

# SE – Systems Engineering

Engenharia de Sistemas

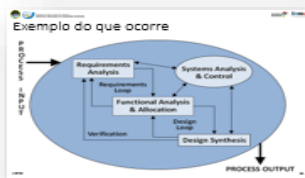
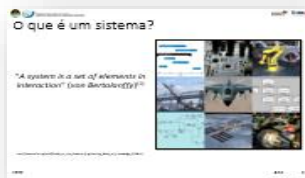
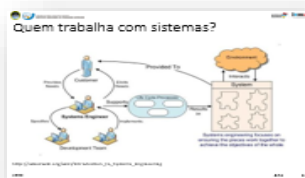
# Engenharia de Sistemas → Sistematizar

## sistematizar

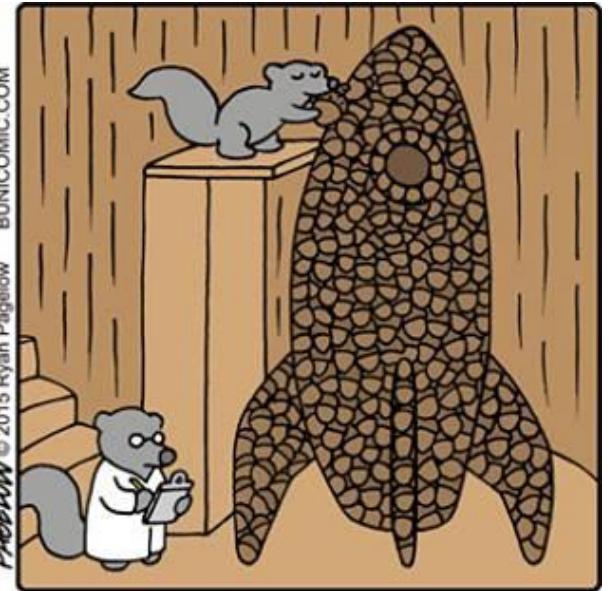
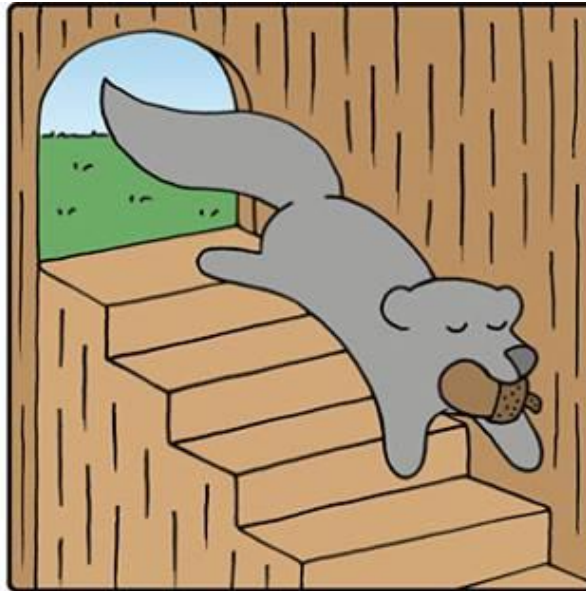
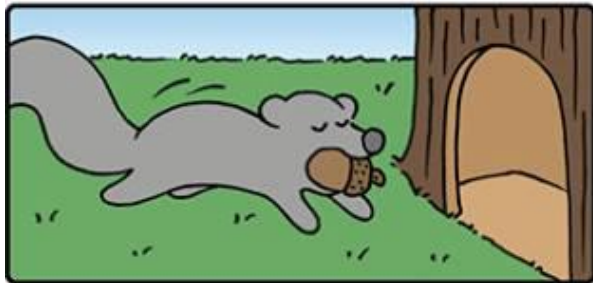
verbo

1. *transitivo direto*  
organizar (diversos elementos) em um sistema.  
"o plano sistematizava as medidas impostas pela segurança"
2. *transitivo direto*  
reduzir (fatos, conceitos, opiniões etc.) a um corpo de doutrina.
3. *transitivo direto e pronominal*  
tornar(-se) sistemático, metódico, ordenado, coerente.  
"o engenheiro sistematizou a distribuição da água no prédio"

Sistematizando o Problema:



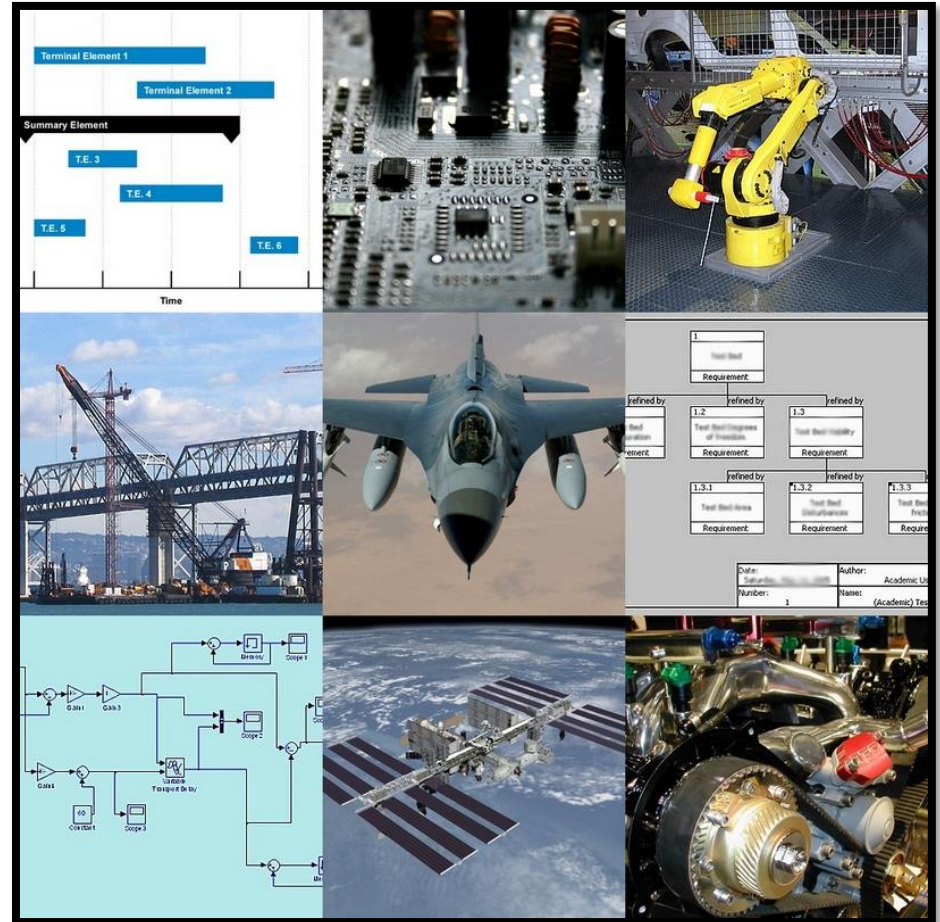
# Sistematizando o Problema:



PÁGELOW © 2015 Ryan Págelow BUNICOMIC.COM

# O que é um sistema?

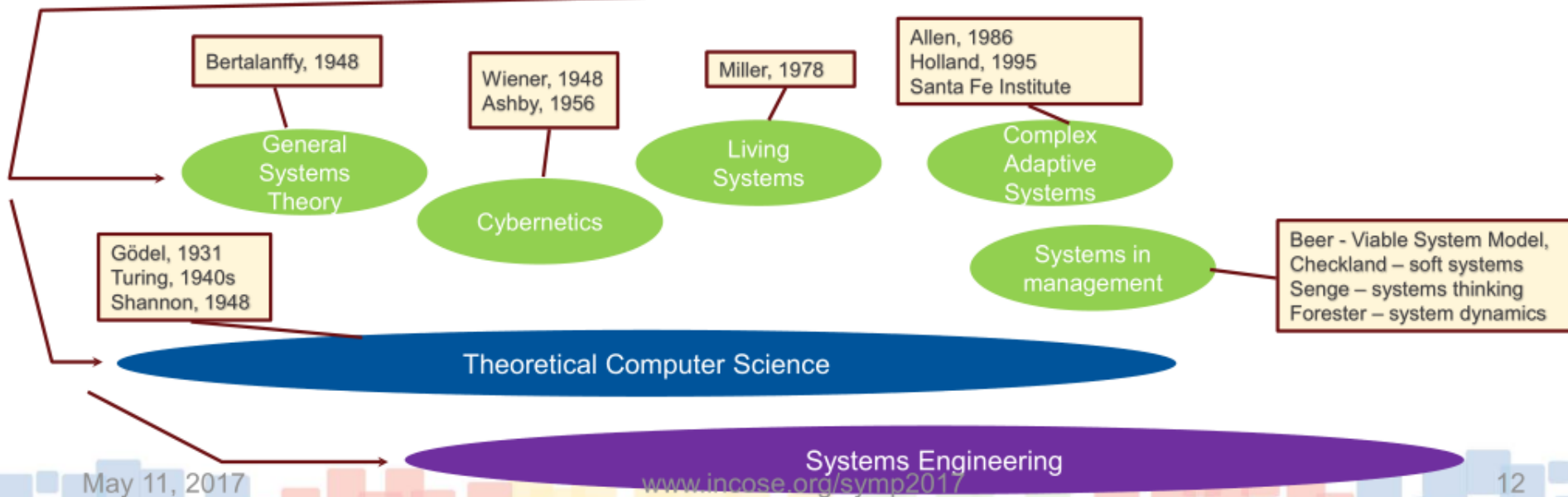
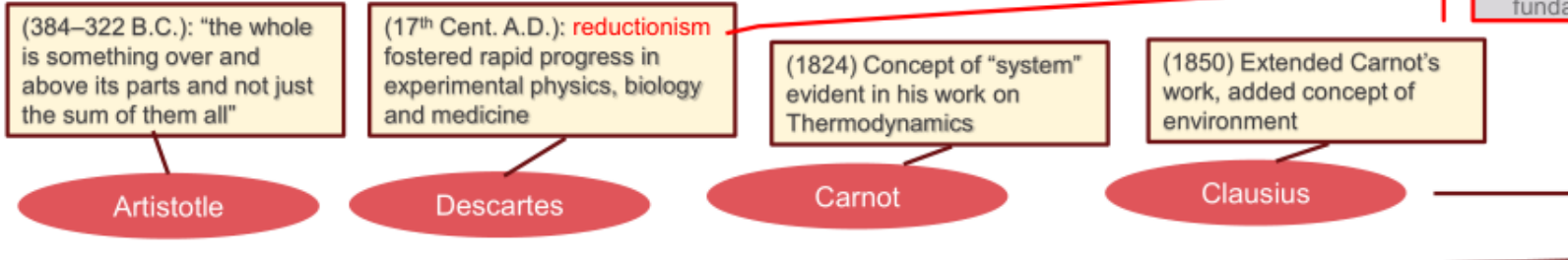
*“A system is a set of elements in interaction” (von Bertalanffy)<sup>(1)</sup>*



