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USV: Unmanned Space Vehicle

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Abstract. This paper reports an overview of the Unmanned Space Vehicle Programme, led by CIRA, in the frame of PRORA, focusing on the first dropped transonic flight performed on 24 February 2007, performed in order to do accomplish the DTFT mission based on stratospheric balloon. The vehicle reached the target altitude by means of a stratospheric balloon system. The flight had the objective to test the vehicle behaviour in transonic regime.

Key words. USV

1. Introduction

Conceived in 2000 and started in 2002, the USV (Unmanned Space Vehicles) program in 4 years has obtained its main result with the first flight on Feb 07, with "Castore" vehicle (reaching the 80% of the mission objectives it has been a success not only for CIRA, but for the whole Italian aerospace system). Now the activities for a second flight are ongoing. It is scheduled by the end of 08 with the second experimental vehicle "Polluce". The main objectives of the next mission is the acquisition of data characterizing the transonic e supersonic flight with the perspective to investigate, in the next future, the hypersonic flight in atmosphere and reentry from space which is necessary to build up the main technologies e methodologies related to development of next generation space transportation systems. Within the framework of the PRORA-USV project, the Italian Aerospace Research Center (CIRA) has developed several methodologies and tools in the fields of meteorological conditions forecast and balloon trajectory prediction and optimization.

The main objective of the PRORA-USV programme was to design and manufacture two unmanned Flying Test Beds (FTB1 for atmospheric flights and FTBX for re-entry demonstrations), conceived as multi-mission flying laboratories, in order to test and verify advanced functionalities and critical operational aspects peculiar of the future Reusable Launch Vehicle (RLV). The nominal atmospheric mission profile (named DTFT) was based on a drop of the FTB1 vehicle from a stratospheric balloon at an altitude between 19 km and 21 km, inside a specific Target Area, lifting off from a launch base located in Arbatax, Sardinia, Italy.

2. USV Programme outline

USV programme is composed of:

– USV_TECH dedicated to develop enabling technologies (GNC, Aerodynamic/Aerotermodynamics, Hot Structure based on UHTC)

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Fig. 1. USV_1 and USV_X.

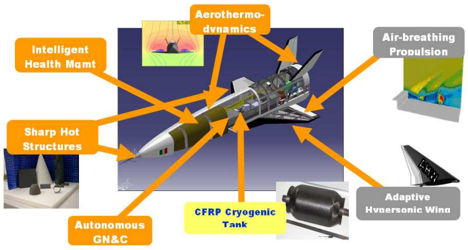

Fig. 2. USV_TECH summary.

– USV_1 dedicated to develop Flying Test Beds (FTB) releasing from Stratospheric Balloon for trans- super- and hypersonic flights;
– USV_X for sub-orbital and orbital trajectories typical of re-entry flight: target launcher VEGA

The USV_TECH is a set of R&D projects currently in progress aim at the critical aspects of the USV FTBs realization, but also

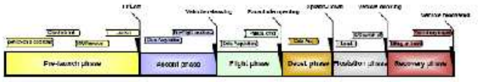

Fig. 3. Mission phases.

at various themes connected to the development of future generations reusable systems. The Figure1 shows the USV_1 and USV_X system,

3. The System for DTFT Mission

The entire system was constituted of a carrier subsystem, whose function is to drive the vehicle to the desired altitude, and of the vehicle itself. The carrier is made by a structure, which we call gondola, connected to the balloon through the launch chain. The gondola houses all the electrical and mechanical equipment devoted to control the ascent flight and to assist the FTB_1 demonstrator in this phase. For instance, the venting valves telecommand and the auxiliary ballast discharge system for the balloon guidance are both located onboard the equipped gondola. The gondola has a dedicated parachute which is integrated between the stratospheric balloon and the gondola itself. This parachute has a twofold purpose, indeed it has to insure a safe termination of the mission in the case of an emergency and the safe descent of the gondola once separation from the vehicle has been accomplished in nominal mode.

The vehicle is mechanically linked to the gondola and is separated from it by means of a pyrotechnique device. The FTB_1 demonstrator is a slender, non-propelled, winged vehicle able to perform experiments on structure and materials, autonomous guidance navigation and control, and thermo-aerodynamics.

The needs cited above led to the implementation of an airplane-like configuration for FTB_1 with a main physical structure housing a certain number of subsystems. The external configuration has been developed following the design driving features listed below:

– aerodynamic efficiency of L/D>2.5 from transonic to supersonic regimes

Fig. 4. DTFT system.

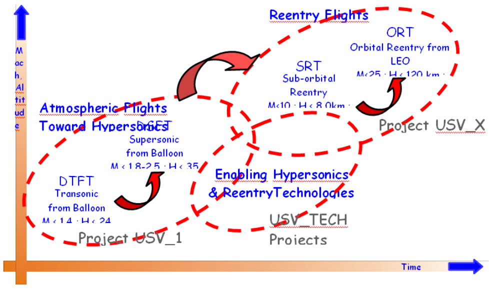

Fig. 5. USV programme approach.

