• Science and launch highlights
• On-orbit constellation overview
• Venture Class status/accomplishments/selections/plans
• Budget reminder
• Mission development status/plans
• ESD on the ISS
• Issues
The LDCM Observatory was lifted to orbit by a United Launch Alliance Atlas V rocket launching from Vandenberg Air Force Base, Calif. The launch capped a flawless countdown.

The Observatory separated from the Centaur upper stage approximately 79 minutes after launch.
LDCM Mission Overview

Mission Objectives
Provide continuity in the multi-decadal Landsat land surface observations to study, predict, and understand the consequences of land surface dynamics

- Land cover/use change
- Human settlement and population
- Ecosystem dynamics
- Landscape scale carbon stocks
- Resource management/societal needs

Instruments
- Operational Land Imager – BATC
- Multi-spectral imager
- Thermal Infrared Sensor – GSFC
- Thermal Infrared Imager

Spacecraft
- GDAIS
- Mission Team
- NASA SMD/ESD
- NASA GSFC
- Dept. of Interior’s USGS
- NASA KSC

Currently in Commissioning, Launched 11 Feb 2013
5yrs. of Operations (excluding TIRS) with 10 years of fuel

Alaska Ground Station
Gilmore, AK

LDCM Orbit
705 km circular
sun sync, 10am DNLT
16-day repeat

LDCM Observatory
(OLI, TIRS)

TDRSS

Atlas V
VAFB

Representative IC
Canada

Landsat Ground Station
Sioux Falls, SD

X-band
RT Broadcast
384 Mbps

S-band S5A
1 kbps Forward
2 or 32 kbps Return

S-band CMD uplink 1 or 32 kbps
S-band RT downlink 32 kbps
S-band combined Stored &
RT TLM downlink 1 Mbps

X-band Stored Science
RT+PB or 2 PB @ 384 Mbps

S-band Store Science
RT+PB or 2 PB @ 384 Mbps

X-band RT Broadcast
384 Mbps

Mission Team
- NASA SMD/ESD
- NASA GSFC
- Dept. of Interior’s USGS
- NASA KSC

NASA GN
Wallops Island, VA
<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>DATE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S/C Sub-system Activation (initialize GPS, SADA, SSR, X band, ACS)</td>
<td>Feb. 11-17</td>
<td>Complete</td>
</tr>
<tr>
<td>OLI and TIRS power up</td>
<td>Feb. 16</td>
<td>Complete</td>
</tr>
<tr>
<td>1st Engineering Burn</td>
<td>Feb. 17</td>
<td>Complete</td>
</tr>
<tr>
<td>Began generating and downlinking OLI and TIRS test pattern data</td>
<td>Feb. 17</td>
<td>Complete</td>
</tr>
<tr>
<td>Open OLI shutter to begin dryout</td>
<td>Feb. 18</td>
<td>Complete</td>
</tr>
<tr>
<td>ACS calibration maneuvers</td>
<td>Feb. 20 - Mar. 3</td>
<td>Complete</td>
</tr>
<tr>
<td>TIRS cryocooler launch lock deployment, uncage, and electronics power on</td>
<td>Feb. 24</td>
<td>Complete</td>
</tr>
<tr>
<td>Load OLI pixel map</td>
<td>Feb. 26</td>
<td>Complete</td>
</tr>
<tr>
<td>TIRS earth shield deployment, Passive cooldown begins</td>
<td>Mar. 4</td>
<td>Complete</td>
</tr>
<tr>
<td>TIRS focal plane electronics (FPE) power up, Scene Select Mirror (SSM) Activation</td>
<td>Mar. 5</td>
<td>Complete</td>
</tr>
<tr>
<td>TIRS Cryogenic Cooldown begins</td>
<td>Mar. 6</td>
<td>In Progress</td>
</tr>
<tr>
<td>ACS calibration maneuvers (post earth shield deploy)</td>
<td>Mar. 6 - 12</td>
<td>In Progress</td>
</tr>
<tr>
<td>OLI dryout complete, cooldown begins</td>
<td>Mar. 6</td>
<td>In Progress?</td>
</tr>
<tr>
<td>First TIRS Preliminary Engineering Data</td>
<td>Mar. 7</td>
<td></td>
</tr>
<tr>
<td>TIRS calibrations begin</td>
<td>Mar. 10</td>
<td></td>
</tr>
<tr>
<td>Ascent Burn 1</td>
<td>Mar. 10</td>
<td></td>
</tr>
<tr>
<td>Ascent Burn 2</td>
<td>Mar. 13</td>
<td></td>
</tr>
<tr>
<td>OLI calibrations begin</td>
<td>Mar. 14</td>
<td></td>
</tr>
<tr>
<td>First OLI Image</td>
<td>Mar. 18</td>
<td></td>
</tr>
<tr>
<td>Goal: Approach 400 scenes / day before Underfly</td>
<td>Mar. 27</td>
<td></td>
</tr>
<tr>
<td>Landsat 7 Underfly</td>
<td>Mar. 28 - Apr. 1</td>
<td></td>
</tr>
<tr>
<td>Ascent Burn 3</td>
<td>Apr. 7</td>
<td></td>
</tr>
<tr>
<td>Ascent Burn 4 - Arrive on WRS-2 Grid</td>
<td>Apr. 11</td>
<td></td>
</tr>
<tr>
<td>WRS-2 16-day cycle demonstration begins</td>
<td>Apr. 26</td>
<td></td>
</tr>
</tbody>
</table>
AIRBORNE ACTIVITIES:
EV-1 (EV-S) Summary Status

