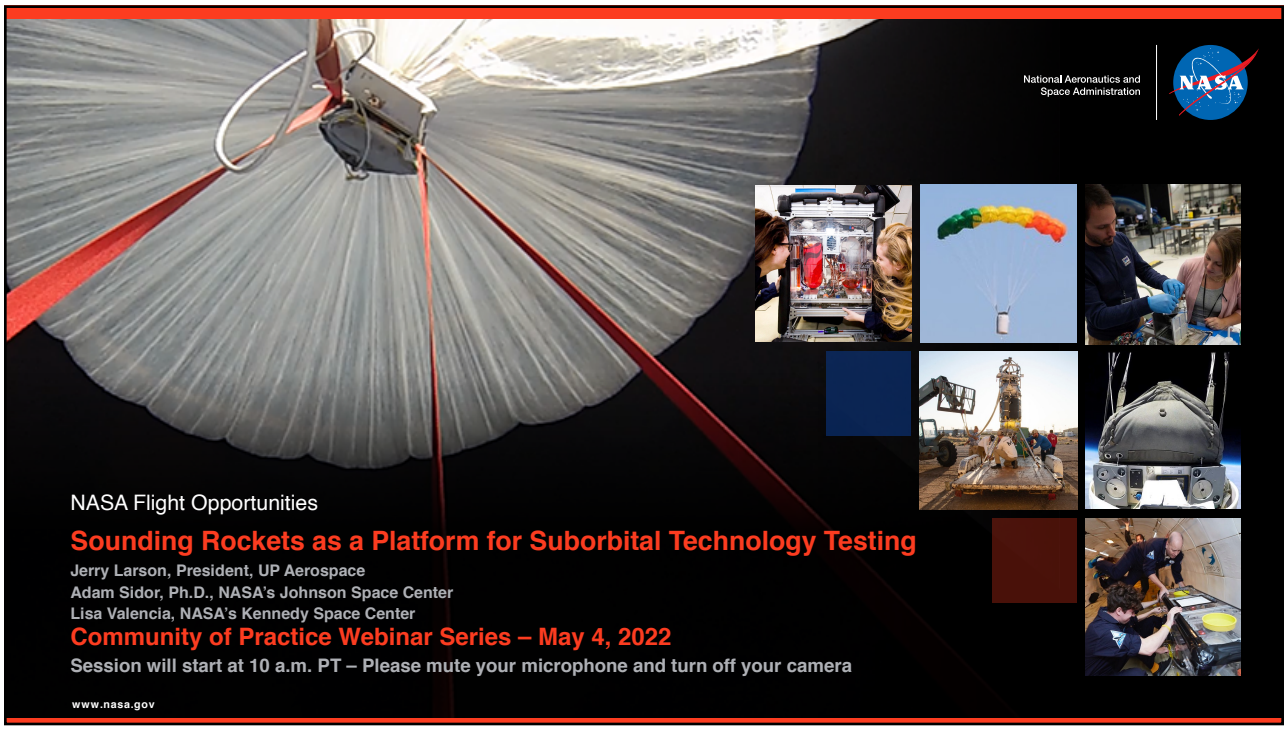
National Aeronautics and Space Administration
NASA
NASA Flight Opportunities
Sounding Rockets as a Platform for Suborbital Technology Testing
Jerry Larson, President, UP Aerospace
Adam Sidor, Ph.D., NASA's Johnson Space Center
Lisa Valencia, NASA's Kennedy Space Center
Community of Practice Webinar Series – May 4, 2022
Session will start at 10 a.m. PT – Please mute your microphone and turn off your camera
www.nasa.gov

