Georgia Tech Research Institute

Leveraging the RFLP MBSE Methodology for Assessing Model Compliance

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Taylor Fields
Abigail Williams
Mohammed Yousif

Systems Engineering Research Division
Electronic Systems Laboratory (ELSYS)

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OUTLINE

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- Problem Definition
- Technical Approach
- Implementation Example
- Conclusion

Introduction

PROBLEM STATEMENT

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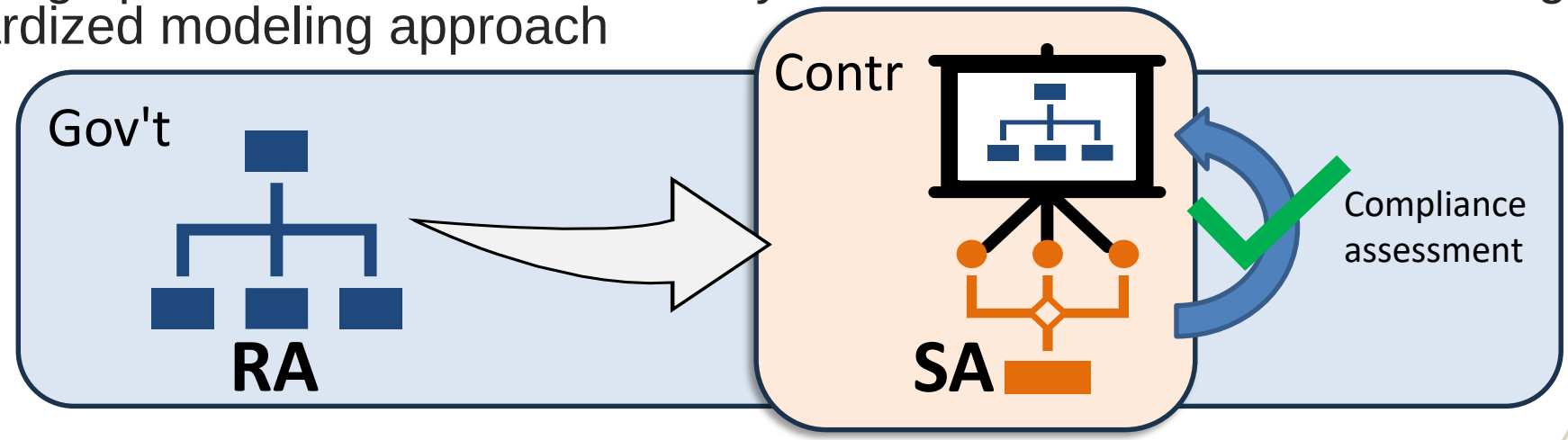
PROBLEM STATEMENT

- ***Context*: Acquisition process**
  - Government contracts out for a solution while providing reference architecture
  - Contractor's solution must utilize and conform to the provided reference architecture
- ***Question*:** How does the government ensure that the contractor's solution architecture is compliant with the reference architecture?
- ***Proposition*: Enable the assessment of a solution architecture's (SA) compliance with a reference architecture (RA)...**
  - By subjecting the architectures to standardized modeling methodologies
    - In this case, *RFLP,* but any MBSE methodology can be used with this approach (OOSEM, etc.)
  - By setting up the facilitation of continuity between the architectures through the standardized modeling approach

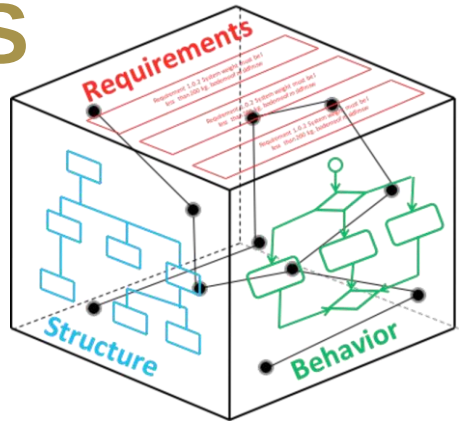


Introduction

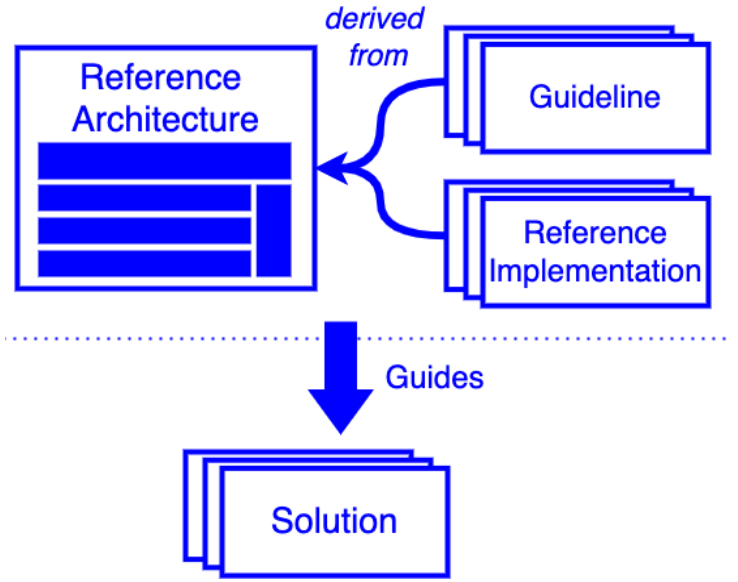
BACKGROUND AND MOTIVATION

NEED FOR REFERENCE ARCHITECTURES

- **Reference Architecture definition:**
  - DoD: An authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions[1]
  - ISO/IEC/IEEE 42010/20/30: Shared and agreed generic reference description instantiated as architectures used for specific community's business purposes[2]
- **Model-Based Systems Engineering (MBSE) and the Systems Modeling Language (SysML) continue to increase in popularity**
  - As a result, the models and artifacts produced tend to increase in complexity, number, and customization
- **Why Reference Architectures:**
  - Represent a culmination of common knowledge and information for a particular domain[3]
    - Serves as a foundation for subsequent models also known as SAs
  - Reduces number of customized models
  - Increases reusability
  - Common language for various users
  - Standardized modeling approach
  - Technology implementation uniformity
  - Standards adherence
  - SA validation



Bajaj, Manas & Cole, Bjorn & Zwemer, Dirk. (2016). Architecture To Geometry - Integrating System Models With Mechanical Design. 10.2514/6.2016-5470.



https://medium.com/geekculture/reference-architectures-e98595545baa

The reference architecture approach alone is insufficient for evaluating compliance efficiently without being coupled with a standardized modeling approach

