Spaceplanes & Spaceports –
The Next Generation of Aerospace Transportation
Gdansk International Air & Space Law Conference

November 15, 2013

Current Suborbital Flight Markets

COMMERCIAL HUMAN SPACEFLIGHT
Human spaceflight experiences for tourism or training
Individuals
Corporate
Contests and promotions
In-space personnel training

BASIC AND APPLIED RESEARCH
Basic and applied research in a number of disciplines, leveraging the unique properties of and access to the space environment and microgravity
Biological and physical research
Earth science
Space science
Human research

AEROSPACE TECHNOLOGY TEST AND DEMONSTRATION
Aerospace engineering to advance technology maturity or achieve space demonstration, qualification, or certification
Demonstrations requiring space/launch environment
Hardware qualification and test

MEDIA AND PUBLIC RELATIONS
Using space to promote products, increase brand awareness, or film space-related content
Film and television
Media, advertising, and sponsorship
Public relations and outreach
Space novelties and memorabilia

EDUCATION
Providing opportunities to K-12 schools, colleges, and universities to increase access to and awareness of space
K-12 education
University educational missions

SATELLITE DEPLOYMENT
The use of SRVs to launch small payloads into orbit
Very small satellite launch

REMOTE SENSING
Acquisition of imagery of the Earth and Earth systems for commercial, civil government, or military applications
Commercial Earth imagery
Civil Earth imagery
Military surveillance

POINT-TO-POINT TRANSPORTATION
Future transportation of cargo or humans between different locations
Fast package delivery
High-speed passenger transportation (civil)
High-speed troop transportation (military)

