

# The Informal Nature of Systems Engineering

by *Gerrit Muller* Embedded Systems Institute

e-mail: `gerrit.muller@embeddedsystems.nl`

`www.extra.research.philips.com/natlab/sysarch/`

## 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:

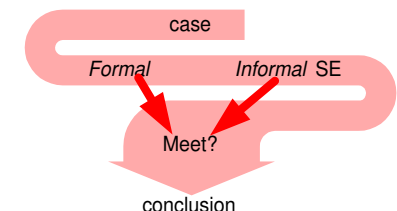
- well defined formalized SE methods
- strong process focused
- “common sense”, based on human experience and intelligence

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.

### Distribution

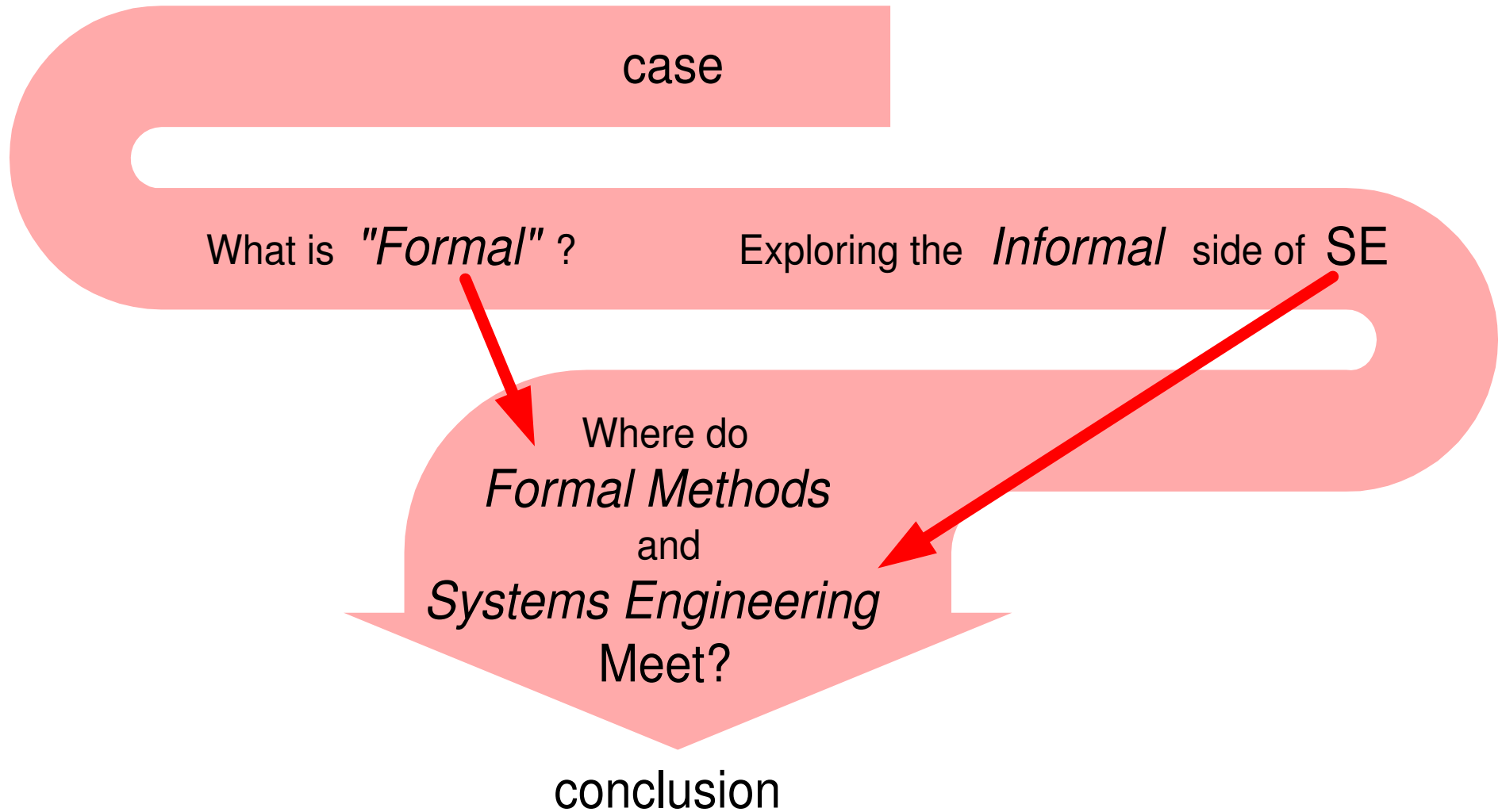
This article or presentation is written as part of the Gaudí project. The Gaudí project philosophy is to improve by obtaining frequent feedback. Frequent feedback is pursued by an open creation process. This document is published as intermediate or nearly mature version to get feedback. Further distribution is allowed as long as the document remains complete and unchanged.

