Industry Standards Compliance using MBSE

For: TGCC System Engineering Conference

Presented by:

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1

Introduction

- System Design to Standards is ubiquitous in many industries
- Multiple Standards can be "required" in a system design
- The "Required" Standards can be:
  - written by different organizations
  - conflicting based on organization authoring standard
  - have overlapping specification and subjects
  - revised during system design
- System has to:
  - meet all / the most restrictive standard
  - be compliant and auditable
 - verified to meet the standard(s)

System Design

- Dependent on recognizing Requirements, Functions, Components, etc.
- Requirement Architecture –
  - System Level Requirements – top of the hierarchy
  - Goal: ONE System Requirement to "cover" more than one Standard Clause
- Traceability to (multiple Standards) is needed
  - Even if a Stakeholder / Originating Need states a certain Requirement

3

Objective

- Expand the "nominal" System Engineering elements in model to capture Standard Document and the clauses contained in the Standard Document
- Traceability of Clauses
  - … to the Standard Document
  - … to System Design Requirements
  - … to identify gaps in coverage
  - … to verification that the system meets the standard
  - … to provide an auditable trail
  - … to support device certification
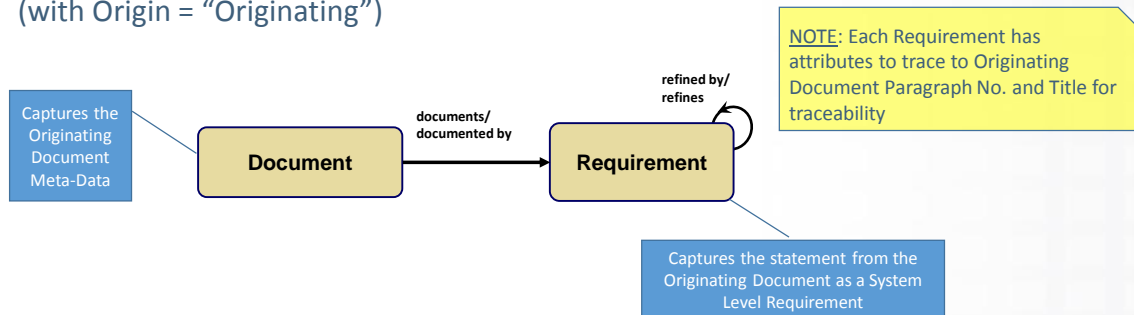
4

