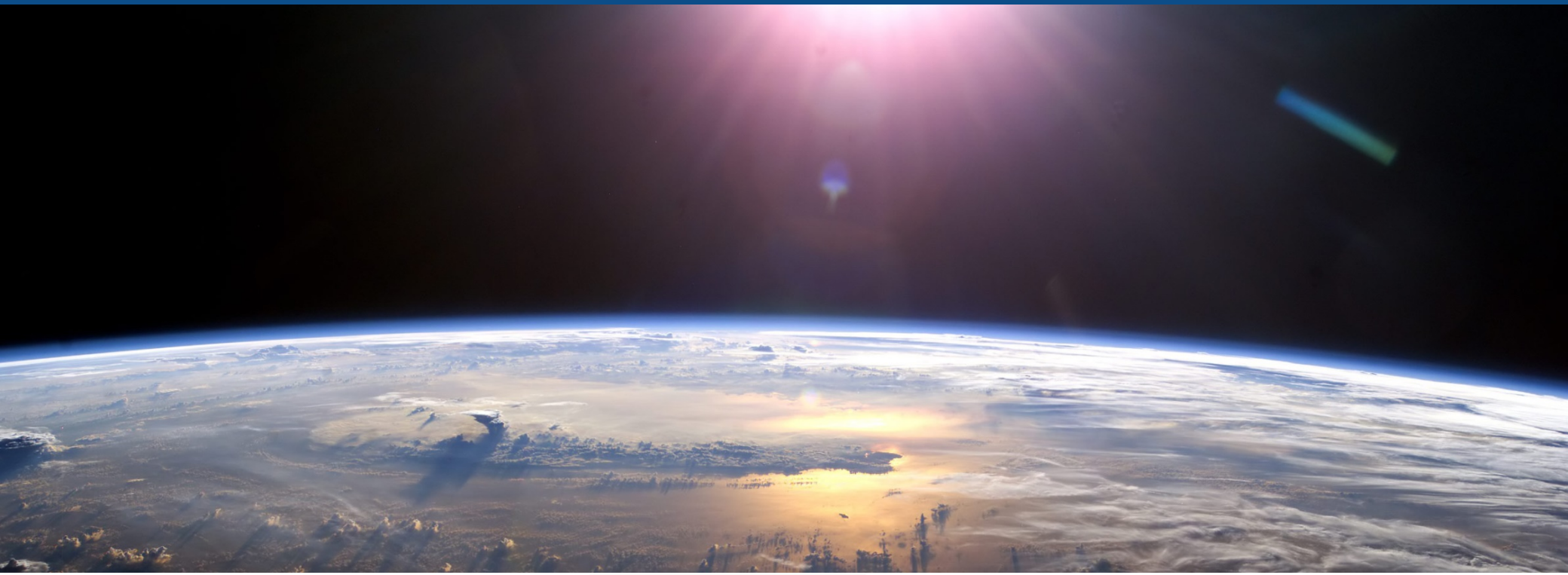

Emerging Business Models for Commercial Spaceports: Current Trends from the US Perspective

Janet K. Tinoco, Ph.D. and Chunyan Yu, Ph.D.