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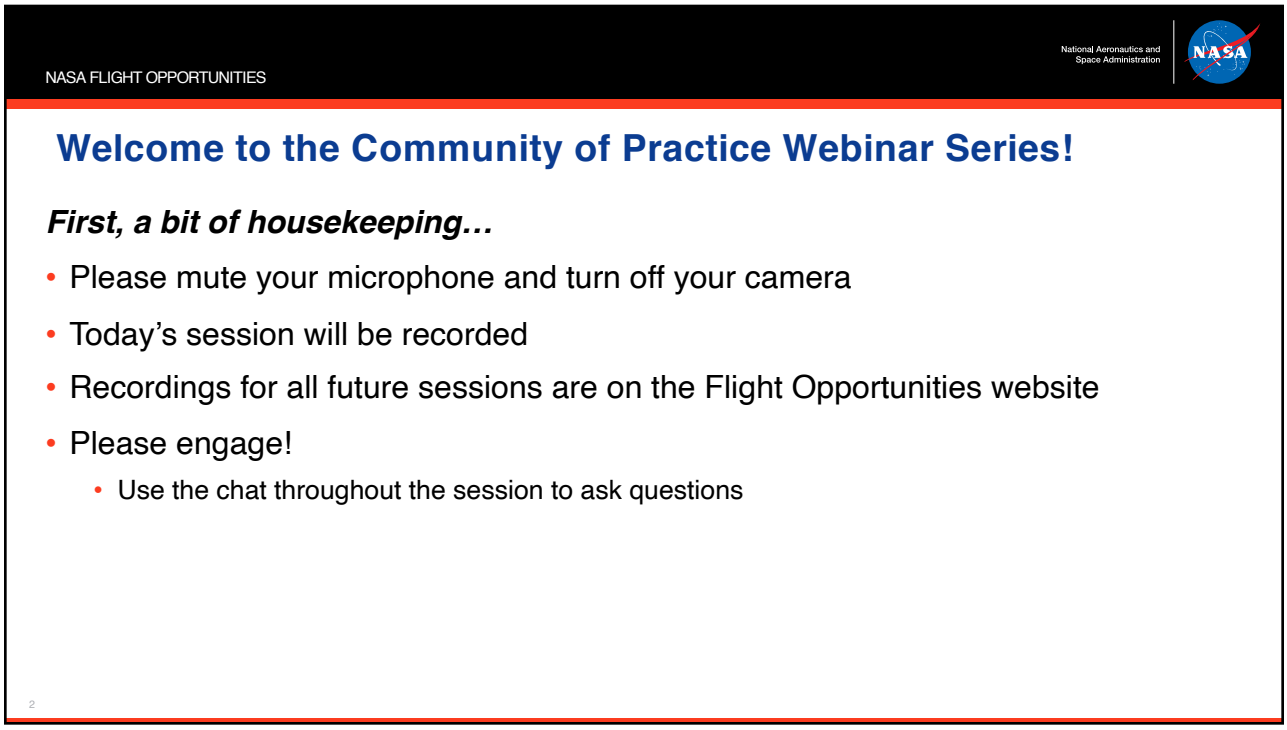

NASA FLIGHT OPPORTUNITIES
National Aeronautics and Space Administration
NASA
Welcome to the Community of Practice Webinar Series!
First, a bit of housekeeping…
• Please mute your microphone and turn off your camera
• Today's session will be recorded
• Recordings for all future sessions are on the Flight Opportunities website
• Please engage!
• Use the chat throughout the session to ask questions
2

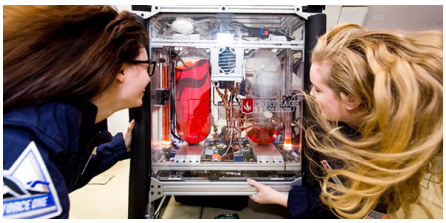
2

NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Flight Opportunities Mission

The Flight Opportunities program facilitates **rapid demonstration** of promising technologies for space exploration, discovery, and the expansion of space commerce through **suborbital testing with industry flight providers**.



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NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Join us for future Community of Practice webinars!

Subscribe to our newsletter to see next month's topic!

https://go.usa.gov/xupxP

Future webinars

- Webinars are held 1st Wednesday of each month at 10 a.m. PT
- Topics will be announced in the Flight Opportunities newsletter and website
- Session recordings will be posted on the Flight Opportunities website
- Let us know session topics you would like to see covered

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NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Upcoming Opportunities

NASA TechLeap PRIZE

NASA TechLeap Prize - Nighttime Precision Landing Challenge No.1

Seeking proposals for sensing systems that can detect hazards from an altitude of 250 meters or higher and process the data in real time to help spacecraft land safely in the dark

- Open to researchers from qualified commercial businesses and academic institutions, as well as individual entrepreneurs and other innovators
- **Register by May 5, 2022!**
- Applications due May 19, 2022

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NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Upcoming Opportunities

