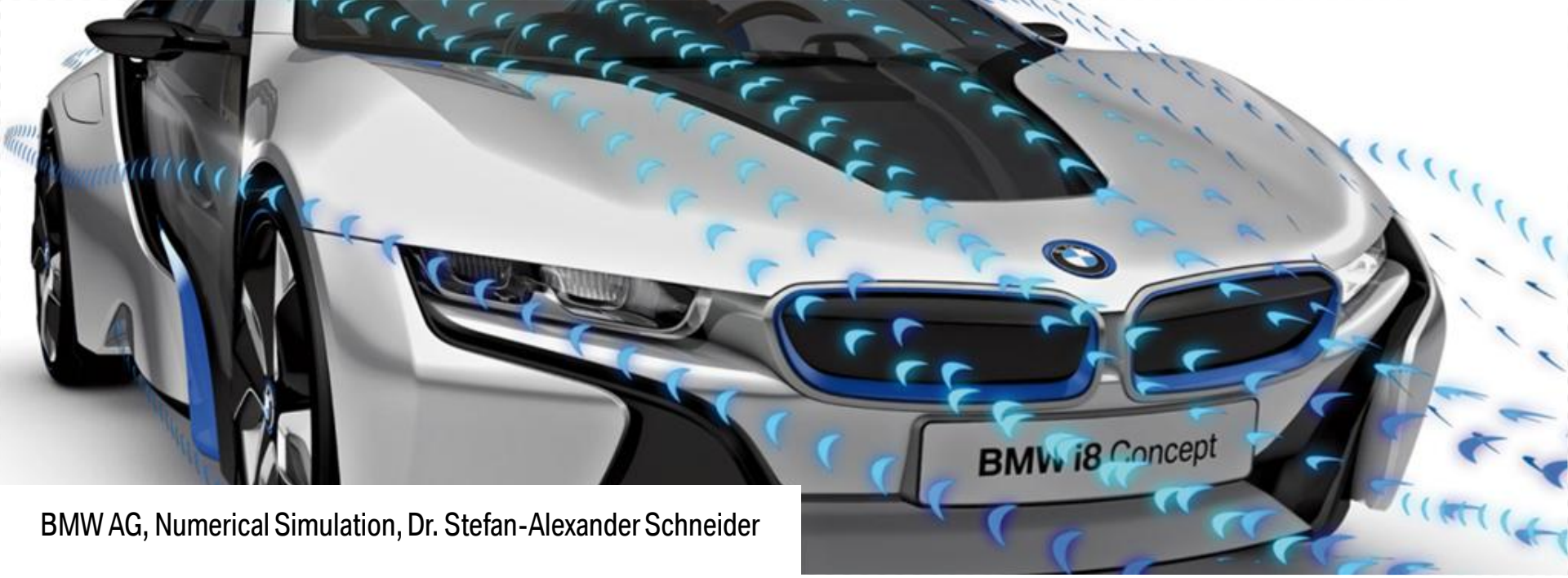


BMW AG, Numerical Simulation, Dr. Stefan-Alexander Schneider

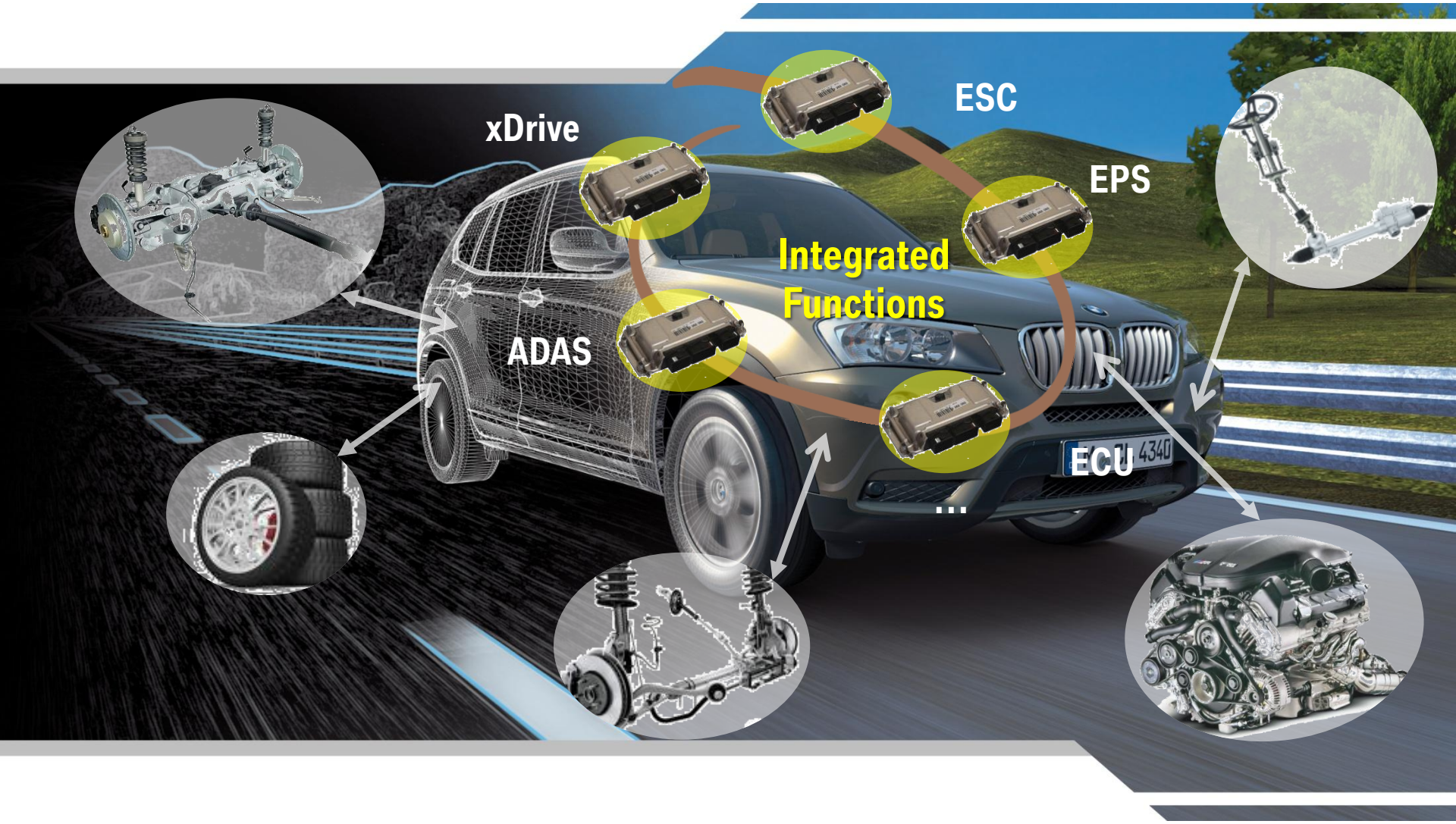
USE CASES FOR FMI.

FMI -Tutorial on Modelica Conference.

