JPL’s First Payload Development Experiences for the M-Cubed/COVE CubeSat Flight Experiment

Paula J. Pingree
Supervisor, Flight Instrument Electronics & SmallSat Technology Group (389F)
Principal Investigator, CubeSat Onboard processing Validation Experiment (COVE)
Principal Investigator, AIST08 - MSPI On-Board Processing

Jet Propulsion Laboratory
California Institute of Technology

September 7, 2010
CubeSat/SmallSat Technical Interchange with The JPL Innovation Foundry
Motivation for COVE
JPL/U. Michigan Collaboration
COVE Payload: High-Level Block Diagram
COVE Board Development
Final Stages
Payload Development Experiences
Summary
Acknowledgements
Motivation for COVE

**MSPI: Multi-angle SpectroPolarimetric Imager**

- Measures cloud and aerosol properties
- 8-fixed and 1-gimballed cameras, each with 16 channels
- A single MSPI camera must process 95 Mbytes/sec of raw video data; data reduction to 0.45 Mbytes/sec is required

The information technology processing challenge is to apply on-board processing to extract intensity and polarimetric parameters from the real-time data stream across each camera thereby reducing the data volume by 2-orders of magnitude without loss of science information.
M-Cubed/COVE OBJECTIVES:

- Raise TRL of ESTO Technologies relevant to the Earth Science Decadal Survey Missions
  - MSPI On-Board Processing (OBP) algorithm
  - Xilinx Virtex-5QV Single event Immune Reconfigurable FPGA (SIRF)
- Capture and downlink mid-resolution images of the Earth
- Educate and train the next generation of engineers in the Aerospace Industry

SmallSat platforms can rapidly advance the TRL of key instrument components and serve as platforms for new science observations
COVE Board Development

Engineering Model
(Commercial Virtex-5)

Flight Model
(V5QV Production SIRF)

Flight Spare
(V5QV Engineering Sample SIRF)

Press Release: Xilinx Space-Grade Virtex-5QV FPGA in Production with Mega-Rad Capability (July 21, 2011)
Final Stages

✓ COVE FM Payload (V5QV SIRF) delivered to U. Michigan, July 27
✓ M-Cubed/COVE Integration & Test Complete
  ✓ Vibration, Thermal & Shock Tests Complete
  ✓ Delivered to Cal Poly SLO for P-Pod Integration on Aug. 31
• Launch via NASA Space Operations Mission Directorate (SOMD) CubeSat Launch Initiative on ELaNa 3
  – NPP Mission (as a secondary payload)
  – VAFB on Oct. 25, 2011
COVE Payload Development Experiences

1. Xilinx V5QV SIRF Delivery
2. DC-DC Converter Component Failure
3. JPL Institutional Requirements for Flight Hardware
4. University of Michigan Partnership
**COVE Payload Development Experiences**

**Xilinx V5QV SIRF Delivery**

<table>
<thead>
<tr>
<th>Month</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 25</td>
<td>Xilinx Engineering Sample (ES) devices received</td>
</tr>
<tr>
<td>7/7</td>
<td>JPL delivers COVE ES-1 Payload to UM; HRCR held 7/5</td>
</tr>
<tr>
<td>7/20</td>
<td>Xilinx V5QV SIRF production device received</td>
</tr>
<tr>
<td>7/27</td>
<td>JPL delivers COVE FM (SIRF) Payload to UM; HRCR held 7/26</td>
</tr>
</tbody>
</table>

May 2010 - Task Start
-- Xilinx V5QV advertised available to order in Dec. 2010

3/31 – JPL/Xilinx face-to-face meeting

M-Cubed/COVE I&T (incl. vibe, thermal, shock)

M-Cubed/COVE delivered to CalPoly SLO for P-Pod integration
• LTM4619 DC-DC Converter: Commercial-grade, LGA

• Component DOA on first power check

• Component removed and replaced (heroic effort by 374 & 512)

• 5X investigating component failure
COVE Payload Development Experiences
Institutional Requirements

- Memo documents institutional process agreement for COVE Task compliance to FPPs, DPs, CoFR
- PI worked with Safety & Mission Assurance (5X) to define content
- 8X is preparing a Task Implementation Plan (TIP) for CubeSat Technology Validation
COVE Payload Development Experiences
U. Michigan Partnership

- Student CubeSat team mentored by Dr. Jamie Cutler (COVE Co-I)

- U. Michigan CubeSat experience
  - RAX (Radio Aurora eXplorer): 1st NSF-sponsored CubeSat, launched Nov. 19, 2010 from Kodiak Island, Alaska
  - RAX2 and M-Cubed are both secondary payloads on NPP launch

- Weekly M-Cubed team meetings with JPL telecon participation

- Collaborative development of the M-Cubed/COVE Interface Control Document (ICD)

- ESTO Interim (6-month) and Annual Reviews held at U. Michigan
Summary

- **JPL Participation**
  - ESTO: Charles Norton
  - 389: Paula Pingree (PI), Thor Wilson (Co-I), Brian Franklin, Nooshin Meshkaty, Chris Peay
  - 388: Thomas Werne, Dmitriy Bekker
  - 374: Atul Mehta, Noly Neverida, Hung Truong
  - 512: Reza Ghaffarian, John Kennedy

- **Schedule – 18 months**
  (from Task Start to Launch!)

- **Total Cost - $1.185M**
  (includes Launch cost and Mission Ops support)

- √ JPLs 1st CubeSat Payload to Launch
- √ JPLs 1st installation of 1752-pin CCGA device
- √ 1st Xilinx V5QV SIRF production part to fly
Acknowledgments

The research described in this presentation was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. Sponsored by NASA/Earth Science Technology Office (ESTO)