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Pittsburgh, PA 15213-3890

Measuring Systems Interoperability

Conference on the Acquisition of Software-Intensive Systems
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Presentation Outline

- Introduction to the Problem
- SEI's Research Goals
- Typical Questions
- Some Definitions
- Approaches to Measuring Interoperability
  - Scorecard Approach
  - Levels of Information Systems Interoperability (LISI)
  - Management Performance Measures
- Next Steps

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The Challenge

Interoperability is the number one problem in joint force & combined operations. It is the CINC's top issue*.

The problem may be getting worse

- Real-world operations, evaluations and exercises continue to highlight joint/combined warfighting capability shortfalls
- As new coalition partners develop, complex systems are acquired, and "fixes" to past problems are applied in stove-piped fashion
- Joint Vision 2010 and 2020 call for increasingly network-centric warfare, dependent upon fully interoperable systems

* As stated by Ms. Robin Quinlan, Deputy Director, Systems Interoperability, Office of the Secretary of Defense [Quinlan, 2000].

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Common Measurement Questions

Are we able to identify the root causes of interoperability problems?

Are new system acquisitions becoming more effective at avoiding the same types of interoperability problems that occurred *yesterday*?

How does one quantify interoperability in an actionable way?

How do we measure the tradeoffs between systems interoperability and other fundamental attributes of C4I systems including

- Security
- Survivability
- Performance
- Availability
- Flexibility

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SEI Research Goals In This Area

Understand the state of the practice for measuring systems interoperability

- Typical approaches for assessing and measuring interoperability
- Innovations that are currently being explored or piloted for improving the state of the practice

Identify potential measures and validate their usefulness through collaborative field-based investigations

Share the research results with the community

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State of the Practice Report

- Based on previously published reports
- Defines interoperability and surveys the issues involved with achieving interoperability
- Reviews current approaches to the interoperability problem
- Highlights a promising new approach to assessing and measuring interoperability – the Levels of Systems Interoperability (LISI) Model
- Reviews other potential measures for measuring various dimensions of interoperability
- Recommends an initial set of measures for improving interoperability

White paper is available at http://www.psmsc.com/

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Interoperability Defined

Technical interoperability

and

Operational interoperability

Joint Publication 1-02

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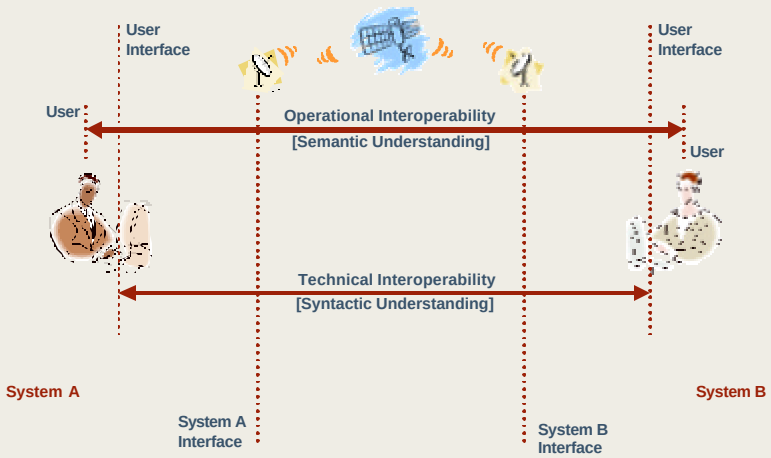
Technical Vs. Operational Interop



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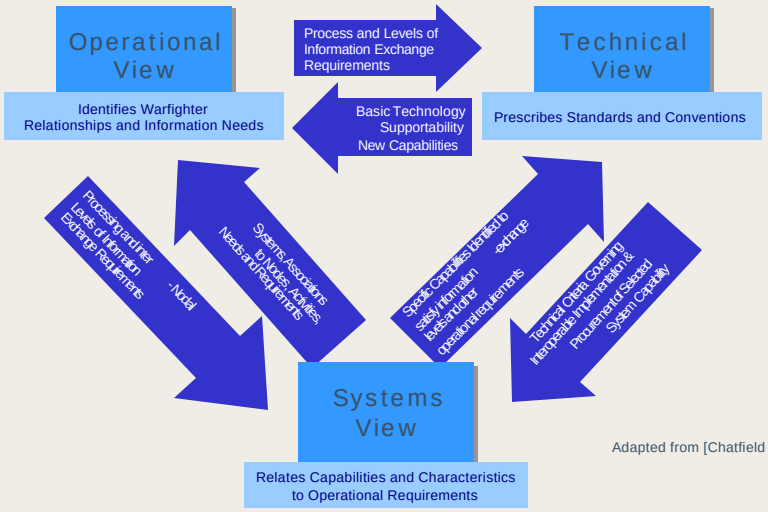
Interoperability – Three Views



