Applying Process Models in a Model-based Safety Analysis Interoperability Platform

Grant Blythe
Mentor Graphics
September 30, 2015

Grant Blythe Bio

Grant Blythe is a member of the Systems Level Engineering team at Mentor Graphics where he specializes in solutions for military and aerospace applications. Prior to joining Mentor Graphics, Grant spent 10 years in systems engineering roles developing both commercial and military avionics. In addition to his role at Mentor Graphics, Grant is a member of the SAE S-18 Airplane System Development Committee which publishes the ARP4754A and ARP4761 standards. Grant holds a B.S. in electrical engineering from Iowa State University and an M.B.A. from the University of Oregon.

Agenda

- **The challenge: “leaning” the safety analysis process**
- **The approach: OSLC, SDM, and Process Models**
- **Developing an ARP4754A based Process Model**
- **Project Results & Continuous Improvement**

Wheel Brake System Safety Process

as presented in ARP4754A/ARP4761/AIR6110

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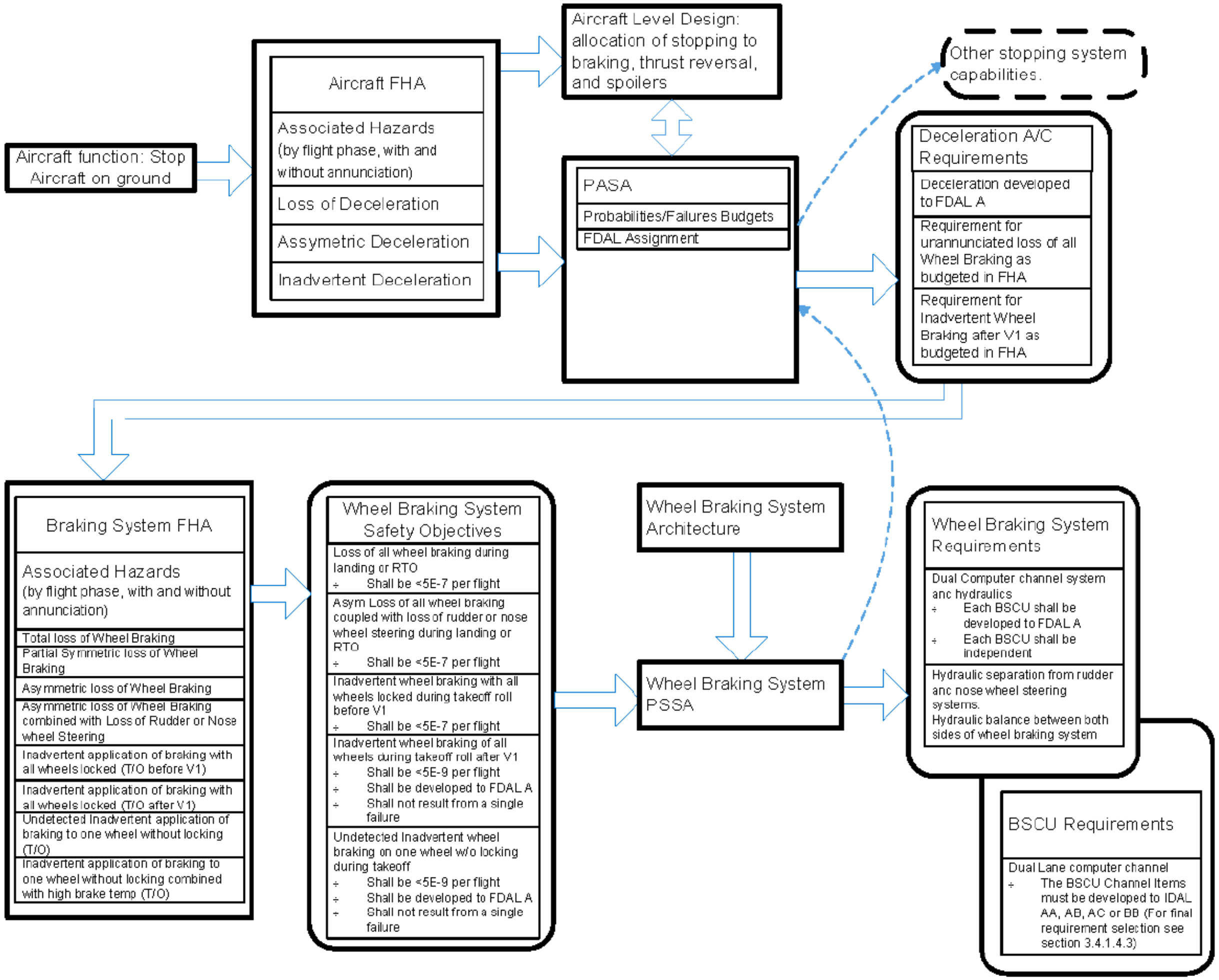


Aircraft function: Stop Aircraft on ground

Aircraft FHA

Associated Hazards (by flight phase, with and without annunciation)

Loss of Deceleration

Assymetric Deceleration

Inadvertent Deceleration

Aircraft Level Design: allocation of stopping to braking, thrust reversal, and spoilers

PASA

Probabilities/Failures Budgets

FDAL Assignment

Other stopping system capabilities.

Deceleration A/C Requirements

Deceleration developed to FDAL A

Requirement for unannunciated loss of all Wheel Braking as budgeted in FHA

Requirement for Inadvertent Wheel Braking after V1 as budgeted in FHA

Braking System FHA

Associated Hazards (by flight phase, with and without annunciation)

Total loss of Wheel Braking

Partial Symmetric loss of Wheel Braking

Asymmetric loss of Wheel Braking

Asymmetric loss of Wheel Braking combined with Loss of Rudder or Nose wheel Steering

Inadvertent application of braking with all wheels locked (T/O before V1)

Inadvertent application of braking with all wheels locked (T/O after V1)

Undetected Inadvertent application of braking to one wheel without locking (T/O)

Inadvertent application of braking to one wheel without locking combined with high brake temp (T/O)

Wheel Braking System Safety Objectives

Loss of all wheel braking during landing or RTO
÷ Shall be <5E-7 per flight

Asym Loss of all wheel braking coupled with loss of rudder or nose wheel steering during landing or RTO
÷ Shall be <5E-7 per flight

Inadvertent wheel braking with all wheels locked during takeoff roll before V1
÷ Shall be <5E-7 per flight

Inadvertent wheel braking of all wheels during takeoff roll after V1
÷ Shall be <5E-9 per flight
÷ Shall be developed to FDAL A
÷ Shall not result from a single failure

Undetected Inadvertent wheel braking on one wheel w/o locking during takeoff
÷ Shall be <5E-9 per flight
÷ Shall be developed to FDAL A
÷ Shall not result from a single failure

Wheel Braking System Architecture

Wheel Braking System PSSA

Wheel Braking System Requirements

Dual Computer channel system anc hydraulics
÷ Each BSCU shall be developed to FDAL A
÷ Each BSCU shall be independent

Hydraulic separation from rudder anc nose wheel steering systems.
Hydraulic balance between both sides of wheel braking system

BSCU Requirements

Dual Lane computer channel
÷ The BSCU Channel Items must be developed to IDAL AA, AB, AC or BB (For final requirement selection see section 3.4.1.4.3)

FIGURE 18 - POPULATED WHEEL BRAKE SYSTEM SAFETY ASSESSMENT PROCESS MAP

Source: Extracted from SAE AIR6110, Contiguous Aircraft/System Development Process Example.

ARP4754A Process with tool layer

Rhapsody

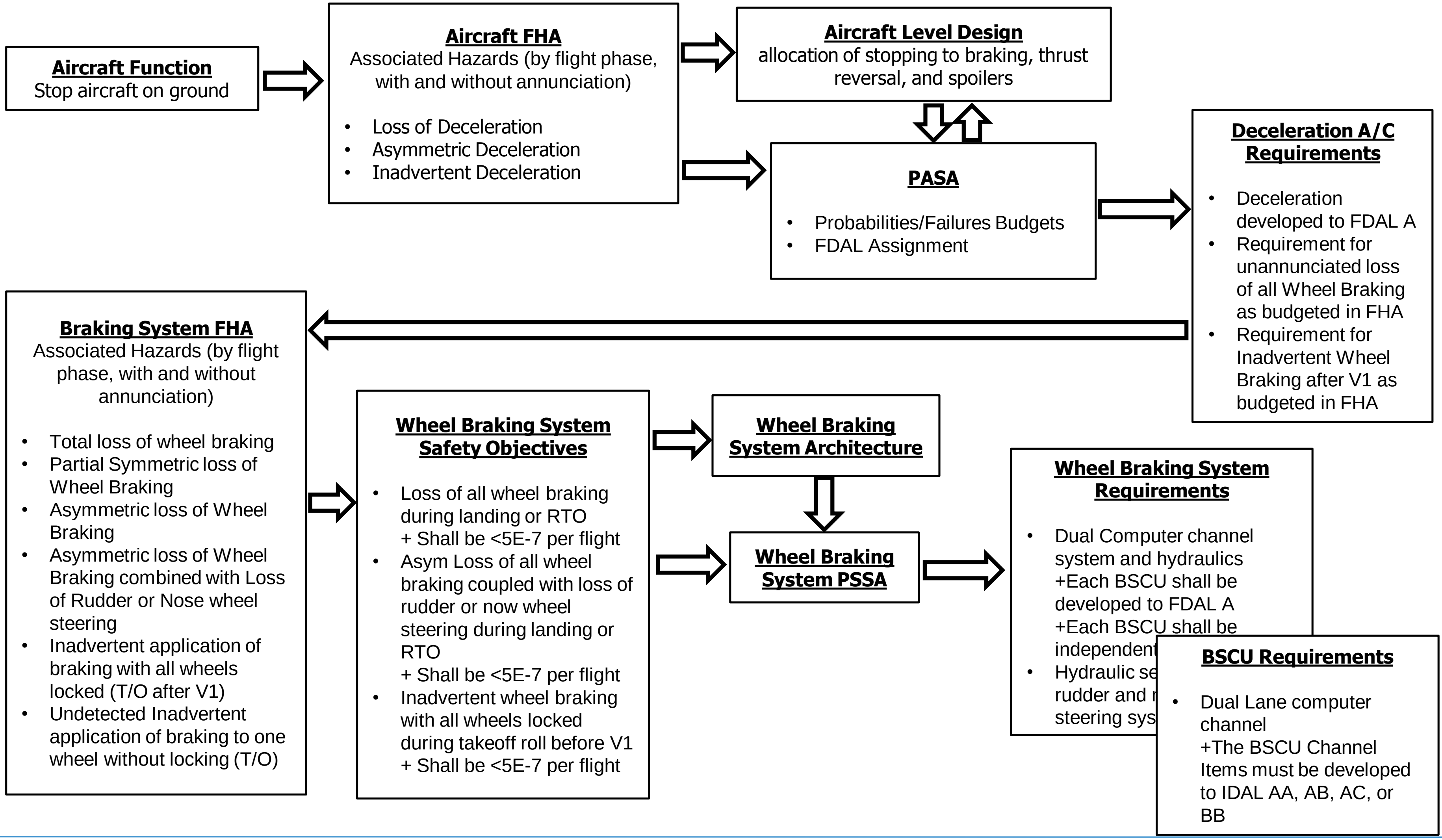
DOORS

Excel/Tbl

PDFs

CAFTA

Matlab/Simulink



Aircraft Function
Stop aircraft on ground

Aircraft FHA
Associated Hazards (by flight phase, with and without annunciation)

