

The Informal Nature of Systems Engineering

by *Gerrit Muller* Embedded Systems Institute

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

`www.gaudisite.nl`

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:

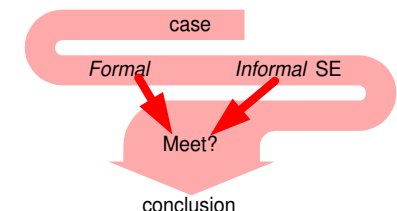
- well defined formalized SE methods
- strong process focused
- “common sense”, based on human experience and intelligence

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.

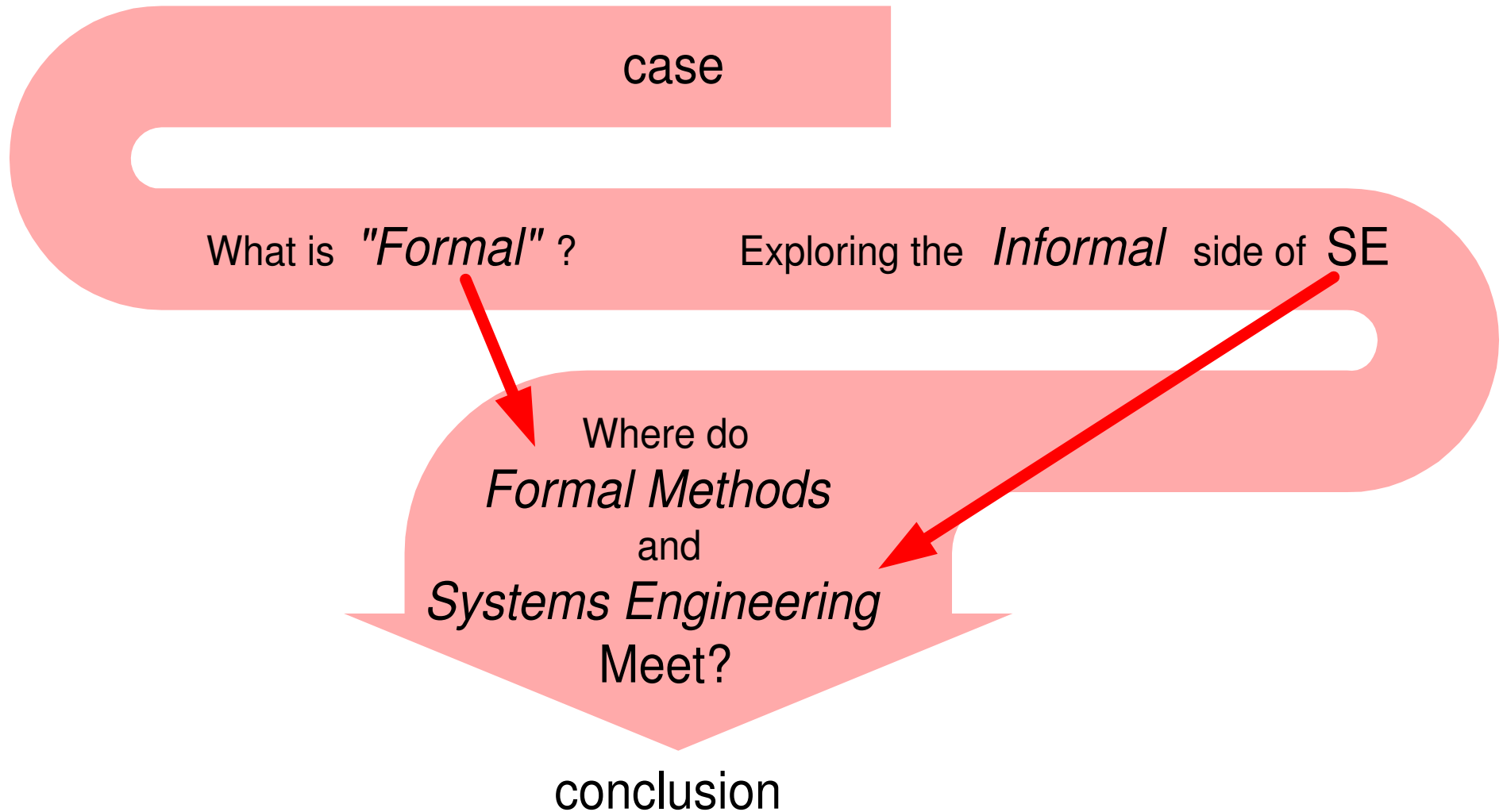
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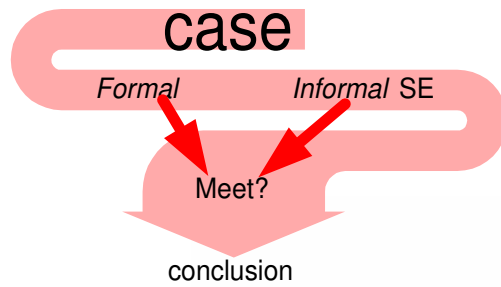
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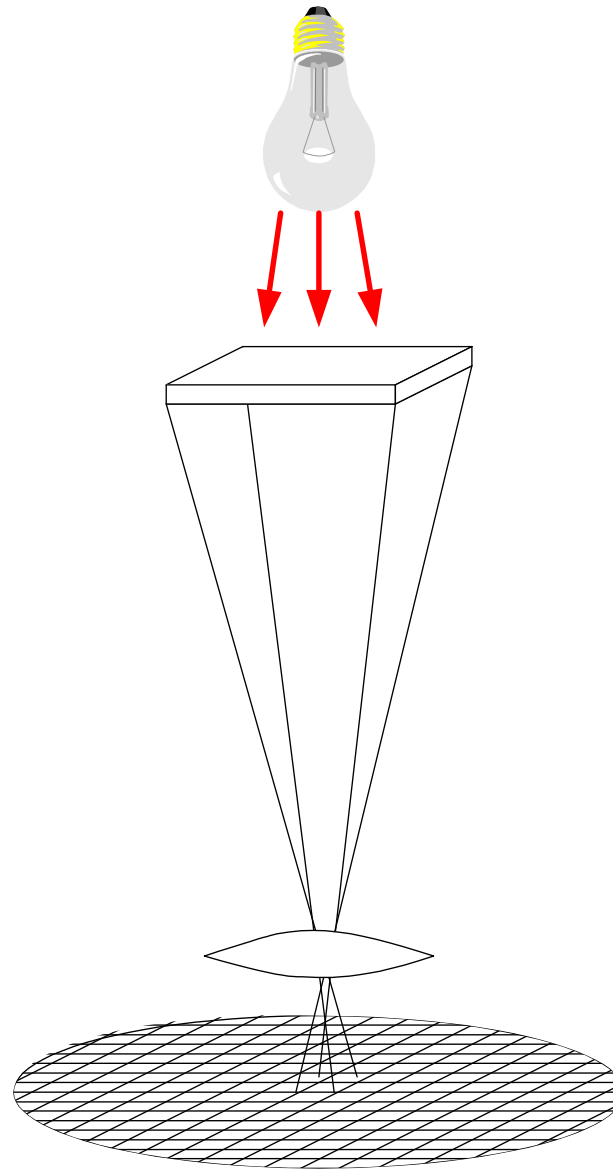
Presentation Outline



