Module SEFS Architecting

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Abstract

Understanding thecontext is essential to understand the problem and the solution space. We discuss the way companies work, the customer, business, and life cycle contexts, and how to scope the work.

October 18, 2020
status: preliminary draft
version: 0

SEFS Architecting Fundamentals

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Abstract

Architecting transforms the needs and understanding of the current situation into a system specification and high-level design. The architecture description captures the overview, the rationale, and provides guidance and rules for the design.

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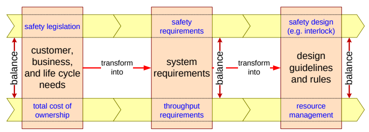
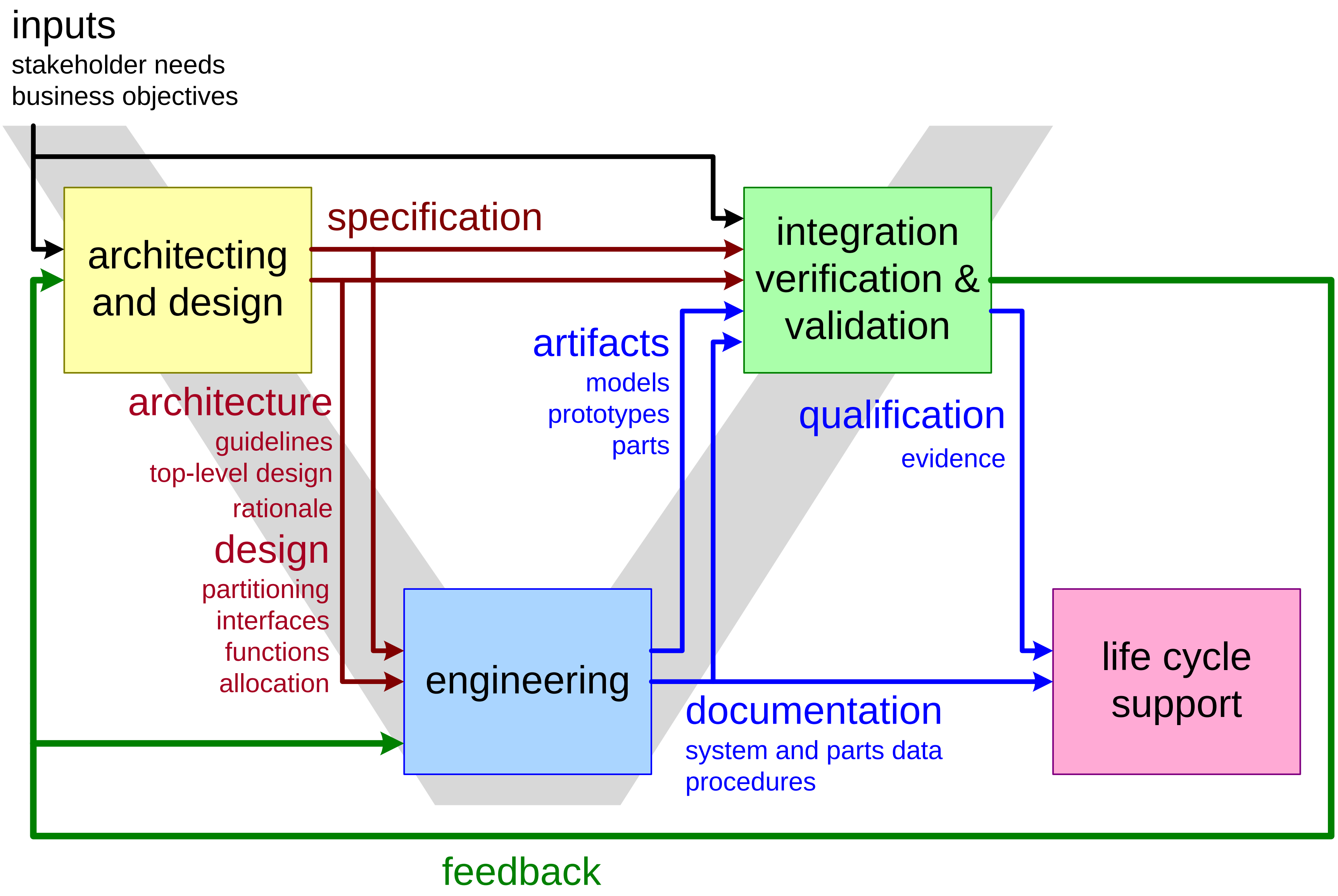
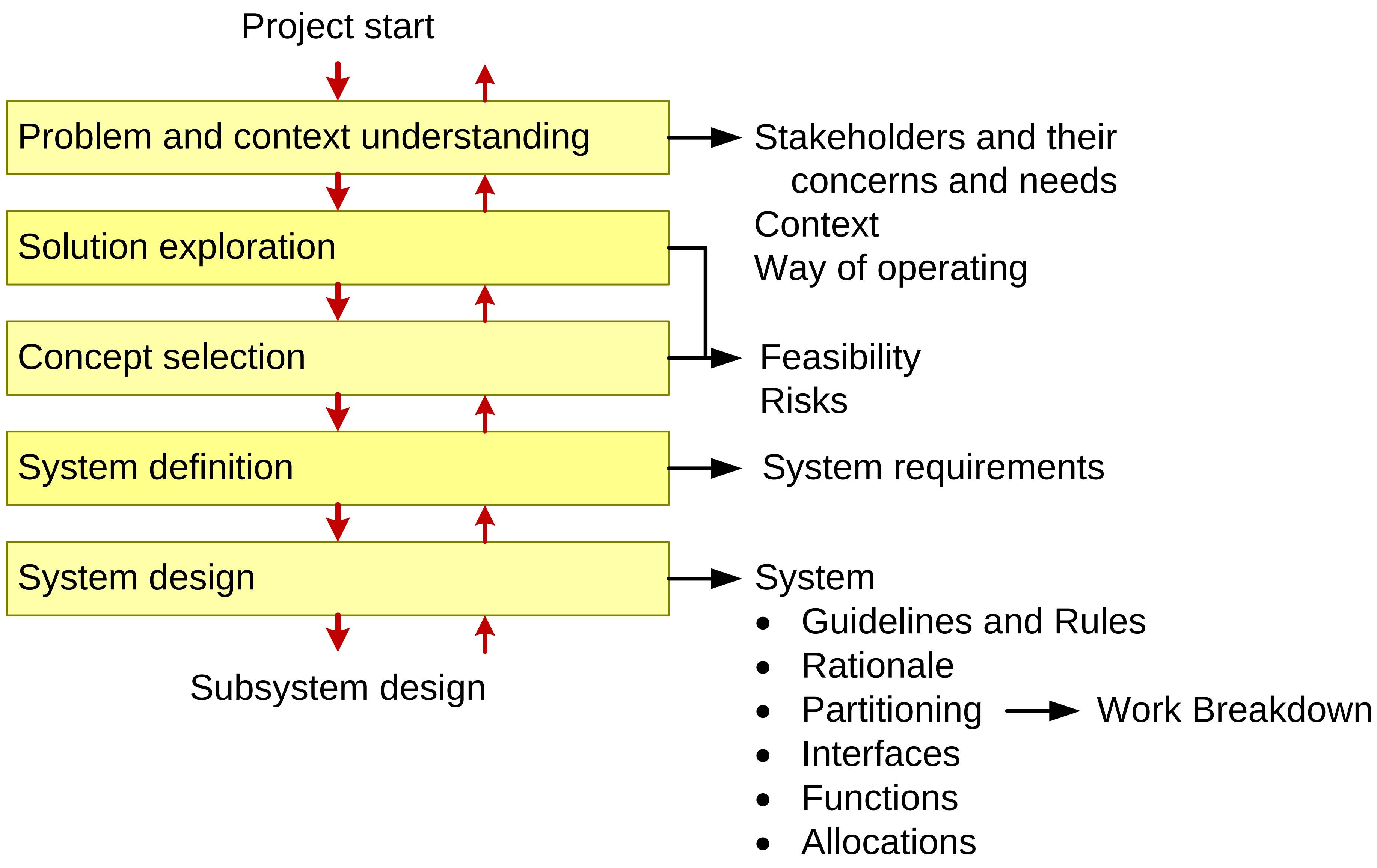