REFERENCE ARCHITECTURE VS. REFERENCE MODEL

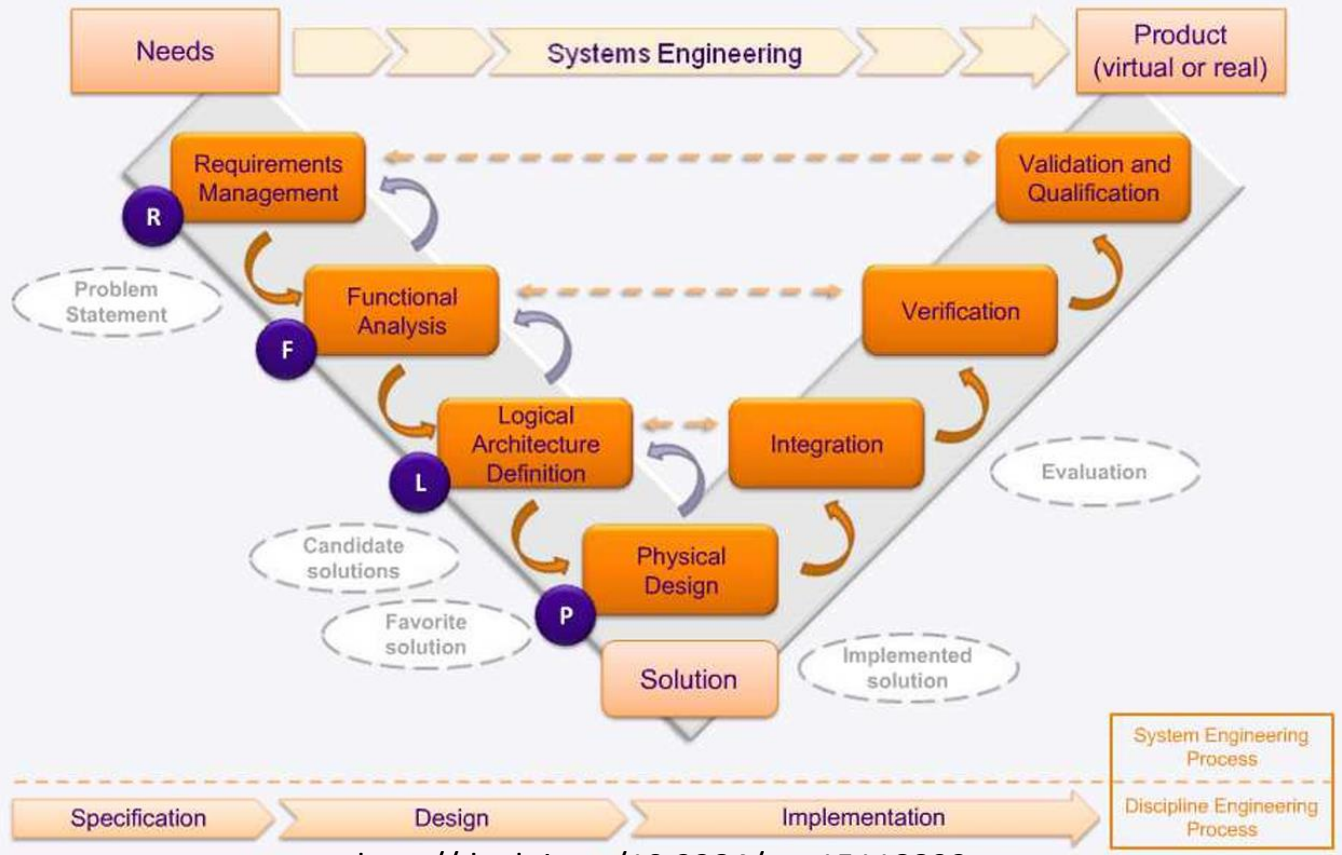
Reference Architecture	Reference Model
• Serves as a blueprint for constructing similar entities in a particular domain or technology area • Consists of reusable information to support the development of architectures for those entities • Used to guide and constrain other architectures in same domain • Often provide the basis for reference models that are used to construct respective models of a solution	• Specific and applicable to all solutions within a particular area • Similar to a RA and is sometimes used as the basis for defining an architecture • Can be a model of a RA

NEED FOR STANDARDIZED MBSE METHODOLOGIES

- **MBSE methodology**
  - Characterized as the collection of related processes, methods, and tools used to support the discipline of systems engineering in a “model-based” or “model-driven” context[4]
  - Used to organize the information expressed via modeling language (e.g. SysML)
  - Options: RFLP, OOSEM, UAF, OPM, MagicGrid, etc.
- **Benefits**
  - Organize models in a way that allows traceability
    - Provides a flow of continuity within and to subsequent models
  - Provides coherent structure
    - Eases navigation through the model
    - Enables grouped views based on the elements they represent
  - Provides modeling consistency
    - Aids in the identification of missing information
  - **Provides guidance for the intended foundational use of the RA for the development of ensuing models**
- **Unconstrained, non-standardized modeling leads to:**
  - Inconsistencies and duplicated work
  - Challenges in providing full traceability and model completeness

A standardized modeling method better prepares compliance assessment due to well-established pathways of traceability and clear intended usage by the SA

RFLP MBSE METHODOLOGY



http://dx.doi.org/10.3384/ecp15118893

- **The RFLP method is a systematic modeling approach[6]**
  - **R**equirements: drives functional definition
  - **F**unctional: captures behaviors
  - **L**ogical: generalized logical design elements that accomplish an allocated function
  - **P**hysical: more refined specific implementation of the logical design
- **A hierarchical approach**
  - Transition requirements to a physical design
  - Cascading steps while simultaneously providing full traceability from the top down

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CURRENT APPROACHES AND LIMITATIONS

- **Assessing a SA's compliance with a RA is difficult when:**
  - Several development organizations each have their own customized modeling approaches (non-standardized)
  - No constraint or consistency is present for the connection from an SA to a RA

Current Approach	Limitation	Results in
Reference Architectures are constructed without its use in mind	No specification of how it intends to be referenced or how it should be conformed to	> Various contractor referencing approaches > Complicated compliance assessment for government that changes for each referencing approach (time and effort costs)
Several customized modeling approaches from various development organizations	Each compliance assessment approach will require to be different for each solution architecture	> Lots of effort and time required to accomplish
Reviewers manually contrast and compare the vendor's SA with the government's RA for compliance	Prone to errors	> Costly design flaws and rework > False passed compliance checks

