GEA Tianjin / 中国民航大学中欧航空工程师学院

Case study: Onboard Information System of the A350 XWB

Adapted from a communication of "Journée AFIS: Architecture des systèmes"

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Stéphane Petit – Airbus

Fly Smart with Airbus (FSA)

Support the good aircraft operation during all its life cycle

- Reduce Turn-Around Time
- Reduce the amount of paper in aircraft

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FSA-NG history

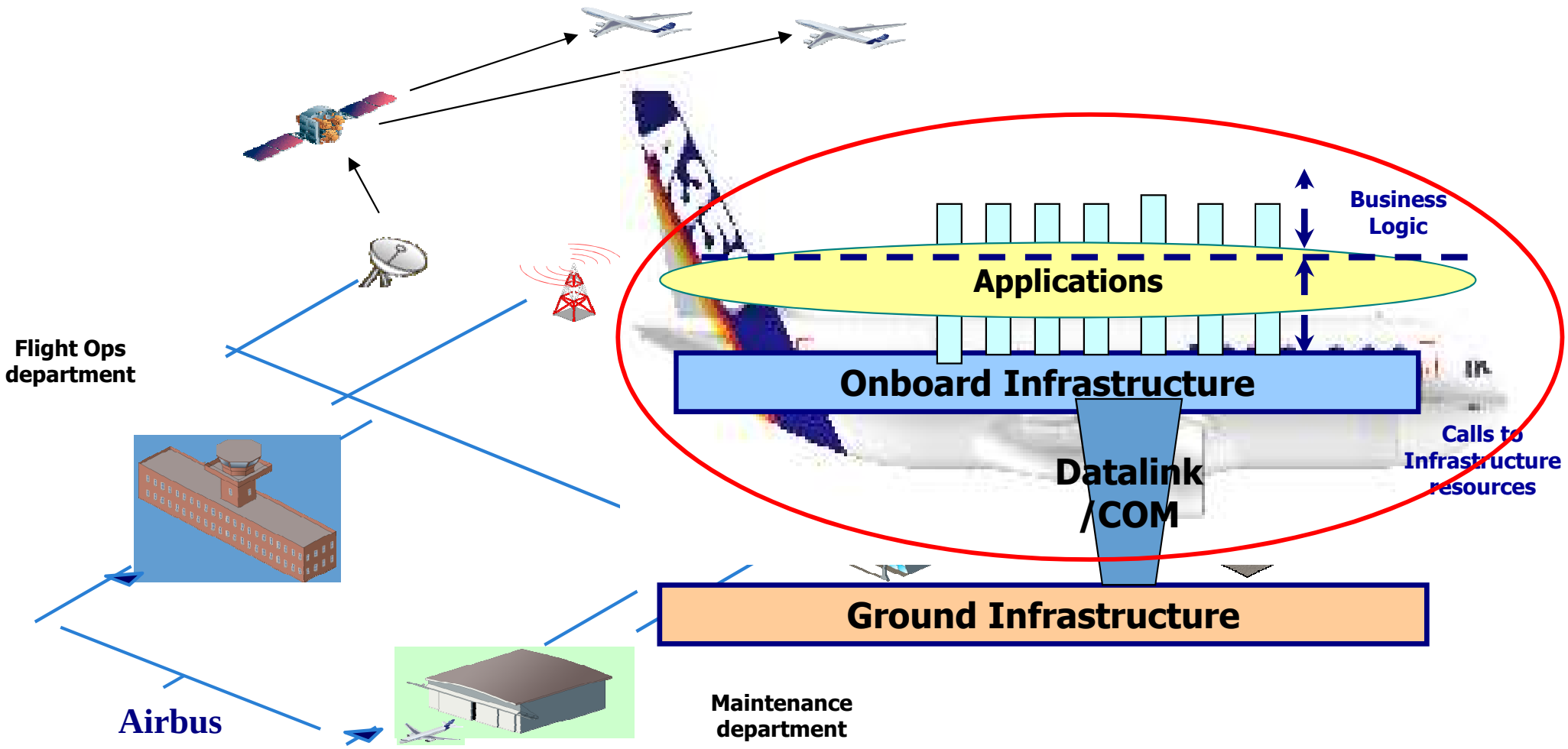
- Before FSA:
  - Lots of Paper to be carried by the pilot:
    - Flight Plan
    - Charts, Abacus
    - Heavy Documentations

- FSA on Long Range (A330-A340): LPC
  - A laptop is introduced inside the cockpit, so called the Electronic Flight Bag and hosts the LPC applications (Less Paper Cockpit) that enables:
    - the consultation of the electronic documentation
    - The calcul of performances Heavy Documentations

- FSA on A380: NSS-OIS
  - Beginning of A/C and Fleet operations Support and host
    - Flight crew applications
    - Cabin crew applications
    - Maintenance applications
    - Communication means

- FSA-NG on A350 XWB
  - **FSA-NG is an Airbus solution to enable Airlines to operate a fleet of aircrafts, to ensure aircraft dispatch, maintenance, and upgrade:**
    - It allows information exchange between A/L ground information system and board
    - It enables to operate the fleet without paper

FSA environment



Strong interaction between aircraft and airline network on ground

Development context

- New and complex system
  - Based on up-to-date technologies (java, virtual machines, …)
  - Must conform to ergonomy standard at Entry into Service (2013)
  - Few operational feedbacks from existing programmes

- Concurrent Engineering
  - Several developments levels, defined by different teams, on several sites
  - Hundreds of people, from different organizations, with various methods and tools
  - Large ratio of sub-contracting

- Domains of competences
  - Skills about Airlines way of working
  - Skills about architecture and complex systems
  - Transverse subjects: operational reliability, data security, safety, certification…

FSA domains

Flight Crew

Line operators

Cabin Crew

Passengers

Aircraft Control Domain	Airline Information System Domain	Passenger Information & Entertainment Domain	Passenger Owned Devices Domain

Air traffic Control

Maintenance centre

Applications

Flight Crew

Maintenance team

Cabin Crew

Passengers

A/C Control Domain

Cockpit Display System,
Head-up Display,...

Communication, Navigation,
Surveillance

Airline IS Domain

E-logbook,
Maintenance terminal

Electronic Flight Bag

Onboard Maintenance System

Passenger IE Domain

In-Flight entertainment

Cabin Information System

Air traffic Control

Maintenance centre

Information and communication architecture

A/C Control Domain	Airline IS Domain	PIESD	
Cockpit Display System, Head-up Display, …	E-logbook, Maintenance terminal, Cabin logbook …	Entertainment & Inf. System	*Operations/ Functions*
Communication, Navigation, Surveillance Flight Controls & Mngt, …	Onboard Maintenance System		*Systems*
Modular avionics, BITE	Onboard Information Mngt		*Middleware, Inf. Systems*
AFDX, ARINC 429	Ethernet	Ethernet	*Network*
VHF, HF, SATCOM, ACARS	SATCOM, Wireless	SATCOM/ Cellular	*Communicatio*

Development constraints

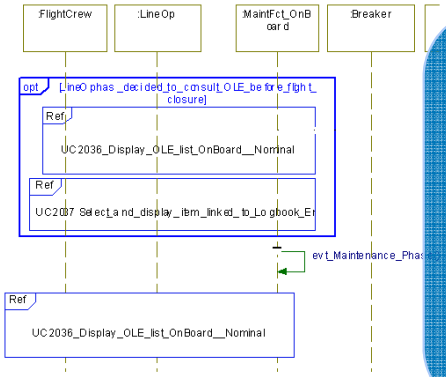
A/C Control Domain	Airline IS Domain	Passenger IE Domain
• **Highly critical:** failure of functions can lead to dangerous situations **Mostly DO-178B level A-C:** high development costs for software	• **Open:** to external communication, including during flights • **Interconnected with airlines information systems** **Mostly DO-178B level C to F:** medium to low development costs for software	• **Availability** • **Open to various devices**

Focus on OnBoard Maintenance System (1/2)

- **Operational need: reduce the maintenance time**

  for the aircraft on ground between 2 flights

Focus on OnBoard Maintenance System (2/2)



