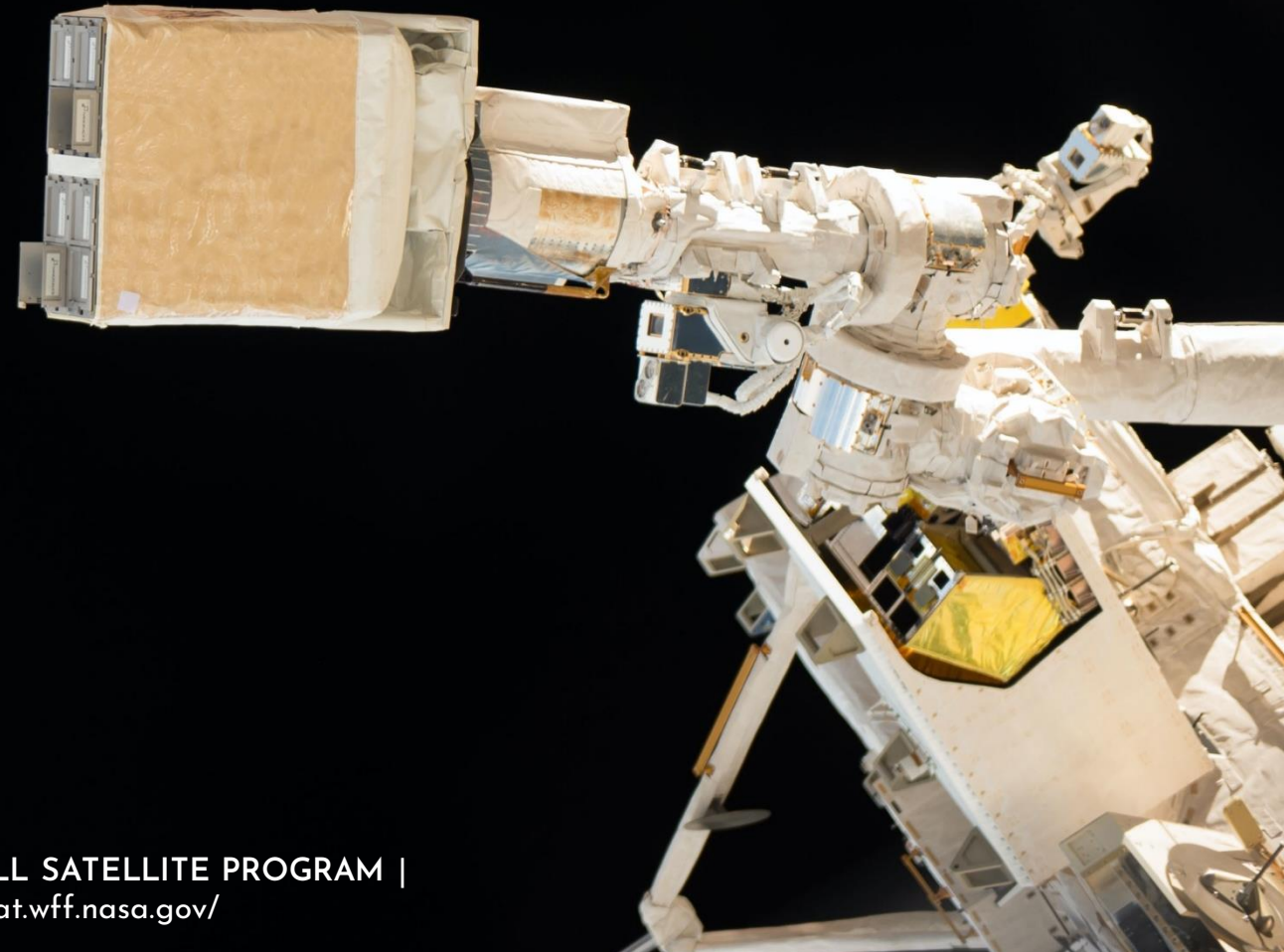




Teaming with Goddard for Small Satellite Opportunities 35th Small Satellite Conference



Presenter: Scott Schaire
Scott.h.schaire@nasa.gov
Advanced Projects Office
Date: August 9, 2021

Agenda



- Science Collaboration
- Integration and Test
- Engineering
- Mission Planning
- Near Space Network
- Technology



