



Innovations in Engineering



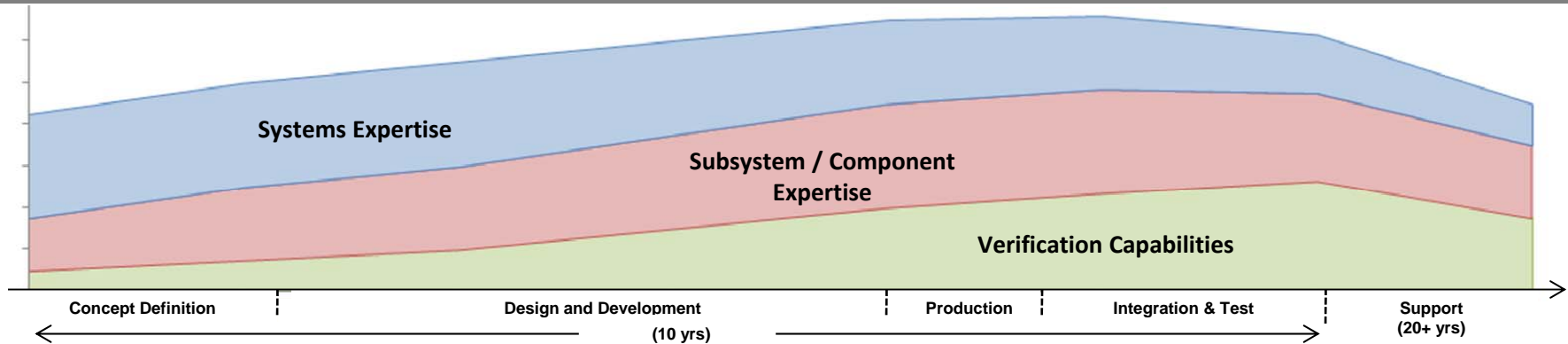
# An Innovative Strategy for System Sustainability

NDIA Systems Engineering Conference  
30 October 2013  
Arlington, VA

# Outline

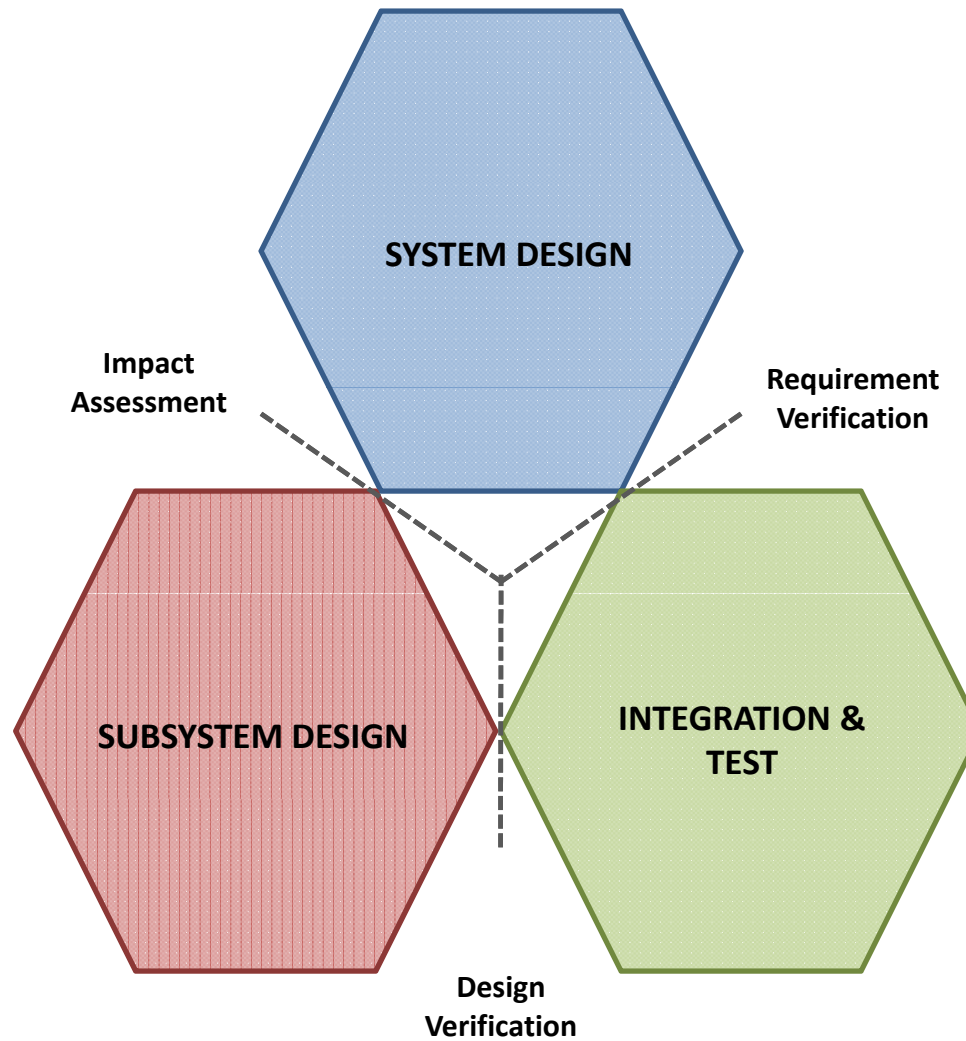
- **Problem Statement**
- **Model-Based Knowledge Capture**
- **Observed Benefits**

