



International Council on Systems Engineering
A better world through a systems approach

Towards a greater understanding of Systems Design and Interoperability between Airbus Commercial and its Suppliers

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Paper #146





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Systems Engineer

Professional Experience

3 Years at AIRBUS in Mobile, AL as a Systems Engineer

- MBSE Lead for the “MBSE for Seats” project
- Version Engineer for Cabin Attendant Seats
- Version Engineer for Passenger Seats



2 Years at the Aerospace Systems Design Laboratory (ASDL) at Georgia Tech

- MDAO
- Design of Experiments
- Sensitivity Analysis



Today's Agenda

- Introduction and Challenges
- A Model-Based Solution
- Collaborative Modeling
- Enhancing Design Reviews
- Limitations and Outlook

Introduction and Challenges

Passenger Seats are **Buyer's Furnished Equipment (BFE)**

- Supplier designs seats
- Airbus oversees and integrates the Seats inside the aircraft
- Airbus requirements shared with the seat suppliers as PDF documents

→ Airbus owns the specification, supplier owns the design,
shared V&V activities

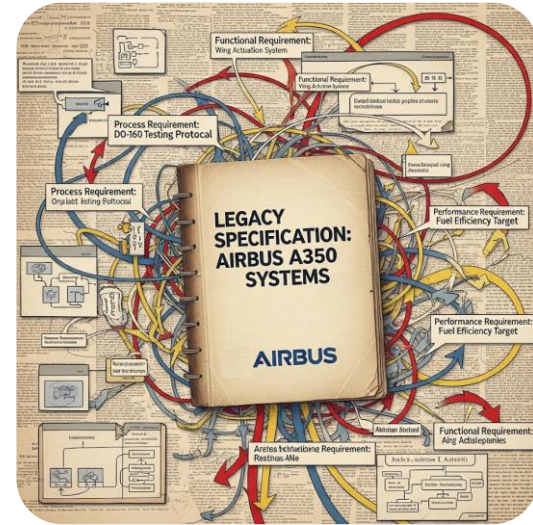


Introduction and Challenges

Legacy Specification

- Specification comes as a 1000+ page document
- Cross-Program requirements, difficult to determine their applicability
- Requirements sometimes not intelligible, outdated
- Gathers different types of requirements: Process, Functional, Performance...

→ Challenge for Airbus to update the specification
and for the supplier to understand the impact on
their designs



Introduction and Challenges

V&V Activities

- V&V and testing activities carried by the supplier, incrementally approved by Airbus during Design Reviews
 - Quantity and Quality of Requirements:
 - Tedious and error-prone manual compliance checks
 - Relies on experts' knowledge
- Risk of subjectivity and bias while checking compliance



Objective

Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities

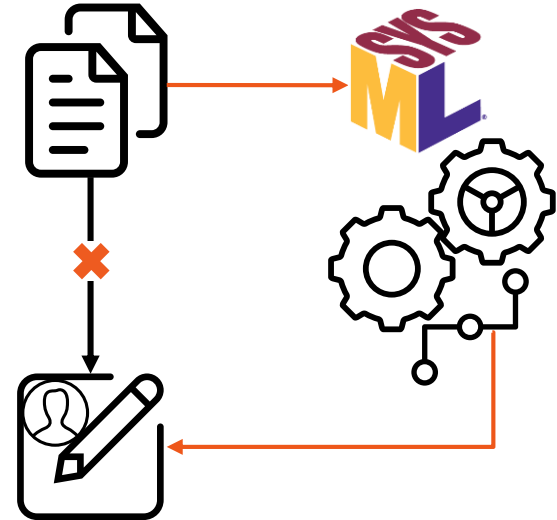
Model-Based Solution

The Foundation

Transforming Specifications

From Documents to Models

- Replace all the specification documents for Seats
 - Provide more context and traceability than traditional textual requirements
- Leverage and improve the existing Requirement management tool database
 - Rewriting, and deleting Requirements
 - Following the Guide to Writing Requirements (INCOSE/ISO 15288)
 - Requirements made unique, verifiable, complete
- Synchronization of Requirements to modeling tool
 - Customization of Requirement Stereotype with additional attributes: Stakeholder, rationale, MoC, Design Review, etc.

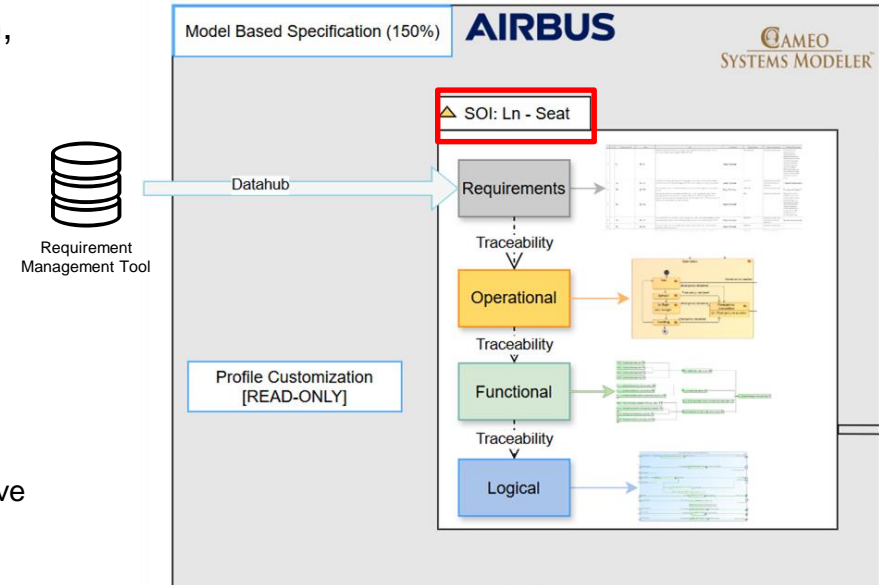


Transforming Specifications

MOFLT Modeling

- Airbus Generic MBSE Framework MOFLT (Mission, Operational, Functional, Logical, Technical).
- Seat as System of Interest
- Development of the Seat specification
 - **Requirements** synchronized from database
 - **Use Cases**, Seat **Life Cycle**
 - High-Level **Functional architecture**
 - Primary **Logical Architecture** of the Seat's main components
 - No Technical Layer developed within the specification to preserve supplier innovation

→ Model-Based Specification (MBS) is sent to seats suppliers alongside the traditional PDF documents