Maintenance Function team

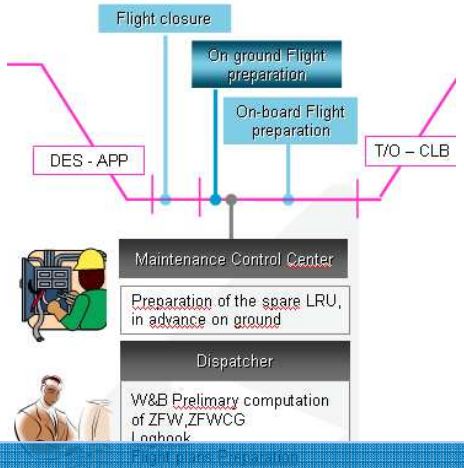
Activities

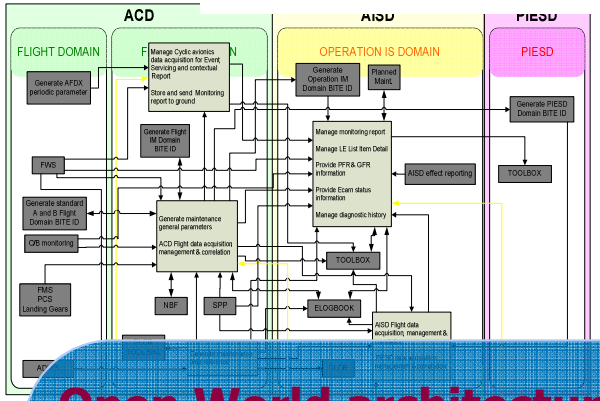
Maintenance Function modeling

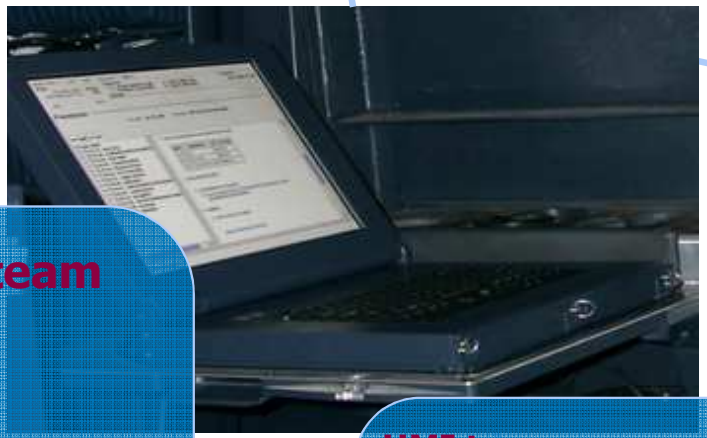
Maintenance Function requirements definition

Validation matrix

Customization and settings







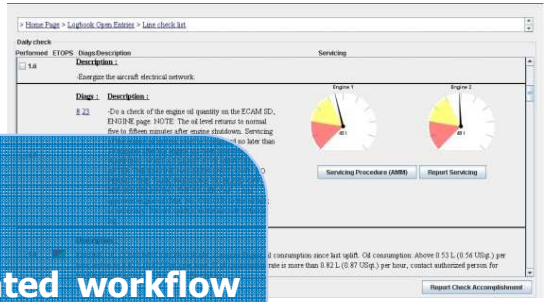
Maintenance Operations team

Activities

Operational needs analysis

New maintenance concepts definition

Operational scenarii definition



Open World architecture team

Activities

Functional breakdown analysis

Architecture definition

Functions allocation on systems

Data security validation

Operating environment definition

Open world architecture process definition

Interface management

HMI team

Activities

Maintenance integrated workflow concept definition

HMI mock-up definition

Human factors evaluations

HMI requirements definition

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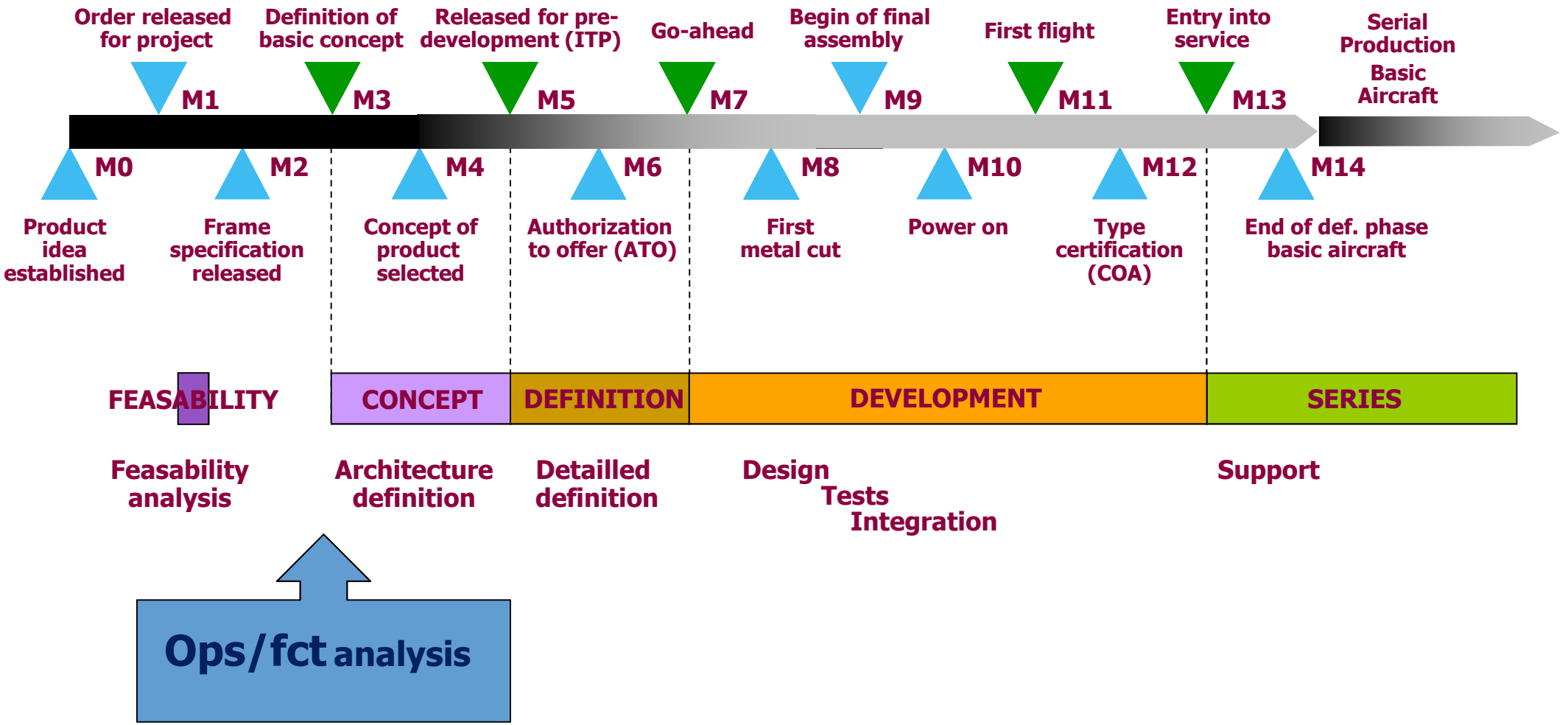
Aircraft Development Process



