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Implementing a Structured Verification Framework to Improve Verification Requirements Quality

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July 19, 2016

The Boeing Company

Introduction

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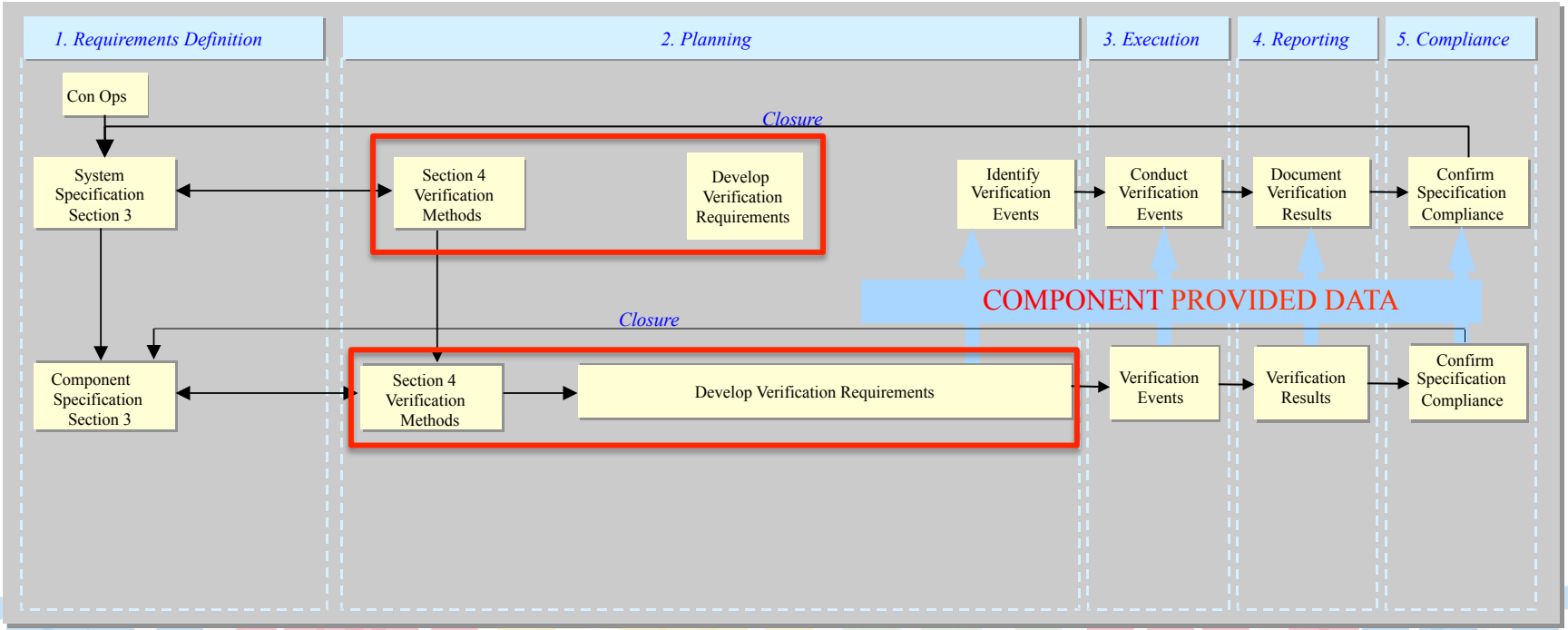

Test

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- Test implements a disciplined process that exercises a controlled test article under a set of specified conditions, against predefined quantitative measurement criteria, to determine compliance with requirements.

Demonstration

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- Demonstration implements the use of observation to monitor and assess functionality, compatibility, or operation of a configuration controlled product against predefined pass/fail criteria to determine if a required attribute is present or absent.

Desktop Analysis

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- Desktop Analysis includes review and assessment of all applicable data to provide an informed judgment on the degree of compliance of the product with the applicable requirements.

Simulation Analysis

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- Simulation Analysis is the process of verifying design features, system behaviour, and performance using models or simulations of the hardware or software.

Similarity Analysis

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- Similarity Analysis is the process of addressing, by review of prior acceptance data that the component is similar or identical in design and manufacturing process to another component that has been previously verified to comply with equivalent or more stringent specification requirements.

