Model-Based Systems Engineering with Capella

STATUS AND PERSPECTIVES

Stéphane Bonnet, Thales Corporate Engineering
April 12th, 2016
Model-Based Systems(*) Engineering

(*) NOT ONLY
Thales: A Wide Spectrum of Complex Systems

1. **N°1 worldwide**
   - Payloads for telecom satellites
   - Air Traffic Management
   - Sonars
   - Security for interbank transactions

2. **N°2 worldwide**
   - Rail signalling systems
   - In-flight entertainment and connectivity
   - Military tactical radiocommunications

3. **N°3 worldwide**
   - Avionics
   - Civil satellites
   - Surface radars

€14 billion in revenues
Engineering Challenge: From Equipment to Global Solution Supplier

**Systems**

- More complex missions, more constraints (safety, environmental impacts, weight, etc.)
- More reliability, versatility and added value, less time to market
- Increasing parts of SW

**Systems Engineers**

- Plan, design, justify, integrate, validate, test, certify...
- Frequently resolve complex issues while considering time, cost, risks.
- Larger teams, with more development interdependencies
Vision 2025 (INCOSE © 2014)

Simulation and visualization

Modeling, simulation, and visualization enable complex system understanding that help us anticipate and verify solutions and their cost before building them. As systems become more complex, understanding their emergent behaviour due to increasingly complex software, extreme physical environments, net-centricity, and human interactions becomes essential for successful systems development.

MBSE, a key lever for improvement of Engineering Performance

Model-based Systems Engineering will become the “norm” for systems engineering execution, with specific focus placed on integrated modelling environments. These systems models go “beyond the boxes”, incorporating geometric, production and operational views. Integrated models reduce inconsistencies, enable automation and support early and continual verification by analysis..."
From Requirement-Driven Practices to MBSE
And from Document-Driven Practices to MBSE
MBSE vs Traditional Systems Engineering

- MBSE does not replace standard Systems Engineering practices

- It formalizes parts of systems engineering
- Combines traditional methods and best practices with rigorous modeling techniques
Models, What For?

- **Answer questions**
  - About the system
    - What is it, how does it work, is the performance adequate, what happens if something breaks?
  - About the design
    - Is it complete, does it support required analyses, does it support impact analysis?

- **Ensure consistency**
  - Across different views, between upstream and downstream engineering, etc.

- **Generate artefacts**
  - Documentation (specification, architecture, interfaces)
  - Pieces of code, database schemas, configuration data, deployment data, etc.
Different Kinds of Model

- Different objectives

- Descriptive, formal, executable, 3D, etc.
Arcadia and Capella

MODEL-BASED METHOD FOR ARCHITECTURAL DESIGN AND ITS SUPPORTING MODELING WORKBENCH

www.thalesgroup.com
Arcadia : MBSE Scalable and Adaptable Method

Improving engineering agility and overall performance

System-wide collaboration
Arcadia: MBSE Scalable and Adaptable Method

- Improving engineering agility and overall performance
- System-wide collaboration
- Complexity mastering
Arcadia : MBSE Scalable and Adaptable Method

- Improving engineering agility and overall performance
  - System-wide collaboration
  - Complexity mastering
  - Concurrent engineering

ViewPoints etc.
- Product Line
- Human Factors
- Performance
- Security
- Safety

Evaluation Rules

Solution Architecture
Arcadia: MBSE Scalable and Adaptable Method

- Improving engineering agility and overall performance
- System-wide collaboration
- Complexity mastering
- Concurrent engineering
- Mastering transitions
Capella: A Modeling Workbench Supporting Arcadia

Not a talk about Capella features, but....

- Methodological browser
- Semantic browser
- Computed graphical views
- Advanced diagram mgt.
- Validation & quick fixes
- Semantic delete
- Replicable elements
- Patterns
- HTML generation
- Transition to sub-systems
- Multi-viewpoint mgt.
Wide Variety of Modeling Objectives
Thales Examples

Coupling with simulation benches

Multi-level MBSE

Measured gains on IVV

Progress Monitoring
Thales Examples

Safety Rules verification

Safety: Essential Data

Evolutions and cost estimation

Legacy Interfaces

Feared Event Analysis: Safety Rules 2 Analysis

Does the Architecture respect

- CRUD Capability
- Integration in Melody Advance

Capacity to:
- Create New Message
- Delete Messages
- Create new Data Structure
- Unlink Message

Link a message to existing selected exchange
Thales Examples

Capella
Open Source Tools for Embedded Systems

Product Line modelling

Code generation

Model-driven IVV

Performance analysis

Thales Examples

Ref number-date
Name of the company/Template: 87204467-DOC-GRP-EN-002
Capella versus and SysML

NOT A DSL BUT A HYBRID APPROACH
The Thales MBSE Odyssey


- Engineering Practices Transformation Plan
- Pilot Deployments
- Real Operational Use

Early Experiments

Corporate Research Program

Commercial Tools Experiments

Dedicated Tool Development

ARCADIA

Method Building

Short-Loop Validation & Adjustment

DoDAF

Nato AF

Capella Tool Open Sourcing

Unified Modeling Language
Back in the past (2003-2008)
Back in the past (2003-2008)

"EMF" outside Java & Eclipse

:-)
Capella Core Concepts: The Wheel is Not Reinvented…
... Things Are Just Simpler ... when possible

Functions = Green

Components = Blue

Interfaces = Pink
Capella Core Concepts: Examples of Language Differences

Support of Functional Analysis

Hands-On!

