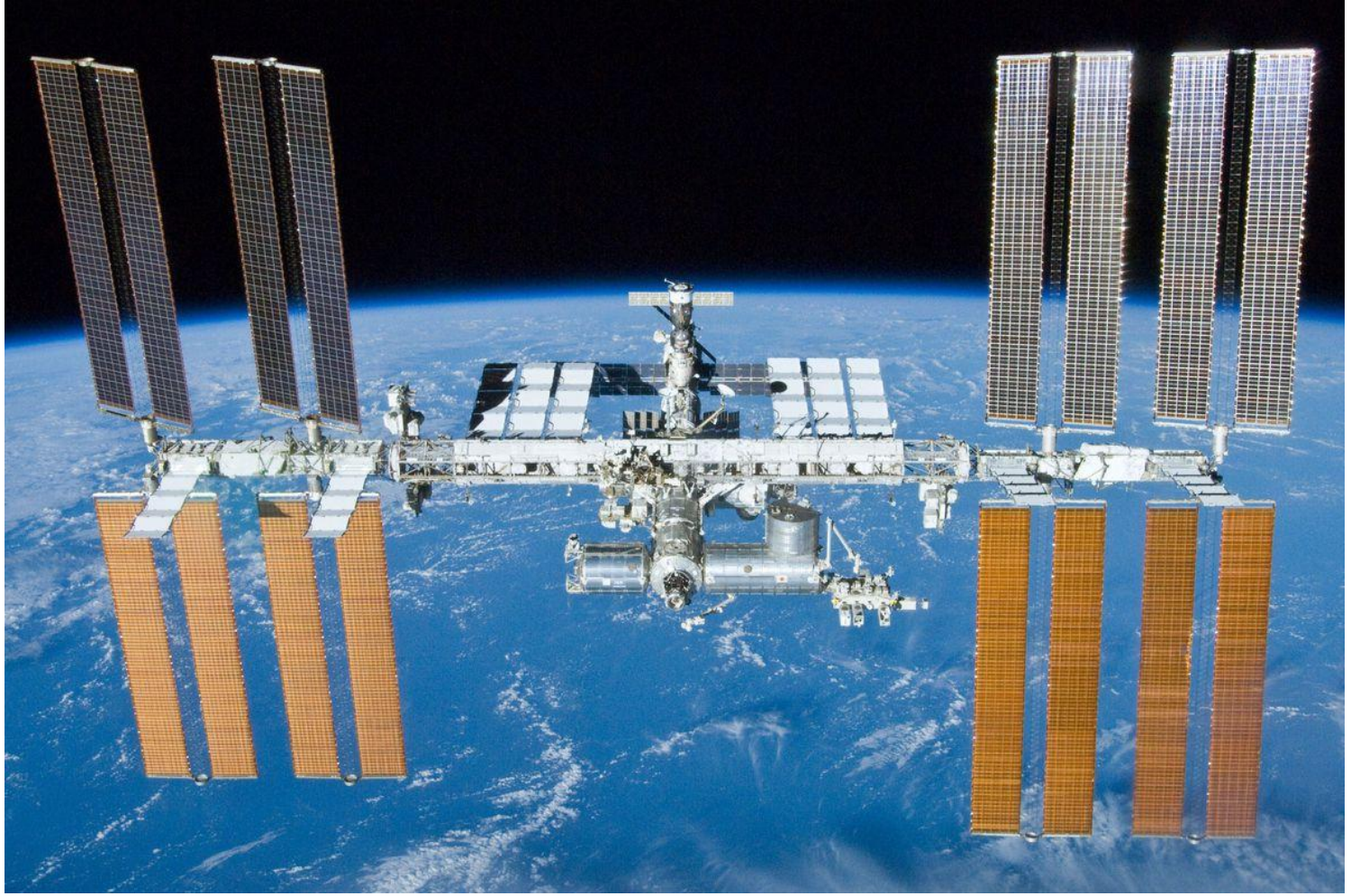

2018 Milestones in Space Development

This slide set was endorsed by the NSS Policy Committee on 6/19/18

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What should be considered a "Milestone in Space Development"?

