20th AIAA Int'l Space Planes and Hypersonic Systems and Technologies Conference,
6 - 9 July 2015, Glasgow, Scotland (UK)

hyplane the Business Case of a Small Hypersonic Airplane for Point-to Point and Space Tourism flights

by

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Space Renaissance Italia

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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 stratospheric and space 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 personal HYpersonic airPLANE

- can fly a series of Space Tourism parabolas at altitude above 70 km, *Space Tourism 2.0*
- 6000 km distances in less than 2 hours with cruise altitude at about 30 km
- integrates state-of-art aeronautic and space technologies

- 6-seats small 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 (Space Tourism, Microgravity Exp, Training)

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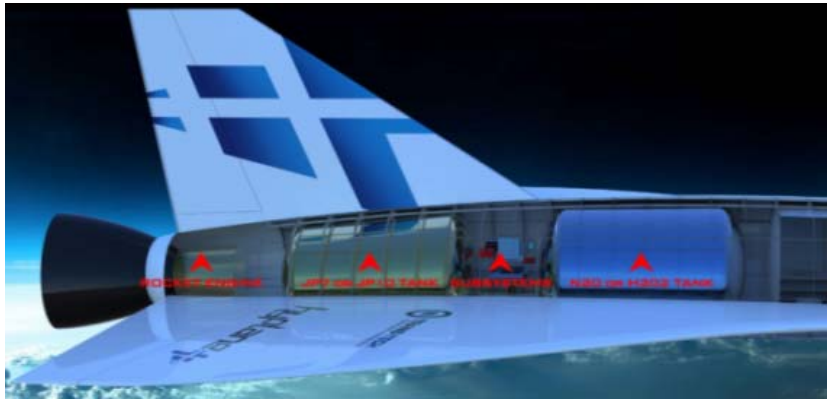
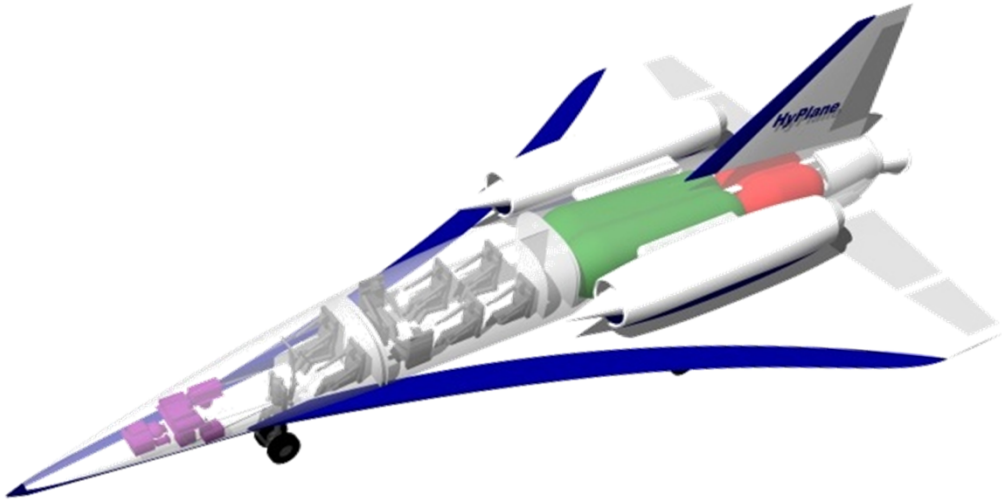
System configuration

- Variable-delta wing + fuselage shape to provide aerodynamic stability and manoeuvrability over a broad speed range
- Powered by TBCC ramjet engines, combined with a throttable 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
- Max speed as high as Mach 4-4.5





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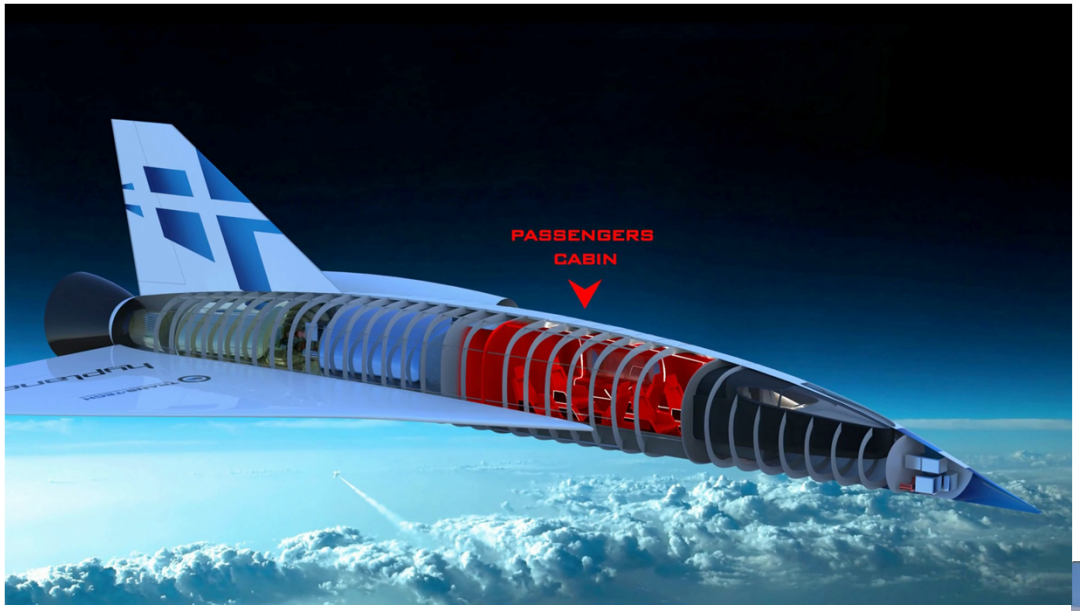

