NORTHROP GRUMMAN

Ground System Architecture Workshop

Defining System Interfaces in System of Systems with SOA

March 1-4, 2010

Jean Tsao
Yeng-Zhong Lee PhD
Northrop Grumman Corporation

© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)

Agenda

NORTHROP GRUMMAN

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

SoS SatCom Planning Value Proposition

NORTHROP GRUMMAN

- 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

© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)

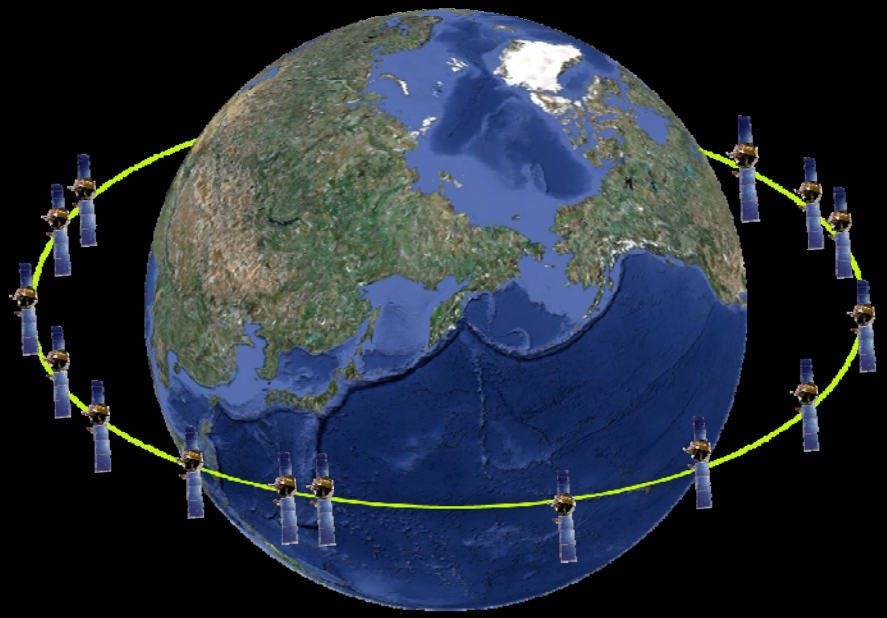
NORTHROP GRUMMAN

INTERFACE DEFINITION CONTEXT

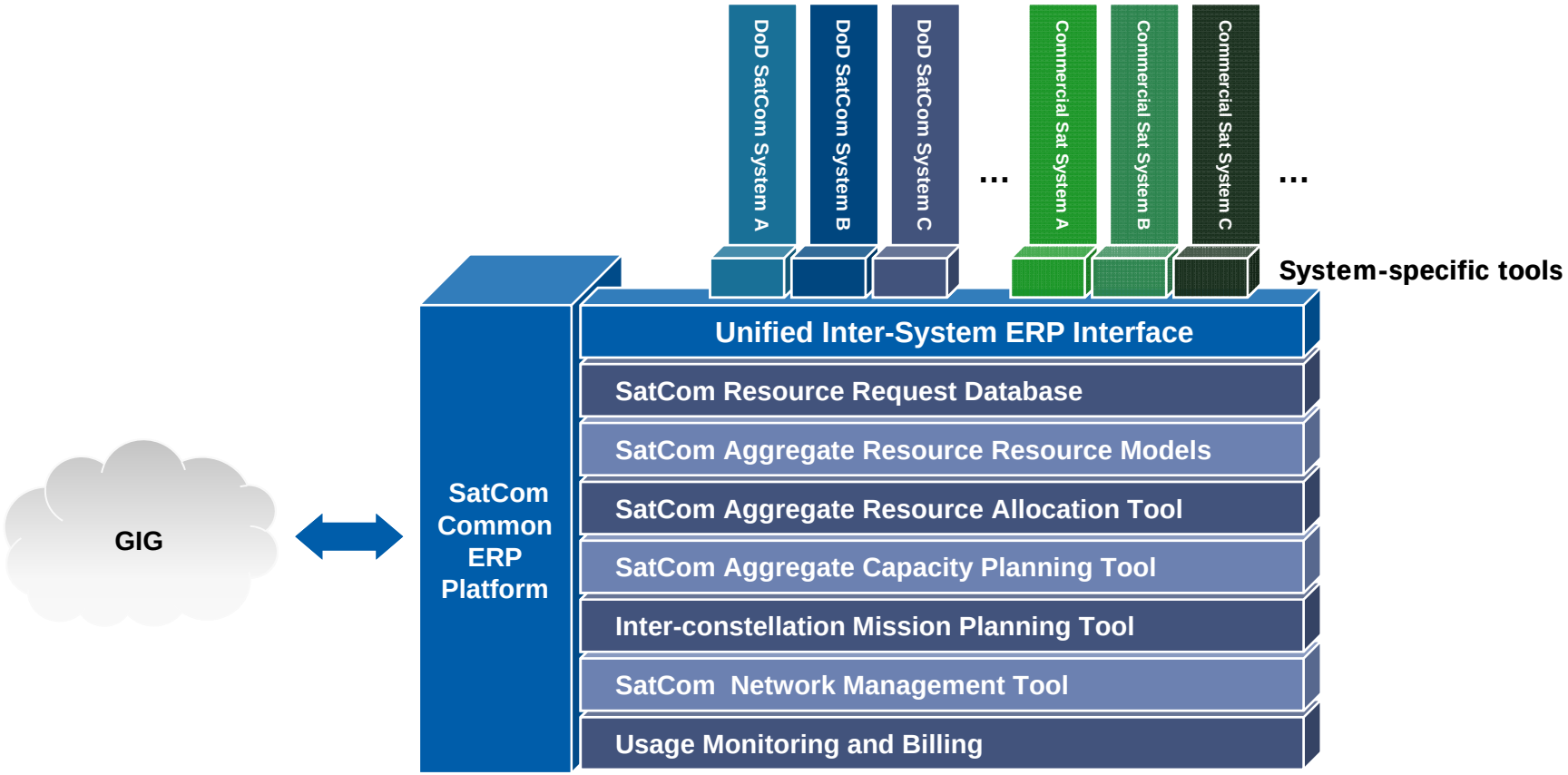
System of Systems

NORTHROP GRUMMAN

- Collaborative satellite systems
  - Collaborative resource management
  - Shared situation awareness/common operation picture



