



Federal Aviation Administration

Update on Future Suborbital and Orbital Flight Operations

2018 FAA Annual Compendium of Commercial Space Transportation

Presented at: *ECAM 2018*

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Global Space Market

- The global space economy, consisting of private industry revenues and government budgets was \$345 billion in 2016
- About \$261 billion (76%) was revenue generated by companies providing services including: 1) Television, 2) Mobile, fixed, and broadband communications, 3) Remote sensing, 4) Satellite systems and ground equipment manufacturing and sales, and 5) Launch services
- The remaining 24% constitutes government space budgets (\$83 billion) and commercial human spaceflight (almost \$2 billion)



- In 2017, global space services providers conducted a total of 90 orbital launches from launch sites in 7 countries
- In 2017, the US had a record number of 23 launches (22 orbital and 1 suborbital) under licenses issued by the FAA Office of Commercial Space Transportation
- The growth trend is expected to continue as SpaceX fulfills its backlog and new companies like Blue Origin, Rocket Lab, Vector, and others introduce launch services





- The number of orbital launches conducted by China has increased since 2010 with a peak of 22 in 2016, including the introduction of 5 new space vehicles
- There are about 50 proposed small launch vehicles being developed worldwide, but most of them are in conceptual stages
- Some of these new vehicles have recently launched or are in advanced stages of development - Electron, LauncherOne, and Vector H are expected to start launching payloads in 2018
- Human spaceflight activities continue - Operational flights of suborbital systems and test flights of commercial orbital systems are expected to begin in 2018



FAA SUPPORT OF COMMERCIAL SPACE OPERATIONS IN THE U.S.

The FAA Office of Commercial Space Transportation was established in November 1995 to:

Regulate the U.S. commercial space transportation industry, ensure compliance with international obligations of the US, and protect the public health and safety, safety of property, and national security and foreign policy interests of the US

Encourage, facilitate, and promote commercial space launches and reentries by the private sector

Recommend appropriate changes in federal statutes, treaties, regulations, policies, plans, and procedures

Facilitate the strengthening and expansion of the US space transportation infrastructure both domestically and internationally



FAA AST Mission Statement

Protect the health and safety of the public and safety of property, while protecting the national security and foreign policy interests of the United States during commercial launch and reentry activities



Commercial Orbital Launch Vehicles Available Outside the US

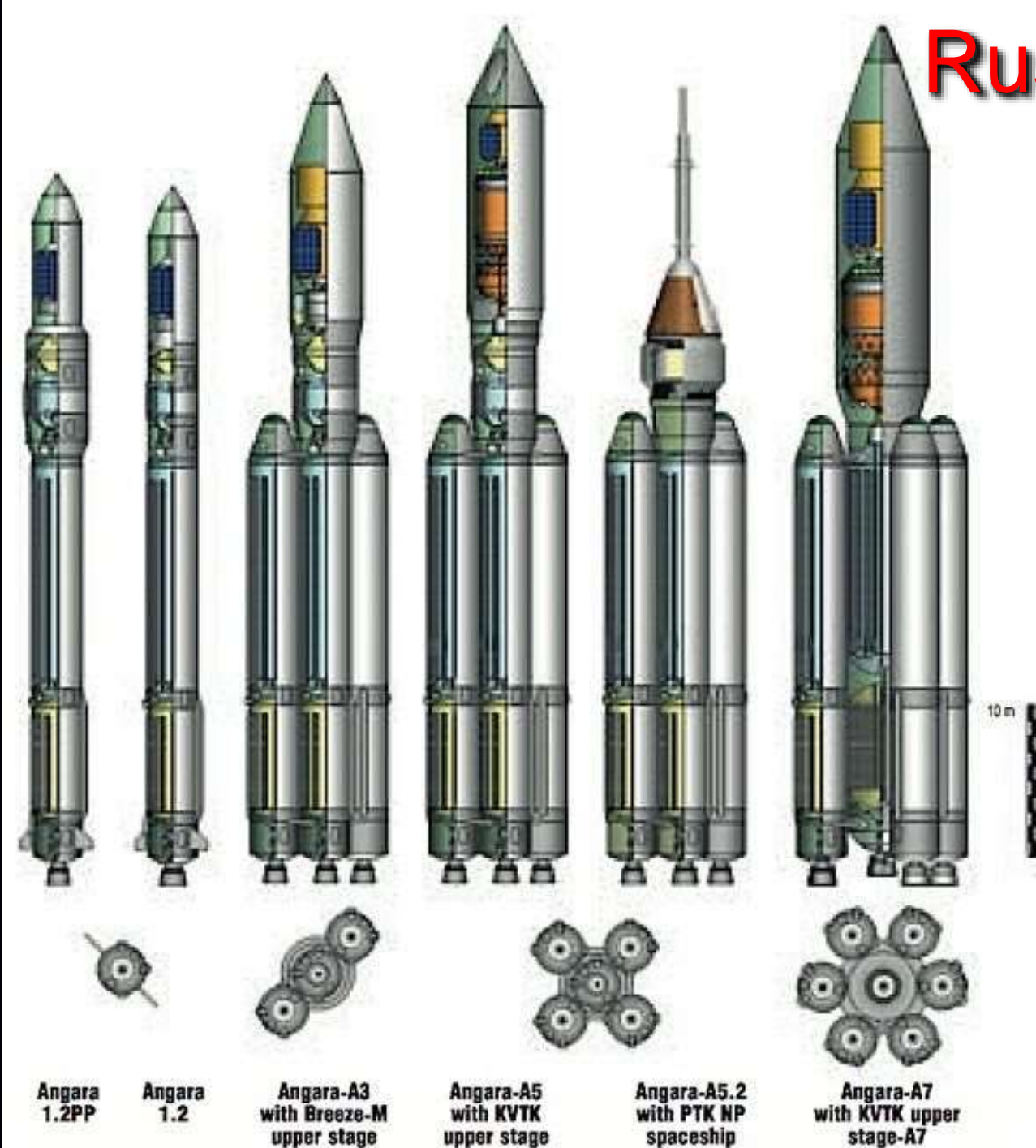


There are 17 expendable launch vehicle types available for commercial use outside the US

The commercial status of the last 2 is unclear

- Angara
- Ariane 5
- GSLV, LVM3
- H-IIA/B
- Kuaizhou 1/1A and 11
- LandSpace 1
- Long March 2D, 3A, 3B, 5, 6, 11
- Proton M
- PSLV
- Rockot
- Soyuz
- Dnepr
- Zenit