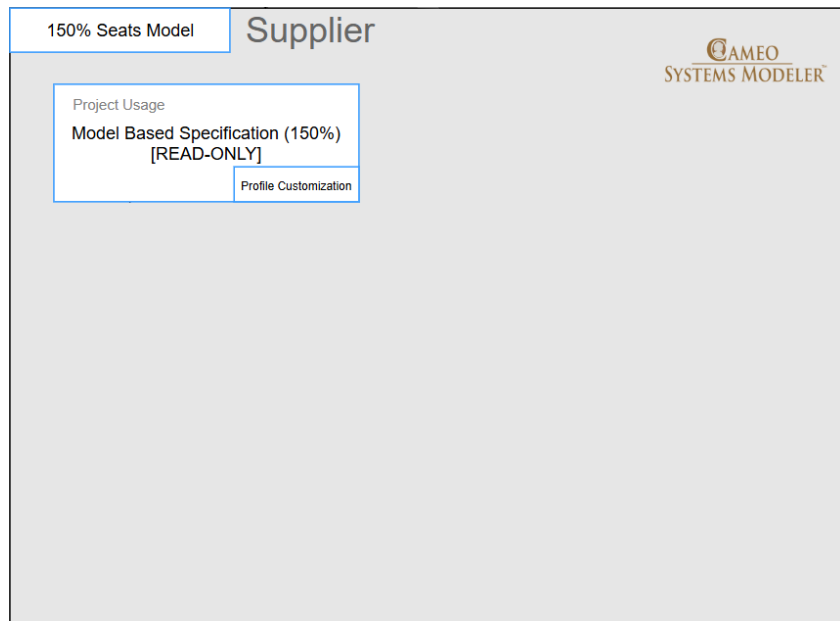


Collaborative Modeling

Bridging Airbus and Suppliers' Designs

Collaborative Modeling

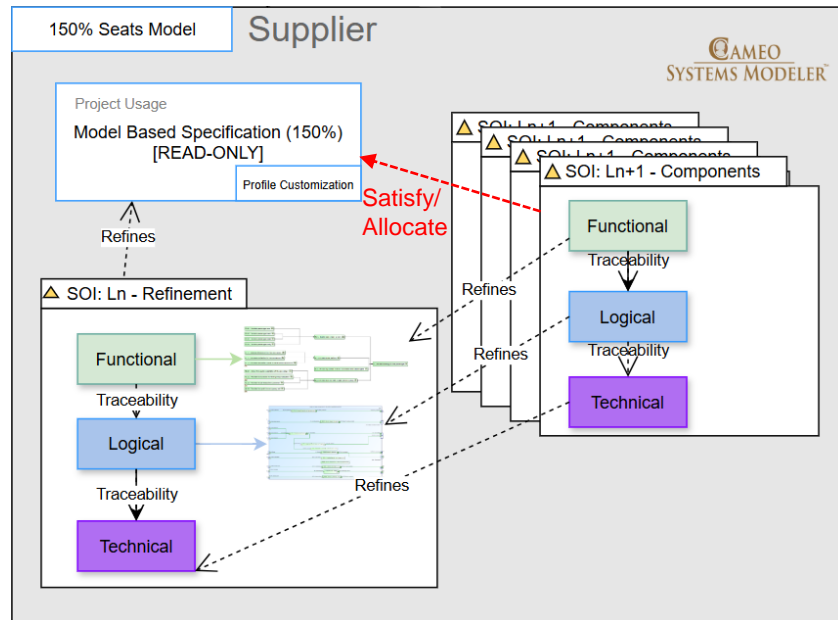
Systems Model MOFLT Structure



- Seat System of Interest (SOI) started by Airbus
- Interface between Airbus and Supplier, between the specification and the design
- Supplier builds their **Functional**, **Logical** layers refining Airbus Functional, and Logical specification
- Supplier is responsible for building the **Technical** Layer

Collaborative Modeling

Systems Model MOFLT Structure



- Seat System of Interest (SOI) started by Airbus
- Interface between Airbus and Supplier, between the specification and the design
- Supplier builds their **Functional**, **Logical** layers refining Airbus Functional, and Logical specification
- Supplier is responsible for building the **Technical** Layer
- Development of Components' Viewpoints (new Systems of Interests) by the Supplier refining the Seat
- **F**, **L**, and **T** layers applied recursively
- Traceability links to Model-Based Specification

Collaborative Modeling

Model-Based Product Line Engineering (**MBPLE**) approach



150%

- Model contains the entire specification, **all possible Seats features**

120%

- Represents a platform seat and contains a reduced specification, with **supplier's offered features**

100%

- Represents a platform seat to be integrated in an aircraft and contains an even more reduced specification with the specific **features selected by the airline**

Collaborative Modeling

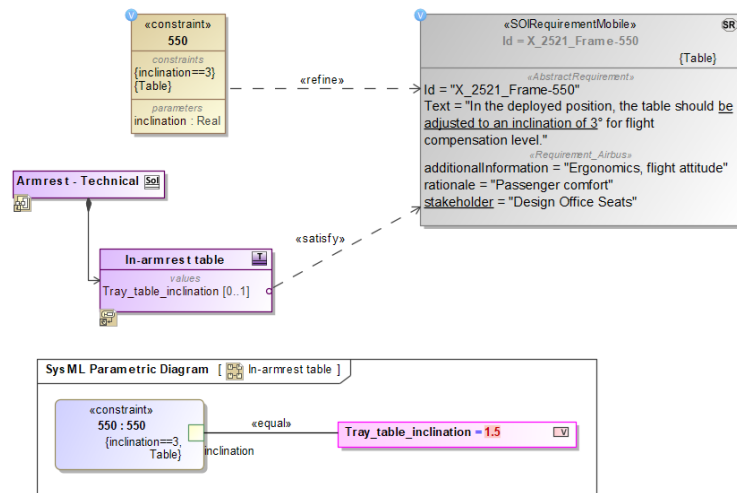
Verification and Model Opinion

- Development of Modeling rules and common ontology to support early verification

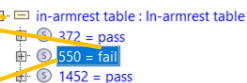
Unit Conversion, Satisfaction Rules

- Leveraging simulation capabilities of the Cameo Simulation toolkit

- Compare Value Properties against requirements/constraints
- Export results to instances and slots



Slot	
Owner	in-armrest table : In-armrest table
Applied Stereotype	
Value	fail [in-armrest table]
Active Hyperlink	
Tagged Value	
Owned Comment	
Owned Element	fail [in-armrest table]
Defining Feature	550 : 550 [Ln+1 Armrest:TECHNICAL..
Owning Instance	in-armrest table : In-armrest table



