SPRUCE

Standardization Practices for a Responsible Use of Computational models in Engineering

MODPROD workshop 3-4/02/2021

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RISE: the Swedish research institute and innovation partner for every part of society

Applied Research and Development

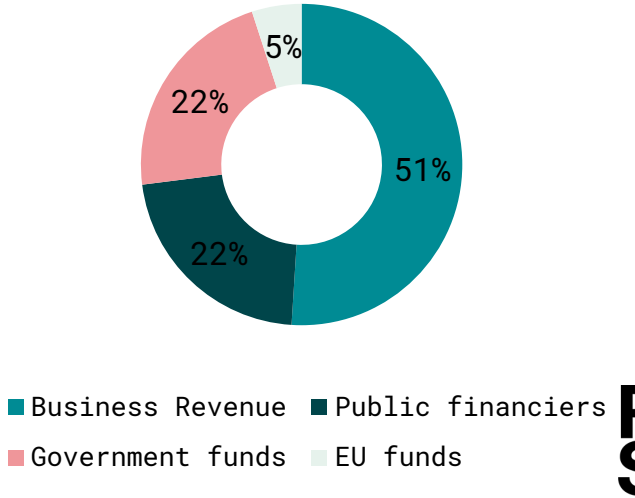
- Research and Innovation projects
- Expert consultation
- Service design and design processes
- Innovation support for SMEs

Industrialisation and Verification

- Testbeds and demonstration facilities
- Technical assessments and verification
- Prototypes and pilot line production

Quality Assurance

- Certification



Applied Mechanics

Short facts

- Department within the Materials&Production Division
- Researchers, engineers, technicians, administrative staff ~ 60 employees (Borås, Gothenburg, Umeå)
- Central node for solid and structural mechanics at RISE
- Large experimental & simulation capabilities. Focus on ***uncertainty quantification***, ***model validation***, ***quality assurance***
- Cross collaborations across entire RISE -> materials, manufacturing, certification
- Active mostly all industrial sectors (primarily, construction industry & infrastructure, automotive, energy)

Example of load frame for material testing

Max force 1.2 MN

What is a standard?

European Committee
for Standardization

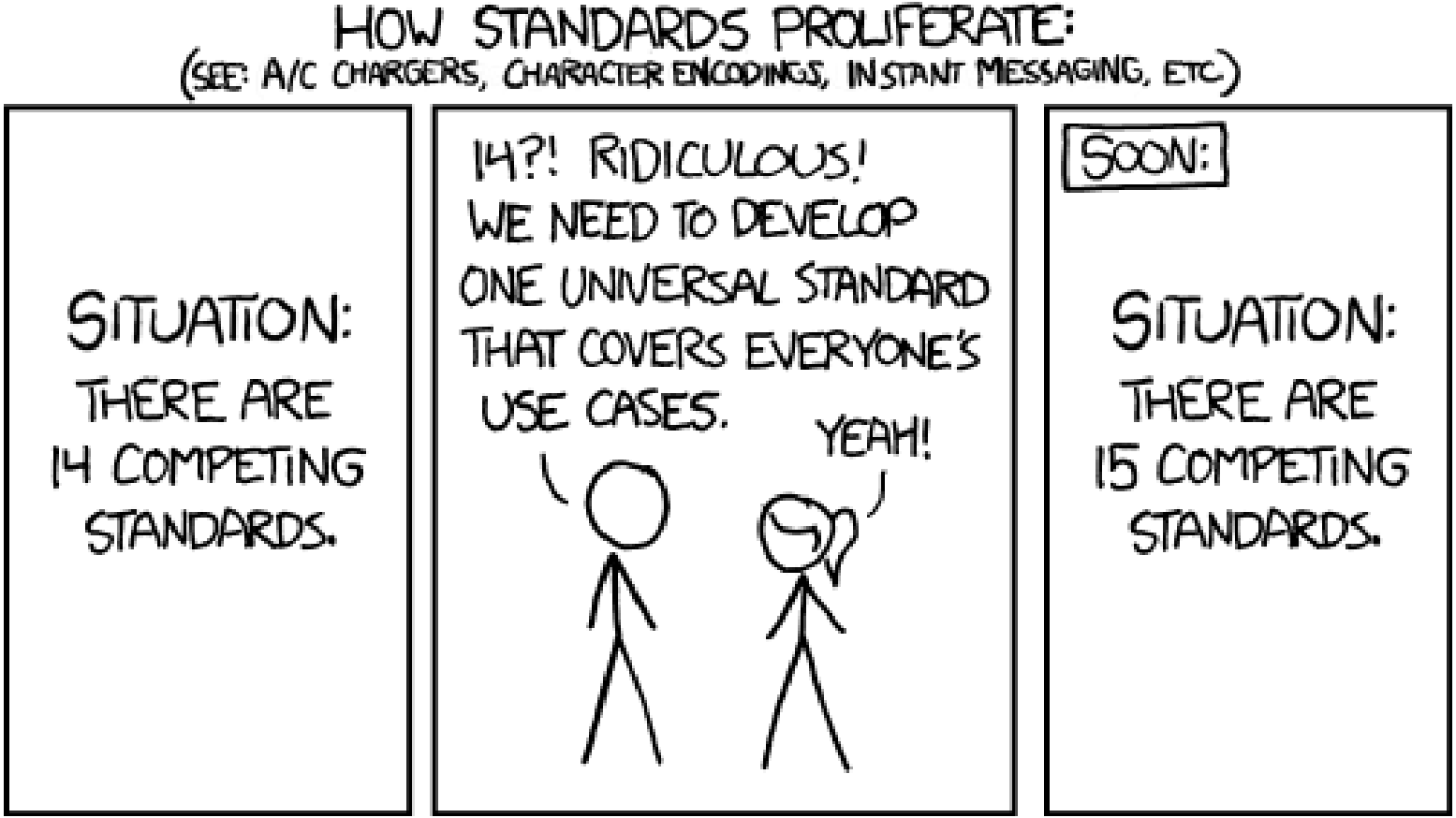
A standard is a technical document designed to be used as a rule, guideline or definition. It is a consensus-built, repeatable way of doing something.

