# Space News

April 3, 2021

Greg Stanley

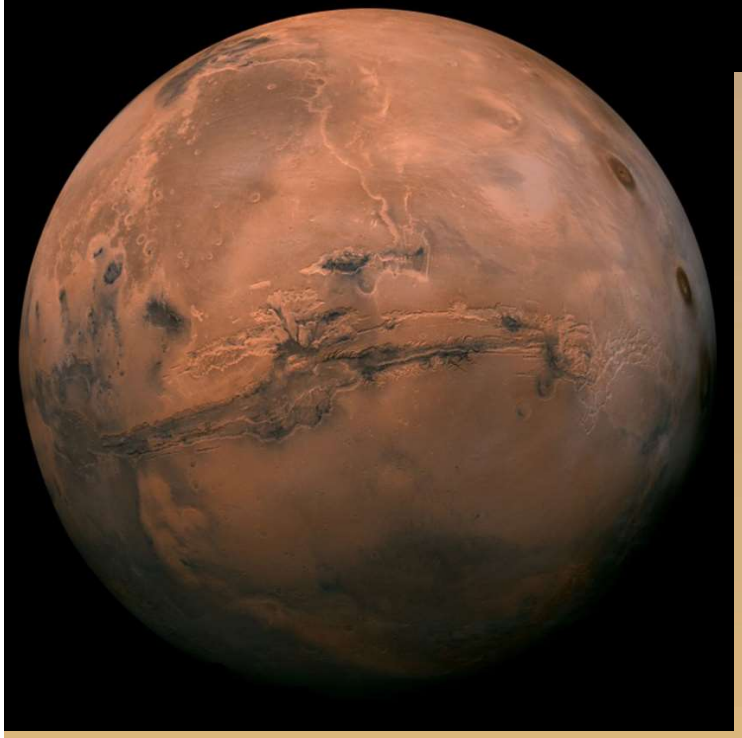

Illustration: NASA JPL

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# NASA's Perseverance Mars rover update

- Completed self tests, scouting for airfield for Ingenuity helicopter
- Deploying helicopter
- Recorded sounds while driving, and while zapping rocks with a laser