The «Dr. Jekyll and Mr. Hide» passengers cabin

Advanced, symplified cockpit with holographic HAD

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Hypersonic Cruise Scenario

20 km , Mach=2.5
Switch to Ramjet mode

Acceleration along a constant dynamic pressure trajectory

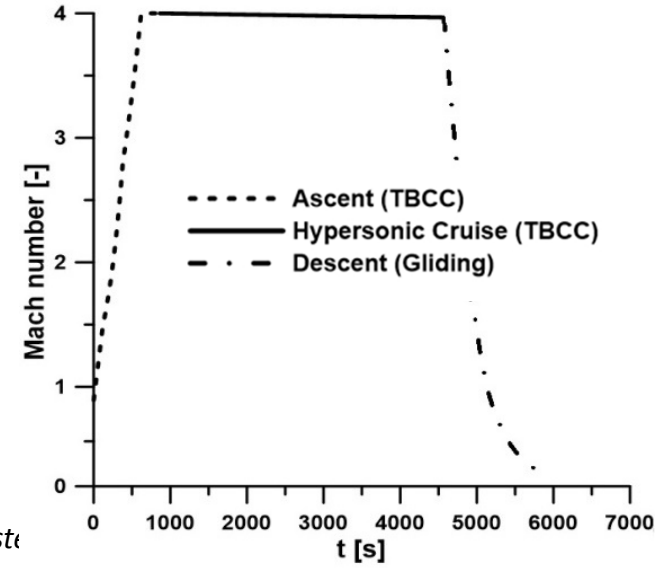
10 km, Mach≈0.7

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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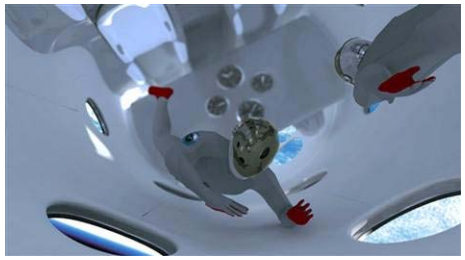
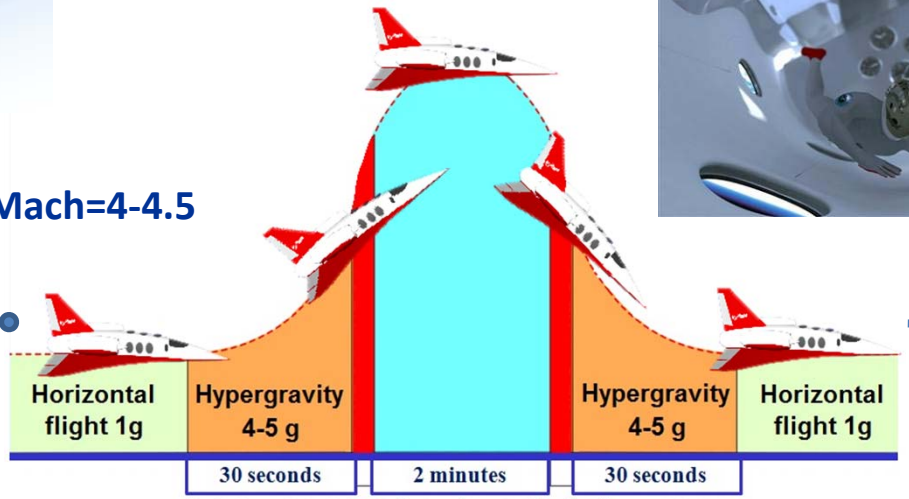
Space Tourism Scenario

>70 km
Weightlessness



30 km , Mach=4-4.5

20 km , Mach=2.5
Switch to Ramjet mode



Descent and approach to terminal area

Sequence of sub-orbital jumps

10 km, Mach=0.6

Horizontal take off

Horizontal landing

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Comparison with other space tourism vehicles

		Cabin Volume [m^3]	Max Altitude [km]	Down-range [km]	Max Accelera-tion [g]	Passengers [#]
	HyPlane	25	>70	1500	4	6 (+2)
	Space Ship 2	15	110	56	6	6 (+2)
	Lynx	-	70	-	4.5	1 (+1)
	EADS Spaceplane	12	100	-	4.5	4 (+1)

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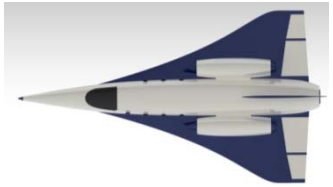
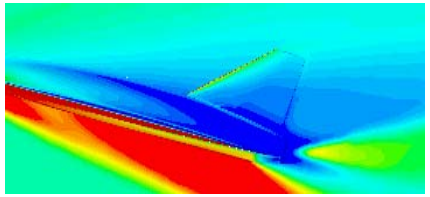
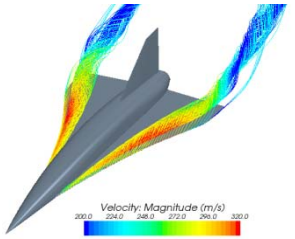
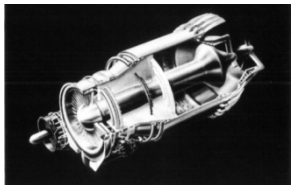
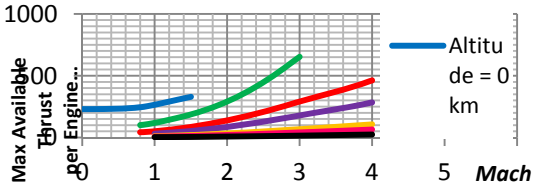
Main Enabling Technologies

