ORS Payload and Bus Technologies Initiative

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ABSTRACT

In 2006, the Office of Force Transformation, now organized under the Director of Defense Research & Engineering, began an initiative for the development of payload and bus technologies for Operationally Responsive Space (ORS). The Naval Research Laboratory (NRL) Naval Center for Space Technology (NCST) was requested to manage the initiative with the objectives and attributes of 1) addressing ORS-unique capabilities, 2) directed at Combatant Commander (COCOM) operational concepts and needs, 3) with primary transition to Joint TACSAT experimentation or ORS payload acquisition, and 4) to expand the ORS industrial base. NRL developed and followed a fully Joint process for solicitation, Industry Day, selection, and execution of 20 projects from a field of 75 proposals. Each potential ORS payload technology was advanced in maturity, with several already transitioning to follow-on development programs or transitioning directly into flight projects. This initiative and similar efforts are critical to developing ORS and the use of military small satellites to their full potential. Recommendations for future processes and a way ahead are offered.

HISTORY

The early history of what we now call Operationally Responsive Space (ORS) was marked by a variety of individual efforts executed by members of the Department of Defense (DoD) to determine whether smaller satellites and more rapid mission design and execution could remain militarily useful. The Office of Force Transformation (OFT) in the Office of the Secretary of Defense (OSD) was an early supporter of aggressive action to mature technologies that would allow ORS to support the warfighter. At the same time, initiatives from the US Air Force were aligned toward more rapid and responsive spacelift. In 2005, Congress recognized the need to improve payload technologies to support ORS efforts. OFT, now part of DDR&E's Rapid Reaction Technology Office, was provided a Congressional plus-up for FY06 and FY07 and directed to execute additional development on payload and bus technologies for the ORS concept. This initiative and similar efforts are critical to developing ORS and the use of military smallsats to their full potential.

EXECUTION

OFT leadership requested that NRL NCST manage the initiative as part of NRL's broader role as Program Manger for OSD's ORS Initiative.

Entering Arguments

The initiative centered on and was planned to be fully compatible with several factors which were part of the

developing ORS concept. OSD established Responsive Space as one of the DoD S&T Vectors, providing guidance for the attributes desired in ORS systems. TACSAT Experimentation had begun to determine utility and operating concepts for space systems that were more timely and responsive directly to the warfighter in the field. The ongoing ORS Bus Standards Development was an effort to document a common set of standard interfaces to enable rapid and predictable integration with a payload and launch vehicle. Finally, the general state of select technologies such as launch and spacecraft systems had reached a point where smaller, more affordable, and more rapidly developed systems could demonstrate military utility.

Desired Attributes/End State

Based on the background of the entering arguments, the following desired attributes and end state for the proposals under the initiative were developed. All proposals must: 1) be ORS-unique, i.e., unlikely for investment via normal DoD or National means, 2) be directed at COCOM operational concepts and needs, 3) have a primary transition path aimed at Joint TACSAT experimentation, and/or ORS payload acquisition, and 4) expand the ORS industrial base.

MIT/LL Study

OFT commissioned MIT Lincoln Labs to conduct a study of the current state of the industry and its readiness to participate in ORS-related development and operations. The focus was to identify and recommend technology areas for OFT investment to "buy down the NRE." This study provided insight as to the areas requiring the most investment.

BAA

The method chosen for executing the initiative was to issue a BAA. This method was selected to maximize the variety of projects that could be chosen, and to enhance impact under end-state #4 discussed above. An Industry Day was held in July 2006 to brief potential offerors on the intent of the BAA. OFT and NRL NCST representatives briefed the planned process and desired attributes. MIT/LL presented their study findings as background. Briefings were provided by all 3 Service departments to emphasize the Joint nature of the process, and to ensure that all Services capability needs were represented in keeping with end-state #2 above.

Award Categories

The ORS Technology effort was aimed primarily to incubate ready-to-fly or almost ready-to-fly technologies for <~$15M payloads. Investments in technologies, processes, procedures, and software that would pay-off in the near future were of highest interest. With that in mind, three award categories were developed for proposals provided under this BAA.