Standards	=	**technical expertise + needs of stakeholders**
(distilled wisdom) ISO, CEN, ASME IEEE, BIN, etc		(manufacturers, sellers, buyers, customers, trade associations, users, regulators, …)

Quality management, environmental management, health and safety, building, food safety, etc.

Benefits:

- Safety, reliability
- Interoperability
- Outcome of R&D
- Common understanding



https://xkcd.com/927/

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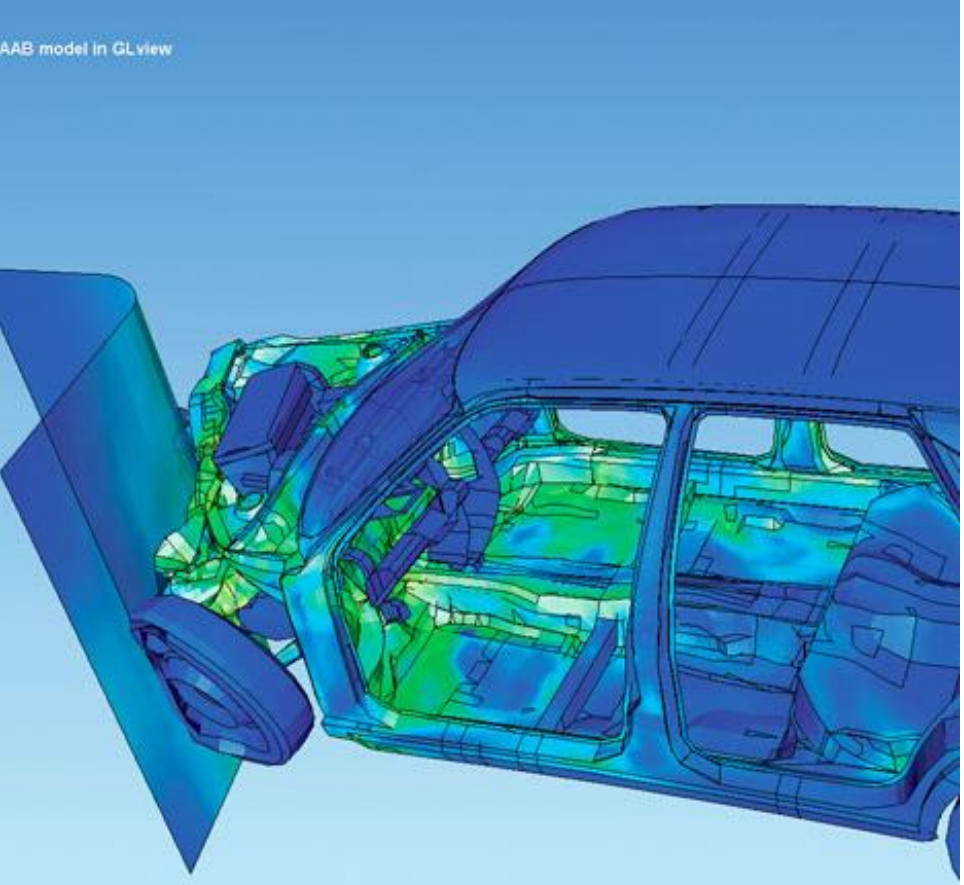


Standards and numerical simulations

- Growing role of numerical simulations in product developement and decision -making processes (e.g. smart maintenance, digital twins)
- Reliability and safety of products are traditionally based on physical testing, quality control and certification processes. Conformity assessment via numerical simulations is gaining acceptance.
- Can we trust models as much as measurement devices?
- Are current standards adequate to safely perform conformity assessment via numerical simulations?
- Are quality standards for numerical simulations widely adopted in industry?

Public Domain, wiki

Standardization and numerical simulations

Why bother? What can go wrong?

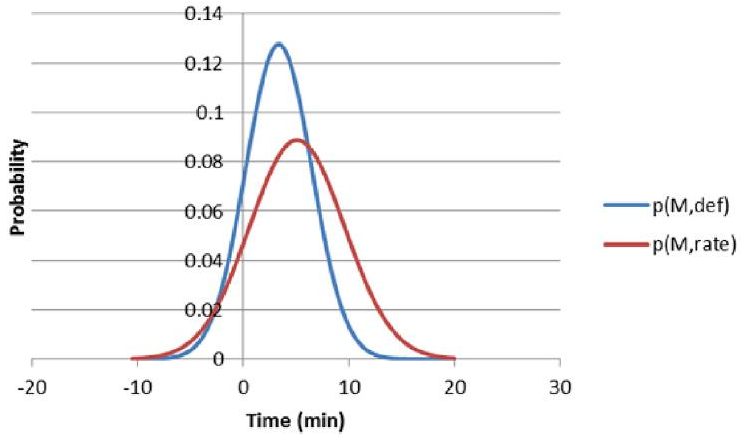
Fire Safety Journal 92 (2017) 64–76

A round robin study on modelling the fire resistance of a loaded steel beam

David Lange *, Lars Boström

RISE Research Institutes of Sweden, Safety and Transport/Fire Research, Sweden

[...] calculations or simulations are now often used as an alternative means of evaluation of structures exposed to fire compared with testing. For building elements and structures in Europe the Eurocodes are the basis for design, and these allow calculations in simple or advanced design methods. For certification of certain building products calculations have the same credibility as testing. However, while for testing there are requirements on accreditation of the test laboratory as well as follow up inspections, this is not the case for calculations. In other words, when evaluating building products for certification based on testing there is a formal control system that must be followed. This type of control does not exist when doing the same job based on calculations.



