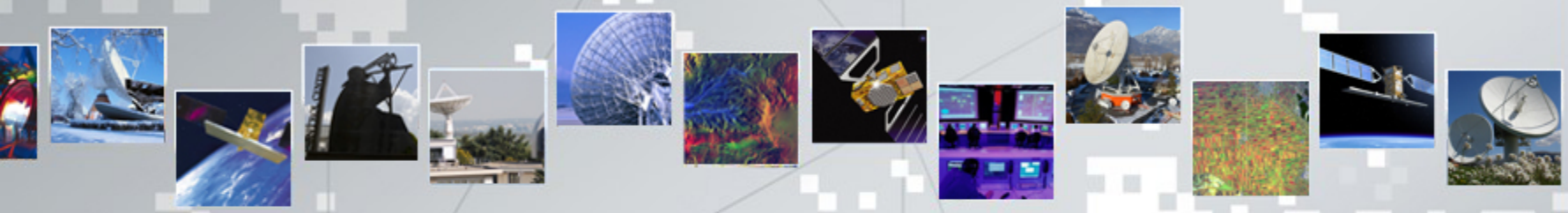


New Modelling Methods in Simulation, Verification and Validation

Final Presentation

ESTEC, 12/12/2017

TELESPAZIO
a LEONARDO and THALES company

AIRBUS

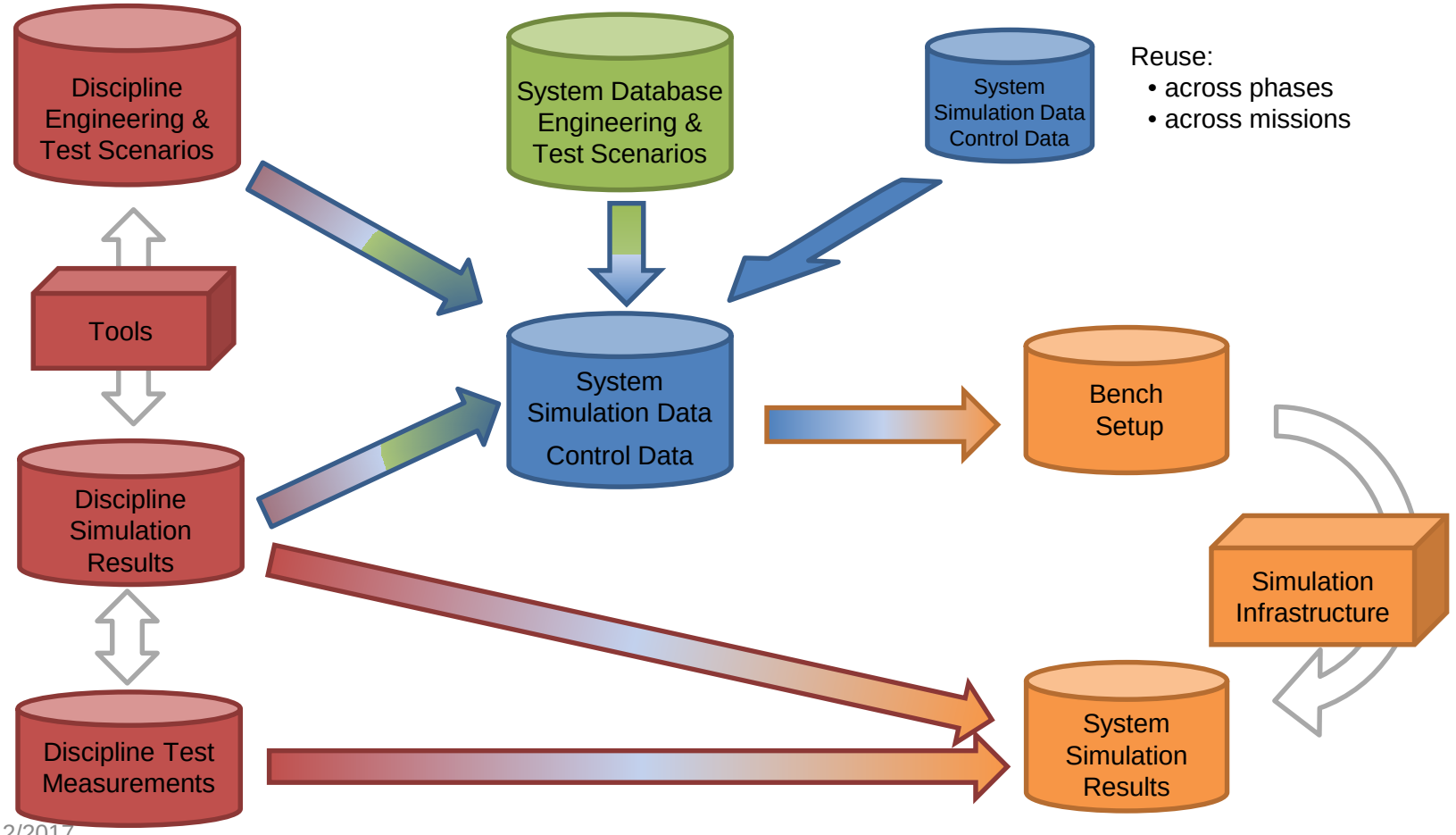
ScopeSET
The Tools Experts

Agenda

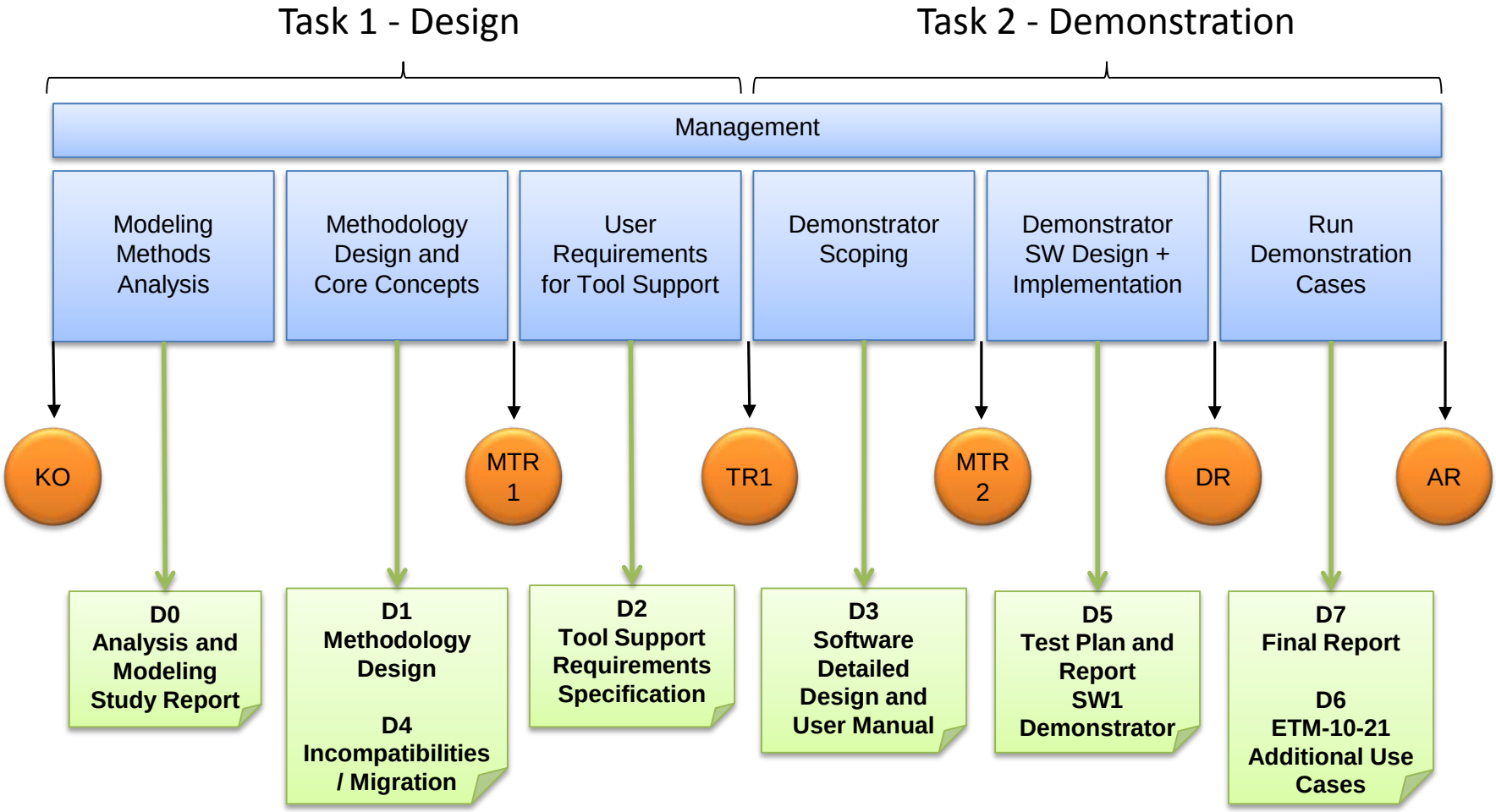
- Study Objective and Logic
- Modelling Methods Analysis
- Methodology Design
- Methodology Core Concepts
- Developed Tools
- Airbus Demonstration Cases
- Telespazio VEGA Demonstration Cases
- Conclusion

Objective and Context

Definition of a Methodology to capture and define the simulation-specific part of the System Database for the creation of a Simulation Model from a Real World System.

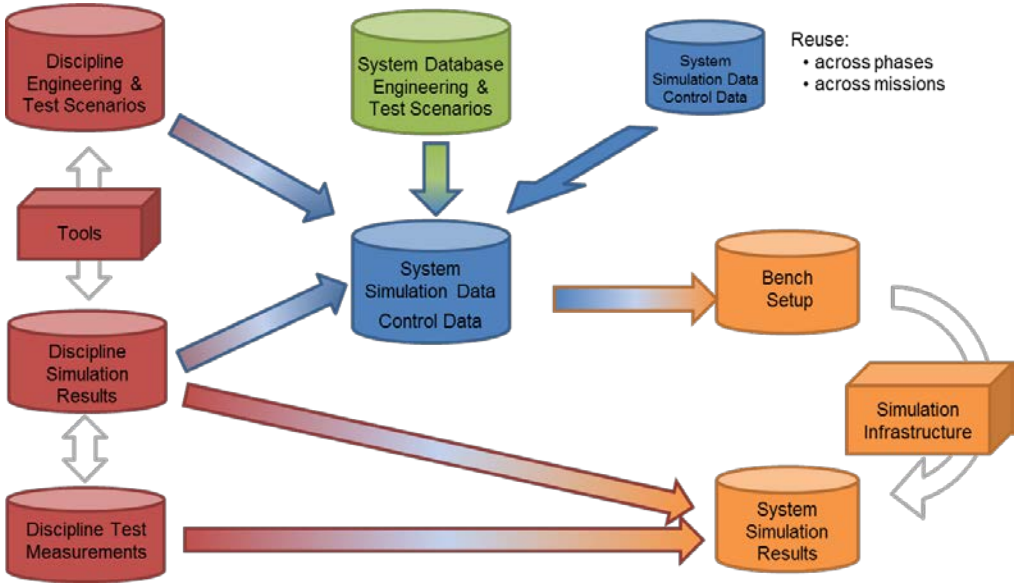


Study Logic


Task 1 - Design
Task 2 - Demonstration
Management
Modeling Methods Analysis
Methodology Design and Core Concepts
User Requirements for Tool Support
Demonstrator Scoping
Demonstrator SW Design + Implementation
Run Demonstration Cases
KO
MTR 1
TR1
MTR 2
DR
AR
D0 Analysis and Modeling Study Report
D1 Methodology Design
D4 Incompatibilities / Migration
D2 Tool Support Requirements Specification
D3 Software Detailed Design and User Manual
D5 Test Plan and Report SW1 Demonstrator
D7 Final Report
D6 ETM-10-21 Additional Use Cases

