Ground System Architecture Workshop

Defining System Interfaces in System of Systems with SOA

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Agenda

• Value Proposition for SoS Planning
• Interface Definition Context
• Shared Business Process
• System of Systems Interoperability Dimensions
• Model Driven Requirements
SoS SatCom Planning Value Proposition

- Provide automated SatCom capacity planning across constellations
- Provide composite, automated situation awareness in SatCom resource utilization across SatCom systems
- Enable resource allocation and mission planning across collaborative SatCom systems
- Phased approach to benefit from incremental degree of coupling
INTERFACE DEFINITION CONTEXT

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System of Systems

- Collaborative satellite systems
  - Collaborative resource management
  - Shared situation awareness/common operation picture
Requirements Definition Assumption
- System of Systems Capacity Planning ERP

Unified Inter-System ERP Interface
- SatCom Resource Request Database
- SatCom Aggregate Resource Resource Models
- SatCom Aggregate Resource Allocation Tool
- SatCom Aggregate Capacity Planning Tool
- Inter-constellation Mission Planning Tool
- SatCom Network Management Tool
- Usage Monitoring and Billing

System-specific tools
Requirements Definition Assumption - SoS ERP Tools

SatCom Inter-fleet Resource Allocation
- Resource Requirement → SDB Mgt & Analysis → Joint SatCom Panel Coordination → Approved SDB → Usage/Monitor & Billing

SatCom Fleet Resource Allocation
- SAR → Simulation & Modeling → Network Configuration → Network Monitor and Maintenance

Inter-fleet Resource Management Tools
- Requirement Database and Analysis → SatCom Resource Configuration Scenarios → SatCom System Model of Resource Mapping → Capacity Planning Configuration

Individual SatCom Fleet Resource Management Tools
- SAR Database and Analysis → SatCom Resource Configuration Scenarios → SatCom System Model of Resource Mapping → Mission Planning Configuration
“The process to increase confidence that the interface requirements are correct and complete, and to define the level of details in requirements at a given stage to effectively reduce risk in developing net-centric systems”
SHARED USE CASES
Shared Business Process and Scenarios

• Existing use cases are often from the perspective of a single SatCom system

• Newly Use Cases needed to define the collaborative aspect of the federated planning system from one consistent perspective of a net-centric ground user and from a net-centric network manager.

• Be generous with the number of military operations (or Business Plan) Scenarios created in the analysis process as a way to validate completeness of requirements

• Use Case Actors – Collaborating satellite constellations
  - NetMgr_SoS or user_SoS (where the point of view resides)
  - SatCom System A: A_sp, A_gnd, A_term*;
  - SatCom System B: B_sp, B_gnd, B_term*;
  - SatCom System C: C_sp, C_gnd, C_term*;
  - ...,

* Each subscriber may be equipped with more than one type of SatCom System terminal.
## Shared Use Cases and Scenarios

- Exhaustive Use Cases and scenarios contribute to completeness of Interface Requirements

<table>
<thead>
<tr>
<th>Example Scenarios</th>
<th>Example Components of Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic scenario #5 Theater XYZ</td>
<td>Preference order and rules across SatCom Systems (A, B, C and so one), which can depend on terminal location, mission type, SatCom systems loading conditions</td>
</tr>
<tr>
<td>Americas Business Hours scenario</td>
<td>Business model/operation context</td>
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<tr>
<td>Special event/emergency/demand</td>
<td>Terminal distribution mapped to geography (over time if mobile)</td>
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<td></td>
<td>Traffic patterns mapped to terminal geographical locations over time</td>
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<td></td>
<td>Applicable business process/military Operation rules</td>
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<tr>
<td></td>
<td>Business process/operations rules</td>
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</table>
DEGREE OF COUPLING
Interoperability for Resource Allocation across SatCom Systems

- Syntactical and protocol interoperability assumed (tools can assist)
- Contextural coupling between the interfacing SatCom systems
  - Depends on the context of each of the interfacing systems
  - The development of contextural interoperability requires knowledge of the “interior” of each of the interfacing systems and the harmonization across systems
  - ICD reflects the result of the harmonization
- Level of coupling between the interfacing SatCom systems
  - Granularity examples:
    - Coarse: Satellite mission (real-time) coverage
    - Finer: channel_beam, channel_time_code_beam, medium spot beam, small spot beam
  - Coarse grain cross-system optimization
    - Fine granularity not exposed to interface
    - Translation from coarse to fine by individual system “wrapper”
  - Fine grain cross-system optimization
    - Fine grain exposed at the interface
Interoperability Approach for SoS ERP

