MBSSE used in the Ariane 6 launcher development

Model-Based System and Software Engineering - Future directions
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Sophie CHERQUI
Patrick CORMERY
David LESENS

AIRBUS SAFRAN LAUNCHERS

Overview

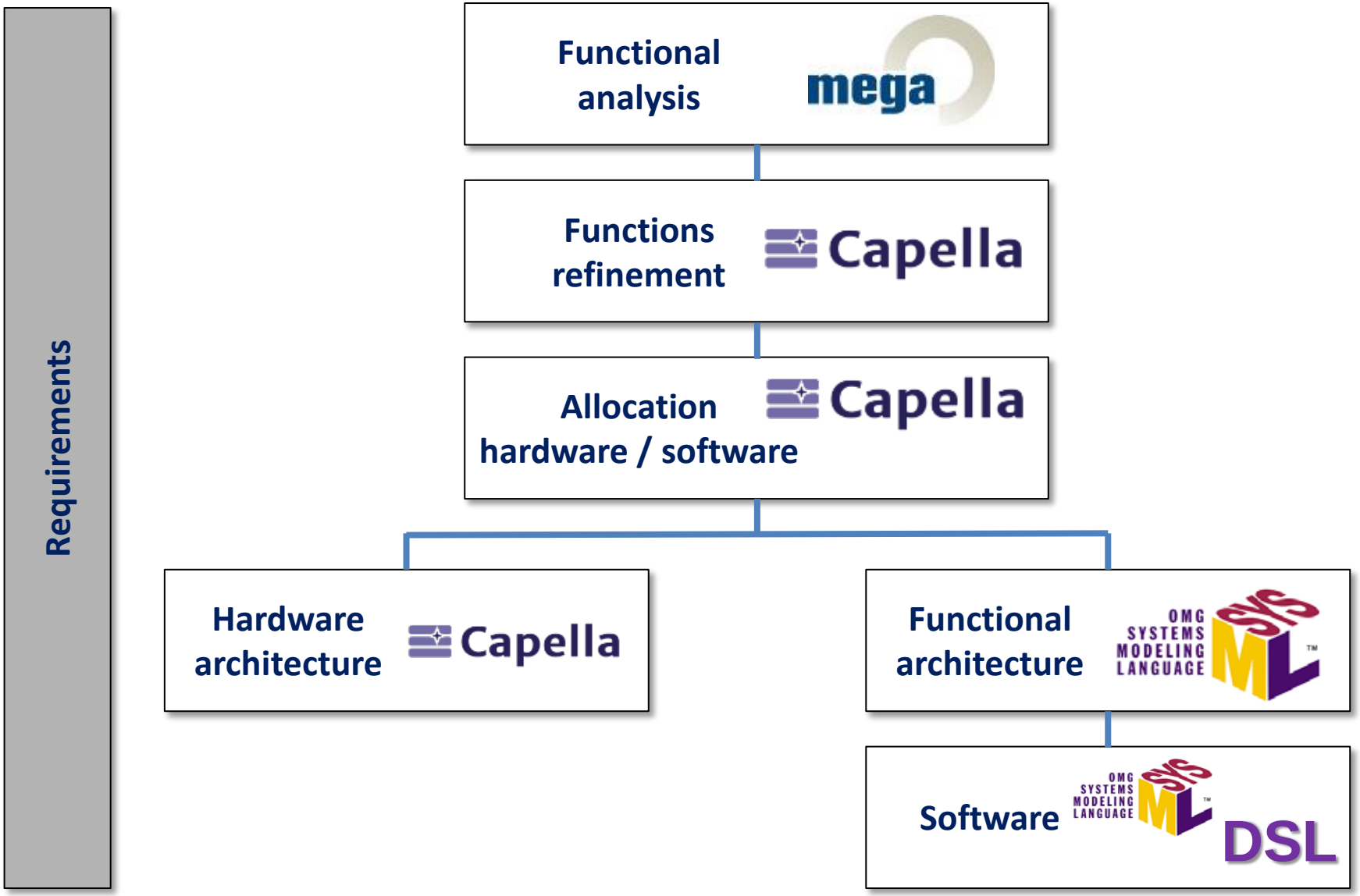
MBSSE on Ariane 6

Way forward

Feedback on COMPASS and TASTE

Conclusion

MBSSE on Ariane 6



Functional analysis with mega

Functions

Life phases

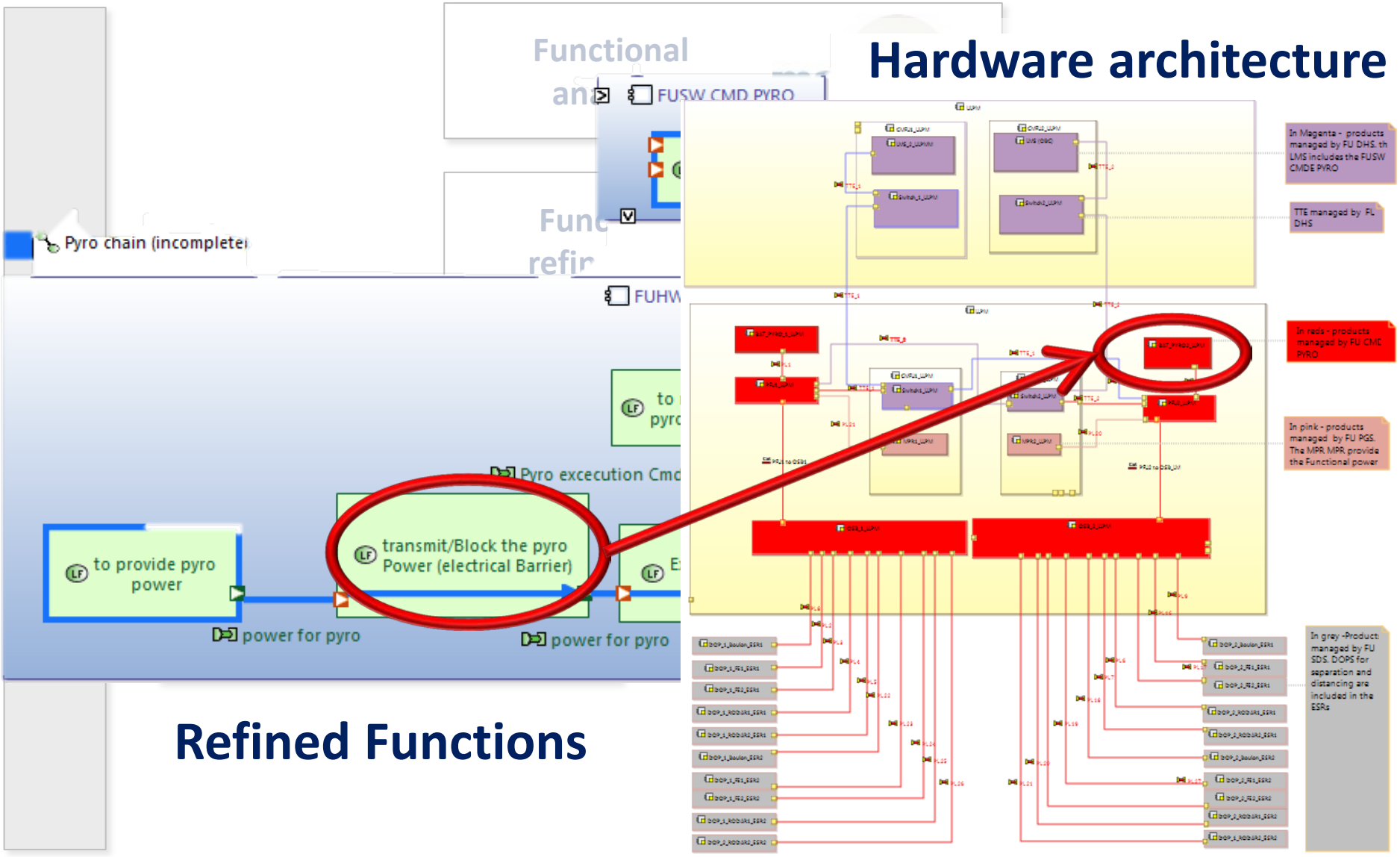
Functions

Life phase

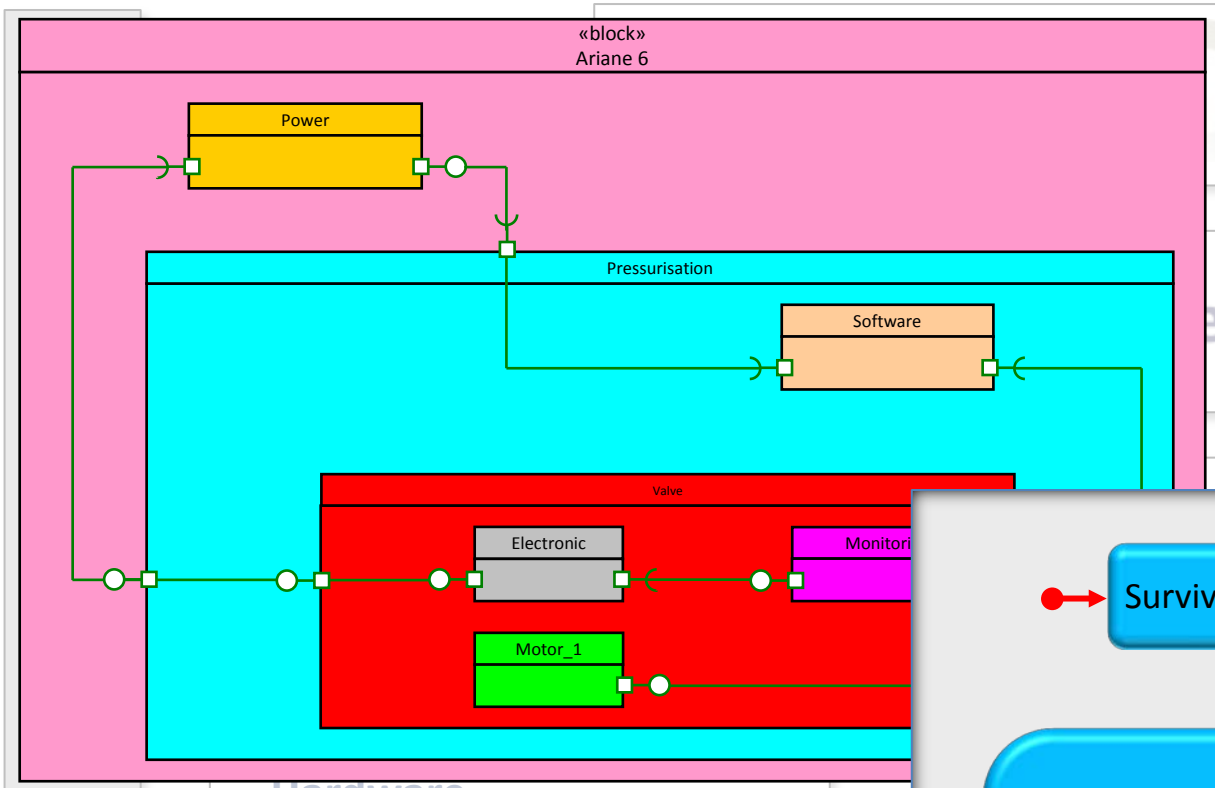
FDIR on Navigation equipments is running GNC is switching modes Guidance, Navigation and Control algorithms are running	FDIR on Navigation equipments is running GNC is switching modes Guidance, Navigation and Control algorithms are running	FDIR on Navigation equipments is running GNC is switching modes Guidance, Navigation and Control algorithms are running Commands are sent towards STVAS 4
✓ Launcher structures shall sustain induced environment of ½ separation: - shocks (pyro ignition & ESRT ignition), - thermal induced environment linked to plume effect.	