Russia - Angara



ESA - Ariane 5



India - GSLV



Japan - H-IIA/B





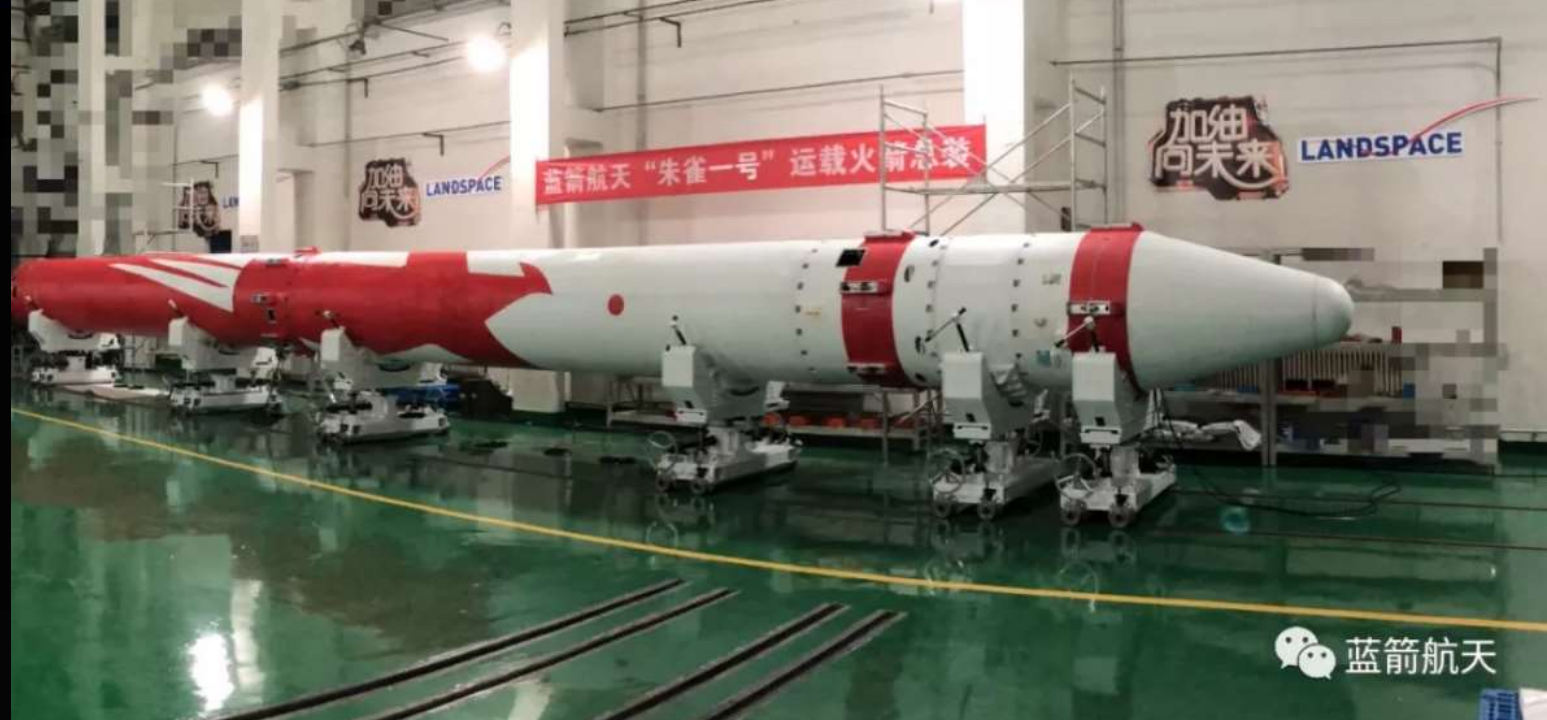
Kuaizhou 1/1A



China - Kuaizhou 11



China – Landspace 1



China - Long March Family

2D, 3A, 3B, 5, 6, 11





Russia – Proton M



India – PSLV



Russia – Rockot



Russia – Soyuz



Russia – Dnepr





Russia – Zenit



Orbital Vehicles
Currently Available for
Commercial Use by US Providers



USA – Antares

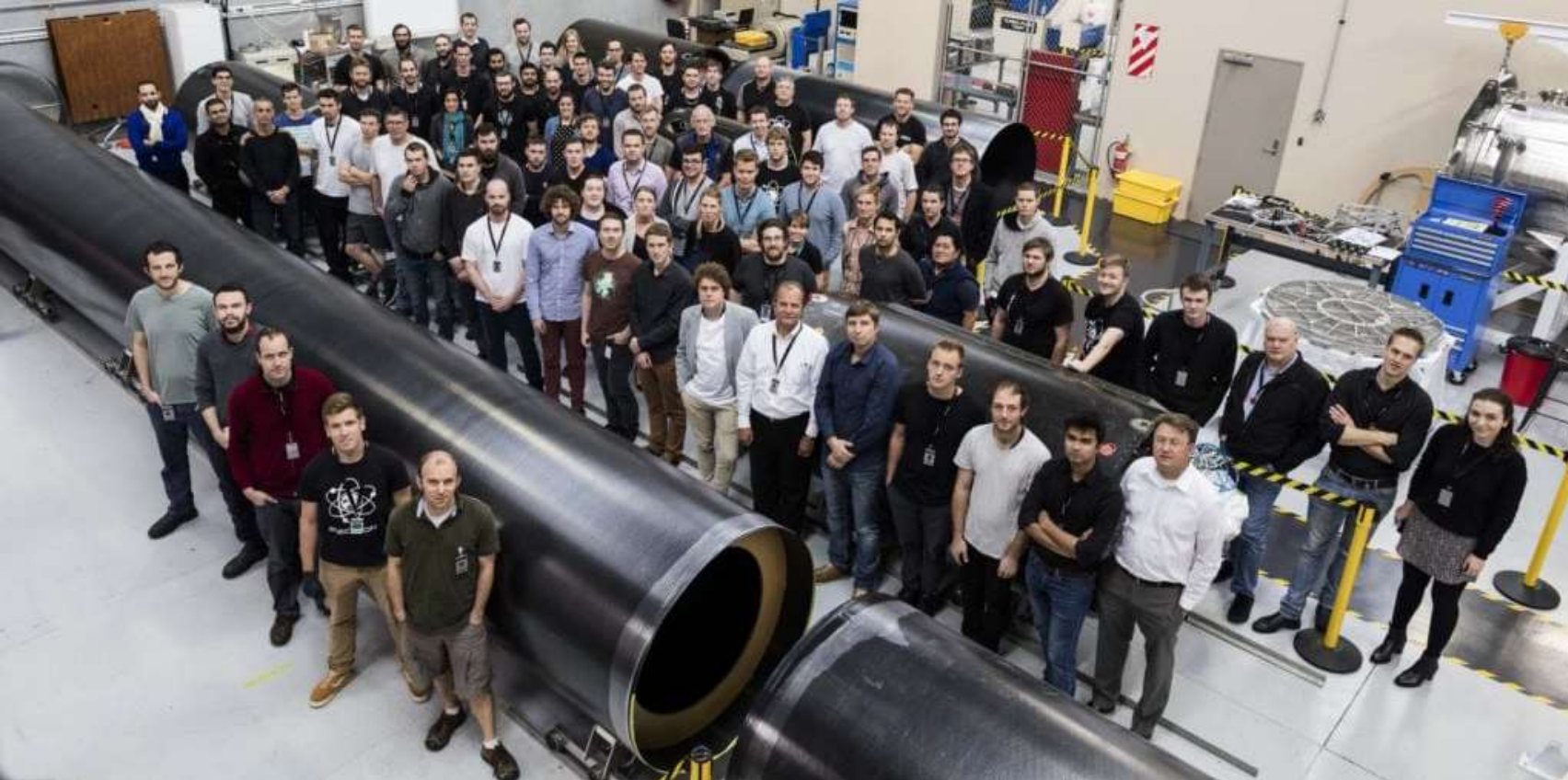
 Mark Usciak / SpaceFlight Insider ©



USA – Atlas V



USA Electron



FLYING INTO SPACE

May 22-June 3

The test window for Electron's first test flight.

\$1.4b

Estimated value of Rocket Lab. The company has received \$25m Government funding.

\$324m

Typical cost of a space rocket launch.

300km-500km

Distance above Earth the rocket is hoping to achieve.

17m x 1.2m

Dimensions of the torpedo-like rocket. Its 3D-printed engine is named Rutherford, after iconic Kiwi scientist Ernest Rutherford.

\$7.1m

Estimated cost of Electron launch.

0

The number of times any nation's first rocket test has reached orbit.





USA – Falcon 9



Minotaur Space Launch Vehicles



USA – Minotaur C





USA

Pegasus XL



Projected Orbital Launch Vehicles
That May Be Available for
Commercial Use in the US