- Loss of Deceleration
- Asymmetric Deceleration
- Inadvertent Deceleration

Aircraft Level Design
allocation of stopping to braking, thrust reversal, and spoilers

PASA

- Probabilities/Failures Budgets
- FDAL Assignment

Deceleration A/C Requirements

- Deceleration developed to FDAL A
- Requirement for unannunciated loss of all Wheel Braking as budgeted in FHA
- Requirement for Inadvertent Wheel Braking after V1 as budgeted in FHA

Braking System FHA
Associated Hazards (by flight phase, with and without annunciation)

- Total loss of wheel braking
- Partial Symmetric loss of Wheel Braking
- Asymmetric loss of Wheel Braking
- Asymmetric loss of Wheel Braking combined with Loss of Rudder or Nose wheel steering
- Inadvertent application of braking with all wheels locked (T/O after V1)
- Undetected Inadvertent application of braking to one wheel without locking (T/O)

Wheel Braking System Safety Objectives

- Loss of all wheel braking during landing or RTO
  + Shall be <5E-7 per flight
- Asym Loss of all wheel braking coupled with loss of rudder or now wheel steering during landing or RTO
  + Shall be <5E-7 per flight
- Inadvertent wheel braking with all wheels locked during takeoff roll before V1
  + Shall be <5E-7 per flight

Wheel Braking System Architecture

Wheel Braking System PSSA

Wheel Braking System Requirements

- Dual Computer channel system and hydraulics
  +Each BSCU shall be developed to FDAL A
  +Each BSCU shall be independent
- Hydraulic se rudder and r steering sys

BSCU Requirements

- Dual Lane computer channel
  +The BSCU Channel Items must be developed to IDAL AA, AB, AC, or BB

Waste in System Development Process

Typical characterizations of some of the wastes in production, and in design

- ***Transportation***
  - **Manually moving/importing/exporting data between multiple design tools**
  - **Manually reformatting/translating data for use in multiple tools**
- ***Motion***
  - **Staff switching & multi-tasking across several unintegrated tools**
  - **Searching for data in multiple locations**
- ***Waiting***
  - **Attempting to start tasks before inputs are ready**
  - **Tasks not performed according to priority (off critical path)**
- ***Over-production***
  - **Creating & maintaining multiple copies of the same data**
- ***Defects***
  - **Defects introduced during non-value add activities such as moving, copying, translating data**

With attention to these – and other sources of waste, a model driven systems engineering approach can yield improvements in productivity, schedule and repeatability that yield higher quality results and enable continuing improvement of the process over iterations and time

Agenda

- **The challenge: “leaning” the safety analysis process**
- **The approach: OSLC, SDM, and Process Models**
- **Developing an ARP4754A based Process Model**
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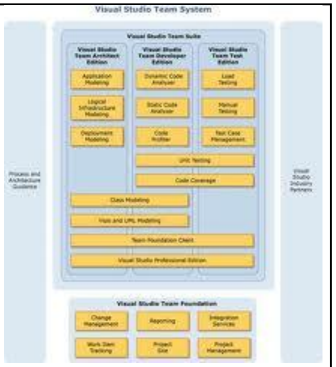
Need for better integration approaches

Past integration approaches provided limited choice and coverage

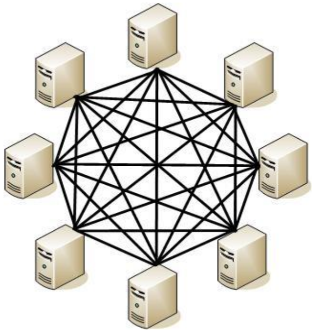
Single repository

“Can I really expect one vendor to provide all the functionality I need? And what about my existing tools?”



Point-to-point integrations

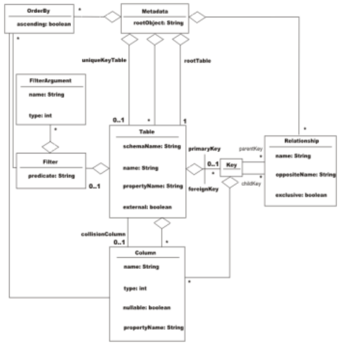
“How can I ever upgrade one tool without breaking everything else?”



Past integration approaches were disruptive and slow to emerge

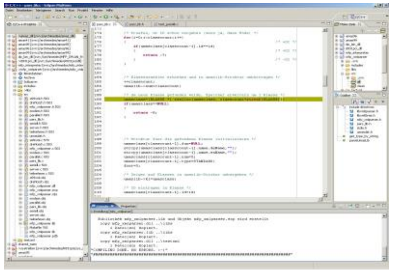
Universal metadata standard

“How did I ever think all those vendors would be able to agree?”



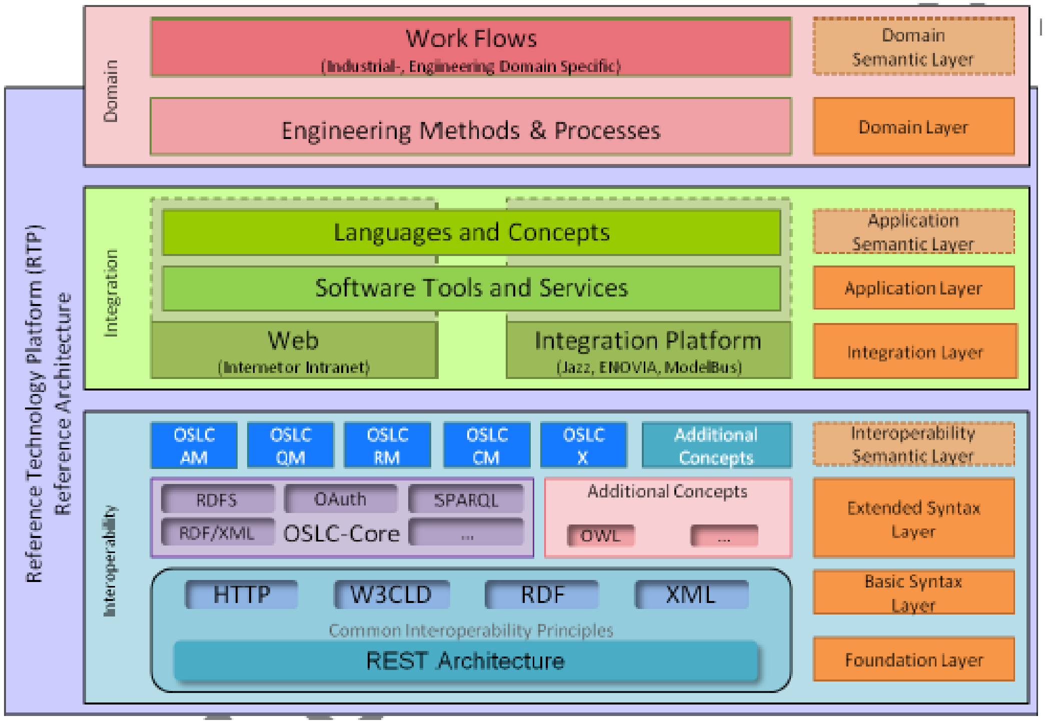
Standard implementations

“Did I really believe that every vendor would rewrite their tools on a single framework?”



Pilot Project Technology Platform

CESAR Technology Platform (D_SP1_R1.6_M4)



Chosen Platform

Tailored MetaModels (User Processes)

Generic MetaModels (ARP4754A, ARP4761, etc.)

Design Tool Integrations & Plugins

Context SDM Platform

Enabling Technologies

REST, OSLC, etc.

Layer 1: Interoperability
Open Services for Lifecycle Collaboration

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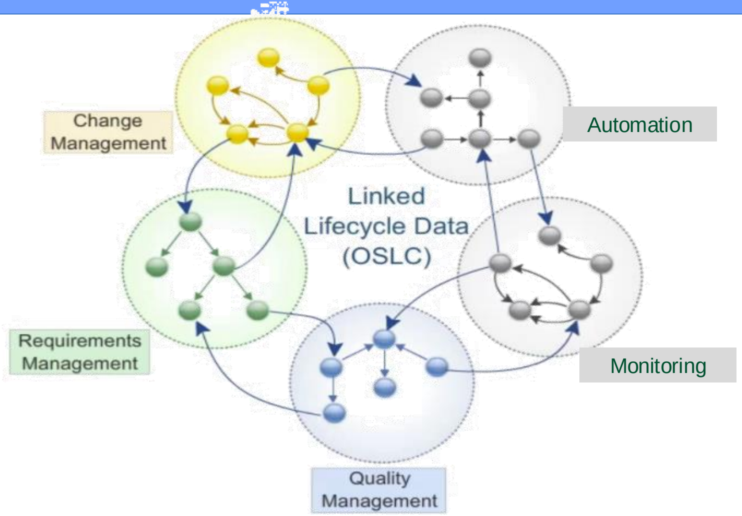
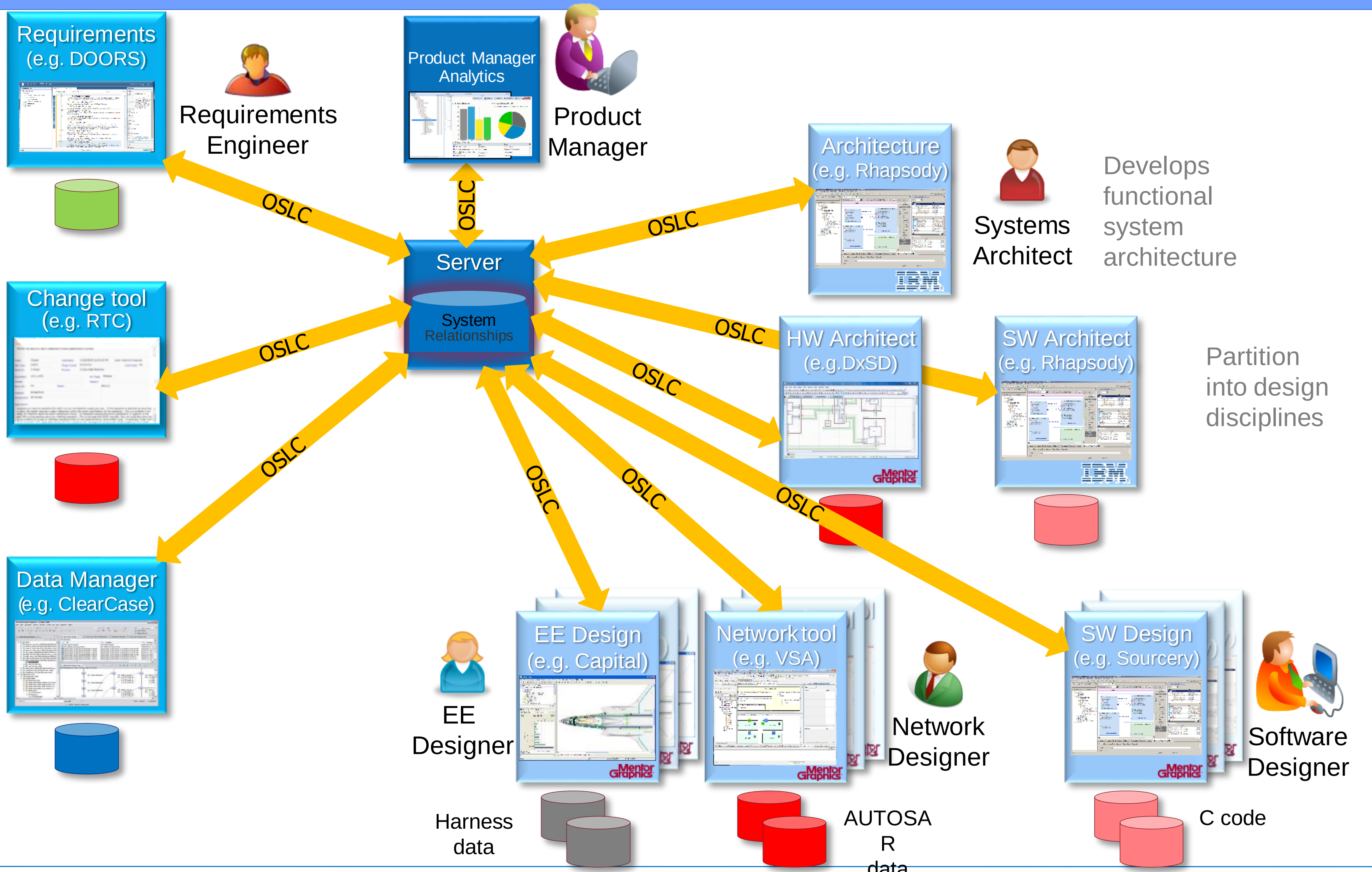
- **Management of linked data**
- **Tool to tool integration**
- **Standards-based communication**



