Vehra-SH Suborbital Manned Vehicle

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The Astronaute Club Européen (ACE) was formed in 2005 to promote suborbital flight in Europe. In this paper, we consider an airborne launch system with a suborbital manned vehicle to carry three to six passengers. It would fly at the edge of space (above 100 km of altitude) propelled by a liquid oxygen / kerosene rocket engine. A "safety first" approach and development of the spacecraft is based on the technologies on the shelf. This project dubbed VSH is following an airlike operations (airborne take-off and smooth landing on a runway).

ACRONYMS

ACE	:	Astronaute Club Européen
CNES	*:*	Centre National d'Études Spatiales
RD	:	Raketa Dvigatel (rocket engine)
SS1	*:*	SpaceShipOne
TSTO	*:*	Two Stage To Orbit
VEHRA	*:*	Véhicule Hypersonique Réutilisable Aéroporté
VSH	:	Vehra Suborbital Habité

INTRODUCTION

In 2004, the successful flights of SpaceShipOne (SS1) revealed an historical new paradigm to transport people at the edge of space. It was the first privately funded manned spaceship. Europe should not miss this new sector. This is the reason why ACE takes up the challenge to promote a rocket-powered suborbital manned vehicle : Vehra-SH (VSH). The paper will describe this project and the associated customer experience of space travel.

ACE: THE CRADLE OF THE PROJECT

This project is supported by the Astronaute Club Européen, an association created on 3rd December 2005 and located in Paris. The founding members are:

- Jean-Pierre Haigneré;
- Laurent Gathier;
- Alain Dupas.

In the past months, several personalities joined ACE to support our projects and bring their expertise (European astronauts, industrials, designer, etc.).

Fig. 1 - *The French designer Jacques Dress created the logo of Astronaute Club Européen. The head office of the association is located in the "Aéroclub de France".*

ACE aims to promote a more proactive participation of the general public to the new developments of the space exploration. Since its recent creation, ACE has already participated to :

- Book publications;
- Conferences organization;
- Space events;

- Proposal of studies to universities, etc.

In the near future, ACE will promote the development of new activities offering to the private sector to participate to this unique experience of space exploration with parabolic flights (zero gravity sessions) and later suborbital travel. This is the reason why, ACE is committing in the development of a reusable suborbital manned space transport initiated on existing studies.

ORIGINS AND DEVELOPMENT SCHEDULE

European engineers have participated in many aspects of reusable launch and space vehicle development (Hermes spaceplane, X-38, TSTO studies, etc.), either for national or international projects. In particular, Dassault Aviation has applied, since 1998, this experience to the design of a new space transport system based on an airborne reusable hypersonic vehicle dubbed Vehra[1]. Launched from the back of a european commercial jet (Fig.2), its own rocket propulsion system boost it into suborbital trajectory. The airborne launch technique provides a performance edge over conventional ground-launched boosters, as well as eliminating the most serious restrictions due to launch and recovery infrastructures.

Fig.2 - *The Vehra Air-Launch concept has been adopted for the VSH*

The design of Vehra has been perfected over the years and was considered in a manned version in 2002. It was dubbed VSH, French acronym for Vehicule Suborbital Habité. The resulting design can be seen in Fig.3. For the VSH, the design team will apply innovative solutions studied in Vehra project. The concept is based on a gradual, controlled-risk approach to development.

VSH is a step by step programme. It would be developed in three years period (tentatively schedule):

- **Year One** - The project will begin with a detailed conception phase using the most advanced tools (CATIA / ENOVIA / VPM).

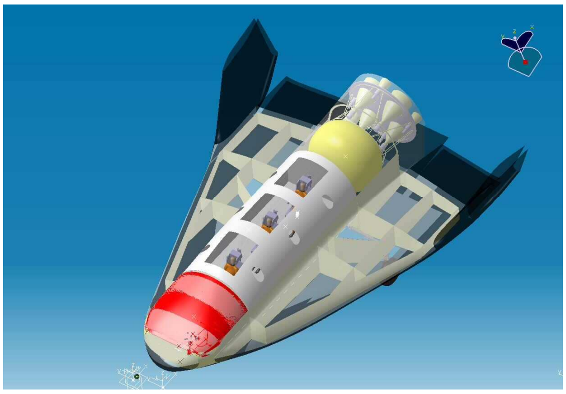
- **Year Two** - The aerodynamic shape of the vehicle will be validated by a detailed CFD analysis and several wind tunnel tests. Beginning of the flight model development and the building of ground infrastructures (vehicle processing facility, launch complex, training facility, etc.) .

- **Years Three to Five** - Assembly of the vehicle and beginning of flight testing. Testing of the VSH will occur incrementally. Several captive tests and flight tests are considered before being used for carrying space travellers.

VSH will use technologies on the shelf. In fact, computer based analysis and design tools, coupled with advanced manufacturing techniques enable small teams to rapidly design this spaceship.

THE SUBORBITAL ROCKET-POWERED AIRCRAFT

The suborbital rocket-powered manned vehicle is a small winged aircraft with a shape close to the former "Hermès" spaceplane project.