Inspection

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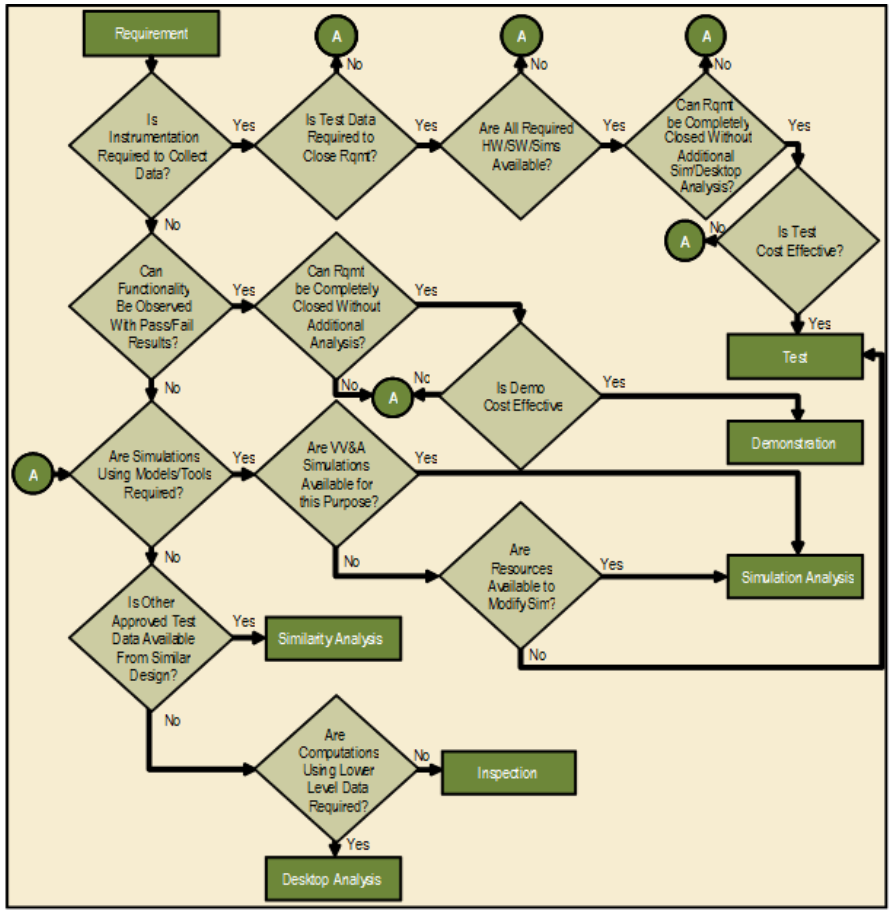
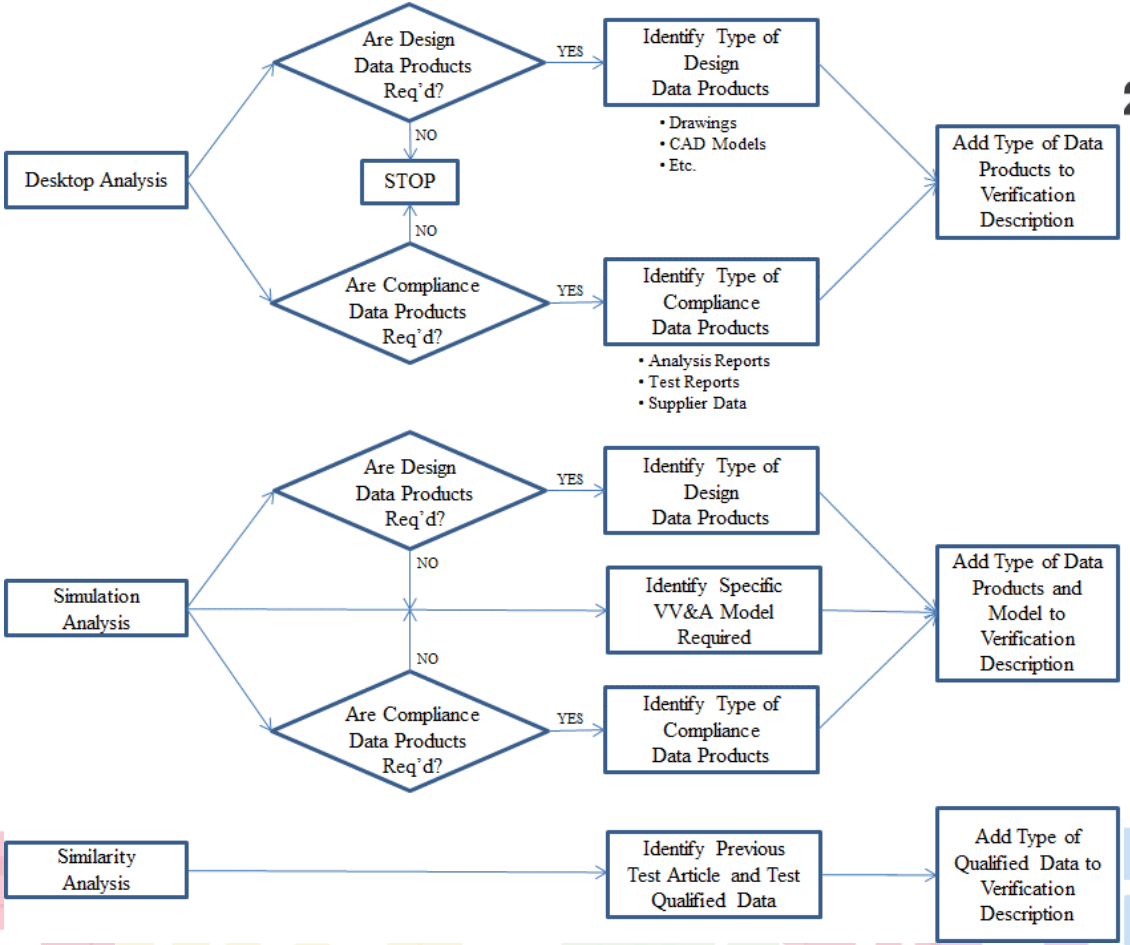
- Inspection implements the use of direct visual examination of data to confirm the presence or absence of a required attribute.

