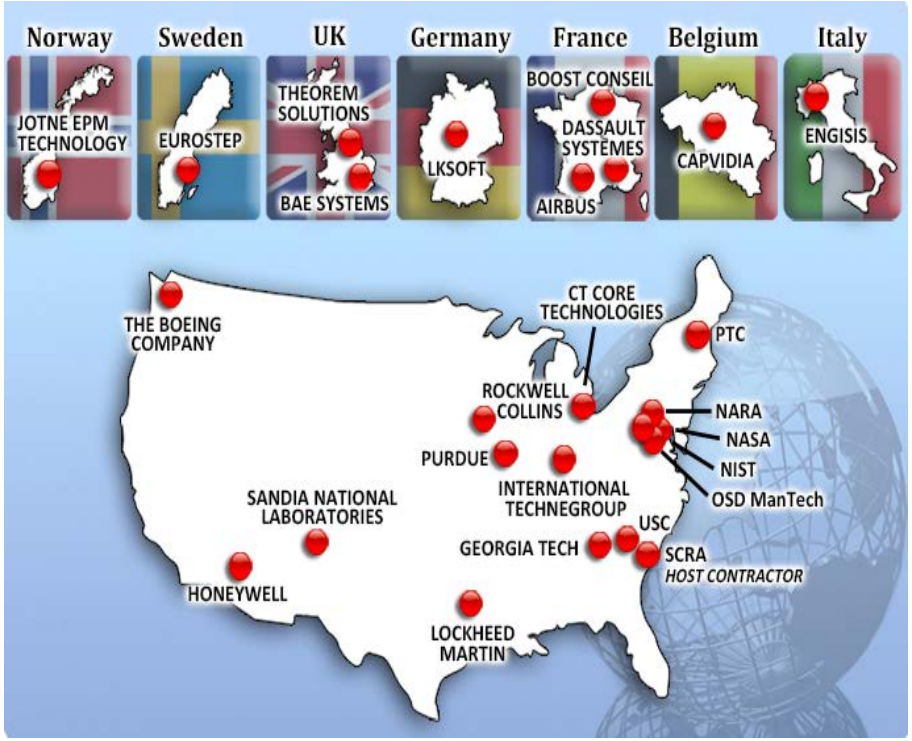
Multi-Domain Systems Engineering Interoperability

MBE Summit

18 December 2013

Greg Pollari, Rockwell Collins
John Russell, Honeywell
PDES Systems Engineering Project Leads

Joint PDES – SAVI Presentation



PDES, Inc. is an international industry/government/university consortium committed to accelerating the development and implementation of standards enabling enterprise integration and PLM interoperability for its member companies.

The AVSI SAVI Program is a collaboration between aerospace system development stakeholders that aims to advance the state of the art of technologies that enable virtual integration of complex systems.

Systems Engineering Interoperability

"Integrate, Analyze, then Build"

www.pdesinc.org/

http://savi.avsi.aero/

Supply Chain Tiers

Multiple Data Formats

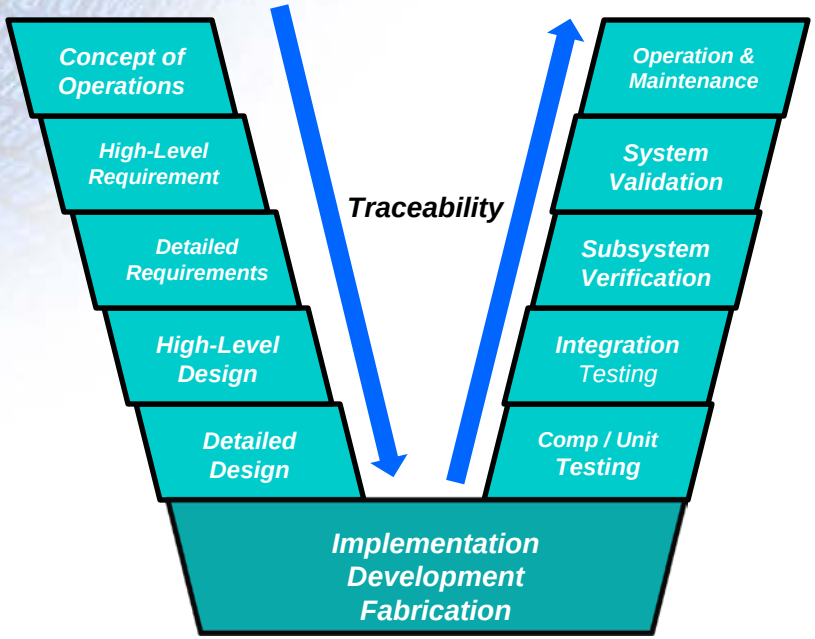
Multiple Data Repositories

THE SITUATION

Product Development SE Data Exchanges

PDES, Inc.®

Text	Trend	Models & DB's	Trend	Diagrams	Trend
80%	↓	10%	↑	10%	↑
60%	↓	10%	↑	30%	↑
50%	↓	20%	↑	30%	↑
10%	–	30%	↑	60%	↓
10%	–	40%	↑	50%	↓
20%	↓	40%	↑	40%	↓

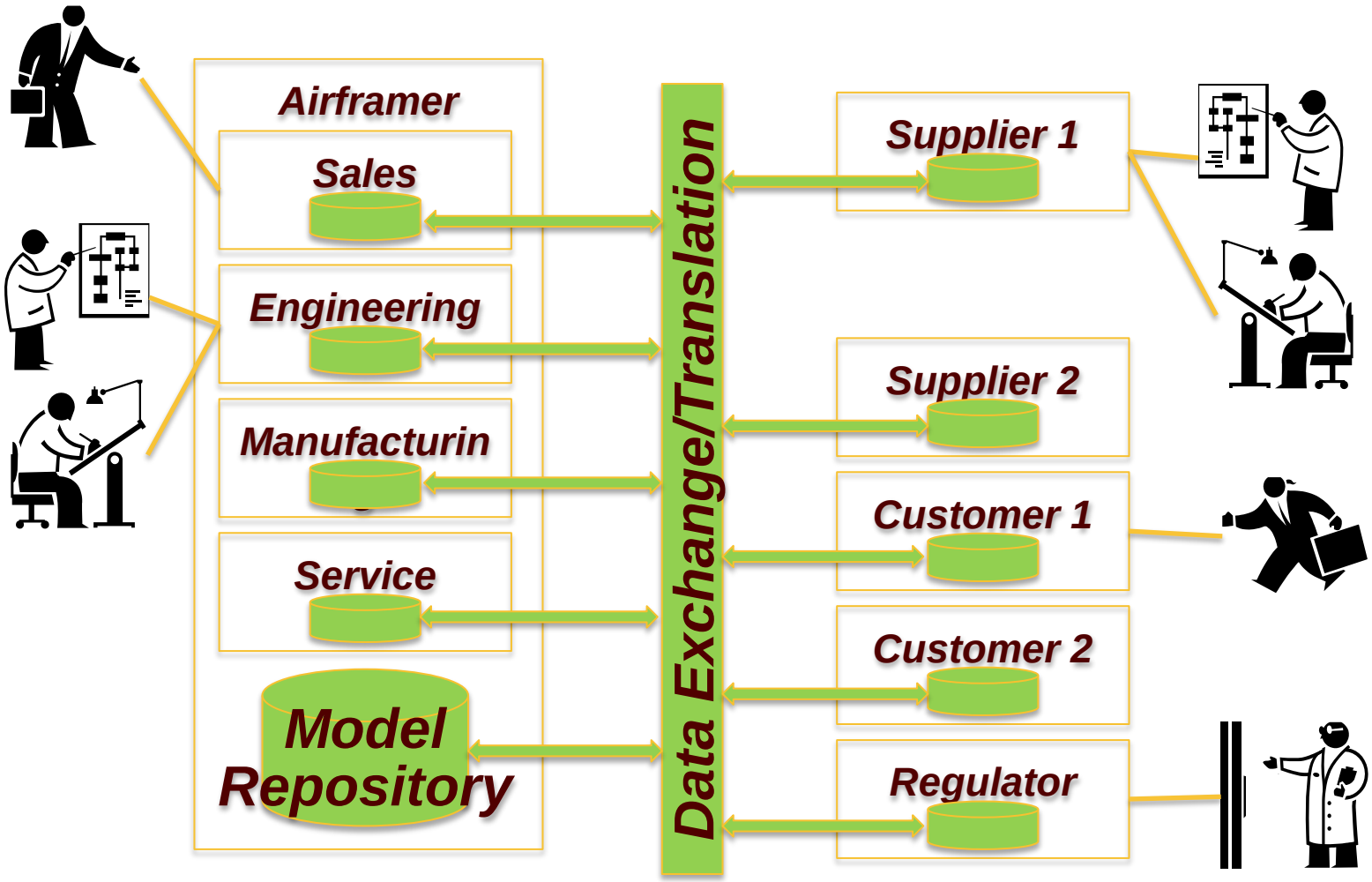


Text	Trend	Models & DB's	Trend	Diagrams	Trend
40%	↓	40%	↑	20%	↑
30%	↓	60%	↑	10%	↑
30%	↓	60%	↑	10%	↑
30%	–	65%	↑	5%	↓
20%	–	75%	↑	5%	↓
20%	↓	40%	↑	40%	↓

- MBD / MBE Impacting Systems Engineering Processes
- Percentages Driven by an Organization's MBE Adoption & Maturity
  - **Models exchanges increasing**
  - **Text based requirements will not go away**

© PDES, Inc. 2013

Multiple Groups/Tools/Repositories



Cross-Domain Linking

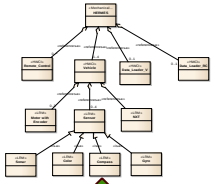
Model Explosion

Increasing Complexity

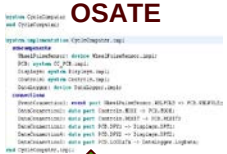
THE MODEL ENVIRONMENT

Models Across the Supply Chain

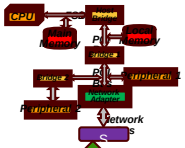
SysML
Enterprise Architect



AADL
OSATE

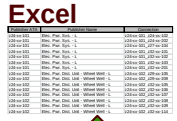


RTES Analysis
ASIIST

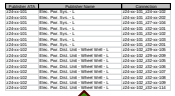


3D Solid Geometry
SolidWorks, NX

Correspondence Pub-Sub
Excel



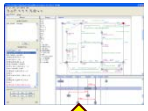
Requirements
DOORS, Excel



Fault Tree
CAFTA

Constraint Analysis
LUTE

Behavior
UPPAAL

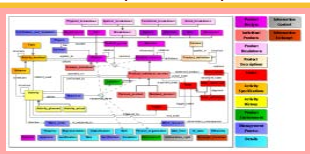


Hazard Table
Excel

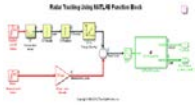
FMEA
Excel

Markov Chains
PRISM

SAVI MR/DEL
Standards: PLCS/DEX, STEP, ReqIF, XMI, OSLC, Eclipse
Proprietary: Intentional SW, The Mathworks