[http://sebokwiki.org/wiki/Guide\\_to\\_the\\_Systems\\_Engineering\\_Body\\_of\\_Knowledge\\_\(SEBoK\)](http://sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK))

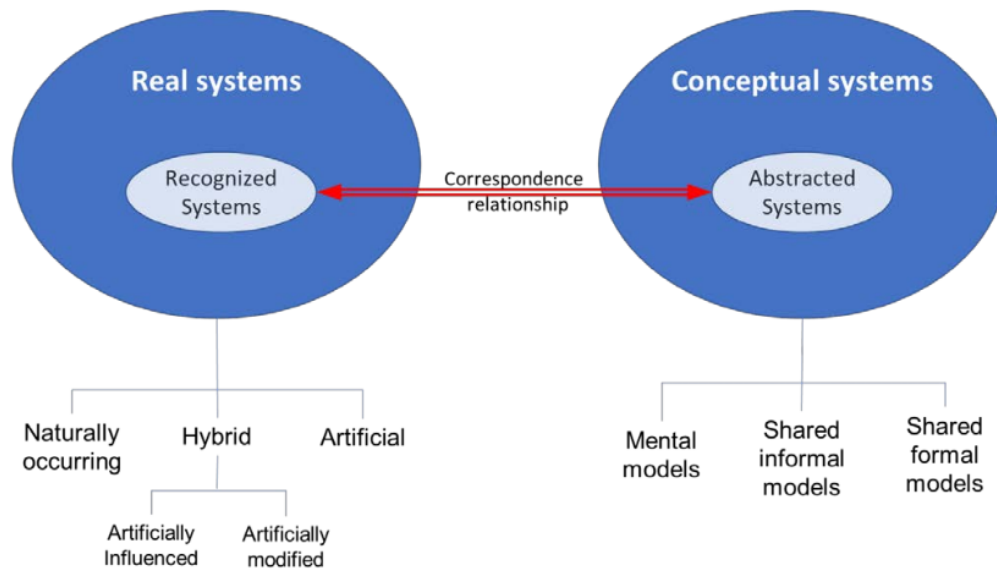
# Some schools of thought in systems

**Reductionism:** the practice of analyzing and describing a complex phenomenon in terms of its simple or fundamental constituents





# Summary: Proposed Framework for System Definition and Classification



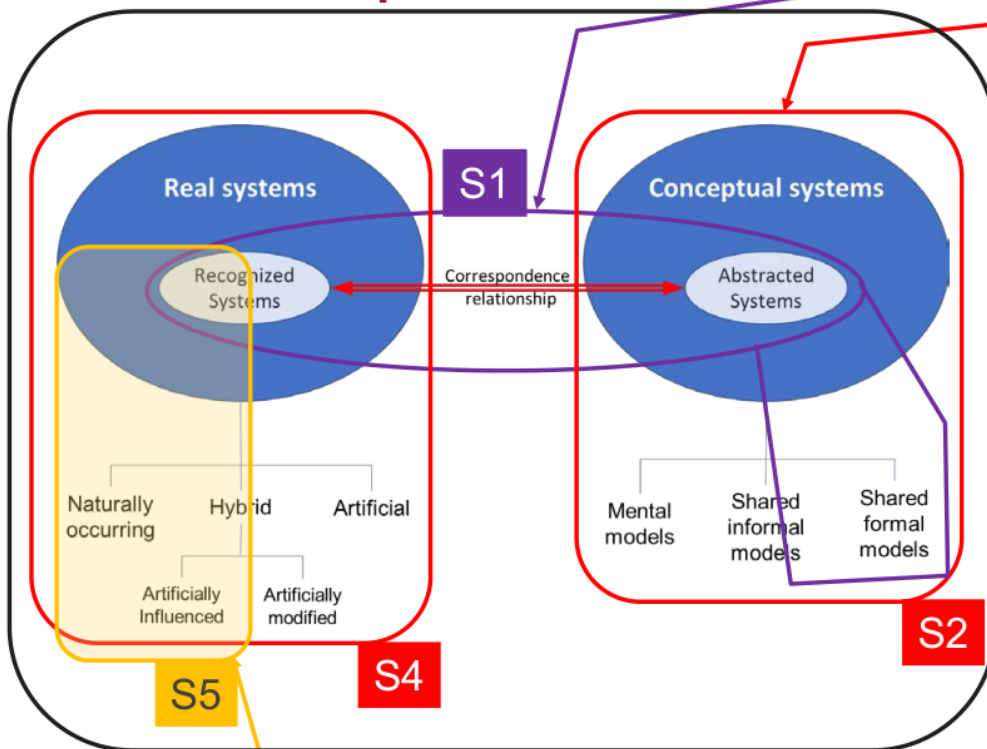
- **Real System and Conceptual System are Systems.**
- **Real systems** exist in the physical world.
- **Conceptual systems** are the product of human thought.
- **Conceptual Systems** may be: **mental models, informal shared models, or formal shared models.**
- **Abstracted Systems** are **conceptual systems** which represent (“are abstractions of”, or “are abstracted from”) **real systems.**
- **Real Systems** may be **Naturally-occurring, Artificial, or Hybrid** (containing both naturally-occurring and artificial elements).
- **Hybrid systems** may be **Artificially Modified or Artificially Influenced.**
- **Hybrid Systems and Artificial Systems** may be **intended or unintended.**
- **Recognised Real Systems** are recognised to exist in the real world.
  - They may be recognised by their **structure, function or behaviour.**
- **Real Systems** can be characterised by their internal capacity for communication, decision making, and adaptive control.
- **Real Systems** that share the characteristics of “viable systems” and “living Systems” exhibit homeostasis, resilience and ability to cope with unforeseen circumstances.
- **Information systems** are conceptual systems hosted in real systems.

**NB:** Most belief systems only recognise some of these system types as valid.

We believe future SE practice needs to use a framework that includes all of them, and that practitioners will be more effective if willing to at least “suspend disbelief” about the elements they don’t agree with!

May 11, 2017

# Mapping of Worldviews to Conceptual Model



Five (possibly six) distinct worldviews or belief systems are revealed in the survey responses – just within our community

- Worldview S1: (S = System)
  - A formal minimalist view based on mathematics and logic
- Worldview S2:
  - Constructivist - systems are purely a mental construct
  - For now, we include “system concept as a mode of description” within this category
- Worldview S3:
  - Moderate realist
- Worldview S4:
  - Strong and Extreme Realists
- Worldview S5 –
  - Complex, viable and living systems

## SO WHAT? We believe:

This conceptual model encompasses (more or less adequately) all belief systems and worldviews revealed by the Fellows' and SSWG surveys and discovered by literature review.

This conceptual model also spans all Systems Engineering activities we can imagine based on the SE 2025 vision.

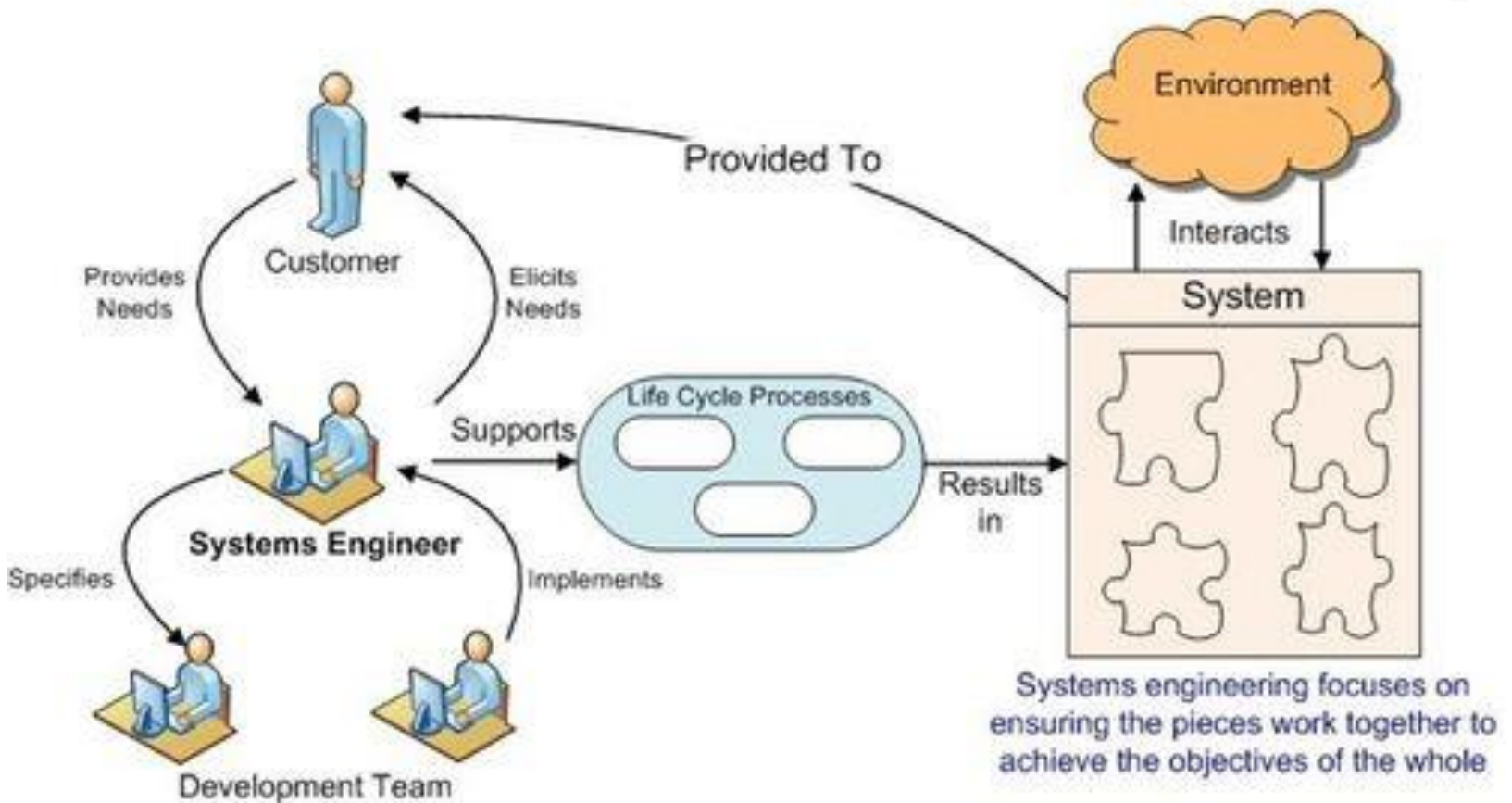
It is grounded in widely recognised prior research and should therefore be acceptable across the range of systems communities.