Embry-Riddle Aeronautical University

Daytona Beach, Florida USA

SIRIUS Research Workshop

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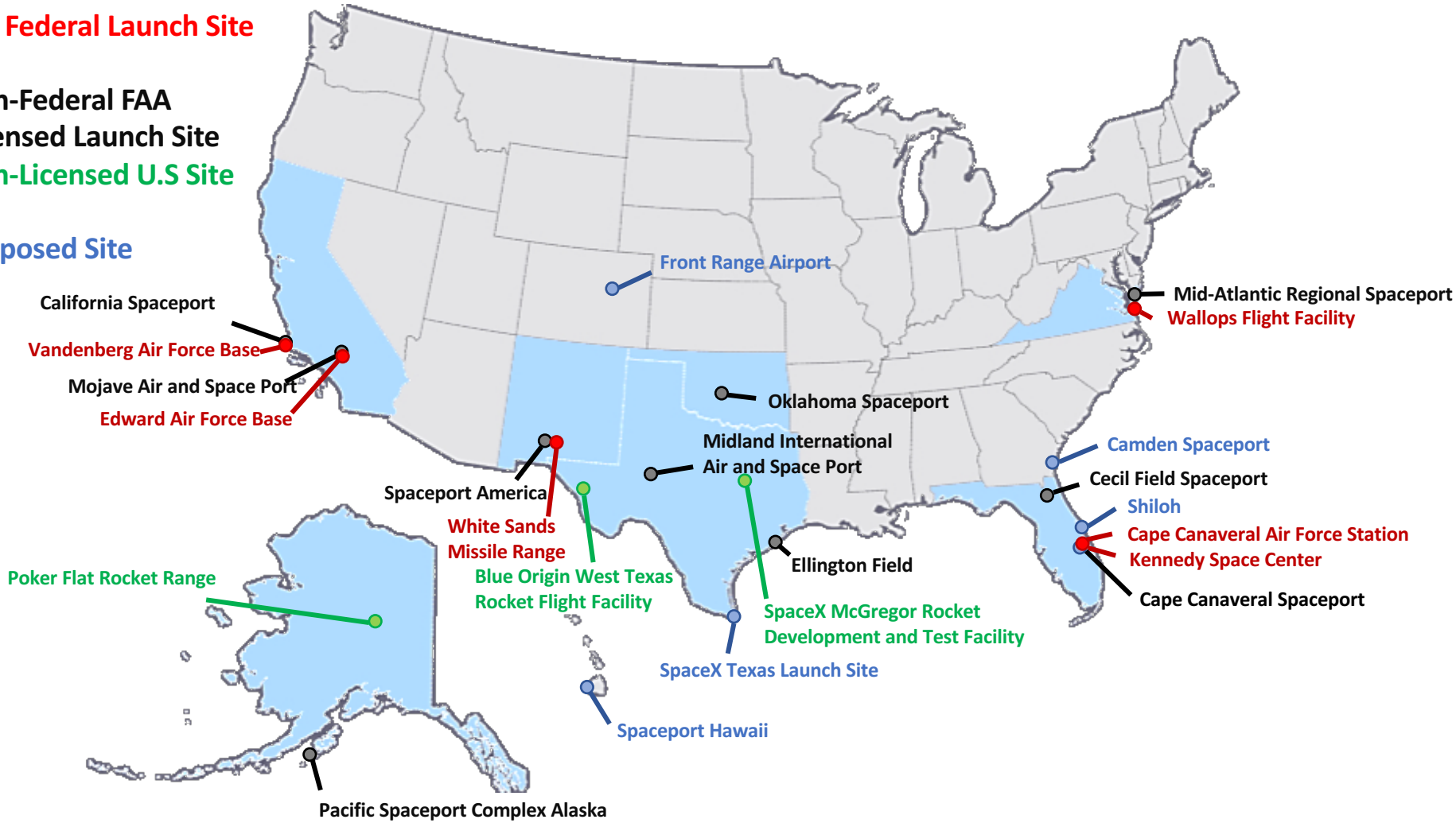
Agenda

- US commercial/government active launch sites
- Why commercial spaceports?
- Spaceport business model drivers
- Spaceport multi-modal facility and infrastructure requirements
- Emerging spaceport business models
- Summary and concluding remarks

Commercial/ Government Active Launch Sites

- U.S Federal Launch Site
- Non-Federal FAA Licensed Launch Site
- Non-Licensed U.S Site
- Proposed Site



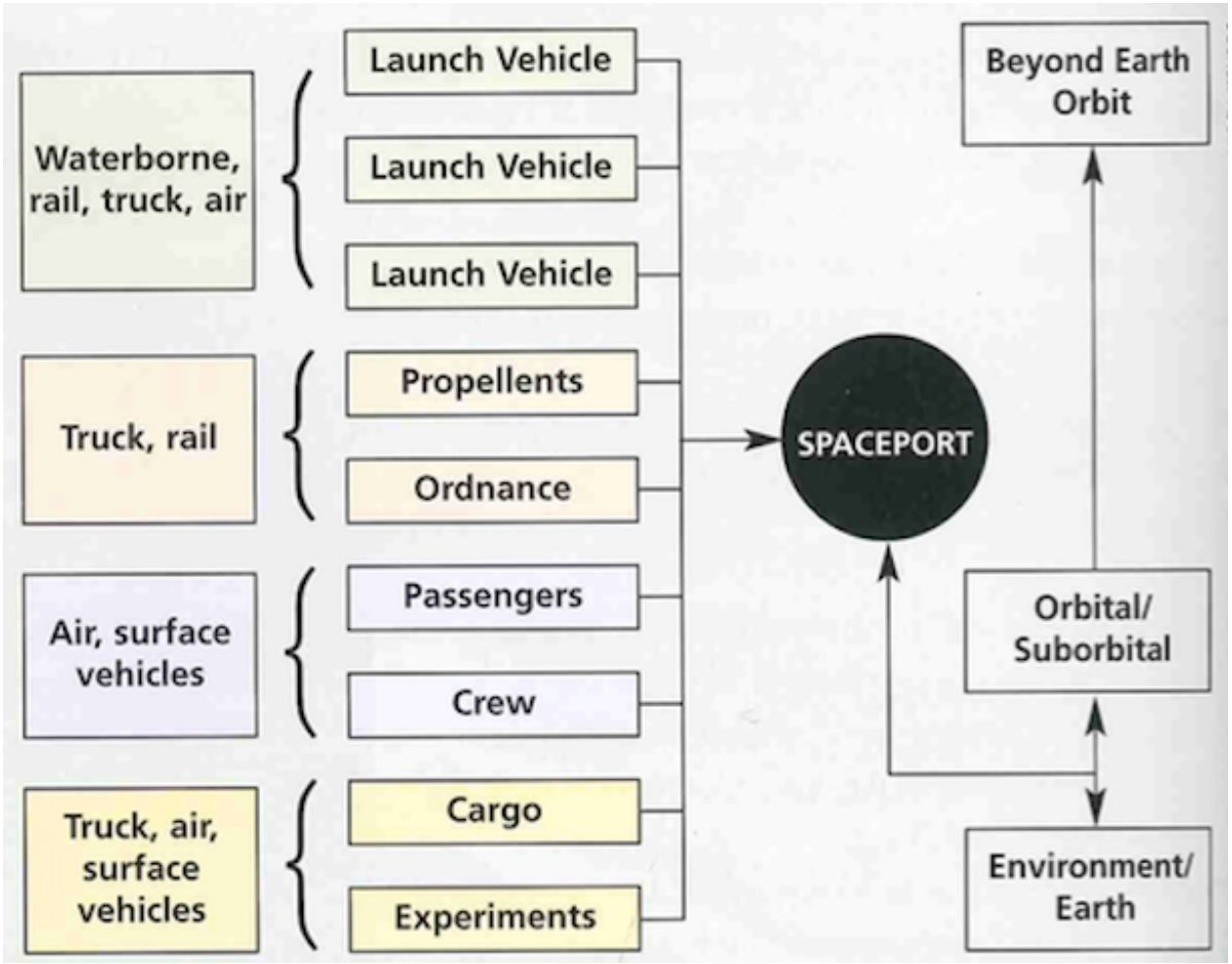
Why Commercial Spaceports?

