ECAD & MCAD Model Virtual Integration Using Data Interoperability Standards

Greg Pollari, Rockwell Collins

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT
2015

ELYSIUM   Parker | Aerospace   NORTHROP GRUMMAN   BOEING

Gregory Pollari

Greg Pollari is a Principal Systems & Process Engineer at Rockwell Collins where he has worked for 29 years. During his career, Mr. Pollari has designed integrated circuits, power supplies, and digital electronic hardware and has had systems engineering, project management, and team leadership/management responsibilities for navigation products business area. He has also worked on business process redesign initiatives for marketing and engineering development processes. Mr. Pollari currently works as a systems engineer in the Rockwell Collins Advanced Manufacturing and Test & Equipment Services organizations. His focus is on finding ways to engage the manufacturing and test organization earlier in the systems engineering product development phase.

Mr. Pollari holds B.S in Physics, M.S. in Electrical & Computer Engineering and MBA degrees.

SAVI (Systems Architecture Virtual Integration) is a project at the AVSI (Aerospace Vehicle Systems Institute)

Rockwell Collins

NASA

United Technologies

Honeywell

Software Engineering Institute

GE

SAVI
System Architecture Virtual Integration

AIRBUS

FEDERAL AVIATION ADMINISTRATION

BOEING

DEPARTMENT OF DEFENSE · UNITED STATES OF AMERICA

EMBRAER

Tool Vendor Partners:
Adventium Labs, Esterel Technologies, Eurostep

ELYSIUM

Parker

NORTHROP GRUMMAN

BOEING

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Agenda

- **The problem and demonstration objectives**
- **Approach**
    - **The tool being used**
- **Demonstration of consistency checking**
    - **Original Data set**
    - **Test cases**
- **Applying Intellectual Property protection to the problem**
- **Achievements and next steps**
- **Questions**

4

Agenda

- **The problem and demonstration objectives**
- Approach
  - The tool being used
- Demonstration of consistency checking
  - Original Data set
  - Test cases
- Applying Intellectual Property protection to the problem
- Achievements and next steps
- Questions

Fit Demonstration Objectives

- **Demonstrate MR/DEL infrastructure and capabilities**

- **Show standards-based data interoperability foundation**

- **Show SAVI consistency checks applied to system (Excel), mechanical (MCAD), and electrical (ECAD) models**

- **Detect integration errors in model set prior to physical integration (using a known problem)**

- **Show SAVI capability adding value to current product development process at a Tier 1 supplier**

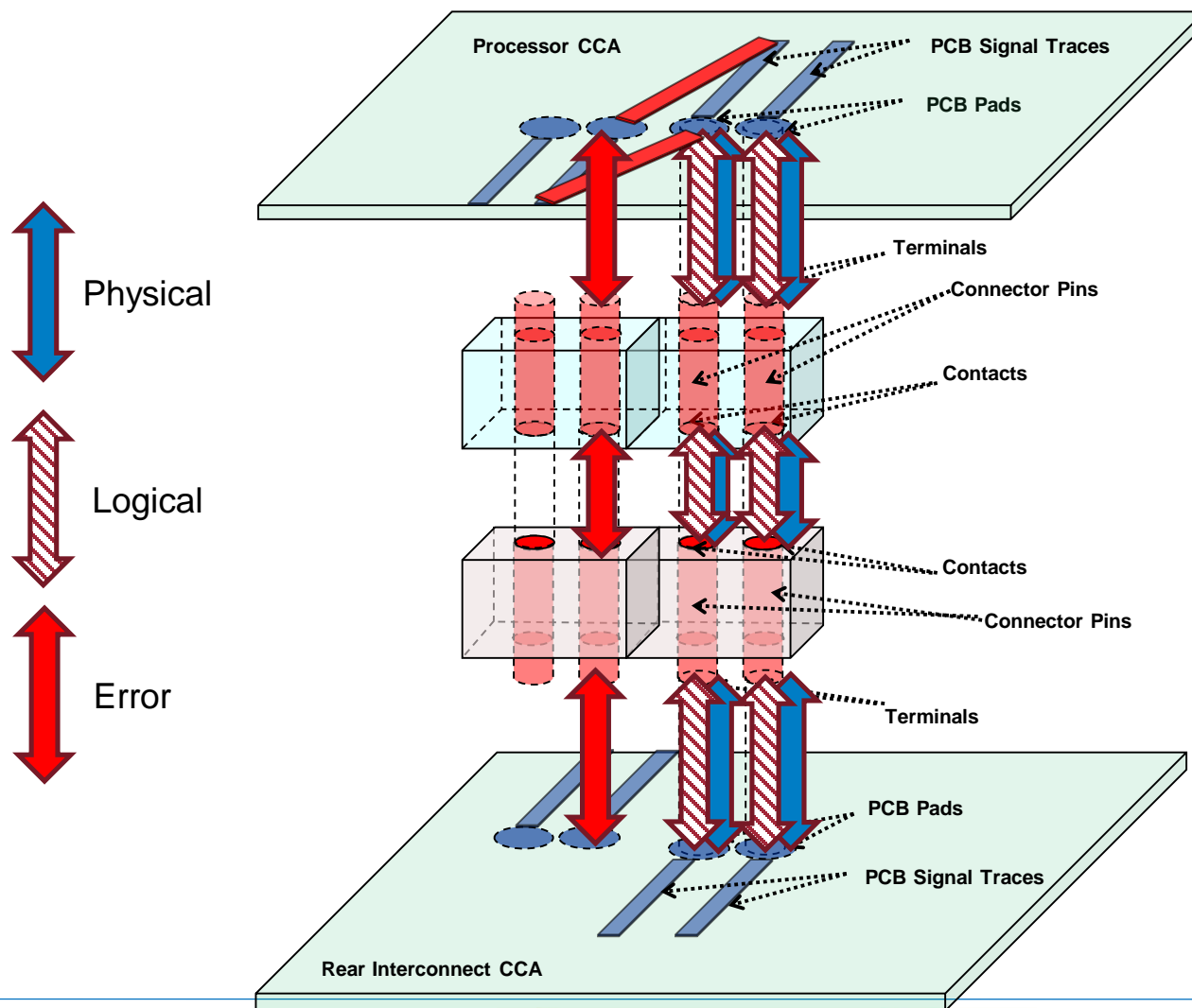- **Show protection of Intellectual Property (IP)**

- **Signal names and pin numbers do not match (physically or logically) across two connectors**

  - **Mating connector pin number mismatch**

  - **Logical (schematic) signals are connected to the wrong pin**

- **Such errors are sometimes not identified until testing of built systems**

  - **Incurring both cost and delay**

  - **Risk of unpredicted emergent behavior from the system if error not found**
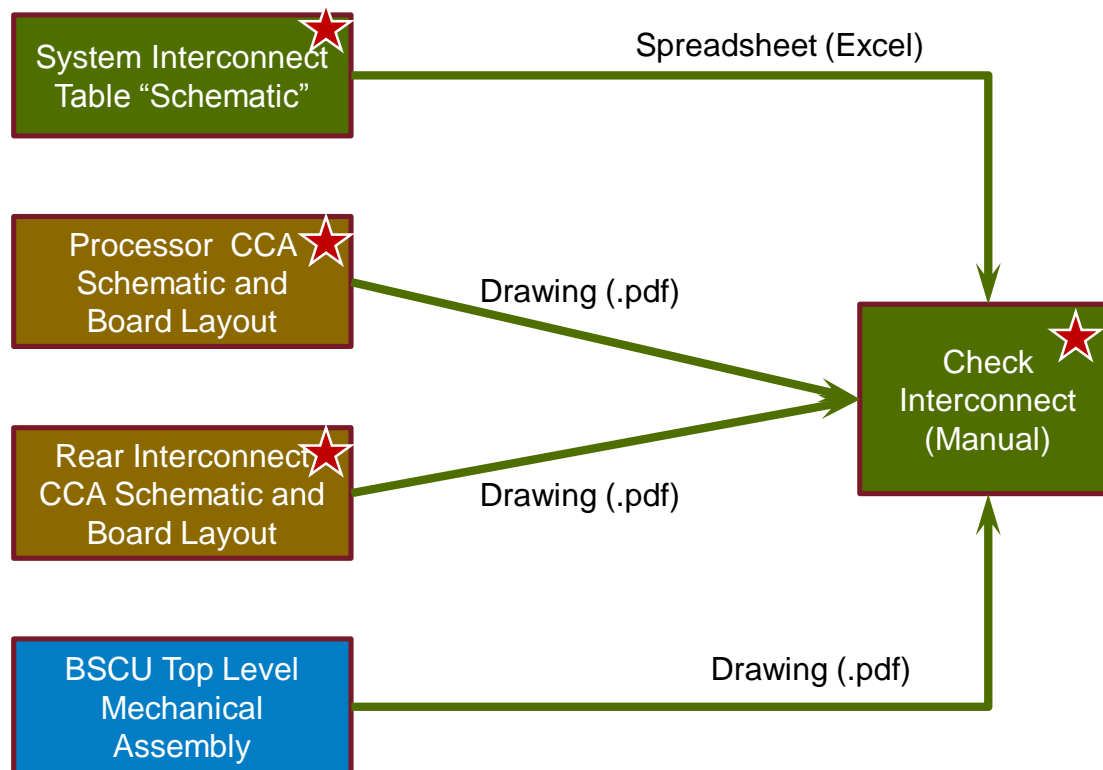
Prove Physical = Logical

Electro-Mechanical System

System Interconnect Table "Schematic" →(Spreadsheet (Excel))→ Check Interconnect (Manual)