# Enhanced Retention of System Knowledge Required

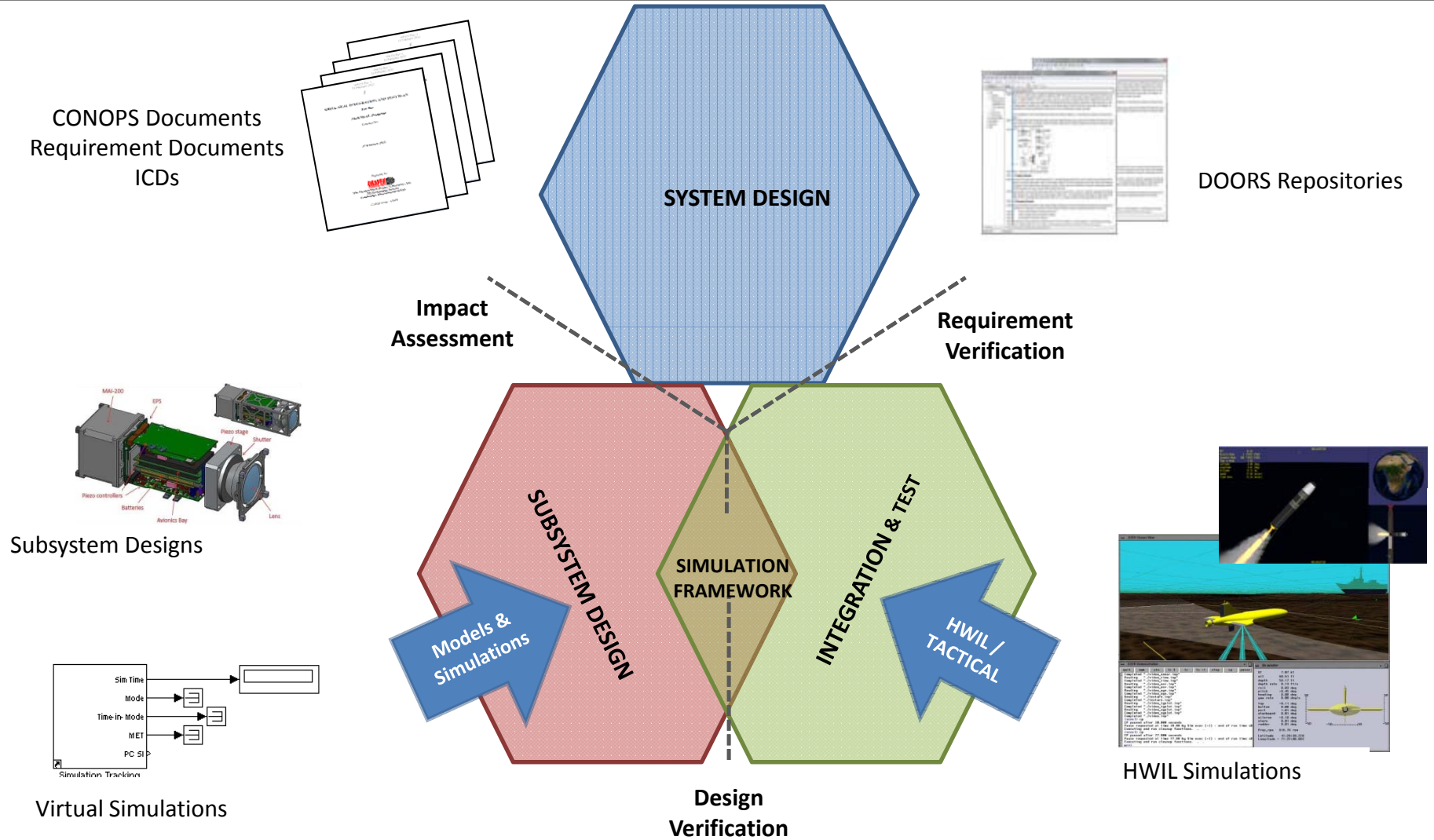


- **Large scale, legacy system sustainment context**
  - Systems experience can diminish in later lifecycle phases
  - Static infrastructure for information and processes
- **Modernization and upgrades often subsystem focused**
  - Subsystem changes yield risk of emergent systems behavior
  - Unable to accomplish systems-level re-optimization
- **System sustainability needs**
  - Prevent erosion of system level knowledge & capability
  - Understand impact of requirement/ design changes
  - Quickly obtain confidence of design's ability to meet requirements

