



**Jet Propulsion Laboratory**  
California Institute of Technology

# PI LAUNCHPAD

## VIRTUAL SUMMIT

JUNE 14-25 2021

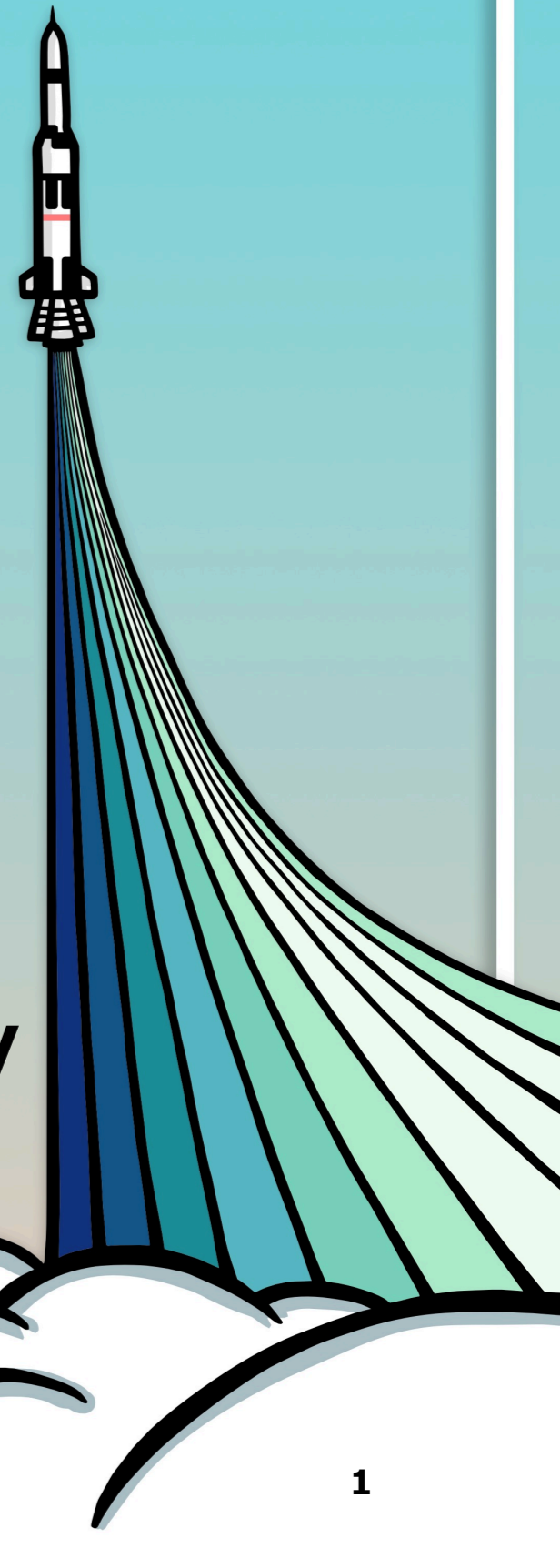
### Developing Your Science Story

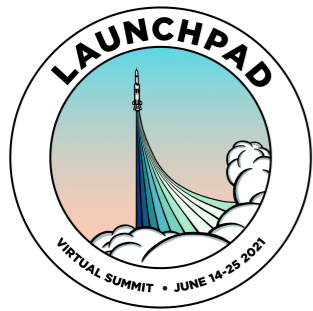
CL#21-2323

Randii R. Wessen (JPL)

Advanced Design Engineering Group

Project Systems Engineering & Formulation Section





# Agenda

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- NASA is Looking for Compelling Science
- Concept Maturity Levels
- Baseline and Threshold Science Missions
- Science Return Diagram
- Final Thoughts

## Developing Your Science Story

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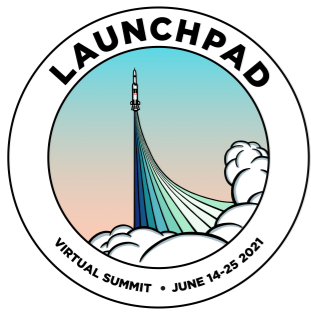
# NASA is Looking for Compelling Science

