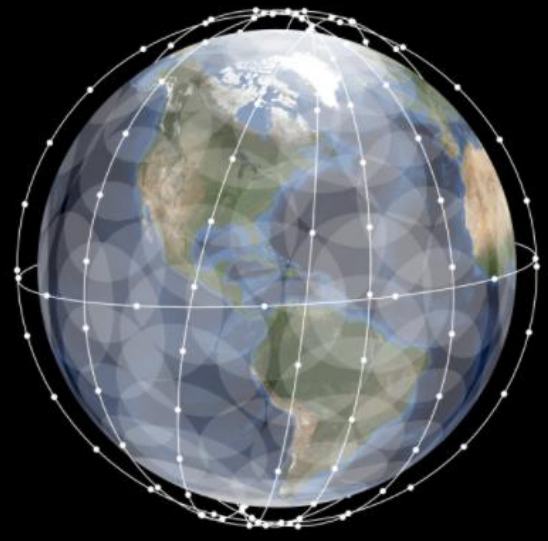


Monthly Space News

Greg Stanley

Sept 4, 2021



NSS North Houston
 **Space Society**

Lunar news



How to NOT to get humans to the moon by 2024:

- SLS test flight may slip to next year
- Spacesuits may hold up Artemis 2024 human landing
- Blue Origin lawyers may hold up Artemis 2024 human landing

Humans to Moon in 2024 delayed by...spacesuits?

- NASA Inspector General: \$1B program is late: 2025 for 2 space suits at earliest
 - NASA spent \$420 M since 2007, plans \$625.2 M more for test suit at ISS + 2 crew suits
 - 27 organizations building parts, vs. 2 to build ISS suits
 - Current 45-year-old ISS suits too restrictive, not designed for long moon walks
 - Current SpaceX flight suits for short-term protection, not long duration outside use
 - Inspector General basically said, “that’s it, we can’t get there by 2024”, not “fix this”!
- NASA will continue work, but now also award commercial contract in 2022

2019 spacesuit prototype (NASA JSC) Credit: Joel Kowsky/NASA



Humans to Moon 2024 delayed by...Blue Origin lawyers?

- Background on Artemis Human Landing System (HLS)
 - HLS takes astronauts between lunar orbit and lunar surface
 - Artemis Human Landing System (HLS) budget was cut
 - NASA awarded HLS contract to SpaceX for a Starship variant
 - Blue Origin protested
 - GAO (Government Accountability Office) rejected the protest
 - Blue Origin also offered \$2B discount (but still \$1B above SpaceX bid)



Image credit: SpaceX

Image credit: Blue Origin

Humans to Moon 2024 delayed by...Blue Origin lawyers?

- Blue Origin is now suing NASA

- NASA halted work under contract again until at least Nov 1
- Analogous to Amazon suit over Pentagon's \$10B JEDI contract
 - Despite initial rulings favoring Microsoft, tied up in court so long that Pentagon abandoned the effort to modernize its IT infrastructure
- Jeff Bezos (2019) (comparing 2019 to Apollo era):

"Today ... the losers would sue the federal government because they didn't win ... The thing that slows things down is procurement. It's become the bigger bottleneck than the technology"
- Costing a lot of good will for company falling farther behind SpaceX, and apparently suffering some brain drain

