Manfred Lochs Conference on Regulation of Emerging Modes of Transportation

XP Program Briefing

May 24, 2013

The Suborbital Markets

Figure 1: SRV market definitions

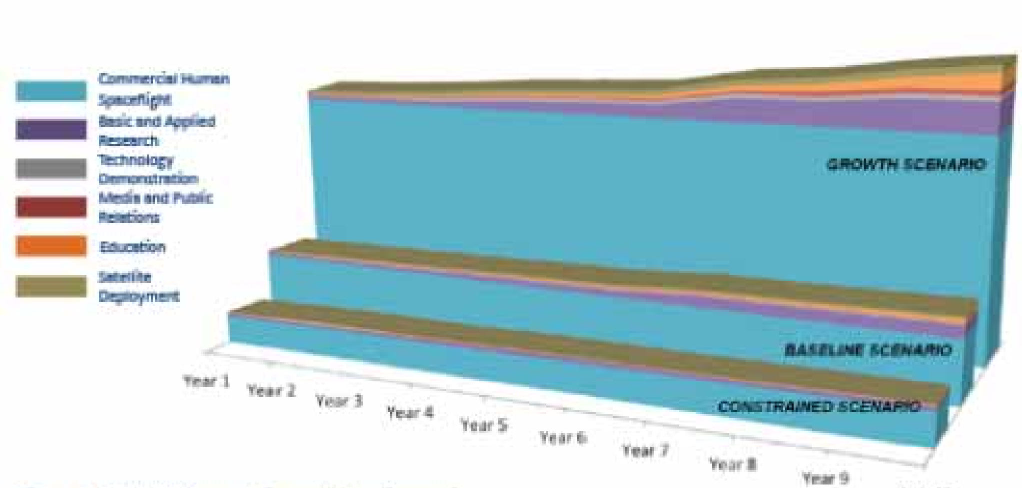


Figure 2: Total SRV forecast by market and scenario

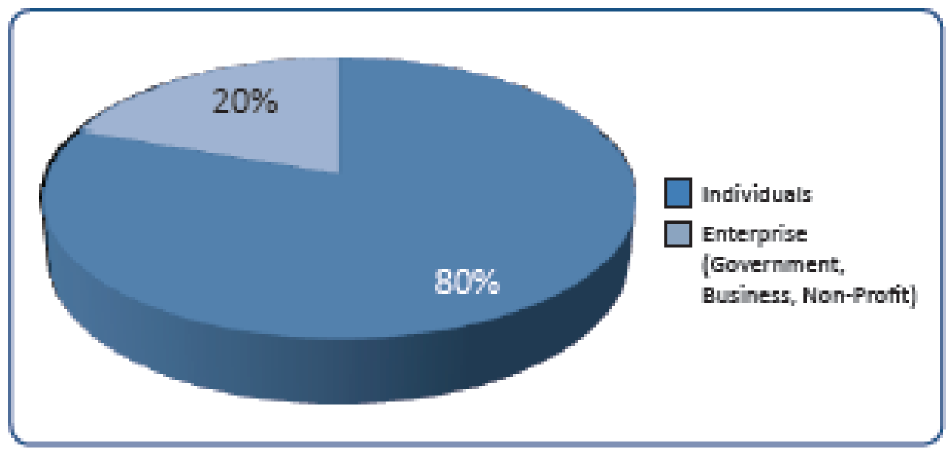
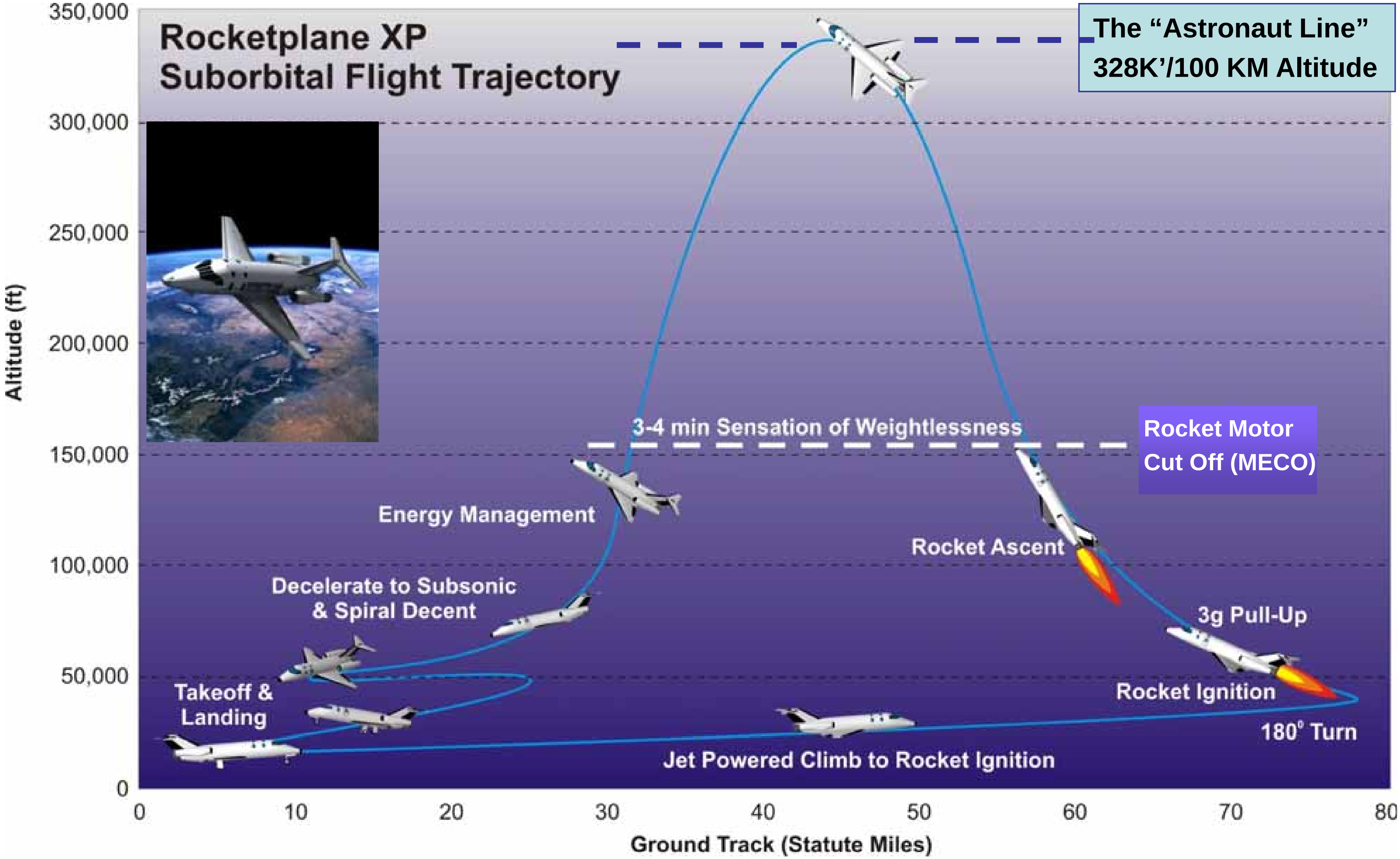