Twinscan AT1100



What is a waferstepper



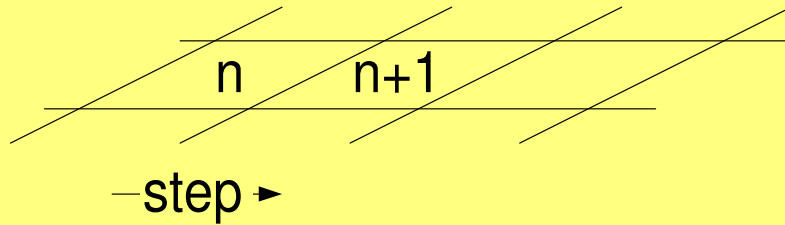
source

reticle

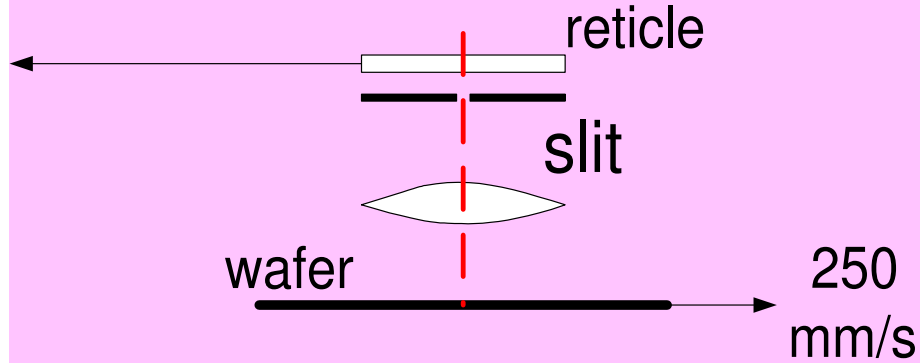
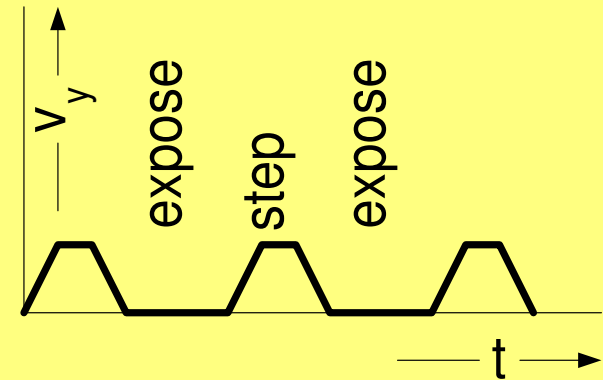
lens

