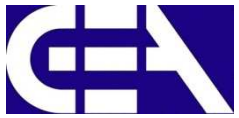



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# MODEL BASED SYSTEM ENGINEERING

## Programme

- Definitions and examples of models
- Positioning Models in Engineering activities
- Examples of modeling techniques

## Why Models ? From the INCOSE Forum

- "… I could never read a long document without scribbling some diagrams…"
- "It's hard to imagine the Apollo program not having been an example of SE because they used paper-based documents as a basis for models."
- " … we are using models, as Moliere's M. Jourdain was using prose, without knowing it."

source : MBSE – A Historical Perspective, Promises and Pitfalls
Cecilia Haskins, PhD, CSEP, 3rd IC-MBSE, George Mason University

## Model: Definition

- A model is
  - An abstract representation of the reality, according to a viewpoint
  - **Physical/logical architecture**
  - **Functional behavior**
  - **Requirements/concept of operations**
  - **Non functional: safety, thermics, acoustics, aerodynamics, …**
  - **… expressed numerically**

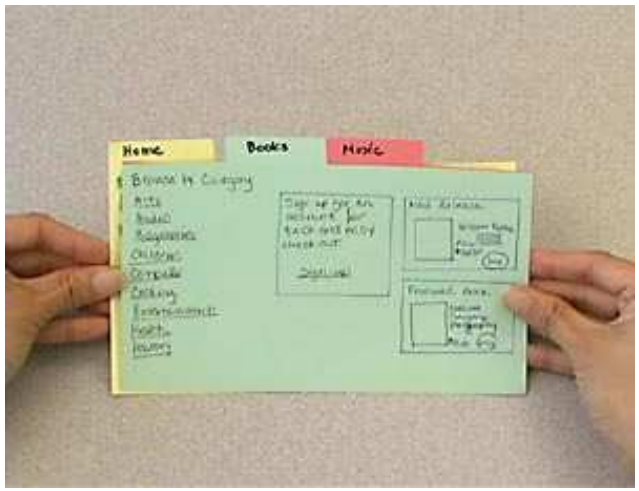
# Model, Mockup and prototype

- A mock-up is a physical representation of the final product
  - **Geometry, Space, looks, …**
- A prototype is a working version of the final product
  - **Can be tried in close to operational conditions**
  - **Most functionalities present, but …**
  - **Usually lacking in scale, robustness, safety, reliability, …**
- These three notions can be combined
  - E.g. Digital mock-up
  - E.g. Prototypes integrating models of unfinished parts

# Prototyping

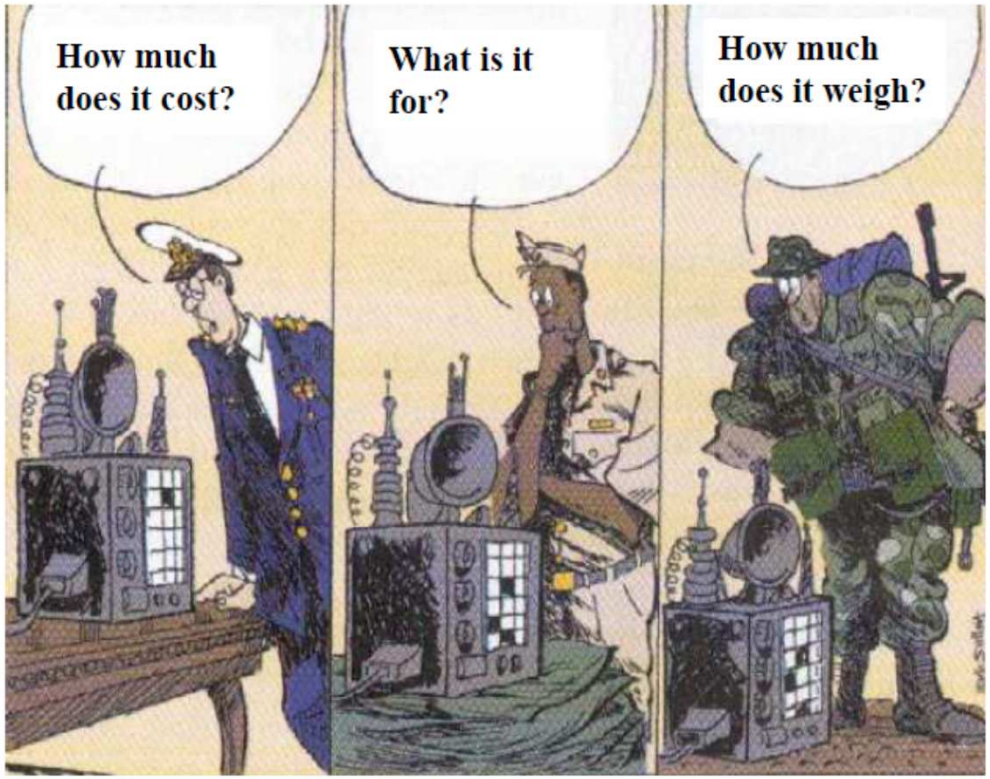
- Can help find new functionalities, discuss usability, and establish priorities.

- Prototypes can take many forms:
  - Paper prototypes (see http://www.paperprototyping.com/ )
  - Screen mock-ups
  - Interactive prototypes
  - Models (executables)
  - Pilot systems…

