SURREY
SATELLITE TECHNOLOGY US

Changing the economics of space

Celestis

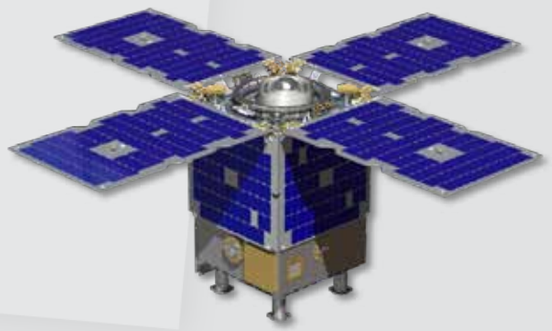
An Amazing Ride

CC-1's Experience over OTB's Mission Life

7/21/2017

Interesting Facts

- Hosting spacecraft
  - Surrey Satellite Technology US's Orbital Test Bed (OTB-1)
- How high above the surface of the Earth will Celestis Capsule (CC-1) fly?
  - Orbital Altitude: 720 km (~447.4 miles) - Circular
- What angle relative to the equator is the orbit plane?
  - Orbital Inclination: 24^{o} (Roughly the latitude of the launch site; KSC – 28.6^{o} N)
- How many times per day will CC-1 orbit the Earth?
  - CC-1 will experience 14.5 sun rises and sun sets in a days time
- How fast will CC-1 be moving?
  - 7.49 km/s (~16,764 mph)



Who's On-Board?

- Our biggest passenger …
  - … and the item that drove the design of both the mission and the spacecraft
  - JPL's Deep Space Atomic Clock (DSAC) drove the design – 50 times more accurate than today's best atomic clock
    - Jet Propulsion Laboratory is an extension of NASA well known for conducting interplanetary missions
  - Atomic clocks are used for navigation and operational autonomy to minimize errors in time sensitive objectives
    - When something is moving as fast as an interplanetary spacecraft, small errors in time can result in large errors in distance!
- Our payloads …
  - FlexRX experimental receiver, RadMon (radiation) sensor
- Who else is onboard?
  - Secondary payloads are "along for the ride" as the orbit is acceptable for their mission
  - iMesa (Radiation monitoring), MSA (experimental solar panel), CC-1 (Memorial)

Where Will the Satellite Be Operated ?

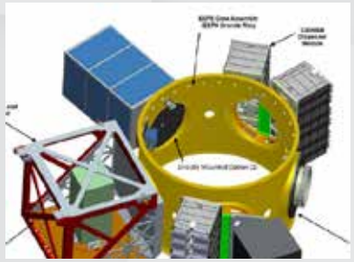
- Englewood, Colorado…
  - SST-US Mission Operations Center (MOC)
  - A file containing all the commands required to collect and downlink data are uplinked when the satellite is within view of the ground station (NASA JPL)
  - Vehicle health related information will downlinked along with payload data from the spacecraft daily and monitored by engineers here at the facility
  - Payload data will also be downlinked and sent to the customers
    - Satellite can store up to three days worth of data collected from the payload to account for any problems that might arise with the spacecraft or the ground station that would prevent the files from being downlinked

Configuration

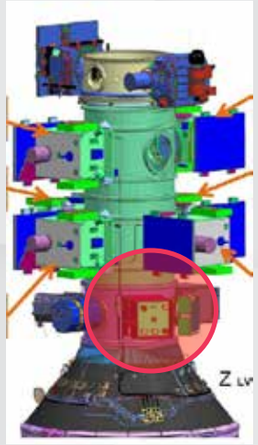
- 1. CC-1 is attached to OTB-1 here:

- 2. OTB-1 is attached to this adapter:

- 3. Like this:

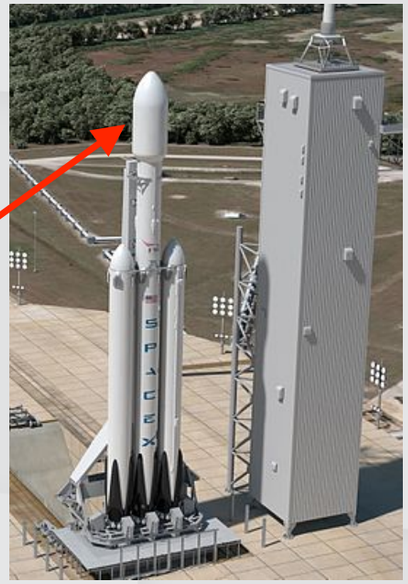


- 4. And stacked along with other segments like this:



- 5. This stack is mounte in a fairing like this:

- 6. Which is mounted to the rocket here:



Background

- The OTB-1 mission was born from the desire to collect data on the payloads, including a state-of the-art clock, in an operationally representative environment
  - Experiments performed on the ground do not fully represent all variables and how they contribute to a design's performance nor do they fully demonstrate design vulnerabilities
    - Temp extremes (no convective cooling or heating), unattenuated radio signals (no atmosphere, no weather, high radiation (no magnetic field), etc.
- The spacecraft is designed to accommodate the size, weight and power required
- As a consequence, there is usually valuable space in (and on) the spacecraft that smaller experiments can utilize and the CC-1 payload is utilizing some of this space
- However, CC-1 is not purely a "passenger", but more of a "crew mate" (it does provide a functional role on the spacecraft)
- The mass of CC-1 helps to fine-tune the location of the spacecraft center-of-mass into a desirable position
- And this allows the spacecraft to behave in a predictable way when subject to external forces during launch, while on-orbit, and during deorbit

The Simplified Mission Sequence

- Launch
  - When the first stage of the launch vehicle ignites, CC-1 will be violently shaken and experience vibration across a range of frequencies from 2000Hz to 20000Hz
  - The rocket will then accelerate into space
  - When the rocket experiences an acceleration of 5g, the main engine shuts off (MECO)
    - First stage expended, second stage separation, and the bulk of the energy has been supplied to the orbit
  - The second stage engine starts and drops the various spacecraft off along the way until it reaches 5g
    - At this point, all of the energy has been supplied to the orbit, and all of the spacecraft have been jettisoned including OTB-1
- OTB-1 Separation
  - The second stage jettisons OTB-1 and the spacecraft is tumbling anywhere from 3 degrees per second all the way up to 10 degrees per second
- De-tumble
  - OTB-1 uses the magnetic field of the Earth to reduce these rates to zero, but remains spinning about 1 axis, to allow for the sun to provide power and maintain an even heat distribution over the spacecraft
    - Like a hot dog on a roller at a 7-11 ☺
- The spacecraft then alters this spin rate to provide gyroscopic stability
  - The spacecraft resists disturbances like a top resists falling over under the influence of gravity