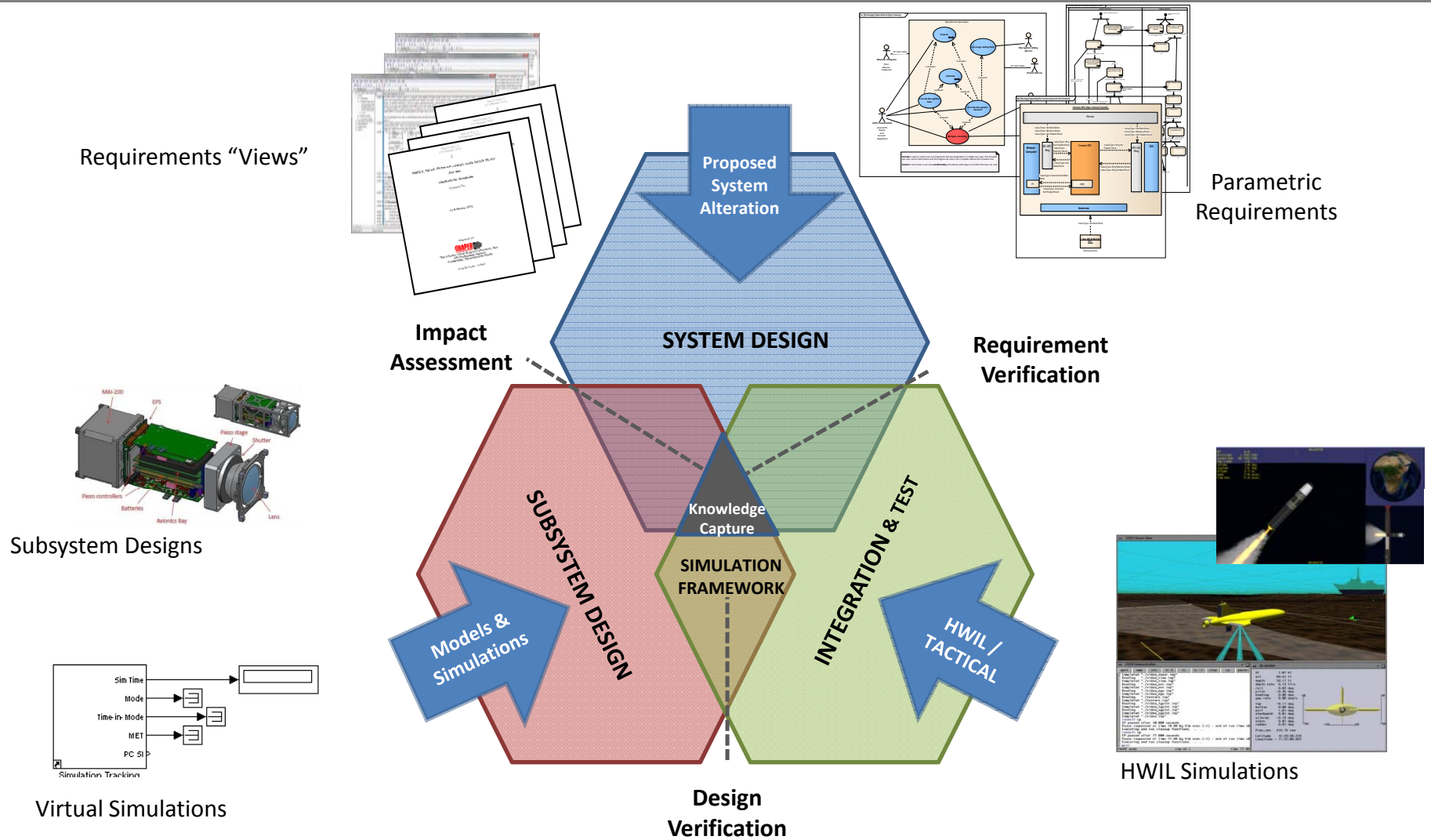
# General Product Datatypes



# Traditional Data Sharing



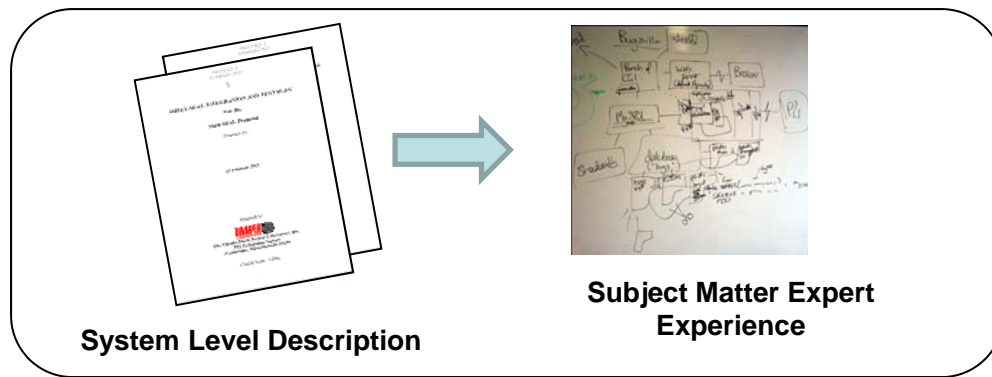
# Fully Integrated Data Sharing



# Traditional Knowledge Capture

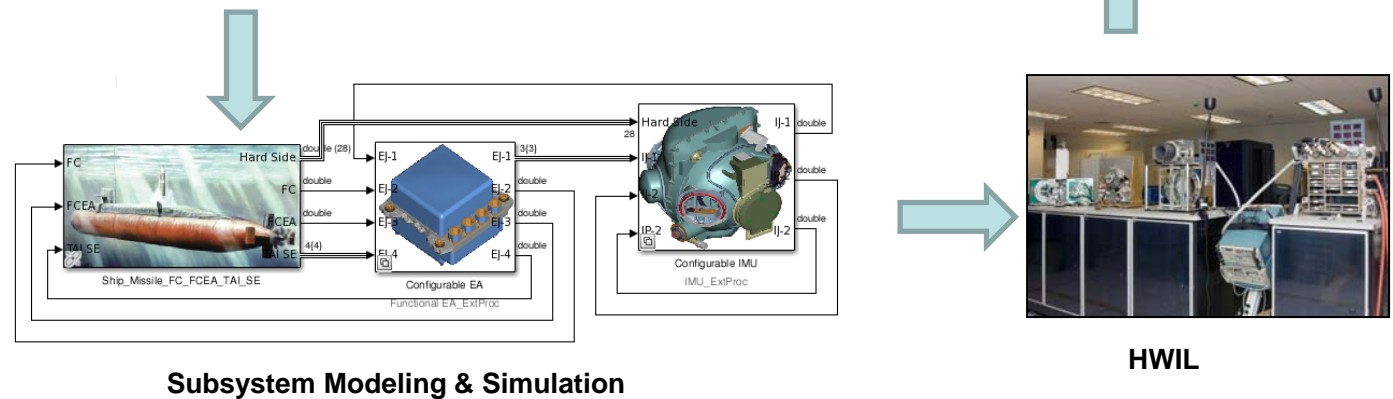
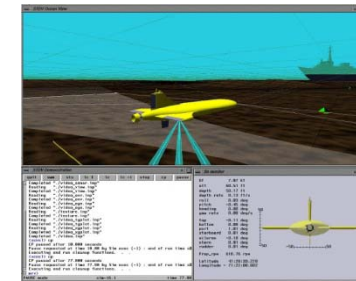
## Systems Knowledge

- Federated Documents
  - Manual generation
- Manual traceability of requirements
- Reliance on domain experts to assess impacts



