

MATLAB EXPO

**Bridging the Gap Between Systems Engineers'
Architecture Models and Model-Based Design**

Paul Urban
Principal Product Manager

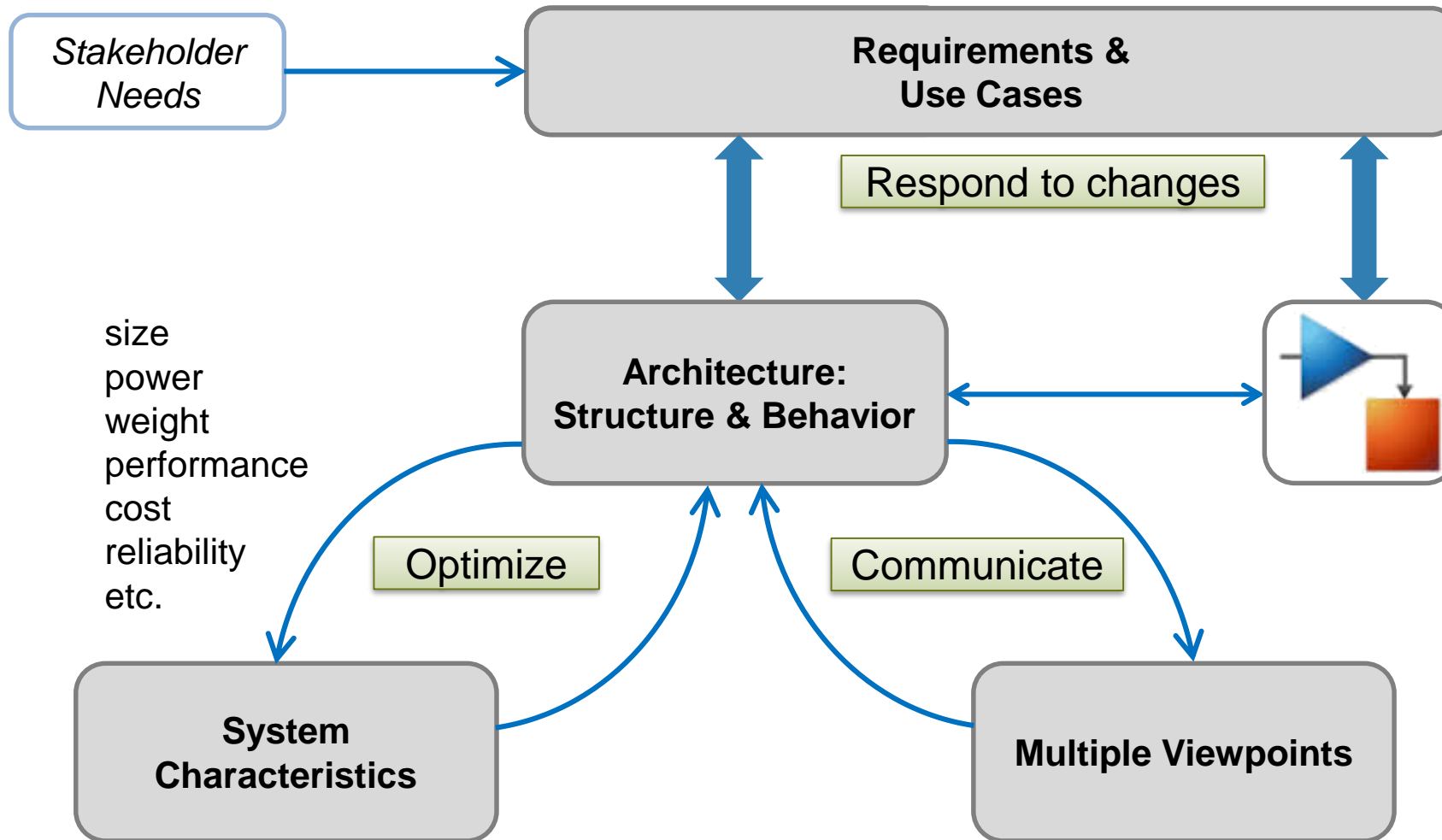


Key Takeaways

Unified environment with no data duplication enabling:

- Optimization through analysis and simulation
- Communication with various stakeholders using focused views
- Responding to changes through the digital thread

System Engineering Workflow

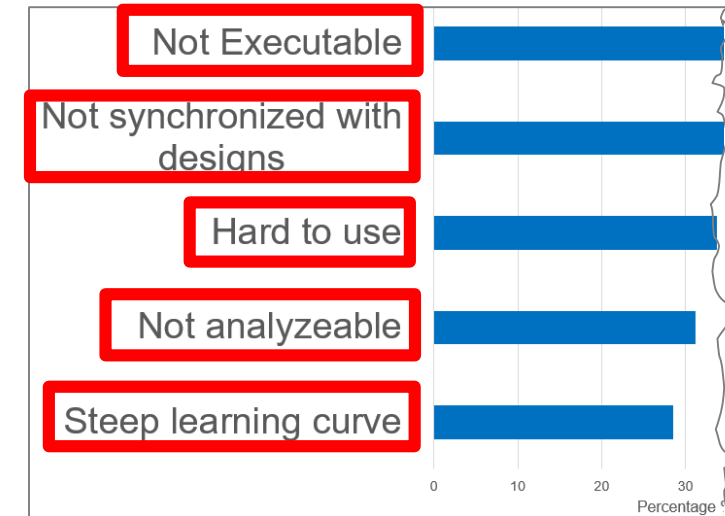
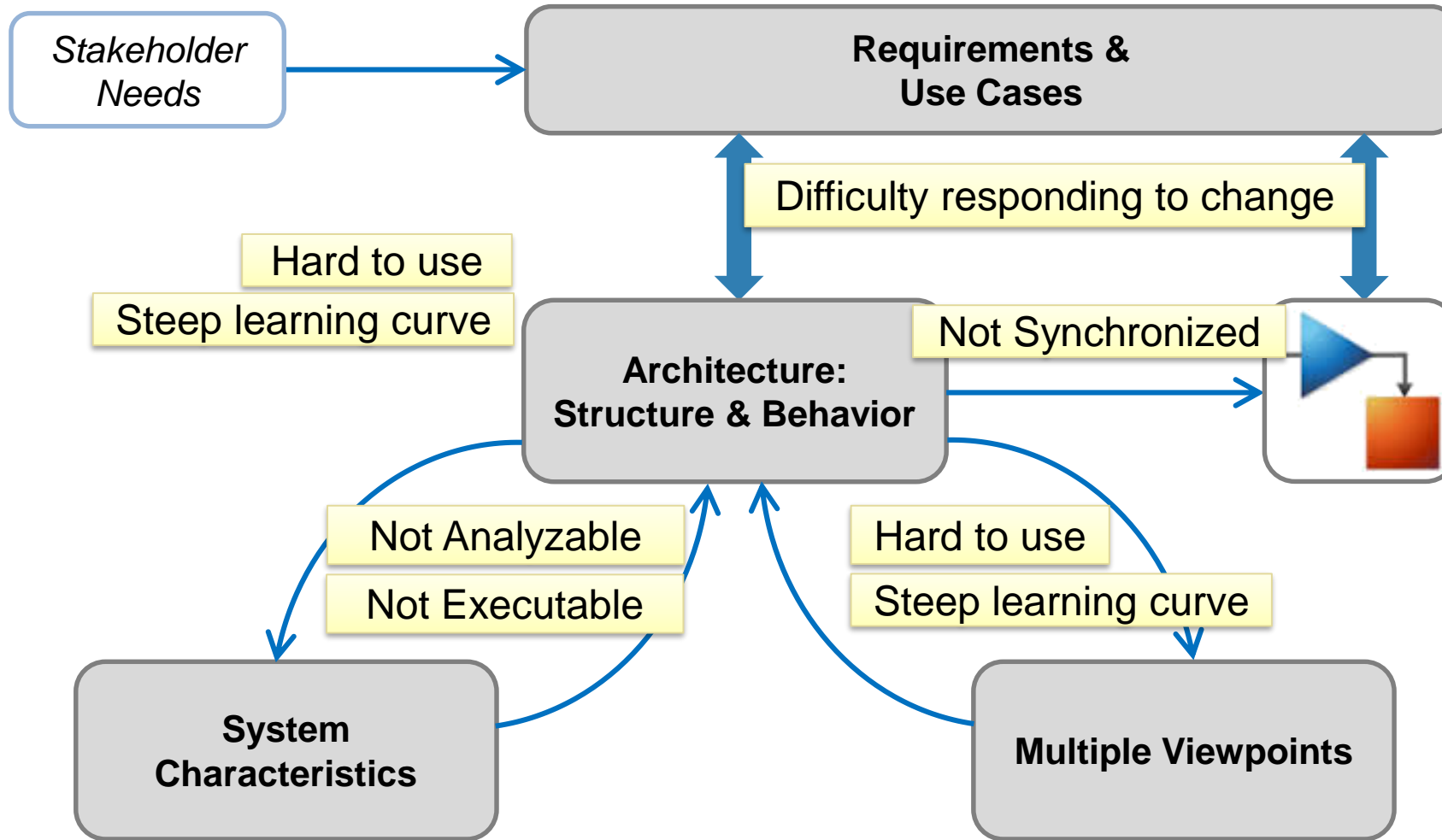


Highly Iterative
Highly Collaborative

Deliverables:

- Specifications
- ICDs
- Reports
- Code
- More....

Mapping the problems users report with their current tooling



Deliverables:

- Specifications
- ICDs
- Reports
- Code
- More....