• CARVE
  – Data analysis ongoing

• ATTREX
  – Science flights ongoing (mid Jan – Feb/Mar)
    • 6 flights total planned, completed (2 March 2013)

• HS3
  – Data analysis ongoing

• DISCOVER-AQ
  – California deployment complete
  – Data analysis ongoing

• AirMOSS
  – Data analysis ongoing
  – Science flights ongoing (local from Ellington Field 13 -18 Feb, Costa Rica 19 Feb – 3 Mar; deployment interrupted to fix instrument)
Ten science flights documented the details of two successive PM2.5 episodes in the San Joaquin Valley
- 176 flight hours
- P3B, King Air
- UC Davis Mooney also flew
- PODEX/ER-2 collaboration

(Photo taken from ER-2 during PODEX flight on 20 January)

Bakersfield PM2.5
(16 January - 7 February)

Aerosol Scattering from the P-3B shows the build up of fine particles to be concentrated in a shallow layer below 2000 feet.

*Orange line (36 ug/m³) is the 24hr average threshold for violating National Ambient Air Quality Standards
PODEX
Polarimeter Definition Experiment @ NASA Dryden, Jan/Feb 2013

Objective: Airborne field experiment on NASA ER-2 to compare radiometric and polarimetric measurements from three instrument designs (alphabetically)

**AirMSPI** Multiangle SpectroPolarimetric Imager (JPL)

**PACS** Passive Aerosol and Cloud Suite (UMBC/Goddard)

**RSP** Research Scanning Polarimeter (GISS)

- Coordinated with DISCOVER-AQ (DAQ) (EV-1)
- Augmented by AMS, CPL, SSFR instruments on ER-2

- 10 flights
- 49 flight hours
- Observations include:
  - Bright (snow) and dark (ocean) targets
  - Aerosols over dark, bright, and urban areas (with DAQ correlative data)
  - Clouds – Fog, Stratus, Stratocumulus, Cirrus
### Objectives

- Advance testing of \(\text{CO}_2\) & \(\text{O}_2\) measurements under day and night conditions.
- Assess \(\text{CO}_2\) & \(\text{O}_2\) measurements over Railroad Valley (RRV) with GOSAT overpass.
- Obtain reflectance and \(\text{CO}_2\) & \(\text{O}_2\) measurements over fresh and aged snow surfaces.
- Evaluate \(\text{CO}_2\) & \(\text{O}_2\) measurement performance in presence of thin cirrus clouds.
- Obtain reflectance data from ocean surface with high wind speeds (~10 m/s) and assess \(\text{CO}_2\) & \(\text{O}_2\) performance over tall coastal forest conditions.
- Evaluate derivation of \(\text{XCO}_2\) from combination of \(\text{CO}_2\) & \(\text{O}_2\) measurements.

### Implementation

- **Flight Test Candidate ASCENDS Instruments:**
  - LaRC/Exelis IM-CW \(\text{CO}_2\) Lidar (MFLL);
  - GSFC \(\text{CO}_2\) Lidar Sounder;
  - JPL \(\text{CO}_2\) LAS;
  - GSFC Broadband \(\text{CO}_2\) Lidar (shown above installed on DC-8)

- **Conduct Eight DC-8 Flight Tests from NASA Dryden Palmdale Base:**
  - Engineering Flight; CA Central Valley Flights (day & night); RRV Flight
  - Three long-range flights over snow surfaces east of Rocky Mountains
  - Long-range flight over Pacific with sampling over CA/OR coastal forest
The first science campaign for the EV-1 selected ATTREX investigation is occurring now with a NASA Global Hawk from DFRC.

- 5 science flights of >24 hours have occurred since 2/5/13 (1st was planned for 1/15)
- 1 more flight planned this campaign, with hard end date of 3/15 (including reserve).
- The next 2 campaigns are planned for January 2014 in Guam and July 2014 in either Australia or Okinawa.

- The Global Hawk is now performing altitude profiles numerous times each flight through air masses colder than the aircraft was test-rated. This required significant discussion with Northrup.
- This year’s tropical tropopause is much colder than normal due to the same atmospheric transport processes that warmed this year’s Arctic vortex.
- ATTREX measurements are showing the lowest atmospheric water vapor concentrations ever measured.
- This combined set of observations (12 instruments), along with MLS on Aura, should significantly improve our understanding of the control of stratospheric water vapor, cirrus formation, and atmospheric transport.
Aquarius Seasonal Salinity

Summer 2011

Autumn 2011

Winter 2011/2012

Spring 2012

Summer 2012

Autumn 2012

Sea Surface Salinity (psu)

30 32 33 34 34.5 35 35.5 36 37 38 40

Aquarius Version 2 Data was released 2/25 (available at PODAAC). This version is released for scientific analysis and fully documented for the oceanographic community.