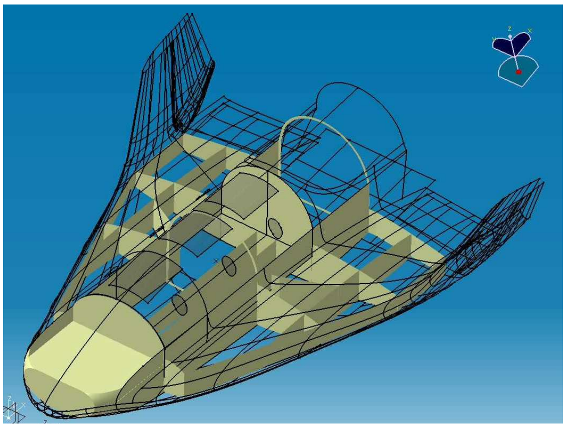


Fig.3 - *Suborbital rocket-powered aircraft structural arrangement (early design)*

Main characteristics of ACE's VSH spaceplane	
• Length	: 11,7 m
• Wingspan	: 9,3 m
• Height	: 2,4 m
• Weight	: 11,6 t

The flight envelope of the VSH (Mach 3,5 and 100 km of altitude) foresees reduced aero/thermal loads or mechanical stress during the reentry compare to an orbital vehicle. This is the reason why no exotic materials or special thermal protection system has to be developed. VSH will be based on a conventional metallic construction.

The Russian RD-0110 motor (KB Khimautomatiki of Voronezh) is considered as baseline to boost into suborbital trajectory. This rocket engine is fuelled by liquid oxygen and kerosene (non toxic propellants). Used for the 3rd stage of the Soyuz launch vehicle, it's a very reliable engine with high degree of safety. For this project, the RD-0110 will be partially reusable (to be confirmed by tests).

During the spaceflight phase, additional thrusters will provide attitude control of the vehicle. During the atmospheric phase, two microjets (as an example, the Microturbo TRI60-30) will be used to improve spacecraft trajectory control and safety.

"SAFETY FIRST" & OPERATIONS

Exploring the edge of space safely and with reliably is a fundamental issue for the concept of general public space travel. This is the reason why the safety is the chief aim of this project and the VSH will use several operation modes and redundant systems.

- **Air launch** - The ACE "Safety First" approach starts with the Air launch concept applied to the project. The use of a conventional aircraft as a "first stage" for a suborbital launch system brings significant advantages in term of operational flexibility[2]. This suborbital transportation allows in particular the reversibility for all initial phases.

- **Liquid propulsion** - As for propulsion, the use of no toxic kerosene and liquid oxygen is safer than solid rocket motor[3]. In case of emergency, the RD-0110 can be instantaneously shut off. The spaceship will also incorporate two air-breathing engine to easily place it into a safe trajectory for landing on runways.

- **Crew safety** - Space travellers will wear pressure intra-vehicular suits. Initially, each of them will be positioned on ejection seats (our baseline is Zvezda K36D). Flight control management will ensure the comfort of passengers through management of g-loads during re-entry.

Spaceflight operation will be performed from Europe. ACE is considering numerous locations for its home base and launch site, with respect to operational and environmental constraints.

Fig.4 - *The VSH returning to runway…*

HEALTH & TRAINING ISSUES

Suborbital flights will have their specific constraints relative to operations. The future astronauts will be trained accordingly before boarding the VSH spaceship.

Besides a tailored medical check-up, the passenger preparation will also include a familiarisation with the on board systems, the flight mechanics, the space environment and a training on the safety equipments and procedures.

The training of space travellers will include to practice the nominal and off nominal situations. The objective is to have them reaching the highest level of familiarity with what they are expected to experience when comes the time to fly the actual suborbital mission.

THE "FAR-OUT EXPERIENCE"

The "Far-Out experience" will start immediately when the space travellers arrive at the VSH training facility.

The space travellers will be faced to the following events in their suborbital flight :

- Commercial jet, with VSH attached on its top, take-off from a conventional runway and initial climb to separation altitude.

- VSH separates from carrier during a gentle glide, the carrier returning to the home base.

- VSH starts its rocket engine which burns for 70 s, climb at an increasing speed up to Mach 3,5.

- After engine cut-off, the spaceship continues its climbs on a ballistic trajectory beyond 100 km (62 miles) during which passengers experience weightlessness. Each passenger will have large windows from which they will be able to contemplate their planet and enjoy the experience of space.

- Re-entry with control of g-loads.

- VSH glides back to the home base runway for a conventional glider landing, around one hour later.

Each space traveller will have a "personal communications, orientations and navigation panel" for internal communications and with the ground. This equipment will also record their experience and provide informations about localisation and mission status.

As for the professional missions, the "Far-Out experience" will include traditions and ceremonials to enlight the exceptional aspects of the unique experience of each spaceflight and honour the new private astronauts.

The VSH project will enable thousands of people to realize their historical of visiting space. It will provide to each of them an unforgettable and unique experience of their life.

ACE is convinced that its suborbital reusable spaceship will create a growing enthusiasm among its users and will provide a highly appreciated instrumental for the public support of manned exploration in Europe.

Fig.5 - *A panoramic experience above the Earth*

NOTES

[1] - **Philippe COUÉ**, "VEHRA, an air-launched spaceplane", in *News from Prospace*, Paris, 05/03, pp. 5-6.

[2] - **Michel RIGAULT**, *Air launched reusable hypersonic experimental vehicle*, ARVS, AAAF, Arcachon, 03/03.

[3] - The historical benign failure ratio for kerosene-LOX engines is 0.6% while the catastrophic failure ratio is 0.2%. The number of solid rocket motor failures is also small but they have all been catastrophic.