Typical (simplified) System Engineering Workflow

Stakeholder Needs

Requirements

**Architecture:
Structure & Behavior**

**System
Characteristics**

Multiple Viewpoints



How does this common approach of System Engineering work

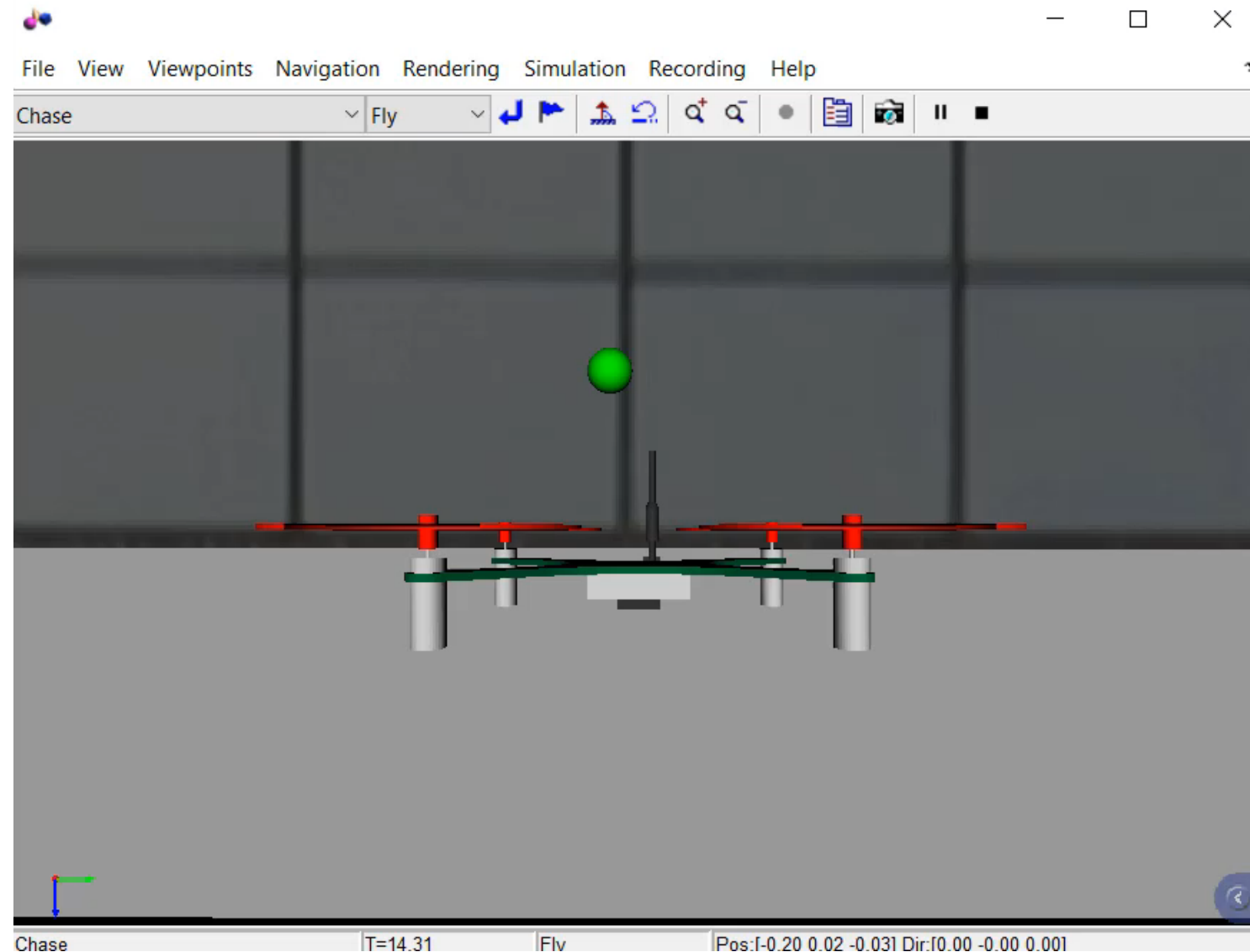
Stakeholder Needs

Requirements

**Architecture:
Structure & Behavior**

**System
Characteristics**

Multiple Viewpoints



Start with a basic set of Stakeholder Needs

Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

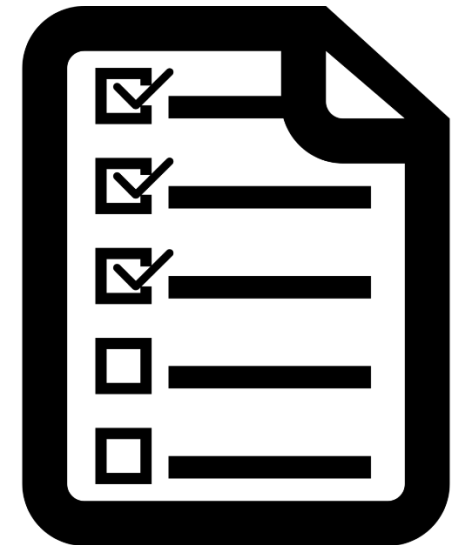
System
Characteristics

Multiple Viewpoints



It needs to track
a target for at
least 4 min

It needs to fit in
a laptop bag



Requirements define what the system shall do

Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



#6: Target Color

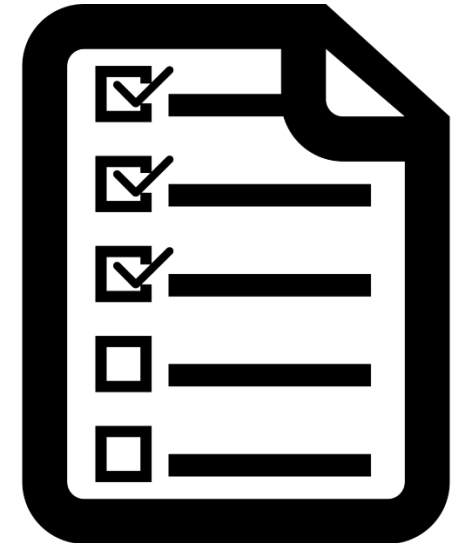
The target shall be a ball that is green in color

#8: Mission Duration

The system shall be capable of persistent target tracking for greater than or equal to 4 minutes.

#9: System Size

The aircraft with attached payload shall fit inside a 15cm x 30cm x 8cm container.



Identify WHAT the System should do and HOW the system is built

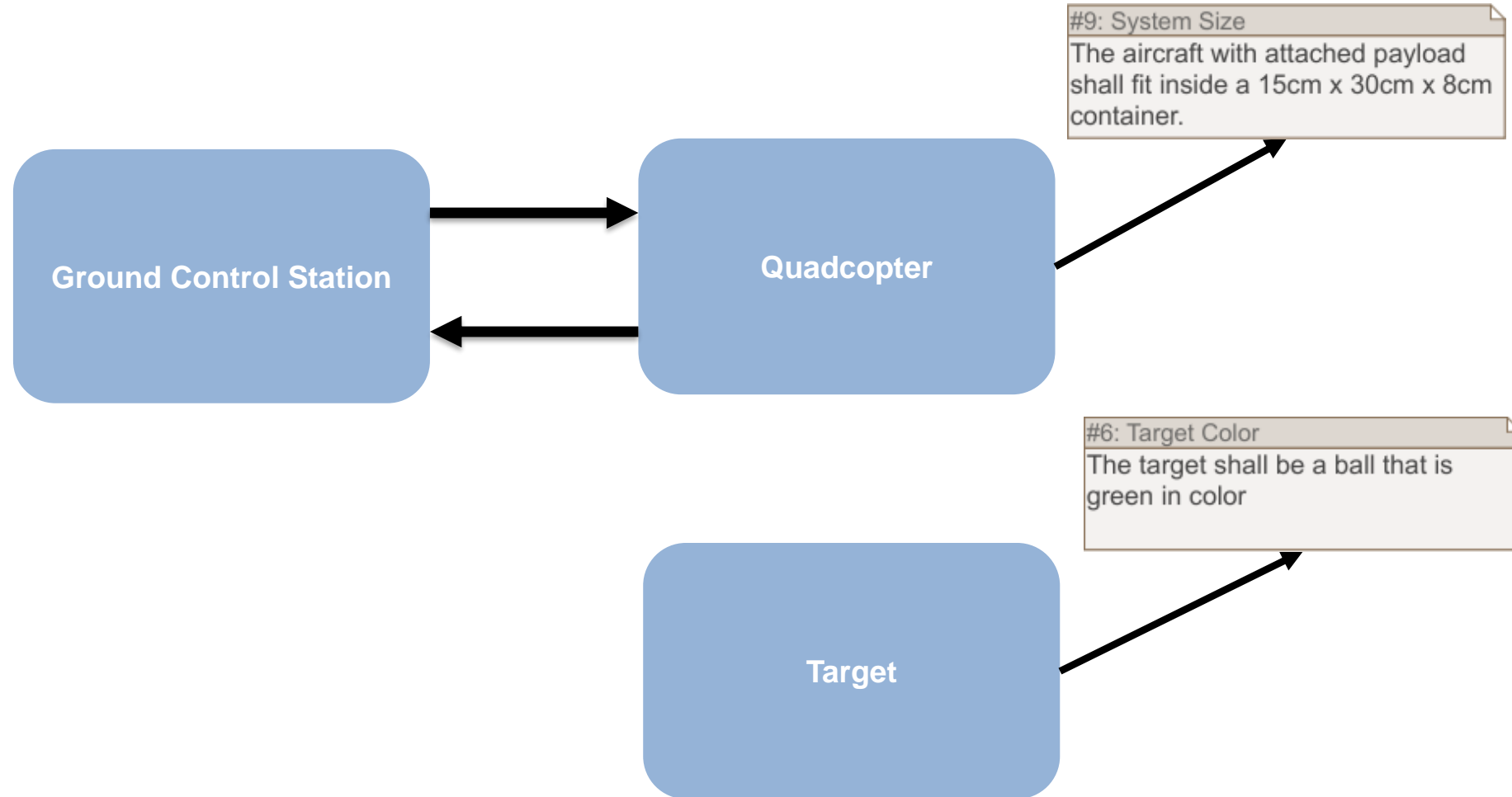
Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



Perform Trade Study to Compare Different System Components

Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



DIY Mini Drone



Tello



Parrot Mambo

Views are used to simplify complexity

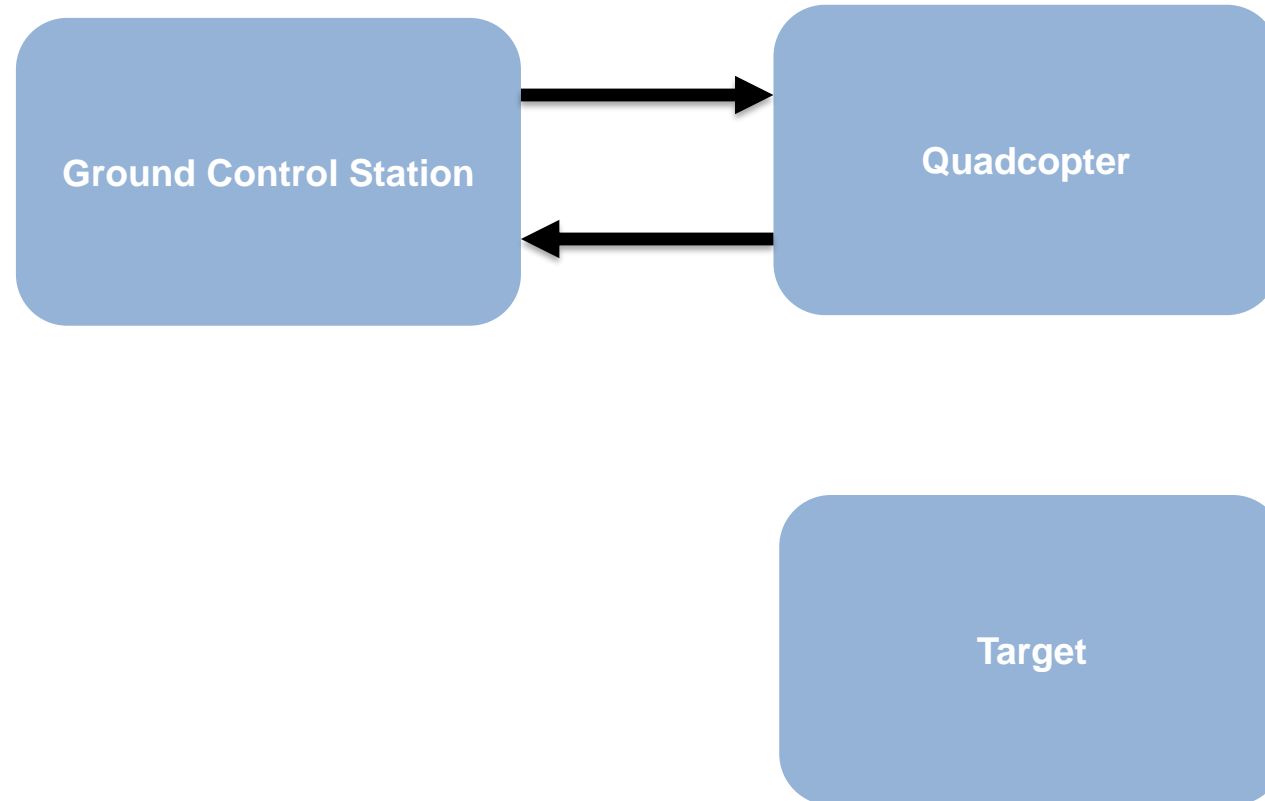
Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