MBSE Basics

5
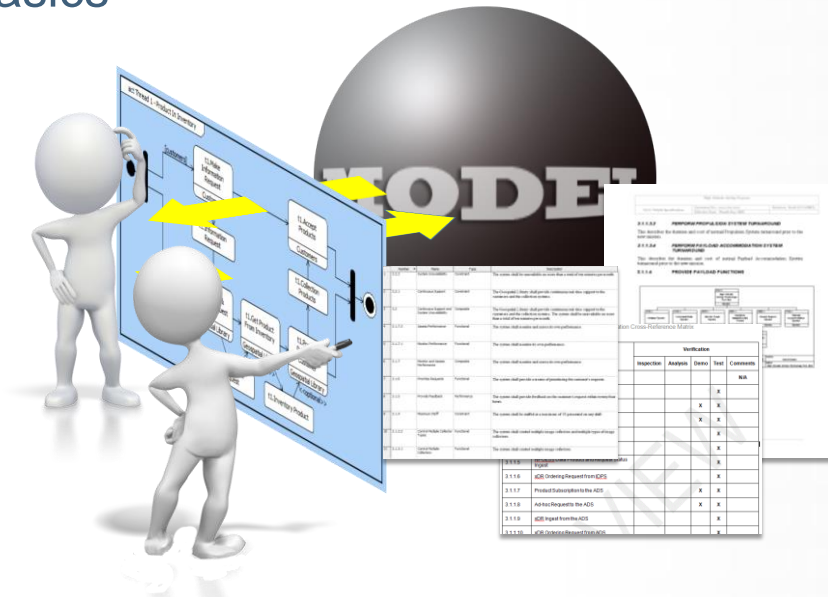
Extending the MODEL

- Want to include the "Standard Clause" in the model
- Relate the Standard Clause to System Requirements
- Do so in such a way that we can capture multiple Standards
- Support Auditable Traceability
  - How does the system design comply with a (particular) standard?
  - How do we demonstrate system performance complies with the standard(s)?
- GOAL: "Connect" the design model to Standard Clauses thru relations
  - What "kind of" entities do we need?
  - How do they relate to the system design?
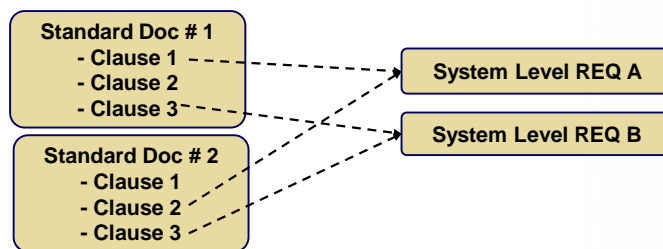 - What attributes do we need?

6

A typical MBSE Model…

We recognize Source Documents *"document"* Requirement(s)
(with Origin = "Originating")

NOTE: Each Requirement has attributes to trace to Originating Document Paragraph No. and Title for traceability

Captures the Originating Document Meta-Data

Document

documents/ documented by

refined by/ refines

Requirement

Captures the statement from the Originating Document as a System Level Requirement

This arrangement allows for capturing a set of Originating Documents and the (requirement) statement in the document.

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Industry Standards trace to System Requirements

Standard Doc # 1
- Clause 1
- Clause 2
- Clause 3

Standard Doc # 2
- Clause 1
- Clause 2
- Clause 3

System Level REQ A
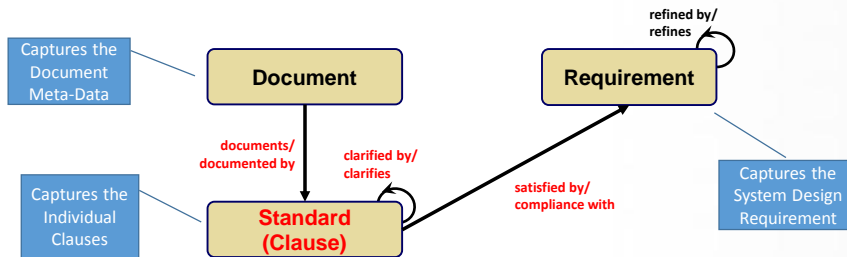
System Level REQ B

However, if we look at Standard Requirement Documents and which to provide unique traceability to these Standards, we need to provide a way to discriminate the standard clause

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Including Standard clauses in the system model

Provide a mechanism for capturing individual Standard statements from a Standard

- A Document *"documents"* the Standard statement
- Standard statement are *"satisfied by"* System Requirements

Captures the Document Meta-Data

Document

refined by/ refines

Requirement

documents/ documented by

clarified by/ clarifies

satisfied by/ compliance with

Captures the System Design Requirement

Captures the Individual Clauses

Standard (Clause)

Red Text indicates an extensions to the basic schema to support Standard Requirement Traceability

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9

Standard Class Properties

Attributes included to:
- provide traceability to standard section
- allow for mandatory and optional applicability
- Rationale for including the standard

Text taken directly from source Standard

Section Number from source Standard

Standard Applicability:

Mandatory
Recommended
Not Required

Rationale Text box – to allow explanation or reason for including the standard

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10

5

Traceability from a Standard to the System Requirements

Taking a given standard, how would we trace from the standard to the System Design?
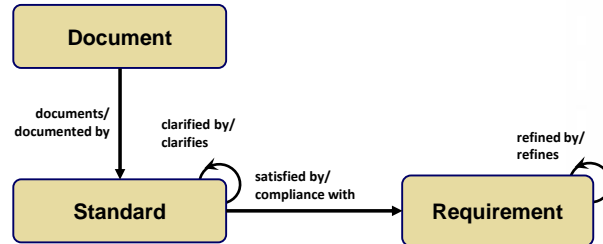
Traceability starts with the Document Entity and traces to individual standard statements (or clause) and then to the (system level) requirements that satisfy the Standard.