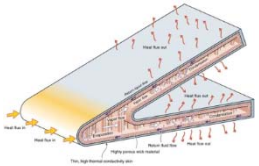
1. Low wing loading aerodynamics

2. Combined cycles hypersonic propulsion (turbo-ramjet)

3. Integrated hot structures and thermal control



4. Reduced environmental impact due to sonic boom

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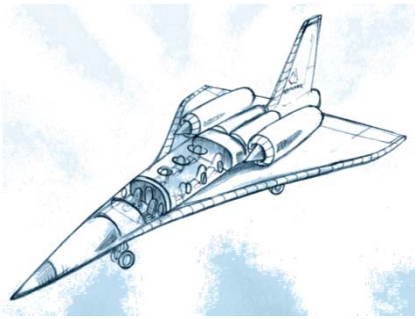
Prospective Markets

1. Extended duration space tourism
2. Hypersonic intercontinental transportation
3. Urgent business travel
4. Fast cargo transportation
5. Low gravity Research
6. Aerospace testing and development
7. Remote sensing



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Potential Market

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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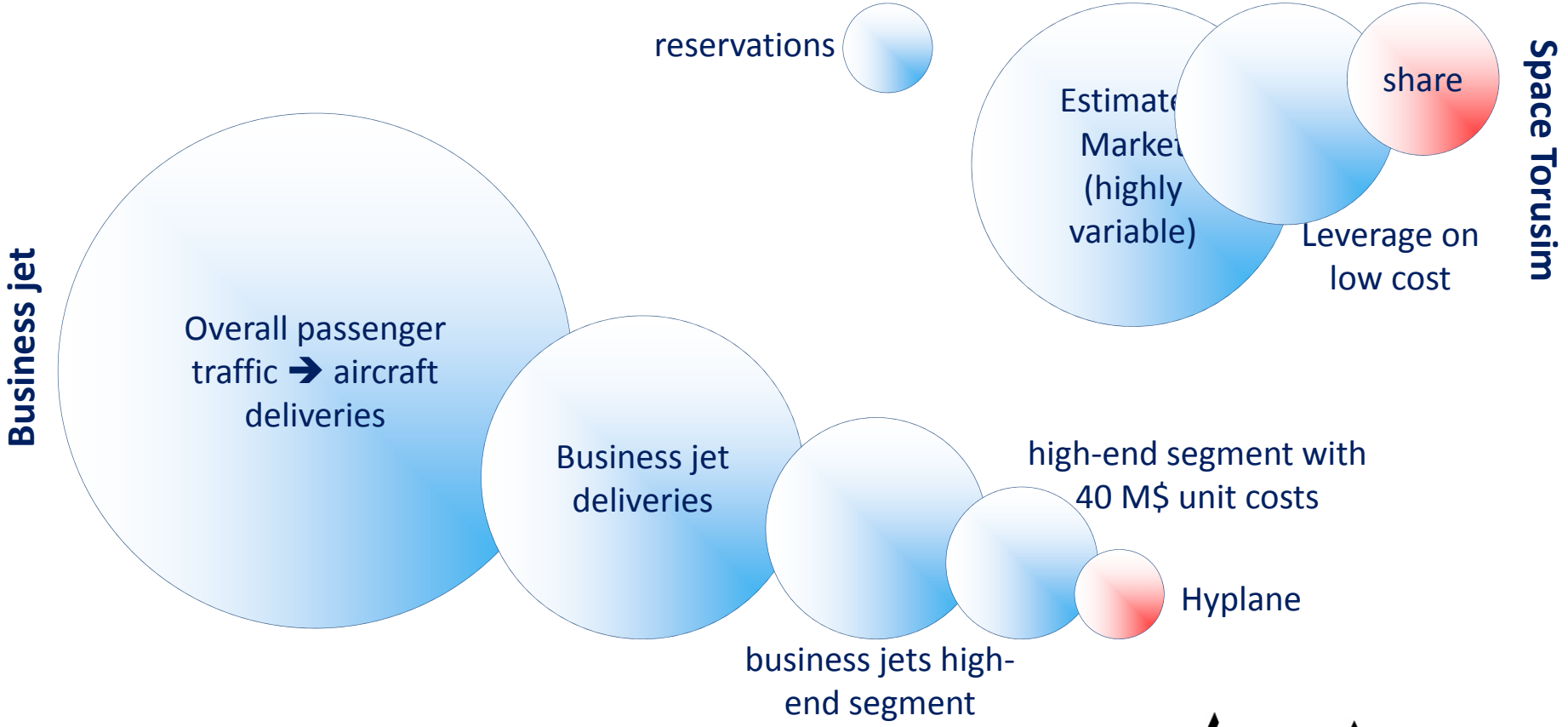
Analysis approach

An inductive approach is used, making use of available analyses.



