The Role of Information Elements in Net Centric Data Management

Presentation to the Sixteenth Systems and Software Technology Conference, April 2004

By Silver Bullet Solutions, Inc.

Briefing Outline

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- Definition of Information Elements
  - Roles in
    - Architecture
    - System Engineering
    - Information Requirements Description
    - Systems Analysis
    - Capabilities Definition
- Net Centric Data Strategy
  - Goals and Elements
  - IE Roles in the Elements
    - COI Determination and Interaction
    - Understanding and Discovery
    - Ontologies
    - Taxonomies
    - Harmonization and Mediation
    - Metadata Attributes

Working Definitions

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- Information Element
  - From “information” --“data in context”
  - e.g., “Electronic Order of Battle for KP”, “SPAWAR Execution Year Budget (OMN)”, “Landing Gear part number for F/A-18 E/F”
  - Language of humans: operators, engineers, designers can communicate
- Data Element
  - An entity, attribute, or relationship or equivalent
  - e.g., FACILITY, FACILITY-TYPE, FACILITY-GEOLOCATION, FACILITY-MATERIEL-ITEM-ESTABLISHMENT-NORM, MATERIEL-ITEM-RF-EQUIPMENT, etc. (for EOB)
  - Language of machines: computer knows what to access

Equivalences:

E-R Model	Class Diagram	Relational Database	Object DBMS	XML DTD / Schema	TADILs	MTF
Entity	Class	Table	Class	Element	Message	Message
Attribute	Attribute	Field / Column	Attribute	Child Element or Element Attribute	DFI	FFIRN / FFN / FUDN
Domain Value		Instance, Value			DUI	FUD

Roles in Architecture

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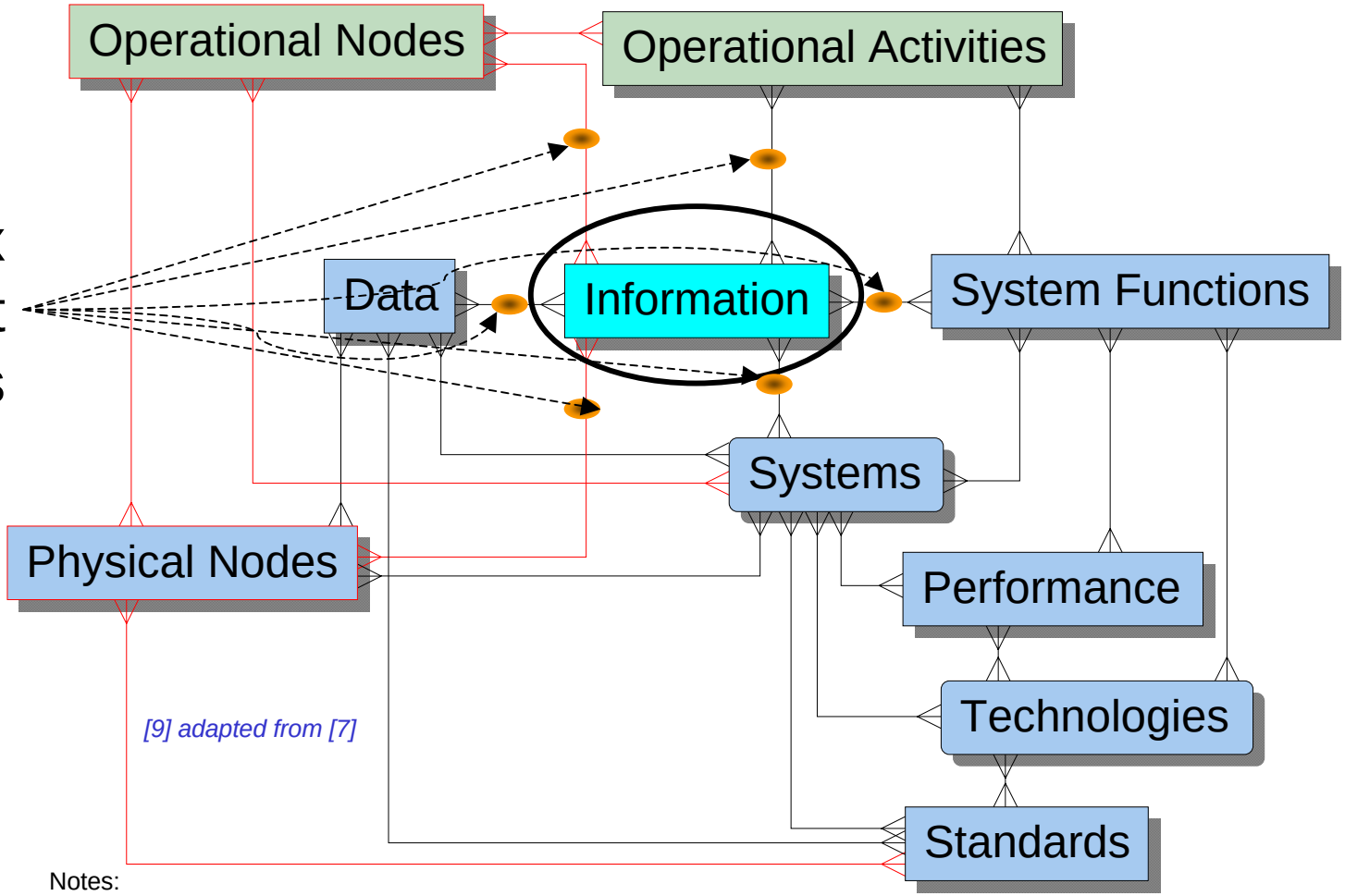
Six important roles