1. Basic efforts to be funded $100K-$500K; Primary deliverable: Technical report.
2. Moderate efforts to be funded $500K-$2M; Example deliverables: PDR level design, or in some cases, a brass-board/bread-board piece of hardware or software, experiment results, designs/process descriptions.
3. Complex/Large efforts to be funded $2M to $5M; Example deliverables: CDR level design, brassboard/breadboard hardware or software, nearly-ready-to-transition designs.

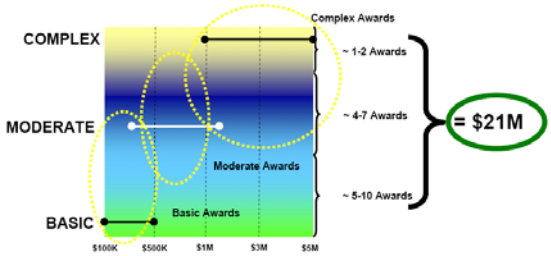

Figure 1: Distribution of BAA Award Categories

Figure 1 shows the notional distribution of funding used to begin the selection process. Due to the complexities of the award portfolio dictated by the varying award size, the initial "BASIC" award cut-line was drawn arbitrarily small. The average BASIC level proposal was approximately $400K, with a desired number of awards of 5-10. Thus, the initial cut line was established at $2.5M for "BASIC" proposals. The "BASIC" proposals were first evaluated only by the numerical ranking scores of the "BASIC" category. In the event of a tie at the cut line, the cut line will be moved up temporarily to eliminate the tie.

"MODERATE" AND "COMPLEX" proposals were evaluated together. The average "MODERATE" proposal was for approximately $1.3M. The average "COMPLEX" proposal was for approximately $3.5M. The intent was to fund at least 3 MODERATE proposals, and at least 1 "COMPLEX" proposal. Further, COMPLEX and MODERATE proposals might require iteration in the selection process with questions and answers to the companies. This iteration would add time and complexity that was addressed on a case-by-case basis. The iterations and case-by-case discussions were successfully mitigated with the structured process and numerical ranking process discussed below.

After those cut lines were established, and the decisions made, the remaining funds were examined and additional decisions made to fund additional projects as follows. If the next COMPLEX level proposal in

numerical order was affordable, it would be chosen. If not, the next MODERATE level proposal would be checked to see if it fits under the cut line. Additional Basic awards will be used to fill in any balance. This process was iterated until all of the funding was exhausted. Final selections are discussed below.

SELECTION PROCESS

NRL put a great deal of effort into developing and following a fully Joint process for selection of project from the proposals offered. The Air Force, led by Air Force Research Lab (AFRL), and the Army, led by Space and Missile Defense Center (SMDC), were integral to the selection process, providing evaluation teams from across their Services to collaborate with the Navy-Marine Corps team assembled by NRL.

Process

NRL developed a detailed process for evaluation and selection of received BAA proposals. The intent was to ensure that the process was timely, Joint, and equitable. It is reproduced below.

1. Proposals were distributed for government evaluation.
2. Each Service team evaluated the proposals and completed a proposal evaluation form for the project. Each Service provided a rank ordering of their evaluated proposals. A combined evaluation form was assembled by NRL.
3. At the completion of each team's evaluations, the team leader created two priority lists: by funding class, and an aggregate of all projects.
4. The team leaders returned their lists and copies of all evaluation forms to NRL.
5. The aggregate scores from the Naval, Army, and Air Force evaluations are used to create a consolidated list.
6. The cut lines are drawn on the ordered list.
7. Once the final project rankings are completed, they will be forwarded to OFT and STRATCOM for concurrence and to NRL contracts to begin the contractual part of the process.

Evaluation Criteria

To support the process, a standard evaluation form was created. Proposal evaluation forms provide written, formal documentation of the evaluation process. It is important that they be thoughtfully and completely filled out by each evaluation team, at least one evaluation per proposal. In cases where a particular proposal was evaluated by more than one person, an aggregate evaluation form was required. Individual forms may also be submitted, but an aggregate form was mandatory.