Simulink



SCADE

Behavior
Modelica

Proprietary

PDM/PLM
TeamCenter, Enovia, Windchill

ERP

SVN

Eurostep *Share-A-space®*

© AVSI

Requirements Model

A/C Reqts (excerpt)

Requirement	Description	Derived	Traced From
S18-ACFT-R-0009	Aircraft shall have a means to decelerate on the ground in accordance with 14CFR 25.735	14 CFR Part 25.735	Minimum standard required for aircraft certification
S18-ACFT-R-0110	Aircraft shall have autobrake function	Derived	Technological improvements in CAT IIIb auto-landing capability and market research, (report MRS18- XXX) about the customer needs
S18-ACFT-R-0135	Aircraft shall provide an anti-skid function.	Derived	All weather operation and stability of the aircraft during runway
S18-ACFT-R-0184	Aircraft shall have hydraulically-driven brake function	Derived	
S18-ACFT-R-0185	The pilot shall be allowed to override the autobrake function.	14CFR 25.735(c)(2)	

A/C FHA (excerpt)

Failure Condition (Hazard Description)	Phase	Effect of Failure Condition on Aircraft/Crew	Classification
Loss of Deceleration Capability	Landing, RTO, Taxi	See Below	See Below
a. Unannunciated loss of Deceleration Capability	Landing, RTO	Catastrophic	Crew is unable to decelerate the aircraft,resulting in a high speed overrun
b. Annunciated loss of Deceleration Capability	Landing	Hazardous	Crew selects a more suitable runway,notifies emergency ground support, and prepares occupants for runway overrun.
c. Unannunciated loss of Deceleration Capability	Taxi	Major	Crew is unable to stop the aircraft on the taxi way or gate resulting in low speed contact with terminal, aircraft, or vehicles.
d. Annunciated loss of Deceleration Capability	Taxi	No Safety Effect	Crew steers the aircraft clear of any obstacles and calls for a tug or portable stairs.

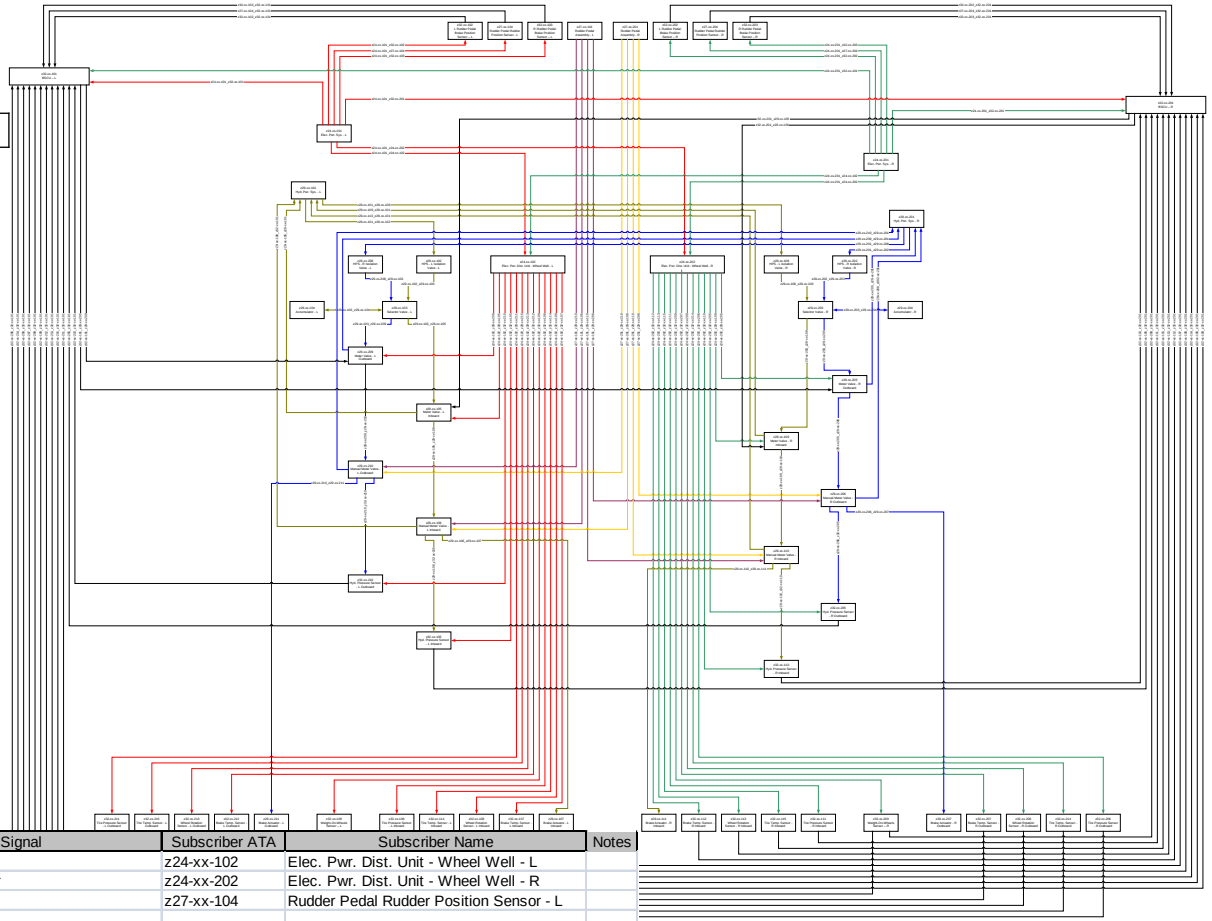
WBS FHA (excerpt)

Function	Failure Condition (Hazard Description)	Phase	Effect of Failure Condition on Aircraft/Crew	Classification	Reference to Supporting Material	Verification
Decelerate Aircraft using Wheel Braking	Total Loss of wheel braking	Landing or RTO	See Below			
	a. Unannunciated loss of wheel braking	Landing or RTO	Crew detects the failure when the brakes are operated. The crew uses spoilers and thrust reversers to the maximum extent possible. This may result in a runway overrun.	Hazardous		S18 Aircraft FTA
	b. Annunciated loss of wheel braking	Landing	Crew selects a more suitable airport, notifies emergency ground support, and prepares occupants for runway overrun. The crew uses spoilers and thrust reversers to the maximum extent possible.	Hazardous	Crew procedures for loss of normal and reserve modes	S18 Aircraft FTA
	Partial Symmetrical Loss of Wheel Braking	Landing or RTO	See below			
	a. Unannunciated partial symmetrical loss of wheel braking	Landing or RTO	The crew detects the failure when the brakes are used. Crew uses available wheel braking, spoilers and thrust reversers available to maximum extent to decelerate the aircraft. The temperature on wheels of the loaded brakes increases and could reach point where wheel/fire failure occurs. Depending on number of brakes lost result could be an overrun.	Major to Hazardous	Additional study required to determine classification	Potentially catastrophic â€" to be confirmed by analysis
	b. Annunciated partial symmetrical loss of wheel braking	Landing	The crew is aware that there is a partial loss of braking before landing. Crew uses wheel braking, spoilers and thrust reversers available to maximum extent to decelerate the aircraft. The temperature on wheels of the loaded brakes increases and could reach point where wheel/fire failure occurs. Depending on number of brakes lost result could be an overrun.	Major		
	Asymmetrical Loss of Wheel Braking	Landing or RTO	See below			
	a. Asymmetrical loss of wheel braking â€" brake system failure only	Landing or RTO	Decrease in braking performance. Tendency to veer off the runway. For braking performance and brake temperature the effects are the same as partial brake loss above. The crew keeps the aircraft on the runway by using rudder at high speed and nose wheel steering at low speed. Consequences are TBD pending results of the justification studies.	Potentially catastrophic â€" to be confirmed by analysis	Additional studies required to determine classification.	
	b. Asymmetrical loss of wheel braking and loss of rudder or nose wheel steering	Landing or RTO	Decrease in braking performance. Tendency to veer off the runway. For braking performance and brake temperature the effects are the same as partial brake loss above. The crew cannot maintain runway centerline and results in an offside excursion.	Hazardous		S18 Aircraft FTA
	Inadvertent wheel brake application		See below			

© AVSI

Publisher/Subscriber Model

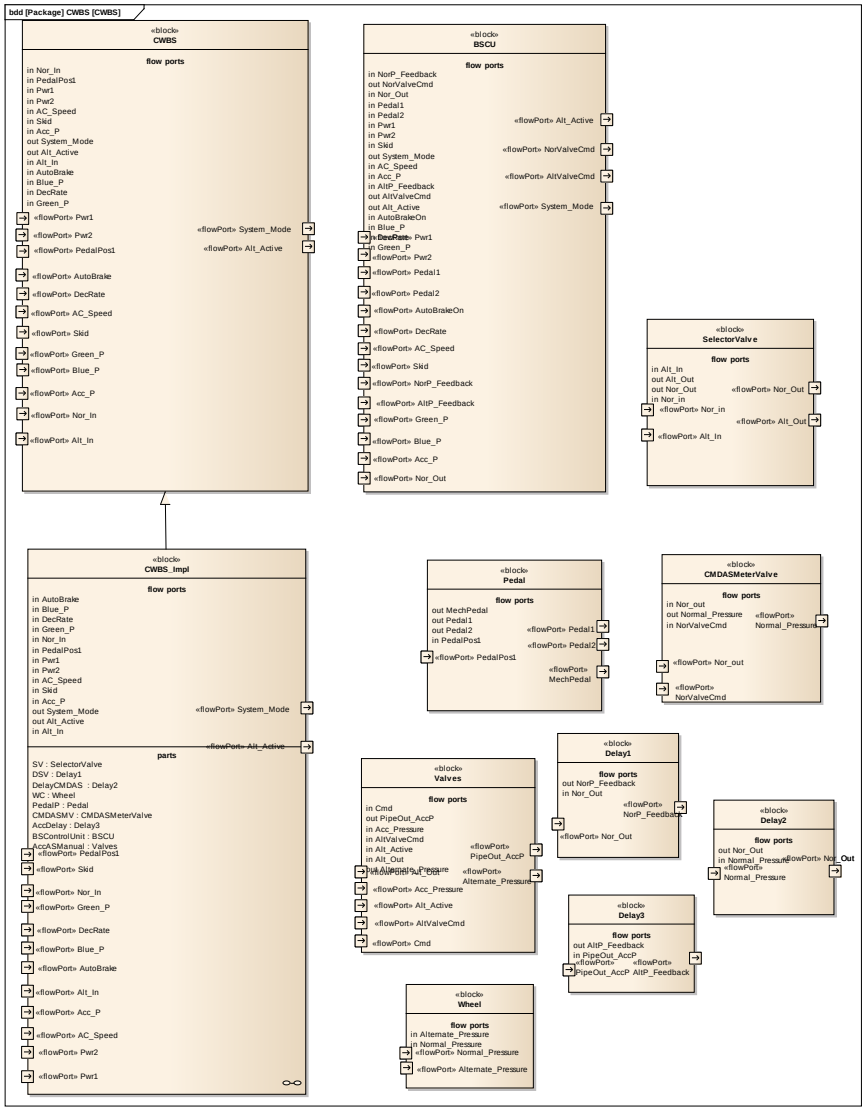
ATA	Name
z24-xx-101	Elec. Pwr. Sys. - L
z24-xx-102	Elec. Pwr. Dist. Unit - Wheel Well - L
z24-xx-201	Elec. Pwr. Sys. - R
z24-xx-202	Elec. Pwr. Dist. Unit - Wheel Well - R
z27-xx-101	Rudder Pedal Assembly - L
z27-xx-104	Rudder Pedal Rudder Position Sensor - L
z27-xx-201	Rudder Pedal Assembly - R
z27-xx-204	Rudder Pedal Rudder Position Sensor - R
z29-xx-101	Hyd. Pwr. Sys. - L
z29-xx-102	HPS - L Isolation Valve - L
z29-xx-103	Selector Valve - L
z29-xx-104	Accumulator - L

