JPL Rapid Mission Architecture (RMA) Overview

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Planetary Science Decadal Survey Steering Group Meeting
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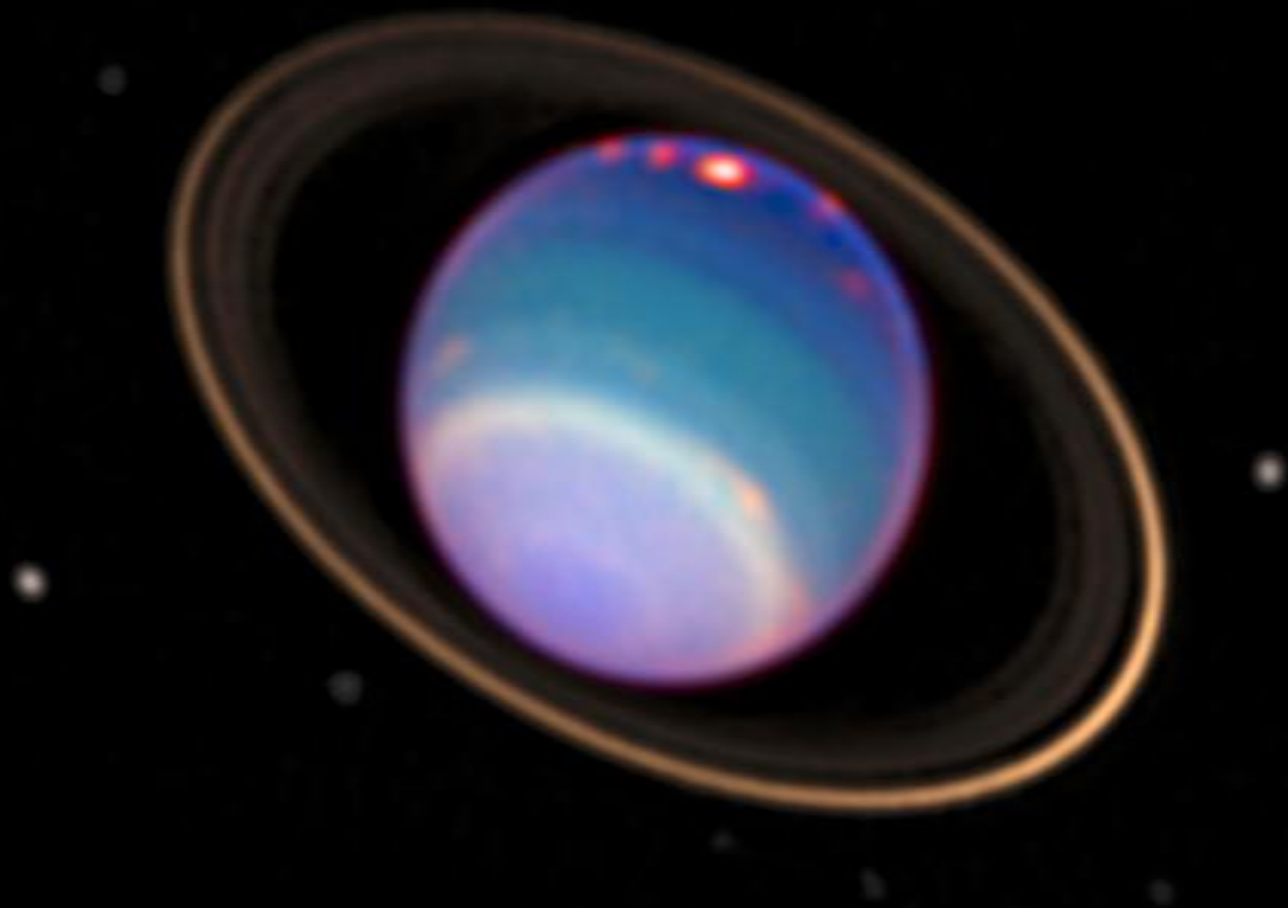
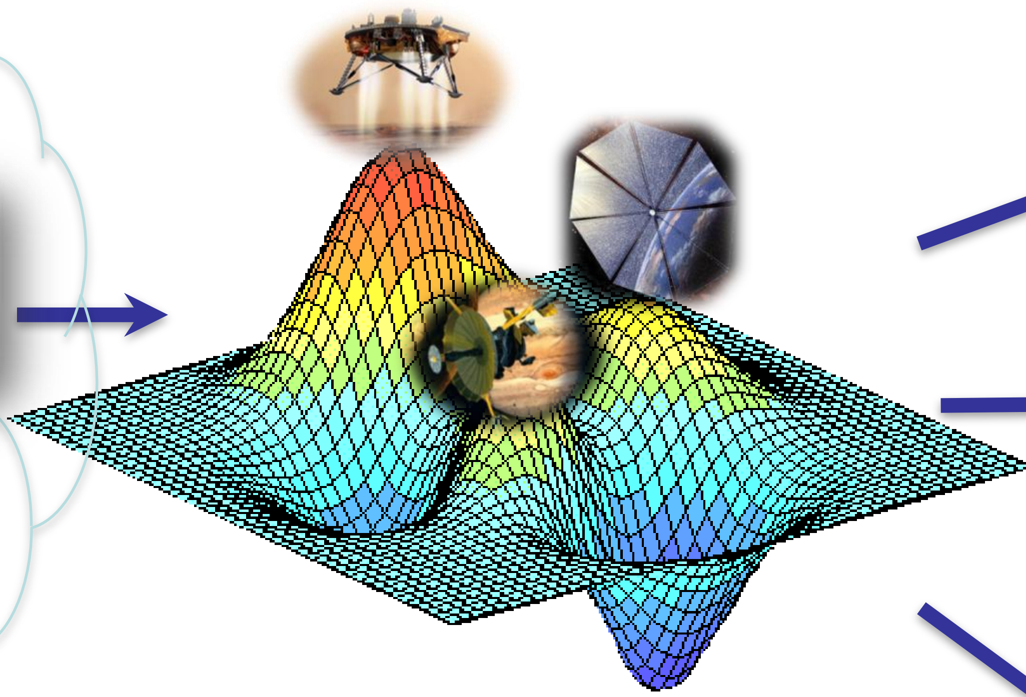
What are the most promising Flagship mission architecture options to achieve compelling science at Enceladus?