wafer

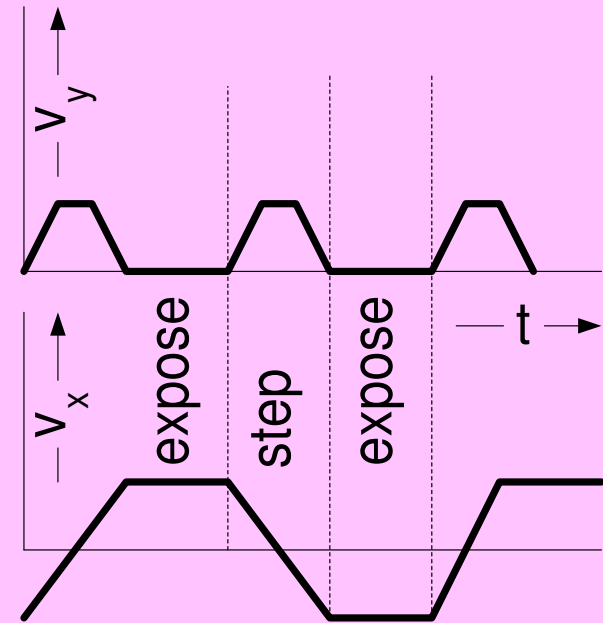
From stepping to scanning



stepper: static exposure of field

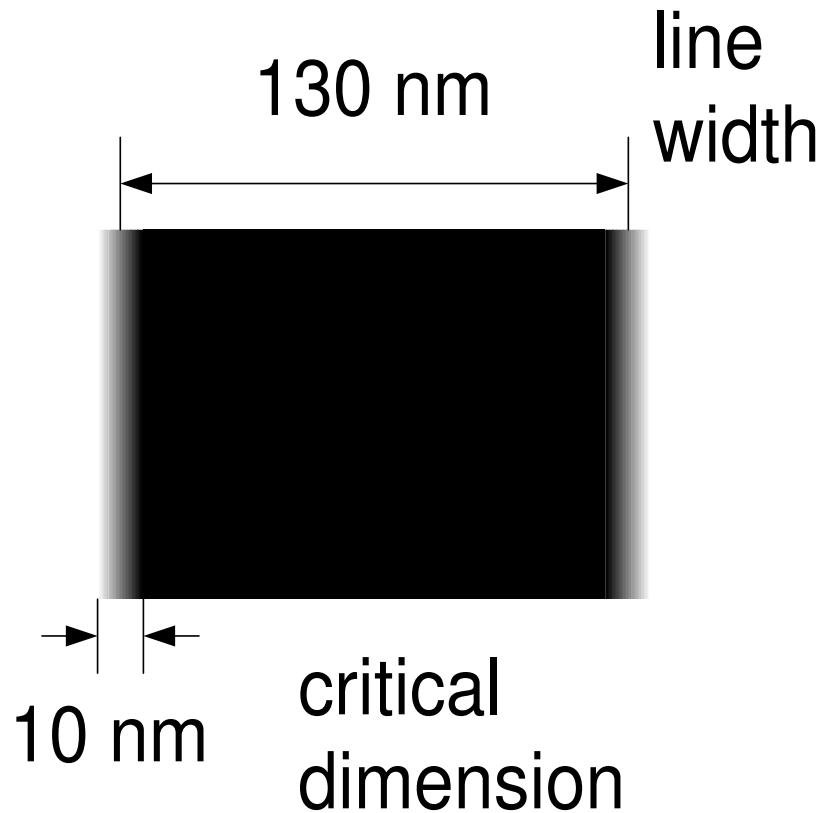


scanner: dynamic exposure through slit

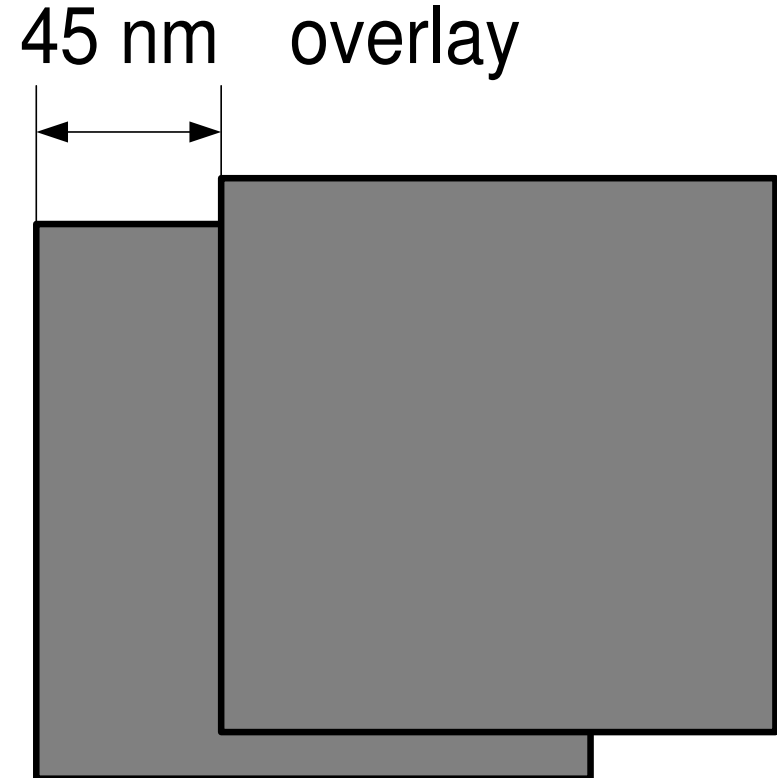


Key specifications waferstepper

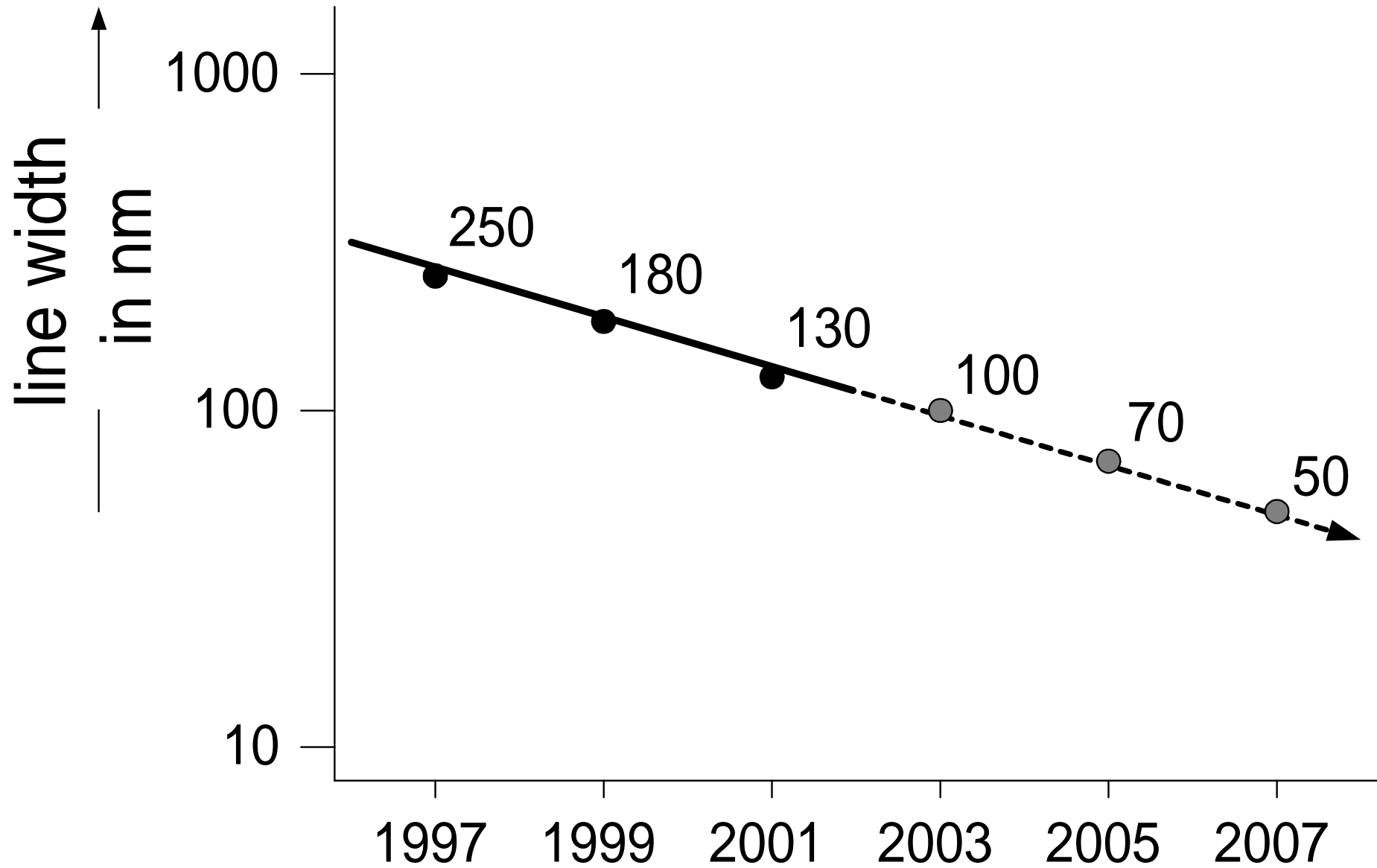
imaging



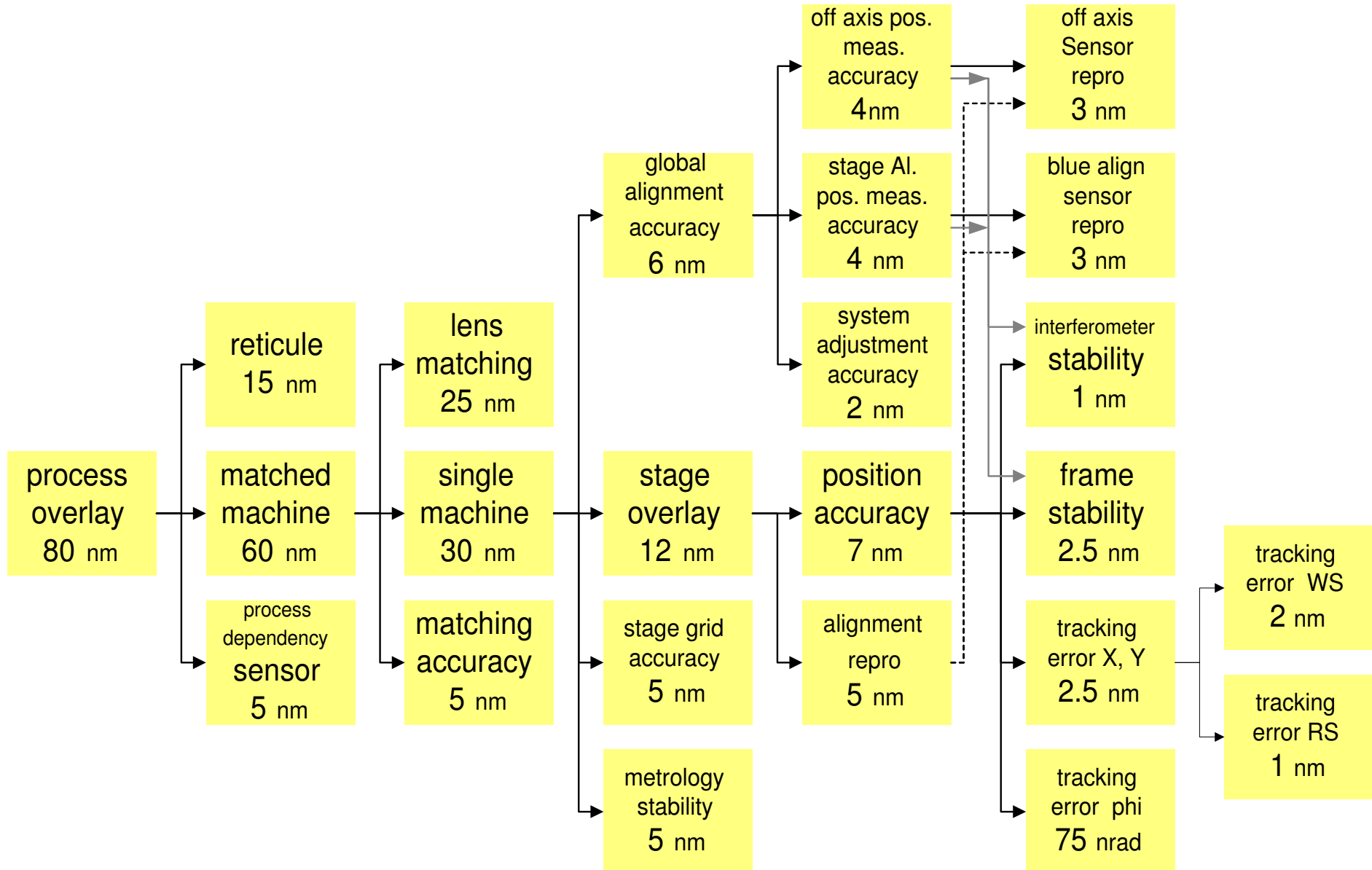
alignment



Moore's law



Overlay budget (1999)

