Enterprise-Wide, Net-Centric System-of-Systems Engineering and the Global Information Grid

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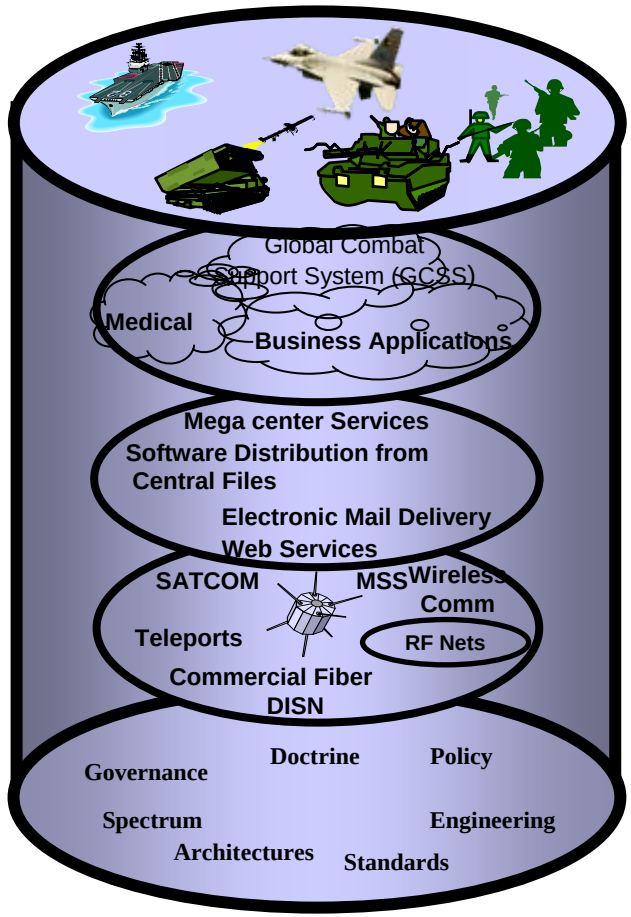
Outline

- **Fundamental challenges**
- **Enterprise-wide, net-centric SOS engineering solutions**
- **Recommendations**

- **Netted systems engineers**
- **NC SOSE to the edge**

Fundamental Challenges

- How to develop hundreds / thousands of appropriately interoperable systems / net-centric services
  - Optimized to different requirements
  - Different developers
  - Interacting missions
- How to get the most from them:
  - Performance, cost, risk, agility
- How to:
  - Allocate resources
  - Coordinate capabilities
  - Manage development
  - Encourage experimentation
  - Continually transition from legacy to new