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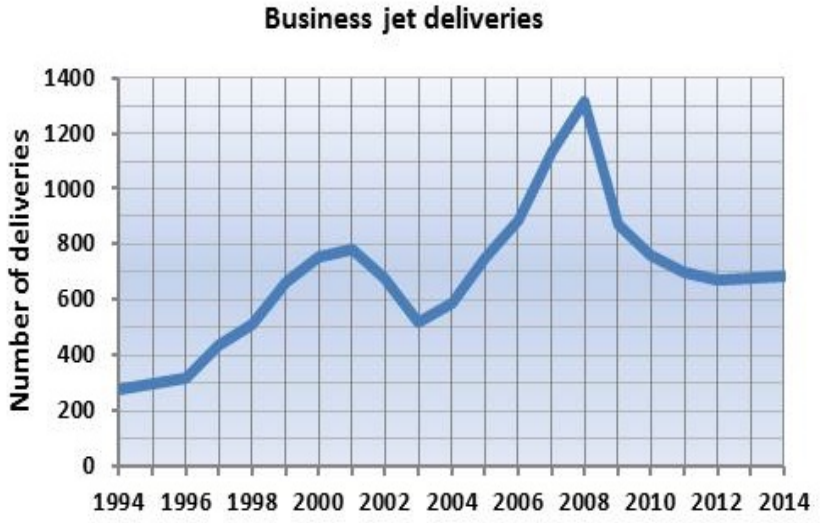
A) Business Jet Market: Overview and Projections

Passenger air traffic demand increased continuously since 1950 and is still expanding, even if this market is very sensitive to the economic downturns: Twin Towers attack (2001) and the financial crisis (2008) ➔ forecasted average annual growth rate for the next 10 years = 3-5%

The **business jet market** represents today the aviation industry segment with the largest growing potential. The highest peak was recorded in 2008, with 1313 business jets delivered. At the moment, the deliveries per year are close to 700 ➔ expected annual growth rate over the next 20 years = 3,5%



By the end of 2034 the active business jet fleet will be about 24000 units (FAA) with about 10000 new vehicles plus 4500 replacing units, for a total jet deliveries over the **next 20 years** estimated **14500 vehicles**, with an average of 725 jets delivered per year

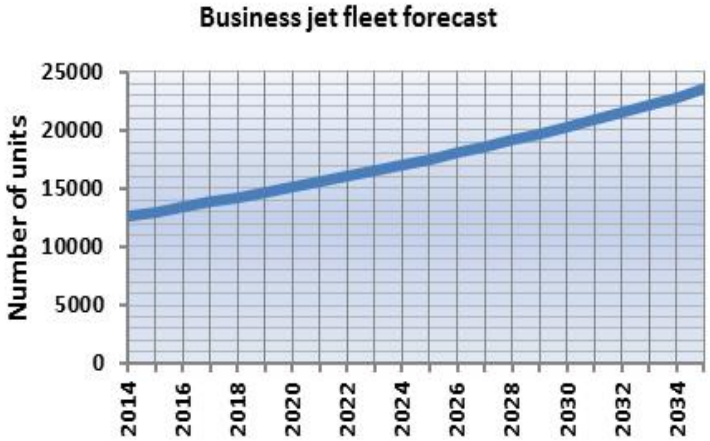


Fig. 3: Business jet fleet forecast over the next 20 years. Source: FAA Survey and Forecast

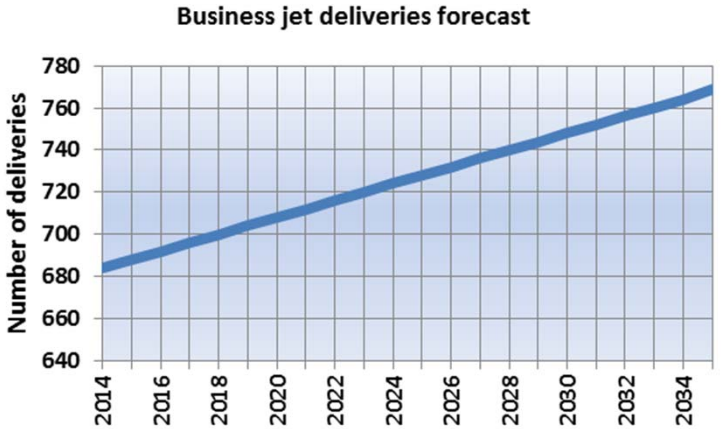
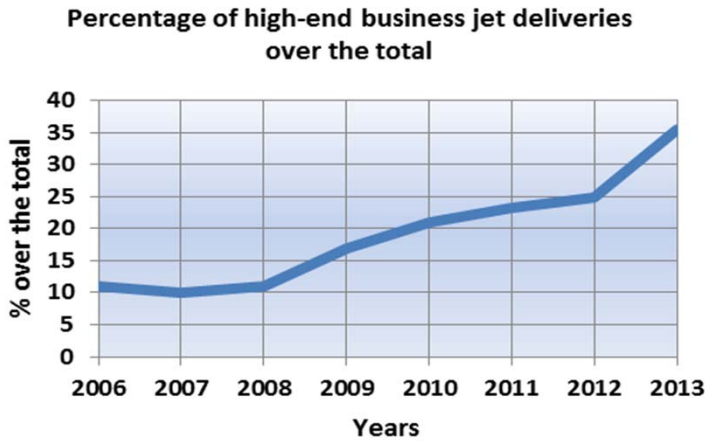


Fig. 4: Business jet deliveries forecast; source: FAA Survey and Forecast

B) Supersonic Business Jet Demand

The business jets high-end segment is constantly increasing its market share and has passed from the 10% in 2006 of the total business jet market to around **35%** in 2013. It means that approximately one third of the business jet deliveries are in the high-end segment.



