AFIS - CT MBSE

MBSE at Airbus Defence & Space – Space Systems – Launchers

Presented by Marc André and David Lesens

16 May 2014

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AIRBUS GROUP

Tom Enders

Employees*: ~ 140,000
Revenues*: ~ € 56 bn

AIRBUS

Fabrice Brégier

Employees*: ~ 73,500
Revenues*: ~ € 39 bn

AIRBUS HELICOPTERS

Guillaume Faury

Employees*: ~ 22,400
Revenues*: ~ € 6.3 bn

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Bernhard Gerwert

Employees**: ~ 40,000
Revenues**: ~ € 14 bn

* in 2012
** estimate for 2014

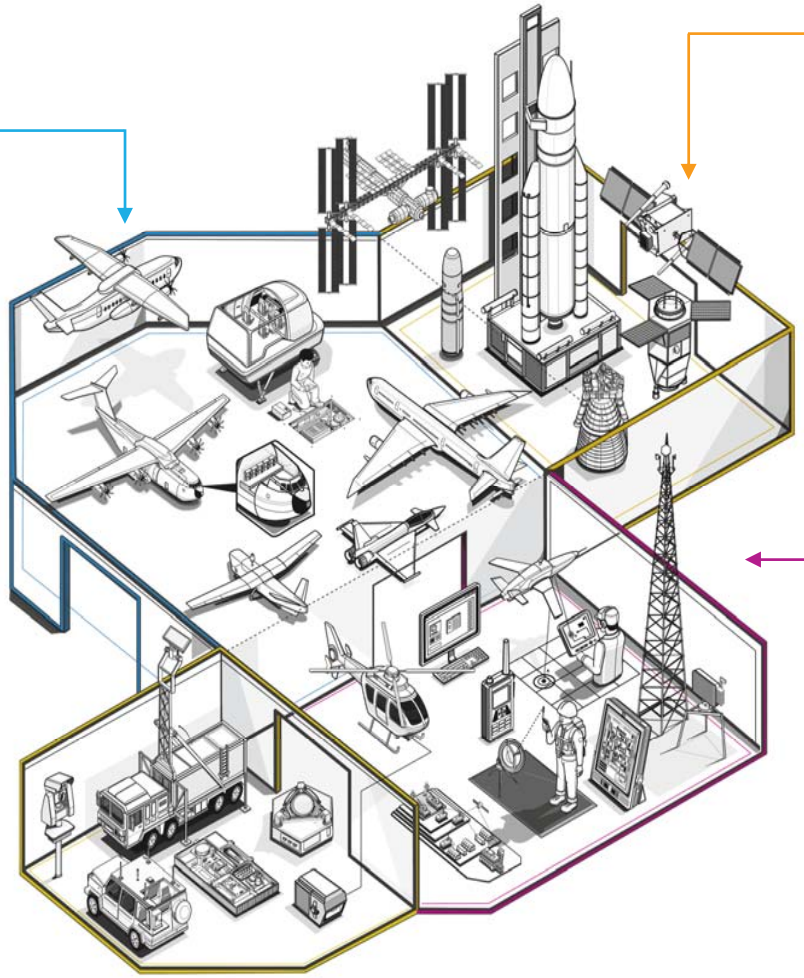
Airbus Defence and Space: 4 Business Lines

Military Aircraft

- A400M, A330 MRTT, CN235, C212, Orlik
- Eurofighter, Tornado
- Barracuda, Atlante, Harfang, Euro Hawk, Future European Male, Tracker, Tanan, Survey Copter

Electronics

- Radars and Identification Friend or Foe (IFF) Systems, Electronic Warfare, Mission Avionics, Space Platform Electronics, Space Payload Electronics



Space Systems

- Ariane 5, Automated Transfer Vehicle, Eurostar E3000, Pléiades, Gaia, Skynet, oberservation satellites (Spot, TanDEM-X, TerraSAR-X), MetOp, Swarm, M51, International Space Station ISS, interplanetary probes (Herschel, Mars Express, Solar Orbiter), Lunar Lander

Communication, Intelligence & Security (CIS)

- Surveillance and Security Solutions, Secure Communications Solutions, Cyber Security, Coastal Surveillance Systems, NATO SATCOM Post-2000, Wireless Intranet Solutions in Theatre, Farmstar Expert, Tetra Systems

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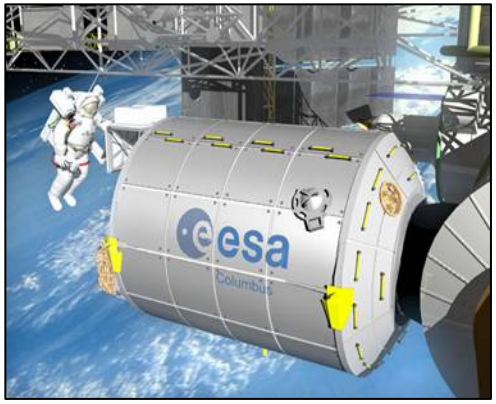
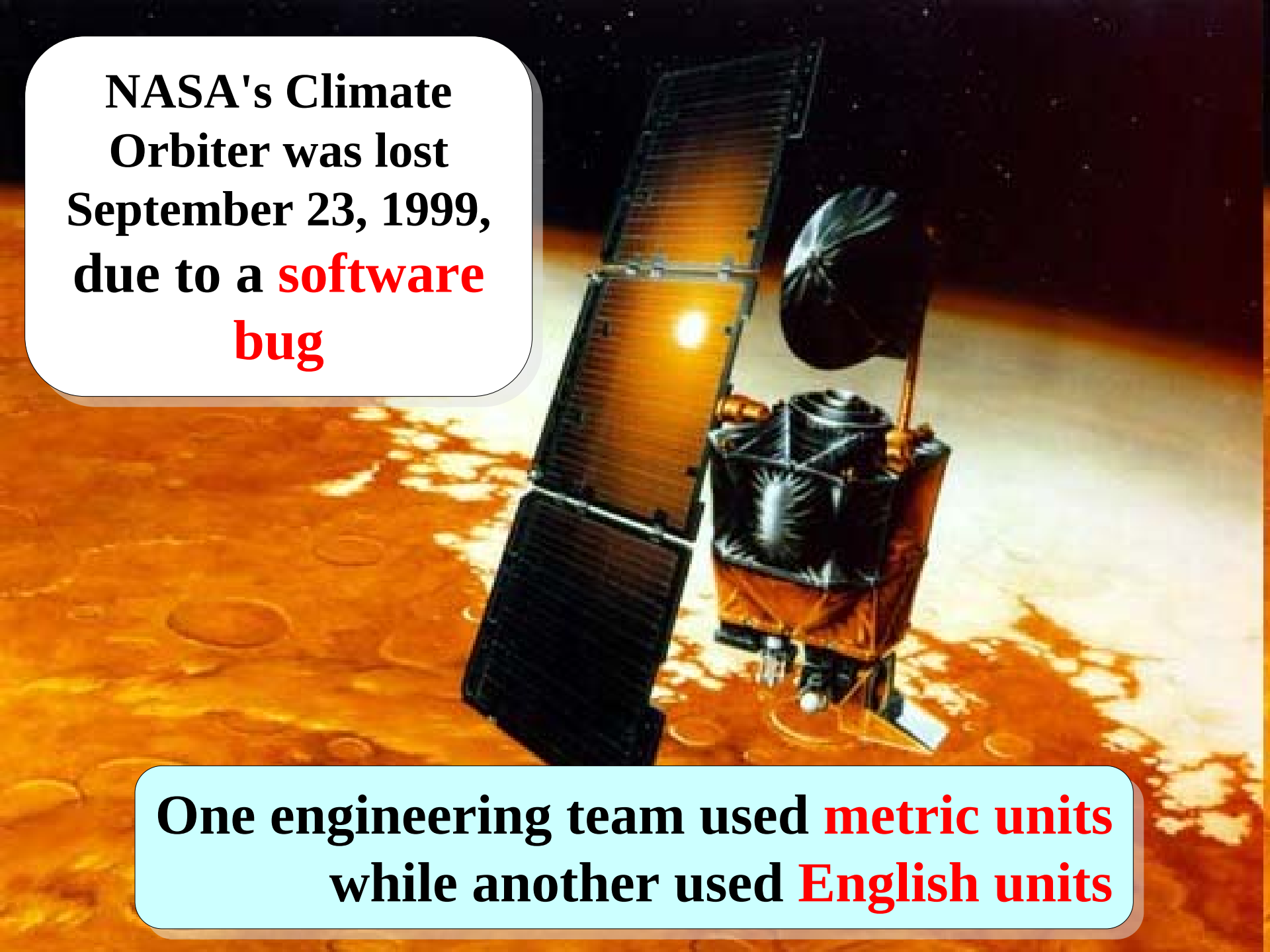
Launchers and spacecraft

