DoD's Perspective on Radar Open Architectures

June 2010

Mr. Scott Lucero[1], Dr. Scott Kordella[2], Dr. John Nelson[3], Dr. David Zasada[4], Mr. E. Douglas Jensen[5], Mr. Gerard Walles[6]

[1]OUSD(AT&L)/DDRE/SE, [2]MITRE, Mclean VA, [3]MIT/LL, Lexington MA, [4]MITRE, Rome NY, [5]MITRE, Bedford MA, [6]NAVAIR, Patuxent River Naval Air Station, MD

ABSTRACT

The way radars are viewed by the Department of Defense (DoD) is migrating from that of monolithic "black box" providers of primary interpretable radar data products for pre-planned users, to that of flexible providers of on-demand sensing services widely available to an interconnected network of unanticipated users. Radar systems open architecture(s) are the key to fully realizing the promise of the paradigm shift to enterprise sensing. To that end, they offer reusable technology for radar systems, facilitate the use of commercial-off-the-shelf (COTS) components from a diversified vendor base while respecting intellectual property rights, expedite flexible and fast technology refresh, create a means for distributing innovative techniques and technologies – and thus lower the expense of developing new radar systems, and maintaining deployed ones.

1. Introduction

We are entering a world of rapidly evolving, layered, net-centric sensor and C3 enterprise services. This combination of remotely available sensor services has been termed "enterprise sensing." The radar systems providing input to the enterprise sensing architecture (Figure 1) can range from space-borne/high altitude radars providing synoptic sensing with a global reach, through airborne/ground-based radars providing persistent surveillance and fire control over a regional area of regard, to low altitude airborne UAV-borne and small, perhaps disposable unattended ground sensors.

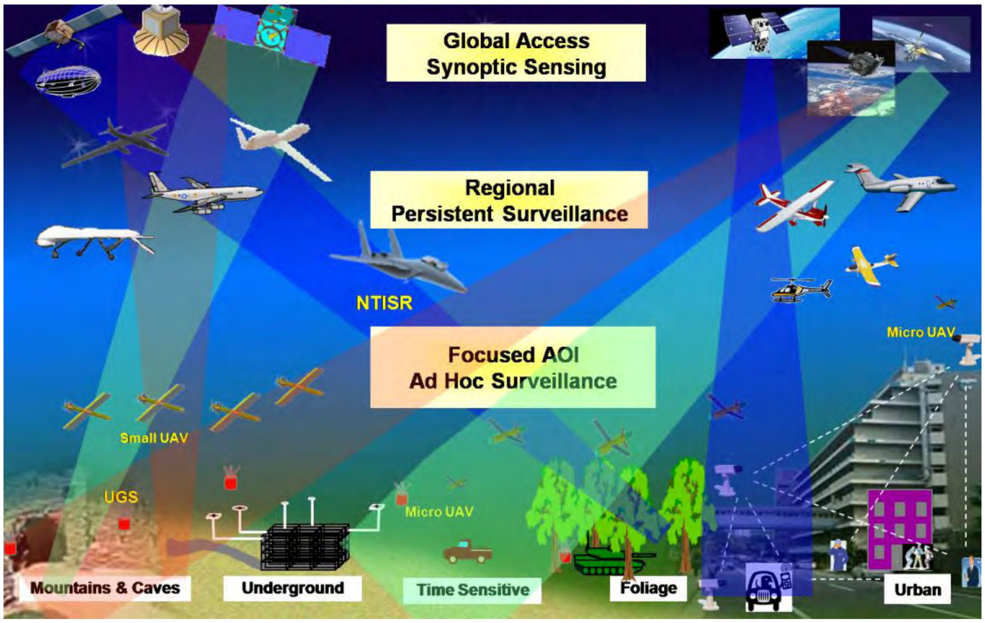

Figure 1: Enterprise Sensing

The users of these emerging enterprise sensing services have articulated what they require from the radar community to enable net-centricity, composability, interoperability, and quick and easy upgrades. Specifically, they are seeking:

- Integration of legacy radar systems
- Plug and Play capability to include both government-owned and commercial radar systems, (e.g. weather systems), and technologies
- Rapid insertion of cost effective new radar capabilities
- Flexible, scalable, and affordable technology refresh and maintenance
- Diversification of component vendor bases
- Multi-phenomenology, multi-aspect sensing with multi-source fusion to provide classification and identification
- Enterprise-wide perception sharpening, including the elimination of redundant and confusing, information
- Robustness.