$M \sim T - C$ (Prediction by Test – Prediction by Calculations)

$Prob(M < 0 \equiv \text{unsafe calculation}) \approx 13\%$

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From standards and numerical modelling to standards *for* numerical modelling

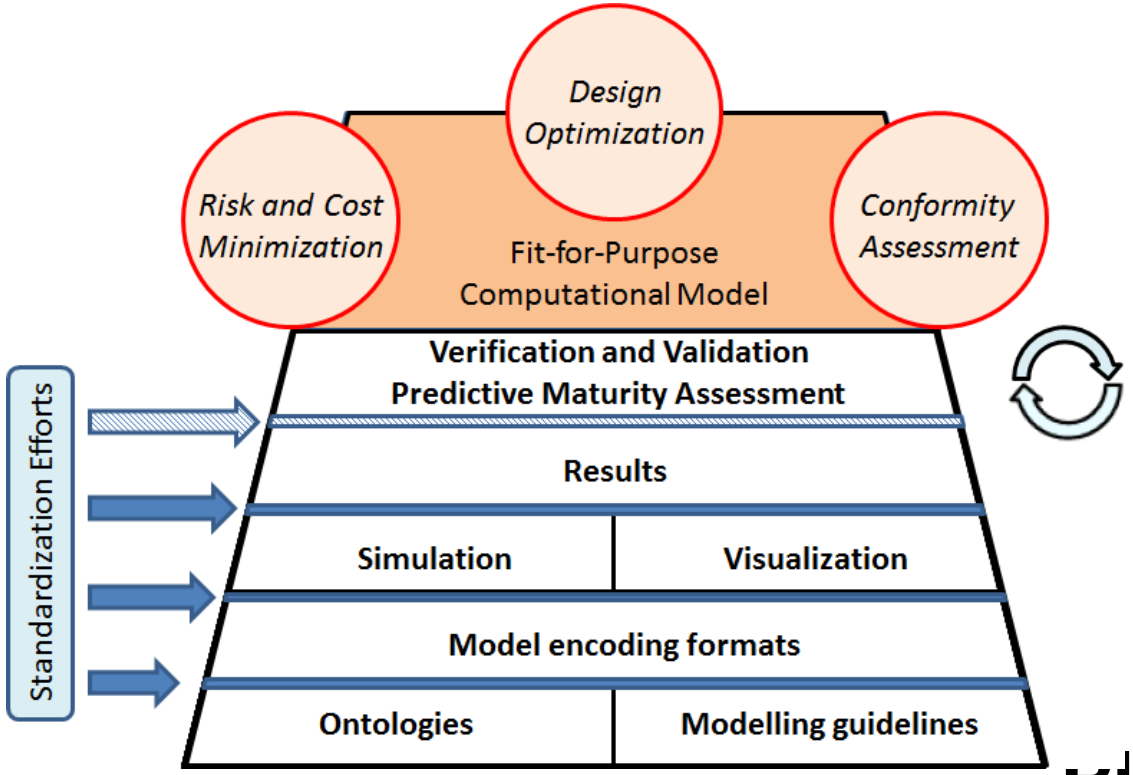
- Standardization can affect many aspects of modelling and simulation
- Standardized practices for verification and validation as key elements to secure the *fitness for purpose* (alt. *credibility*) of computational models.

NAFEMS Standards Initiative

https://www.nafems.org/publications/standards/

Interoperability for integrated modelling of manufacturing processes:

VMAP https://itea3.org/project/vmap.html



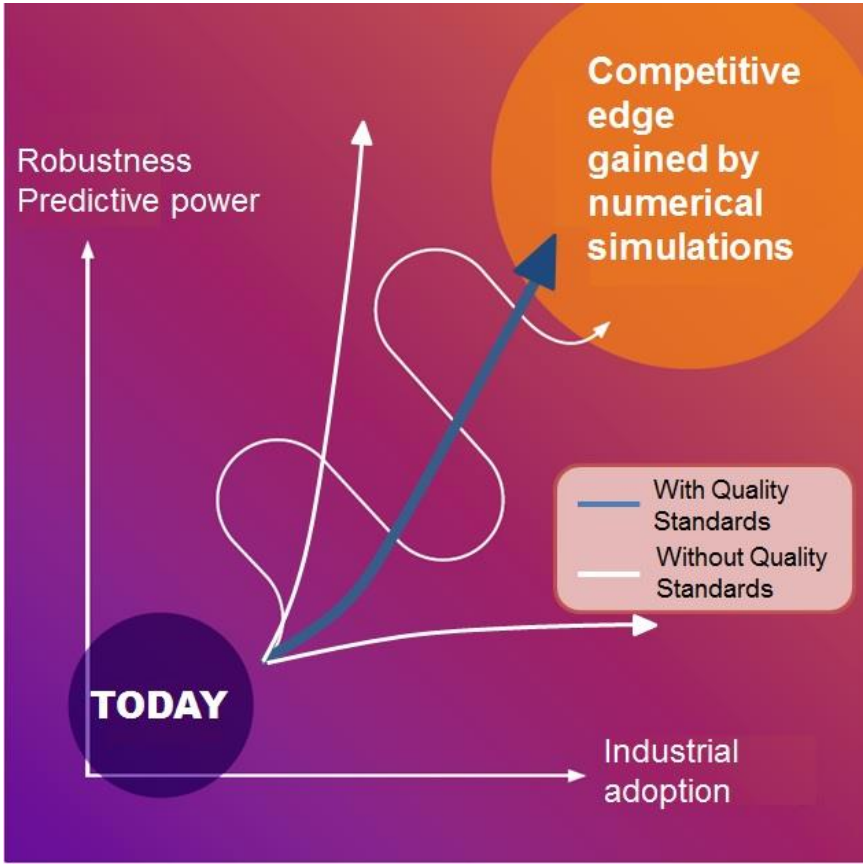
Project SPRUCE

Scope and limitations

- The focus of the study is on standards and quality assurance methodologies for numerical simulations with possible applications in Swedish industry.
- No development or implementation of specific solution, only survey.

Goals

- Produce a mapping of current practices and identify industrial needs in the area of quality assurance of numerical simulations.
- To develop a roadmap/ strategy for standardization initiatives in quality assurance of numerical simulations in industry



Introduction

- The survey was developed in August – October 2019 and interviews conducted from November 2019 to early February 2020.