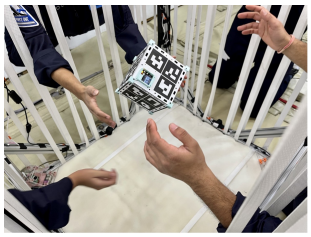
NASA TECHFLIGHTS

NASA TechFlights 2022

- Provides up to $**750K** for testing space technologies in relevant environments through flights on U.S. commercial suborbital rockets, rocket-powered lander vehicles, high-altitude balloons, and aircraft following reduced-gravity flight profiles, as well as for payloads hosted on commercial orbital platforms.
- STMD is strongly committed to ensuring that proposal review is performed in an equitable and fair manner that reduces the impacts of any unconscious bias. To this end, this year's TechFlights solicitation will employ a **dual-anonymous peer review (DAPR) process.**

Key Dates

- Live Q&A: May 9, 2022, at 9am PDT
- Mandatory Preliminary Proposals due: June 2, 2022
- Full proposals (by invitation only) due: August 29, 2022



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NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Today's Speakers

Lisa Valencia
Engineer and Project Manager
NASA's Kennedy Space Center

Adam Sidor, Ph.D.
Aerospace Technologist
NASA's Johnson Space Center

Jerry Larson
President
UP Aerospace

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Autonomous Flight Termination System (AFTS) and

GNSS GPS-Galileo Interoperability Payloads

Flight Opportunities Program

Lisa Valencia, Project Manager and Systems Engineer
NASA HQ/Overlook Systems

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What is AFTS?

- **Concept of Autonomous Flight Termination System**
  - **Box on the vehicle (AFTU)**
    - Tracking from GPS and INS sensors
    - Rule set built in pre-flight period
    - If a rule is violated the flight is terminated
  - **Radar and Command stations recede into past**
  - **Telemetry down-link drops from safety critical to sit awareness, post-flight, & mishap**
- **Advantages**
  - Cost reduction due to decreased need for ground-based assets
  - Global coverage (vehicle does not have to be launched from a range)
  - Increased launch responsiveness
  - Boundary limits increase due to 3-5 second gain from not having MFCO
  - Can support multiple vehicles simultaneously (such as flyback boosters)

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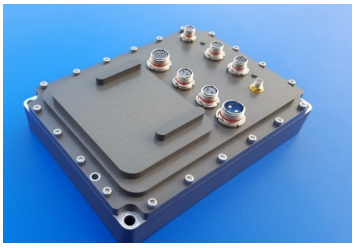
AFTS Hardware



AFTU Overview

- < 1.3kg
- Nominally <7 watts at 28 V DC
- Estimate 5cm X 14cm X 19cm
- Outputs discrete signals or up to 5.5 amps at 28 V DC
- Term or TermNOT (for normally closed valves) configurable
- Using Mil-spec parts (simplified piece parts plan) in critical circuits
- Qualified to AF/NASA/FAA range requirements
- Up to 5 sensor combinations may be connected to one AFTU
- -GPS, INS, GPS/INS hybrid or IMU
- Single or cross strapped configurations
- No single point failure (failsafe exception for single AFTU)
- Ensure no inadvertent termination
- 0.999 Reliable at 95% Confidence

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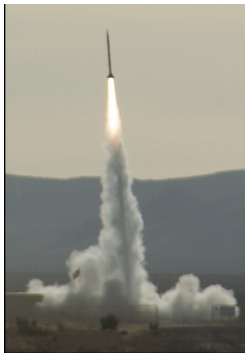
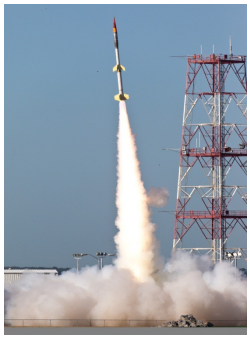
AFTS Hardware Launch Demonstrations



UP Aerospace Spaceloft Launch

Rocket Lab Electron Launch



Sounding Rocket at WFF

- NASA AFRC Flight Opportunities Program (FOP) purchased 6 units; two units were flown on the UP Aerospace SL-12 launch, two were flown on a RL launch, the two from SL-12 were recovered and re-flown on UP Aerospace SL-14, and the last two were sent to NASA WFF for software testing in their AFTS lab

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AFTS Operational Launch

- After successfully completing several shadow/certification flights, the NASA/DARPA AFTU was used operationally for the first time on Rocket Lab Electron Launch 10 from New Zealand on Dec 6, 2019.
- Several launch vehicles have baselined the NASA/DARPA AFTS units into their vehicles for operational use in the future.
- Several DoD weapons test programs are leveraging the NASA/DARPA AFTU design and miniaturizing the unit for their applications.

