National Defense Industrial Association (NDIA) Systems Engineering & Supportability Conference and Workshop

Open Systems Approach - Integrated Diagnostics Demonstration (OSAIDD) Program

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Topics of Discussion

- Background
- Objectives
- Team
- Research Approach
- Findings
- Recommended Approach
- Recommended Actions and Expected Benefits
- Roadmap
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Project Background

OSD Integrated Diagnostics Initiatives

- GIMADS and IDSS Programs of the 1980's
- Program Element initiated in FY1990 for integrated diagnostic demonstrations
  - Shipboard Mechanical Diagnostics Demonstration (CBM for HM&E)
  - Missile Integrated Diagnostics Demonstration (IDD) for the Patriot
  - F/A-18 Aviation Maintenance IDD most recently completed project that integrated flight line diagnostic elements
  - Joint Factory-to-Field Integration of Defense Test Systems Project initiated in 1995
  - Trident Missile Launcher Demonstration
  - Diagnostics for Acquisition
- August 1996 Joint Service Integrated Diagnostic Workshop

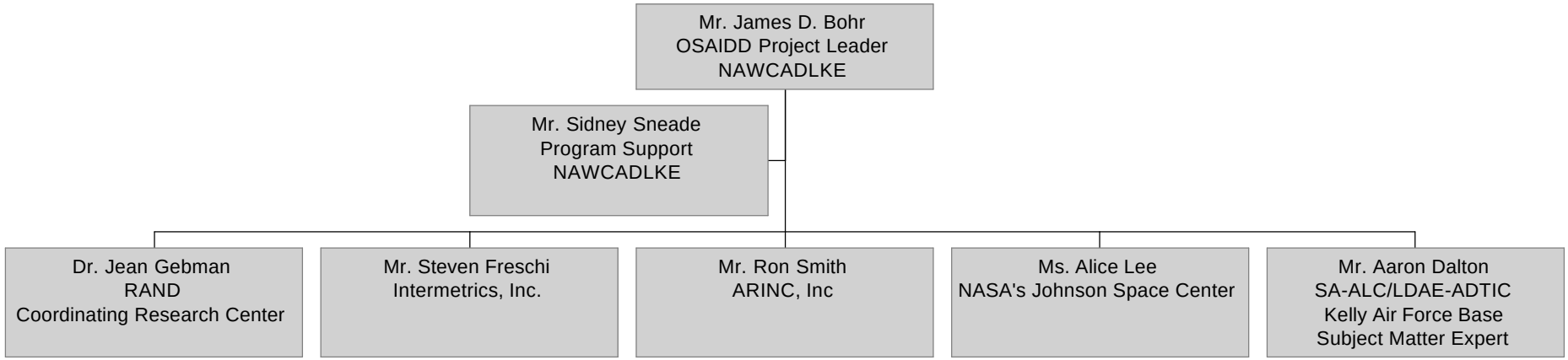
Related Initiatives

- Automatic Test System (ATS) Policy in 1992 established DoD ATS families and use of "critical interfaces and elements" to migrate towards a common solution
- F-16 Integrated Maintenance Information System
- Helicopter Health Use Monitoring Initiatives (RITA, H-53 IMD and JAHUMS)
- The Army's Diagnostic Improvement Program (ADIP) initiated in 1997