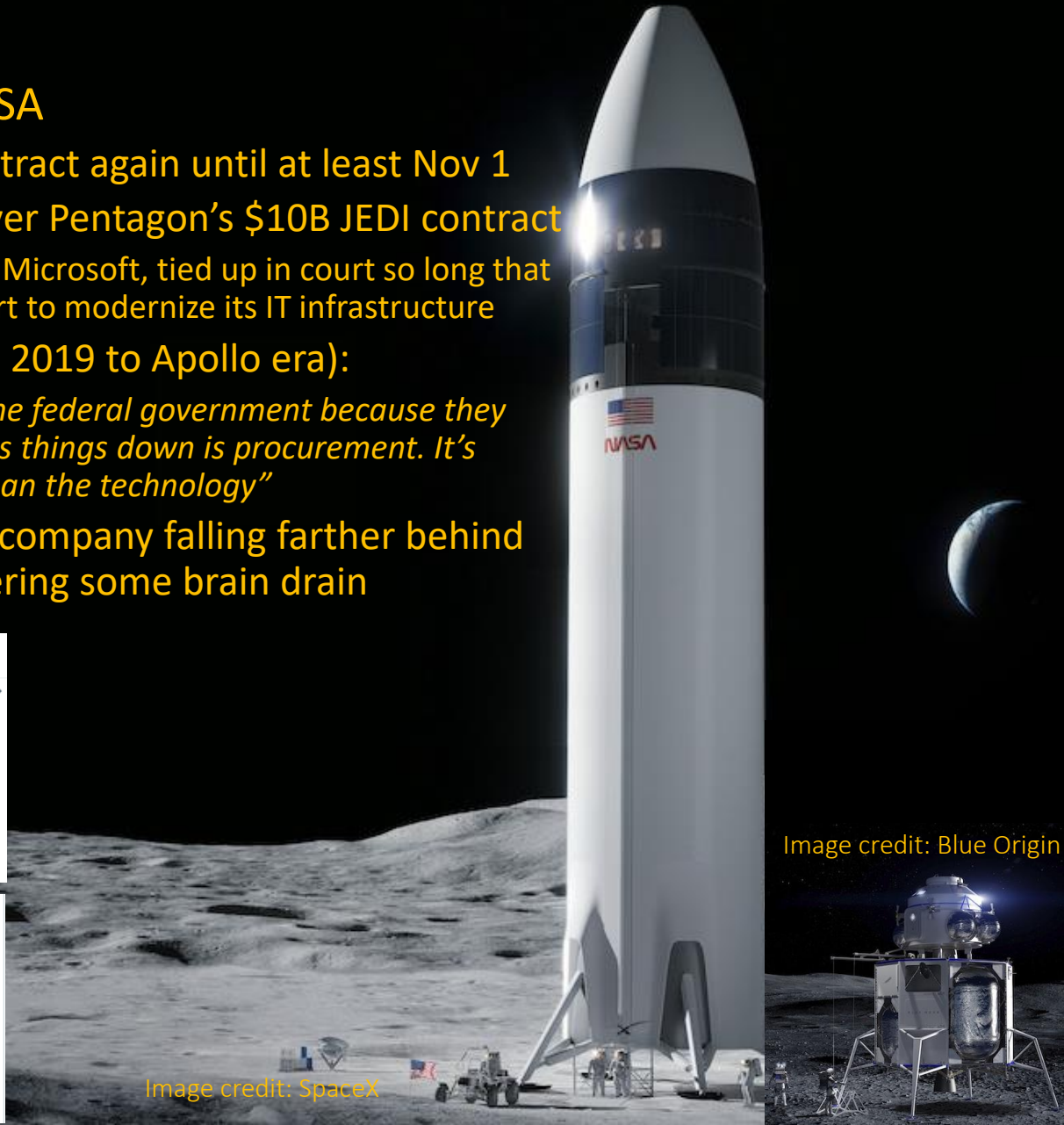


Image credit: Blue Origin

Image credit: SpaceX

← Tweet

 **Elon Musk** ✓
@elonmusk

Replying to @elonmusk and @spacex360

If lobbying & lawyers could get u to orbit, Bezos would be on Pluto rn

9:06 PM · Aug 11, 2021 · Twitter for iPhone

 **Elon Musk** ✓
@elonmusk

Turns out Besos retired in order to pursue a full-time job filing lawsuits against SpaceX ...

12:27 AM · Aug 27, 2021

104K 3.8K Share this Tweet

Mars news

- Status: Mars rovers, helicopter, lander



Picture from Chinese Tianwen-1: CNSA/CASC

NASA Perseverance Mars rover loses its first sample

- First rock sample drilled, thought to be stored, but material was lost
- Leading theory: sample crumbled to dust
- Another theory...



**IM NOT SAYING IT WAS
ALIENS...**

BUT IT WAS ALIENS...