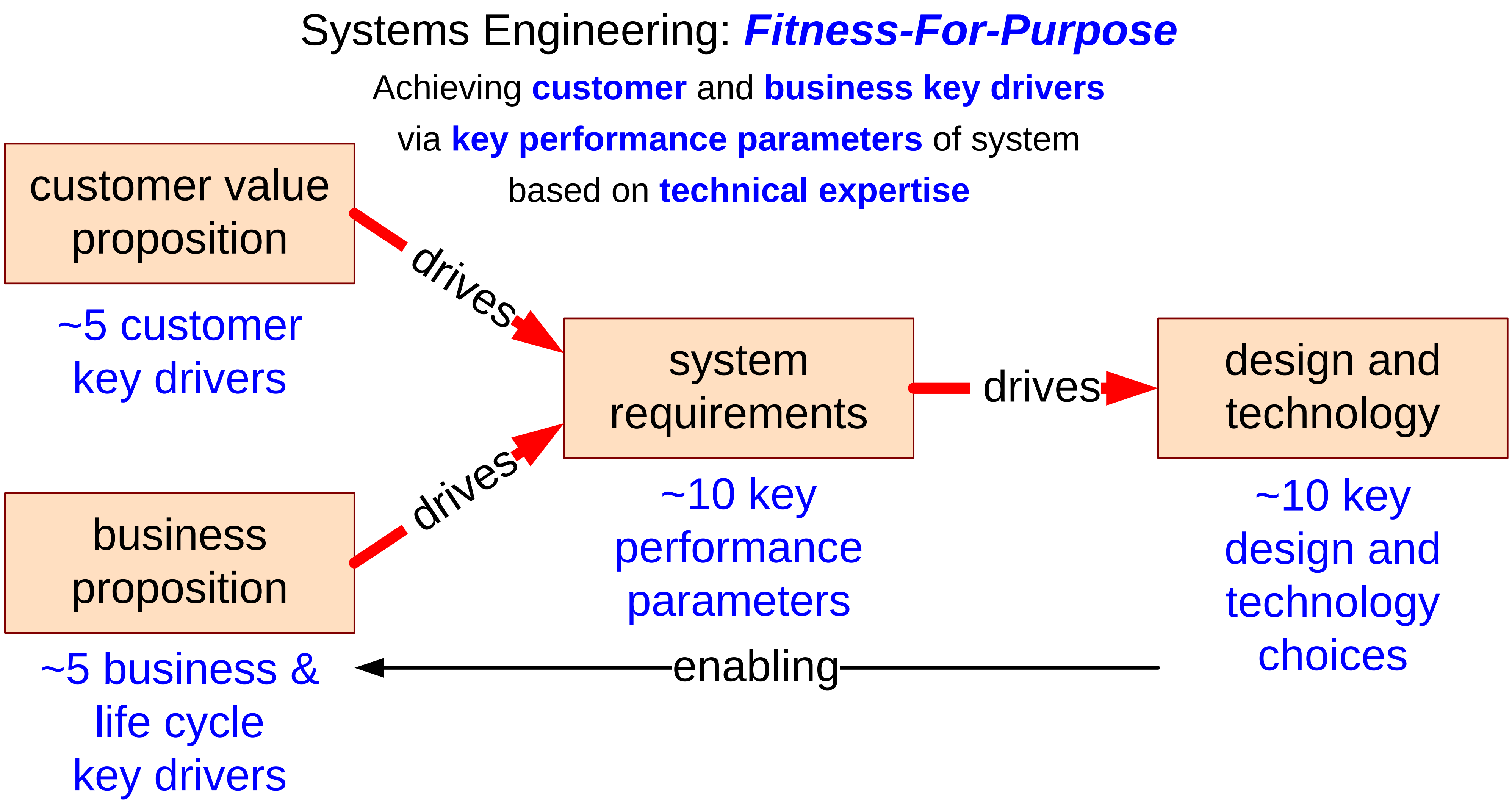
Architecting and Design in the V-model



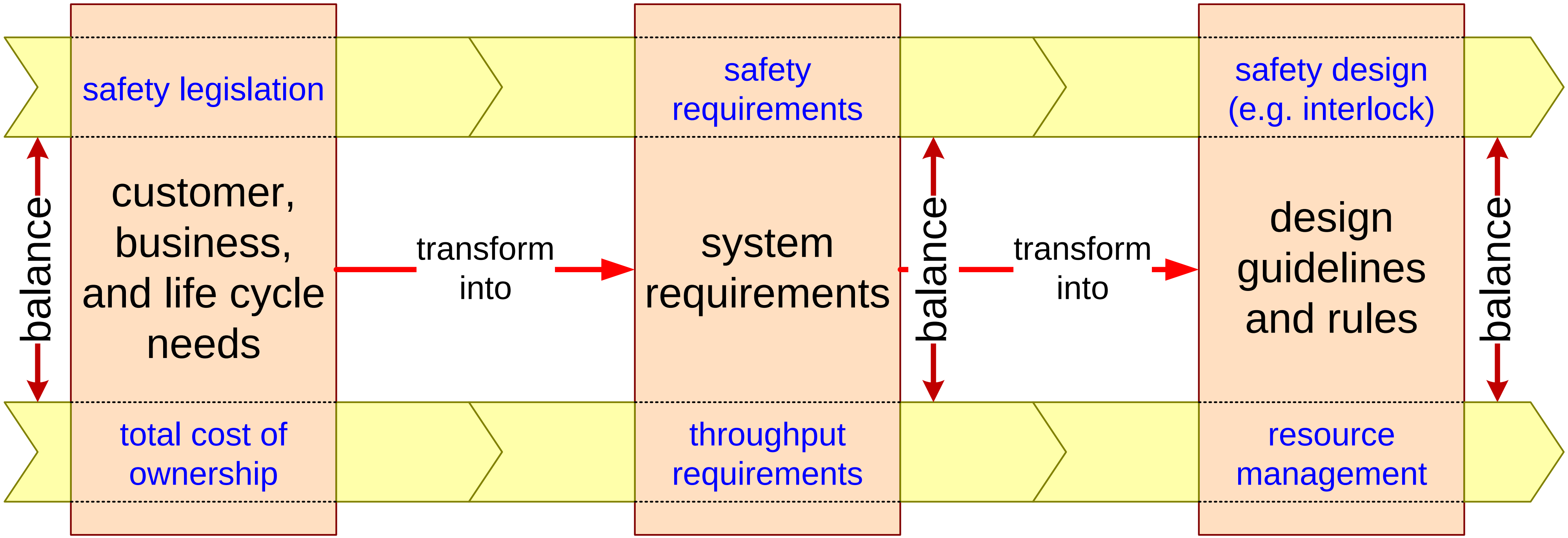
Architecting Workflow



The Architecture Captures the Rationale



Architecture Provides Guidelines and Rules



SEFS Concept Selection

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Abstract

Concept selection is useful at many levels, from the customer application to the technology concept for specific functions. The Pugh matrix is a lightweight decision matrix facilitating early phase concept selections. When the design is crystallizing out, then trade-off analysis provides a more specific insight in the relation between specification and design parameters.