Notes:
1. Conceptual view of Core Architecture Data Model (CADM) [9] in DoDAF 1.0 [7]
2. 'crows feet' means 'many'; on both ends means 'many-to-many'
3. All entities have recursive 'many-to-many' with themselves (not shown)

Roles in Architecture (Reports)

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APPLICABLE ARCHITECTURE DATA ELEMENT SETS

TAXONOMY TYPES	STRUCTURE	AV		Operational View (OV)							System View (SV)											Tech View	
		1	{2}	1	{2}	{3}	{4}	{5}	{6}	{7}	{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}	{10	{11	{1}	{2}
Operational Nodes *Organizations, Types of Organizations, and Occupational Specialties*	Generalization & Composition		●		●	●	●	●	●		⊙					⊙							
Operational Activities (and Tasks)	Composition		●			●		●	●						●	⊙							
Information Elements and Data Elements	Generalization & Composition		●		⊙	●		●	●	●				⊙		⊙				⊙	●	⊙	⊙
Physical Nodes *Facilities, Platforms, Units, and Locations*	Generalization & Composition		●								●	●	⊙	⊙		●							
Systems *Families-of-Systems, Systems-of-Systems, Networks, Applications,*	Generalization & Composition		●								●	●	●	●	⊙	●	●	●	●	●		⊙	⊙
System Functions	Composition		●								⊙			●	●	●	⊙	⊙	⊙	●			
Triggers / Events	Generalization & Composition		●			●		●	●					●		●				●			
Performance Attributes	Generalization & Composition		●					●						●		●	●	●	●				
Technical Standards *Info Processing, Info Transfer, Data, Security, and Human Factors*	Generalization & Composition		●								●	●		⊙		●		●	●		⊙	●	●
Technology Areas *Systems and Standards*	Generalization & Composition		●																●				●

Adapted from [7]

● = Taxonomy element plays a primary role ⊙ = Secondary role blank = element not part of this datase

Roles in System Engineering

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Example from AADC System Spec.

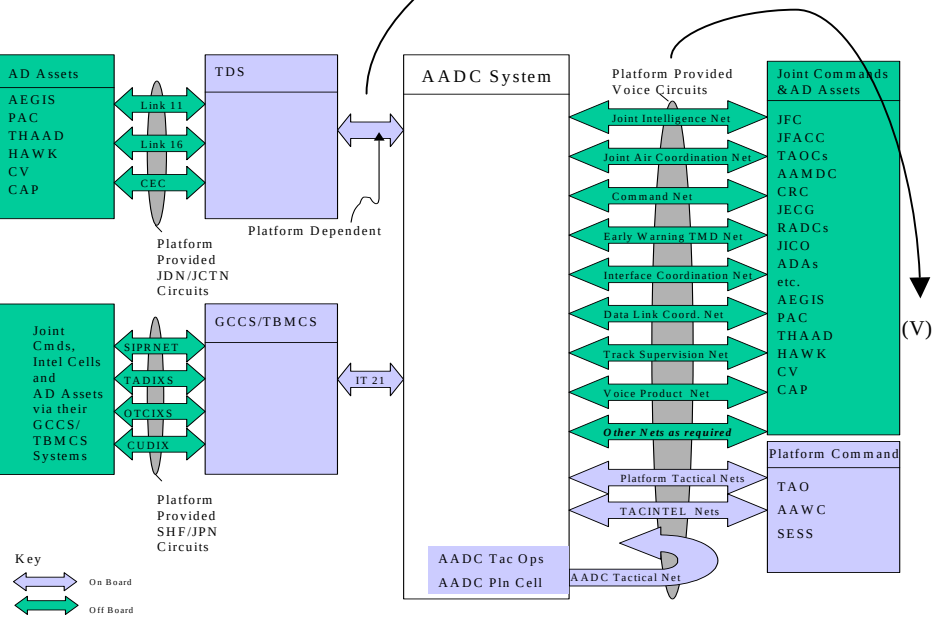
3.3.1 TDS Interfaces

(2) The AADC system shall be capable of interfacing with multiple TDS systems.including, but not limited to, AEGIS and Advanced Combat Decision System (ACDS).