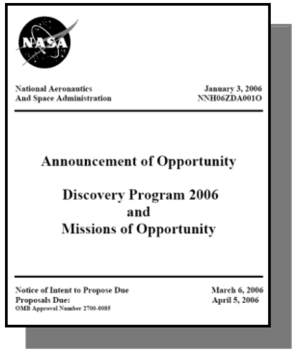


What mission architecture candidates in the New Frontiers and Flagship classes best address the science questions at Uranus?

RMA identifies and evaluates a broad trade space in early mission formulation



Proposal Teams


National Aeronautics
And Space Administration

January 3, 2006
NNH06ZDA001O

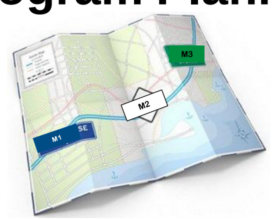
Announcement of Opportunity

Discovery Program 2006
and
Missions of Opportunity

Notice of Intent to Propose Due: March 6, 2006
Proposals Due: April 5, 2006

Advanced Studies

Roadmapping & Program Planning



RMA

CML 1–3

"Cocktail napkin" through trade space exploration

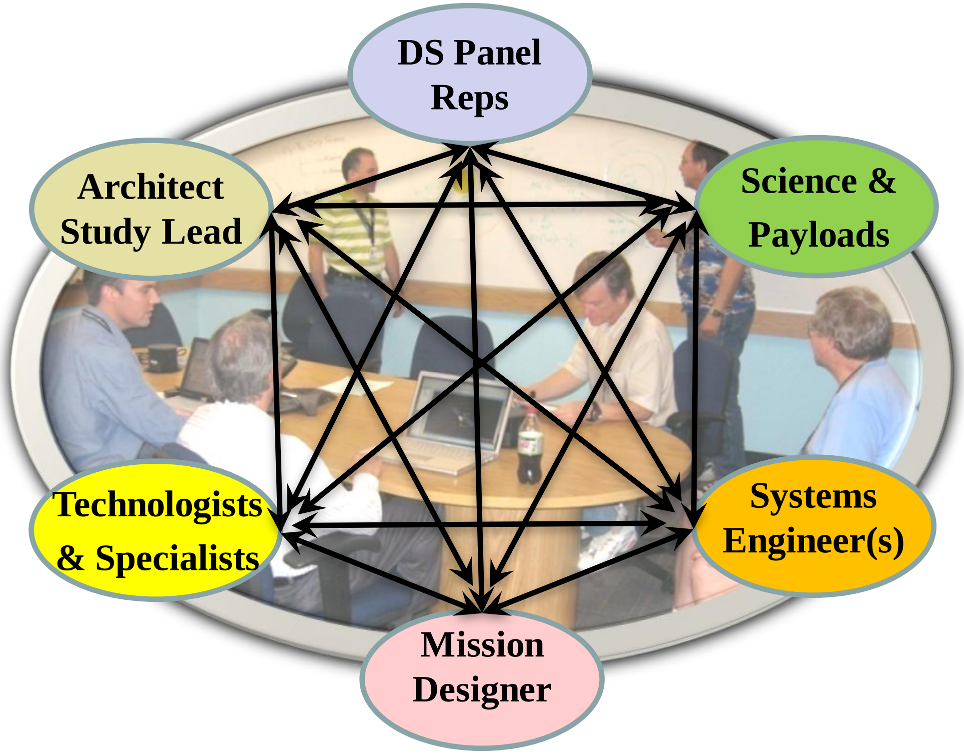
CML 4+

Point design & beyond

RMA is a small team-based approach for exploring diverse mission concepts

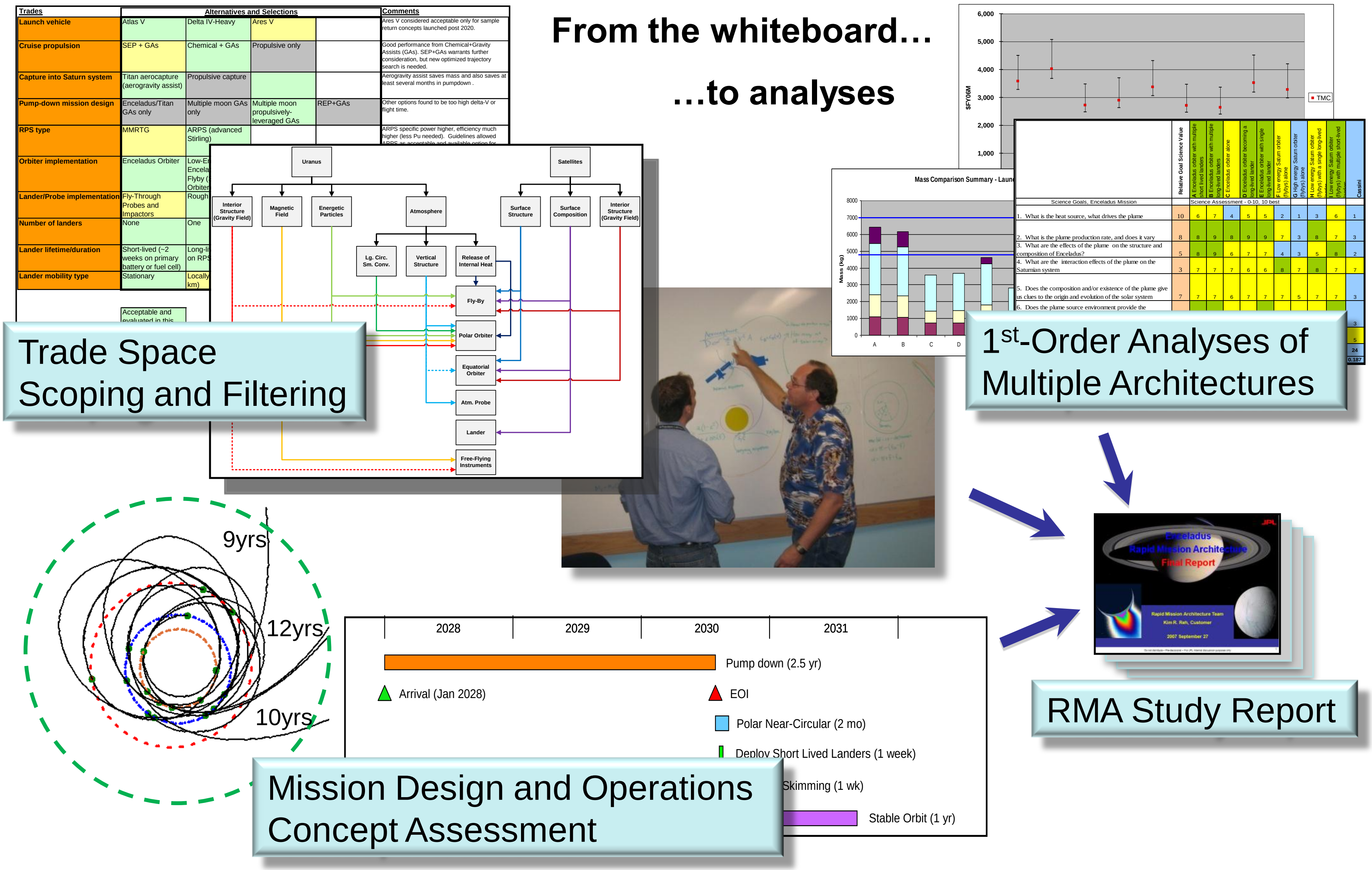
RMA integrates a team of architecture-level experts to:

- **Explore a broad trade space driven by science objectives**
- **Avoid driving to a baseline prematurely**
- **Identify innovative, unforeseen paths**
- **Rapidly analyze preliminary feasibility**

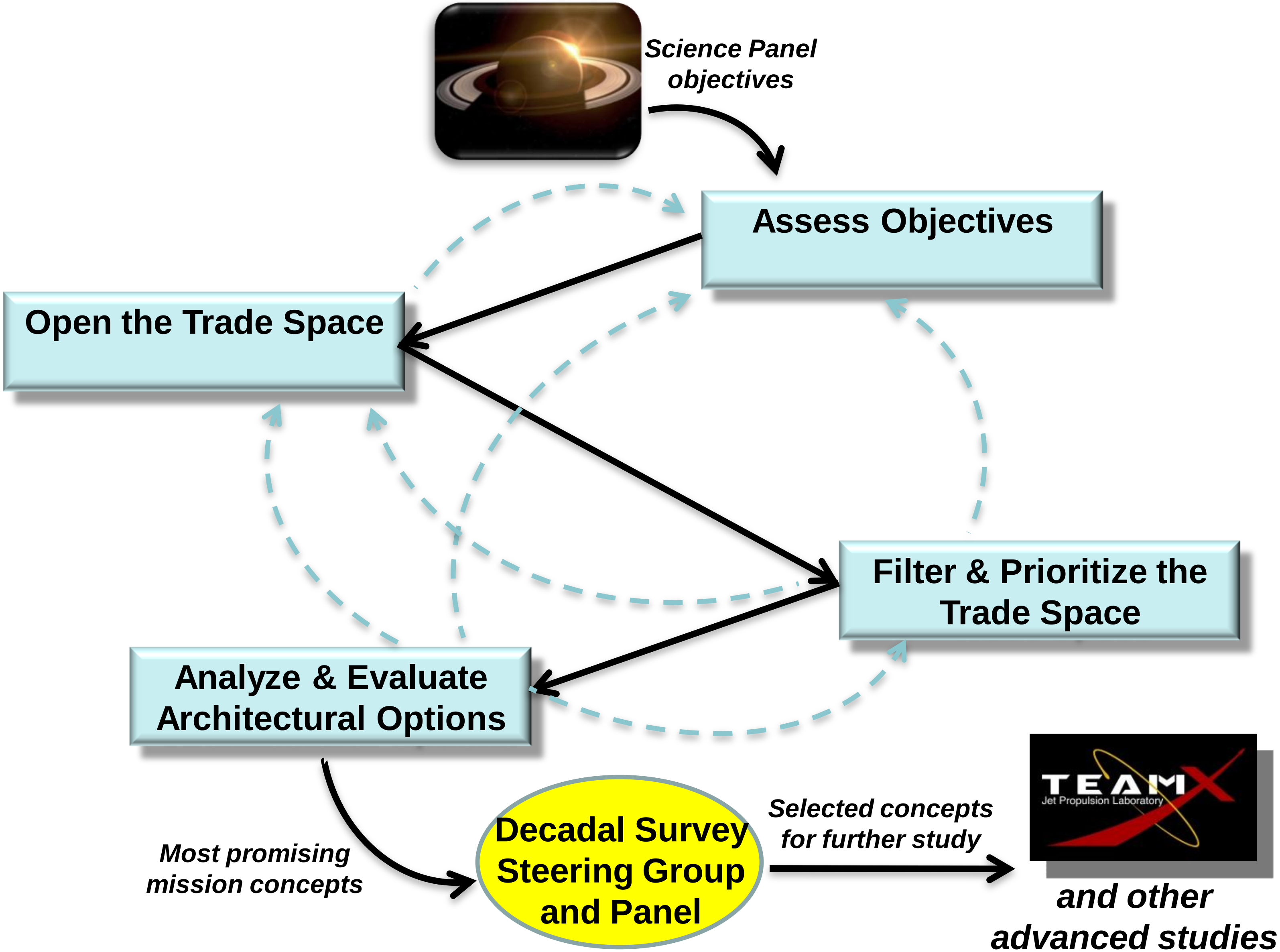


Typically 6-10 people in 1-2 weeks of concurrent sessions

Products are tailored to the needs of mission architecture-level analyses



RMA approach promotes assessment of multiple early mission concepts



Essential elements of an RMA study

- **Inputs (from the Science Panels)**
  - Science objectives and preliminary prioritization
  - Preliminary instruments and measurements
- **Concurrent Team Collaboration (during the RMA study)**
  - Science Panel representatives participate directly as part of RMA team
  - Small multidisciplinary team efficiently explores a trade space of multiple creative architecture solutions
- **Outputs (from the RMA study)**
  - Identification of promising candidate mission concepts for further study through integrated evaluations (science value, cost "bin", risk, etc.)
  - Report documenting basis and rationale for assessments across multiple architectures

Direct science panel participation is key in an RMA study

Planning and "Pre-Session"

- Panel reps interact "offline" to identify study scope and mission objectives
- Help identify any additional prep work needed before study

RMA Concurrent Sessions

- Panel reps integrated into team to affect key decisions in real-time
- Concurrent sessions span 1-2 weeks
- Typically ~5-8 sessions, ~2-3 hrs each