- **23 questions** (with sub-questions), partly **quantitative** and partly **qualitative**, structured in five chapters: 1) Terms and definitions; 2) Persona and organisation; 3) Process and methodology; 4) Tools and environment; 5) Confidence building and quality appraisal activities

- No rigorous design of the sample (no conclusions by statistical inference, the primary goal was mapping out the state of art)

- About 40-45 people contacted for interviews, **30 accepted**. Focus on experts of numerical simulations (any field) in Swedish ***industry***

- Data collection through **interviews** in person or remotely

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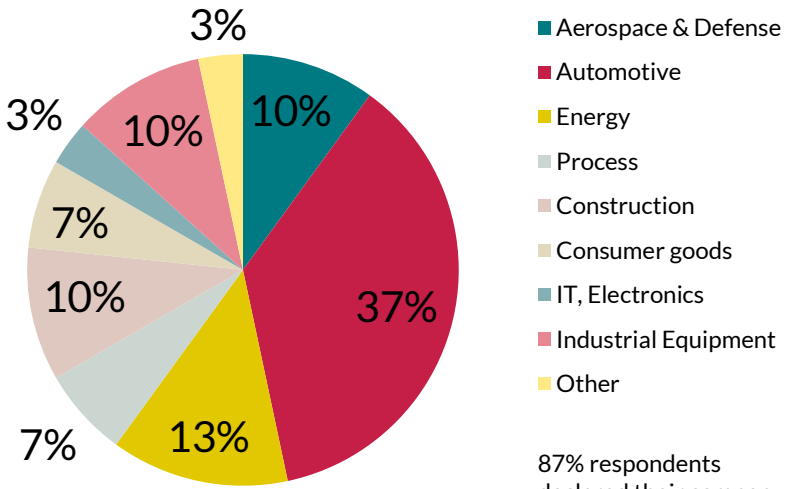
Survey structure

- Sample characterization
    - industrial background
    - qualifications and work environment
    - methods, tools and applications
- Analysis management
- Quality/credibility assessment
- Challenges and vision

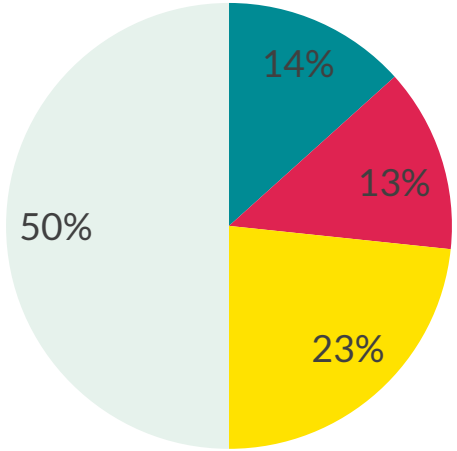
Sample characterization

Respondents distribution per industrial sector



87% respondents declared their company resorts to numerical simulations *continually*

