

Module 33, Architectural Reasoning Design Fundamentals

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Abstract

This module discusses fundamental design methods and techniques, especially partitioning, interface, behavior, and quantified performance design.

Distribution

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System Partitioning Fundamentals

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Abstract

The fundamental concepts and approach system partitioning are explained. We look at physical decomposition and functional decomposition in relation to supply chain, lifecycle support, project management, and system specification and design.

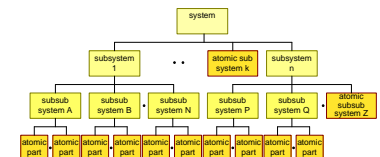
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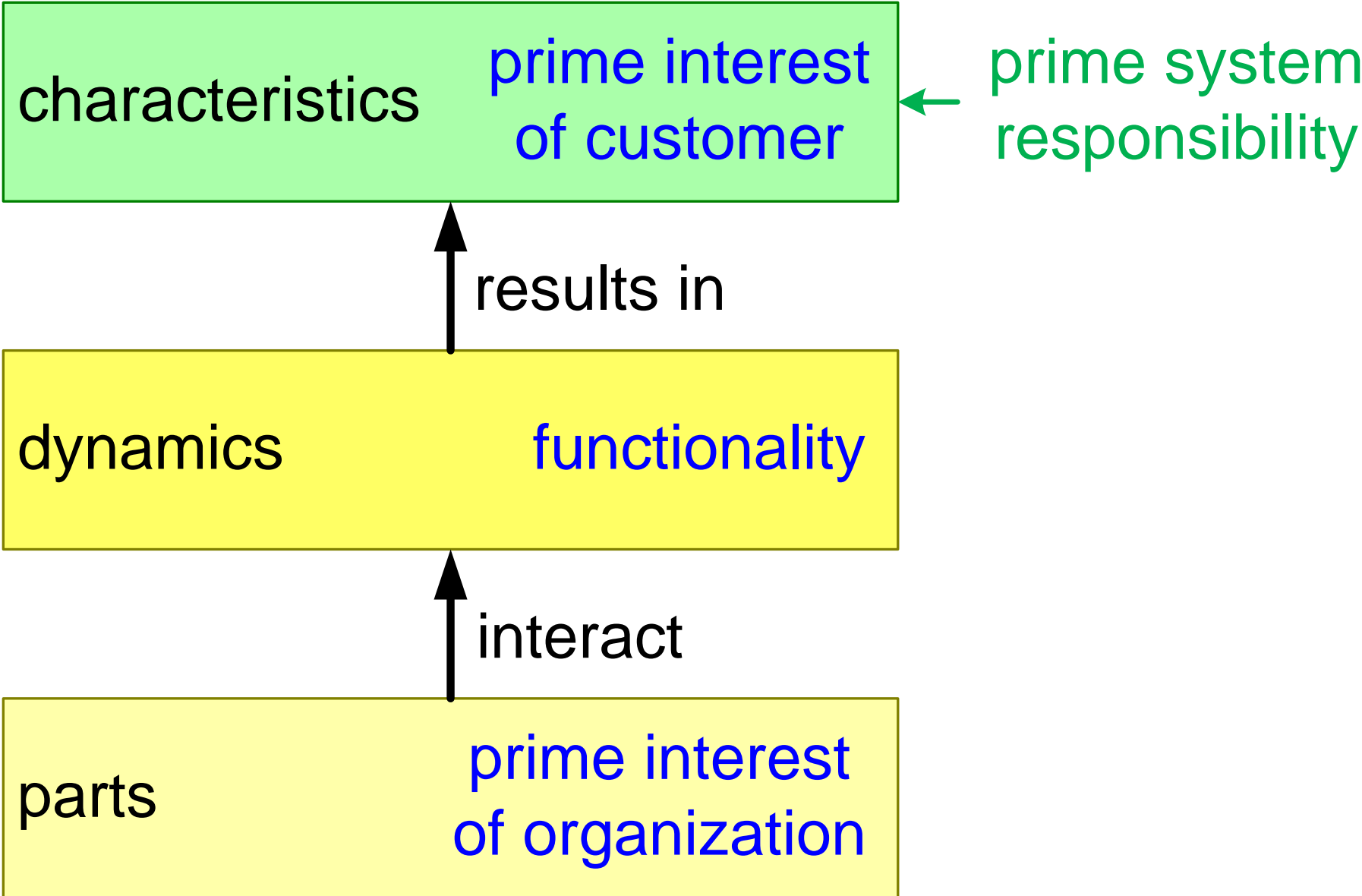
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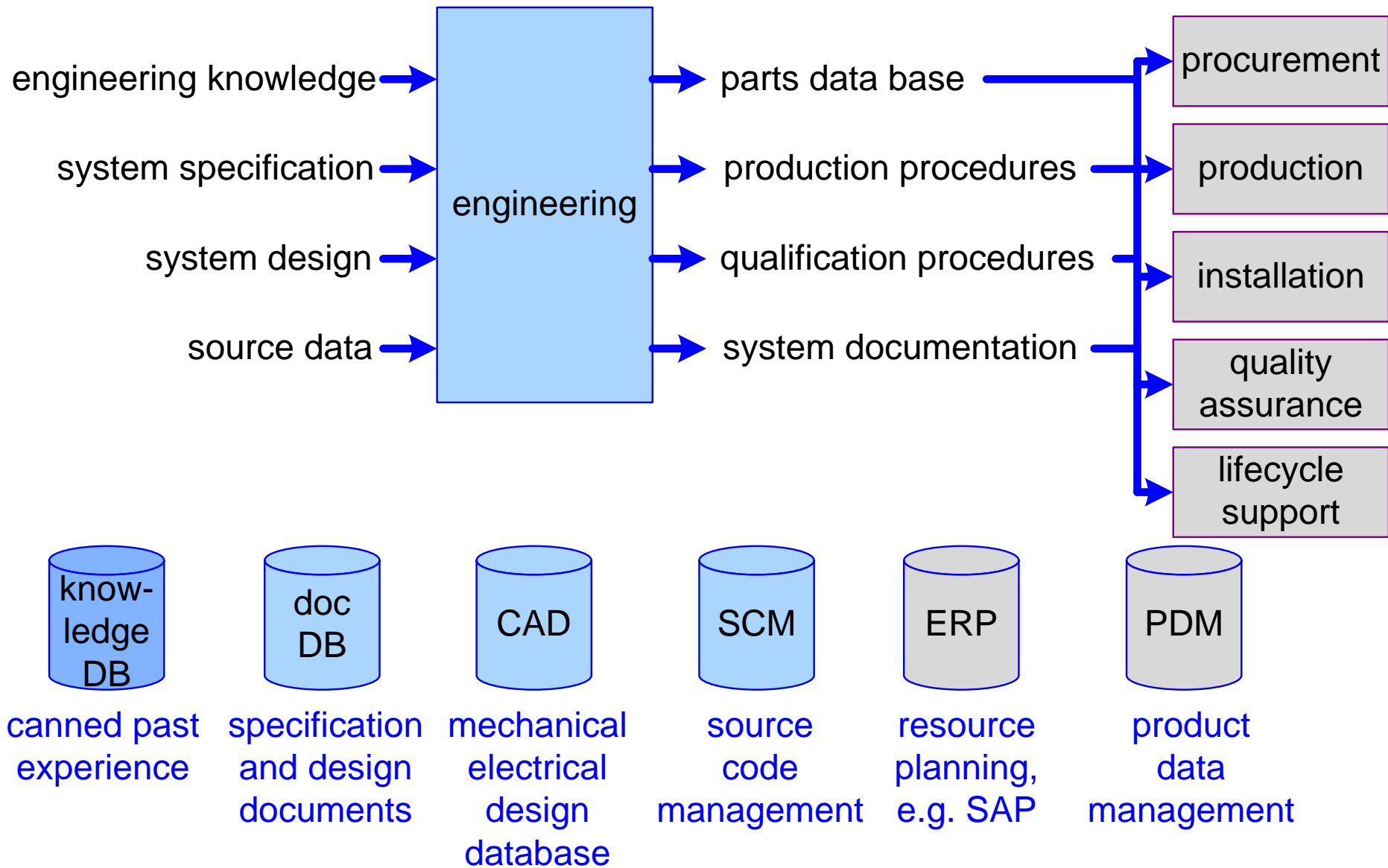
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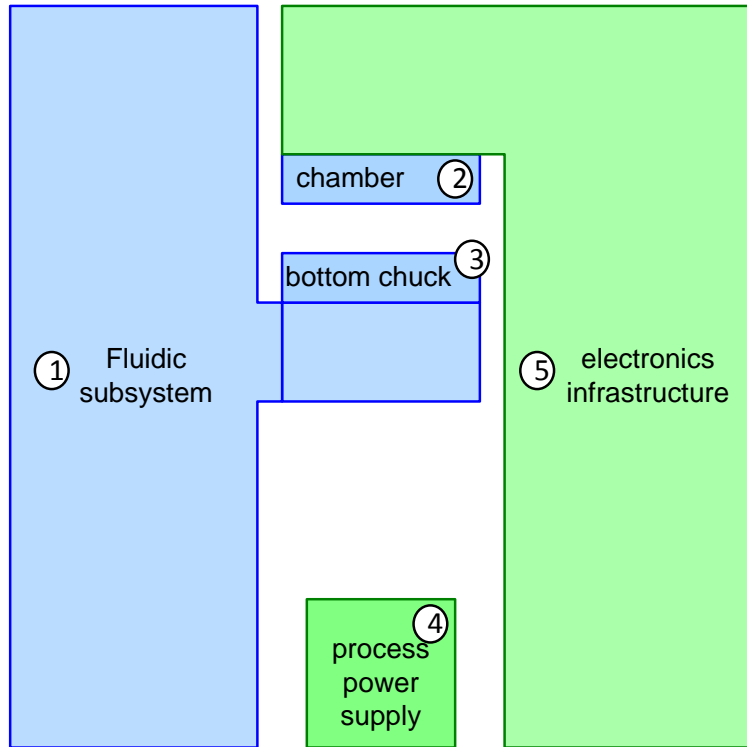
Parts, Dynamics, Characteristics