- Events with the following characteristics:
  - New
  - Public
  - Verifiable
  - Not a paper event
  - Supports space development and settlement in some fashion
    - Not focused on exploration milestones per se
    - Clearly there is a connection between exploration, development, and settlement
- Themes:
  - Competition
  - Partnerships
  - Diverse efforts
  - Synergy between exploration and development
  - NASA is important/vital but not the main player

Why is Space Development important?

- Commercially-enabled exploration can reverse the trend of exploration becoming more and more expensive with time
- Development leads to benefits on Earth
  - Weather satellites, GPS, comsats, eventually SPS
- Development leads to settlement
- Development will extend range of exploration
- A self-sustaining space economy does not depend on the whims of Congress
- A self-sustaining space economy is protected from the effects of an ageing US population

Milestones so far in 2018

- **Jan. 13:** First return of MIS ZBLAN results on CRS-13
- **Jan. 20:** First Rocket Lab orbital launch
- **Feb. 6**: First Falcon Heavy Flight
- **Feb. 22:** First flight of Starlink test satellites
- **April 2**: Launch of Robotic refueling mission 3 on CRS-14
- **April 2:** ESA Remove Debris test launched on CRS-14
- **April 5:** Return to flight by Space Ship Two
- **April 18:** Launch of TESS
- **April 25**: Planetary Resources Arkayd-6 Declared a Success
- **April 29**: 2nd flight of new version of New Shepard
- **May 11:** First flight of Block 5 Falcon 9

Jan. 13: First return of MIS ZBLAN results on CRS-13

- **Who:** Made In Space (ZBLAN)/SpaceX Dragon (Return from Space)
- **What:** First return of ZBLAN test materials from Space
- **Where:** Pacific Ocean off the cost of Baja California
- **Why important**: ZBLAN optical fiber made in space has the potential to be the first profitable product actually manufactured in space. Also, Dragon capsule AND F9 first stage for launch were both re-used.

Jan. 20: First Rocket Lab orbital launch

- **Who:** Rocket Lab
- **What:** First orbital launch of “Electron” rocket
- **Where:** New Zealand
- **Why important:** Built of composites, and featuring electric pumps with “drop-away” batteries, the Electron promises to bring lower per flight costs to cubesats. Can launch up to 150 kg to sun-synchronous orbit