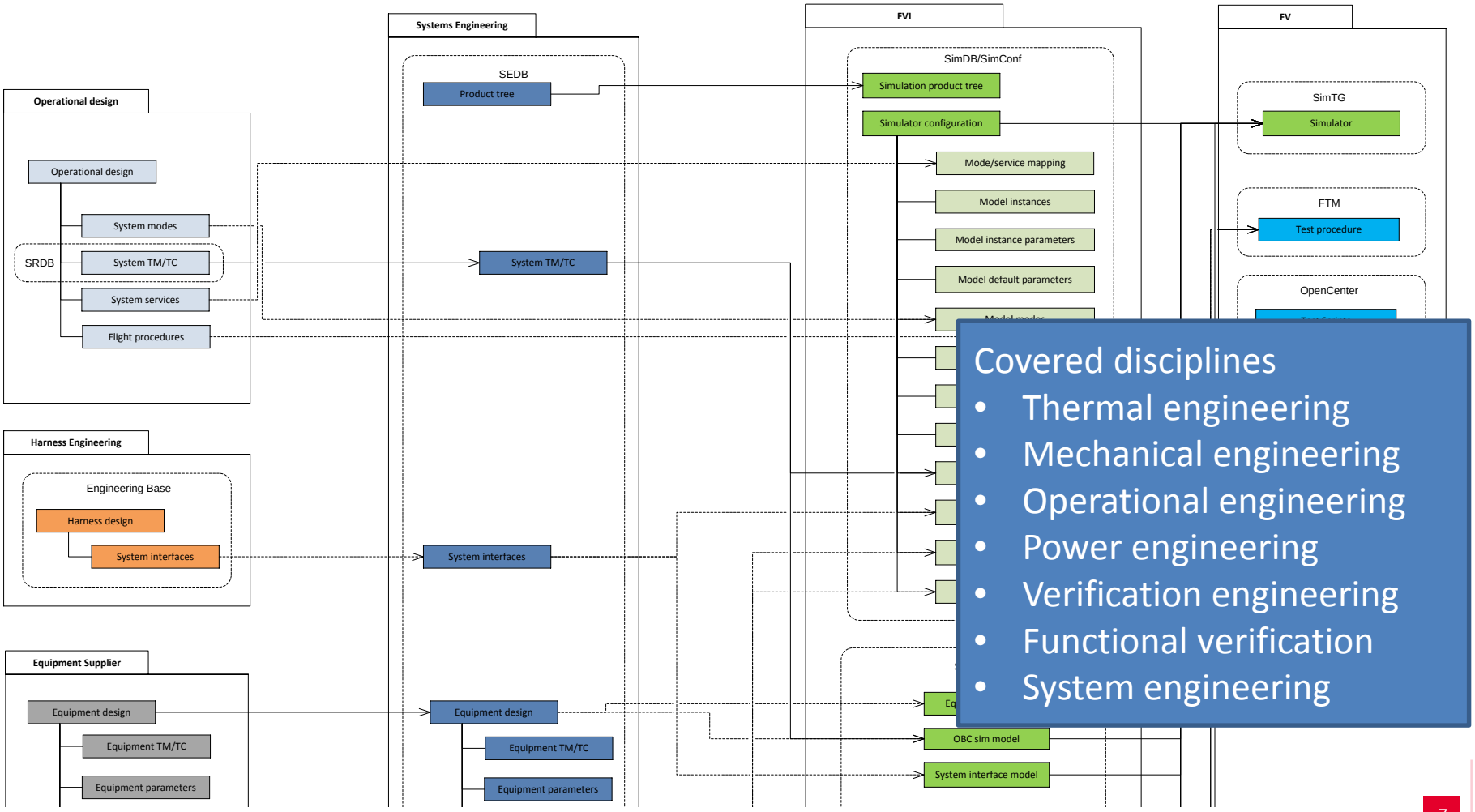
Modelling Methods Analysis

Scope of Analysis w.r.t. ECSS-E-TM-10-21A test facilities



SCS | MPS | FES | FVT | SVF | AIV | GSTS | TOS

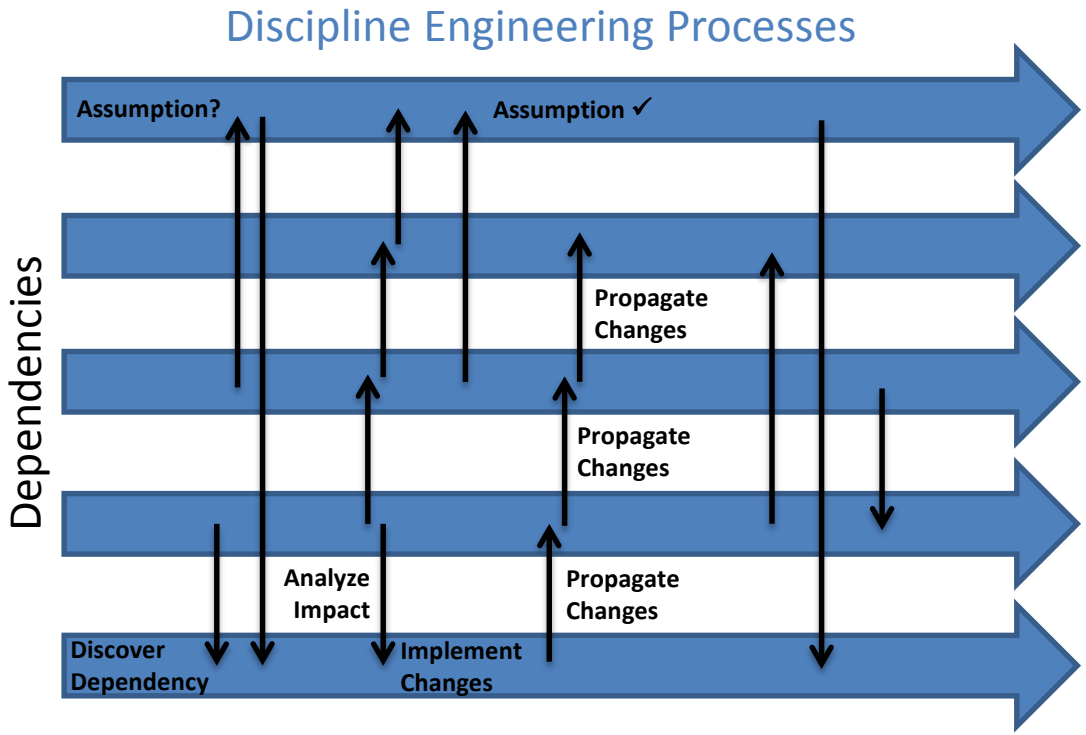
Detailed analyses of engineering processes contributing to system simulation



Covered disciplines

- Thermal engineering
- Mechanical engineering
- Operational engineering
- Power engineering
- Verification engineering
- Functional verification
- System engineering

Challenges within engineering processes contributing to system simulation

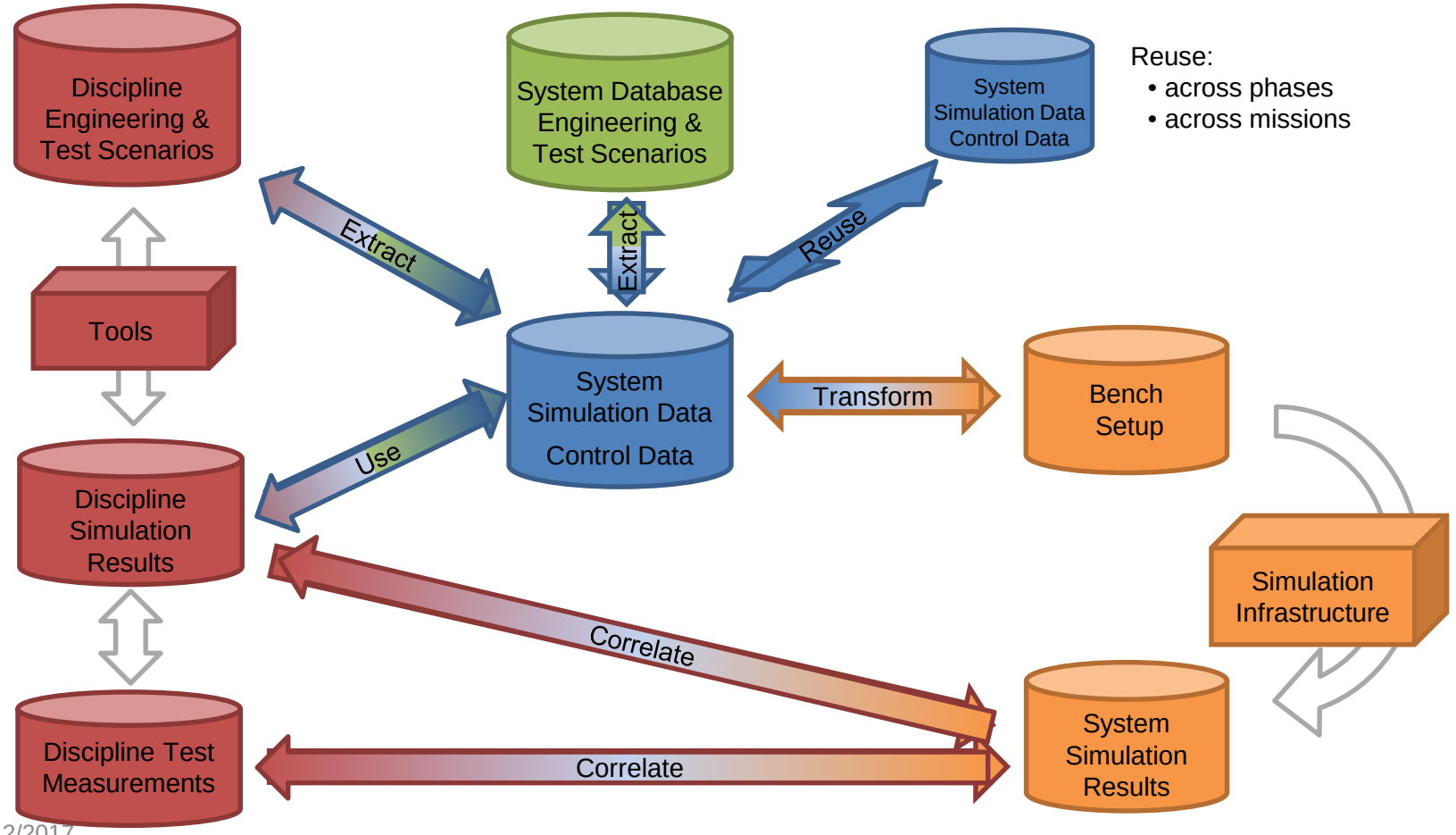


- Dependency chains forming among several engineering processes
- Challenge to continuously integrate updates on objects that serve as process input
- Challenge to provide a consistent set of simulation models across the whole system, across all disciplines
- Usage of assumptions for starting engineering processes without having all input objects on a stable level

Methodology Design

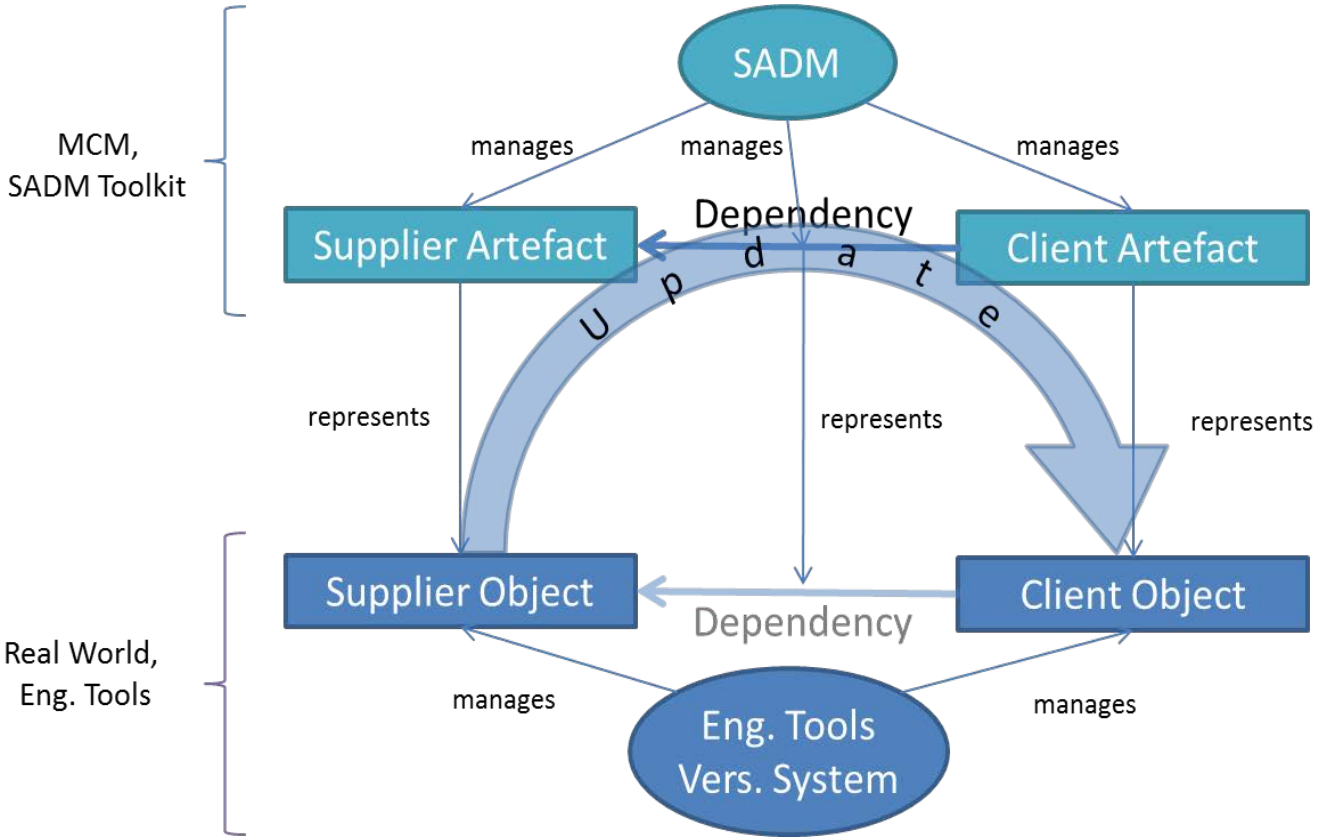
Definition of Dependencies between Objects

Data Update ?

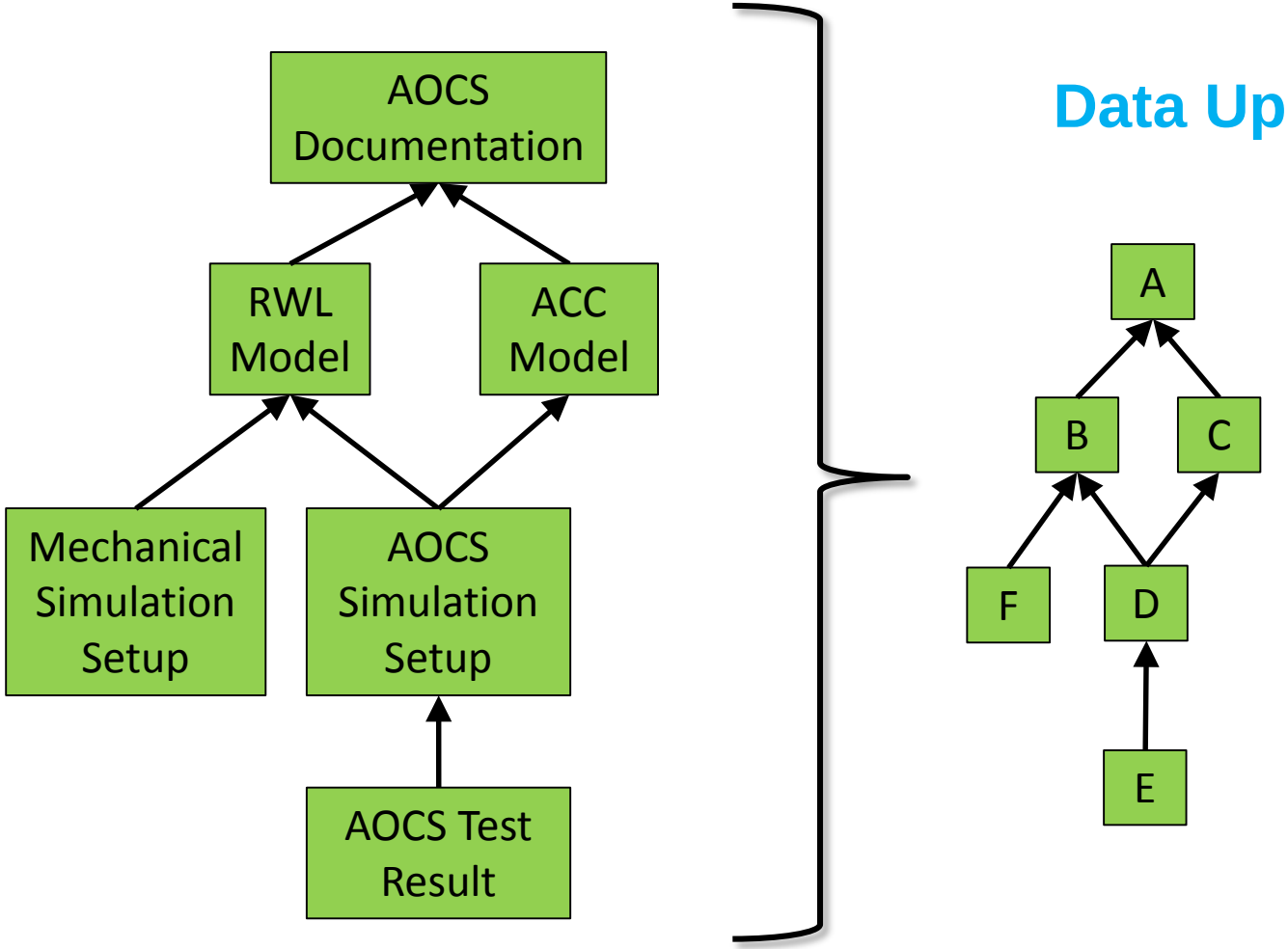


Simulation Artefact Dependency Management (SADM)