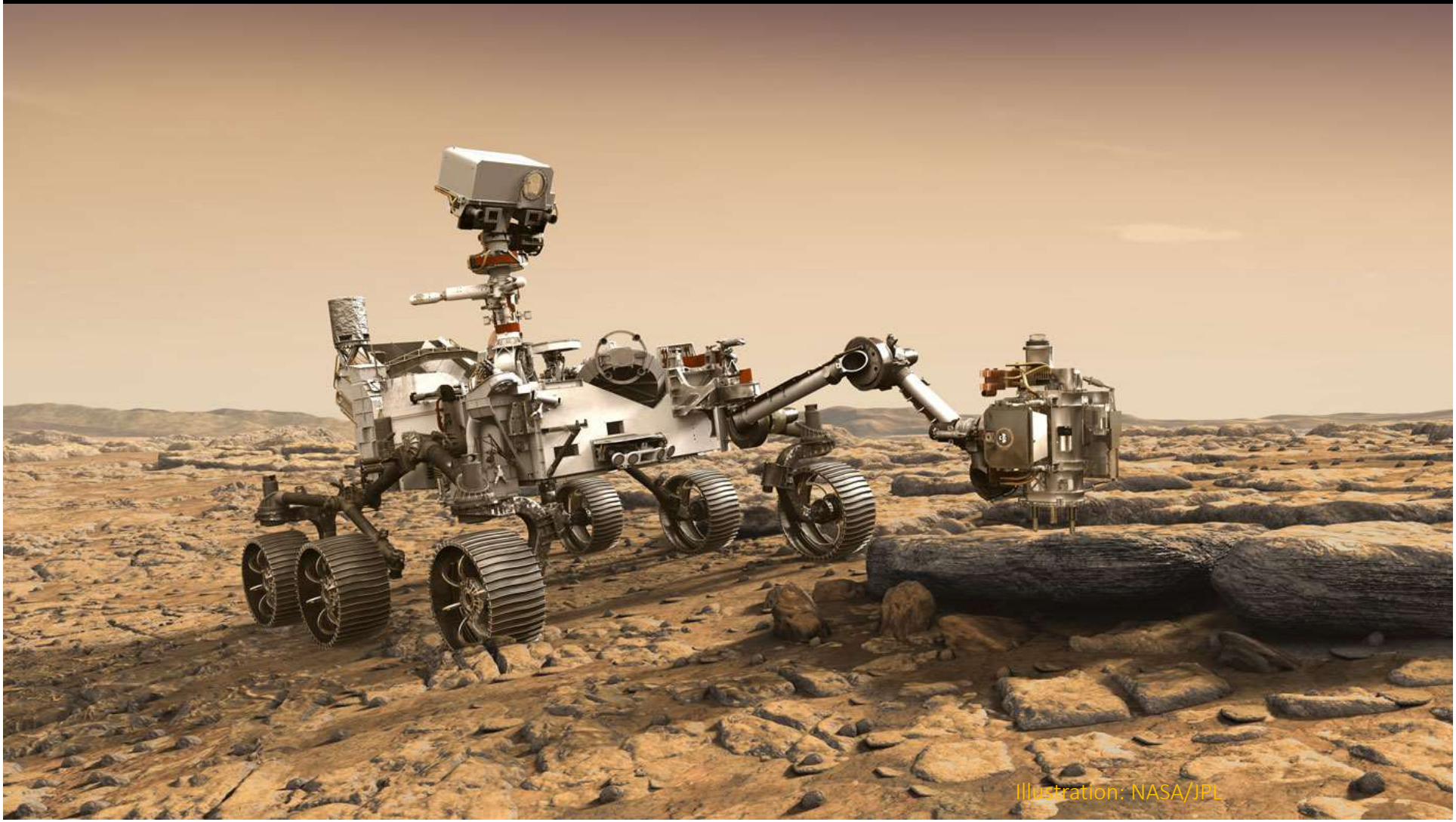