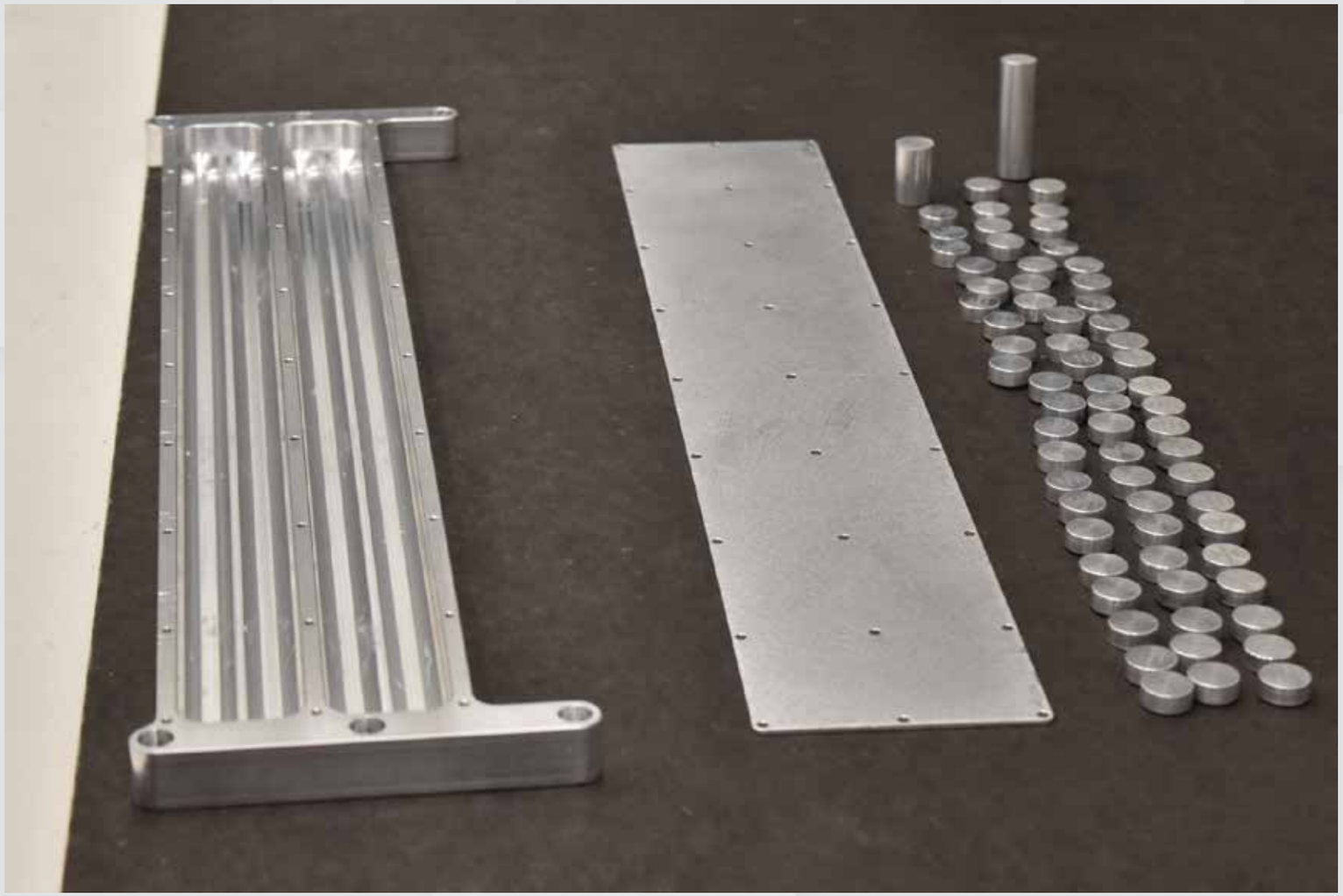
The Mission Sequence (Continued)

- Check Out
  - With the spacecraft now stabilized, warm, and generating power, each subsystem is powered up and tested to make sure everything survived launch and is working properly
  - The solar panels are then deployed
  - When everything is in order, various activities are performed to ready the payload for its mission
- Nominal Operations
  - The spacecraft is now ready to support the payload's mission objectives
  - The spin rate is reduced and the spacecraft modes itself into an orientation that keeps its antennae pointed at Earth as it moves through the orbit
  - Science is then conducted
- De-Orbit
  - At the end-of-mission, the spacecraft must re-enter the atmosphere with a period of 25 years to avoid threatening other spacecraft which are still active
  - A device is deployed which uses the changing direction of Earth's magnetic field to extract energy from the orbit and "bring it down"
  - As the spacecraft drops, its speed increases and friction from the atmosphere generates significant heat
  - As the spacecraft gets hotter, its structural integrity is comprised and somewhere between 200 and 100km (186-124mi) the spacecraft is vaporized and CC-1 has reached its final destination