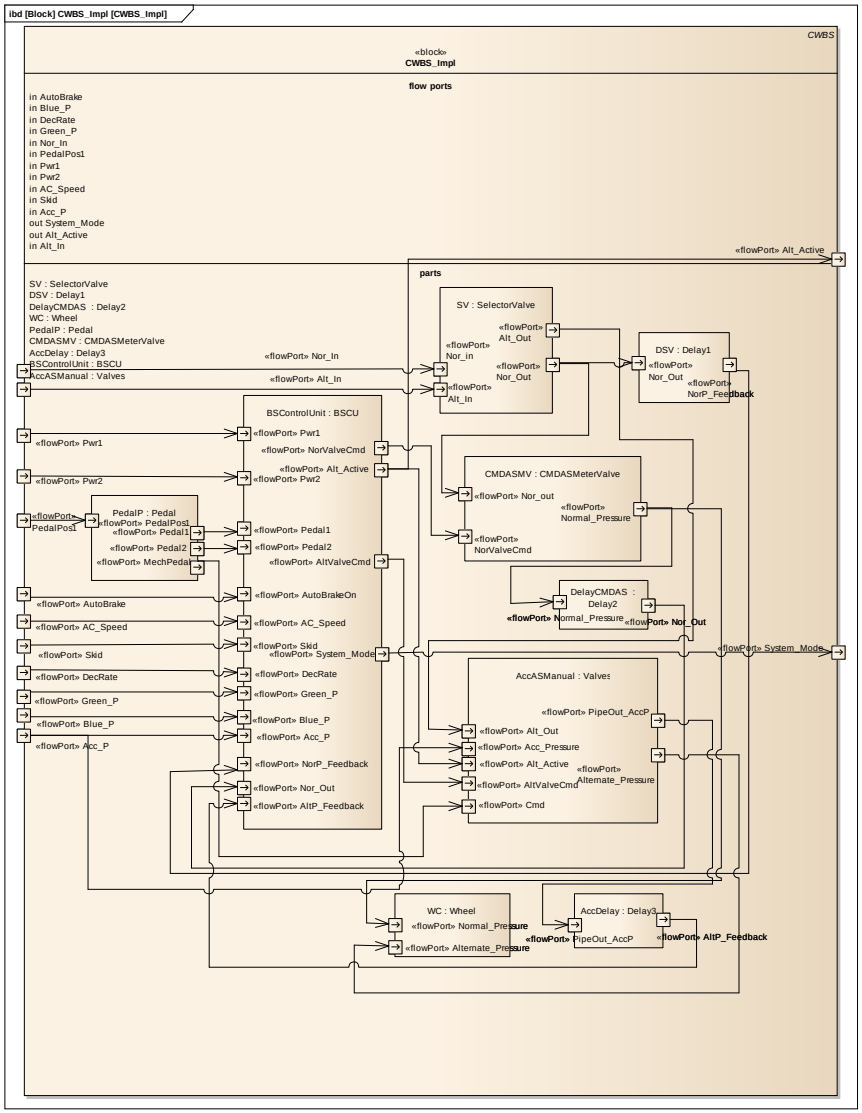


Publisher ATA	Publisher Name	Connection	Signal	Subscriber ATA	Subscriber Name	Notes
z24-xx-101	Elec. Pwr. Sys. - L	z24-xx-101_z24-xx-102	Primary Power	z24-xx-102	Elec. Pwr. Dist. Unit - Wheel Well - L	
z24-xx-101	Elec. Pwr. Sys. - L	z24-xx-101_z24-xx-202	Secondary Power	z24-xx-202	Elec. Pwr. Dist. Unit - Wheel Well - R	
z24-xx-101	Elec. Pwr. Sys. - L	z24-xx-101_z27-xx-104	Main Power	z27-xx-104	Rudder Pedal Rudder Position Sensor - L	
z27-xx-101	Rudder Pedal Assembly - L	z27-xx-101_z29-xx-110	Mechanical Power	z29-xx-110	Manual Meter Valve - R Inboard	
z27-xx-101	Rudder Pedal Assembly - L	z27-xx-101_z29-xx-206	Mechanical Power	z29-xx-206	Manual Meter Valve - R Outboard	
z29-xx-101	Hyd. Pwr. Sys. - L	z29-xx-101_z29-xx-102	Hyd. Power (Pressure)	z29-xx-102	HPS - L Isolation Valve - L	
z29-xx-103	Selector Valve - L	z29-xx-103_z29-xx-104	Hyd. Power (Pressure)	z29-xx-104	Accumulator - L	Bi
z29-xx-105	Meter Valve - L Inboard	z29-xx-105_z29-xx-101	Hyd. Power (Return)	z29-xx-101	Hyd. Pwr. Sys. - L	
z32-xx-101	BSCU - L	z32-xx-101_z29-xx-205	Meter Valve – R Outboard Command	z29-xx-205	Meter Valve - R Outboard	
z32-xx-101	BSCU - L	z32-xx-101_z29-xx-209	Meter Valve – L Outboard Command	z29-xx-209	Meter Valve - L Outboard	
z32-xx-109	Weight-On-Wheels Sensor - L	z32-xx-109_z32-xx-101	Weight-On-Weels Sensor – L Reading	z32-xx-101	BSCU - L	
z32-xx-109	Weight-On-Wheels Sensor - L	z32-xx-109_z32-xx-201	Weight-On-Weels Sensor – L Reading	z32-xx-201	BSCU - R	

© AVSI

SysML Model


bdd [Package] CWBS [CWBS]
«block» CWBS
flow ports
in Nor_In
in PedalPos1
in Pwr1
in Pwr2
in AC_Speed
in Skid
in Acc_P
out System_Mode
out Alt_Active
in Alt_In
in AutoBrake
in Blue_P
in DecRate
in Green_P
«flowPort» Pwr1
«flowPort» Pwr2
«flowPort» PedalPos1
«flowPort» AutoBrake
«flowPort» DecRate
«flowPort» AC_Speed
«flowPort» Skid
«flowPort» Green_P
«flowPort» Blue_P
«flowPort» Acc_P
«flowPort» Nor_In
«flowPort» Alt_In
«flowPort» System_Mode
«flowPort» Alt_Active
«block» BSCU
flow ports
in NorP_Feedback
out NorValveCmd
in Nor_Out
in Pedal1
in Pedal2
in Pwr1
in Pwr2
in Skid
out System_Mode
in AC_Speed
in Acc_P
in AltP_Feedback
out AltValveCmd
out Alt_Active
in AutoBrakeOn
in Blue_P
in DecRate
in Pwr1
in Green_P
«flowPort» Pwr2
«flowPort» Pedal1
«flowPort» Pedal2
«flowPort» AutoBrakeOn
«flowPort» DecRate
«flowPort» AC_Speed
«flowPort» Skid
«flowPort» NorP_Feedback
«flowPort» AltP_Feedback
«flowPort» Green_P
«flowPort» Blue_P
«flowPort» Acc_P
«flowPort» Nor_Out
«flowPort» Alt_Active
«flowPort» NorValveCmd
«flowPort» AltValveCmd
«flowPort» System_Mode
«block» SelectorValve
flow ports
in Alt_In
out Alt_Out
out Nor_Out
in Nor_in
«flowPort» Nor_in
«flowPort» Nor_Out
«flowPort» Alt_Out
«flowPort» Alt_In
«block» CWBS_Impl
flow ports
in AutoBrake
in Blue_P
in DecRate
in Green_P
in Nor_In
in PedalPos1
in Pwr1
in Pwr2
in AC_Speed
in Skid
in Acc_P
out System_Mode
out Alt_Active
in Alt_In
«flowPort» System_Mode
«flowPort» Alt_Active
parts
SV : SelectorValve
DSV : Delay1
DelayCMDAS : Delay2
WC : Wheel
PedalP : Pedal
CMDASMV : CMDASMeterValve
AccDelay : Delay3
BSControlUnit : BSCU
AccASManual : Valves
«block» Pedal
flow ports
out MechPedal
out Pedal1
out Pedal2
in PedalPos1
«flowPort» PedalPos1
«flowPort» Pedal1
«flowPort» Pedal2
«flowPort» MechPedal
«block» CMDASMeterValve
flow ports
in Nor_out
out Normal_Pressure
in NorValveCmd
«flowPort» Normal_Pressure
«flowPort» Nor_out
«flowPort» NorValveCmd
«block» Valves
flow ports
in Cmd
out PipeOut_AccP
in Acc_Pressure
in AltValveCmd
in Alt_Active
in Alt_Out
out Alternate_Pressure
«flowPort» PipeOut_AccP
«flowPort» Alternate_Pressure
«flowPort» Acc_Pressure
«flowPort» Alt_Active
«flowPort» AltValveCmd
«flowPort» Cmd
«block» Delay1
flow ports
out NorP_Feedback
in Nor_Out
«flowPort» NorP_Feedback
«flowPort» Nor_Out
«block» Delay2
flow ports
out Nor_Out
in Normal_Pressure
«flowPort» Normal_Pressure
«flowPort» Nor_Out
«block» Delay3
flow ports
out AltP_Feedback
in PipeOut_AccP
«flowPort» PipeOut_AccP
«flowPort» AltP_Feedback
«block» Wheel
flow ports
in Alternate_Pressure
in Normal_Pressure
«flowPort» Normal_Pressure
«flowPort» Alternate_Pressure


