Tutorial Software as Integrating Technology in Complex Systems

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Abstract

This tutorial describes the integrating value of software in complex systems. The extensive use of software technology to integrate other technologies has a significant impact on the product characteristics and on the product creation organization and process. This tutorial provides insight in the relation between software and the system, and it provides insight in the consequences for the product and the organization. Some recommendations are provided to cope with these consequences.

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status: concept
version: 0.1

logo
TBD

Program

- Case: the waferstepper and it's context
- The role of software in general
- Levels of abstraction
- Software -> System Functionality and Qualities
- Requirements perspective
- Evolution and Growth
- Why do we always have problems with software?
- Conclusion

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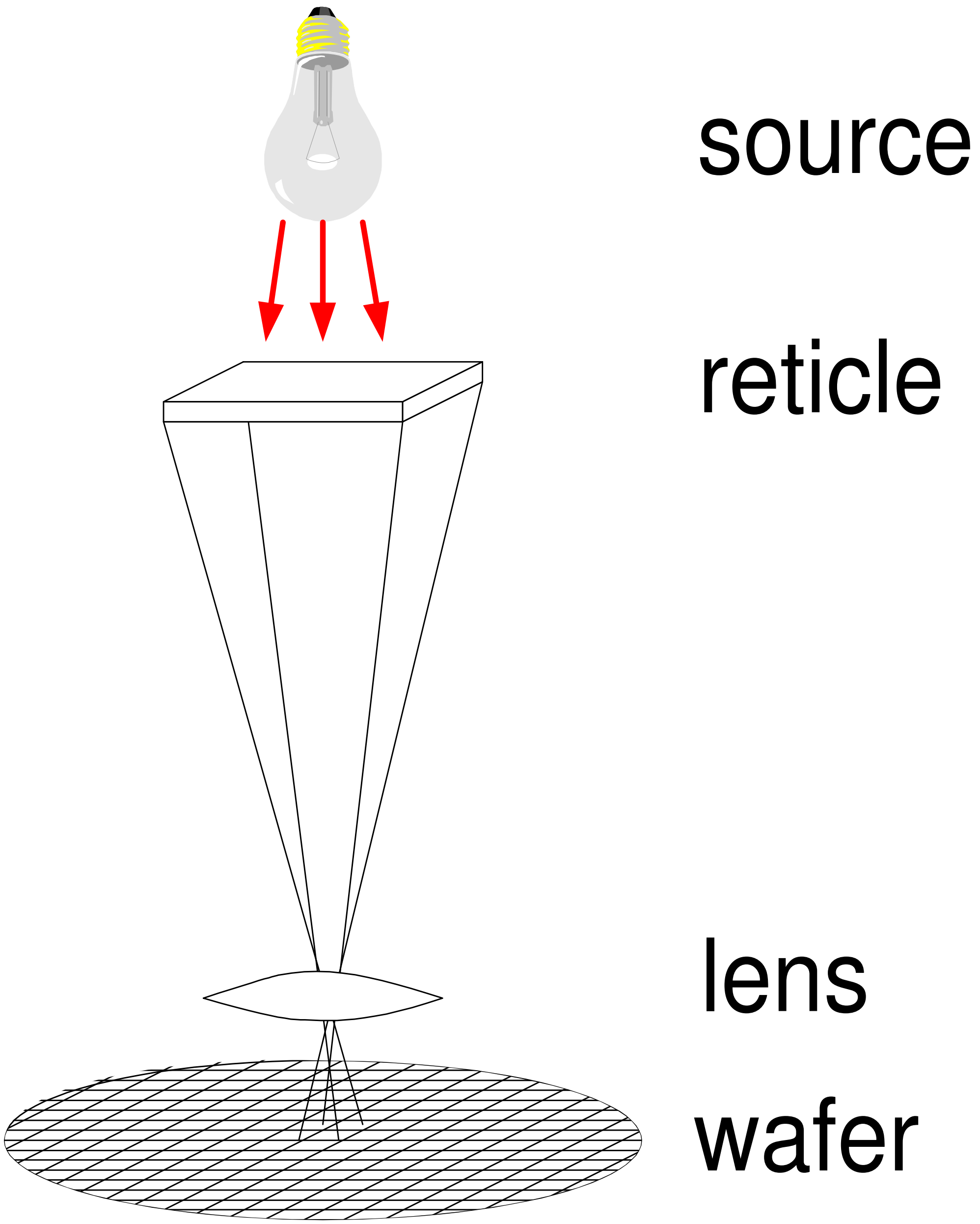
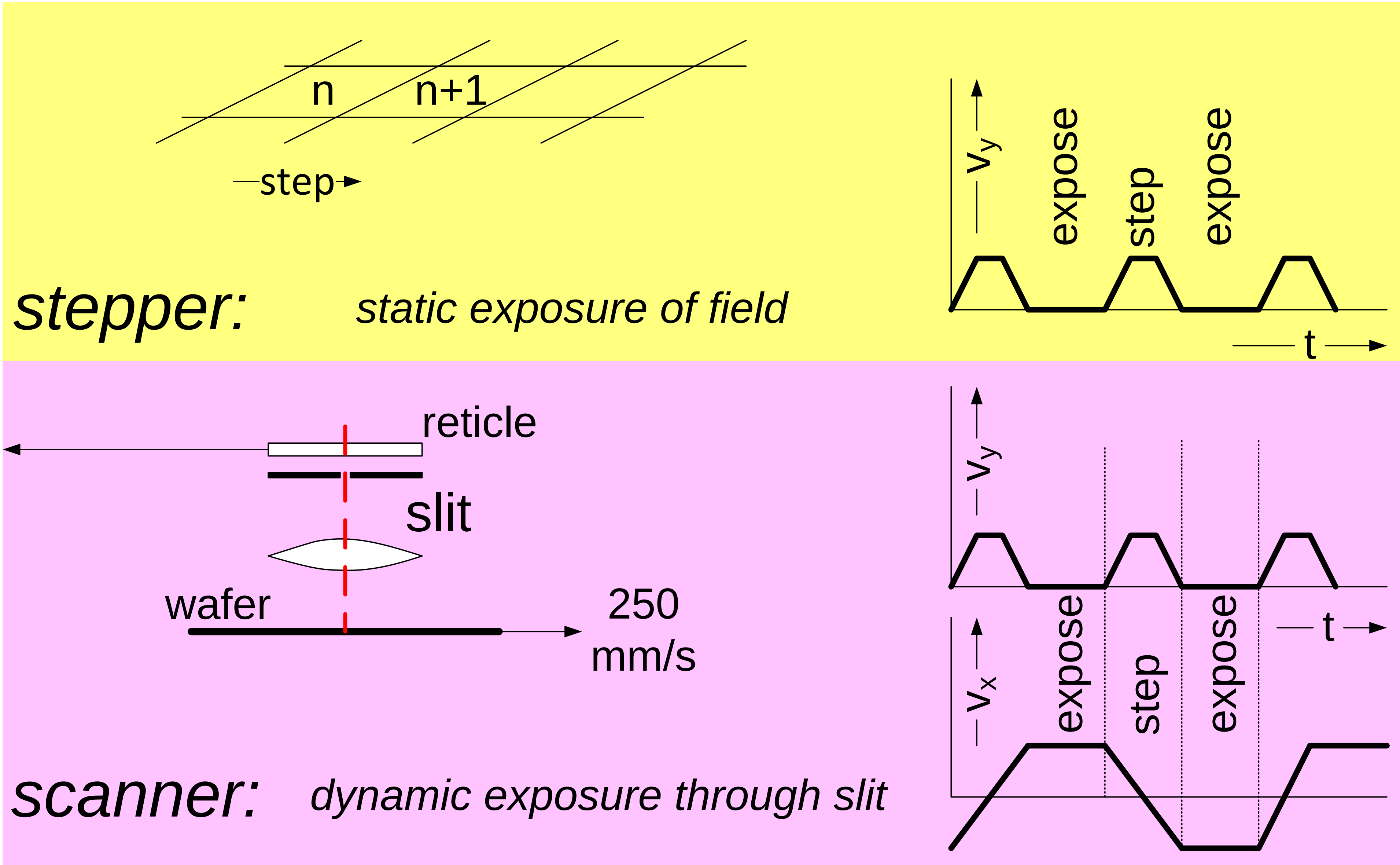
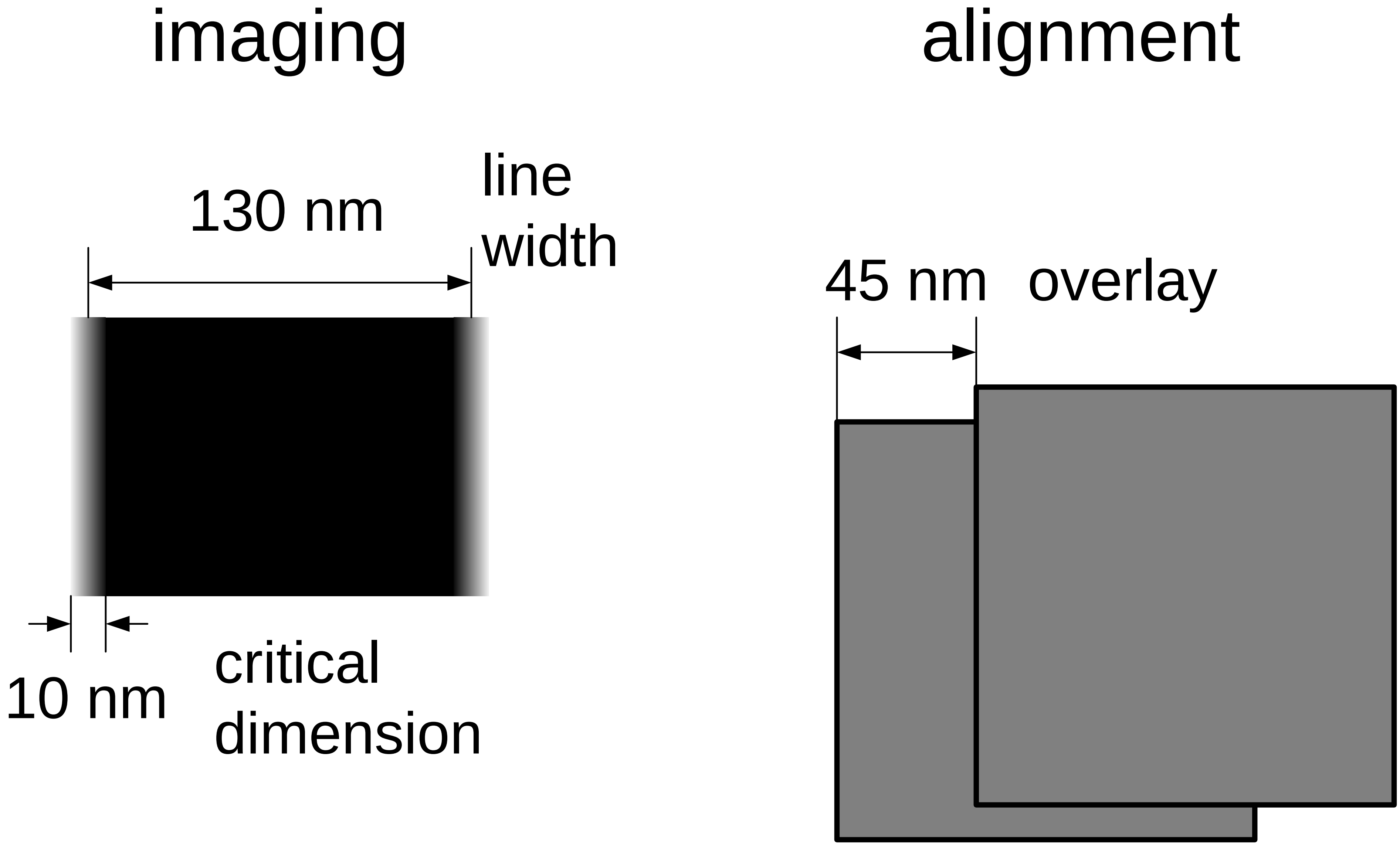
What is a waferstepper