The table below shows the advancement of this product over prior version (1.3). Further advancement toward Level 1 requirements is expected with Version 3 (later in 2013).

<table>
<thead>
<tr>
<th>Level 1 Science Mission Requirement</th>
<th>Baseline Mission</th>
<th>Minimum Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Aquarius Mission shall collect the space-based measurements to retrieve Sea Surface Salinity (SSS) with global root-mean-square (rms) random errors and systematic biases no larger than 0.2 \text{ psu} on 150 km by 150 km scales over the open ocean.</td>
<td>V1.3: 0.44</td>
<td>V1.3: 0.38</td>
</tr>
<tr>
<td>2. <strong>SSS Averaging Interval</strong></td>
<td>1 Month</td>
<td>3 Months</td>
</tr>
<tr>
<td>3. <strong>Mission Duration</strong></td>
<td>At least 3 Years</td>
<td>At least 1 Year</td>
</tr>
<tr>
<td>4. <strong>Deliver data products to a NASA Distributed Active Archive Center (DAAC).</strong></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Level 1a <strong>Reconstructed Unprocessed Instrument Data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1b <strong>Calibrated Sensor Units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2 <strong>Derived Geolocated SSS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 3 <strong>Time-space averaged SSS on a standard Earth Projection</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Reinvigorate On-Orbit Constellation (1 of 2)**

<table>
<thead>
<tr>
<th>Mission</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSTM/Jason-2</td>
<td>Launched 6/2008</td>
</tr>
<tr>
<td>OCO</td>
<td>Launched 2/2009 (LV Failure)</td>
</tr>
<tr>
<td>Glory</td>
<td>Launched 3/2011 (LV Failure)</td>
</tr>
<tr>
<td>Aquarius/SAC-D</td>
<td>Launched 6/2011</td>
</tr>
<tr>
<td>NPP</td>
<td>Launched 11/2011</td>
</tr>
<tr>
<td>LDCM</td>
<td>Launched 2/2013</td>
</tr>
<tr>
<td>GPM</td>
<td>On Schedule for 2/15/2014</td>
</tr>
<tr>
<td>OCO-2</td>
<td>On Schedule for 7/1-7/2014</td>
</tr>
<tr>
<td>SAGE-III/ISS</td>
<td>On Schedule for 8-12/2014</td>
</tr>
<tr>
<td>SMAP</td>
<td>On Schedule for 10/31/2014</td>
</tr>
</tbody>
</table>
ESD Operating Missions (2013)

Bi-annual Senior Review on schedule; proposals received 1 March
• **Venture-Class is a Tier-I 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 fully funded, with 3 “strands”**
  – EV-1: suborbital/airborne investigations (5 years duration)
    o Solicited in May FY09 (selections in FY10) *and every 4 years*
    o 5 investigations selected; flights began in FY11
  – EV-2: small complete missions, Class D (5 years development)
    o Solicited in FY11 *and every 4 years*
    o Small-sat or stand-alone payload for MoO; $150M total development cost
    o AO released 17 June 2011, **CYGNSS selected July 2012**
  – EV-Instrument: spaceborne instruments for flight on MoO (5 years dev.)
    o Solicited in FY11 *and every 18 months thereafter*
    o AO release Feb 7; proposals received May 2012; **TEMPO selected Nov 2012**
    o ~$90M development costs, accommodation costs budgeted separately
VENTURE-CLASS UPDATE/STATUS (cont)

• EV-1 (Airborne)
  – All 5 investigations will have completed at least 1 sustained field campaign by early in CY2013
    o All EV-1 investigations will fly during 2013
  – Second “EV-3” (“EV-Suborbital”) solicitation funded, in preparation for release on schedule in mid-2013

• EV-2 (Small-sat)
  – CYGNSS PI team and NASA program office making good progress, should be under contract by late CY2012 (planned 2016-2017 launch)
  – ESD/SMD developing detailed “Class D” management approaches and processes

• EV-I (Instrument)
  – TEMPO selected for GEO hosted payload opportunity (2017 launch)
  – ESD initiating formal host selection/negotiation process
  – Second “EV-Instrument2” solicitation funded, on schedule for release ~August, 2013
CYclone Global Navigation Satellite System

Chris Ruf, PI (U. Michigan)

CYGNSS is a constellation of 8 microsatellites that will use direct and reflected GPS signals to measure ocean surface wind speeds during most precipitation levels. This will increase the understanding of Tropical Cyclone genesis and intensification.