2. Legacy Radar Systems

Legacy radar systems consist of specialized collections of antennas (arrays and dishes) with analog receiver components, special purpose computer boards and very high speed analog-to-digital converters. Specialized, highly optimized and efficient radar signal processors then convert this massive but highly structured digitized input data to an aggregated intermediate state for further processing. General purpose back end processors then further reduce intermediate data to standard products which are machine exploitable, human interpretable, or both. Each processing step increases information content per reported bit at the price of flexibility and adaptability. Our legacy sensors are typically built as monolithic systems under a single prime contractor, and often, indeed usually, contain embedded proprietary hardware and software that cannot be readily segregated from the rest of the system. These were satisfactory or suitable choices as long as the users, products, and communications assets associated with the radar systems remained constant over the useful lifetime of the radar system.

This approach to radar systems does not meet the needs for providing the emerging enterprise sensing services. Radars that produce binary formatted reports designed decades ago are insufficiently flexible to accommodate a rapidly evolving enterprise, even if these binary formatted reports are enhanced by XML encapsulation and metadata add-ons. Further, single purpose systems will be supplanted by multi-mission, and composable radars that may be switched from mission to mission using an enterprise paradigm. The time and costs to maintain and upgrade legacy style radar systems to meet the changing threat environments increasingly exceeds the resources allocated to them. A new, open, net-centric radar design paradigm is required. Specifically, radars must evolve to become service providers on an enterprise-wide sensor network. Special attention is required to insure that new sensors entering the government's inventory support the enterprise sensing paradigm and that legacy sensors receive appropriate retrofits.

3. Radar Systems Open Architecture

To facilitate our radar systems' migration into an open, net-centric radar design paradigm, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) directed that radar open systems be reviewed for use by DoD acquisition, technology, and logistics activities. Accordingly, a Radar Open System Architecture (OSA) Defense Support Team (DST) has been established and is being lead by the USD(AT&L) Defense Research and Engineering (Systems Engineering Directorate) Director. [1]. The mission of the Radar OSA DST is to foster movement towards implementation of common open net-centric radar system architecture(s) to the maximum extent possible with a goal of lowering radar life cycle costs while providing for enhanced technology refresh and, potentially, radar performance.

The proposed Radar Open Architecture paradigm will be component-based, and provide common, open layered radar infrastructure where most feasible and practical, with modular sub-functions and open interfaces. The architectural components will be independent of the computing environment, transportable from radar system to radar system, and reusable. The elements of the component-based radar open architecture under consideration consist of:

- An open radar system functional decomposition based on common open components
- A shared library of open radar components
- A common, open set of radar component interface standards, where practical
- A common, open layered radar infrastructure, where practical
- A common, open radar component implementation template.

The component-based radar open architecture model is felt to be appropriate in that it will closely follow the functional design decomposition of any given radar system. A_functional decomposition (Figure 2) partitions a radar system into subsystems, and subsystems into assemblies, each of which performs a separate function. Reusability must be considered in creating each subsystem. For new designs, open subsystems would be created so that they can be reused in future products. For redesign and technical refresh, subsystems would be created to maximize the use of existing open, potentially commercially available products. Flexibility and openness are more important than optimality. Open hardware, software, human-machine, and machine-machine interfaces must all be explicitly considered.

As an example, the Office of Naval Research's (ONR) Digital Array Radar (DAR) program has taken the approach to build an advanced radar using seven functional subsystems: Aperture, Beamformer, Receiver/Exciter, Signal Processor, Control Processor, Human/Machine Interface and External Communication. These subsystems are procured separately and successfully integrated through the use of system interface control description.

