Open Technology Development

Jeffrey C. McHarg

IDGA Interoperable Open Architecture

11 September 2013

This work was sponsored by the Department of the Air Force, under Air Force Contract No. FA8721-05-C-0002. The opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the United States Government.

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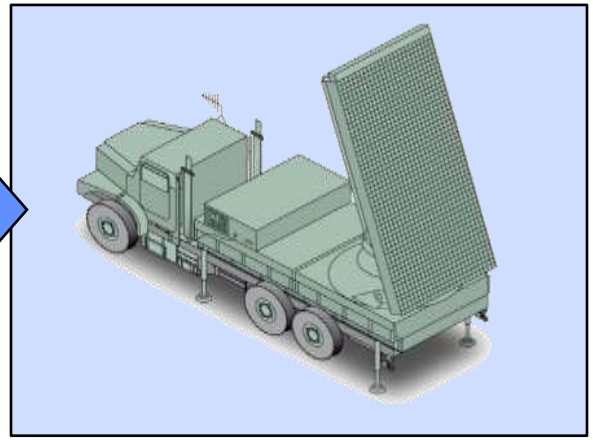
USAF Long Range Search Radar Evolution

1970* TPS-43	1987* TPS-75	201? 3DELRR



- **Tactical 3D radar**
- **Stacked beams**
- **Vacuum tube amplifier**

- **Upgraded TPS-43**
- **Enhanced antenna**
- **Improved signal processing**

- **Improved range**
- **Higher efficiency**
- **Faster revisit**
- **Open architecture**

*** Dates refer to Initial Delivery**

3DELRR represents a completely new radar for 21st century mobile operations

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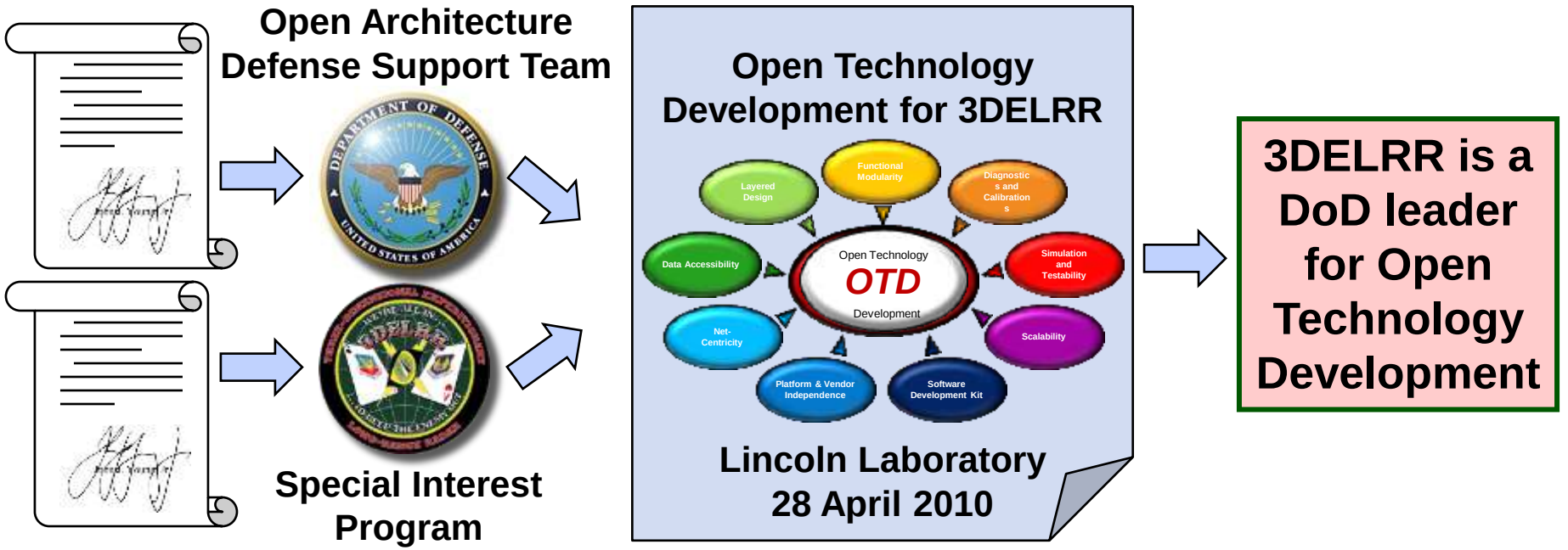
3DELRR Open Technology Development (OTD) Vision