October 18, 2020
status: preliminary draft
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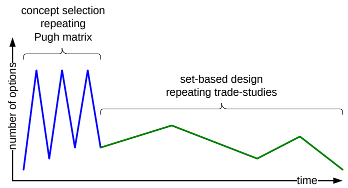
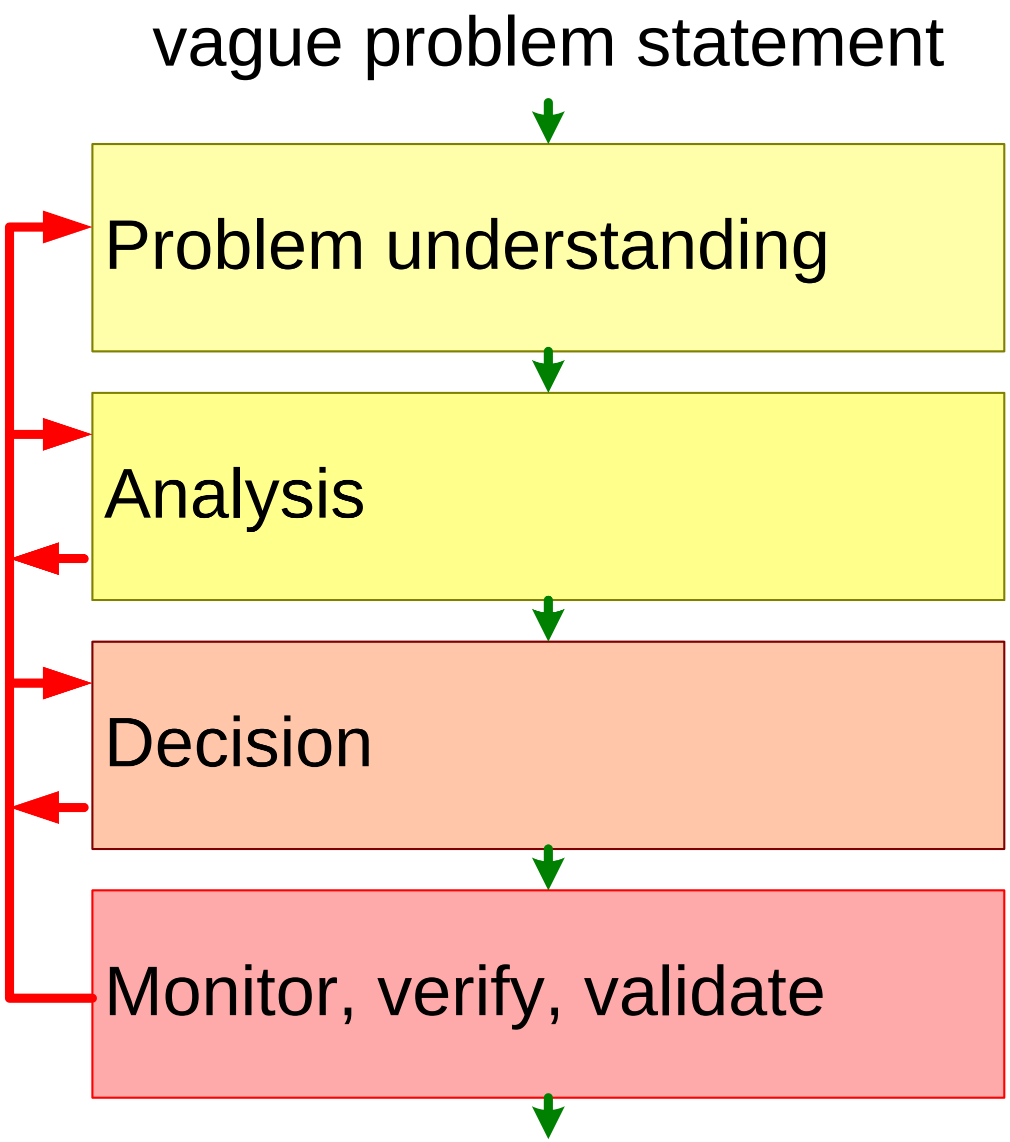


Exploration and Analysis Flow of Concepts



Pugh Matrix: a Light-Weight Decision Matrix

Define at least 3 concepts

Define 7 to 10 criteria for selection

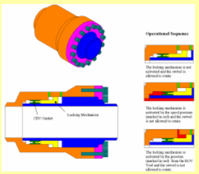
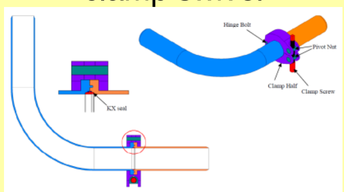
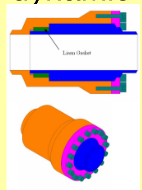
Score the concepts against the criteria, for example using a scale from 1 to 5: 1 = very poor, 5 = very good

Recommend a concept with a rationale

	concept 1	concept 2	concept 3
criterion 1	1	3	5
criterion n	4	4	2
			recommended, because ...