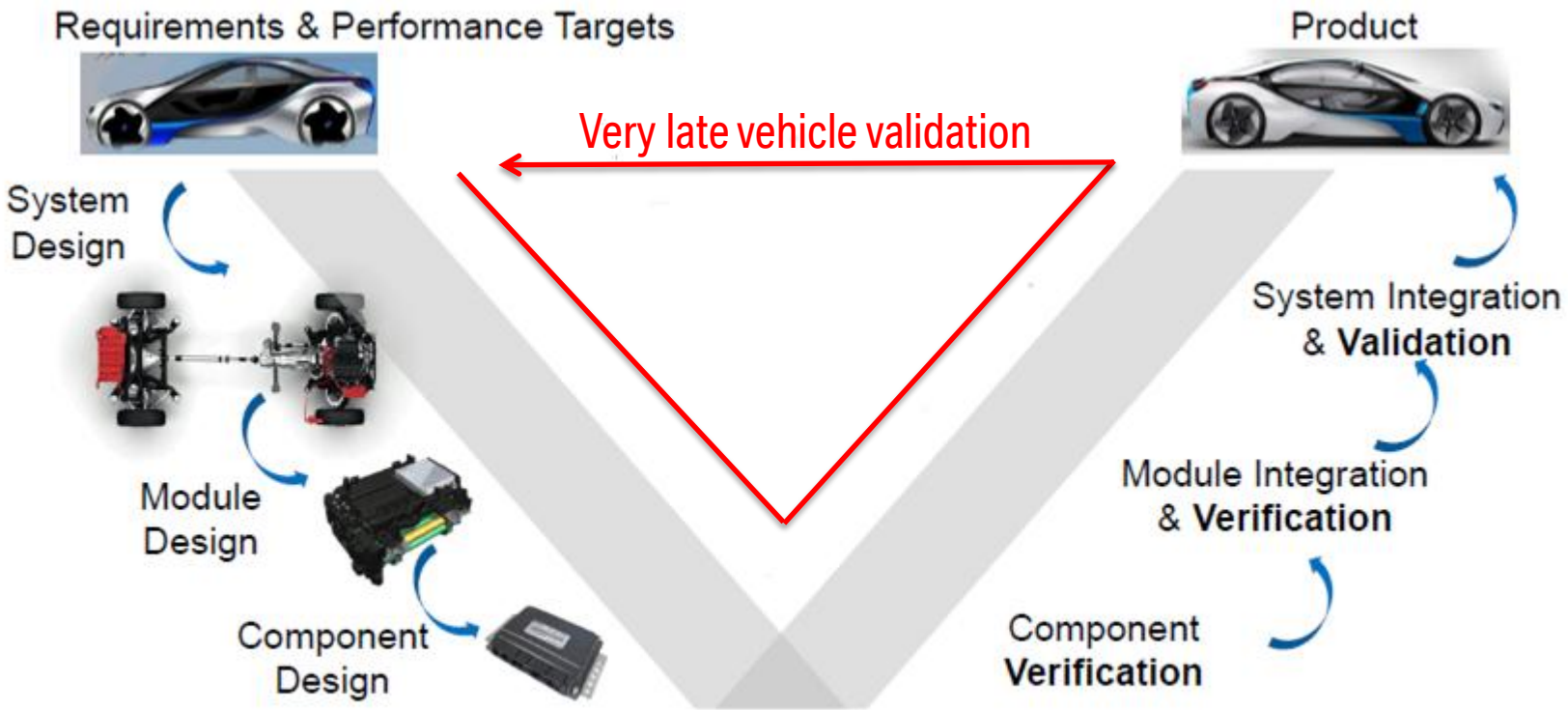
BMW GROUP

Inreasing number of variants.

Increasing complexity.



