



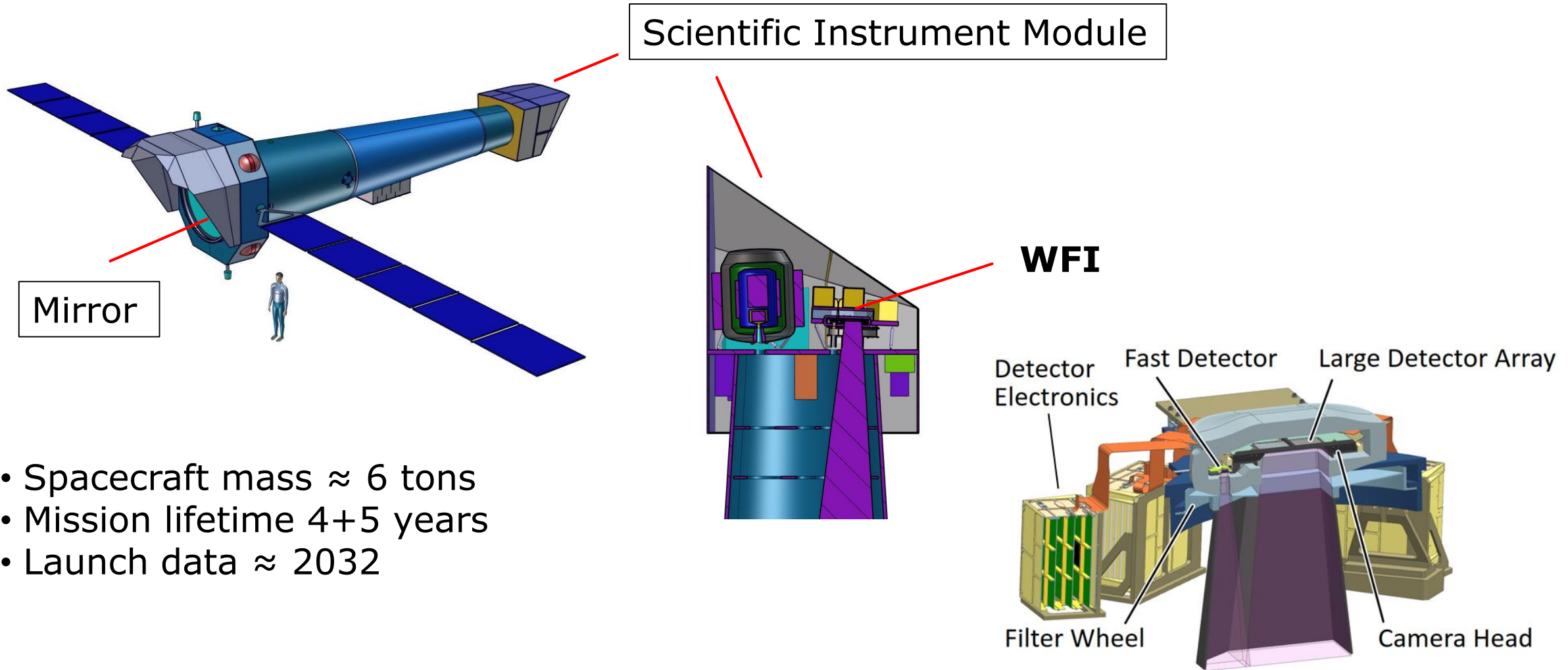
MBSE-based Development of the Athena WFI ICPU