## Verification through Simulation

- Now using auto-code generation
- Dynamic parameters setting
- Subsystem requirement verification
  - Often manually performed





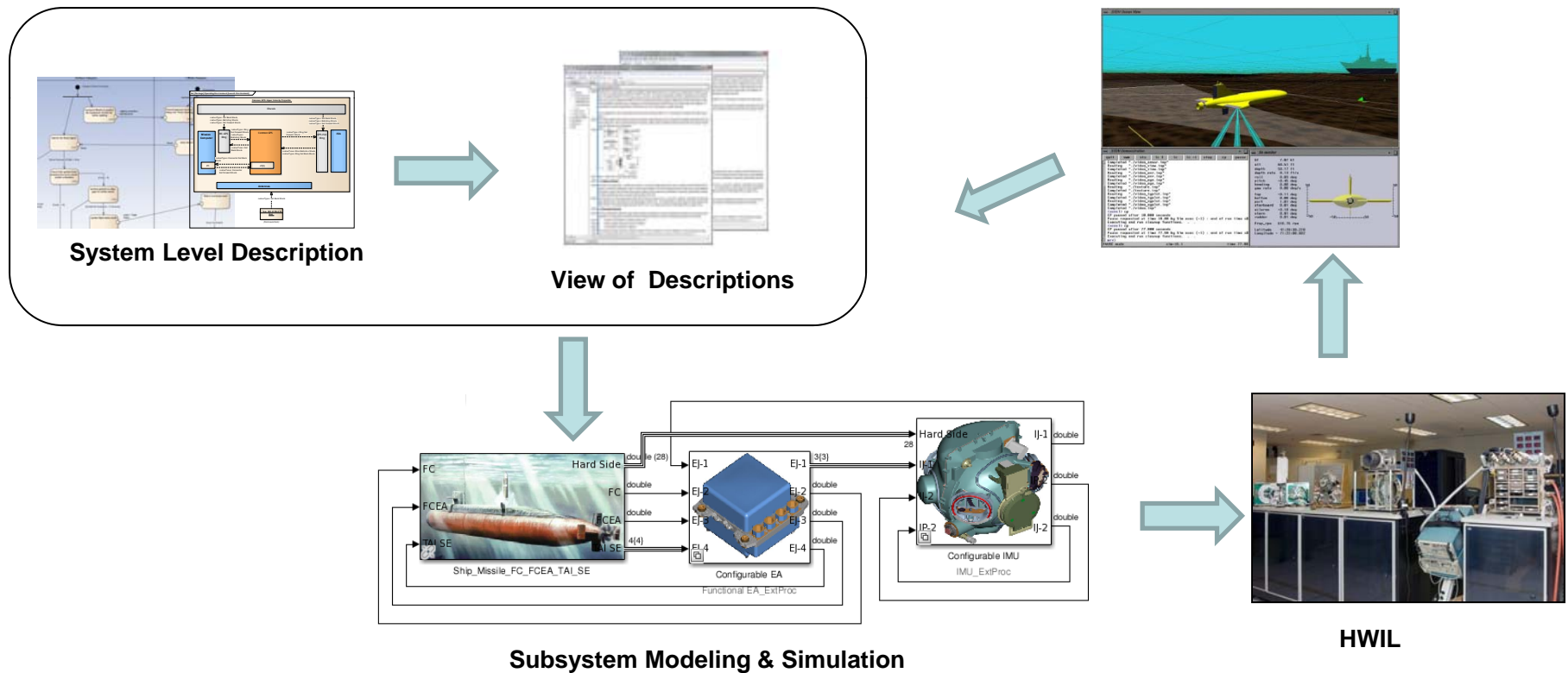
# Integrated Knowledge Capture

## Systems Knowledge

- Dynamically decompose to subsystem models
- Capture systems requirements, designs, tradeoffs
- Automatic specification generation