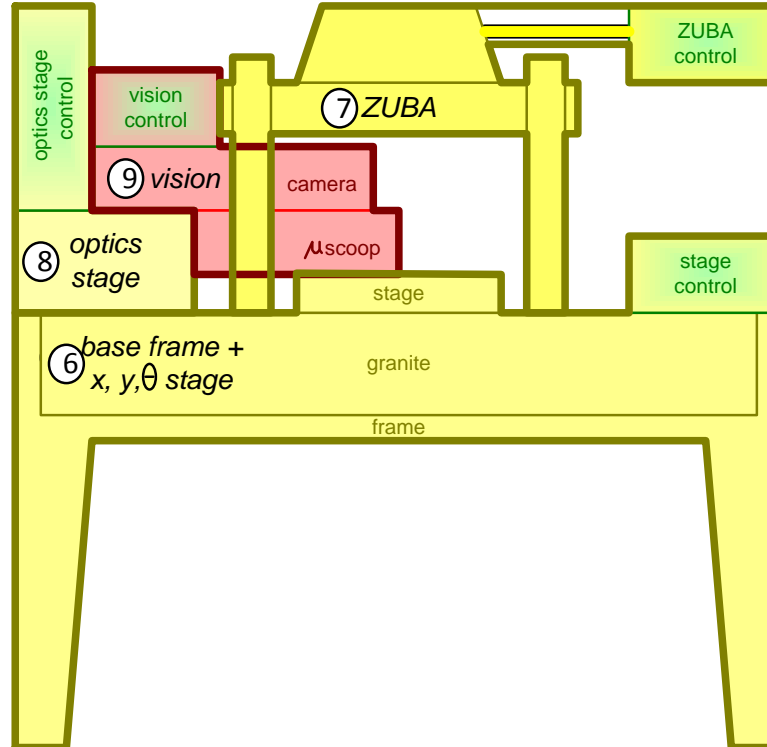
Engineering



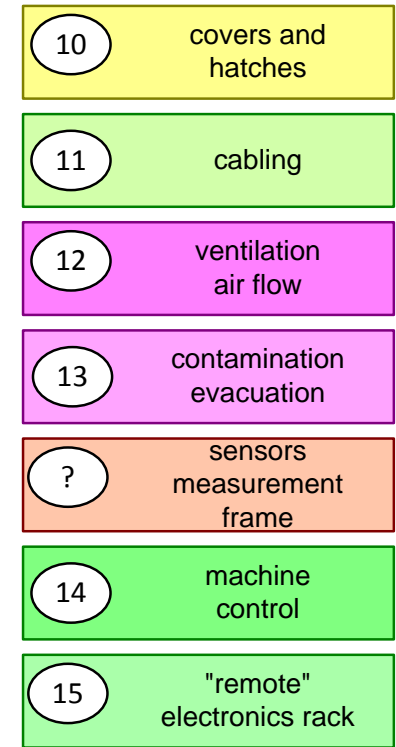
Example Physical Decomposition



back side view

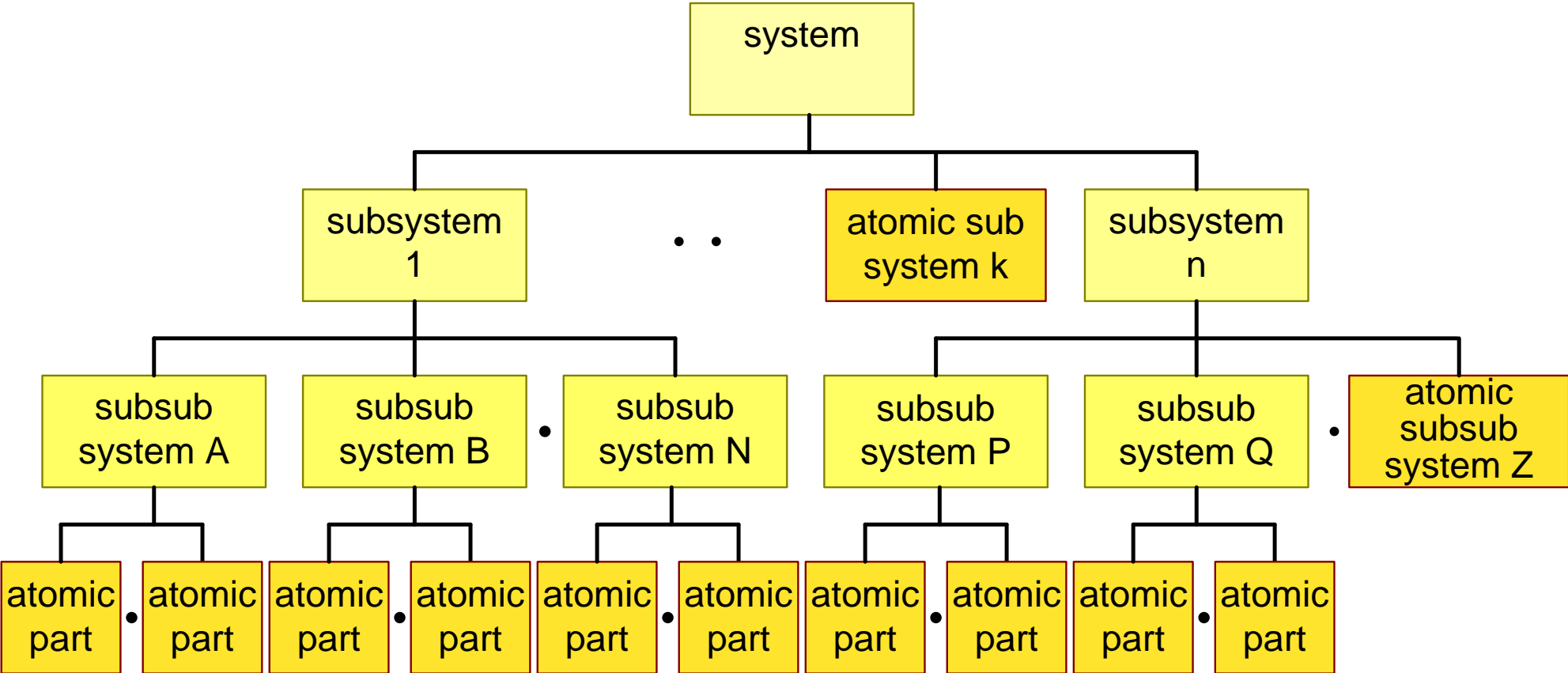


front side view

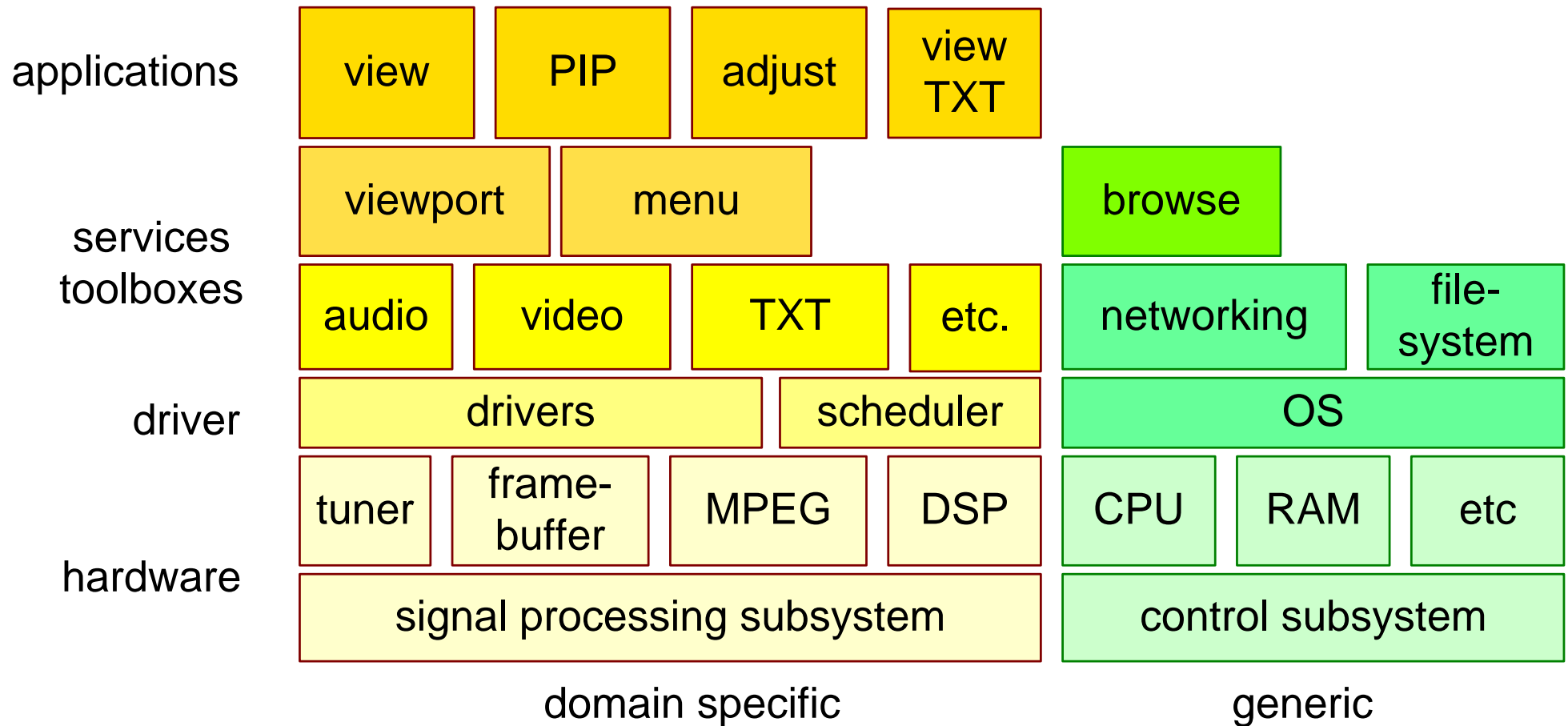


integrating

Partitioning is Applied Recursively



Software plus Hardware Decomposition



the part is cohesive

functionality and technology belongs together

the coupling with other parts is minimal

minimize interfaces

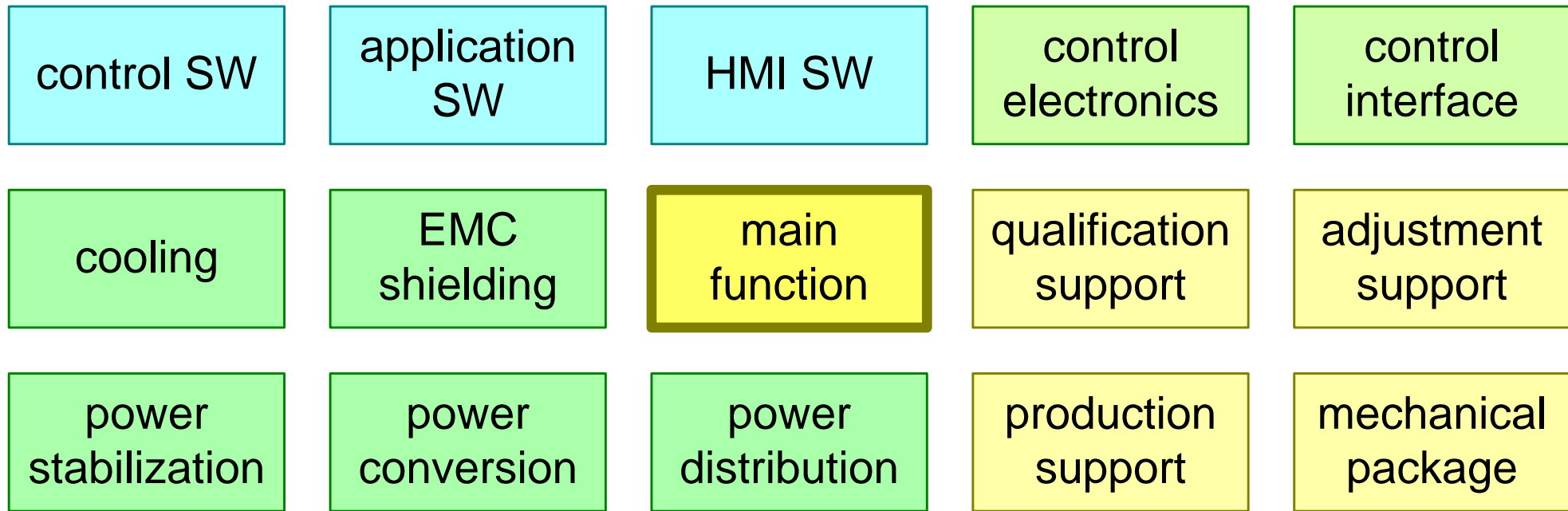
the part is self-sustained for production and qualification

can be in conflict with cost or space requirements

clear ownership of part

e.g. one department or supplier

How much self-sustained?