<table>
<thead>
<tr>
<th>System Attributes</th>
<th>Interoperability Approach</th>
<th>Capability (C) and Development Needed (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System unique SAR/resource requests</td>
<td>• Common abstraction of SAR/resource requests</td>
<td>(D) Harmonizing existing SAR formats</td>
</tr>
<tr>
<td></td>
<td>• Global prioritization rule set and attributes</td>
<td>(D) One set of priority assignment scheme across all resource requests</td>
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<td></td>
<td>• Visualization of planned terminal locations</td>
<td>(C) Fine-grain visualization and visualization tools</td>
</tr>
<tr>
<td>System unique payload and terminal models</td>
<td>• Common payload and terminal modeling framework; each system has its own unique instantiation</td>
<td>(C) Payload and terminal modeling platforms as well as link analysis tool</td>
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<tr>
<td></td>
<td>• Link analysis tool</td>
<td>(D) Cross-constellation resource mapping</td>
</tr>
<tr>
<td></td>
<td>• Global superposition of ground track and potential beam coverage</td>
<td></td>
</tr>
<tr>
<td>Terminal inventory</td>
<td>Terminal inventory</td>
<td>(C) Terminal modeling and inventory management</td>
</tr>
<tr>
<td>System unique resource allocation constraint rules</td>
<td>Common abstraction of resource allocation rules; each system has unique instantiations</td>
<td>(C) Terminal modeling platforms and inventory management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(D) Harmonized SAR formats</td>
</tr>
<tr>
<td>System unique teleport model</td>
<td>Common teleport model</td>
<td>(C) Teleport models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(D) Harmonized teleport modeling</td>
</tr>
<tr>
<td>System Unique GIG interface</td>
<td>Common model for GIG interface</td>
<td>(C) GIG interface models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(D) Harmonized GIG interface modeling</td>
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* Common abstraction model allows individual system instantiations
### Interoperability Approach for SoS ERP

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<th>Industry Capability (C) and Development Needed (D)</th>
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<tr>
<td>Mission Planning Tool</td>
<td>• Common abstraction of Mission Event representation</td>
<td>(D) Harmonizing SAR formats</td>
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<tr>
<td></td>
<td>• Scenario generation</td>
<td>(C) Fine-grain event planning and scenario analysis</td>
</tr>
<tr>
<td>SatCom Resource Allocation Tool</td>
<td>• Collection of individual system tools</td>
<td>(C) Resource allocation tool</td>
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<tr>
<td></td>
<td>• Cross-constellation arbitration and optimization tool</td>
<td>(D) Tools for inter-constellation loading</td>
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<tr>
<td></td>
<td>• Cross-constellation load optimization</td>
<td>(D) Tools for inter-constellation resource allocation arbitration and optimization</td>
</tr>
<tr>
<td>Network Management</td>
<td>• Interface to individual system tools</td>
<td>(C) Network management tools</td>
</tr>
<tr>
<td></td>
<td>• Common abstraction of SatCom network resource representation for high level configuration and monitoring</td>
<td>(D) Common network management abstraction at SoS interfaces</td>
</tr>
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**Reusing Existing Individual System Implementations**

- Harmonizing Resources Exposed
- Understand Resources of Constituent Systems

*Common abstraction model allows individual system instantiations*
1. Integrated model of SatCom resource across the SatCom systems
   • Payload model:
     - Transponder connectivity
     - Channelizer routing Antenna pointing and contour
     - Antenna beam layout
     - Payload gain setting
   • Terminal model: Modem and waveform
   • Communication link model
   • Configuration constraint rule set
Inter-constellation Capacity Planning
Coarse-grain Planning Example

2. Aggregate SatCom resource request database

3. Cross-constellation scenario analysis using modeling and simulation tools

4. Coarse-grain global SatCom resource allocation and capacity planning
MODEL Driven Requirements
SOA Framework and Recommended SoS Interface Requirements Scope

Business process is either part of SoS interface definition or a document tightly coupled to interface definition.
Requirements Definition Assumption - Service Definitions and Composite Analysis Tools

Web Service Construct

- Presentation Layer
- Process Model (BPMN)
- Executable Process Layer (BPEL)
- Registry & Repository
- Business Services Layer
- Intermediate Services Layer
- Technical Services Layer
- Existing Information Systems Layer

Interface Functional Requirements Analysis Tools

- Use Cases
- DODAF Views
- Business Processes
- Customer Requirements & Flowdown
  - Service Definition
  - Operation Definition
  - Message Identification
  - Message Definition
Model Driven ICD Web Service Definition

- Define UML models with standard web service development process
- Messages binds with the operations defined in the service specifications to generate WSDL (COTS tools can perform automatic binding)
- Emulate business logic as input/output generators only (focus is on validating interface requirements)
- Utilize universal client for service invocation and validate runtime results
- Rapid validation process throughout requirements development process
Tools-captured Requirements

Relationship Among Requirements Artifacts

Message Model | Service Specification | WSDL | Service Deployment

![Message Model](image1)
![Service Specification](image2)
![WSDL](image3)
![Service Deployment](image4)
Model Driven Requirements Definition

- Cross-constellation level interoperability promoted using standards-based tools
- Implementation cycle for “the other side of the interface” accelerated
- Streamlined program management of specifications to implementation over the same development environment
- Reduction in technical risks using the same automated development environment from specifications to product generation
- Interface requirements represented accurately with standards-based UML features promoting product interoperability
- Tools-based requirements and artifacts traceability and mapping
- Increased flexibility in automated translation from XML representation to other schema
- Best practices incorporated in tool to provide real-time content generation check
Summary for SoS ERP in an SOA Construct

- Constituent technologies and analysis tools exist to realize integrated SatCom systems as an enterprise resource
  - Harmonizing (not redesigning) of existing systems

- Recommended artifacts for interface requirements in an SOA construct for a green field integrated SatCom system
  - Use Cases that are tailored for the federated system from a network manager’s and for a user’s point of view
  - Degree of coupling goals specifically expressed in collaboration and cross-system resource allocation optimization

- Requirements captured in tools for early validation of requirements
  - Interface requirements expressed as exposed services, web service operations and messages, using tools generated results