✓ Launcher structures shall sustain induced environment of 2/3 separation (shocks induced by pyro ignition).	✓ Mechanical integrity STRUCT shall sustain: - Thrust transmission - induced environment (Nozzle swiveling, PO…) - natural radiation & thermal environment
✓chill-down (TBC), maintain pressurisation in qualified range, environment constraints	✓chill-down (TBC), maintain pressurisation in qualified range, environment constraints	✓ - chill-down (TBC), maintain pressurisation in qualified range, environment constraints - If distancing is done in this phase and supported by LIQ PRO
✓	✓	✓
✓ ESRL Propulsive flight phase should guaranty: - P/L Radio Frequency link with ground, - Induced mechanical environment linked to induced or natural environment compliant with a TBD level (QSL, acoustic, random, shocks), - electromagnetic fields compliant with a TBD level, - P/L depressurization rate around fairing - thermal flux radiated onto the payload < 1000 W/m ^{2}, - a cleanless level class 5000, - a low contamination: • particle : obscuration ratio (overall mission ratio < 0,005) & organic deposition • molecular (overall mission cont. ≤2. 10^{-7} g /cm^{2}TBC)	✓ ESRL Propulsiv - P/L Ra… Fre - Indu… mec… atural environment c… ndom, shocks), - electromagnetic fields compliant with a TBD level, - P/L depressurization rate around fairing - thermal flux radiated onto the payload < 1000 W/m ^{2}, - a cleanless level class 5000, - a low contamination: • particle : obscuration ratio (overall mission ratio < 0,005) & organic deposition • molecular (overall mission cont. ≤2. 10^{-7} g /cm^{2}TBC)	✓ ESRL Propulsive flight phase should guaranty: - P/L Radio Frequency link with ground, - P/L shall receive power supply (opt) - Induced mechanical environment linked to induced or natural environment compliant with a TBD level (QSL, acoustic, random, shocks), - electromagnetic fields compliant with a TBD level, - P/L depressurization rate around fairing - thermal flux radiated onto the payload < 1000 W/m ^{2}, - a cleanless level class 5000, - a low contamination: • particle : obscuration ratio (overall mission ratio < 0,005) & organic deposition • molecular (overall mission cont. ≤2. 10^{-7} g /cm^{2}TBC)
✓	✓	✓
✓	✓	✓

