Lambda

Applying MDE to Embedded System Design

First results and perspectives from the Lambda project

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Le Pôle et ses projets de R&D sont soutenus par :

The Lambda project

Industrials

THALES

AIRBUS

Platform providers

ARION

PRISMTECH
Powering Netcentricity

AdaCore
The GNAT Pro Company

atego

kontron

Tool vendors

ESTEREL Technologies

CoFluent Design

beo
Model Driven Company

Academics

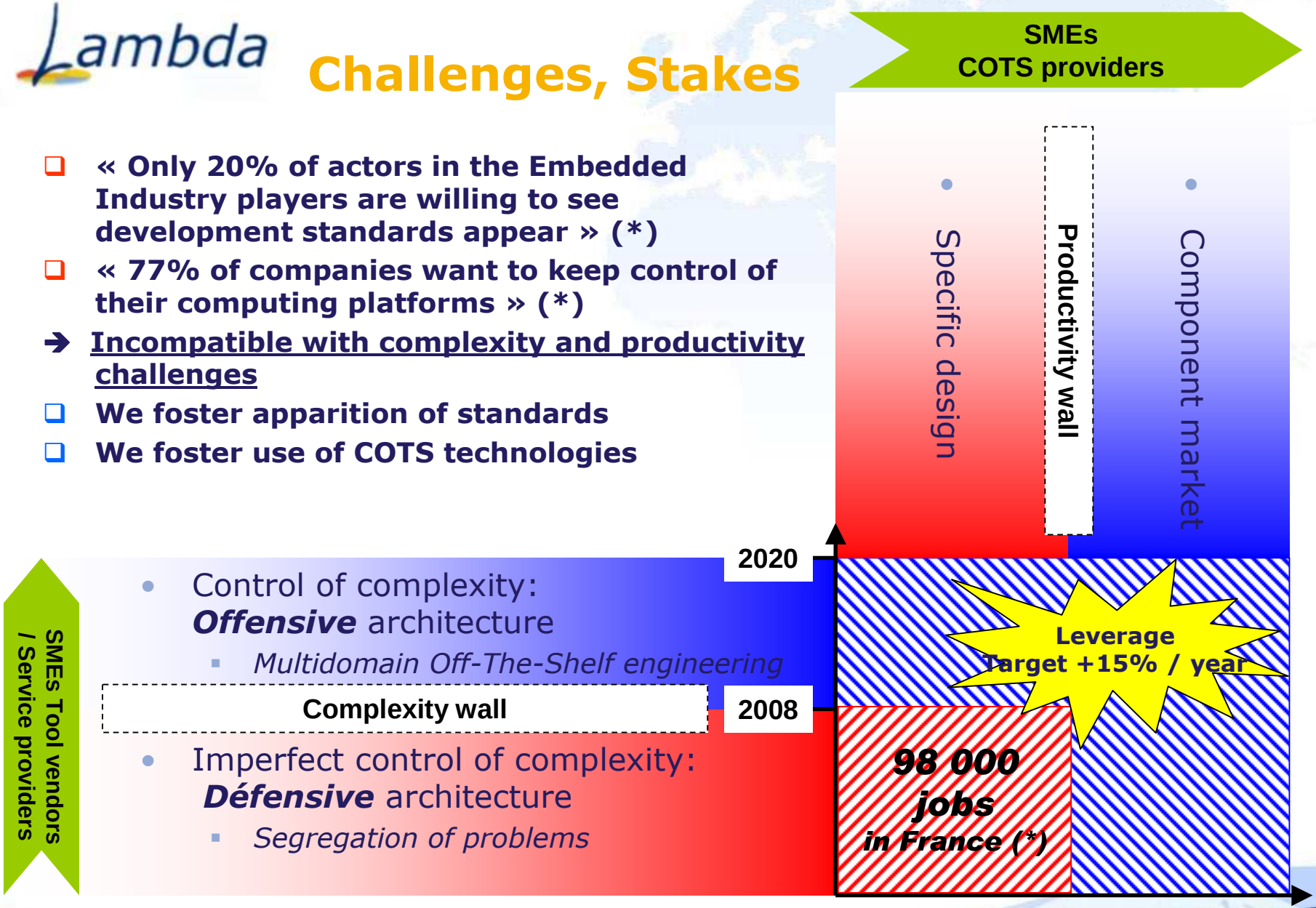
cea list

INRIA

Supélec

Challenges, Stakes

- « Only 20% of actors in the Embedded Industry players are willing to see development standards appear » (*)
- « 77% of companies want to keep control of their computing platforms » (*)
- ➔ **Incompatible with complexity and productivity challenges**
- We foster apparition of standards
- We foster use of COTS technologies