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# Science Must be Compelling

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T. Zurbuchen's "Writing Successful Proposals: Observations from NASA"

- **Science Story**
  - "Make science beautiful – want to tell a compelling story about discovery and exploration"
  - "Make all decisions flow from overarching science questions to ensure no decisions prevent answering those questions (start with that, then modify)"
  - "If the importance of science is not clear or not communicated sufficiently, it can derail your success!"
- **How much science is enough?**
  - "Incremental science is not enough"
- **How much risk is too much?**
  - NASA ... "is comfortable with taking technical risks if necessary to achieve great science, but are willing to cancel missions and payloads to manage risk"

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# Concept Maturity Levels

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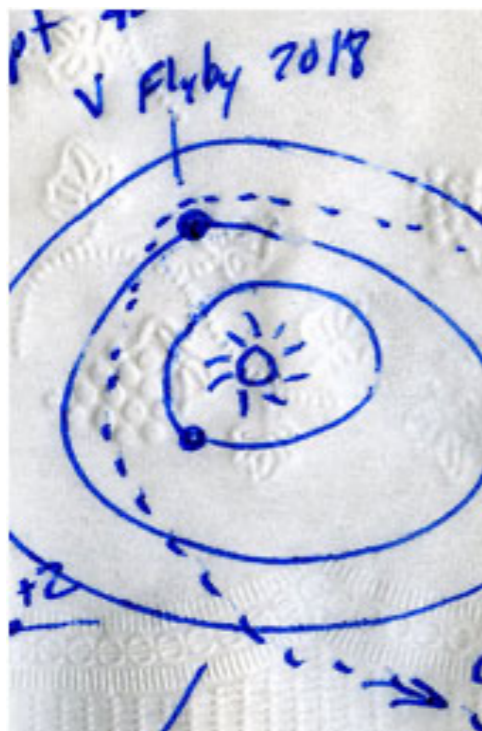
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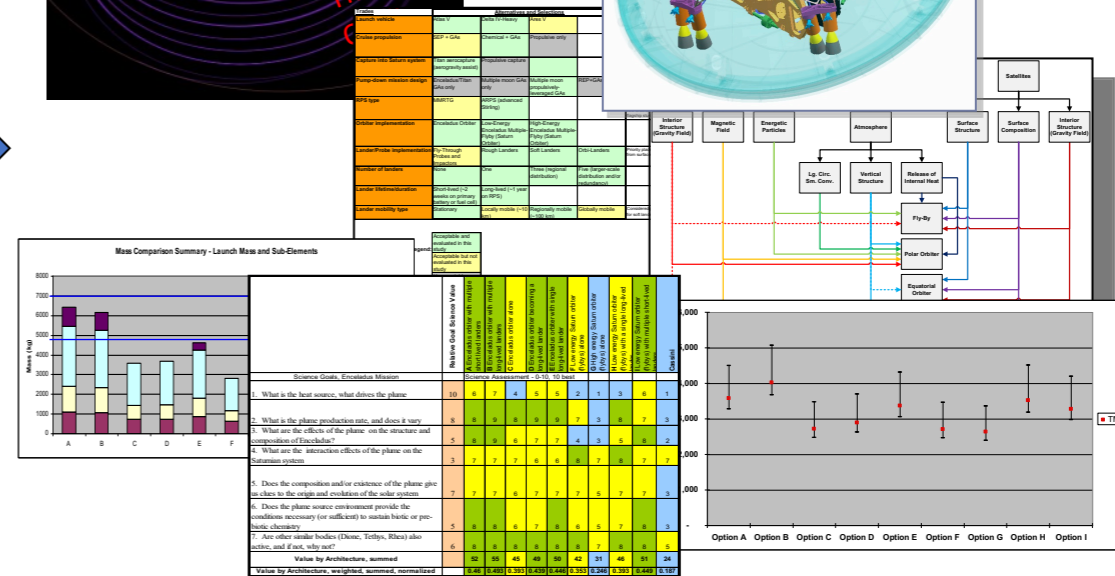
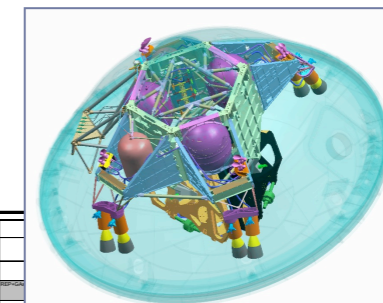
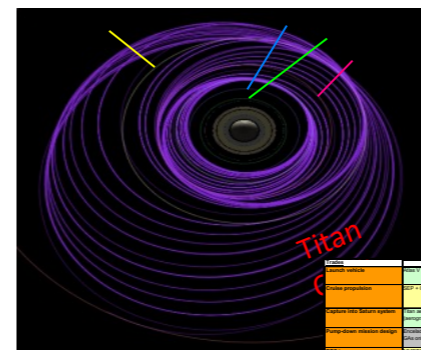