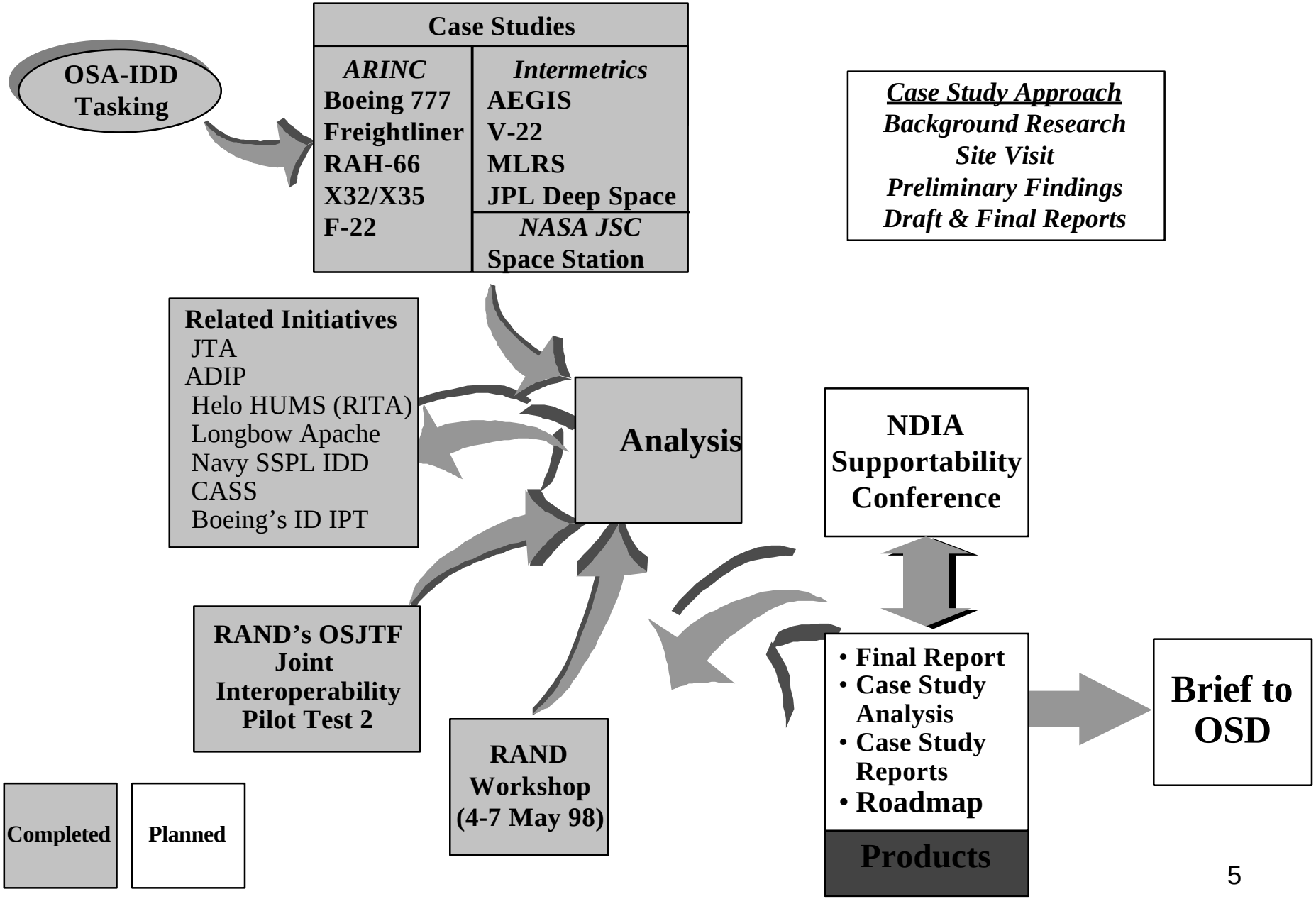
External Factors and Policy

- Fiscal Constraints and Infrastructure Reductions
- Acquisition Reform and the Elimination of Military Specifications and Standards
- Increasing Use of Commercial Items
- Open Systems Joint Task Force (OSJTF) and Joint Technical Architecture (JTA)

OSA-IDD Program Team



OSA-IDD Program Approach



Open System Goals and Objectives for Integrated Diagnostics

Strategic Goals

- *Reduced Cost*
- *Increased Interoperability*
- *Faster Technology Insertion*

Diagnostic-Related Tactics

- *Insight to Operation & Support Costs*
- *Rapid Product Maturation*
- *Higher Confidence in Fault Isolation*
- *Leverage Information from CAD/CAM for diagnostics*
- *Commercial Products & Processes*
- *Favorable System Architectures*
- *Flexible Diagnostic Architectures*

Specific Objectives

- *Identify Critical Interfaces and Elements*
- *Consistent Model of Diagnostic-related Information*
- *Interchangeable Sensors & Instruments (hardware)*
- *Interchangeable Diagnostic Algorithms (software)*
- *Consistent, Measurable Diagnostics Process & Metrics*
- *Integration of Diagnostics with Design & Engineering*
- *Advanced Communication Technology*

Findings

Diagnostic Trends

- Increasing system complexity and integration
- Models as basis of diagnostic design and functionality (model-based diagnostics)
- Increasing system autonomy (machine learning)
- Dedicated diagnostic subsystems (area managers)
- Communication of component-level behavior for self-reporting.
- Standard communicating methods for diagnostic data
- Obsolescence as design consideration, source of hardware changes and opportunity to affect diagnostics
- Information systems as means for affecting legacy systems

Findings

Keys to Success

- Reducing diagnostic ambiguities and inaccuracies
- Effective use of information
- Correlation of diagnostics with operational performance
- Business dynamic with incentives to improve performance and reduce cost
- Complementary infrastructure systems (MIS/DSS)
- Measurable and relevant metrics
- Empowered advocacy within purchasing/acquisition
- Industry standards facilitated by a domain specific organization

