

Save Money by Investing In Models; Failing Early is More affordable Than Failing Late

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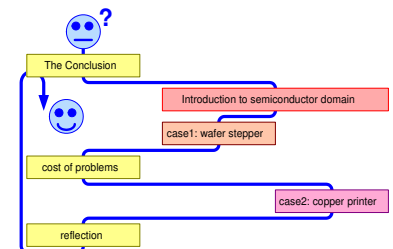
Abstract

Many stakeholders in systems development are unaware of the unknowns. Making and using virtual and physical models helps to validate assumptions, to calibrate the understanding, and to identify uncertainties and unknowns. A major risk is that some stakeholders think that they can afford to skip the laborious phase of trial, error, trouble shoot, and validation. It is an old wisdom that it is less costly to fail early than to fail late. We will use two cases from the semiconductor industry for illustration.

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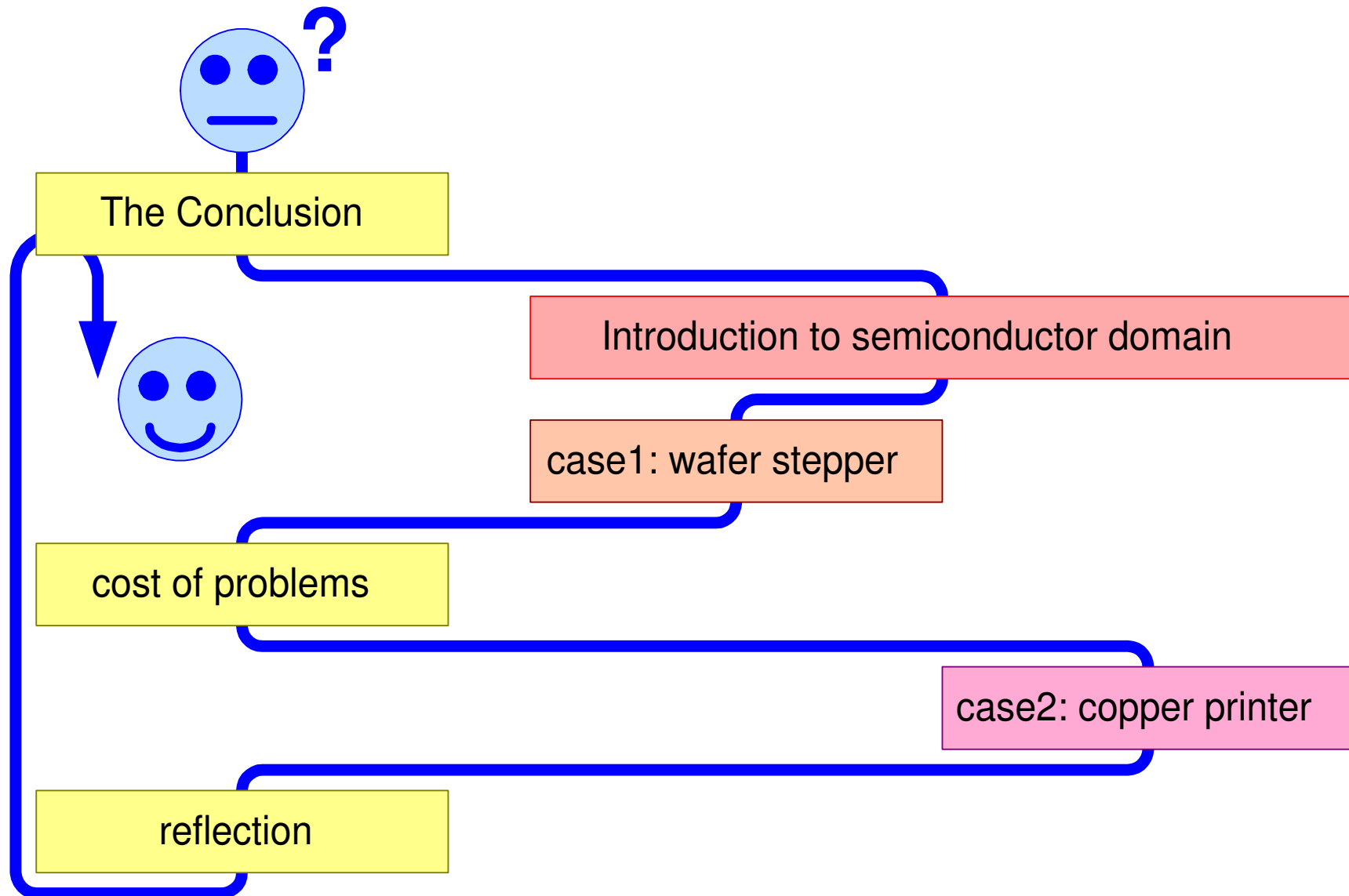


Early ***investments*** in

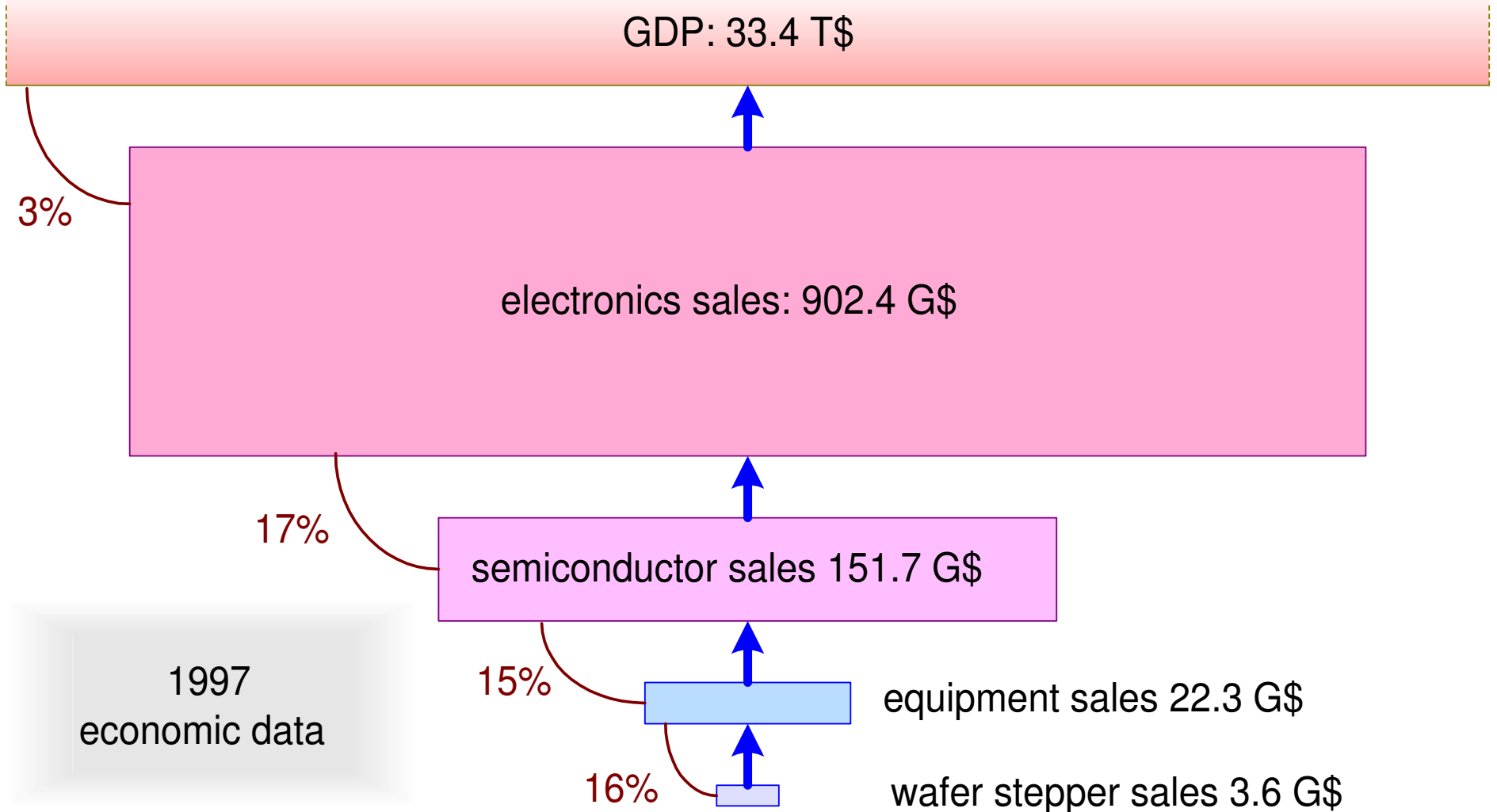
test rigs, prototypes, virtual models, and simulations