Figure 1: SRV market definitions

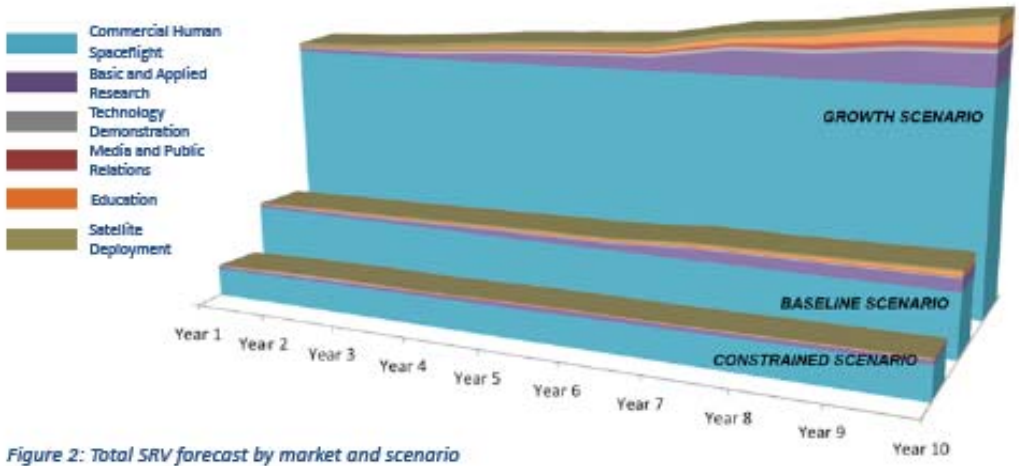


Figure 2: Total SRV forecast by market and scenario

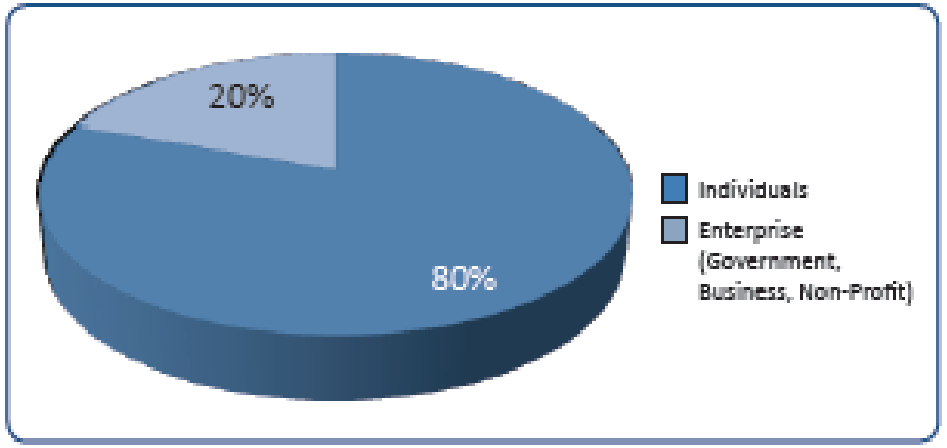


Figure 5: Enterprise demand and individual demand in baseline case

Source: FAA/AST – SpaceFlorida Suborbital Market Study by Tauri Group, July 2012

Suborbital Space Vehicles

Space Ship 2 ©Virgin Galactic


LynX ©XCOR


SOST ©Armadillo Aerospace


New Shepard ©Blue Origin

RocketplaneXP ©Rocketplane


Xogdor ©Masten Space Systems

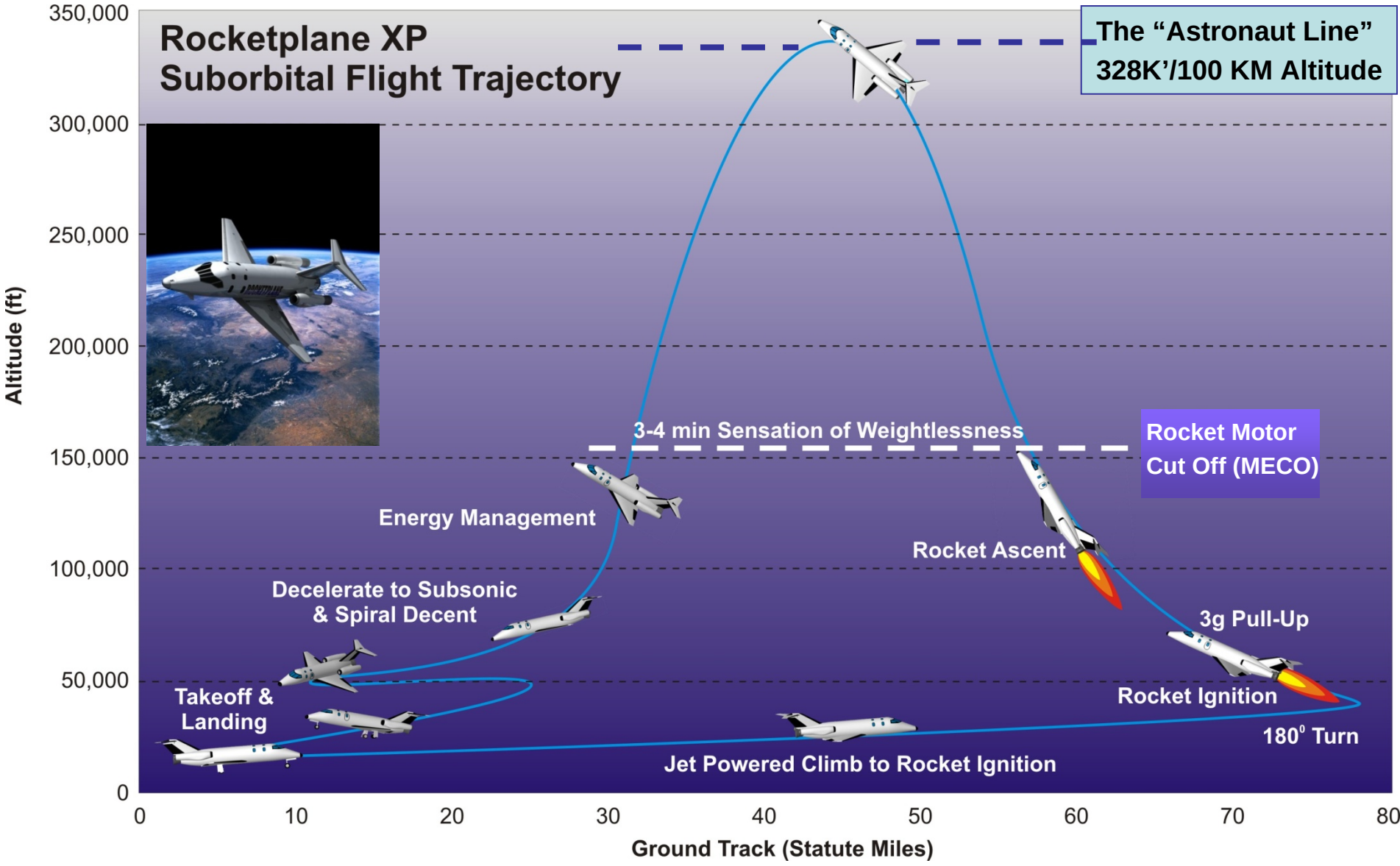

TBN ©EADS Astrium


Swiss Space Systems


Enterprise ©Project Enterprise


Heart ©Copenhagen Suborbitals

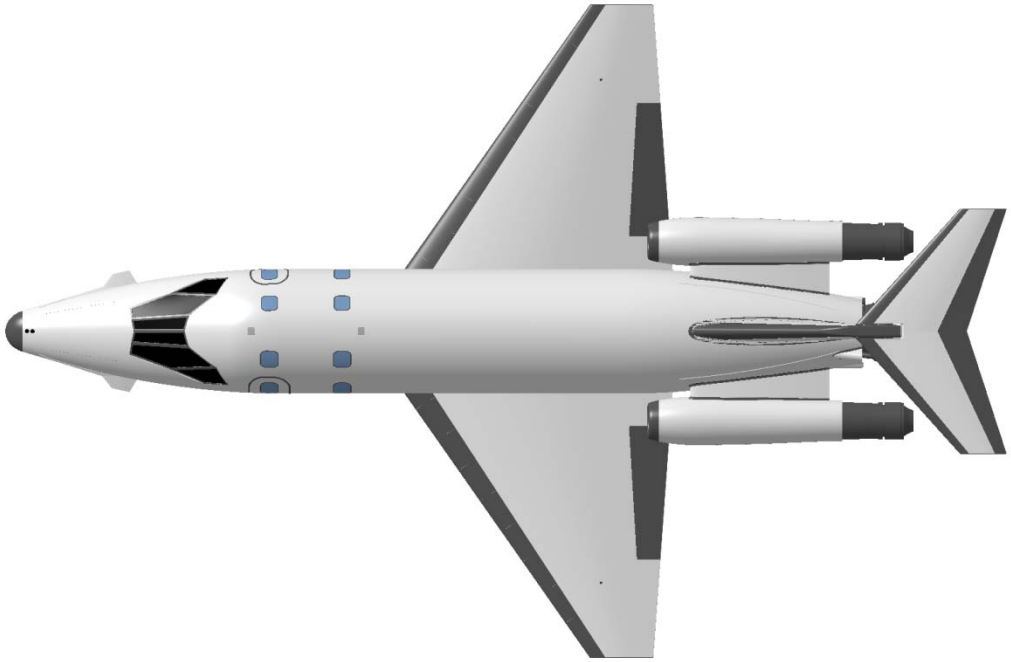
The Rocketplane Flight Profile

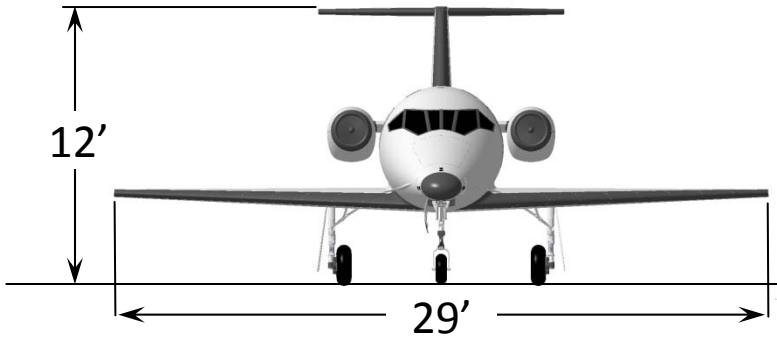


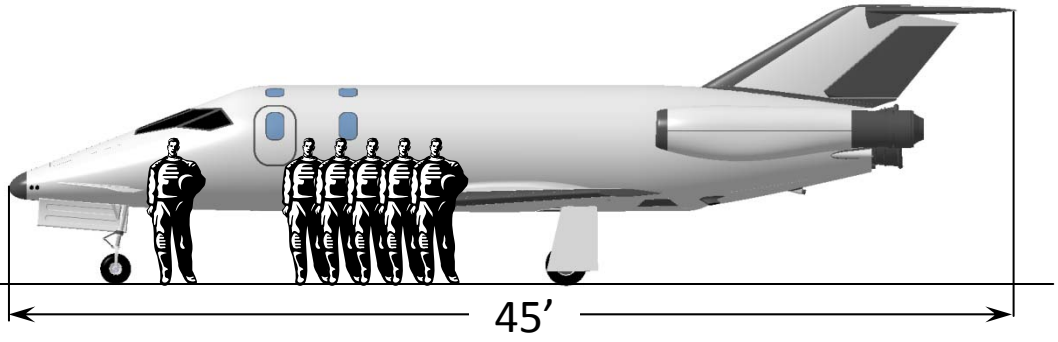
The View From 100 km