(*) French Ministère de l'Industrie, Syntec informatique and RNTL

Project overview

Interoperability

Design supported by tools

UML MARTE

AADL

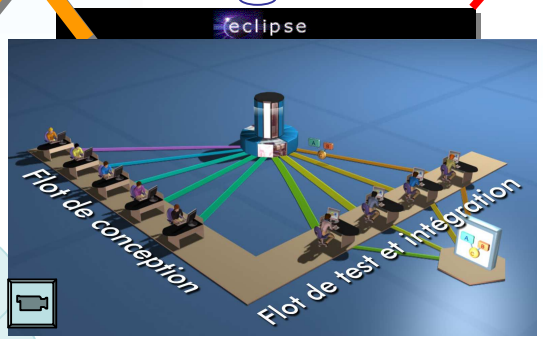
The SPIRIT Consortium

Standards

Knowledge of key characteristics of execution platforms (analysis or simulation)

Feasibility

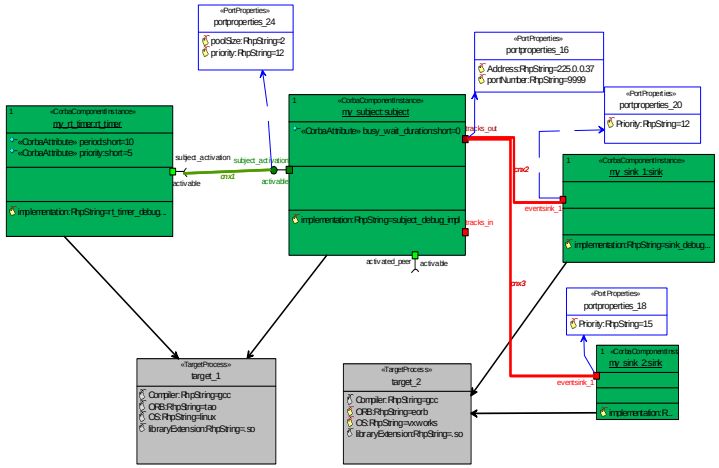
Realisation of model-driven software engineering



Stake:
Maturity at Entry In Service

Execution platform modelling

Example of systems engineer's issues



Requirement: End-to-end processing time less than 100 ms

Image processing function (Application)

Component frameworks

Single-Board Computers (bi-processors, dual-cores)

FPGA accelerators

Gigabit Ethernet

Kontron high performance rack (Platform)

Latency / Throughput?

Optimize CPU consumption?