(U) The AADC system shall receive the TDS track file through an interface to the host TDS including:

2.1.1.1	Position
2.1.1.2	Velocity
2.1.1.3	Acceleration
2.1.2	PVA Confidence
2.1.3	Time
2.1.4	Identification
2.1.5	Threat Intentions
2.1.6	Attributes
2.1.7.1	ESM/ELINT
2.1.7.5	Navigation
2.1.7.6	Radar
2.1.7.7	EO/IR
7.1	Data Exchange Controls
7.2	Identification Management
7.3	Parametric Data Coordination
7.4	Correlation/Association Management
7.6	Reporting Coordination

IEs



(V) The AADC system shall provide digital force orders to Air Defense assets over Link 11, Link 16 or CEC via the host TDS, depending on host TDS implementation of these functions, including:

5.1	Target Data; Offensive / Integrated Prioritized Target List
5.2	Surveillance/Sensor Plans
5.4	Communications Plans
5.7	Defensive/Force Protection
5.8	Movement
6.1	General Tasking
6.3	Tactical Orders
6.3.4	Direct Employment of Communications, Sensor, and Weapon
6.3.6	Engaging Unit/Target Dynamics
6.3.7	Third Party Targeting Data
6.3.8	Platform Resource Allocation
6.3.9	Tactical Order Responses

Role in Information Requirements Description (EEIs)

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Multi-INT Study EEI Sources (~3700)

ASOC
ATNDB
CINA
CINF
Urban GIRH
J2-USFK
Navy
CINC Worksheets

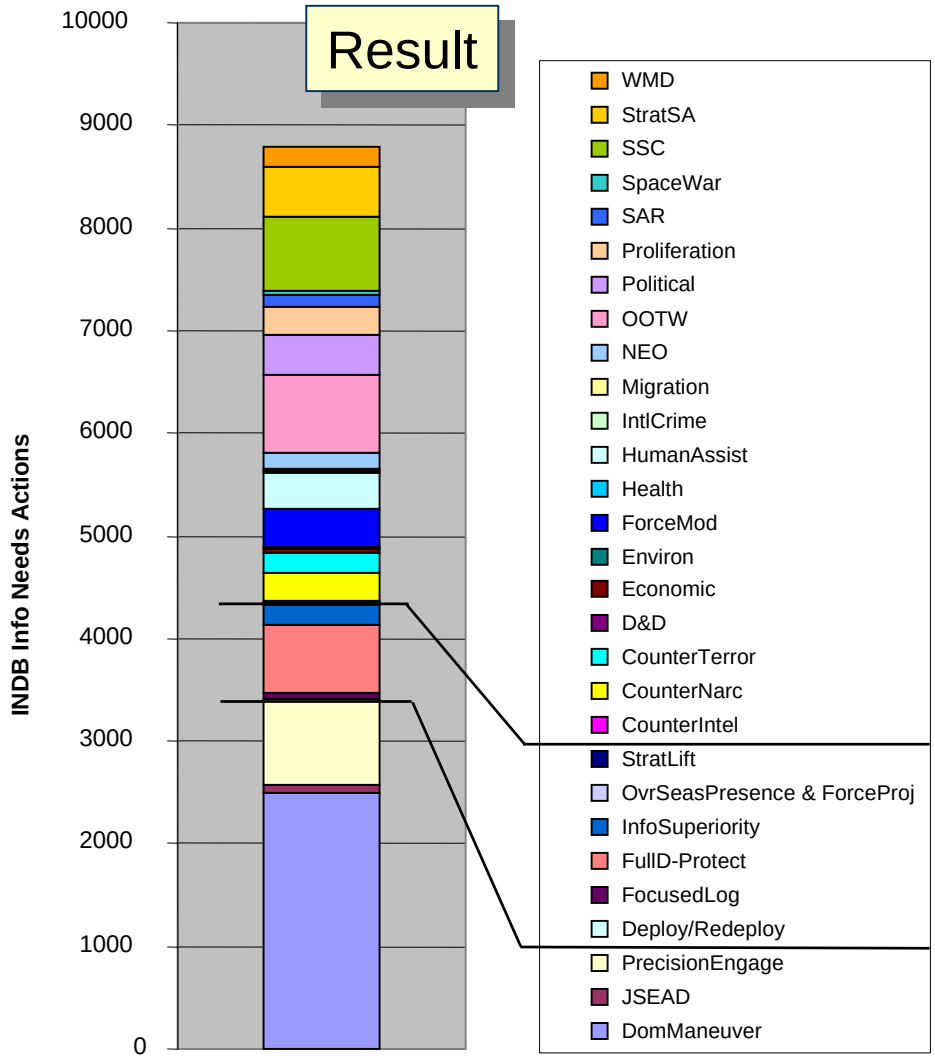
Analysis

Map
- Locate
- Track ...
- Identify ...
- Activity/Status ...
- Capability ...
- Intent ...