Figure 5: Enterprise demand and individual demand in baseline case

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

The Rocketplane Flight Profile

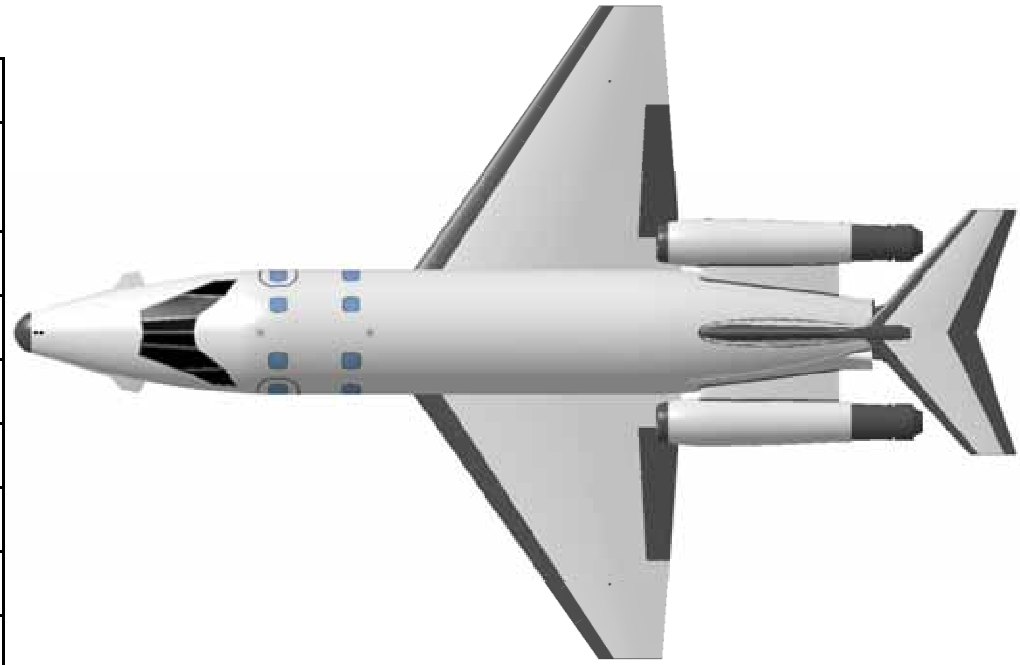


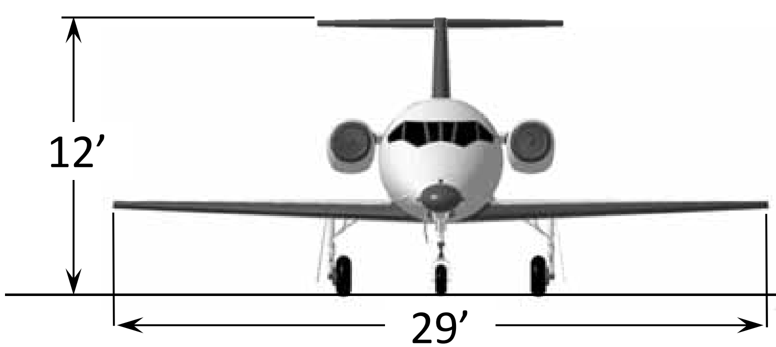
The View From 100 km

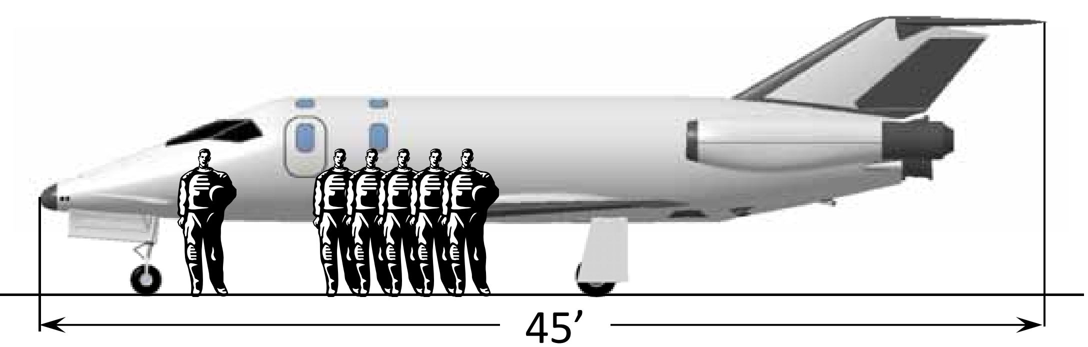
XP Vehicle Specifications

ROCKETPLANE GLOBAL

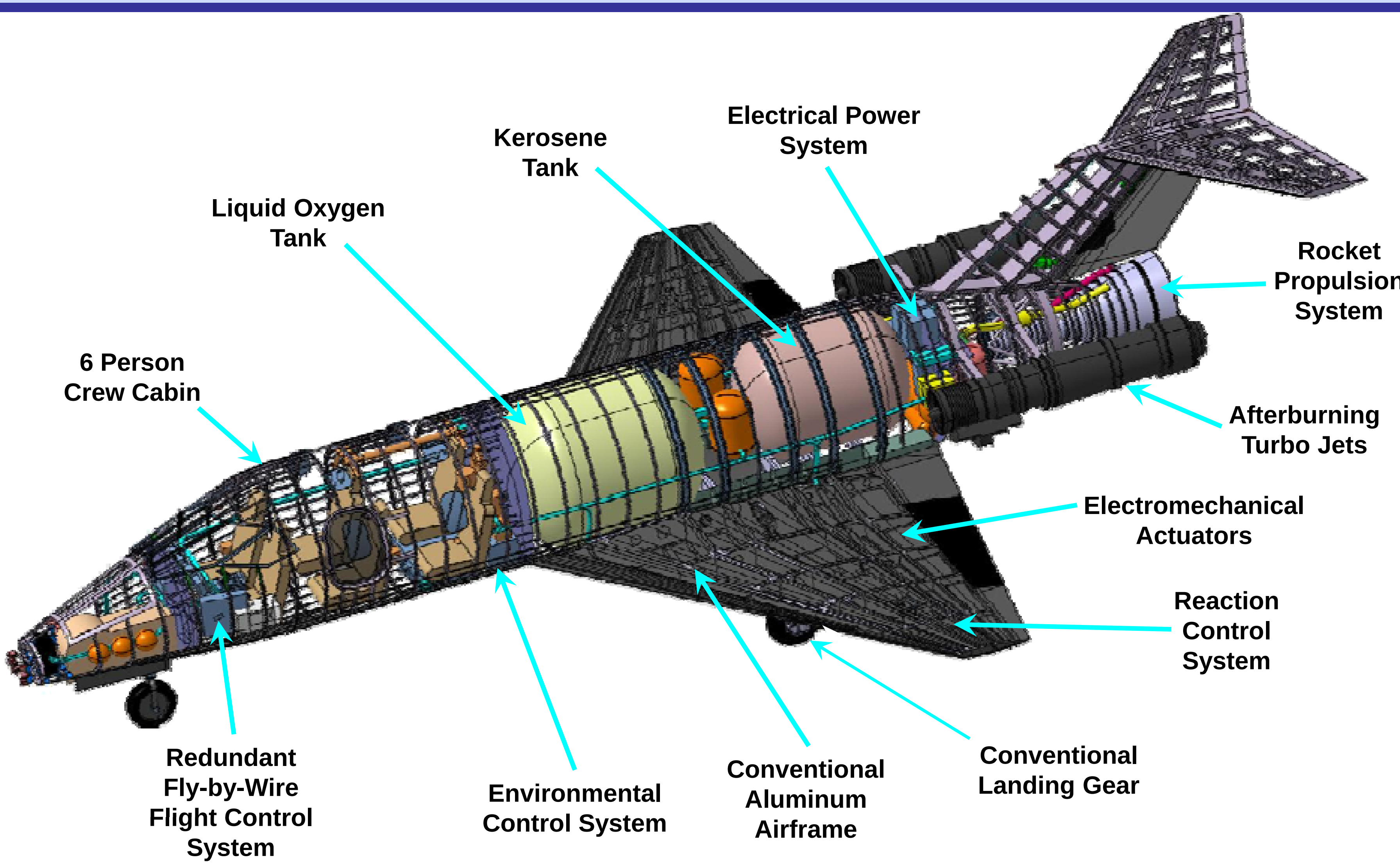
Cockpit Crew	1
Seating Capacity	6 (5 passengers + pilot)
Seat Pitch	36 in (0.91 m)
Takeoff Field Length	9200 ft (2800 m)
Landing Field Length	4300 ft (1300 m)
Max. Altitude	340,000 ft (104 km)
Mission Time (μG Time)	45 min (3+ min)
Jet Engine Type	GE J-85 w/ AB
Rocket Engine Type	Polaris AR-36