Views are used to simplify complexity

Stakeholder Needs

Requirements

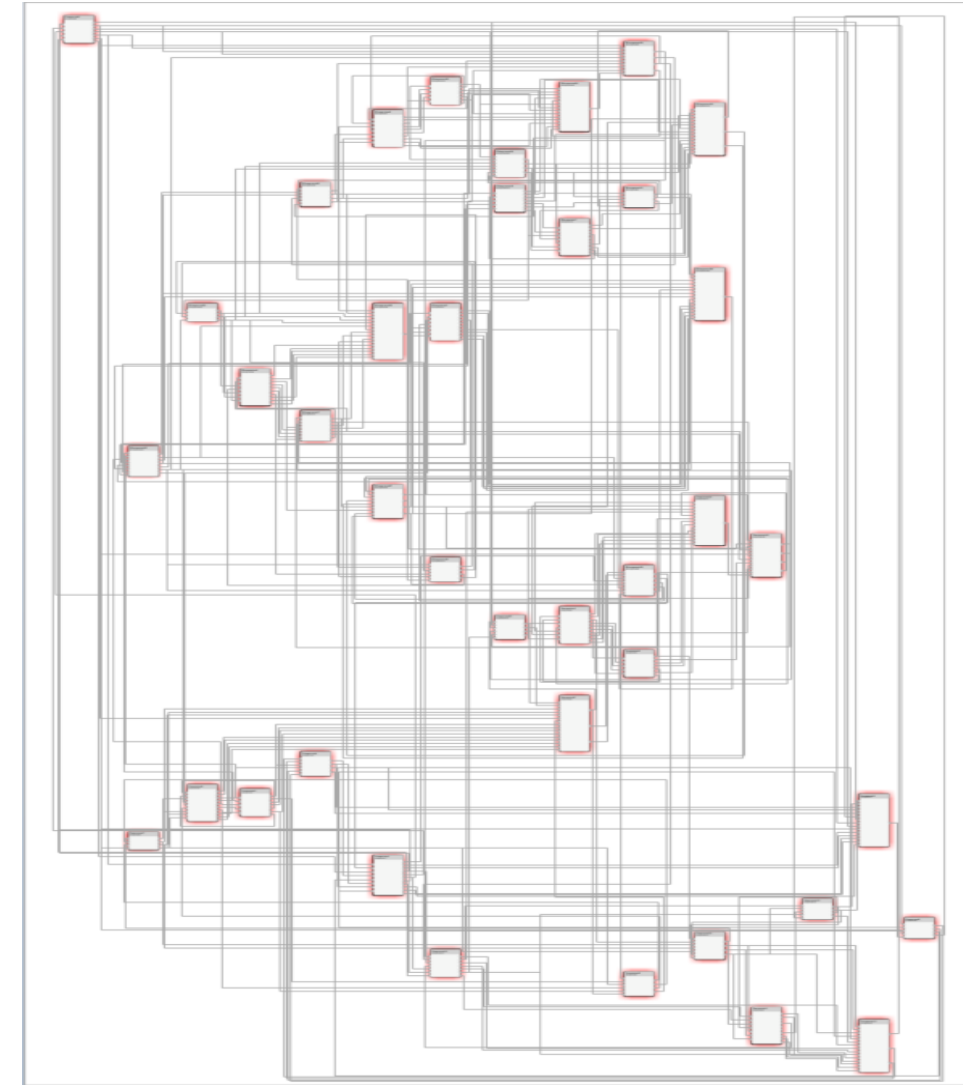
Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



- Architecture models can be complex
- Spaghetti models are just as problematic as spaghetti code



Views are used to simplify complexity

Stakeholder Needs

Requirements

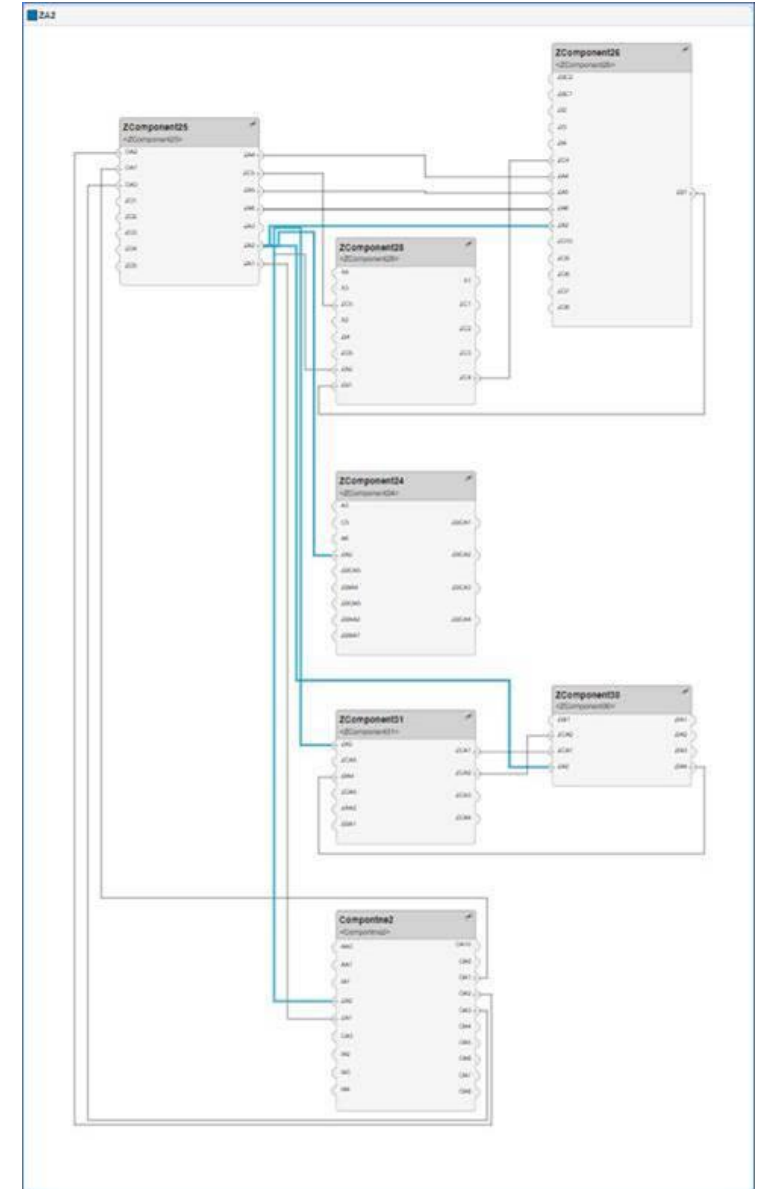
Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



- Architecture models can be complex
- An Architecture View can simplify the diagram to contain only the relevant parts



Views are used to highlight specific concerns

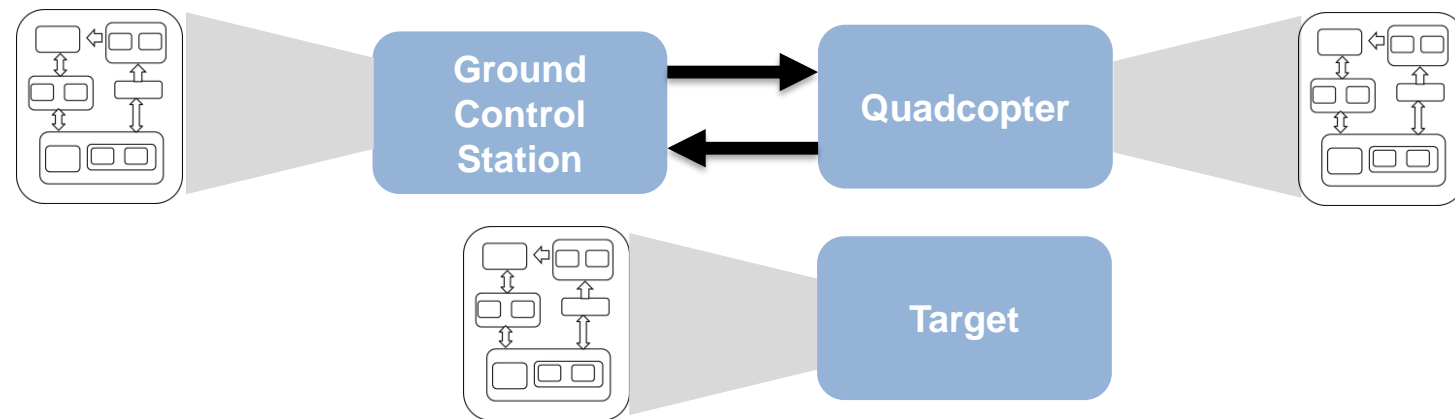
Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