- National space centers are expanding commercial space programs.
- Commercial spaceports developing as commercial space transportation activities grow
- Commercial space transportation activities include
  - Payload and International Space Station (ISS) crew transportation
    - Shift for federal government from launch service provider to customer
  - Space travel and tourism
  - Space mining (ex. planetary resources/asteroid mining)
- Methods of transport
  - Point-to-point (ex. Virgin Galactic)
  - Single point – launch and return
  - Single point launch (ex. SpaceX and Mars)

Spaceport Business Model Drivers – Interrelated

- Shifting US government role
- Expansion of commercial transportation activities
- Enabling legislation tied to commercial space: local, state, and federal laws and policies
- Funding availability for spaceports
- Type of vehicle launch and return– horizontal or vertical
- Airspace and jurisdiction
- Physical infrastructure and feasibility of adding/building infrastructure for spaceport
- Multimodal transportation access for spaceport activities
- Environmental impacts – natural, population
- Market opportunities
- Economic benefit to the community

Spaceport – Multimodal Transportation Facility



Source: Finger, What Happens at a Spaceport, TR news, Nov/Dec 2015

Spaceport Infrastructure Requirements – Safety is Paramount

- Infrastructures for vertical and horizontal launch and landing
  - Launch pads and landing pads
  - Runways (>/= 12,000ft), taxiways and ramp areas
- Mission control centers
- Air control towers
- Hangars
- Storage areas (fuel/oxidizers)
- Payload integration facilities
- Emergency facilities
- ……

Emerging Spaceport Business Models

- Airports to air and space ports
  - General aviation (GA) and commercial, former/current military airfields
    - Examples: **Cecil Spaceport**, **Mojave Air and Space Port**, Midland Air and Space Port, Houston Spaceport at Ellington
  - Integration of current airport operations and infrastructures
- Greenfield spaceports
  - Examples: **Spaceport America**; Blue Origin-West Texas (private); Space X- Brownsville, Texas (private)
- National space and military centers
  - Examples
    - **Wallops Flight Center/Mid-Atlantic Regional Spaceport (MARS)**
    - NASA Kennedy Space Center/Cape Canaveral Air Force Station

Cecil Spaceport Jacksonville, FL

Cecil Spaceport Business Model

- Jacksonville Aviation Authority granted a launch site operator license in January 2010
  - Cecil Airport - GA airport, formerly military airfield
- Launch type - departing Cecil Spaceport as an aircraft – **horizontal**
  - Short term: launch and reentry horizontally launched reusable launch vehicles (RLVs) using suborbital trajectories
  - Long term: point-to-point transportation
- Assumptions: +250 flights annually within 20 years from the commencement of commercial operations if obtain 10% of commercial space operations market.

Revenues and Cost Estimates for Infrastructure Improvement

- Revenues (assumption)
  - Launch fees
  - Fixed based operator (FBO) - type services
  - Lease agreements: Current lease tenants for Cecil Airport include Boeing Global Services and Support; none directly tied to the spaceport.
- Early stages of infrastructure conversion to spaceport
- Initial cost estimates for physical infrastructure improvements
  - Short Term (2012-2016) $21.9M Road, utilities, operator sites - construct
  - Medium Term (2017-2021) $17.8M Taxiways –construct/reconstruct
  - Long Term (2022-2031) $48.6M Reconstruct runway/construct visitor center