OSLC
Inspired by the web

- **Open Services For Lifecycle Collaboration(OSLC) solves traditional tool integration challenges**
  - **Resilient, standards based approach minimizes IT maintenance**
  - **Seamless experience maximizes user productivity**
  - **Tool vendor IP protection maximizes commercial appeal**

Layer 2: Integration



Layer 3: Domain Models

Aerospace

ARP4754A/ARP4761
DO-178b/c
DO-254

Automotive

ISO26262

Medical

IEC 60601

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Metamodel Development and Architecture

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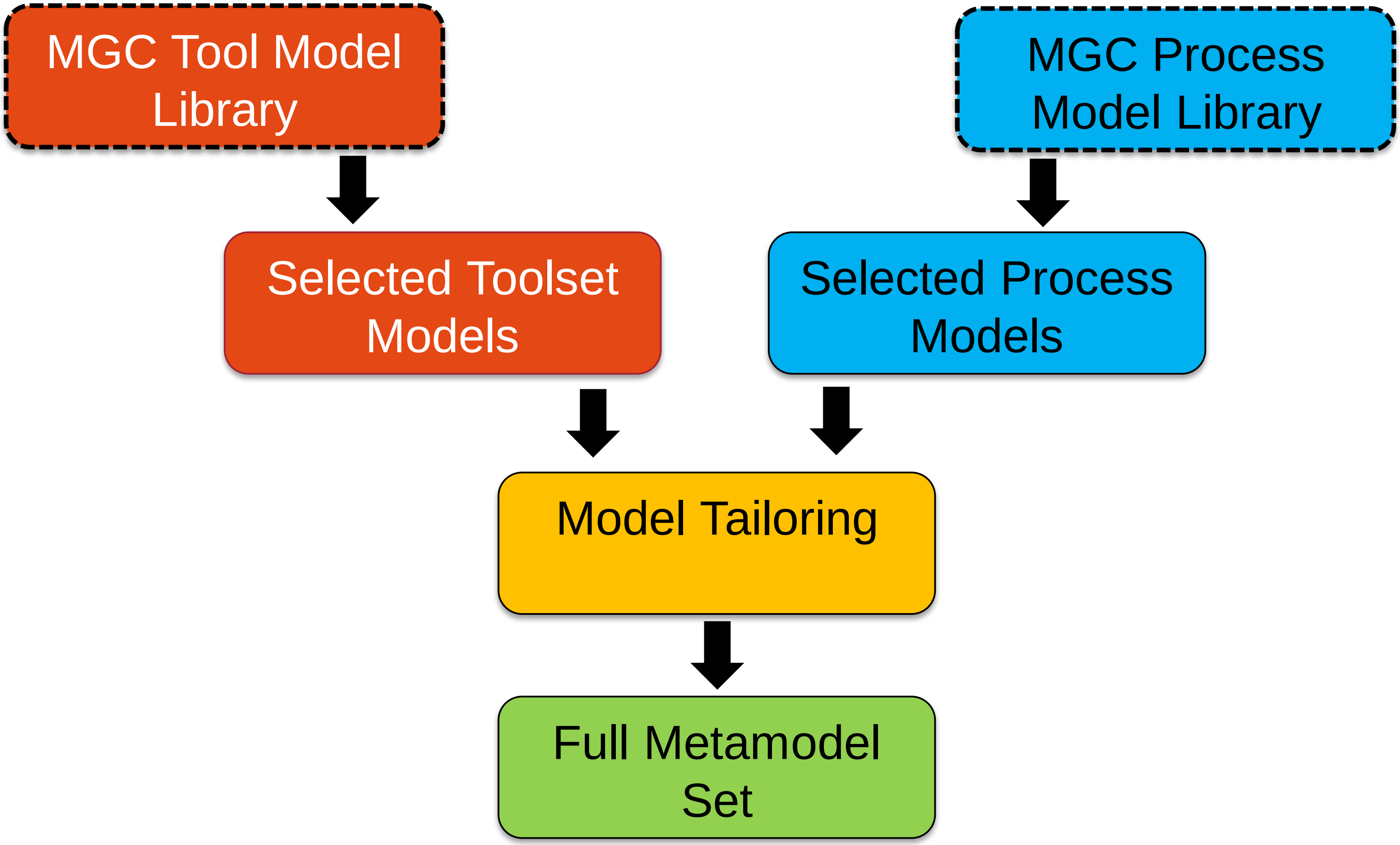
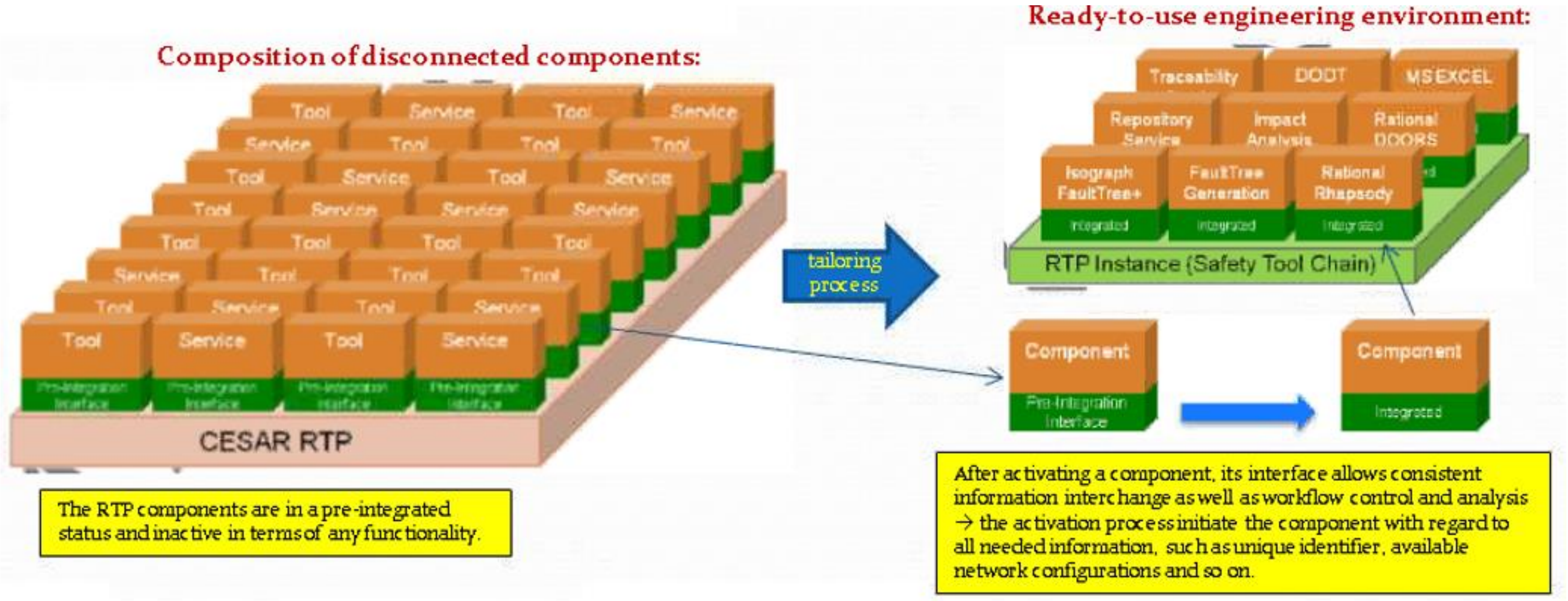


Platform Tailoring - CESAR

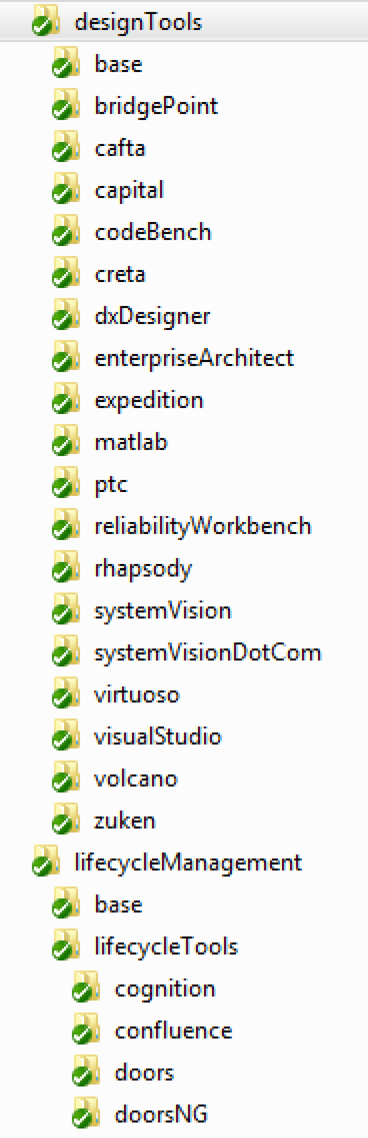


The RTP components are in a pre-integrated status and inactive in terms of any functionality.

After activating a component, its interface allows consistent information interchange as well as workflow control and analysis → the activation process initiate the component with regard to all needed information, such as unique identifier, available network configurations and so on.

Tool Metamodels

- **Platform Library of Supported Tools**
- **Both a metamodel and a plugin/interface**
- **Developed by Mentor Graphics**
  - **Opportunity for user development of new tools integrations in next phase**



- designTools
  - base
  - bridgePoint
  - cafta
  - capital
  - codeBench
  - creta
  - dxDesigner
  - enterpriseArchitect
  - expedition
  - matlab
  - ptc
  - reliabilityWorkbench
  - rhapsody
  - systemVision
  - systemVisionDotCom
  - virtuoso
  - visualStudio
  - volcano
  - zuken
- lifecycleManagement
  - base
  - lifecycleTools
    - cognition
    - confluence
    - doors
    - doorsNG

Process Model Development

- MGC developed metamodel to generically follow applicable standard
- User organizations can further tailor model to match enterprise processes
- Full process model includes models, views, queries, action listeners, reports, etc.