Findings

Diagnostic Challenges

- Improving the use of information
- Effective human-machine interface (HMI)
- Isolating and affecting sources of diagnostic ambiguities & inaccuracies
- Improving legacy systems
- Improving the on-off product interface
- Standard BIT/diagnostic data encapsulation
- Validation and verification of diagnostic performance
- Systems engineering methods/tools to support diagnostics
- Prognostics (electrical)
- Effective implementation of artificial intelligence
- A consistent architecture for integrating diagnostic elements

Findings: *Diagnostic Functions and the On-Product Test and Diagnostics Component*

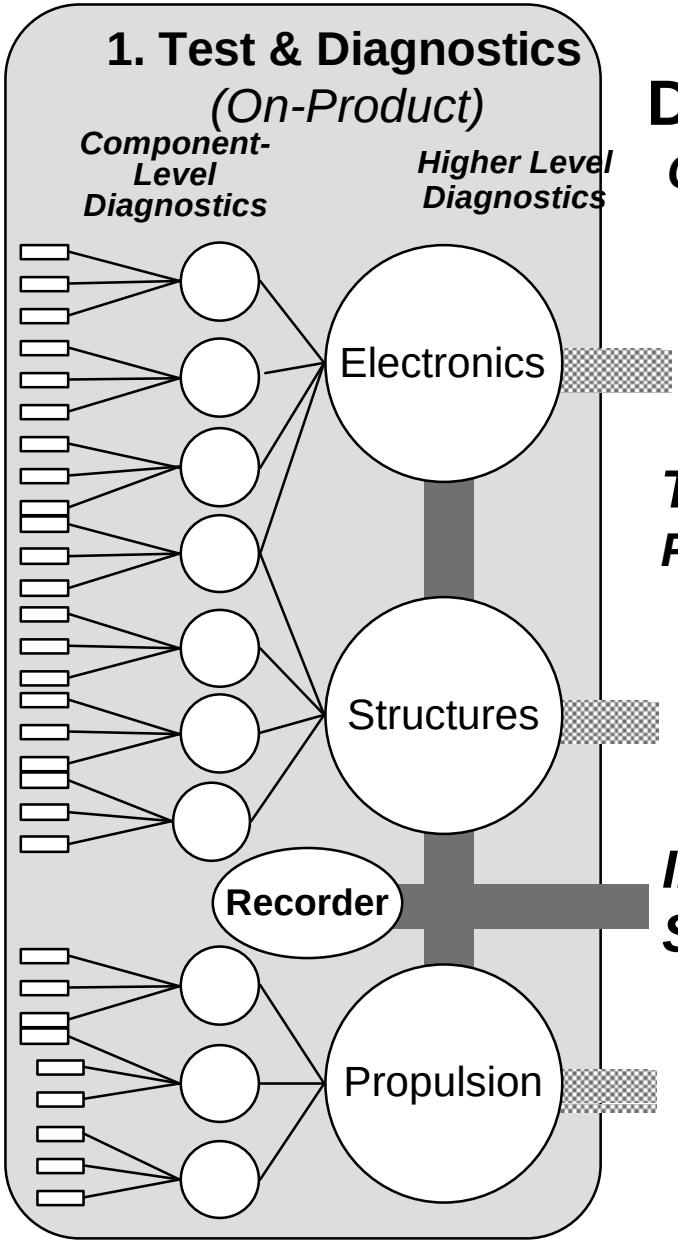
Sensor Characteristics

Measurements:

- **acceleration**
- **pressure**
- **force,**
- **etc.**

Signals Generated:

- ***Frequency***
- ***Velocity***
- ***Inductance***
- ***Resistance***
- ***etc.***