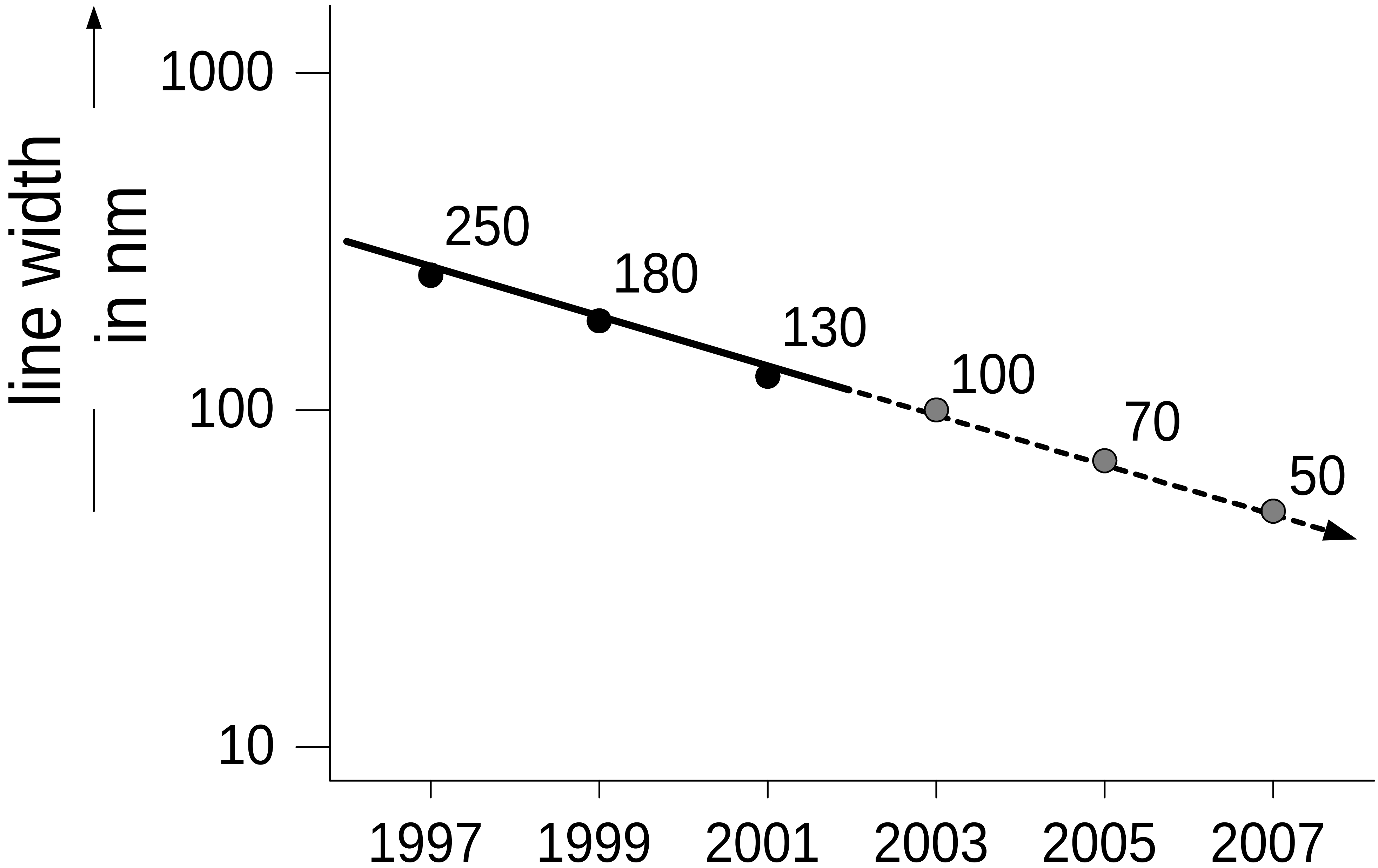
From stepping to scanning



Key specifications waferstepper

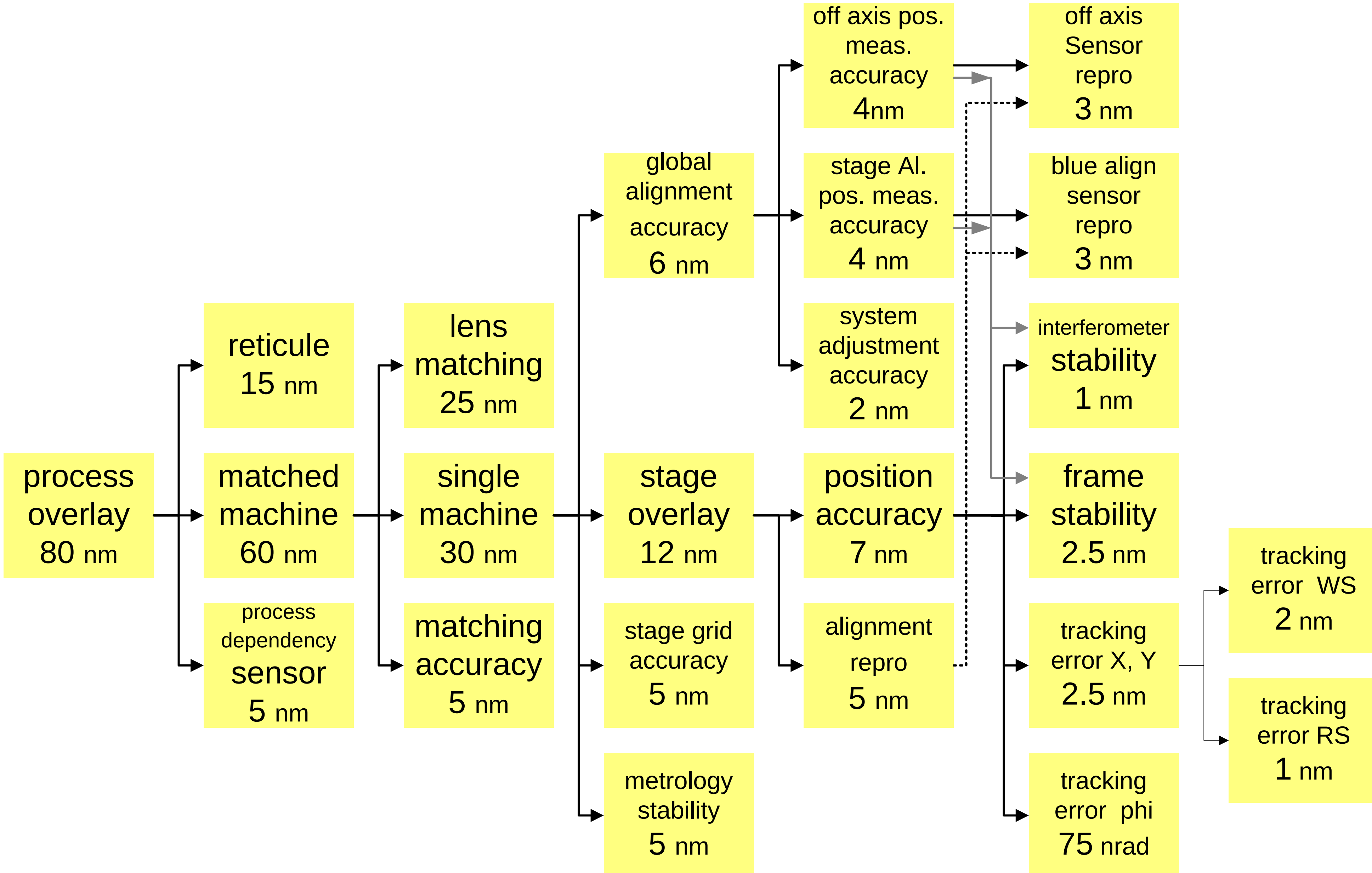


Moore's law

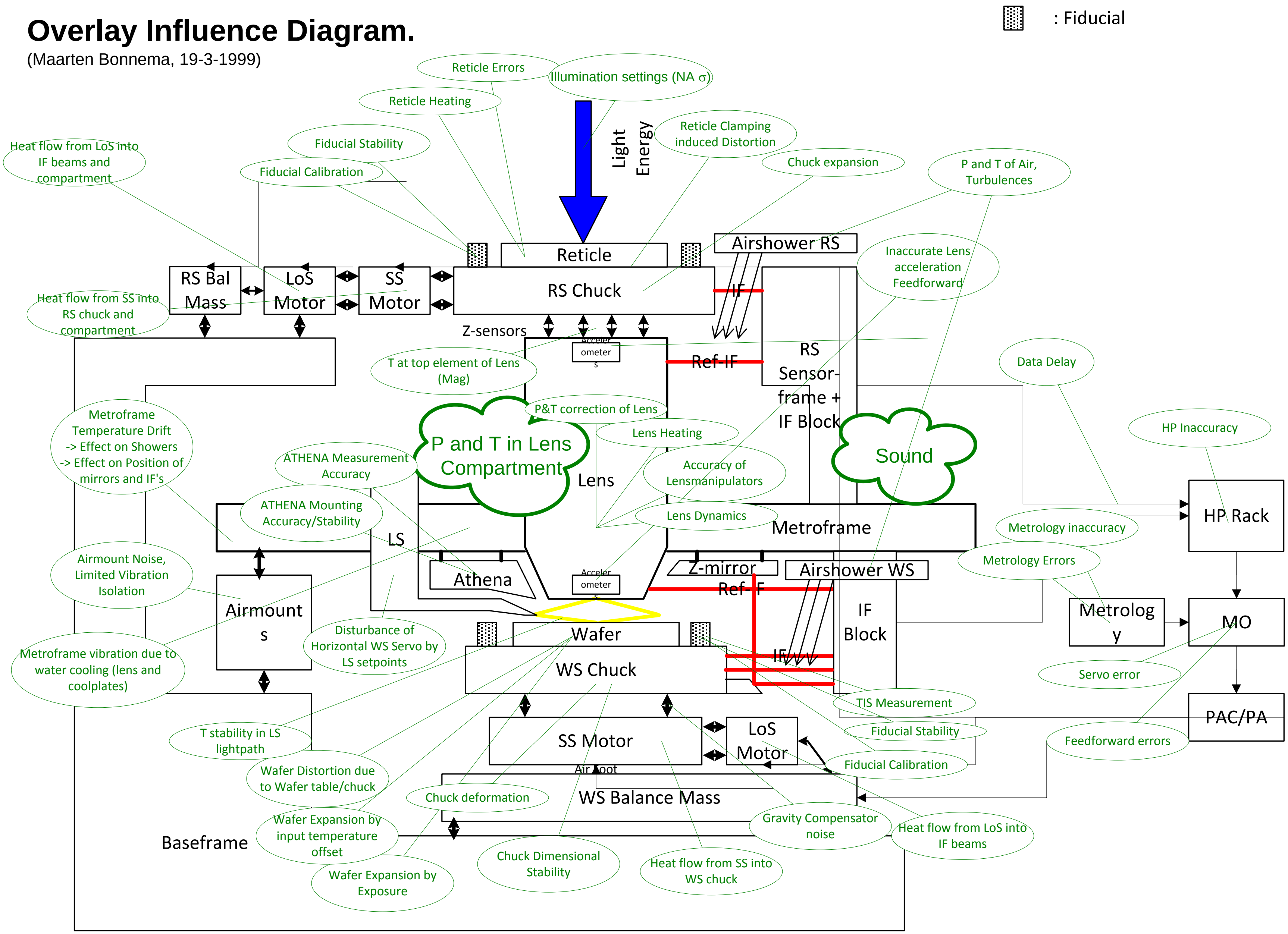


line width
in nm
1000
100
10
250
180
130
100
70
50
1997
1999
2001
2003
2005
2007

Overlay budget (1999)



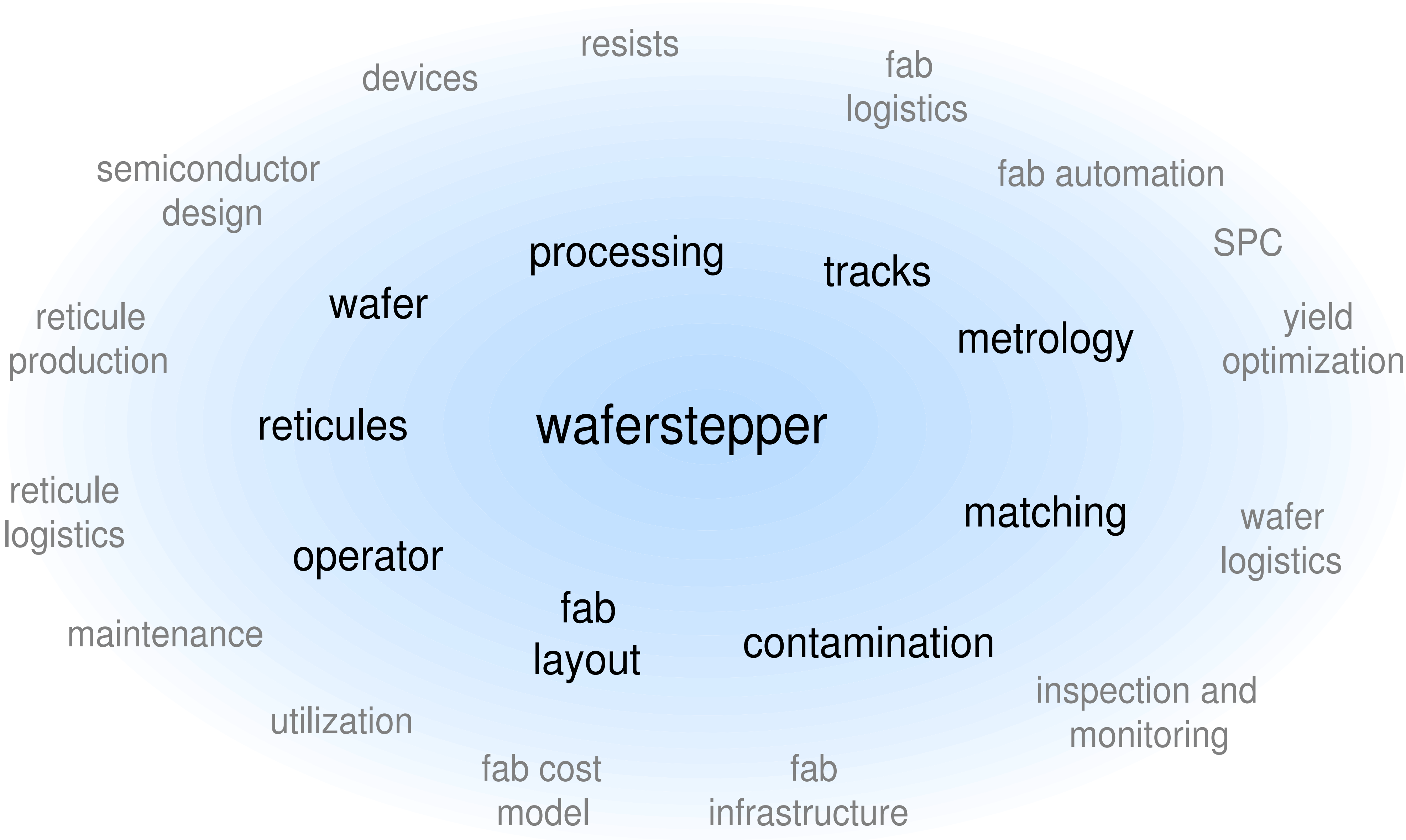
Everything influences overlay



Exercise 1, 10 minutes

Make a 3 picture description (What, How, biggest challenge) of your own system.