25th April 2005  
status: planned  
version: 0

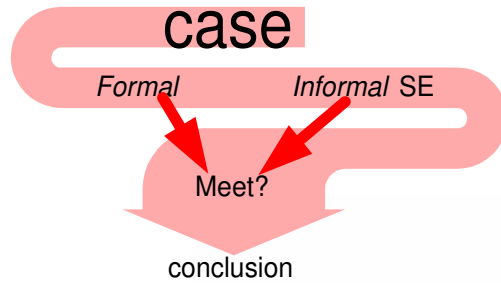


# Presentation Outline

---

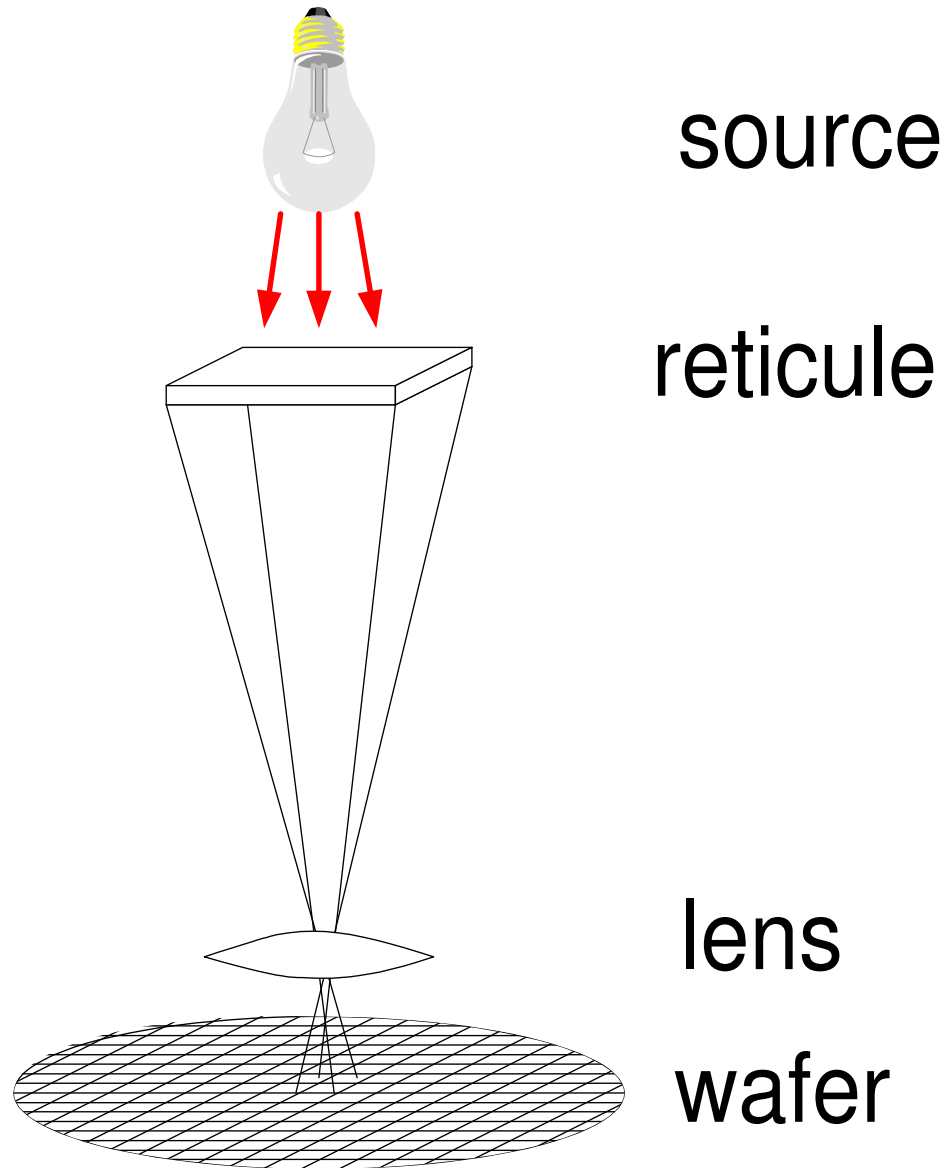


# Twinscan AT1100

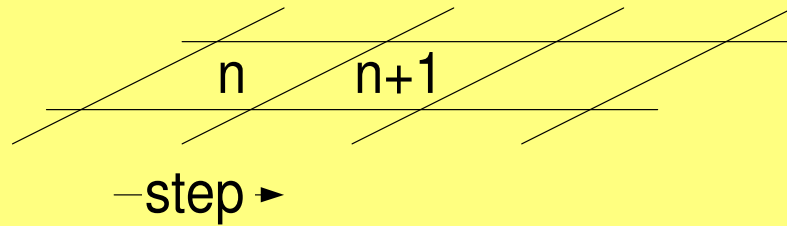


# What is a waferstepper

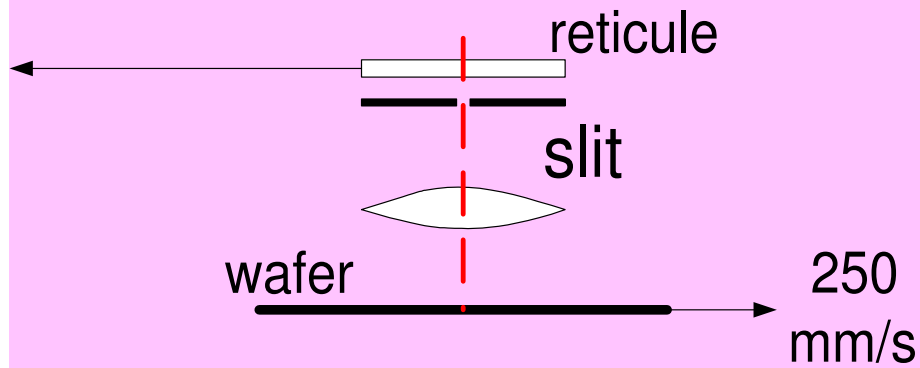
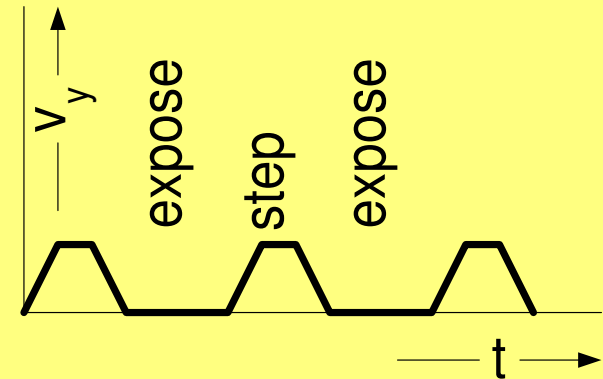
---



