THE UNIVERSITY OF TEXAS AT EL PASO

Northrop Grumman

Satellite Modularity Design & Implementation

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Project Overview

Objective

Use digital engineering to validate and implement modularity in satellite technology

Current Satellite Methods

One-Off Satellites, expensive, inaccessible, and limited to fixed operations

Our Approach

Uses of CAD Simulation and MBSE to create an initial design for a modular satellite

Our Results

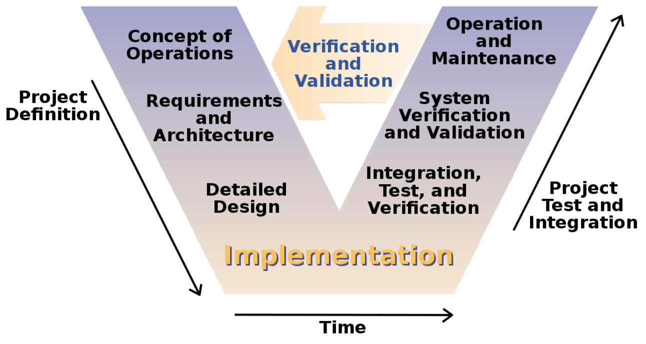
Our approach suggests DE could help achieve modularity by continuous V&V and Requirement traceability

Need statement

- Northrop Grumman is pursuing a case study to explore the possibilities of On Orbit Attachable Components (OACs).

- We aim to aid NG in the development of innovative modifications to satellite operations.

Implemented Approach



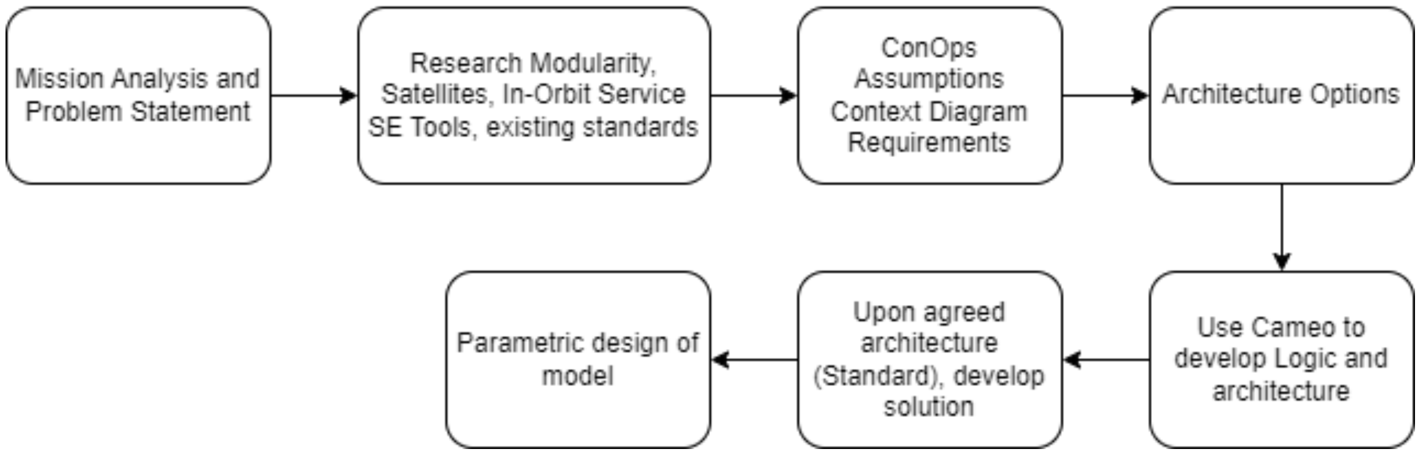
- Systems Engineering methodology (ISO/IEC/IEEE 15288)
- Model-Based Systems Engineering (OOSEM Methodology)

Ensure that mission requirements are met

Support continuous Verification and Validation

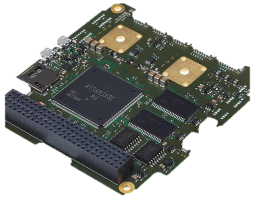
MBSE model provides a reference architecture for future mission modifications

Engineering Process Workflow



Research

Do you have to send a new one?



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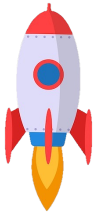


= 10M

Structure	Processing	Communication	Sensor(Payload)	Sensor(Payload)
1M	1M	1M	1M	10M

Why sending a whole new satellite, when you can only send part of it?

- Interoperability
- Interfaces

Modular Systems Approach

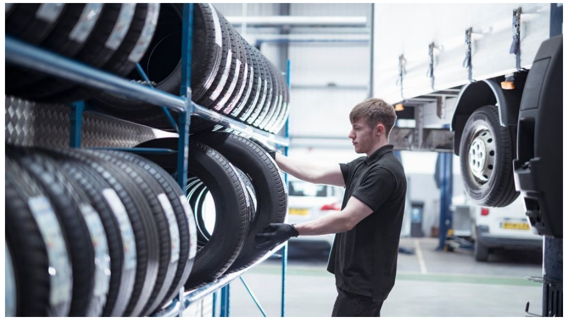
What is known about modularity?

- Modularity has existed for a long time

They all have in common:
Standards and Interfaces

SAE J537_201105

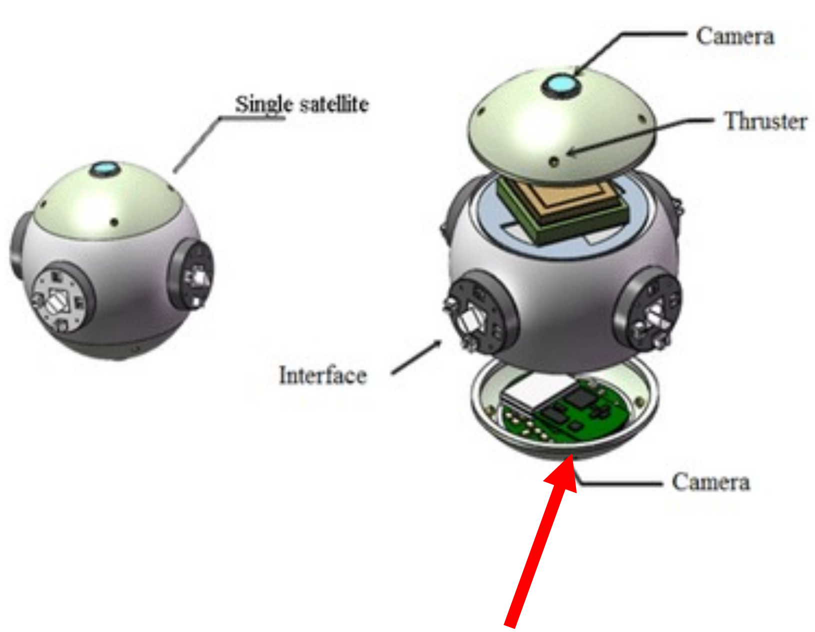
USB XHCI

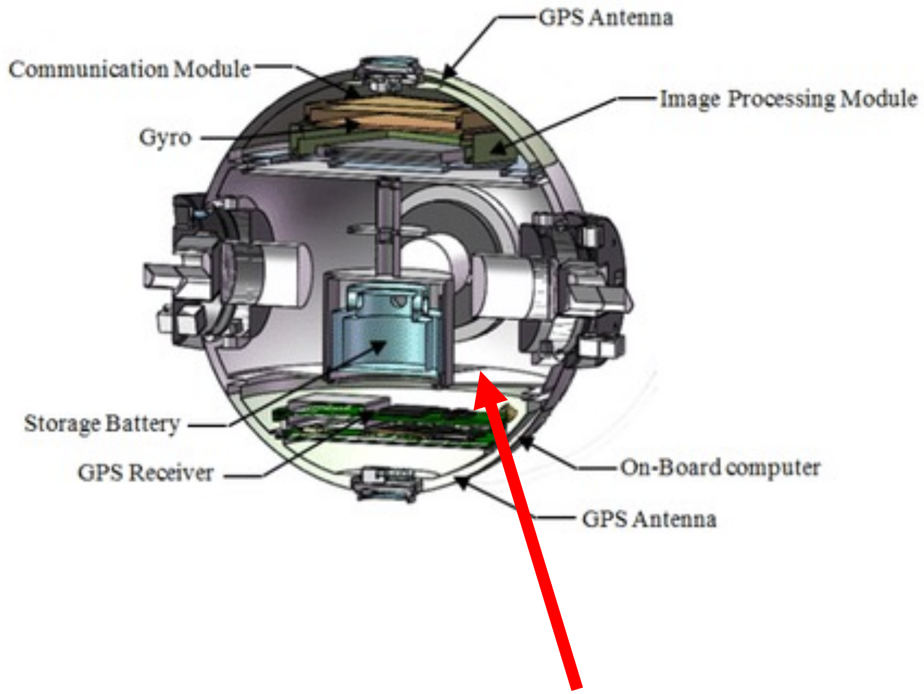


NHTSA-2019-0011

Research

Satellites are very inaccessible; what happens if they fail?





