WE LOOK AFTER THE EARTH BEAT

Integration of automatic code generation in a AOCS development process: feedback and perspectives

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Agenda

Introduction

TAS-F experience in AOCS code generation

Automated code generation (ACG) : which impact ?

Integration of ACG in a development process

Conclusions and perspectives

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Introduction: model-based design & code generation

Why ? Take benefit of current way of working of AOCS engineers

> Use of graphical methods for architecture's design & texted code for core algorithm (analysis & implementation)

> Most of the information is included in the model

Model-based design :

1/ Model a plant

2/ Synthesize a controller

3/ Simulate & check the system

4/ Embedded code production   **-> ACG**

5/ Verification & Validation of the system

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TAS-F experience

First benchmark : 2005

Selection of **TargetLink** (Dspace) vs RTW / SCADE / BEACON / RT-Builder:

> Code performance & quality

> Tools maturity

> Support

> Best User interface

> Price

Main limitation : **code perimeter** = core algorithms only (~50% of the code)

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TAS-F experience

Spacecraft:

> **Earth observation satellite :** launch February 2009 (~2 years)

> **SENTINEL-3 :** launch February 2016, 8 months

> **Earth observation satellite :** launch expected end of 2016

Feedback

> ACG efficient : no bug introduced, CPU and memory slightly altered

> Gain planning & cost : small in a classical **V-cycle** process

>> ACG itself only impacts the implementation phase, not dimensioning

>> Bugs are often located at interfaces (specification misunderstanding, underspecified…)

> Tool not easy to handle, need dedicated training

> Lack of C code readability & documentation of algorithms

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TAS-F experience

Second Benchmark 2016: Why?

> New members in the market: **Embedded Coder** (Mathworks), **Qgen** (AdaCore)…

> Strong evolution of the tools including :

  – Possibility to produce more than AOCS core algorithms,

  – Tools simplification,

  – Number of model blocks supported,

  – Management of libraries,

  – readability, traceability....

> New model-based design approach: **testability**

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Benchmark 2016 : ACG, what do we expect from it?

> Answer AOCS application constraints & needs: **code perimeter**

>> Mode management / TM / TC / Interfacing / Parameters…

> No bug

> Maximum reuse of existing code & simulator

> Reduction of validation

> Automatic documentation generation

> Traceability & readability

> Project team friendly

> Maximum reuse from one project to another

> Integration in a global V&V process

Final selection: Embedded Coder

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Benchmark 2016 : AOCS needs
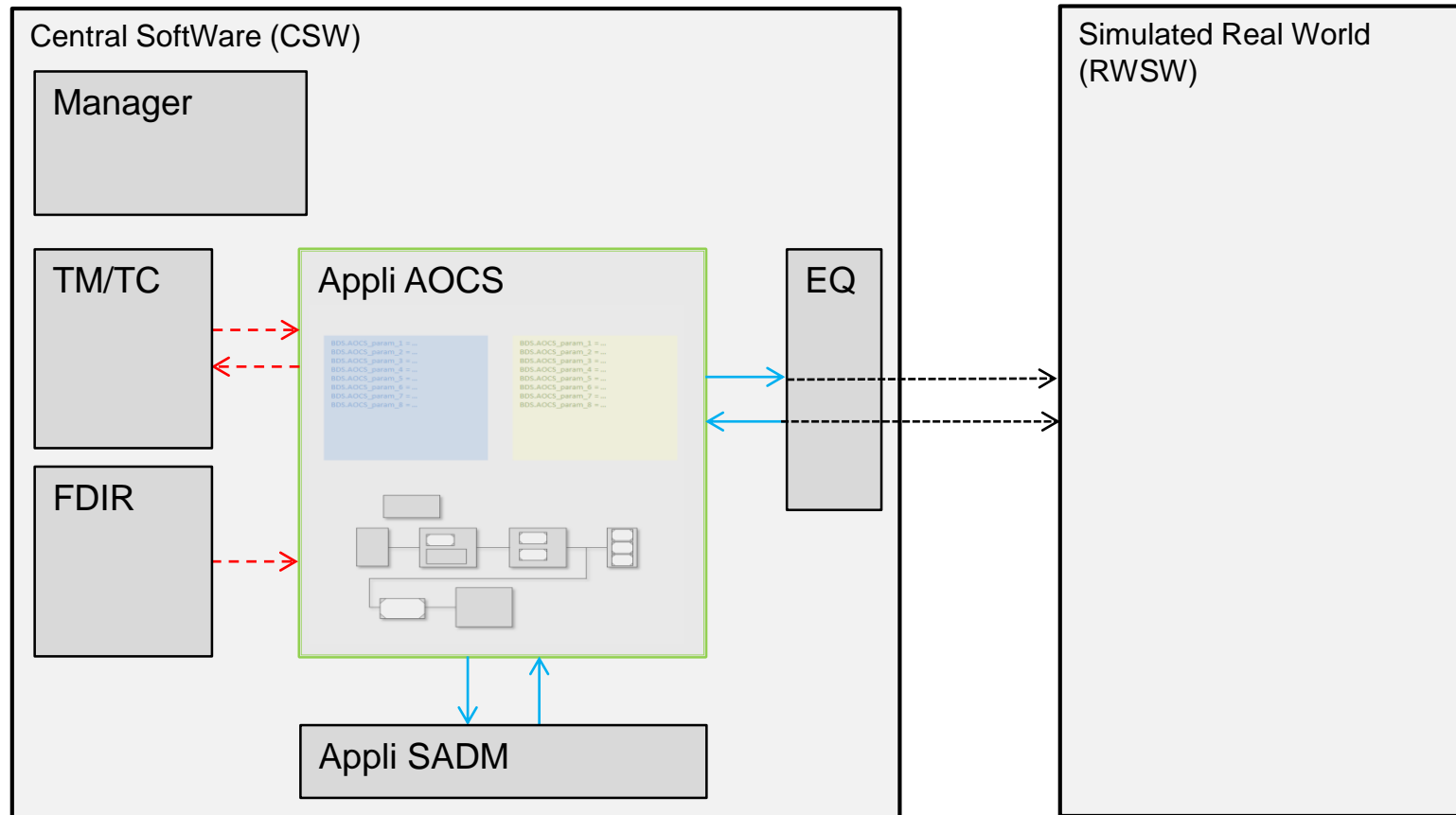
Automated code generation : which impact ?