XP Vehicle Specifications

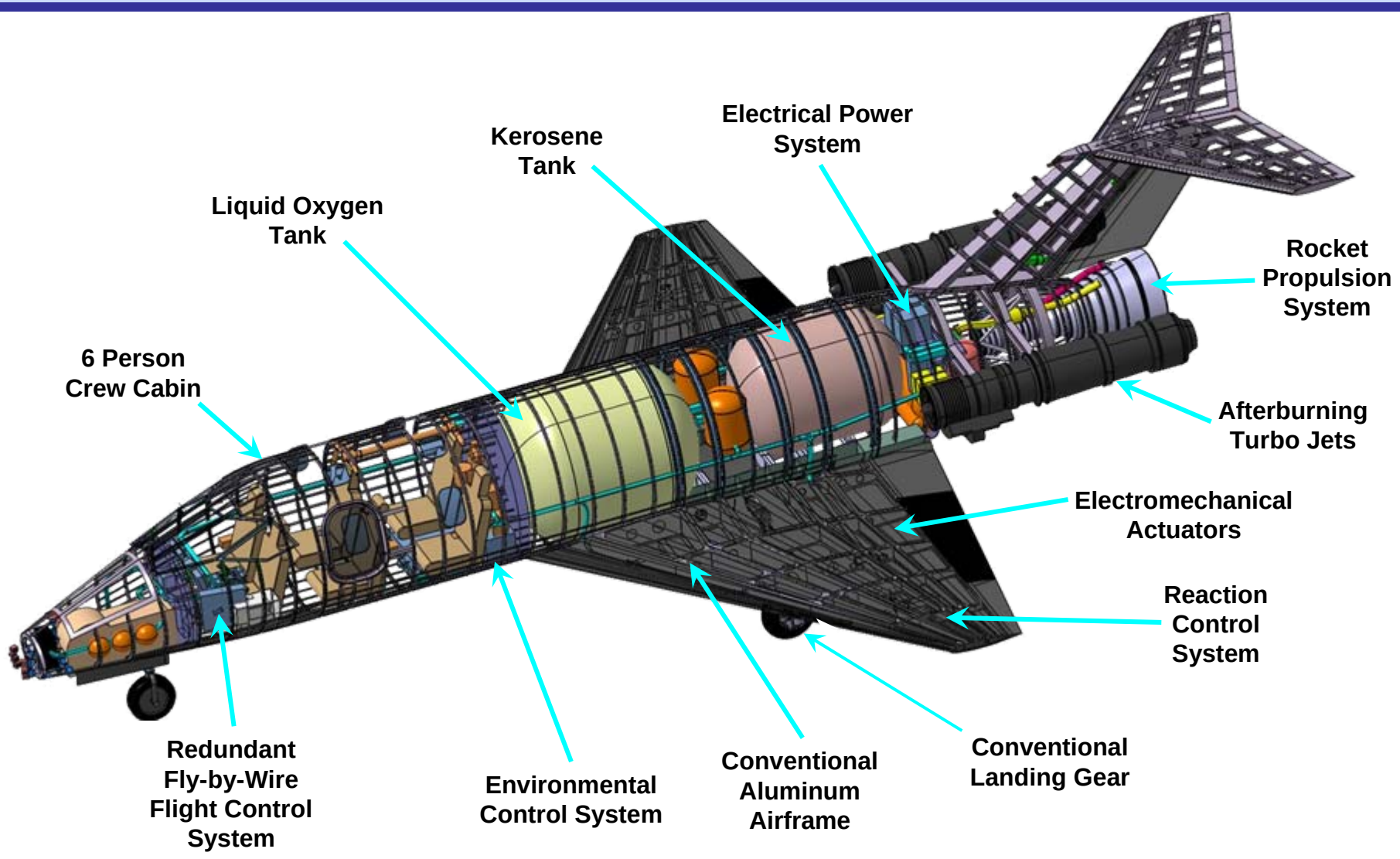
Cockpit Crew	1
Seating Capacity	6 (5 passengers + pilot)
Seat Pitch	36 in (0.91 m)
Takeoff Field Length	9200 ft (2800 m)
Landing Field Length	4300 ft (1300 m)
Max. Altitude	340,000 ft (104 km)
Mission Time (μG Time)	45 min (3+ min)
Jet Engine Type	GE J-85 w/ AB
Rocket Engine Type	Polaris AR-36







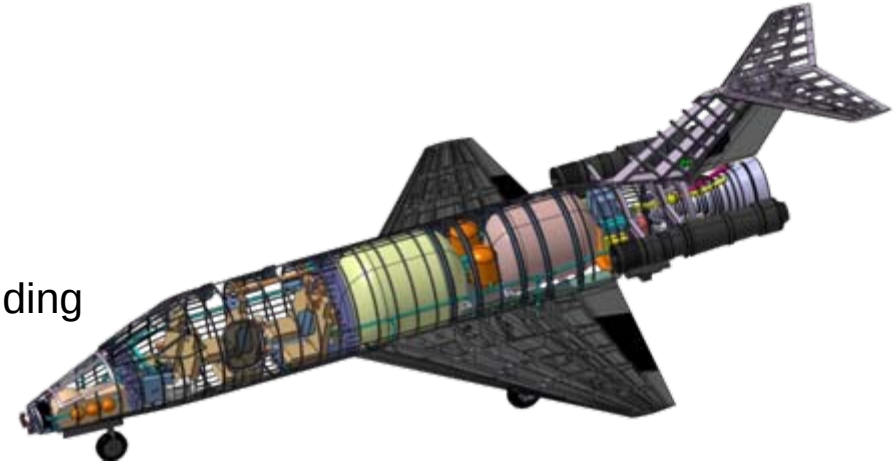
Systems Overview



Designed For Safety

- **Combined Jet-Rocket Architecture Allows More Abort Options**
  - RP is a Fuel Used By Both XP Rocket and Jet Engines
  - Designed to meet 10^{-4} Risk Standard per IAASS Safety Guidelines

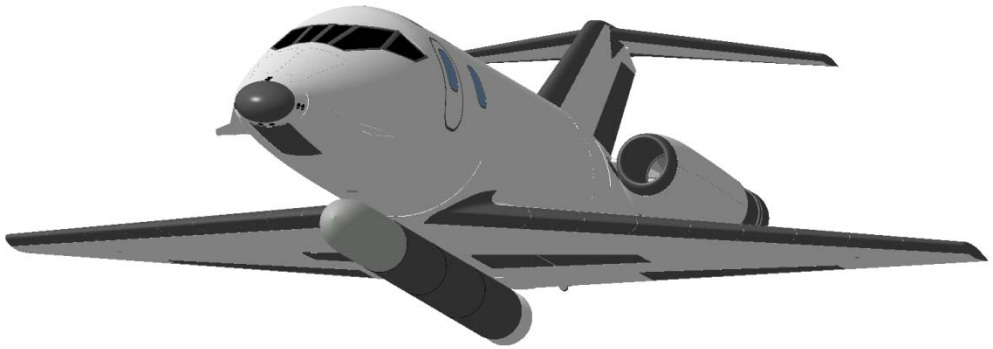
- **Abort Scenarios:**
  - During Jet-Powered Profile
    - Jettison LOX
    - Transfer RP as Required
    - Fly Conventional Aircraft Mode to Landing



