Model Driven Engineering in High Tech Industry

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LUCAS-dagen, Lund, October 2016

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Where innovation starts

Short introduction of myself

- 1992 - 1997: Assistant professor at UvA (NL)
- 1997 - 2005: Senior researcher at CWI (NL)
- 2006 - now: Full professor TU/e (NL)
  - Chair of Software Engineering and Technology (SET)
  - SET focuses on Model Driven Software Engineering:
    - Domain specific language design
      - dynamic semantics
    - Analysis of model transformations
      - metrics and visualization
      - verification
    - Modeling of Functional Safety in Automotive Domain
  - Industry motivated research

Introduction

- **Software Engineering and Technology (SET) group has strong cooperation with High Tech industrial partners:**
  - **ASML (lithography systems for the chip industry)**
  - **DAF ((long distance heavy) trucks)**
  - **Océ (document handling)**
  - **Philips Healthcare (medical equipment: MRI, CT, X-ray, invasive surgery)**
  - **VanDerLande Industries (luggage handling, warehouses)**

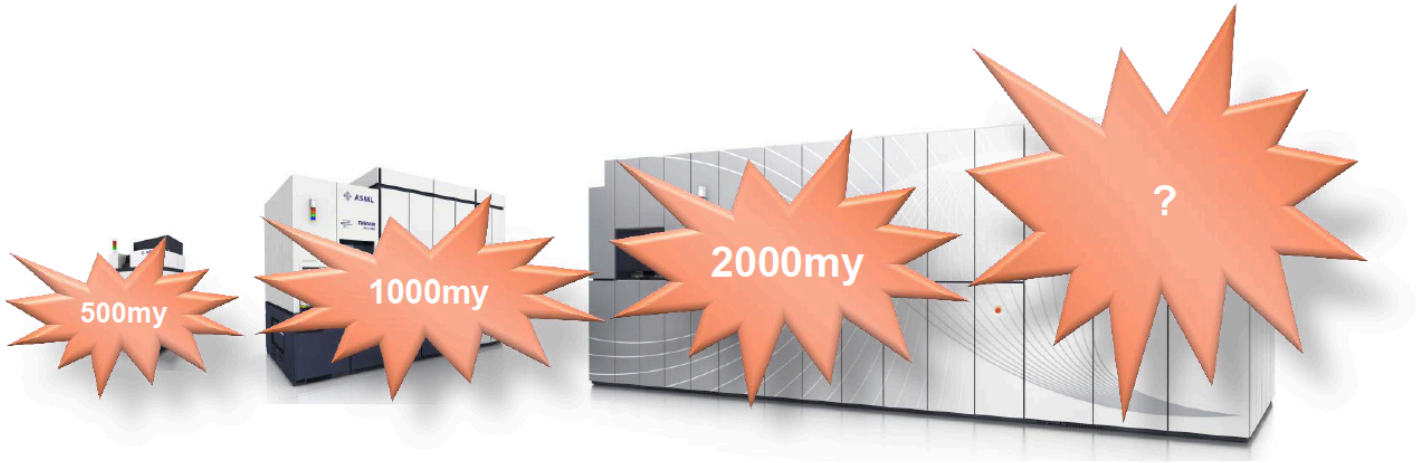
Introduction

ASML

Public
Slide 14
18 May 2015

Moore's law for ASML software development

Software effort doubles every new generation



We need to stop this trend, it is not sustainable

Introduction

ASML

Public

Slide 11

18 May 2015

ASML software in numbers

- TWINSCAN software consists of
  - 40 million lines of code
  - 2000 components, 60.000 files
- 20+ computing nodes running more than 200 processes
- 1000+ engineers

- 40 million lines of code corresponds to several thousand ManYears of work

Introduction

- Software evolves, continuous growth in:
  - size of software (amount of LOC)
  - complexity of software
  - features in (software) systems
  - costs to build software
  - number of programming languages in software systems