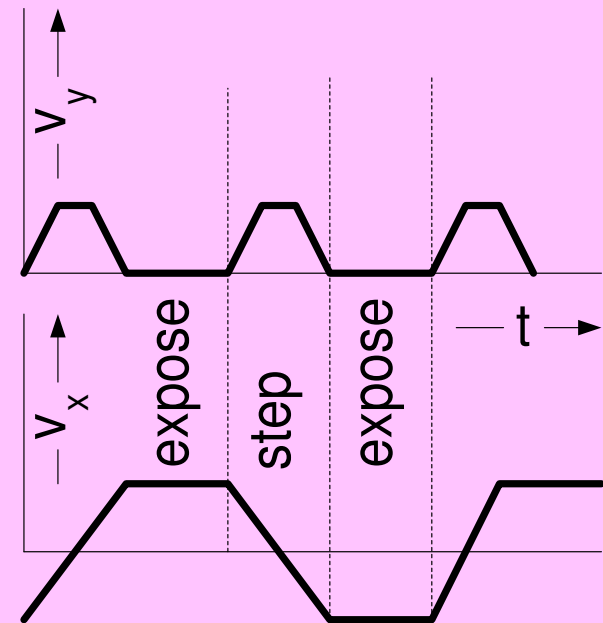
# From stepping to scanning



**stepper:** static exposure of field

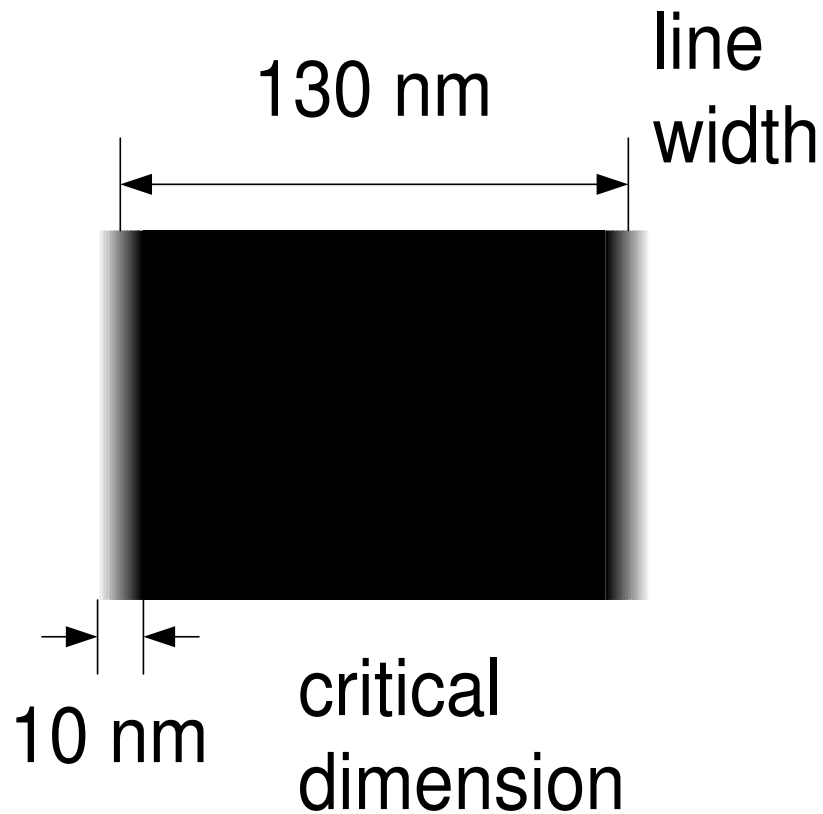


**scanner:** dynamic exposure through slit

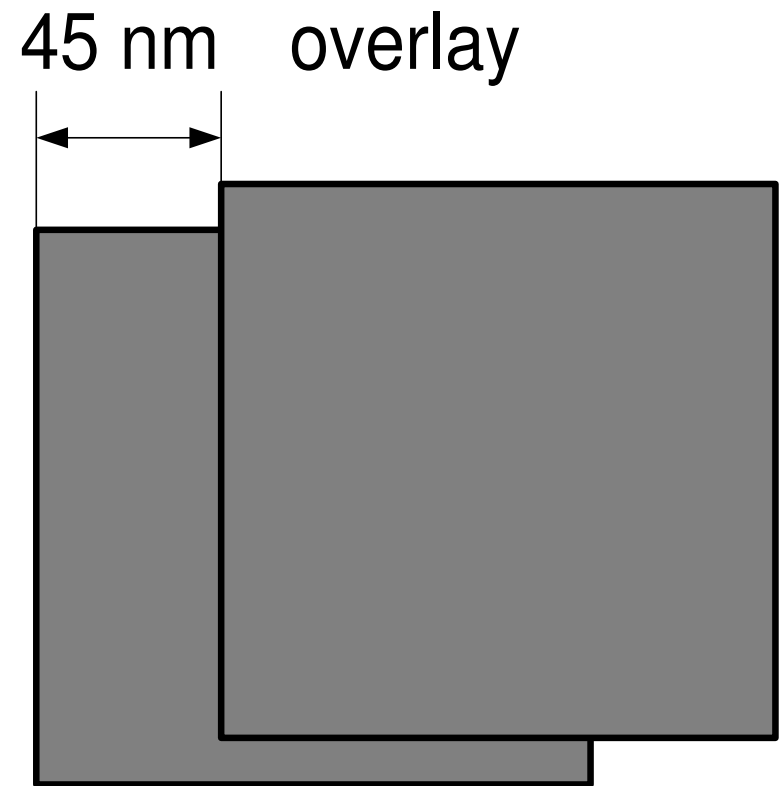


# Key specifications waferstepper

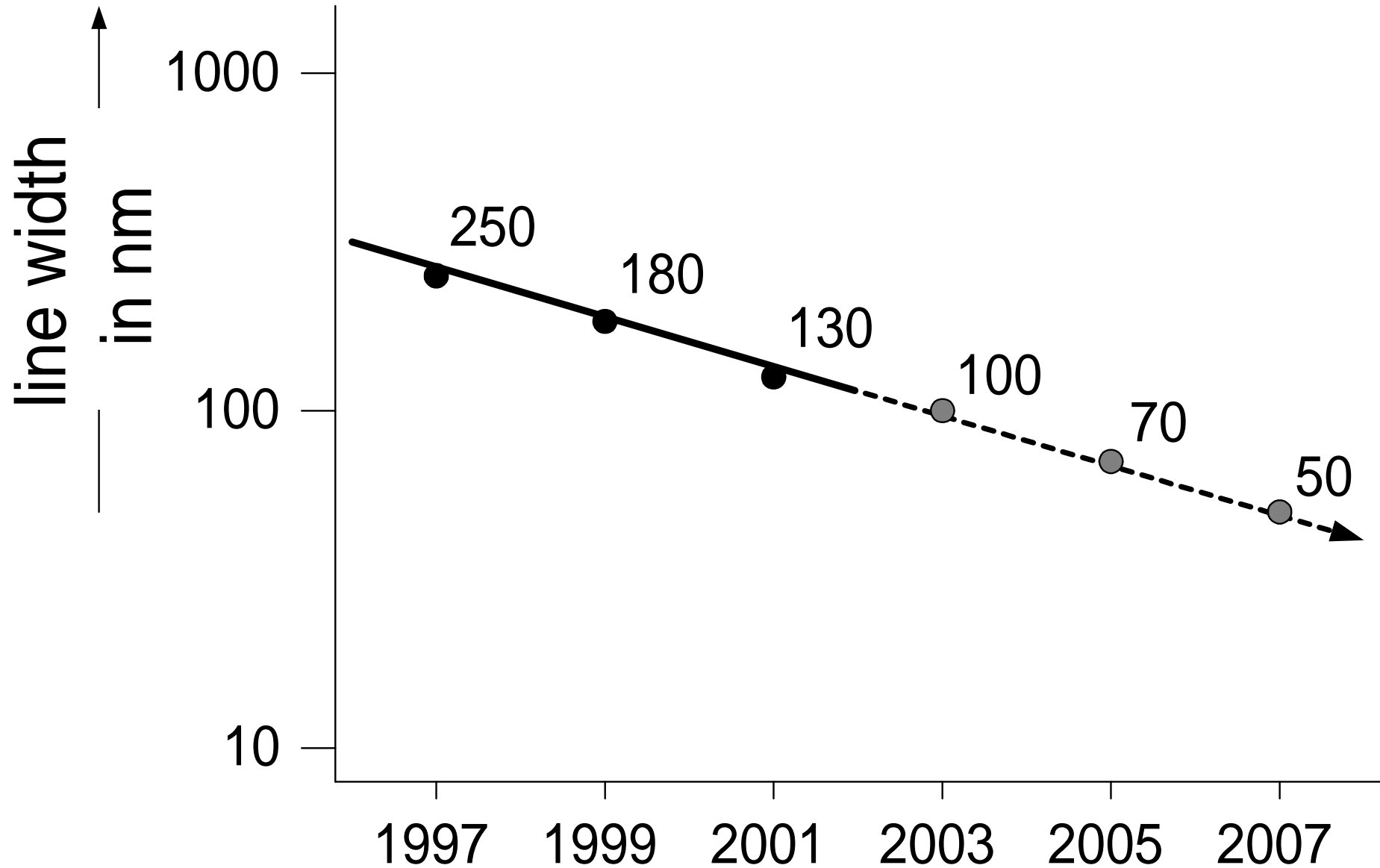
