32nd Annual INCOSE international symposium
hybrid event
Detroit, MI, USA
June 25 - 30, 2022

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Don't Mix the Tenses: Managing the Present and the Future in an MBSE Context

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SAAB – Current Aerospace Development Projects

Gripen E/F

GlobalEye

T-7

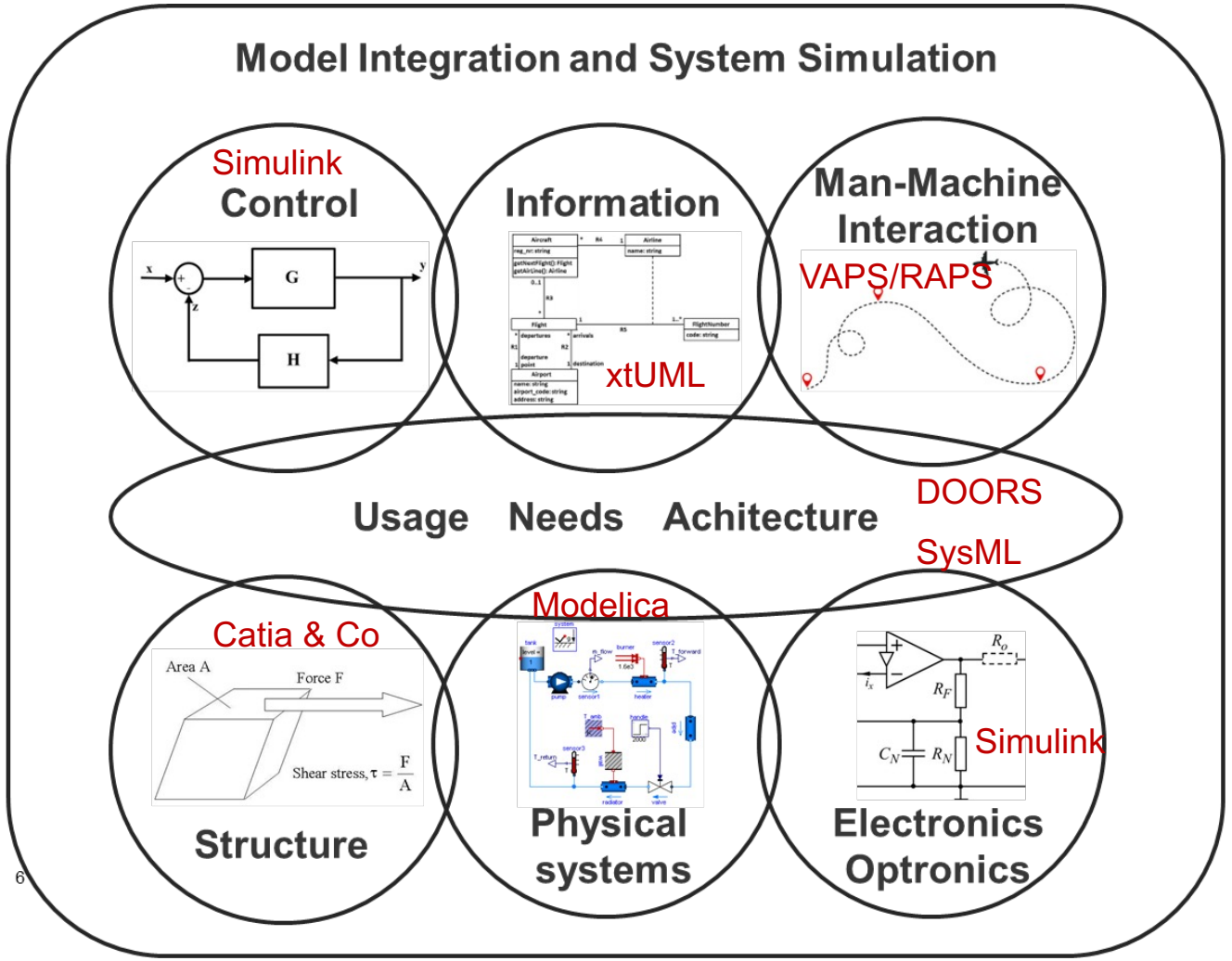
Desired development system properties

Speed, **flexibility** and **quality**!

Achieved by:

- **Frontloading**
  - Thorough understanding of the **problem space** and **stakeholder needs** and **requirements**
  - Evaluation of **multiple concepts**
- Extensive **simulation** support for early feedback
  - At **multiple levels of detail**, based on system design and structure
- Application of **Model-Based Engineering** tools and environments
  - Ensuring digital threads
- A **product family** approach
  - Capability to quickly configure customer specific variants
- Comprehensive **Configuration management** capability

Baseline MBSE Experience



Models of information, objects, needs, services

Models of physical objects

MBSE: The Gripen experience

Easier

Operations models

- Represents a future view
- One model, one language
- Black box
- Limited complexity – rather few details

Difficult

Systems models — Declaration

- Many parts to be integrated, incremental set-up
- Several aspects – many models
- Uncertainty in time – difficult to predict when entirety is reached
- Need to be kept up to date over the lifecycle

Easier

Engineering discipline models — Declaration

- Direct connection from definition to design
- Limited number of configurations
- Many teams, few models per team
- Few people per model

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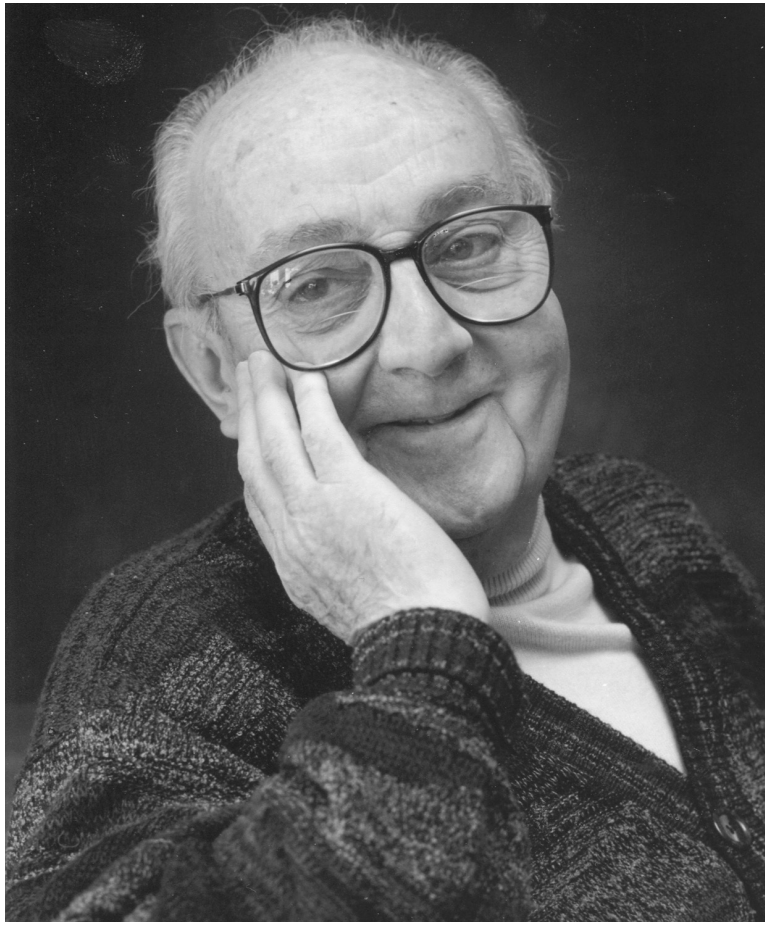
All models are approximations.

Essentially, all models are wrong but some are useful.

George Box



Sample Model Properties

- **Fidelity:** the level of detail provided in the simulation
- **Credibility:** how well the model/simulation represents the realised product
  - Which may or may not be in existence
- No conclusions can be drawn from a model or simulation without a good understanding of its **Fidelity** and **Credibility**

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Combining MBSE and Incremental development

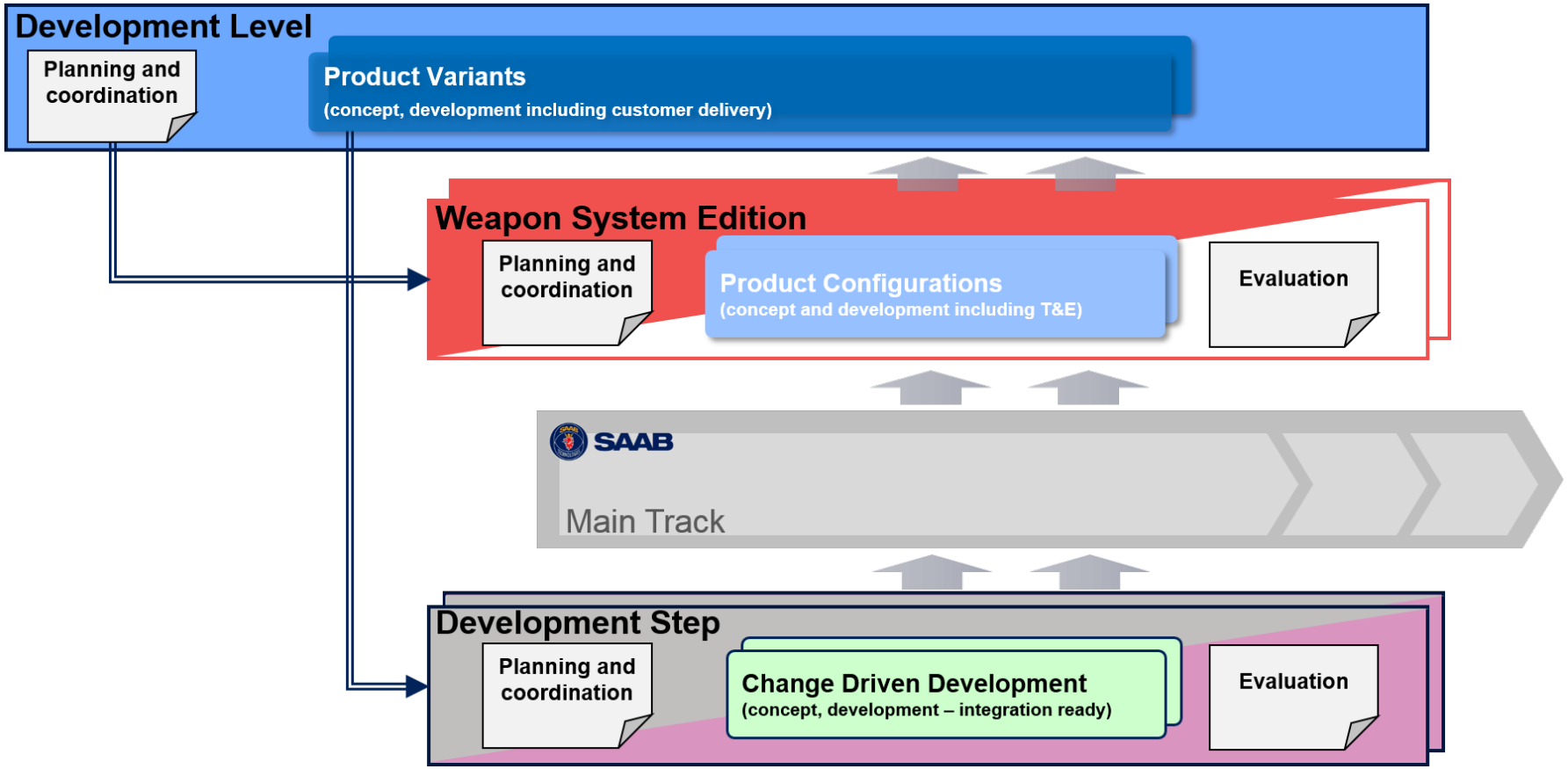
Analysis

It is unreasonable to expect that a single model can capture all aspects of a system from early concept Definition to Realisation for all engineering disciplines.

Our need:

- **Multiple models** and model types for multi-disciplinary products
  - At **multiple levels of detail**
  - All models (executable or communicative) must have a **stated purpose** and a **credibility** declaration stating how well it meets its purpose
    - Our understanding of the credibility of an individual model may **change over time**
- **Need to define a framework for the kind of models needed in development and the expectations on them**

Incremental development – Four boxes in parallel



Development Level

- Establish a weapon system with common functionality
- Customer interface

Weapon System Edition

- Set of weapon system configurations by integration of product changes

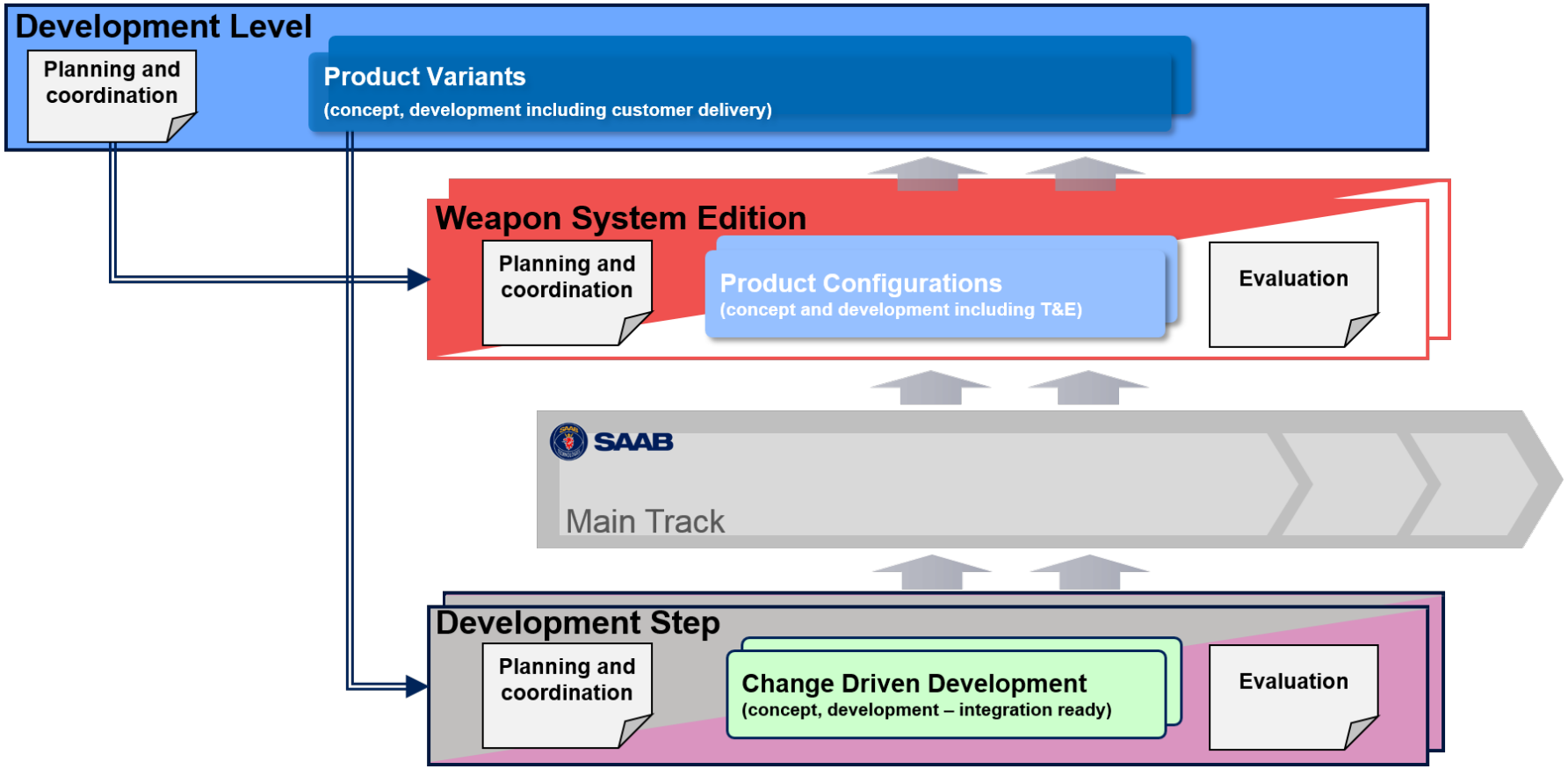
Main Track

- Warehouse of realised components available for integration within a product configuration

Development Step

- Activities for incremental and change driven implementation on system elements

Development process applied – Understanding the tenses



Future tense – what it shall become at the end

Present tense – the content of individual configurations
A realised product – or a model of it

Realisation of capability – turning future to present

pment process applied – Understanding the

Coarse model
What it will be in the long-time perspective

Detailed models how everything is realised using what is available now

Model describing detailed component/capability design – how it will be in near future

Development Level

Planning and coordination

Product Variants
(concept, development including customer delivery)

Weapon System Edition

Product Configurations
(concept and development including T&E)

Evaluation

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Main Tra

Development St

ning and ordination

It is clearly impossible to manage these tenses in ONE single model…!

Future tense – what it shall become at the end

Present tense – the content of individual configurations
A realised product – or a model of it

Realisation of capability – turning future to present

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Structuring models based on tense

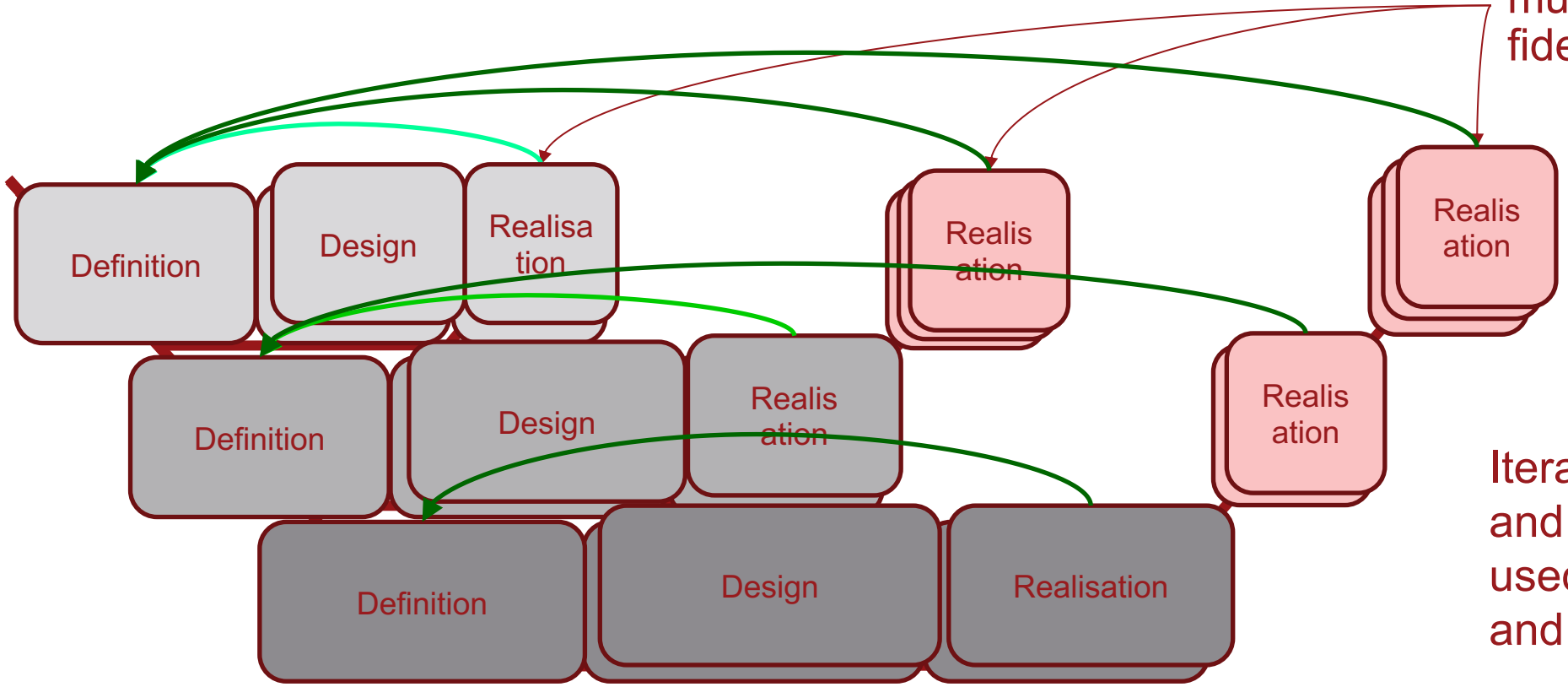
In the model world

- **Definition model**
  - Captures the **intended architecture**
  - Relatively **undetailed**
  - Purpose is for **communication** and **long term memory**
  - For example, **SysML** as a common language
  - Change management/development planning

- **Design model**
  - Captures a system element from a **particular perspective**
    - Interfaces and key properties
  - Multiple **Design models** may be required to adequately represent the intent in a Definition model
    - **Multiple languages**, e.g. Simulink, Modelica, CFD, …
- **Realisation** (physical and virtual)
  - **Multiple virtual** Realisations with different fidelities and perspectives may be created
    - FMI standard preferred for definition of Realisation interfaces
  - Realisation **interconnection models** are required for composite Realisations

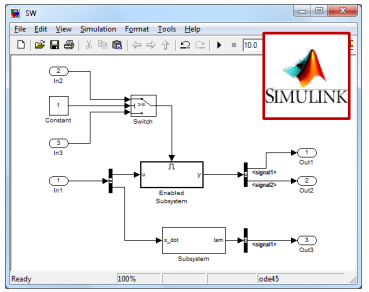
Feedback using virtual Realisations

Multiple virtual Realisations – multiple perspectives, fidelities and credibilities



Iterative feedback from virtual and physical Realisations are used to shape the Definition and Design models

Model-Based Development of aircraft vehicle systems (Gripen E)



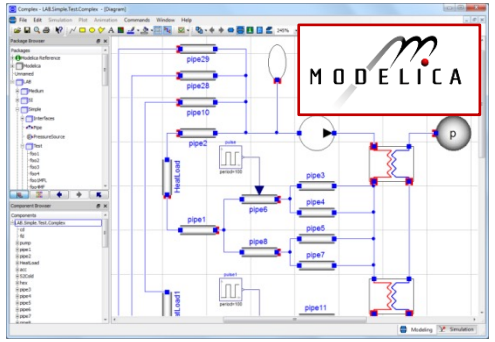
Design & Implementation of S/W

Test rigs & simulators

Test aircraft

1

Reuse



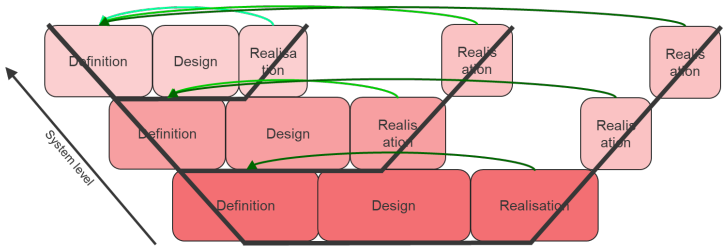
M&S of physical systems

2

3

Calibration and validation of models
Minor updates of system design

Model evolution over time



Definition model version evolution

Design models

Coarse models

Intermediate models

Detailed model

Multiple virtual realisations for a single definition model version:

Simple virtual realisation

Function oriented virtual realisation

Realisation oriented (detailed) virtual realisation

Physical realisation

Tenses in MBSE How to realise it

- Fine grain Configuration Management support for all model elements
  - Loose coupling – don't mix tenses in a model
- Select iterface standards for enabling integration of models from different sources
  - FMI, SSP
- Which models can be combined?
  - Single classification framework for all models
- To what extent can we trust our integrated models?
  - Introduce model Credibility measure

Summary

To remember from this presentation!

- For compelx systems it is never **ONE model** or **ONE language**
- Manage model content based on tense, i.e., Separation of **Definition** & **Design**
  - Driven by development evoluation
- MBSE is the **future**
  - Need to understand, manage and configure models to manage the **complexity**
  - **Configuration management** is an essential part for succeeding in implementing **MBSE**
    - Configuration management is supported in modern development environments
- **All models are wrong, but some are very useful** – the **right model** in the **wrong configuration** context is very dangerous

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