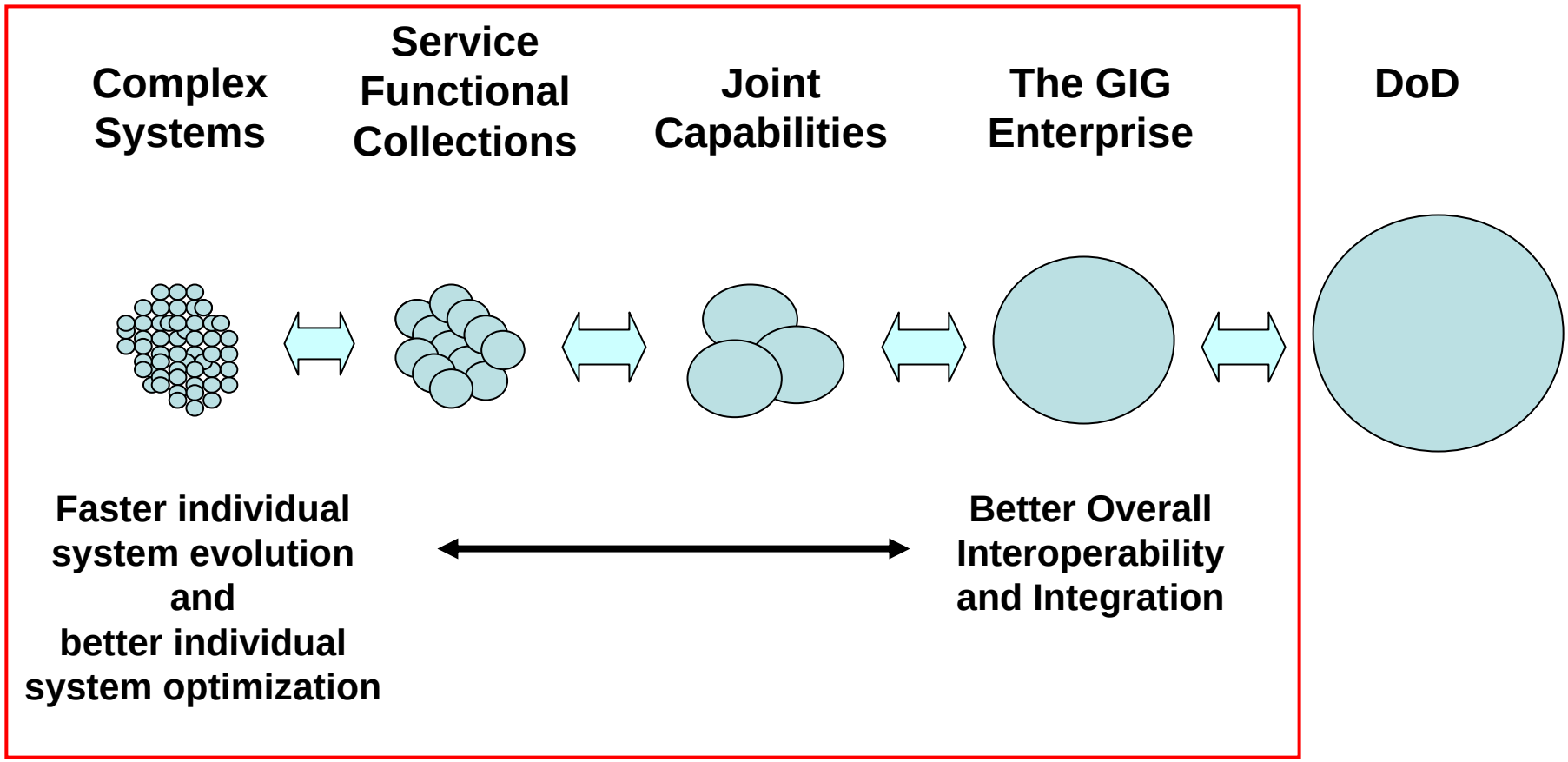
Definitions

- **System: “A set of components organized to accomplish a specific function or set of functions.” - IEEE 1471 –2000 (Recommended Practice for Architectural Description of Software-Intensive Systems)**
- **System-of-systems: A large, complex, enduring collection of interdependent systems under development over time by multiple independent authorities to provide multiple, interdependent capabilities to support multiple missions**

Comparison of Systems of Components and Systems-of-Systems

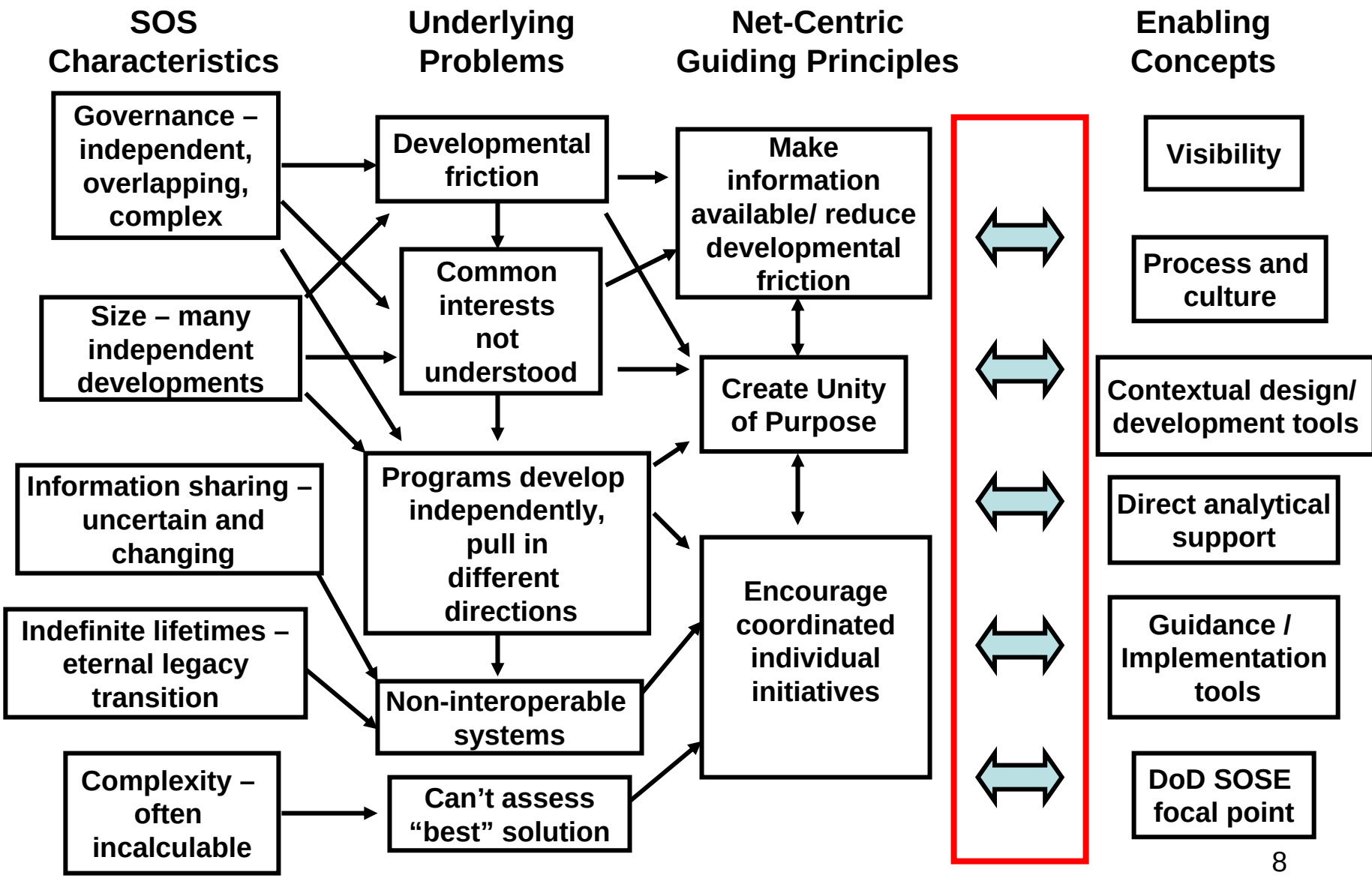
	Systems of Components	Systems-of-Systems
Governance	One dominant influence	Multiple, overlapping spheres of influence
Lifetime	Specific design lifetime (lifetime may be extended)	Indefinite (infinite) lifetime
Information flows	Well understood internal information flows and need lines	Poorly understood information flows - potentially universal information sharing
Size	Usually local	Frequently global
- Boundaries	Well-defined	May change over time; may be subject to dispute
- Independent developments	Rare	Common
Complexity	Optimized to agreed-upon measures	Highly complex and rarely optimized
Constituents	Components	Systems
- How developed	Commercial off the shelf or developed under control of system authority	Developed by others (very rarely commercial off-the-shelf), not by ensemble authority
- Complexity	Simpler – complexity designed out	More complex – complexity encouraged or ignored