- Complex Systems
- System of systems
- From system to hardware and software




NASA's Climate Orbiter was lost September 23, 1999, due to a software bug
One engineering team used metric units while another used English units

Overview

Why Model Based Systems Engineering?

Complex Systems Architecting

System to software engineering with SysML

Conclusion

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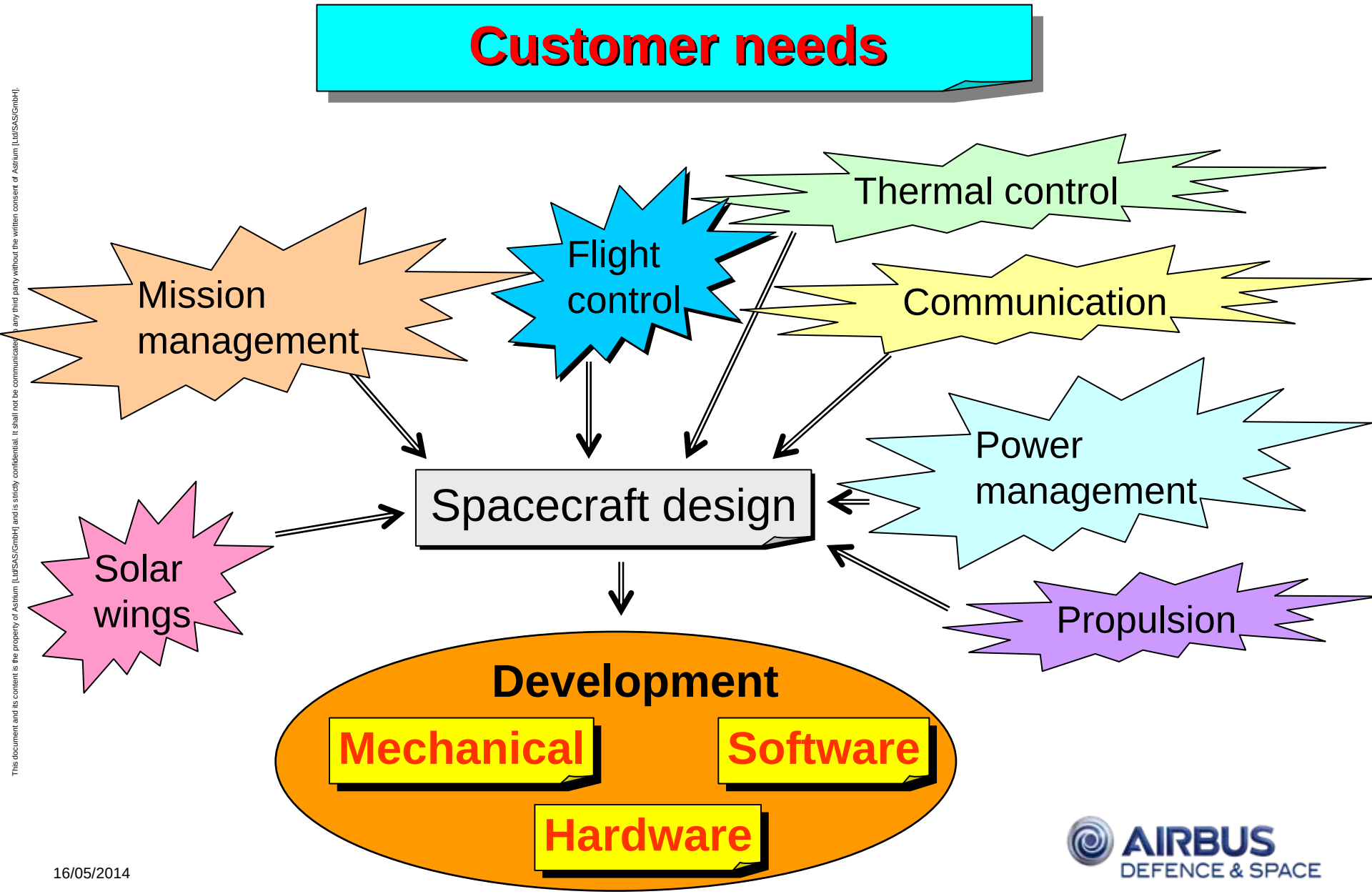
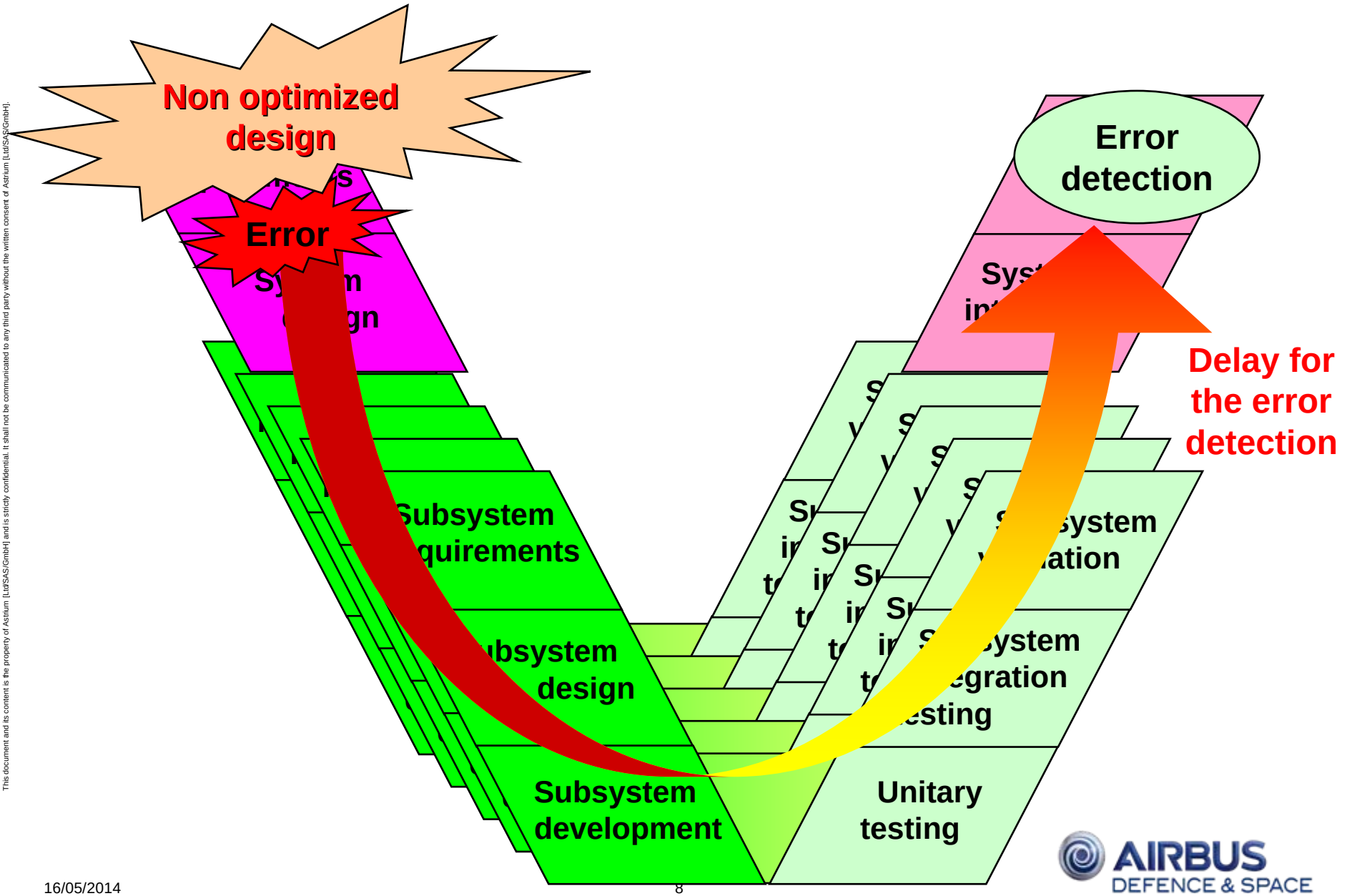
Why is Systems Engineering complicated?