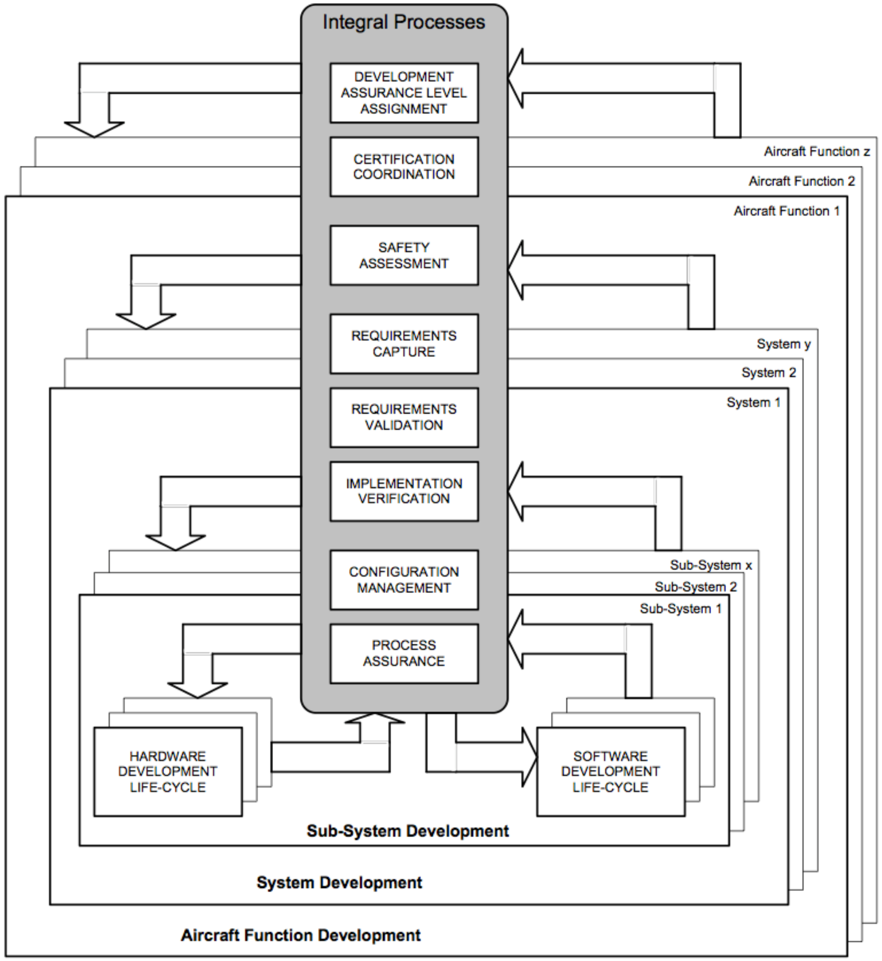
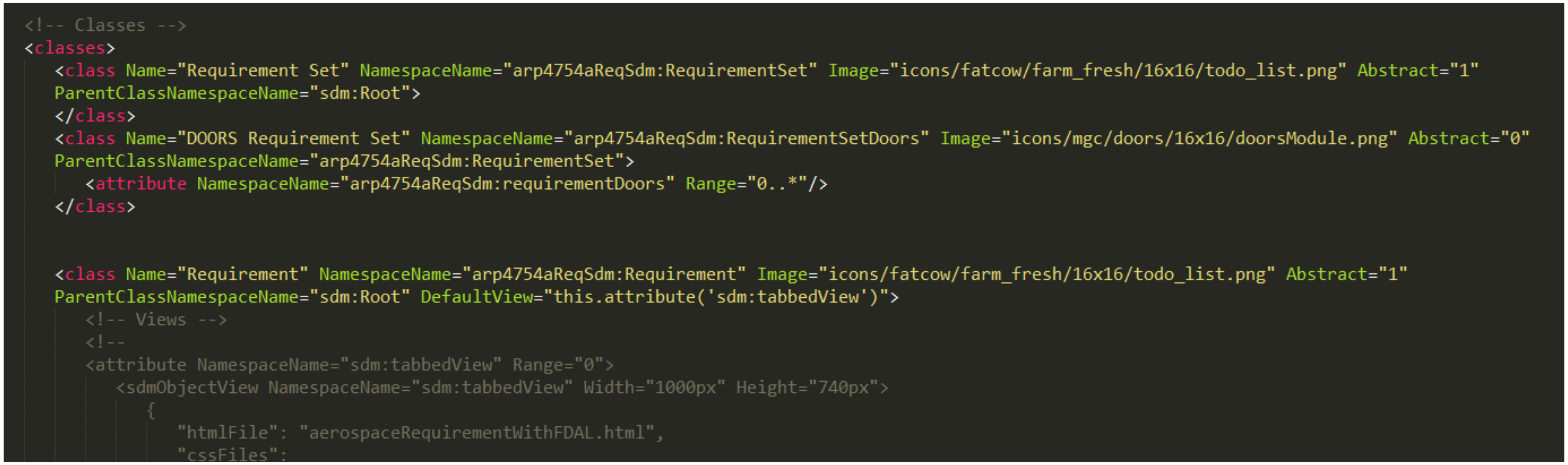


FIGURE 6 - AIRCRAFT FUNCTION IMPLEMENTATION PROCESS

Metamodels – Technical Overview

- **XML Based**
- **Main building block is a "Class"**
  - **Classes have attributes of any type (int, Boolean, enums, etc.)**
  - **References are links to other classes**



```
<!-- Classes -->
<classes>
   <class Name="Requirement Set" NamespaceName="arp4754aReqSdm:RequirementSet" Image="icons/fatcow/farm_fresh/16x16/todo_list.png" Abstract="1"
   ParentClassNamespaceName="sdm:Root">
   </class>
   <class Name="DOORS Requirement Set" NamespaceName="arp4754aReqSdm:RequirementSetDoors" Image="icons/mgc/doors/16x16/doorsModule.png" Abstract="0"
   ParentClassNamespaceName="arp4754aReqSdm:RequirementSet">
      <attribute NamespaceName="arp4754aReqSdm:requirementDoors" Range="0..*"/>
   </class>


   <class Name="Requirement" NamespaceName="arp4754aReqSdm:Requirement" Image="icons/fatcow/farm_fresh/16x16/todo_list.png" Abstract="1"
   ParentClassNamespaceName="sdm:Root" DefaultView="this.attribute('sdm:tabbedView')">
      <!-- Views -->
      <!--
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            {
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               "cssFiles":
```

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ARP4754A Process with tool layer

Rhapsody

DOORS

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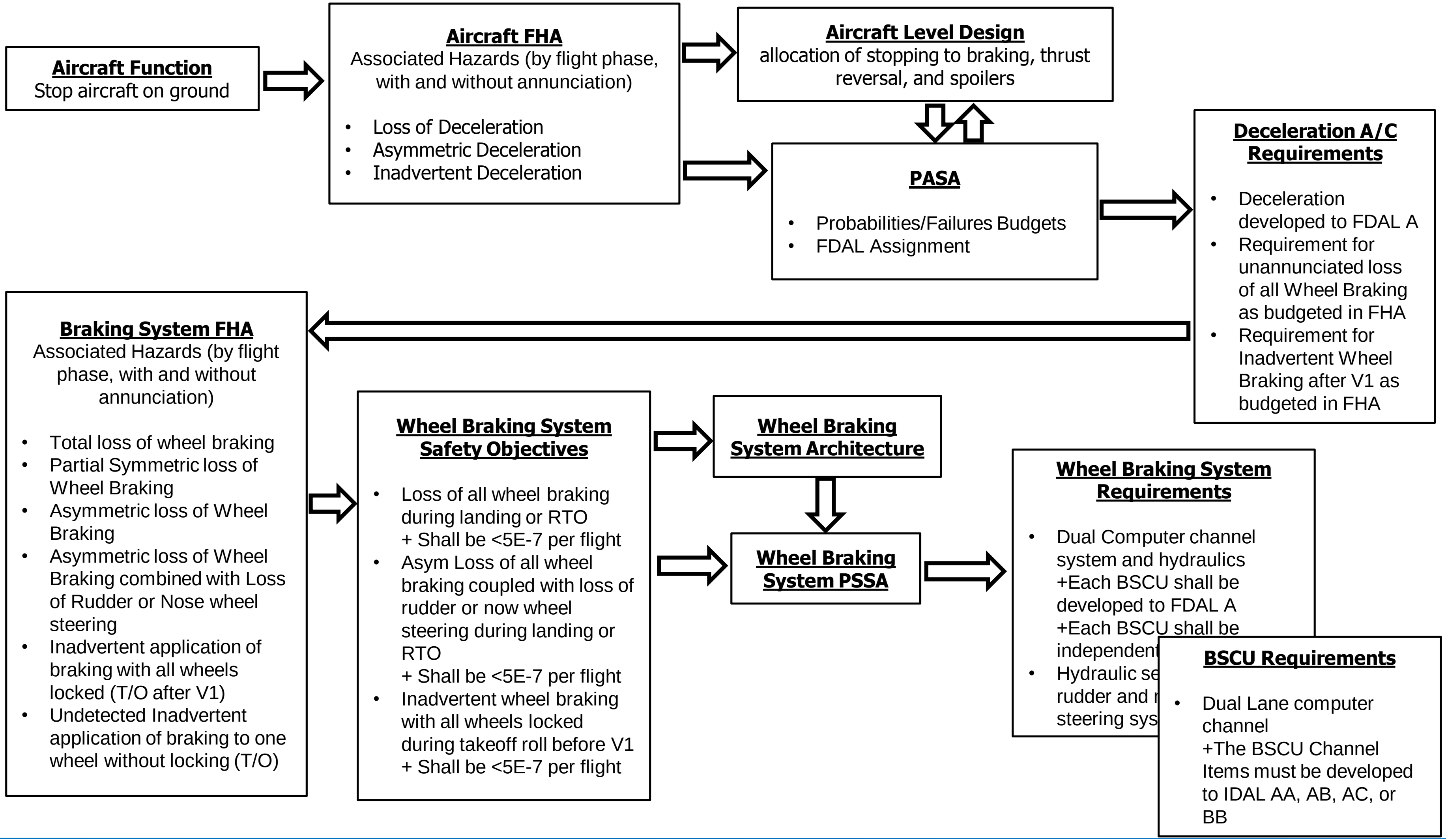

Aircraft Function
Stop aircraft on ground

Aircraft FHA
Associated Hazards (by flight phase, with and without annunciation)

- Loss of Deceleration
- Asymmetric Deceleration
- Inadvertent Deceleration

Aircraft Level Design
allocation of stopping to braking, thrust reversal, and spoilers

PASA

- Probabilities/Failures Budgets
- FDAL Assignment

Deceleration A/C Requirements

- Deceleration developed to FDAL A
- Requirement for unannunciated loss of all Wheel Braking as budgeted in FHA
- Requirement for Inadvertent Wheel Braking after V1 as budgeted in FHA

Braking System FHA
Associated Hazards (by flight phase, with and without annunciation)

- Total loss of wheel braking
- Partial Symmetric loss of Wheel Braking
- Asymmetric loss of Wheel Braking
- Asymmetric loss of Wheel Braking combined with Loss of Rudder or Nose wheel steering
- Inadvertent application of braking with all wheels locked (T/O after V1)
- Undetected Inadvertent application of braking to one wheel without locking (T/O)

