

National Aeronautics and
Space Administration



EXPLORESCIENCE

Heliophysics Sounding Rockets, Balloons, CubeSats
Decadal Survey Supplemental Presentation

Dr. Nicola Fox

Heliophysics Division Director
Science Mission Directorate



Overview

- Heliophysics projects executed within Research and Technology Flight Programs
 - Sounding Rockets, Balloons
 - CubeSats
- CubeSats
 - Evolution from previous decade
 - NASA management
- Data Archiving
 - Regulation, Agency requirements



Research and Technology Flight Programs

- Research and Technology (R&T) Flight Program Objectives:
 1. Rapid scientific progress through short duration investigations
 2. Rapid development of new technology, observables and operational strategies
 3. Development of the cadre of future spaceflight experimentalists to conduct the next generation of spaceflight missions to fulfill NASA Science Goals
- Projects solicited and selected via open competitions
 - Heliophysics Low-Cost Access to Space (LCAS) [[ROSES-2022, B.9](#)]
 - Sounding Rockets
 - Scientific Balloons
 - Airborne
 - Commercial Suborbital [[STMD Flight Opportunities Program \(FOP\)](#)]
 - Small (<\$3M) ISS and CubeSat
 - Heliophysics Flight Opportunities for Research and Technology [[ROSES-2022, B.11](#)]
 - CubeSats/SmallSat
 - ISS payloads
 - Hosted payloads (e.g. DoD Space Test Program)
- All programs and competitions emphasize both scientific return and technology development
- Education and professional development is fundamental to R&T flight and is a selection consideration



Research and Technology Flight Programs

- Management under [NPR 7120.8](#), supported through grants and cooperative agreements
 - PI-led investigations
 - Award funding defined at selection
 - Period of performance can be longer than typical research and technology awards
 - H-LCAS are typically 2-3 years, 4 years with justification
 - H-FORT are typically 3-4 years, 5 years with justification
- Schedule, performance, and cost in flight project management
 - Schedule and performance are adjusted to deal with unexpected developments
 - Science Traceability Matrix is used to evaluate impact of any performance changes on the ability of the investigation to achieve the proposed science objectives
 - Cost is fixed at selection; augmentations are subject to program budget constraints and granted in rare circumstances
 - Cost augmentations are most commonly granted when disruptions in NASA-provided services impose additional costs on investigation (e.g. reschedule of remote launch campaign)
 - Cost challenges in the project that cannot be overcome with acceptable modifications to schedule or performance require a NASA-conducted cost review. Augmentations require justifications based on unforeseeable new work necessary to achieve investigation success.
 - *Note:* Recent increased occurrence due to COVID-19 public health situation and supply chain challenges. These augmentations were needed at the time and will not be normal practice in the future.
 - When schedule, performance, and cost issues are not resolved through augmentation or adjustment, project continuation is considered through a competitive re-proposal



Sounding Rockets, Balloons

- This program has a long history of supporting projects, current state is stable and scientifically productive
 - Supports development and demonstration of technologies that are later used in spaceflight missions (e.g. Explorers)
- Program Offices provide infrastructure and support to these projects, funded by SMD
 - Sounding Rocket Program Office is supported, managed by Heliophysics Division
 - Balloon Program Office is supported, managed by Astrophysics Division
- Proposed projects are not subject to a cost cap by the solicitation, but selections and project awards are limited by program funding availability.
 - Current program funding level permits a healthy project cadence
- Projects are selected as fixed-cost, PI-led investigations managed under NPR 7120.8 to encourage prioritizing risk approach and innovative solutions
- Data Archiving
 - Scientific publications are the primary product of these projects
 - Data plan is required for every selected mission since 2018
 - Ensures archiving to accessible storage of raw data and calibration processes
 - Overall trend to archive in NASA-supported data repositories
 - Ensuring that sufficient funds remain at the end of the effort for successful archival activities is often a challenge that must be managed.