How self sustained should a part be?

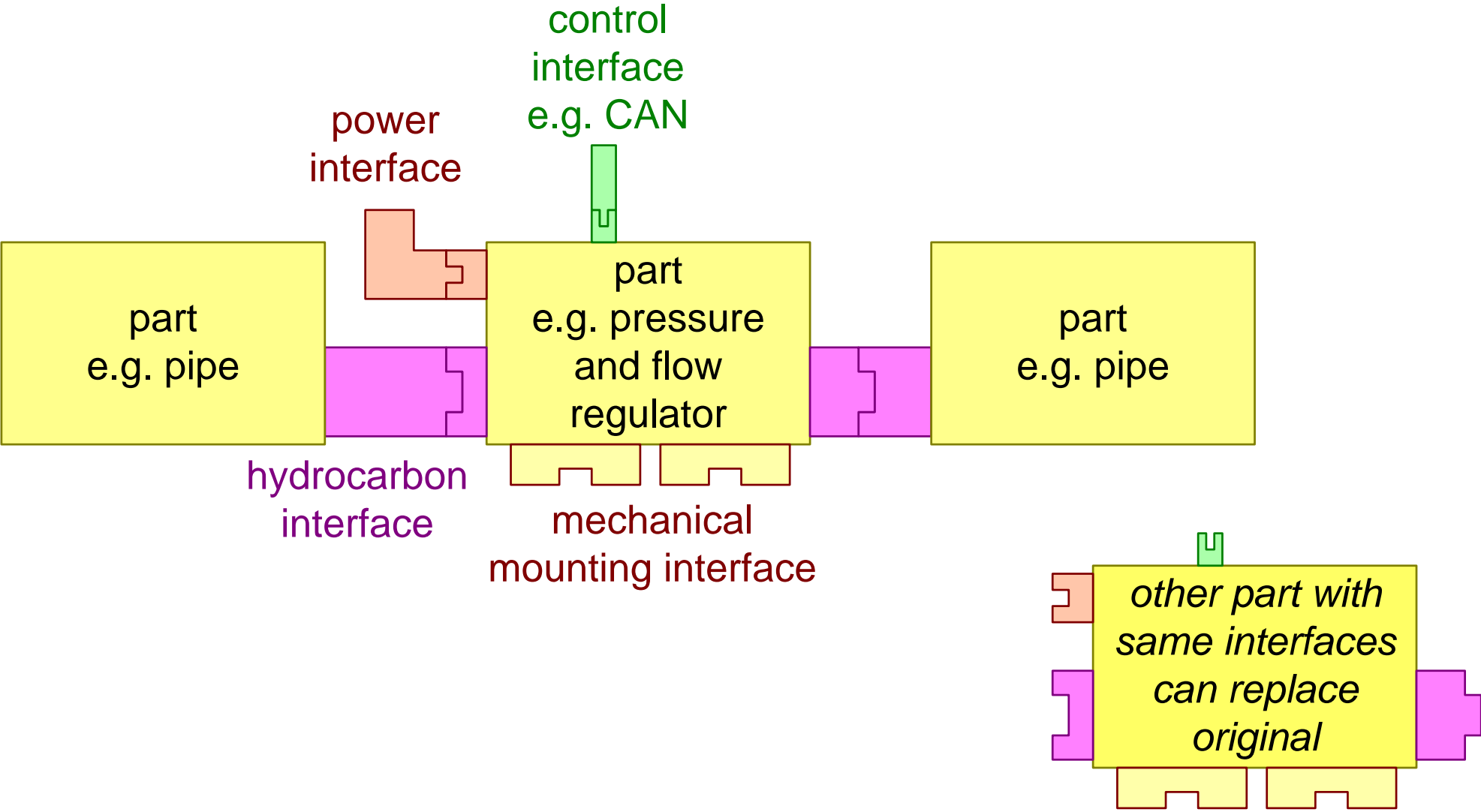
trade-off:

cost/speed/space
optimization



logistics/lifecycle/production
flexibility
clarity

Decoupling via Interfaces



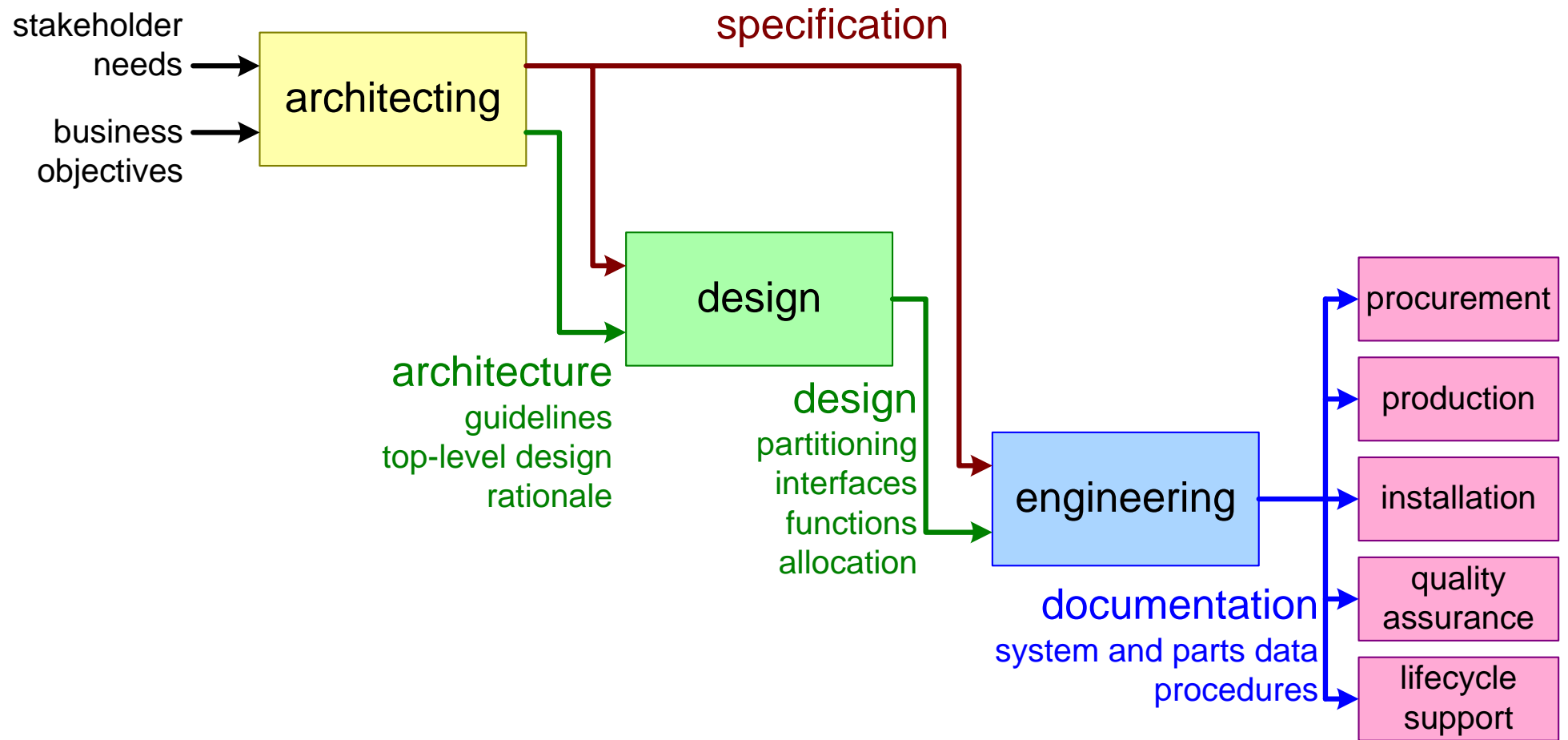
The Ideal Modularity

System is composed

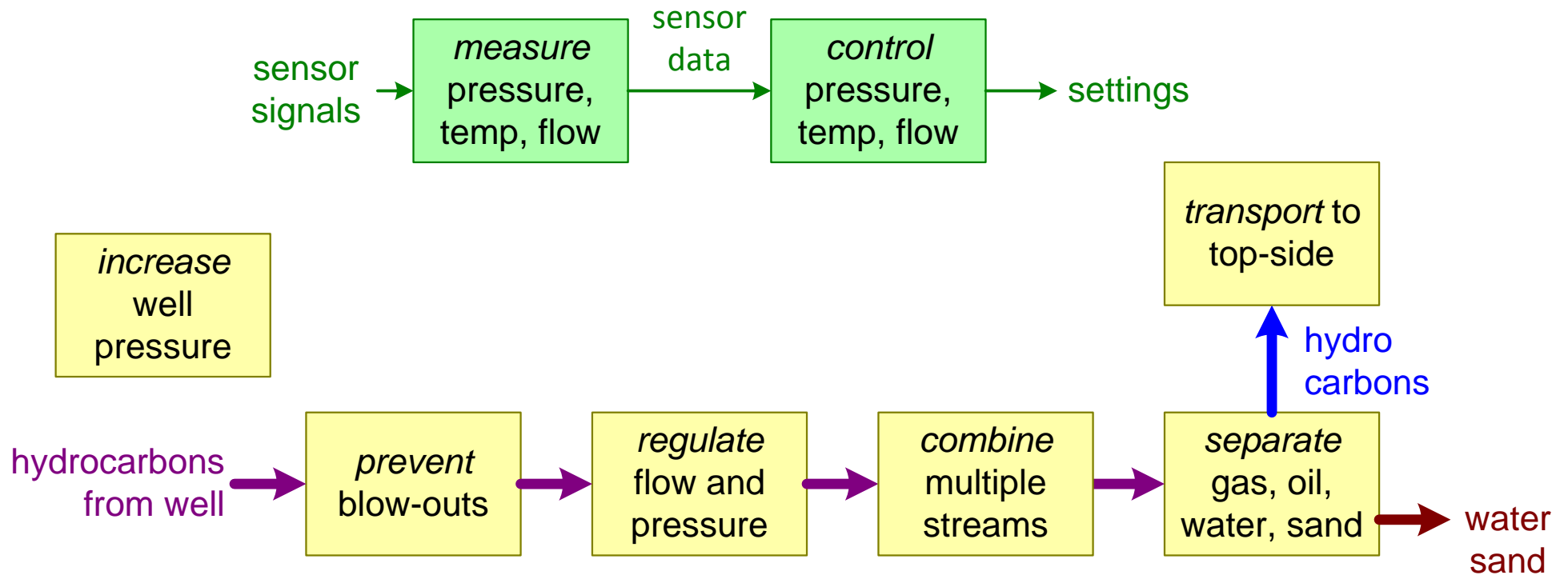
by using standard interfaces

limited catalogue of variants (e.g. cost performance points)

System Creation



Simplistic Functional SubSea Example



Functional Decomposition

How does the system work and operate?

Functions describe *what* rather than *how*.

Functions are *verbs*.

Input-Process-Output paradigm.