Adapted from [Chatfield 98]

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Technical Interoperability Scorecard

Operational View | **Technical View** | Systems View

System	Compliance†
S_1	R
S_2	Y
S_3	G
S_4	G
S_5	R
S_6	Y
⋮	⋮
S_n	R

Adapted from [Committee 99]

† The entries rate as pass/marginal/fail (green, yellow, or red) the compliance of systems S_1, S_2 … S_n with the relevant standards and guidance.

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Systems Interoperability Scorecard

Operational View | Technical View | **Systems View**

	S1	S2	S3	S4	S5	···	S_n
S1							
S2	G						
S3	Y	R					
S4	Y	G	N/A				
S5	G	G	R	Y			
.	⋮	⋮	⋮	⋮	⋮		
S_n	G	Y		G	G		

The entries rate as pass/marginal/fail (green, yellow, or red) the pairwise interoperability of the systems indicated in the row and column headings.

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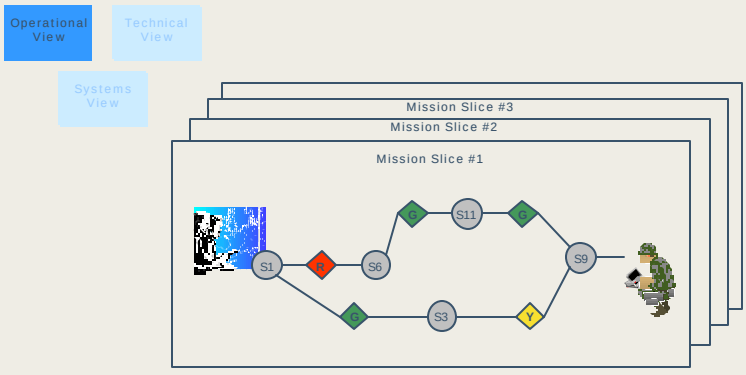
Operational Interoperability Scorecard



The diamonds rate as pass/marginal/fail (green, yellow, or red) the ability of the systems (indicated as circles) to provide the required information flows (indicated by arrows) for a particular mission slice.

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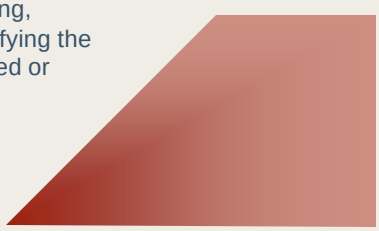
Levels of Information Systems Interoperability [LISI]

- Project initiated by MITRE, The C4ISR Integration Task Force, and the C4ISR Architecture Working Group
- LISI is a reference model and process for assessing information systems' interoperability.
- It provides a discipline for defining, measuring, assessing, and certifying the degree of interoperability required or achieved between systems.



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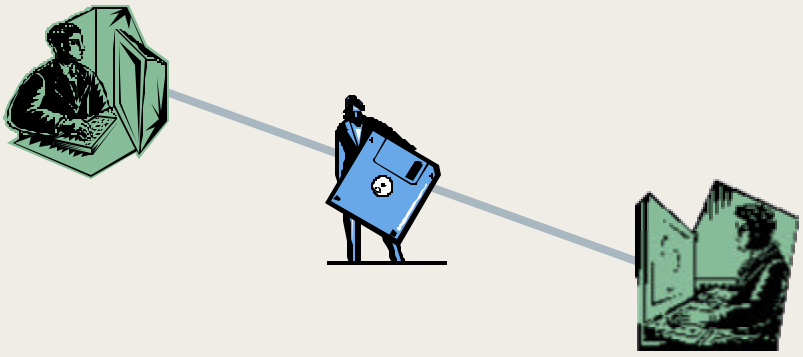
Level 0: Isolated

