Defining Modeling Types with a Few Examples

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Abstract

We use the term models for many different types of models. This presentation shows various classification dimensions for models. A few examples illustrate how actual methodologies map on this interpretation.

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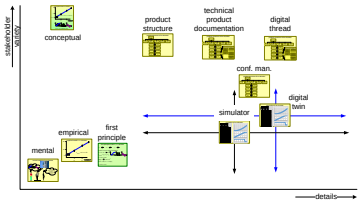
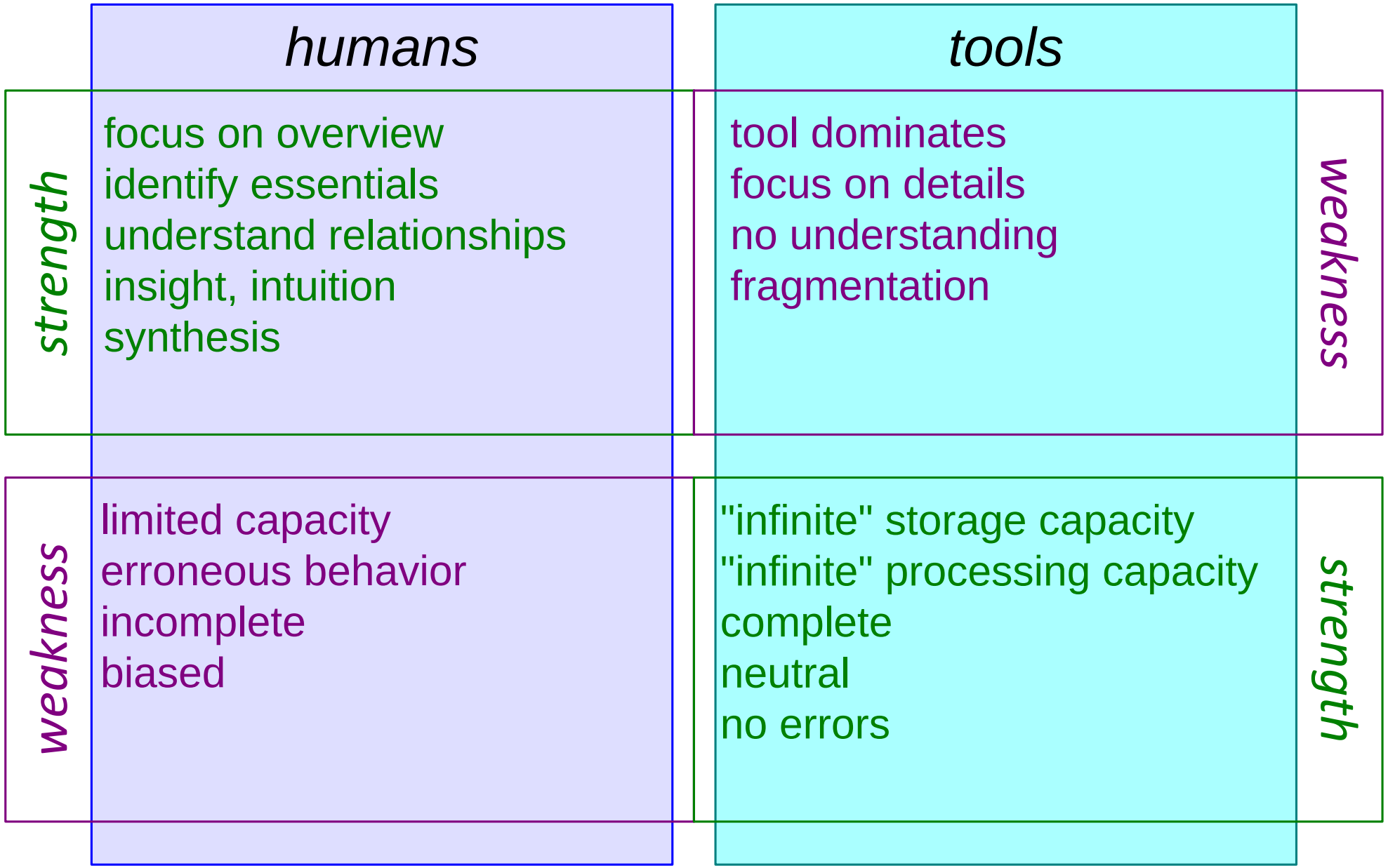