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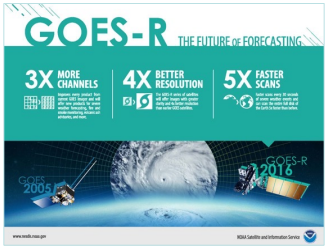
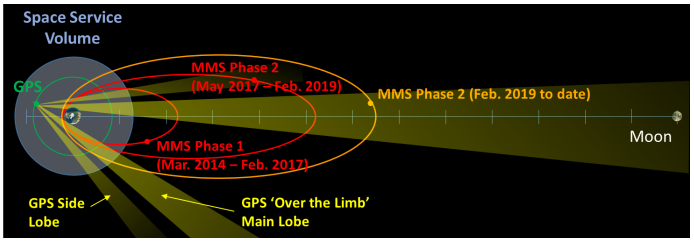
GPS Use in High Earth Orbit (HEO)

GPS is already being used in HEO because it significantly improves real-time navigation performance, supports quick trajectory maneuver recovery, reduces need for expensive on-board clocks, and supports increased satellite autonomy while lowering operations costs



GOES-R: GOES-16 launched in 2016. Operational use of GPS main and side lobe signals at GEO altitude to meet stringent navigation requirements needed for improved weather forecasting.

Magnetospheric Multiscale (MMS) Mission:
Demonstrated GPS main and slide lobe signal tracking halfway to the Moon



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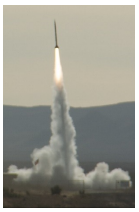
Pursuing GPS-Galileo Interoperability

If space users could rely on signals from more than one GNSS constellation, then signal coverage would greatly be improved. There would also be an increase in the diversity of system architecture, frequencies, and geometry. This, in turn, will further improve the overall PNT performance available to space users.

GPS-Galileo Receiver:
Weight: 0.7 Kg
Size: 16.8 x 12.6 x 3.5 cm
Power: 5V, 1A, 5W



UP Aerospace SL-14: GPS & Galileo tracked in highly dynamic environment. Launched Nov. 2019.

UP Aerospace SL-15: GPS & Galileo integrated with AFTS in highly dynamic environment. Launch scheduled for Nov 2022

Commercial Lunar Payload Services (CLPS) 19D: GPS & Galileo to Lunar Surface on Firefly Blue Ghost Lander 2024

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AMTPS

Additive Manufacturing of Thermal Protection Systems (AMTPS)

Project and Flight Test Overview

An Early Career Initiative (ECI) funded by NASA
Space Technology Mission Directorate (STMD)

PI: Adam Sidor (adam.t.sidor@nasa.gov)
NASA Johnson Space Center
5/4/22

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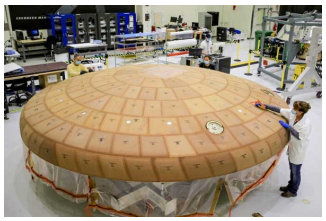
AMTPS

Developing additive manufacturing for heat shields

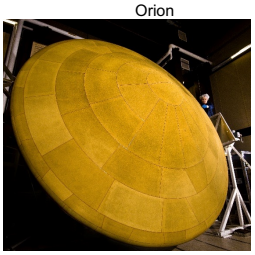
Traditional Approaches

Manual fabrication, bonding in segments, single formulation

Apollo



Orion



Mars Science Laboratory

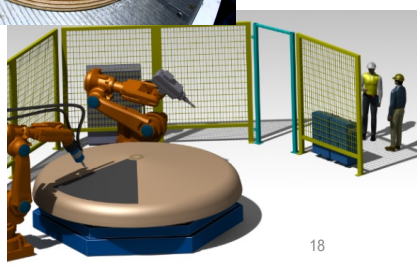
Photo Credits:
Left: B. Anthony Stewart/National Geographic/Getty Images, The Amazing Handmade Tech That Powered Apollo 11's Moon Voyage – HISTORY
Top right: NASA/Isaac Watson, Heat Shield Milestone Complete for First Orion Mission with Crew | NASA
Bot right: NASA/JPL-Caltech/Lockheed Martin, Large Heat Shield for Mars Science Laboratory – NASA's Mars Exploration Program

