NASA'S PI LAUNCHPAD

ANN ARBOR, MI

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Prelude to the STM

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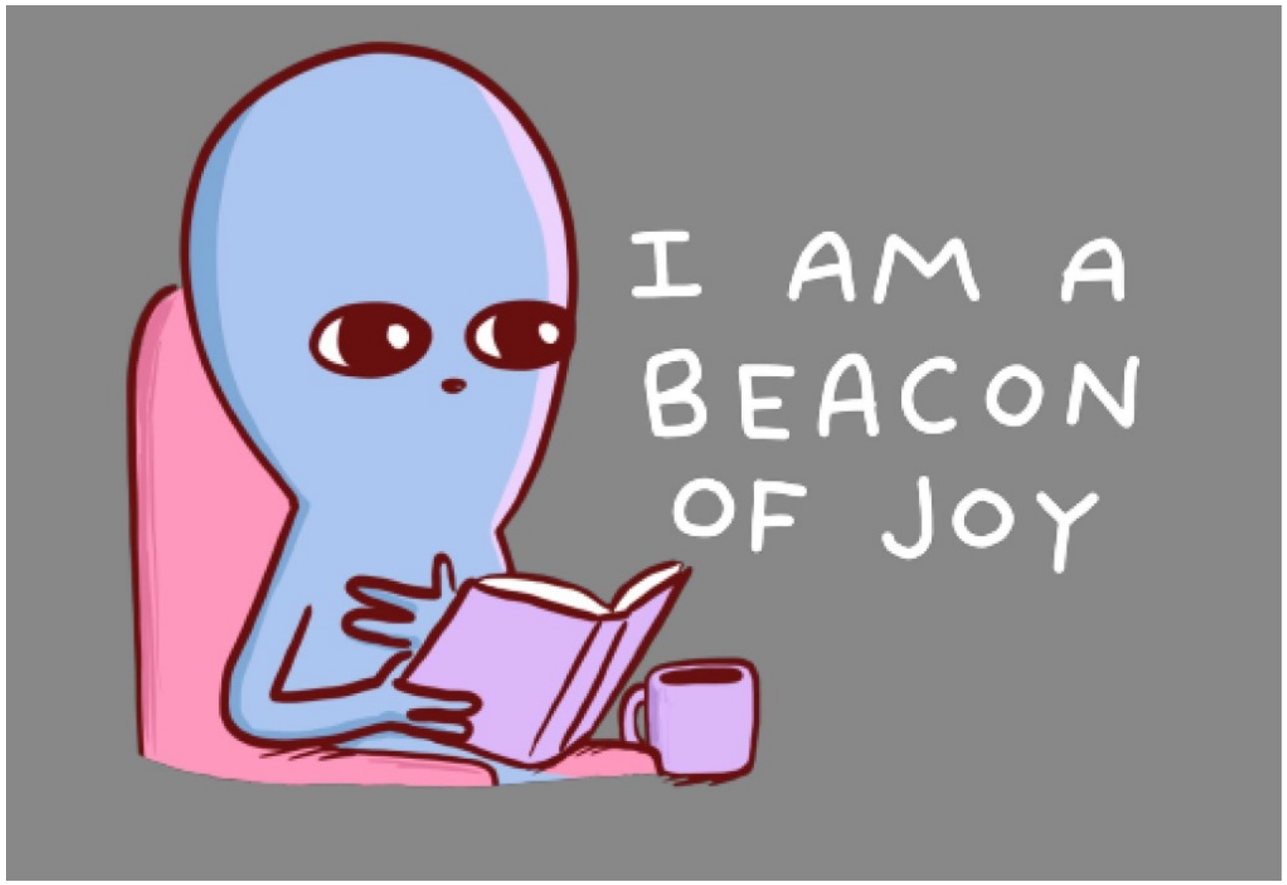
About me



Goals → Objectives → Requirements

STM

In the hours ahead…

Foundations…
science case development

Why?...

…this mission?

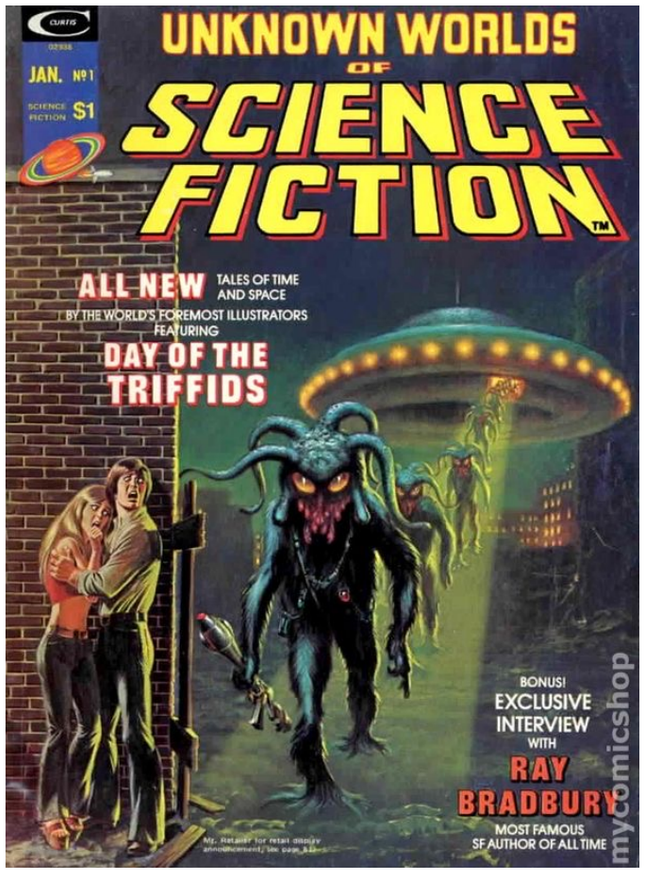
…this science?

