Technology Demonstrations & Infusions

- Technology and continued technological progress is critical for the future of SMD and its future missions
- Technology investments are pathways to flight as strategic elements of SMD programs
- SMD is actively developing flight opportunities for new technologies as part of AOs.
  - Based on our experiences, performance metrics and feedback, we will continually adjust.

– Goal: Fly at least one new technology with every science mission

GREEN PROPELLENT INFUSION MISSION

GPIM will test a new propulsion system that runs on a high-performance and non-toxic spacecraft fuel. This technology could help propel constellations of small satellites in and beyond low-Earth orbit.	7120.5 Space Flight Phase E	Category: 3 Risk Class: D

Objectives:

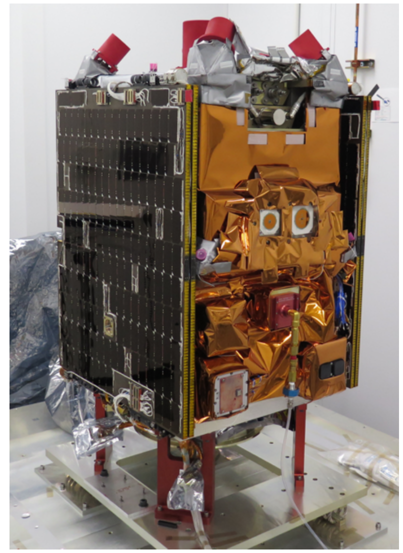
- Demonstrate the on-orbit performance of a complete AF-M315E propulsion system suitable for an ESPA-class spacecraft
- Demonstrate AF-M315E steady-state performance of delivered volumetric impulse at least 40% greater than hydrazine
- Demonstrate spacecraft propellant loading and cleanup without need for personal protective equipment

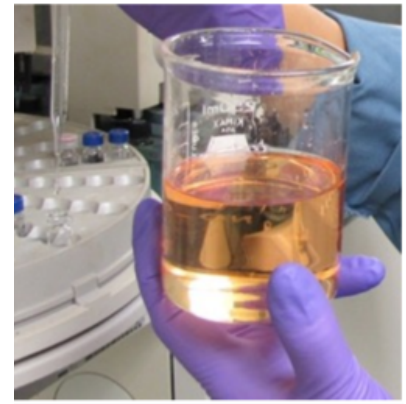
Access to Space:

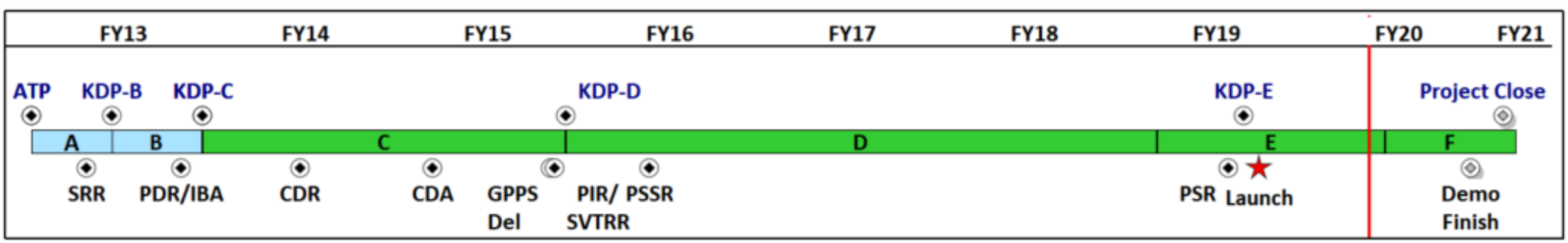
- Launched into space June 25,2019 on a Falcon Heavy Rocket, as part of the USAF Space Test Program-2 (STP-2) mission
- USAF SMC operates GPIM using AFSCN ground stations
- 13 months of on-orbit operations

Team:

- Lead: Ball Aerospace
- Partners:
  - Aerojet Rocketdyne: Thruster & propulsion system
  - Air Force Research Laboratory: AF-M315E development, propellant loading
  - Glenn Research Center: Plume modeling
  - Goddard Space Flight Center: Slosh & Flow Testing
  - Kennedy Space Center: Propellant handling/testing
  - AF SMC: AFSCN ground stations, MMSOC operations







DEEP SPACE ATOMIC CLOCK

Spaceflight of a hosted payload to demo a small, low-mass atomic clock with unprecedented stability for deep space navigation and science.	7120.5 Space Flight	Phase E

Objectives:

- Demonstrate Allan deviation < 2.0E-14 @ one day
- Demonstrate < 10m orbit determination using one-way deep space scenario
- Build physics package < 7kg and < 30W

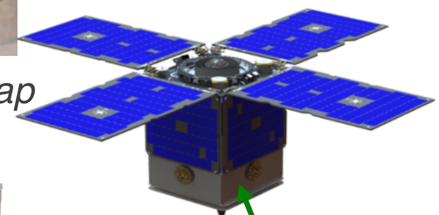
Access to Space:

- **Launched June 2019**
- Hosted payload on Surrey Satellite Technology-US OTB (civil) spacecraft
- OTB ESPA-class spacecraft on a Falcon Heavy LV (USAF STP-2)
- General Atomics operates OTB
- JPL operates DSAC payload
- 7 week commissioning; 1 year on-orbit experiment

Team:

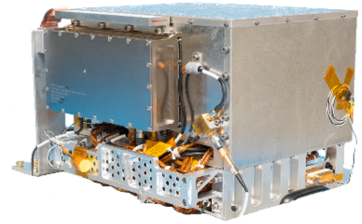
- JPL (lead) – building clock system, operate DSAC payload
- General Atomics – Host Mission Provider (CO) – integrates & operates OTB
- BRE (Moog) – GPS Receiver (AZ)
- FEI – Ultra Stable Oscillator (NY)
- Microsemi – Synthesizer (MA)
- LASP – UV Detector (CO)
- Partners: HEOMD SCaN