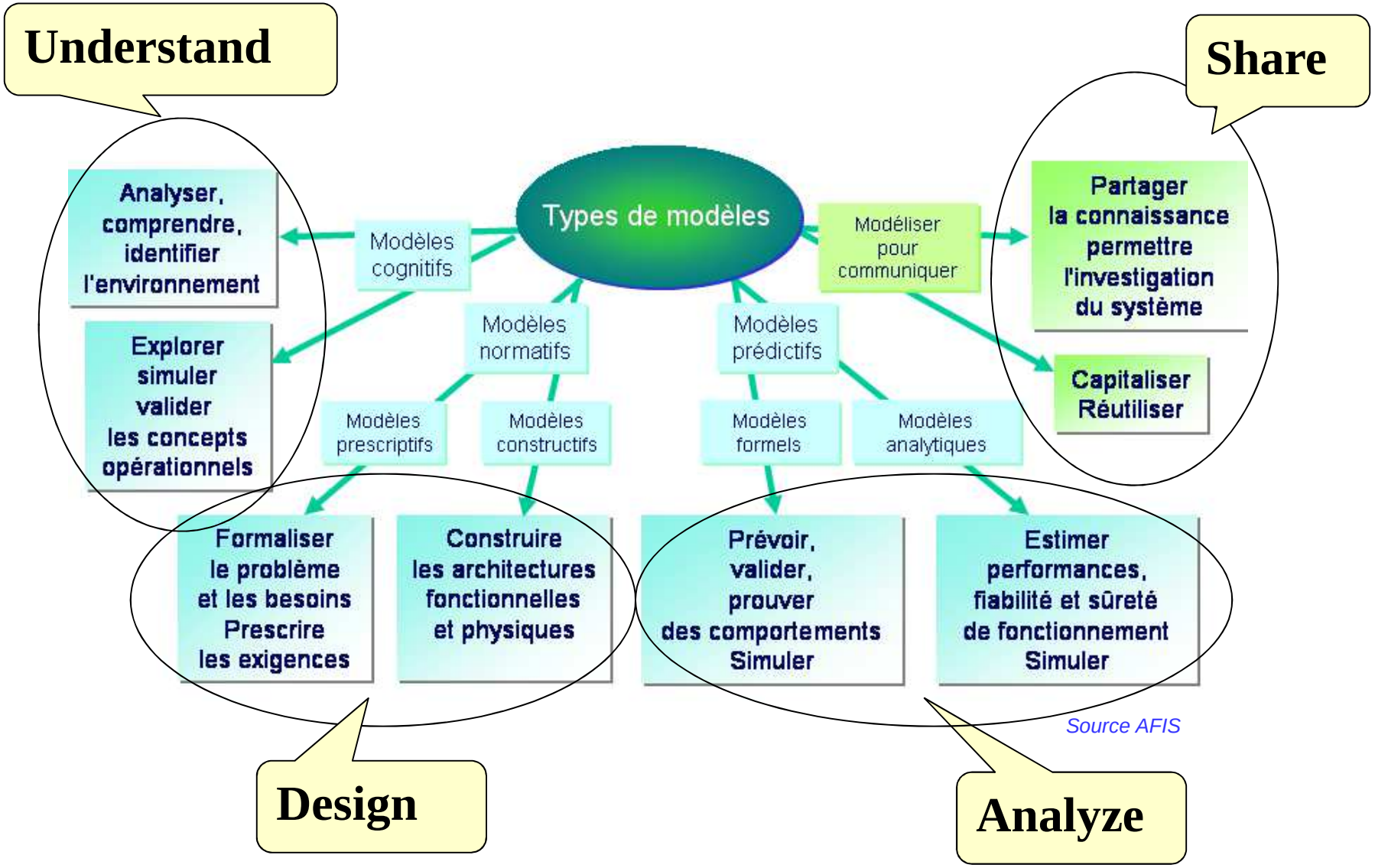


## Using models

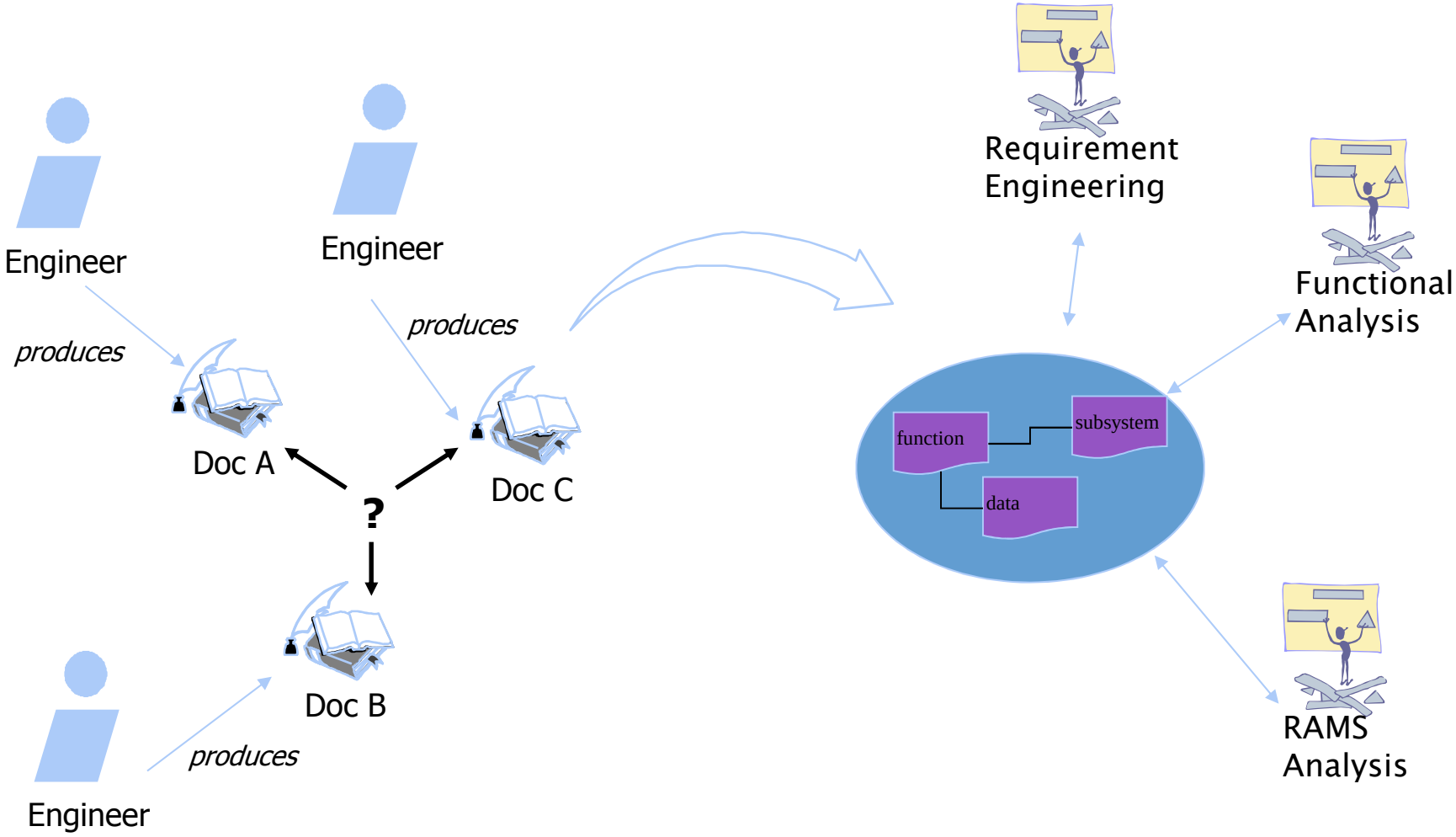
"All models are wrong, but some are useful."
- George E.P. Box (Quality and Statistics Engineer)



