GATeL et la génération de séquences de tests fonctionnels: impact opérationnel et certification

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Juin 2015

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Related Software Activities and Testing Challenges

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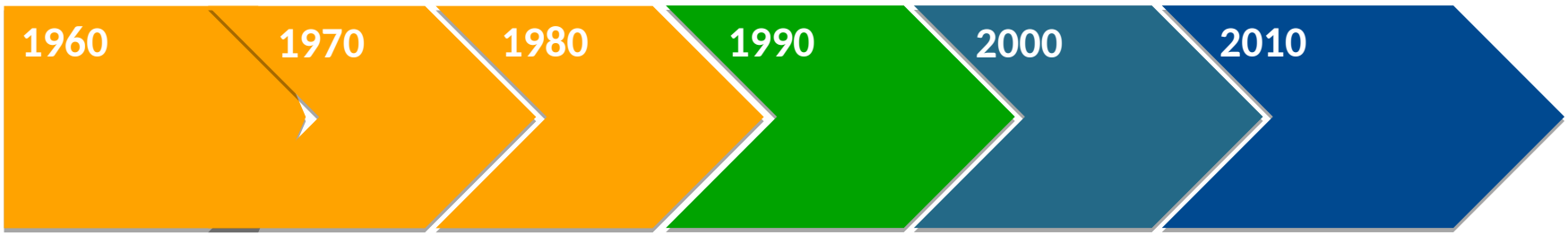
Our history

A continuous experience on the nuclear market since 1960s



1960	1970	1980	1990	2000	2010
Cooperation with CEA on neutron detection and Multibloc technology	Fessenheim 1 operating with our I&C systems (NIS, RCS, detectors, boronmeter, etc.)	First digital reactor protection system (SPIN) worldwide in Paluel 2	First long term support agreement with EDF for the French nuclear fleet	I&C retrofit of Dukovany VVER reactors from 2000 to 2009	Certification of Spinline technology by NRC, the US safety authority

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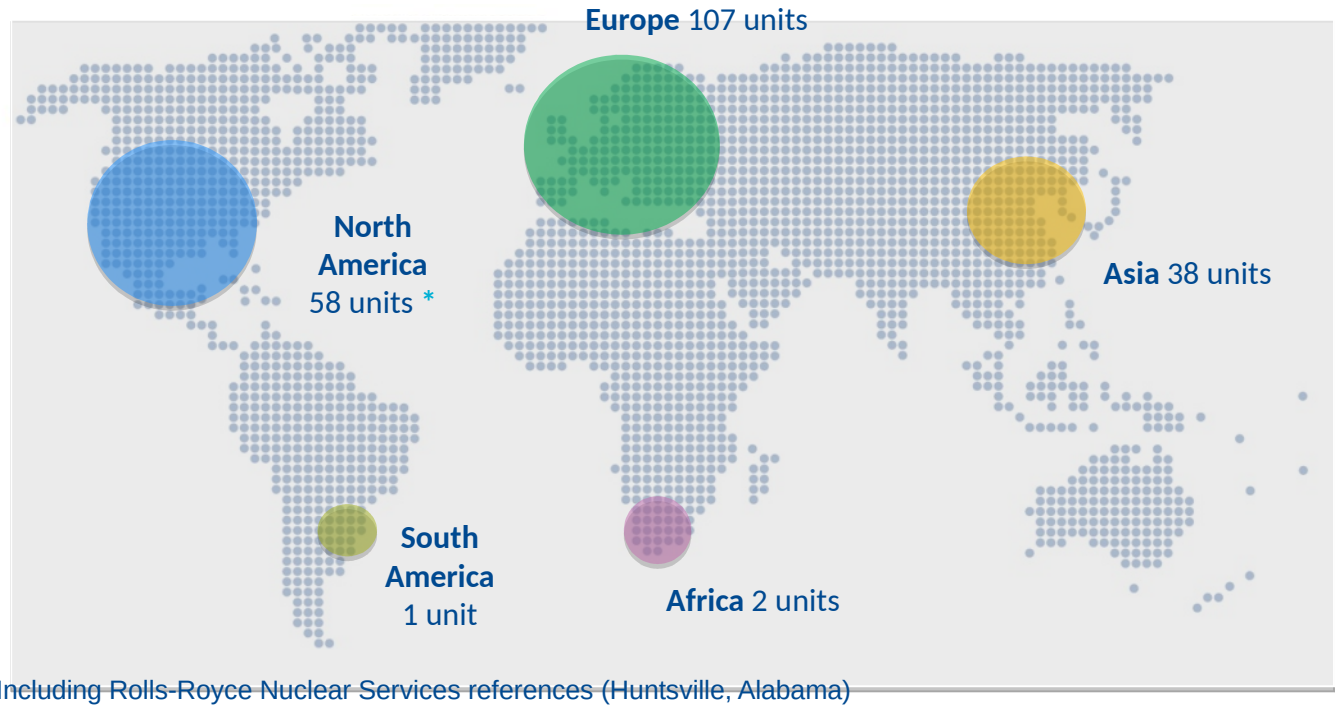
Our references