Original Live Model

Model Copy

AIRBUS

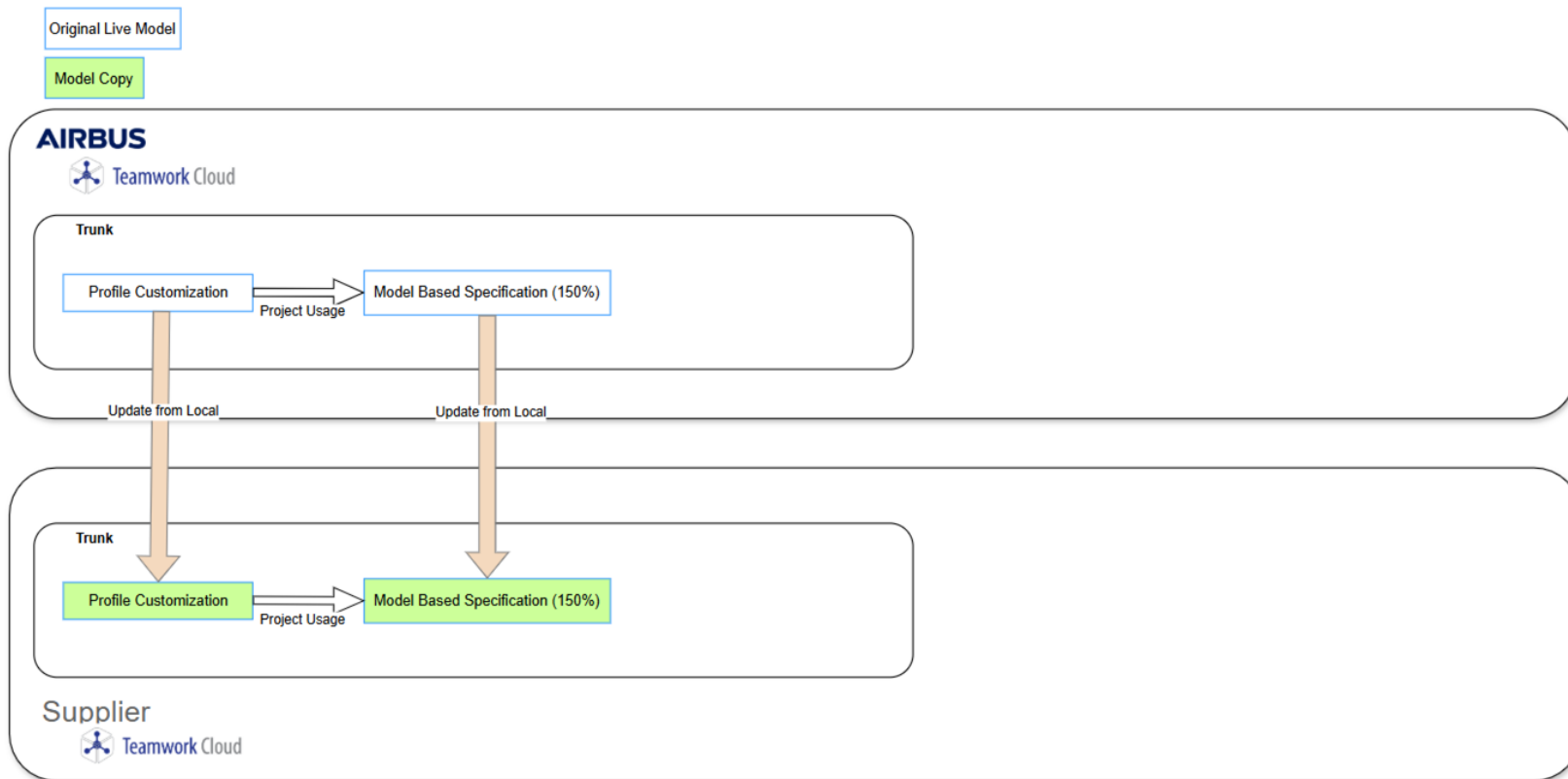


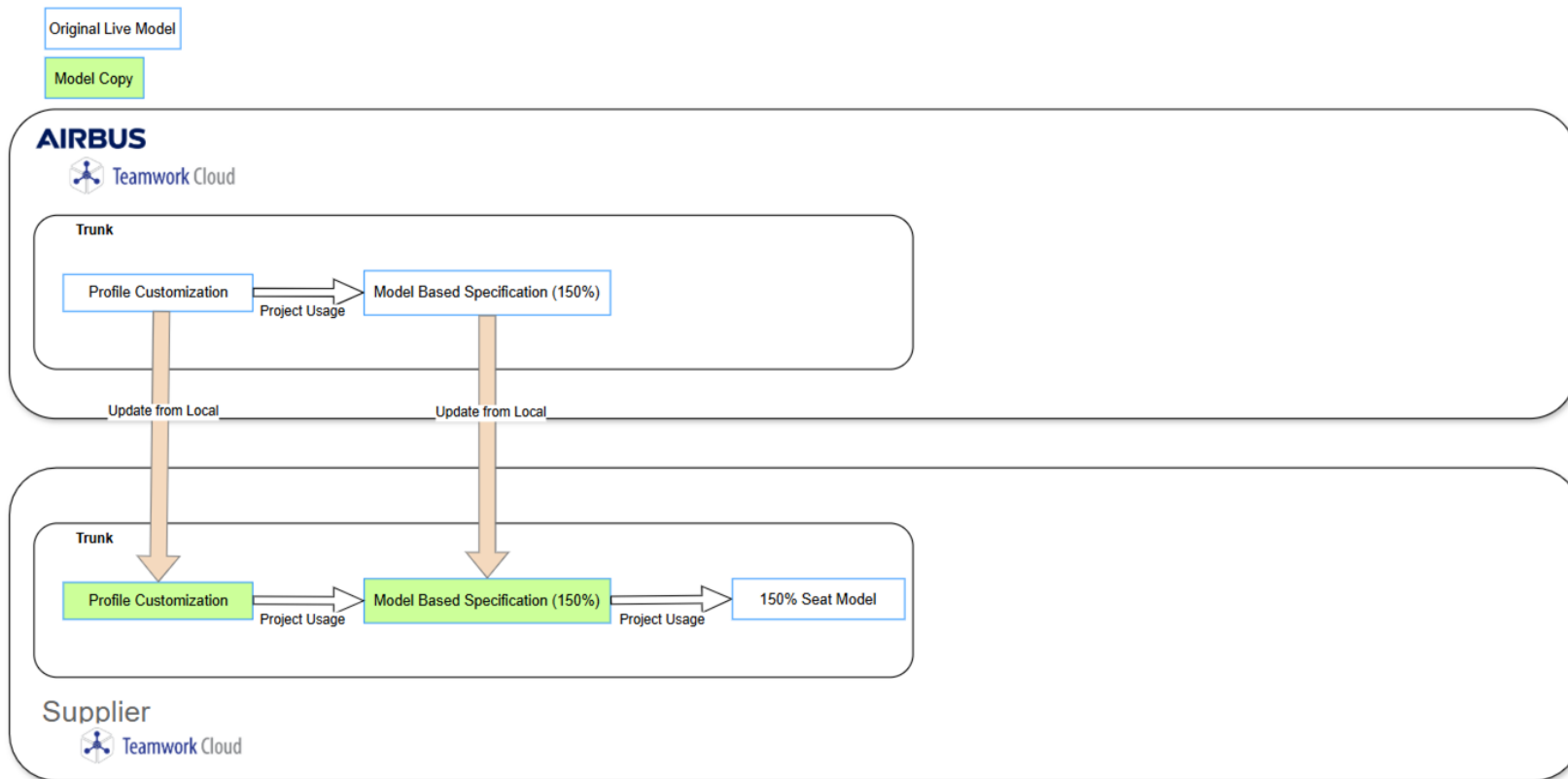