CubeSats, Previous Decade

- CubeSats have advanced beyond a novel implementation
 - [CubeSat Design Specification \(Cal Poly\)](#) [2004]
 - [Achieving Science with CubeSats: Thinking Inside the Box](#) [2016]
- CubeSat mission expectations have evolved with technology and vendor maturation
 - Costs
 - Full development cost is significantly higher than originally projected
 - Actual cost is ~\$4-8M per project (Low Earth-orbiting)
 - Additional programmatic issues, cost drivers
 - Engineering, Mission Assurance
 - Launch services
 - Communications license process
 - International, National, and Agency requirements
 - Conjunction Avoidance (CARA)
 - De-orbit and residual debris requirements (ODAR)
 - Security (IT, communications)
 - Work effort
 - Work required for a successful CubeSat investigation significantly exceeds that for Sounding Rocket/Balloon payloads due to spacecraft system development; can be comparable to an AO-solicited Mission of Opportunity



CubeSats, Management

- SMD CubeSats initiative was started to speed growth, investment
 - Established management process following the SMD Suborbital program
 - NPR 7120.8
 - In 2014, CubeSat competitive selections had the dual emphasis of
 - 1) determining the utility of the platform, and
 - 2) achieving a meritorious science investigation
 - By 2018, CubeSats' useful capabilities were demonstrated,
 - CubeSat program management was turned over to individual divisions
 - CubeSat programs were incorporated into successful Explorers projects
- CubeSat development processes have evolved in a quickly changing landscape
 - Multiple suppliers and providers
 - Different capabilities, levels of reliability
 - Platform
- NASA management has increased over time in response to increasing programmatic overruns
 - Retained “light touch” management philosophy (PI has freedom on project work)
 - Increased NASA participation in lifecycle reviews
 - Required bi-monthly project status reviews
 - Instituted status monitoring by SmallSat Program Office (NASA Wallops Flight Facility)



Data Archiving

- NASA-supported projects are required to archive data products
 - See following policy documents
 - [Increasing Access to the Results of Federally Funded Scientific Research](#) (Office of Science and Technology Policy Memorandum)
 - [SMD Policy Document 41](#), [HPD Science Data Management Policy](#)
 - Increased community expectations for data usefulness and usability
 - Data plan is required in all R&T Flight programs (since 2018)
 - Archiving effort primarily at investigation's end (see discussion below)
- NASA supports data infrastructure, but does not provide significant project-level support
 - NASA archives: Solar Data Analysis Center (SDAC) and Space Physics Data Facility (SPDF)
 - Some researchers archive data on institutional servers rather than NASA archives
- Not all R&T Flight projects have successfully scoped the effort required to fulfill the archiving requirements
 - Challenges include:
 - Requirements are evolving
 - Data is not ready to meaningfully archive until mission completion
 - Projects have fixed award sizes, face budget limitations at mission completion



Request for the Decadal Survey

Charge to the Decadal Survey Committee: ***Develop a comprehensive ranked research strategy that provides an ambitious, but realistic, approach to address these science goals.*** *The strategy will include consideration of:*

- a. The combination of ground- and space-based investigations to enhance progress on the prioritized science goals;*
 - b. Data and computing infrastructure needed to support the research strategy and the long-term utility, usability, and accessibility of acquired data;*
- Discuss the role and responsibilities for Research and Technology (R&T) Flight projects in the research strategy
 - Discuss challenges faced by the R&T projects in the completion of compelling science investigations, and potential changes to NASA process that could improve outcomes, including but not limited to:
 - Challenges and solutions that particularly impact Primarily Undergraduate Institutions and Minority Serving Institutions
 - Considerations for NASA's program-level support of R&T data archiving activities
 - Clearly incorporate budgetary guidance for investments and projects

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space filled with numerous small stars and a prominent, bright blue nebula on the right side. The bottom half shows a similar starry field but with a warm, golden-yellow and greenish glow, suggesting a different nebula or a different spectral filter. The text "#HelioRocks" is centered in a white, sans-serif font across the middle of the image.

