NORTHROP GRUMMAN

A Structured Approach to Integration

Cory Kinsel
Engineer Systems Architect

8/4/2021

Background

Cory Kinsel, Engineer Systems Architect
Northrop Grumman Space Systems

- Member of MBSE Solutions Team
  - Supported 6+ Programs/Teams
- Trained Engineers in MBSE Methodology and Tools
- 5+ years of Modeling and Simulation Experience
- B.S. AAE from Purdue University

What does it mean to integrate?

NORTHROP GRUMMAN

Definitions

- Integrate
  - to form, **coordinate**, or blend into **a functioning** or unified **whole**
- Interface
  - the place at which **independent** and often unrelated **systems** meet and act on or **communicate** with each other
- Structured Approach
  - a **process** oriented approach, aiming to **break a large complex problem** into a series of **smaller**, more **manageable pieces**
- Class of Information
  - a way of collecting or **organizing** together similar types of **information**

NORTHROP GRUMMAN

DISCOVERY: What problem are we trying to solve?

Given:

1. Two Independent Model types need to exchange data
2. ModelCenter enables this data exchange

Problem:

1. How do I consistently enable an integration and ensure repeated success?
2. How do I enable a team of engineers to execute this process, minimizing the training time to execute?

Solution:

Create a process that captures each class of information independently, allowing for focused development

NORTHROP GRUMMAN

Step 1: Create Representation of Analysis

- Identify the engineering work to be executed
  - What is the goal of this work?
  - What resulting decisions need to be made?
  - How does this analysis tie into other engineering work?
  - What requirements are driving this effort?

NORTHROP GRUMMAN

Step 2: Identify the Independent Models

- Who are the stakeholders in this integration process?
  - Who is needing the decisions from the analysis?
  - Who is performing the analytic work?
- Are there existing analytic models (Excel, Matlab, CAD, etc)?
- Is there any new development that needs to occur?

NORTHROP GRUMMAN

Step 3: Identify the Interfaces

- For analytic models:
  - What are the Input/Output Parameters? Parameter Dimensions? Units?
- For descriptive models:
  - What classes of information need to be captured? Dimensions? Units?
  - Givens
    - Requirement Parameters
    - Assumptions
    - Results from other Analyses
    - Architecture Constraints
  - Results

NORTHROP GRUMMAN

Step 4: Integrate the Interfaces

- Mapping the data across the models
- Process checkpoint
  - If steps 1-3 were completed successfully, this should be seamless
  - Extra Parameters, non-successful integration indicate missed items