Second rock sample, more solid, appears successful

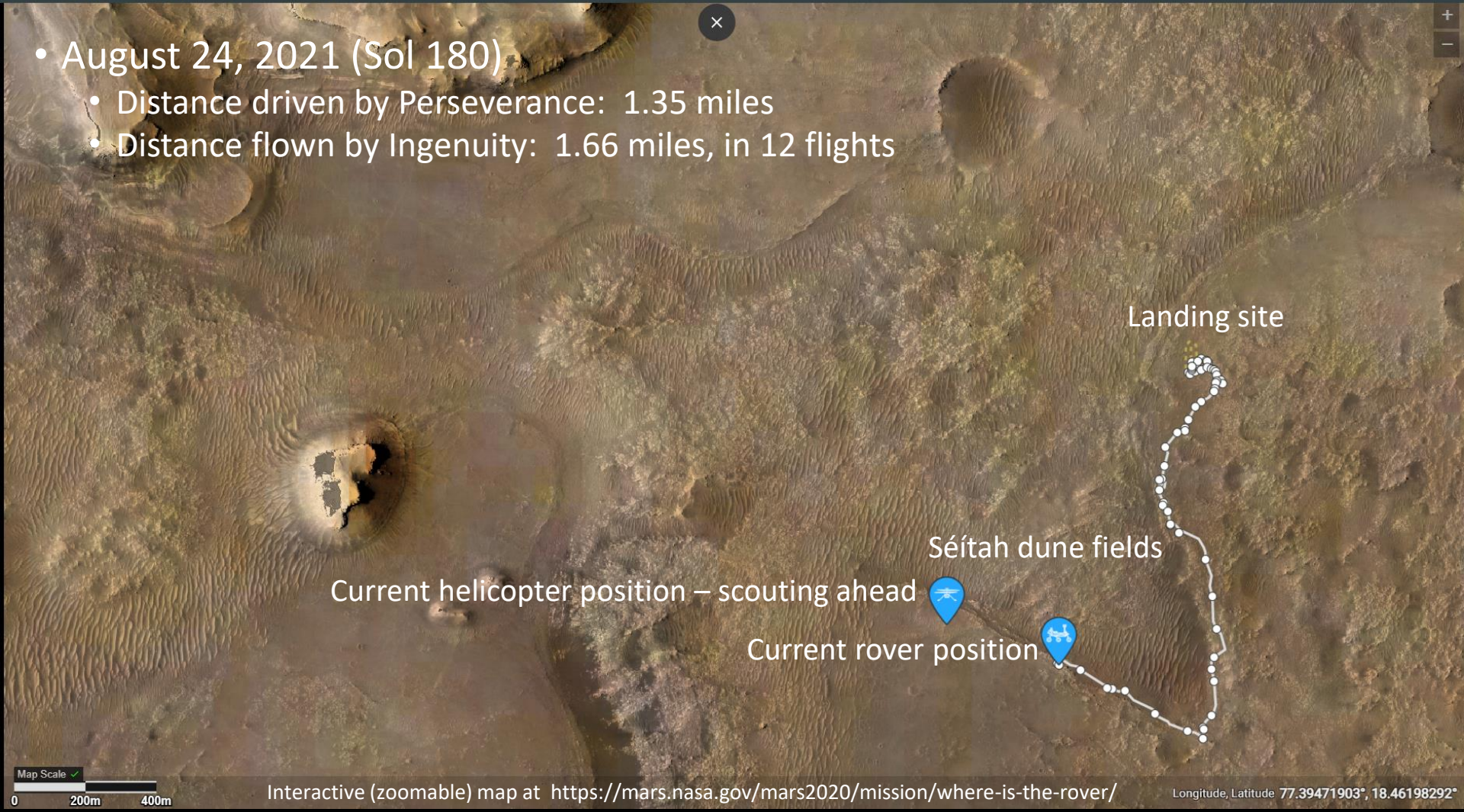


Where are Perseverance and its helicopter?

- Perseverance moved on to a different location after first sampling failure
- Ingenuity is scouting out sample locations, taking pictures where rover can't go

Perseverance's Location Sol 180 | Distance Driven 1.35 miles / 2.17 km

- August 24, 2021 (Sol 180)
 - Distance driven by Perseverance: 1.35 miles
 - Distance flown by Ingenuity: 1.66 miles, in 12 flights



What about other active Mars rovers?

- Chinese rover completed primary 3 month mission, driving .55 miles
- NASA Curiosity rover active for 9 years, driven 16.4 miles, climbed 1,073 feet