A single definition encompassing all types of system in the conceptual model is possible, but may be too vague to be useful.

A family of definitions aligned to this conceptual model is possible and has the potential to be useful.

The best way of expressing these definitions is almost certainly natural language and will be contentious

# Quem trabalha com sistemas?



[http://sebokwiki.org/wiki/Introduction\\_to\\_Systems\\_Engineering](http://sebokwiki.org/wiki/Introduction_to_Systems_Engineering)

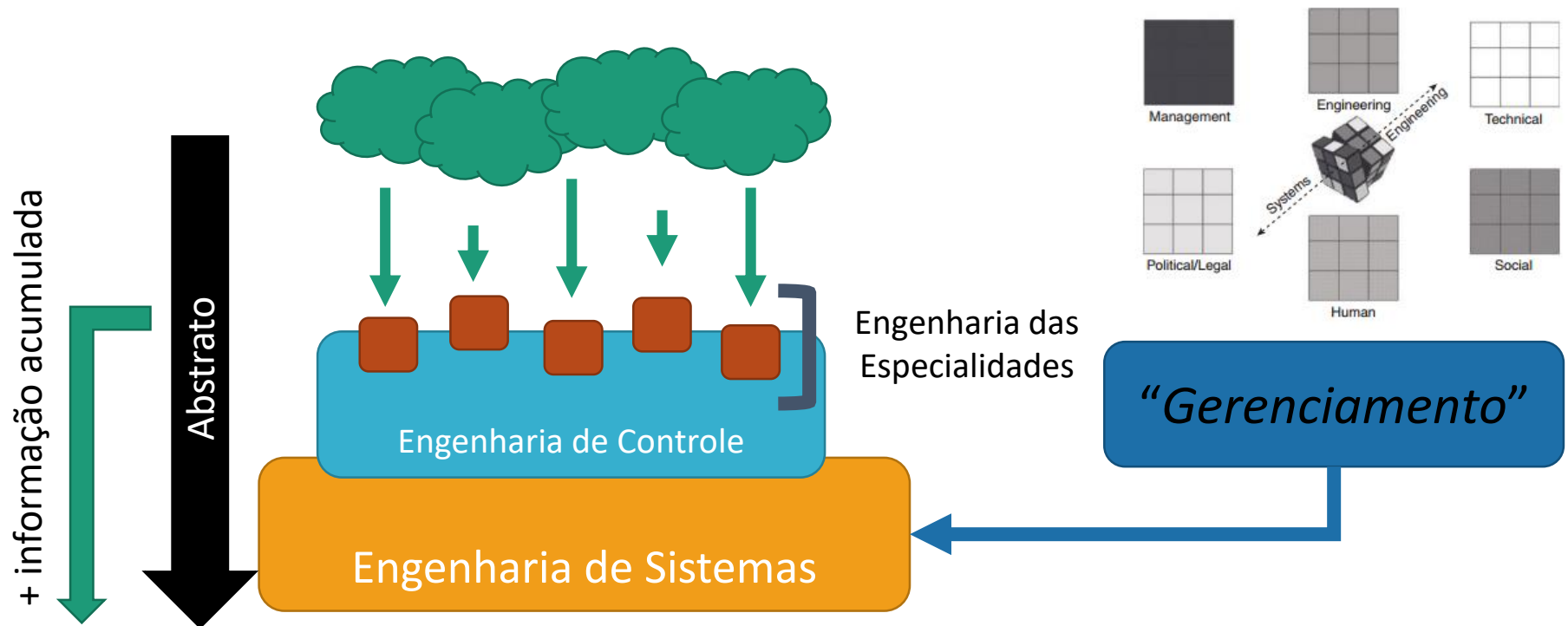


# Definição Engenharia de Sistemas

“Systems Engineering is an **engineering discipline** whose responsibility is **creating and executing an interdisciplinary process** to ensure that the customer and stakeholder's **needs are satisfied** in a high quality, trustworthy, cost efficient and schedule compliant manner **throughout a system's entire life cycle**”

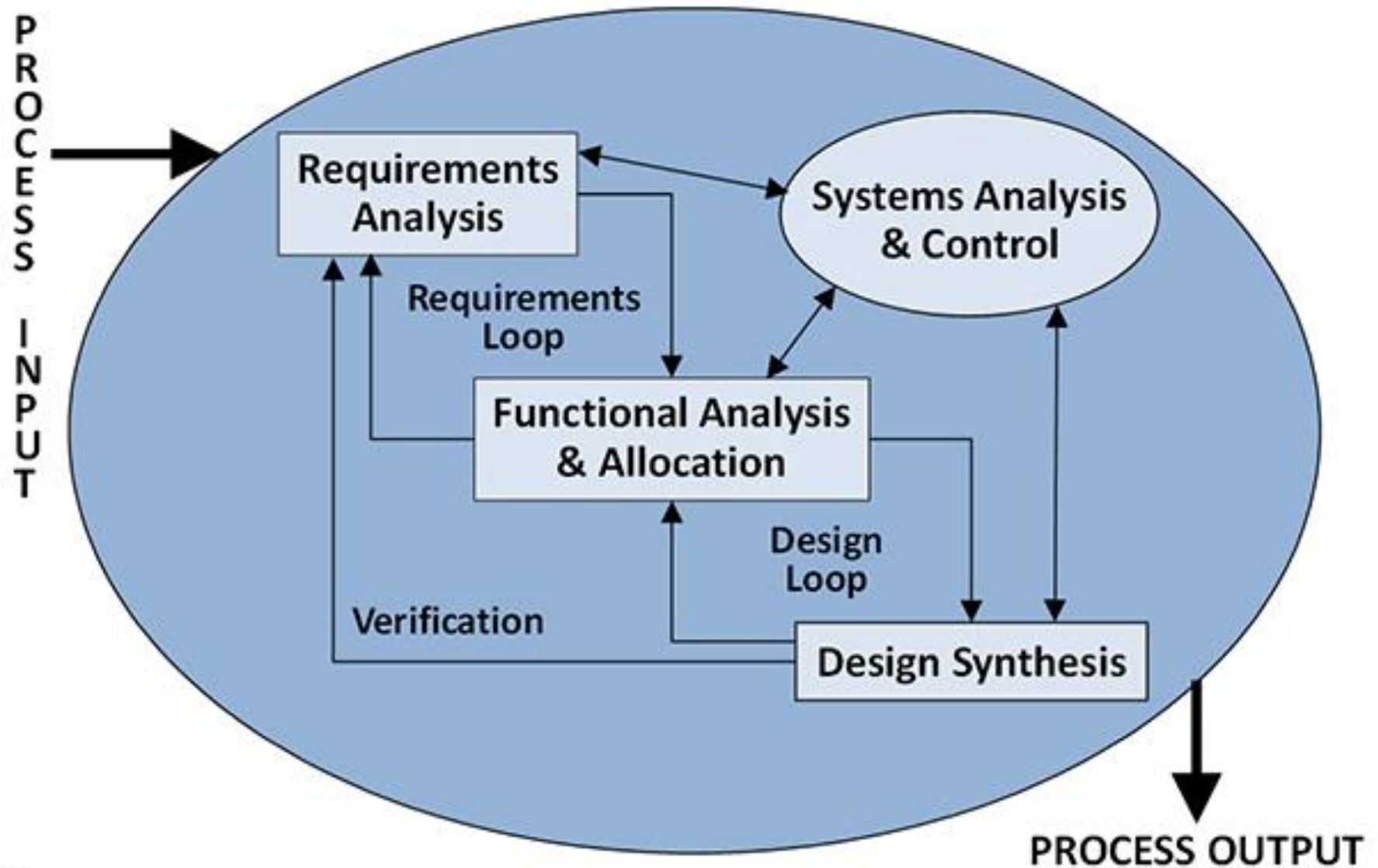


# Origens da Engenharia de Sistema



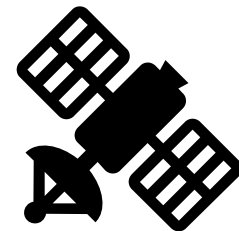
<http://www.incose.org/AboutSE/history-of-systems-engineering>  
[http://collegebuddi.com/system\\_engineering/systems\\_domains.php](http://collegebuddi.com/system_engineering/systems_domains.php)

# Exemplo do que ocorre



# [ Sistema de Engenharia ou Engenharia de Sistemas??? ]

An engineered system is an open **system** of technical or sociotechnical elements that exhibits emergent properties not exhibited by its individual elements. It is created by and for people; has a purpose, with multiple views; satisfies key stakeholders' value propositions; has a life cycle and evolution dynamics; has a boundary and an external environment; and is part of a system-of-interest hierarchy.

