GAINING CLARITY WITH SYSTEMS THEORY

INCOSE Enchanment Capter 2023

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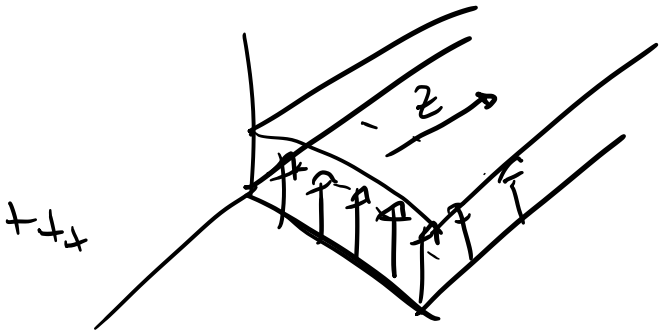
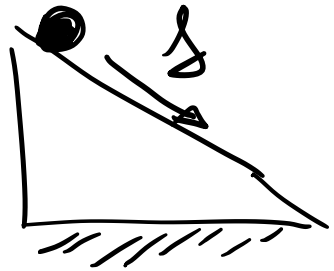
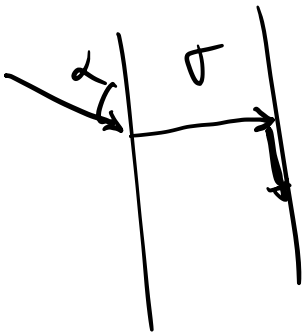
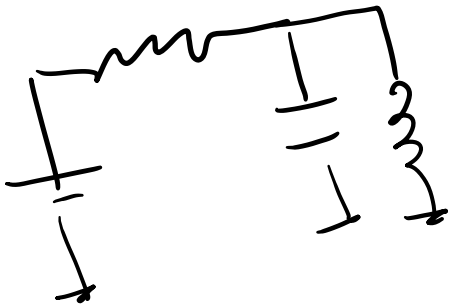
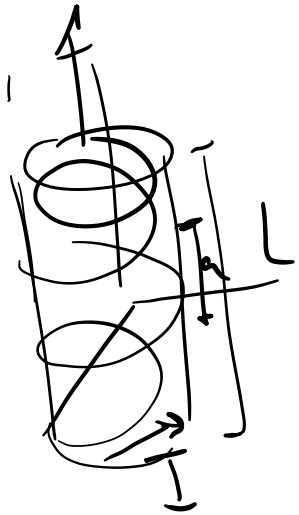
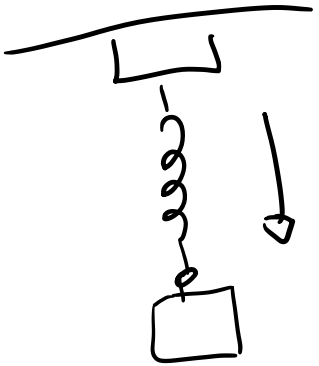