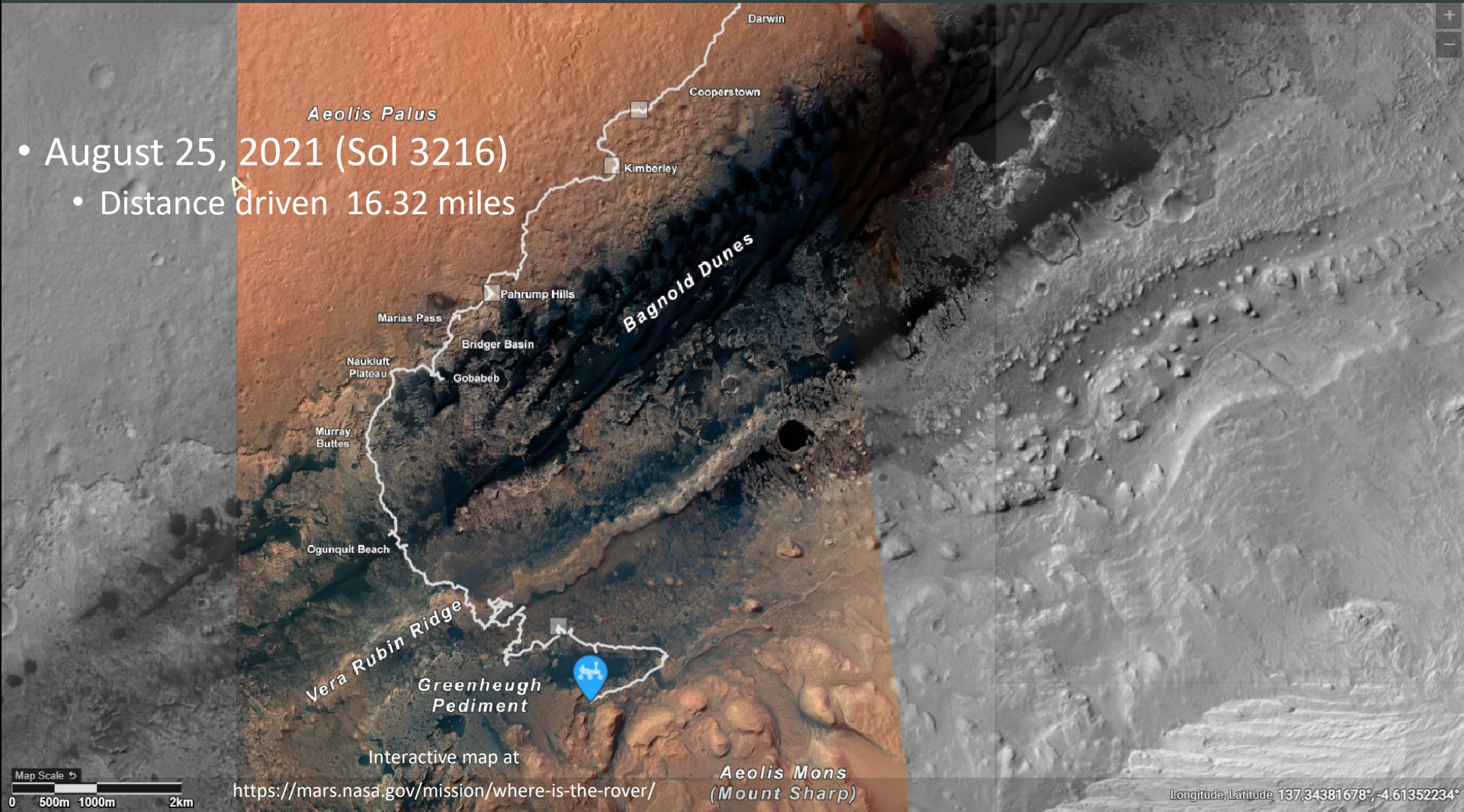


Path taken by the Curiosity rover

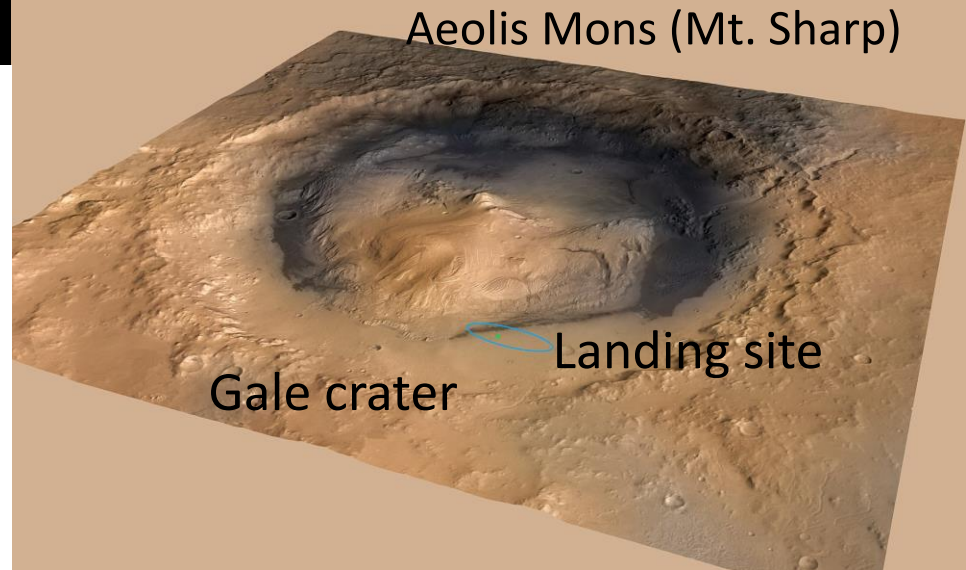
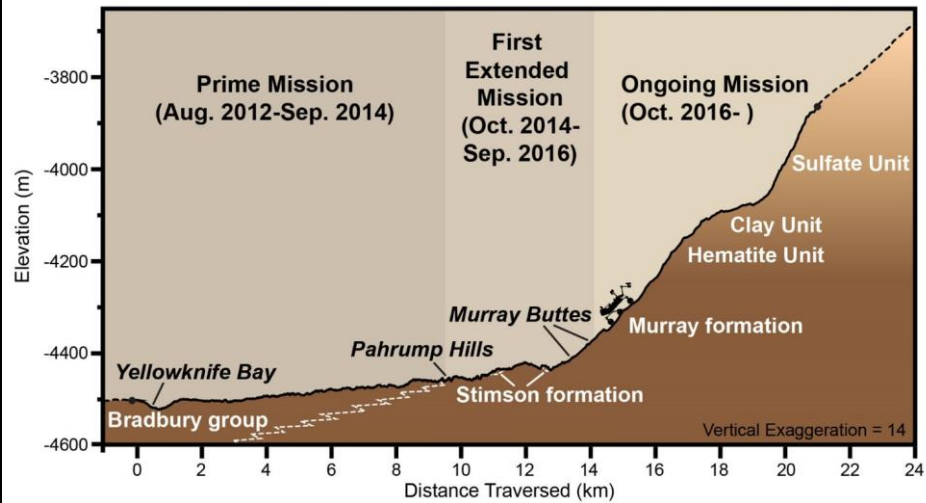
- Exploring geology and possible past life at different altitudes within Gale crater
- Climbing Mount Sharp (18,000 ft/3.4 mile high mountain in Gale crater)

Curiosity's Location Sol 3216 | Distance Driven 16.32 miles / 26.27 km

- August 25, 2021 (Sol 3216)
 - Distance driven 16.32 miles



Curiosity rover path



Curiosity rover view of Mount Sharp, Sept 9, 2015



NASA's Insight Mars lander status

- Purpose: study interior of Mars, using seismic, sound & magnetic analysis, heat flow measurements, weather
- Insight lander active for 2.75 years
 - New papers: determined center of Mars is molten, crust is thinner than expected
 - Heat probe supposed to go down 16 ft., but only achieved 14"
 - Solar panels obscured 80% by dust, probably forcing end of mission in 2022
 - Dropping coarse sand helped