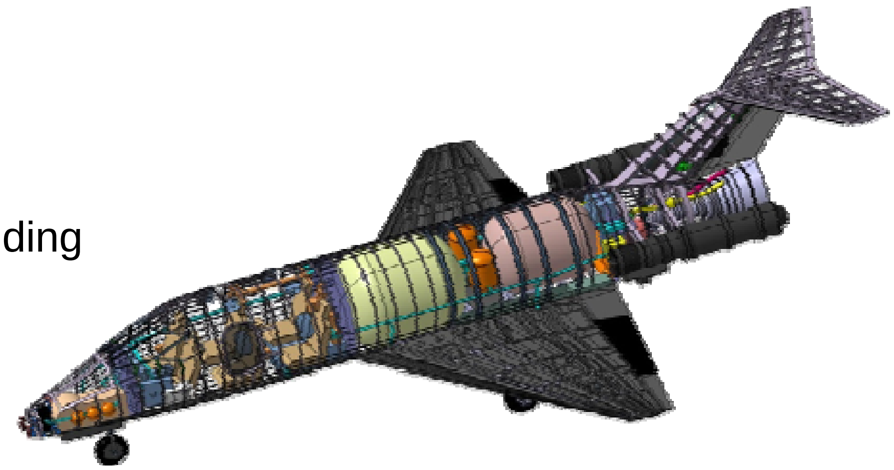
Systems Overview



Designed For Safety

- **Combined Jet-Rocket Architecture Allows More Abort Options**
  - RP is a Fuel Used By Both XP Rocket and Jet Engines

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



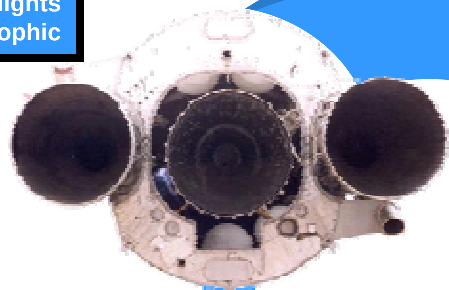
  - During Rocket Assent
    - Jettison LOX
    - Transfer RP as Required
    - Fly Conventional Aircraft Mode to Landing

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

Proven Rocket Technology

ROCKETPLANE GLOBAL

Atlas Sustainer Engine
(1959) *Rocketdyne*
Over 550 Successful Flights
Only 3 failures all non-catastrophic



Navajo (1956)
North American Aviation

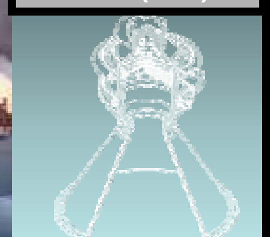
Thor / LR-79 (1958)
Rocketdyne

Atlas booster (1959)
Rocketdyne

Delta (1960)
Boeing

Saturn H-1 (1959)
Rocketdyne

RS-88 (2004)



POLARIS

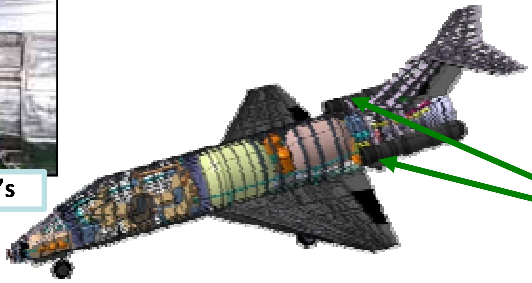
Polaris AR-36 (2008)	
Propellants	LOX / RP
Isp (vac)	309 sec
Thrust (vac)	36,000 lbf
Thrust to Weight	80

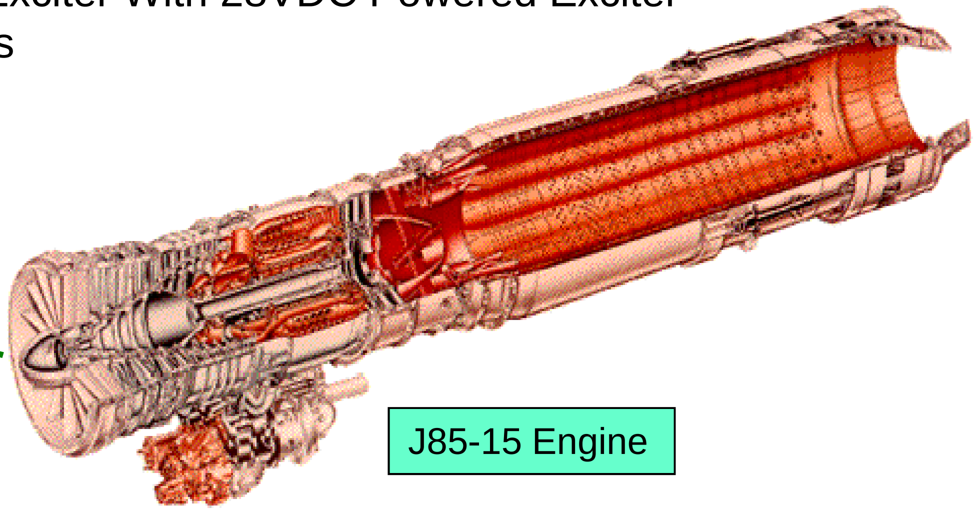
This

Jet Propulsion System

- **XP Uses Two J85-15 Turbojet engines**
  - Millions of Operating Hours- Military and Commercial
  - Each provide 4300 lbf of thrust 11 engines Purchased from Canadian Air Force

- **Orenda Turbines Selected Supplier**
  - Subsidiary of Magellan Aerospace Corp
  - Repair, Modification and Testing
- **Modifications:**
  - Replace QEC Kit With Air Start Inlet Check Valve For Ground Start Capability
  - Replace the AC-Powered Ignition Exciter With 28VDC Powered Exciter
  - Blank Off the Customer Bleed Ports



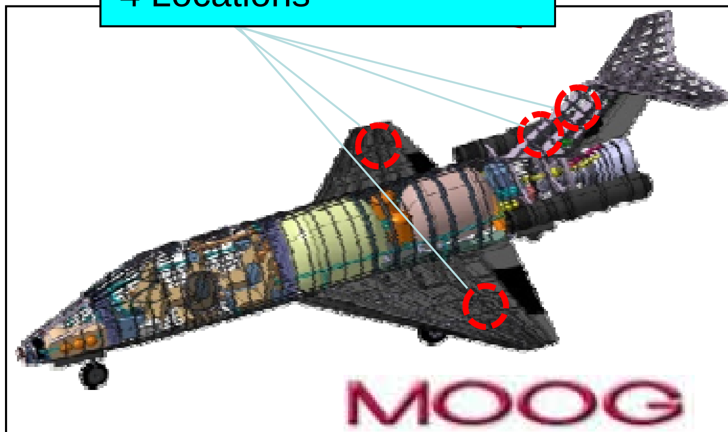


Flight Control Actuators

- **Use: Atmospheric Attitude Control and Maneuverability**
- **Design:**
  - **Off-The-Shelf, Proven Design**
  - **Used on Boeing 787**
  - **Developed by Moog**
  - **Quality Supplier With Decades of Aerospace Experience Electromechanical Actuators**
  - **Drive Flaperons, Horizontal Stabilizer, Rudder**
  - **System is Redundant and Fully Electric (270V)**
- **Status**
  - **Firm Fixed Price From Moog**
  - **Conceptual Design Complete**

Boeing 787

Common Actuator In All 4 Locations

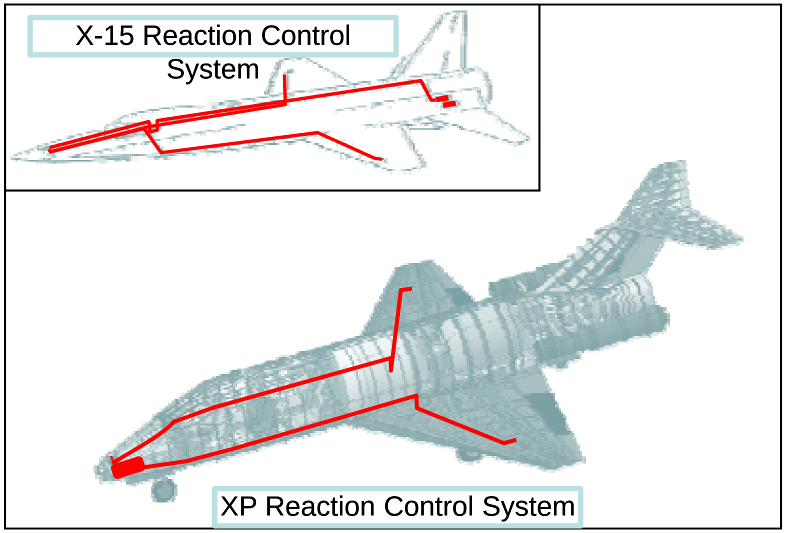


•Fully Electric
•Redundant Motors

XP Actuator

Reaction Control System

- **Use: Space Attitude Control and Maneuverability**
- **Design:**
  - **Off-The Shelf Components, Proven Design**
  - **Used For Maneuvering During Space Flight**
  - **Based on X-15 Flight Control System**
  - **Hot Gas System Utilizing 90% H_2O_2**
  - **Pitch and Yaw Thrusters: 75 lbf**
  - **Roll Thrusters: 15lbf**
  - **Eight Thrusters In Nose**
  - **Two On Each Wing**
  - **Redundant For Safety**
- **Status:**
  - **Conceptual Design Established**
  - **Notional Routing Layout Complete**