#HelioRocks

HPD Sounding Rocket Launches [FY23]

Launch Date	Project [Mission]	Experimenter	Organization	Discipline	Range
9/17/2023	B-SPICE [36.382 UE]	GILCHRIST	UNIV OF MICHIGAN	GEOSPACE SCIENCES	WS
8/10/2023	TOMEX-Plus [36.335 CE]	CLEMMONS	AEROSPACE CORP.	GEOSPACE SCIENCES	WI
8/10/2023	TOMEX-Plus [41.123 CE]	CLEMMONS	AEROSPACE CORP.	GEOSPACE SCIENCES	WI
8/10/2023	TOMEX-Plus [41.124 CE]	CLEMMONS	AEROSPACE CORP.	GEOSPACE SCIENCES	WI
8/1/2023	MaGIXS 2 [36.385 NS]	WINEBARGER	NASA/MSFC	SOLAR & HELIOSPHERIC	WS
6/27/2023	VERIS 2 [36.337 DS]	CRUMP	NRL	SOLAR & HELIOSPHERIC	WS
6/1/2023	EVE [36.389 US]	WOODS	UNIV OF COLORADO	SOLAR & HELIOSPHERIC	WS
5/22/2023	FURST [36.366 US]	KANKELBORG	MONTANA STATE UNIV	SOLAR & HELIOSPHERIC	WS
2/12/2023	DISSIPATION [45.007 GE]	BENNA	NASA/GSFC	GEOSPACE SCIENCES	FB
2/12/2023	Beam-PIE [52.009 AE]	REEVES	LOS ALAMOS NAT. LAB	GEOSPACE SCIENCES	FB
2/10/2023	VortEX [36.361 UE]	LEMACHER	CLEMSON UNIV	GEOSPACE SCIENCES	NOR
2/10/2023	VortEX [36.362 UE]	LEMACHER	CLEMSON UNIV	GEOSPACE SCIENCES	NOR
2/10/2023	VortEX [41.127 UE]	LEMACHER	CLEMSON UNIV	GEOSPACE SCIENCES	NOR
2/10/2023	VortEX [41.128 UE]	LEMACHER	CLEMSON UNIV	GEOSPACE SCIENCES	NOR
11/16/2022	ACES-2 [36.359 UE]	BOUNDS	UNIV OF IOWA	GEOSPACE SCIENCES	NOR
11/16/2022	ACES-2 [36.364 UE]	BOUNDS	UNIV OF IOWA	GEOSPACE SCIENCES	NOR

HPD Sounding Rocket Launches [FY22]

Launch Date	Project [Mission]	Experimenter	Organization	Discipline	Range
5/11/2022	Endurance [47.001 GE]	COLLINSON	GSFC	GEOSPACE SCIENCES	SVAL
4/7/2022	INCAA [36.360 UE]	KAEPPLER	CLEMSON UNIV.	GEOSPACE SCIENCES	FB
4/7/2022	INCAA [46.031 UE]	KAEPPLER	CLEMSON UNIV.	GEOSPACE SCIENCES	FB
3/9/2022	HERSCHEL [36.307 DS]	TUN	NAVAL RESEARCH LAB	SOLAR & HELIOSPHERIC	WS
3/5/2022	LAMP [36.351 GE]	HALFORD	GSFC	GEOSPACE SCIENCES	FB
12/1/2021	C-REX 2 [49.004 UE]	CONDE	UNIV OF ALASKA	GEOSPACE SCIENCE	NOR
10/8/2021	CLASP-2.1 [36.374 NS]	MCKENZIE	NASA/MSFC	SOLAR & HELIOSPHERIC	WS

HPD Sounding Rocket Launches [FY20, FY21]

Launch Date	Project [Mission]	Experimenter	Organization	Discipline	Range
9/9/2021	EVE [36.353 US]	WOODS	UNIV OF COLORADO	SOLAR & HELIOSPHERIC	WS
7/30/2021	MaGIXS [36.319 NS]	WINEBARGER	NASA/MSFC	SOLAR & HELIOSPHERIC	WS
7/11/2021	DYNAMO-2 [36.357 GE]	PFAFF	GSFC	GEOSPACE SCIENCES	WI
7/7/2021	DYNAMO-2 [36.358 GE]	PFAFF	GSFC	GEOSPACE SCIENCES	WI
5/27/2021	VIPER [46.028 UE]	BONNELL	UNIV. OF BERKELEY	GEOSPACE SCIENCES	WI
5/18/2021	EUNIS [36.322 GS]	DAW	NASA/GSFC	SOLAR & HELIOSPHERIC	WS
4/19/2021	SHIELDS [36.324 US]	HARRIS	UNIV OF ARIZONA	SOLAR & HELIOSPHERIC	WS
1/26/2020	PolarNOx [36.356 UE]	BAILEY	VA TECH	GEOSPACE SCIENCES	FB
12/10/2019	CHI [36.349 UE]	LARSEN	CLEMSON UNIV.	GEOSPACE SCIENCES	SVAL
11/26/2019	ICI-5 [46.029 IE]	MOEN	UNIV OF OSLO	GEOSPACE SCIENCE	SVAL