Processor CCA Schematic and Board Layout →(Drawing (.pdf))→ Check Interconnect (Manual)

Rear Interconnect CCA Schematic and Board Layout →(Drawing (.pdf))→ Check Interconnect (Manual)

BSCU Top Level Mechanical Assembly →(Drawing (.pdf))→ Check Interconnect (Manual)

★ **Potential sources of inconsistency (error) due to manual steps**

Processor CCA
827-9999-956

Rear Interconnect CCA
827-9999-958

Processor CCA
Connector P2

Rear Interconnect CCA
Connector J2
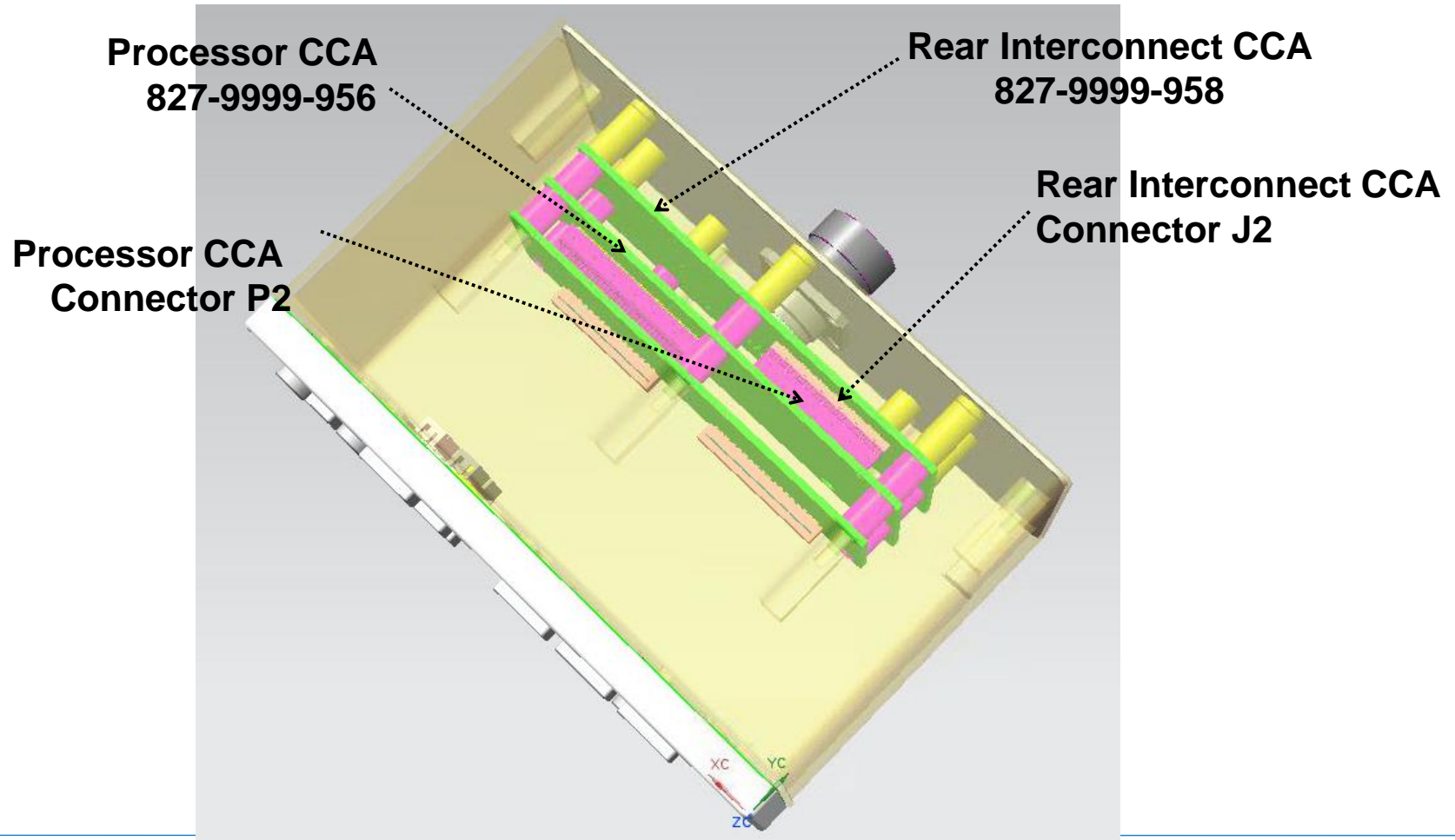
Model Set

- **(1) System interconnect model (Excel)**

- **(1) Top Level Assembly model (MCAD)**

- **(2) CCA (Circuit Card Assembly) models (ECAD)**

- **Also a variety of associated documents**

  - **PDF documents, native CAD models**

4 models with different, but (intended) consistent views.

Nature of the Problem

- **ECAD and MCAD have evolved in different silos**

- **ECAD and MCAD aren't good at sharing data**

- **MCAD has no "electrical awareness"**

- **ECAD is "2 ½-D" whereas MCAD is 3D**

- **Connector models are not "electrically aware"**

If this was easy, it would have been fixed already.

Part 1 Agenda

- **The problem and demonstration objectives**

- **Approach**
  - **The tool being used**

- **Demonstration of consistency checking**
  - **Original Data set**
  - **Test cases**

- **Applying Intellectual Property protection to the problem**
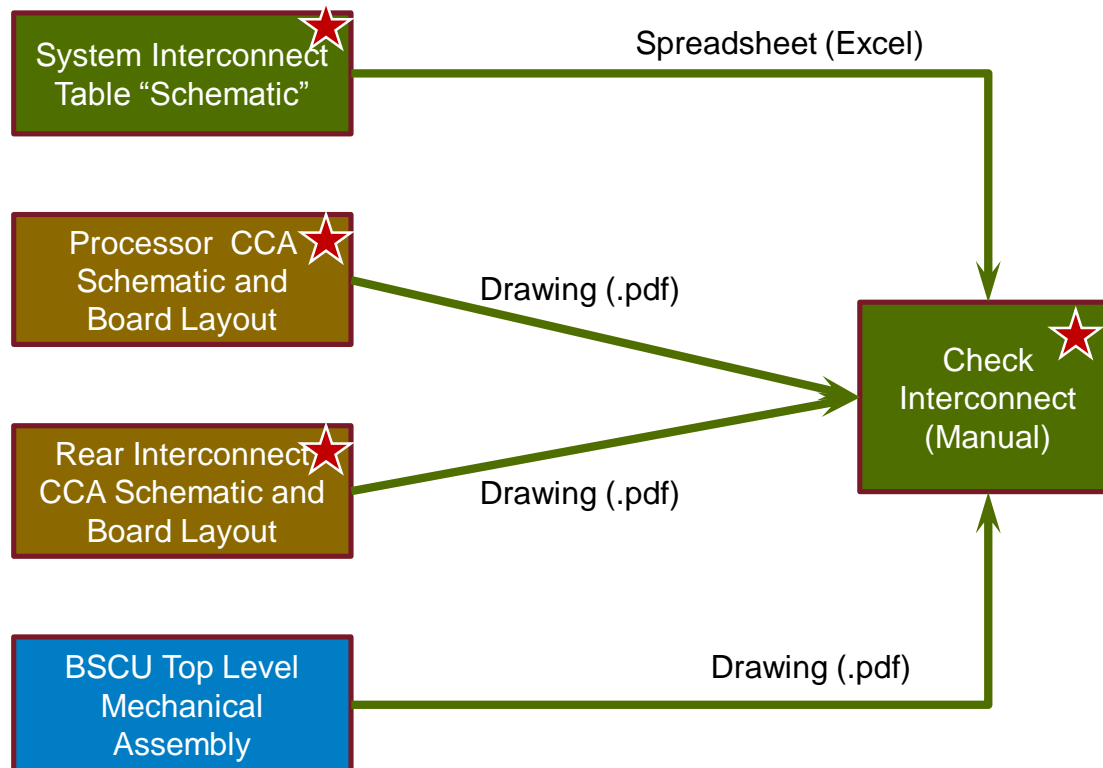
- **Achievements and next steps**