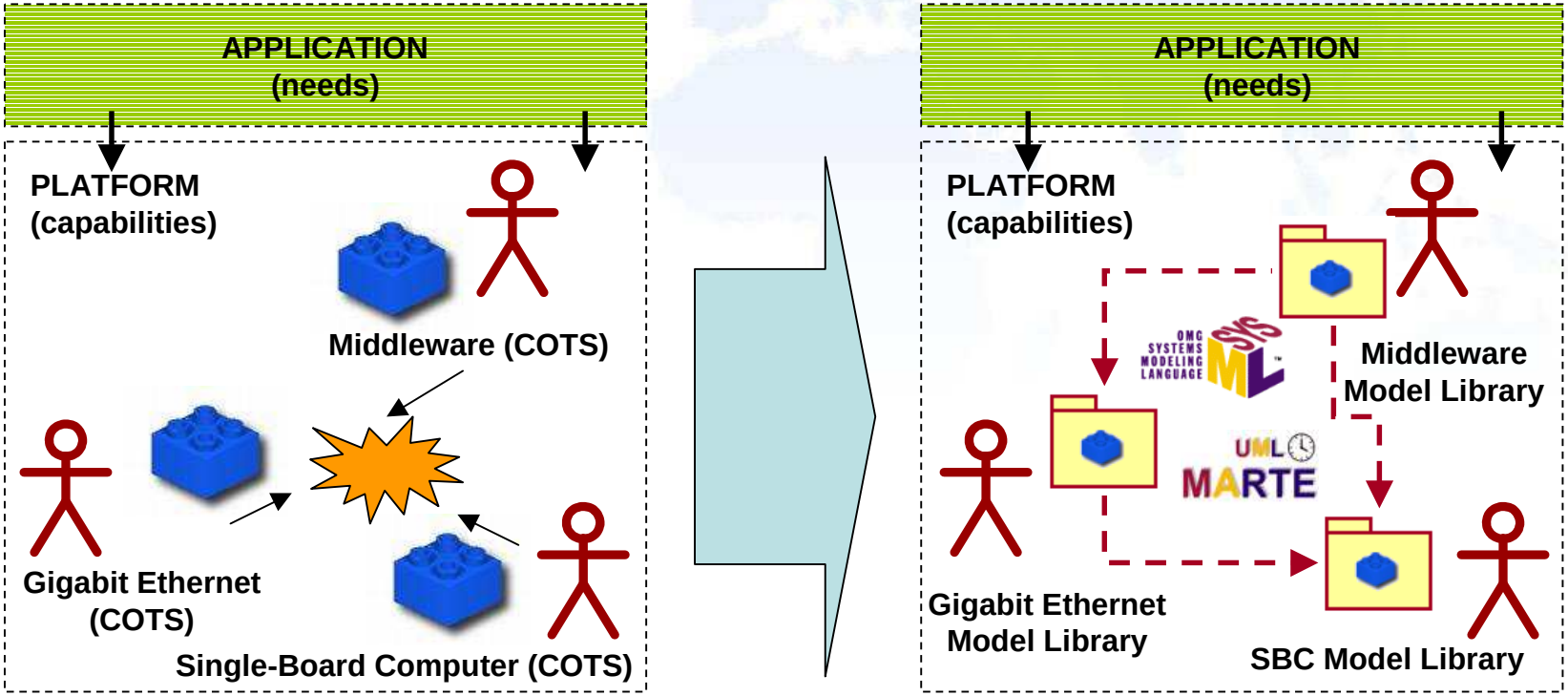
Network configuration (VLAN, buffers, MTU)

Component deployment strategies?

System Integrator

Execution platform modelling

Models to facilitate integration and validation



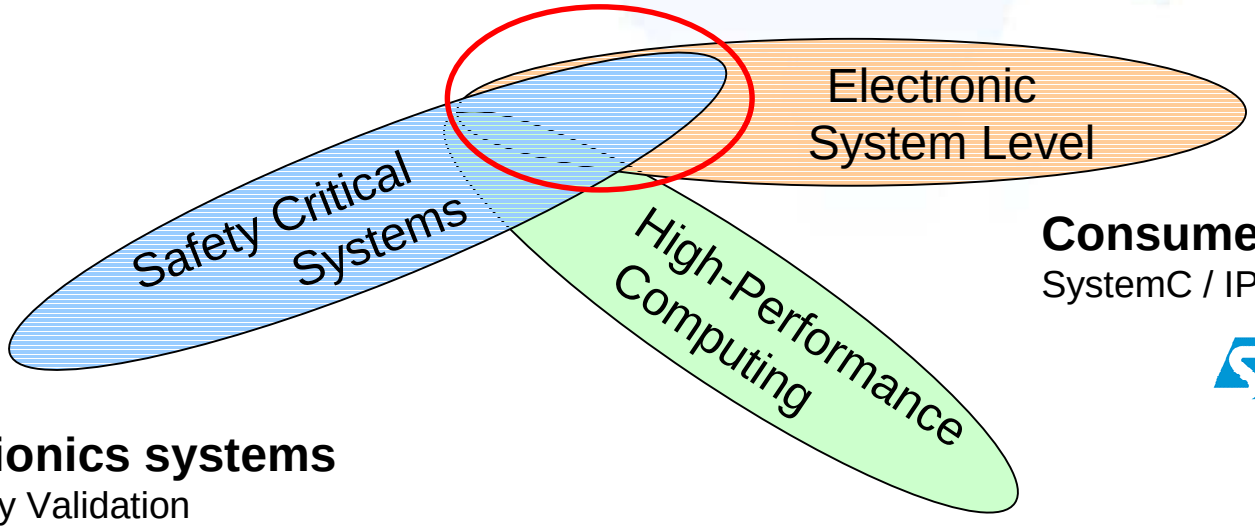
- System integration issues
- Difficulties when configuring COTS components