Unsurpassed Science Collaboration

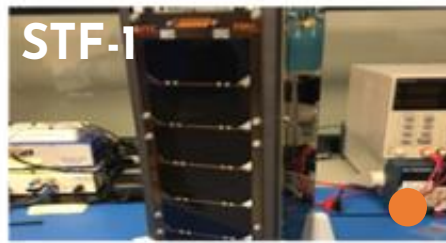
NASA Goddard SmallSats

National Aeronautics and
Space Administration



Goddard has a rich history of supporting innovative science through SmallSat platforms with a strong emphasis on Heliophysics investigations

On-Orbit

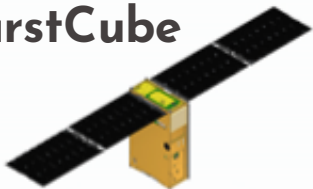


PI: J. Morris/Goddard

- Heliophysics
- Astrophysics
- Earth Science

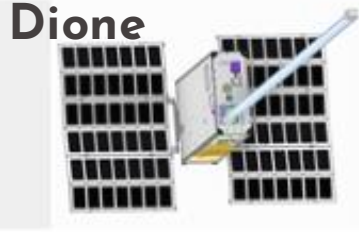
Upcoming

BurstCube



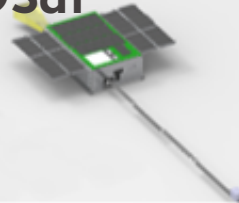
PI: J. Perkins/Goddard

Dione



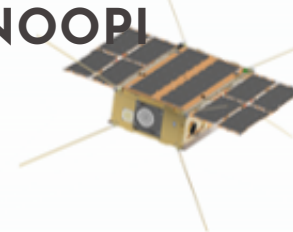
PI: E. Zesta/Goddard

GTOSat



PI: L. Blum/Goddard

SNOOPI



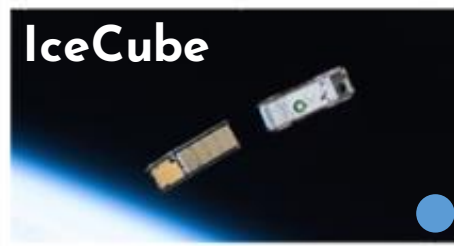
PI: J. Garrison/Purdue

petitSat



PI: J. Klenzing/Goddard

IceCube



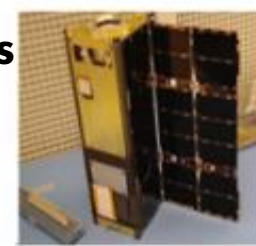
PI: D. Wu/Goddard

HaloSat



PI: P. Kaaret/U. of Iowa

CeREs



PI: S. Kanekal/Goddard

Dellinger



PI: Larry Kepko/Goddard

Past Missions

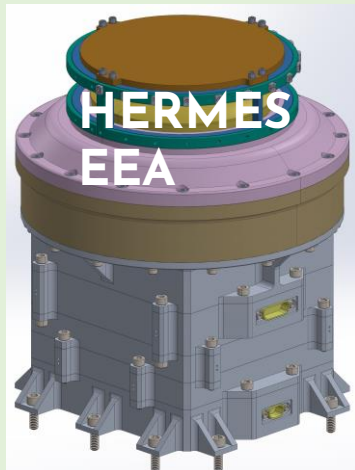
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Goddard Miniaturized Heliophysics Instruments

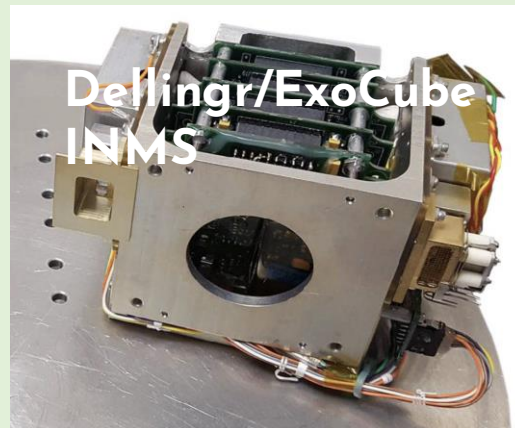
National Aeronautics and
Space Administration



Goddard Heliophysics Science Division has a long-term commitment to advance miniaturized instrumentation that can take advantage of SmallSat platforms