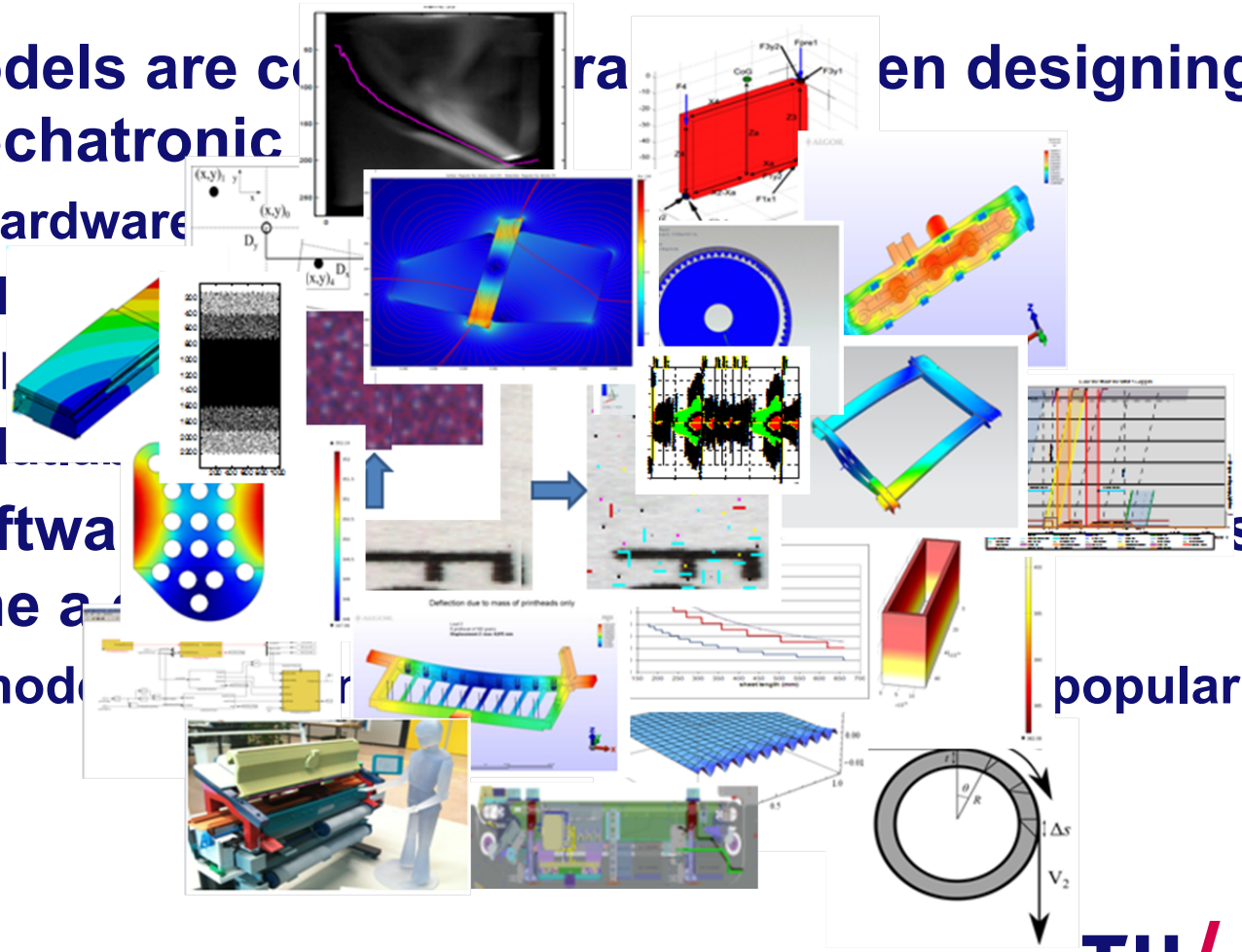
- Software has become big data

Introduction

- The increase in software has raised:
  - the need for efficient software development
  - the awareness with respect to legacy software
  - the opportunities of virtualization

Introduction

- Models are c ra en designing mechatronic
  - hardware
  - el
  - pl
  - M
- Softwa same time a
  - mod popular



Introduction

- **Model driven engineering**
  - **considers models as first class citizens**
  - **increases level of abstraction because of the use of models**
  - **offers the choice between general purpose modeling languages or domain specific languages**
    - **the first may lead to a vendor lock-in**
    - **the second may involve a huge investment in language design, implementation, and tooling**

Introduction

- A few (research/engineering) challenges:
  - Identification of common semantic concepts in a certain domain:
    - High-Tech Industry
      - real-time, state machines, supervisory control, material flow (paper, wafers, luggage), etc.
    - Capturing these concepts in semantic based workbenches
  - Quality and correctness of model transformations wrt
    - property preservation
    - underlying semantics
  - Modularity of meta-models and composition semantic building blocks
  - Evolution of meta-models and co-evolution of models
  - Mixing multiple domain specific languages