  Total $88.3M
- Funding Sources

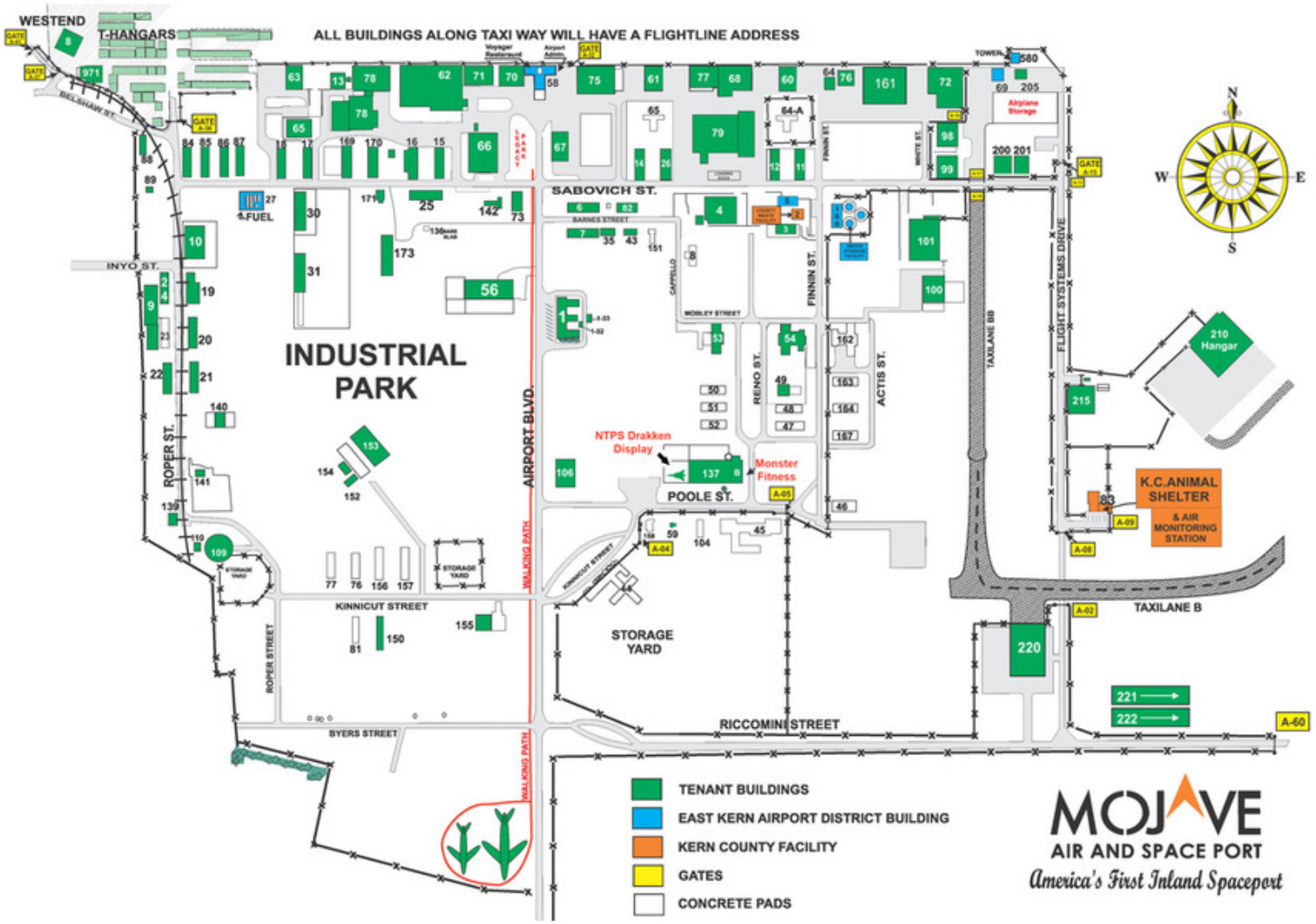
  Jacksonville Aviation Authority; State of Florida; Federal

Mojave Air and Space Port

Mojave Air and Space Port Business Model

- First facility to be licensed in the United States for **horizontal** launches of reusable spacecraft. Certified as a spaceport by FAA on June 17, 2004—East Kern Airport District.
- Broad business model
  - Main Tenants: XCOR Aerospace, Masten Space Systems, Virgin Galactic, The Spaceship Company, Stratolaunch Systems, Firestar Technologies, Orbital Sciences Corporation and Interorbital Systems
  - 51% of the revenue generated at Mojave Air and Space Port comes from companies engaged in privately-funded commercial spaceflight research and development (R&D).
  - Test, manufacturing, development