Respondent distribution per company size

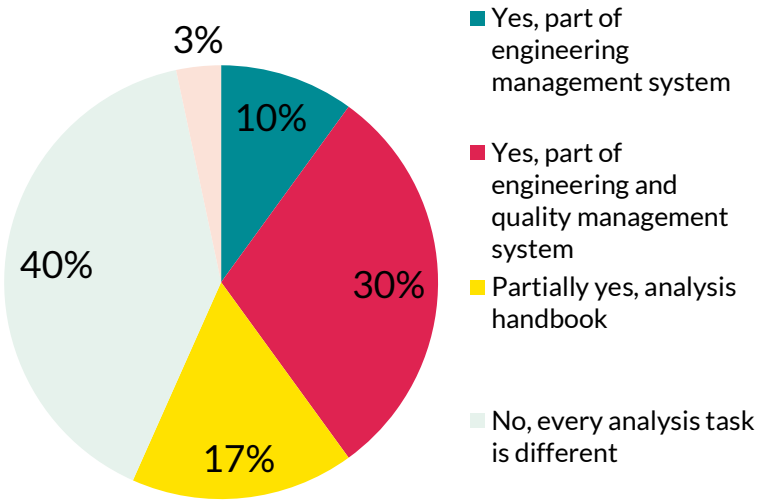


Number of employees

<= 500 | 500-2000 | 2000-10000 | > 10000

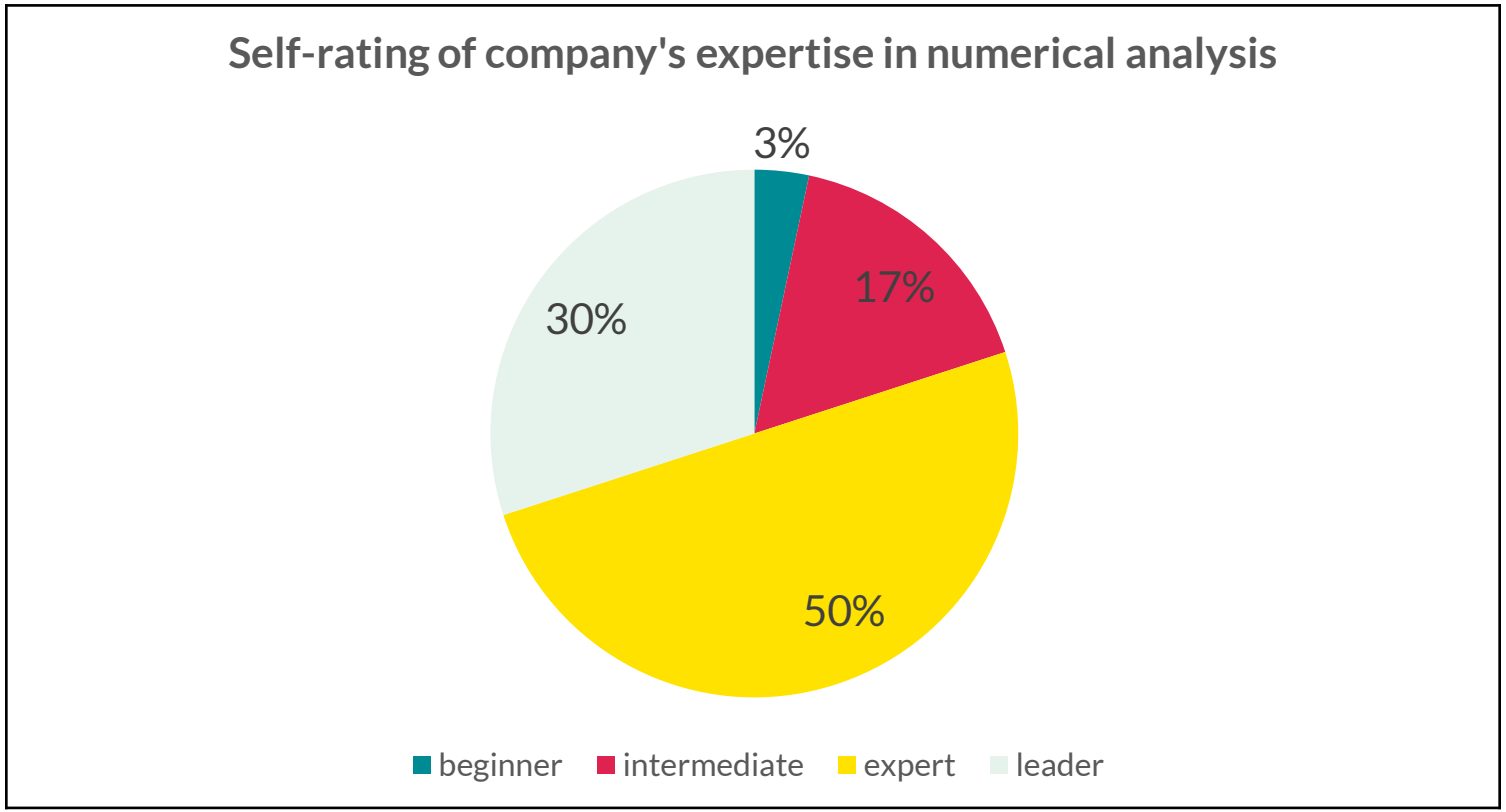
Analysis management

Process model for analysis management



Typical steps in analysis	
1	sales of analysis services/dialogue, including estimation of time to complete the tasks;
2	start up meeting with the client;
3	execution of the analysis and control (supervision);
4	review of the results (possibly, comparison with hand calculations) and analysis files;
5	Delivery to the client (+ documentation, including decision)

Quality/credibility assessment



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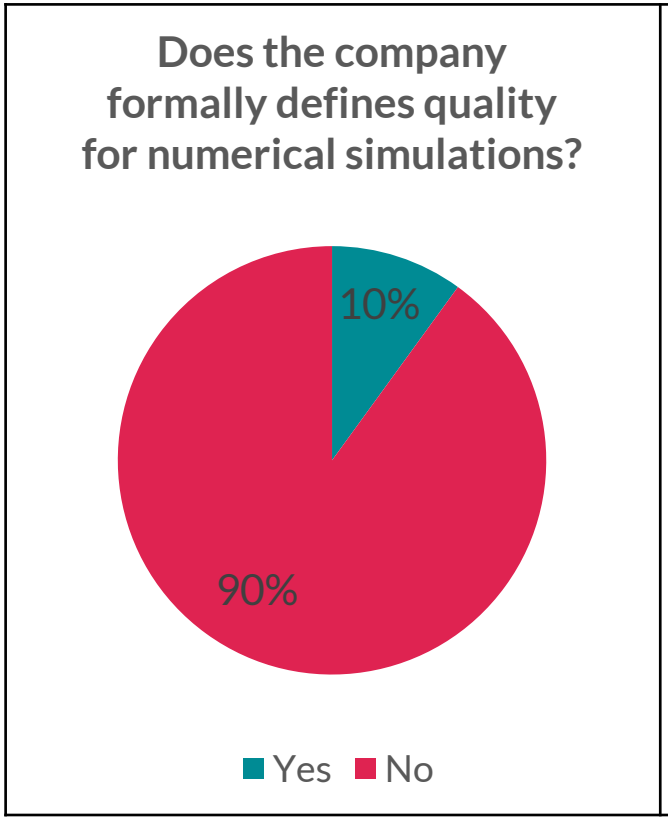

