

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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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.



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 $t_{\text{top floor}}$ elevator

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

Position in case of uniform acceleration:

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

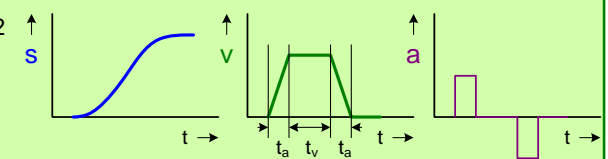
$$t_{\text{top floor}} = t_a + t_v + t_a$$

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

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

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

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

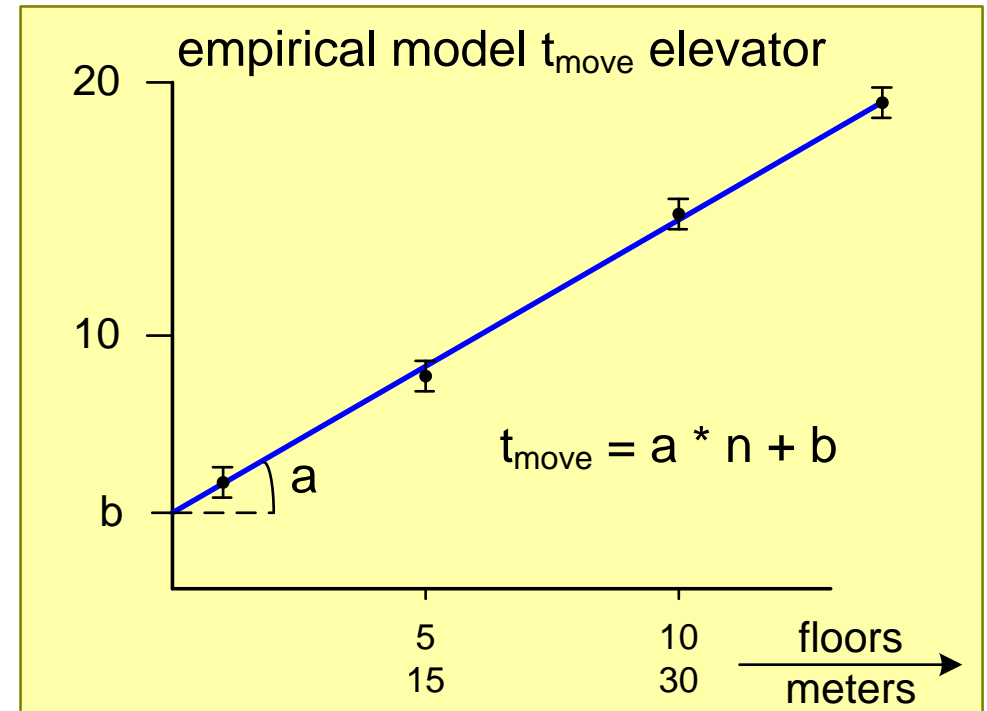


Empirical Models

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

An empirical model **describes** the observations.

