

Systems Engineering and Modeling at Start-Up Company

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Abstract

We have been assisting in applying Systems Engineering techniques and methods in a small (tens of persons) start-up company in the semiconductor process and equipment market. We report our observations in this start-up company with an innovative product operating in a dynamic environment. Start-up companies in general explore new applications or new technologies: an environment full of unknowns, uncertainties and other surprises. In the specific case of semiconductor process and equipment the system is highly multi-disciplinary, amongst others: high precision mechanical, control, optics, chemical, signal processing, and power electronics.

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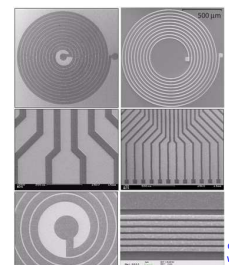
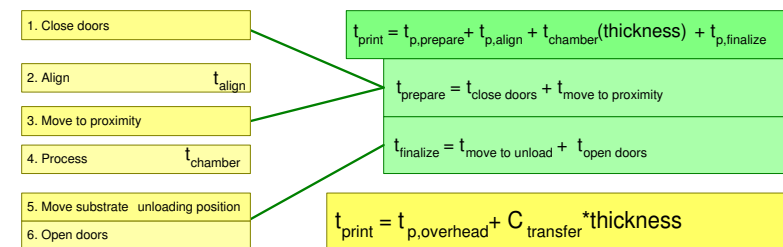
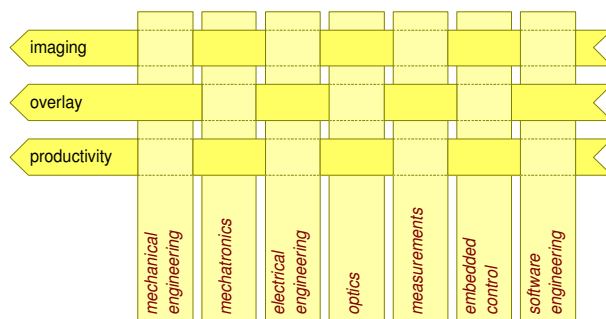
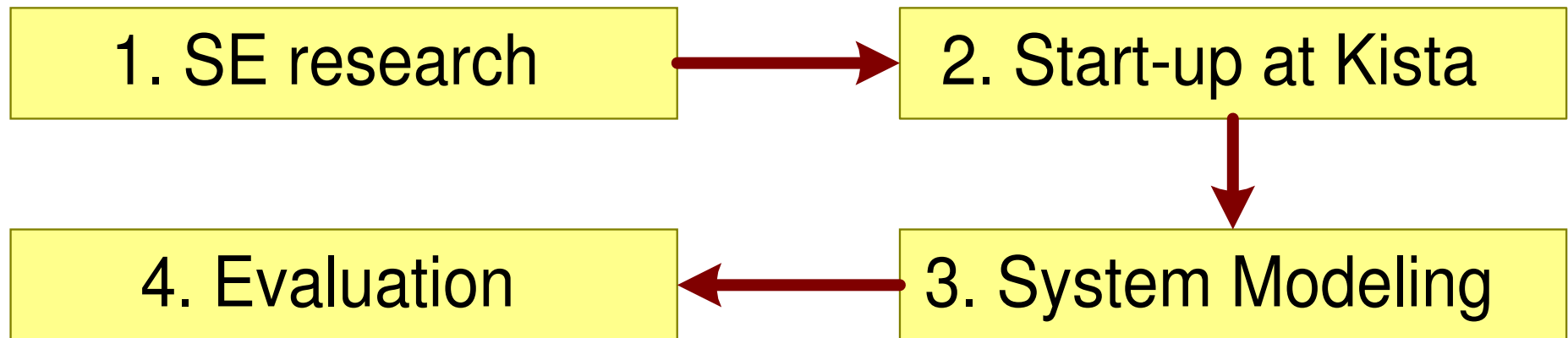
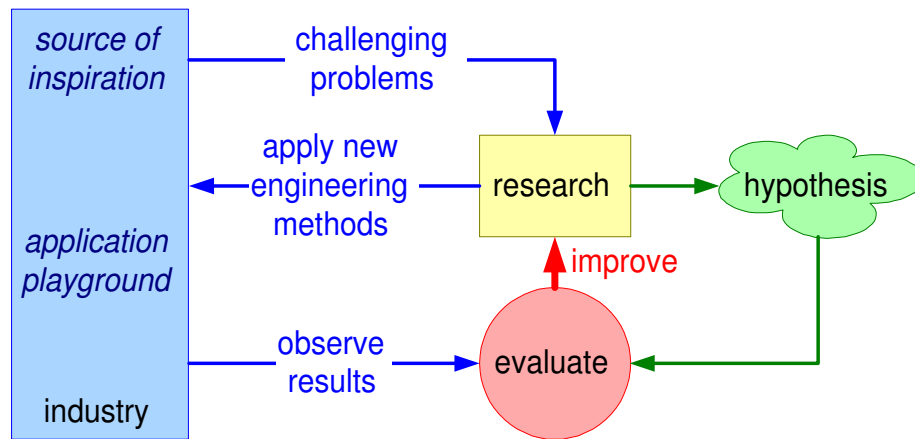
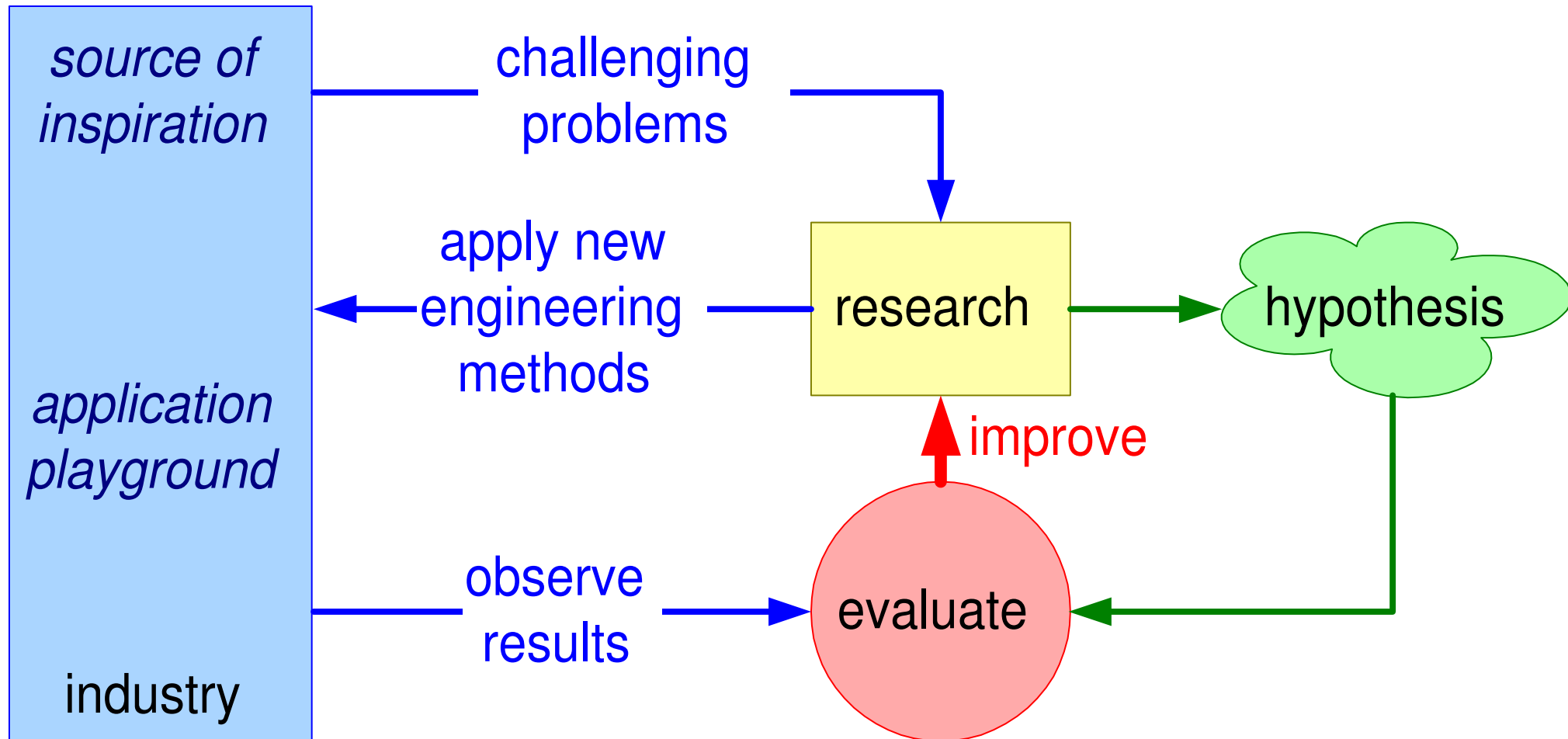