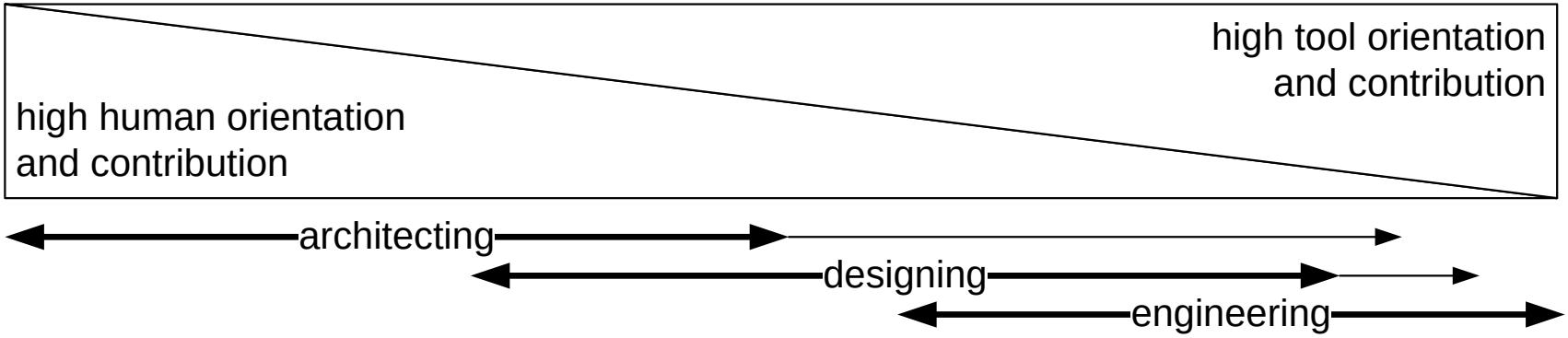
Dimensions to Classify Model Types

- purpose
  - determines desired model properties
- fidelity
  - degree of realism and detail
    - determines accuracy and effort to create and maintain
- degree of formality
  - degree of well-definedness
    - determines usability for tools and analysis
    - determines required human intelligence for use
- executable

Humans and Tools Have Complimentary Strengths



The Modeling Space



purpose	shared understanding, communication, reasoning, decision making	supporting process and organization: problem and solution space exploration	problem and solution space analysis	managing tracing qualifying
fidelity	very limited sufficient for decisions	increasing over time and phase		
degree of formailty	very limited interaction is crucial	increasing over time and phase		
executable	fast prototyping: executable	problem and solution space: executable		managing and tracing: navigatable and analyzable qualifying: executable

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**.

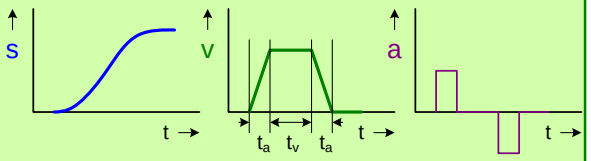
A first principle model **requires values** for **incoming parameters** to calculate results.

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:

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



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

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

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

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

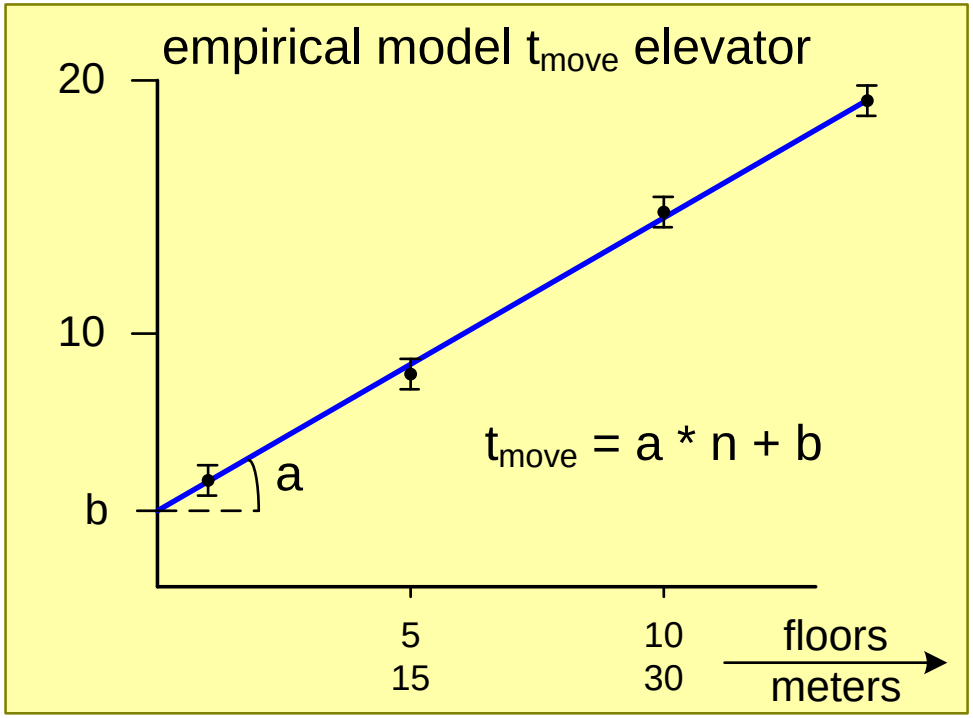
$$t_v = S_{linear} / v_{max}$$

Empirical Models

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

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

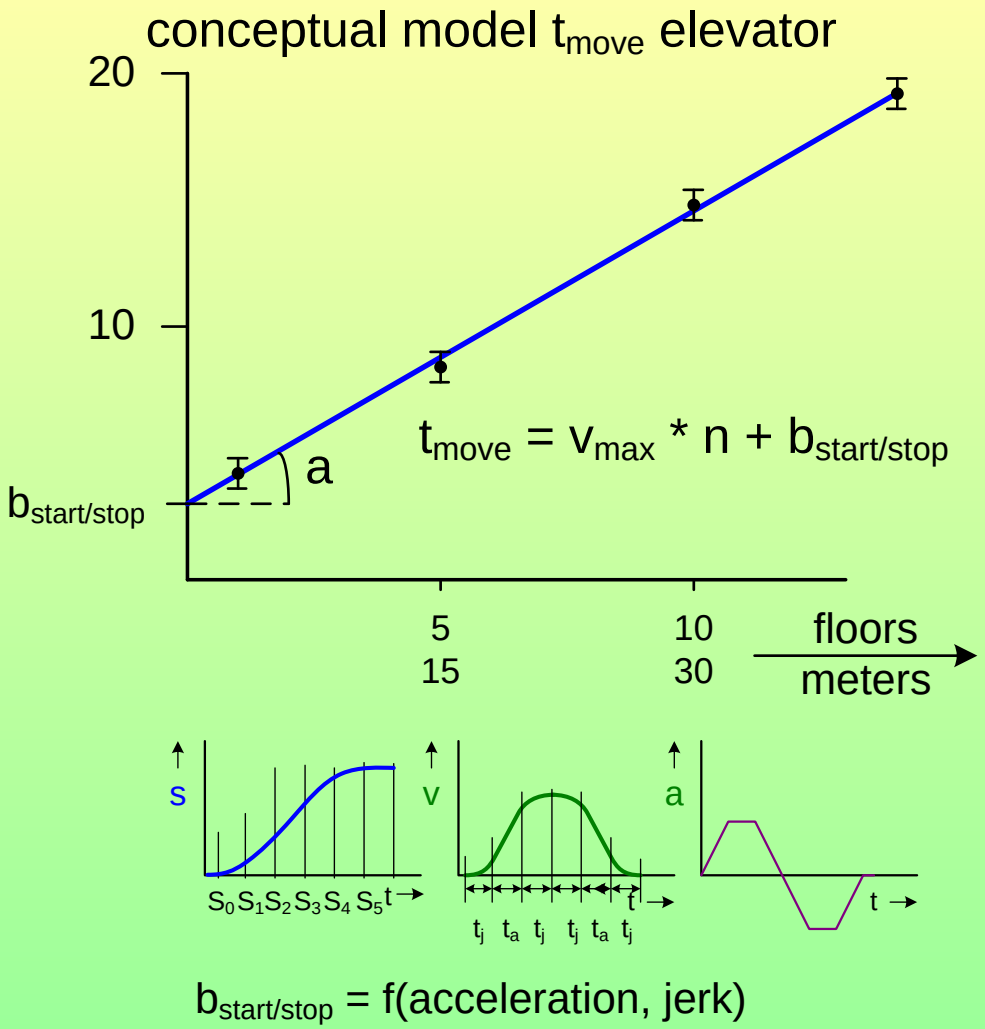
An empirical model provides **no understanding**.



Conceptual Models

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**.