Classical Vee – Model.



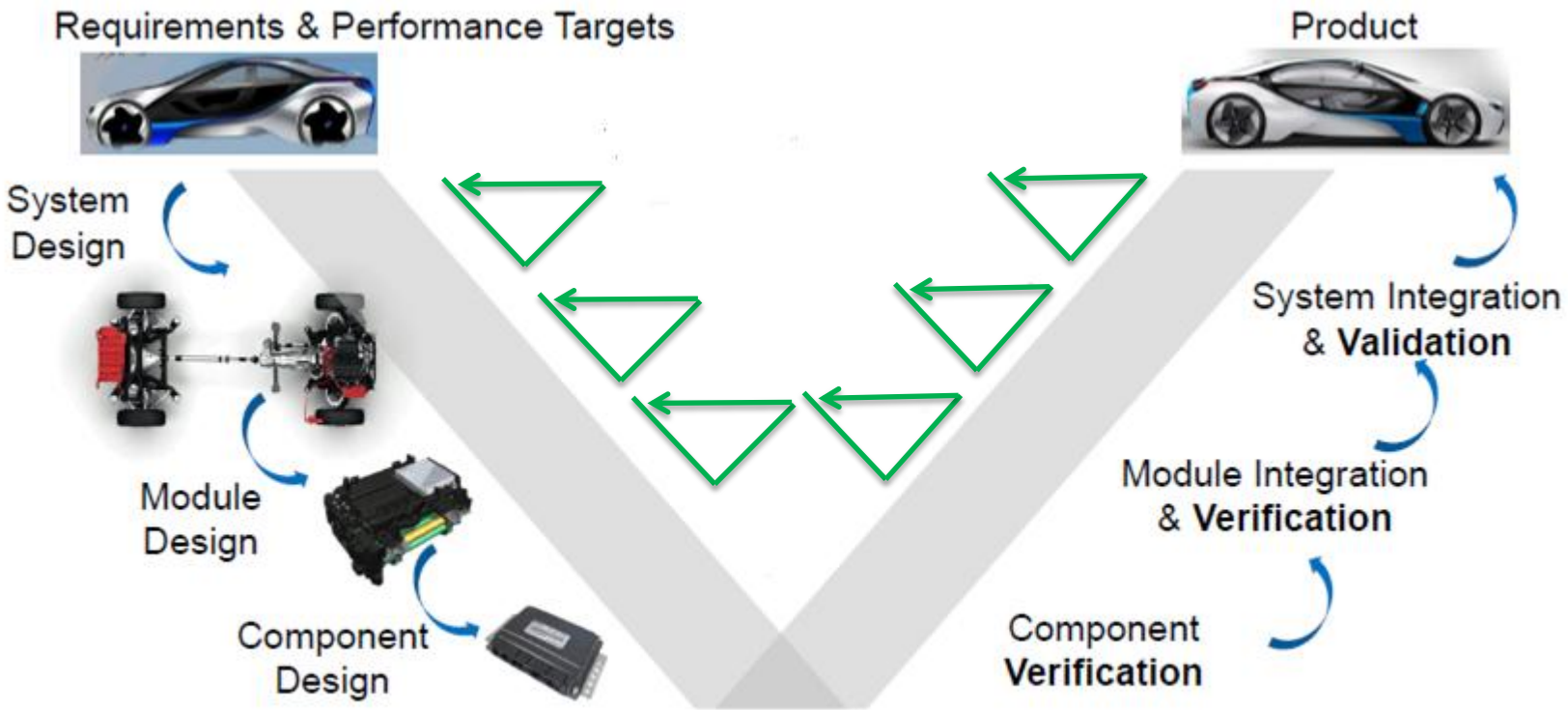
Experience with the Full Vehicle Integration.