Landing Gear System

ROCKETPLANE GLOBAL

Landing Gear System: Simple Design With Off-The-Shelf Components

- **Design**
  - Based on Gear From the F-5 Fighter Jet
  - Features Nose Wheel Steering
  - Features Brakes/Antiskid Functions
  - Self-Contained Electro-Hydraulic Retract/Deploy System
- **Status**
  - Conceptual Design Complete


SR-71


F-117


F-16


F-5


F-18

ECLSS Preliminary Design Is Mature

ECLSS Test Chamber

- Complete and Checked Out
- Used For Development & Qualification Testing
- Interim Technical Review completed May 06
- ECLSS design at PDR level
- Components identified
- Schematic complete
- FMECA Completed

Camera System

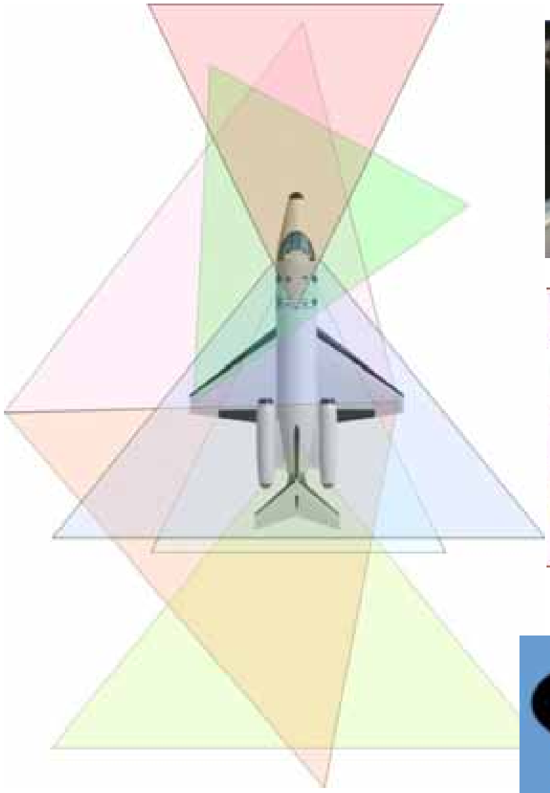
ROCKETPLANE GLOBAL

- **XP Camera Uses**
  - **Flight Test (Visual and IR (Heat) Capable)**
  - **Hi-Res Science and Reconnaissance Missions**
  - **Passenger “SPACE VISION”**

Cameras

Video Compression Unit

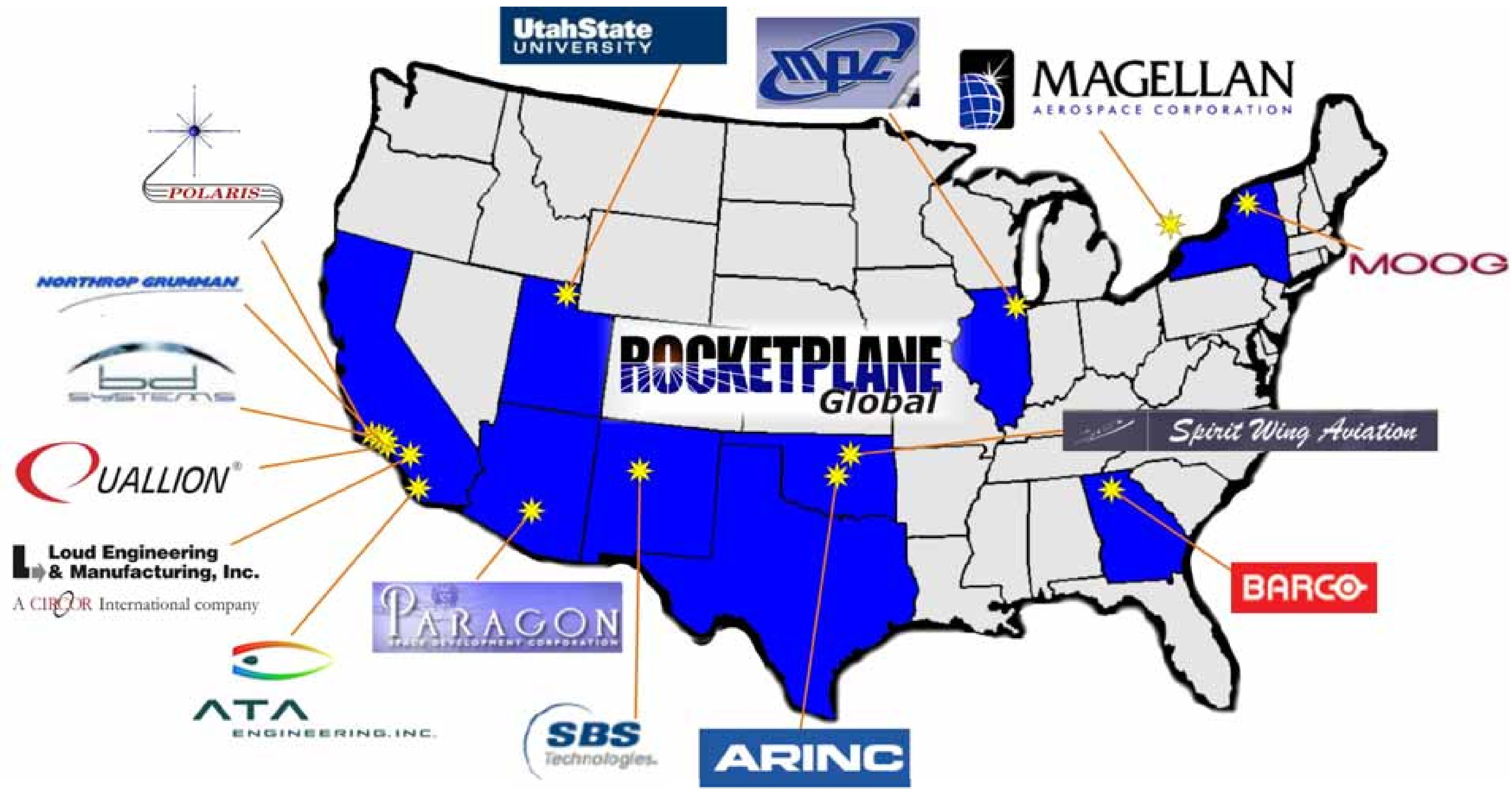
- **XP Has 8-Camera System**
  - **Part of Data Acquisition System (DAS)**
  - **5+ Lenses Available for Tailored Views, Even “Fish-eye”**
  - **Full Resolution Video Compressed and Stored on Board**
  - **Variable Frame Rate & Resolution Transmitted to Ground**
  - **Full Resolution Streamed to Passenger Monitors-”SPACE VISION”**



