

Are We Doing Enough in Requirements Management?

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Outline



- Why Do I Need More Than a Spreadsheet?
- What Kinds of Requirements Are We Trying to Capture?
- How Can I Improve My Requirements Management and Analysis Capabilities?

Why Do I Need More Than a Spreadsheet?

What Do Spreadsheets Do?

- Pro
 - Spreadsheets are a wonderful tool for dealing with numbers
 - Excel can perform significant math functions
 - Excel can also plot the numbers very well
- Con
 - Spreadsheets require a schema for collecting information
 - Most Requirements are not pure numbers
 - Functional requirements require context
 - Non-functional requirements are often non-numerical
 - Spreadsheets are not databases (CM, Baselineing and other capabilities are difficult)
 - Spreadsheets cannot provide the functional analysis and simulation capabilities needed

So why are we using spreadsheets for requirements management?

Why Are Spreadsheets Used?

- It's what I have
- I know how to use it
- It's cheap
- Everyone has MS Office
- My management won't buy anything else
- The requirements tools are complicated and expensive
- I don't want to learn a new tool

The end result is poor quality requirements are developed and the cost of fixing them later in the lifecycle grows by orders of magnitude

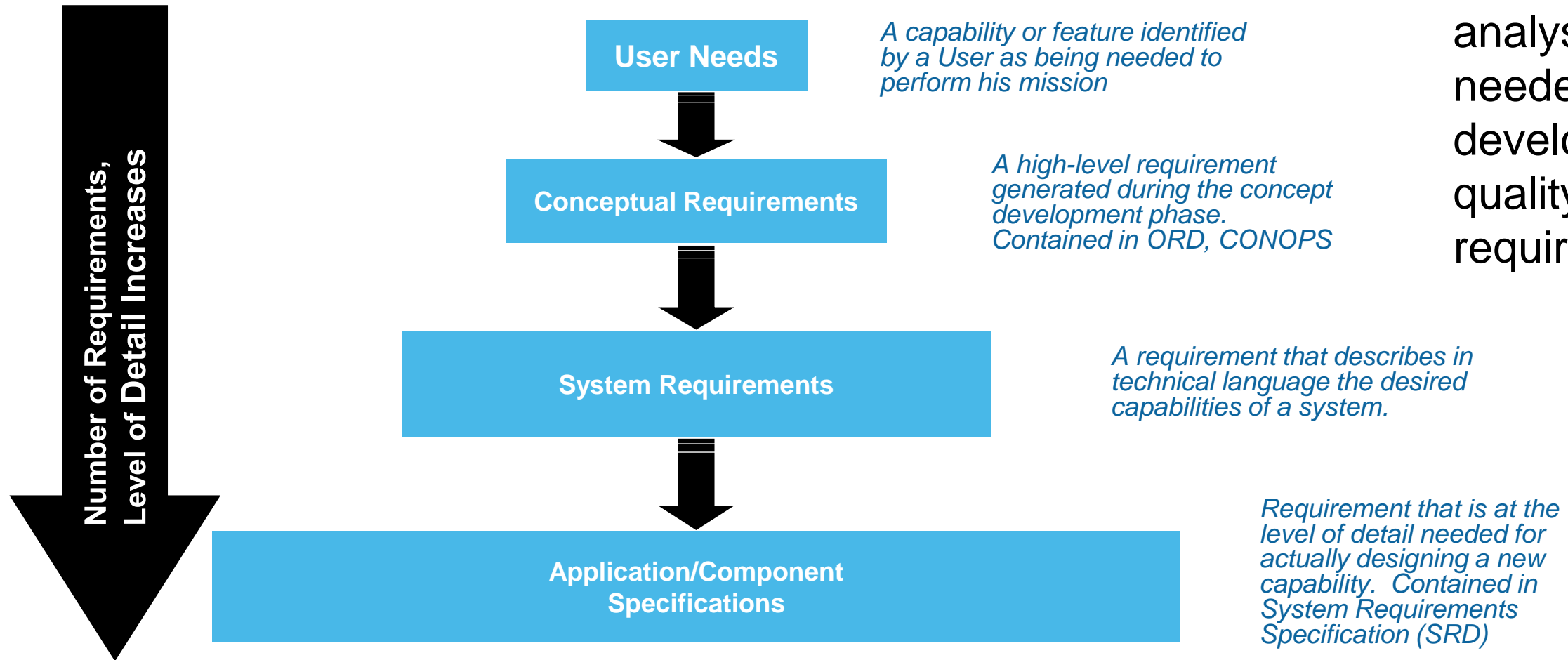
To High Quality Requirements We Need to:

- Support requirements analysis
 - Quality attributes
 - Quality checkers
- Support requirements management
 - Importing capability
 - Configuration Management (i.e. change history, baselining)
- Support functional analysis
 - Includes simulation for verification of models
- Track to Test Results
 - Traceability between test results and requirements
- Be collaborative
 - Commenting capability
- Be scalable
 - Need to store and visualize large number of objects in a database

What Kinds of Requirements Are We Trying to Capture?

What Level Am I Trying to Capture?