Requirements Definition Assumption – System of Systems Capacity Planning ERP

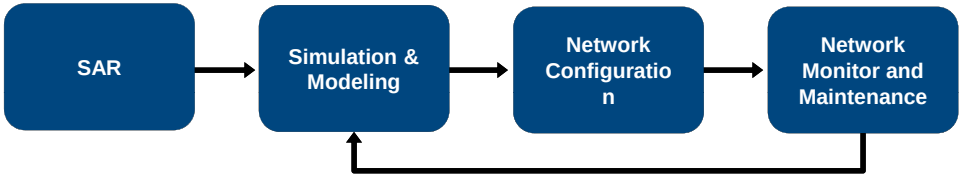


Requirements Definition Assumption – SoS ERP Tools

NORTHROP GRUMMAN

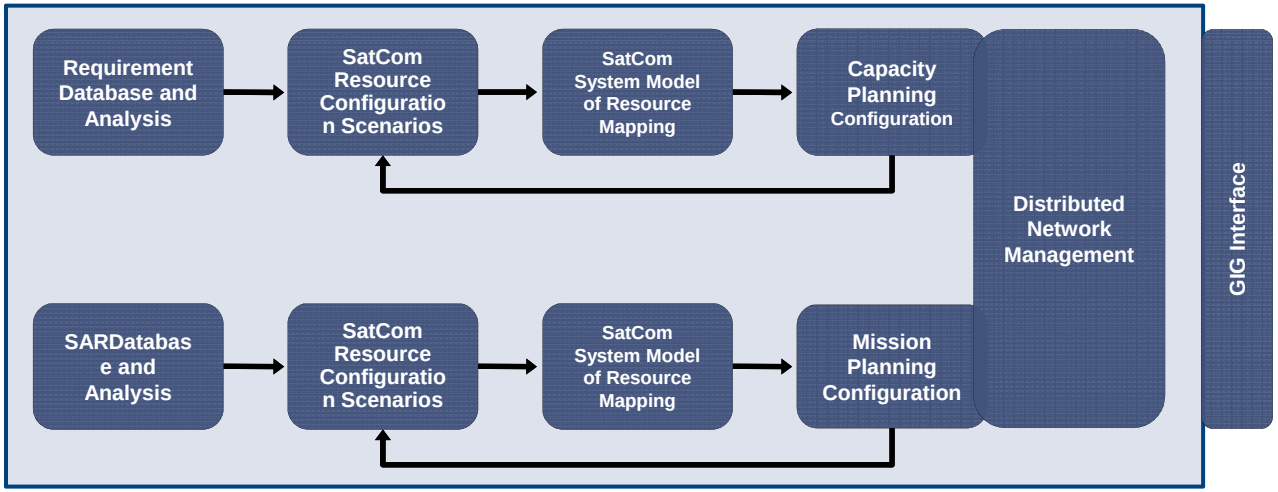
SatCom Inter-fleet Resource Allocation

SatCom Fleet Resource Allocation

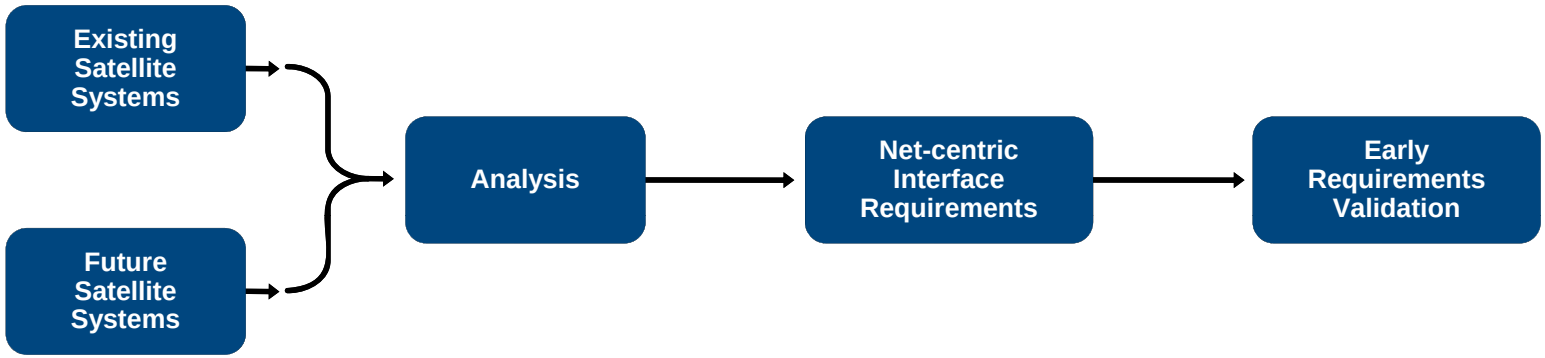


Inter-fleet Resource Management Tools

Individual SatCom Fleet Resource Management Tools



Requirements Definition Process



"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"

© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)

NORTHROP GRUMMAN

SHARED USE CASES

Shared Business Process and Scenarios

NORTHROP GRUMMAN

- 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

NORTHROP GRUMMAN

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

Example Scenarios
Strategic scenario #5 Theater XYZ
Americas Business Hours scenario
Special event/emergency/demand

Example Components of Scenarios
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
Business model/operation context
Terminal distribution mapped to geography (over time if mobile)
Traffic patterns mapped to terminal geographical locations over time
Applicable business process/military Operation rules
Business process/operations rules

© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)

NORTHROP GRUMMAN

DEGREE OF COUPLING

Interoperability for Resource Allocation across SatCom Systems

NORTHROP GRUMMAN

- 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

NORTHROP GRUMMAN

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

** Common abstraction model allows individual system instantiations*

Interoperability Approach for SoS ERP

NORTHROP GRUMMAN

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

Reusing Existing Individual System Implementations
Harmonizing Resources Exposed
Understand Resources of Constituent Systems

