



Customer-Oriented Product Engineering of Micro and Nano Devices

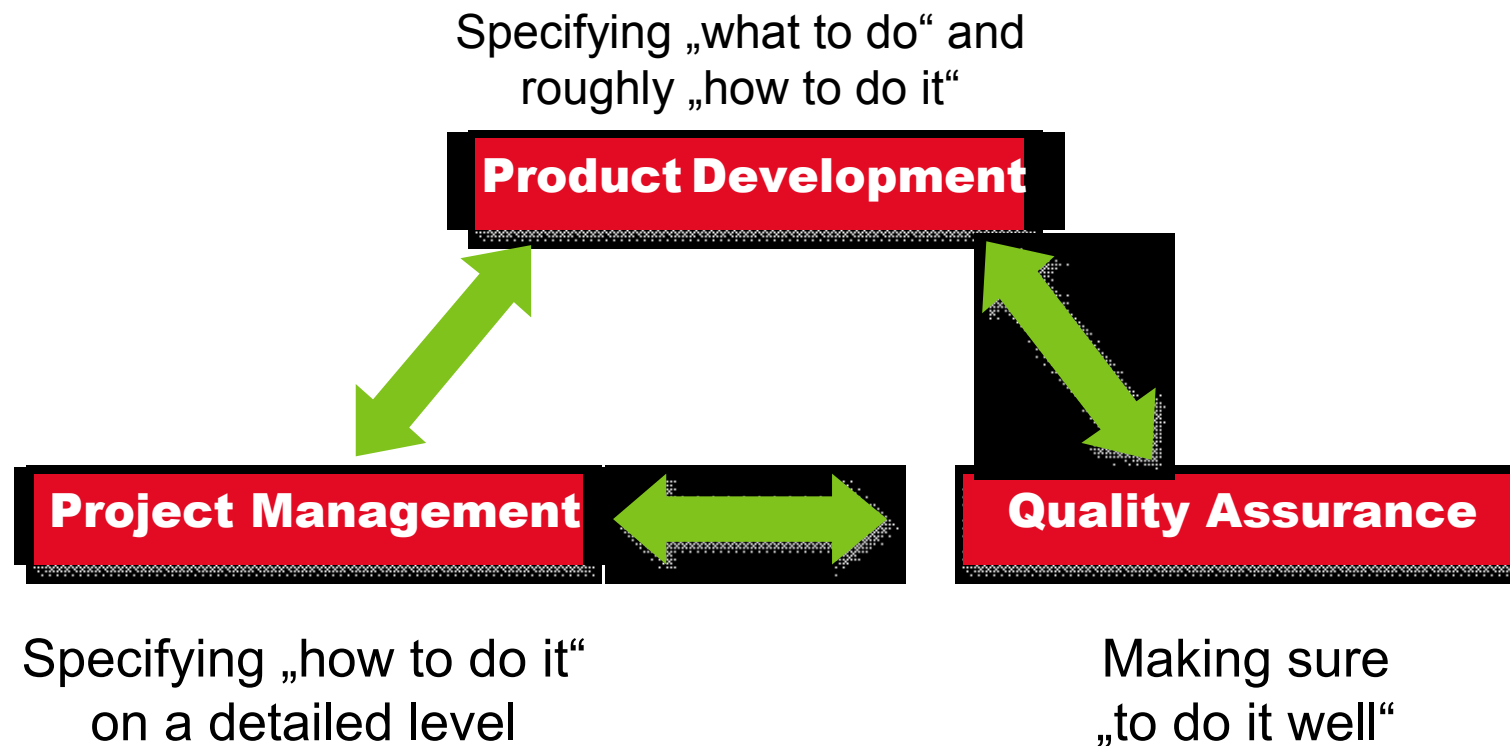
CORONA: Innovative Product Engineering Tools for MEMS

Christine Neuy, IVAM

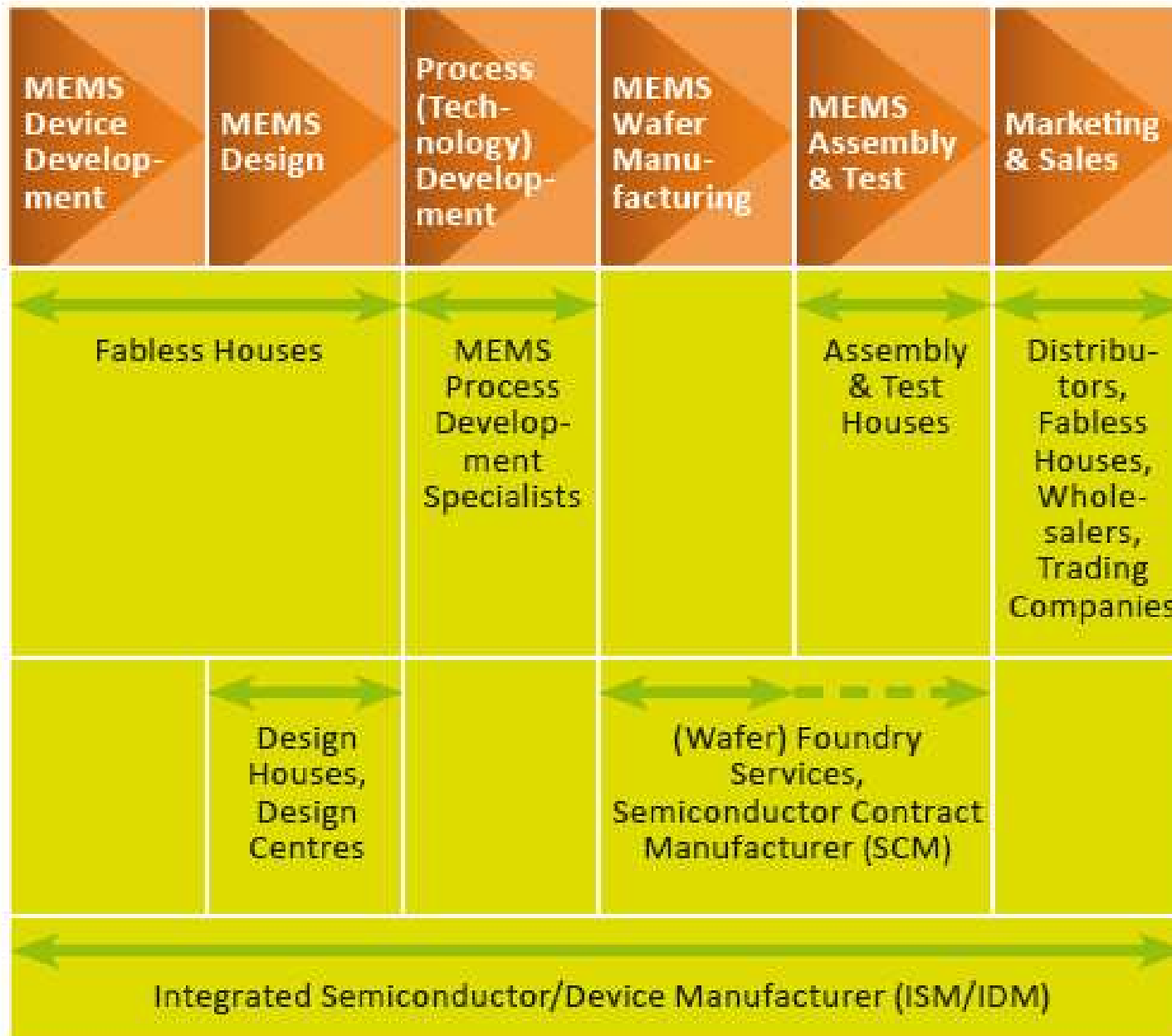
April 21, 2010, Forum Innovations for Industry



- ... is the process of gradually turning the idea of a technical device into a physical realisation.
- ... includes both the design and the fabrication stages.



Value chain in MNT

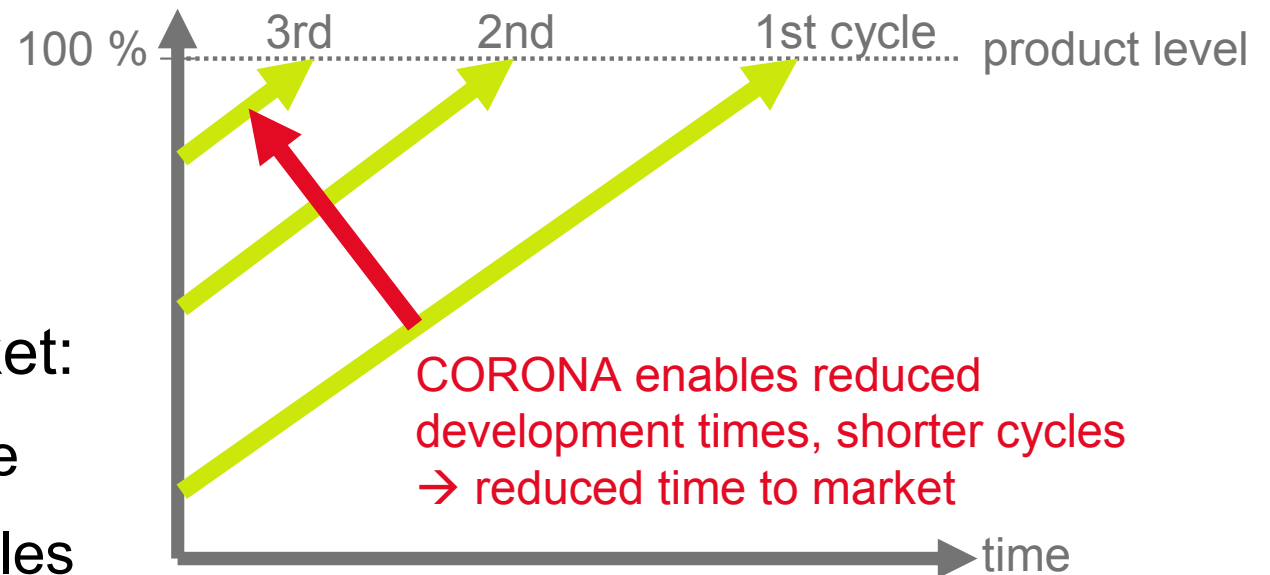




- **A large variety of business models**
 - From large IDMs to specialised companies
- **Distributed development and manufacturing**
 - Different companies (or departments) at different locations
- **SME focus**
 - Frequently SMEs involved with small development budget
- **Customer orientation**
 - Only the customer knows product and constraints

- **But...**
 - There is currently no appropriate product engineering methodology and tools available to support these aspects.

■ What can be expected from MNT product engineering?