- Early Validation of system properties
- Virtual component integration

Key role of platforms in the design process of embedded systems

Execution platform modelling

SysML/MARTE as pivot language



Consumer electronics

SystemC / IP-XACT simulation

Avionics systems

Early Validation

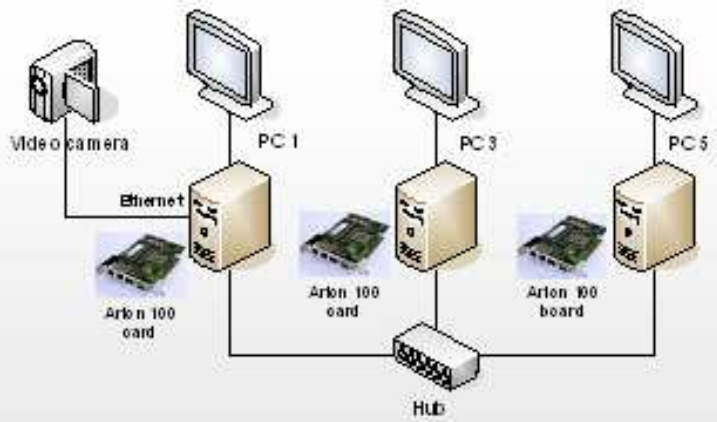
Worst-Case Response Time

Image / data processing

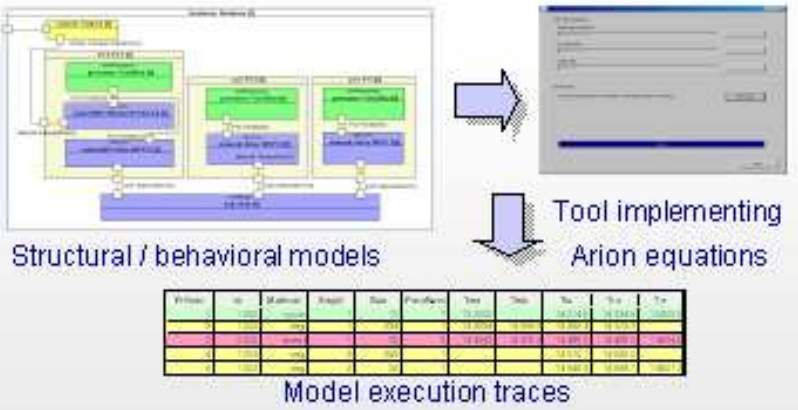
Hybrid simulation techniques

Execution platform modelling

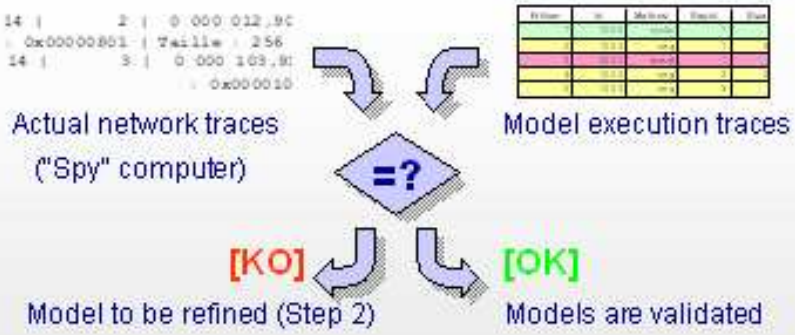
Building the platform models



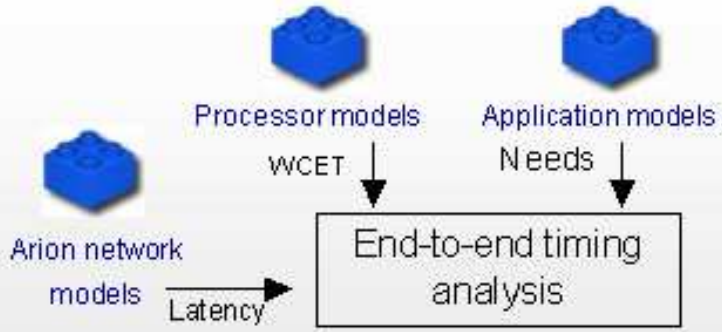
1. A reference application is known and available (e.g. Arion Real-time Ethernet demonstrator)



2. The platform is characterised and modeled in SysML/MARTE along with timing analysis tools



3. Models are calibrated and validated against actual measurements on the platform



4. Validated models are packaged in reusable libraries, contributing to an end-to-end analysis

Execution platform modelling

Current results

- Platform models available in analysis/simulation tools to support dimensioning and deployment
  - Computing platforms, networks, software runtimes
- Key methodological findings
  - A combination of SysML and MARTE provides relevant support to capture application needs and platform capabilities
  - Difficulty to get started with MARTE with no support from experts
    - ✓ After a first stage, common practices appeared around a limited subset of MARTE (e.g. NFP, Time model)
  - No « silver-bullet » simulation/analysis technique relevant for all the experimentations
    - ✓ Different practices in the Safety-critical, HPC and ESL communities
- On-going work to write synthesis and conclusions

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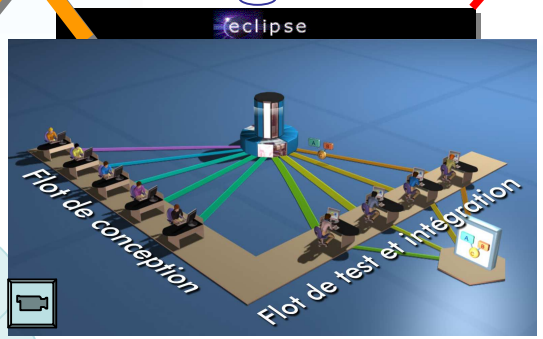