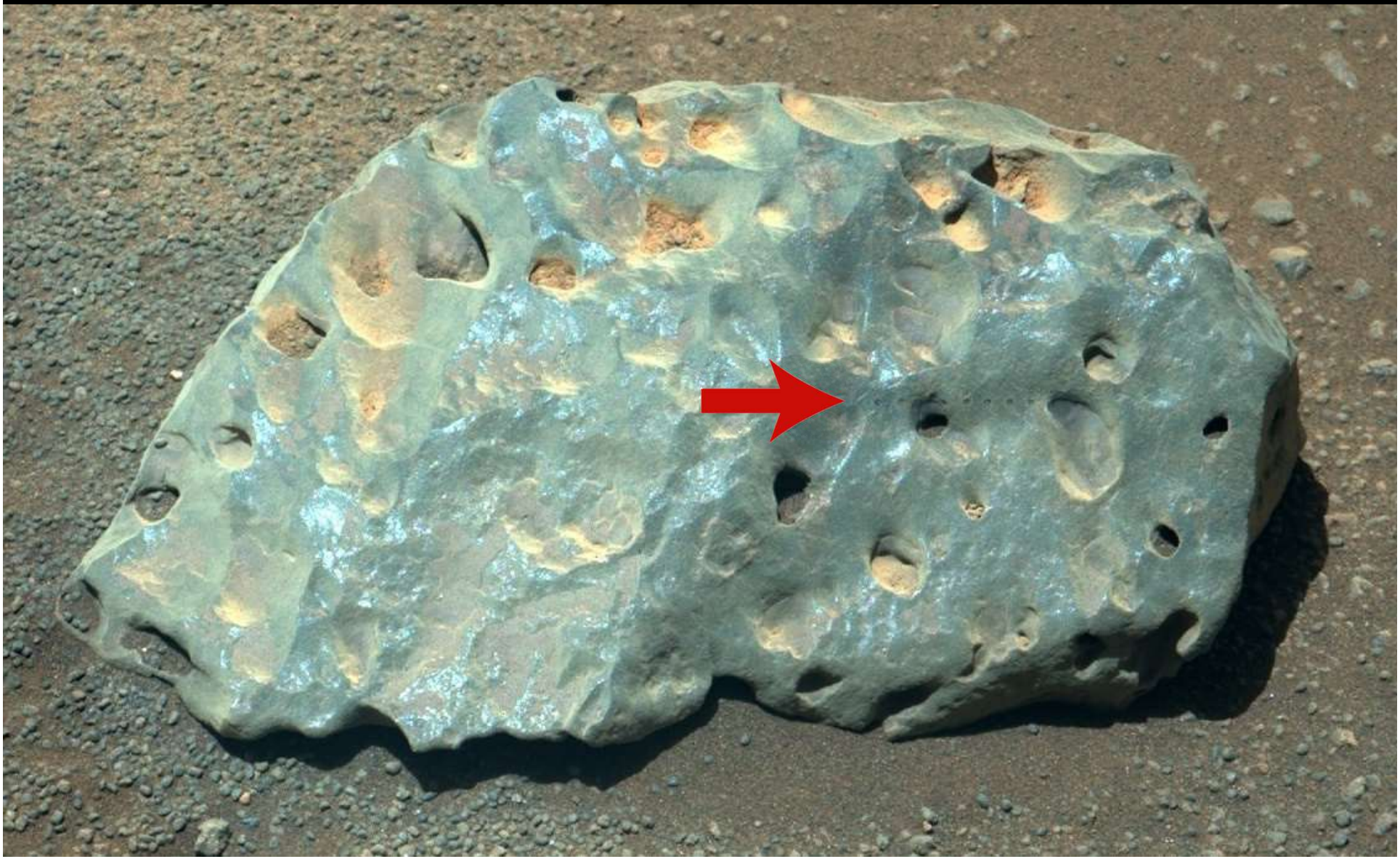