- Shorter time-to-market:
 - Reduced cycle time
 - Fewer learning cycles
- Access to knowledge-bases on design and fabrication
 - ICT based structure and tools
 - Improved transfer of knowledge from design to production
- Customer-lead multi-site product development

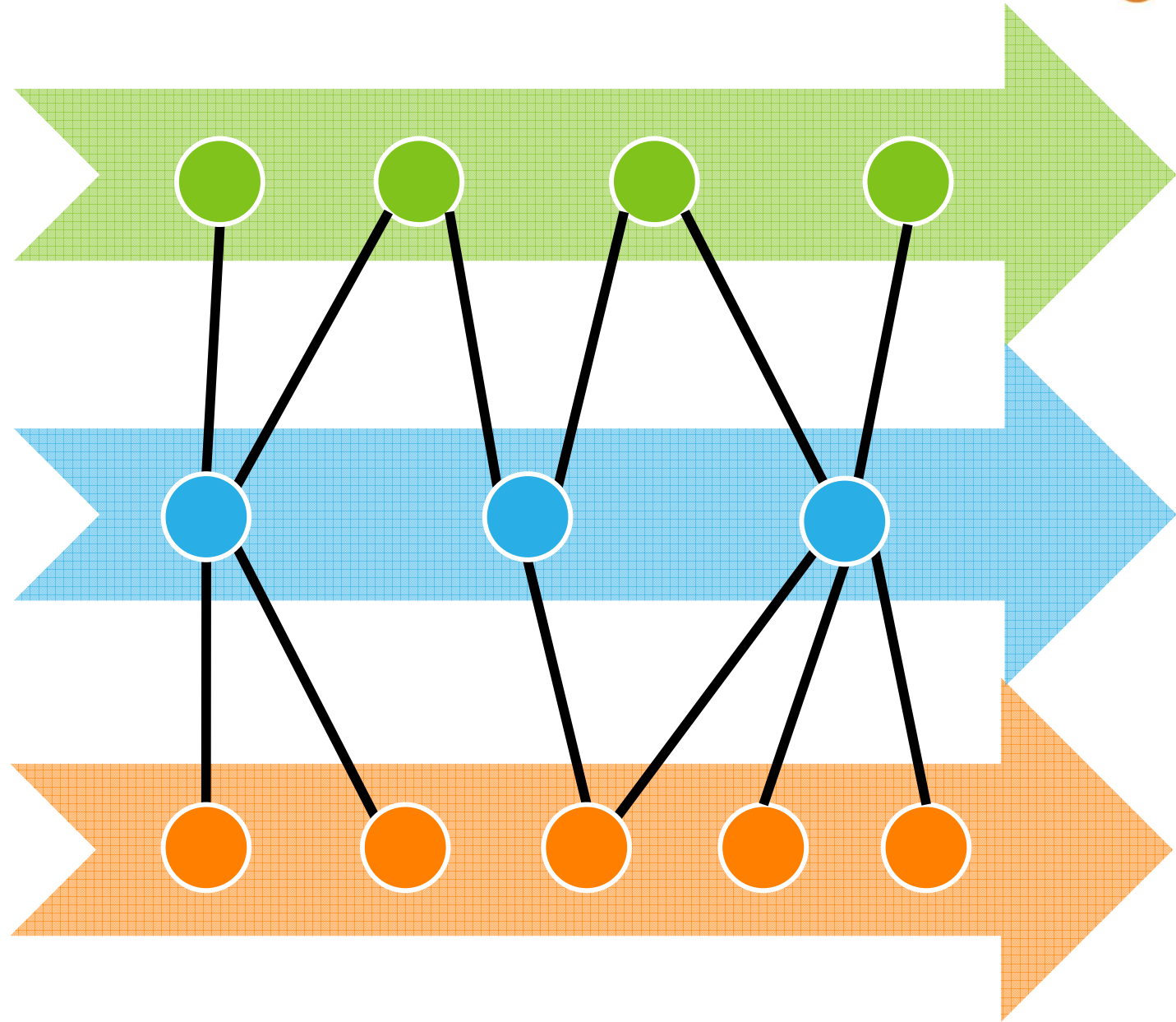
Workflow in CORONA



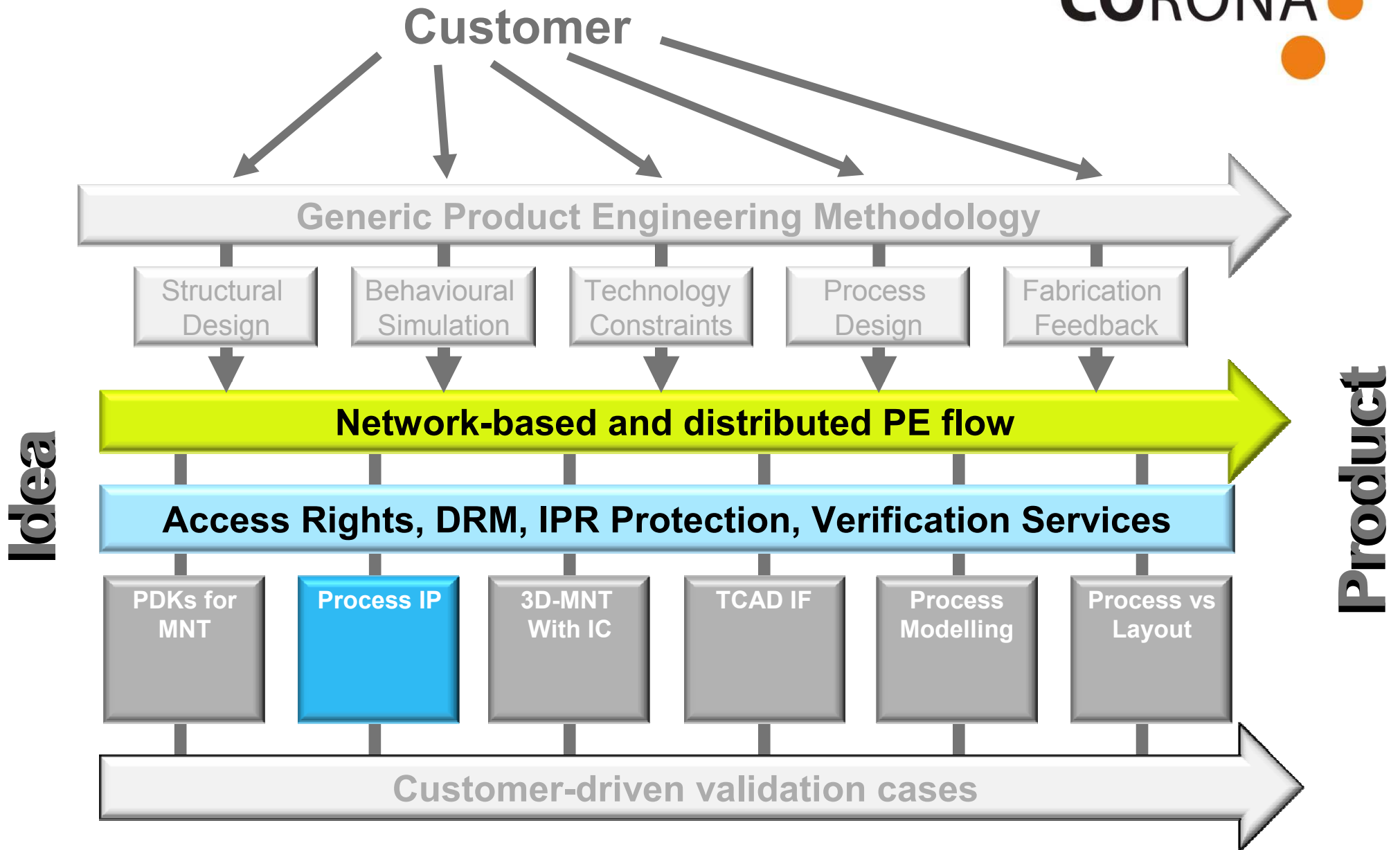
Methodology
Workflow Definition

**Middle Ware
& Tools**
Workflow/Designflow
Integration

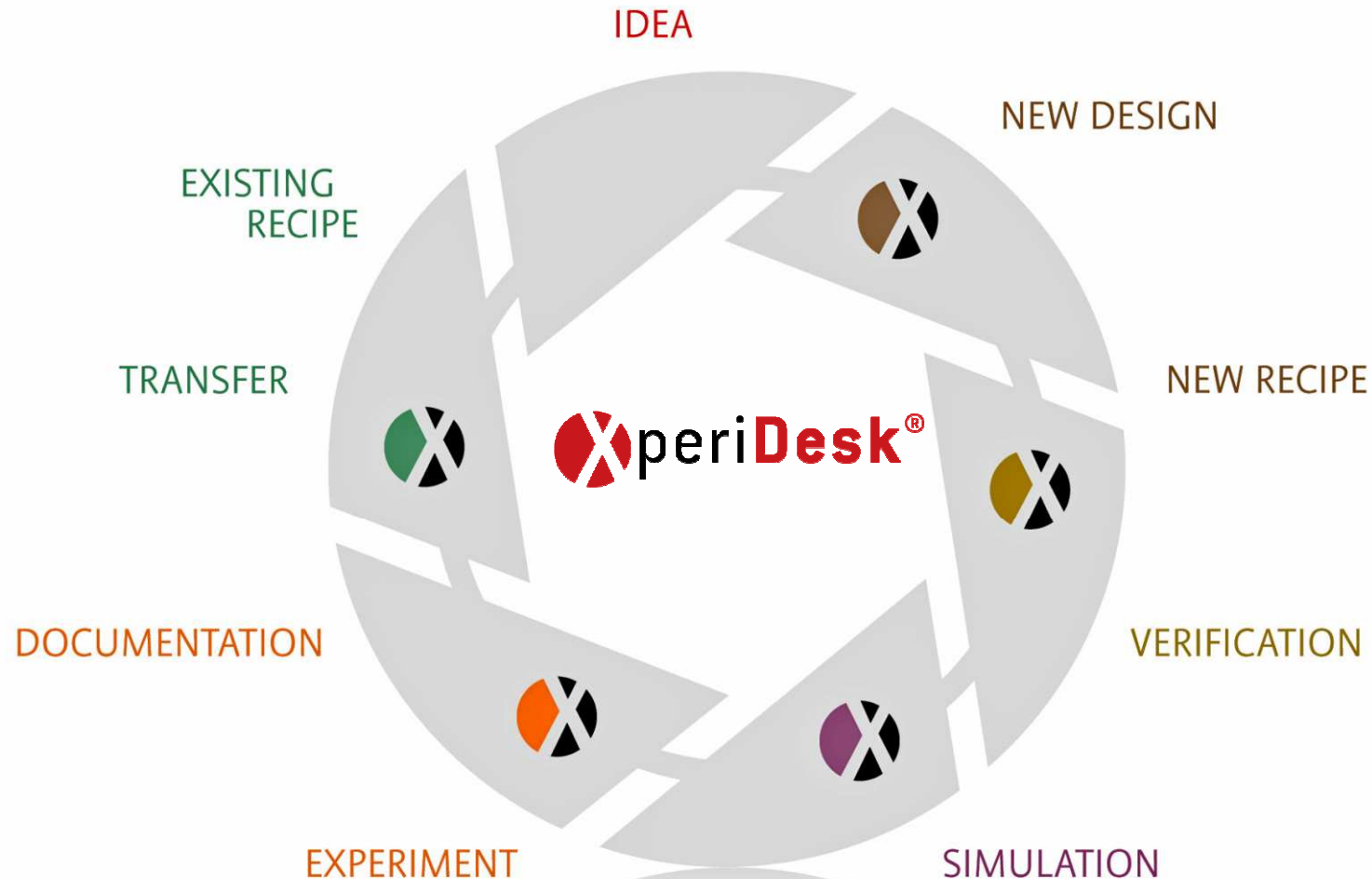
Validation
by real-life business
cases



Process IP



Process development cycle



Management of Entity Rights



XperiDesk 2009.2 - Run 2 of Demonstrator process 1 (#2)

File Settings Simulation Help

Tracking experiments

Tools & Models Process flows

Process steps Materials & Wafers

Users & Groups Parameters & Units

Tracking experiments

- Artefact
- Assessment
- Experiment
- Lot
- Maskset
- Project
- IMS Dir
- Tool
- Tracked Process flow
 - Demonstrator process 1 2008-04-15 11:59:51.087
 - Run 1 of Demonstrator process 1 (#5)
 - Run 2 of Demonstrator process 1 (#2)**
 - Demonstrator process 2 2008-04-15 14:58:00.676
 - Schneiden 2009-07-07 05:04:21.196 (#1)
- Wafer
- Wafer Piece

Common Properties Forum Search

Search

- Search
 - Hydrogen Search
 - Process steps depositing certain material
 - test
 - Wafers seen process step type**

Tracked Process flow - Run 2 of Demonstrator process 1 (#2)

Within this tab tracked process flows can be edited.