Movies

- Launch

Photos



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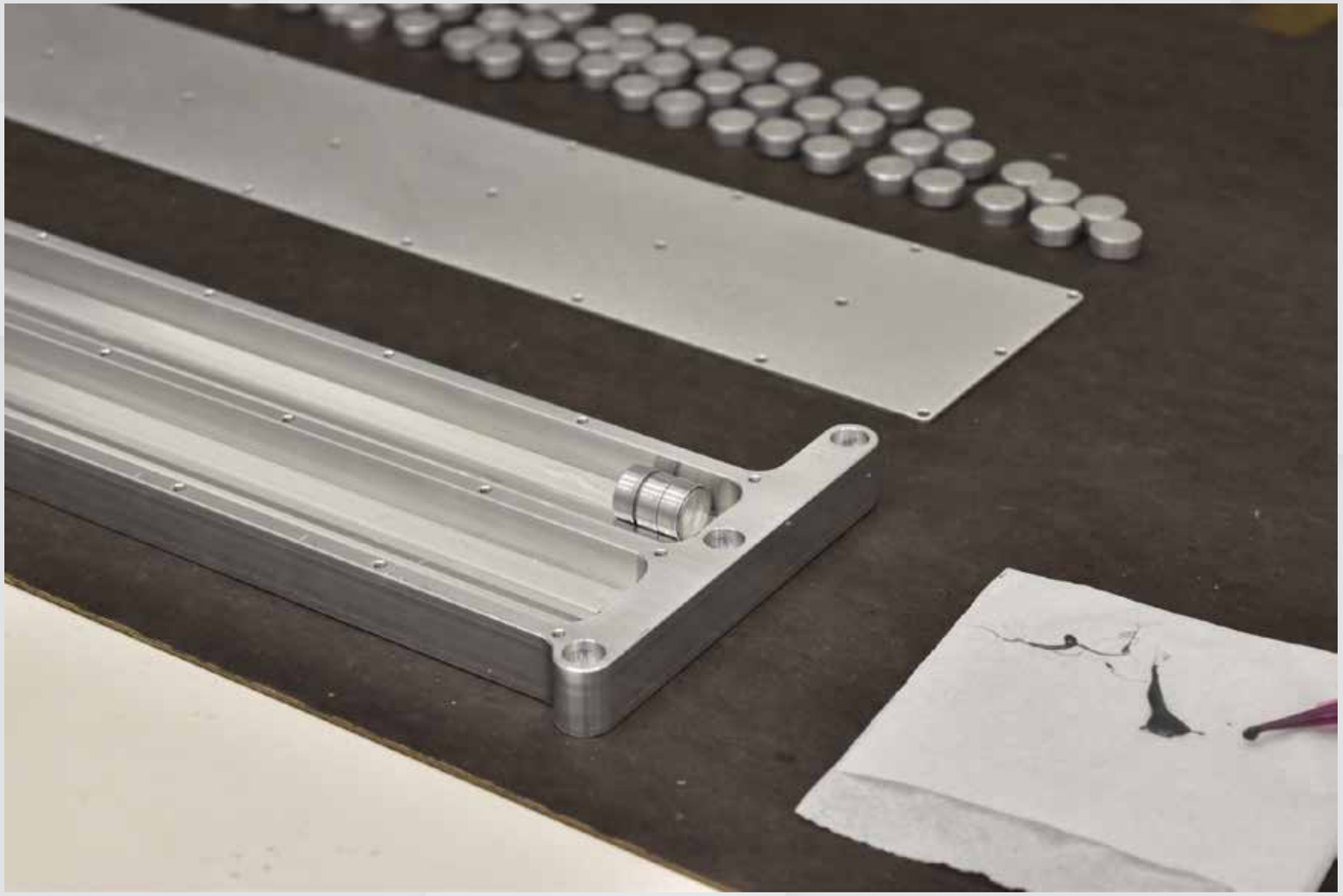