Figure Of Contents™



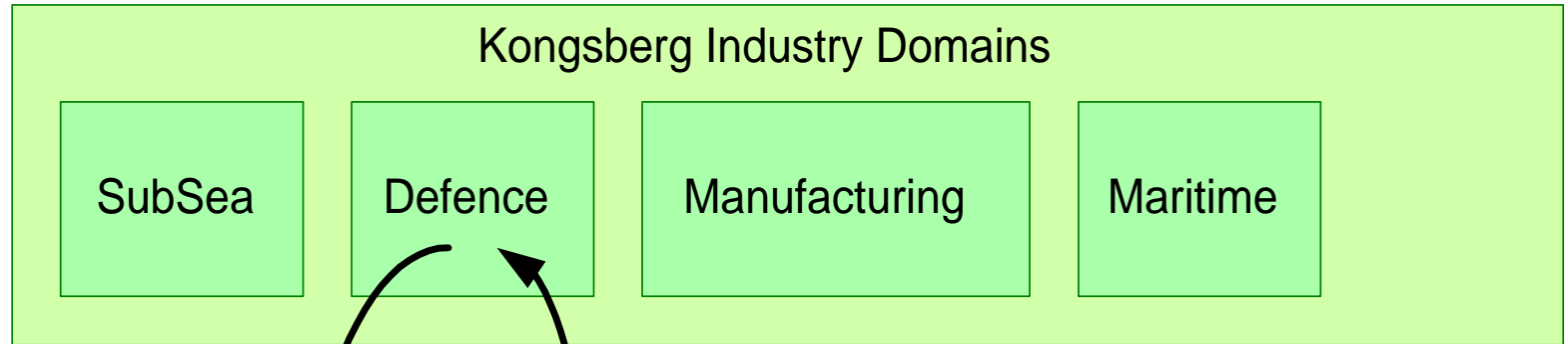
note: original diagram was annotated with actual performance figures for confidentiality reasons these numbers have been removed

Industry as Laboratory



Industry as Laboratory (2)

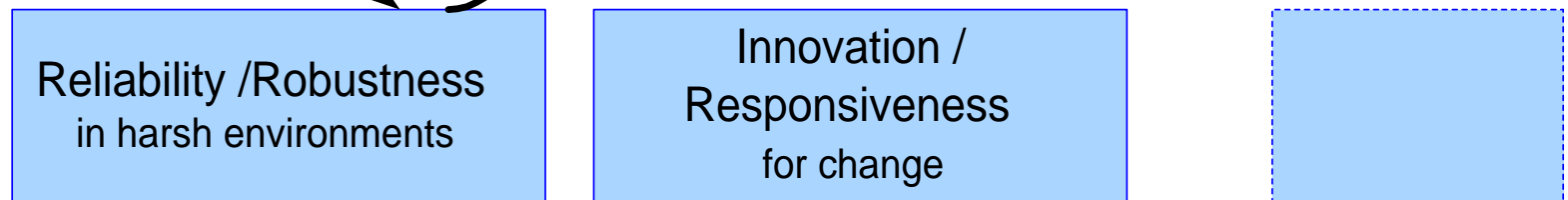
intended dissemination and research partners



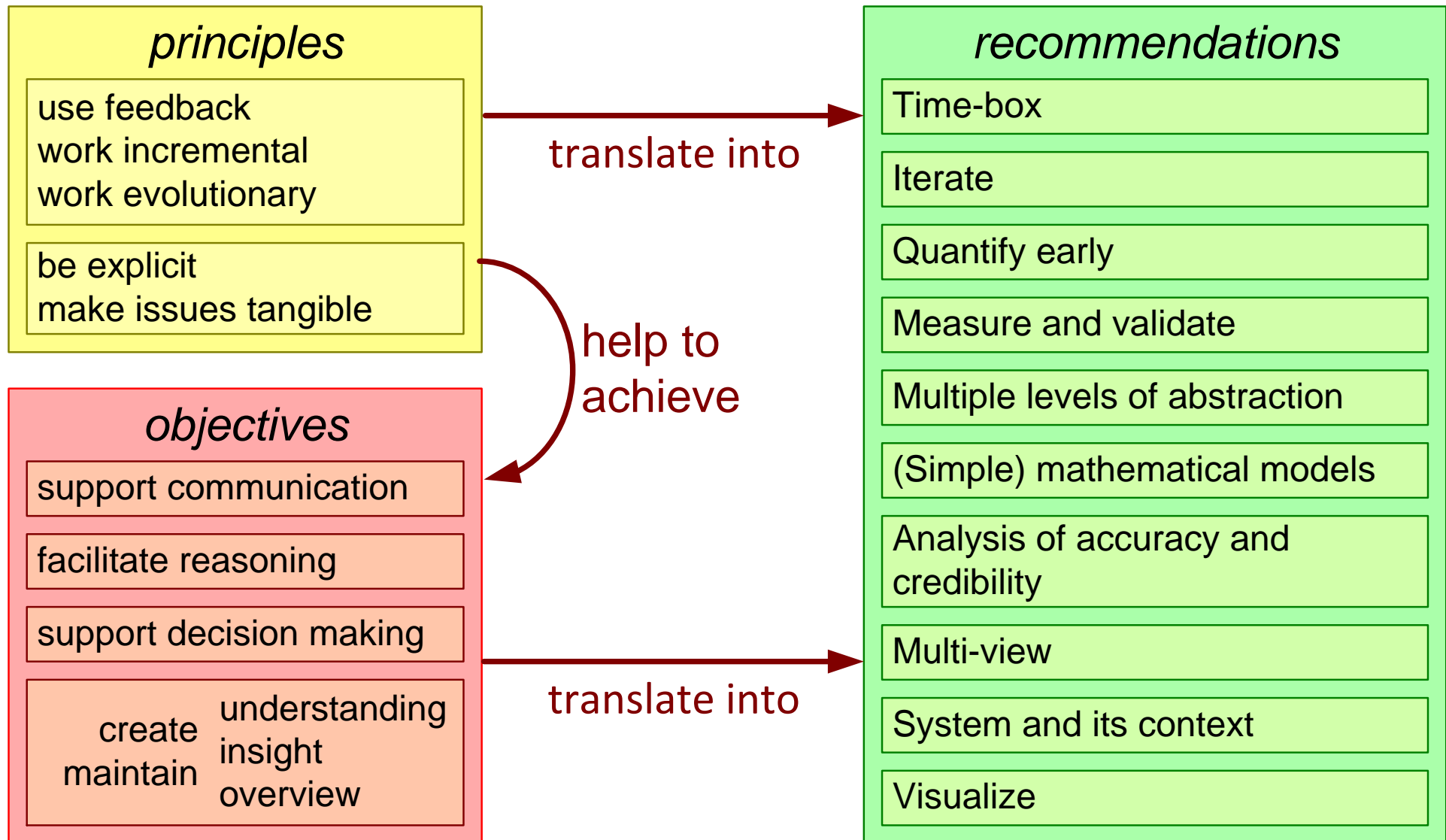
generalization and consolidation to facilitate use in other domains

single domain research focus on industrial problem

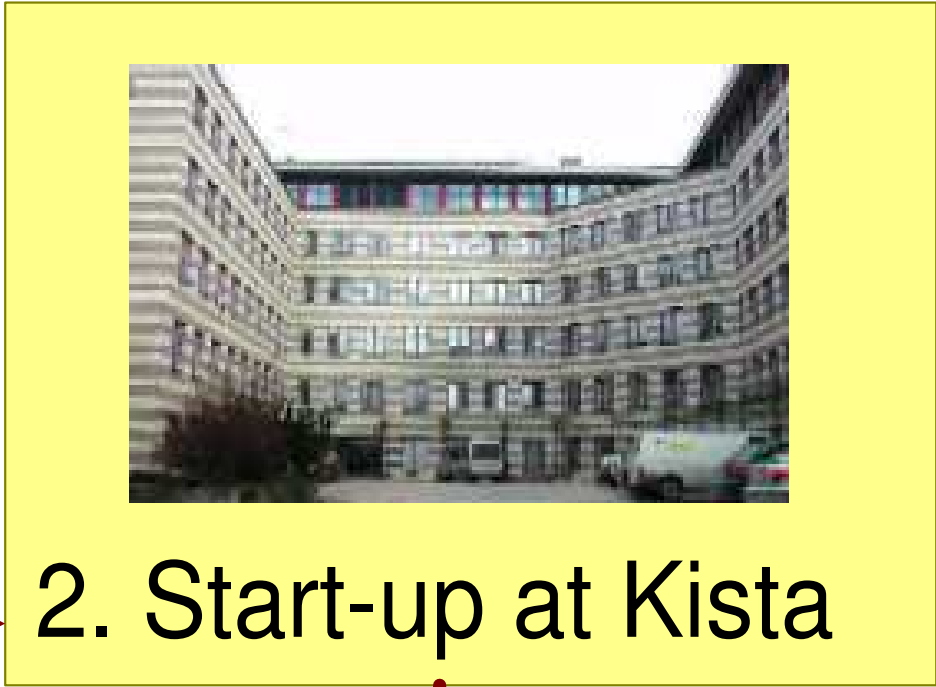
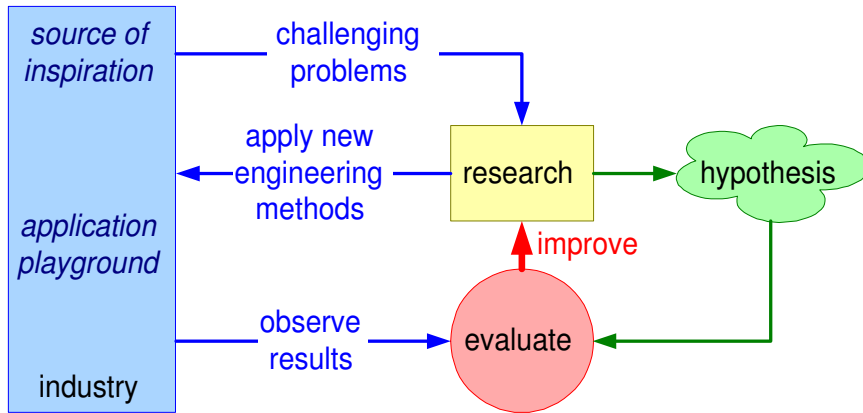
multi-domain research and expertise