# Absent: A Common Language for Concepts

How mature is your concept?



← This or that? →



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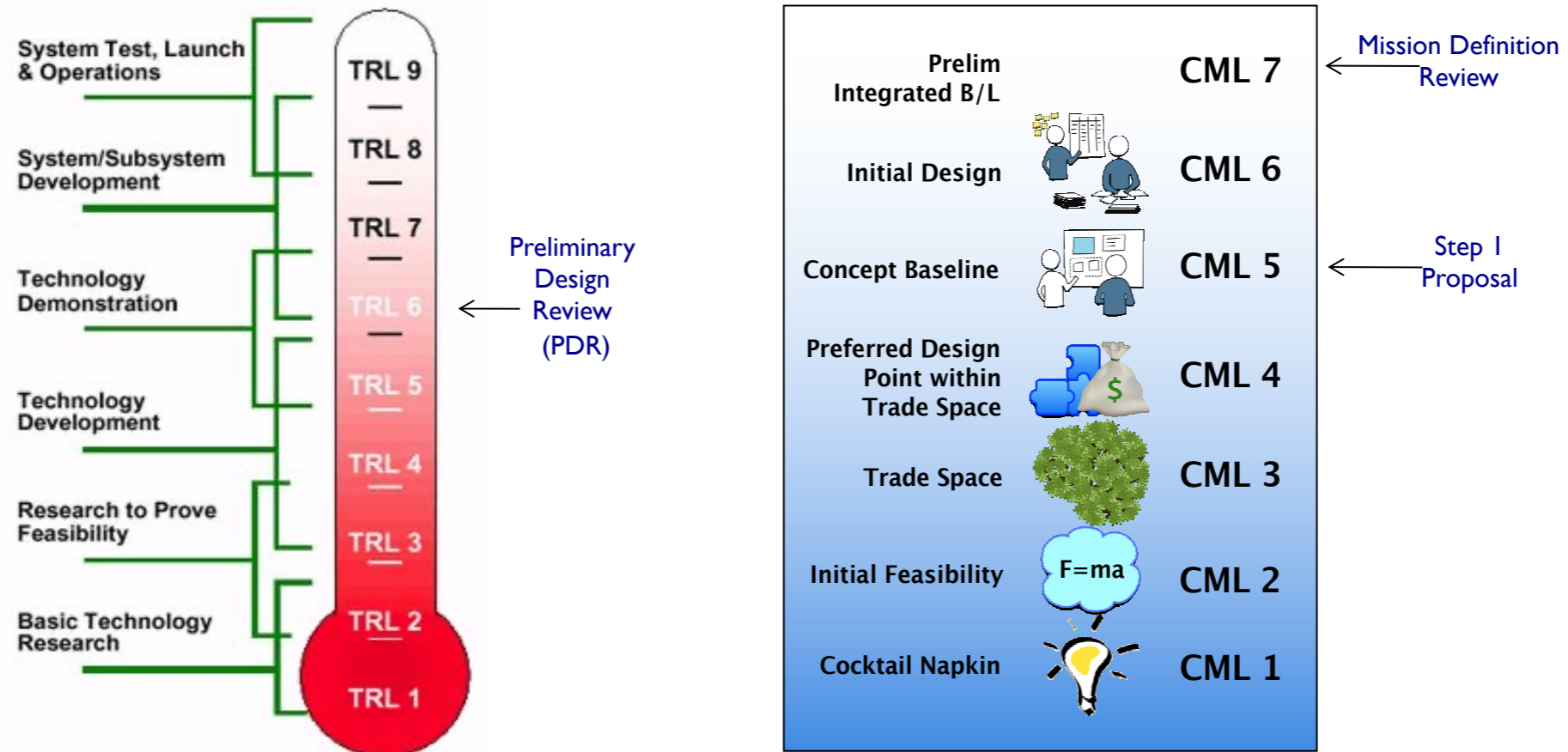
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# Concept Maturity Levels (CMLs)