- **Multiple contractors contribute to a single sensor system**
  - **TD phase participants forge an OTD agreement**
  - **RFP and final contract built on OTD principles**
  - **Selected integrator has demonstrated OTD capability & buy-in**
  - **Niche-players contribute in specialty areas**
    - **Large and small companies**
    - **Laboratories and universities**
- **Subsystem/software components open to multiple vendors**

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Outline

- Introduction
- Open Systems Architecture Background
- Open Technology Development Tenets
  - Functional Modularity
  - Layered Design
  - Data Accessibility
  - Net-Centricity
  - Platform and Vendor Independence
  - Software Development Kit
  - Scalability
  - Simulation and Testability
  - Diagnostics and Calibration
- Summary

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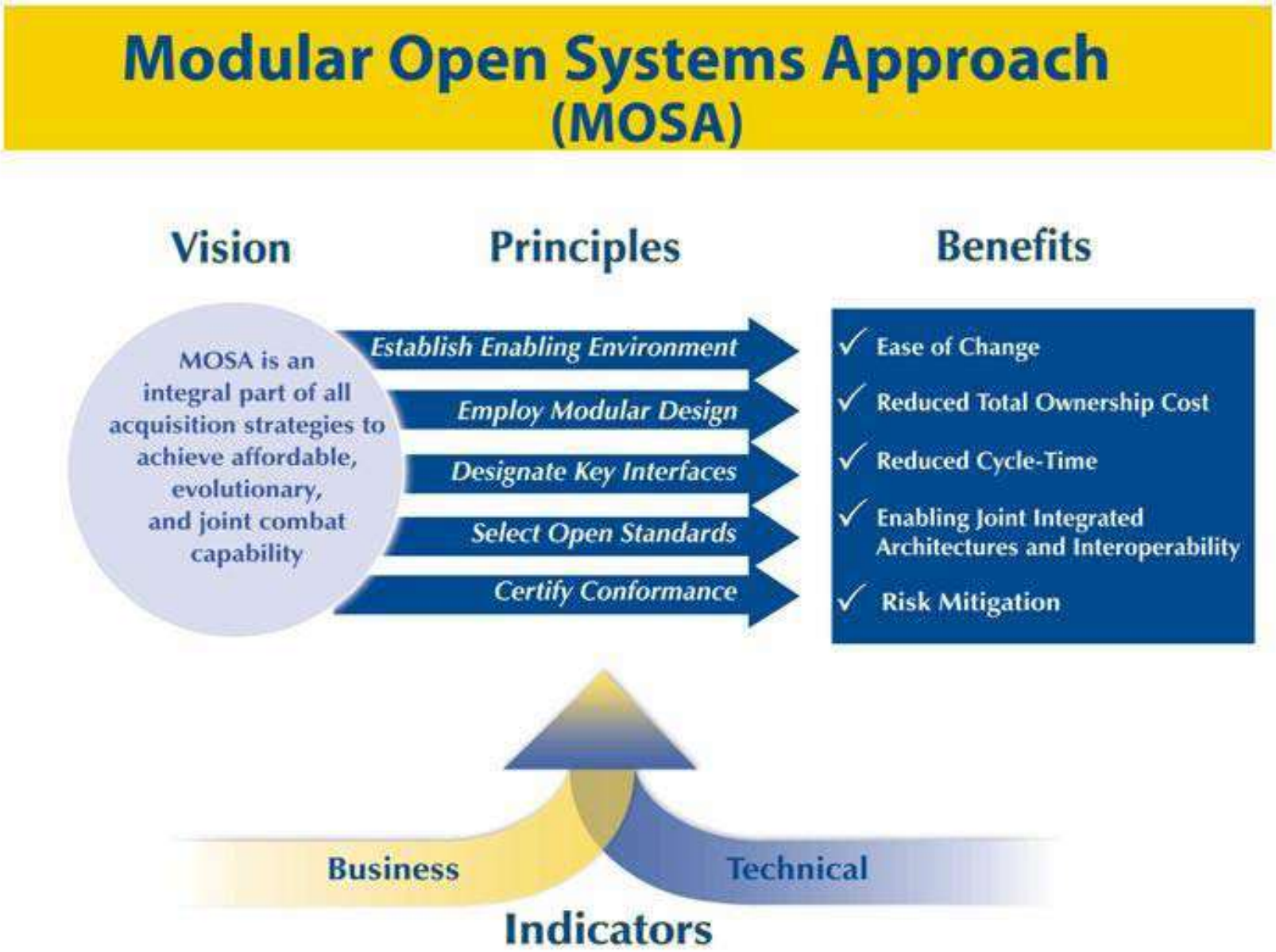
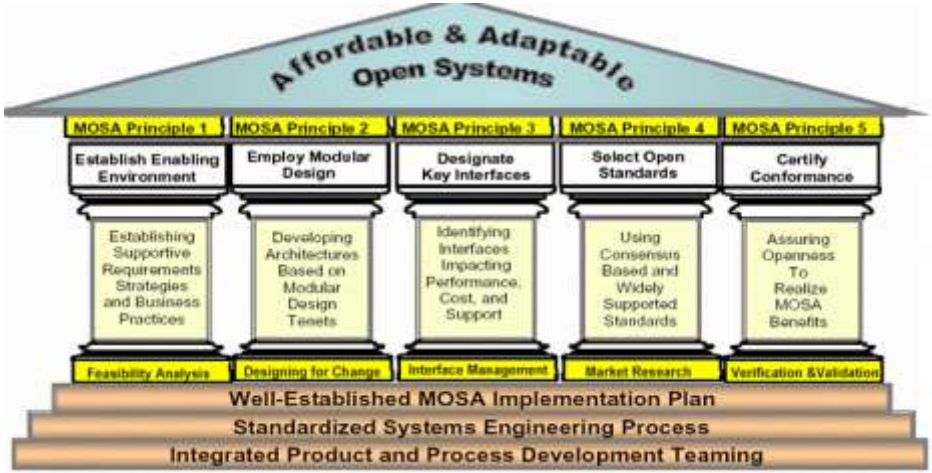
Open Systems Joint Task Force