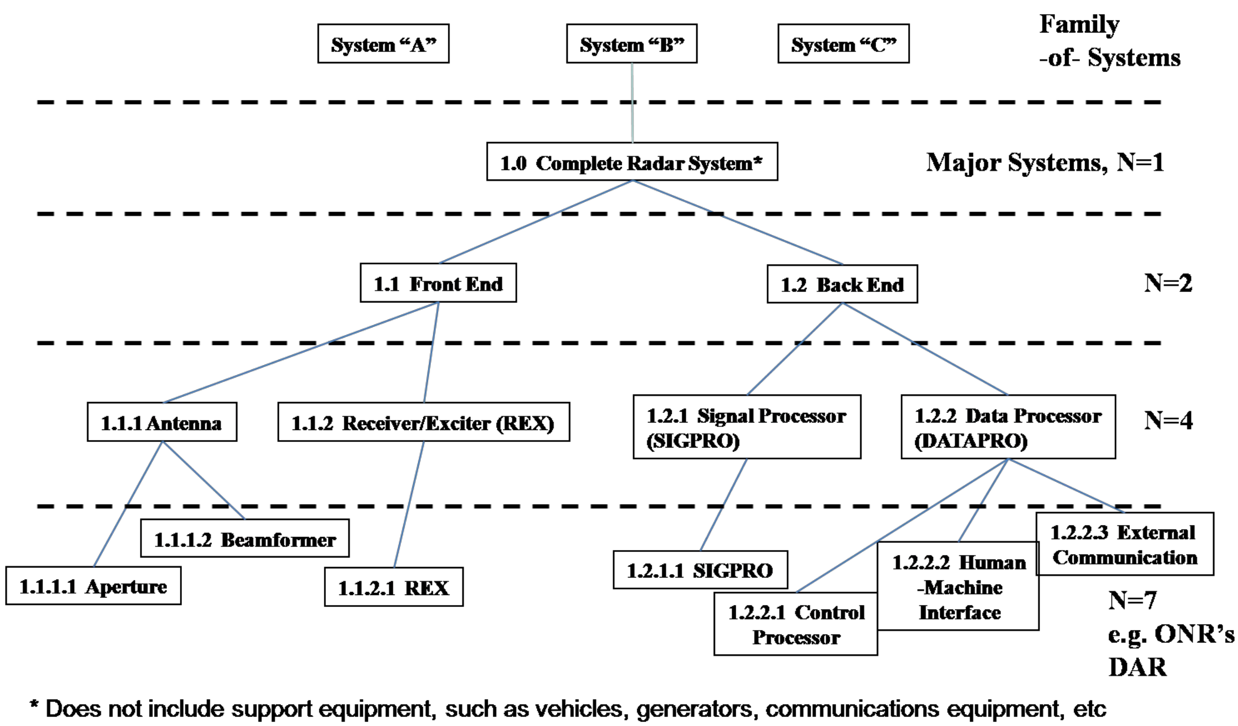

Figure 2: Radar System Common Element Functional Decomposition

In addition to COTS hardware and software, the shared library of open components will initially include widely used open standards for hardware, firmware, software, and data. Standards will be open at multiple levels, and a business infrastructure capable of supplying and consuming a modular and open set of library components (including the intellectual property of providers) will be supported. The shared library also will establish a set of open, standards-based designs to provide the foundation for enterprise-wide integration.

Each component will share a common component interface to the infrastructure through a thin "applications isolation" layer. It is desired to eliminate direct component-to-component communication links. Instead, all component-to-component communications will be mediated by the infrastructure to allow and enable component modularity through abstraction and encapsulation. For radar products that require real time C4I operations, component-to-component links shall be evaluated to meet overall system level performance timelines. Figure 2 illustrates the layered infrastructure concept.

A set of open standards, based on a high degree of reuse of existing standards to the greatest extent possible, will describe the open layered data model hierarchical structure, and configuration or model of a radar system. Each layer will provide a set of accessible functions that can be controlled and used by the functions in the layer above it. This will enable radar system description, design, development, installation, operation, improvement, and maintenance to be performed at a given layer or layers in the hierarchical structure, without affecting the implementation of the other layers. It will allow the alteration of system performance by the modification of one or more layers without altering the existing equipment, procedures, and protocols at the remaining layers.