Electron spectrometer
Principal Investigator (PI):
D. Gershman/Goddard



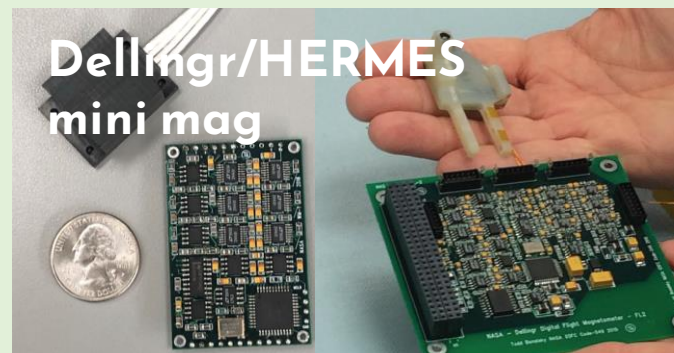
Ion-neutral mass spectrometer
PI: N. Paschalidis & S. Jones/Goddard



Energetic particles
PI: S. Kanekal/Goddard



Dellinger



Fluxgate magnetometer
PI: E. Zesta/Goddard

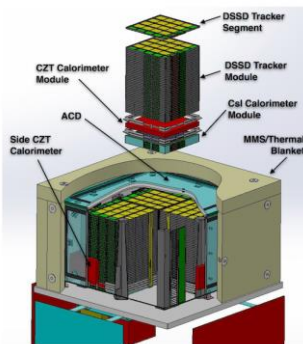
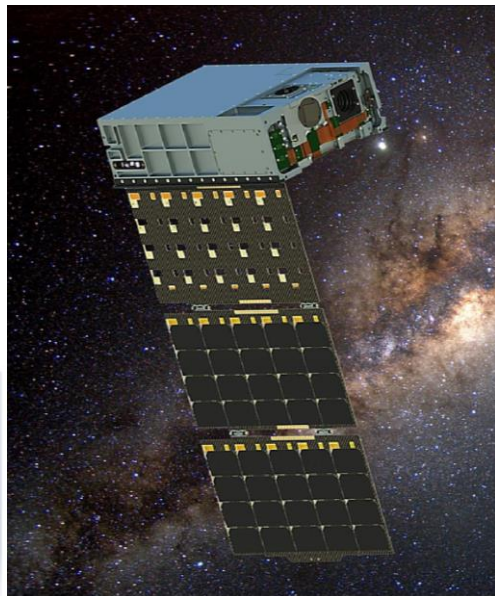
SmallSats Opportunities in Planetary and Lunar at Goddard



- There are a number of Planetary and lunar mission concepts in work every year
 - Success with New Frontiers, Discovery, Lunar and other opportunities
- One of the largest space flight planetary and lunar instrument developers and providers
- The combination of Goddard's mission leadership experience, science and instrument depth can create opportunities for small spacecraft and CubeSat missions partnerships
 - Payloads and Research Investigations on the Surface of the Moon (PRISM), Artemis and other rideshares are the primary mission class for partnerships with Goddard Small Satellites
- Contact Michael Amato, michael.j.amato@nasa.gov for Planetary and Lunar Applications

Goddard Astrophysics Small Platform Science

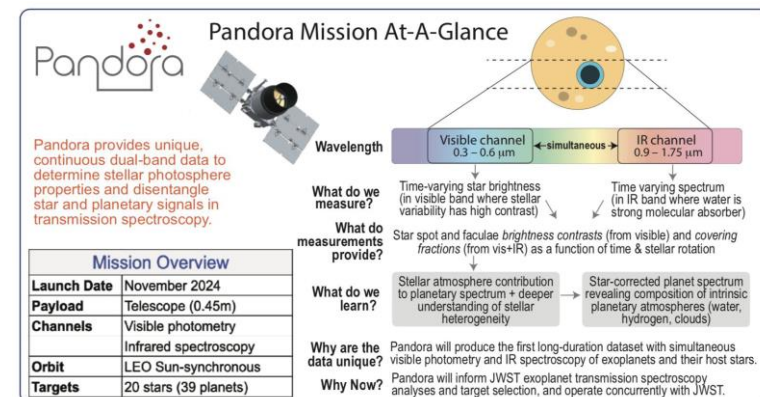
Technology Development: Astrophysics Research and Analysis (APRA)