Stake:
Maturity at Entry
In Service

Integration and interoperability

Addressing key obstacles to a full-scale deployment of MDE

- Full-scale deployment of MDE in the Industry requires a consolidation of the developed modelling infrastructure
  - Model repositories
  - Model injection and transformation tools
- Several studies and prototyping activities to:
  - Identify key issues
  - Anticipate solutions
  - Start to specify the features of 2nd generation MDE tools
- Themes addressed
  - Maintenance Repair and Operations (MRO) of modelling workbenches
  - Paper studies and benchmarks to assess scalability of modelling repositories and model transformation tools
  - Studies on integration of synchronous languages with SysML/MARTE
  - Integration of non-functional properties in SysML

Integration and interoperability
Current results

- Elements of the complexity under study
  - Managing a large number of artifacts.
  - Managing large scale artifacts.
  - Complexity of relations between artifacts.
  - Using model repositories
  - Building and using libraries of reusable modeling artifacts
  - Managing traceability
  - Managing geographical distribution
  - Managing collaborative work
  - Managing metamodels evolution
  - Configuration management for models
  - Managing multiple viewpoints
  - Managing model engineering workflows and dataflows
  - Managing technological heterogeneity
  - Managing complex systems
  - Managing unbounded models (data flow, infinite streams)
  - Managing legacy systems
  - Definition of a complex system management workbench
  - Ergonomic and rendering issues due to large number of artifacts
- Follow-up work in the context of the ANR Galaxy project

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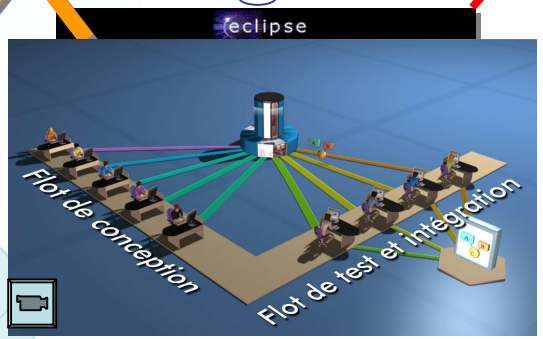

