

# 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:

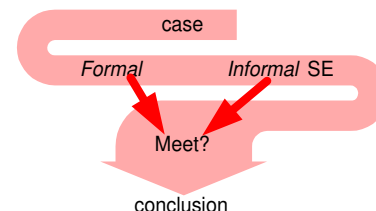
- well defined formalized SE methods
- strong process focused
- “common sense”, based on human experience and intelligence

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.

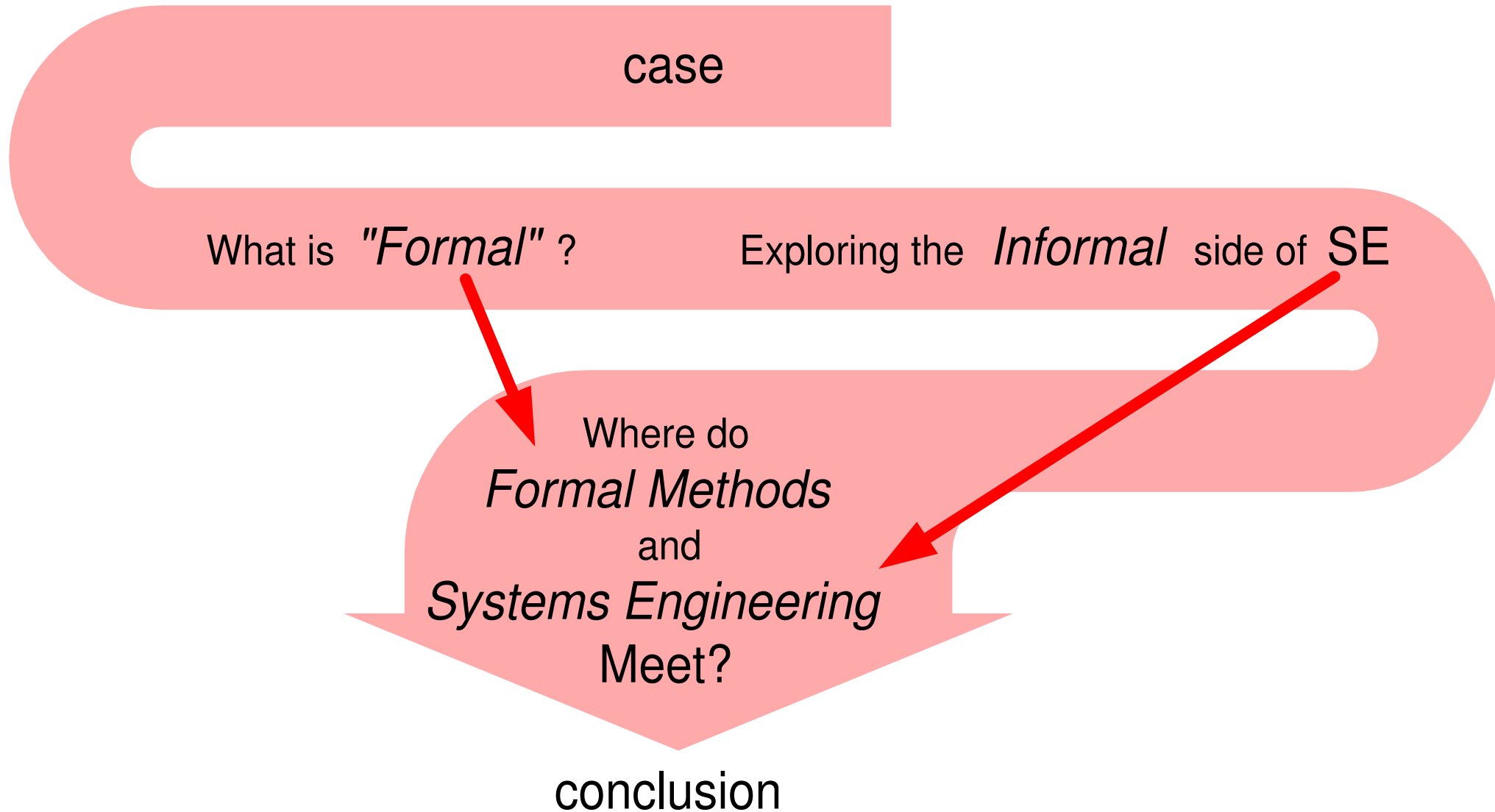
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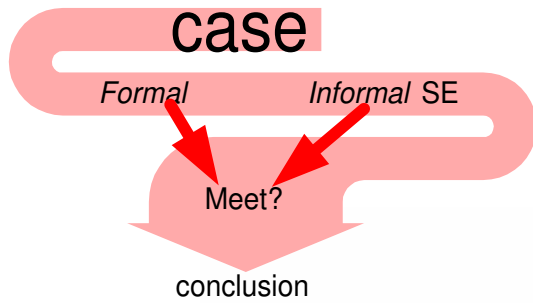
October 20, 2017  
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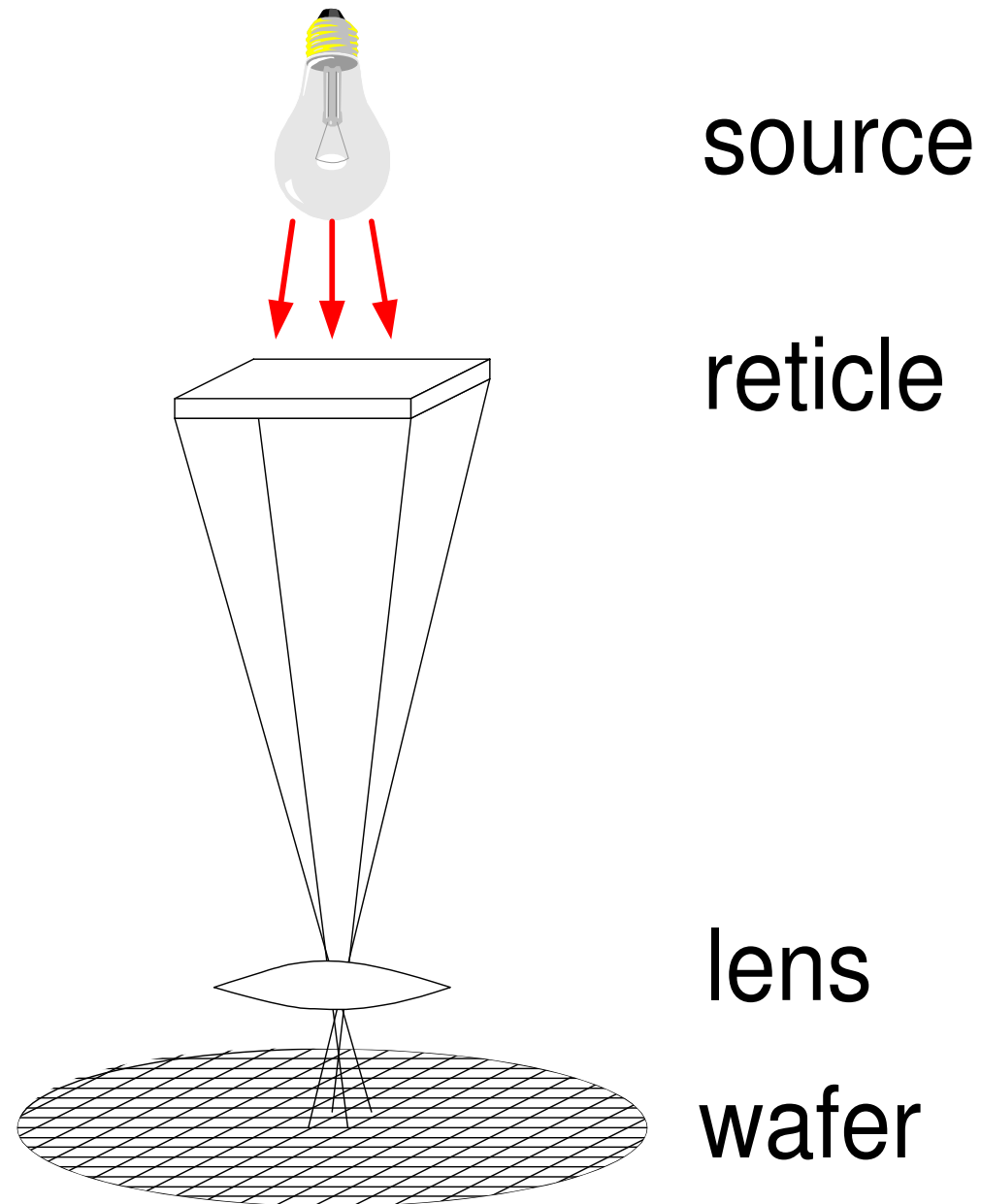
# Presentation Outline