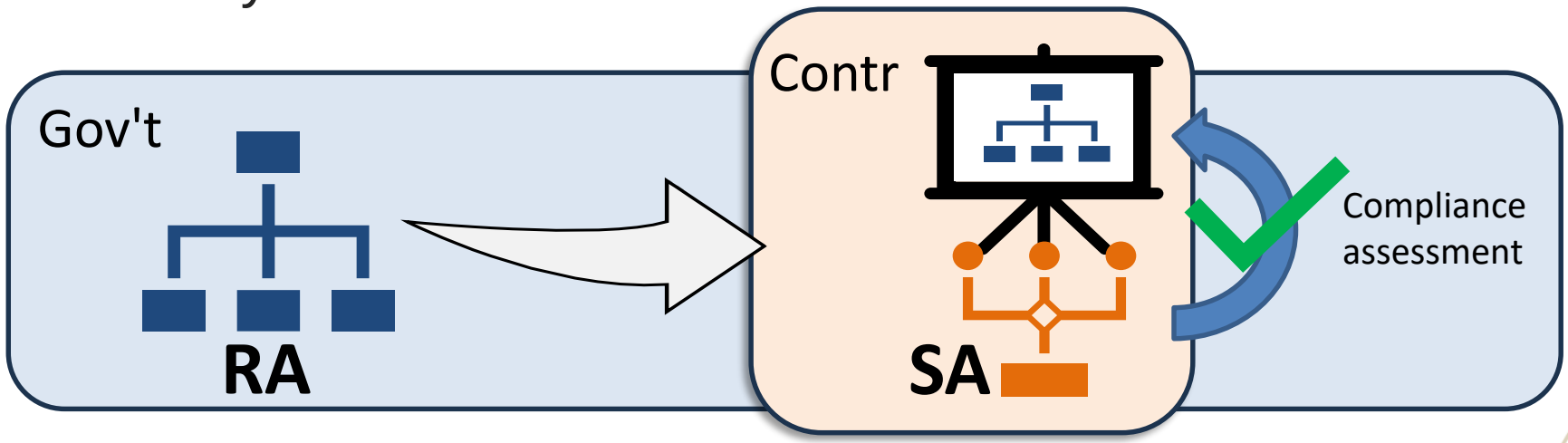
Need an approach for a RA that not only captures common information for a distinct domain, but also provides a clear pathway for intended usage that enables compliance assessment

Introduction

PROBLEM DEFINITION

PROBLEM DEFINITION AND IMPACT

- **Assessing direct compliance between the RA and SA is difficult when there isn't a standardized modeling approach**
  - Both models will lack consistency in structure, organization, and traceability
- **Utilizing a standardized modeling approach enables consistency, reusability of the RA, and direct compliance assessment**
  - Benefits the government as they can reuse their RA to save costs and time, and directly assess contractors SA



TECHNICAL APPROACH

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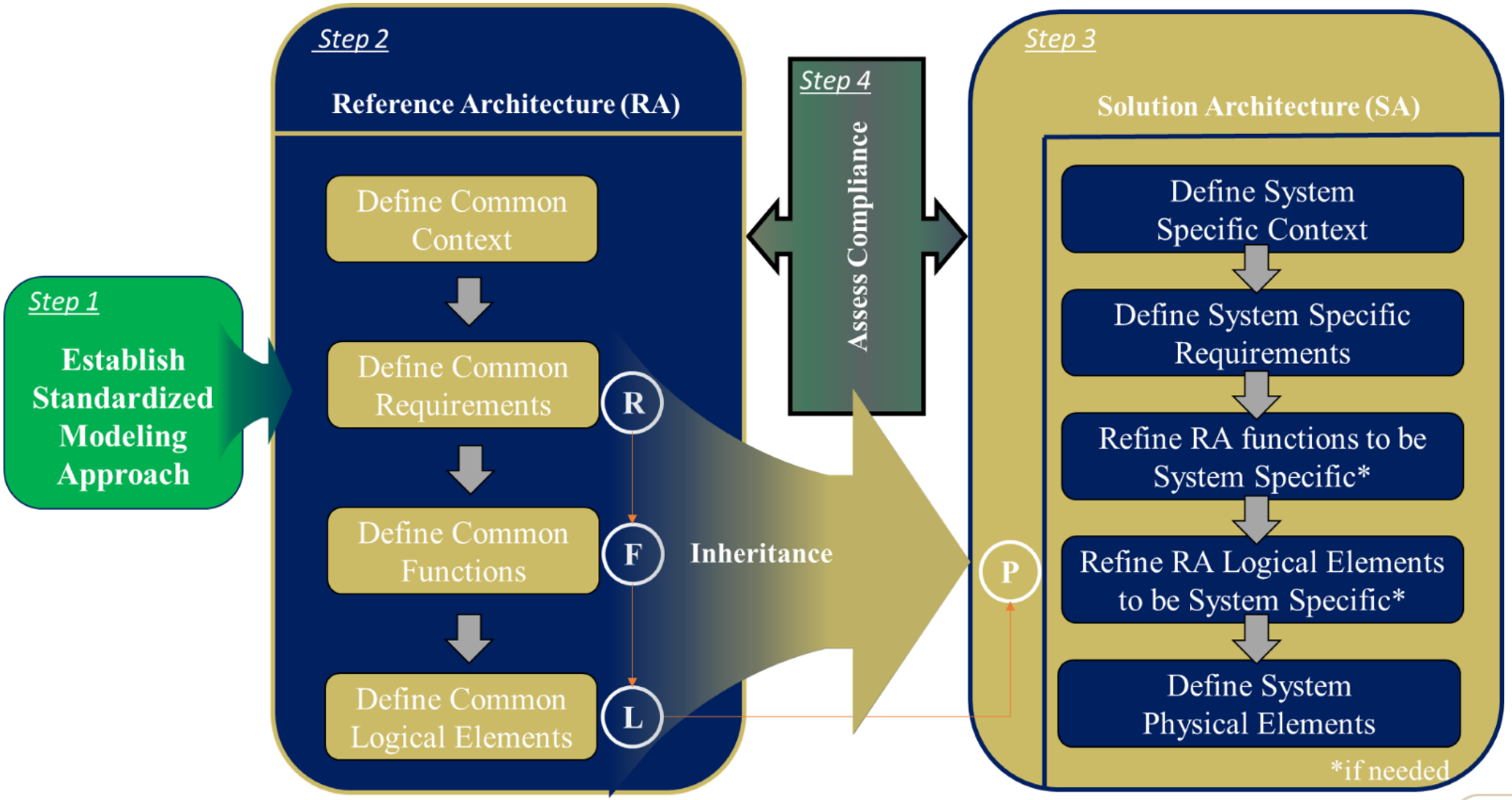
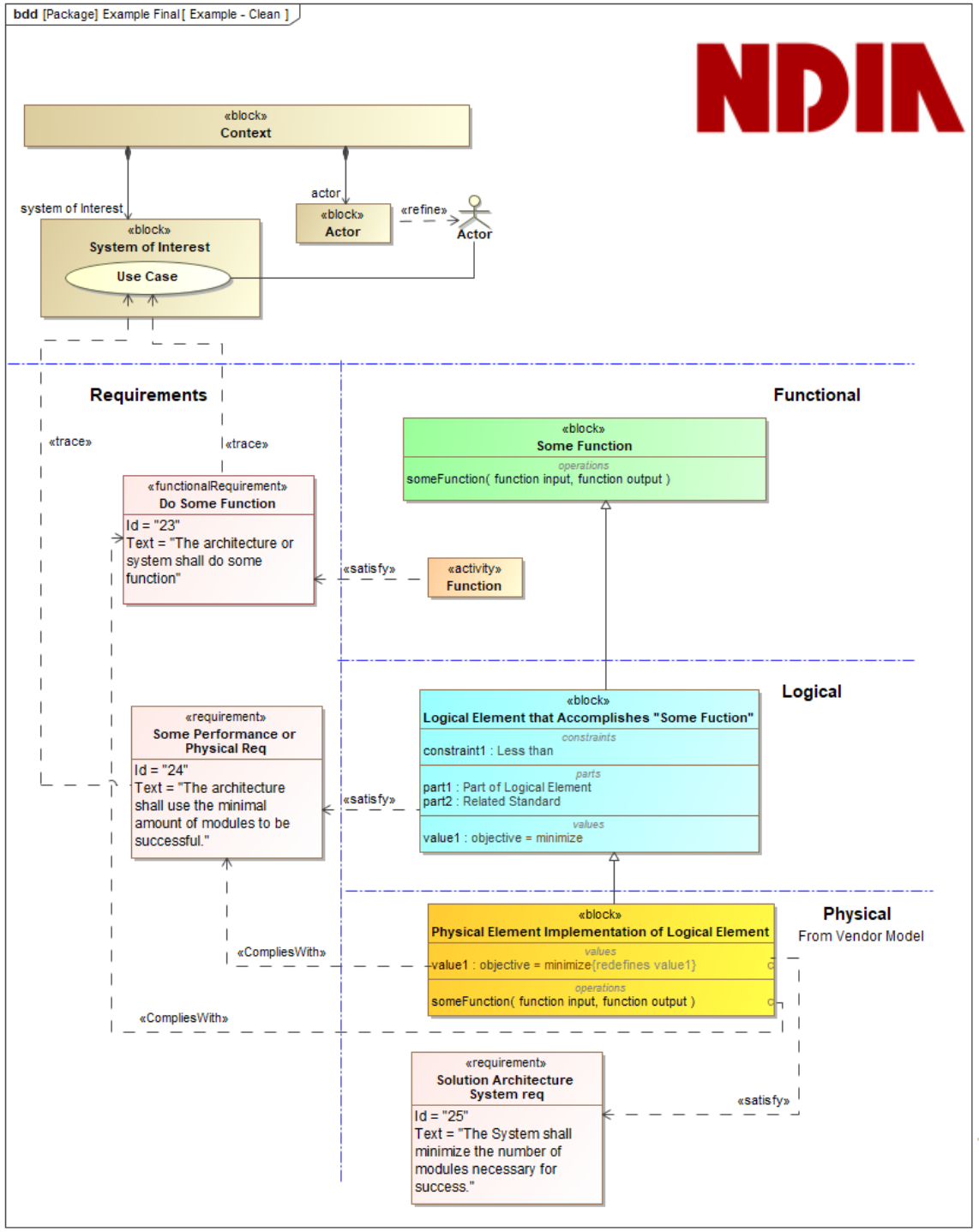
Overview of Technical Approach