# Using models

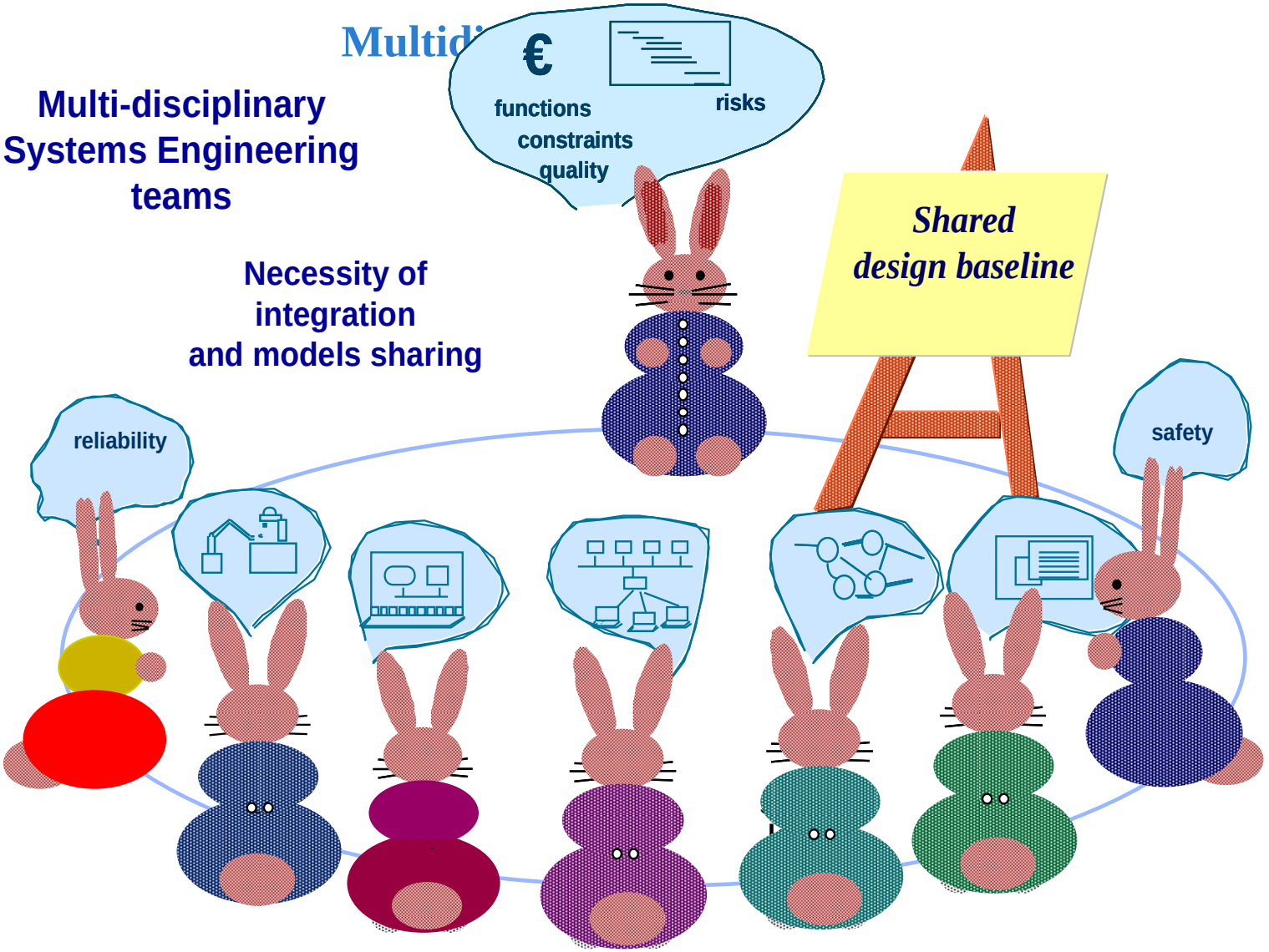


# The challenge !
# From documentation process to a model centered process …




IDEAL PLANES
OR WHAT CAN HAPPEN IF ONE OF THE TEAM GETS ALL THEIR OWN WAY!
FUSELAGE GROUP
WEIGHTS GROUP
MECHANICAL CONTROLS GROUP
COMPUTER AIDED DESIGN GROUP
HYDRAULICS GROUP
PRODUCTION ENGINEERING GROUP
MAINTENANCE GROUP
EQUIPMENT GROUP
ARMAMENT GROUP
WING GROUP
AVIONICS GROUP
AERODYNAMICS GROUP
EMPENNAGE GROUP
POWERPLANT GROUP
STRESS GROUP

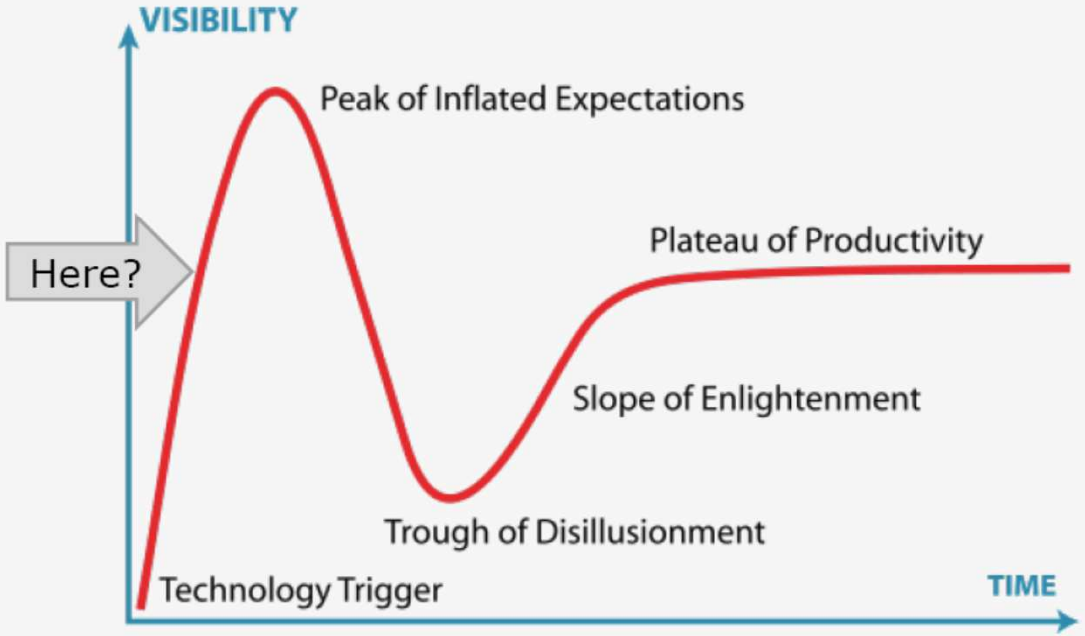
## Multi-disciplinary Systems Engineering teams




Necessity of integration and models sharing

# Technology hype curve

- Where is MBSE? Have we really just begun, or…




3rd International Conference on Model-Based Systems Engineering

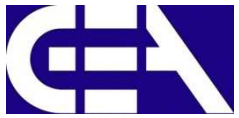
source : MBSE – A Historical Perspective, Promises and Pitfalls
Cecilia Haskins, PhD, CSEP, 3rd IC-MBSE, George Mason University

# Technology hype curve

- Where is MBSE? Or is it too hard to track because of the near-continuous technology advancements?