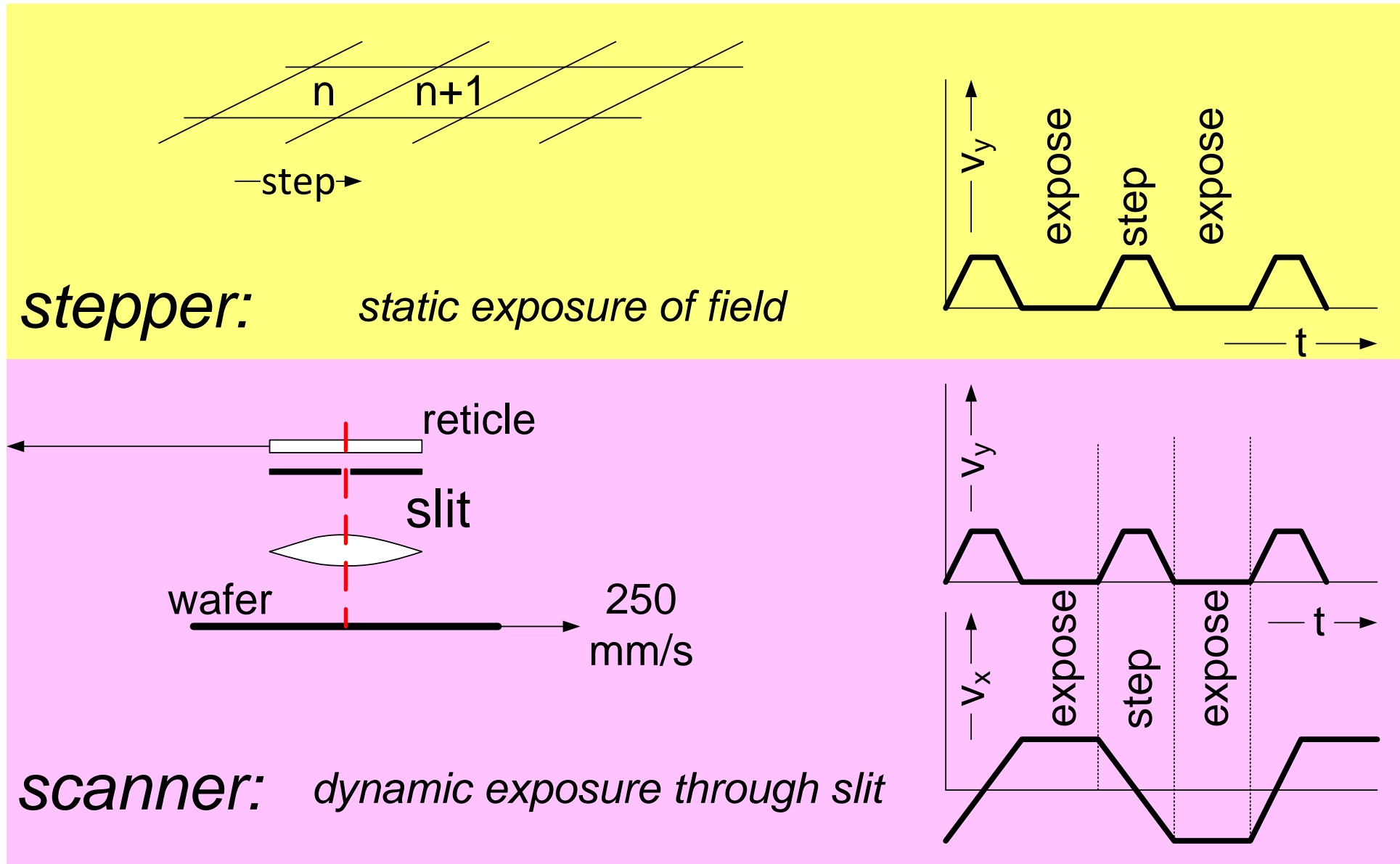
# Twinscan AT1100



# What is a waferstepper

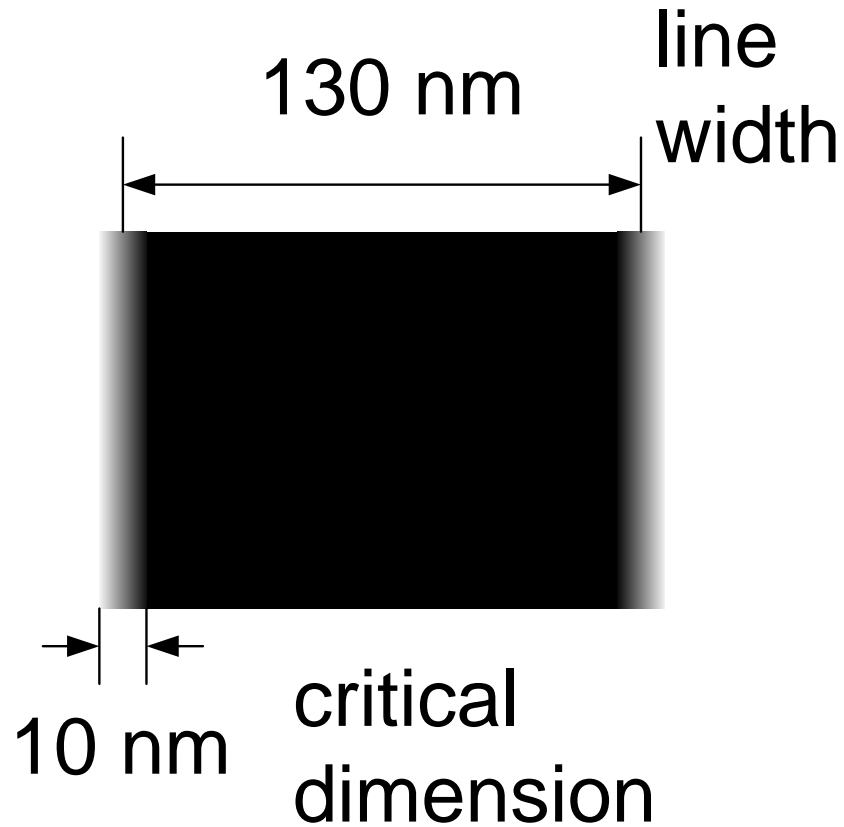


# From stepping to scanning

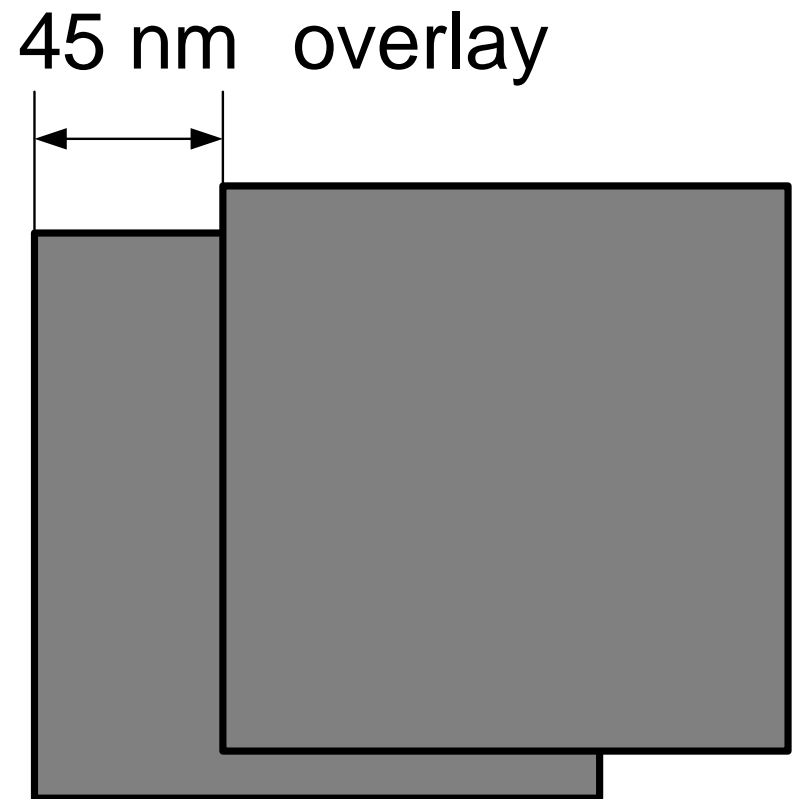