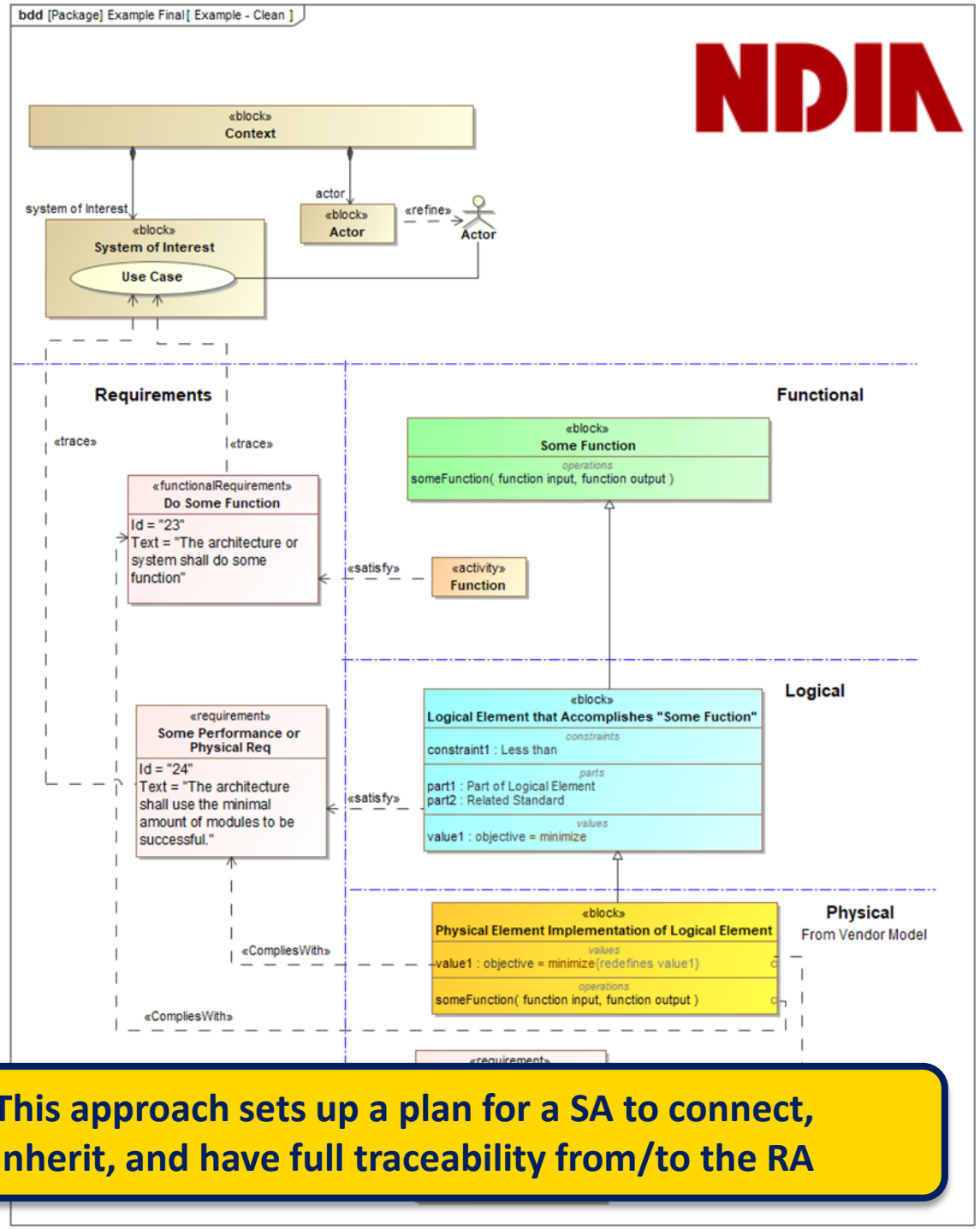
Step 1: Establish Standardized Modeling approach (1/2)

- **RFLP selected as Standardized MBSE methodology**
  - Note: any methodology can be used to develop the RA
- **Modeling pattern is represented by meta-model**
  - Context represents relevant actors and any vital elements external to the system of interest
    - Use cases represent the objectives of the RA system of interest
  - Requirements identified as functional or non-functional
    - Traceability from requirement to use case



Step 1: Establish Standardized Modeling approach (2/2)