The Requirements Hierarchy



Different kinds of analyses are needed to develop high quality requirements

The SE Process Develops Requirements

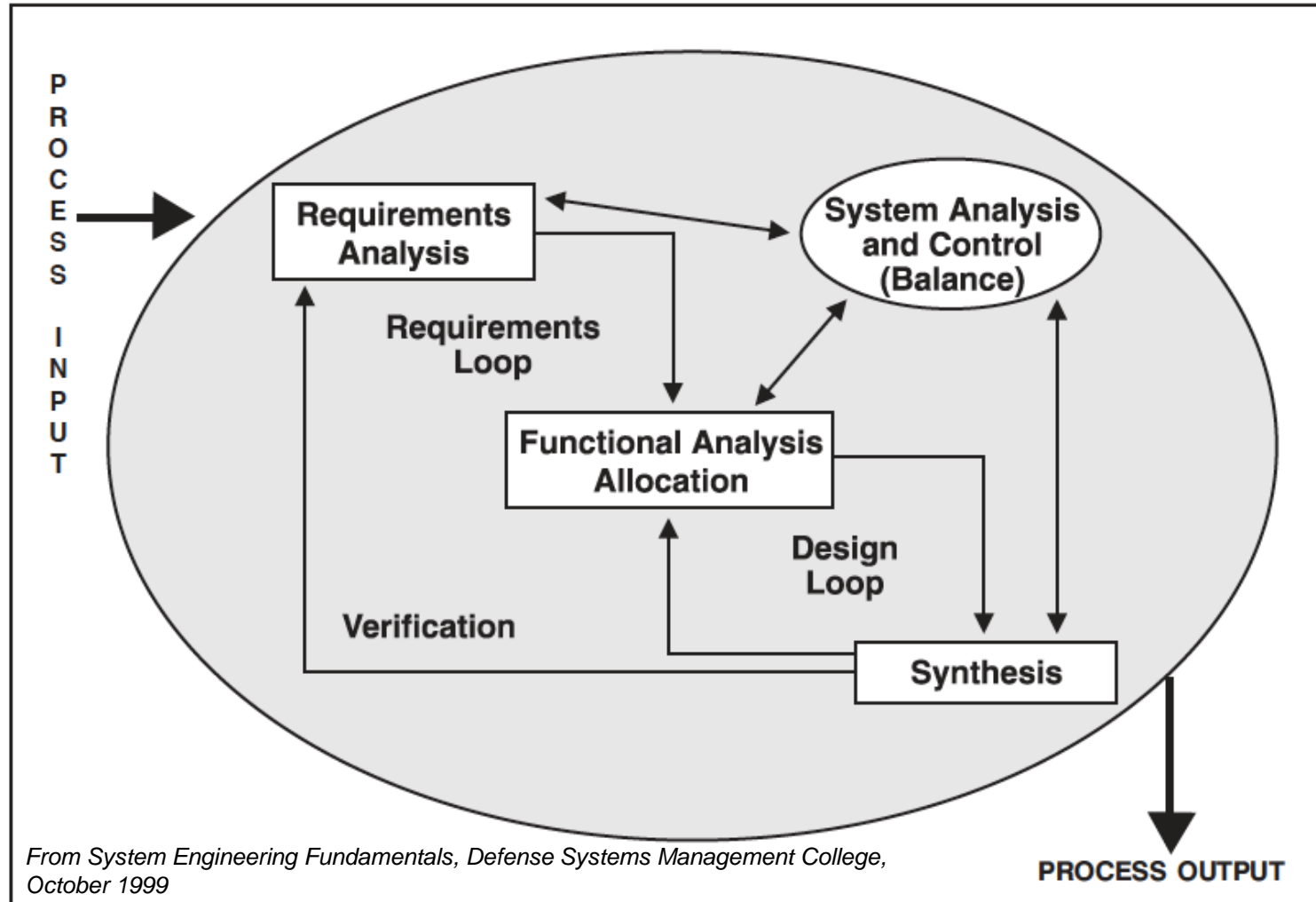
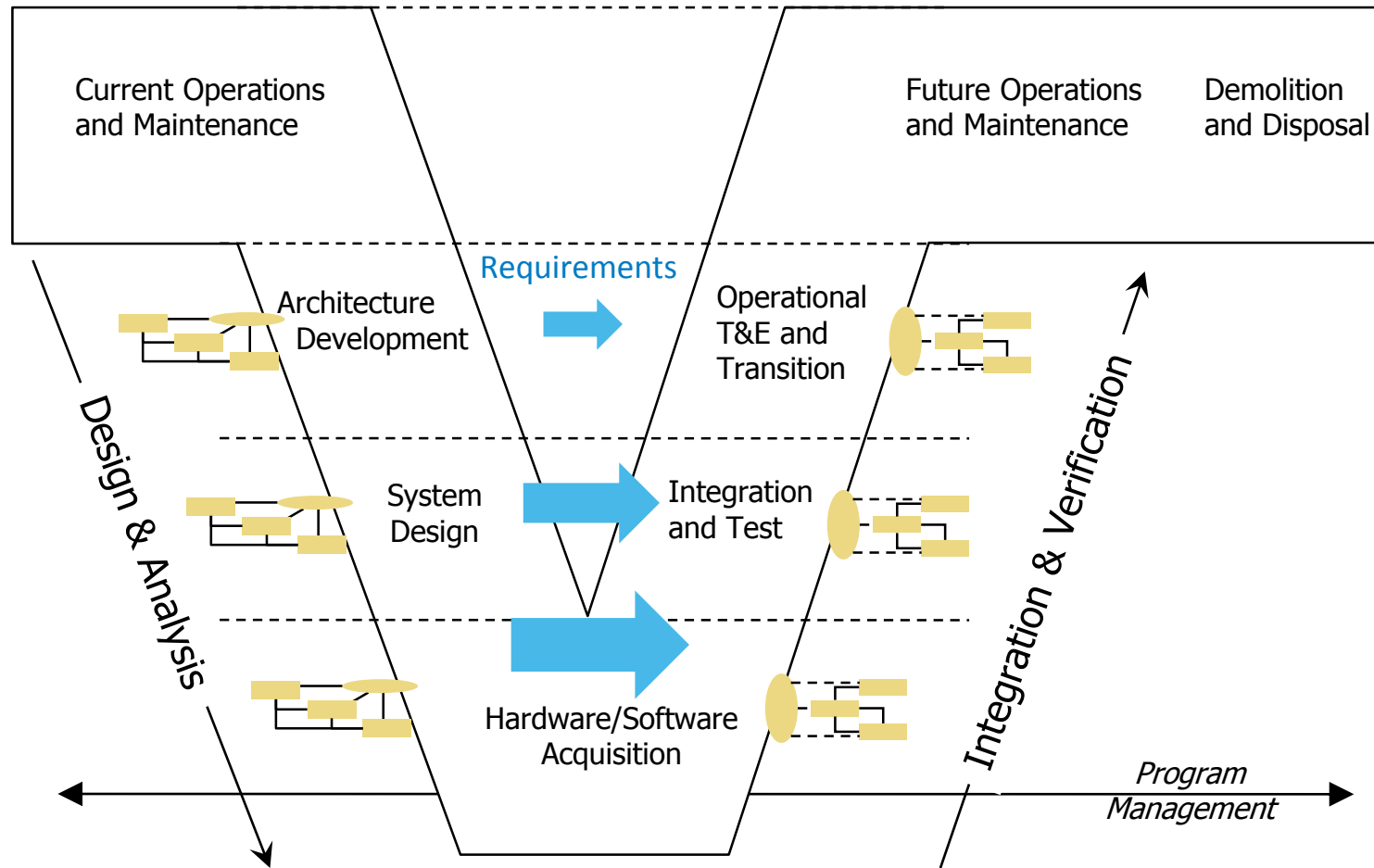


Figure 1-3. The Systems Engineering Process

- Process input starts with user needs
- Process output results in specifications for the next level of decomposition
- The steps in the process can be executed in any order and simultaneously
- Result is *functional* and *non-functional* requirements for each level