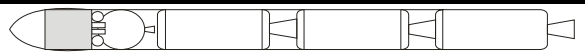
  - During Rocket Assent
    - Jettison LOX
    - Transfer RP as Required
    - Fly Conventional Aircraft Mode to Landing

  - During Ballistic Trajectory
    - Continue Unpowered Profile
    - Fly Normal Glide-Assist Aircraft Mode to Landing

Small Satellite Launch Missions



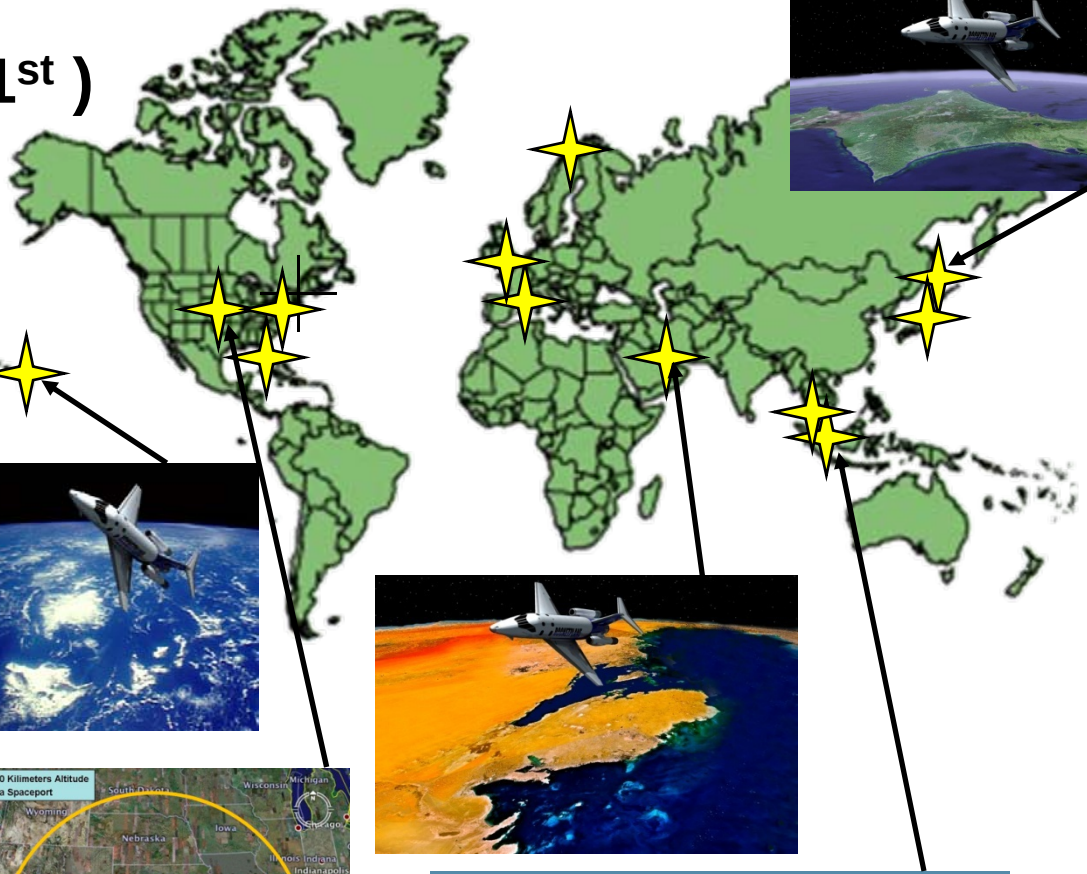
- **With Upper Stage:**
  - Micro/NanoSat ~50kg to 100km LEO
- **Reconnaissance/Tech Demo**
  - XP can carry >2000lb payload in lieu of passengers without major modification
  - At apogee horizon approximately 700 miles
  - Payload mount on seat rails, modified window viewport
  - Tech Demo: Telescopes, Star Trackers, Air Data Systems, IVHMS & other avionics
- **Operational Demonstration: Rapid Turn Around, Rapid Time-To-Launch, etc.**
-

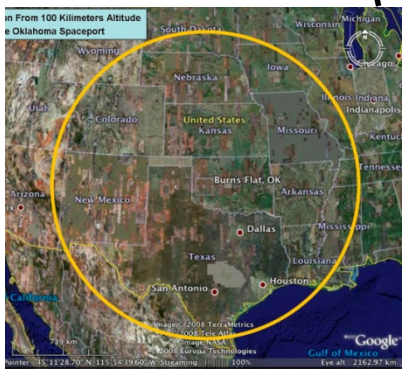
XP ORS		Upper Stage
Small Sat	~25-50kg 100km	

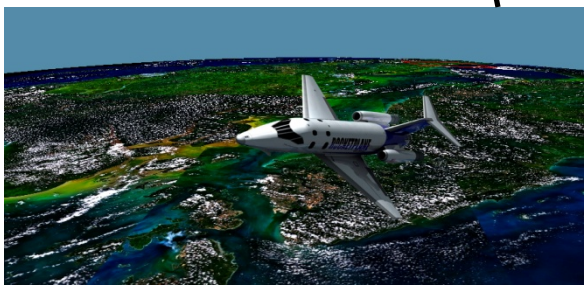
A Developing Global Spaceport Network

ROCKETPLANE GLOBAL

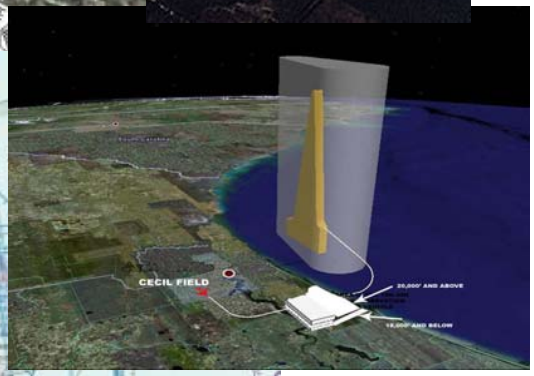
- **Spaceport Oklahoma (1st)**
  - Licensed Spaceport
  - Flight Test and Manufacturing
  - Continued 1-2 ship operations
- **Secondary Spaceports**
  - Cecil Spaceport FL
  - Kennedy Space Center
  - Spaceport Hawaii
  - Spaceport Barcelona
  - EU Spaceport Lelystad
  - Singapore Spaceport
  - Qatar Spaceport
- **Future Potentials**
  - Hokkaido Spaceport
  - Ibaraki Spaceport
  - Puerto Rico Spaceport
  - Swedish Spaceport
  - Virginia Spaceport
  - Spaceport Malaysia



