Opportunities for Small Satellites in NASA’s Earth System Science Pathfinder (ESSP) Program

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Origin of Earth Venture Program

• National Research Council – *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, 2007*

  – Restore more frequent launch opportunities

  – Facilitate the demonstration of innovative ideas and higher risk technologies

  – NASA should create a new Venture class of low-cost research and application missions (≈$100 to $200 million)

  – Focus on training future leaders
ESSP Venture Class

- **Venture Class: a Tier-1 Decadal Survey Recommendation**
  - Science-driven, PI-led, competitively selected, cost- and schedule-constrained, regularly solicited, orbital and suborbital
  - Venture-class investigations complement the systematic missions identified in the Decadal Survey and provide flexibility to accommodate scientific advances and new implementation approaches

Venture-class is *complementary* to systematic missions; no single Venture mission is essential for overall program success
ESSP Venture Class Defined

- **Venture Class is fully funded, with 3 elements**
  - EV Suborbital (EVS)-x: suborbital/airborne investigations (5 years duration); multiple selections per solicitation; cost capped at $150M total per solicitation; solicited in 2009 and *every 4 years*
  - EV Mission (EVM)-x: small complete missions (5 years to launch); Class D allowable; small-sat or stand-alone payload; cost capped at $150M; solicited in FY11 and *every 4 years*
  - EV Instrument (EVI)-x: spaceborne instruments for flight on Missions of Opportunity (≤5 years for development); Class C or Class D allowable; cost capped at $94M/$30M for development and operations; solicited in FY12 and *every 15-18 months*

**Diverse Program Elements require diverse approaches to program management**
## Solicitation Schedule

<table>
<thead>
<tr>
<th>Mission</th>
<th>Mission Type</th>
<th>Release Date</th>
<th>Selection Date</th>
<th>Major Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVS-1</td>
<td>Suborbital</td>
<td>2009</td>
<td>2010</td>
<td>Complete 2015</td>
</tr>
<tr>
<td>CYGNSS (EVM-1)</td>
<td>Full Orbital</td>
<td>2011</td>
<td>2012</td>
<td>Launch ~2017</td>
</tr>
<tr>
<td>TEMPO (EVI-1)</td>
<td>Instrument Only</td>
<td>2011</td>
<td>2012</td>
<td>Delivery in 2017</td>
</tr>
<tr>
<td>GEDI &amp; ECOSTRESS (EVI-2)</td>
<td>Instrument Only</td>
<td>2013</td>
<td>2014</td>
<td>Delivery NLT 2019</td>
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<tr>
<td>EVS-2</td>
<td>Suborbital</td>
<td>2013</td>
<td>2014</td>
<td>Complete 2019</td>
</tr>
<tr>
<td>EVI-3</td>
<td>Instrument Only</td>
<td>2015</td>
<td>2016</td>
<td>Delivery NLT 2021</td>
</tr>
<tr>
<td>EVI-4</td>
<td>Instrument Only</td>
<td>2016</td>
<td>2017</td>
<td>Delivery NLT 2022</td>
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<tr>
<td>EVM-2</td>
<td>Full Orbital</td>
<td>2015</td>
<td>2016</td>
<td>Launch ~2021</td>
</tr>
<tr>
<td>EVI-5</td>
<td>Instrument Only</td>
<td>2017</td>
<td>2019</td>
<td>Delivery NLT 2024</td>
</tr>
</tbody>
</table>

*Dates subject to change*
EV Suborbital

• PI wholly responsible to accomplish investigation objectives using his/her own management processes, procedures, and methods

• Risk Management
  – PI specifies risk mitigation plan, including descopes
  – Allow an aggressive risk posture compared to spaceflight missions (consistent with Research & Analysis (R&A) investigations)

• NASA Oversight
  – Consistent with NPR 7120.8 – aka non-spaceflight investigations
  – Track highest risk elements of investigation

• Investigations have minimal, streamlined reviews: ICR, FRR/ ORR, PSR, Annual Science Review

• Expectations: EVS is R&A with more programmatic rigor balanced by higher science return
EV Mission

• PI defines technical implementation and project management approach. Trade space includes performance margins, quality assurance, and reliability