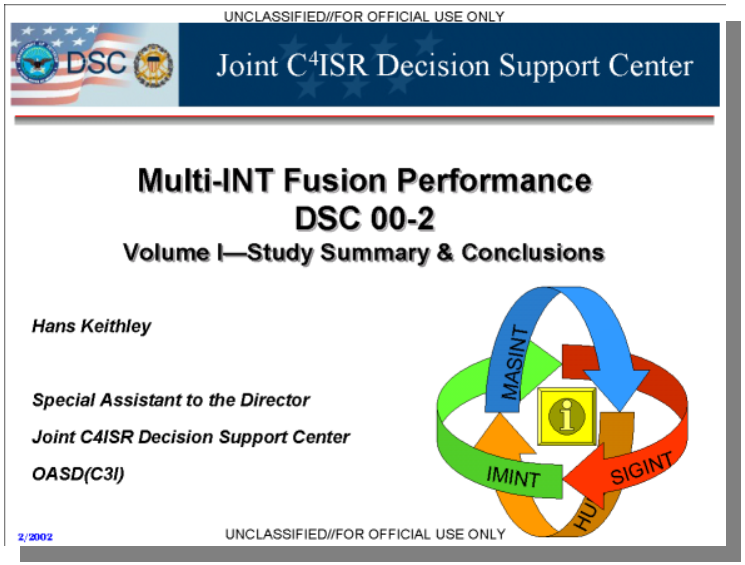
Map
- OB (Mobile)
- Infrastructure (Fixed) ...
- Geospatial ...
- Networks ...
- Political ...

From [15]

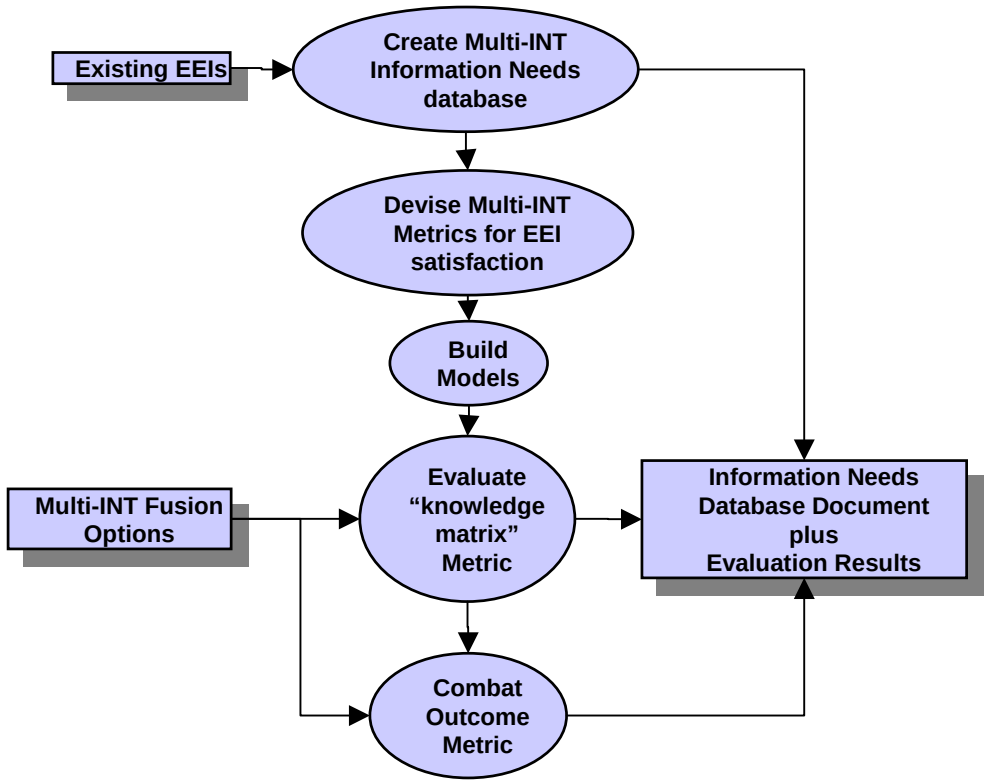
(based on comprehensive analysis of many EEI sources)



Role in Systems Analysis



From [15]



$$\left[\frac{\Delta \text{ Combat Outcome}}{\Delta \text{ C4ISR}}\right] = \left[\frac{\Delta \text{ Data}}{\Delta \text{ C4ISR}}\right]\left[\frac{\Delta \text{ Knowledge}}{\Delta \text{ Data}}\right]\left[\frac{\Delta \text{ C2}}{\Delta \text{ Knowledge}}\right]\left[\frac{\Delta \text{ Combat Outcome}}{\Delta \text{ C2}}\right]$$

