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Industrial and optimized auto-coding process for AOCS SW development in CD phase

Session 2 - Automated Code Generation for AOCS

Jérôme Bourdon, Flight Dynamics and AOCS/GNC Process Owner
AIRBUS DEFENCE AND SPACE
20th October 2016

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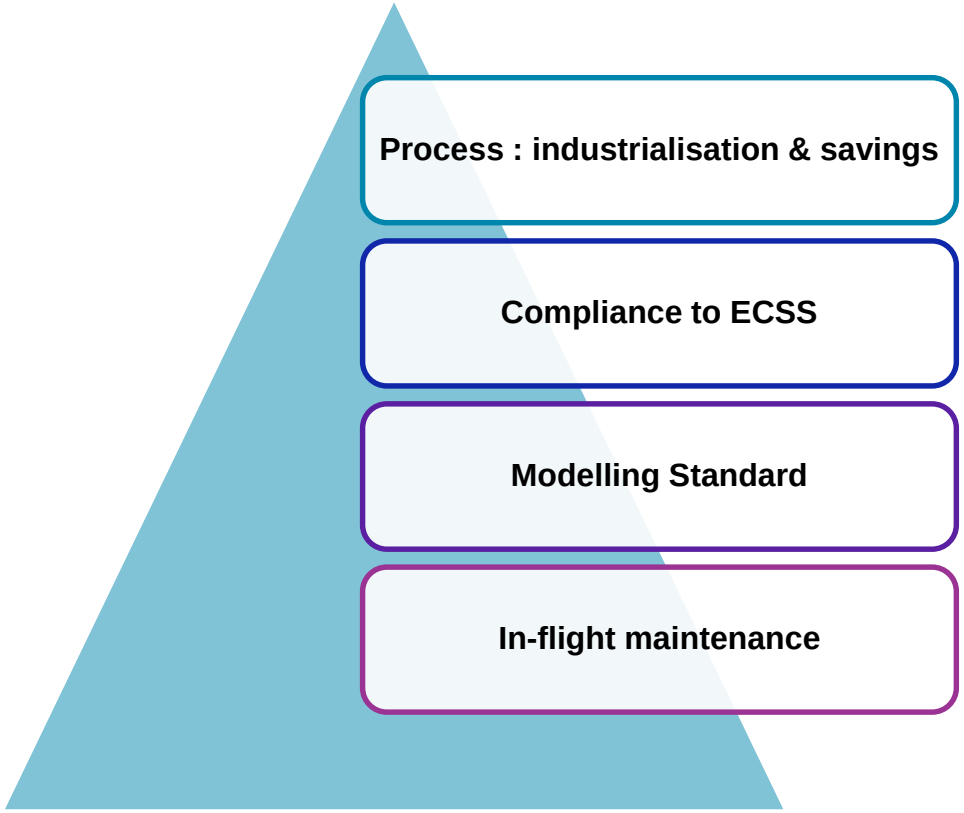
Auto-coding process for AOCS SW development

Roadmap / context

- **Two demonstrators** have been carried out with CNES and DLR, from April 2012 to March 2013
- Positive conclusion of the autocoding Go / No-Go review within Airbus Defence and Space declared the **"autocoding process" as the baseline for future projects** (2013)
- **Positive feedback from technical directorates** ESA (ESTEC and ESOC), CNES and DLR in the frame of autocoding process deployment into demonstration projects (2013-2014)
- AOCS Autocoding selected for **AS400 product line** - covering **NGSAR** and **MetOp-SG** - **Merlin**, **JUICE**, **Quantum** and **Eurostar Neo product line**