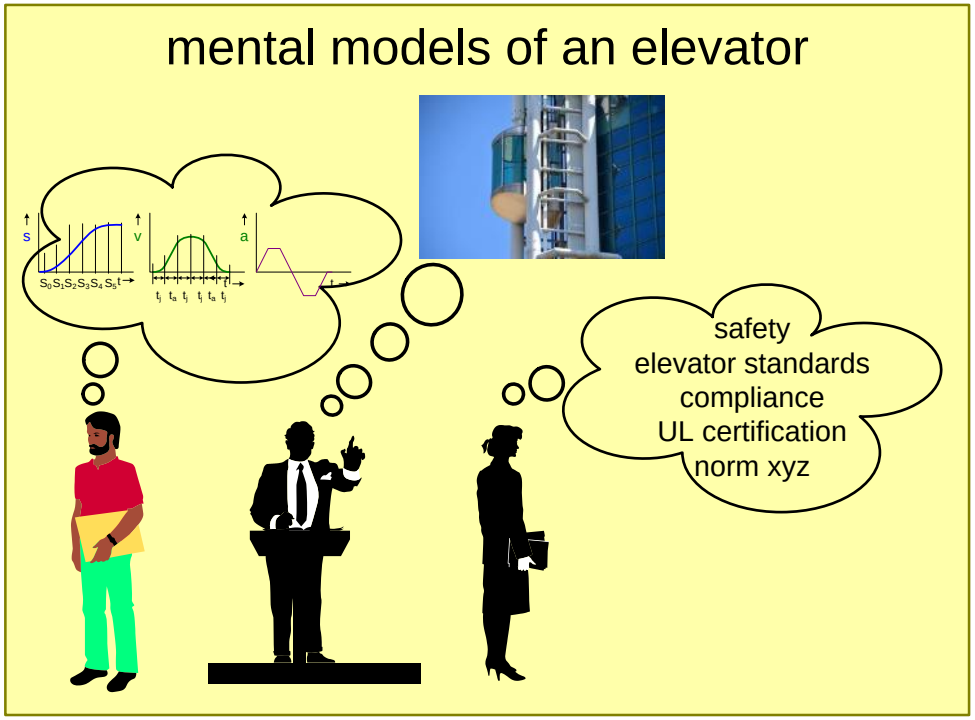


Mental Models

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**.

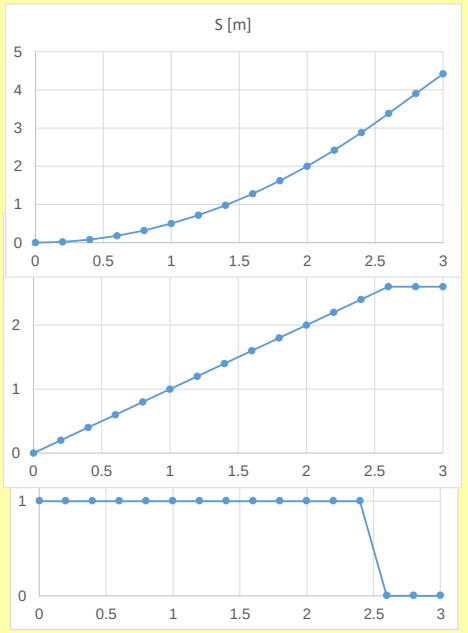
Designers run simulations to ***explore***, ***analyze***, and ***gain insights*****.**