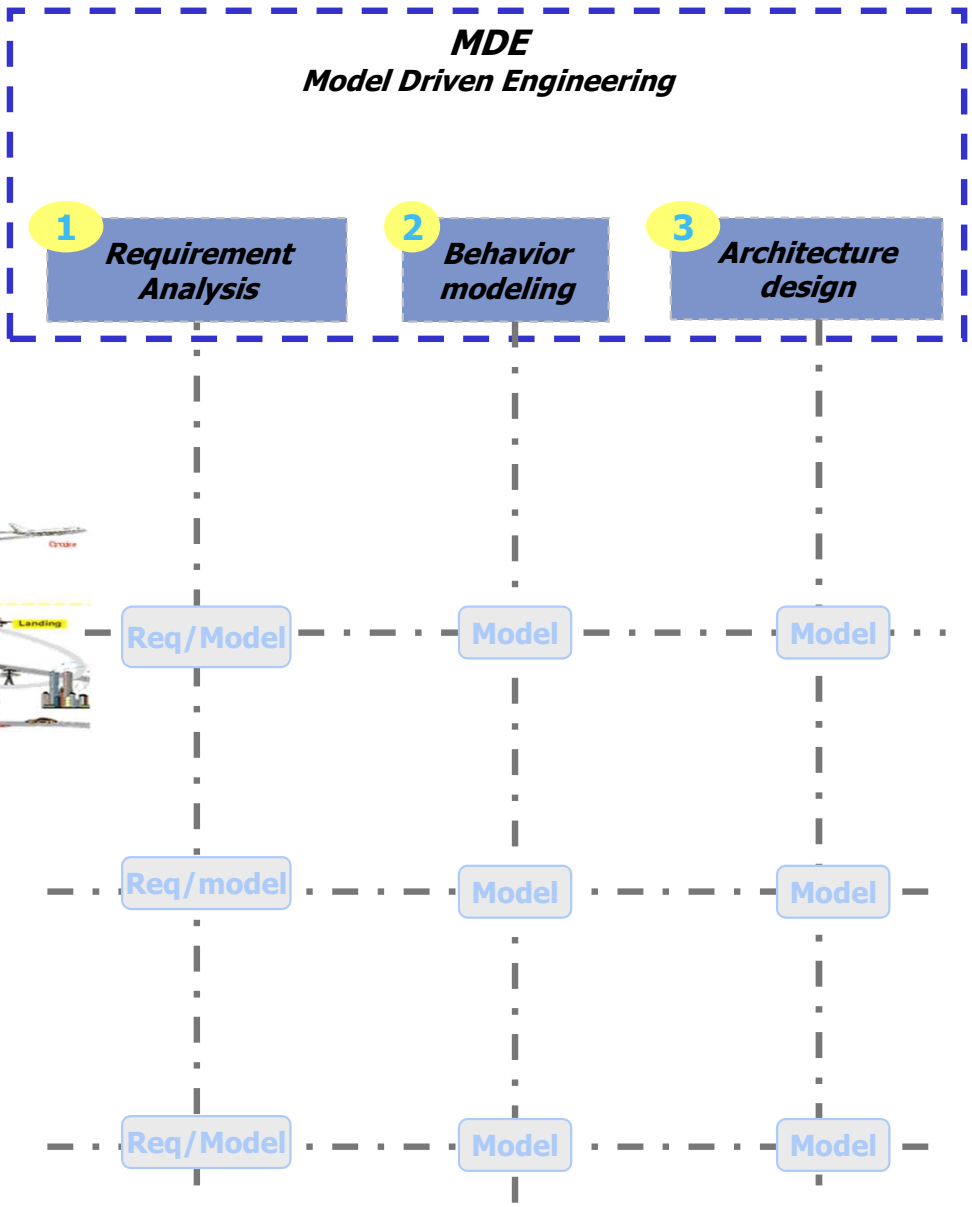
Model Driven Engineering Approach Example

3 axes

1. Requirement Analysis & Traceability
2. Behavior Op&Functional Modeling
3. Solution definition and architecture design

3 Levels

A. Operational Context Analysis
B. Black box description
C. White box description



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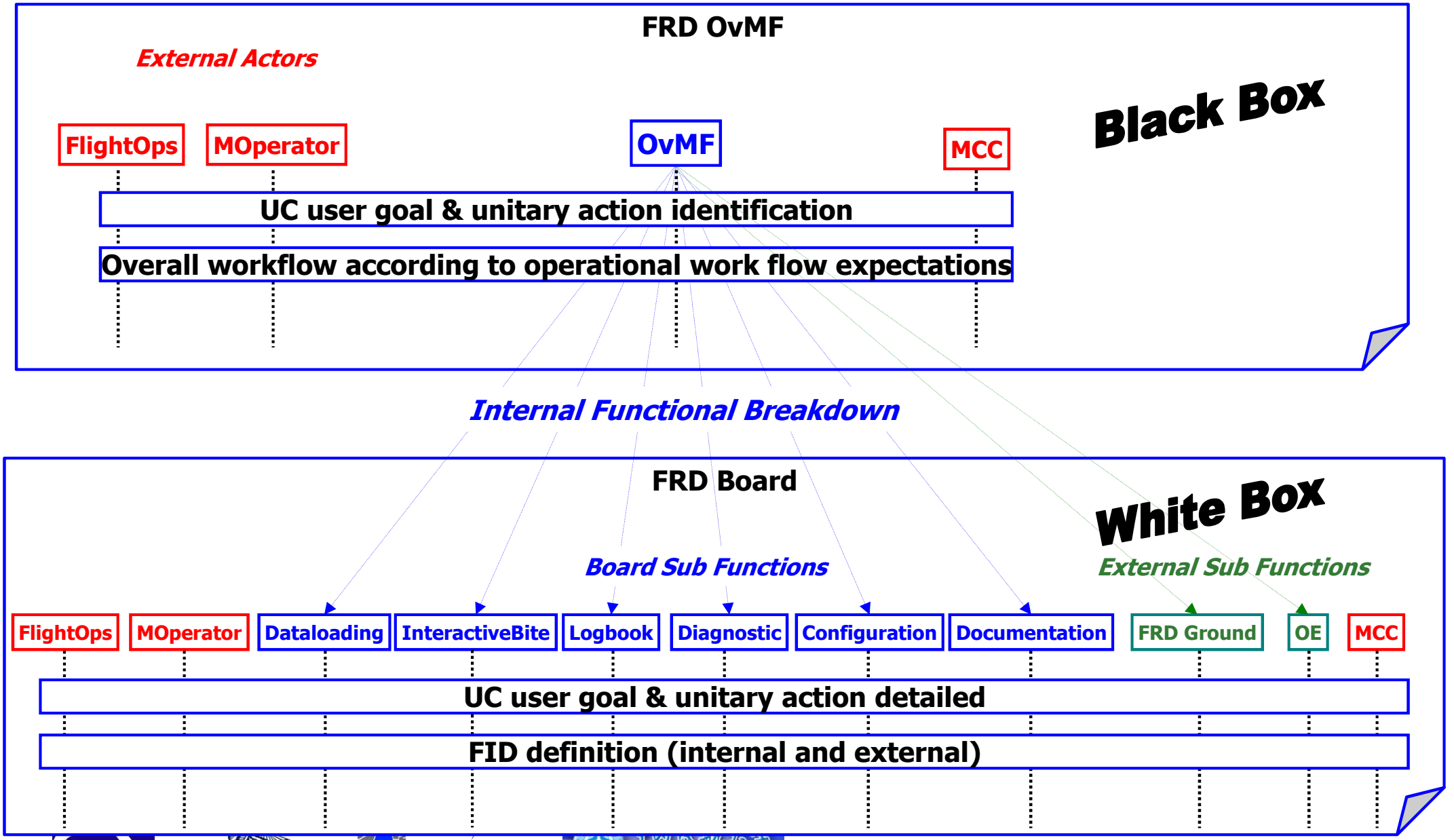
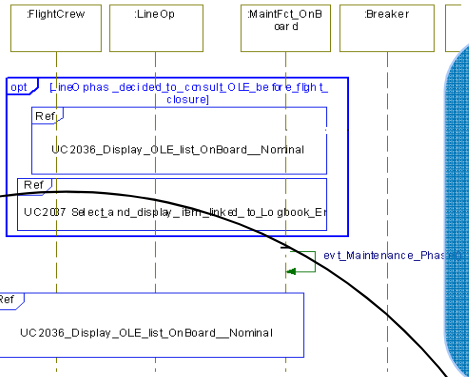
Zoom on Functional Requirement Document – content



