

CubeSats in the Heliophysics Division Flight Program

Presentation to the Heliophysics Advisory Committee

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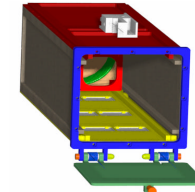
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Historical Perspective on CubeSat use for Heliophysics Research

➤ 1999: California Polytechnic State University/Stanford developed the concept of a standardized form factor spacecraft for educational purposes.

- Standardization needed to develop deployers
- Deployers turned out to be key enabling development



3-U P-POD Design
(Poly Picosat Orbital Deployer)

➤ Early 2000's: DoD considered extensive use of CubeSats (2000-2007)

- AFRL and NRL initiate a series of programs
 - ESPA-ring developed during this effort in response to the size limitations of CubeSat

➤ 2010: NSF initiated a CubeSat program within Geosciences

- Mix of educational and scientific objectives
- On orbit success rate ~50% with some notable heliophysics science success

➤ 2014 NASA began an exploration of CubeSats with scientific return as the metric for success.

- Science Mission Directorate CubeSat Initiative Panel (SCIP) is started to fund & manage investigations across the directorate
- SMD Commissioned National Academy study on CubeSats
 - Released in 2016: *Achieving Science with CubeSats: Thinking Inside the Box* <https://doi.org/10.17226/23503>
- Heliophysics Division hosts the SCIP activity

• Heliophysics Technology & Instrument Development for Science (HTIDeS) Low Cost Access to Space (LCAS) program element of ROSES is used for HPD CubeSat selection

- LCAS selected CERES (GSFC) in 2013 - **Pre-SCIP**
- LCAS used as the “on-ramp” for all SCIP selections
- The NPR 7120.8 approach of LCAS provided appropriate level of management and success rate expectations
 - Good match - even though LCAS “Sub-orbital Program” may seem to be misnomer for CubeSat orbital missions

HPD CubeSats

➤ LCAS Funded (2013)

1. CERES - A Compact Radiation Belt Explorer to Study Charged Particle Dynamics in Geospace

➤ SCIP Funded (2014)

1. MinXSS - Miniature X-ray Solar Spectrometer
2. TBEx – Tandem Beacon Experiment
3. SORTIE - Scintillation Observations and Response of The Ionosphere to Electrodynamics
4. ELFIN STAR- Electron Loss and Fields Investigation with Spatio-Temporal Ambiguity Resolving
5. CuSP - CubeSat Mission to Study Solar Particles

➤ SCIP + LCAS Funded

➤ 2015

1. CuPID - Cusp Plasma Imaging Detector

➤ 2016

1. LLITED - Low-Latitude Ionosphere/Thermosphere Enhancements in Density
2. petitSat- Plasma Enhancements in The Ionosphere-Thermosphere Satellite
3. SPORT - Scintillation Prediction Observations Research Task
4. CURIE - Cubesat Radio Interferometry Experiment

➤ 2017

❖ NO SPOILERS!

➤ Explorers 2016

1. SunRISE: The Sun Radio Interferometer Space Experiment Mission of Opportunity Phase A Study Award
 - Important Note: Explorer MO is conducted as a 7120.5 Class D mission
 - Contract procurement instead of grant
2. Numerous competitive proposals employing SmallSat constellations in both SMEX and MO

Future of CubeSats in HPD

- **SCIP is ending this year (FY18)**

- Beginning in FY19, each division will conduct an independent CubeSat/SmallSat program
- Division-level knowledge sharing within SMD will be achieved through Small Sat Working Group (SSWG)
- Directorate/Center-level knowledge sharing within NASA will be achieved through Small Sat Coordination Group (SSCG)

- **SCIP Experience (11 HPD CubeSats) provides basis for future direction within HPD**

- Imperative to continue exploiting new capabilities where demonstrated during SCIP
- Imperative to correct erroneous assertions made under programs with different performance metrics
- Under SCIP, budgets were underestimated for a large fraction of investigations
 - There is a scientifically meritorious class but very specialized class of HPD investigations in the \$2M-\$3M budget regime (appropriate for LCAS)
 - There is another, broader class of CubeSats in the \$5M-\$10M budget regime
- Under SCIP, hardware development durations were often much longer than scheduled
 - Underestimated budgets frequently result in development delays
 - Operations and data analysis budgets frequently absorbed before launch
 - Schedule delays defeat the promise of rapid scientific and technical development
- LCAS proposal format does not provide sufficient technical detail to adequately determine the likelihood of technical success
 - There is no CubeSat Program Office*, so the scope of work for the investigation team is much, much more diverse (*intentionally - to avoid stifling technology & industry innovation)
 - HTIDeS is a science program and typical reviewer expertise is primarily science and instrument technology
 - The length of the LCAS proposal limits technical detail required for a TMC (Technology, Management and Cost) evaluation

CubeSat/SmallSat in ROSES 2018

- Solution: add fourth element to HTIDeS for CubeSat/SmallSat
 - Appendix B.3, HTIDeS, will consist of:
 1. Laboratory Nuclear Atomic & Plasma Physics
 2. Instrument Technology Development
 3. LCAS
 4. Small Orbital Mission (CubeSat/SmallSat) – *New Element*
- Grant size of typical investigation in new element - \$4.5M typical
 - Possibly up to \$10M for compelling investigations – TEX (Tiny Explorer)?
 - CubeSat investigations in the ~\$2.5M class remain in LCAS
- New element missions conducted under NRP 7120.8 - Still "Sub-Orbital Program"
 - Unclear if NPR 7120.5 - Class D can be avoided if a \$10M investigation is selected
- Review of Small Orbital Mission proposals conducted under modified Explorer model
 - LCAS-type proposal is submitted in competition for 4-month Phase A study
 - Science Merit and Science Implementation Feasibility are primary selection criteria
 - NASA-funded development of technical and management details
 - End product of Phase A is a Concept Study Report with sufficient detail to evaluate mission viability
 - Concept Study Report (CSR) from Phase A study is used to competitively down-select for implementation/flight
 - Langley Research Center (LaRC) Science Office for Mission Assessments (SOMA) will evaluate CSR for TMC
 - Implementation Feasibility and Risk are primary selection criteria
 - Entire cycle is completed in time for proposal modification and re-submission the following year