Manual gateway



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Level 1: Functional

Email, FM voice, tactical data links, text files

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Level 2: Functional

Annotated imagery, maps w/ overlays

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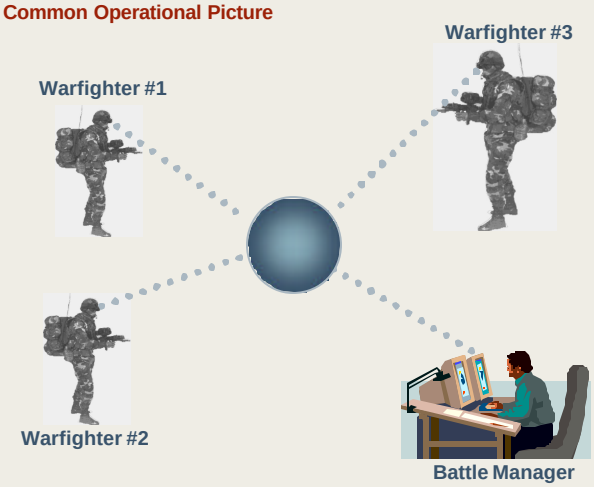
Level 3: Domain

Common Operational Picture



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Level 4: Enterprise

Event-triggered global database update

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LISI Maturity Levels - Summary

4	Enterprise	• Cross-domain information & advanced collaboration • Interactive manipulation of shared data & applications
3	Domain	• Shared data but separate applications • Sophisticated collaboration
2	Functional	• Minimal common functions; separate data & applications • Heterogeneous product exchange • Basic collaboration
1	Connected	• Electronic connected; separate data & applications • Homogeneous product exchange
0	Isolated	• Non-connected • Homogeneous product exchange

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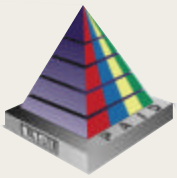
LISI Capabilities Model



Description	Computing environment	Level
Enterprise	Universal	4
Domain	Integrated	3
Functional	Distributed	2
Connected	Peer-to-Peer	1
Isolated	Manual	0

Interoperability Attributes

PAID

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The PAID Attributes

P Policies and procedures that enable systems to exchange information capabilities and services

- Standards
- Security Policy
- Management
- Operations

A The set of applications that enable information exchange, processing, or manipulation (based on user requirements).

I The infrastructure required to support the systems operations

- Communications and Networks
- System Services
- Hardware
- Security Equipment

D The data and information structures used to support both the functional applications and system infrastructure

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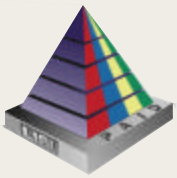
LISI Capabilities Model



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Interoperability Attributes

PAID

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LISI Capabilities Model

Level (Environment)			Interoperability Attributes P	A	I	D
Enterprise Level (Universal)	4	c	Multi-National Enterprises	Interactive (Cross applications)	Multi-Dimensional Topologies	Cross-Enterprise Models
		b	Cross Government Enterprises			
		a	DoD Enterprises	Full Object Cut and Paste		Enterprise Models
Domain Level (Integrated)	3	c	Domain (Service/Agency Doctrine, Procedures, Training)	Shared Data (e.g., Simulation Displays, Direct DB exchange)		DBMS
		b		Group Collaboration		Domain Models
		a		Full Text Cut & Paste		
Functional Level (Distributed)	2	c	Common Operating Environment (e.g., DICOE Level 5 Compliance)	Web Browser	LAN	Program Models and Advanced Data Formats
		b		Basic Operations (Documents, Spreadsheets, Pictures, ect.)		
		a	Program (Standard Procedures, Training, etc.)	Advanced Messaging (Message Parsers, Email w/ attachments)		
Connected Level (Peer-to-Peer)	1	d	Standards Compliant (e.g., JTA)	Basic Messaging (e.g., Simple Text))	Two-Way	Basic Data Formats
		c		Data File Tansfer		
		b	Security Profile	Simple Interaction (e.g., Telemetry, Remote Access, Voice, Fax)		
		a			One Way	
Isolated Level (Manual)	0	d	Media Exchange Procedures	N/A	Removable Media	Media Formats
		c	Manual Access Controls		Manual Re-Entry	Private Data
		b				
		a				
		0	No known interoperability			