Modeling techniques and tools

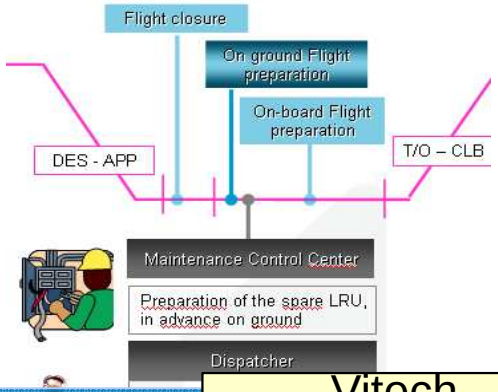


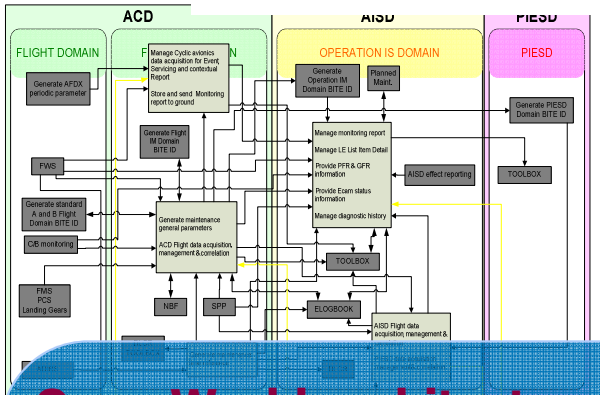
IBM

Rhapsody

Maintenance Functi

- Activities
- Maintenance Function modeling
- Maintenance Function requirements definition
- Validation matrix
- Customization and settings



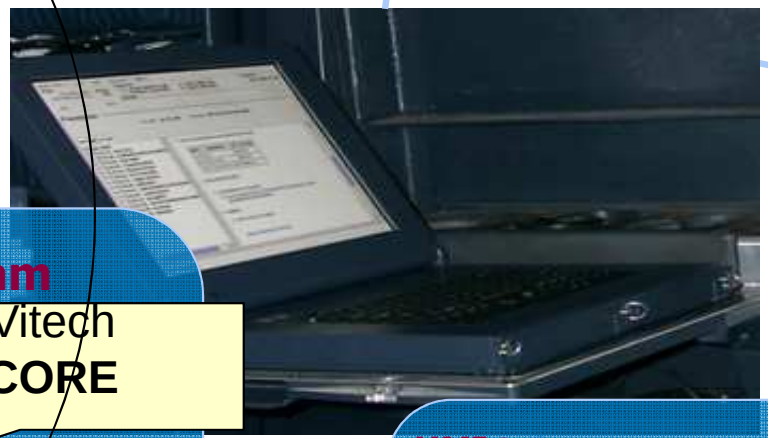


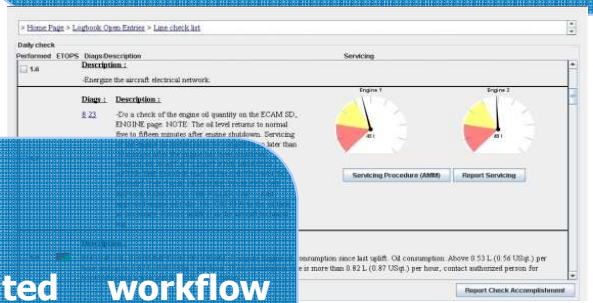
Vitech

CORE

Maintenance team

- Activities
- Operational needs analysis
- New maintenance concepts definition
- Operational scenarii definition





Open World architecture team

- Activities
- Functional breakdown analys
- Architecture definition
- Functions allocation on systems
- Data security validation
- Operating environment definition
- Open world architecture process definition
- Interface management

Vitech

CORE

HMI team

- Activities
- Maintenance integrated workflow concept definition
- HMI mock-up definition
- Human factors evaluations
- HMI requirements definition

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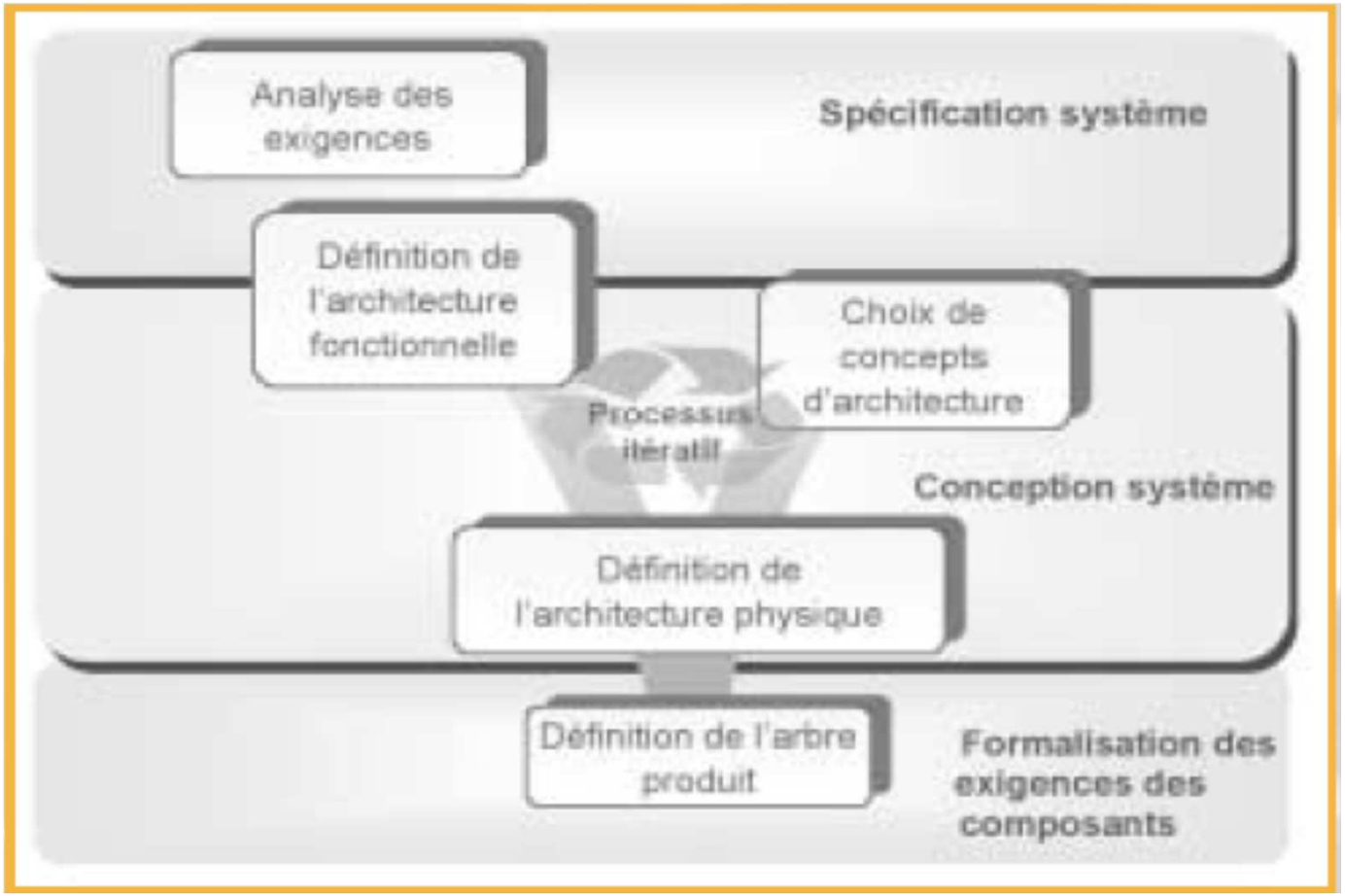
Modelling: using multi formalisms/Multiple tools

Using one single formalism/tool is not always possible, nor desirable

- Multiple teams, and competences

- No universal modeling language
  - Several design levels, needing different views and levels of details
  - Structure, electricity, aerodynamics, control systems, hardware/software, thermics, safety, acoustics, …..
  - A functional architecture <> a logical/physical architecture
  - Event driven, Data flow, control flow, synchronous, asynchronous, parallel, …