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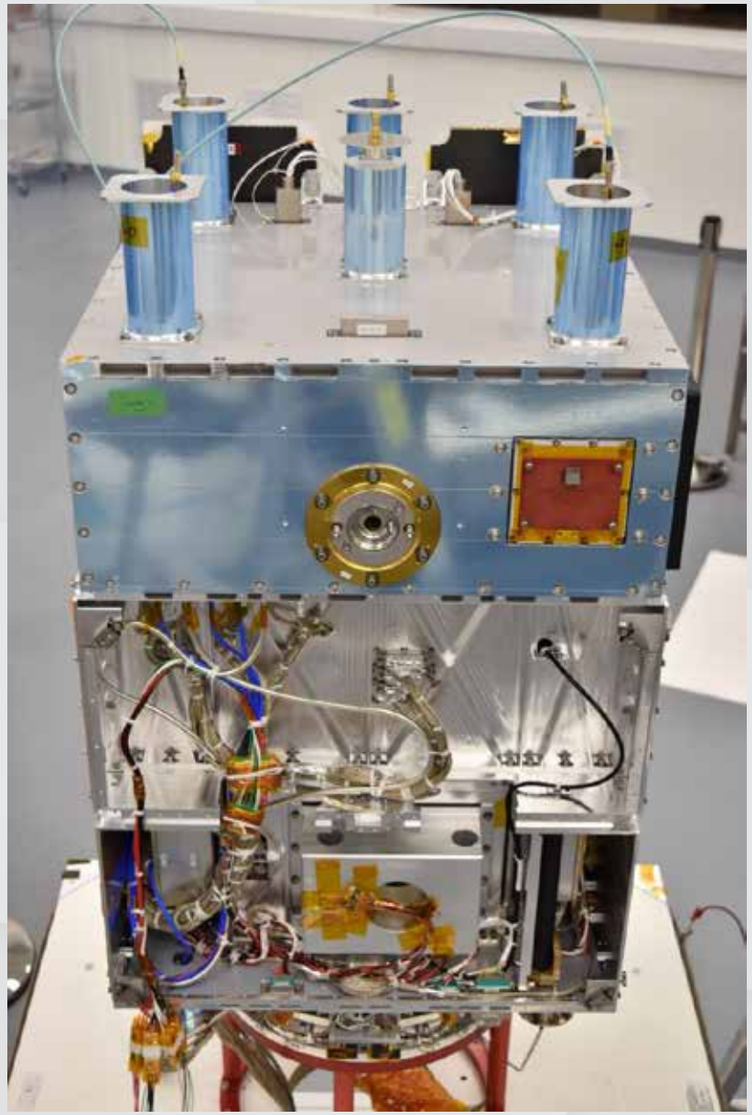

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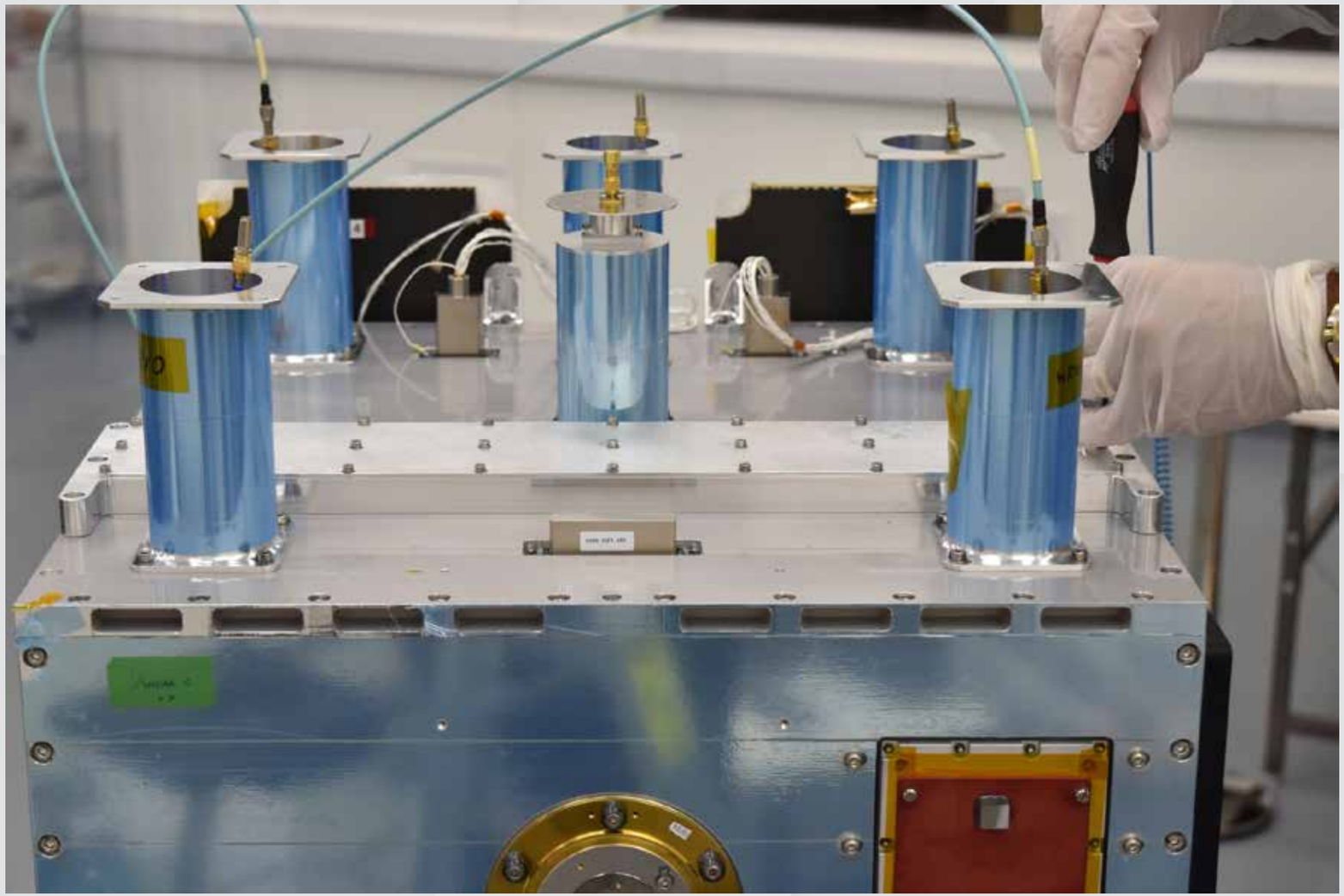