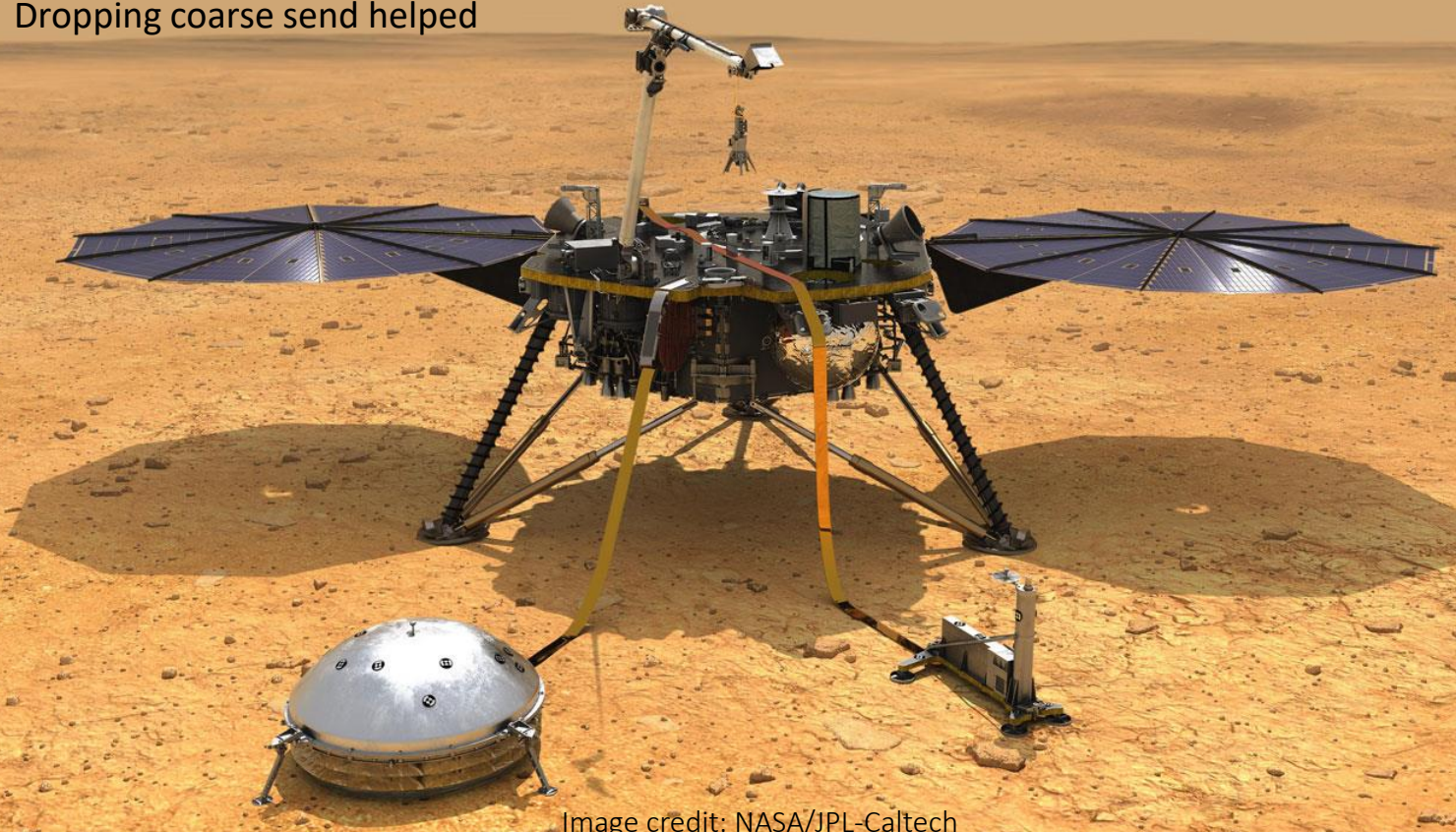


Image credit: NASA/JPL-Caltech

Earth-Mars solar conjunction

- All Mars communications will cease for about 2 weeks around Oct. 7
- All rovers hold their positions and data transmissions
- Earth and Mars are on opposite sides of the sun
- This solar conjunction occurs about every 2 years



Earth orbit news

- Some comparisons of the two August ISS cargo deliveries and later returns
- SpaceX Starlink internet service update



Image credit: NASA

August ISS cargo resupply: Dragon vs. Cygnus

	SpaceX Cargo Dragon 2 / Falcon 9 rocket	Northrop Grumman Cygnus (enhanced) / Antares rocket
Docking	Fully automated, direct to dock	Astronauts manually grapple with robot arm
Re-use	Reusable 5 times – splashdown	Disposable only – burns up in atmosphere
Payload to/from ISS (max)*	13,200 lbs. up 6,600 lbs. return cargo ("downmass")	8400 lbs. up 0 downmass return - burn trash only

* Maximum ever delivered was 8400 lbs (Cygnus)

- Downmass is key to any space manufacturing
- Only Dragon 2 supports downmass!