Trunk

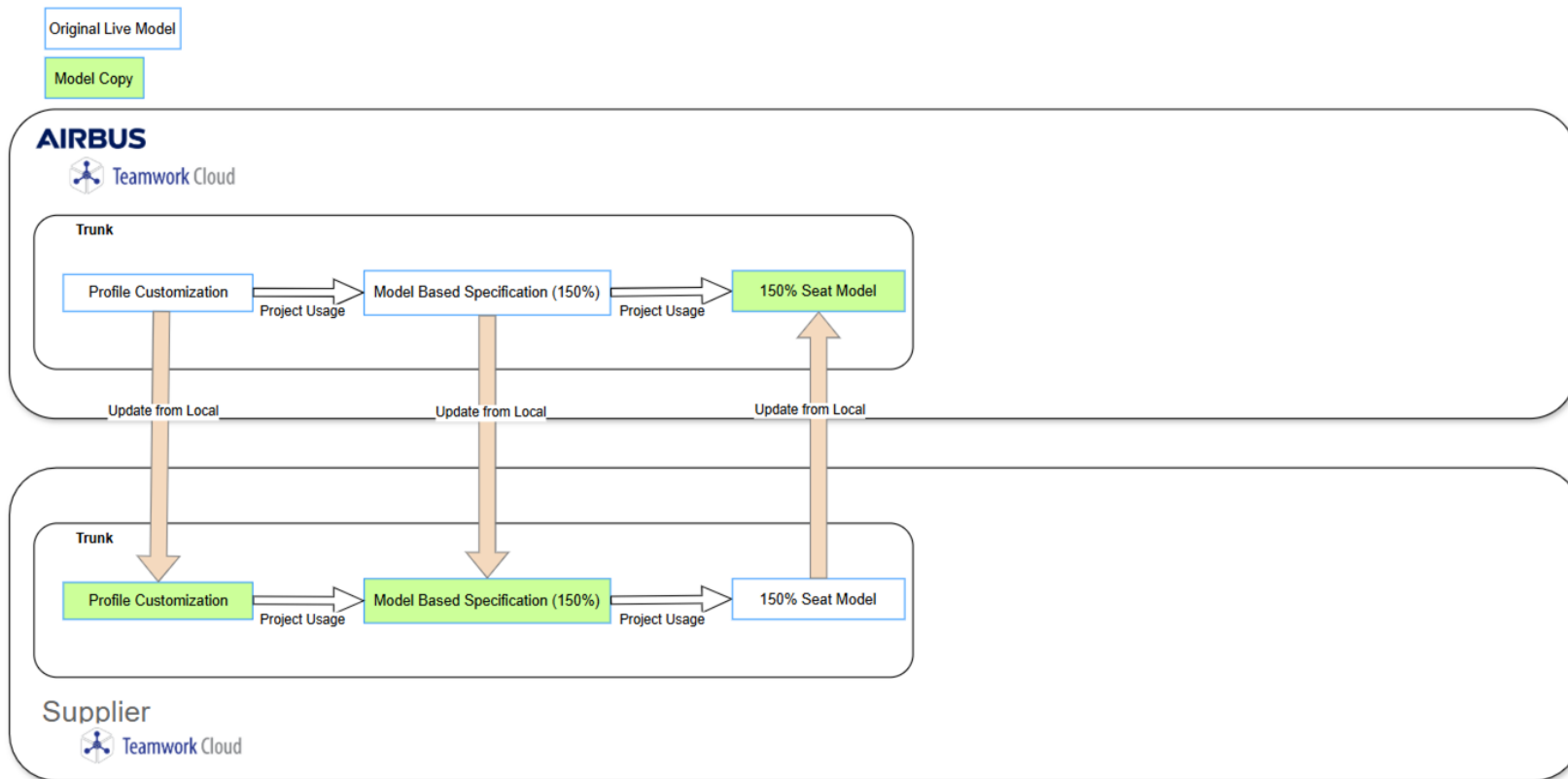
Profile Customization

