NASA Disaster Program

• NASA HQ: Earth Sciences, Applied Science Program, Disaster Management Element: Program Manager: Frank Lindsay, PhD.

• Oversees ROSES calls related to Disaster Elements:
  • ROSES 2011; A33 - DISASTERS
  • ROSES 2011; A35 - WILDFIRES

From 2013 Budget Plan:

• Provides $1.8 billion for research and a robust fleet of Earth observation spacecraft to strengthen U.S. leadership in the field, better understand climate change, improve future disaster predictions, and provide vital environmental data to Federal, State, and local policymakers.
• ARRA-funded effort to sustain and mature data collection over fires and partnership arrangements (2009-2011) ended.

• NASA ROSES 2011, A35 ES Applications: WILDFIRE
  • Implemented in two stages:
    • Stage 1: Feasibility Study (12-months;
    • Stage 2: Option 3-year Decision Support projects awarded at end of Stage 1.
  • Proposals submitted: 16 December 2011; proposed start dates: June 2012; Selection Letters sent ~10-8-12

• We (NASA-ARC / USFS / NIFC team) were NOT selected, despite having very high scores.

• List of successful, unknown (as of 11-2-12).
AMS Transition Update
AMS Transfer Agreement

- Addendum to / reference Interagency Agreement – SAA2-401894 between USFS-RSAC and NASA-ARC.

- Agreement signed by S. Hippskind (Chief, Earth Science Division, NASA-ARC) and T. Harbour (Director, Fire & Aviation Management) on 8/27/12 & 9/14/12 respectively.

- Transfer of AMS airborne sensor to USFS.

- Allow partnership use to support NASA and community Fire Research objectives…
  “…to “extent that there is excess capacity as a reimbursable option.”

- Partners “work-share” in sensor system operational transition.

- Terms of agreement: 14 September 2012 to 13 September 17 (5-years).
## AMS Wildfire Sensor

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength $\mu$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.42 - 0.45</td>
</tr>
<tr>
<td>2</td>
<td>0.45 - 0.52</td>
</tr>
<tr>
<td>3</td>
<td>0.52 - 0.60</td>
</tr>
<tr>
<td>4</td>
<td>0.60 - 0.62</td>
</tr>
<tr>
<td>5</td>
<td>0.63 - 0.69</td>
</tr>
<tr>
<td>6</td>
<td>0.69 - 0.75</td>
</tr>
<tr>
<td>7</td>
<td>0.76 - 0.90</td>
</tr>
<tr>
<td>8</td>
<td>0.91 - 1.05</td>
</tr>
<tr>
<td>9</td>
<td>1.55 - 1.75</td>
</tr>
<tr>
<td>10</td>
<td>2.08 - 2.35</td>
</tr>
<tr>
<td>11</td>
<td>3.60 - 3.79</td>
</tr>
<tr>
<td>12</td>
<td>10.26 - 11.26</td>
</tr>
<tr>
<td>13</td>
<td>1.55 - 1.75</td>
</tr>
<tr>
<td>14</td>
<td>2.08 - 2.35</td>
</tr>
<tr>
<td>15</td>
<td>3.60 - 3.79</td>
</tr>
<tr>
<td>16</td>
<td>10.26 - 11.26</td>
</tr>
</tbody>
</table>

Two environmental enclosures (data disks & GPS; and power supplies & controllers)

Data System Enclosure

Scan Head

Total Field of View: 42.5 or 85.9 degrees (selectable)

IFOV: 1.25 mrad or 2.5 mrad

Spatial Resolution: 3 – 50 meters (variable)
US Forest Service

• Coordinate / cooperate with NASA-ARC in AMS sensor installation, training and maintenance;

• Participate with other partners to support ongoing satellite sensor calibration and validation efforts;

• Cooperate in technology transfer activities.
AMS Transition Responsibilities

NASA-ARC

• Provide system training in the operational use of the AMS sensor and ancillary equipment;

• Coordinate with / advise the Forest Service on sensor installation on USFS aircraft;

• Provide guidance / advice as maintenance / repair issues arise;

• Direct external cooperators to the USFS for the purpose of cooperative research efforts which directly involve the use of the AMS sensor;

• Support technology transfer, education and outreach activities.
AMS Transition Schedule

- Short-term (~1yr) support from NASA HQ to NASA-ARC engineering / management staff to get AMS operational on USFS aircraft.
- Allow testing in off-fire-season 2012/13 with ARC team.
- Establish framework to mature and exchange support capabilities between agencies related to fire / disaster imaging.