Less than

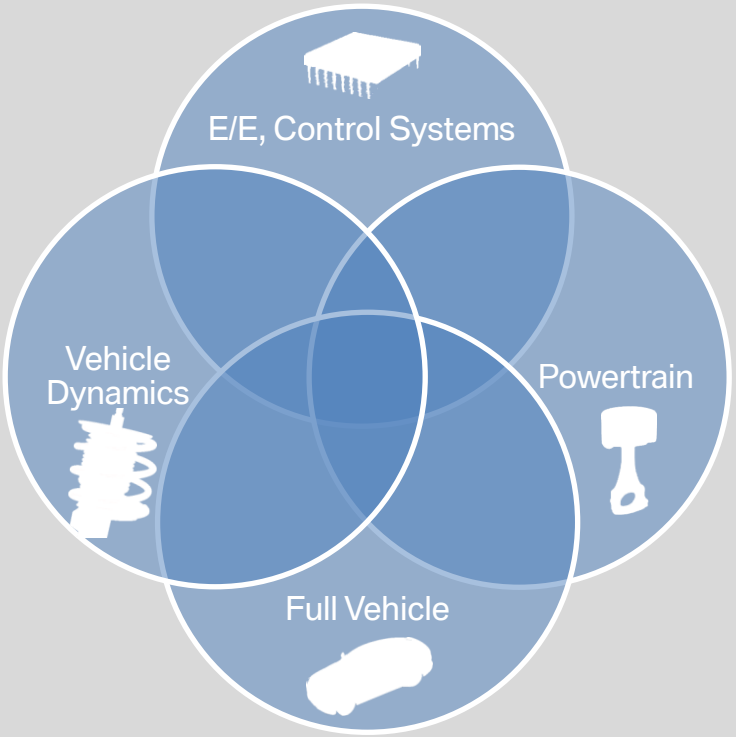
10%

of the engineers get evaluation experience in the full vehicle.

MiL, SiL, HiL: Cross-Domain Simulation.



Cross-Domain Simulation.



Varied Tool Landscape:

C++

SIMULATION X
Powered by ITI

Adams
MSC Software

LMS

MATLAB
SIMULINK

IPG

...

Why a standardised Interface?

Model Author

- Develop model in the best **authoring tool**.
- Develop model by a dedicated specialist for the domain.

Architect

- **Define interfaces** and dependencies between components
- Allow models to be shared across departments and companies

Model Integrator

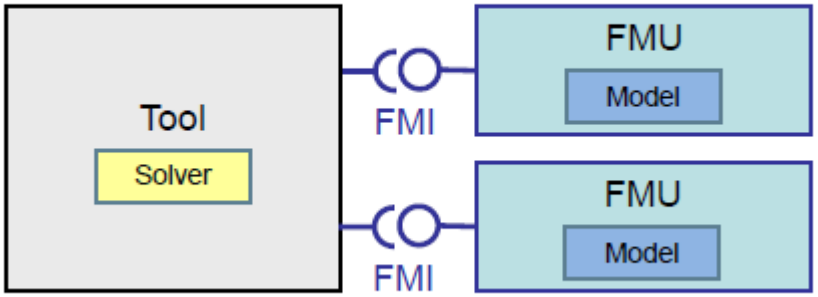
- Couple and simulate models in an **integration tool** that is the best for the specific analysis, test case or parameter study.