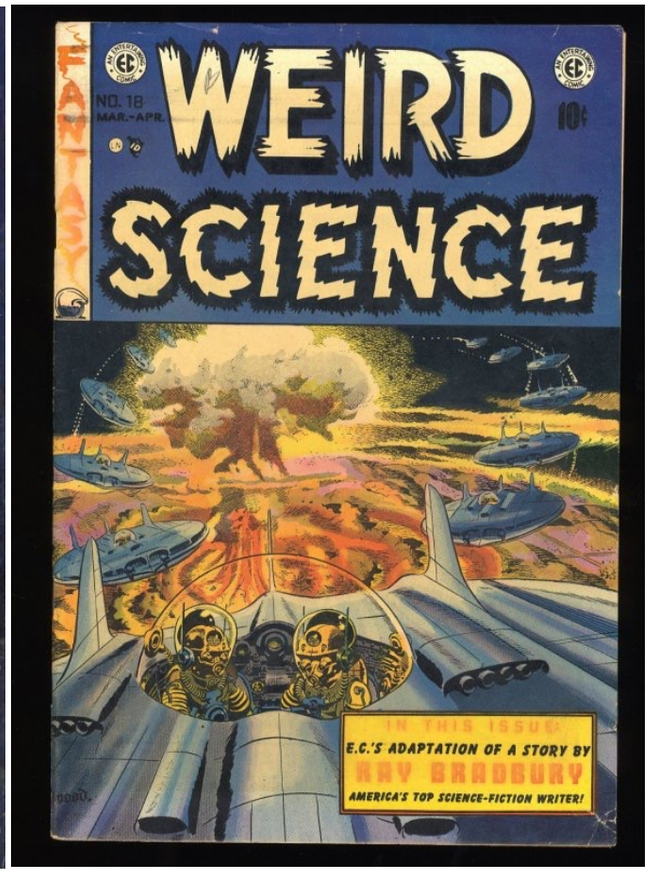
…this planetary body?

…this series of measurements?

…now?

Communicating the science case…
storytelling





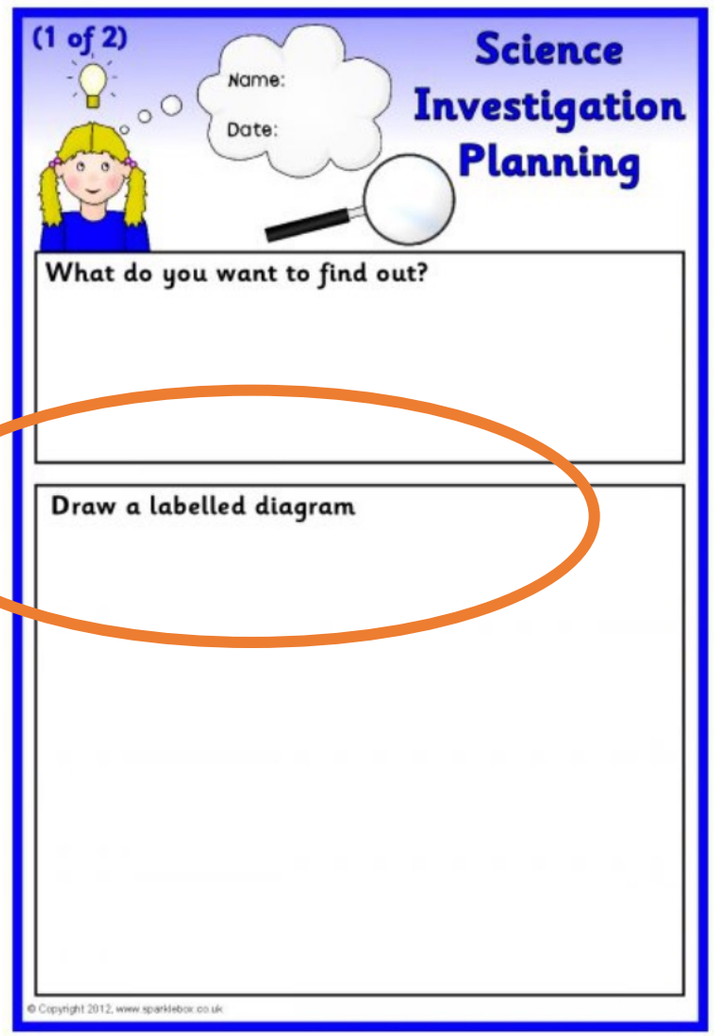
Day 1: Goals and Objectives

In the days ahead…

The language and mechanics of requirements

Organizing

Science Traceability Matrix



Day 2: Requirements → STM

Goals → Objectives → Requirements

STM

In the days ahead…

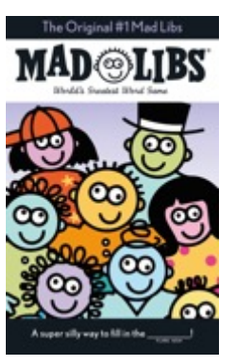
The language and mechanics of requirements

Benevolent introduction to requirements:

- Language & structure
- Levels and use
- Connection to the STM

Requirements

Requirement: The *agreed-upon* **need, desire, want, capability, capacity, function or demand** for **instruments, personnel, equipment, facilities, or other resources or services** by specified quantities for specific periods of time or at a specified time **expressed as a "shall" statement**.