Primary Science Objectives

- Measure ocean surface wind speed in almost all precipitating conditions including those in the Tropical Cyclone eyewall
- Measure ocean surface wind speed in the Tropical Cyclone inner core with sufficient frequency to resolve genesis and rapid intensification.

| Partners                        | Southwest Research Institute: Primary Observatory development
|                                | NASA Ames Research Center: Deployment Module
| Risk                           | 7120.5D Category 3; 8705.4 Payload Risk Class D
| LRD                            | Target date February 2016
| Orbit                          | 35 deg inclination, 500 km altitude
| Duration                       | 2 year
| Payload                        | Delay Doppler Mapping Instrument
| LCC                            | $151.7M (RY$)
Earth Venture Instrument-1 Selection
Tropospheric Emissions: Monitoring of Pollution

PI: Kelly Chance, Smithsonian Astrophysical Observatory
Instrument Development: Ball Aerospace
Project Management: LARC (Wendy Pennington, PM; Dave Flittner, PS)
Other Institutions: GSFC, NCAR, Harvard, NOAA, UC Berkeley, SLU, UAH, EPA, Nebraska
RY$: 93.2M

Orbit requirements: Geostationary Orbit. NASA plans to host instrument on a commercial Geostationary communication satellite.

Scientific and Programmatic Characteristics
• Tropospheric pollution observations from Geostationary Orbit using a UV and Visible Offner Grating spectrometer
  • Retrieve Ozone, NO₂, SO₂, aerosols, CH₂O, others.
  • TEMPO will be simultaneous with, and complements, EU/GEMS Sentinel 4 and Korean GEO AQ observations, forming a global AQ constellation in GEO.
• Operational agencies like EPA and NOAA are part of the science team.
• TEMPO will be a pathfinder to using hosted commercial payloads from GEO
TEMPO Overview

TEMPO's concurrent high temporal (hourly) and spatial resolution measurements from geostationary orbit (GEO) of tropospheric ozone, aerosols, their precursors, and clouds create a revolutionary dataset that provides understanding and improves prediction of air quality (AQ) and climate forcing in Greater North America (GNA).

SCIENCE OBJECTIVES:
- Collect simultaneous high temporal and spatial resolution measurements of pollutants over GNA.
- Measure the key elements in tropospheric ozone chemistry and aerosol cycles.
- Observe aerosols and gases for quantifying and tracking evolution of pollution.
- Integrate observations from TEMPO and other platforms into models to improve representations of processes.
- Serve as the North American geostationary component of an international constellation for air quality monitoring.
- Determine the diurnal instantaneous radiative forcings associated with pollutants and other climate agents on the continental scale.

SCIENCE TEAM:
- Kelly Chance, (PI)
- Xing Liu
- James Carr
- Ronald Cohen
- UC Berkeley
- David Edwards
- Jack Fishman
- St. Louis U.
- David Flittner
- Jay Herman
- UMBR
- Daniel Jacob
- Scott Jans
- GSFC
- Joanna Joiner
- Nickolay Krotkov
- GSFC
- James Leibert
- Randall Martin
- SAD
- Donovan Neill
- Michael Newchurch
- UAH
- R. Bradley Pierce
- Robert Spurr
- RT Solutions
- Reid Suleiman
- James Slyman
- EPA
- Omar Torres
- Jun Wang
- U. Nebraska

INVESTIGATION OVERVIEW:
TEMPO is an innovative use of a well-proven technique, able to produce a groundbreaking dataset. It is led by Dr. Kelly Chance, SAD, who for over 30 years has been at the forefront of atmospheric composition and pollution remote sensing. Dr. Chance and the Science Team have extensive expertise in algorithm development for GOME-1 & 2, SCIAMACHY, OM6, and OMPS. The PI is supported by the NASA Langley team, which brings project management and space flight instrument development expertise (CALIPSO, CERES, SAGE III) with emphasis on hosting science payloads on a variety of platforms. The TEMPO imaging grating spectrometer is designed and built by Ball (with heritage in building OMPS and SAGE III) to take advantage of a GEO host spacecraft. Image navigation and registration is led by Carr Astronautics (GOES-R). Science data processing capabilities are operational algorithms used with current LEO instruments. TEMPO will launch at an early time to be the U.S. component of a global GEO constellation for pollution monitoring.

INVESTIGATION ORGANIZATION:
Provides clear lines of authority with accountability and ownership.

SYSTEMS ENGINEERING
- Project Management
- Project Engineer
- NASA Langley
- Project Office
- SAD

INVESTIGATION ADVISORY PANEL
- Science Advisory Panel
- Project Management
- Project Engineer
- NASA Langley
- SAD

SYSTEMS ENGINEERING
- Project Office
- NASA Langley
- Project Systems, NASA Langley
- Safety & Mission Assurance

INVESTIGATION ADVISORY PANEL
- PI: Kelly Chance, SAD
- Science Team

SCHEDULE:
With margin, enables U.S. participation in a global GEO constellation to monitor pollution.