Partnership Approach:

- Team with Goddard Astro for proposal and project opportunities
- Explain your “science” and your “collaboration needs”, to explore partnership opportunities
- Contact Dave Richardson, david.h.richardson@nasa.gov for Astrophysics Applications

Science Exploration: Pioneers



Earth Science: Designated Observable: Surface Biology and Geology Decadal Study

Goddard is Exploring Small Satellite Architectures with other NASA Centers



An ash plume drifts from Paluweh volcano in Indonesia in 2013, seen by the NASA-United States Geological Survey (USGS) Landsat 8

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Desired Measurements

Earth surface geology and biology, ground/water temperature, snow reflectivity, active geologic processes, vegetation traits and algal biomass

- Flows of energy, carbon, water and nutrients sustaining terrestrial and marine ecosystems
- Inventory global volcanoes and geology of exposed land surfaces
- Global carbon cycle, associated climate and ecosystem impacts
- Functional traits and diversity of terrestrial and aquatic vegetation
- Composition and temperature of volcanic products following eruptions
- Variability of land surface and fluxes of water, energy and momentum
- Snow accumulation, melt and spectral albedo
- Land and water use effects, surface temperatures, evapotranspiration
- Water balance from headwaters to the continent



Comprehensive Integration and Test

Goddard Wallops SmallSat Integration and Test

E109 Engineering

- Labs for Prototyping, Harness Fabrication, Component Testing, Software Development, Global Positioning System (GPS) Lab

F7 Integration and Test

- Cleanroom for SmallSat processing
- Antenna Chamber
- Electromagnetic Interference (EMI) Chamber
- Thermal Vacuum
- Machine Shop

F10 Test and Environmental

- Vibration and Moment of Inertia Test Facility
- Spin Balance
- Attitude Control Testing
- Magnetics Facility
- Machine Shop

N161

- Near-Space Network (NSN) Integration and Testing for Reliable Operations (NITRO) Lab

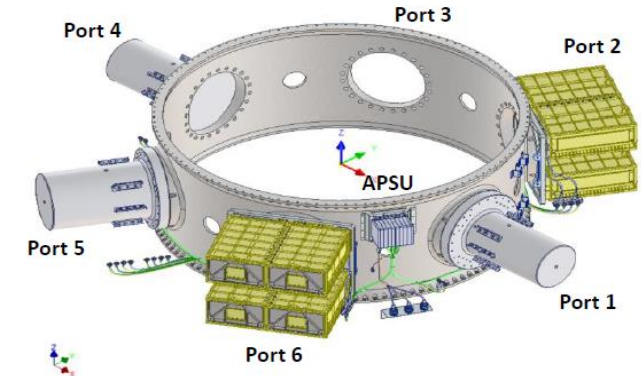


Goddard Wallops Rideshare Integration Services

- Development of non-recurring Integration and Test (I&T) hardware
 - Mechanical Ground Support Equipment
 - Electrical Ground Support Equipment
- Receipt, Inspection and Preparation of Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) hardware
- Integration activity (payload-to-ESPA)
- Integrated ESPA pre-ship checkout prior to shipment to Launch Vehicle site
- Support ESPA integration to Launch Vehicle at launch site



*Integrated ESPA ring
prior to leaving Wallops
for Vandenberg*



*Successful Landsat 9
Integration at Wallops*



Delivery at Vandenberg



Experienced Engineering with Small Satellites

Goddard Wallops Engineering



- Includes Mechanical Systems, Electrical, Systems Software, and Guidance Navigation & Control & Missions Systems Engineering
- Offers a broad range of skills in conjunction with Wallops' exhaustive array of Integration & Test facilities
- Provides an array of useful tools to support the life cycle of mission operations including the Wallops Arc Second Pointer (WASP) and the Mission Planning Lab (MPL)