=

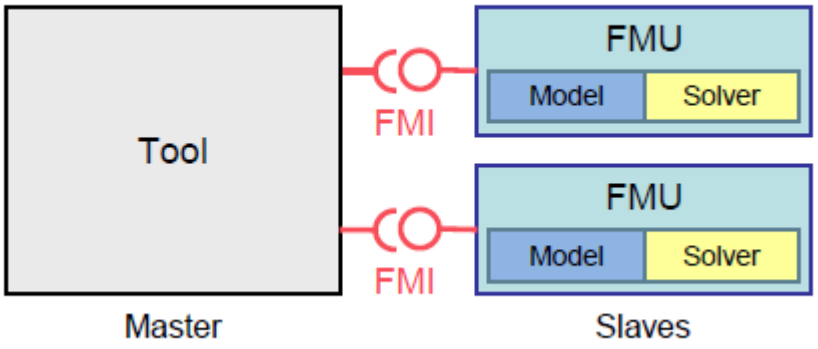
- N Authoring tools and M integration Tools would lead to N x M interfaces !
- Sustainable model exchange possible only with standardised interface.

The Functional Mock-up Interface.

- FMI for Model Exchange

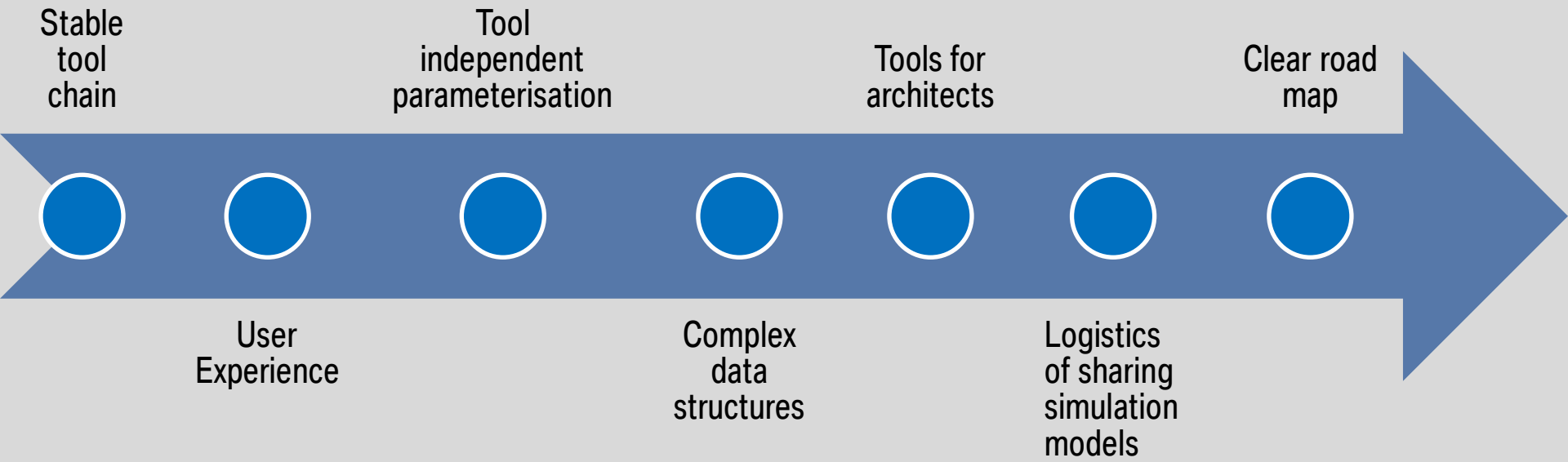


- FMI for Co-Simulation



→ Best chance yet to establish cross-domain simulation

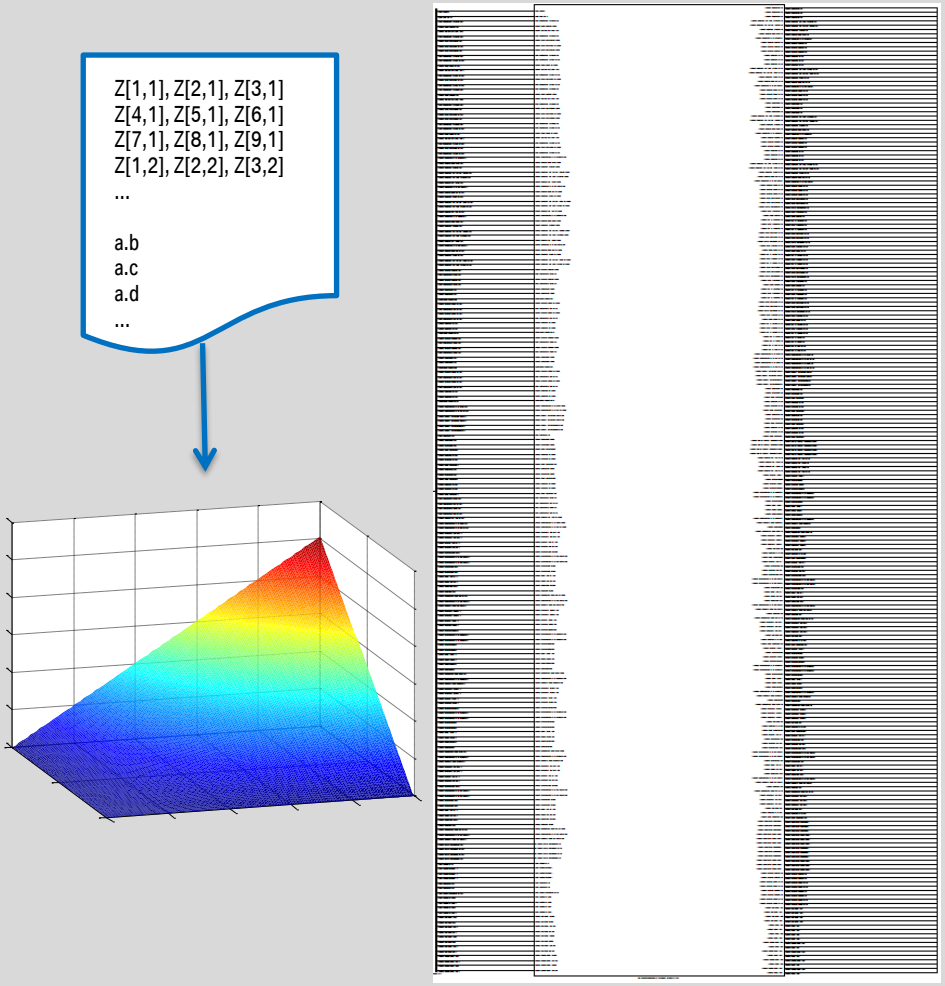
Towards an Industrialisation of FMI.



1. Stable, centrally managed Tool Chain.

- Cross-checkers and test cases
- Solve teething problems
- Centrally manage installations and licenses