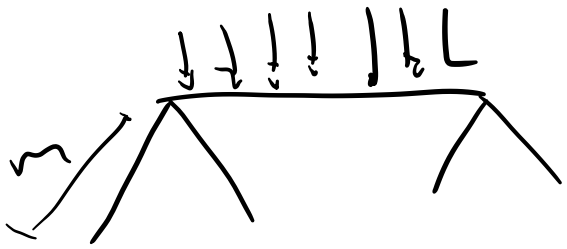


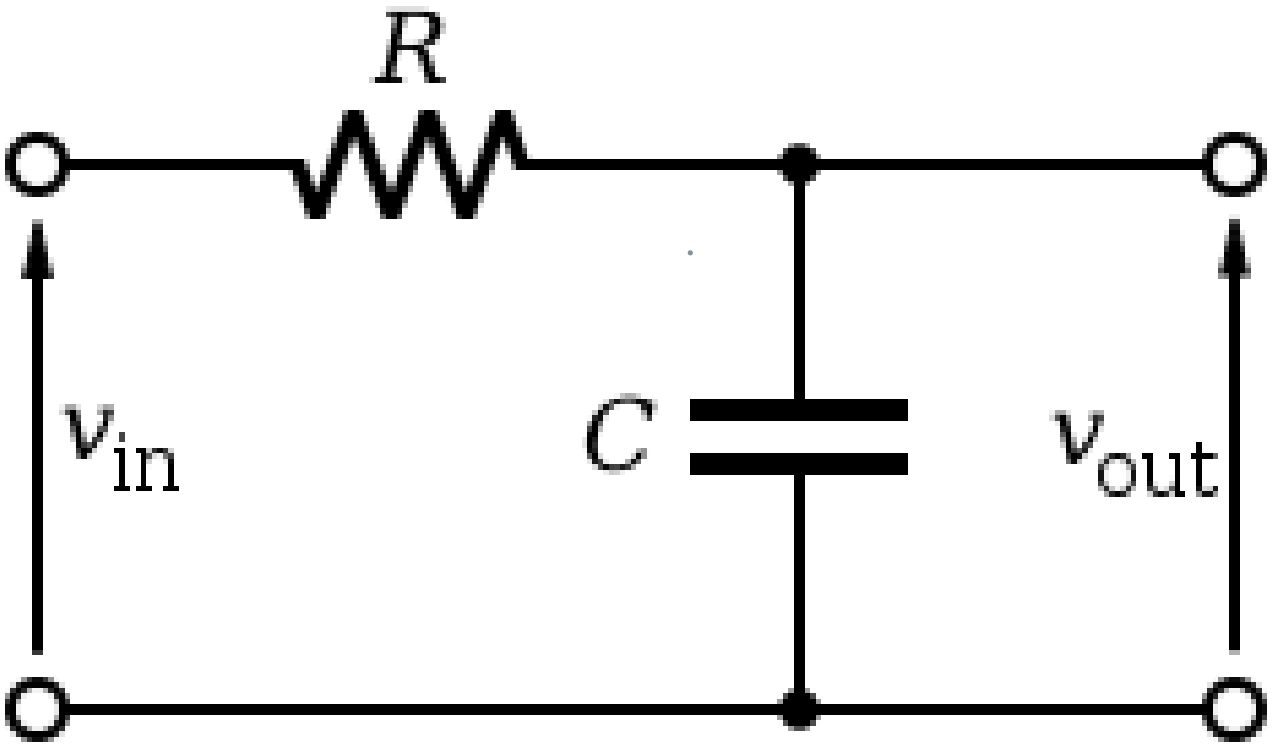












$$F = m \cdot a$$

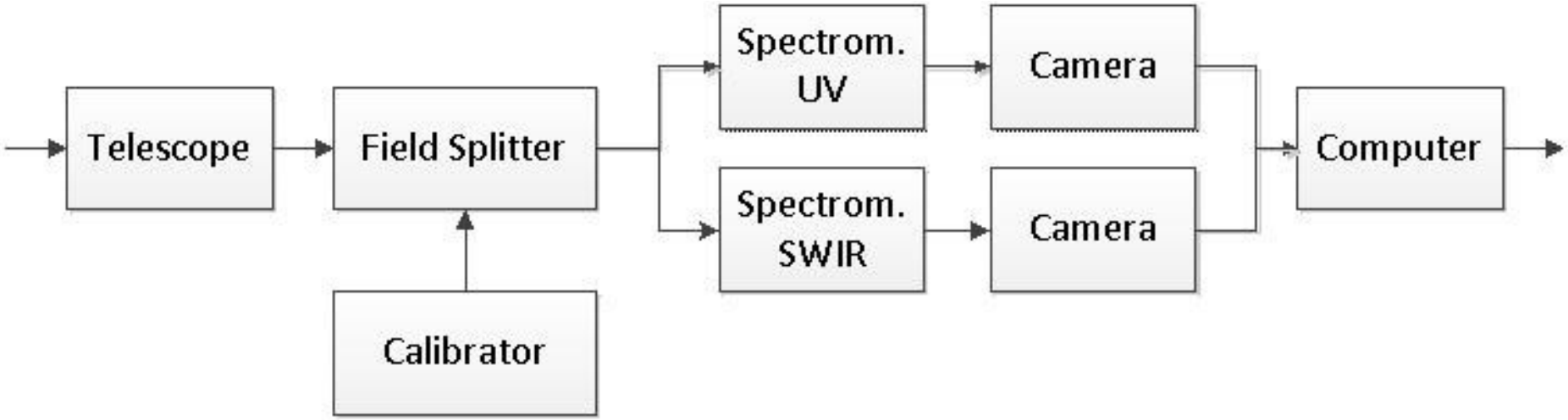
$$\nabla \cdot \mathbf{D} = \rho$$

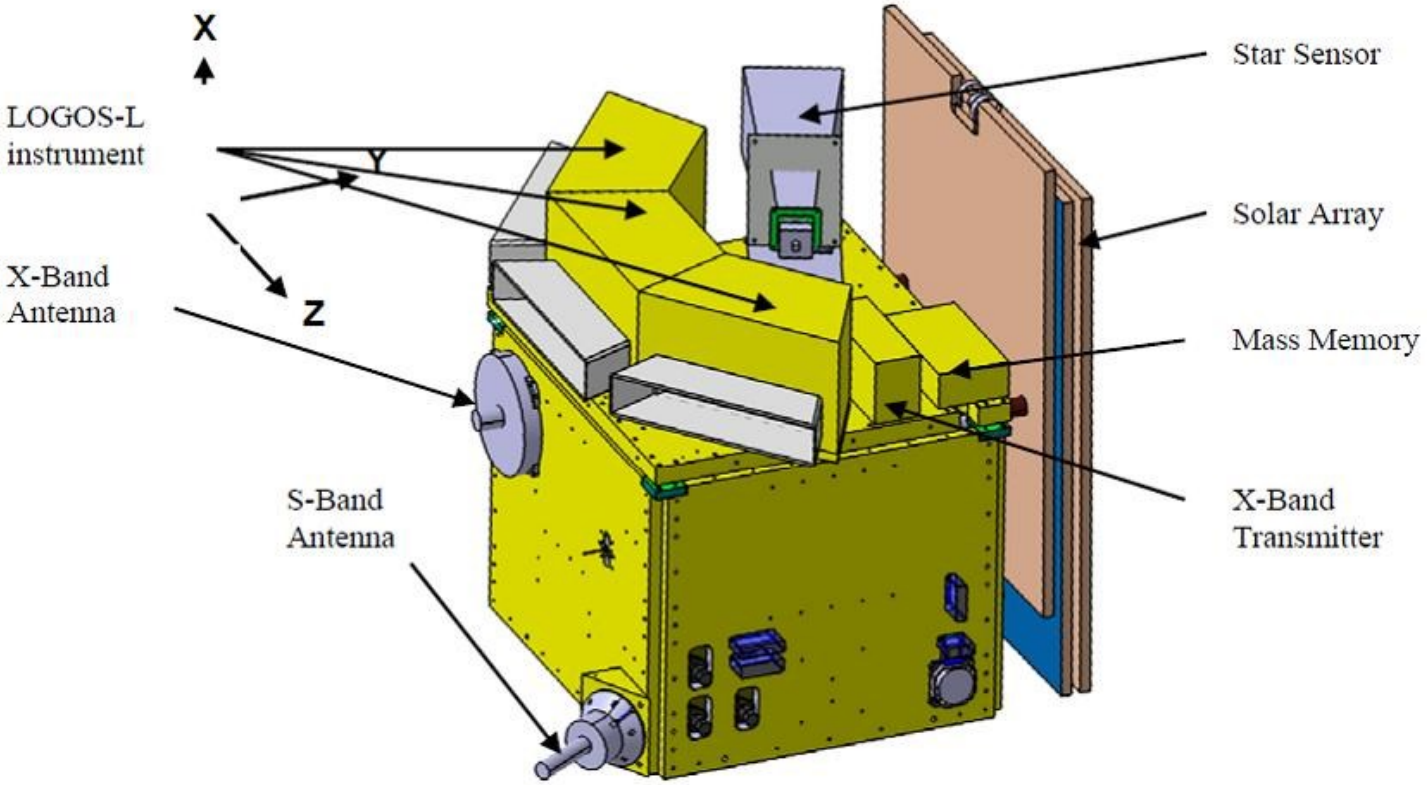
$$\nabla \cdot \mathbf{B} = 0$$

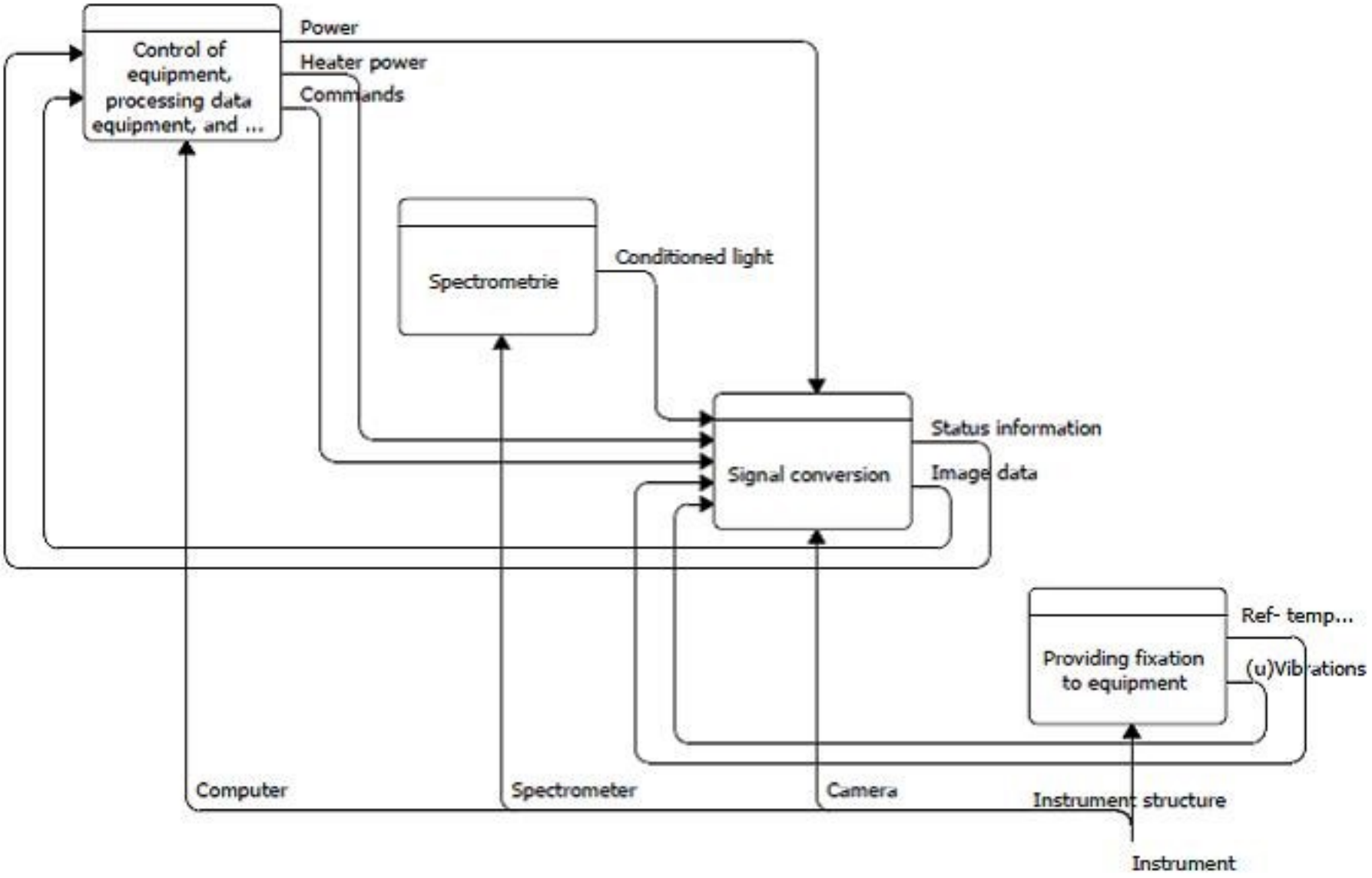
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