save a lot of money

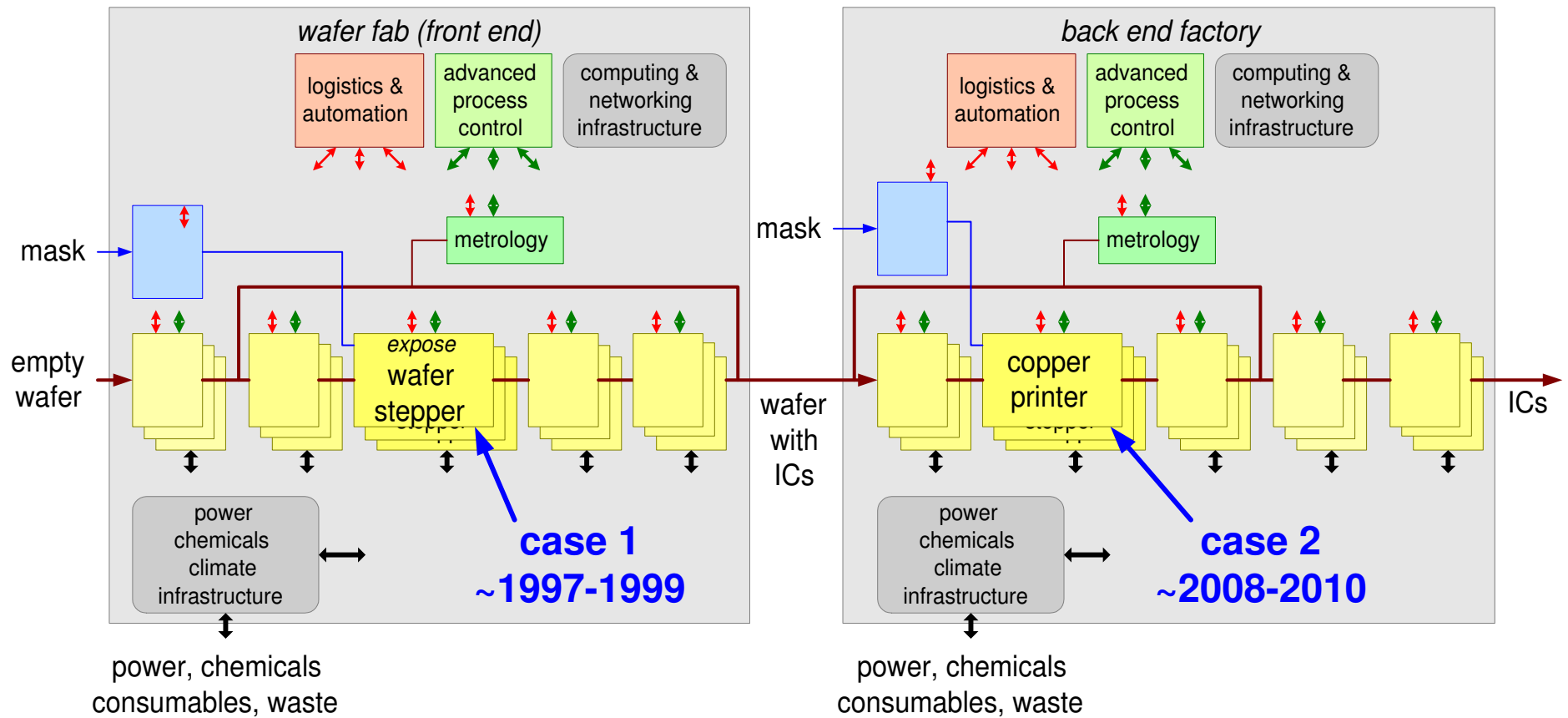
Figure Of Contents™



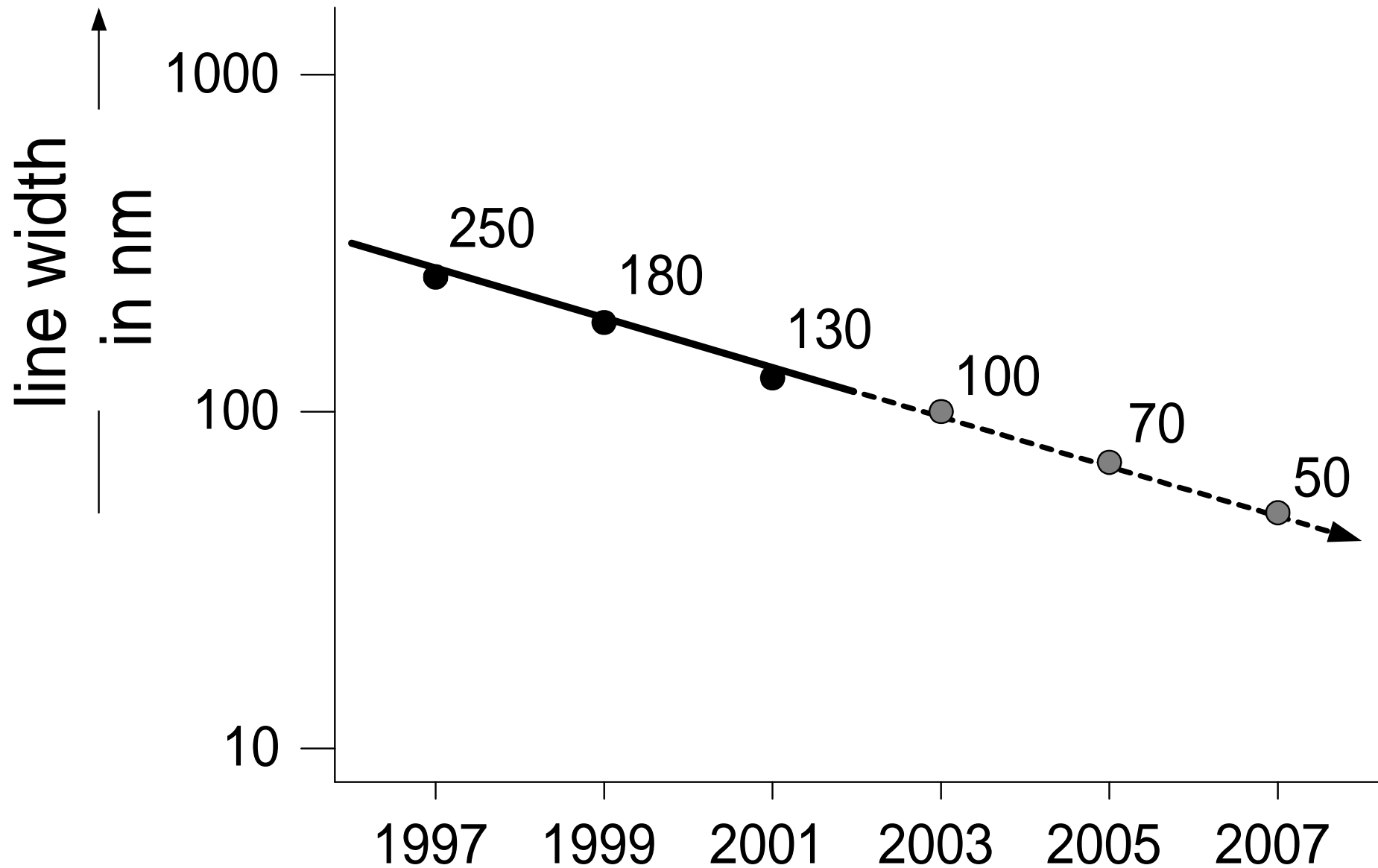
Semiconductor Economics

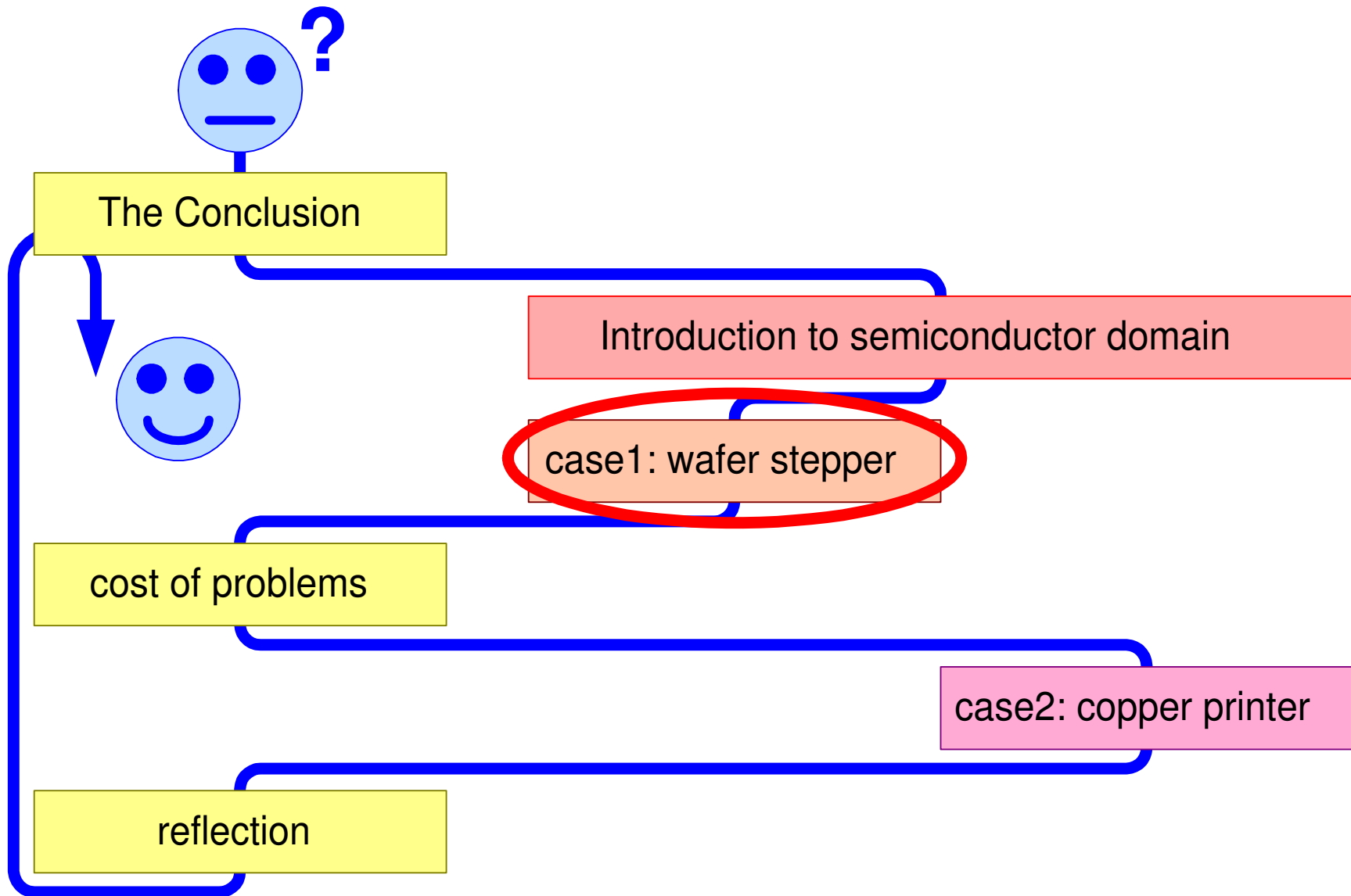


Semiconductor IC manufacturing



Moore's law

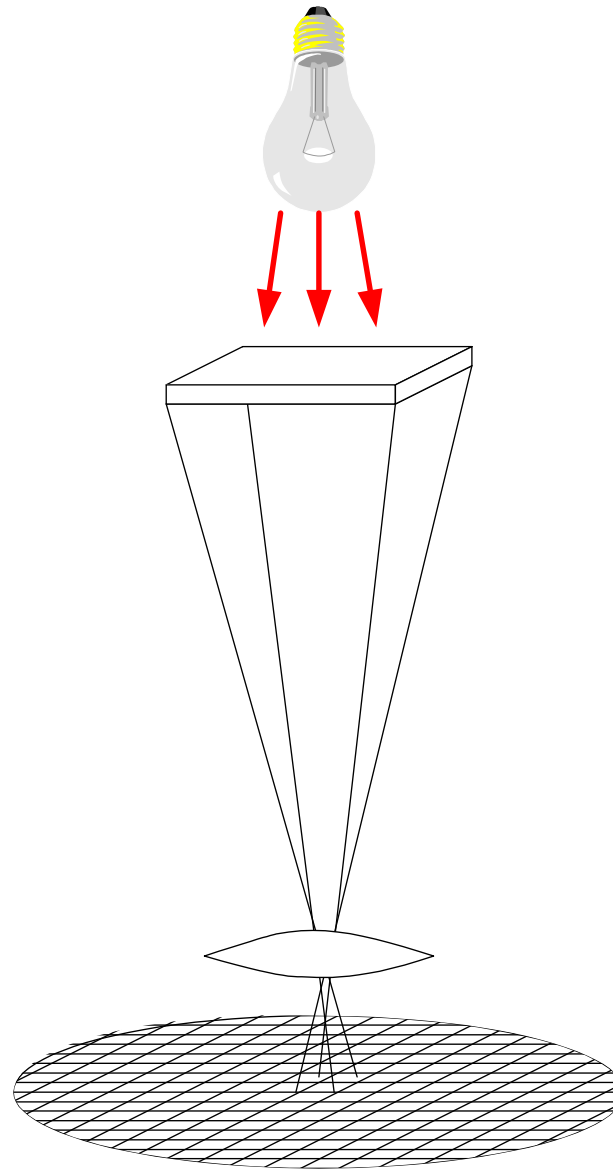




Twinscan AT1100



What is a waferstepper



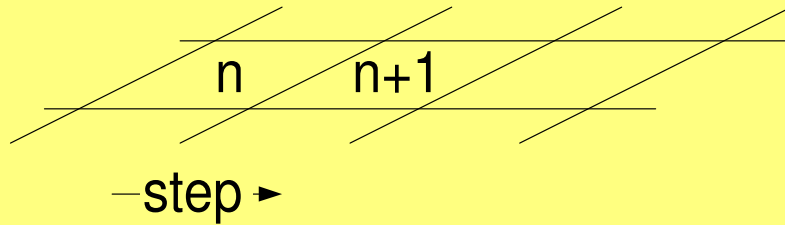
source

reticle

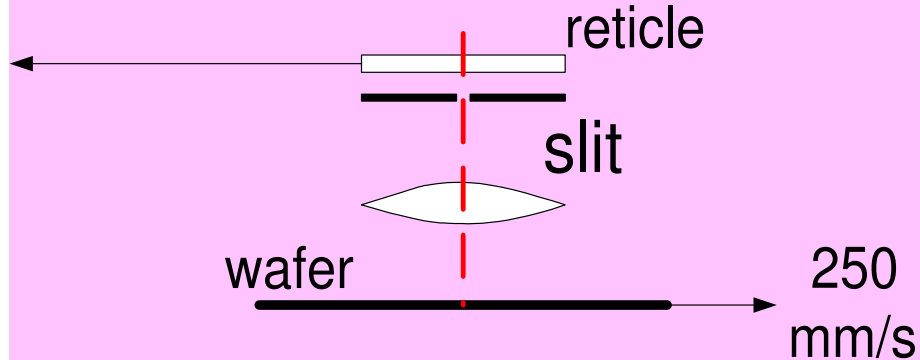
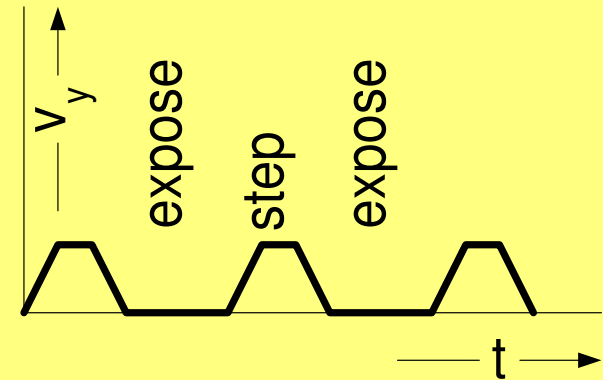
lens