S. Ott, M. Spagnolli, M. Plattner

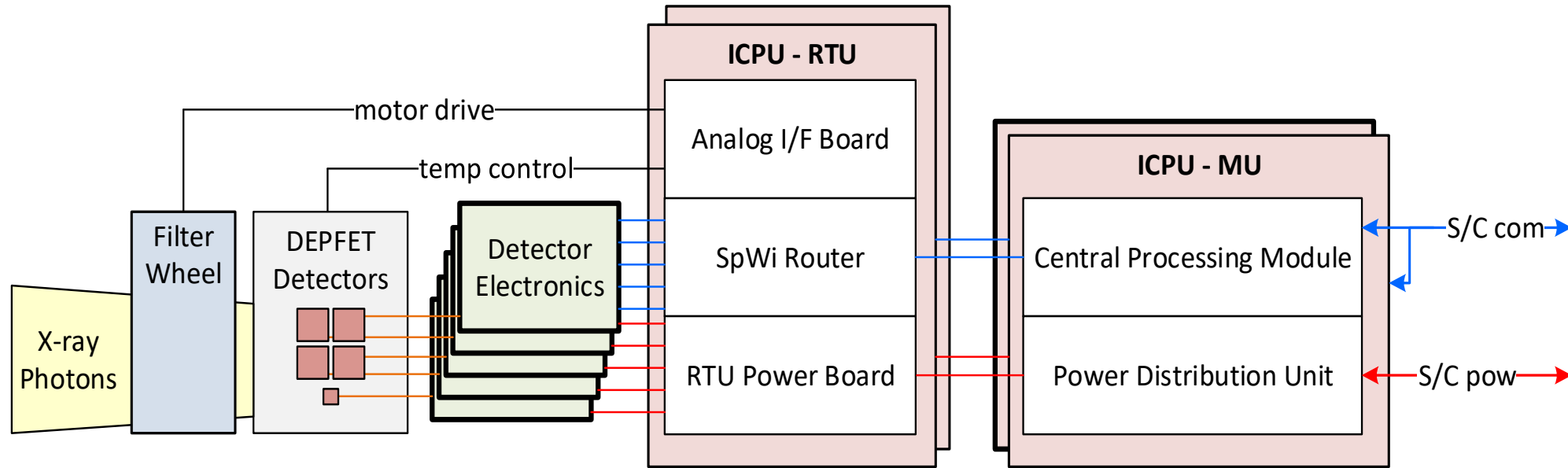
18.09.2020

MBSE Workshop, 2020





- Spacecraft mass \approx 6 tons
- Mission lifetime 4+5 years
- Launch data \approx 2032

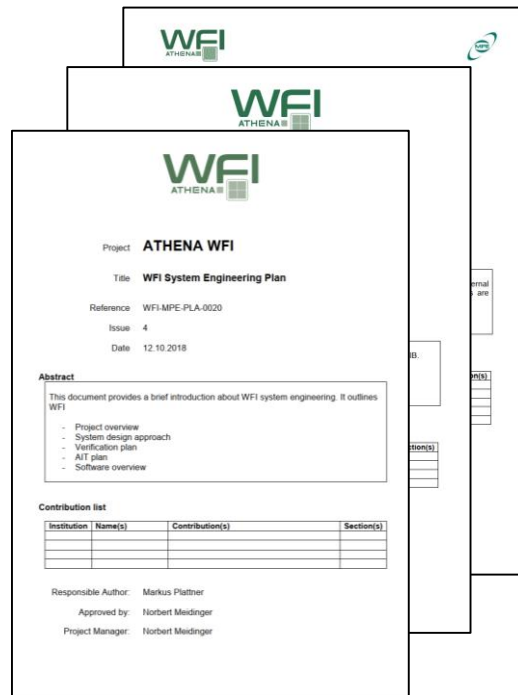


Instrument Control and Power Distribution Unit (ICPU)

- combines the data streams of the DEs
- is the secondary power supply of WFI
- controls the WFI instrument and performs house keeping



Document based System Engineering



Project **ATHENA WFI**

Title **WFI System Engineering Plan**

Reference WFI-MPE-PLA-0020

Issue 4

Date 12.10.2018

Abstract

This document provides a brief introduction about WFI system engineering. It outlines WFI

- Project overview
- System design approach
- Verification plan
- All plan
- Software overview

Contribution list

Institution	Name(s)	Contribution(s)	Section(s)