The evaluation criteria used were first articulated at the ORS Payload Technology industry day and are listed below:

1. ORS Uniqueness: Does proposal support ORS uniquely in the sense that it would be unlikely to be funded via normal DoD or national venues?
2. ORS Applicability: Can the proposed effort provide significant value-added to ORS technology & relevant missions such as identified by COCOMs & Services for TACSAT-3 and TACSAT-4?
3. ORS Roadmap/Transition: Does the proposed effort mature technology to the point of readiness for TACSAT selection (or possibility operational procurement), or if lower level readiness such as a study, does it provide path for further ORS technology or ORS system enhancements?
4. Technical Reality: Does the proposal provide a clear picture of the technical effort?
5. Schedule Reality: Given the efforts proposed by the offeror, does the proposal outline a schedule that provides reality given the technical efforts, manufacturing, and other processes that must be completed?
6. Cost Evaluation: Given the proposal and efforts described, is the effort commensurate with the cost proposed? Further, does the evaluator believe that the effort is a good value to the government?

Numerical scores were assigned to each of the evaluation criteria. The numerical scores were weighted as shown in Table 1, and summed to provide a composite score for each proposal. That composite score was then used to create each service's proposal ranking. To assist in the contracting process, a consolidated proposal evaluation form was generated including the comments from all of the Service teams.

Table 1: Proposal Scoring Table

Totalized Score

Metric	Description	Weight	Score	Total
1	ORS Uniqueness	3		
2	ORS Applicability	2		
3	ORS Technology Roadmap/Transition	2		
4	Technical Evaluation	6		
5	Schedule Evaluation	3		
6	Cost Evaluation	4		
TOTAL				/ 200

SELECTED PROJECTS

A total of 74 proposals were received and evaluated by the Joint Army, Air Force, and Naval team. OSD RRTO and STRATCOM concurrence was obtained for all selections. The distribution of funds was executed in very similar fashion to the plan. Seven projects were selected from the 37 "BASIC" (≤ $0.5m) proposals, falling well within the 5-10 planned. In the "MODERATE" ($0.5M-$2.0M) category, 27 proposals

were received and evaluated with 4 selected, one more than expected. Ten "COMPLEX" ($2.0M-$5.0M) proposals were received, and three were selected, significantly more than the minimum of one planned. These projects represented key needs elucidated by the Services, so the decision was made to allocate funding as needed to advance those technologies.

As shown in Figure 1, each Service department received an equal number of first choices from their ranked lists. The spread among their lesser-ranked choices was also fairly tight. The established Joint evaluation and ranking process smoothed the negotiations and made it easy to allocate funds to meet as many needs as possible within limited funding.

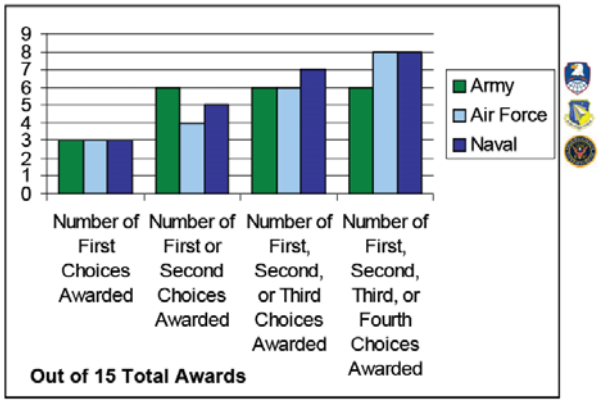

Figure 1: Distribution of BAA Award Categories

"COMPLEX" Projects

Ball Aerospace & Technologies Corp – L-Band SAR Technology Development - $3.8M effort to provide wide area radar coverage with tactical utility, using innovative technology to fold large array into small fairing area.

Assurance Technology Corporation – Advanced On-Orbit Software Reprogrammable RF/Digital Payload (RDP) - $3.2M project to produce a wideband digital transceiver prototype with appropriate software.

Goodrich Electro-Optical Systems E-O Sensor System for ORS - $2.5M project to adapt the high resolution SYERS-2 airborne reconnaissance system, currently deployed on the U-2, into an "ORS Class" reconnaissance system.

"MODERATE" Projects

SEAKR Engineering - Space Network Interface Card (SNIC) - $1M project to provide a payload independent interface to an IP based network system, adapting legacy or new payload data interfaces to space-based IP networks.