Role in Capabilities Definition

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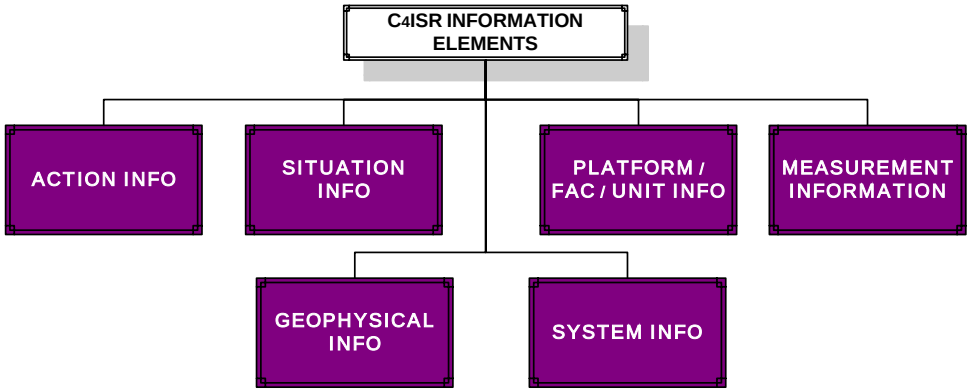
- JBMC2 -- what information?

		Information Categories and Examples					
Object Categories	**Examples**	**Location**	**Movement**	**Identify**	**Status**	**Activity**	**Intent**
OOB	Units, vehicles, sites, facilities, aircraft, ships, satellites	lat/long	spd/hdg	country / alliance, type/class	readiness	targeting, reconitering	COA
Infrastructure	Comm, power, transportation, water/sewer	network, grid	throughput, flow rates, amps	name, part-of relationships	BDA, op levels	repair, broadcasts	expansion plans
Sociological	Culture, religion, economic, ethnic, government, history, languages	temples, historic structures	relocations	names and associations	stability, vulnerabilities	political or religious activities	religious or political plans
Geophysical	Terrain, weather, climatology, oceanography, astrometry	feature lat/long, alt/dpth	flowraters, tides	names	sea and river levels, temperature	storms, volcanos	forecasts

Working papers from [14]

Example Service IE Taxonomy



From [17]

11.4 - Classification
11.4.1 - Category
11.4.1.1 - Confidence Level
11.4.1.2 - Estimate Type
11.4.1.2.1 - Alternative
11.4.1.2.2 - Evaluated Decision
11.4.1.3 - Value
11.4.1.3.1 - Air
11.4.1.3.2 - Land
11.4.1.3.3 - Space
11.4.1.3.4 - Subsurface
11.4.1.3.5 - Surface
11.4.2 - Platform / Point / Feature Type
11.4.3 - Specific Type
11.4.4 - Type Modifier
11.4.5 - Unit

11.8 - Kinematics
11.8.1 - Pos / Vel / Acc (PVA)
11.8.1.1 - Acceleration
11.8.1.1.1 - Angular
.1.1.2 - Linear
2 - Estimate Type
.1.2.1 - Estimated
.1.2.2 - Observed
.1.2.3 - Predicted
.1.2.4 - Smoothed Data
3 - Position
.1.3.1 - Bearing Angle
.1.3.2 - Location; 2D Horizontal
.1.3.3 - Vertical
4 - Velocity
.1.4.1 - Horizontal
.1.4.2 - Vertical
VA Confidence
1 - Bearing Angle
2 - Bearing Angle Rate
3 - Covariance Matrix
11.8.2.4 - Elevation
11.8.2.5 - Elevation Angle Rate
11.8.2.6 - Horizontal AOP
11.8.2.7 - Horizontal Circular
11.8.2.7.1 - TQ
11.8.2.8 - Range
11.8.2.9 - Vertical

- Generalization to fundamental semantics allowed mapping across diverse representations such as:
  - TADILs –IBS
  - VMF –MIDB
  - USMTF –C2 Core
- Recognition of the equivalent or similar semantics in the differing representations would be a first step toward harmonization or mediation
  - A way to manage “isSimilarTo” [8]

Matching	The data elements are equal
Mapping	The data elements are equivalent

Elements of Net-Centric Data Strategy

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Goals \ Elements	COI	Model (structure) Registry	XML Registry	Discovery Services	Content Metadata	Transformation Services	GIG Policies	Ontologies	Taxonomies	Pedigree Model	Security Model	NCES
Visible	✓	✓	✓	✓			✓			✓	✓	✓
Accessible		✓					✓					✓
Governance	✓						✓					
Understandable	✓		✓	✓	✓			✓	✓			
Trusted	✓			✓						✓	✓	✓
Interoperable	✓	✓	✓			✓	✓					✓
Responsive	✓						✓					

Derived from [2], [3], [4], [6], and [8]

A Spectrum of Data Mgmt

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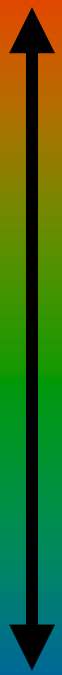
- Human filtered
- Mitigated by other information
- Opportunity for correction



- Coupling and deep integration
- Ultra-high reliability
- Irreversible sudden operational consequence

Weather

COP

Log

Examples

CTP

Working papers for [14]