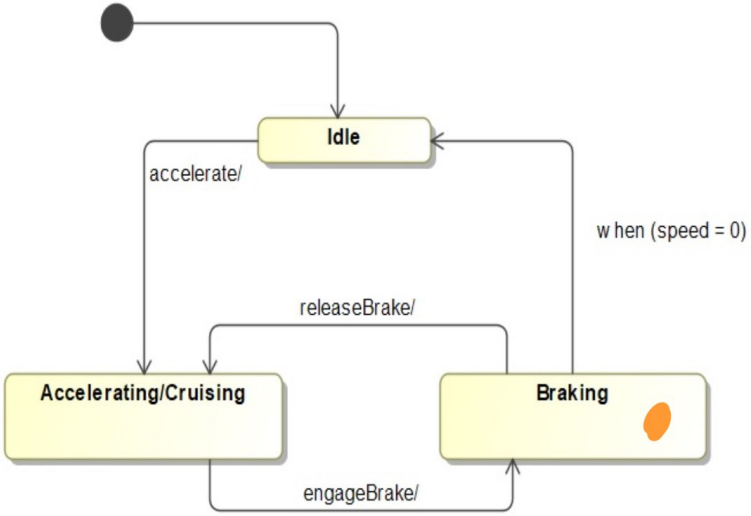
$$V = R \cdot I$$







Consider a car's behavior modeled as follows:



How does the CAR react when releaseBrake & speed=0?

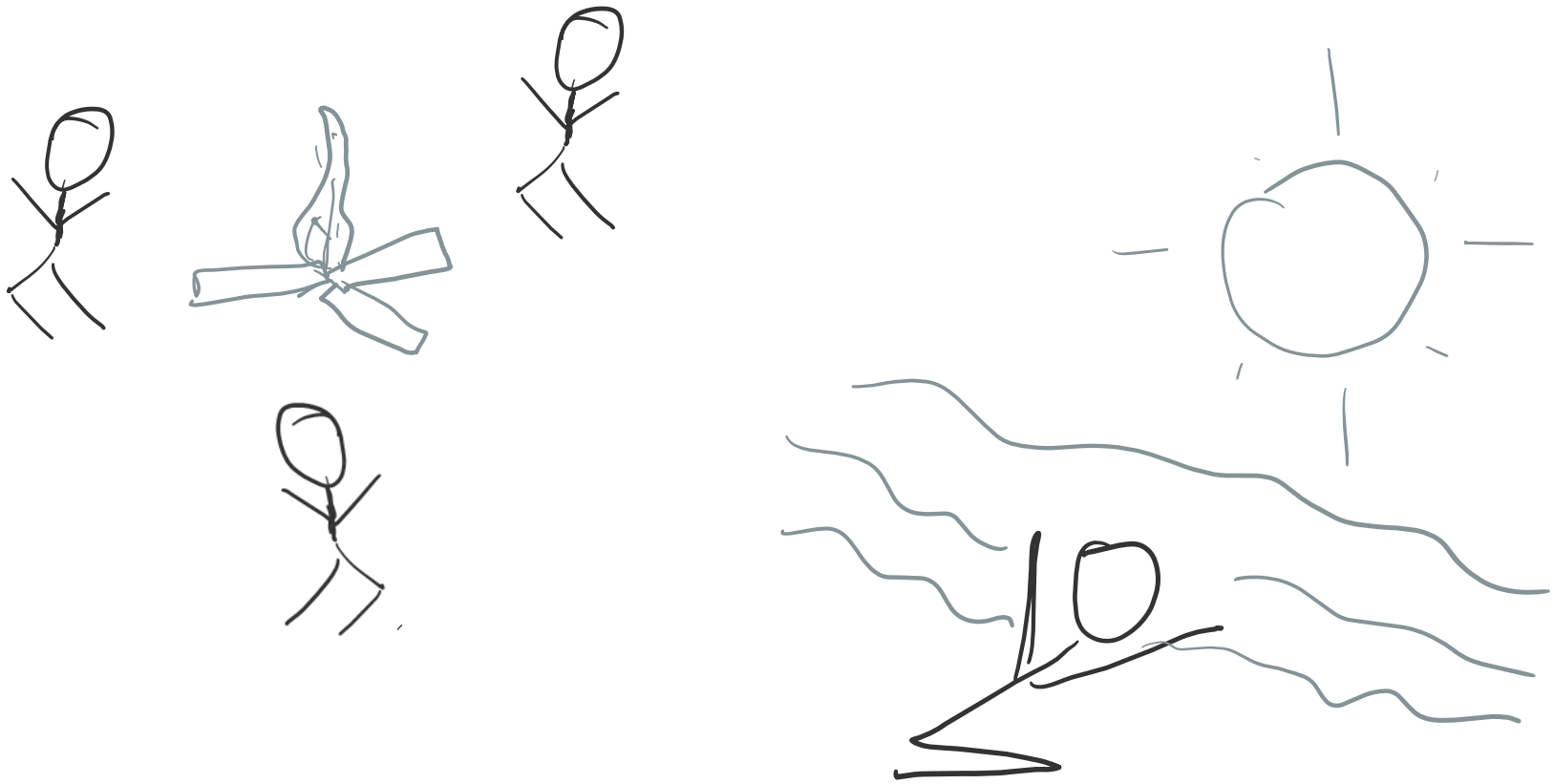
OPTIONS

- **Ignore**/Stay in Braking
- **Undefined**/uncontrolled
- Transition to **Idle**
- Transition to **Accel./Cruis.**
- **Incomplete**/incorrect
- **NOT** an expected condition