Illustration: NASA/JPL

# Perseverance zaps Mars rocks (… "analyzes"…)

- Zapped this 6-inch rock with laser to determine composition



# Where is Perseverance now?


Image: NASA

# Helicopter on Mars: Ingenuity

- Main goal:  technology demo -- show we can fly aircraft on another planet!
  - Gather information for designing next generation
  - Future Mars missions, future helicopter on Saturn's moon Titan in 2030's
- Future benefits
  - Scouting ahead for rovers or humans
  - Faster exploration
  - Areas unreachable by rovers

- More risk and shorter development is acceptable for a technology demo
  - Brand new, built from scratch, unlike Perseverance
  - Open source software
  - Used consumer and some military grade off-the-shelf components

Illustration:  NASA JPL

# Helicopter on Mars: Ingenuity

- 4 lbs, 1.6 feet tall, two counter-rotating 4 foot diameter blades
- Solar cell powered, recharging lithium-ion batteries
- 30 day design life, 5 90-second autonomous flights

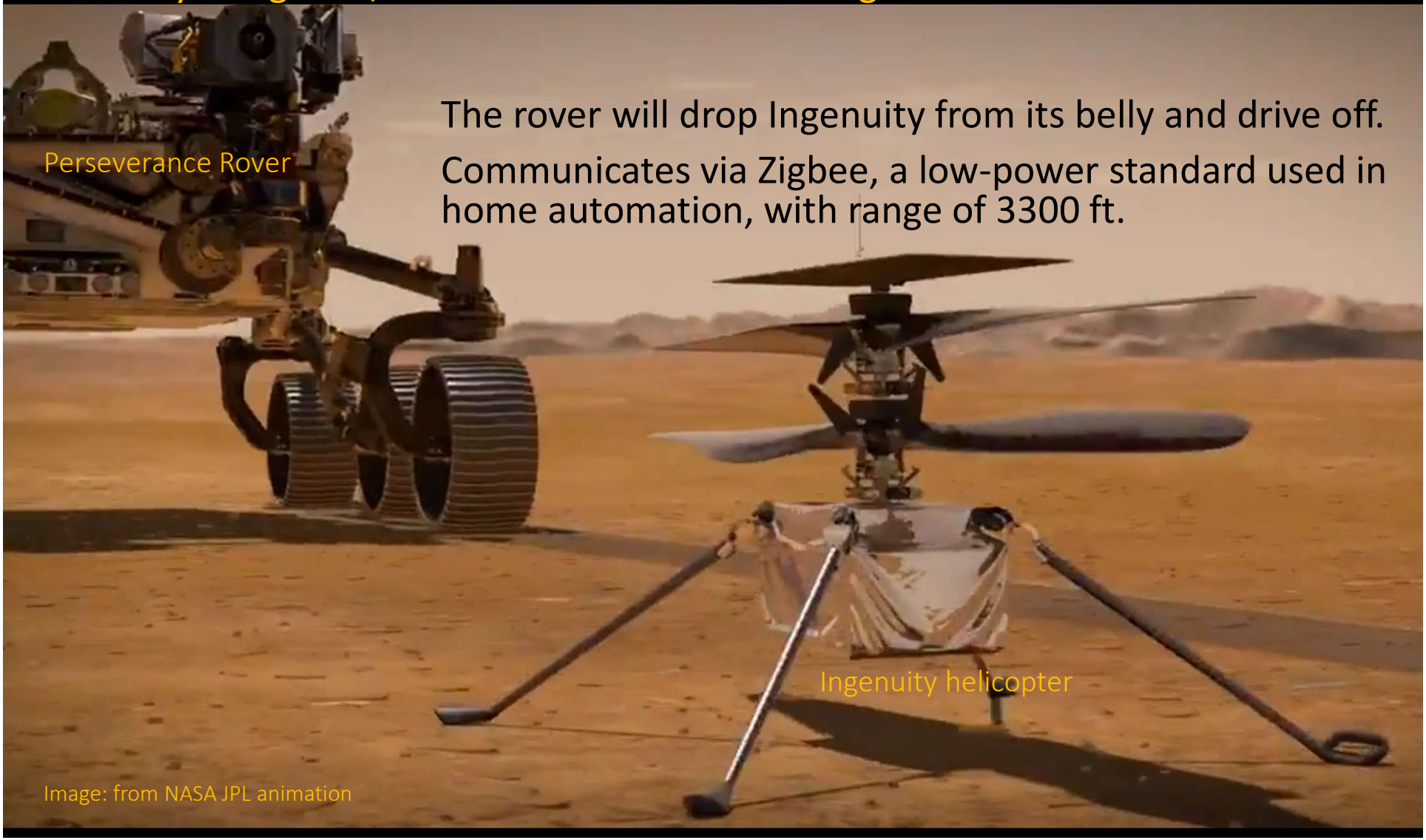



Image: from NASA JPL animation

# It's not your grandfather's drone

- Need heaters for electronics and battery to survive -150 °F night
  - 40 WH batteries equivalent to 3 smartphone batteries
  - Charge in 1 day, but 2/3 of charge is for warming, mostly at night
- Mars surface atmospheric density 1% of Earth, like 100,000 ft. on Earth
  - Helicopter blades spin at 2300-2900 RPM (5-10x faster than Earth helicopters)
    - Mach 0.7 speed at blade edge
  - Blades need to be stiffer than on Earth
    - Vibrations damped by Earth's thick atmosphere would destroy blades in thin atmosphere