- **Questions**

Approach

- **Extract relevant properties from models (ECAD, MCAD, Excel)**

- **Convert to common representation (STEP AP-239)**

- **Perform SAVI VIP consistency check in common environment**

Candidate for data exchange standards-based solution.
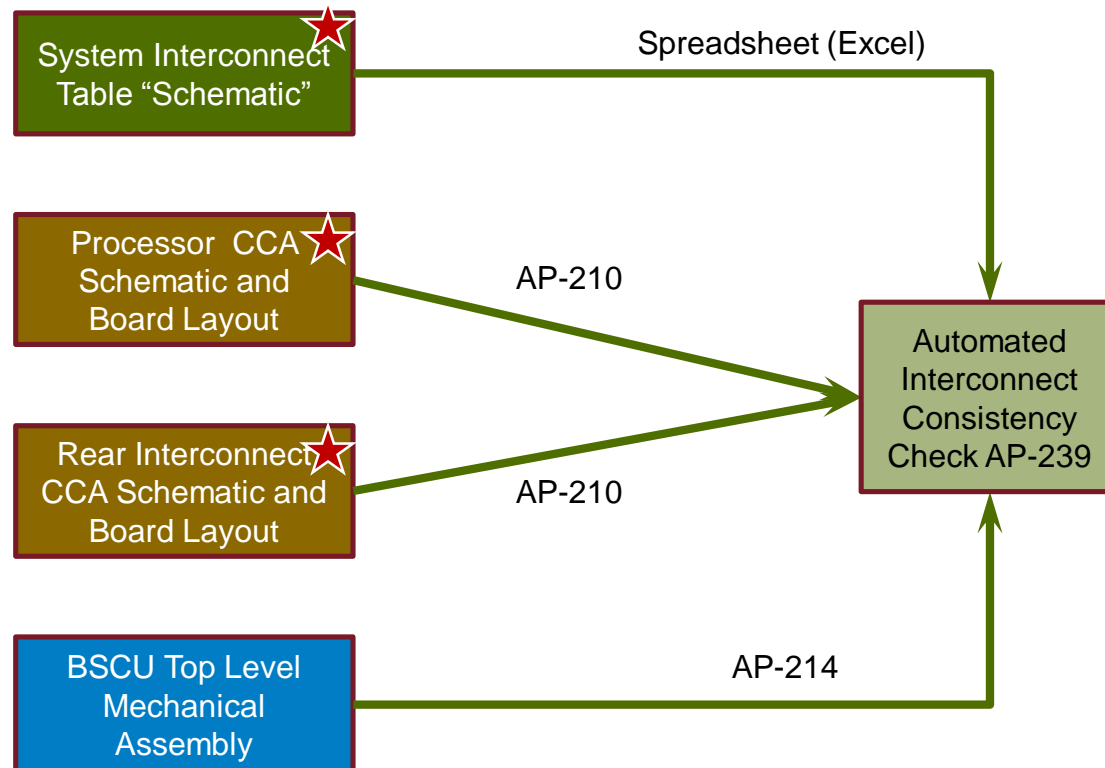
Tedious Manual Visual Verification

System Interconnect Table "Schematic" ★

— Spreadsheet (Excel) →

Processor CCA Schematic and Board Layout ★

— Drawing (.pdf) →

Rear Interconnect CCA Schematic and Board Layout ★

— Drawing (.pdf) →

BSCU Top Level Mechanical Assembly

— Drawing (.pdf) →

Check Interconnect (Manual) ★

★ **Potential sources of inconsistency (error) due to manual steps**

SAVI Automated Consistency Check

System Interconnect Table "Schematic" → Spreadsheet (Excel) → Automated Interconnect Consistency Check AP-239

Processor CCA Schematic and Board Layout → AP-210 → Automated Interconnect Consistency Check AP-239

Rear Interconnect CCA Schematic and Board Layout → AP-210 → Automated Interconnect Consistency Check AP-239

BSCU Top Level Mechanical Assembly → AP-214 → Automated Interconnect Consistency Check AP-239

★ **Potential sources of inconsistency (error) due to manual steps**

Processor CCA

FrameEP2

FrameP2

Connector P2

FrameP2 Offset

FrameEP 2 Offset

Assembly Frame950

FrameJ2 Offset

Connector J2

FrameJ2

FrameEJ2 Offset

Rear Interconnect CCA

FrameEJ2

ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING
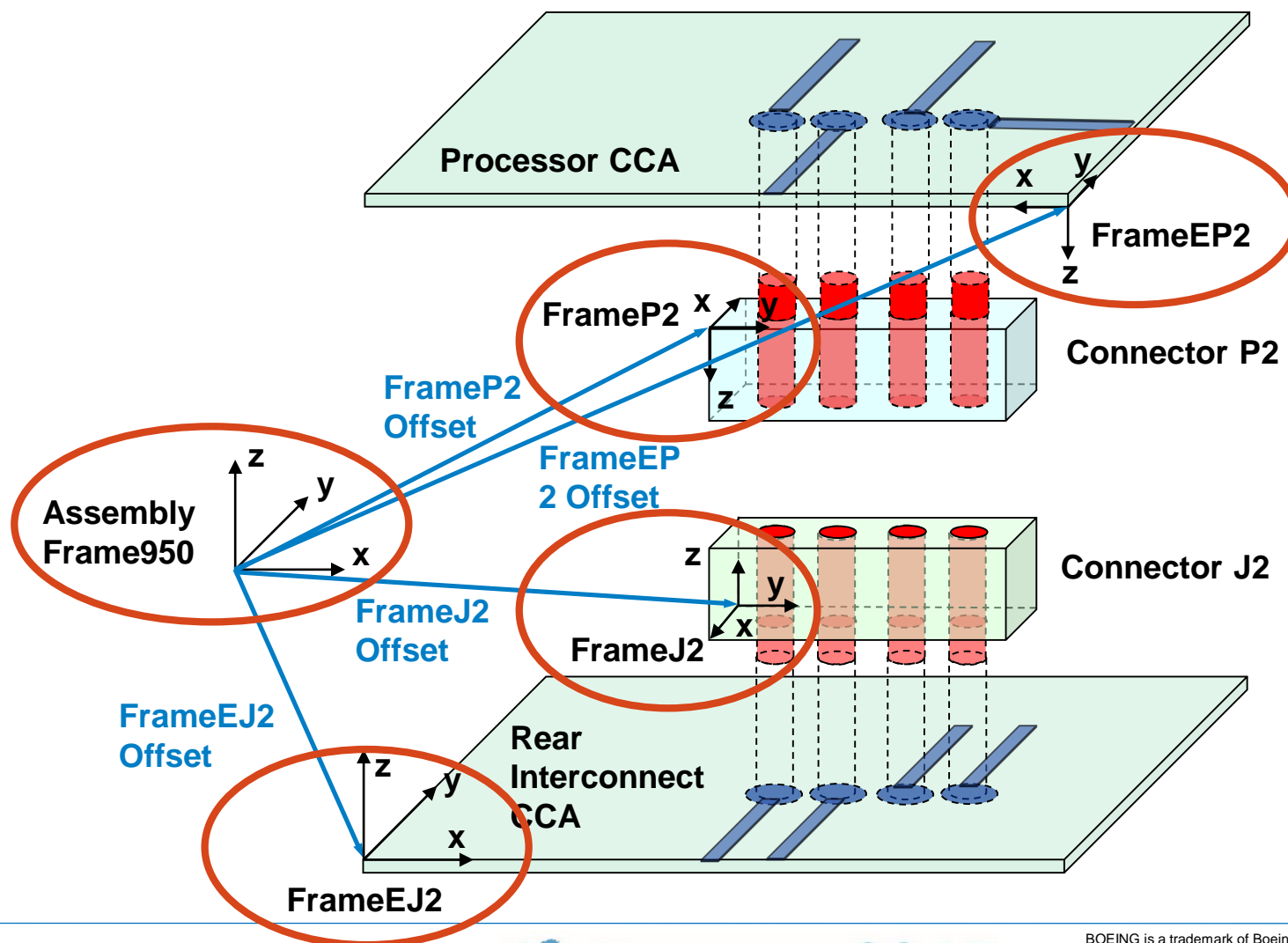
GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT **2015**

Agenda

- The problem and demonstration objectives
- Approach
  - **The tool being used**
- Demonstration of consistency checking
  - Original Data set
  - Test cases
- Applying Intellectual Property protection to the problem
- Achievements and next steps
- Questions

Tool Chosen for Reference Implementation

- **Share-A-space® is designed to enable the management of product and related data across enterprises and between systems, for to support collaboration and change management**
  - **It has a rich internal data model based on the STEP & PLCS (AP239) standards**
  - **It has information access control by organization and by detailed element**

- **In this case the data set to be loaded is partitioned across multiple technologies and tools**
  - **as well as across organizations**

ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING   GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Specification Based Approach – Tool Independent!

- **Eurostep use SysML diagrams as a specification mechanism for how the various information sources are processed**

- **The core of the specification is a Business Object Model**
  - **This acts as an integration model for the different inputs**

- **The Business Object Model is mapped to Share-A-space's internal model**

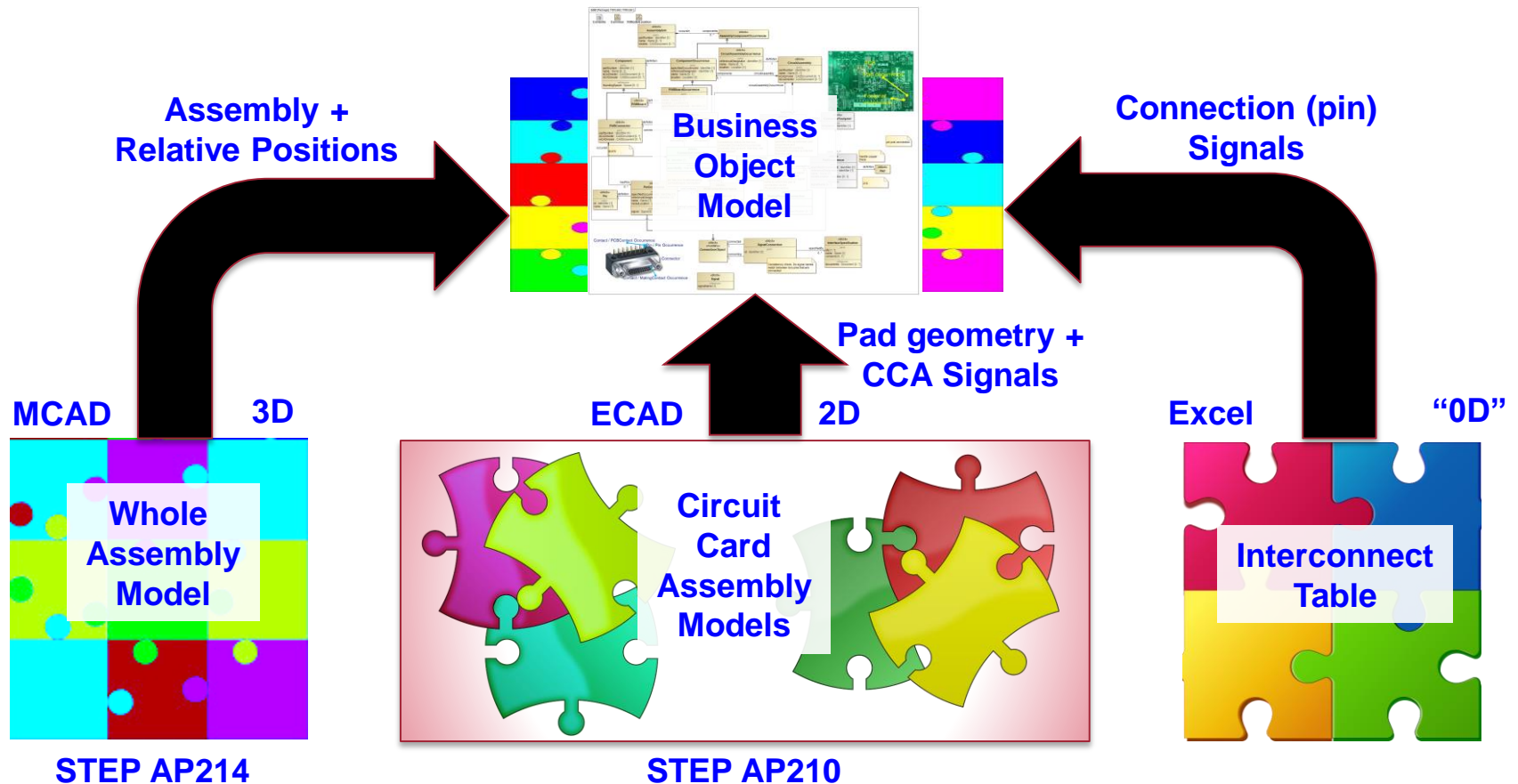- **The resulting specification is available in [html] as a deliverable to SAVI**