Responsible Author: Markus Plattner

Approved by: Norbert Meidinger

Project Manager: Norbert Meidinger

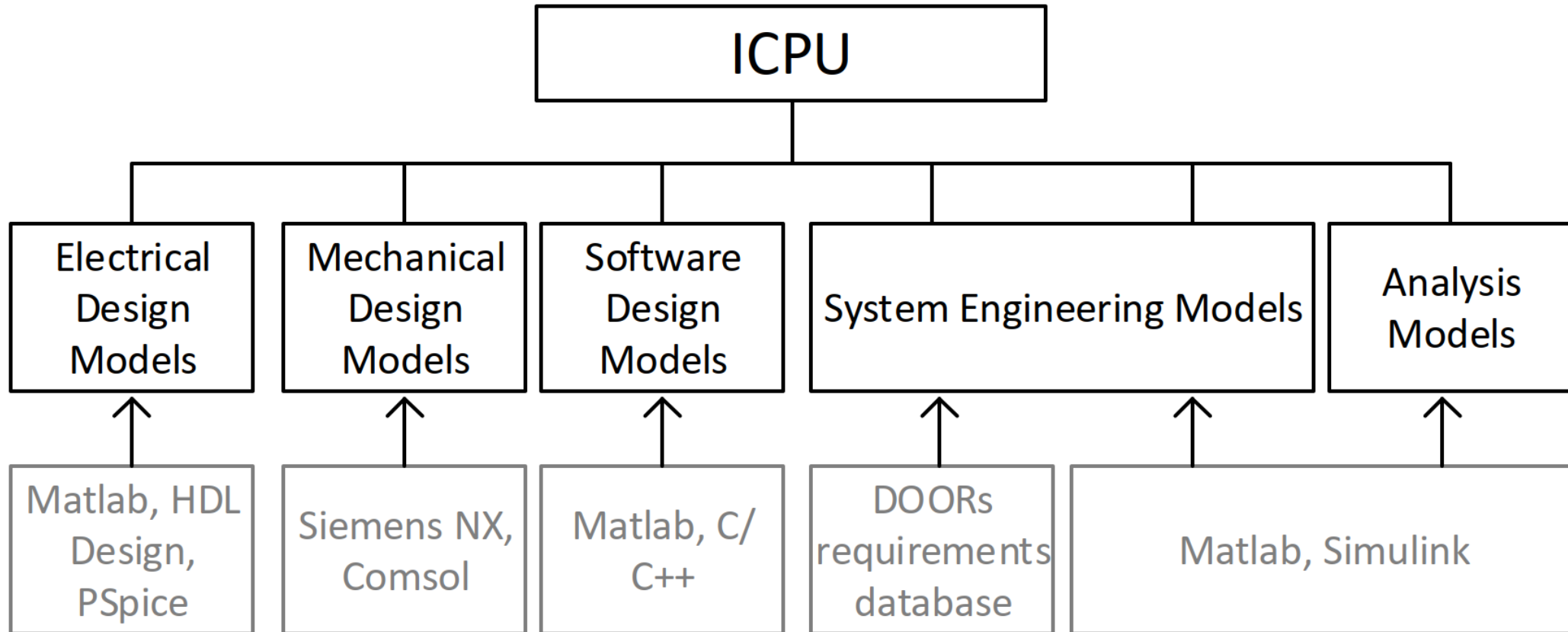


Moving from document
centric to model centric

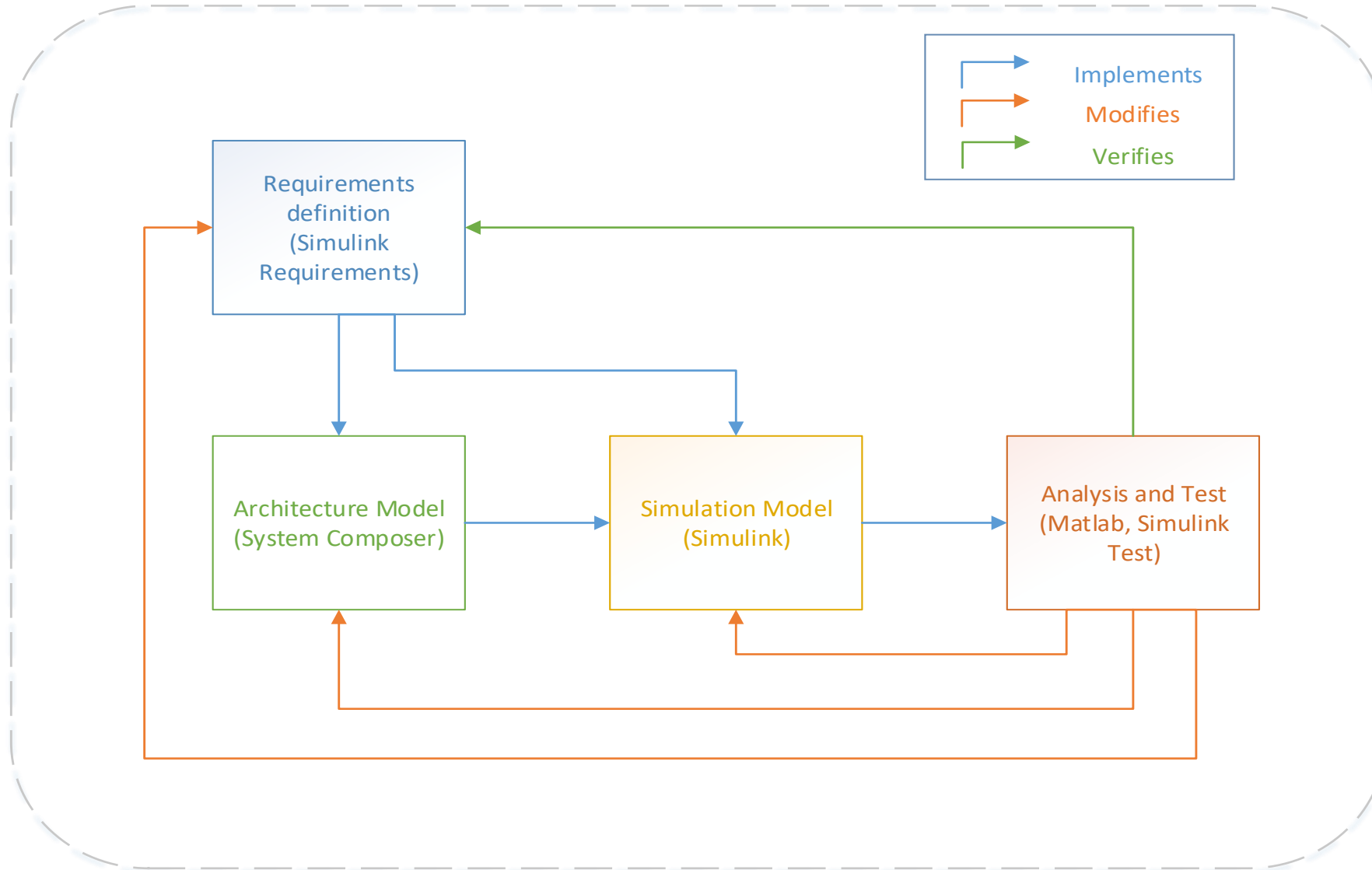
Model based System Engineering