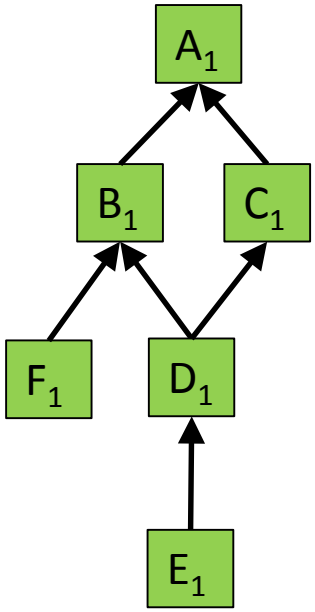
- Capturing of the artefacts needed to provide a system simulation
- Capturing of the dependencies existing between different artefacts
- Procedures to manage a dependency



Artefact Dependency Tree Example (TOS)



Generic Artefact and Dependency Evolution Matrix

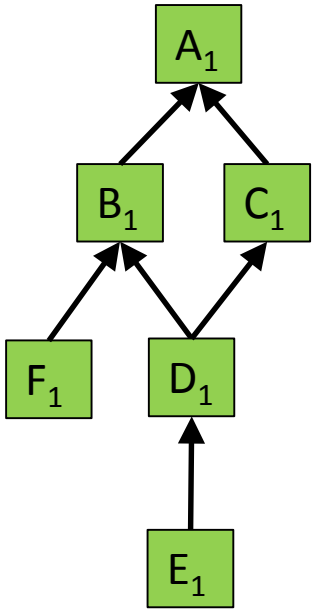


Artefact →

Artefact Version Number →

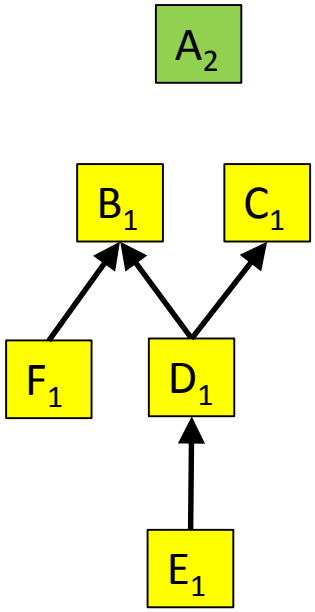
	1	2	3	4	5	6	7	8	9
A	-								
B	A1								
C	A1								
D	B1, C1								
E	D1								
F	B1								

Generic Artefact and Dependency Evolution Matrix
Baseline 1



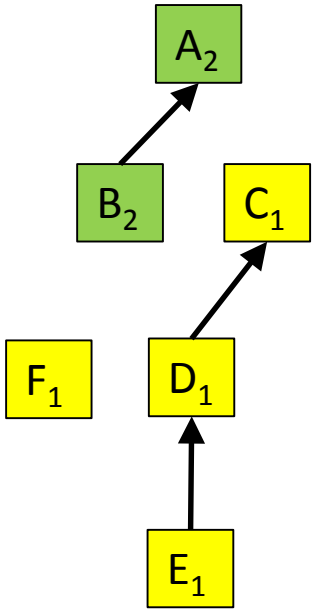
	1	2	3	4	5	6	7	8	9
A	-								
B	A1								
C	A1								
D	B1, C1								
E	D1								
F	B1								
	BL1								

Generic Artefact and Dependency Evolution Matrix



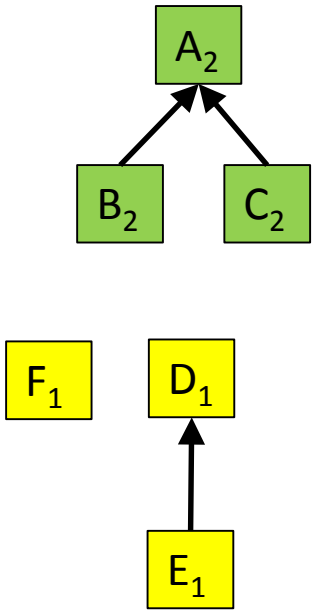
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1								
C	A1								
D	B1, C1								
E	D1								
F	B1								
	BL1								

Generic Artefact and Dependency Evolution Matrix



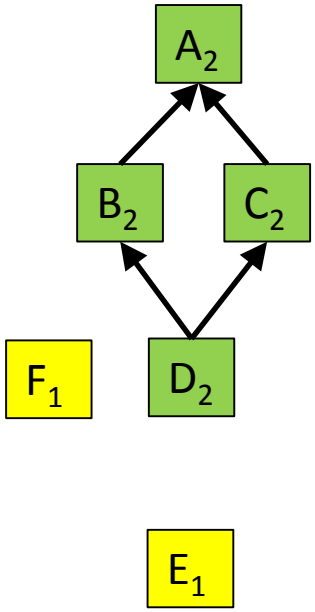
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1	A2							
C	A1								
D	B1, C1								
E	D1								
F	B1								
	BL1								

Generic Artefact and Dependency Evolution Matrix



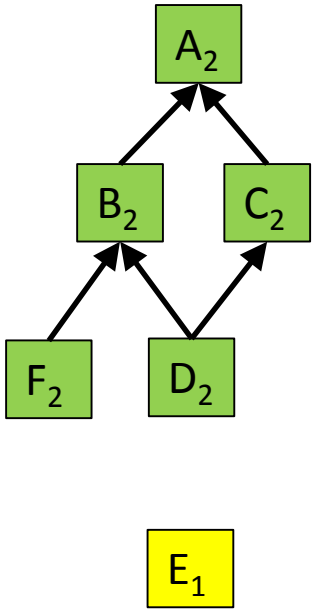
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1	A2							
C	A1	A2							
D	B1, C1								
E	D1								
F	B1								
	BL1								

Generic Artefact and Dependency Evolution Matrix



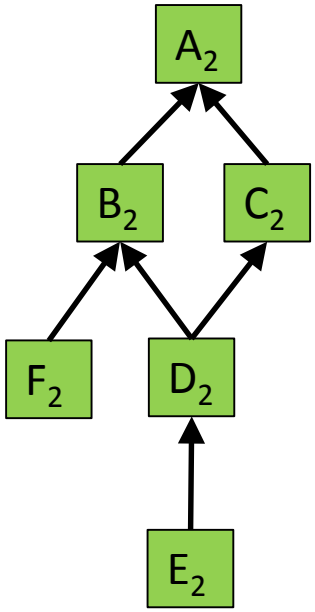
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1	A2							
C	A1	A2							
D	B1, C1	B2, C2							
E	D1								
F	B1								
	BL1								

Generic Artefact and Dependency Evolution Matrix



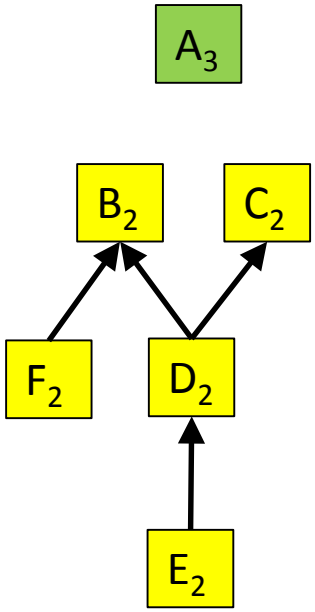
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1	A2							
C	A1	A2							
D	B1, C1	B2, C2							
E	D1								
F	B1	B2							
	BL1								

Generic Artefact and Dependency Evolution Matrix



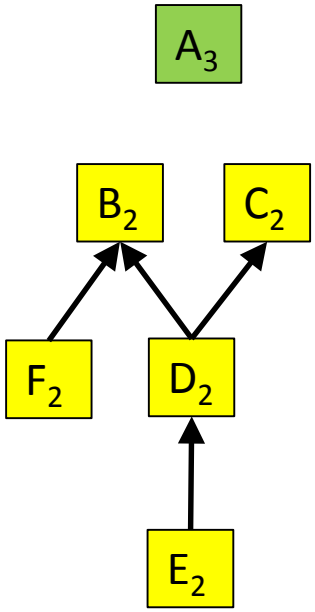
	1	2	3	4	5	6	7	8	9
A	-	-							
B	A1	A2							
C	A1	A2							
D	B1, C1	B2, C2							
E	D1	D2							
F	B1	B2							
	BL1								

Generic Artefact and Dependency Evolution Matrix



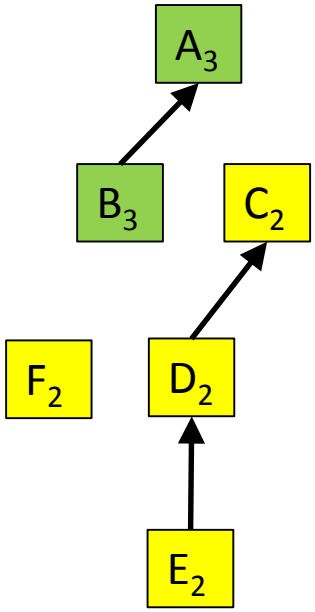
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2							
C	A1	A2							
D	B1, C1	B2, C2							
E	D1	D2							
F	B1	B2							
	BL1								

Generic Artefact and Dependency Evolution Matrix Baseline 2



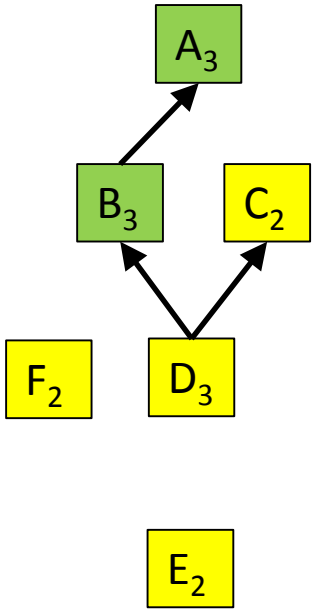
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2							
C	A1	A2							
D	B1, C1	B2, C2							
E	D1	D2							
F	B1	B2							
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



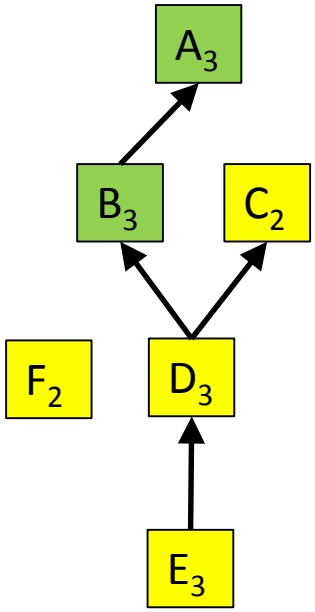
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2							
D	B1, C1	B2, C2							
E	D1	D2							
F	B1	B2							
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



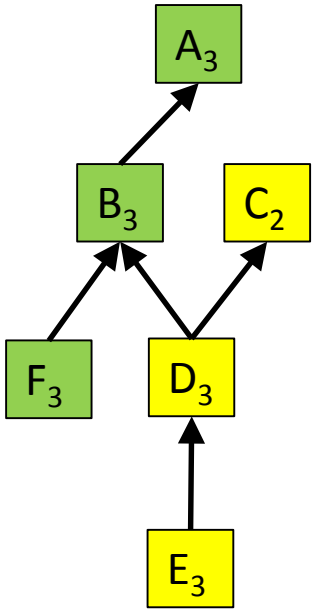
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2							
D	B1, C1	B2, C2	B3, C2						
E	D1	D2							
F	B1	B2							
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



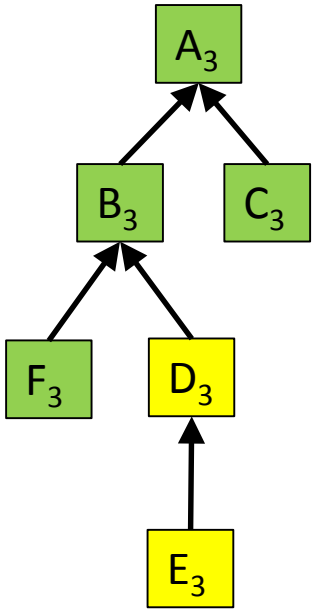
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2							
D	B1, C1	B2, C2	B3, C2						
E	D1	D2	D3						
F	B1	B2							
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



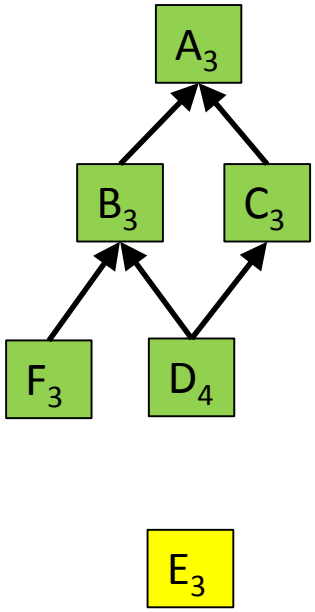
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2							
D	B1, C1	B2, C2	B3, C2						
E	D1	D2	D3						
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



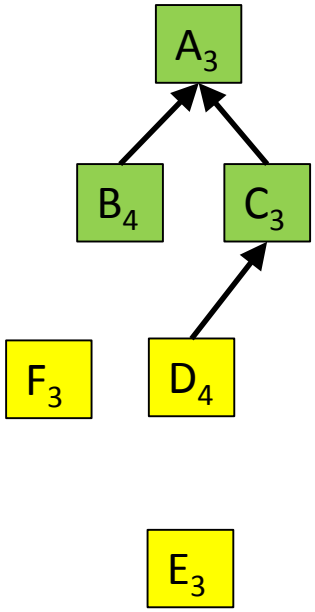
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2						
E	D1	D2	D3						
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



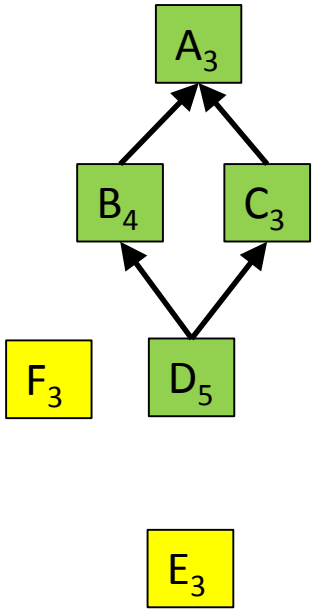
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3						
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3					
E	D1	D2	D3						
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