- Run FMUs without requiring license from authoring tool

2. Emphasis on User Experience with Version 1.

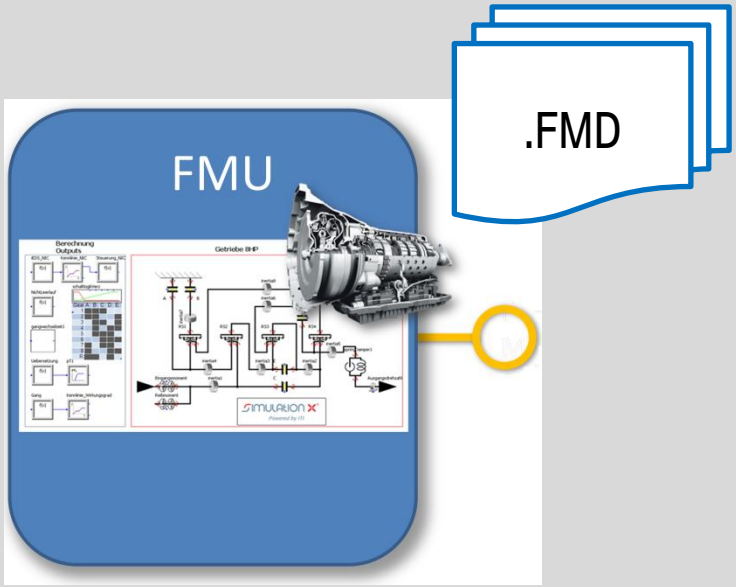


- **Support** complex **interfaces**
- **Authoring tools**: Export variables using hierarchical naming conventions
- **Integration tools**: Deduce variable structure from naming conventions.
- **Simplify** connecting and parameterising FMUs
- **Declare** and **log internal signals**
- Concepts for **debugging**

3. Tool independent Parameterisation.

FMU Data File Format (.FMD) V1.0

FMU Data File Format (.FMD)