Examples of Pugh Matrix

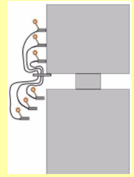
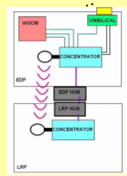
Swivel concept selection

CBV swivel	clamp swivel	dynamic
		

evaluation criteria	weight	CBV		clamp		dynamic	
Maturity	10						
Development level		5	50	2	20	2	50
Cost	20						
Hardware cost		4	80	2	40	5	100
Development cost		5	100	2	40	2	40
Design robustness	25						
Design life							
swivel cycles		5	125	3	75	3	75
pressure cycles		5	125	4	100	5	125
Pressure range							
internal		4	100	4	100	4	100
external		2	50	5	125	2	50
Temperature range		4	100	4	100	4	100
Installation	20						
Initial installatio/retrieval		2	40	3	60	4	80
Connection/disconnection		2	40	4	80	5	100
Operation	25						
Swivel resistance		1	25	4	100	5	125
Spool Length Short		1	25	4	100	5	125
Spool Length Long		3	75	5	125	5	125
Hub loads		2	50	4	100	5	125
Σ points			985		1165		1290

from master paper Halvard Bjørnsen, 2009

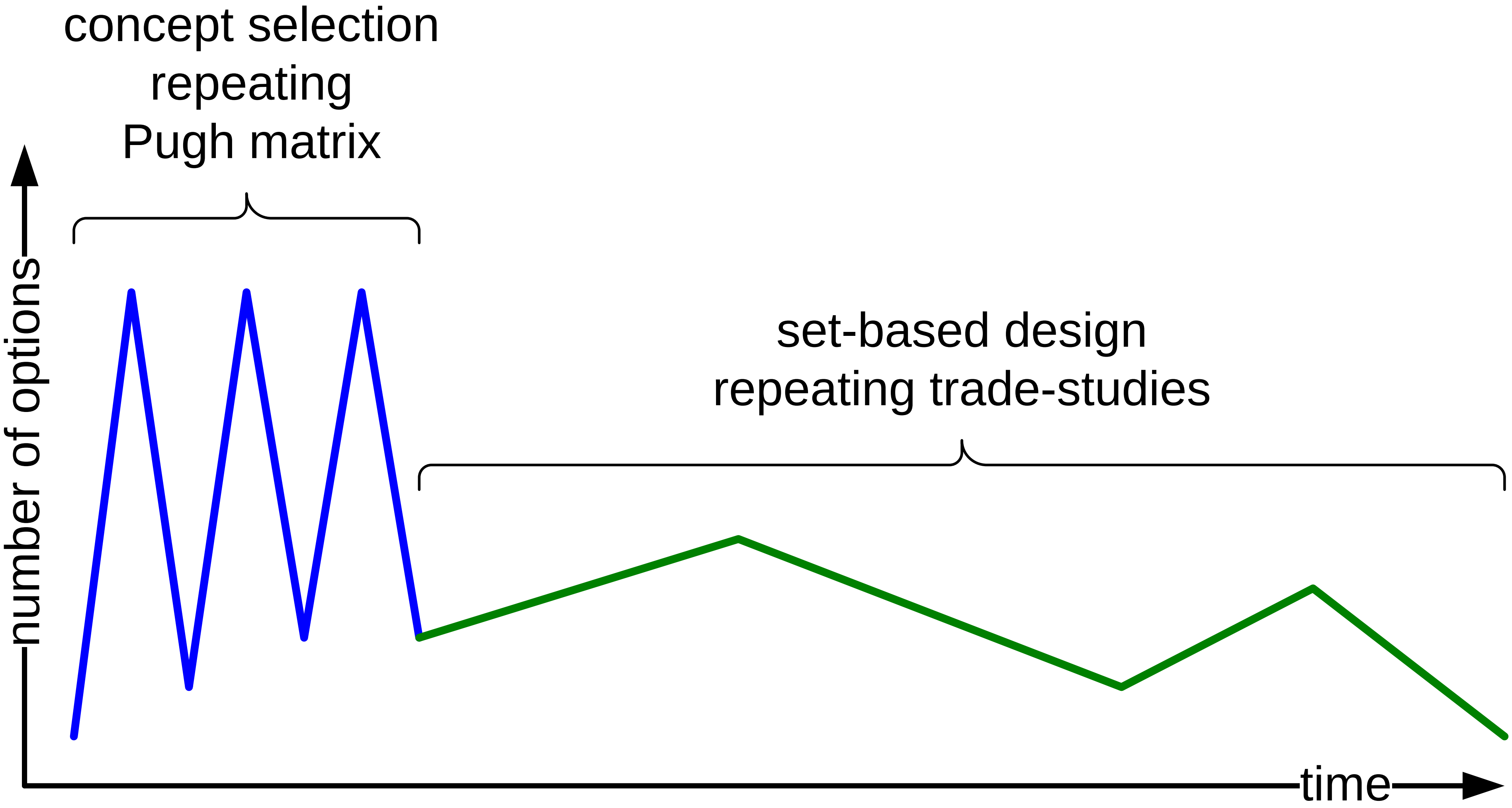
EDP-LRP connection