Schedule:

- Engineering Fit checks: 11/12 to 1/13
- Installation: 2/13
- Test Missions: 3/13-4/13
- Operational Use: summer 2013
Instrument Payload Module (IPM) / AMS Collaboration Task
• Dramatically improve onboard processing (OBP) for high data rate missions, in particular, HyspIRI satellite mission (~2022)
• Build a series of increasingly complex and higher fidelity onboard computation scenarios
• Mesh with realistic operational scenarios using airborne assets
  • Use HyspIRI as the target for a sample Decadal mission
  • Gather benchmarks to enable future design tradeoff decisions
• Infuse lessons learned into operations concept for the HyspIRI mission and possibly similar NASA Decadal Mission

• Partner with NASA-ARC and USFS / NIFC to allow Instrument Payload Module (IPM to interface to AMS during mission phases to testbed / prove capabilities.
IPM Airborne Approach

**Objective**

- Employ Tilera components on airborne sensor missions to ensure operability and enhance the TRL levels for future satellite (HyspIRI) operations via the use of multicore processor technology.
- Demonstrate the end-to-end operations concept for use of the Intelligent Payload Module (IPM) for low latency users of NASA Decadal Survey missions using airborne vehicles as initial feasibility testbed platforms.
- Provide delivery of data products in near real-time for quick-looks assessment of processed information from a proven autonomous sensor system.

**Approach**

- Integrate IPM test-bed into box that can be flown in collaboration with the NASA Autonomous Modular Scanner (AMS) sensor onboard a US Forest Service Citation jet, during missions of opportunity over fires in the western US.
- Configure the IPM as though it is on a satellite:
  - Send real-time processing commands through IPM, dictating development of AMS sensor Level II products to derive/deliver.

**Airborne Mission Test Collaboration**

US Forest Service, National Interagency Fire Center - National Infrared Operations (NIFC-NIROPS); NASA-Ames Research Center; CSUMB, UPC
**Intelligent Payload Module (IPM):**
- Small box containing Tilera TILEncore GX board for processing AMS data and streaming NRT products to data telemetry system (AirCell) for use on ground.

**Requires either of two scenarios:**
- Two-way comm through AirCell between ops on ground and sensor package.
- Operator on-board A/C to manage data flow tests.

**Can probably be completed during AMS shakedown mission series,**
NASA Hyperspectral Infrared Imager (HyspIRI) Mission Design Plans
NASA HyspIRI TIR Channels

Science Questions:
TQ1. Volcanoes/Earthquakes
   - How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

TQ2. Wildfires
   - What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

TQ3. Water Use and Availability
   - How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

TQ4. Urbanization/Human
   - How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

TQ5. Earth surface composition and change
   - What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

Measurement:
- 7 bands between 7.5-12 μm and 1 band at 4 μm
- 60 m resolution, 5 days revisit
- Global land and shallow water

Andean volcano heats up
Volcanoes
Water Use and Availability
Urbanization
Surface Temperature
Evapotranspiration

Multispectral Scanner
Schedule: 4 year phase A-D, 3 years operations
High Heritage
### HyTES, PHyTIR, and HyspIRI

#### Airborne Instruments

<table>
<thead>
<tr>
<th>Airborne Name</th>
<th>TIMS</th>
<th>MASTER</th>
<th>QWEST</th>
<th>HyTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of TIR Bands</td>
<td>6</td>
<td>10</td>
<td>56</td>
<td>256</td>
</tr>
</tbody>
</table>

#### Spaceborne Instruments (incl. lab prototypes)

<table>
<thead>
<tr>
<th>Spaceborne Name</th>
<th>ASTER</th>
<th>Landsat 8 (LDCM)</th>
<th>PHyTIR</th>
<th>HyspIRI-TIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year of Operation</td>
<td>1999</td>
<td>2013</td>
<td>2014</td>
<td>2020</td>
</tr>
<tr>
<td>Number of TIR Bands</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Swath Width</td>
<td>60 km</td>
<td>185 km</td>
<td>600 km</td>
<td>600 km</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>10/10/2012</td>
<td>90m</td>
<td>100 m</td>
<td>60 m</td>
</tr>
</tbody>
</table>
HyspIRI, HyTES, and PHyTIR

Science Risk Reduction

Hyperspectral Thermal Emission Spectrometer (HyTES)

Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR)