Methodology



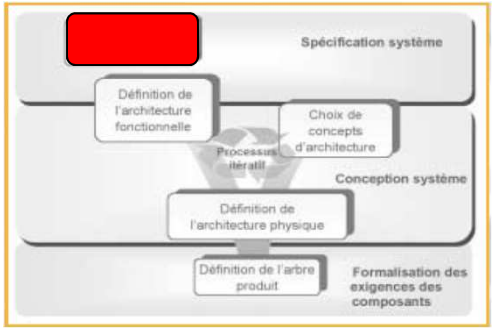
Source AFIS

- From functional analysis to physical architecture in a common Core® (Vitech) model

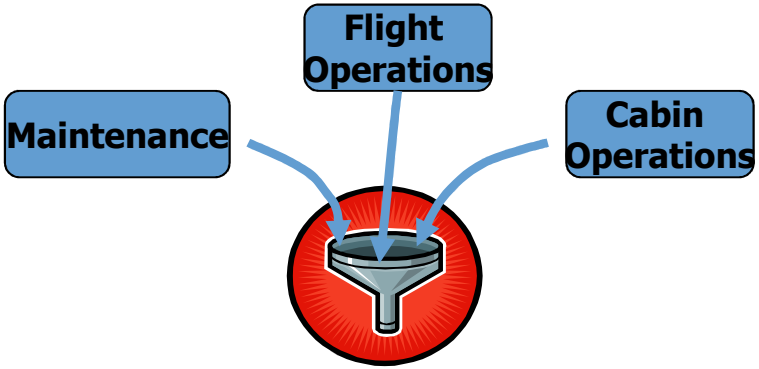
Content

- Requirements analysis
- Functional architecture definition
- Architecture concepts and definition
- Physical architecture
- From method to tool
- Figures

Requirements analysis



- Requirements elicitation performed by different teams:
  - By domains of competences – operational, functional and performance aspects



  - By architecture team – major constraints for architecture

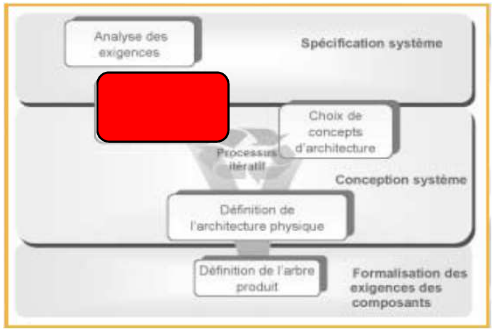
- ✓ Identification of requirements inconsistencies

Modelling scheme

Requirements

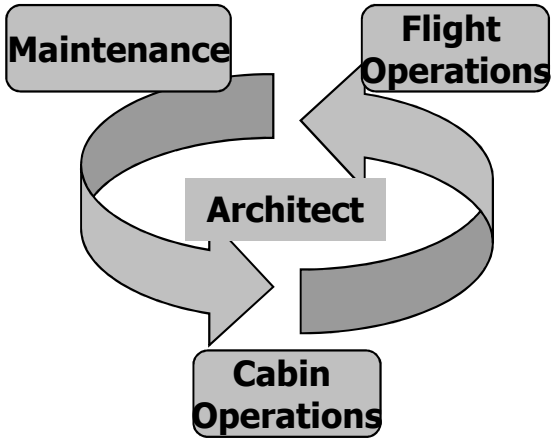
e.g. " ***Information system shall enable maintenance operator to export maintenance report to a USB key"***

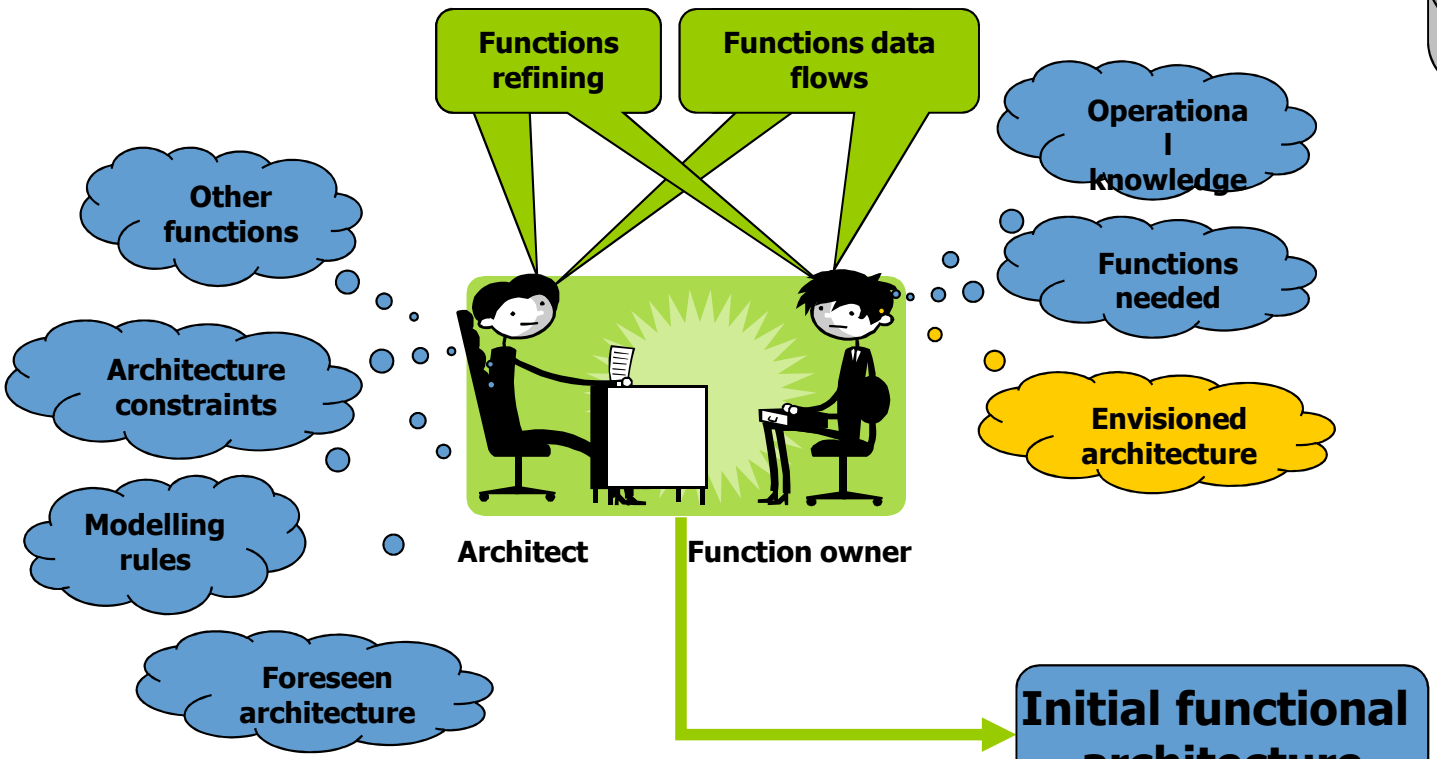
Functional architecture definition



- Objective: Define functional decomposition answering to identified system needs

- 1st step: “Spiral-interviews”





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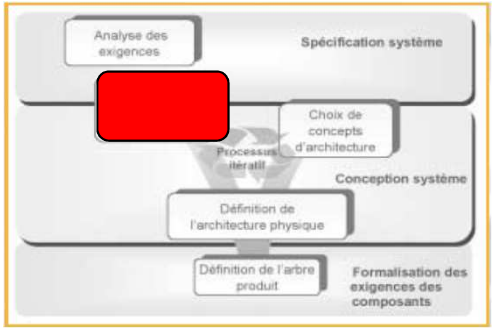
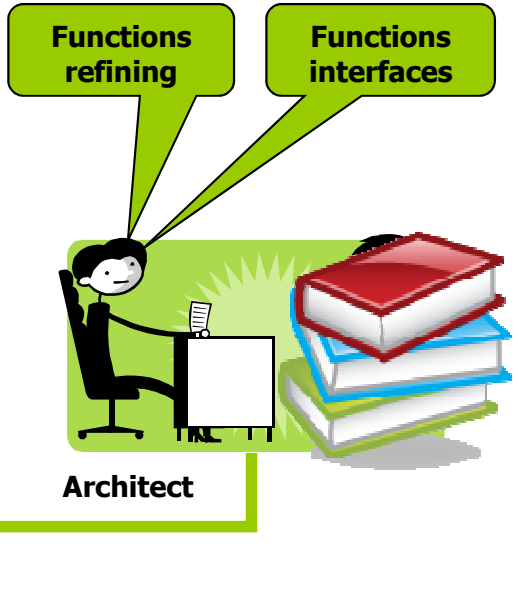
Functional architecture definition