# Key specifications waferstepper

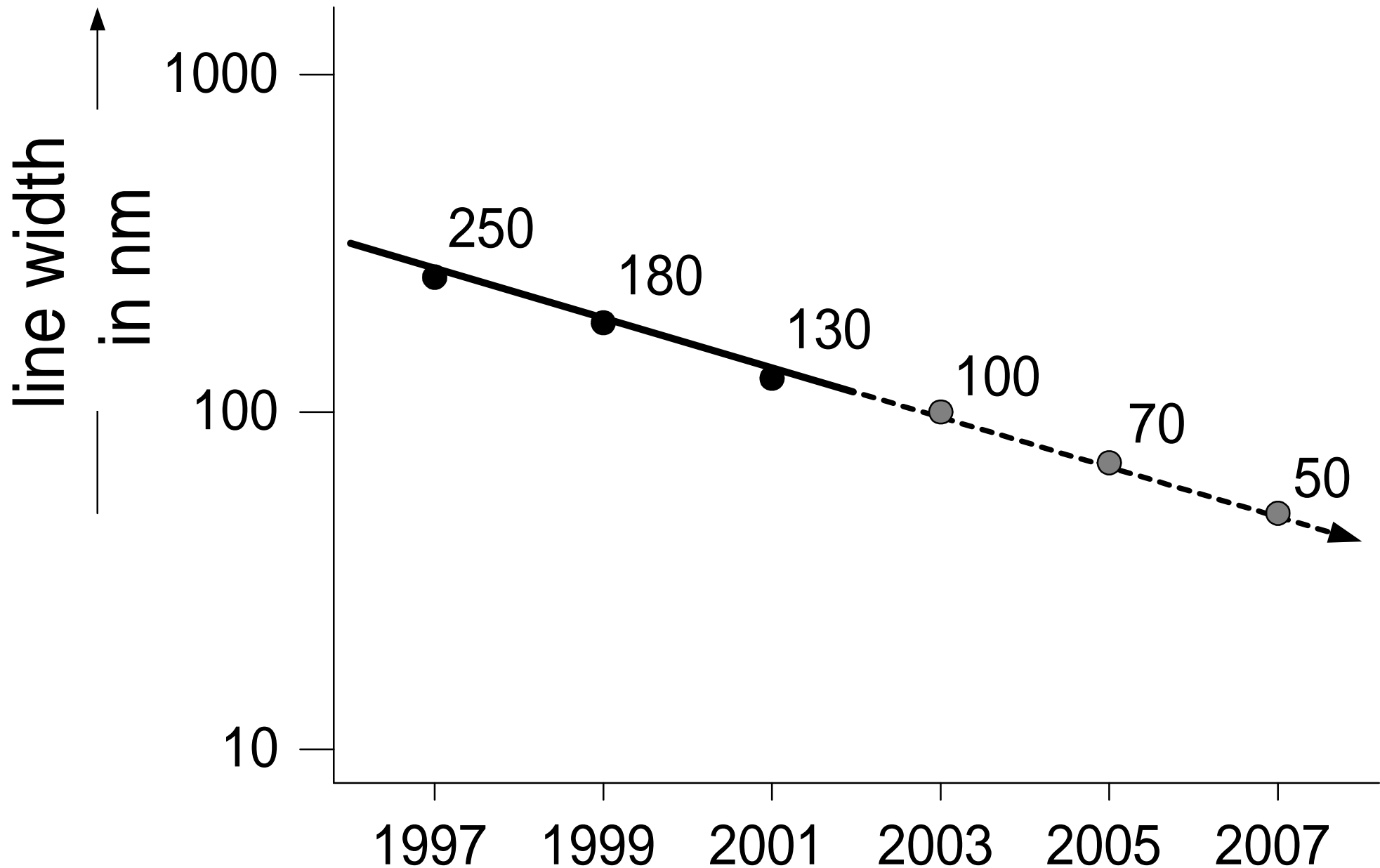
## imaging



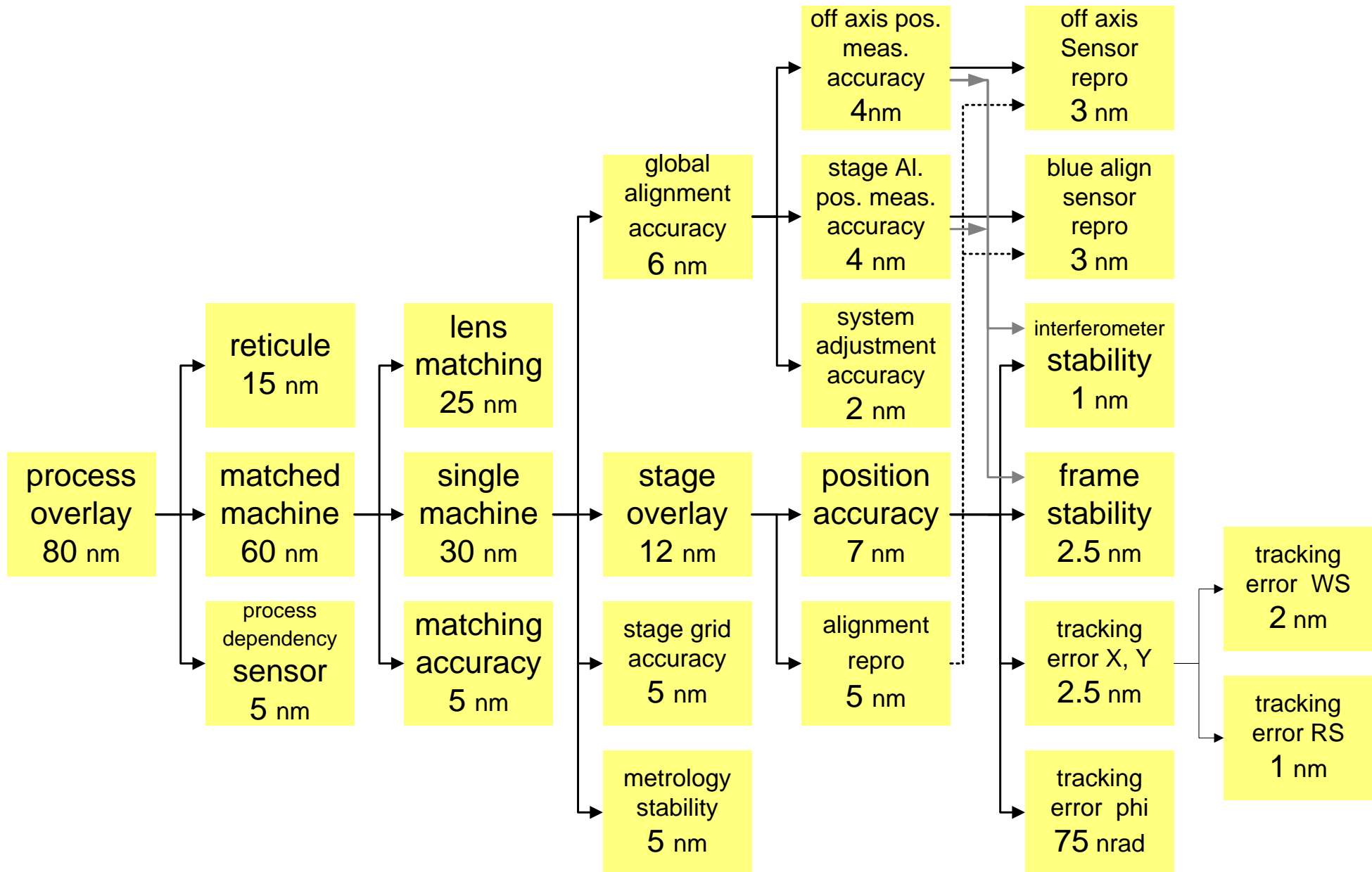
## alignment



# Moore's law



# Overlay budget (1999)



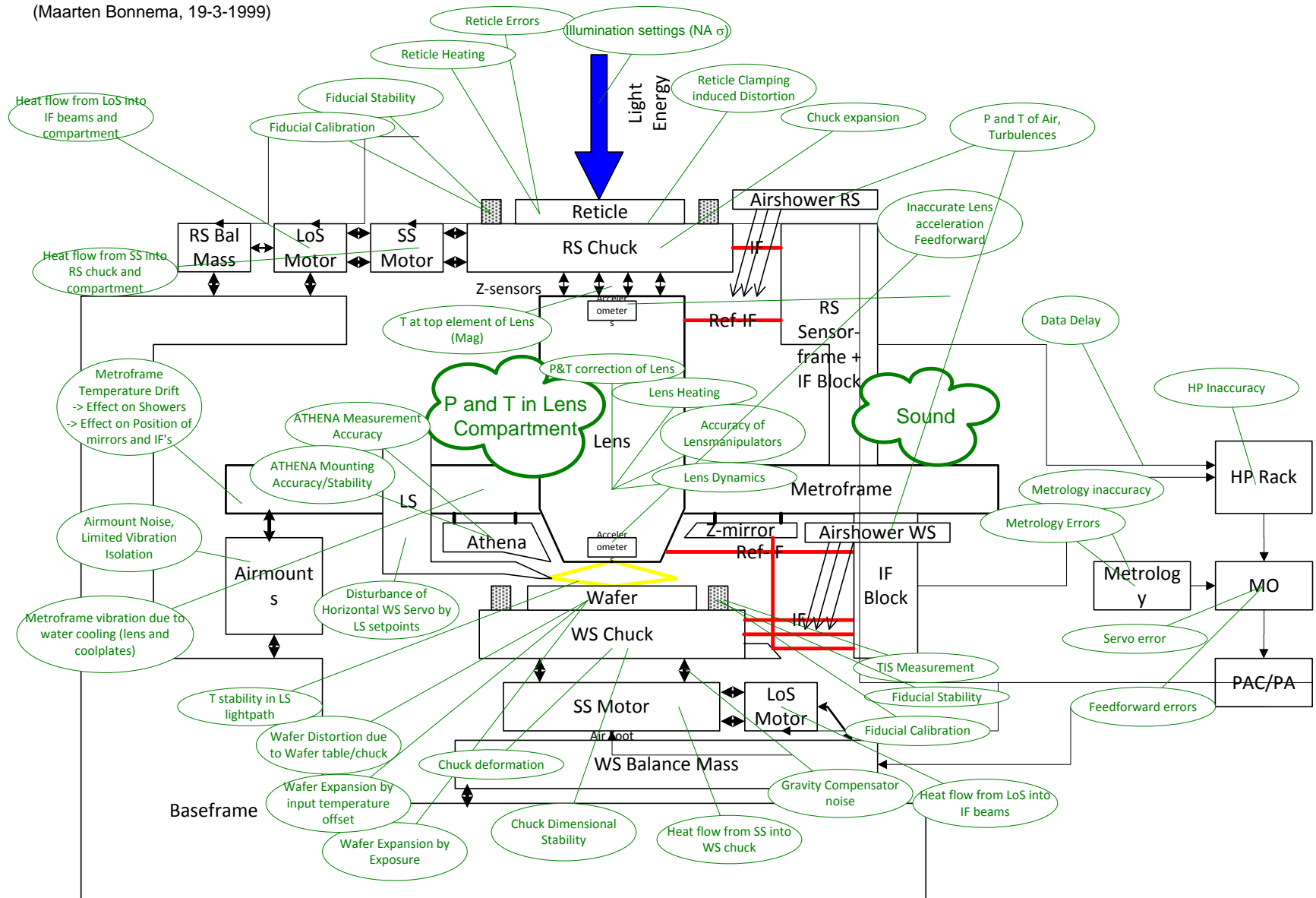


# Everything influences overlay

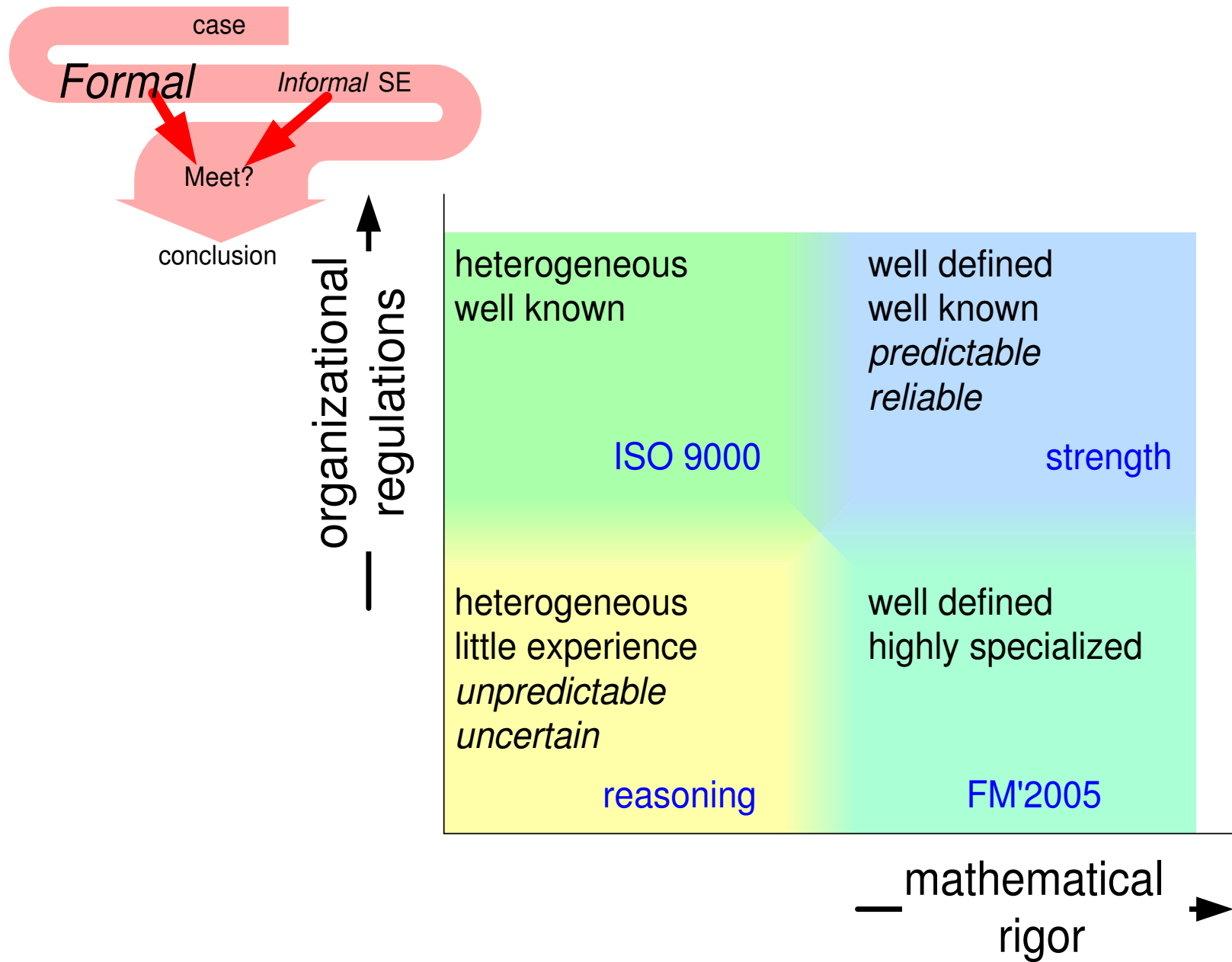
## Overlay Influence Diagram.

(Maarten Bonnema, 19-3-1999)

