2nd International Symposium "Hypersonic Flight: from 100.000 to 400.000 ft"
Rome, Italy, 30 June-1 July 2016

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a Low Hypersonic Suborbital Capability

by

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- Other hypersonic commercial designs tend toward large aircrafts, characterized by hundreds of tons of mass and hundreds of passengers
- A small passenger hypersonic plane (< 10 seats), designed by integrating state-of-the-art aeronautic and space technologies, may offer access to suborbital space and stratospheric flights as safe, convenient and commonplace as today's commercial air transportation, and represent a first step towards the development of larger and more complex systems, but at the same time may open new markets and applications

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A business HYpersonic airPLANE

- 6-seats, Mach 4-4.5 spaceplane
- HTHL from 80% of available airports (L<1000 m) within the present set of governing rules
- Urgent Travel market segment
- Suborbital flight (Microgravity Exp., Space Tourism, Training)

- can fly above the Karman line and can run a series of Space Tourism parabolas at altitude above 70 km
  - ➔ *Space Tourism 2.0*
- ~7000 km distances in less than 2 hours with cruise altitude at about 30 km
- integrates state-of-art aeronautic and space technologies

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System configuration

- Variable-delta wing + fuselage shape to provide aerodynamic stability and manoeuvrability over a broad speed range
- Powered by either (i) Supercharged Ejector RamJet (SERJ) engines or (ii) turbo-ramjet engines plus a liquid rocket
- GTOW = 27 t
- 30 km altitude flight, due to the low wing loading, offers also a better Earth view and may open to new applications
- Sub-orbital "jumps" up to 100 km (Karman Line)

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System configuration

The
«Dr. Jekyll and Mr. Hide»
passenger cabin

Advanced, simplified cockpit
with holographic HAD

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Comparison with other space tourism vehicles

		Cabin Volume [m³]	Max Altitude [km]	Down-range [km]	Max Accelera-tion [g]	Passengers [#]
	HyPlane	25	>100, 1 jump ~70, km 3 jumps	300 each jump	4.2	6 (+2)
	Space Ship 2	15	110	56	6	6 (+2)
	Lynx	~6	100	-	4.5	1 (+1)
	EADS Spaceplane	12	100	-	4.5	4 (+1)

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HYPLANE Mission Profile

- Horizontal take off at 60 m/s speed
- Subsonic climb from 0 to 10 km altitude, speed up to about 240 m/s or Mach 0.8
- Aero-assisted climb from 10 to 30 km altitude, speed from 240 to 1350 m/s or Mach from 0.8 to 4.5
- Cruise at 30 Km altitude, Mach 4.5
- Eventual sub-orbital maneuver/s
- Gliding descent from 30 to 5 km altitude, speed from 1350 to 200 m/s or Mach from 4.5 to 0.6
- Final approach from 5 to 0 km altitude, speed down to 100 m/s
- Horizontal landing at 60 m/s speed

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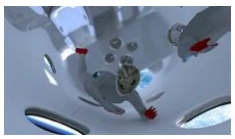
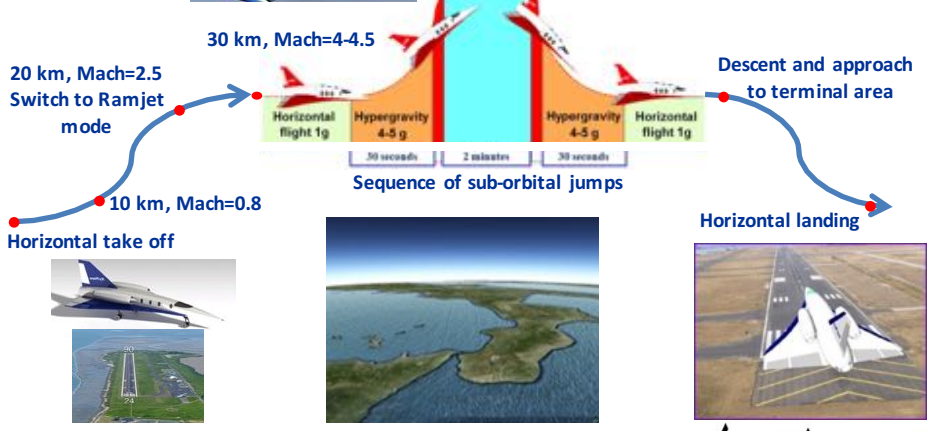
Suborbital Flight Scenario





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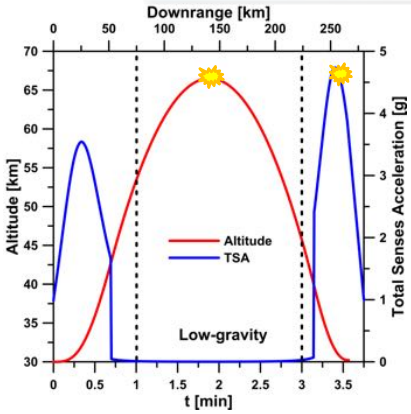
Suborbital Flight Performances