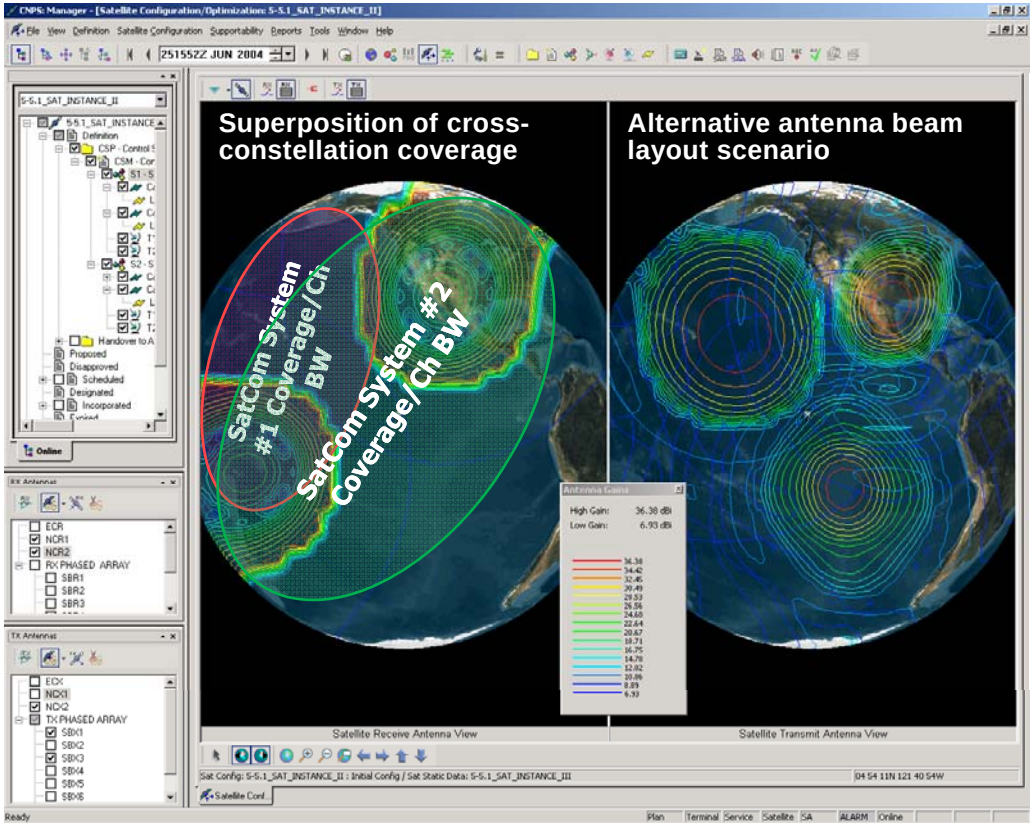
** Common abstraction model allows individual system instantiations*

