

## **ACMoM Project Proposal**

Architecture-Centric Model Management for Architecture-Centric Virtual Integration Process

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### **Outline**

- Context
- State of the Art and Preliminary Work
- **Technical Objective**
- **Conclusion**

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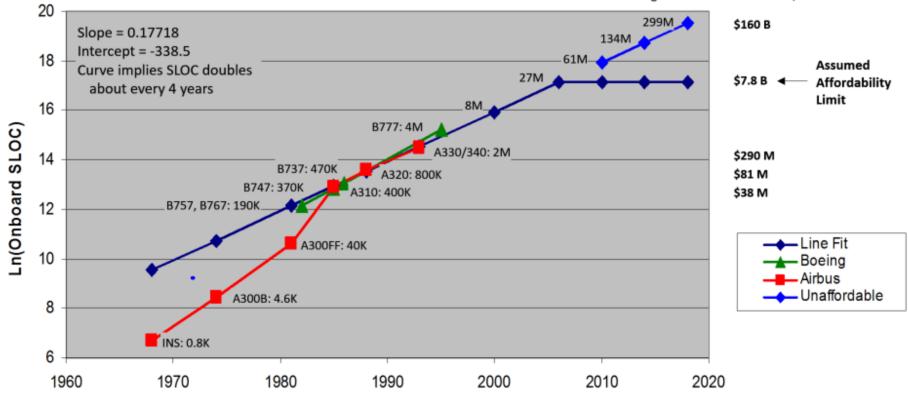


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# **Increasing Systems Complexity and Unaffordable Development Costs**

#### Estimated Onboard SLOC Growth

Airbus data source: J.P. Potocki de Montalk, Computer Software in Civil Aircraft, 6th Annual Conference on Software Assurance, (COMPASS 1991) Boeing data source: J.J. Chilenski, 2009.



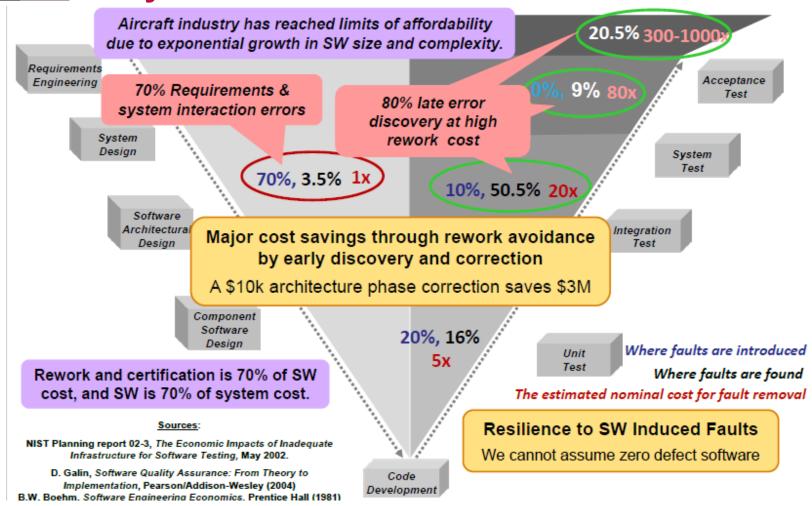
Year From Feiler, Hansson, de Niz and Wrage. "System Architecture Virtual Integration: An Industrial Case Study", 2009.





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## V-Cycle Model with Rework Costs