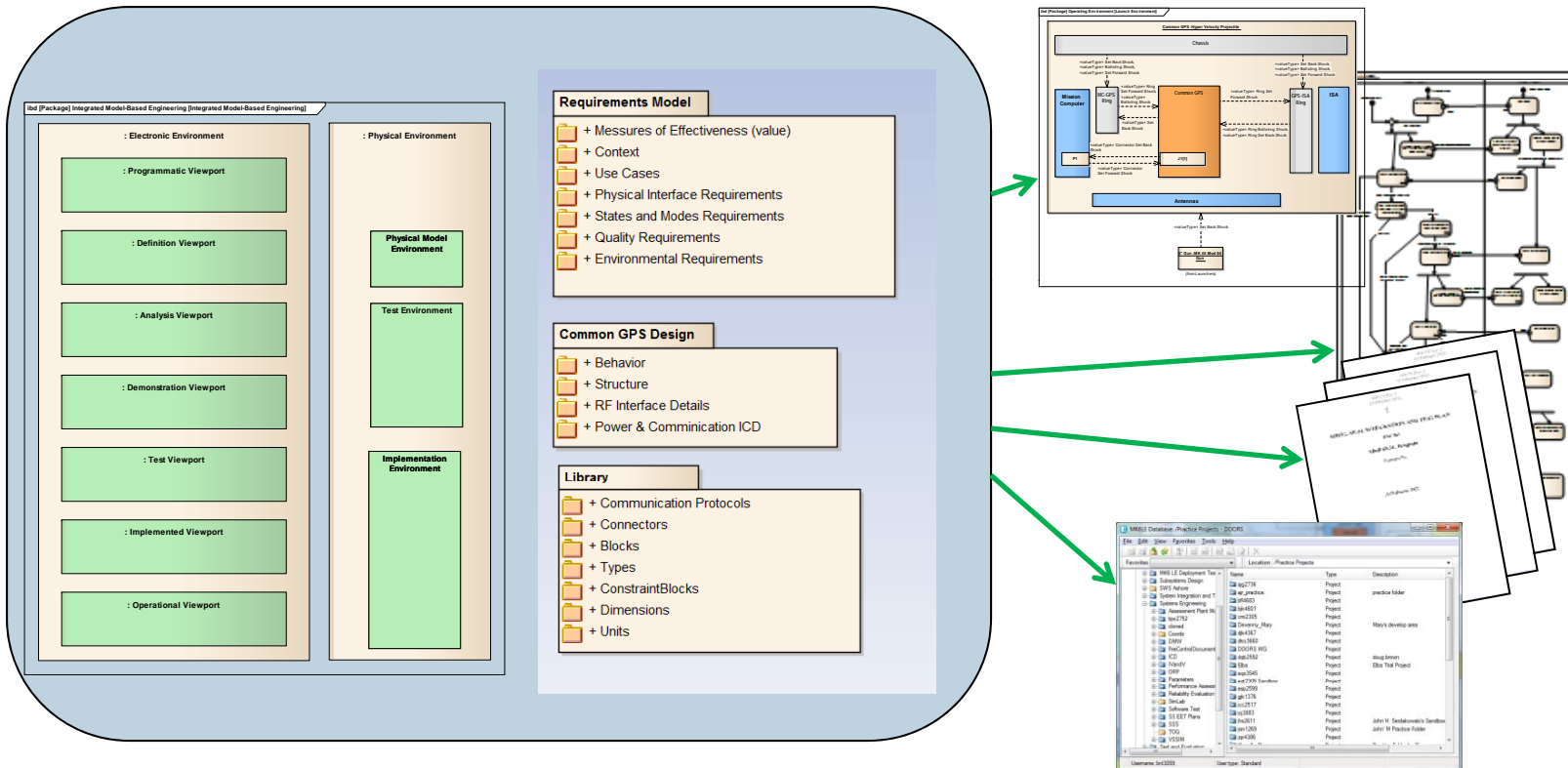
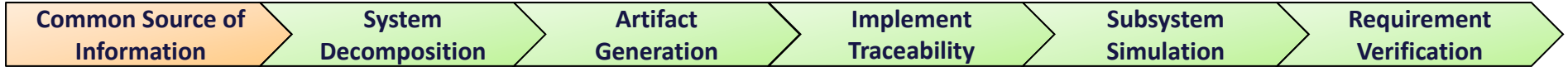
## Integration with Simulation

- Shared data
- Automatic requirement verification
- Store results for future reference





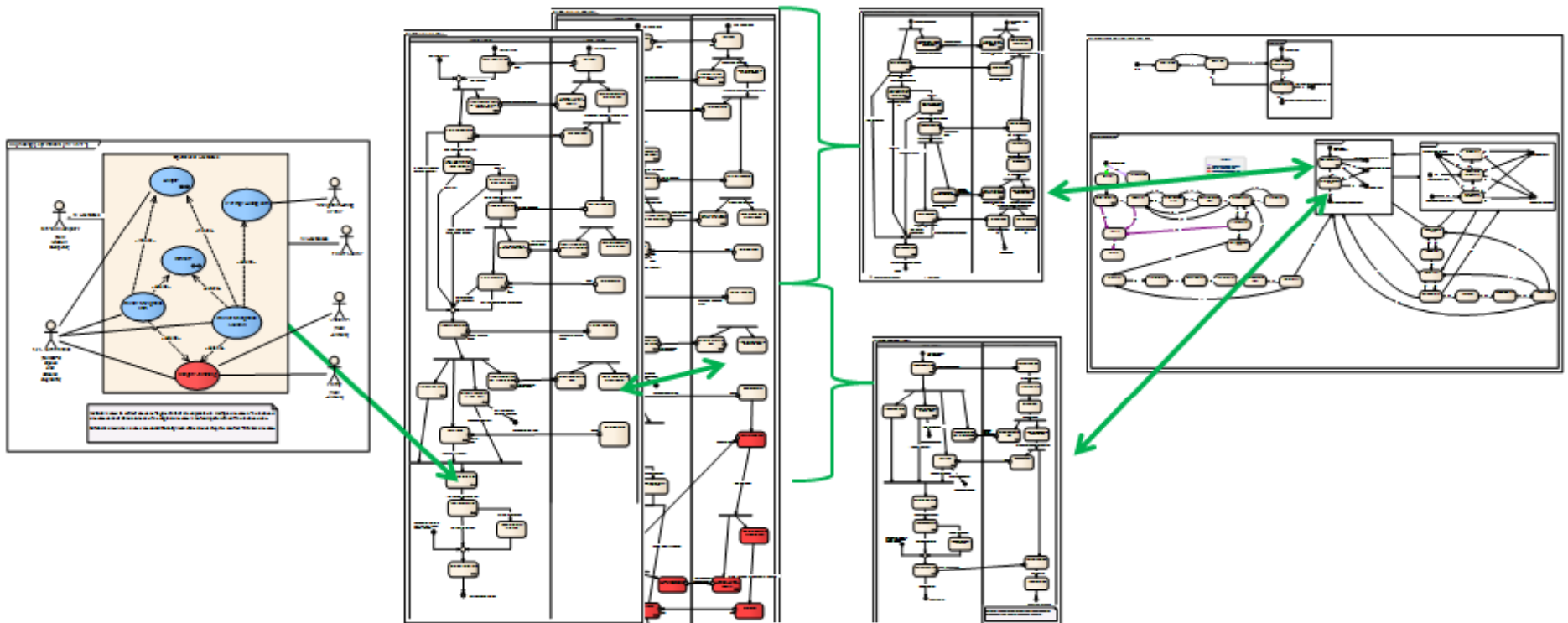
# Getting the Right Information, Right Away



