RATIO-SIM: Interactive Session

Rationalisation of Simulator Tools (RATIO-SIM)

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Robert Blommestijn
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• Introduction
• Stakeholder Positions
• Interactive Panel Discussion
• Conclusions
• Way forward

The detailed summary can be downloaded at: http://esaconferencebureau.com/2017-events/17c01/sesp-2017-proceedings
RATIO-SIM General

Introduction
RATIO-SIM: Objective

Alignment of simulation tools in the European Space Domain, to allow for a smooth model-based process underlying the different ETM 10-21 System Simulator Infrastructures supporting the project life cycle (cross-tool building block exchange):

- **Improvement** of overall functionality and quality while reducing cost and development time and increase the commercial viability. Building blocks could be existing or newly developed - could be COTS or made open source - could have license that allow for adaptations or extensions.

- **Obsolescence**: current Simulation infrastructures (EuroSim, SimSat, SimTG, K2, Basiles etc.) are more than 10 years old, some technology is not first choice anymore, costly to maintain

For this activity all the **major stakeholders** need to be consulted, committed and involved. This means the Primes (Airbus, Thales, OHB, ...), Agencies (CNES, DLR, ESTEC/ESOC, ...) and some SMEs (EuroSim Consortium, ...) or Vendors.
RATIO-SIM: General scope

- **System Concept (SCS)**
- **Mission Performance (MPS)**
- **Functional Engineering (FES)**
- **Software Validation (SVF)**
- **Real-time Test Bench (RTB)**
- **Avionic Test Bed (ATB)**
- **Assembly, Integration, and Verification (AIV)**
- **Training, Operations, and Maintenance (TOMS)**

**System Reference Database (SRDB)**

**Swaps**
- SW only
- HW in the loop

**Infrastructure**

**Model Reuse**
- (partial) model reuse

**Functional Validation**
Current status

**Facility chain**: due to the differences in their Use-Cases (and related specifications) and the complex Customer and Supplier Project settings in the space domain, today no single facility can exist.

**Tool chain**: connection and alignment of different modelling and simulation tools.

**In house solutions**: bespoke proprietary components with dedicated interfaces which are non-standardized (on European level).

**Heterogeneous/overlapping tools**: number of partly overlapping tools and components which are either commercial, in-house built or shared tools within a small community.
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Stakeholders position
Stakeholder Positions

• Questionnaire
  o Current status: *Major bottlenecks maintaining or replacing infrastructure?*
  o Opportunities: *Main drivers to renew current simulation infrastructure?*
  o Common interest: *European industry (Primes and SMEs) willing to cooperate?*
  o Approach: *next steps, who is in charge, who develops and maintains?*

• Stakeholders
  o Airbus Defence & Space (ADS TSOTC)
  o Centre National d’Études Spatiales (CNES)
  o Deutsches Centrum für Luft- und Raumfahrt (DLR)
  o European Space Operations Centre (ESOC)
  o OHB System AG (OHB)
  o Thales Alenia Space (TAS)
ADS TSOTC Position

• SimTG highly integrated in overall design and development process
  o Using a strong product line approach

• New requirements emerging:
  o Link to MBSE
  o Early simulations
  o Compatibility with the FMI standard
  o Improved modelling using in-orbit data
  o Automatic testing
  o Automatic modelling based on system architecture and data

• A global modelling and standardization approach is welcomed
  o However, simulation is considered a competitive advantage differentiator

• The SMP standard could be improved
  o Considering an agreed standard reference architecture
CNES Position

- Basiles is used in all CNES projects for FES, SVF, AIVS and TOMS
- Full SMP2 compliance and an MBSE approach are considered necessary
  - ESA UMF already under test by CNES, Licensing and support could be improved
- Model design tools seems easier to share than execution runtime products
  - Transformation to new tools may be complex
  - Lack of independence may be critical for maintenance and adaptation
- An agreed standard reference architecture with functional building blocks and a normalized SMP2 is considered a priority
- Open Source developments shall be considered
DLR Position

- No need for additional standards
  - Complexity of existing standards such as SMP is too high
  - Improvements needed on training and lowering the learning curve
- No one simulator for all
  - Allow full control over implementation to adjust to individual business needs
- Simulator development has to start and be considered beginning from the system model
- SSRA and SMP shall be updated considering other emerging standards such as OCDT and EGS-CC
- Provision of accessible reference implementations e.g. for FES and SVF, including the relevant models, would be a great step forward
ESOC Position