ibd [Block] CWBS_Impl [CWBS_Impl]
CWBS
«block» CWBS_Impl
flow ports
in AutoBrake
in Blue_P
in DecRate
in Green_P
in Nor_In
in PedalPos1
in Pwr1
in Pwr2
in AC_Speed
in Skid
in Acc_P
out System_Mode
out Alt_Active
in Alt_In
«flowPort» Alt_Active
parts
SV : SelectorValve
DSV : Delay1
DelayCMDAS : Delay2
WC : Wheel
PedalP : Pedal
CMDASMV : CMDASMeterValve
AccDelay : Delay3
BSControlUnit : BSCU
AccASManual : Valves
«flowPort» Nor_In
«flowPort» Alt_In
«flowPort» Pwr1
«flowPort» Pwr2
«flowPort» PedalPos1
«flowPort» AutoBrake
«flowPort» AC_Speed
«flowPort» Skid
«flowPort» DecRate
«flowPort» Green_P
«flowPort» Blue_P
«flowPort» Acc_P
«flowPort» Alt_Out
«flowPort» Nor_Out
«flowPort» NorP_Feedback
«flowPort» Normal_Pressure
«flowPort» NorValveCmd
«flowPort» Alternate_Pressure
«flowPort» PipeOut_AccP
«flowPort» AltP_Feedback
«flowPort» System_Mode
«flowPort» Cmd

System & SW Architecture with AADL

AADL - ARP4761/advanced/integration/main.aadl - Eclipse

File Edit Navigate Search Project OSATE Analyses Run Window Help

Generate Excel Report Import Lattix file Generate DSM Matrix Export AADL int

Import Simulink model

Quick Access AADL IMV Team Synchronizing

AADL Navigator

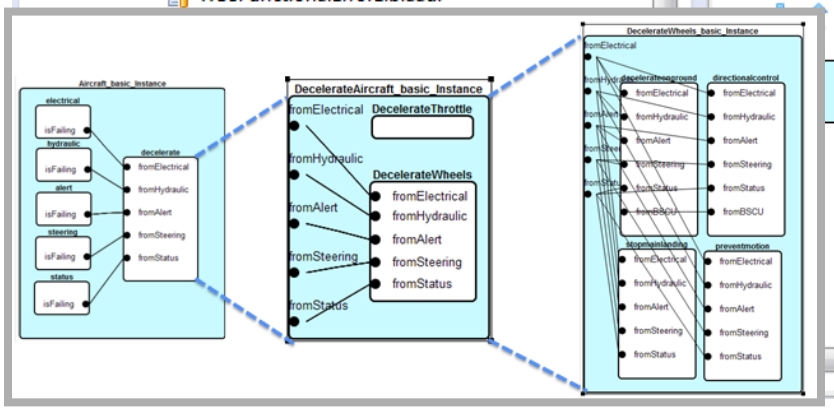
- > ARP4761 [examples master]
  - > advanced
    - common
    - > functional
      - imv
        - hydraulic.imv
      - > wbs
        - command-control.aadl
        - > generic.aadl
        - > main.aadl
      - electrical.aadl
      - generic_functions.aadl
      - > hydraulic.aadl
      - > main.aadl
      - throttle.aadl
      - WBSFunctionalErrorLib.aadl

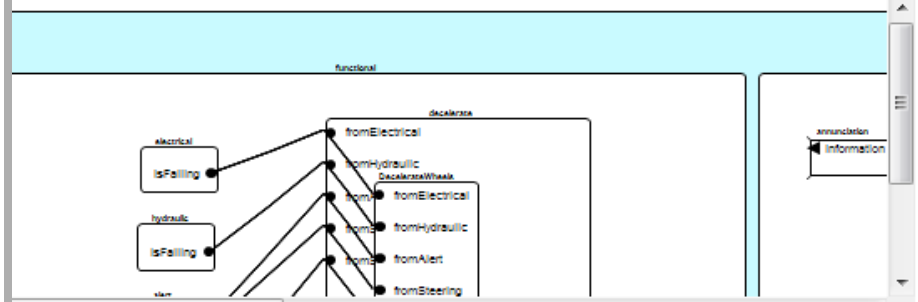
hydraulic.aadl | main.aadl

```
system implementation main.impl
subcomponents
    functional : system functional::main::Aircraft.basic;
    wbs_impl   : system impl::wbs::wbs.ima;
properties
--  We bind the WBS physical components to functions
--  On the physical components, we have to explicitly define bindings propaga
--  and on the function, we define processor bindings. Right now, we make use
--  of the processor binding mechanism to bind functions with their associate
--  runtime component.
    Actual_Processor_Binding => (reference (wbs_impl.bscu)) applies to functi
    Actual_Processor_Binding => (reference (wbs_impl)) applies to functional.
    Actual_Processor_Binding => (reference (wbs_impl.blue_pump),reference (wb
    Actual_Processor_Binding => (reference (wbs_impl.power),reference (wbs_im
```

*main_main_impl_Instance.imv

52%



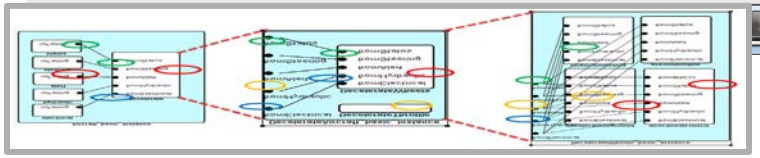


© AVSI

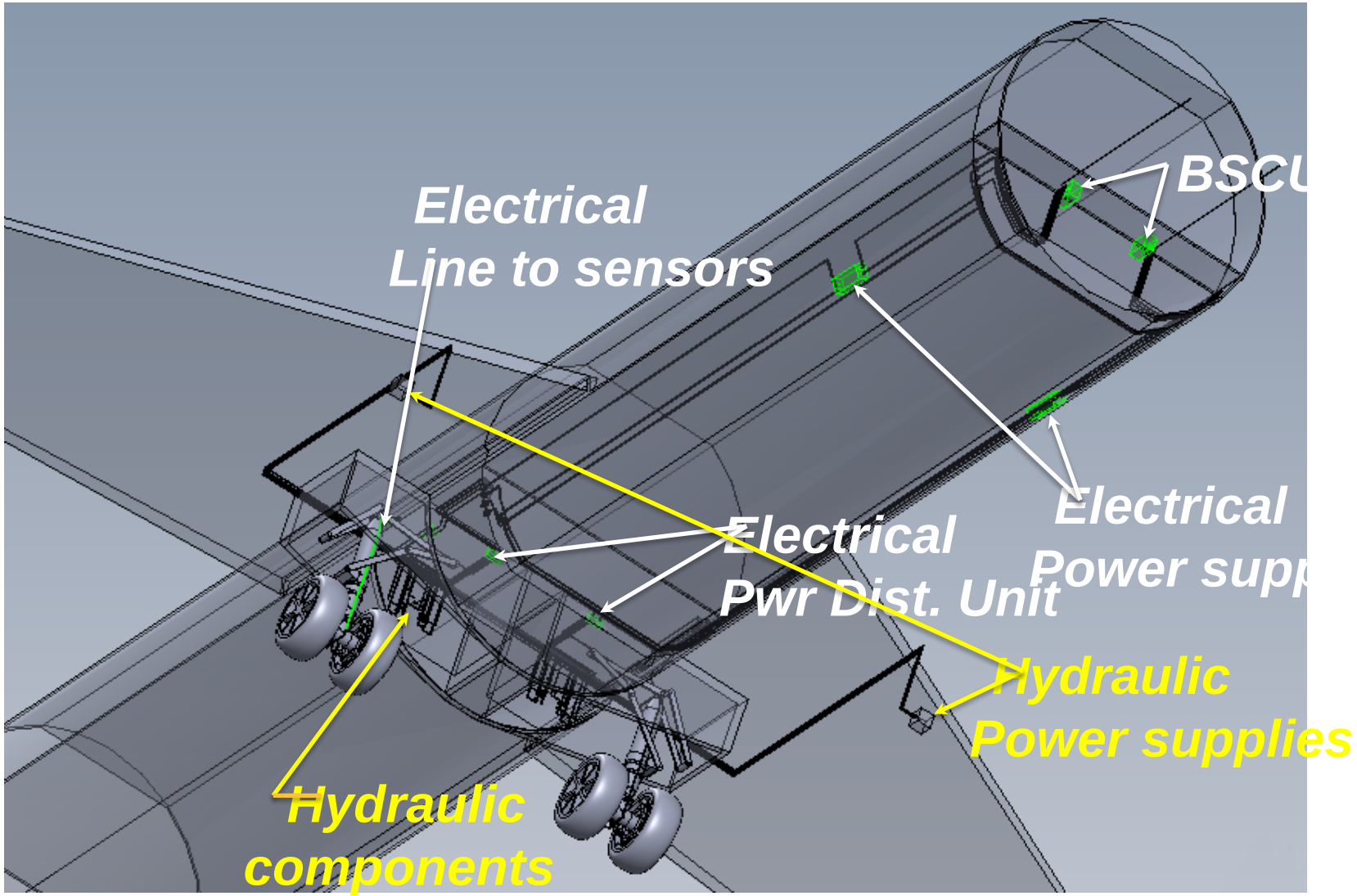
Architecture Fault Model

AADL - 01.07.01 - Meter valve standard/hyd_meter_valve.aadl - OSATE2

```
annex emv2 {**
      use types  hydraulic_errorlibrary,current_driver_bus_errorlibrary,hyd_meter_valve_errorlibrary;
      use behavior hyd_meter_valve_errorlibrary::metervalveerrorbehavior;

          error propagations
            hyd_bus_in: in propagation  {hydraulicerrors};
            hyd_bus_in: out propagation {hydraulicerrors};
            metered_hyd_bus_out : in propagation {hydraulicerrors};
            metered_hyd_bus_out : out propagation {hydraulicerrors};

            -- TODO check with Rizzi here
            hyd_ret : out propagation {hydraulicerrors};
            hyd_ret : in propagation {hydraulicerrors};


        flows
            -- local failure modes
             el1 : error source hyd_bus_in{lost_pressure} when mechanically_failed{meter_valve_leaking};
             eo1 : error source metered_hyd_bus_out{no_pressure} when mechanically_failed{meter_valve_stuck_closed};
             eo2 : error source metered_hyd_bus_out{pressure_error} when mechanically_failed{meter_valve_stuck_open};

              -- operational failure propagations
              -- when operational faults propgate through components
             nf1 : error path hyd_bus_in {hydraulicerrors} -> metered_hyd_bus_out;
             bp1 : error path metered_hyd_bus_out {lost_pressure} -> hyd_bus_in;
            end propagations;


    component error behavior

      --
        propagations
```