A common component implementation template will provide a "container" of standard component functions. This will allow each module to perform typical housekeeping functions in a standardized manner and jump-starts component applications implementation. Examples of typical housekeeping functions include, but are not limited to, initialization, standby, system run, local run, error handling and diagnostics, failover, and halt.

A component-based radar open architecture containing the five elements discussed above is shown below in Figure 3.

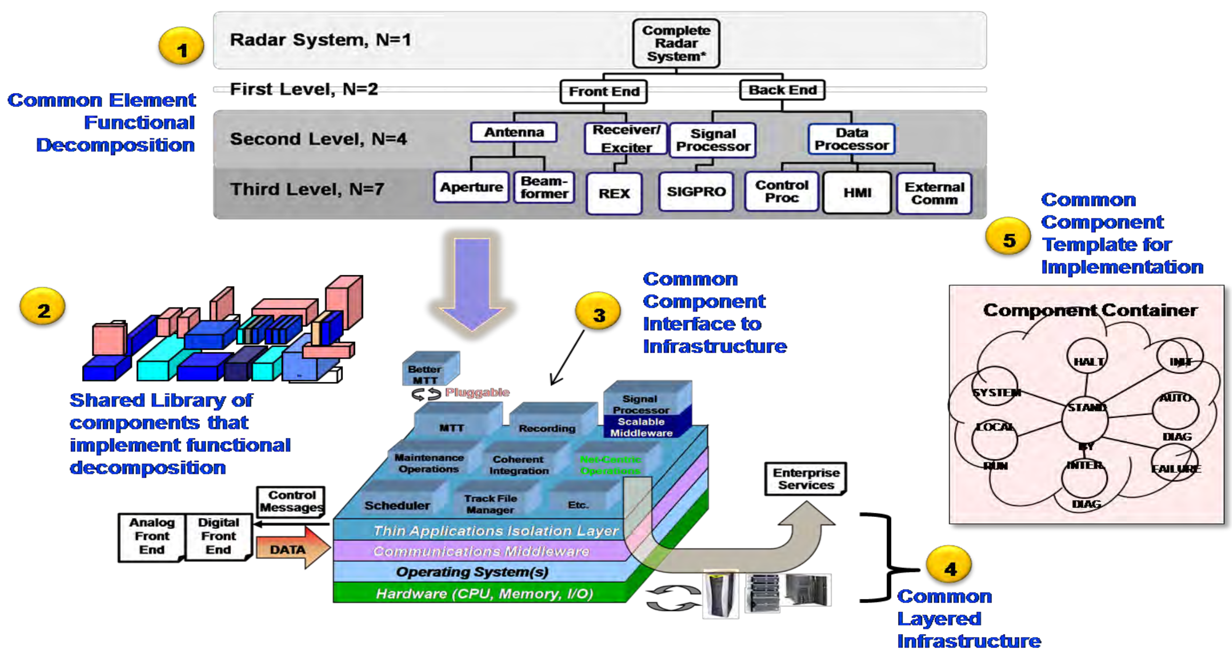

Figure 3: A component-based radar open architecture

The initial focus of the radar OSA DST is to collect (and augment as necessary) a set of open radar data standards that can be combined to build and modernize radars. The major characteristic that sets sensor services apart from typical enterprise services is the sheer volume (multiple terabytes) of raw data that can be quickly generated by most radars. As discussed above, legacy tightly coupled processing approaches extract pre-determined information from the incoming raw sensor data, format it into a primary interpretable product standard, and send it to pre-determined users. The radar community is rapidly reaching the conclusion that this tightly coupled radar processing approach loses too much potentially critical information. Hence, additional standards are now emerging to extract, archive, and advertise upstream (raw and partially processed) data to the enterprise for originally unanticipated uses. One example of such an emerging standard is the Sensor Independent Complex Data (SICD) format [2]. Also, capabilities for common brokering, control and composability of radars are extremely important. These capabilities are key to developing and providing multi-mission capabilities in a radar system.