• The SIMULUS package including the SIMSAT kernel is used for all ESOC supported missions
• Levels of rationalization and reuse apply to:
  ▪ Processes and standards, tooling, the basic simulator architecture and generic models, reference spacecraft architecture and specific models
• The balance between highly generic features and specific features shall be such that the optimum for economic reuse benefit is reached
• Reuse of models can only be reached if:
  ▪ An agreed reference architecture exists
  ▪ Model suppliers have an incentive to develop reusable models
• Governance of shared tools shall be agreed, e.g. using Open Source
OHB Position

- SMP runtime environment Rufos is used together with platform and common models to compose the OHB Software Base Simulator shared between projects.
- Future rationalization of Modelling and Simulation Infrastructure is supported when a modular approach is followed, with single well-defined improvement projects for specific parts of tools.
  - With an incremental migration path for individual parts costs can be minimized.
- Standardization work must keep up with new (software) technologies.
TAS Position

• The simulation platform K2 concerns a centralized architecture, models sharing using SMP, and simulation kernel and services
  ▪ One-time model development at an organization central level, continuously increasing the maturity, successively for AOCS FES, SVF, AIVS and TOMS

• Next generation Simulators to be based on a new architecture driven by tools sharing and models sharing (native SMP solution)
  ▪ The RATIO-SIM study shall in the short term clarify the technical perimeter, i.e. the chosen reference architecture, the identification of building blocks and the definition of the high-level requirements
  ▪ Future customer needs shall be considered, such as improved performance and parallelization (multiple emulators)
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Panel discussion
Interactive Discussion

- Organization and approach
- Discussion Panels
  - Panel 1: Competition or Joining Forces?
  - Panel 2: Make or Buy?
  - Panel 3: What to Rationalize?
  - Panel 4: Rationalization or Standardization?
  - Panel 5: Where are we today?
  - Panel 6: Any other suggestions?
Panel 1: Competition or Joining Forces?

**Single or multiple implementations?**

**Sharing development and maintenance costs?**

- Competition is envisaged at the level of Primes
  - Simulation provides a differentiating business value
- SMEs may not have sufficient resources for development
  - Reference implementations for specific building blocks
  - Based on shared developments and/or Open Source
- Competition at the lower levels
  - Small companies may lead innovation in specific areas
- Joining Forces especially for innovative developments
  - Focus on areas not yet covered by existing tools:
    - Model Development Tools, Open Tool Chains, Shared Models
      - Consider Interoperability of Tool Chains
  - Application of emerging technologies: Big Data, AI, Digital Engineering
Panel 2: Make or Buy?

Is the Space Domain special?

COTS vs dedicated solutions, spin-in?

• To maintain a proper supplier base "buy" is important
• Reuse OSS/COTS to increase commonalities with other applications
  ▪ Build only if it does not yet exist
  ▪ Do not reinvent the wheel, look at other domains
• Buy only COTS supporting open standards
  ▪ Promoting or creating these open standards
• Strong product policy needed to allow the reuse across projects
Panel 3: What to Rationalize?

What should be the scope?
Which facilities/components/building blocks?

- First a consensus on the Workflows, Reference Architecture and Interfaces should be reached before implementation can start
  - Further elaboration on SSRA and REFA required
  - Interfaces may be subject to Standardization
- Hereafter some weak spots in the tooling should be tackled
  - Modelling tools, Archiving, Drivers, reusable SCOEs

*If the tooling is modular enough, the Reference Architecture and Standards become less important*
Panel 4: Rationalization or Standardization?

Are current standards (SMP/SSRA) all we need? Which interfaces could be agreed upon?

- First standardization then rationalization
  - Excess rationalization may kill competitiveness
  - Flexibility for customization and differentiation is required
- Standards must be simple to allow for easy adoption
  - Tooling, reference implementations, documentation, compliance suites
  - SMP standardization beyond level 2: architectures, conceptual data models
- New areas of standardization could be considered
  - Simulator configuration, automation of writing test procedures and performing test execution, distributed simulation, simulation data archiving and data exchange
- Prefer existing standards above inventing new ones
  - Considering the use of Electronic Data Sheets (EDS) for simulators
  - Lessons learned from other industries (e.g. automotive, FMI)
Panel 5: Where are we today?

