Emerging LEO Economy

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THE TAURI GROUP

Potential LEO Markets

- ✓ Commercial human spaceflight and accommodation (tourism)
- ✓ Basic and applied research
- ✓ Aerospace test & demo
- ✓ Education
- ✓ Media and public relations
- ✓ Remote sensing (vehicle/platform based)
- ✓ Satellite deployment and operation
- ✓ On-orbit transportation
- ✓ Infrastructure support (servicing, propellant depots, midware)
- ✓ Resource acquisition/utilization
- ✓ Manufacturing
- ✓ Point-to-point transportation

Today's Commercial LEO Economy

Blue Origin
New Shepard

Virgin Galactic
SpaceShipTwo

XCOR
Lynx

Blue Origin
Space Vehicle

Boeing
CST-100 Starliner

SpaceX
Dragon

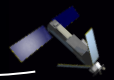
SNC
Dream Chaser

Launch/Payload Broker
Spaceflight Industries

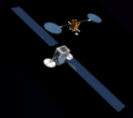
Payload Integrator
NanoRacks

ISS

Bigelow Aerospace
BEAM, BA 330



Satellites
Telecommunications, remote sensing, weather, navigation



Satellite Servicing
ViviSat

Golden Spike

Space Adventures

Planetary Resources
Arkyd

SpaceX

SUBORBITAL TRANSPORT

ORBITAL TRANSPORT

OTHER SERVICES

DESTINATIONS

SUBORBITAL MARKETS

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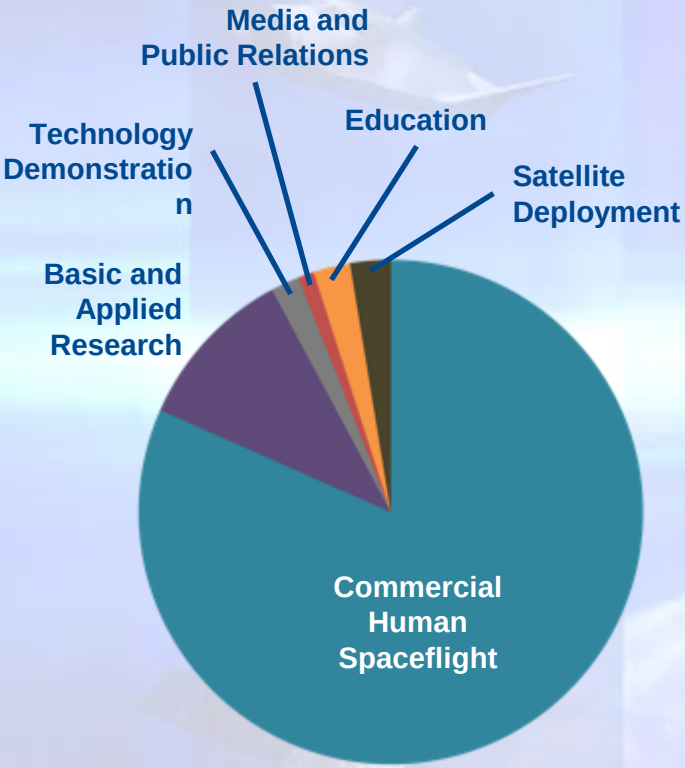
Suborbital Commercial Human Spaceflight Providers

Company	Suborbital Reusable Vehicle		Seats*	Locker Equivalents (estimated)	Cargo (kg)	Price per Seat	Ticket Reservations	Expected Operational Date
Blue Origin	New Shepard		6	5	120**	Not announced	Not announced	2017
Virgin Galactic	SS2		6	36	600	$200K	700+ *(as of October 2015)*	2017
XCOR Aerospace	Lynx Mark I		1	3	120	$150K***	300+ *(as of July 2015)*	2016
	Lynx Mark II		1	3	120	$150K***		2017
	Lynx Mark III		1	28	770	$150K per seat, $500K for small sat launch***		2018