Automatic Carrier Landing System signals

Fly-by-wire guidance system data

Self-destruct message data

COI Topologies

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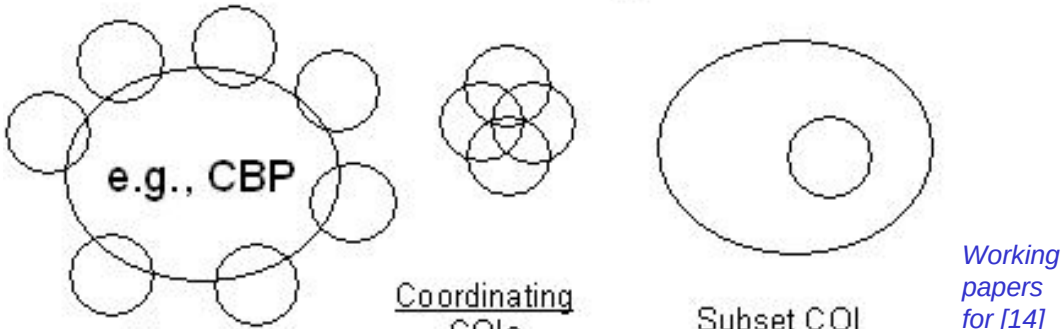
- Types of COIs
  - Expedient
  - Institutional
  - Functional
  - Cross-Functional
  - + others yet to be determined
- COI Intersections

	Functional	Cross-Functional
Expedient	Tactically driven, Implied authority, Formal processes modified for need, Relatively many entities (e.g., New Imagery Analysis capability for Damage Assessment)	Tactically driven, Derived authority, Ad hoc processes, Many entities (e.g., Forward deployed JTF planning New Threat Response)
Institutional	Explicitly recognized, Longer term, More formalized processes based on span of control, Relatively few entities (e.g., PSAs such as Logistics)	Explicitly or implicitly recognized, Longer term but priority driven, Blended processes resulting from agreements (e.g., JS area such as Battlespace Awareness)

From [3]

Examples of COI Topologies and Resultant Governance Agreements



Working papers for [14]

COIs and Architecture

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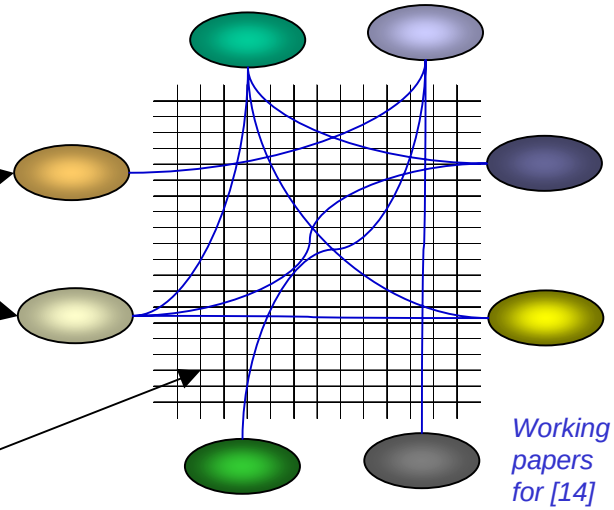
- COIs represent clustering of needs to share information by
  - "Op Nodes"
    - Organizations
    - Types of organizations
    - Operational Roles
    - Occupational Specialties
  - Operational Activities or Tasks
  - System Functions
  - Systems
  - Physical Nodes
  - others?
  - The "means" by which they interact is the "grid"



Working papers for [14]

- In Architectures these would be clusters of:
  - Needlines (Op Nodes)
  - Activitylines (Op Activities / Tasks)
  - Functional Interfaces (System Functions)
  - System Interfaces

IEs Support Discovery and Understanding

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Top Level
(Reconcile - Map)

Mid Level
(Bridge between Architecture, SoSE, Info. Rqmts and Implementation Design)

Lower Level
(Reconcile - Map)

- **JTAMDO IEs**
- **Navy IEs**
- **GIG Arch IEs**
- **C2 FCB Arch IEs**
- **SIAP IEs**
- **INDB EEIs**
- **etc.**

The middle looks like a taxonomy

child-parent can be:
- is-a-part-of
- is-a-type-of

TADIL A/B/C/J	**C2 Core/JCDB/C2IEDM**
IBS	**JMCDM**
OTH-T Gold	**USIGS**
MIDB / GMI NS	**FDL**
VMF	**SHADE**
NATO Link-1	**NID/Mer Ship DB**
ATDL-1	**MEPEDS**
USMTF	**EPL/EWIR/NERF**
CEC	**etc.**