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

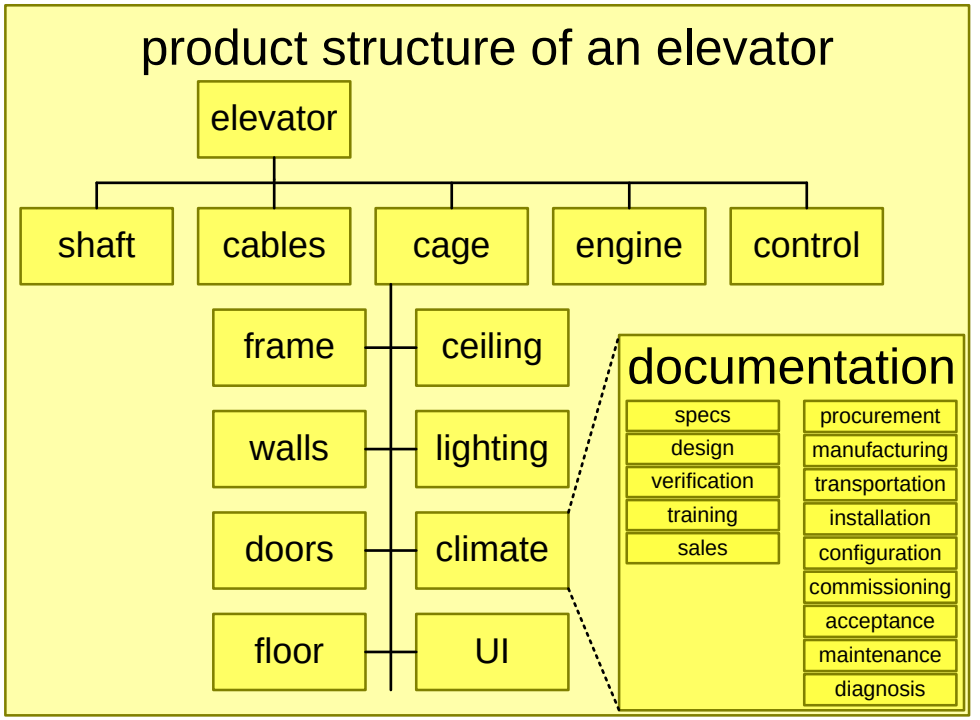
t (s)	s (m)	v (m/s)	a (m/s2)
0	0	0	1
0.2	0.02	0.2	1
0.4	0.08	0.4	1
0.6	0.18	0.6	1
0.8	0.32	0.8	1
1	0.50	1	1
1.2	0.72	1.2	1
1.4	0.98	1.4	1
1.6	1.28	1.6	1
1.8	1.62	1.8	1
2	2.00	2	1
2.2	2.42	2.2	1
2.4	2.88	2.4	1
2.6	3.38	2.6	0
2.8	3.90	2.6	0
3	4.42	2.6	0
3.2	4.94	2.6	0
3.4	5.46	2.6	0