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Resulting Traceability …

Standard Number	Doc. Name	Section Number	Standard	Satisfied by Req
IEC 62196	Condutive Charging of Electric Vehicles	10	Protection against electric Shock	
		10.1	Accessories non-accessiblity	System Requirement 101
		10.2	Accessory Design	System Requirement 102
		10.3	Inadvertent Assembly	System Requirement 103
		11	Size and Coloring of earthing conductors	
		12	Provision for earthing	
		12.1	Ground connection on Accessories	System Requirement 106
		12.2	Metal Parts Grounding	System Requirement 107
ISO 17409	Electically Propelled Road Vehicles Standard	5	Protection from electric shock	
		5.1	Basic Protection	System Requirement 101
		5.2	Protection Under Single Falure Conditions	System Requirement 102
		5.3	Isolation Resistance	System Requirement 104
		5.4	Protection from unintended voltage	System Requirement 105
		5.5	Insulation coordination	System Requirement 108
		6	Protection aganst thermal incident	
		6.1	Overcurrent protection	System Requirement 110
		6.2	Arc Protection for DC Connections	System Requirement 111
		6.3	Residual energy after disconnection	System Requirement 112
		7	Requirements for vehicle inlet, plug, and cable	
		7.1	Requirements for Plug and Cable	System Requirement 109
		7.2	Requirement for Vehicle Inlet	System Requirement 113
		8	Requirement for AC Power Supply	
		8.1	Standard AC external Power Supply	System Requirement 114
		8.2	Current Characteristics	System Requirement 115
		8.3	DC Fault Currents	System Requirement 116
		8.4	Touch current	
		8.5	Unitended reverse power flow	
		8.6	Power Factor	
		8.7	Locking the vehicle connector	

Creating a table to trace from the Standard to the System Requirement.

Table created and "run" using the Excel Connector for GENESYS

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Traceability using diagrams
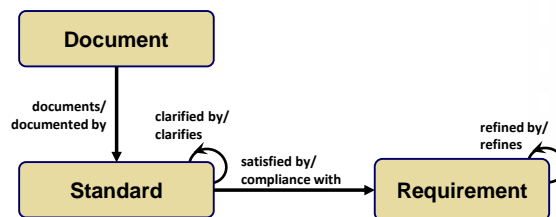
Alternative to generating an Excel Table
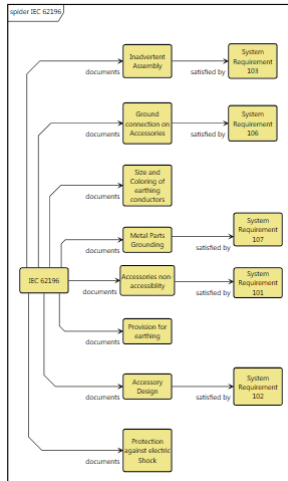
Examine traceability using a variety of diagramming views.

- Quickly identify potential gaps in Standard compliance

13

Traceability from Requirements to Standards

Sometimes the question is reversed.
From the System Requirements, how would we trace to the standard?

Traceability starts with the Requirement and trace back to the Standard Clause and the Standard Document the Standard Clause came from.