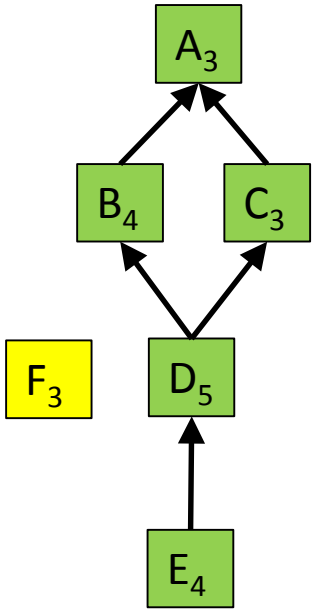
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3	A3					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3					
E	D1	D2	D3						
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



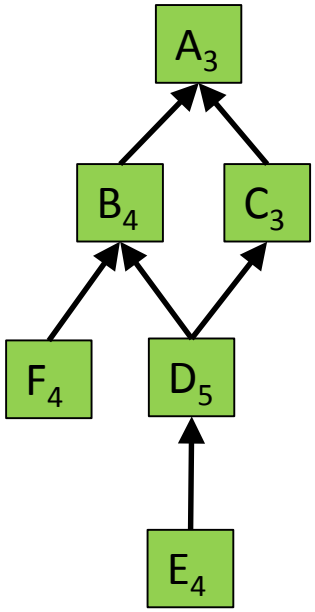
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3	A3					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3						
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



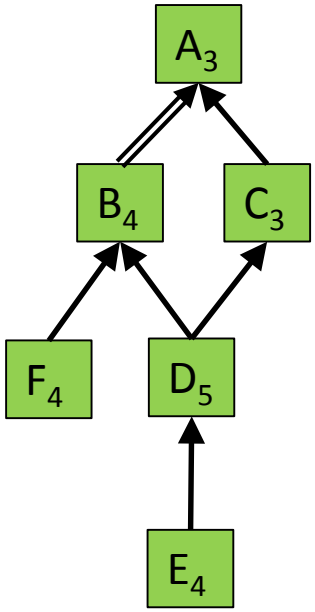
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3	A3					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3	D5					
F	B1	B2	B3						
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



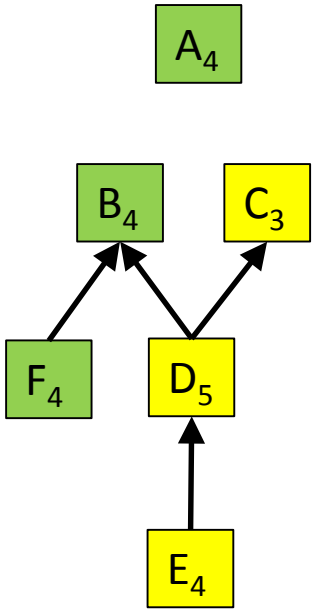
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3	A3					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3	D5					
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix
Dependency Lock



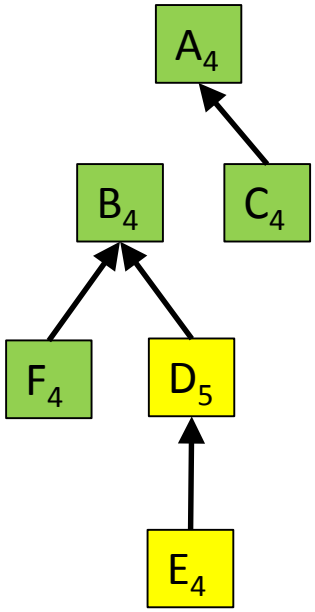
	1	2	3	4	5	6	7	8	9
A	-	-	-						
B	A1	A2	A3	**A3**					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3	D5					
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



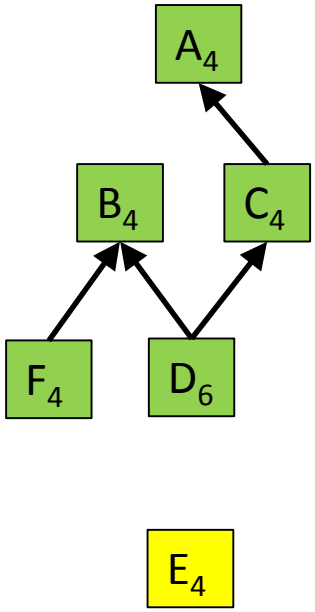
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	**A3**					
C	A1	A2	A3						
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3	D5					
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



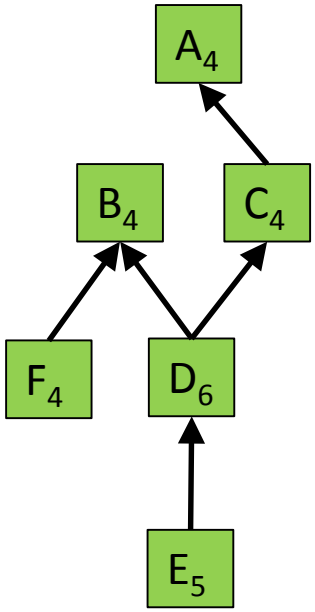
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	**A3**					
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3				
E	D1	D2	D3	D5					
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



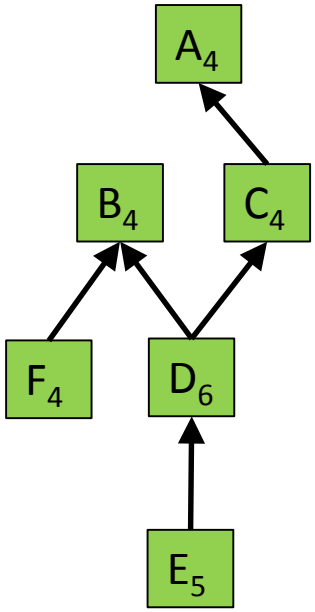
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	**A3**					
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4			
E	D1	D2	D3	D5					
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix



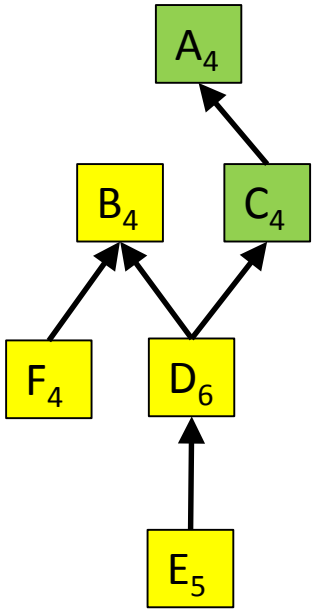
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	**A3**					
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4			
E	D1	D2	D3	D5	D6				
F	B1	B2	B3	B4					
	BL1	BL2							

Generic Artefact and Dependency Evolution Matrix Baseline 3



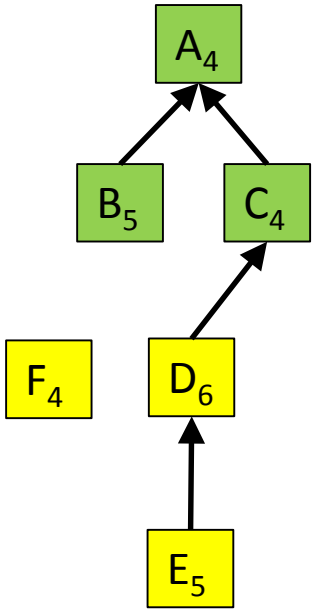
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	**A3**					
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4			
E	D1	D2	D3	D5	D6				
F	B1	B2	B3	B4					
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix
Dependency Unlock



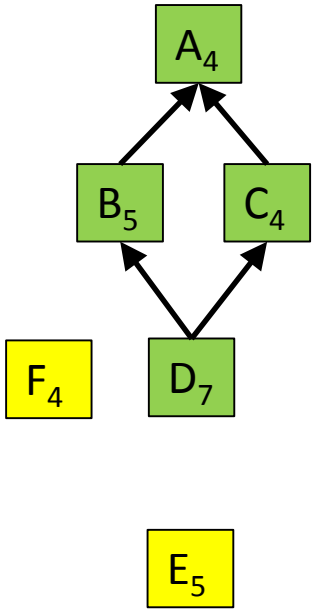
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3					
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4			
E	D1	D2	D3	D5	D6				
F	B1	B2	B3	B4					
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



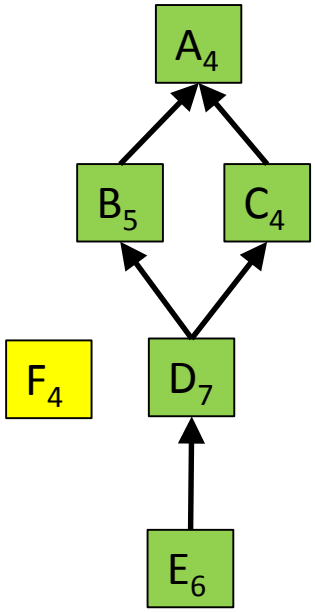
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4			
E	D1	D2	D3	D5	D6				
F	B1	B2	B3	B4					
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



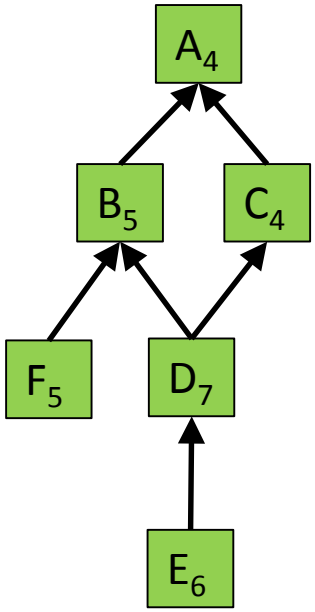
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4		
E	D1	D2	D3	D5	D6				
F	B1	B2	B3	B4					
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



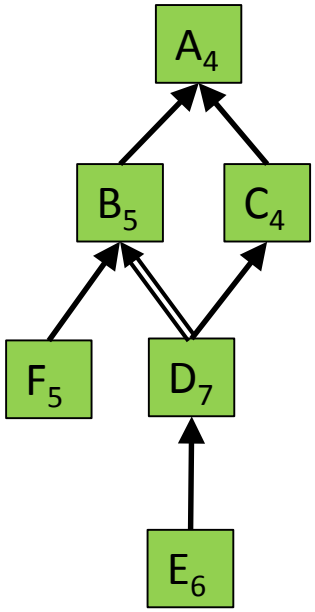
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4					
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



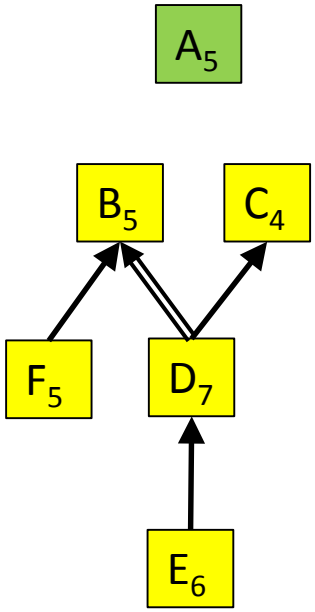
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5				
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix
Dependency Lock



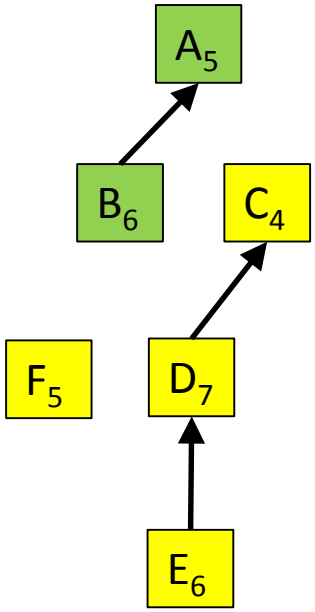
	1	2	3	4	5	6	7	8	9
A	-	-	-	-					
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	**B5**, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5				
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



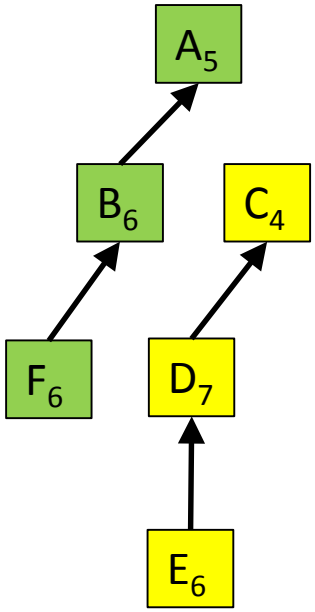
	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4				
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	**B5**, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5				
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



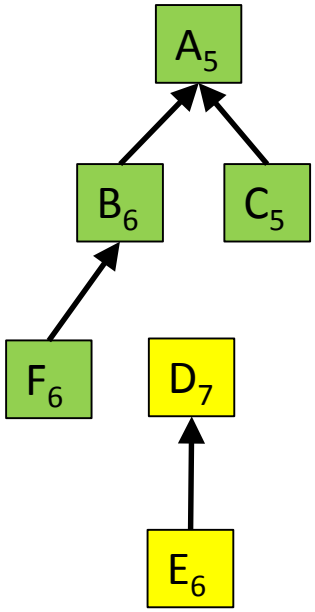
	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	**B5**, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5				
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4					
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	**B5**, C4		
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4	A5				
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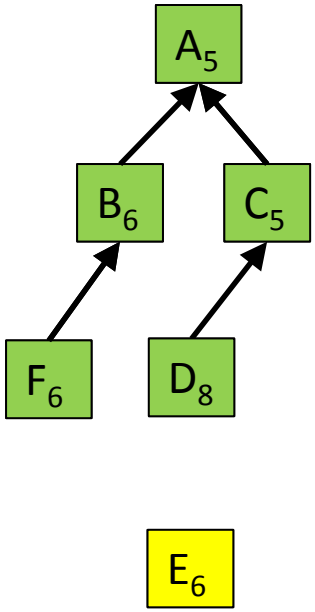
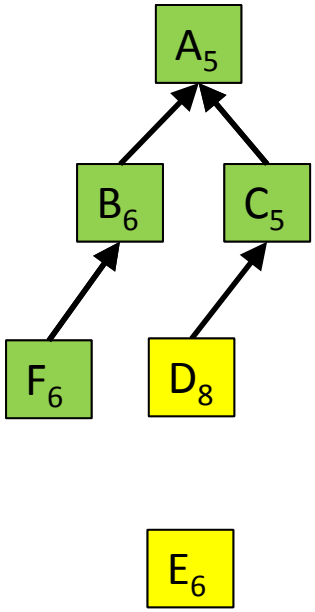
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