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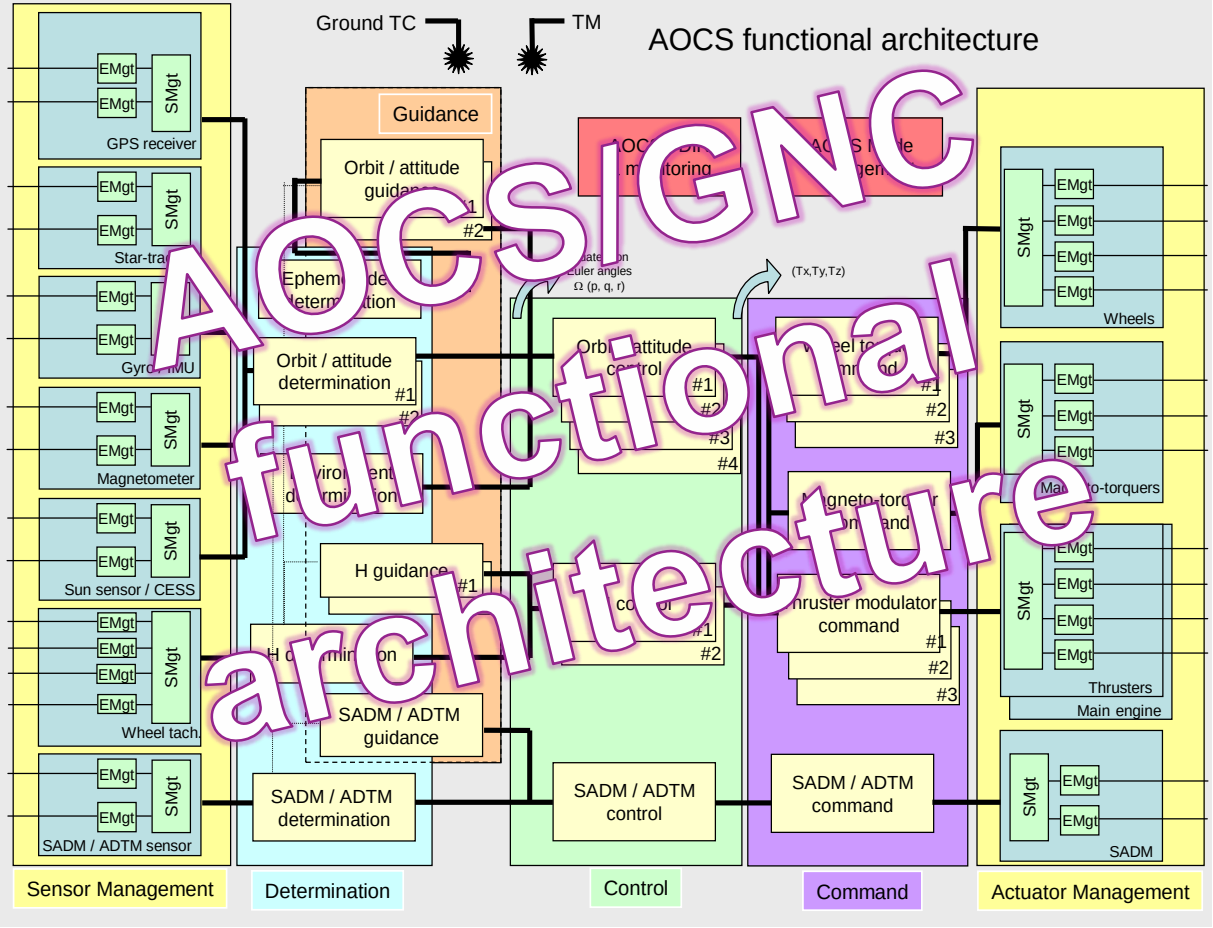
Auto-coding process for AOCS SW development