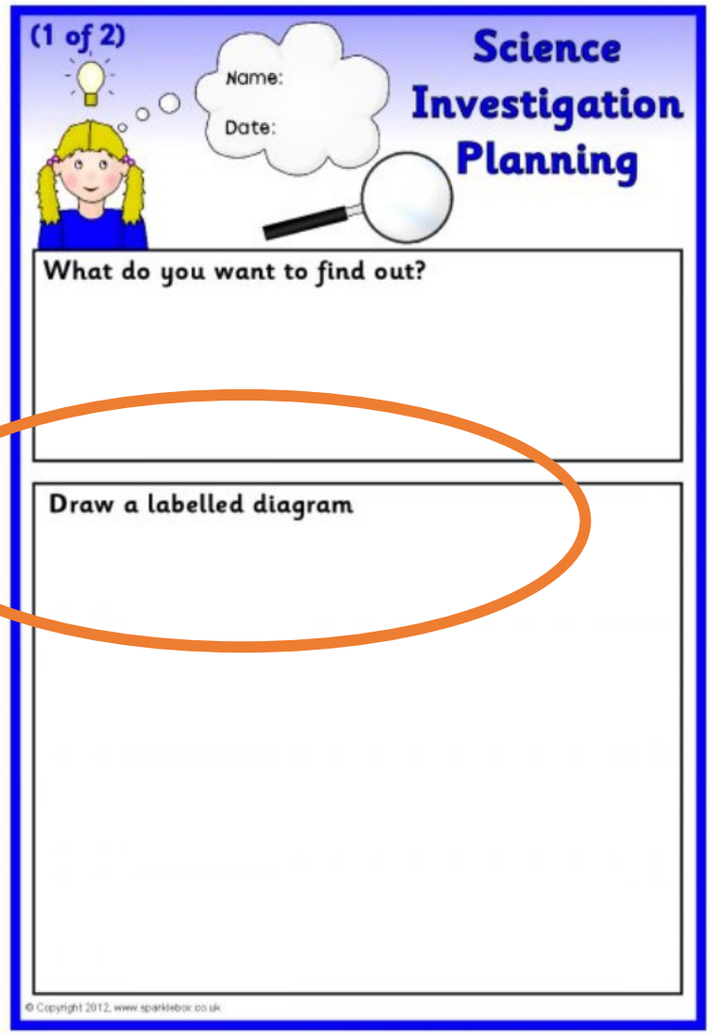


General Language:

The [*noun*] **shall** [*quantitative verb*] [*aspect of the physical system*] [*preposition*] [*verification parameter(s)*].

In the days ahead…

Organizing
Science Traceability Matrix



- Does the science address NASA goals?
- Does the investigation address the science?
- Does the instrument/mission implement the investigation robustly?

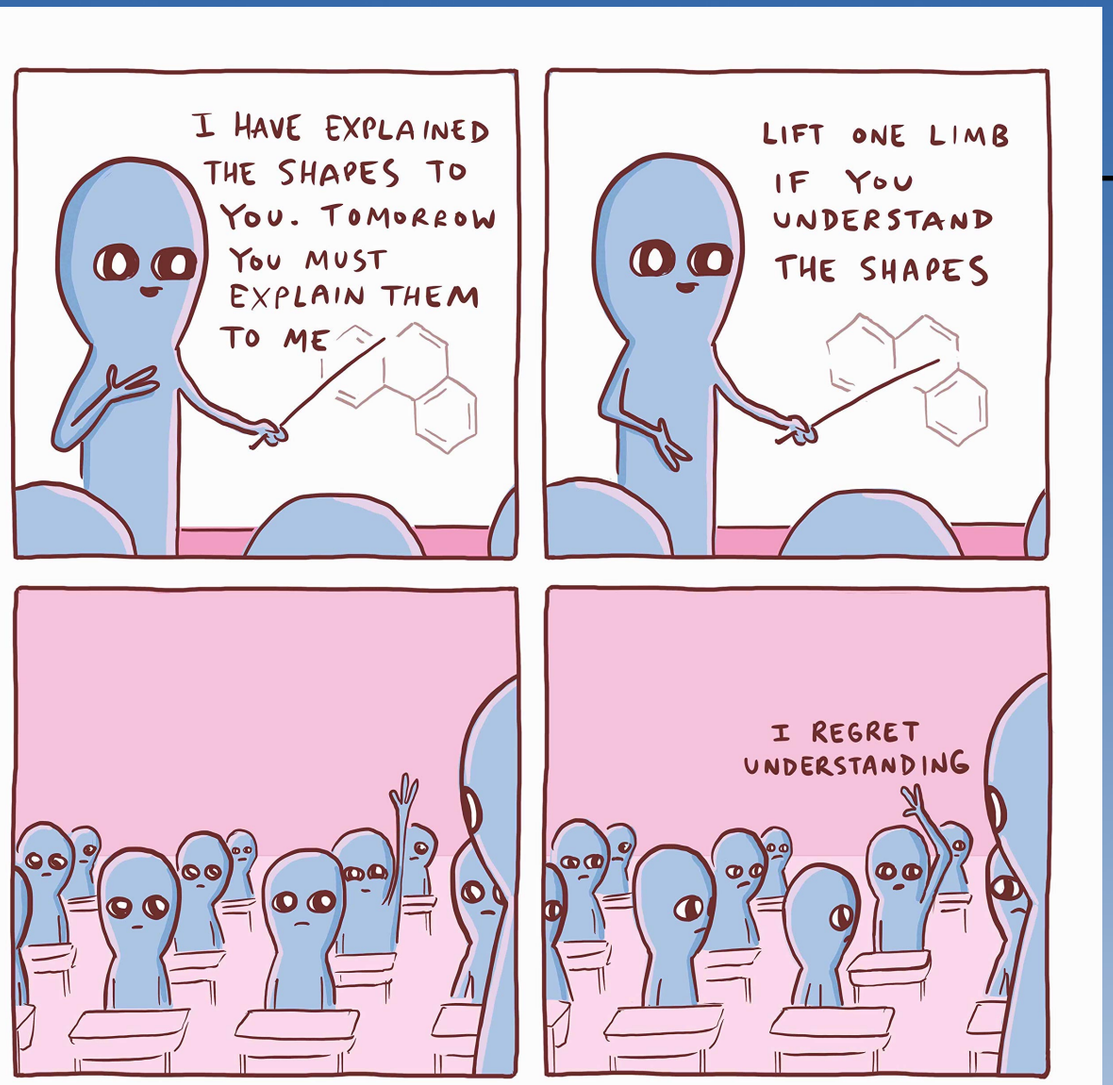
Science Traceability Matrix is a tool to:

- Track the overall mission requirements
- Provide engineers with fundamental requirements needed to design the mission
- Show effects of any descoping or losses of elements to the overall science

ChatGPT3's answer wasn't too shabby:
"Building a science traceability matrix is an important aspect of scientific research and experimentation. A traceability matrix helps establish clear links between requirements, specifications, test cases, and other project elements, ensuring that each requirement is properly verified and validated. "

Goals → Objectives → Requirements

STM



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Backup Slides

Science Question → Science Goals & Objectives

Why?...