Fab Context of Waferstepper



Business Context

yield

value of
performance
(MHz)

CD control

key driver trade-off

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

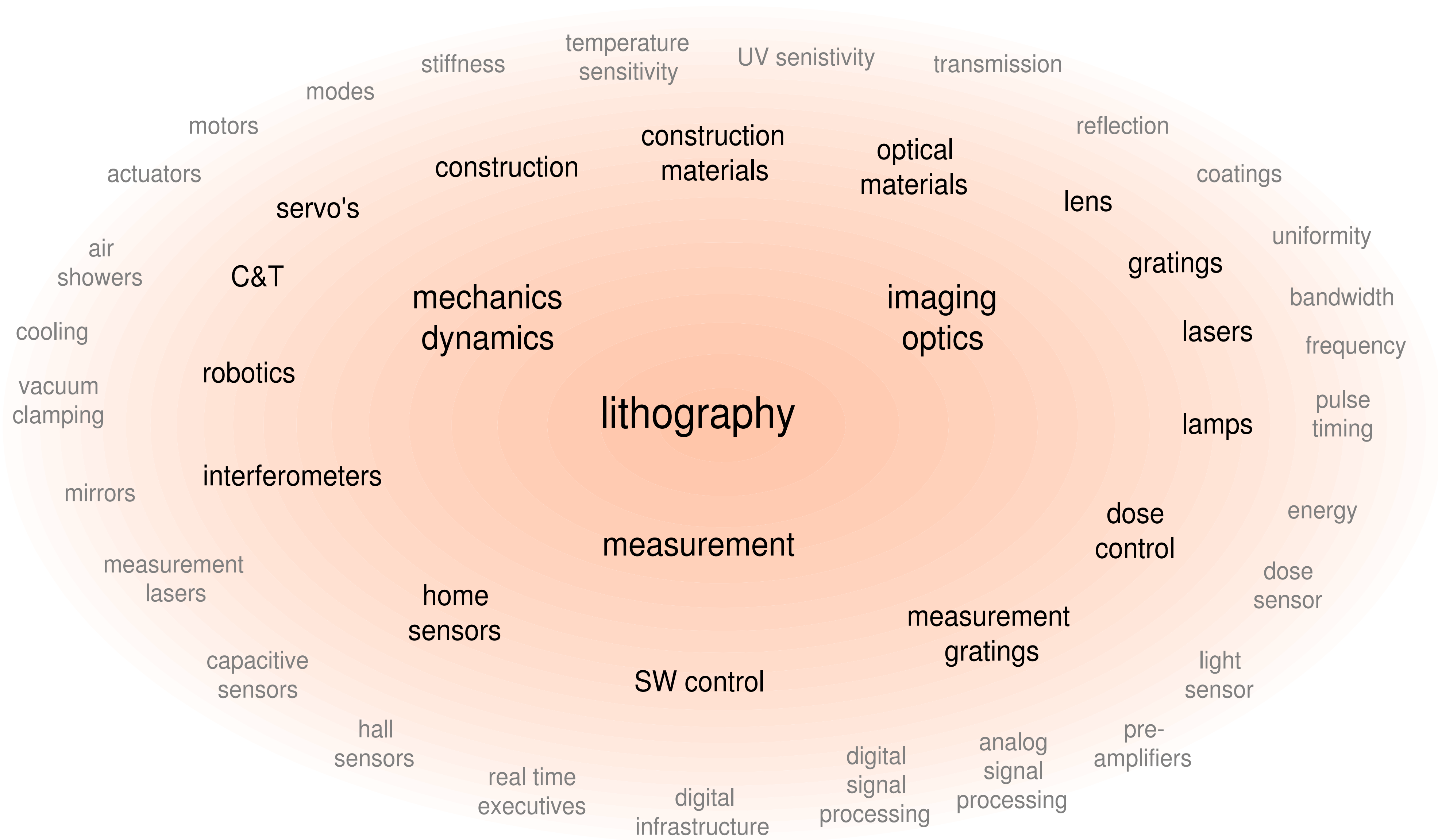
"internal"

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

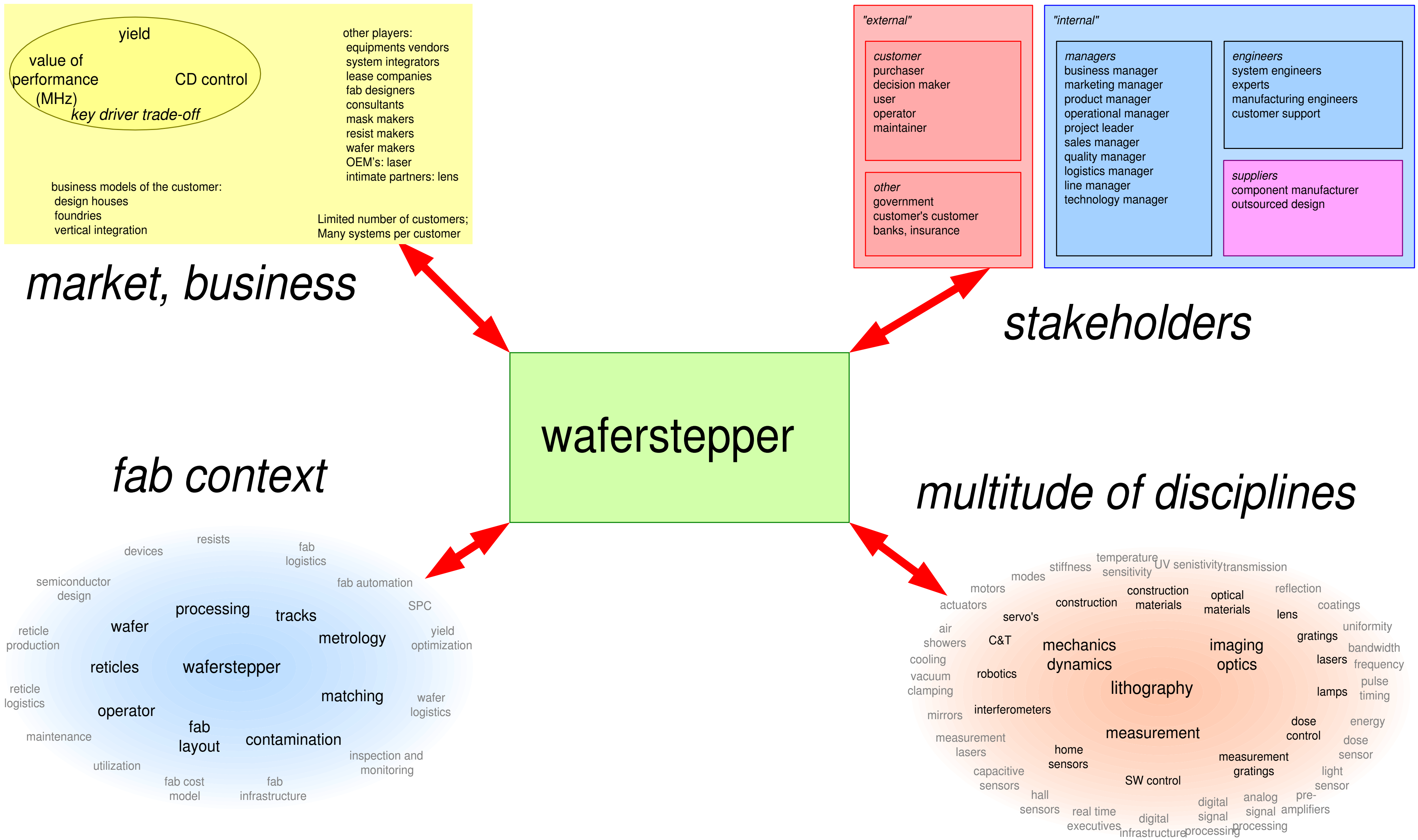
engineers
- system engineers
- experts
- manufacturing engineers
- customer support

suppliers
- component manufacturer
- outsourced design

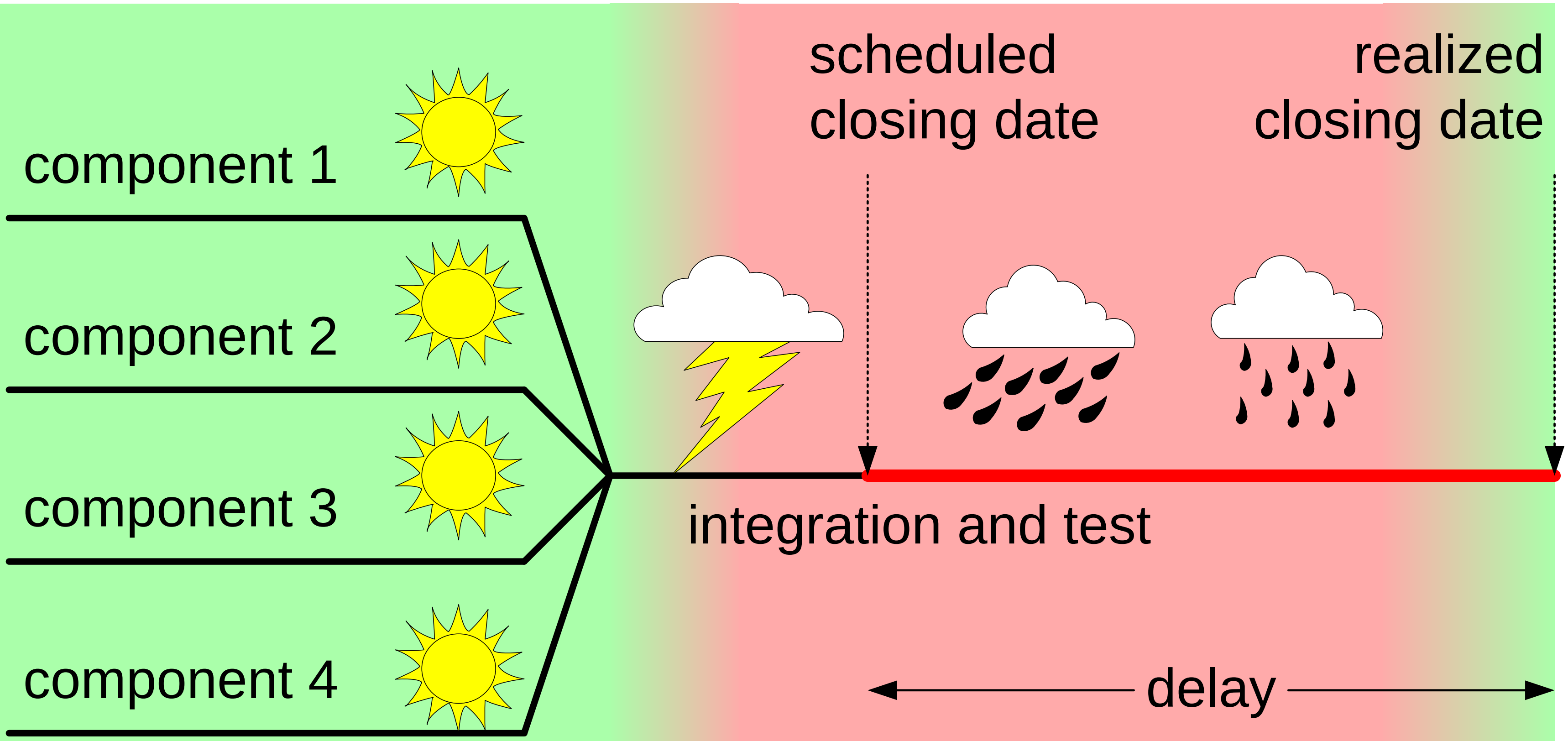
Multitude of Disciplines



Complexity of Waferstepper Context



Symptom: Delays appear during Integration



Do you have any design issues for the design meeting?