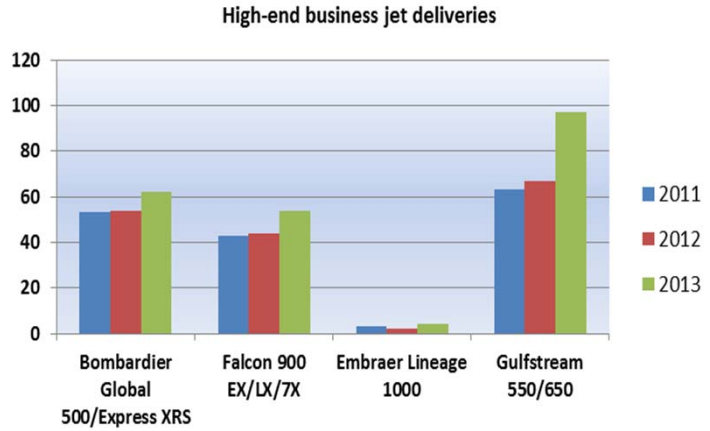


Fig. 6: High-end business jet deliveries; Source: "General Aviation Statistical Databook & 2014 Industry Outlook"

Let us now consider jets within the high-end segment characterized by a unit costs higher than US$ 40 millions.

The segment has **constantly increased its market share** with respect to other business jet segments, mainly because it is less sensitive to the economic fluctuation:

- people willing to buy such a jet do not consider the price as the first purchase parameter;
- first they look at the comfort, max range, max velocity and design.

Therefore the **elasticity** of that market is extremely low.

Assuming an average market share along the years of 25%, in the next 20 years **we expect a demand of high-end segment jets of 3625**.

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The market for supersonic/hypersonic jets is strictly related to the one of subsonic high-end segment jets ➔ several studies exist.

Main parameter is the vehicle costs. According to M.H.Reichel (2011):

- with a reference price of US$80M, **43%** of the high-end business jet demand will be switched to the supersonic jet one
- with a price of US$90M, the switched demand will be **29%**
- with a price of US$100M, the switched demand will be **14%**,
- with a price of US$110 million or more, **no one** will be willing to buy a supersonic airplane

HYPLANE market price is estimated around 80 M€/unit

(anyway no higher than 100 M€)

Thus, with a price range from 80 to 100 million US$, the projected demand could vary from 507 to 1559 new supersonic jets in a period of 20 years, or from **25 to 78 per year in average**

It is also clear that, if new supersonic/hypersonic vehicles will cost no more than 150% of the average purchase price of high-end subsonic jets, this latter market **will probably lose a significant share**.

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C) Suborbital Space Tourism Market

A market demand for suborbital tourism exists and it is demonstrated by the reservations made to Virgin Galactic, XCOR and Armadillo:

	2012	**mid-2013**
Virgin Galactic	550	640
XCOR	175	300
Armadillo	200	*200*
TOTAL	**925**	**1140**

Source for 2012 data: The Tauri Group

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The Tauri Group study in 2012 selected a pool of wealthy individuals with a minimum net worth of $5 million.

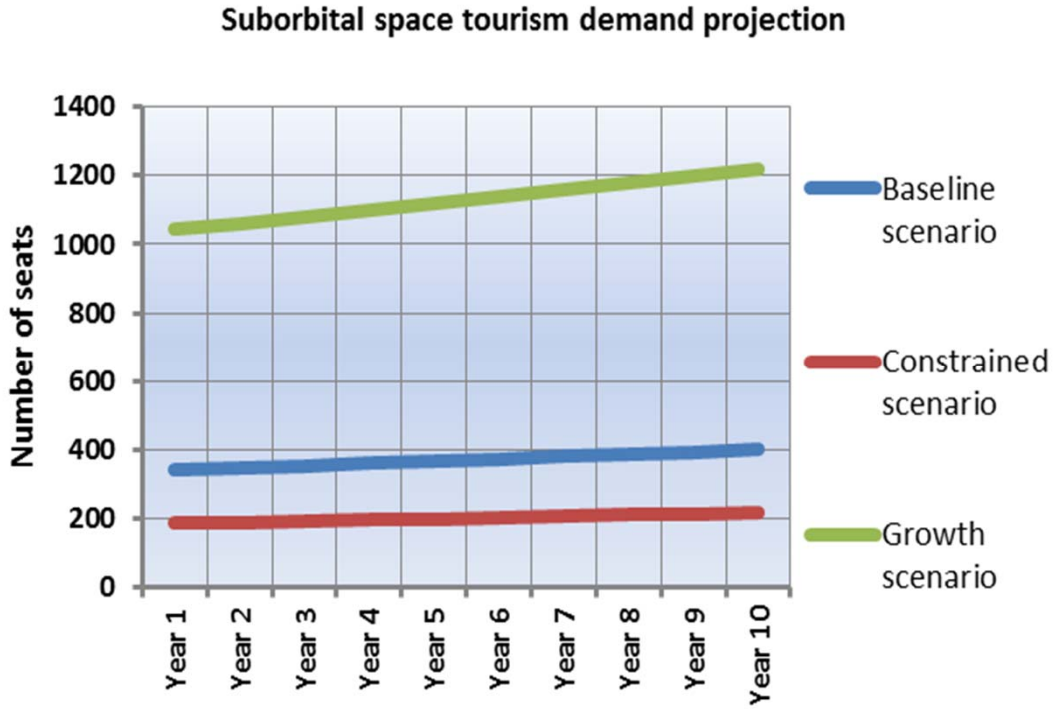

Fig. 7: Suborbital Space Tourism demand projection; source: "Suborbital Reusable Vehicles: A 10-Year Forecast of Market Demand", Tauri Group

Baseline: stable political situation today. **3600 seats over 10 years with $600 M revenues**

Constrained: persistence of the economic crisis. **2000 seats over 10 years with $300 M revenues**

Growth: improved technology, high private investment, successful marketing. **>11000 seats over 10 years with $1600 M revenues**

Another assessment was conducted by IPSOS

The study took into account six different pricing scenarios.