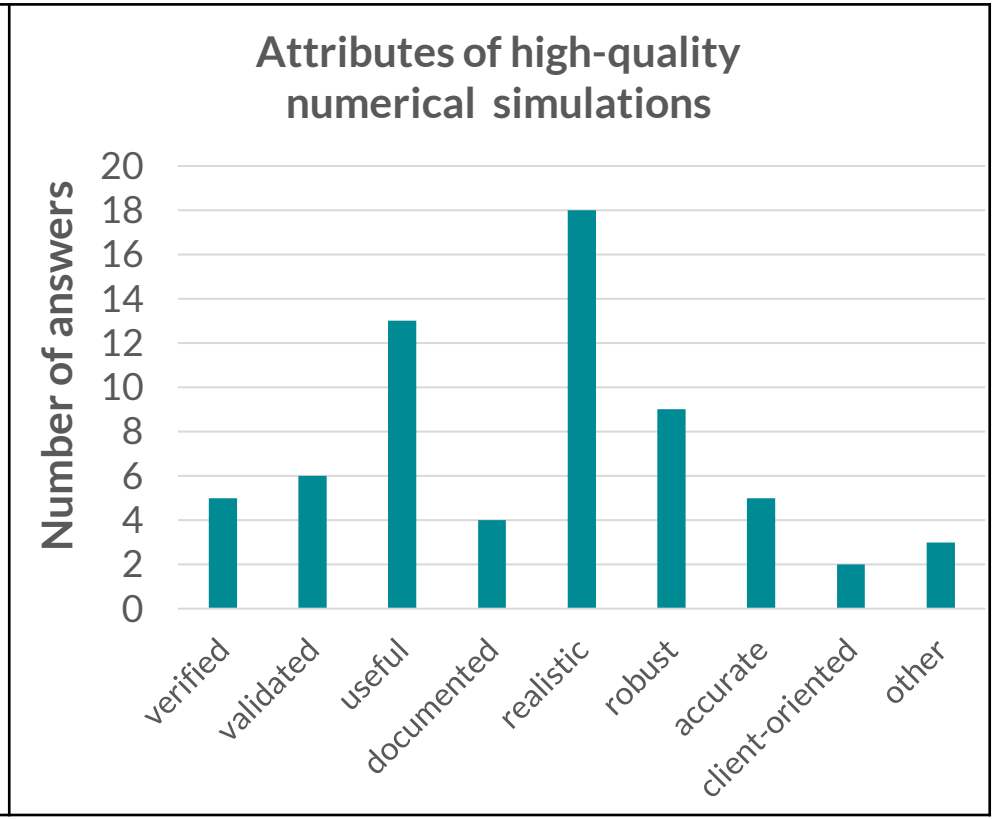

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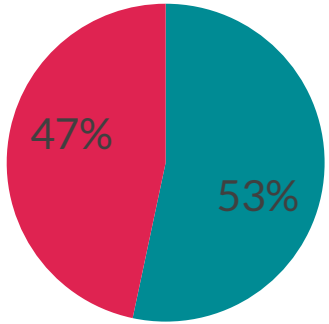
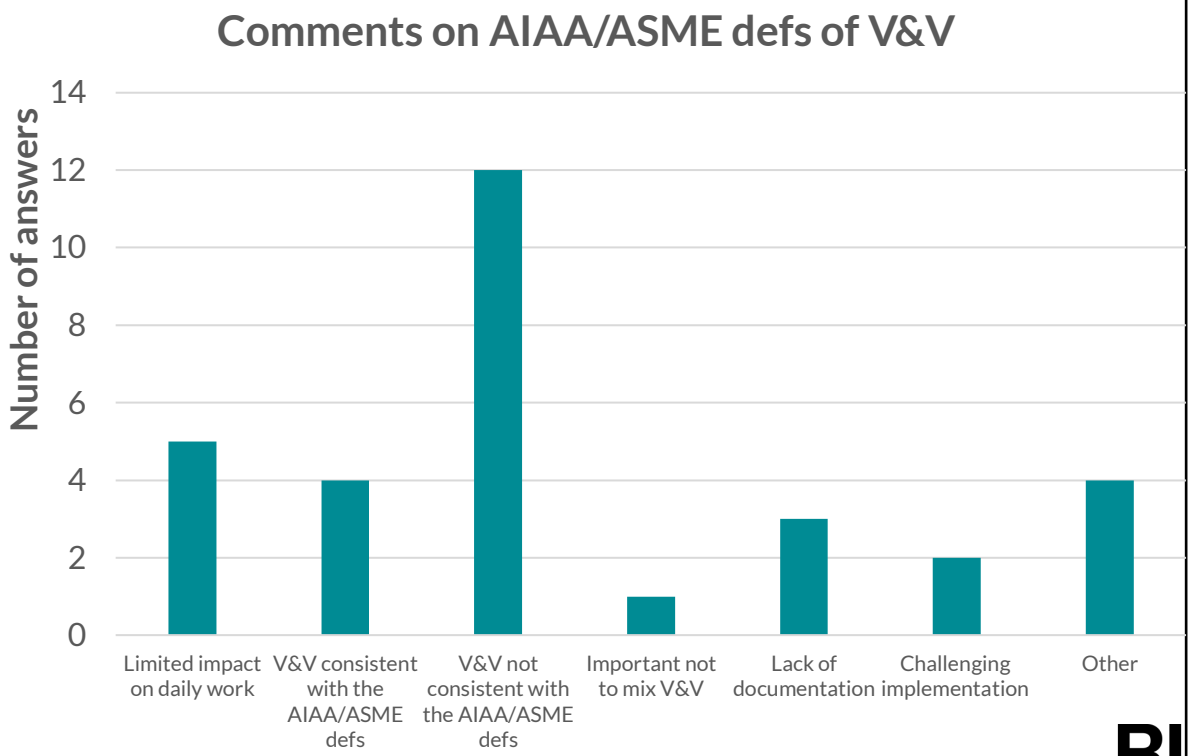


Check if you built:
- the model right (***Verification***)
- the right model (***Validation***)