…this mission? …now?

…this science?

…this planetary body?

…this series of measurements?

STM

1. Science Goals	2. Science Objectives (SO #.#)	Scientific Measurement Requirements		Instrument Requirements			8. Top-Level Mission Functional Req's
		3. Physical Parameters	4. Observables	5. Category	6. Threshold Mission	7. Baseline Mission Requirement	

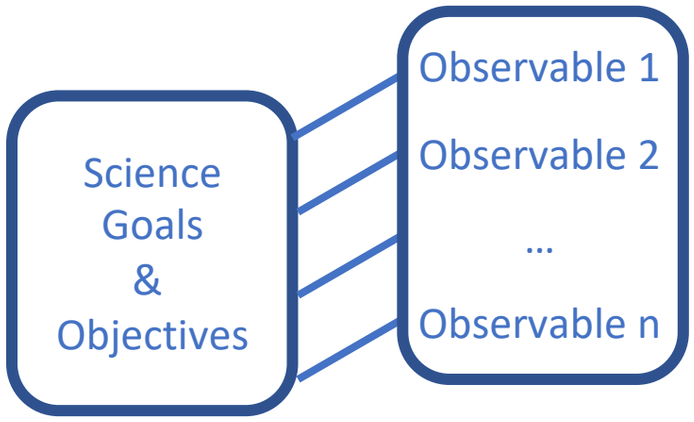
Science Goals & Objectives

COLUMN 1: Science goals are:

- Broad
- Identified by NASA as "high value"
- Established by relevant priorities from NASA and National Academies documents

COLUMN 2: Science Objectives are:

- Specific
- Capable of being validated



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Scientific Measurement Requirements

COLUMN 3: Physical Parameter
Real-world property of the target under investigation

COLUMN 4: Observables
- Measured observables to determine/infer physical parameters of the body under investigation
- Quantify how well those parameters need to be determined to meet your science objectives.

Instrument Requirements:
Functional requirements for each instrument

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		3. Physical Parameters	4. Observables	5. Category	6. Threshold Mission	7. Baseline Mission Requirement	
		You can't always get what you want, but if you try sometimes, you just might find, you get what you need...				I want it all, I want it all, I want it all...	

Science Goals & Objectives

Observable 1	—	Variable 1A , 1B, 1C, …
Observable 2	—	Variable 2A , 2B, 2C, …
…	—	…
Observable n	—	Variable nA , nB, nC, …

Variables measured on

Instrument 1 … Instrument n

Photo - https://www.loc.gov/exhibits/british/brit-7.html

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Science Goals & Objectives

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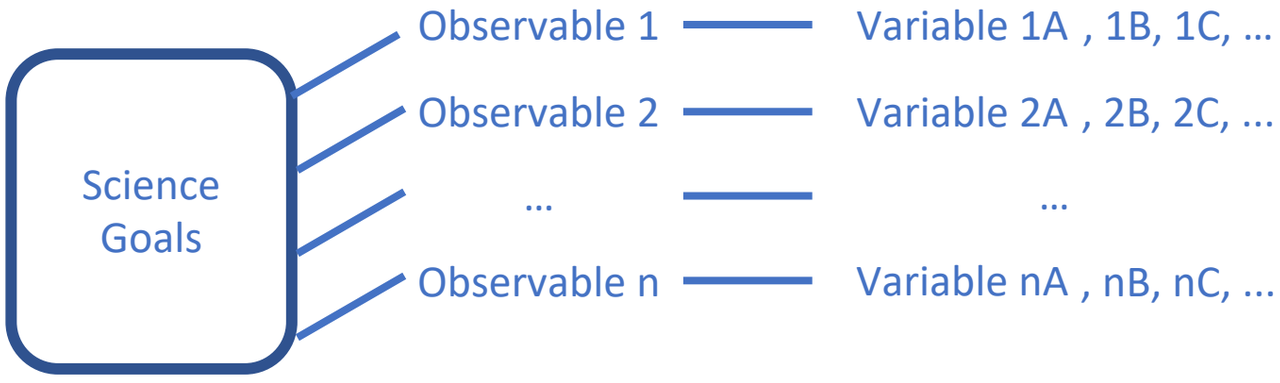
Variables measured on