How can you replace it with a better Camera?

How do you repair this in space?

Case Study Assumptions

- Is not within the scope making a grappling system for the MRV to onboard the satellite.
- MRV and RSGS robotics will be provided by Northrop Grumman
- A scratch design of a satellite is not required nor designing the circuits
- It is not within the scope of the project to consider the real life details of a satellite such as weight, space, launch logistics.

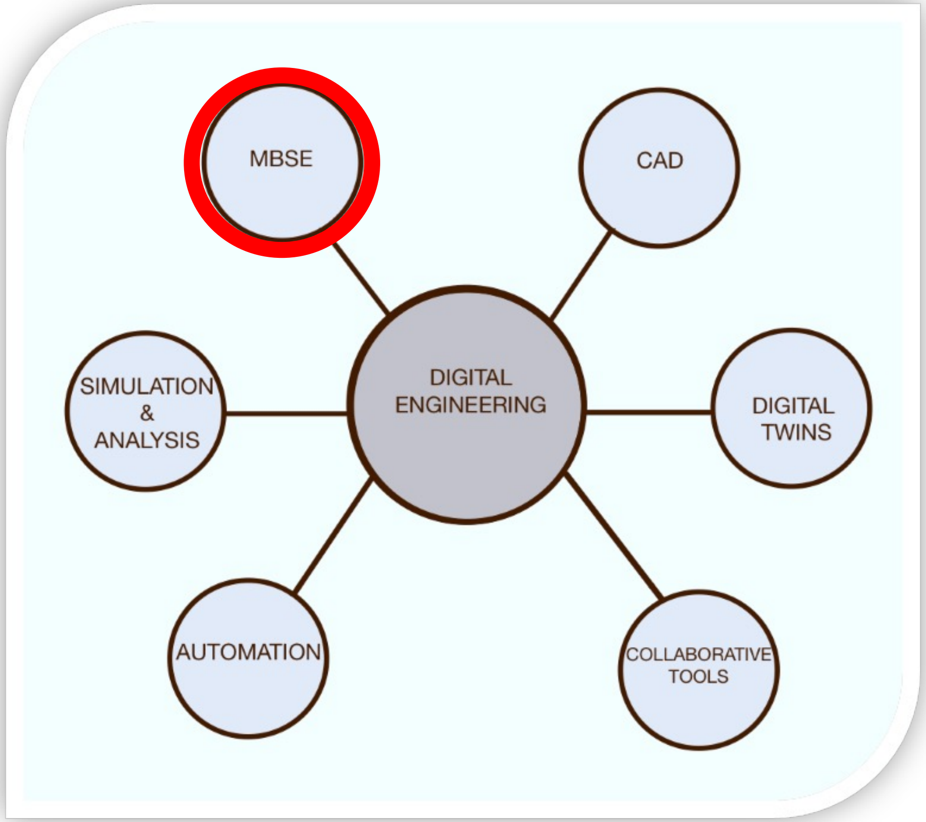
Case Study Assumptions	
Our mission will start considering that a compatible satellite is:	
	Already on GEO
	MRV is already attached to satellite and carrying a prepared module to make a modification to satellite.

The concepts generated will apply for the development of future satellites following the same concepts

Our Case Study

Representing modulatory in satellite reference

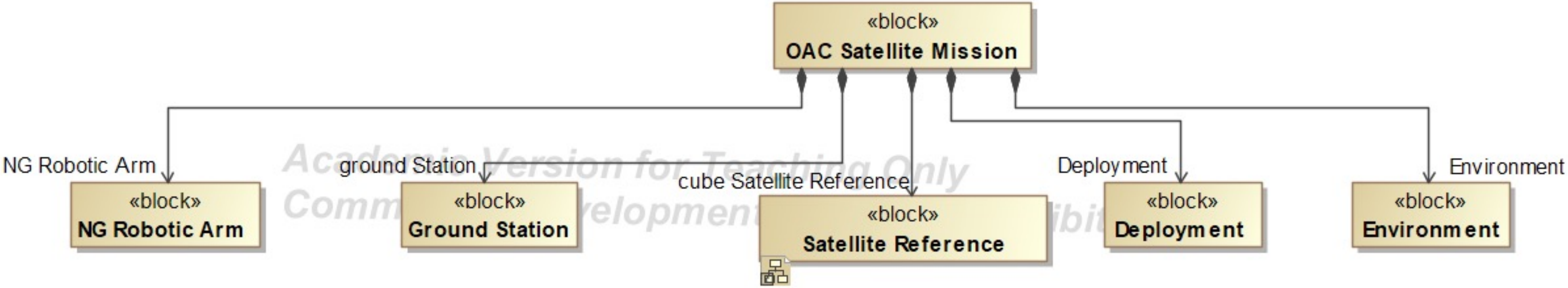
Tools Aimed To Achieve Modularity?



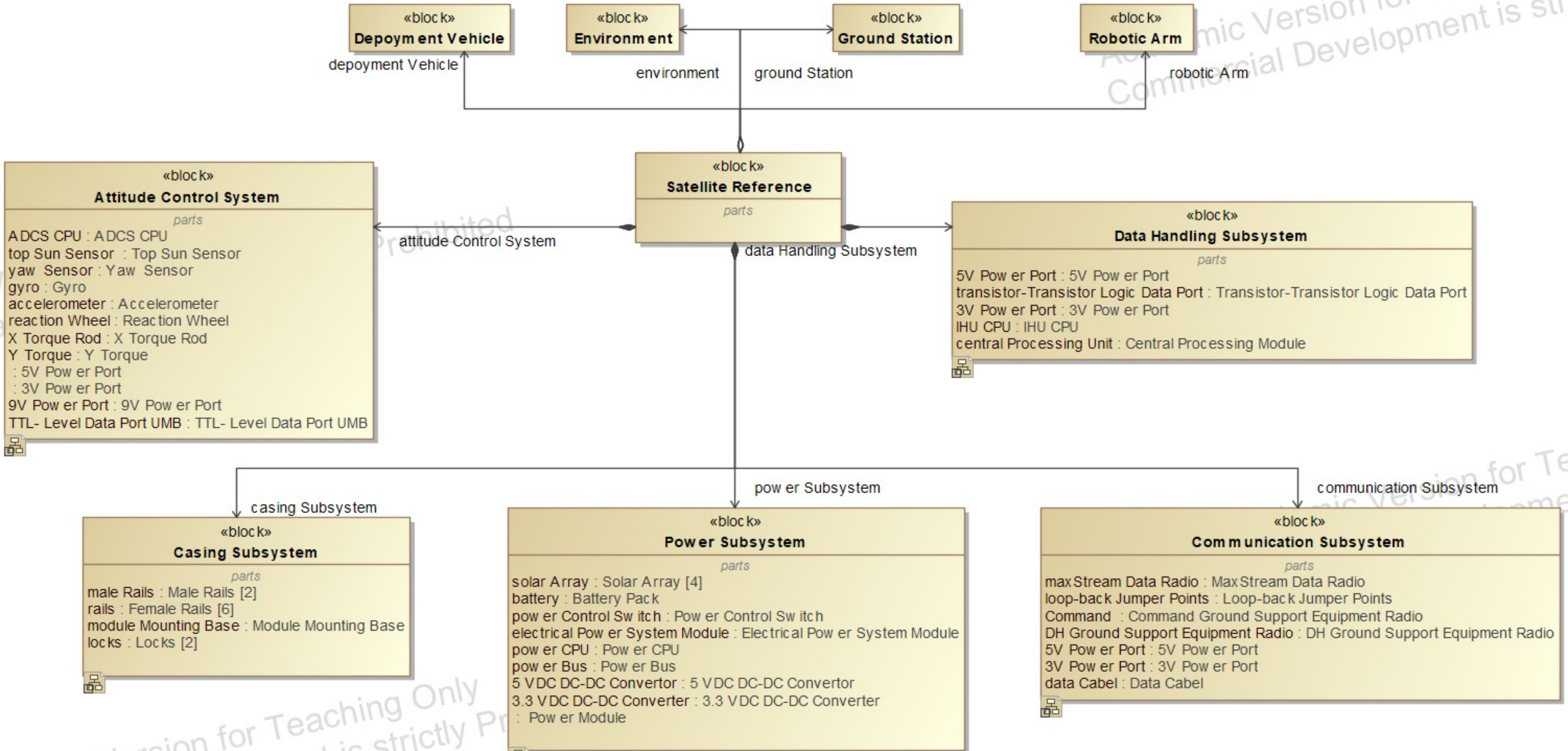
Magic Systems of Systems Architect (CAMEO)

