Operationally Responsive Space (ORS) Payload and Bus Technology Initiative (Final Update)

J.A. Gherlone Jr., LCDR, USN (Ret.)
Christopher Huffine
Michael Hurley

Naval Research Laboratory

Col Thomas Doyne
Office of the Assistant Secretary of Defense

USU Small Satellite Conference, 12 August 2007
ORS Payload Technology Initiative

Purpose

- Congressional mandate to OSD: coordinate ORS payload tech development
- OSD’s Office of Force Transformation (OFT) provided funding
- NRL Issued BAA – Industry Day Held with Joint Participation
- Entering Arguments
  - ORS Bus Standards Development
  - DoD ORS S&T Vector
  - TacSat Experimentation
  - General state and need of select technologies
- Desired Attributes/End State
  - ORS-Unique (unlikely investment via normal DoD or National)
  - Address COCOM operational concepts / needs
  - Primary transition
    - Joint TacSat experimentation, and/or
    - ORS payload acquisition
  - Expand ORS industrial base
Status: Proposal Selections and Awards
(1 of 2)

• **Proposal Selection Process**
  – 75 Proposals Received
  – Categorized Based On Proposal Cost
  – Joint Army, Air Force, And Naval Evaluations Performed
  – OSD And STRATCOM Concurrence Obtained

• **Basic Projects <= $0.5m**
  – 38 Proposals Received And Evaluated
  – 8 Selected
    - SPACEDEV – CORRI - Combined Optical, Radio, Radar -- Study complete
    - MSI - UIE - Universal Payload Electronics – Hardware delivered
    - AMASST - Enhancing Space Control With Structured Light Sensor – Study Complete
    - GD-AIS - HIGRISE (Hi Res Imaging Sensor And Exploitation) – Study complete
    - SSGINC - Manufacturing Techniques For ORS – Study complete
    - JHUAPL - Self Heal CD&H (For Commercial Electronics Use In Space) – Study complete
    - INNOFLIGHT - IP Transceiver Experiment – Hardware transitioned to SBIR
    - Vulcan Wireless – UHF Tactical Communications – In progress
Status: Proposal Selections and Awards (2 of 2)

- **Moderate Projects $0.5M-$2.0M**
  - 27 Proposals Received and Evaluated
  - 4 Selected
    - SEAKR - Reprogrammable Space Network Interface Card (SNIC) – Sept 2008
    - ICS - Autonomous Tasking and Checkout of Responsive Space Payloads – Transition to TS-4
    - JHUAPL - "WISPER" : Wafer Integrated Spectrometer (SAA mission oriented)
      - also provides a Payload for AF FalconSat-4
    - Raytheon - CIRCE - Advanced Hyperspectral Payload Technology – Main study complete
    - Composite Technology Development (CDT) -- Large Aperture Deployable Composite Reflector for Operationally Responsive Space – Study complete

- **Complex Projects $2.0M-$5.0M**
  - 10 Proposals Received and Evaluated
  - 3 Selected
    - Assurance Technology Corporation (ATC) – Radio Frequency Digital Payload (RDP) – Hardware delivered
    - Ball Aerospace – Lightweight L-Band SAR Technology Development – PDR Level complete
    - Goodrich – Advanced E-O Airborne Sensor (OASIS) – PDR level completed
Results

• Increased working relationship between AFRL, SMDC and NRL
  – Leverage subject matter experts from across the services to assist in the technical management of projects
  – Identify and work areas of interest to each specific service while keeping the broader goals of the ORS Tech initiatives closer to site

• Transition Opportunities
  – In all technology developments, a key indicator of success is the transition of that technology development to follow-on efforts and capability
  – Several ORS Technology initiatives continue in one form or another through continued efforts
    ➢ Joint Capability Technology Demonstration (JCTDs)
    ➢ SBIRs
    ➢ Flight manifested

• Partnerships
  – An opportunity for combining FFRDC research efforts with a USAF Academy effort was noted and leveraged
Lessons Learned (1 of 4)