14

System Requirement to Standards

REQ No.	REQ Name	Complies with Standard Requirement:	Standard	Standard Title	Section Number
R.1	System Requirement 101	Accessories non-accessiblity	IEC 62196	Condutive Charging of Electric Vehicles	10.1
		Basic Protection	ISO 17409	Electically Propelled Road Vehicles Standard	5.1
R.2	System Requirement 102	Accessory Design	IEC 62196	Condutive Charging of Electric Vehicles	10.2
		Protection Under Single Falure Conditions	ISO 17409	Electically Propelled Road Vehicles Standard	5.2
R.3	System Requirement 103	Inadvertent Assembly	IEC 62196	Condutive Charging of Electric Vehicles	10.3
R.4	System Requirement 104	Isolation Resistance	ISO 17409	Electically Propelled Road Vehicles Standard	5.3
R.5	System Requirement 105	Protection from unintended voltage	ISO 17409	Electically Propelled Road Vehicles Standard	5.4
R.6	System Requirement 106	Ground connection on Accessories	IEC 62196	Condutive Charging of Electric Vehicles	12.1
R.7	System Requirement 107	Metal Parts Grounding	IEC 62196	Condutive Charging of Electric Vehicles	12.2
R.8	System Requirement 108	Insulation coordination	ISO 17409	Electically Propelled Road Vehicles Standard	5.5
R.9	System Requirement 109	Requirements for Plug and Cable	ISO 17409	Electically Propelled Road Vehicles Standard	7.1
R.10	System Requirement 110	Overcurrent protection	ISO 17409	Electically Propelled Road Vehicles Standard	6.1
R.11	System Requirement 111	Arc Protection for DC Connections	ISO 17409	Electically Propelled Road Vehicles Standard	6.2
R.12	System Requirement 112	Residual energy after disconnection	ISO 17409	Electically Propelled Road Vehicles Standard	6.3
R.13	System Requirement 113	Requirement for Vehicle Inlet	ISO 17409	Electically Propelled Road Vehicles Standard	7.2
R.14	System Requirement 114	Standard AC external Power Supply	ISO 17409	Electically Propelled Road Vehicles Standard	8.1
R.15	System Requirement 115	Current Characteristics	ISO 17409	Electically Propelled Road Vehicles Standard	8.2
R.16	System Requirement 116	DC Fault Currents	ISO 17409	Electically Propelled Road Vehicles Standard	8.3
R.17	System Requirement 117				

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15

Verification of System Performance

Many times you need to show that system performance meets the Standard(s) requirements.

- The system design repository has traceability from Requirements to Verification Requirement
- This allows us to trace from the Standard, to the Requirement, then to the Verification Requirement

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16
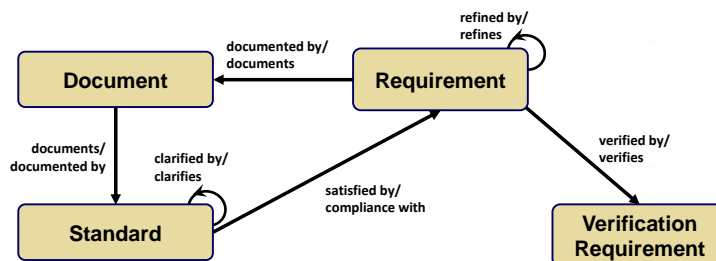
Trace from Standard to Verification

Standard Number	Section Number	Standard	Satisfied by Req	Verified by VR	Method	Status
IEC 62196	10	Protection against electric Shock				
	10.1	Accessories non-accessiblity	System Requirement 101	Verification Requirement 101	Test	Completed - Satisfactory
	10.2	Accessory Design	System Requirement 102	Verification Requirement 102	Inspection	Completed - Satisfactory
	10.3	Inadvertent Assembly	System Requirement 103	Verification Requirement 106	Demonstration	Completed - Satisfactory
	11	Size and Coloring of earthing conductors				
	12	Provision for earthing				
	12.1	Ground connection on Accessories	System Requirement 106	Verification Requirement 106	Demonstration	Completed - Satisfactory
	12.2	Metal Parts Grounding	System Requirement 107	Verification Requirement 110	Test	Not Yet Planned
ISO 17409	5	Protection from electric shock				
	5.1	Basic Protection	System Requirement 101	Verification Requirement 101	Test	Completed - Satisfactory
	5.2	Protection Under Single Falure Condition	System Requirement 102	Verification Requirement 102	Inspection	Completed - Satisfactory
	5.3	Isolation Resistance	System Requirement 104	Verification Requirement 103	Analysis	Completed - Satisfactory
	5.4	Protection from unintended voltage	System Requirement 105	Verification Requirement 105	Test	Completed - Satisfactory
	5.5	Insulation coordination	System Requirement 108	Verification Requirement 106	Demonstration	Completed - Satisfactory
				Verification Requirement 107	Test	Completed - Satisfactory
	6	Protection aganst thermal incident				
	6.1	Overcurrent protection	System Requirement 110			
	6.2	Arc Protection for DC Connections	System Requirement 111	Verification Requirement 107	Test	Completed - Satisfactory
	6.3	Residual energy after disconnection	System Requirement 112	Verification Requirement 107	Test	Completed - Satisfactory
	7	Requirements for vehicle inlet, plug, and cable				
	7.1	Requirements for Plug and Cable	System Requirement 109	Verification Requirement 109	Inspection	Completed - Satisfactory
	7.2	Requirement for Vehicle Inlet	System Requirement 113			
	8	Requirement for AC Power Supply				
	8.1	Standard AC external Power Supply	System Requirement 114	Verification Requirement 111	Demonstration	In Progress
	8.2	Current Characteristics	System Requirement 115			
	8.3	DC Fault Currents	System Requirement 116	Verification Requirement 110	Test	Not Yet Planned
	8.4	Touch current				
	8.5	Unitended reverse power flow				
	8.6	Power Factor				
	8.7	Locking the vehicle connector				