OACs Satellite Mission

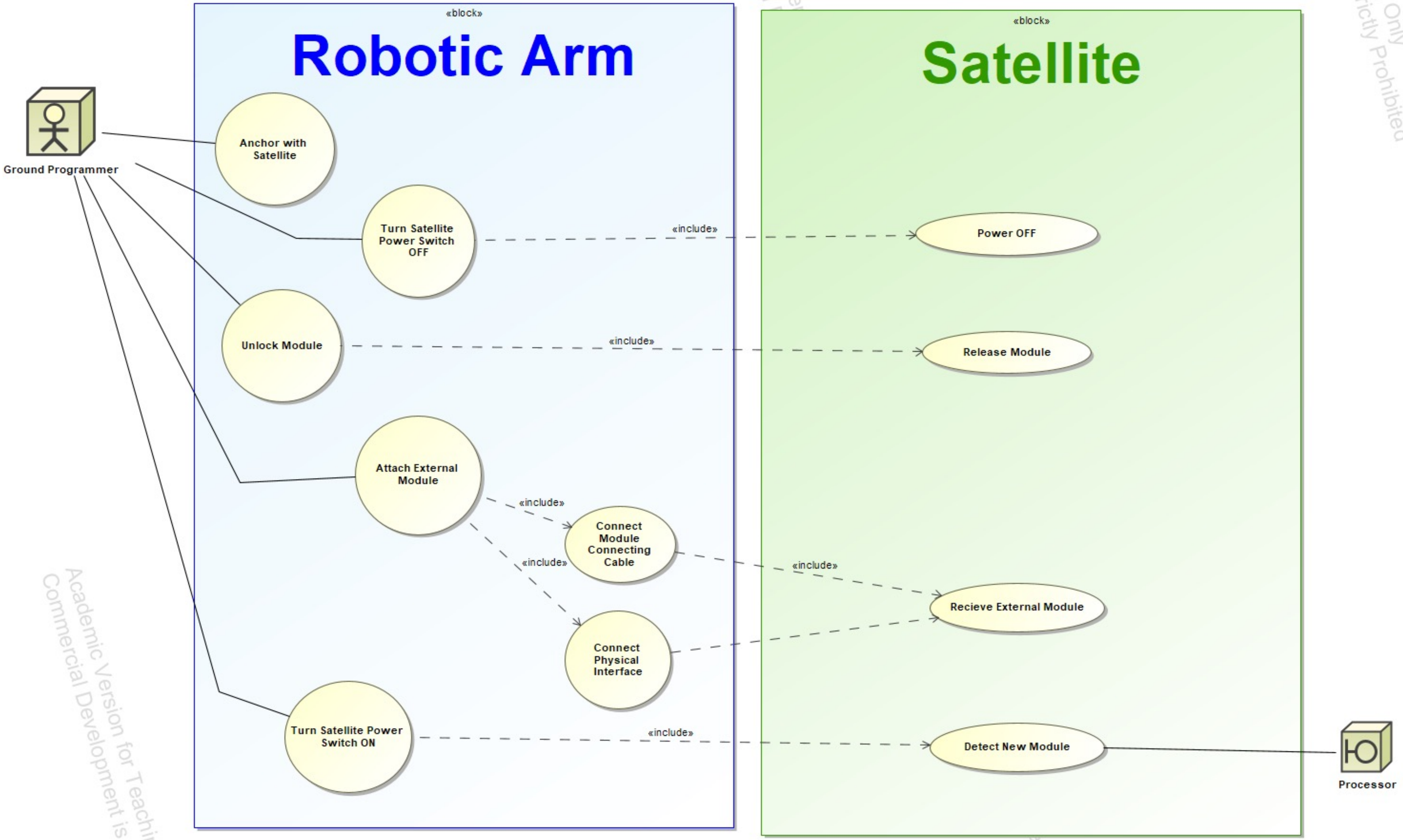
Identifies System of Interest and its Enabling systems



Reference Context Diagram



Use Case Diagram



General Requirements

Requirements elicitation, management, and traceability

1 Mission Requirement	The System Shall implement modularity throughout the entirety of its life cycle.
1.1 Functional Requirements	
1.1.1 Compatibility	The System shall be compatible with existing satellites of same standard
1.1.2 Module Components	The System shall have interchangeable components
1.1.3 Mounting Mechanism	The System shall physically mount to existing satellites of same standard
1.1.4 Module Incorporation	The System shall physically have modules that couple to each other successfully
1.1.5 Module Release	The System shall have a quick release mechanism for modules
1.1.7 Produce Power	The System shall produce power
1.1.11 Data Handling	The System shall handle data
1.2 Interface Requirements	
1.2.1 Data Transfer	The System shall interchange data with existing Satellites of same standard once physically connected
1.2.2 USB Connection	The System shall be compatible with USB port
1.3 Physical Requirements	
1.3.1 Dimensions	The System's base shall be 10 x 10 cm
1.3.2 Total Weight	The System shall weigh less than 3kg in total