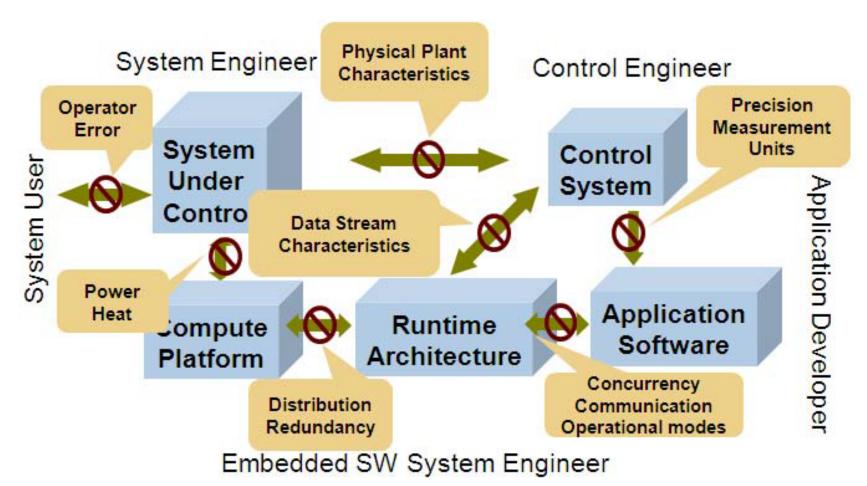


From P. Feiler and J. Delange, "Design and Analysis of Cyber-Physical Systems: AADL and Avionics Systems", 2013





# Mismatched Assumptions in Collaborative **Engineering**



From P. Feiler, "Model-based validation of safety-critical embedded systems", 2010

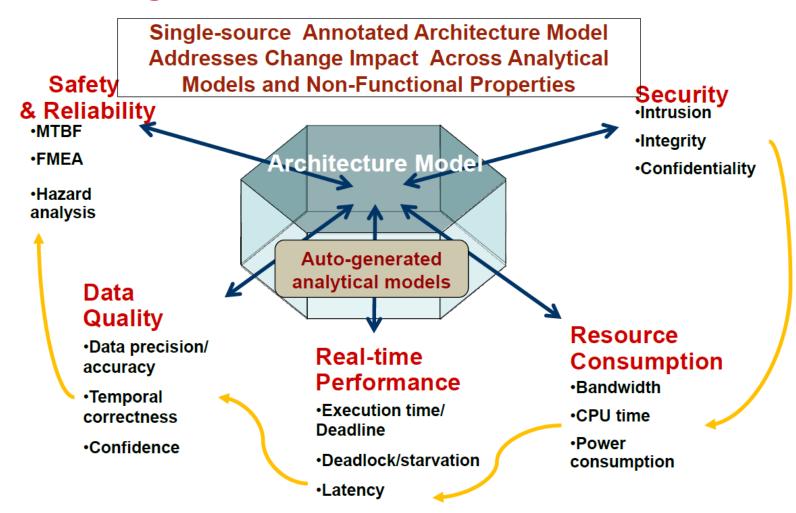
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# **SAVI: System Architecture Virtual** Integration



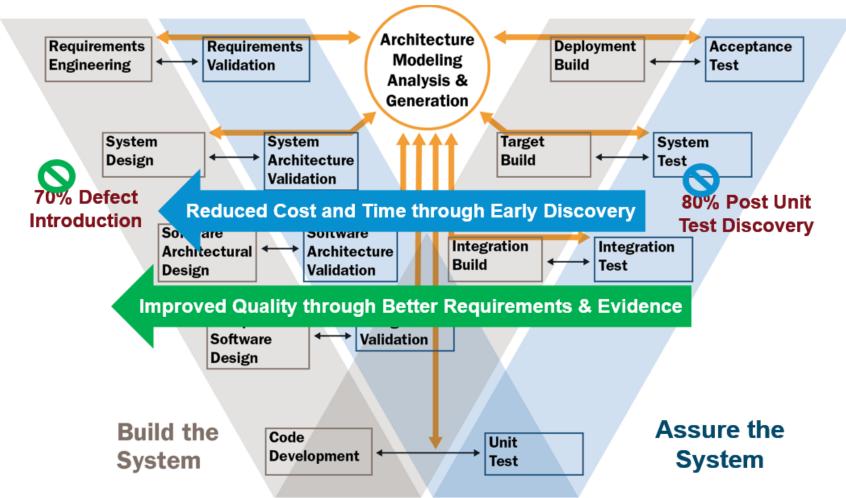
From Feiler, Hansson, de Niz and Wrage. "System Architecture Virtual Integration: An Industrial Case Study", 2009.