two sided	connectors in hub	connectors in hub	wireless
			

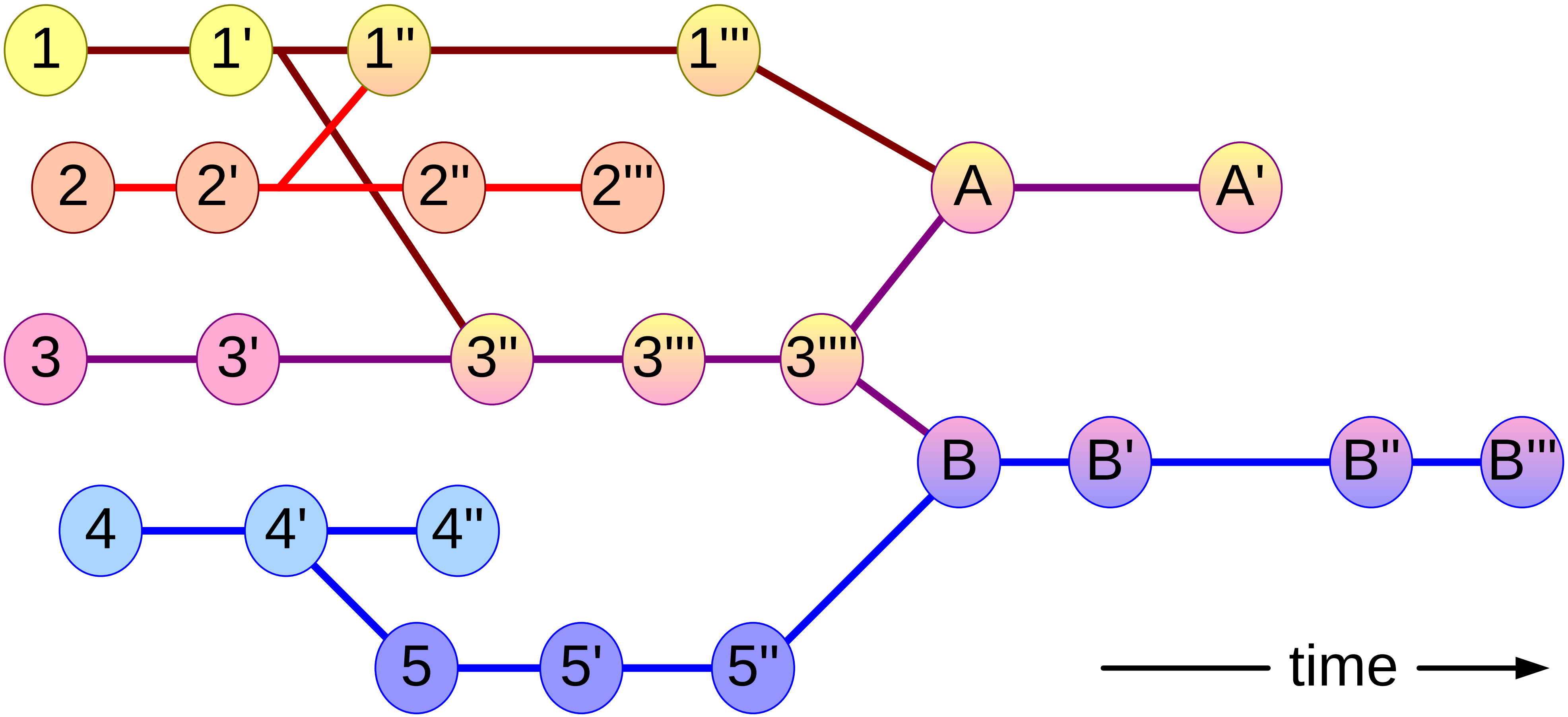
Evaluation Criteria	Score	Concepts 1	2	3	4
Time to connect					
Need for ROV		-	+	+	+
Design		-	+	+	+
Robustness					
Connector design		-	S	S	+
Number of parts		-	-	+	+
Handle roll-off		+	-	S	+
Influence other		+	S	-	S
Redundancy					
Design		+	-	-	S
Interchangeability		+	-	-	-
Cost					
HW cost		-	-	-	-
Manufacturing cost		S	S	-	S
Engineering cost		+	-	S	-
Service cost		-	+	+	+
Maturity		-	-	S	+
	Σ-	7	7	5	3
	ΣS	1	3	4	3
	Σ+	5	3	4	7
	Pos.	3	4	2	1

from master paper Dag Jostein Klever, 2009

Repeated Divergence and Convergence



Set-based Design



SEFS Dynamic Behavior

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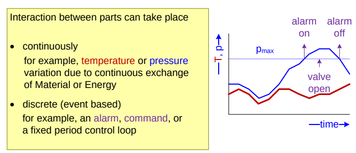
Abstract

The desired system behavior and performance emerges from the interaction of the parts. The challenge in architecting is capturing the relevant dynamic behavior to facilitate reasoning about system behavior and performance.