• Joint, Joint, Joint
  – OSD’s initial guidance was to keep the process as joint as possible
  – Project selections were kept as egalitarian as possible

  – We didn’t do as well keeping the project execution/monitoring as joint as we would have liked
    ➢ Personnel commitments and other factors sometimes limited interest from other services in supporting projects
    ➢ But once committed, interested users were found from the other services, very useful collaborations and interactions were possible
    ➢ Need as much high-level commitment from other organizations to support the efforts as possible

  – “Joint” in this ORS Technology context was Navy, Army and Air Force
    ➢ Interest was also articulated from other areas within the US Government
    ➢ Without over-complicating things, it may useful to bring in other government agencies to lend their experience
Lessons Learned (2 of 4)

• If you Build It, Will They Come??

  – For DoD projects, there is always a tension between the desire to advance S&T and the need to field new capability

  – The ORS Technology initiatives, by design, were selected at various Technology Readiness Levels (TRLs) from some area of basic research

  – Engaging our customers is crucial for continued support

    ➢ Temper the promise of new technology with the reality of its available timeline – i.e. “Truth in advertising”

    ➢ They will come – but a comprehensive roadmap showing the progression of technology is useful to show the building blocks
Lessons Learned (3 of 4)

• Industry is energized, and there are more good ideas than money to fund
  – The number of proposals received for the 2006 NRL ORS Tech initiative and
    more recently the 2008 ORS Office BAA shows the level of interest in the
    community
  – Many proposals were for specific mission areas or “niches” but many were
    broadly applicable
  – In any case, the results of the 2006 NRL ORSTECH effort was broadly based
    across software and hardware as well as mission and technology
    development

• Selection process needs to be rigorous but also clear and concise for the
  reviewer
  – Most evaluators provide their insights as subject-matter-experts on a “part-
    time basis”
  – By using clearly defined metrics and explanations of decisions, the
    evaluation process provides quantitative results
  – Numerical scoring is augmented by discussions lead by the effort lead
  – Content counts: the proposals are thoroughly read and evaluated by
    technical experts
Lessons Learned (4 of 4)

• Users know what they want, but don’t know how to you what they want
  – The core user isn’t a space expert or professional
  – They understand the data they need, but not necessarily the path to obtain that data or the supporting infrastructure to get there
  – It is useful for the user to understand some of the limitations and requirements for space
  – But it is also useful for the S&T project leads and decision makers also to stay well connected with the user so that we can best interpret their requirements

• Execute, don’t debate
  – The NRL ORS Tech initiative fell behind in its award process mainly from the workload of evaluating the proposals
  – Once the final rankings were chosen, the NRL contracting office very effectively worked to issue contracts
  – Most projects stayed close to schedule and have completed so that further efforts can continue
Final Thoughts and Conclusions

• The NRL team thanks industry for their participation and interest in the first ORS Tech efforts and their continue interested now that the ORS office has taken the reins

• The ORS Tech effort has, itself, been “transitioned” to the ORS Office with its establishment
Complex Projects
Background

• High Priority Responsive Space Missions Enabled Through the Development of Space Based Software Defined Radio and Low Power Processing Technologies
• On-Demand Tactical Mission Capability using In Theater and On-Orbit Reprogrammability
• Flexible and Agile in Bandwidth and Frequency
• Directly Applicable to 48% of the Missions Identified by the COMOs for TacSat 3 and 4
• Use of Open Standard Spacecraft Interfaces

Tasks

• Compact Tunable RF Transceiver
• Wideband Digital Transceiver
• Reconfigurable Low Power Computing Resource
• RDP Infrastructure Software
• Web Based Ground Station Control Software
• RDP Assembly with Power Converter

Cost And Schedule: $2,900K

Contractor PM Contact Information
• Bob Burdett burdett@assurtech.com, 703-765-6623
Goodrich Electro-Optical Systems  
E-O Sensor System for Operationally Responsive Space (ORS)