Let’s see how this process looks

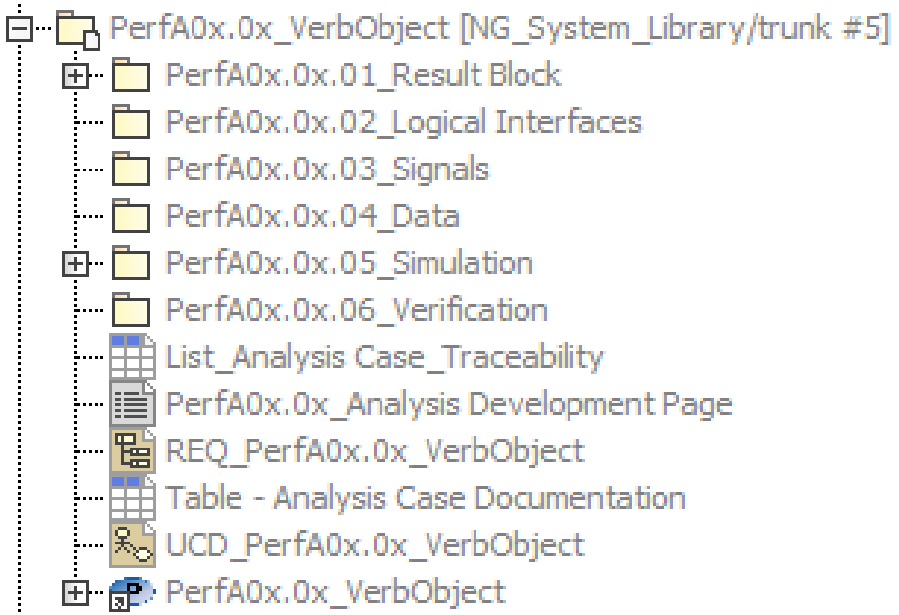
NORTHROP GRUMMAN

The Example

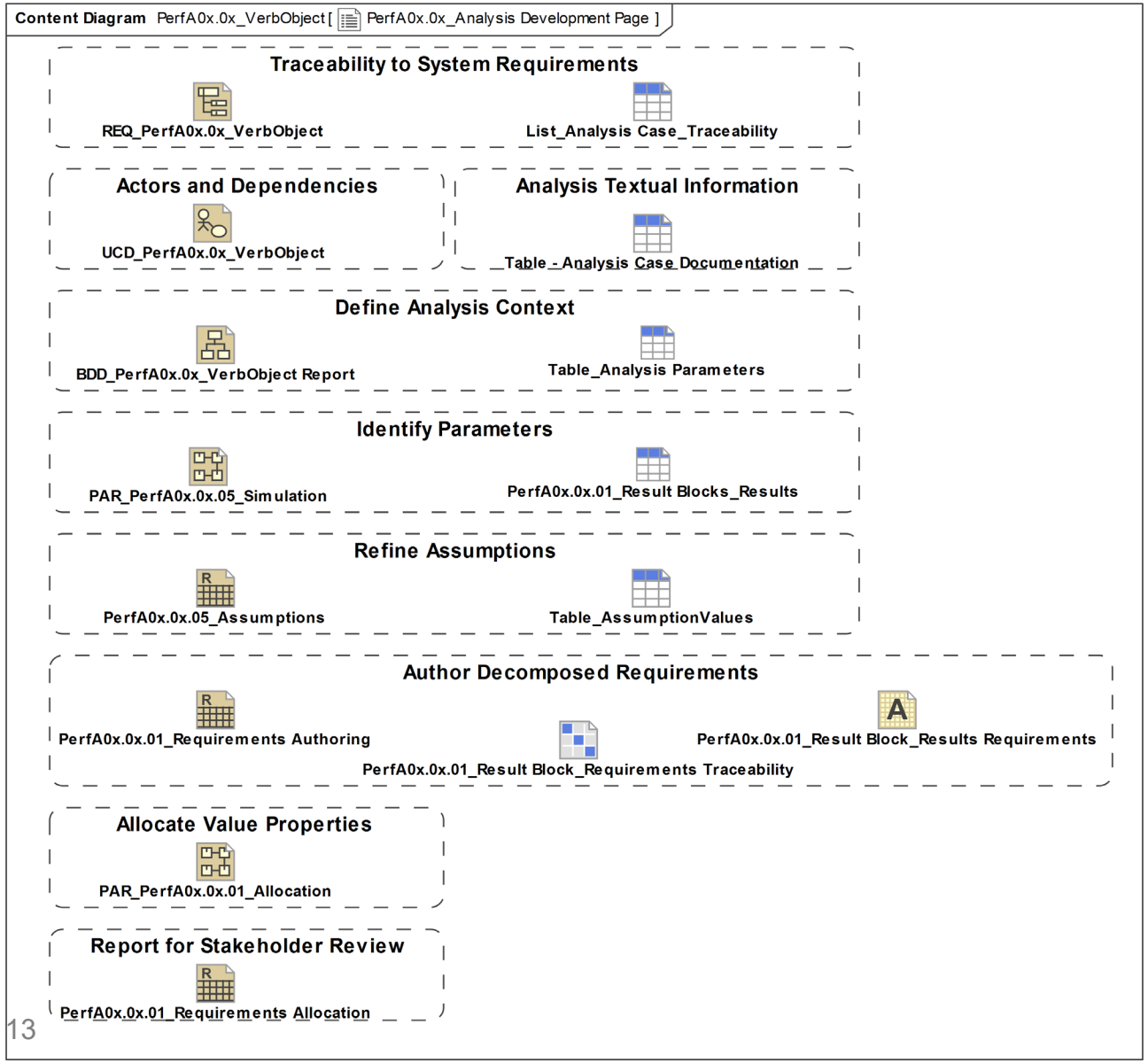
- Phoenix Integration's Turbofan Demonstration Exercise
  - Given Requirements for:
    - Geometry (Bypass Ratio)
    - Performance (TSFC, Specific Thrust, Conditions)
  - Find: A feasible solution for an engine design to be able to write requirements against specific component performance