Modeling Recommendations as Applied



Start-Up Company Replisaurus in Kista (Sweden)

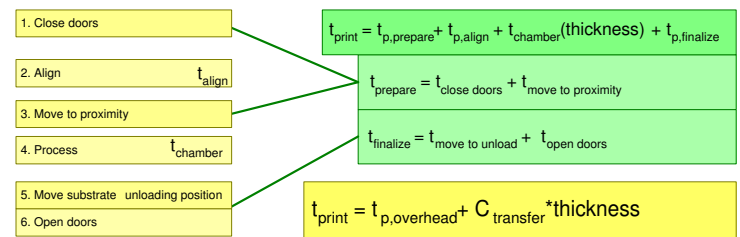
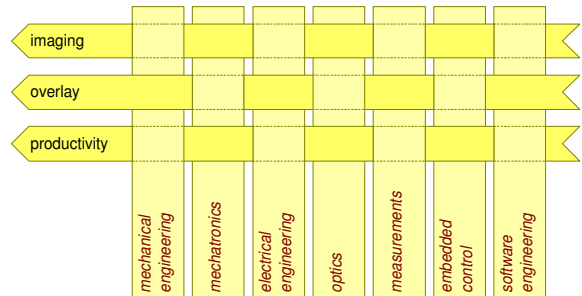


1. SE research

2. Start-up at Kista

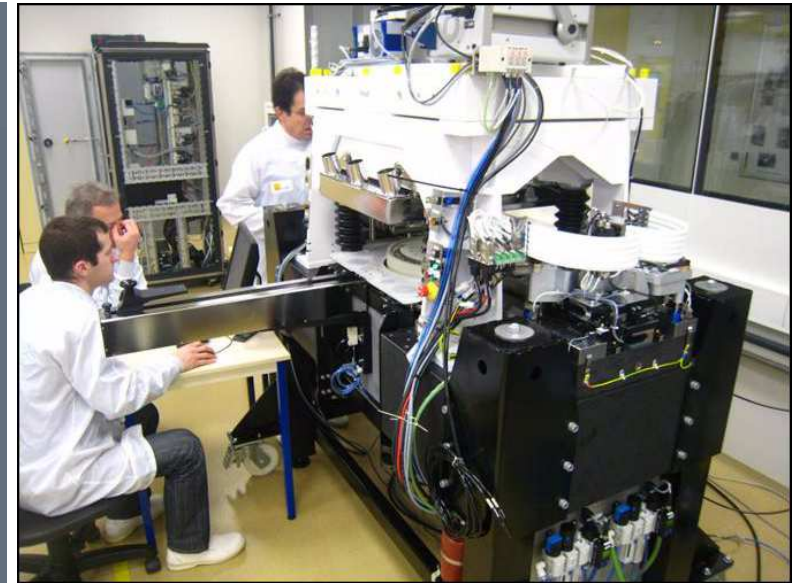
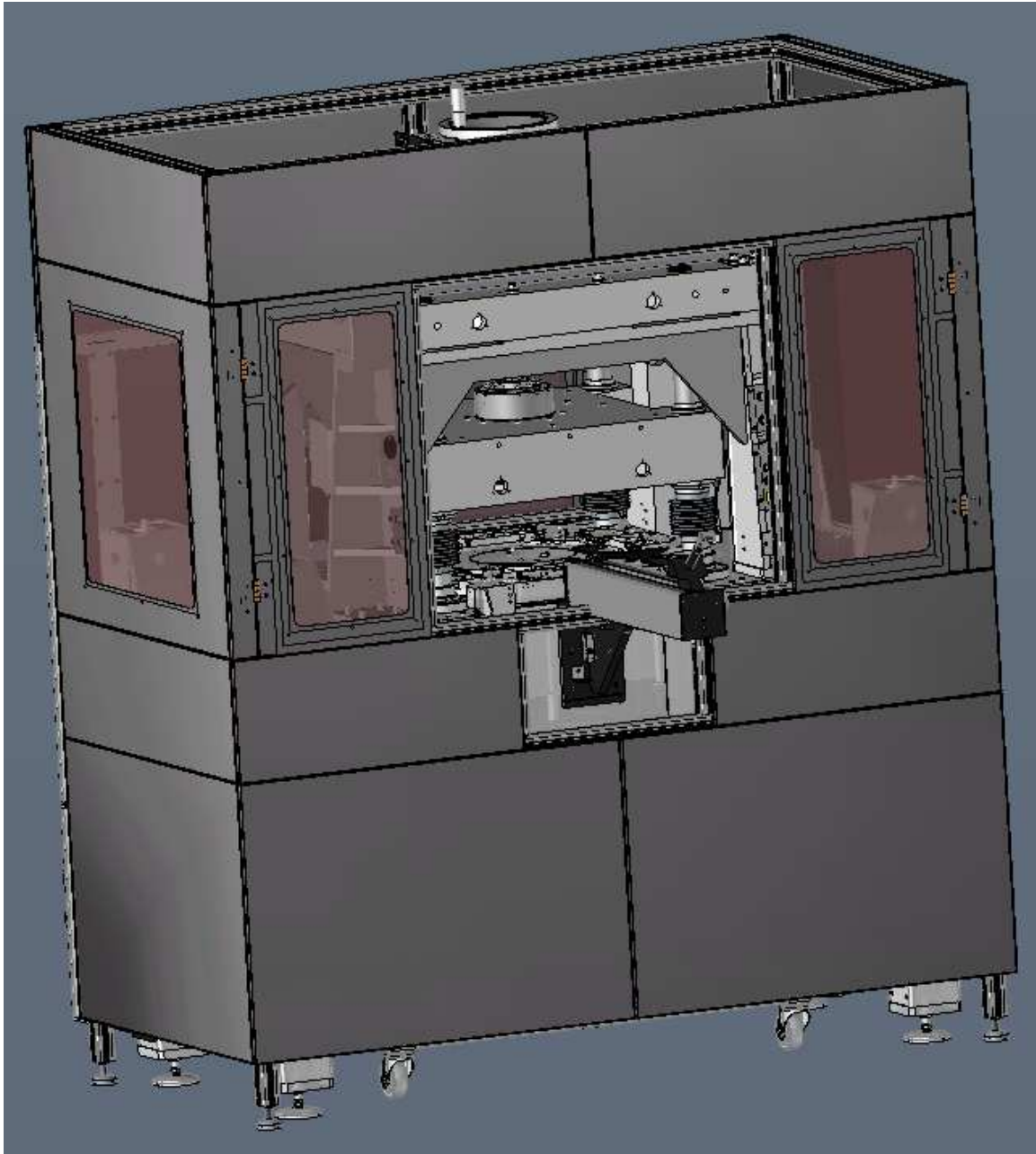
4. Evaluation