Inter-constellation Capacity Planning

Coarse-grain Planning Example

NORTHROP GRUMMAN

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

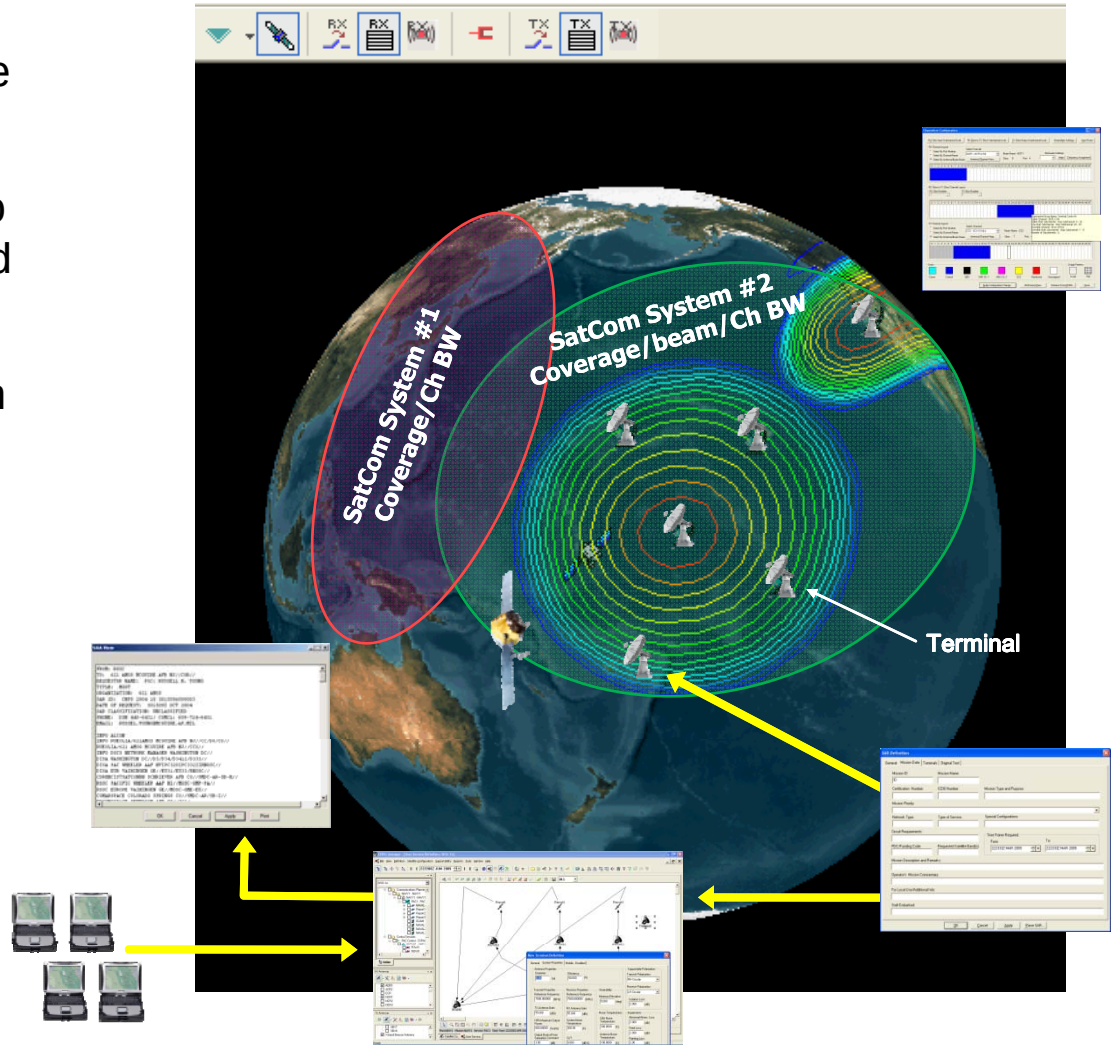


Inter-constellation Capacity Planning

Coarse-grain Planning Example

NORTHROP GRUMMAN

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



© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)

