
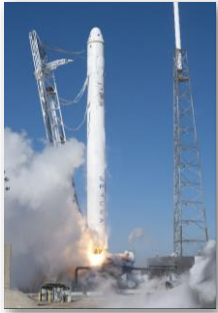


Today's Class: NASA's Commercial Space projects

- Reading for next class on Space Telescopes: Sections 5.1-5.2 and Sections 6.1-6.3 in Cosmic Perspective.
- Homework #3 next week.

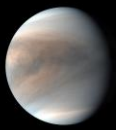
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1

Life On Venus

Presenter: Aiden Chase

- Scientists have found "phosphine" on Venus.
- Phosphine is a gas only produced by Biological Processes!
- It has been named as a Russian Planet.
Can Russia Claim a planet before they have even explored it?



2

Last Lecture

- Overview of Space Shuttle Program
 - History of Shuttle Program
 - Space Shuttle mission profile
- Servicing the Hubble Space Telescope
- The International Space Station (ISS)
- Tragic accidents: Challenger & Columbia
- Costs to launch the Space Shuttle

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3

Today's Class

- NASA's Commercial Orbital Transportation Services Program**
 - Northrup Grumman's *Antares + Cygnus*
 - SpaceX's *Falcon + Dragon*
 - Sierra Nevada *Dream Chaser*
- NASA's Commercial Crew Program**
 - Space X
 - Boeing CST-100, *Starliner*
- Project Artemis**
 - Human crew landing by 2024.
 - Buy lander services from commercial companies

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NASA's ISS Commercial Resupply Program

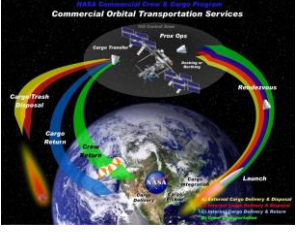
- NASA has invested over \$800 million toward cargo space transportation development to LEO. Companies are paid as they achieve milestones.
- Three companies had first contracts:
 - **Space X** - \$1.6 billion for 12 flights
 - **Northrup Grumman** - \$1.9 billion for 8 flights
 - **Sierra Nevada** - undisclosed

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Goals for Commercial Resupply Program

- Transfer Low-Earth orbit operations to the private sector
- Purchase low-Earth orbit services**
- Limited Government Investment
- Lower barriers of entry
 - o Reduce stringent requirements
 - o Expand technological capabilities
- Fixed price (as opposed to cost plus) milestones





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Northrup Grumman: Antares + Cygnus

- Antares rocket + Cygnus spacecraft.
- Antares has 2-stages:
 - 1st stage is LOX & kerosene.
 - 2nd stage is solid rocket motor.
- Cygnus (pressurized volume = 27 m³) does not survive re-entry.






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Space Exploration Technologies (Space X): Falcon + Dragon

- Falcon 9 rocket + Dragon capsule.
- Falcon 9 has 2-stages:
 - 1st stage has 9 LOX + kerosene engines.
 - 2nd stage is one of same engines.
- Dragon provides pressurized cargo to Earth (payload volume 11 m³).
Reusable.


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SIERRA NEVADA CORPORATION
Space Systems
A WORLD CLASS LEADER IN SPACE SYSTEMS & TECHNOLOGIES

- *Dream Chaser* development is in Louisville, CO.
- Reusable lifting-body spacecraft carries cargo to and from LEO, including to & from the ISS.
- Launches vertically on a United Launch Alliance (ULA) Vulcan.
- Capable of free flight in LEO and of docking to the ISS & other orbital destinations
- Low-g re-entry (< 1.5 g) protects science experiment return samples
- Low-impact horizontal landing on a conventional runway
- Large cross-range with frequent landing opportunities

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NASA's Commercial Crew Program

- **Goal:** achieve safe, reliable and cost-effective human access to & from the ISS and LEO.
- Awarded \$8.2 billion in technology-sharing & contracts in 2 phases.
- **Commercial Crew's Approach for Obtaining Crew Transportation Systems:**
 - NASA's works closely with companies to develop crew transportation systems.
 - Interested companies are free to design the transportation system they think is best. Each company must meet NASA's pre-determined set of requirements.
 - Companies apply efficient & effective manufacturing & business operating techniques throughout the process.
 - Companies own and operate their own spacecraft and infrastructure.
 - Partnership approach allows NASA insight into a company's development process while the agency's technical expertise and resources are accessible to a company.




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NASA Funded 2 Companies for Commercial Crew

- Boeing - \$460 million in initial seed funding
- Space X - \$440 million in seed funding
- In September 2014, NASA down-selected to 2 companies:
 - Boeing - \$4.2 billion
 - Space X - \$2.6 billion




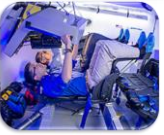
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Crew Space Transportation CST-100

- The CST-100 or *Starliner* is designed to transport up to seven passengers or a mix of crew and cargo to low-Earth orbit destinations such as the International Space Station (ISS) and the Bigelow planned station.
- **Key Features**
 - Reusable up to 10 times
 - Weldless structure
 - Tablet technology
 - Wireless Internet
 - Boeing LED "Sky Lighting"

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Space X Commercial Crew



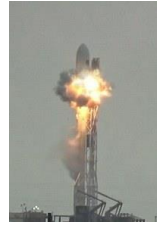
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video

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Class Exercise

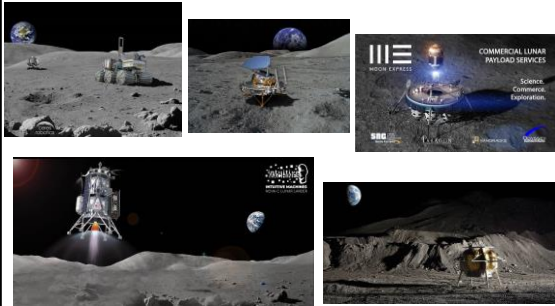
Both Space X and Northrup Grumman have suffered losses of their rockets and payloads during launch. How do you think the American public and the Congress would deal with an explosion during a Commercial Crew launch?



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Commercial Lunar Payload Services



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17

Candidate Human Lunar Lander Systems



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What did we learn today?

- **NASA's Commercial Orbital Transportation Services Program**
 - Northrup Grumman's *Antares + Cygnus*
 - SpaceX's *Falcon + Dragon*
 - Sierra Nevada *Dream Chaser*
- **NASA's Commercial Crew Program**
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