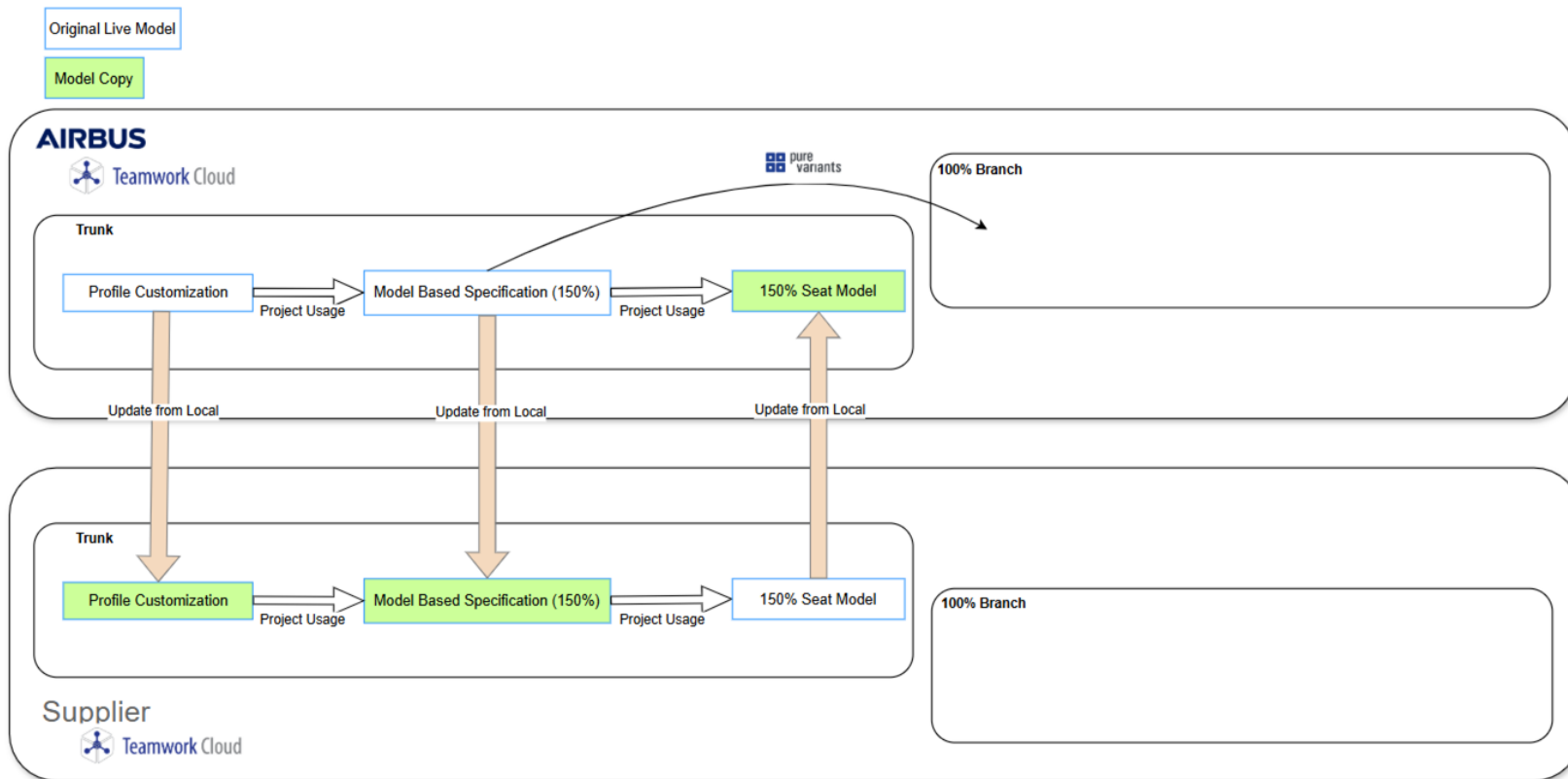


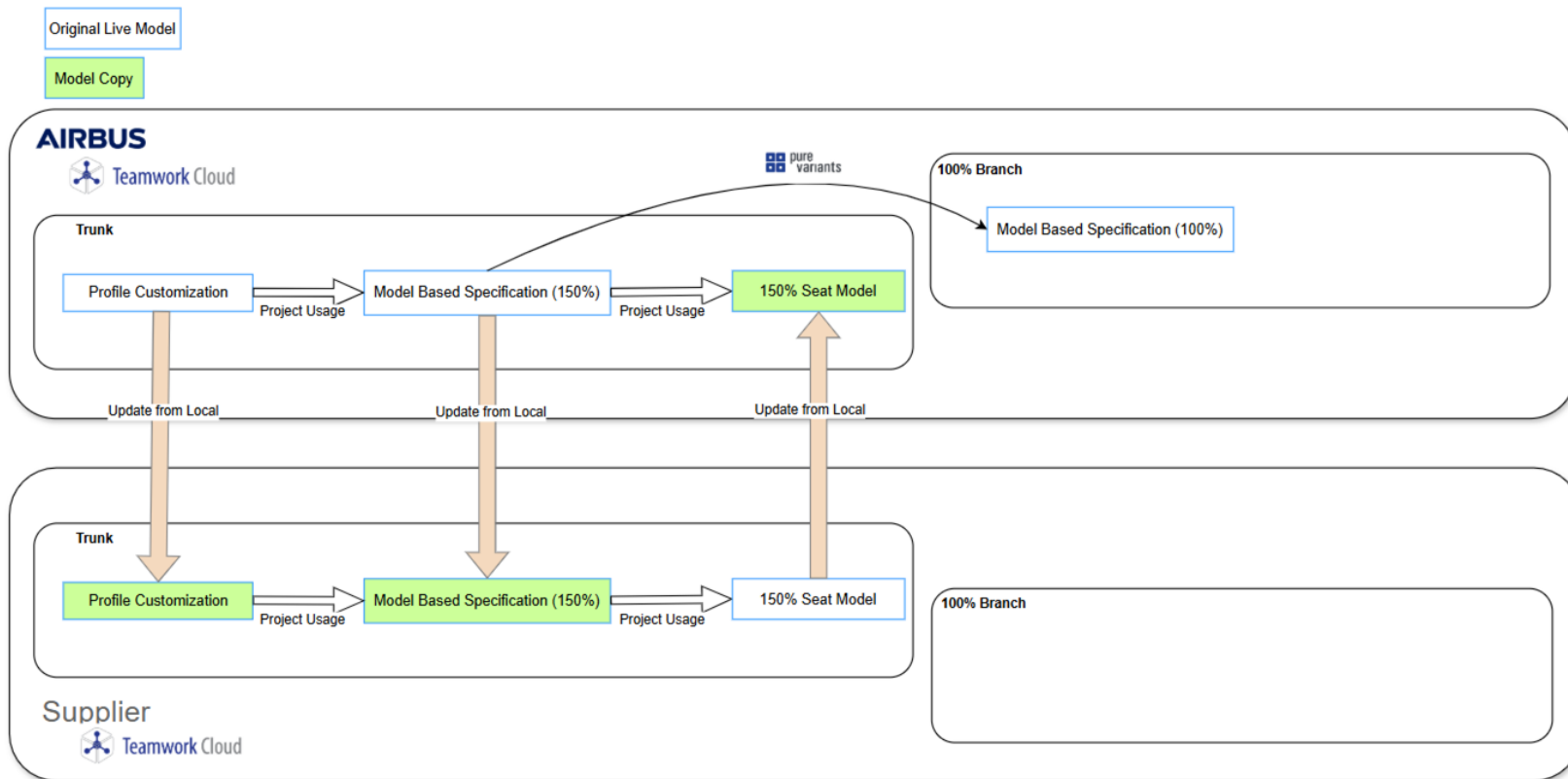
Model Based Specification (150%)