Late detection of errors



Model Based Systems Engineering (**MBSE**) main objectives

Improving the communication between the stakeholders

- In a system of systems
- In a system: Guidance, Navigation, Control, thermal…
- Software: specification, design, coding, verification & validation…
- And also customers and external reviewers

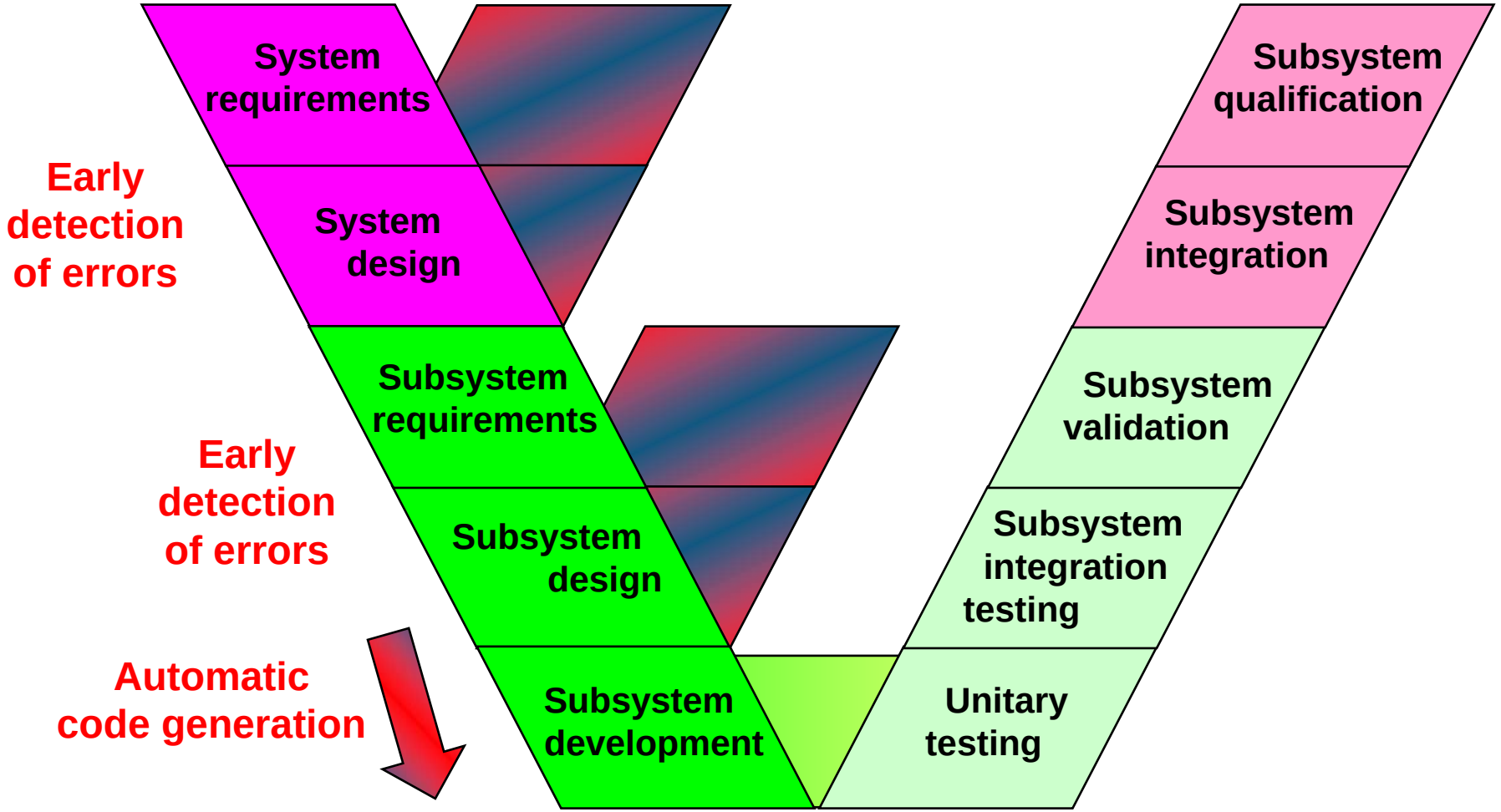
Developing the system

- Performing a trade-off of design
- Automatic code / parameters generation

Improving the verification and validation

- Model syntax and semantics checking
- Model simulation and formal proof

Verification with model MBSE



MBSE = Model Based Systems Engineering

Overview

Why Model Based Systems Engineering? ☞

Complex Systems Architecting ➡ ☞

System to software engineering with SysML ☞

Conclusion ☞

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Complex Systems Architecting:
Process and Practices