Role of Requirements in the Lifecycle

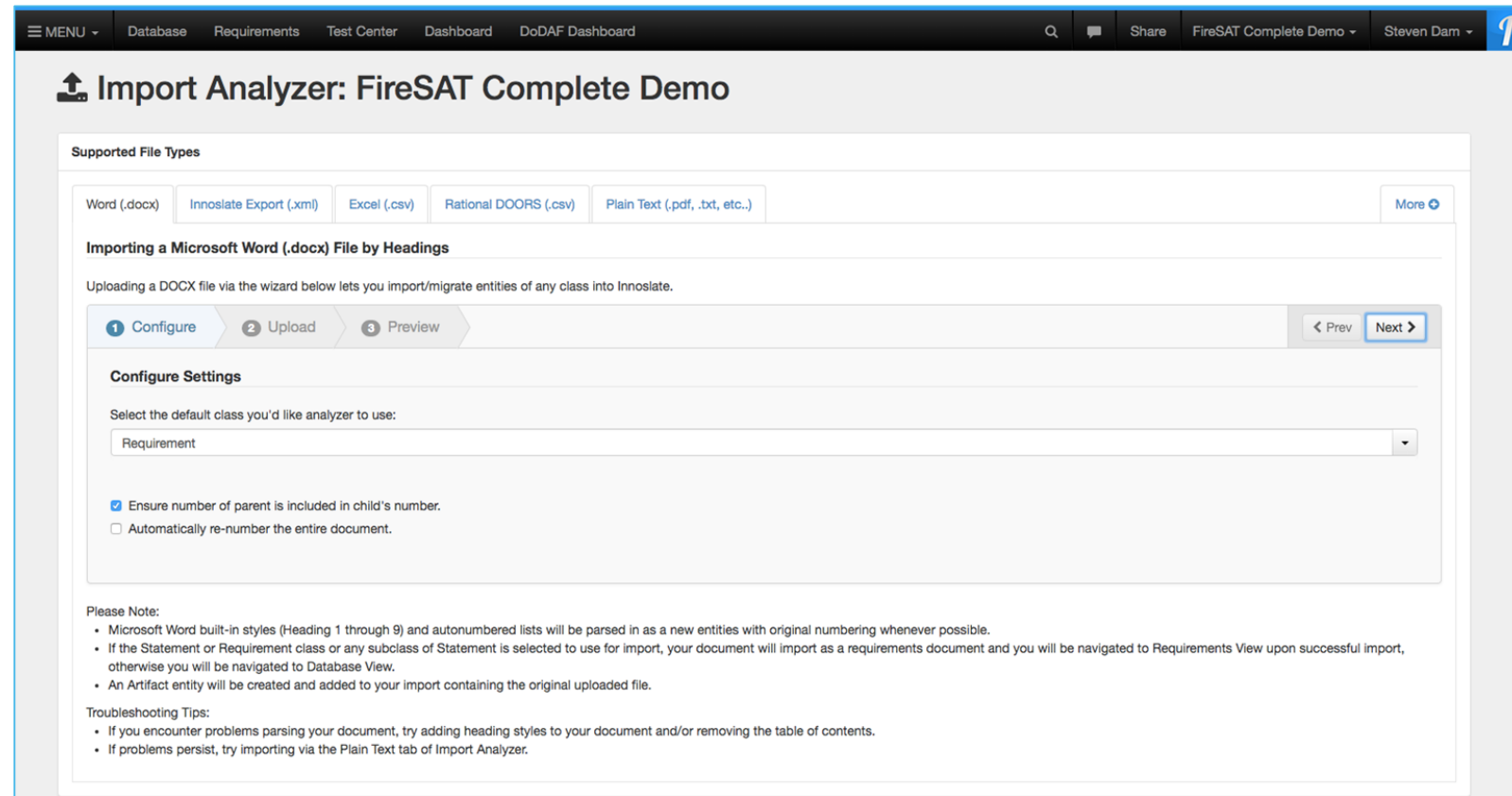


- Requirements are developed at the beginning of the lifecycle
- Resulting components, systems, and complete architectures are validated later in the lifecycle using these requirements
- The number of requirements increases as we decompose the architecture

How Can I Improve My Requirements Management and Analysis Capabilities?

Step 1: Capture Originating Artifacts

- Import directly
 - MS Word files
 - CSV
 - DOORS CVS
 - Plain Text (PDF)
 - XML
- Analyze numbering scheme to create parent-child relationships automatically
- Preview before saving



MENU Database Requirements Test Center Dashboard DoDAF Dashboard

Import Analyzer: FireSAT Complete Demo

Supported File Types

Word (.docx) Innoslate Export (.xml) Excel (.csv) Rational DOORS (.csv) Plain Text (.pdf, .txt, etc.) More

Importing a Microsoft Word (.docx) File by Headings

Uploading a DOCX file via the wizard below lets you import/migrate entities of any class into Innoslate.

1 Configure 2 Upload 3 Preview

Configure Settings

Select the default class you'd like analyzer to use:

Requirement

Ensure number of parent is included in child's number.
 Automatically re-number the entire document.

Please Note:

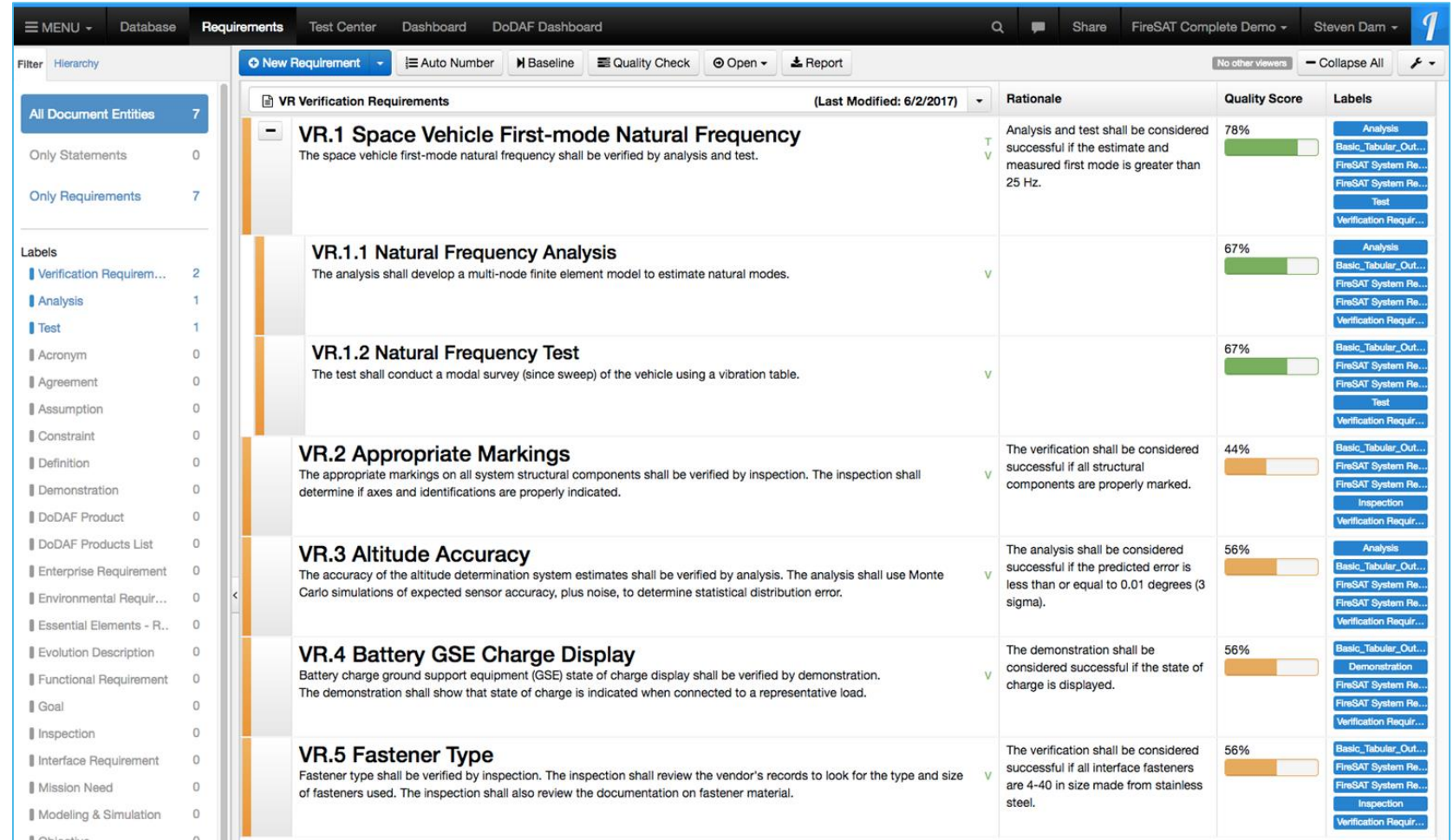
- Microsoft Word built-in styles (Heading 1 through 9) and autonumbered lists will be parsed in as a new entities with original numbering whenever possible.
- If the Statement or Requirement class or any subclass of Statement is selected to use for import, your document will import as a requirements document and you will be navigated to Requirements View upon successful import, otherwise you will be navigated to Database View.
- An Artifact entity will be created and added to your import containing the original uploaded file.

Troubleshooting Tips:

- If you encounter problems parsing your document, try adding heading styles to your document and/or removing the table of contents.
- If problems persist, try importing via the Plain Text tab of Import Analyzer.

Step 2: Analyze Requirements

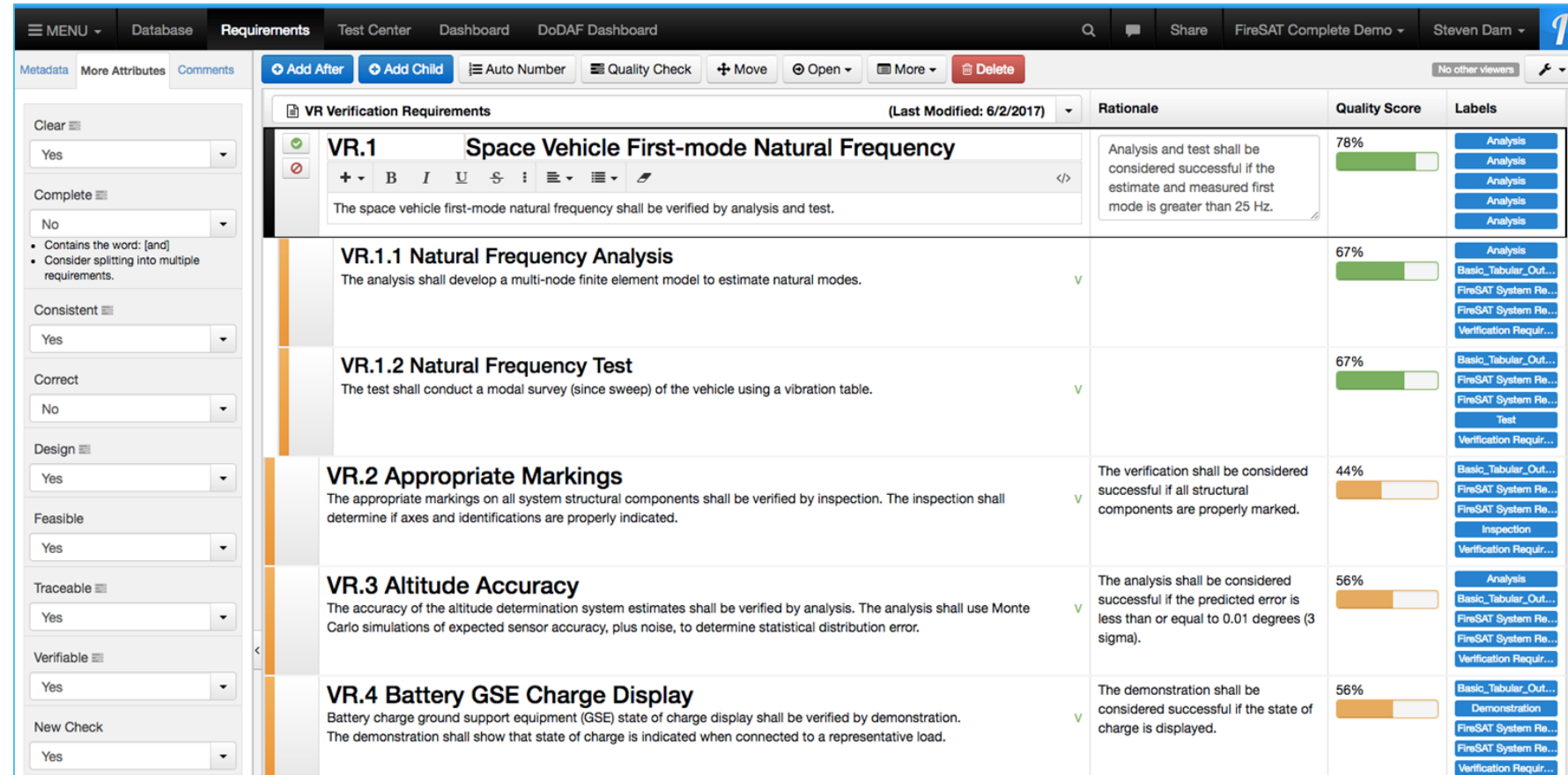
- Quality Check each requirement
- Add a Rationale
- Create Reports
- Visualize requirements