Mapping

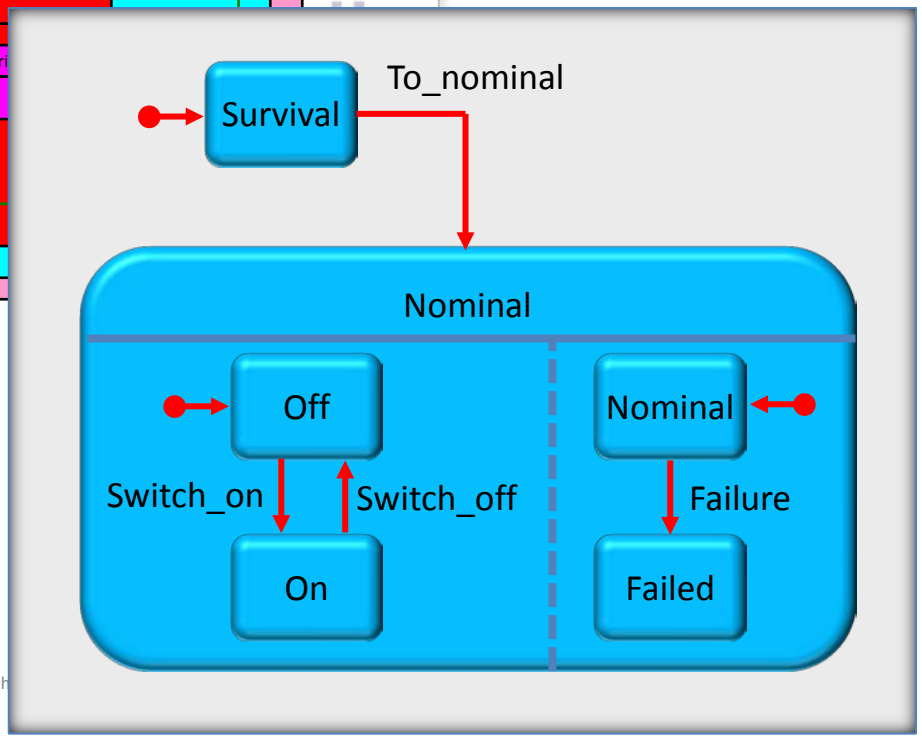
Functions allocation with Capella



Functional Unit modelling with



Functional architecture



Behaviour

Software modelling with SysML and a **DSL**

DSL = “Domain Specific Language”

Requirements

Multi-threading architecture

```
thread T1 is
      period (100 ms);
      processing (P1; P2);
end;
```

```
thread T2 is
      period (50 ms);
      processing (
            when 0 => (P3; P4);
            when 1 => (P3));
end;
```

And then Automatic Code Generation

```
package P_M_2x2 is new P_Numeric_F32.Generic_Matrices
  (N => 2, M => 2, V_N => P_V_2, V_M => P_V_2);

subtype T0 is P_Matrix_2x2_F32.T_Matrix;
function "+" (L  : in T0; R : in T0) return T0 renames P_M_2x2."+";
function "*" (L  : in T1; R : in T2) return  T0 renames P_M_2x2."*";
function Zeros return T0 is (C_Null_Matrix_2_2_F32);
```