imaging



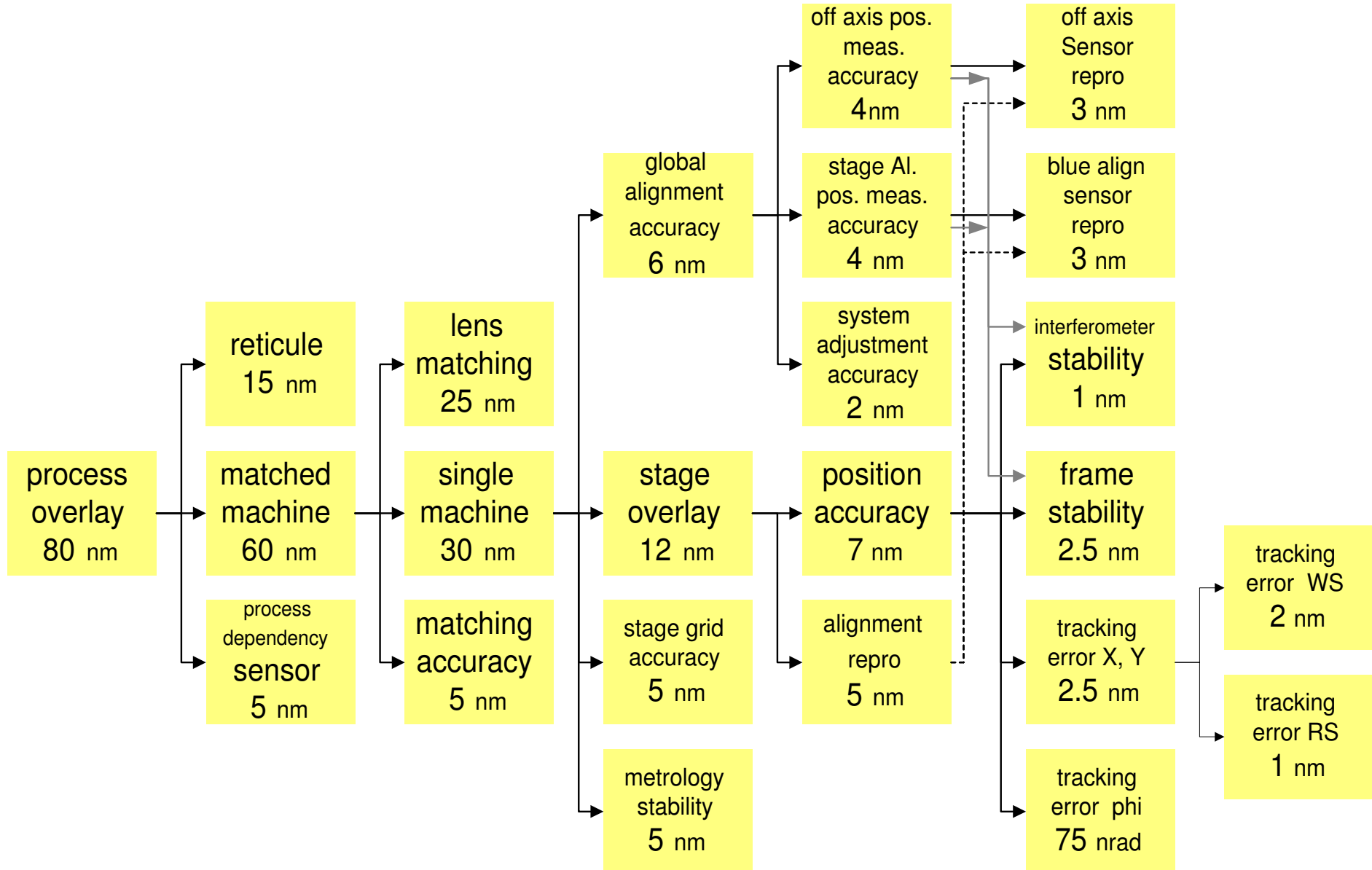
alignment



# Moore's law



# Overlay budget (1999)

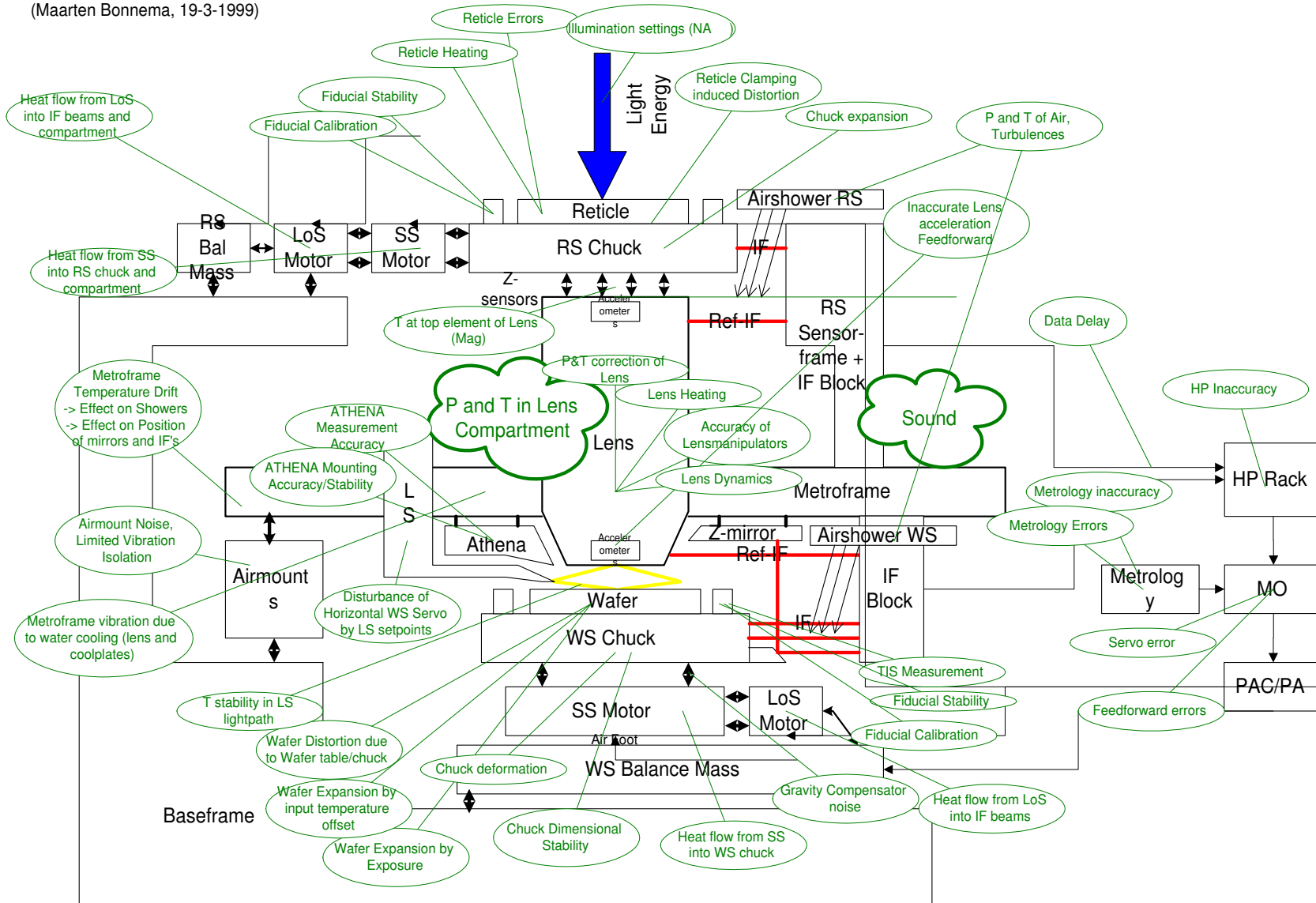


# Everything influences overlay

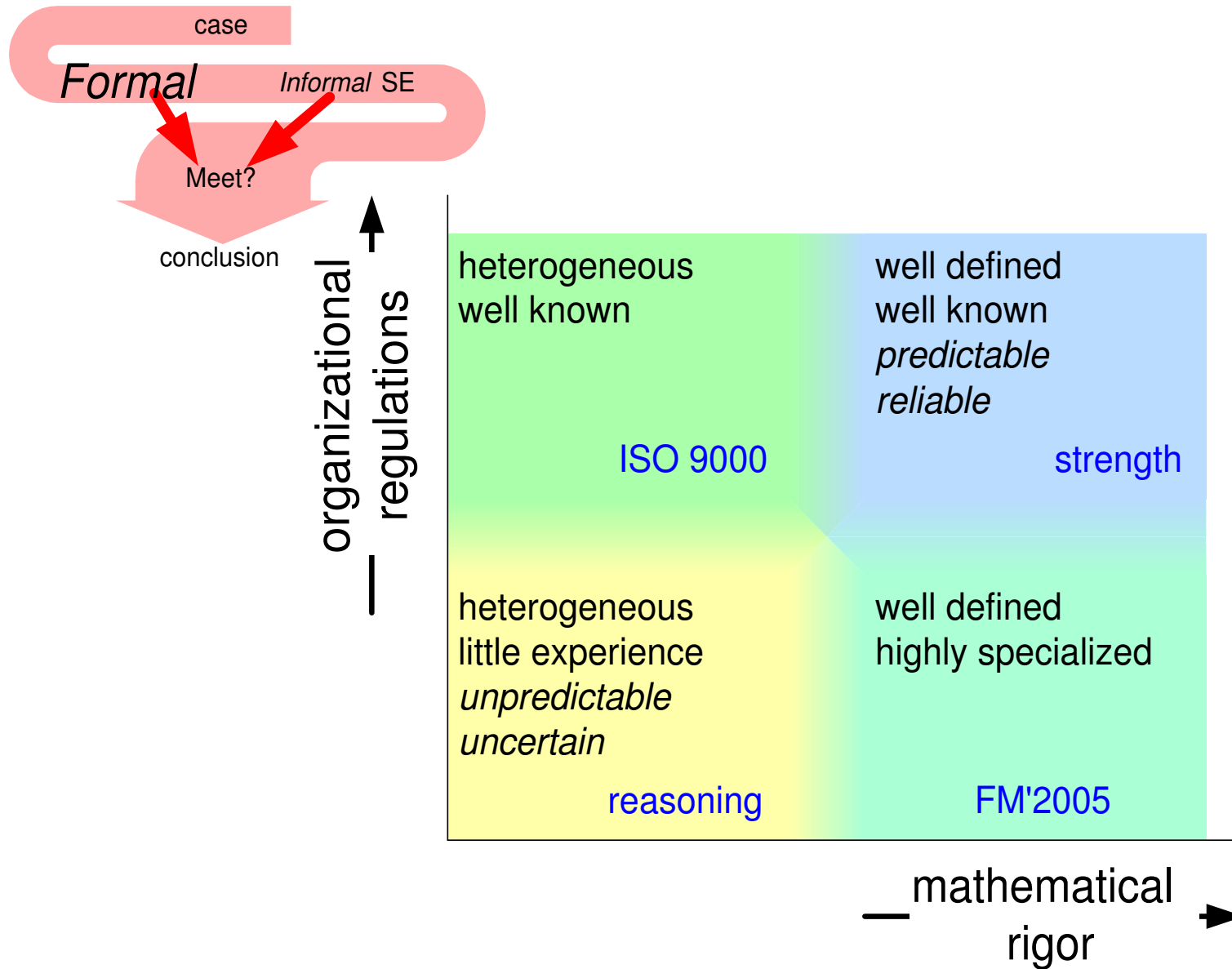
## Overlay Influence Diagram.

(Maarten Bonnema, 19-3-1999)