Model is now the reference for the embedded code

New perimeter of responsibility between AOCS & SW team

> Who performs the job? black box for SW engineers?

New modelling constraints for AOCS designers

> Code quality (readability/traceability, data naming/typing, protections ...)

Simplicity of modelling a preliminary design must not be altered.
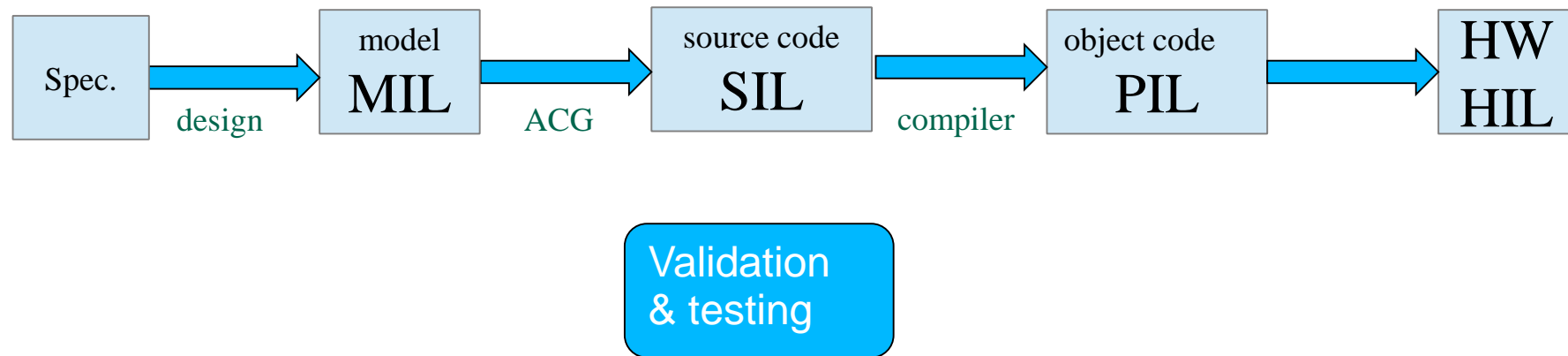
Strong process modification:

> No more specification / documentation to be defined

> Embedded code V&V: what to be validated? at which stage?

Huge impact on cost and planning gain (ECSS process agreement)

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- Select the right team to generate the code (additional training)

- Minimize ACG constraints on AOCS engineers up to end of phase B (incremental constraints),

- Definition of Guidelines (AOCS designers / Tools user)

- Definition of the new validation plan & documentation to be agreed with clients

- Integration in a more global avionics process : AOCS is not alone !