- Panel rep can be physically present at all sessions (preferred), or present at key early sessions followed by videocon/telecon participation

Product Generation

- Panel reps contribute directly and co-own the products (e.g., science objectives, science value, assessment of architectures)

Enceladus RMA examples

Identify the primary science questions

Science leads provide the questions that guide the study:

- **What is the heat source; what drives the plume?**
- **What is the plume production rate, and does it vary?**
- **What are the effects of the plume on the structure and composition of Enceladus?**
- **What are the interaction effects of the plume on the Saturnian system?**
- **Does the composition and/or existence of the plume give us clues to the origin and evolution of the solar system?**
- **Does the plume source environment provide the conditions necessary (or sufficient) to sustain biotic or pre-biotic chemistry?**
- **Are other similar bodies (Dione, Tethys, Rhea) also active, and if not, why not?**

Open the trade space for Enceladus

Enceladus Mission Architecture Types

Flybys only
- High energy flybys
- Low energy flybys

Orbiter only
- Fly through plume
- No plume fly through

Flybys with in-situ element(s)
- Flybys with impactor(s)
- High energy flybys with lander(s)
- Low energy flybys with lander(s)
  - Multiple options
- Flybys with low altitude plume fly-through probe

Orbiter with in-situ element(s)
- Orbiter with probe(s)
- Orbiter with lander(s)
  - Multiple options
- Orbi-lander
  - Multiple options