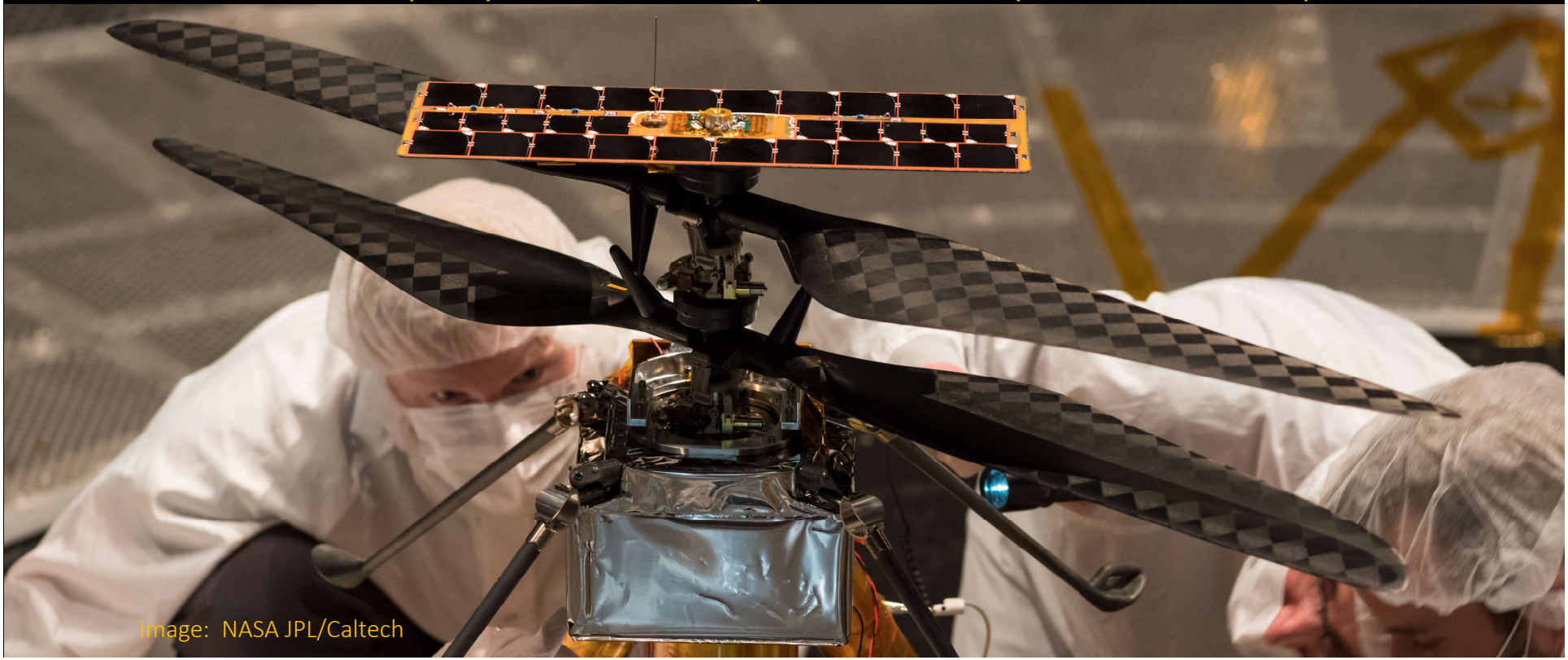


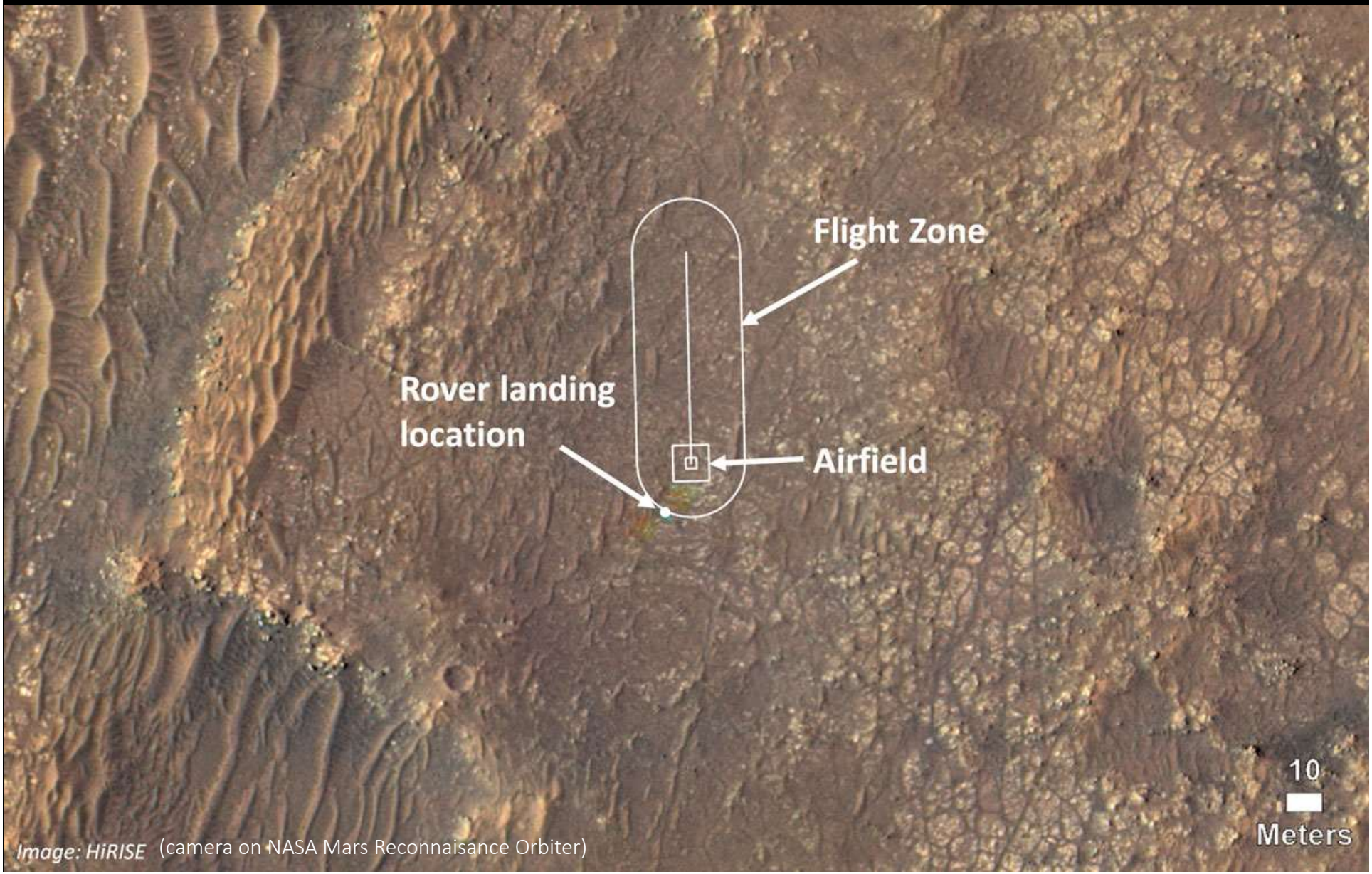
Image: NASA JPL/Caltech

# Ingenuity helicopter computing: software fault tolerance rather than radiation hardening

- Uses commercial cell phone processor
  - Qualcomm 2.26 GHz quad-core Snapdragon 801 running LINUX
  - Much more powerful than radiation-hardened processors on Perseverance
  - Radiation-hardened processors aren't fast enough for real-time vision & control
- Will fail periodically due to radiation flipping bits – maybe every 2 minutes
- Additional radiation-tolerant hardware to detect problems
- If problem is detected, reboots.
  - Helicopter will start falling
  - Reboot completes in a few hundred milliseconds and flight resumes

Picture: Veritasium.com

# Ingenuity helicopter plan: 5 flights over 30 days



# Ingenuity GNC (Guidance, Navigation and Control)

- Navigates by inertial navigation, by solar tracking, downward-facing camera
  - Inertial navigation uses accelerometers, gyroscopes, altimeter, inclinometer
  - Mars magnetic field is too weak & inconsistent to use a compass
- Executes a pre-planned sequence of commands - not remote control