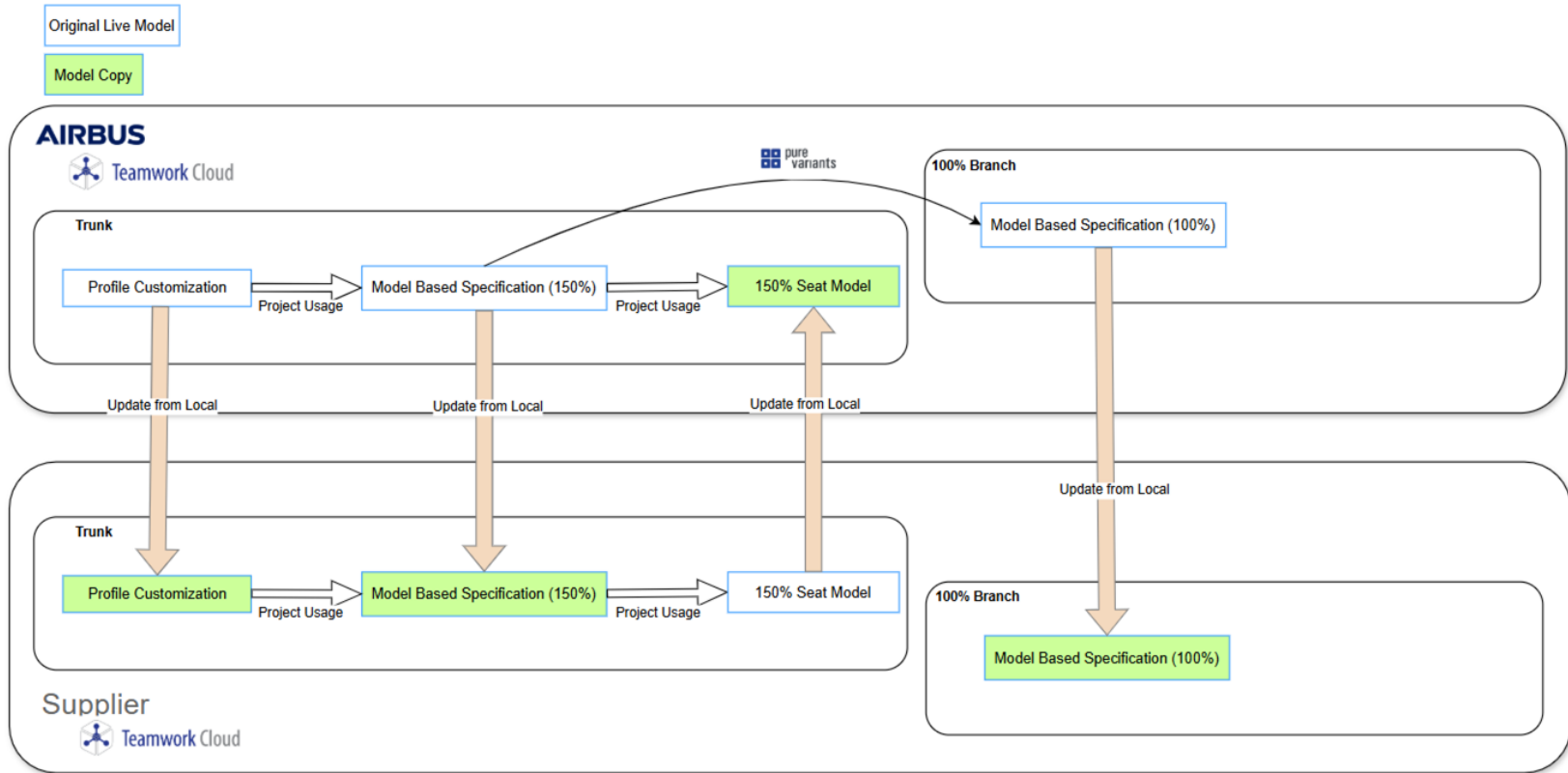


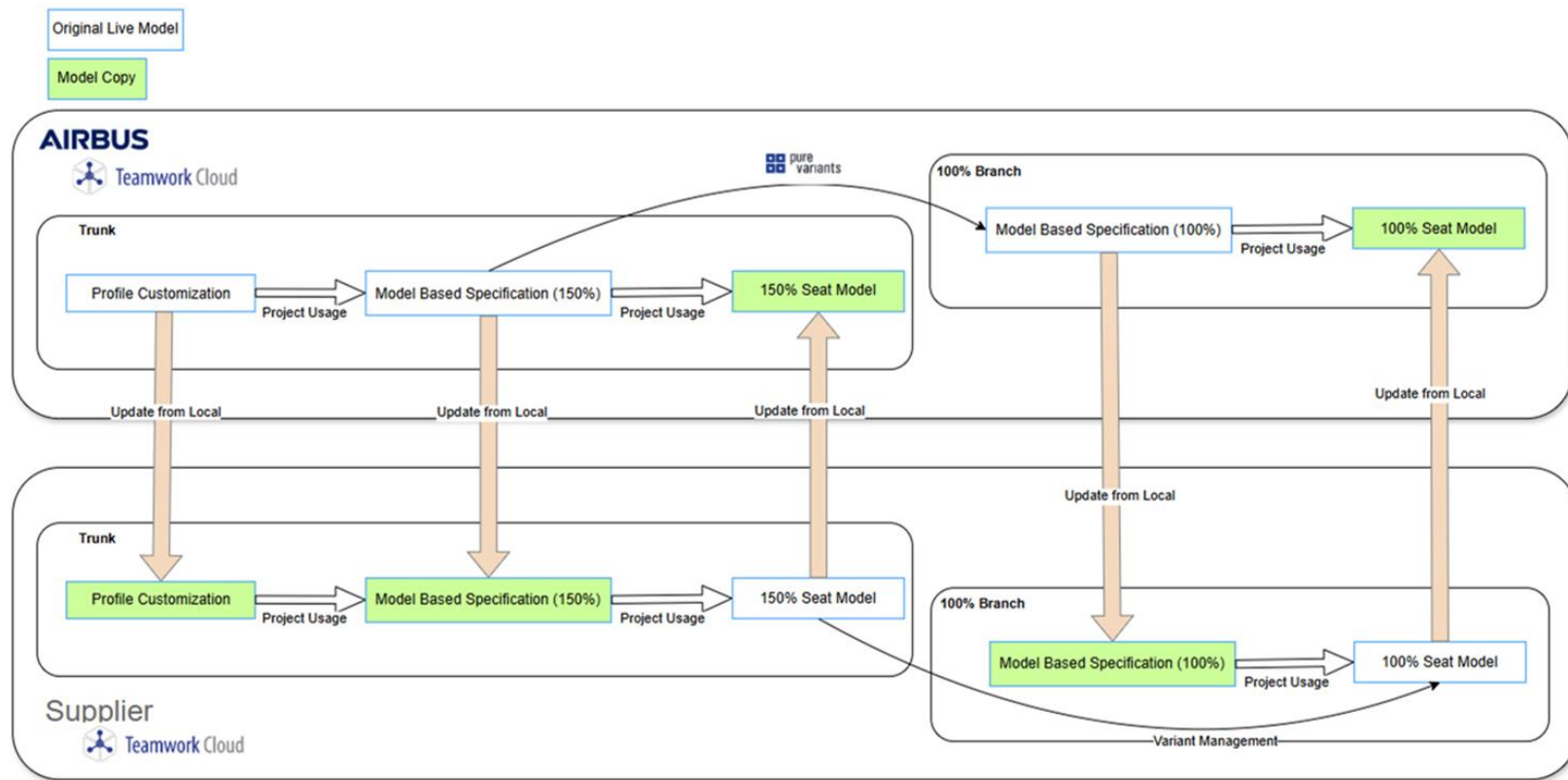












Design Review Assistant

The User Interface

Model Export

- Export to JSON-LD/OWL format based on ontology entities built within Cameo
- The ontology used for the export is independent from the stereotype and framework used

```
"_2021x_2_ae00251_1725998105020_104885_4446": "X_2521_Frame-5326",
"_2021x_2_ae00251_1685711989264_728890_1918": "If there is more than one impact, for the final impact that is above the severity at which the ILD is intended to deploy, the maximum protection of the ILD must be provided.\n",
"_2021x_2_ae00251_1694791489279_326642_124": "For ensurance of protection during secondary impacts.\n",
"_2021x_2_ae00251_1685711989265_697645_1920": "Design Office Seats",
"_2021x_2_ae00251_16968617411286_384647_153": [
  "_2021x_2_ae00251_1694797252570_264583_12558"
],
"_2021x_2_ae00251_1713885063280_711242_268": [
  "_2021x_2_bea0301_1702557338442_364440_5964"
],
"_2021x_2_ae00251_1730757625567_892025_273": "DTP\nDTR",
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"_2022x_2_ae00251_1747072986146_826656_73": "[[A], [4], [CDR, FPDR], [Do], [Seat, In-Flight Seat, Seat Furniture], [V/C, P/C], [320, 330, 350, 380]]",
"_2022x_2_ae00251_1751401137846_937988_66929": "Document",
"_2022x_2_ae00251_1751401155198_814342_66931": "MoC 4 - Laboratory tests",
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],
"@id": "_2021x_2_ae00251_1694797252765_528593_12583",
"shortName": "SOI Requirement Mobile",
"name": "Ln - Seat::REQUIREMENTS::PTS-X-2521-PAX-Seat-Frame::Product Requirements::Aircraft Interfaces::Attachments to Aircraft::Inertia Locking Device::"
```

- **Bridges the gap** between systems models and seats engineers
- Independent tool **enhanced by System Models**
- **Assists engineers** during Design Reviews by providing **applicable requirements** to be reviewed
- Integrates **Test Report Results** from Airbus database
- **Stores history** of System Development throughout Design Process
- **Exports results** to traditional certification format

Design Review History

0.2.43

←

DOR Design Review

Download DCM

Syn Trj

Mark as complete

Test Search

x_2021_Plane

Category

S...

MSSE Compliance Option

Any

Previous Compliance

Any

Compliance

Any

Requested Evidence

Submit...

Provided Evidence

Select Acceptance

Acceptance

Select Acceptance

Requestor ID

Description

State Issues

Category

Applicable Design Reasons

MSSE Compliance Option

Previous Compliance

Compliance

Requested Evidence

Provided Evidence

Trace Graph

Final Comment

Acceptance

x_2021_Plane-100

The total mass accommodate accounts encompassing the 2-year old child to the 99th percentile male.

Design Officer: A

O

FSR
DOR
CDR

MSSE Compliance Option
Full

Previous Compliance
Full

Compliance
Full

Requested Evidence
Full

Provided Evidence
Full

Trace Graph
Full

Final Comment
Full

Acceptance
Not A

x_2021_Plane-111

The Weight Report shall be delivered in the standard Airbus format provided in ERM-423343 by the Weight Department Mass Properties, submitted as PDF (signed) and native Rev by the FTY Tool.

Mass Properties

C

CDR
CDR
PPSR

MSSE Compliance Option
Full

Previous Compliance
Partial

Compliance
Partial

Requested Evidence
Full

Provided Evidence
Full

Trace Graph