Sample Subsystem Requirements - Casing Subsystem

Hierarchical approach for better traceability

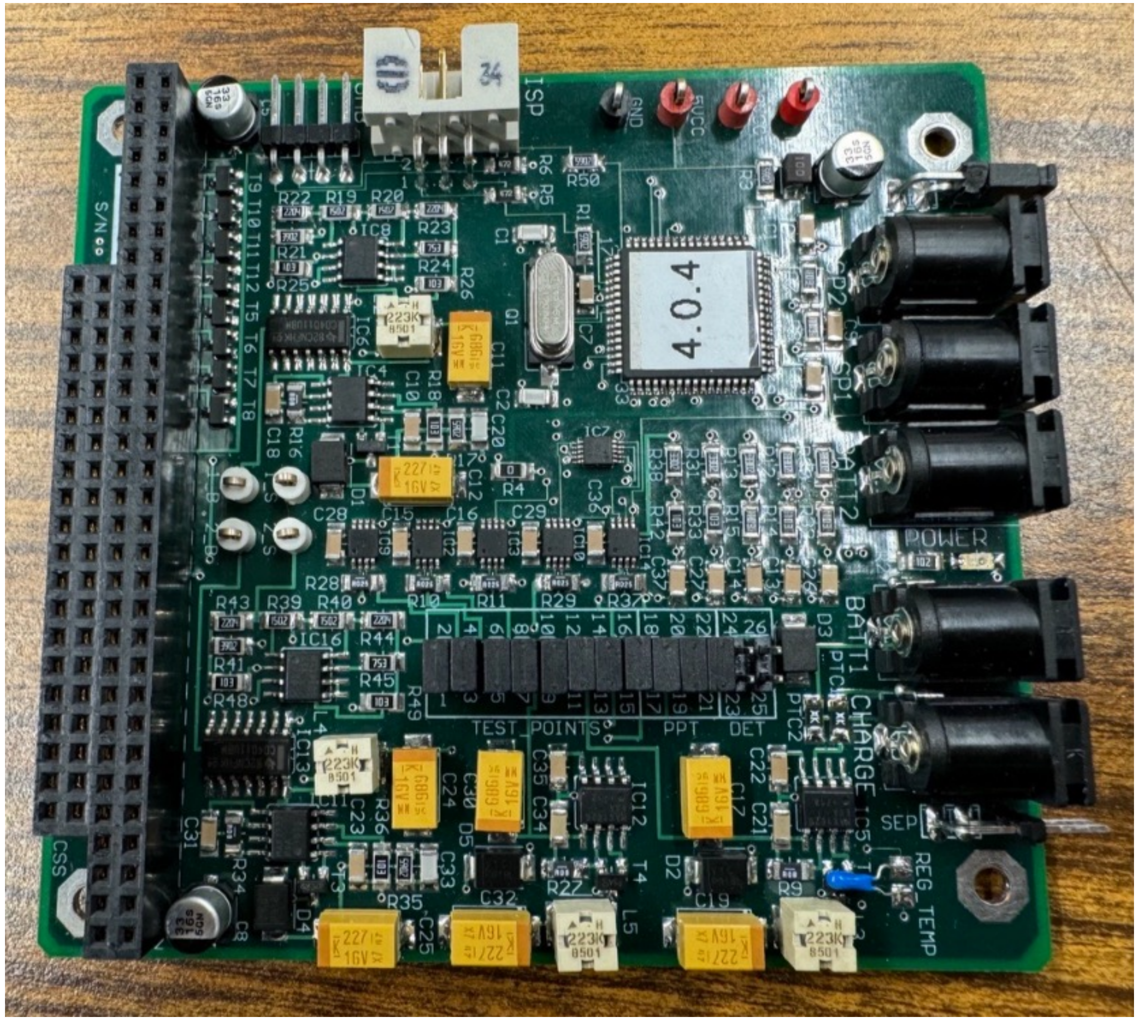
1.4 Design Requirements	
1.4.1 Casing	The System's circuit boards shall have individual casing
1.4.1.1 Casing Rails	
1.4.1.1.1 Male Rails	The System shall have 2 male rails at the top of the casing
1.4.1.1.1.1 Male Measurement	The male rail dimensions shall be a: 12.9808 mm, b: 18.3397 mm, side angles: 75 degrees, length: 59.5 mm
1.4.1.1.2 Female Rails	The System shall have 6 female rails
1.4.1.1.2.1 Bottom of Casing	The System shall have 2 female rails at the bottom of the casing
1.4.1.1.2.1.1 Bottom Rail Measureme	The female rail dimensions shall be a: 13.4808 mm, b: 18.8391 mm, side angles: 75 degrees, length: 130 mm
1.4.1.1.2.2 Back of Casing	They System shall have 4 female rails at the back of the casing
1.4.1.1.2.2.1 Lower Back Rail Measur	The female rail dimensions of the lower side of back phase of casing shall be a: 13.4808 mm, b: 18.8391 mm, side angles: 75 degrees, length: 36.25 mm
1.4.1.1.2.2.2 Upper Back Rail Measur	The female rail dimensions of the lower side of back phase of casing shall be a: 13.4808 mm, b: 18.8391 mm, side angles: 75 degrees, length: 28.75 mm
1.4.1.1.3 Rail Shape	All System rails shall have an inverted trapezoid prism shape
1.4.1.2 Locks	
1.4.1.2.1 System Locks	The System shall have 2 locks
1.4.1.2.1.1 Lock Handles	The System shall have 2 hexagonal prism shape lock handles
1.4.1.2.1.1.1 Lock Pins	The system shall have a rectangular pin on each handle

Casing Requirements

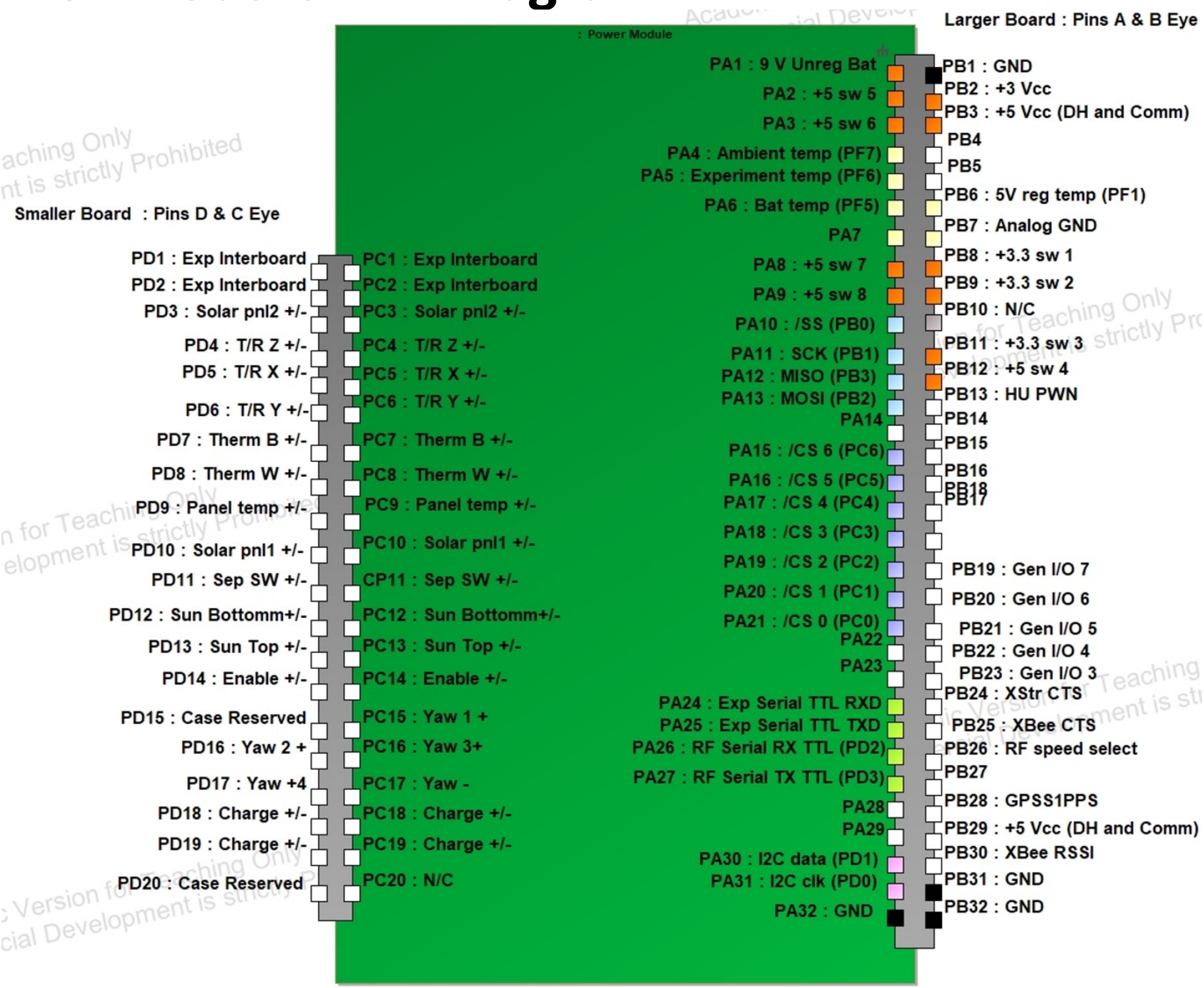
The specificity facilitates System-level Testing, Verification and Validation