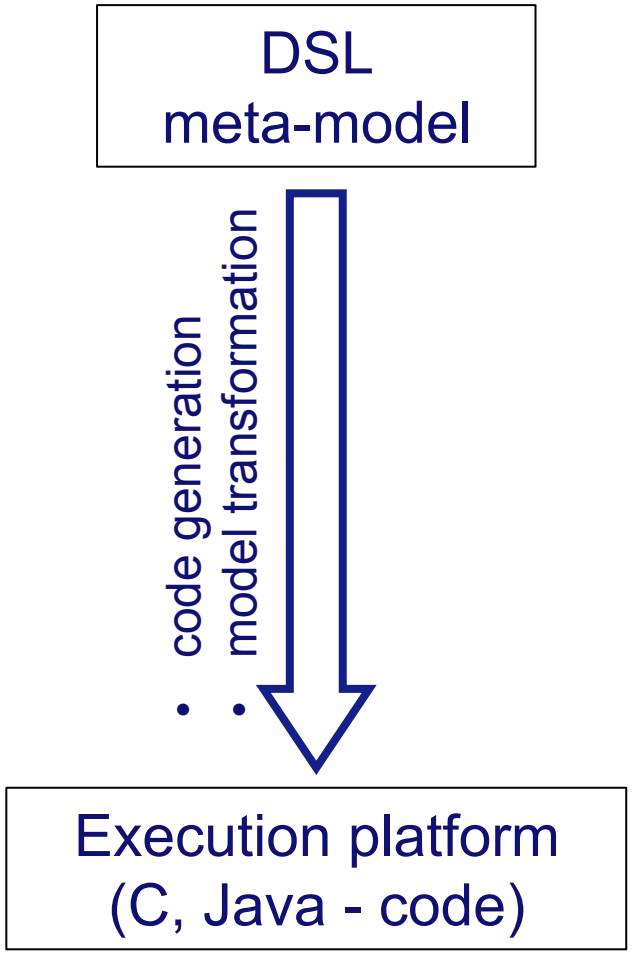
Domain Specific Languages

- **What is a Domain Specific Language (DSL)?**
  - **A DSL is a formal, procesable language targeting at a specific aspect of a system**
  - **Its semantics, flexibility and notation is designed in order to support working with that aspect as efficiently as possible**
  - ***"A language that offers, through appropriate notations and abstractions, expressive power focused on, and usually restricted to, a particular problem domain"***

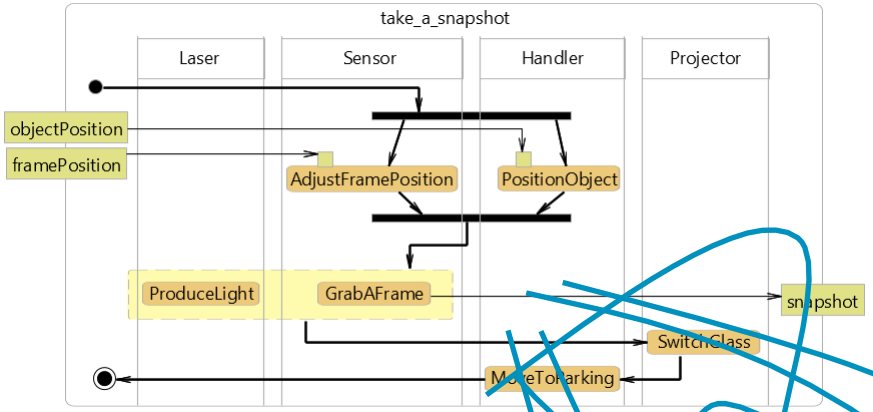
Domain Specific Languages

- **DSL design alternatives:**
  - **Use an existing language "as is"**
    - **add domain specific functionality via libraries**
  - **Adapt/extend an existing language**
    - **introduce new language constructs**
  - **Develop a new language from scratch**
    - **syntax, semantics and tooling**

Domain Specific Languages



Domain Specific Languages



Model transformations
and
Code generation

C-code

Domain Specific Languages

- **Model driven software engineering offers**
  - **Reduction of development time via increase of abstraction**
  - **Increase of robustness via verification of models and model transformations**