Views are used to highlight specific concerns

Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints

Software
View

GUI

Video
Processing

On Board Processor



Views are used to highlight specific concerns

Stakeholder Needs

Requirements

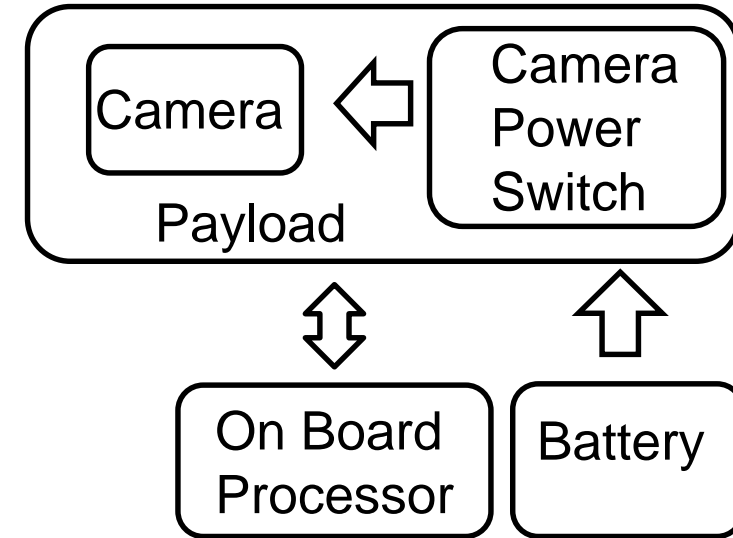
Architecture:
Structure & Behavior

System
Characteristics

Multiple Viewpoints



Mechanical
View



Views are used to highlight specific concerns

Stakeholder Needs

Requirements

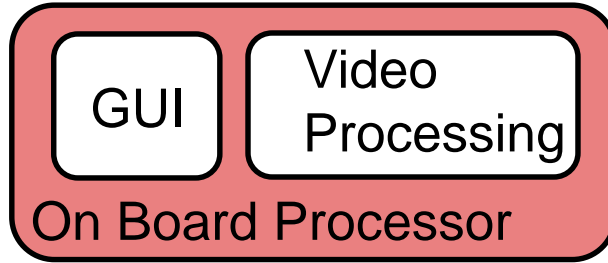
Architecture:
Structure & Behavior

System
Characteristics

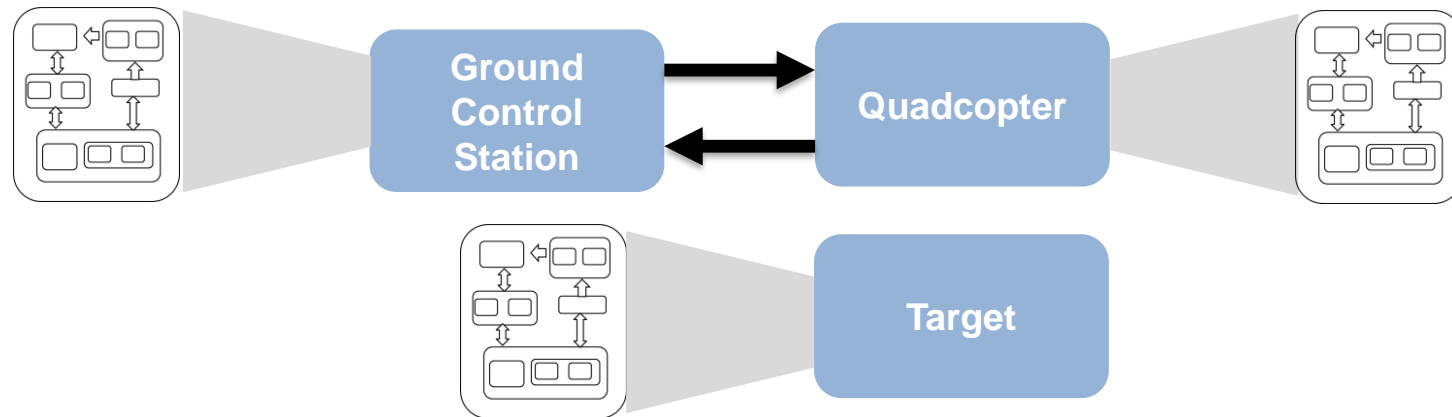
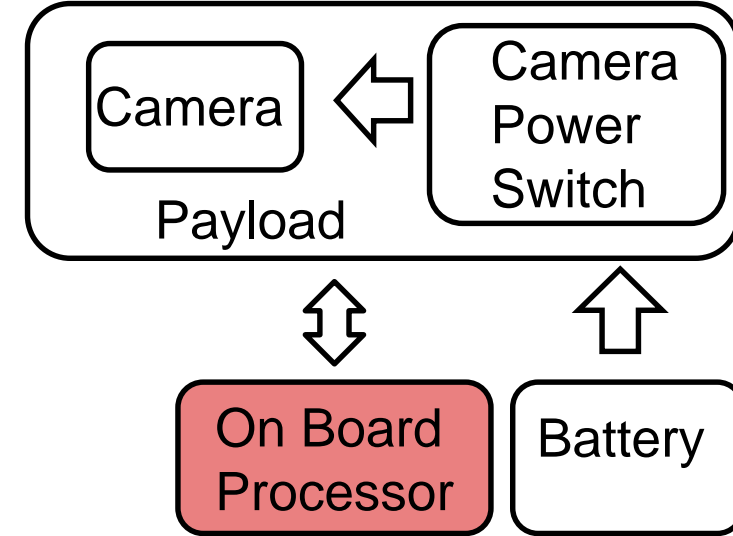
Multiple Viewpoints



Software
View



Mechanical
View



Design and Implement the System

Stakeholder Needs

Requirements

Architecture:
Structure & Behavior

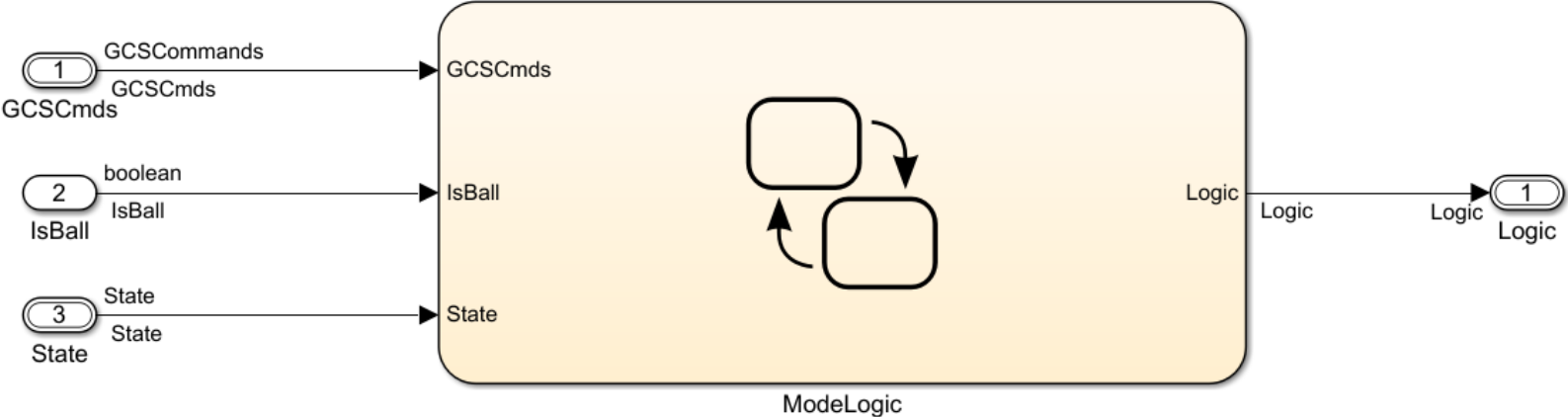
System
Characteristics

Multiple Viewpoints

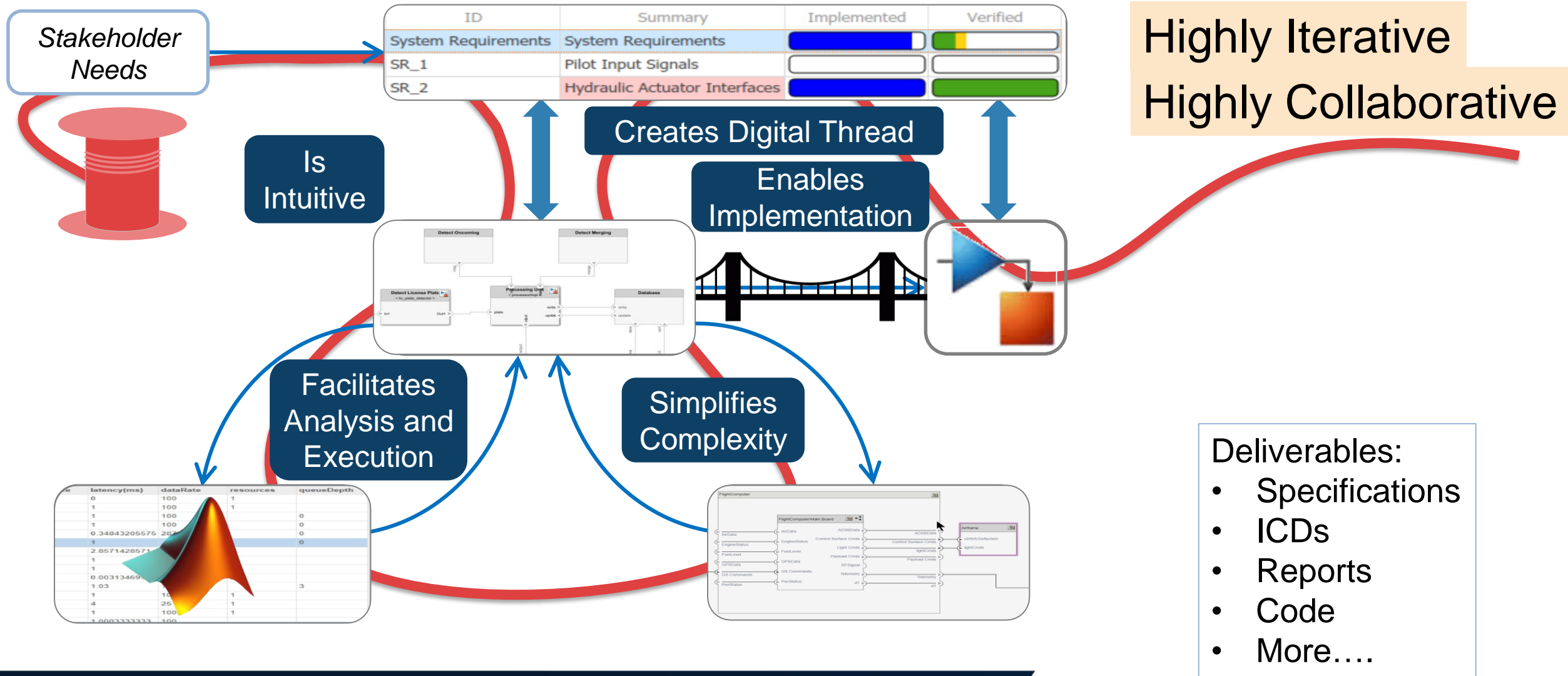


OUTPUT: Mode

1 = WaitForComms
2 = Init
3 = Calibration
4 = ReadyForTO
5 = TrackAlt
6 = Track3D
7 = LostBall
8 = Land
9 = Crash