Verification Method Flow



Req Para/Title	Verification Method	Verification Description	Verification Success Criteria	Verification Comments

Analysis Verification Methods



Structured Analysis

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- Desktop Analysis. The desktop analysis shall use data from the design documentation (identify specific types of drawings, CAD Models, etc.) and compliance documentation (identify specific Analysis data (structural, thermal, electrical, etc.), Test data (functional, random vibration, thermal cycle, etc.), Supplier data (qualification test report, etc.)) to verify the “TBD” requirement (e.g. display illumination).

Structured Analysis (cont.)

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- Simulation Analysis. The simulation analysis shall use the TBD model (identify specific model) and data from the design documentation (identify specific types of drawings, CAD Models) and compliance documentation (identify specific Analysis data (structural, thermal, electrical), Test data (functional, random vibration, thermal cycle), Supplier data (qualification test report)) to verify the “TBD” req.

Structured Analysis (cont.)

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- Similarity Analysis. The similarity analysis shall use the test qualified data from the “component” test article to verify the “TBD” requirement.

Inspection Verification Methods

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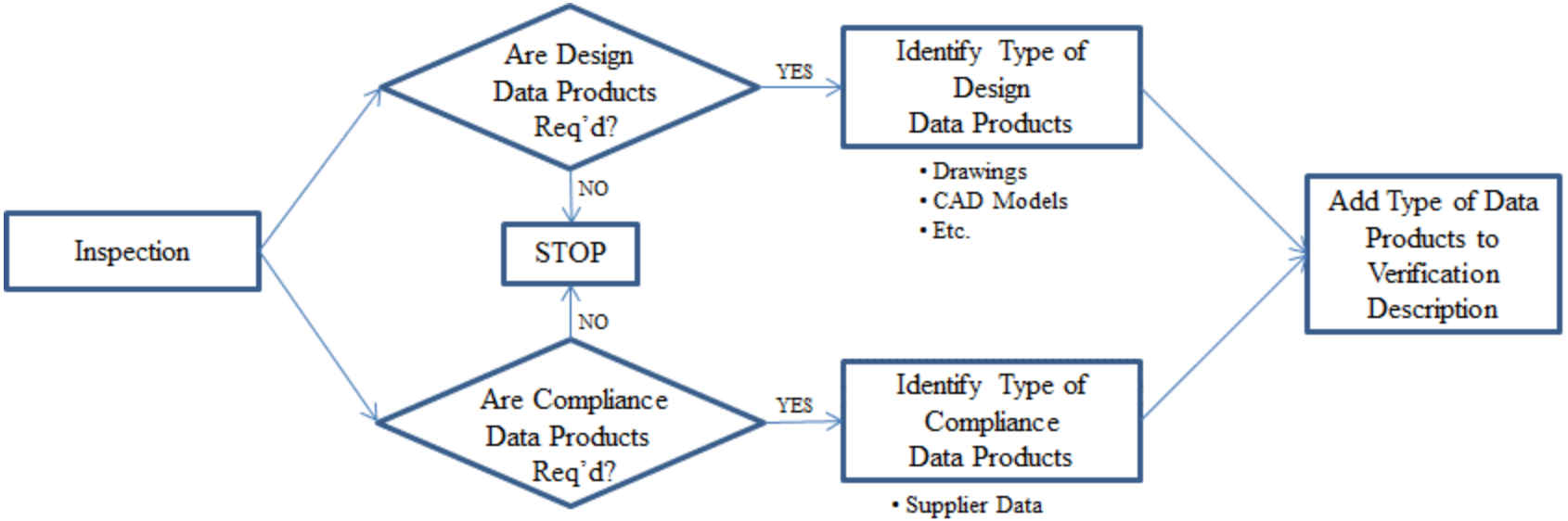