Solid Geometry Model



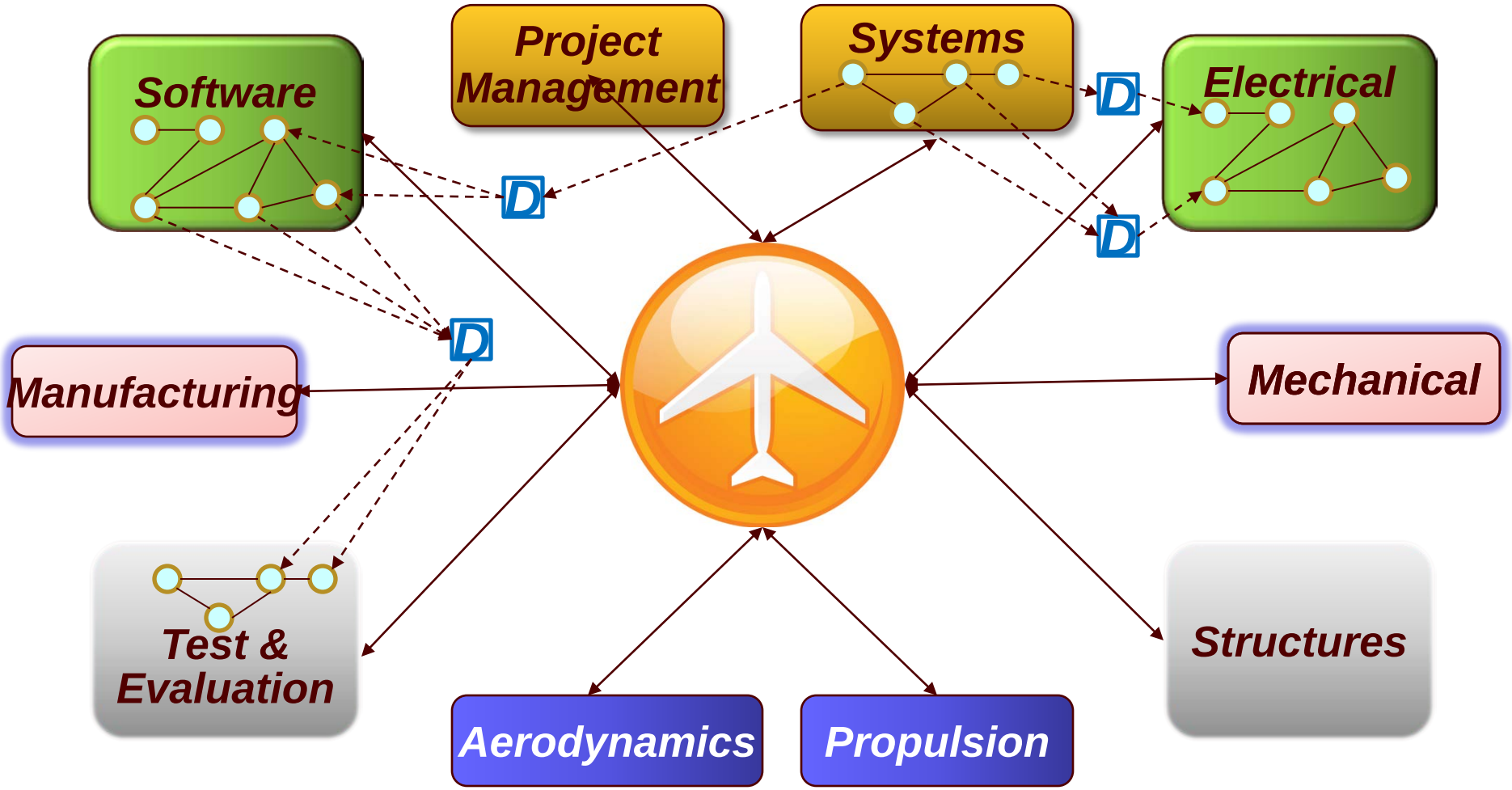
Requirements Exchange

Inter-Model Dependencies

Inter-Model Consistency Checks

USE CASES

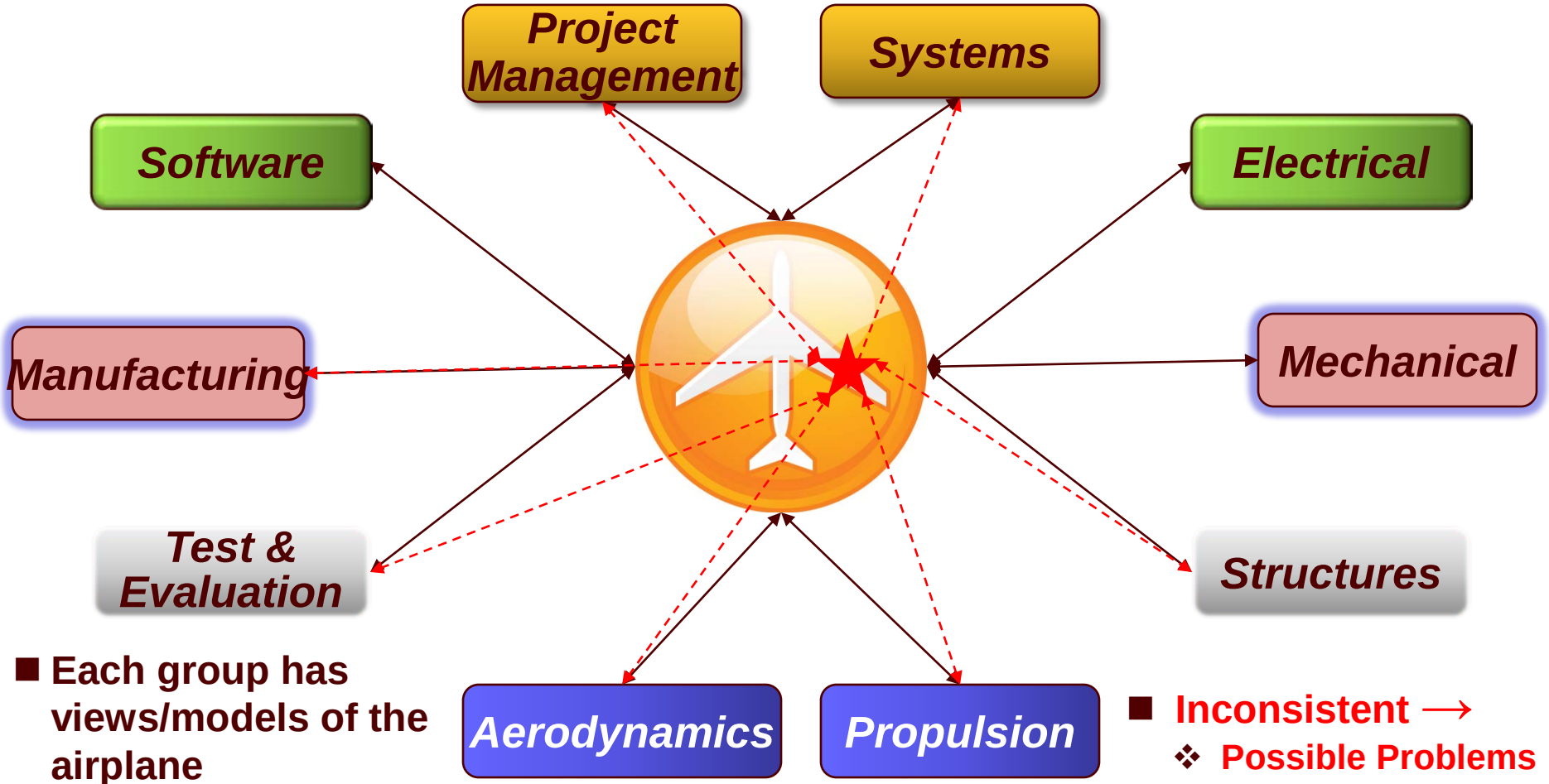
Dependencies Are Key



- Each dependency needs to be identified, ***tracked and checked throughout the life cycle***

© AVSI

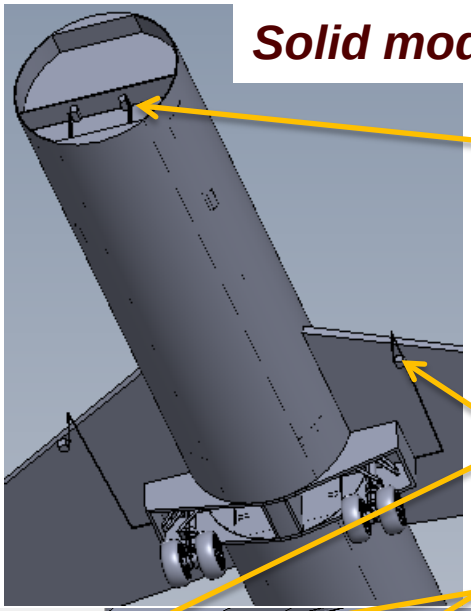
Inter-Model Consistency



- Each group has views/models of the airplane
- Relations/Dependencies exist between the views/models used
- Inconsistent ⟶
  - Possible Problems
  - *Not Valuable*

