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The Suborbital Space Tourism Project of EADS Astrium

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On June, 13th 2007 EADS Astrium made public its entrepreneurial oriented project of Suborbital Spaceplane with presenting the full-scale mock-up of the cabin of a brand new vehicle. This initiative launched early 2006 addresses since then all the perspectives related to this emerging and promising business : commercial standpoint, legal matters and engineering as well. The objective of EADS is to get a first flight by the mid of next decade with a fleet of vehicles flying once a week at least, provided that funding for development being gathered in due time. Beyond the birth of this new business, this program is also the opportunity to get first hand experience of some relevant technologies/techniques (aircraft-like operations of a rocket propelled vehicle) for developing a quick access to Space System or an ultra high-speed Transportation System of the XXIst century.

I. Introduction

Since the very early days of the space age the nowadays possible space applications which turn in reality were already in the books : telecommunications, remote sensing, space exploration. Even space-manned missions were foreseen much before Sputnik was flown including imagining routinely access to space for various purposes as space tourism. The X-Prize implemented at the turn of the twentieth century sparked a renewed interest for large-scale Space Tourism.

Accounting from the historical flight of Yuri Gagarine in 1962 less than 500 human beings reached the edge of space including all nations : Russia, USA, Japan, Europe, etc... Among them 1% were non professionals, i.e. space tourists who traveled to ISS for two weeks or so after roughly six months of demanding training. Ticket for such trip is in the range of 20 M$ and will remain so for long when considering the energy to be provided for reaching long-time stable orbit whatever the altitude. In addition such service is possible today thanks to investments endorsed by Space Agencies for decades : the Soyuz Launch System, the International Space Station and all stuff for supporting the preparation and training of astronauts. Amortizing such budgets is definitely beyond business oriented organization with Non Recurring Costs much beyond 100 billions $ when referring to the International Space Station only.

Suborbital Space tourism is a complete different story. Relevant technology for such flight is far less demanding than launchers as Japanese H-II or European Ariane 5 when accounting for energy requested to perform a « jump » to space and then recover the vehicle.

Same statement applies for reentry technologies as well : energy to be dissipated at space descent is as the same as energy provided at ascent. It translates in limited heating and then no need for developing a challenging system as the Space Shuttle Thermal Protections System (TPS) which account for roughly 1/3 of the maintenance costs of the Orbiter in between two flights.

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With the complete set of relevant space transportation technologies on hand, EADS Astrium which is the industrial prime contractor of forefront programs as Ariane 5 and the Automated Transfer Vehicle (ATV) initiated its privately funded Spaceplane project evaluating all the sides : business standpoint, design aspects and programmatics as well.

Market evaluations conducted by such independent companies as Futron confirms since years that Space Tourism market is there.

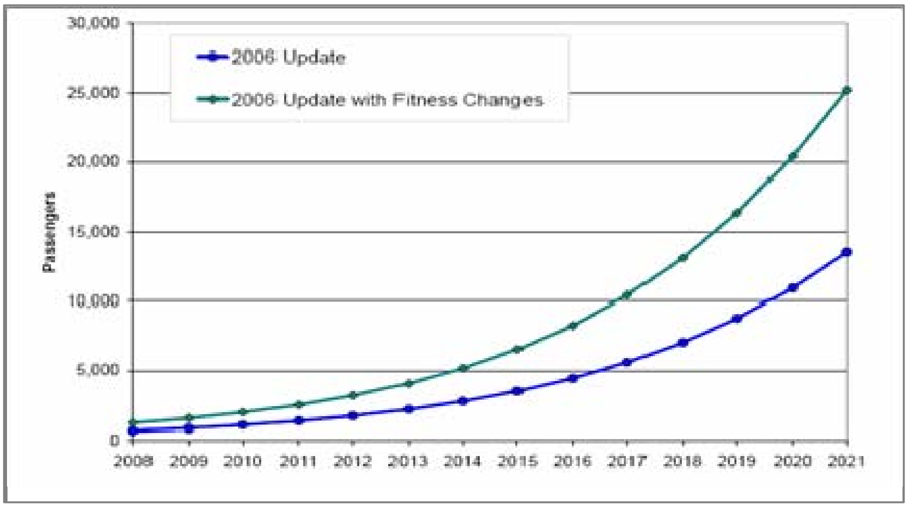


Figure 1. Suborbital Space Tourim market (Futron source)