Consider trying to complete a jigsaw puzzle using pieces from four different puzzles formats and dimensions by taking specifics from each source to make one picture

Assembly + Relative Positions

Connection (pin) Signals

Pad geometry + CCA Signals

MCAD   **3D**

Whole Assembly Model

ECAD   **2D**

Circuit Card Assembly Models

Excel   **"0D"**

Interconnect Table
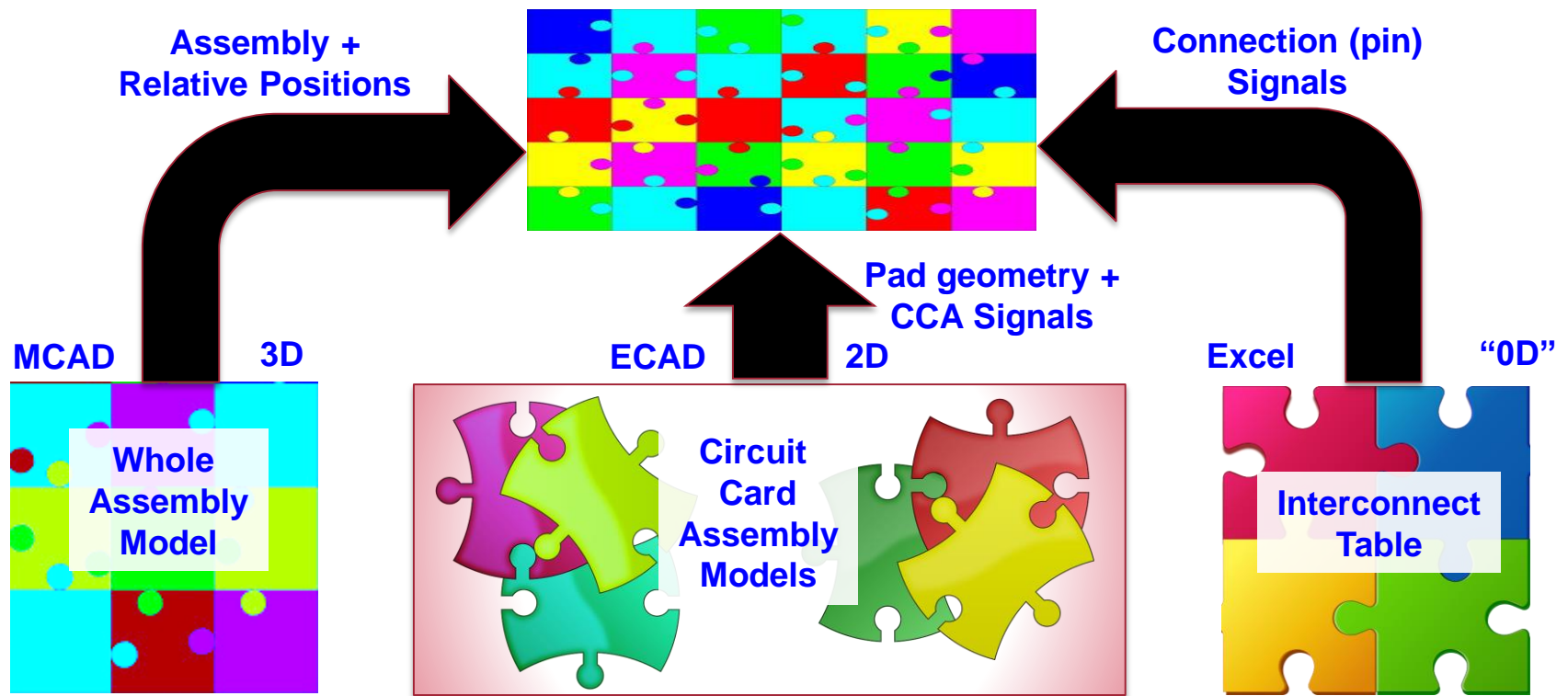
ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING   GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Using standards (AP214 and AP210) . . .
. . . we design the target jigsaw to do the job

Business Object Model

Assembly + Relative Positions

Connection (pin) Signals

Pad geometry + CCA Signals

MCAD   **3D**   **ECAD**   **2D**   **Excel**   **"0D"**

Whole Assembly Model

Circuit Card Assembly Models

Interconnect Table

STEP AP214   **STEP AP210**

ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING

Using standards (AP214 and AP210) . . .
. . . we design the **target jigsaw** to do the job

Business Object Model

MCAD   **3D**

Whole Assembly Model

STEP AP214

ECAD   **2D**

Circuit Card Assembly Models

STEP AP210

Excel   **"0D"**

Interconnect Table

ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING   GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Reference implementation uses Share-A-space® to hold the inputs and resulting consolidated data set

Business Object Model

share A space

MCAD   **3D**   **ECAD**   **2D**   **Excel**   **"0D"**

Whole Assembly Model   **Circuit Card Assembly Models**   **Interconnect Table**

STEP AP214   **STEP AP210**

Need to know which files to read and who is owner

- **An Excel document provides this info (1 file/owner)**
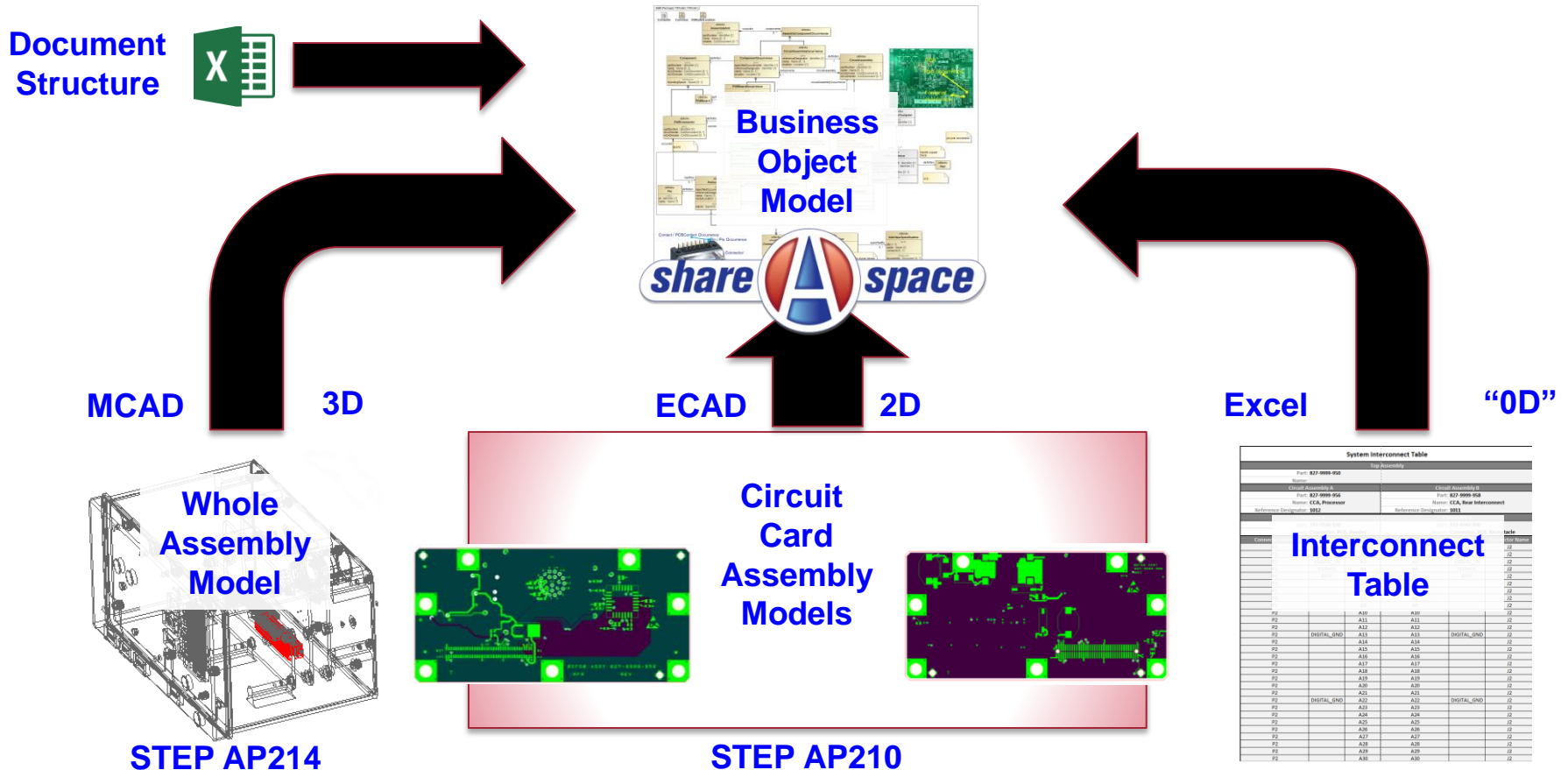
Document Structure