Stake:
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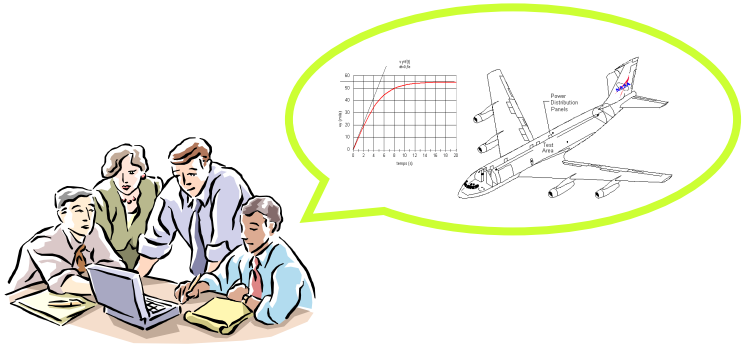
In Service

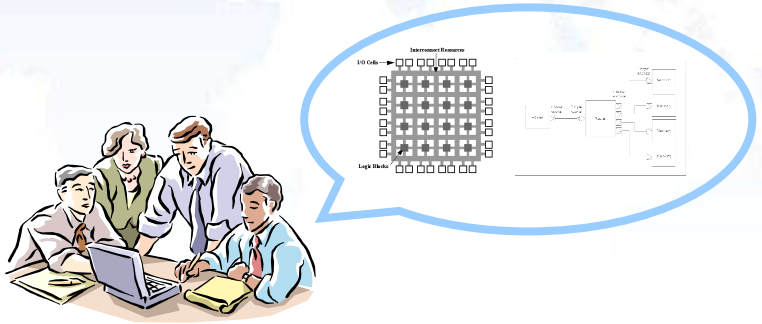
Stakes of standard/tool convergences

State of the art

Different engineering standards for embedded systems design, defined by different communities