Spaceport Activities – Test, Manufacturing, Development

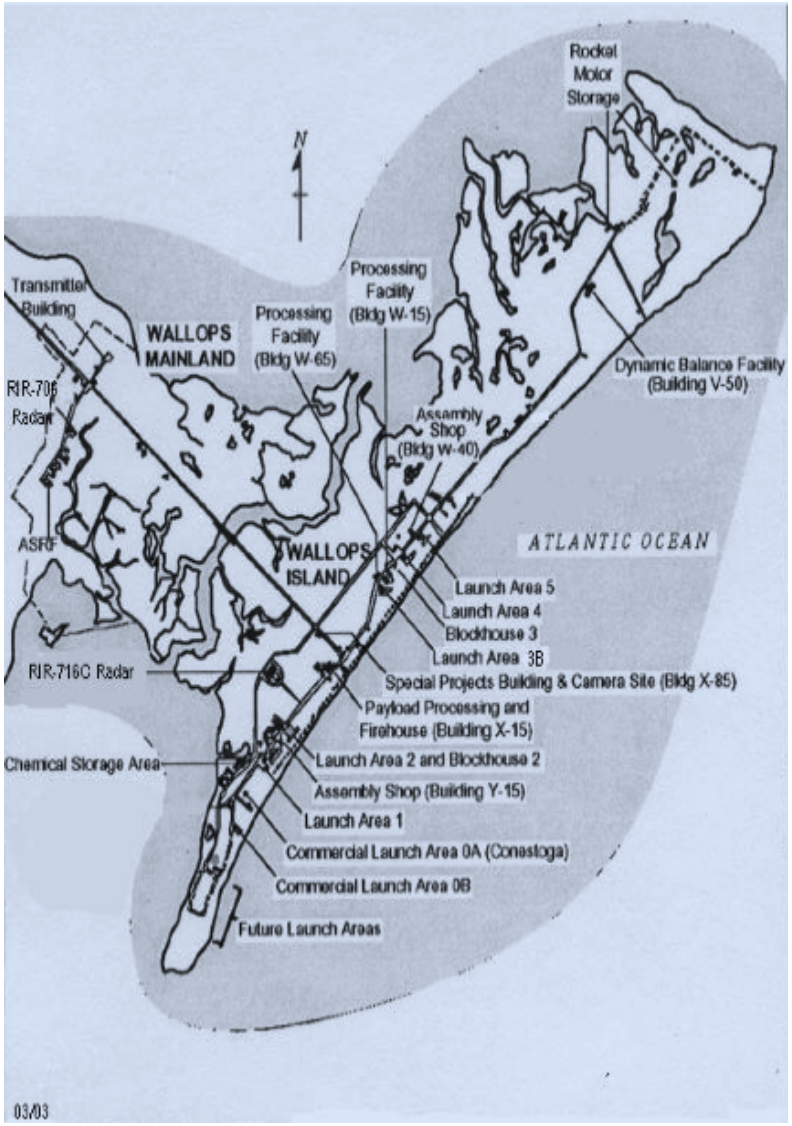


Source: http://www.mojaveairport.com/directory.html

Mid-Atlantic Regional Spaceport (MARS), Wallops Island, VA

MARS- Background

- Located within NASA Wallops Island Flight Center
  - Reimbursable Space Act Agreement with NASA permitted use of land with launch pads
- Managed and developed by Virginia Commercial Space Flight Authority (VCSFA) “Virginia Space”; license 1997
- Approved for **vertical** launch to orbit
- Developed 2 launch pads
  - MARS Pad 0A is a Mid-Class Launch Facility (MCLF) – Orbital ATK Antares
  - MARS Pad 0B is a Small-Class Launch Facility (SCLF)