Systems-of-Systems Defined, and SOS Engineering Performed on Many Scales

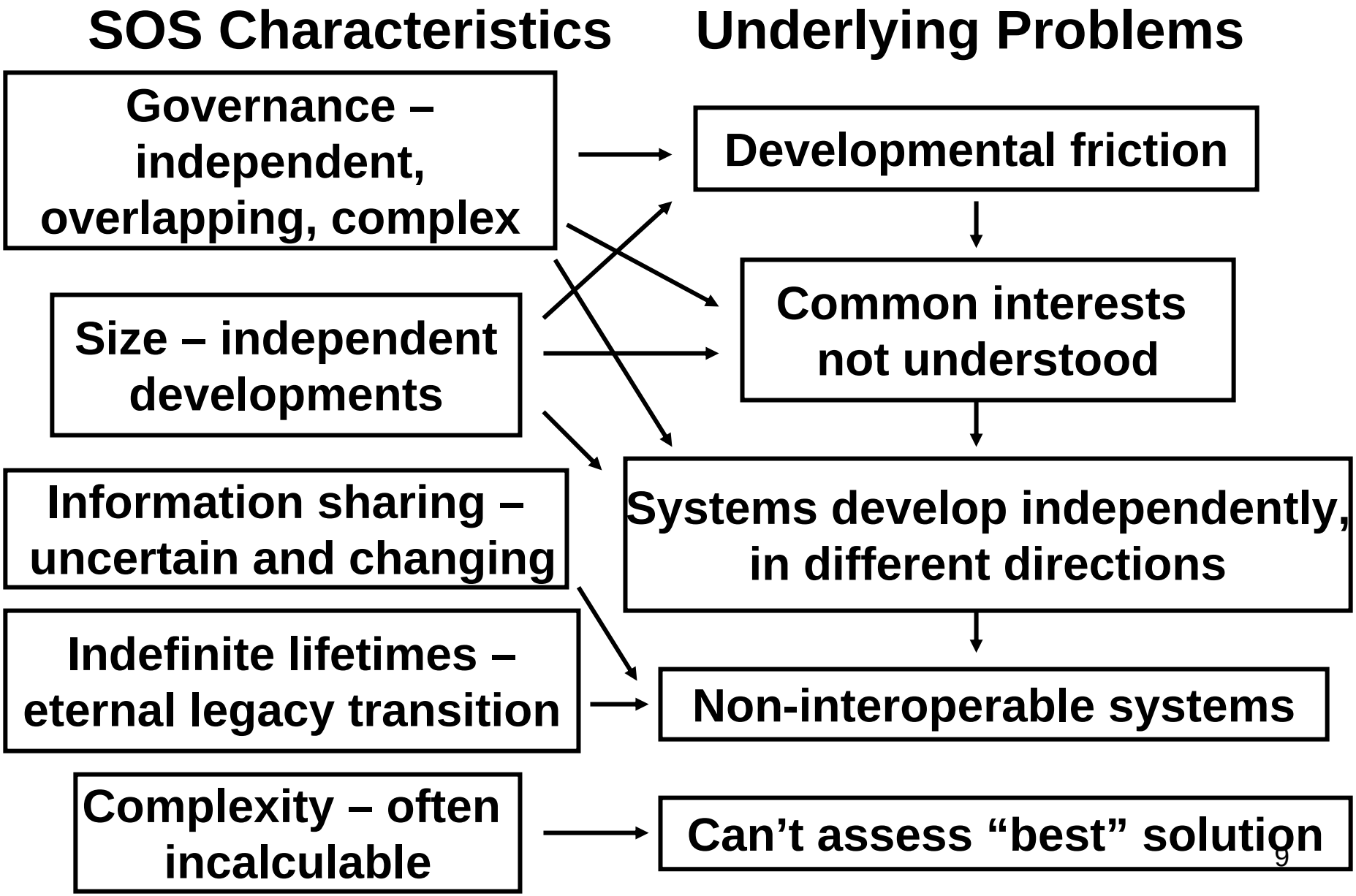


Today's Focus

Characteristics, Problems, Net-Centric Guiding Principles and Solution Groups



Characteristics and Underlying Problems



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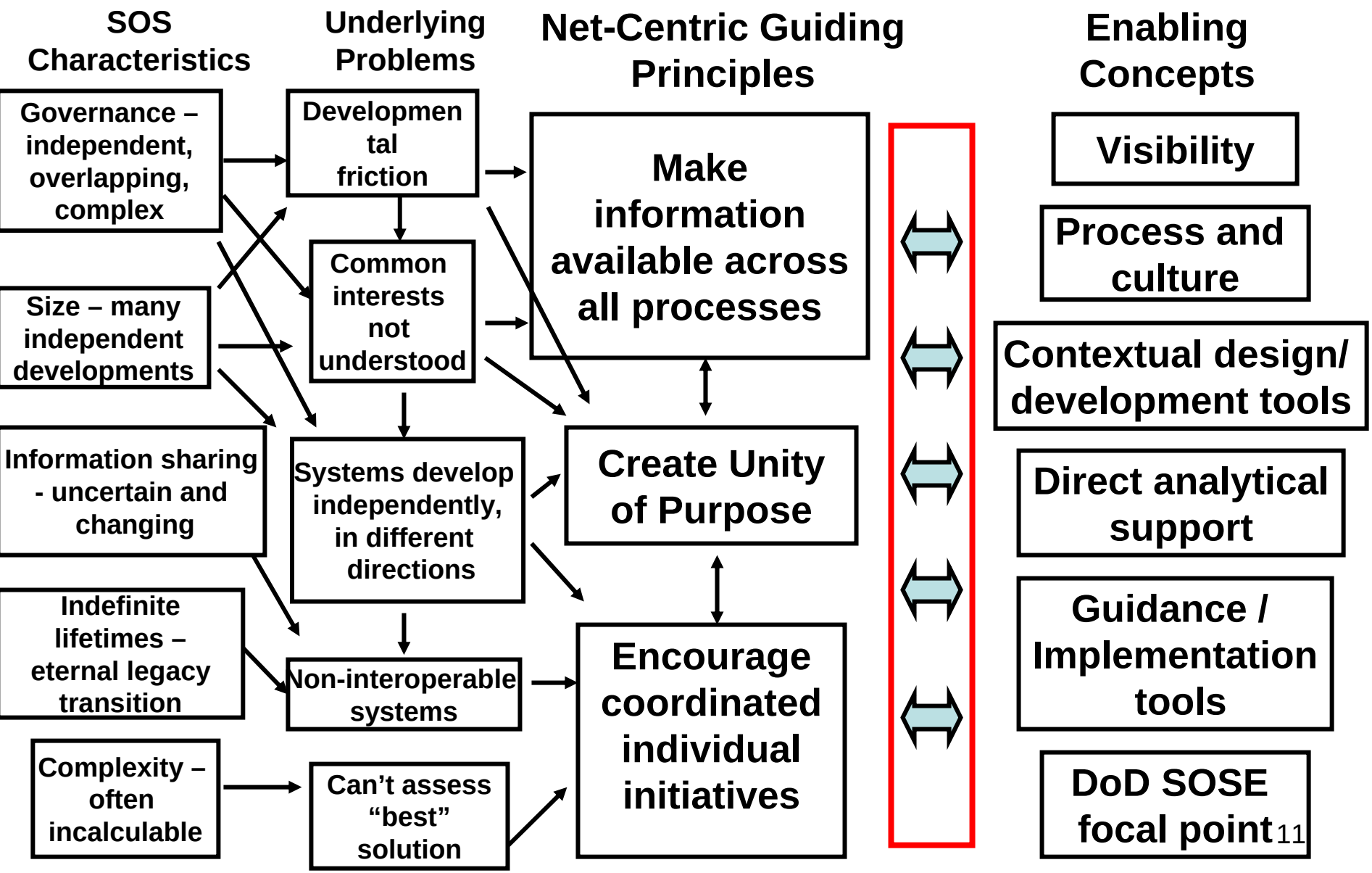
- **Fundamental challenges**
- **Enterprise-wide, net-centric SOS Engineering solution**
- **Recommendations**

- **Netted systems engineers**
- **NC SOSE to the edge**