Structured Inspection

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- Inspection. The inspection shall use data from the design documentation (identify specific types of drawings, CAD Models, etc.) and compliance documentation (identify specific Supplier data (qualification test report, analysis reports, etc.)) to verify the “TBD” requirement.

Demonstration Verification Methods

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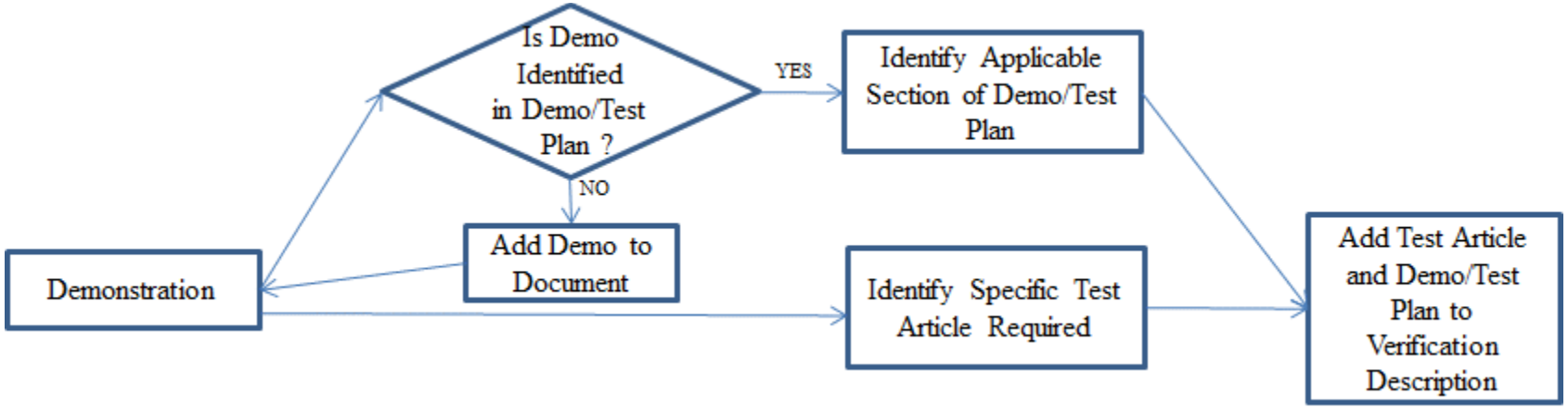

Structured Demonstration

- Demonstration. The demonstration shall subject the TBD test article to the TBD demonstration (identify specific type of demonstration) performed in accordance with the TBD Demo/Test Plan, Section TBD to verify the “TBD” requirement.

Test Verification Methods

Environmental Test / Component	Electrical or Electronic	Thermal	Moving Mechanism Assembly	Pressure	Structural
	Component A	Component B	Component C	Component D	Component E
Performance/ Functional	R	R	R	R	--
Pressure	--	--	--	R	--
Leakage	--	R	R	R	--
Shock	R	R	R	--	--
Random or Acoustic Vibration	R	R	R	R	--
Temperature	R	R	R	--	--
Thermal Cycle	R	R	R	--	--
Thermal Vacuum	R	R	R	--	--
Rain	R	R	R	--	R
Sand & Dust	R	R	R	--	R
Fungus	R	R	R	--	R
Humidity	R	R	R	--	R
Static Load	--	--	R	--	R
EMI/EMC	R	--	--	--	--
Life	--	--	R	R	--
Mass Properties	R	R	R	R	R
NOTES: R - Required, -- Not Required					