"A Modular Open Systems Approach (MOSA) to Acquisition, Program Manager's Guide," Version 2.0, Sep 2004, www.acq.osd.mil/osjtf/pmguide.html , p. 3, Figure 1



Modular Open Systems Approach (MOSA)



MOSA framework based on 5 key principles:

1. Establish an enabling environment
2. Employ modular design
3. Designate key interfaces
4. Select open standards
5. Certify conformance

"Ensure that the system components and selected commercial products avoid utilization of vendor-unique extensions to interface standards."

1993 — DoD 5000.01 - A modular, open-systems approach shall be employed, where feasible.

1994 — Kaminski, USD for Acquisition & Technology – directive to use open systems

1994 — DoD 5000.02 – directive to use MOSA

1994 — Open Systems Joint Task Force (OSJTF) formed

1996 — Memo issued in 1996 extending the reach of open systems approaches to command, control and communication and intelligence (C3I) systems with inclusion of Special Operations Command, Defense Airborne Reconnaissance Office, and the Ballistic Missile Defense Organization, later recast as the Missile Defense Agency

2004 — Open System Joint Tasks Force (OSJTF) completes work

2008 — John Young, Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics, issued directives pertaining to the use of open systems architecture. The first directive called for the creation of a Joint Analysis Team (JAT)

2009 — As a result of the activities of the JAT, Young issued a directive in February 2009 establishing a Radar Open Systems Architecture (ROSA) Defense Support Team.