HPD Sounding Rocket Launches [FY19]

Launch Date	Project [Mission]	Experimenter	Organization	Discipline	Range
9/30/2019	ESIS [36.320 US]	KANKELBORG	MONTANA STATE UNIV.	SOLAR & HELIOSPHERIC	WS
6/19/2019	TooWINDY [36.344 UE]	HYSELL	CORNELL UNIV.	GEOSPACE SCIENCES	KWAJ
6/19/2019	TooWINDY [36.345 UE]	HYSELL	CORNELL UNIV.	GEOSPACE SCIENCES	KWAJ
4/11/2019	CLASP 2 [36.332 NS]	MCKENZIE	NASA MSFC	SOLAR & HELIOSPHERIC	WS
4/5/2019	AZURE [51.001 UE]	LARSEN	CLEMSON UNIV.	GEOSPACE SCIENCES	NOR
4/5/2019	AZURE [51.002 UE]	LARSEN	CLEMSON UNIV.	GEOSPACE SCIENCES	NOR
1/4/2019	CAPER-2 [52.005 UE]	LABELLE	DARTMOUTH COLLEGE	GEOSPACE SCIENCES	NOR
12/8/2018	TRICE-2 [52.003 UE]	KLETZING	UNIV. OF IOWA	GEOSPACE SCIENCE	NOR
12/8/2018	TRICE-2 [52.004 UE]	KLETZING	UNIV. OF IOWA	GEOSPACE SCIENCE	NOR
12/7/2018	VISIONS 2 [35.039 GE]	ROWLAND	NASA GSFC	GEOSPACE SCIENCE	SVAL
12/7/2018	VISIONS 2 [35.040 GE]	ROWLAND	NASA GSFC	GEOSPACE SCIENCE	SVAL

HPD Sounding Rocket Launches [FY17, FY18]

Launch Date	Project [Mission]	Experimenter	Organization	Discipline	Range
9/7/2018	FOXSI [36.325 US]	GLESENER	UNIV. OF MINNESOTA	SOLAR & HELIOSPHERIC	WS
6/18/2018	EVE [36.336 UE]	WOODS	UNIV. OF COLORADO	GEOSPACE SCIENCES	WS
5/29/2018	Hi-C [36.342 NS]	WINEBARGER	NASA/MSFC	SOLAR & HELIOSPHERIC	WS
1/26/2018	SUPER SOAKER [41.119 CE]	AZEEM	ASTRA	GEOSPACE SCIENCE	FB
1/26/2018	SUPER SOAKER [41.120 CE]	AZEEM	ASTRA	GEOSPACE SCIENCE	FB
1/26/2018	SUPER SOAKER [41.122 CE]	AZEEM	ASTRA	GEOSPACE SCIENCE	FB
9/9/2017	WINDY [36.321 UE]	HYSELL	CORNELL UNIV.	GEOSPACE SCIENCES	KWAJ
9/9/2017	WINDY [29.042 UE]	HYSELL	CORNELL UNIV.	GEOSPACE SCIENCES	KWAJ
5/5/2017	RAISE [36.309 US]	HASSLER	SWRI	SOLAR & HELIOSPHERIC	WS
3/1/2017	JETS [36.301 GE]	PFAFF	GSFC	GEOSPACE SCIENCE	FB
3/1/2017	JETS [36.306 GE]	PFAFF	GSFC	GEOSPACE SCIENCE	FB
3/1/2017	ISINGLASS [36.304 UE]	LYNCH	DARTMOUTH COLLEGE	GEOSPACE SCIENCE	FB
2/22/2017	ISINGLASS [36.303 UE]	LYNCH	DARTMOUTH COLLEGE	GEOSPACE SCIENCE	FB
1/27/2017	POLARNOX [36.302 UE]	BAILEY	VIRGINIA TECH	GEOSPACE SCIENCE	FB