General Relations TrackedProcessFlow **User Rights**

User rights

User	Right
Marc Randal	read
Administrator	owner
	aware
	read
	create
	update
	delete
	owner

Linsay Helmfrid
LoadingJob

Group rights

Group	Right
Administrator	
Design Manager	
Design User	
Tracking Manager	
Tracking User	

Wafer search results

Wafer search results

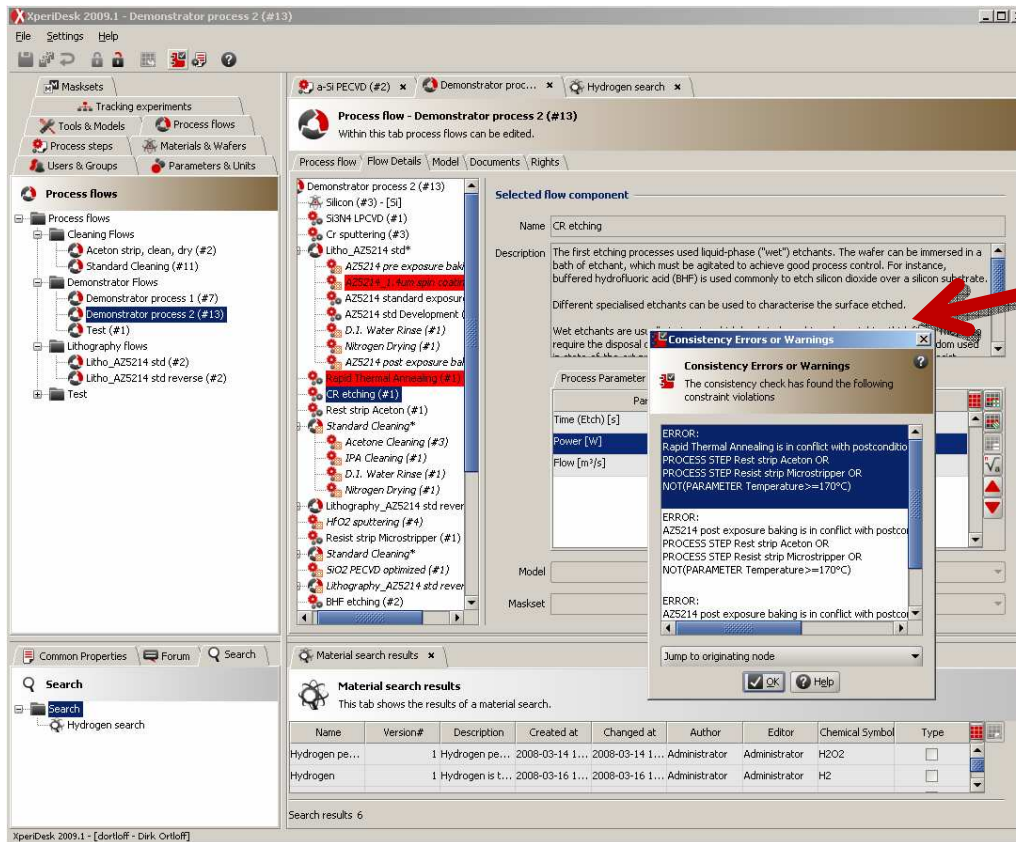
This tab shows the results of a wafer search.

Name	Version#	Description	Created at	Changed at	Author	Editor
L1_a-Si_3	1		2008-04-15 14:2...	2008-04-15 14:2...	Administrator	Administrator

Search results: 5

XperiDesk 2009.2 - [dortloff - Marc Randal]

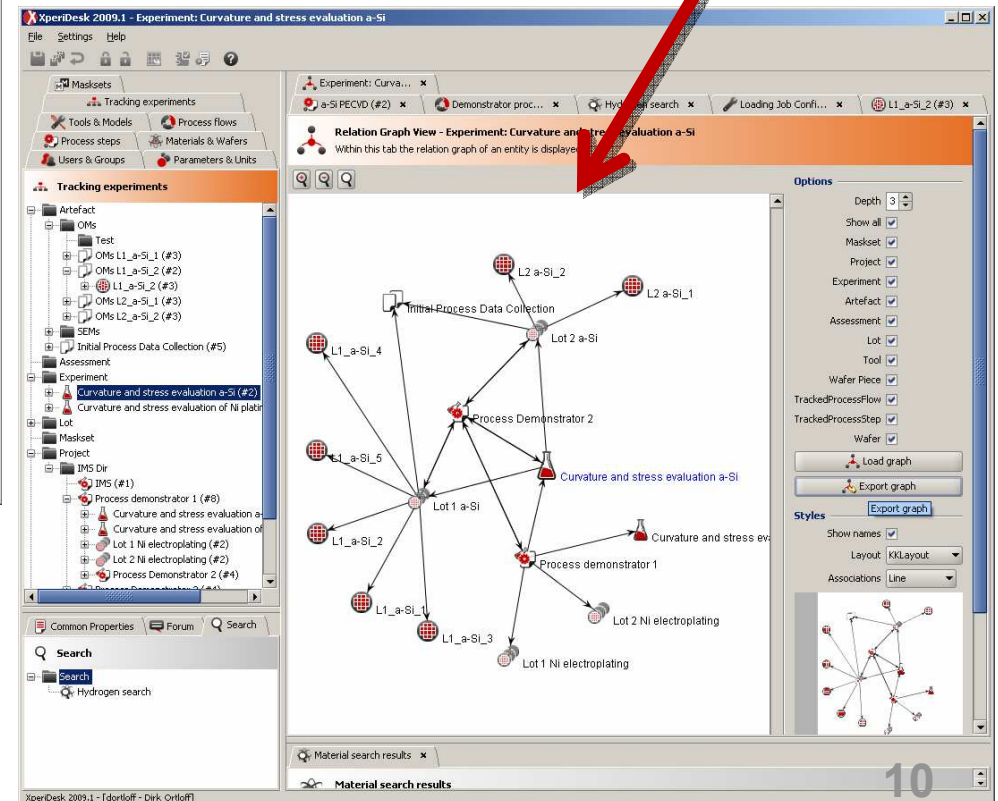
- A framework for process design verification and tracking



The screenshot shows the 'Process Flow Editor' interface. On the left, a tree view displays process flows, with 'Demonstrator process 2 (#13)' selected. The main area shows the 'Selected flow component' for 'CR etching', including its description and parameters. A 'Consistency Errors or Warnings' dialog box is open, listing several errors such as 'Rapid Thermal Annealing is in conflict with postcondition' and 'AZ5214 post exposure baking is in conflict with postcondition'. A red arrow points from the XperiDesk logo to this dialog box.

Process Flow Editor

Process Tracking



The screenshot shows the 'Relation Graph View' interface. The main area displays a complex network graph with nodes representing process steps and artifacts, such as 'Initial-Process Data Collection', 'Lot 1 a-Si', and 'Curvature and stress evaluation a-Si'. A red arrow points from the XperiDesk logo to the graph. The right side of the interface includes an 'Options' panel with settings for depth, show all, maskset, project, experiment, artefact, assessment, lot, wafer piece, tool, wafer, and wafer piece. The bottom right corner features a '10' page indicator.

Ways to build PKDKs



- Export experiment data from graphic view

The screenshot displays the XperiDesk 2009.2 interface. The main window is titled "Tracked Process Flow: Run 2 of Demonstrator process 1". The central pane shows a "Relation Graph Tab" with a network diagram of process steps. The graph includes nodes such as "SEMs L2_Ni_plating_2", "L2_Ni_plating_2", "L1_a-Si_3", "L1_a-Si_2", "L1_a-Si_5", "Initial Process Data Collector", "Lot 1 a-Si", "Run 2 of Demonstrator process 1", "L2_Ni_plating_1", "SEMs L2_Ni_plating_1", "Run 1 of Demonstrator process 1", "L1_Ni_plating_2", "L1_Ni_plating_1", "L1_Ni_plating_3", "SEMs L1_Ni_plating_2", "SEMs L1_Ni_plating_1", and "SEMs L1_Ni_plating_3". The "Export graph" button in the right-hand "Options" panel is circled in red. Below the graph, the "Wafer search results" tab is active, showing a table of search results.

Name	Version#	Description	Created at	Changed at	Author	Editor
L1_a-Si_3	1		2008-04-15 14:2...	2008-04-15 14:2...	Administrator	Administrator