**Background**
Adapts the high resolution SYERS-2 airborne reconnaissance system, currently deployed on the U-2, into an “ORS Class” reconnaissance system

- Based on evolving airborne product line with proven recurring cost and demonstrated schedule performance
- Provides multi-spectral visible and IR imagery from space to operational users via standard data links and infrastructure
- Leverages TacSat 2 and TacSat 3 interfaces and command/tasking protocols and standard bus specifications
- Provides direct path to Operational TacSat

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**Phase 1A Tasking (Funded)**
- System Reqt's Definition/Flow-down: 22 Aug '07
- Prelim Design/Analyses/Trade Studies: 31 Aug '07
- Interim Design Review: 19 Sep '07

**Phase 1B Tasking (Unfunded Option)**
- Detailed Design/Analyses
- Final Design Review

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**Cost and Schedule:** Phase 1A Funding $2.5M

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<th>CY 2007</th>
<th>CY 2008</th>
<th>CY 2009</th>
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<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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<tr>
<td>Phase 1A – Preliminary Design</td>
<td>Interim Design Review</td>
<td>Phase 1B Opt. – Detailed Design</td>
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Goodrich PM: Bill Cidzik  (P): 203.797.6642 / bill.cidzik@goodrich.com

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Ball Aerospace & Technologies Corp – L-Band SAR Technology Development

Background

• Desired capability - wide area coverage with tactical utility
• Quick repeat collections with sensitivity to change is needed
• All weather and day/night operation is advantageous

Tasks

• Kick-off – April 20, 2007
• Preliminary Component Thermal Testing – July, 2007
• Preliminary Design Review – October 10, 2007
• Aperture Panels fabricated – December, 2007
• Aperture Panels tested – February, 2007
• Support Structure Completed – February, 2007
• Integrate Aperture Panels with Support Structure – March 2007
• Final Testing Complete – March 2007
• Final Design Review – March 2007

Cost and Schedule

Budget is $3.8 million
Schedule is 1 year – April 07 to April 08

Contractor PM Contact Information –
Mark Webster, Ball Aerospace
mswebste@ball.com
303-533-7979
Moderate Projects
Background

- SNIC will provide a payload independent interface to an IP based network system
- Adapts legacy or new payload data interfaces to Space based IP networks
- LEON3 microcontroller and hardware accelerator FPGA perform data conversion between native and IP formats
- 3U cPCI based processor board with custom mezzanine card adapts to various payload interfaces

Tasks

- Concept Design Review completed - June 07
- Prototype board/FPGA design - Sept 07
- Prototype hardware build – Oct 07
- Prototype system development and test – March 08
- Final prototype system demonstration – April 08
- Final report complete – May 08

Cost and Schedule

Contract Value: $1.024 M
Schedule: March 2007 – May 2008

Contractor PM Contact Information
SEAKR Engineering (303) 790-8499
Matt Fehringer (matt.fehringer@seakr.com)
ICS - Autonomous Tasking and Checkout of Responsive Space Payloads

Background

- ICS developing technical reports and deliver flight software to define and implement a concept of operations for Autonomous Payload Tasking and Checkout (APTC) capabilities for Operationally Responsive Space (ORS).
- ICS will also define a set of payload tasking message protocols to support ORS. ICS is proposing a development schedule that would permit demonstration of the APTC software on the ORS Phase3/TacSat 4 mission.

Tasks

- Define Concept of Operations for Autonomous Operations and Checkout
- Define Tactical Tasking Messaging Protocols
- Define Requirements for Autonomous Operations and Checkout
- Port OOCE and ATE Software to the Standard Bus Flight Software
- Design Review for Flight Software Components
- Enhance and Expand the Baseline Software to Create the Autonomous Payload Tasking and Checkout System.
- Flight Knowledge Base Development for Operations and Checkout
- Testing, Demonstrations and Final Report