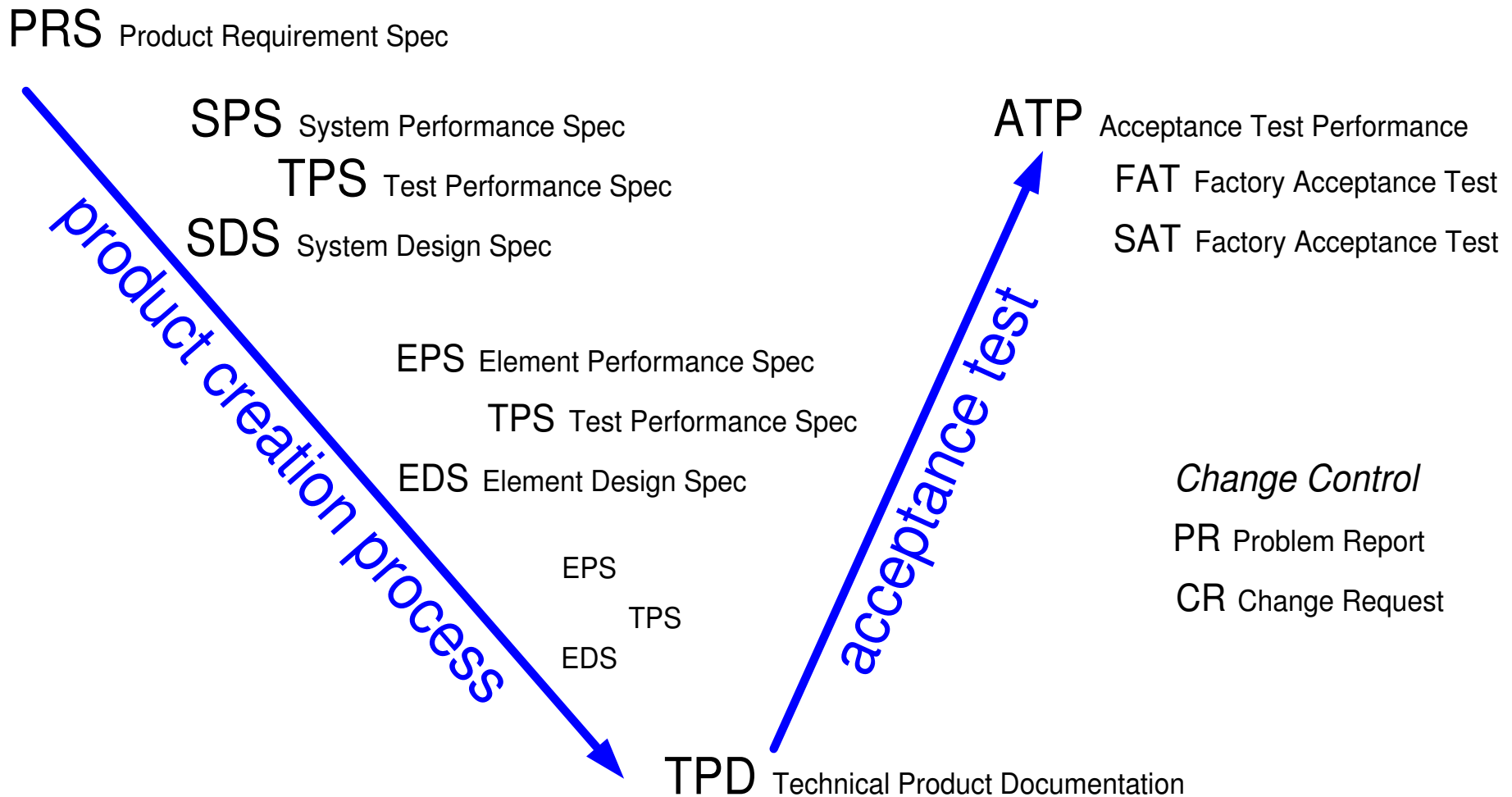
□ : Fiducial



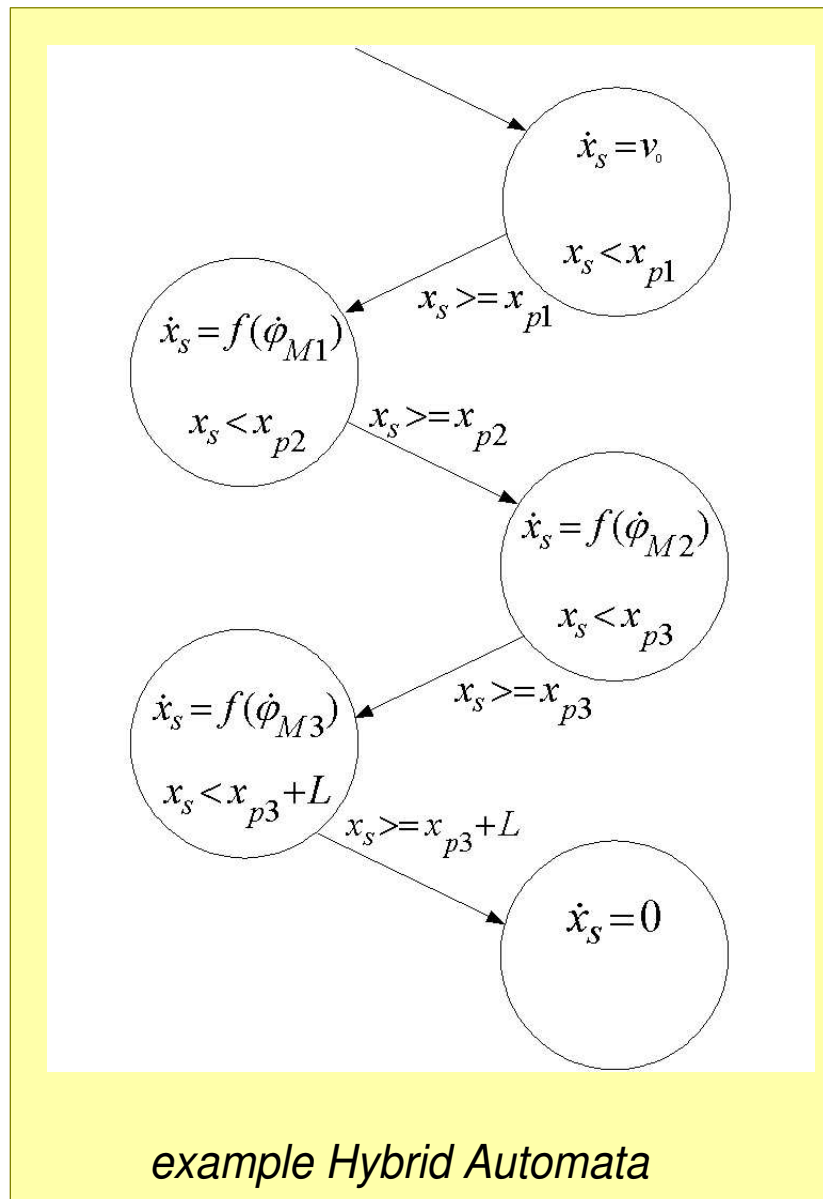
# What is Formal?



# Process: Formal Documents



# Formal in Mathematical sense

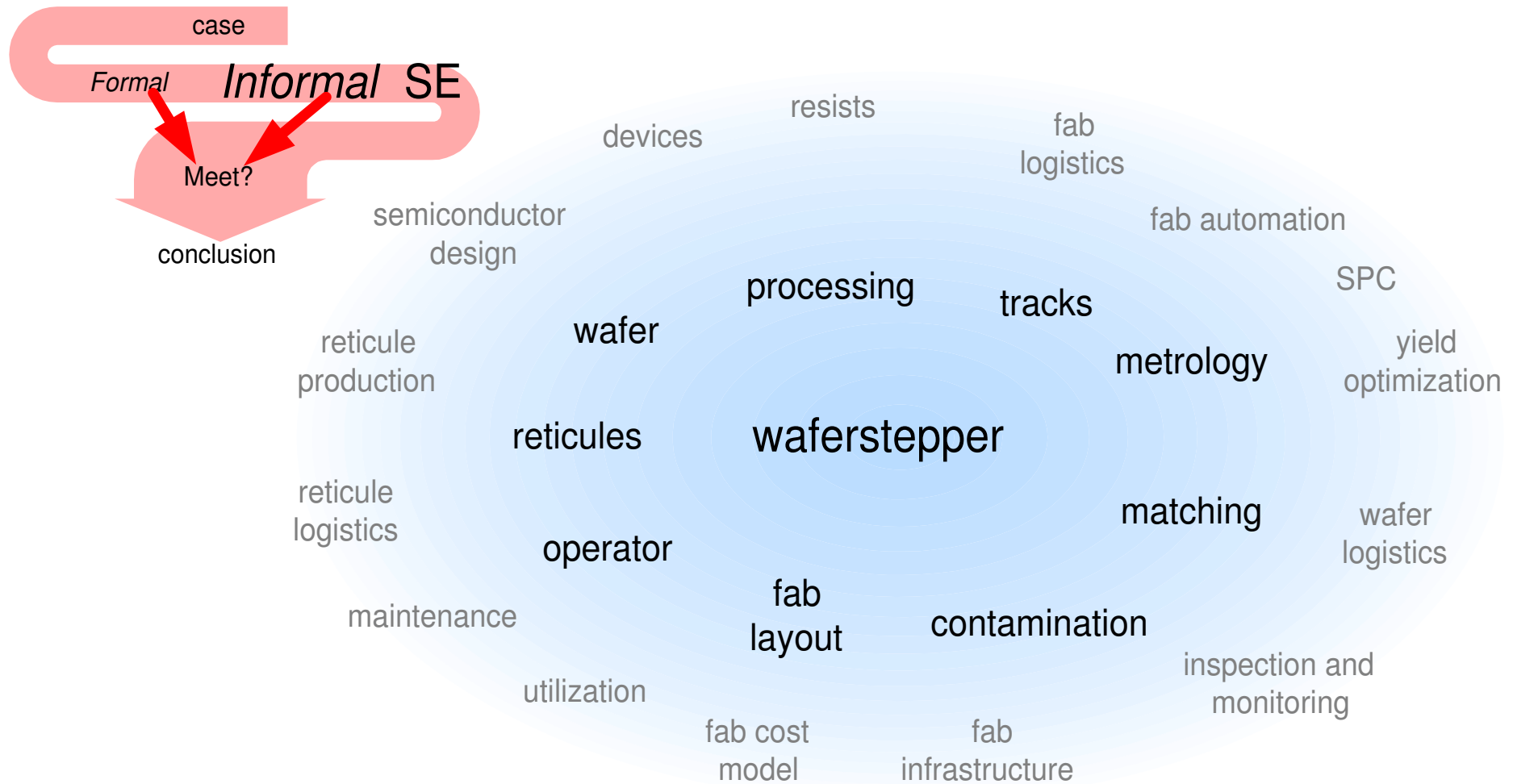


$$\dot{x}_s(t) = \begin{cases} v_0 & \text{if } x_s < x_{p1} \\ A_1 x_s(t) + B_1 u(t) & \text{if } x_s \geq x_{p1} \wedge x_s < x_{p2} \\ A_2 x_s(t) + B_2 u(t) & \text{if } x_s \geq x_{p2} \wedge x_s < x_{p3} \\ A_3 x_s(t) + B_3 u(t) & \text{if } x_s \geq x_{p3} \wedge x_s < x_{p3} + L \\ 0 & \text{if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