Wheel Braking System Safety Objectives

- Loss of all wheel braking during landing or RTO
  + Shall be <5E-7 per flight
- Asym Loss of all wheel braking coupled with loss of rudder or now wheel steering during landing or RTO
  + Shall be <5E-7 per flight
- Inadvertent wheel braking with all wheels locked during takeoff roll before V1
  + Shall be <5E-7 per flight

Wheel Braking System Architecture

Wheel Braking System PSSA

Wheel Braking System Requirements

- Dual Computer channel system and hydraulics
  +Each BSCU shall be developed to FDAL A
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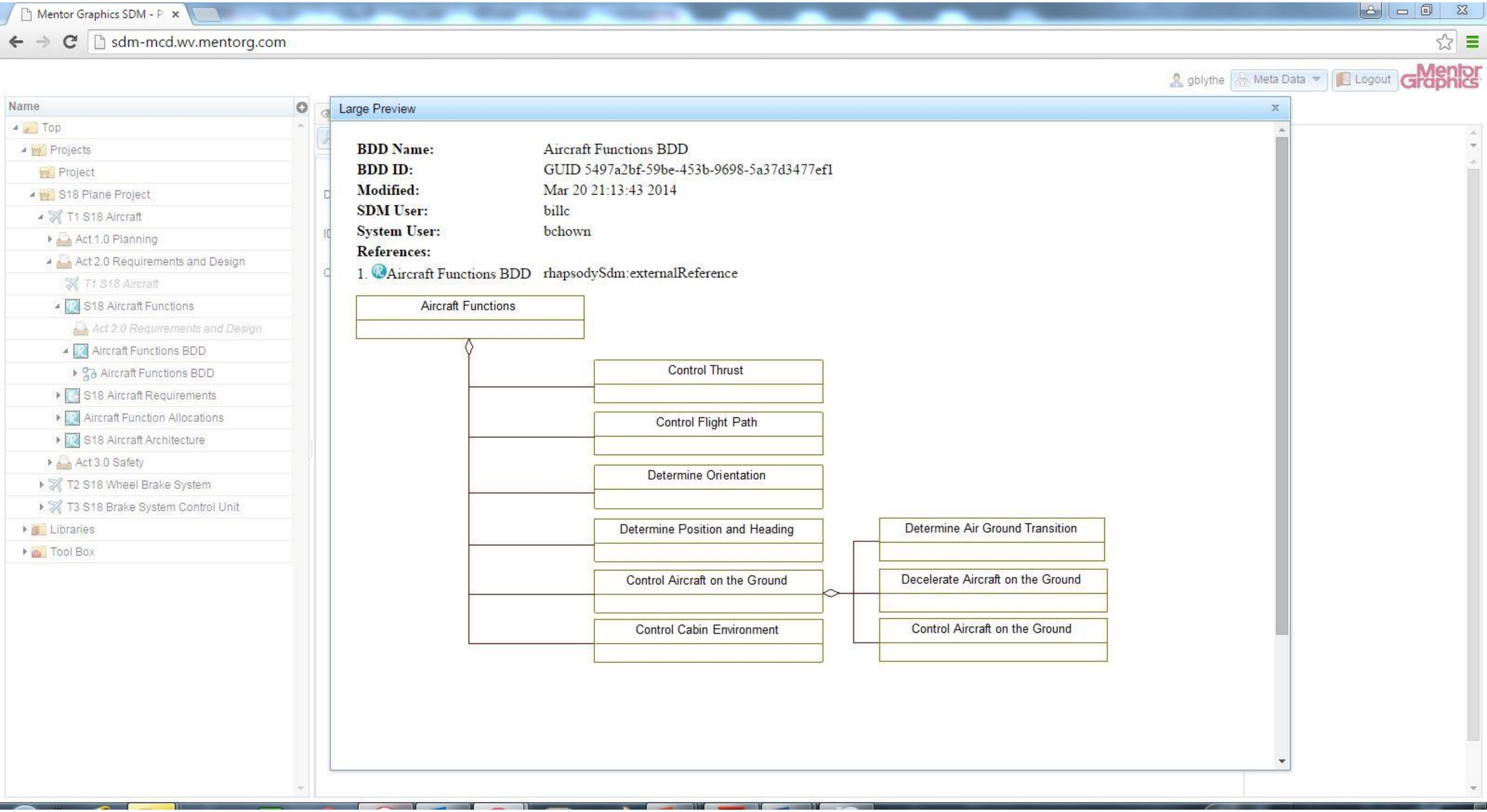
BSCU Requirements

- Dual Lane computer channel
  +The BSCU Channel Items must be developed to IDAL AA, AB, AC, or BB

ELYSIUM Parker NORTHROP GRUMMAN BOEING GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

Results - Aircraft Functions



- Top
  - Projects
    - Project
    - S18 Plane Project
      - T1 S18 Aircraft
        - Act 1.0 Planning
        - Act 2.0 Requirements and Design
          - *T1 S18 Aircraft*
          - S18 Aircraft Functions
            - *Act 2.0 Requirements and Design*
            - Aircraft Functions BDD
              - Aircraft Functions BDD
          - S18 Aircraft Requirements
          - Aircraft Function Allocations
          - S18 Aircraft Architecture
        - Act 3.0 Safety
      - T2 S18 Wheel Brake System
      - T3 S18 Brake System Control Unit
  - Libraries
  - Tool Box

BDD Name: Aircraft Functions BDD

BDD ID: GUID 5497a2bf-59be-453b-9698-5a37d3477ef1

Modified: Mar 20 21:13:43 2014

SDM User: billc

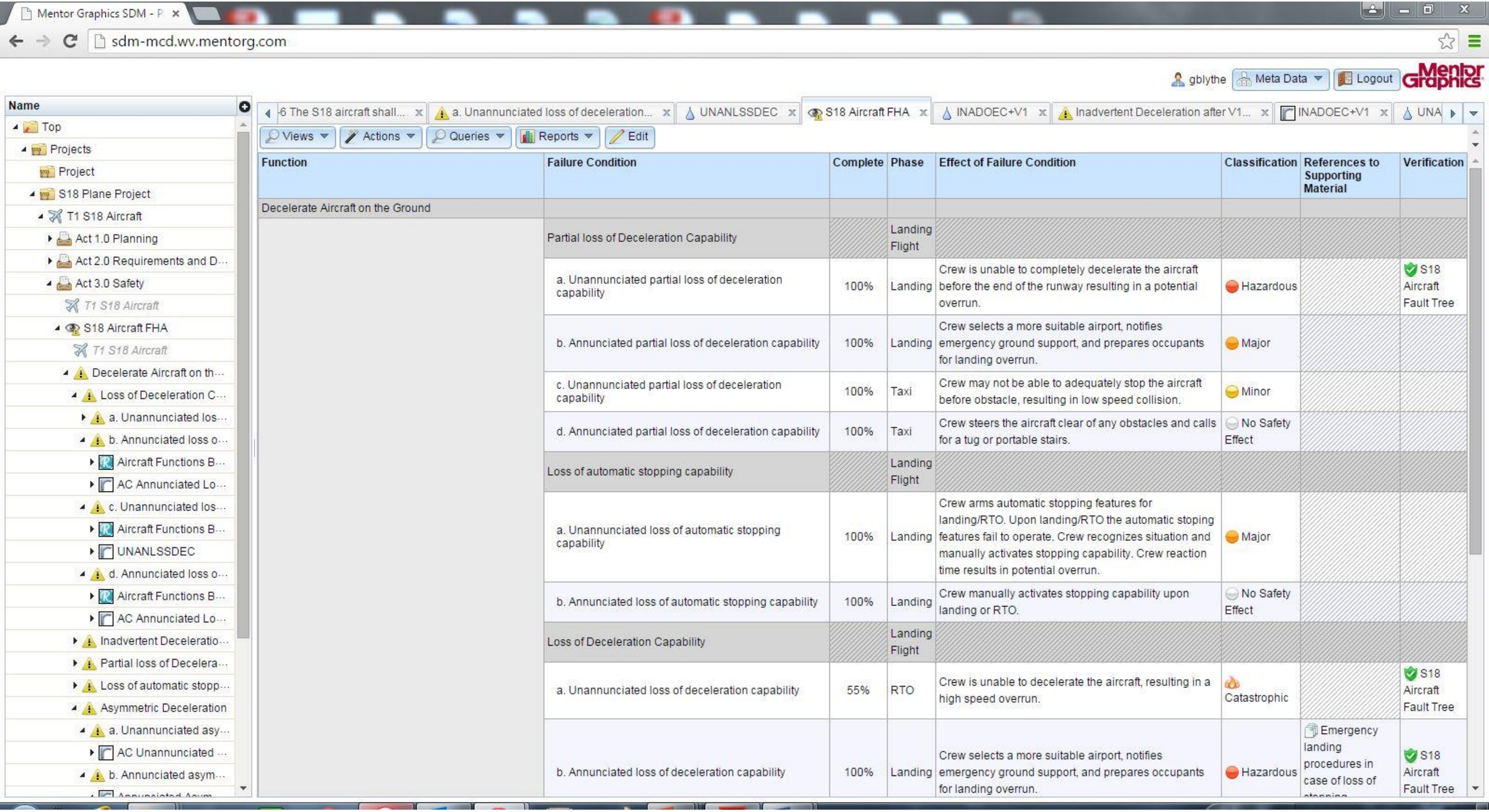
System User: bchown

References:

1. Aircraft Functions BDD rhapsodySdm:externalReference

Aircraft Functions
Control Thrust
Control Flight Path
Determine Orientation
Determine Position and Heading
Control Aircraft on the Ground
Control Cabin Environment
Determine Air Ground Transition
Decelerate Aircraft on the Ground
Control Aircraft on the Ground

Results - Functional Hazard Assessment



Name

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  - Projects
    - Project
    - S18 Plane Project
      - T1 S18 Aircraft
        - Act 1.0 Planning
        - Act 2.0 Requirements and D...
        - Act 3.0 Safety
          - *T1 S18 Aircraft*
          - S18 Aircraft FHA
            - *T1 S18 Aircraft*
            - Decelerate Aircraft on th...
              - Loss of Deceleration C...
                - a. Unannunciated los...
                - b. Annunciated loss o...
                  - Aircraft Functions B...
                  - AC Annunciated Lo...
                - c. Unannunciated los...
                  - Aircraft Functions B...
                  - UNANLSSDEC
                - d. Annunciated loss o...
                  - Aircraft Functions B...
                  - AC Annunciated Lo...
              - Inadvertent Deceleratio...
              - Partial loss of Decelera...
              - Loss of automatic stopp...
              - Asymmetric Deceleration
                - a. Unannunciated asy...
                  - AC Unannunciated ...
                - b. Annunciated asym...
                  - Annunciated Asym...