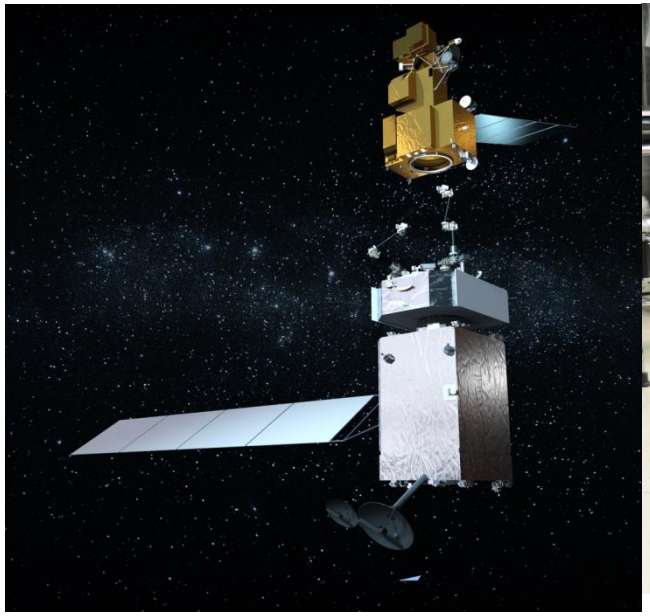
February 6: First Falcon Heavy Flight

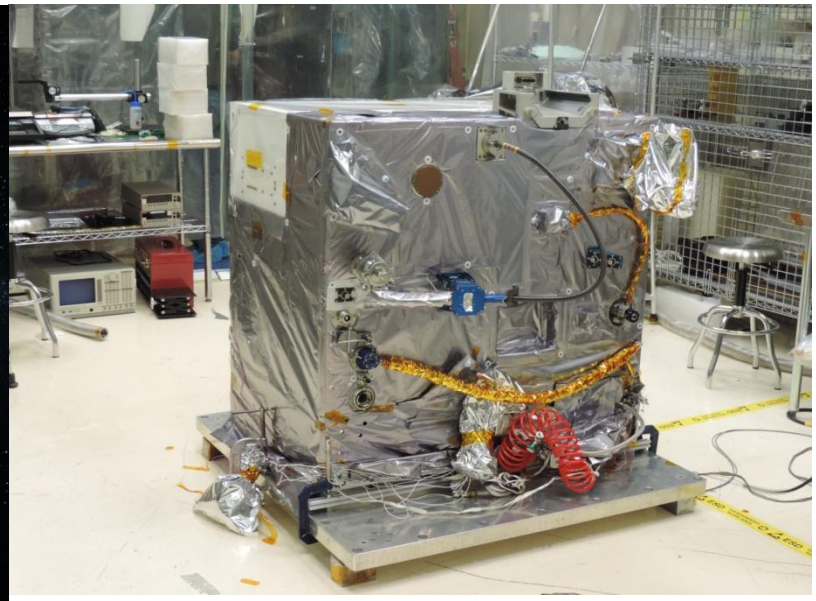
- **Who:** SpaceX
- **What:** First orbital launch of “Falcon Heavy” sends Red Tesla toward Mars
- **Where:** Kennedy Space Center Launch Complex 39A
- **Why important:** Sets new low price point per pound launched; re-usable center core and side boosters promise new era of low-cost heavy lift. From SpaceX perspective, allows SpaceX to compete for large military satellite launches. Can launch 63MT to LEO.

Feb. 22: First flight of Starlink test satellites

- **Who:** SpaceX
- **What:** First launch of Starlink demo satellites TinTinA and TinTinB
- **Where:** Vandenberg Air Force Base, California
- **Why important**: Tests technology needed for 4,500 Low Earth Orbit broadband data communications satellites that SpaceX plans to launch to provide global low-cost, low-latency Internet access, with the profits funding Mars settlement. Musk has since tweeted that they are getting 25 msec latency compared to 600-800 msec for geosynchronous satellites used today.

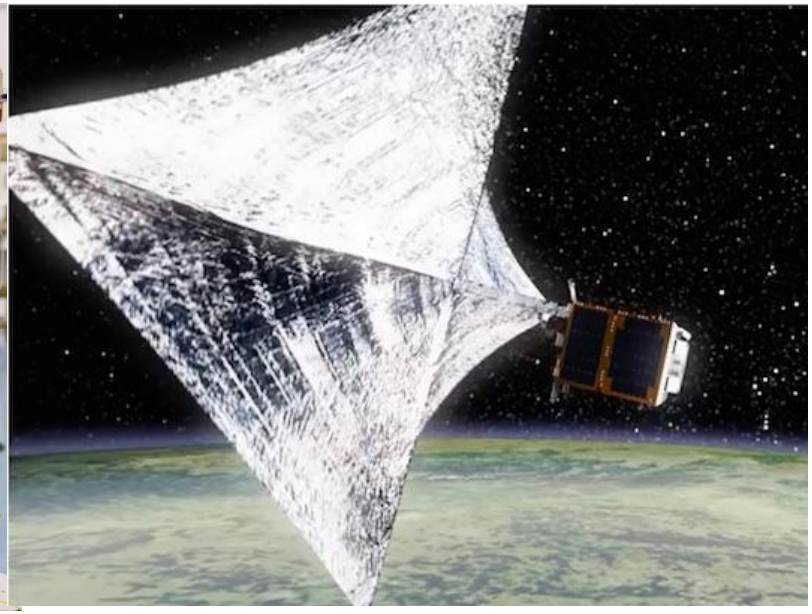
April 2: Launch of Robotic Refueling Mission 3 on CRS-14





- **Who:** NASA Goddard (test robot)/SpaceX (launch of CRS-14)
- **What:** Phase 3 of the Robotic Refueling test program
- **Where:** Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida
- **Why important**: ISS based test has two objectives (1) transfer cryogenic liquid methane in microgravity and (2) store the fluid for six months with zero boil-off. It is hard to find an experiment more important to space development than this one! Virtually all plans for large-scale operations in space require fuel transfer and fuel depots.