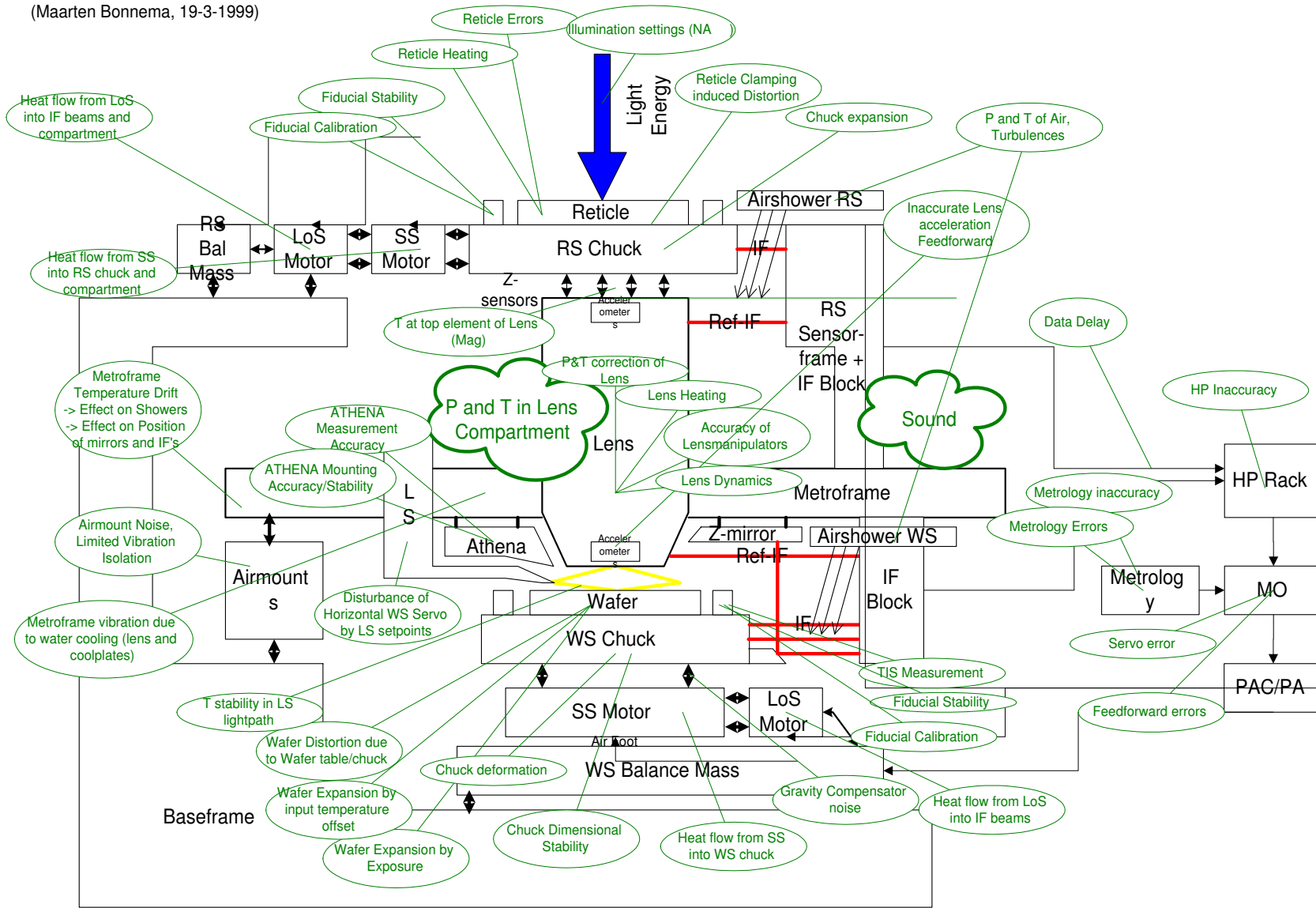


Everything influences overlay

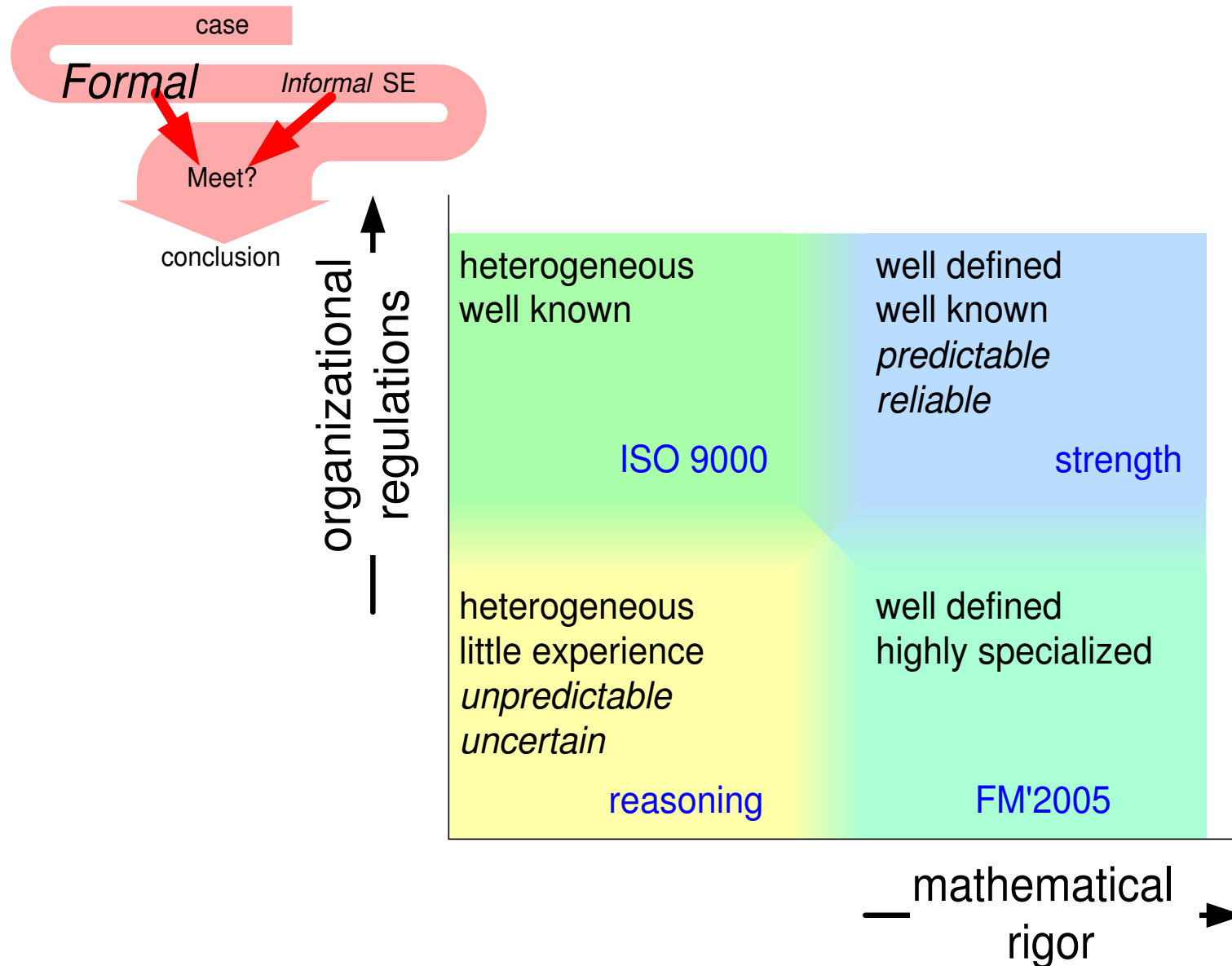
Overlay Influence Diagram.