Mercury Ion Trap

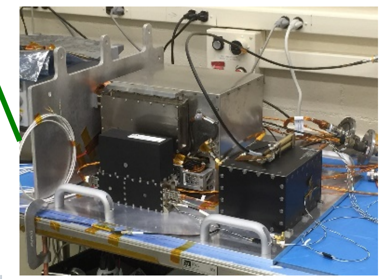


DSAC Payload DU, USO, GPSR

General Atomics OTB



DSAC Demonstration Unit (DU)



OTB one of 26 spacecraft

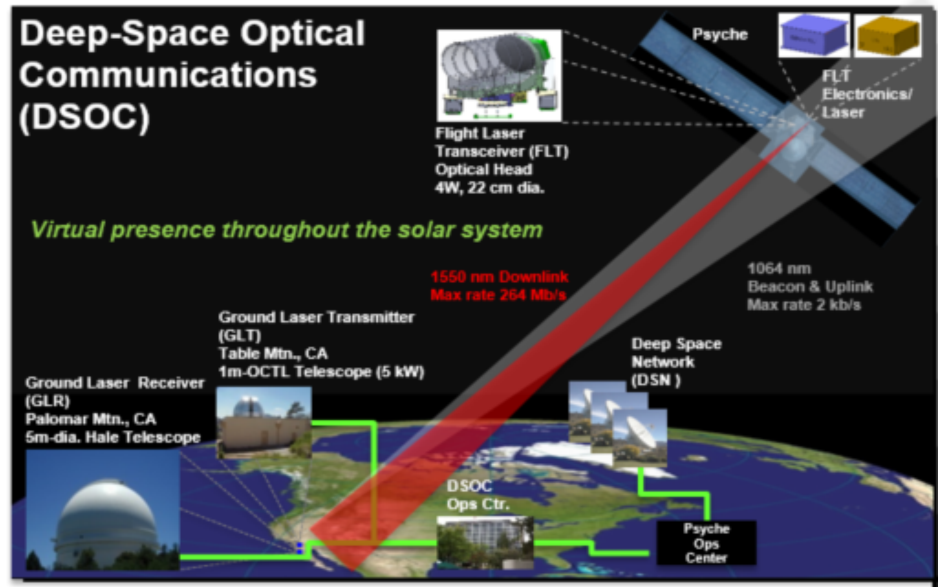
Launched June 25, 2019

DEEP SPACE OPTICAL COMMUNICATIONS

Spaceflight of a hosted payload to demo a small, low-mass optical communication system on a planetary scale to provide substantially greater communications speeds at great distances	7120.5 Space Flight	Phase C

Objectives:

- **Demonstrate deep space optical communication capability**
  - Designed for 0.1 to 2.7 AU
  - Sun-Earth Probe Angle > 25° (TBC)
- **Develop a Flight Laser Transceiver (FLT) for accommodation on Psyche spacecraft**
  - Downlink data-rate of **0.256 - 200 Mb/s**
  - Uplink data-rate of **[2 kb/s]**
  - Prime demonstration duration **1 year**
- **Develop ground network**
  - GLT for transmitting laser beacon out to 2.7 AU
  - GLR retrofitted with photon counting receiver
  - Mission Operations System



Project Manager (PM): Bill Klipstein
Project Technologist (PT): Abi Biswas

Sponsors:

STMD/TDM (flight), HEOMD/SCaN (ground), SMD (host)

Facilities:

Optical Comm and Environmental Test Labs at JPL
Vendor site Labs and test facilities
Optical Communication Telescope Laboratory (OCTL)
Caltech Optical Observatories/Hale Telescope Observatory
Psyche mission host

Key Milestones:

(Aug, 2022 launch on Psyche (Mars fly by)
FY14-16 GCD Technology Development Phase
FY17 Phase A Start, SRR/MDR
FY19 Flight PDR
FY20 Flight CDR, Ground PDR
FY20 Downlink I+T start at JPL
FY21 Del to S/C, start I+T at Hale and OCTL
FY22 ORR, Launch
FY22-23 Ops

EXTREME ENVIRONMENT SOLAR POWER (EESP)

EESP technology offers increased solar power for NASA missions in the general vicinity of Jupiter [~5 Astronomical Units (AUs)]. EESP is designed to operate in areas with low-intensity sunlight and low temperatures (LILT) as well as in higher radiation environments such as that around Jupiter.

Transformational Array

- Modular and integrated reflector / PV flexible blanket assembly on DSS Roll Out Solar Array (ROSA)
- Integral reflector elements reliably deploy as blanket assembly unrolls
- Wide off-pointing acceptance angles (alpha: +/- 5-deg [up to +/-10) before non-cosine losses; beta: typical cosine loss behavior)
- SSL/ATK CellSaver 7-yr+ GEO experiment suggests this concentrator architecture is viable

Technical Capabilities include increased

- Beginning of life solar cell efficiency, >35% (1 AU)
- End of life solar cell efficiency, >28% (LILT, 4×10^{15} 1 MeV e/cm^2 dosage)
- End of life specific power, > 8 W/kg
- Stowed packaging density: 51 kW / m^3

Enabled by SolAero-developed IMM4 solar cell technology, applicable to *<u>concentrator</u>* *and* *<u>planar</u>* *arrays*

Exploration & Science Impact

- Enable subset of future NASA missions at larger distances from the sun using solar power
- Increase mission life, capability, and/or decrease mission mass for these missions

Innovative technological approach that has continuing applicability to future SMD missions