The Template

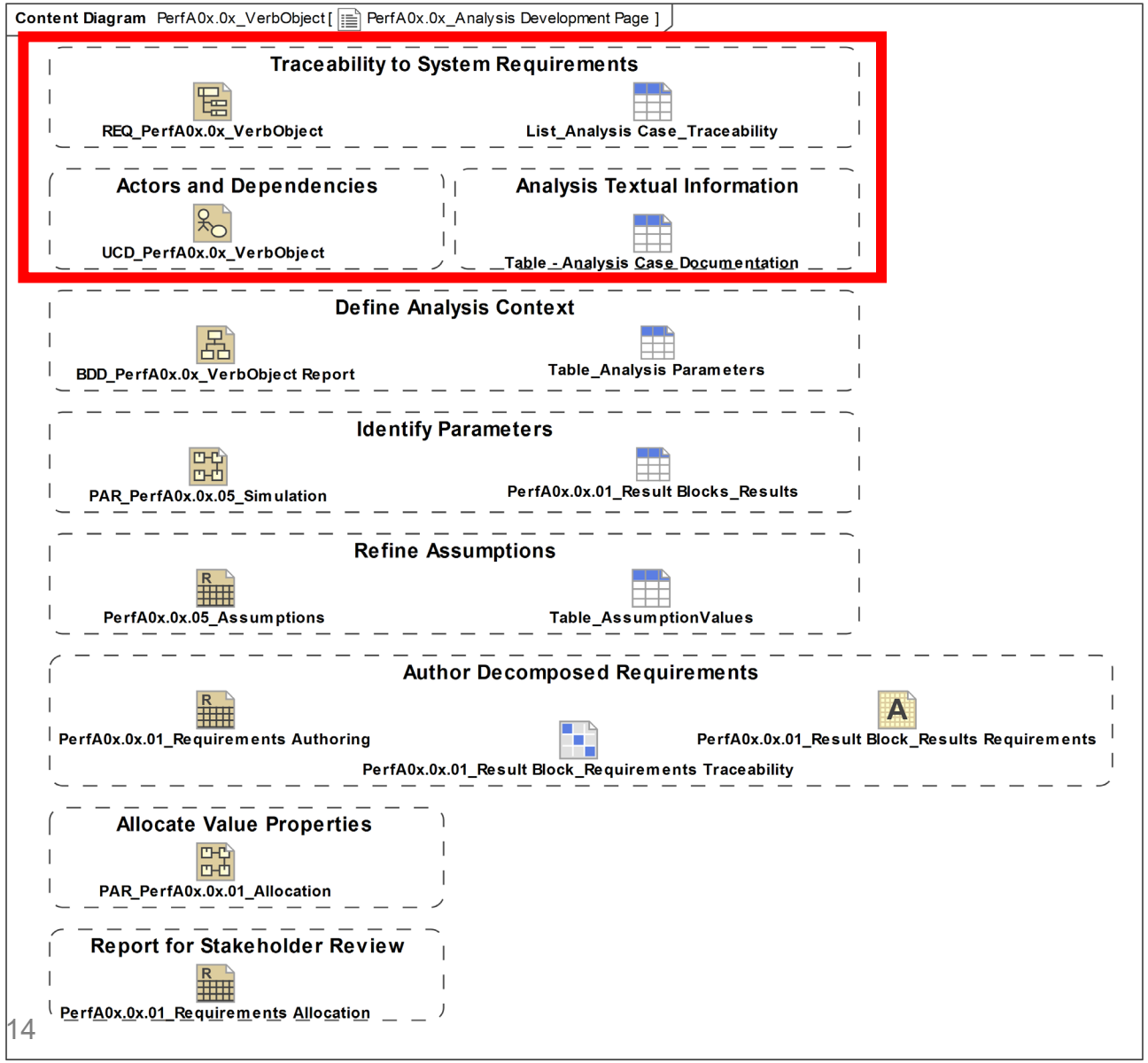
- Package structure is copied and pasted per analysis
- Contains:
  - Package structure to organize data
  - Preconfigured views to capture data
  - Development page to focus engineering effort