April 2: Remove Debris test launched on CRS-14



- **Who:** European Commission plus consortium of corporations (Remove Debris Satellite)/SpaceX (Launch of CRS-14)
- **What:** Launch of test satellite from ISS using a Nanoracks carrier and the Kibo launcher.
- **Where:** Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida
- **Why important**: Tests using nets and harpoons to remove space debris. Will be the biggest satellite yet launched from the ISS. Space debris have the potential to shut down space development, so fixing the problem is of great importance.

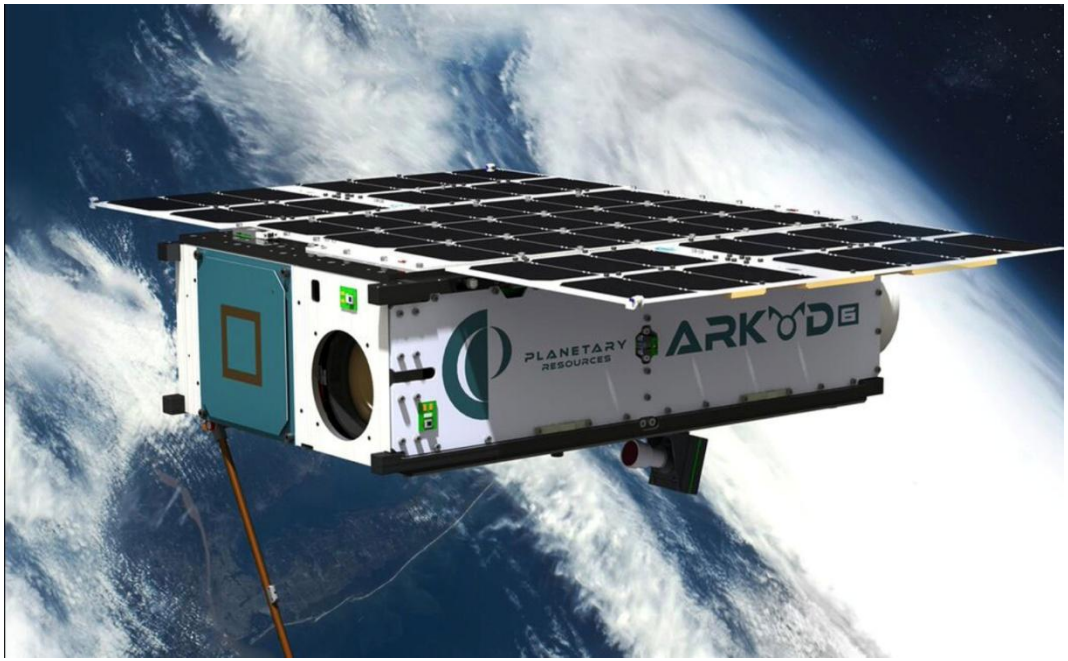
April 5: Return to flight by Space Ship Two

- **Who:** Virgin Galactic/VSS Unity
- **What:** First powered flight of Space Ship Two after a fatal crash 3 ½ years ago
- **Where:** Mojave, California
- **Why important**: Gets Virgin Galactic back on track to compete with Blue Origin for the sub-orbital space tourism market. Flight reached Mach 1.87 and a height of 25K meters before safely returning to the Mojave Air and Space Port runway. These numbers bettered those achieved prior to the accident in October 2014 which killed one of the two pilots.

April 18: Launch of TESS

- **Who:** NASA(money)/SpaceX (launch)/Orbital ATK(satellite)
- **What:** Launch of Transiting Exoplanet Survey Satellite (TESS)
- **Where:** Space Launch Complex 40 at Cape Canaveral, Florida
- **Why important**: Similar to Kepler but will scan the entire sky. Expected to find more than 5,000 exoplanets, including 50 Earth-sized planets. Will work in combination with James Webb Space telescope to understand exoplanets. During the 60s, the knowledge that Mars was a parched desert and Venus a hell-world led to decreased public interest in space. We now have the potential to find Earth-like worlds around distant suns, and eventually to confirm the existence of life remotely. TESS is an important step in this journey.