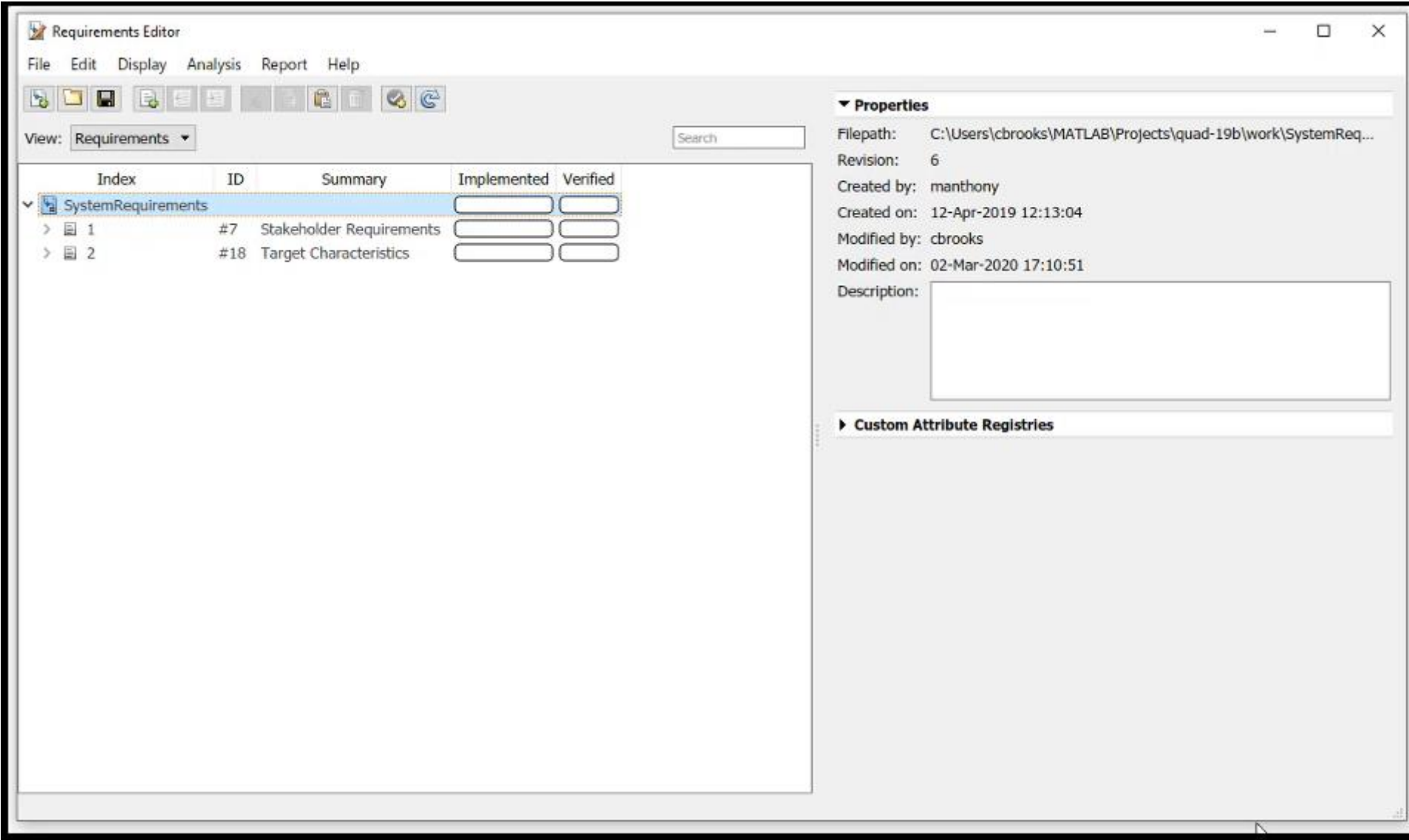


Unified Environment for MBSE and Model-Based Design

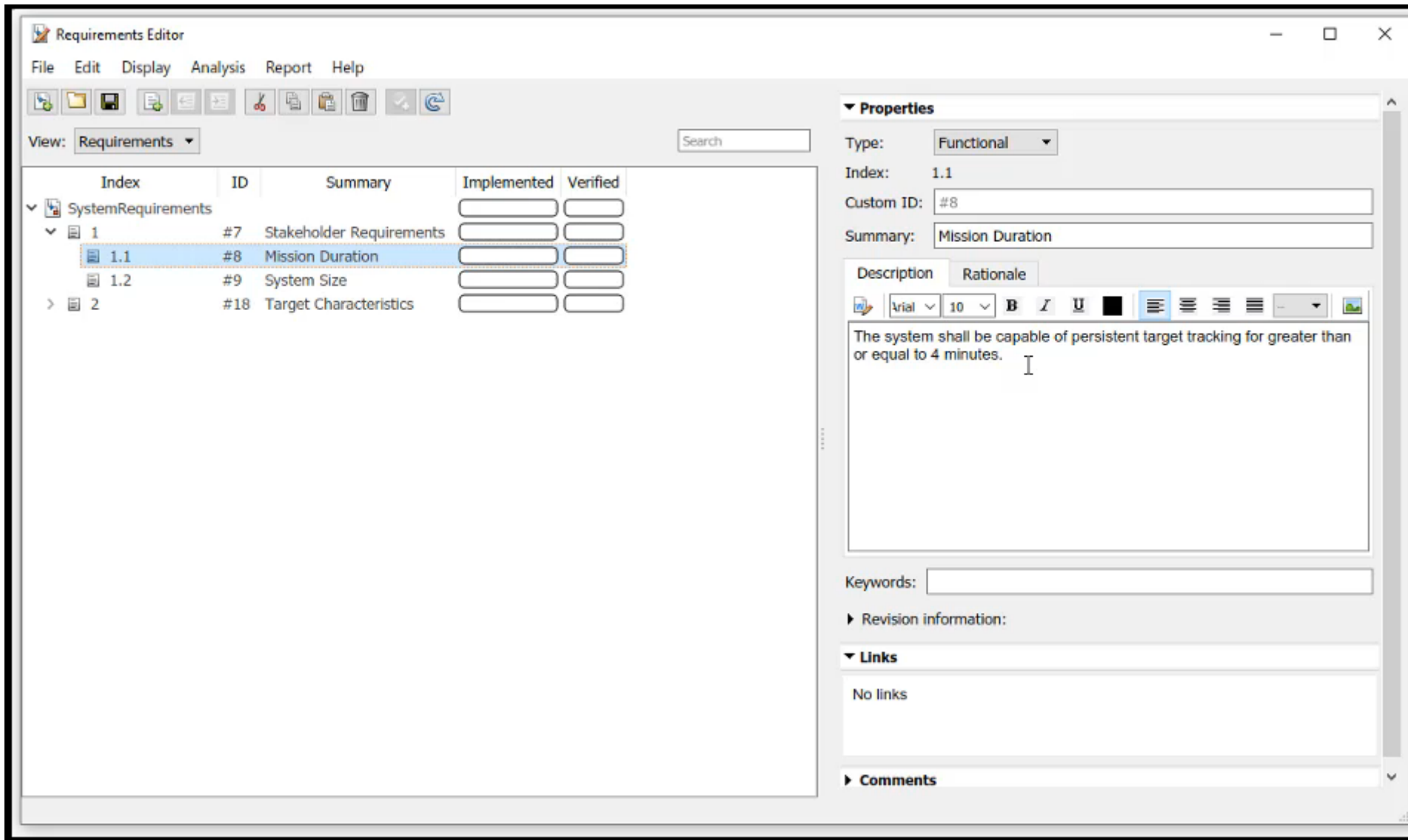


Now let's see it in action

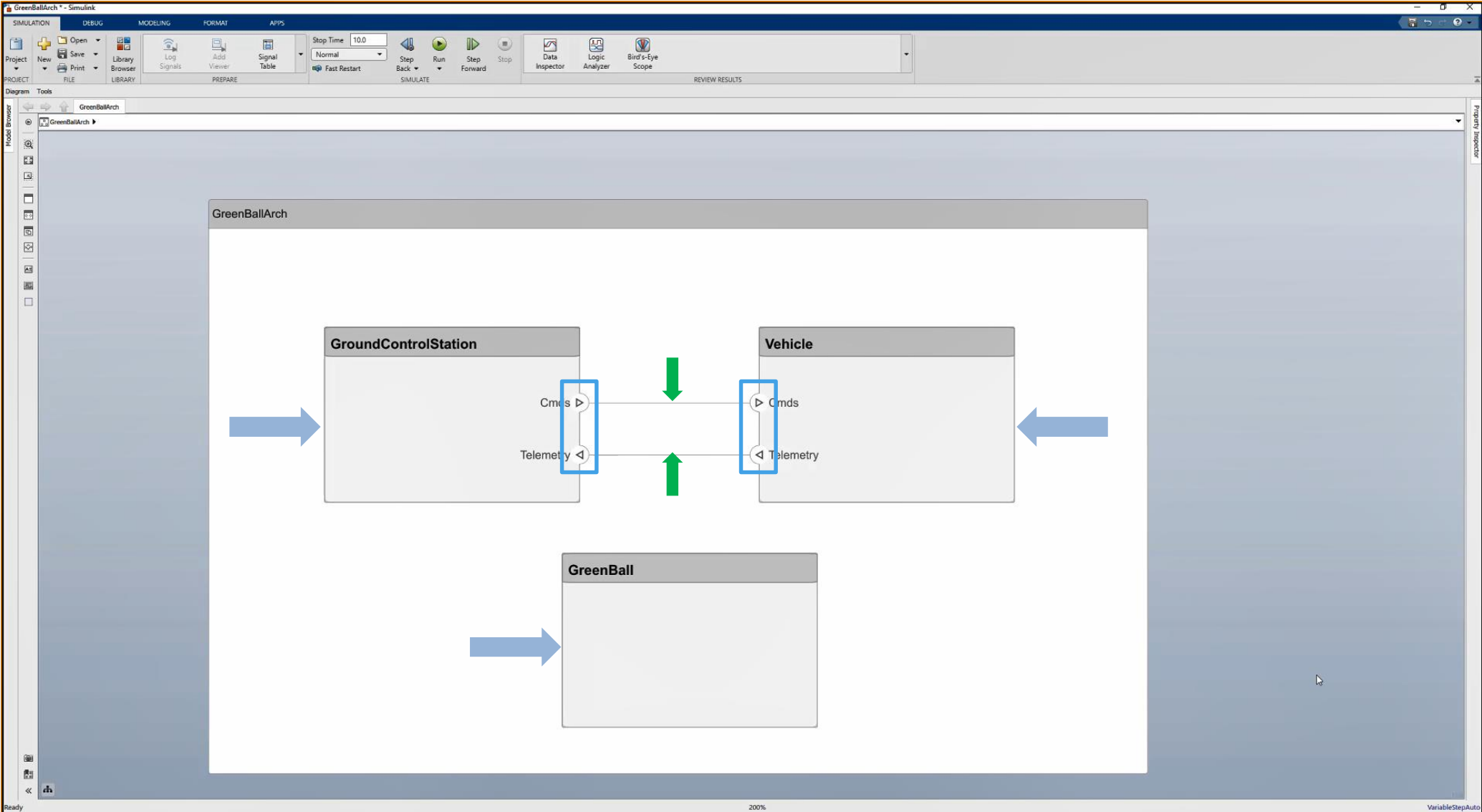
Requirements Engineering



Requirements Engineering



Architecture Modeling



Requirements Allocation

GreenBallArch - Simulink

SIMULATION

DEBUG

MODELING

FORMAT

APPS

REQUIREMENTS

Save All

Requirements Editor

New Requirement Set

Import

Open

Highlight Links

Layout

Check Consistency

Share

FILE

EDIT

REQUIREMENT SET

VISUALIZE

ANALYZE

SHARE

Diagram

GreenBallArch

GreenBallArch

GroundControlStation

Vehicle

GreenBall

Cmnds

Telemetry

Cmnds

Telemetry

Property Inspector

Requirement: #2

Details

Properties

Type: Functional

Index: 1.1

Custom ID: #2

Summary: Target Movement

Description

Rationale

The target shall be tracked in 3 dimensions above the ground

Keywords:

Revision information:

Links

No links

Comments

Requirements - GreenBallArch

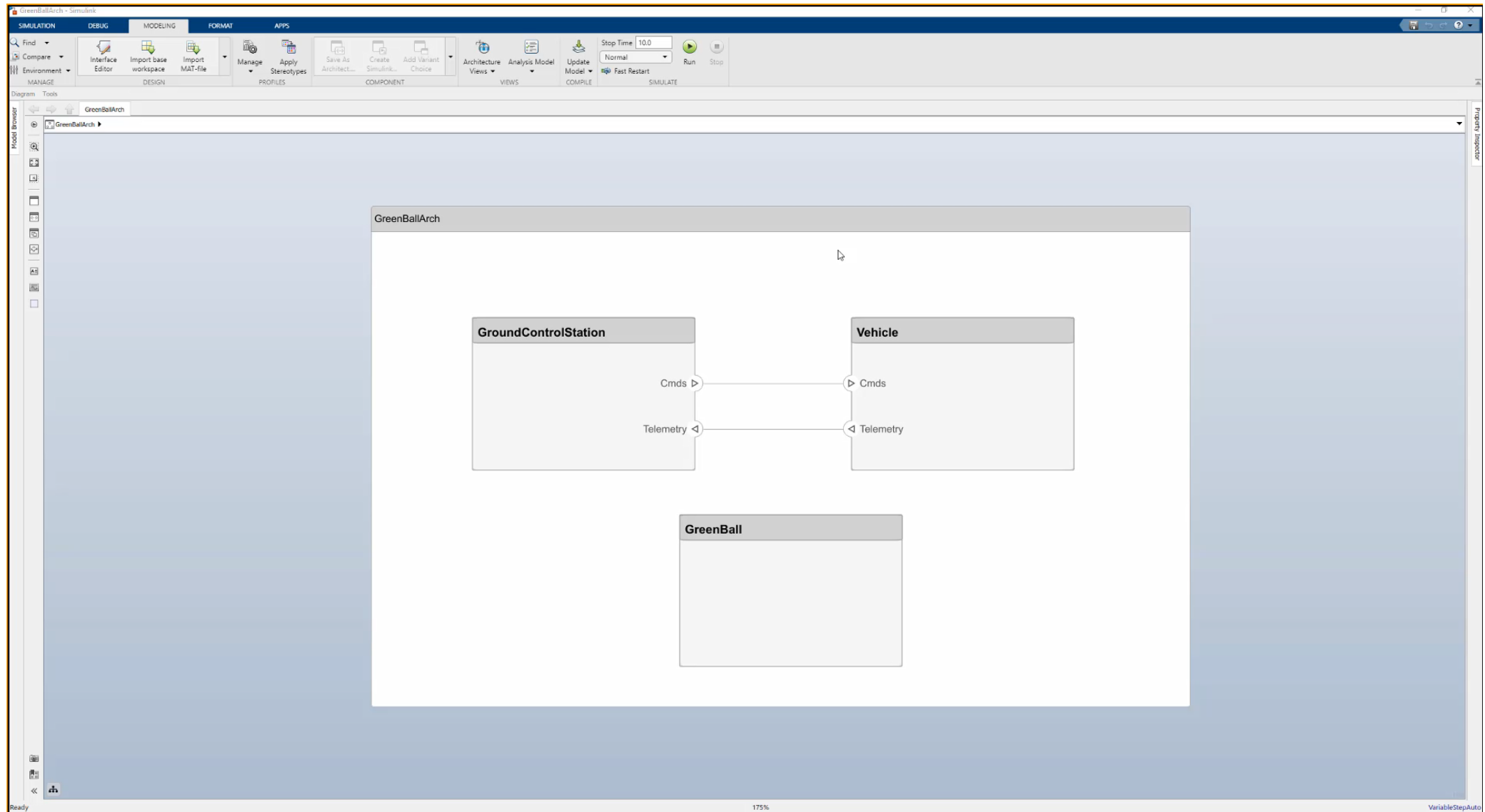
View: Requirements

Search

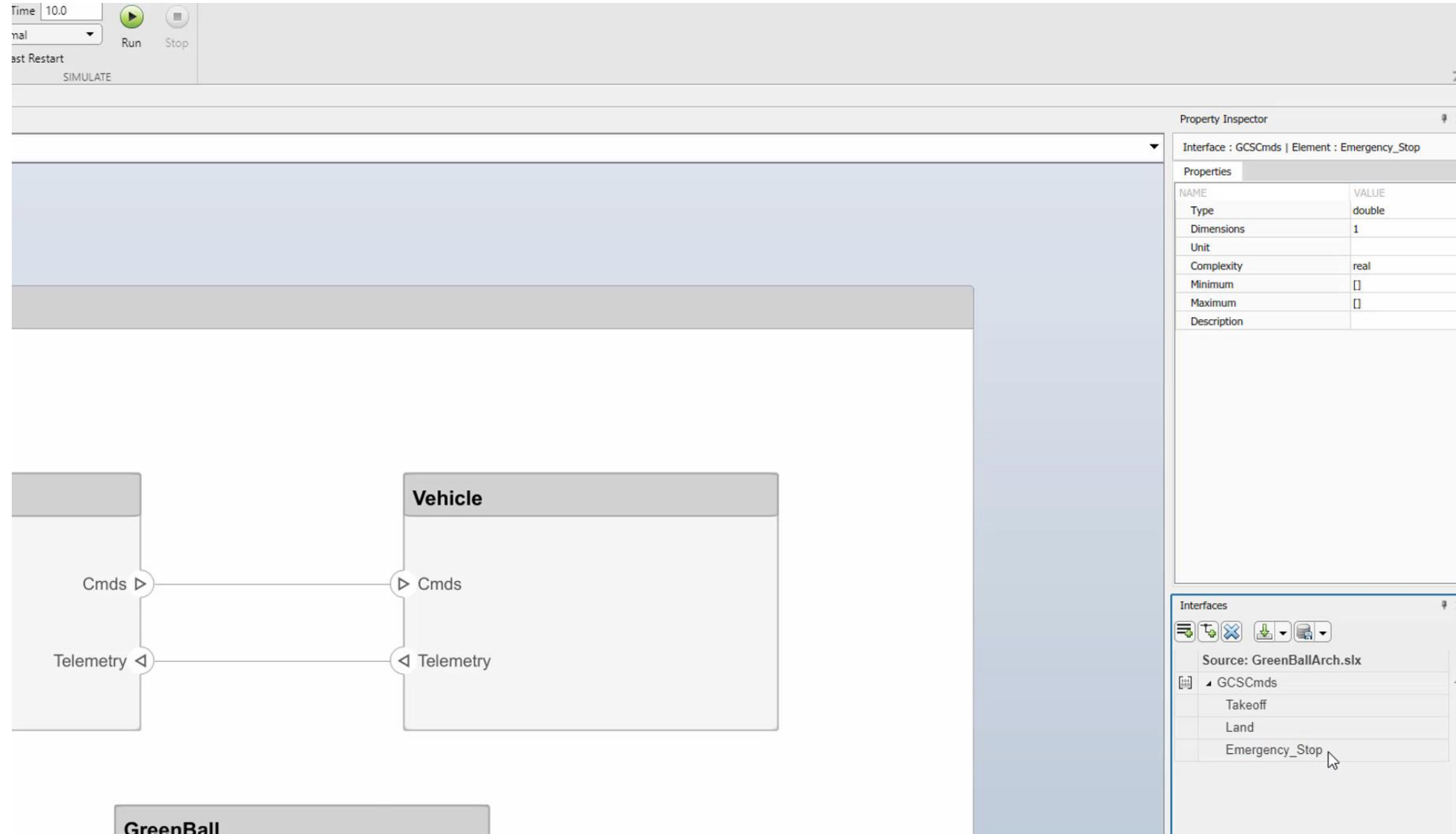
Index	ID	Summary	Implemented
conops			
1	#1	Target Characteristics	
1.1	#2	Target Movement	
1.2	#3	Target Environment	
1.3	#4	Target Velocity	
1.4	#5	Target Size	

Ready94%VariableStepAuto

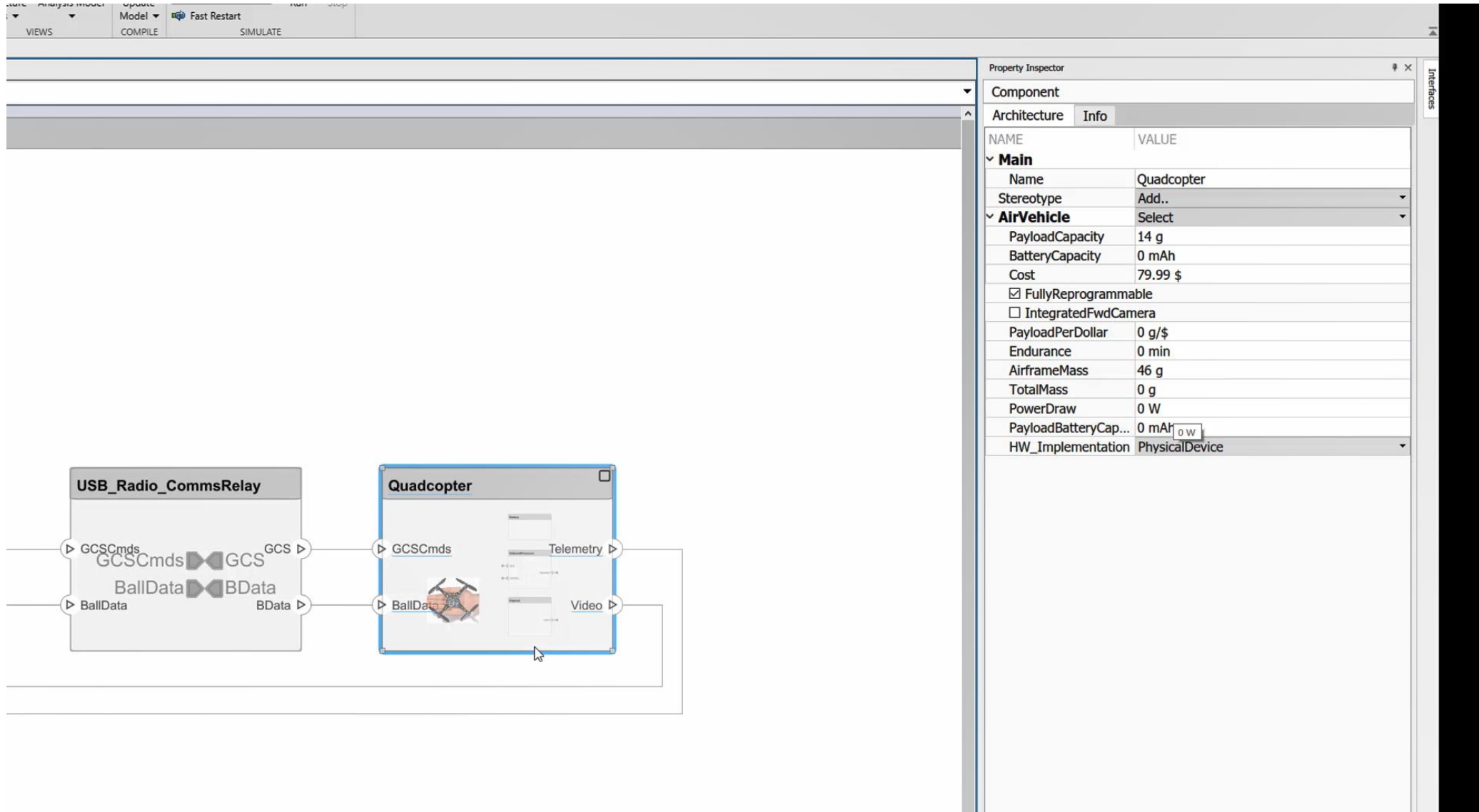
Creating and Applying Interfaces – Top Down



Creating and Applying Interfaces – Bottom Up



Capture System Characteristics & Properties



Facilitate Analysis & Trade Studies

Analysis Viewer (Technical Preview)

HOME

New Open Save Delete Analyze Arguments BottomUp Refresh Automatic Overwrite Update