***Model provides a central location for access to data where updates are automatically distributed***

# Insure Consistency through Data Reuse

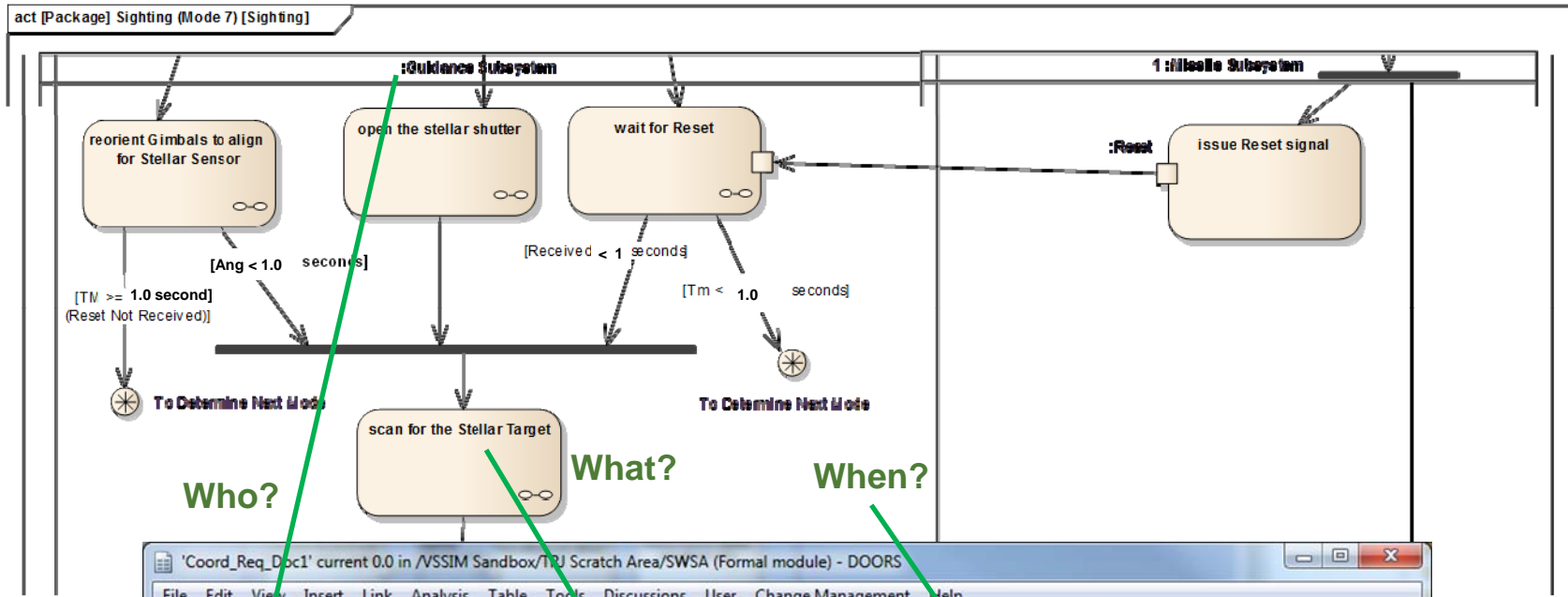
Capture the Data Once and Reuse as Needed



**Model-based approach enforce consistent relationships - prevent errors and miscommunication**

# Automatic Requirement Generation

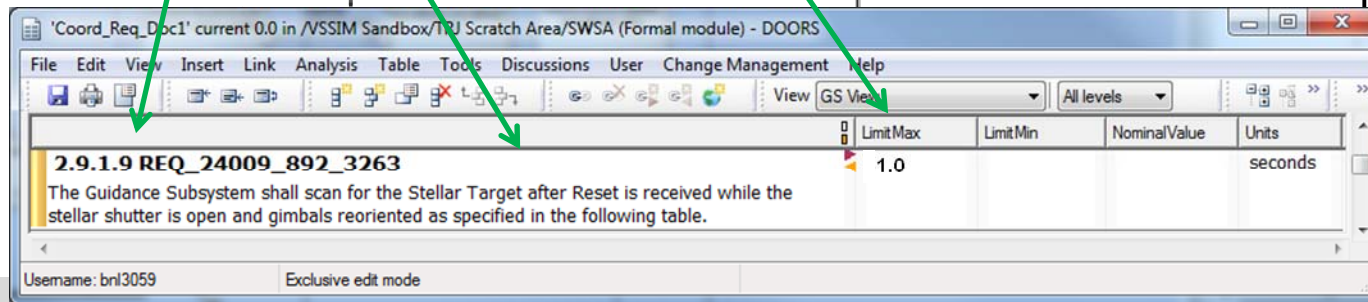
Reducing Manual Translation and Errors



Who?

What?

When?