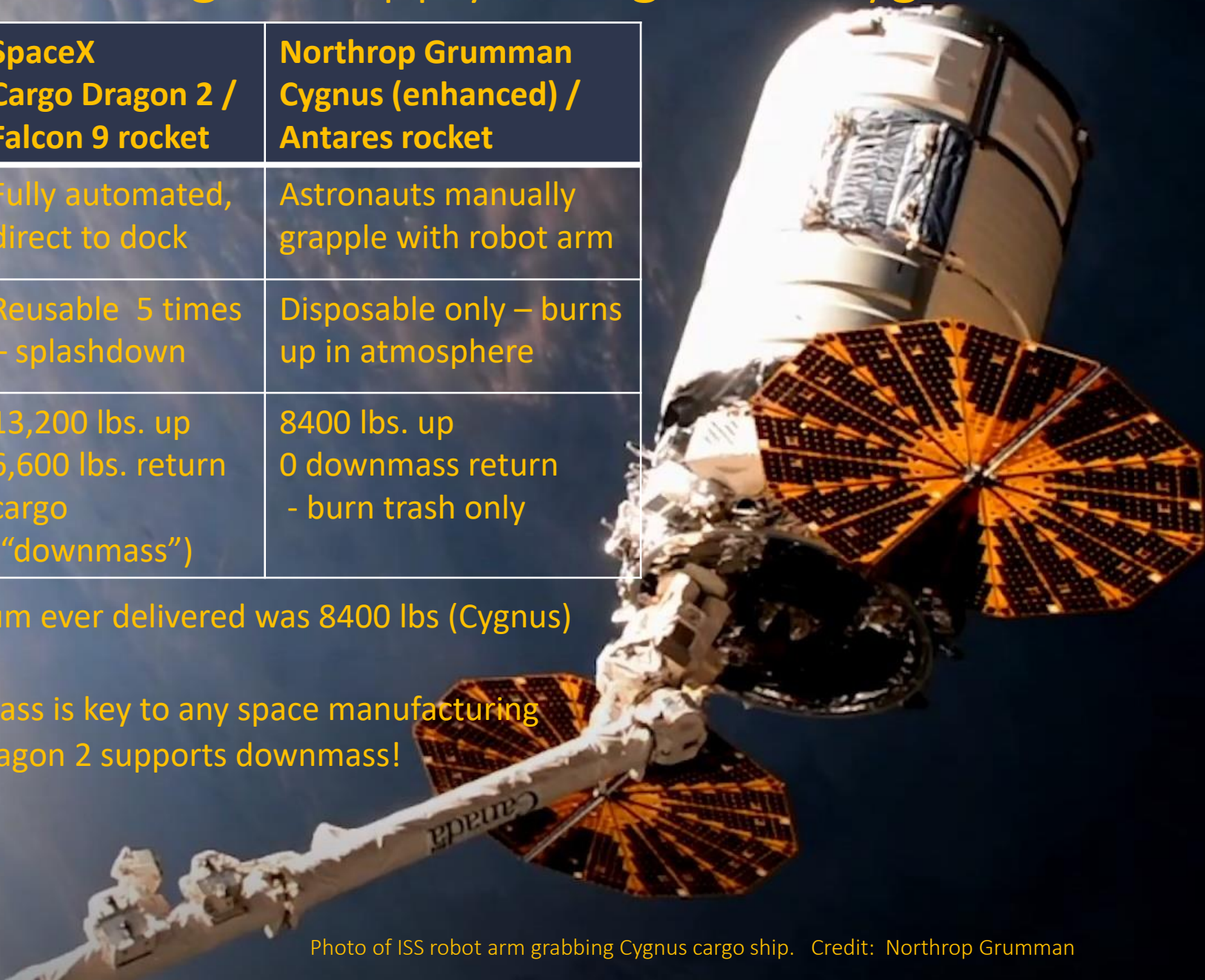


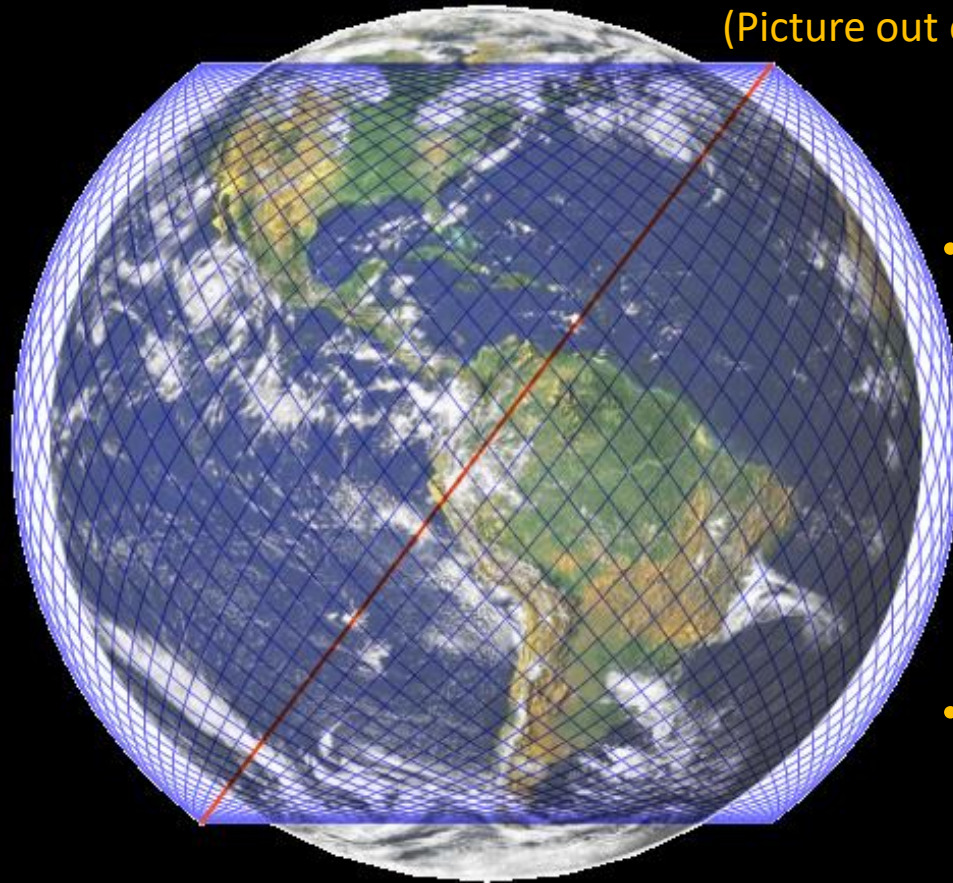
Photo of ISS robot arm grabbing Cygnus cargo ship. Credit: Northrop Grumman