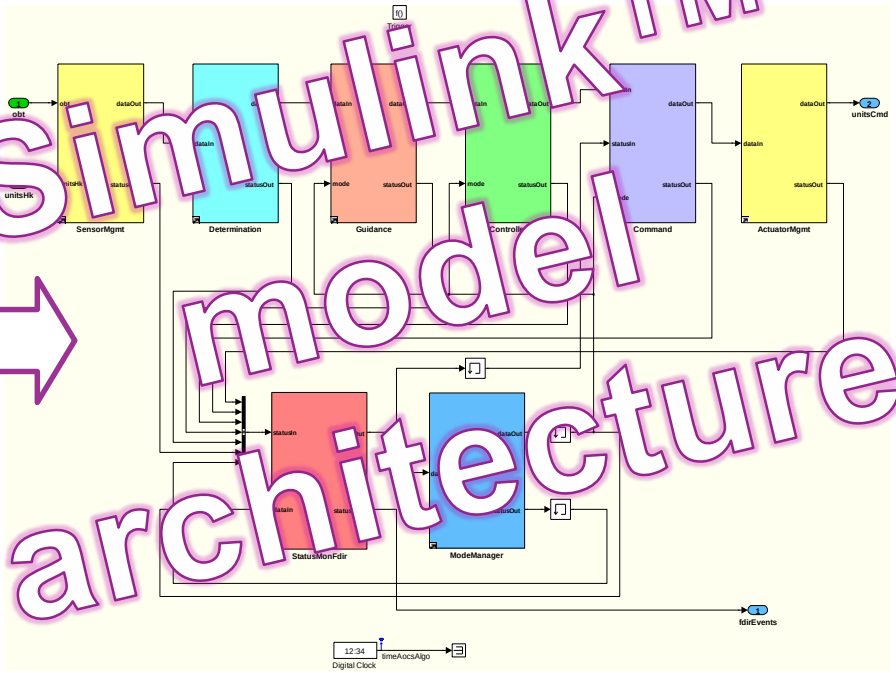
Model Based Design with respect to AOCS functional architecture

Common transnational architecture

- Easing communication with SW, OPS and FDIR engineers
- Harmonising new developments and supporting autocoding



AOCS/GNC functional architecture



Simulink™ model architecture

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Auto-coding process for AOCS SW development

AOCS model (MCL) perimeter within Central Software (CSW) Architecture

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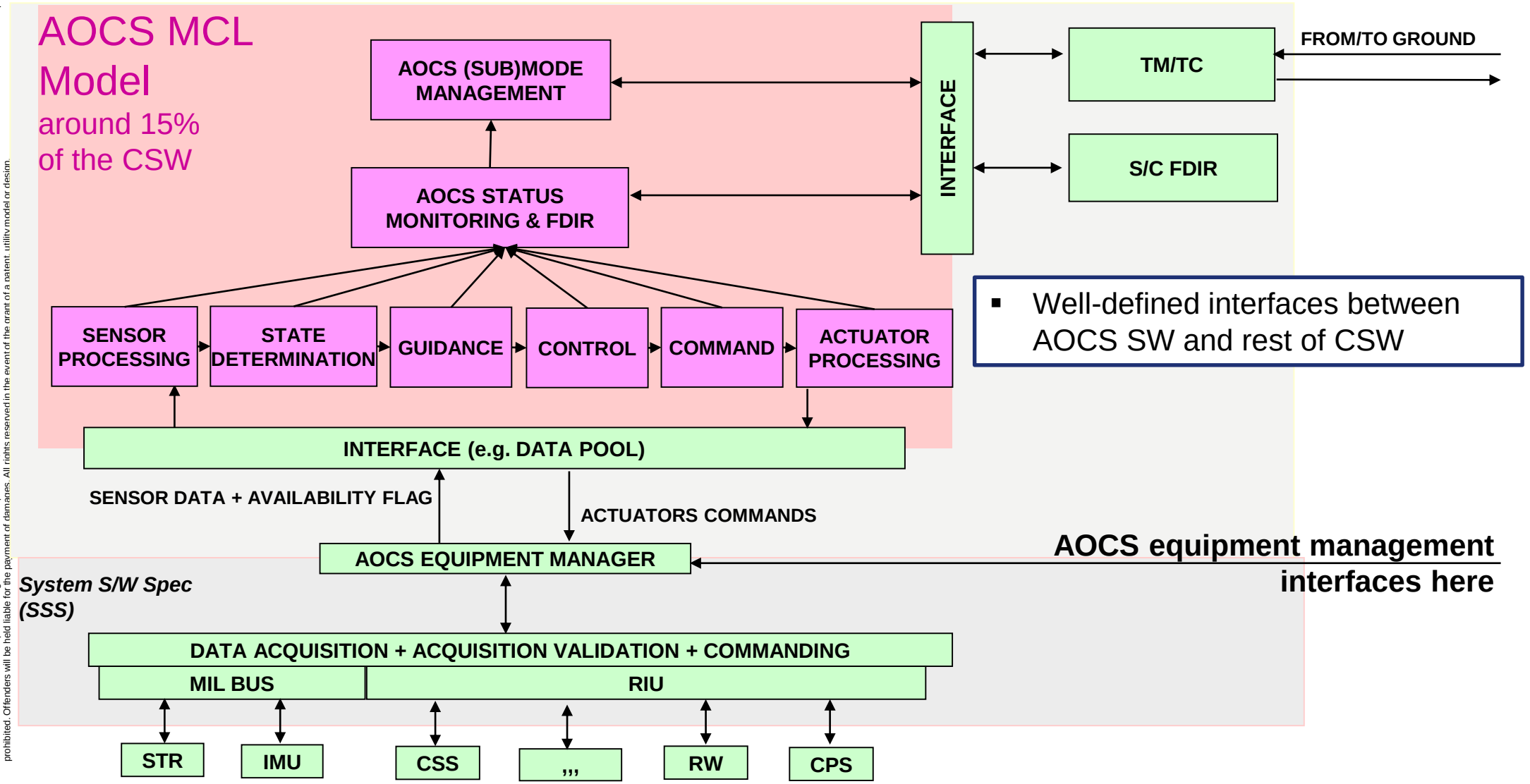