Diagnostic Functions

Core Diagnostic Functions

Fault Detection
Fault Recovery
Fault Isolation
Corrective Action

Test Sub-Class of Functions

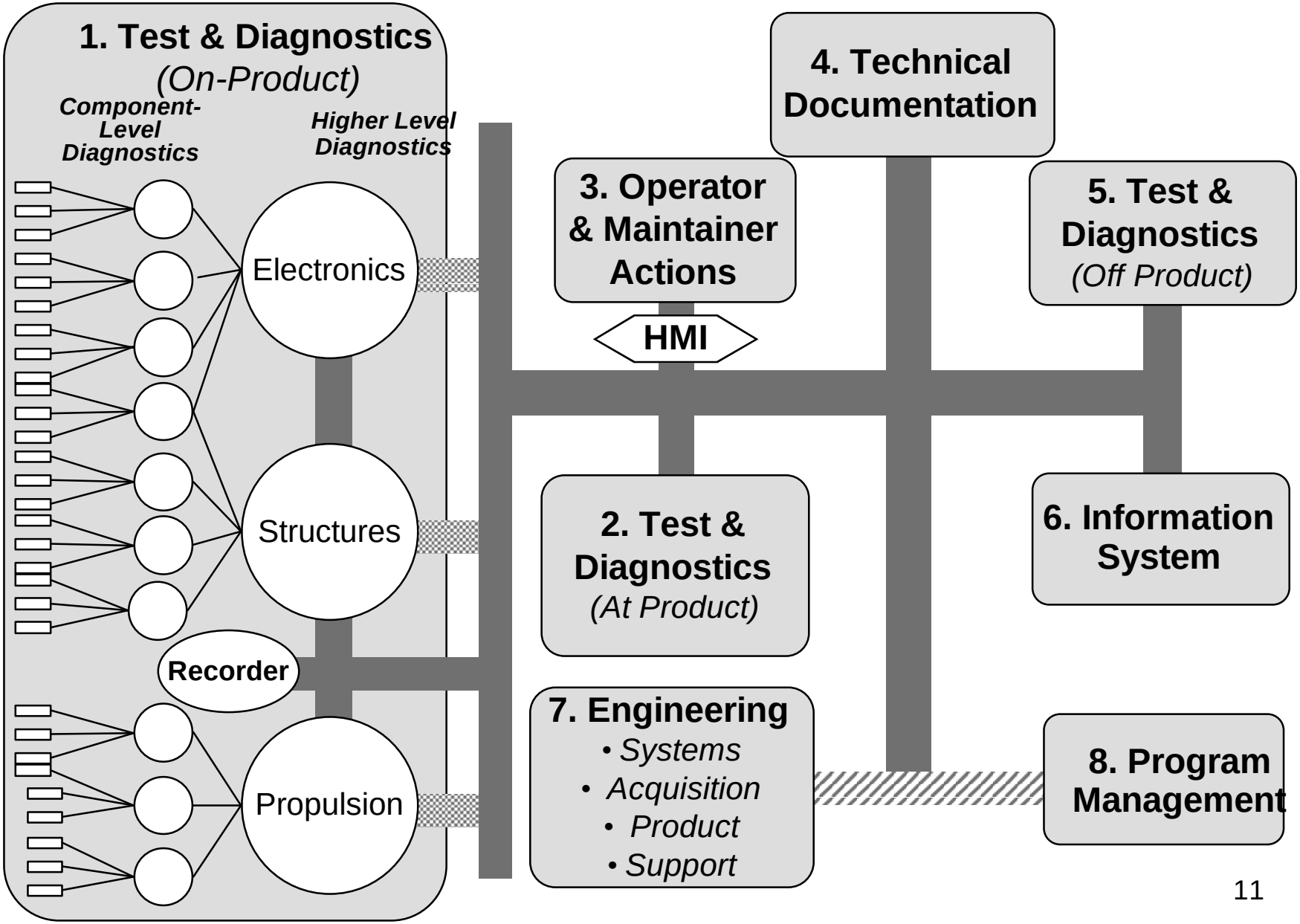
Stimulus
Measure
Compare
etc.

Information Fusion Sub-Class of Functions

Trend Analysis
Machine Learning
Data Mining
etc.