- **Flight Proven Hardware Flown on Shuttle, Multiple NASA and DoD Missions**

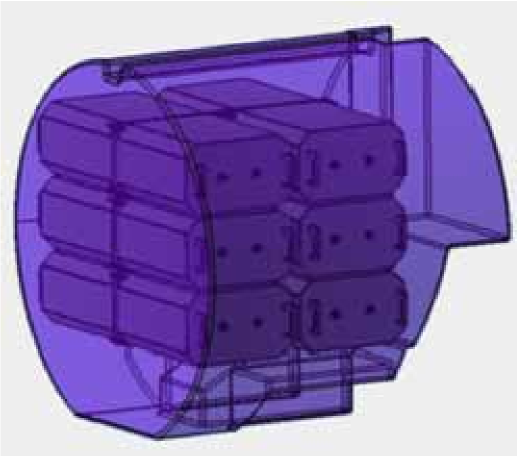
ECLIPTIC

Contractor Team

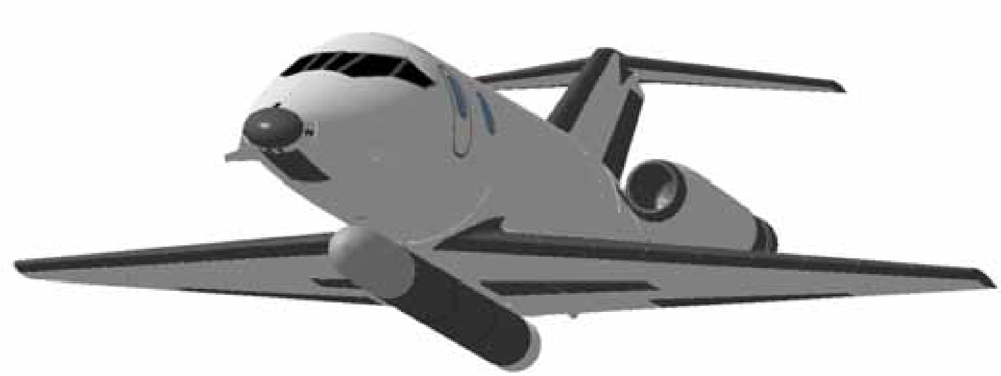


NASA KSC FastRack Program

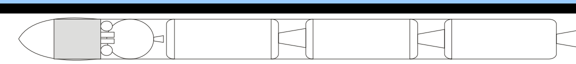
- **GOAL – bring suborbital microgravity research activity to KSC**
- **Modular System**
  - 1 FastRack = 1passenger seat
- **Prototype Completed**
- **Flight Testing August 2009**
- **Space Life Sciences Lab payload integration support facilities available**
- **XP provide on-board Payload Specialist work station for customers**



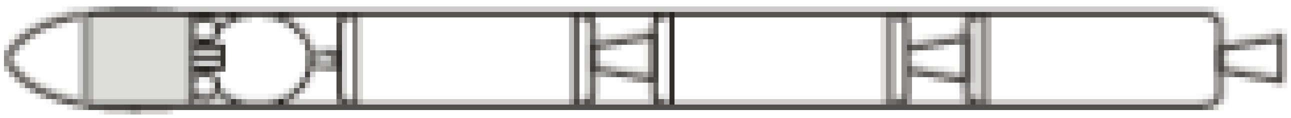
Small Satellite Launch Missions



- **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	

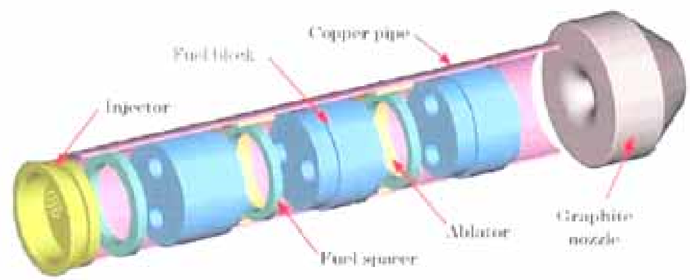
Several Upper Stage Options

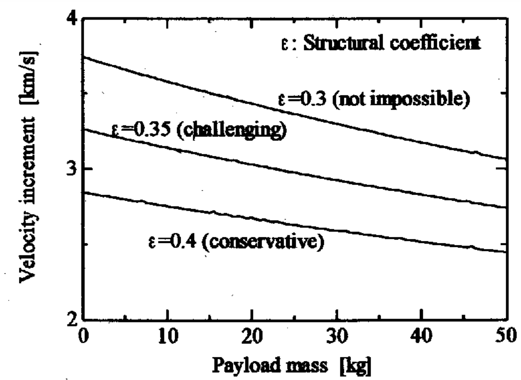


Star 20B Stack – MATRA alternative?

CAMUI Hybrid Rocket

New Liquid Fuel Upper Stages

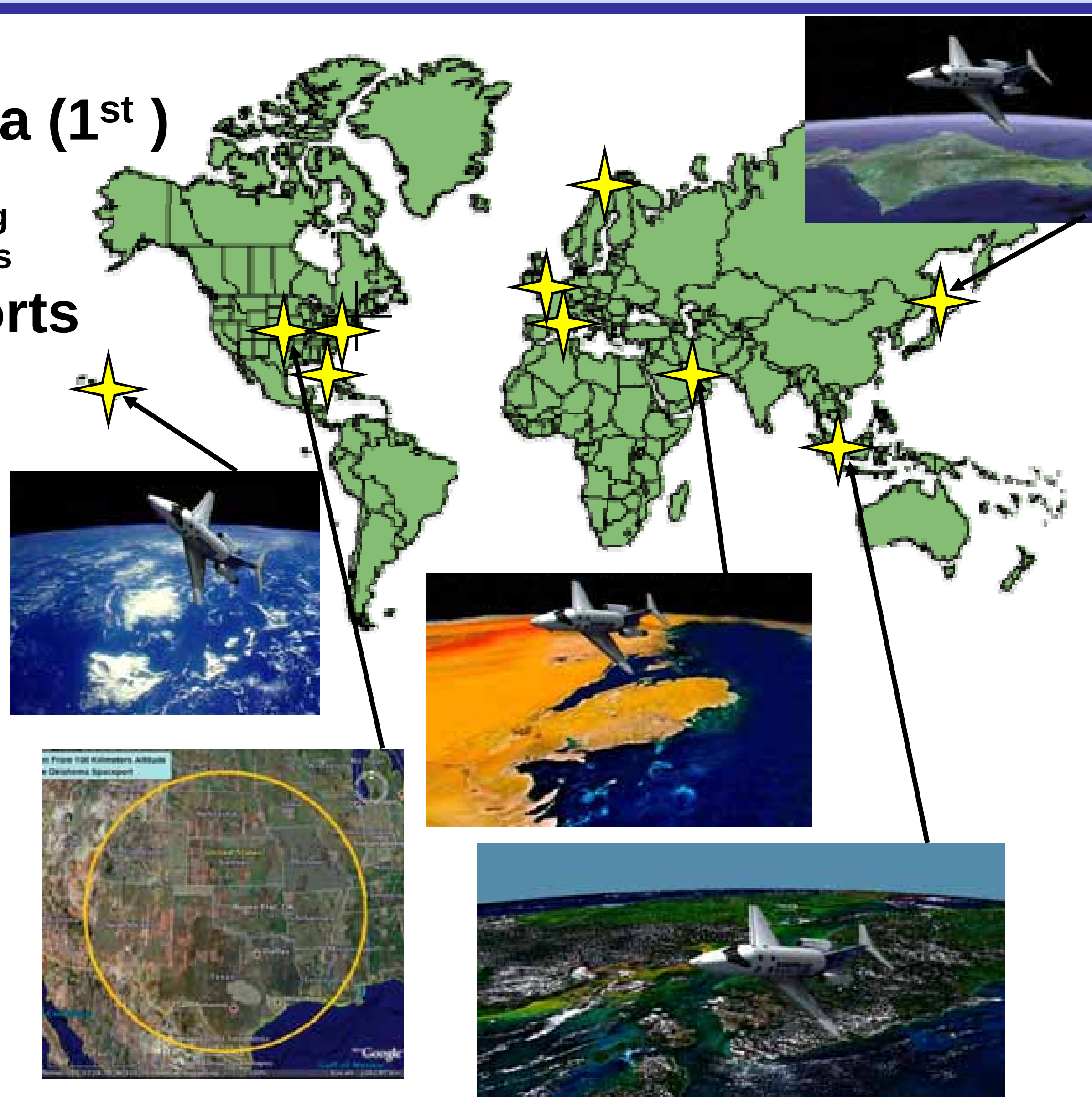




Velocity increment vs. Payload mass (Isp = 317 s)