(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

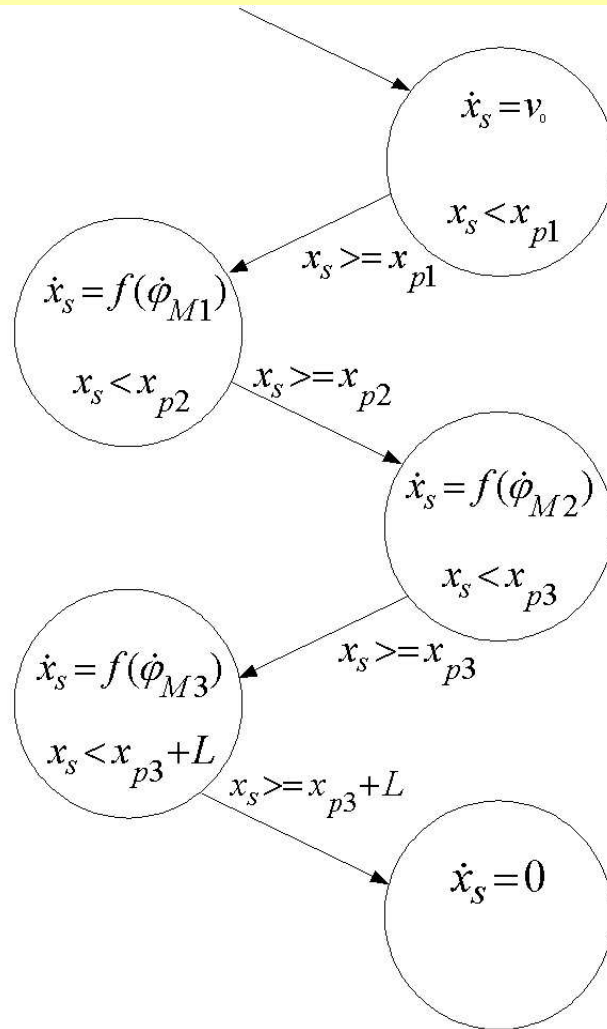
acceptance test

Change Control

PR Problem Report

CR Change Request

Formal in Mathematical sense



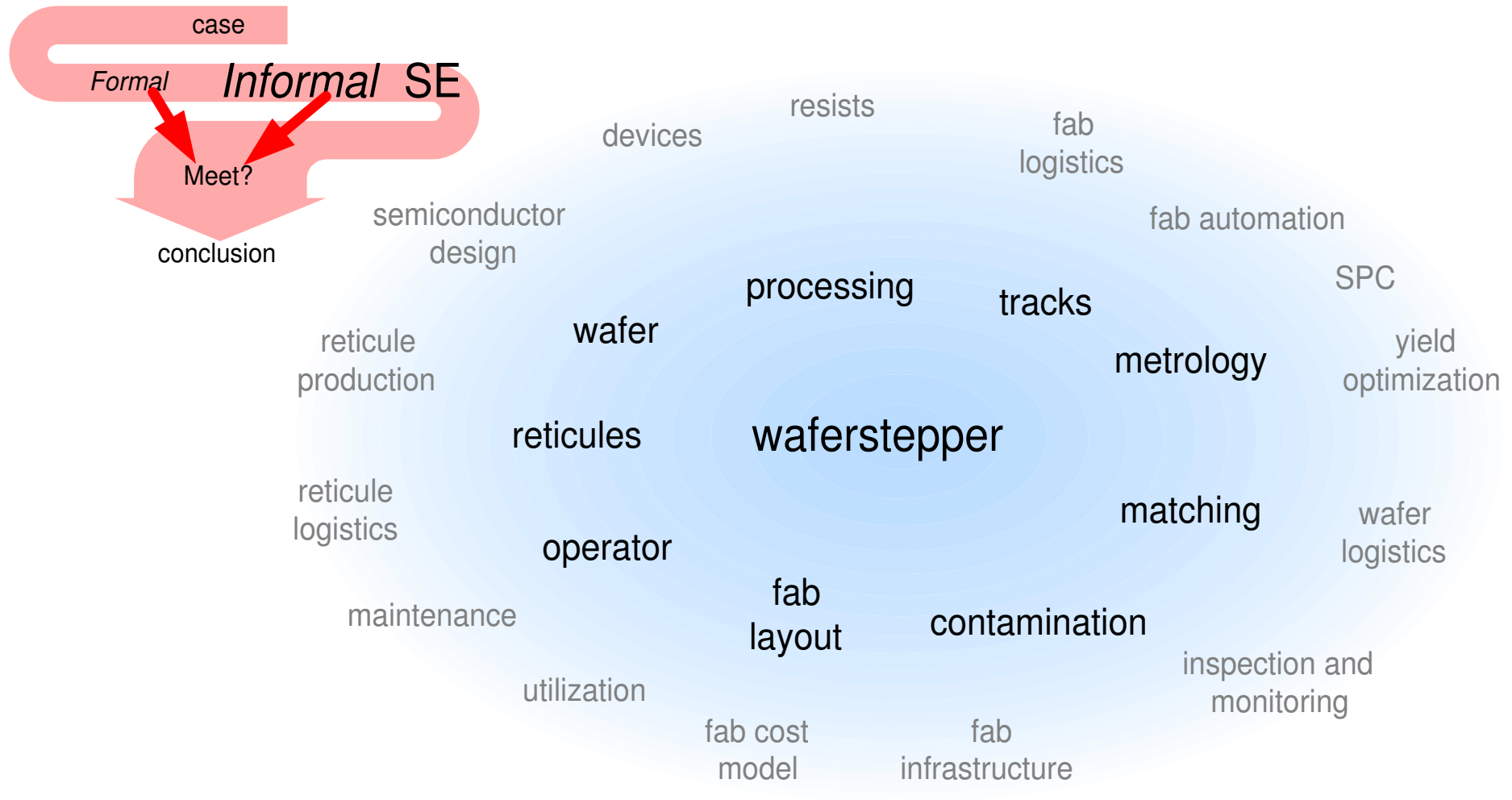
example Hybrid Automata

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

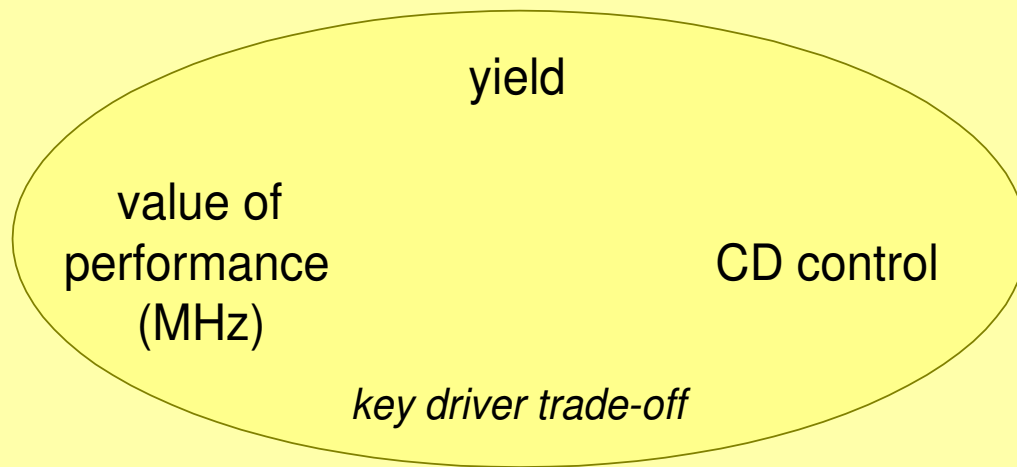
example PieceWise Linear Systems

Examples of *Hybrid Modeling Formalisms*
 Björn Bukkems and Marieke Cloosterman
 Boderic 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