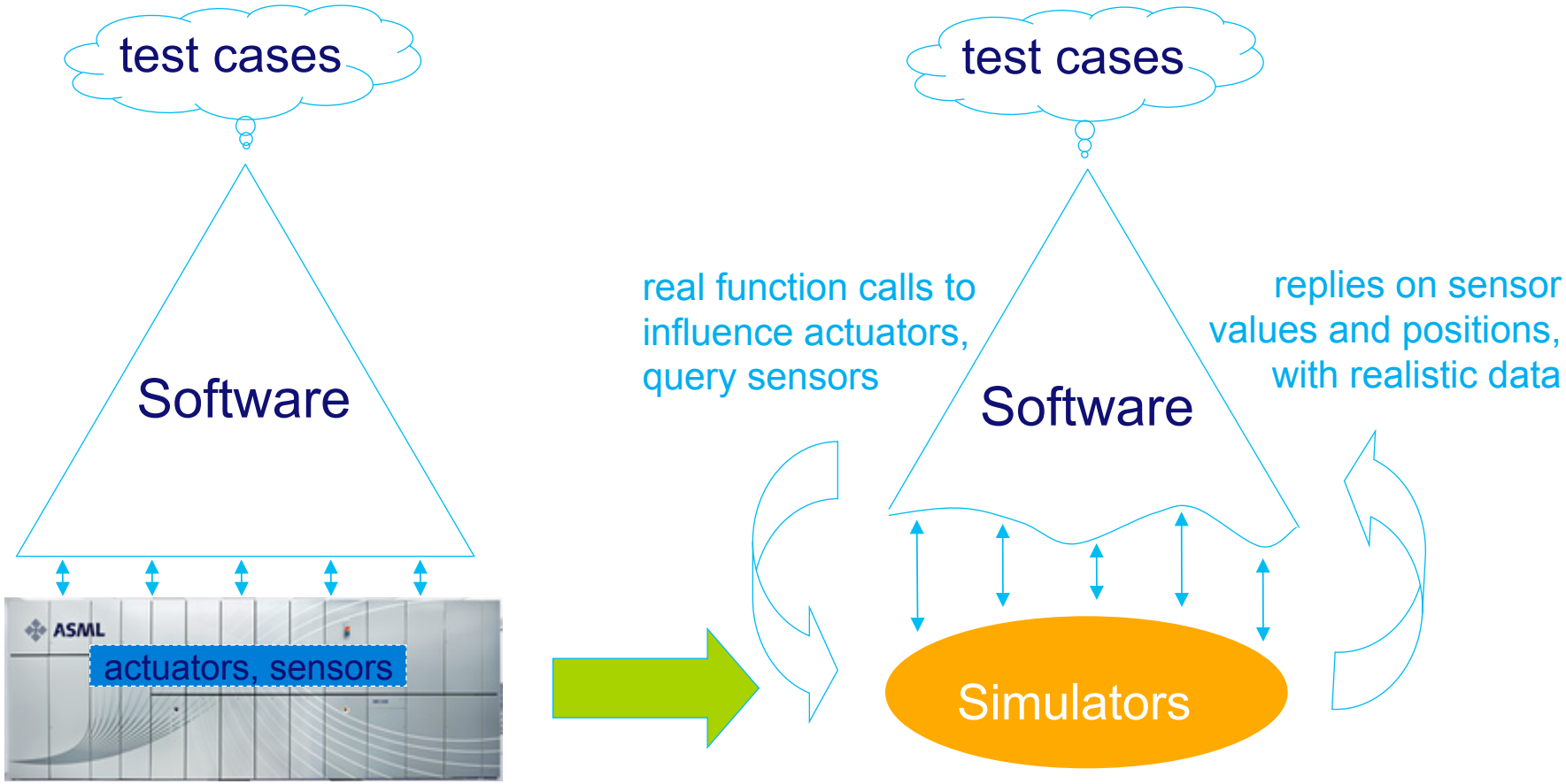
- **However,**
  - **efficient design of domain specific languages and corresponding tooling has to be implemented**

Meta-modeling

- ASML has
  - 22 DSLs built using EMF + OCL
  - 5500 models created using the meta-models
- Two of these DSLs in more detail:
  - VPDSL
    - model driven engineering meets virtualization
  - LACE
    - exercise in defining the dynamic semantics

Domain Specific Languages

Software in a Loop Simulation



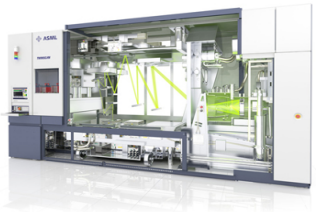
TWINSCAN

Domain Specific Languages

- **TWINSCAN Platforms and Machine Types**

TWINSCAN product family

TWINSCAN platforms



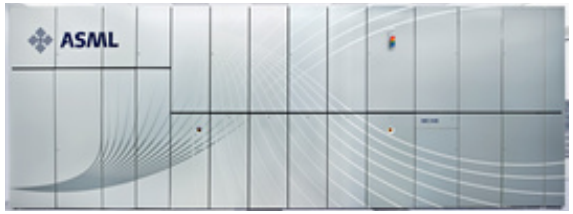
	XT platform	NXT platform	NXE platform
Main specifications	downto 38 nm upto 150 wafers/hr	below 38 nm above 175 wafers/hr	below 27 nm above 60 wafers/hr
Machine types	XT:1950Hi XT:1900Gi XT:1700Fi XT:1450G ...	NXT:1950i ...	NXE:3100 ...

common and unique HW (& SW) modules to maintain material (wafer) flow

How to create wafer-flow simulator efficiently for this product family?