VR Verification Requirements	(Last Modified: 6/2/2017)	Rationale	Quality Score	Labels
VR.1 Space Vehicle First-mode Natural Frequency The space vehicle first-mode natural frequency shall be verified by analysis and test.	T V	Analysis and test shall be considered successful if the estimate and measured first mode is greater than 25 Hz.	78%	Analysis Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Test Verification Requir...
VR.1.1 Natural Frequency Analysis The analysis shall develop a multi-node finite element model to estimate natural modes.	V		67%	Analysis Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Verification Requir...
VR.1.2 Natural Frequency Test The test shall conduct a modal survey (since sweep) of the vehicle using a vibration table.	V		67%	Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Test Verification Requir...
VR.2 Appropriate Markings The appropriate markings on all system structural components shall be verified by inspection. The inspection shall determine if axes and identifications are properly indicated.	V	The verification shall be considered successful if all structural components are properly marked.	44%	Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Inspection Verification Requir...
VR.3 Altitude Accuracy The accuracy of the altitude determination system estimates shall be verified by analysis. The analysis shall use Monte Carlo simulations of expected sensor accuracy, plus noise, to determine statistical distribution error.	V	The analysis shall be considered successful if the predicted error is less than or equal to 0.01 degrees (3 sigma).	56%	Analysis Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Verification Requir...
VR.4 Battery GSE Charge Display Battery charge ground support equipment (GSE) state of charge display shall be verified by demonstration. The demonstration shall show that state of charge is indicated when connected to a representative load.	V	The demonstration shall be considered successful if the state of charge is displayed.	56%	Basic_Tabular_Out... Demonstration FireSAT System Pe... FireSAT System Pe... Verification Requir...
VR.5 Fastener Type Fastener type shall be verified by inspection. The inspection shall review the vendor's records to look for the type and size of fasteners used. The inspection shall also review the documentation on fastener material.	V	The verification shall be considered successful if all interface fasteners are 4-40 in size made from stainless steel.	56%	Basic_Tabular_Out... FireSAT System Pe... FireSAT System Pe... Inspection Verification Requir...

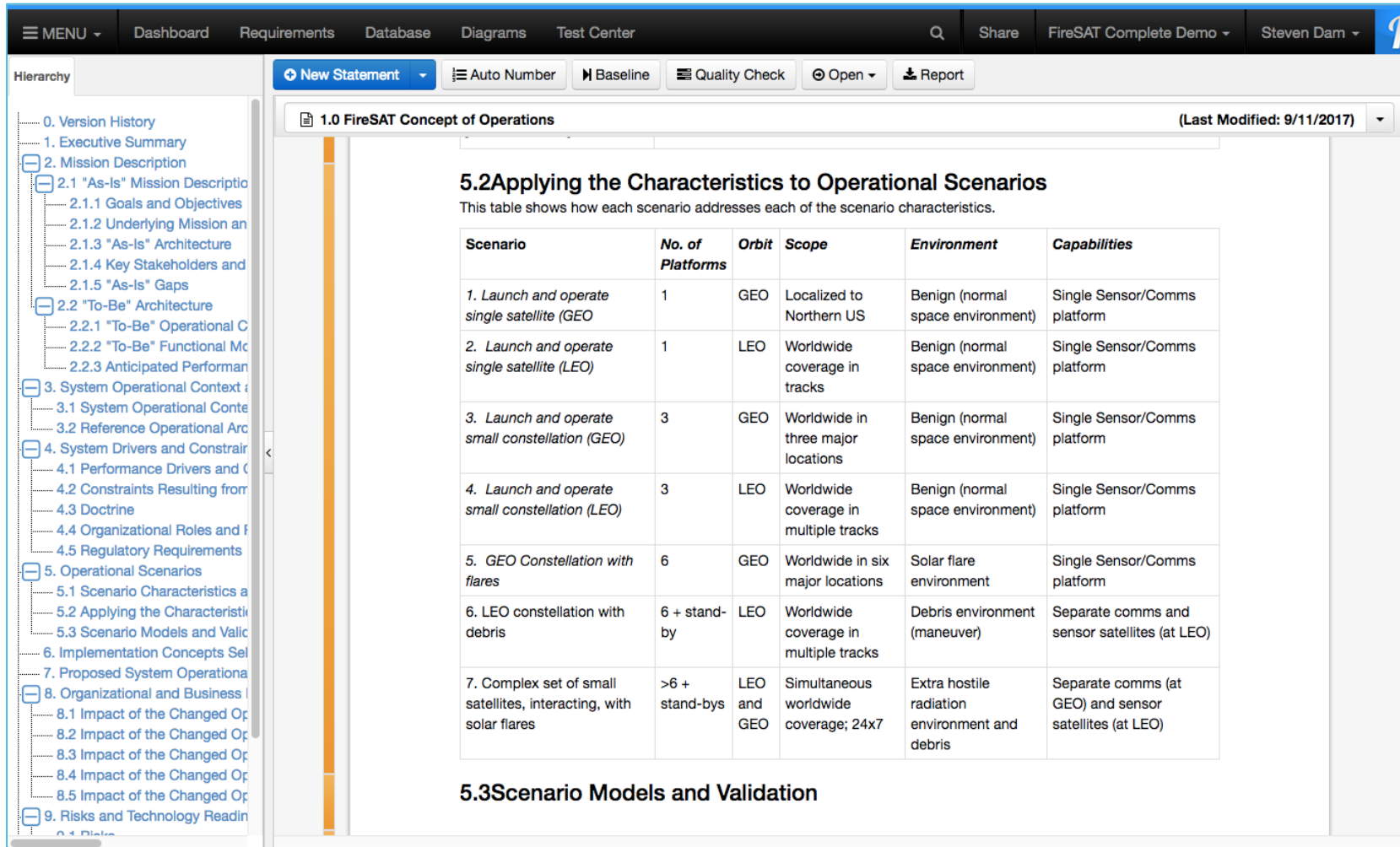
Step 3: Review and Approve Requirements

- Have reviewers provide comments on requirements, but don't let them change the requirement
- If you want reviewers to change requirements create a branch for them to edit
- Baseline requirements when completed