The Development Page



Step 1: Create Representation of Analysis



Capture:

- Goal of Analysis
  - "The goal of this analysis is to find a valid solution point to write requirements to be levied against specific components of the turbofan."
- Traceability to Requirements
  - The on-design conditions shall be evaluated at M = 0.8, Ta = 217 K, Pa = 18750 Pa.
  - The specific thrust must be at least 120.1 N-s/kg
  - The TSFC of the turbofan must be no more than 1.56E-5 kg/N/s.

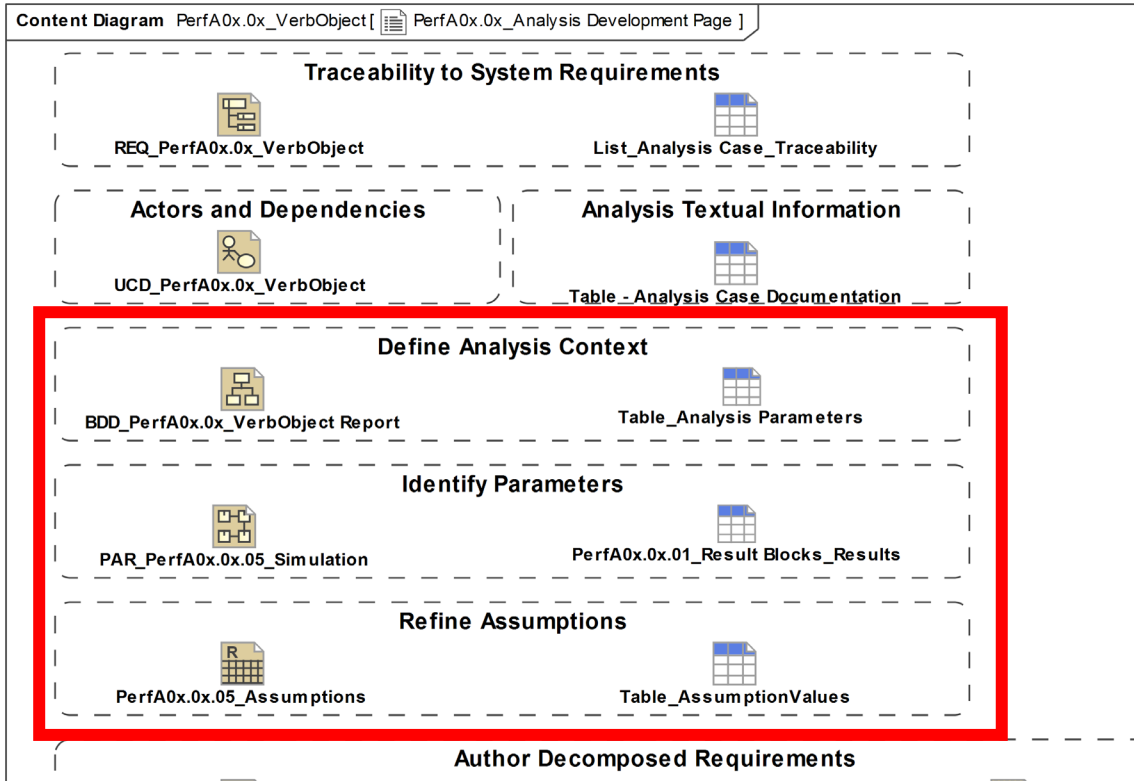
NORTHROP GRUMMAN

Step 2: Identify the Independent Models

- Who are the stakeholders in this integration process?
  - Systems Engineering needs to breakdown system level requirements
  - Propulsion Engineering has design and part selection authority
- Are there existing analytic models (Excel, Matlab, CAD, etc)?
  - 3 models (Core Performance, Nozzle Performance, Overall Performance)
  - Each has impact on future lower-level requirements
- Is there any new development that needs to occur?
  - May need to create a workflow that automates these calculations