NORTHROP GRUMMAN

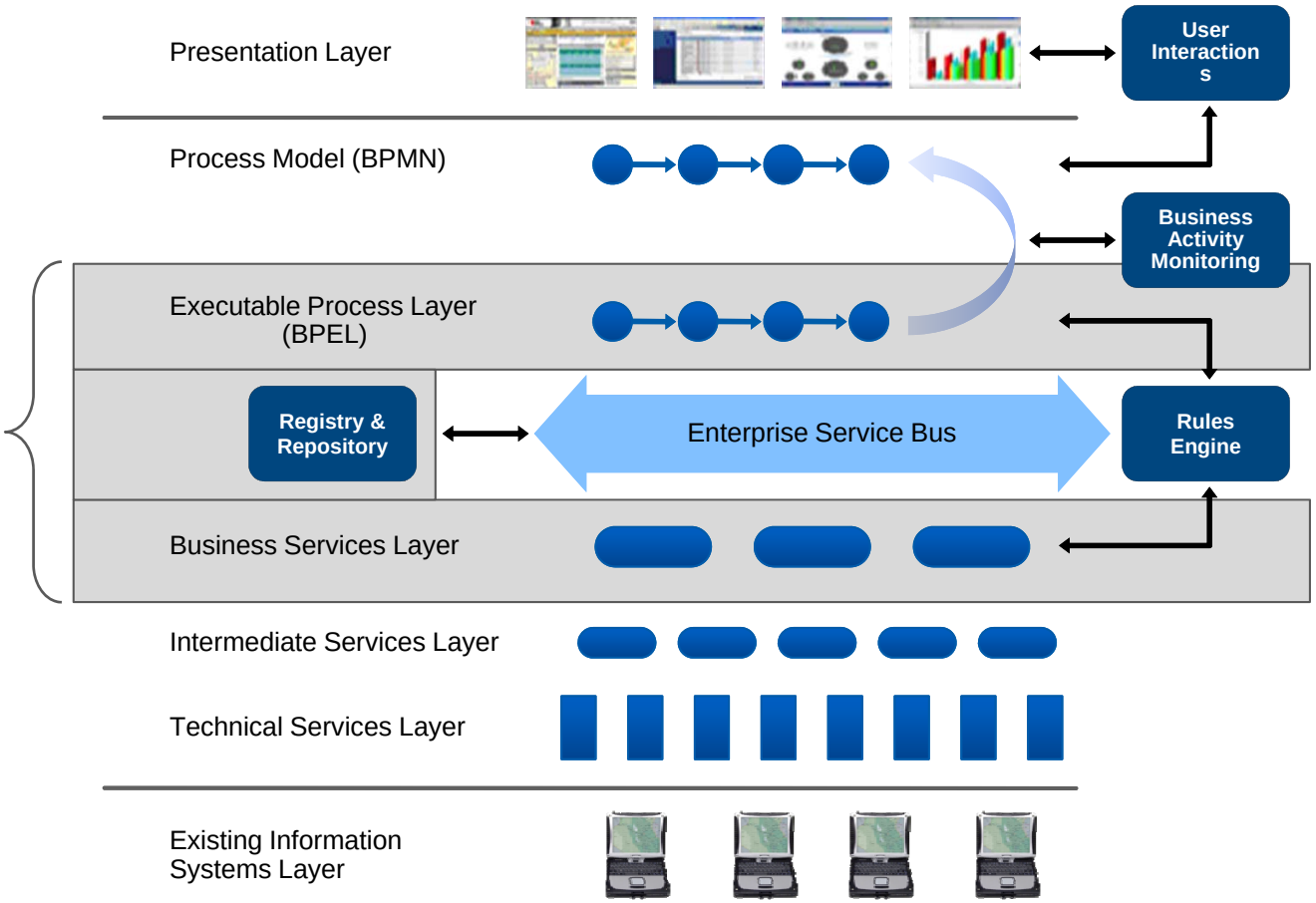
MODEL DRIVEN REQUIREMENTS

SOA Framework and Recommended SoS Interface Requirements Scope

NORTHROP GRUMMAN

Business process is either part of SoS interface definition or a document tightly coupled to interface definition