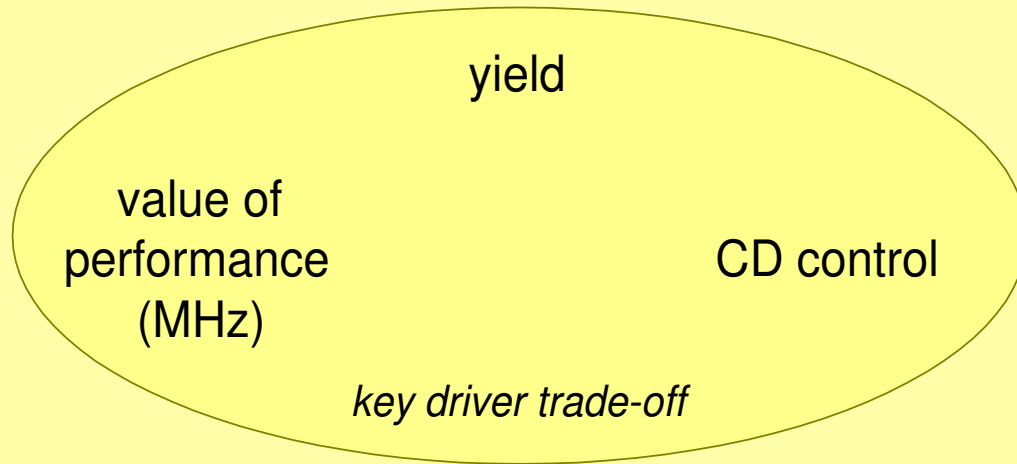
*example PieceWise Linear Systems*

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

# Fab Context of Waferstepper



# Business Context

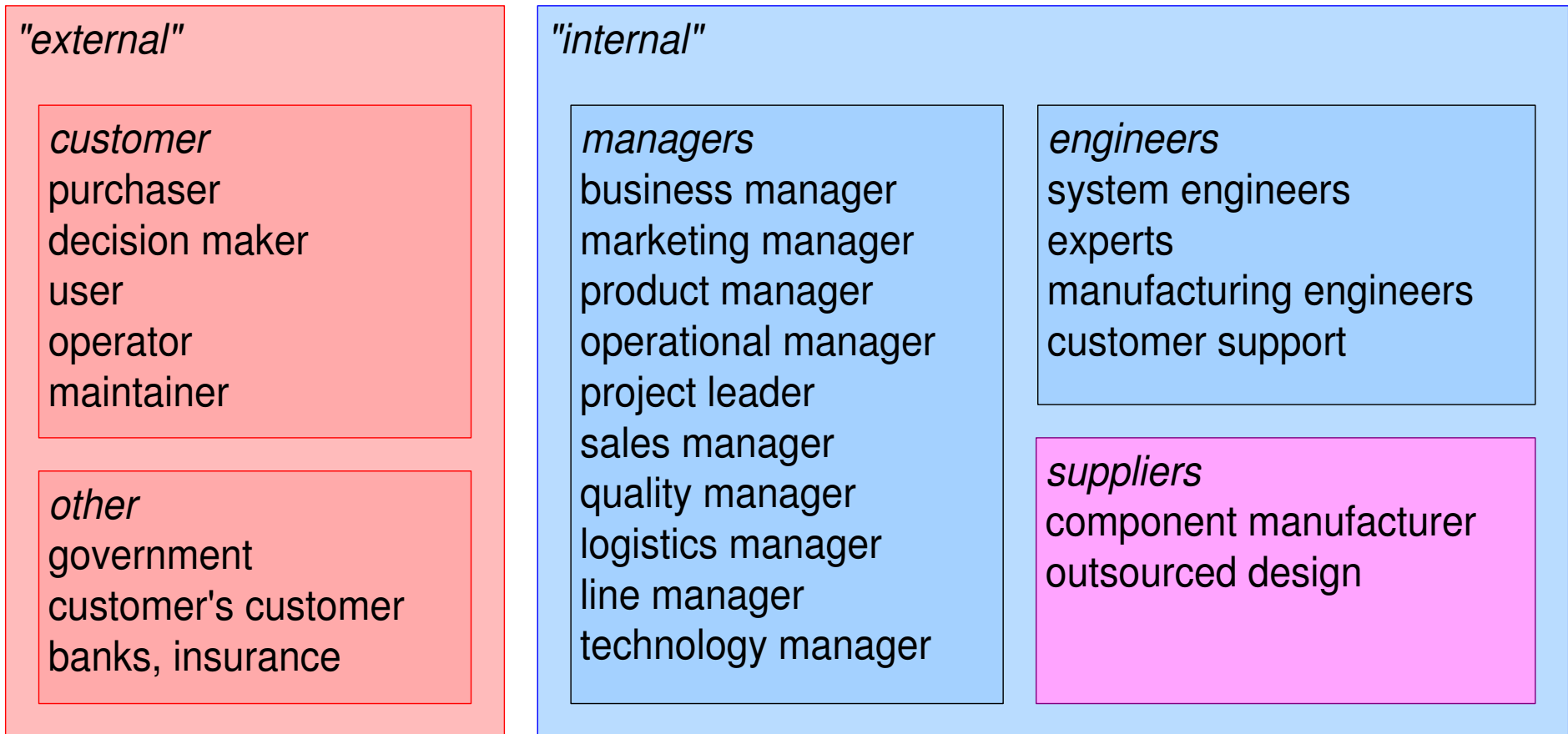


other players:  
equipments vendors  
system integrators  
lease companies  
fab designers  
consultants  
mask makers  
resist makers  
wafer makers  
OEM's: laser  
intimate partners: lens

business models of the customer:  
design houses  
foundries  
vertical integration

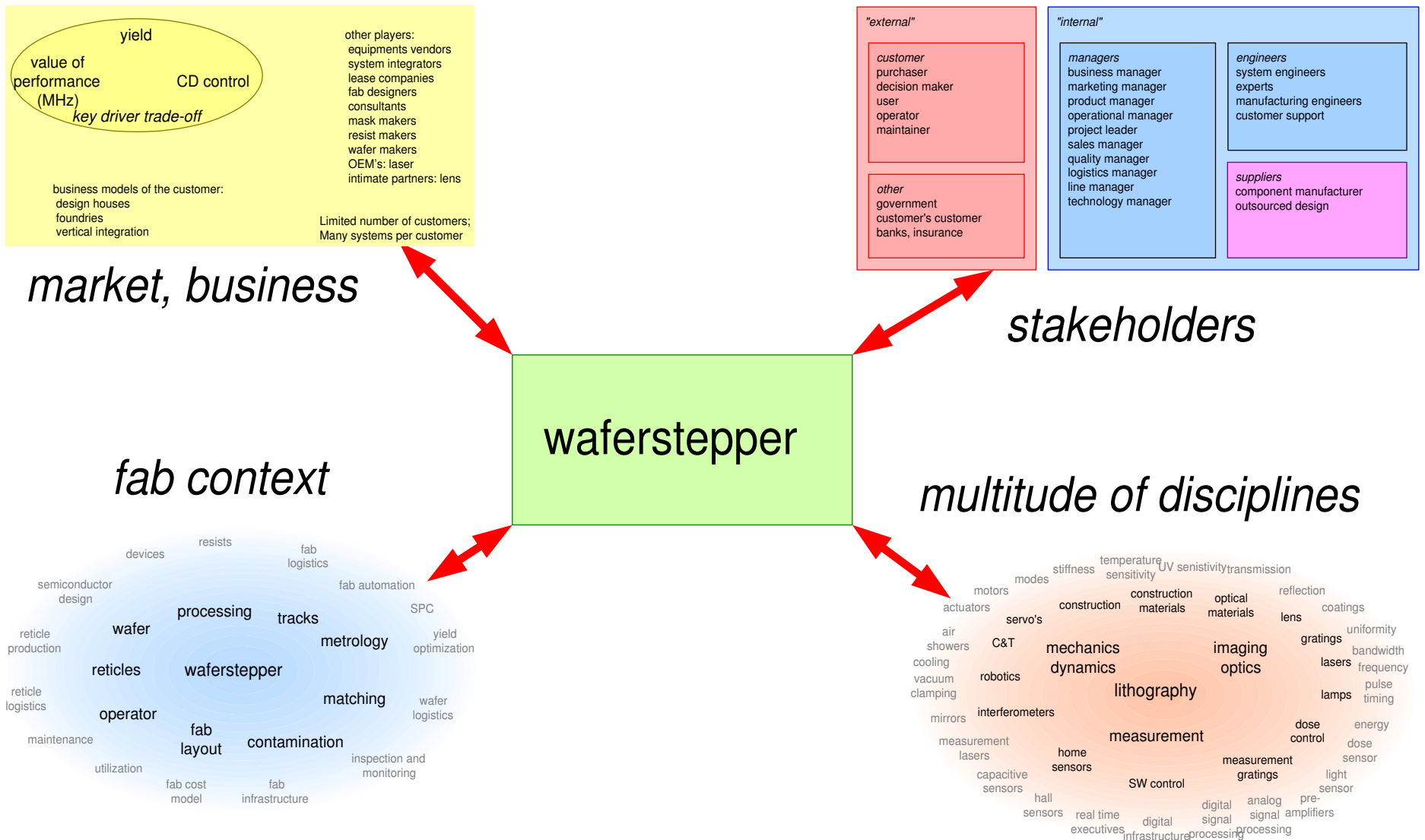
Limited number of customers;  
Many systems per customer