Findings

Diagnostic-related Components, Interfaces and Partitions



Recommended Approach

An Expanded Definition of Integrated Diagnostics

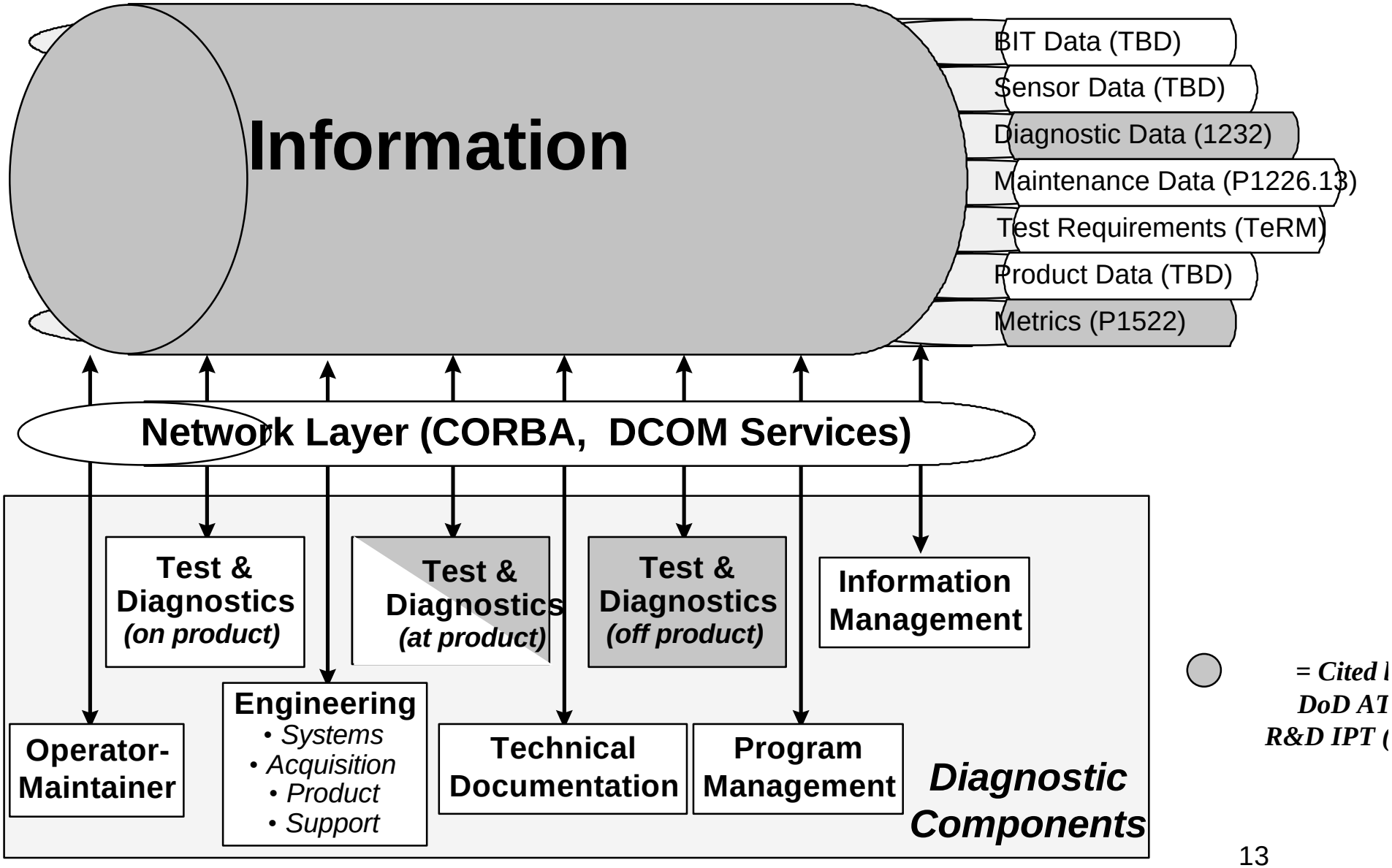
"...a structured process which maximizes the effectiveness of diagnostics by integrating the individual diagnostic elements of testability, automatic testing, manual testing, training, maintenance aiding, and technical information ."
Keiner, 1990

"...represents a systems approach where integrating diagnostic elements creates a total diagnostic capability that outperforms individual support and maintenance tools operating alone ." **Brown, 1996**

"…is part of the systems engineering (or reengineering) process in which diagnostic functions are partitioned to components, both on and off the product, to optimize economic and functional performance throughout a products life cycle . Optimal performance is achieved by ensuring effective communication of information relevant to the test and diagnostic process occurs between diagnostic functions and components and across each life cycle phase." OSAIDD Study, 1998

Recommended Approach

An Information-Based Integrated Diagnostic Architecture



Recommended Actions and Expected Benefits

Architecture

Formally Define and Model Information in the Diagnostics Process

- Effective capture and use of diagnostic information
- Consistent diagnostic metrics
- Faster diagnostic maturation
- Consistent basis for evaluating a product's integrated diagnostic capability
- Reduced diagnostics development time and cost

Demonstrate and Implement a "Plug-and-Play" Diagnostic Sensor Architecture (hardware)

- Faster, Less Costly Technology Insertion
- Obsolescence Management
- Continuous diagnostic performance improvement
- Reduced sustainment cost and manpower

Demonstrate and Implement a "Plug-and-Play" Diagnostic Algorithms Architecture (software)

- Increase use of COTS
- Increase competitive base among suppliers
- Reduce sustainment cost and manpower
- Improved prognostics and condition-based maintenance

Demonstrate and Implement a Consistent Approach to Component-Level Built-in-Test (BIT) Data

- Increased maintenance efficiency & accuracy
- Reduced manpower
- Reduced ambiguity (i.e., could-not-duplicates, no-faults-found, etc.)