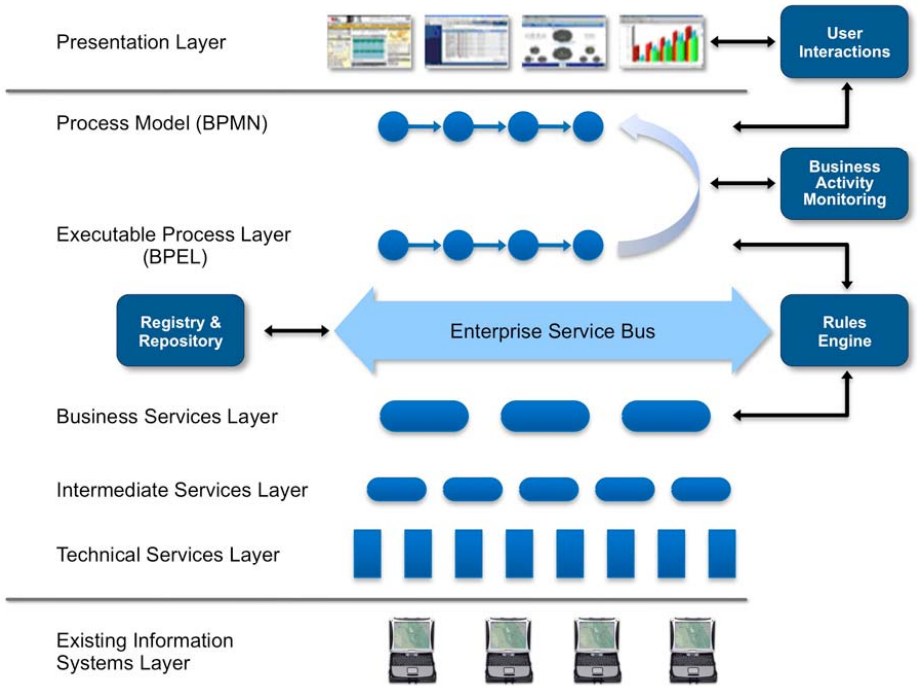
Interface Requirements Scope



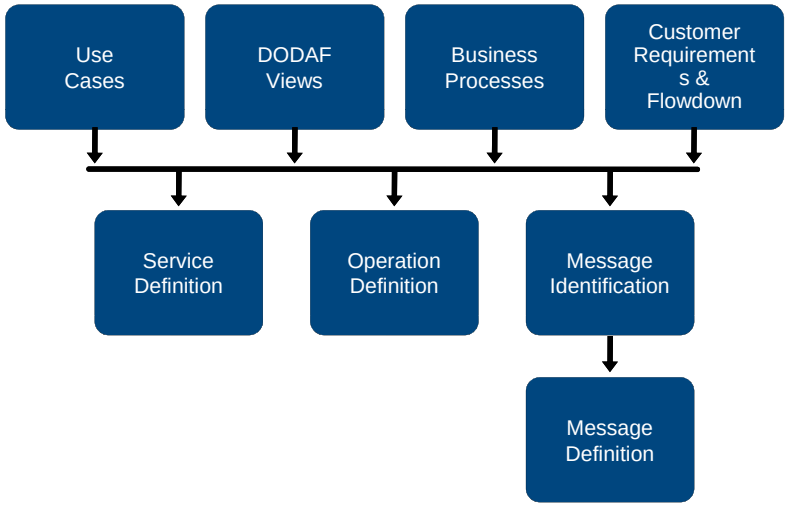
Requirements Definition Assumption – Service Definitions