- F11, F121, F122, F21, F22 are OpaqueActions
- F1, F2, F12 are CallBehaviorActions referencing Activities
Capella Core Concepts: Examples of Language Differences

Management of instances (1/2)

SysML Blocks and Parts
(available in Capella through configuration options)

The need: Instance-driven modelling
Capella Core Concepts: Examples of Language Differences

Management of instances (2/2)

One solution: REC-RPL mechanism. The same language concepts are used for both types and instances.

A « type » can be anything, including multi-root sets of elements.
Tooling and API Perspective

Model extension and exploitation
Viewpoints, validation rules, queries, diff/merge, bridges, etc.

Domain / Method Native EMF API

UML/SysML EMF API

UML/SysML Profile

<< LC >>
Block

<< LF >>
Action

Domain or method meta-model

LC

LF
The Capella Ecosystem

A YEAR AND A HALF LATER
Thales: Significant Contributor to Eclipse Modeling & Polarsys communities

Phase 1:
Get OSSing competence & prepare environment

Phase 2:
OSSing MDE technical components & solutions (MDK)

Phase 3:
OSSing Melody & Publishing Arcadia

Built upon

Hosted by
What is Open Source?

Focus on one's value
- Keep as competitive Advantage

Share
- Co-develop
- Contribute
- Use

Value

Expertise, Know-how, Core business

Domain end-user solutions

Domain platform

Technical platform
What is Open Source?

Viewpoints
- IVV
- Product Line
- Safety
- Performance
- Etc.

Advanced add-ons
- Teamworking
- Model maintenance
- Non functional
- Etc.

Focus on one’s value
- Keep as competitive Advantage

Share
- Co-develop
- Contribute
- Use

Capella
Kitalpha
Sirius
eclipse
CLARITY Consortium in a Nutshell

CLARITY facts & figures
- French (LEOC) proposal
- T0: September 1st, 2014, Duration: 36 months, Budget: 16 M€

CLARITY objectives
- Arcadia standardisation & Melody Open Sourcing
- Further innovation (functional, non-functional) around Melody
- Ecosystem building around Arcadia & Melody
- Driven by industries, supported by Services & Technologies providers, enriched by research teams

CLARITY highlights
- 19 major reference partners all along the value chain
- Major promotion efforts: Communities, Conferences, Book, Training
- Standardisation objectives
  - Melody de facto standardisation
  - Arcadia standard technical document
Capella: Open innovation at work

**COMMUNITIES**
- Sharing
- Standardisation
- Communities

**SERVICE PROVIDERS**
- Consulting
- Training
- Deployment

**END-USER ORGANIZATIONS**
- Evaluation
- Consolidation
- Collaboration

**TOOLS & TECHNO PROVIDERS**
- Technologies
- Tools
- Commercialisation

**RESEARCH & ACADEMIA**
- Academic training
- Engineers
- Research
Capella : First return of experiments

Sept. 2015
Clarity plenary session
First year milestone
Ongoing Experimentations, Evaluations, Usage

- CONOPS of military project
- Launcher Avionics

- Core design and transient analysis
- Fluid systems design
- Primary components design
- Handling equipment design
- I&C specifications
- I&C Architecture
- Human Factors engineering

See CSD&M 2015
**Ongoing Work**

- **Modes, States, Configurations**
  - Prototype available for Clarity members
  - Experimentations in 2016, adjustments of tool and method based on operational feedback
  - Integration in the core of Capella in 2017

- **Refinement of modeling solutions for instance / building blocks**
  - Bring the REC-RPL mechanism one step further with enhanced merging possibilities

- **Requirements traceability**
  - Enhanced requirement import-export capabilities (through ReqIf)

- **End-user solutions for model querying**
  - Enhanced user interface for IncQuery patterns
Ongoing Work

ALL4TEC – SAFETY ARCHITECT

ALL4TEC – MATELO (TEST CASE GENERATION)

ARTAL – CITRUS (SIMULATION ENV)
Thank You! Questions?

Capella website:
http://www.polarsys.org/capella/
LinkedIn  
http://www.linkedin.com/company/capella-modelling-workbench
Twitter  
https://twitter.com/capella_arcadia
Arcadia forum:
https://polarsys.org/forums/index.php/f/12/
Capella forum:
https://polarsys.org/forums/index.php/f/13/
IFE model & doc.:
http://www.polarsys.org/capella/start.html
www.thalesgroup.com