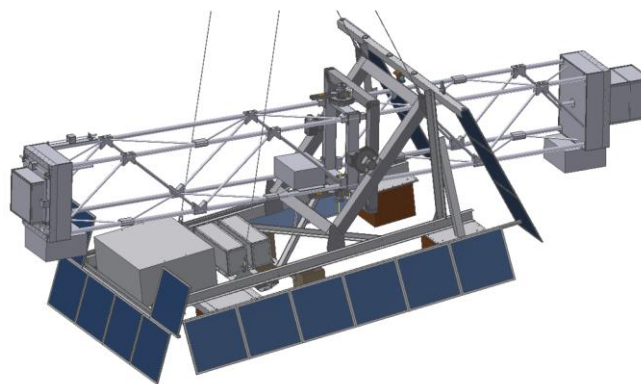


**Low Density
Supersonic
Decelerator
(LDSD)**

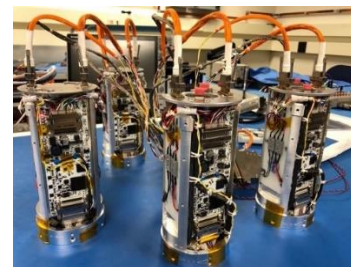
www.nasa.gov



**Pointing
Systems for
Balloons and
International
Space Station
(ISS) Payloads**



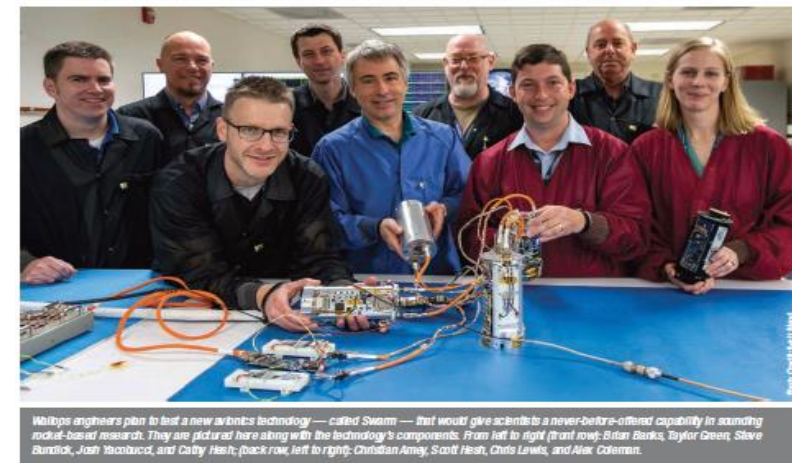
WASP



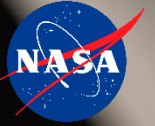
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<https://smallsat.wff.nasa.gov/>

Communicating with a Swarm

Sounding Rocket Technology Could Enable Simultaneous, Multi-Point Measurements



During SubTec-8, Wallops demonstrated a new technology that could deploy multiple soda can-sized sub-payloads to varying altitudes where their onboard miniaturized instruments could gather multi-point measurements – a never-before-offered capability



Wallops Provided Mission Planning Services for Small Satellite and Suborbital Missions

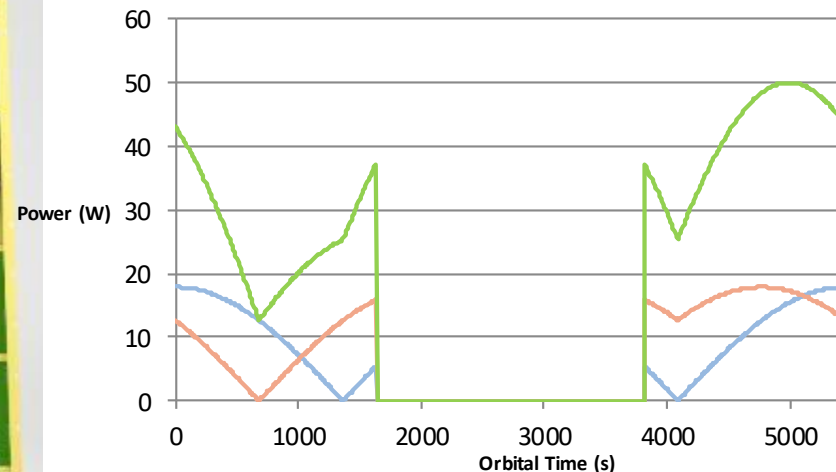
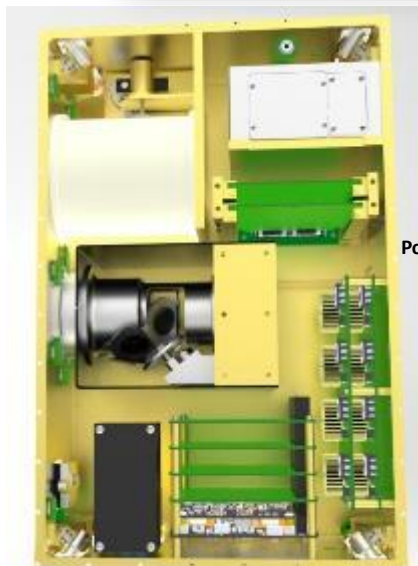
Goddard Wallops MPL - SmallSat/CubeSat Design