Engineering Risk Reduction

Hyperspectral Infrared Imager (HyspIRI)
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>BASELINE</th>
<th>SCIENCE REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Resolution (m)</td>
<td>60</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Revisit (days)</td>
<td>5</td>
<td>&lt;6</td>
</tr>
<tr>
<td>Noise equivalent delta temperature (K)</td>
<td>0.2</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Absolute accuracy (K)</td>
<td>0.5</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Saturation – low temperature bands (K)</td>
<td>500</td>
<td>&gt;400</td>
</tr>
<tr>
<td>Saturation – high temperature band (K)</td>
<td>1200</td>
<td>&gt;1100</td>
</tr>
<tr>
<td>Overpass time (hh:mm)</td>
<td>10:30am</td>
<td>10-3pm</td>
</tr>
<tr>
<td>Nighttime imaging</td>
<td>Yes</td>
<td>Required</td>
</tr>
<tr>
<td>Number of Bands (spectral range: 3 – 12 μm)</td>
<td>8</td>
<td>&gt;=8</td>
</tr>
<tr>
<td>Coverage</td>
<td>Land and coastal regions</td>
<td>Land and coastal regions</td>
</tr>
<tr>
<td>Data latency</td>
<td>2 days</td>
<td>&lt; 1 week</td>
</tr>
</tbody>
</table>
• Successful program to develop, test and apply new instrument design concepts to improve wildfire science and applications uses. These proposals have been “assigned” to NASA-ARC for evaluation and management.

• Two current SBIR developments in various stages of maturity:
  • 2008 – Wide Area Imager (WAI); Xiomas
    • Phase III, in operations testing for use by partners in USFS
    • Partnership arrangement with Photo Sciences for commercial use.
  • 2011 – Thermal Mapping Airborne Simulator for Small Satellite Sensor (TMAS); Xiomas.
    • Completed Phase I; under evaluation for Phase II.
• Discussions with NASA ARC SmallSat Development Office (C. Frost) about a design concept for expansion of the TMAS envelope to include development into a SmallSat instrument candidate for supporting wildfire observations from an orbital system at high spatial resolution, daily temporal resolution and globally.

TMAS
• 110 degree field of view (same as MODIS)
• 50-94 meter spatial resolution (in Phase III) (similar to ASTER)
• 3 Spectral Bands (more can be added in Phase III)

• Operating at the same altitude and velocity as MODIS the TMAS will have the same capability to map the globe every one to two days
NASA UAS Updates
• Surplus from USMC to BLM; BLM to NASA-ARC; received 7/12.
• US Marine Corps aircraft and operating system (ref TM11015A-12&P/2A). Built by AeroVironment. (9 years heritage use by DOD)
• COTS system (no changes to any system component except map uploading).

• **Class 1 UAS**

• **Aircraft specs**
  - Wingspan: 45 inches
  - Length: 36 inches
  - Weight: <6 pounds
  - Cruise speed: 35 mph
  - Max altitude: 500’ AGL
  - Power: Electric propulsion

• **Aircraft possesses a Stage III frequency clearance for CONUS use.**
  - Aircraft GCS operates using a digital FM transmitter in the frequency range of 381 MHz-400 MHz with a max output power of 1 watt.
  - The vehicle operates using a digital FM video and telemetry transmitter in the frequency range of 1,765 MHz-1,840 MHz with a max output power of 2 watts.

• **Ames inventory catalogued, systems ground tested.** GCS reloaded with regional maps. Flight lines developed and simulations run.
• Per DOD specifications, system consists of 1 ea ground station, 3 ea aircrafts, complete with nose payloads (3 ea cameras per nose) and extensive spare parts and repair kit.

• ARC has ~25 complete kits (~75 UAS platforms), plus spares.
Test Mission Plan

• FHL Test Flights November 29/30, 2012
  • Goal: aircraft familiarization and crew proficiency development
    • Day one, system set up and aircraft launch and landing
    • Day two exercise of flight lines.
  • Secondary goal: payload familiarization, imagery collection
  • Dragon Eye Team: (SIERRA Core Team)
    • PIC, Don Herlth
    • Crew Chief, Richard Kolyer
    • GCS, Bruce Storms
    • RSO, Randy Berthold
  • Met all FHL regulations for flight and ground operations, spectrum management and safety.
• **Area of operations:** Tule Airfield, a remote, isolated area, utilized for GSAR payload. No urban habitation for 5 mile radius.

Flight operations will not exceed ¼ mile west of Tule Airfield nor 2 miles south.
AMS Sensor
Questions?