3. System Modeling

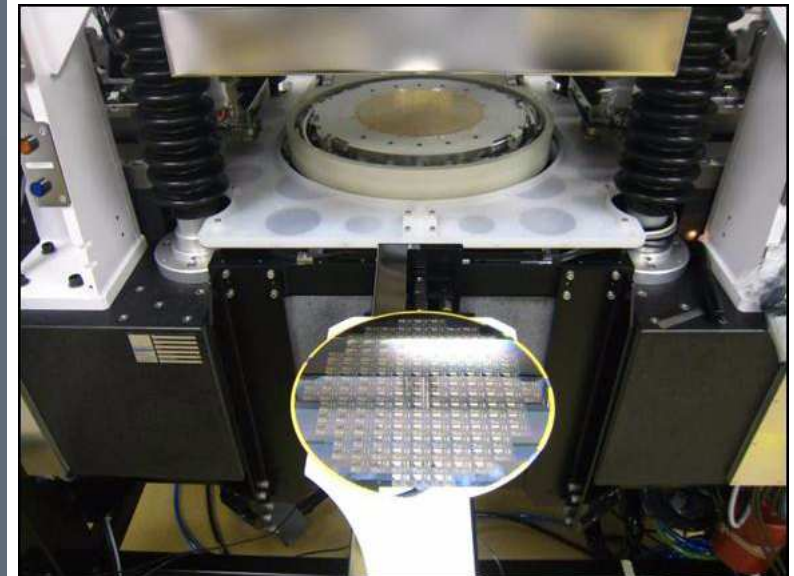


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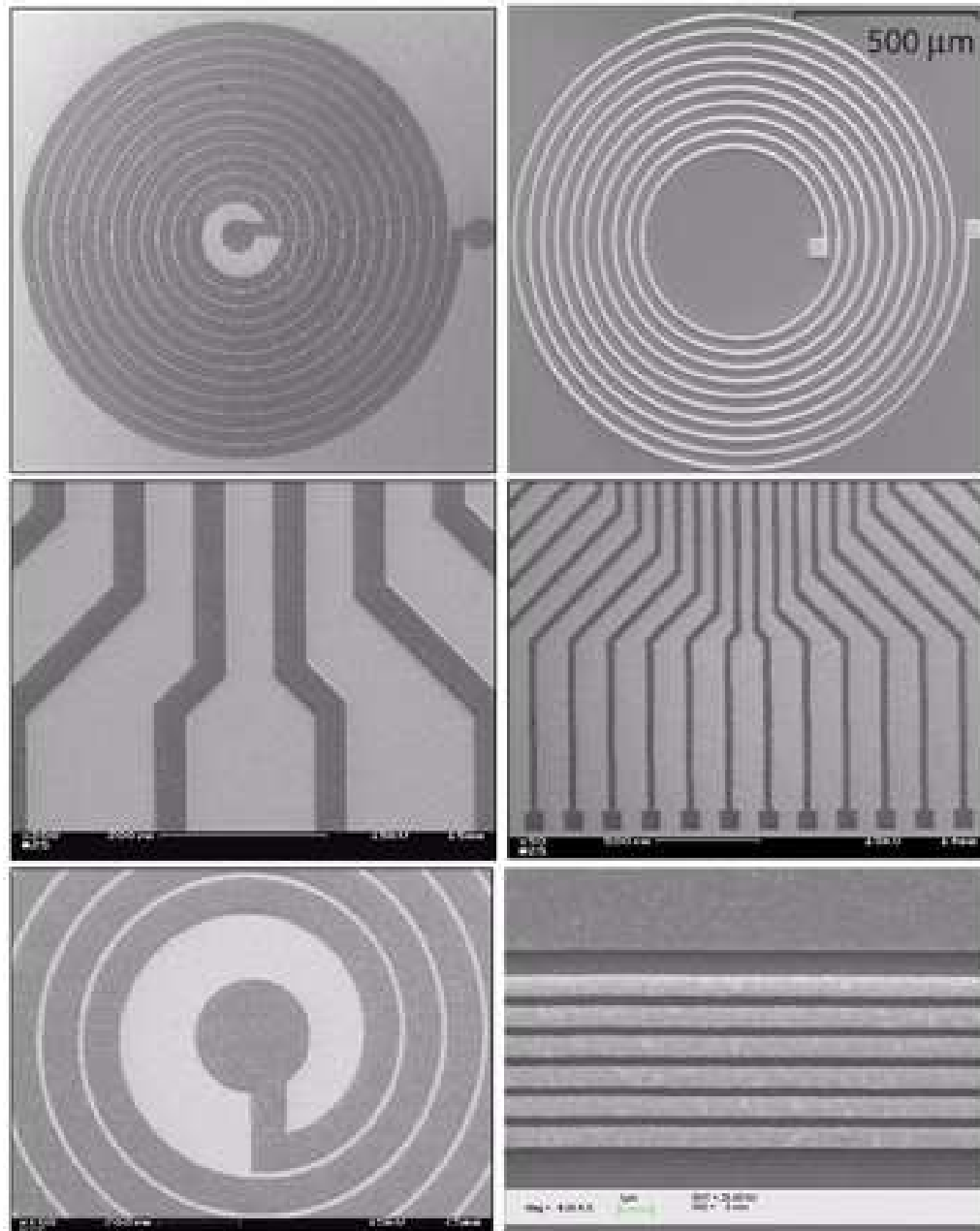
The Copper Printer



courtesy Replisaurus
www.replisaurus.com



Example of printed copper structures

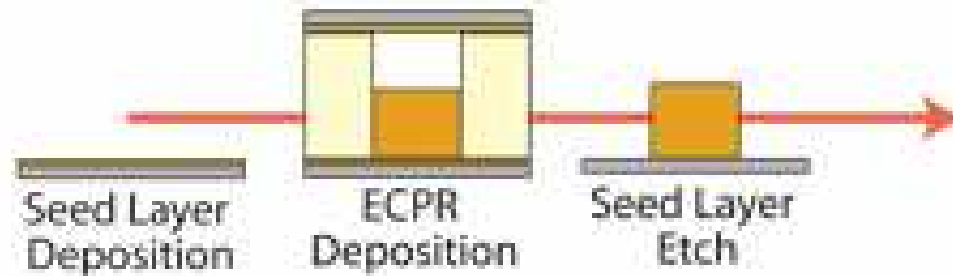


courtesy Replisaurus
www.replisaurus.com

ECPR technology replaces 6 process steps by 1 step

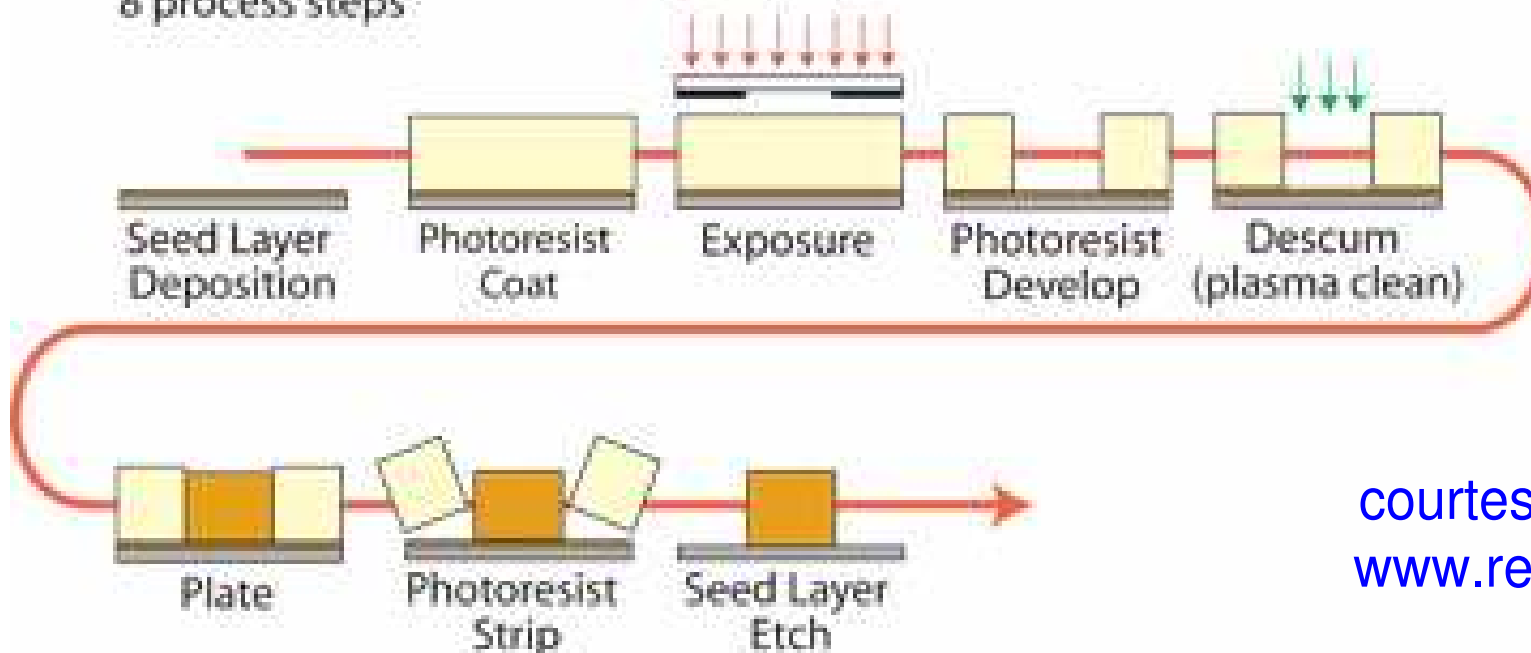
ECPR - ElectroChemical Pattern Replication

3 process steps



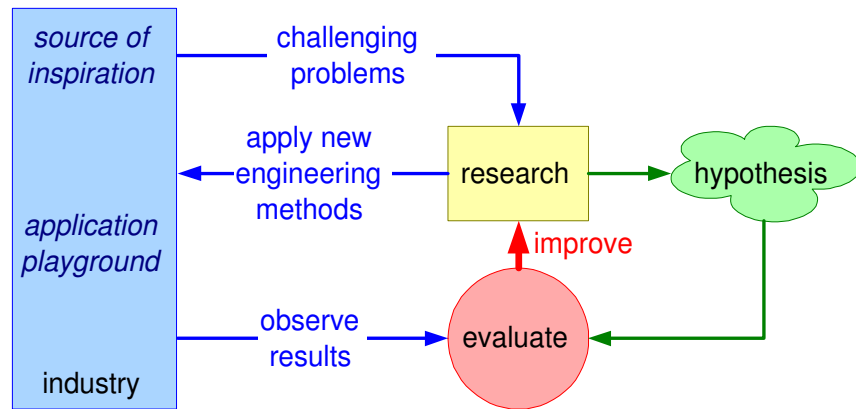
Conventional lithography based metallization