** Maximum number of space flight participants, exclusive of crew (several vehicles are piloted)*
*** Net of payload infrastructure*
**** Effective January 1, 2016*

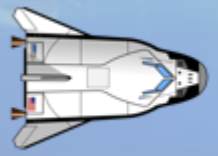
Suborbital Demand

SUBORBITAL



ORBITAL MARKETS

Commercial Human Orbital Spaceflight Providers

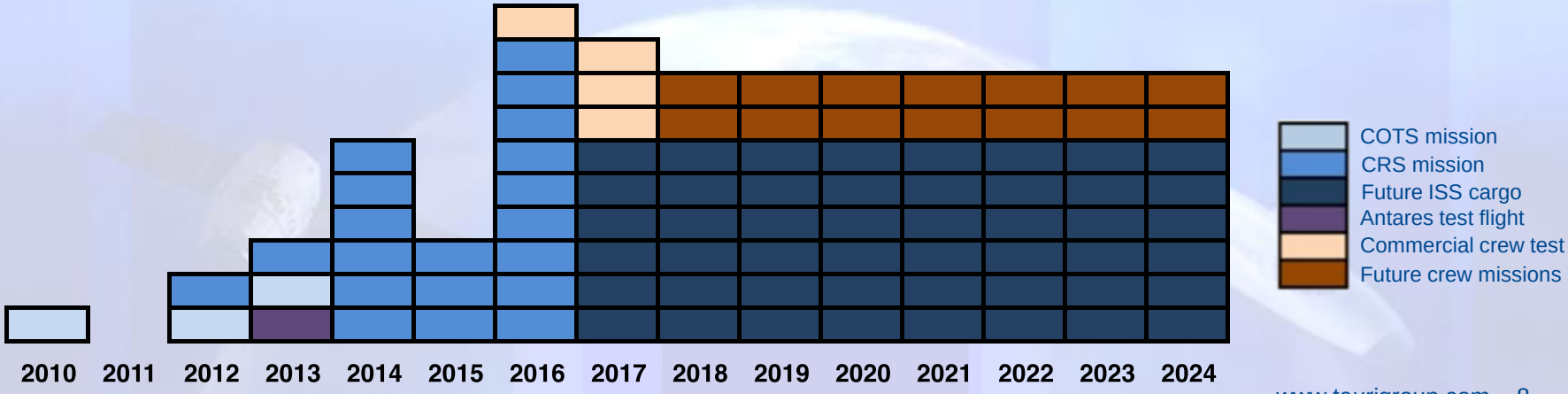
Company	Orbital Vehicle		Launch Vehicle(s)	Max. Crew	First Flight	NASA Funding Awarded to Date	2015 Highlights
Blue Origin	Space Vehicle		Atlas V Blue Origin RBS	7	TBD	$25.6M	Orbital launch vehicle announced, with site selected at Cape Canaveral
Boeing	CST-100Starliner		Atlas V Delta IV Falcon 9	7	2017	$4.8B	Completed processing facility at KSC (formerly OPF-3) and announced new name of vehicle
Sierra Nevada Corp.	Dream Chaser		Atlas V	7	2019	$363.1M	Still developing crewed vehicle, but focusing on cargo version in anticipation of CRS-2. Established science mission partnership with OHB System
SpaceX	Dragon (Cargo)		Falcon 9	0	2012 (actual)	$396M (COTS) $1.5B (CRS)	Conducted 3 cargo missions, one lost in launch failure
	Dragon (Crew)		Falcon 9	7	2017	$3.1B	Successful pad abort test

COTS – Commercial Orbital Transportation Services, CRS – Commercial Resupply Services, CCDev – Commercial Crew Development, CCiCap – Commercial Crew Integrated Capability.