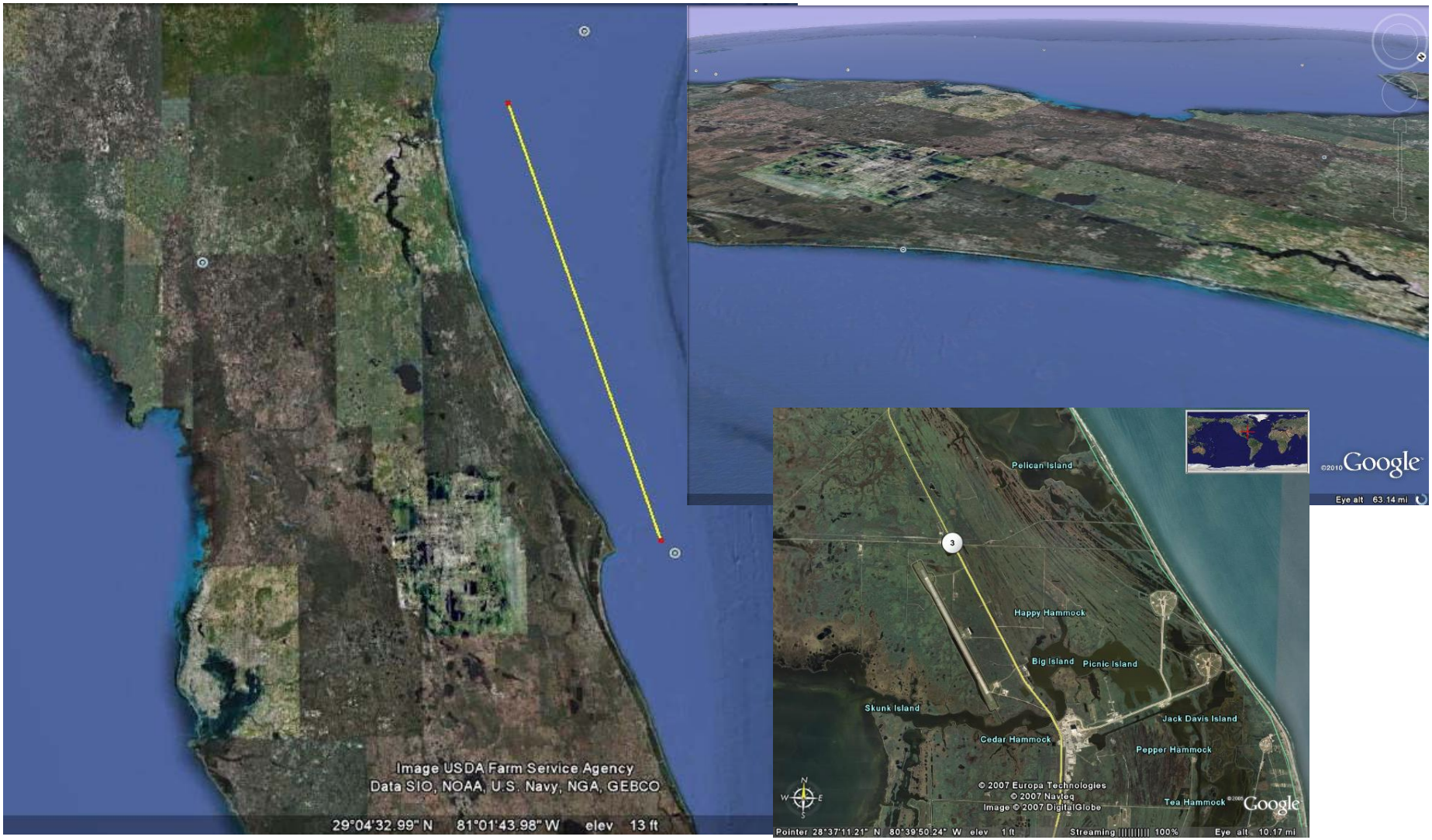




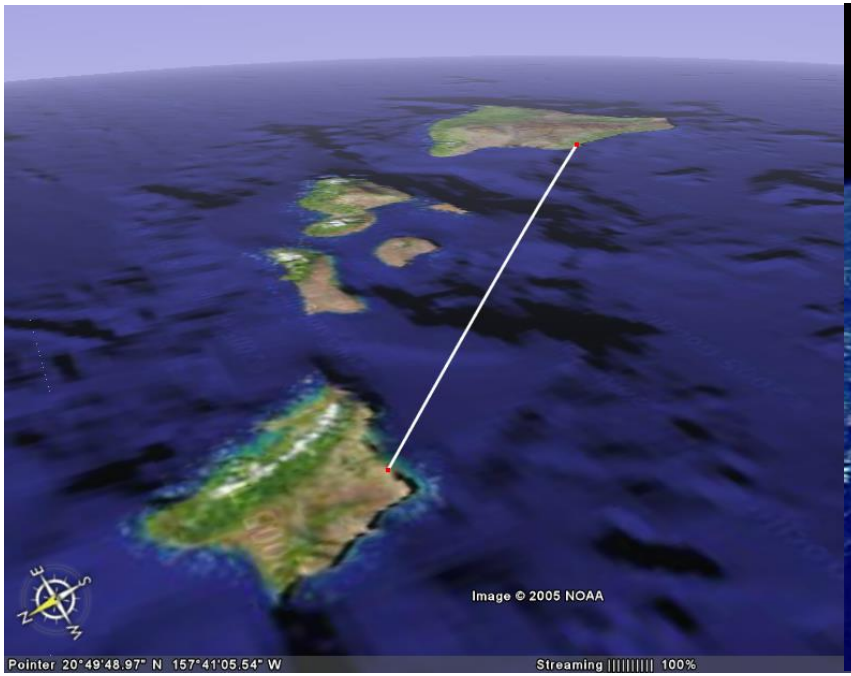
Cecil Spaceport -JAX Florida
FAA/AST License Approved