**Generating Requirements from Higher Level Design is a Standard Practice - Now Tools Can Do This for Us**

# Integration with Subsystem Definition

Link to Requirements or other Design Tools

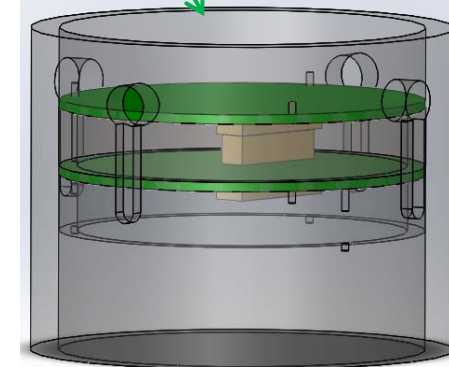


**Requirements**

ID	Req	Description	Units	Normal Value	Limit/Max
101	2.5.1.1 REQ_48398_892_3710	The Guidance Subsystem shall update flight status mode after (1) Reset received, (2) Asset timeout, or (3) Gimbal an failure properly load up.			
102	2.5.1.2 REQ_48398_892_48399	The Guidance Subsystem shall transmit flight status.			
103	2.5.1.3 REQ_48069_892_3260	The Guidance Subsystem shall open the stellar shutter after flight status is updated to Mode 7.			
104	2.5.1.4 REQ_34061_892_3262	The Guidance Subsystem shall reorient Gimbal to align for Stellar Sensor after flight status is updated to Mode 7.			
105	2.5.1.5 REQ_48419_892_3359	The Guidance Subsystem shall command Missile to lock the ES for stellar sighting after flight status is updated to Mode 7.			
106	2.5.1.6 REQ_48419_892_48420	The Guidance Subsystem shall transmit sighting steering vector.			
107	2.5.1.7 REQ_48133_892_3261	The Guidance Subsystem shall wait for Stellar Target after flight status is updated to Mode 7.			
108	2.5.1.8 REQ_48133_892_48156	The Guidance Subsystem shall accept Reset.			
109	2.5.1.9 REQ_24609_892_3263	The Guidance Subsystem shall scan for Stellar Target after Reset is received while the stellar shutter is open and gimbal is repositioned as specified in the following table.	Max. Scan Time	This is the maximum time allowed to perform the stellar scan.	seconds
110	2.5.1.10 REQ_48670_892_3265	The Guidance Subsystem shall close the stellar shutter upon Stellar Target scan complete.			
111	2.5.1.11 REQ_48127_892_3165	The Guidance Subsystem shall generate navigation corrections upon after location computed as specified in the following table.	Computation Time	Computation Time	seconds
112	2.5.1.12 REQ_55276_892_3226				

**MBSE Specification**

Block	Package	Height	Length	Width	Max. Scan Rate
Issue HNP GPS	Round Card	40 [in]			
Issue PCK GPS	Rectangular	3.08 [in]	0.30 [in]	1.00 [in]	300 [Hz]
Issue Tricollar GPS	Round Card	0.6 [in]			
	max diameter	2.10 [in]			



## Subsystem Parameters

**Subsystem Parameters**

ID	Name/Long	Name/Short	Units	Normal Value	Limit/Max
SWSP45	Max time allowed aft	MSN_ALLOWED	T_ALLOWED	sec	0.0 1.0 1.0
SWSP51	Allowable time to slew th	GDC_T_STAR_CALC	T_STAR_CALC	sec	0.0 1.0 1.0
SWSP52	IFOG maximum slew rate	IFOG_COMP_PARAM_TSLEW_TACT	IFOGCOMP_TSLEW_TACT	sec	0.0 1.0 1.0
SWSP53	IFOG maximum slew rate	IFOG_COMP_PARAM_MAX_GYRO_SLEWRATE_TACT	IFOGCOMP_MAXGYRO_SLEW_RATE_TACT	1/sec	0.0 1.0 1.0
SWSP54	IFOG compensation plat	IFOG_COMP_PARAM_MAX_GYRO_SLEWRATE_TEST	IFOGCOMP_MAXGYRO_SLEW_RATE_TEST	1/sec	0.0 1.0 1.0
SWSP55	Maximum allowable rotat	IFOG_COMP_GYRO_TSETTLE	IFOGCOMP_MAX_GYRO_TSETTLE	1/sec	0.0 1.0 1.0
SWSP32	Maximum allowable rotat	PLATFORM_ERR_W	PLATFORM_ERR_W	Unitless	0.0 1.0 1.0
SWSP31	Maximum allowable rotat	PLATFORM_ERR_V	PLATFORM_ERR_V	Unitless	0.0 1.0 1.0
SWSP27	Maximum allowable rotat	PLATFORM_ERR_U	PLATFORM_ERR_U	Unitless	0.0 1.0 1.0
SWSP21	Minimal allowable excurs	PARAMETER_A	PARAMETER_A	feet	0.0 1.0 1.0

**Inheritance of Inalterable Parameters Insures that Consistent Values are Used in Design and Verification**

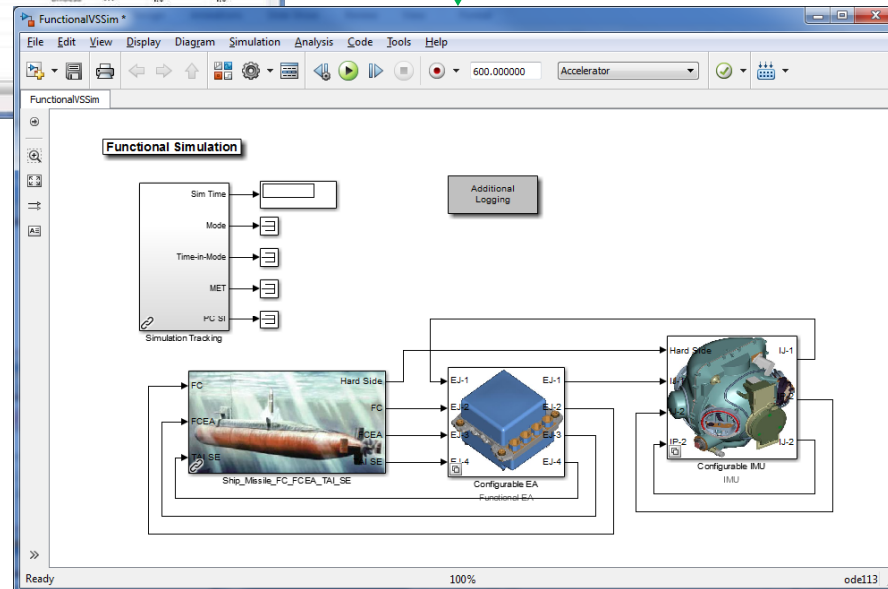
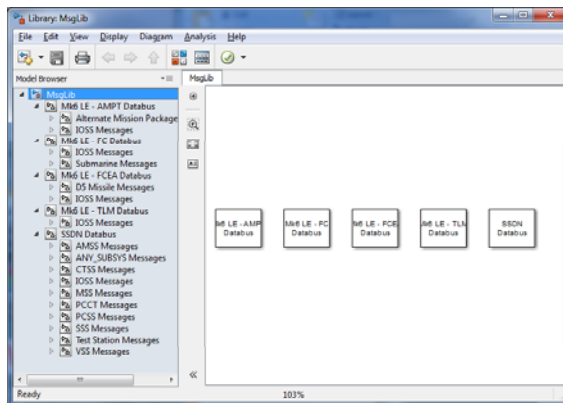
# Provide Early Design Confidence