SpaceX Starlink (internet service) status

- Starlink now has 1,619 working satellites in orbit, 1414 operational
 - 100,000 beta test users in 12 countries, 500,000 pre-orders
 - Average 117 mbps down, 16.5 mbps up, 48 ms ping (2-way time delay)
 - Will get \$886M subsidies from US Government for rural service
 - Investment in geosynchronous satellites for internet now dried up

(Picture out of date: there are 10 in polar orbits now)



- SpaceX has 2 “bet the company” projects requiring large upfront investment before revenue, both promising major market disruptions:
 - Starlink
 - \$5B - \$10B investment to positive cash flow
 - Maybe \$30B investment long term
 - Starship
 - \$5B investment
- But, compare to cost of a single new semiconductor plant (“fab”)
 - \$12B - \$20B for new fabs



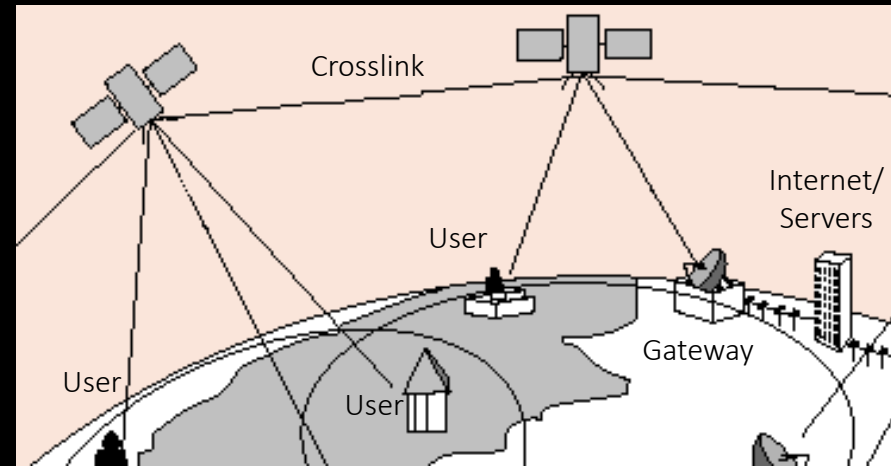
SpaceX Starlink (internet service) future

- Soon: V1.5 satellites with laser crosslinks
 - Links to adjacent satellites in same orbital plane or adjacent plane
 - Ground stations/gateways not needed in remote regions, oceans, hostile countries
 - Lower latency (time delays) due to fewer hops, optical fiber light speed 2/3 vs. vacuum
 - No Starlink launches since May 15 – upgrading all satellites for laser links

- Current phase approved for up to 4,408 satellites
- Revision proposed for Gen2 includes about 30,000 satellites
 - Bigger, with more power, and ability to carry small payloads (Swarm?)
 - 328-614 km (vs. current 550km/340 miles)
 - Various orbital planes, including sun-synchronous for peak demands (mostly 53° now)
 - Future launches with Starship will loft 400 satellites at a time, directly to desired orbit instead of lower, avoiding months of delays

- Still expecting 10x revenue from Starlink as from launch business
 - Perhaps \$30B/year

- Blue Origin is protesting next phase
 - 2 alternatives: Starship ready or not
 - Complaint: that's too many proposals





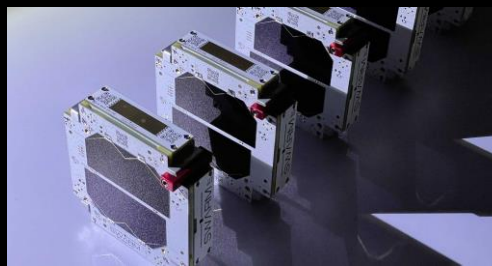
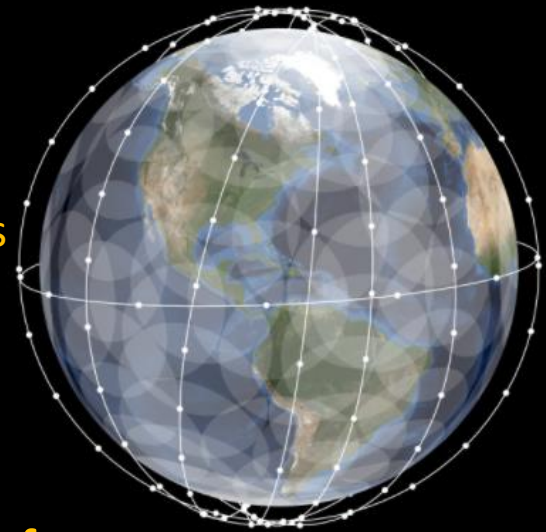
SpaceX Starlink (internet service) competition