# Human Context: Stakeholders

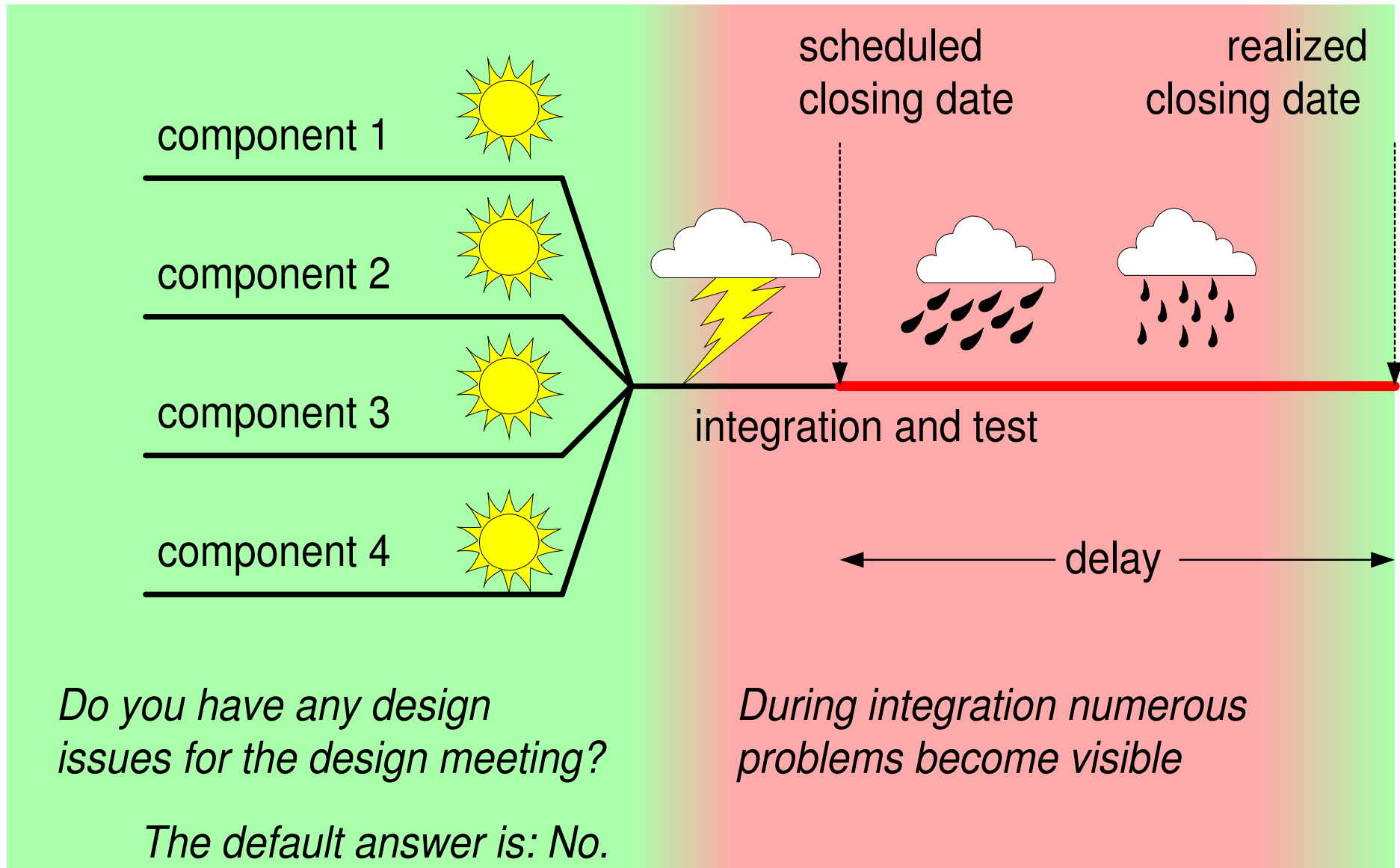




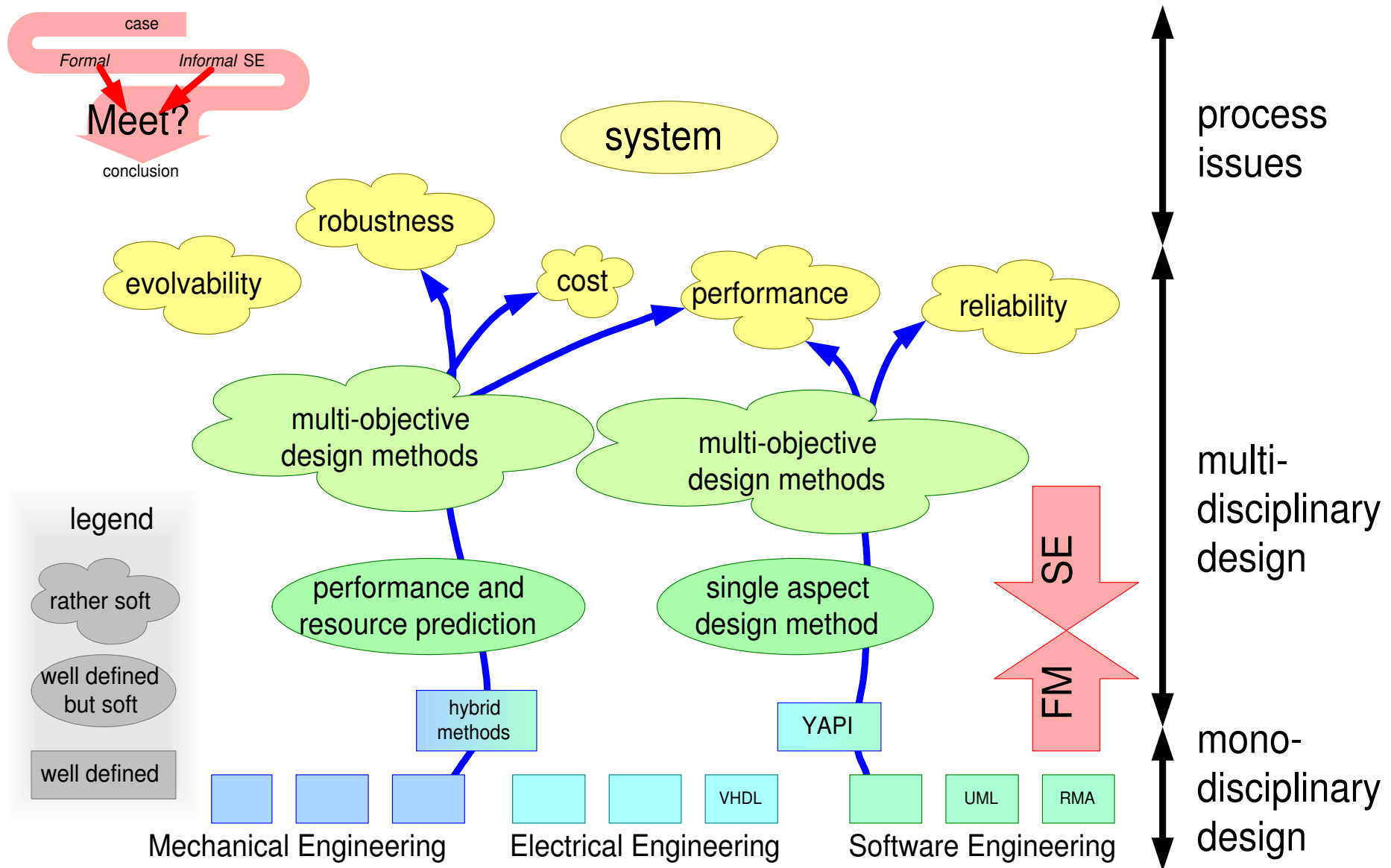
# Complexity of Waferstepper Context



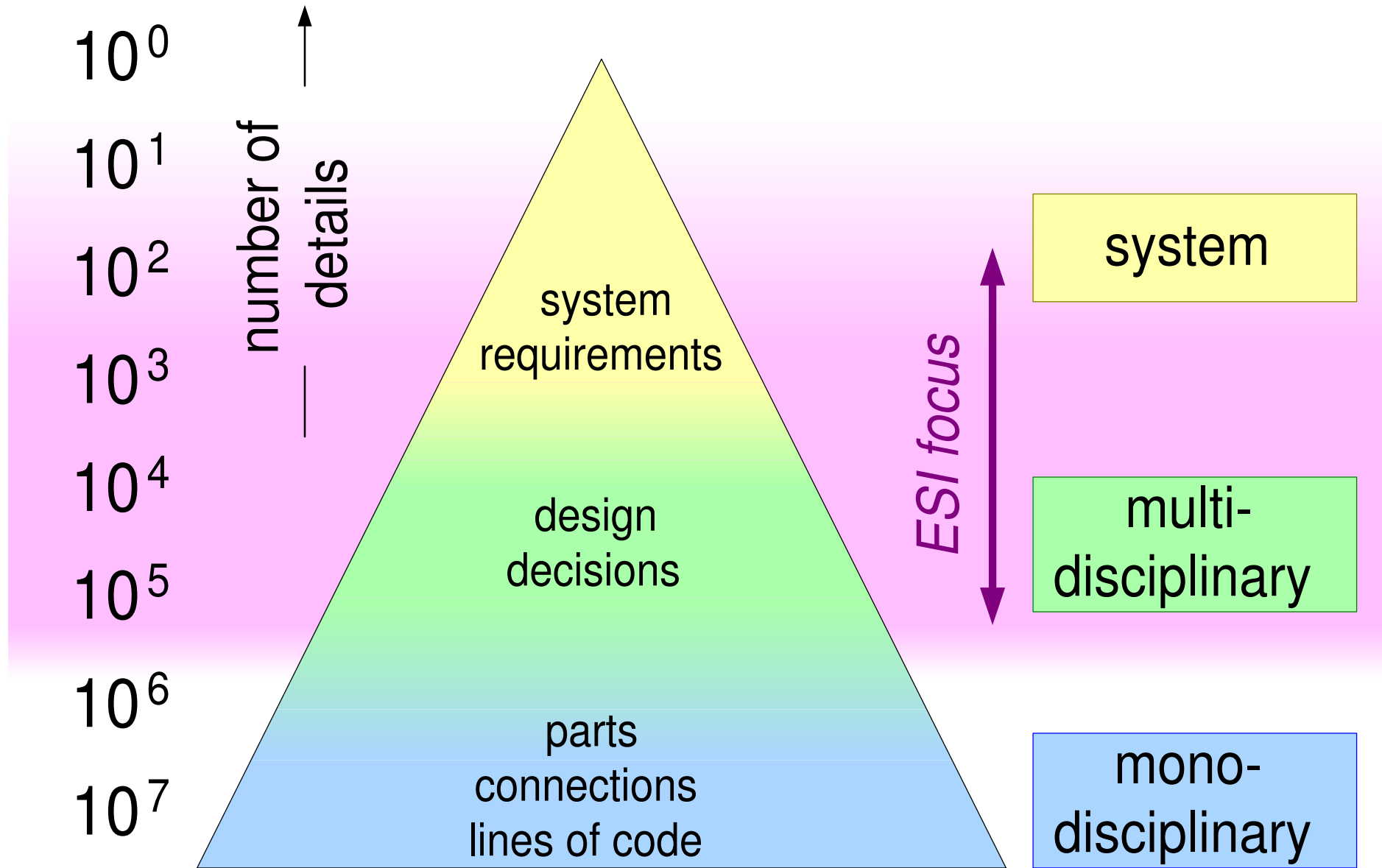
# Symptom: Delays appear during Integration