Our systems are present on 200 reactors in 20 countries



* Including Rolls-Royce Nuclear Services references (Huntsville, Alabama)

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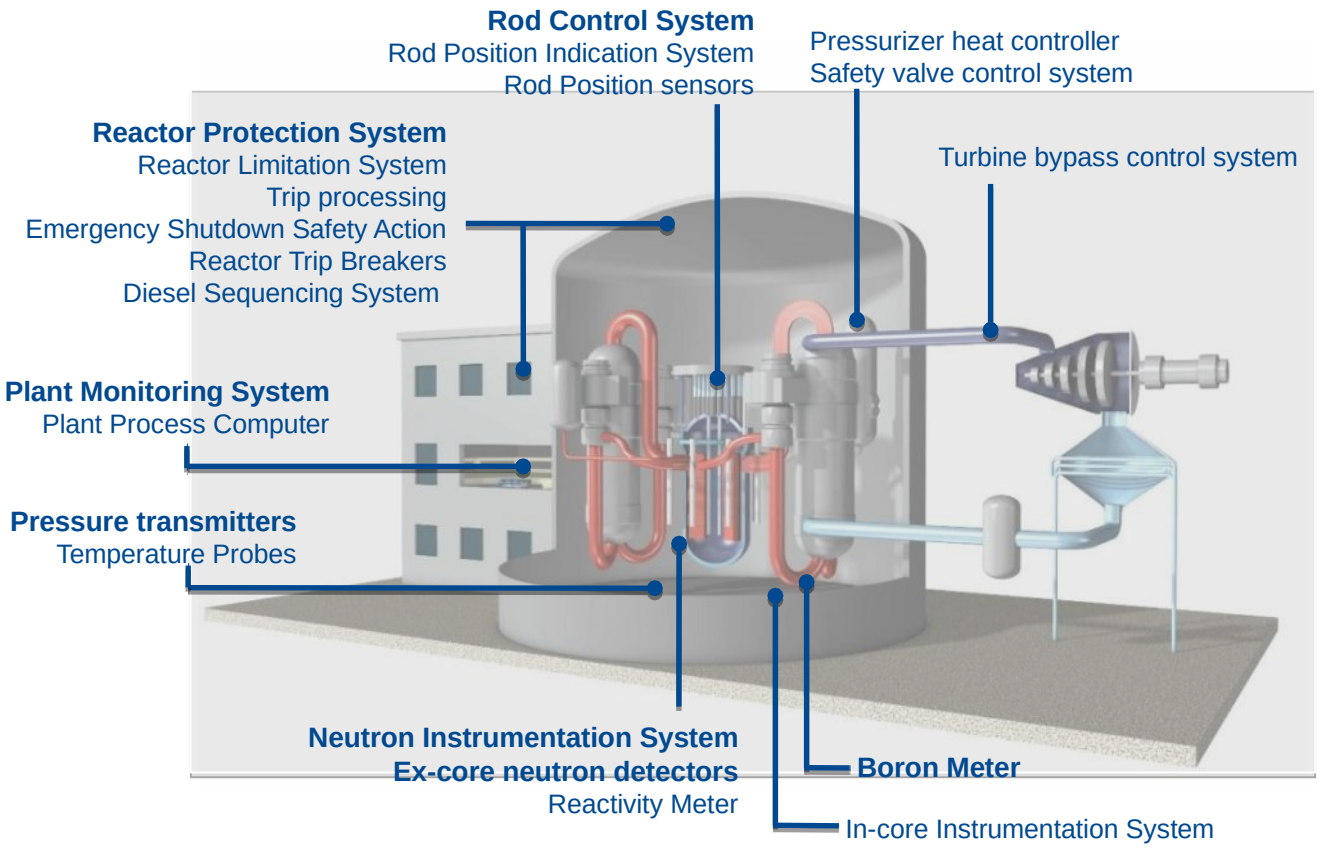
A complete range of I&C systems