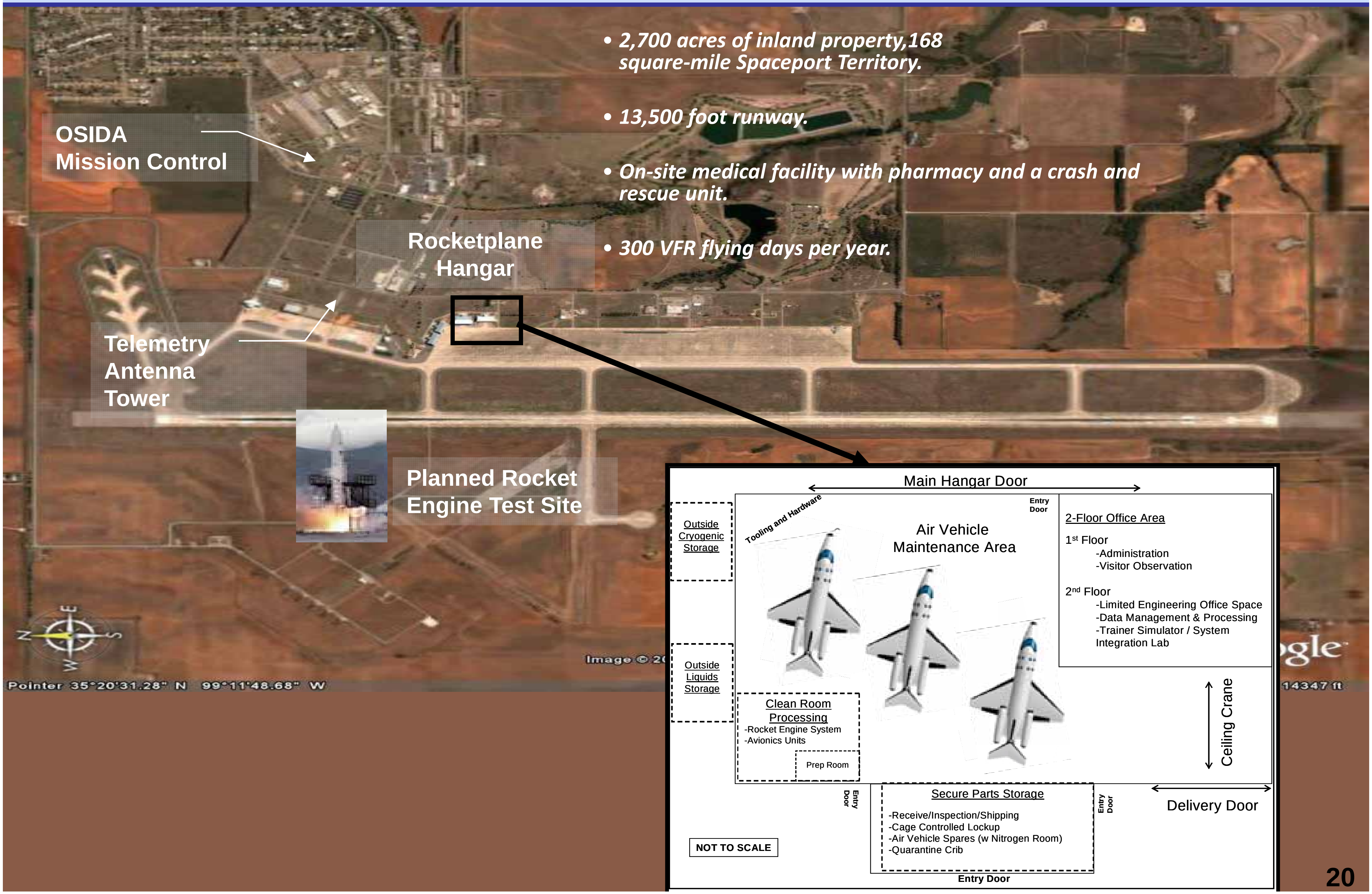
A Global Spaceport Network

- **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
- **Future Potentials**
  - Hokkaido Spaceport
  - Puerto Rico Spaceport
  - Swedish Spaceport
  - Virginia Spaceport

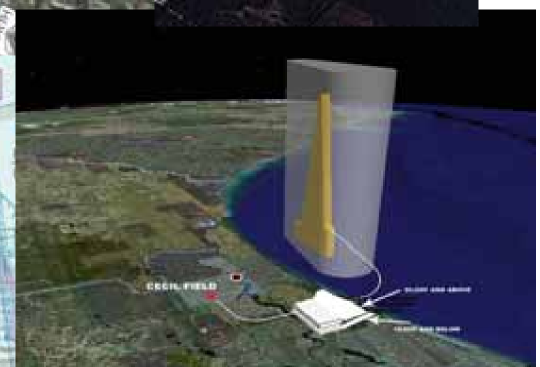


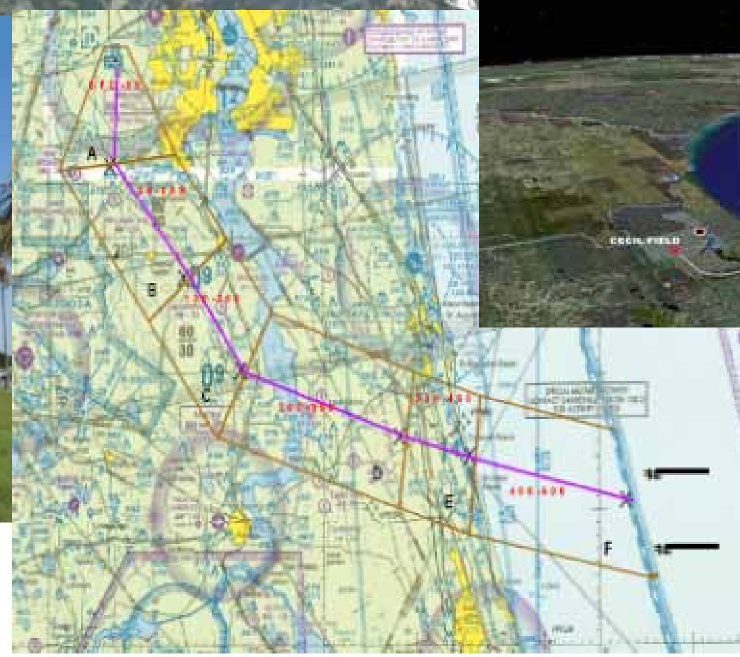
Oklahoma Flight Operations

- *2,700 acres of inland property,168 square-mile Spaceport Territory.*
- *13,500 foot runway.*
- *On-site medical facility with pharmacy and a crash and rescue unit.*
- *300 VFR flying days per year.*