8 process steps



courtesy Replisaurus
www.replisaurus.com

System Modeling



1. SE research

2. Start-up at Kista

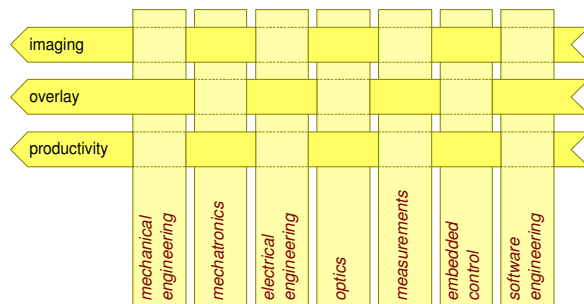
4. Evaluation

3. System Modeling

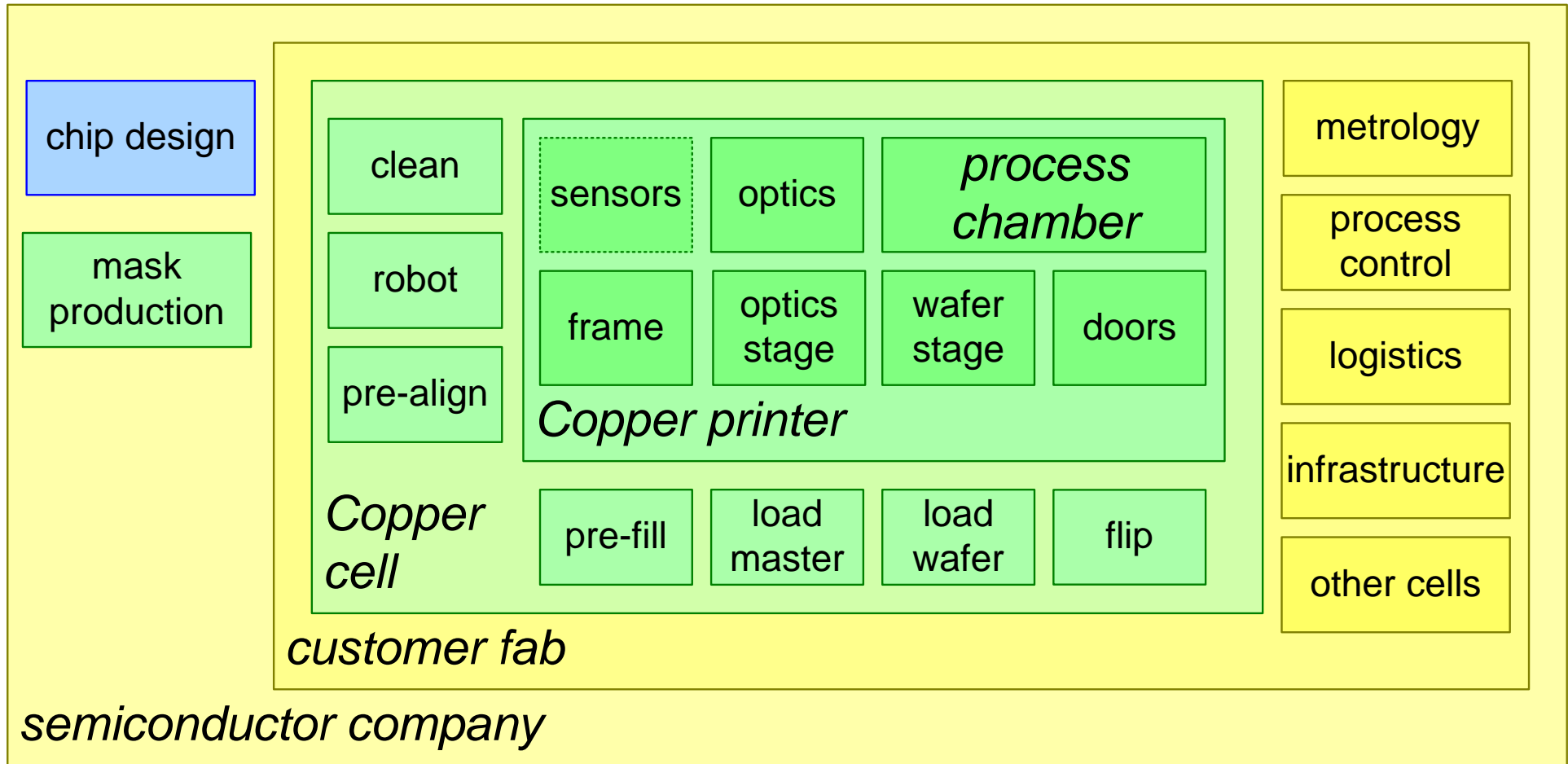
1. Close doors		$t_{\text{print}} = t_{p,\text{prepare}} + t_{p,\text{align}} + t_{\text{chamber}}(\text{thickness}) + t_{p,\text{finalize}}$
2. Align	t_{align}	
3. Move to proximity		
4. Process	t_{chamber}	
5. Move substrate unloading position		$t_{\text{print}} = t_{p,\text{overhead}} + C_{\text{transfer}} * \text{thickness}$
6. Open doors		

$t_{\text{prepare}} = t_{\text{close doors}} + t_{\text{move to proximity}}$
 $t_{\text{finalize}} = t_{\text{move to unload}} + t_{\text{open doors}}$

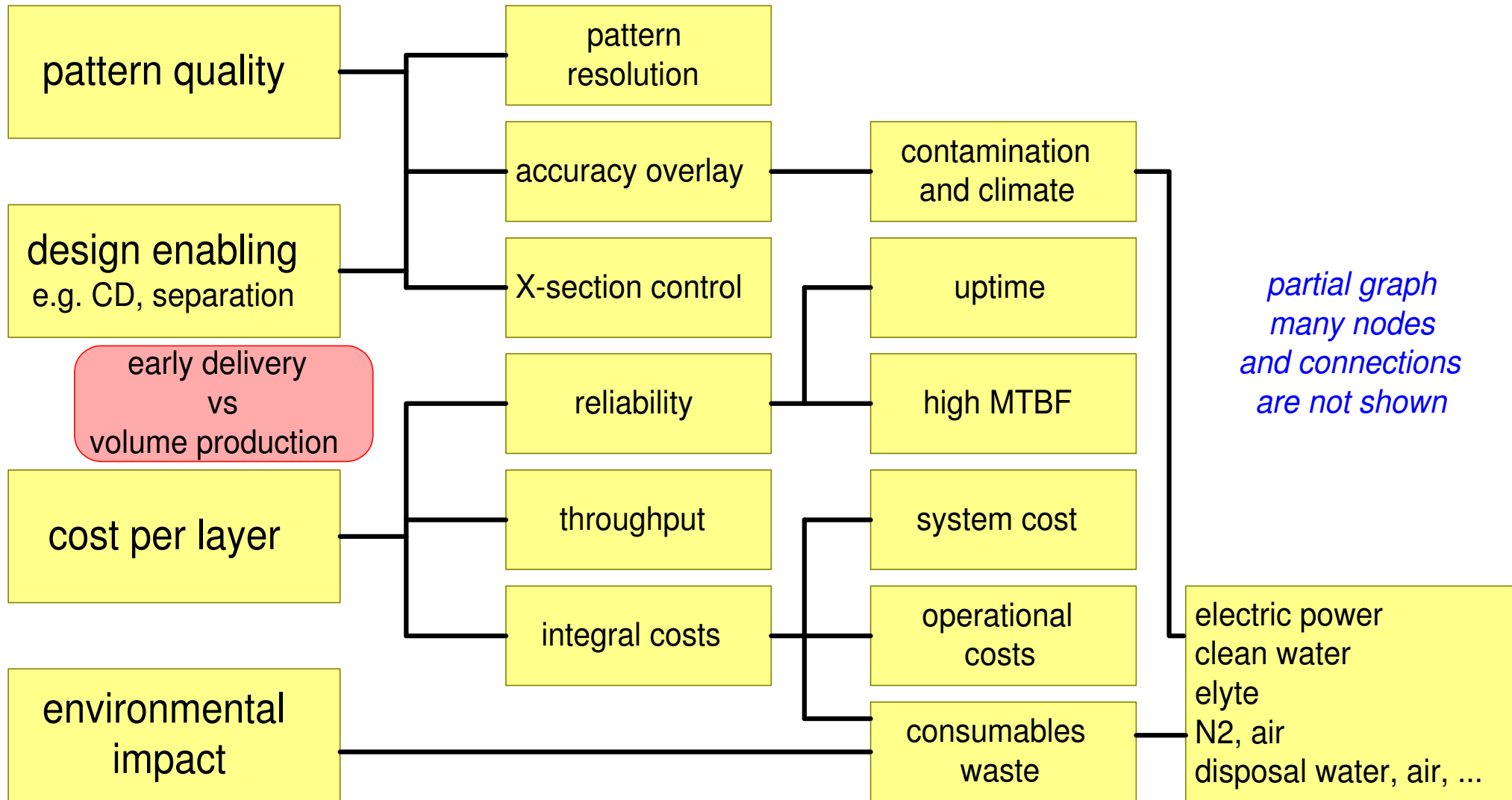
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Overview of the different scopes