Falcon Heavy



LauncherOne



New Glenn



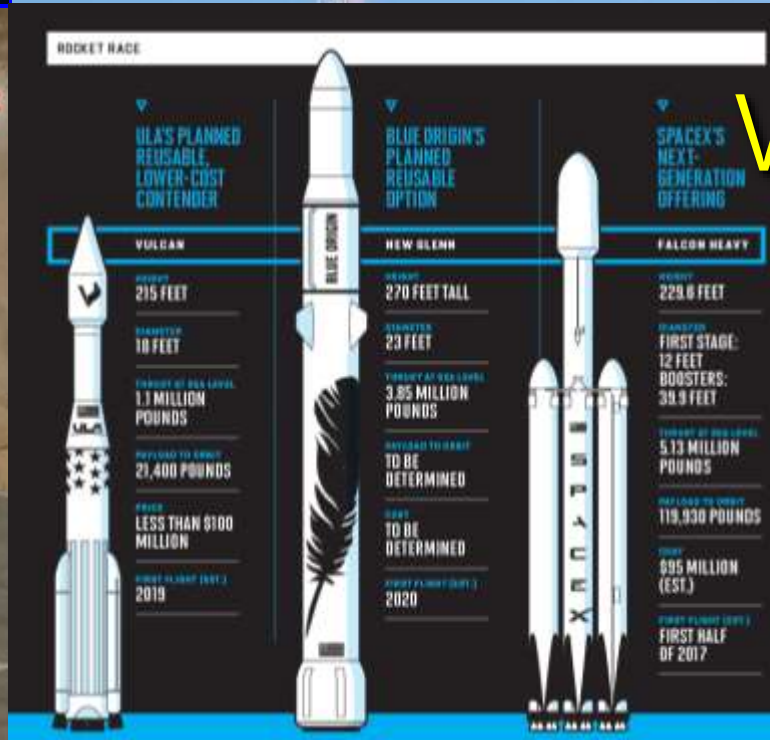
SpaceX



Blue Origin



NASA



Suborbital Reusable Launch Vehicles





USA

New Shepard





USA Zodiac



USA - SpaceLoft XL





USA - SpaceShipTwo



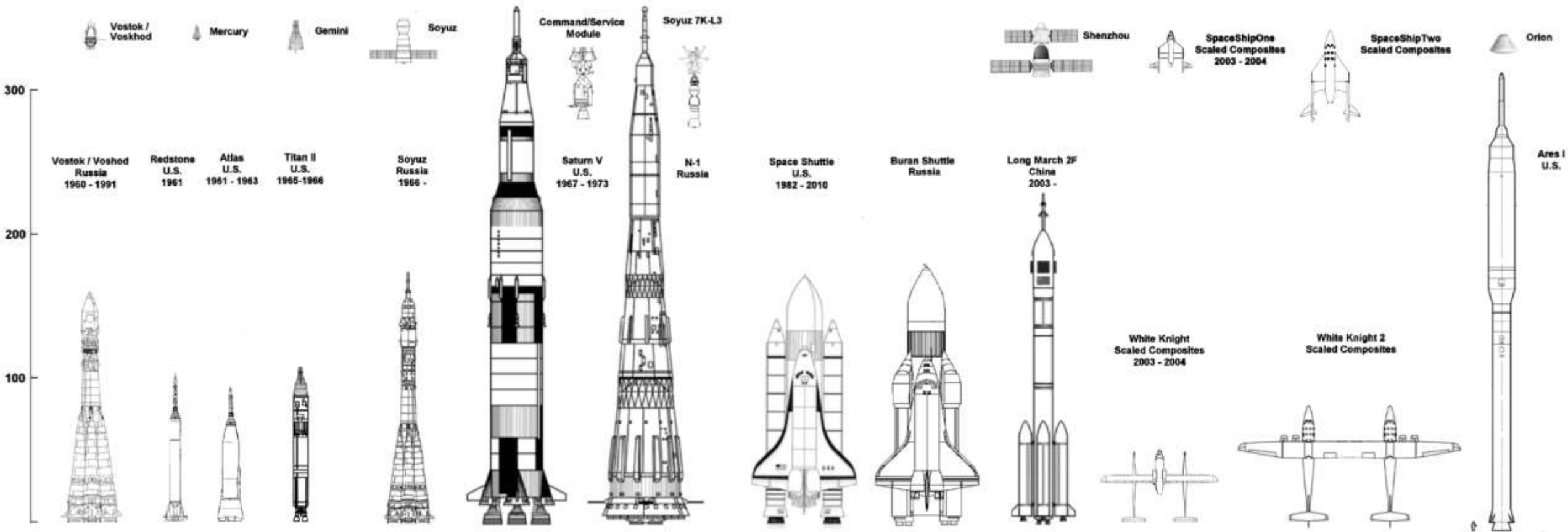
USA - Voyager



57 Years of Human Spaceflight