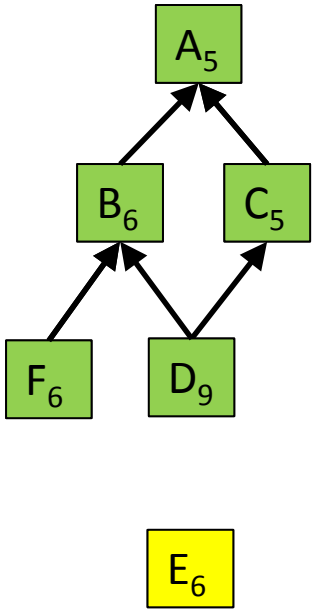
	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4	A5				
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	**B5**, C4	**B5**, C5	
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix
Dependency Unlock



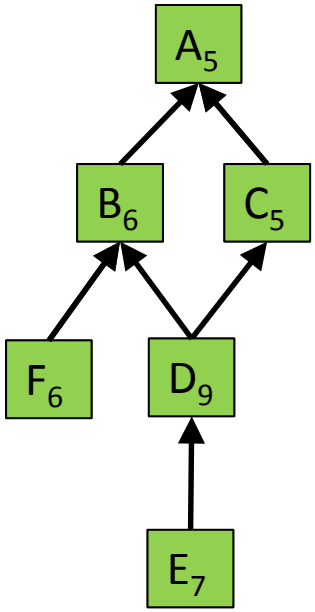
	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4	A5				
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4	B5, C5	
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

Generic Artefact and Dependency Evolution Matrix



	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4	A5				
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4	B5, C5	B6, C5
E	D1	D2	D3	D5	D6	D7			
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

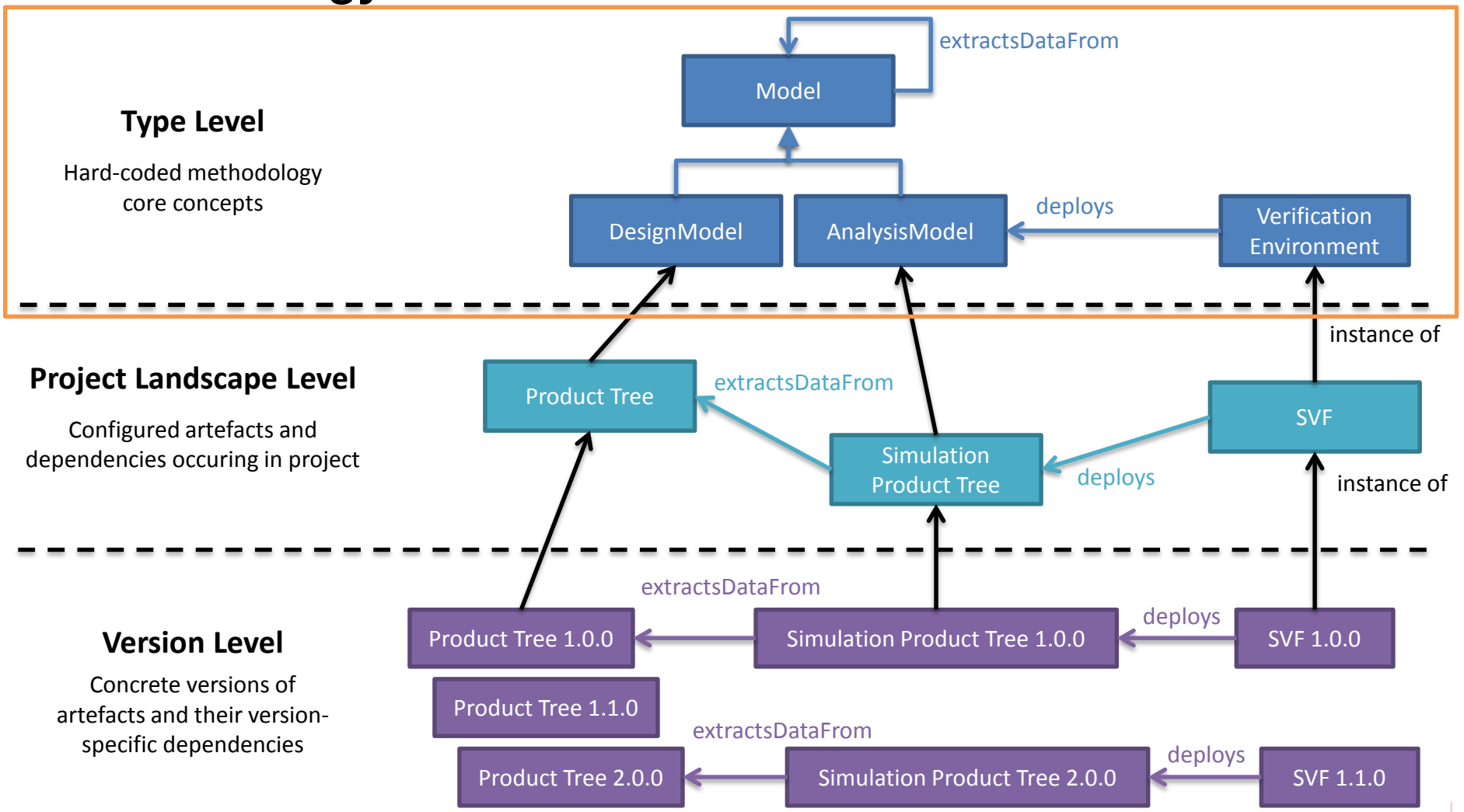
Generic Artefact and Dependency Evolution Matrix



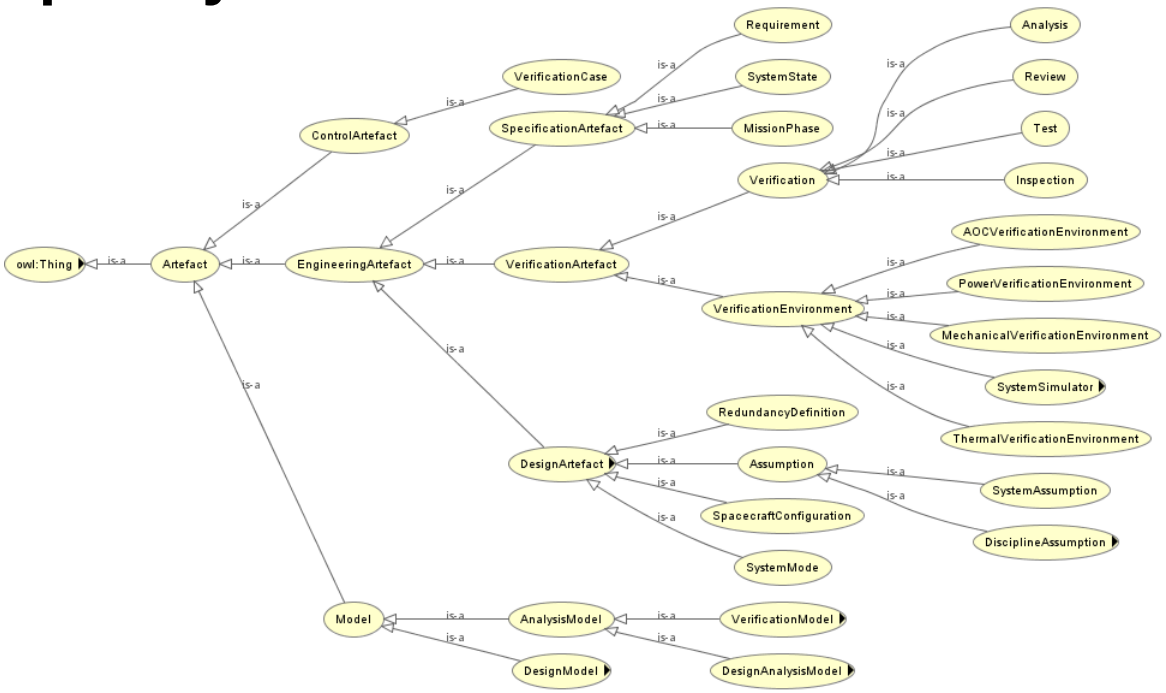
	1	2	3	4	5	6	7	8	9
A	-	-	-	-	-				
B	A1	A2	A3	A3	A4	A5			
C	A1	A2	A3	A4	A5				
D	B1, C1	B2, C2	B3, C2	B3, C3	B4, C3	B4, C4	B5, C4	B5, C5	B6, C5
E	D1	D2	D3	D5	D6	D7	D9		
F	B1	B2	B3	B4	B5	B6			
	BL1	BL2		BL3					

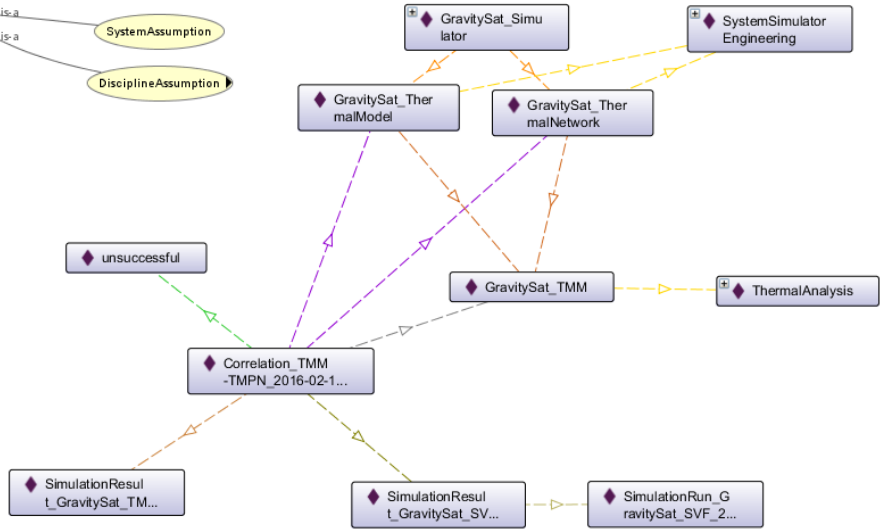
Methodology Core Concepts

Methodology Levels



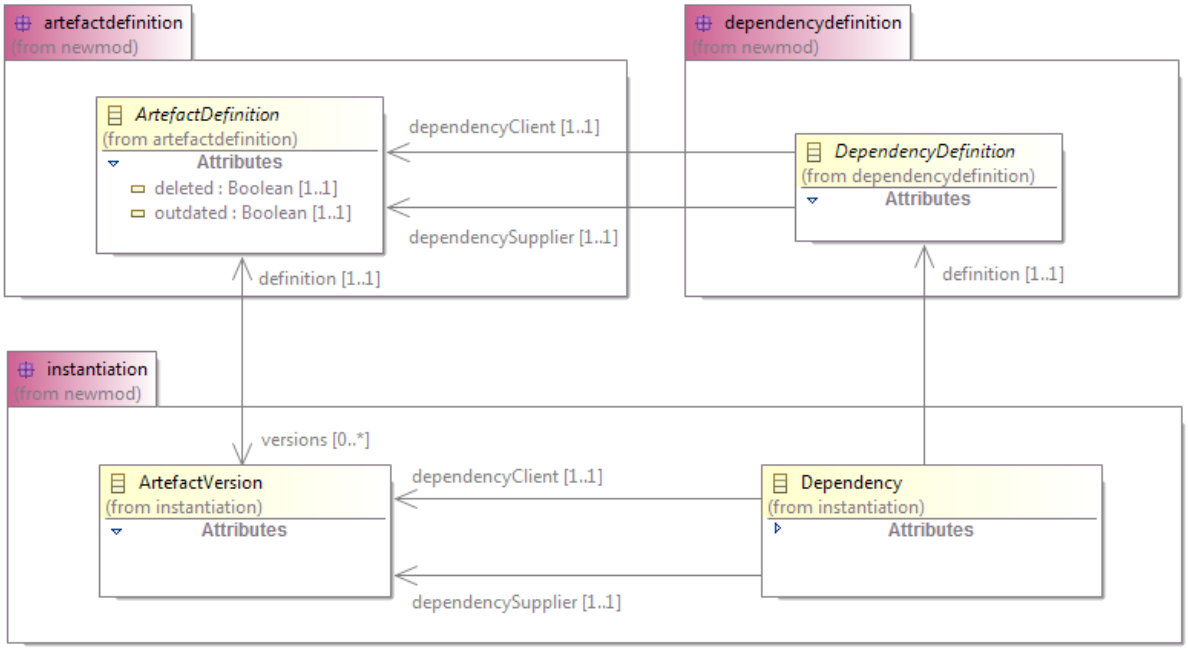
Ontology used for scoping the problem, and to iterate quickly on instance and class level



