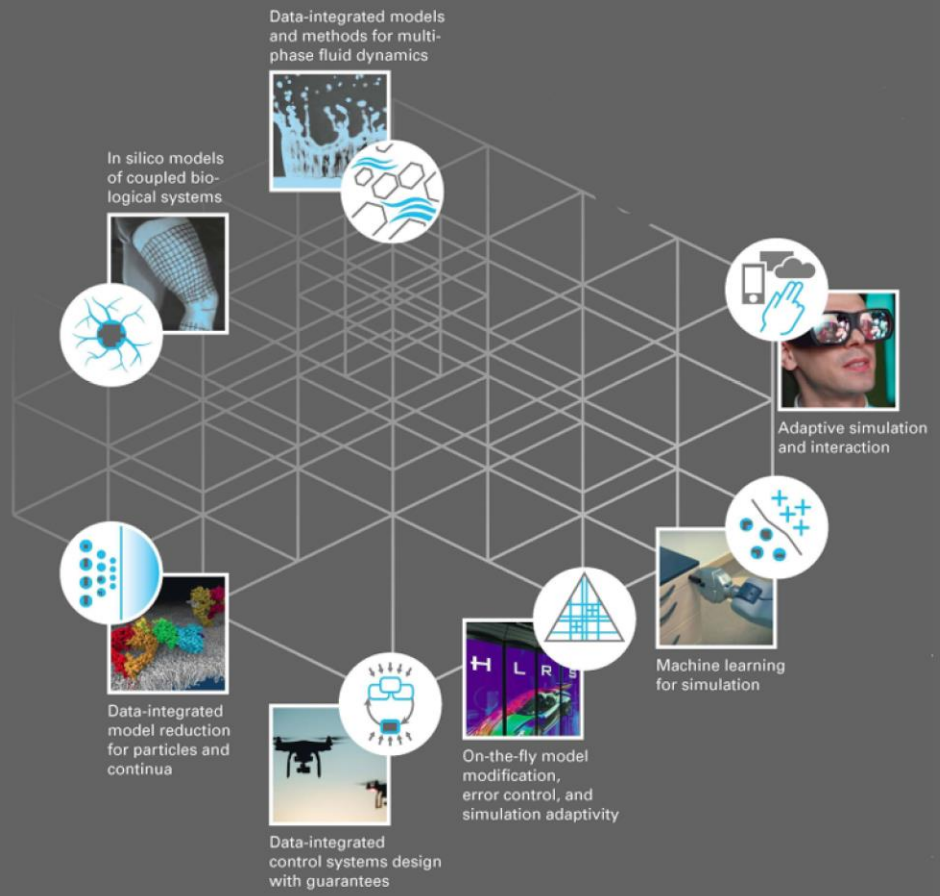
University of Stuttgart
Cluster of Excellence SimTech



Documentation for FAIR Modelling

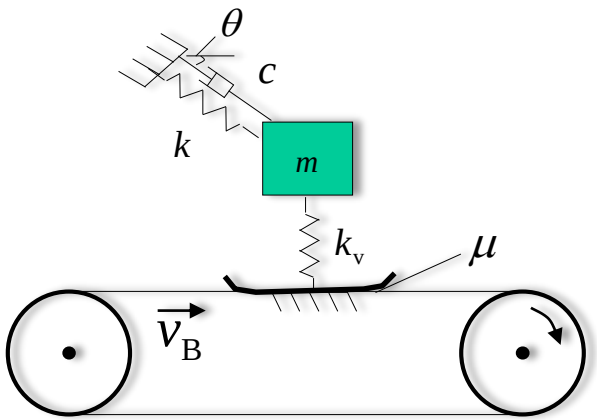
Sibylle Hermann

Institute of Engineering and Computational Mechanics, SimTech, University Library

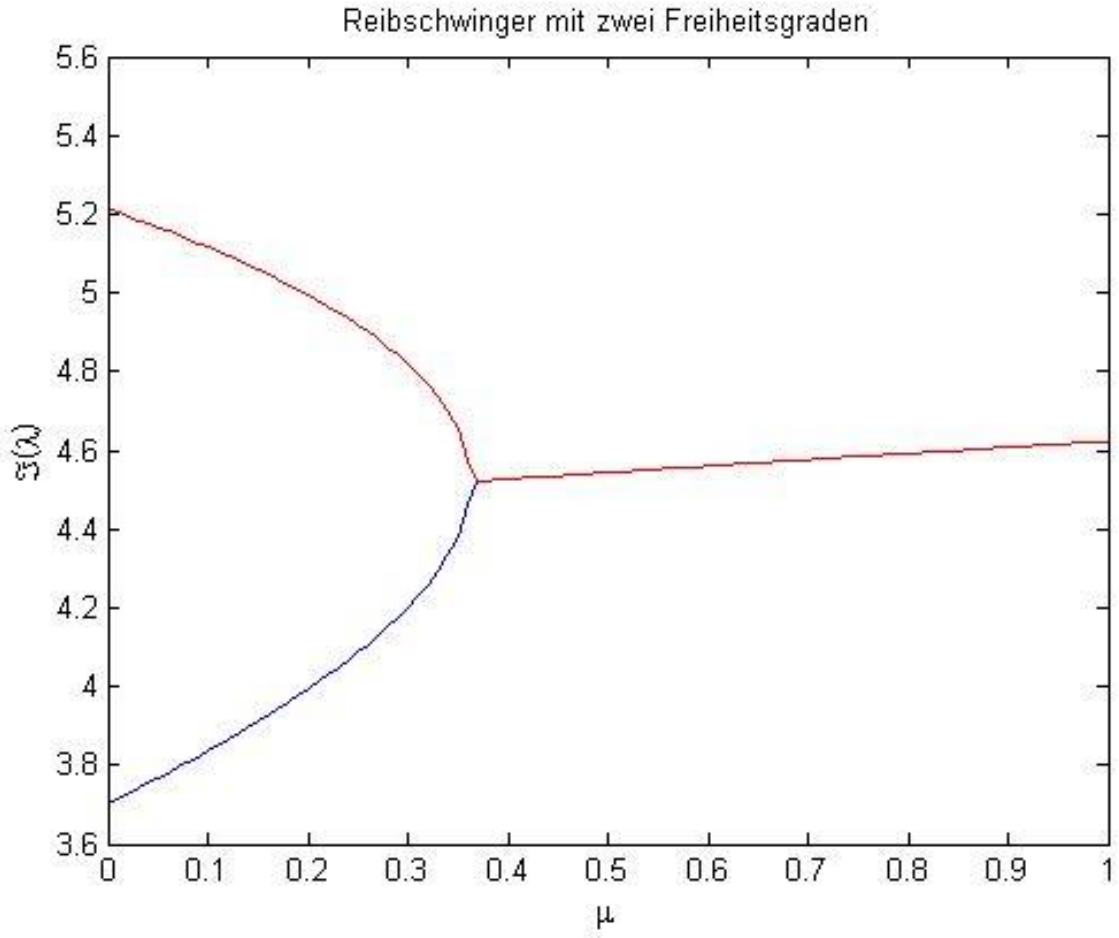
Jörg Fehr, Andreas Baumann, Denis Pfeifer

SimTech

My first RDM experience



$$\begin{bmatrix} m & 0 \\ 0 & m \end{bmatrix}\begin{pmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{pmatrix}+\begin{bmatrix} c_{11} & -c_{12} \\ -c_{21} & c_{22} \end{bmatrix}\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix}+\begin{bmatrix} k_{11} & -k_{12} \\ -k_{21} & k_{22} \end{bmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}=\begin{pmatrix} -F_R \\ 0 \end{pmatrix}$$



Lost in translation

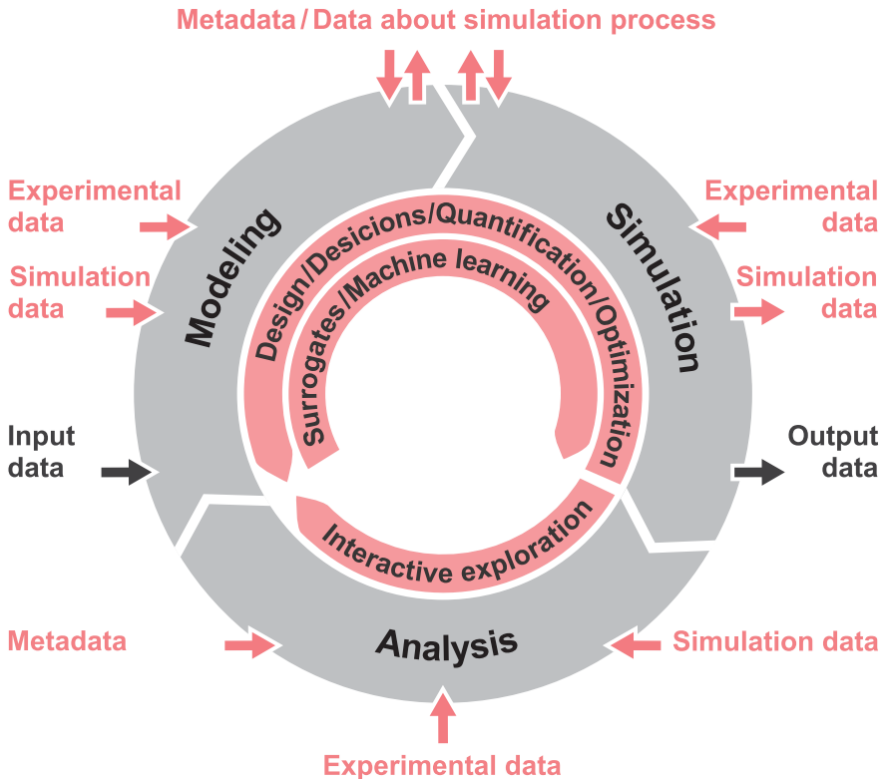
```
opts.tol = 0.01 ;
[m n] = size(A) ;
x = ones (n,1) ;
y = A*x ;
[c R P info] = spqr (A, y, opts) ;
info
Rs = R (:, 1:m) ;
fprintf ('condest(Rs) %g\n', condest (Rs)) ;
xs = x (1:m) ;
xm = x (m+1:n) ;
A2 = -Rs \ R (:, m+1:n) ;
y2 =  Rs \ c ;
norm(A2*xm + y2 - xs)   % should be very small
nnz (A2)                % should also be as small as possible
```

Ansys → MSC Nastran™

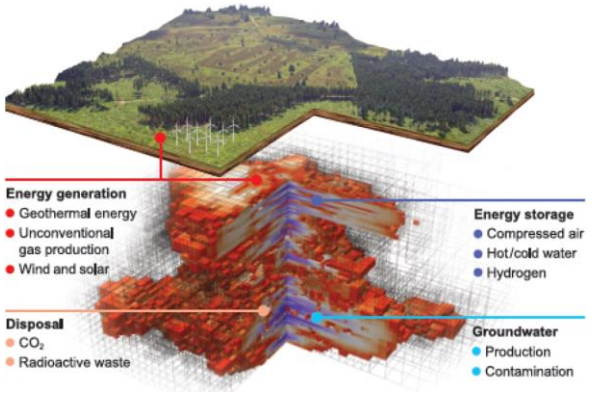
Industry Leading Multidisciplinary FEA Solution

```
BEGIN BULK
$.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10
MDLPRM,HDF5,1
PARAM,POST,0
PARAM   PRTMAXIM YES
$.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10
EIGRL         1     .1            30      0                MAX
CORD2C        1     0     0.      0.      0.      0.      0.      1.+FEMAPC1
+FEMAPC1      1.    0.    1.
CORD2S        2     0     0.      0.      0.      0.      0.      1.+FEMAPC2
+FEMAPC2      1.    0.    1.
```

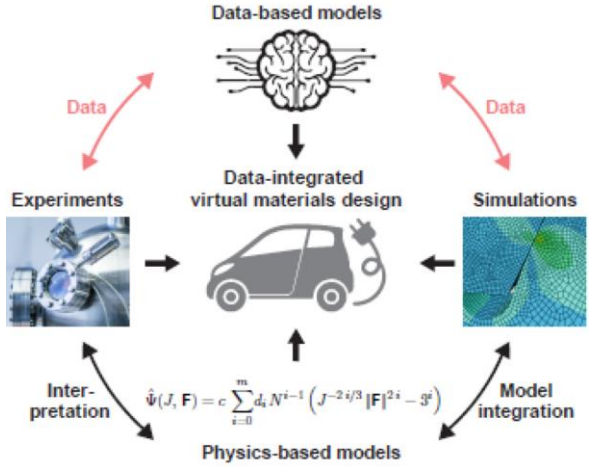
Modelling, simulation and analysis to solve visonary examples



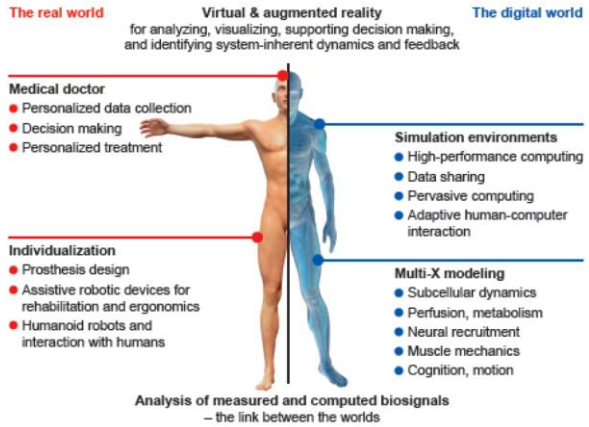
Common Methodology



Engineered Geosystems



Next-Generation Virtual Materials Design

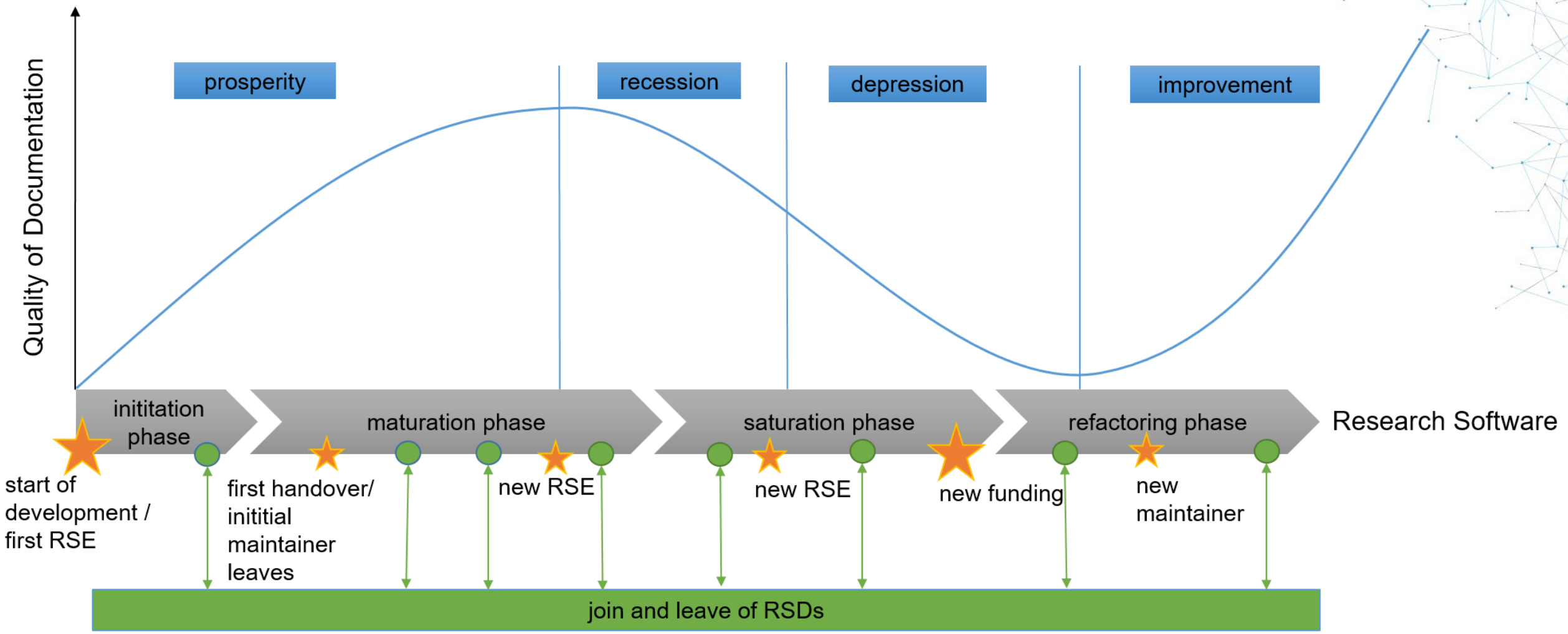


Digital Human Model

Example: Neweul-M^2

- Written in Matlab
- Dynamic analysis of mechanical systems
- Multibody system method

Documentation has a history

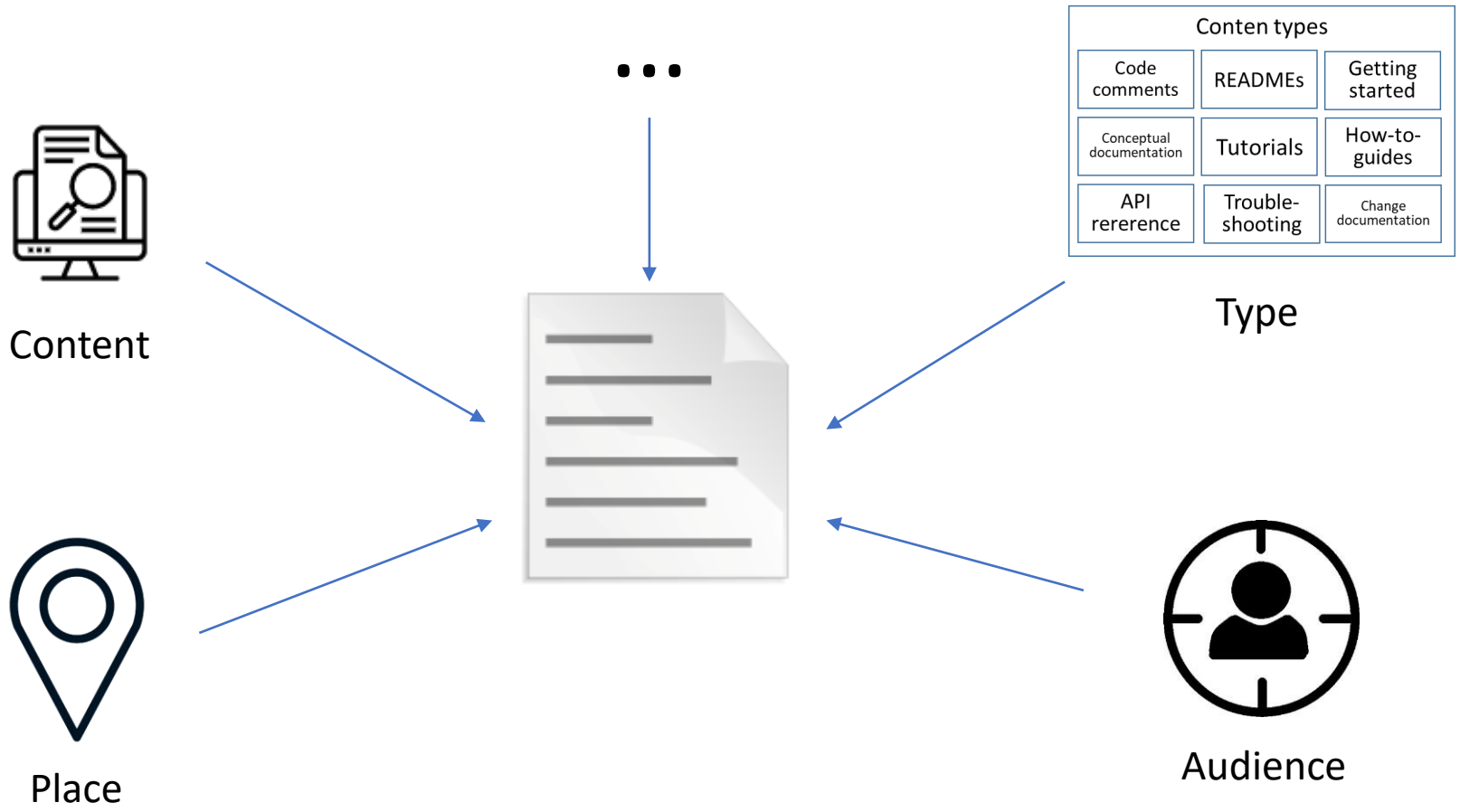


https://doi.org/10.1038/s41598-022-10376-9

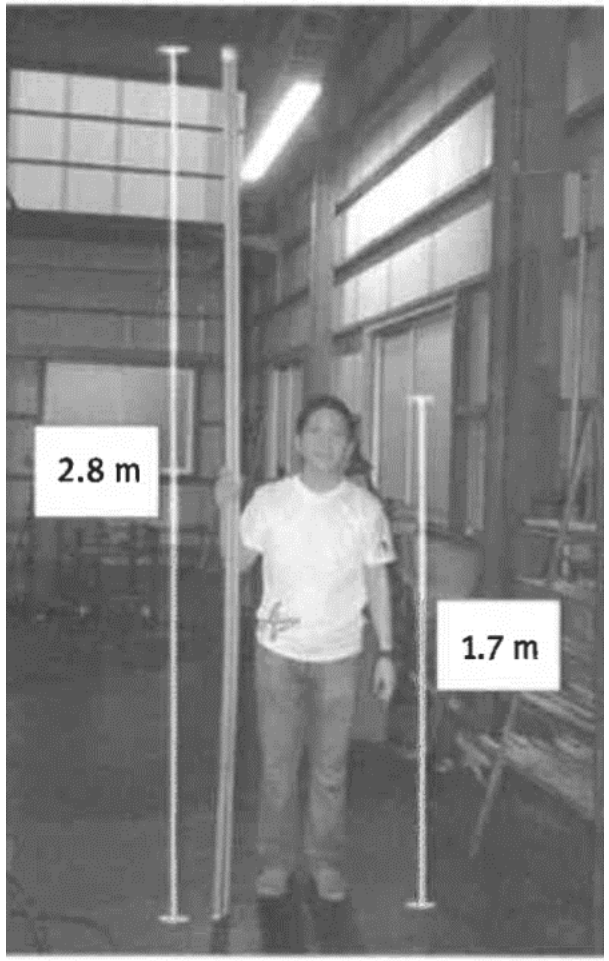
But how can we do better?

Tools

Different aspects of documentation

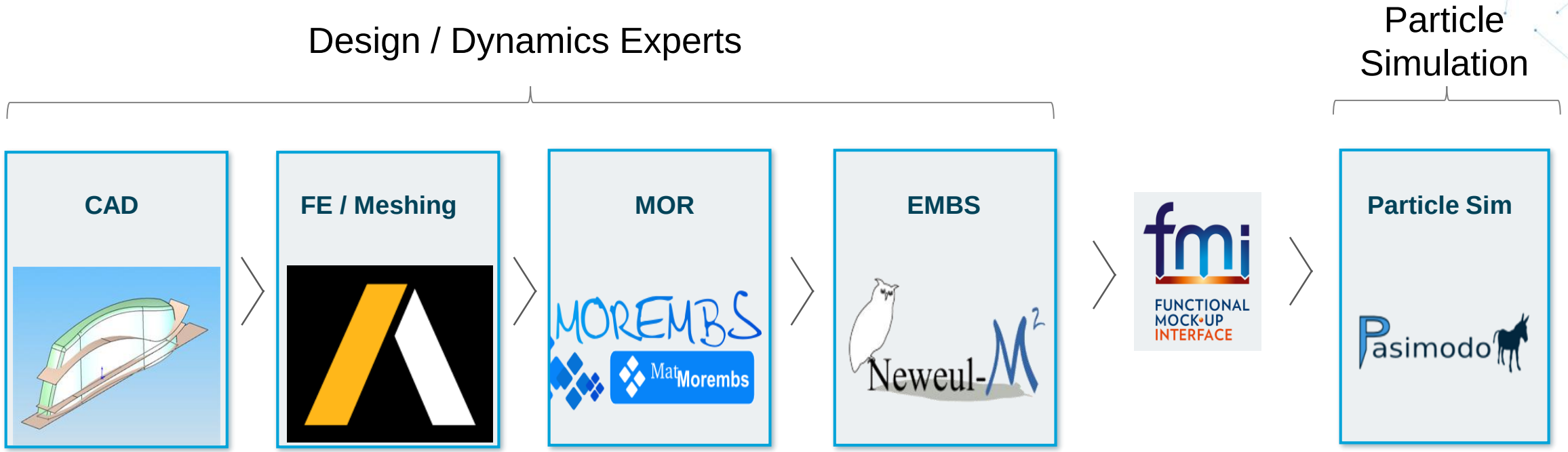


Research Andreas – Deep hole drilling



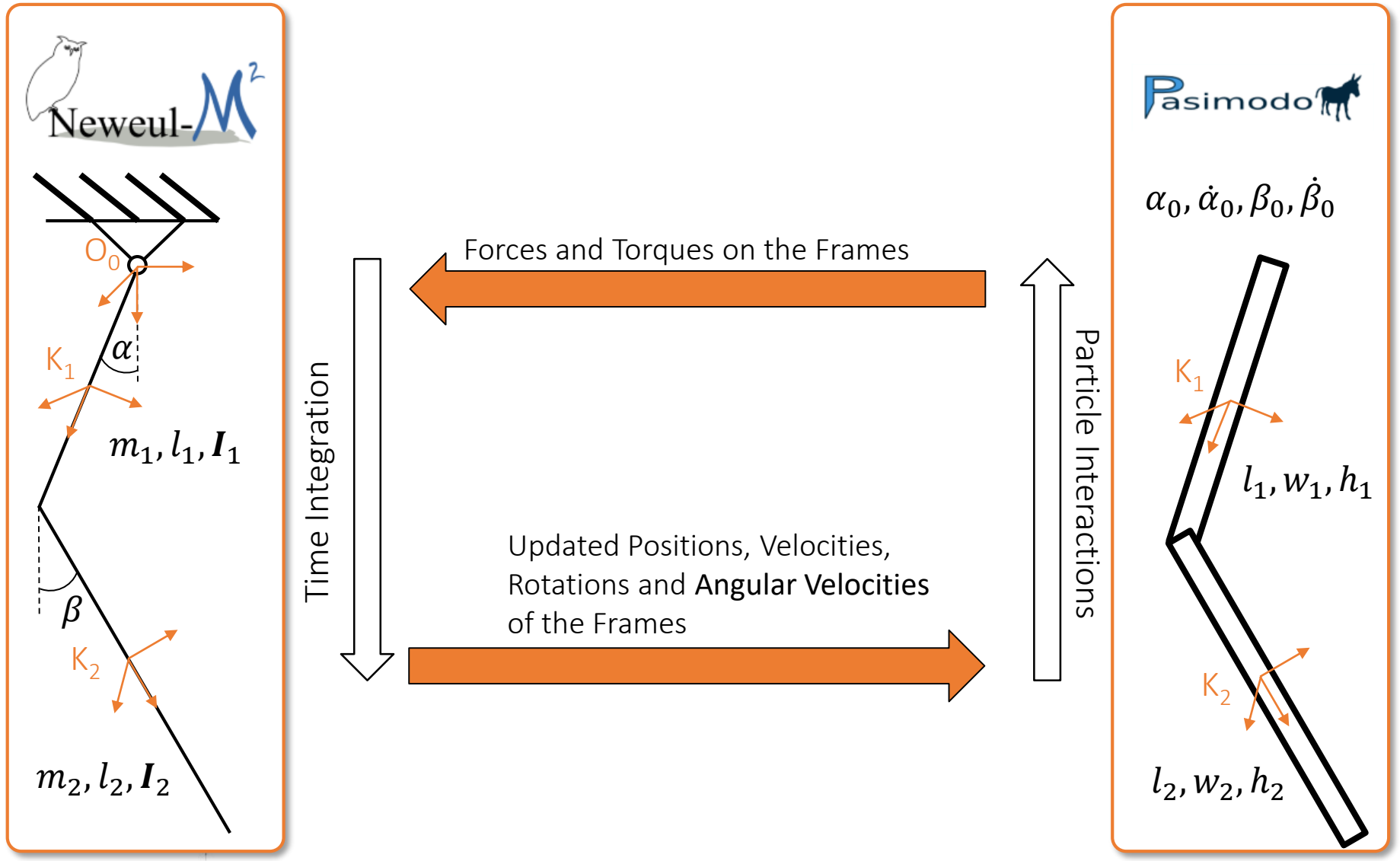
Source: WoonTnayYeap18

Toolchain Andreas



Toolchain to analysis of the cutting fluid behavior with a modified micro single-lip deep hole drilling tool [1]

Example from Andreas



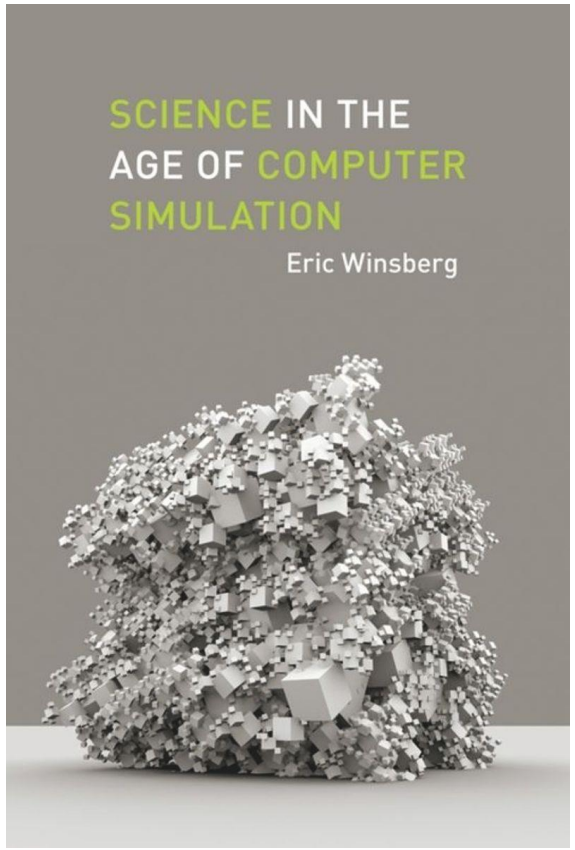
Software Engineering: Docs as code

Documentation as Code (Docs as Code) refers to a philosophy that you should be writing documentation with the same tools as code:

- Issue Trackers
- Version Control (Git)
- Plain Text Markup (Markdown, reStructuredText, Asciidoc)
- Code Reviews
- Automated Tests

https://www.writethedocs.org/guide/docs-as-code/

Philosophy of Science

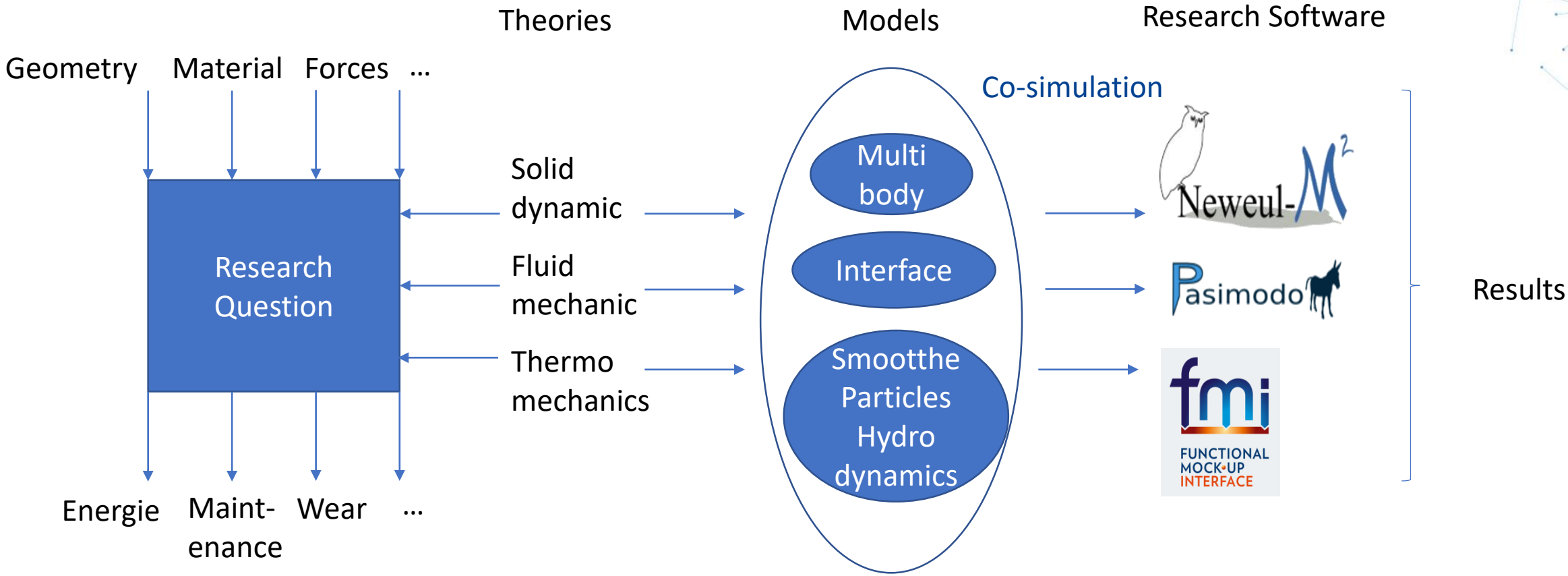


Science in the Age of Computer Simulation
Eric Winsberg

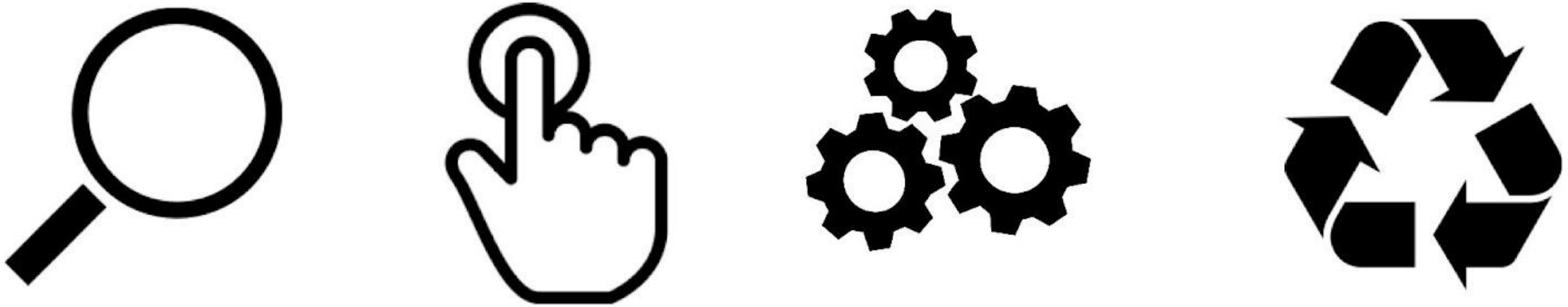
"But simulations more often involve the application rather than the testing of scientific theories."

https://doi.org/10.7208/9780226902050

Co-Simulation



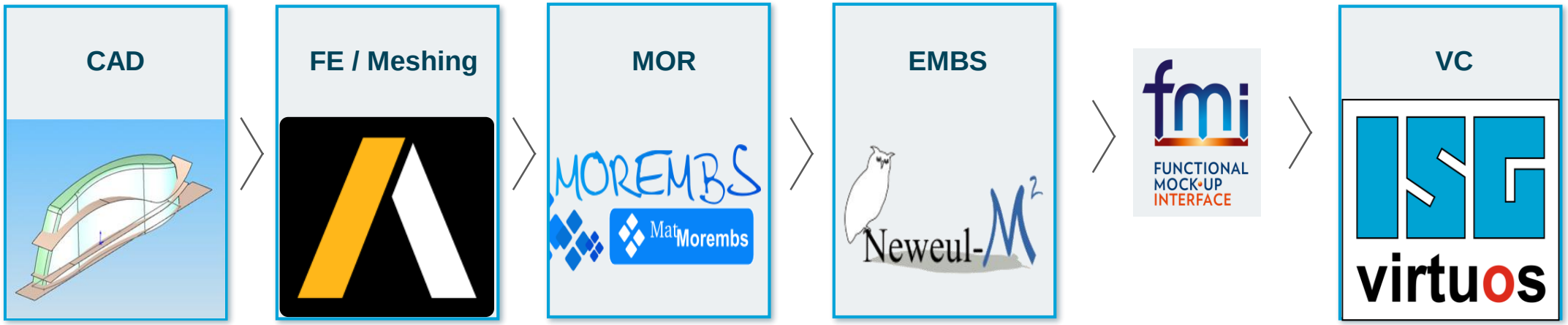
Findable Accessible Interoperable Reusable



Toolchain Denis

Design / Dynamics Experts

Virtual Commissioning



Toolchain for simulation of digital twins within a virtual commissioning aproach

Verification and Validation

Software Engineering

Verification: solving the chosen equations correctly

Validation: choosing the correct equation

https://doi.org/10.1016/j.jcp.2004.10.036

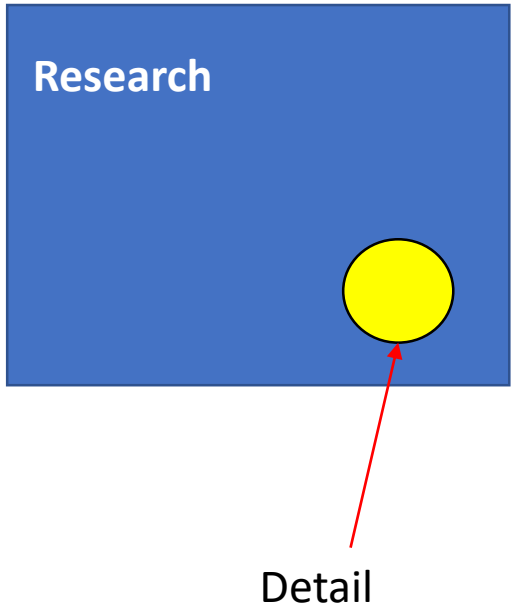
Philosophy of Science

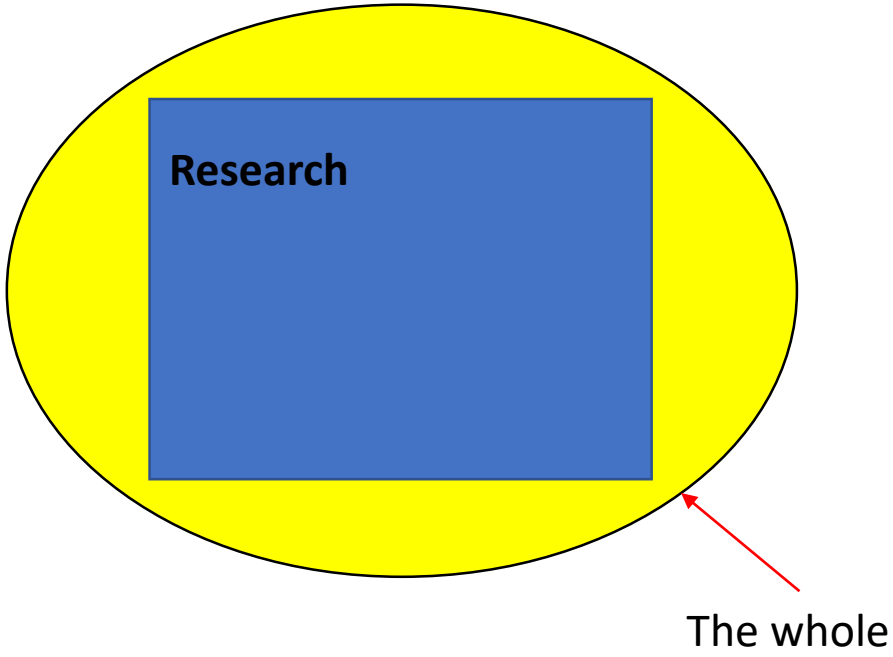
Verification: transparency

Validation: skill

https://doi.org/10.1515/aot-2018-0066

Micro vs. Macro Documentation





What to do

- Think about your own research and what is important to document
- Publish research results and document in a way others can understand it
- Think about your audience → who needs the documentation for what
- Think about the whole process

Conclusion

- Documentation is more complex than we would like to admit.
- Focus must be on the method not on tools, they change.
- Documentation happens at the end of the project and within the research process.
- Documentation is multidisciplinary.
- The research question determines the documentation.
- Micro and macro documentation is needed.