DEVELOPMENT OF COMMERCIAL SPACEPORT AND ASSOCIATED GROUND SEGMENT DRIVEN BY SPECIFIC SPACEPLANE VEHICLE AND MISSION OPERATION REQUIREMENTS

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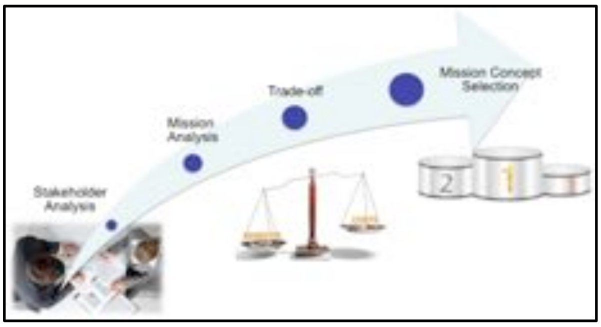
INTRODUCTION

Study case of an initiative aimed at establishing suborbital flight capabilities with emphasis to the development of the Ground Segment and evaluation of a site as candidate Spaceport

From stakeholder analysis to the mission concept selection

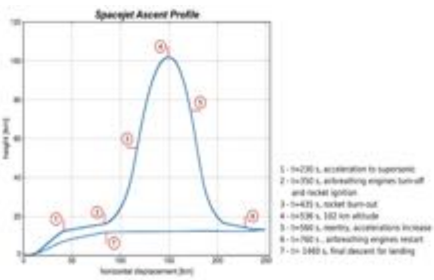


Space mission analysis and design: iterative and recursive process, permitting a continue refinement of requirements and constraints leading to a deeper component definition level

THE REFERENCE MISSION

Suborbital Parabolic Mission

- Safe VTOL passengers transportation for touristic purposes up to 100 Km altitude over a parabolic flight and reach at least 120 seconds of microgravity
- Capability to execute microgravity science during parabolic flights



THE REFERENCE MISSION

Point to Point Mission

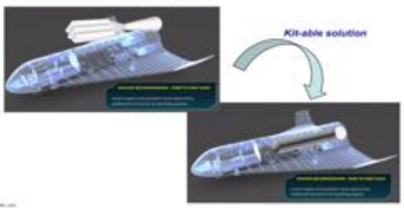
- VTOL passengers transportation in the commercial aeronautical airspace over a 2000 Km range. Passengers may enjoy cutting edge cabin technology for their comfort and safety throughout the entire flight

Spaceplane reconfiguration

- Rocket Engine and propellant tanks are replaced with additional jet fuel tank when reconfiguring the Spaceplane from parabolic to point to point mission

THE REFERENCE SPACEPLANE

Spaceplane reconfiguration



Two 150 KN each Turbofan Engines

One 300 KN Rocket Engine

Reconfigurable cabin for 4 passengers

Cutting edge cabin technology for improved comfort

GROUND SEGMENT CONCEPT

The Spaceplane Ground Segment provides all the functionalities and capabilities required to support tracking and monitoring of the flight segment in accordance with the vehicle characteristics and mission profile.

Largely depends on the definition of the reference mission and relevant requirements. In particular different support scenarios can be identified when dealing with parabolic flights or point-to-point flights.

Spaceplane top Level Operations Flow:

GROUND SEGMENT CONCEPT

- Ground Stations selection and deployment for TM monitoring, tracking, voice/video links, Internet, payload access
- Requirements Definition for Control Center as a Mission Central Ground Facility and managing Safety and Mission rules
- Identification of Ground Links
- Definition of facilities and tools to support Operations and Logistics at the Spaceport, mission preparation and launch activities
- Space to Ground Communication Capabilities

Spaceplane Control Center Positions

- Flight director
- Medical
- Vehicle Manager
- Ground Manager
- Passengers/Customers POC
- Trajectory Officer
- Propulsion officer
- Guidance, navigation, and control
- Maintenance, mechanical&crew systems engineer
- Power systems engineer
- Data Processing Systems Engineer
- Flight activities officer
- Environmental systems engineer
- Instrum. and comm. systems engineer
- CAPCOM vehicle communicator

SPACEPORTS

Spaceports driving evaluation criteria

Operations Criteria

- Takeoff and Landing Operations
- Location and climate
- Proximity of alternate landing sites
- Provision of Air Traffic Management
- Spaceport Maintenance
- Support activities to the spaceport, storage, handling and transportation of solid and liquid propellants
- Environmental Impact