October 18, 2020
status: preliminary draft
version: 0.2

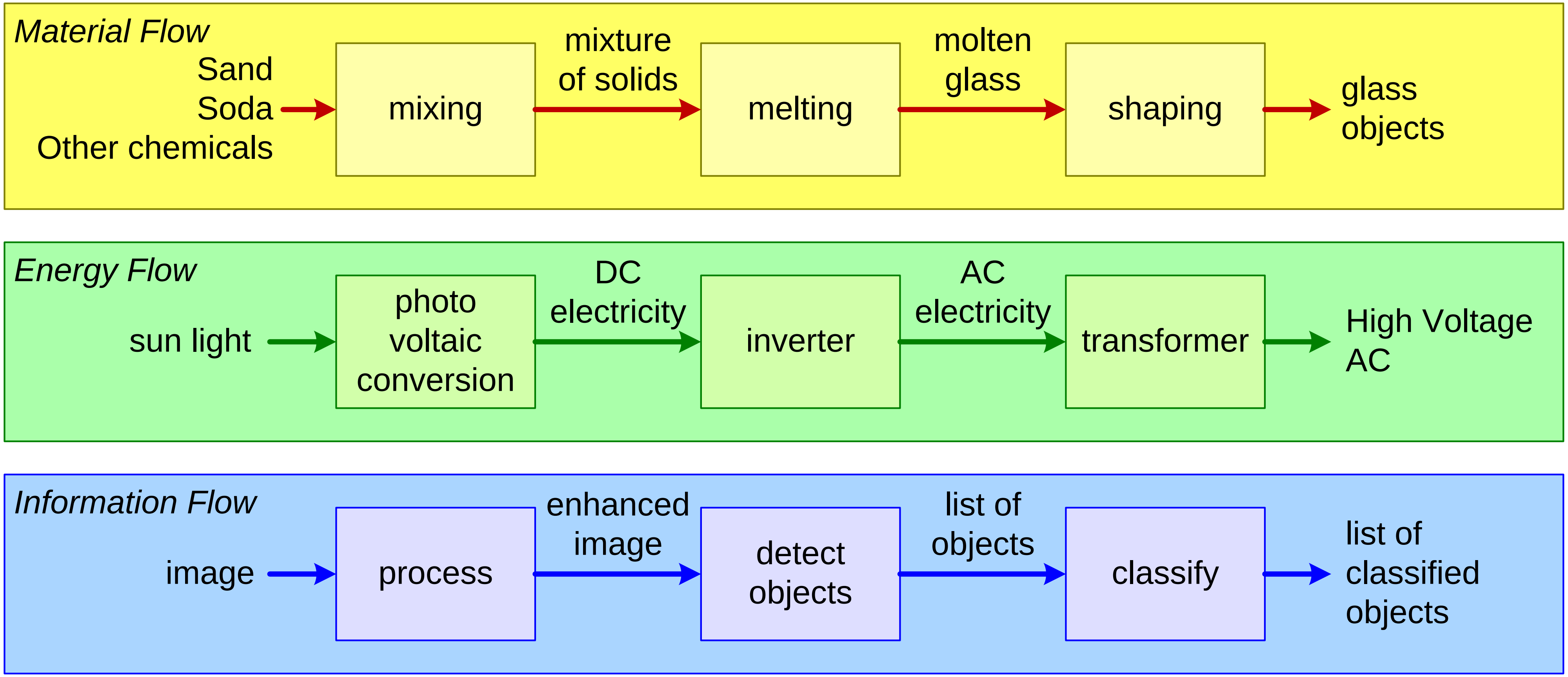


Interaction Results in Dynamic Behavior

Interaction between parts takes place via exchange of

- **M**aterial
- **E**nergy
- **I**nformation

Simple Examples of MEI Flows



Dynamic Behavior and Time

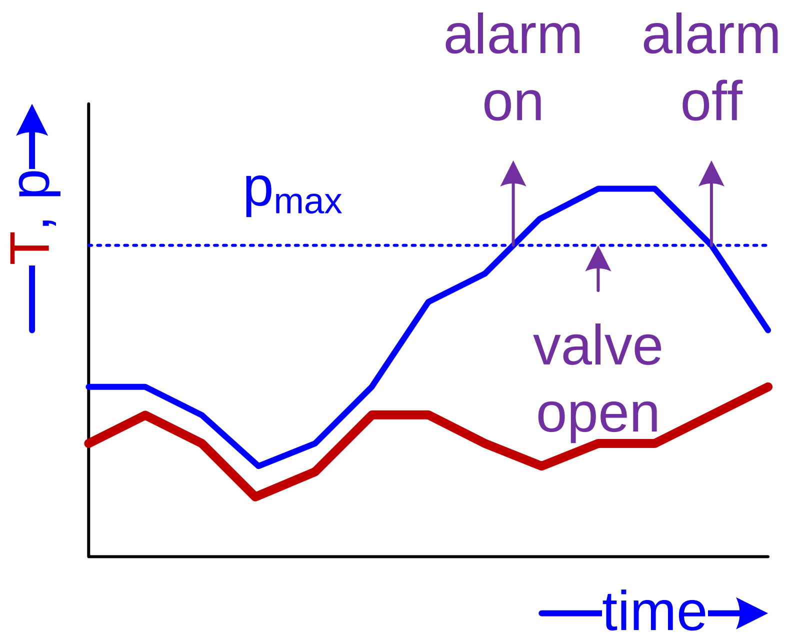
Interaction between parts can take place

- continuously

  for example, temperature or pressure variation due to continuous exchange of Material or Energy

- discrete (event based)

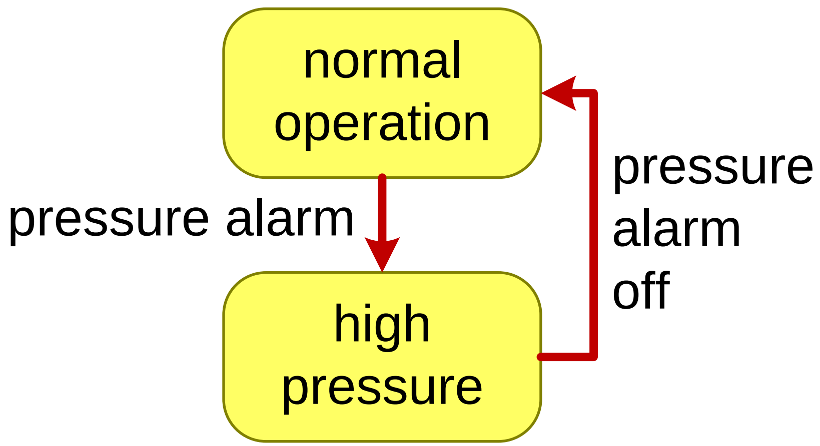
  for example, an alarm, command, or a fixed period control loop

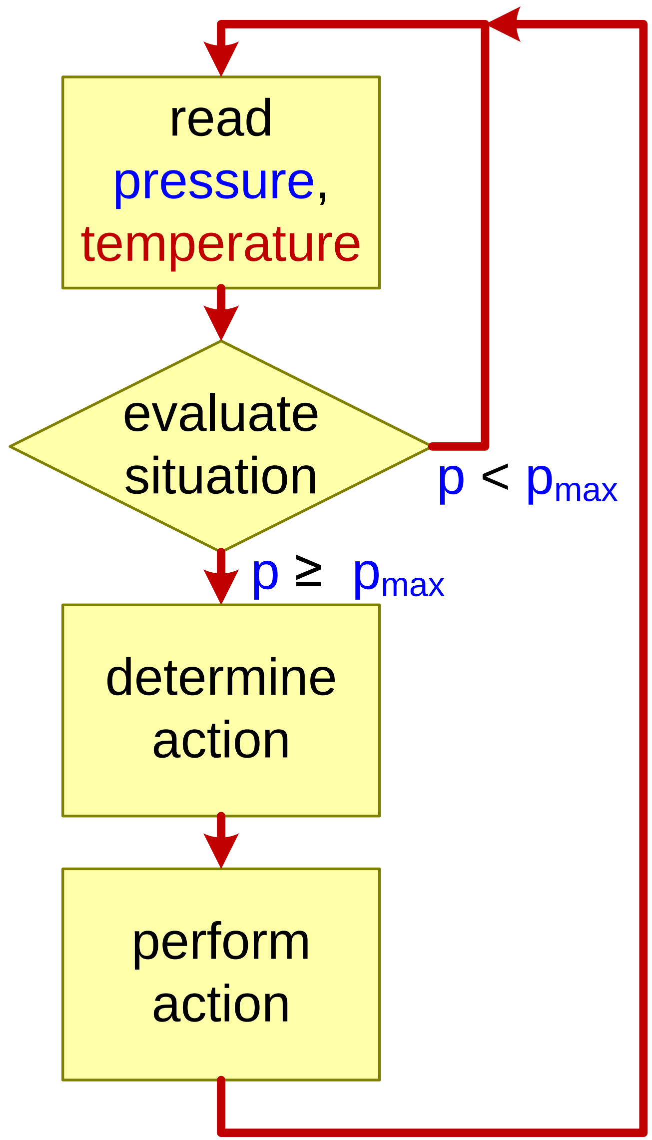


Simple Examples of Dynamic Behavior

Every second:

- read **pressure**, **temperature**
- evaluate situation (e.g., $p < p_{max}$)
- determine action
  - (e.g., lower pressure by opening valve)
- perform action (e.g. **open valve**)





SEFS Modeling

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Abstract

In systems engineering we use many kinds of models. We use simulations for analysis, capture system structure information in MSBE models, and create conceptual models for understanding, communication, reasoning, and supporting decision making.

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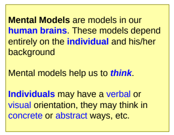
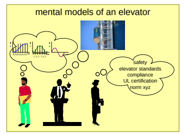




First Principle Models

First principle model: a model based on **theoretical** principles.

A first principle model **explains** the desired property from first principles from the **laws of physics**.