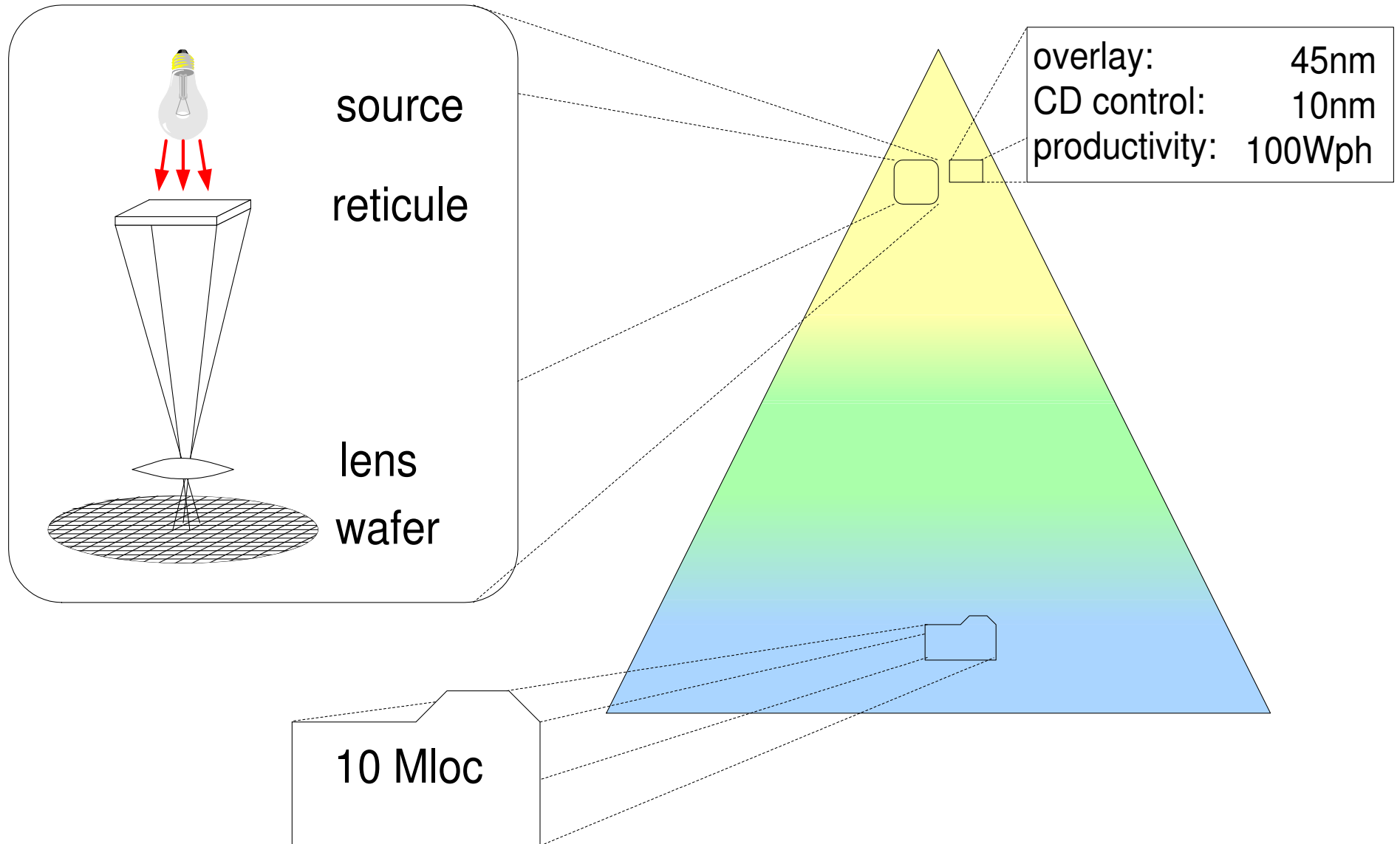
# From Mono-Disciplinary to System



# Exponential Pyramid, from requirement to bolts and nuts



# Waferstepper Example



# Postulate

---

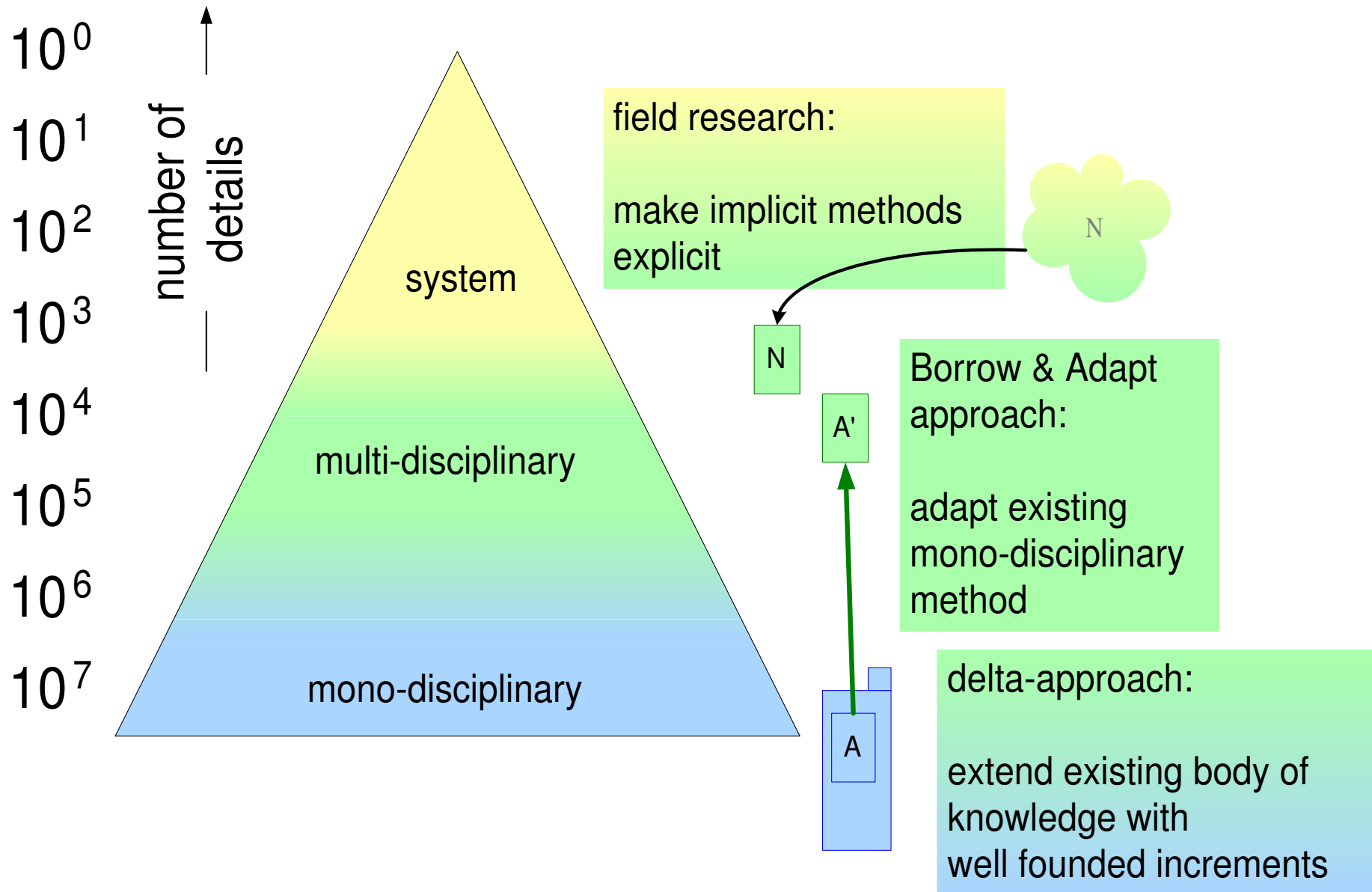
engineering  
architecting  
formal

engineering  
architecting  
formal

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

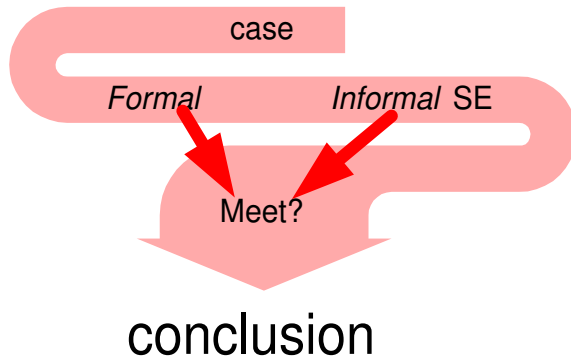
skills of "formal" people:  
analytical  
structural  
firm of principle  
consistent

# Multi-disciplinary Research Approaches



# Conclusion

---



*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