and Composite Analysis Tools

NORTHROP GRUMMAN

Web Service Construct



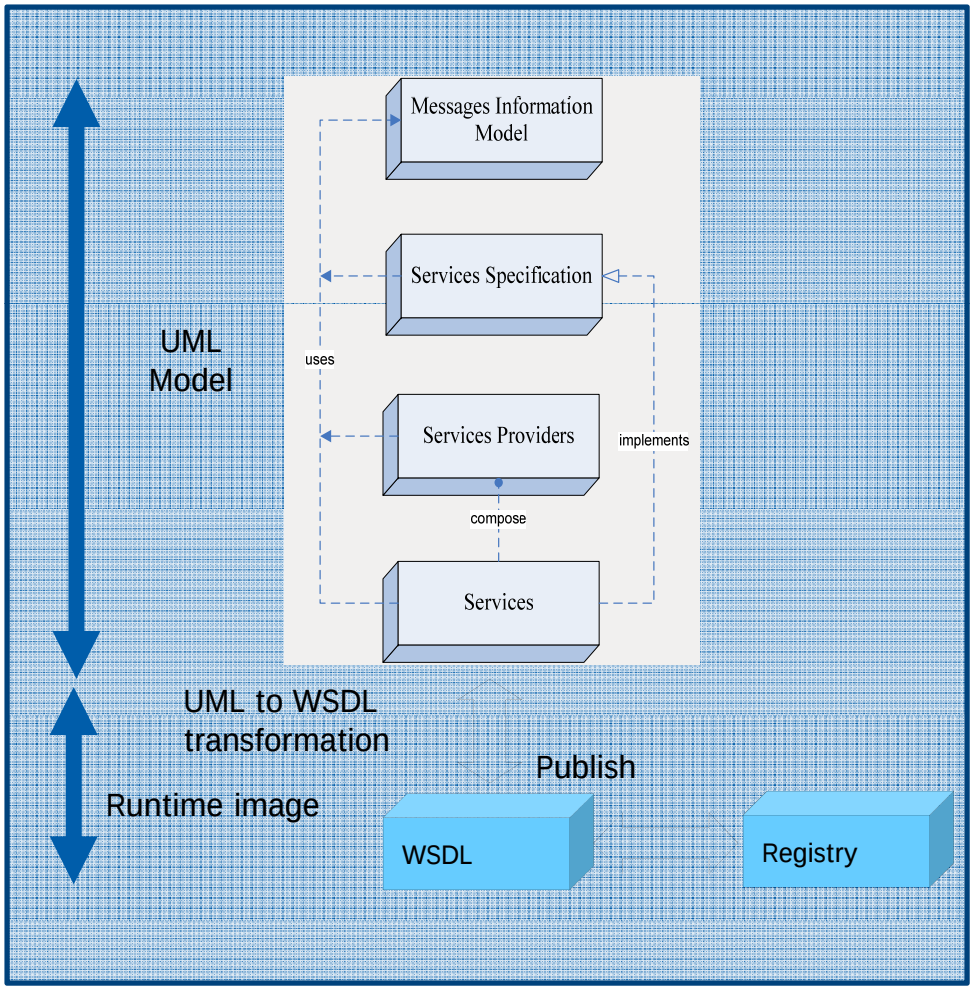
Interface Functional Requirements Analysis Tools