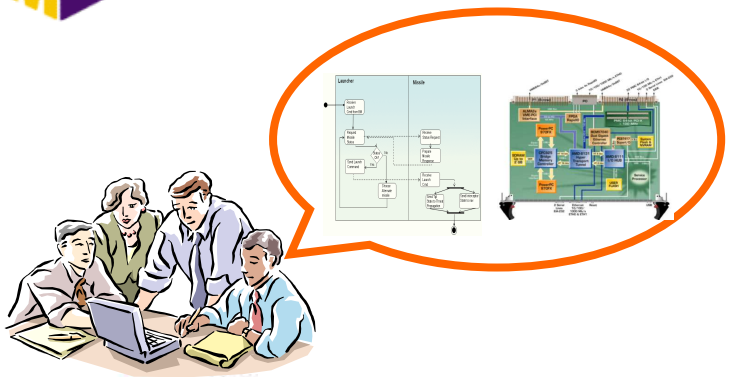


OMG SYSTEMS MODELING LANGUAGE SysML™

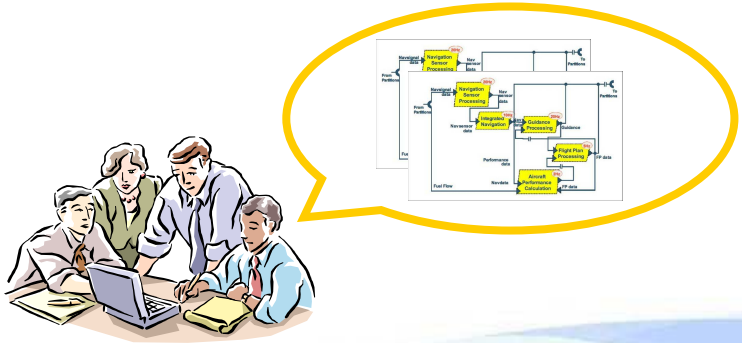


SYSTEMC™

The SPIRIT Consortium



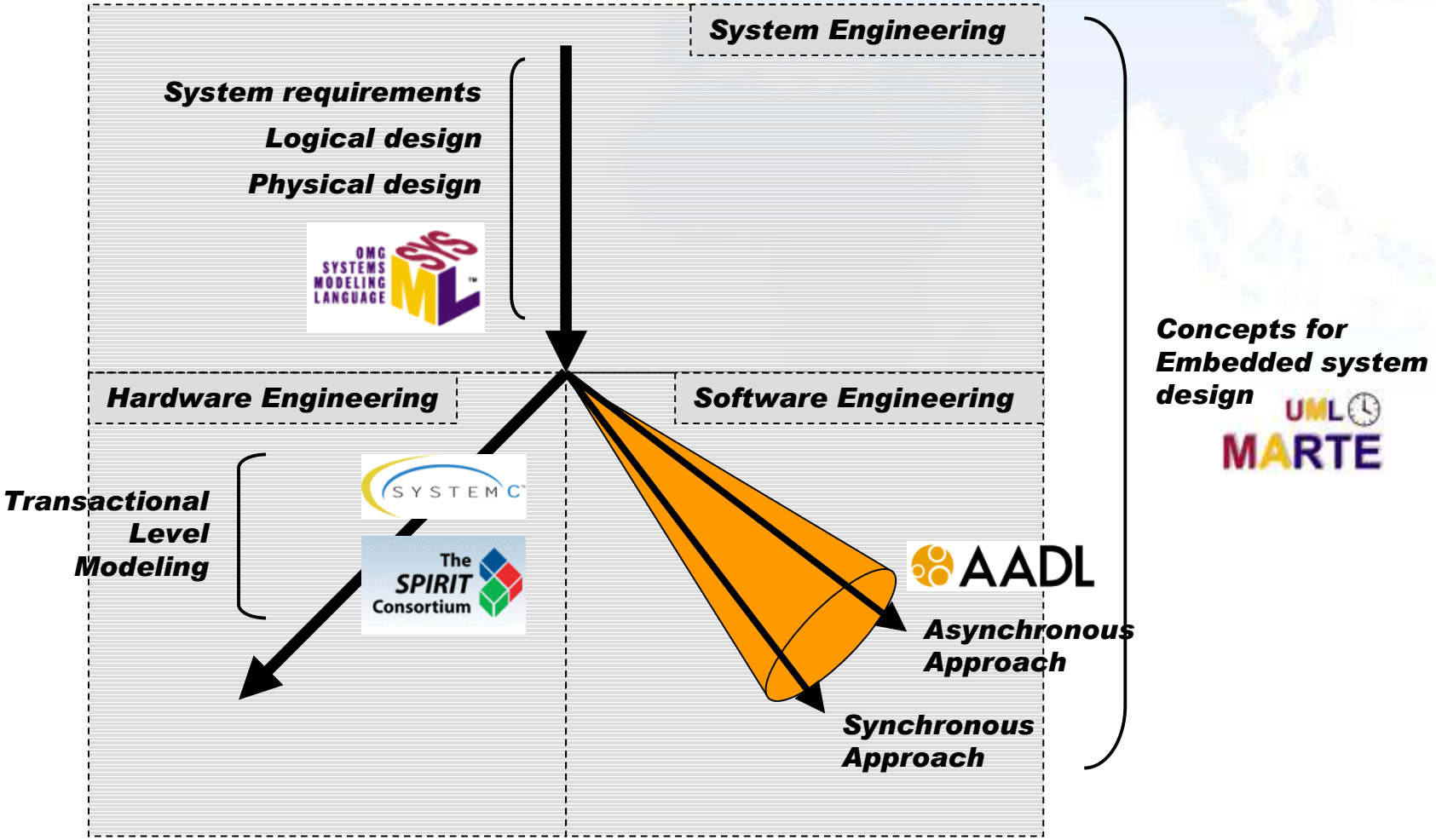
UML MARTE



AADL

Stakes of standard convergences

Vision



Continuity between SE/SW and SE/HW flows requires interoperability between supporting standards