II. Level-0 specifications

When considering the suborbital space tourism market evaluation available and the expectations of customers, the level-0 specifications applicable to the EADS Astrium Project were carefully drafted and may be summarized as follows :

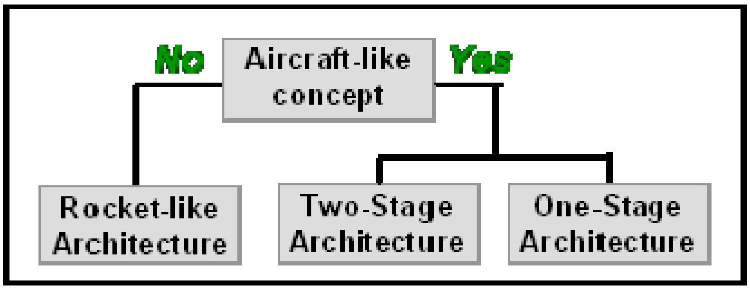
- Payload : four Passengers (PAX) ;
- Reach an apogee altitude beyond 100 km. At such altitude, when vertical above Paris, the passengers will enjoy the complete Alps range and Mediterranean sea ;
- Cabin design : maximize volume available per passenger inside and then offer free-floating experience. Such expectation is clearly felt as a once in a lifetime experience whished ;
- Environment friendly. Such statement is especially driving the rocket propellants class : not only for safety purposes but also for limiting impact to Earth atmosphere as well ;
- Safety oriented approach that will drive the System design : ensure maximized level of safety throughout the mission meaning a Design-To-Safety architecture oriented ;
- Minimize Operating Costs : this is one key specifications for balancing the business case ;
- Operations rate : flights twice a week and per vehicle at least. Such requirement will help to address as much as 15.000 customers in years from now according to FUTRON evaluation (see fig.2 above)

III. Vehicle architecture options traded

Referring to the set of requirements above, first job conducted was to trade the different System architectures possible :

- Rocket-like architecture featuring one or two rocket propelled stages with a capsule on top as Soyuz launcher is, e.g.. When considering technologies developed at EADS Astrium since decades for Launch Systems and reentry vehicles as well including the Atmospheric Reentry Demonstrator (ARD) as well (see below and Ref.2) ;

- Aircraft-like option with two possible different design : Two-Stage including one carrier aircraft and one stage reaching the proper maximum space altitude or One stage fulfilling the end-to-end mission.



Relying on expertise available in-house both space and aeronautic oriented at EADS Astrium and some EADS Business Units beyond, the three options were carefully addressed and in the end the One-Stage architecture was down-selected for further development steps. When comparing to a pure rocket-like architecture, main reasons were the passenger expectations and comfort on one side and safety and costs related matters on the other side. Two-stage architecture would mean to develop a dedicated carrier aircraft and then to operate it in addition to the rocket vehicle.

Finally when focusing on future upgrades and growth potential intrinsic to a single vehicle towards a reusable first stage of an advanced launch system or ultra high spee transportation system is definitely an additional asset.

The Atmospheric Reentry Demonstrator (ARD)

In 1994 Aerospatiale Espace & Defence which is now a Business Unit of EADS Astrium proposed to ESA to conduct an in-flight test for benefiting as far as possible from relevant background gathered during Hermes development since 1985 : this is the ARD program.

Under ESA funding and with EADS Astrium as Prime, a European industrial team conducted the ARD crash program aiming at demonstrating that Europe masters the guided & controlled reentry of as space vehicle. It was initiated in 1994 for a test flight planned in late 1996 on-board the second qualification flight of Ariane 5. For complying with so a short challenging development planning, three guidelines were implemented :

- get on hand a flight proven aeroshape : as such the venerable Apollo capsule-shape was selected ;
- take benefit from background related to French ballistic missiles programs and ESA Ariane 5 program as well ;
- get the Qualification and Flight models within the same Proto-flight Model.