- Well-defined interfaces between AOCS SW and rest of CSW

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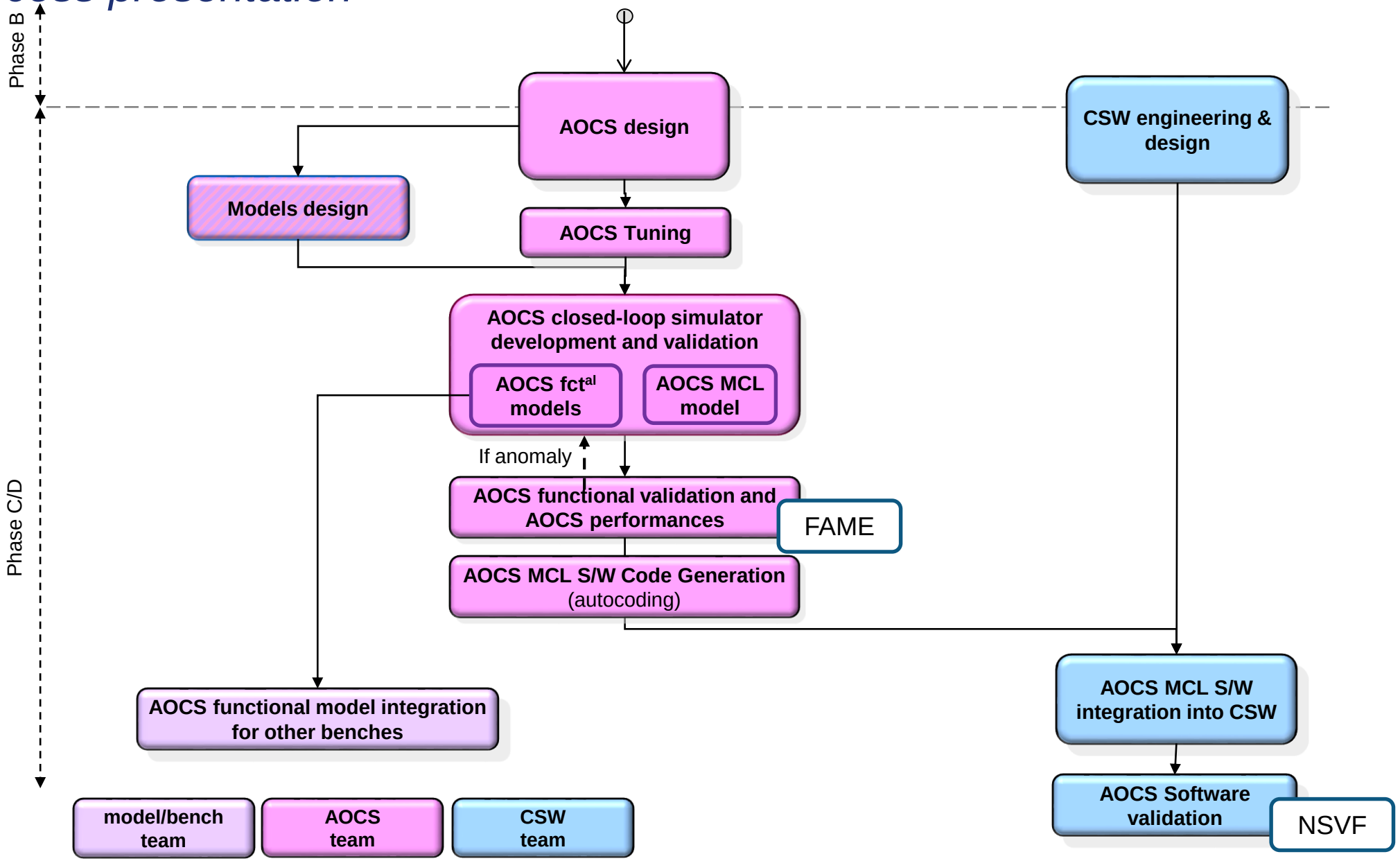
Auto-coding process for AOCS SW development