Domain Specific Languages

How to Build a Wafer Flow Simulator?



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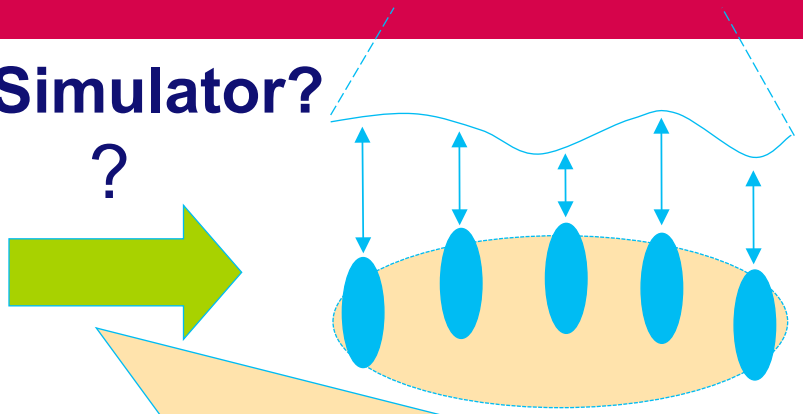
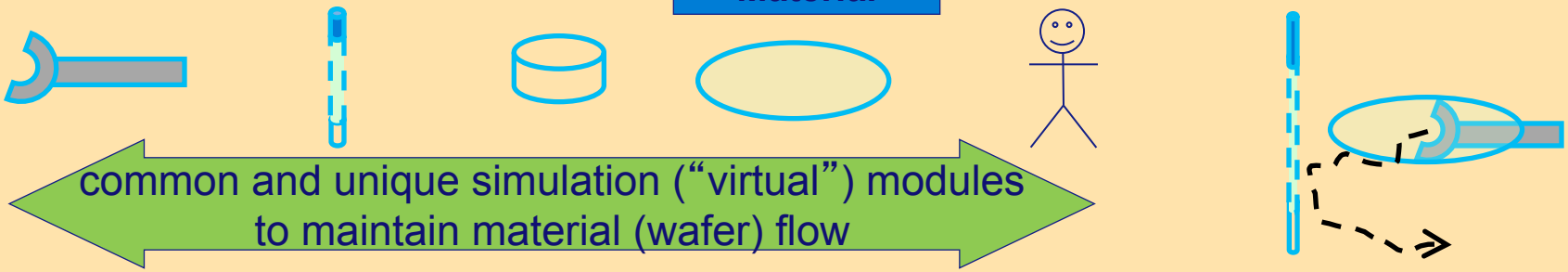


…try to re-create a virtual replica of the real world…

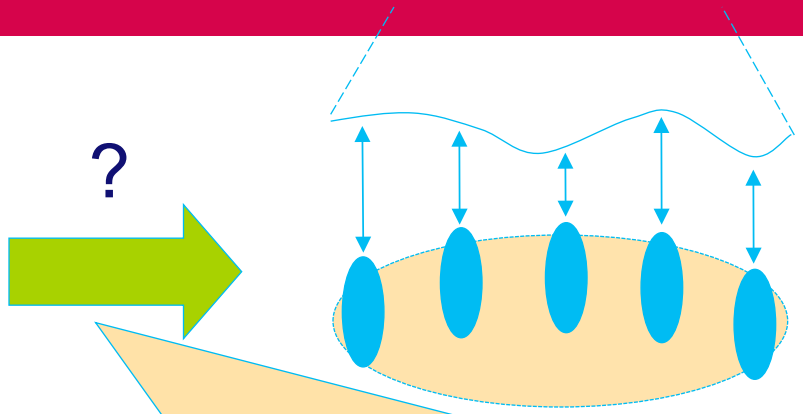
Actuators | Sensors | Holders | **Transportable Material** | Operator | *Interactions* | …



Domain Specific Languages

How to Build a Wafer Flow Simulator?
Error Scenarios

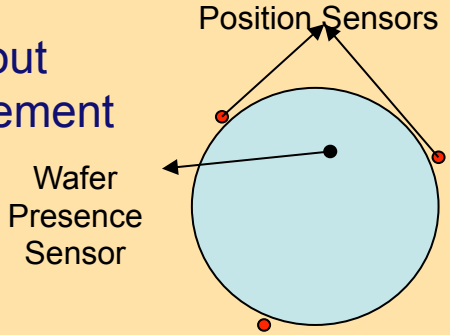
?