• Risk Management
  – PI designated risk process consistent with NPR 8705.4 Class D guidelines
  – Potential higher risk acceptance by NASA based on detailed information, careful evaluation, and a conscious decision

• NASA Oversight
  – PI has a large degree of freedom and responsibility to accomplish proposed science objectives and implement mission
  – PI may propose to tailor NASA processes or use their institution’s processes
  – Only essential oversight to ensure implementation is responsive NPR 7120.5 for Class D implementations

• Reviews conducted by Independent Review Teams
  – Tailoring permitted
EV Mission Expectations

• Stakeholders
  – Ensure the Class D characteristics are applied to all reviews and evaluations
  – Ensure cost cap criteria is maintained

• NASA
  – Maintain Class D risk posture through launch
  – Encourage innovative implementations
  – Maintain vigilance against requirements creep and risk suppression

• Principal Investigator
  – Keep open communications on mission implementation
  – Risk tolerant/Risk informed Not risk ignorant
  – Recognize that possibility of termination is real
    • Maintain cost cap, schedule and value of science content
EV Instrument

• PI manages all work necessary to deliver a spaceflight qualified instrument within cost cap and <5 years

• Risk Management
  – TEMPO is Class C (med priority, med risk)
  – Future selections will be Class C or Class D and can include cubesats
  – PI identifies risks and mitigations while NASA examines consistency with NPR 8705.4 Class D guidelines

• NASA Oversight
  – Only essential oversight to ensure project implementation responsive to NPR 7120.5
  – Access to space provided on NASA determined flight of opportunity

• Reviews conducted by Independent Review Teams

Expectations: mitigate critical instrument development risks prior to making external commitment with stakeholders on life-cycle cost and launch date
EV Instrument is Unique

- PI managed mission cost for instrument investigation excludes the integration of the instrument to the selected platform
- CubeSat investigation excludes the integration of the CubeSat to the selected launch vehicle and launch services
- Scope of effort includes science team, instrument personnel, and key management and engineering staff activity in Phase D
- Assume two years for Phase D
Summary

• Decadal Survey recommended more frequent, diverse, exploratory science missions
• NASA responded with three new program elements established: EVS, EVI, EVM

Program management approaches tailored to the specific risk posture, implementation approach and science objectives will enable cost effectiveness and science performance to drive NASA’s decisions

With diverse mission approaches, acute risk awareness and a steady tempo of new mission selections, NASA’s Earth Venture missions are positioned to continue NASA’s world-class earth system science
Backup Material
AirMOSS (Airborne Microwave Observatory of Subcanopy and Subsurface): *Measuring soil moisture in the root zone of North American ecosystems*

ATTREX (Airborne Tropical Tropopause Experiment): *Processes that control the flow of atmospheric gases into stratosphere*

CARVE (Carbon in Arctic Reservoirs Vulnerability Experiment): *Experimental insights into Arctic carbon cycling*

DISCOVER-AQ (Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality): *Improve the interpretation of satellite observations to diagnose near-surface air quality*

HS3 (Hurricane and Severe Storm Sentinel): *Investigate intensity change of hurricanes in the Atlantic*
GRACE (Gravity Recovery and Climate Experiment): *measure Earth’s gravity field and its variations with time*

CloudSat: *measure clouds to analyze their role in Earth’s radiation budget*

CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations): *measure the vertical distribution of clouds and aerosols*

Aquarius: *observe and model seasonal as well as year-to-year variations of Sea Salt Salinity and how these relate to changes in the water cycle and ocean circulation*

OCO-2 (Orbiting Carbon Observatory – 2): *global measurements of atmospheric CO₂ with precision, resolution, and coverage needed to characterize its sources and sinks on regional scales and quantify their variability over the seasonal cycle*
Missions in Development

**TEMPO** (Tropospheric Emissions: Monitoring of Pollution): *concurrent high temporal and spatial resolution measurements from GEO of tropospheric ozone, aerosols, their precursors, and clouds*

**CYGNSS** (Cyclone Global Navigation Satellite System): *understand the coupling between ocean surface properties, moist atmospheric thermodynamics, radiation and convective dynamics in the inner core of a Tropical Cyclone (TC)*