## A Vocabulary Based on TRLs



TRL = Technology Readiness Levels

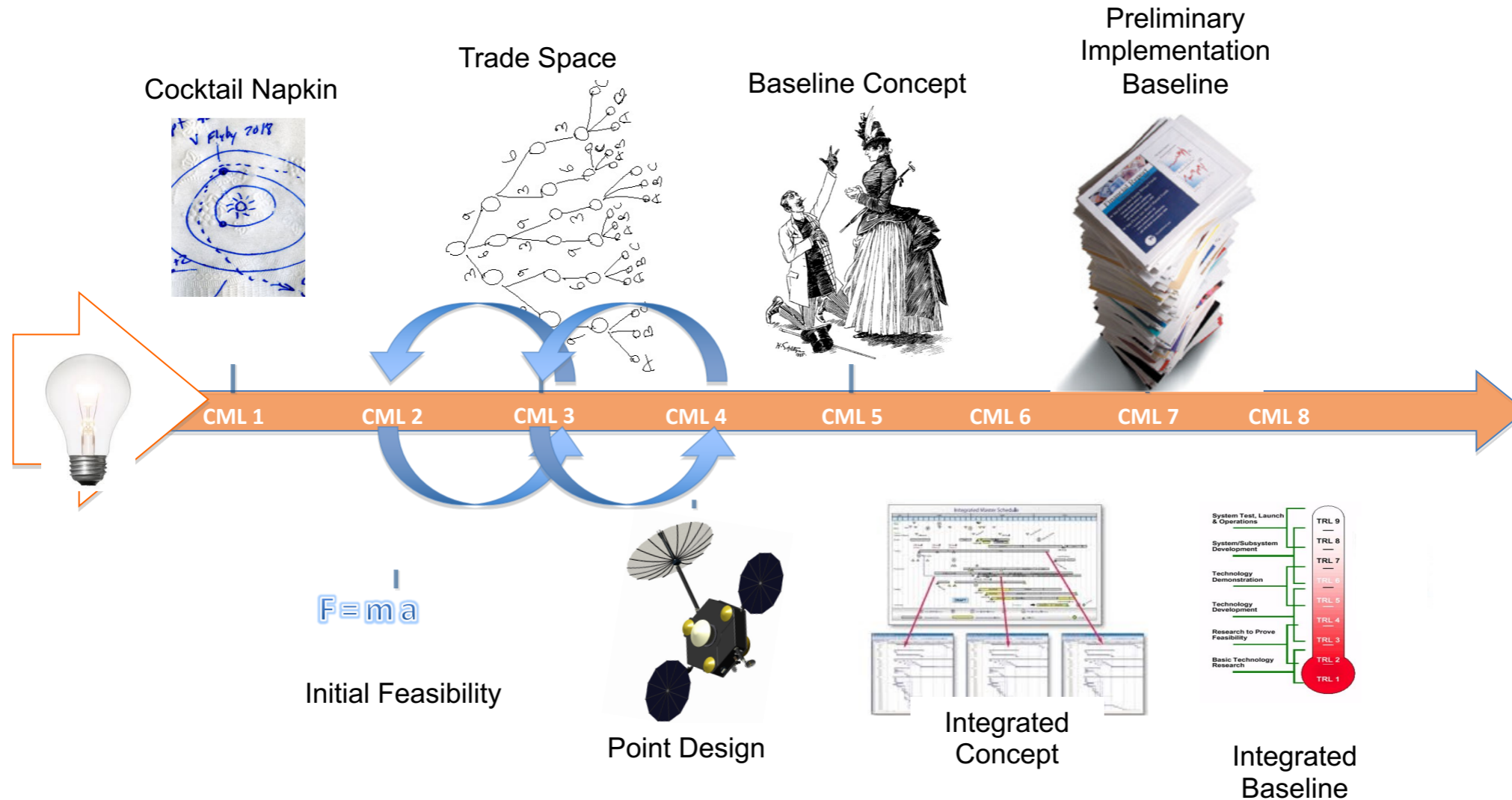
CML = Concept Maturity Levels

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# CMLs: A Powerful Communication Tool