Additive Manufacturing of Thermal Protection Systems (AMTPS)

FY21/22 Early Career Initiative (ECI) funded by NASA
Space Technology Mission Directorate (STMD)

Automated, monolithic fabrication, graded formulation

Video: G. Larsen/ORNL



OAK RIDGE National Laboratory
University of Kentucky

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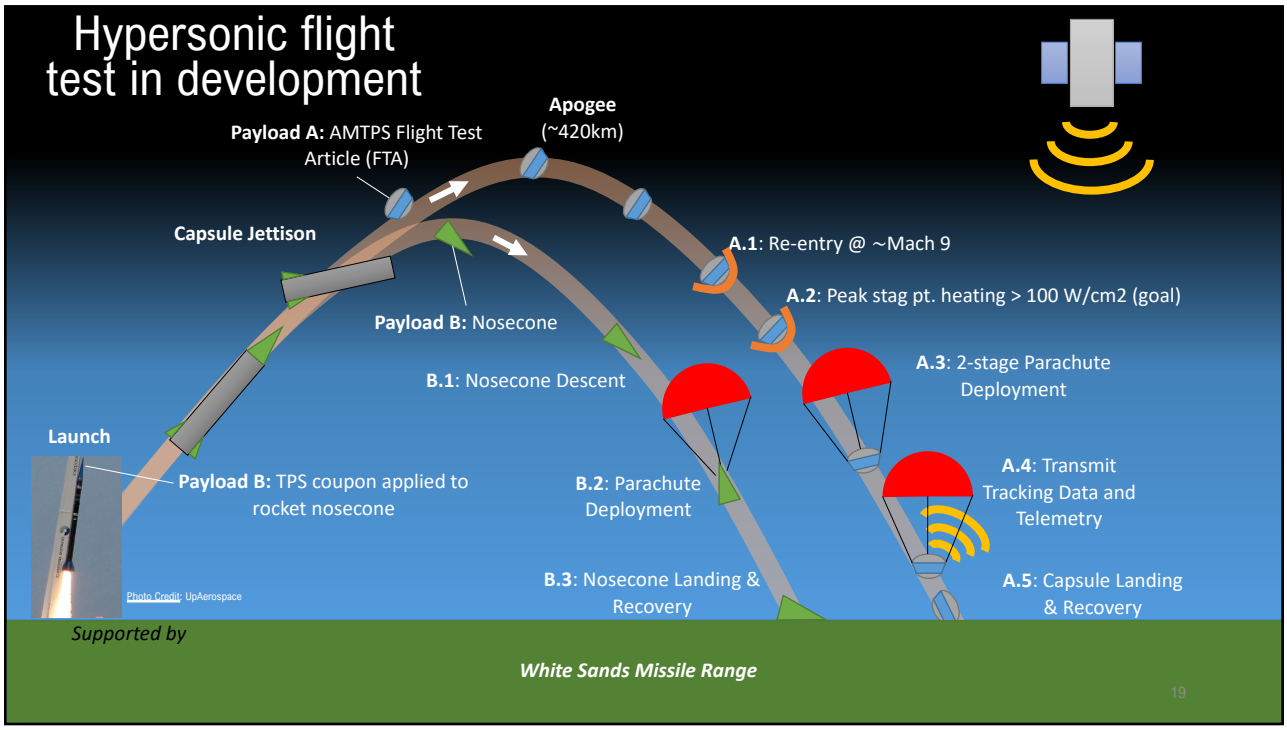
Hypersonic flight test in development
Payload A: AMTPS Flight Test Article (FTA)
Apogee (~420km)
Capsule Jettison
A.1: Re-entry @ ~Mach 9
A.2: Peak stag pt. heating > 100 W/cm2 (goal)
Payload B: Nosecone
B.1: Nosecone Descent
A.3: 2-stage Parachute Deployment
Launch
Payload B: TPS coupon applied to rocket nosecone
B.2: Parachute Deployment