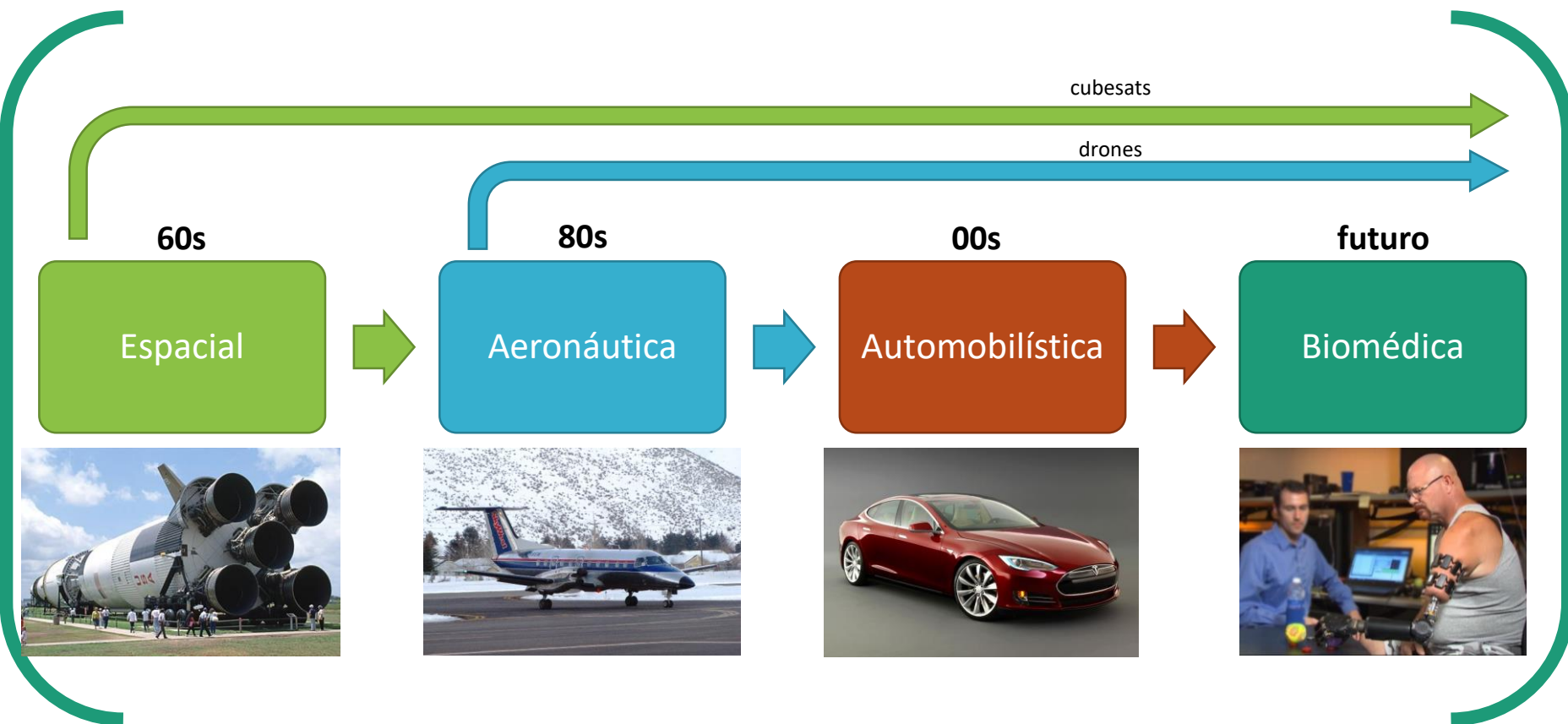


Systems engineering is “an interdisciplinary **approach** and means to enable the realization of successful (engineered) systems”. It focuses on holistically and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, and evolving solutions while considering the complete problem, from system concept exploration through system disposal.



# Quem segura o bastão?!

Evolução de quem domina as boas práticas, e melhores técnicas de Engenharia de Sistemas





# Engenharia de Sistemas para Pequenos Satélites

# O que levar em conta

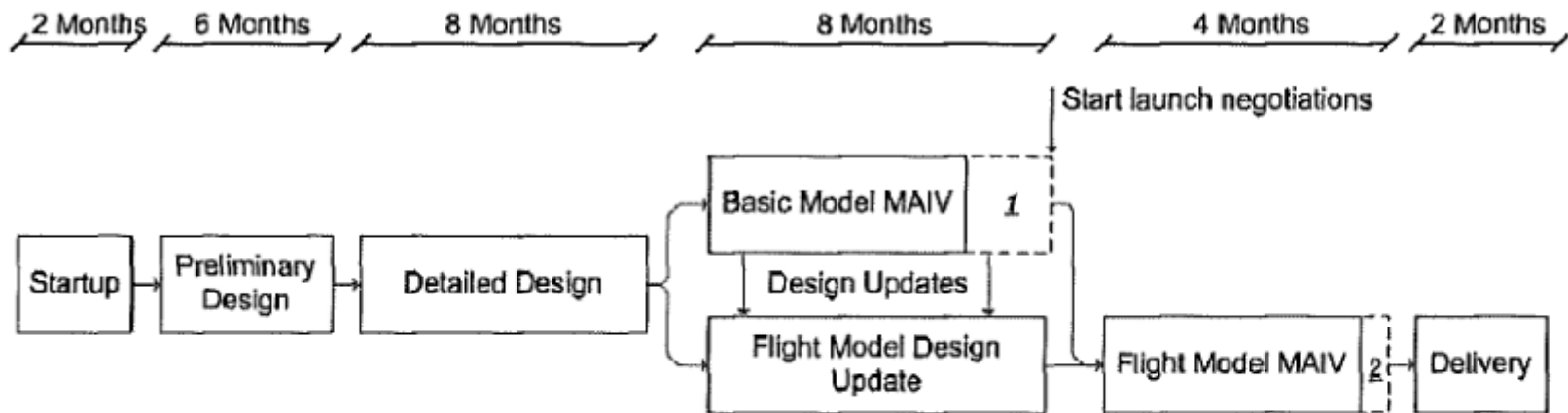
- Relativo curto tempo de desenvolvimento ~2 anos
- Equipes pequenas, voláteis, ~integradas
- Haverão requisitos tardios (muitos)
- Curva de aprendizado das primeiras iterações
- Desenvolvimento ágil
- Utilização de COTS, e Reuso

# Filosofia de Modelos

CubeSat Model Approach

	Prototypes	Basic Model	Protoflight Model
Purpose	Proof of subsystem functions	Achieve an integrated and functional architecture	Fully functional satellite
Functionality	Subsystem subfunctions Subsystem functionality Proof of concept	Comparable to EM boards EPS architecture functional CHDS architecture functional	Flight Model Fully integrated Upgraded Basic Model
Verification	Verify functions	Qualification testing	Acceptance testing
Examples	Battery conditioning board Power distribution board	Basic EPS in stack	Flight EPS in stack

# Organizando o tempo...



## Throughout lifecycle:

- (2) weekly team meeting
- Subsystem status/issues/planning
- PMSE update and decision moment
- Proper meeting documentation

## 1. Main delay causes:

- CDHS Implementation
- EPS implementation
- Redesigns

## 2. Main delays causes:

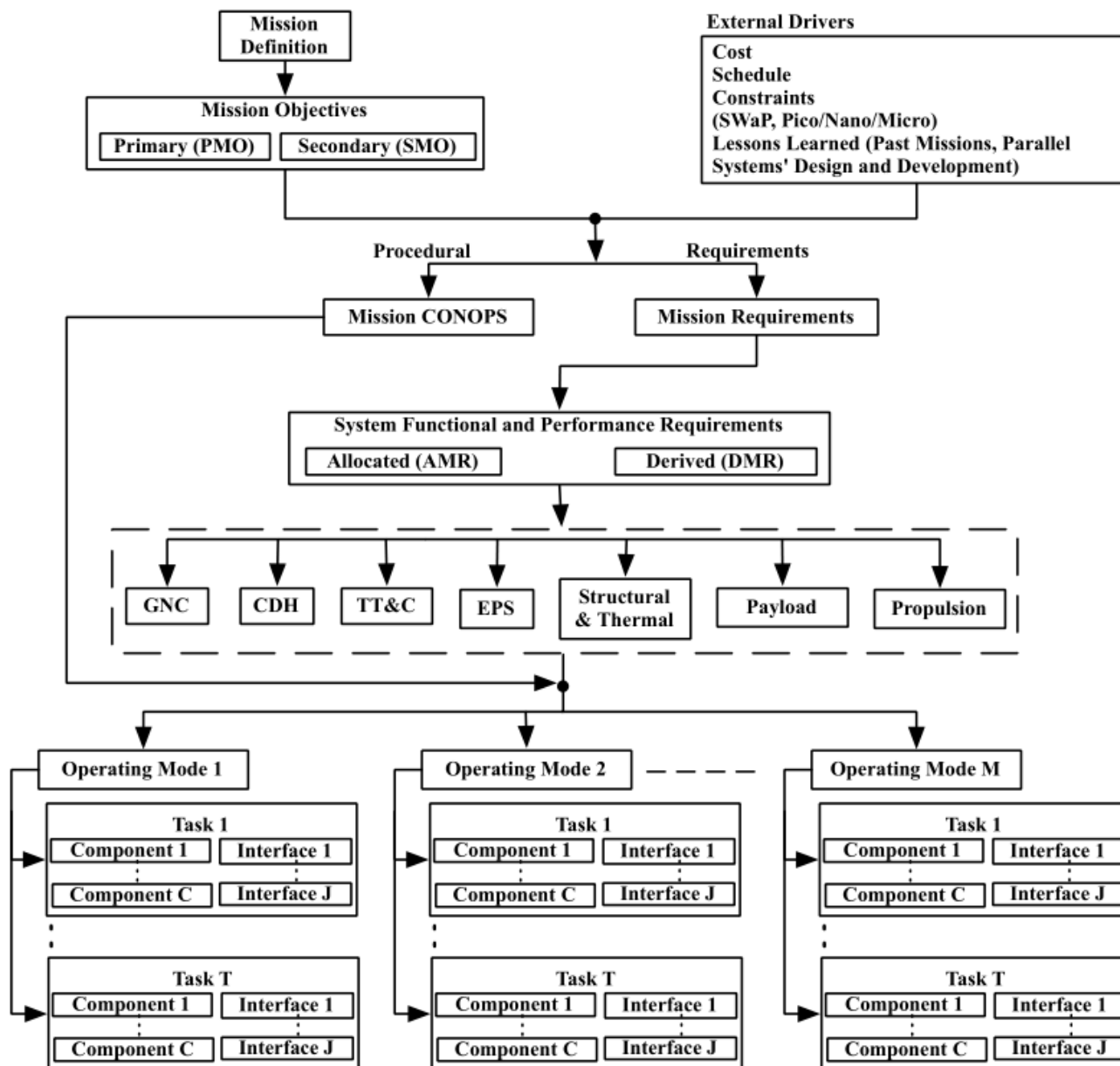
- Errors in redesigns
  - Workmanship
  - ...
- Delays are expected to be much less than in 1*

## MAIV Control gates:

- Subsystem readiness review
- Integration readiness review
- Environmental readiness review
- MAIV closeout review

Manufacturing, Assembly, Integration and Verification (MAIV)

# Requisitos....





- Análise, definição e validação de requisitos
- Verificação e validação dos softwares.
- Desenvolvimento de equipamentos (EGSE) e de procedimentos de teste.
- Apoio as atividades de teste
- Previsão de performance do sistema.
- Desenvolvimento e validação de procedimentos operacionais.
- Avaliação de solução de problemas
- Treinamento de equipes