Safety Criteria

- Minimize risk to the public, personnel at the takeoff and landing area
- Safety Risk Management, aimed at:
  - Initial identification of hazards
  - Analysis and assessment of the risks, and identification of mitigation controls
  - Possible infrastructure improvements
- Spaceports should have a formal Safety Management System (SMS) to handle safety hazards and mitigate the risk
- Spaceport Safety Critical Systems

SPACEPORTS

SOME ITALIAN SITES OF INTEREST

TARANTO GROTTAGLIE

ALTEC has signed a collaboration agreement with Aeroporti di Puglia and Politecnico di Bari on the evaluation of the M. Arlotta airport site at Grottaglie versus the Federal Aviation Administration regulations and the future additional requirements levied upon by the Italian Authority for Civil Aviation (ENAC)

SPACEPORTS

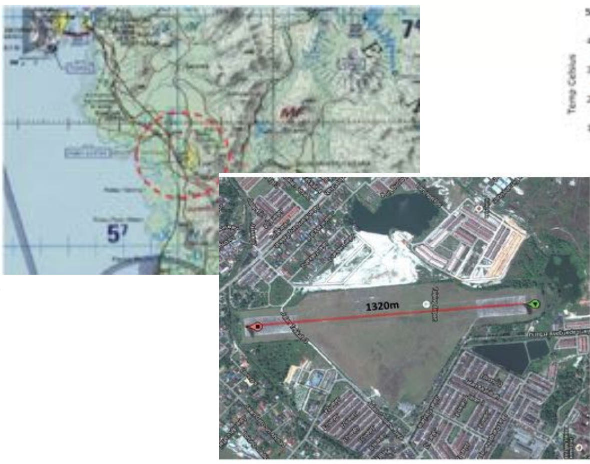
SOME ITALIAN SITES OF INTEREST

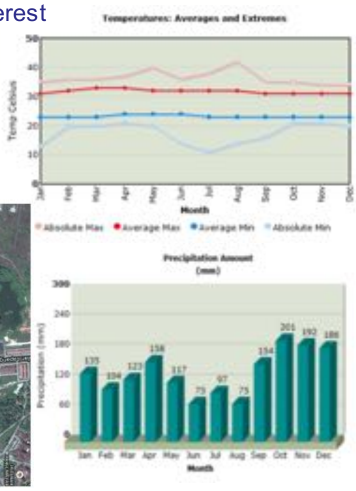
GRAZZANISE-TORTOLI'

DECIMOMANNU

THE TAIPING SPACEPORT STUDY CASE

The Taiping Site in Malaysia has been evaluated on an Operations and Safety standpoint as a case study, even though the specific reference Spaceplane can operate from any other locations of commercial interest





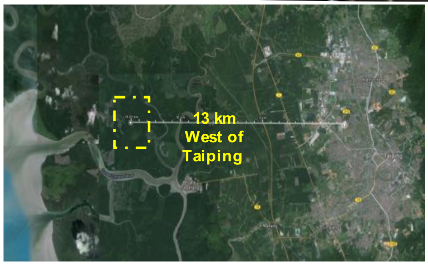
THE TAIPING SPACEPORT STUDY CASE

The reference spaceplane has two jet engines and a rocket engine for VTOL and point-to-point operations

- Fuel type Jet-A1, necessary for Jet engines, is missing at Taiping Airport
- Storage area for large amount of fuel and propellant shall be analysed

Due to the surrounding populated area, according to the Minimum Distance Requirements, no rocket propellants can be used or stored in the Taiping airport area

Area identified at about 13 Km West of Taiping, to build VTOL Pad and relevant infrastructure that allows also storage of the relevant propellants at safe distance from the Taiping base.



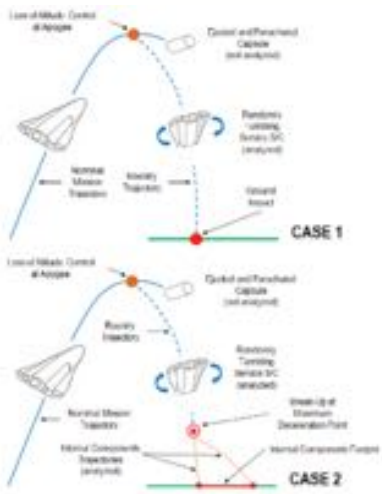
REENTRY RISK AND FOOTPRINT ANALYIS

Preliminary analysis allows prediction of the debris impact zone and implementation of the necessary actions

Assumed separation of the vehicle into the survival capsule and the remaining part of spaceplane only:

Case 1:
- Loss of attitude control at the apogee
- Survival capsule is ejected and spaceplane randomly tumbles to ground

Case 2:
- Loss of attitude control at the apogee
- Survival capsule is ejected and spaceplane randomly tumbles until it reaches the maximum deceleration
- Then vehicle fragmentation occurs and the internal components are released and reach the ground.