Recommended Actions and Expected Benefits

Technology

Demonstrate and Implement Advanced Communication Technologies for Off-Product Diagnostic Data Transmission

- Enable effective communication
- Reduced cost and maintenance time
- Increase Maintenance efficiency

Demonstrate Benefits of Applying Functional Description Languages to Diagnostics

- Increase diagnostic confidence
- Reduced development cost for diagnostics
- Simulateable functional models for hardware and software

Engineering Tools

Demonstrate and Implement a Consistent Approach to Sharing Information between the Design, Test and Diagnostic Processes

- Better diagnostics sooner
- Modeling and simulation tools to increase confidence of designs
- Validation and verification of diagnostics

Recommended Actions and Expected Benefits

Policy

Establish OSD-level Advocacy and Leadership

- Enable life cycle cost reduction and diagnostic maturation
- An OSD-Level Agent to broker enabling guidance/policy
- A DoD Center of Excellence to target research & development
- Collaborations with industry consortia

Acquisition Guidance and Education Initiatives

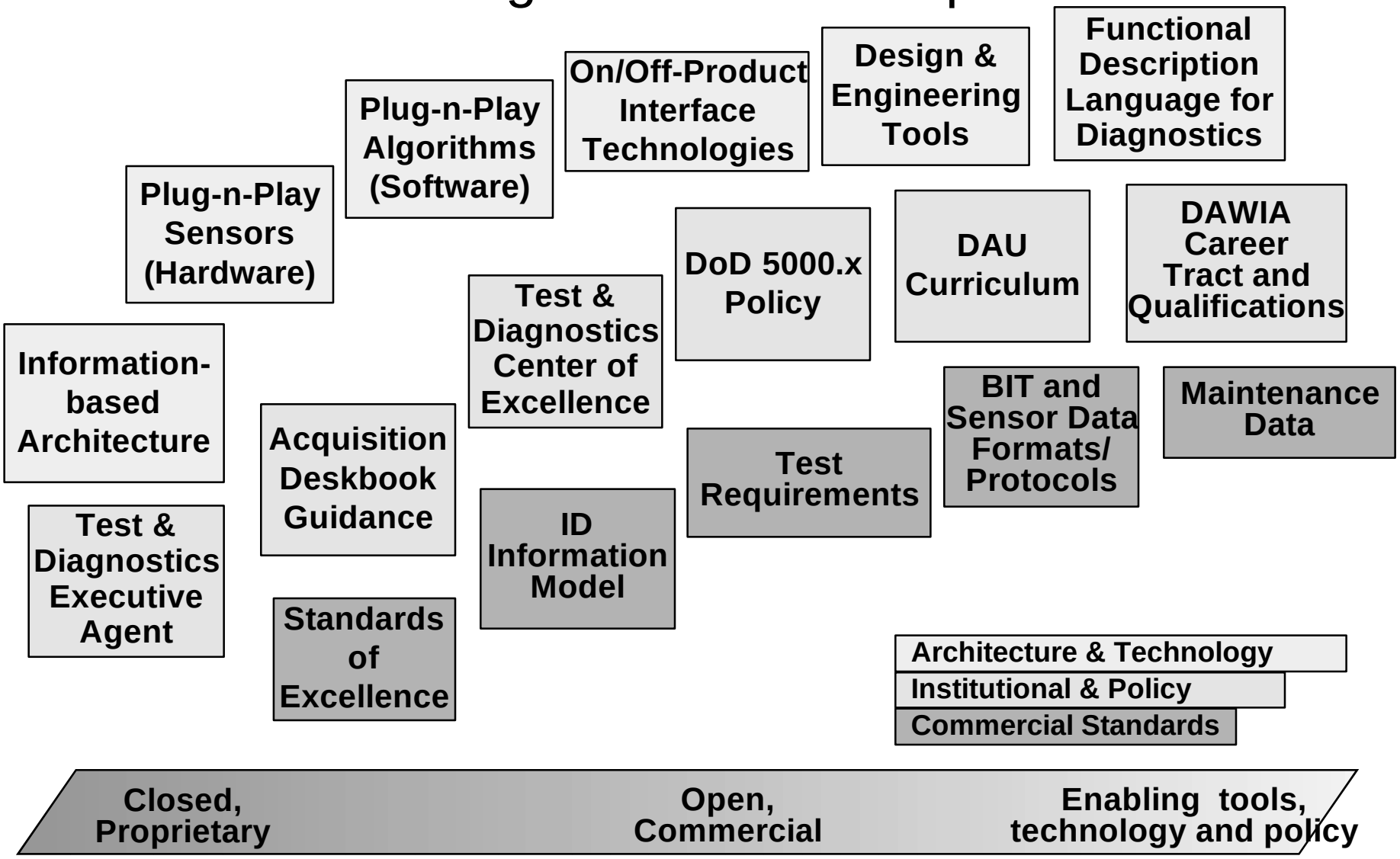
- Project Manager guidance in Acquisition Deskbook
- Curriculum at Defense Acquisition University
- Enable open systems approaches
- Favorable contract structures