- Consistent and complete I/F management
- Track all changes during development and system Specification
- Capture, analyze, share and manage the requirements among the ICPU consortium
- Holistic requirements engineering



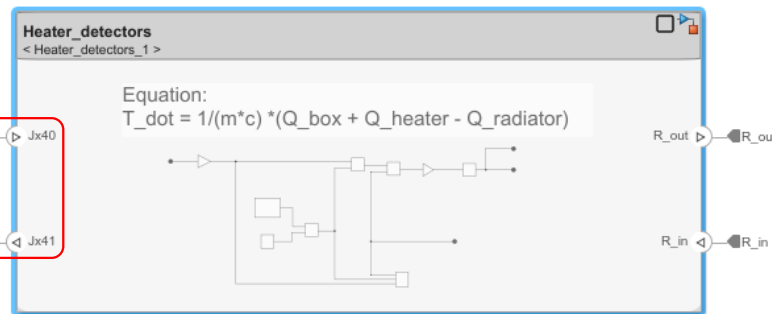
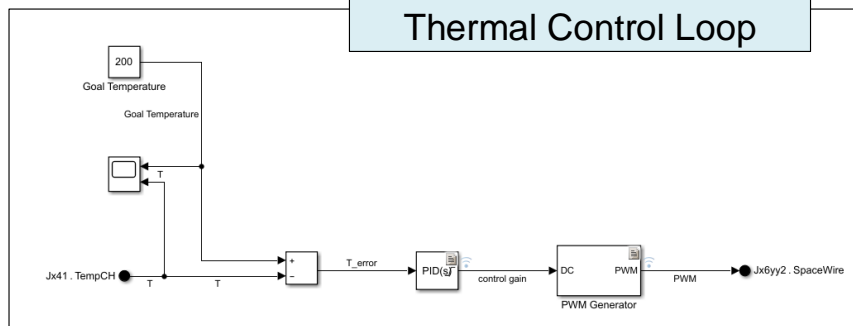