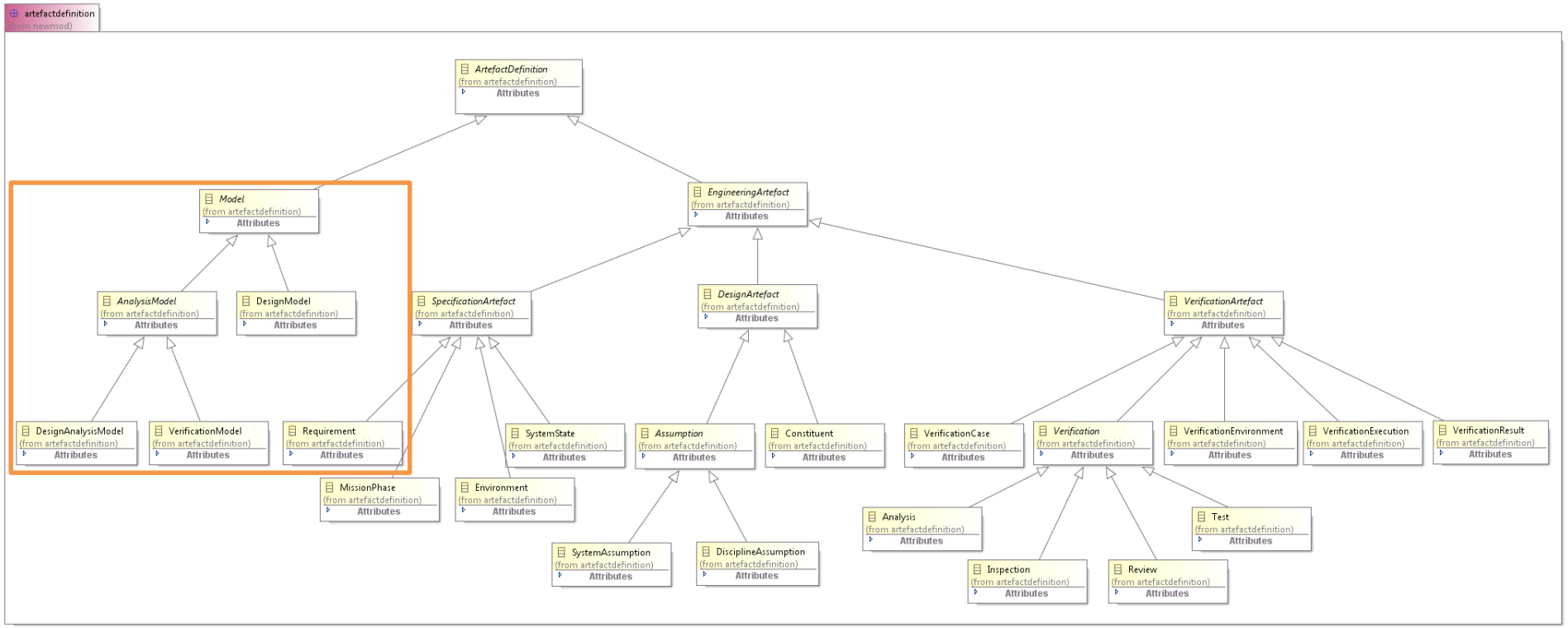


Methodology core concepts

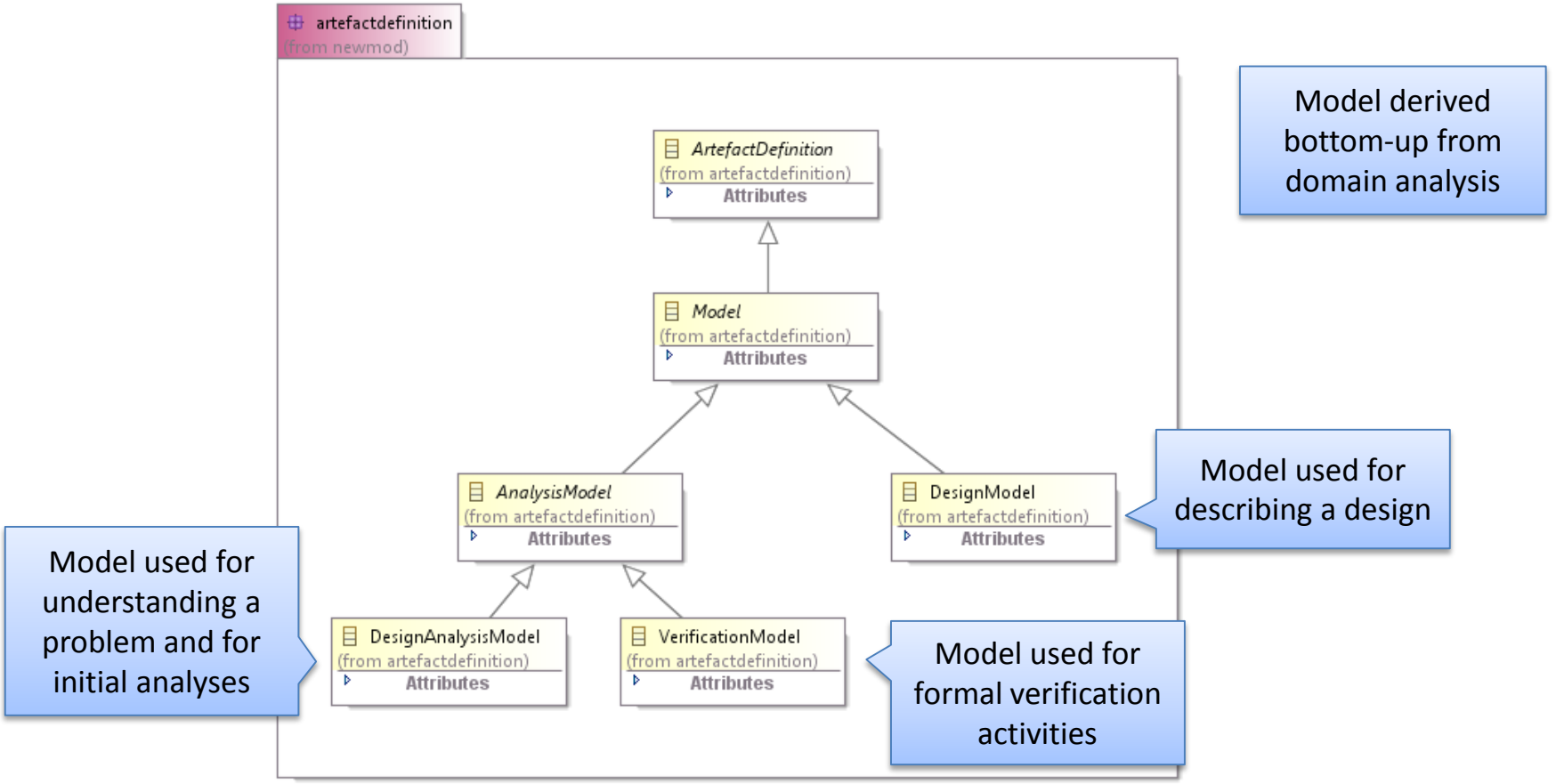
- For implementation of the methodology tools, a Conceptual Data Model (CDM) of the methodology concepts was defined
- Methodology CDM follows the conventions established in other data-driven specifications of ECSS (e.g. ECSS-E-TM-10-23 and -25)
- Separation of specification and usage levels



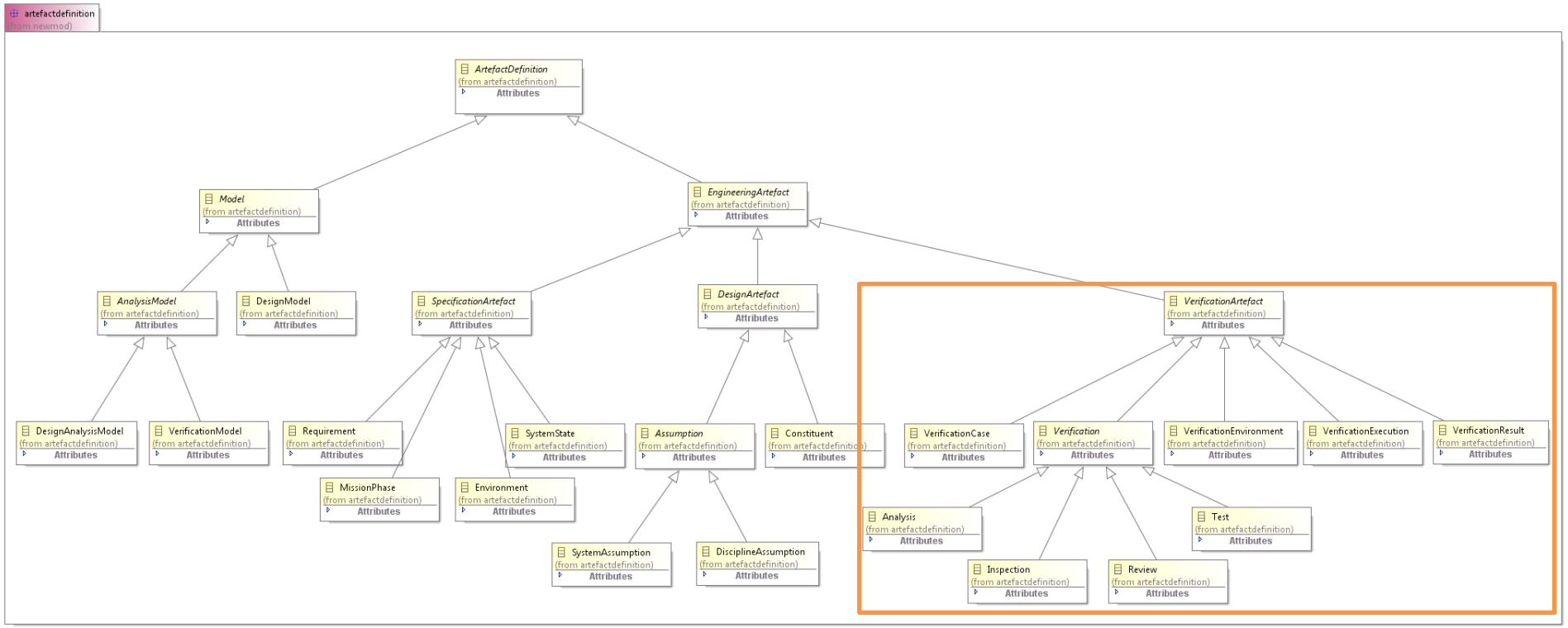
ArtefactDefinitions forming a taxonomy of commonly used artefact types