3rd International Conference on Model-Based Systems Engineering

source : MBSE – A Historical Perspective, Promises and Pitfalls
Cecilia Haskins, PhD, CSEP, 3rd IC-MBSE, George Mason University





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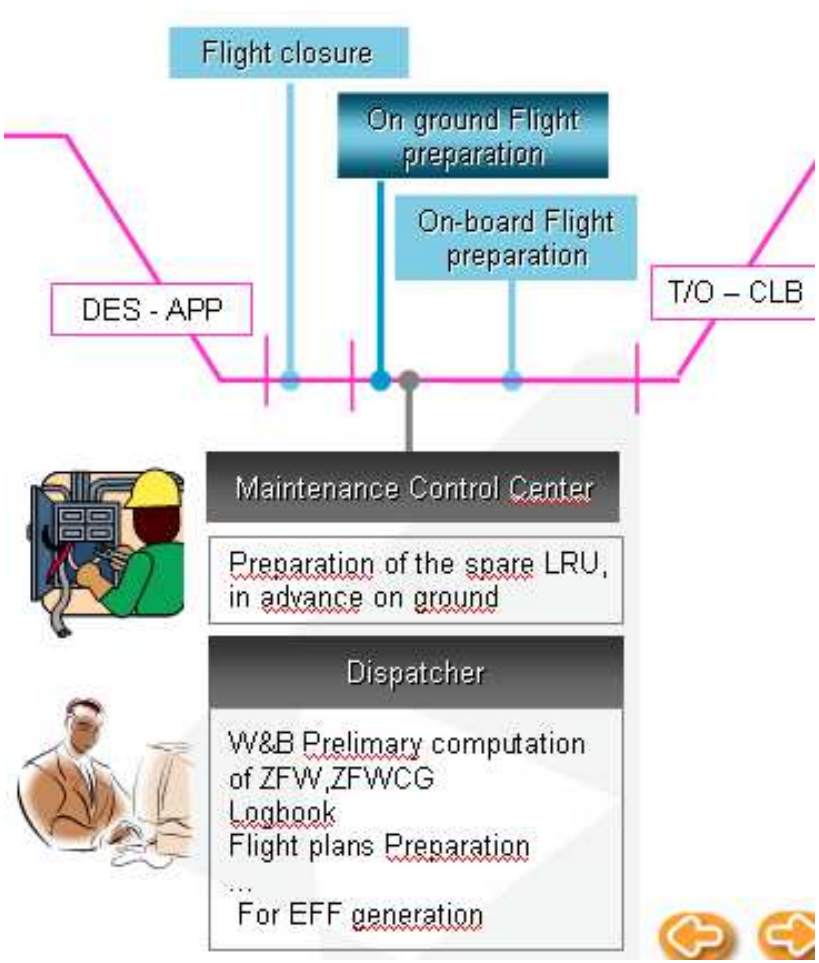
# EXAMPLES OF MODEL

# Understand: drawings

Example: Cabin styling

# Understand: mock-up of HMI

# Understand: Description of operation

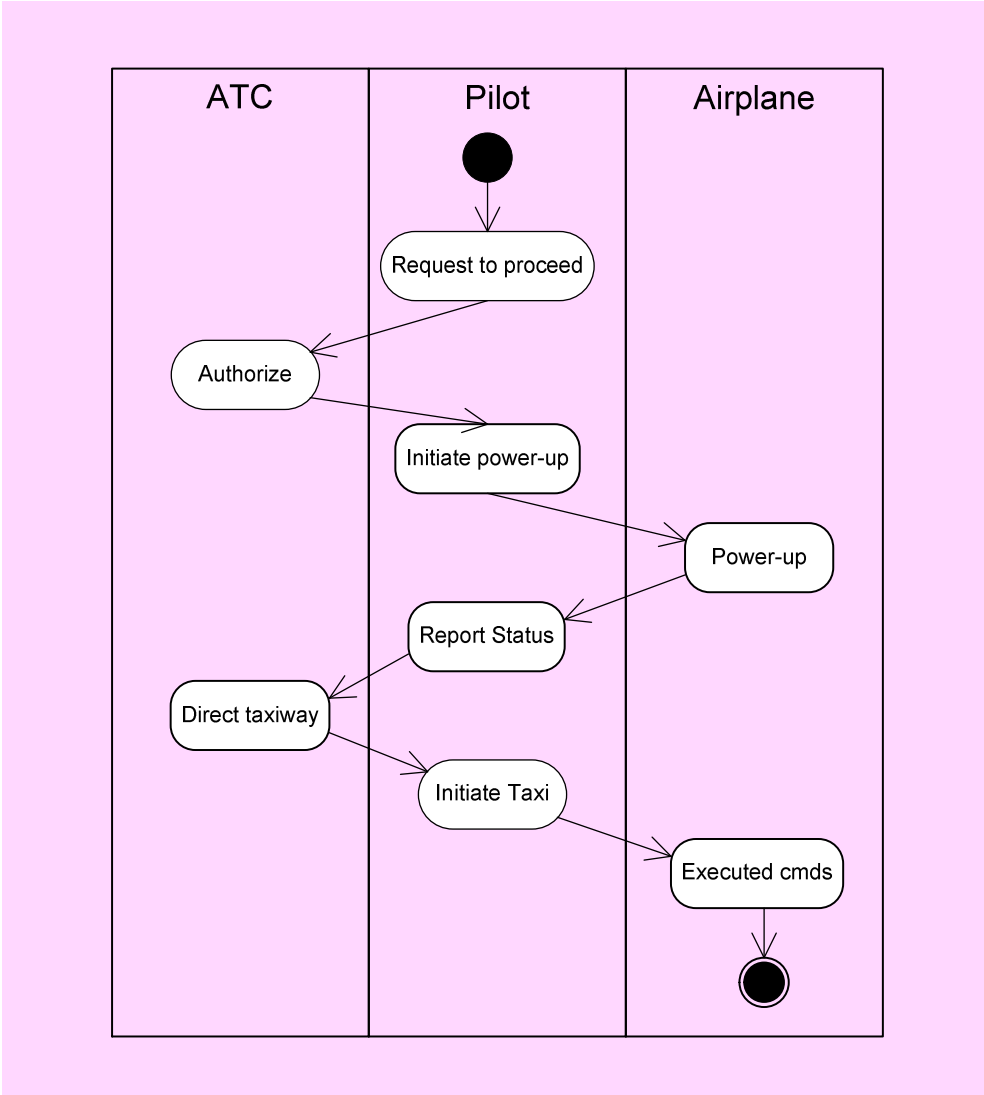



Operational cycle

Actors

Operation

# Understand: Formalizing Operations

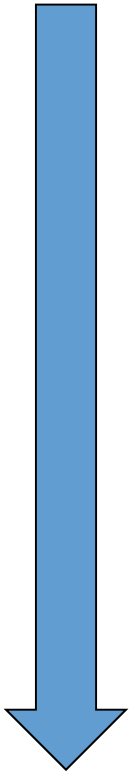



UML
(activity diagram)

## Design: Logical architecture

# Open Systems Interconnection model

| OSI Model | | | |
|---|---|---|---|
| | Data unit | Layer | Function |
| Host layers | Data | 7. Application | Network process to application |
| | | 6. Presentation | Data representation and encryption |
| | | 5. Session | Interhost communication |
| | Segment | 4. Transport | End-to-end connections and reliability |
| Media layers | Packet | 3. Network | Path determination and logical addressing |
| | Frame | 2. Data Link | Physical addressing |
| | Bit | 1. Physical | Media, signal and binary transmission |