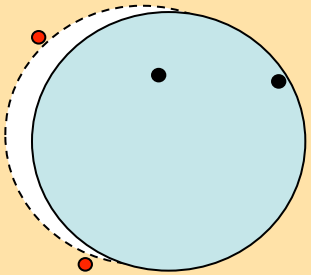


…however, the real world usually does not “behave” perfectly…

Error-injection Scenarios in Simulation

Transfer without wafer displacement

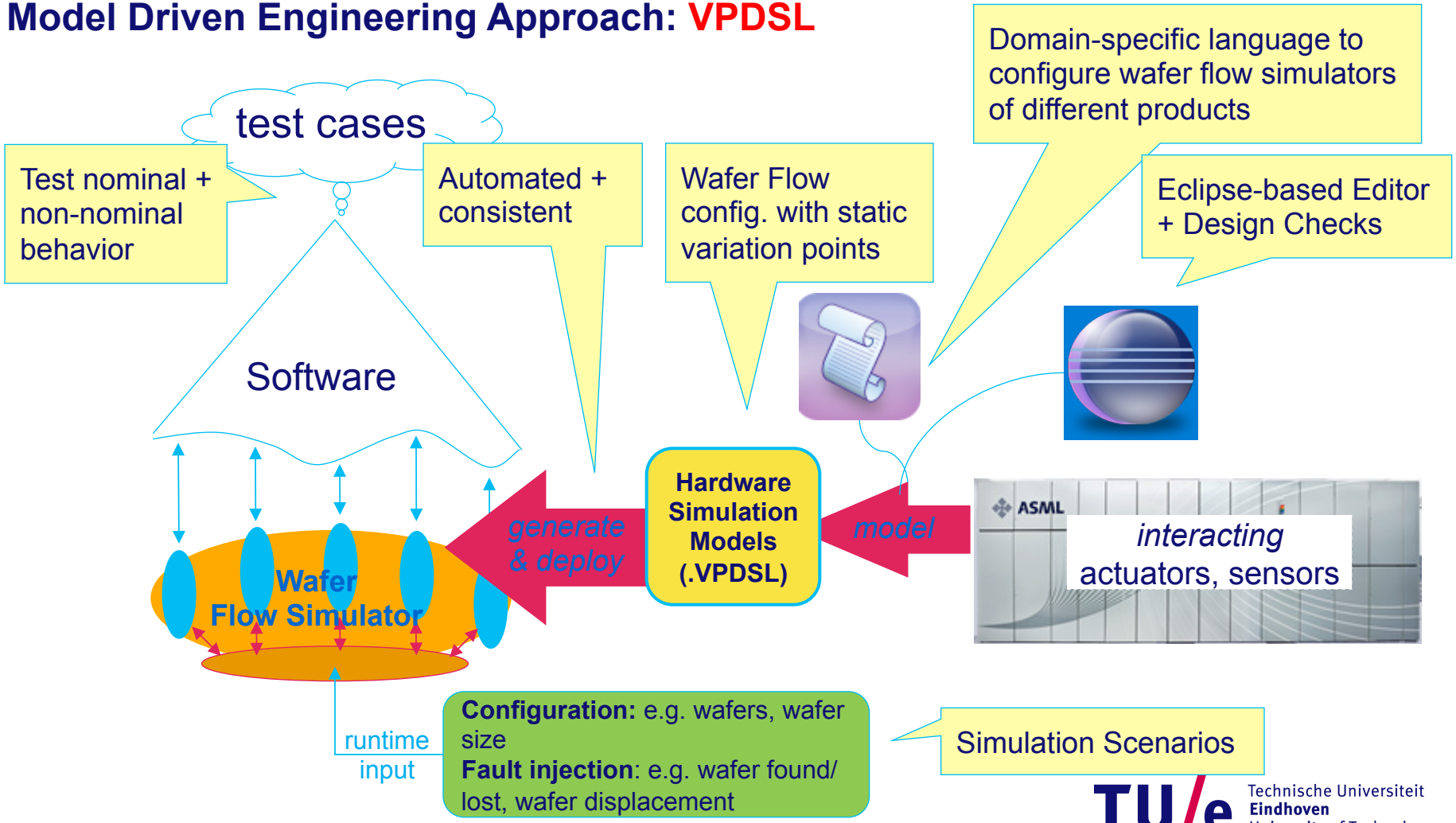




Transfer with wafer displacement

Domain Specific Languages

Model Driven Engineering Approach: VPDSL



Domain Specific Languages

Design Workflow

mechanical engineer

Specify VPDSL model

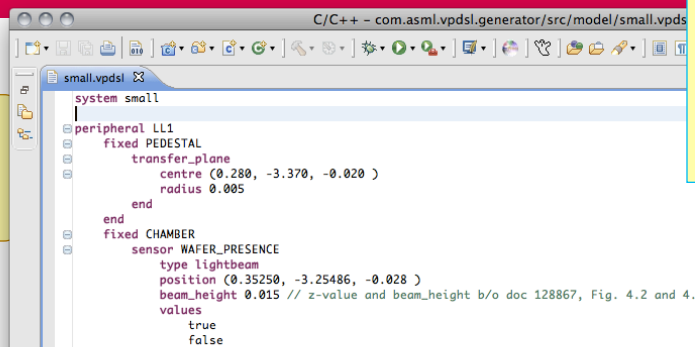
X LoC

Generate simulation code

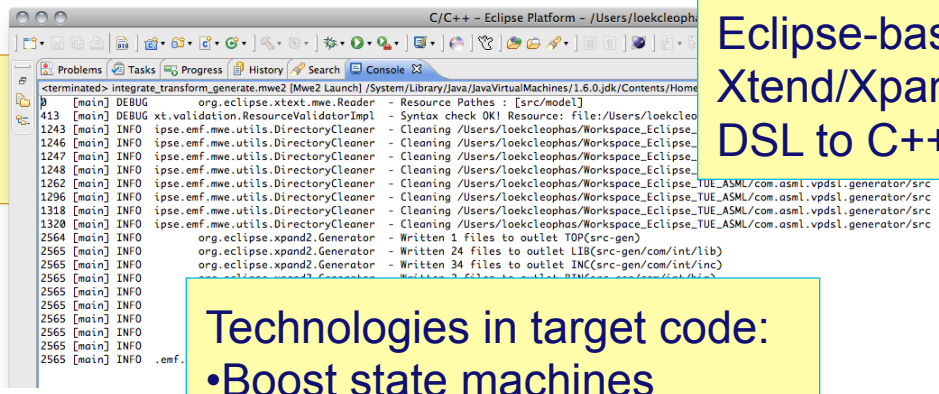
12*X LoC
(8*X model-dependent)