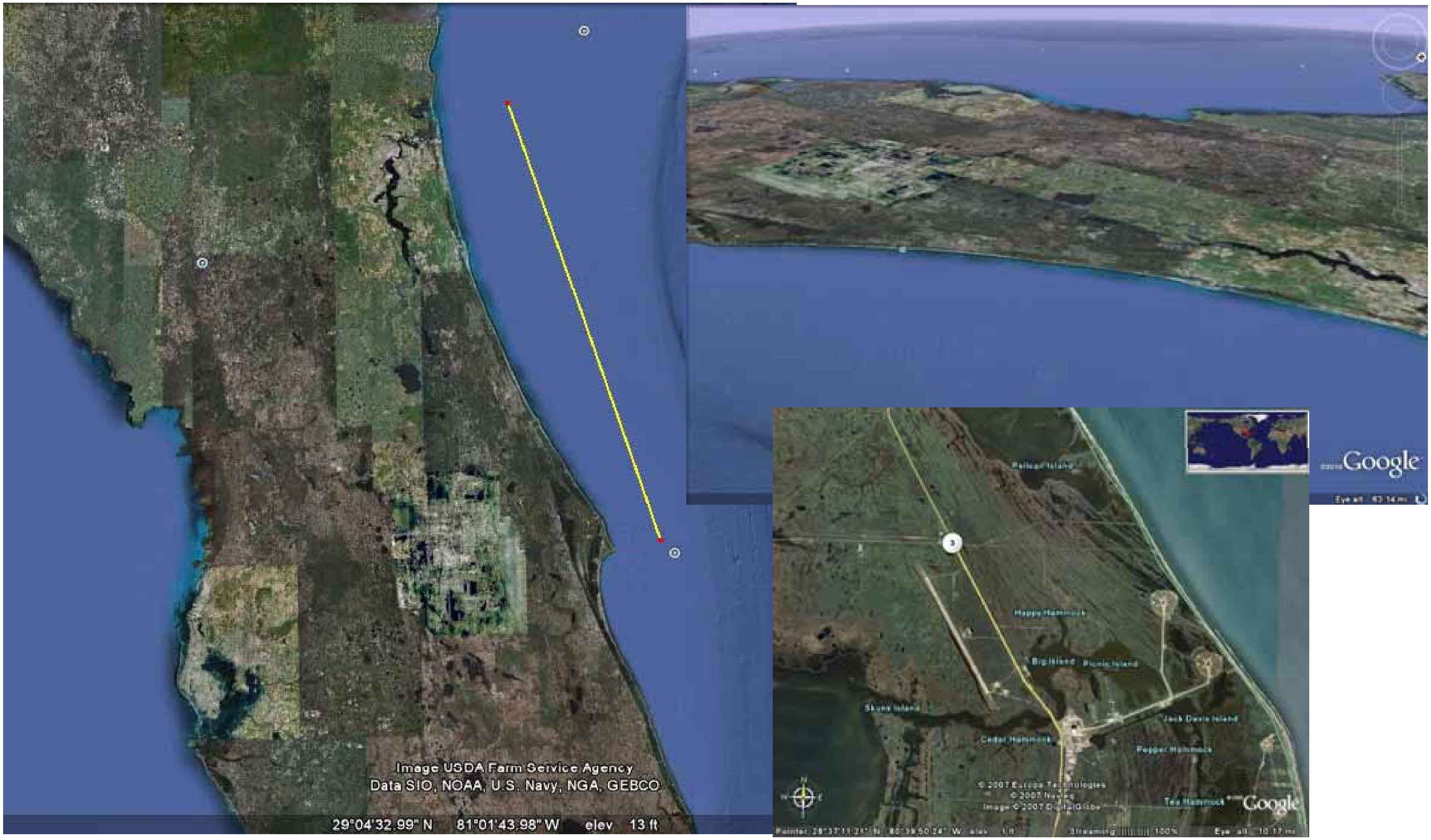
Cecil Spaceport -JAX Florida
FAA/AST License Approved