Sticking to these basic principles, the development of the 2.8 metric tons ARD was thoroughly conducted and readied for flight as planned.

ARD in the workshop

Due to the ill-fated maiden flight of Ariane 5 in June 1996, the ARD test flight was postponed to October 1998 on board the 3rd Ariane 5 mission. It performed perfectly its mission ending in Pacific Ocean. After recovery, it was returned to Europe for extensive inspection and post-flight analysis.

ARD recovered in Pacific Ocean (Oct. 1998)

Thanks to this program, EADS Astrium has on hand a set of flight proven key technologies for mastering the development of a vehicle experiencing a descent back to ground : guidance and flight control, accurate navigation mixing GPS and IMU-like data, software validation Reaction Control System jets-flow field interactions, etc..

IV. The spaceplane of EADS Astrium

The bizjet-sized vehicle in development at EADS Astrium is a winged vehicle featuring an hybrid propulsion : aeronautic-like propulsion, two turbofans, for the aeronautic phases of the mission and one rocket engine for the space phases.

Figure 2. The EADS Astrium Suborbital Spaceplane

So the mission analysis of the vehicle may be summarized as follows :

- Preparation phase for the mission : propellants loading, flight preparation including weather check,
- Take-off from a standard runway
- Climbing to the Space Ascent Gate box (altitude & velocity)
- Transition from aeronautic mode to space : this is the Space Ascent Gate
- Ignition of the rocket engine and then rocket propelled phase
- Ballistic phase for some minutes which is the key phase of the mission – maximum altitude reached
- Space descent during which the vehicle will brake for lowering its speed
- Space Descent Gate : transition from space mode to aeronautic
- Aeronautic descent and lading on the home runway
- Passengers unloading
- On-line maintenance for next mission

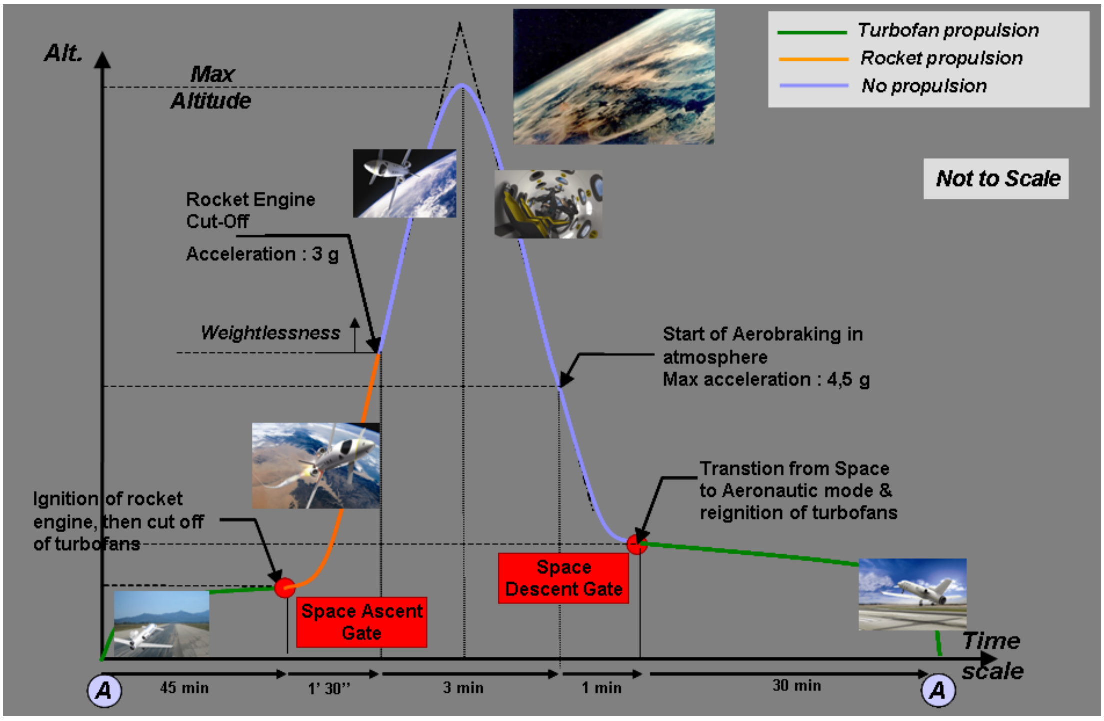


Figure 3. The EADS Astrium Suborbital Spaceplane mission

The competitive advantages of the EADS Astrium are three-fold and are detailed in sections below :