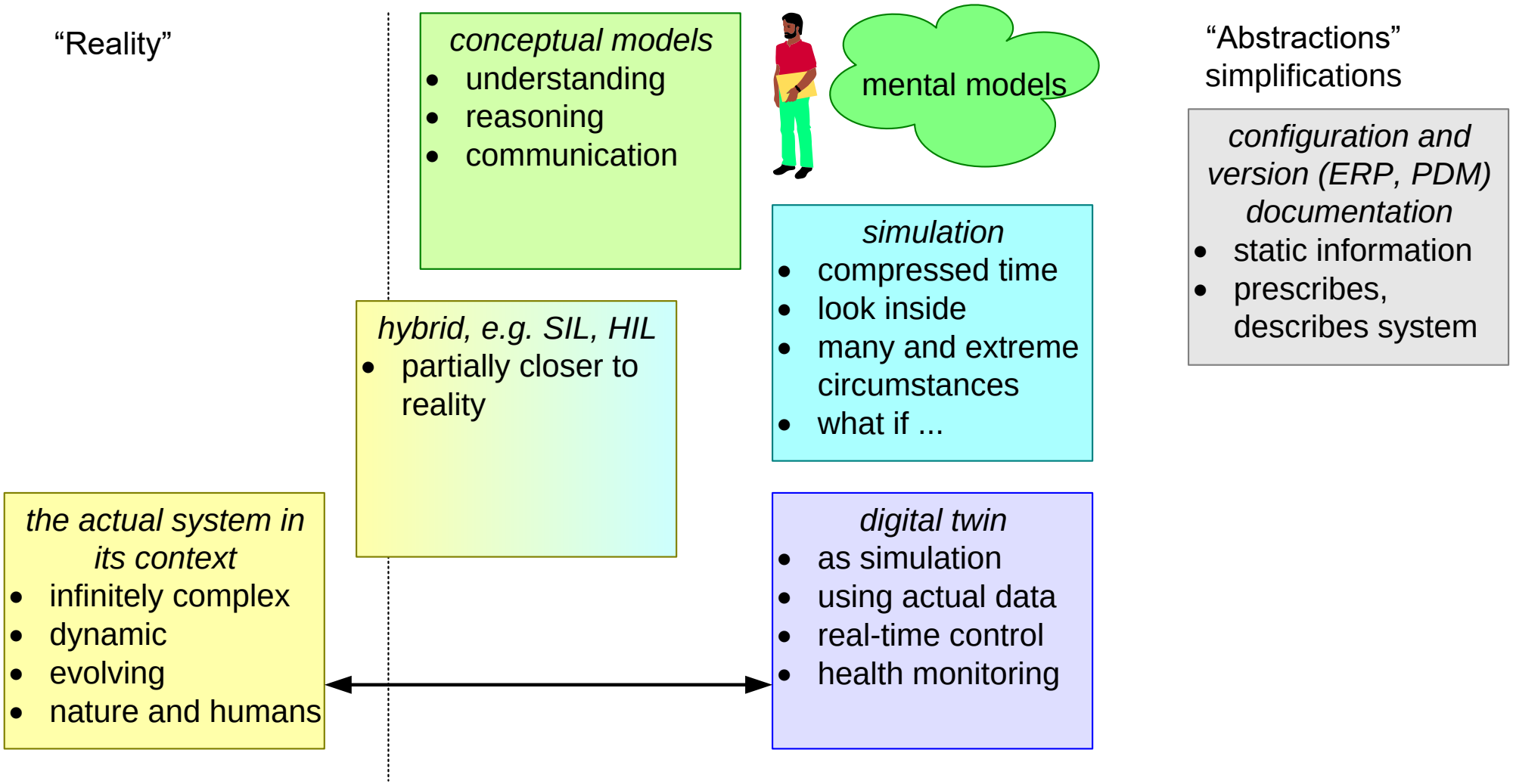
Product Structure and Documentation

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

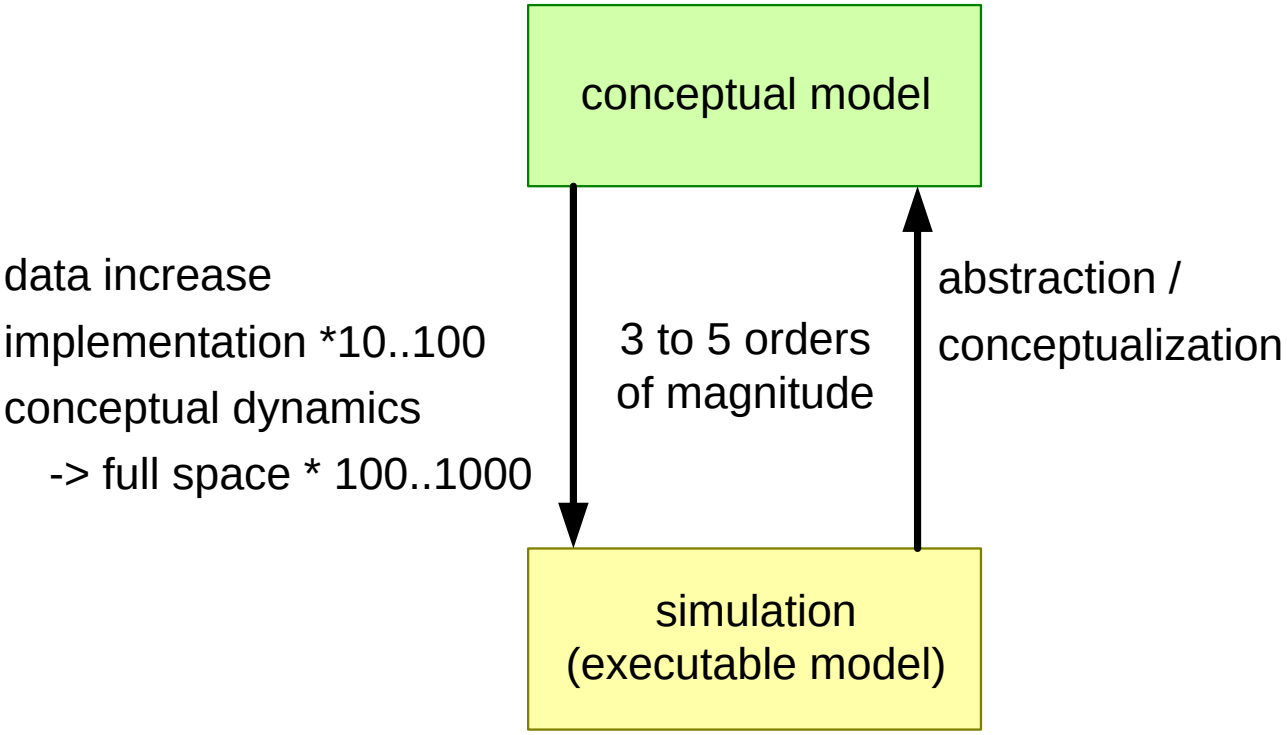
The Product Structure and associated documentation help the organization to ***manage*** all processes from creation to decommissioning and recycling, via **ERP**, **PDM**, **PLM** etc. systems.