## CTEE



# MBSE – Model Based System Engineering

ENGENHARIA DE SISTEMAS BASEADA EM MODELOS

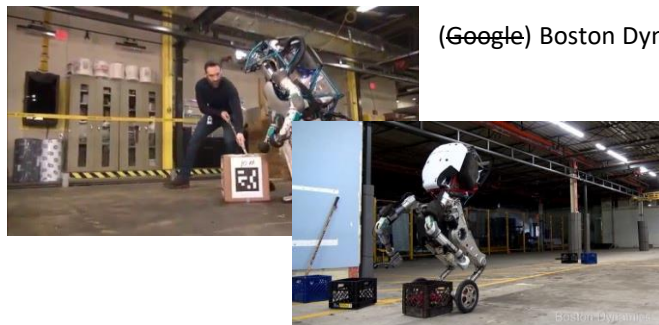
# Motivação Produto



(SpaceX) Grasshopper Test

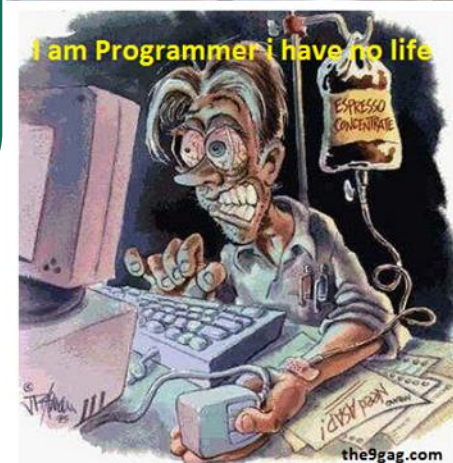
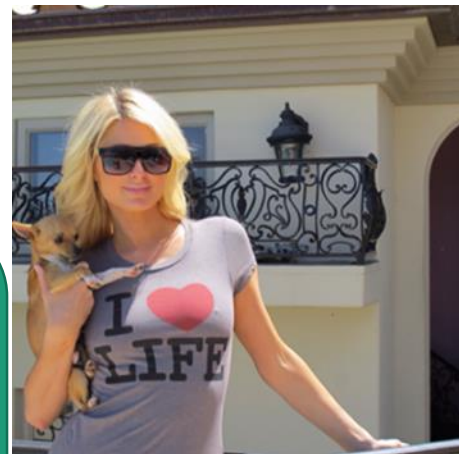


(Google) Self-drive Car



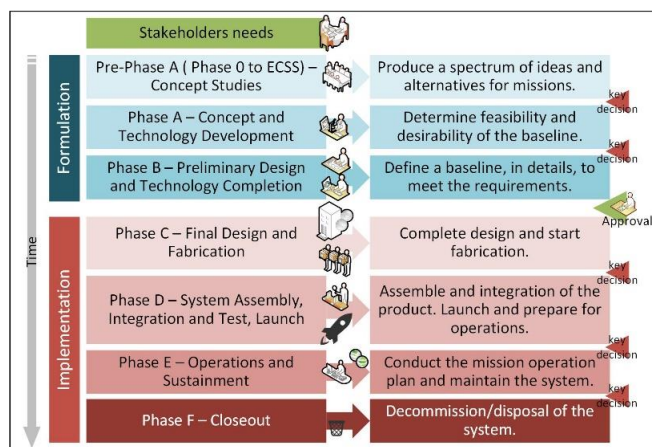
(Google) Boston Dynamics

*Será que é possível fazer todos esses produtos na mão?!?*

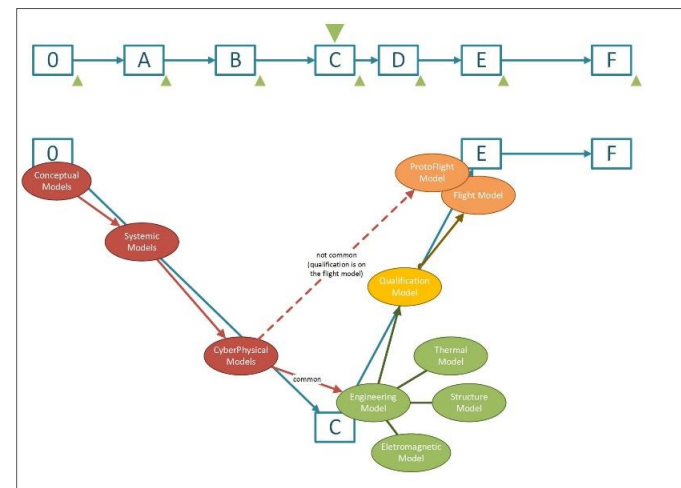


# Typical Life-Cycle

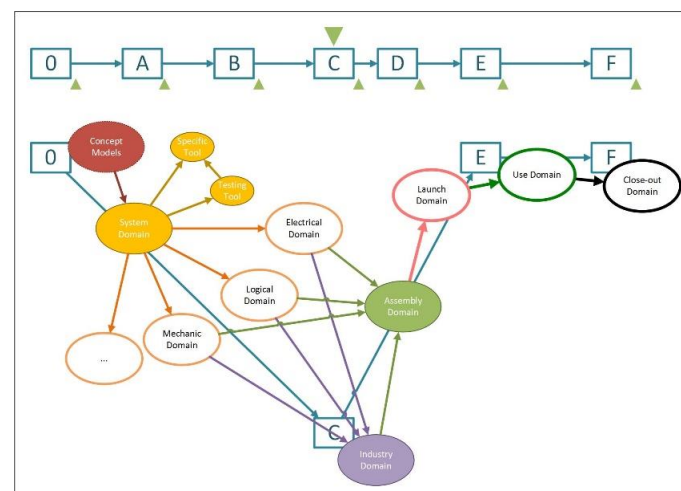
## Standard Approach



## Model Philosophy



## Domains





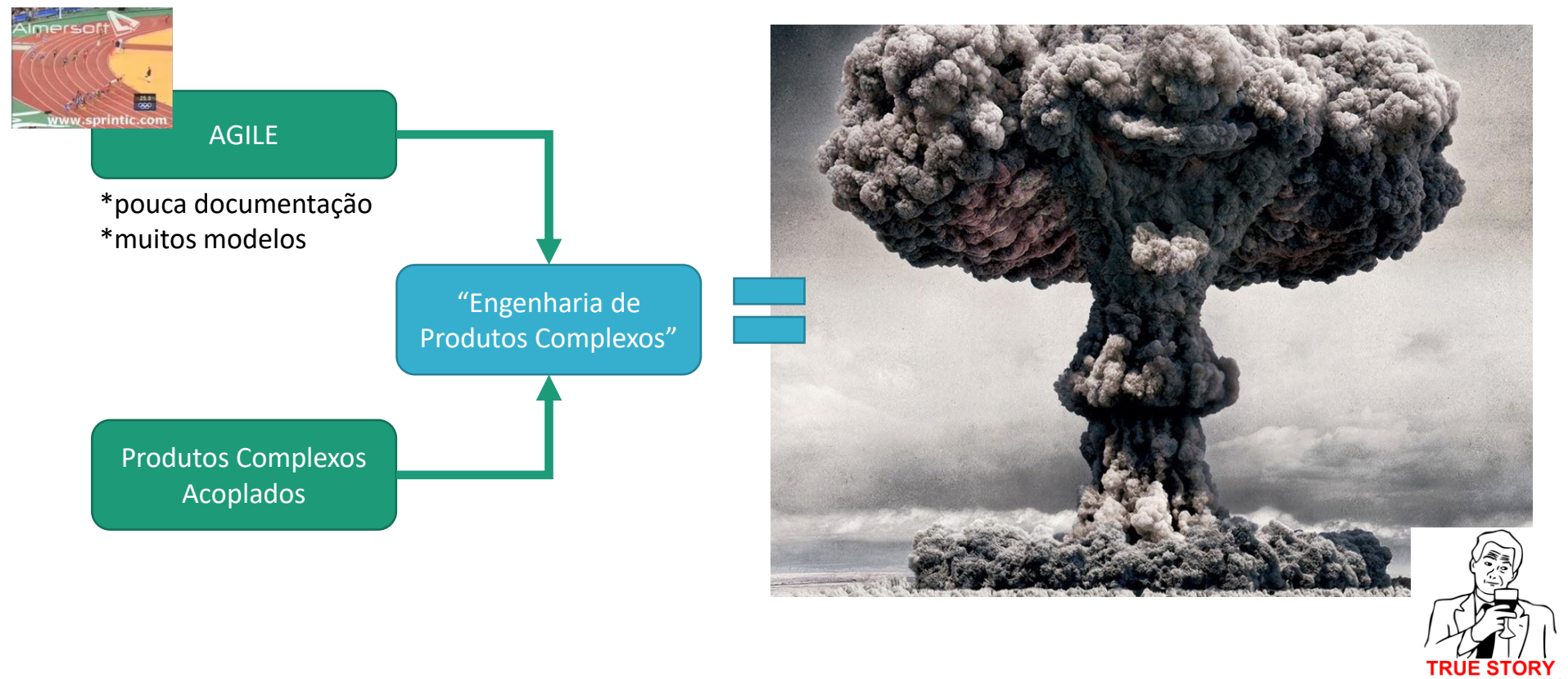
# Motivação Processo/Organização

ThalesAlenia  
A Thales / Finmeccanica Company *Space*

SATELLITE AIT  
in one day



# Produtos Complexos Interdisciplinares e Acoplados



# Até entrar a Computação: Modelos ..... Simulações

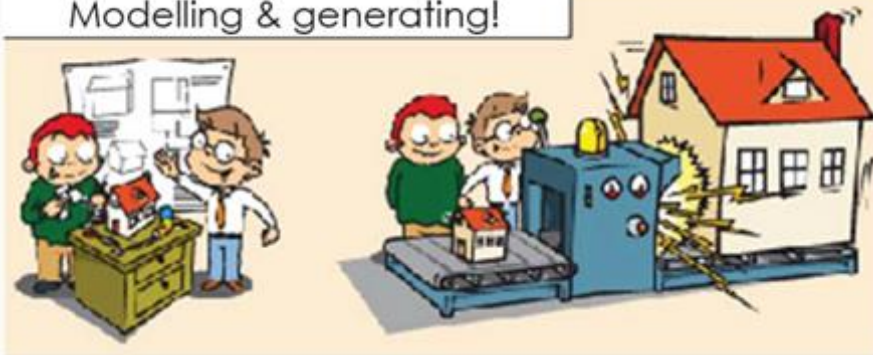
Programming?



Engineering?

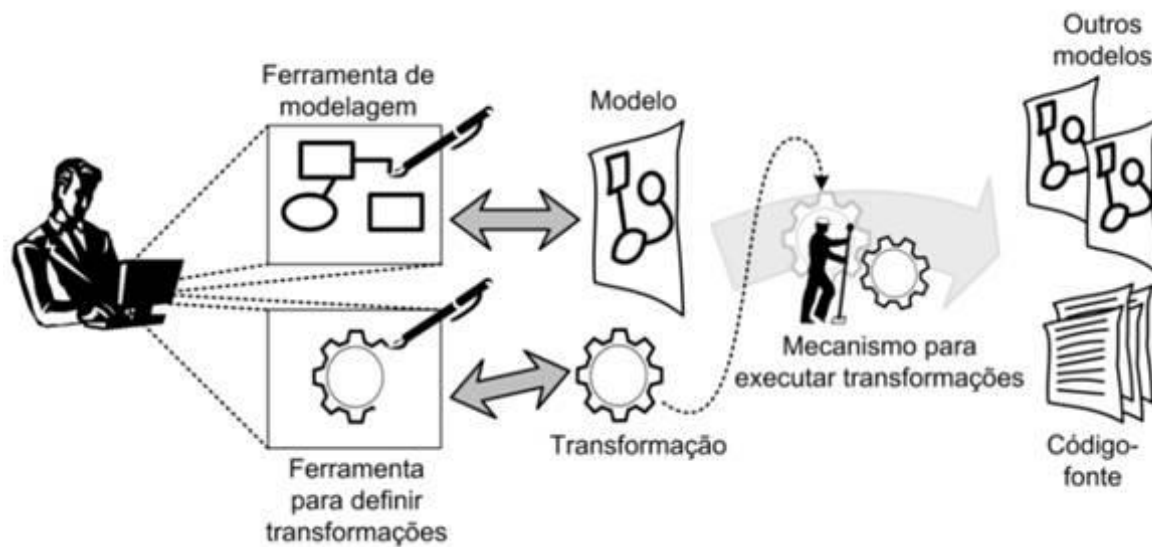


Modelling & generating!