wafer

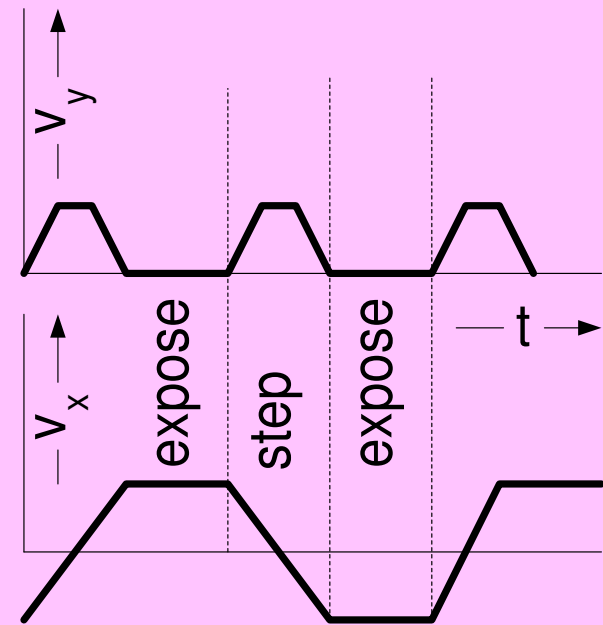
From stepping to scanning



stepper: static exposure of field

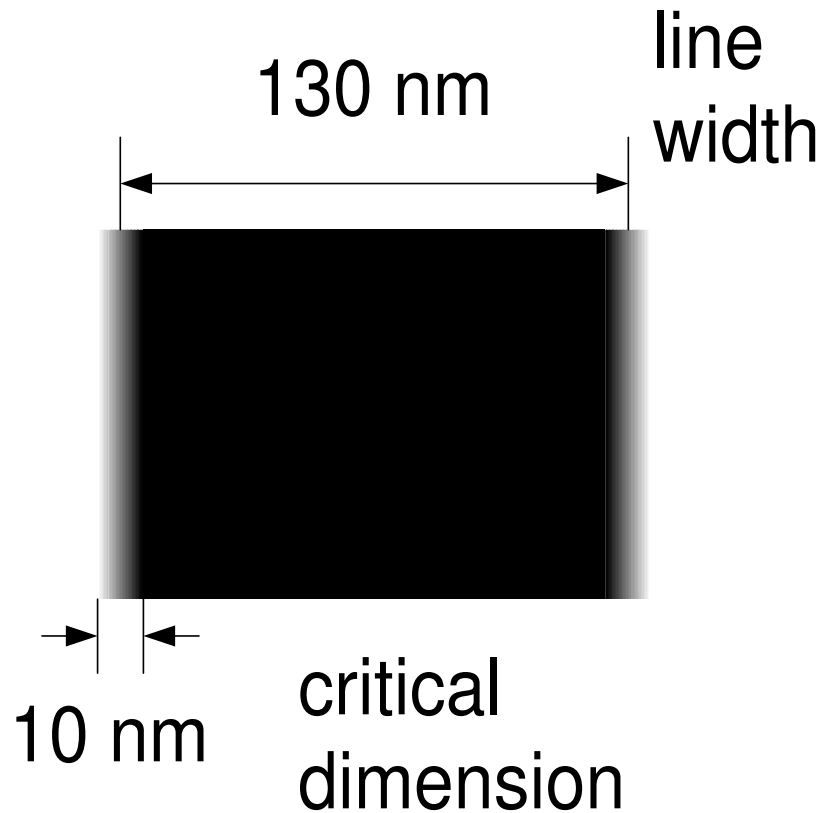


scanner: dynamic exposure through slit

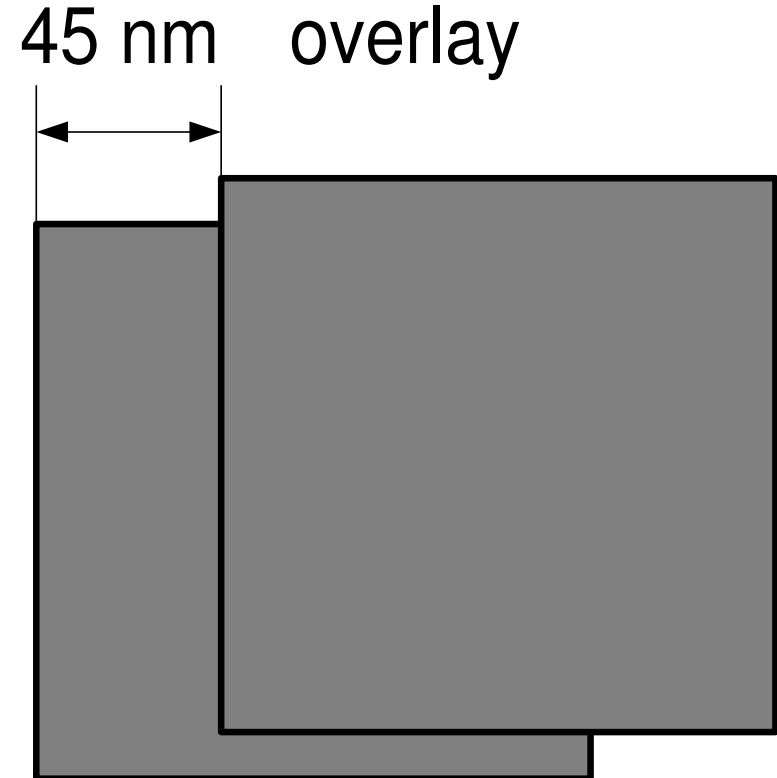


Key specifications waferstepper

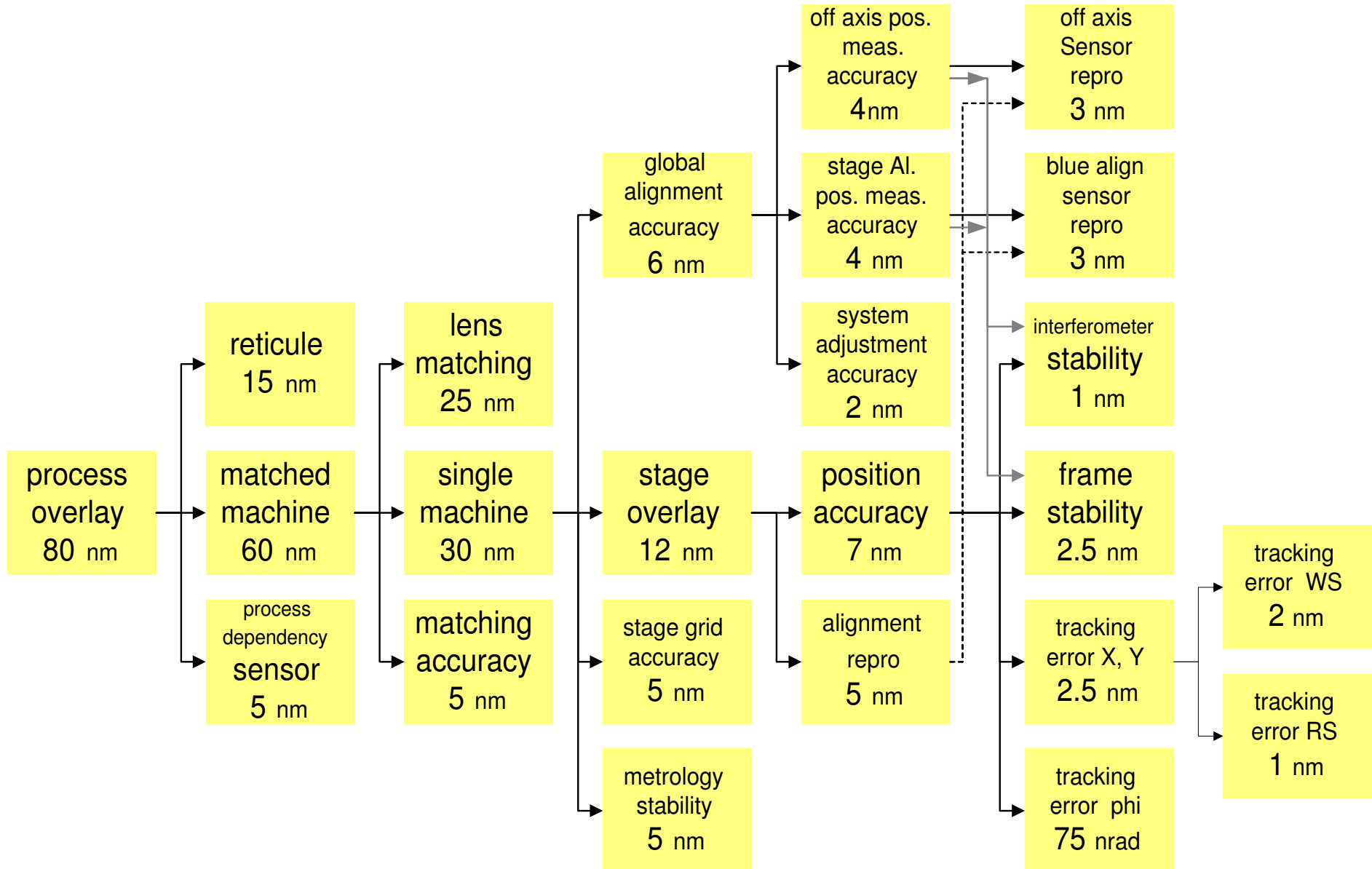
imaging



alignment



Overlay budget (1999)

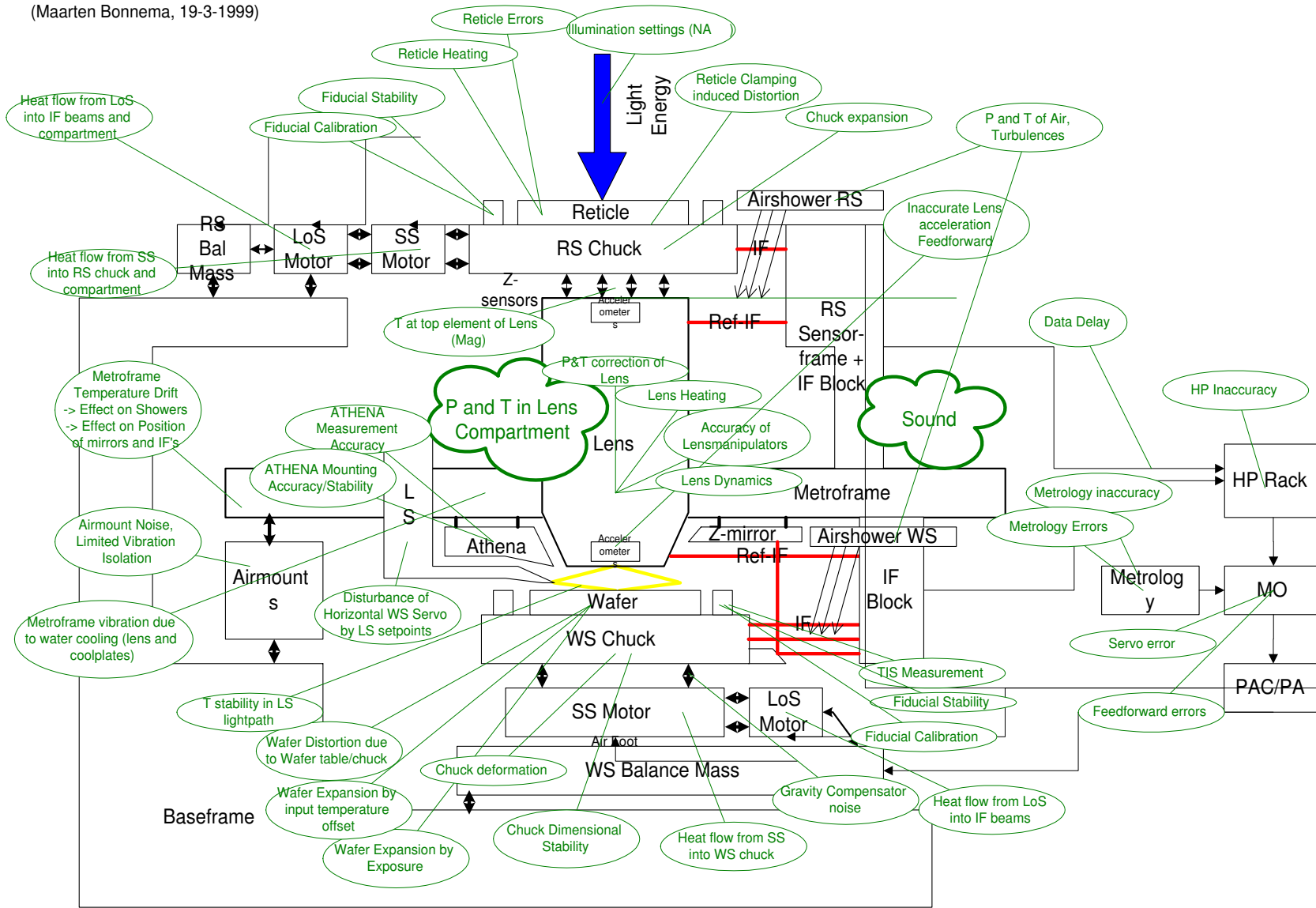


Everything influences overlay

Overlay Influence Diagram.

(Maarten Bonnema, 19-3-1999)

□ : Fiducial



Integration of Overlay

test models for
critical functions

scanning stage

build core
machine

*stages, lens,
alignment, level
sensor,
illumination*

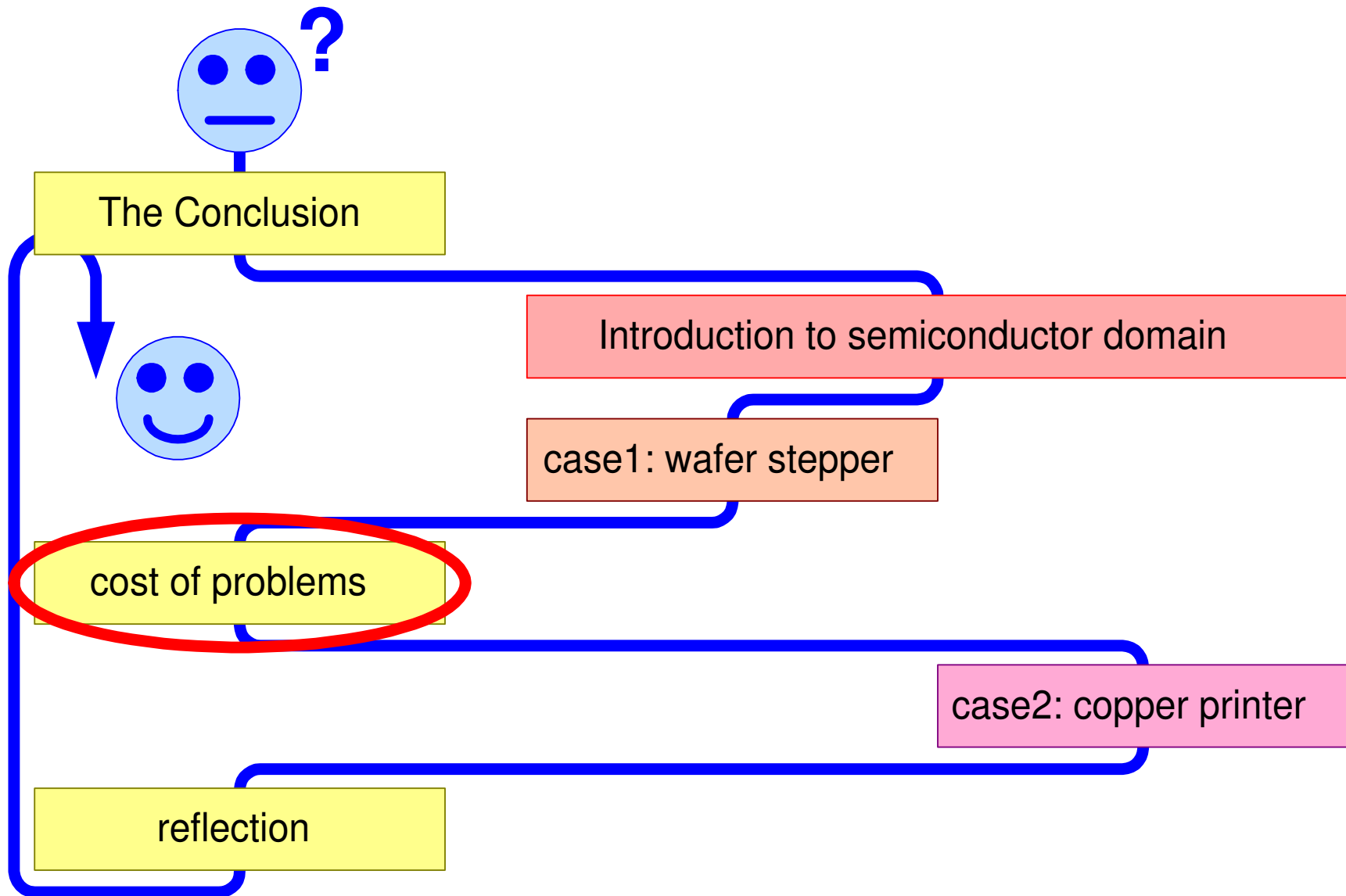
run manual
sequence

*load wafer,
align, focus,
dose setting,
and many more*

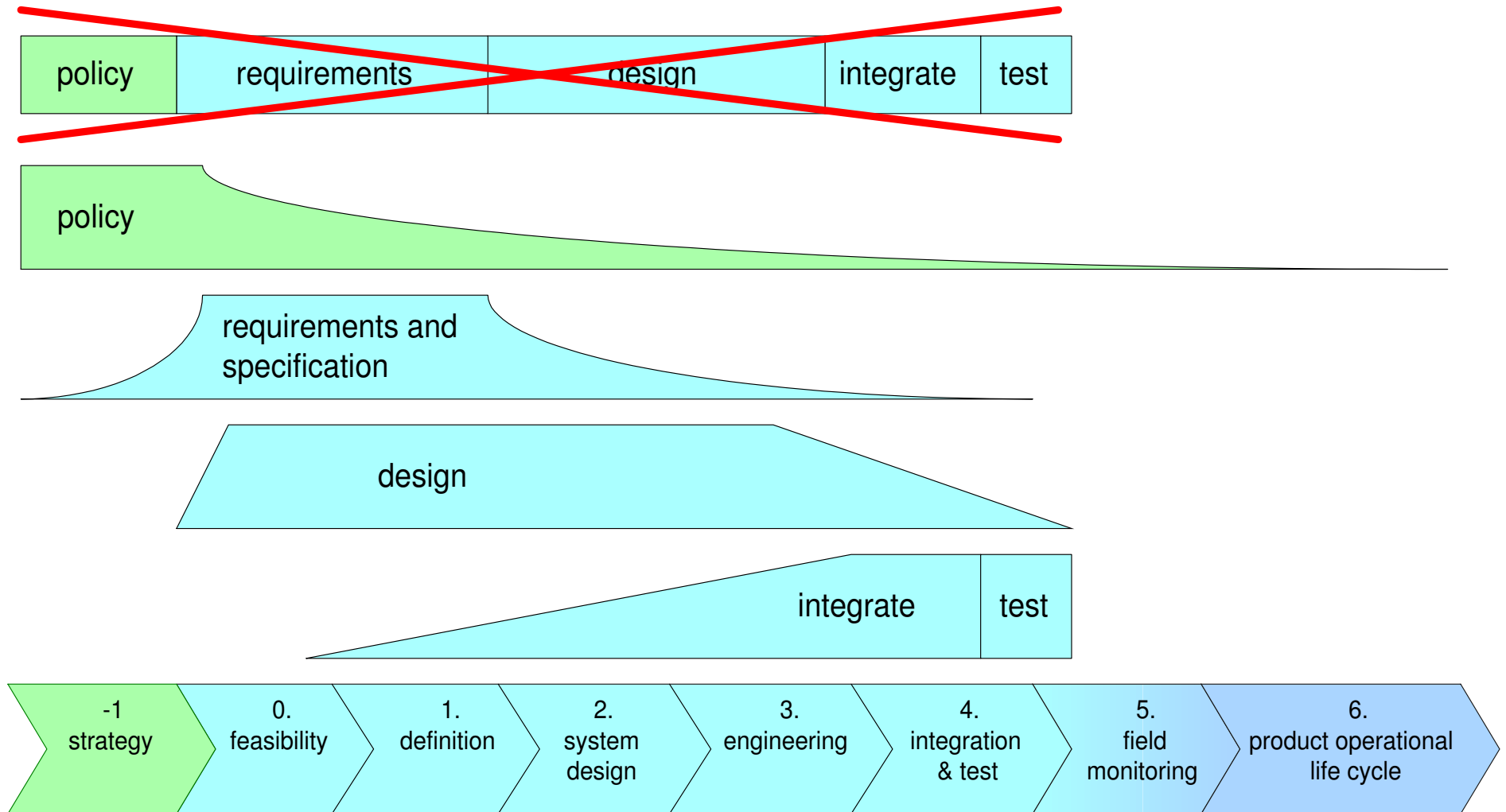
expose

*process wafer
measure overlay*

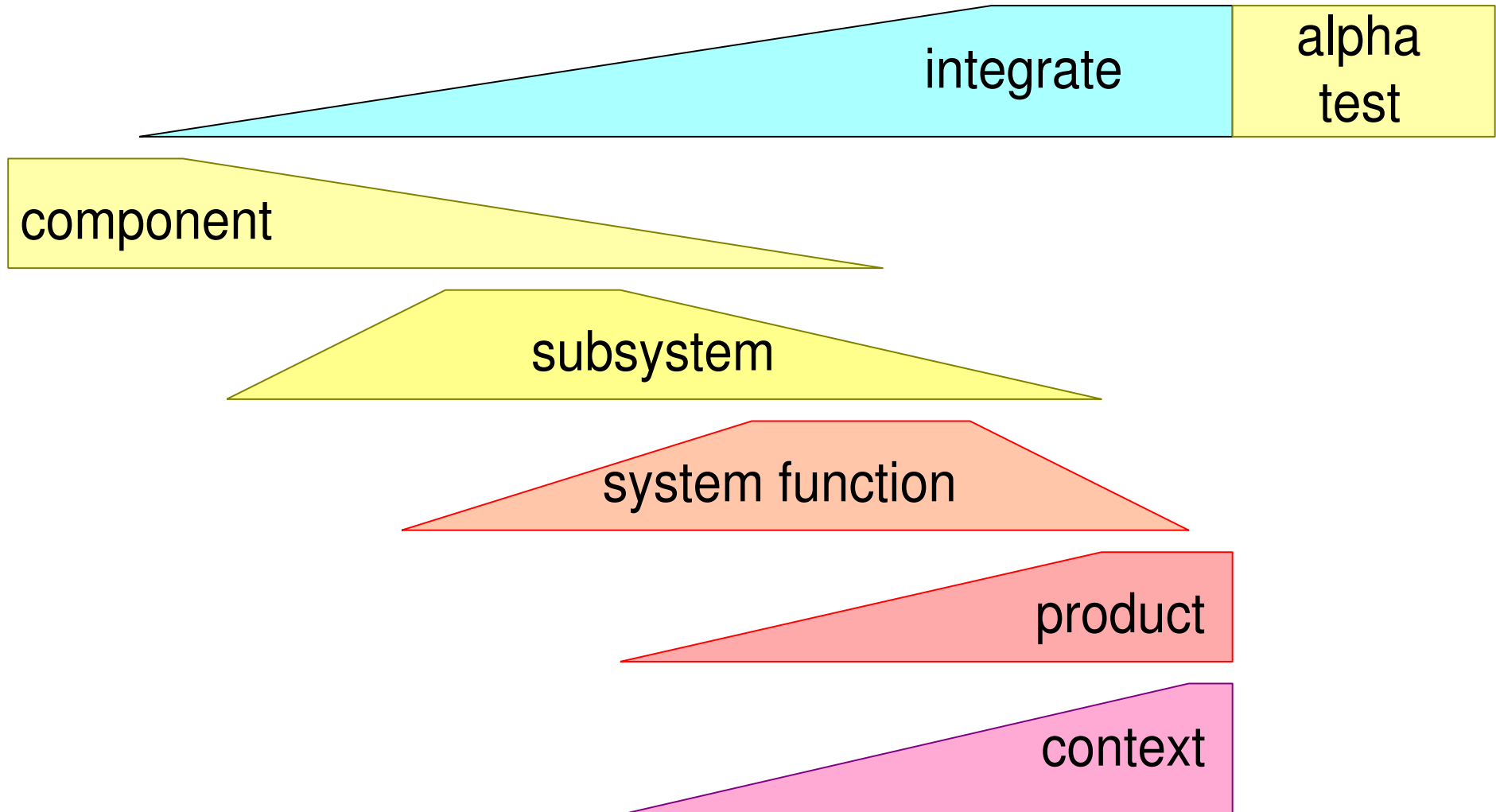
blood, sweat, and tears
trouble shooting
and learning



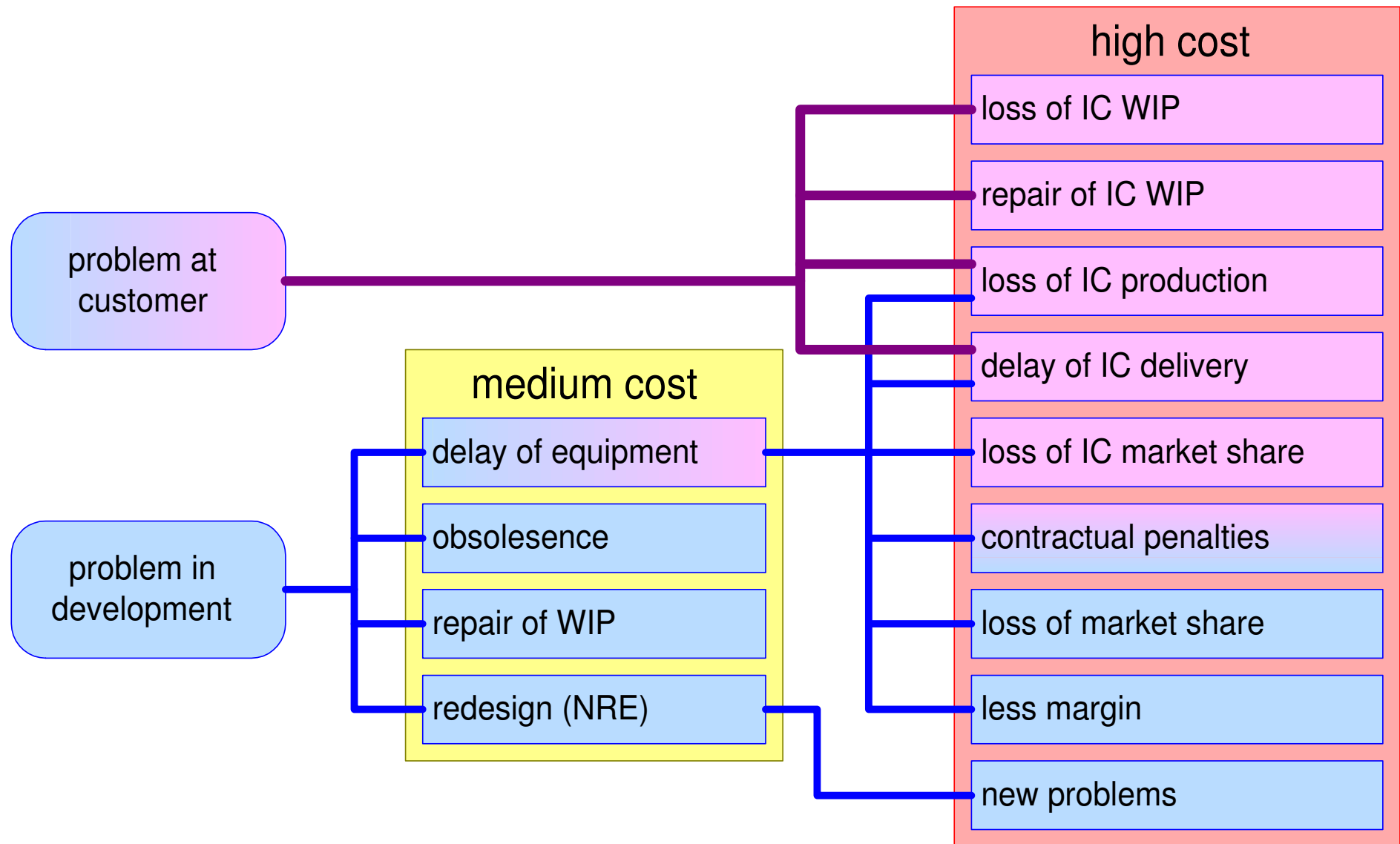
Typical Concurrent Product Creation Process



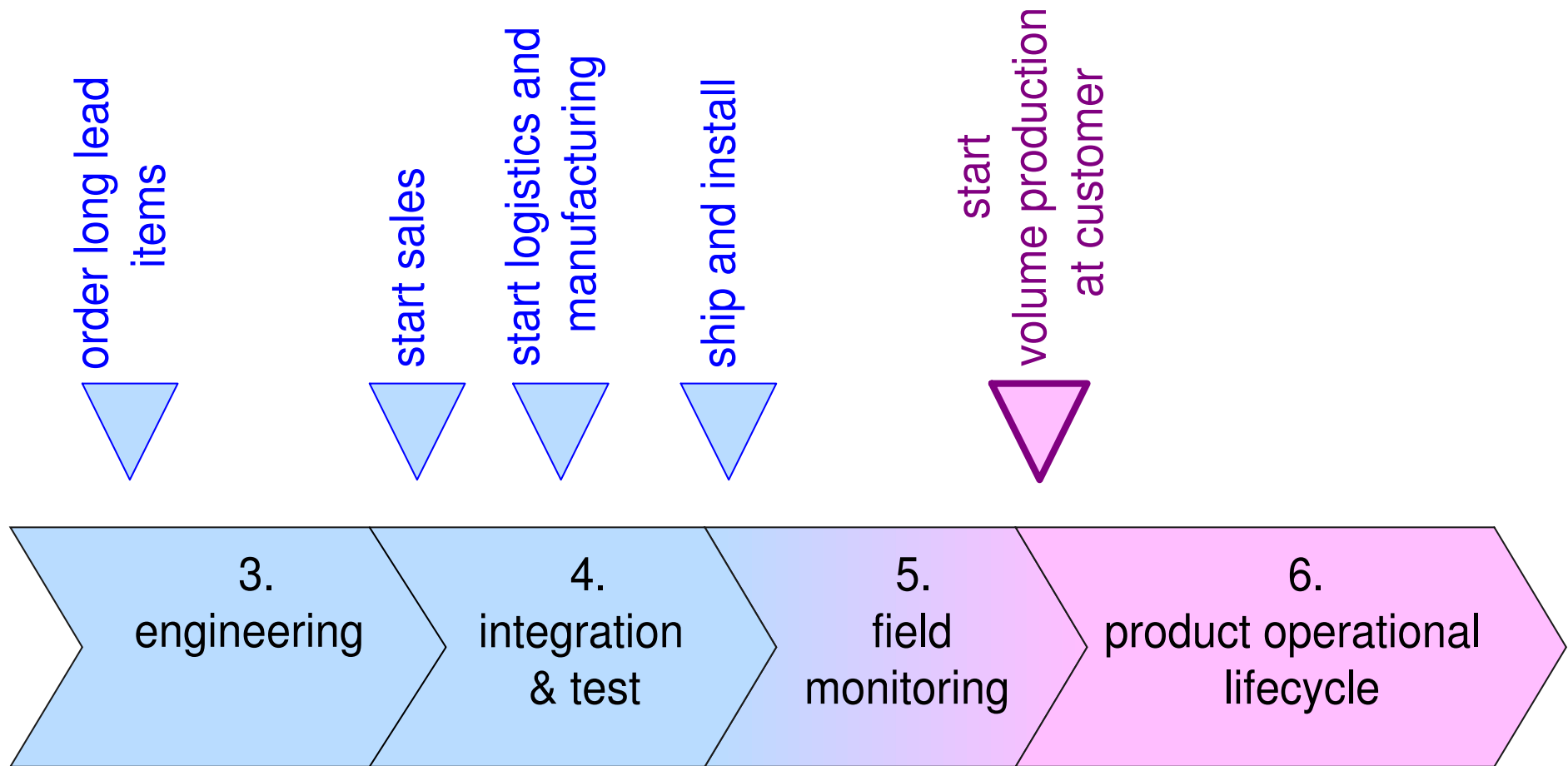
Integration Takes Place in a Bottom-up Fashion

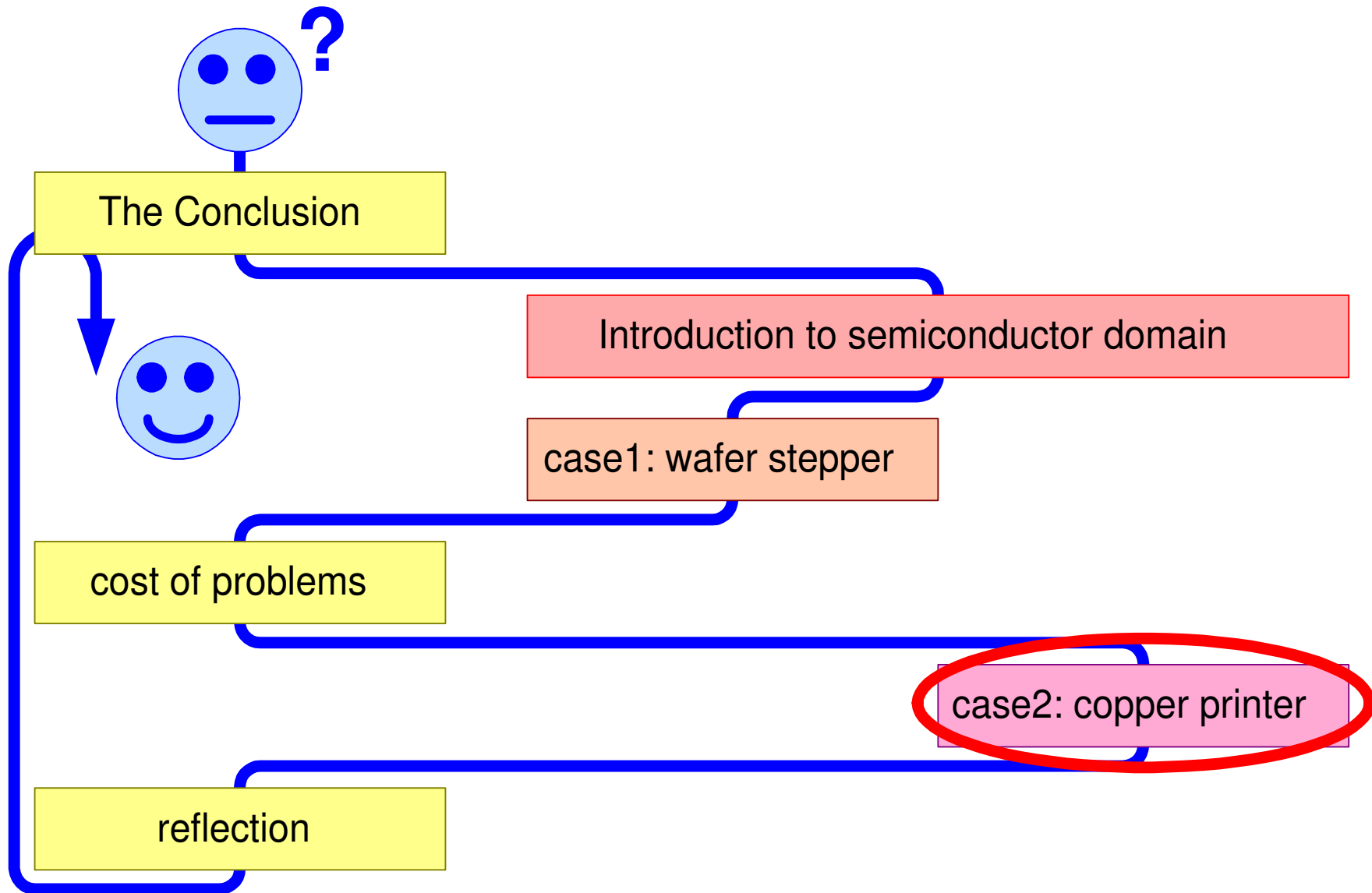


Costs of Encountered Problems

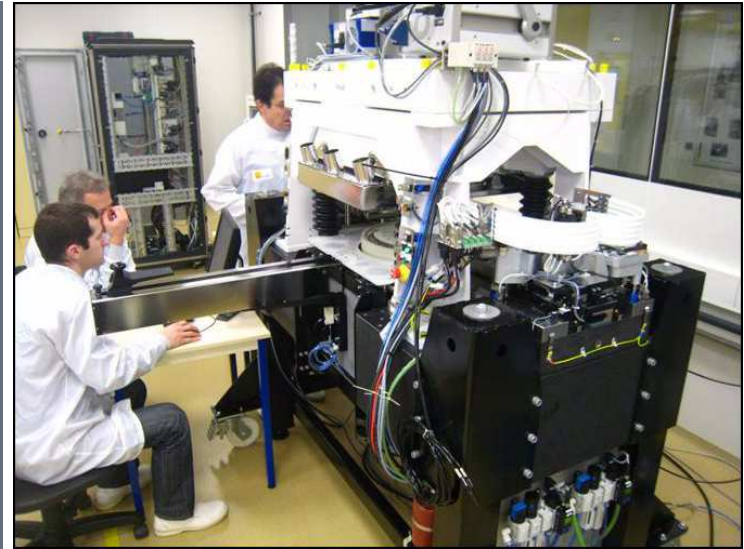
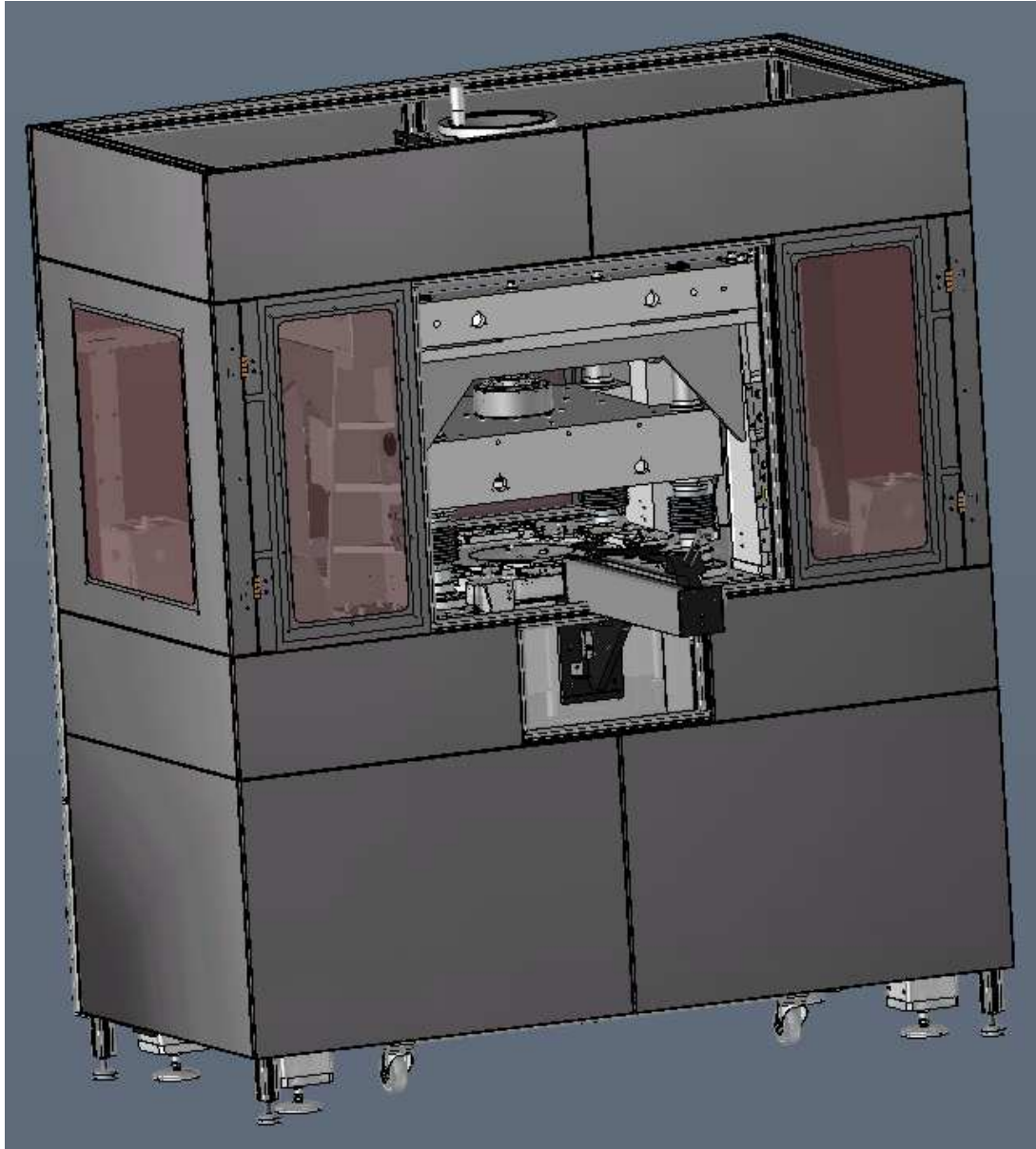


Cost Related Milestones

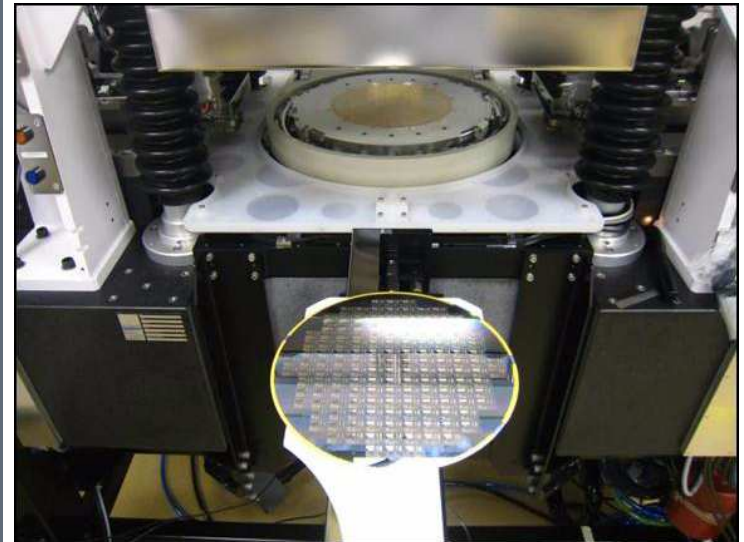




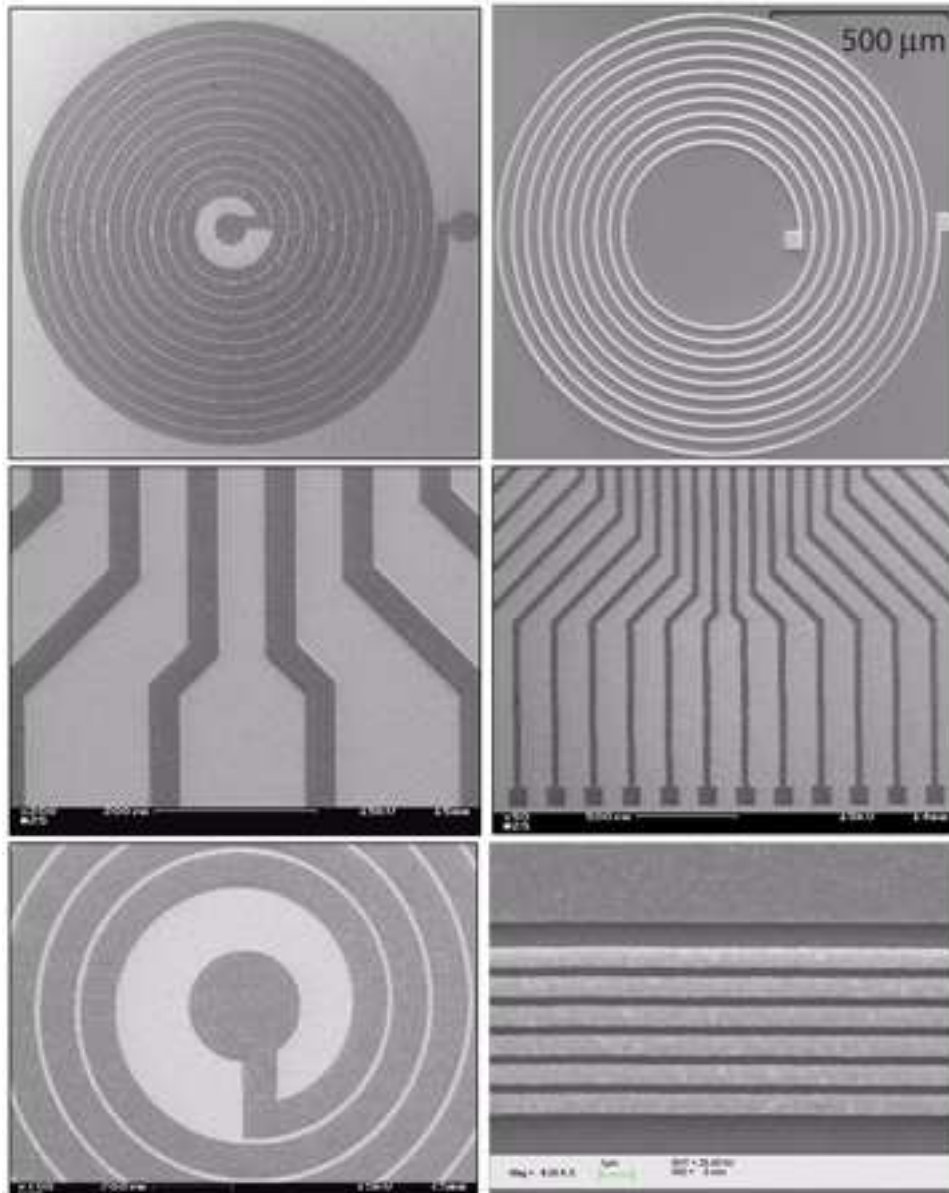
Case 2 Replisaurus Copper Printer



courtesy Replisaurus
www.replisaurus.com



Example of printed copper structures

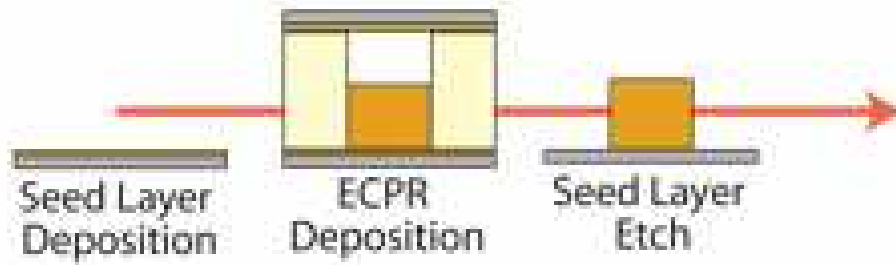


courtesy Replisaurus
www.replisaurus.com

ECPR technology replaces 6 process steps by 1 step

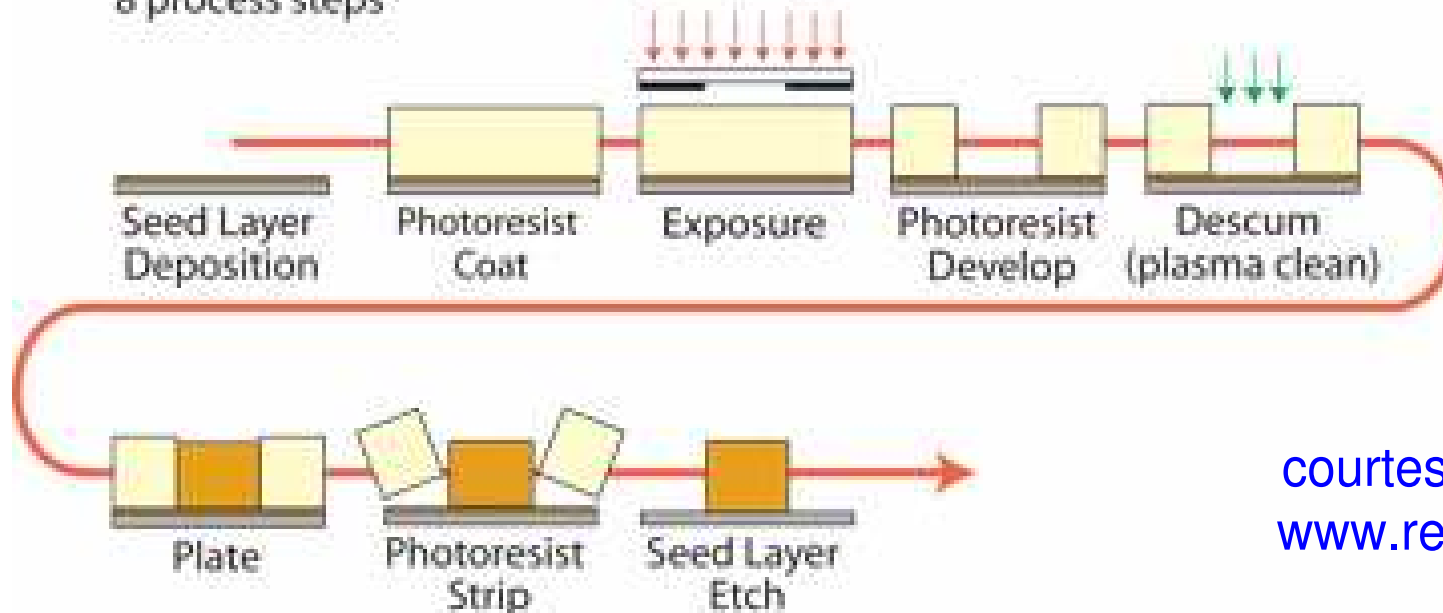
ECPR - ElectroChemical Pattern Replication

3 process steps



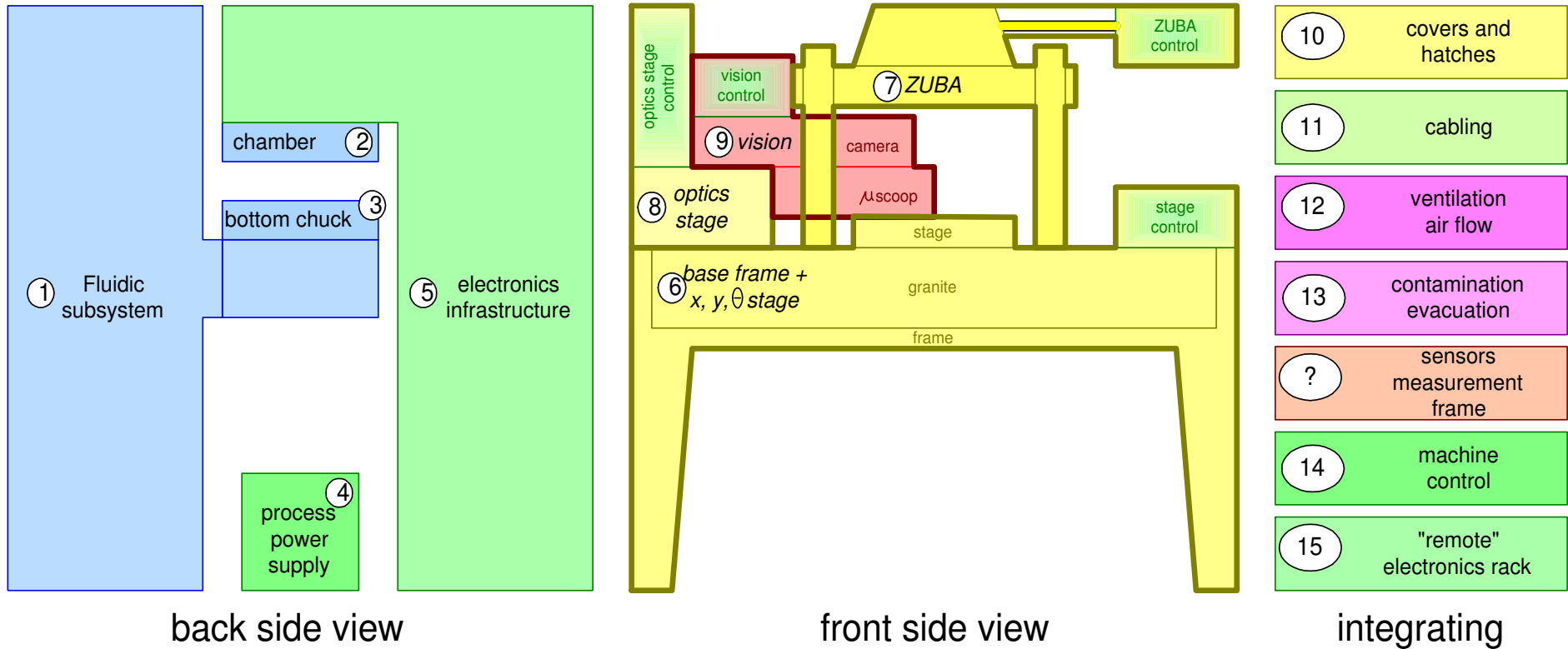
Conventional lithography based metallization

8 process steps

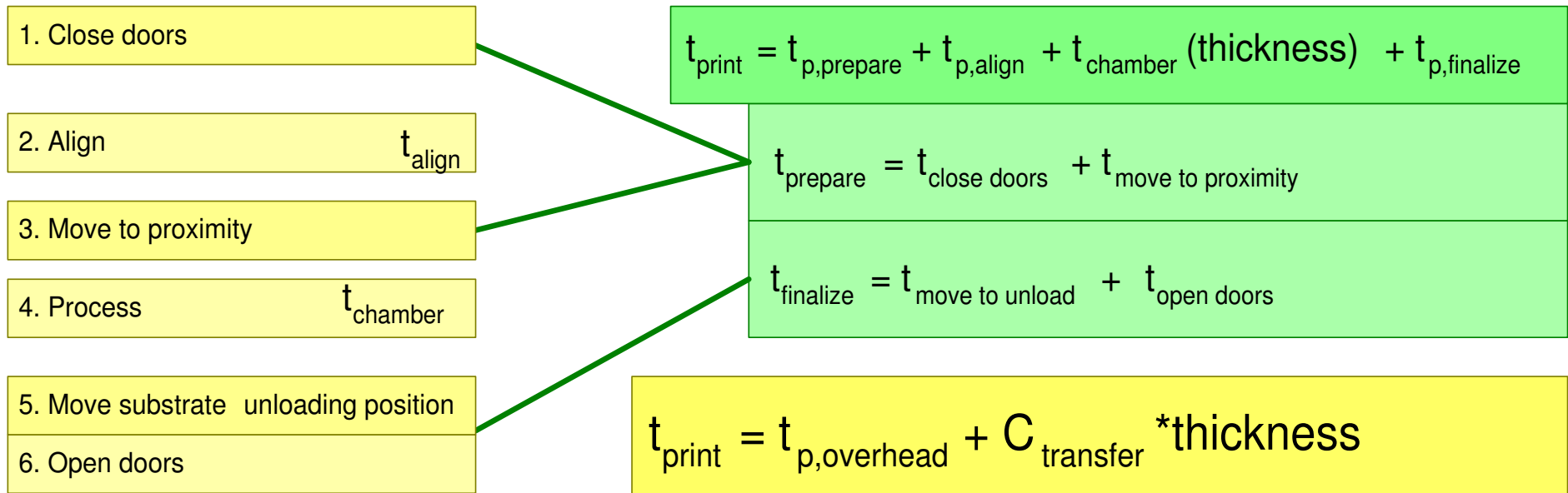


courtesy Replisaurus
www.replisaurus.com

Decomposition in sub systems



Ca. 2 days per quarter used for simple models



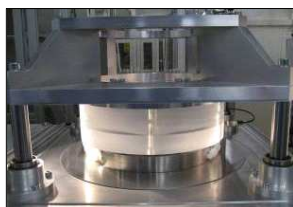
*note: original diagram was annotated with actual performance figures
for confidentiality reasons these numbers have been removed*

Continuous Modeling and Learning

200mm ECPR tools

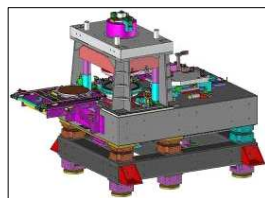
300mm ECPR tools . Can be configured with 200 or 300mm kits.

2006
R&D 1.0



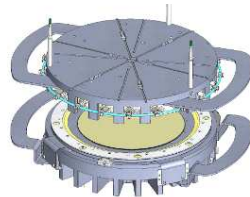
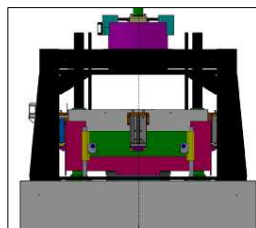
200mm hydraulic non aligned tool for chamber & process development

2007
REX 1.0



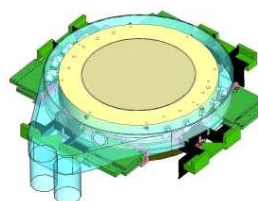
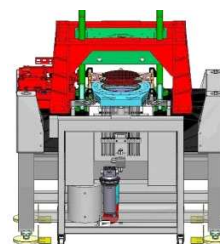
First aligned ECPR dev. tool. 200/300mm compatible.

2008
R&D 2.0



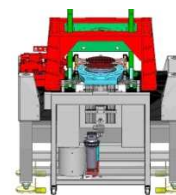
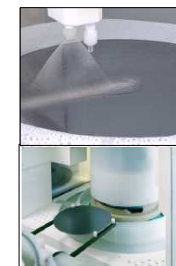
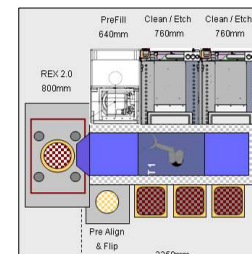
Integrated ECPR control. Non aligned, Footprint, confinement

2009
REX 2.0



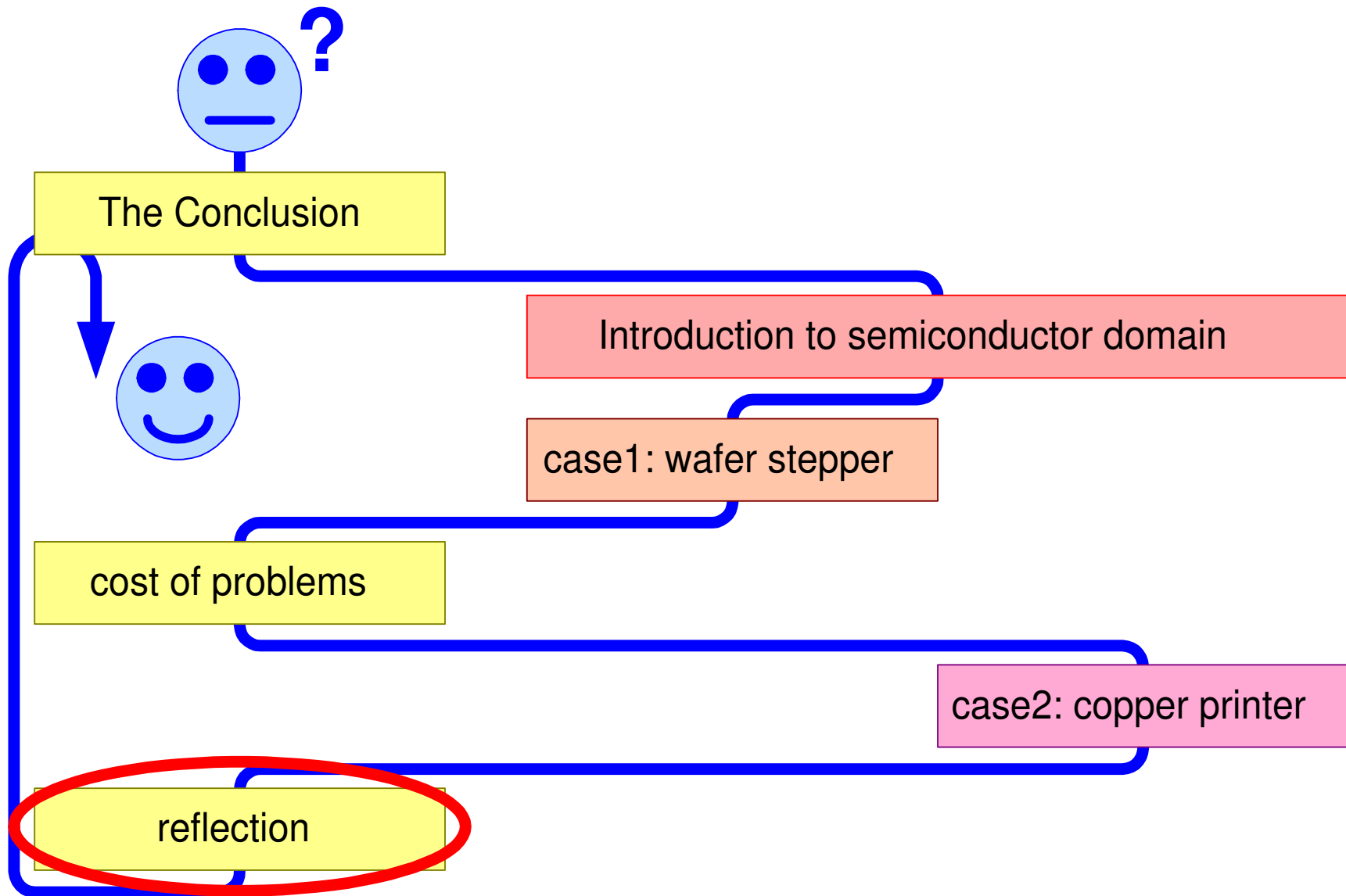
Production oriented print module. Cycle time, overlay, confinement & footprint focus.

2010
Alpha 1.0



First integrated tool prefill - clean - print - seed etch.

courtesy Replisaurus



What We Teach:

functional decomposition

physical decomposition

modularity

interface management

seperation of concerns

low coupling between components/functions

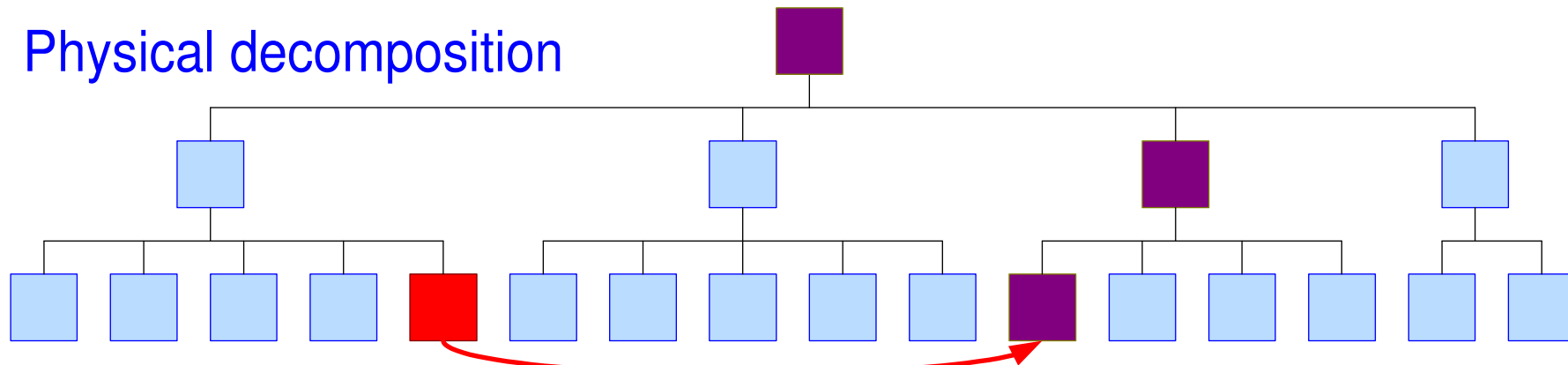
high cohesion within components/functions

SMART (Specific, Measurable, ...)



traceability

Root Cause is Often Elsewhere

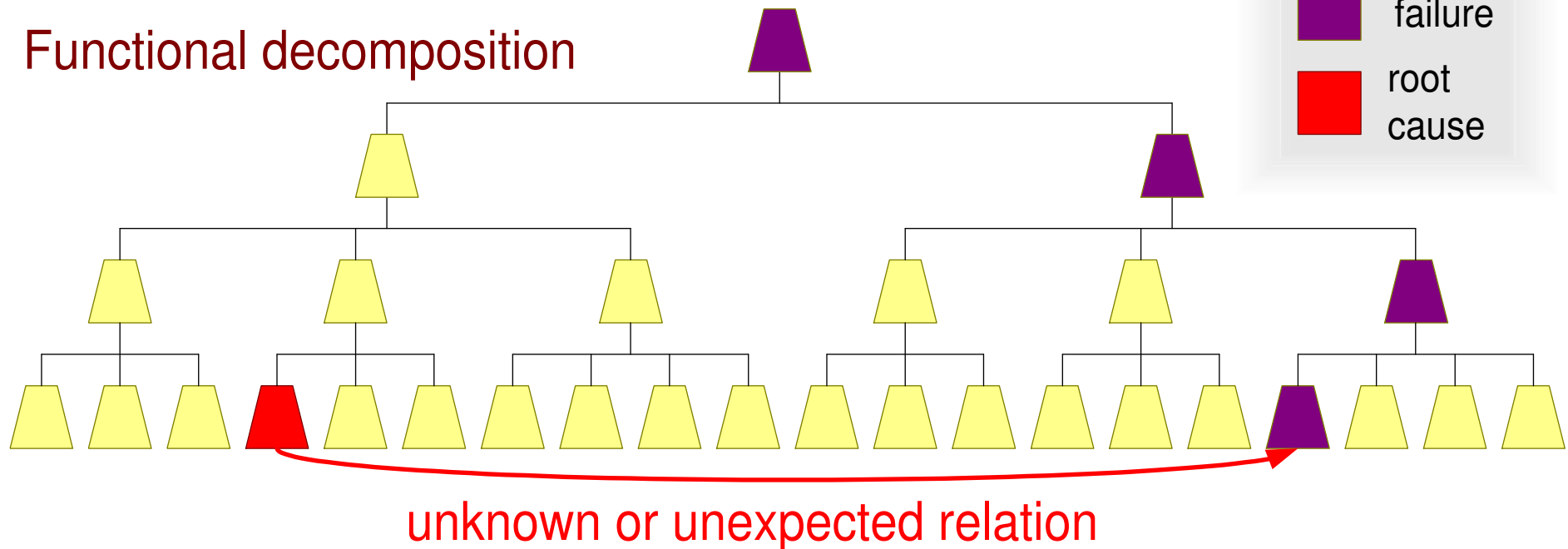
Physical decomposition



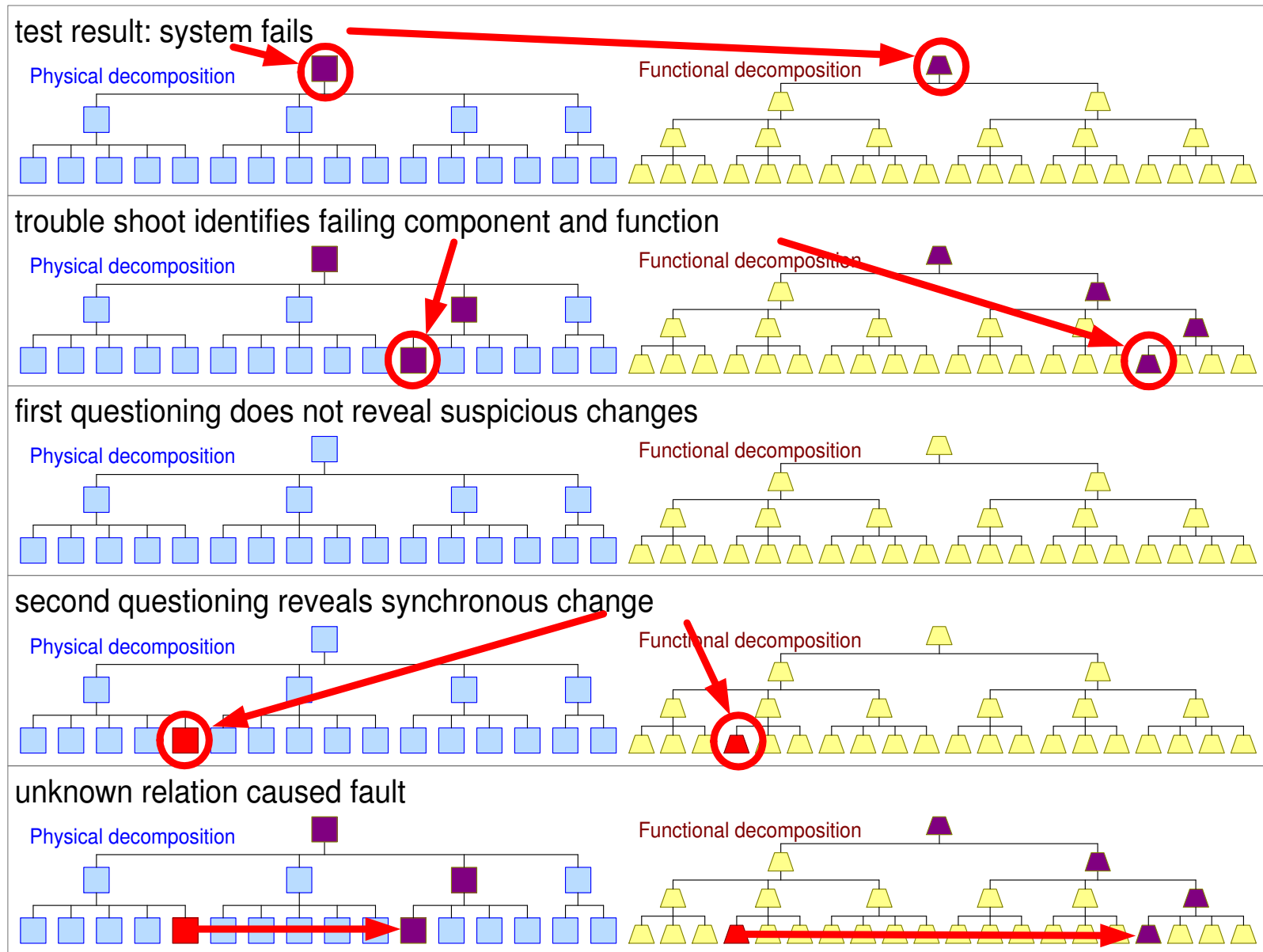
legend

-  failure
-  root cause

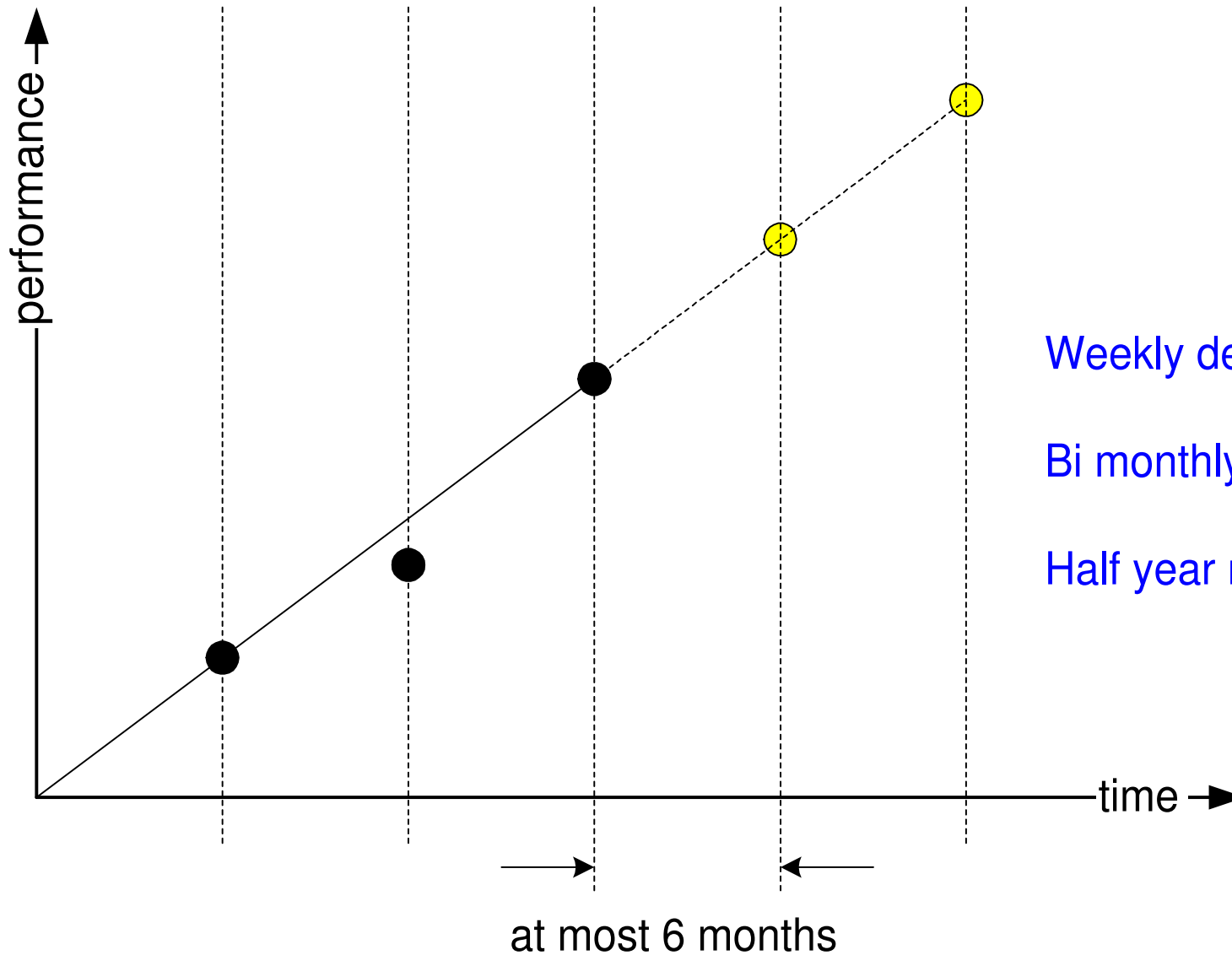
Functional decomposition



“Nothing has been changed...”



Monitoring Performance Targets

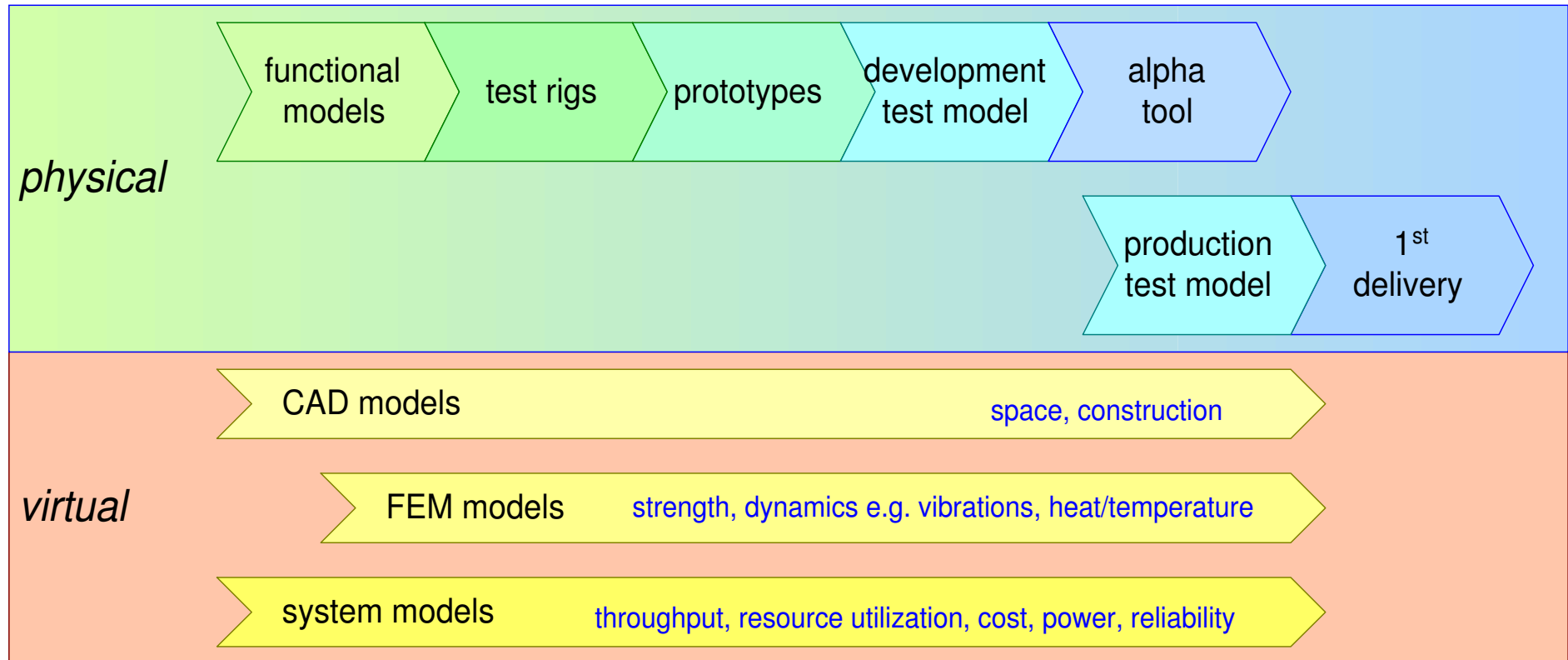


Weekly design meetings

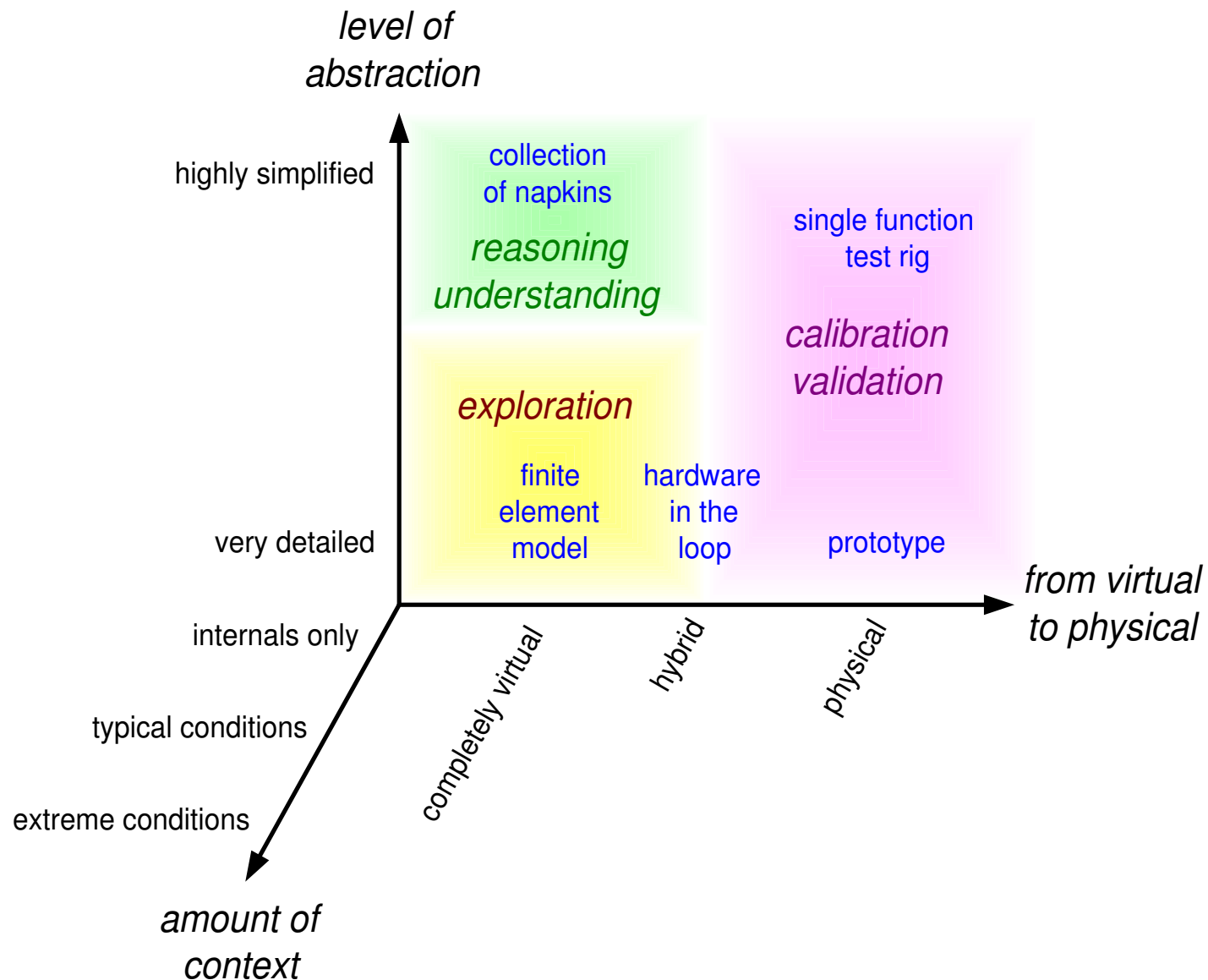
Bi monthly design reviews

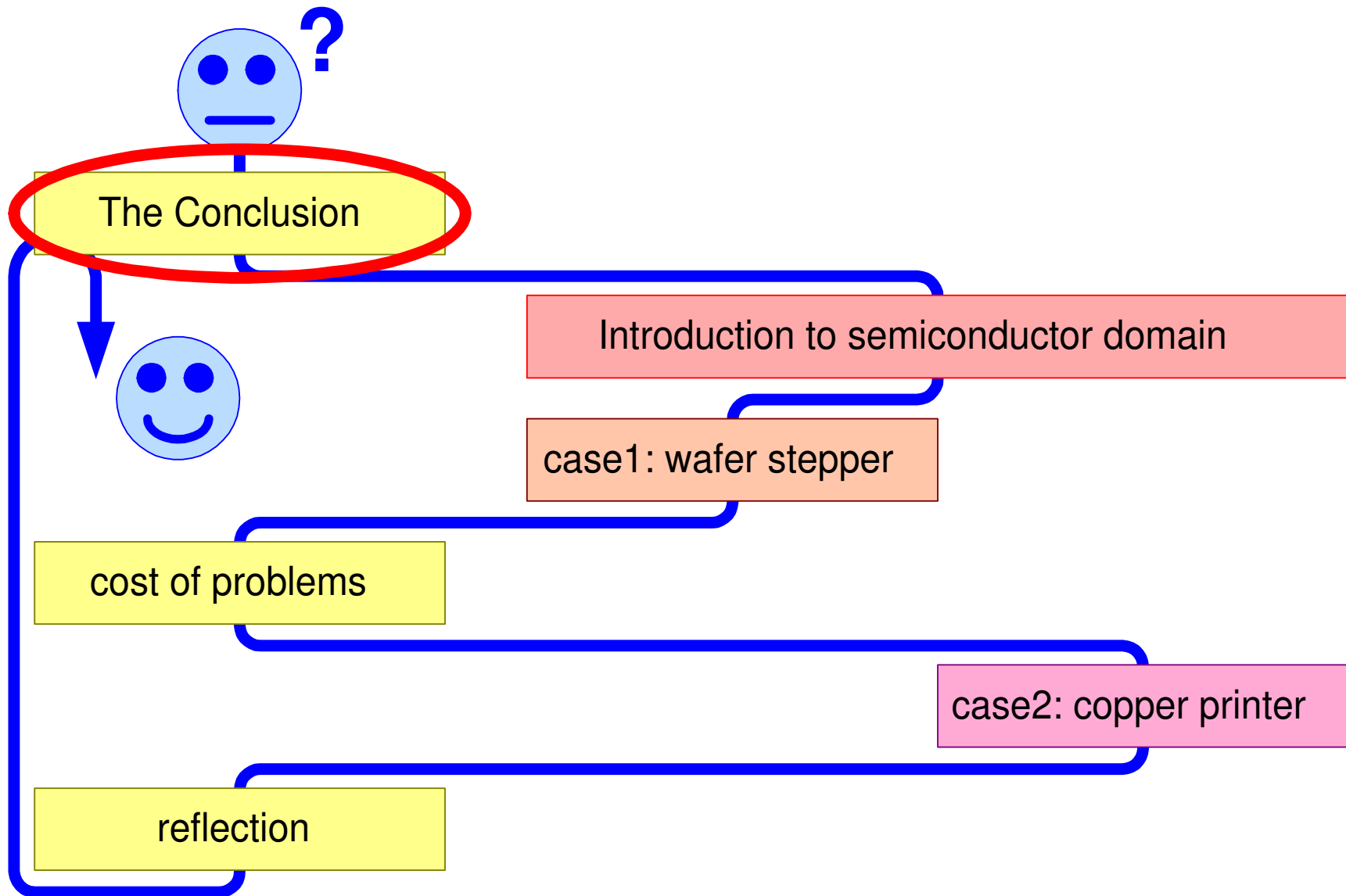
Half year milestones

Phasing of Models



Modeling Space





Conclusion from Semiconductor Cases

semiconductor domain conclusions

performance increase in semiconductor equipment is amazing

"bleeding edge": unforeseen, unknown, uncertain = normal

failing late = very costly

failing early = learning very fast

lessons for other domains

other domains with increasing innovation rate (decreasing time-to-market) will get more unforeseen, unknown, uncertain issues

failing early is always better than failing late

Early ***investments*** in

test rigs, prototypes, virtual models, and simulations

save a lot of money