1st scenario: during the first year after the market start, estimated 606 potential passengers, becoming 43.148 during the 16th year.

6th scenario: the most optimistic one, projected 756 potential passengers in the first year and more than 80.000 16 years after.

Given the number of expected players, it is estimated that Hyplane will capture 20 % of the market ➔ something like 540-1000 seat/yr .

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Potential Customers and Buyers Analysis

According to D. Webber (2012) "Exploring the possibility of a commercial traveler market for point-to-point suborbital space transportation", the Concorde market experience supports an estimation of some 37500 passenger/year, including business as well as leisure purposes travellers.

some 100-150 passengers daily

This data suggests that small supersonic/hypersonic aircrafts (with less than 10 seats) will be a good investment

Potential buyers could be:

Fractional owner companies

Private individuals

Governments

International/multinational companies

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Economics: Cost and Revenue Breakdown

A) *Manufacturer Perspective*

MANUFACTURER COSTS	PHASES COVERED	COST TYPE	ESTIMATE
Development costs	• Feasibility • Preliminary definition • Detailed definition • Prototype/Demonstrator production and certification (~85%)	NRC	**2 B€**
Financing costs	(4% on development costs)	NRC	840 M€/20 years
Production costs	• Production of the vehicle • Testing and qualification	RC / fixed and variable	**40 M€** on average / vehicle

2015 c.e.c.

the lessor (manufacturer) provides aircraft, crew, maintenance and insurance (ACMI), while the leesee (operator) covers expenses for fuel, airport fees and any other taxes or duties

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Assumptions:

- HYPLANE will capture 20% of the supersonic/hypersonic business jet market
  ➔ conservatively **102** units over 20 years (3 delivery at start, rising up to 10)
- HYPLANE will be requested of **10** units for space tourism market (wet lease). An extra aircraft per year.
- Production cost = **40** M€ Selling Price = **80** M€
- Each spaceplane will be used as a mean for 1 fight/day for 300 days/yr

2015 c.e.c.

Development costs	2,00 B€
Financing costs	0,84 B€
Production costs	4,48 B€
Wet lease cost	0,47 B€
TOTAL COSTS	**7,79 B€**

Revenues from vehicles sold (*business jet*)	8,16 B€
Revenues from vehicles in wet leasing (*space tourism*)	3,36 B€
TOTAL REVENUE	**11,52 B€**

First Operating Margin = **EBITDA = 3.73 B€ over 20 years**

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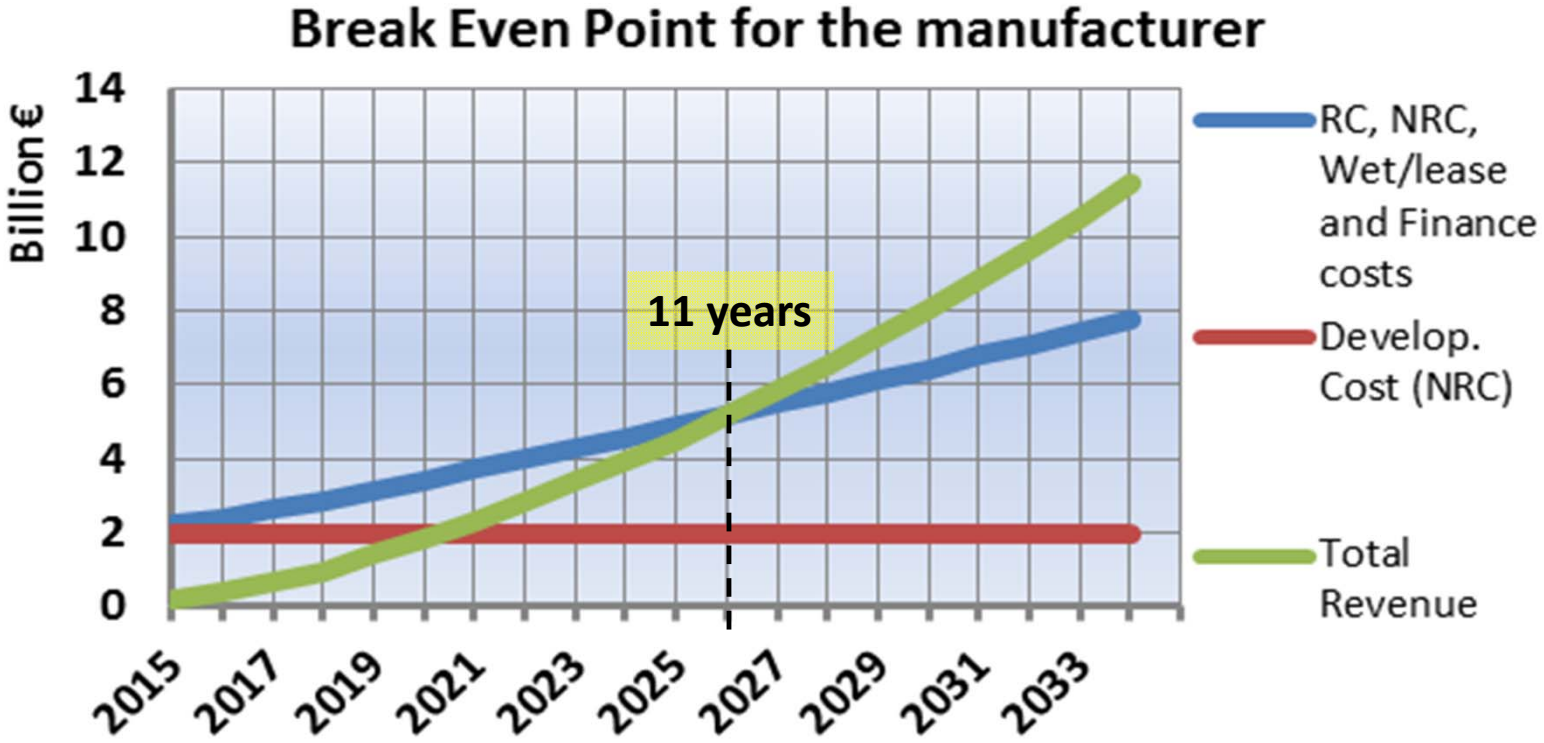