- OneWeb -- UK govt./Bharti Global (Indian company)
 - Now at 288 satellites of planned 648 by 2022
 - 745 mile orbit vs. 340 miles for SpaceX
 - Focused more on business customers than individuals
 - Investors funded \$2.7B since bankruptcy in March, 2020
- Telesat Lightspeed: \$5B constellation
 - Planned 298 LEO satellites, service in 2024
- Others: O3b, ViaSat-3, Amazon Kuiper, China

- Iridium (the pioneer) not really a competitor right now
 - Low power applications to handheld devices, mainly voice
 - Low-speed, low-power internet
 - But now SpaceX wants a piece of this business too ...

Swarm acquisition by SpaceX

- “Honey, I shrunk the Starlink system”
 - 150 small (sandwich-sized) , low cost SpaceBEE satellites
 - ¼ Cubesat, 400 g, in flat packs to launch in volume
 - At least 40 ground stations (2020 figure), licenses
 - Selling service since February, 2021
 - Total funding by investors: \$36 M
- Data communications with small devices/ internet of things
 - Small modems: \$119 Swarm Tile (1"x2"), with GPS
 - Asset tracking, relaying sensor data
 - Low power, low data rates – 5 kbps, with encryption
 - Water monitoring (agriculture); tracking trucks, ships, buoys
- Low cost, 2-way data communications globally
 - \$5/month per tile for 750 messages/month
 - Typically 1 message (192 bytes) per hour
 - Cheaper than Iridium by factor of 4 to 20
- Store-and-forward network
 - Buffer in tile and in satellites



How many launches since the last meeting (Aug 7)?

*This includes failed launches only if they lift off the launch pad and only includes launches that attempt going into orbit
This failed launch counts*



Counting: India's GSLV Mk.2 rocket liftoff (before 3rd stage failure, reaching 87 miles). Credit: ISRO

Launches since last meeting (August 7, 2021)

 Aug 10 – Antares – Cygnus cargo ship to ISS (International Space Station)

 Aug 11 – GSLV Mk.2 (India) – EOS 3 geo orbit imaging satellite (FAIL)

 Aug 16 – Vega (Arianespace) – Earth observation satellite, 4 rideshares

 Aug 18 – Long March 4B – pair of radar mapping satellites (for 3D maps)

 Aug 21 – Soyuz – 34 OneWeb internet service satellites (now at 288 total)

 Aug 24 – Long March 2C – 2 test satellites for future Starlink competitor

 Aug 24 – Long March 3B – Chinese geostationary military satellite

 Aug 28 – Astra Rocket 3.3 – test flight attempting to reach orbit (FAIL)

 Aug 29 – Falcon 9 – Dragon cargo capsule launched to ISS, docked 8/30

 Sept 3 – (Firefly) Alpha – first orbital test flight, small satellites (FAIL)

Impact of COVID-19 and related shortages

- Schedules for SpaceX, ULA, and others are at risk due to liquid oxygen shortage for oxidizing propellant
 - O₂ is needed in hospitals
- Trucks repurposed from liquid N₂ to O₂ also led to liquid nitrogen shortage, is delaying a ULA Landsat satellite launch
 - (N₂ is used for testing, purging and other purposes)
- Global semiconductor shortage is also delaying space business
 - (e.g., Starlink ground terminals)

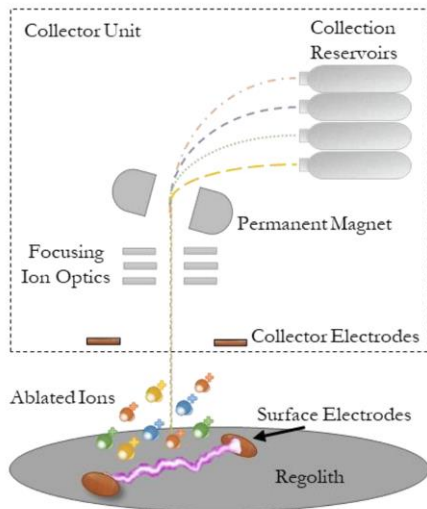
Discussion & questions?



Featured speaker: Dr. Amelia Greig



- Assistant professor in Aerospace & Mechanical Engineering, University of Texas in El Paso (UTEP)
- Leads the electric propulsion and small satellite programs
- Applying electric propulsion & plasma technologies to lunar mining
- PhD in plasma physics at Australian National University
- Postdoc at Caltech in applied plasma physics group
- Degrees in mechanical & aerospace engineering, theoretical physics
- NASA Innovative Advanced Concepts (NAIC) fellow, with phase 1 funding to research harvesting lunar water (and more)



• TOPIC: Ablative arc mining for In-Situ Resource Utilization (ISRU)

- ISRU is a key for sustainable expansion into space
- Using electric arcs on a mobile crawler could enable mining multiple materials at once, not just water