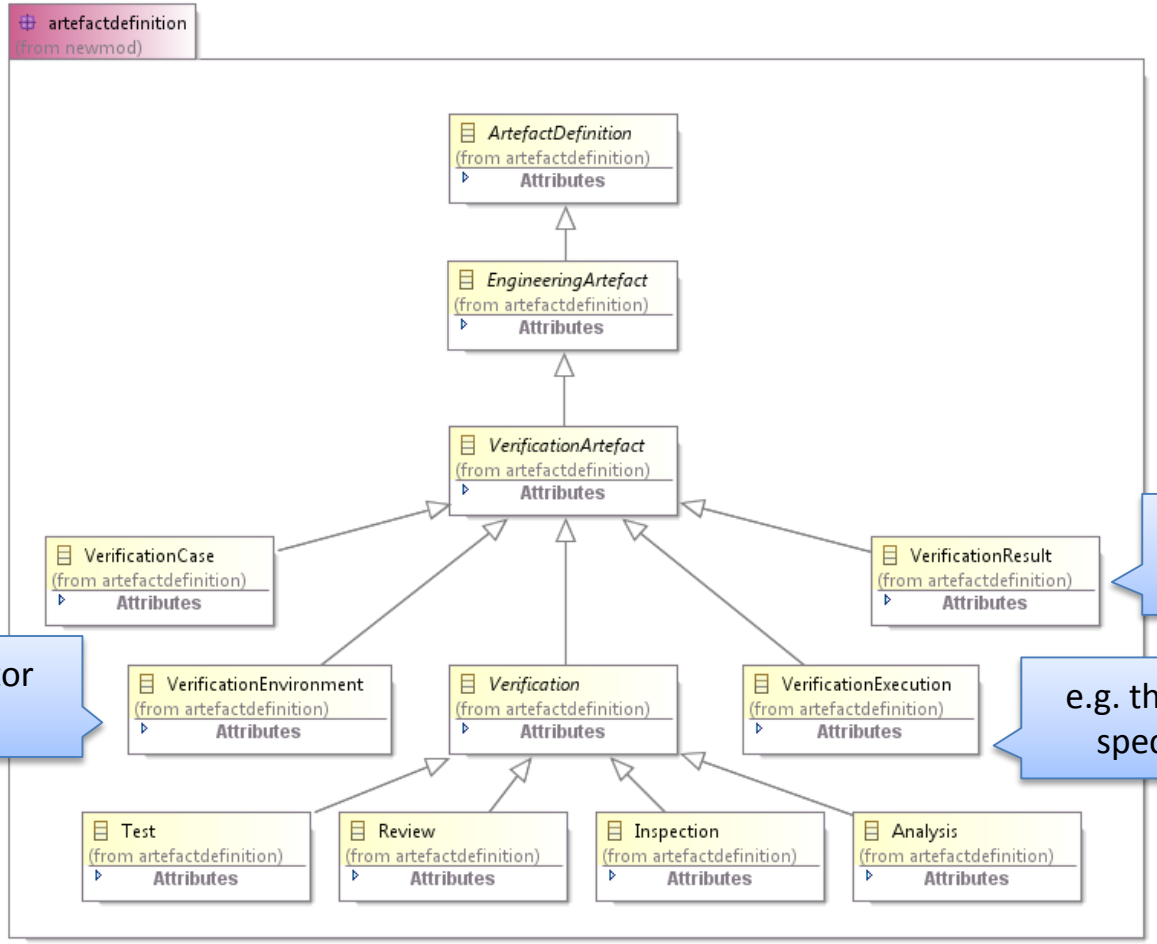
Taxonomy of model types



ArtefactDefinitions forming a taxonomy of commonly used artefact types



Taxonomy of verification artefact types

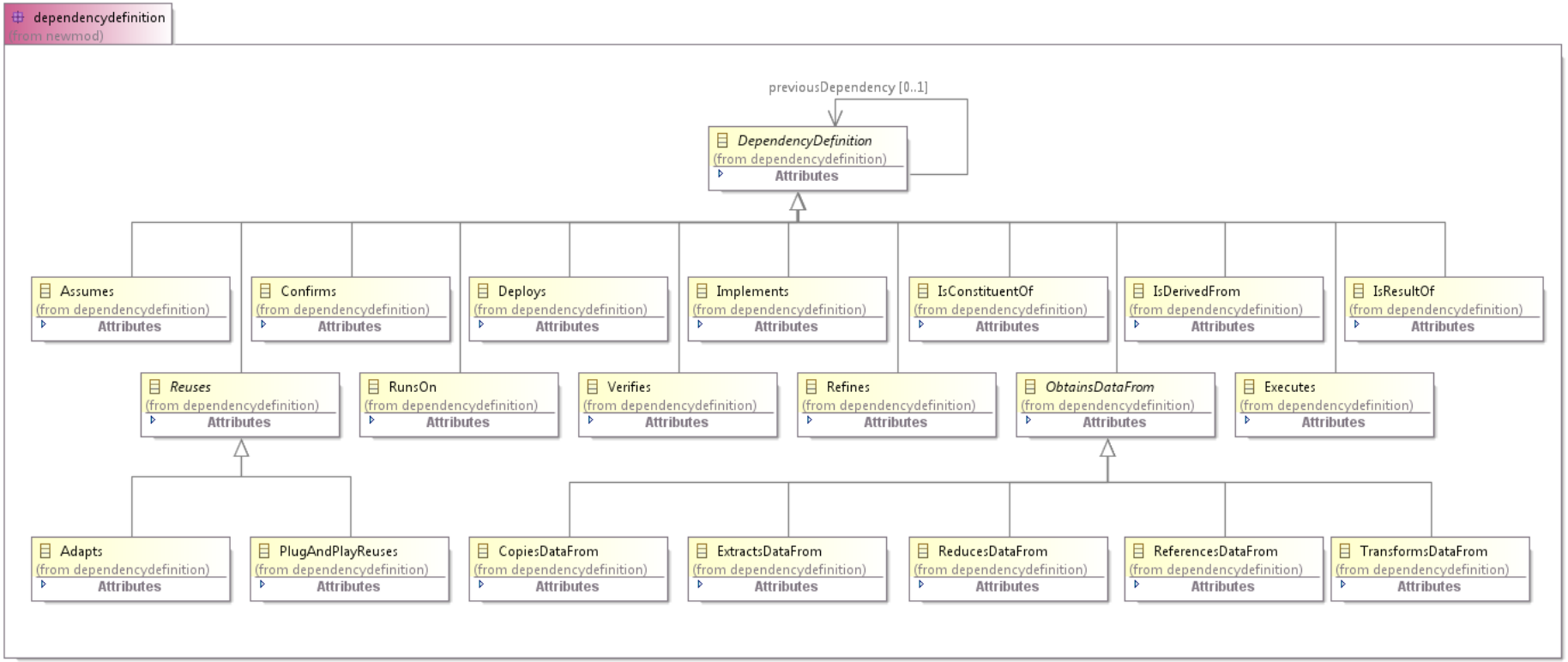


e.g. the result of a run of a specific test

e.g. a simulator bench

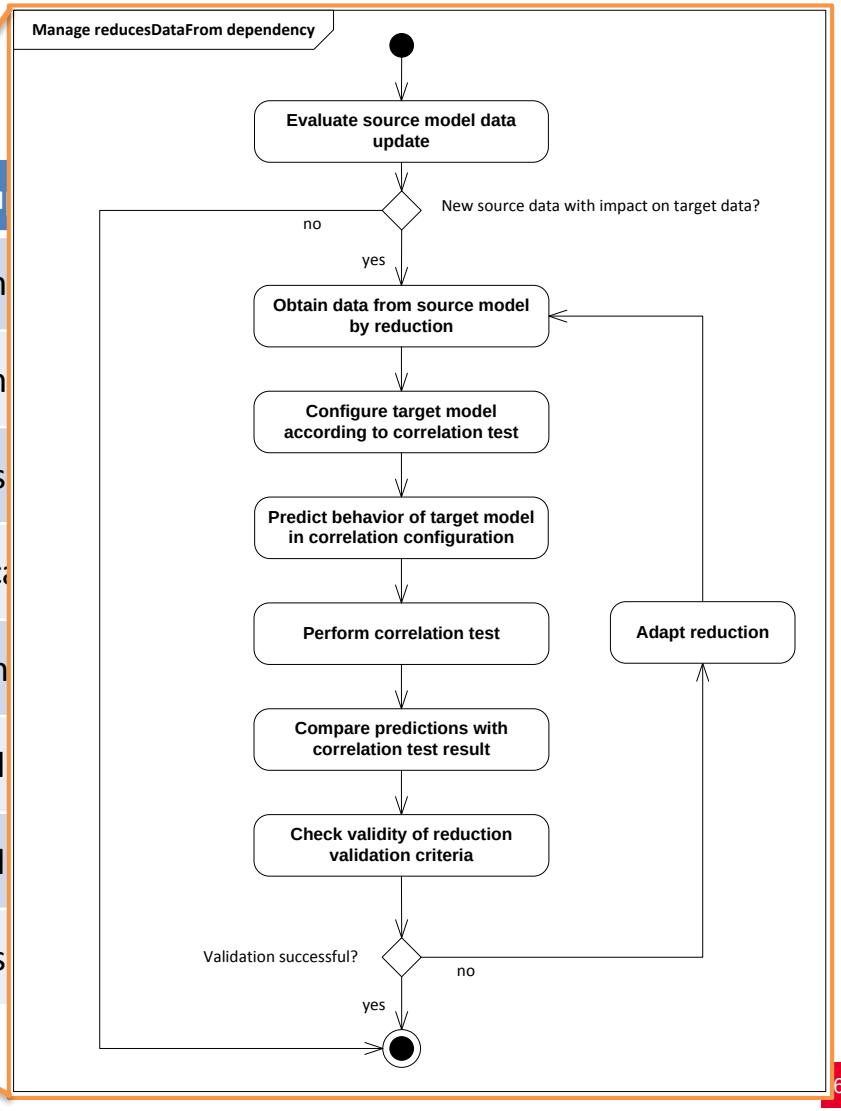
e.g. the run of a specific test

Taxonomy of dependency types



Dependency and artefact combination examples

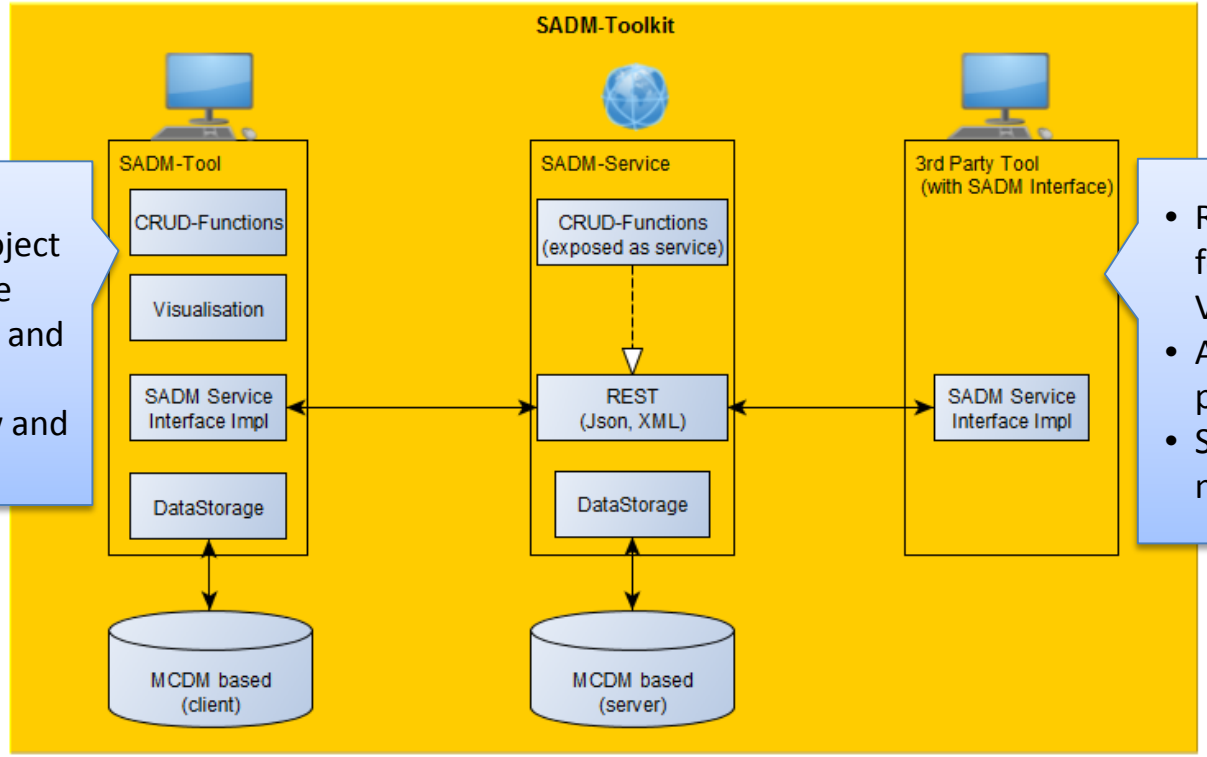
Client artefact	Dependency	Su
Design Model	assumes	Assum
Analysis, Test	confirms	Assum
Verification Environment	deploys	Analys
Analysis, Test	runsOn	Verifica
Verification	verifies	Design
Model	reducesDataFrom	Model
Model	transformsDataFrom	Model
AnalysisModel	plugAndPlayReuses	Analys



Developed Tools

Three elements of tool support: Service, SADM tool, and integrated 3rd party tools

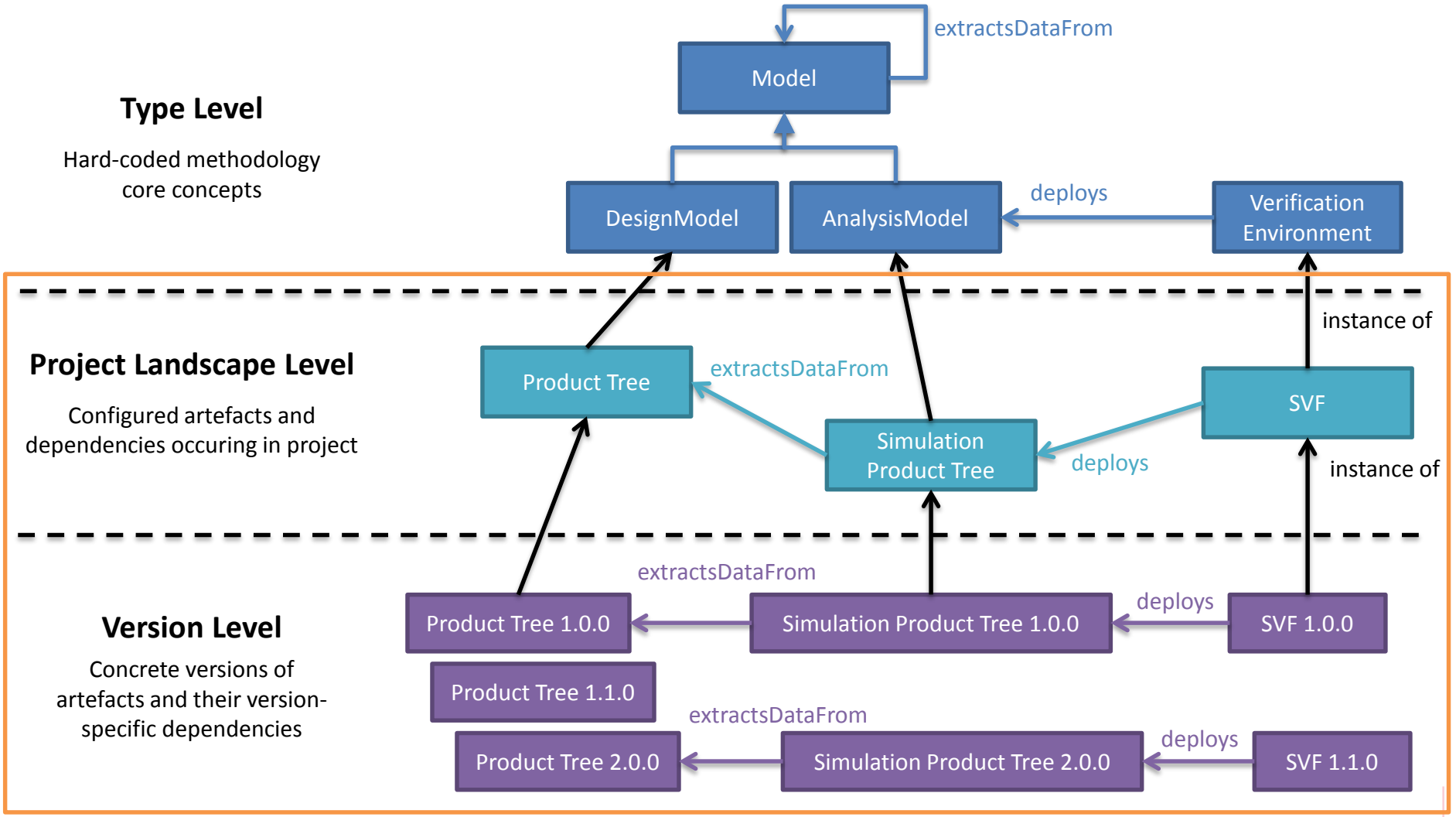
- Define artefact landscape for project
- Manually manage Artefact Versions and dependencies
- Provide overview and visualize

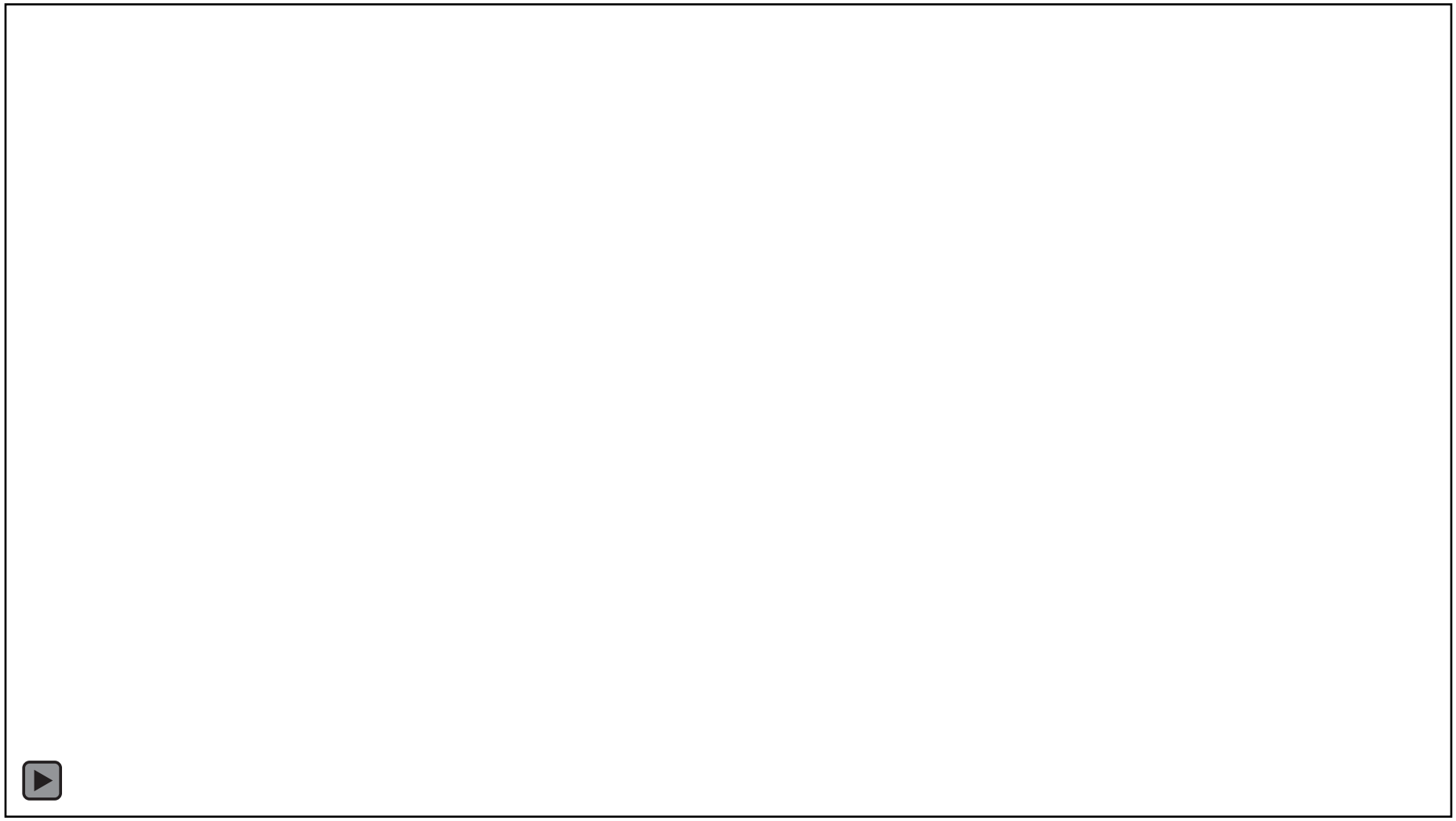


- Receive notifications for new Artefact Verisons
- Automatically perform activities
- Send notifications for new Artefact Versions