Characteristics, Problems, Net-Centric Guiding Principles and Solution Groups



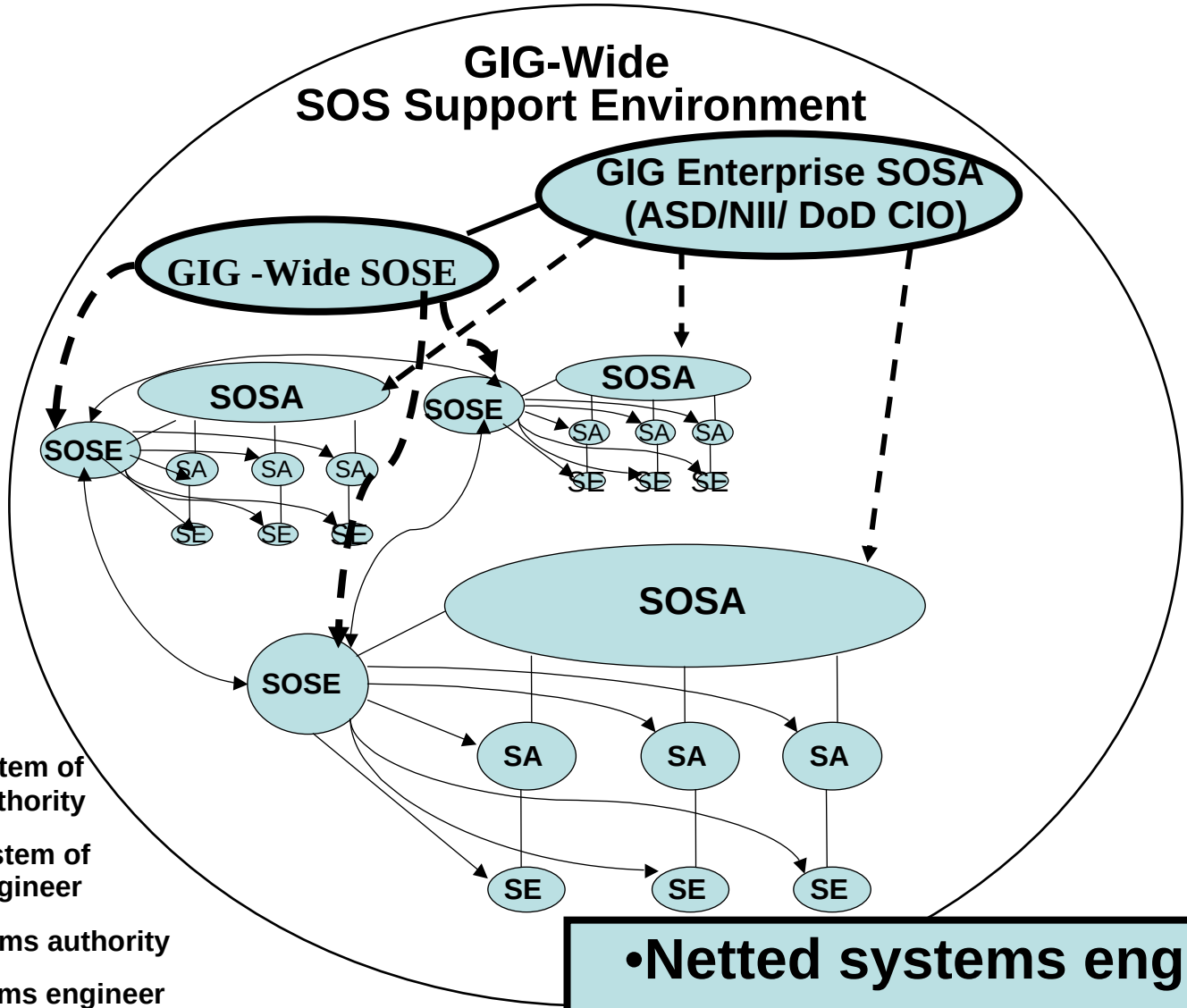
SOSAs and SOSEs

- SOSAs have authority derived from oversight, resource control, requirements definition, or certification
  - Examples: Military service PEO/PM, OSD Principal Staff Assistants, Joint Staff JCIDS Functional Capabilities Boards
- SOSAs are responsible for creating the "best" systems-of-systems
- A SOSE requires and works for a SOSA
- Existing governance relationships are not affected

