Acquisition and Early Evaluation of Architecture with Arcadia and Capella

NASA JPL MBSE SYMPOSIUM – JAN 26TH, 2016

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Thales: A wide spectrum of complex systems

<table>
<thead>
<tr>
<th>Nº1 worldwide</th>
<th>Payloads for telecom satellites</th>
<th>Air Traffic Management</th>
<th>Sonars</th>
<th>Security for interbank transactions</th>
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</table>

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<tr>
<th>Nº2 worldwide</th>
<th>Rail signalling systems</th>
<th>In-flight entertainment and connectivity</th>
<th>Military tactical radiocommunications</th>
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<tr>
<th>Nº3 worldwide</th>
<th>Avionics</th>
<th>Civil satellites</th>
<th>Surface radars</th>
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€14 billion in revenues
Scope

Enterprise Architecting (operational capabilities and need, orientations, etc.)

Multi-physics: 3D, power models, thermal models, etc.

Algos, Real-time Analysis, NF, Etc.

Detailed design, development

Method

Workbench

Arcadia

Capella

V&V
Scope

Understand the real customer need

Define and share the solution among stakeholders

Secure SYS/SW/HW engineering, prepare subcontracting

Early evaluate and justify architectural design

Prepare and master V&V
Arcadia: A "Simple" Engineering Language
Tight coupling method/tool
A practitioner-driven journey started in Thales...

Practitioner-driven Capella development

Multi-domain Thales working groups on language and method
... now open source *(it’s free!)*

http://www.polarsys.org/capella

Initial 3-year (French) collaborative project

Larger industry consortium currently being initiated
Method and Workbench Highlights

A COMPREHENSIVE, METHODOLOGICAL, AND TOOL-SUPPORTED APPROACH
Operational Analysis

WHAT THE USERS/STAKEHOLDERS NEED TO ACCOMPLISH

Support of discussions with the customer, capabilities, scenarios and processes
System Need Analysis

WHAT THE SYSTEM HAS TO ACCOMPLISH FOR THE USERS

Boundaries, external interfaces, specification, v&v procedures, feasibility of requirements
Logical Architecture

HOW THE SYSTEM WILL WORK SO AS TO FULFIL EXPECTATIONS

High-level architecture description, functional refinement, architectural drivers, functional allocation, first trade-offs, modes and states analysis
Physical Architecture

HOW THE SYSTEM WILL BE DEVELOPED AND BUILT

Implementation constraints, reuse, refined trade-offs, M/T/B strategy, finalized detailed interfaces

ViewPoints
C1
C2
C3
C4

F1
F2
F3
F4
F5
F6

F21
F22

F7

C11
C12

C2
C3
C4

ViewPoints

e.g. Processors

e.g. Buses

e.g. SW, HW components
Physical Architecture

HOW THE SYSTEM WILL BE DEVELOPED AND BUILT

Implementation constraints, reuse, refined trade-offs, M/T/B strategy, finalized detailed interfaces
Focus on Functional Analysis

Ease of modeling, complexity management
Functional analysis workflows

Top-down

1

2
Functional analysis with Capella
Functional analysis with Capella
Functional analysis with Capella
Functional analysis with Capella
Functional analysis with Capella
Architecture (early) evaluation

Parametric analyses, coupling with specialty tools
Architecture early evaluation

Autonomous viewpoints

Birectional coupling with specialty tools

Performance
Mass
Safety
...

Citrus simulation env.

All4Tec Safety Architect
Example 1: Capella – Safety Architect (All4Tec)

Feared event added to Capella dataflows (viewpoint)

In Capella, visualization of fault trees as critical functional chains

In Safety Architect, analysis of block local failure conditions

Functional Hazard Analysis (FHA)

In Safety Architect, automated generation of fault-trees
Example 2: Architecture Parametric Analysis

Enrich model with consumption information (Marte-based HW and parametric extension to Capella)

Progressive consolidation of consumptions for each function

Architecture Dimensioning

Dashboards showing estimations and measures
Not developed here but important… (and addressed)

Modes and states
Analyzing the variability of the system during its operation

Model-based V&V
Driving v&v activities by expected functional content

Product Line
Variability management based on feature models
Arcadia and Capella:
a value-added combination for Space products engineering

M. Reboul, L. Saoud, G. Garcia
Key aspects for space systems engineering

- Recursive application brings value in each step of the engineering chain
- Consistent management of engineering data and production of consistent artifacts
- Strong enablers for product line definition and reuse of building blocks
- Architecture early validation and V&V preparation
## Target systems and modeling activities

<table>
<thead>
<tr>
<th>End-to-end Space Systems</th>
<th>Ground Segments (telecom, navigation, observation)</th>
<th>Spacecrafts (telecom, observation, exploration)</th>
<th>Sub-Systems &amp; Equipment</th>
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<tbody>
<tr>
<td>• Operational concept definition and refinement</td>
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<tr>
<td>• Ground/board functional allocation trade-off and interface definition</td>
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<td></td>
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<tr>
<td>• Architecture definition, early validation and Interfaces mastering</td>
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<td>• Definition of product line: variability management, derivation of specification</td>
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<td>• Sub-systems proper functional allocation and specification</td>
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<td>• Definition of product line: variability management, derivation, specification of derivation</td>
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<tr>
<td>• Specification and link with software modeling tool</td>
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<tr>
<td>• Definition of building blocks</td>
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**Production of consistent artifacts**

- System specifications,  
- Architecture Documents,  
- IRD/ICD  
- Sub-system / Equipment User Requirement Documents
Definition of operational concepts
System need-level analysis
Trade-offs based on reference architecture

Cost/Risk  CPU  Timing  Product Line  Reliability
Complexity  Security  Flexibility  Legacy
TM/TC Bandwidth  Responsiveness  ...

Subsystems specification
Perform functional allocation

Alternative 1: Legacy payload
Ground commands all the payload sub-systems

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<th>Legacy Payload</th>
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<td>CPU</td>
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Perform functional allocation

Alternative 2: Autonomous payload
Manage its state itself

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Example of a Capella automation feature

Automated projection of functional allocation
Global engineering environment

Functional Design
Operations, functions, architecture
Capella

Physical Design
Mechanical, thermal, etc.

Analysis
Mechanical, thermal, radiations, etc.

Simulation
Multi-physics, functional

Consumption
MCI, Power, Dissipation

Process
Workflows, KPI, reviews, etc.

Engineering PDM

Phase A

Phase B

Next phases C, D, E

Digital continuum along satellite lifecycle

Partners & sub-contractors

Customer
Contact

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