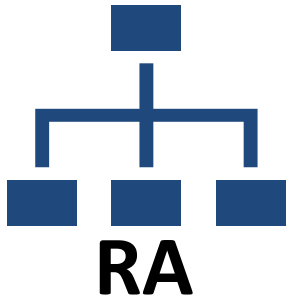
- **Modeling pattern is represented by meta-model**
  - Functions represented by Functional blocks
    - Owned operations capture I/Os of function
    - Activities describe method of the operations
  - Logical components represented by blocks
    - Path of traceability with generalization with two purposes
      1. Allocate to the function (activity)
      2. Inheritance from the function (functional block)
  - Satisfy relationship
    - Activities satisfy functional requirements
    - Logical components and properties satisfy non-functional requirements
  - Context, R, F, & L make up the RA, whereas the physical layer makes up the SA
    - The physical is the specific implementation of the common logical element
    - Inheritance enables common attributes to be passed from logical to physical and allows for redefinition
    - Custom relationship, *CompliesWith*, used to show how the SA intends to conform to the RA
  - Inheritance pattern enables common attributes to be passed from F → L → P while also providing traceability

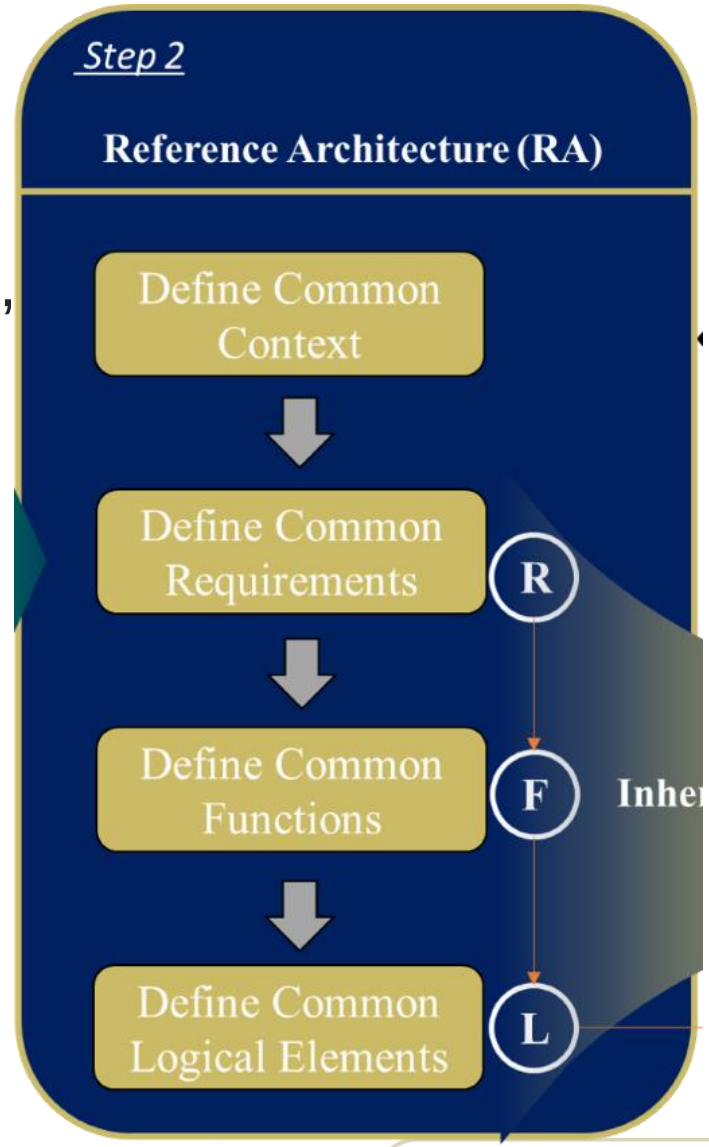


This approach sets up a plan for a SA to connect, inherit, and have full traceability from/to the RA

STEP 2: REFERENCE ARCHITECTURE DEVELOPMENT

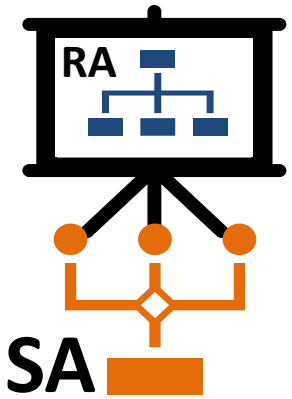
- **The RA is developed using the RFLP modeling approach**
  - Captures contextual information, common requirements, common functions, and common logical components
  - Traceability is established from the contextual elements to the requirements
  - Requirements are analyzed to create functions and logical components
  - The inheritance pattern established from the functional to logical to setup the cascading of information to the solution architecture (SA) through the physical layer