Standards

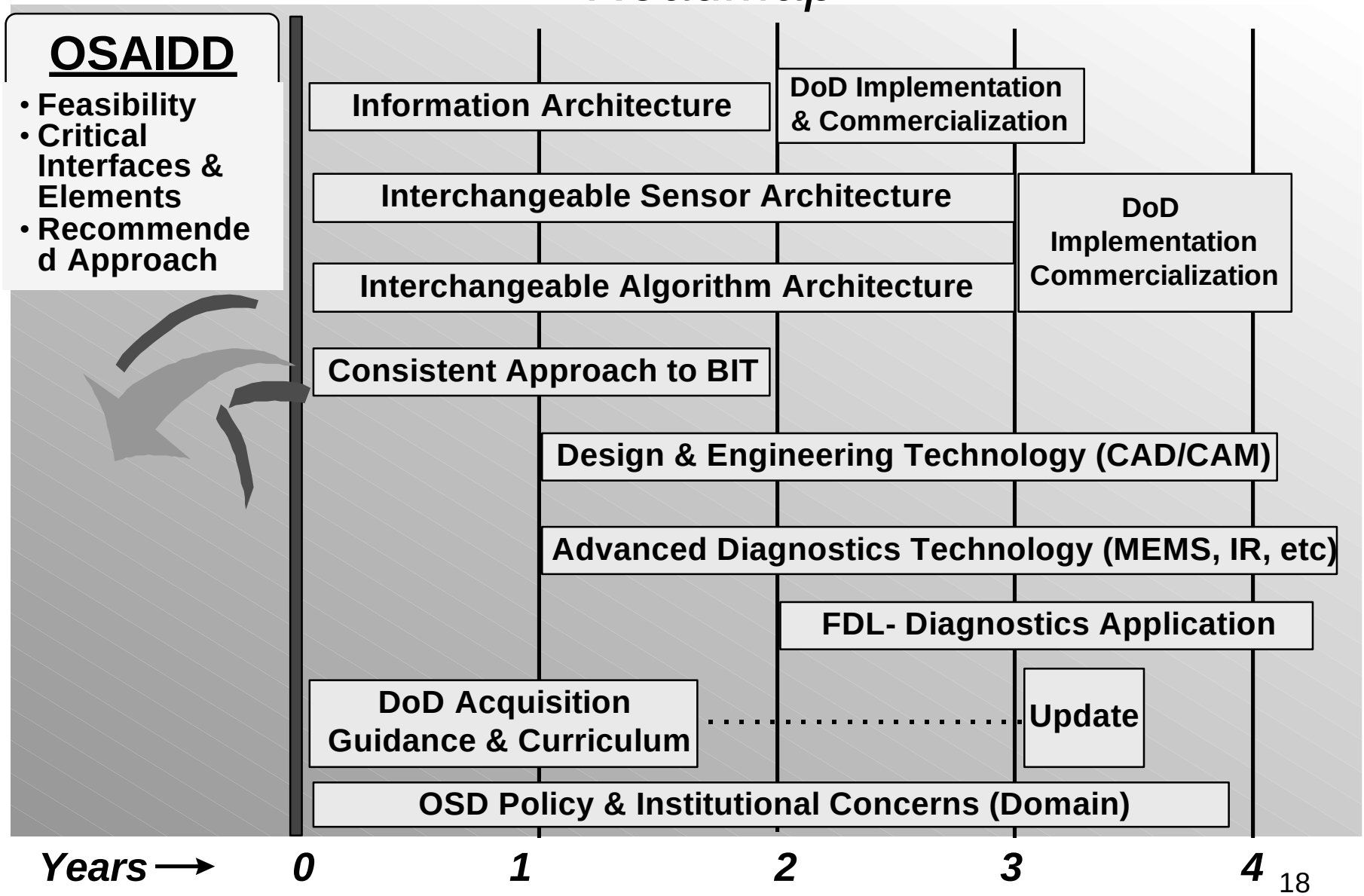
Participate in Commercial Standards Development efforts and Industry Consortia

- Standards of excellence for diagnostics
- Transfer demonstrated technology and processes to commercial supplier base
- Affect supplier base from focused customer perspective
- Reduce cost of technology insertion