Function	Failure Condition	Complete	Phase	Effect of Failure Condition	Classification	References to Supporting Material	Verification
Decelerate Aircraft on the Ground							
	Partial loss of Deceleration Capability		Landing Flight				
	a. Unannunciated partial loss of deceleration capability	100%	Landing	Crew is unable to completely decelerate the aircraft before the end of the runway resulting in a potential overrun.	● Hazardous		✓ S18 Aircraft Fault Tree
	b. Annunciated partial loss of deceleration capability	100%	Landing	Crew selects a more suitable airport, notifies emergency ground support, and prepares occupants for landing overrun.	● Major		
	c. Unannunciated partial loss of deceleration capability	100%	Taxi	Crew may not be able to adequately stop the aircraft before obstacle, resulting in low speed collision.	● Minor		
	d. Annunciated partial loss of deceleration capability	100%	Taxi	Crew steers the aircraft clear of any obstacles and calls for a tug or portable stairs.	○ No Safety Effect		
	Loss of automatic stopping capability		Landing Flight				
	a. Unannunciated loss of automatic stopping capability	100%	Landing	Crew arms automatic stopping features for landing/RTO. Upon landing/RTO the automatic stoping features fail to operate. Crew recognizes situation and manually activates stopping capability. Crew reaction time results in potential overrun.	● Major		
	b. Annunciated loss of automatic stopping capability	100%	Landing	Crew manually activates stopping capability upon landing or RTO.	○ No Safety Effect		
	Loss of Deceleration Capability		Landing Flight				
	a. Unannunciated loss of deceleration capability	55%	RTO	Crew is unable to decelerate the aircraft, resulting in a high speed overrun.	Catastrophic		✓ S18 Aircraft Fault Tree
	b. Annunciated loss of deceleration capability	100%	Landing	Crew selects a more suitable airport, notifies emergency ground support, and prepares occupants for landing overrun.	● Hazardous	Emergency landing procedures in case of loss of stopping	✓ S18 Aircraft Fault Tree

Results – Fault Tree Analysis

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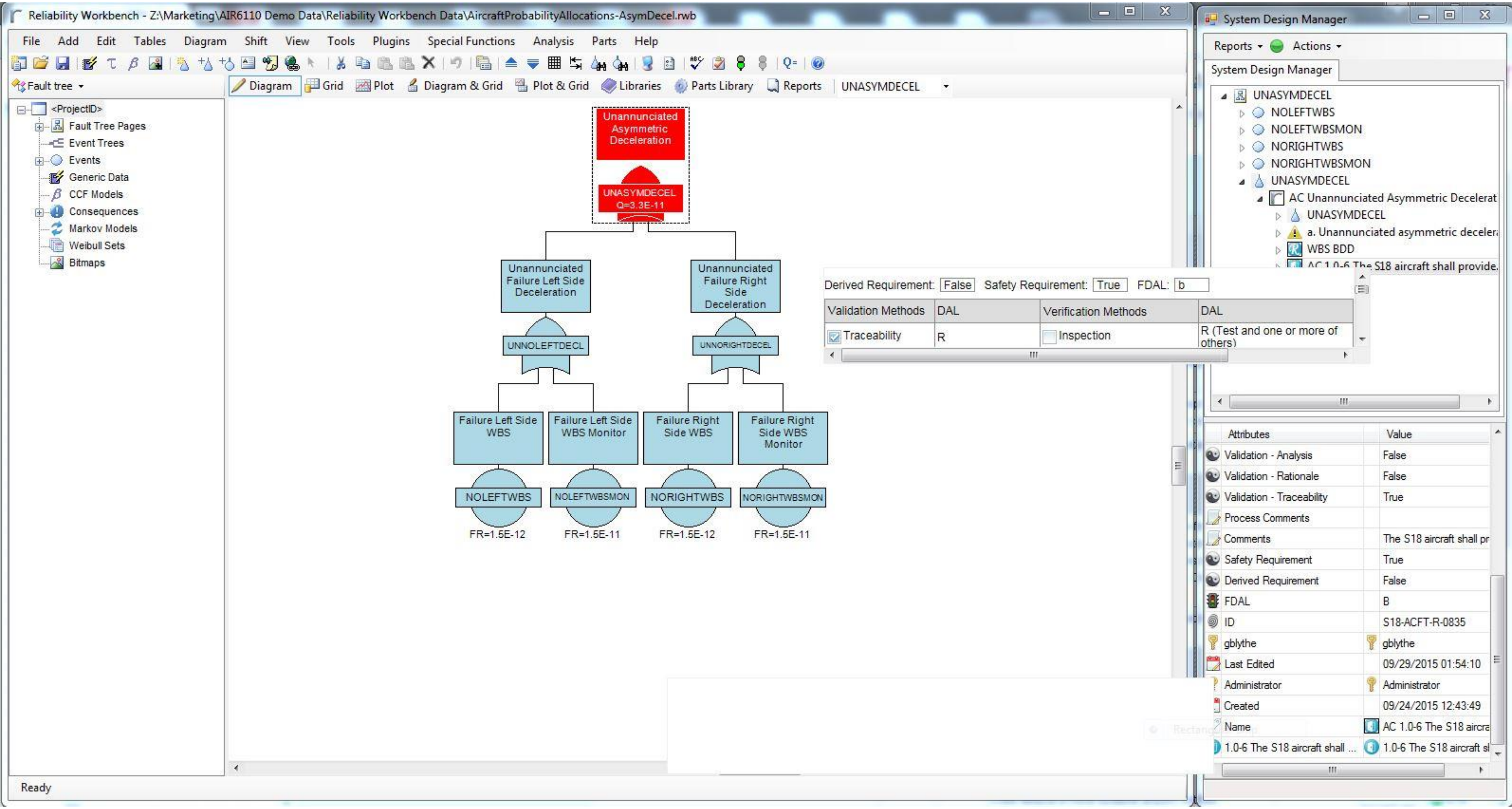
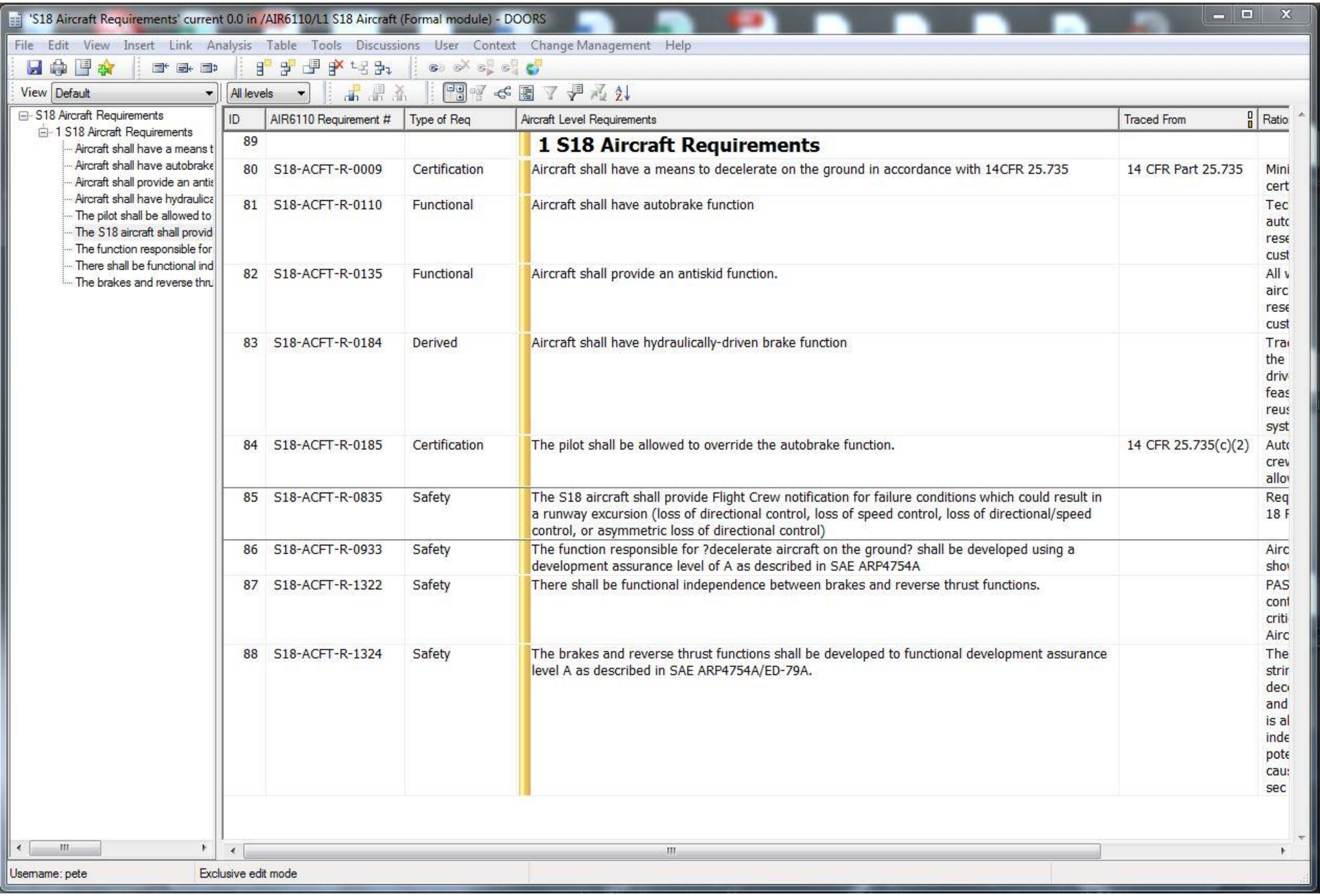


Derived Requirement: False Safety Requirement: True FDAL: b

Validation Methods	DAL	Verification Methods	DAL
☑ Traceability	R	□ Inspection	R (Test and one or more of others)

Attributes	Value
Validation - Analysis	False
Validation - Rationale	False
Validation - Traceability	True
Process Comments	
Comments	The S18 aircraft shall pr
Safety Requirement	True
Derived Requirement	False
FDAL	B
ID	S18-ACFT-R-0835
gblythe	gblythe
Last Edited	09/29/2015 01:54:10
Administrator	Administrator
Created	09/24/2015 12:43:49
Name	AC 1.0-6 The S18 aircra
1.0-6 The S18 aircraft shall ...	1.0-6 The S18 aircraft sl

Results – Requirements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File Edit View Insert Link Analysis Table Tools Discussions User Context Change Management Help
View Default
All levels

S18 Aircraft Requirements
1 S18 Aircraft Requirements
Aircraft shall have a means t
Aircraft shall have autobrake
Aircraft shall provide an antis
Aircraft shall have hydraulica
The pilot shall be allowed to
The S18 aircraft shall provid
The function responsible for
There shall be functional ind
The brakes and reverse thru

ID	AIR6110 Requirement #	Type of Req	Aircraft Level Requirements	Traced From	Ratio
89			**1 S18 Aircraft Requirements**		
80	S18-ACFT-R-0009	Certification	Aircraft shall have a means to decelerate on the ground in accordance with 14CFR 25.735	14 CFR Part 25.735	Mini cert
81	S18-ACFT-R-0110	Functional	Aircraft shall have autobrake function		Tec autc rese cust
82	S18-ACFT-R-0135	Functional	Aircraft shall provide an antiskid function.		All v airc rese cust
83	S18-ACFT-R-0184	Derived	Aircraft shall have hydraulically-driven brake function		Trac the driv feas reus syst
84	S18-ACFT-R-0185	Certification	The pilot shall be allowed to override the autobrake function.	14 CFR 25.735(c)(2)	Autc crev allov
85	S18-ACFT-R-0835	Safety	The S18 aircraft shall provide Flight Crew notification for failure conditions which could result in a runway excursion (loss of directional control, loss of speed control, loss of directional/speed control, or asymmetric loss of directional control)		Req 18 F
86	S18-ACFT-R-0933	Safety	The function responsible for ?decelerate aircraft on the ground? shall be developed using a development assurance level of A as described in SAE ARP4754A		Airc shov
87	S18-ACFT-R-1322	Safety	There shall be functional independence between brakes and reverse thrust functions.		PAS cont criti Airc
88	S18-ACFT-R-1324	Safety	The brakes and reverse thrust functions shall be developed to functional development assurance level A as described in SAE ARP4754A/ED-79A.		The strir decı and is al inde pote caus sec