Modelling and  
auto-build?

# Model Driven Development ...

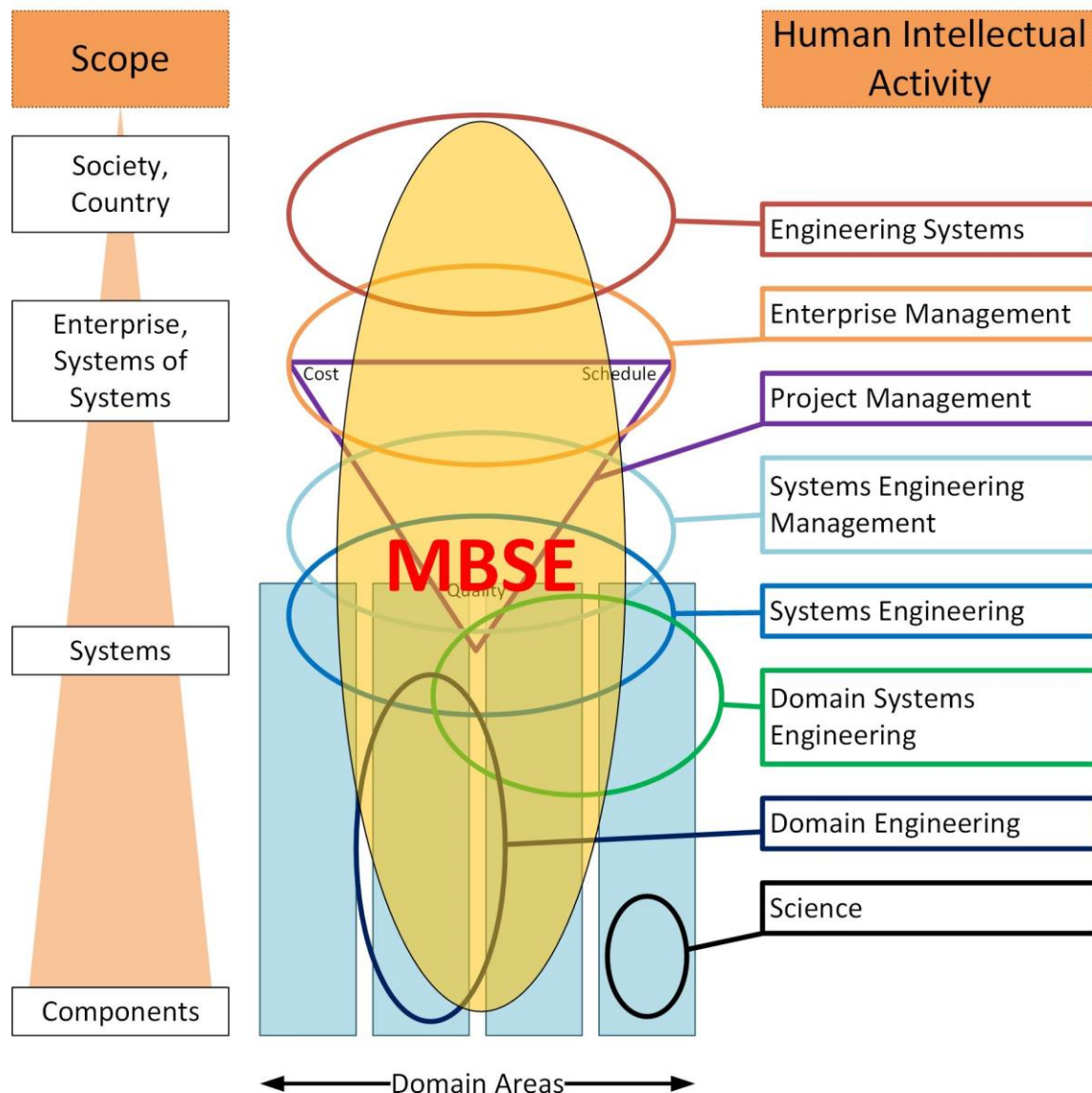


- **MDD** – Model Driven Development
- **MDSD** – Model Driven Software Development
- **MDA** – Model Driven Architect
- **MDSE** – Model Driven Software Engineering
- **MDRE** – Model Driven Reverse Engineering
- **MM** – Model Management
- **ADM** – Architecture Driven Modernization
- **DDD** – Domain Driven Design
- **MBD** – Model Based Development
- ... → infinito

<http://www.devmedia.com.br/model-driven-architecture-com-enterprise-architect/33898>

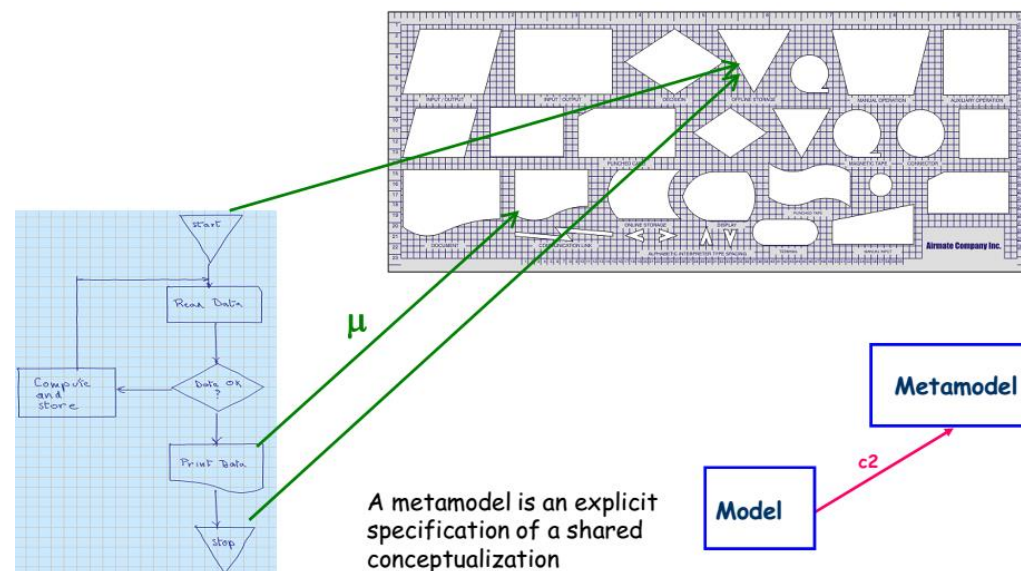


# Modelos





# Metamodelos

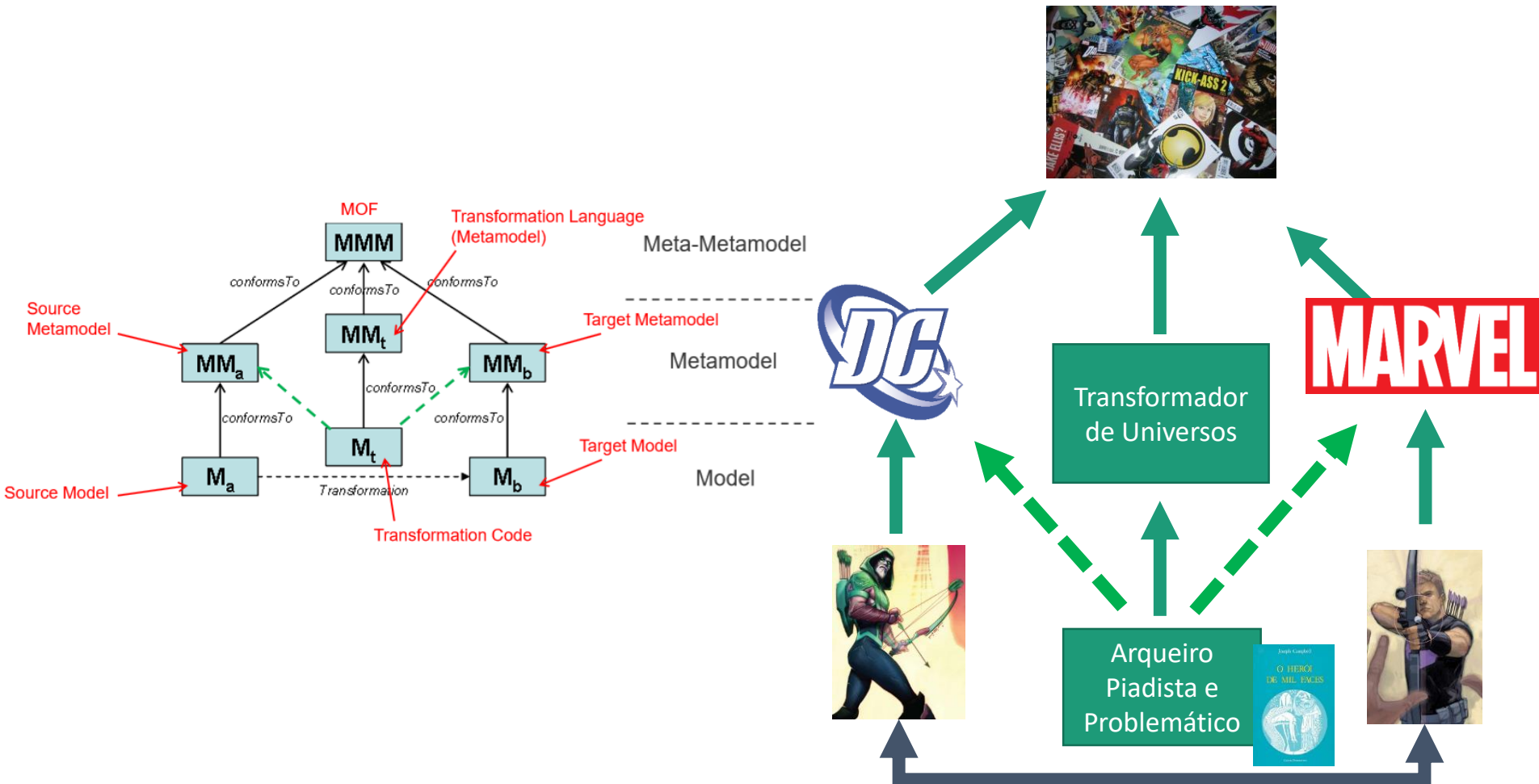


(Bézivin e Gerbé, 2001)