Process presentation



FAME: Simulink™ simulator
NSVF: Real time simulator

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Auto-coding process for AOCS SW development

AOCS & GNC activities

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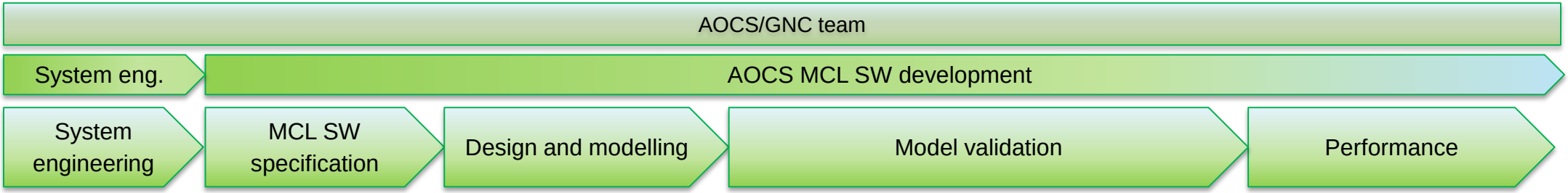

- AOCS/GNC analyses and trade-offs
  - ➢ Contribution to System requirements

- AOCS/GNC model architecture
- System requirement analysis
  - ➢ AOCS/GNC MCL SW Specifications (AMS & AMSW ICD)

- AOCS/GNC detailed design
- AOCS/GNC MCL model development
  - ➢ AOCS/GNC MCL model
  - ➢ Algorithms Functional Description (AFD)

AOCS
- Reference cases definition and execution in FAME
  - ➢ AOCS/GNC reference test cases description (RTCD)
- Functional Validation MCL model
  - ➢ AOCS/GNC reference test cases report

SW
- Model Standard analysis
- Model Complexity analysis
- Model Peer review
- Model coverage
  - ➢ AOCS/GNC MCL VCD & SQAR

- AOCS/GNC performance assessment and validation
  - ➢ AOCS/GNC performance report