Multiple kinds of flows:

- physical (e.g. hydrocarbons)

- information (e.g. measurements)

- control

At lower level one part \sim one function

- pump pumps, compressor compresses, controller controls

At higher level functions are complex interplay of physical parts

- e.g. regulating constant flow, pressure and temperature

Quantification

Size 2.4m * 0.7m * 1.3m

Weight 1450 Kg

Cost 30000 NoK

Reliability MTBF 4000 hr

Throughput 3000 l/hr

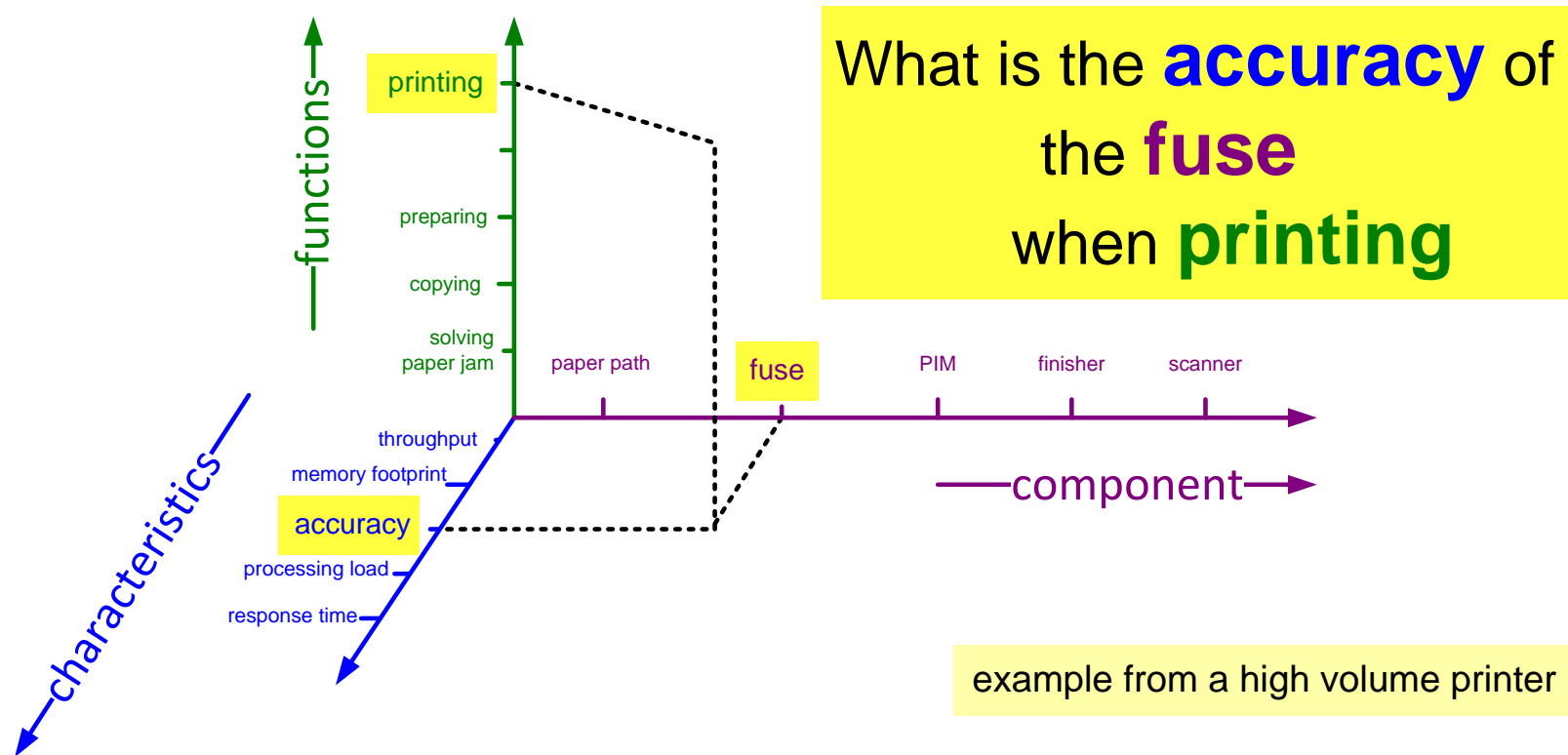
Response time 0.1 s

Accuracy +/- 0.1%

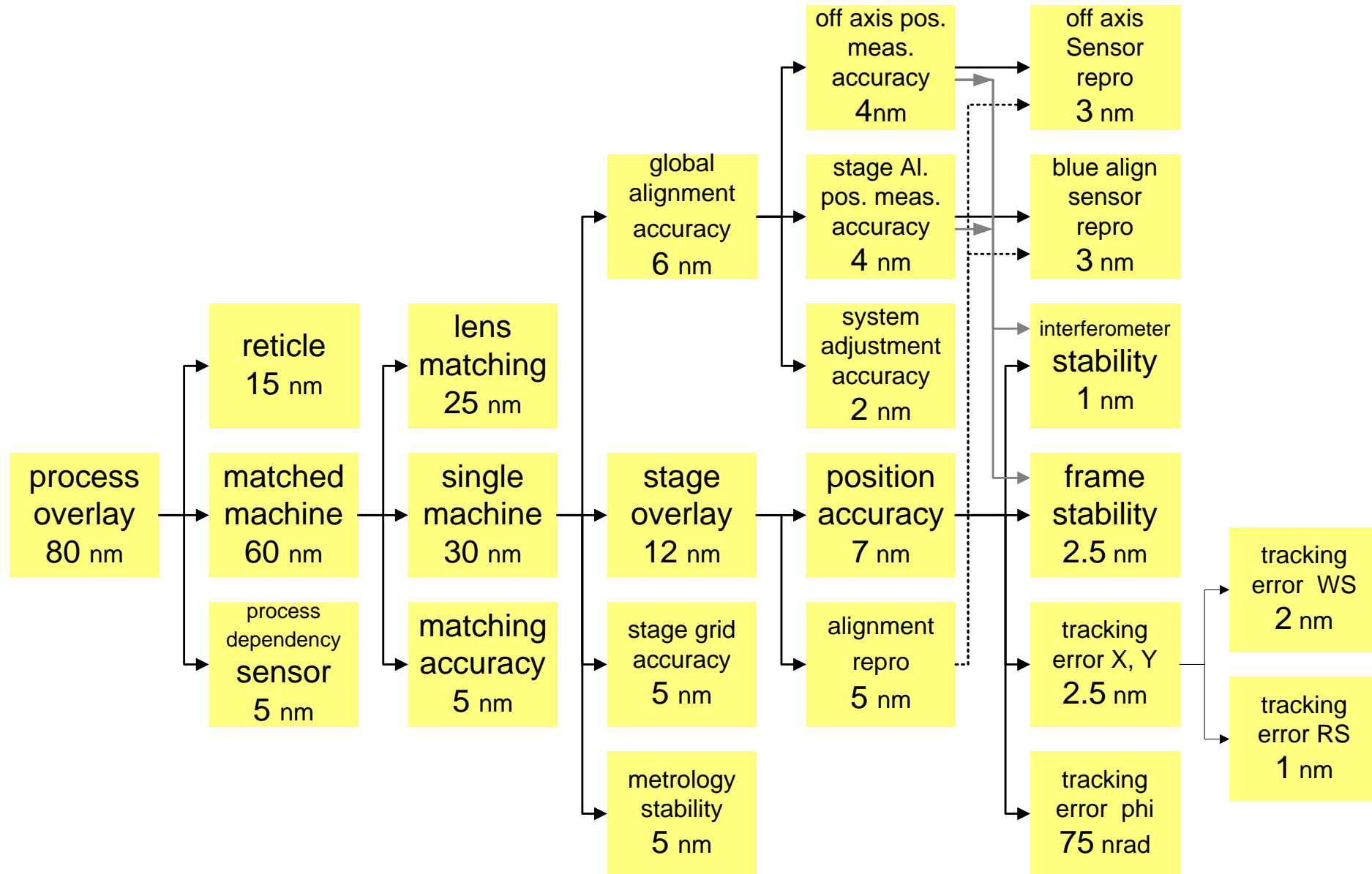
*many characteristics
of a system, function or part
can be quantified*

*Note that quantities
have a **unit***

How about the **<characteristic>**
of the **<component>**
when performing **<function>**?

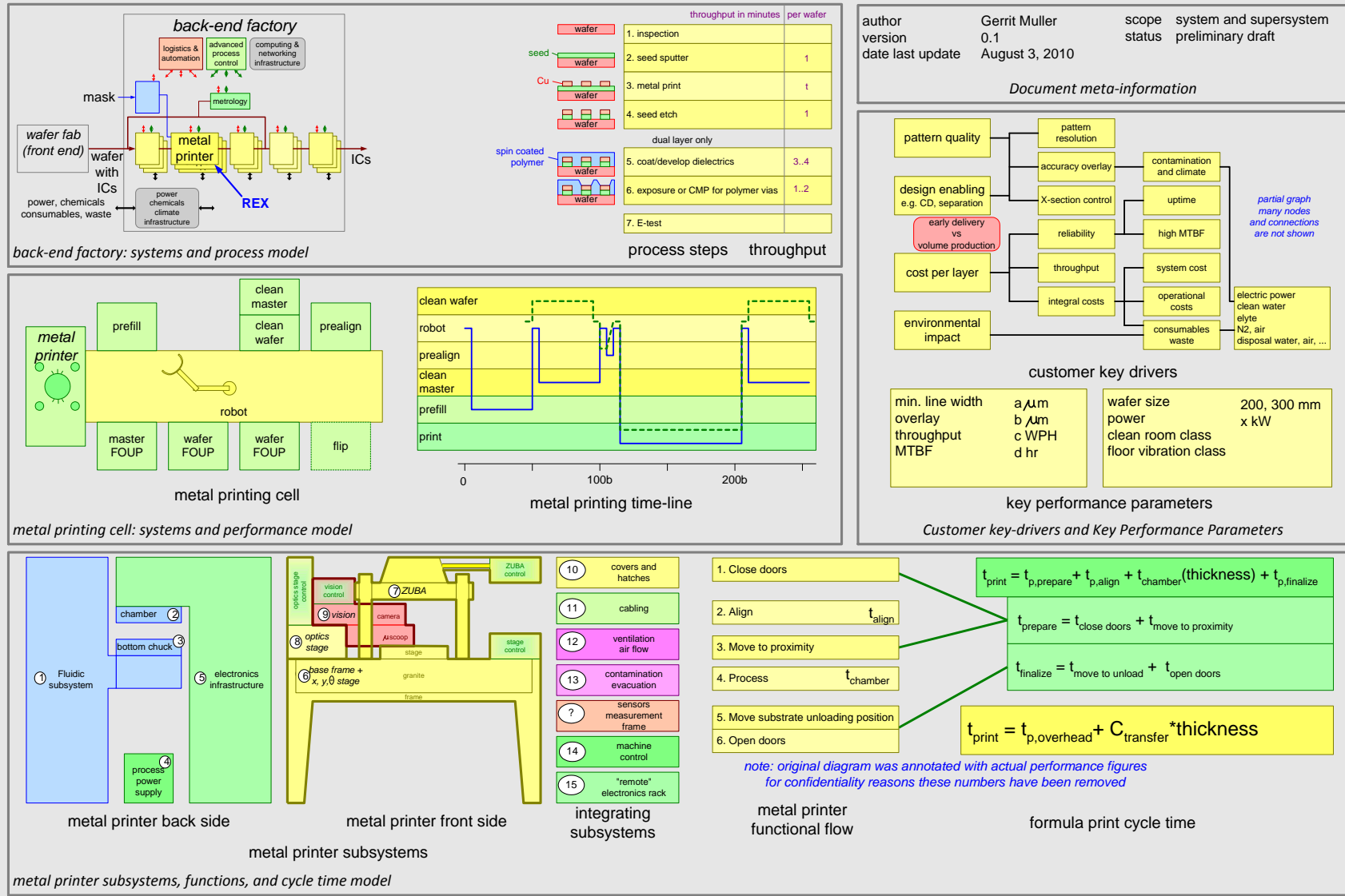


Example Technical Budget



Example of A3 overview

A3 architecture overview of the Metal Printer (all numbers have been removed for competitive sensitivity)



Visualizing Dynamic Behavior

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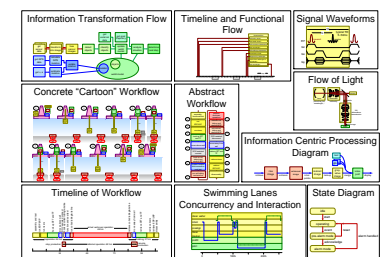
Abstract

Dynamic behavior manifests itself in many ways. Architects need multiple complementary visualizations to capture dynamic behavior effectively. Examples are capturing information, material, or energy flow, state, time, interaction, or communication.