SysML does not offer an answer…
open to interpretation

Systems engineering is based on

THEORY



Today's systems engineer

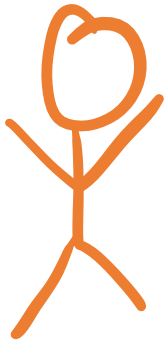
PRINCIPLES

There is a **common** mission

Think about the **end** before the beginning

Every solution creates new **problems**

Solving the **wrong** problema is fruitfless



Someone with **experience**

Traditional T-shape profile

Acts as an engineering ***manager***

SE is **not** a dedicated engineering discipline

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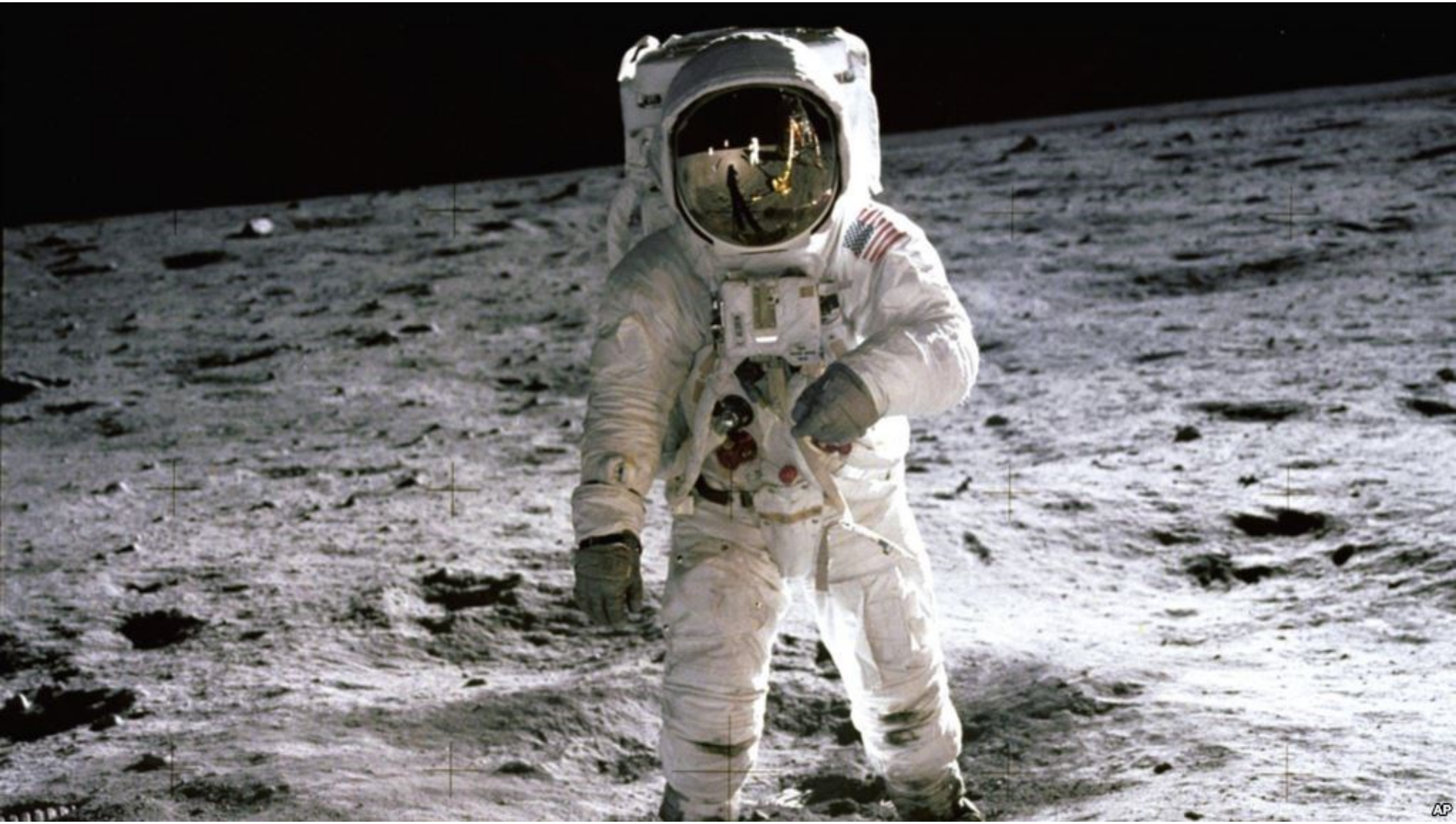


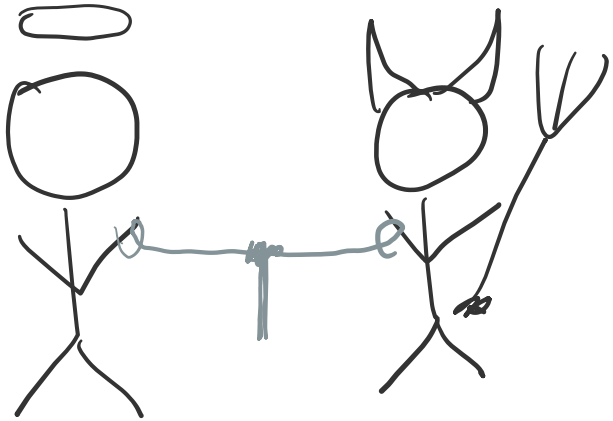
Source: https://www.voanews.com/a/apollo-11-45-year-anniversary-moon-landing/1960612.html

You need to conduct the **STRUCTURAL** analysis of an airplane.

Would you task an **ELECTRONICS** engineer with a **1-week** seminar in mechanical engineering?

You have to write the
REQUIREMENTS for a $100M system.

Would you task a **MECHANICAL** engineer with a **1-week** seminar in requirements engineering?