1.4.1.3 Casing Holes	
1.4.1.3.1 System Lock Holes	The System shall have 2 holes on the upper half of the front side of the casing
1.4.1.3.1.1 Casing Holes height Placeme	Casing holes' center point shall be located 17 mm from the top of the casing
1.4.1.3.1.2 Casing Holes distance Placer	Casing holes shall be separated by a length of 17.8 mm
1.4.1.3.2 System Lock Pin Holes	The System shall have 2 pin holes on the bottom half of the front side of the casing
1.4.1.3.2.1 Lock Pin Holes Measuremen	The Pin holes shall have dimensions of length: 27 mm , width: 7.5 mm, height: 26 mm
1.4.1.4 Casing Measurements	The casing dimensions shall have dimensions of length: 201 mm, width: 130 mm
1.4.1.4.1 Length	The casing length shall be 201 mm
1.4.1.4.2 Width	The casing width shall be 130 mm
1.4.3 PCB Placement	PCB shall be placed on the connector side closest to the back side of the casing

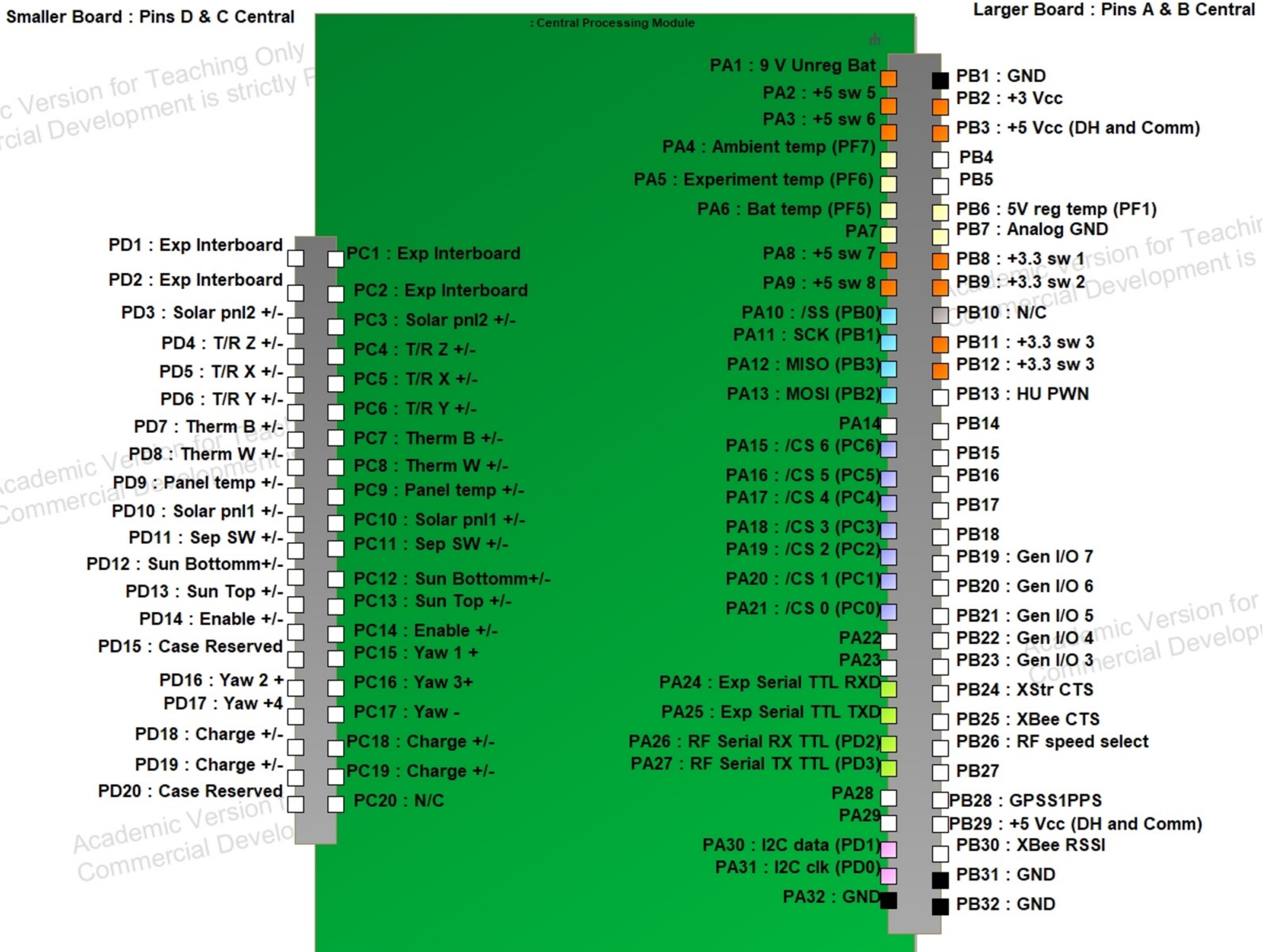
Internal Composition



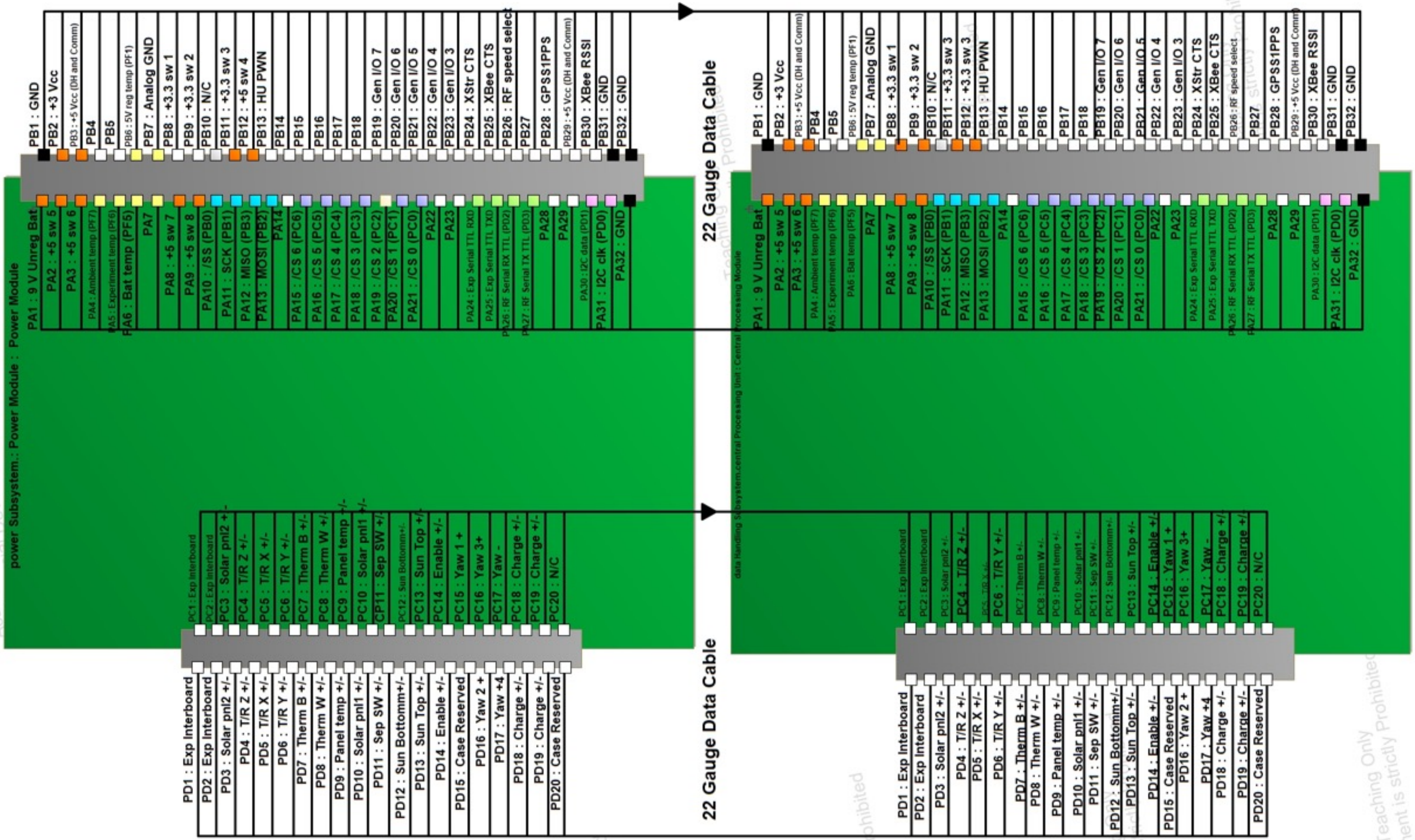
Power Module IBD Diagram



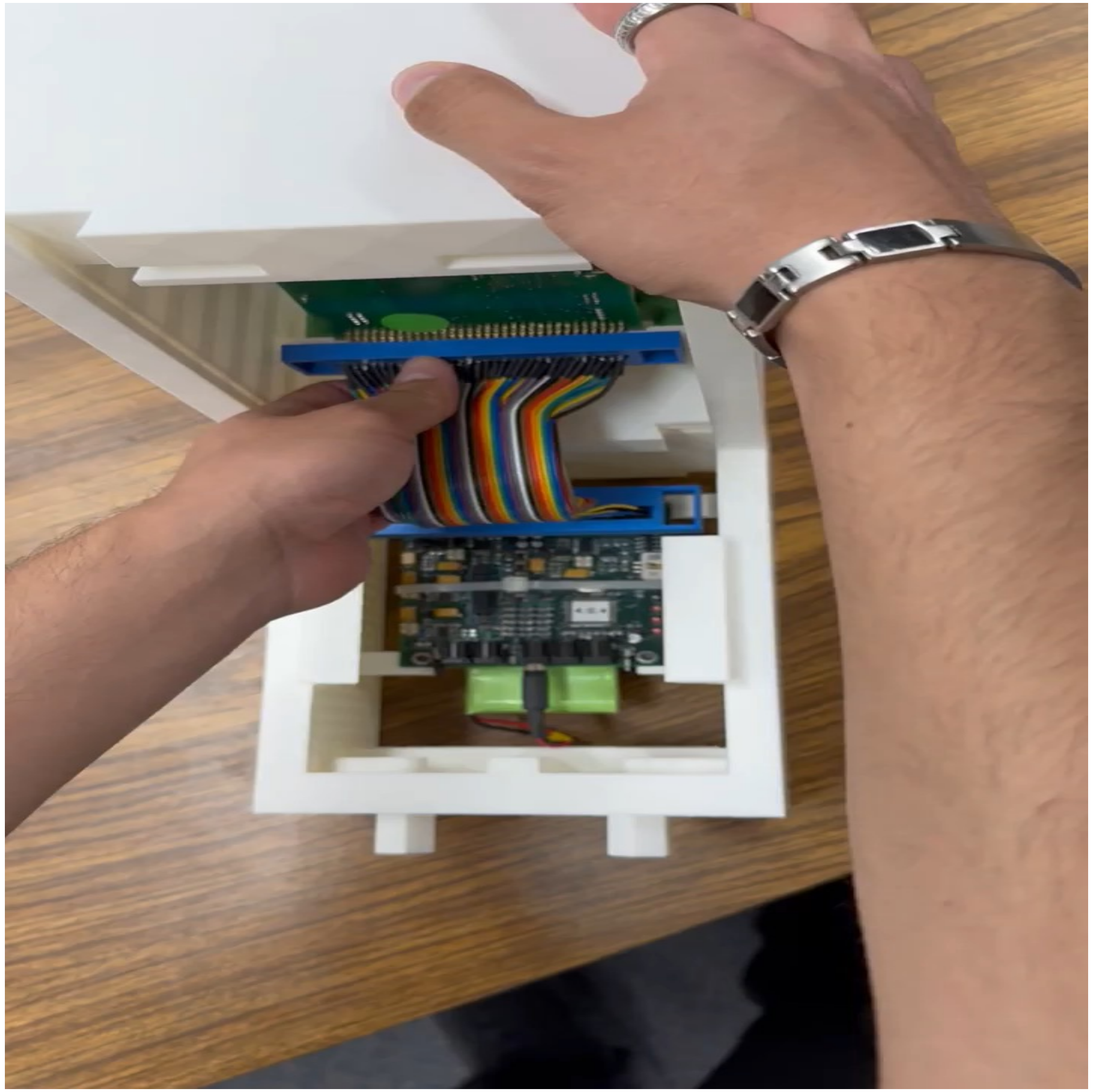
Central Processing Module IBD Diagram



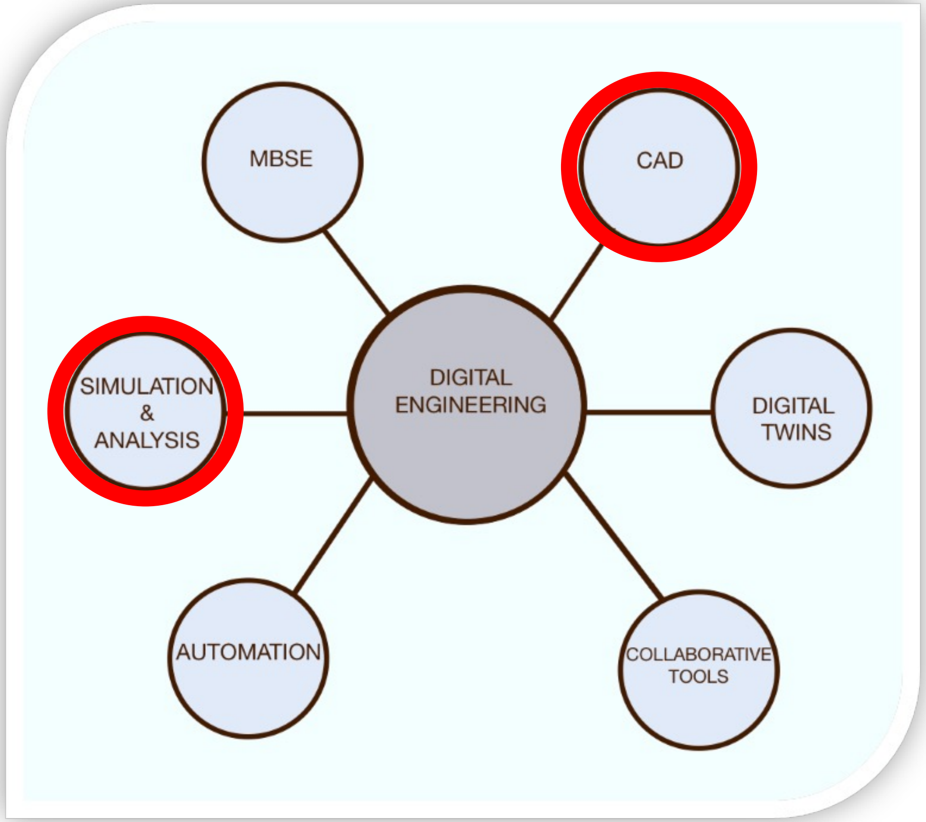
Connection IBD Diagram



Physical Representation



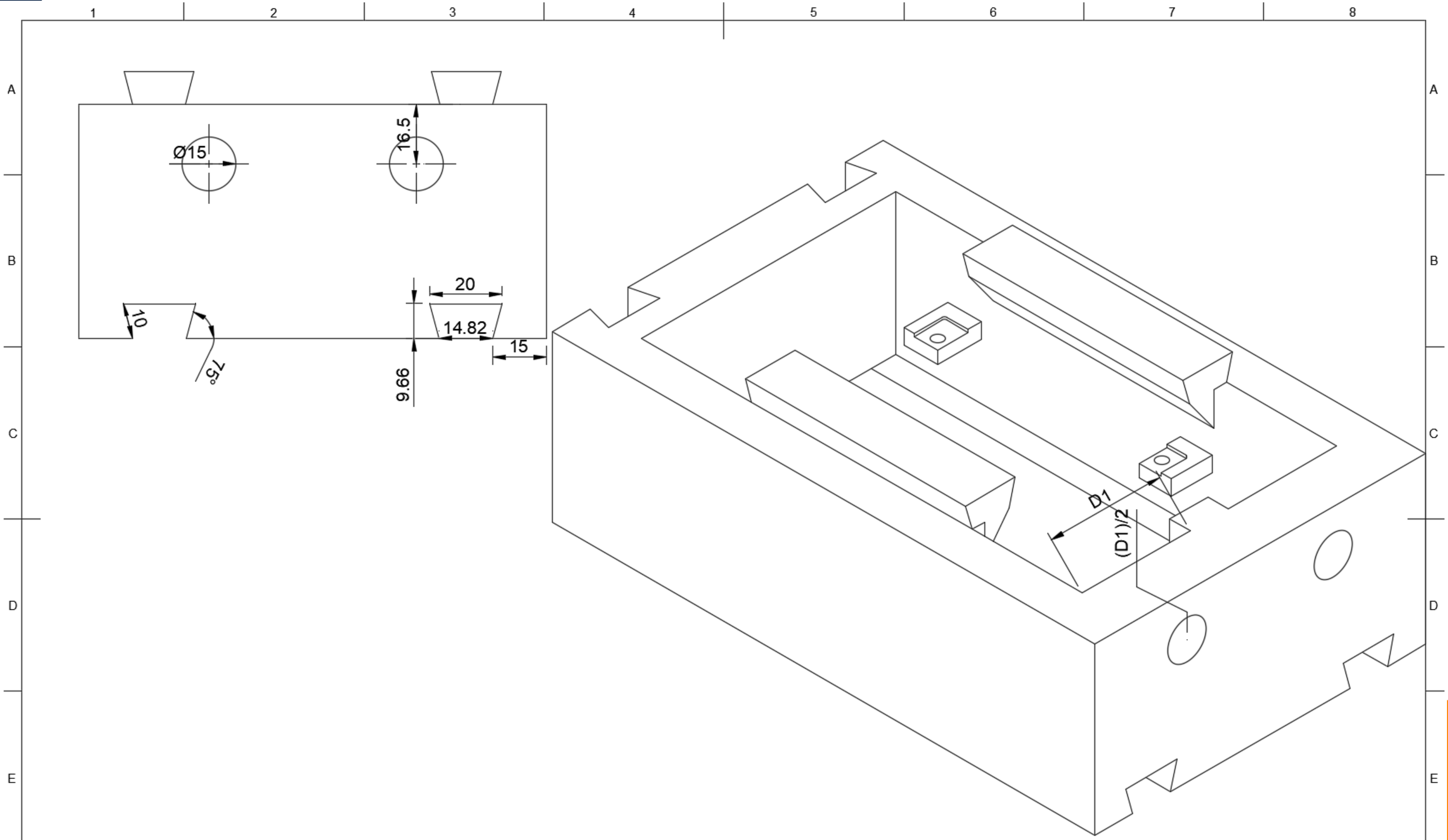
Tools Aimed To Achieve Modularity?