REENTRY RISK AND FOOTPRINT ANALYIS

CASE 1

CASE 2

Limit objects have been respectively defined:

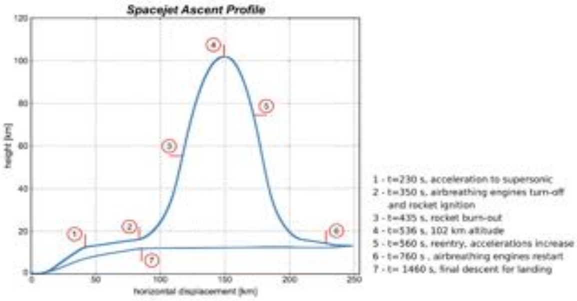
- The propellant tank ("light and large" object)
- A linear actuator ("heavy and small" object)

CASE 2, Detail

THE GROUND STATION

Ground Stations provide space-to-ground communications with the Spacejet to allow monitoring of all the flight. For this study case one Ground Station was placed nearby the takeoff/landing Pad

It was assumed that the area where the launch pad and antenna are located has no masking at horizon by hills/mountains and/or trees or forests

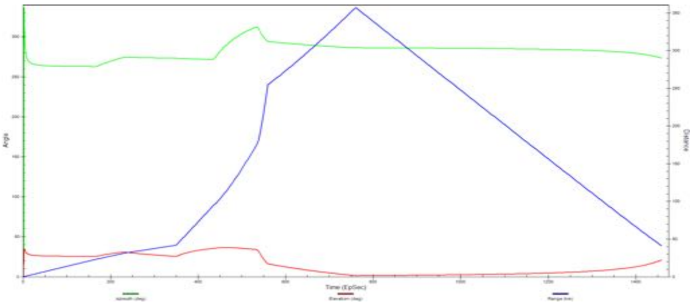


THE GROUND STATION

Preliminary visibility assessment was performed basing upon the available trajectory data from models and using the Satellite Tool Kit tool

Evaluated Azimuth, Elevation and Range (geometrical distance) values of the communication link between the antenna and the spacecraft, as function of the mission elapsed time.

Evaluated minimum antenna elevation around 4 Deg to allow Spacejet visibility



THE GROUND STATION

The ground stations permits to keep track of the SPACEJET vehicle and thus to control its trajectory.

This is achieved through telemetry reception by exploiting GPS information (if available) and/or localization measurement units available (e.g. Inertial Measurement Units).

Another means of keeping track of the vehicle under control is through the antenna positioning and the ranging functionalities. This mechanism, although less precise, can be very helpful in case of emergency or in case when the position data of the vehicle is not available into TM (e.g. GPS lock lost).

Through the use of vehicle position information it is possible to predict its trajectory through the implementation of dedicated software. In particular this topic can be really helpful in case of emergency, for instance with no Telemetry, to predict where the vehicle will land (either on sea or on ground).

THE SPACE CITY

Malaysia intends to create a 'Space city' in the country to advance research into the field of aerospace

A proper area has already identified for the purpose and very suitable for spaceflight operations, including suborbital flights

Besides a fully outfitted Spaceport, Spacecity will include proper infrastructures and research centers that will focus on space education and training.

THE SPACE CITY

SPACEPORT & SPACE TECHNOLOGIES RESEARCH CENTRE PROPOSED LOCATION SITEMAP.

THE SPACE CITY

THE SPACE CITY

A new regulatory workframe will have to be developed for suborbital flights, associated with proper integration between space and aeronautic laws

Initial assumption is that the FAA policy will be applied to suborbital flights in Malaysia

The Malaysian Authority for civil aviation will have to be involved via specific agreements to tailor the FAA regulations to the local regulatory frame system

CONCLUSIONS

The development of suborbital flight capabilities has to address the evaluation of Ground Segment and Spaceports in parallel to the studies on the flight segment, technologies and associated mission requirements

The process has to be carried out since the beginning, to allow full consistency between flight segment and ground support/infrastructures and properly and safely support the fulfilment of the operating mission objectives

It is possible to apply proper methodologies and develop consistent ground infrastructure and Spaceport concepts that allow operational flexibility and fulfilment of the customer requirements in a commercial suborbital market