ICS - Autonomous Tasking and Checkout of Responsive Space Payloads - $672K to deliver flight software to define and implement a concept of operations for Autonomous Payload Tasking and Checkout (APTC) capabilities.

The Johns Hopkins University Applied Physics Laboratory – WISPERS Wafer Integrated Spectrometers - $841K to demonstrate WISPERS instrument on FalconSAT-5 with an on-board ion source, allowing measurements of the ion plume produced in LEO.

Raytheon - CIRCE - (Cost-effective Imager for Real-time Chromatic Exploitation) - $1.85M to perform a breadboard demonstration of an added wide field of view capability to the existing ARTEMIS (TACSAT 3) HSI instrument.

CTD - Lightweight, Large Aperture Deployable Composite Reflector for ORS - $1M for engineering development model and test data for a high data rate, deployable reflector that can be procured within an ORS mission budget.

"BASIC" Projects

SPACEDEV – CORRI (Combined Optical, Radio, Radar) - $496K for engineering development model and test data for a modular and scalable sensor/communications suite to reduce payload cost and footprint for ORS mission.

MicroSat Systems Inc. - Universal Interface Electronics - $513K to provide a flight demonstration of ORS Spacewire Interface Standard for Payloads.

AMaSST - Enhancing Space Control with Structured Light Sensor - $176K to develop and demonstrate a bench level, low cost, low resource intensive sensor system by which another satellite can be detected, imaged, and tracked.

GD-AIS - HIGHRISE (Hi Res Imaging Sensor and Exploitation) - $500K for a design study for a combined-aperture radar and EO/IR payload capable of providing space situational awareness via high resolution imaging in the millimeter-wave, visible near-infrared, and mid-wave IR bands.

L3 Communications SSG-Tinsley - ORS Optical Systems - $500K to evaluate the applicability and scalability of near-net-shape cast ~0.1 – 1.0m silicon carbide (SiC) optics and structures for high performance and environmentally stable optical systems with significantly reduced cycle times.

Design Net Engineering – Flight and Ground Software Test Bed - $500k to develop a software test bed to mature software standards. This effort includes some emphasis on bridging various existing standards improve interoperability beyond component level toward system level interoperability.

AFRL - Guidance Navigation and Component Integration and Miniaturization - $500k. These funds contributed to a broader AFRL development effort involving several companies including Microcosm.

The Johns Hopkins University Applied Physics Laboratory - Modular, Self-Healing C&DH Flight Architectures for Rapid Development - $346K to develop low-cost, compressed-schedule space missions, by reducing cost and schedule constraints for software development based on the Linux operating system and open source standards and software.

Vulcan Wireless Inc. – Tactical UHF Communications - ~$250k. This effort involves development of a small, lightweight UHF transponder, which is capable of handling the high Doppler shifts seen in low earth orbits. This effort also performs preparatory work needed to achieve an integrated COMSEC management approach for ORS Tactical UHF Communications.

INNOFLIGHT - IP Transceiver Experiment - $170K to design and demonstrate an Internet Protocol (IP) compatible high speed frequency programmable transmitter (SGLS & USB) that meets cost and schedule requirements for ORS.

RESULTS

The execution of the projects was as Joint as the selection process. With AFRL and SMDC leading as in the selection process, Air Force and Army provided technical team members to supplement and assist the NRL Contracting Officer's Technical Representatives (COTRs) for the oversight and guidance of each project.

For the modest investment provided in the Congressional plus-up, we believe that great strides were made in advancing ORS. A group of companies with the skills to further advance ORS has been identified, several have now developed teaming arrangements to enhance their capabilities, and the majority of the projects are either being transitioned to a program, being continued under other funding, or being flown.

Transitions

The primary intended transition path for the initiative overall was to the newly formed Joint ORS Office at Kirtland AFB, Albuquerque, NM. To that end, a briefing was held in January 2008 to provide the Joint ORS Office a status update of the projects, with an eye toward their investment decision process for 2008 and 2009. Copies of all final reports have been provided to the ORS Office for future use in TACSAT, OPSAT or other ORS planning and development.

The ATC RDP project is being used as a pathfinder for a series of software-defined radio payload projects being conducted or planned in Navy programs, administered by NAVAIR and SPAWAR.