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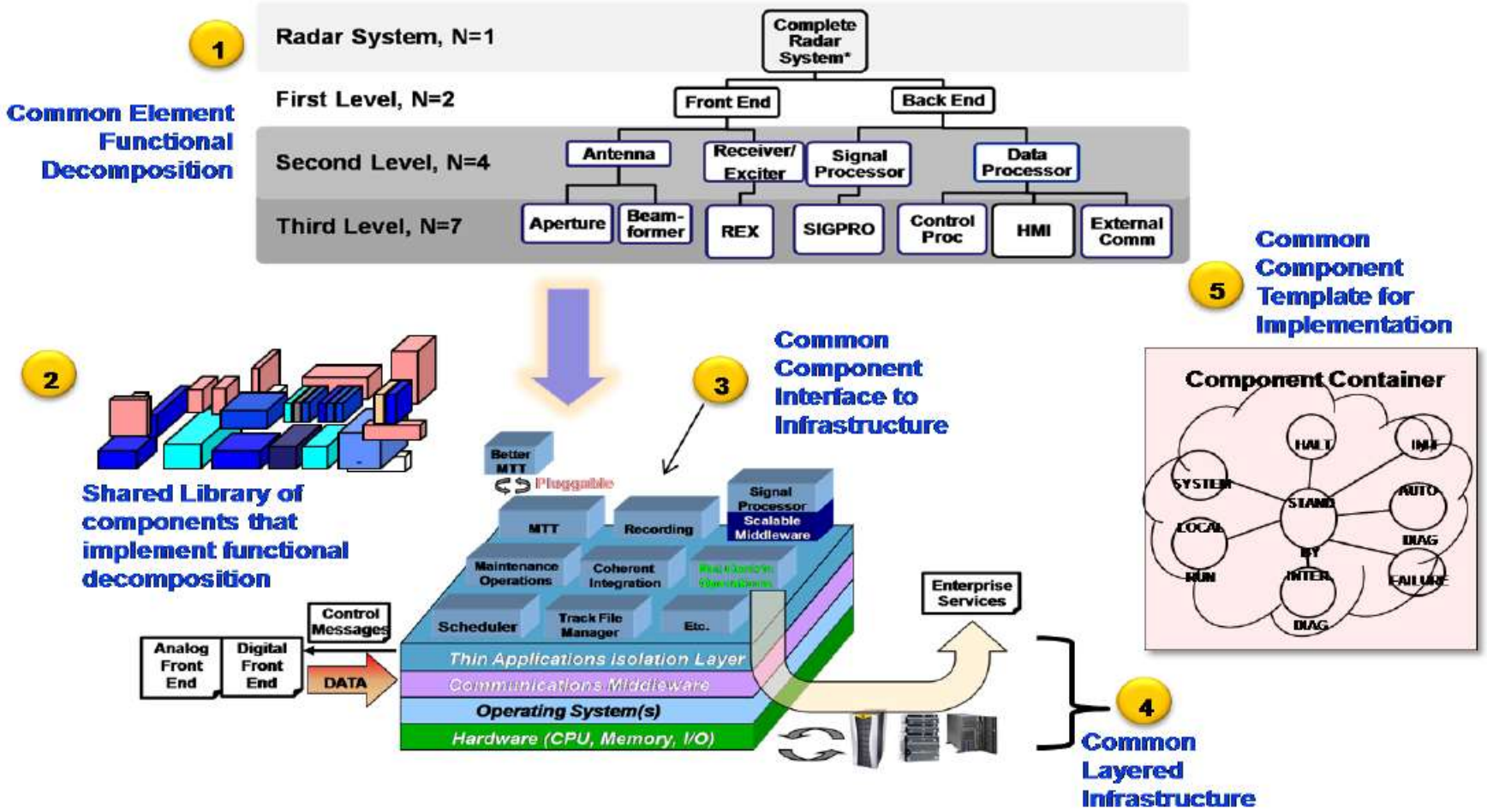
OSD Radar Open Systems Architecture Defense Support Team

Lucero, D. S., "Radar Open Systems Architectures," 13th Annual NDIA Systems Engineering Conference, 28 October 2010, http://www.dtic.mil/ndia/2010systemengr/ThursdayTrack10_10916Lucero.pdf