SOSE Roles

- **A SOSA uses its SOSE** to develop and evolve “best” mission-oriented **capabilities**
- **A SOSE has three major roles:**
  - Provide and coordinate **overall analytical support (classical systems engineering) for the SOSA**
  - Enhance program and technical **coordination across programs – create the environment**
  - **Coordinate** technically with SOSAs and SOSEs **in related areas**.

GIG Net-Centric System-of-Systems Engineering



- SOSA = System of systems authority
- SOSE = System of systems engineer
- SA = Systems authority
- SE = Systems engineer

- **Netted systems engineers**
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Outline

- **Fundamental challenges**
- **Enterprise-wide, net-centric SOS engineering solutions**
- **Recommendations:**
  - **Empower a GIG EW SOSE to create the environment**
  - **Adopt the 3 principles**
  - **Adopt specific recommendations in 6 enabling areas**

- **Netted systems engineers**
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Recommended E-W Initiatives

Enabling Area	Near-term	Mid-term
Visibility	• Minimum Posting requirements •SOS architectures	• Productivity tools that post • Dependency tracking software
Process and Culture	• Standards activities • Mission /capability champions	• Curriculum and education
Contextual design and development tools	• Modeling forum, stds, tools • Interoperable GIG Mission performance models	• Joint, networked experiment, development, test environments
Direct analytical support		• Performance / cost / risk analyses across SOSs
Guidance and Implementation tools	• Net-centric SOSE guidance • Advocate NETOPS (enterprise management) approaches	• Mandate improved DISR • NETOPS (enterprise management) guidance
GIG EW SOSE focal point organization	• Create the Environment • SOSA and SOSE forum • Missionary work	• Lead and promote activities

More on Culture

- **SOSAs should**
  - **Expect to be asked questions about performance of their SOS in the context of other systems**
  - **Automatically create SOSEs**
  - **Automatically post and share information across systems-of-systems and developmental processes**
- **SOSEs should**
  - **Know their 3 roles, the available SOSE tools, basic interoperability requirements and support products**
  - **Be able to find the SOSEs they should work with**
  - **Expect other SOSEs to have products to enable visibility, interoperability, functional integration, and common performance analyses**