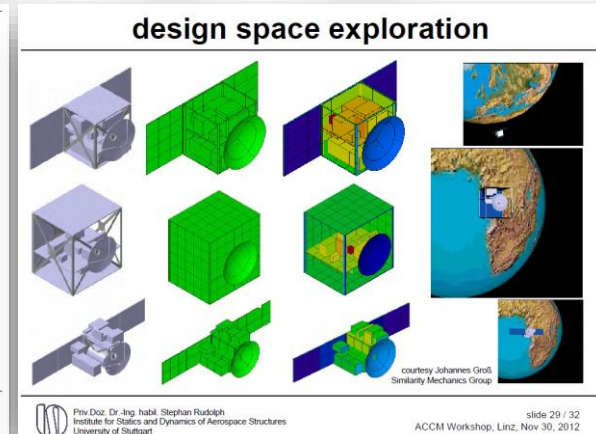
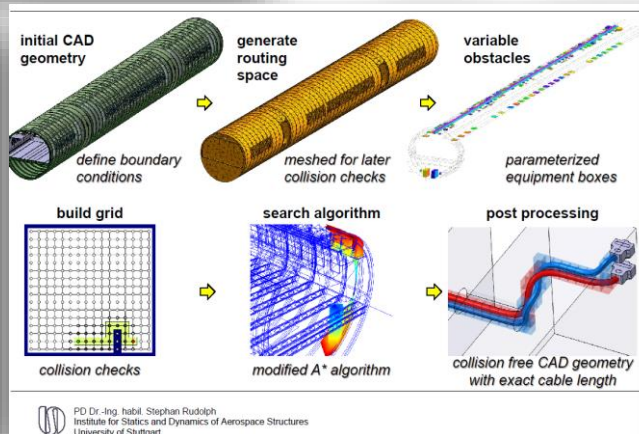
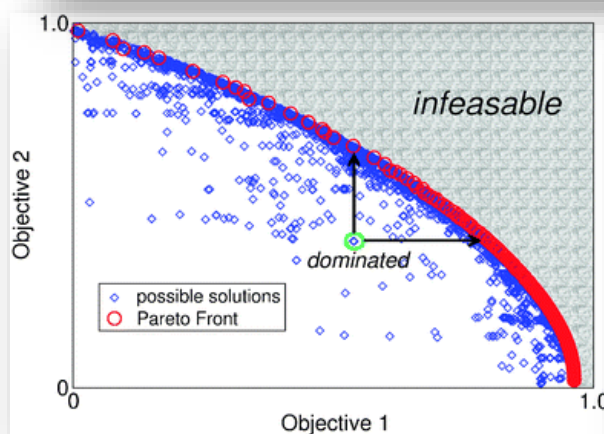
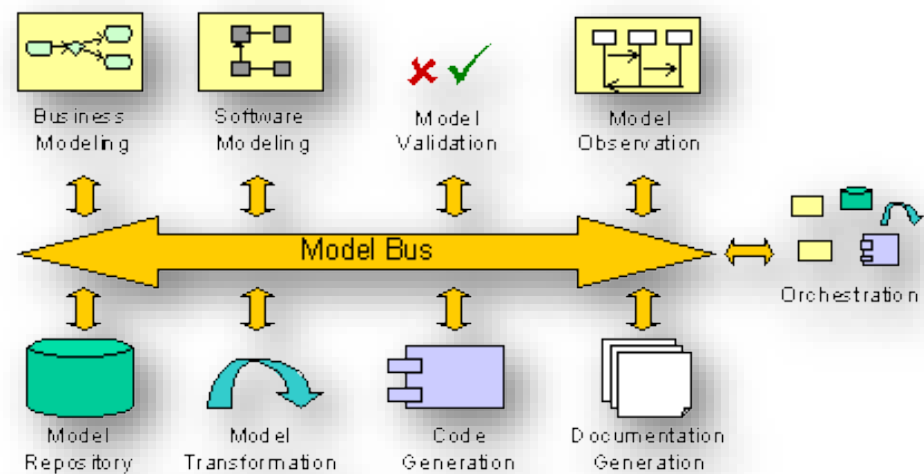
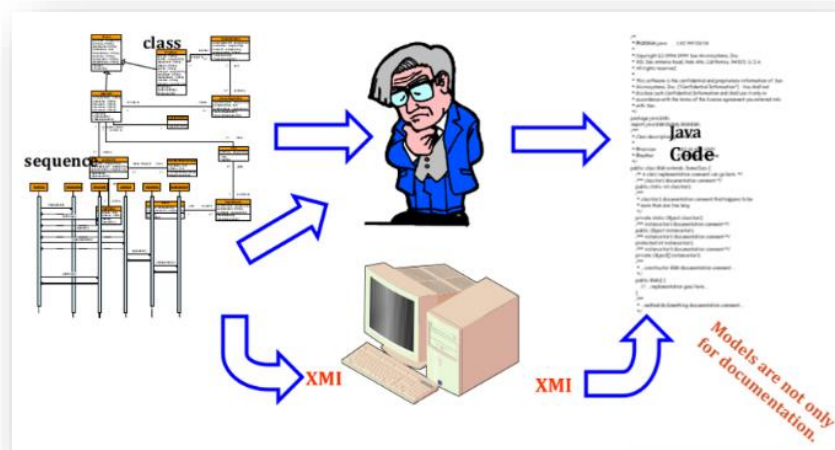


“Metamodelo é uma **especificação explícita** de uma abstração. Para definir uma abstração, um metamodelo identifica uma **lista de conceitos relevantes** e uma **lista de relações relevantes** entre os conceitos, sendo usado como um **filtro de possibilidades** de uma dada atividade de modelagem.”

# Transformações de Modelos



# Benefícios






(joke) motto



**Paige Bailey** @DynamicWebPaige · 9 de jul

- 1) Pick an industry
- 2) Ask people in that industry what they use spreadsheets for
- 3) Build something better

 Traduzir do inglês



54



825



2,2 mil



# MBSE

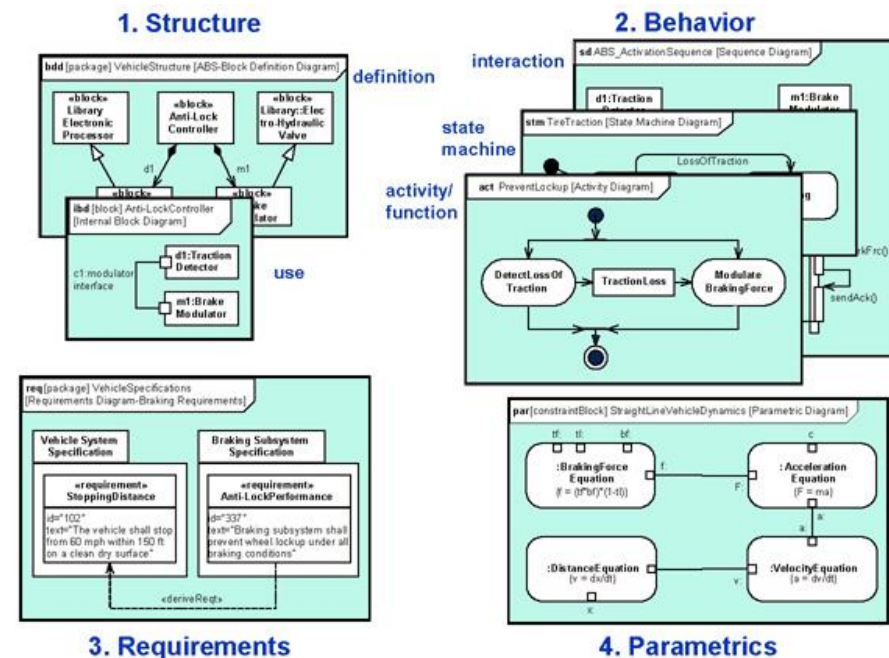
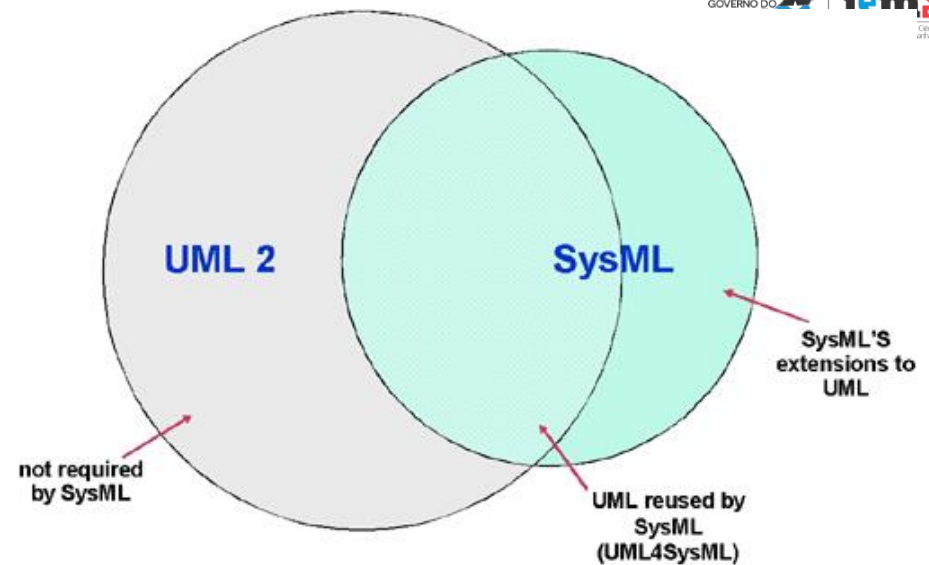
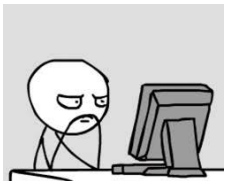
**“Model-based systems engineering (MBSE) is a systems engineering methodology that focuses on creating and exploiting domain models as the primary means of information exchange between engineers, rather than on document-based information exchange.”**

“the formalized application of modelling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. MBSE is part of a long-term trend **toward model-centric approaches** adopted by other engineering disciplines, including mechanical, electrical and software. In particular, MBSE is expected to **replace the document-centric** approach that has been practiced by systems engineers in the past and to influence the future practice of systems engineering by being fully integrated into the definition of systems engineering processes.”