Instrument 1 … Instrument n

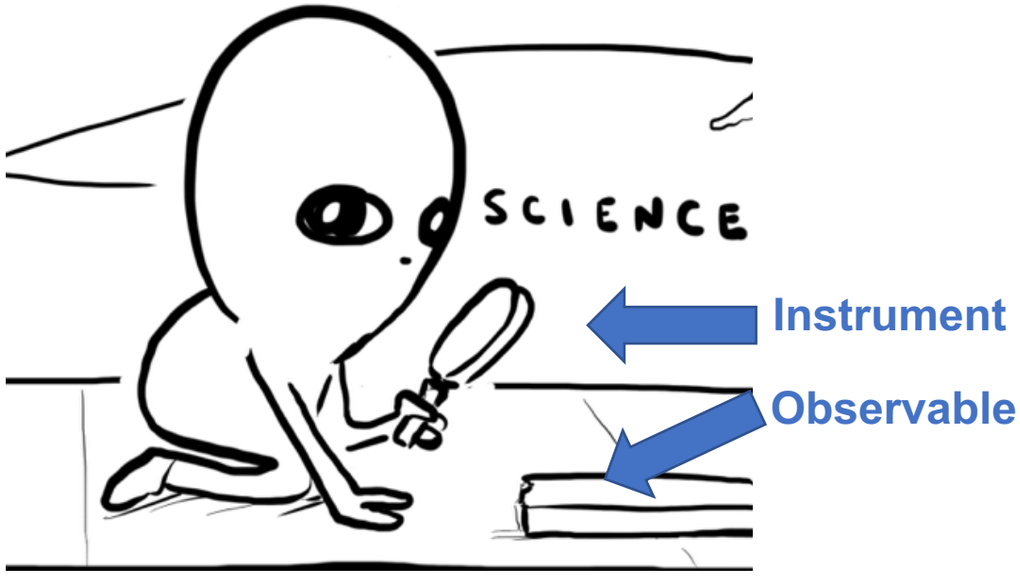


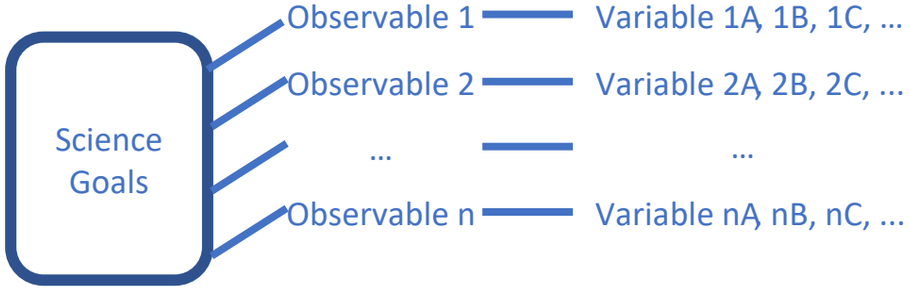
Variables measured on

Technology Development & Technology Readiness Levels (TRL)

Data Sufficiency

Risk





Variables measured on

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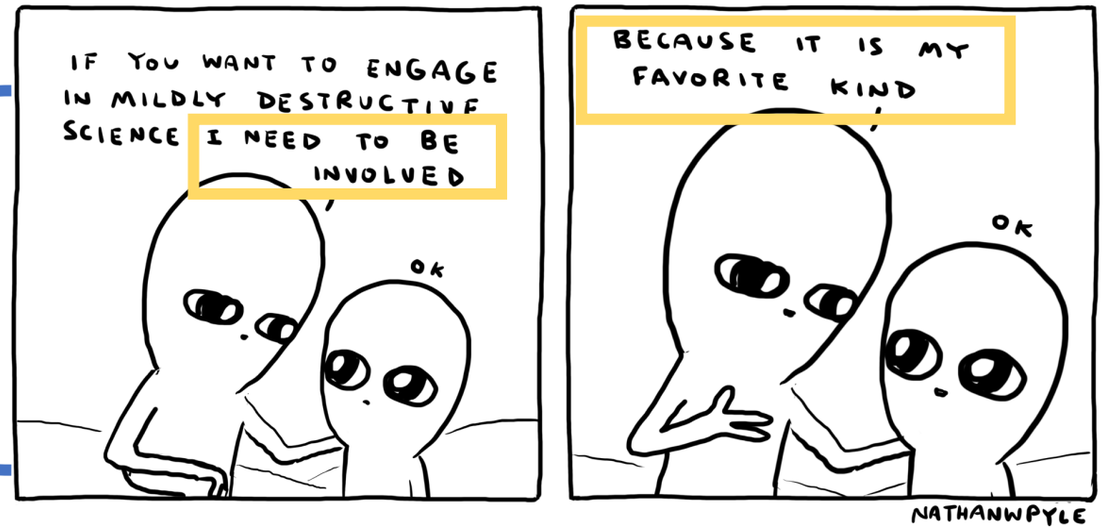
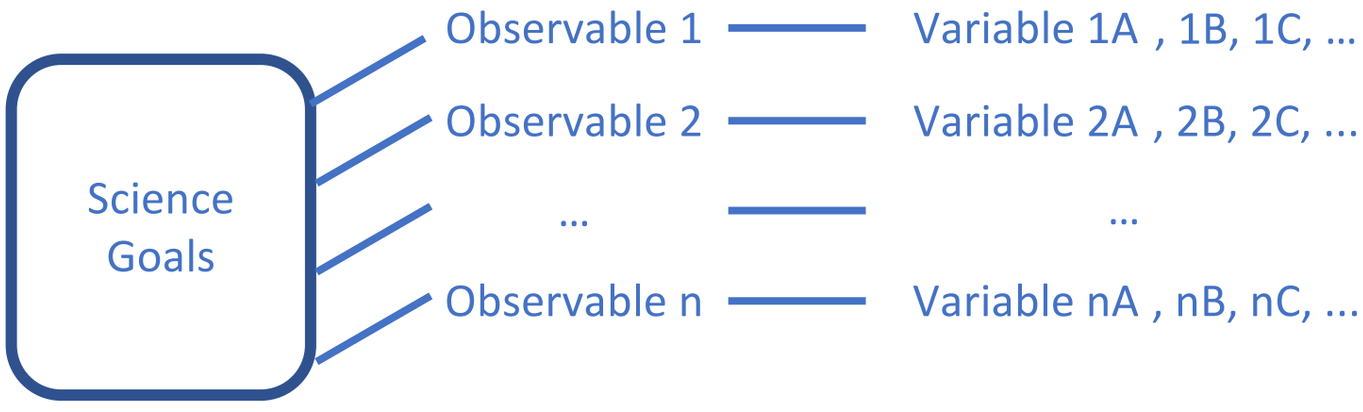
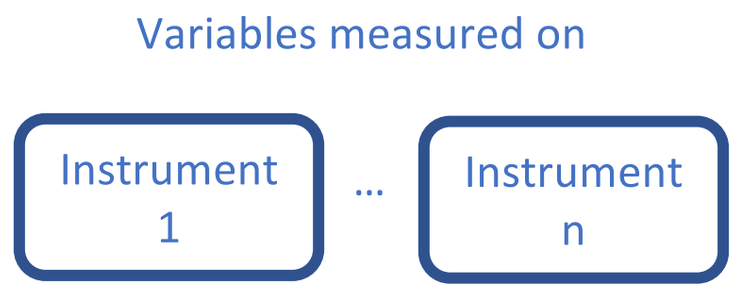
Technology Development & Technology Readiness Levels (TRL)