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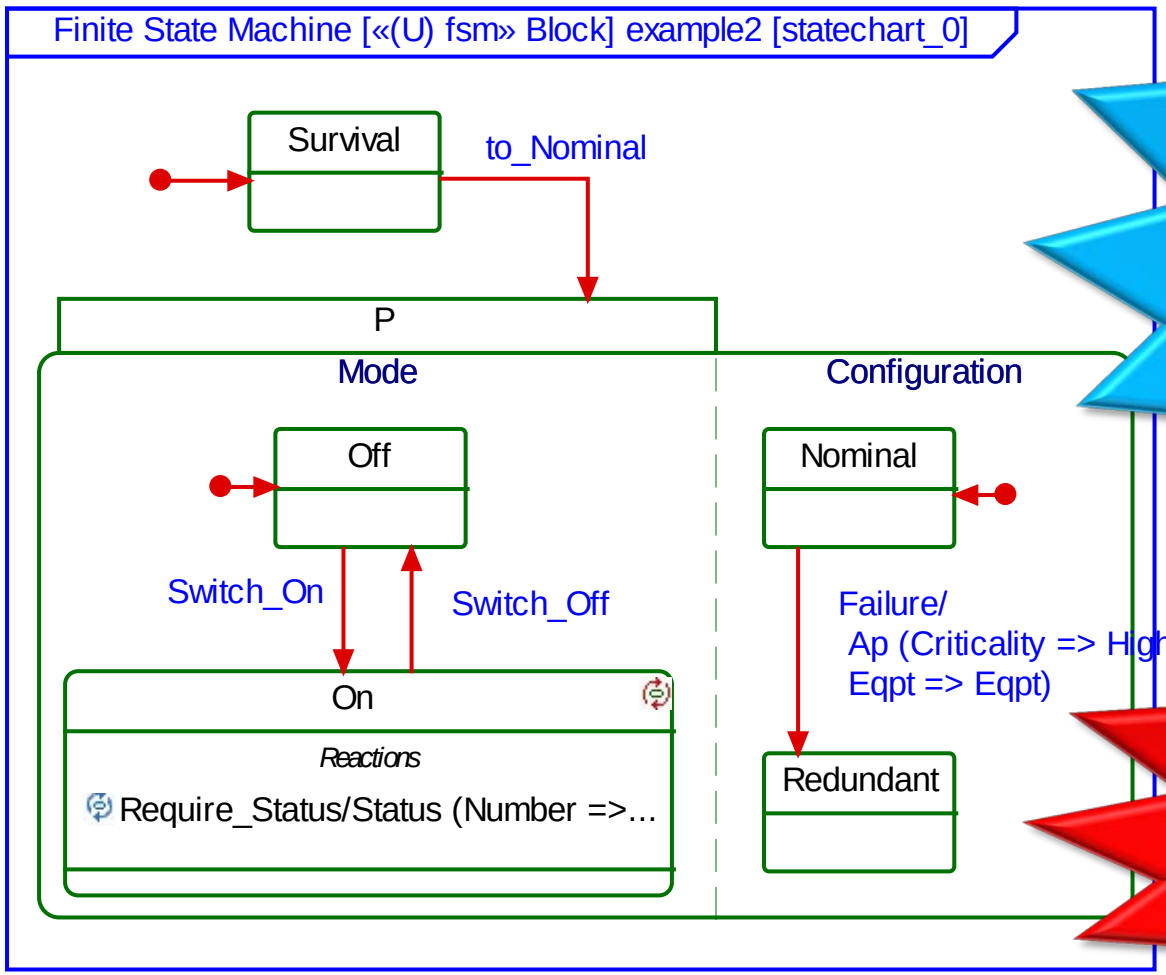
Next steps of avionics architecture modelling

Extension of MBSE scope

- ✓ Digital continuity
- ✓ Avionics engineering
- ✓ Fluidic engineering
- ✓ Ground operations
- ✓ Validation & Verification
- ✓ RAMS (Reliability, Availability, Maintainability, Safety)