Distribution

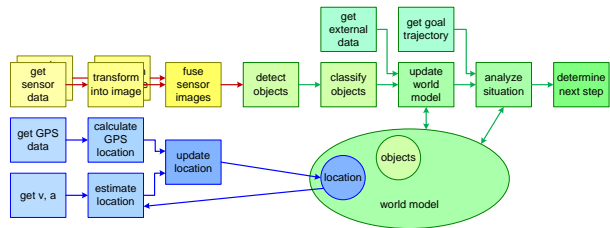
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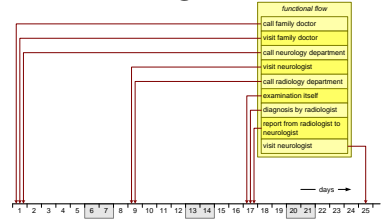


Overview of Visualizations of Dynamic Behavior

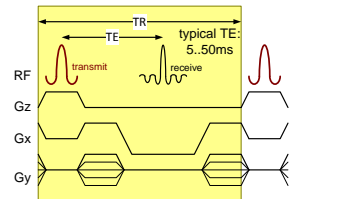
Information Transformation Flow



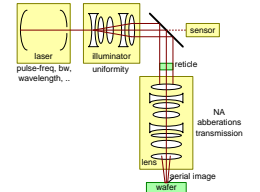
Timeline and Functional Flow



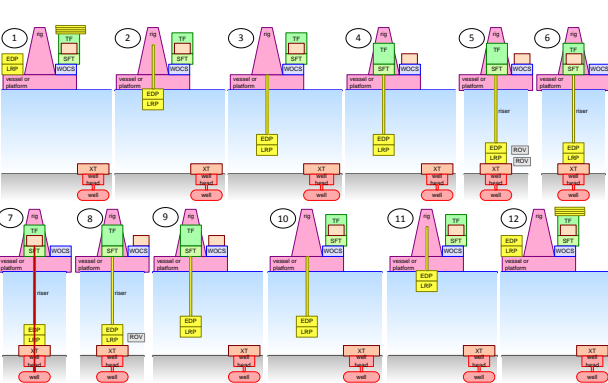
Signal Waveforms



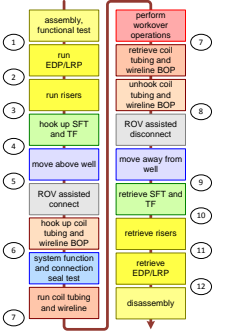
Flow of Light



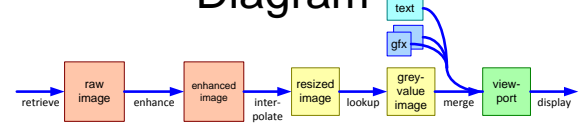
Concrete "Cartoon" Workflow



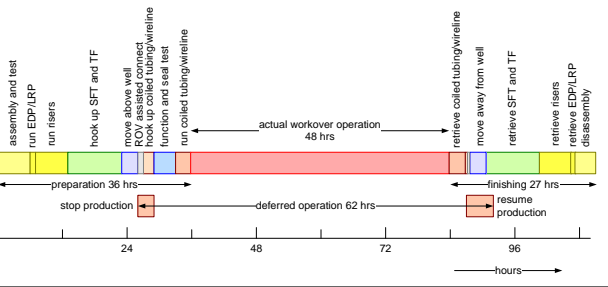
Abstract Workflow



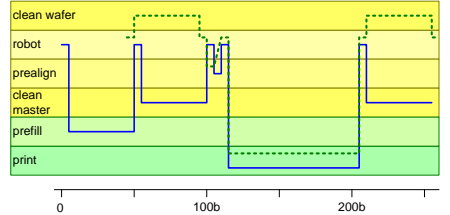
Information Centric Processing Diagram



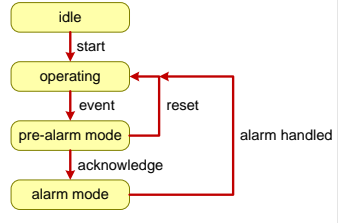
Timeline of Workflow



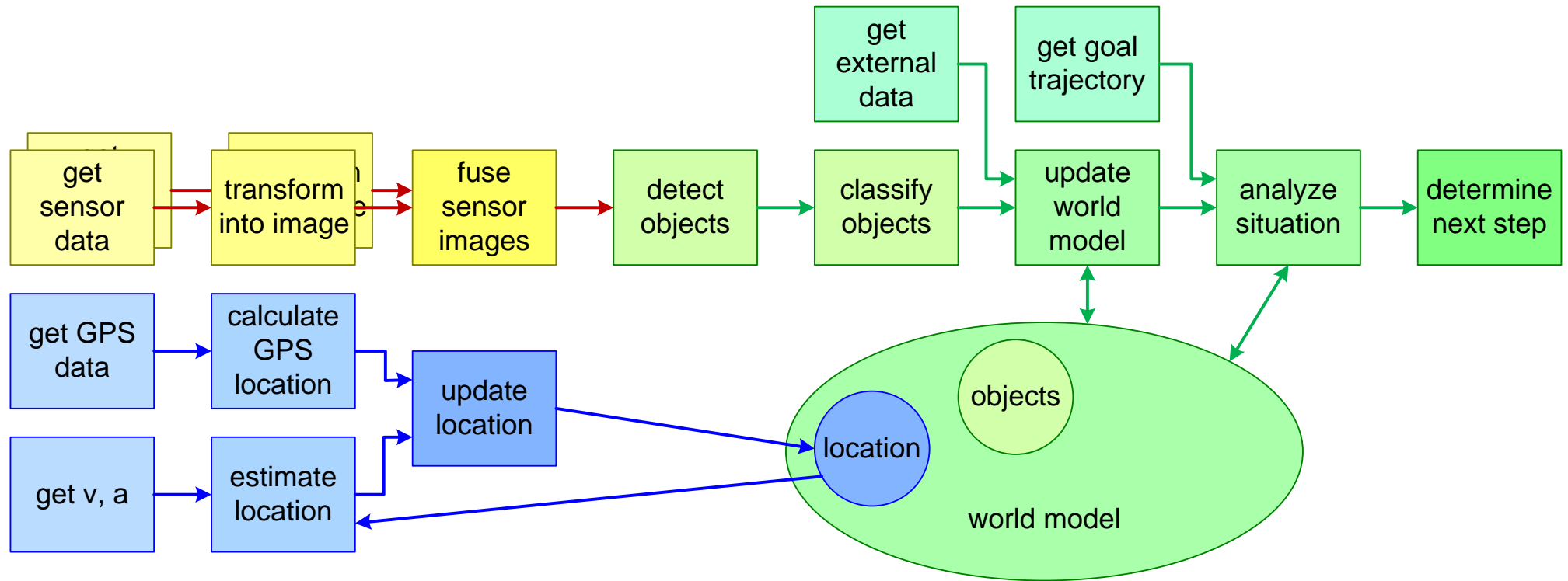
Swimming Lanes Concurrency and Interaction