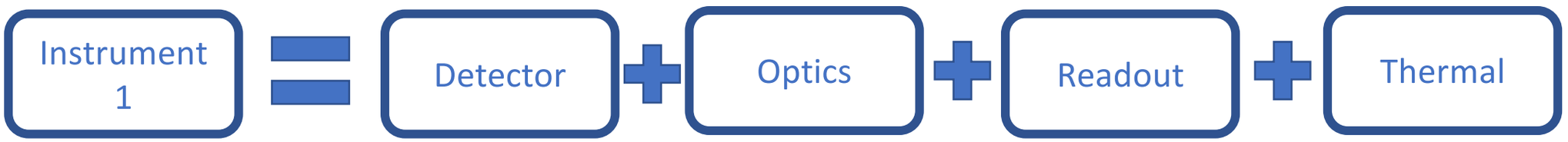


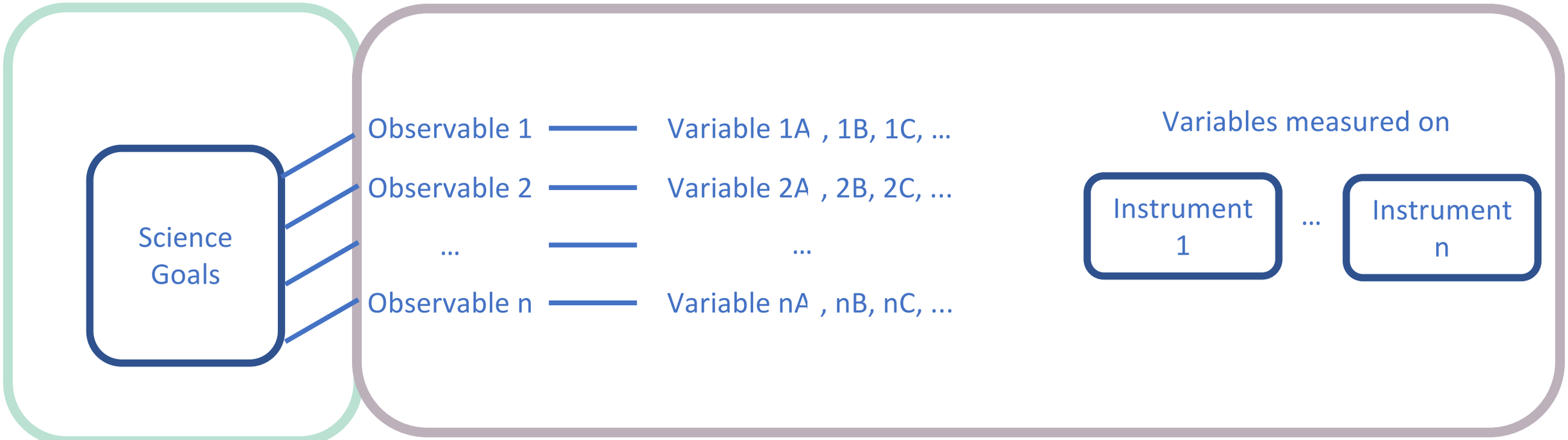
Team Building

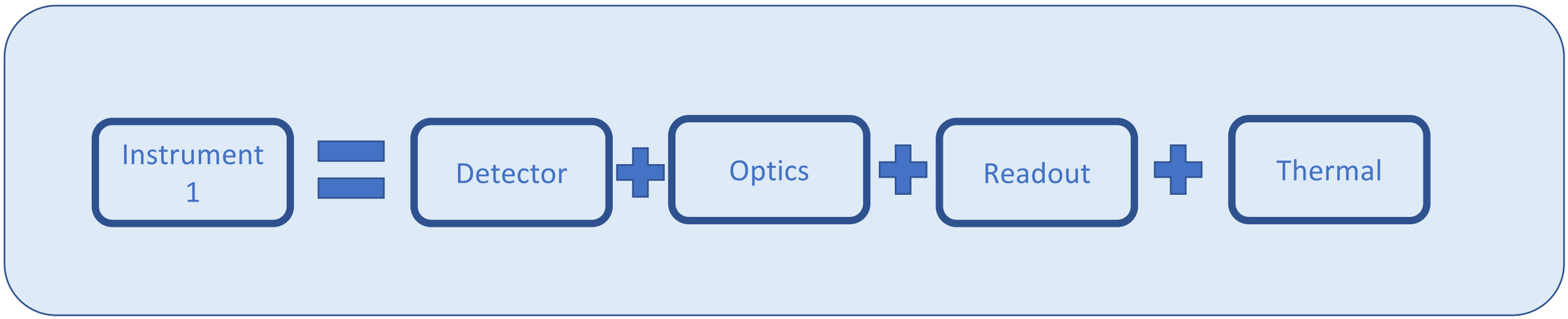




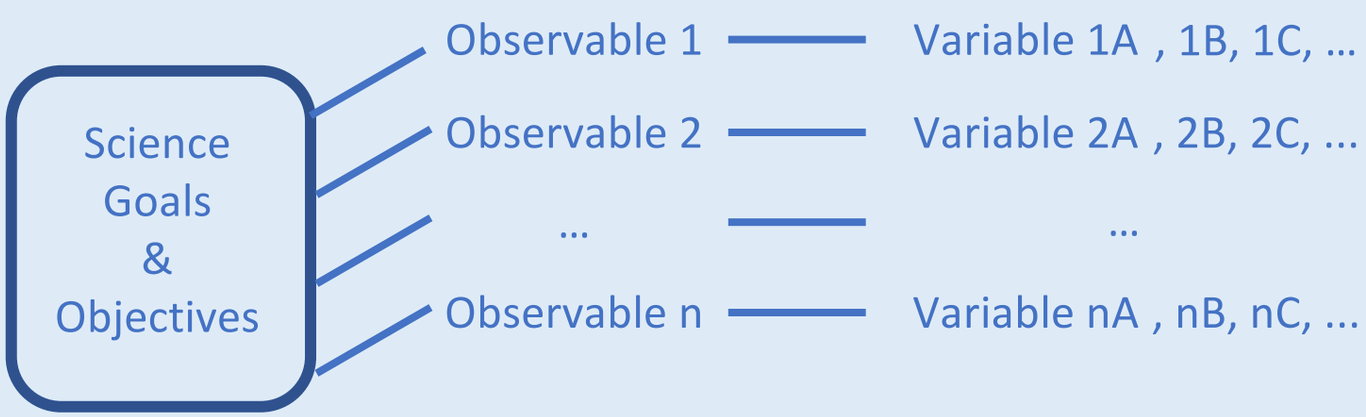
Functional/Engineering Requirements:



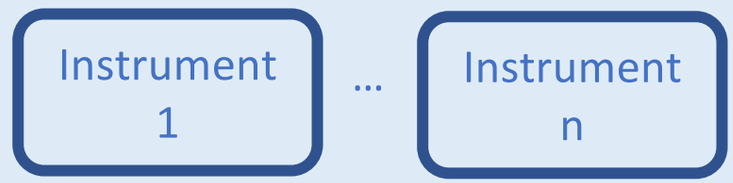

Science Goals
Observable 1
Variable 1A , 1B, 1C, …
Observable 2
Variable 2A , 2B, 2C, …
…
…
Observable n
Variable nA , nB, nC, …
Variables measured on
Instrument 1
…
Instrument n


Instrument 1
Detector
Optics
Readout
Thermal

Science



Payload



Instrument