Business Object Model

share A space

MCAD   **3D**   **ECAD**   **2D**   **Excel**   **"0D"**

Whole Assembly Model

Circuit Card Assembly Models

Interconnect Table

STEP AP214   **STEP AP210**

SAVI Consistency Checks

Do the signals match across the CCAs and connector? Are any signals missing?

Do the Pads match between the CCAs?
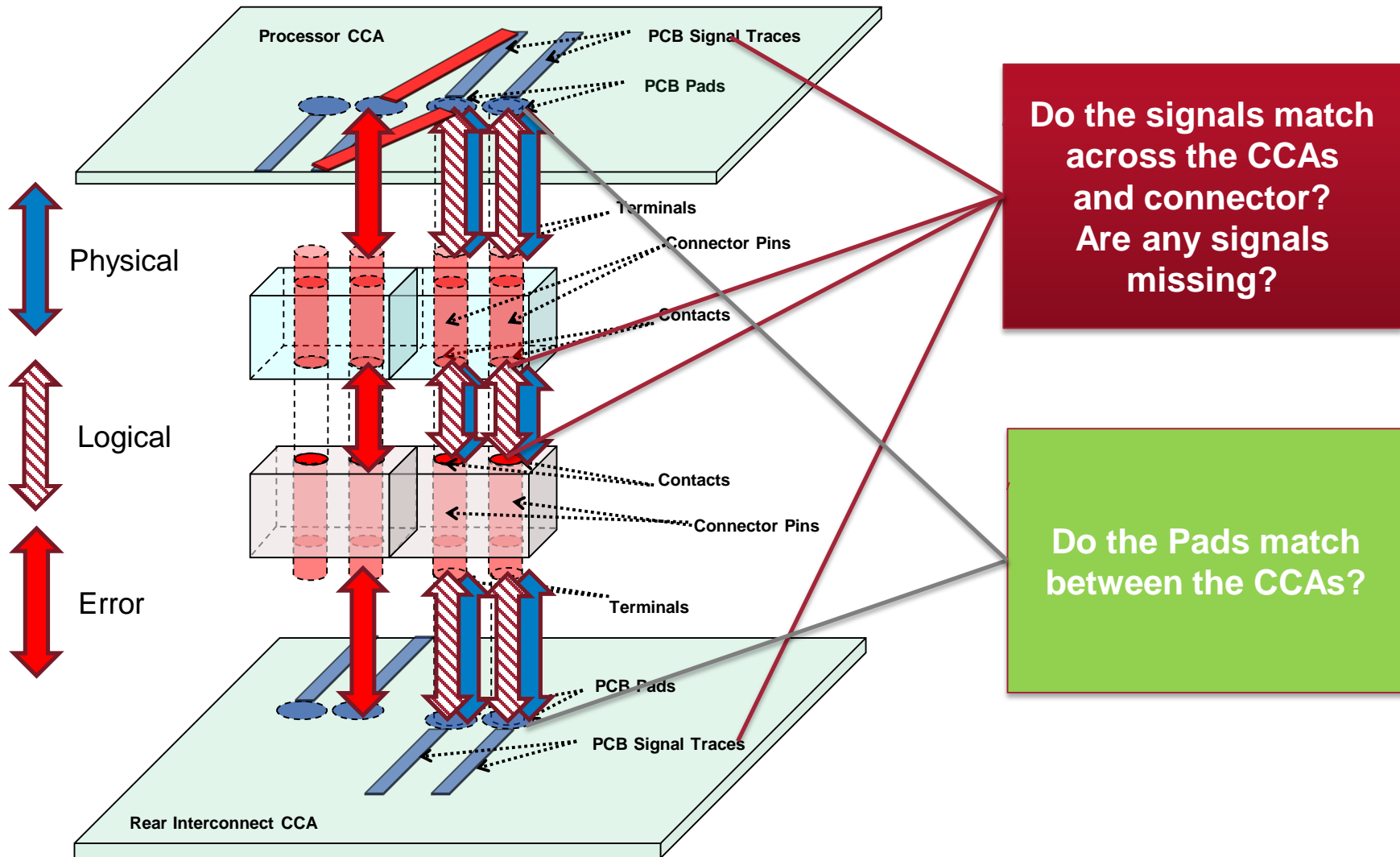
SAVI Consistency Check Graphical Viewer
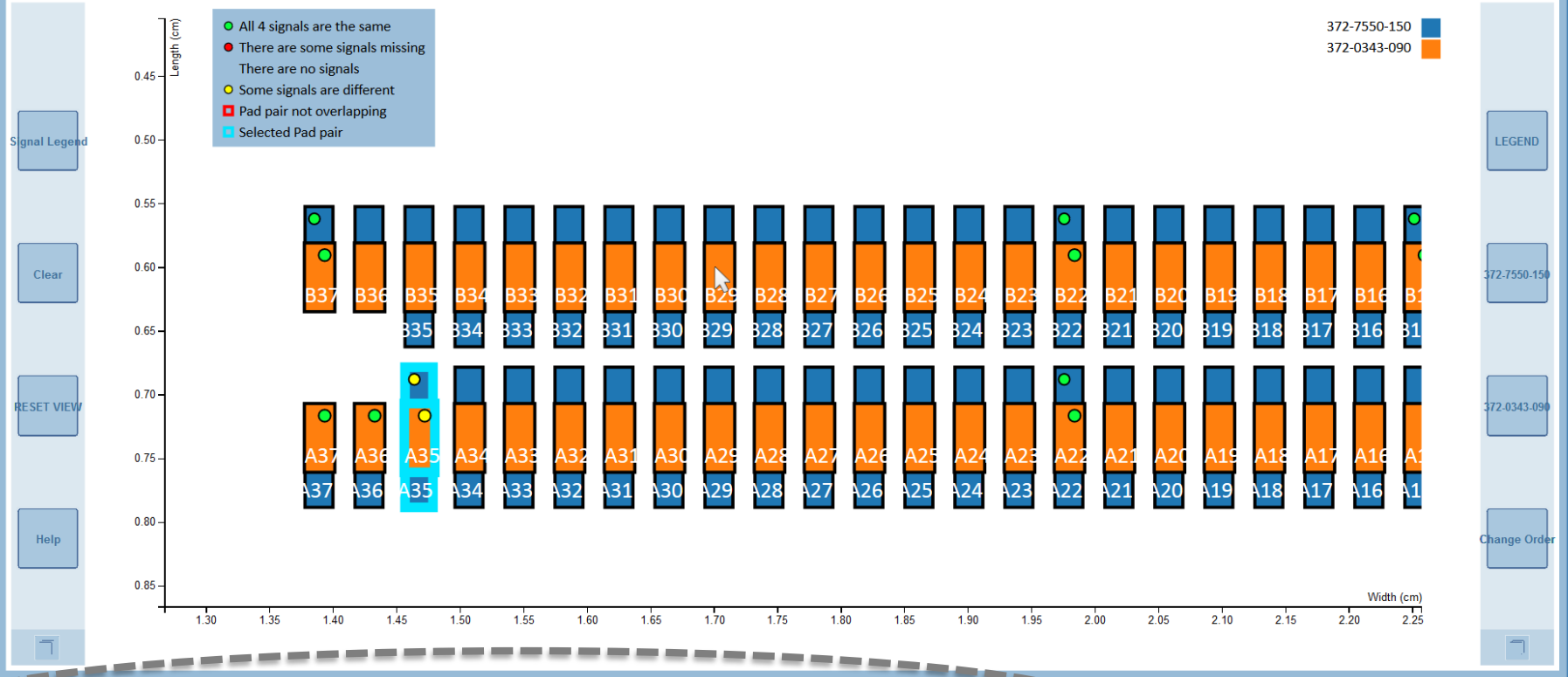
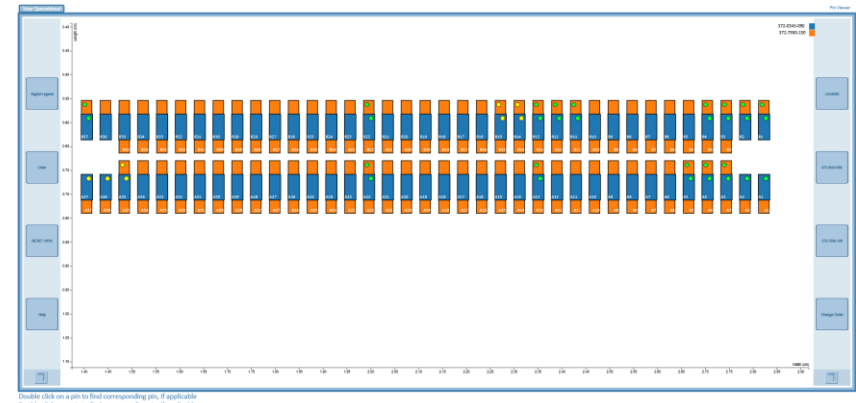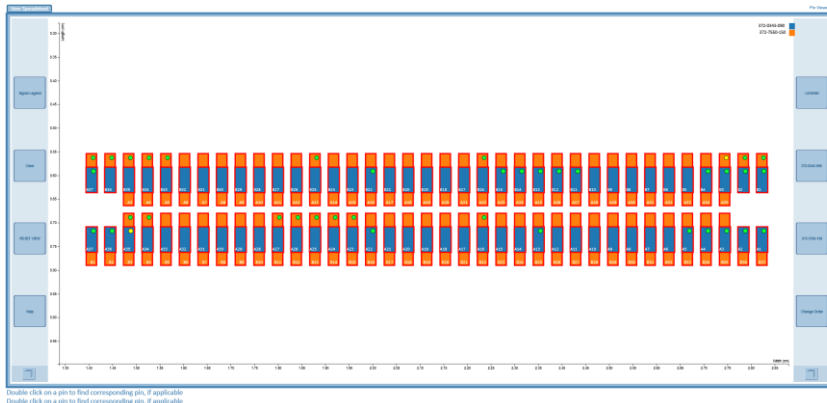| Part : 372-7550-150 | Pos : P2 | PinNum : A35 | Signal Board : ' DISC_IN44 ' | Signal Interconnect : ' DISC_IN44 ' |
| Part : 372-0343-090 | Pos : J2 | PinNum : A35 | Signal Board : ' $1N885 ' | Signal Interconnect : ' $1N885 ' |