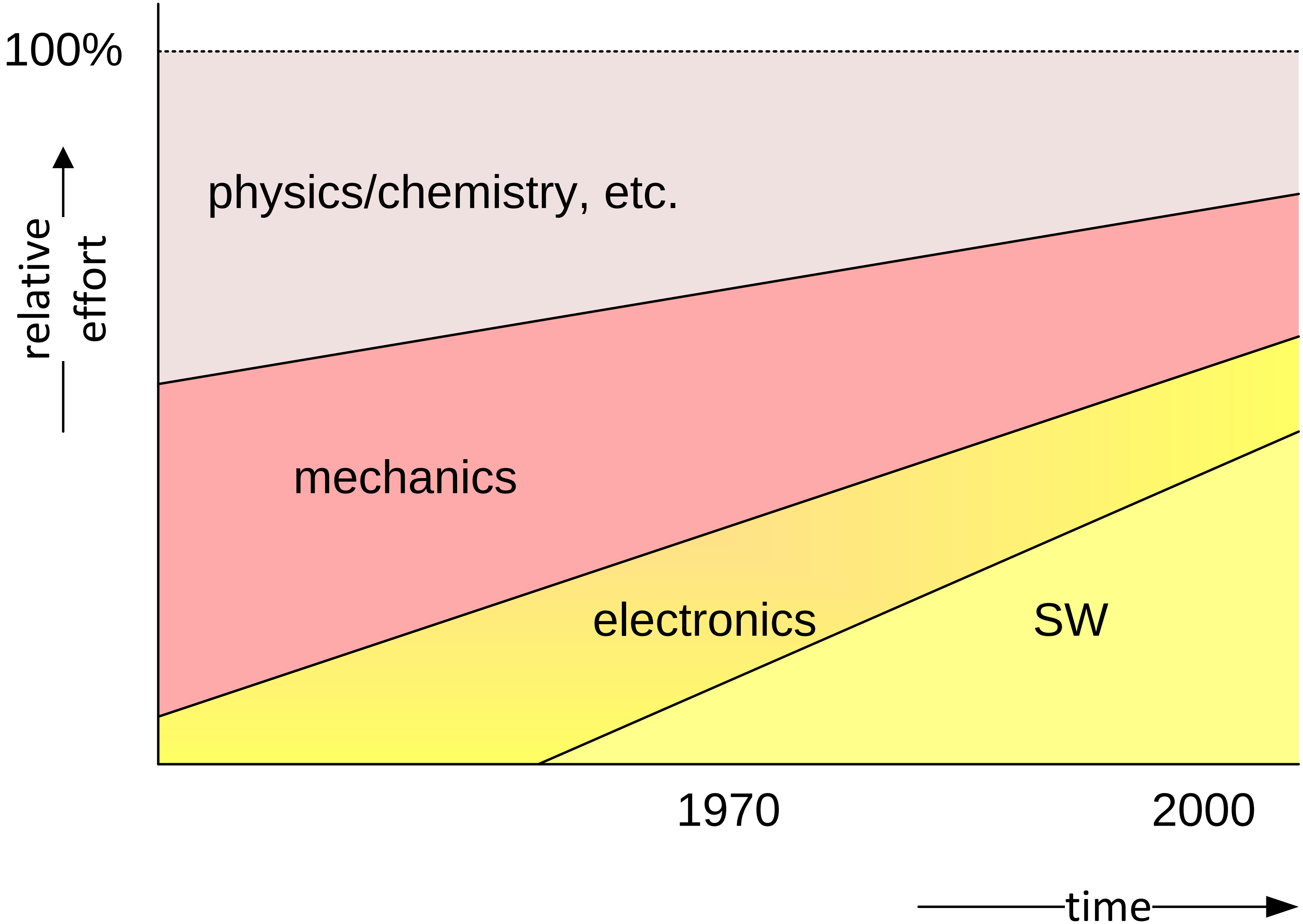
The default answer is: No.

During integration numerous problems become visible

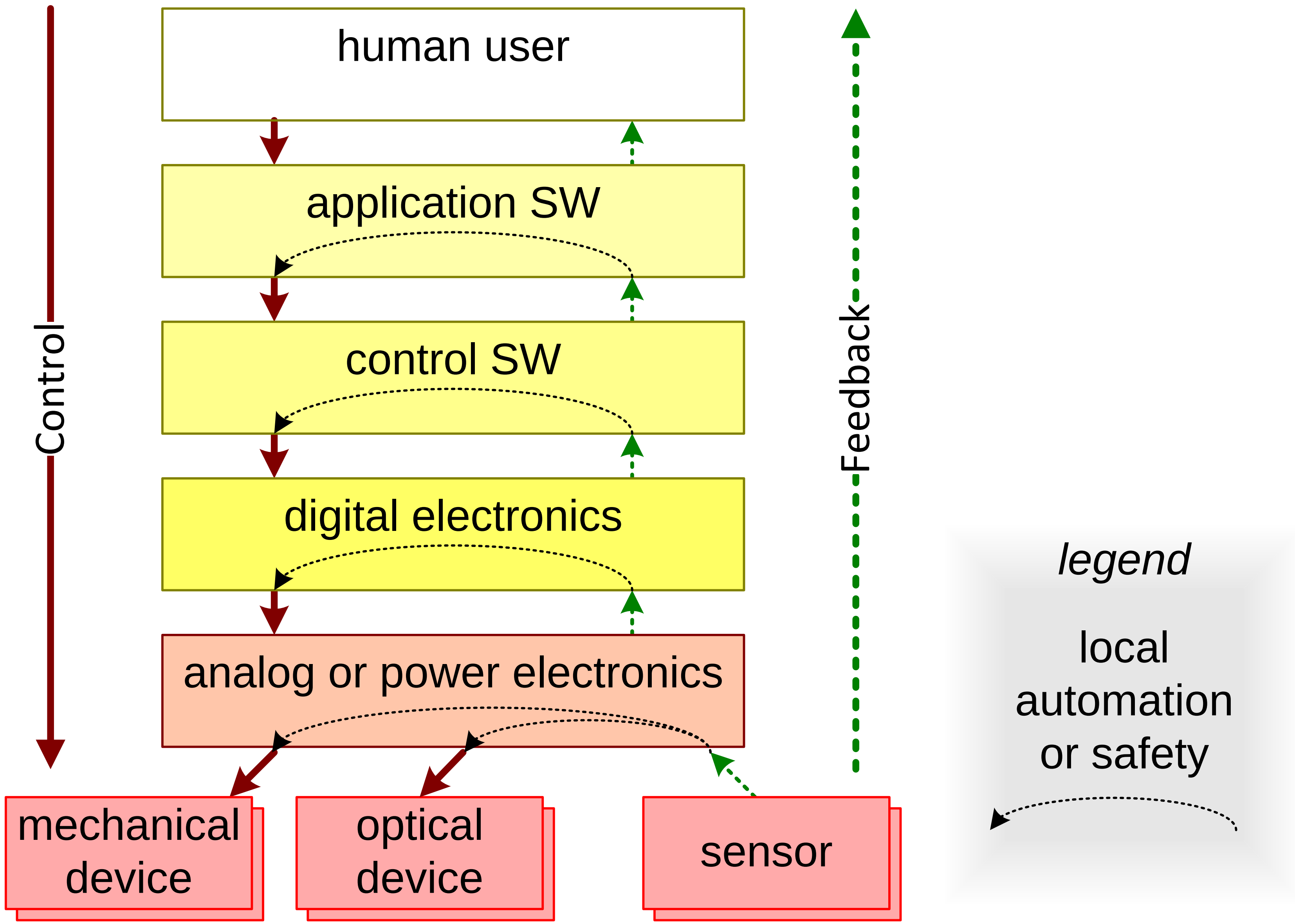
Exercise 2, 10 minutes

Make a 3 picture description (Application context, Value chain, technologies) of your own system.