Cost and Schedule

- $671,988.56
- 14 months
Background – Friend or Foe Determination

• Demonstrate WISPERS instrument on FalconSAT-5, (on-board ion source, allowing measurements of the ion plume produced in LEO)
• Determine production mechanism of the ions, and assess if similar ions could be detected from a cold gas thruster in GEO
• Evaluate detection of primary and secondary ions created by an ion thruster and help validate thruster plume models
• Establish detection thresholds across a variety of naturally occurring plasma environments, including plasma sheet and polar cusp
• Characterize energy distribution of detected ions from thrusters and distinguish these from the natural background

Teams: The Johns Hopkins University Applied Physics Laboratory
- USAF Academy (USAFA) & NASA/GSFC

Tasks
• Front End Electronics Design (complete)
• Design of the Front end sensor head array (in process)
• Fabrication of qual model electronics
• Integration
• Test and Evaluation
• University Grade flight model fabrication
• Integration and Test
• Test and Evaluation Reports

Cost and Schedule

JHUAPL $841,535
USAFA $202,000

• USAFA responsible for space vehicle integration and operational costs
• 12 Month program ready for flight integration
• Planned launch on Minotaur rocket in fall 2009

Contractor PM Contact Information:
JHUAPL Ann Garrison Darrin ann.darrin@jhuapl.edu
USAFA Geoff McHarg 719-333-3510
240-228-4952
Raytheon - CIRCE - (Cost-effective Imager for Real-time Chromatic Exploitation)

Background

• Goal is ~33x increase in ARTEMIS coverage rate
• Breadboard demonstration using a 8192x96 pixel COTS camera
• WFOV, NFOV, and Dual FOV
• Define:
  • Size, weight, power
  • Flight FPA and electronics
  • Processing H/W & S/W
  • Environmental test reqs
  • CONOPS

Tasks

• Functional requirements definition
• System Concept Development
  • Definition and Trades
  • Optomechanical trades and design
  • Focal Plane Array Trades
  • Processing H/W and S/W trades
  • Bus/ground interfaces
• Spectrometer Breadboard
• Design finalization
• Drawings
• Final Report

Cost and Schedule

• $1.846M
• Approximately 10 month schedule
Lightweight, Large Aperture Deployable Composite Reflector for ORS

**Background:**
- Obtaining ORS mission goals will be challenged by data rates possible with currently available antenna reflectors.
- Solid reflectors will not fit into ORS launch fairings & deployable mesh reflectors are too expensive.
- New high data rate, deployable composite reflectors are necessary to meet mission and cost goals of ORS.

**Program Goal/ Tasks:**
- **Goal:**
  - Develop technology for a 4M, high data rate, deployable reflector that can be procured within an ORS mission budget.
- **Tasks**
  - Requirements Definition (8/07)
  - System Preliminary Design (1/08)
  - 2.5M Reflector Model (10/07)
  - 2.5M Reflector performance testing and concept validation (12/07)

**Cost and Schedule:**
- **Cost:** $1,086,356
- **Schedule:** 9 Months (See also tasks)

**Deliverables:**
- PDR
- 2.5M Reflector
- Breadboard test report

**Contractor PM:**
Rory Barrett
rory.barrett@ctd-materials.com
(303) 664-0394 x132
BASIC Projects
Background

- SpaceDev has developed a concept for a sensor/comm suite, known as Combined Optical, Radio, Radar Instrument (CORRI)
- CORRI is planned to be modular and scalable from nanosatellites upward.
- Plan to develop and test CORRI to a “moderate” level with only basic level cost and schedule investment.
- Based on concept developed in competition for the USAF ANGELS program.
- Development CONOP – ANGELS-like – ride-along with host S/C for checkout and anomaly resolution

Tasks

- Ground hardware will be built and tested to the PDR level supporting a flight payload design for a TACSAT-sized bus
- Optical analysis and performance testing
- RF performance testing
- Radar performance testing
- Final analysis

Cost and Schedule

- $496,295
- 8 months for execution

Contractor PM Contact Information

- Keith Beals
- 858-375-2049
- Keith.Beals@SpaceDev.com
MicroSat Systems Inc.  
Universal Interface Electronics