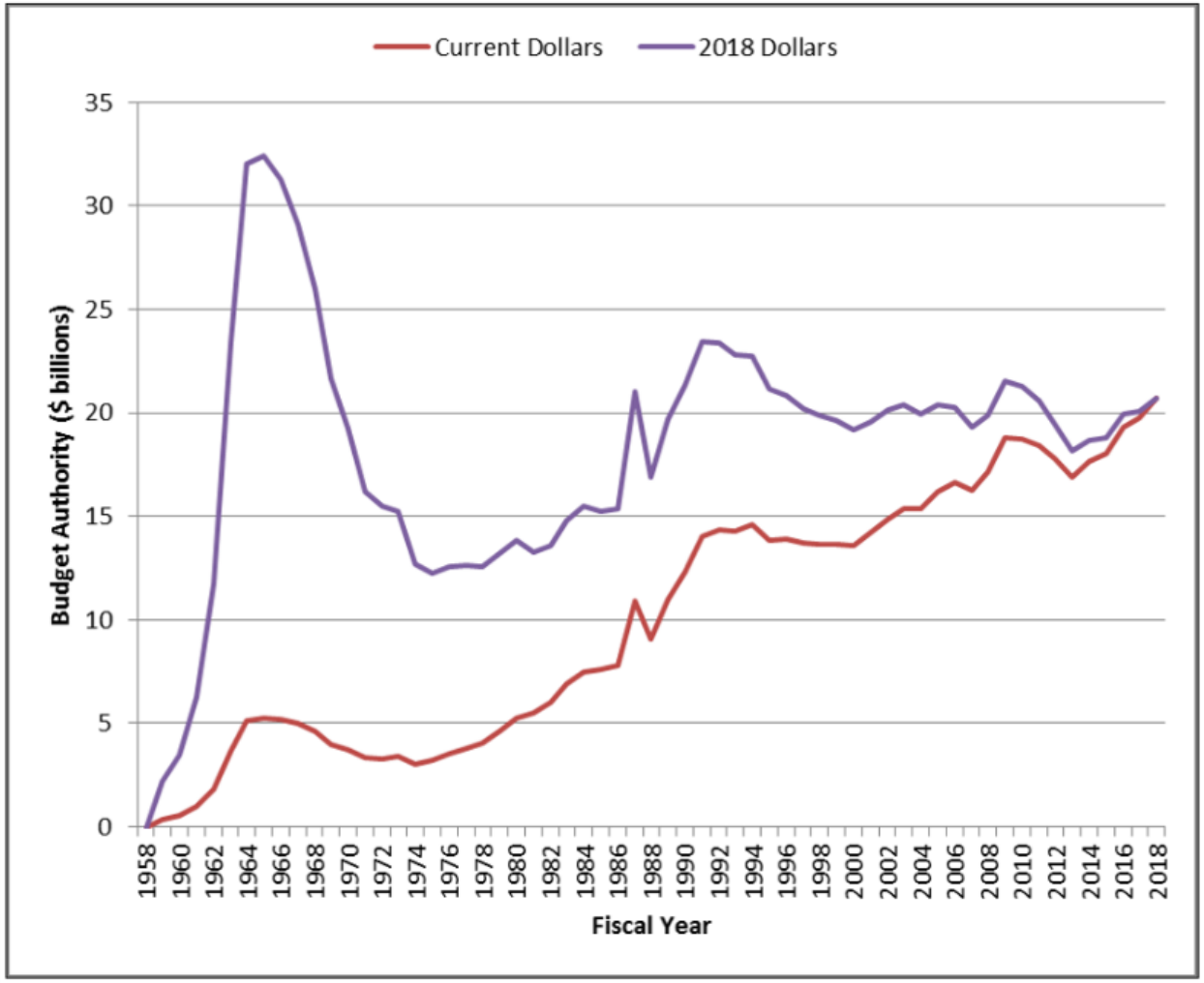


EVANGELIZATION of processes and methods

IMPOSITION of processes and methods

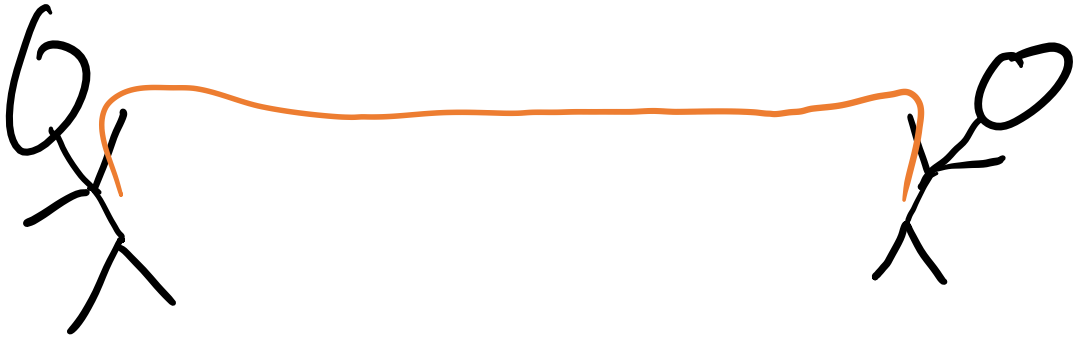
SOME THINGS HAVE **CHANGED**

Figure 1. NASA Funding, FY1958-FY2018



Source: Compiled by CRS. FY1958-FY2008 from National Aeronautics and Space Administration, *Aeronautics and Space Report of the President: Fiscal Year 2008 Activities*, http://history.nasa.gov/presrep2008.pdf, Table D-1A. FY2009-FY2012 from NASA congressional budget justifications, FY2011-FY2014. FY2013-FY2018 as in **Table 1**. Current dollars deflated to FY2018 dollars using GDP (chained) price index from President's budget for FY2019, Historical Table 10.1, https://www.whitehouse.gov/wp-content/uploads/2018/02/hist10z1-fy2019.xlsx.

Note: Transition quarter between FY1976 and FY1977 not shown.



Fast to market

Long lifetime

New solutions

Specialization

High technological diversity

Long development times

Frequent upgrades

No time for learning

Contractual structures

Integration and maintenance

Needs & requirements

V&V planning

Verification models

System architecture

Organizational structure

Uncertainty & complexity

Development processes

Probability theory

Epistemic **logic**

Systems theory

Belief theory

Organizational theory

Knowledge representation

Decision theory

Behavioral economics

Economics

Psychology

AN APPLICATION TO REQUIREMENTS

What are the differences between **needs** and **requirements**?

What are the differences between **requirements** and **constraints**?