Example Implementation Options Table

WAN
- SIPRNET
- JWICS
- NIPRNET
- (Internet)
- DISN LES
- VSAT
- DISN

NET
- Link 16
- Link 22
- UHF Radio
- VHF Nets
- Ethernet
- Token Ring
- Other Nets

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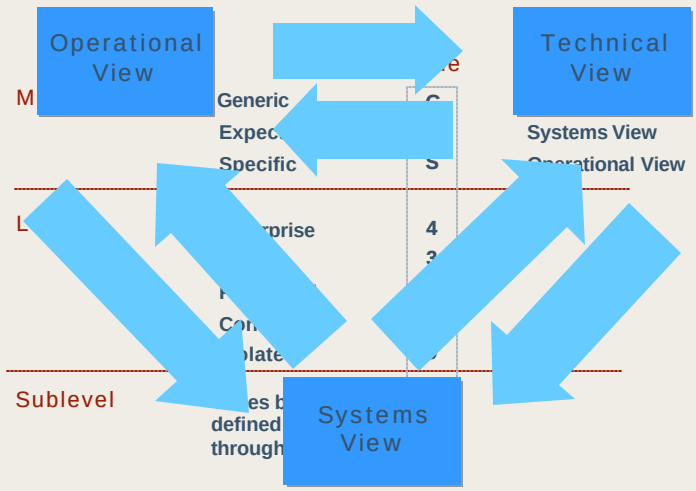
The LISI Metric



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Technical View

Example LISI Profile & Resulting Metric for Single System

Level (Environment)			Interoperability Attributes: P	A	I	D
Enterprise Level (Universal)	4	c				
		b				
		a				
Domain Level (Integrated)	3	c	Service-approved MNS & ORD, WAN addressing scheme		TCP/IP WAN, NFS, SNMP, ISDN card	MIDB, SQL
		b				
		a		IE 4.0		
Functional Level (Distributed)	2	c				NIFT.2
		b	DII COE Compliant. Windows-std file name extensions	MS Office, Access CMTK, 5D, MPEG Viewer	IPLAN NES NTP.X.500	USMTF, x.400, .wks, .xls, DTED, DBDB, .ppt, .doc, RPF, CGM, JBIG, JPEG, HTML, VPF
		a	On line Documentation	Eudora	TBS, LINK 16 & 22	
Connected Level (Peer-to-Peer)	1	d	Windows Interface Design Guide (JTA)		HF Data Modem, Kermit, STU III, GSM Cellular	MPEG 1.2 GKS, wmf
		c		FTP		
		b	ITU-T Rec X.509. Mil Std 2045-28500 Security Labels	Chat 2.0 Win32 API.PPS		
		a			GBS	
Isolated Level (Manual)	0	d	Login procedures			
		c				
		b				
		a				
		0	No known interoperability			

System *generic* metric is "G2c"

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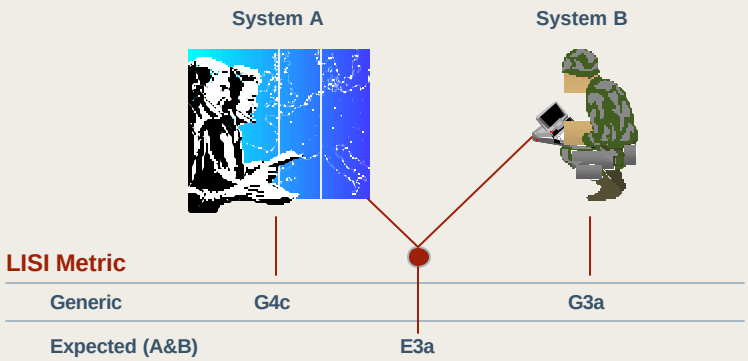
Systems View

When Comparing Two Systems

The LISI metric is simply the lesser of the two systems' generic levels. This is the **expected** LISI metric.