Table created and "run" using the Excel Connector for GENESYS

17

Reusing Standards

STANDARDS Library

Project: Standard ABC

- Document Element
- Standard Clause

Project: Standard LMN

- Document Element
- Standard Clause

Project: Standard XYZ

- Document Element
- Standard Clause

* Each Standard Document is its own Project

PROJECT Repository

Project: New System

- Component
- Functions
- Interfaces
- Requirement
- Other (s)
- Standard Clause

Import the Standards needed for the particular design
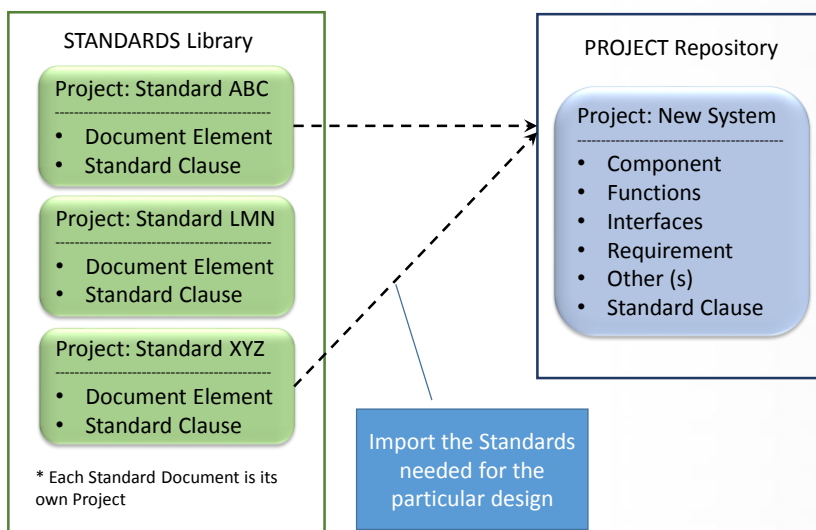
18

Standards Volatility

STANDARDS Library

Project: Standard ABC

- Document Element
- Standard Clause

Project: Standard LMN

- Document Element
- Standard Clause

Project: Standard XYZ

- Document Element
- Standard Clause

* Each Standard Document is its own Project
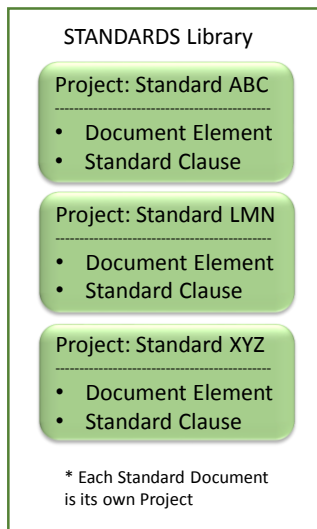
<u>Change to Standard ABC Work Flow</u>
- Using Project: Standard ABC
- Modify DOCUMENT
- Capture Changes using CHANGE REQUEST
- Modify individual Standard Clause entities based on changes
- Traceability to Change Request *"results in"* relation
- Save new project "Standard ABC – Rev 1"

How to tell what changed?
- Traceability from Change Request
- Sort on "Last Modified Date" attribute

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19

Summary

Extending the nominal MBSE schema to capture the clause / statements from individual Standard documents provides:

- Ability to develop system requirements able to satisfy multiple Standard Document requirement clauses
- Allows traceability from the Standard to the System Design
- Allows justification of the system requirements
- Provides an auditable path for certification of the system

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20

Questions?

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