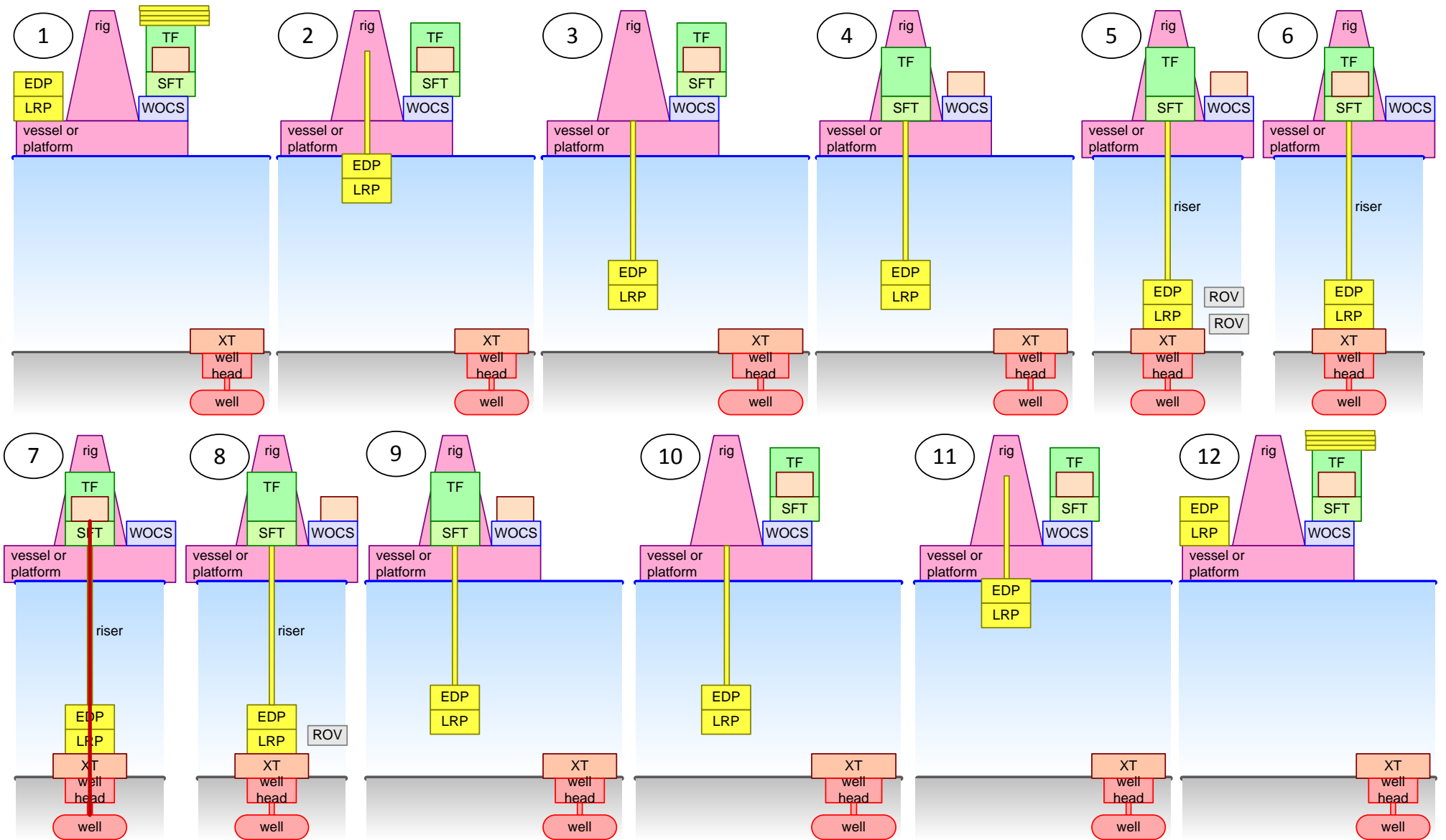
State Diagram



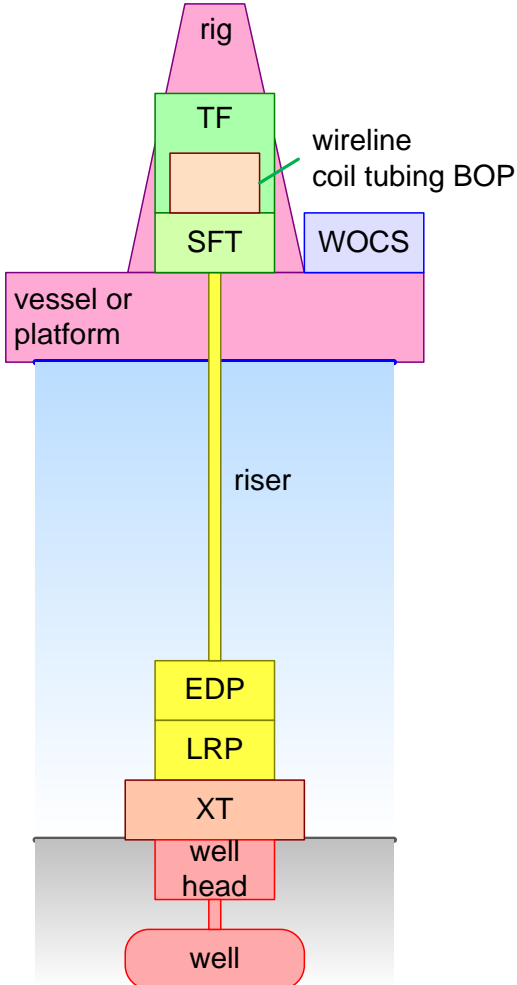
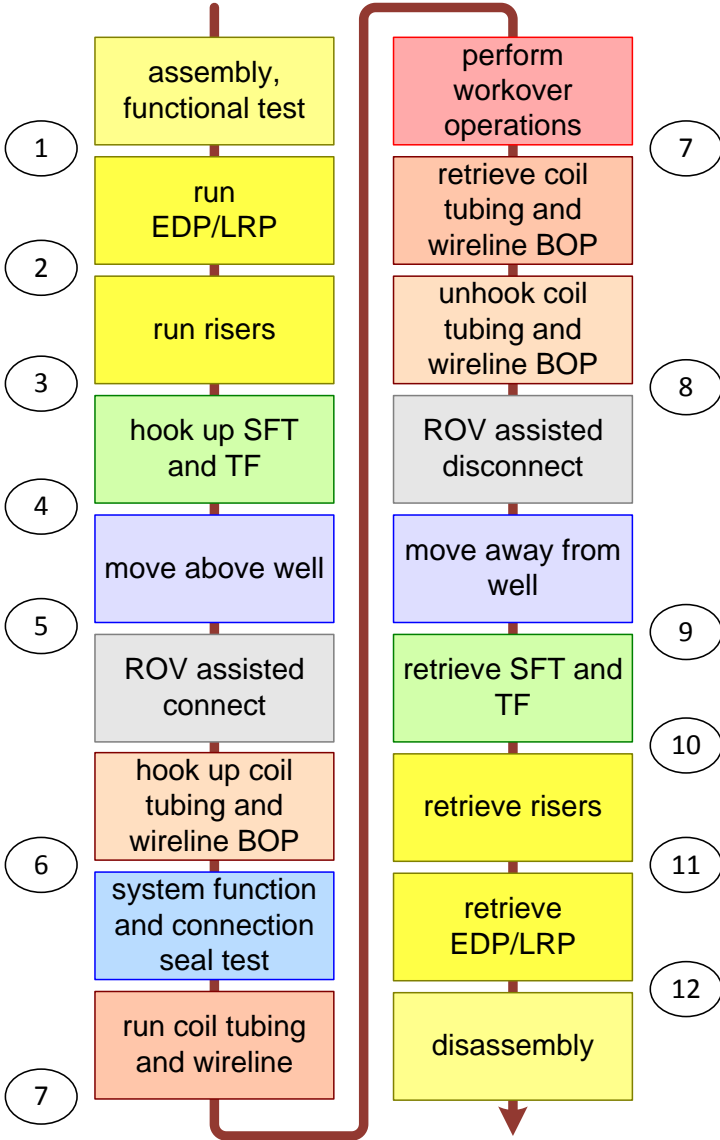
Example Functional Model of Information Flow