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## V-Cycle Model with Virtual Integration Activities (Architecture-Centric Virtual Integration Process)

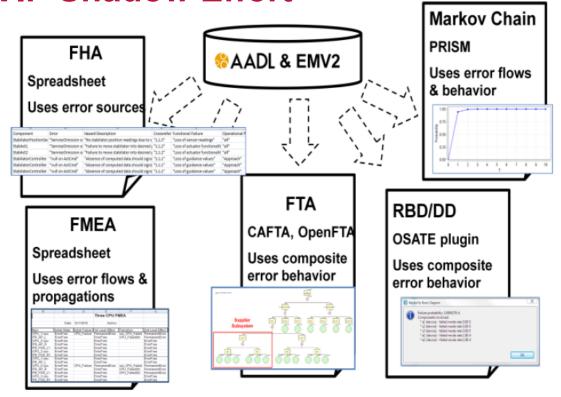


From McGregor, Gluch, and Feiler, "Analysis and Design of Safety-critical, Cyber-physical Systems", 2017.





Joint Common Architecture Demonstration **ACVIP Shadow Effort** 



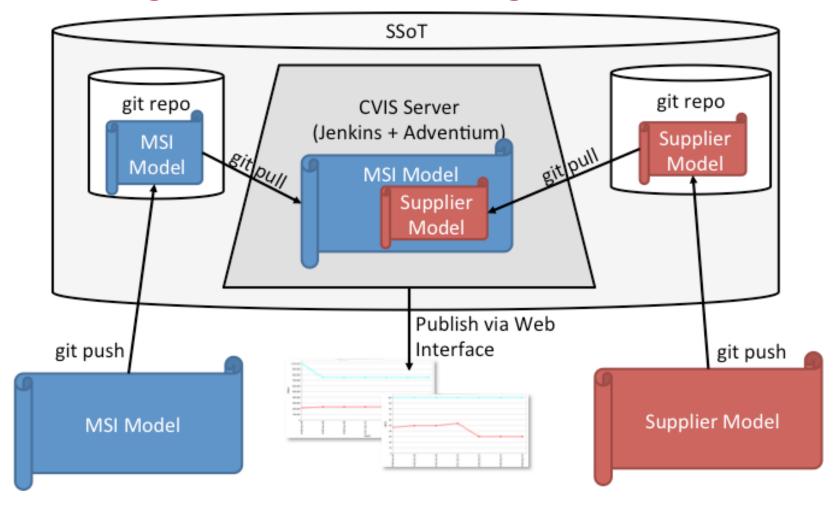
"Also, translation and exchange of models among different languages (e.g., UML, SysML, AADL, MatLab/Simulink and SCADE) and tools needs to be worked to allow government, integrators, and component suppliers to communicate seamlessly."

From A. Boydston, P. Feiler, S. Vestal and B. Lewis, "Joint Common Architecture (JCA) Demonstration

Architecture Centric Virtual Integration Process (ACVIP) Shadow Effort", 2015



# Adventium Labs' Continuous Inter-Organization Virtual Integration



From T. Smith, R. Whillock, R. Edman, B. Lewis and S. Vestal, "Lessons Learned in Inter-Organization Virtual Integration", 2018

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## **Need for Model Management**

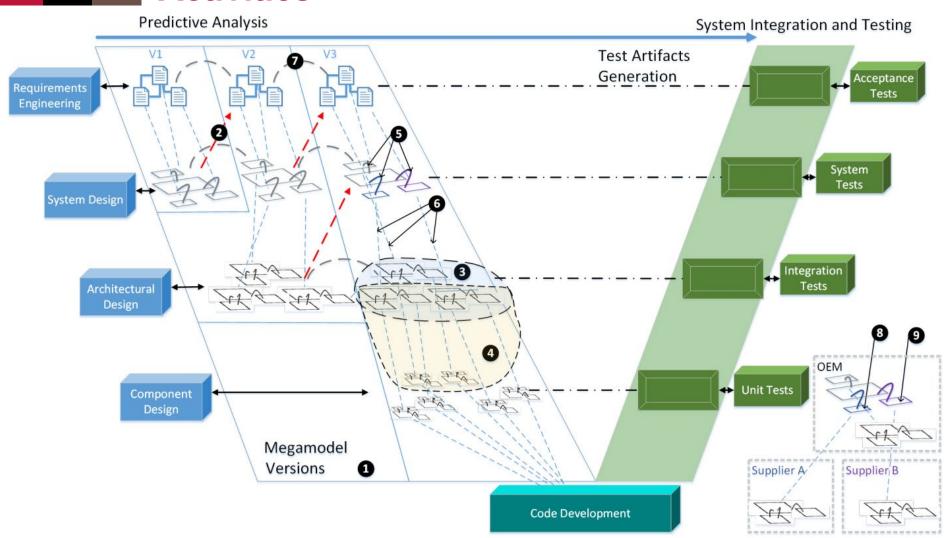
- Many models are employed:
  - Joint Common Architecture Demonstration ACVIP Shadow Effort
  - PST project

- Adventium Labs' ontinuous virtual integration
- Information overlap between models
- Multiple teams manipulate models concurrently
- Model management is required!