Matlab/Simulink Environment

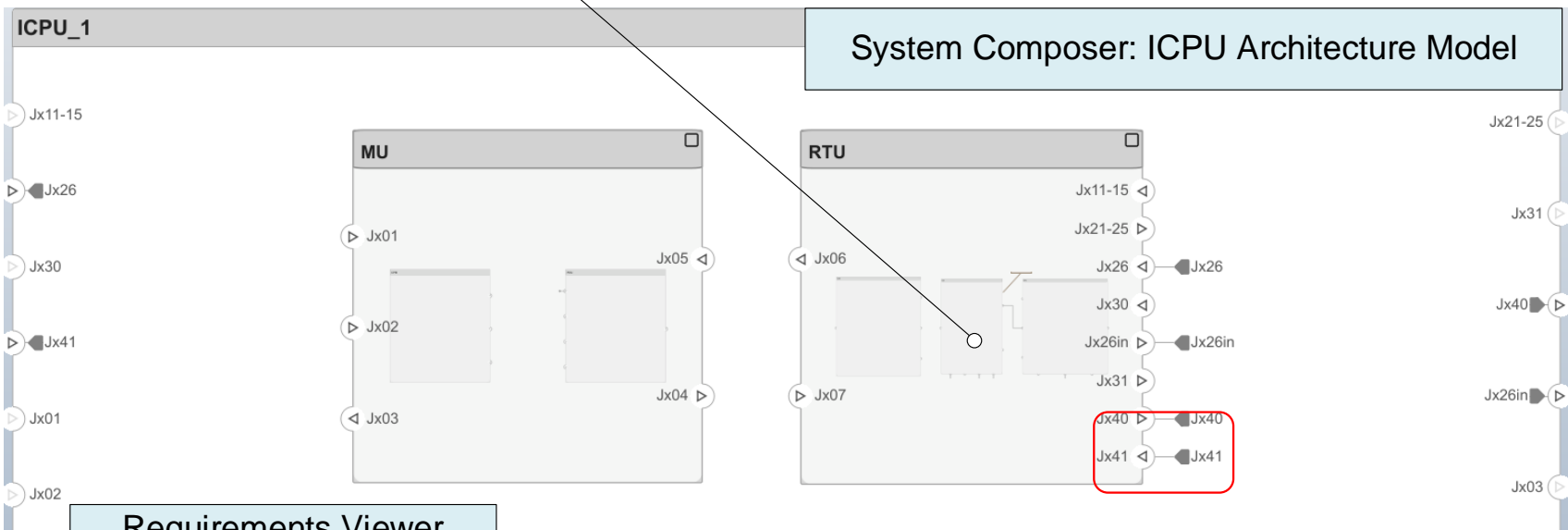


Case Study: Thermal Control Loop

Simulink Model:
Thermal Control Loop



System Composer: ICPU Architecture Model



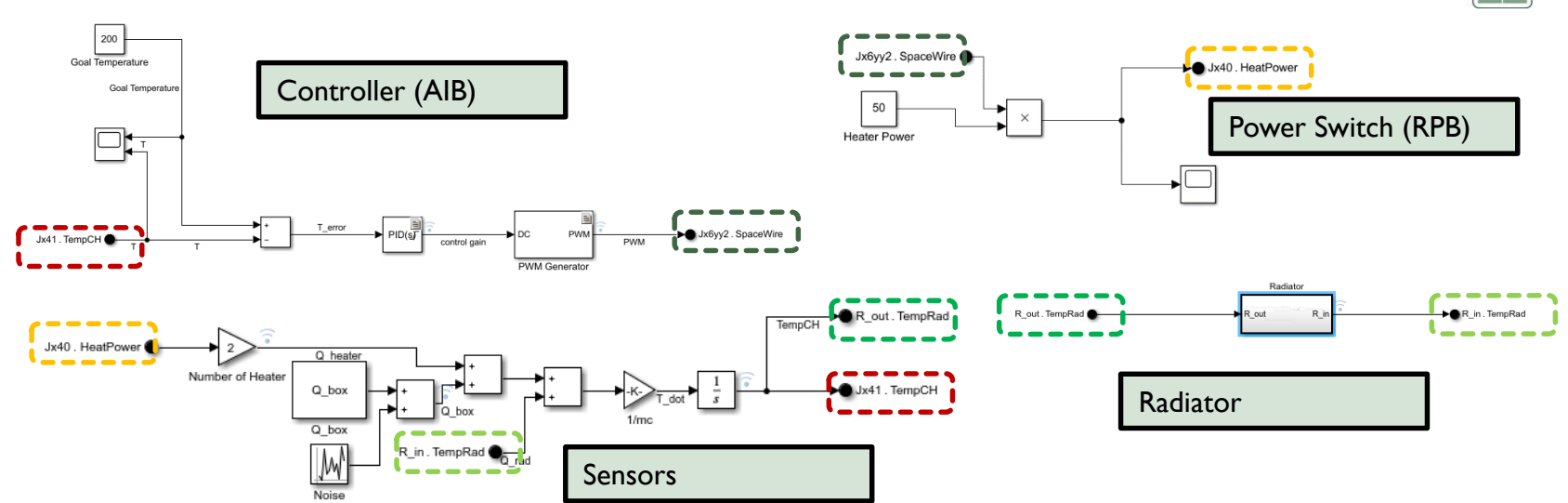
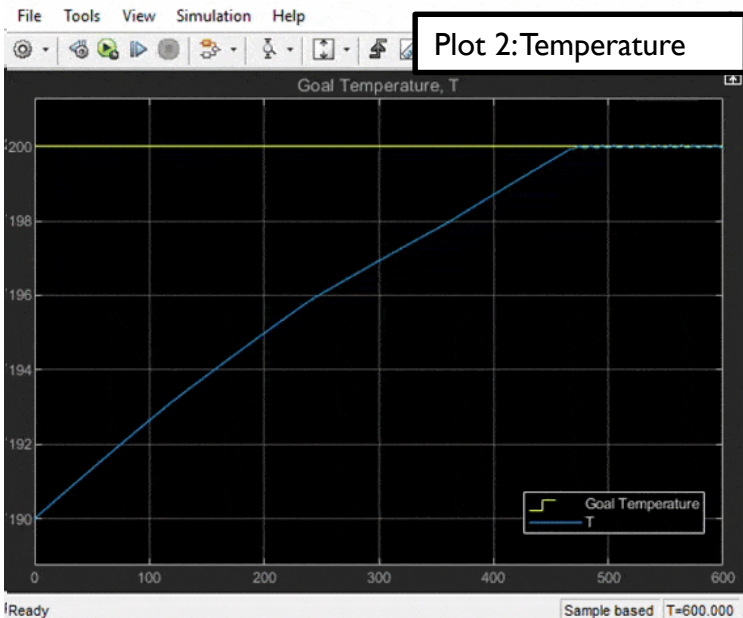
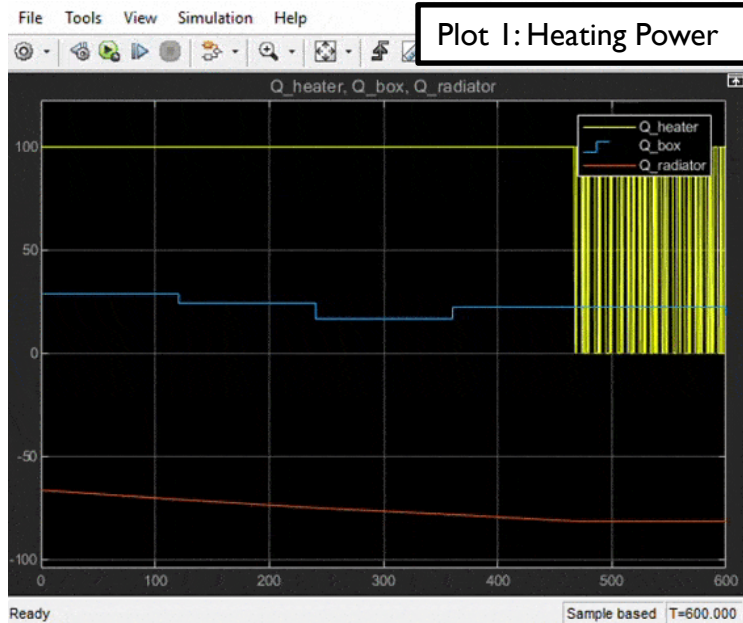
- Sensors range: 193 K - 213 K
- PID controller (AIB) sends PWM signal to power switch (RPB) of heater
- Top-Down approach
- Architecture in System Composer
- Simulation in Simulink
- RE in Simulink Requirements linked to IBM Rational DOORS

Requirements Viewer

Index	ID	Summary	Description	Implemented	Verified
5.1.1.7	186	Heater Control		<div><div></div></div>	<div><div></div></div>
5.1.1.7.1	187		The AIB shall control the DEPFET temperature by controlling a 50 W heater.	<div><div></div></div>	<div><div></div></div>
5.1.1.7.2	213		The DEPFET temperature control shall be designed to achieve a temperature stability of ± 0.5 K at the thermal I/F.	<div><div></div></div>	<div><div></div></div>
5.1.1.7.3	192		The AIB shall control the FEE temperature by controlling a tbd W heater. (tbd)	<div><div></div></div>	<div><div></div></div>
5.1.1.7.4	214		The FEE temperature control shall be designed to achieve a temperature stability of ± 2 K at the thermal I/F.	<div><div></div></div>	<div><div></div></div>
5.1.1.7.5	291		The AIB shall control the switches within RPB for heater control.	<div><div></div></div>	<div><div></div></div>



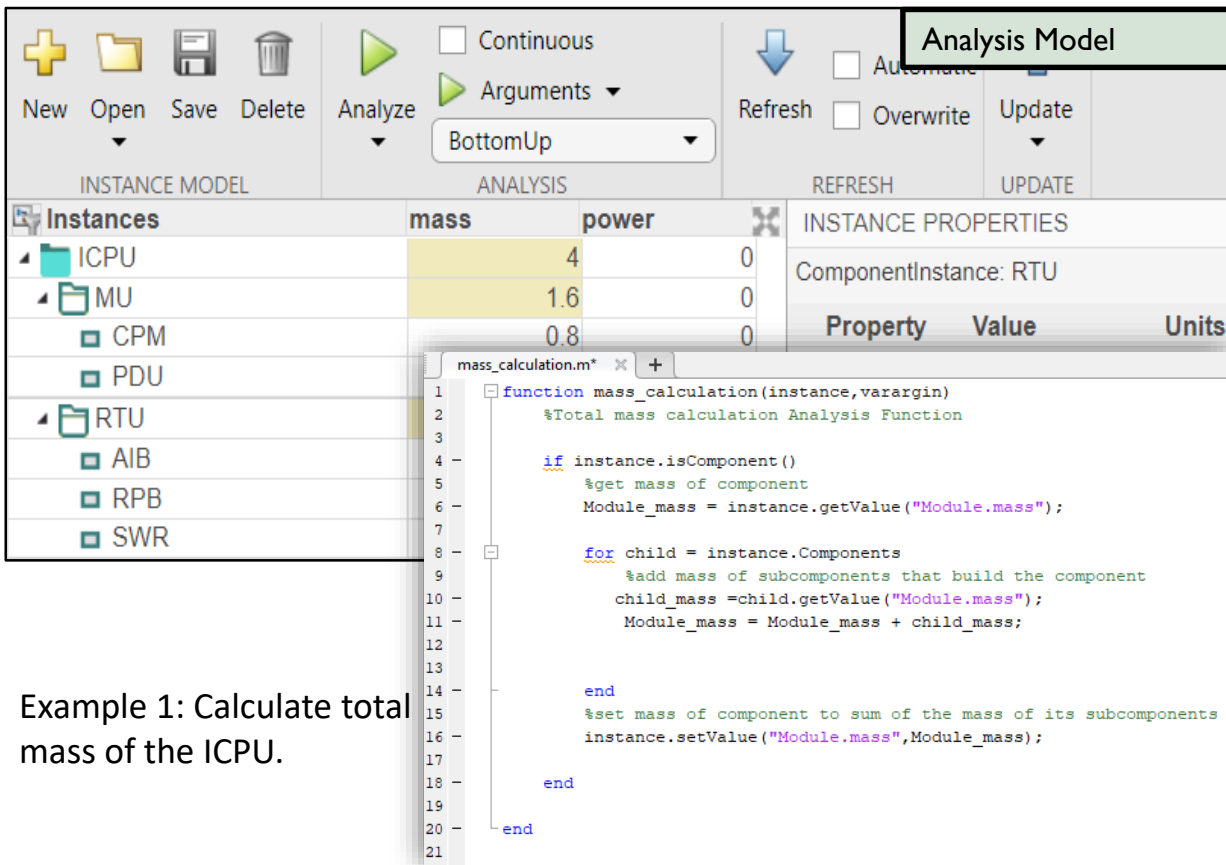
THERMAL CONTROL SIMULATION



- Heat control loop simulation with 2 x 50 W heaters
- Interaction of 4 subsystems in this setup:
 - AIB
 - RPB
 - Camera Head Sensors
 - Radiators
- Change in performance, analysis and verification of loop by changing initial conditions (Temperature, number of heaters, radiator area etc.)



Use stereotypes to assign quantifiable characteristics of an instance (e.g. mass)
Stereotypes are used as arguments for MATLAB functions



Analysis Model

Instances table:

Instances	mass	power	
ICPU	4	0	
MU	1.6	0	
CPM	0.8	0	
PDU			
RTU			
AIB			
RPB			
SWR			

INSTANCE PROPERTIES

ComponentInstance: RTU

Property Value Units

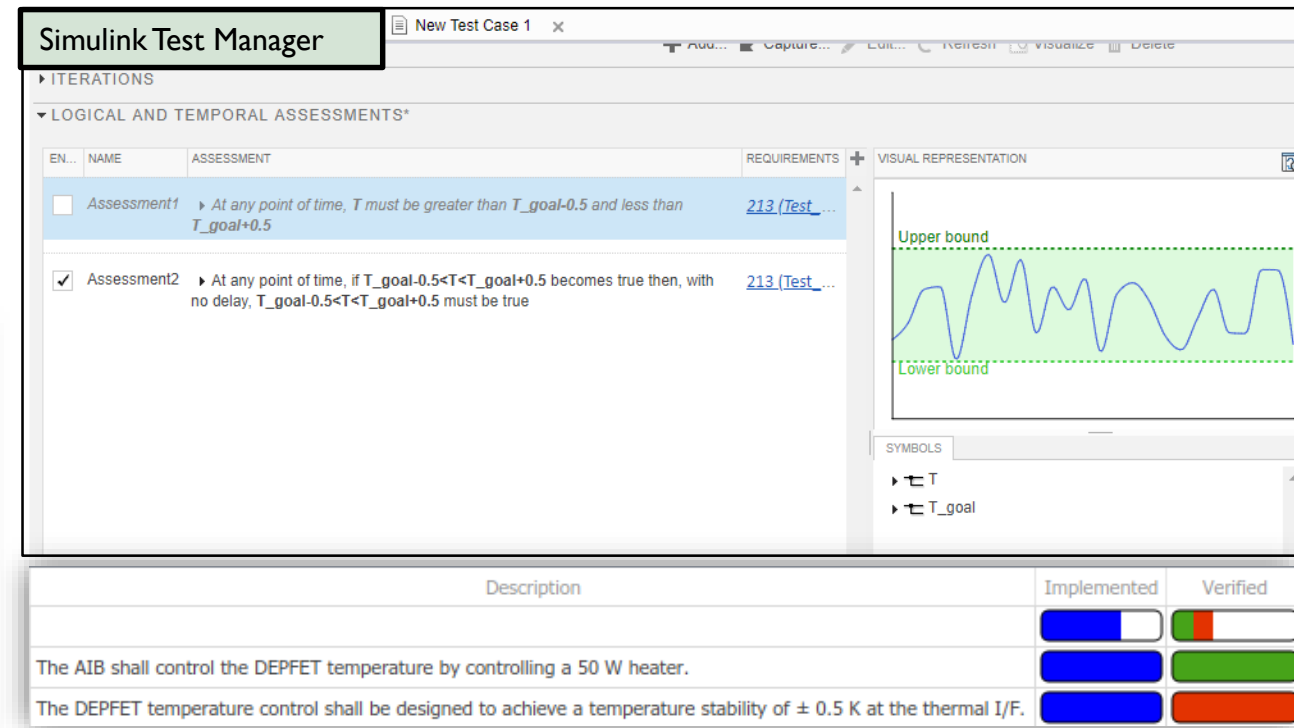
mass_calculation.m

```

1 function mass_calculation(instance, varargin)
2     %Total mass calculation Analysis Function
3
4     if instance.isComponent()
5         %get mass of component
6         Module_mass = instance.getValue("Module.mass");
7
8         for child = instance.Components
9             %add mass of subcomponents that build the component
10            child_mass = child.getValue("Module.mass");
11            Module_mass = Module_mass + child_mass;
12
13        end
14
15        %set mass of component to sum of the mass of its subcomponents
16        instance.setValue("Module.mass", Module_mass);
17
18    end
19
20 end
21
  
```

Example 1: Calculate total mass of the ICPU.

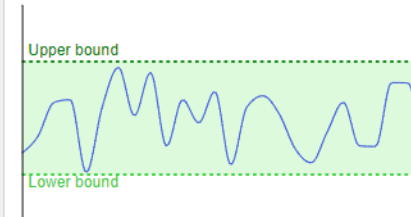
- Create Test cases on Test Manager
- Link Test to implemented Requirement
- Verify requirements and identify needed design modifications directly



Simulink Test Manager

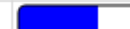



NEW Test Case 1

LOGICAL AND TEMPORAL ASSESSMENTS*

EN...	NAME	ASSESSMENT	REQUIREMENTS	VISUAL REPRESENTATION
<input type="checkbox"/>	Assessment1	At any point of time, T must be greater than T_goal-0.5 and less than T_goal+0.5	213 (Test...	
<input checked="" type="checkbox"/>	Assessment2	At any point of time, if T_goal-0.5 < T < T_goal+0.5 becomes true then, with no delay, T_goal-0.5 < T < T_goal+0.5 must be true	213 (Test...	

SYMBOLS

- T
- T_goal

Description	Implemented	Verified
The AIB shall control the DEPFET temperature by controlling a 50 W heater.		
The DEPFET temperature control shall be designed to achieve a temperature stability of ± 0.5 K at the thermal I/F.		

Example 2: Verify Heater Control Functional Requirements.



- The MBSE approach based on MatLab Simulink and the System Composer is straight forward when having the software available and working together in a group of developers.
- It provides the possibility to connect the model with the requirements defined in an IBM Rational DOORS database.
- The software framework provides the possibility of instrument modelling, simulation and verification.
- We will investigate how reports and data packages can be generated automatically for the support of milestone reviews.