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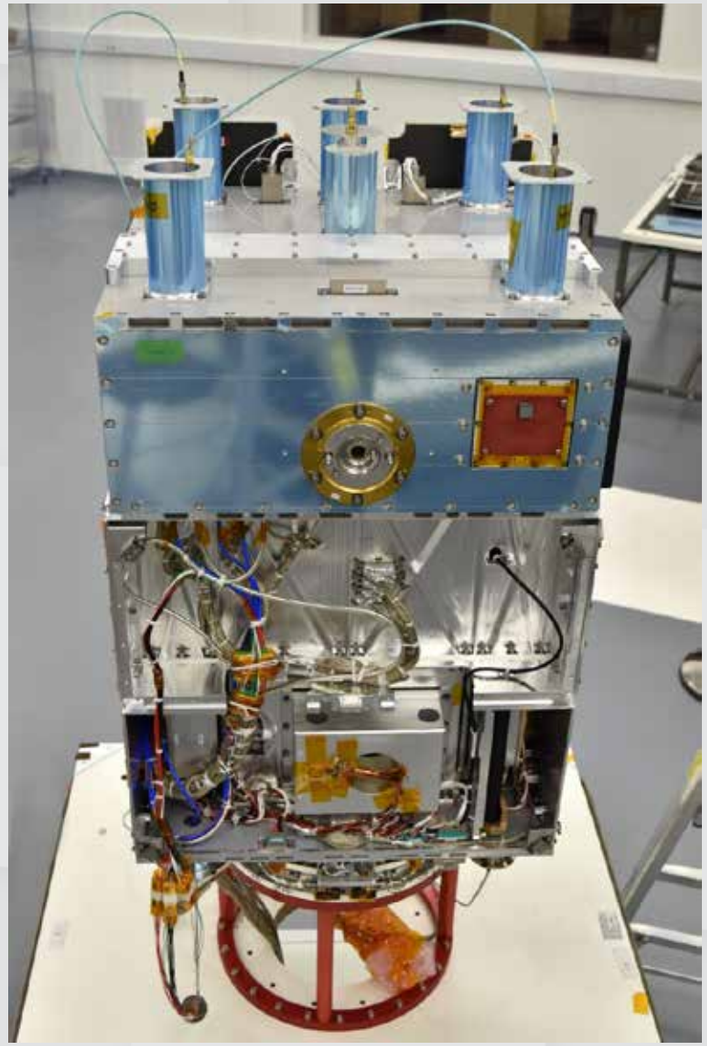