Ways to build PKDKs

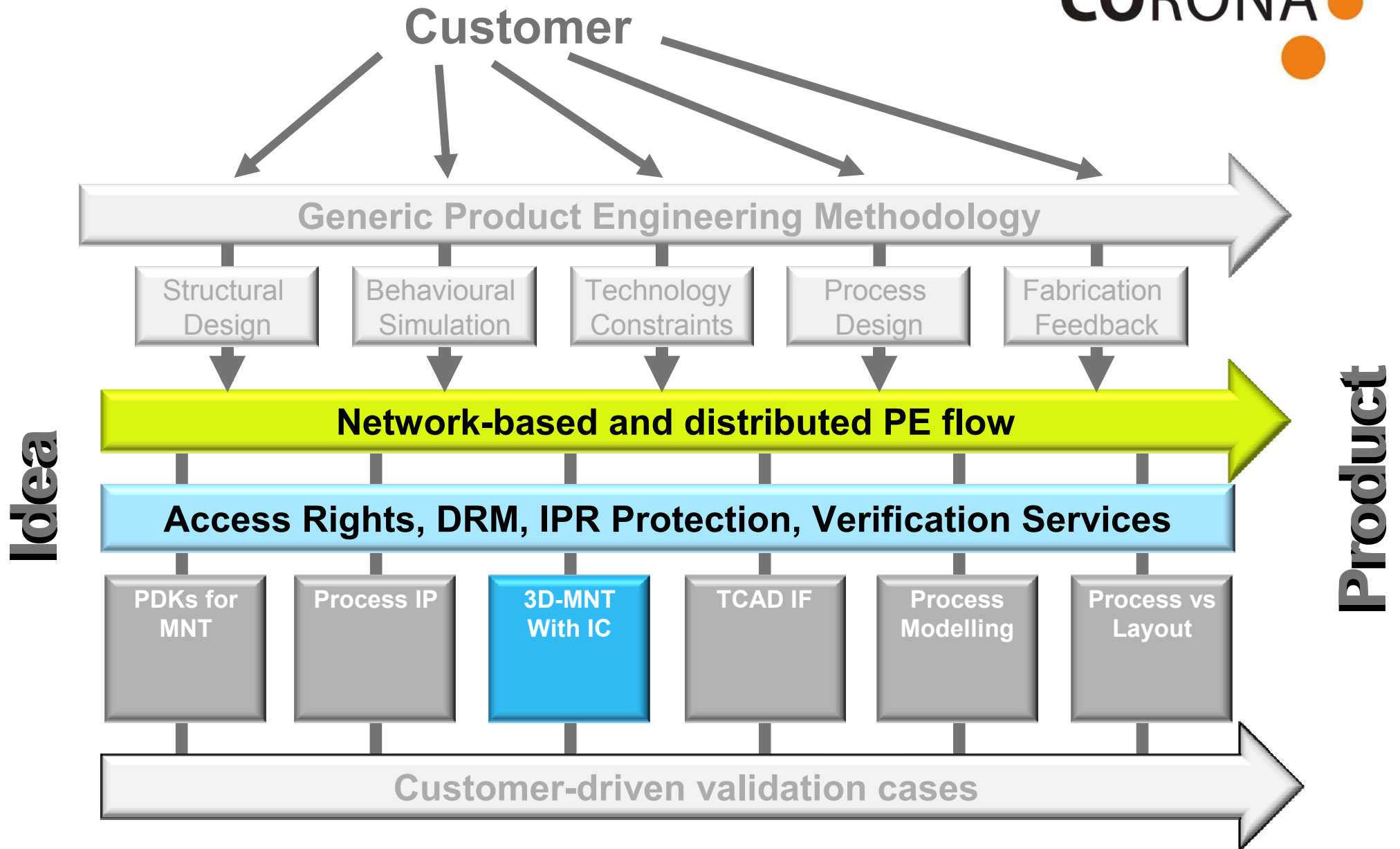


Export search results

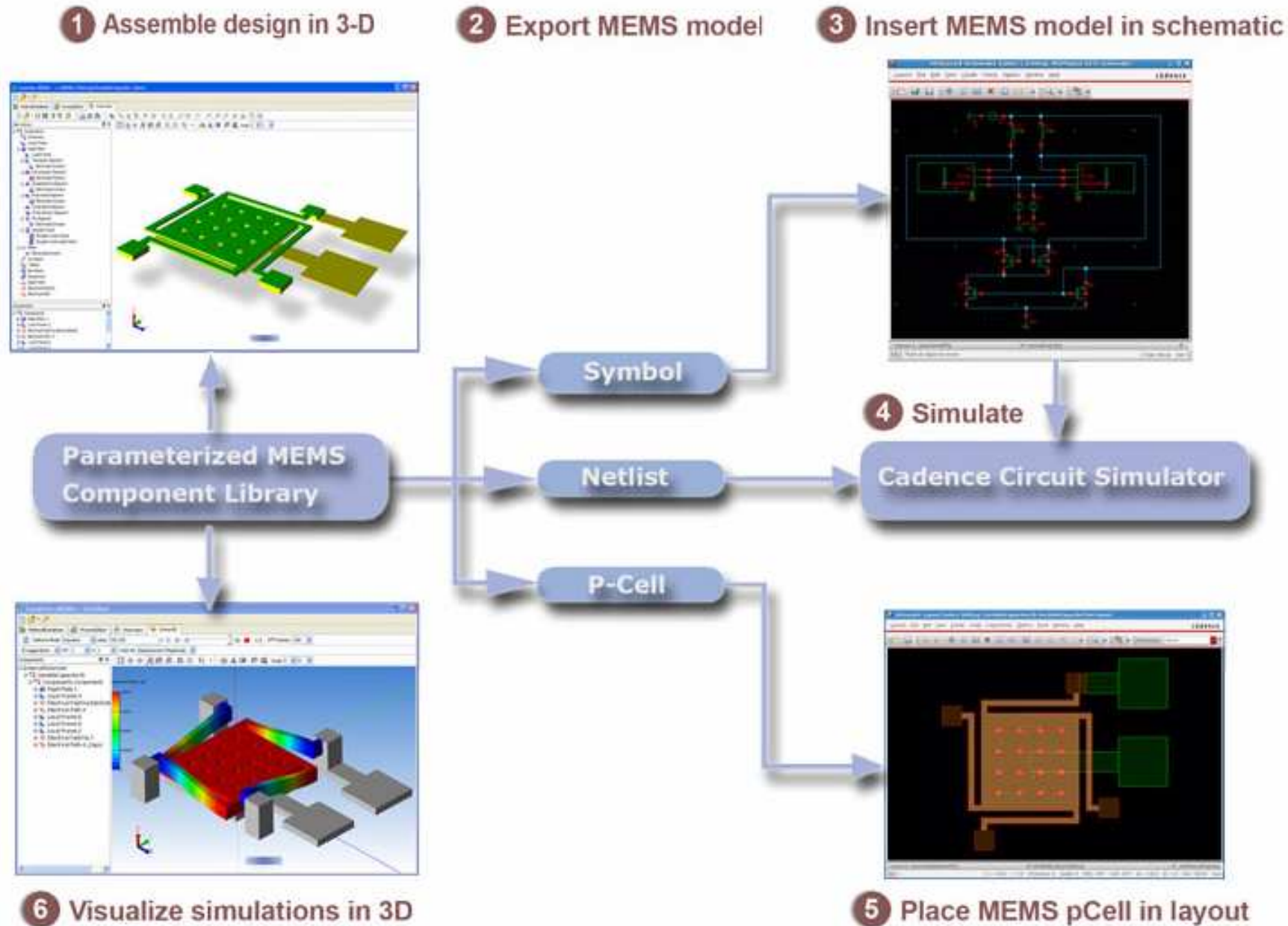
The screenshot shows the XperiDesk 2009.2 interface. The main window is titled 'XperiDesk 2009.2 - Wafers seen process step type'. The left sidebar shows a tree view of 'Tracking experiments' with various SEMs and process steps. The main area is divided into two tabs: 'Search - Wafers seen process step type' and 'Wafer search results'. The 'Search' tab shows a search configuration for 'Wafers seen process step type' with a description: 'This search retrieves all manufactured wafers which have seen a step of the class Annealing and a PECVD manufacturing step but no CMP.' The 'Wafer search results' tab shows a table of search results with 5 rows. A red circle highlights the 'Export' icon in the bottom right corner of the table.

Name	Version#	Description	Created at	Changed at	Author	Editor
L1_a-Si_3	1		2008-04-15 14:23:25	2008-04-15 14:23:25	Administrator	Administrator
L1_a-Si_2	3		2008-04-15 14:23:25	2008-11-20 09:07:49	Administrator	Administrator
L1_a-Si_5	1		2008-04-15 14:23:25	2008-04-15 14:23:25	Administrator	Administrator
L1_a-Si_1	3		2008-04-15 14:23:25	2008-11-20 09:07:21	Administrator	Administrator

3D-MNT With IC



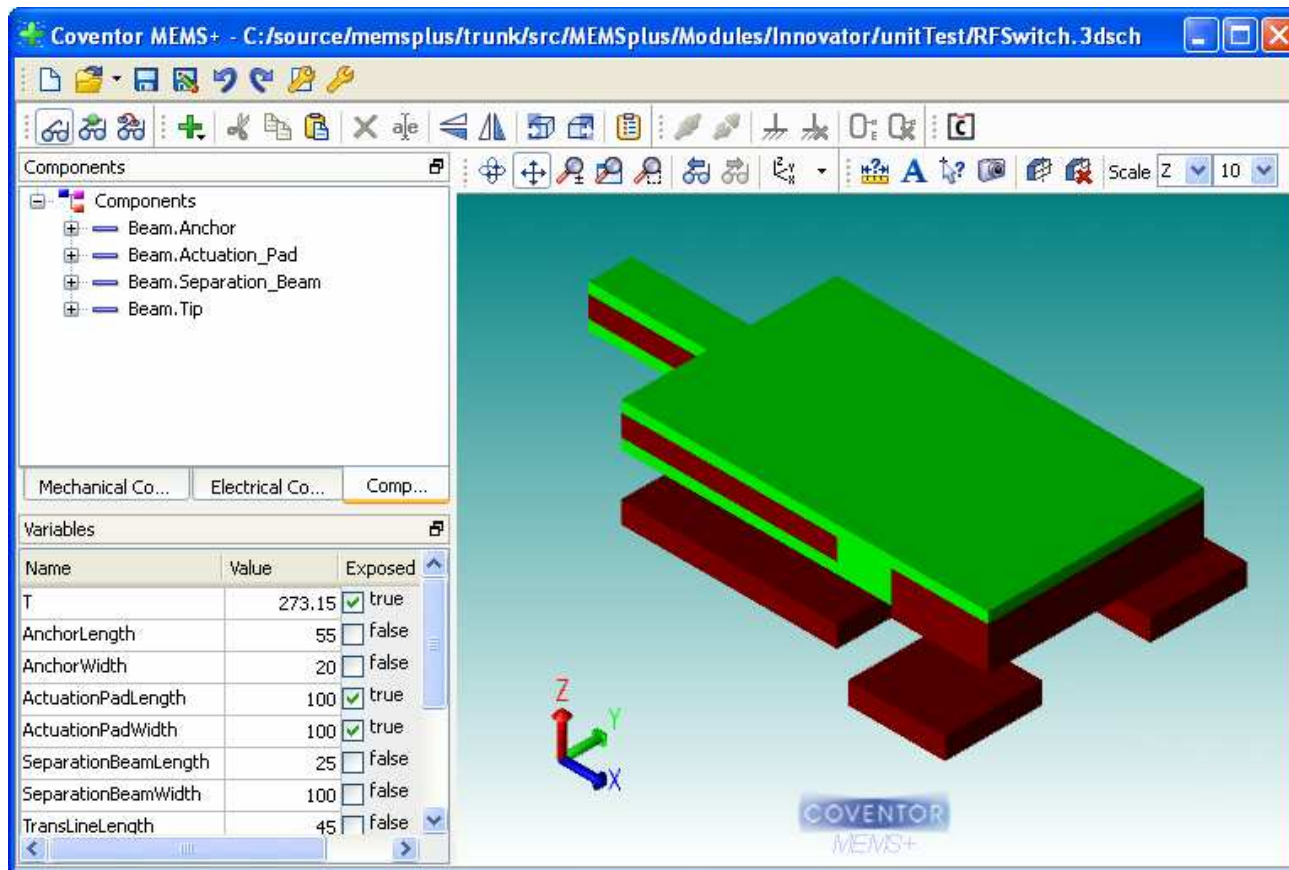
Design of 3D MEMS with IC



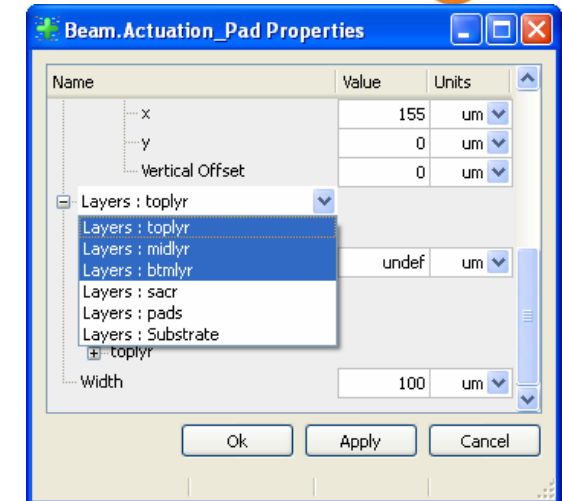
3D Schematic Editor for MEMS



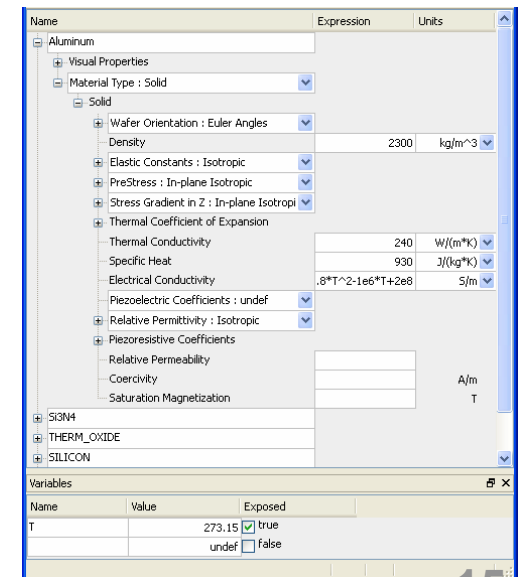
- **MEMS Design in 3D**
 - Intuitive 3D environment for device creation
 - Based on validated MEMS component library
 - Parameterization of material, process and design



3-D view of RF switch in new 3D schematic Editor GUI (Graphical User Interface)



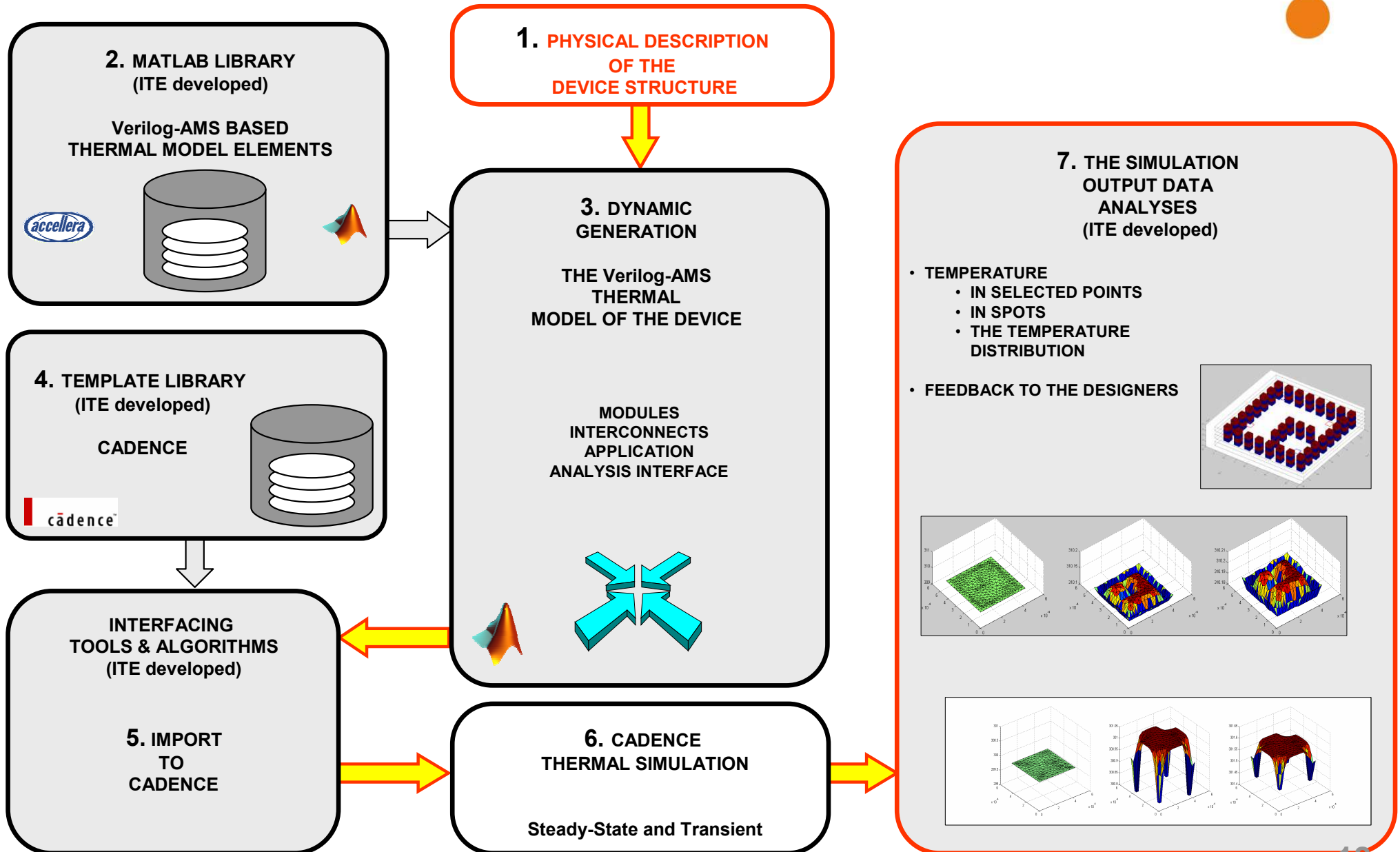
Layer Browser in a Property Window of a Straight Beam Component