Full

Final Comment
Full

Acceptance
Not A

x_2021_Plane-110

It shall be demonstrated by test and appropriate static strength analysis for all components and loading conditions that the aircraft Right seat Fuel Tanker withstands the ultimate load factors for the load factors according to ERM-423343 (ultimate load factors for the 2000kg 110 kg AOC) (any Decision observer load factors for long range AOC).

Stress

B

FSR
DOR
CDR
PPSR

MSSE Compliance Option
Full

Previous Compliance
Full

Compliance
Partial

Requested Evidence
Full

Provided Evidence
Full

Trace Graph
Full

Final Comment
Full

Acceptance
Not A

x_2021_Plane-112

all parts' net consumption (e.g. paint, sealant, surface protection etc.) shall be considered in the Weight Report (consumption in all parts).

Mass Properties

C

FSR
DOR
CDR

MSSE Compliance Option
Not

Previous Compliance
Partial

Compliance
Not

Requested Evidence
Full

Provided Evidence
Full

Trace Graph
Full

Final Comment
Full

Acceptance
Not A

Design Review Assistant

AIRBUS | DRA

Design Review Assistant 0.2.43



← DDR DesignReview -

Download SCM

Sync VT3

Mark as complete



[9E991]

Based on model run: d36d007b-0e06-4af5-9c36-49f6228034ce

Text Search

Category

MBSE Compliance Opinion

Previous Compliance

Compliance

Requested Evidence

Provided Evidence

Acceptance

x_2521_frame

S...

Any

Any

Any

Sele...

Select Pr...

Select Acceptance

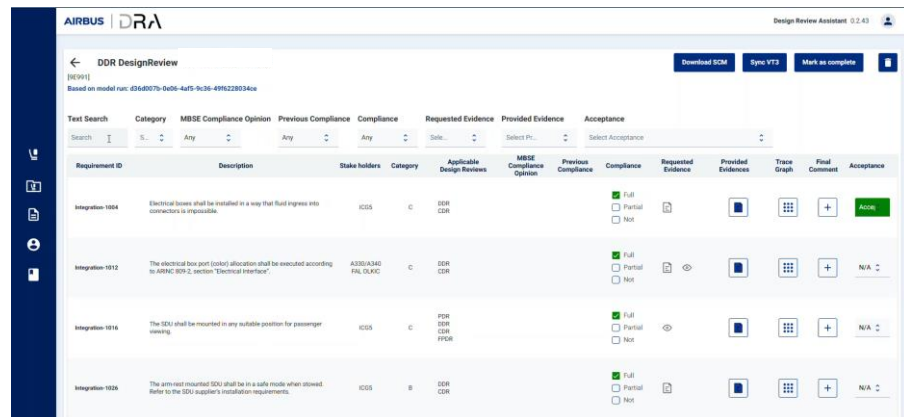
Requirement ID	Description	Stake holders	Category	Applicable Design Reviews	MBSE Compliance Opinion	Previous Compliance	Compliance	Requested Evidence	Provided Evidences	Trace Graph	Final Comment	Acceptance
X_2521_Frame-101	The seat must accommodate occupants encompassing the 2-year old child to the 99th-percentile male.	Design Office Seats	A	PDR DDR CDR		✓ Full	<input checked="" type="checkbox"/> Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					Not A
X_2521_Frame-111	The Weight Report shall be delivered in the standard Airbus format provided in X25ME1825439 by the Airbus Mass Properties Department Mass Properties, submitted as pdf (signed) and native file via the VT* tool.	Mass Properties	C	DDR CDR FPDR			<input checked="" type="checkbox"/> Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					Not A
X_2521_Frame-1119	It shall be demonstrated by test and appropriate static strength analysis for all components and loading conditions that the seat/in-flight seat/seat furniture withstand the ultimate load factors/flight load factors according to [Section Ultimate load factors for SA, DOORS_ID 2842] for A320family [Section Ultimate load factors for long range, DOOR ...	Stress	B	PDR DDR CDR FPDR		✓ Full	<input checked="" type="checkbox"/> Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					Accept
X_2521_Frame-112	All parts incl. consumables (e.g. paint, sealant, surface protection etc.) shall be considered in the Weight Report (estimated or calculated).	Mass Properties	C	PDR DDR CDR		✗ Not	<input checked="" type="checkbox"/> Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					N/A
X_2521_Frame-5780	The distance between last row seat fixation and partition fixation shall be minimum 5 mm (0.197 inch).	Design Office Seats	C	PDR DDR CDR	✓ Pass		<input checked="" type="checkbox"/> Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					N/A