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Step 4: Develop Scenarios



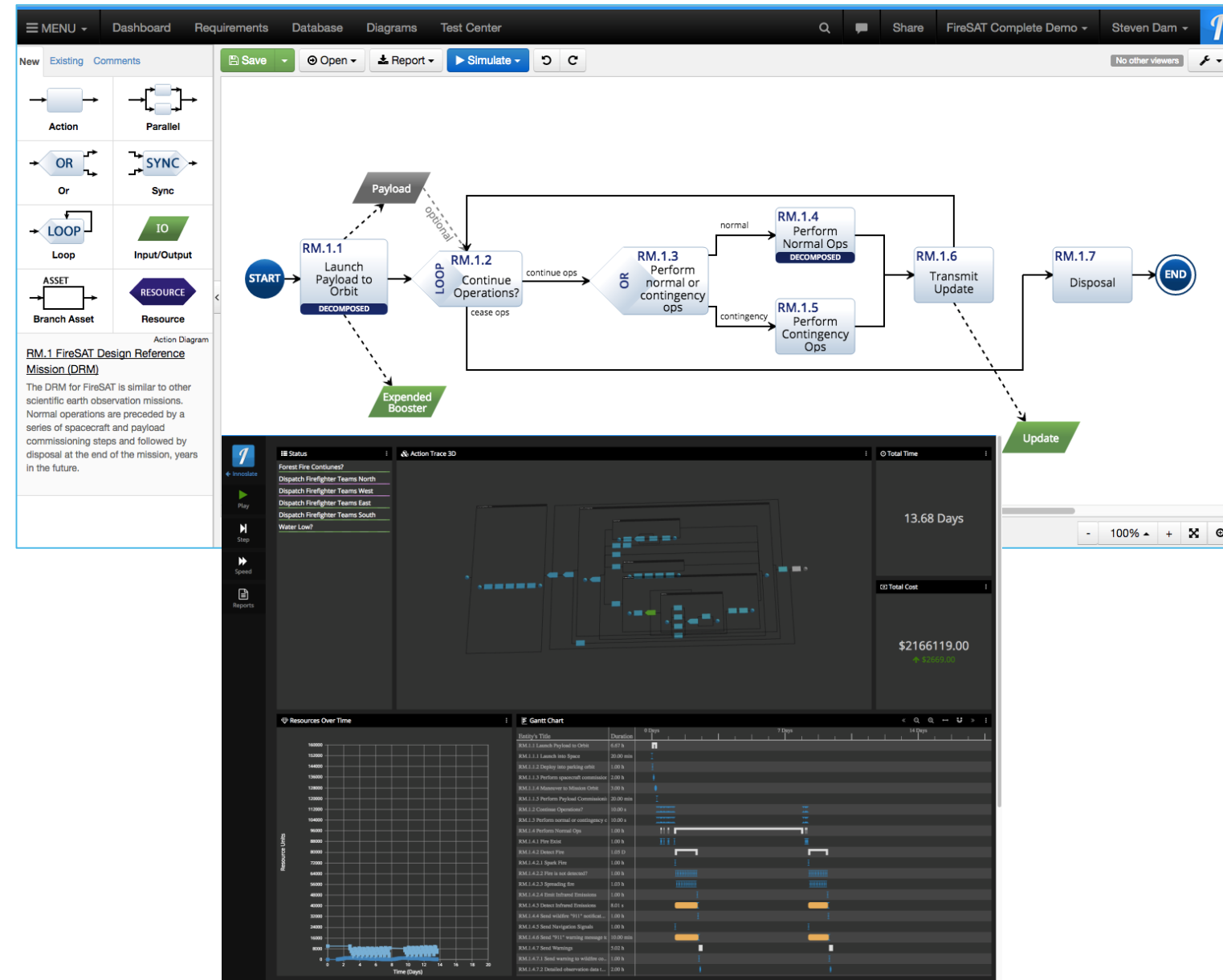
The screenshot shows a software interface with a navigation menu on the left and a main content area. The main content area displays a table titled "5.2 Applying the Characteristics to Operational Scenarios". The table has five columns: Scenario, No. of Platforms, Orbit, Scope, Environment, and Capabilities. The table lists seven scenarios, including launch and operation of single satellites (GEO and LEO), small constellations (GEO and LEO), and a complex set of small satellites interacting with solar flares.

Scenario	No. of Platforms	Orbit	Scope	Environment	Capabilities
1. Launch and operate single satellite (GEO)	1	GEO	Localized to Northern US	Benign (normal space environment)	Single Sensor/Comms platform
2. Launch and operate single satellite (LEO)	1	LEO	Worldwide coverage in tracks	Benign (normal space environment)	Single Sensor/Comms platform
3. Launch and operate small constellation (GEO)	3	GEO	Worldwide in three major locations	Benign (normal space environment)	Single Sensor/Comms platform
4. Launch and operate small constellation (LEO)	3	LEO	Worldwide coverage in multiple tracks	Benign (normal space environment)	Single Sensor/Comms platform
5. GEO Constellation with flares	6	GEO	Worldwide in six major locations	Solar flare environment	Single Sensor/Comms platform
6. LEO constellation with debris	6 + stand-by	LEO	Worldwide coverage in multiple tracks	Debris environment (maneuver)	Separate comms and sensor satellites (at LEO)
7. Complex set of small satellites, interacting, with solar flares	>6 + stand-bys	LEO and GEO	Simultaneous worldwide coverage; 24x7	Extra hostile radiation environment and debris	Separate comms (at GEO) and sensor satellites (at LEO)

- Scenarios are used to validate user needs and identify functional requirements
- Use CONOPS to create a good set of scenarios