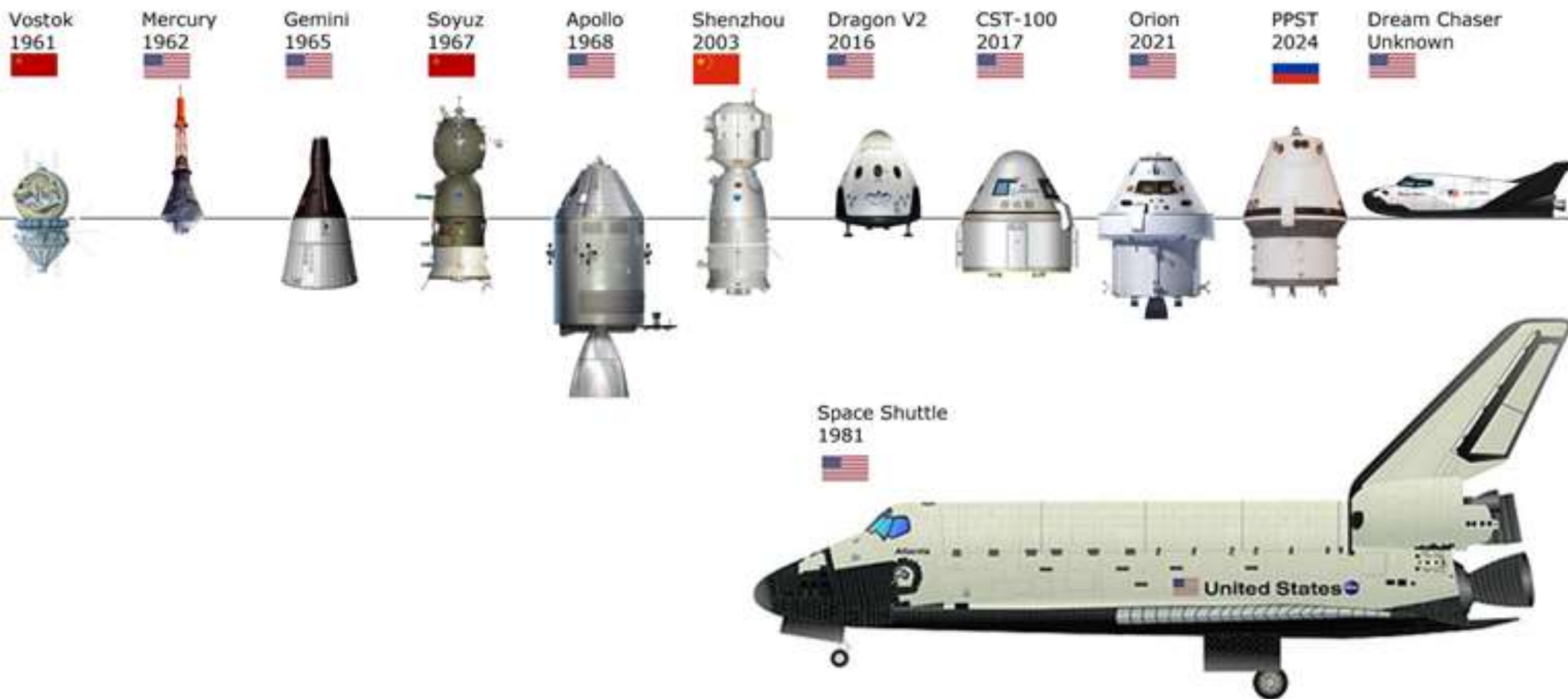


Crewed Spacecraft



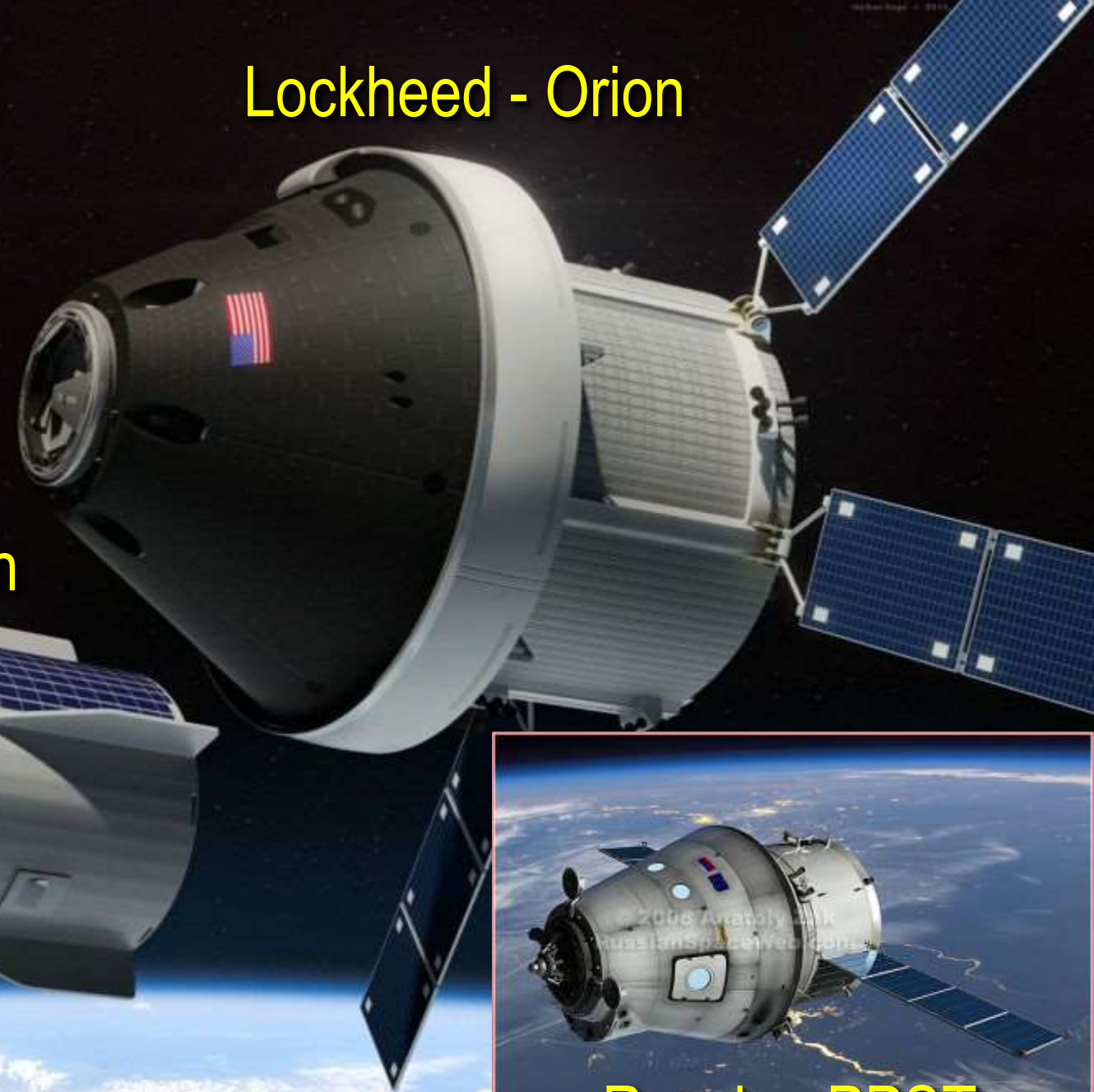
Orbital Spacecraft

0 2 4
meters





Sierra Nevada
Dream Chaser

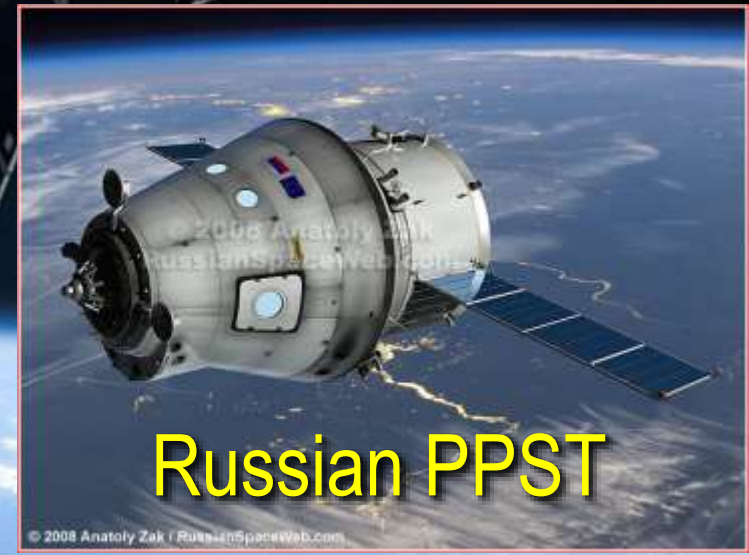


Lockheed - Orion

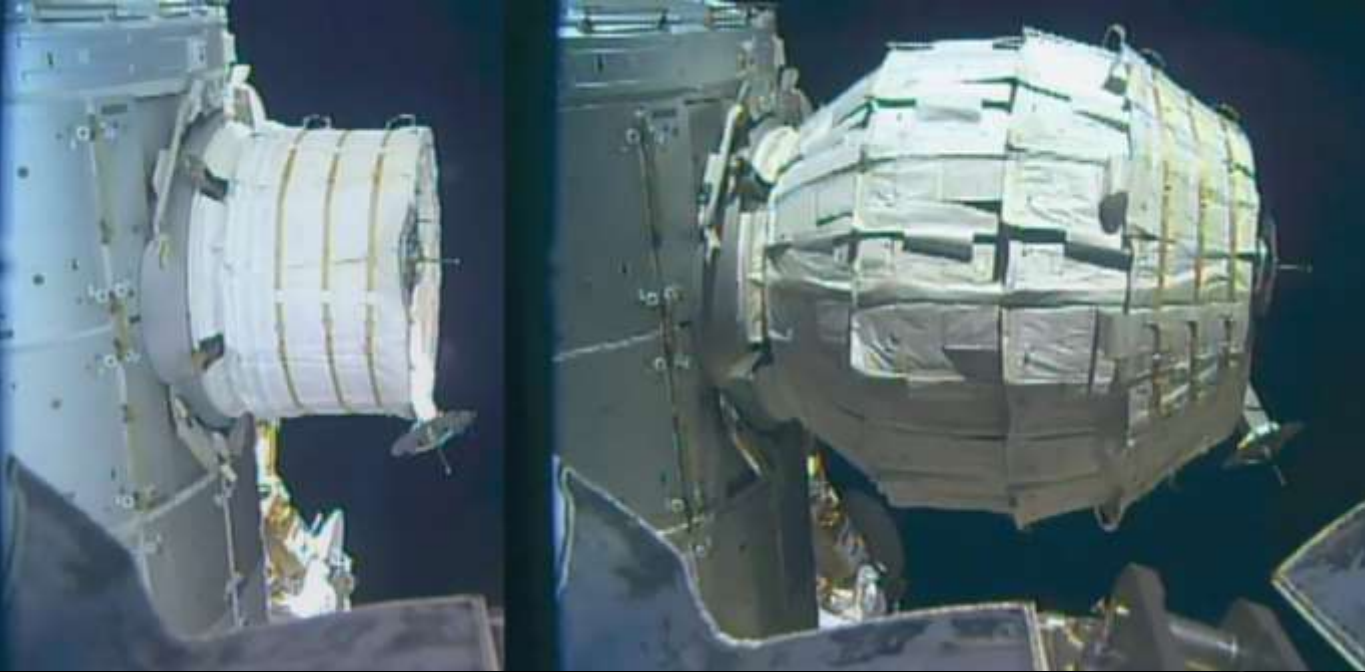


SpaceX Dragon

Boeing
CST-100



Russian PPST



Robert Bikgelow's Inflatable Space Station



US-Based Launch & Reentry Sites



19 U.S. Government and Commercial Launch & Reentry Sites

- 8 Managed by US Government
- 10 Managed by State Agencies in partnership with Private Industry
- 1 Managed by a University
- 4 Orbital launches only
- 10 Suborbital launches only
- 5 Orbital & Suborbital launches