Florida P2P Testbed Corridor

ROCKETPLANE GLOBAL

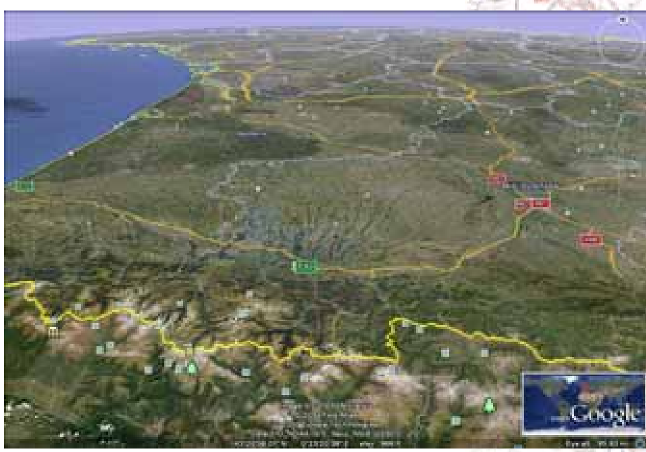


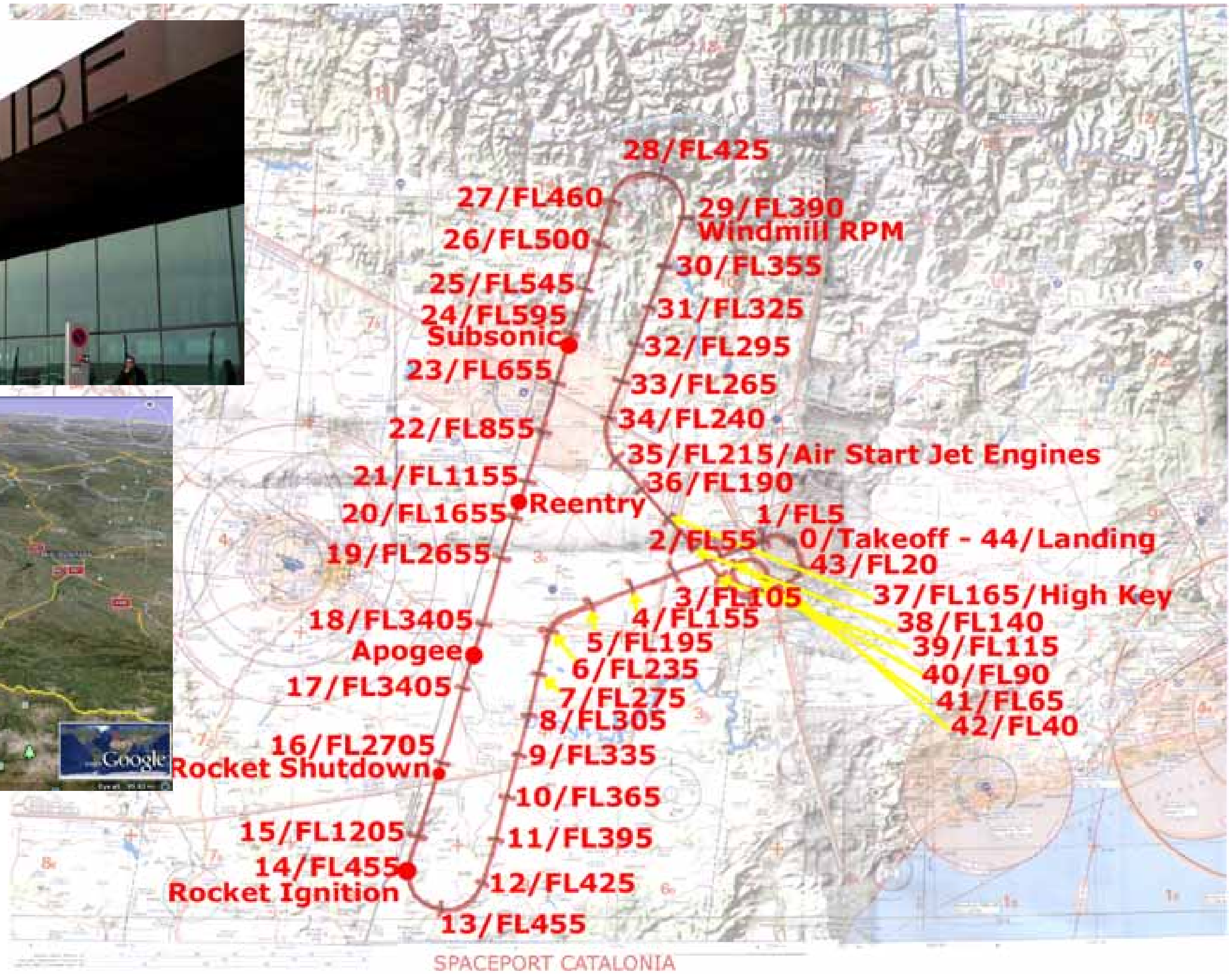
SPACEPORT HAWAII

ROCKETPLANE GLOBAL

- 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

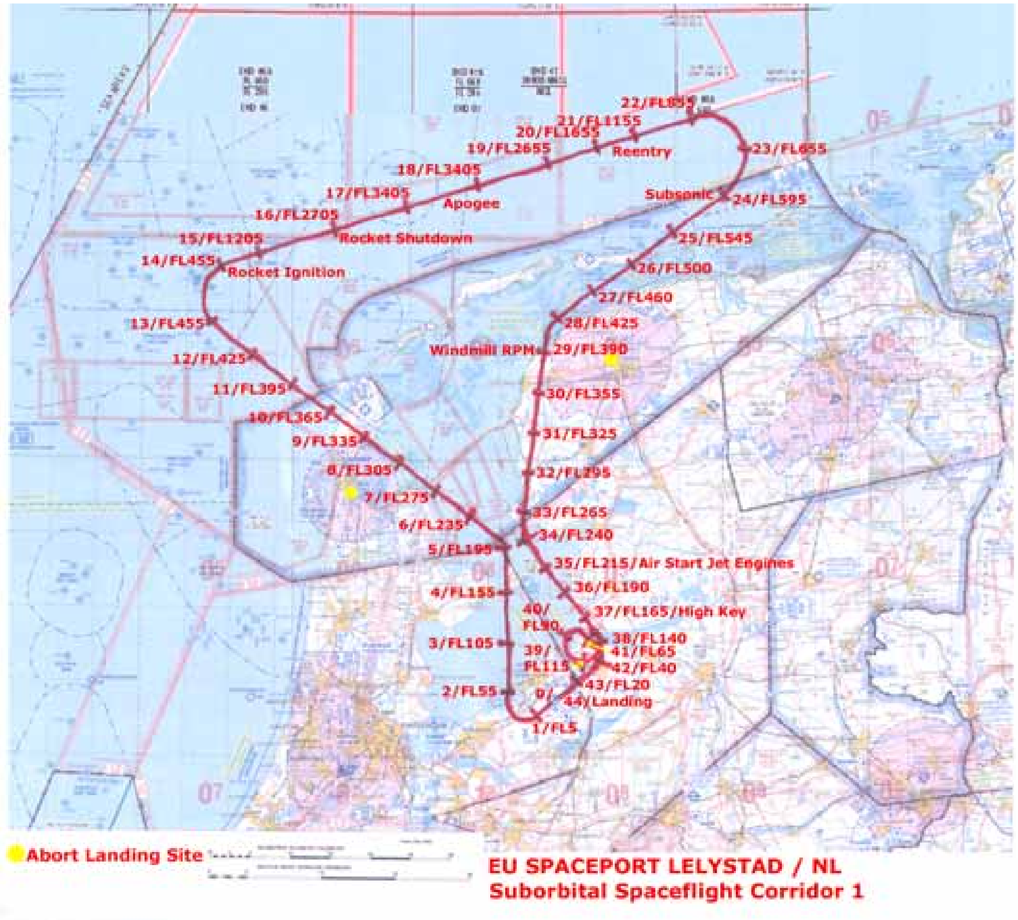
Barcelona Spaceport





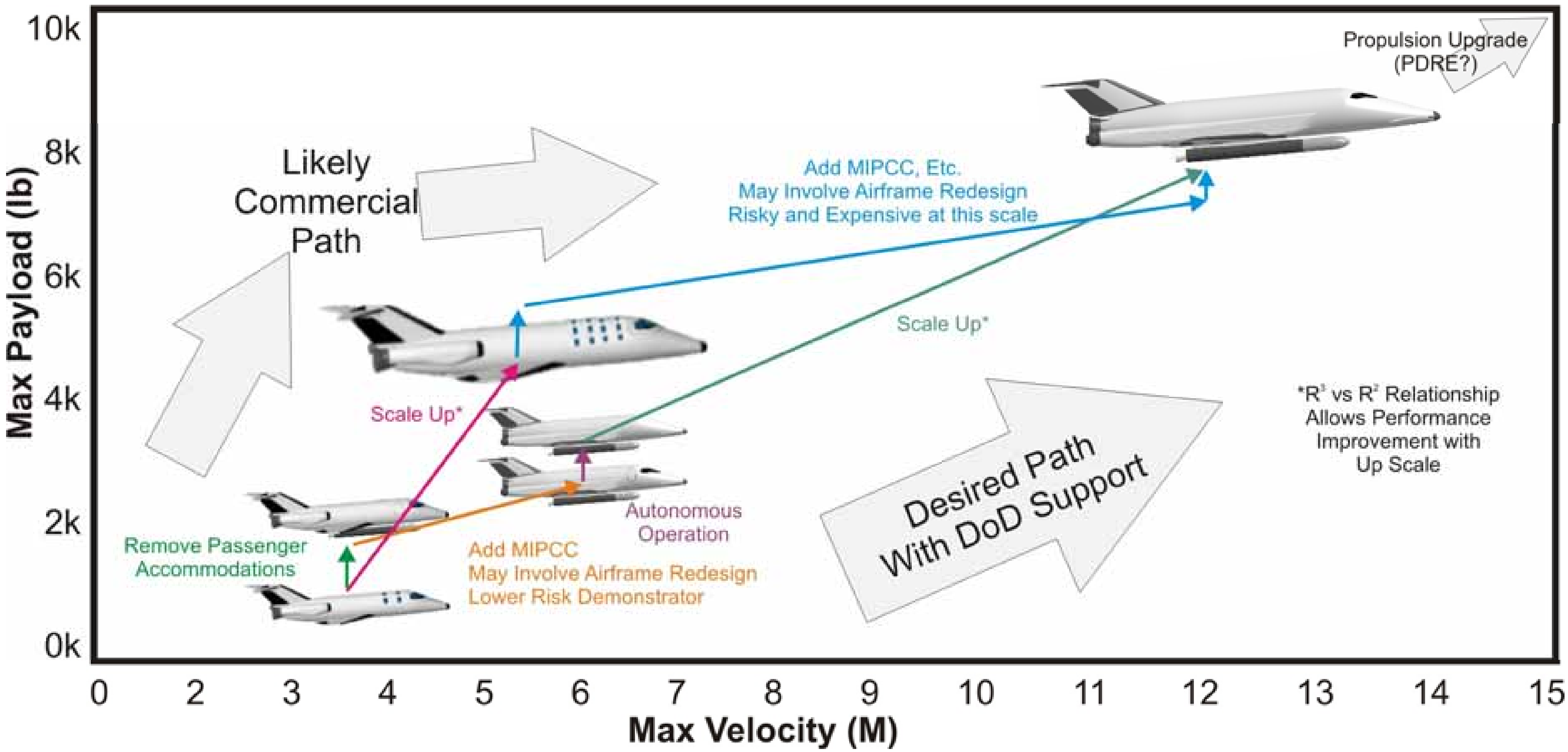
EU Spaceport Lelystad/NL

- **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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First EU Suborbital International Passenger and Cargo Hub

ROCKETPLANE GLOBAL

Netherlands to Spain Spaceflight Corridor

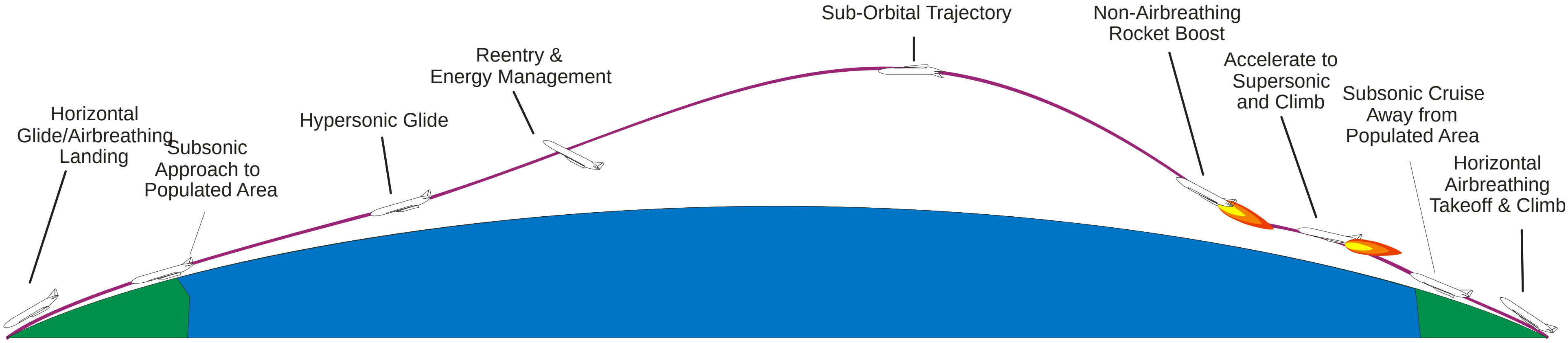
Netherlands to Doha Spaceflight Corridor

Netherlands to Singapore Spaceflight Corridor

The Future Vision Is Point-To-Point

- **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**



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 undue 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**