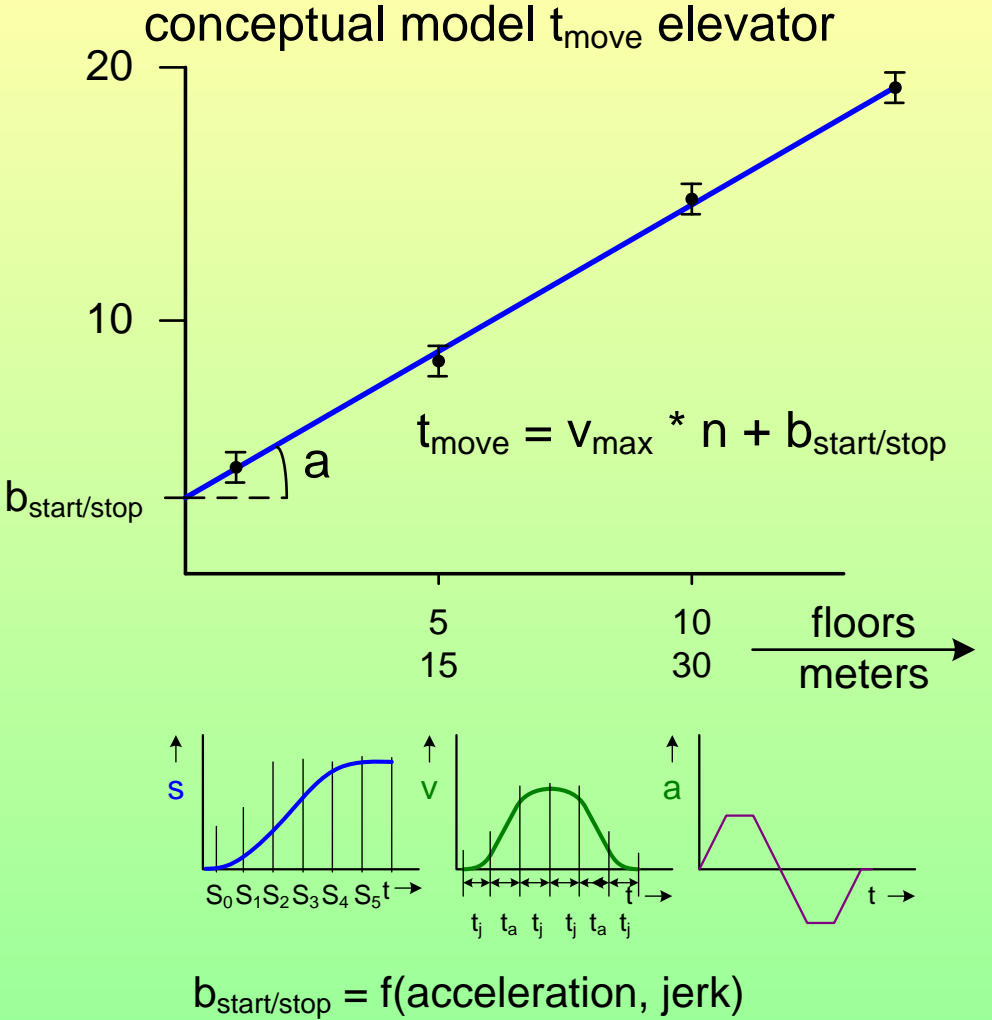
An empirical model provides **no understanding**.



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**.