© AVSI

Inter-Model Consistency Checks

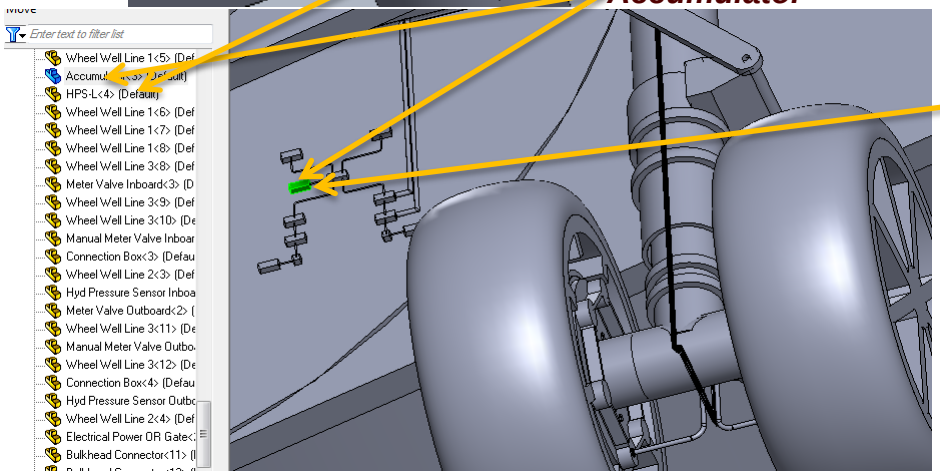


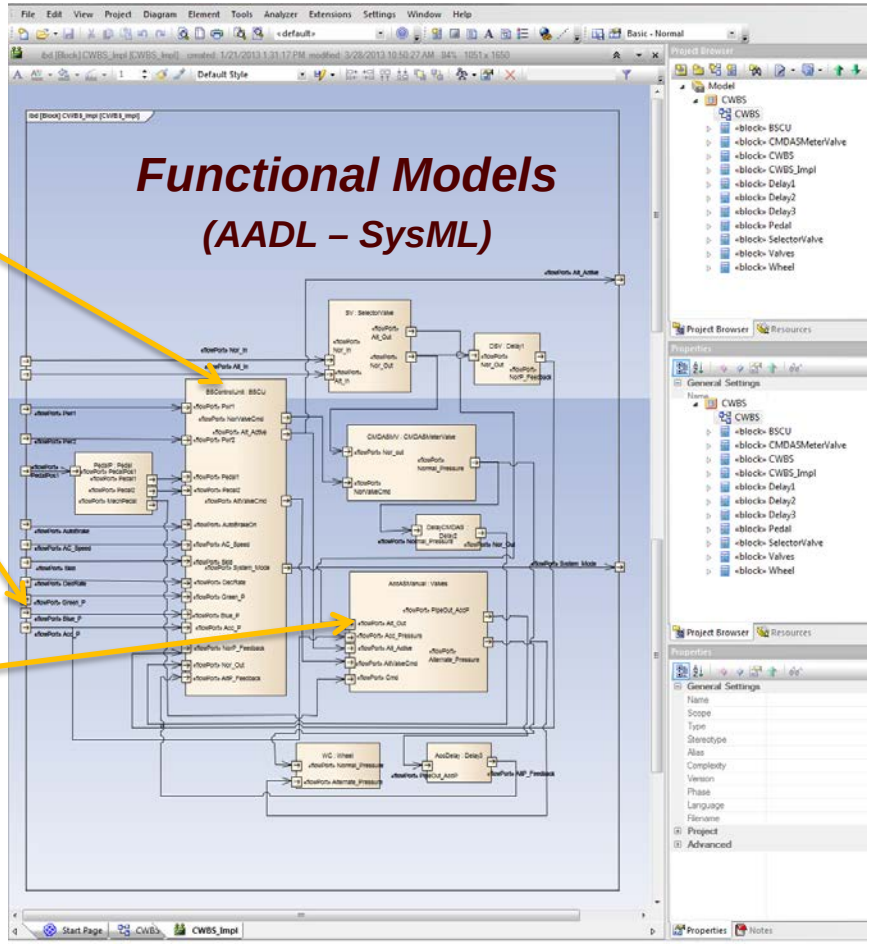
Solid models

BSCU

Hyd power supply

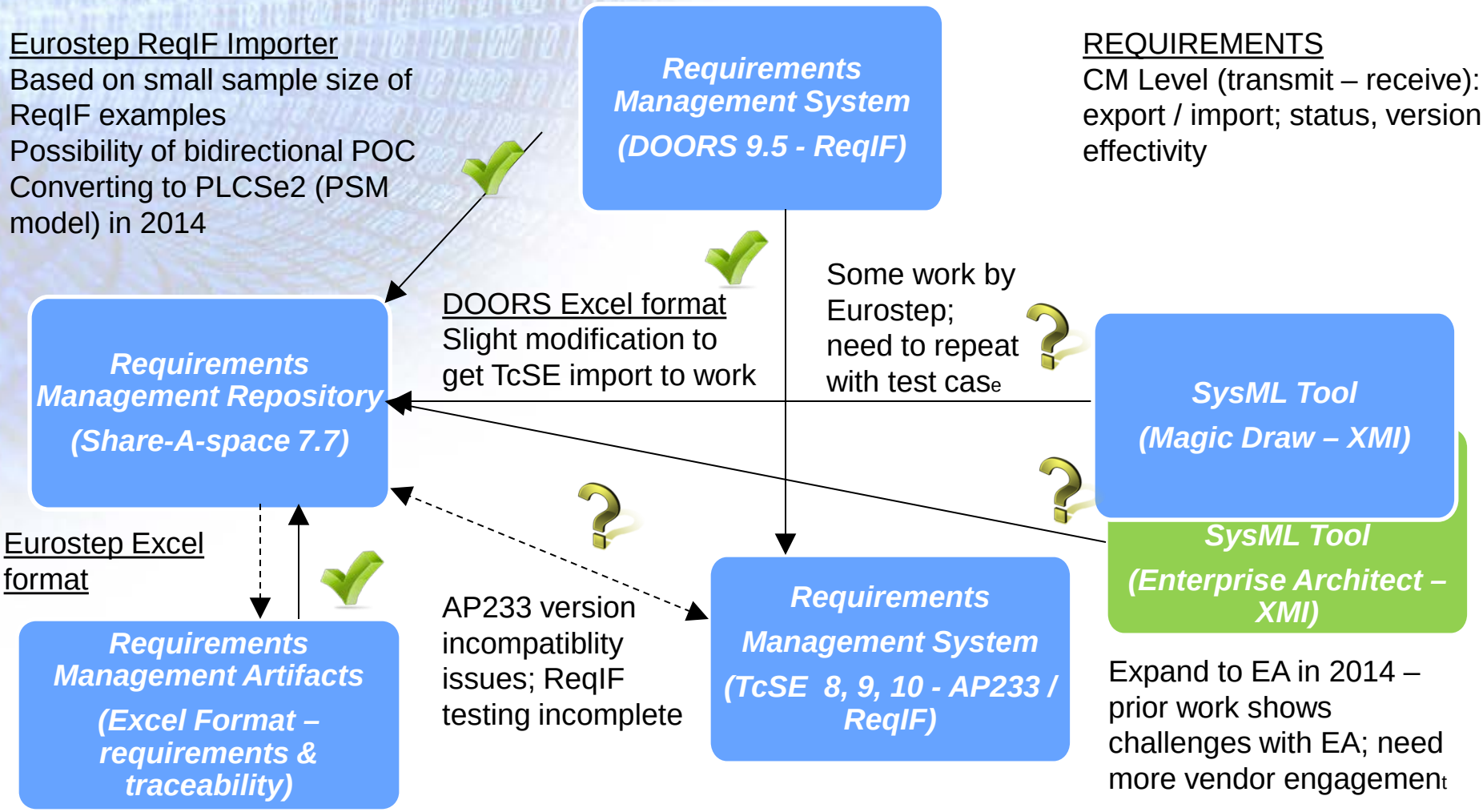
Accumulator





DEMONSTRATIONS

2013 Proof of Concept



More Roundtrip Testing Needed with PDES / SAVI Use Cases

© PDES, Inc. 2013

PDES, Inc.®

2013 Results to Date

- Limited Funding and Resources Allowed Small Amount of Testing in Q3/Q4 2013
  - PDES, SAVI, and independent participation
  - Majority of effort in setting up environment and test cases
  - **Results are very preliminary**
  - Simple public test cases:
    - » Training example from DOORS
    - » Set of 10 requirements with tracing and doc relationships using Eurostep Excel template
- Word / Excel
  - Most tools do a good job of exchanging raw text, but sometimes paragraphs become requirements, loss of subtyping can happen
  - Users need to take care not to break templates
  - Change Management and graphics/attachments problematic if not setup well; loss of attachments in some translations regardless

© PDES, Inc. 2013

2013 Results to Date (continued)

- ReqIF
  - Supported by several tools, but no CM / versioning in systems tested
  - Worked reasonably well into Share-A-space – no exporter yet
  - Supported by DOORS, TcSE, and other RM tools
  - Need to be careful when exchanging partial data sets with earlier versions of DOORS
- AP233
  - TcSE 8, 9, 10 use a very early version of AP233 that is not compliant with PLCSe1 or e2. Needs investigation to see how difficult it would be to map or convert
  - TcSE AP233 worked well between versions (forward and backward) and instances during limited testing; some use for migrations found
  - Update coming from Eurostep in early 2014 will enable better testing with other tools

© PDES, Inc. 2013

DOORS, Excel

Share-A-space ™

SysML, AADL

SolidWorks, NX

THE TOOLS AND LANGUAGES

DOORS ReqIF 9.5 Import to Share-A-Space 7.7

PDES, Inc.®

share A space

User: John.Russell@honeywell.com (Honeywell) Id Context: Honeywell, Honeywell

Requirement Version | Versions | Identifiers | Classifications | Used In | Time Roles | Properties | Traced by

_134_b4708631-29f8-4ea9-9f98-b8da6f4d233f

Id	Name	Value	Start Date	Role	Application Context
ReqIF.ForeignID	ReqIF.ForeignID	134	12/12/2013 1:22:13 PM	Actual	[/IGNORE//IGNORE] /IGNORE
ReqIF.ForeignCreatedThru	ReqIF.ForeignCreatedThru	Manual Input	12/12/2013 1:22:13 PM	Actual	[/IGNORE//IGNORE] /IGNORE
ReqIF.Text	ReqIF.Text	The car shall be assembled from modules by 1 person in 1 working day.	12/12/2013 1:22:13 PM	Actual	[/IGNORE//IGNORE] /IGNORE

Requirement

_12_d3c7c3... Verif...
_125_7a28a... Indic...
_130_c984f... Syste...
_131_cc2c0... Relia...
_132_c8814...
_133_c9b12... Modu...
_134_b4708...
_135_5f656... Failur...
_136_47221...
_137_ee8d1... Fuel...
_138_506fa...
_139_da47c...