SYERS-2 is being looked at for an upcoming ORS sat mission. The maturity of this payload is very attractive for fielding as a demonstration of ORS capability.

Ball's L-Band SAR is an official, although not yet fully funded, Joint Capability Technology Demonstration (JCTD) candidate with operational sponsorship.

ICS Autonomous Tasking and Checkout is being implemented on an existing TACSAT project. TACSAT-4 is a 10 channel UHF communication platform to be placed in HEO in late FY09/early FY10. The techniques and software developed in this project will be integrated into the TACSAT-4 mission.

MSI UIE is also being partially implemented on TACSAT-4. It will verify aspects of the bus-to-payload Spacewire interface which is defined in the ORS Bus Standards documents.

INNOFLIGHT IP Transceiver experiment is being continued under a NASA Ames SBIR. The transmitter was completed under this initiative, and the receiver will be completed under the SBIR. Funding permitting, the two will be integrated for a bench demonstration of an integrated transceiver.

Partnerships

JHU APL WISPER was an excellent example of a partnership which allowed both organizations to benefit. The US Air force Academy matched the $841K for this project with $202K for integration. The result is a flight opportunity for both projects. This project provides a model for partnership efforts in future – great benefit can be achieved in this way.

LESSONS LEARNED AND WAY AHEAD

During the execution of this initiative, the coordinators noted some lessons for the execution of future initiatives. We offer these observations to inform those future efforts.

Joint, Joint, Joint

OSD and NRL started this effort with the intent of ensuring that each Service had a voice, and could participate to the extent of their ability and resources. Funding was carved out as part of the executing funds to ensure that organizations could fully support the selection process and the execution of the projects. The project selections were kept as egalitarian as possible. Military operations are Joint, and so must be our approach to developing ORS enabling capabilities.

If you build it, will they come??

The ORS Technology projects have been broadly briefed to OSD and to all the Services. For example, all the USN Fleet staffs were briefed – 7th, 5th, and 6th expressed interest in participating in experimentation. While this is good news, the briefings were clearly premature – what warfighter wants to hear about something you may be able to do in a few years – their time horizon is minutes or hours. While it is critical to continue to build and experiment, it is also vital to provide "truth in advertising." Gen Cartwright (at the time, COMSTRATCOM) once told us to "under-promise, and over-deliver," and we must maintain that perspective. OSD and NRL envisioned this initiative as maturing a set of building blocks from which capabilities can be built. Each of the projects was matured and can contribute to the growing ORS concept, but none is a panacea. It is important to continue this building block approach, and to involve the warfighter at every step.

COCOMs know what they want, but not how to tell you what they want

In keeping with the lesson of the last paragraph, we must all remember that there are few space experts on COCOM and Joint Force staffs. They know what they need, but they may not be able to express it in our jargon. We need to get out there and learn their professional language and always remember that they are the customer. Congress, while they show interest, is not our customer. Neither are the Service staffs. The warfighter is the customer, and we need to get into his skin, learn his lingo, and shape our grand ideas to his needs.

Execute, don't debate

The process that OSD and NRL established for this effort was centered on Jointness, but also on timely completion. The structured approach and numerical ranking system helped to identify common interests and thresh out the most critical needs of each stakeholder. With that data, selection of the most needed and most qualified proposals was executed with a minimum of discussion. We highly recommend the use of a similar process in future efforts.

ORS Office FY08 BAAs

While this paper was being written, the ORS Office issued three FY08 BAAs to continue the process. The new BAAs have expanded and refined the mandate of the initiative to include all of the topics currently anticipated to be enabling capabilities required to bring ORS to a full operational capability.

ACKNOWLEDGMENTS

The authors would like to acknowledge and thank our sponsors from the Office of Force Transformation, which became the Rapid Response Technology Office of the Director of Defense Research and Engineering. Many thanks to LtCol Jim 'Gris' Griswold for his guidance and assistance throughout the conduct of these projects. In addition, the participation of numerous members of Army SMDC, Air Force Space Command and Air Force Research Laboratory, HQ Marine Corps, US Strategic Command, and various other government agencies was invaluable in selecting and executing the projects in a Joint fashion for the benefit of all.