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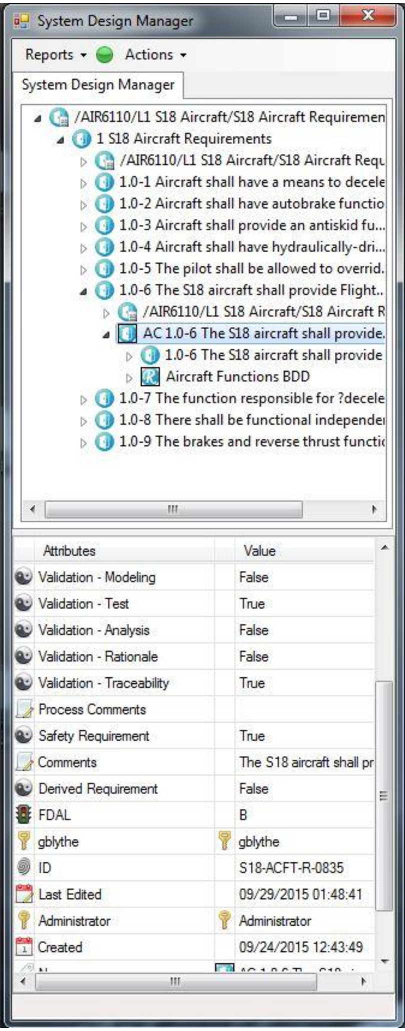

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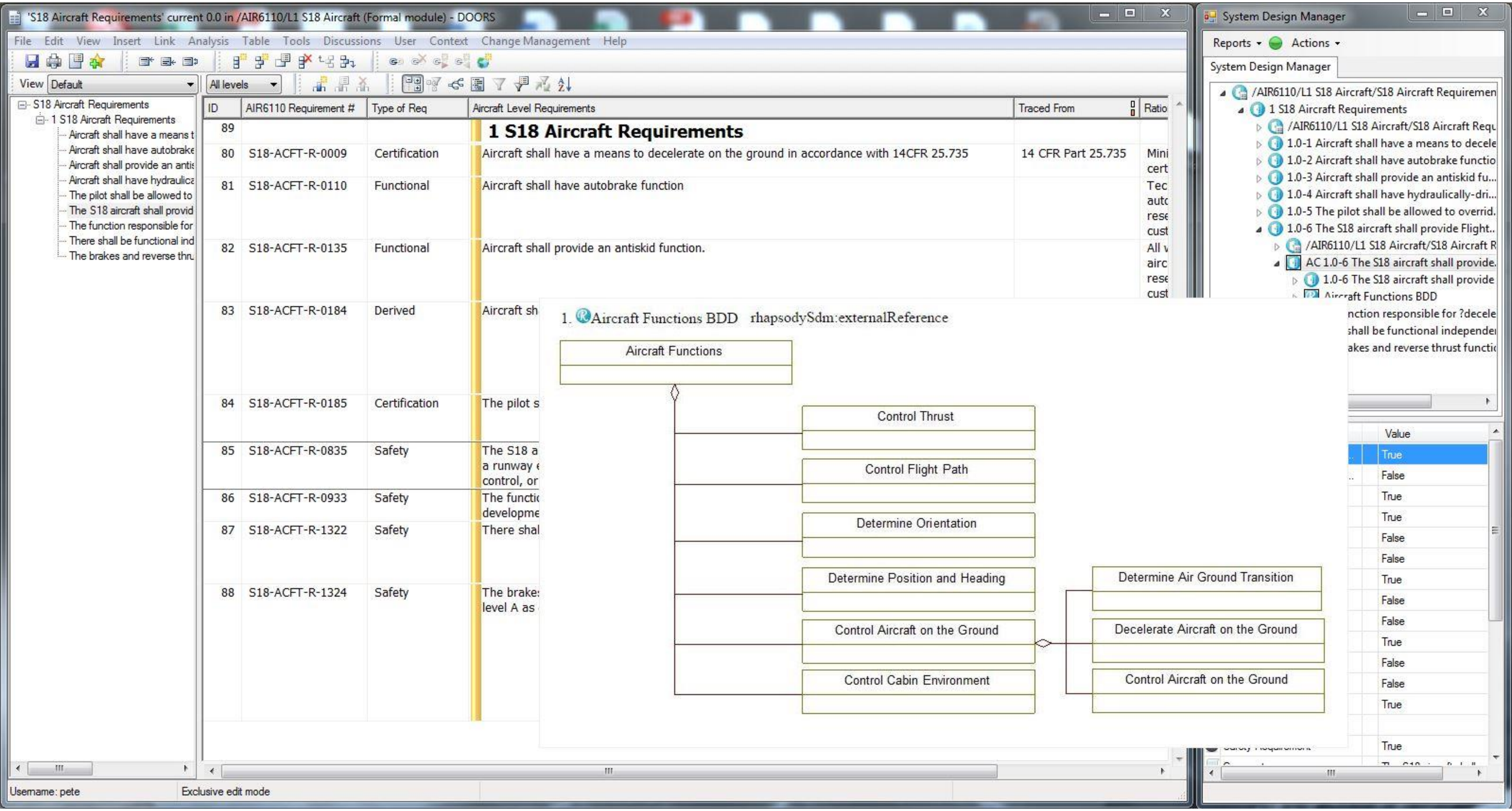
1 S18 Aircraft Requirements
/AIR6110/L1 S18 Aircraft/S18 Aircraft Requ
1.0-1 Aircraft shall have a means to decele
1.0-2 Aircraft shall have autobrake functio
1.0-3 Aircraft shall provide an antiskid fu...
1.0-4 Aircraft shall have hydraulically-dri...
1.0-5 The pilot shall be allowed to overrid.
1.0-6 The S18 aircraft shall provide Flight..
/AIR6110/L1 S18 Aircraft/S18 Aircraft R
AC 1.0-6 The S18 aircraft shall provide.
1.0-6 The S18 aircraft shall provide
Aircraft Functions BDD
1.0-7 The function responsible for ?decele
1.0-8 There shall be functional independe
1.0-9 The brakes and reverse thrust functic

Attributes	Value
Validation - Modeling	False
Validation - Test	True
Validation - Analysis	False
Validation - Rationale	False
Validation - Traceability	True
Process Comments	
Safety Requirement	True
Comments	The S18 aircraft shall pr
Derived Requirement	False
FDAL	B
gblythe	gblythe
ID	S18-ACFT-R-0835
Last Edited	09/29/2015 01:48:41
Administrator	Administrator
Created	09/24/2015 12:43:49

Results – Requirements traced to Design



'S18 Aircraft Requirements' current 0.0 in /AIR6110/L1 S18 Aircraft (Formal module) - DOORS
File Edit View Insert Link Analysis Table Tools Discussions User Context Change Management Help
View Default
All levels
System Design Manager
Reports Actions
System Design Manager
Value
Username: pete
Exclusive edit mode

- S18 Aircraft Requirements
  - 1 S18 Aircraft Requirements
    - Aircraft shall have a means t
    - Aircraft shall have autobrake
    - Aircraft shall provide an antis
    - Aircraft shall have hydraulica
    - The pilot shall be allowed to
    - The S18 aircraft shall provid
    - The function responsible for
    - There shall be functional ind
    - The brakes and reverse thru

ID	AIR6110 Requirement #	Type of Req	Aircraft Level Requirements	Traced From	Ratio
89			**1 S18 Aircraft Requirements**		
80	S18-ACFT-R-0009	Certification	Aircraft shall have a means to decelerate on the ground in accordance with 14CFR 25.735	14 CFR Part 25.735	Mini cert
81	S18-ACFT-R-0110	Functional	Aircraft shall have autobrake function		Tec autc rese cust
82	S18-ACFT-R-0135	Functional	Aircraft shall provide an antiskid function.		All v airc rese cust
83	S18-ACFT-R-0184	Derived	Aircraft sh		
84	S18-ACFT-R-0185	Certification	The pilot s		
85	S18-ACFT-R-0835	Safety	The S18 a a runway e control, or		
86	S18-ACFT-R-0933	Safety	The functio developme		
87	S18-ACFT-R-1322	Safety	There shal		
88	S18-ACFT-R-1324	Safety	The brakes level A as		

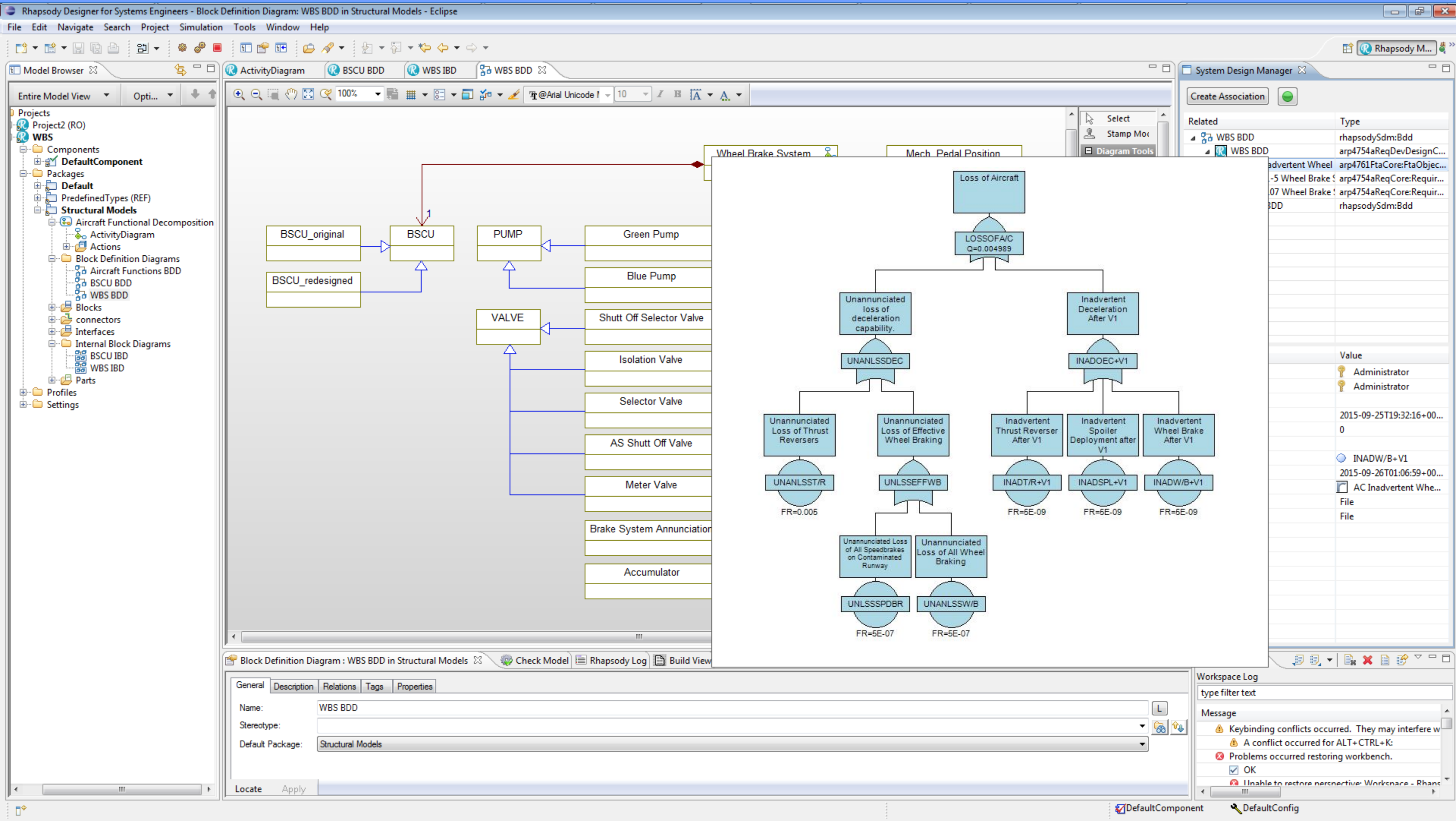
- /AIR6110/L1 S18 Aircraft/S18 Aircraft Requiremen
  - 1 S18 Aircraft Requirements
    - /AIR6110/L1 S18 Aircraft/S18 Aircraft Requ
    - 1.0-1 Aircraft shall have a means to decele
    - 1.0-2 Aircraft shall have autobrake functio
    - 1.0-3 Aircraft shall provide an antiskid fu...
    - 1.0-4 Aircraft shall have hydraulically-dri...
    - 1.0-5 The pilot shall be allowed to overrid.
    - 1.0-6 The S18 aircraft shall provide Flight..
      - /AIR6110/L1 S18 Aircraft/S18 Aircraft R
      - AC 1.0-6 The S18 aircraft shall provide.
        - 1.0-6 The S18 aircraft shall provide
        - Aircraft Functions BDD
    - nction responsible for ?decele
    - shall be functional independer
    - akes and reverse thrust functio