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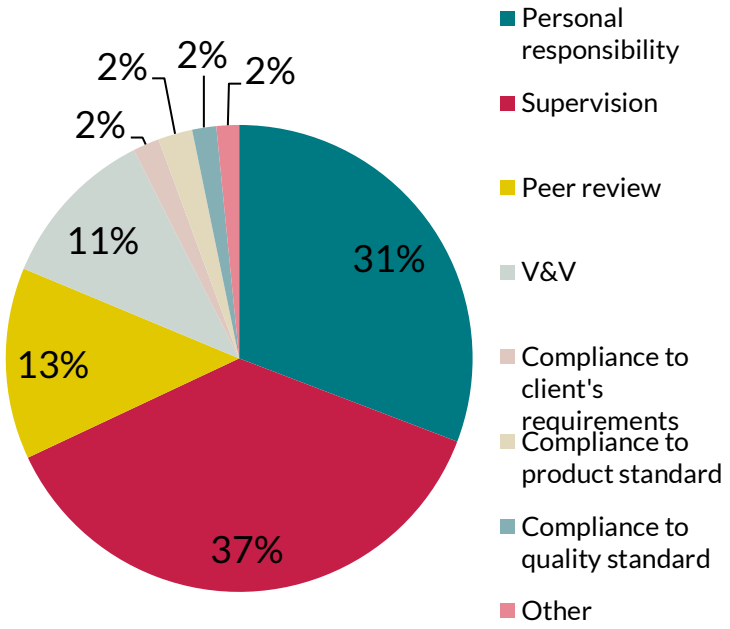
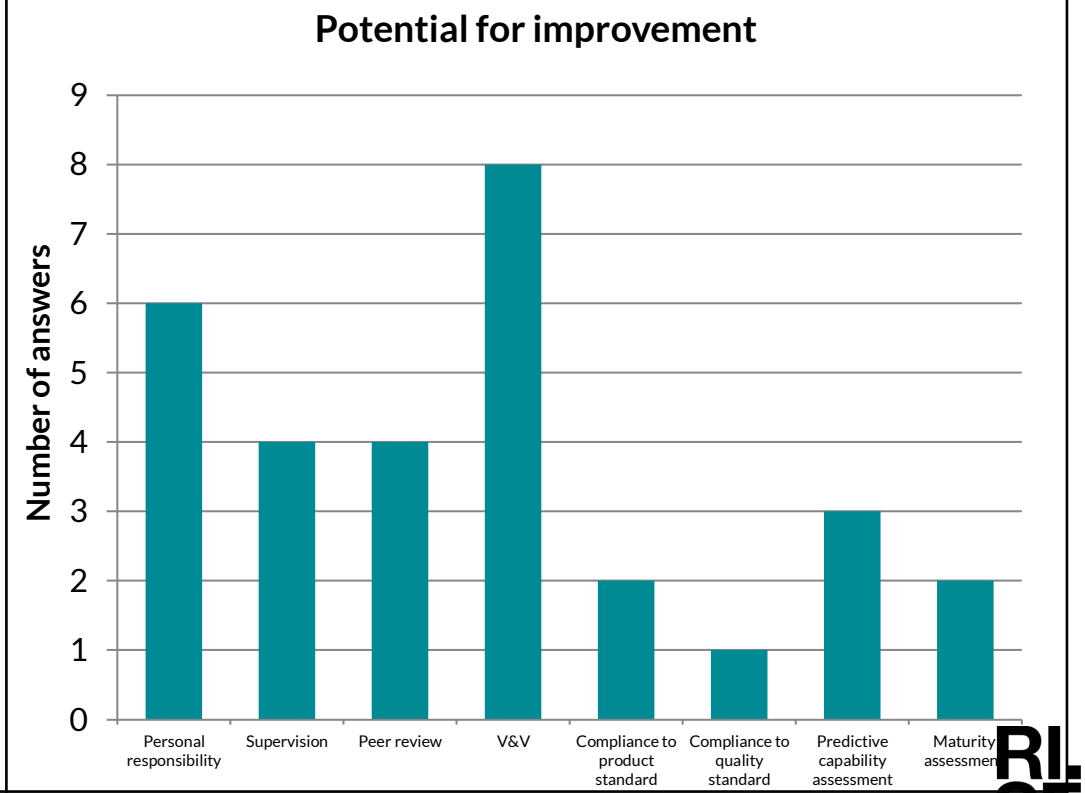
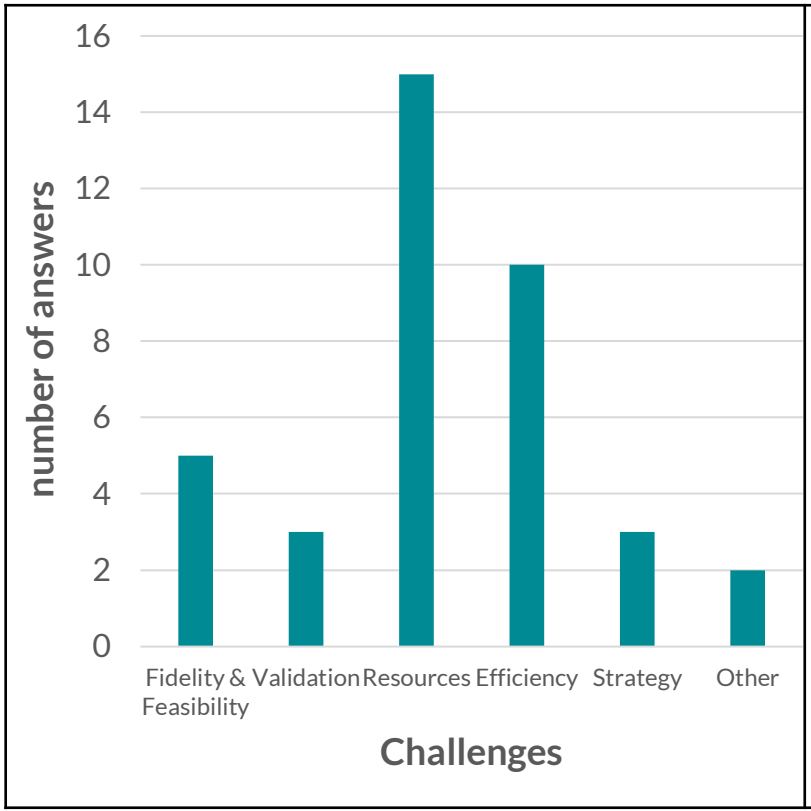
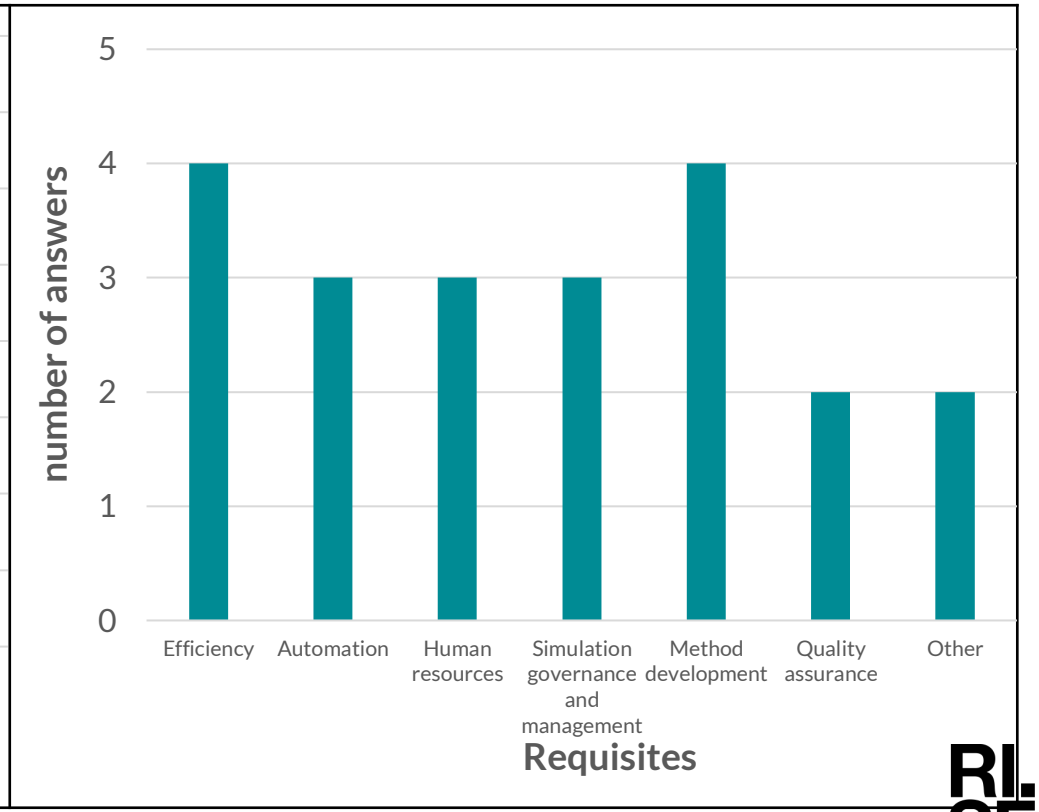