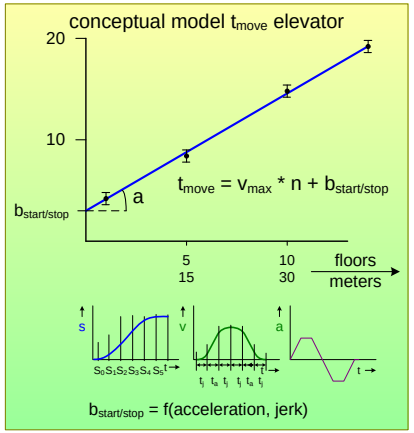


Map of Various Model Types

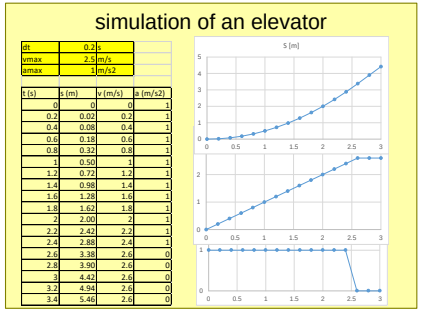


Conceptualization Reduces 3 to 5 Orders of Magnitude

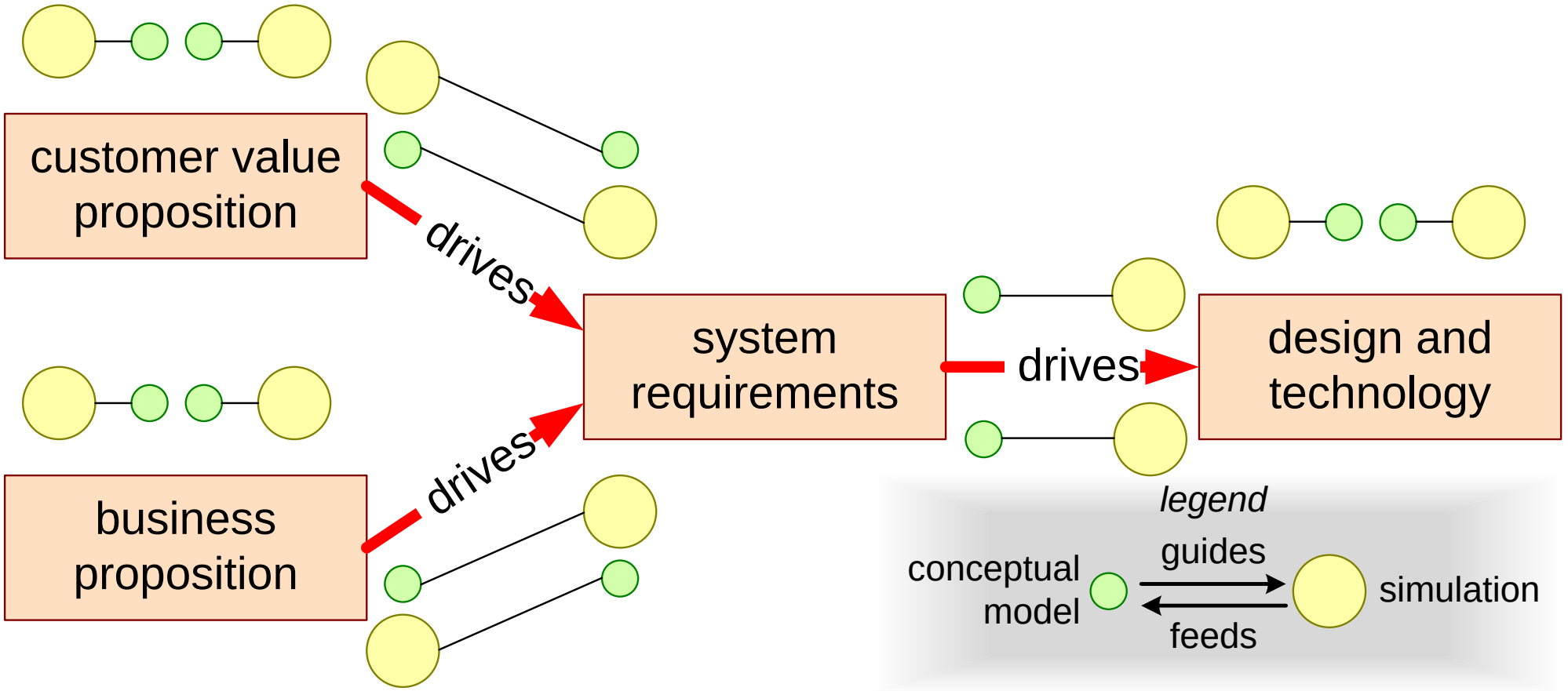