Component-Based Radar Open Architecture



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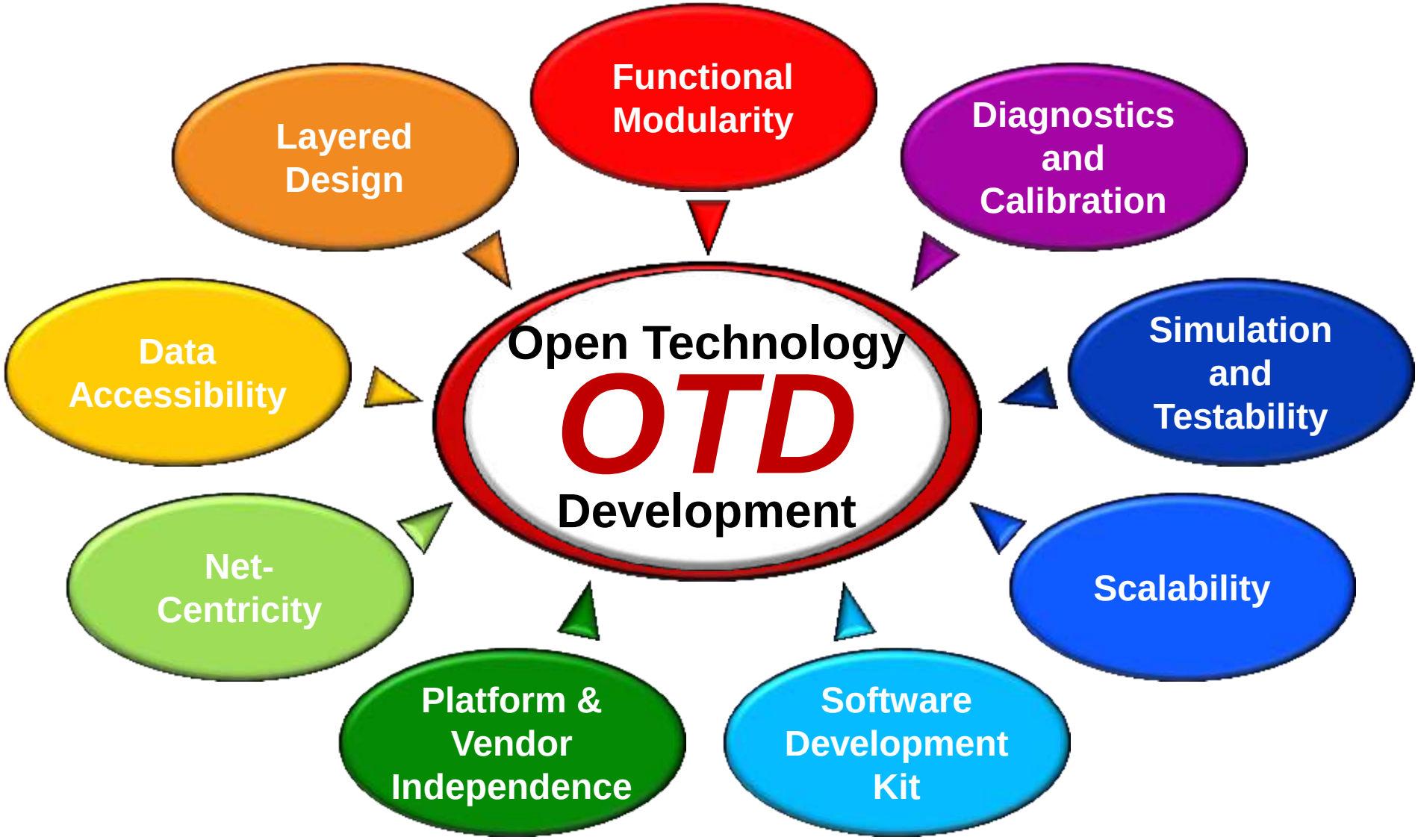
Open Technology Development Tenets



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Open Technology Development for Three-Dimensional Expeditionary Long-Range Radar (3DELRR)

Nine Design Tenets for Lower Life-Cycle Cost Applied to Ground-Based Surveillance Radar Acquisition

3DELRR Acquisition Program

New integrated air and missile defense sensor for 21st century mobile operations replaces AN/TPS-75

Improved Range
Higher Efficiency
Faster Revisit
Modern Targets
Open Architecture

3DELRR Program Office tasks Lincoln Laboratory to develop government/industry consensus on OTD contract language and metrics

Lincoln Laboratory formulates nine OTD tenets (colored headings) and their subtenets (bold)

3DELRR program defines requirements, some using scoring formulas and deliverables (italics)

DST cites 3DELRR as leader in OTD for acquisition

Department of Defense Open Systems Architecture History

1994 – DoD directive promotes Open Systems Architecture (OSA) use in weapons acquisition
2004 – Open Systems Joint Task Force publishes "Program Manager's Guide to Modular Open Systems Approach, v. 2.0"
2006 – OSD outlines Open Technology Development (OTD)
2009 – Under Secretary of Defense establishes Defense Support Team (DST) to review and apply OSA to radar development and acquisitions

Functional Modularity

- Subsystems and components defined by functionality
- Interfaces between modules are well defined
- Modules are independent (loose coupling)
- System composition is highly configurable
- Components are drawn from a collection of reusable modules

*SCORING**
Decomposition – Each sensor function is isolated to a single component
Coupling – Data products are only communicated through identified key interfaces
Composability – Sensor composition is configurable at build time, run time, and dynamically
Common Services – Multi-use functionality (services) are separated into distinct components