April 25: Planetary Resources Arkyd-6 Declared a Success



- **Who:** Planetary Resources
- **What:** First results from launch of Arkyd 6 test vehicle
- **Where:** Launched Jan.11 on Indian Polar Satellite Launch Vehicle (PSLV)
- **Why important**: Using the first commercial mid-wave infrared imager, the Arkyd 6 demonstrated the technologies that will be used by the 2020 targeted Arkyd 301 to detect asteroids with water so that they can be processed into rocket fuel and oxygen.

April 29: 2nd flight of new version of New Shepard

- **Who:** Blue Origin
- **What:** 2nd launch of new version of the "New Shepard"
- **Where:** Blue Origin West Texas launch site
- **Why important**: Step toward crewed flights with tourists; also carried experimental payloads from German universities (3), NASA's Johnson Space Flight Center, and a Solstar payload testing wifi for future New Shepard passengers.

May 11: First flight of Block 5 Falcon 9

- **Who:** SpaceX (launch)/Thales Alenia Space(satellite)
- **What:** First Launch of the Block 5 Falcon 9; carried Bangabandhu-1 to orbit for Bangladesh
- **Where:** Launch Complex 39A at Kennedy Space Center, Florida
- **Why important**: The Block 5 version of the F9 is designed to be flown 10 times without refurbishment. There are 100s of improvements, including titanium grid fins, improved turbine blades, more thrust, fully retractable legs, and improved heat shields. The Block 5 has the potential to significantly lower the cost of reaching orbit.

Projected 2H 2018 Milestones

- **June 29**: Launch of ZBLAN Phase 2 on CRS-15
- **June-Oct:** Hayabusa 2 at Asteroid Ryugu
- **Nov:** Launch of IDA-3 on CRS-16
- **Nov:** Launch of FOMS on CRS-16
- **Nov:** Solar Sail on FH 2nd flight
- **Dec. 3:** Osiris Rex at Asteroid Bennu
- **2H 2018:** Re-use of Block 5 Falcon 9
- **2H 2018**: First flight of VG Launcher One
- **2H 2018**: Space Ship Two crosses Karman line
- **2H 2018**: New Shepard flies with a crew
- **2H 2018**: Boeing Commercial Crew demo flight
- **2H 2018:** SpaceX Commercial Crew demo flight

June 29: Launch of ZBLAN Phase 2 on CRS-15

- **Who:** Made in Space (ZBLAN), SpaceX (launch)
- **What:** 2nd launch MIS ZBLAN experiment
- **Where:** Florida, USA
- **Why important**: Progress toward products being made profitably in space.

June-Oct: Hayabusa 2 at Asteroid Ryugu

- **Who:** JAXA (Japanese space agency)
- **What:** Probe to retrieve sample of asteroid Ryugu
- **Where:** Launched Dec 4, 2014 on a H-IIA 202 from Tanegashima Space Center
- **Why important**: Step toward asteroid mining. Planetary Resources estimates Ryugu is worth $83B. Ryugu is a rare near-Earth asteroid that is both C-type (carbonaceous) and G-type (may contain clay/mica). It is about 1 km In diameter. Shows synergy between exploration and development.