Kick-off

MCL SW SRR

MCL SW PDR

MCL SW CDR

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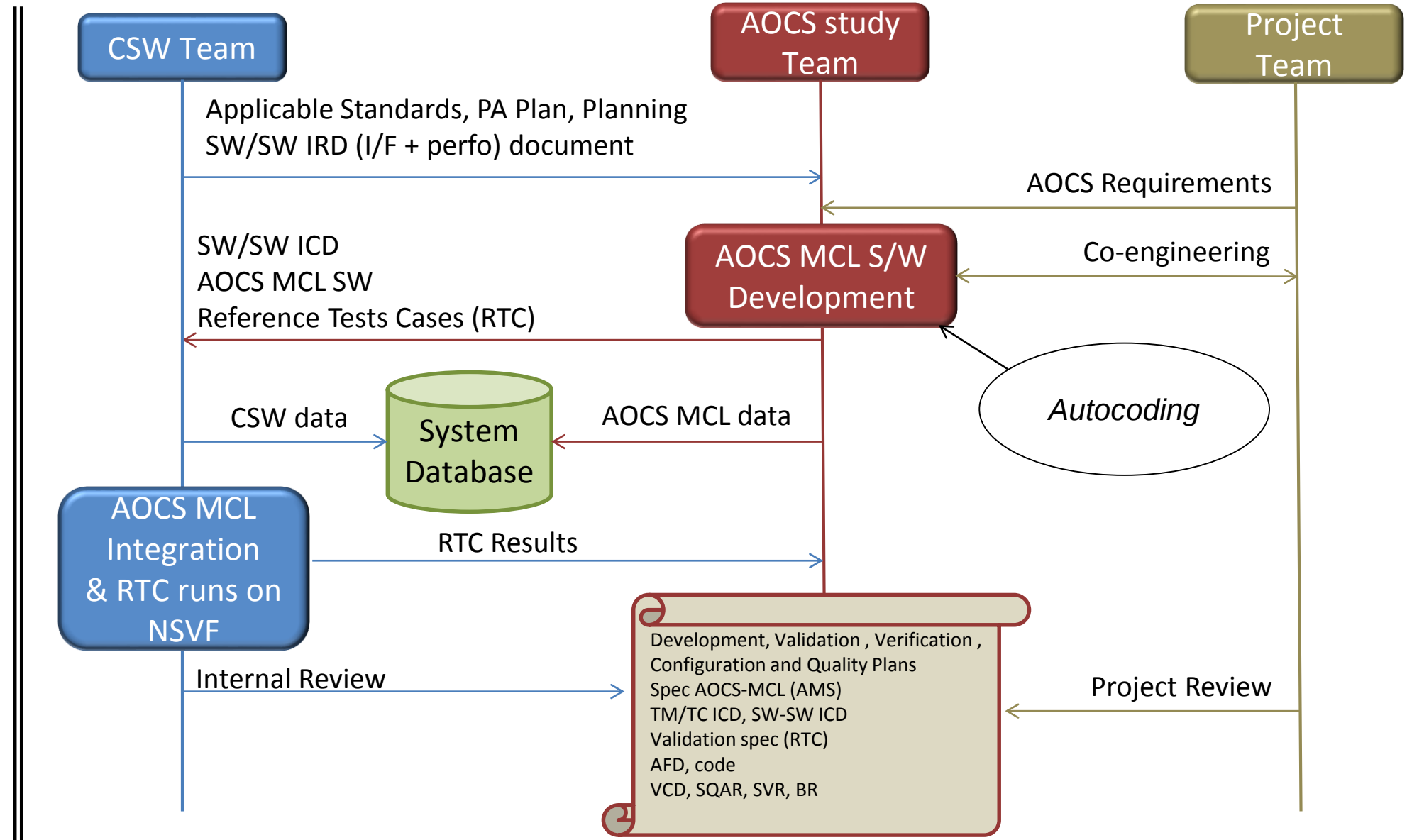
Auto-coding process for AOCS SW development

Summary of CSW - AOCS Interactions



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Auto-coding process for AOCS SW development

A multi-disciplines process

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This AOCS SW development process defines **different roles and responsibilities** leading to the following challenges:

- Development coordination between disciplines (deliveries and reviews phasing)
- Common understanding of the disciplines needs and constraints (ECSS applicability, quality rules)
- Sharing or delegation of activities (SW performances budget estimation)

To face those challenges, Airbus Defence and Space organization has been adapted by creating the **Functional Avionics entity**, gathering a multi-disciplines perimeter (AOCS, SW, Simulator team, Database, FDIR, Operation and Functional Validation), **coordinated by the functional avionics lead.**

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Auto-coding process for AOCS SW development

Auto-coded AOCS SW properties

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Auto-coded AOCS SW properties are driven by the **application of modeling standard** on the MATLAB™ source code. This modeling standard has been developed based on in-house know-how and in coordination with Mathworks™ and space agencies (ESA, CNES and DLR).