Relative Contribution of SW

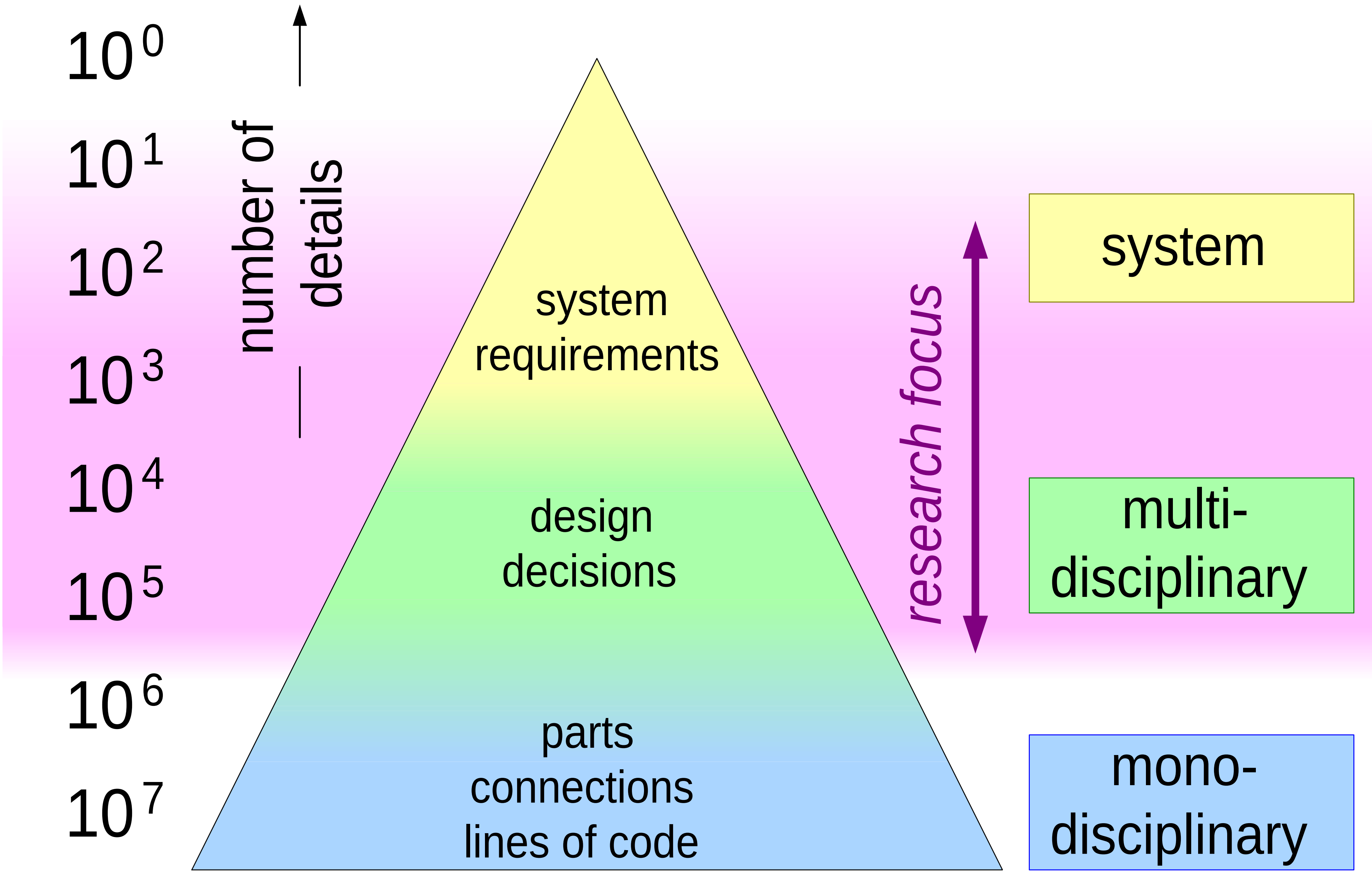


Control Hierarchy along Technology axis

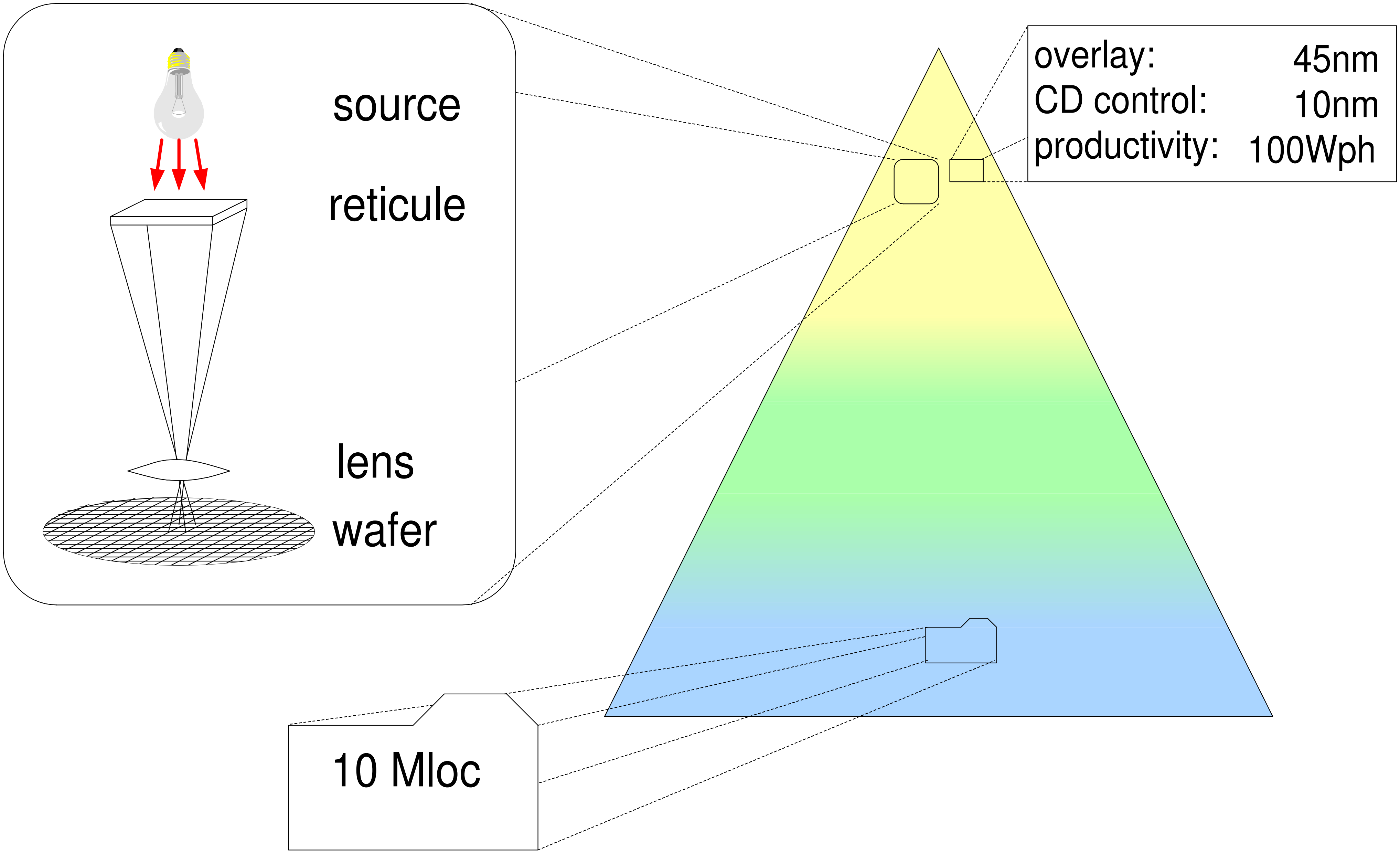


Characterization of disciplines

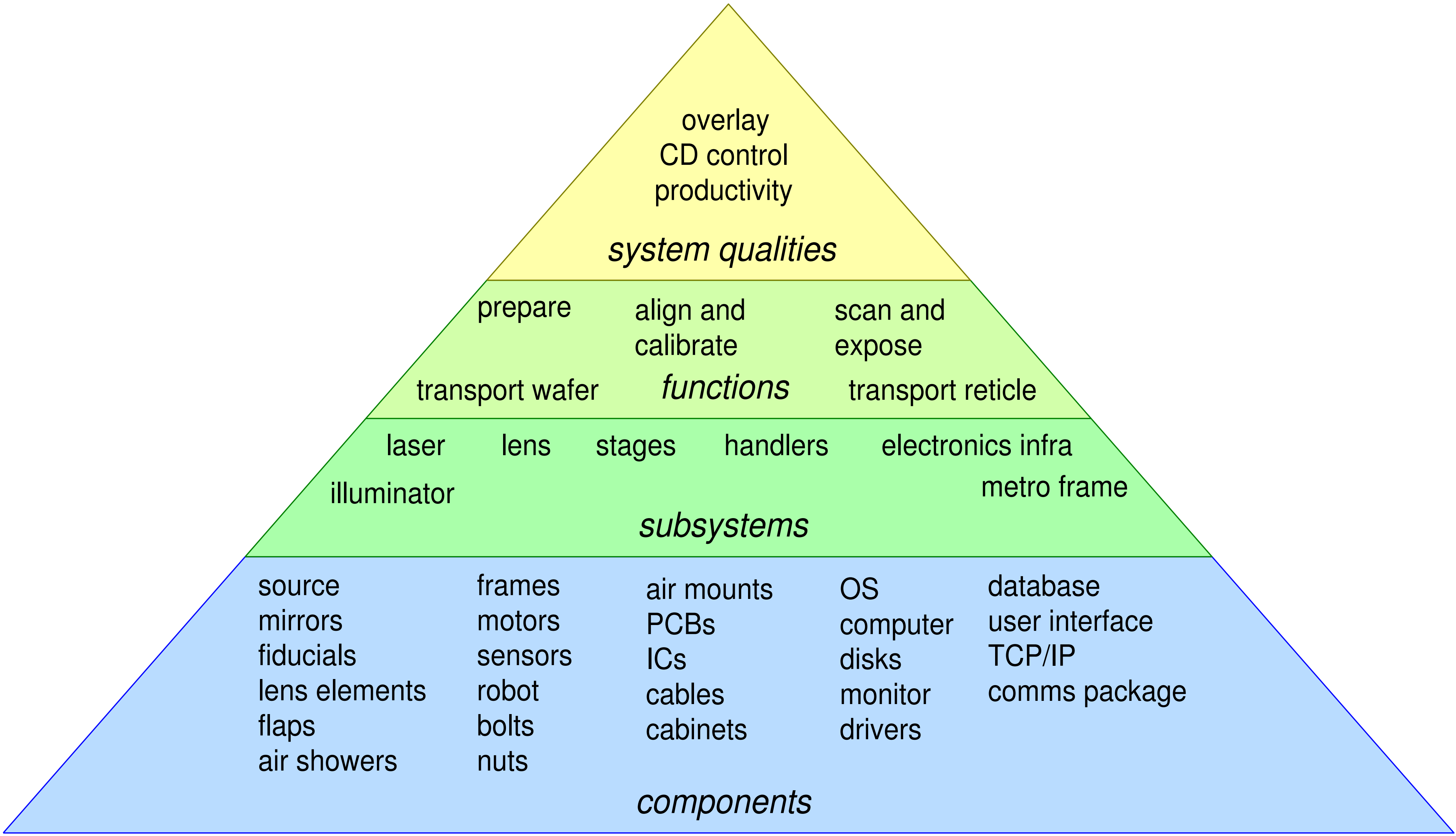
Exponential Pyramid, from requirement to bolts and nuts



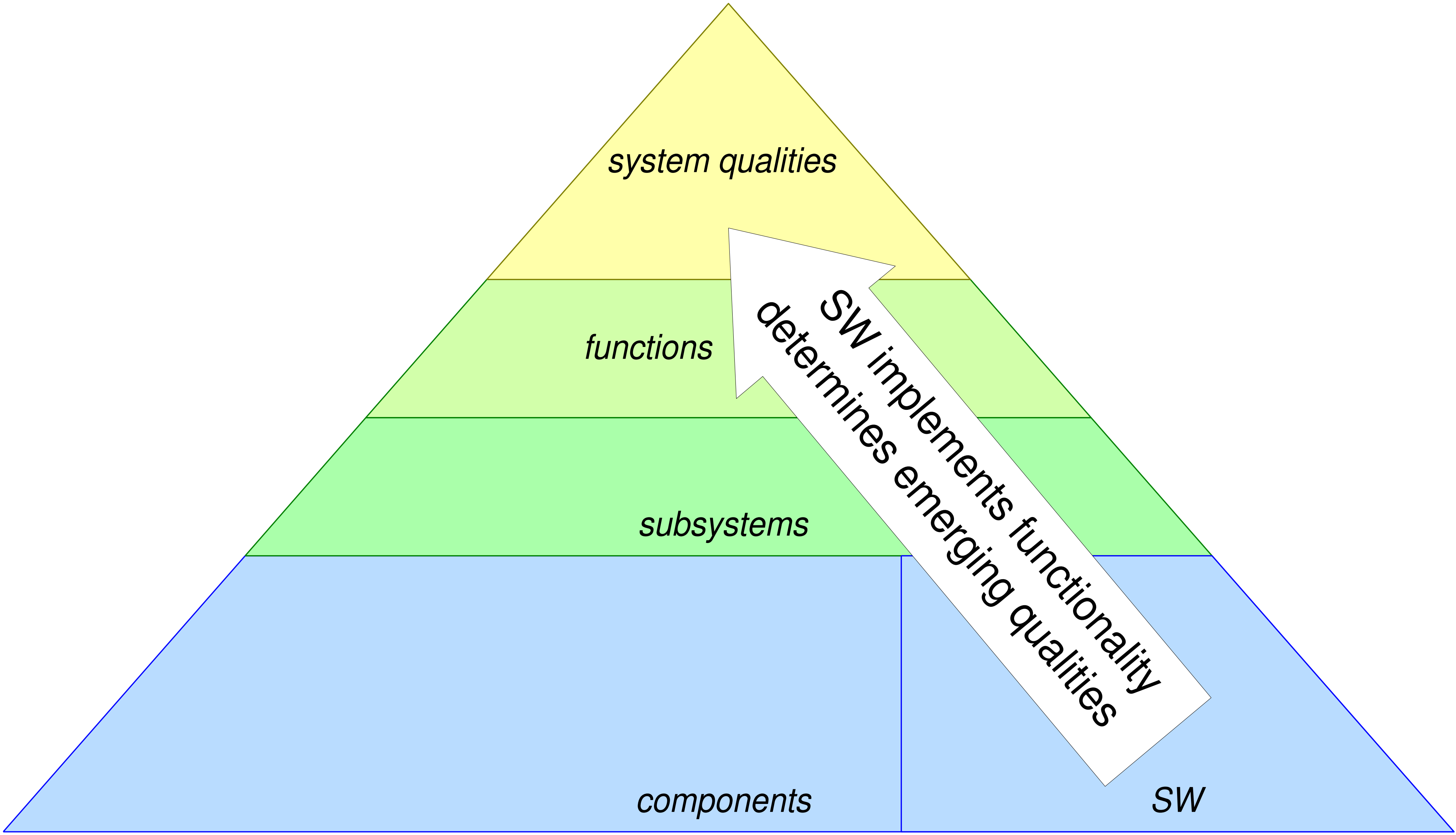
Waferstepper Example



From Components to System Qualities



Role of Software



Exercise 3, 10 minutes

Make a toplevel decomposition of the software in your system and estimate the amount of software of the constituting parts