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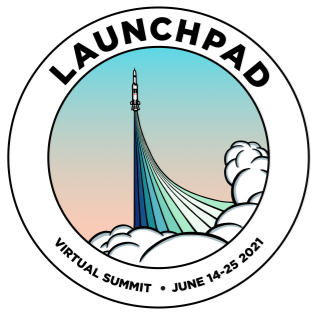
# Baseline and Threshold Science Missions

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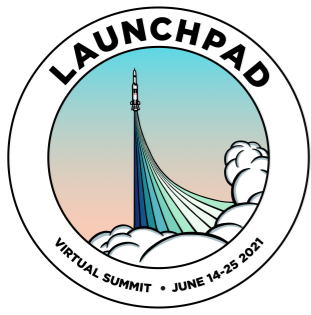


# NASA's Definition of Baseline and Threshold Science Missions

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- Baseline Science Mission \*
  - “The “Baseline Science Mission” is the mission that, if fully implemented, would fulfill the Baseline Science Requirements, which are the performance requirements necessary to achieve the full science objectives of the mission.”
- Threshold Science Mission \*
  - “The “Threshold Science Mission” is a descoped Baseline Science Mission that would fulfill the Threshold Science Requirements, which are the performance requirements necessary to achieve the minimum science acceptable for the investment.”

\* Text taken from the Draft Discovery 2019 Announcement of Opportunity



# Implications of a Baseline and Threshold Science Missions

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- **Baseline Science Mission \***
    - Science obtained must be "more" than the state-of-the-art
    - Must achieve compelling science with minimal cost & technical risk
  - **Threshold Science Mission \***
    - Evaluators will assume that the science mission will achieve the threshold science for the baseline cost
    - Cannot use descopes in operations (Phase E) as a basis for the threshold science mission
      - Example: Reducing operations from 4 to 3 years does very little to reduce development costs and risks
    - Baseline and Threshold Science Mission can be the same IF and ONLY IF:
      - **There is excess amounts of margin in most of the spacecraft resources (i.e., dollars, mass, power, s/c memory, etc.)**
- \* Text taken from the Draft Discovery 2019 Announcement of Opportunity

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# Science Return Diagram (SRD)

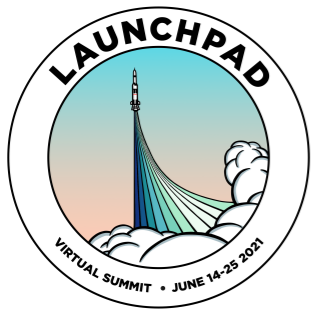
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# Science Objectives Drive the Science Return Diagramming Process

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- Generate an SRD for each science objective
  - Explicitly state the science mission concept for:
    - State of the art (basis for comparison)
    - Enhancement
    - Enabling
    - Breakthrough science
- Define:
  - Spatial requirements
  - Temporal requirement
  - Spectral range
  - Mission requirements (e.g., altitude, inclination, number of spacecraft)
  - etc.



# Science Return Diagramming

## Small Body Example: Asteroid Structure

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art			
Enhancing			
Enabling			
Breakthrough			

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# Science Return Diagramming

## Small Body Example: Asteroid Structure

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing			
Enabling			
Breakthrough			

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# Science Return Diagramming

## Small Body Example: Asteroid Structure

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
Enabling			
Breakthrough			

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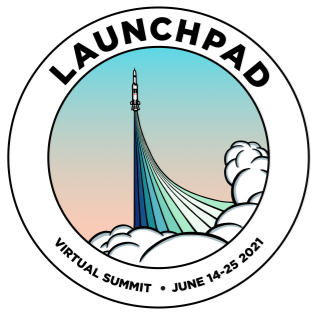
# Science Return Diagramming