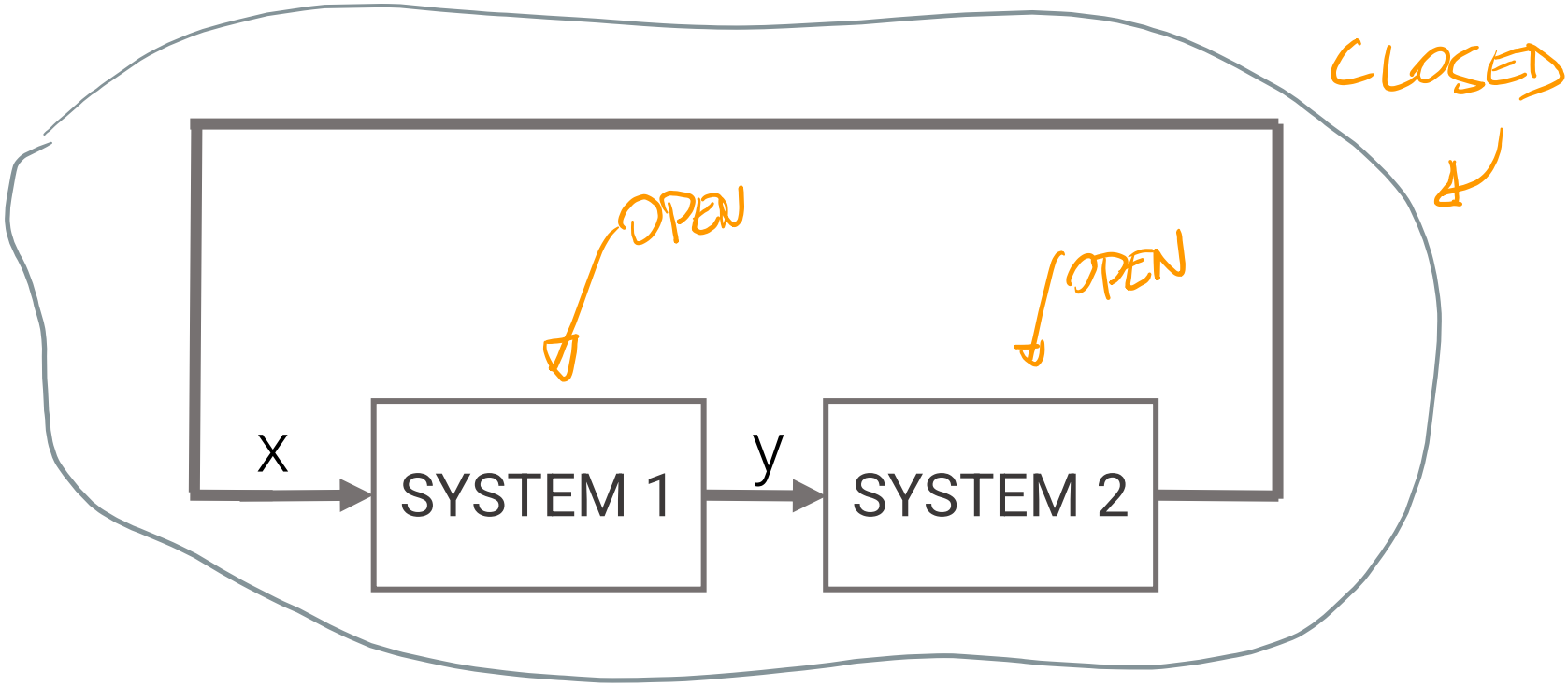
How many **kinds** of requirements are there?

How do you **model** a requirement?

What are the **problem** and the **solution** spaces?

Are **cost** and **schedule** requirements or constraints?

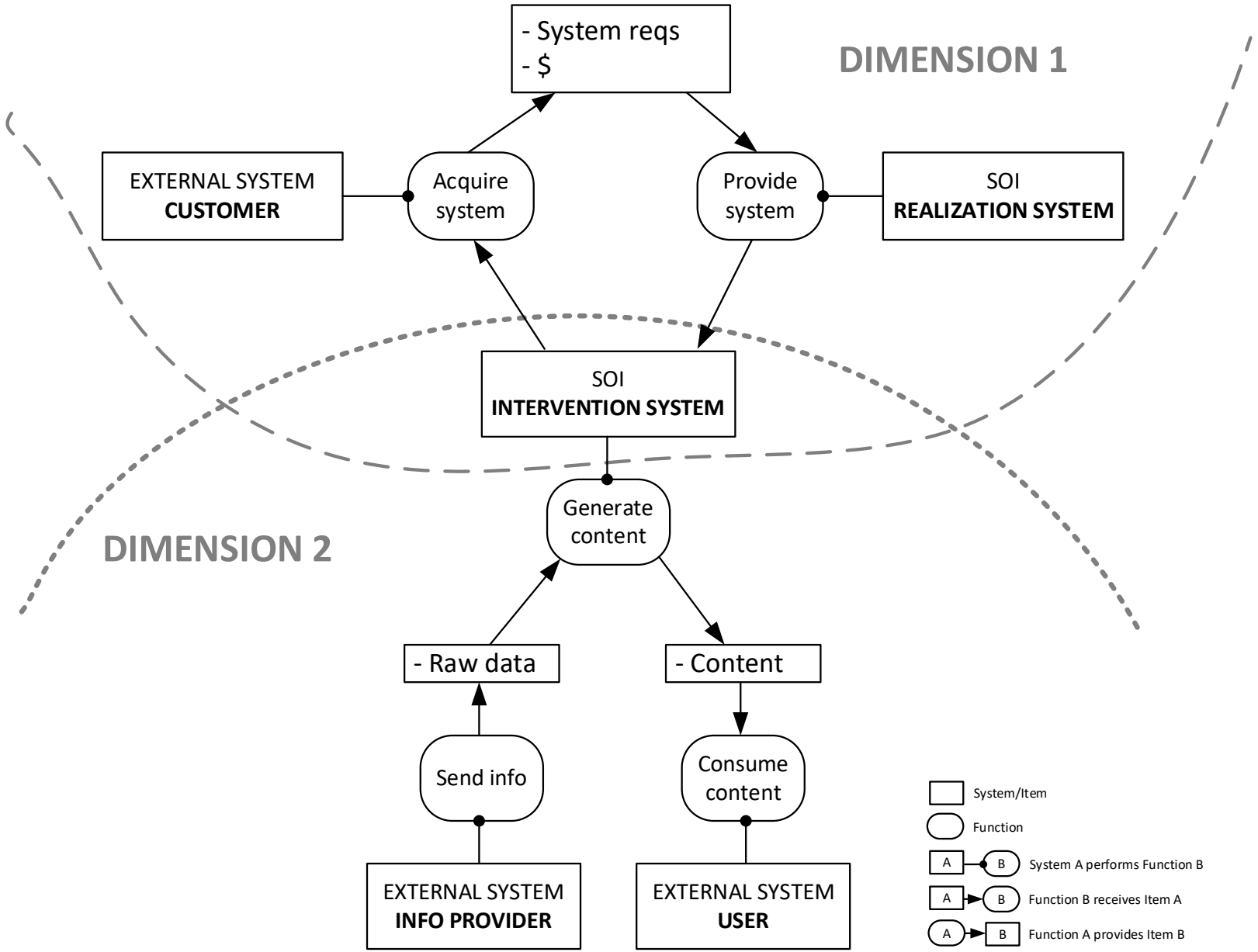
Are requirements and **SOW** the same?