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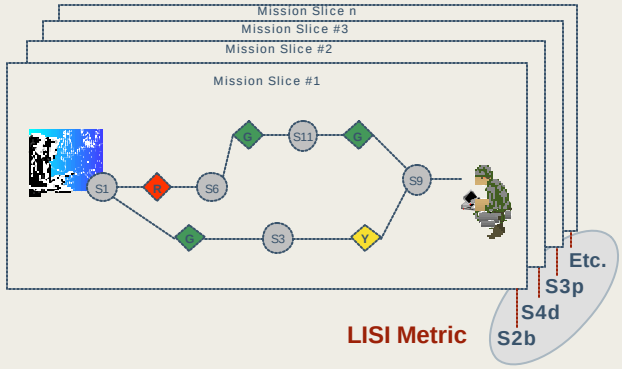
Two Systems in Operational Use

This LISI metric takes into account the environmental factors and specific mission requirements. This is the **specific** LISI metric.



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Operational Detailed Measures of Interest - Examples

- Connectivity
- Capacity
- System Overload
- Underutilization
- Undercapacity
- Data latency
- Information interpretation & utilization

$$Q_{eff} = (Q_{max} - Q_{oh}) \times (t_f - t_p)$$

Where:

Q_{eff} = Effective system capacity (data rate)
Q_{max} = Maximum data rate
Q_{oh} = System overhead data rate

- Percentage of initial transmission messages received correctly by shooters
- Percentage of consistency/disparity of redundant data sources
- Number of tries needed to establish connections
- Delay in sending critical command messages and time to receive acknowledge messages

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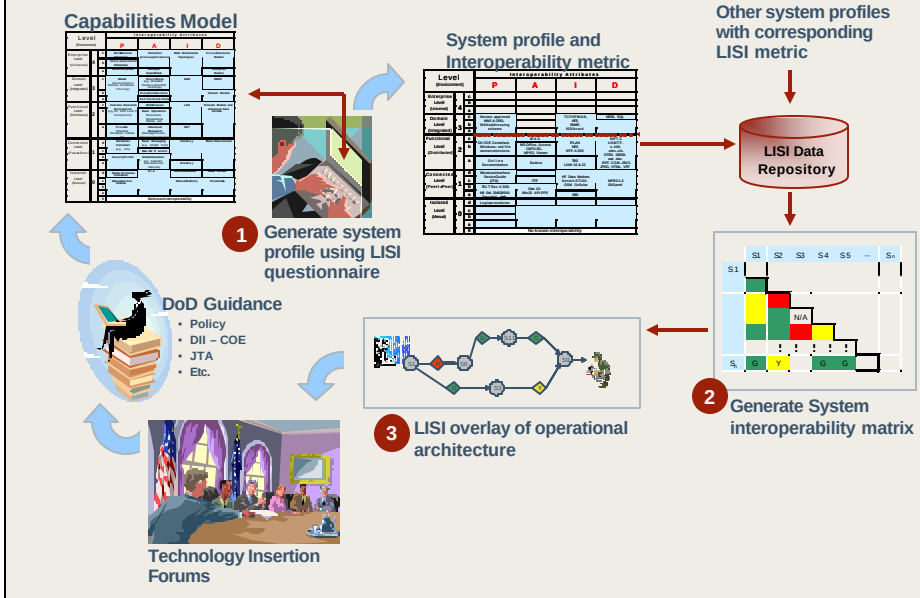

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Measuring Management Commitment to Interoperability

The Committee to Review DoD C4I Plans and Programs found that:

> **"achieving C4I interoperability is more a matter of organizational commitment and management than one of technology"**

Potential management measures

- **Number of systems certified to be interoperable**
- **Time (or personnel required to develop time-phased force and deployment data**
- **Time need to stand up a tactical network for a joint task force**
- **Number of individuals trained in the use of specific C4I systems**

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Next Steps

1. Establish collaborative relationships with stakeholders who are conducting interoperability assessments.
2. Provide guidance for measurement aspects of the assessment process(es).
3. Pilot the process using measures developed in stage 2.
4. Conduct a lessons learned to evaluate the utility of the measures that were piloted.
5. Assess the results of the pilot study, develop recommendations and publish the results for the community.

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