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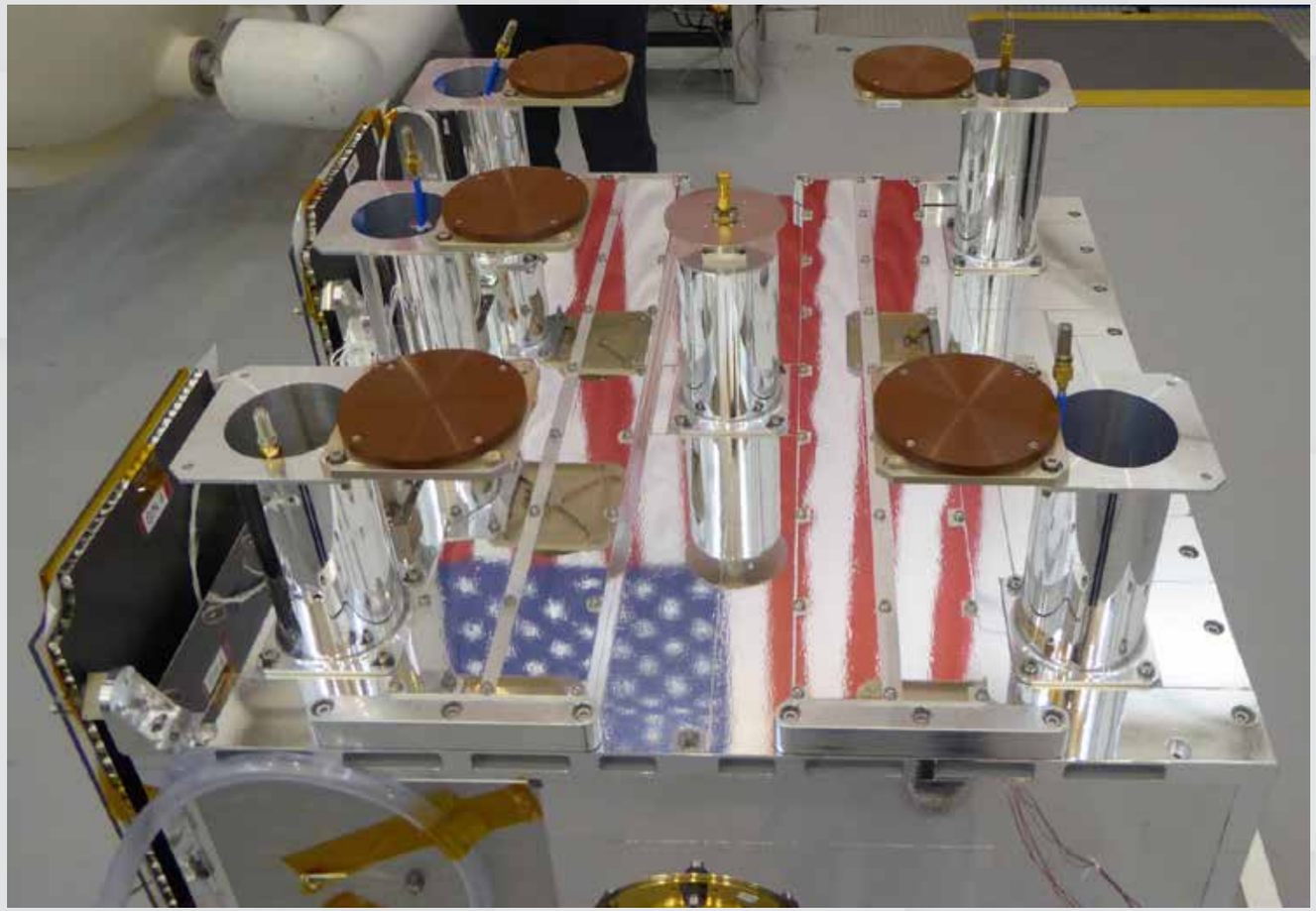