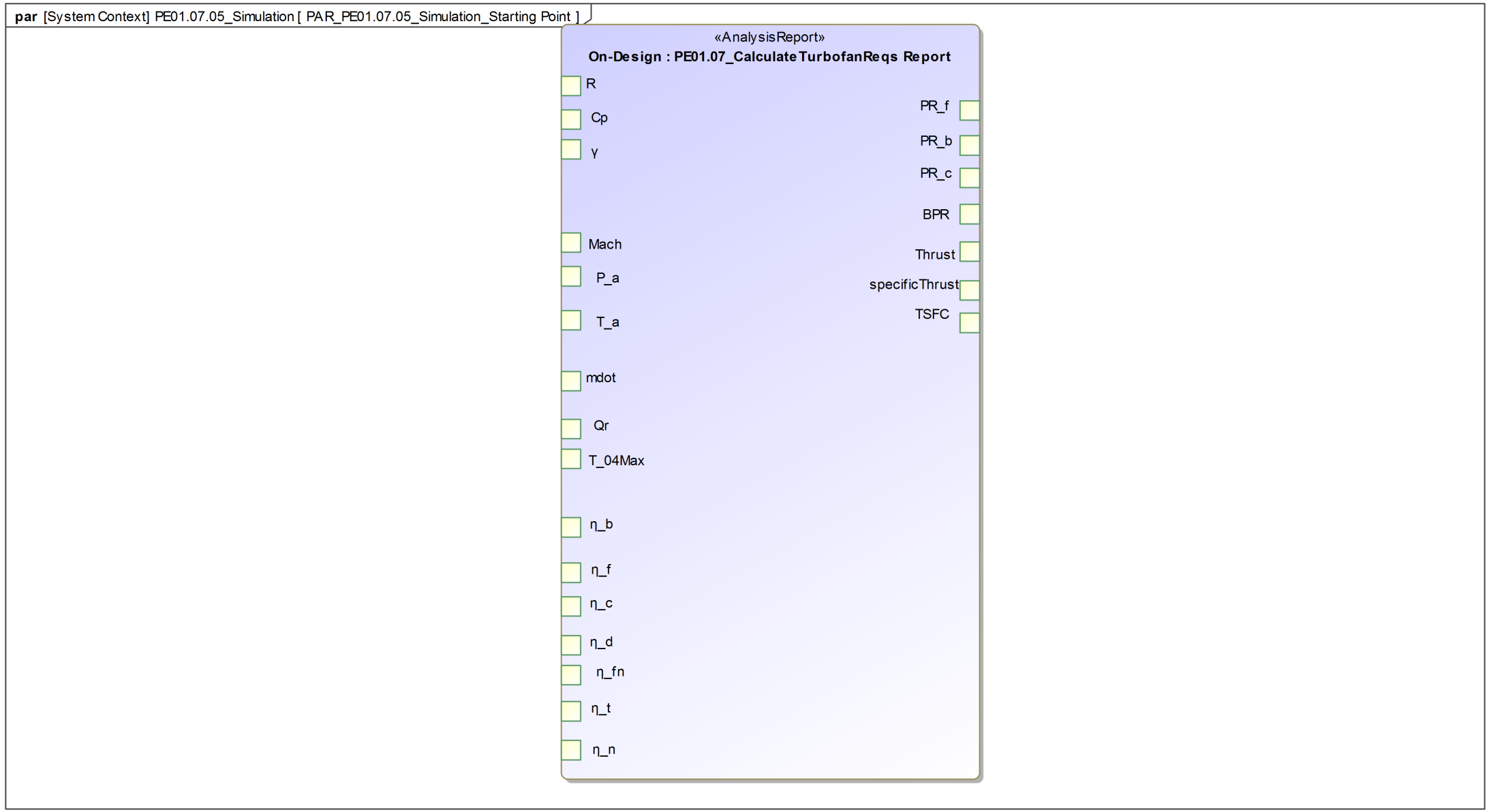
Step 3: Identify the Interfaces

- Capture inputs and outputs of analytic models
- Identify architecture components as source of values
  - Requirements
  - Assumptions
  - Known Constants
  - Component Performance
- Ensure matching Dimensions and Units