Step 5: Model and Verify Scenarios

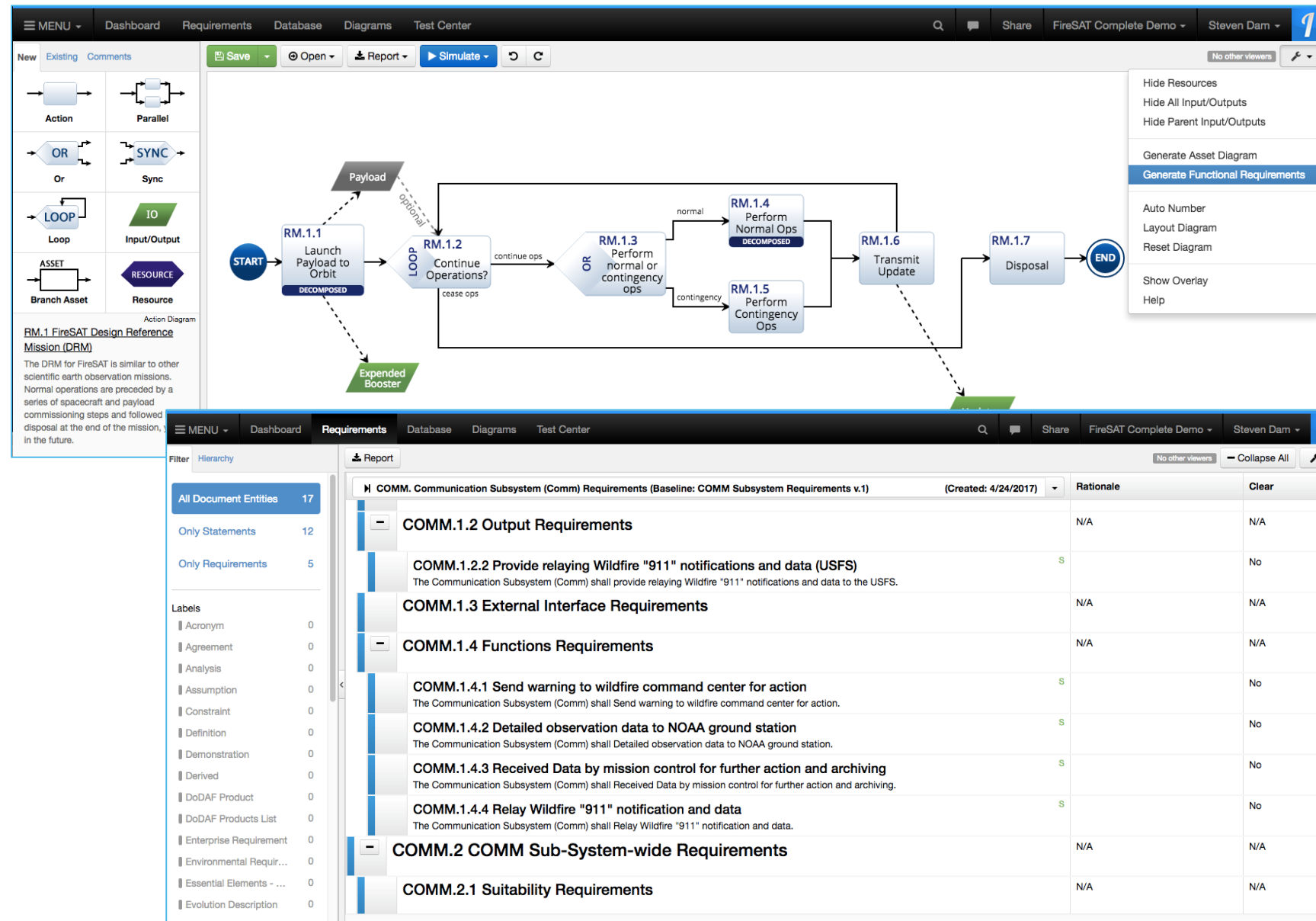
- Decompose to get more detailed functional requirements
- Include physical constraints and resources to obtain non-functional (performance) requirements
- Verify models/ requirements via simulation



The screenshot displays the FireSAT Complete Demo software interface. The top navigation bar includes 'MENU', 'Dashboard', 'Requirements', 'Database', 'Diagrams', and 'Test Center'. The main workspace shows a flowchart of the mission design reference mission (DRM) for FireSAT. The flow starts with 'START' leading to 'RM.1.1 Launch Payload to Orbit' (DECOMPOSED), which is linked to 'Payload' and 'Expend Booster'. This leads to 'RM.1.2 Continue Operations?' (LOOP), which branches into 'normal ops' leading to 'RM.1.3 Perform normal or contingency ops' (OR), and 'cease ops' leading to 'RM.1.4 Perform Normal Ops' (DECOMPOSED) and 'RM.1.5 Perform Contingency Ops' (DECOMPOSED). Both 'RM.1.4' and 'RM.1.5' lead to 'RM.1.6 Transmit Update', which then leads to 'RM.1.7 Disposal' and finally 'END'. A green 'Update' button is visible at the bottom right of the diagram.

Below the diagram, the simulation results are displayed. The 'Status' panel shows 'Forest Fire Continues?' and 'Dispatch Firefighter Teams North', 'Dispatch Firefighter Teams West', 'Dispatch Firefighter Teams East', 'Dispatch Firefighter Teams South', and 'Water Low?'. The 'Action Trace 3D' panel shows a 3D visualization of the mission. The 'Total Time' panel shows '13.68 Days' and 'Total Cost' of '\$2166119.00'. The 'Resources Over Time' panel shows a graph of resource usage over time. The 'Gantt Chart' panel shows a detailed view of the mission tasks and their durations.

Step 6: Generate Lower Level Requirements



The screenshot displays the software interface for generating lower-level requirements. The top section shows a flowchart with requirements RM.1.1 through RM.1.7, including actions like 'Launch Payload to Orbit', 'Continue Operations?', 'Perform Normal Ops', 'Perform Contingency Ops', 'Transmit Update', and 'Disposal'. The bottom section shows a table of generated requirements for the COMM. Communication Subsystem.

Requirement ID	Description	Rationale	Clear
COMM.1.2	Output Requirements	N/A	N/A
COMM.1.2.2	Provide relaying Wildfire "911" notifications and data (USFS) The Communication Subsystem (Comm) shall provide relaying Wildfire "911" notifications and data to the USFS.	S	No
COMM.1.3	External Interface Requirements	N/A	N/A
COMM.1.4	Functions Requirements	N/A	N/A
COMM.1.4.1	Send warning to wildfire command center for action The Communication Subsystem (Comm) shall Send warning to wildfire command center for action.	S	No
COMM.1.4.2	Detailed observation data to NOAA ground station The Communication Subsystem (Comm) shall Detailed observation data to NOAA ground station.	S	No
COMM.1.4.3	Received Data by mission control for further action and archiving The Communication Subsystem (Comm) shall Received Data by mission control for further action and archiving.	S	No
COMM.1.4.4	Relay Wildfire "911" notification and data The Communication Subsystem (Comm) shall Relay Wildfire "911" notification and data.	S	No
COMM.2	COMM Sub-System-wide Requirements	N/A	N/A
COMM.2.1	Suitability Requirements	N/A	N/A

- Generate requirements from models
- Edit lower level requirements
- Publish (baseline) requirements












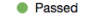

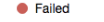
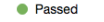

Step 7: Develop Verification Requirements



- In parallel with steps 3-6, you can derive the verification requirements
- These requirements specify the verification methods as well