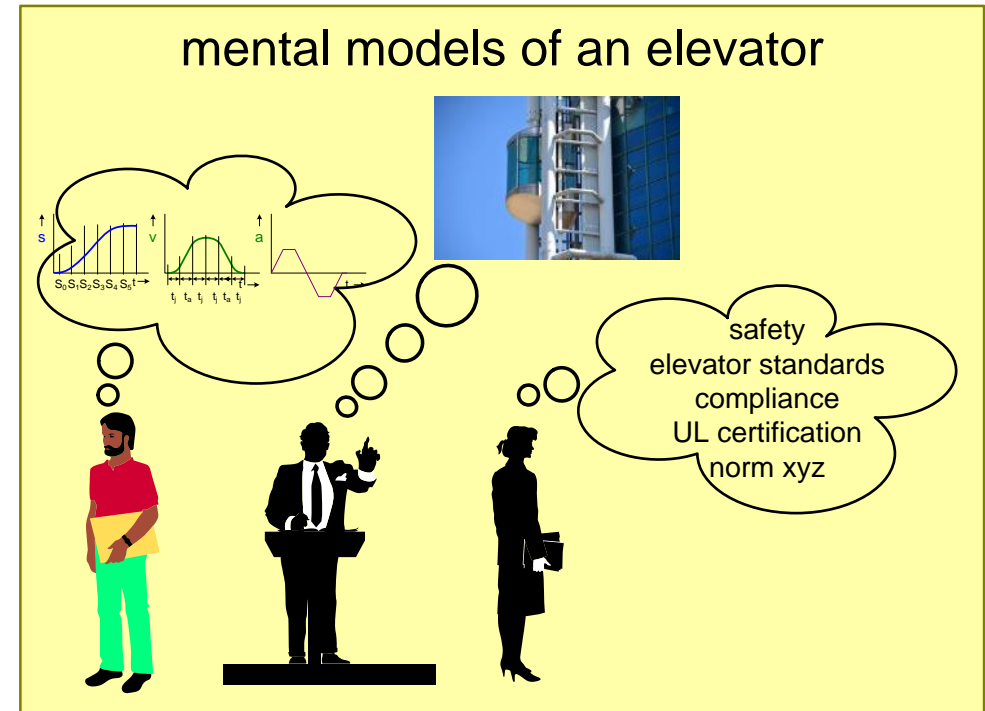


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Simulations

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

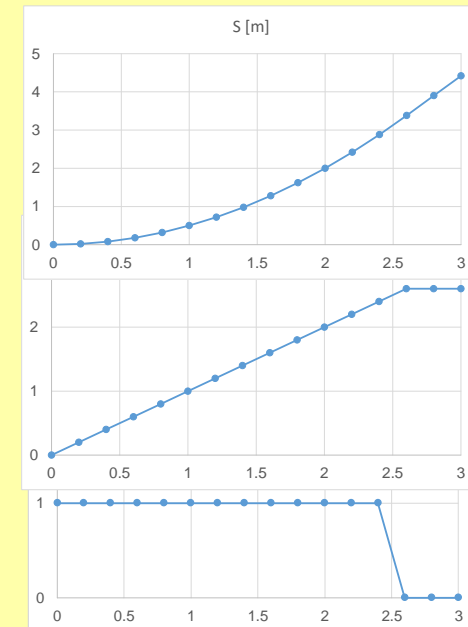
Designers run simulations to **explore**, **analyze**, and **gain insights**.

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/s ²

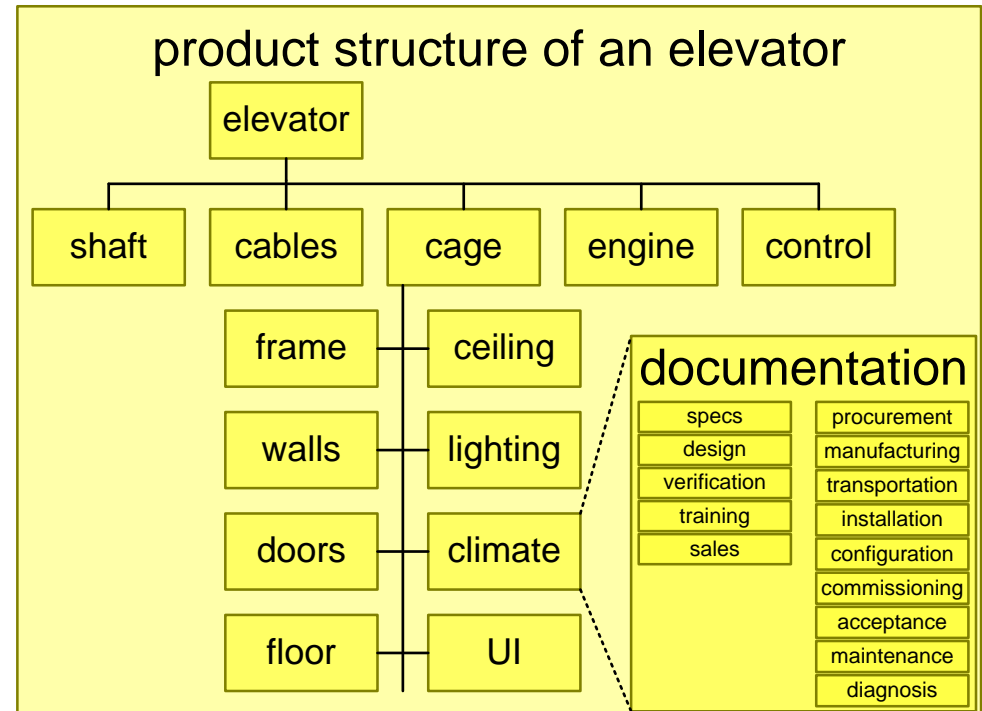
t (s)	s (m)	v (m/s)	a (m/s ²)
0	0	0	1
0.2	0.02	0.2	1
0.4	0.08	0.4	1
0.6	0.18	0.6	1
0.8	0.32	0.8	1
1	0.50	1	1
1.2	0.72	1.2	1
1.4	0.98	1.4	1
1.6	1.28	1.6	1
1.8	1.62	1.8	1
2	2.00	2	1
2.2	2.42	2.2	1
2.4	2.88	2.4	1
2.6	3.38	2.6	0
2.8	3.90	2.6	0
3	4.42	2.6	0
3.2	4.94	2.6	0
3.4	5.46	2.6	0