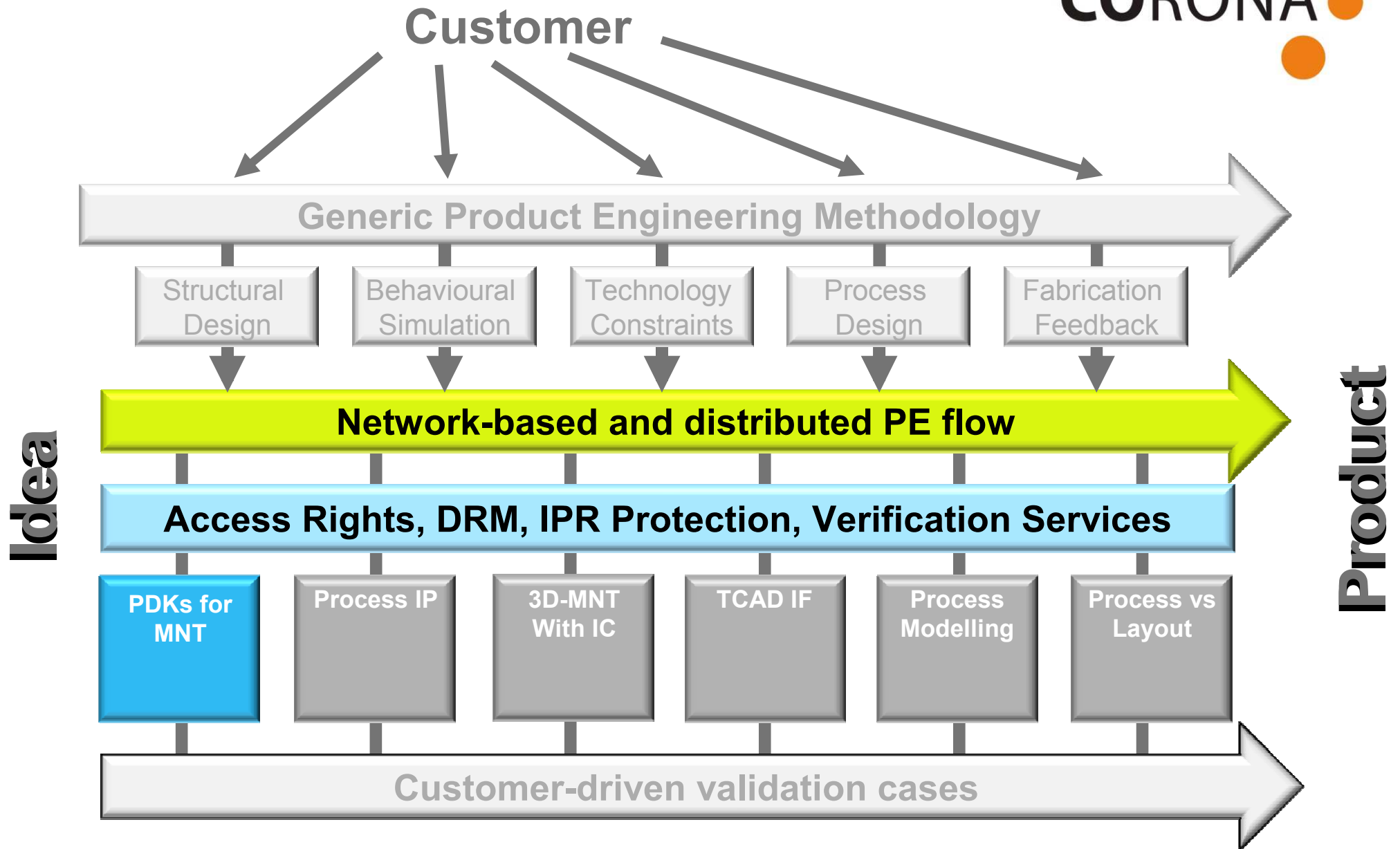
Material Property Editor

HETEROGENEOUS
DEVICE
ORIENTED
SIMULATION

- **HDL-based**
- **3D multimodule structures**
- **Fast and easy thermal model implementation**
- **Thermal device simulation**
- **Verification of temperature distribution**



PDKs for MNT



Design Kit Motivation



Designer

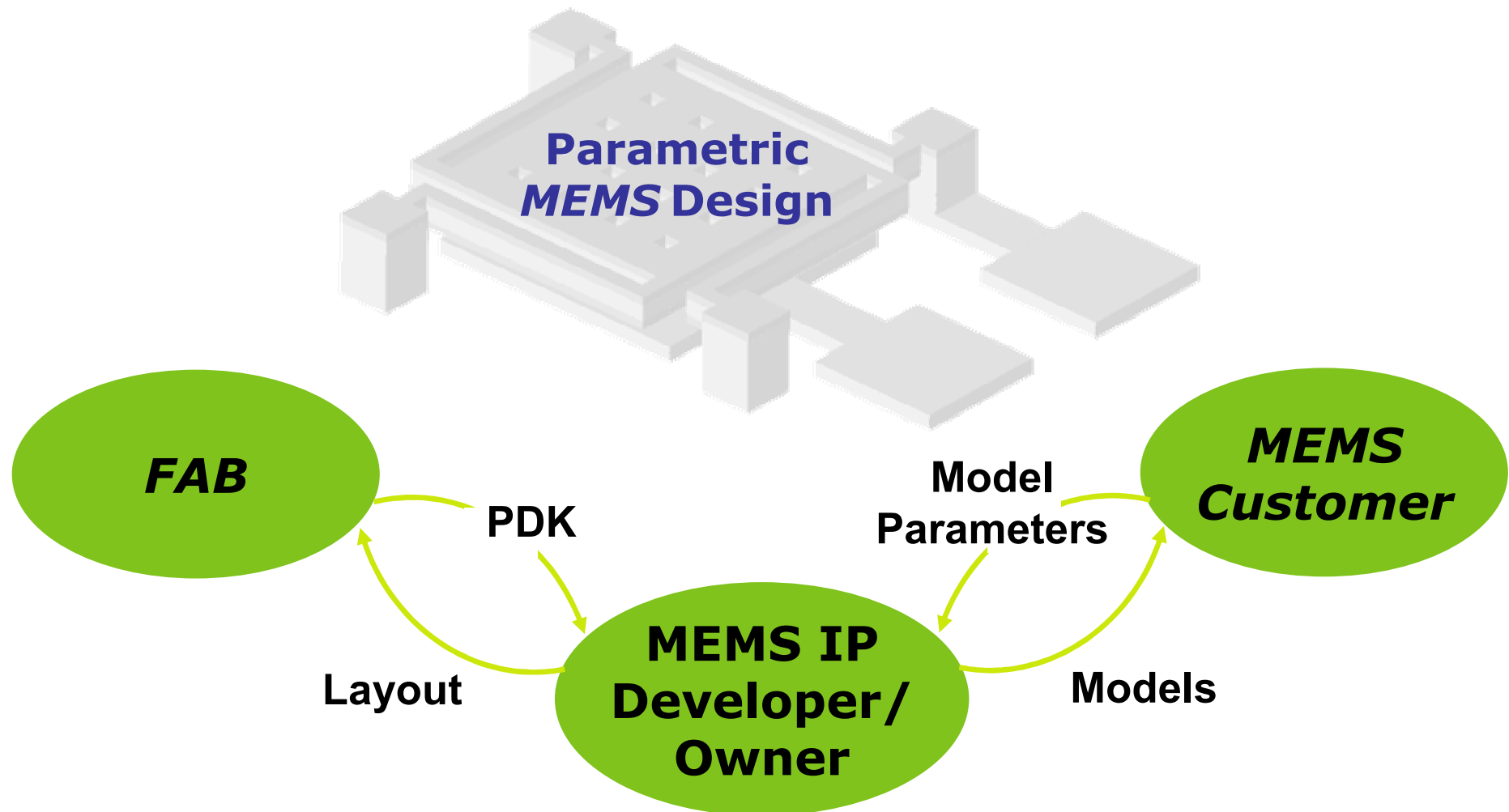


... use tools to build a bridge

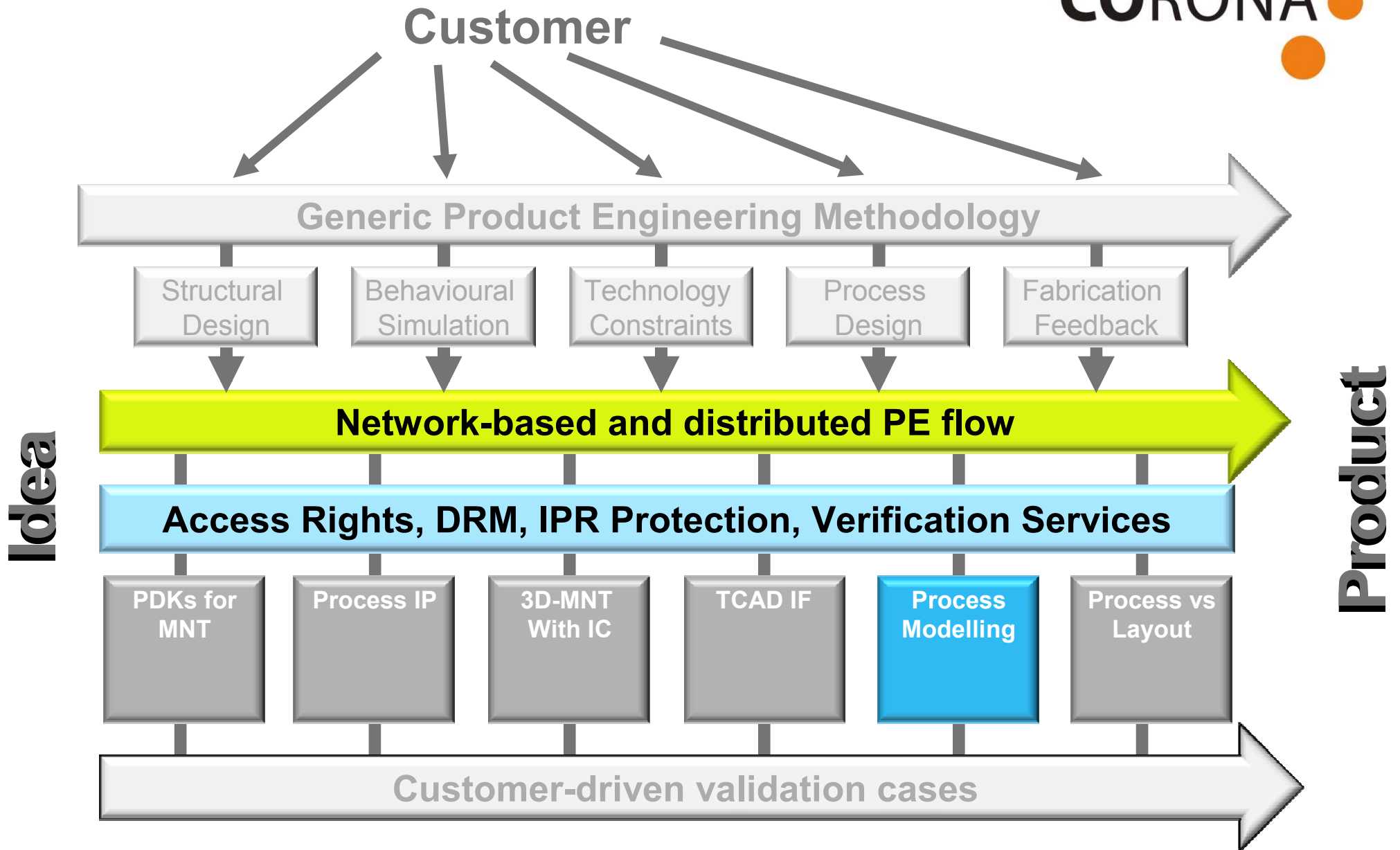
Enable MEMS Eco-System



- Facilitate communication between the distributed partners of the MEMS eco-system