Launch Site	Operator	State or Country	Type of Launch Site	Type of Launches Supported	Currently Available for Commercial Operations?
California Spaceport	Harris Corporation	CA	Commercial	Orbital	Yes
Cape Canaveral Air Force Station	U.S. Air Force	FL	Government	Orbital	SLC-41 (Atlas V) SLC-37B (Delta IV) SLC-40 (Falcon 9) SLC-36 (Blue Origin) Landing Strip
Cecil Field Spaceport	Jacksonville Airport Authority	FL	Commercial	Suborbital	Yes
Edwards Air Force Base	U.S. Air Force	CA	Government	Suborbital	No
Ellington Airport	Houston Airport System	TX	Commercial	Suborbital	Yes
Florida Spaceport	Space Florida	FL	Commercial	Orbital/ Suborbital	Yes
Kennedy Space Center	NASA	FL	Government	Orbital	LC-39A (Falcon 9/Heavy) Shuttle Landing Facility
Mid-Atlantic Regional Spaceport	Virginia Commercial Space Flight Authority	VA	Commercial	Orbital	Yes
Midland International Air and Space Port	Midland International Airport	TX	Commercial	Suborbital	Yes
Mojave Air and Space Port	East Kern Airport District	CA	Commercial	Suborbital	Yes
Oklahoma Spaceport	Oklahoma Space Industry Development Authority	OK	Commercial	Suborbital	Yes
Pacific Missile Range Facility	U.S. Navy	HI	Government	Suborbital	No
Pacific Spaceport Complex Alaska	Alaska Aerospace Corporation	AK	Commercial	Orbital/ Suborbital	Yes
Poker Flat Research Range	University of Alaska Fairbanks Geophysical Authority	AK	Non-Profit	Suborbital	Five pads available for suborbital launches
Ronald Reagan Ballistic Missile Defense Test Site	U.S. Army	Republic of the Marshall Islands	Government	Orbital/ Suborbital	Omelek Island launch pad
Spaceport America	New Mexico Spaceport Authority	NM	Commercial	Suborbital	Yes
Vandenberg Air Force Base	U.S. Air Force	CA	Government	Orbital/ Suborbital	SLC-2 (Delta II) SLC-3E (Atlas V) SLC-4E (Falcon 9 and Falcon Heavy) SLC-6 (Delta IV) SLC-8 (Minotaur) SLC-576E (Minotaur-C)
Wallops Flight Facility	NASA	VA	Government	Orbital/ Suborbital	No
White Sands Missile Range	U.S. Army	NM	Government	Suborbital	No

SpaceX McGregor Rocket
Development and Test Facility
(McGregor, TX)



Non-Licensed US Sites

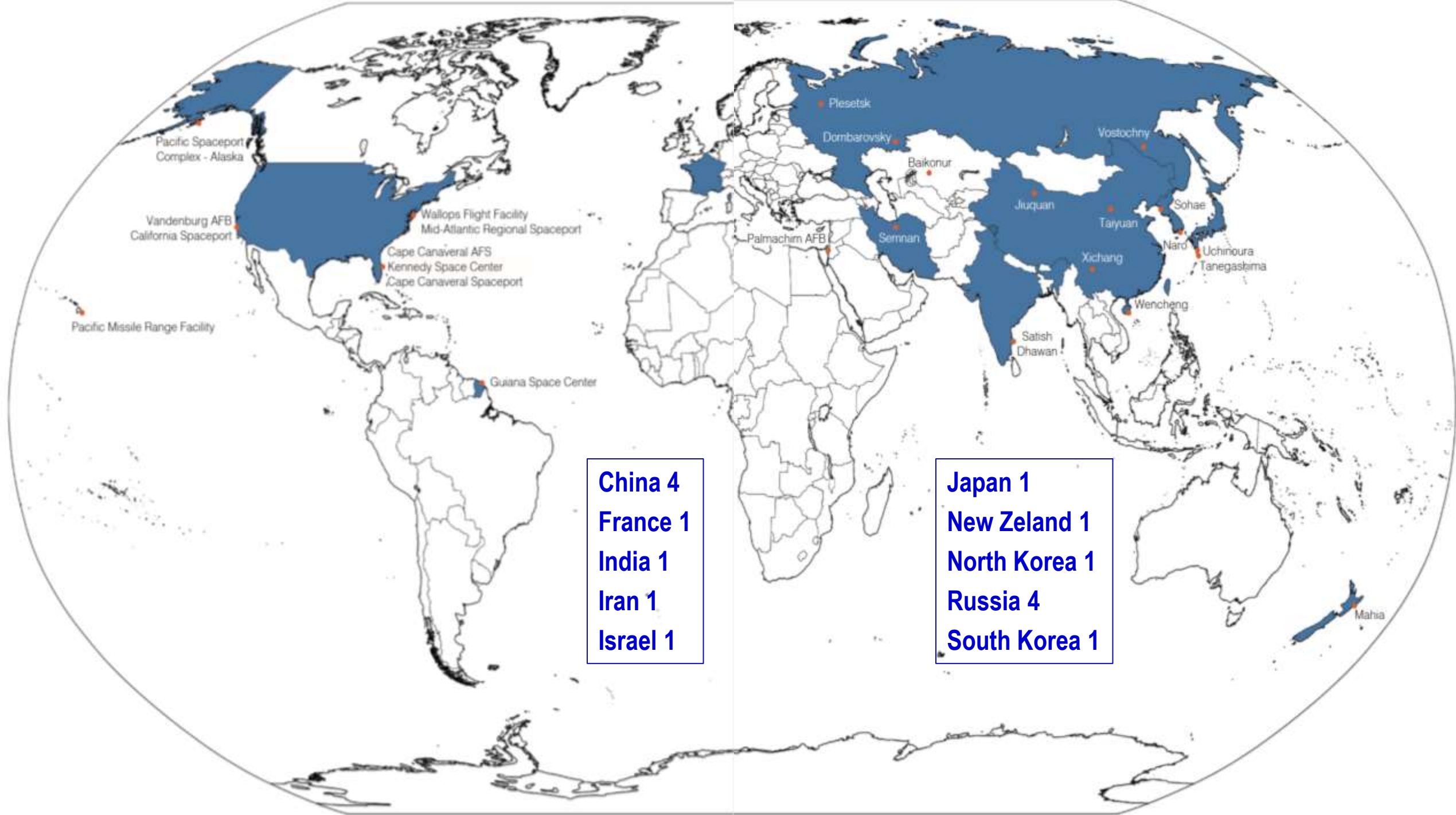
Poker Flat Rocket Range
(Near Fairbanks, AK)