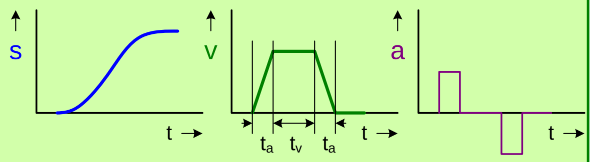
A first principle model **requires values** for **incoming parameters** to calculate results.

first principle model $t_{top\ floor}$ elevator

$$v = \frac{dS}{dt} \qquad a = \frac{dv}{dt} \qquad j = \frac{da}{dt}$$

Position in case of uniform acceleration:

$$S_t = S_0 + v_0 t + \frac{1}{2} a_0 t^2$$



$$t_{top\ floor} = t_a + t_v + t_a$$

$$t_a = v_{max} / a_{max}$$

$$S(t_a) = \frac{1}{2} * a_{max} * t_a^2$$

$$S_{linear} = S_{top\ floor} - 2 * S(t_a)$$

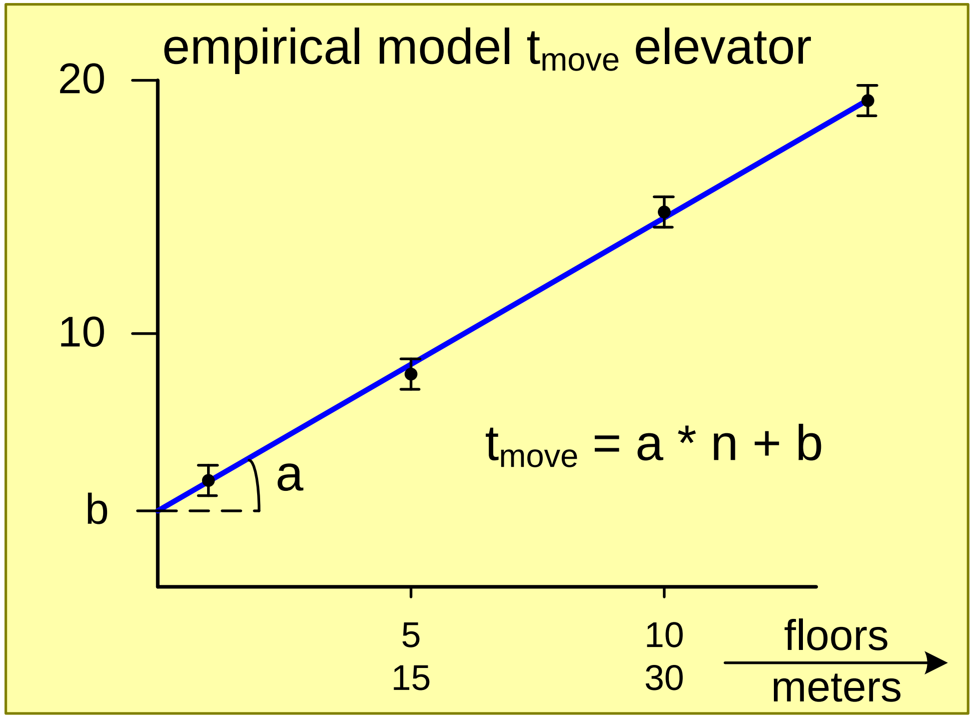
$$t_v = S_{linear} / v_{max}$$

Empirical Models

Empirical model: a model based on **observations** and **measurements**.

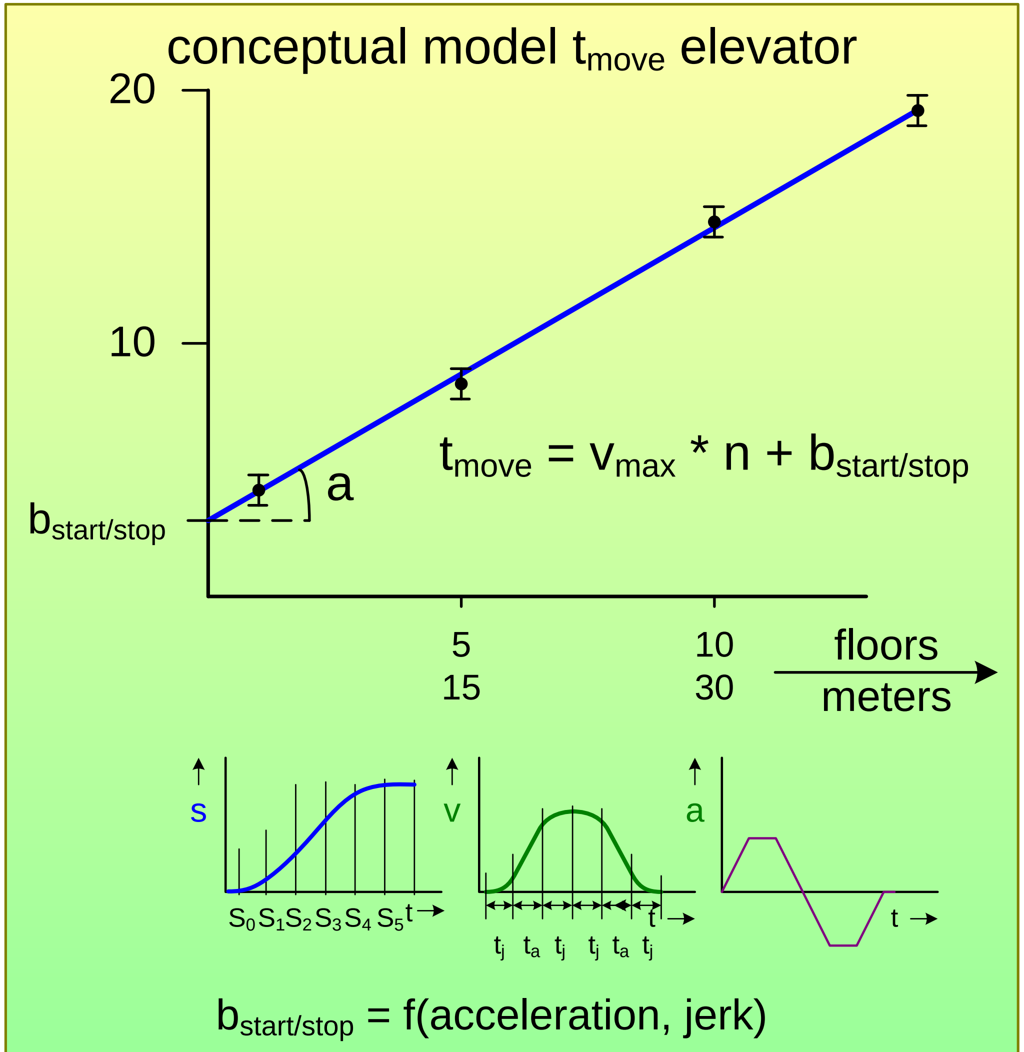
An empirical model ***describes*** the observations.

An empirical model provides **no understanding**.



Conceptual model: a model **explaining observations** and **measurements** using a selection of **first principles**.