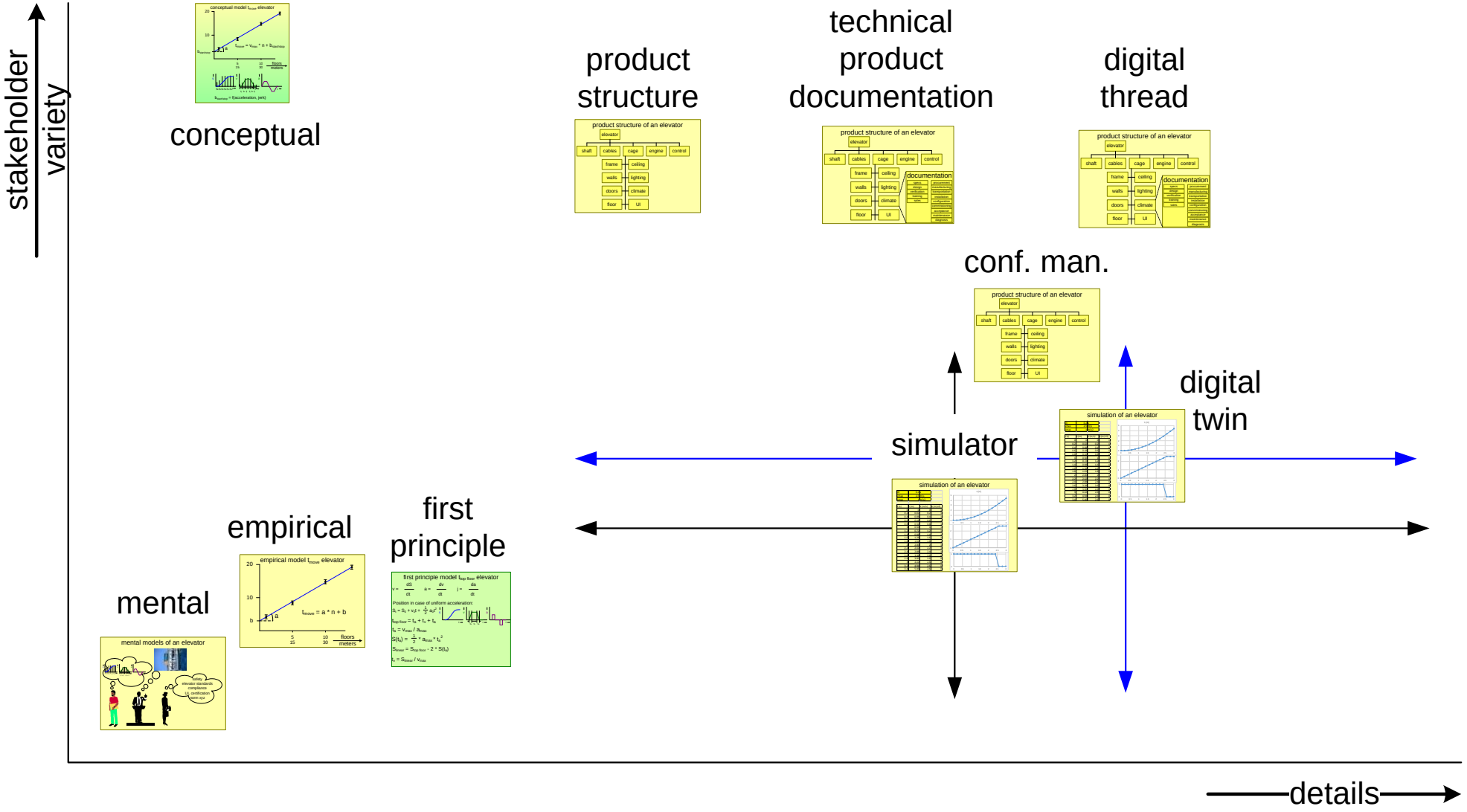
S, a, v, j
t_{floor}, t_v, t_a



Conceptual Models are at All Levels



Map of the Modeling Types



Scope Increases from Technical to Include Socio-Political