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Test Verification Methods

Component Tests	Qualification Test Margins / Duration	Test Tolerances
Performance/Functional - mechanical and electrical specification performance	Electrical/mechanical performance test before, during, and after each environmental test, as appropriate.	Time: +/- 2 %
Random Vibration - exposure to the expected vibration environment	3 dB above envelope of MPE and minimum workmanship level, for 3 minutes in each of 3 axes.	Vibration Frequency: +/- 2 % Power spectral density: 20 - 100 Hz: +/- 1.5 dB 100 - 1000 Hz: +/- 1.5 dB 1000 - 2000 Hz: +/- 3.0 dB Overall: +/- 1.0 dB
Thermal Cycle - operation over the design temperature range	(+/- 18 Deg F beyond acceptance temps) for 24 cycles.	+/- 5.4 Deg F
Thermal Vacuum - thermal vacuum conditions and temperature extremes	(+/- 18 Deg F beyond acceptance temps) for 3 cycles.	+/- 5.4 Deg F
Static Load - strength and stiffness, when subjected to simulated critical environments	1.5 times Design Limit Loads, duration of loading sufficient to record load test data.	+5/-0 percent

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Test Verification Methods (cont.)

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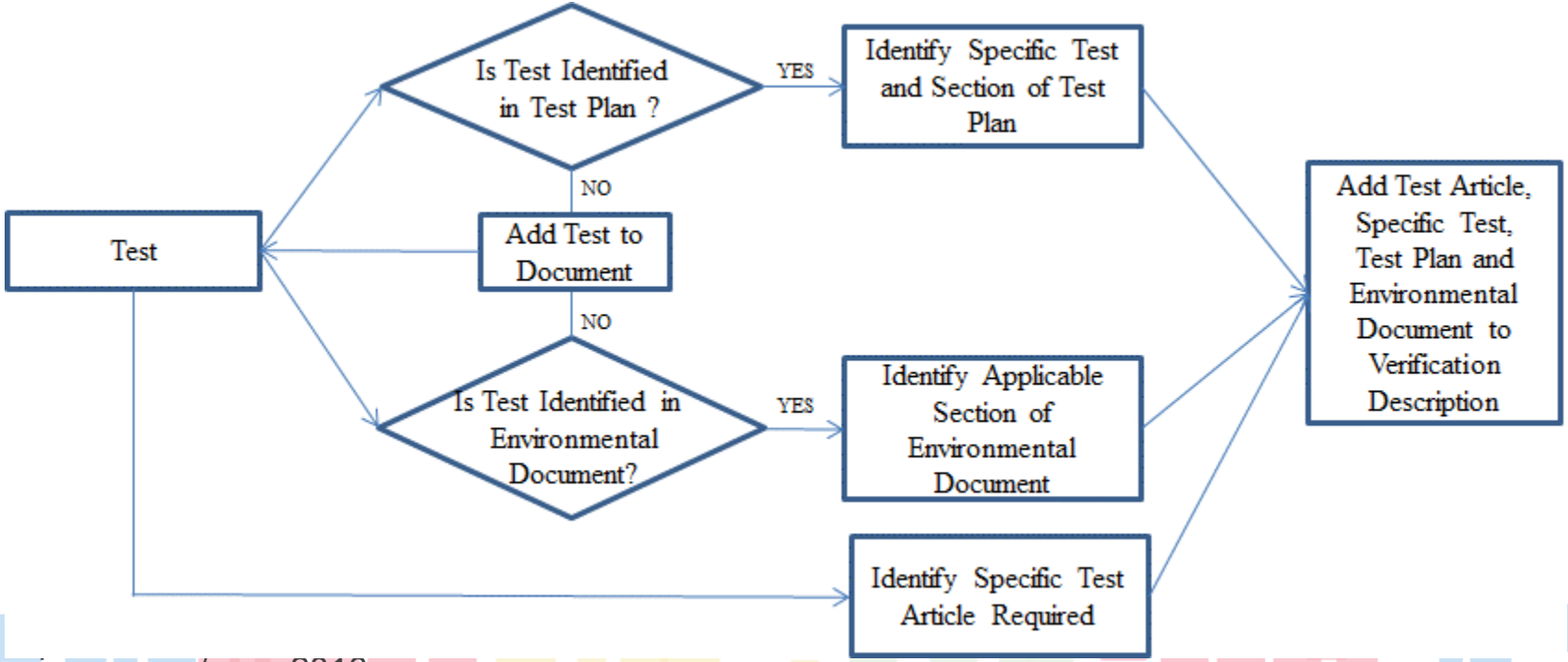

Structured Test

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- Test. The test shall subject the TBD test article to the TBD test (identify specific type of test (functional, shock, random vibration, thermal cycle, life, etc.)) performed in accordance with the TBD Test Plan, Section TBD, and the TBD Environmental Test Document, Section TBD, to verify the “TBD” requirement.