Value
True
False
True
True
False
False
True
False
False
True
False
False
True
True

1. Aircraft Functions BDD rhapsodySdm:externalReference

Aircraft Functions
Control Thrust
Control Flight Path
Determine Orientation
Determine Position and Heading
Control Aircraft on the Ground
Control Cabin Environment
Determine Air Ground Transition
Decelerate Aircraft on the Ground
Control Aircraft on the Ground

Results – System Design



- Projects
  - Project2 (RO)
  - **WBS**
    - Components
      - **DefaultComponent**
    - Packages
      - **Default**
      - PredefinedTypes (REF)
      - **Structural Models**
        - Aircraft Functional Decomposition
          - ActivityDiagram
          - Actions
        - Block Definition Diagrams
          - Aircraft Functions BDD
          - BSCU BDD
          - WBS BDD
        - Blocks
        - connectors
        - Interfaces
        - Internal Block Diagrams
          - BSCU IBD
          - WBS IBD
        - Parts
    - Profiles
    - Settings

Related	Type
WBS BDD	rhapsodySdm:Bdd
WBS BDD	arp4754aReqDevDesignC...
ıadvertent Wheel	arp4761FtaCore:FtaObjec...
.-5 Wheel Brake !	arp4754aReqCore:Requir...
.07 Wheel Brake !	arp4754aReqCore:Requir...
3DD	rhapsodySdm:Bdd

Value
Administrator
Administrator
2015-09-25T19:32:16+00...
0
○ INADW/B+V1
2015-09-26T01:06:59+00...
AC Inadvertent Whe...
File
File

Name: WBS BDD

Stereotype:

Default Package: Structural Models

Message
```
⚠ Keybinding conflicts occurred.  They may interfere w
   ⚠ A conflict occurred for ALT+CTRL+K:
⊗ Problems occurred restoring workbench.
   ☑ OK
   ⊗ Unable to restore perspective: Workspace - Rhaps
```

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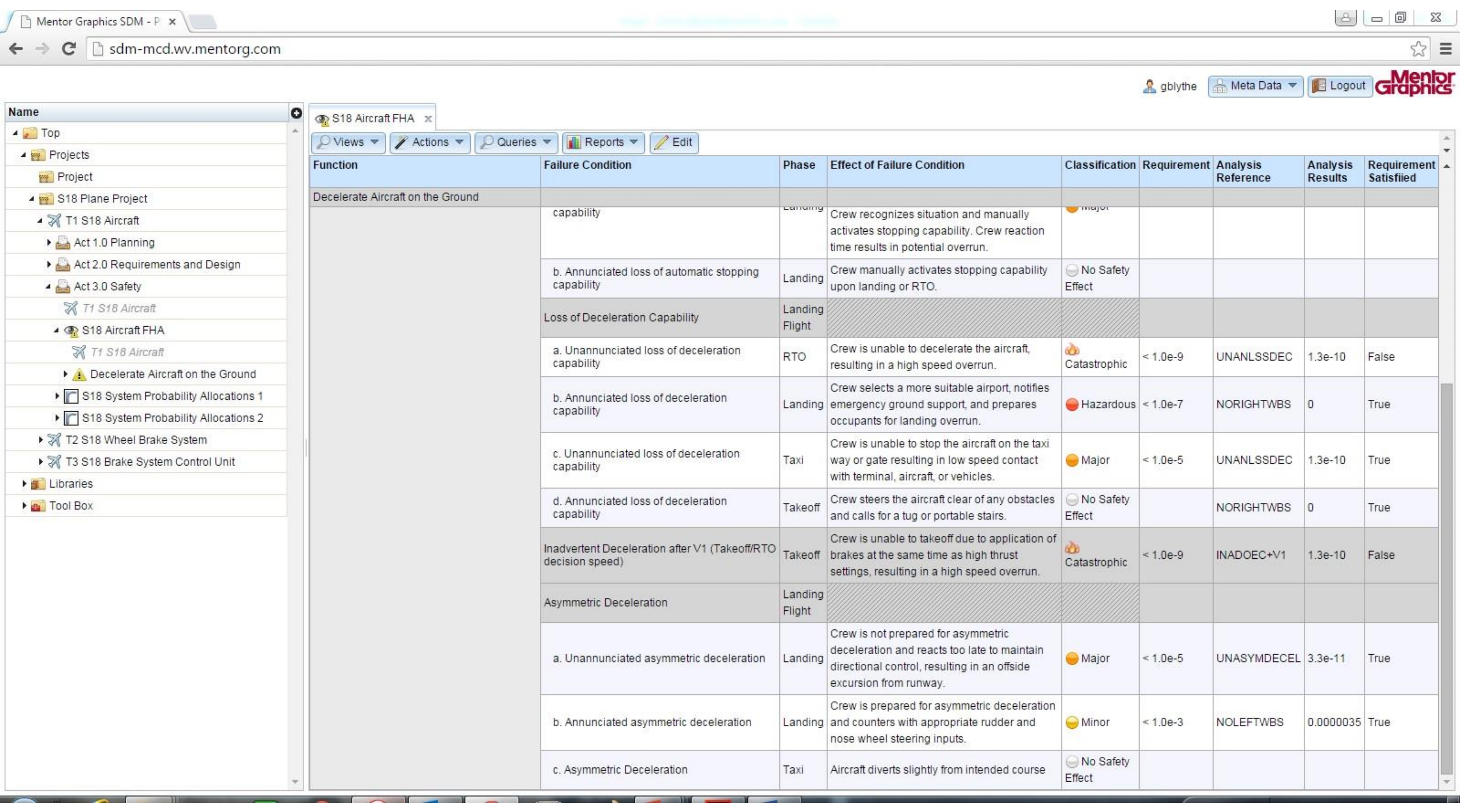
Results – Safety Analysis



Name

- Top
  - Projects
    - Project
    - S18 Plane Project
      - T1 S18 Aircraft
        - Act 1.0 Planning
        - Act 2.0 Requirements and Design
        - Act 3.0 Safety
          - *T1 S18 Aircraft*
          - S18 Aircraft FHA
            - *T1 S18 Aircraft*
            - Decelerate Aircraft on the Ground
          - S18 System Probability Allocations 1
          - S18 System Probability Allocations 2
      - T2 S18 Wheel Brake System
      - T3 S18 Brake System Control Unit
  - Libraries
  - Tool Box

Function	Failure Condition	Phase	Effect of Failure Condition	Classification	Requirement	Analysis Reference	Analysis Results	Requirement Satisfied
Decelerate Aircraft on the Ground								
	capability		Crew recognizes situation and manually activates stopping capability. Crew reaction time results in potential overrun.					
	b. Annunciated loss of automatic stopping capability	Landing	Crew manually activates stopping capability upon landing or RTO.	○ No Safety Effect				
	Loss of Deceleration Capability	Landing Flight						
	a. Unannunciated loss of deceleration capability	RTO	Crew is unable to decelerate the aircraft, resulting in a high speed overrun.	Catastrophic	< 1.0e-9	UNANLSSDEC	1.3e-10	False
	b. Annunciated loss of deceleration capability	Landing	Crew selects a more suitable airport, notifies emergency ground support, and prepares occupants for landing overrun.	● Hazardous	< 1.0e-7	NORIGHTWBS	0	True
	c. Unannunciated loss of deceleration capability	Taxi	Crew is unable to stop the aircraft on the taxi way or gate resulting in low speed contact with terminal, aircraft, or vehicles.	● Major	< 1.0e-5	UNANLSSDEC	1.3e-10	True
	d. Annunciated loss of deceleration capability	Takeoff	Crew steers the aircraft clear of any obstacles and calls for a tug or portable stairs.	○ No Safety Effect		NORIGHTWBS	0	True
	Inadvertent Deceleration after V1 (Takeoff/RTO decision speed)	Takeoff	Crew is unable to takeoff due to application of brakes at the same time as high thrust settings, resulting in a high speed overrun.	Catastrophic	< 1.0e-9	INADOEC+V1	1.3e-10	False
	Asymmetric Deceleration	Landing Flight						
	a. Unannunciated asymmetric deceleration	Landing	Crew is not prepared for asymmetric deceleration and reacts too late to maintain directional control, resulting in an offside excursion from runway.	● Major	< 1.0e-5	UNASYMDECEL	3.3e-11	True
	b. Annunciated asymmetric deceleration	Landing	Crew is prepared for asymmetric deceleration and counters with appropriate rudder and nose wheel steering inputs.	● Minor	< 1.0e-3	NOLEFTWBS	0.0000035	True
	c. Asymmetric Deceleration	Taxi	Aircraft diverts slightly from intended course	○ No Safety Effect				

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Next Steps: Pursuing Continuous Improvement

Where is non-value added work still existing in the value-stream?

Transportation

Manually moving/importing/exporting data between multiple design tools

Manually reformatting/translating data for use in multiple tools

Motion

Staff switching & multi-tasking across several unintegrated tools

Searching for data in multiple locations

Waiting

Attempting to start tasks before inputs are ready

Tasks not performed according to priority (off critical path)

Over-production

Creating & maintaining multiple copies of the same data

Defects

Defects introduced during non-value add activities such as moving, copying, translating data

Improved Usability

More robust integrations with toolsets

Configuration Management

Better Integrating CM between the selected toolset

Reporting/Analysis

Deeper analysis of data. Improved automation of reports

Thank you!

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For Questions…

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