■ : Fiducial



# What is Formal?



# Process: Formal Documents

PRS Product Requirement Spec

SPS System Performance Spec

TPS Test Performance Spec

SDS System Design Spec

EPS Element Performance Spec

TPS Test Performance Spec

EDS Element Design Spec

EPS

TPS

EDS

ATP Acceptance Test Performance

FAT Factory Acceptance Test

SAT Factory Acceptance Test

TPD Technical Product Documentation

*product creation process*

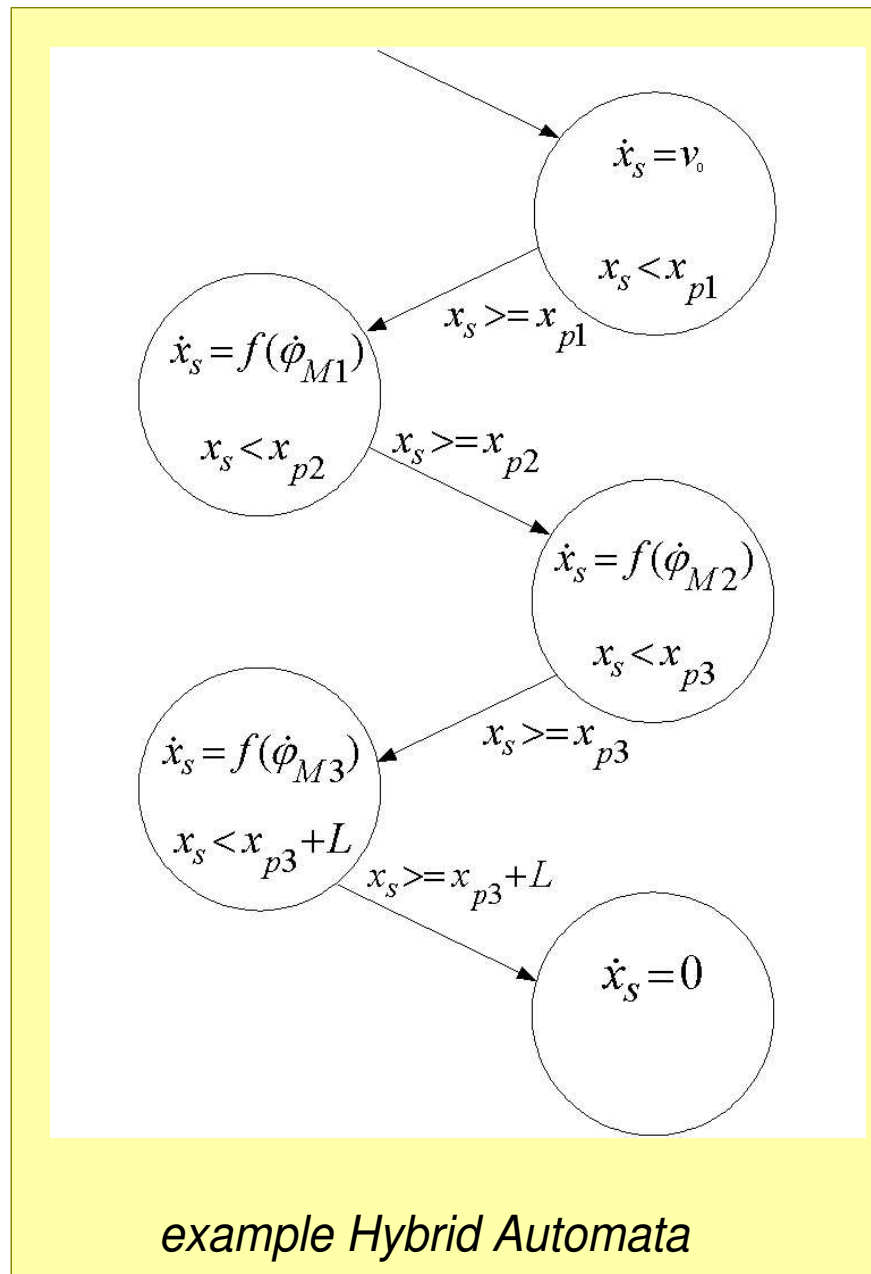
*acceptance test*

*Change Control*

PR Problem Report

CR Change Request

# Formal in Mathematical sense

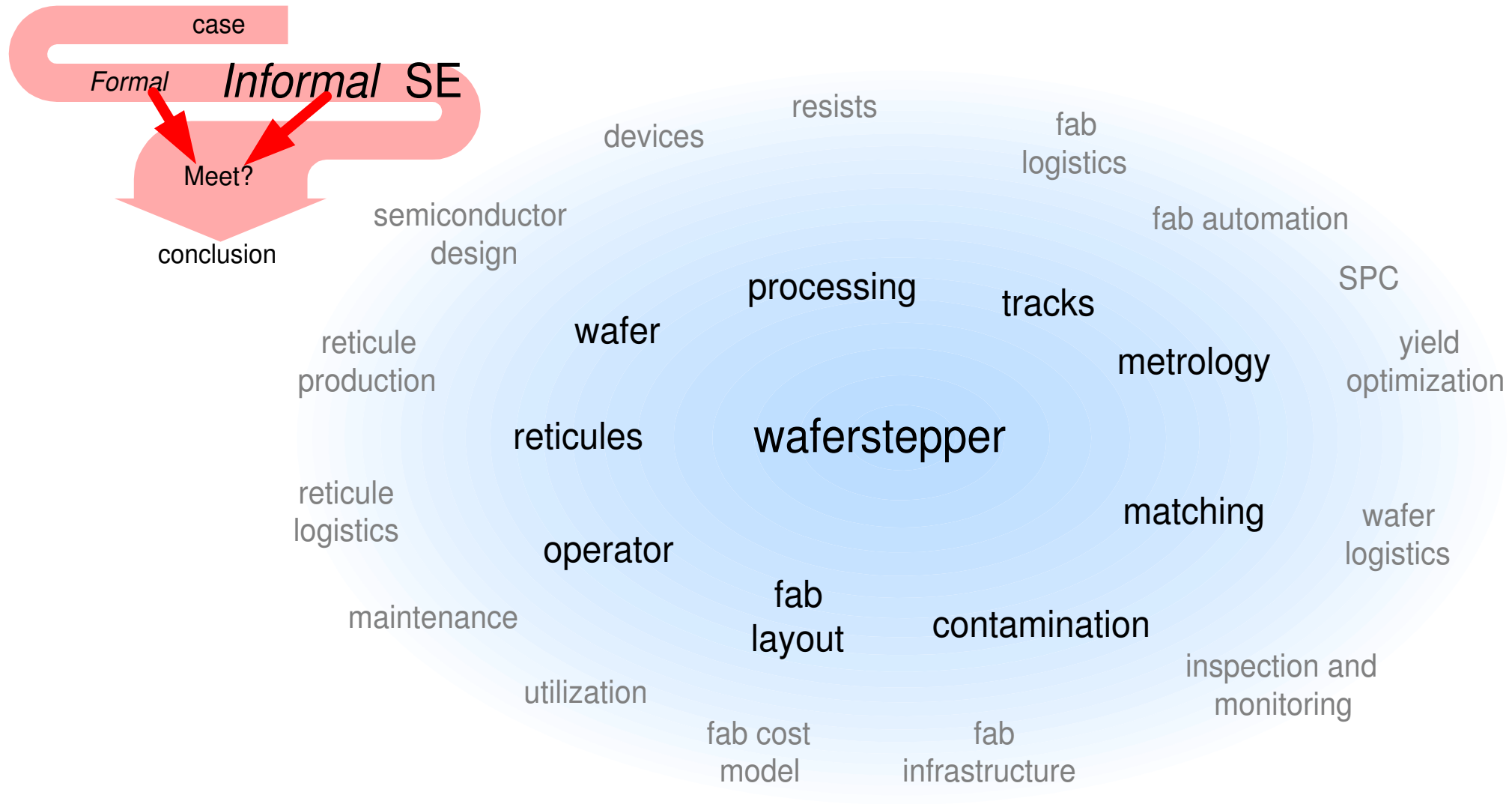


$$\dot{x}_s(t) = \begin{cases} v_0 & \text{if } x_s < x_{p1} \\ A_1 x_s(t) + B_1 u(t) & \text{if } x_s \geq x_{p1} \wedge x_s < x_{p2} \\ A_2 x_s(t) + B_2 u(t) & \text{if } x_s \geq x_{p2} \wedge x_s < x_{p3} \\ A_3 x_s(t) + B_3 u(t) & \text{if } x_s \geq x_{p3} \wedge x_s < x_{p3} + L \\ 0 & \text{if } x_s \geq x_{p3} + L \end{cases}$$