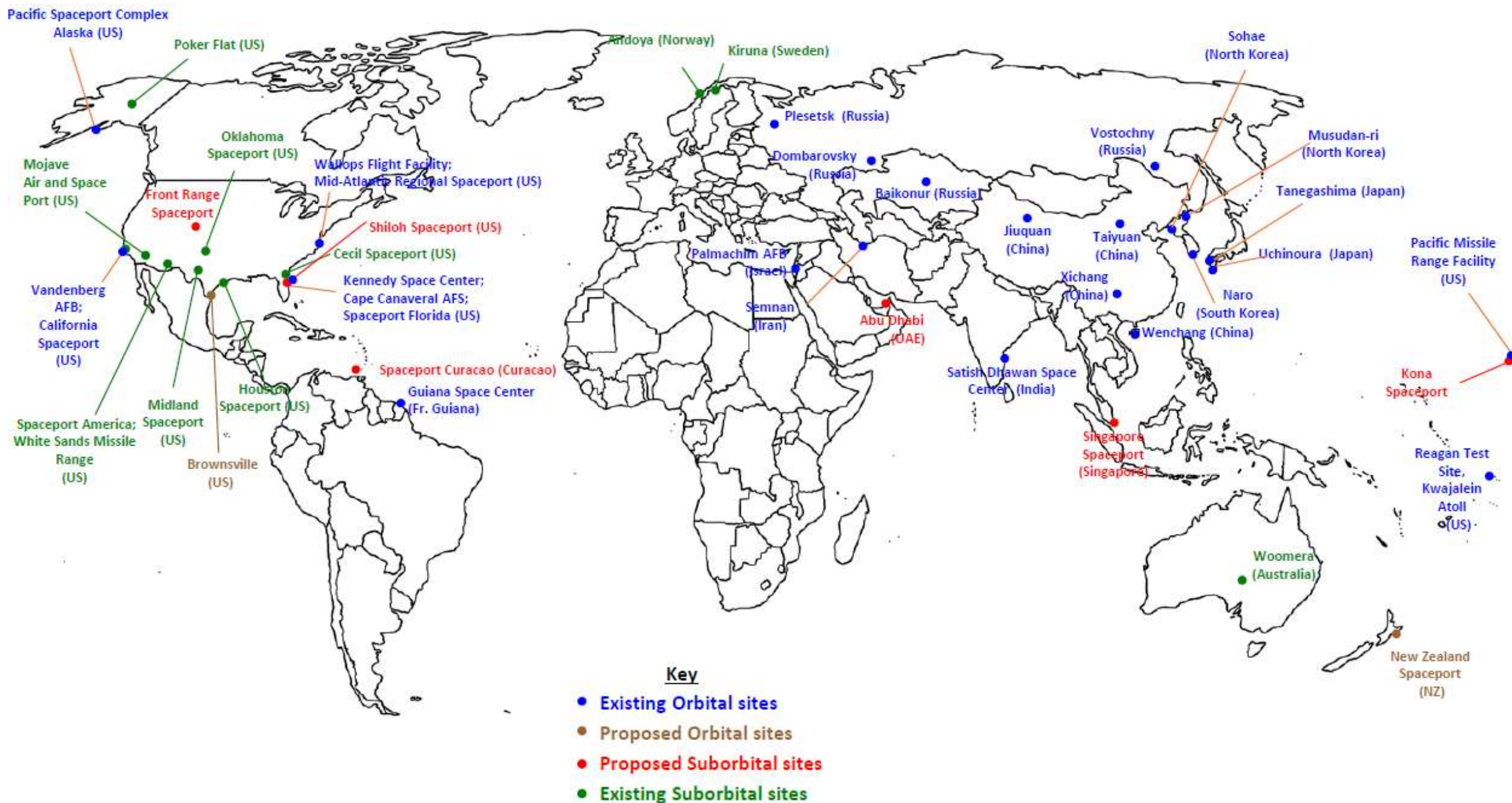
Blue Origin West Texas
Rocket Flight Facility
(Near Van Horn, TX)



Non-US
Launch & Reentry
Sites in 10 Countries



Existing and Proposed Global Launch Sites



State of the Spacecraft Industry



Commercially Launched Spacecraft – Mission Types

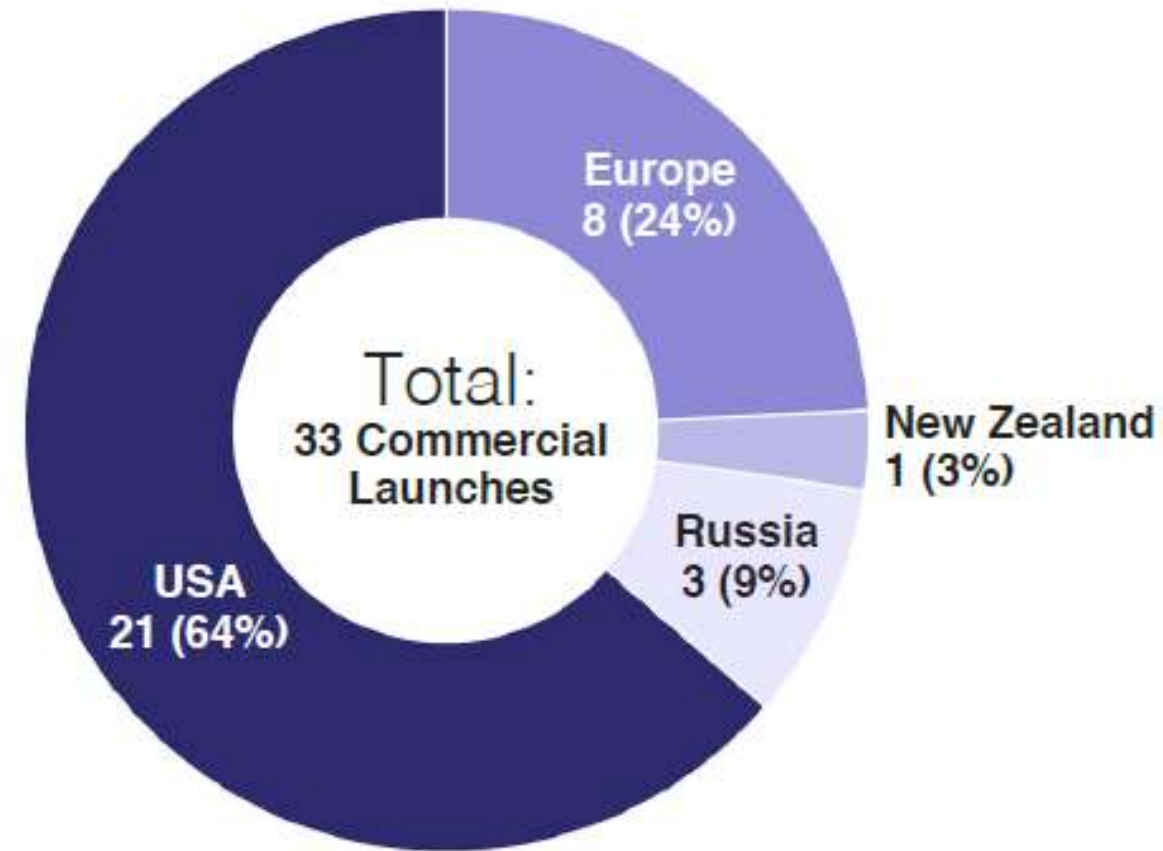
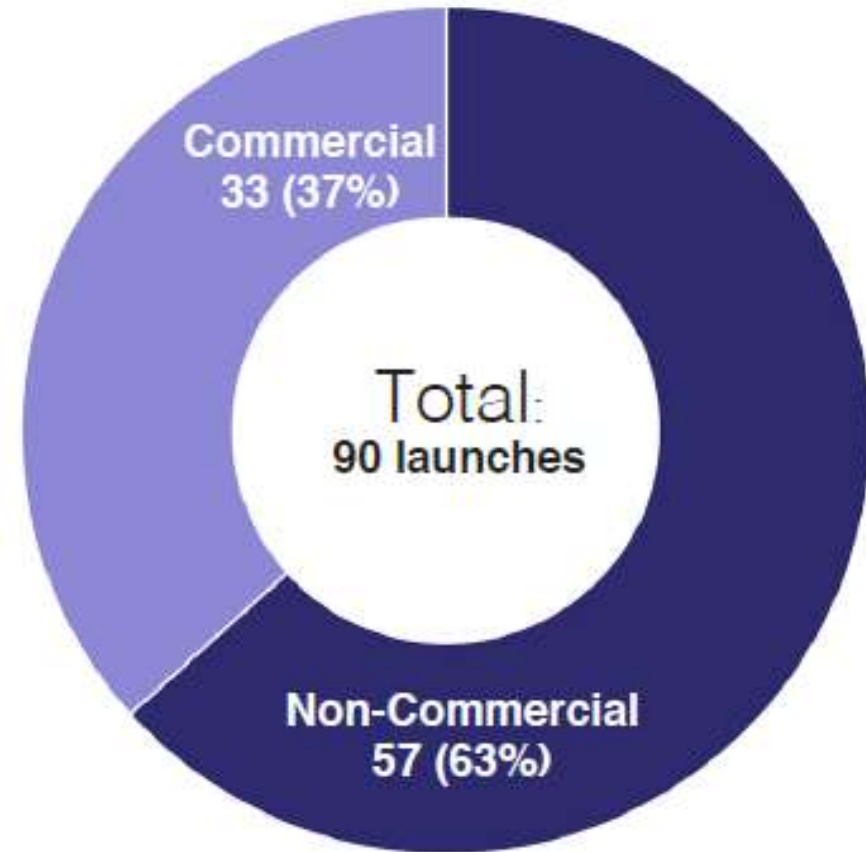
- Communications satellites
- Remote sensing or Earth observation satellites
- Crew and cargo missions - including on-orbit vehicles and platforms
- Launch vehicle test and demonstration missions - typically involving telemetry packages or dummy payloads
- Other commercially launched payloads - usually satellites launched for various purposes by governments of countries not having orbital launch capability