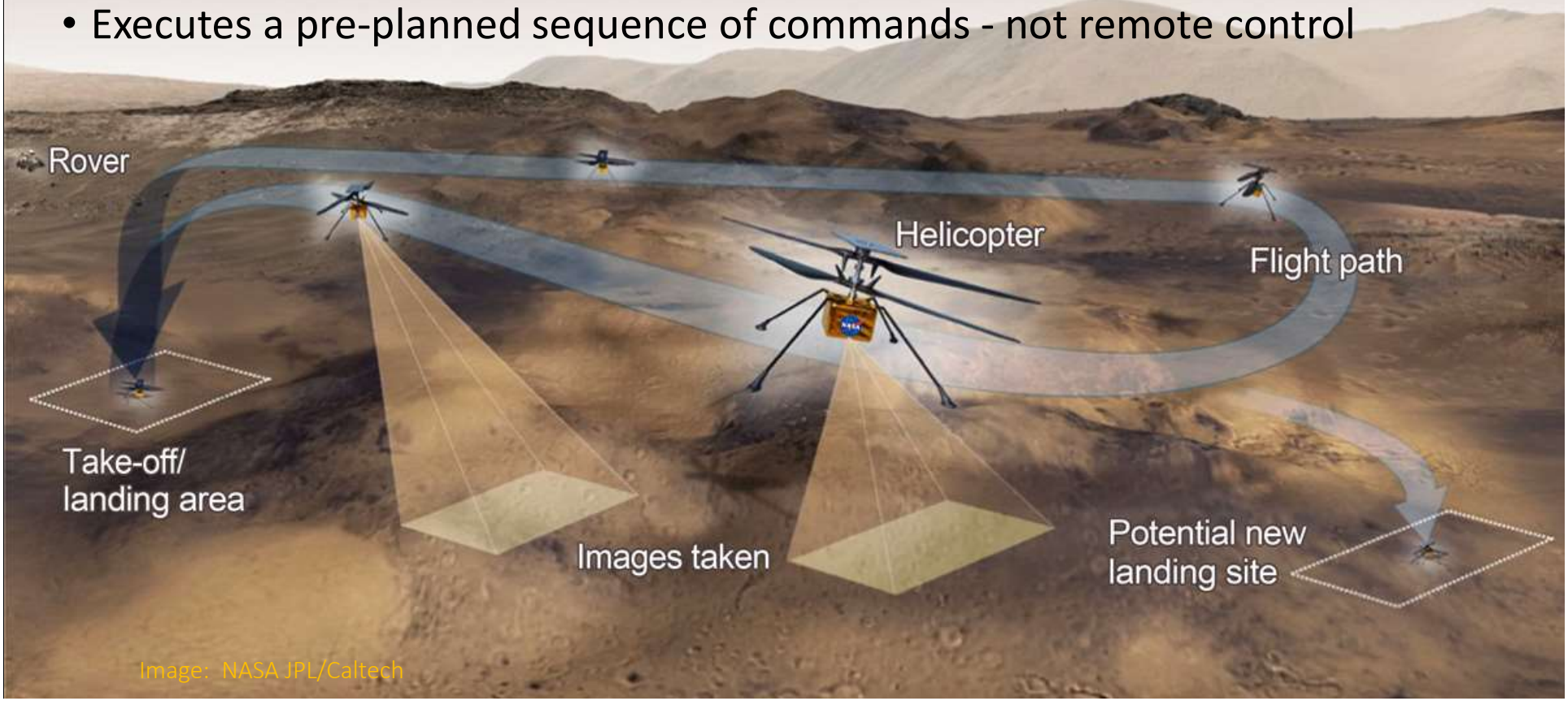



Image: NASA JPL/Caltech

# Ingenuity status

- Airfield was chosen, based on aerial photos and scouting by Perseverance
  - Flat area
  - Enough surface texture to navigate using downward-facing camera
- 6  day deployment started

- Not dropped final 5 inches yet
- Scheduled flight: April 11

Picture:  NASA JPL

# Space debris cleanup testing by Astroscale

- Space debris cleanup problem is getting worse with so many more satellites
  - ESA says 26,000 objects in orbit, 90% of which are not functioning
- Japanese company Astroscale launched “End-of-Life-Services” test
  - 200 employees in Japan, UK, US, Israel, Singapore
- 2 small satellites (423 lbs total) launched together on a Soyuz rocket to LEO
  - “Client” acts as a target – simulating an old satellite or rocket body to de-orbit
  - “Servicer” grabs it by docking, using magnets