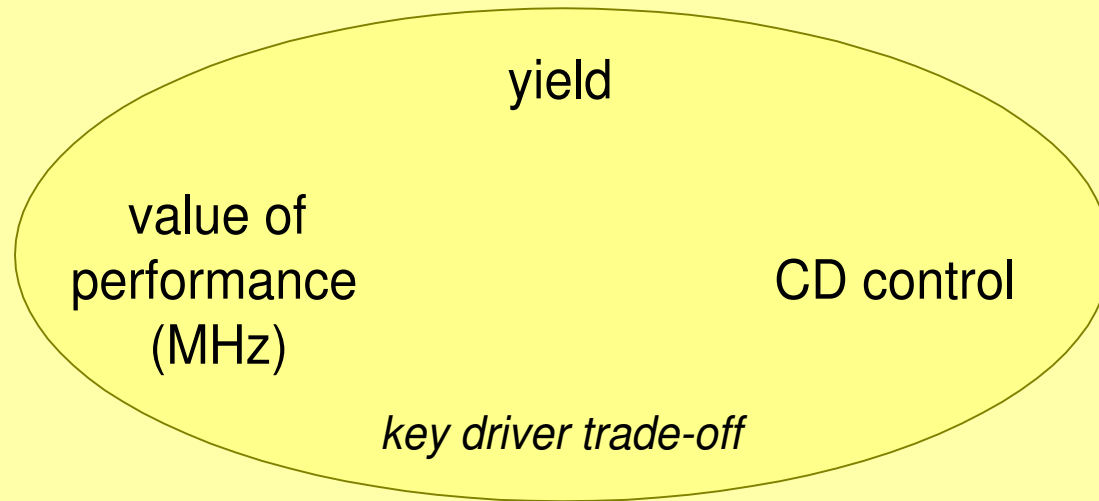
*example PieceWise Linear Systems*

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

# Fab Context of Waferstepper



# 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

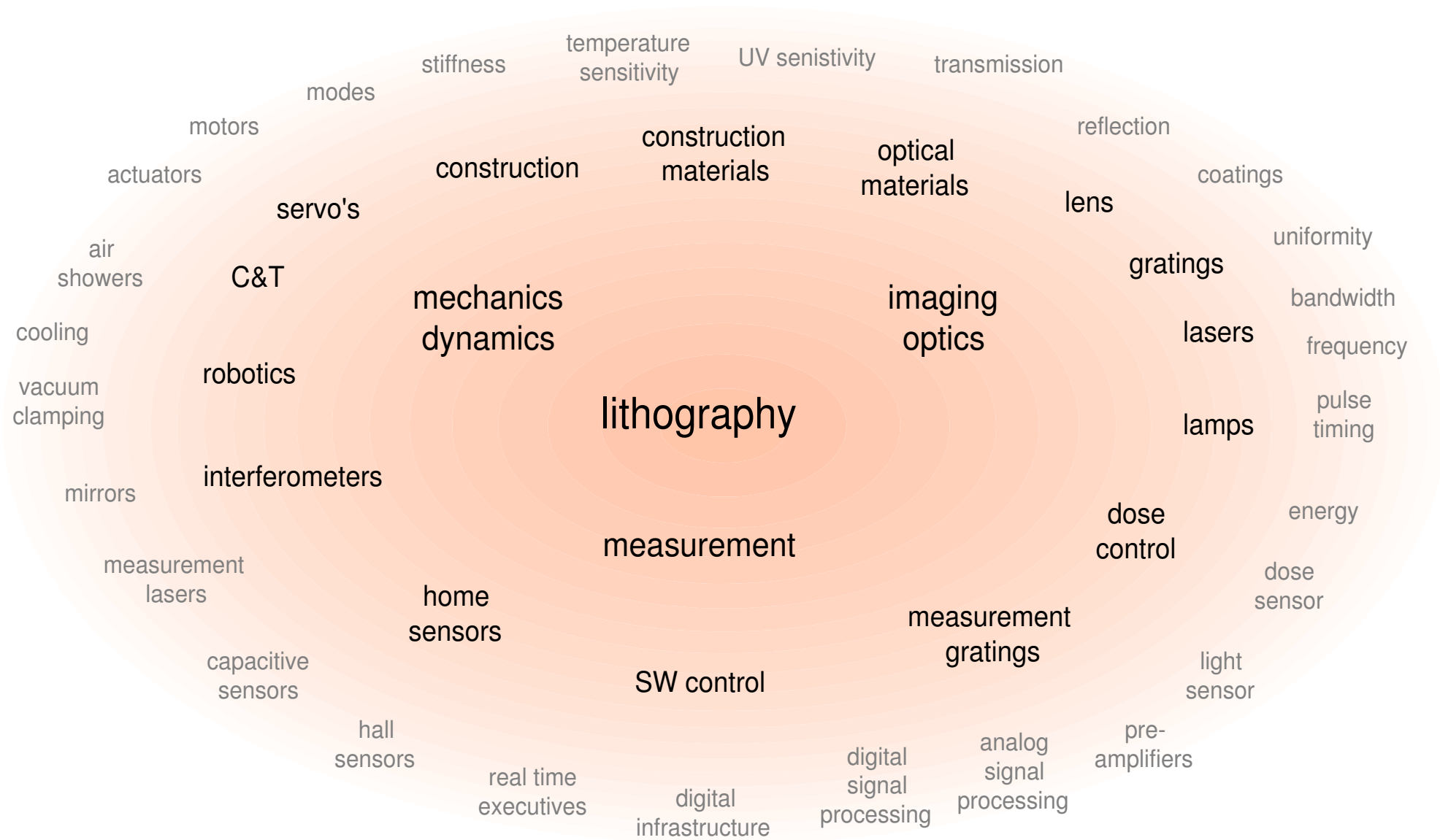
## "internal"

*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

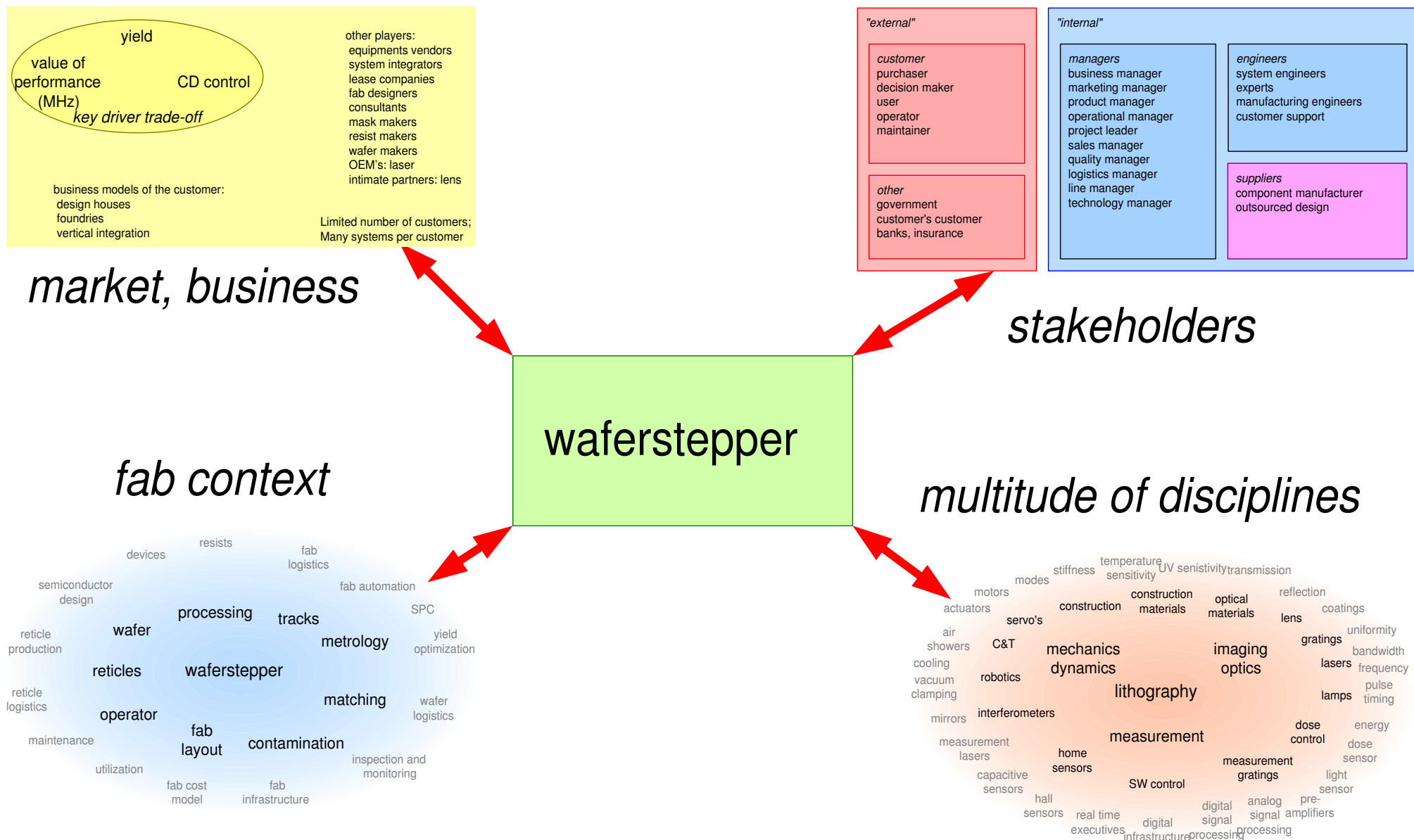
*suppliers*  
component manufacturer  
outsourced design