Stakes of standard/tool convergences

Current situation

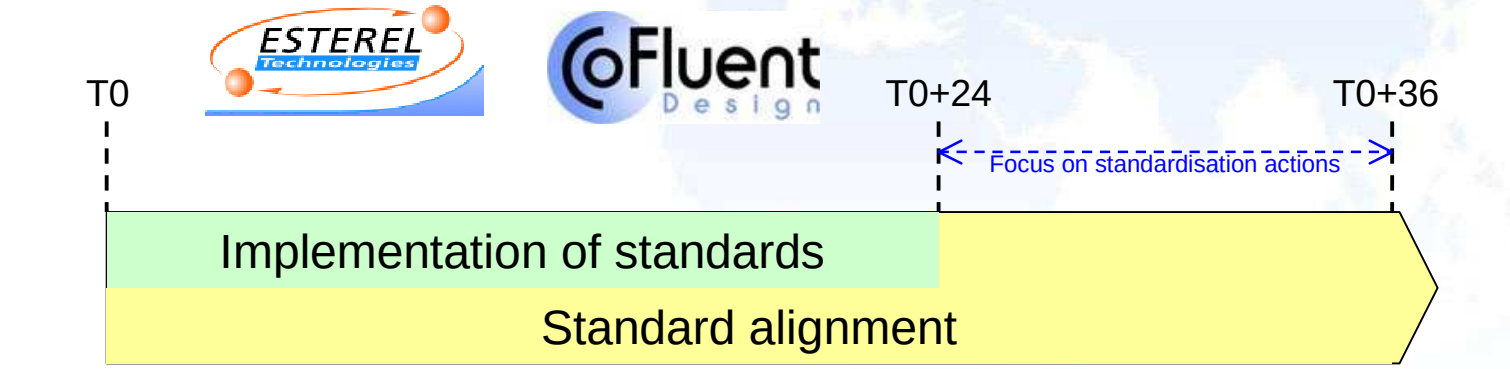
- Standard adoption may face a certain inertia
  - Overview of implemented and commercialized standards:

Standard	Date adoption	Date implantation	Solutions commerciales (COTS, OSS)
UML 2	2003	2005	15
SysML	2006	2006	8
MARTE	2007	2009	2
AADL v1	2004	2007	1
SystemC-TLM2	2008	2008	10
IP-XACT	2006	2006	29
Sources: OMG UML/SysML vendor directory, vendor web sites			

- Some technical domains seem to deal better with the situation (e.g. ESL) Why?
- Standard adoption requires coordinated collaboration between tool vendors and end users

Lambda standardisation activities

Work plan



1. Consolidate a key subset of SysML/MARTE at OMG
2. Ensure alignment of this subset with SAE AADL v2
3. Bridge the gap with standards and adopted practices in ESL (SystemC, IP-XACT) and Software communities (Ravenscar)

Lambda standardisation activities

Current results

- Finalization of the MARTE 1.0 standard
- Elaboration of a mapping of MARTE and AADL
  - Acknowledged by OMG and SAE communities
- Comprehensive support for physical quantities in SysML 1.2
  - Collaboration with ESA and NASA experts
- Joint-response by Lambda partners to the "Future of UML"
  - Thales, Airbus, CoFluent, INRIA, Adacore
  - A common vision for embedded system design

Lambda standardisation activities

First feedback

- Collaborative R&D projects constitute good environments for standard elaboration or evolution
- Involvement of end users AND vendors is key to ensure standard adoption
- Standardisation is a long-term effort
  - Defining a new standard at OMG: ~3 years
  - First implementations of OMG standards: +2 years

➔ Need to define a step-by-step strategy to deal with impedance mismatch between R&D projects and standards

Conclusions

- **The work carried out in the Lambda project demonstrated the importance of platforms in the embedded system design process**
  - **For end-users, platform vendors and tool vendors**
  - **Towards a market of model libraries and supporting tools**
- **First feedback from the modelling experiments: on the need of methodological support to get started with SysML and MARTE**
- **Integration and interoperability studies started to address key obstacles to a full-scale deployment of MDE in the Industry**
  - MRO of modelling workbenches
  - Scalability of modelling tools
- **Cross-fertilisation between modelling experiments and standard activities fostered convergence between standards and tools**
- **The final year of the project will focus on dissemination and standardisation activities in the community**