Layered Architecture

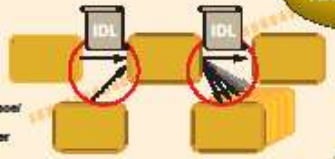
- Open System Interconnection reference model used
- Application, Presentation, Session, Transport, Network, Data-Link, and Physical layers
- Middleware, Component Infrastructure, Isolation and System Management (Application sublayers)
- Application implementation is independent of communication, operating system, hardware, utility function, and computational layers
- Libraries contain all common, standardized, sharable routines

REQUIREMENT
Math – An open computation layer is supported

*SCORING**
Code Independence – Changes to middleware, networking, operating systems, hardware, and quality of service do not require application source code changes
Redundant Code – Algorithms used in multiple components are located in libraries

Data Accessibility

- Key data products are easily available for use by other subsystems or components
- Data transport conforms to standardized publish/subscribe paradigm
- Data format is openly defined in standardized interface/data description language
- Domain and community standards are used wherever applicable

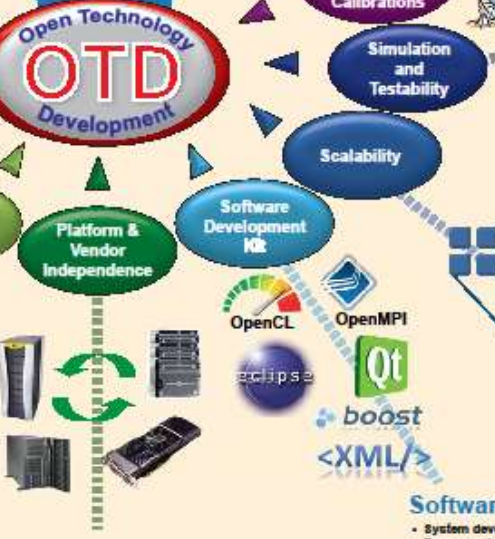


*SCORING**
Interface Attributes – Data pathways are open, configurable, standardized, and expandable
Uniformity – Data pathway access is the same for all components
Community of Interest (COI) – COI standards are used

Net-Centricity

- Net-centric operations are a DoD requirement
- Applies to all locally configurable and controllable aspects
- Covers both real-time and non-real-time parameters
- External interfaces can access all key data products

*REQUIREMENTS**
Net-Centric Military Operations – Execution of joint operational activities is fully supported
Data Accessibility – Net-centric data/information is visible, accessible, understandable, trustable, and interoperable
Tagging – Data products are tagged per the Defense Discover Metadata Specification (DDMS) for external data products
Formatting – External information is exchanged in Government-approved standardized data formats (i.e., XML)
Community of Interest (COI) – Existing COI data/information standards and semantics are used
Registry – The DoD Metadata Registry and its standards for data discovery and data description are used
Internet Protocol – Infrastructure supports both IPv4, as defined by RFC 791, and IPv6 as defined by RFC 2460
Services – Interoperable technologies (e.g., Web services) for external request/response transfers are used
Streaming – Dynamic establishment of streaming input and/or output data feeds is supported



Platform & Vendor Independence

- Application software is independent of specific hardware, middleware, and vendors
- Pre-Planned Product Improvement (PPPI) addresses obsolescence and antiquated technology advances
- Open and available isolation layers wrap all proprietary technology
- International, industry, or government standards are used where feasible

*SCORING**
Availability – Multiple sources exists as part of a supportability plan
Upgrades – Planned upgrades include hardware and software refresh
Standards – Hardware/software conforms to open industry standards

Diagnostics & Calibration

- In situ and off-line diagnostics provide rapid failure analysis and performance histories
- All subsystems/components measure and report real-time status and fault conditions
- Uniform system approach to system/subsystem/component measurements yields field calibrations

*REQUIREMENTS**
Performance Monitoring – On-line and off-line health/performance monitoring and diagnostic testing is supported
Fault Location – Failures are isolated to the line replaceable unit
Element Failures – Antenna auto-compensation corrects errors due to element failures

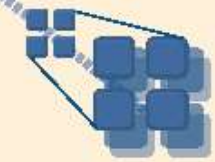
Simulation & Testability

- A comprehensive system approach to simulation and test is used
- System simulation for mission planning and operator training includes hardware and software test targets
- Subsystem/component simulation for maintenance and integration supports isolated and coordinated testing
- Unit test code for all subsystems and components is open and available
- Hardware subsystems include the capability to simulate all inputs and monitor all outputs