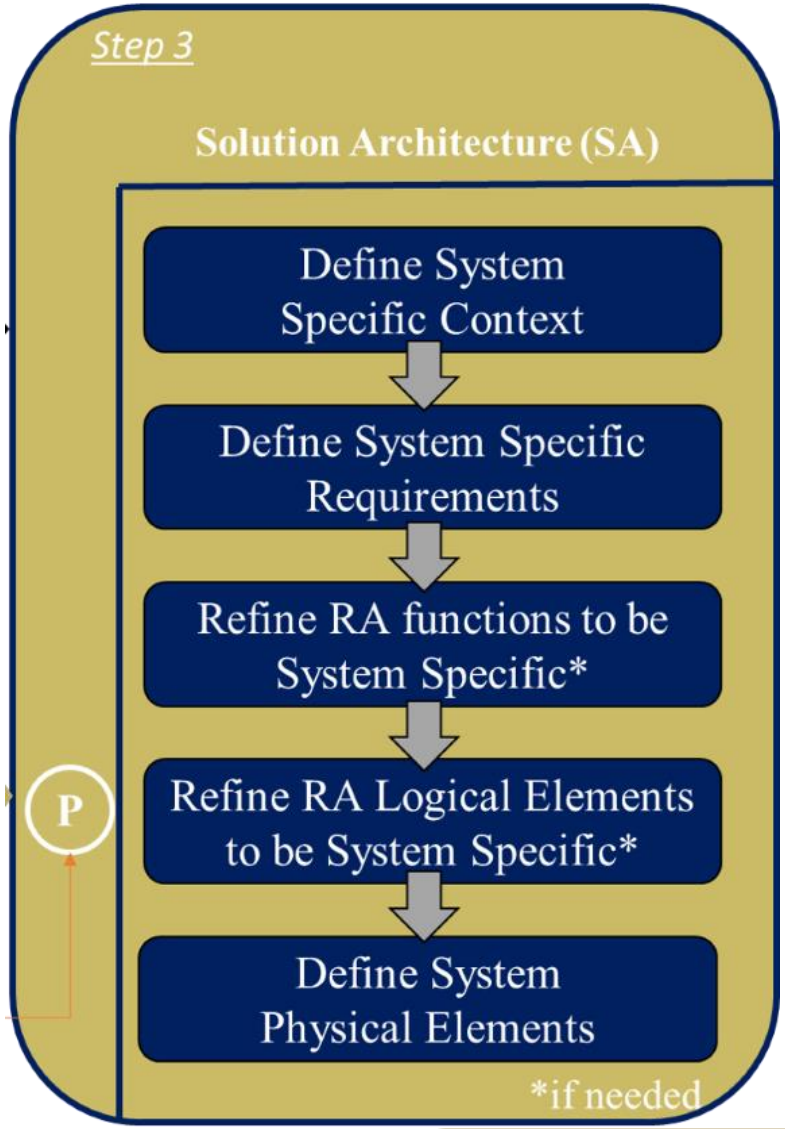




STEP 3: SOLUTION ARCHITECTURE DEVELOPMENT

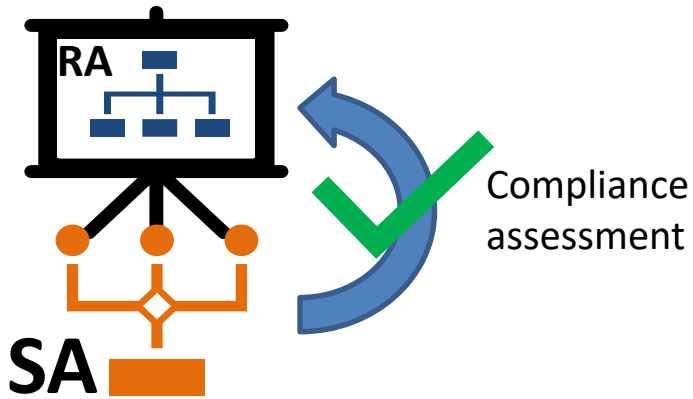
- The SA is developed as the physical layer implementation of the RFL portions in the RA
- SA will inherit the RA requirement relationships, functional operations, and logical components and their properties through the generalization relationship
- SA can redefine the inherited information to satisfy the specific system requirements
- *CompliesWith* relationship acts as a Satisfy to the RA requirements, which is the direct compliance assessment relationship





STEP 4: COMPLIANCE ASSESSMENT

- **Leveraging the standardized modeling approach and inheritance pattern to develop the RA and the SA enables compliance assessment by…**
  - Providing a clear plan for traceability from the SA elements to the relevant RA elements
  - Exploiting the custom CompliesWith relationship to depict the SA's intentionality of complying with the RA requirements/standards
  - Enabling the creation of viewpoints for specific reviewer perspectives based on the prescribed established relationships



IMPLEMENTATION EXAMPLE

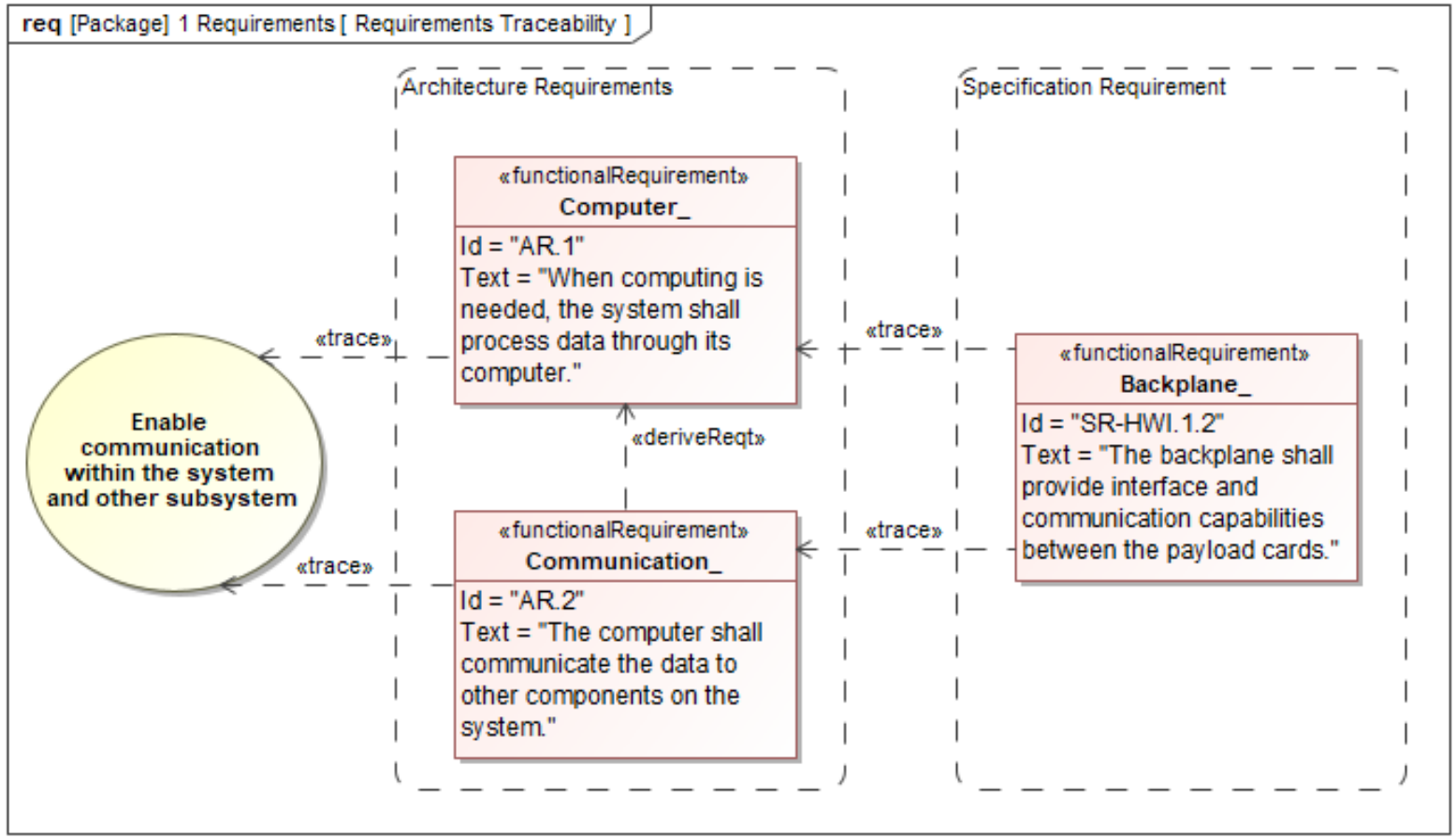
IMPLEMENTATION EXAMPLE: CONTEXT

- **UxS Mothership is an unmanned ground combat platform that is a central hub for deployable drones**
  - Mission is to perform a successful Intelligence, Surveillance, Reconnaissance mission
  - Focus is on the reconnaissance portion, gathering intelligence and information on an area from a distance using drones
  - Processes and communicates information received from the drone using the on-board computer
- **Ground System RA (GSRA)**
  - Common ground system **R**equirements, **F**unctional, & **L**ogical elements
  - Scoped to common ground system hardware elements for computer
- **UxS Mothership SA (UMSA)**
  - **P**hysical elements (specific implementations of logical)
  - Inherits the common functions and logical components from the GSRA
  - Scoped to the specifics of the on-board computer