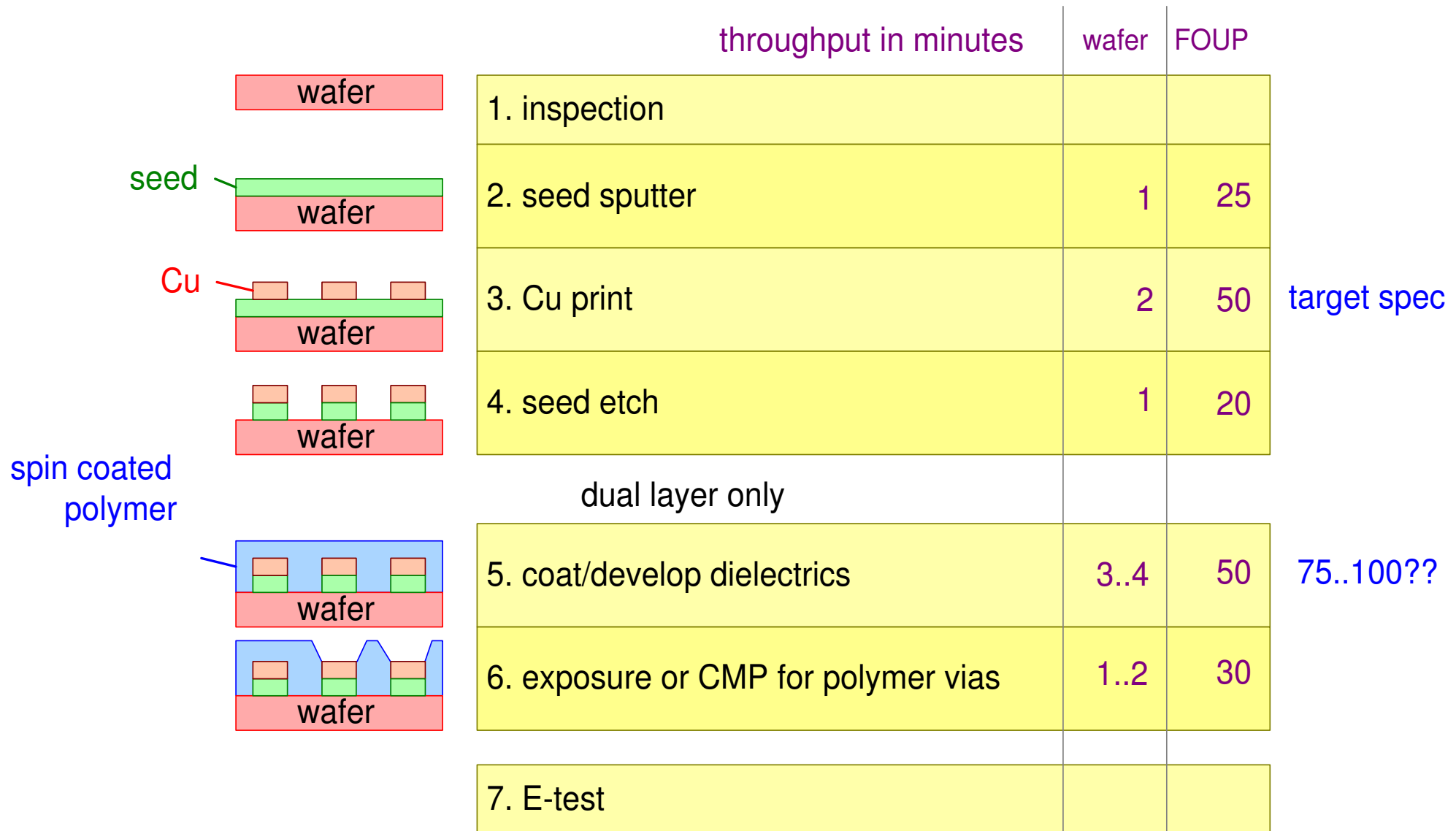


Customer key driver graph



*partial graph
many nodes
and connections
are not shown*

Process flow at fab level, from inspection until testing



Work flow in the Copper Printer

0. Loading Master&substrate

1. Close doors

2. Align

3. Move to proximity

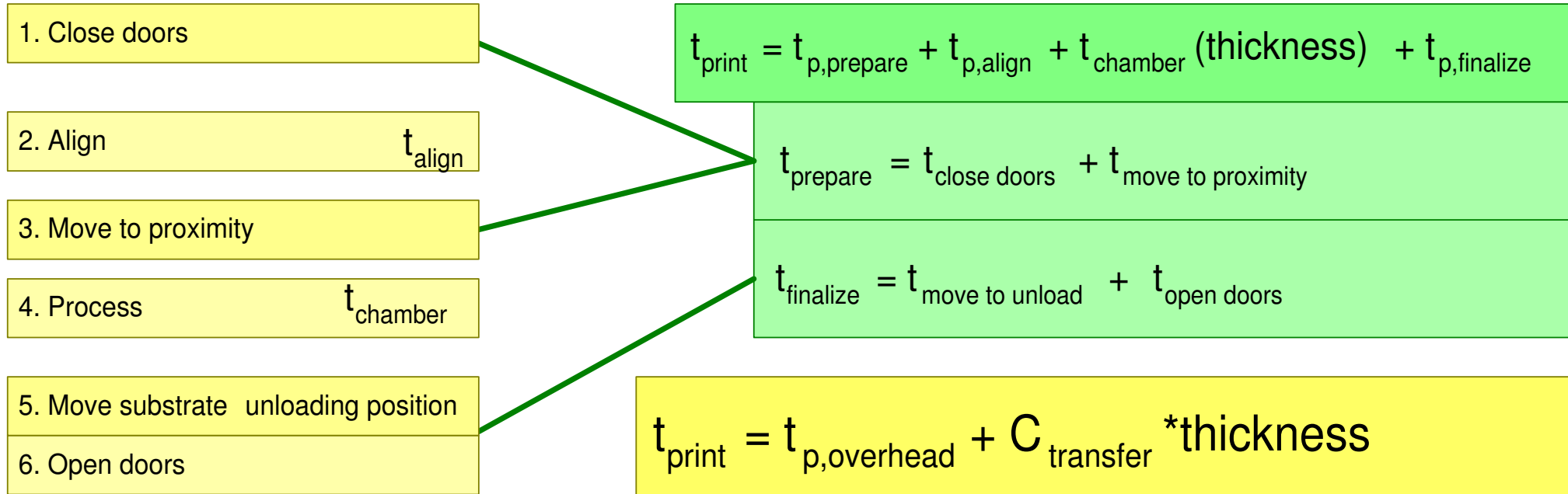
4. Process incl. rinse&dry

5. Move substrate unloading position

6. Open doors

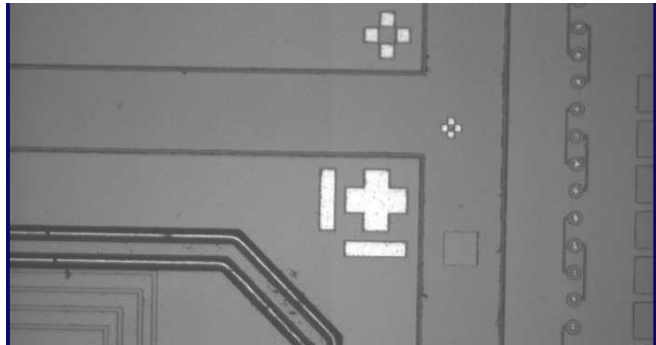
7. Unloading Master&substrate

Formula of printer throughput time



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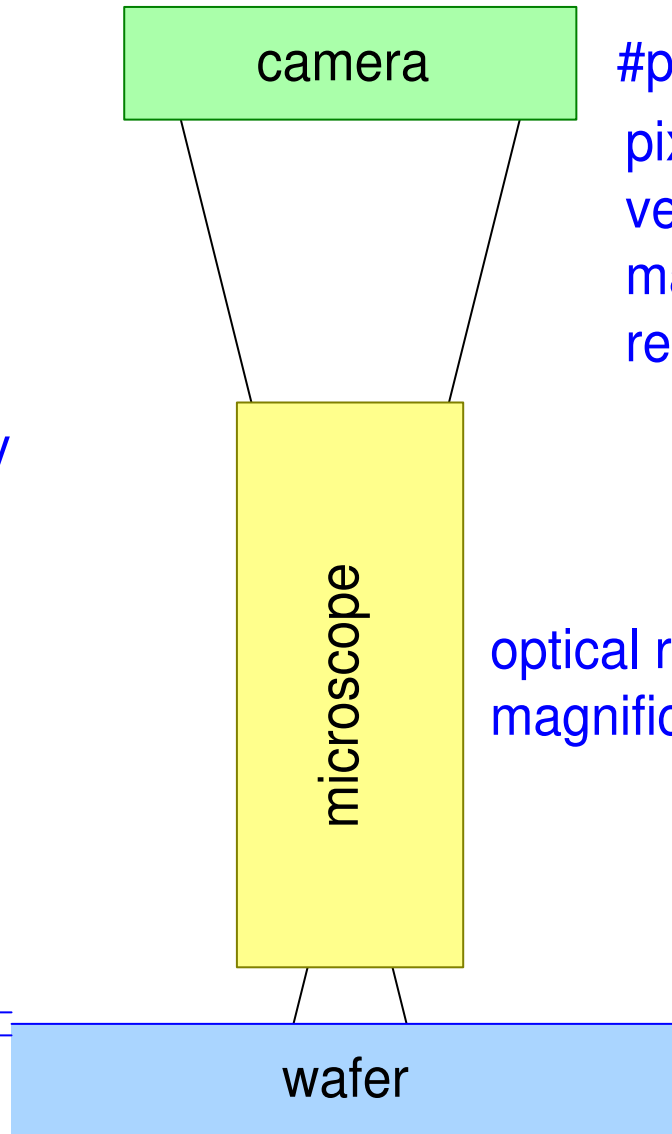
Optical path to measure marker position