Simulated flights provides confidence that the design meets requirements



ID	Name/Label	Name/Label	Units	Limit	Normal Value	Limit/Max
SWSP45	MIN_TALLOWED	TALLOWED	sec	0.0	1.0	1.0
SWSP46	MAX_TALLOWED	TALLOWED	sec	0.0	1.0	1.0
SWSP47	FOG_COMP_PARAM_TSLW_TACT	FOGCOMP_TSLW_TACT	sec	0.0	1.0	1.0
SWSP48	FOG_COMP_PARAM_MAX_OYRD_SLEWRATE_TACT	FOGCOMP_MAXOYRD_SLEWRATE_TACT	1/sec	0.0	1.0	1.0
SWSP49	FOG_COMP_PARAM_MAX_OYRD_SLEWRATE_TEST	FOGCOMP_MAXOYRD_SLEWRATE_TEST	1/sec	0.0	1.0	1.0
SWSP50	FOG_COMP_OYRD_TSETTLE	FOGCOMP_MAXOYRD_TSETTLE	1/sec	0.0	1.0	1.0
SWSP51	Maximum allowable rotation in Z	PLATFORM_ERR_W	Unitless	0.0	1.0	1.0
SWSP52	Maximum allowable rotation in Y	PLATFORM_ERR_V		0.0	1.0	1.0
SWSP53	Maximum allowable rotation in X	PLATFORM_ERR_U		0.0	1.0	1.0
SWSP54	Minimal allowable excursion	PARAMETER_A				

High Level Requirements and Implementation Parameters



Closed-loop Simulation running externally-specified parameters

Simulations and Flight SW operate on the same data used to generate ICD

# Automatic Assessment of Ability to Meet Requirements

Common Source of Information

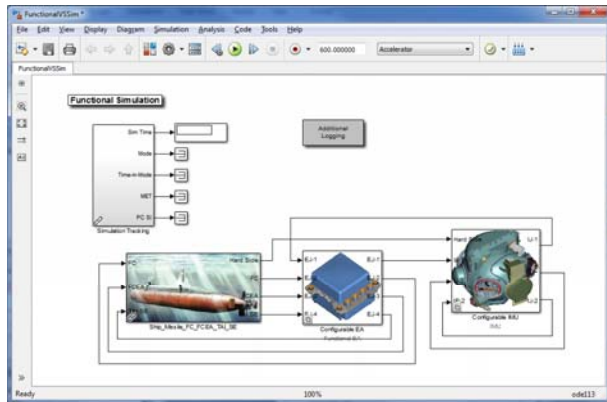
System Decomposition

Artifact Generation

Implement Traceability

Subsystem Simulation

Requirement Verification



Post results back to repository for review

The screenshot shows the 'SWSA\_Measurements' application window. It displays a table of test results. The table has the following columns: TestDate, NameMachine, TestValue, PassFail, TestDataSetID, and TestUnitID. The data is as follows:

TestDate	NameMachine	TestValue	PassFail	TestDataSetID	TestUnitID
14-May-2013 13:10:58	STELLAR SCAN2	26.02000	FAIL	DS00001	VSSim LE-Sim03
Save (Ctrl+S) 13:10:58	STELLAR SCAN1	16.41000	FAIL	DS00001	VSSim LE-Sim03
14-May-2013 13:10:58	STELLAR SCAN2	26.02000	FAIL	DS00001	VSSim LE-Sim03
14-May-2013 13:10:58	STELLAR SCAN1	16.41000	FAIL	DS00001	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN2	23.64000	FAIL	DS00001	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN1	8.52000	PASS	DS00001	VSSim LE-Sim03
15-May-2013 07:37:57	STELLAR SCAN2	25.65000	FAIL	DS00004	VSSim LE-Sim03
15-May-2013 07:37:57	STELLAR SCAN1	16.37000	FAIL	DS00004	VSSim LE-Sim03
14-May-2013 15:32:20	STELLAR SCAN2	99999.99900	FAIL	DS00003	VSSim LE-Sim03
14-May-2013 15:32:20	STELLAR SCAN1	16.41000	PASS	DS00003	VSSim LE-Sim03
14-May-2013 15:32:20	STELLAR SCAN1	16.41000	PASS	DS00003	VSSim LE-Sim03
14-May-2013 13:10:58	STELLAR SCAN2	26.02000	FAIL	DS00003	VSSim LE-Sim03
14-May-2013 13:10:58	STELLAR SCAN1	16.41000	FAIL	DS00003	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN2	23.64000	PASS	DS00002	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN1	8.52000	PASS	DS00002	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN2	23.64000	PASS	DS00002	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN1	8.52000	PASS	DS00002	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN2	23.64000	PASS	DS00001	VSSim LE-Sim03
13-May-2013 09:00:45	STELLAR SCAN1	8.52000	PASS	DS00001	VSSim LE-Sim03

Requirements satisfaction status is automatically updated

Simple visualization allows teams to quickly identify and react to problems



# Conclusions

- Systems model can greatly increase systems knowledge retention
  - A central data source greatly improves knowledge dissemination
  - Dynamically decomposable models improve data retrieval
  - Models enforce consistency and remove ambiguity
- Linked elements, models, and text facilitate change impact assessment
  - Automatic requirement generation reduces rework
  - Auto requirements saves time
  - Shared data reduces errors and redesign times
- Integrated simulations enable continuous verification
  - Provides design confidence earlier
  - Can reduce the extent of hardware testing
  - Automatic requirement verification reduces “overhead”



# Questions?

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