software engineer

Integrate simulation code with control software



Eclipse-based Xtext DSL editor



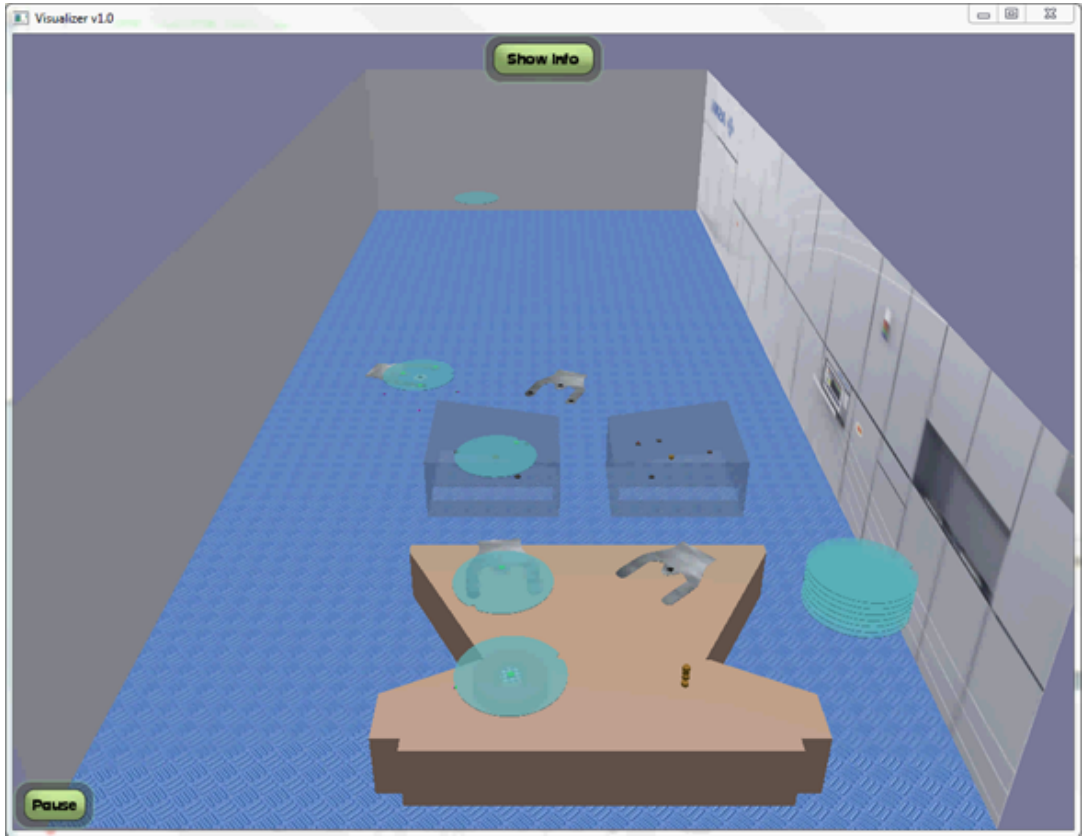
Eclipse-based Xtend/Xpand DSL to C++

Technologies in target code:
- Boost state machines
- Geometry library