Process Modelling



Virtual Fabrication



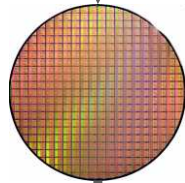
Actual Fab

Blank wafer



Move wafer thru line,
following recipe
(partial or full sequence)

Processed wafer



*Sample,
image,
measure*

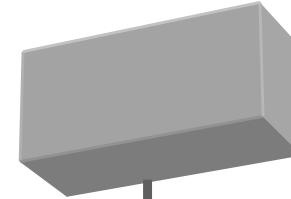


2-D layout

*Virtual Fab
software*

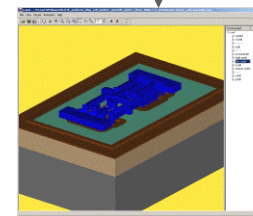


*Rectangular
area of interest*



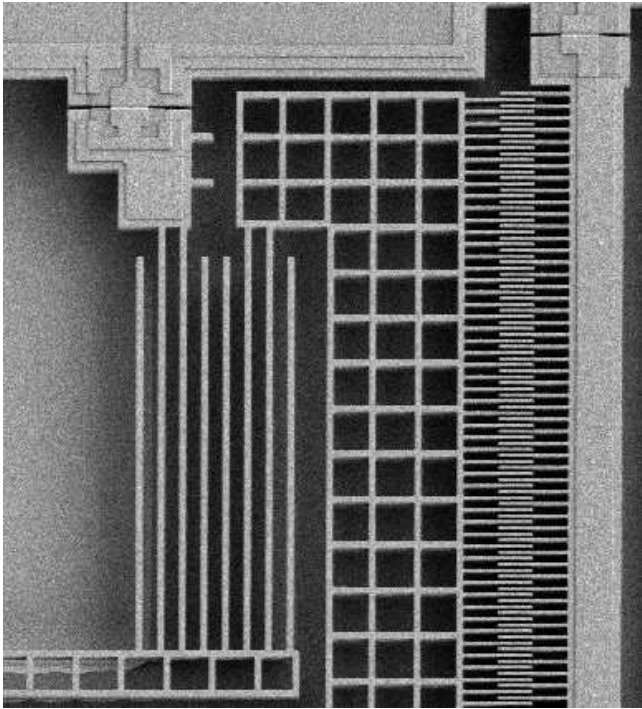
Mimic equipment
to build 3-D model
(partial or full sequence)

3-D model

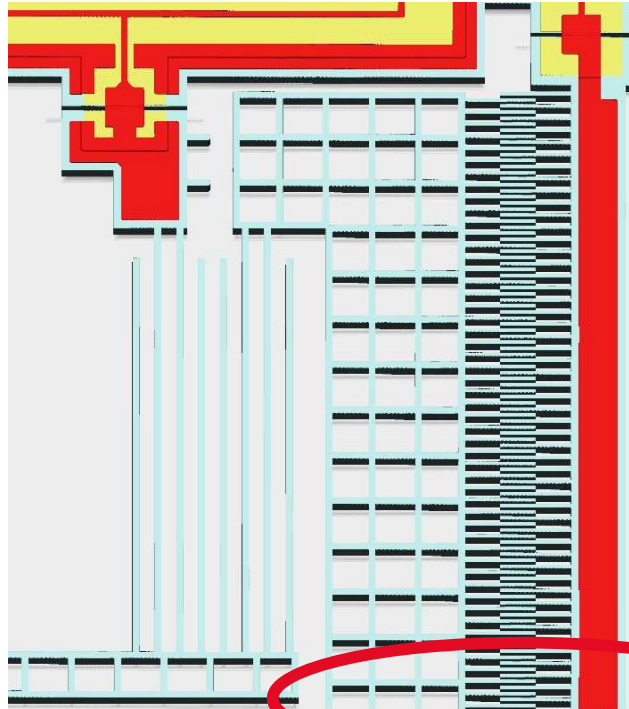


*Visualize,
image,
measure*

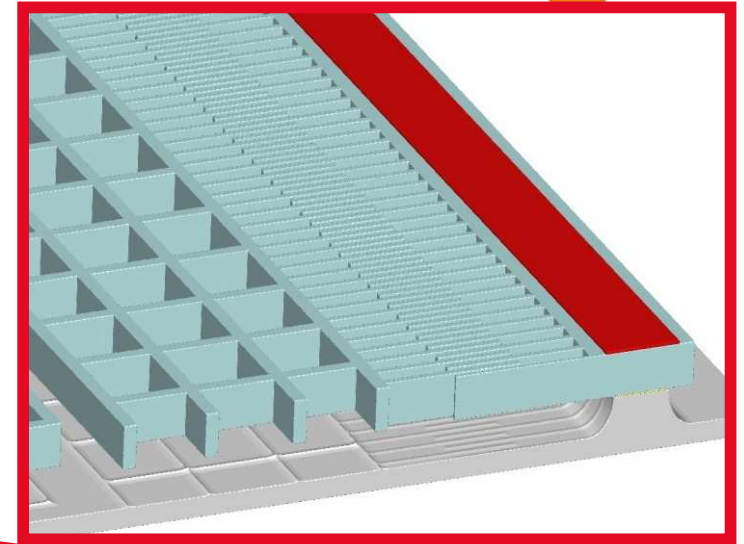
Use case example: X-FAB SOI



SEM image



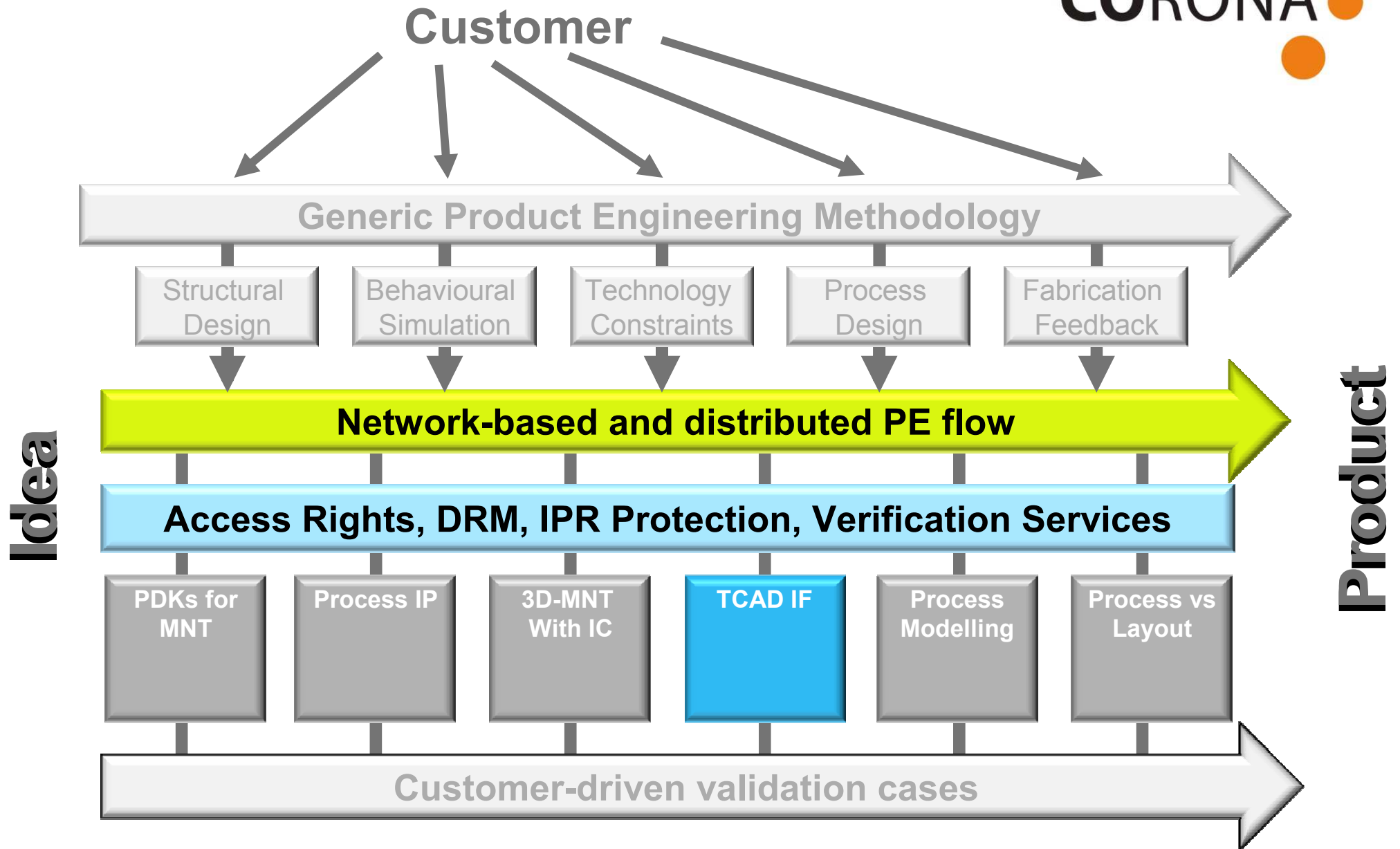
images created with SEMulator3D



X-FAB uses virtual fab runs for...

- Customer support, marketing of MEMS foundry technologies
- Checking new designs prior to actual fabrication
- Process development
- Failure analysis