Model Driven ICD Web Service Definition

NORTHROP GRUMMAN

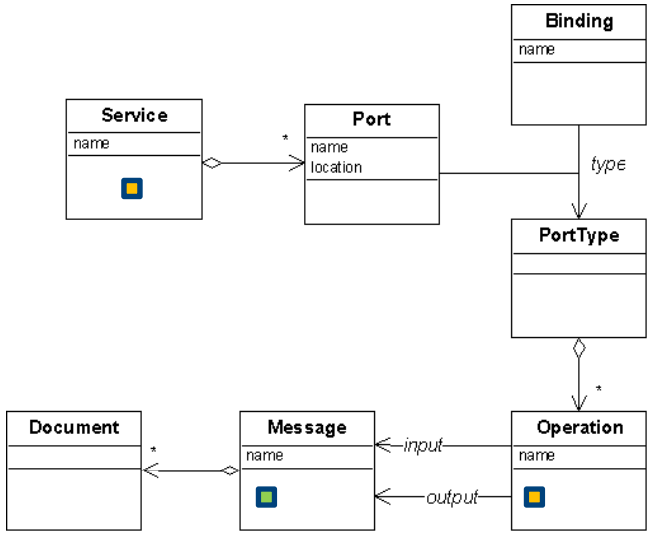
- Define UML models with standard web service development process
- Messages binds with the operations defined in the service specifications to generate WSDL (COTS tools can perform automatic binding)
- Emulate business logic as input/output generators only (focus is on validating interface requirements)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

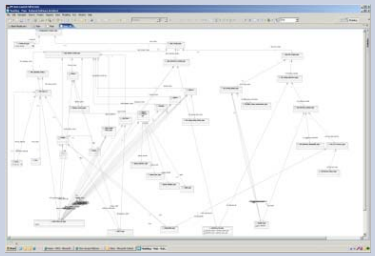
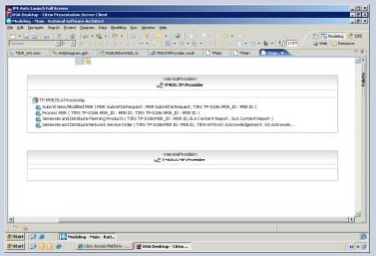
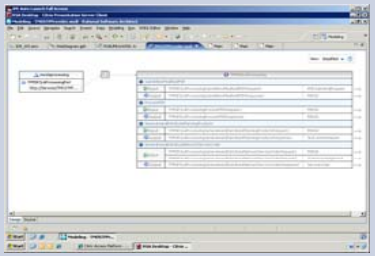
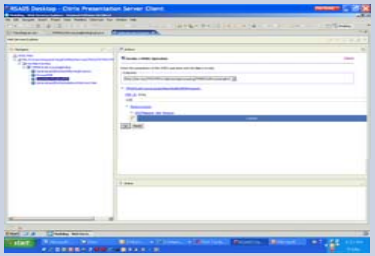


Tools-captured Requirements

NORTHROP GRUMMAN

Relationship Among Requirements Artifacts



Message Model	Service Specification	WSDL	Service Deployment
			

Model Driven Requirements Definition

NORTHROP GRUMMAN

- 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

NORTHROP GRUMMAN

- 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

© 2010 Northrop Grumman Corporation. All rights reserved. (Log # DSD-10-13)