- 2nd step: Formal requirements analysis
- Considering aircraft life cycle (In Operation, FAL, tests, maintenance, …)
- Functions refined down
  - Target: functions allocation on physical architecture

- ✓ Better understanding between actors
- ✓ Early identification of interfaces potential problems



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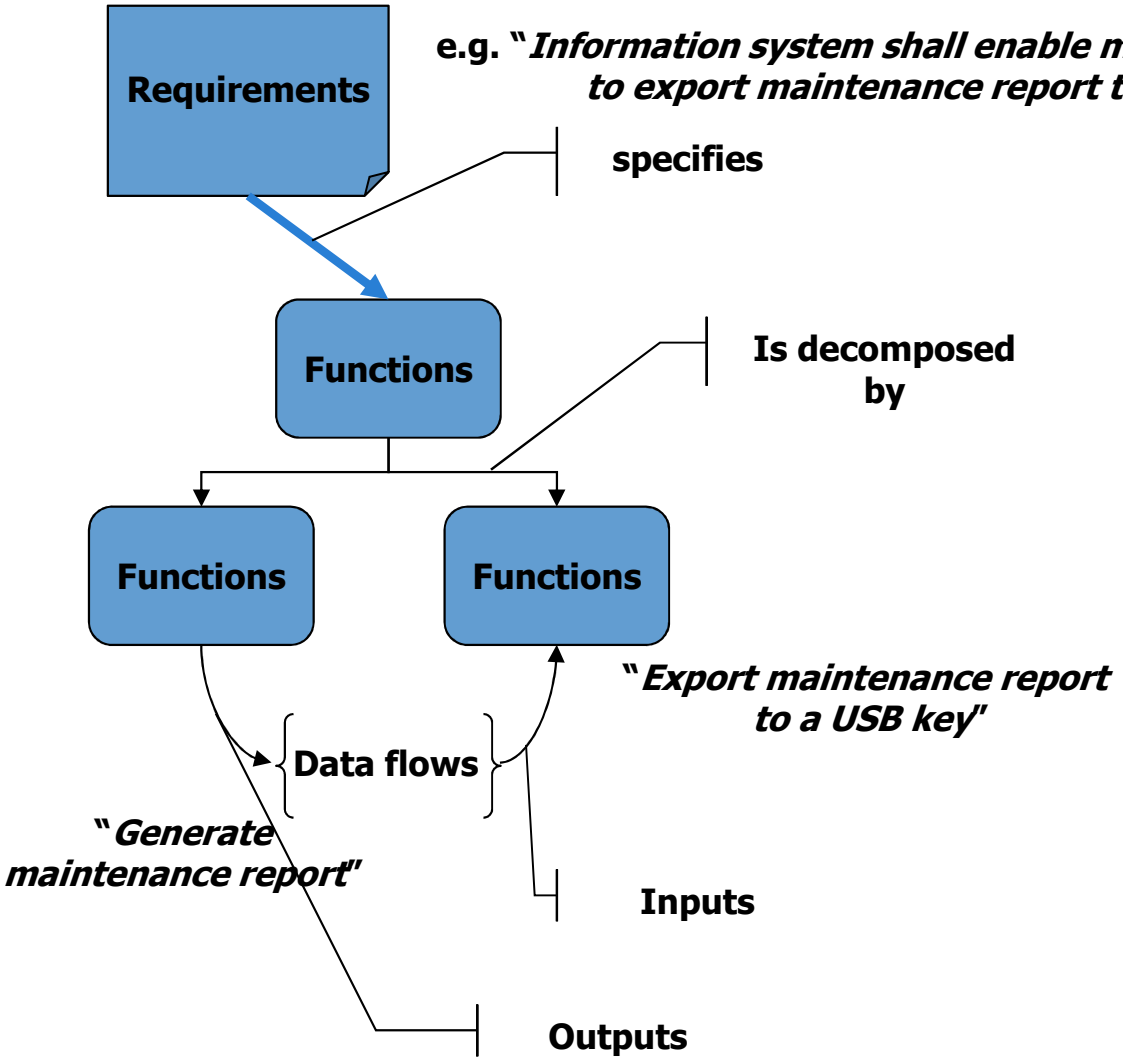
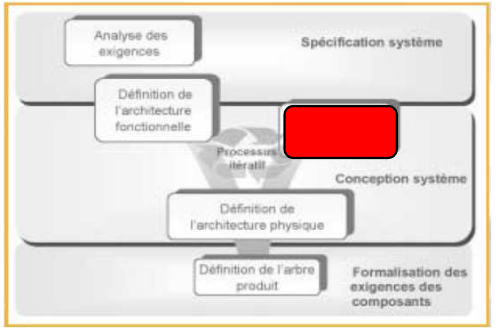
Modelling

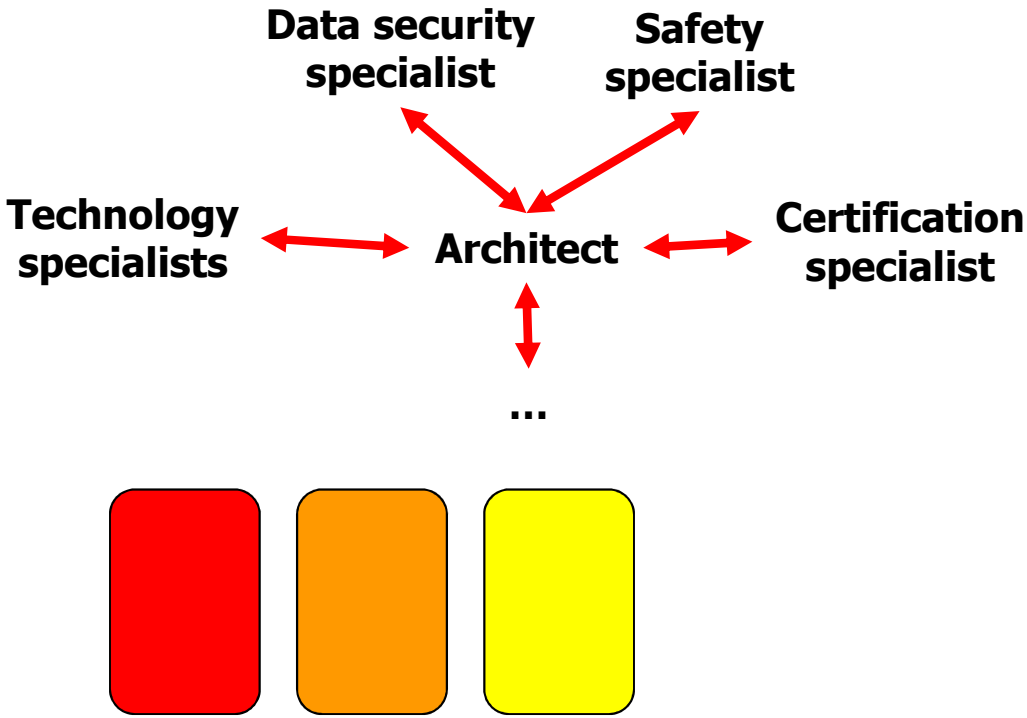

Requirements
e.g. "Information system shall enable maintenance operator to export maintenance report to a USB key"
specifies
Functions
Is decomposed by
Functions
Functions
"Export maintenance report to a USB key"
Data flows
"Generate maintenance report"
Inputs
Outputs