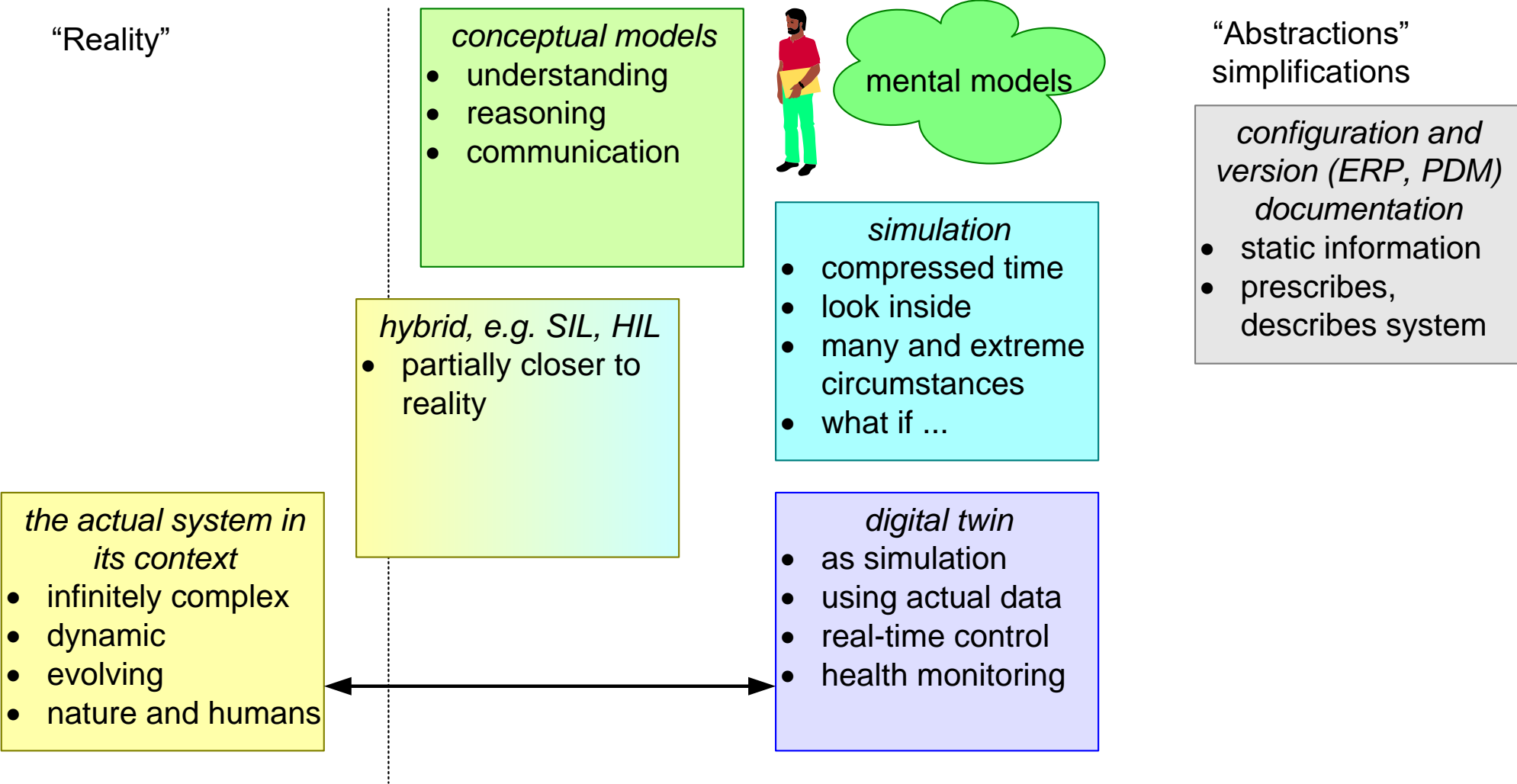
Product Structure and Documentation

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

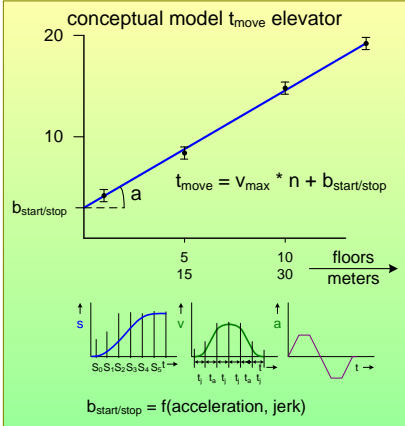
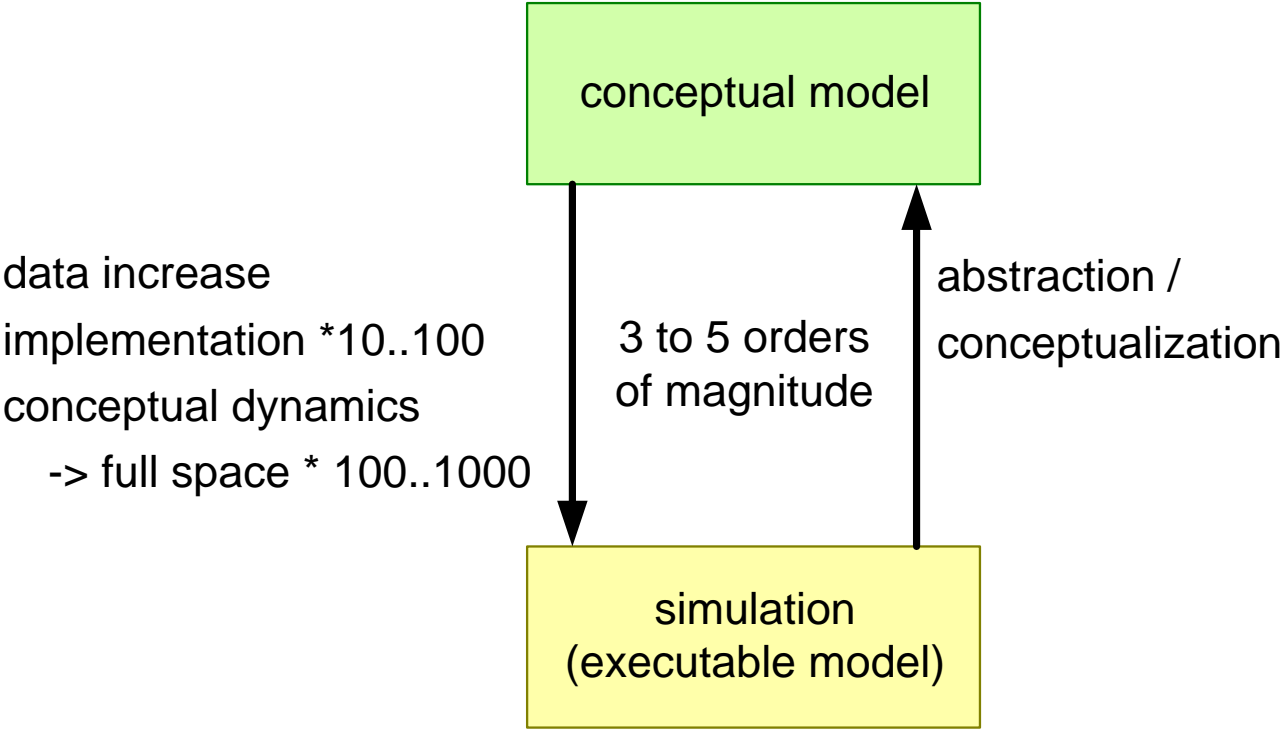
The Product Structure and associated documentation help the organization to **manage** all processes from creation to decommissioning and recycling, via **ERP**, **PDM**, **PLM** etc. systems.



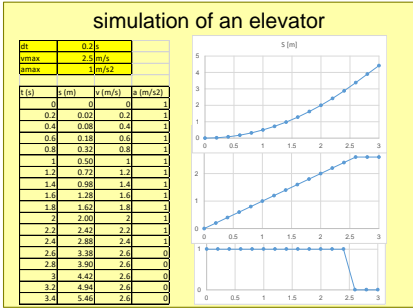
Map of Various Model Types



Conceptualization Reduces 3 to 5 Orders of Magnitude



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



Conceptual Models are at All Levels