A.4: Transmit Tracking Data and Telemetry
B.3: Nosecone Landing & Recovery
A.5: Capsule Landing & Recovery
Photo Credit: UpAerospace
Supported by
White Sands Missile Range
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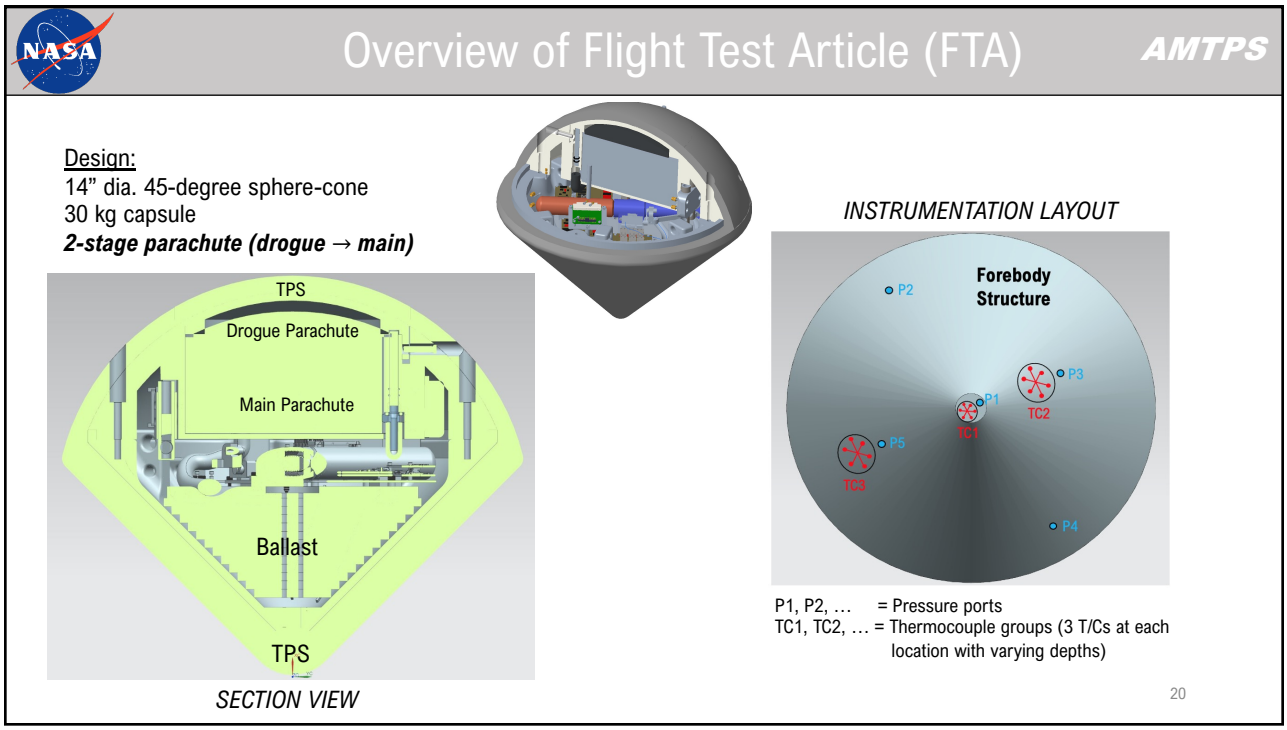
NASA
Overview of Flight Test Article (FTA)
AMTPS
Design:
14" dia. 45-degree sphere-cone
30 kg capsule
2-stage parachute (drogue → main)
TPS
Drogue Parachute
Main Parachute
Ballast
TPS
SECTION VIEW
INSTRUMENTATION LAYOUT
Forebody Structure
P1
P2
P3
P4
P5
TC1
TC2
TC3
P1, P2, … = Pressure ports
TC1, TC2, … = Thermocouple groups (3 T/Cs at each location with varying depths)
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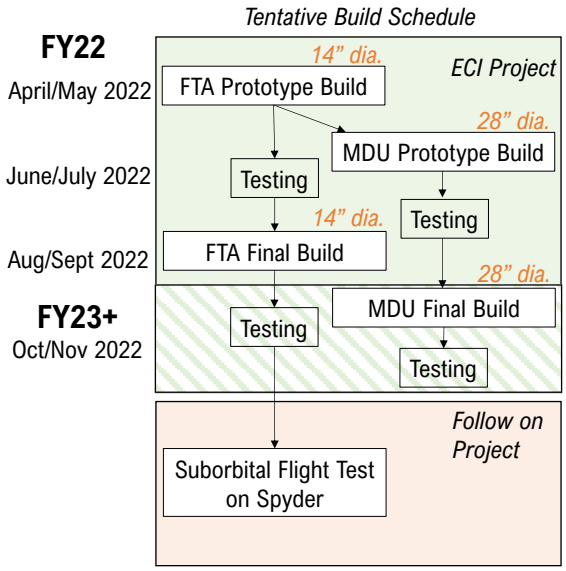
Why a flight test?