Challenges and vision





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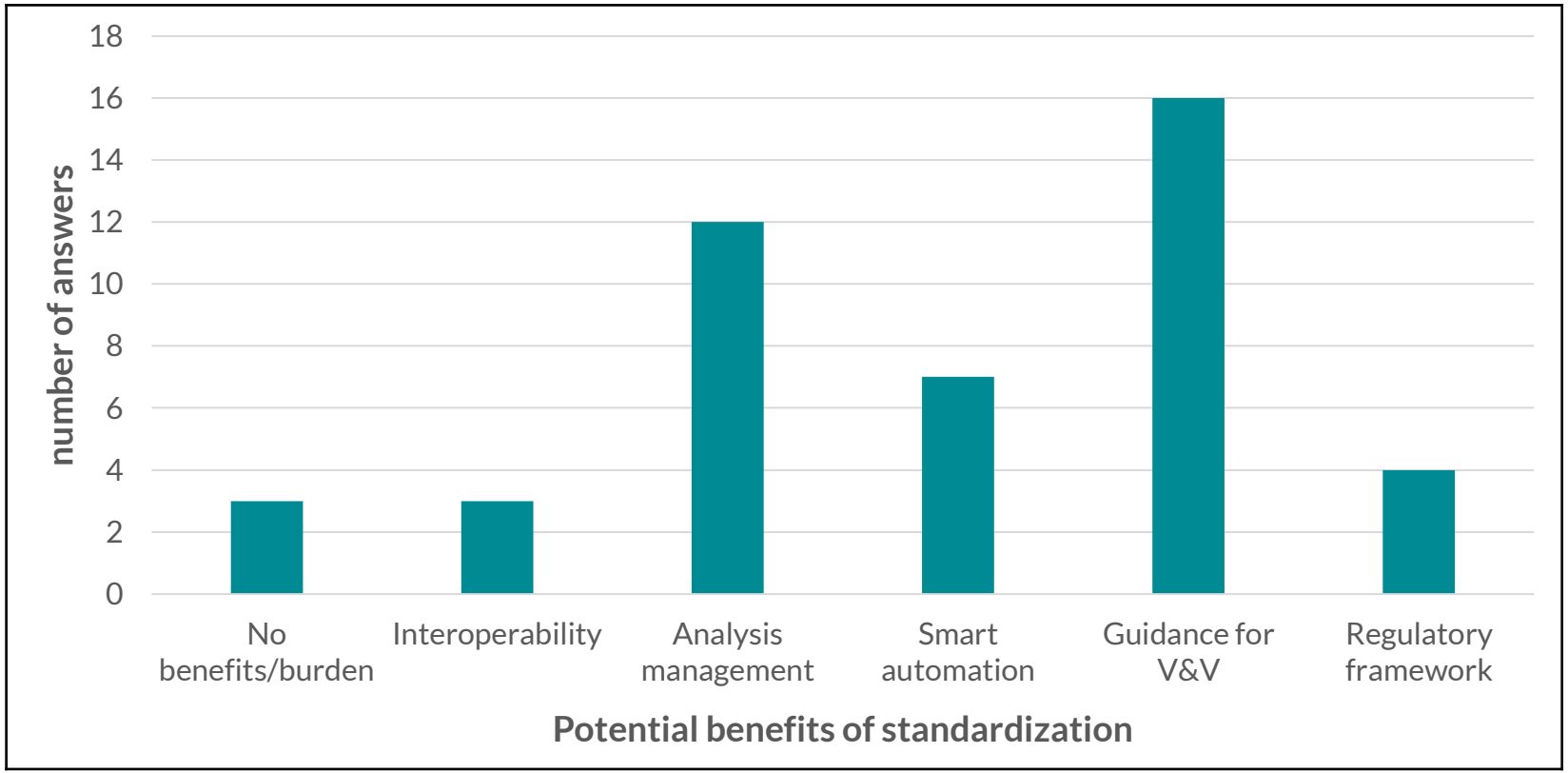

Project and results in a nutshell (1)

- Standardization plays a role in different aspects of numerical simulations:
  - definition of common terminology
  - interoperability (neutral interfaces for the exchange of data and models between different tools)
  - verification and validation (V&V)
  - overall quality management

Special focus on these topics

- A survey was conducted among simulation experts in Swedish industry with the purpose of mapping out the current practice regarding quality assurance and credibility assessment of numerical simulations.

- The survey collected answers from 30 respondents with relatively long industrial experience across different companies (automotive, energy, aerospace) which heavily use numerical simulations in product development (especially in concept and engineering phases).

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Project and results in a nutshell (2)

- Credibility assessment is currently largely based on personal responsibility of the analyst and supervision by peers/more experienced personnel. Verification and validation are recognized as important activities, but often done to a limited extent and following ad hoc (rather than standardized) procedures.

- There is a clear need of standardization in the practive of evaluation of numerical simulations in supports to certification and compliance to regulatory requirements. Existing product standards provide limited, if any, guidance to model building, but nothing to credibility assessment tasks.

- Management support and simulation governance (i.e. clear decision chain for planning and managing analysis) are crucial for the effective deployment of numerical simulations.

- Standardization is seen as a potential benefit in the areas of analysis management (e.g. as a prerequisite to process automation) and credibility assessment, provided that it does not add excessive constraints to design creativity and ”overhead” (i.e. paperwork) to model development.

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Future plans

Recently funded new proposal from VINNOVA:

STEERING (STandardization Experiments for Enhanced Reliability of engineerING simulations),

1.2 MSEK budget, kickoff 10th February: design of industrial use cases for standardization in numerical simulation workflows, targeting *existing* standards, e.g.

LOTAR (LOng Term Archiving and Retrieval)

Get in touch for more info, opportunity to get involved!

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