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B) Operator Perspective for Business Transportation

- Vehicle operating life: 20 years
- Average flight frequency: 2 per day
- Average occupancy rate: 5 seats over 6
- Average operating days per year: 302 (increasing over the years)

2015 c.e.c.

Variable operating costs per flight		Fixed operating costs	
Fuel and oil	€16000	Annual insurance costs: hull + liability insurance	€200000
Flight crew	€2500	Annual Hangar expenses	€77000
Labor and part expenses	€2000	Annual Office expenses	€10000
Passenger services	€1000	Annual maintenance	€300000
Other consumables (10% of fuel)	€1600	Marketing and commercial costs	€600000
Others: - fees for air navigation, landing, parking, handling, airport	€2600	Total per year	€1,187 million
Total per flight	**€25700**	**Total per flight**	**€1978**

Cost per flight = 27678 € ; Cost per passenger = ~5500 €

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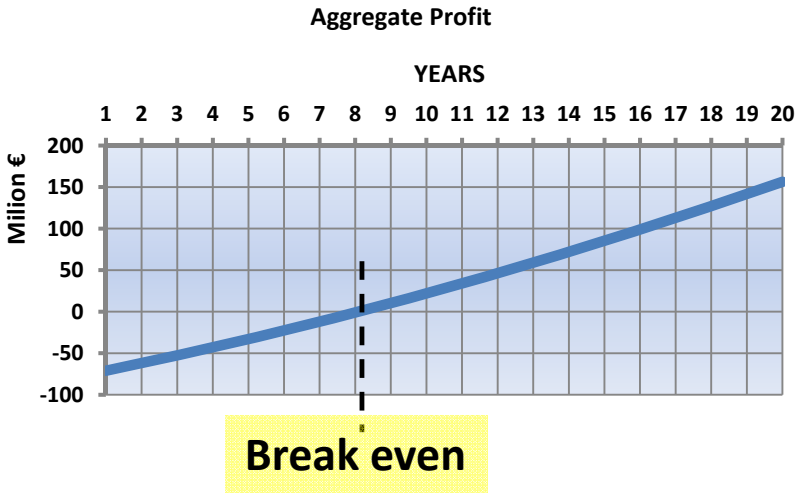
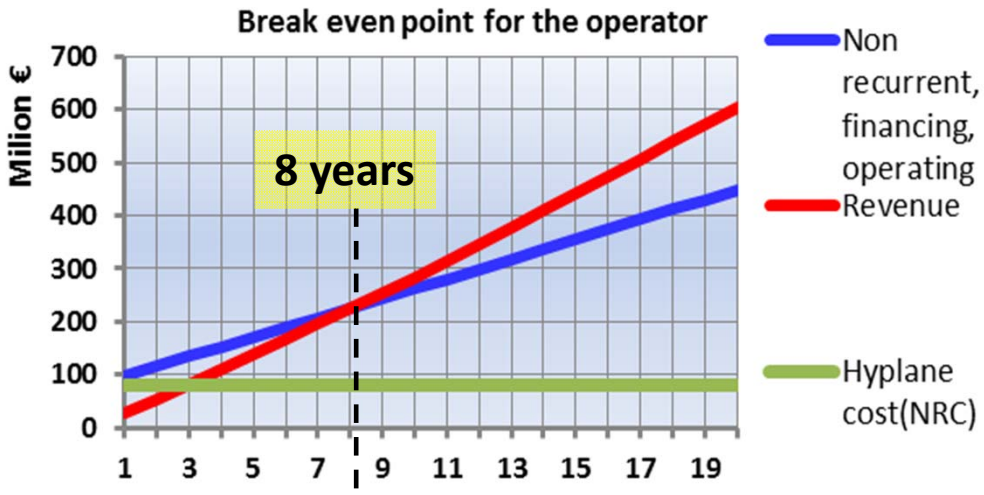
- Ticket price = 10000 € (with profit of 45%)
- Break even point at 8 years
- Aggregate profit = 150 M€





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C) Operator Perspective for Space Tourism Missions