measurement accuracy
determines
required resolution



DoF \updownarrow

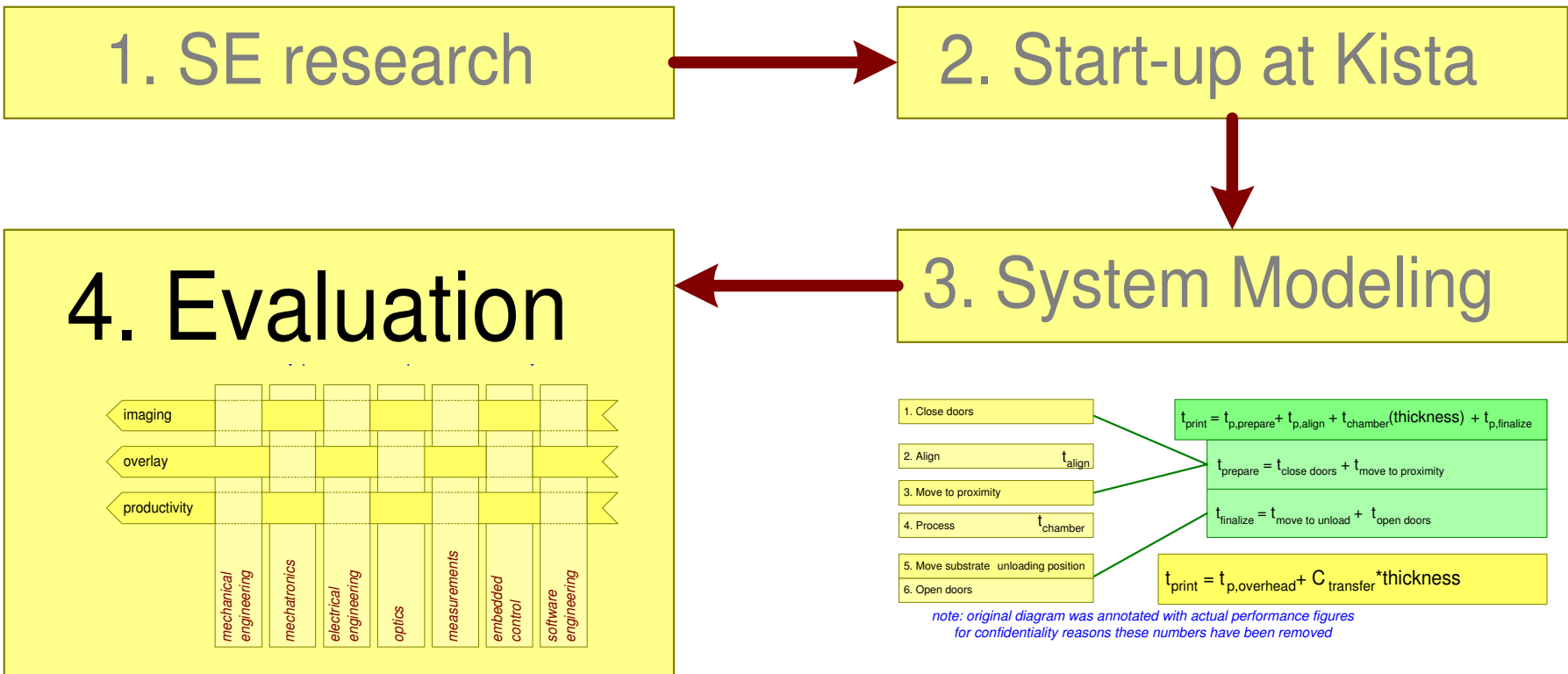
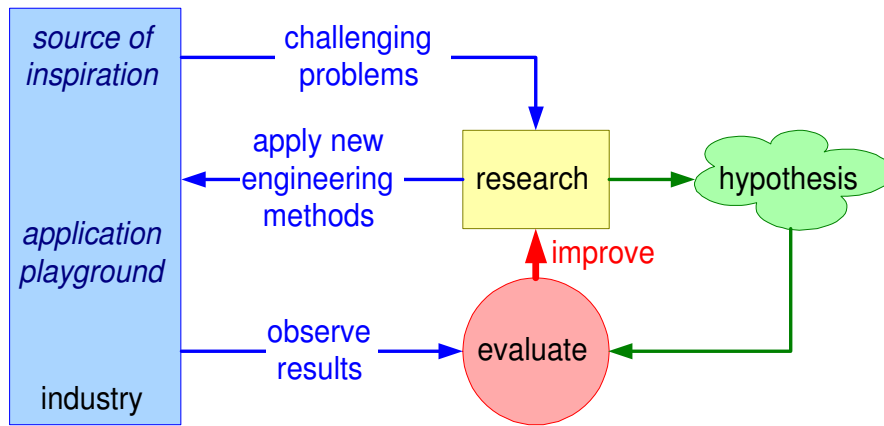


#pixels \sim 5M
pixel resolution
versus
maximum Field of View
read-out and processing time

optical resolution
magnification

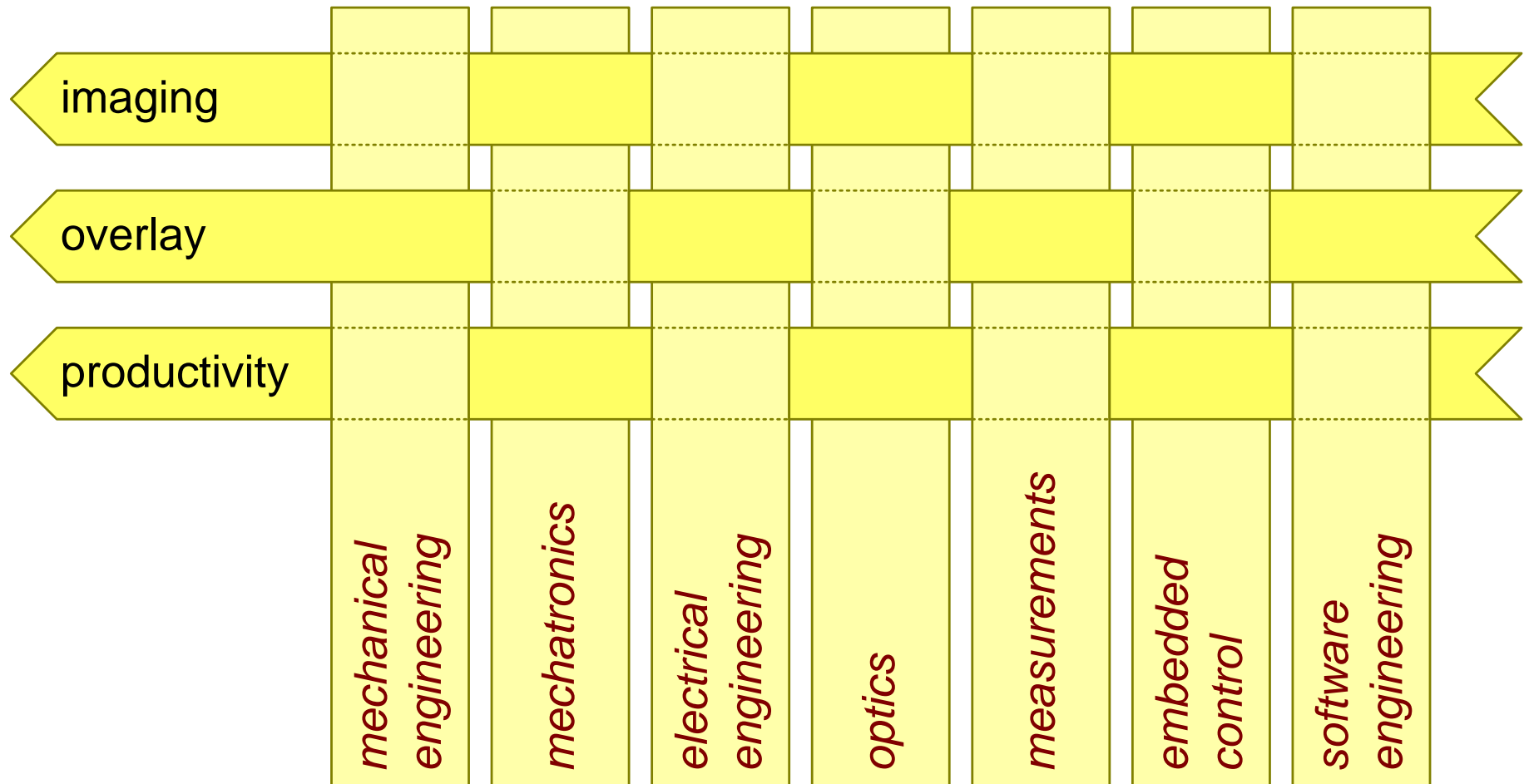
displacement
determines
required Field of View

