The Informal Nature of Systems Engineering

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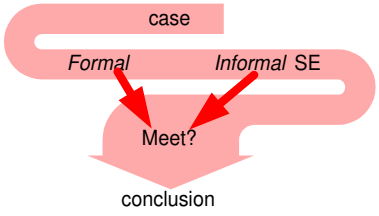
Abstract

The Systems Engineering (SE) discipline is an integrating discipline. SE integrates and guides mono-disciplines, such as mechanical engineering, electrical engineering, and software engineering, to create reliable systems. The SE discipline comprehends multiple approaches:

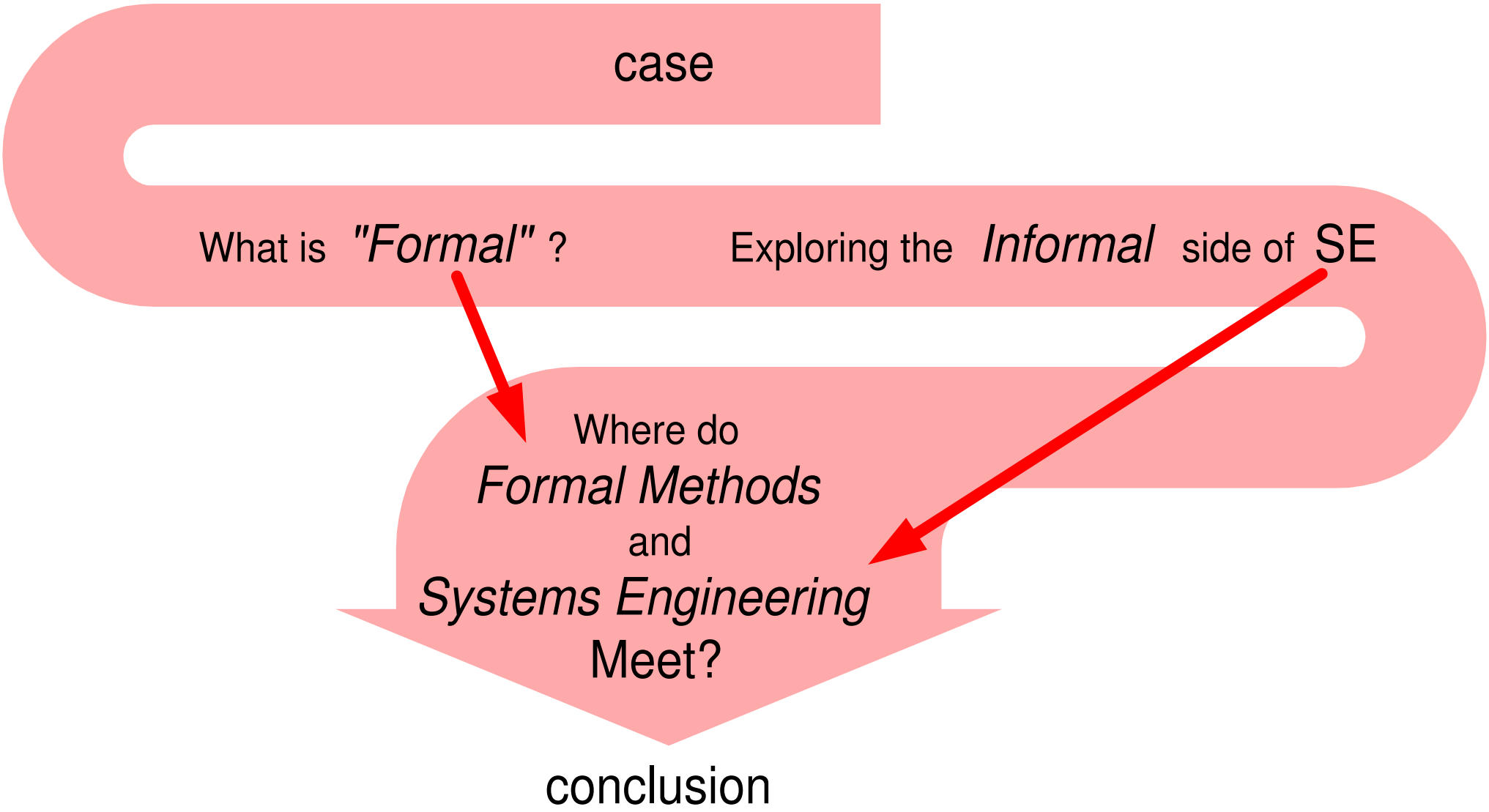
- well defined formalized SE methods
- strong process focused
- “common sense”, based on human experience and intelligence

A balance of these three approaches yields successful products. In this document we will discuss this balance and especially the, often underrated, informal side of SE.

September 9, 2018
status: planned
version: 0



Presentation Outline



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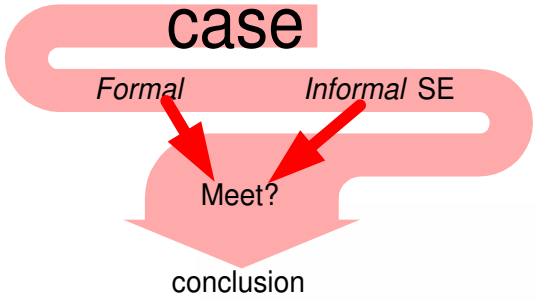
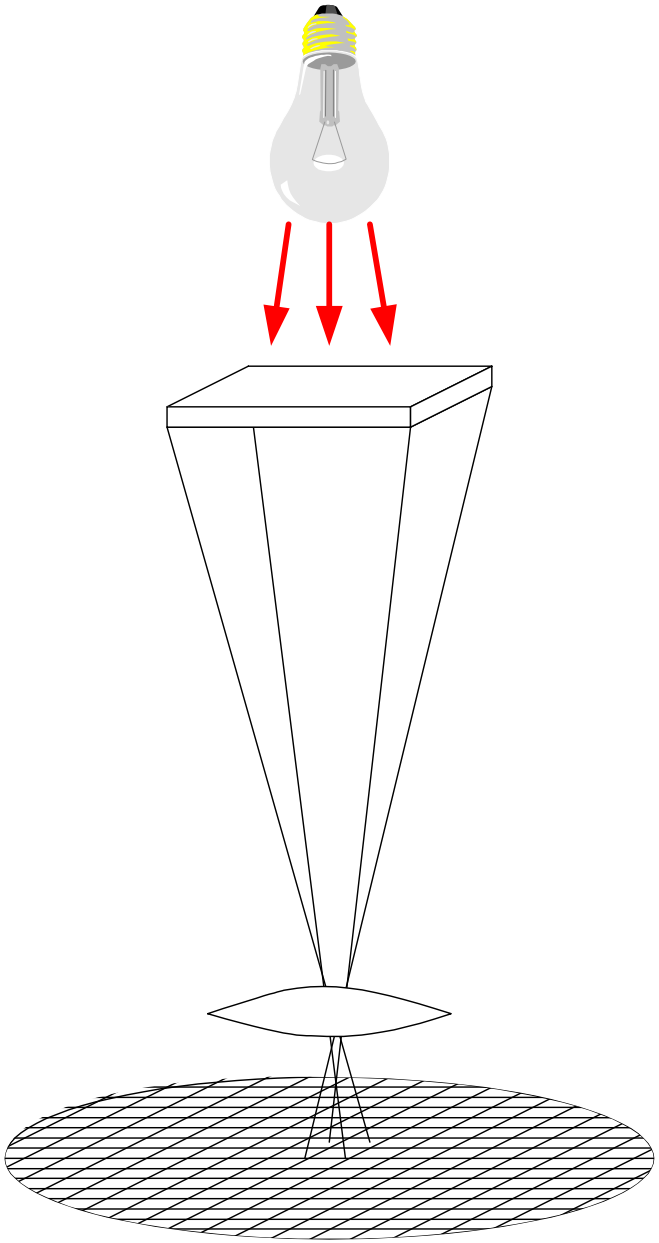


What is a waferstepper



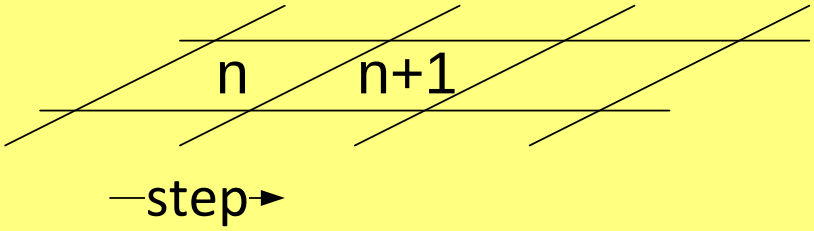
source

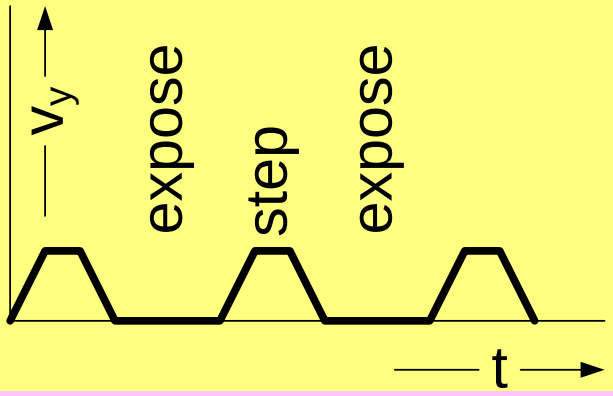
reticle

lens

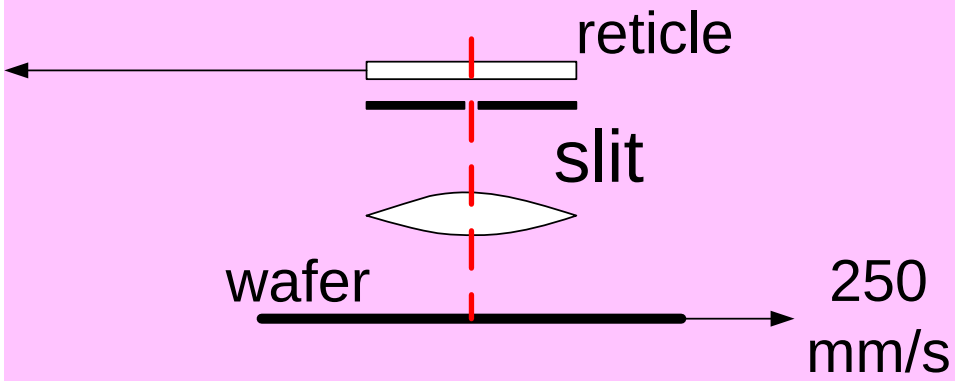
wafer

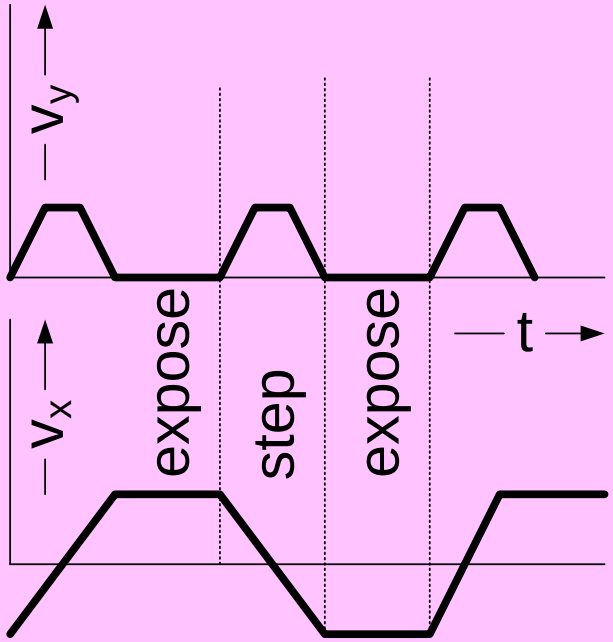
From stepping to scanning





stepper: *static exposure of field*

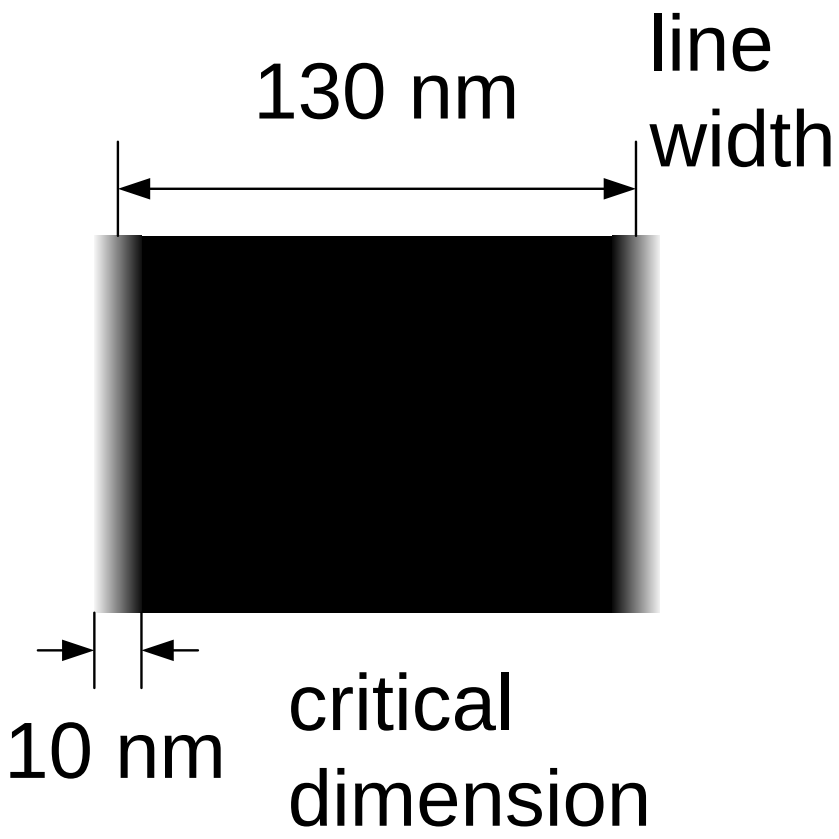




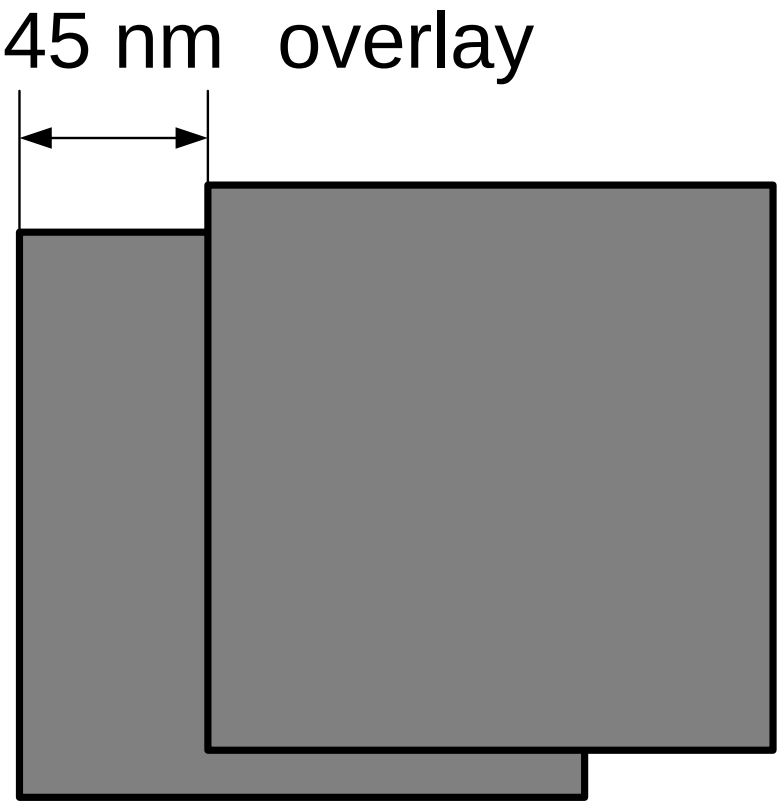
scanner: *dynamic exposure through slit*

Key specifications waferstepper

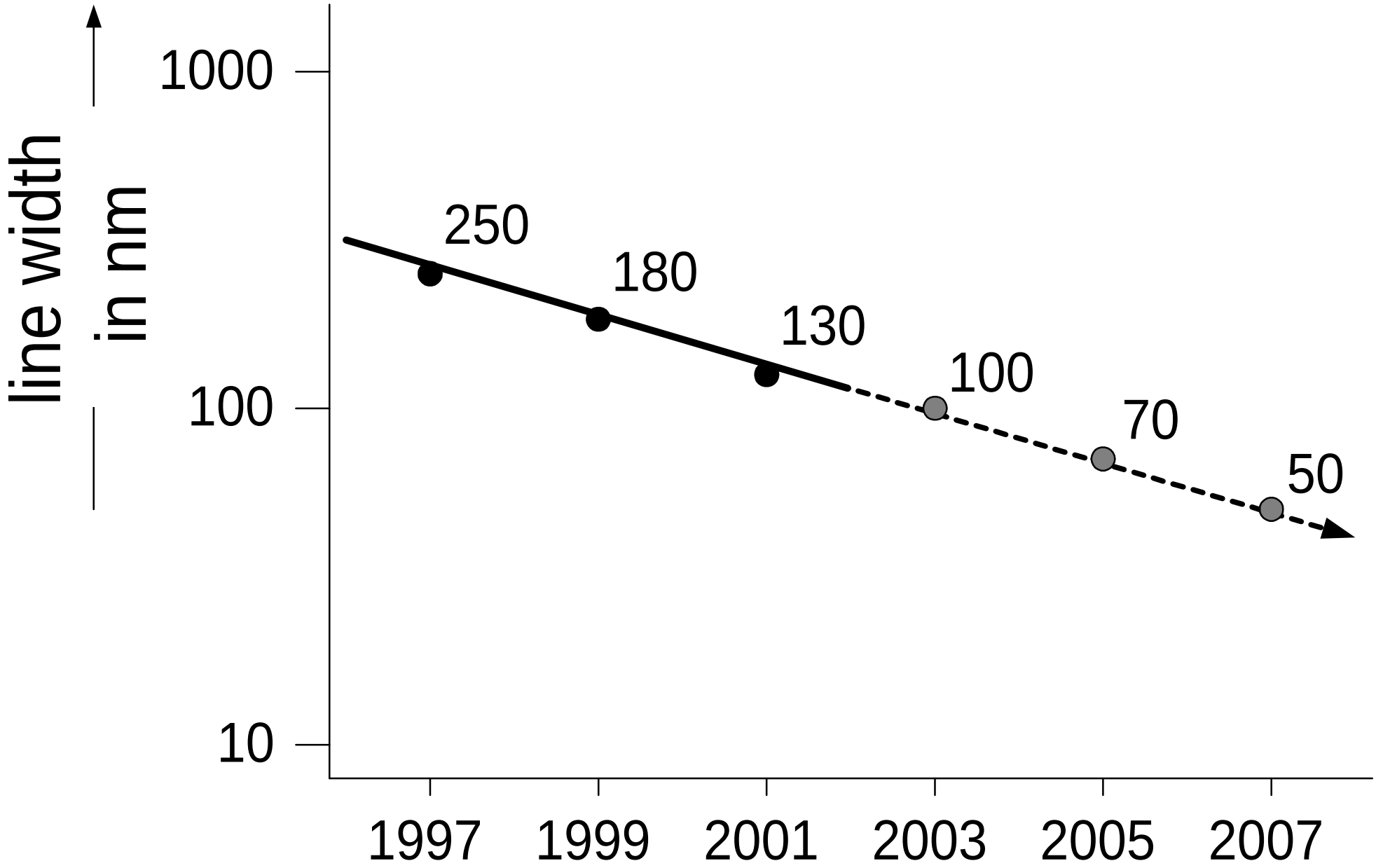
imaging



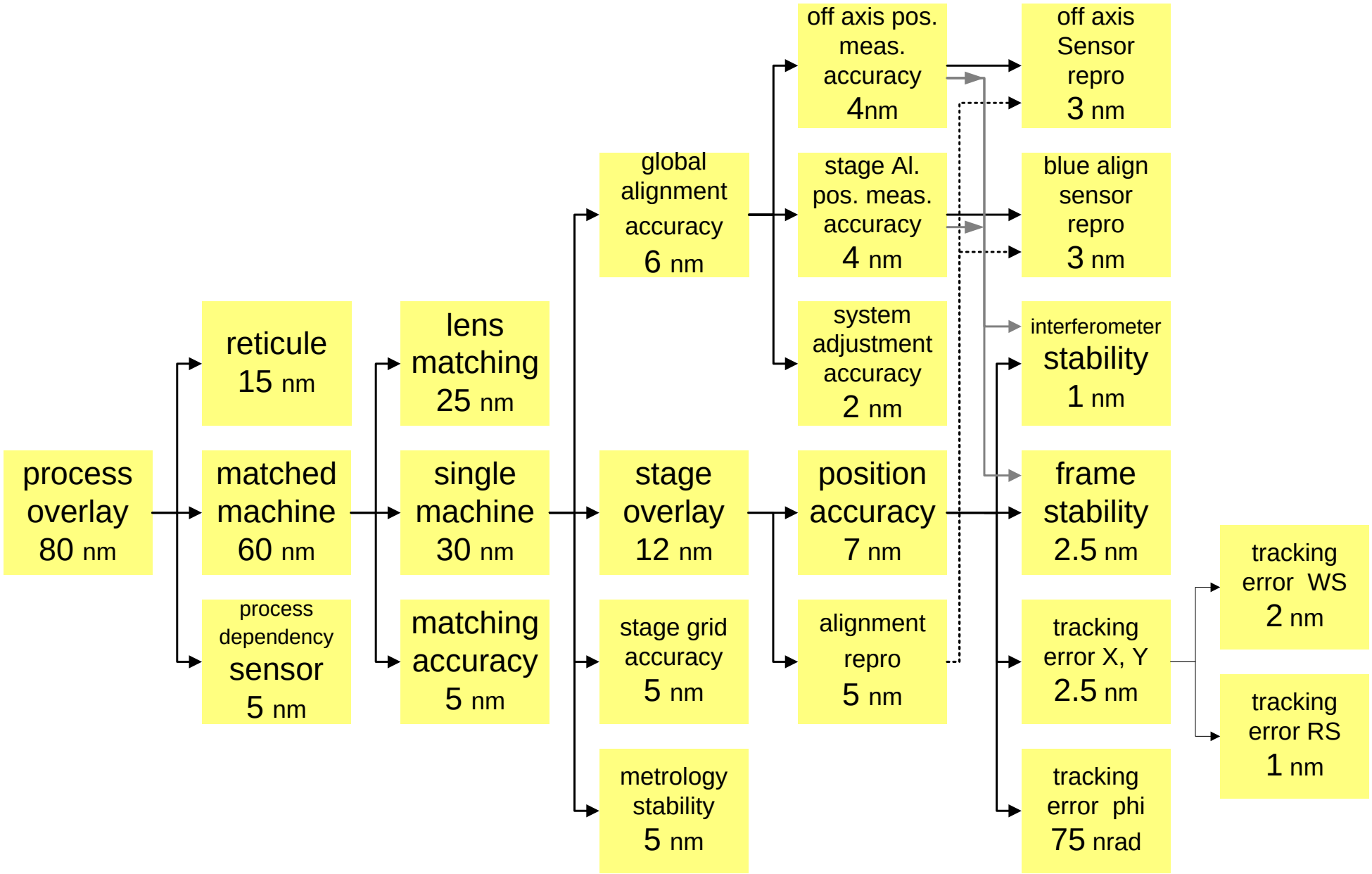
alignment



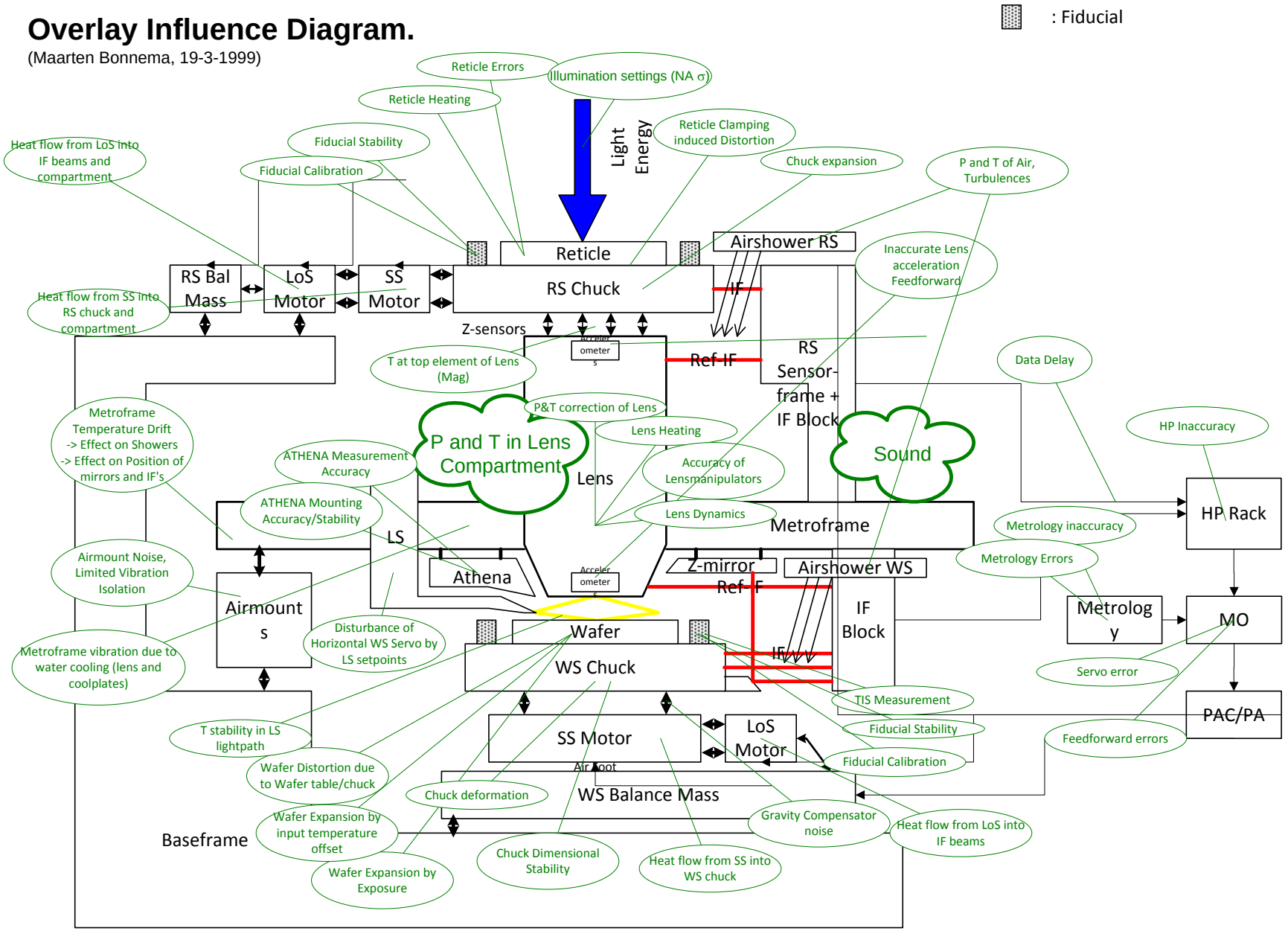
Moore's law


line width
in nm
1000
100
10
250
180
130
100
70
50
1997
1999
2001
2003
2005
2007

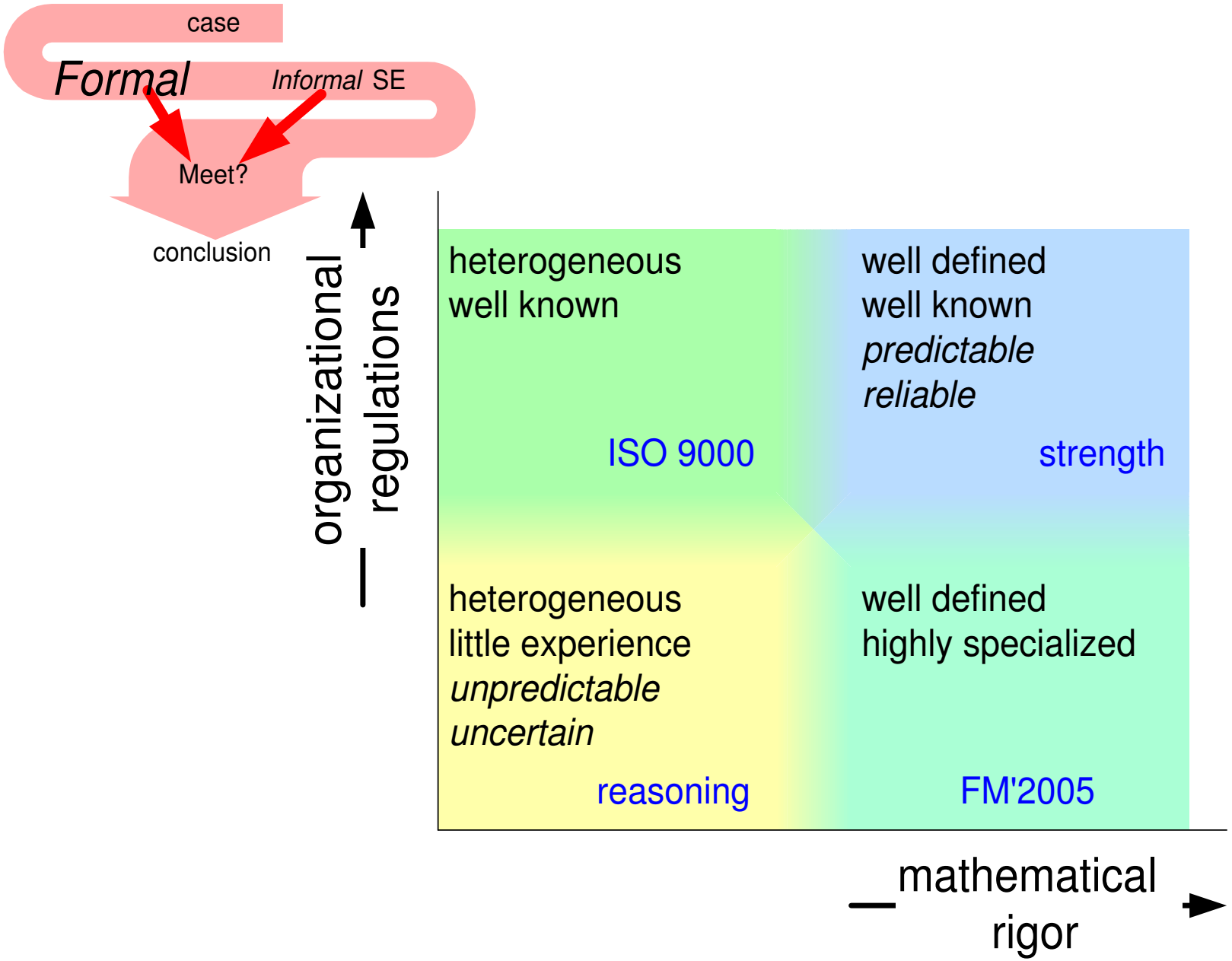
Overlay budget (1999)



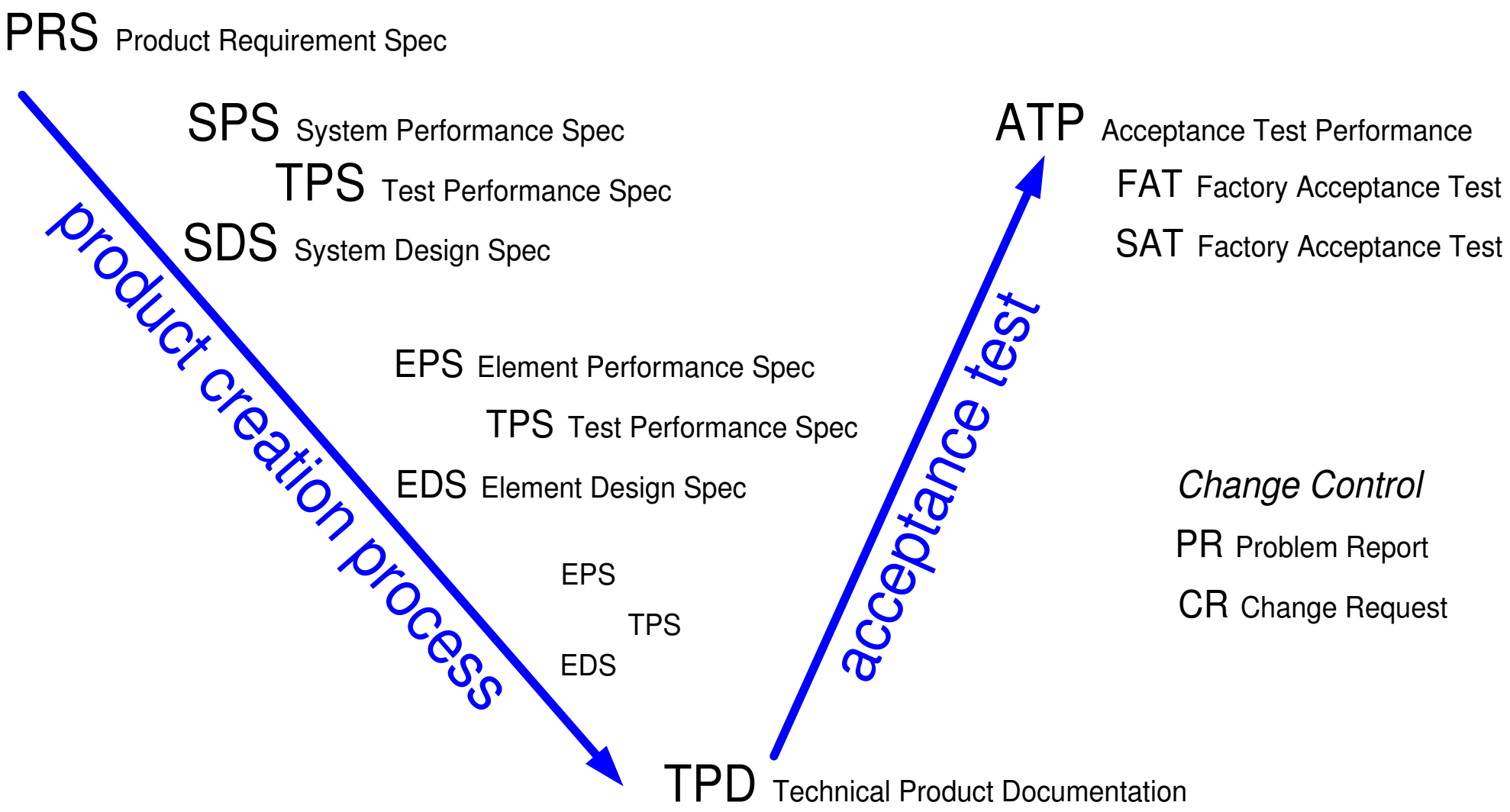
Everything influences overlay



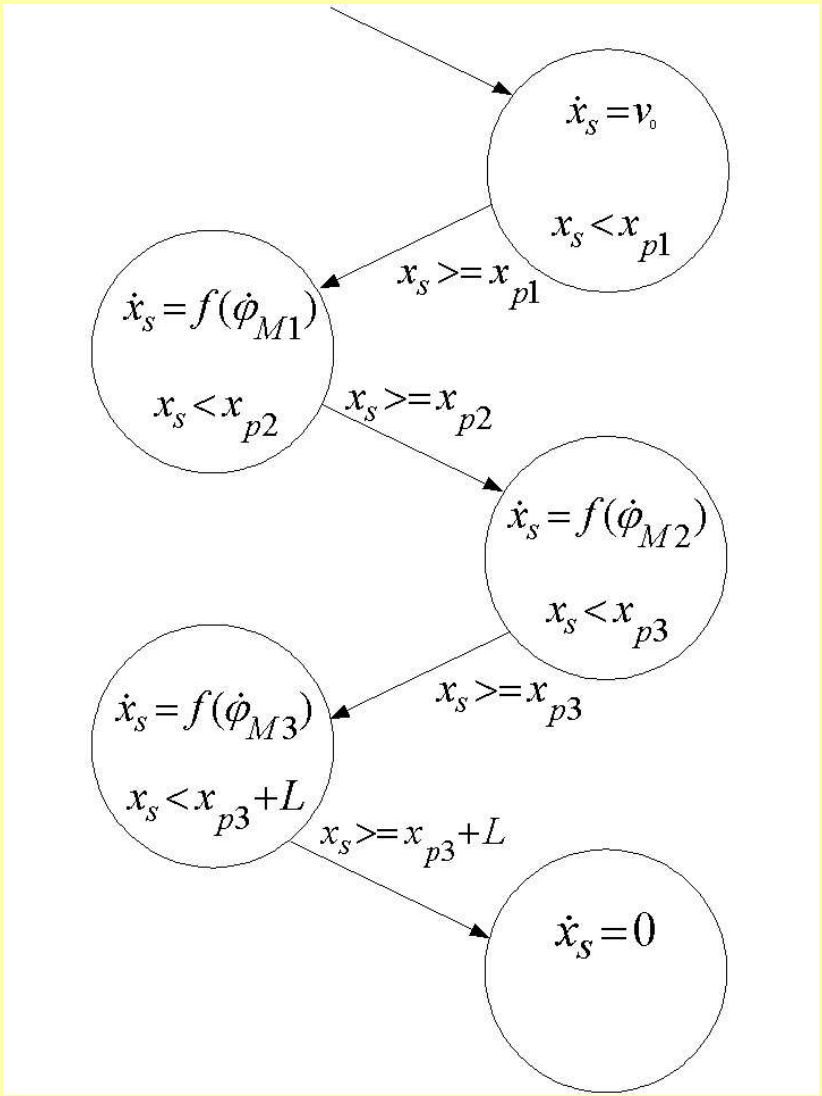
What is Formal?



Process: Formal Documents



Formal in Mathematical sense



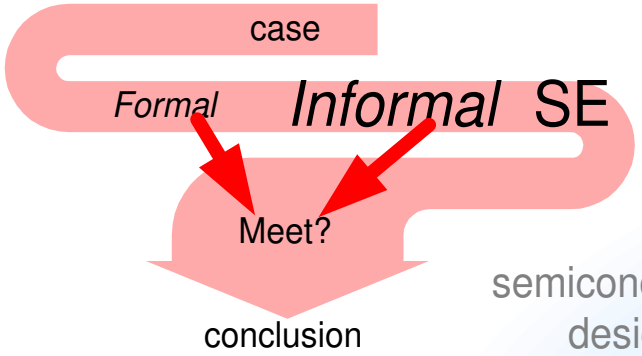
example Hybrid Automata

$$\dot{x}_s(t) = \begin{cases} v_0 & \text{if} \quad x_s < x_{P1} \\ A_1 x_s(t) + B_1 u(t) & \text{if} \quad x_s \geq x_{P1} \wedge x_s < x_{P2} \\ A_2 x_s(t) + B_2 u(t) & \text{if} \quad x_s \geq x_{P2} \wedge x_s < x_{P3} \\ A_3 x_s(t) + B_3 u(t) & \text{if} \quad x_s \geq x_{P3} \wedge x_s < x_{P3} + L \\ 0 & \text{if} \quad x_s \geq x_{P3} + L \end{cases}$$

example PieceWise Linear Systems

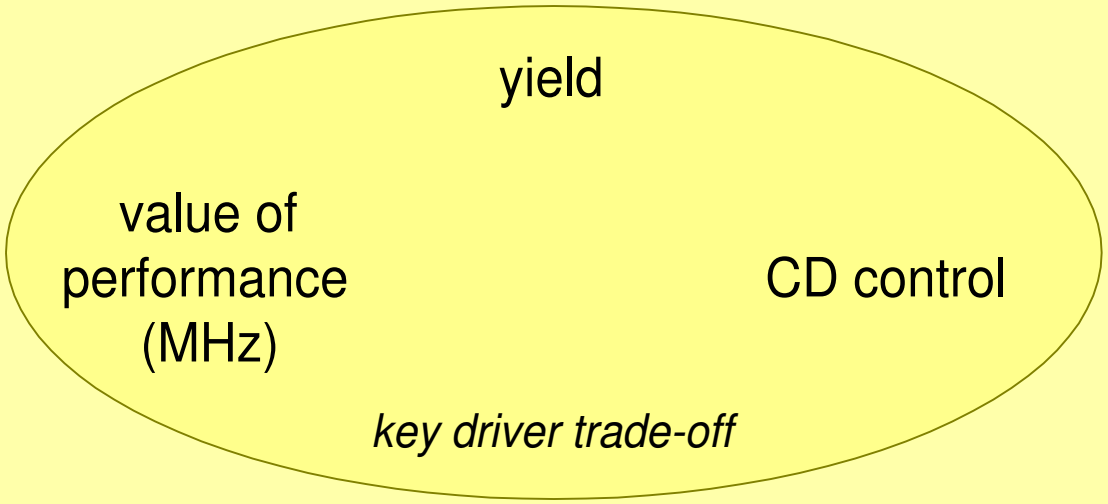
Examples of *Hybrid Modeling Formalisms*
Björn Bukkems and Marieke Cloosterman
Boderc Symposium 2005

Fab Context of Waferstepper



resists
devices
fab logistics
semiconductor design
fab automation
SPC
processing
tracks
wafer
reticule production
metrology
yield optimization
reticules
waferstepper
reticule logistics
matching
wafer logistics
operator
fab layout
maintenance
contamination
inspection and monitoring
utilization
fab cost model
fab infrastructure

Business Context



other players:
- equipments vendors
- system integrators
- lease companies
- fab designers
- consultants
- mask makers
- resist makers
- wafer makers
- OEM's: laser
- intimate partners: lens

business models of the customer:
- design houses
- foundries
- vertical integration

Limited number of customers;
Many systems per customer

Human Context: Stakeholders

"external"

customer
purchaser
decision maker
user
operator
maintainer

other
government
customer's customer
banks, insurance

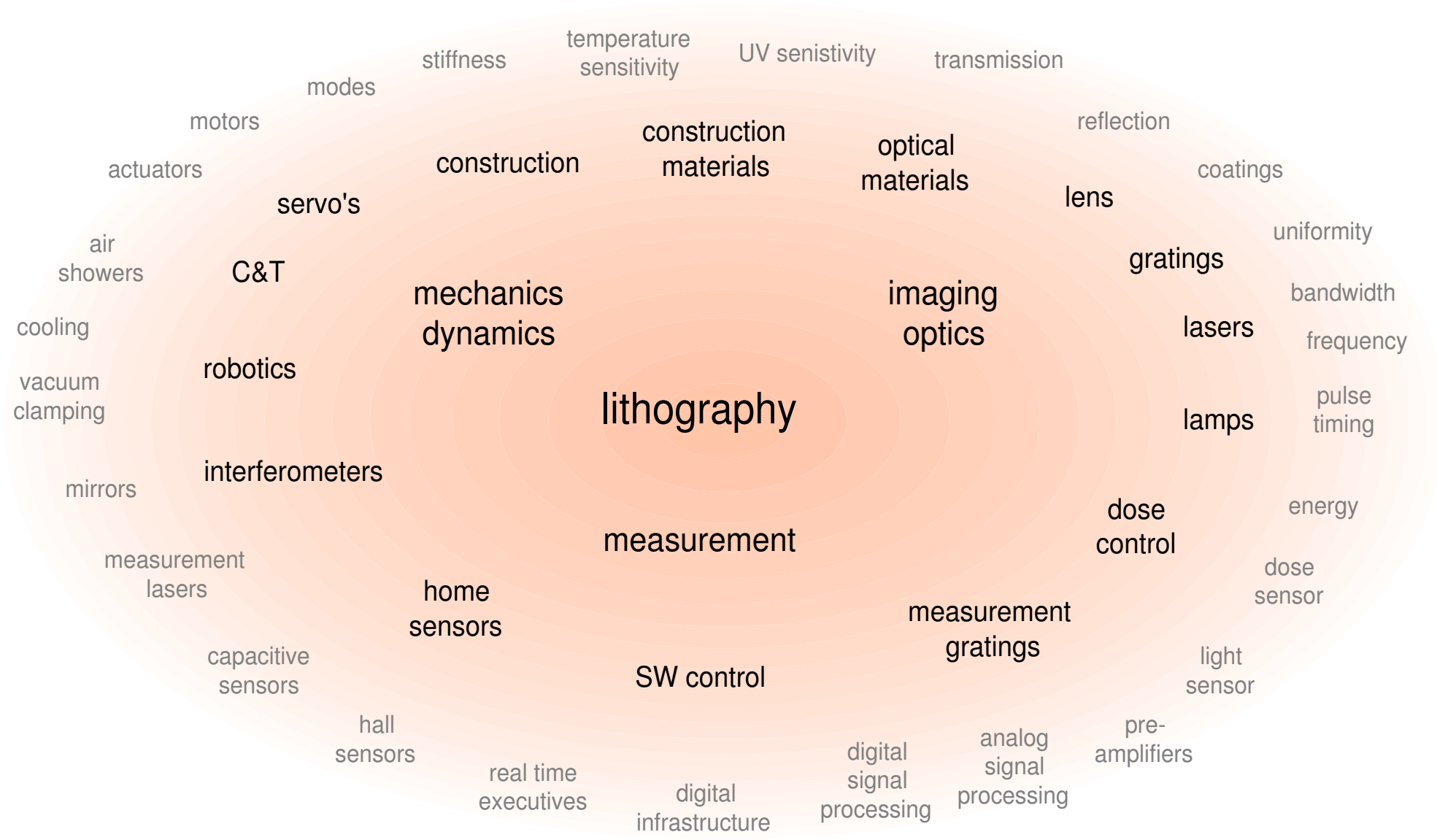
"internal"

managers
business manager
marketing manager
product manager
operational manager
project leader
sales manager
quality manager
logistics manager
line manager
technology manager

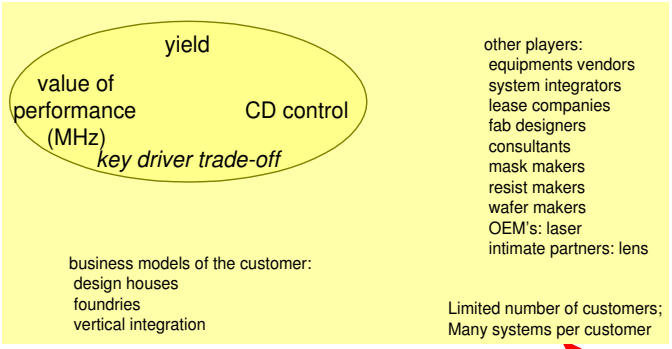
engineers
system engineers
experts
manufacturing engineers
customer support

suppliers
component manufacturer
outsourced design

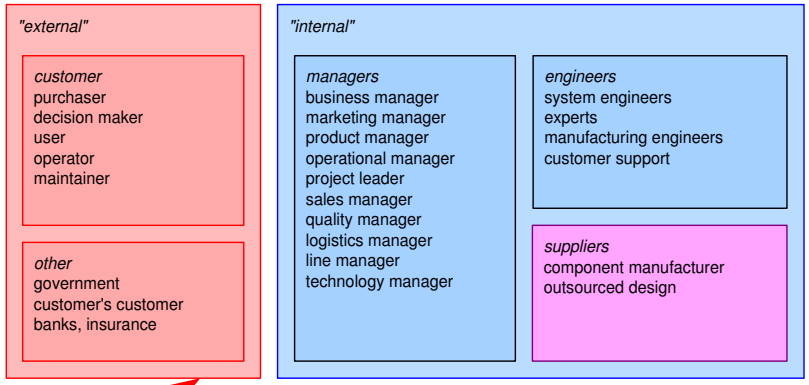
Multitude of Disciplines



Complexity of Waferstepper Context



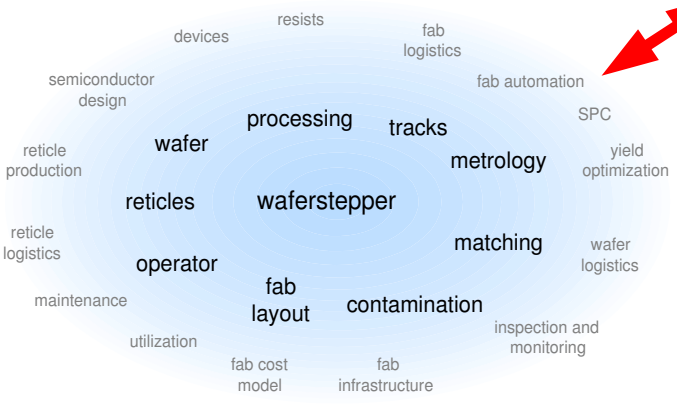
market, business



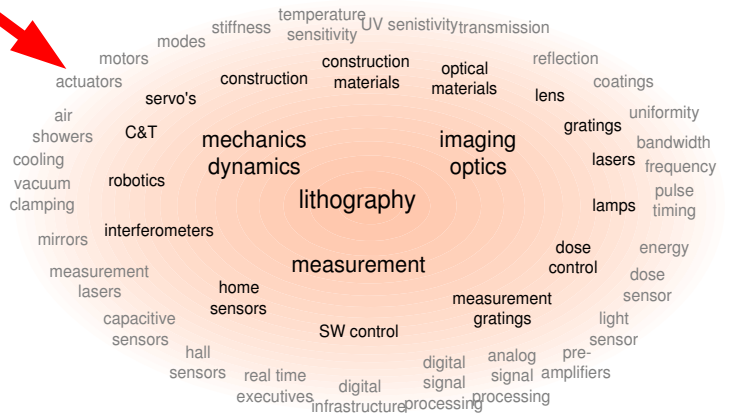
stakeholders

waferstepper

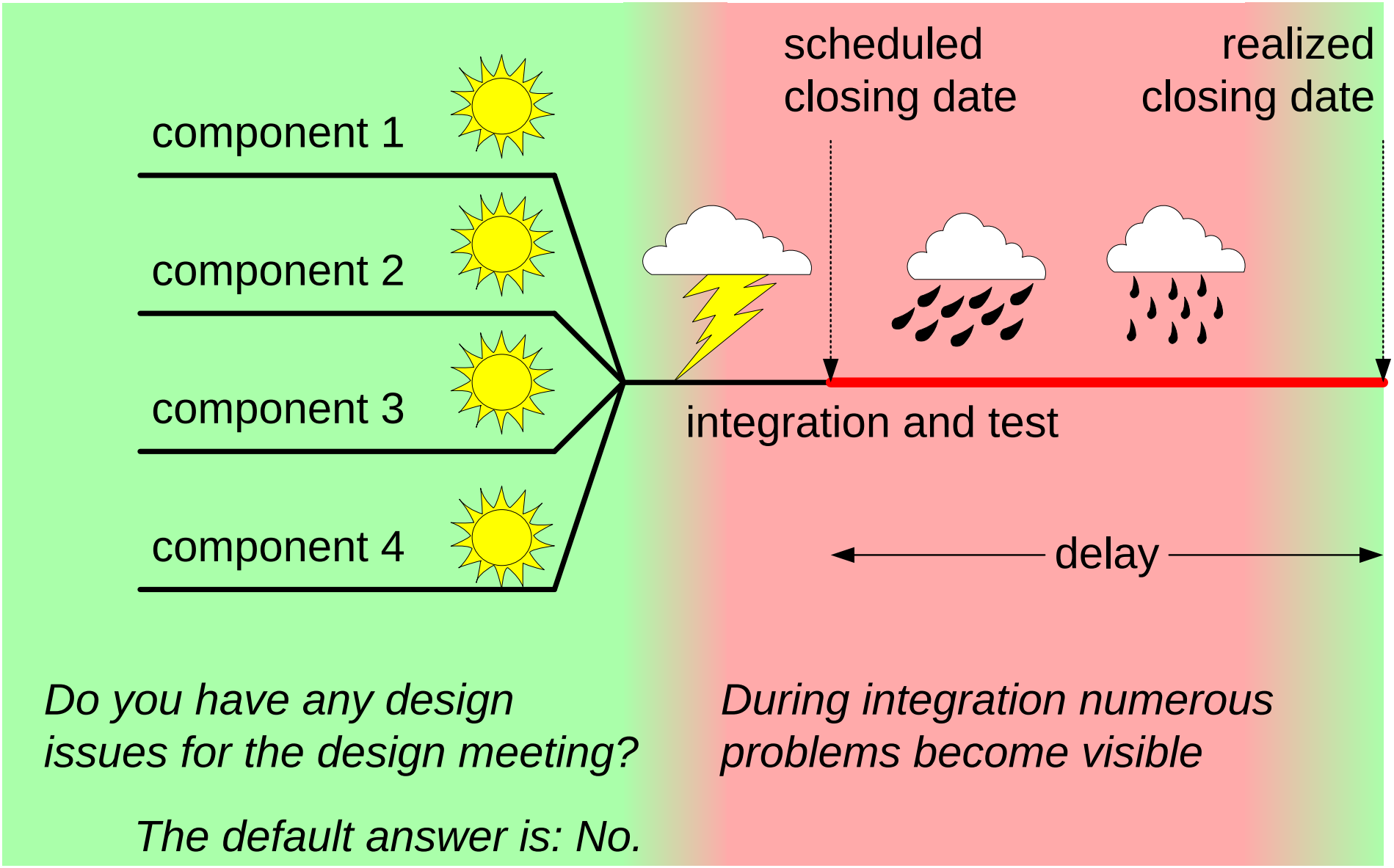
fab context



multitude of disciplines



Symptom: Delays appear during Integration

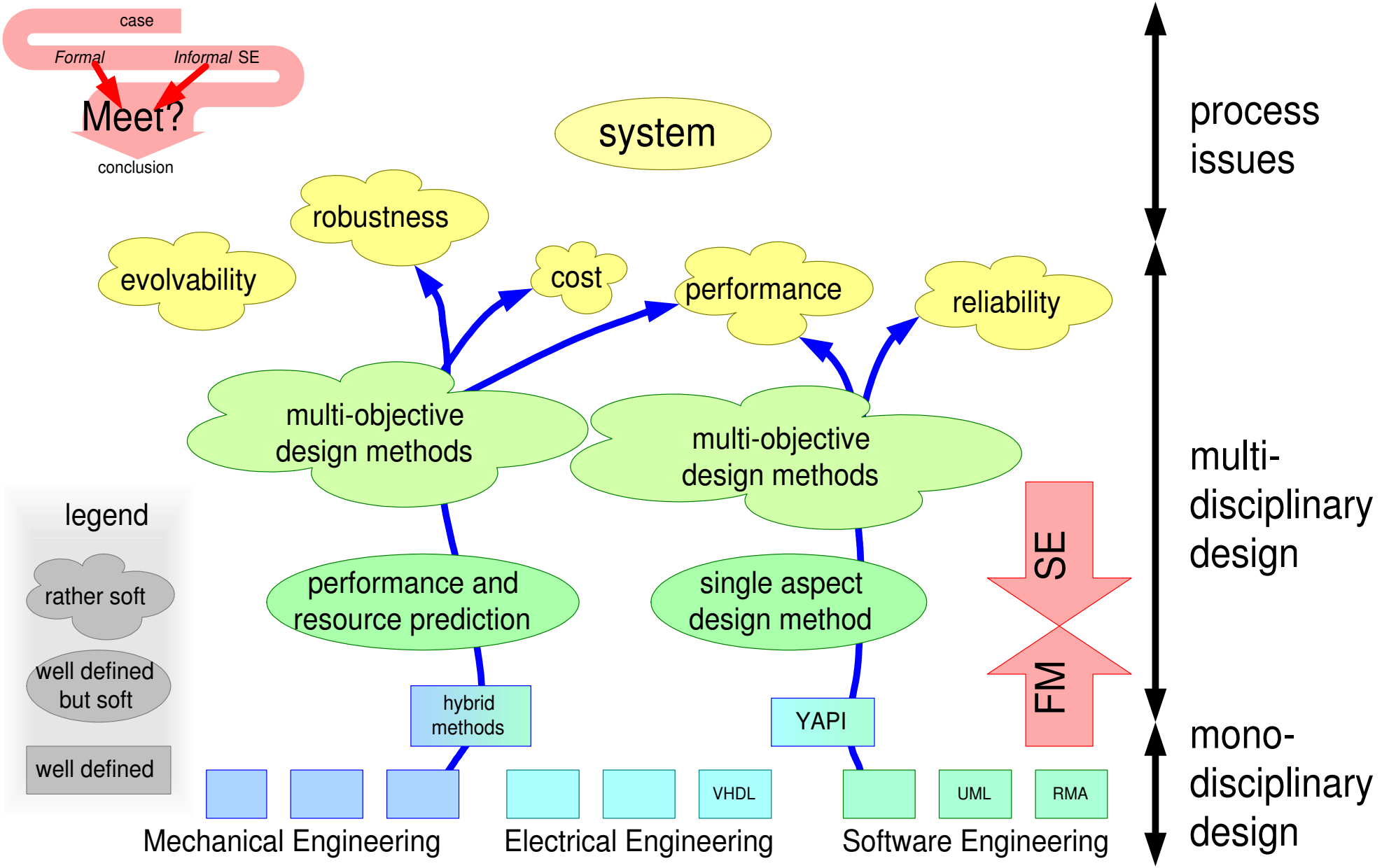


Do you have any design issues for the design meeting?

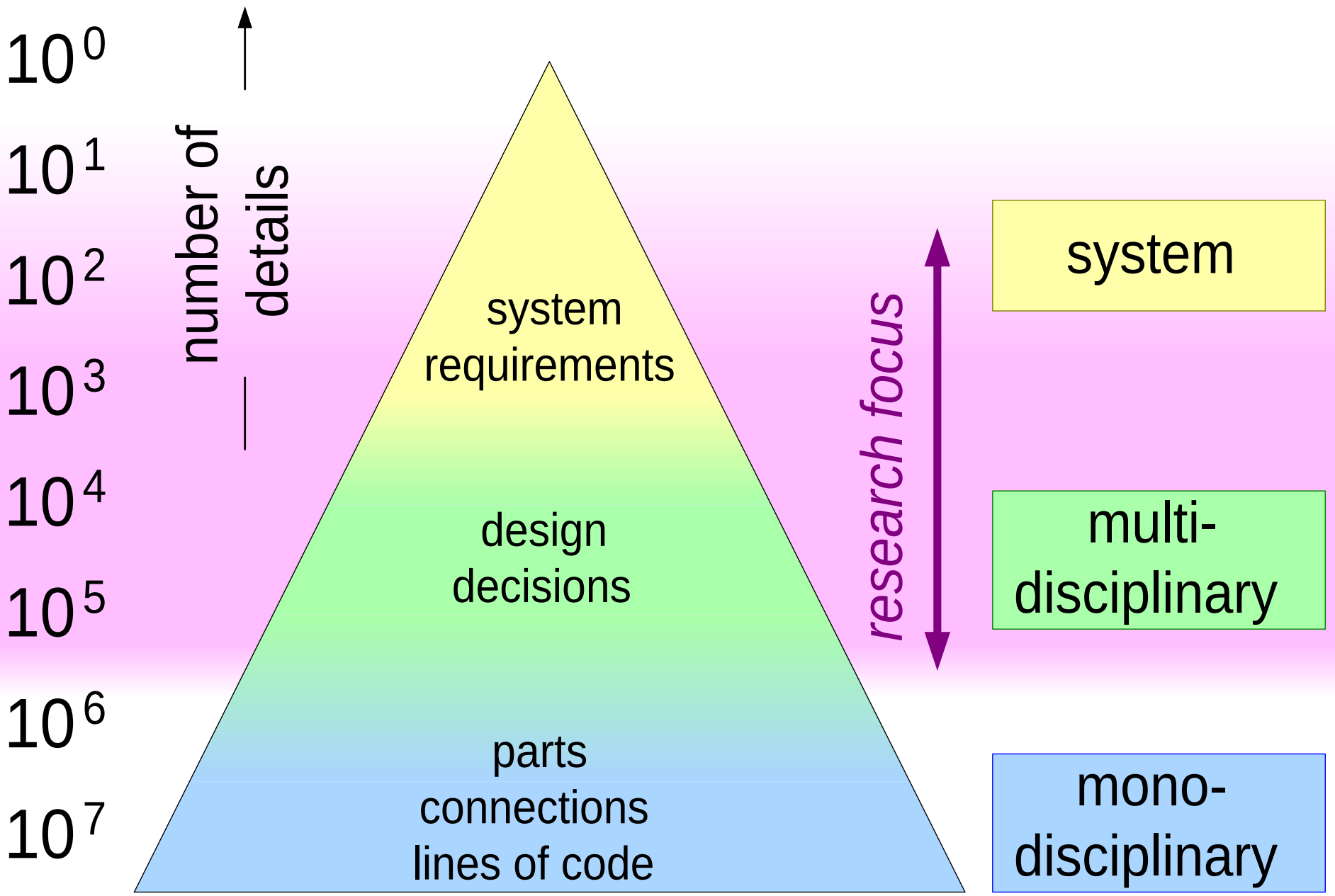
The default answer is: No.

During integration numerous problems become visible

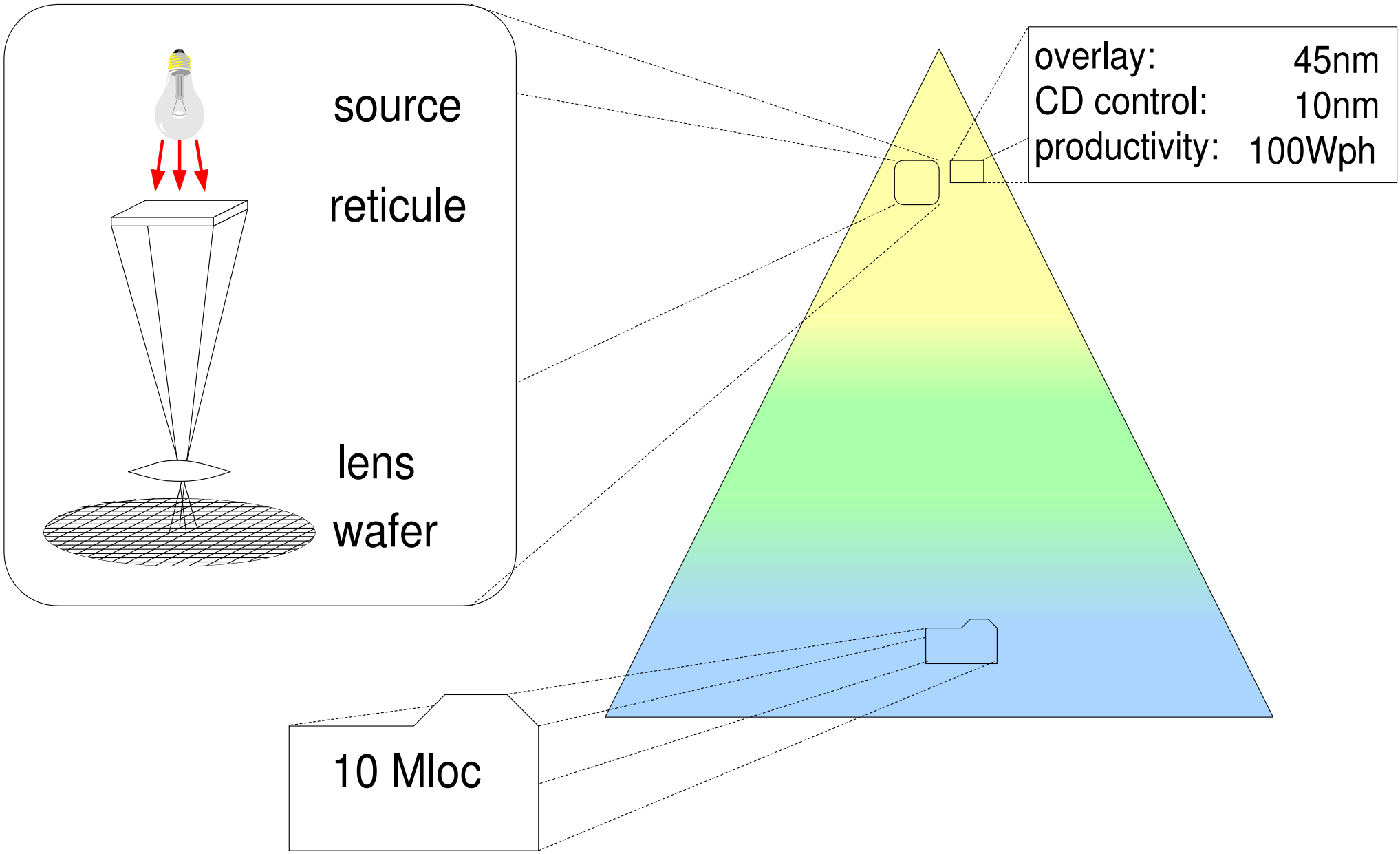
From Mono-Disciplinary to System



Exponential Pyramid, from requirement to bolts and nuts



Waferstepper Example



Postulate

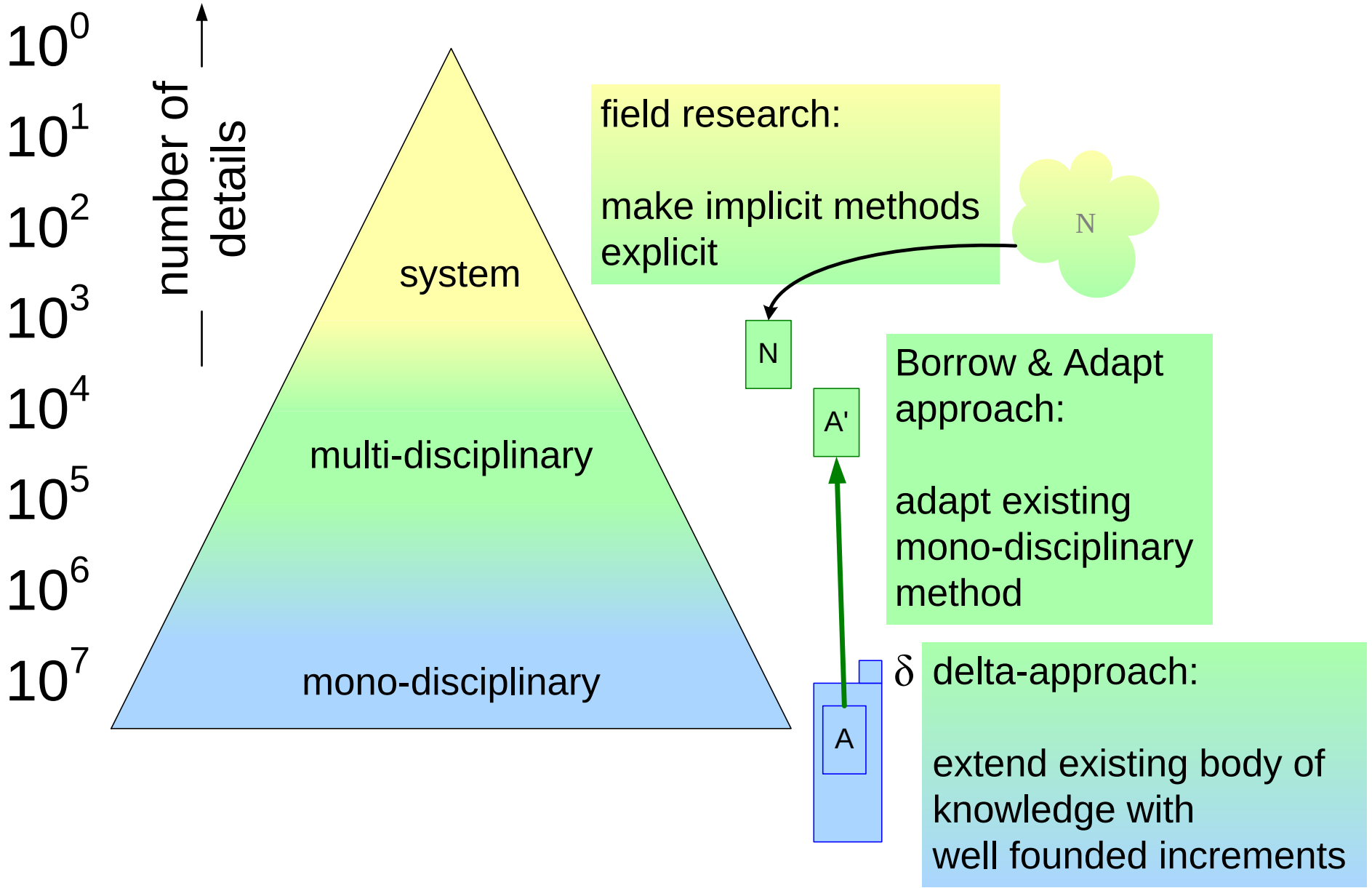
engineering
architecting
formal

engineering
architecting
formal

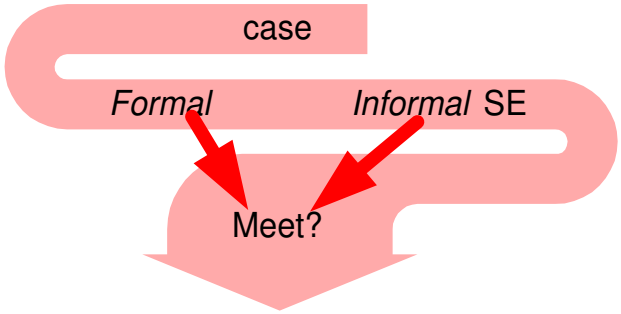
Skills are much more important than **methods**

skills of "formal" people:
analytical
structural
firm of principle
consistent

Multi-disciplinary Research Approaches



Conclusion



conclusion

Systems Engineering :

heterogeneous, the art of ignoring details

Formal Methods : systematic and accurate:

works on well defined homogeneous problems

SE uses FM-thinking: Borrow and Adapt

Formal methods provides input to SE for specific niches

SE sets the boundaries for the application of Formal Methods