3.1 Einfaches Beispiel

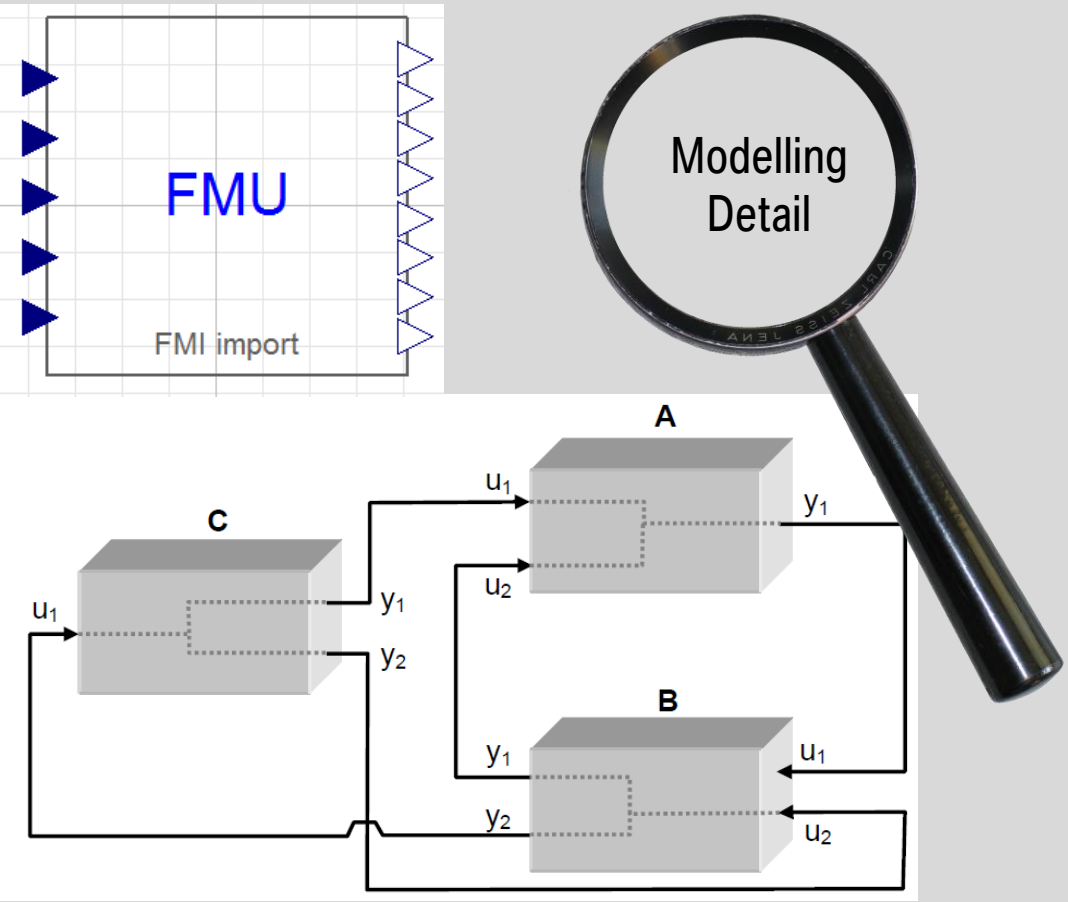
```
#% fmd:FileVersion = "1.0"
x1 = 0.35 # Comment
# Comment Line
int1 = 4  # Integer Data
y1=4. # Real Data

z = 4.0e-5 # Real Data with Exponent
b[1] = true # Boolean True
b[2] = false # Boolean False
q.s1 = "1.0" # String Data
q.s2 = "This is
a string" # String Data with Line Breaks
s1 = "\"1\\0\"" # String Data With Escapes
```

3.2 Komplexes Beispiel mit Sonderfällen

```
#% fmd:FileVersion = "1.0"
#% fmd:name = "HiPerformance Adaptive Brake"
#% fmd:description = "Parameters for HiPerformace System V1.0"
#% fmu:modelName = "BRAKE_FMU"
#% MyVersion = "5.6"
#% "Another Attribute" = 5.6
x1 = -0.35 # First Data Line with Real Data
#% Treated as normal comment, since not in preamble.
int1 = 4  # Integer Data
y1=4. # Real Data
z.y   =  -4.0e-5 # Real Data with Exponent
z.q   =  4.e+5 # Real Data with Exponent
b1 = true # Boolean True
b2 = false # Boolean False
"Id With = and Spaces" = "String Value with \\ escapes \"1.1\""
```