- maximum thickness of wing profile: 8%
- nominal nose radius: < 50 mm
- a four-vertical-fins configuration, in order to reduce interference with wings, with parachute at deployment, and structural constraints, as well as to match stability and control requirements.

The FTB_1 is 9 m long with a weight of 1300 kg. Both systems are depicted in Fig. 2 where the gondola and FTB_1 vehicle linked together and suspended from the launch machine on the launch pad in Arbatax during the preflight operations.

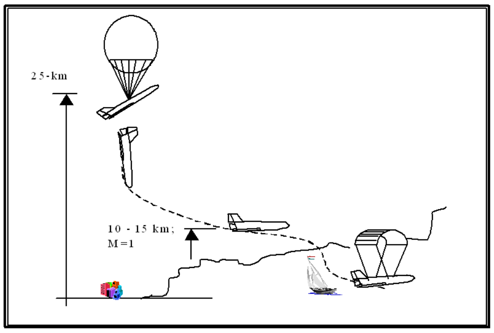

Fig. 6. Mission profile.

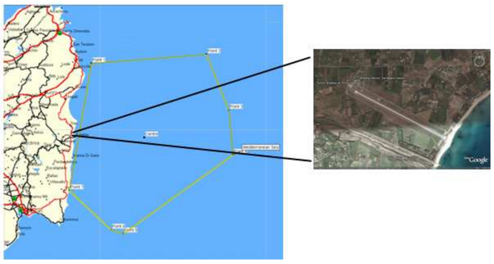

Fig. 7. Balloon inflation.

4. Programme Approach

The overall programme is based on an increasing complexity approach, in terms of Mach, altitude and experiments to be performed. Each mission will have more complex requirements and objectives, in order to Obtain gradually the programme expected results and verify the USV technologies projects outcomes.

5. DTFT Mission description

DTFT Dropped Transonic Flight Test performed by a system made of:

- Carrier based on stratospheric balloon as first stage
- Winged flight test bed as second stage
- Ground segment

The mission profile (briefly depicted in figure 2) has been developed through the following main steps:

- Launch
- Ascent up to the releasing altitude

Fig. 8. Launch site.

– Vehicle releasing
– Autonomous flight
– Deceleration
– Splash-down
– Sea-recovery

The mission phases and relevant sub-phases are described in Figure 3.

Pre-launch phase
This phase started about 20.00 p.m. on 23rd February and it included all the operations to be accomplished the launch once the flight segments were integrated. These operations provided a complete vehicle and carrier last check-up of all equipments and housekeeping data before the lift-off.

Launch phase
This phase started about 6 hours before the lift-off of the stratospheric balloon and it included all the operations on the launch pad,. The operations were focused on the last controls of the flight segment functionalities and on the deployment and inflation of the balloon.

Flight phase
At the 10.08 a.m. (after 1h38min of ascent phase) was performed the release of the FTB1 at 20km of altitude.

Deceleration phase
This phase wasn't correctly accomplished. After 37sec of flight the on board parachute (Recovery system) was activated in order to provide a deceleration of the vehicle, but the first of three stages didn't work properly.

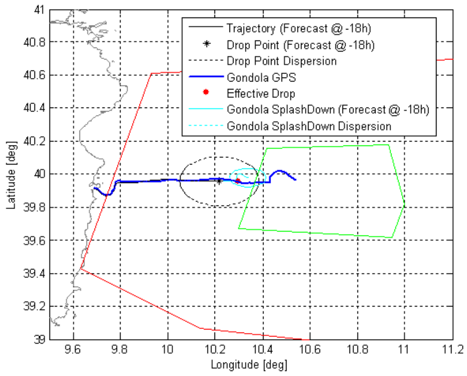

Fig. 9. DTFT mission actual trajectories.

Recovery phase
During this phase were recovered from sea, by a boat of the Italian Navy, the gondola, the balloon and the damaged vehicle. The recovery operations ended at 22.30p.m. They lasted about 12 hours.

Launch Site
Arbatax-Tortol Airport in Sardinia and all the mission phases (ascent and flight) have been executed in a safety area as shown in the Figure 8.

6. Conclusions

Hereafter are listed the mission coordinates:

- Points of release
  - FTB1: Lat. 39.95108 Long. 10.29903 H 20141 mt (after 1h38'59" from Lift off)
  - Gondola: Lat. 39.94928 Long. 10.30653 H 20687 mt
- Points of splash-down:
  - FTB1: Lat. 39.94294 Long. 10.37512
  - Gondola: Lat. 39.96152 Long. 10.54243 H 15mt (last measurement)

The Figure 9 shows the predicted and real trajectories of the flight system and the location of effective drop.