Airbus D&S is confronted with complexity in Systems Architecting

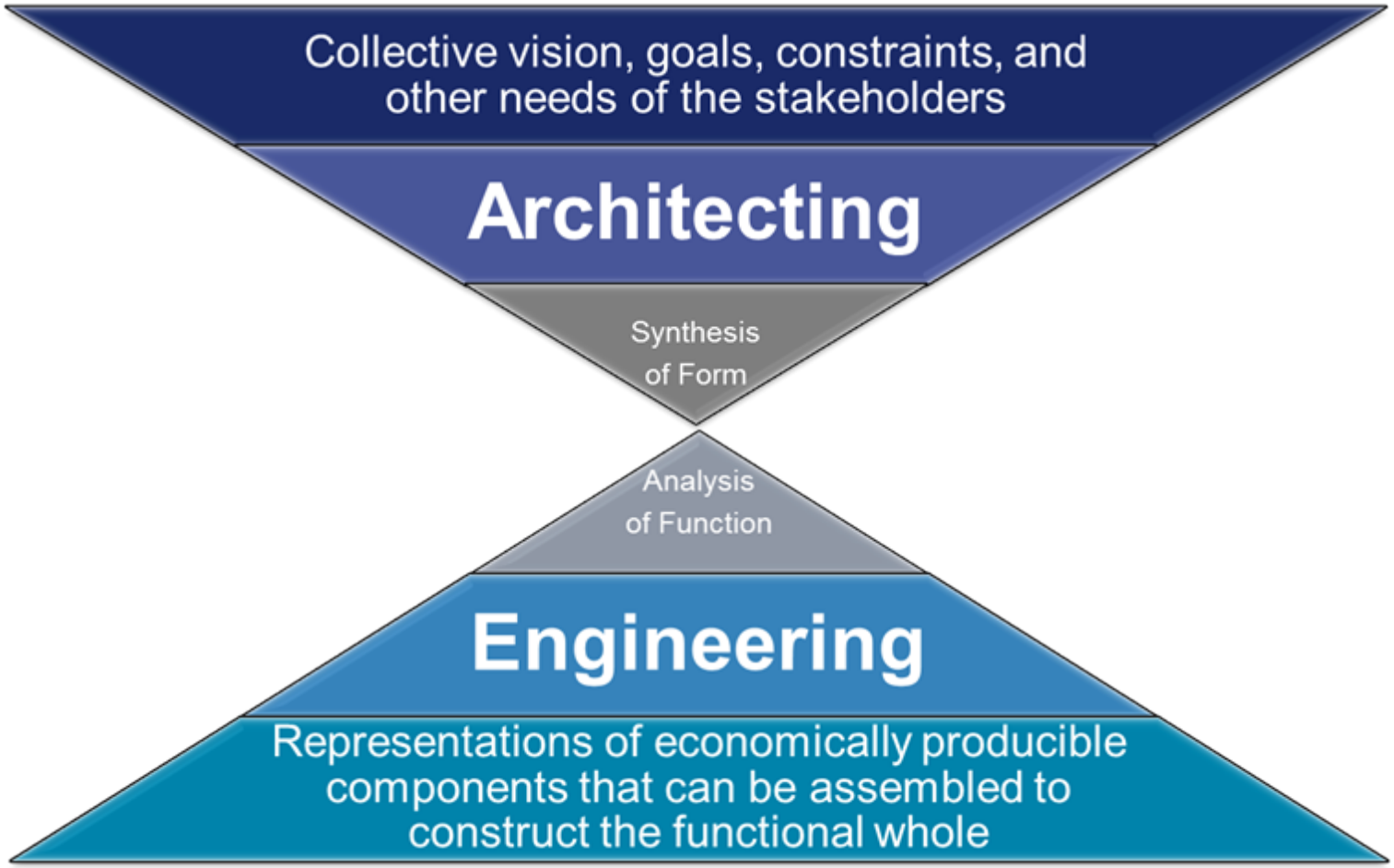
Multiple factors may affect the architecting and engineering processes

- Number and variety of stakeholders and organizations
- Number of constraints due to the *integration in the loop of already in-use systems*
- Desynchronization between the different life cycles
- No common rules, laws and processes
- Lack of knowledge of some important concepts, interfaces or data
- No common engineering language / culture between the teams working on the different systems
- Number and the variety of interfaces
- Difficulty to decompose or modularize the system
- Difficulty to model synchronized interactions
- Difficulty to master complex system behaviour
- Various architectures and difficulty to balance contradictory needs through trade-off
- Difficulty to integrate technologies
- Highly risk-driven systems where risk and uncertainty cannot be captured or understood
- Difficulty of allocating performances to different systems
- Management of knowledge and skills seamlessly during long programme

MBSE is way to deal with complexity

Architecting vs. Engineering role

- Is it worth to dedicate resource and time for architecting?