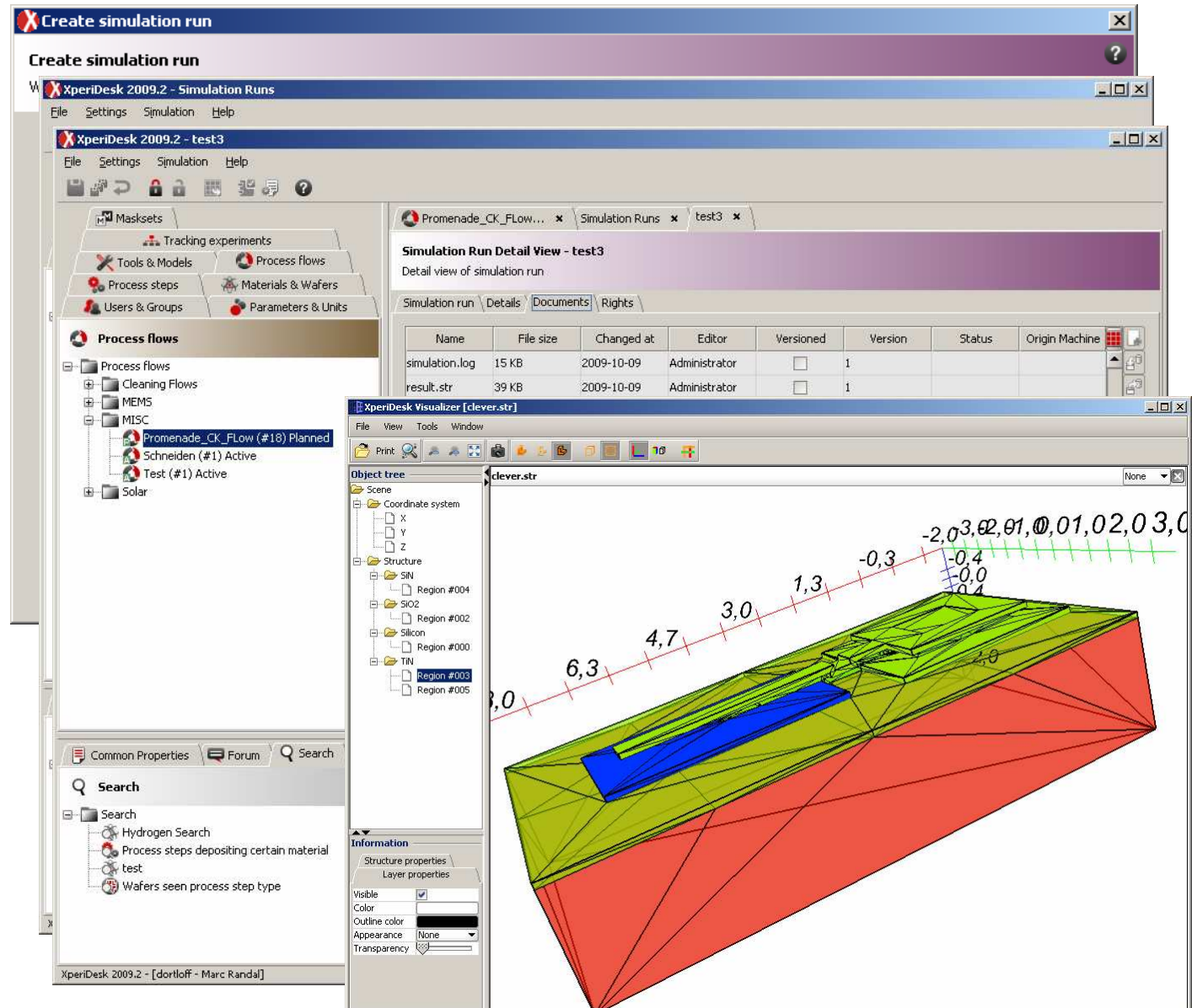
TCAD Interface



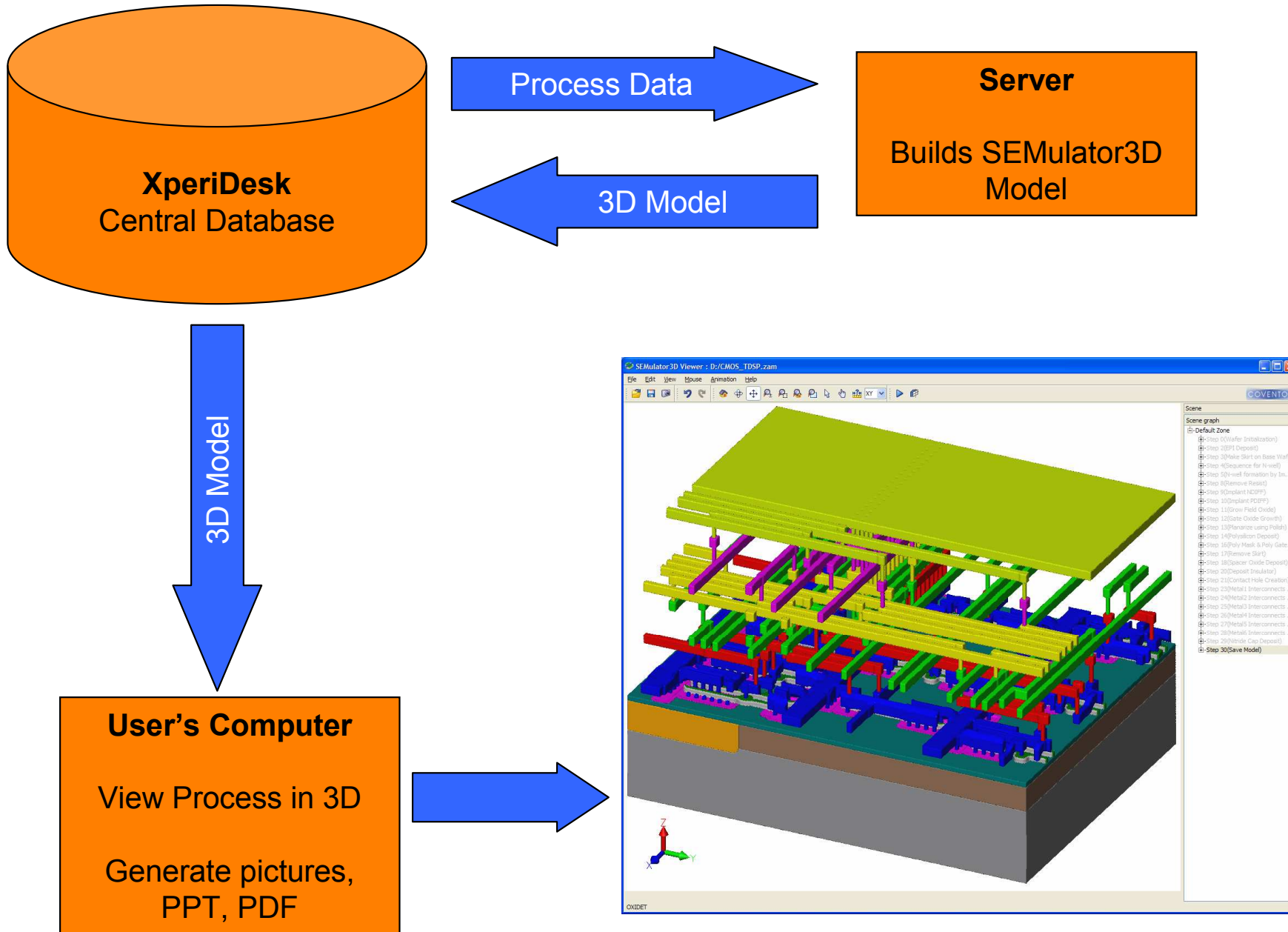
- Starting a simulation

- Checking previous runs

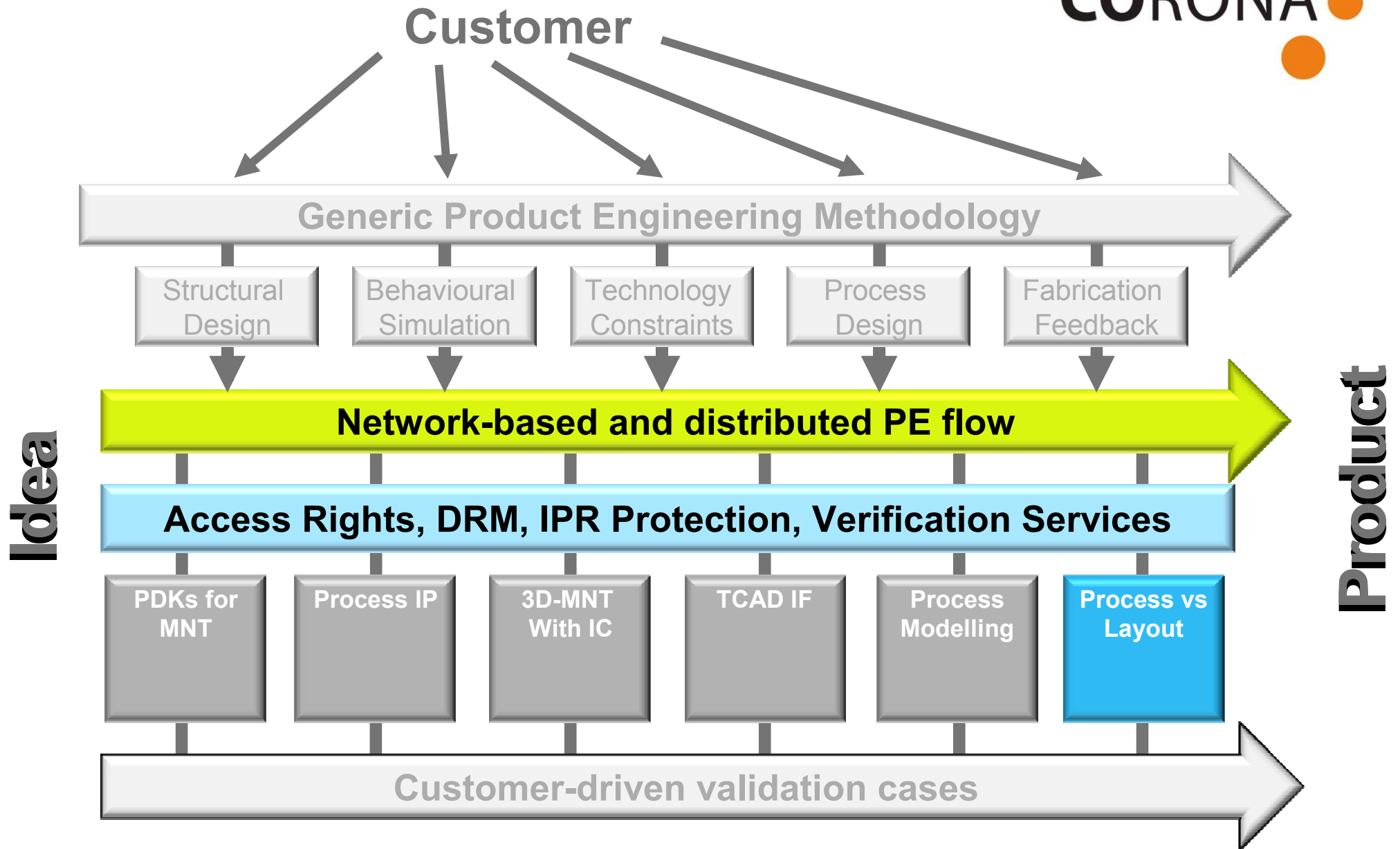
- Previous run details



SEMulator3D and XperiDesk Bi-Directional Integration



Process vs. Layout



Cross Section Editor Prototype

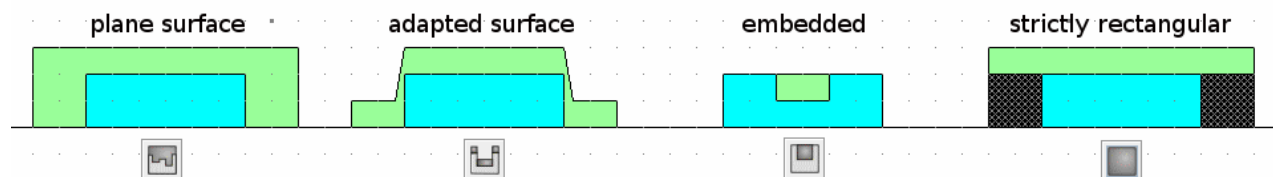
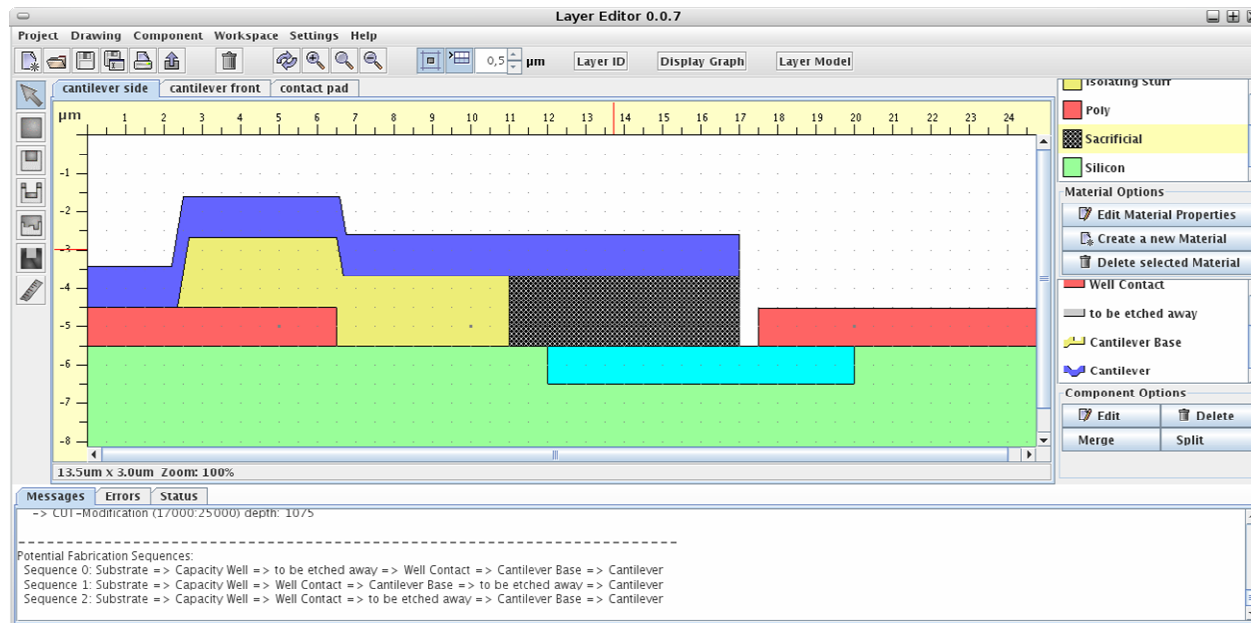