# Design: Logical architecture

## Sender

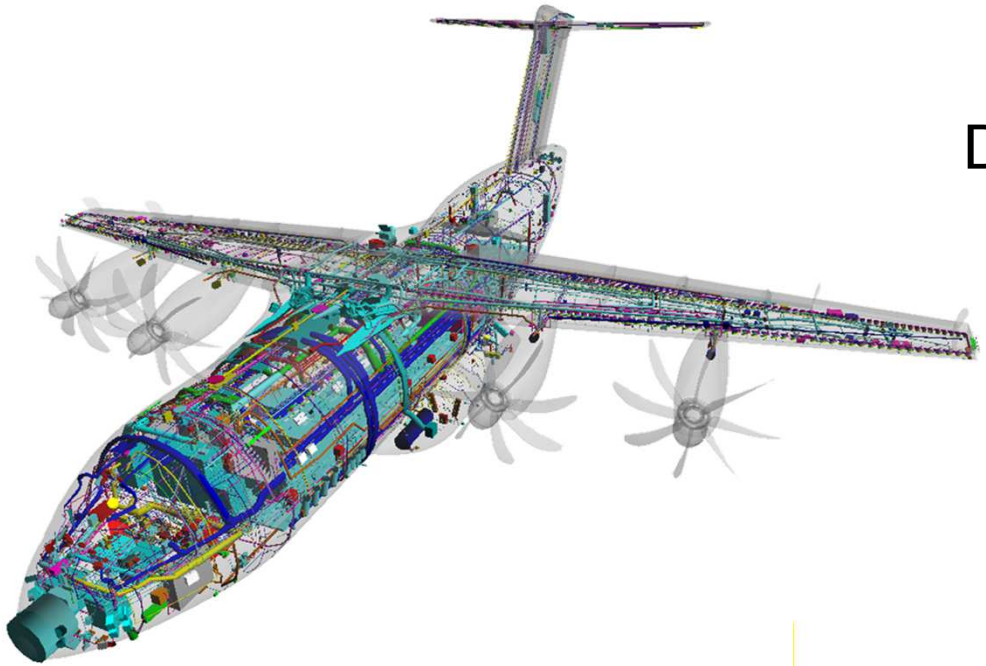
| OSI Model | | | |
|---|---|---|---|
| | Data unit | Layer | Function |
| Host layers | Data | 7. Application | Network process to application |
| | | 6. Presentation | Data representation and encryption |
| | | 5. Session | Interhost communication |
| | Segment | 4. Transport | End-to-end connections and reliability |
| Media layers | Packet | 3. Network | Path determination and logical addressing |
| | Frame | 2. Data Link | Physical addressing |
| | Bit | 1. Physical | Media, signal and binary transmission |

## Receiver

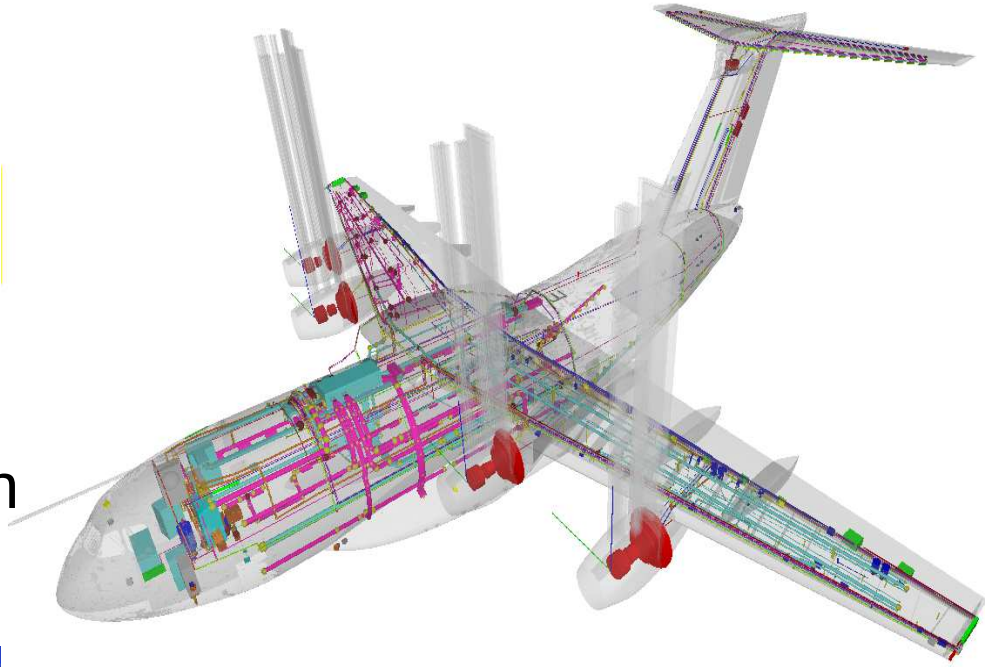
| OSI Model | | | |
|---|---|---|---|
| | Data unit | Layer | Function |
| Host layers | Data | 7. Application | Network process to application |
| | | 6. Presentation | Data representation and encryption |
| | | 5. Session | Interhost communication |
| | Segment | 4. Transport | End-to-end connections and reliability |
| Media layers | Packet | 3. Network | Path determination and logical addressing |
| | Frame | 2. Data Link | Physical addressing |
| | Bit | 1. Physical | Media, signal and binary transmission |