# Multitude of Disciplines

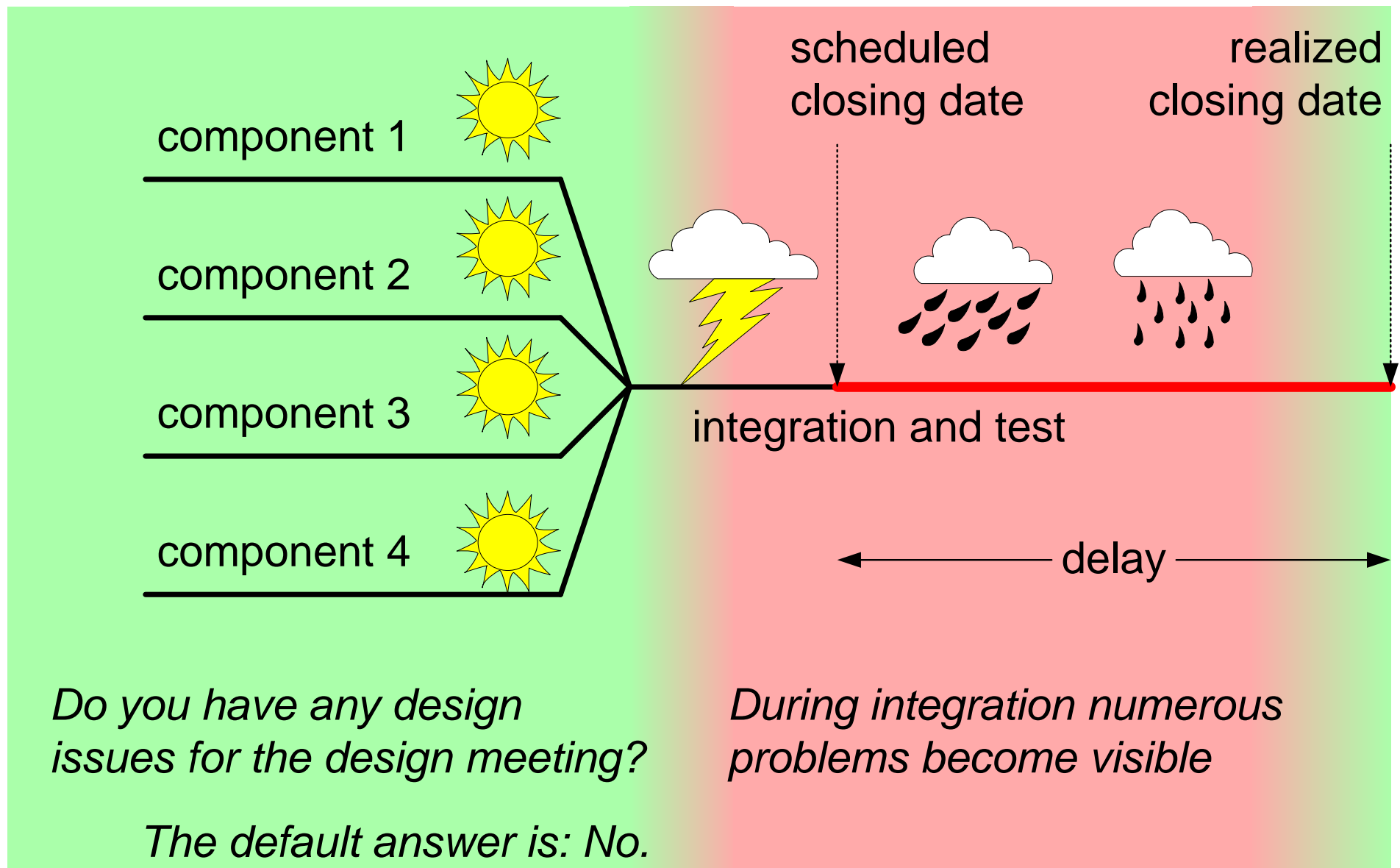




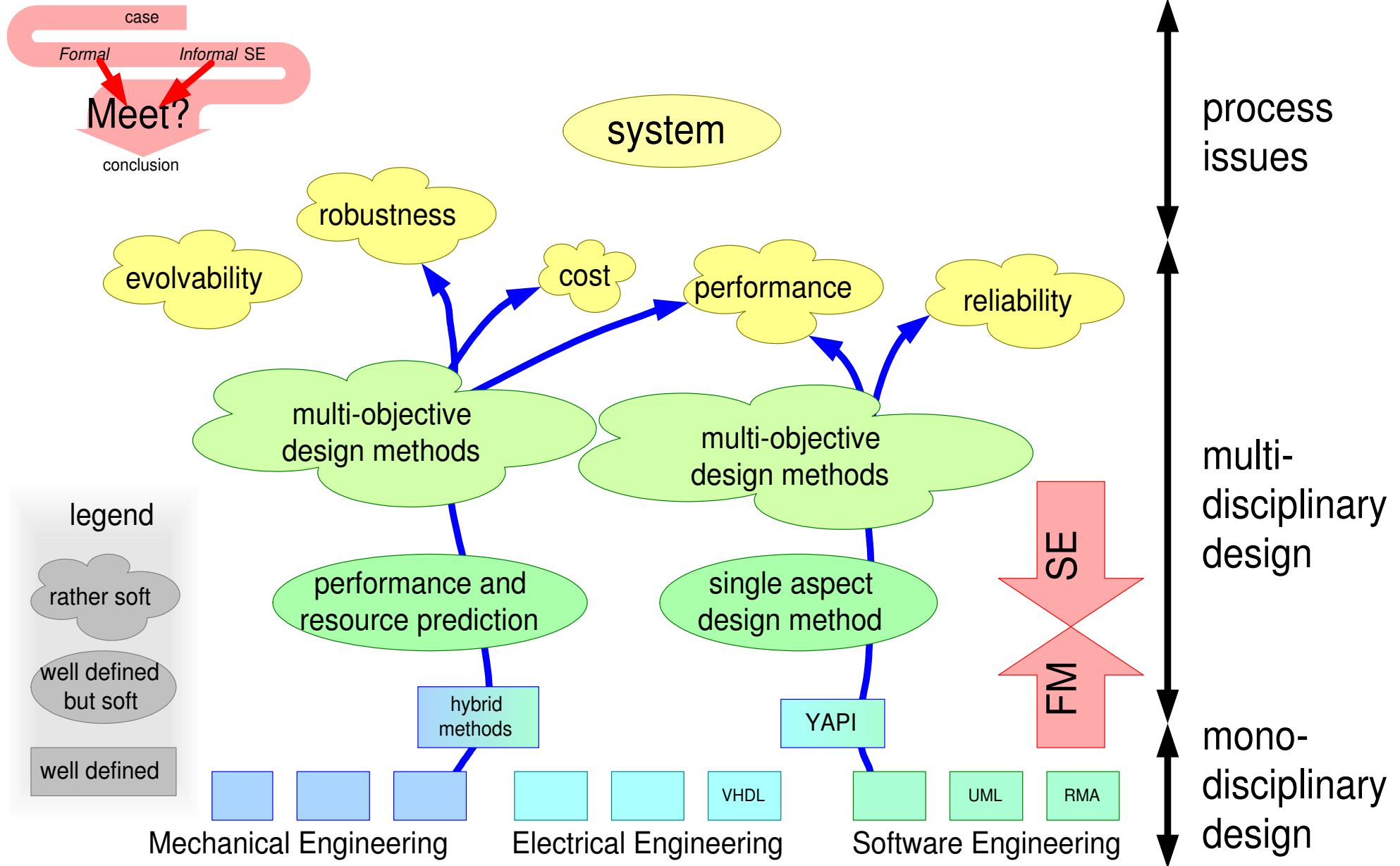
# Complexity of Waferstepper Context



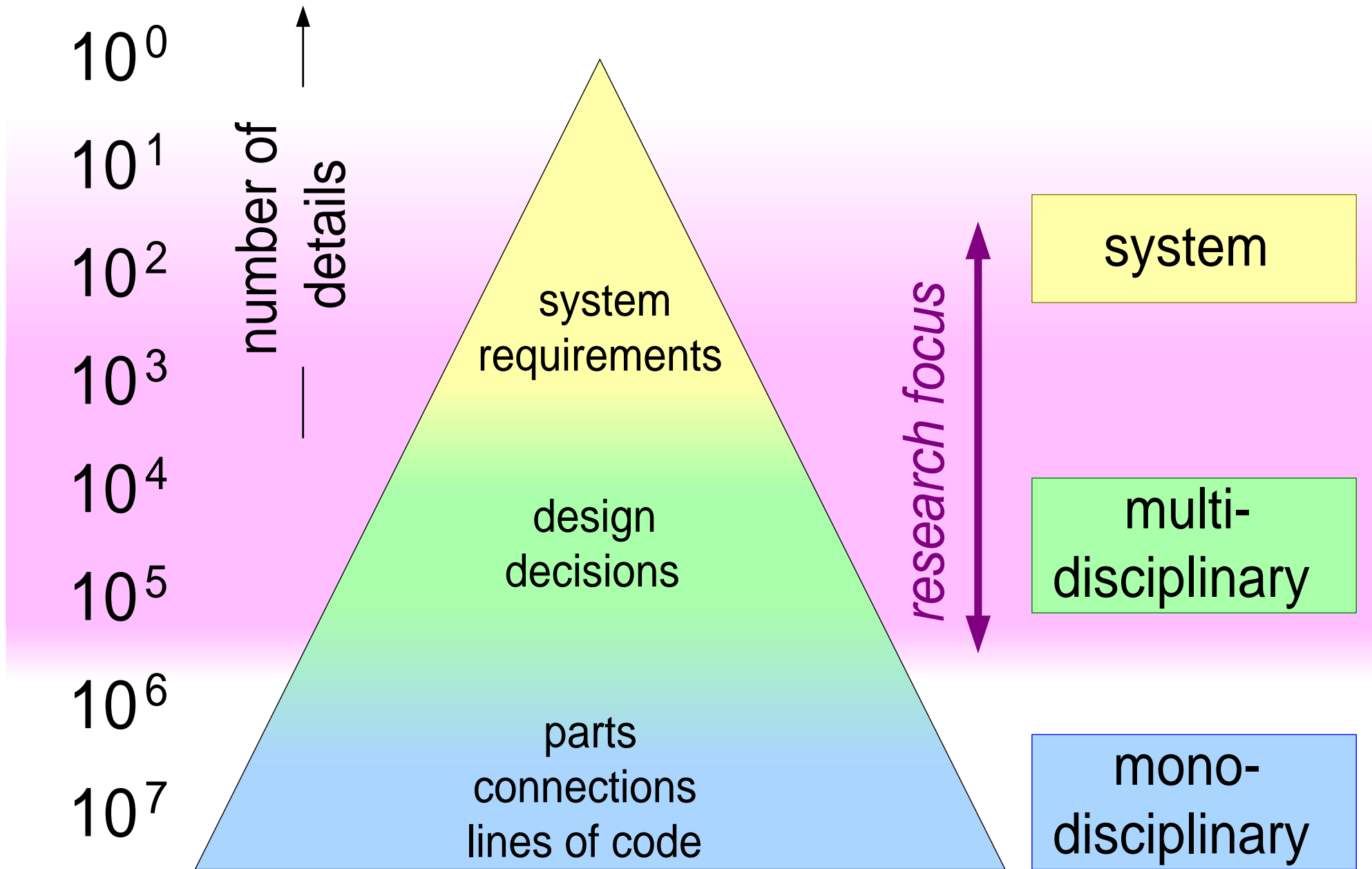
# Symptom: Delays appear during Integration