Values for selected pair of Pads

Error Test Cases

- ## Two error test cases
  - ### Rotated connector
  - ### Signals connected to wrong pins on one board

Test Case 2

Test Case 3

Agenda

- The problem and demonstration objectives
- Approach
  - The tool being used
- Demonstration of consistency checking
  - Original Data set
  - Test cases
- **Applying Intellectual Property protection to the problem**
- Achievements and next steps
- Questions

IP (Intellectual Property) Protection – Demo Objectives

Objectives

- **Show that data owner determines who has access**

- **Show that each party has appropriate access (and no more)**

- **Phase 1 demonstrates file level access control/protection**

  - **Phase 2 will demonstrate data object level access control/protection**

IP Protection

827-9999-950, BSCU Top Level
- 827-9999-951 Front Panel
- 827-9999-952 Chassis
- 827-9999-953 Back Cover
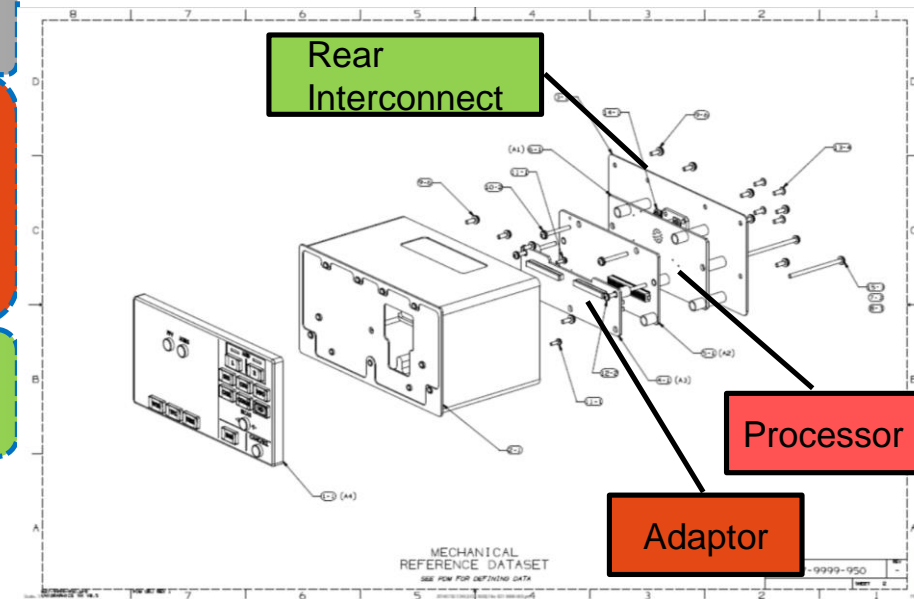- 827-9999-954 CCA, Adapter
  - 827-9999-955 PWB, Adapter
- 827-9999-956 CCA, Processor
  - 827-9999-957 PWB, Processor
  - 828-7360-001 Schematic, Processor
  - 372-7550-150 Connector, PCB, Header, 74 pin, P2
- 827-9999-958 CCA, Rear Interconnect
  - 827-9999-959 PWB, Rear Interconnect
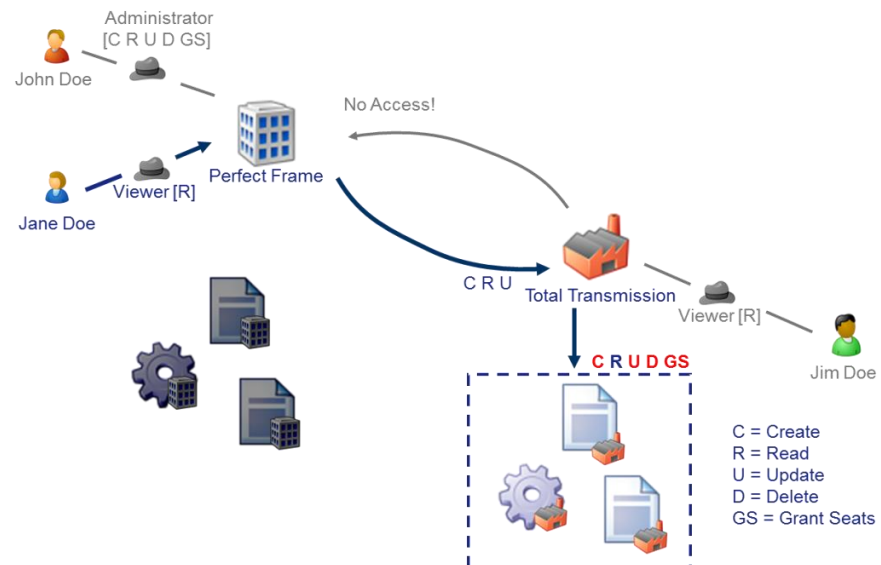 - 372-0343-090 Connector, PCB, Receptacle, 74 pin, J2

Rear Interconnect

Processor

Adaptor

MECHANICAL REFERENCE DATASET
SEE PDM FOR DEFINING DATA

OEM

Supplier A

Supplier B
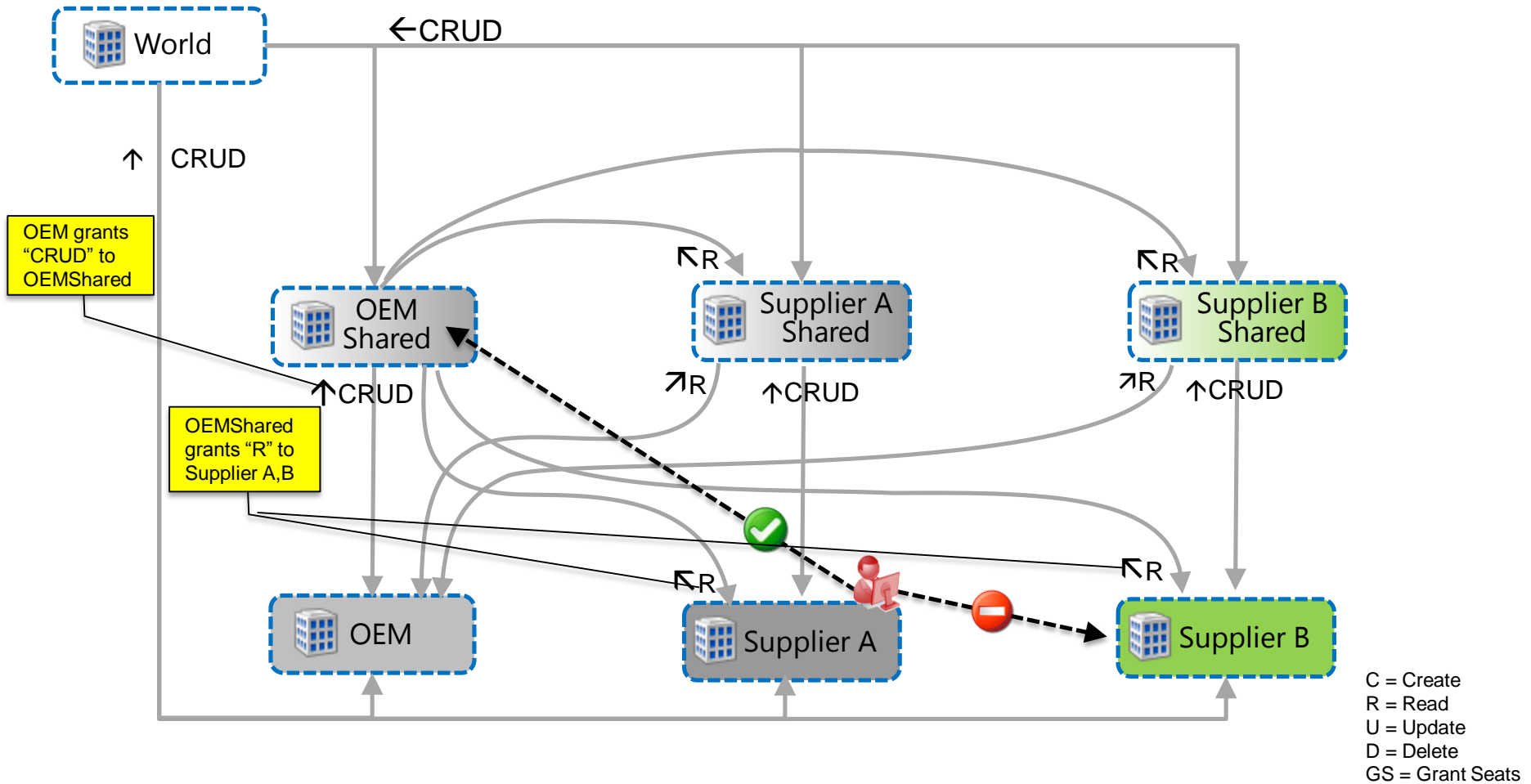
ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING   GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