Florida P2P Testbed Corridor

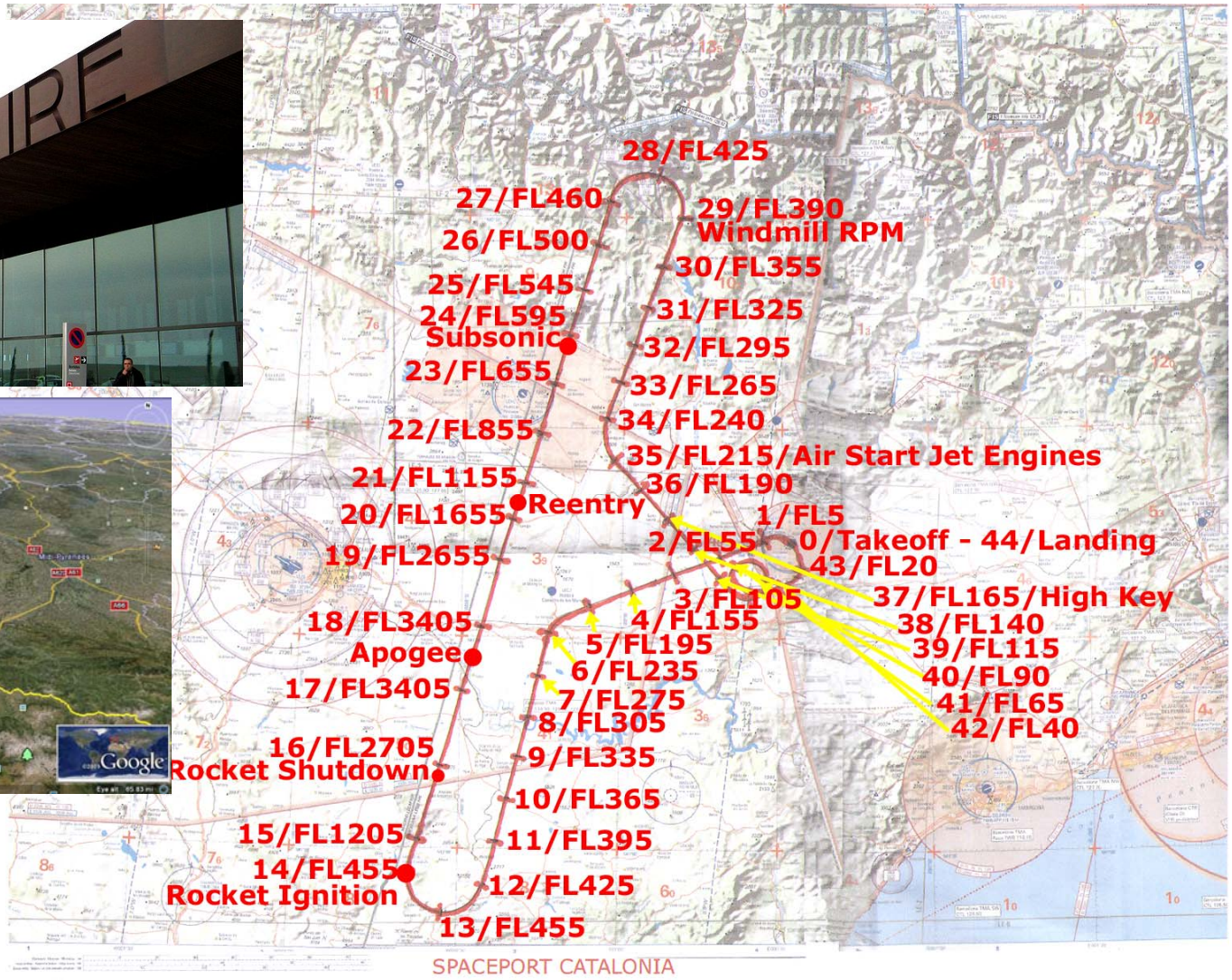


SPACEPORT HAWAII



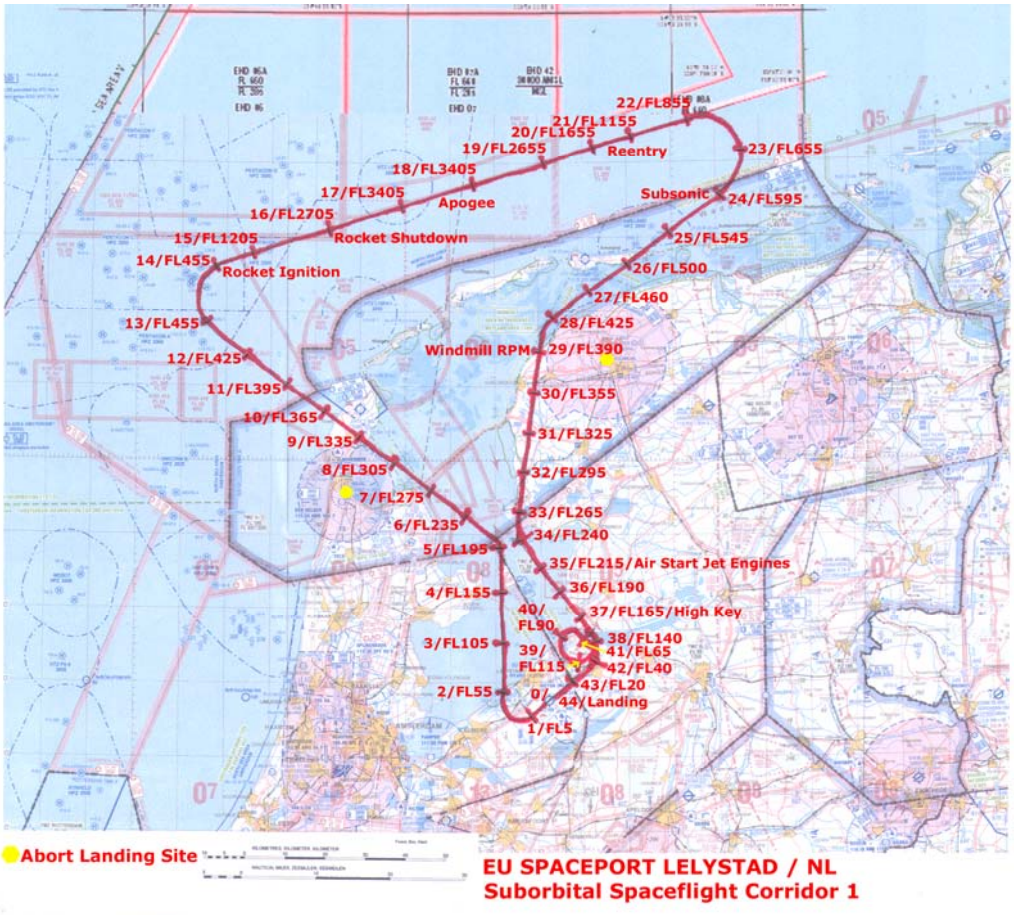
- **A Rocketplane XP Suborbital flight operations base with related space-themed tourist attraction developments**
- **Prototype business model for global spaceport projects at major tourist destinations around the world**
- **Use of existing airport infrastructure & 5 Star resort lodging**