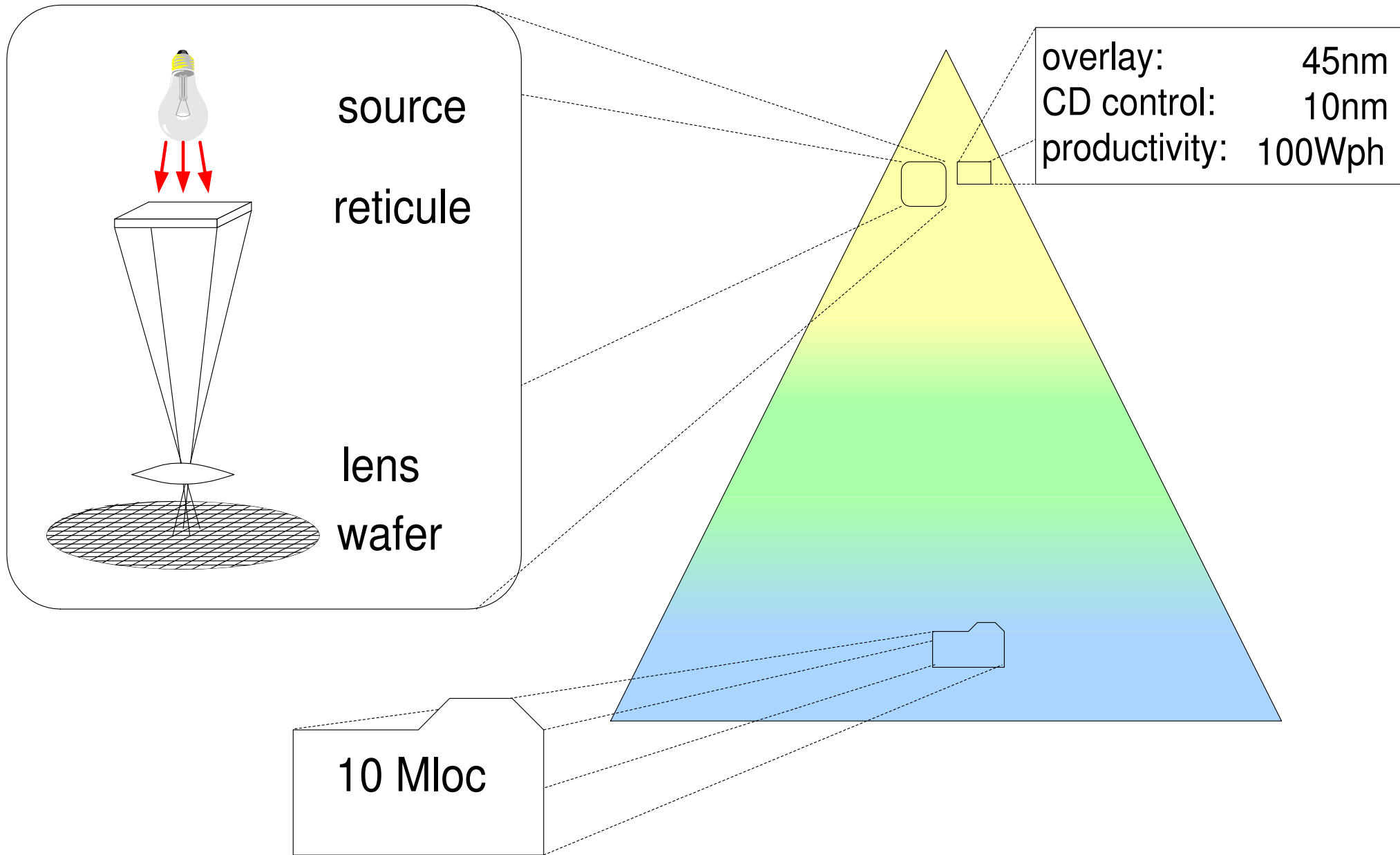
# From Mono-Disciplinary to System



# Exponential Pyramid, from requirement to bolts and nuts



# Waferstepper Example



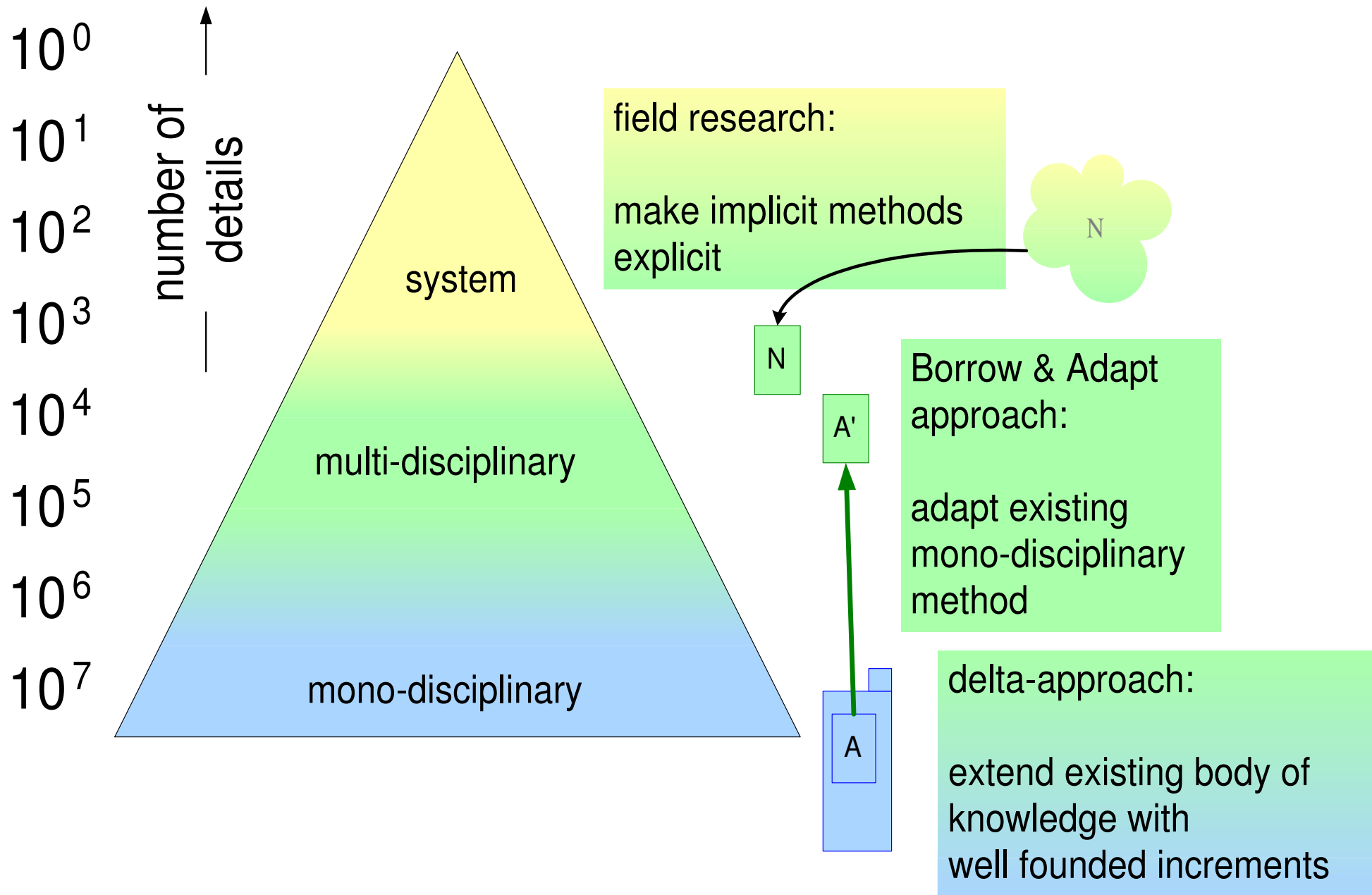
engineering  
architecting  
formal

engineering  
architecting  
formal

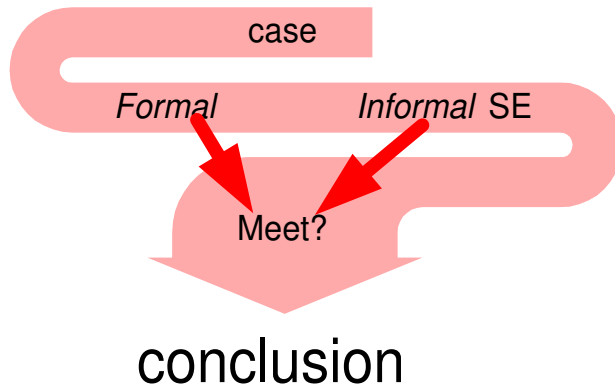
**Skills** are much more important than **methods**

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

# Multi-disciplinary Research Approaches



# Conclusion



*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