When SW engineers demand "requirements",

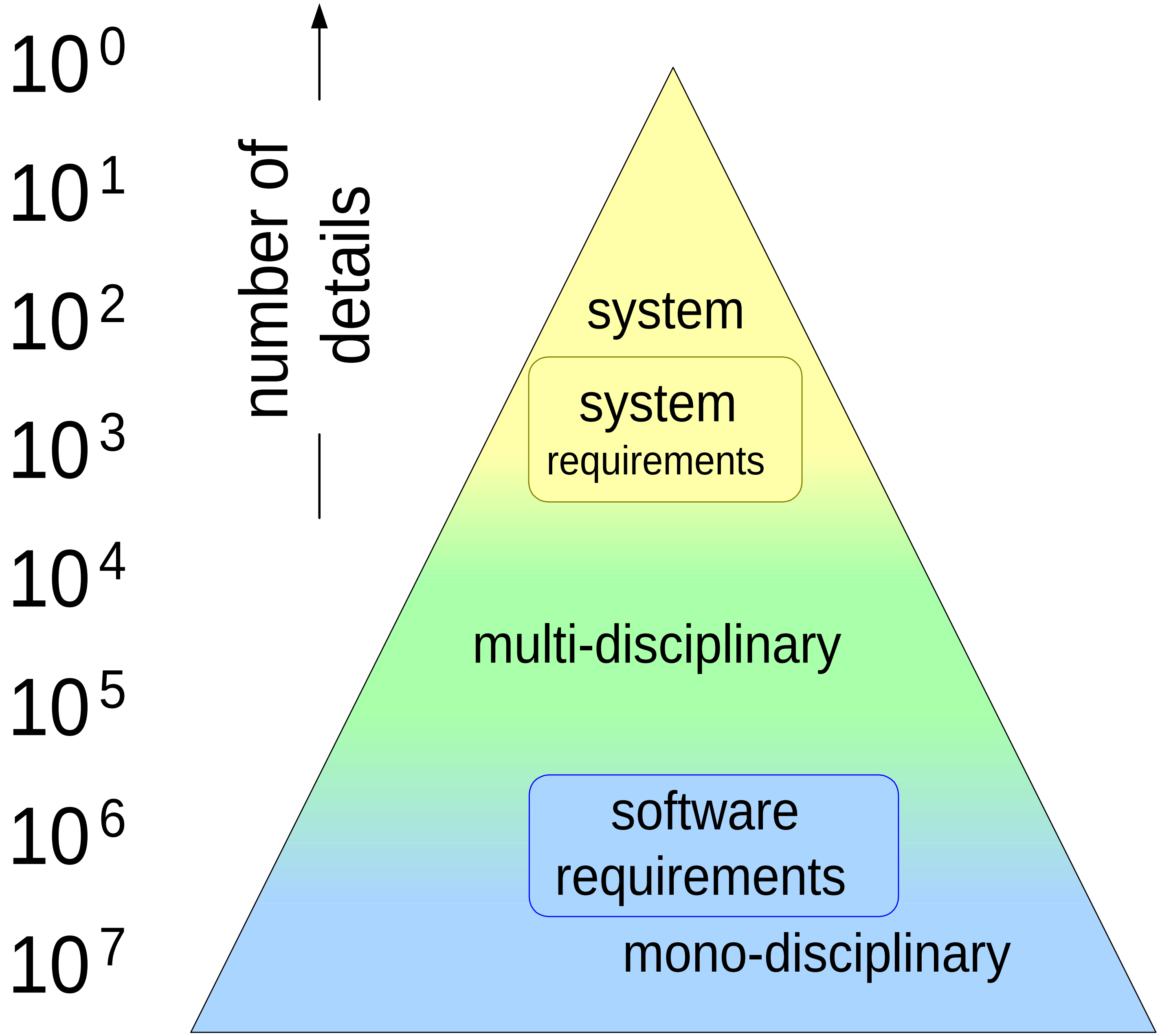
then they expect *frozen* inputs

to be used for

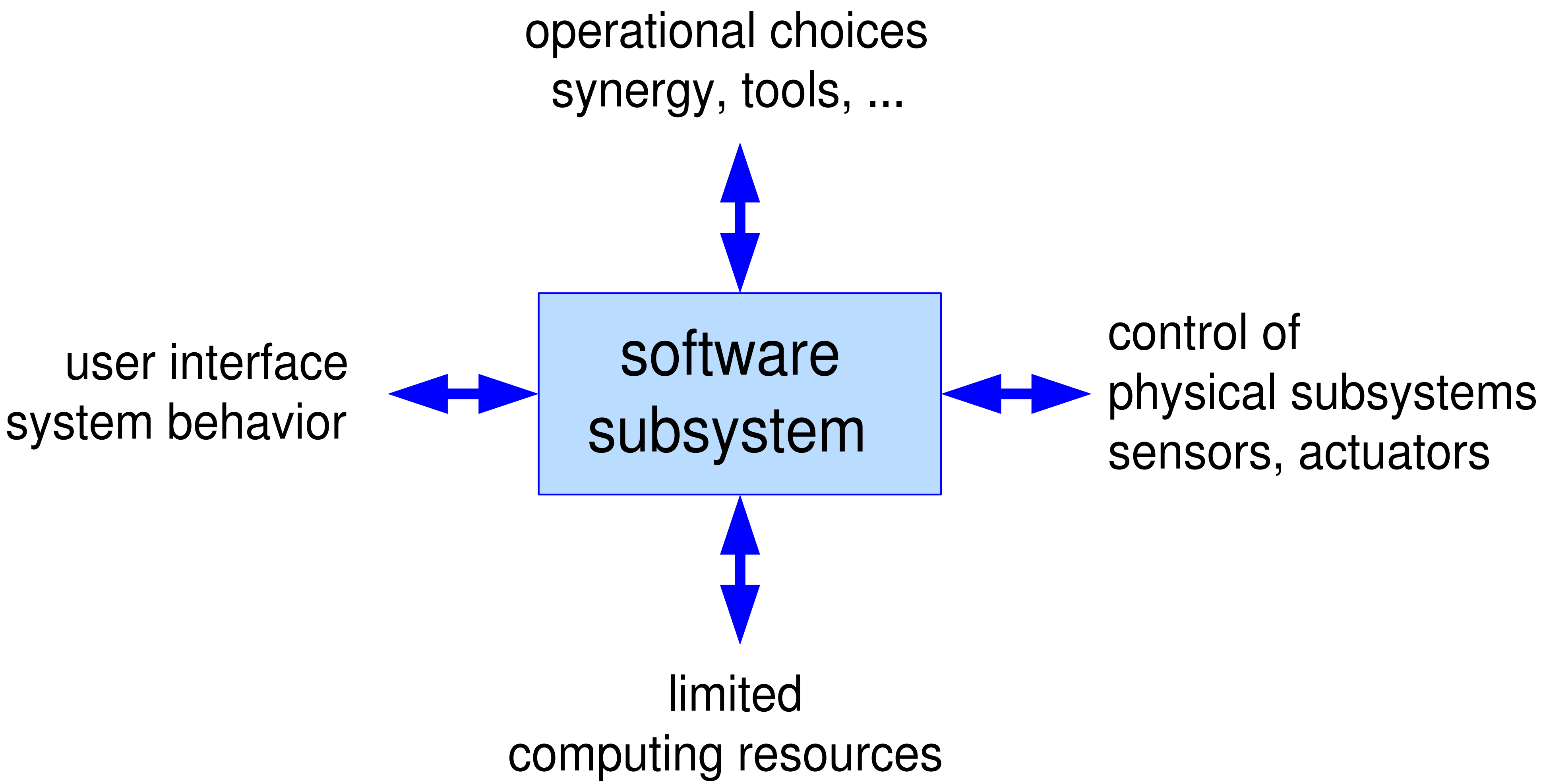
the design, implementation and validation

of the software

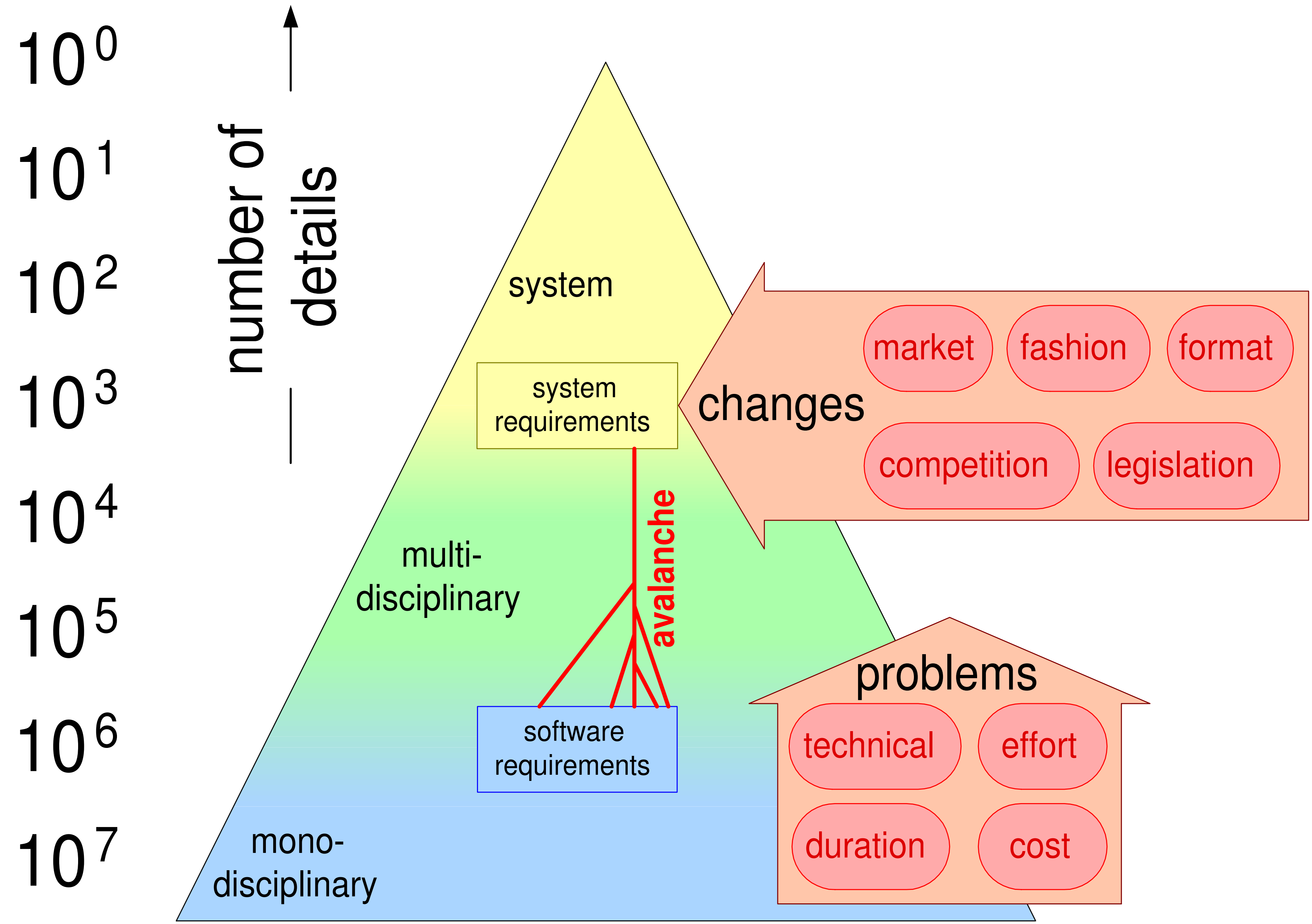
System vs Software Requirements



Why is the Software Requirement Specification so Large?



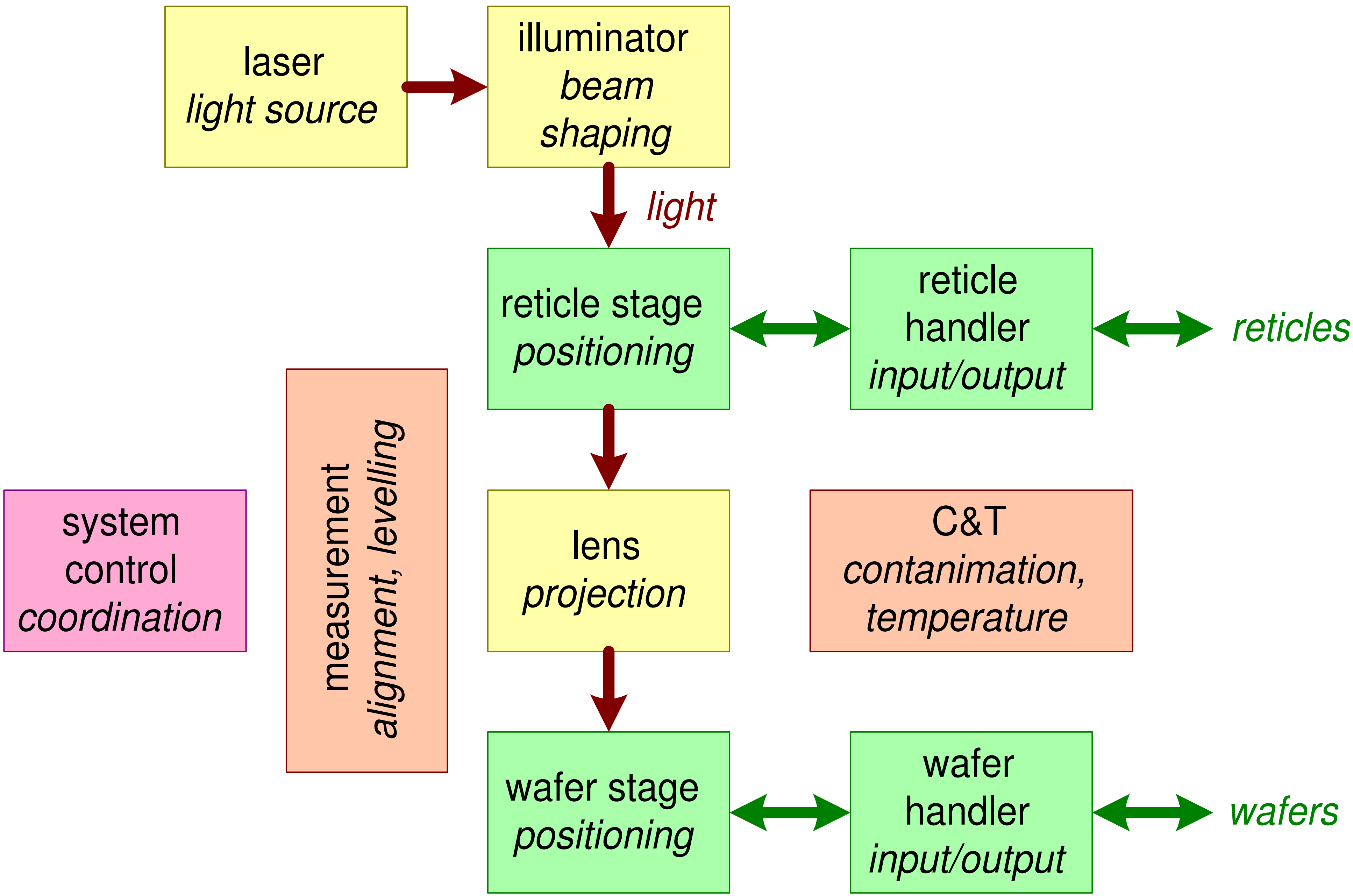
And why is it never up-to-date?