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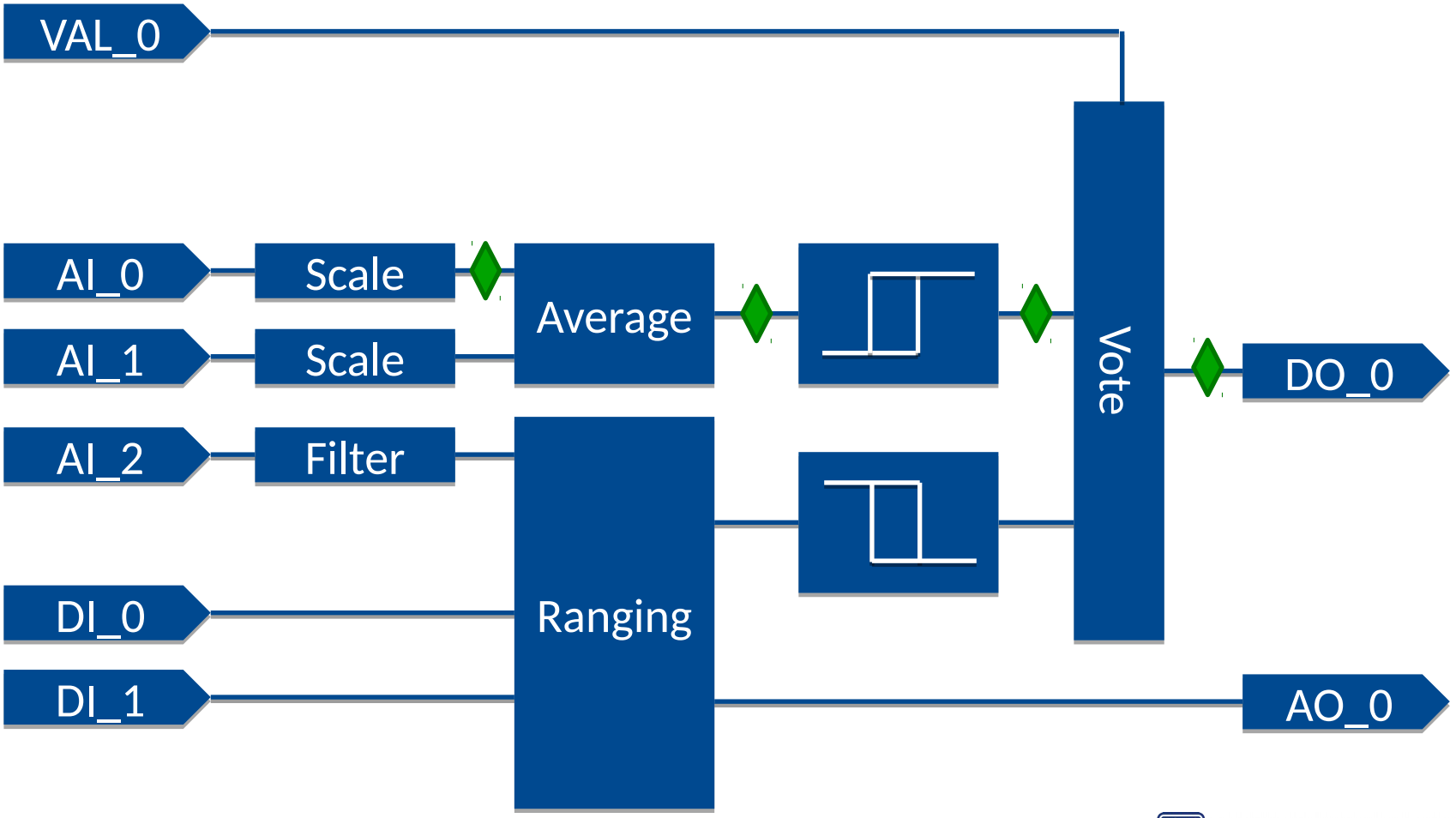
Example of safety I&C processing requirements (1/2)



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Upstream Requirements and activities

Our system requirements are typically expressed as functional diagrams fixing the structure of the SW design.