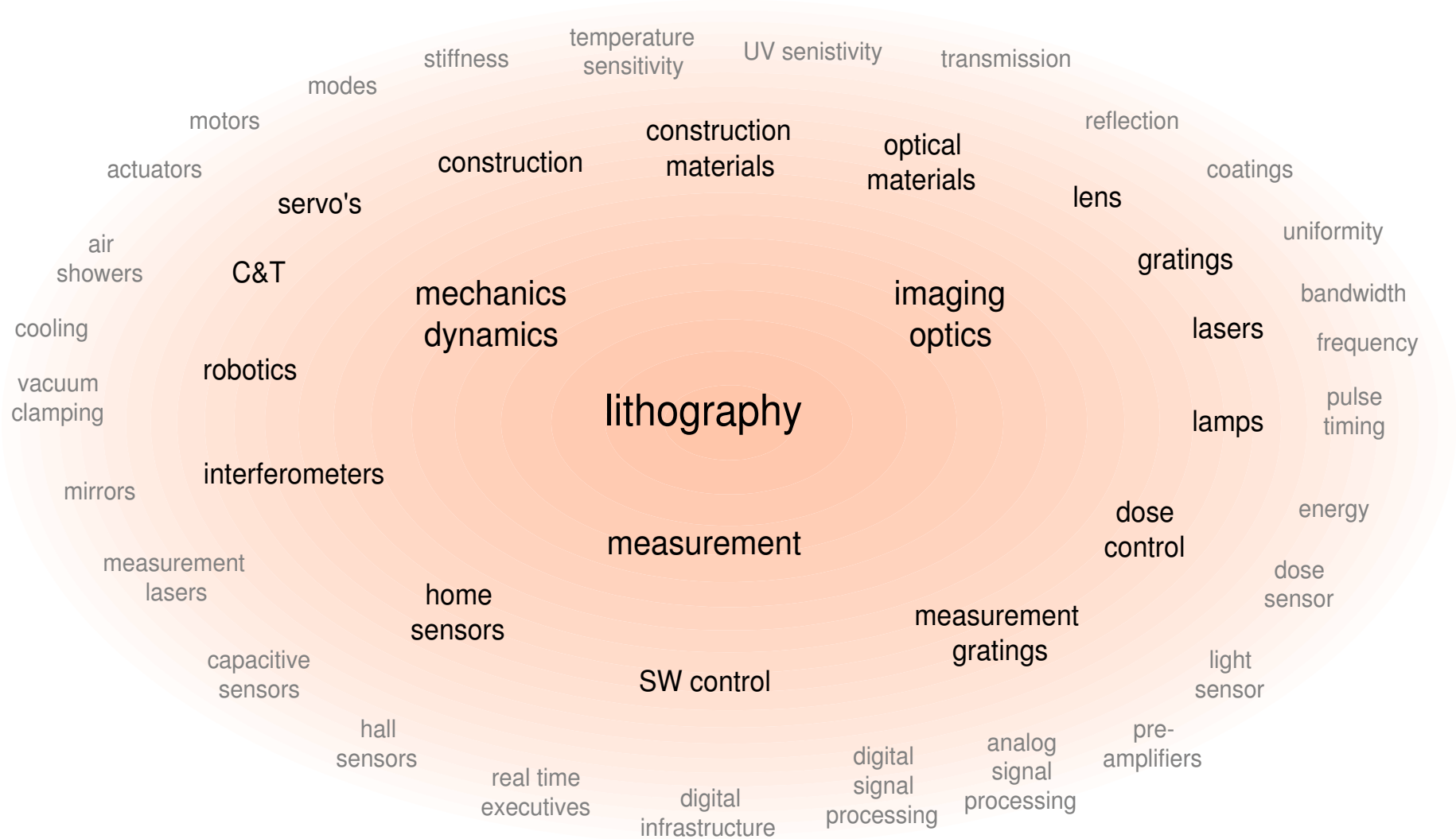
"internal"

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

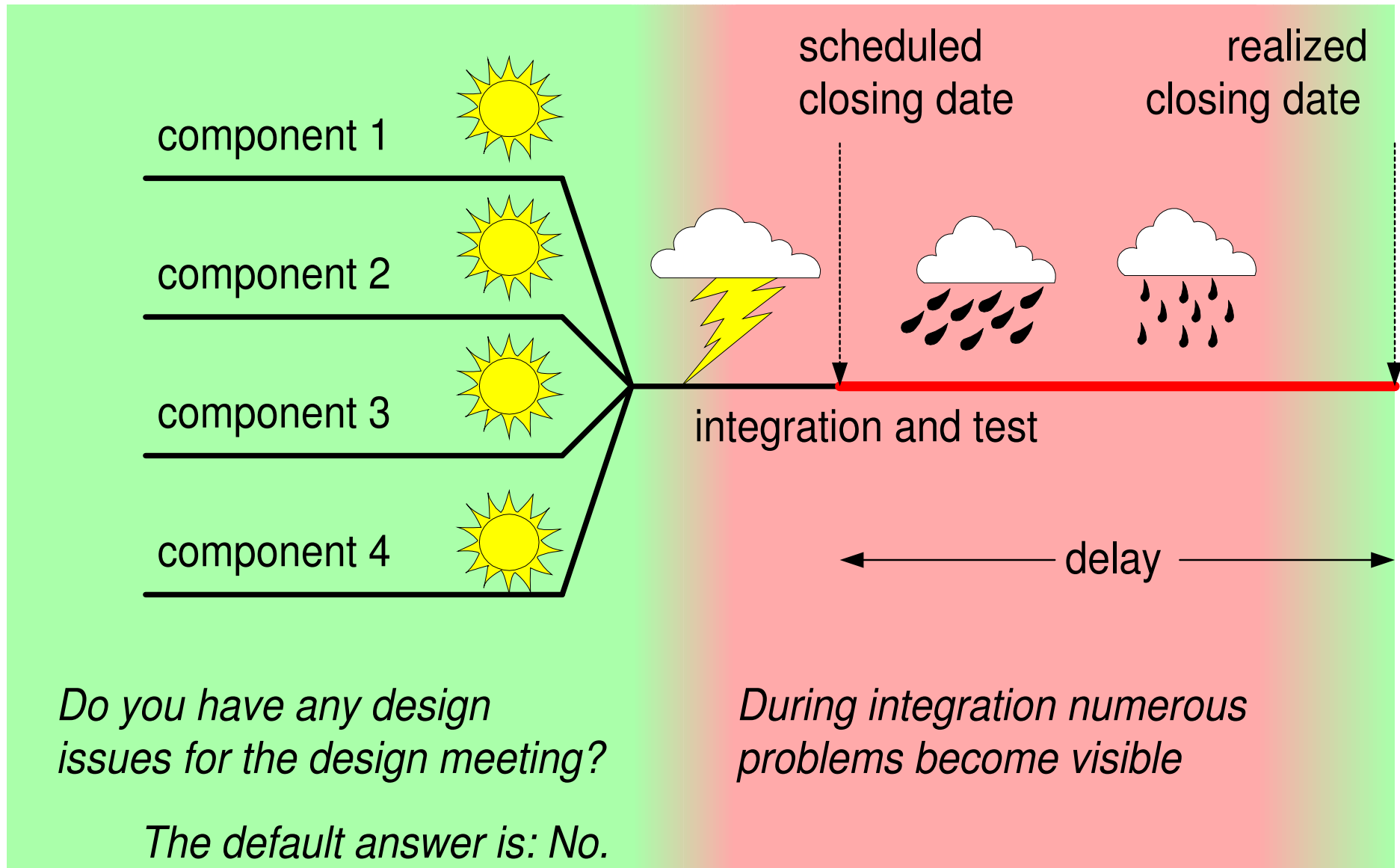
engineers
system engineers
experts
manufacturing engineers
customer support