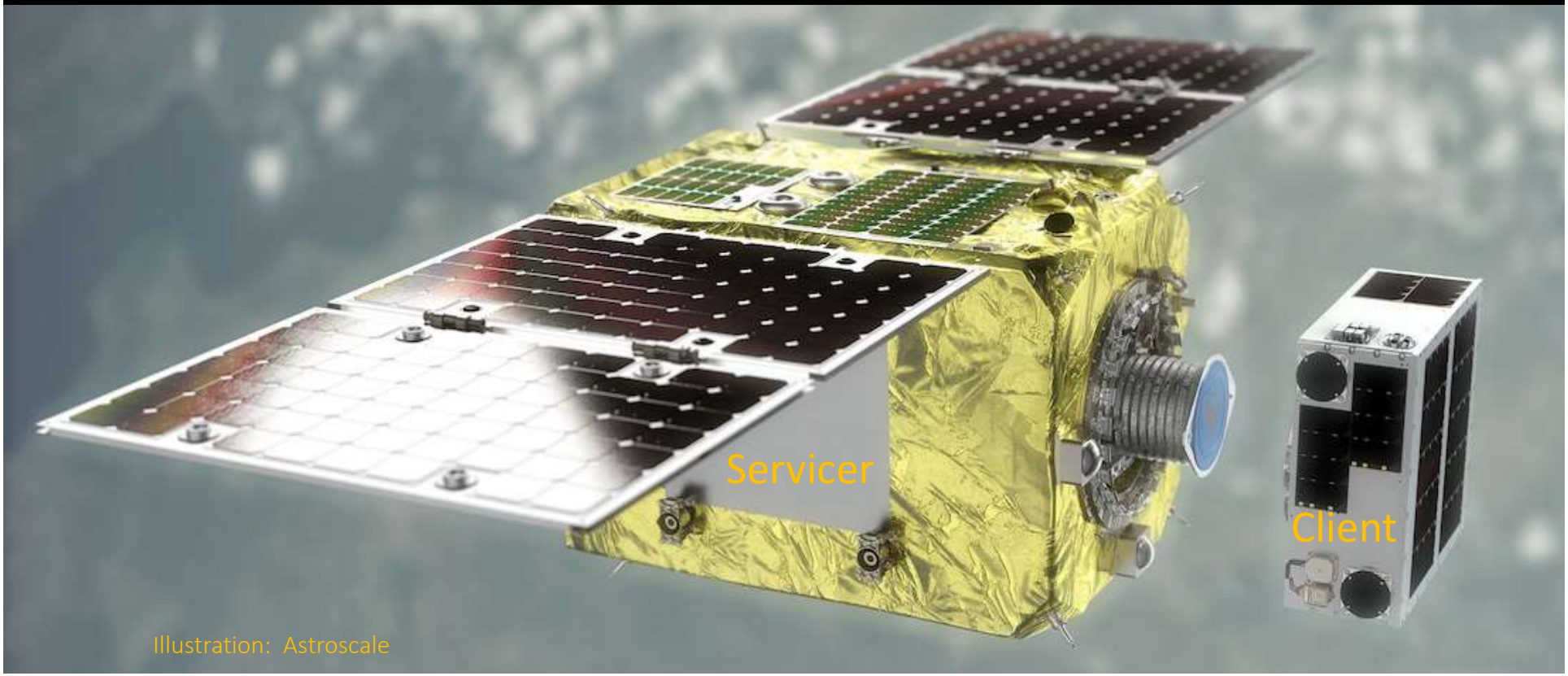



Illustration: Astroscale

# Space debris cleanup testing by Astroscale

- Target has magnetic docking plate, painted pattern so servicer can determine its range, motion, and tumbling
- Servicer determines how to match client for docking to capture it, circling to match rotation if needed
- Testing:
  - Grab the target in scenarios without tumbling, then with tumbling
  - Search for client, then approach safely
  - Fly-around to inspect the client
  - De-orbiting (this mission video shows de-orbiting together – reusability?)
- The catch: only applies when docking plate is present
- Northrop-Grumman "Mission Extension Vehicle" (MEV-1) docked with an Intelsat satellite in 2020, changed orbit, without a special docking plate, but knowing geometry of the target (grabbing inside a rocket nozzle). Non-tumbling case.
- These companies are pioneering the "In-Orbit Services" category of the developing space economy

Image: Astroscale

# It’s looking like there may be continuity in space policy (under president Biden)

- Evidence:
  - White house press secretary said so
  - National Space Council will continue (which had been revived by Trump after a 25-year hiatus, and strongly supported by industry), almost taken over by the National Security Council
  - Retaining the U.S. Space Force (started under Trump)
  - Continuing NASA’s Artemis lunar program (started under Trump)
- Jim Bridenstine (previous NASA administrator) said that’s the first time in 30 years, and it’s a good thing
  - Also supports nomination of former Florida senator and astronaut Bill Nelson as the next administrator

# How many launches since the last meeting (Mar 6)?

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

SpaceX Starship prototype SN11 test didn't count: it was sub-orbital (10 km/6.2 miles)

(The explosion during descent didn't disqualify it)

# Launches since last meeting (Mar 6, 2021)


Mar 11 – Falcon 9 – 21st batch of 60 Starlink (internet service) satellites


Mar 11 – Long March 7A – experimental satellite


Mar 12 – Long March 4C – 3 military reconnaissance satellites


Mar 14 – Falcon 9 – 22nd batch of 60 Starlink (internet service) satellites


Mar 22 – Soyuz – 38 "rideshare" payloads

- Included demo satellites to clear space junk, by Astroscale (Japanese company)


Mar 22 – Electron (Rocket Lab) – 7 small satellites


Mar 24 – Falcon 9 – 23rd batch of 60 Starlink (internet service) satellites

- Now at 1,321 active satellites of 1,440 for their first "shell", eventual 30,000


Mar 24 – Soyuz – 36 OneWeb (internet service) satellites

- Service expected to start for northern areas this year, globally in 2022
- Now at 146 of 648 satellites for their initial constellation


Mar 30 – Long March 4C – Earth observation satellite

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# Discussion & questions?

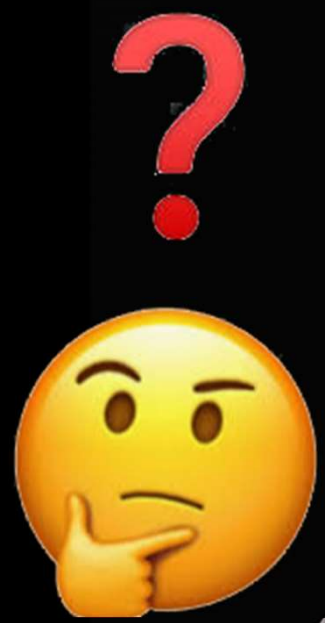

Image: NASA

# Featured speaker: George Salazar
# "Beyond earth orbit mission challenges"

- Evolution of human spaceflight
- Dramatic increase in complexity to support human missions
- Challenges for future deep space mission success (Moon, Mars, … )

- George is at the NASA Johnson Space Center
  - Technical Lead on human-computer Interfaces
  - Displays and Controls Subsystem Manager for Commercial Crew program
- 35 years in telemetry, avionics, project management, systems engineering
  - Space station, space shuttle, X-38 spacecraft crew return vehicle
  - Received patents in voice recognition and intelligent systems
- Bachelor of Science in Electrical Engineering, University of Houston
- Masters of Science in Systems Engineering from Southern Methodist University