Evaluation

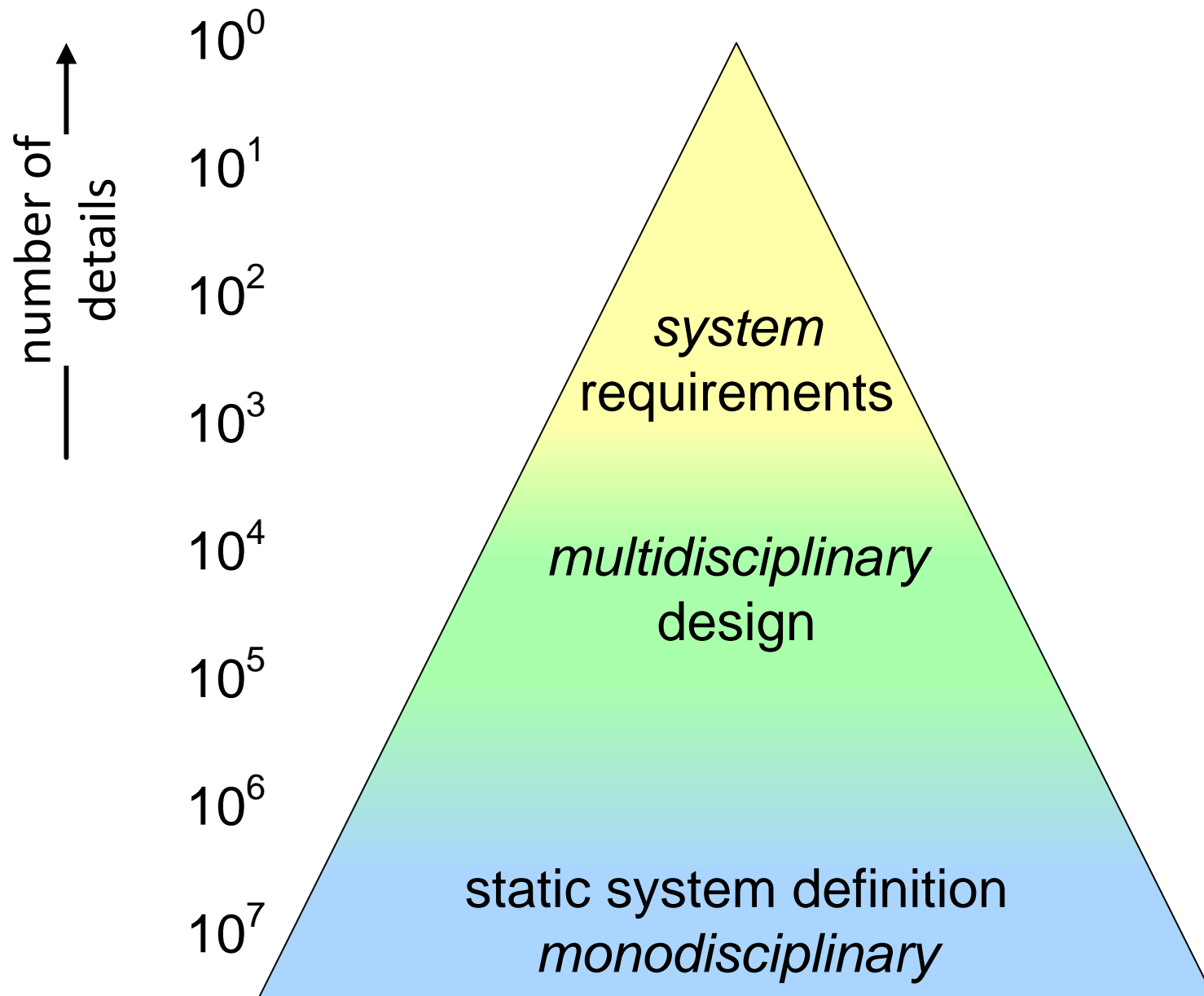


From Engineering Disciplines to System Qualities

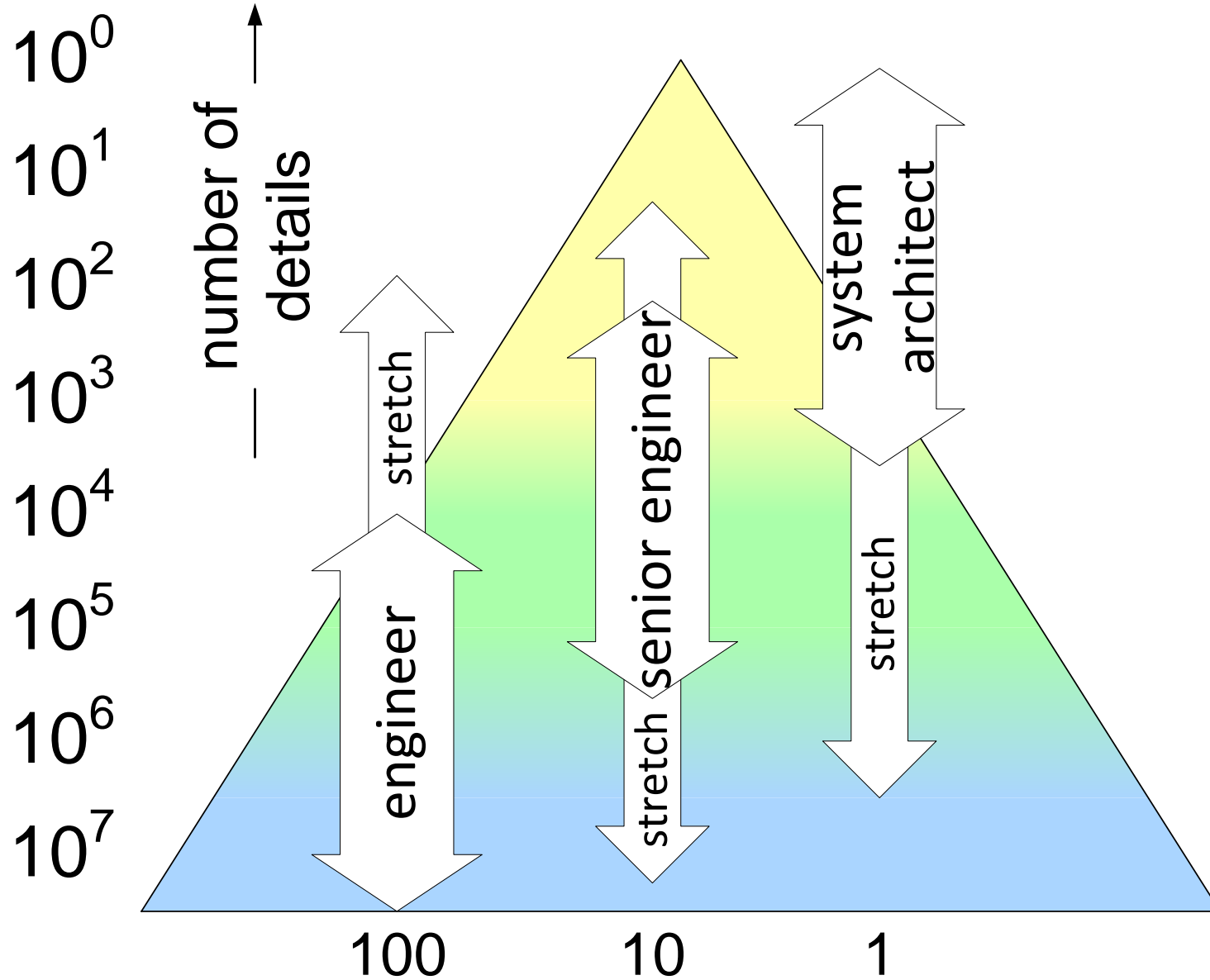
Systems Engineering: responsible for customer key drivers and key performance parameters of system



Levels of Abstraction



Lifting Engineers to System Concerns



Systems Engineering at Start-Up companies is applicable

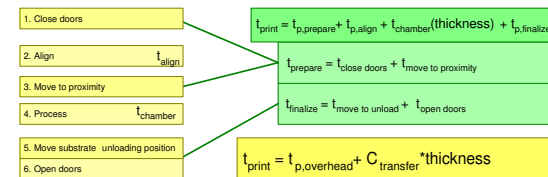
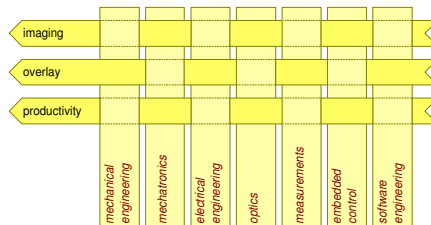
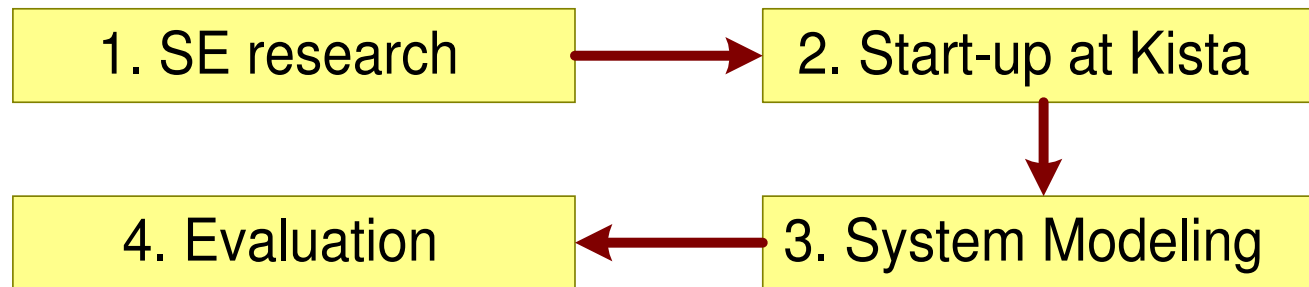
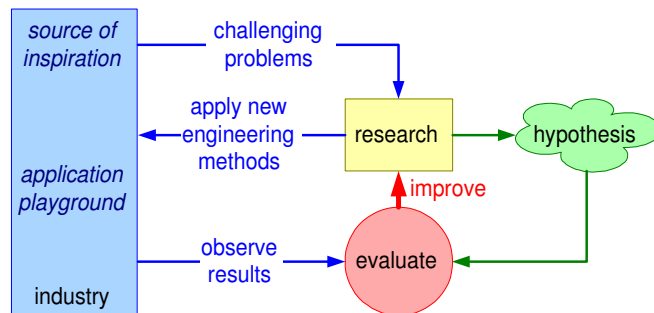
customization is required to adapt to:

company size

market and technology maturity

system models help to "lift" engineers to system level concerns

Application of theory in practice



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is required for **learning and validation**