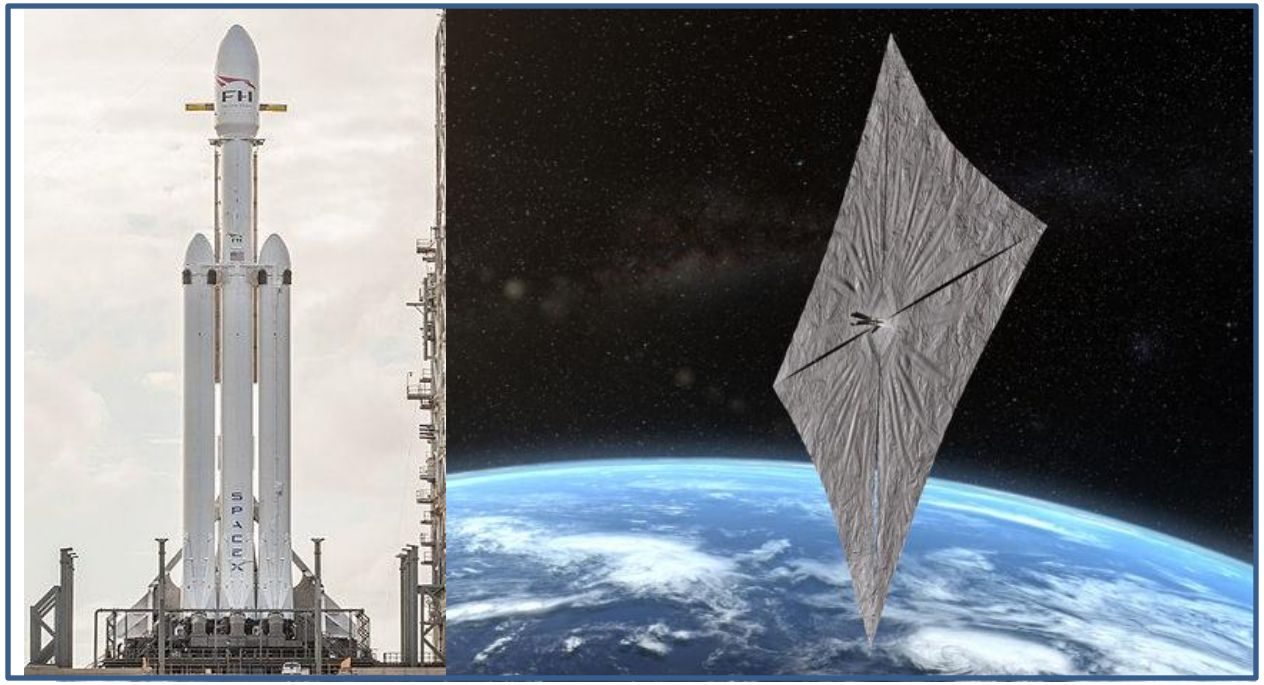
Nov: Launch of IDA-3 on CRS-16

- **Who:** NASA (IDA-3)/SpaceX Falcon 9-Dragon(launch)
- **What:** Addition of 2nd International Docking Adaptor to ISS
- **Where:** Planned to be launched from Florida
- **Why important**: Replaces IDA-2 which was destroyed when CRS-7 was lost in 2015. Commercial crew uses the IDAs, and two are needed for redundancy. Installing IDA-3 is a key step toward making Commercial Crew operational.

Nov: Launch of FOMS on CRS-16

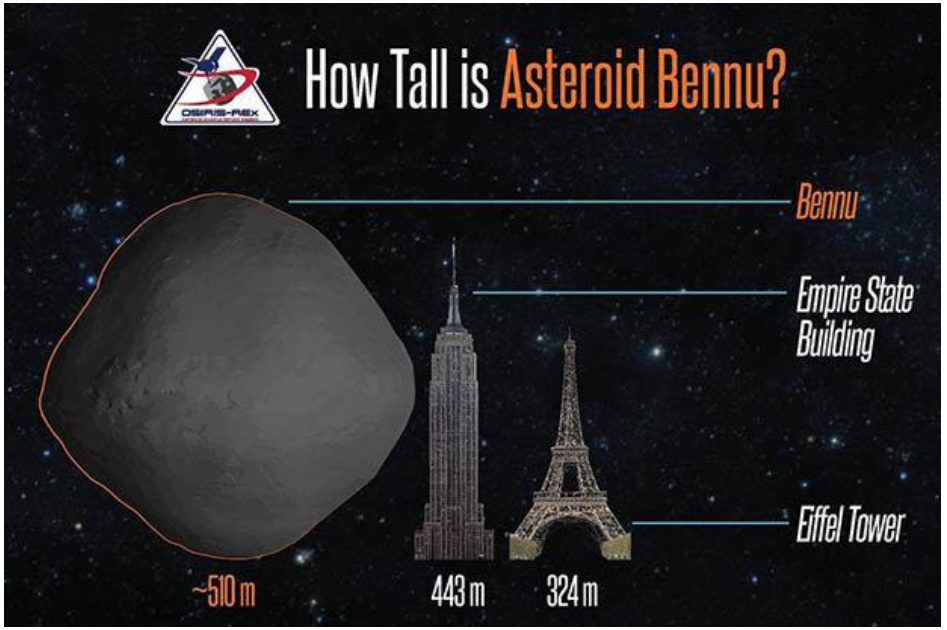
- **Who:** FOMS, Inc. (ZBLAN), SpaceX (launch)
- **What:** Competitor to MIS making fiber optic cable in space
- **Where:** Florida, USA
- **Why important**: Progress toward products being made profitably in space. Two companies doing the same kind of thing validates the marketplace.