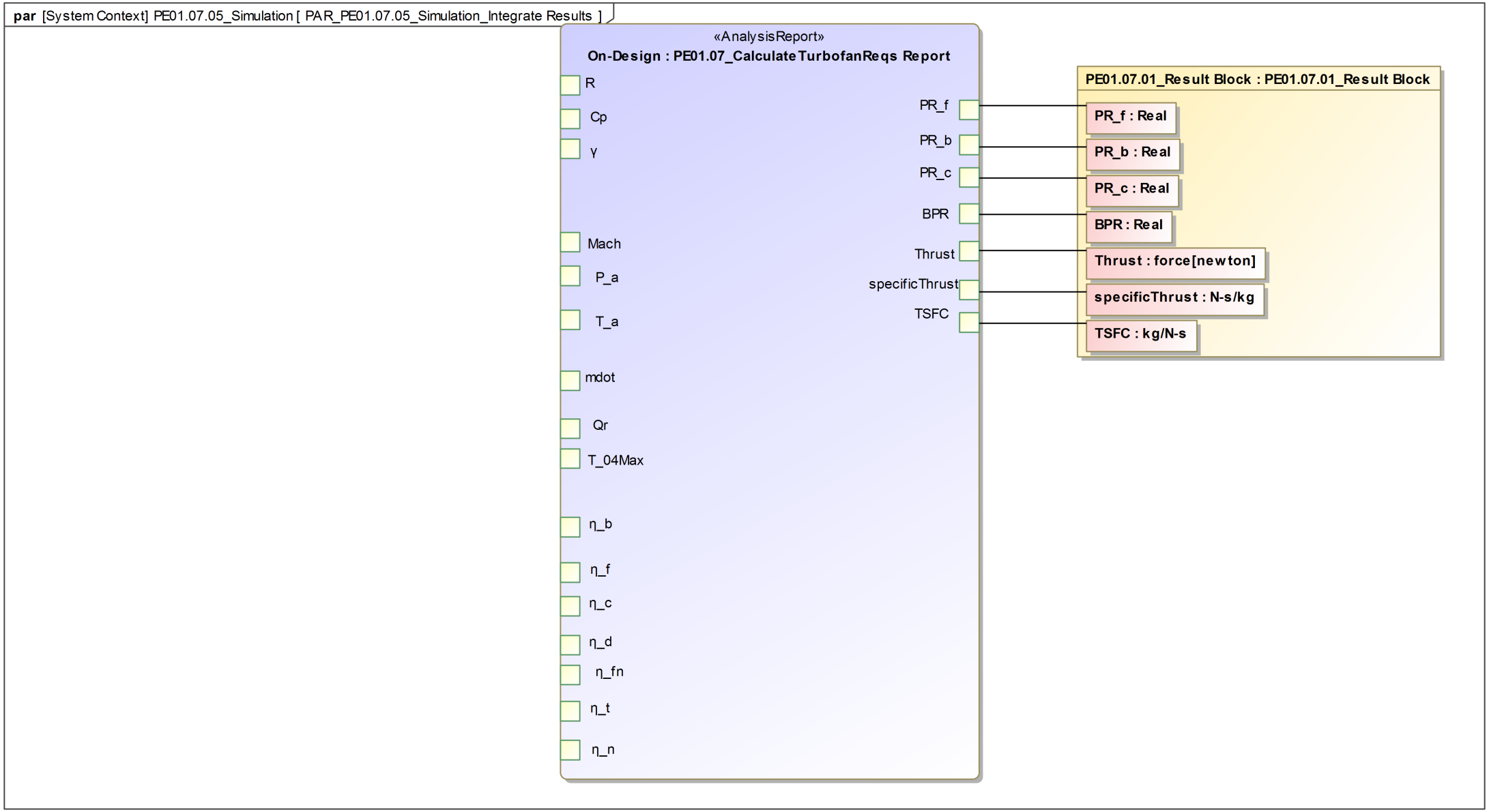


#	Name	Documentation	Type	Units
1	BPR		Real	
2	Cp		Real	
3	Mach		Real	

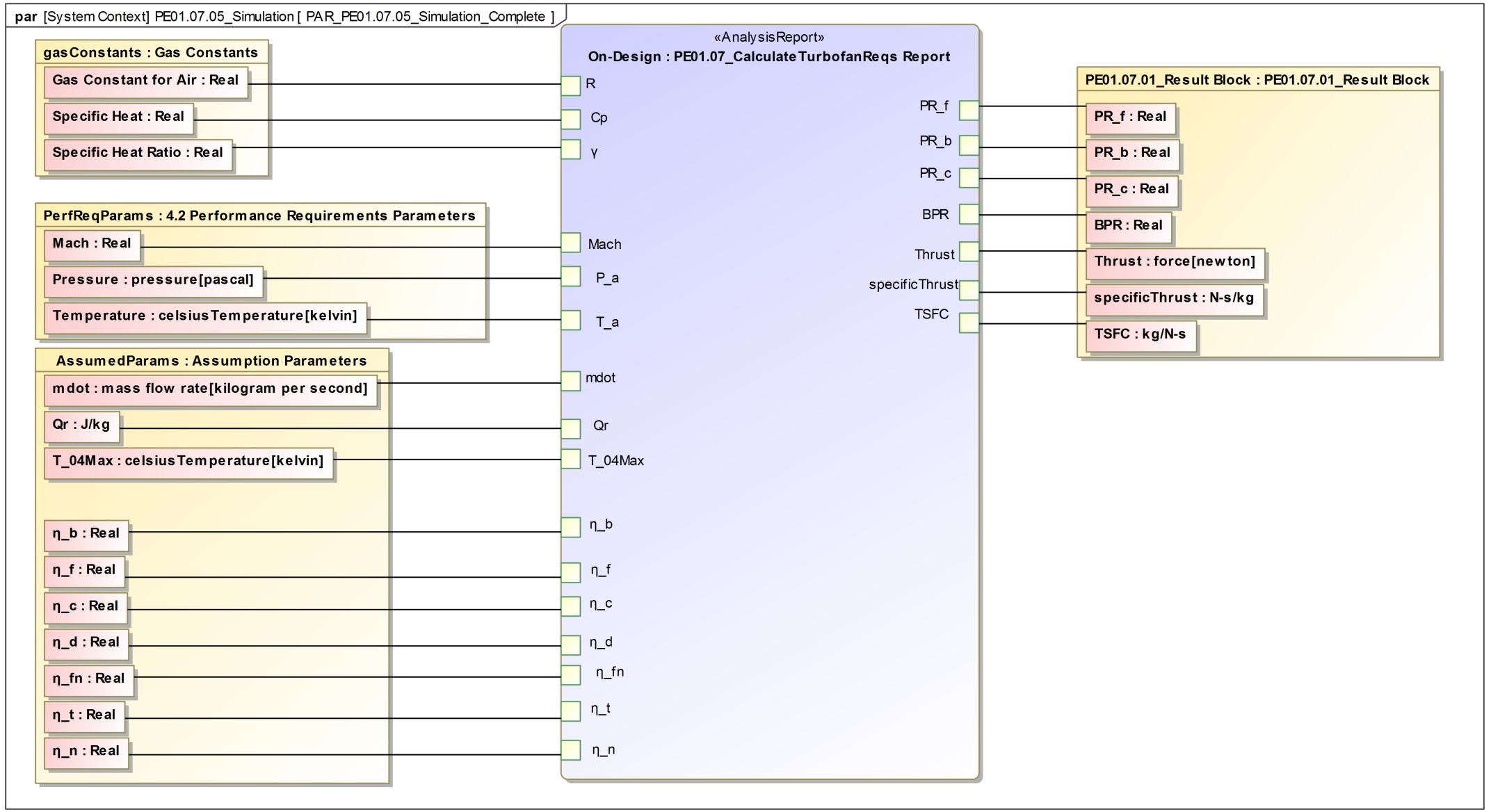
Step 4a: Starting the Integration



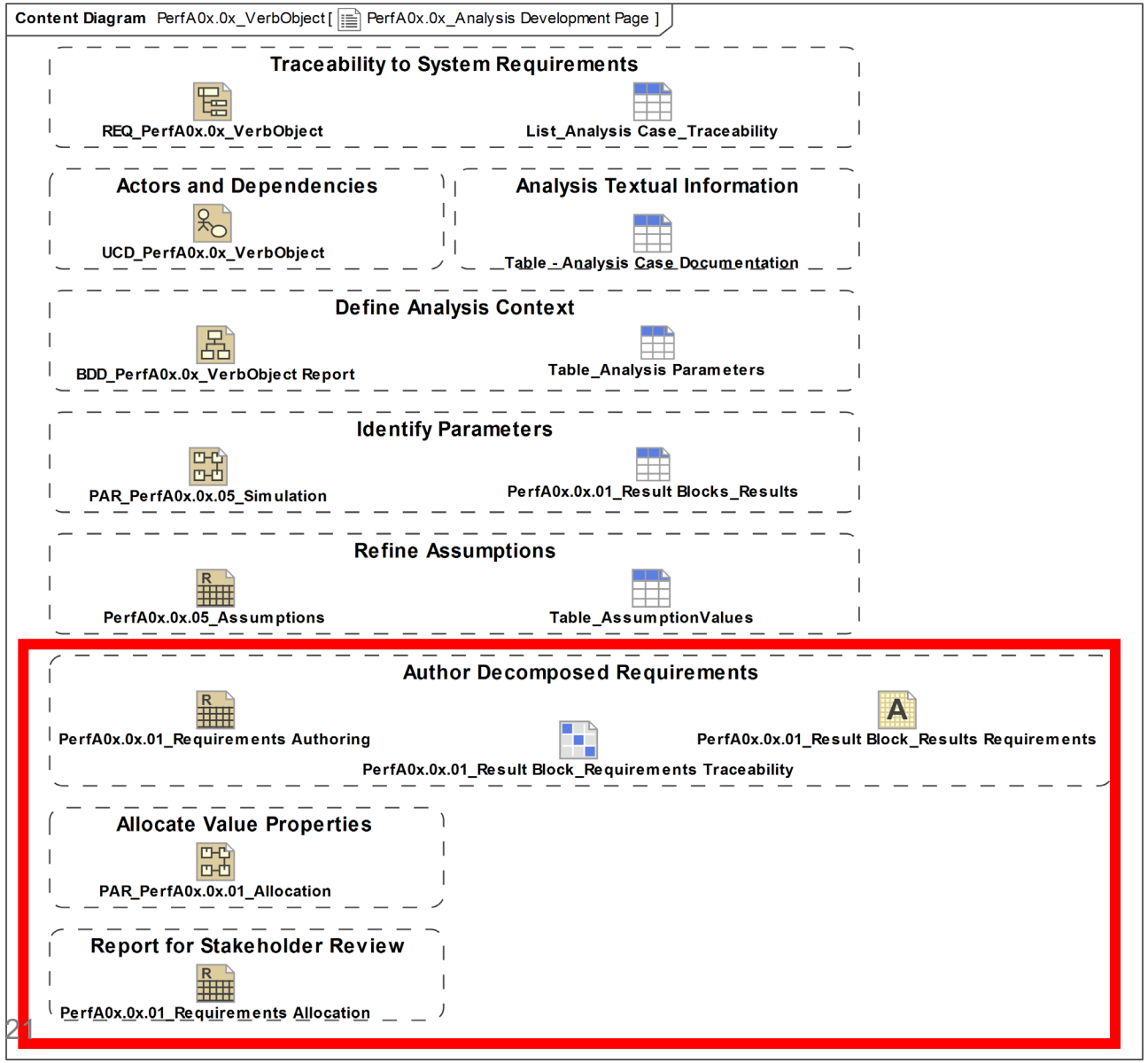
Step 4b: Integrating the Results



Step 4c: Integrate the Inputs



Post-Analysis Activities



After performing analysis:

- Write requirements against results
  - Fan Pressure Ratio Limit
  - Burner Pressure Ratio Limit
  - Compressor Pressure Ratio Limit
  - Update Thrust, TSFC
- Trace authored requirements
- Allocate expected values to components
- Allocate requirements to components

NORTHROP GRUMMAN

In Summary,

- There are many classes of information regarding any integration
- A structured approach separates out each class of information
- This separation enables effective means of communicating and coordinating two or more independent models (systems)
- Integrating these two modeling spaces yields one true development story

What do you think?


NORTHROP
GRUMMAN