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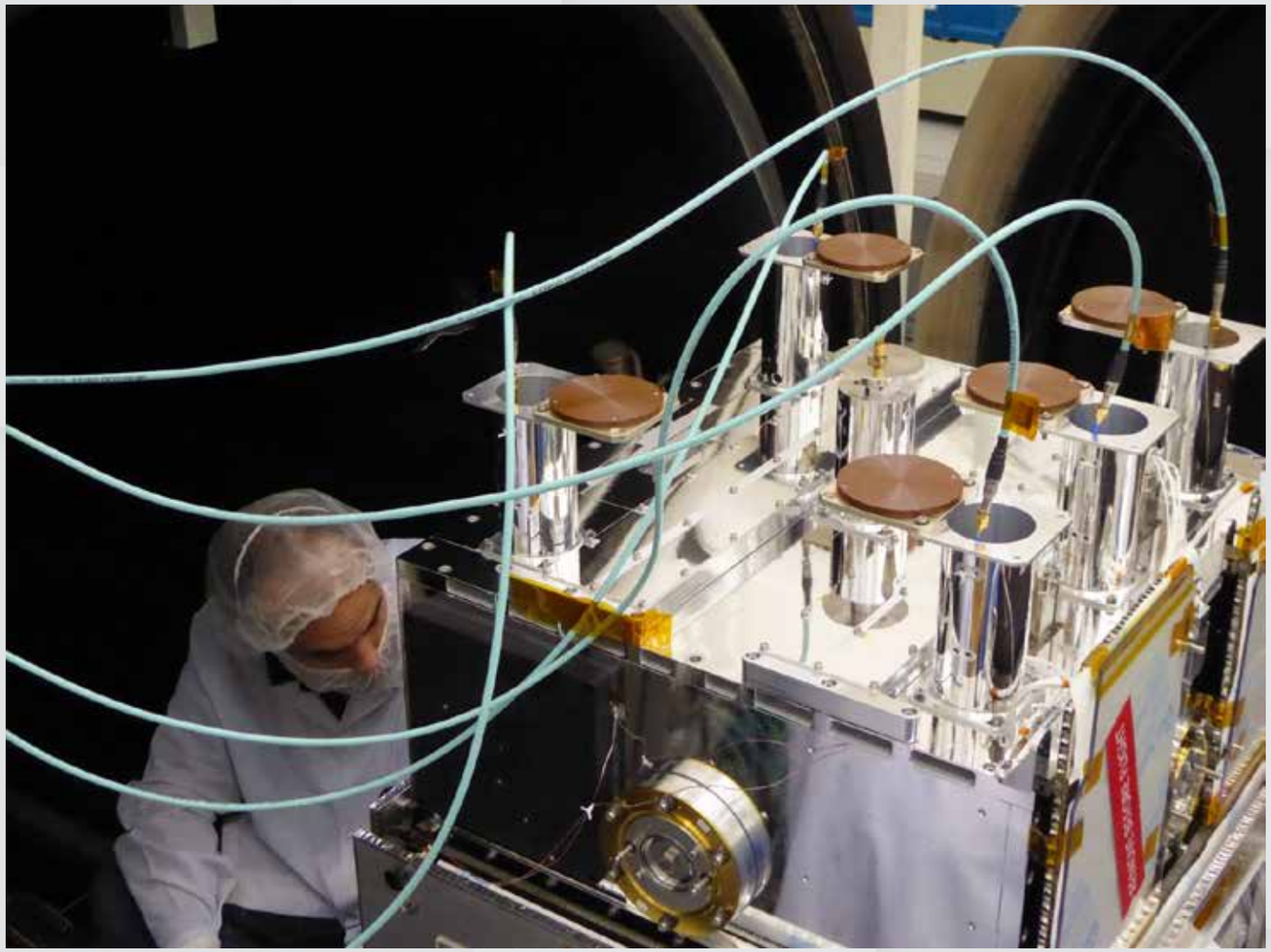

Photos

In Closing

- SST-US is honored to have been chosen to be a part of such a unique memorial for your loved ones. At some point in our lives, we were touched and inspired by the possibilities that space offers, and its role in advancing our understanding of humanity's presence in the universe. The fact that you are with us today would suggest that your loved one, at some point in his or her life, was affected in the same way. As people who chose a profession that is rooted in this fascination, we feel a common bond and a deep personal connection to the great people aboard CC-1. To the friends and families of the departed, we sincerely hope this to be a lasting and memorable experience for you, and one that your loved one would have been proud to be a part of.

SURREY
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Thank You

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