"Cartoon" Workflow

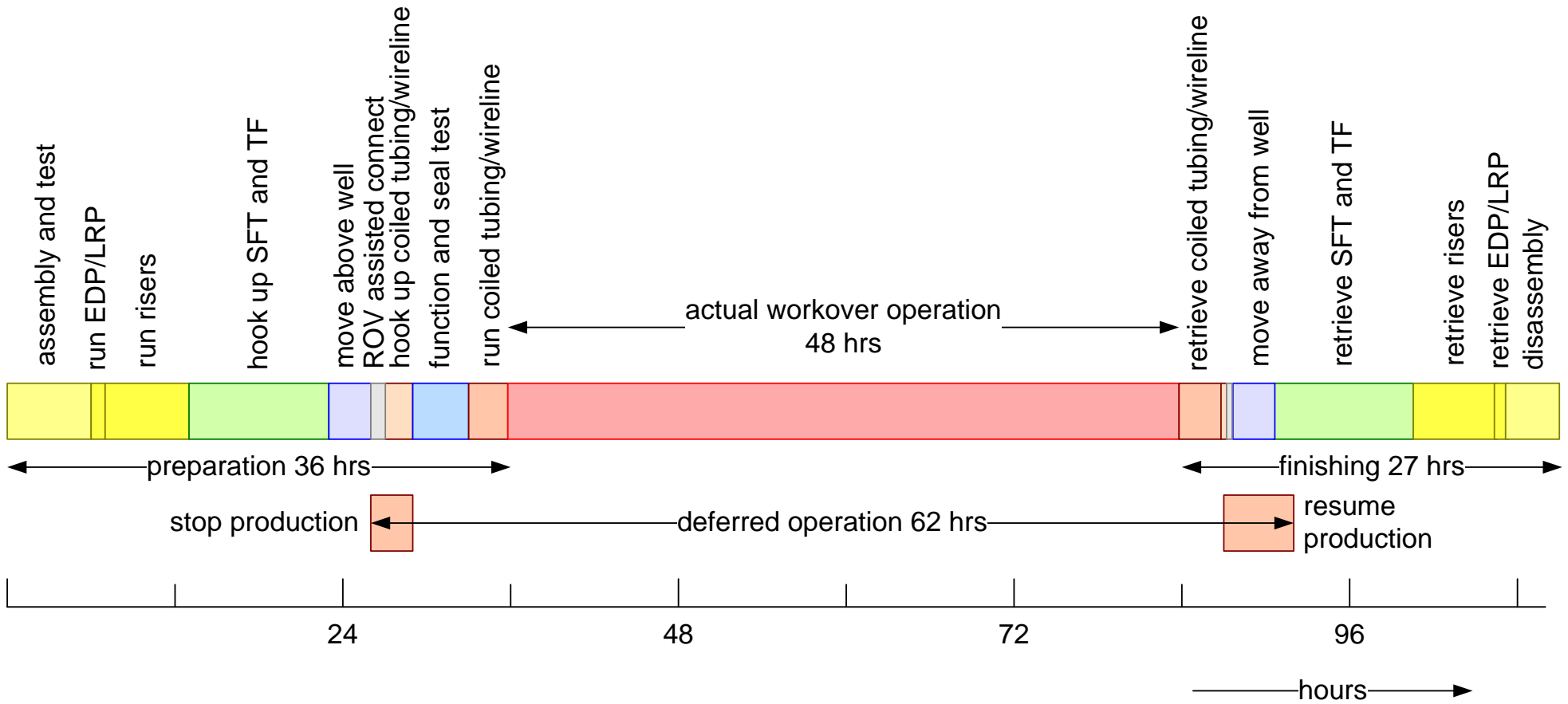


Workflow as Functional Model

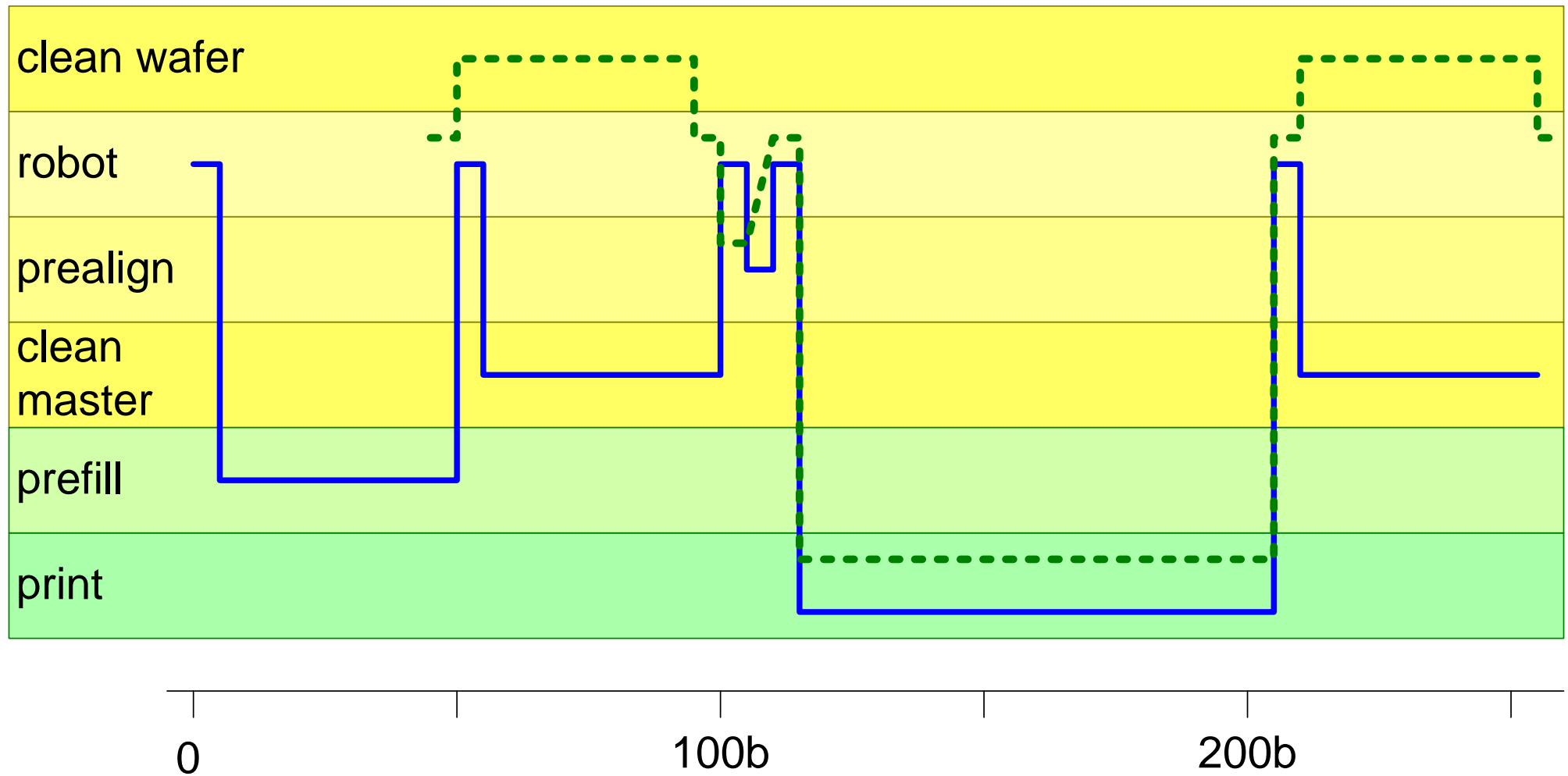


Workflow as Timeline

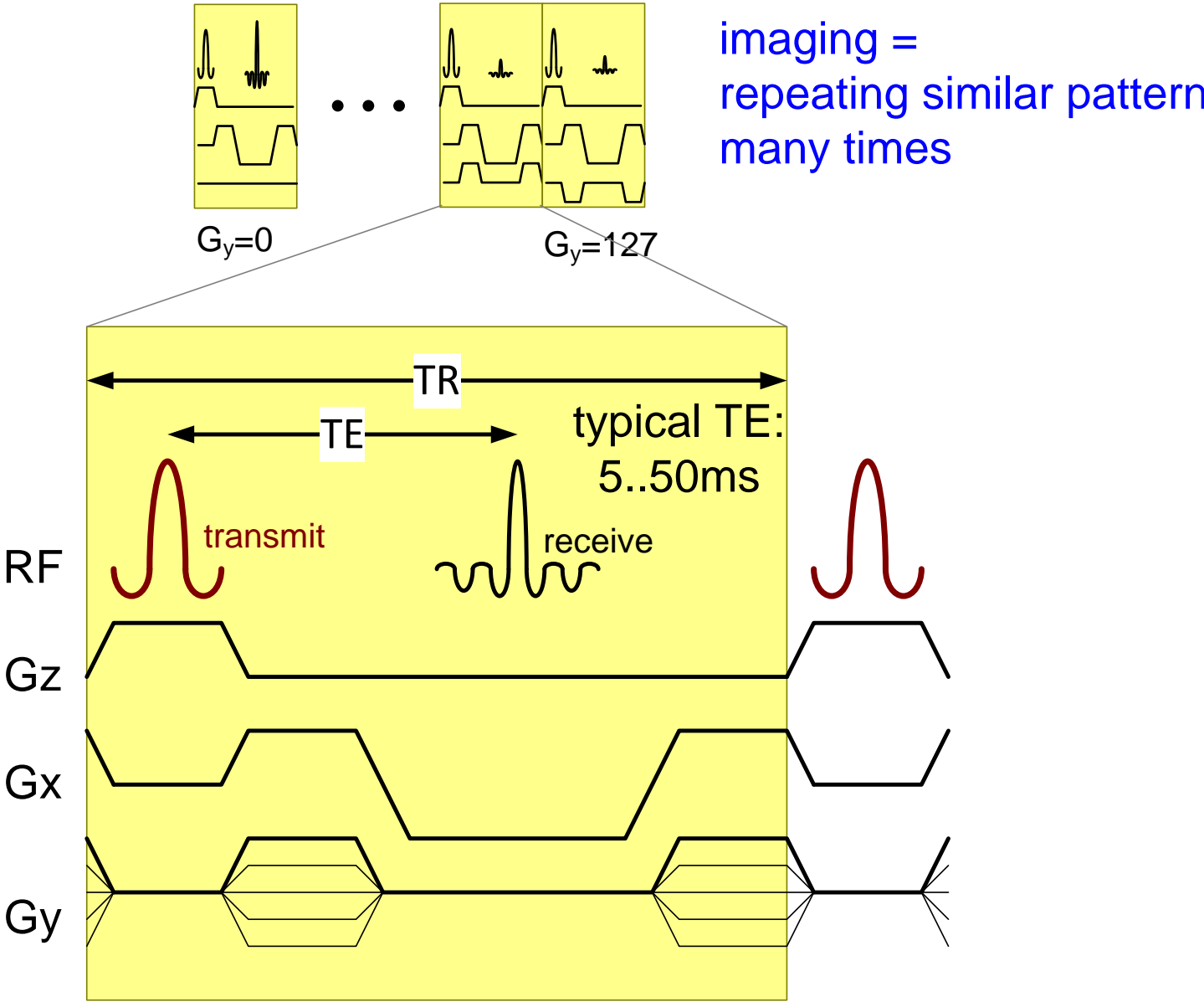
assumptions:
 running and retrieving risers: 50m/hr
 running and retrieving coiled tubing/wireline: 100m/hr
 depth: 300m