Mission
Planning with
Project
Management
expertise in
NPR 7120.8
Revision A,
NASA
Research and
Technology
Program and
Project
Management
Requirements

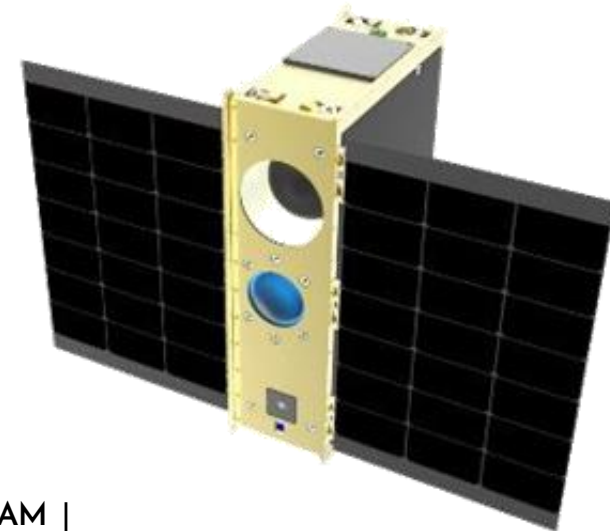
www.nasa.gov

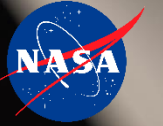


Subsystem	Component	Power (W)	Cycle Length (hours)	Science Mode (Deploy)		Science Mode (Deploy) + Tx		Detumble Mode	
				Duty Cycle	WHrs Used/Cycle	Duty Cycle	WHrs Used/Cycle	Duty Cycle	WHrs Used/Orbit
Experiment	CMOS	0.6	1.5	0.22200	0.200	0.22200	0.200	0.000	0.000
	Interface Board	1	1.5	0.22200	0.333	0.22200	0.333	0.000	0.000
	Filter Motor	5	1.5	0.00556	0.042	0.00556	0.042	0.000	0.000
	Blue Canyon XACT	1.2	1.5	1.00000	1.800	1.00000	1.800	1.000	1.800
	Fine Sun Sensor	1	1.5	1.00000	1.500	1.00000	1.500	1.000	1.500
	Thrusters	0.3	1.5	1.00000	0.450	1.00000	0.450	1.000	0.450
	Photo Diodes	0.5	1.5	1.00000	0.750	1.00000	0.750	1.000	0.750
Comm	Tx	6.4	1.5	0.00000	0.000	2.67000	25.632	0.000	0.000
	Rx	6.4	1.5	1.00000	9.600	1.00000	9.600	1.000	9.600
	Antenna	0.0264	1.5	1.00000	0.040	1.00000	0.040	1.000	0.040
C&DH	CHREC	2.58	1.5	1.00000	3.870	1.00000	3.870	1.000	3.870
Power	EPS	0.1	1.5	1.00000	0.150	1.00000	0.150	1.000	0.150
	Custom Card	1	1.5	1.00000	1.500	1.00000	1.500	1.000	1.500
Batteries	Consumption	0.3	1.5	1.00000	0.450	1.00000	0.450	1.000	0.450
Heaters	Batteries	0.594	1.5	0.10000	0.089	0.10000	0.089	0.100	0.089
Total Consumed					20.773		46.405		20.199
Consumption EPS Losses =				10.0%	2.077		4.641		2.020
Consumption Harness Losses =				5%	1.039		2.320		1.010
Consumption Battery Losses =				5%	1.039		2.320		1.010
Total Consumed (Inc EPS, Harness and Battery Losses)					24.928		55.686		24.238
Worst Case Energy Production (Beta = 0, Orbit Average X Orbit Length)					56.3		56.3		0
Charging EPS Losses =				15.0%	8.445		8.445		0.000
Charging Battery Losses =				5.0%	2.815		2.815		0.000
Worst Case Energy Production (Including EPS and Battery Losses)					45.040		45.040		0.000
Net WHrs Per Cycle (Production - Consumption)					20.112		-10.646		-24.238
#orbits on a typical day (Orbit length = 90 minutes)					15.00		1		
Net WHrs on a day (Net WHrs per Orbit * #Orbits)					301.682		-10.646		