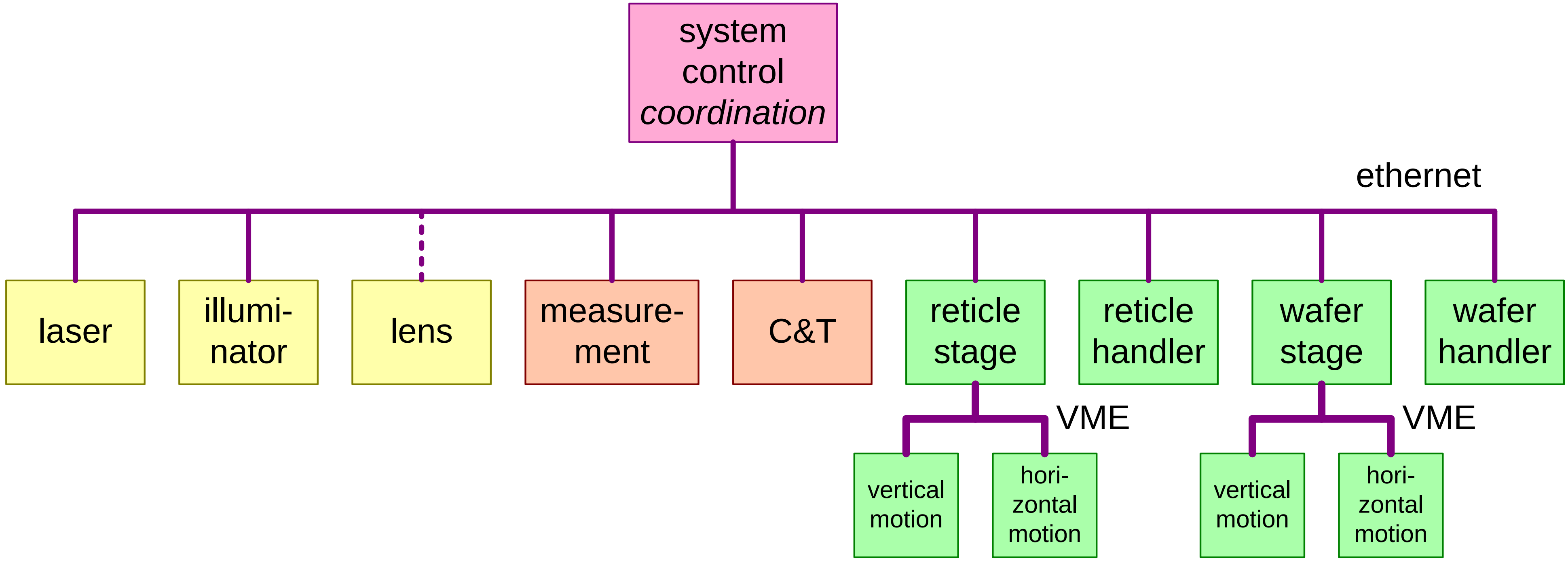
Exercise 4, 2 minutes

How many pages are in your Software Requirements Specification?

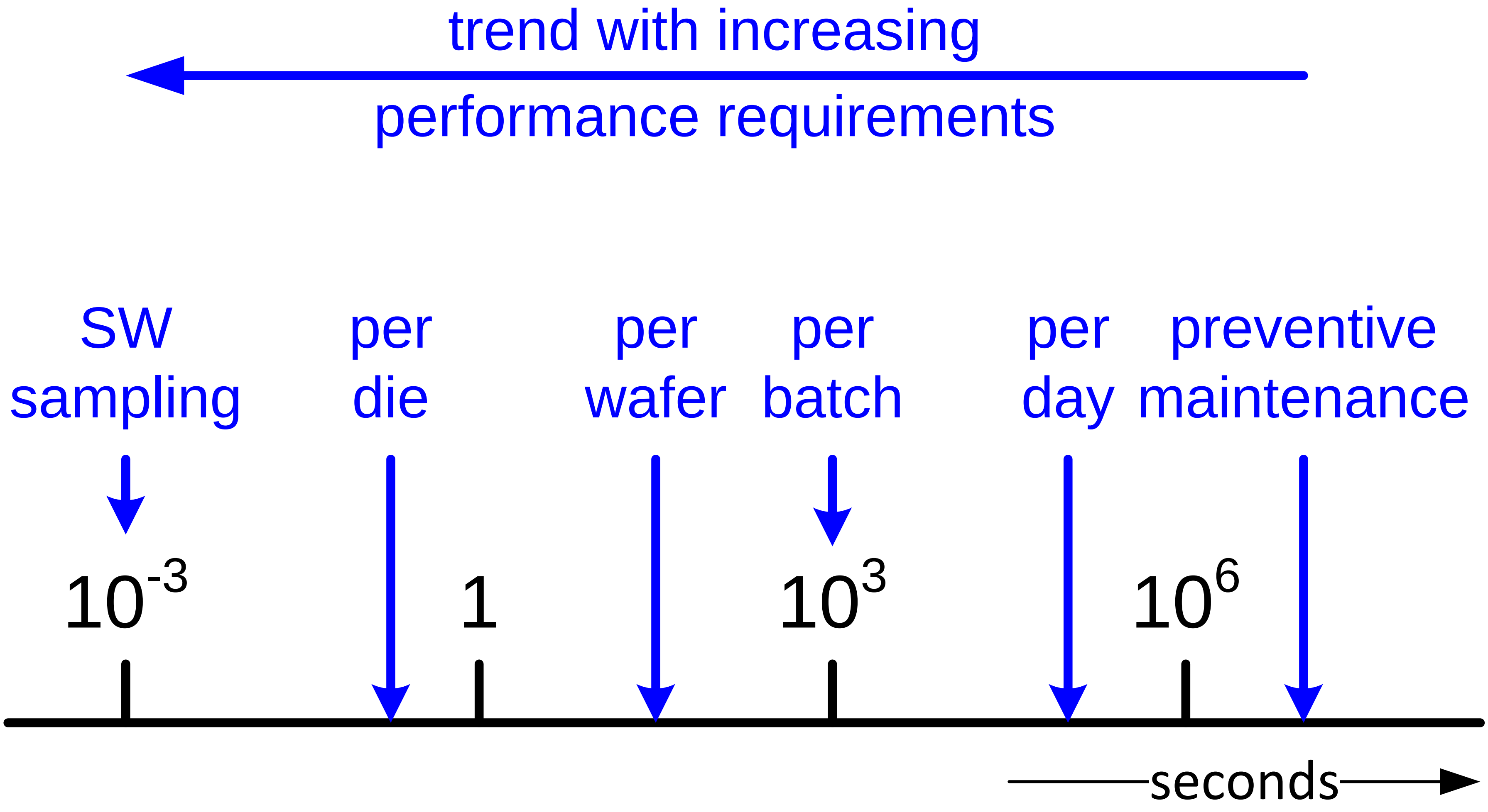
Block Diagram of a Waferstepper



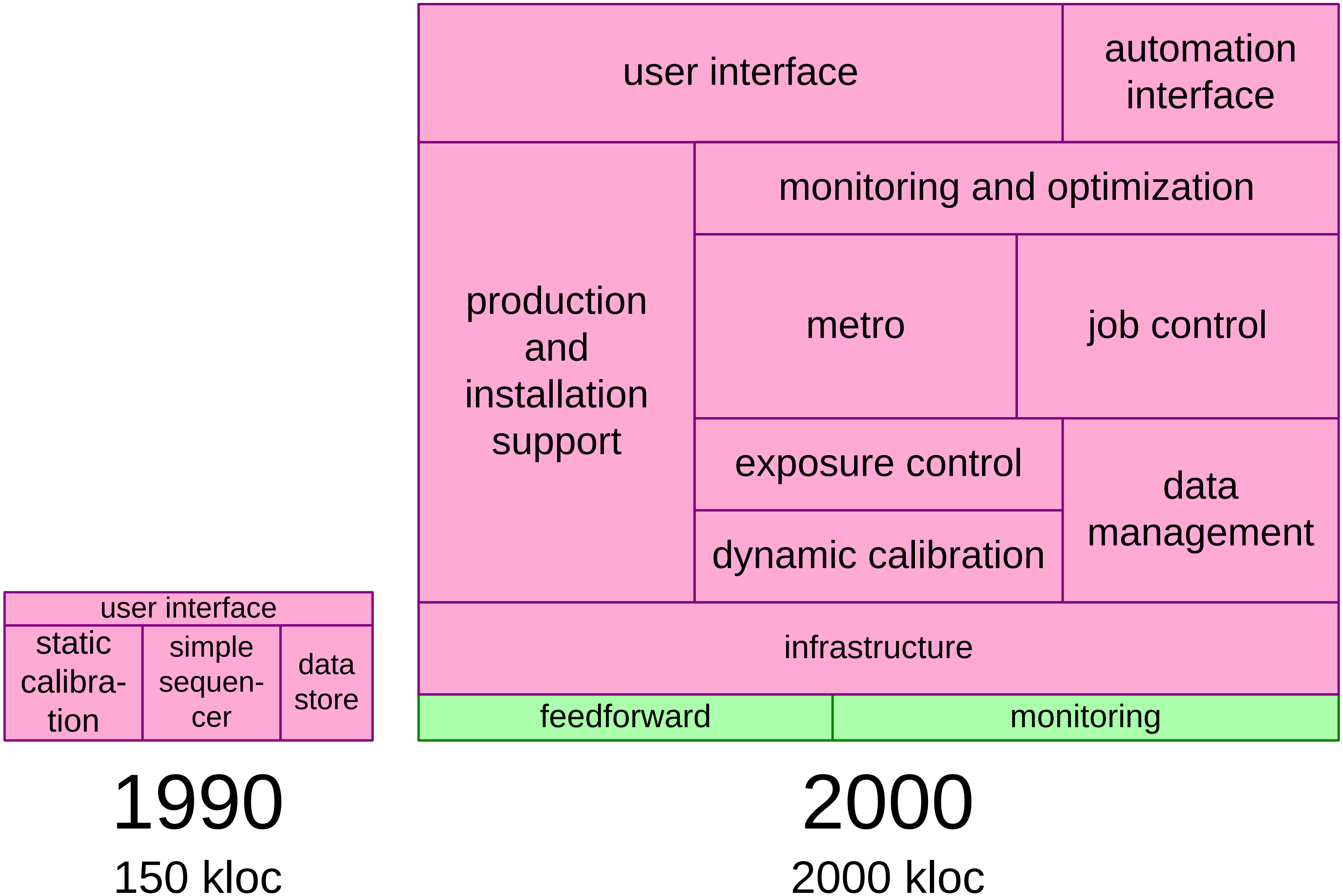
Control Hierarchy of a Waferstepper



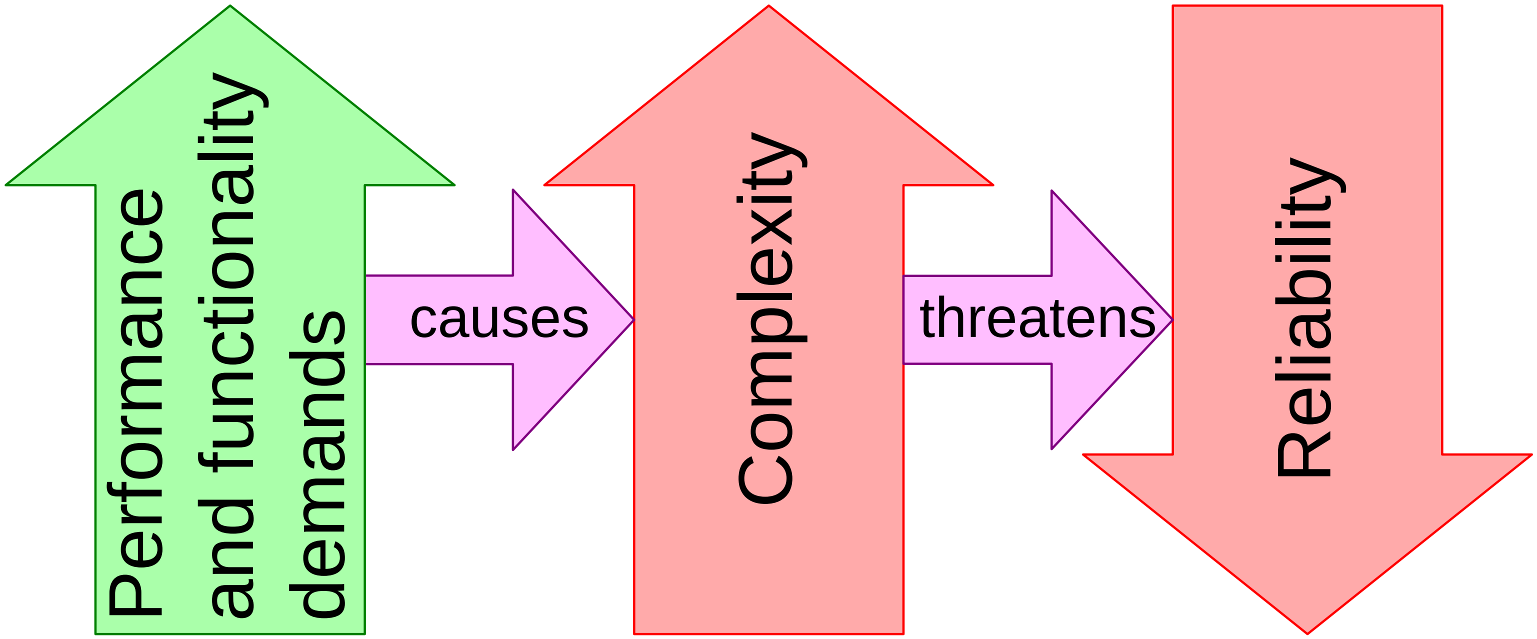
Frequency of Control Actions



Evolution of System Control



Consequences of Evolution



loss of overview (150kloc fits in 1 mind, 2Mloc not)

(more than?) exponential increase of coupling

1:1 relation HW:SW becomes n:m relation

autonomous subsystems — paradigm shift! → *integrated system*

Exercise 5, 10 minutes

Visualize the (SW) evolution of your system. What is your current phase?