Validation & Verification of models

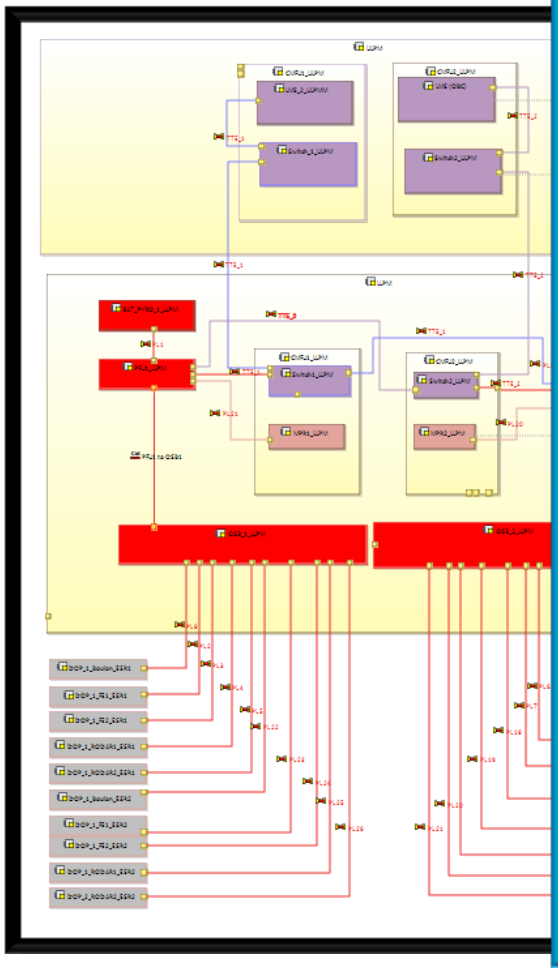


Automatic test generation

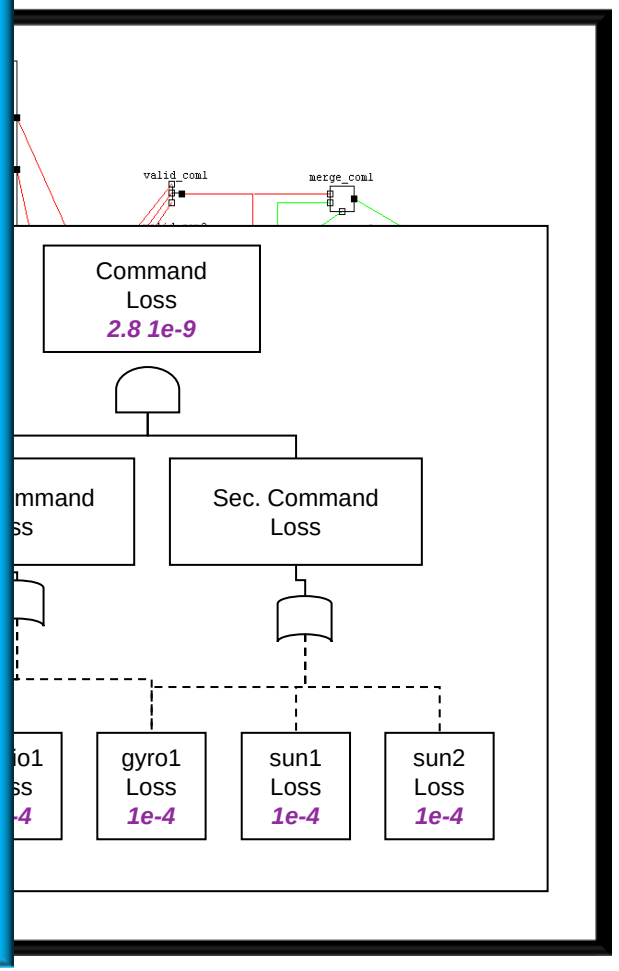
Formal proof

RAMS analysis

Engineering model



RAMS model



Shared model

=

Engineering

+

RAMS

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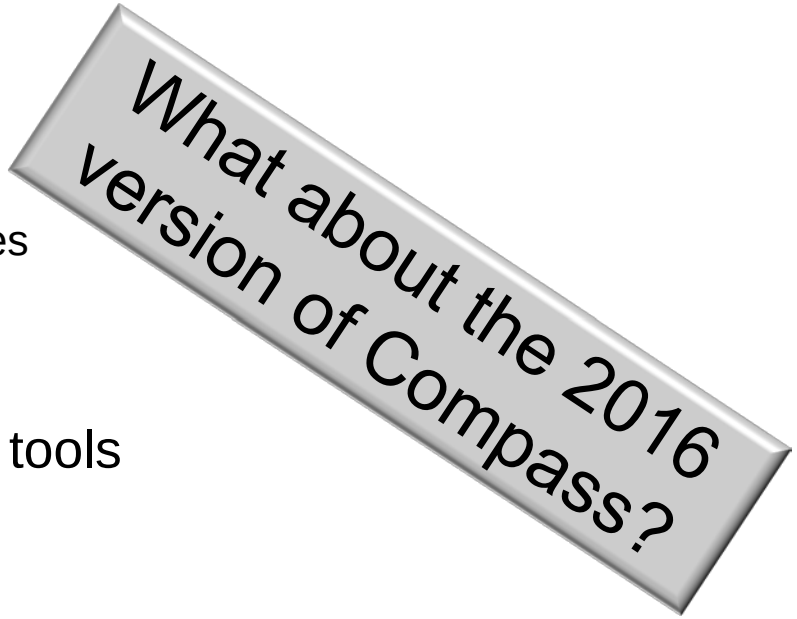
Recall: Conclusion on Compass (February 2014)

- Some improvements still needed for deployment
  - Semantics of some language constructs
    - Zeno behaviour
    - Time divergence
  - Limitation of the modelling language
    - Expressiveness of the Finite State Machines
    - Modelling of the communication network
  - Link with SysML or Capella tool
  - Improve performances on the analysis tools
  - …



- But Compass could bring great benefits
  - It allows early RAMS analyses before the actual development
  - RAMS analyses are automated

Recall on components based development (TASTE like – 2008)

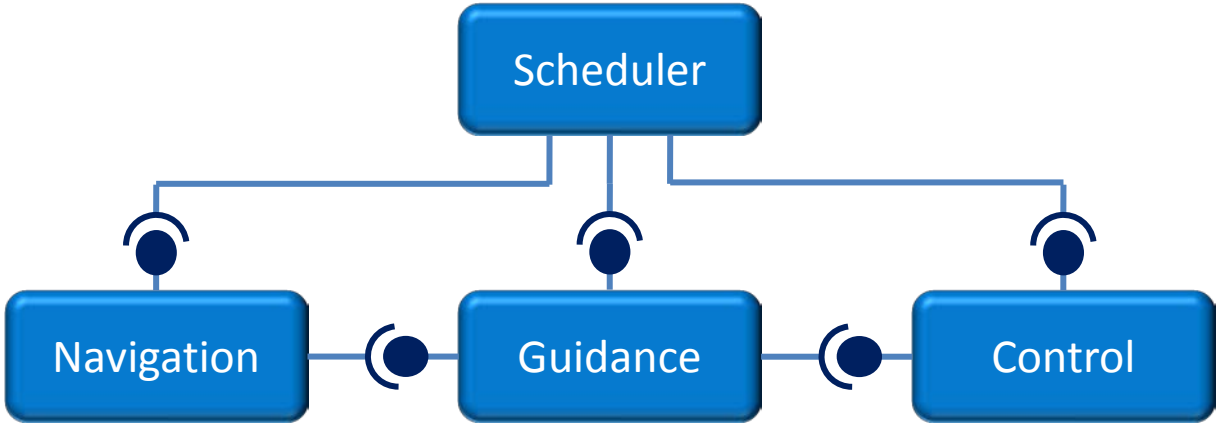
Advantages

- Standard & formal description
- WCET analysis
- Automatic Code Generation

Limitations

- Limited to the software
- Not fully adapted to a dataflow architecture
  - E.g. GNC oriented software
  - Requires the modelling of a sequencer
  - Not fully mastering of the real time behaviour
- Compatibility with SysML (?) and Capella

What about the 2016 version of TASTE?



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Launchers versus satellites

- Some specific needs
  - Flexibility is a key driver for a satellite
  - Determinism is a key driver for a launcher
  - Service oriented versus data flow oriented
- But a lot of common needs
  - Complexity
  - WCET analysis
  - Avionics analysis (power, mass…)
  - FDIR / RAMS analysis
  - …
- And a lot of possible synergies
  - Definition of common modelling languages (SysML, Capella)
  - Documentation generator
  - Analysis tools
  - …

Thank you for your attention

Contact:

- ***sophie.cherqui@airbusafran-launchers.com***
- ***patrick.cormery@airbusafran-launchers.com***
- ***david.lesens@airbusafran-launchers.com***