- ASML sw. facilities

ASML

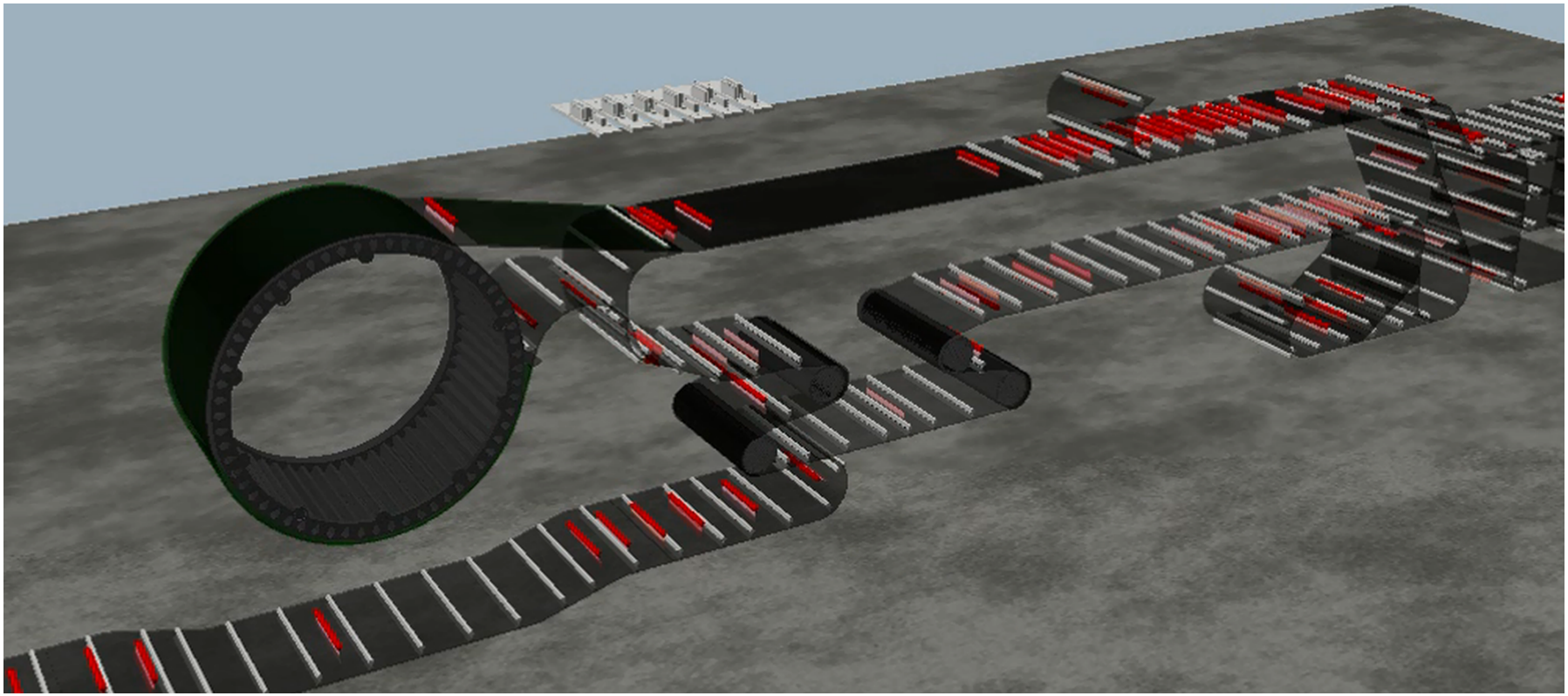
TU/e Technische Universiteit Eindhoven University of Technology

Domain Specific Languages



Domain Specific Languages

- **Another example of virtualization via a DSL**



Questions