Fusion 360

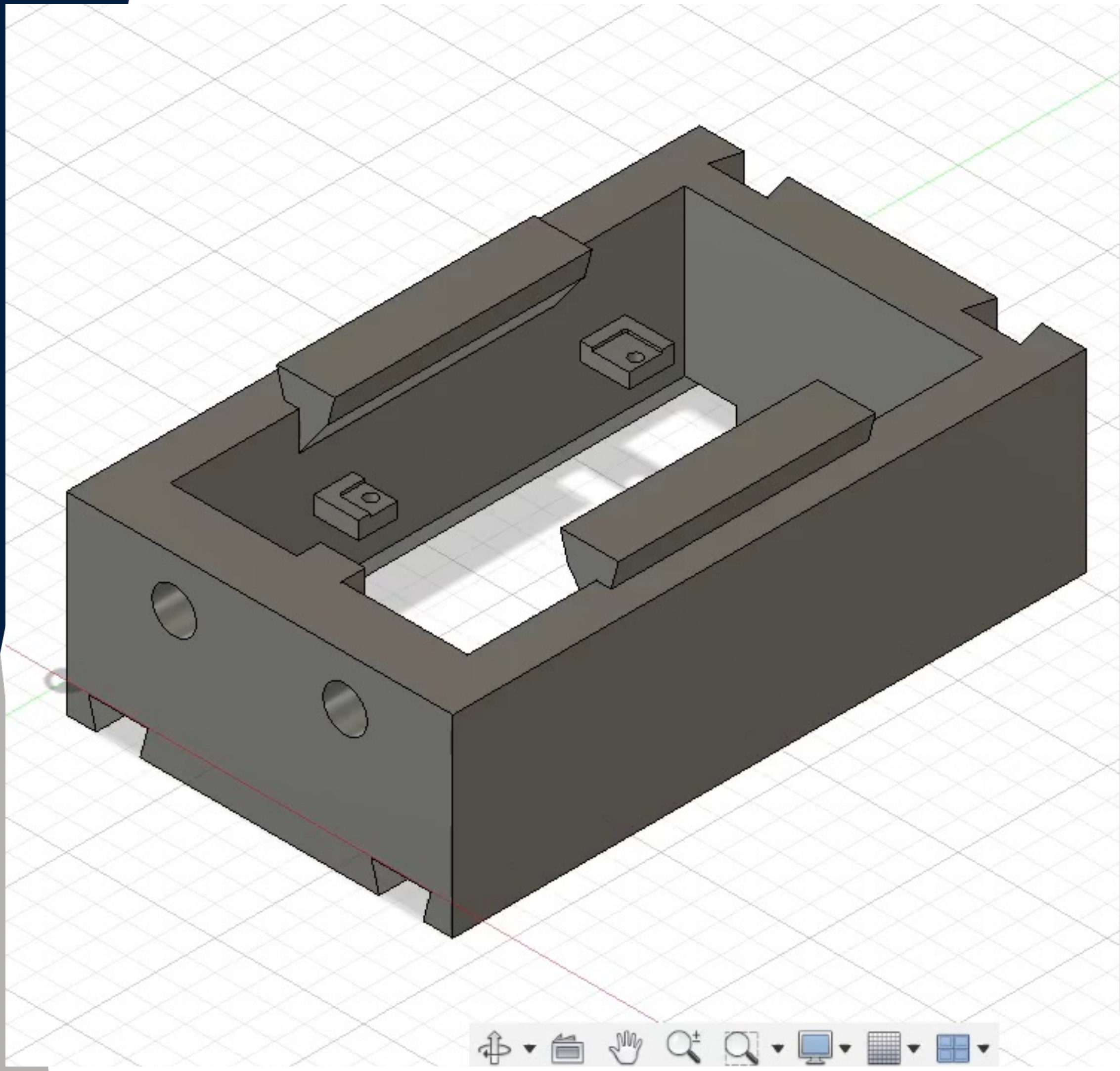
Parametric Design

Mathematical Formulas



Parametric Design

Mathematical Formulas



CONFIGURATION TABLE

Parameters | Properties

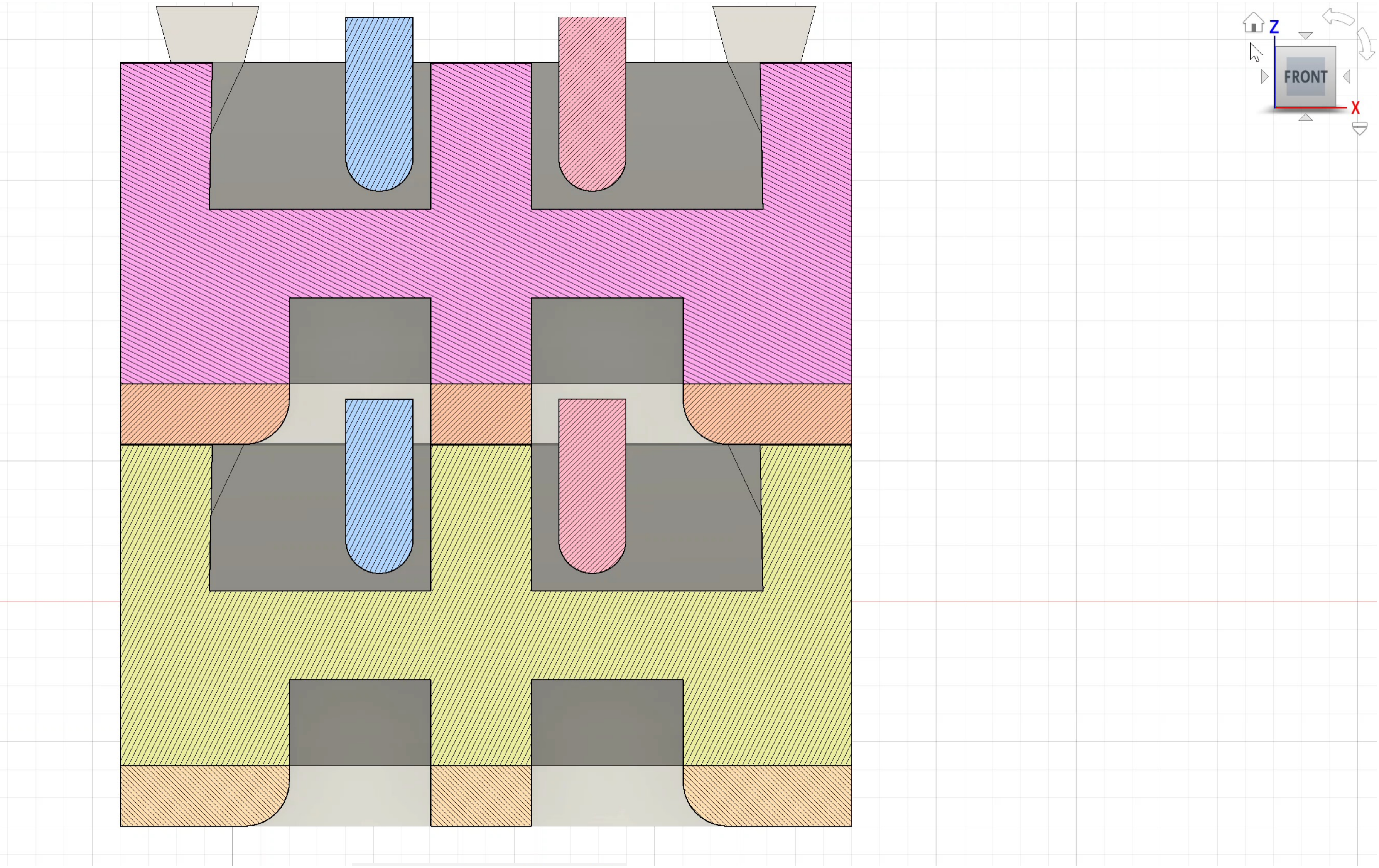
Configurations [3]

Name	Lengthe	Width	Height
NGC Modular1	160 mm	100.00 mm	55 mm
NGC Modular 2	160 mm	100 mm	80mm
NASA Modular1	300mm	300	200

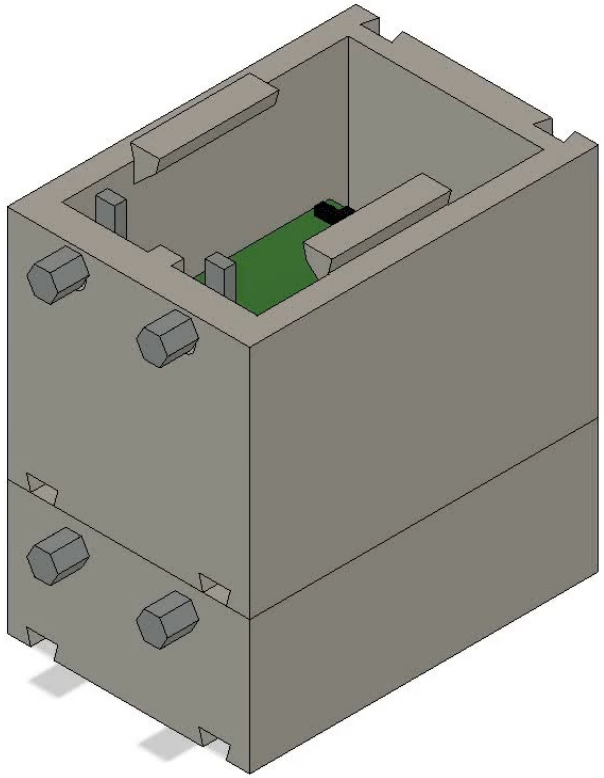
1

Close

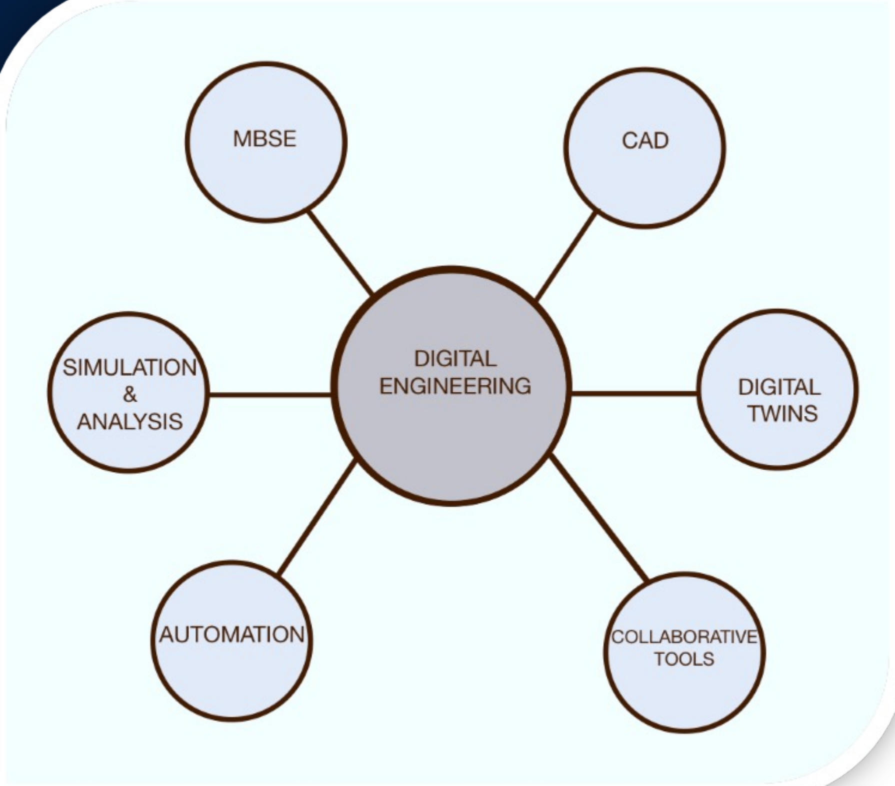
Simulation



System Design Interaction



Conclusion



By utilizing Digital Engineering, we have devised a methodology aimed to redefine satellite modularity. Through the application of digital engineering principles, we have crafted a blueprint that offers interface adaptation and interoperability in satellite technology.

Our results enable Northrop Grumman to seamlessly integrate on-orbit attachable components and enhance operational missions across a spectrum of satellite platforms.

Acknowledgments

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Questions?