A conceptual model is a **hybrid** of empirical and first principle models; **simple** enough to **understand** and to **reason, realistic** enough to make **sense**.

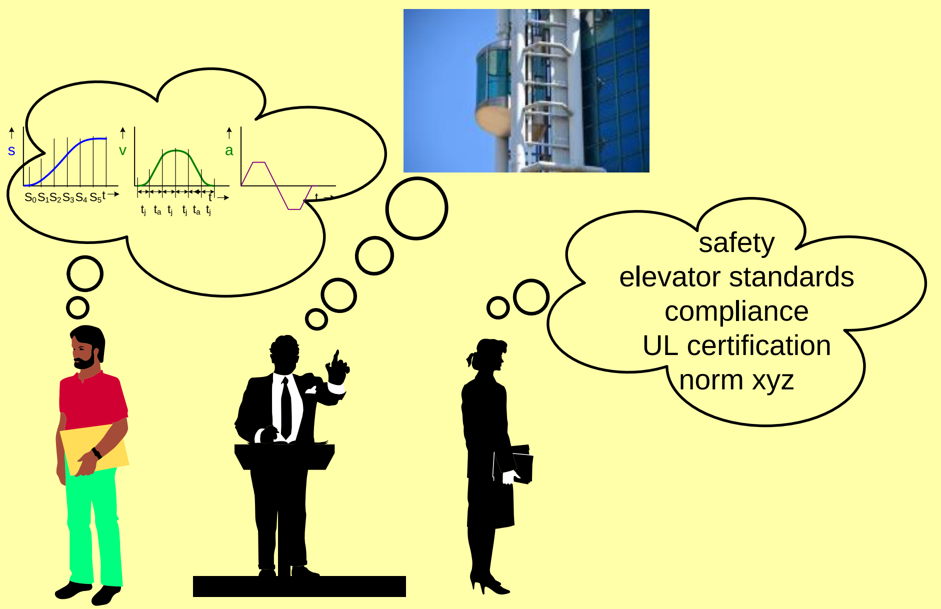


Mental Models

Mental Models are models in our **human brains**. These models depend entirely on the **individual** and his/her background

Mental models help us to ***think***.

Individuals may have a verbal or visual orientation, they may think in concrete or abstract ways, etc.



Simulations

Simulation: an executable model based on **first principle** and **empirical models**.

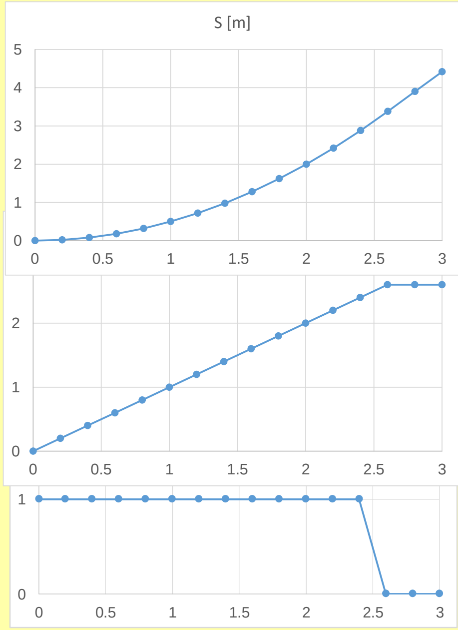
Designers run simulations to ***explore***, ***analyze***, and ***gain insights***.

A simulation provides **understanding**, when **the users transform** the outcomes into **insights**.

simulation of an elevator

dt	0.2	s
vmax	2.5	m/s
amax	1	m/s2

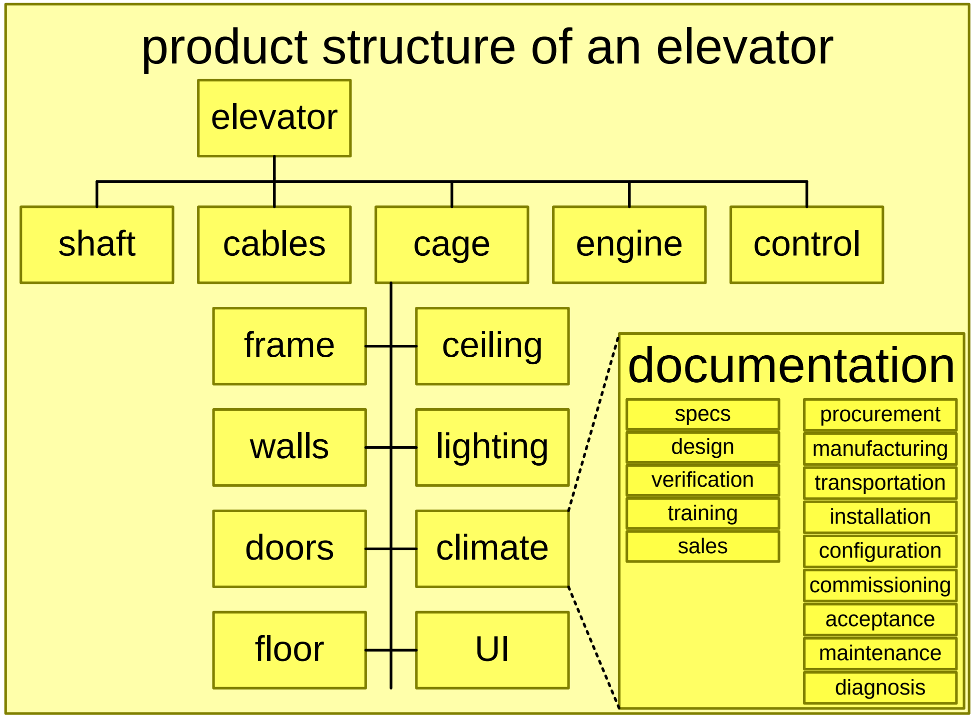
t (s)	s (m)	v (m/s)	a (m/s2)
0	0	0	1
0.2	0.02	0.2	1
0.4	0.08	0.4	1
0.6	0.18	0.6	1
0.8	0.32	0.8	1
1	0.50	1	1
1.2	0.72	1.2	1
1.4	0.98	1.4	1
1.6	1.28	1.6	1
1.8	1.62	1.8	1
2	2.00	2	1
2.2	2.42	2.2	1
2.4	2.88	2.4	1
2.6	3.38	2.6	0
2.8	3.90	2.6	0
3	4.42	2.6	0
3.2	4.94	2.6	0
3.4	5.46	2.6	0



Product Structure and Documentation

The **Product Structure** prescribes the **parts hierarchy**. Each part in the hierarchy has associated **documentation** and **information** for the entire **life cycle.**

The Product Structure and associated documentation help the organization to ***manage*** all processes from creation to decommissioning and recycling, via **ERP**, **PDM**, **PLM** etc. systems.



Map of Various Model Types