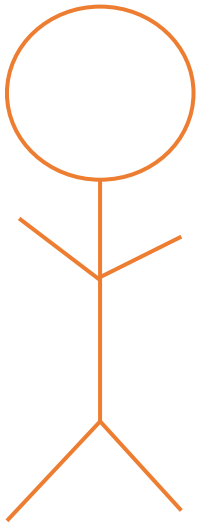


FUNCTION → CAPABILITY → ENGAGEMENT → OUTCOME

OPEN SYSTEM	Function, outputs
CLOSED SYSTEM	State, outcomes

VALUABLE FOR SOMEONE





STAKEHOLDERS

SYSTEM

Stakeholder **needs**

What the stakeholder needs to achieve with the system

ELICITATION

System **requirements**

What the system has to do

DERIVATION

System **attributes**

What the system does

DESIGN

CONTEXT DEPENDENT

STAKEHOLDER NEED

What is **needed** the system **for**

The system needs **interaction** with **external** systems to satisfy the need

Can only be checked when the system is **put into context**

CONTEXT INDEPENDENT

SYSTEM REQUIREMENT

What the system **has to do**

The system can fulfil it by **its own**

Can be checked in **“any” context**

SYSTEM DEPENDENT

SYSTEM ATTRIBUTE

What the system **does**

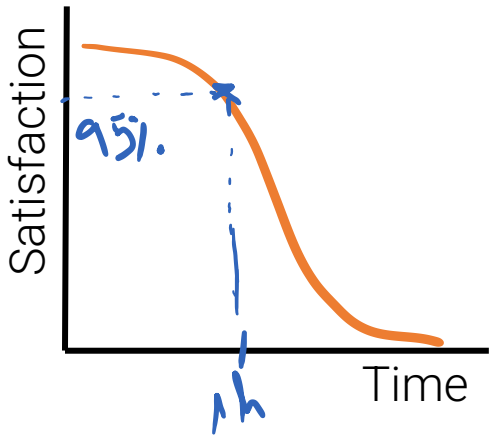
It is an **inherent** characteristic of the system

The **user needs** to go from A to B in less than 1 h

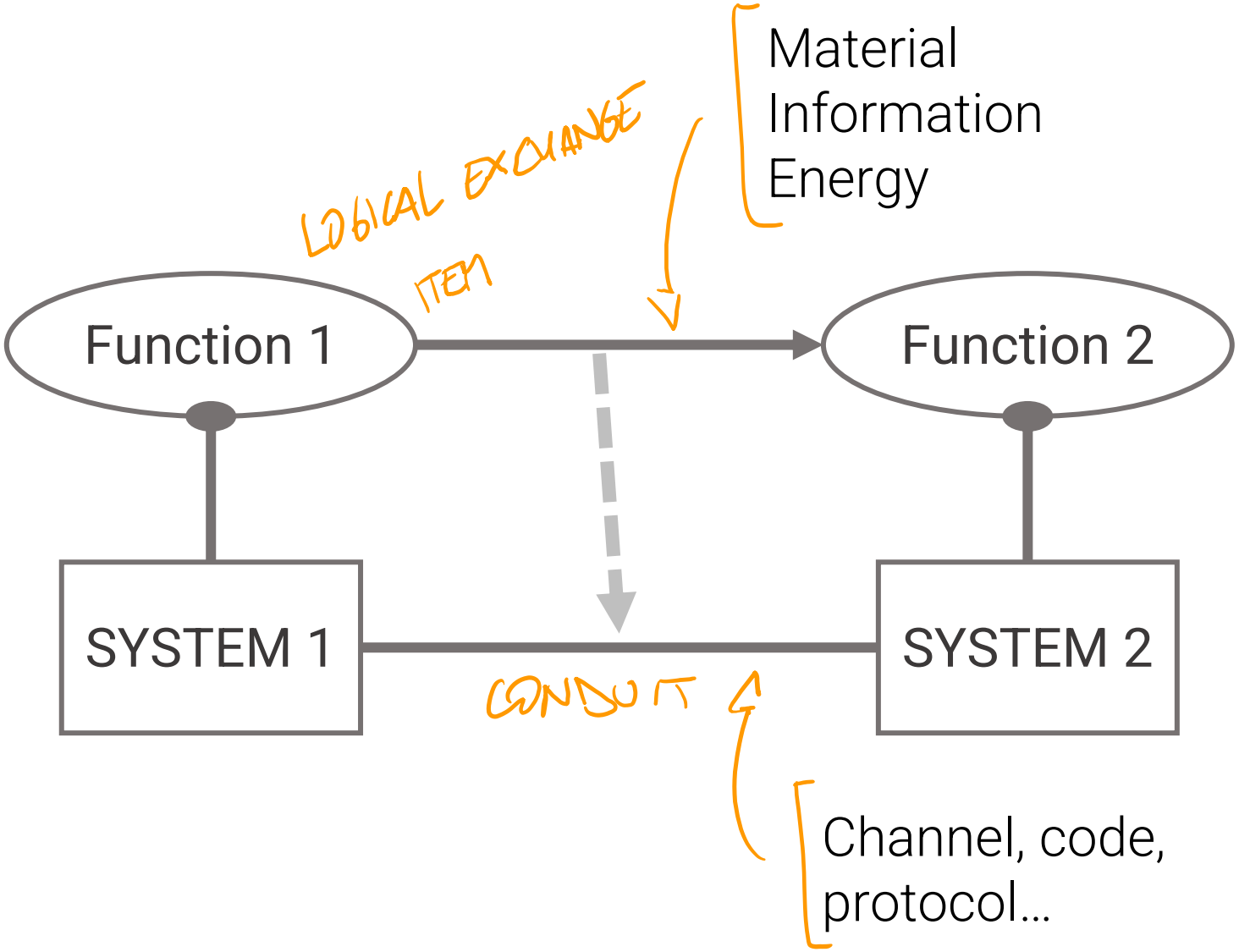
The system shall **bring the user** from A to B in less than 1 h