suppliers
component manufacturer
outsourced design

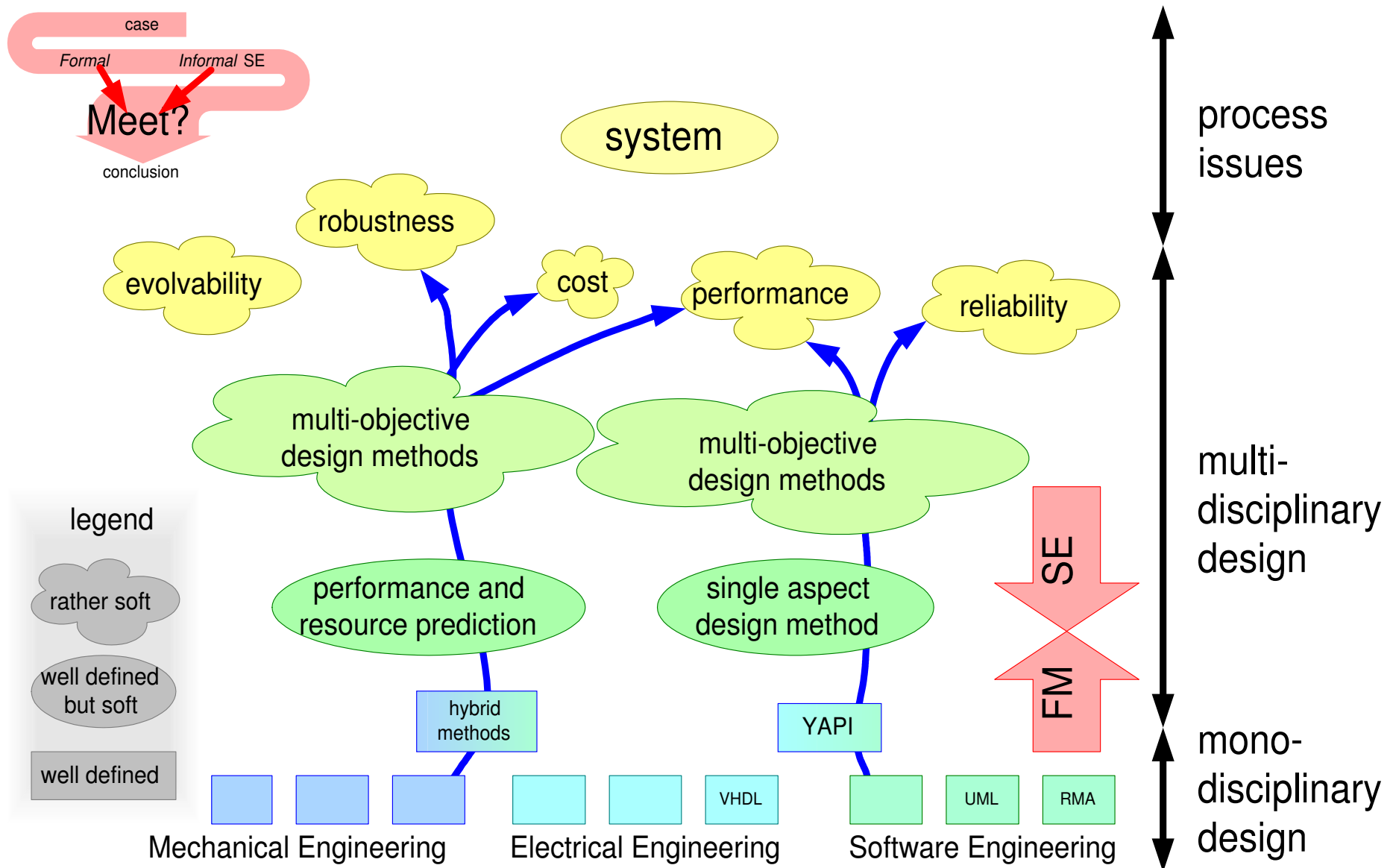
Multitude of Disciplines



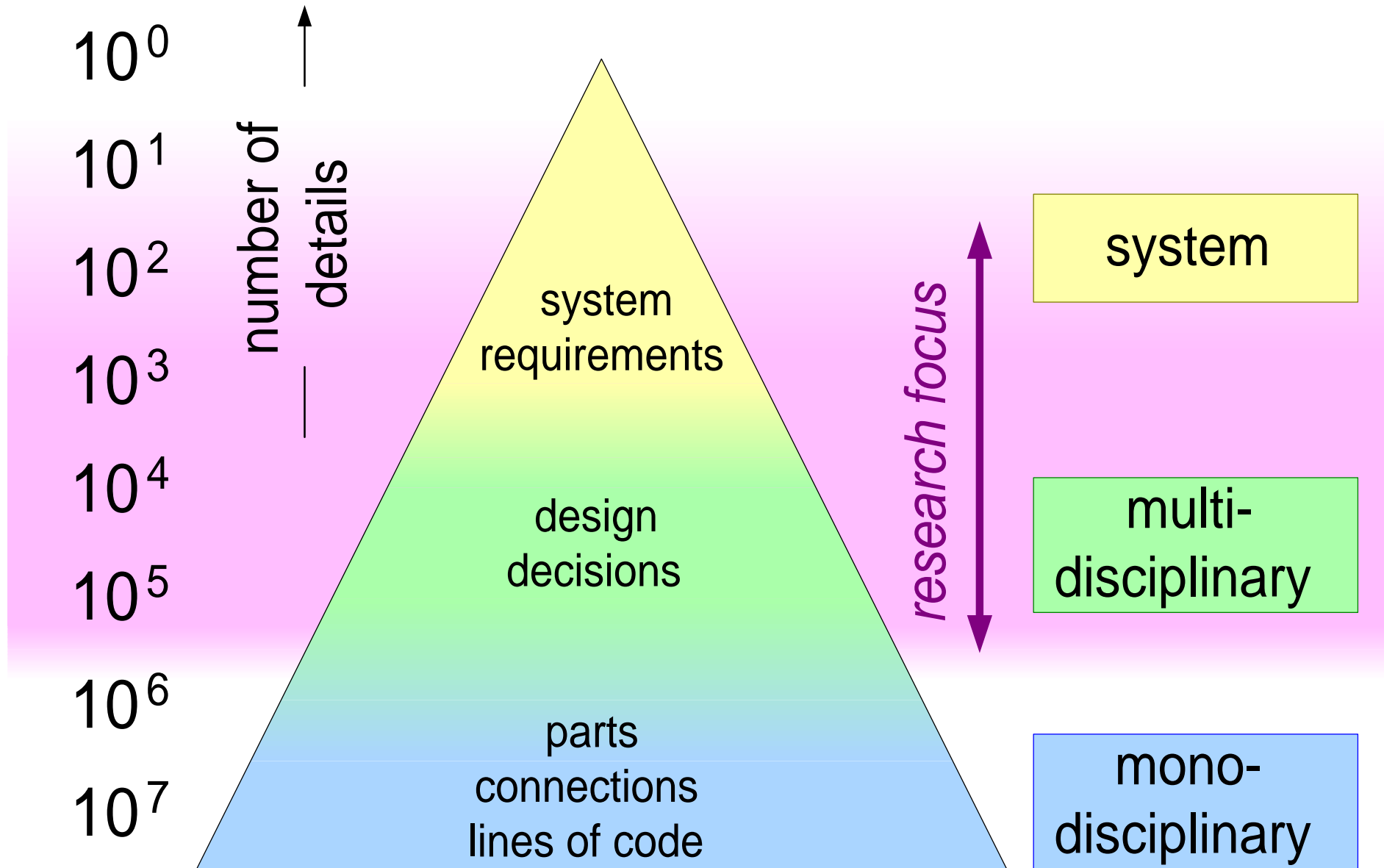
Symptom: Delays appear during Integration



