.

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