## V-Cycle Model with Model Management **Activities**



From H. Giese and D. Blouin, miGMM DFG Project Proposal, 2016

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# Multi-directional Transformation and Synchronization



Is this needed?

Organizers

■ Bi-directional case is already difficult...



In the series Dagstuhl

Reports each Dagstuhl Seminar and

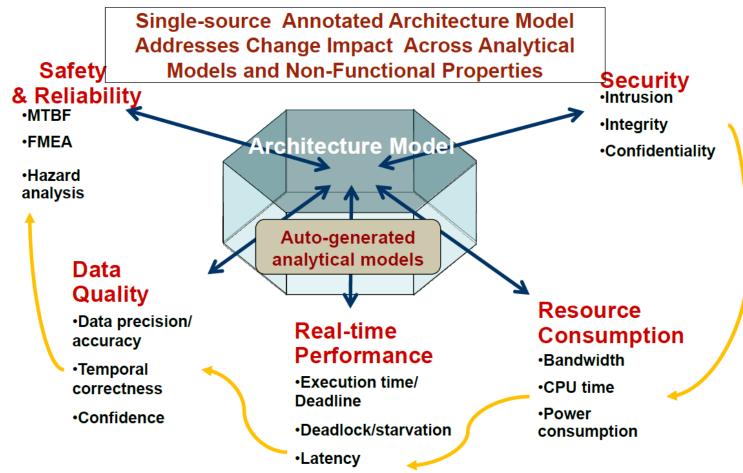


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Anthony Cleve (University of Namur, BE)

# ACMoM: Architecture-Centric Model **Management for ACVIP**

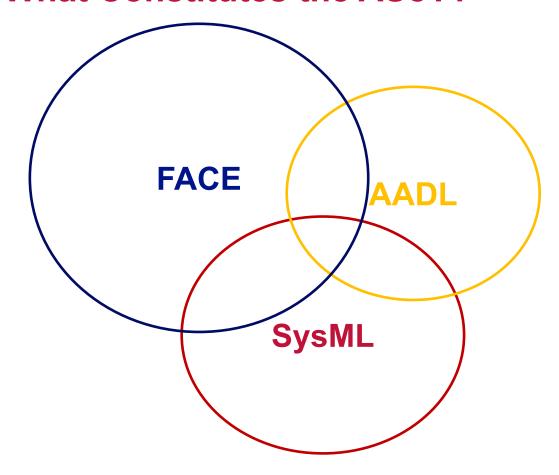
**Authoritative Source of Truth (ASoT)** 







### What Constitutes the ASoT?



Cannot have all information annotated in all 3 models





## **Need for Model Management Framework**

- Employed models, languages and tools?
- How are they related?
  - Simple traceability (PST)?
  - Batch transformations?
  - Synchronization?
- Development process
  - Workflows
  - Modeling activities and constraints
- Configuration
  - What is the ASoT?
  - What model can be changed?

- By who?
- When?





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## Multi-Paradigm Modeling (MPM)

- Initiated by Hans Vangueluwe
- MPM principles:
  - Model every part and aspect of a system explicitly
  - At the most appropriate level(s) of abstraction
  - Using the most appropriate modeling formalism(s)
- → Also model model management:





## Megamodeling

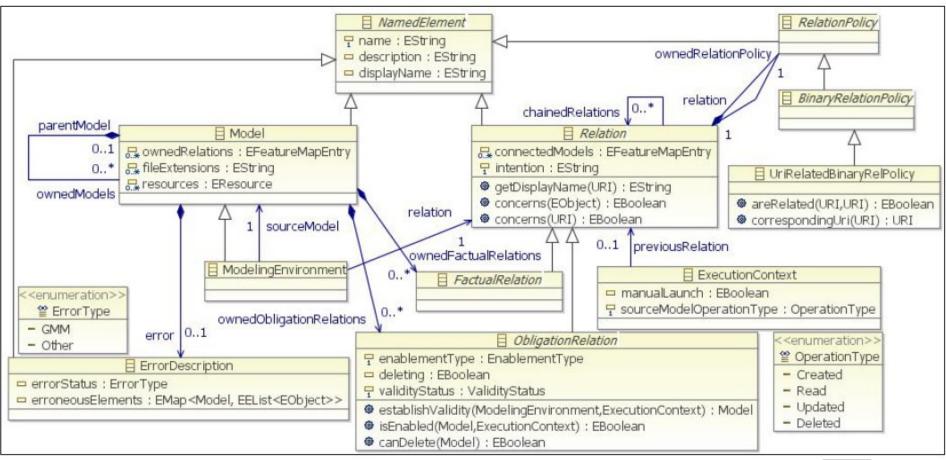
- "A megamodel is a model with other models as elements". "A megamodel contains relationships between models." (Bézivin, 2003 / 2007)
- "... the idea behind a megamodel is to define the set of entities and relations that are necessary to model some aspect about MDE". "A megamodel is a model that represents this kind of complex arrangements without entering into the details of each artifact" (Favre 2004 / 2005





# Megamodeling Approaches: GMM (Global **Model Management)**

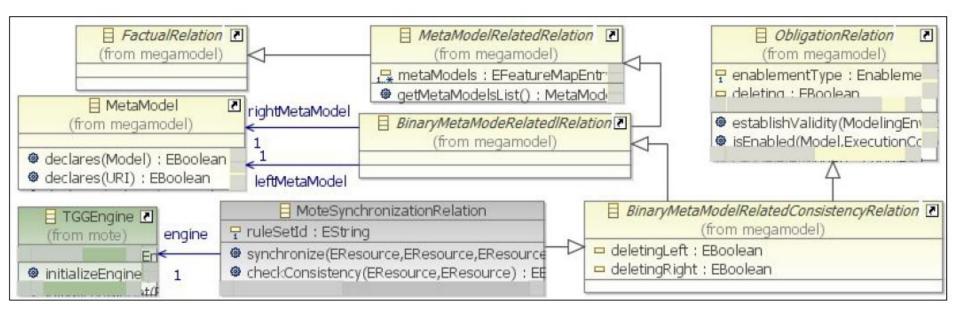
Models, their languages and their relations







### **GMM: Tool Adapters**



- Operationalize a model relation by using a tool:
  - MoTE TGG for bi-directional synchronization
  - Capra for simple traceability management
  - ATL for batch transformations

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Etc.





## **GMM:** Languages and Language Subsets

- When can we say that a model is well-formed?
  - **Well-formedness** is the quality of a clause, word, or other linguistic element that conforms to the grammar of the language of which it is a part (Wikipedia)
- Are AADL legality rules sufficient?
- Depends on what we want to do with the model

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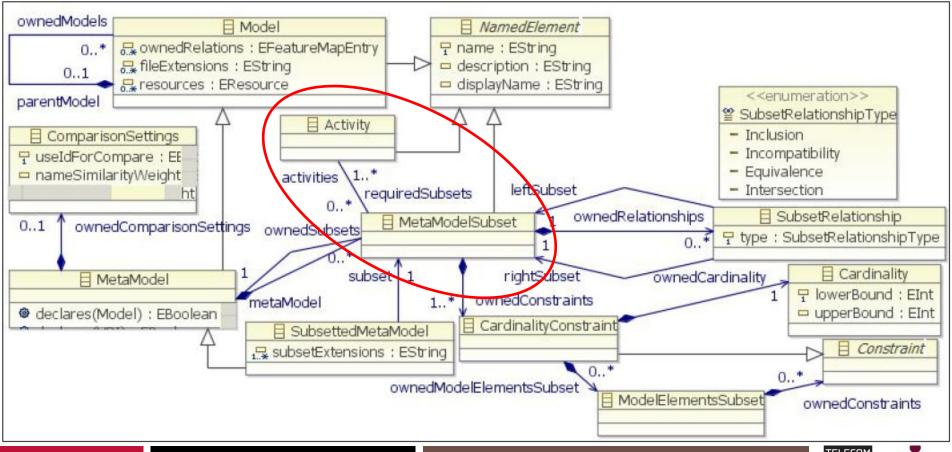
Need for a set of rules for what we want to do with the model (per activity)