- ## Access based on "ownership" of each object

- ## Access to an object is "owned" by an organization

  - ### Grant access to another organization (granting access to all users having a role in that organization)

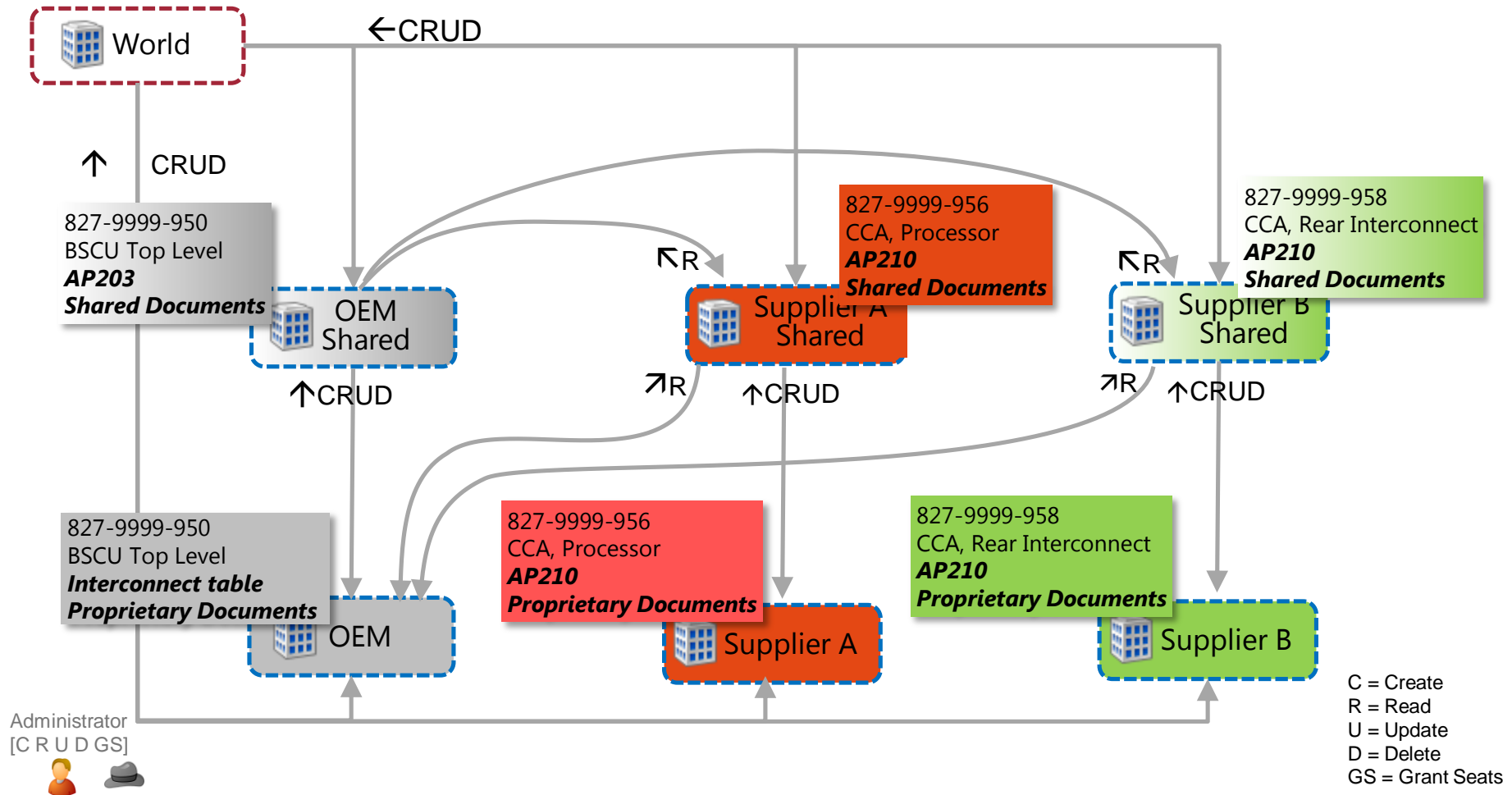 - ### Assign a named user as specific role in the owning organization

Access Relationships

C = Create
R = Read
U = Update
D = Delete
GS = Grant Seats

Access Relationships

World

←CRUD

↑ CRUD

827-9999-950
BSCU Top Level
AP203
Shared Documents

OEM
Shared

↑CRUD

827-9999-956
CCA, Processor
AP210
Shared Documents

Supplier A
Shared

↗R
↑CRUD

827-9999-958
CCA, Rear Interconnect
AP210
Shared Documents

Supplier B
Shared

↖R
↑CRUD

↖R

827-9999-950
BSCU Top Level
Interconnect table
Proprietary Documents

OEM

827-9999-956
CCA, Processor
AP210
Proprietary Documents

Supplier A

827-9999-958
CCA, Rear Interconnect
AP210
Proprietary Documents

Supplier B

Administrator
[C R U D GS]

C = Create
R = Read
U = Update
D = Delete
GS = Grant Seats

ELYSIUM Parker NORTHROP GRUMMAN BOEING GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Access Relationships

Supplier A has granted rights to ….

Supplier A has been granted (received) rights to ….
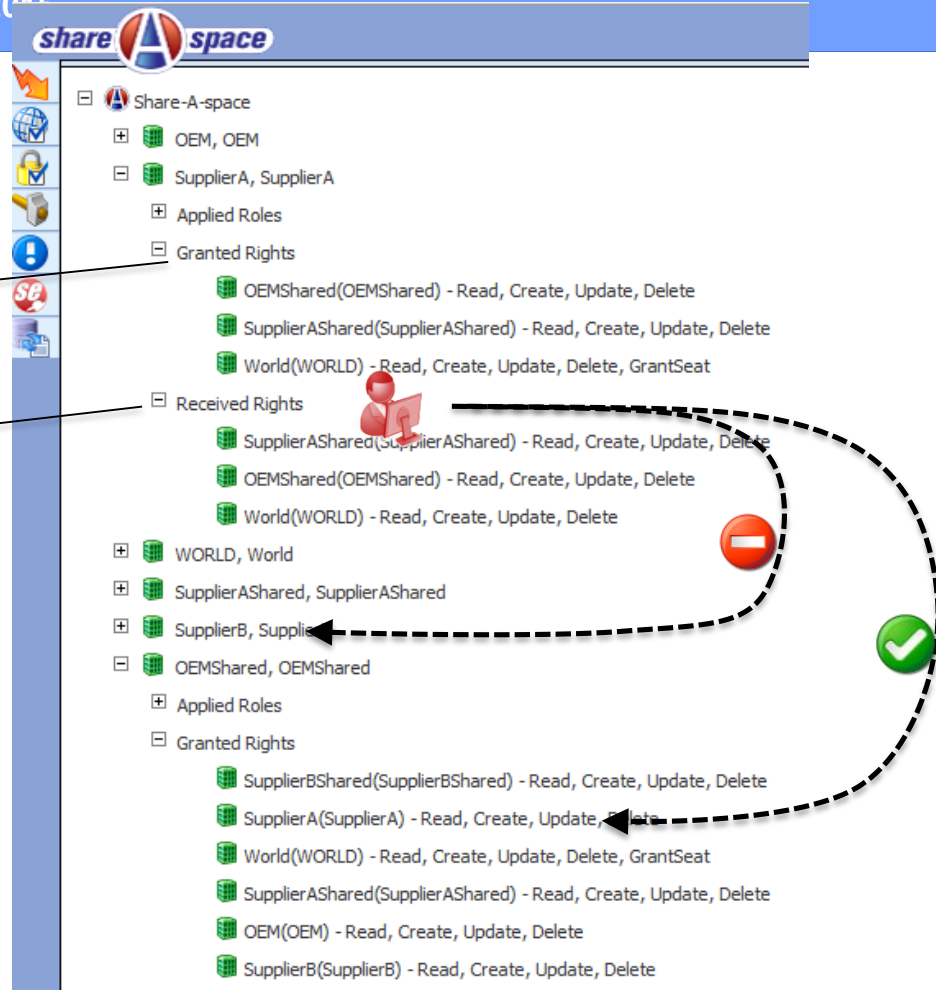
Supplier A