Human communication
Broad audience
Shorthand meaning

Machine communication
Software Engineers only
Explicit meaning

IEs Support Ontology Development

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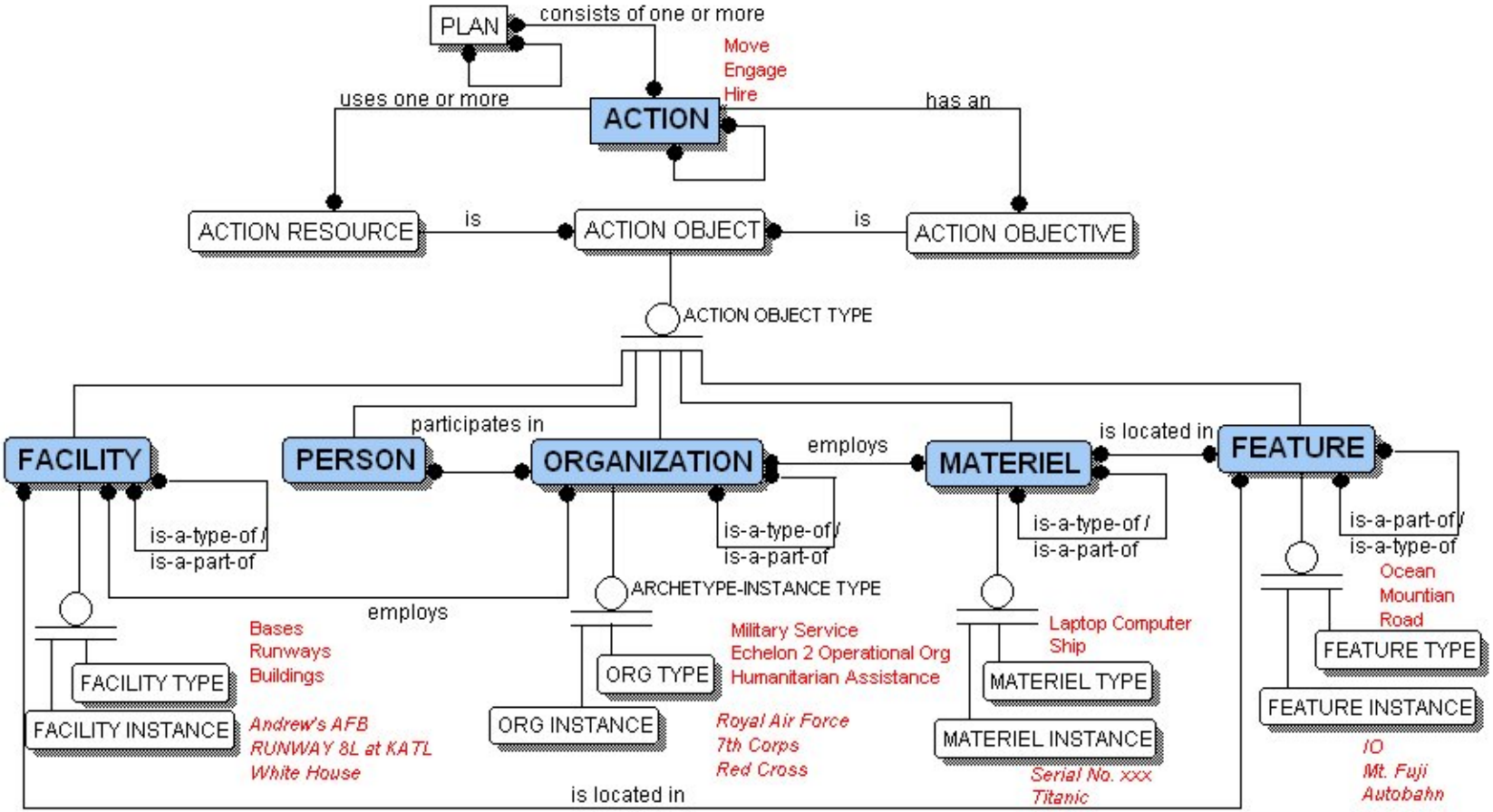
- C2 Core [10] (C2IEDM [11] / JCDB) Concepts



From [16]

IE - DE Mappings Support Mediation and Harmonization Management

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Existing Databases:

Modernized Integrated Data Base (MIDB)	National source for order of battle, facilities, etc.
EW Integrated Reprogramming (EWIR)	Frequency, PRI, PW, etc. for all radars
GCCS Shared Data Environment (SHADE)	Commonly used reference data p/o Net-Centric metadata registry
Military Characteristics and Performance data (MEPEDS)	Technical data on ships, aircraft, etc.
Joint Operations Planning and Evaluation System (JOPES)	Planning data
Status and Operational Readiness and Testing System (SORTS)	Readiness data
Common Cryptologic Data Base (CCDB)	Frequency, carriers, nodes and links
GCCS Track File (TBDM)	From which COP arises

Message Standards:

Tactical Digital Information Link (TADIL)	Standard for command and control
Variable Message Format (VMF)	Part of TADIL-J family
United States Message Text Format (USMTF)	Standard for planning messages
Integrated Broadcast System (IBS)	Standard for intelligence surveillance data
FAAD Data Link	Forward Area Air Defense data link
CEC Datalink	CEC
Over the Horizon Targeting, Gold (OTH-T Gold)	COP datalink
TACINTEL II	Primary datalink for SIGINT systems
IDS / IRS / ICD	Interfaces between systems

Data Standards:

XML Registry	Namespaces for Ground Ops, GMI, COP, etc.
Defense Data Dictionary System (DDDS)	Legacy registry p/o Net-Centric metadata registry

Standard Models:

Command and Control Core Data Model	Data model used in JCDB and C2IEDM
Joint METOC Conceptual Data Model	Oceanographic and meterological
Unmanned Aerial Vehicle / Joint Airborne Surveillance Architecture	Datalinks for UAVs
Defense Data Architecture models	Funtional area models p/o Net-Centric metadata registry

Visions and Architectures

Fn / FCS / MC2C information requirements	Future service architectures
NCOW Ref Model ICOMS	DoD level architecture

IEs are a Tool for Object Semantics

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Transportation

Size:
Packaged_weight:
Pick_up_location:
Destination:

Mission Planning

Desired_impact_point:
Time_on_target:
Lethality_characteristics:
Applicable_aircraft:

Finance

Unit_cost:
Number_required:
Funding_program:
Contract_number:

What's a bomb?

(Answer – all)

Ground Operations

Attachment_time_required:
Wing_placement:
Assembly_instructions:
Arming_instructions:

Flight Planning

Weight:
Minimum_drop_altitude:
Approach_type:
Drop_angle:
Drag_coefficient:

Engineering

Intended_target:
Casing_thickness:
Detonation_mechanism:
Attachment_mechanism:
Explosive_type:

Adapted from MITRE Corp

IEs provide tractable visibility and concurrence mechanisms, in context and in succeeding levels of detail in integrated architectures

Correct IERs Support Net Centric Data Management

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- IERs are defined as materiel independent descriptions of information sharing needs for operations

Op Node that needs the information	(org, org type, op role, occupational specialty)
To do what	(op activity, task, process, …)
Op node that produces the info	(org, org type, op role, occupational specialty)
In the course of what	(op activity, task, process, …)
What kind of info	(information element)
With any special attributes?	
How fast?	(timeliness)
How secure?	(security)
How much?	(size)
How protected?	(IA)
How accurate?	(accuracy)
etc.	

IERs Do NOT Address Communications -- Point-to-Point, GIG, or otherwise

Summary

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- IEs support many elements of Net-Centric Data Strategy

Information Elements	COI	Model (structure) Registry	XML Registry	Discovery Services	Content Metadata	Transformation Services	GIG Policies	Ontologies	Taxonomies	Pedigree Model	Security Model	NCES
	Net Centric Data Strategy Elements											
Exchanges, Requirements, and Interfaces	✓					✓					✓	
IE Taxonomies				✓	✓			✓	✓			
Data Element Mappings		✓		✓		✓						
Exchange and Interface Attributes			✓							✓	✓	
IE-Level Conceptual Models		✓						✓	✓			

References

1) "DoD Data Administration", DODI 8320.1, OASD (NII) / DoD CIO, 26 Sept 1991
2) "Department of Defense Net-Centric Data Strategy", OASD (NII) / DoD CIO, 20 April 2003
3) "Communities of Interest in the Net-Centric DoD Frequently Asked Questions (FAQ), Draft", OASD (NII) / DoD CIO, 13 March 2004
4) "The DoD Net- Centric Data Strategy And Discovery & Mediation Enterprise Services", briefing by OASD (NII) / DoD CIO, 3 Nov 2003
5) "DoD Net-Centric Data Management Strategy: Metadata Registration", memorandum, OASD (NII) / DoD CIO, 3 April 2003
6) "Department of Defense Discovery Metadata Specification (DDMS), Version 1.0", Deputy Assistant Secretary of Defense (Deputy Chief Information Officer), 29 September 2003
7) "Department of Defense Architecture Framework, Version 1.0", OASD (NII) / DoD CIO, 9 Feb 2004
8) DoD XML Registry at http://diides.ncr.disa.mil/
9) CADM documentation and model at https://pais.osd.mil/enterprisearchitectures)
10) C2 Core documentation and model at http://www-datadmn.itsi.disa.mil/datadmn/dda/c2core.html
11) C2IEDM documentation and model at Multilateral Interoperability Program: http://www.mip-site.org/
12) Defense Data Architecture (DDA), documentation and models available at http://diides.ncr.disa.mil/
13) Information Integration for Concurrent Engineering (IICE), IDEF5 Method Report, Armstrong Laboratory (AL/HRGA), Wright-Patterson Air Force Base, Ohio, 21 Sept 1994
14) Joint Battle Management Command and Control (JBMC2) Roadmap, OUSD (AT&L) / JFCOM, Feb 2004
15) Keithley, H., Multi-INT Fusion Performance, Joint C4ISR Decision Support Center, OASD(C3I), Washington, D.C., 2001
16) Ontology and Fusion (McDaniel, D., "Multi-Hypothesis Database for Large-Scale Data Fusion", Proceedings of the Fifth International Conference on Information Fusion, International Society of Information Fusion, Sunnyvale, CA, 2002)
17) Naval C4ISR Operational Architecture, Space and Naval Warfare Systems Command (SPAWAR), 1997