Different Focus of Software and System

System engineering focus

qualities
productivity
image quality
reliability

concepts
domain requirements
models

concerns
integral design (quality, balance)
system context
lifecycle
operational processes

education
principles
heuristics
analysis and synthesis
processes

SW engineering focus

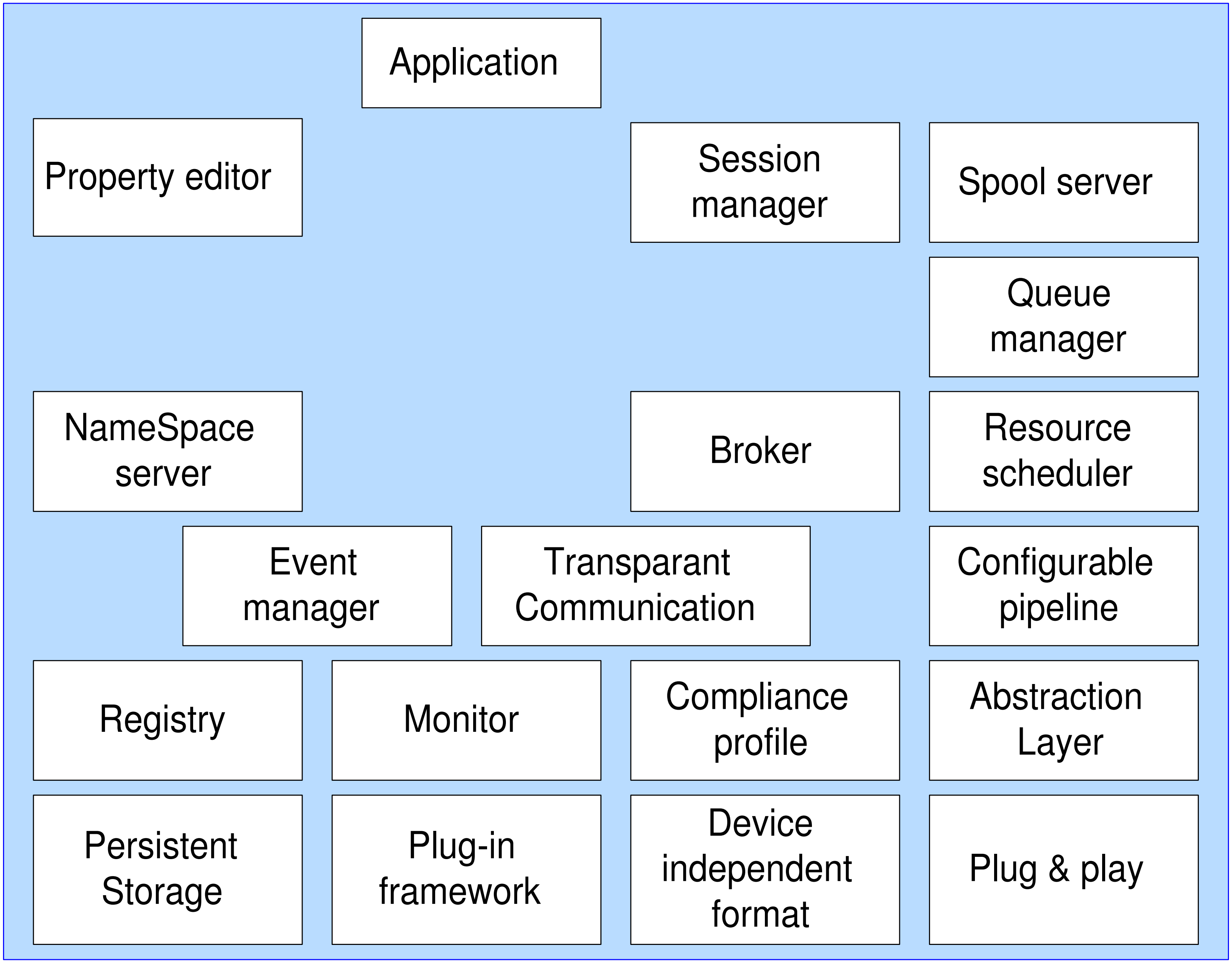
qualities
functionality
maintainability
variability

concepts
structure
(generic) mechanisms

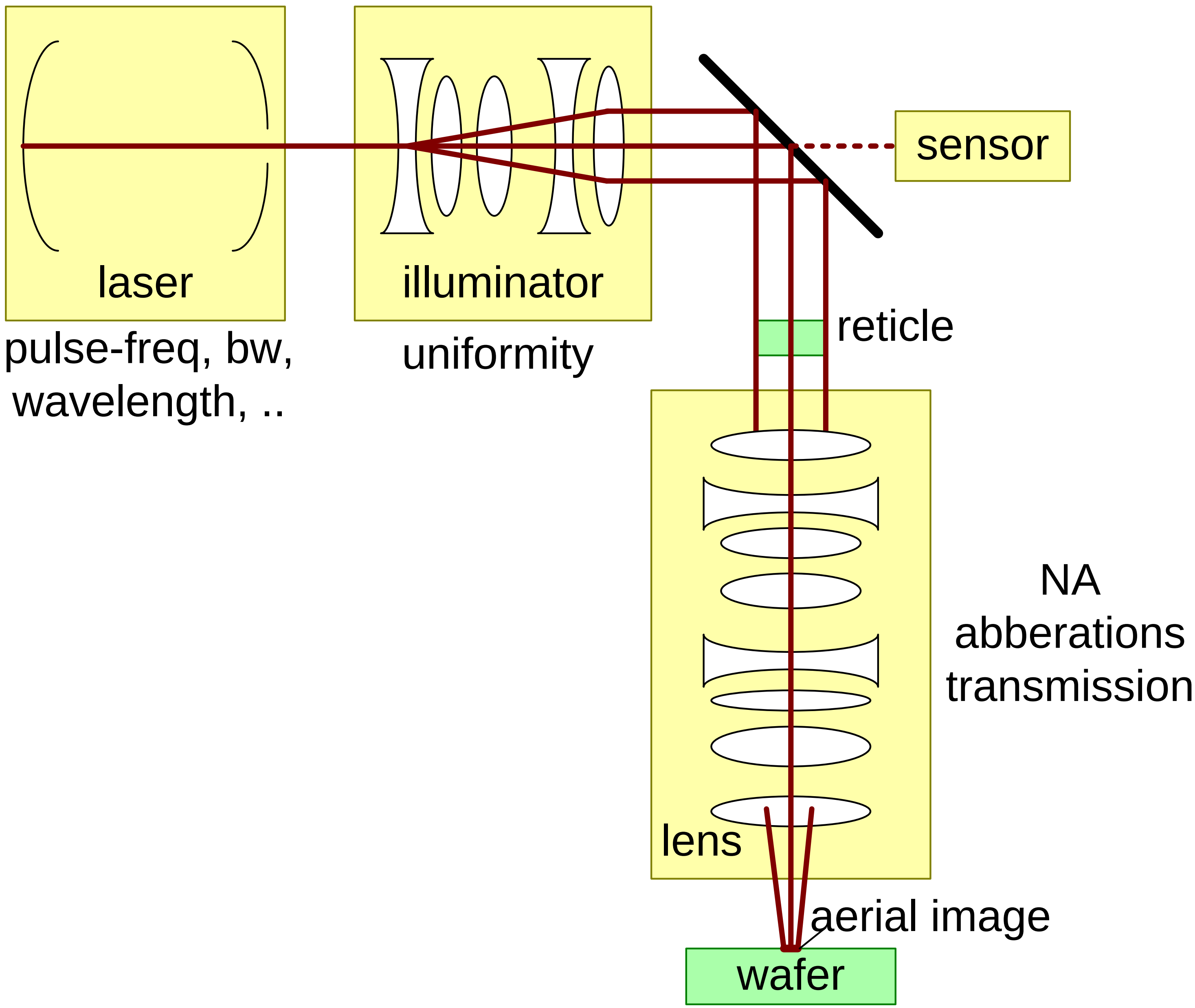
concerns
configuration management
release procedure
tools
SW processes
SW problems, change requests

education
languages
operating systems
algorithms
formal methods

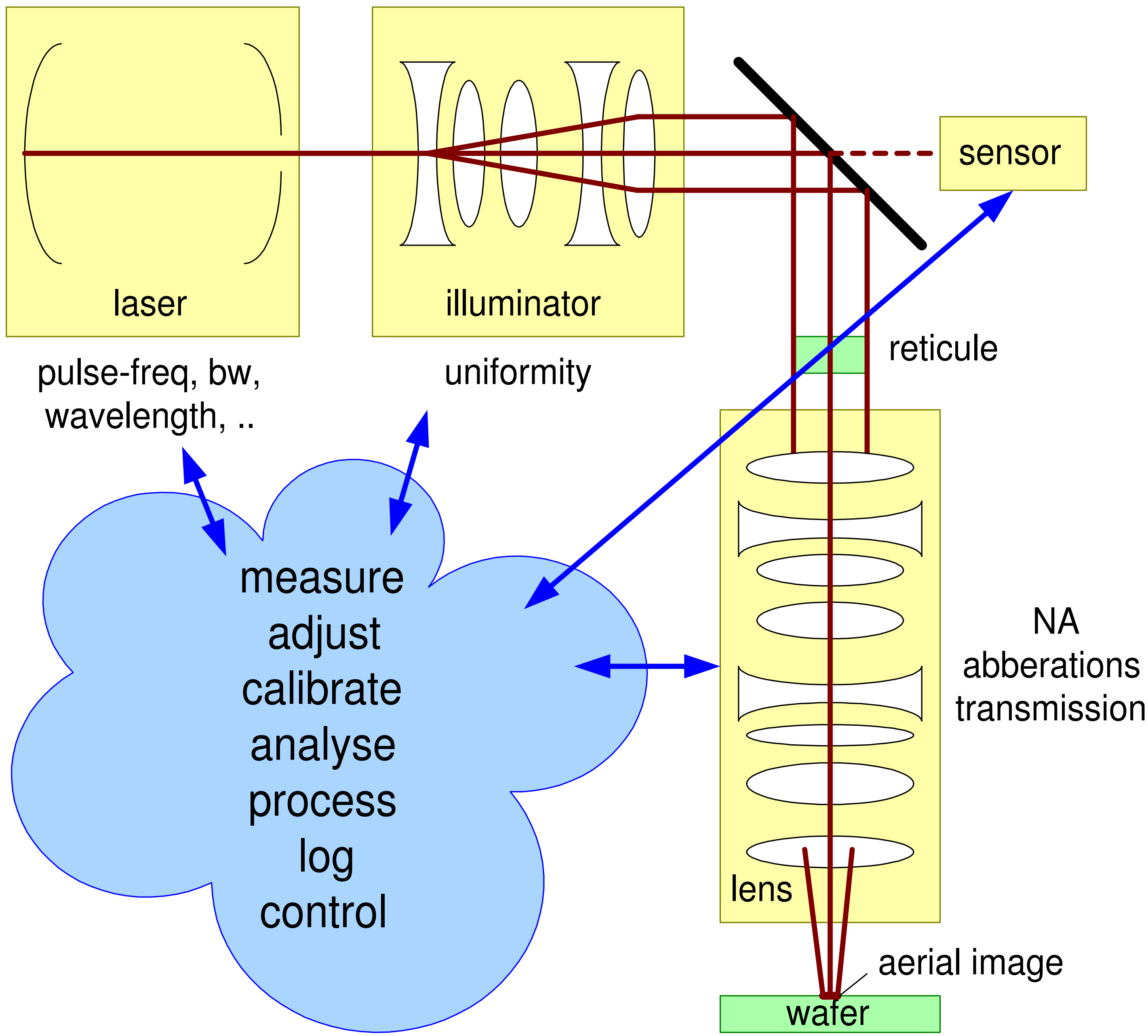
Caricature of a SW Architecture



Caricature of Physics Systems View



Relation SW and Physics



Symptoms of too isolated SW efforts

symptoms	*counter measures*
SW people are clustered together	colocation per function, subsystem or quality
SW is alpha tested before system integration	continuous system integration
SW team uses own specification and design process	higher level processes are shared
SW specification is in SW jargon or formalism	interaction between SW, HW and system engineers

Exercise 6, 5 minutes

What is the degree of integration or isolation of SW in your organization?

Different Mindsets and Characteristics