Details

Tracing Relationship

ID

Name

Start-date 2013-12-12

End-date ∞

Parent _135_5f6561b1-abb3-4749-9b2f-edee84d5f686 Failure modes /IGNORE

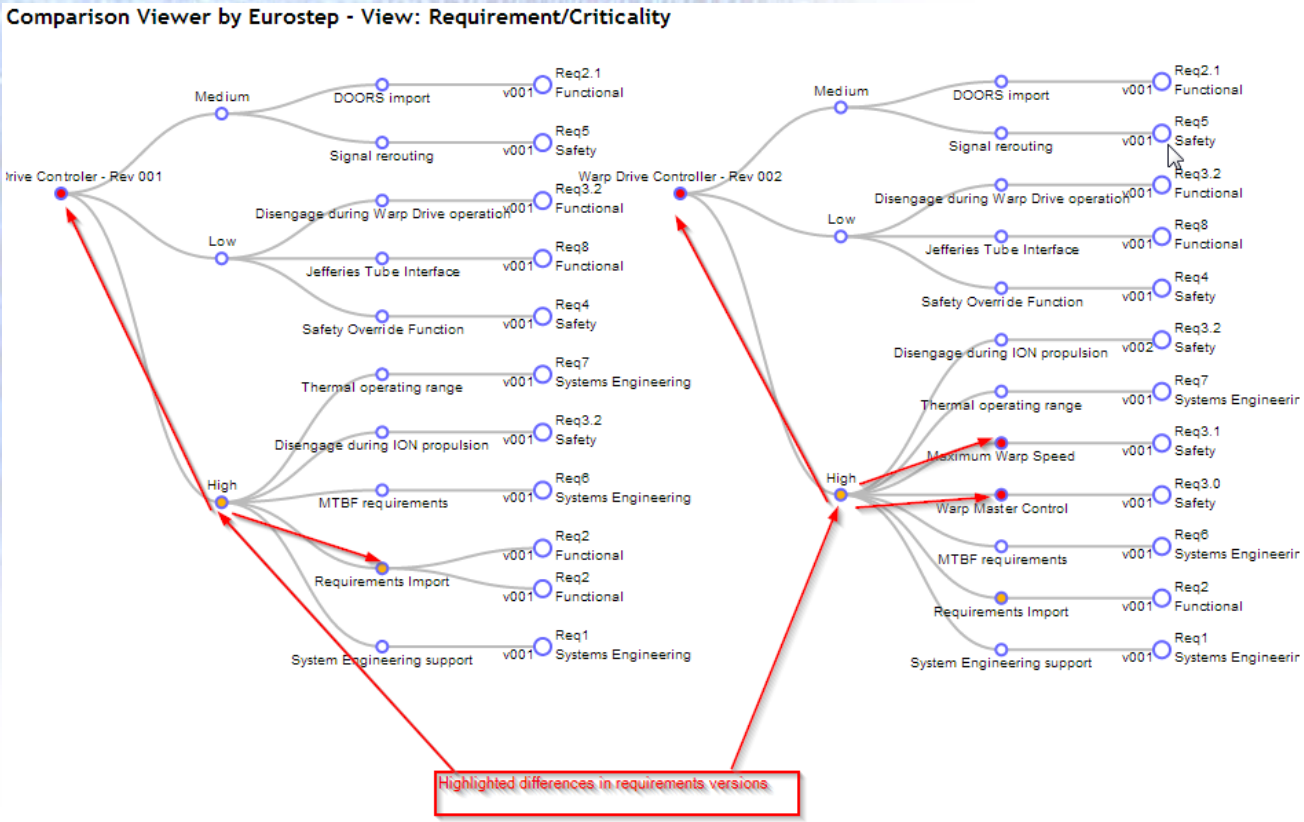
Child _136_47221792-b7a1-45c1-a455-134bf67d821f /IGNORE

Ok

Matrix: Tracing Relationship

© PDES, Inc. 2013

POC Comparison Tool



ReqID/Requirement Name/Criticality
Requirement Name/ReqID
Line/Requirement Name
ReqID/Requirement Name/Version
Traced From/Source Document/Requirement Name
Requirement - sorted by name
Requirement/Criticality

Line: 9
name: Signal rerouting
Version: v001
ReqID: Req5
ParentID: 0
Description: The solution shall provide easy physical and logical access to anyone named Scotty to reroute output signals to be used for or controlled by other ship functions
Criticality: Medium
Release: undefined
TracedFrom:
SourceDocument: Script Guidelines
Type: Safety

General Need for Comparisons of Versions – POC Discussion Topics

- ***What are the use cases?***
- ***What input formats should be supported?***
- ***How will this approach fit for large datasets? – human factors will be a major consideration***
- ***Are there better approaches?***

© PDES, Inc. 2013

Structure imported from STEP files

share space

User: savi.user@savi.com (WORLD) Id Context: WORLD, World

Part Version | Versions | Actors | Identifiers | Classifications | Breakdowns | Uses | Requirements

wbs_assembly_single_channel, , wbs_assembly_single_channel

Type	Value		Context
Identifier	wbs_assembly_single_channel		SAVI
Name	wbs_assembly_single_channel		SAVI
Version Identifier			SAVI

Identifier	Version	Name	Description	Quantity	Start Date	End Date	Role	Identifier	Name	Version	Description	Application Context
wbs_assembly_single_channel		wbs_assembly_single_channel										
1093					2013-12-04 14:05:19		Actual	mirrorbrakeline 2	mirrorbrakeline 2			MechanicalAsDesignedAsPlann
1094					2013-12-04 14:05:19		Actual	brakeline 2	brakeline 2			MechanicalAsDesignedAsPlann
1095					2013-12-04 14:05:19		Actual	mirrorbrakeline	mirrorbrakeline			MechanicalAsDesignedAsPlann
1096					2013-12-04 14:05:19		Actual	brakeline	brakeline			MechanicalAsDesignedAsPlann
1097					2013-12-04 14:05:19		Actual	mirrorsensor wire to meter valve outboard	mirrorsensor wire to meter valve outboard			MechanicalAsDesignedAsPlann
1098					2013-12-04 14:05:19		Actual	mirrorsensor wire to hyd sensor outboard	mirrorsensor wire to hyd sensor outboard			MechanicalAsDesignedAsPlann
1099					2013-12-04 14:05:19		Actual	sensor wire to meter valve outboard	sensor wire to meter valve outboard			MechanicalAsDesignedAsPlann
1100					2013-12-04 14:05:19		Actual	sensor wire to hyd sensor outboard	sensor wire to hyd sensor outboard			MechanicalAsDesignedAsPlann
1101					2013-12-04 14:05:19		Actual	mirrorsensor wire to hyd sensor inboard	mirrorsensor wire to hyd sensor inboard			MechanicalAsDesignedAsPlann
1102					2013-12-04 14:05:19		Actual	sensor wire to hyd sensor inboard	sensor wire to hyd sensor inboard			MechanicalAsDesignedAsPlann
1103					2013-12-04 14:05:19		Actual	mirrorsensor wire to meter valve inboard	mirrorsensor wire to meter valve inboard			MechanicalAsDesignedAsPlann
					2013-12-			sensor wire to	sensor wire to meter			

© AVSI

© Eurostep AB 2000-2013

Structure imported from AADL file

share space

User: savi.user@savi.com (WORLD) Id Context: WORLD, World

Breakdown Element Version | Versions | Actors | Identifiers | Uses | In Breakdowns

_9Q2zcE-pEeOiQIMVbeU-Og

Owner SAVI (SAVI)

Creation date 2013-12-04 13:11:06

Identifier	Version	Name	Description	Quantity	Start Date	End Date	Role	Identifier	Name	Version	Description	Application Context
_9Q2zcE-pEeOiQIMVbeU-Og												
					2013-12-04 14:11:01		Actual	_9SJM5E-pEeOiQIMVbeU-Og	rightMLG			
					2013-12-04 14:11:01		Actual	_9SJz8E-pEeOiQIMVbeU-Og	ext_hyd_bus_blue			
					2013-12-04 14:11:01		Actual	_9SNeUU-pEeOiQIMVbeU-Og	green_isolation_valve			
					2013-12-04 14:11:01		Actual	_9SQhok-pEeOiQIMVbeU-Og	accumulator			
					2013-12-04 14:11:01		Actual	_9SOFYk-pEeOiQIMVbeU-Og	blue_isolation_valve			
					2013-12-04 14:11:01		Actual	_9SOsck-pEeOiQIMVbeU-Og	selector_valve			
					2013-12-04 14:11:01		Actual	_9SKbBE-pEeOiQIMVbeU-Og	int_hyd_bus_green			
					2013-12-04 14:11:01		Actual	_9SM3Qk-pEeOiQIMVbeU-Og	int_hyd_selected_alt			
					2013-12-04 14:11:01		Actual	_9SKbAE-pEeOiQIMVbeU-Og	ext_hyd_bus_green			
					2013-12-04 14:11:01		Actual	_9SLCE0-pEeOiQIMVbeU-Og	int_hyd_bus_blue			
					2013-12-04 14:11:01		Actual	_9SLpI0-pEeOiQIMVbeU-Og	acc_seg			
					2013-12-04 14:11:01		Actual	_9SQhpE-pEeOiQIMVbeU-Og	leg_subassembly			
					2013-12-04 14:11:01		Actual	_9SS94k-pEeOiQIMVbeU-Og	inboard_meter_valve			
					2013-12-04 14:11:01		Actual	_9STk8U-pEeOiQIMVbeU-Og	hyd_valve_assembly			
					2013-12-04 14:11:01		Actual	_9SdV8k-pEeOiQIMVbeU-Og	int_hyd_norm_meter_actuator			
					2013-12-04 14:11:01		Actual	_9Scu4k-pEeOiQIMVbeU-Og	int_hyd_nor_meter_manual			
					2013-12-04 14:11:01		Actual	_9SWoRE-pEeOiQIMVbeU-Og	inboard_manual_meter_valve			
					2013-12-04 14:11:01		Actual	_9SYdck-pEeOiQIMVbeU-Og	outboard_manual_meter_valve			

© AVSI

© Eurostep AB 2000-2013

Requirements imported from Excel

Share-A-space 1.7.0.25668 - Internet Explorer

http://savi.share-a-space.com/Share-A-space/browse/ExternalWindow?externalTargetAction=TreeTable/InitLegacy&selectedObjectId=abf7d743-9f93-4f92-862b-4064637bfda9_3113&ParamNames=[0]=EXTERNALROUTE&ParamValues=[