Strong and Weak points, Opportunities and Threats
Processes, Methods and Tools, Infrastructures

- Weakness: Current state of SMP
  - Model exchange still challenging
  - Standard limited to space industry only
  - Difficult licensing process
  - No SMP compliance suite
  - Validation not addressed
  - Models are not fully Plug-and-Play

- Opportunity: Coupling the model development to MSBE and Digitization
  - Considering the FMI standard

- Thread: Level of investment and legacy of companies
Panel 6: Any other suggestions?

*Burning questions/remarks?*

*Any bright or disruptive ideas?*

*Way forward: Roadmap, Outlook, etc.*

- Lessons learned
  - Look at other industries (automotive, aeronautic, nuclear, banks)
  - Collaborate with other agencies and universities
  - Start small – make it work – enhance it
  - Different simulations have different users, e.g. TOMS: operator with focus on the MCS, SVF: OBSW software developer with focus on the CPU

- Potential topics for harmonization: failure injection, Artificial Intelligence (AI), reusing flight data to improve simulation models, multi-physics modelling, providing a “playground” for development, demonstration and training

- Potential topics for standardization: SMP compatibility with FMI, configuration and parameterization, system design translated to model design, better documentation of standards to allow for easy adoption and “play around”, applying modern knowledge management tools (Web pages, Wiki, social networks)
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Conclusions
Conclusions (I)

• An evolutionary approach is preferred over a revolutionary approach
  o Considering the current level of investment and available legacy systems
• Starting from a commonly agreed architecture, building blocks could be identified and standardized interfaces could be defined
• Simulation is considered a competitive advantage discriminator for the primes
  o The harmonization of core simulation components may be difficult to achieve
  o Replacing these core components will imply major work, including the effort required to reach the needed maturity, including revalidation
Conclusions (II)

• Start with those building blocks that are still in rather unexplored territory, or at the forefront of (software) technology
  ▪ Artificial Intelligence (AI), the Digital Twin and use of flight data to update or check the simulation in real-time, Parallel, Distributed and Cloud computing, etc.
  ▪ Small companies may be involved here, as these may be more flexible and effective in adopting new emerging technologies
  ▪ Open Source could be used here to support shared developments and the easy dissemination of the results amongst all of the stakeholders
Conclusions (III)

• The SMP standard is currently widely used for space system simulators
  ▪ The current ECSS SMP effort shall stabilize the level 1 and level 2 standards

• Standards shall be as simple as possible to allow for easy adoption
  ▪ Proper documentation and training material shall be provided
  ▪ For smaller players freely available reference implementations would be beneficial
  ▪ Validation approaches and conformance suites shall be considered
  ▪ Modern knowledge management tools, such as Web pages, Wiki, social networks, may be utilized
  ▪ Online familiarization tools, model testing tools and conformance checking tools may be provided

• Considering the further evolution of SMP beyond level 1 and level 2
  ▪ Support for standardized architectures and conceptual data models
  ▪ SMP compatibility with the FMI standard, emerging from the automotive industry
Conclusions (IV)

• Further evolution of Reference Architectures, such as REFA and SSRA
  ▪ Possibly be converging into a single generic architecture
  ▪ Covering all possible use cases from any of the stakeholders
    o Possibly utilizing a “standardization-like” process
  ▪ Linking this architecture to the system engineering models (MBSE)
  ▪ Considering other avionics standards
    o Electronic Data Sheets (EDF), providing equipment engineering data

• Other potential topics for standardization:
  ▪ Simulator configuration, automation of writing test procedures and performing test execution, distributed simulation, simulation data archiving and data exchange, visualization, etc.
Way forward

RATIO-SIM is listed in GSTP compendium
[Ref: GT17-053SW, Budget: 1.5M€]

- **Preparation**
  - Activity Objectives
  - Workshops with stakeholders

- **Phase 1: Definition**
  - Reference Architecture
  - Engineering Processes

- **Phase 2: Implementation**
  - Interfaces and Standardization
  - Building Blocks
  - Emerging Technologies, proof of concept
  - Methods and Tools
  - Other Considerations
Thank you for your attention