Functional Mock-up Interface:
An empirical survey identifies research challenges and current barriers

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Motivation

Method

Results
Barriers for FMI [1]

Promising standards and tools [2]

Motivation

Which approach for coupling simulators?

Promising for the future?

Goals

Which standard?

Which tool?

In general: Strengths and weaknesses of co-simulation

..., research needs, current barriers, ...
**Delphi Study**

- empirical research method that relies on the systematic compilation of knowledge from a selected group of experts

- especially useful for addressing interdisciplinary research problems, where the experts’ opinions are heterogeneous

- the Delphi method provides structured circumstances that "[. . . ] can generate a closer approximation of the objective truth than would be achieved through conventional, less formal, and pooling of expert opinion"
Two-stage Delphi study

First Round

Second Round
First round

**Using Qualitative Content Analysis**

- Identifying key-topics
- Identifying contradictions
First round

How to ask the right questions in the first round?

- Authors published “SOTA” papers in the field of Co-Sim
- Comprehensive literature study

What kind of questions?

- In the first round, the majority of questions asked were qualitative
Second round

How to ask the right questions in the second round?

• Analyze the first round!

What kind of questions?

• In the second round, the majority of questions asked were quantitative
Experts [Response rate: 76%]

**Industry**
- Software development
- Mobility
- Energy Systems
- System engineering
- Railways

**Academia**
- Software development
- Mathematics
- Automotive
- Energy related applications

**TOTAL: 53 EXPERTS**

- Industry 44%
- Academia 56%
Results
Keyword "Co-Simulation"
Barriers for FMI
FMI - Barriers

In the first round of expert interviews, we identified the following barriers:

• Limited support for discrete event co-simulation
• Limited support for hybrid co-simulation
• Certain requirements that would be widely needed by industry and academia are not supported
• No pre-implemented master algorithms
• Insufficient documentation and a lack of examples, tutorials, etc.
• Lack of transparency in features supported by FMI tools
• There is a lack of (scientific) community, forums, groups
• Not enough cooperation (theoretical, implementation, application/industry) in defining and developing the FMI standard
• It is difficult to implement FMU’s (API, connecting/linking different subsystems)
• Simulations are slow compared to monolithic simulations
• There is a lack of tools that sufficiently support FMI
• Concerns of industry/academia regarding FMI and IP protection
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<tr>
<td>5</td>
<td>Somewhat agree</td>
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<td>The standard does not support certain requirements that would be widely needed by industry and academia</td>
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<td>Lack of transparency in features supported by FMI tools</td>
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