*REQUIREMENTS**
Embedded Simulation Capability (ESC) – Digital depiction of real-world scenarios includes targets, electronic attack, clutter, and weather
Simulation Modes – ESC shall include "Simulation Only" and "Simulation Over Live" playback
Hardware Simulator – Interface to a Radar Environment Simulator (RES) are provided

Scalability

- Additional and/or improved hardware can be incorporated without source code modifications
- Parallel computation libraries (e.g., Parallel VSIPL++) are used
- Multiple operating systems (e.g., Linux, VxWorks), processor architectures (e.g., x86, SPARC), and system architectures (e.g., cluster, SMP, GPU) are simultaneously supported



*SCORING**
Scaling Out – The sensor supports the addition of computing units
Scaling Up – The sensor supports an increase in computer performance
Operating Systems – The sensor is distributable across multiple operating systems
Compute Platforms – The sensor is distributable across multiple hardware architectures

Software Development Kit (SDK)

- System development tools must be affordably available to third party contributors
- Programming environment and documentation should support C, C++, or Java
- Comprehensive example code should demonstrate common component/interface types and use of core services
- Complete documentation can be automatically generated and includes interface specifications and infrastructure layers

*REQUIREMENT**
Ease of Use – The SDK includes source code, is open-source tool based, and is sufficient to generate a minimal component.

*SCORING**
Programming Language – The SDK fully supports C, C++, or Java
Additional Languages – The SDK may support additional languages
Documentation – The SDK documentation covers developing, using and interfacing to the sensor, including the document generation tool, the source code repository, and the build system
Sample Components – The SDK includes a complete set of sample components

**SCORING and REQUIREMENTS are paraphrased. See 3DELRR Technical Requirements Document for official wording.*

Key: OTD tenet (colored heading) Subtenet (bold) Requirements and deliverables (italics)

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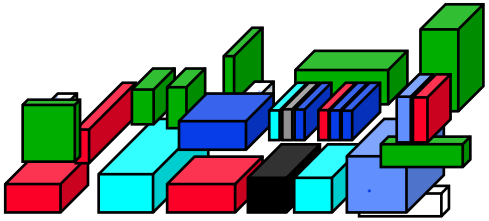

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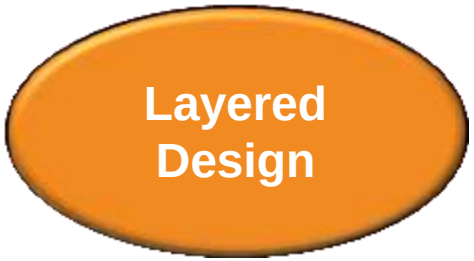

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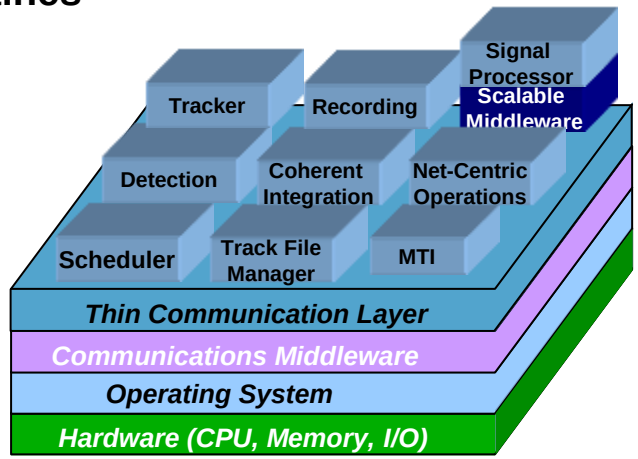