Identifier	Version	Name	Description	Quantity	Start Date	End Date	Role	Identifier	Name	Version	Description	Application Context
6110-0	v001	Aircraft Level Functions	Aircraft Level Functions									
					2013-12-05 00:00:00		Actual	6110-0.8	Provide Control on the Ground	v001	Provide Control on the Ground	
					2013-12-05 00:00:00		Actual	6110-0.8.2	Control Direction	v001	Control Direction	
					2013-12-05 00:00:00		Actual	6110-0.8.3	Landing Gear Extension & Retraction	v001	Landing Gear Extension & Retraction	
					2013-12-05 00:00:00		Actual	6110-0.8.1	Control Speed	v001	Control Speed	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1	Decelerate aircraft on the ground (stopping on the runway)	v001	Decelerate aircraft on the ground (stopping on the runway)	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1.4	Remove Forward Thrust	v001	Remove Forward Thrust	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1.1	Provide Primary Stopping Force	v001	Provide Primary Stopping Force	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1.3	Decrease Lift/ Create Drag/ Enhance Braking Effectiveness	v001	Decrease Lift/ Create Drag/ Enhance Braking Effectiveness	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1.5	Transfer Stopping Forces to Structural Integrity Components (i.e. Landing Gear)	v001	Transfer Stopping Forces to Structural Integrity Components (i.e. Landing Gear)	
					2013-12-05 00:00:00		Actual	6110-0.8.1.1.2	Provide Secondary Stopping Force	v001	Provide Secondary Stopping Force	
					2013-12-05 00:00:00		Actual	6110-0.1	Provide Structural Integrity	v001	Provide Structural Integrity	
					2013-12-05 00:00:00		Actual	6110-0.2	Provide Stability & Control	v001	Provide Stability & Control	
					2013-12-05 00:00:00		Actual	6110-0.2.2	Control Roll	v001	Control Roll	
					2013-12-05 00:00:00		Actual	6110-0.2.5	Automatic Flight Control & Guidance	v001	Automatic Flight Control & Guidance	
					2013-12-05 00:00:00		Actual	6110-0.2.4	Flight Control Augmentation	v001	Flight Control Augmentation	
					2013-12-05 00:00:00		Actual	6110-0.2.3	Control Yaw	v001	Control Yaw	
					2013-12-05 00:00:00		Actual	6110-0.2.1	Control Pitch	v001	Control Pitch	
					2013-12-05 00:00:00		Actual	6110-0.3	Provide Control of Energy	v001	Provide Control of Energy	
					2013-12-05 00:00:00		Actual	6110-0.3.2	Control Lift & Drag	v001	Control Lift & Drag	
					2013-12-05 00:00:00		Actual	6110-0.3.1	Control Thrust	v001	Control Thrust	

Requirements tracing relationships

share space

User: savi.user@savi.com (WORLD) Id Context: WORLD, World

Requirement Version | Versions | Identifiers | Traced by

S18-BSCU-R-0001, v001, The BSCU shall be designed to Functional Development Assurance Level A based on the catastrophic classification of "Inadvertent braking due to BSCU".

Description The BSCU shall be designed to Functional Development Assurance Level A based on the catastrophic classification of "Inadvertent braking due to BSCU".
Owner SAVI (SAVI)
Creation date 2013-12-05 11:52:24

Requirement	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...	S18-WBS-...
S18-BSCU-... v001 The...				✓							
S18-BSCU-... v001 The...								✓			
S18-BSCU-... v001 The...									✓		
S18-BSCU-... v001 The...										✓	
S18-BSCU-... v001 No...											✓
S18-BSCU-... v001 BSCU...											
S18-BSCU-... v001 BSCU...											
S18-BSCU-... v001 BSCU...	✓										
S18-BSCU-... v001 BSCU...		✓									
S18-BSCU-... v001 BSCU...			✓								
S18-BSCU-... v001 Each...			✓								
S18-BSCU-... v001 Each...			✓								
S18-BSCU-... v001 Each...											
S18-BSCU-... v001 Each...											
S18-BSCU-... v001 The...					✓						

Matrix: Tracing Relationship

© AVSI

“This Ain’t Your CAD Model Data Exchange”

THE CONCLUSIONS

PDES, Inc.®

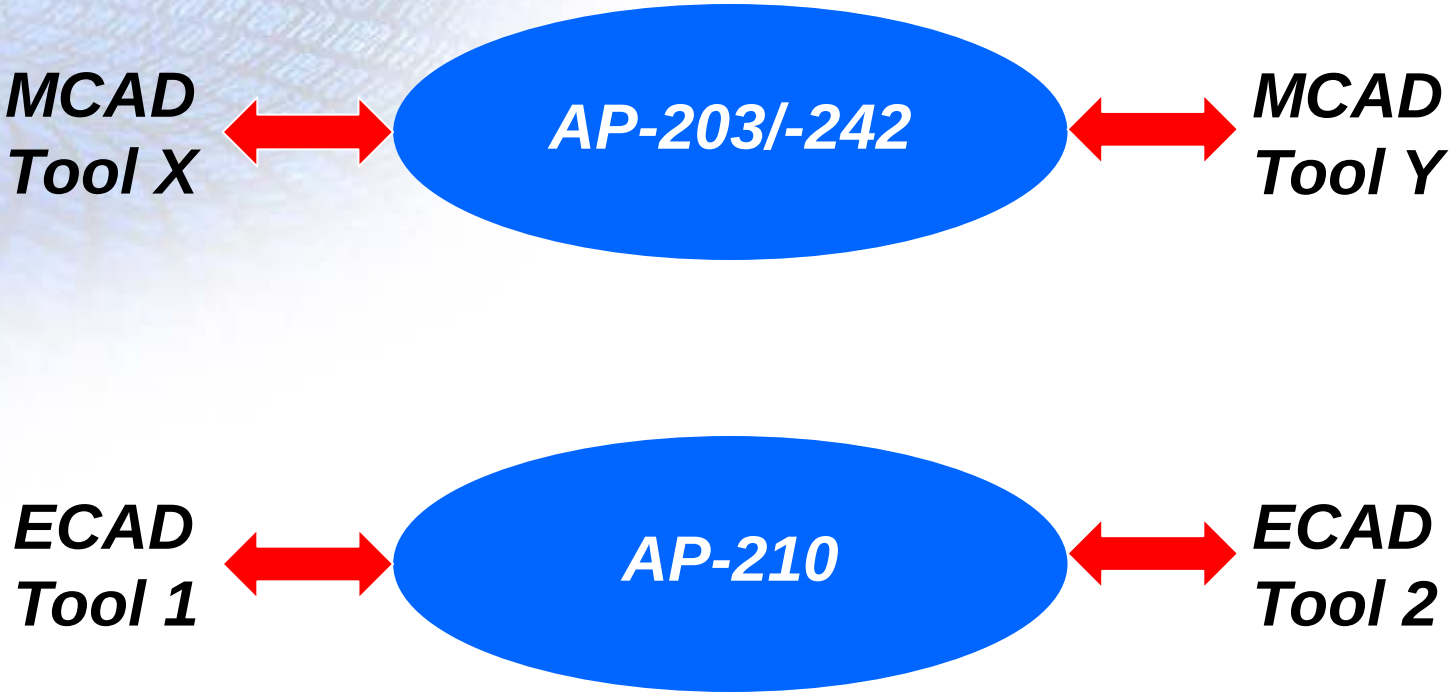
Key Takeaways

- Systems Engineering use cases expose a new layer of complex interoperability requirements
  - Multi-domain
  - Subsets of shared properties data exchange
  - Relationships (not exchange) of dissimilar properties
    - » Consistency
    - » Traceability
    - » Dependency
    - » Association
- Not a “zero sum game” for tool providers
  - Interoperability is the opportunity to participate

© PDES, Inc. 2013

Intra-Domain Interoperability

- File exchange/translation example



© PDES, Inc. 2013

PDES, Inc.®

Inter-Domain Interoperability

Environmental

Requirements

LVCS

SysML

AADL

MCAD

Simulink

Security

MODAF

DODAF

ASIIST

EMI

MISSION

Config

Scenario

Mgmt

ECAD

CAFTA

FEA

DFD

Model

Checkers

Modelica

Interoperability Standards

AP-233/-239

© PDES, Inc. 2013

Model Repository/Data Exchange Layer

Leverage

- Architecture models
- Existing tools
- Existing IT systems
- Existing repositories

Most Important Requirements

- Protect IP
- Process Neutral
- IT Independent
- Standards Based
- Clear Ownership
- Auditable
- Secure Access
- Flexible Content

SAVI MR/DEL

Standards: PLCS/DEX, STEP, ReqIF, XMI, OSLC, Eclipse
Proprietary: Intentional SW, The Mathworks

PDM/PLM
TeamCenter, Enovia, Windchill

ERP

SVN

Eurostep *Share-A-space*®

Technical Data Package

It’s All About the Data

CONCLUSION

Technical Data Package

- Systems Engineering Model Set
  - High complexity
  - Cross domain
  - Linking subsets of model properties
- Standards based
  - Process and tool independent
  - Protect Intellectual Property
- PDES & SAVI research and demonstrations

PDES Systems Engineering Workshop

- March 10, 2014
- Gaithersburg
- Candidate Topics
  - Interoperability demonstration results: PDES, SAVI
  - Web services demonstration results
  - Business case for users and solution providers
  - Walkthrough data interoperability process
  - MoSSEC
  - Link between systems engineering and system simulation
  - Other industry efforts
- All are welcome
- Provide contact information to receive an invitation

Contacts

John Russell,
Honeywell
john.russell@honeywell.com

Don Ward,
AVSI
savipgm@gmail.com

Greg Pollari,
Rockwell Collins
gmpollar@rockwellcollins.com

Dave Redman,
AVSI
dredman@tamu.edu

BACKUP

PDES, Inc.®

Next Steps

- Prepare results for INCOSE discussions
- Coordinate with vendors
- Integrate SAVI use and test cases
- Install and Test Eurostep AP239 e1&e2 import / export functions in 2014
- Develop smaller, more targeted test cases with diagrams and hardware references
- Test larger datasets with more tools
- Coordinate industry XMI test cases
- Expand white paper on TDP use & interoperability in Systems Engineering
- Seek funding for more complete project

© PDES, Inc. 2013

Proposed Demonstration – Phase 1

Tier 1

REQUIREMENTS
- CM / PLM: export / import; status, version, effectivity
- Safety / hazard,
- Locking (?) – investigation
- Linking Requirements with Different Names
  - Requirement with 2 names
- Grouping of requirements (both scenarios)
- Issue tracking (observation – AP233/239)

PRIME
Requirements Management System
(AP233)

REGULATOR
-How could they use this?
-Is there a report we could produce?
- Military / Civilian Airworthiness considerations?

Tier 2

ORG 1
Requirements Management System
(DOORS - ReqIF)

INDEPENDENT VERIFICATION
- Metadata on verification
- Artifacts
- Electrical, Mechanical, Software
- Certification Metadata
- Separation of OEM and derivative requirement data

ORG 2
Requirements Management System
(TcSE - AP233 / ReqIF)

Tier 3

ORG 3
Requirements Management System
(PTC - ReqIF)

ORG 3
SysML Tool
(Magic Draw – XMI)

ORG 4
Simulation
(Open Modelica – FMI)

© PDES, Inc. 2013