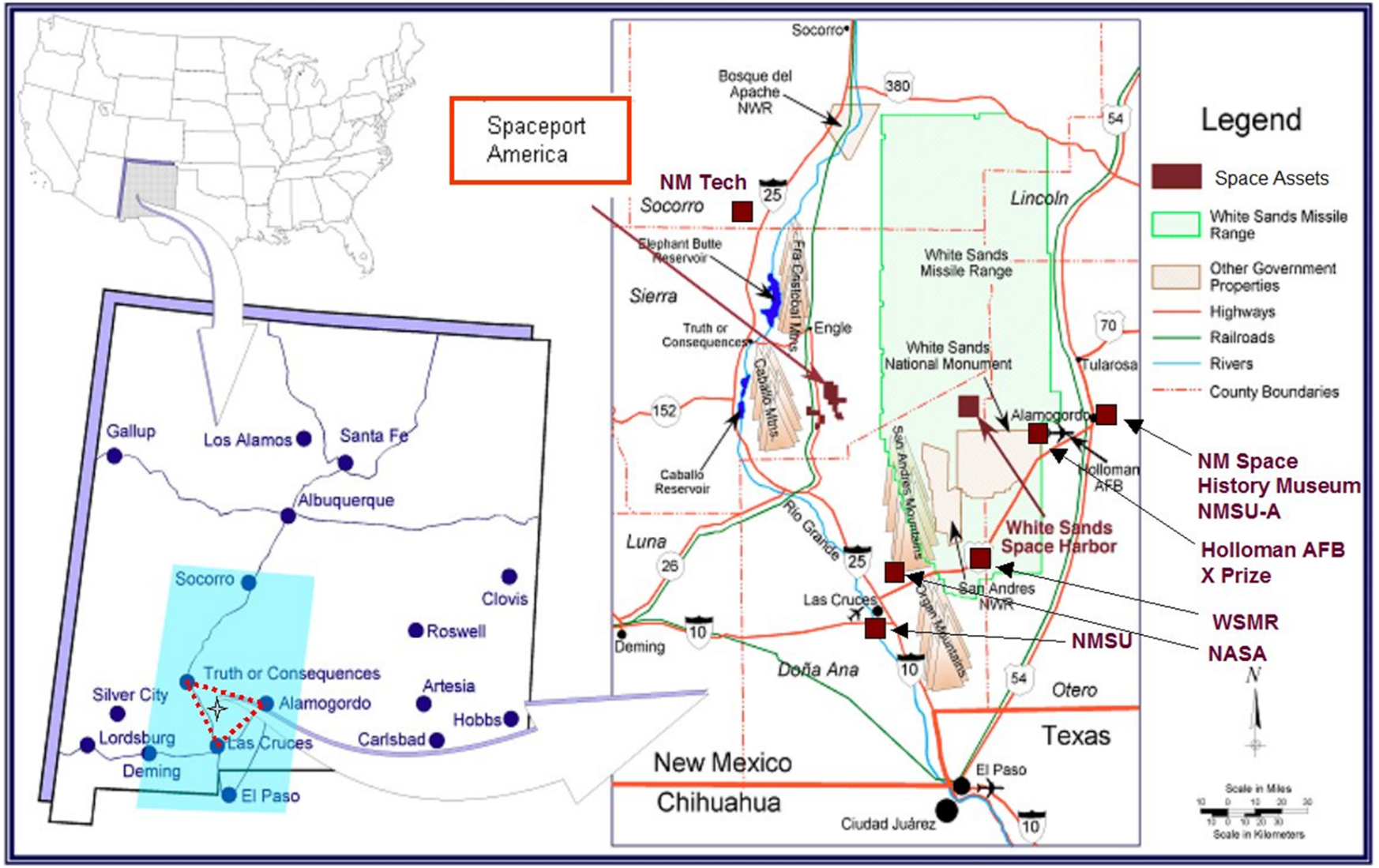


MARS Business Model

- Operate on government land with mix of NASA and Virginia Space assets
- Two launch pads for commercial vertical launch – low cost access to space
- Range services, ground and flight safety, launch vehicle flight certificates
- Facilities – logistic support
  - Scheduling, maintenance, and inspection to ensure optimal accomplishment of ground processing and launch.
  - Provision of supplies, commodities, and consumables to support mission operations.
- Revenues derived from launch fees and services
- Initial infrastructure costs (1995-2003) $4.9M
- Funding sources: Virginia Space; State of Virginia; Federal

Spaceport America

Spaceport America



Changing Business Model

- +$200 million spaceport – **horizontal and vertical** launch
  - Anchor tenant - Virgin Galactic for space tourism
  - Other business
    - SpaceX – tenant
    - UP Aerospace - Suborbital vertical launches
    - Fly/lease/build
    - Events space
    - Tours
- Projected 2017 revenues
  - Virgin Galactic lease and user fees ($1.6M)
  - Other aerospace customers ($.7M)
  - Other, incl. special events, tourism, merchandising ($1.8M)
  - New Mexico General Fund ($2.2M)

Spaceport Business Model Summary

	Cecil Spaceport	Mojave Air and Space Port	MARS	Spaceport America
Launch type	Horizontal	Horizontal	Vertical	Horizontal and vertical
Purpose	“Airport” for space	Test, manufacturing, etc.	Launch – low cost access	Space tourism
Infrastructure	GA airport; formerly naval airfield	GA airport; formerly military field	NASA property	Greenfield
Initial infrastructure costs	$88.3M est.	?	$4.9M	>$200M
Revenues	Launch/user fees, FBO-type services; lease fees	Lease fees, projects, services	Launch fees and related services	Lease and user fees; services; tourism