Source: MITRE

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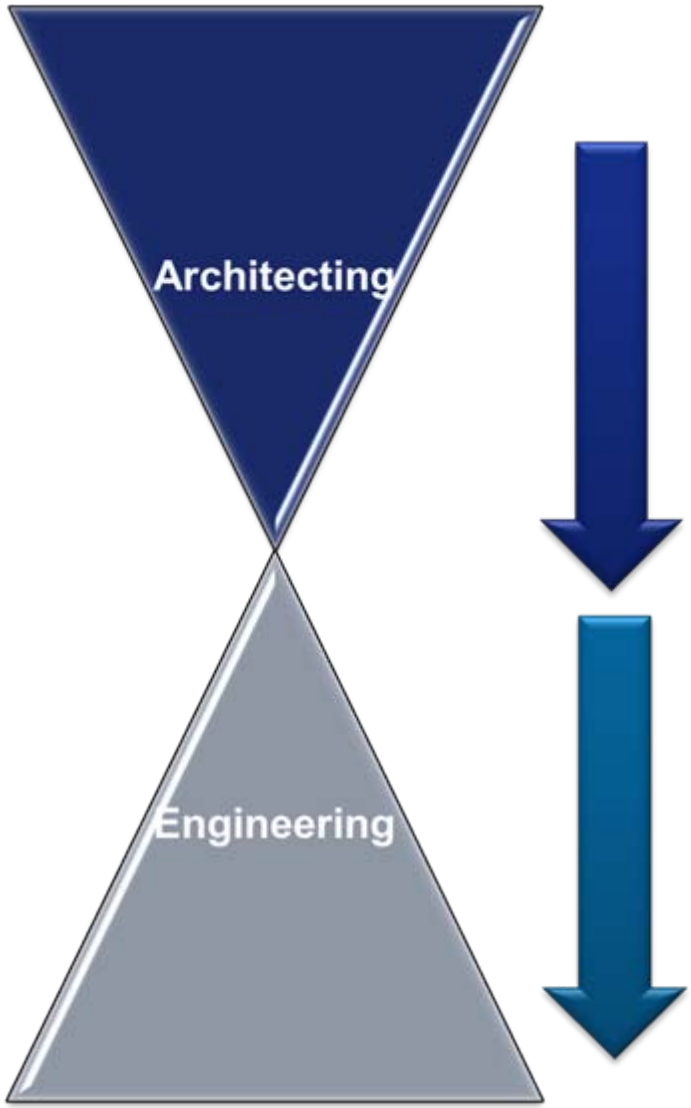
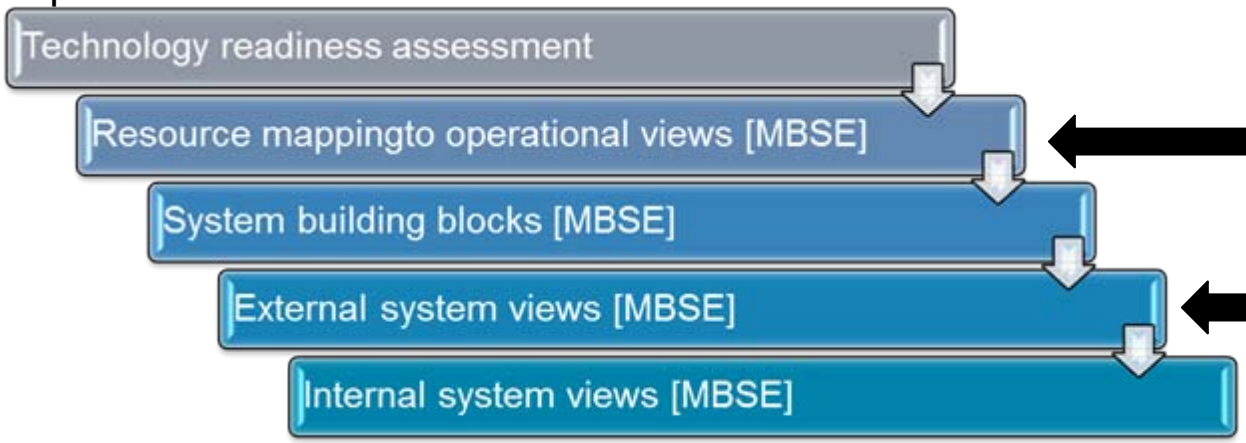
Architecting vs. Engineering role



- Iteratively compose separate elements to form a coherent whole

- Iteratively decompose and separate a primarily functional representation of a whole



Stakeholders' agreement

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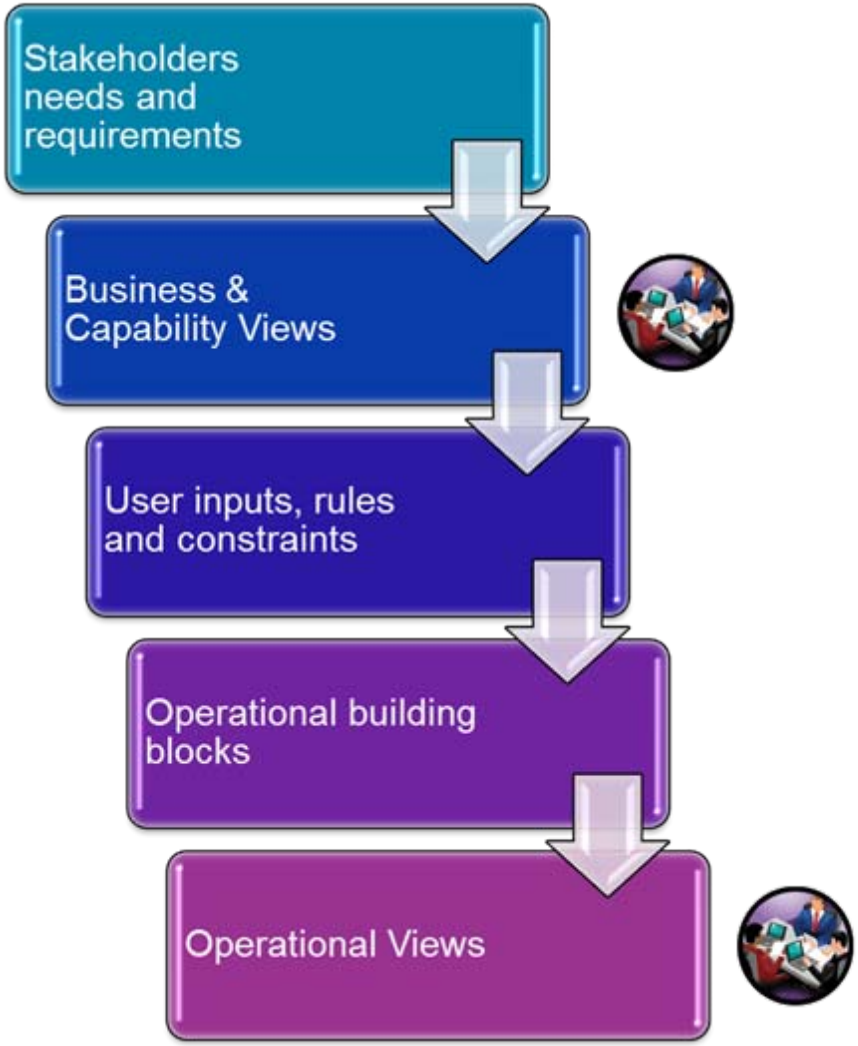
Architecting vs. Engineering role:
Architecting Complex Systems



- Stakeholder Requirements Definition Process: elicitation, negotiation, documentation, and maintenance

- Architecture Vision: Business value and changes
- Architecture Roadmap: Target Architecture WP, Gaps wrt Baseline Architecture
- Operational concept: High level use cases, CONOPS document
- Taxonomy of Architecture Views: Functional and non-functional areas

- Inputs completing the requirements (ex. MMI), rules and constraints impacting the design (ex, doctrine, manning)

- Nodes of activities or artefacts supporting capabilities
- Roles and Functions
- Flows: needline, message, energy, materiel, etc
- Conceptual data model: information structure, semantics

- Connectivity: interaction matrix
- Activities: detailed uses cases
- Functional processes: functional chains,
- Trade-off: MCDA/MCDM