Cross-Section

- Common Method for illustrating process capabilities

Cross-Section Editor

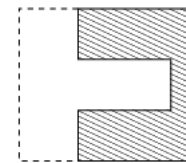
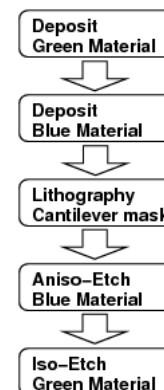
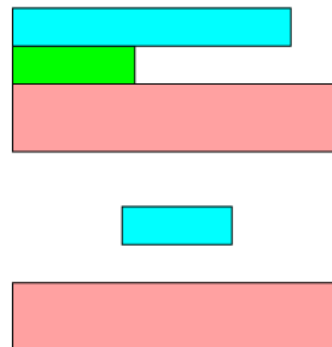
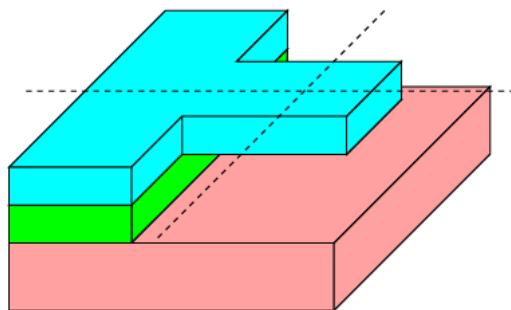
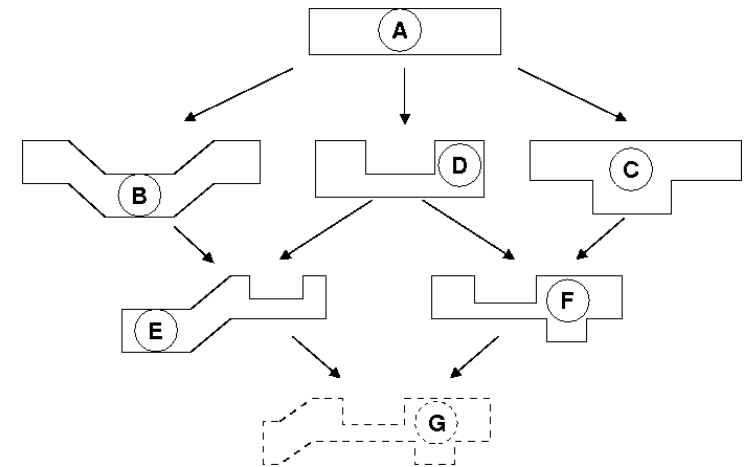
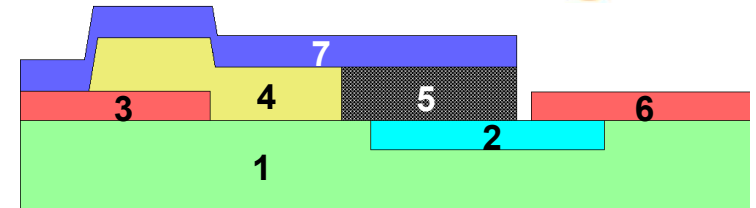
- Drawing support for typical cross-section geometries
- Prevents drawing of non-manufacturable geometries



Physical Layer Analyzer

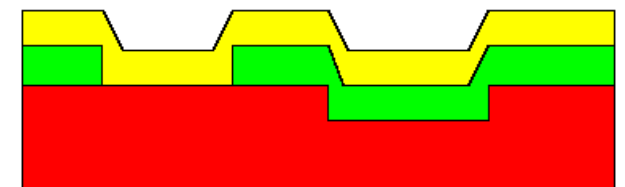


- Identification and classification of
 - Layers
 - Topological Dependencies
 - Shapes
 - Modifications
- Structural Decomposition
- Preparation of Layer Model



Cut-Modification

Shape-Modification

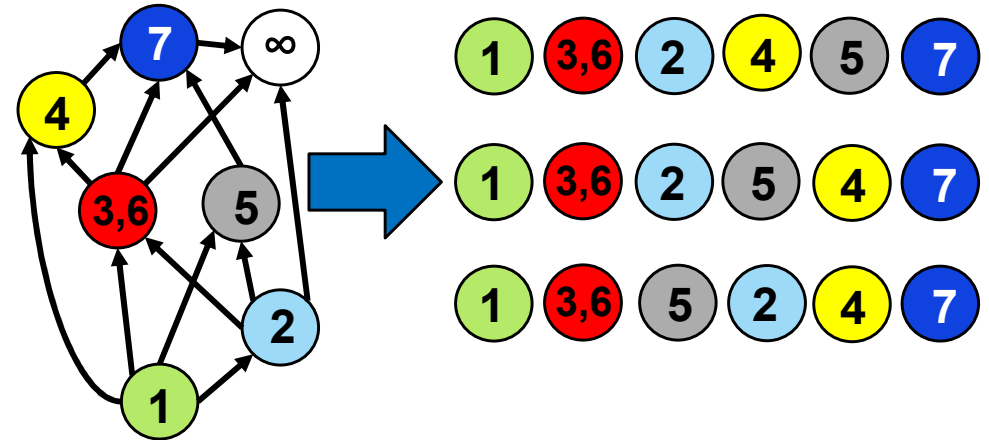


Technology Recommender



- **Defines Sequence of**
 - Layer generation
 - Layer modifications
 - Lithography masks

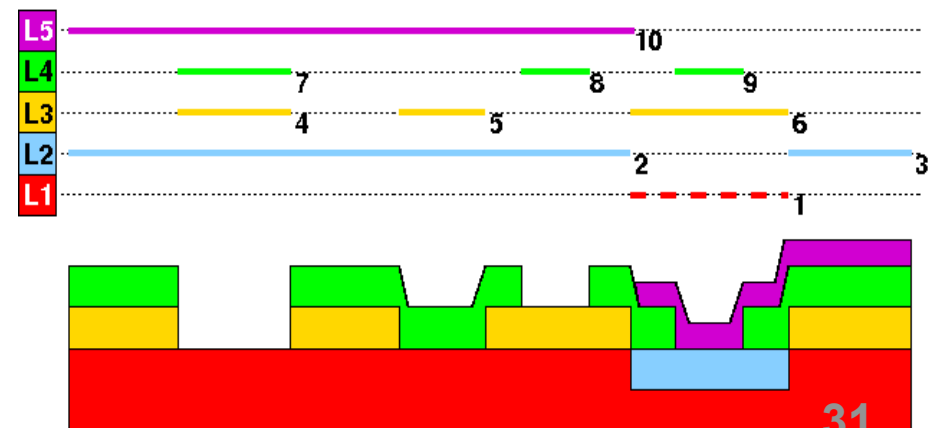
- **Prepares process draft**
 - Recipe Search
 - Process Design



```

Messages Errors Status
-> CUT-Modification (17000:25000) depth: 1075
-----
Potential Fabrication Sequences:
Sequence 0: Substrate => Capacity Well => Well Contact => Cantilever Base => to be etched away => Cantilever
Sequence 1: Substrate => Capacity Well => Well Contact => to be etched away => Cantilever Base => Cantilever
Sequence 2: Substrate => Capacity Well => to be etched away => Well Contact => Cantilever Base => Cantilever
    
```

	Layout	Modifications	Action	
			Visibility	Order
A			block	block
B			propagate	propagate
C			propagate	block

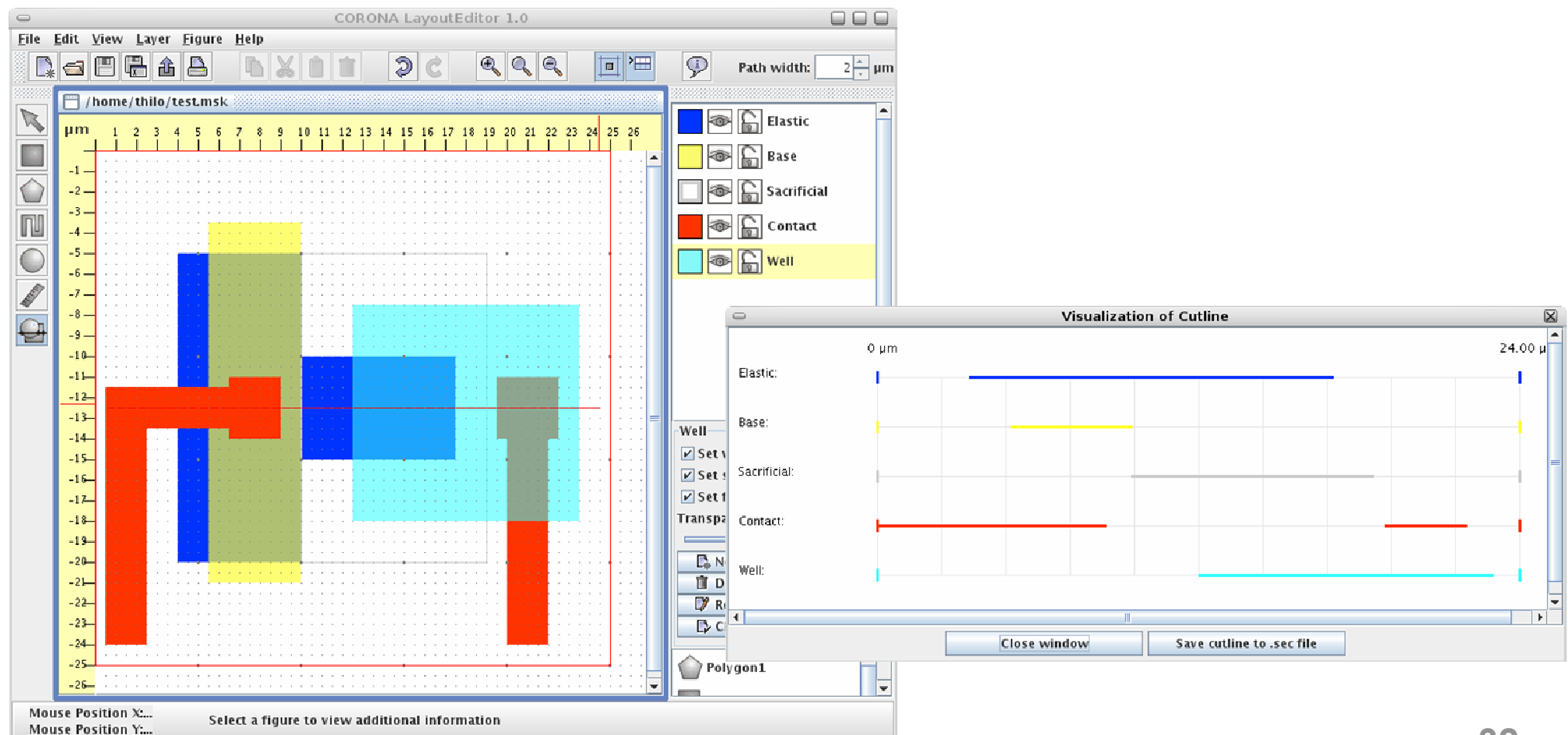


Process vs. Layout

Layout Editor



- Layout editor with basic editing functions
- Goal: Linking layer model (analyzer) to physical layout



Contact

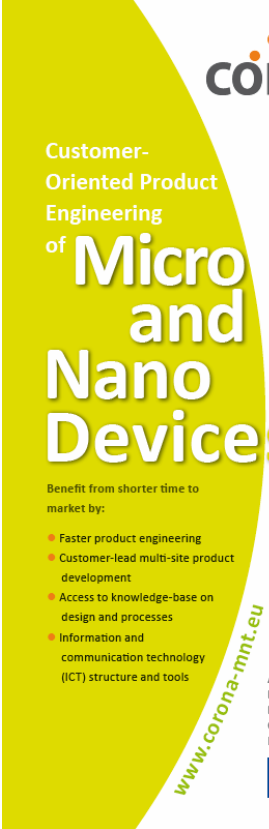
CORONA

c/o IVAM Microtechnology Network

www.corona-mnt.eu

Meet us at the  booth

in hall 6, H16/C1



CORONA

Customer-Oriented Product Engineering of **Micro and Nano Devices**

Benefit from shorter time to market by:

- Faster product engineering
- Customer-lead multi-site product development
- Access to knowledge-base on design and processes
- Information and communication technology (ICT) structure and tools

www.corona-mnt.eu

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NMP2-SL-2008-213969