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<https://smallsat.wff.nasa.gov/>





Access to Near Space Network for Telemetry and Commanding

Current Goddard NSN Infrastructure





Technology Ahead of the State of the Art

Goddard core Flight System (cFS) Overview

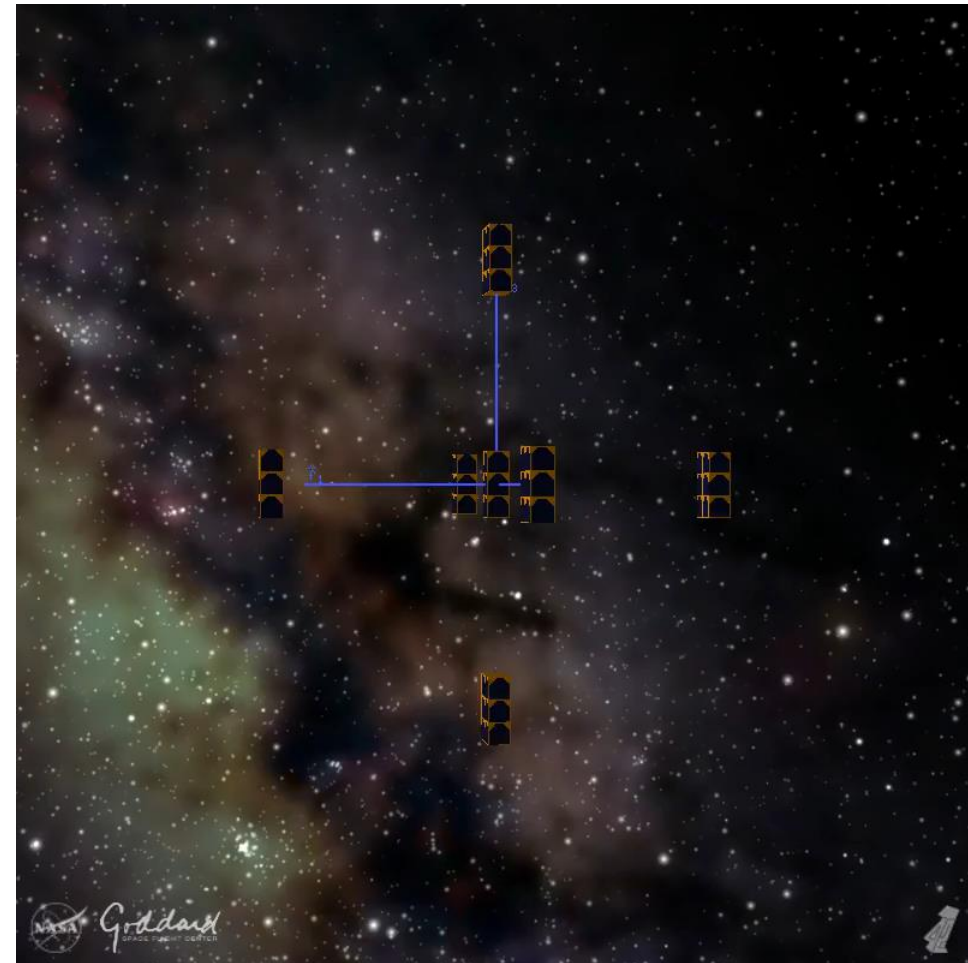
- Used in dozens of space missions ranging from CubeSats to NASA flagship spacecraft and human exploration
- Winner of 2020 NASA Software of the Year award
- Designed as a platform and project independent reusable flight software framework and set of reusable flight software applications
 - Framework provides core functionality such as a publish and subscribe message bus
 - Applications provide mission functionality
- Offers important features
 - Layered architecture
 - Component-based design
 - Portable to multiple operating systems and architectures
 - App-based modularity
- Used at Goddard as part of the SmallSat software suite
 - NASA Operational Simulator for Small Satellites (NOS3)
 - 42 simulator (spacecraft attitude, orbit dynamics, and environmental models)
 - COSMOS ground software