PROPOSED TOTAL MISSION COST:
FY13 FY14 FY15 FY16 FY17 FY18 FY19 FY20 FY21
KDP-B $93,216,782
KDP-C
KDP-D
KDP-E
KDP-F
L-2 Initial Release
SCS Complete
SPCC Complete
LAUNCH
PROPOSED TOTAL MISSION COST:
FY14 LIFE CYCLE COST: $93,216,782
FY14 LIFE CYCLE COST: $93,216,782
Earth Science Program/Budget Strategy

Maintain a balanced program that:

• advances Earth System Science
• delivers societal benefit through Applications Development
• provides essential global spaceborne measurements supporting science and operations
• develops and demonstrates technologies for next-generation measurements, and
• complements and is coordinated with activities of other agencies and international partners

Support Research, Applied Sciences, Technology Development, and E/PO programs
Continue to fund operations and routine data products for all on-orbit NASA research missions
Develop and launch remaining foundational missions: LDCM, GPM, OCO-2
Continue execution of the full Venture Class program
Continue working with NOAA and OSTP to address approaches for providing sustained, long-term spaceborne measurements.
Provide significant support to National Climate Assessment, USGCRP, and international (CEOS) coordination activities
Formulation & Development Mission Plans

GPM
Feb 2014
w/ JAXA; Precip
H-IIA

OCO-2
July 2014
Global CO₂
Delta II

SAGE III
Late 2014
Ozone & Trace Gases
Falcon-9

GRACE FO
Aug 2017
w/Germany; Global Mass
& Water Variation
German-supplied LV

CYGNSS
2016-2017
Tropical Cyclone
Generation, Air-sea
Interaction in Extreme
Conditions

ICESat-2
Jul 2016
Ice Dynamics
Delta II

SMAP
Oct 2014
w/CSA
Soil Moist., Frz/Thaw
Delta II
Reinvigorate On-Orbit Constellation (2 of 2)

- GRACE-FO: Formulation for launch 8/2016
- ICESAT-2: Confirmed for launch 12/2016
- CYGNSS (EVM): Formulation for launch late 2016
- OCO-3/ISS: Formulation for launch 2017
- TEMPO (EVI): Formulation for launch 2017
- PACE: Acquisition Strategy under evaluation, launch 2020
- SWOT: Formulation for launch 2020
NASA Earth Science
Planned Missions (2013-2023)
Earth Observations from the ISS: NASA/ESD Status and Plans

- On-orbit instruments funded by non-ESD sources, ESD funding for analysis
  - HICO (Hyperspectral Imager for the Coastal Ocean)
    - Launched September, 2009 on HTV; mounted on JEM-EF
  - ISERV (Digital Camera and Telescope)
    - Launched July, 2012 on HTV-3; mounted internally on WORF

- Planned instruments funded by NASA/HEOMD, ESD funding for analysis
  - CATS (Cloud-Aerosol Transport System for ISS)
    - LIDAR, summer 2013, HTV, JEM-EF
  - Rapid-Scat (Ku-band scatterometer)
    - Launch early CY2014, Falcon/Dragon
  - Lightning Imaging Sensor (under consideration)
  - Hyperspectral Follow-on to HICO (under consideration)

- Approved instruments funded by ESD
  - SAGE-III (Stratospheric Aerosol and Gas Expt)
    - In Phase-C; 8/2014 Launch on Falcon/Dragon; ESA provides hexapod pointing p’form
  - OCO-3 (Orbiting Carbon Observatory-3 instrument only)
    - Phase-A November 2012; Launch Fall, 2017
ESD/SAGE III (2014)
ISS/RapidSCAT (2014)
ISERV (2012)
JEMEF
ESD/OCO-3 (2017)
ISS/CATS (2014)
ISS/HICO (2009)
ISERV: The ISS / SERVIR
Environmental Research and Visualization System

ISERV Pathfinder in WORF

<table>
<thead>
<tr>
<th>@ 350 km alt.</th>
<th>Angular</th>
<th>Spatial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>1.65 arc sec</td>
<td>2.8m</td>
</tr>
<tr>
<td>FOV</td>
<td>2.38° x 1.59°</td>
<td>14.5km x 9.8km</td>
</tr>
<tr>
<td>Spectral</td>
<td>350nm to 800nm</td>
<td></td>
</tr>
</tbody>
</table>

Applications

- **Primary** – Humanitarian Response/Disaster Analysis (assessment, ground operations support)
- **Secondary** – Deforestation Survey, Space Archaeology, Agriculture Inventory

Current Status

- Fit check and HFIT verification – 11Jan2012
- Payload delivery to CMC @ JSC – 12Jan2012
- Shipment to JAXA – 23Jan2012
- Launch aboard HTV-3 – 21July 2012
- System operations initiation – February 2013

ISERV Pathfinder is a COTS-based, visible spectrum instrument designed to provide a low cost path to experience and expertise in data acquisition, and system design and implementation. Pathfinder is the first step in an envisioned suite of Earth observing instruments aboard ISS, culminating in a broad spectrum, multipurpose, externally mounted sensor system.
February 18, 2013: The Rio San Pablo in Veraguas, Panama, as it empties into the Golfo de Montijo

Image dimensions: ~15 km x 13 km.
North is to upper right.
ESD Programmatic Summary: 2007 - 2013