VR Verification Requirements		(Last Modified: 8/4/2017)	Rationale	Clear
VR.1	Space Vehicle First-mode Natural Frequency The space vehicle first-mode natural frequency shall be verified by analysis and test.	T V	Analysis and test shall be considered successful if the estimate and measured first mode is greater than 25 Hz.	Yes
VR.1.1	Natural Frequency Analysis The analysis shall develop a multi-node finite element model to estimate natural modes.	S T V		Yes
VR.1.2	Natural Frequency Test The test shall conduct a modal survey (since sweep) of the vehicle using a vibration table.	V		Yes
VR.2	Appropriate Markings The appropriate markings on all system structural components shall be verified by inspection. The inspection shall determine if axes and identifications are properly indicated.	V	The verification shall be considered successful if all structural components are properly marked.	Yes
VR.3	Altitude Accuracy The accuracy of the altitude determination system estimates shall be verified by analysis. The analysis shall use Monte Carlo simulations of expected sensor accuracy, plus noise, to determine statistical distribution error.	V	The analysis shall be considered successful if the predicted error is less than or equal to 0.01 degrees (3 sigma).	Yes
VR.4	Battery GSE Charge Display Battery charge ground support equipment (GSE) state of charge display shall be verified by demonstration. The demonstration shall show that state of charge is indicated when connected to a representative load.	V	The demonstration shall be considered successful if the state of charge is displayed.	Yes
VR.5	Fastener Type Fastener type shall be verified by inspection. The inspection shall review the vendor's records to look for the type and size of fasteners used. The inspection shall also review the documentation on fastener material.	V	The verification shall be considered successful if all interface fasteners are 4-40 in size made from stainless steel.	Yes

Step 8: Develop Test Cases

	Expected Result	Actual Result	Status	Status Roll-Up
1 System Acceptance Test Final Test to ensure system meets all requirements	Meets all acceptance criteria	TBD	In Progress	
1.1 Propulsion Module Acceptance Test	Meets all propulsion module acceptance criteria	TBD	In Progress	
1.1.1 Propellant Tank Leak Test	Less than 2 parts/million detected	Met all test criteria	Passed	
1.1.1.1 Propellant Tank Inspection	All seams appear complete	Met all test criteria	Passed	
1.1.2 Propulsion Module Structural Test	Must pass "shake and bake" test	Met all test criteria within expected tolerances	Passed	
1.1.3 He Tank Leak Test	Less than 10 parts/million He detected	5.7 parts/million detected	Passed	
1.1.3.1 He Tank Inspection 1. All seams properly welded 2. Marked with axes orientation 3. Marked with Component identification 4. Uses proper mechanical fasteners	Meets all test criteria	Met all test criteria	Failed	
1.1.4 Propellant Management Subassembly Acceptance Test	Meets all test criteria	Met all test criteria	Passed	
1.1.4.1 Line Inspection	Inspect line to ensure no breaks have occurred	Met all test criteria	Passed	
1.1.4.1.1 Valve Functional Test	Values function as designed	Met all test criteria within expected tolerances	Passed	
1.1.4.1.2 Pressure Transducer Functional Test	Pressures match levels used	Met all test criteria within expected tolerances	Passed	
1.2 Baseplate Module Acceptance Test	Full "shake and bake"	Inspection determined sufficient	Passed	
1.3 Top Panel Module Acceptance Test	Meets all acceptance criteria	Awaiting results of lower level tests	Blocked	
1.4 Solar Array Acceptance Tests	Produces greater than 10.7 MWatts	Produced less than 8.9 MWatts	Failed	
1.5 Payload Module Acceptance Tests	Meets all acceptance criteria	Met all criteria	Passed	
2 Operational Test & Evaluation Executes the design reference mission for a single satellite. Diagram of total process shown below. Individual steps are not assessed independently in this test.	All aspects of the mission deemed validated by users	TBD	Not Run	

- Capture test cases and results (when it's time)
- Roll-up more detailed test cases to higher levels
- Link to test plan and requirements (next slide)

Step 9: Trace Verification Requirements to Test Cases

- Use tools to show all relationships or comparison matrix for a specific relationship
- Modify attributes and relationships as needed
- Produce RVTM and other reports to show requirements are met

The screenshot displays a software interface for requirements management. The top window shows a 'Requirement' detail for 'Space Vehicle First-mode Natural' (VR.1). The bottom window shows a 'Matrix' view with a 'Target Entity' of 'VR Verification Requir...' and a 'Target Relationship' of 'verifies'. The matrix compares the system against various verification requirements (VRs) and test cases.

	VR.1 Space Vehicle First-mode Natural	VR.1.1 Natural Frequency Analysis	VR.1.2 Natural Frequency Test	VR.2 Appropriate Markings	VR.3 Altitude Accuracy	VR.4 Battery GSE Charge Display	VR.5 Fastener Type
1 System Acceptance Test	X		X	X			
1.1 Propulsion Module Acceptance Test		X	X	X			X
1.1.1 Propellant Tank Leak Test			X				
1.1.1.1 Propellant Tank Inspection				X			
1.1.2 Propulsion Module Structural Test			X	X			
1.1.3 He Tank Leak Test			X				
1.1.3.1 He Tank Inspection		X	X	X			X
1.1.4 Propellant Management Subassem...				X			X
1.1.4.1 Line Inspection				X			X
1.2 Baseplate Module Acceptance Test				X			X
1.3 Top Panel Module Acceptance Test				X	X	X	
1.4 Solar Array Acceptance Tests		X	X	X			X
1.5 Payload Module Acceptance Tests		X	X	X	X	X	X

The diagram on the right shows a hierarchical structure of requirements and tests. 'R.1 Space Vehicle First-mode Natural' is the root, which is traced from 'OR.1 Space vehicle first-mode natural' (sourced by 'OR.1 Originating Requirements'). 'R.1' is decomposed into 'VR.1.2 Natural Frequency Test' and 'Payload Module Acceptance Tests'. 'VR.1.2' is further decomposed into '1 System Acceptance Test', '1.1 Propulsion Module Acceptance', and '1.2 Baseplate Module Acceptance'. '1 System Acceptance Test' is decomposed into '1.3 Top Panel Module Acceptance' and '1.4 Solar Array Acceptance Tests'. '1.1 Propulsion Module Acceptance' is decomposed into '1.1.1 Propellant Tank Leak Test' and '1.1.2 Propulsion Module Structural Test'. '1.1.1' is further decomposed into '1.1.1.1 Propellant Tank Inspection'. '1.1.2' is further decomposed into '1.1.3 He Tank Leak Test' and '1.1.3.1 He Tank Inspection'. '1.1.3.1' is further decomposed into '1.1.4 Propellant Management Subassem...' and '1.1.4.1 Line Inspection'. '1.2 Baseplate Module Acceptance' is further decomposed into '1.5 Payload Module Acceptance Tests'.

Next Steps

- Repeat steps 1-9 as needed for lower levels of decomposition
- Stop when you have the selection criteria to decide what to buy or build
- Then go through the integration and verification process (right side of “V”) and document results as you go
- Make sure that the overall model meets good modeling practices
- Perform risk analysis and other analyses as needed

Summary

- Requirements analysis is a critical part of requirements management
- Modeling and simulation are critical to ensuring you have the requirements you need and are developing systems that work
- To be successful in moving from spreadsheets to model-based systems engineering you need help from your process and tool
- You will know you are successful when your system gets fielded ahead of schedule and under budget