Success Criteria

- Verification shall be considered successful when the (analysis, inspection, demonstration, or test) shows that the “product …” (use requirement text without “shall” and add quantifiable data).

Verification Requirement Generation

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- Implementing a structured verification framework will ensure that consistent high-quality verification requirements are developed for each type of verification method.
- Verification requirements can be auto-generated using a requirements management tool by selecting the specific data required for each verification method.

Analysis Verification Requirement

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Verification Description	Verification Success Criteria	Compiled Verification Requirement
Verification Method		
The desktop analysis	Verification shall be considered successful when the desktop analysis shows that the "product …"	The desktop analysis shall use data from the design documentation (“component” drawings) and compliance documentation (“component” functional test data) to verify the MIL-STD-1553 data bus configuration. Verification shall be considered successful when the desktop analysis shows that the MIL-STD-1553 data bus complies with MIL-STD-1553, Paragraph 4.6.3.
Shall Statement		
shall use data from the		
Verification Product	**Type of Verification Product**	
Design Documentation	TBD drawings	
	TBD CAD models	
and		
Verification Product	**Type of Verification Product**	
Compliance Documentation	TBD Analysis data	
	TBD Test data	
	TBD Supplier data	
to verify		
Requirement Title		
TBD.		

Inspection Verification Requirement

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Verification Description	Verification Success Criteria	Compiled Verification Requirement
Verification Method		
The inspection	Verification shall be considered successful when the inspection shows that the "product …"	The inspection shall use data from the design documentation (“component” drawings, “component” CAD model) to verify the general identification markings. Verification shall be considered successful when the inspection shows that the “component” complies with MIL-STD-130, Identification Marking for U.S. Military Property, Paragraph 4, for product markings.
Shall Statement		
shall use data from the		
Verification Product	**Type of Verification Product**	
Design Documentation	TBD drawings	
	TBD CAD models	
and		
Verification Product	**Type of Verification Product**	
Compliance Documentation	TBD Supplier data	
to verify		
Requirement Title		
TBD.		

Demo Verification Requirement

Verification Description	Verification Success Criteria	Compiled Verification Requirement
Verification Method		
The demonstration	Verification shall be considered successful when the demonstration shows that the "product …"	The demonstration shall subject the "component" test article to the human engineering demonstration performed in accordance with the Human Engineering Demonstration Plan, Section 3.2.1 to verify display illumination. Verification shall be considered successful when the demonstration shows that the "component" provides adjustable illumination that meets the display illumination criteria specified in MIL-STD-1472, Section 5.2.1.2.1 for visual displays that must be read under darkened conditions.
Shall Statement		
shall subject the		
Test Article		
TBD test article		
to the		
Type of Demonstration		
TBD demonstration		
performed in accordance with the		
Verification Document		
TBD Demo/Test Plan, Section TBD		
to verify		
Requirement Title		
TBD.		

Test Verification Requirement

Verification Description	Verification Success Criteria	Compiled Verification Requirement
Verification Method		
The test	Verification shall be considered successful when the test shows that the "product …"	The test shall subject the “component” test article to the random vibration test performed in accordance with the “component” Test Plan, Section 3.2.5, and the “component” Environmental Test Document, Section 3.6 to verify random vibration. Verification shall be considered successful when the test shows that the “component” complies with the performance requirements in Paragraph 3.2.1 after exposure to the MPE for random vibration shown in Figure 5 and Table 5.
Shall Statement		
shall subject the		
Test Article		
TBD test article		
to the		
Type of Test		
TBD test		
performed in accordance with the		
Verification Document		
TBD Test Plan, Section TBD		
and the		
Environmental Test Document		
TBD Environmental Test Document, Section TBD		
to verify		
Requirement Title		
TBD.		

Return on Investment

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- So, what difference does this make? Does writing structured high-quality verification requirements have a measurable effect on the program?

Return on Investment (cont.)

- This verification framework has been implemented on military and space programs and has proven that developing high-quality verification requirements provide consistent content for each type of verification method
  - Simplifies the development and review of the verification requirements by the technical teams and the customer.

Summary

- A structured verification framework provides a cost effective and minimal risk approach for ensuring that all required verification planning data is defined in the verification requirements.
- A requirements management tool can be used to auto-generate the high-quality verification requirements for a complete specification based on the type of verification methods