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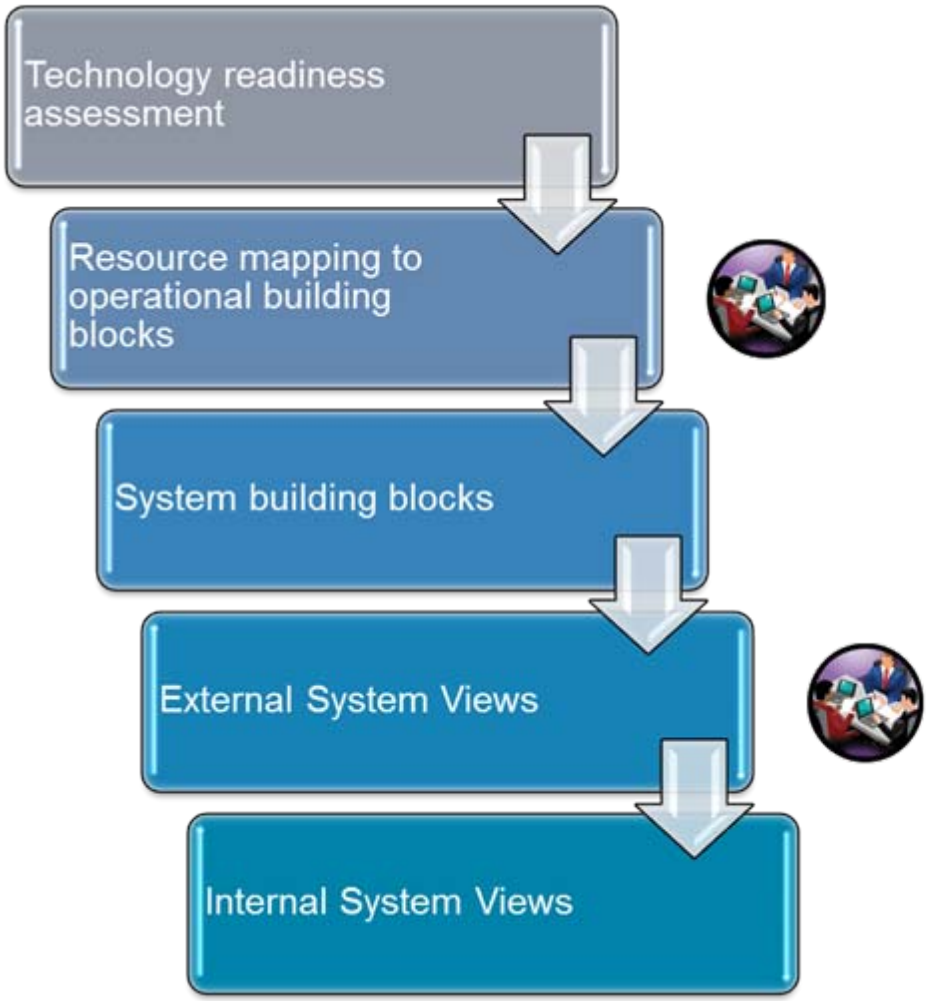
Architecting vs. Engineering role:
Engineering Complex Systems



- Technology Readiness Level
- Integration Readiness Level

- Resources identification: legacy and new, HW, SW
- Resources mapping to nodes and artefacts

- Resource nodes
- Rules controlling system functions
- Standards

- Systems interconnectivity
- High level system(s) functions

- Logical and physical data models
- System(s) functions and user interaction
- Trade-off: MCDA/MCDM
- Mapping to system(s) requirements
- Model inputs for Software Engineering

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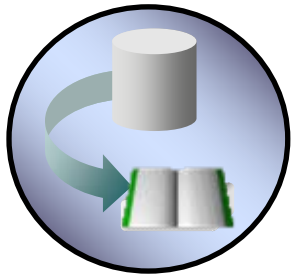
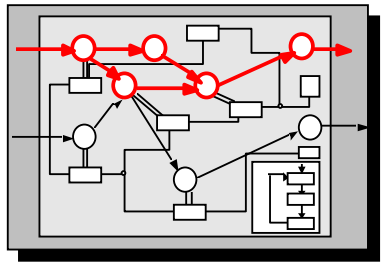
Communicating with stakeholders:
Efficient generation of deliverables



- Generate Architecture Definition and Requirements Specifications Documents from Architecture/Requirements Repositories with a minimum of document tidying up
  - Minimize fastidious complements in documents: include all relevant information in the repository
  - Develop “descriptors” that seamlessly transfer repository information in the intended section of the documents
- Build models and views that improve coherence and readability
  - Proportion your diagram to facilitate document insertion
  - Highlight the critical processes
- Include captions that add value to the graphic
  - Put a message across the graphic, not a simple legend describing the figure



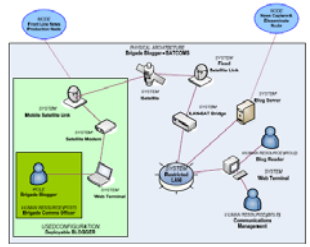


Figure X: *Thanks to this network architecture the operators are able to …*

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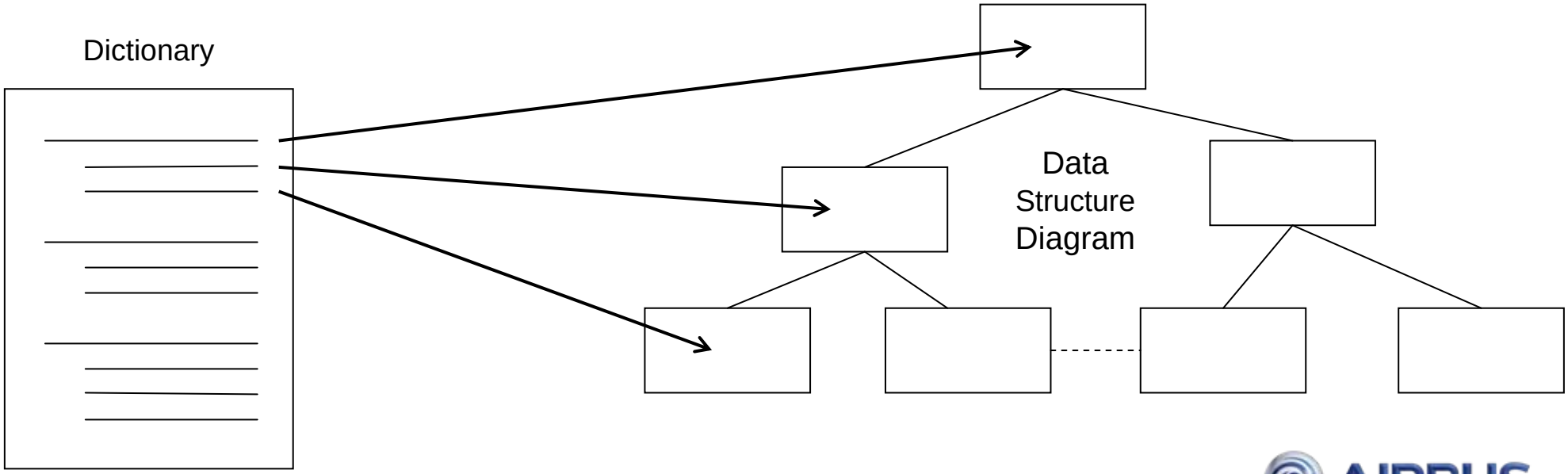
Communicating with stakeholders:
Dictionary and Conceptual Information

- **Dictionary** contains definitions of terms used in architecture descriptions
- **Conceptual Information** presents concepts that must be understood by decision makers to make decisions within the scope of the described architecture
- **Conceptual Information Model** represents the high level view of the information in terms of generalized concepts. This model is of interest to users wishing to verify the scope of the information structure.