Goddard Constellation Management



- Tools for planning formation flying of small satellite constellations
 - Provides orbit visualization, selection, and analysis for SmallSat formation flying missions
 - Helps identify propellant efficient formations and control strategies
 - Enables future formation missions such as virtual telescopes and servicing





Questions?
Scott.h.schaire@nasa.gov

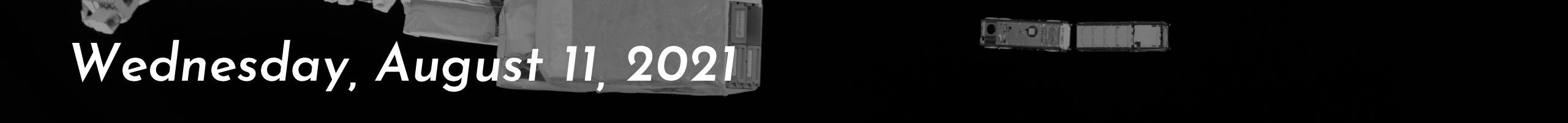
Monday, August 9, 2021

Time (MT)	Time (EST)	Session	Speaker(s)
2:00-3:00 PM	4:00-5:00 PM	Science/Mission Payloads: The Pandora SmallSat: Multiwavelength Characterization of Exoplanets and their Host Stars	Elisa Quintana, Knicole Colon, Greg Mosby, Joshua Schlieder- NASA Goddard; Pete Supsinskas, Jordan Karburn, Jay Vixler, Philip Rittmuller- Lawrence Livermore National Laboratory
3:00-4:00 PM	5:00-6:00 PM	NASA Townhall	



Tuesday, August 10, 2021

Time (MT)	Time (EST)	Session	Speaker(s)
9:00-10:00 AM	11:00-12:00 PM	Future Directions	Florence Tan NASA HQ
10:00-11:00 AM	12:00-1:00 PM	NASA Partnerships	Diane Frazier NASA Partnerships Office, Deputy Director
11:00-12:00 PM	1:00-2:00 PM	Educational Programs: Online Small-Sat Knowledge Repositories and Modeling Tools for Risk Reduction and Enhanced Mission Success	Arthur Witulski, Brian Sierawski, Gabor Karsai, Nag Mahadevan, Robert Reed, Ronald Schrimpf - Vanderbilt University; Allyson Yarbrough - The Aerospace Corporation; Michael Campola - NASA Goddard
12:00-1:00 PM	2:00-3:00 PM	Advanced Technologies 1: NASA SpaceCube Edge TPU SmallSat Card for Autonomous Operations and Onboard Science Data- Data Analysis	Justin Goodwill, Gary Crum, James MacKinnon, Cody Brewer, Michael Monaghan, Travis Wise, Christopher Wilson- NASA Goddard
1:00-2:00 PM	3:00-4:00 PM	CubeSat Core Team: 5 CubeSats, Single Team, Challenges and Lessons Learned	John Valliant NASA Goddard, Greenbelt Campus SmallSat Portfolio Manager
2:00-3:00 PM	4:00-5:00 PM	NASA Goddard Office Hours	



Wednesday, August 11, 2021

Time (MT)	Time (EST)	Session	Speaker(s)
9:00-10:00 AM	11:00-12:00 PM	Space Access	NASA Science Mission Directorate Rideshare Office
10:00-11:00 AM	12:00-1:00 PM	NASA Goddard Wallops Flight Facility Student Flight Opportunities	Joyce Winterton NASA Goddard Senior Advisor for Education and Leadership Development
12:00-1:00 PM	2:00-3:00 PM	Ground Systems: NASA Leveraging Commercial Communication Ground Stations for Small Satellites	Chitra Patel, Scott Schaire, Yen Wong, Leslie Ambrose, Obadiah Kegege- NASA Goddard; Denise Thorsen- University of Alaska, Fairbanks
1:00-2:00 PM	3:00-4:00 PM	Navigating SMA and Electronic Parts in NASA Smallsat Science Missions	Jesse Leitner NASA Goddard, Chief Engineer for Safety and Mission Assurance
2:00-3:00 PM	4:00-5:00 PM	NASA Goddard Office Hours	