Barcelona Spaceport



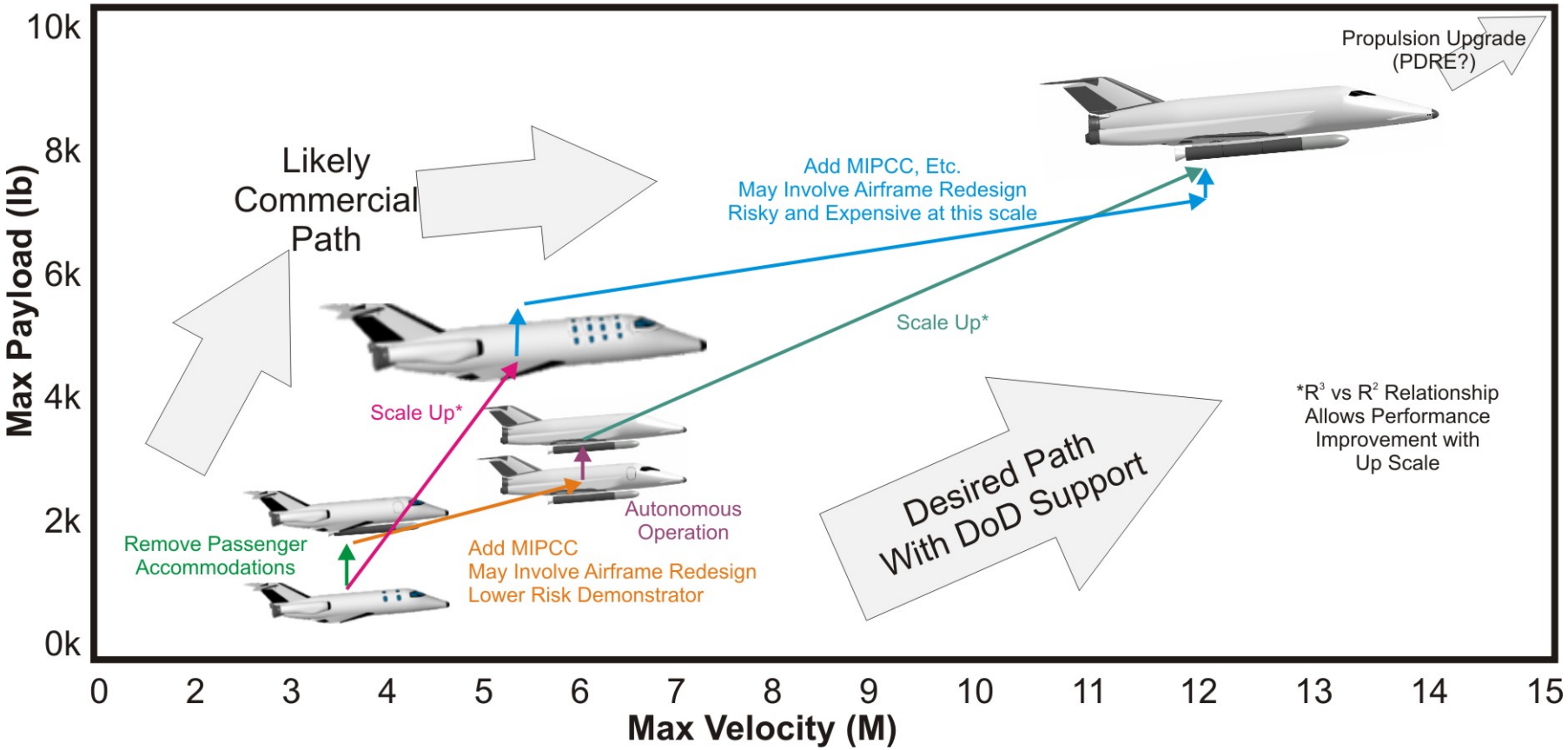
EU Spaceport Lelystad/NL

- **Dual use GA airport + Spaceport**
- **Becomes a major regional tourist attraction**
- **Leverages billions in existing tourism & culture investments**
- **Co-located with NL National Aerospace Museum**
- **Use of North Sea military restricted areas for spaceflight**



Rocketplane Growth Path

- Commercial Path unlikely to allow rapid advances in propulsive capability
- DoD Support Could accelerate development at small scale generating residual capabilities and big dividends for future capability.



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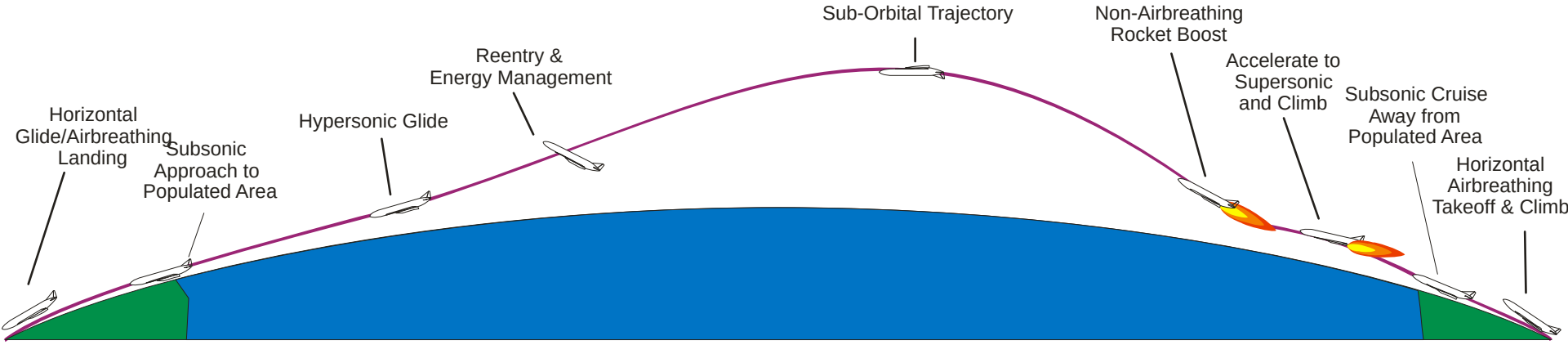
The Future Vision Is Point-To-Point

ROCKETPLANE GLOBAL

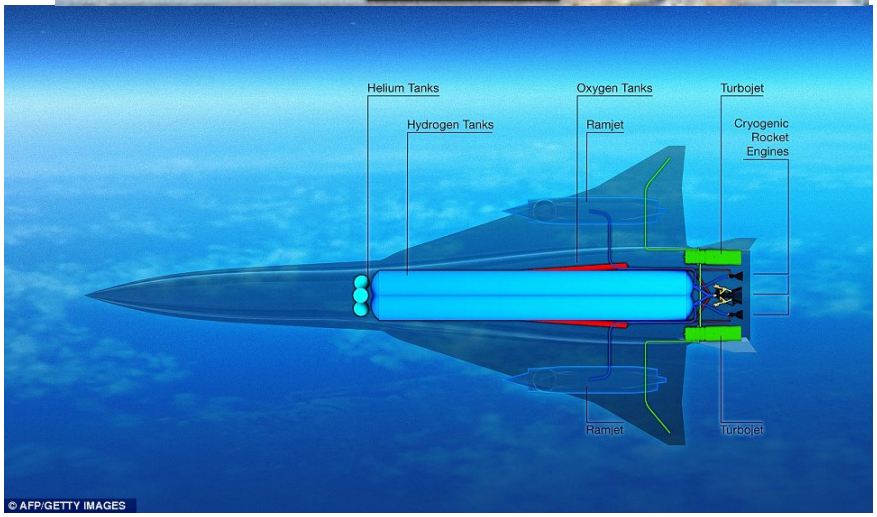
- **Develop A New Commercial Aerospace Industry**
- **Develop A World-Wide Network of Spaceports**
- **World-Wide P2P Service in <2hrs**
- **Global Same Day Logistics Service as Lead Market**

Flight	Distance	Airliner	P2P Rocketplane
New York – Los Angeles	**2,500 miles**	**5 hrs**	**1.0 hr**
Memphis – Paris	**4,600 miles**	**9.25 hrs**	**1.25 hrs**
Los Angeles – Tokyo	**5,500 miles**	**12 hrs**	**1.5 hrs**