HPD Balloons [FY18 – FY22]

NASA Balloon Program Launches for Heliophysics Science					
Date	Launch Time (UTC)	Location	Experiment	Flight #	Duration [h]
09/08/22	13:25	FtS	HASP	724N	21.12
09/07/22	14:04	FtS	BALBOA (BALloon-Based Observations for sunlit Aurora)	723N	8.75
08/23/22	18:48	FtS	Salter Test Flight/CiS RB-7	721NT	5.00
07/10/22	1:42	Esrangle	Sunrise III	719N	6.00
09/14/21	14:02	FtS	HASP	716N	16.68
08/30/21	15:29	FtS	Salter Test Flight/CiS RB-6	714NT	10.00
06/10/21	12:29	FtS	Salter Test Flight/ASHI	711N	17.67
06/08/21	12:56	FtS	Mullenax Test Flight/ BOOMS+BALBOA piggyback	710N	20.50
05/04/21	17:30	FtS	Balloon-Borne Chripsounder	709N	7.33
09/18/19	14:55	FtS	BITSE	699N	9.66
09/05/19	13:03	FtS	HASP	698N	10.83
09/08/18	23:35	FtS	SITF/CiS CR-4	689N	6.66
09/04/18	14:03	FtS	HASP	688N	11.50
07/08/18	7:27	Esrangle	PMC-Turbo	684N	143.33
06/24/18	22:29	Esrangle	HiWind	683N	136.22
05/15/18	22:08	Esrangle	AESOP-LITE	682N	135.92

HPD Balloons [FY11 – FY17]

NASA Balloon Program Launches for Heliophysics Science					
Date	Launch Time (UTC)	Location	Experiment	Flight #	Duration [h]
09/04/17	14:04	FtS	HASP	680N	11.31
09/01/16	16:08	FtS	HASP	670N	18.33
08/28/16		Esrangle	BARREL 4F		
08/24/16	17:24	Esrangle	BARREL 4E		16.25
08/21/16		Esrangle	BARREL 4D		
08/21/16		Esrangle	BARREL 4C		
08/16/16	20:02	Esrangle	BARREL 4B		7.83
08/13/16	22:24	Esrangle	BARREL 4A		7.33
01/19/16	1:40	McM	GRIPS	668N	278.00
09/25/15	17:05	FtS	RaD-X	666N	22.00
09/07/15	13:47	FtS	HASP	665N	29.00
08/25/15	10:58	Esrangle	BARREL 3G		22.12
08/25/15	7:10	Esrangle	BARREL 3F		25.25
08/21/15	7:05	Esrangle	BARREL 3E		35.50
08/19/15	6:02	Esrangle	BARREL 3D		6.80
08/17/15	12:08	Esrangle	BARREL 3C		15.40
08/13/15	4:30	Esrangle	BARREL 3B		12.66
08/10/15	13:50	Esrangle	BARREL 3A		6.66
08/18/14	15:36	FtS	WASP/HySICS	650N	9.00
09/29/13	13:39	FtS	HyperSpectral Imager for Climate Science	647N	8.50
09/21/13	11:50	FtS	HERO	645N	26.00
06/12/13	5:38	Esrangle	Sunrise III	640N	127.00
10/15/11	17:04	FtS	Solar Disk Sextant	628N	5.75
06/13/11	23:12	Esrangle	HiWind	620N	96.00
06/10/11	0:19	Esrangle	AESOP	619N	112.00
05/27/11	1:21	Esrangle	LEE	618N	110.00
04/18/11	22:13	Alice Springs	HERO	617N	34.50
12/17/10	21:00	McM	Barrel	613N	36.50
12/13/10	21:44	McM	Barrel	612N	122.80