• 1/2007: Decadal Survey Released
  – Legacy missions under development: Jason-2/OSTM, OCO, Glory, Aquarius/SAC-D, NPP, LDCM, GPM (Core+LIO)
  – ~55%/45% split between Flight, non-Flight
  – ~1000 hours planned flight time for Airborne Science Program
  – No budgeted competitive flight program (no ESSP solicitations)
  – FY2007 ESD budget request - ~1.45B (after $55M for rescission)

• Decadal Survey Recommendations
  – Re-invigorate on-orbit constellation – launch legacy missions
  – Preserve programmatic balance
  – Embark on 15 new missions in 3 tiers
  – Institute competitive flight program (Venture-Class)
  – Increase use of airborne science program
  – Increase ESD budget by 30-40% (to $2B/year [FY07 $$] by 2010
  – Implement missions in a more cost-effective way, while preserving NASA core expertise
What ESD Did: 2007 – 2013

- 6 Legacy Missions Launched (4 successfully); 1 more to launch before 2/2014
  - GPM: 2/15/14

- Climate Initiative developed: OCO-2 (7/14), SMAP (10/14), SAGE-III/ISS (late CY2014) to launch in 2014

- 7 additional missions funded for launch by 2020 (ICESAT-2, CYGNSS, TEMPO, GRACE-FO, OCO-3, PACE, SWOT)

- Airborne hours increased x 2.5, including ICEBridge, EVS

- Venture-Class funded, selected, next round on schedule (all 3 strands)

- Budget increased to ~$1.8B/year
ISSUES

• Launch Vehicle cost, availability

• Potential significant external budget perturbations from sequestration, FY14-18 budget submit, etc.
Performance shown below rounded down to nearest 50kg in the Small class and nearest 100 kg in the Medium and Intermediate classes. For detailed performance data see http://elvperf.ksc.nasa.gov

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Small</th>
<th>Medium</th>
<th>Intermediate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Vehicle</td>
<td>Falcon 1</td>
<td>Pegasus XL</td>
<td>Athena lc</td>
</tr>
<tr>
<td>Offeror</td>
<td>SpaceX</td>
<td>OSC</td>
<td>LMSSC</td>
</tr>
<tr>
<td>Perf @ 600 km Sun Synch</td>
<td>150kg</td>
<td>200kg</td>
<td>300kg</td>
</tr>
<tr>
<td>Perf @ C3 of 10</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Certification Cat</td>
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<td>Cat 3</td>
<td>n/a</td>
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<tr>
<td>Launch Sites</td>
<td>RTS</td>
<td>CCAFS WFF</td>
<td>RTS</td>
</tr>
</tbody>
</table>

*Antares 120 performance @ C3 of 10 is not available. Data shown is for Antares 122 performance @ C3 of 10 // Antares 130 performance to sun synch not available. Data shown is for Antares 131 performance to 600km sun synch. NOTE: Delta IV is not currently offered on NLS II.
# NLS II Launch Vehicles

For detailed performance data see [http://elvperf.ksc.nasa.gov](http://elvperf.ksc.nasa.gov)

NOTE: Delta IV and Antares are not currently offered on NLS II

<table>
<thead>
<tr>
<th>Launch Vehicle</th>
<th>Falcon 1</th>
<th>Pegasus</th>
<th>Athena I</th>
<th>Falcon 1e</th>
<th>Taurus XL</th>
<th>Athena II</th>
<th>Delta II 7320</th>
<th>Falcon 9 Blk1</th>
<th>Falcon 9 Blk2</th>
<th>Atlas V 401</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offeror</td>
<td>SpaceX</td>
<td>OSC</td>
<td>LMSSC</td>
<td>SpaceX</td>
<td>OSC</td>
<td>LMSSC</td>
<td>ULS</td>
<td>SpaceX</td>
<td>SpaceX</td>
<td>ULS</td>
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<tr>
<td>Perf @ 600 km Sun Synch</td>
<td>175 kg</td>
<td>240 kg</td>
<td>320 kg</td>
<td>505 kg</td>
<td>950 kg</td>
<td>1175 kg</td>
<td>1700 kg</td>
<td>6490 kg</td>
<td>7540 kg</td>
<td>6640 kg</td>
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<td>Certification Cat</td>
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<td>Cat 3</td>
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<td>n/a</td>
<td>Cat 2</td>
<td>n/a</td>
<td>Cat 3</td>
<td>n/a</td>
<td>n/a</td>
<td>Cat 3</td>
</tr>
<tr>
<td>Launch Sites</td>
<td>RTS</td>
<td>CCAFS WFF, RTS, VAFB</td>
<td>CCAFS KLC WFF</td>
<td>RTS</td>
<td>CCAFS WFF, VAFB</td>
<td>CCAFS KLC WFF</td>
<td>VAFB</td>
<td>CCAFS RTS</td>
<td>CCAFS RTS</td>
<td>CCAFS VAFB</td>
</tr>
</tbody>
</table>
The GPM Core Observatory was removed from the GSFC SES Chamber on January 27th.
SMAP: Reflector Boom Assembly Mesh and Web Have Been Completed!
SAGE III: Hexapod Electronics Unit Status