Airbus Demonstration Cases

Methodology Levels



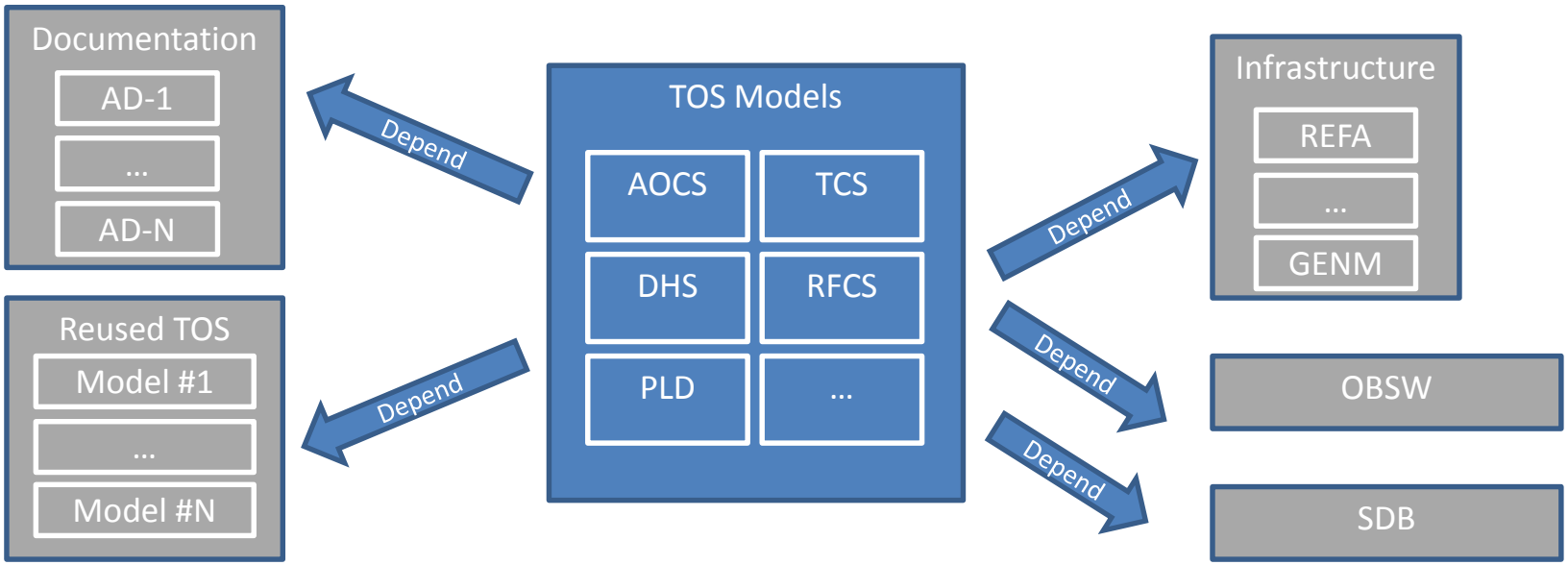


Telespazio VEGA Demonstration Cases

TOS Demonstration

SADM Tool Utilisation in the TOS Lifecycle

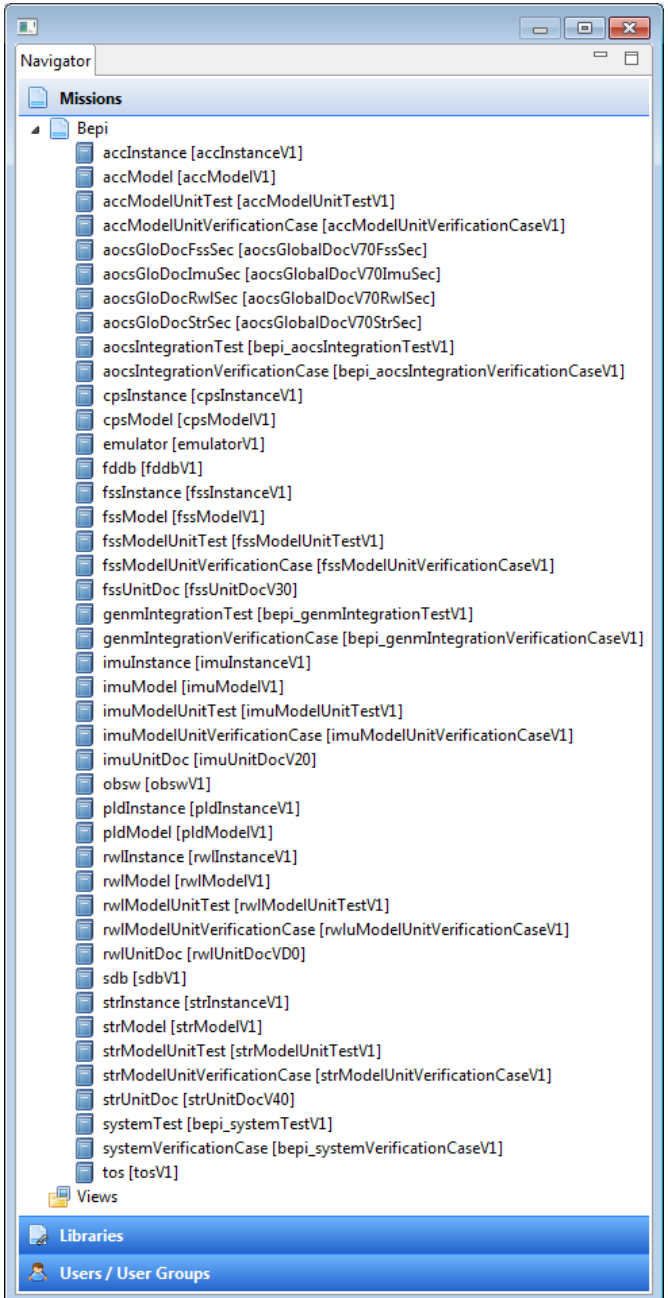
- Capture and update the dependencies of the simulation models of a typical TOS
- One “set up” test case representing the capturing of the dependencies at project kick off
- Multiple “simulator evolution” test cases triggered by the update of an item that the TOS depends on



TOS Demonstration

AOCS related Artefacts

- AOCS documentation
- Flight dynamics database
- OBSW
- Emulator
- TM/TC database
- AOCS simulation models
- AOCS simulation setup (instances)
- Simulation model unit tests
- System tests
- TOS Simulator

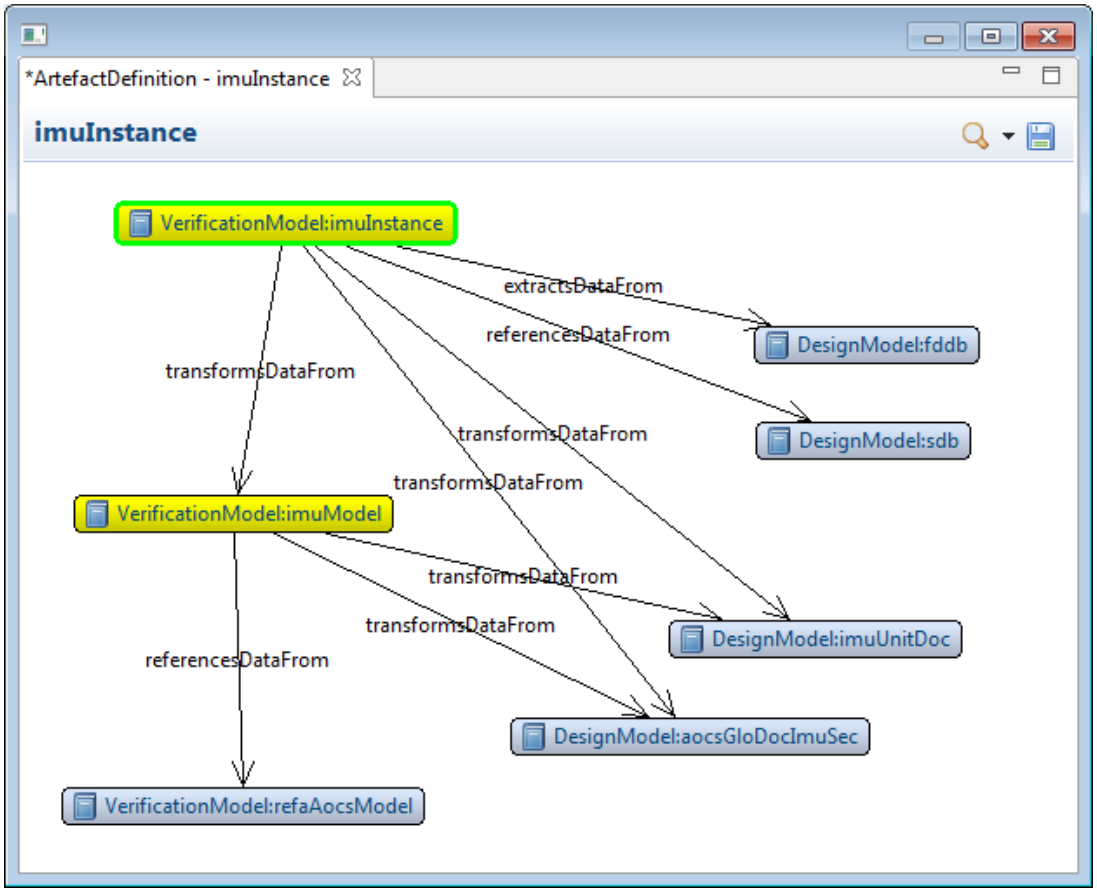


TOS Demonstration

Update of IMU Design Documentation –> effect on Models

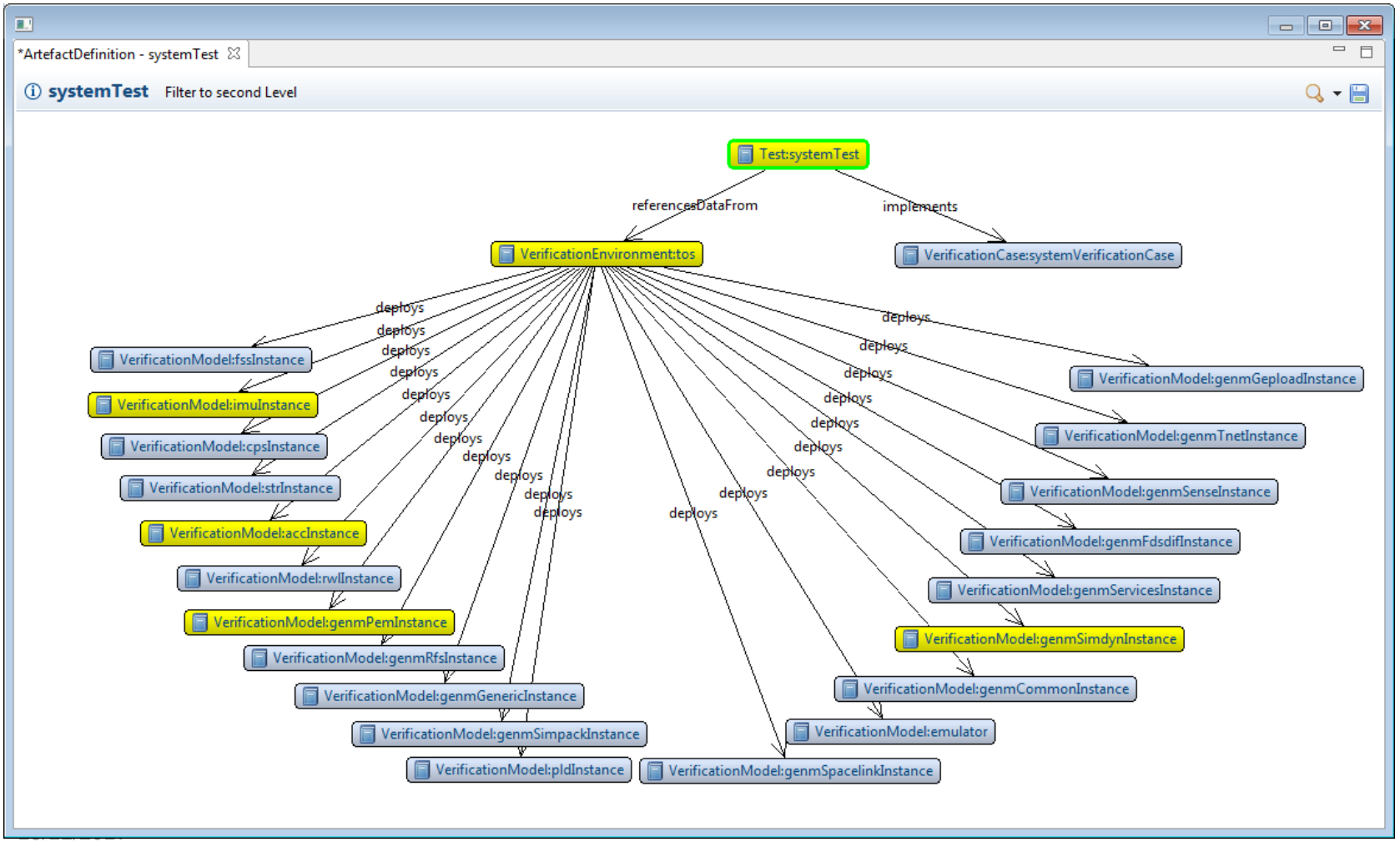
- IMU Model
  - transforms data from
    - Unit documentation
    - Global documentation
  - references data from
    - REFA AOCS model

- IMU Model instance
  - transforms data from
    - Unit documentation
    - Global documentation
    - IMU Model
  - references data in
    - TM/TC database
  - extracts data from
    - Flight Dynamics DB



TOS Demonstration

Update of IMU Design Documentation –> effect on System Test



TOS Demonstration

Results

- The SADM covers the typical objects involved in the TOS development and their relations
- The SADM could model the required TOS updates upon:
  - new documentation baseline
  - update of reused models from another mission
  - update of infrastructure libraries (generic models / reference architecture)
  - new versions of OBSW
  - new TM/TC database releases

Conclusion

Conclusion

The established methodology and the developed SADM functionality provide the following benefits:

- Reduction of simulator development effort and time by providing:
  - clear traceability of artefact updates needed upon incoming artefact changes
  - guidelines to integrate given changes on dependent artefacts
  - automatic update of artefacts across artefact chains
- Mitigation of simulator design errors by reducing inconsistencies between simulation artefacts
- Capability to make better informed decisions by:
  - providing an overview on the whole simulation artefact landscape and their status
  - explicitly tracking intangible artefacts such as assumptions

THANK **YOU** FOR YOUR ATTENTION

TELESPAZIO
a LEONARDO and THALES company

AIRBUS

ScopeSET
The Tools Experts