Architecture concepts



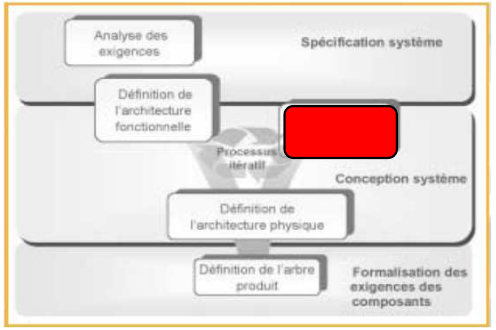
At the same time…

- Definition of high-level architecture considering:
  - Safety
  - Data Security
  - Access to Communication Means
  - Portability…

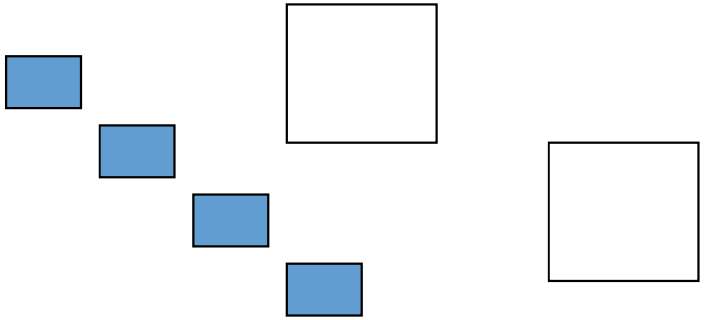


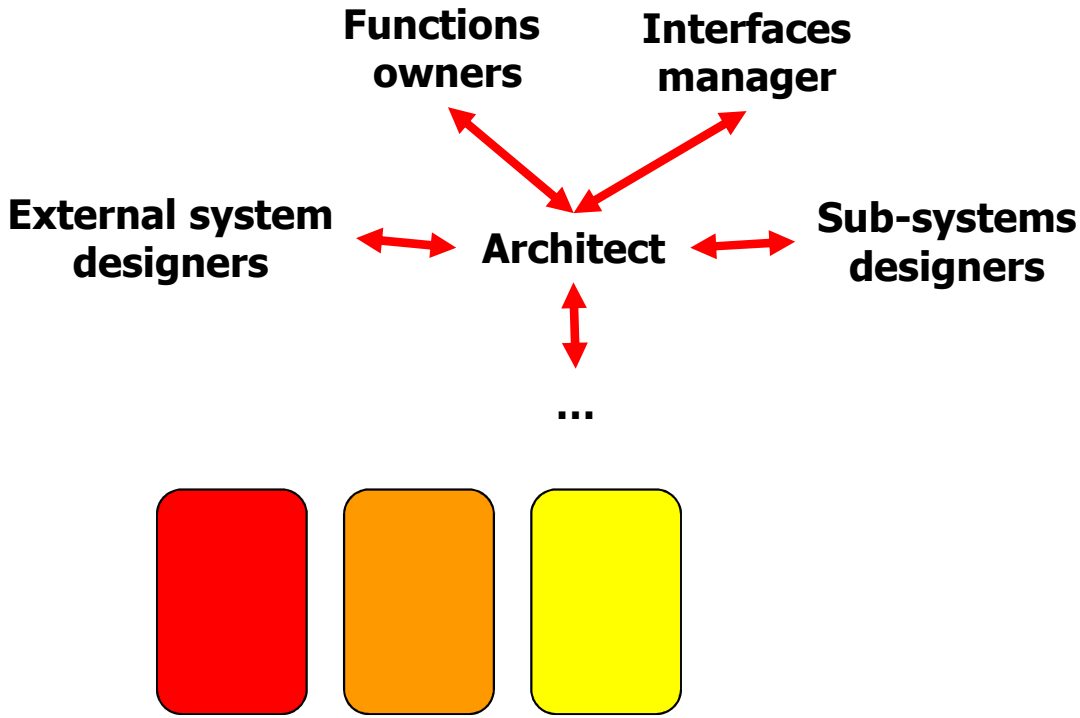
- … and represented by logical domains

Architecture definition



- Identification of functions clusters …
- … according to architecture drivers …
  - Reduce interfaces
  - Reuse
  - Communication capabilities
  - Customisation…
- … and allocated to domains





- Each domain has its own directives for sub-systems development

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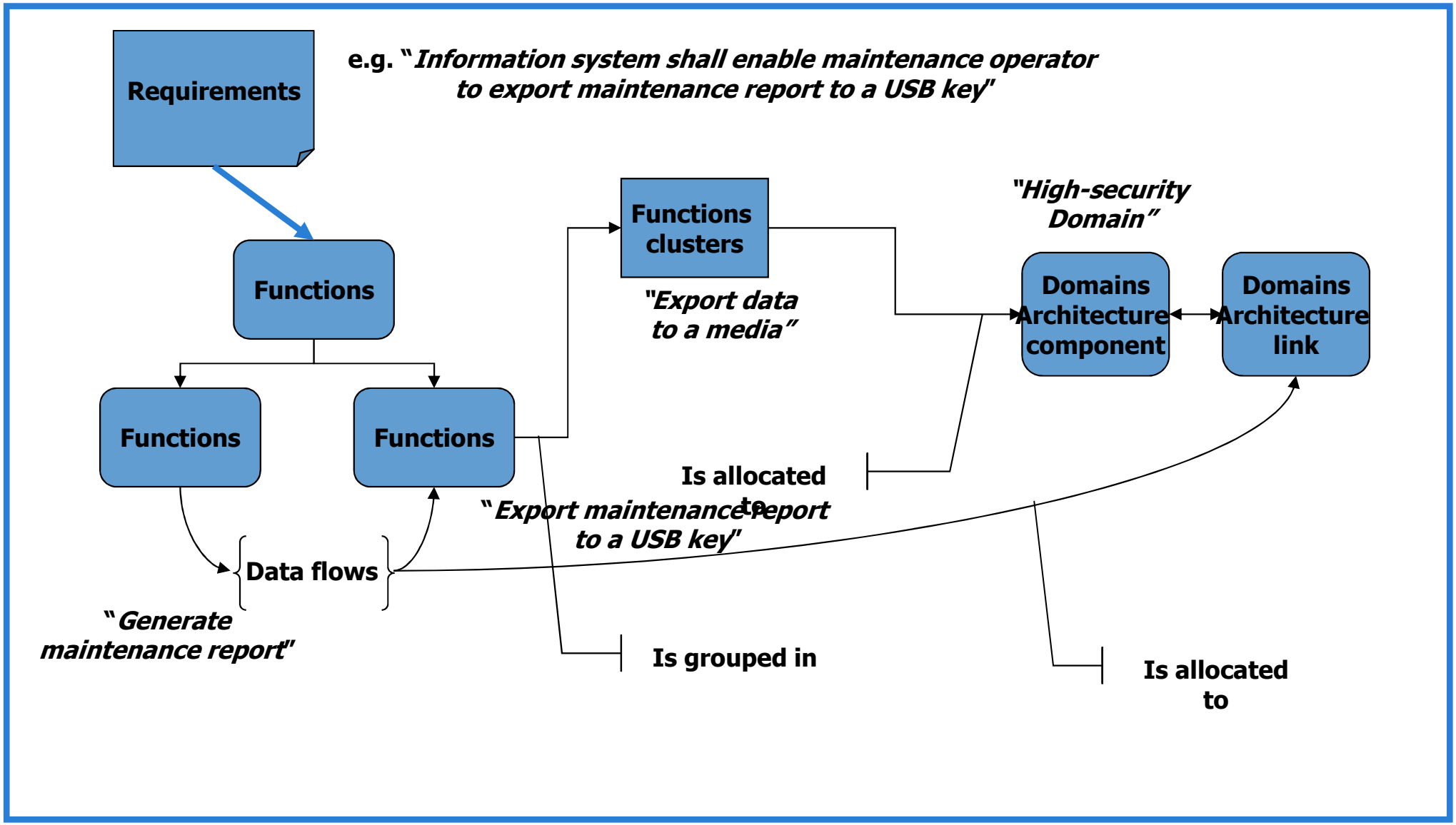
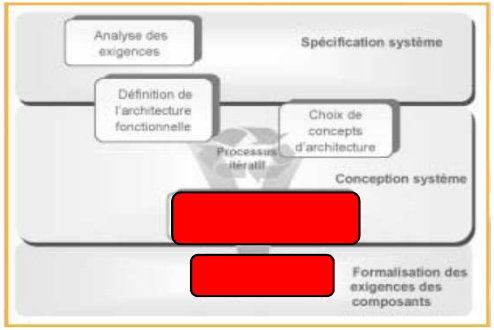
Modelling