Orbital Demand

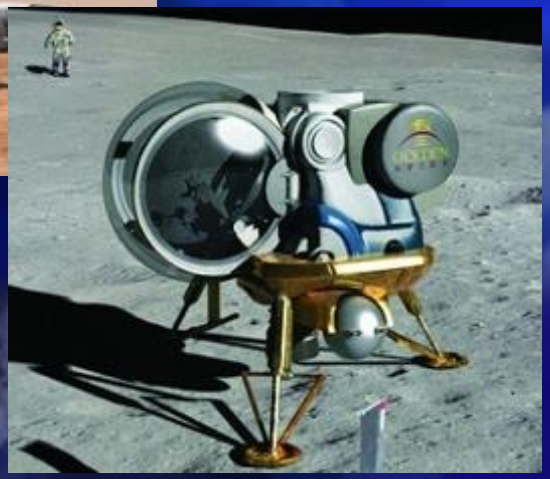
ORBITAL

- NASA currently drives LEO demand for human spaceflight
  - NASA demand is well understood in near to mid term;
  - Contracts are in place
- Limited systematic assessment of non-NASA markets available publicly
- Most commonly targeted potential customers (non NASA) appear to be
  - ISS partners (research, tech demo)
  - Other nations (training, space experience, research, tech demo)
  - Satellite launch
- Anecdotal information about other potential applications



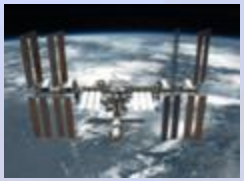
Source: NASA HQ (May 2015), updated to reflect actual flights

ON-ORBIT DESTINATIONS



On-orbit Destinations for Commercial Human Spaceflight

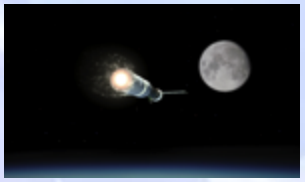
Destination	Mission Profile	Company	Launch Vehicle(s)	On-orbit Transportation Vehicle	First Flight
LEO	Genesis I	Bigelow Aerospace	Dnepr	N/A	2006
	Genesis II		Dnepr	N/A	2007
	BEAM		Falcon 9	Dragon CRS-8 (trunk)	2016
	BA 330		Atlas V	Dragon, CST-100 Starliner	2017
	BA 2100		Falcon Heavy, SLS	Dragon, CST-100 Starliner	TBD
	ISS	Space Adventures	Soyuz Atlas V	Soyuz CST-100	1998 TBD
Moon	Surface	Golden Spike	TBD	Lunar Lander (Northrop Grumman)	TBD
	Orbit	Space Adventures	Soyuz	Soyuz and habitation module (Deep Space Expedition Alpha)	2018
Mars	Mars	SpaceX	Future large vehicle	TBD	2030s



ISS

Bigelow Aerospace BEAM

Bigelow Aerospace BA 330



Space Adventures DSE-Alpha

Golden Spike

SpaceX on Mars

On-Orbit Destination Demand

- LEO Platforms
  - ISS
    - New demand may be associated with availability of commercial transportation
    - May be concern regarding potential procedural barriers to use
    - Limited demand to date for ISS availability for research; may be related to transportation access
  - Bigelow
    - Appears to have targeted national actors as customers; MOUs with 7 governments
    - Recent NASA contract
    - No other announced sales to date
- Moon/Mars
  - One reported ticket sale to date
  - Target customers (when characterized) typically high net worth individuals or national actors

Potential Benefits to Government of a Commercial LEO Economy

- Enhanced capability
- Buy by the yard
- More opportunities to test
- Researchers and citizen scientists
- Increased visibility of space activities
- Reduced costs
  - Launch
    - Competition
    - Launch rate
  - Technologies
  - ISS

Market Dynamics/Reality Check

- Proposed systems largely viewed as technically credible
- Mix of business experience, from global entrepreneurial superstars to technologists building companies
- Meaningful investment with potential for more
- Business case not proven; uncertain demand and revenue potential
  - Significant commercial demand for suborbital services, demonstrated ticket sales; supply side somewhat uncertain
  - Potential commercial demand for orbital services and LEO destinations, limited analysis
  - Unknown demand for Moon/Mars destinations, very little data
- Major challenges: magnitude of investment is massive, technology is complex, timelines are long

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