Part Number	Part Name	Document Id
827-9999-954	CCA, Adapter	827-9999-954 Adapter CCA NX prt.prt
827-9999-955	PWB, Adapter	827-9999-955 Adapter PWB NX prt.prt
827-9999-956	CCA, Processor	827-9999-956- SAVI Background Proprietary Information stp.stp.ind
827-9999-956	CCA, Processor	827-9999-956 Processor CCA IDF brd.brd
827-9999-956	CCA, Processor	827-9999-956 Processor CCA IDF pro.pro
827-9999-956	CCA, Processor	827-9999-956 Processor CCA NX prt.prt
827-9999-957	PWB, Processor	827-9999-957 Processor PWB NX prt.prt
372-7550-150	Connector, PCB, Header, 74 pin	372-7550-150 PW csv.csv

Supplier A Shared

Part Number	Document Id
827-9999-950	
827-9999-954	827-9999-954 Adapter CCA 2DPDF pdf.pdf
827-9999-954	827-9999-954 Adapter CCA STEP stp.stp
827-9999-955	827-9999-955 Adapter PWB 2DPDF pdf.pdf
827-9999-955	827-9999-955UG Adapter PWB 2DPDF pdf.pdf
827-9999-956	827-9999-956- SAVI Background Proprietary Information stp.stp
827-9999-956	827-9999-956 Processor CCA 2DPDF pdf.pdf
827-9999-956	827-9999-956 Processor CCA STEP stp.stp
827-9999-957	827-9999-957 Processor PWB 2DPDF pdf.pdf
827-9999-957	827-9999-957 Processor PWB STEP stp.stp
372-7550-150	372-7550-150 PW AP203 stp.stp

Supplier B

Part Number	Part Name	Document Id
827-9999-958	CCA, Rear Interconnect	827-9999-958 Rear Interconnect CCA NX prt.prt
827-9999-958	CCA, Rear Interconnect	827-9999-958 Rear Interconnect IDF brd.brd
827-9999-958	CCA, Rear Interconnect	827-9999-958 Rear Interconnect IDF pro.pro
827-9999-959	PWB, Rear Interconnect	827-9999-959 Rear Interconnect PWB NX prt.prt
372-0343-090	Connector, PCB, Receptacle, 74 pin	372-0343-090 PW csv.csv

Supplier B Shared

Part Number	Part Name	Document Id
827-9999-950	BSCU Top Level	
827-9999-958	CCA, Rear Interconnect	827-9999-958- SAVI Background Proprietary Information stp.s
827-9999-958	CCA, Rear Interconnect	827-9999-958 Rear Interconnect CCA 2DPDF pdf.pdf
827-9999-958	CCA, Rear Interconnect	827-9999-958 Rear Interconnect CCA STEP stp.stp
827-9999-959	PWB, Rear Interconnect	827-9999-959 Rear Interconnect PWB 2DPDF pdf.pdf
827-9999-959	PWB, Rear Interconnect	827-9999-959 Rear Interconnect PWB STEP stp.stp
372-0343-090	Connector, PCB, Receptacle, 74 pin	372-0343-090 PW AP203 stp.stp

OEM

Part Number	Part Name	Document Id
827-9999-950	BSCU Top Level	Processor-CCA-to-Rear-Interconnect-CCA System Interconnect Table xlsx.xlsx
827-9999-950	BSCU Top Level	827-9999-950 BSCU Top Level NX prt.prt
827-9999-951	Front Panel	827-9999-951 Front Panel NX prt.prt
827-9999-952	Chassis	827-9999-952 Chassis NX prt.prt
827-9999-953	Back Cover	827-9999-953 Back Cover NX prt.prt

OEM Shared

Part Number	Document Id
827-9999-950	
827-9999-950	827-9999-950 BSCU Top Level STEP RevA stp.stp
827-9999-950	827-9999-950 BSCU Top Level STEP stp.stp
827-9999-951	827-9999-951 Front Panel 2DPDF pdf.pdf
827-9999-951	827-9999-951 Front Panel STEP stp.stp
827-9999-952	827-9999-952 Chassis 2DPDF pdf.pdf
827-9999-952	827-9999-952 Chassis STEP stp.stp
827-9999-953	827-9999-953 Back Cover 2DPDF pdf.pdf
827-9999-953	827-9999-953 Back Cover STEP stp.stp

Who Sees What: Product Structure

827-9999-950, BSCU Top Level
- 827-9999-951 Front Panel
- 827-9999-952 Chassis
- 827-9999-953 Back Cover
- 827-9999-954 CCA, Adapter
  - 827-9999-955 PWB, Adapter
- 827-9999-956 CCA, Processor
  - 827-9999-957 PWB, Processor
  - 828-7360-001 Schematic, Processor
  - 372-7550-150 Connector, PCB, Header, 74 pin, P2
- 827-9999-958 CCA, Rear Interconnect
  - 827-9999-959 PWB, Rear Interconnect
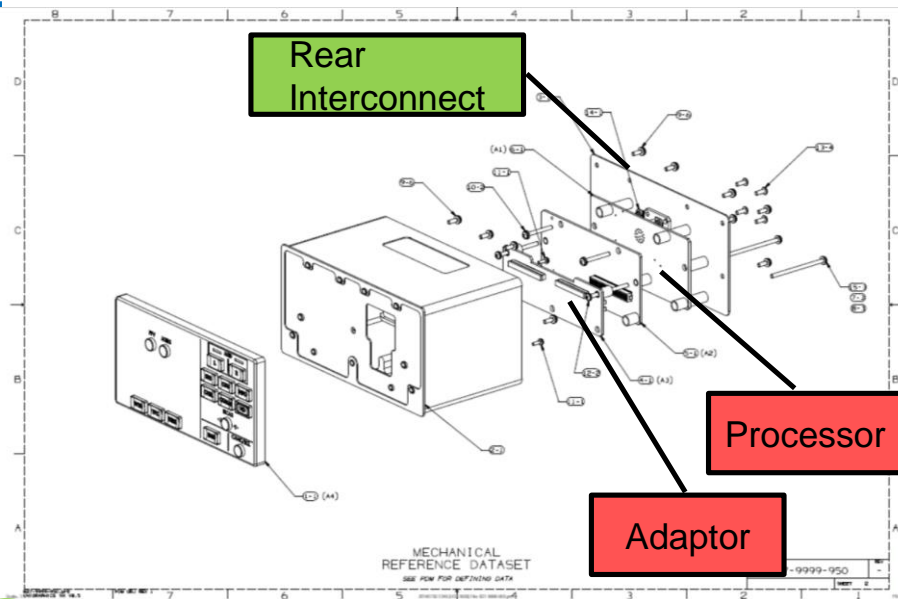 - 372-0343-090 Connector, PCB, Receptacle, 74 pin, J2

OEM

Supplier A

Supplier B

Rear Interconnect

Processor

Adaptor

MECHANICAL REFERENCE DATASET
SEE PDM FOR DEFINING DATA

	Has Access to						
	World	OEM	OEM Shared	Supplier A	Supplier A Shared	Supplier B	Supplier B Shared
World		X	X	X	X	X	X
OEM	CRUD	-	CRUD	X	R	X	R
OEM Shared	CRUD	X	-	X	R	X	R
Supplier A	CRUD	X	R	-	CRUD	X	X
Supplier A Shared	CRUD	X	R	X	-	X	X
Supplier B	CRUD	X	R	X	X	-	CRUD
Supplier B Shared	CRUD	X	R	X	X	X	-

Agenda

- **The problem and demonstration objectives**
- **Approach**
  - **The tool being used**
- **Demonstration of consistency checking**
  - **Original Data set**
  - **Test cases**
- **Applying Intellectual Property protection to the problem**
- **Achievements and next steps**
- **Questions**

Conclusions – Objectives Satisfied

- Demonstrate MR/DEL infrastructure and capabilities
  - Share-A-space® based collaboration hub

- Show standards-based data interoperability foundation
  - AP239, AP210, AP214

- Show SAVI consistency checks applied to system (Excel), mechanical (MCAD), and electrical (ECAD) models
  - Electrical interconnect consistency check

- Detect integration errors in model set prior to physical integration (using a known problem)
  - Demonstrated "sunny day" and error test cases

- Show SAVI capability adding value to current product development process at a Tier 1 supplier
  - Production process at Rockwell Collins

- Show protection of Intellectual Property (IP)
  - Demonstrated at file level

ELYSIUM Parker NORTHROP GRUMMAN BOEING GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Next Steps

- Demonstrate MR/DEL infrastructure and capabilities
  - Share-A-space® based collaboration hub
  - Expand number of model types (PackageWright, wire harnesses and connectors)
- Show standards-based data interoperability foundation
  - AP239, AP210, AP214
  - SysML, Simulink, Modelica, AADL (Behavior Use Cases)
- Show SAVI consistency checks applied to system (Excel), mechanical (MCAD), and electrical (ECAD) models
  - Electrical interconnect consistency check
  - Connector-to-CCA, wiring harnesses, L0 and L1 interconnect, more complex geometry
- Detect integration errors in model set prior to physical integration (using a known problem)
  - Demonstrated "sunny day" and error test cases
  - Expand to behavior and wiring harness use cases
- Show SAVI capability adding value to current product development process at a Tier 1 supplier
  - Production process at Rockwell Collins
  - Zonal Safety Analysis
- Show protection of Intellectual Property (IP)
  - Demonstrated at file level
  - Demonstrate at individual model property level

Questions

Web API – presentation model

File format

Web API to SAS mapping
Parametric diagrams. Web API mapped to Share-A-space® model (mapping specs)

File to SAS mapping
Parametric diagrams. File format mapped to Share-A-space® model (mapping specs)

Domain Object model
Bespoke Business Object models for a domain / project

SAslib Template
Business high level Template

BoM to SAS mapping
Parametric diagrams. BOM mapped to Share-A-space® model (mapping specs)

Share-A-space® model
PLCS based information model