<http://www.omgwiki.org/MBSE/doku.php>

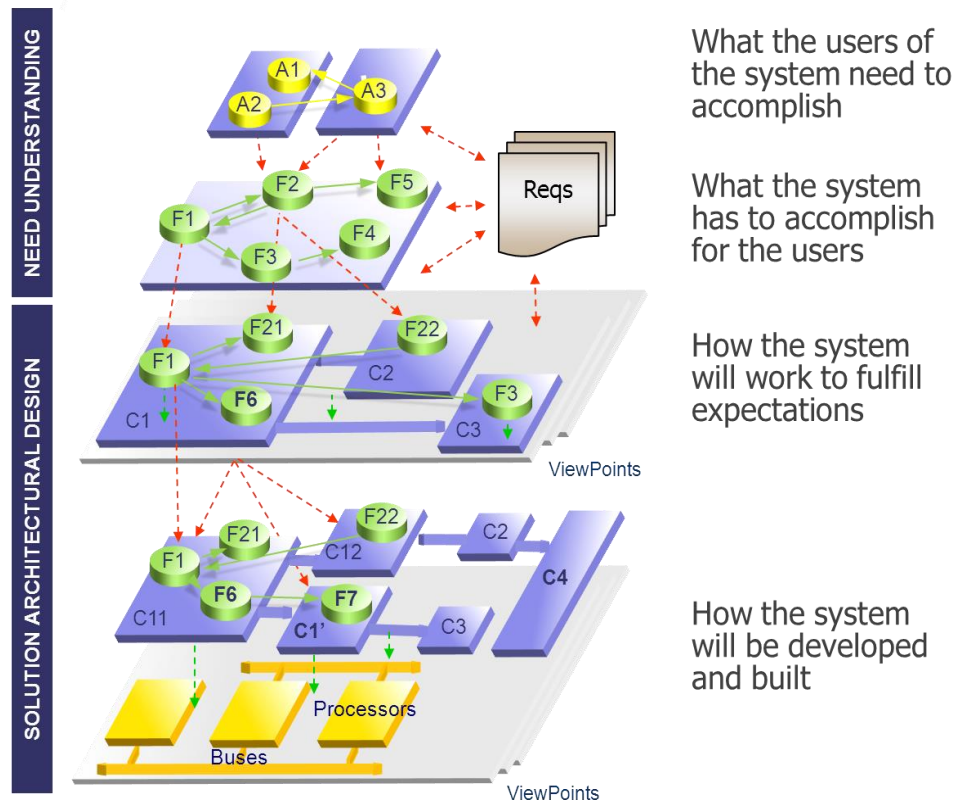
# SysML

- SysML é uma **linguagem de modelagem gráfica**, em resposta ao UML, para Sistemas
- SysML suporta especificação, **análise, projeto, verificação e validação** de sistemas incluindo hardware, software, dados, pessoal, procedimento e infraestruturas.
- <http://www.omgsysml.org/>
- SysML V1.4 Beta Specification
- Março 2014



# Arcadia / Capella

- **Polarsys Group**
  - Thales Alenia
- Phases **0 - C**
- Capella is a layer above the Eclipse IDE
- Eclipse Modelling Framework (EMF)
- diagrams:
  - operational architecture, use cases, dataflow, architecture, logical, physical, tree, sequence, state, and classes

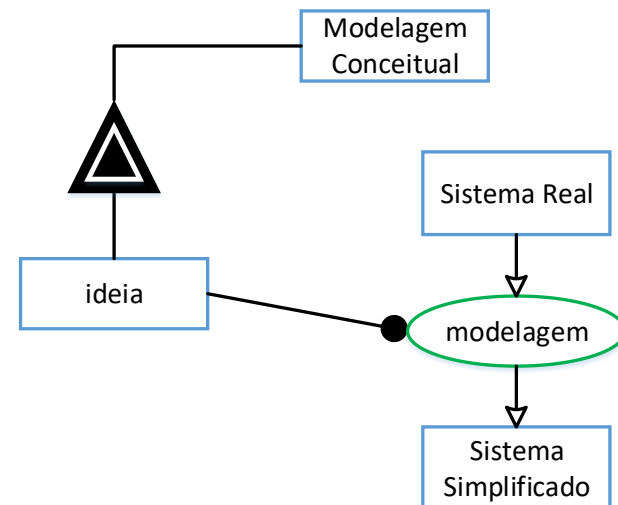
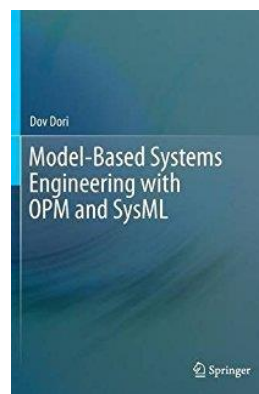
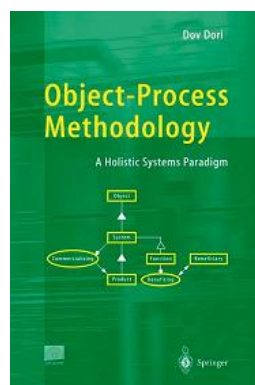
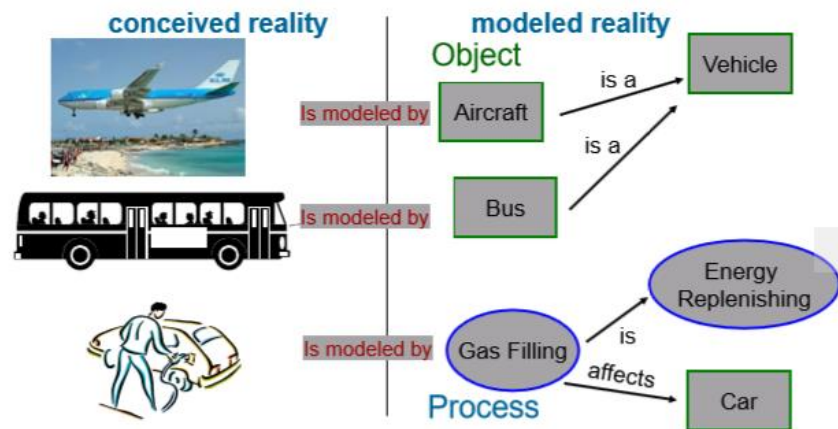


<https://www.polarsys.org/capella/>



# OPM – Object-Process Methodology

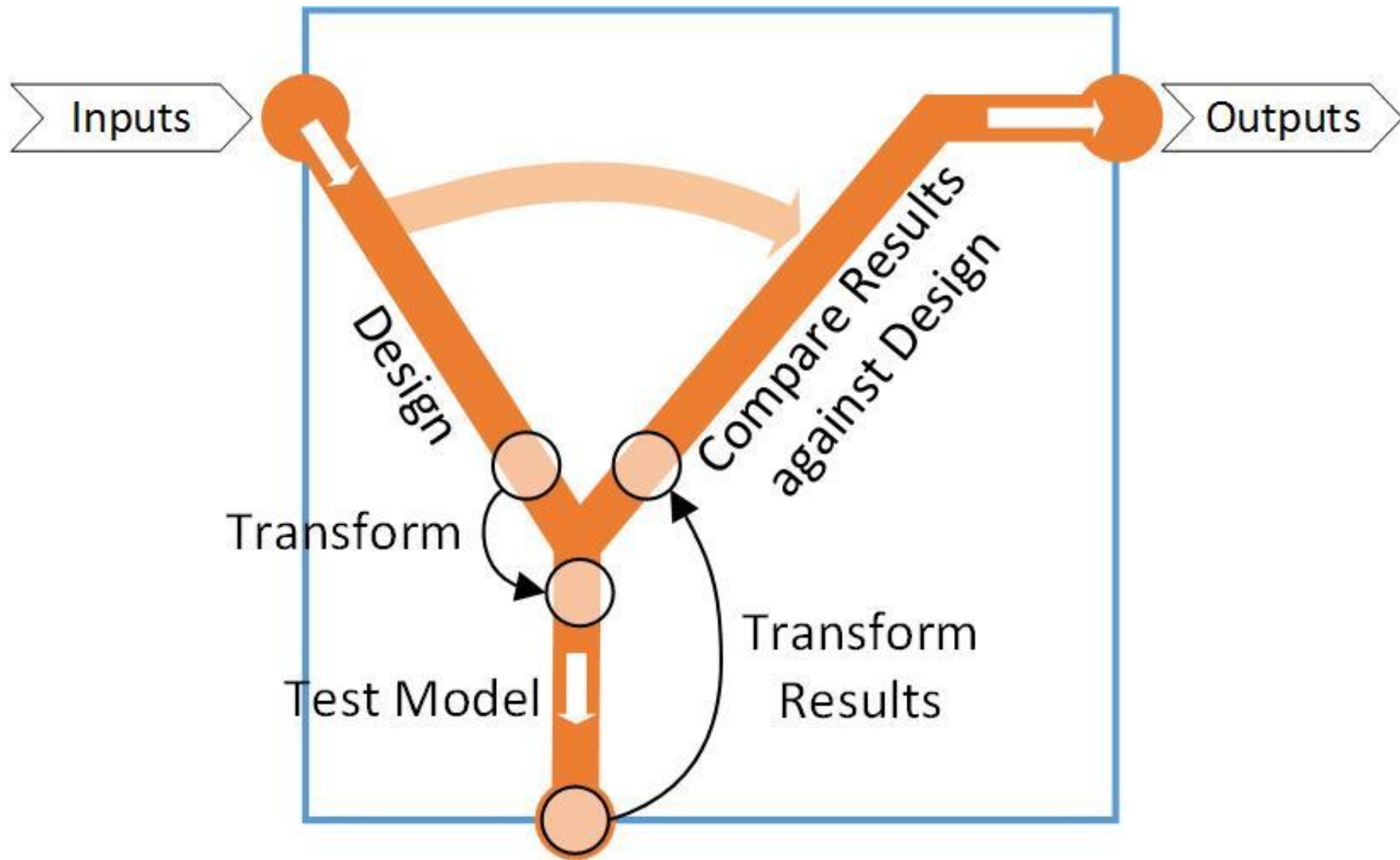
- OPM aspectos **estruturais e de comportamento** coexistem
- Três blocos básicos de entidades: objetos, processos e estados
- Apenas **um** diagrama – possibilita melhor compreensão do sistema como um todo
- Ontologicamente completo.



[http://esml.iem.technion.ac.il/?page\\_id=1849](http://esml.iem.technion.ac.il/?page_id=1849)

<http://sdm.mit.edu/the-maturation-of-model-based-systems-engineering-opm-as-the-iso-conceptual-modeling-language-standard/>

# Com software em cada fase é possível...



0

A

B

C

D

E

F

tempo

Concepção

Conceitual

Detalhado

Industrial

Integração  
TestesUtilização  
Descarte

Sis

SubS

Equip

V – Waterfall

Ys – Prototype Cascade

“quantidade de trabalho + profundidade de detalhes”

Figura do autor



# Influência no Ciclo de Vida (Transferência de Artefatos)