•Netted systems engineers

•NC SOSE to the edge

Questions

Comparison of Principles

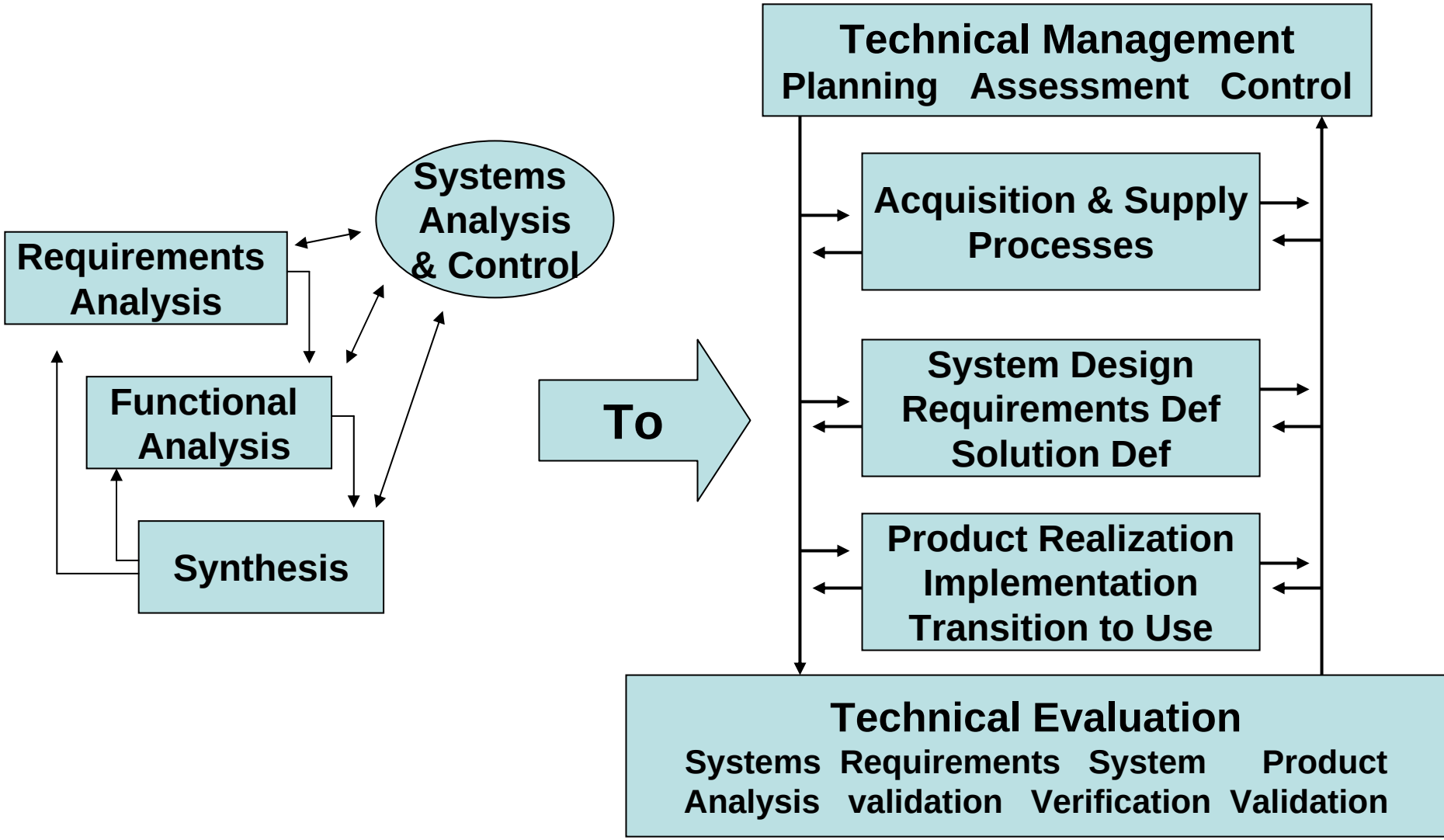
Systems Engineering

- Defining (Requirements analysis)
- Bounding (Functional analysis)
- Optimizing (Synthesis)

System-of-Systems Engineering:

- Visibility
- Unity of purpose
- Coordinated individual initiatives

Systems Engineering



Mil Std 499B - 1974

ANSI/GEIA EIA632 - 2003

Net-Centric Recommendations for Individual System-of-Systems Engineers

- Visibility across a SOS
  - System Posting Requirements
  - Productivity tools that post
  - Joint Systems/Services Architecture
  - Joint Operational Architecture
  - Dependency tracking tool
  - Create the SOS portal
- Contextual tools for a SOS
  - Stakeholders' modeling forum
  - Modeling Framework
  - Modeling standards and tools
  - Mission performance model
  - Distributed networked experiment development/test environment
- Guidance for a SOS
  - Interoperability IT Standards (consistent with DISR)
  - Interoperability COI Data (syntax and semantics)
  - Guidance compliance tools
- Culture for a SOS
  - SE Training
  - Create SE forum
  - Create technology roadmap
- Systems engineering support & analysis for a SOSA
  - Performance, cost, risk analyses
  - Support for higher level reviews
  - Program Reviews - technical support
  - Support/leadership of IPT's
  - Work across SOS boundaries
  - Concepts for operational management of the SOS
  - Better functional processes

Net-Centric Recommendations for DoD SOS Engineering

- **Visibility across DoD**
  - Minimum Posting Requirements
  - Joint Systems / Services Architecture
  - Joint Operational Architecture
  - COI data repository
  - Future Interoperability Technologies
- **Tools for DoD**
  - Productivity /Posting Software
  - Dependency Tracking software
  - Modeling and Simulation
  - Joint Distributed Development & Test Environment
- **Focal Point Organization**
  - Lead and Promote DoD Activities
  - SOSA / SOSE Councils
  - Analytical Capabilities
  - Promote SOSE field
  - List, clarify, make visible relationships
- **Guidance for DoD**
  - Open interoperability standards
    - Commercial Participation
    - Reenergize activities
    - Enterprise services
    - Mandated Use
  - Integrated Operational Management (NETOPS)
  - Implementation Guidance for Systems Engineers
- **DoD-wide culture & process**
  - Share All Information across DoD
  - Appoint & Empower Mission and Capability Champions
  - More Joint Acquisitions
  - Joint Acquisition Agency
  - Reenergize, encourage Interoperability Processes
  - Create a SOSE Curriculum and Educational Program

Example Systems of Systems

- **COCOM Sponsored**
  - **USTRANSCOM's System-of-Systems**
  - **Joint Battle Management Command and Control (JBMC2)**
- **Service controlled**
  - **LandWarNet**
  - **C2 Constellation and ConstellationNet**
  - **ForceNet**
  - **Army's Future Combat System**
  - **MAGTF system of systems**
- **DoD-wide**
  - **GCCS and GCSS**
  - **NCES**
  - **GIG**
- **Potential**
  - **ISR systems**
  - **Communications systems**

GIG Enterprise-Wide SOSE

- **Goal**
  - Develop and evolve “best” mission-oriented **capabilities** for DoD
- **Net-centric guiding principles:**
  - Improve **information availability**
  - Enhance **unity of purpose**
  - Encourage **coordinated individual initiatives**
- **Activities:**
  - Provides a **focal point for net-centric SOSE**
  - Creates an **information-sharing culture and environment**
  - Enhances **visibility across programs and systems**
  - Provides **contextual experiment, design and development environments, and contextual design tools**
  - Creates **analytical support across GIG**
  - Leads the **development of guidance** that NII/CIO can promulgate
  - **Coordinates with SOSEs in related areas** (e.g., weapons systems acquisition)

Definitions

- **System-of-systems: A large, complex, enduring collection of interdependent systems under development over time by multiple independent authorities to provide multiple, interdependent capabilities to support multiple missions**
- **System-of-systems engineering: The cross system, cross-community process that ensures the development and evolution of mission-oriented capabilities to meet multiple stakeholders' evolving needs across periods of time that exceed the lifetimes of the individual systems that comprise it**

Definition of a System

- **“A set of components organized to accomplish a specific function or set of functions.” - IEEE 1471 –2000 (Recommended Practice for Architectural Description of Software-Intensive Systems)**
- **“An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective.” - Systems Engineering Fundamentals – Jan 2001 – DoD Systems Management College**

Benefits

- **Better integration of requirements, resource allocation, acquisition, and development**
- **Better development within systems of systems**
- **Better development across systems of systems**
- **Better operational management of GIG resources**

Better war fighter value

Complex Relationships Systems, Functions, Missions and Overall Multi-Mission Effectiveness