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Integration of ACG in a development process : verification & validation

```
┌────────┐         ┌──────────┐        ┌─────────────┐          ┌─────────────┐         ┌────────┐
│        │         │  model   │        │ source code │          │ object code │         │  HW    │
│ Spec.  │ ──────▶ │   MIL    │ ─────▶ │    SIL      │ ───────▶ │    PIL      │ ──────▶ │  HIL   │
│        │  design │          │  ACG   │             │ compiler │             │         │        │
└────────┘         └──────────┘        └─────────────┘          └─────────────┘         └────────┘
```

Validation & testing

At which stage and how?

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Verification & Validation of the embedded code: current & future

Design requirements

HIL or Code inspection → MIL & spec traceability

Performances requirements (RS campaign)

MIL & SIL with 2 simulators → Merge platform of simulation
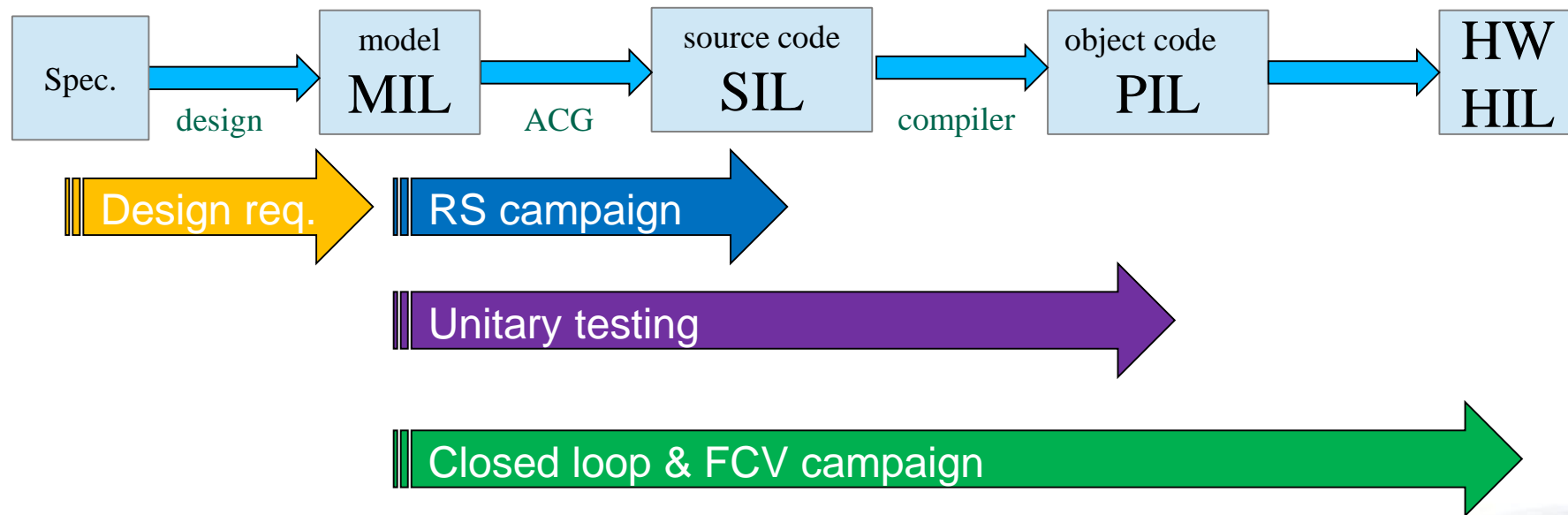
Unitary testing (software validation)

PIL (including MIL ref run) → MIL / SIL / PIL using common platform of simulation

AOCS application : closed loop

HIL (FCV) → MIL / SIL / PIL / HIL with common testing tools up to PIL at least

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Integration of ACG in a development process : verification & validation


```
Spec.  --design-->  model      --ACG-->  source code  --compiler-->  object code  ---->  HW
                    MIL                   SIL                          PIL                 HIL
```

Design req.

RS campaign

Unitary testing

Closed loop & FCV campaign

Conclusions

ACG is mature (code quality & performance, user interface...)

Gain in planning and cost achieved only when :

> Integrated in a global development process including verification & validation

> AOCS mode or application level

Main perspectives & warnings

> Agreement on verification & validation plan (ECSS)

> New constraints on AOCS users & perimeter of responsibility to be considered internally

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Questions

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