HEU Printed Wiring Board Status

- Power Motherboard
- Fuse Board
- Power Board #2
- Power Board #1
- SPLC CPU
- Analog Input Board
- SEPLOCDRV (M)
- SEPLOCDRV (R)
- Motor Drive (1M)
- Motor Drive (1R)
- Motor Drive (2M)
- Motor Drive (2R)*
- Motor Drive (3M)*
- Motor Drive (3R)*

Hexapod Mechanical Assembly (HMA)  Hexapod Electronics Unit (HEU)

- All boards inspected and **all boards need replacement or rework!**
- Discussing recovery plans with ESA and ISS

* Rework main board / remanufacture piggy back board
# LDCM Commissioning Events (planning dates)

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>S/C Sub-system Activation (initialize GPS, SADA, SSR, X band, ACS)</td>
<td>Feb. 11-17</td>
<td>Complete</td>
</tr>
<tr>
<td>OLI and TIRS power up</td>
<td>Feb. 16</td>
<td>Complete</td>
</tr>
<tr>
<td>1st Engineering Burn</td>
<td>Feb. 17</td>
<td>Complete</td>
</tr>
<tr>
<td>Began generating and downlinking OLI and TIRS test pattern data</td>
<td>Feb. 17</td>
<td>Complete</td>
</tr>
<tr>
<td>Open OLI shutter to begin dryout</td>
<td>Feb. 18</td>
<td>Complete</td>
</tr>
<tr>
<td>ACS calibration maneuvers</td>
<td>Feb. 20 - Mar. 3</td>
<td>In Progress</td>
</tr>
<tr>
<td>TIRS cryocooler launch lock deployment, uncage, and electronics power on</td>
<td>Feb. 24</td>
<td>Complete</td>
</tr>
<tr>
<td>Load OLI pixel map</td>
<td>Feb. 26</td>
<td>Complete</td>
</tr>
<tr>
<td>TIRS earth shield deployment,Cooldown begins</td>
<td>Mar. 4</td>
<td></td>
</tr>
<tr>
<td>TIRS focal plane electronics (FPE) power up, Cryocooler commissioning</td>
<td>Mar. 5</td>
<td></td>
</tr>
<tr>
<td>ACS calibration maneuvers (post earth shield deploy)</td>
<td>Mar. 6 - 12</td>
<td></td>
</tr>
<tr>
<td>OLI dryout complete, cooldown begins</td>
<td>Mar. 6</td>
<td></td>
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<tr>
<td><strong>First TIRS Image</strong></td>
<td>Mar. 8</td>
<td></td>
</tr>
<tr>
<td>OLI and TIRS routine calibrations begin</td>
<td>Mar. 10</td>
<td></td>
</tr>
<tr>
<td><strong>First OLI image</strong></td>
<td>Mar. 14</td>
<td></td>
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<tr>
<td>Ascent Burn 1</td>
<td>Mar. 16</td>
<td></td>
</tr>
<tr>
<td>Ascent Burn 2</td>
<td>Mar. 19</td>
<td></td>
</tr>
<tr>
<td>Goal: Approach 400 scenes / day before Underfly</td>
<td>Mar. 27</td>
<td></td>
</tr>
<tr>
<td><strong>Landsat 7 Underfly</strong></td>
<td>Mar. 28 - Apr. 1</td>
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<tr>
<td>Inclination Adjust Maneuver</td>
<td>Apr. 3</td>
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<tr>
<td>Ascent Burn 3</td>
<td>Apr. 9</td>
<td></td>
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<tr>
<td>Ascent Burn 4 - Arrive on WRS-2 Grid</td>
<td>Apr. 12</td>
<td></td>
</tr>
<tr>
<td>WRS-2 16-day cycle demonstration begins</td>
<td>Apr. 26</td>
<td></td>
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# Airborne Science 6-month Schedule

## NASA Airborne Science Program 6-Month Schedule starting January 2013

*(generated 2/13/2013)*

<table>
<thead>
<tr>
<th>FY13</th>
<th>Q2</th>
<th>Q3</th>
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<tr>
<td>Jan</td>
<td>Feb</td>
<td>Mar</td>
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</table>