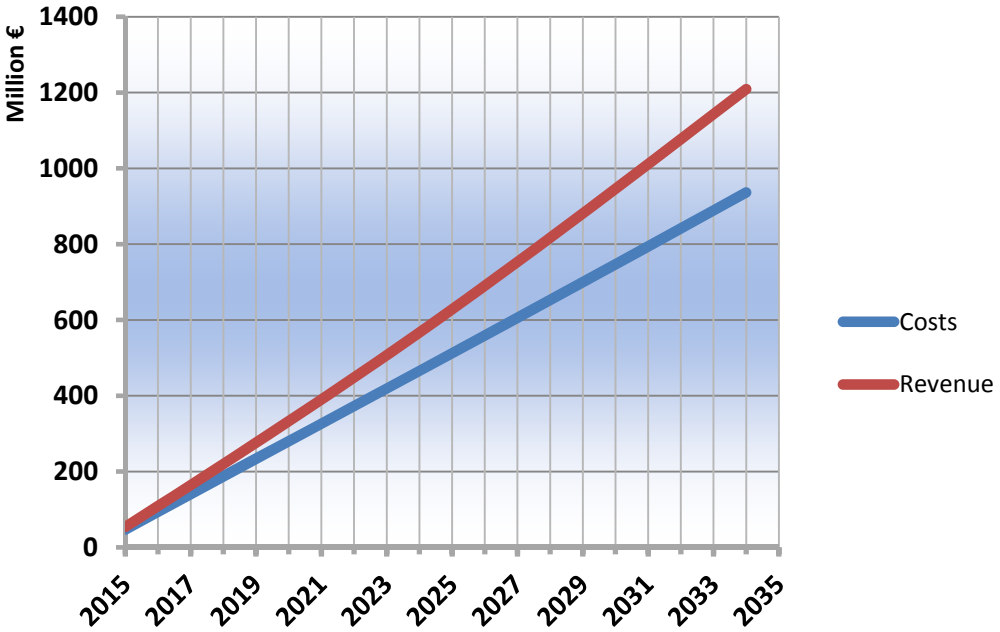
- Vehicle operating life: 20 years
- Average flight frequency: 1 per day
- Average occupancy rate: 5 seats over 6
- Average operating days per year: 300 (increasing over the years)

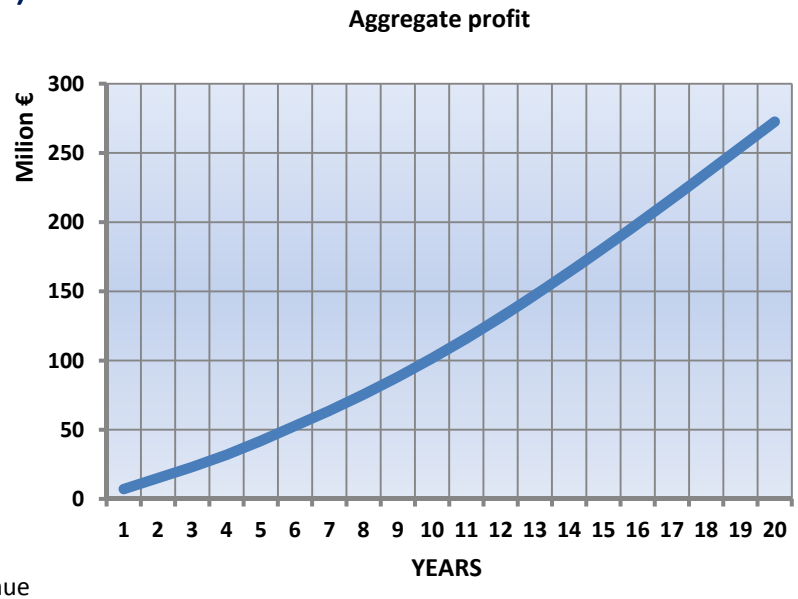
2015 e.c.

COSTS AND REVENUES FOR 1 VEHICLE OPERATED	
Wet lease contract per year	€30M
Operating costs per flight: fuel, airport fees and taxes	€22856 (fuel cost) + €5000(fees and taxes) = €27856
Yearly marketing and commercial costs	€600000 per year
Yearly office expenses	€10000 per year
Cost for participants training program (per flight)	€25000 (€5000 per participant)
Total cost per flight	**€155000**

Cost per flight = 155000 € ; Cost per passenger = 31500 €

- Wet leasing contract = 30 M€/yr
- Ticket price = 50000 € (with profit of 38%)
- Break even point: not applicable
- Aggregate profit = 270 M€





TRANS-TECH
TECHNOLOGY TRANSFER and ENGINEERING SERVICES

Department of Industrial Engineering,
University of Naples "Federico II"

BUSINESS PLAN SUMMARY (conservative)

- Reference time frame: 20 years
- Number of units:
  - 14500 new BJ, of which 25% SBJ
  - If the purchasing cost is 80-100 M€, HBJ can take over at least 14% of the SBJ market
  - A mean of some 1000 passengers captured by Hyplane for space tourism over 20 years
  - So, HYPLANE will capture 20% of both markets ➔ **102 units** from SBJ/HBJ **+ 10 units** from space tourism in 20 years
- HYPLANE selling price:
  - **80 M€** (SBJ=60 M€, BJ=5-55 M€)
- Development cost (NRC) = **2 B€**
- Production cost of one vehicle (RC) = **40 M€**
- Operating cost:
  - P2P = **28 k€/flight**
  - TS = **155 k€/ flight**
- Ticket price = 10 (P2P) and 50 (ST) k€ (➔ 50-250 k€/day, 6-32 k€/hr)
- Break Even Point between **8 and 11 years** depending of financial approach.

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20th AIAA Int'l Space Planes and Hypersonic Systems and Technologies Conference,
6 - 9 July 2015, Glasgow, Scotland (UK)

hyplane