HPD CubeSats Launched

CubeSat Launches for Heliophysics Science

<i>Investigation</i>	<i>Principal Investigator</i>	<i>Lead Institution</i>	<i>Launch Date</i>	<i>Duration</i>	<i>Note</i>
MinXSS-1 - Miniature X-ray Solar Spectrometer	Tom Woods	University of Colorado	12/6/2015	16 months	Normal operations until re-entry
ELFIN - Electron Losses and Fields Investigation	Vassilis Angelopoulos	UCLA	9/15/2018	4 years	Safely deorbited at end of life, as expected, in September 2022
MinXSS-2 - Miniature X-ray Solar Spectrometer	Tom Woods	University of Colorado	12/16/2018	1 month	Lost radio contact during single event upset
CeREs	Shri Kanekal	NASA GSFC	12/16/2018	N/A	Never established radio contact
SORTIE - Scintillation Observations and Response of the Ionosphere to Electrodynamics	Geoff Crowley	Orion Space Solutions	12/5/2019	2.75 Years	Safely deorbited at end of life, as expected, in September 2022
CuPID - Cusp Plasma Imaging Detector	Brian Walsh	Boston University	9/27/2021	11 months	No contact has been made with the spacecraft to date
DAILI - Daily Atmospheric Ionospheric Limb Imager Mission	Jim Hecht	The Aerospace Corporation	12/21/2021	6 months	Mission experienced a reaction wheel failure and has de-orbited
MinXSS-3 - Miniature X-ray Solar Spectrometer	Tom Woods	University of Colorado	2/14/2022	7 months	Payload on INSIRESat-1, fully functional
CuSP - CubeSat Mission to Study Solar Particles	Mihir Desai	Southwest Research Institute	11/16/2022	On-going	
petitSat - Plasma Enhancements in the Ionosphere Thermosphere Satellite	Jeff Klenzing	NASA GSFC	11/26/2022	On-going	
SPORT - Scintillation Prediction Observations Research Task	Charles Swenson	Utah State University	11/26/2022	On-going	

HPD CubeSats in Development

CubeSats In-Development for Heliophysics Science

<i>Investigation Short Title</i>	<i>Principal Investigator</i>	<i>Lead Institution</i>	<i>Launch Date</i>
AERO - Auroral Emissions Radio Observer	Philip Erickson	MIT Haystack Observatory	1/24/2023
VISTA - Vector Interferometry Space Technology Using Auroral Emission Radio Observer	Frank Lind	MIT Haystack Observatory	1/24/2023
LLITED - Low Latitude Ionosphere Thermosphere Enhancements in Density	Rebecca Bishop	The Aerospace Corporation	2/1/2023
CIRBE - CubeSat Inner Radiation Belt Experiment	Xinlin Li	University of Colorado	2/9/2023
REAL - Relative Electron Atmospheric Loss	Robyn Millan	Dartmouth College	3/27/2023
CURIE - CubeSat Radio Interferometry Experiment	David Sundkvist	University of California, Berkley	4/1/2023
AEPEX - Atmosphere Effects of Precipitation through Energetic X-Ray	Robert Marshall	University of Colorado	4/30/2023
Dione	Eftyhia Zesta	NASA GSFC	8/1/2023
LARADO - Laser-sheet Anomaly Resolution and Debris Observation	Andrew Nicholas	NRL	3/1/2024
OWLS - The Occultation Wave Limb Sounder for Thermospheric Gravity Wave Studies	Ed Thiemann	University of Colorado	7/1/2024
CubIXSS - The CubeSat Imaging X-ray Solar Spectrometer	Amir Caspi	Southwest Research Institute	12/1/2024
SunCET - Sun Coronal Ejection Tracker	James Mason	John's Hopkins Applied Physics Laboratory	4/23/2025
DYNAGLO - Dynamics Atmosphere Global Connection	Aimee Merkel	University of Colorado	4/30/2025
PADRE - Solar Polarization and Directivity X-ray Experiment	Juan Carlos Martinez	University of California, Berkley	7/1/2025
ICOVEX - Ionosphere Composition and Velocity Experiment	Keiichi Ogasawara	Southwest Research Institute	8/27/2025
WindCube - A CubeSat Thermospheric Wind Instrument	Scott Sewell	University Corporation for Atmospheric Research	9/5/2025
GTOSat - Geosynchronous Transfer Orbit Satellite	Larry Kepko	NASA GSFC	TBD