- HyPlane is able to execute up to three parabolas during one single flight. Max downrange for each sub-orbital jump is 300 km
- Relatively low max acceleration ~4.5g immediately prior to two minutes of weightlessness (~70 km altitude)
- Opportunity to execute micro-gravity research under repeated, relatively long duration weightlessness



- Unique possibility to follow a more flexible research approach (using typical laboratory-type instrumentation, participation of the research team on their experiments during flight, reusability)

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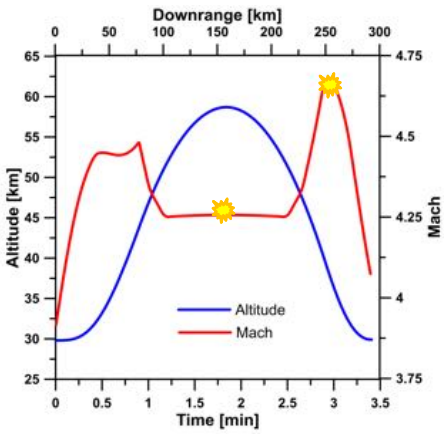
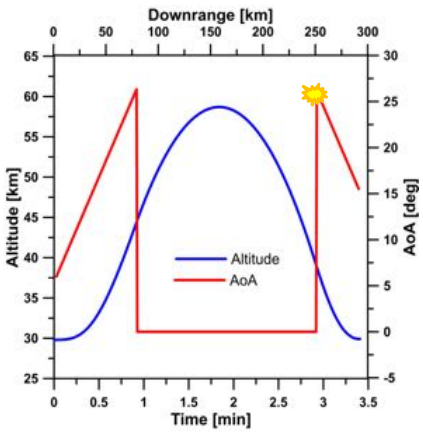
Suborbital Flight Performances





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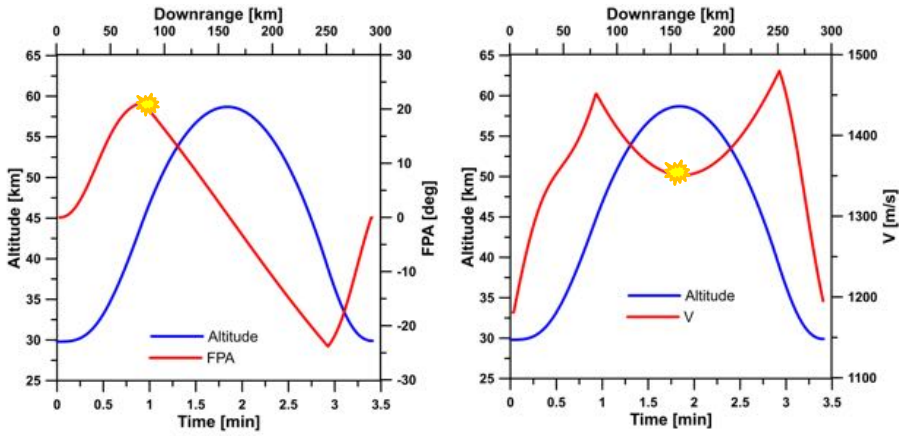
Suborbital Flight Performances



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The advantage of the coastal line

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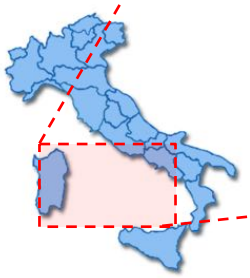
(NOtice To AirMen)



- Segregated areas for operations
- Geographical location, climate, population density
- Security procedures of the site and the area

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Hypersonic Cruise Scenario

20 km, Mach=2.5
Switch to Ramjet mode

Acceleration along a constant dynamic pressure trajectory

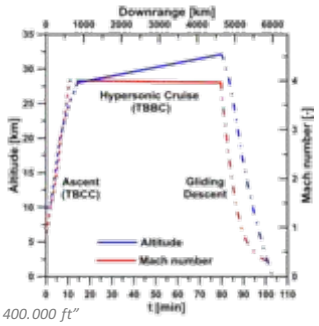
10 km, Mach=0.8

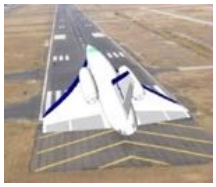
Horizontal take off

Cruise phase,
30 km, Mach=4-4.5
(Range >6000 km)