Background

• Demonstrate ORS Spacewire Interface Standard For Payloads.
• Demonstrate Real-Time User-Reprogrammability To Accommodate Legacy Interfaces To Spacewire Standard
• Provide Data Conversion Between TacSat 4 Spacewire interface and ODTML SCP RS-422 interface
• Demonstrate 80/20 Avionics Architecture
• Flight Qualification Of Modular Avionics Interface Module And Processor

Tasks

<table>
<thead>
<tr>
<th>Flight Universal Interface Electronics Development</th>
<th>Start Date</th>
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<tbody>
<tr>
<td>Phase 1 UIE Detailed Design</td>
<td>12/22/06</td>
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<tr>
<td>Software/Firmware Development</td>
<td>7/13/07</td>
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<tr>
<td>Engineering Model Fab/Verification</td>
<td>7/20/07</td>
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<td>Flight UIE Development</td>
<td>8/31/07</td>
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<td>Flight Unit Delivery</td>
<td>9/3/07</td>
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Cost and Schedule

Contract Type: CPFF

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<tr>
<th>PoP</th>
<th>Start Date</th>
<th>End Date</th>
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<td>10/26/07</td>
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Jeff Summers
303-285-5153
jsummers@microsatsystems.com

UIE Provides Real-Time User-Programmable Protocol Conversion

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**AMaSST - Enhancing Space Control with Structured Light Sensor**

**Background**

- The goal of this sensor concept is to provide a low cost, low resource intensive (mass, power, data rate, etc) method by which another satellite can be detected, imaged, and tracked.
- The Structured Light Sensor (SLS) is a sensor concept in which an object (or area) of interest is illuminated by a structured array of light.
- Imaging by a high resolution camera is processed into a 3-dimensional map of the surface being imaged.
- Development CONOP – secondary P/L for HVA to allow local SA while on-orbit. Goal is to support sufficient volume and dynamic response to identify both slow and fast moving encroachment, and to distinguish between debris and other vehicle.

**Tasks**

- Basic effort to develop and demonstrate a bench level SLS sensor system that can be used for DCS and OCS missions.
  - Requirements definition
  - System design
  - System assembly and calibration
  - System testing
  - Deliver draft final report
  - Deliver final report

**Cost and Schedule**

- $175,916
- 9 months for execution

**Contractor PM Contact Information**

- Dana Cox
  - 818-341-8909
  - dcox@amasst.com

- Small Business
GD-AIS - HIGHRIZE (HI RES IMAGING SENSOR AND EXPLOITATION)

Background

- General Dynamics Advanced Information Systems (GDAIS) will develop HIGHRIZE, a combined-aperture radar and EO/IR payload capable of providing high resolution imaging in the millimeter-wave, visible near-infrared, and mid-wave IR bands.

- This combination of radar and optical sensors into a common aperture on the order of ten inches diameter in size is suitable for mounting on platforms that have restrictive volumetric and weight restraints.

- Development CONOPS – GEO SSA survey. Allows improved GEO catalog maintenance while in transit, and permits a discrete series of approaches to Objects of Interest for further characterization.

Tasks

- Basic study that will adapt an existing sensor concept to the ORS mission.
  - Develop and analyze mission requirements.
  - Modeling and simulation for the HIGHRIZE system.
  - Derive sensor requirements from mission requirements.
  - Conduct experiments to demonstrate that key component technologies are feasible to support the concept level design.
  - Deliver final technical report.