Some Customers require Integrated Dictionary and Information Model



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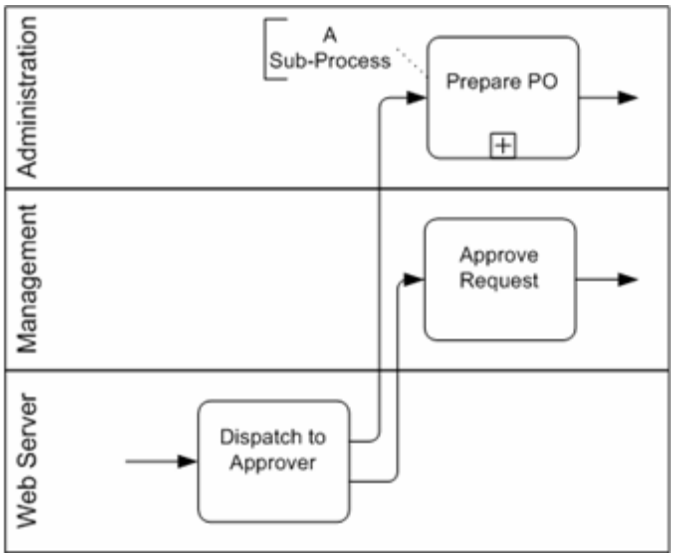
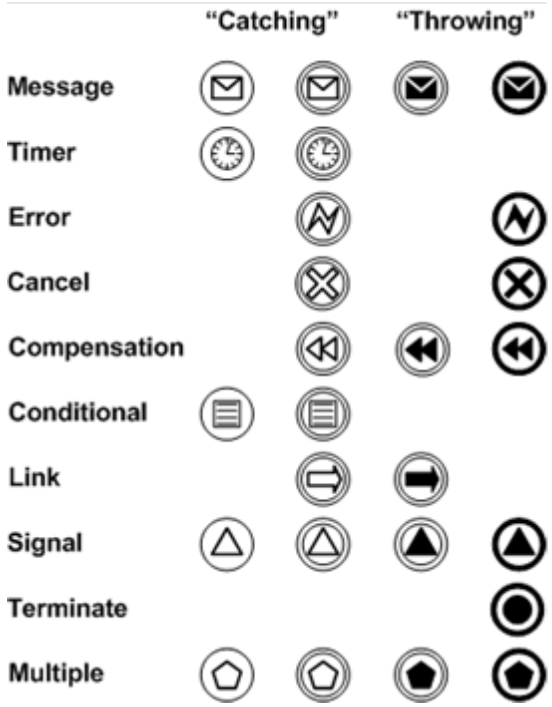
Communicating with stakeholders:
Architecture Description Languages

- Representation with ADL (e. g. BPMN, UML, SysML) could be confusing for Customer
  - ➢Simplify for better communication with stakeholders
  - ➢Apply user-centred design principles to architecture views
    - Organize workshop with stakeholders in order to delineate visuals guidance
    - Seek adhesion through examples





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Overview

Why Model Based Systems Engineering? ☞

Complex Systems Architecting ☞

System to software engineering with SysML ☞

Conclusion ☞

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Why SysML at Airbus Defence and Space?

Avoiding information duplication on complex systems

Improving coherency and communication among the various experts by using the same language

- Electrical system, GNC(*), Software

Formalizing and unifying the best practices already used “without specific tools”

- Data flow, State-charts …

Extracting system and software documentation from a single model

Automatic code generation

*** GNC = Guidance, Navigation, Control**

SysML is a complicated language

Use case Diagrams

Requirement Diagrams

Internal Block Diagram

Sequence Diagram

State Machine Diagram

…

Can it be used by non modelling experts?

- ✓ GNC
- ✓ Propulsion
- ✓ Mission management
- ✓ Power
- ✓ …

Precise guidelines are mandatory
With adequate trainings

*** GNC = Guidance, Navigation, Control**

Some modelling tools

SysML is a graphical language

➔ Need of a graphical editor

- Rhapsody
- System Architect
- Magicdraw
- Papyrus

What about the long term availability of these tools

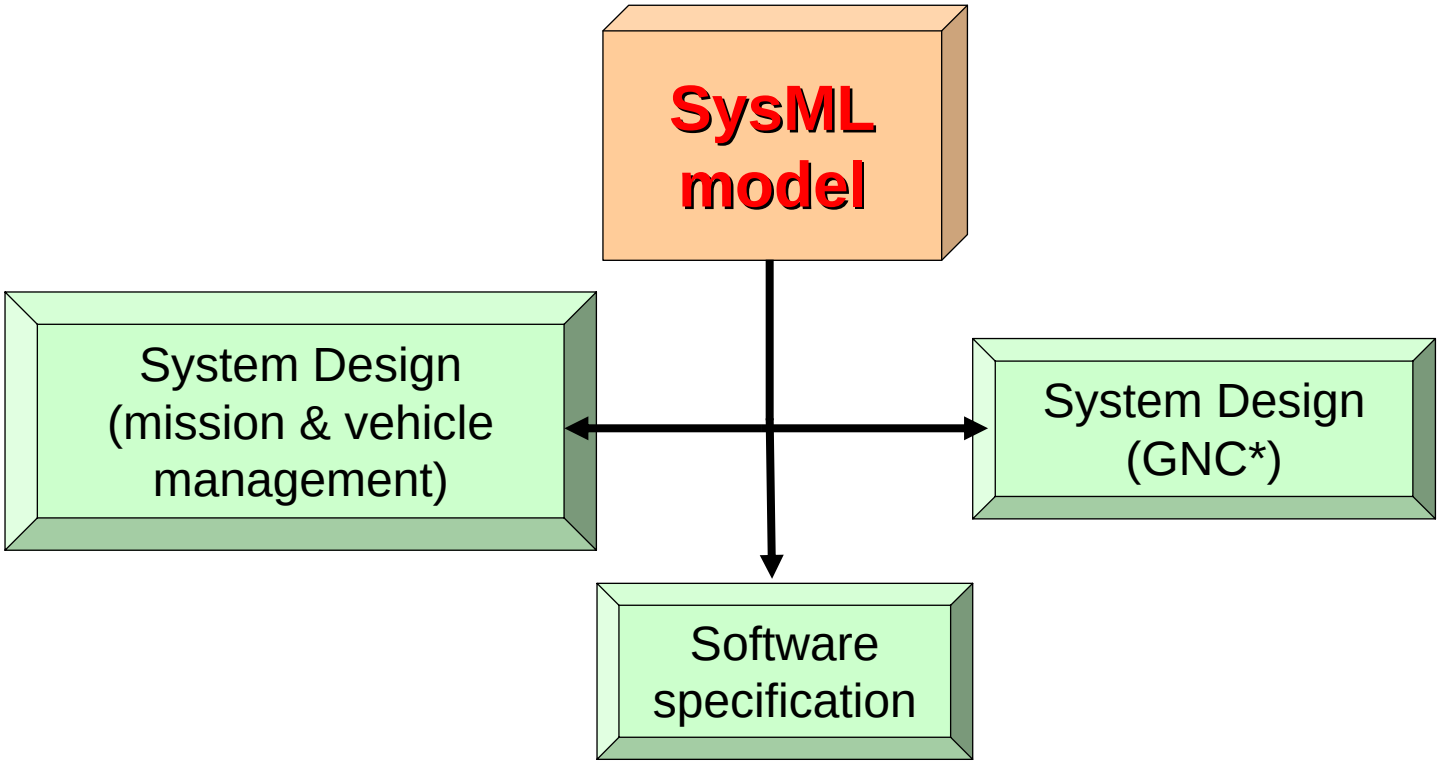
➔ Possible future solution with open source and the Polarsys Eclipse Industrial Working Group