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Technology Development & Technology Readiness Levels

Risk

Data Sufficiency

Team Building

WBS

Goals

Objectives

Architecture

Science Question

Storytelling

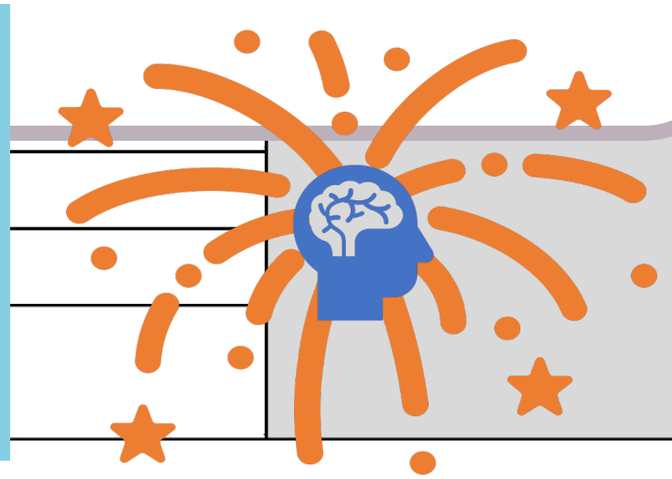
Requirements

Science Goals & Objectives

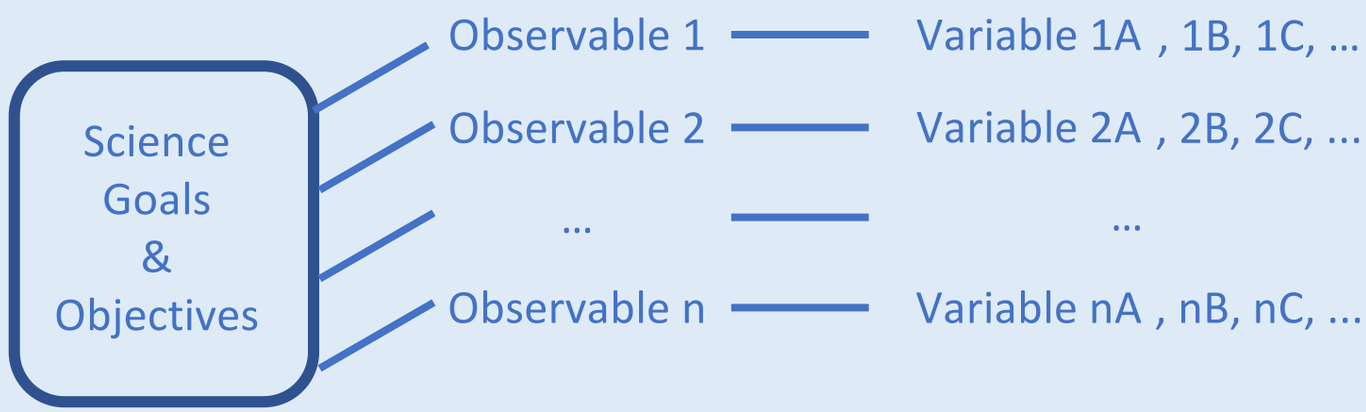
Observable 1	Variable 1A , 1B, 1C, …
Observable 2	Variable 2A , 2B, 2C, …
…	…
Observable n	Variable nA , nB, nC, …

Variables measured on

Instrument 1 … Instrument n



Science Work Breakdown Structure (WBS)