Civil, Military, Non-Profit and Commercial Spacecraft Launched in 2017

Country of Manufacturer	Civil	Military	Non-Profit	Commercial	Total
Argentina	0	0	0	1	1
Australia	0	0	5	0	5
Canada	2	0	1	0	3
Chile	0	0	1	0	1
China	9	14	7	6	36
Ecuador	0	0	1	0	1
Europe	8	1	25	57	91
India	8	0	1	0	9
Israel	1	0	1	0	2
Japan	6	2	5	3	16
Kazakhstan	0	0	1	0	1
Russia	13	5	5	1	24
South Africa	0	0	2	0	2
South Korea	0	0	3	0	3
Taiwan	1	0	1	0	2
Turkey	0	0	2	0	2
UAE	0	0	1	0	1
Ukraine	0	0	1	0	1
USA	9	13	22	224	268
TOTALS	57	35	85	292	469

Global Orbital Launches in 2017



5 launches failed

Commercial ***Space Transportation*** **Forecast**



Commercial Space Transportation Payload and Launch Forecast

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total	Avg.
Payloads												
GSO Forecast	28	23	23	20	21	20	20	20	20	20	215	21.5
NGSO Forecast	341	397	339	305	256	253	260	242	243	210	2,846	284.6
Total Payloads	369	420	362	325	277	273	280	262	263	230	3,061	306.1
Launches												
GSO Medium-to-Heavy	21	19	19	17	17	18	16	17	18	18	180	18
NGSO Medium-to-Heavy	17	18	18	15	15	15	16	13	14	12	153	15.3
NGSO Small	14	13	14	8	7	8	8	6	6	6	90	9
Total Launches	52	50	51	40	39	41	40	36	38	36	423	42.3

US and International Commercial Space Transportation Laws and Policies



FAA Regulatory Authority

- The U.S. Congress has only incrementally expanded DOT/FAA authority over commercial space transportation
 - 1984 included launch authority
 - 1998 added reentry authority
 - 2004 added firm authority over commercial human space flight (CSLAA)
- U.S. law contains limitations on FAA authority:
 - The FAA can only regulate “to the extent necessary”
 - The FAA does not certify space launch vehicles; it licenses the launch operation
 - Mission success is the responsibility of the commercial launch operator
 - Included in the 2004 Commercial Space Launch Amendments Act (CSLAA): “...the regulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew or space flight participants to avoidable risks as the public comes to expect greater safety for crew and space flight participants from the industry.”
- **FAA cannot protect people onboard space vehicles**
 - Congress extended industry “Learning Period” to September 30, 2023—meaning no new regulations related to human safety can be introduced
 - Thus: Informed Consent

International Policy Framework for Space Operations



- 
- **Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (1967)**
 - **Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (1968)**
 - **Convention on the International Liability for Damage Caused by Space Objects (1972)**
 - **Convention on the Registration of Objects Launched into Outer Space (1974)**

International Outer Space Treaty

- Article I: The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out *for the benefit and in the interest of all countries*
- Article II: Outer space, including the moon and other celestial bodies, *is not subject to national appropriation by any means*

International Outer Space Treaty

- Article V: The astronauts of one State shall render all possible assistance to the astronauts of other States
 - Definition of an Astronaut (Webster's): A person who travels beyond the earth's atmosphere

International Outer Space Treaty

- Article VI: The activities of *non-governmental entities* in outer space shall *require authorization and continuing supervision by the appropriate State*
- Article VII: Each State that launches or procures the launching of an object into outer space, and each State from whose territory or facility an object is launched, *is internationally liable for damage to another State*

International Outer Space Treaty

- Article VIII: A State on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, *and over any personnel thereof*, while in outer space (crime issues)
- Article IX: In the exploration and use of outer space States shall be guided by the *principle of cooperation and mutual assistance*