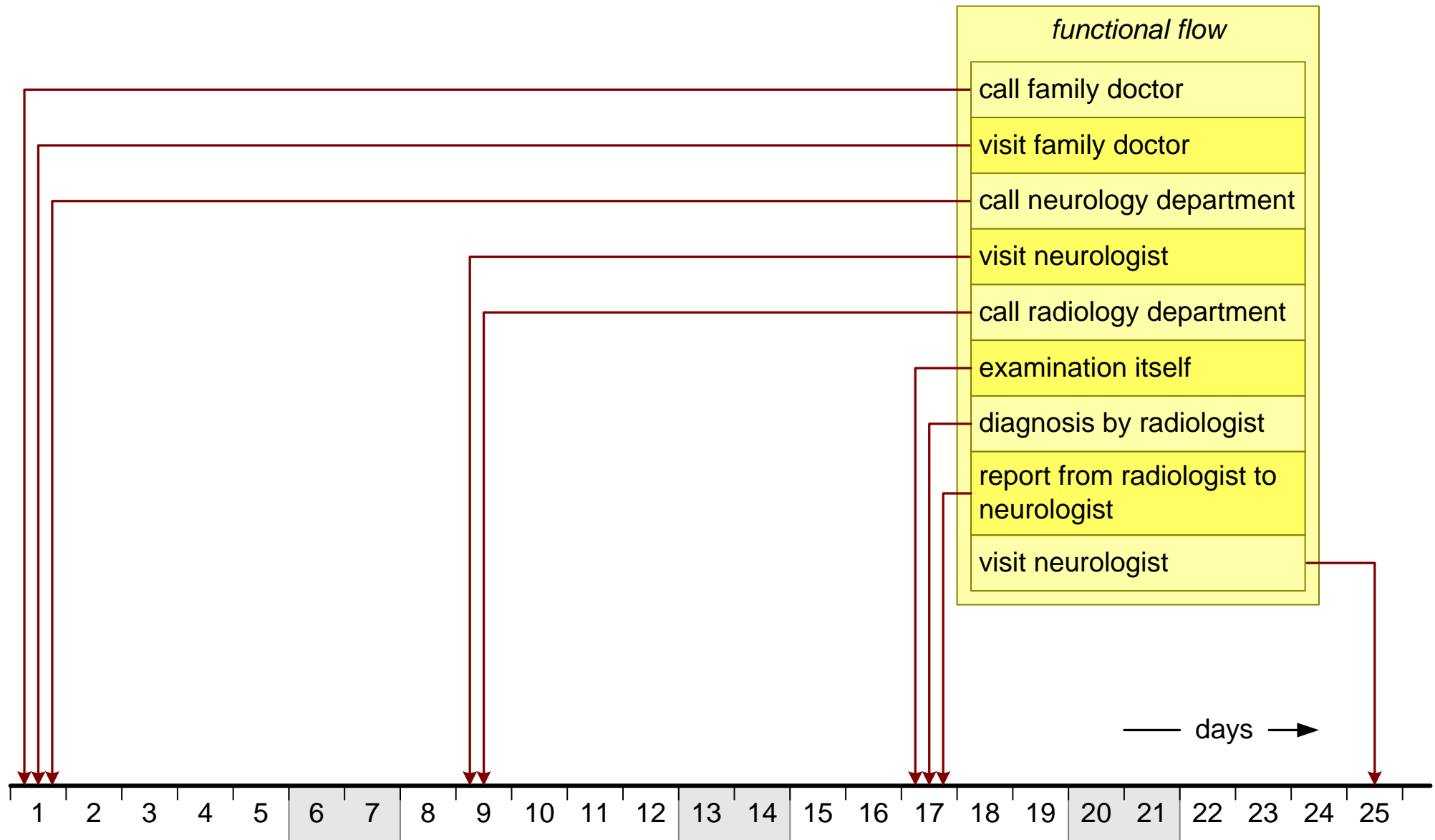
Swimming Lane Example



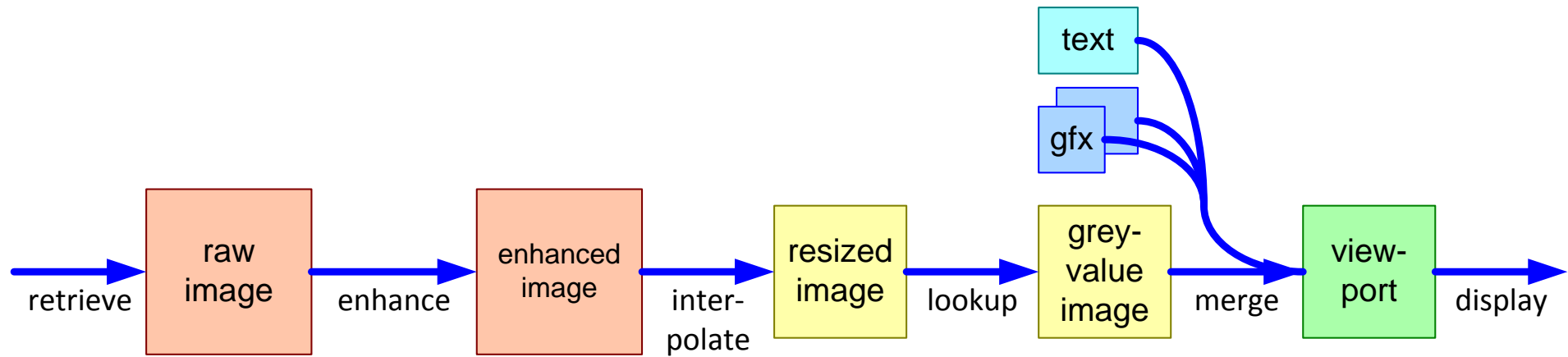
Example Signal Waveforms



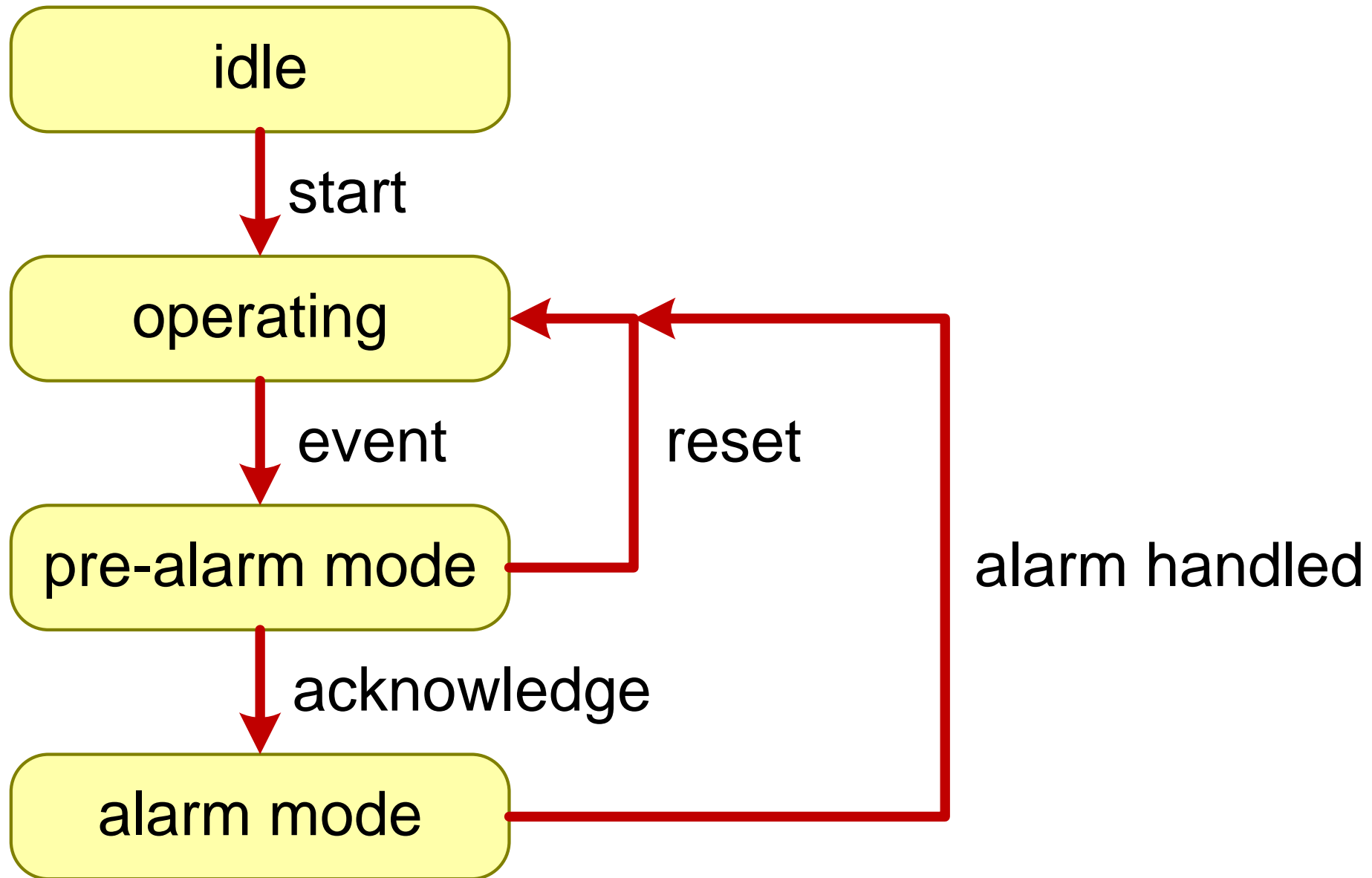
Example Time Line with Functional Model



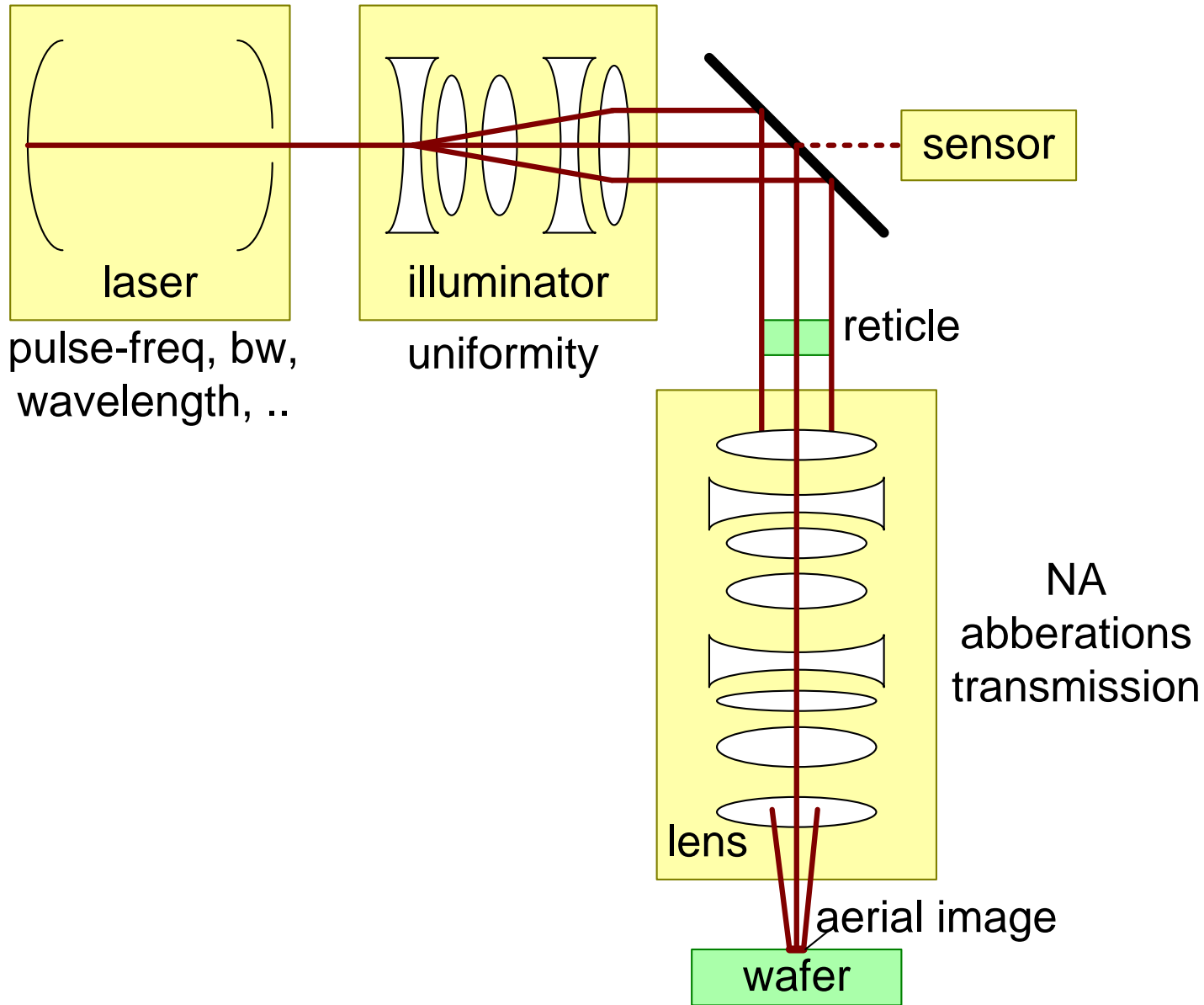
Information Centric Processing Diagram



Example State Diagram



Flow of Light (Physics)



Dynamic Behavior is Multi-Dimensional

How does the system work and operate?

Functions describe *what* rather than *how*.

Functions are *verbs*.

Input-Process-Output paradigm.

Multiple kinds of flows:

physical (e.g. hydrocarbons, goods, energy)

information (e.g. measurements, signals)

control

Time, events, cause and effect

Concurrency, synchronization, communication

multi-dimensional
information and
dynamic behavior

Exercise Dynamic Behavior

Capture the **dynamic behavior** of the **internals** of your system in **multiple** diagrams.

Diagrams that capture dynamic behavior are among others:

- Functional flow (of control or information, material or goods, or energy)
- Activity or sequence diagrams (e.g. with “swimming lanes”)
- State diagrams

Exercise Block Diagram

Make a set of **block diagrams** capturing the **static parts** and **interfaces**.

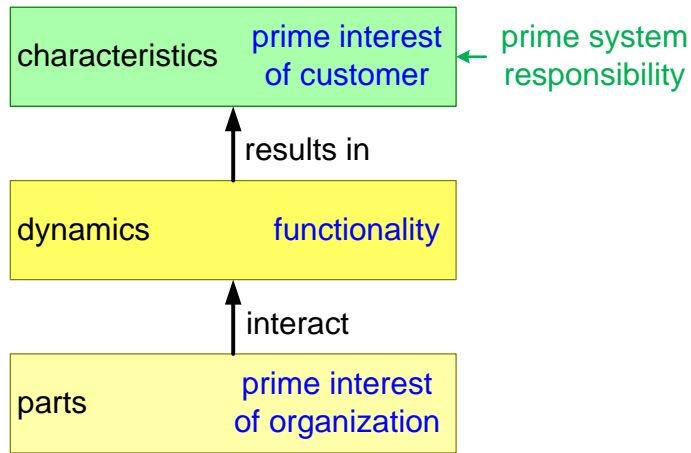
Ensure coverage of the entire system, e.g. including service, training, production, etc.

Show both **hardware** and **software**

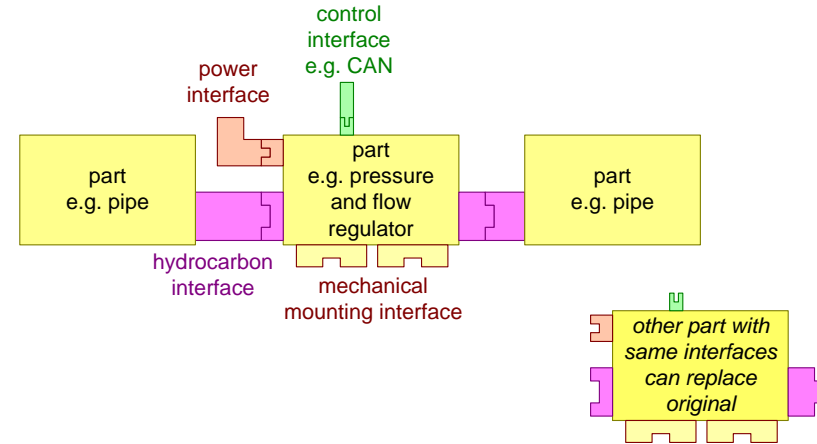
Good block diagrams have in the order of 10 to 20 blocks

Design Fundamentals

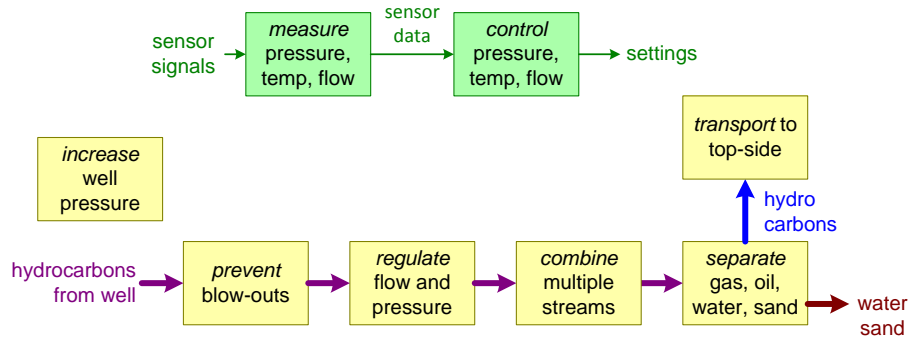
Parts, Dynamics, Characteristics



Decoupling via Interfaces



Dynamic Behavior



Question Generator

How about the **<characteristic>** of the **<component>** when performing **<function>**?