Cost and Schedule

- $499,872
- 9 months for execution

Contractor PM Contact Information

- Peter Colvin
- 734-480-5987
- Peter.Colvin@gd-ais.com
Background

• Optical systems for space based reconnaissance and communication applications typically require ~12+ months for design, fabrication & integration

• Near-net-shape cast Silicon Carbide (SiC) optics and structures have the ability to provide high performance & environmentally stable optical systems with significantly reduced cycle times

• This study evaluates the applicability & scalability of these technologies to optical systems with apertures from ~0.1 – 1.0 meters in diameter

Tasks

• Program Kick Off  2/5/07
• Requirements Refinement  5/15/07
• Trade Study Review  6/8/07
  • Mirror Mfg. Trade Study - primary mirrors from ~0.1 - 1.0 meters – expandable to segmented mirrors
  • Optical Design Trade Study – versatility and scalability of telescope optical design with emphasis on reducing mirror mfg. / alignment time
  • Mechanical Design Trade Study – expandability and versatility of mechanical design with emphasis on simplicity of machining, assembly & alignment
• Preliminary Design Review  9/12/07

Cost Status

Contract Value  500K
Current Cost  288K
Performance  On Track

Schedule Status

Program End  11/3/07
PDR Milestone  9/12/07
Performance  Early Completion

Contact: Brian Rider, Program Manager, 978.694.9991, Brian.Rider@L-3com.com
Background

- Provide Operationally Responsive Space the capability to develop low-cost, compressed-schedule space missions, by reducing cost and schedule constraints for software development.
- Develop an integrated architecture based on the Linux operating system and open source standards and software.
- Leverage vast library of third-party, reliable tools (flash storage, compression, scheduling) for immediate functionality.
- Homogenize the development and runtime environment to enable significant software progress in advance of delivered flight hardware.

Tasks

- Use JHU/APL flight software lab resources to evaluate Linux running on MCP750 single-board computers (2/07)
- Assess software development environment (4/07)
- Explore multiple architectural areas : (4/07)
  - Publish/Subscribe Messaging
  - Distributed processing
  - Tasks as Individual, Memory-Protected Processes
    - Individually upgradeable
    - Automatic recovery via watchdog re-spawning
    - Supports parallel development
    - Aperiodic tasks spawned from command line.
- Demonstrate reference implementations of key concepts (6/07)
- Record results of software architecture investigations (9/07)
  - Technical Assessment of real-time Linux
  - Recommended implementation path

Cost and Schedule

Contract Value: $345,568
Contract Labor Hours: 2366

Contractor PM Contact Information

Edward Birrane, JHU/APL
11100 Johns Hopkins Road
Laurel, MD 20723
(443) 778-7423

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INNOFLIGHT - IP Transceiver Experiment

Background

• The objective of this task is to design and demonstrate an Internet Protocol (IP) compatible high speed frequency programmable transceiver (SGLS & USB) that meets cost and schedule requirements for ORS.

• Traditional spacecraft transponders are designed for 6 sigma performance, cost hundreds of millions of dollars to build, and take more than five years to complete.

• A wide variety of design building blocks have become available as commercial products applicable to space communications.

• Focus is to provide a flexible, cost-effective, readily available communication system for small satellites.

Tasks

• Requirements Definition For A Responsive Transceiver.

• Frequency Programmable Transmitter And Receiver Designs.

• Demonstration

• Deliverables:
  • Prototype Transmitter
  • Preliminary Receiver Design
  • Final Report

Design Features

• 3U form factor, 16 X 10 X 3 cm
• ~500 grams (heat sink driven)
• Uplink Rate: up to 1Mbps
• Downlink Rate: up to 10Mbps
• Analog and Digital telemetry channels
• BPSK/QPSK D/L Waveform
• Innovative and Adaptable Exciter Design
• SEU, Latchup, SEFI mitigation

• Flight Interfaces:
  • Serial RS422 for TX and RX data
  • Serial RS422/485 for control
  • Unregulated bus voltage (10VDC 36VDC)
  • Antenna connections for TX and RX

• Ground Interface:
  • Field Programmable (frequency selection as late as the launch pad)
  • Power
  • Operating temperature range: -25C to +65C

Cost and Schedule

• $169,937
• 6 months for execution

Contractor PM Contact Information

• Jeff Janicik
• 858-638-1580
• jjanicik@innoflight.com

Small Business