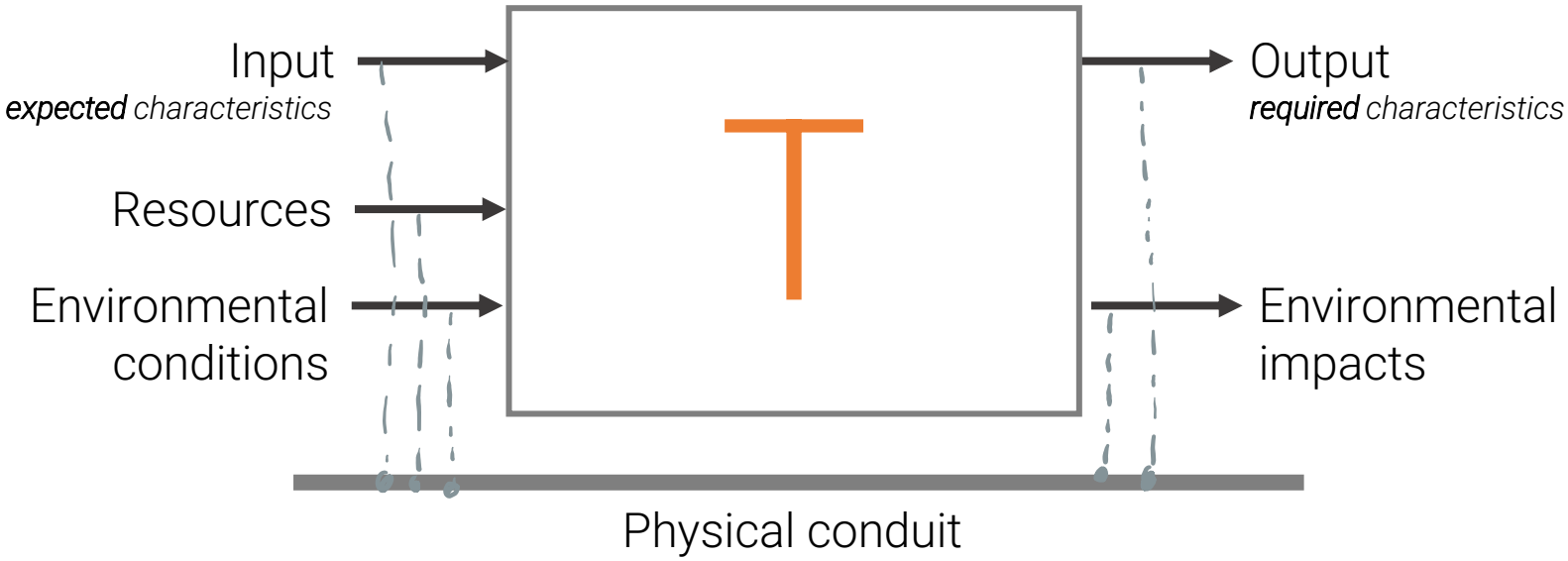
The user needs the system to be ~~**user-friendly**~~.
Instead: An average user needs to operate the system with less than 2 mistakes per session.

Note: An average user is defined as a person aged TBD…
Note: A session is defined as…



$$t(B) - t(A) < 1h$$





WHAT **Functional** transformation

HOW WELL **Performance** of the transformation

WITH WHAT **Resources** employed

WHERE **Environment** where transformation occurs

The SYSTEM shall accept/provide ***item***
given ***conditions*** through **interface**.

No other system (external or internal) in the statement

Measurable (quantitative or logical statement)

Dictionary and notes

Granularity and references

Justification & traceability

Easy / Graphics and other supports

mass, volume...?

YOUR CHALLENGE OR **MY** EXAMPLE?

St1. The user needs the system to protect valuable item from robbery. NEED

Sol 1. Deter the robber.
Sol 2. Deceive the robber.
Sol 3. Resist the robbery.

St1.1. The system shall deter X% of robbers attempting to steal valuable item for Y years. NEED

Sol 1. Make robbery attempt very dangerous for robber.
Sol 2. Male robbery attempt very difficult for robber.
Sol 3. Detect robber and make robber aware of detection.
Sol 4. Detect robber and make robber and owner aware of detection.
Sol 5. Detect robber and make robber and law enforcement aware of detection.

St1.1.1. The system shall detect L% of robbers attempting to steal valuable item for Y years. NEED
St1.1.2. The system shall make Z% of detected robbers aware they have been detected. NEED

Sol 1. Artificial illumination and observation in the visual range.
Sol 2. Observation in the infrared range.
Sol 3. Observe movement.

Sol a. Sound a loud alarm.
Sol b. Emit a dance of lights.
Sol c. Eject ammunition.

St1.1.1.1. The system shall observe Target 1 (def. by image properties). REQUIREMENT
St1.1.2.1. The system shall emit Sound 1. REQUIREMENT

STAKEHOLDER **NEED**	SYSTEM **REQUIREMENT**
Characteristic of an interaction of an external system	Characteristic of a system I/O
Related to stakeholder preferences	External systems have been abstracted
Address the consequence of operating the system	Address what the behavior of the system
Resulting solution space includes different operational solutions	Resulting solution space excludes operational solutions

WHAT'S **NEXT**?

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REGULAR PAPER

WILEY

A systems-theoretic articulation of stakeholder needs and system requirements

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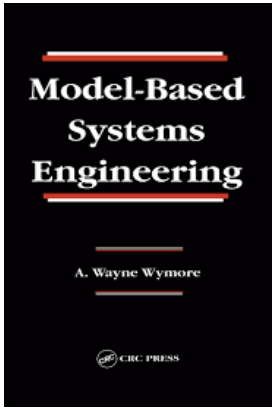
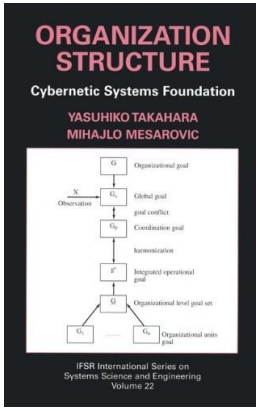
Abstract

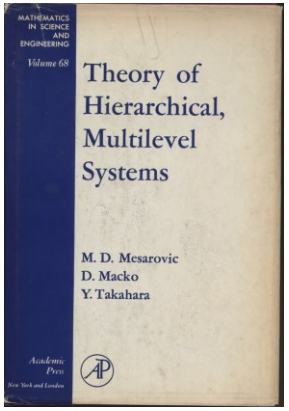
The literature shows disparities in how fundamental systems engineering concepts in the area of requirements engineering, such as stakeholder needs, system requirements, requirements elicitation, requirements derivation, and requirements decomposition, are used within the communities-of-practice and in research. Such disparities can lead to conceptual and application inconsistencies, which have been shown to contribute to the formulation of poor requirements. In this paper, such concepts are articulated using systems theory as the underlying theoretical framework. The concepts of problem space, solution space, open system, and closed system are central to this work. It is argued that the proposed articulations facilitate avoiding usage disparity, ultimately resulting in better formulation of requirements. These articulations are supported by in-depth examples that comprehensively cover different types of needs and requirements, and provide step-by-step insights into how elicitation, derivation, and decomposition occur within a problem formulation effort.

KEYWORDS
requirements engineering, scientific foundations of systems engineering, theory of systems engineering

What are **WE** doing?



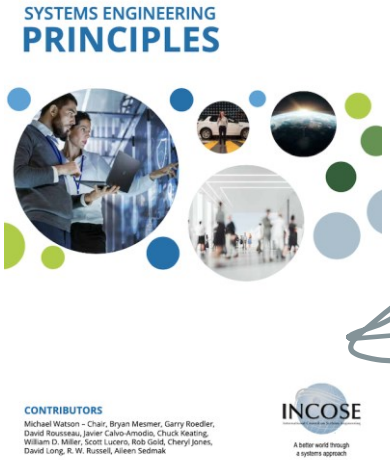




What **BARRIERS** do we have?

Anyone there?

$$



What can **YOU** do?

Be **CRITICAL** with what you read!

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THANK YOU

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