Requirements are synchronous functions combining analog and digital inputs, hard-wired or from network. These functions produce safety orders (digital) or specific measures (analog). Some intermediate nodes are visible through the network.

Our two main activities are:

- **Translating these diagrams into SW (using Esterel Scade) adding all the specific safety and technology-related requirements,**
- **Performing exhaustive V&V on these design.**

SW V&V involves quite a lot of testing. Testing effort (as a whole) is more than 50% of the SW cost.

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Test strategy

Test strategy will tell what are the expected transitions we need to check at the output of a given function.

The test engineer needs to find out the right input sequence that will lead to this expected transition.

Validation is made in black-box. If the required inputs are primary ones, then it is fairly easy. Otherwise the test engineer needs to take into account all the intermediate functions.

This can become a complex and time-consuming analytical process.

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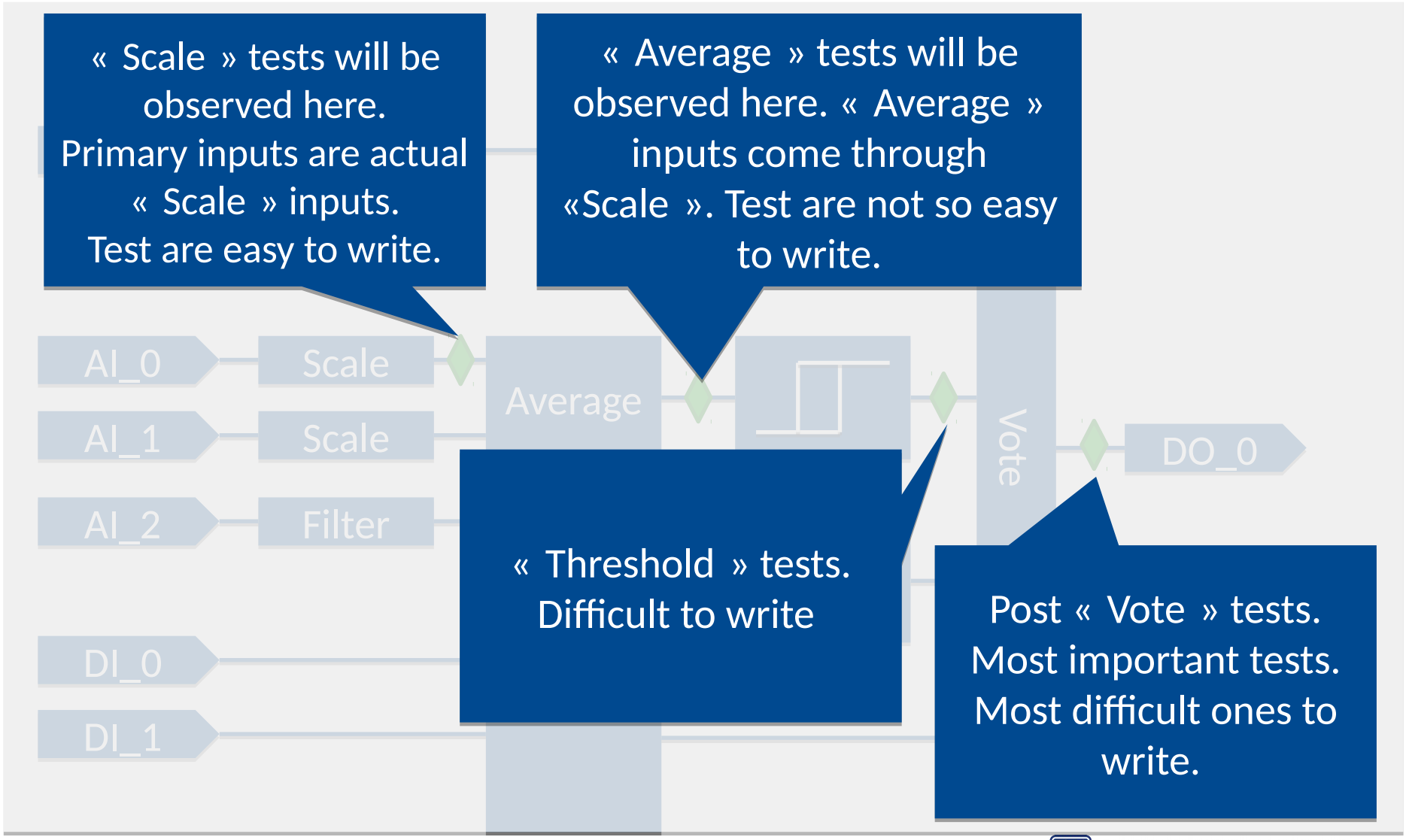
Test and observation of the results



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Problem : how to assist test engineering

Assumption: Test strategy is defined out of any tool context.