Physical Link

# Physical architecture in the large

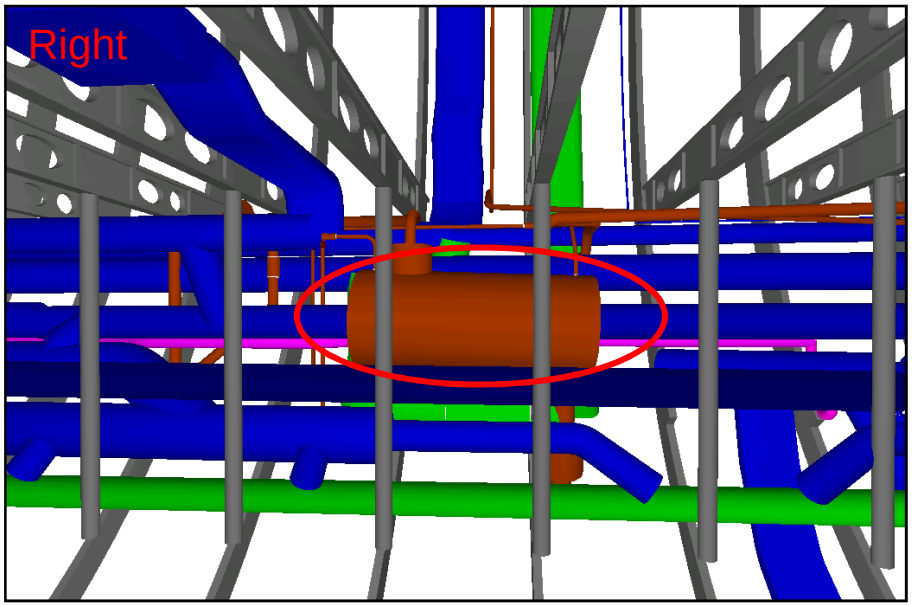


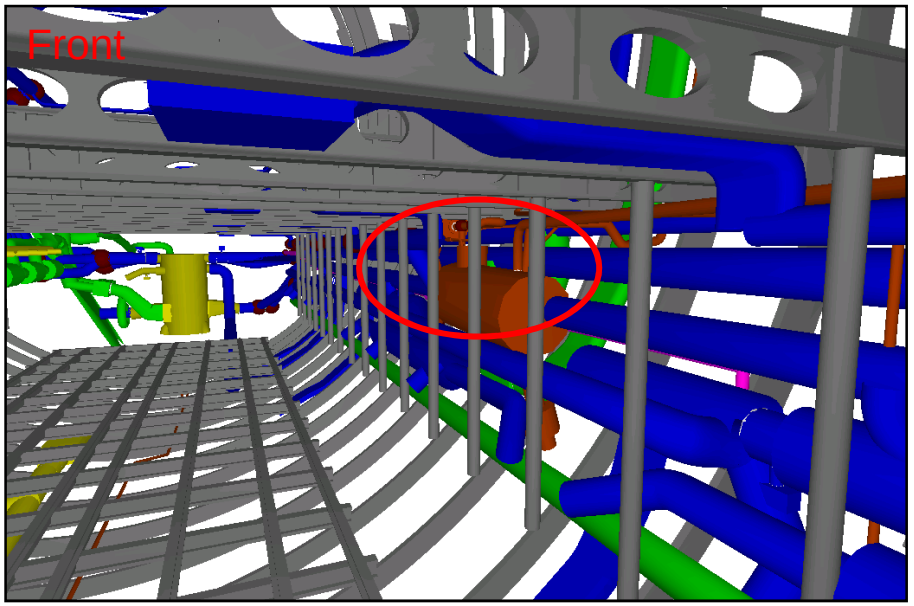
Digital Mock-up

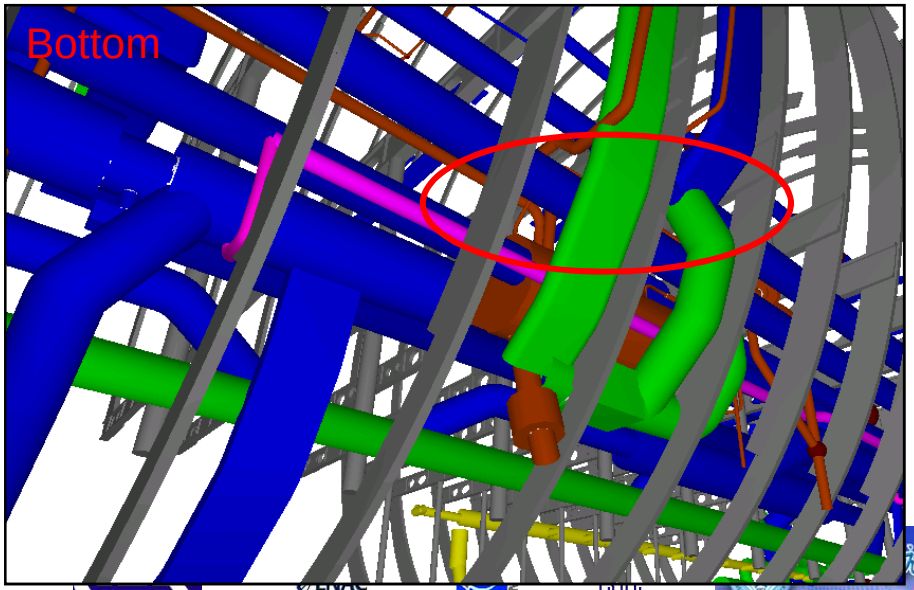


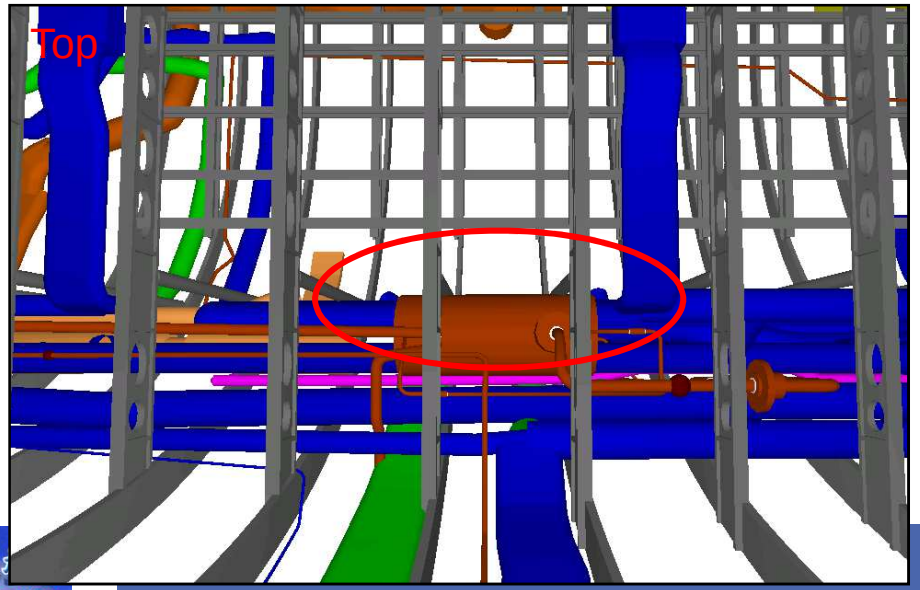
Systems Installation

# Physical architecture in the small



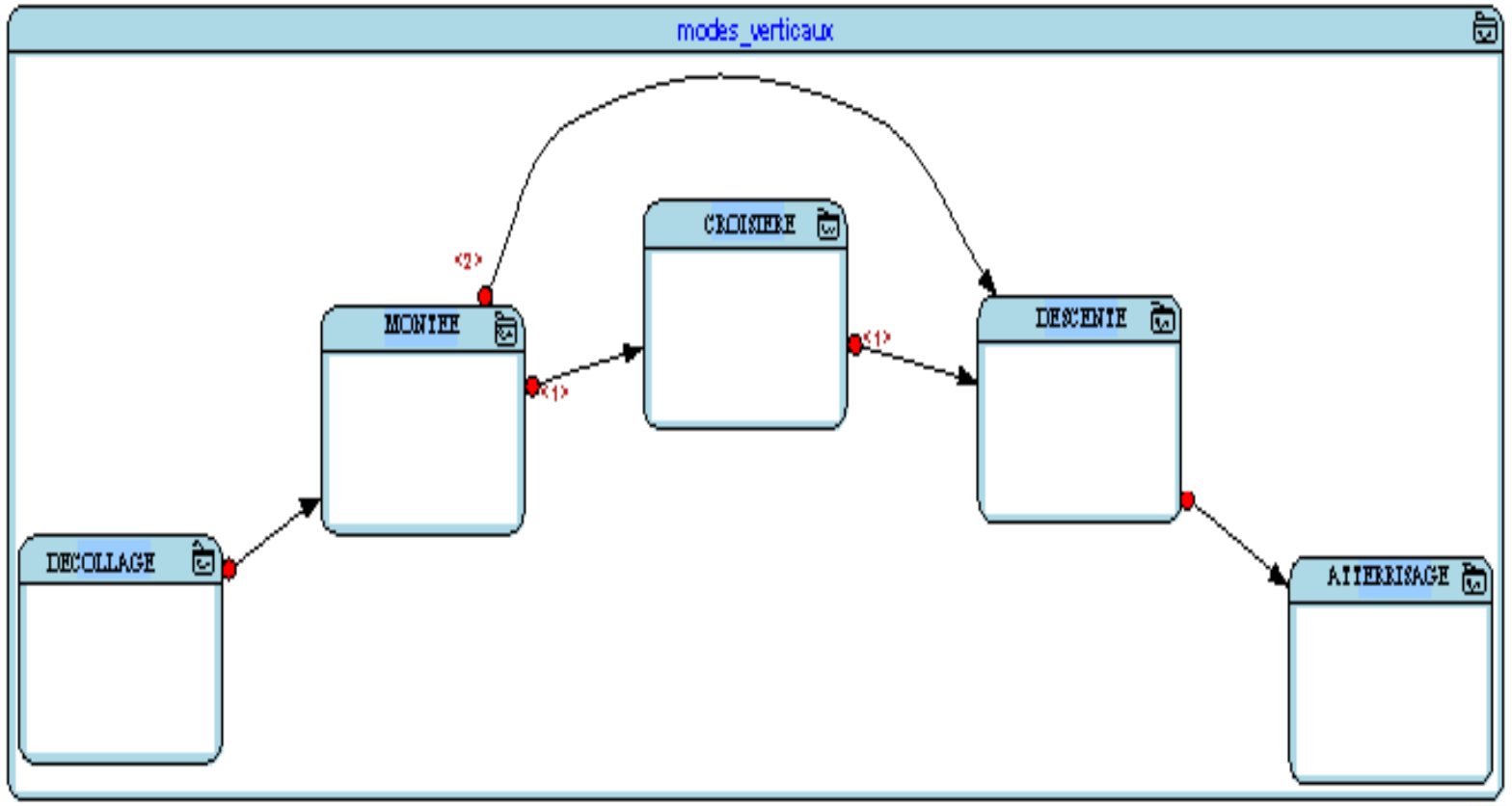



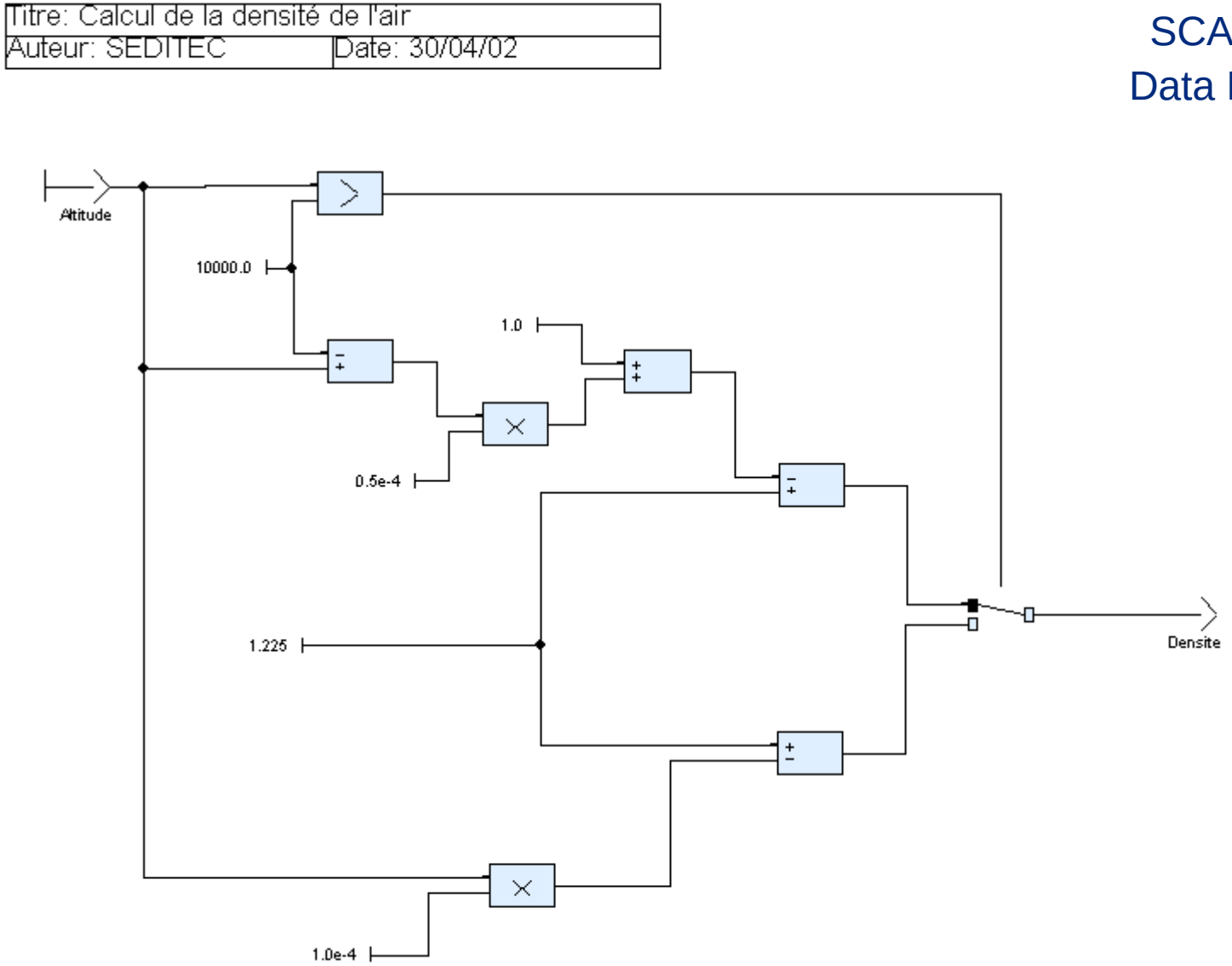