…

Deployment of SysML on Ariane 5 ME

The SysML model is the unique reference

All the documentation is generated from the SysML model



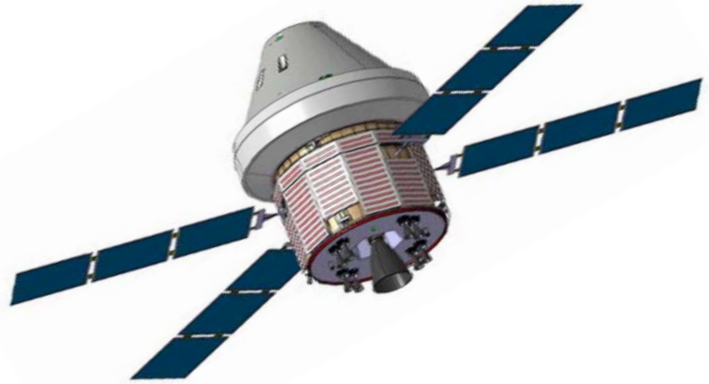
*** GNC = Guidance, Navigation, Control**

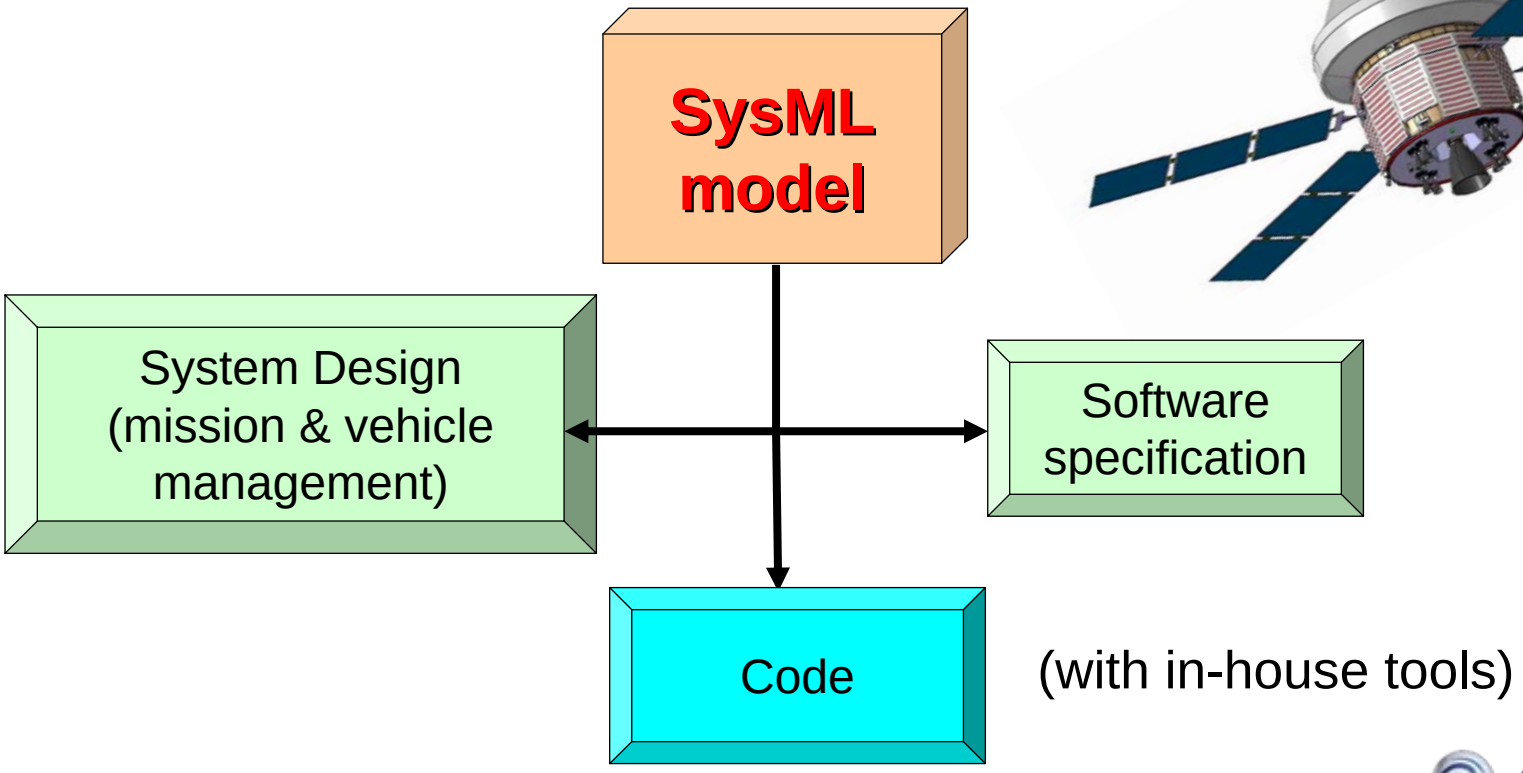
Deployment of SysML on MPCV

The SysML model is the unique reference

All the documentation is generated from the SysML model

Some code is generated from SysML statecharts





(with in-house tools)

Overview

Why Model Based Systems Engineering? ☞

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Conclusion

MBSE

- Relies on standards

MBSE in the space domain

- Is operationally used
- Improves the architecting and engineering of complex systems
- Improves the system to software engineering

But needs

- Clear objectives
- Precise guidelines and processes
- Trained teams
- Adapted tools

And will be in the future

- Used with in a larger perimeter
- With a long term availability

Any questions