<table>
<thead>
<tr>
<th><strong>ASP Supported Aircraft</strong></th>
<th><strong>DC-8</strong></th>
<th><strong>ER-2 #806</strong></th>
<th><strong>ER-2 #809</strong></th>
<th><strong>G-III (D)</strong></th>
<th><strong>G-III (J)</strong></th>
<th><strong>GHawk #871</strong></th>
<th><strong>GHawk #872</strong></th>
<th><strong>P-3</strong></th>
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<tbody>
<tr>
<td>Stateside Deployment</td>
<td>DC-8 B-Check Maintenance</td>
<td>EXRAD Upload</td>
<td>PODEX Upload/PODEX 122022 (AirMSPI)</td>
<td>Holidays Hawaii</td>
<td>992 Maintenance</td>
<td>ATTREX Upload</td>
<td>ATTREX Science Flights</td>
<td>DISCOVER-AQ California</td>
</tr>
<tr>
<td>Flight</td>
<td>ASCENDS</td>
<td>AVIRI</td>
<td>EXRAD</td>
<td>GLIST Local Maintenance</td>
<td>AirMOSS Engineer</td>
<td>AirMOSS M</td>
<td>A/3 Direct Direct</td>
<td>DISCOVER-AQ Science Flights</td>
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<tr>
<td>Reimbursable</td>
<td>ACCESS - ASCENDS</td>
<td>AVIRI</td>
<td>LMA</td>
<td>Central &amp; South America</td>
<td>AirMOSS M</td>
<td>AirMOSS M</td>
<td>Dec</td>
<td>Operation Ice Bridge</td>
</tr>
<tr>
<td>Aircraft Modifications</td>
<td>ACCESS</td>
<td>AVIRI/AVIRI/MAST - HYSPIRI</td>
<td>SPI Flights</td>
<td>California Fault Lines</td>
<td>AirMOSS M</td>
<td>AirMOSS M</td>
<td>Dec</td>
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<tr>
<td>Maintenance</td>
<td>K-Tec</td>
<td>AVIRI/AVIRI/Master Hysp</td>
<td>NPP (eMAS, NAST-I, NAST-M)</td>
<td>Operation Ice Bridge</td>
<td>AirMOSS M</td>
<td>AirMOSS M</td>
<td>Dec</td>
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<td>IRIS</td>
<td>LAC D</td>
<td>SPI Flights</td>
<td>Annual Maintenance and Upgrades</td>
<td>AirMOSS M</td>
<td>AirMOSS M</td>
<td>Dec</td>
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<td>LAC D</td>
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</table>

Source: ASP website calendar at [http://airbornescience.nasa.gov/aircraft_overview_cal](http://airbornescience.nasa.gov/aircraft_overview_cal)
NASA scientists demonstrated the potential of satellite-borne instruments to provide accurate global monitoring of megacity CO₂ emissions using GOSAT observations of column averaged CO₂ dry air mole fraction ($X_{CO2}$) collected over Los Angeles and Mumbai. By differencing observations over the megacity with those in nearby background, they observed robust, statistically significant $X_{CO2}$ enhancements of $3.2 \pm 1.5$ ppm for Los Angeles and $2.4 \pm 1.2$ ppm for Mumbai, and found these enhancements can be exploited to track anthropogenic emission trends over time. They estimated that $X_{CO2}$ changes as small as $0.7$ ppm in Los Angeles, corresponding to a 22% change in emissions, could be detected with GOSAT at the 95% confidence level. Urban areas now house more than half the world’s population, and are estimated to contribute over 70% of global energy-related CO₂ emissions. Many cities have emission reduction policies in place, but lack objective, observation- based methods for verifying their outcomes. The study used data from the Japan Aerospace Exploration Agency’s Greenhouse gases Observing Satellite (GOSAT) and algorithms developed for NASA’s Orbiting Carbon Observatory-2 (OCO-2) mission. Future observations from OCO-2 will enable significant improvements over GOSAT based on better measurement precision, 100x more observations and spatially-resolved urban CO₂ dome sampling along the OCO-2 flight track.
ESD Orbital Flight Portfolio – 2012-2022

- **LDCM** (2/11/2013) – “Landsat-8” including thermal IR, w/USGS ✓ ✓ ✓
- **GPM** (2/2014) – Global Precipitation mapping, w/JAXA
- **OCO-2** (7/2014) – Atmospheric CO2 monitoring, recovery mission
- **SAGE-III/ISS** (8/2014) – Ozone, Temp, Humidity profiles, w/HEOMD, ESA
- **SMAP** (10/2014) – Soil Moisture and Freeze/Thaw cycling, w/CSA (minor)
- **ICESat-2** (late-2016) – Precision Ice Topography, Ecosystem monitoring
- **CYGNSS [EV-Mission/1]** (late 2016)
- **GRACE-FO** (8/2017) – Gravity/Ice Mass/Ground Water, w/GFZ & DLR
- **OCO-3/ISS** (Fall 2017) – CO2 continuity, from ISS, OCO-2 spares
- **TEMPO [EV-Instrument/1]** (2017)
- **SWOT** (2020) – Wide-swath ocean altimetry, land water, w/CNES
- **PACE** (2020) – Ocean Color, possibly Aerosols
- **EV-Instrument/2 Venture-Class** (NLT 2020)
- **L-band SAR** (2021) – Solid Earth, Cryosphere, Ecosystems, w/ISRO
- **CLARREO** (2022?) – Precise global radiation balance, possibly w/UK
- **EV-Mission/2** (NLT 2022)
- **EV-Instrument/3** (NLT 2022)
- Significant studies ongoing for all other Tier-2 Decadal Survey missions