Design Review Assistant

System Model Enhancement

- Glimpse of the model provided through traceability explorer
- Enriches compliance statement with traceability, early verification insights, systems architecture
- Nodes are navigable and contain stereotype relevant information

ID, type, stereotype, relationship to other elements, value, unit, etc.



The screenshot shows the AIRBUS DRA interface. At the top, it says "DOR DesignReview" and "Based on model run: d26d007b-d006-4d75-9c36-499228034dc". Below this is a search bar and several filter tabs: "Text Search", "Category", "MBSE Compliance Option", "Previous Compliance", "Compliance", "Requested Evidence", "Provided Evidence", and "Acceptance". The main table lists requirements with columns for Requirement ID, Description, Stake holders, Category, Applicable Design Reviews, MBSE Compliance Option, Previous Compliance, Compliance, Requested Evidence, Provided Evidence, Trace Graph, Final Comment, and Acceptance.

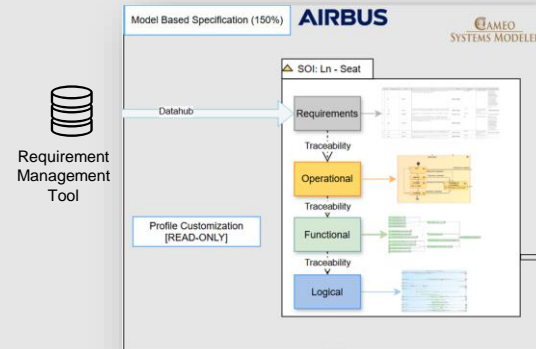
Requirement ID	Description	Stake holders	Category	Applicable Design Reviews	MBSE Compliance Option	Previous Compliance	Compliance	Requested Evidence	Provided Evidence	Trace Graph	Final Comment	Acceptance
Integration 1004	Electrical boxes shall be installed in a way that fluid ingress into connectors is impossible.	ECSS	C	DER CDR			Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					Accept
Integration 1012	The electrical box port (port) allocation shall be executed according to ARINC 809-2, section "Electrical Interface".	A330/A340 FAL DLR/C	C	DER CDR			Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					N/A
Integration 1016	The IDU shall be mounted in any suitable position for passenger viewing.	ECSS	C	PCR DER CDR FFDR			Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					N/A
Integration 1026	The arm rest mounted IDU shall be in a safe mode when stowed. Refer to the IDU supplier's installation requirements.	ECSS	B	DER CDR			Full <input type="checkbox"/> Partial <input type="checkbox"/> Not					N/A

Objective

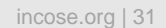
Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities

Objective

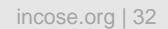
Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities



Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities

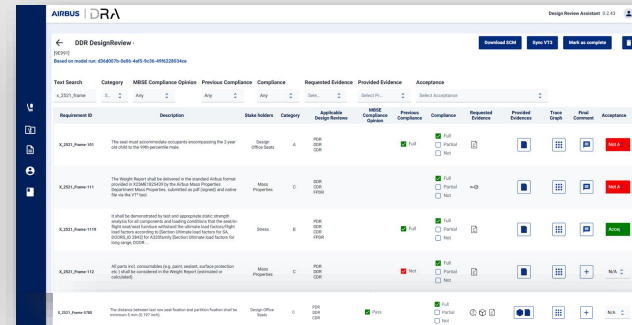


Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities



Objective

Improve the understanding of the Specification and of the Supplier's Design, anticipate design changes' impact, and facilitate Design Review activities



Requirement ID	Description	State	Category	Applicable Design Section	INCOSE Compliance Option	Previous Compliance	Compliance	Requested Evidence	Provided Evidence	Acceptance
R_2021_P000100	The user must acknowledge compliance with the 2-year old data to use the system.	Design Office Data	A	REQ 2021-001	Full	Full	Full	Full	Full	Not a
R_2021_P000101	The Weight Report shall be delivered in the standard Airbus format provided as a 3D model to the Airbus Master Program.	Master Properties	C	REQ 2021-001	Full	Full	Full	Full	Full	Not a
R_2021_P000102	It shall be demonstrated by test and appropriate data, through analysis, that the system is able to handle the specified data. The test results shall be documented in the test report.	Design Office Data	A	REQ 2021-001	Full	Full	Full	Full	Full	Not a
R_2021_P000103	All data shall be documented in the Weight Report (compliance or not).	Master Properties	C	REQ 2021-001	Full	Full	Full	Full	Full	Not a
R_2021_P000104	The system shall be able to handle the specified data and the system shall be able to handle the specified data.	Design Office Data	A	REQ 2021-001	Full	Full	Full	Full	Full	Not a

Conclusion and Outlook

Limitations and Future Considerations

- **Initial Investment**

Time consuming upfront (process development, training, iterations)

- Relies on Airbus and supplier using the **same toolset**

Working on solutions to translate frameworks or collaborate with different tools

- Model spans across **Airbus and Supplier IP**

Clear definition of responsibilities and ownership required

- **Export Control** Classification

Working with Classification experts from Europe and the USA

- Cameo limitations for direct **integration of V&V tools**

Exploring use of ecosystems

- **Significant number** of models expected

Requires strong infrastructures and robust Product Life Cycle Management (PLM) strategy

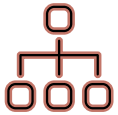
Benefits

- **Improved requirements**
- Applicable **requirements narrowed down** with variation points setup (**MBPLE**)
- End to End **traceability** of Requirements and Model Elements across layers and levels
- **Early verification** of requirements
- **High reusability** of models thanks to 150%/120%/100% configurations
- User interface allows non-modelers to **understand the Systems Model**
- **Informed compliance checks** performed in the Design Review Assistant

Outlook



Increase communication between V&V sources



Enhance the usage of Models during Design Reviews



Generate new perspectives to leverage the models for diverse stakeholders

Thank you!



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