UxS Mothership fictional military vehicle

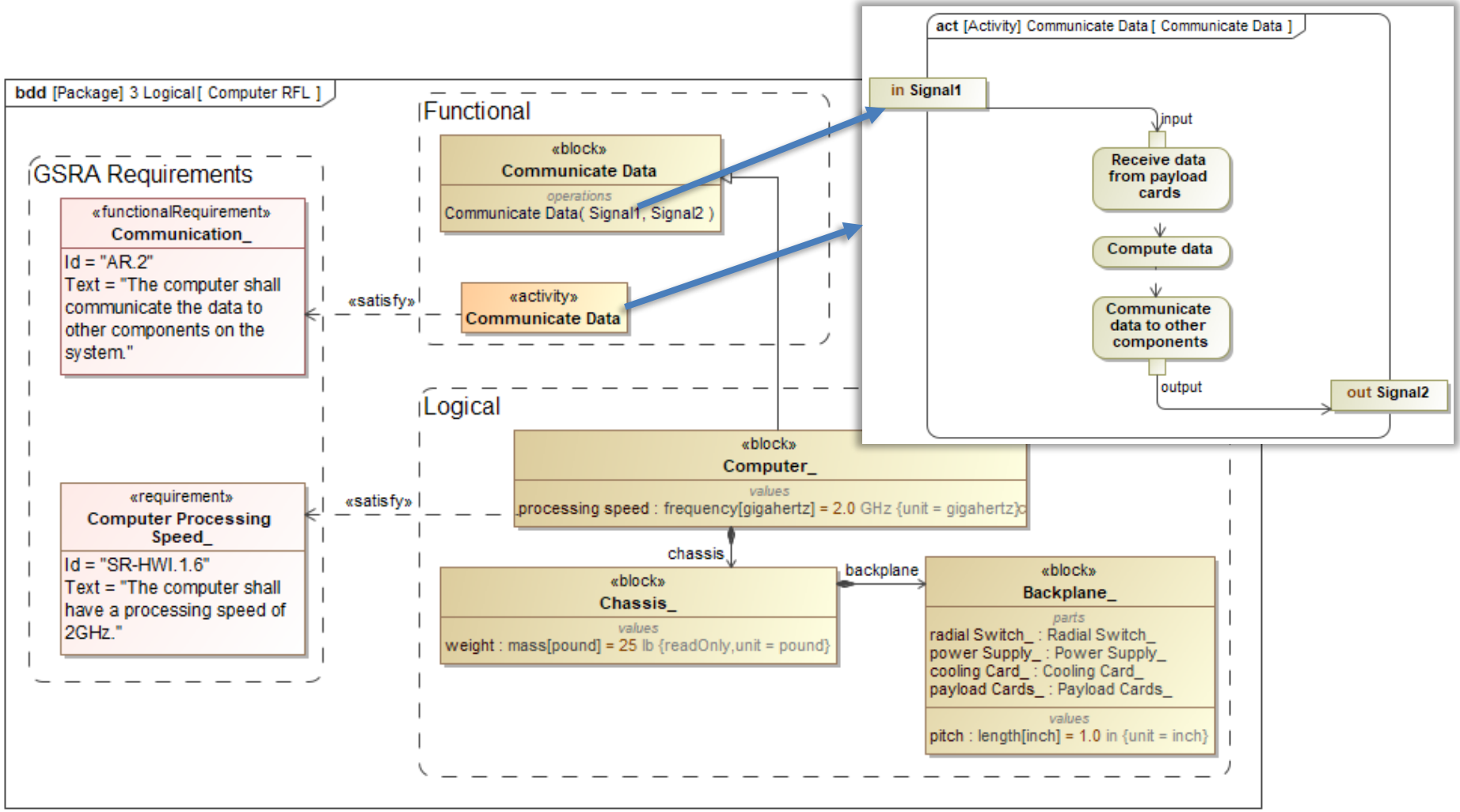
IMPLEMENTATION EXAMPLE: GSRA DEVELOPMENT

- **Context representation**
  - Use cases capture the high-level objectives of a ground system
- **Requirements**
  - Functional & non-functional requirements developed from use cases (with traceability)



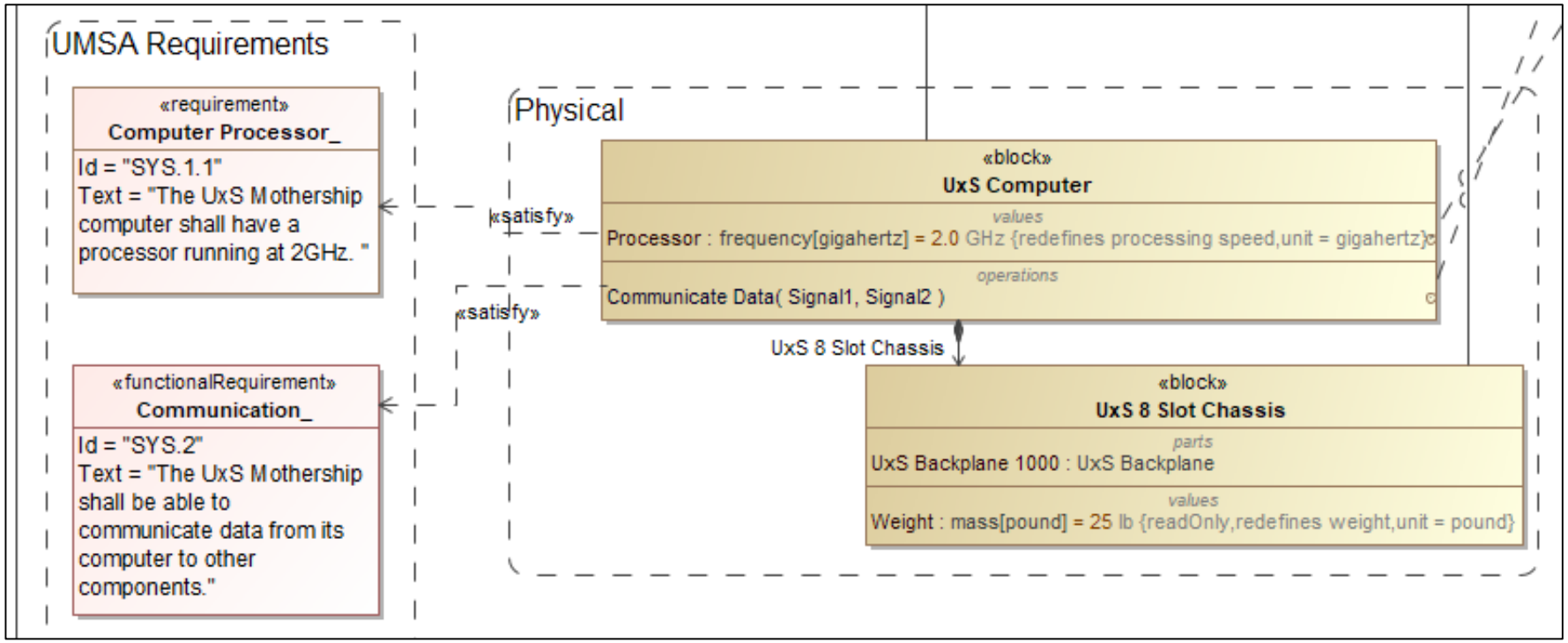
IMPLEMENTATION EXAMPLE: GSRA DEVELOPMENT

- **Functions**
  - Communicate Data functional block owns the operation with I/Os
  - Activity depicts actions of a function
- **Logical representation**
  - Generic representation of computer hardware and attributes
  - Inherits Communicate Data function