SC=Scenarios

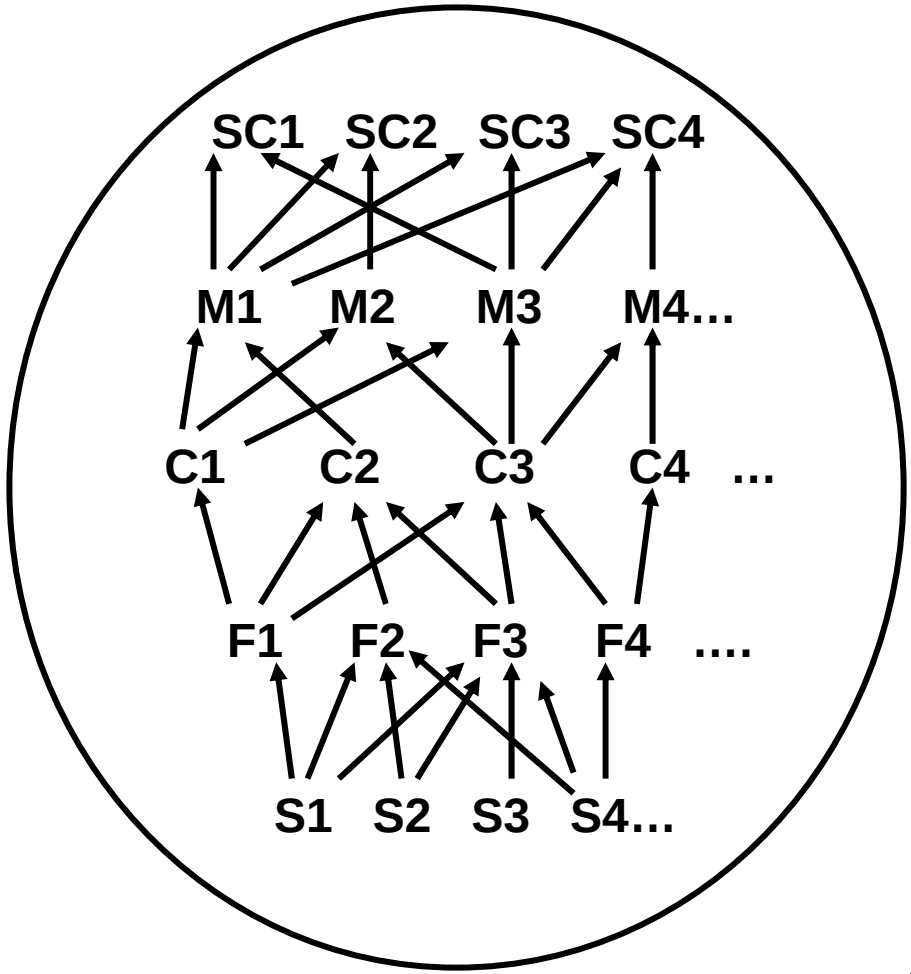
M=Missions

C=Capabilities

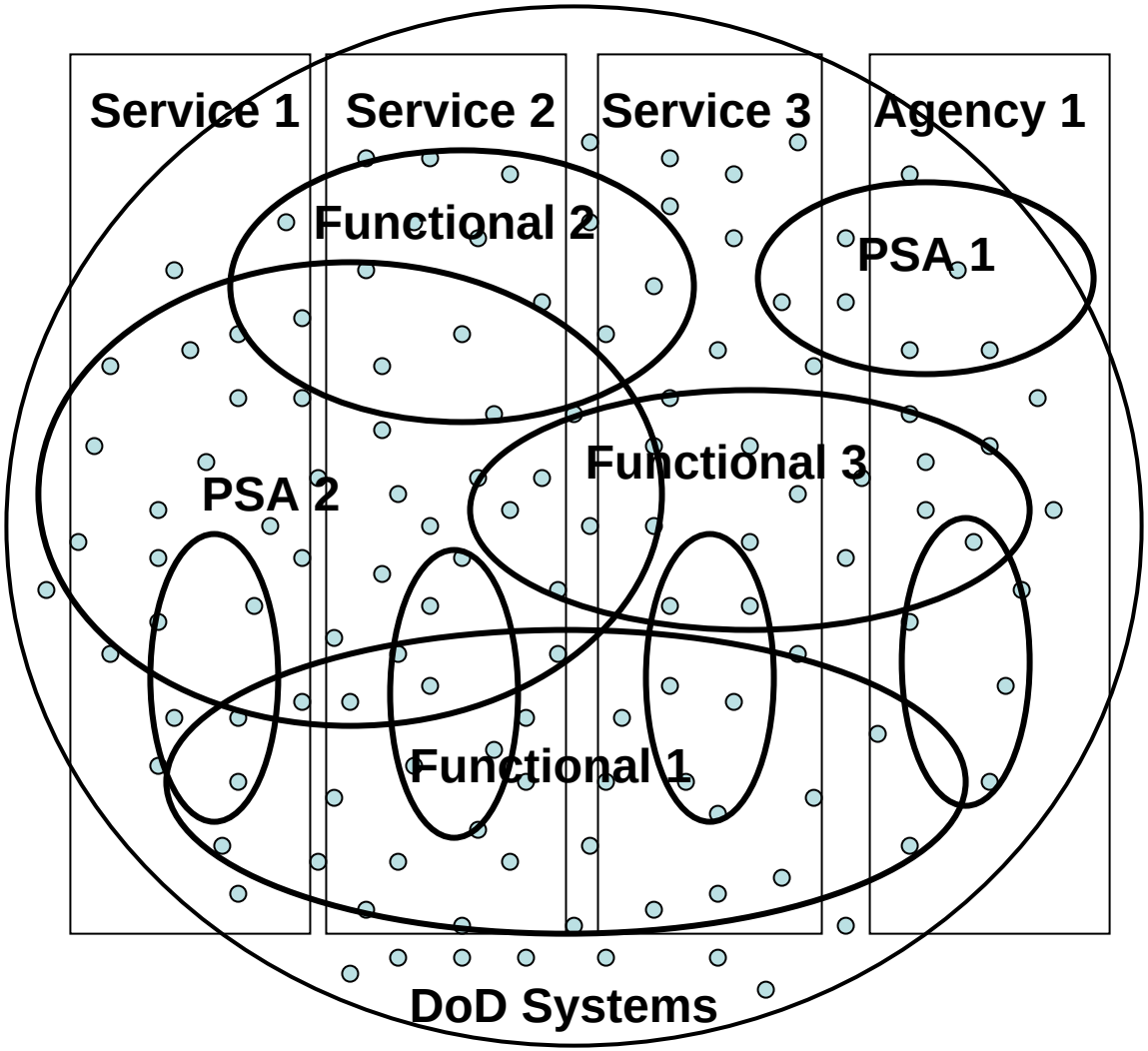
F=Functions

S=Systems or Services

Too complex to calculate!



System-of Systems Engineering Is Done on Many Scales and Across Many Governance Processes Simultaneously



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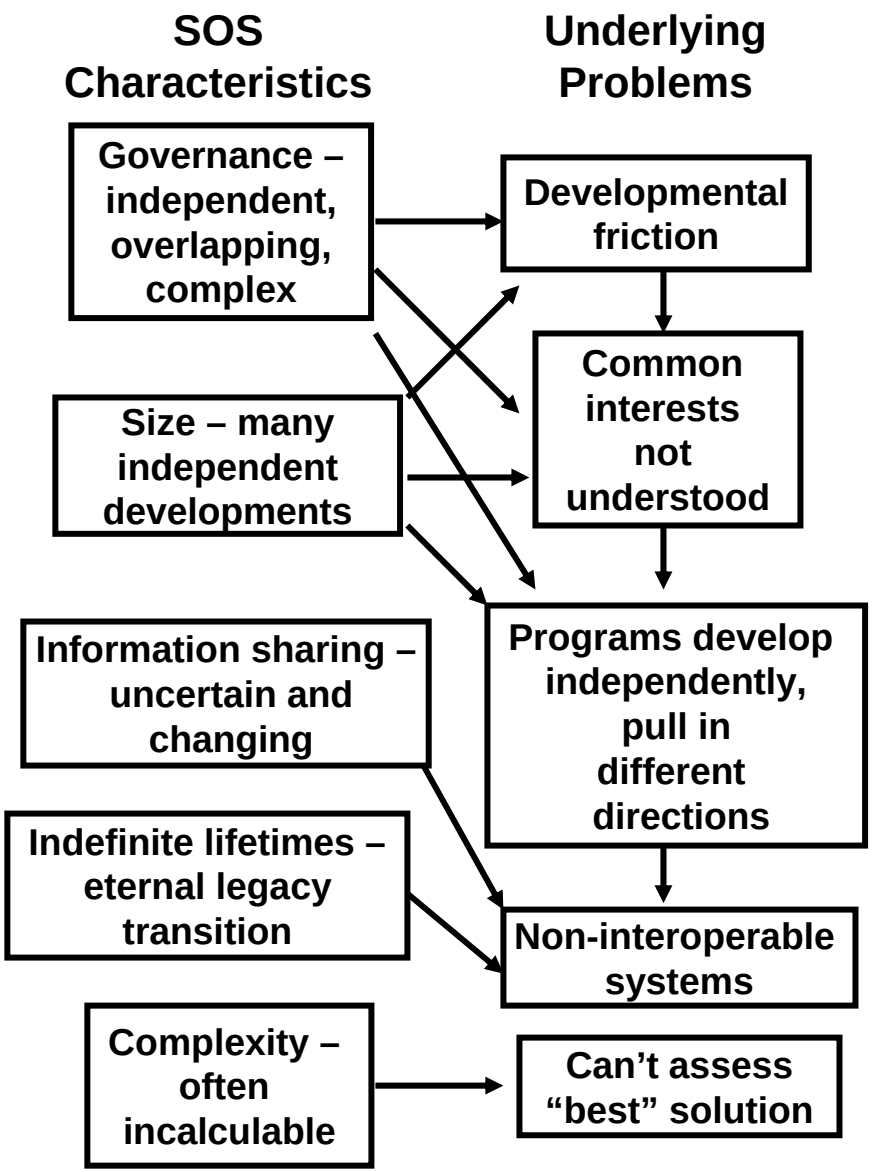

Example Systems of Systems and Major Systems

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- DoD-wide
  - GCCS, GCSS and follow-on SOS
  - NCES
- Potential
  - ISR systems
  - Communications systems
  - All GIG systems and systems-of-systems
- Major systems/SOS
  - DISN communications (including GBE)
  - TCS
  - JTRS

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  - JTRS

Recommended Initiatives

Solution Group	Near-term	Mid-Far term
Visibility	•Minimum Posting requirements •GIG and SOS Portals	•Productivity tools that post •Dependency tracking software •SOS architectures
Process and Culture	•Rationalize and reenergize DoD standards activities - emphasize DoD net-centric standards	•Mission/capability champions •Curriculum and education
Contextual design and development tools	•Modeling forum, standards, tools •Mission performance models	•Joint, networked experiment, development, test environments
Direct analytical support	•(foundation in mission/capability champions, performance models)	•Performance/cost/risk analyses across SOSs
Guidance and Implementation tools	•Net-centric SOSE guidance •Advocate NETOPS (enterprise management) approaches	•Mandate improved DISR •NETOPS (enterprise management) guidance
DoD SOSE focal point organization	•Missionary work •SOSA and SOSE forum	•Lead and promote activities •Promote SOSE field

Governance

- **No obviously “best “ governance**
- **Governance changes over time**
- **SOSE approach must work under all governance structures**
- **SOSE must not add another governance structure, or compete with existing governance structures**