How to help the test engineer in his process of writing these test sequences in order to:

- **Save time & effort,**
- **Ensure quality (e.g. tests are in line with objectives)**

Working on this question, we initiated our work with CEA on GATeL which is able to produce input sequences for given expected output transitions

- **Without changing test strategy!**

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Solution : GATeL

We initiated an internal R&D project to validate our intuition that Gatel could be used as a test generator on a representative case study (for Neutronic Instrumentation Systems).

We worked alongside with the CEA team to address a couple of issues. They provided support, advices, as well as enhancements.

The R&D project went well (nothing blocking), and we realized that, in case of tool limitation, or any other kind of problem, we would be able to work-around them «by hand » as the strategy was un-changed.

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From evaluation to deployment

Technical feasibility

- « Our » ability to model all the functions in Lustre
- « Tool » ability to generate test sequences (e.g. no performance limitations)

Integration in our process

- Confirmation that this solution is test-strategy independent,
- Impact analysis on all the interfaces

Preparation of deployment

- Documentation update (instructions, plans, guides, etc…)
- Development and release of intermediate tools (e.g. test format conversion)

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Application to a real project

Then we decided to go for a real project: the Neutronic Instrumentation System of EDF VD3-1300MW retrofit program.

During the project, we identified and addressed a couple of issues:

- **HW validity combinations not supported by the I/O boards,**
- **Analog signal variations that are physically impossible,**
- **Test documentation was automated, but we had to work on its processing to make it readable « by a human being».**

Good final results:

- **No SW defect identified so far during system validation,**
- **SW and its documentation delivered on schedule,**
- **First-of-a-kind costs partly covered by the savings.**

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Learnings : Positive feedbacks

Requirements quality

- Enforced by an extra modeling stage made by the independent V&V team
- Ensuring clarity and exaustivity

Design exploration

- Generated tests were at times using surprising ways of achieving the objectives
- Allowing to evaluate non-classical ways of thinking the design

Evolution support

- Highly automated process once everything is in place
- Allowing to regenerate all the tests smoothly for last-moment changes

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Learnings : Actual limits and difficulties

Models and Targets

- Working first at model level might hide some limitations/issues
- Which are only visible later on a real target

Mastering Lustre

- Modeling in Lustre needs skills and experience,
- not every V&V engineers are familiar with the language

Mastering Gatel

- Using GATeL requires experience
- which takes some time to get consolidated

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Tool qualification: the IEC 60880 requirements

Our SW development process is aligned with IEC 60880, encouraging test automation tools, given some guidelines.

These guidelines are related to:

- **Tool selection / evaluation prior to use,**
- **Records of tool outputs (exhaustive logs),**
- **Relative criticality of the tool and associated qualification process,**
- **Precautions toward defects introduced by the tool.**

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Formal Tools qualification challenge

For an end user, the reliability of a formal tool is difficult to assess, extremely hard to demonstrate.

If the formal tool is used as a prover, and if these proofs are used for the final validation demonstration, then the tool qualification is a big challenge.

If the formal tool is used as a test generator, and:

- **There is an independent way to ensure the expected results (e.g. through a reference model),**
- **There is a verification process of the generated tests,**

Then there is no need for intensive tool qualification.

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Challenging qualification need

We assume that we are not able to demonstrate Gatel reliability.

So we integrated it in our process in such a way that this demonstration is not required.

We « just » substituted the « manual » test production phase by something assisted by the tool.

We rely our own reference models, as well as our own coverage metrics. We kept all our independent test verification stages.

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Conclusions

Positive experience, positive project outcome,

Smooth integration within our process, inducing improvements now broadly used,

Ability to produce long/complex test cases within a reasonable timeframe,

Simple qualification/certification process,

Requires specific skills ; maintenance of these skills needs a minimal amount of activity.

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Questions?

Thank-you very much for your attention.

Any questions ?

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