- Comfort for the PAX
- Safety
- Low Direct Operating Costs

A. Comfort for the PAX

During the mission, the passengers are looking forward a once in a lifetime experience. So the Cabin and seats have to be carefully designed for ensuring both :

- Maximum comfort during phases prior to and after the space phase ;
- Enjoying the unique view of Earth and black sky ;
- Last but not least the free-floating experience that only happy few have experienced up to now.

Such statements mean to draw a large volume cabin and as much windows as possible and as large as well. The cabin fits patented seats that freely rotate around a main axis allowing to get the PAX body in the stomach-to-back direction whatever the mission phase. As such they may support G's level as high as 20 g's (see Fig. 7 below) which is at least three-fold beyond levels expected during the space flight.

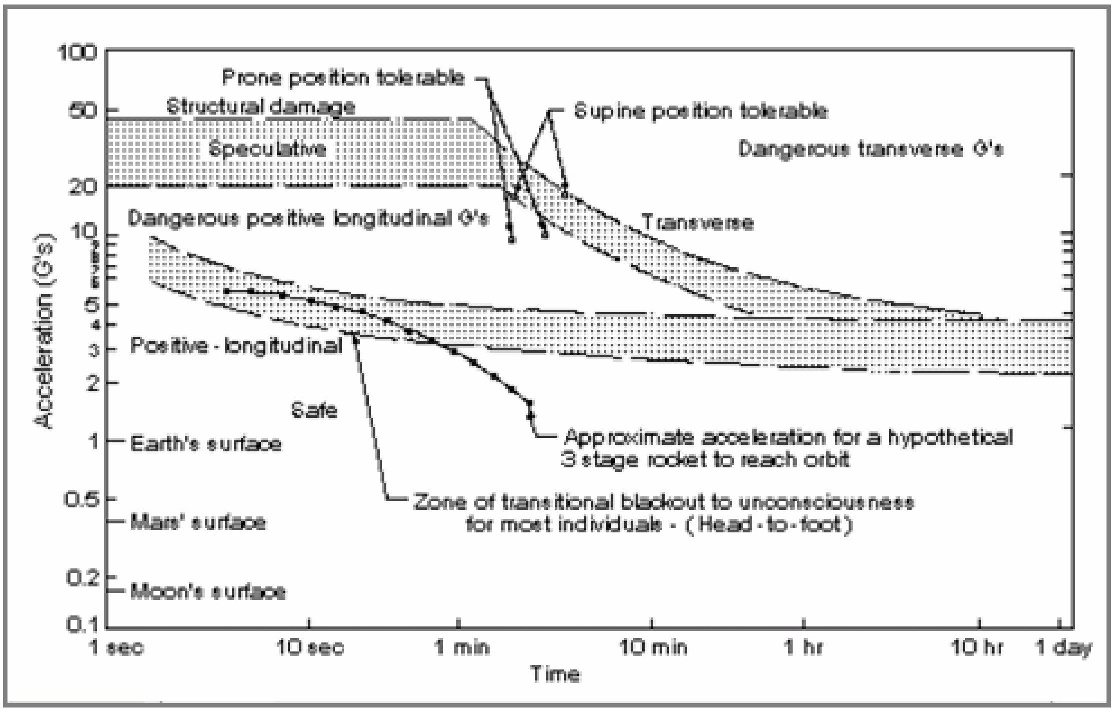


Figure 4. Accelerations acceptable for human bodies (NASA source)

Figure 5. PAX in their seats during rocket propelled phase

Figure 6. PAX free-floating safely inside the cabin

Such seat design is an asset of the EADS Astrium project since readily everyone may experience the space environment without time-consuming and demanding training as astronauts are requested to perform.

In addition Marc Newson, the world-class designer, proposed to EADS Astrium a unique lay-out with well suited straps and windows much larger than standard windows of legacy airplanes.