Requirements
e.g. "Information system shall enable maintenance operator to export maintenance report to a USB key"
Functions
Functions
Functions
Functions clusters
"Export data to a media"
"High-security Domain"
Domains Architecture component
Domains Architecture link
Is allocated to
"Export maintenance report to a USB key"
Data flows
"Generate maintenance report"
Is grouped in
Is allocated to

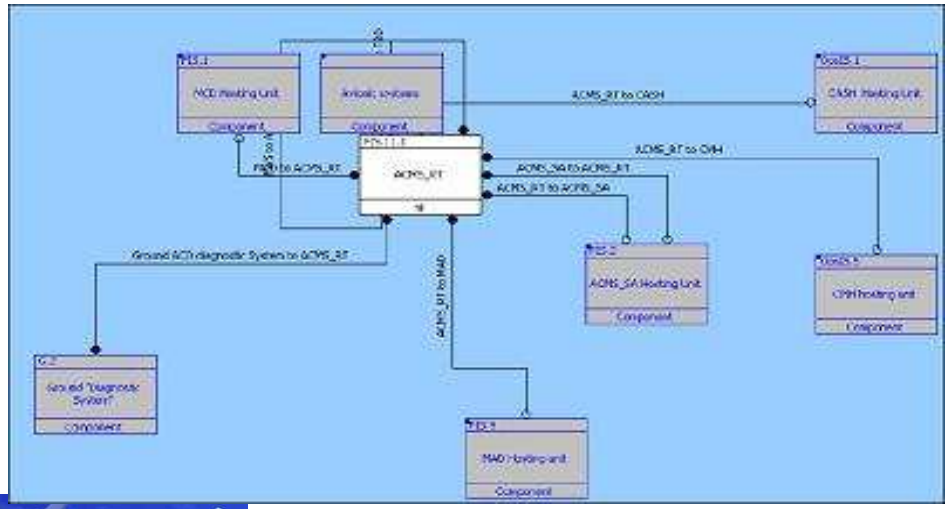
Benefits

- ✓ Architecture optimization
- ✓ Architecture trade-off
  - ✓ Hot topics modelled through architecture patterns
- ✓ Early definition and sharing of
  - ✓ Architecture
  - ✓ Flows going through Air/Ground communication means
  - ✓ Development directives (interfaces, development…)
- ✓ Eased modifications follow-up
- ✓ Early design validation

Physical architecture



- Definition of physical components (HW & SW)
- Allocation of functions to physical components
- In collaboration with sub-systems designers.
- ✓ Identification of sub-systems functional scope and interfaces



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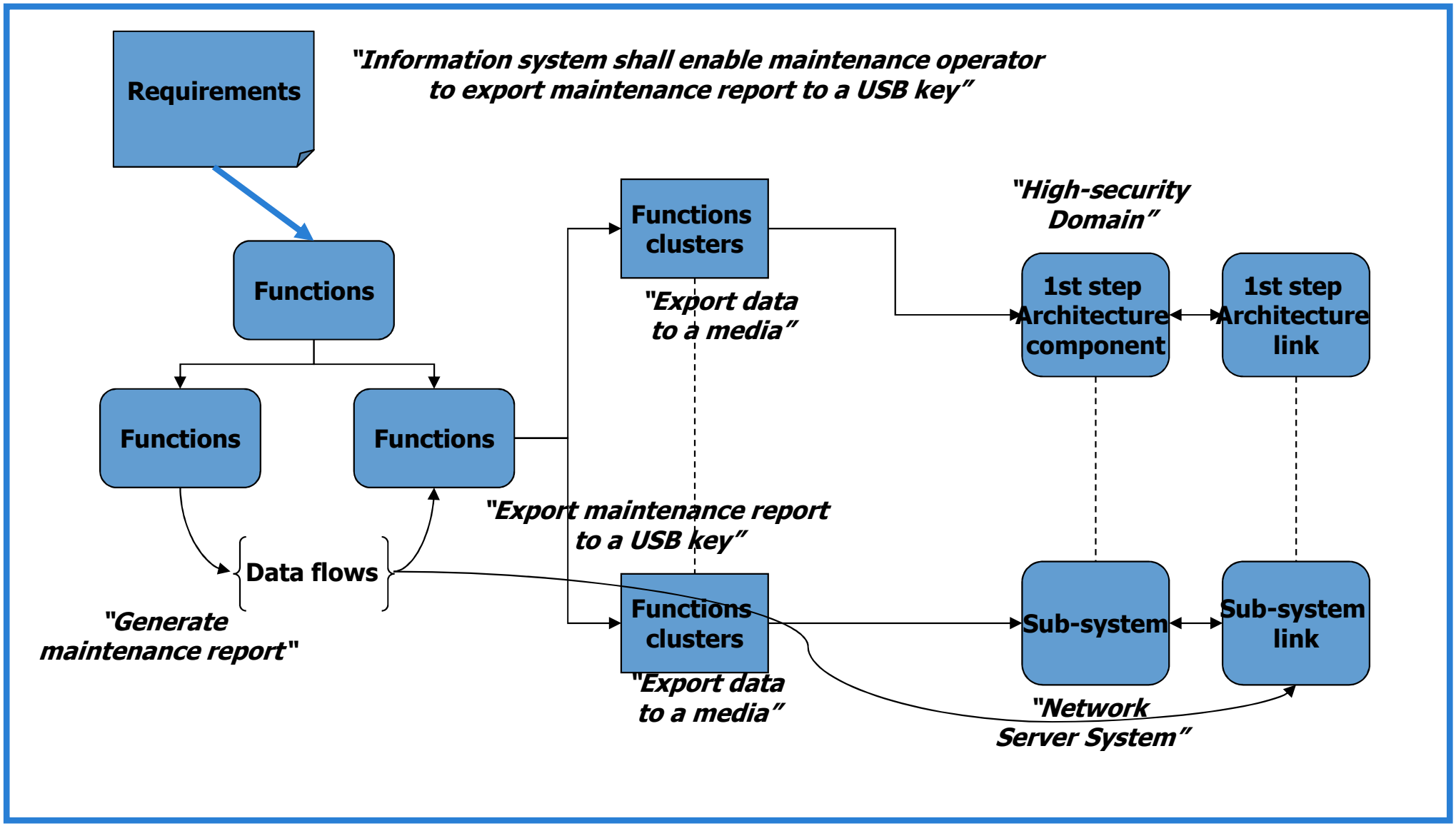
Modelling


Requirements
"Information system shall enable maintenance operator to export maintenance report to a USB key"
Functions
Functions
Functions
Functions clusters
"Export data to a media"
"High-security Domain"
1st step Architecture component
1st step Architecture link
"Export maintenance report to a USB key"
Data flows
"Generate maintenance report"
Functions clusters
"Export data to a media"
Sub-system
Sub-system link
"Network Server System"

Figures

- Up to 10 engineers during 2 years
- Supporting up to 20 domains of competences
  - represented by their experts
- Interfacing with 16 teams for requirements definition
- Interfacing with >30 teams for sub-systems design
- Around 2000 input requirements
- 1605 functions – 2431 data flows
- 148 domain functions clusters – 199 systems functions clusters

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Conclusion

This approach has allowed to model the A350 XWB on-board FSA-NG

- ✓ Stable and mature architecture before the Preliminary Design Review
- ✓ Reference model for all system designers
- ➢ Next steps
  - ❑ Support for Integration and V&V activity
  - ❑ Application to A30X and other programmes
- ➢ Perspectives
  - ❑ Dynamic modelling and simulation
  - ❑ Performance analysis