INSTANCE MODEL ANALYSIS REFRESH UPDATE

Instances	AirframeMass	BatteryCapacity	Cost	Endurance	FullyReprogrammable	IntegratedFwdCamera	INSTANCE PROPERTIES
QuadArch							
FPV Cam_RadioComms							
Quadcopter	46	650	79.9	4.132657767	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Battery							
Payload							
Camera							
CameraPowerSwitch							
RPi Cam_RadioComms							
Quadcopter	46	650	0	3.824743583	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Battery							
Payload							
Camera							
PayloadBattery							
PayloadPowerSwitch							
VideoProcessing							
RPi Cam_WifiComms							
Quadcopter	46	650	0	3.890014208	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Battery							
Payload							
Camera							
PayloadBattery							
PayloadPowerSwitch							
VideoProcessing							

Facilitate Analysis & Trade Studies

Analysis Viewer (Technical Preview)

HOME

New

Open

Save

Delete

Analyze

☐ Continuous

☒ Arguments

BottomUp

Refresh

☐ Automatic

☐ Overwrite

Update

INSTANCE MODEL

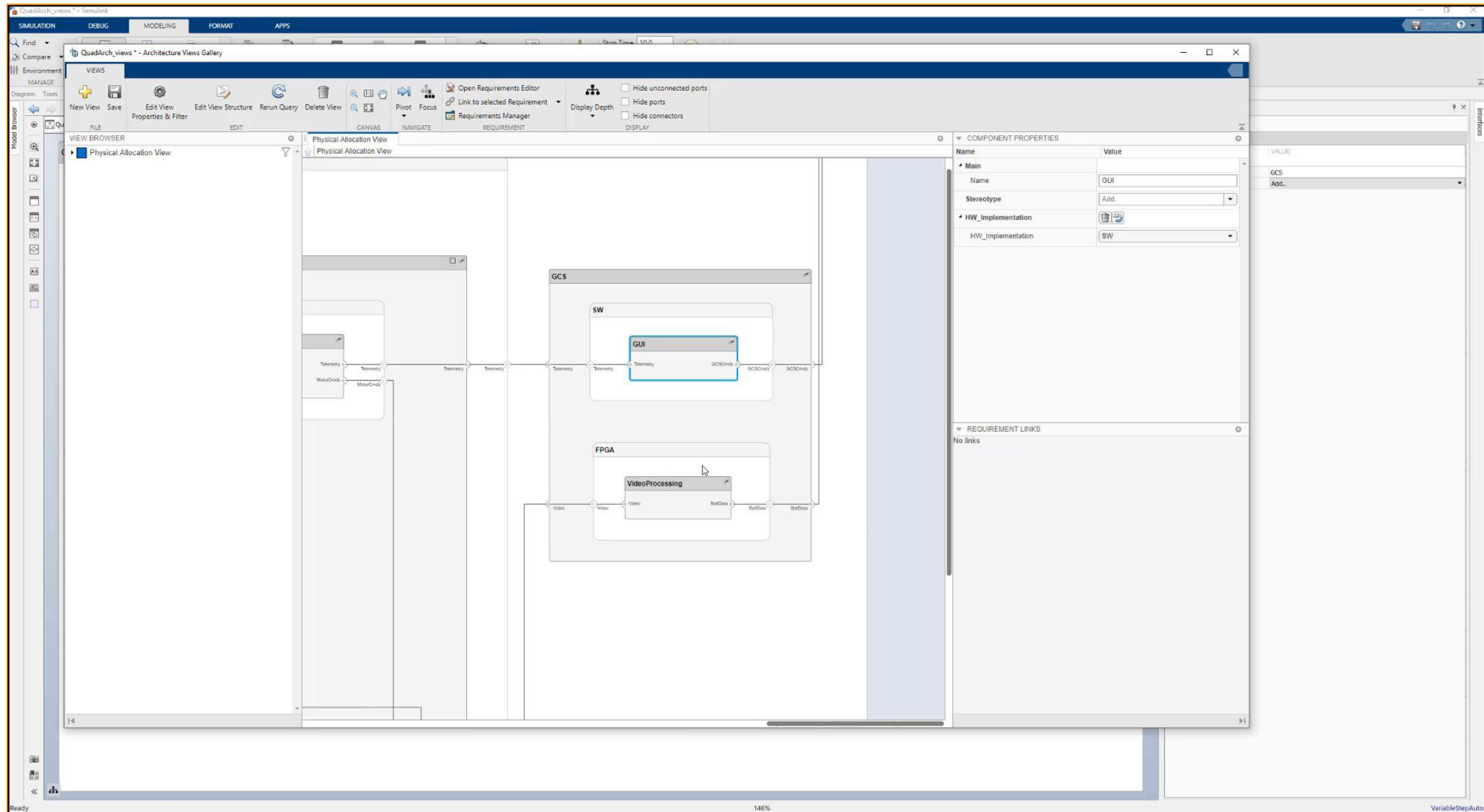
ANALYSIS

REFRESH

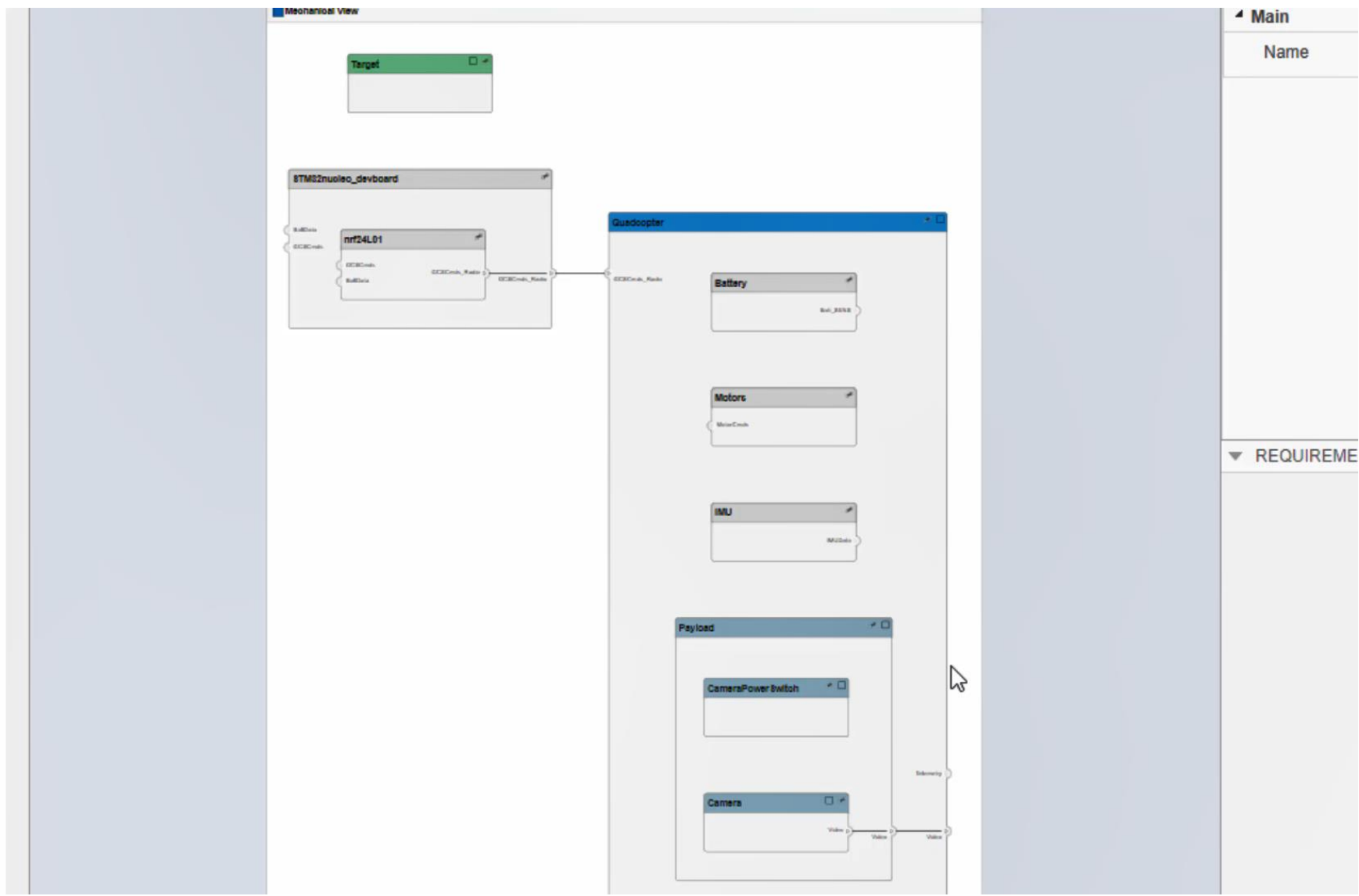
UPDATE

INSTANCE PROPERTIES

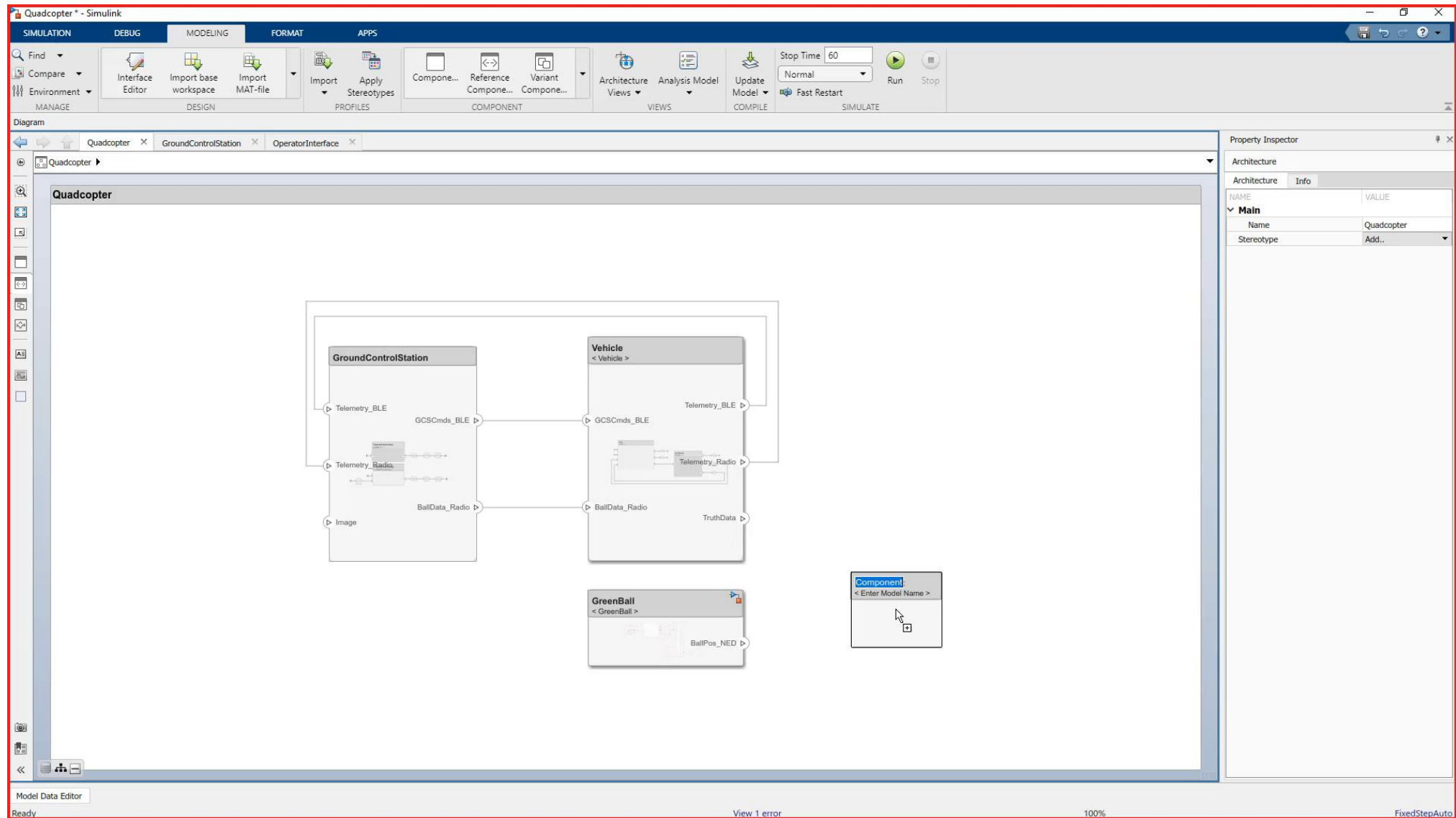
Simplifies Complexity: Live Views for Design Trades