B. Safety

Maximized Safety for such project is not an option. So the vehicle design and mission as well are defined for ensuring built-in safety. The aircraft-like performances of the vehicle, especially its gliding capability, ensure that aeronautic phases at ascent and descent will be safely performed even in case of aborted mission during the space phases.

In addition, the vehicle sub-systems benefit from state-of-the-art design rules applied at EADS for aircraft and rocket programs as well.

C. Low Direct Operating Costs

Operating a bizjet-sized airplane featuring a reusable liquid oxygen & methane rocket engine allows to minimize the operating costs and then offer the best value for money service to the customers. In addition the operations concept of the EADS Astrium project will allow customers to fly on very short notice.

V. The Rocket Propulsion System of the Spaceplane

One system which is key for performance completion of the Astrium spaceplane mission is the Rocket Propulsion System (RPS) as it exhibits original features according to legacy knowledge on hand at EADS.

From operations standpoint the RPS is aircraft-like as it is expected to be operated twice a week. Know-how gathered with operating rocket engine on hot firing test benches will be of direct use.

Concentrating on functional behavior, the RPS is Launcher Upper Stage-like as it is planned to ignite the RPS after some aeronautic phases including take-off and climbing to altitude transition from aeronautic mode to space mode.

From environment standpoint the RPS is Launcher first stage-like as RPS ignition happens when atmosphere density is not yet zero.

Last but not least according to specific mission design of the Astrium Spaceplane, performance has to properly blend Isp level and thrust magnitude as well so that Spaceplane RPS is neither booster stage nor upper stage standards driven.

On top of that, safety will be applied as it applies for propulsion systems on board legacy aircraft. It means to pay attention to events leading to catastrophic conditions and then implement either built-in features or design the mission phases such that safety of the vehicle is properly managed.

VI. Enabling technologies / perspectives

When considering the current space transportation systems operated world-wide, the EADS Astrium project is for shure a unique occasion to gather a valuable set of enabling technologies/techniques applicable for either ultra high-speed air transport systems or advanced launch systems :

- Design an optimized vehicle embedding both aeronautic and rocket propulsion ;
- Reach a safety level related to the Rocket Propulsion System compliant with commercial transport of passengers ;
- Retrieve a vehicle from space several times a week with no off-line maintenance ;
- Operate a rocket engine that flies several times a month and then validate aircraft-like Maintenance, Repair & Overhaul operations

With such flight and operations proven experience EADS Astrium will be in the perfect position to develop point-to-point advanced transport Systems and then offer time duration between anti-podal locations ten times lower than current airlines.

VII. Conclusion

On June, 13th 2007 EADS Astrium made public its entrepreneurial oriented project of Suborbital Spaceplane taking into account that Space tourism is a real credible business growth opportunity. In addition as EADS Astrium is collecting privately funds for this program which is rewarded during commercial operations of the spaceplane, it will not taping scarce institutional European funding resources either civilian or security/military. It is worth mentioning that generated revenues will be as the same order of magnitude as core business segments of EADS Astrium Space Transportation Business Unit : the Ariane 5 launch system program or space infrastructures or Sea-Launch Ballistic Missiles as well. Indeed during the program yearly production activity (vehicles and rocket engines) will be implemented together with on-line and off-line maintenance.

Moreover such program is the birth of a new business :

- a new type of vehicle reaching unprecedented altitudes for airplanes (above 20 km) and below satellites (under 200 km) ;
- an intrinsic growth potential with possible evolutions as spin off missions for scientific purposes (micro-gravity oriented) or dual applications (observation, ..) ;
- an initial step towards advanced transportation systems either high speed transportation or quick access to space.

Last but not least this program will enhance techniques/technologies knowledge of European space transportation industry core business both preserving and enhancing its capabilities and then fostering the next steps of the Space Age.

References

[1] FUTRON Corporation : *Suborbital Space Tourism demand revisited.*, August 2006
[2] Macret, J.L, "Post-flight Analysis of the Atmospheric Re-entry Demonstrator" *IAF Conference*, IAF-00-V.2.05, Brazil, 2000