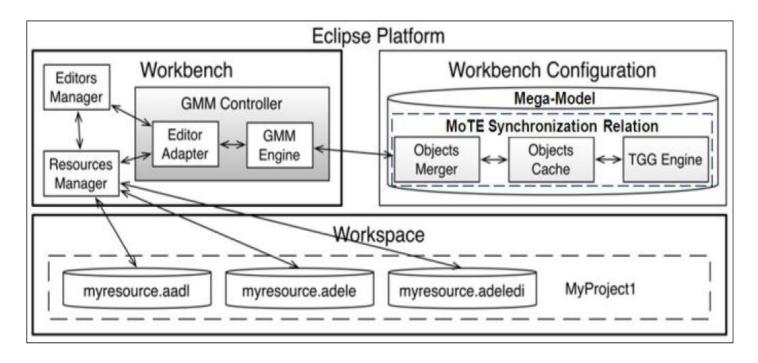
## **GMM:** Languages and Language Subsets

- Constraints that a model must meet for a given activity
- Inspired from AADL subset annex (Gaudel et al., 2013)





### **GMM Infrastructure**



- Started during the ADOSATE project (Adele ←→OSATE synchronization
  - US Army Research Laboratory funded

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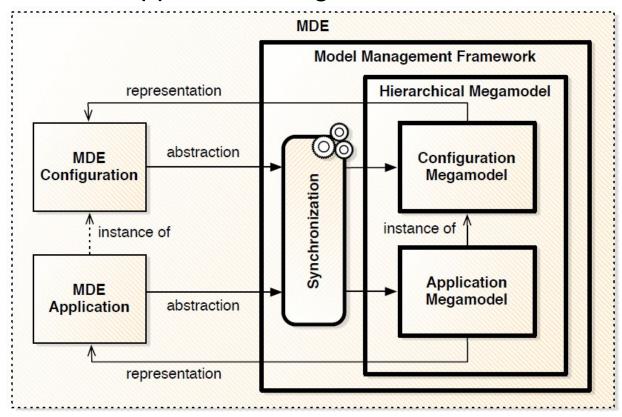
Pursued during the Kaolin project (AADL ←→ VHDL for FPGAs)





# Megamodeling Approaches: MoM (Model Management)

- Hierarchical megamodels
- Configuration and application megamodels



From A. Siebel, 'Traceability and Model Management with Executable and Dynamic Hierarchical Megamodels", 2012

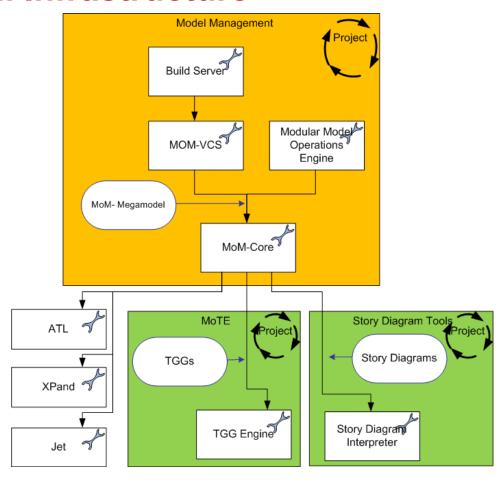
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### **MoM Infrastructure**