Among the different requirements, main features are:

- Limitation of allowed Simulink™ blocks (limited to data flow management and architecture)
- Architectural Conventions
- Mastering of elementary function complexity

As a consequence, **auto-coded AOCS SW properties are mastered at model level**

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Auto-coding process for AOCS SW development

Verification & Validation (V&V) Principles

- Main principle is to realize all the MCL S/W **V&V activities at the MATLAB™ source code level**
- Another important principle is that the **generated code is never modified**

- **Verification**
  - Quality metrics measured on MATLAB™ source code.
  - Unit tests defined and performed on MATLAB™ source code based on complexity criteria.
    - These tests will derisk and complete the functional validation
  - Decision coverage reached on MATLAB™ source code (mainly based on RTC) (target: 100 %)

- **Validation**
  - AMS functional requirements coverage reached by test on FAME (Reference Test Cases-RTCs) (target: 100 %)
  - RTCs also executed on the Real Time Simulator (NSVF) on full CSW Image after integration of the MCL S/W executable

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Auto-coding process for AOCS SW development

Benefits for Verification & Validation cost and planning

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For a development process where AOCS SW and AOCS simulator are developed by a team external to the AOCS one:

The delay between end of coding and first functional validation reaches some months (even if activity is prioritized to reduce this delay) whereas the risk of specification misinterpretation is present. In such context, iterations leads to over cost and delays.

For a development process where AOCS MCL and AOCS simulator are developed by a single AOCS team under a common Simulink™ environment (FAME):

The delay between end of coding and first functional validation **is reduced to some days**.

Indeed, unit tests and early functional tests are ready quite synchronously. This means that iteration on the MATLAB™ units can be performed, taking into account both unit test and functional validation test results.

MATLAB™ unit tests and MATLAB™ code functional validation tests can be performed **very efficiently with a lot of synergy**, integrated in **an iterative design short loop**, leading to **reduce strongly the risk** of design and development errors and **the development planning**.

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Auto-coding process for AOCS SW development
Conclusions

- **6 projects** currently in development
- Process reviewed and **agreed by agencies**
- A **multi-disciplines process** coordinate at Functional Avionic level
- V&V applied at MATLAB™ code level **for cost and planning efficiency**
- Auto-coded SW properties **mastered by applying modelling standard** at MATLAB™ code level

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Auto-coding process for AOCS SW development

Process industrialization: Documentation list

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- 3 AOCS MCL SW dedicated internal standards:
  - Design standard: modelling Standard for autocoding
  - Specification standard: explains how to write the AOCS MCL SW Technical Specification
  - Verification and Validation standard: explains how to verify and validate the AOCS MCL SW Technical Specification, in particular how to design the reference test cases
- 3 AOCS MCL SW plans covering the 5 CSW plans perimeter (same topics as required by ECSS)
  - AMSDP: development plan, configuration management plan and verification plan
  - AMSVP: validation plan
  - AMSQAP: quality assurance plan
- AOCS MCL SW specifications
  - AMSW Specification (AMS)
  - AMSW Interface Control Document (ICD)
  - AMSW TM/TC Interface Control Document (TMTC ICD)
  - AMSW Configuration Item Data List (CIDL)
  - AOCS MCL Specification Requirements Traceability
  - AMSW Interface Requirement Document
- AOCS MCL SW quality
  - Status of Compliance Matrix with AMSW PA Requirements
  - AM Software Quality Assessments Report (AMSQAR)

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