# Behavioural model

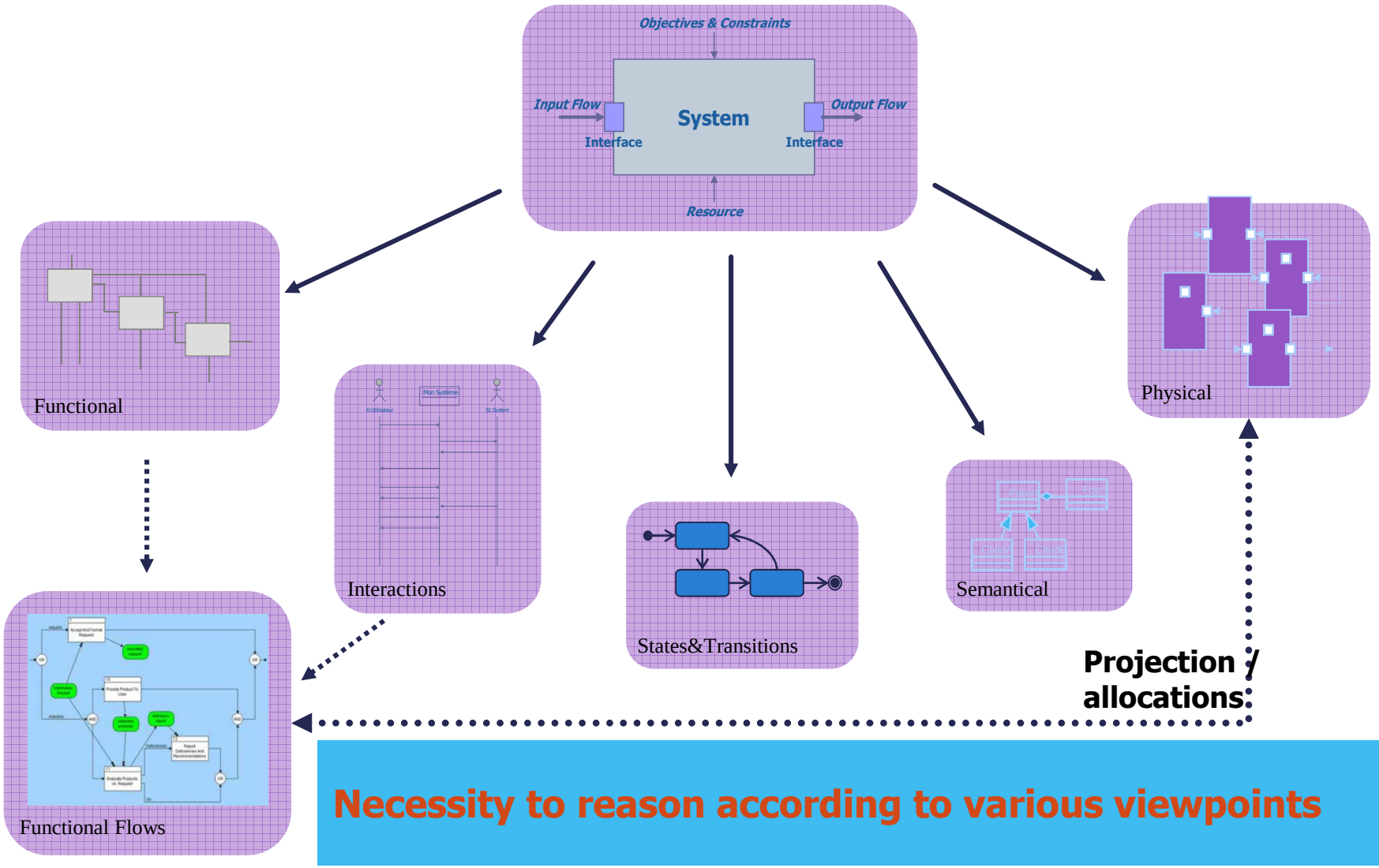
SCADE
Safe State Machine



# SCADE
# Data Flow

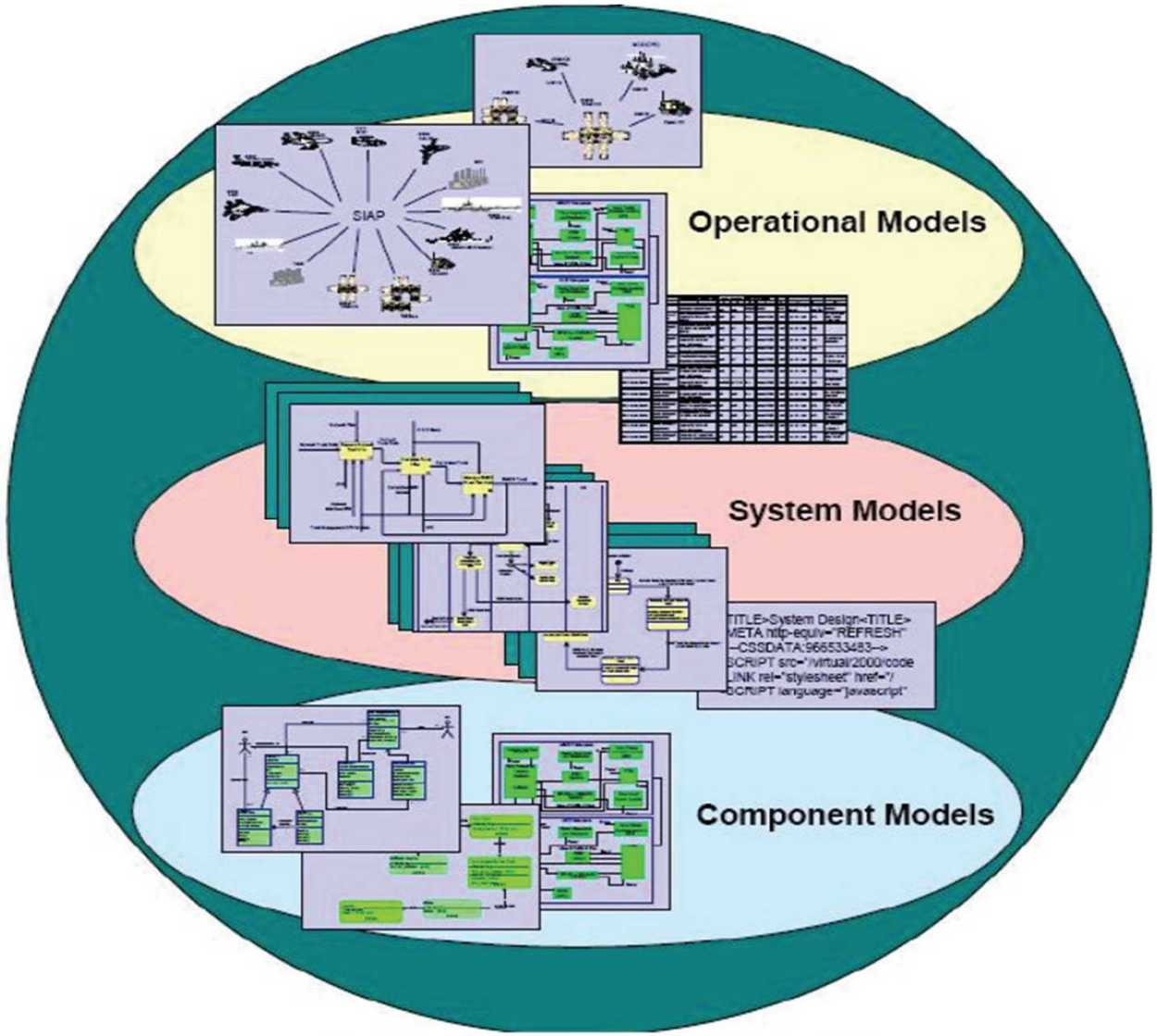


# Models and view points




**Necessity to reason according to various viewpoints**

# Modelling at different levels



## System modeling

*"I prefer drawing to talking.*

*Drawing is faster, and leaves less room for lies."*

*— Le Corbusier*

Various modeling techniques have been developed over the years for system analysis

- IDEF0 : Integrated DEfinition for Function modeling
  - Derived fromSADT (Structured Analysis and Design Technique)
- DFD: Data Flow Diagram
  - Focus on data exchanged between functions
- eFFBD : enhanced Functional Flow Block Diagram
  - Mixing Functional architecture and data flow
- UML2 / SysML : Unify Modeling Language