Nov: Solar Sail on FH 2nd flight



- **Who:** Air Force (money), Planetary Society (solar sail), SpaceX (launch)
- **What:** Launch of Light Sail 2 on 2nd Flight of Falcon Heavy
- **Where:** SLC 39A, Florida USA
- **Why important**: Solar sails hold the promise of inexpensive travel throughout the solar system when rapid acceleration is not a requirement. The 2nd flight of the Falcon Heavy will use “Block 5” technology and demonstrate a key step toward Air Force certification of the rocket.

Dec. 3: Osiris Rex at Asteroid Bennu



- **Who:** NASA Goddard (money), Lockheed (probe), ULA (launch)
- **What:** Osiris Rex reaches asteroid Bennu to collect samples
- **Where:** Launched Sept. 8, 2016 on a ULA Atlas V 411 from LC41 at Cape Canaveral, Florida.
- **Why important**: Step toward asteroid mining and planetary defense. Bennu is a C-type (carbonaceous) asteroid with a 1-in-2700 chance of striking Earth between 2175-2199. Understanding its structure promotes both goals. Shows synergy between exploration, development, and planetary defense.

2H 2018: Re-use of Block 5 Falcon 9

- **Who:** SpaceX
- **What:** 2nd/3rd launch of a F9 “Block 5” first stage
- **Where:** Florida, USA
- **Why important**: The first re-use of the Block 5 F9 will show that SpaceX has carefully examined the first one to fly, and determined that it is wearing as expected. Over time will lead to lower launch costs. The second re-use will make history. Also, NASA is requiring seven Block 5 flights before a crew can fly on one.

2H 2018: First flight of VG Launcher One

- **Who:** Virgin Orbit
- **What:** First launch of “Launcher One” from “Cosmic Girl”
- **Where:** Mojave Air and Space Port, California
- **Why important**: Can place 300 kg into a 500 km sun-synchronous orbit. Will support deployment of OneWeb LEO constellation which competes with Starlink. Provides a new launch option for small satellites, competing directly with Rocket Lab.

2H 2018: Space Ship Two crosses Karman line

- **Who:** Virgin Galactic
- **What:** Powered flight of VSS Unity reaches official edge of space
- **Where:** Mojave Air and Space Port
- **Why important**: Will signal that Virgin Galactic is close to operational status for sub-orbital tourism, and that Blue Origin has a fight on their hands.

2H 2018: New Shepard flies with a crew

- **Who:** Blue Origin
- **What:** First launch of the “New Shepard” with a crew
- **Where:** Blue Origin West Texas launch site
- **Why important**: Key step toward crewed flights with tourists; signals Virgin Galactic will have a fight on their hands.

2H 2018: Boeing Commercial Crew demo flight

- **Who:** NASA (money), Boeing (Starliner), ULA (launch)
- **What:** First uncrewed launch of Starliner on a ULA Atlas
- **Where:** Florida, USA
- **Why important**: Vital first step toward restoring US crew access to the ISS on a US-built capsule. May help build foundation of future orbital tourism industry and support future commercial LEO space stations.

2H 2018: SpaceX Commercial Crew demo flight

Who: NASA (money), SpaceX(Dragon 2), SpaceX(launch)
What: First uncrewed launch of Dragon 2 on a SpaceX Block 5 Falcon 9
Where: Florida, USA
Why important: Vital first step toward restoring US crew access to the ISS on a US-built capsule and launched on a US-built rocket. May help build foundation of future orbital tourism industry and support future commercial LEO space stations.

Questions?