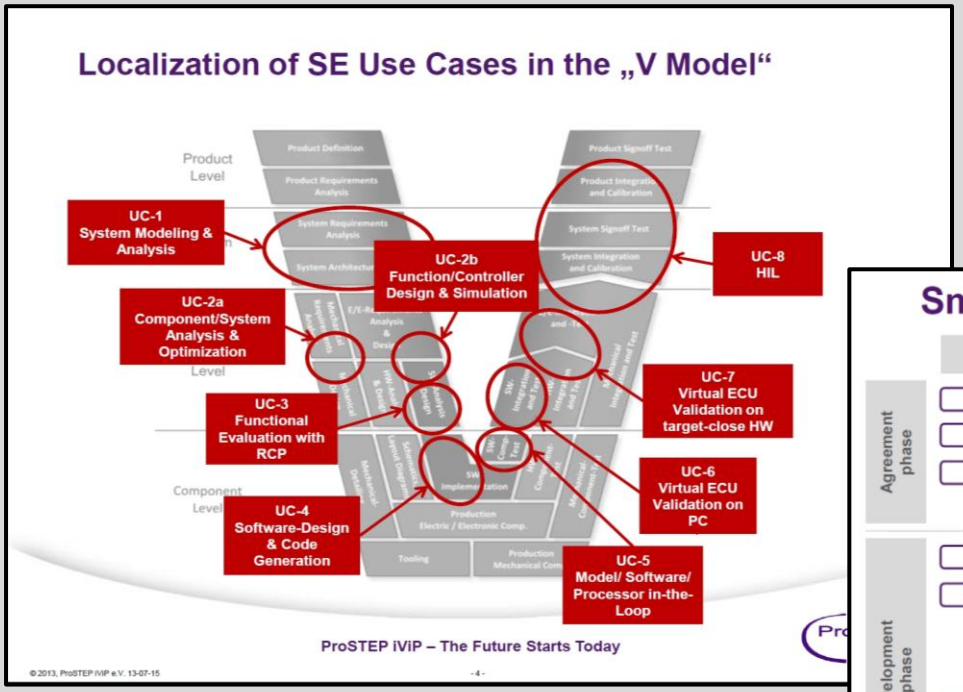
4. Efficient Exchange of complex Data Structure.

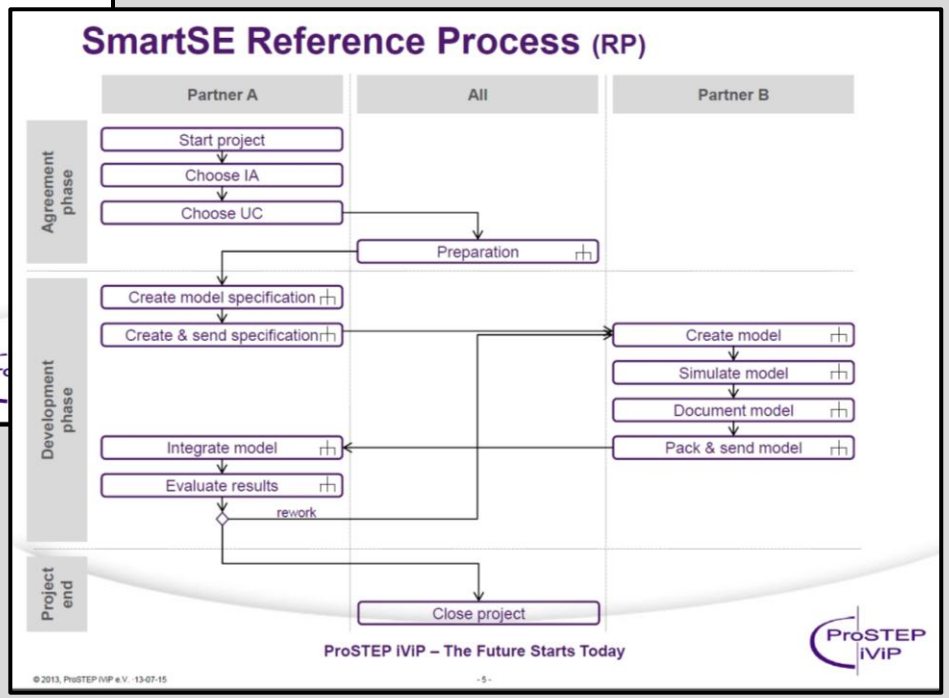
5. Tools for Architects.



- **Varying** modelling scales.
- **Multiple** vehicle architectures.
- Need to design and exchange networks of models.
- Need to reveal dependencies between models.
- Interface definitions need to be exchangeable

6. Concepts for the Logistics of sharing Simulation Models.





7. Clear Road Map and Dependability on Timelines.

Conclusions.

- **Increasing number** of variants and **increasing complexity** require increase in **virtual prototypes**.
- **Virtual prototypes** require **cross-domain simulation**.
- Aim to use best authoring tool for specific domain and best integration tool for specific test case.
- **Varied tool landscape** requires a **standardised interface**, FMI is our best chance yet!
- BMW is fully committed with a wealth of ongoing projects.
- Industrialisation requires a common effort from OEMs, suppliers and tool vendors alike, along key development areas: