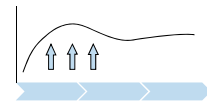# EARLY BIRD

Seamless System Design from Concept Phase to Implementation

CASTOR Software Days 2022

VINNOVA
Sweden's Innovation Agency

| Leif Linderstam (Ericsson), Ingemar Söderquist (Saab), Ingo Sander (KTH) | 2022-09-01 |

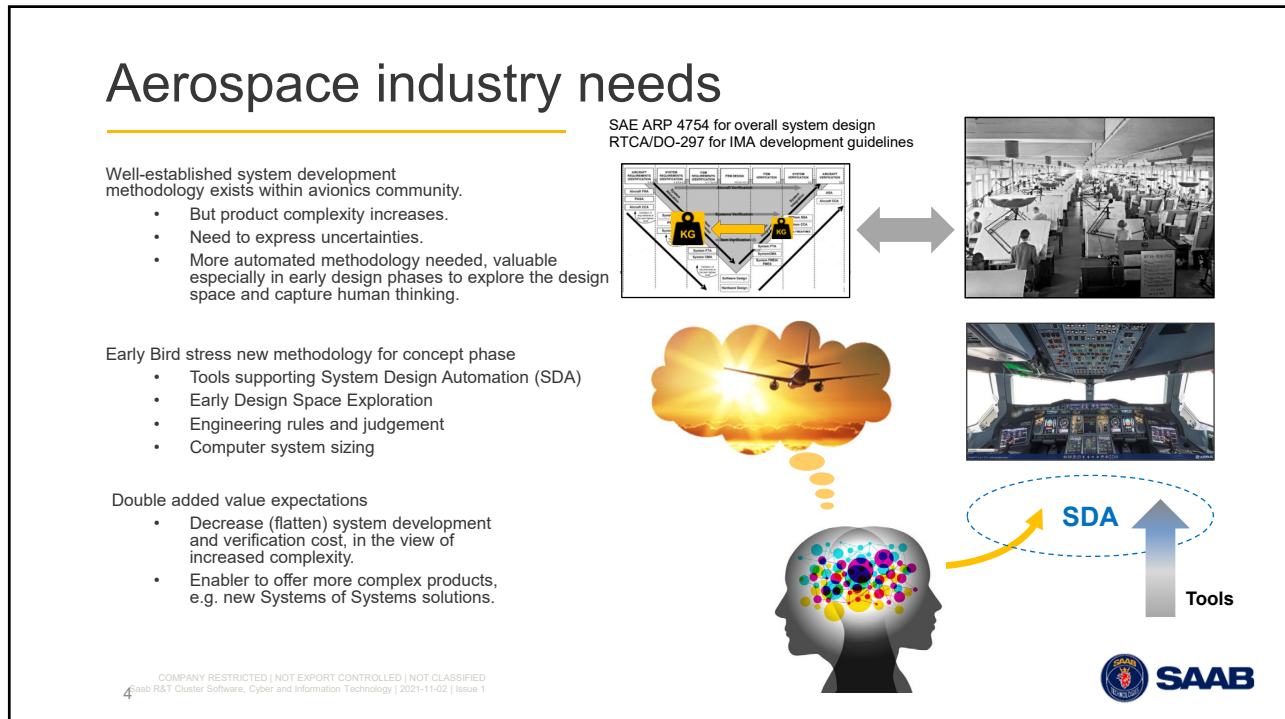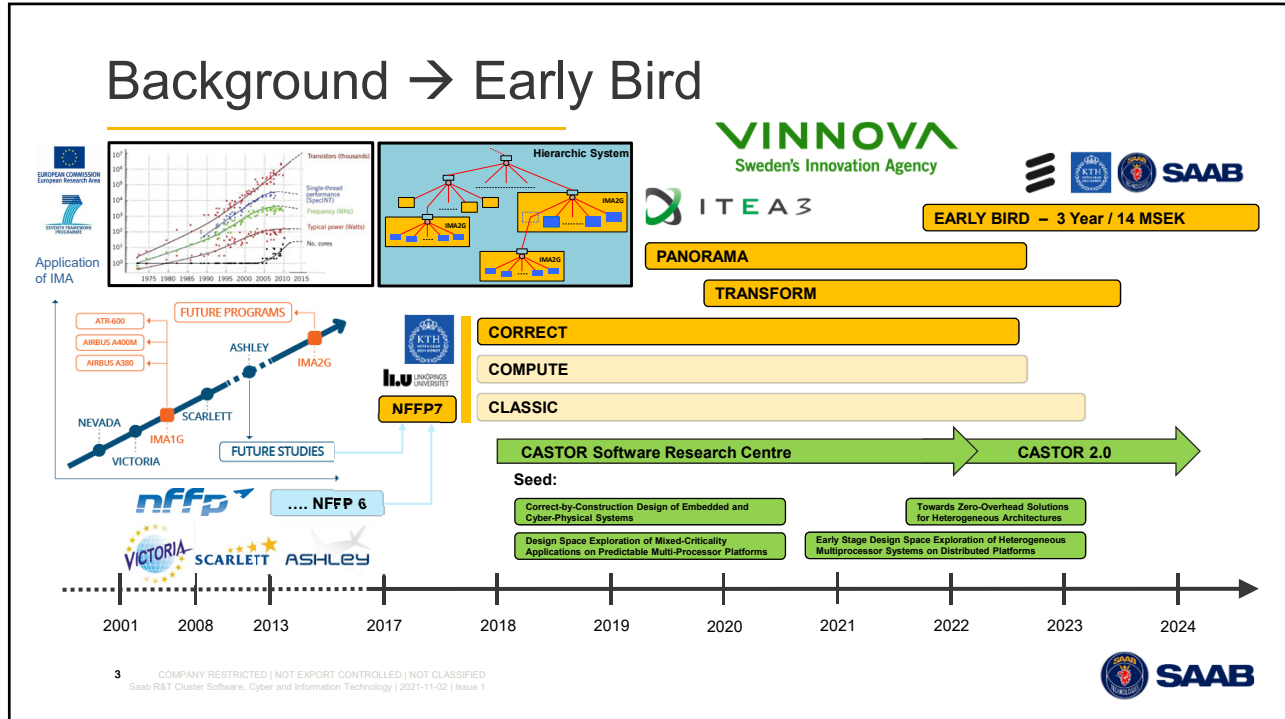# Agenda

Handle … increased complexity and a large design space at the concept phase

… with the uncertainties expressed as part of a formal model.

➡ • Background & needs
• Project idea
• Research challenges
• Questions …

Better understand consequences of early design decisions

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Background → Early Bird

Aerospace industry needs

Well-established system development methodology exists within avionics community.

- But product complexity increases.
- Need to express uncertainties.
- More automated methodology needed, valuable especially in early design phases to explore the design space and capture human thinking.

Early Bird stress new methodology for concept phase

- Tools supporting System Design Automation (SDA)
- Early Design Space Exploration
- Engineering rules and judgement
- Computer system sizing

Double added value expectations

- Decrease (flatten) system development and verification cost, in the view of increased complexity.
- Enabler to offer more complex products, e.g. new Systems of Systems solutions.

SAE ARP 4754 for overall system design
RTCA/DO-297 for IMA development guidelines
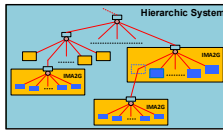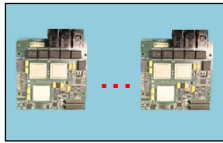
SDA

Tools

Early Concept – IMA Abstraction levels
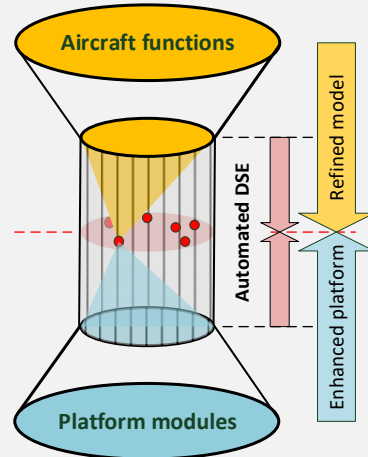
Conceptual requirement

Module library

Multifunctional system

IMA Model
Functions de-composed
to components

IMA System
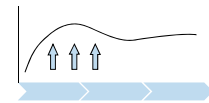Platform with
mapped functions

IMA Platform
Selected modules
and connectivity

Platform modules
HW/SW

Hierarchic System

Aircraft functions

Platform modules

Automated DSE

Refined model

Enhanced platform

5

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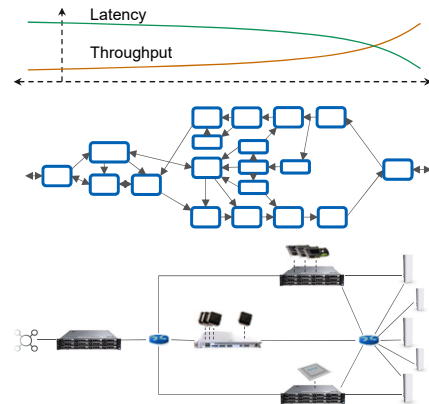- Project idea
- Research challenges
- Questions …

**Better understand consequences
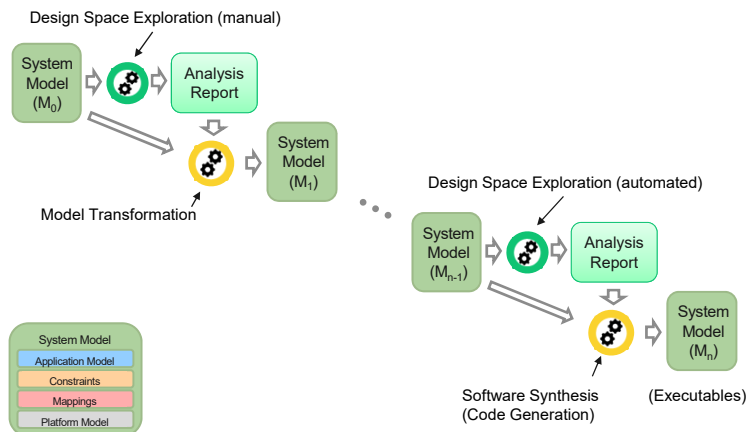of early design decisions**

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Telecom Industry Challenges (focus on RAN)

- Very tough performance requirements on Radio Access Network (RAN) systems
- SW needs to make the most of available HW
- Ever increasing feature set -> increasingly complex SW/HW
- HW diversity increases, as does functional distribution

- Requires more design automation
- Requires more support for early decision-making to cut in the diverse set of options

Latency

Throughput

System Design Flow (Software View)

Design Space Exploration (manual)

System Model (M_0)

Analysis Report

System Model (M_1)

Model Transformation

Design Space Exploration (automated)

System Model (M_{n-1})

Analysis Report

System Model (M_n)

Software Synthesis (Code Generation)

(Executables)

System Model
Application Model
Constraints
Mappings
Platform Model
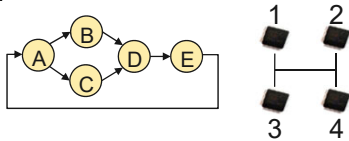
Design Space Exploration

The design space is a multi-dimensional space, examples:
- Scheduling of processes onto CPU cores
- Choice of algorithm to fulfill non-functional constraints
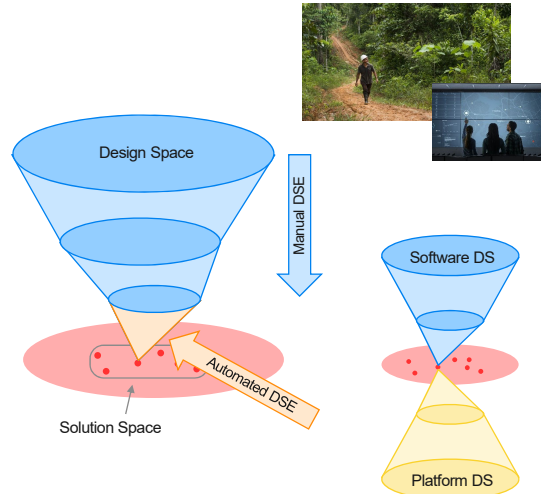- Partitioning of data and computations

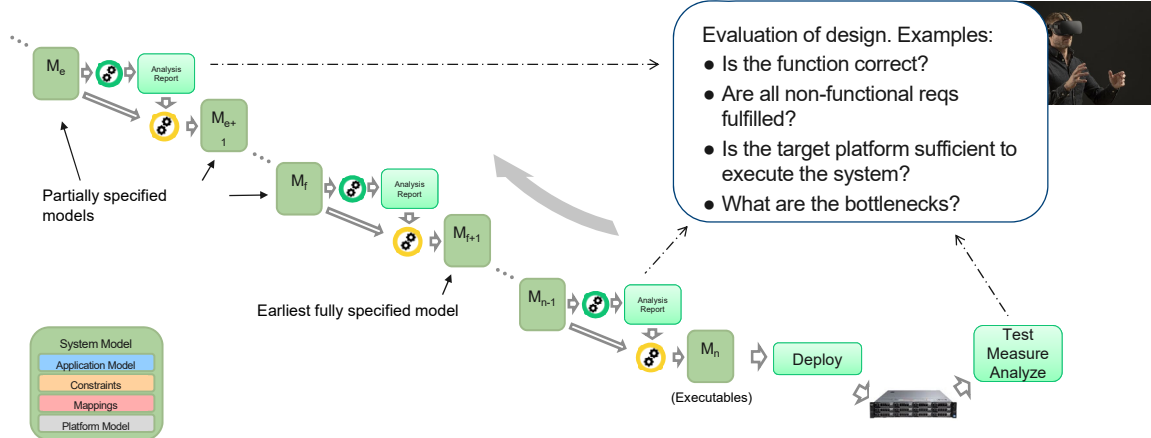Consider simple scheduling example, 5 processes onto 4 CPUs:

Sample solutions:
- Even distribution due to high compute or memory demands
- A, D, E on CPU 1; B on CPU 2; C on CPU 3 due to differences in compute and latency requirements
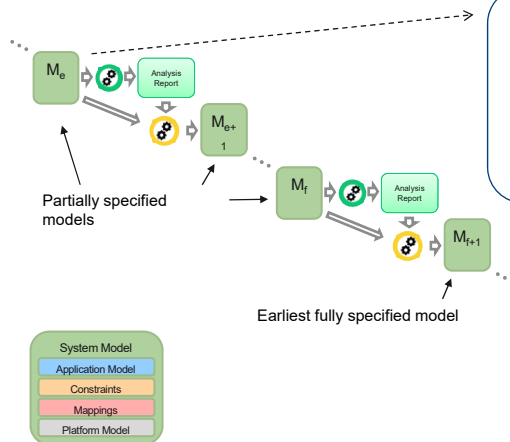- All processes on CPU 1 due to too high latency in interconnect

Vision: Computer Aid for Early-Stage Evaluation and Transformation

Partially specified models

Earliest fully specified model

System Model
Application Model
Constraints
Mappings
Platform Model

(Executables)

Deploy

Test Measure Analyze

Evaluation of design. Examples:
- Is the function correct?
- Are all non-functional reqs fulfilled?
- Is the target platform sufficient to execute the system?
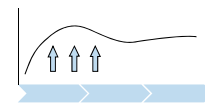- What are the bottlenecks?

Challenges

Partially specified model means we have *uncertainties, so:*

- How do we model uncertainties in an analyzable manner?
- How do we perform automatic Design Space Exploration in the presence of uncertainties?
- How can we do model transformations/synthesis on partially specified models?

Partially specified models

Earliest fully specified model

System Model
Application Model
Constraints
Mappings
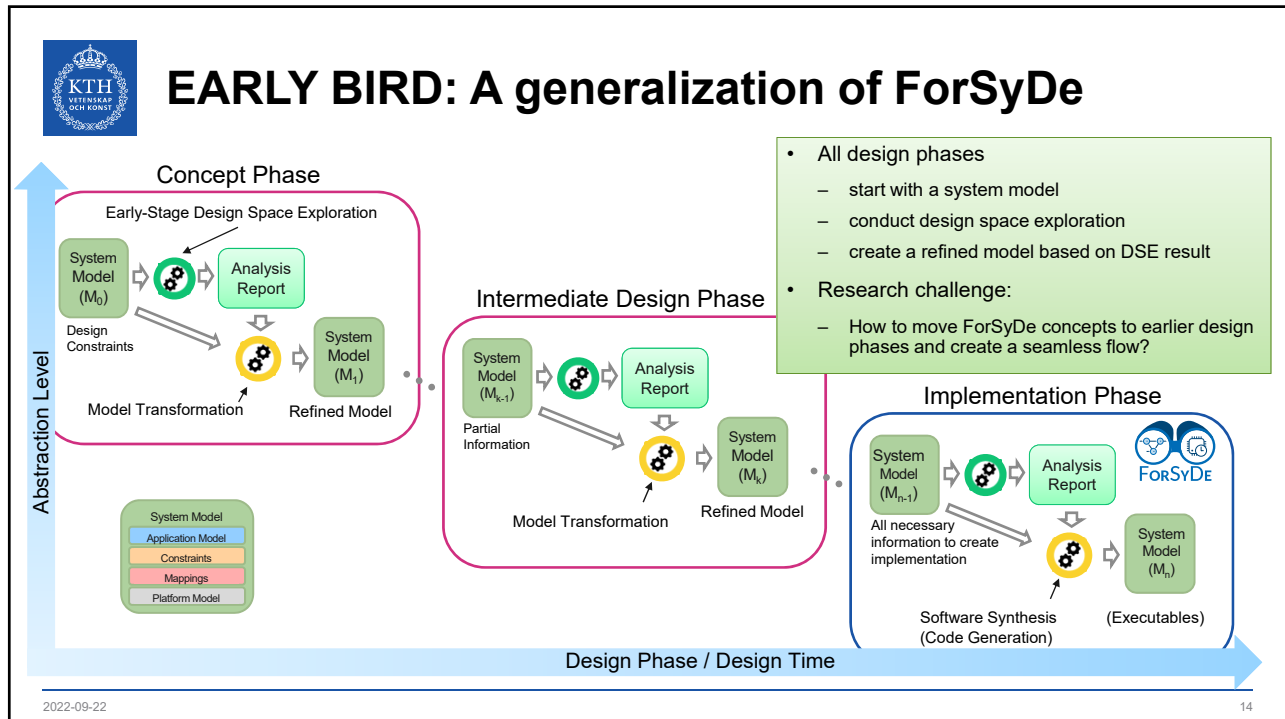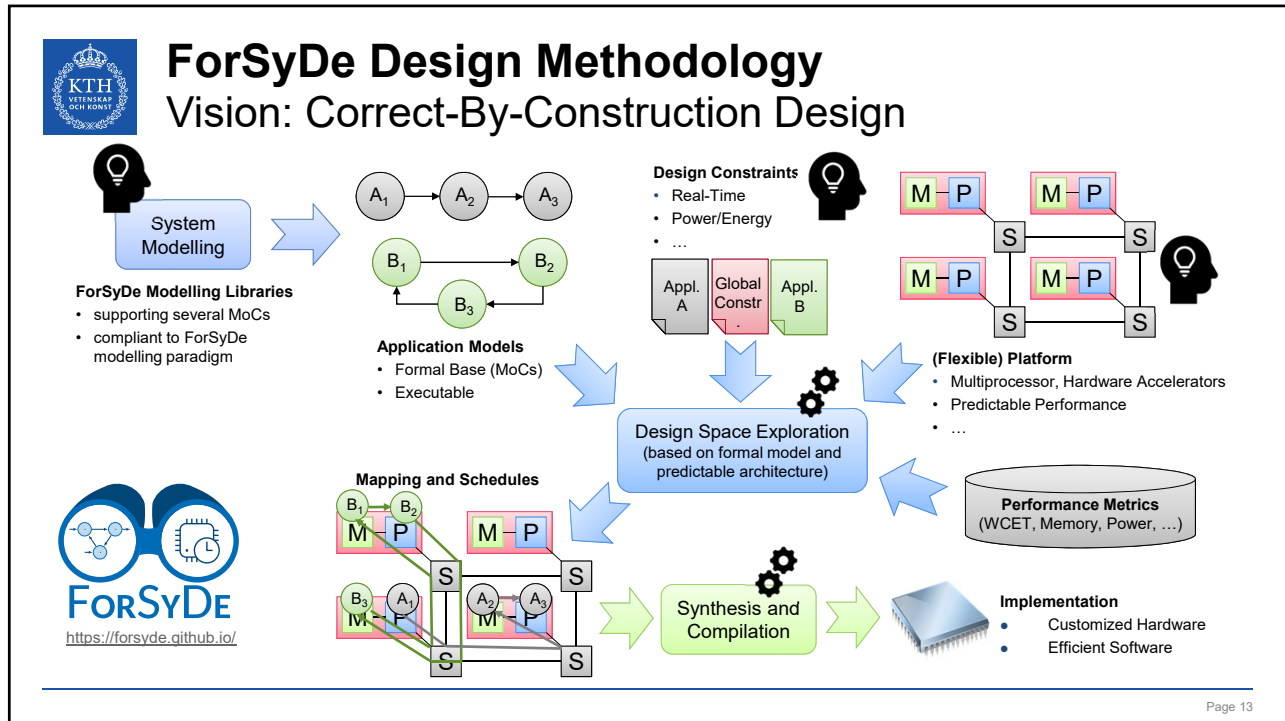Platform Model

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ForSyDe Design Methodology
Vision: Correct-By-Construction Design

EARLY BIRD: A generalization of ForSyDe

Research Challenges

- System Model
  - How to express uncertainties or incomplete information at the early design stages?
  - To what extent can incomplete models be simulated?
- Design Space Exploration
  - How can design space exploration be conducted with partial information?
  - How can designers' knowledge be integrated into the design flow to enable better decisions?
  - How can information about the confidence of the DSE results be produced?
  - How can the confidence of the DSE be increased?
- Model Transformation / Synthesis
  - How to formulate and apply model transformations to create a refined model based on the analysis results of the design space explorations?
  - How to decide which of the possible results of the DSE should be used for synthesis?

EARLY BIRD will utilize results of the previous projects CORRECT, and PANORAMA, and the ongoing project TRANSFORM.

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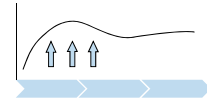
Conclusions

- Current state:
  - Demonstration of the basic ForSyDe concepts in an avionics IMA context
  - ForSyDe modeling libraries and initial set of design tools available as open source
- Project goals:
  - Establish a seamless system design methodology from early concept to implementation
  - Extend ForSyDe modeling and simulation framework to express avionics and telecom applications and platforms, and uncertainties at different stages of the design flow
  - Develop concepts and tools for DSE at different levels of abstraction with emphasis on the early stages of the design process
  - Develop a general concept and tools for model transformation (synthesis) across different design stages from concept phase to the final implementation
  - Demonstrate and evaluate the methodology with relevant industrial use cases from the avionics and telecom domain

2022-09-22   16

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**Thank you for your attention.
Any questions ?**

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