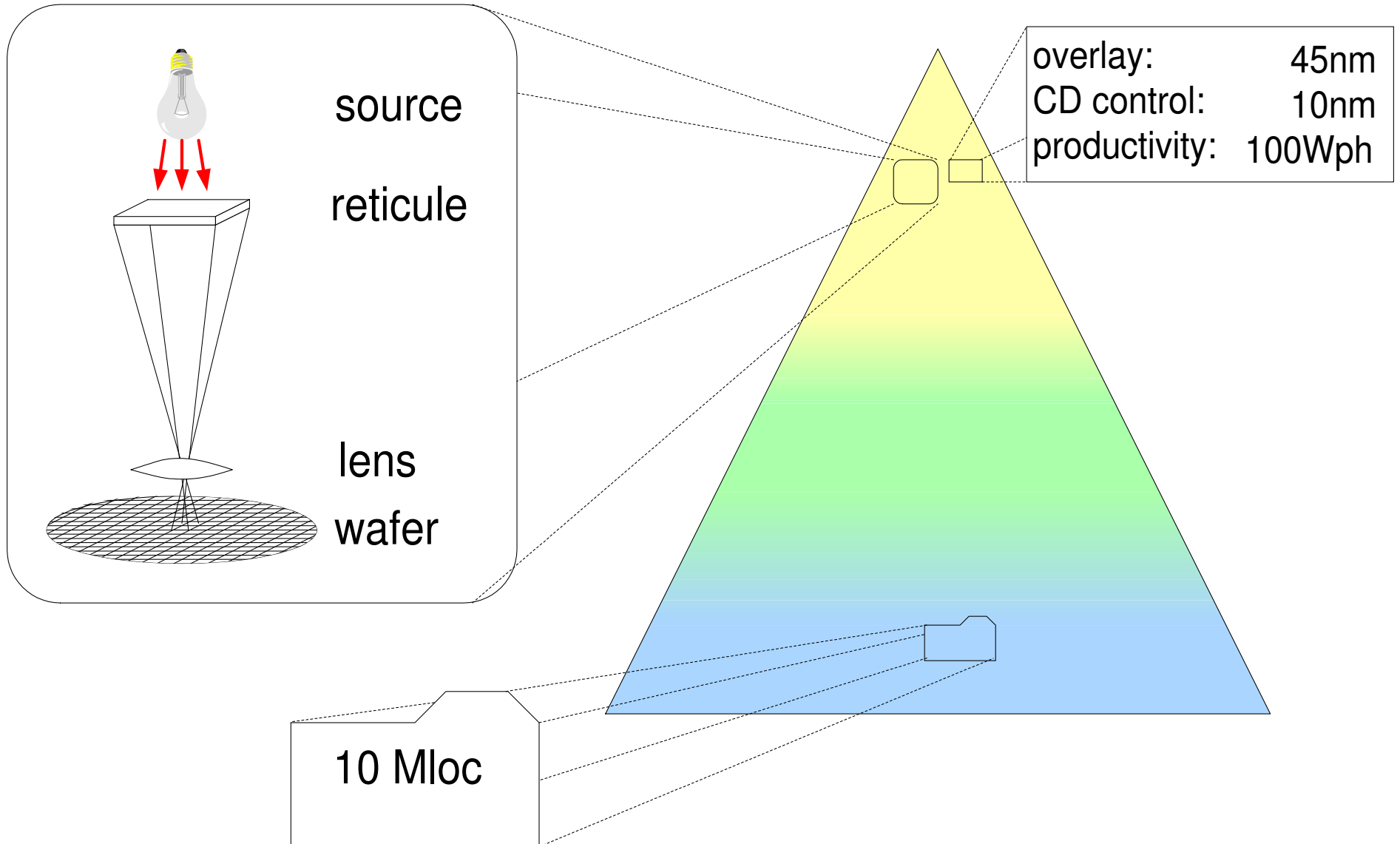
From Mono-Disciplinary to System



Exponential Pyramid, from requirement to bolts and nuts



Waferstepper Example



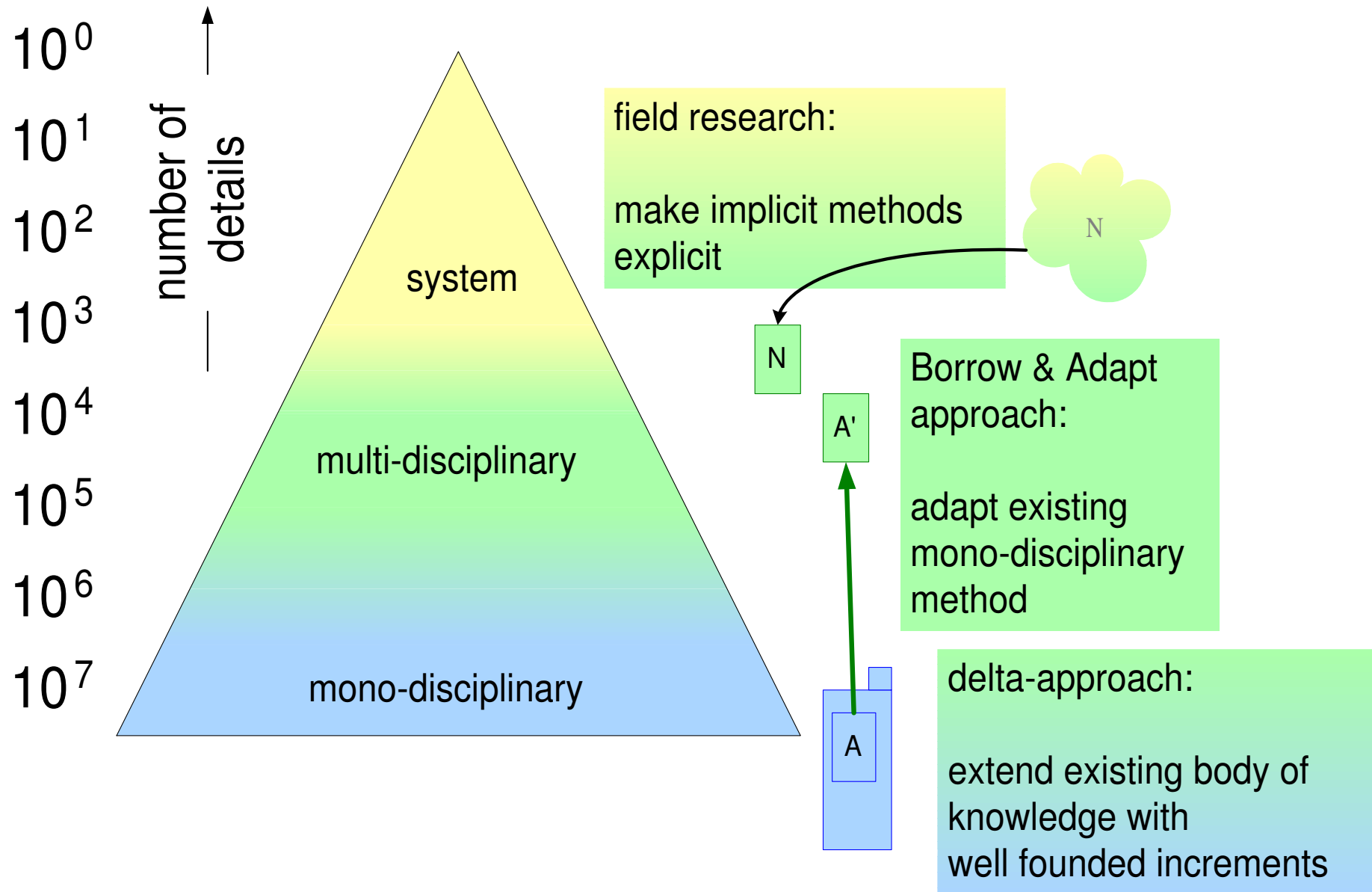
engineering
architecting
formal

engineering
architecting
formal

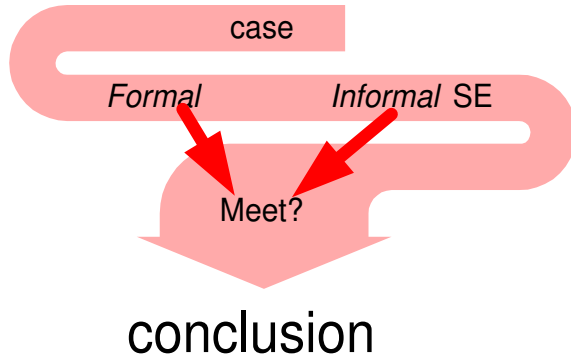
Skills are much more important than **methods**

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