## Small Body Example: Asteroid Structure

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
Enabling			
Breakthrough	Land on surface and return a sample	450 microns/pixel	Continuous

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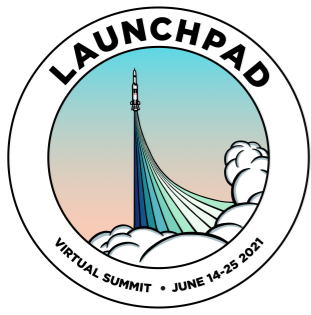
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## Small Body Example: Asteroid Structure

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
Enabling	Add a magnetometer & laser altimeter	35 m/pixel	5.5 hours (LAMO)
Breakthrough	Land on surface and return a sample	450 microns/pixel	Continuous

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# Science Return Diagramming

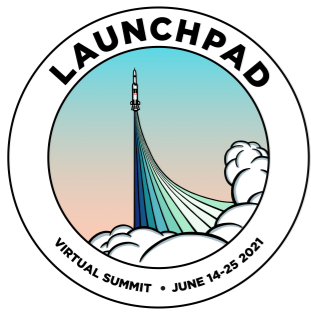
## Small Body Example: Asteroid Structure

█ Baseline Science

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
Enabling	Add a magnetometer & laser altimeter	35 m/pixel	5.5 hours (LAMO)
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# Science Return Diagramming

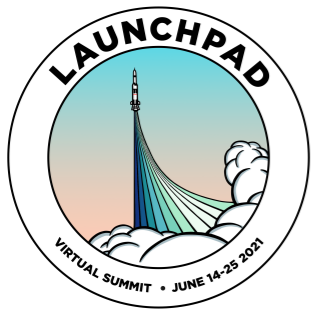
## Small Body Example: Asteroid Structure

█ Baseline Science  
█ █ █ Threshold Science

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
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# Science Return Diagramming

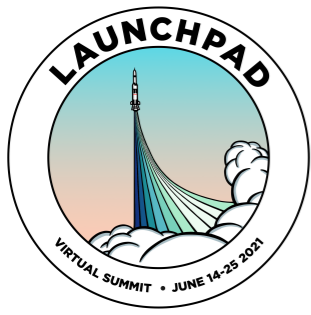
## Small Body Example: Asteroid Structure

- █ Baseline Science
- █ █ █ Threshold Science
- █ Cost Cap

Science Return Level	Mission	Spatial Scale	Temporal Scale
State of the Art	Dawn	35 m/pixel	5.5 hours (LAMO)
Enhancing	Dawn s/c at new class of asteroid	35 m/pixel	5.5 hours (LAMO)
Enabling	Add a magnetometer & laser altimeter	35 m/pixel	5.5 hours (LAMO)
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# The Bridge Between the Science Story and the STM

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- The Science Return Diagram (SRD) is the connection between the science story and the STM
- The SRD is used to:
  - Identify technical values for the Science Traceability Matrix (STM) that are based on enabling science
  - Keeps the STM focused on compelling science rather than a “catch-all” for all science that could be performed
  - Provide a logical and consistent flow between the science story and the STM



# SRD Benefits and Liabilities

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- **Benefits of doing an SRD**
  - **Provides:**
    - An approach for identifying a compelling science mission
    - An understanding of what instruments should be included in the science payload
    - Insight into the Co-I(s) that should be considered for your Science Investigation Team
- **Liabilities of doing an SRD**
  - Must do an SRD for each science objective
  - May be a challenge to reconcile conflicting requirements between different science objectives
  - **May not give you the answer you want**



# Final Thoughts

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- NASA is looking for compelling science mission concepts
- Compelling science is based on having:
  - Hypothesis/prediction pairs that can be traced to NASA's Strategic Objectives (e.g., the Decadal Surveys)
  - A mission concept that produces enabling science
- Proposals for NASA's competed missions must have a baseline and threshold science mission concept
  - Be careful not to over commit
- SRD identifies the enabling and breakthrough science
  - **Includes temporal and spatial measurement requirements (at the least)**