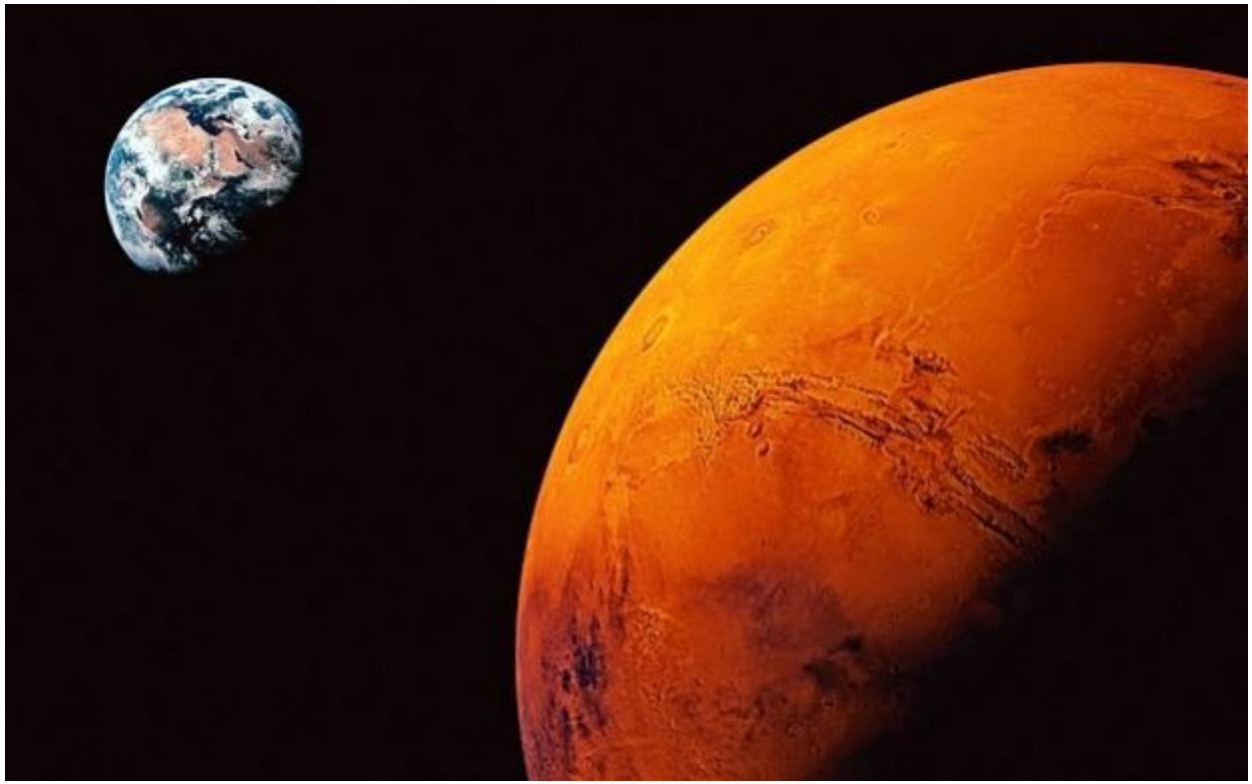
Spaceport Business Model Summary

- Generalities
  - Airports (GA and commercial), spaceport greenfield (port authority, private), and non-government spaceport on government land/assets.
  - Business model drivers are inter-related.
  - Least costly model involves land/property agreements with NASA/government
    - SpaceX 20 Year Property Agreement with NASA Kennedy Space Center for Launch Complex 39A
- Revenue sources
  - Lease (hangars, payload processing facilities, training facilities, test facilities)
  - Launch, user, operations fees
  - Services, including “FBO” type services (maintenance, sale of fuel, propellants, oxidizers), ground and flight safety, vehicle certifications, logistics
  - Other revenues (tourism, events, etc.)

Concluding Remarks

- Challenges
  - Time requirements for spaceport infrastructure development
  - Time and financial requirements for spaceport licensing application
  - Spaceports highly competitive
  - Loss of anchor tenant or lack of focus/purpose
- Positives outweigh the negatives in many cases due to expected return on investment (ROI).
- Both private investors and government entities are increasingly looking to commercial space transportation as the new 6th mode of transportation.

Thank you.



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Total Orbital Launches in 2015

Country/Region	Civil	Military	Commercial	Total
Russia	14	7	5	**26**
USA	4	8	8	**20**
China	12	7	0	**19**
Europe	5	0	6	**11**
India	3	0	2	**5**
Japan	1	2	1	**4**
Iran	1	0	0	**1**
TOTALS	***40***	***24***	***22***	***86***

Table 8. Total orbital launches in 2015 by country and type.

Source: FAA The Annual Compendium of Commercial Space Transportation, 2016

2015 Estimated Revenues for Commercial Launches

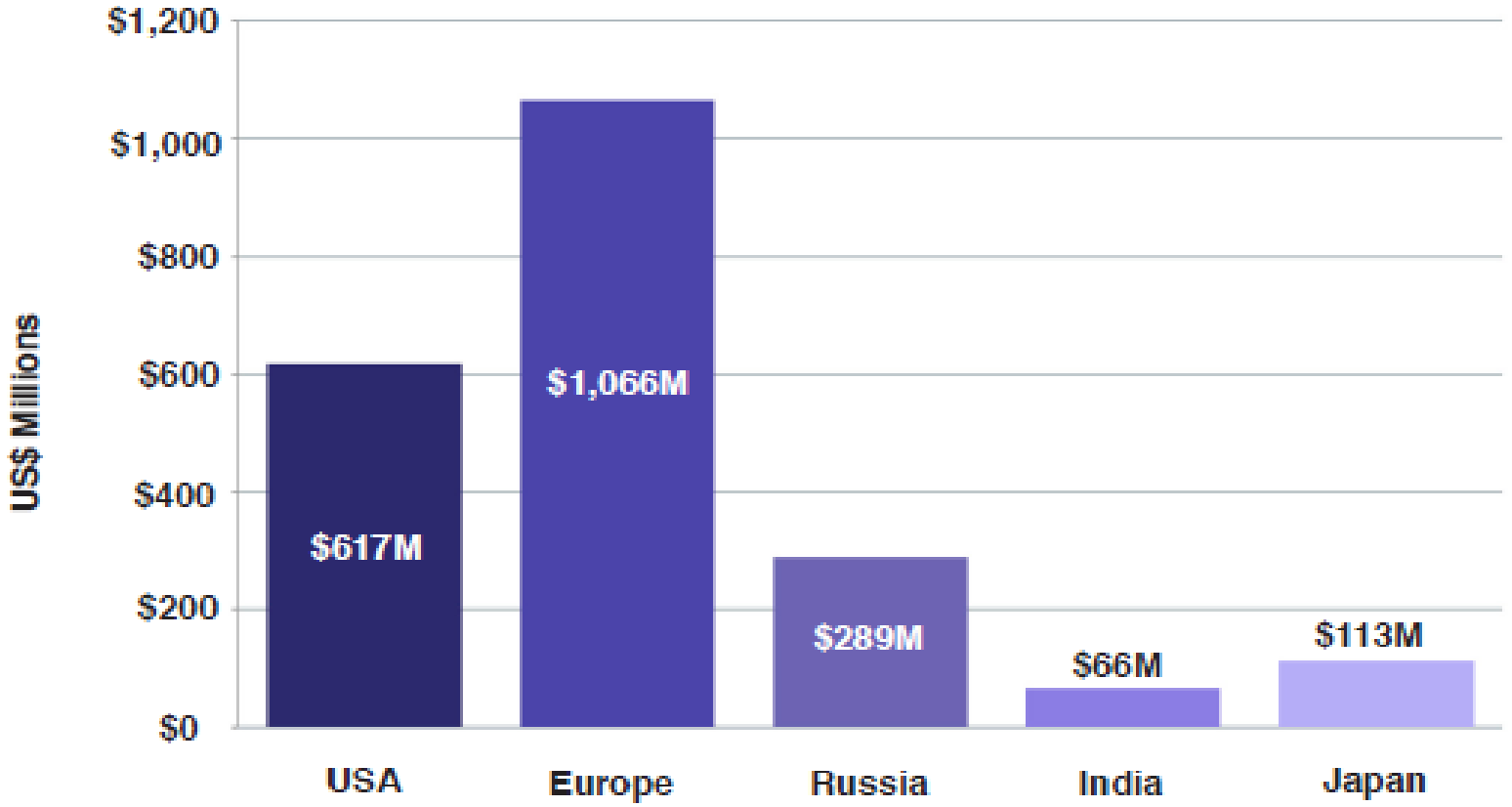


Figure 7. 2015 estimated revenues for commercial launches by country of service provider.

Source: FAA The Annual Compendium of Commercial Space Transportation, 2016

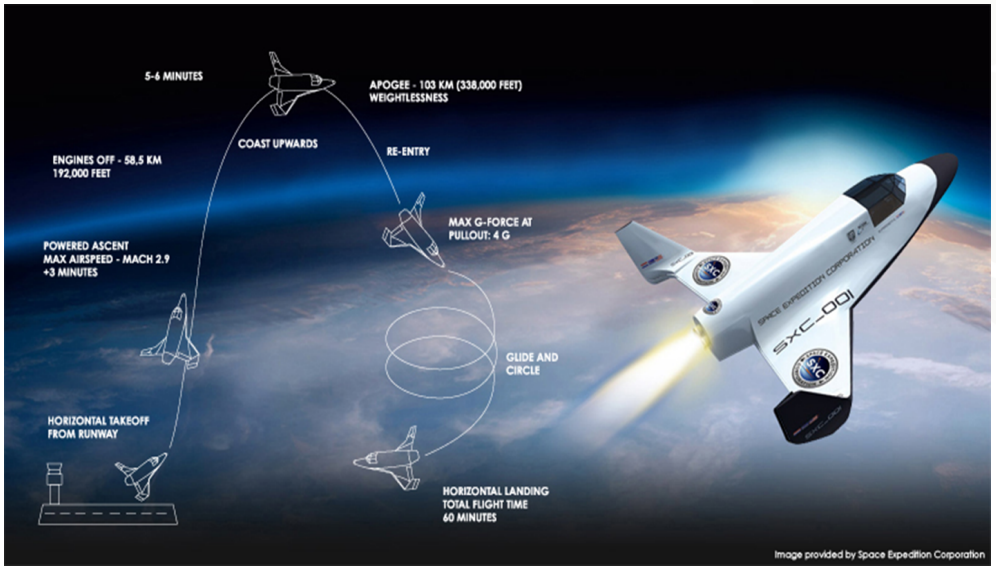
Horizontal Reusable Launch Vehicle (RLV) Concepts

Characteristics	Concept X*	Concept Y	Concept Z
Takeoff	Horizontal	Horizontal	Horizontal
Takeoff Method	Jet powered/Turbofan engines with integrated rocket motors in single stage-to-space	Rocket powered; ignition on ground and rocket power throughout flight	Jet powered
Uses Carrier Aircraft	No	No	Yes: spacecraft separates from aircraft
Landing Method	Glide or jet powered	Glide	Glide or expendable
Suborbital/Orbital	Suborbital	Suborbital	Either
Manned or Unmanned	Manned	Manned	Either
Example	Airbus Spaceplane	XCOR Lynx	Virgin Galactic SpaceShipTwo

*USA Federal Aviation Administration (FAA) designations

Horizontal RLV Concepts: Examples

Concept X: Airbus Spaceplane
Concept Y: XCOR Lynx
Concept Z: Virgin Galactic
SpaceShipTwo



Vertical Launch Vehicles

Characteristics	"Concept A"	"Concept B"
Takeoff	Vertical	Vertical takeoff and landing (VTOL)
Takeoff method	Rocket powered; capsule separation	Rocket powered; capsule separation
Uses Carrier Aircraft	No	No
Landing Method	Reusable rocket vertical return; Capsule free flight; floats down with parachutes	Reusable rocket vertical return; capsule vertical return
Suborbital/Orbital	Suborbital	Orbital
Manned/unmanned	Both	Both
Example	Blue Origin New Shepard	SpaceX Dragon with Falcon

Vertical Launch Vehicle Examples

“Concept A”

“Concept B”