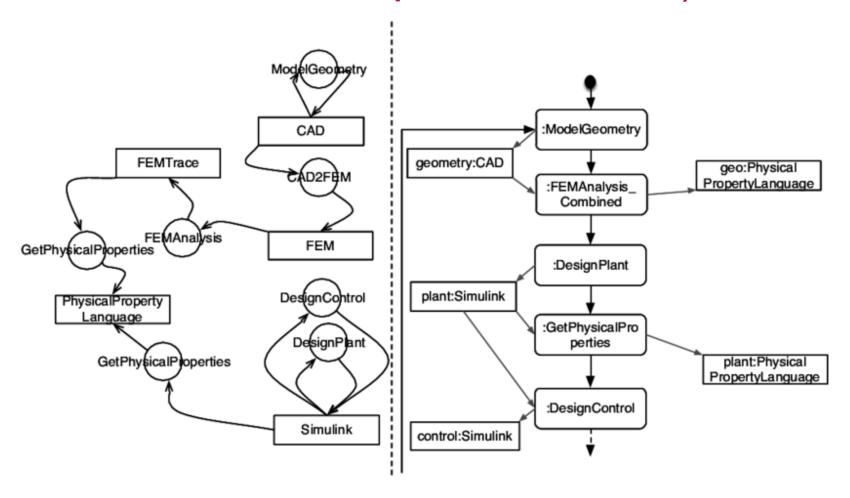


- Developed at Hasso-Plattner Institute, University of Potsdam, Germany
  - MoM Website: https://www.hpi.uni-potsdam.de/giese/public/mdelab/mdelab-projects/momcore/.

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## Megamodeling Approaches: FTG+PM (Formalisms **Transformation Graph + Process Model)**

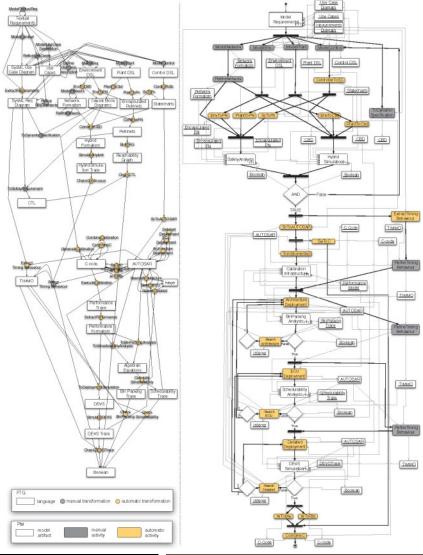


From D. Istvan, J. Denl and H. Vangheluwe, "Towards Inconsistency Management by Process-Oriented Dependency Modeling"





## **Example: FTG+PM for Power Window**







## Other non-Megamodeling Approaches

- OSLC (Open Services for Lifecycle Collaboration)
- STEP AP 242 (ISO 10303-242) "Managed model based 3D engineering" standard
- **Product Life-Cycle Management (PLM) solutions** such as EuroSTEP





# **Comparison of Approaches**

Approach	Configuration Megamodel	Application Megamodel	Tool Adapters	Language Subsets	Change Policies	Process / Workflow	User Interaction
GMM [16]	+	-	+	+	-	-	-
MoM [24]	+	+	~	-	-	-	_
FTG+PM [25]	+	-	+	-	-	+	+
ACMoM	+	+	+	+	+	+	+





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### Foundations for ACMoM

- Core Megamodeling Language and Semantics
- Processes and Workflows
- Change Management Policies

- How?
  - Reuse the best of state of the art approaches





## **Prototyping and Case Studies**

### OSATE / RAMSES

### Several use cases

- Mixed-Criticality Scheduling with the MC-DAG Framework
- Model Refinement and Code Generation with RAMSES
- AADL ←→ FACE Mapping

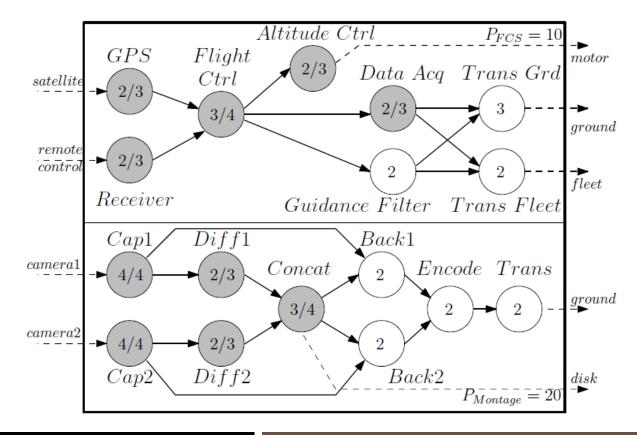




## Mixed-Criticality Scheduling with the MC-**DAG Framework**

**Horizontal transformation** 

- **Bi-directional transformation** 
  - Static scheduling properties valued in original model