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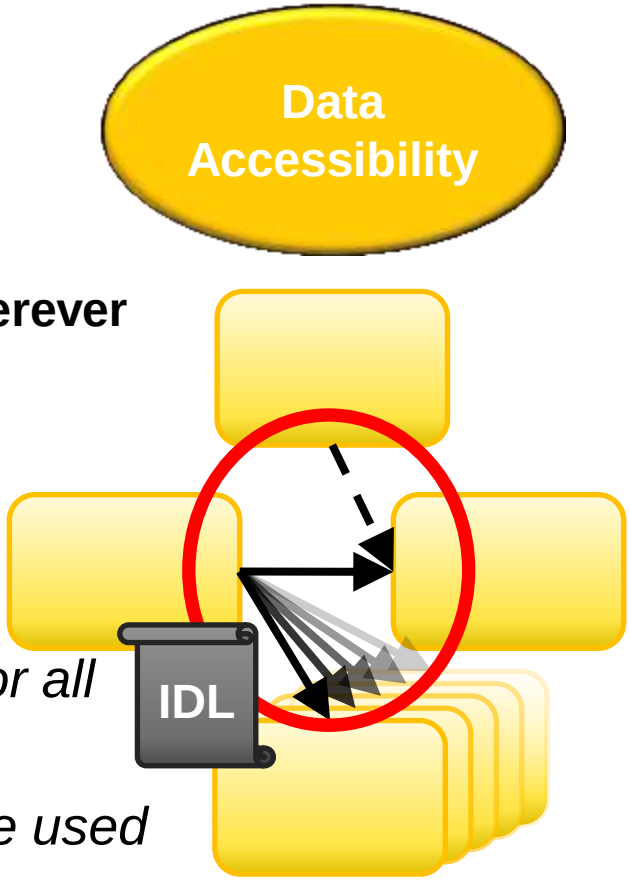

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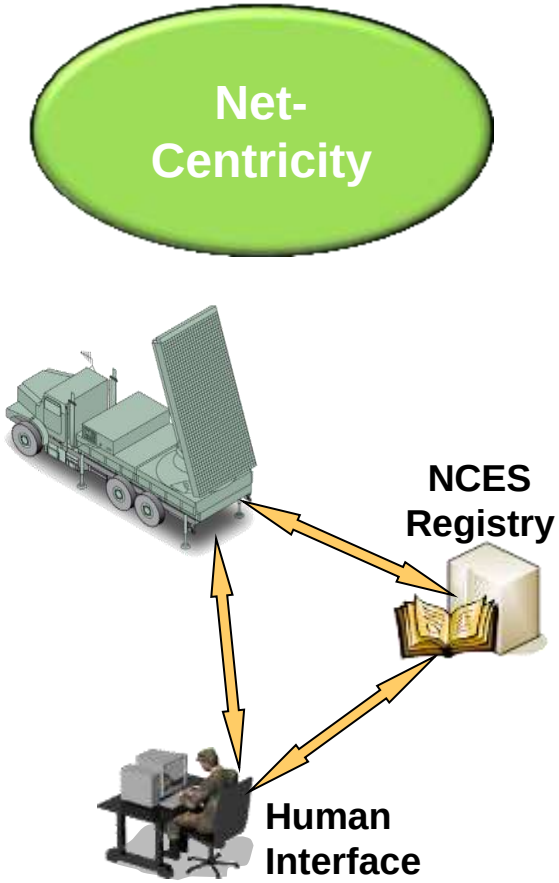

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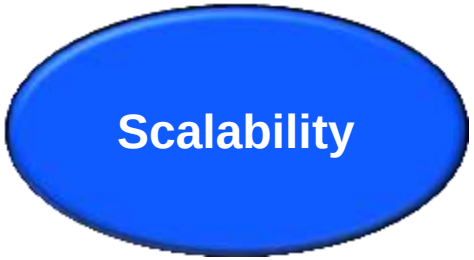

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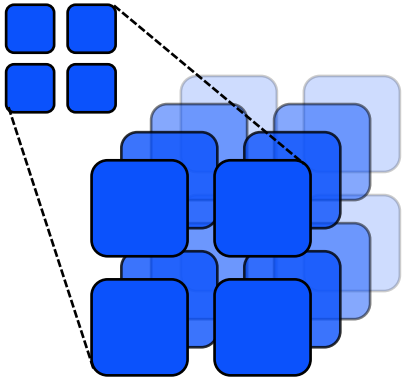

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Summary

- DoD emphasis on Open Systems Architecture is continuing and strengthening
- The Air Force 3DELRR program incorporates 9 key tenets
  - Tenets derived for sensors and sensor systems, but can also be applied to related fields (e.g., communications, real-time computing)
  - Functional Modularity, Layered Design, Data Accessibility, Net-Centricity, Platform and Vendor Independence, Software Development Kit, Scalability, Simulation and Testability, Diagnostics and Calibration
  - Tenets enforced through testable metrics that reflect program goals
- Open Technology Development focuses on low life-cycle cost
  - Useful in all stages of development and acquisition

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