Open, layered radar data and control interface standards are now being designed for use in both active and passive radar systems. Many of these standards may also be useful in scientific systems. An "open source" development model is expected to be used to distribute the resulting technology and to encourage community participation. By providing standard services to make universally formatted upstream (raw or partially processed) and downstream (processed) radar data visible, and providing a standard methodology by which users can broker for the use of and control the behavior of the radar, users can create new functions and products that were never anticipated by the original designers of the individual sensors.

4. Towards a Community Consensus

To foster a community consensus on the component-based radar open architecture approach, the DoD sponsored an Industry Day on 8-9 April 2010 [3]. The OA DST used a consolidated Tri-Service OA set of Business area and Technical area principles to establish a framework for OA discussion as follows:

- Business Area #1: Establishing an Enabling Environment, Demonstrating Life cycle Affordability, Encouraging Competition and Collaboration;
- Business Area #2: Designating Key Interfaces;
- Technical Area #1: Achieving Interoperability between Joint Warfighting Applications, Providing Secure Information Exchange, using Selected Open Standards;
- Technical Area #2: Architecting Modular Designs and Generating Design Disclosures, Employing Modular Designs;
- Technical Area #3: Using Reusable Applications Software;
- Technical Area #4: Certifying Conformance.

Using this framework, the OSA DST constructed an Industry Day event that requested Industry participants to provide their perspectives on the following questions:

1. Specifically, how will radar systems benefit from the use of OA? What can the Government do to assist in making OA a success?
2. How can industry continue to provide innovative and highly capable radar designs, while simultaneously addressing some or all of the business and technical areas?
3. Using architectural elements described in the Radar OA description above, which architectural elements are best suited to OA principles? Where will OA be most valuable from a system life cycle cost perspective? Which architectural elements are most easily implemented; which are more difficult?
4. From a system performance and cost perspective, is it feasible and cost-effective to have prime contractors / system integrators procure and integrate hardware/software components, versus having the Government provide these components as Government-Furnished Equipment (GFE)?
5. What can the DoD radar community do to enable use of MOSA-compliant components (hardware and software) to meet the military's rapid/quick turnaround timelines?
6. Given the Government's goal of achieving OA principles, discuss industry's ability to re-host software and hardware modules across two or more prime integrators. Specifically, what actions would the Government need to take to make this reuse objective successful?

Following these presentations, polling questions associated with various aspects of the business and technical areas were provided, and a real-time response was collected and displayed to the group. Discussion of the rationale for the responses was held to better understand the various perspectives. Finally, a discussion of consensus for a way-ahead was held. Based on the results of the event, the group agreed that:

- A wide-variety of perspectives on OA, with applicability to multiple aspects of radar systems (front end, back end, hardware, software) exists across the radar community;
- There is general agreement of the need to better clarify definitions of Radar OA, how to comply and measure openness, and how to ensure OA is an element of an effective radar enterprise model
- There is a general interest in establishing a partnership mechanism between government & industry to:
  - Identify key architectures and interfaces
  - Document appropriate interface standards

The OA DST is formulating a way-ahead based on these findings.

5. Acknowledgements

This paper is a result of many valuable insights and contributions provided by the members of the Department of Defense, including members from the Office of the Secretary of Defense, and the Tri-Service radar community.

6. References

[1] Young, John J. Jr. “Memorandum for Deputy Under Secretary of Defense for Acquisition and Technology, Director, Defense Research and Engineering, Subject: Radar Open System Architecture Defense Support Team (DST),” 19 February 2009.

[2] National Geospatial Intelligence Agency (Tom Ager), “Sensor Independent Complex Data, Design & Exploitation Description Document,” private communication, 12 February 2010.

[3] Lucero, Scott and Scott Kordella, ”Radar Open Architecture Defense Support Team Industry Day,” April 8-9, 2010, Solicitation Number LLR0304101452, 4 March 2010.