AMTPS

- Demonstrate AMTPS as a viable, flight proven TPS solution for entry vehicles
  - End-to-end test of AMTPS manufacturing, integration, instrumentation, flight, and recovery in a representative flight environment
- Obtain flight data ("test like you fly")
  - In-depth temperatures of AMTPS heat shield used to improve thermal response model
  - Post-flight retrieval, inspection, and analysis of a flown AMTPS
  - Expose alternate TPS materials to ascent heating and recover for post-flight analysis
- Personnel development
  - Team composed of almost entirely early career (EC) personnel
    - 6 EC Civil Servants, 2 Graduate Students, many interns
  - Start-to-finish execution of a flight test
    - Plan → Design → PDR → Prototype build → CDR → Flight hardware build → Conduct flight → Post-flight Analysis

Tentative Build Schedule



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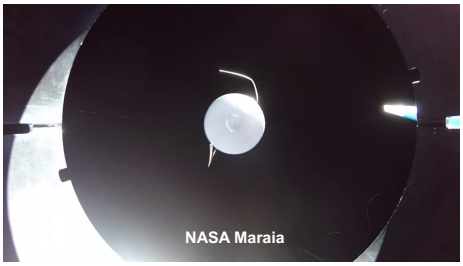
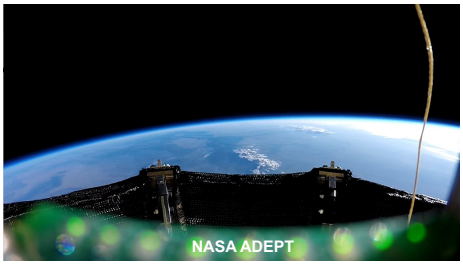
UP Aerospace

NASA Flight Opportunities Program

- 7 launches completed since 2013
  - NASA AFTU mission (Fall 2022)
  - Tech Rise student mission (Spring 2023)
- Microgravity missions
- Separation missions
  1. Maraia re-entry capsule (NASA JSC)
  2. ADEPT (AMES Research Center)
  3. Los Alamos National Labs





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UP Aerospace

NASA Tipping Point (Spyder Development)

- Propulsion Static Flight Qualification Tests (NASA MSFC)
- Attitude Control System Flight Tested onboard SpaceLoft
- Flight Termination System Ordnance Tests

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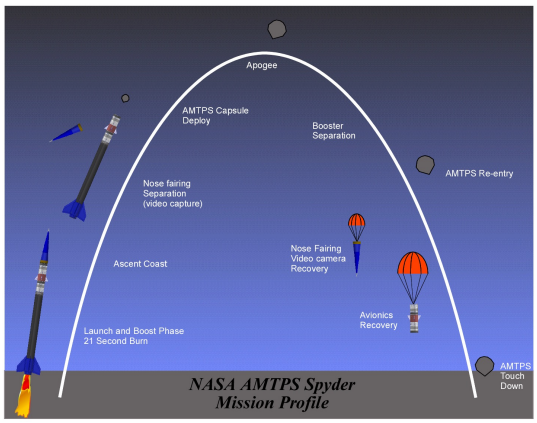
UP Aerospace

Spyder Hypersonic Sub-Orbital Launch Vehicle

- Launch site: Spaceport America / WSMR
- First flight Sept 2023
- 17.25 inch diameter
- Mach 9+ missions (with single stage)
- Accent canard guidance system
- Exo-atmospheric Attitude Control System
- Payload separation system
- Recovery systems
- NASA Automated Flight Termination Unit (AFTU)



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NASA FLIGHT OPPORTUNITIES

National Aeronautics and Space Administration

Thank you!

Flight Opportunities website:
http://nasa.gov/flightopportunities

Contact us:
NASA-FlightOpportunities@mail.nasa.gov

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