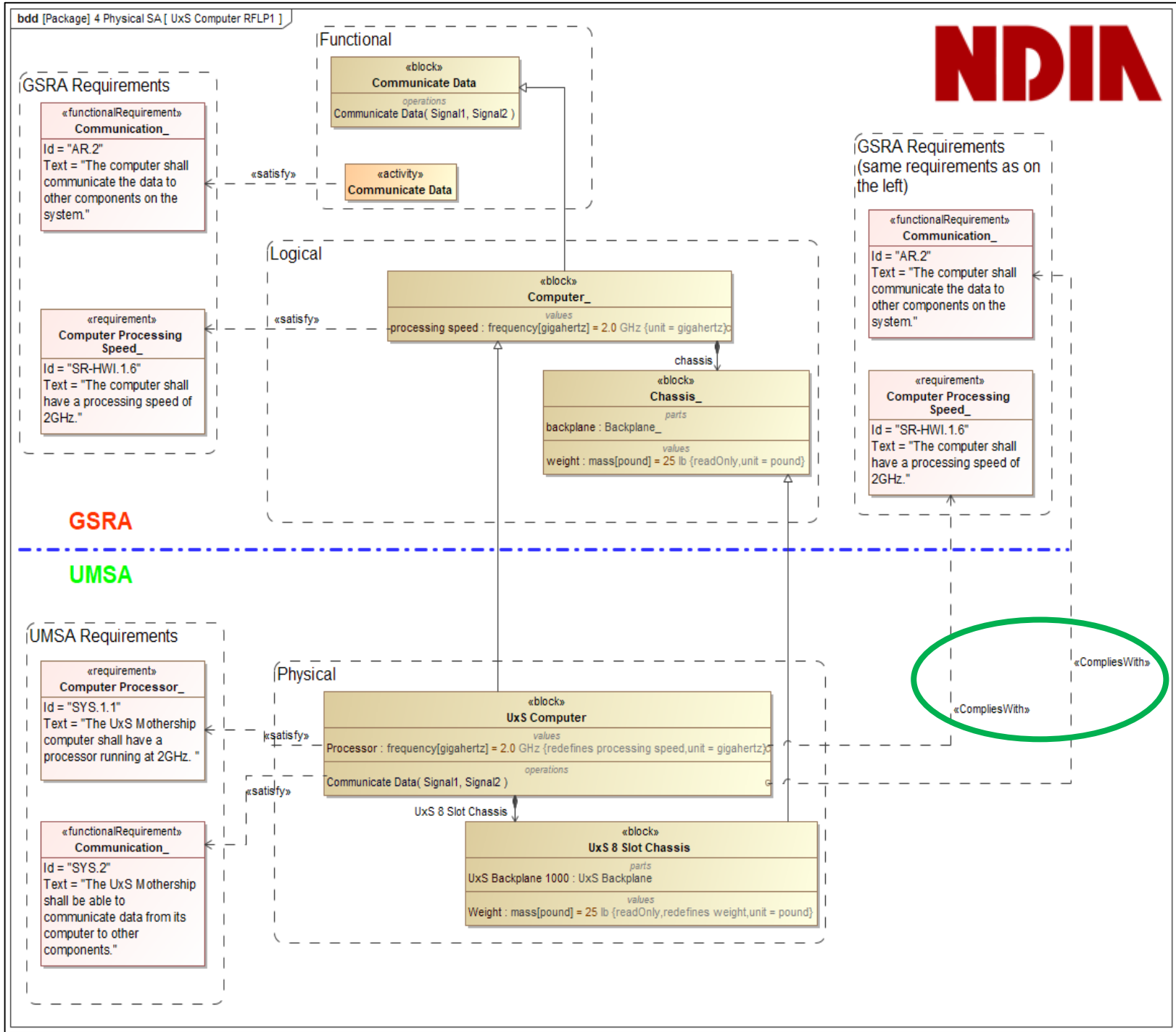
IMPLEMENTATION EXAMPLE: UMSA DEVELOPMENT

- **Physical representation**
  - Even though the SA is represented by the physical layer in this process, it is not limited to only specific element representation
  - The SA also contains requirements specific to the system represented by the SA



UMSA DEVELOPMENT

- **Physical representation**
  - The SA connects to the RA through the RFLP approach
  - Inheriting common attributes reduces amount of work developing the SA
- **Compliance assessment enabled by the *CompliesWith* relationship from SA to RA**



COMPLIANCE ASSESSMENT VIEWS

- **Views tailored to specific domains that show only relevant compliance information for a specific reviewer**
  - Used to quickly inform a reviewer of how the SA intends to reference and comply with the RA by leveraging the traceability through the modeling approach

UMSA

Physical Architecture

#	Id	Name	Text	Applied Stereotype	Satisfied By	SA Physical Element
1	SYS.1.1	Computer Processor_	The UxS Mothership computer shall have a processor running at 2GHz.	Requirement [Class]	Processor : frequency[gigahertz] = 2.0 GHz	UxS Computer
2	SYS.2	Communication_	The UxS Mothership shall be able to communicate data from its computer to other components.	functionalRequirement	Communicate Data(Signal1, Signal2)	UxS Computer

GSRA

RFL Architecture

RA Logical Element	RA Function	RA NF Requirements	RA F Requirements
Computer_	Communicate Data Enable Processing of Data	SR-HWI.1.6 Computer Processing Speed_	AR.2 Communication_ AR.1 Computer_
Computer_	Communicate Data Enable Processing of Data	SR-HWI.1.6 Computer Processing Speed_	AR.2 Communication_ AR.1 Computer_

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CONCLUSION

- **Without the standardized modeling approach, the road to assessing compliance between an SA and an RA is difficult**
  - Due to unconstrained use of the modeling language used to represent them
- **Leveraging the standardized modeling approach provides full traceability and clear direction for intended usage of an RA**
  - Each contractor is constrained to use the same connection approach which leads to easier assessment especially for various contractor submissions
  - Enables subject matter expert (SME) assessors to utilize the organized modeling structure to compare the SA to the RA quickly and efficiently
- **The compliance assessment comparison views coupled with SME knowledge promotes successful architecture compliance assessment**
  - **Easily verifiable through the relationships of the modeling approach**

Potential Future Work

- **Automate the comparison of the SA to the RA through the use of custom SysML validation rules**
  - Could automatically produce a warning for any element in the SA that does not conform to the information in the RA if it does not have an expected *CompliesWith* relationship

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QUESTIONS

Thank you

Taylor Fields – Taylor.Fields@gtri.gatech.edu
Abigail Williams – Abigail.Williams@gtri.gatech.edu
Mohammed Yousif – Mohammed.Yousif@gtri.gatech.edu