Simplifies Complexity: Communicate Effectively with Stakeholders



Enables Implementation: Environment for Architecture and Design



Simulation & Verification

Requirements Editor

File Edit Display Analysis Report Help

View: Requirements

Index

conops

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1.3

1.4

1.5

1.6

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2.1

2.2

3

3.1

#1

#2

#3

#4

#5

#6

#10

#7

#8

#9

#11

#12

Test Manager

TESTS

New Open Save Cut Copy Delete Test Spec Report Run Run with Stepper Stop Parallel Report Visualize Highlight in Model Import Export Preferences Help

FILE EDIT RUN RESULTS ENVIRONMENT RESOURCES

Test Browser Results and Artifacts

Filter tests by name or tags, e.g. tags: test

QuadcopterSystemTests

Stakeholder_Requirement_Tests

2.1 Mission Duration Test

System_Target_Tests

1.1 Target Movement Test

1.3 Target Velocity Test

PROPERTY

VALUE

Name

1.3 Target Velocity Test

Type

Baseline Test

Model

Quadcopter

Simulation Mode

[Model Settings]

Location

C:\Users\icbrooks\MATLAB\...

Enabled

✓

Hierarchy

QuadcopterSystemTests » ...

Tags

Type comma or space separa

1.3 Target Velocity Test

QuadcopterSystemTests » System_Target_Tests » 1.3 Target Velocity Test

Baseline Test

Select releases for simulation: Current

☐ Create Test Case from External File

TAGS

DESCRIPTION

REQUIREMENTS*

Target Velocity.(conops#4)

+ Add - Delete

SYSTEM UNDER TEST*

Model: Quadcopter

TEST HARNESS

SIMULATION SETTINGS OVERRIDES*

PARAMETER OVERRIDES*

CALLBACKS

INPUTS

SIMULATION OUTPUTS

CONFIGURATION SETTINGS OVERRIDES

BASELINE CRITERIA

ITERATIONS

LOGICAL AND TEMPORAL ASSESSMENTS*

Comments

Model Data Editor

Ready

110%

FixedStepAuto

Digital Thread - Navigation

Code Generation Report

Find: Match Case

Contents

Summary

[Subsystem Report](#)

[Code Interface Report](#)

[Traceability Report](#)

[Static Code Metrics Report](#)

[Code Replacements Report](#)

[Coder Assumptions](#)

Generated Code

[-] Main file

[ert_main.c](#)

[-] Model files

[ModeLogic.c](#)

[ModeLogic.h](#)

[ModeLogic_private.h](#)

[ModeLogic_types.h](#)

[+] Shared files (2)

Code Generation Report for 'ModeLogic'

Model Information

Author	manthony
Last Modified By	manthony
Model Version	1.745
Tasking Mode	MultiTasking

[Configuration settings at time of code generation](#)

Code Information

System Target File	ert.tlc
Hardware Device Type	32-bit Generic
Simulink Coder Version	9.3 (R2020a) 18-Nov-2019
Timestamp of Generated Source Code	Fri May 15 15:09:47 2020
Location of Generated Source Code	C:\Users\cbrooks\MATLAB\Projects\quad-20a\work\ModeLogic_ert_rtw\
Type of Build	Model
Memory Information	Global Memory: 90(bytes) Maximum Stack: 8(bytes)
Objectives Specified	Unspecified

Additional Information

Code Generation Advisor	Not run
-------------------------	---------

OK

Help

Digital Thread – Responding to change

The screenshot displays the MATLAB Simulink environment with a quadcopter model and the Requirements Editor window. The model includes components like IMU, OnboardProcessor, Motors, Battery, and Payload. The Requirements Editor shows a hierarchical list of requirements, with 'Target Velocity' selected. The Properties window on the right provides details for the selected requirement.

Requirements Editor - Target Velocity

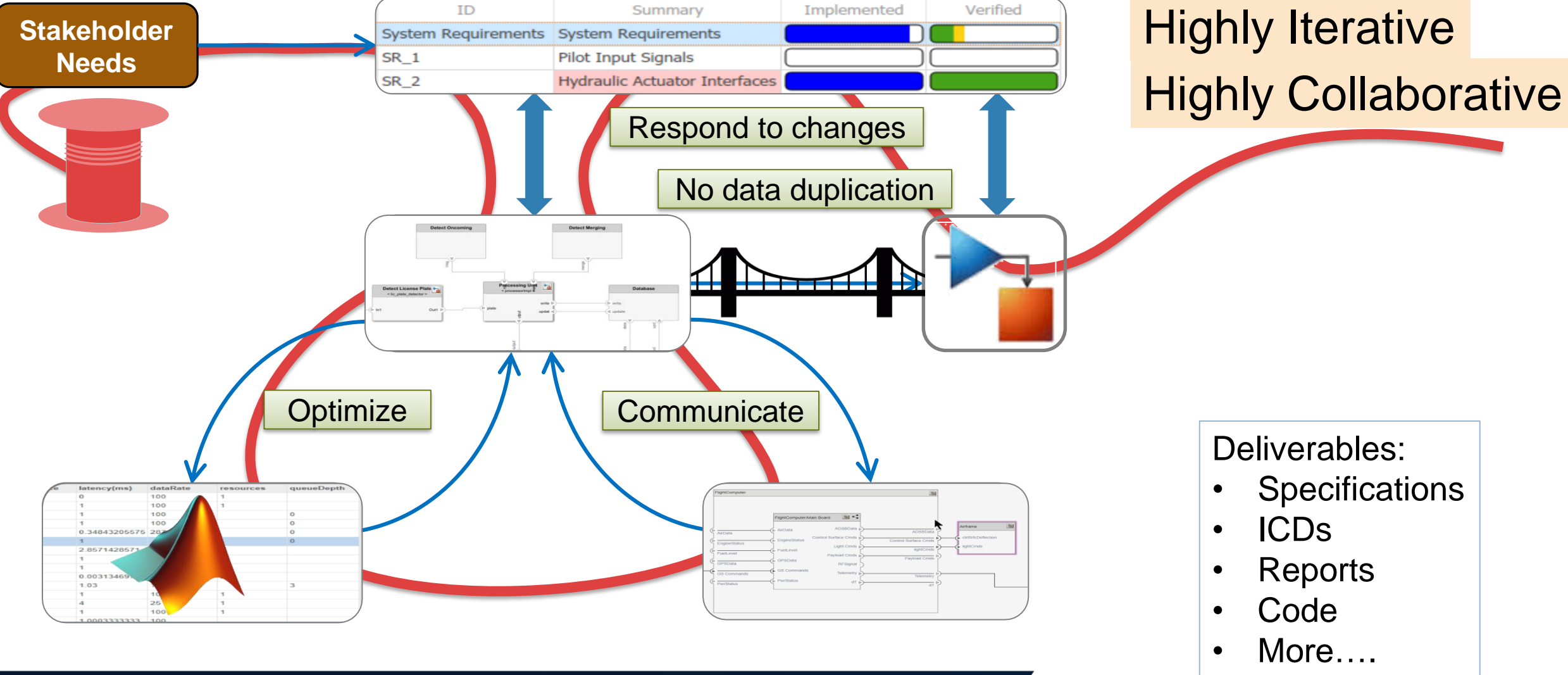
Index	ID	Summary	Implemented	Verified
1	#1	Target Characteristics		
1.1	#2	Target Movement		
1.2	#3	Target Environment		
1.3	#4	Target Velocity		
1.4	#5	Target Size		
1.5	#6	Target Color		
1.6	#10	Target Material		
2	#7	System Requirements		
FCS_requirements				
1	#13	FCS communications		
2	#2	FCS Modes		
3	#3	FCS Navigation		
4	#4	FCS Control		
HLR_ModelLogic				
1	3	Modes of Operation		
2	16	Establish Communications		
3	21	Initialization		
4	25	Calibrate the Sensors		
5	29	Ready for Flight		
6	33	Track Altitude		
7	37	Track Altitude and Position		
8	41	Lost Ball		
9	46	Land		
10	50	Crash		
11	#52	Justifications		
quadcopter				
1	#1	Aircraft Performance		
2	#2	Power System		
3	#3	Mass Properties & Geometry		
4	#4	Flight Control System		
4.1	#16	FCS communications		
4.2	#17	FCS Modes		
4.3	#18	FCS Target Tracking		
4.4	#19	FCS Control		
5	#5	Payload		

Properties - Target Velocity

Type: Functional
Index: 1.3
Custom ID: #4
Summary: Target Velocity

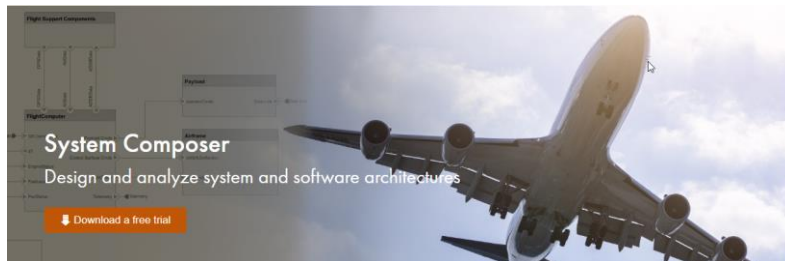
Description: The target shall be tracked at speeds of less than or equal to 0.3 m/s

Summary: Unified Environment for MBSE and Model-Based Design

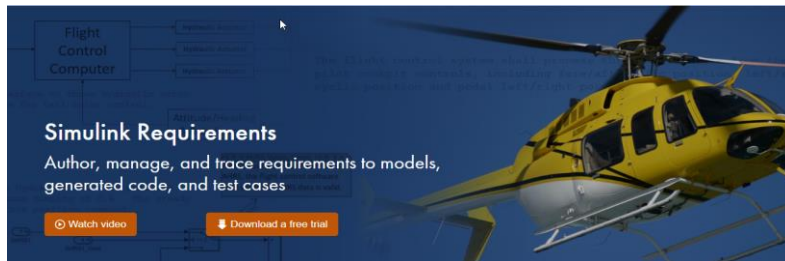


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[Model-Based Systems Engineering](#)



[System Modeling and Simulation](#)



[AUTOSAR](#)