Other Hypersonic Concepts

Reaction Engines LAPCAT A2 Mach 5 300 Passenger Transport

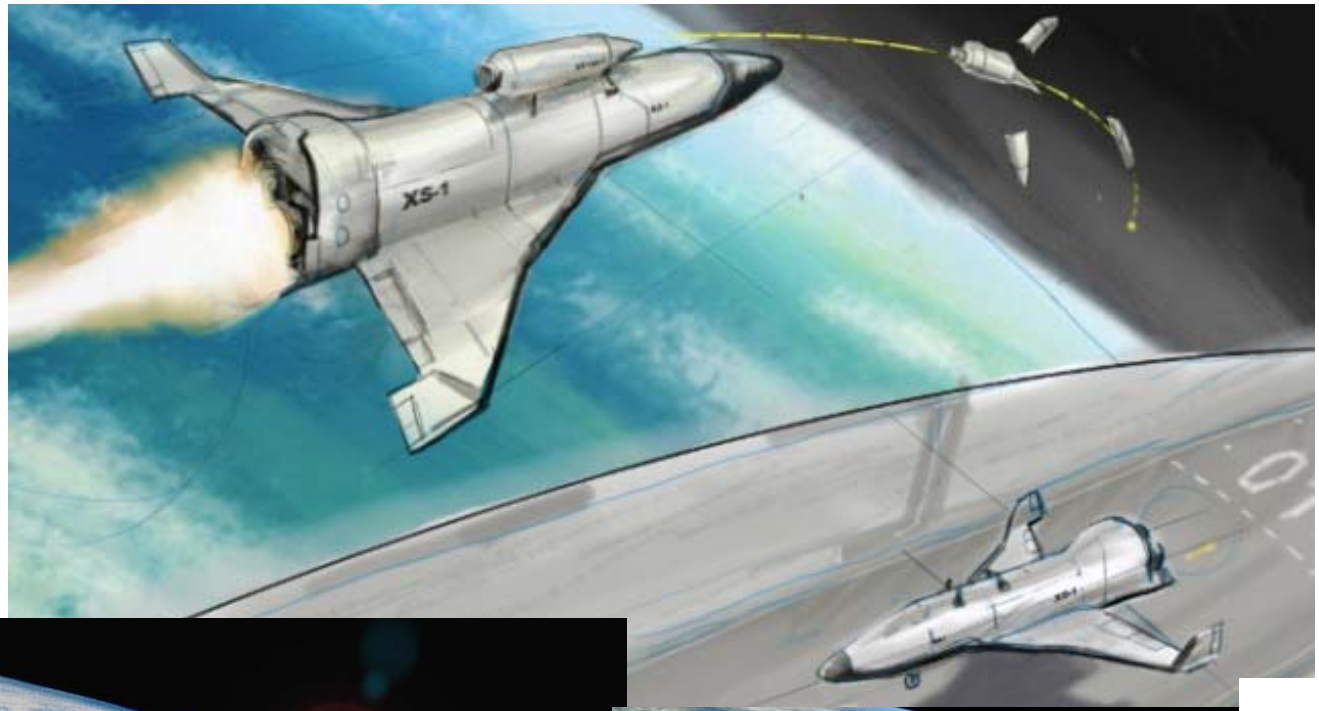


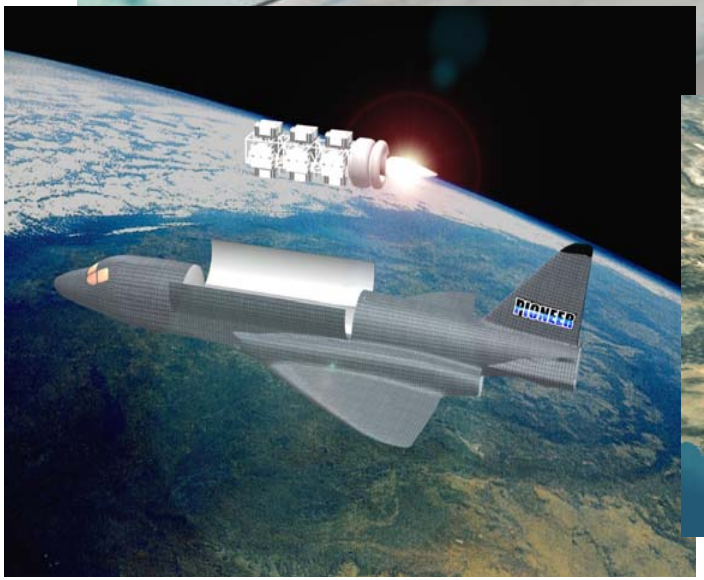
Astrium ZEHST Mach 4

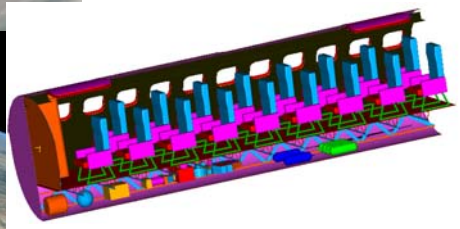
50-100 Passenger Transport

DARPA XS-1 Mach 10 Spaceplane

ROCKETPLANE GLOBAL







First EU Suborbital International Passenger and Cargo Hub

ROCKETPLANE GLOBAL

Netherlands to Spain Spaceflight Corridor

Netherlands to Doha Spaceflight Corridor

Netherlands to Singapore Spaceflight Corridor

Licensing vs. Certification

- **FAA/AST adopted “Fly at your own risk” regulatory model WITH informed consent and signed waivers of liability**
- **Launch licensing protects public safety but NOT space flight participants**
- **Legislation designed to allow new industry to grow and learn BEFORE moving to higher regulatory standards**
- **Flexible Guidelines promote safety without overly restrictive regulatory burden**

Certification Cost Example

- **Embraer Phenom 300 vs. Learjet 25**

- Cruise Speed: 834 km/h Mach 0.78
- Range: 3,650 km
- Passengers: 9 (+1 crew)
- Ceiling: 13,715 m
- Climb Rate: 20.2 m/sec
- Year Certified: 2009
- Price: ~ $8,000,000

- Cruise Speed: 859 km/h Mach 0.81
- Range: 2,853 km
- Passengers: 8 (+2 crew)
- Ceiling: 13,715 m
- Climb Rate: 30.7 m/sec
- Year Certified: 1967
- Price: ~ $500,000

Phenom 300 Certification Costs

- **Quote from Embraer Press Release**
  - "The overall certification campaign involved five aircraft that performed more than 1,200 flight test hours, certifying the aircraft for RVSM (Reduced Vertical Separation Minimum), day and night IFR (Instrument Flight Rules) operations, and flying into known and forecasted icing conditions. In addition, there were full-scale static and fatigue tests, and rigs were used for environmental, avionics, and electrical systems."
- **400 engineers working for 3 years +**
- **Total investment ~ $1 billion**