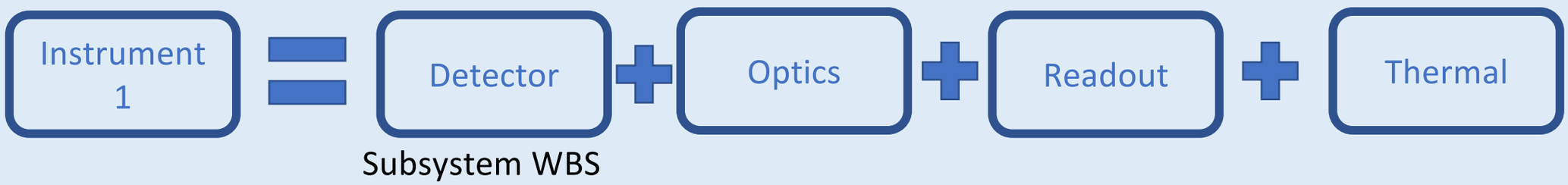


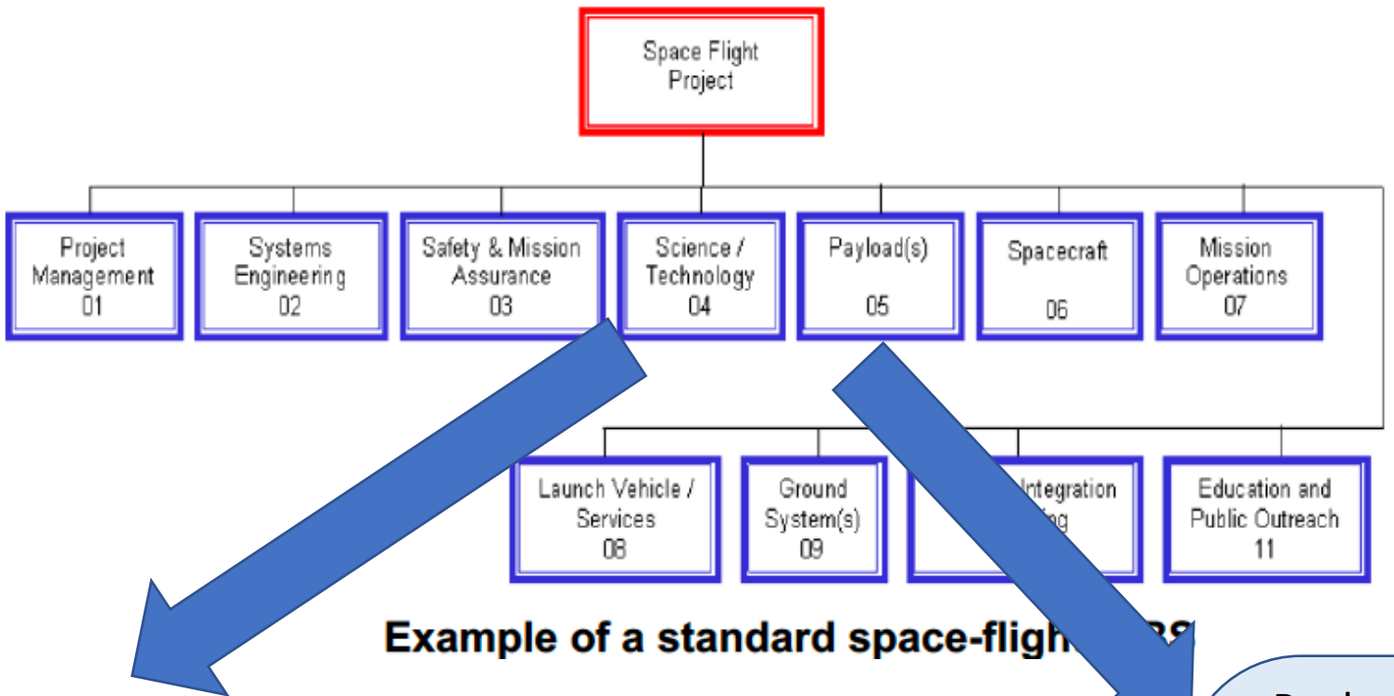
Payload WBS

Variables measured on

Instrument 1 … Instrument n

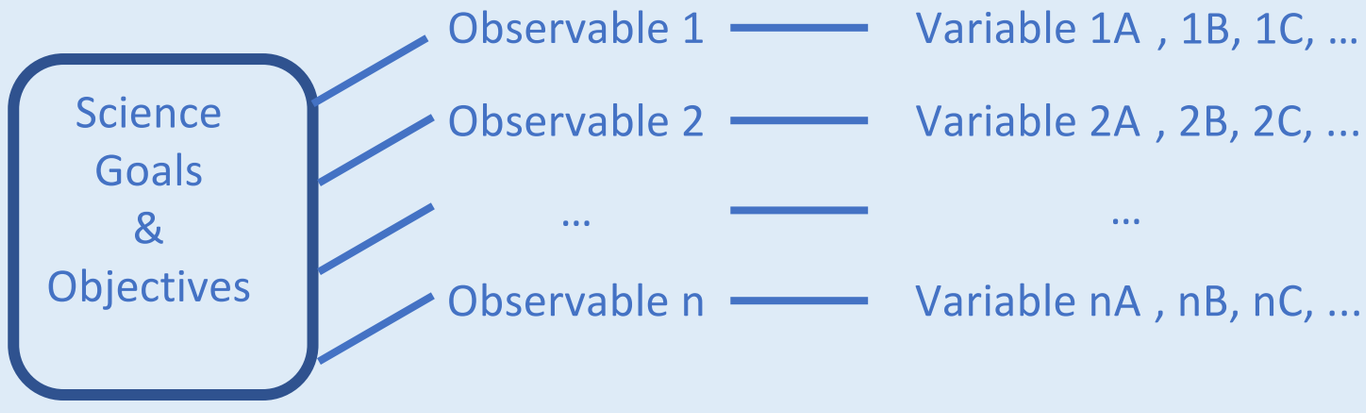
Instrument WBS





Example of a standard space-flight

Science Work Breakdown Structure (WBS)



Payload WBS

Variables measured on