Open Systems Approach for Integrated Diagnostics Roadmap



An Integrated Diagnostics Architecture
Roadmap



Summary

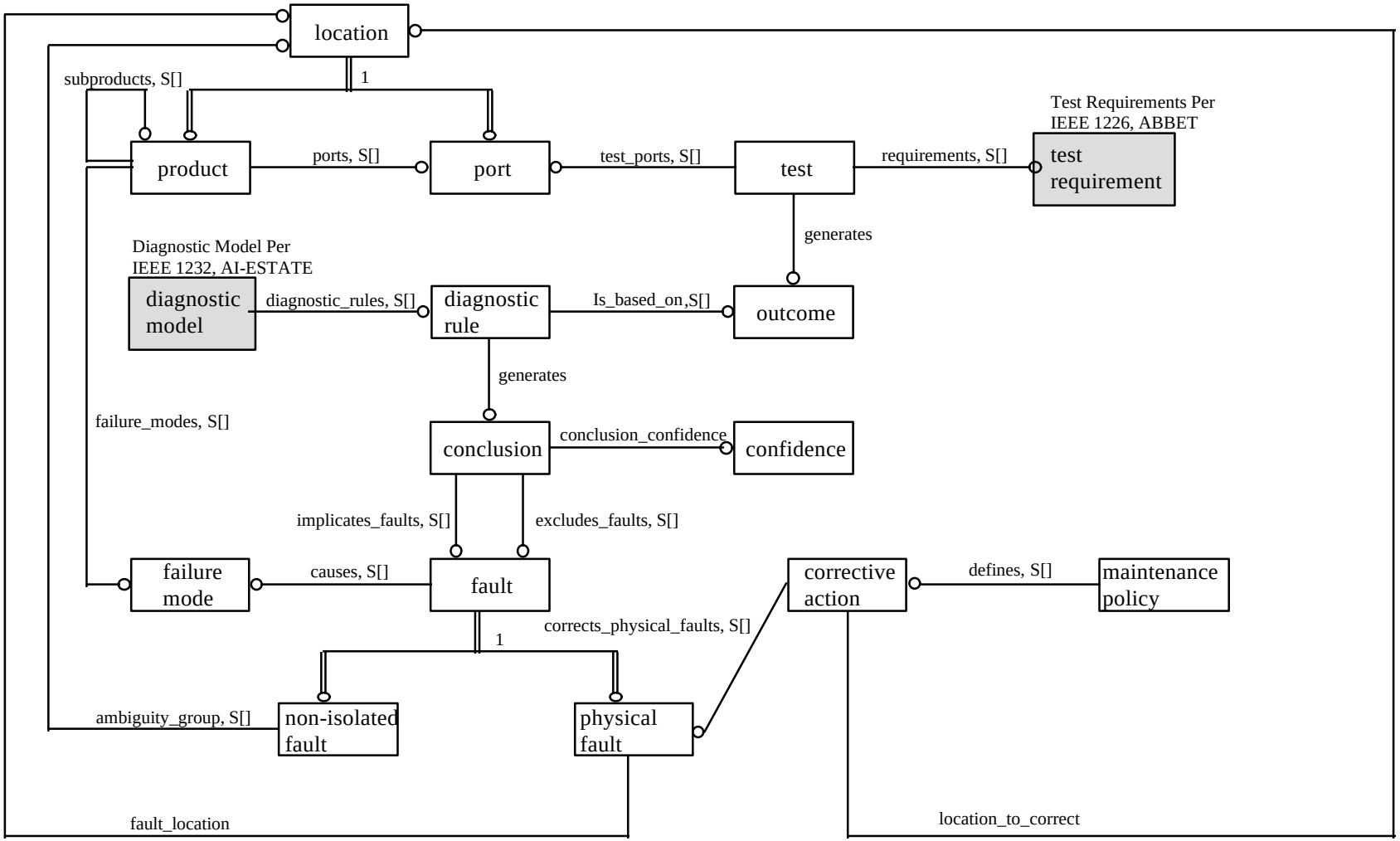
- A consistent approach **is** possible for integrating diagnostic capability yielding implementations that:
  - reduce cost
  - increase interoperability
  - enable faster technology insertion
  - leverage investments across legacy and developmental systems
- OSA-IDD Program has provided:
  - A consistent approach to implementing integrated diagnostic functions
  - Important elements & interfaces of a consistent architecture
  - Roadmap for architecture maturation and implementation
- Targeting Industry Consortia for broad, cross-domain acceptance and participation

Back-up Slides

Case Study Selection Rationale

— Medium level of NAWC interest
= High level of NAWC interest
* Lead for point of contact

Goals	Tactics	JSF	777	CASS	IFTE	AEGIS	V-22	MLRS	COMANCHE	COM SAT	LB APACHE	CATAPULT	COM SHIP	Frt LINER	F-22
1. Reduce costs through common use 2. Reduce costs with better diagnostics 3. Improve availability	Integrated electronics architecture	X	X						X					X	X
	Fault isolation system	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Commercial alternatives	X	X X	X	X	X	X		X	X X			X X	X X	X
	Facilitated domains		X												
Research Priorities (1: Highest 6: Lowest)	RAND	5*	1*	1		2	4	3*	3*	6				2*	4*
	ARINC	5	1						3	6				2	4
	Intermetrics			1		2	4	3							
	NAWC	5	1	1*		2*	4*	3	3	6				2	4

An Integrated Diagnostics Architecture

An Information Model View