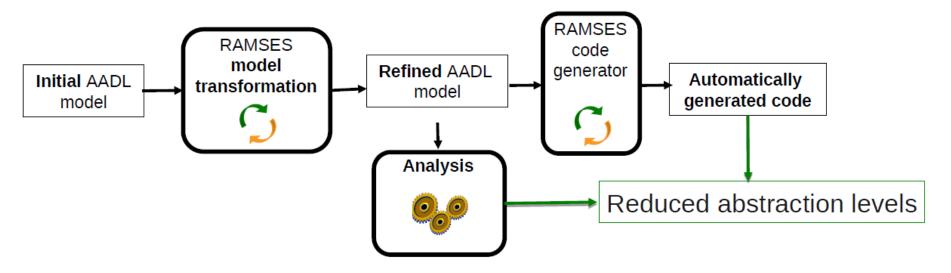






# RAMSES: Refinement of AADL Models for the Synthesis of Embedded Systems

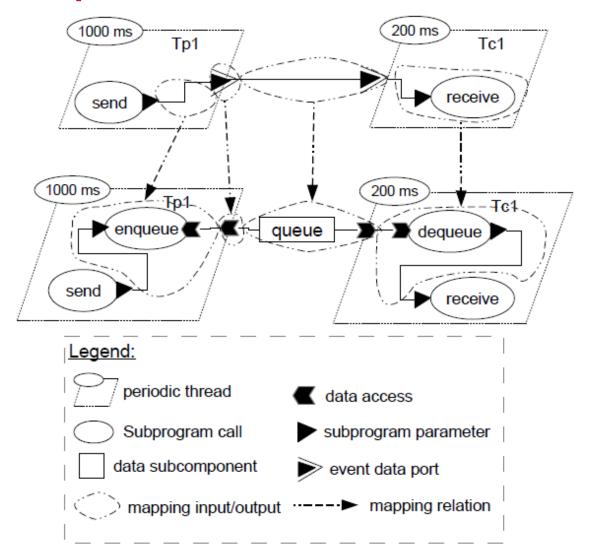
- **Vertical transformation** 
  - Different levels of abstraction
- **Endogenous transformation**
- **Code generation**
- **Model workflows**







## **Example of RAMSES Refinement Rule**

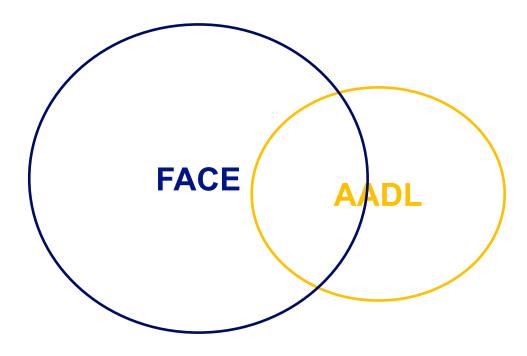






## AADL ←→Face Mapping

- Standardized mapping provided by Adventium Labs
- **Bi-directional**
- Information overlap but does not coincides
- **Change policies**

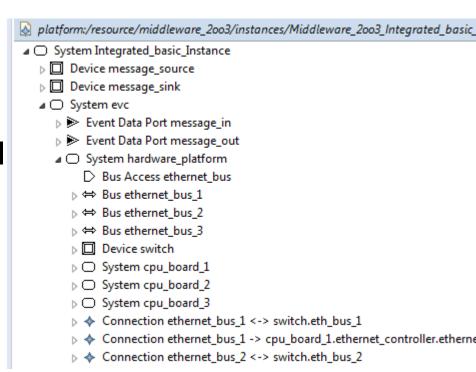






### **Instance Model Uninstantiation**

- OSATE allows to create instance model from declarative one
- Very useful to simplify model operations
- Nice to be able to update the instance model directly
- How to reflect changes into declarative model?
- Study generic uninstantiation transformation







### Team

### Hana Mkaouar

Currently working on benchmark of incremental model transformation approaches and tools

#### **Etienne Borde**

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Initiator of the RAMSES project





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### Conclusion

- Model management is essential
- Need to take into consideration
  - Development process (e.g. ACVIP)
  - Configuration (e.g. ASoT)
- Need to be customizable for other processes
  - E.g; PST development process
- **ACMoM**

- Research the best approaches
- Proposed a first framework
- Prototyped in OSATE for proposed for case studies