Descent and approach to terminal area

Horizontal landing





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Hypersonic Cruise Range Map

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Hypersonic Cruise Range Map

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Hypersonic Cruise Range Map

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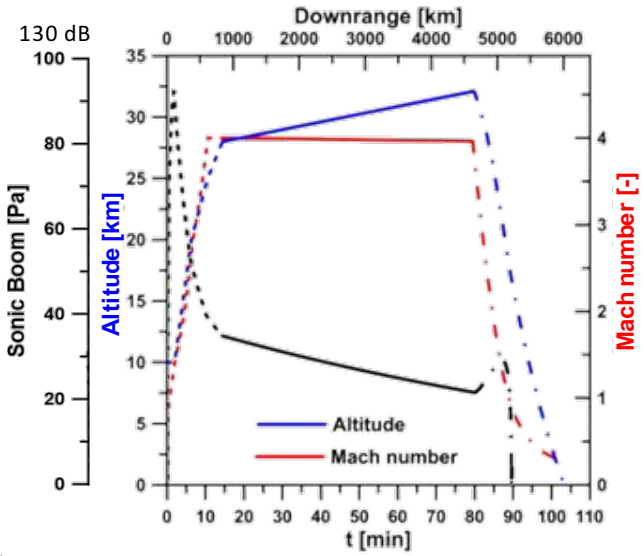

$$\Delta p = \frac{K W^{\frac{1}{2}} (M_0^2 - 1)^{\frac{3}{8}}}{M_0 H^{\frac{3}{4}}}$$

K *from Concorde and Space Shuttle data*
W *instantaneous weight*
Mo *instantaneous Mach*
H *instantaneous altitude*

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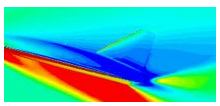
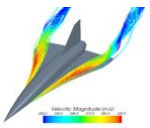
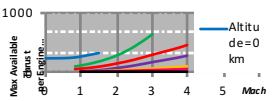
Main Enabling Technologies

1. Low wing loading aerodynamics

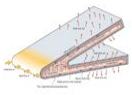




2. Combined cycles hypersonic propulsion (ramjet based)





3. Integrated hot structures and thermal control




4. Reduced environmental impact due to sonic boom

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Prospective Markets








Urgent business travel

Low gravity Research

Hypersonic interconti-nental transportation

Extended duration space tourism

Fast cargo transportation

Space services

Aerospace testing and development

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Potential Market Size

The correct potential marketplace for HyPlane is the combination of two markets:

- **Supersonic/Hypersonic transportation**
- **Suborbital space flight**

The first one addresses mainly the segment of urgent business travel for passengers as well as fast cargo transportation for special goods/products such as mail and express, pharms, valuables live, perishable, transcontinental organ transport
The second one refers mainly to space tourism.

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Business Plan Summary

- Reference time frame: 20 years
- Number of units:
  - **102 units** from SBJ/HBJ
  - **10 units** from suborbital space tourism and services
- Development cost (NRC) = **2 B€**
- Production cost of one vehicle (RC) = **40 M€**
- HYPLANE selling price: **80 M€**
- Operating cost:
  - P2P = **28 k€/flight**
  - TS = **155 k€/ flight**
- Ticket price = **10 k€** (P2P) and **50 k€** (ST) (➔ 50-250 k€/day, 6-32 k€/hr)

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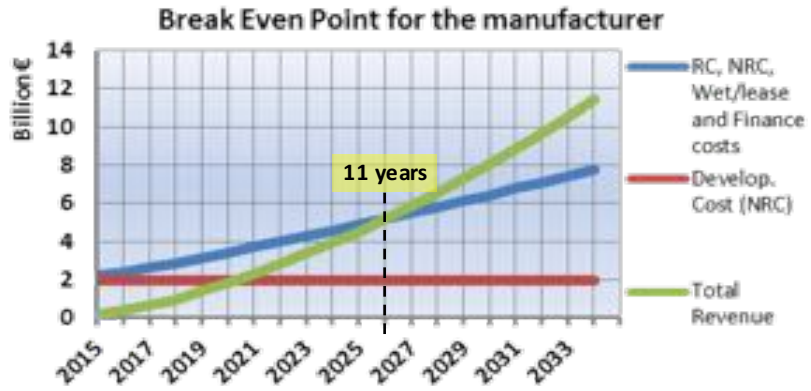

2 B€ development investment
10 B€ total life cyle cost
13.7 B€ total life cycle revenue
3.7 B€ total life cycle First Operating Margin (EBITDA)

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Prototype Demonstrator

- Aerostructure: almost the same
- Propulsion system: twin EJ200 turbofan (from Eurofighter) + rocket booster
- People on board: one experimental pilot
- Target missions:
  - 1 suborbital jump up to 100 km with 300 km downrange
  - <1000 km stratospheric flight
- Development cost: ~1/10 of full development costs
- Development time: ~4 years

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