Sample return
- Surface sample return
- Plume fly-through sample return

Increasing Breadth of Science Return →

07/07/2009

Filter the trade space and identify drivers

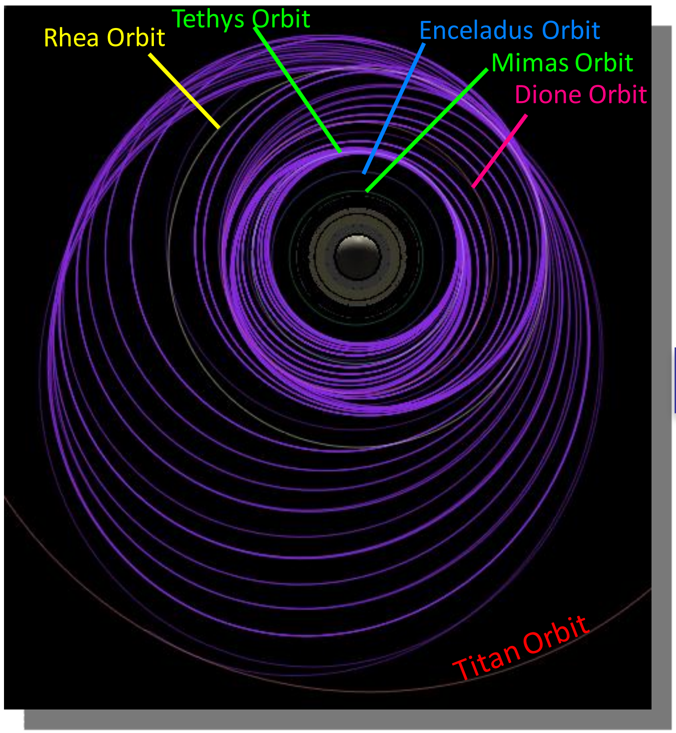
Trades	Options			
Launch vehicle	Atlas V	Delta IV-Heavy	Ares V	
Cruise propulsion	SEP + GAs	Chemical + GAs	Propulsive only	
Capture into Saturn system	Titan aerocapture (aerogravity assist)	Propulsive capture		
Pump-down mission design	Enceladus/Titan GAs only	Multiple moon GAs only	Multiple moon propulsively-leveraged GAs	REP+GAs
RPS type	MMRTG	ARPS (advanced Stirling)		
Orbiter implementation	Enceladus Orbiter	Low-Energy Enceladus Multiple-Flyby (Saturn Orbiter)	High-Energy Enceladus Multiple-Flyby (Saturn Orbiter)	
Lander/Probe implementation	Fly-Through Probes and Impactors	Rough Landers	Soft Landers	Orbi-Landers
Number of landers	None	One	Three (regional distribution)	Five (larger-scale distribution and/or redundancy)
Lander lifetime/duration	Short-lived (~2 weeks on primary battery or fuel cell)	Long-lived (~1 year on RPS)		
Lander mobility type	Stationary	Locally mobile (~10 km)	Regionally mobile (~100 km)	Globally mobile

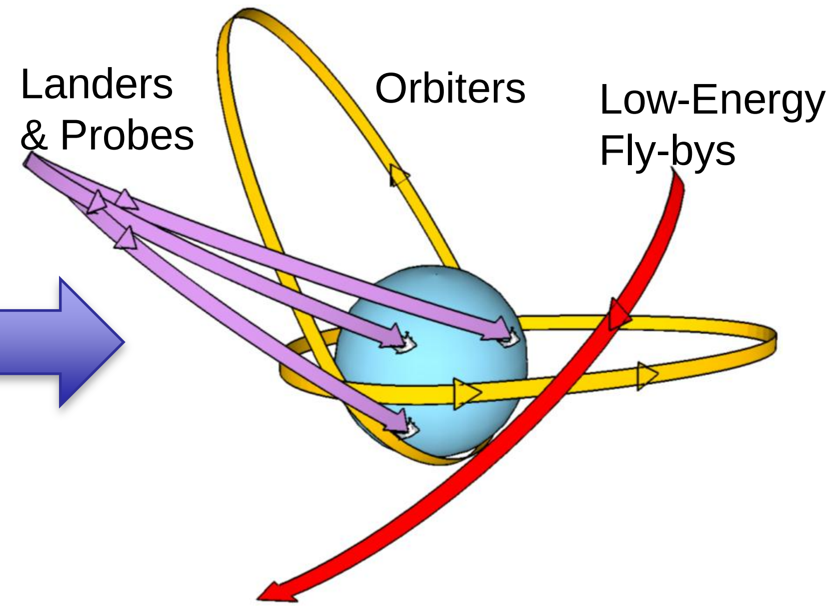
Legend: Green = Preferred option (higher-priority)
Yellow = Allowable option but lower-priority
Gray = Provisionally-rejected option

Address "tall tent poles" early to enable new science mission opportunities

How to enable compelling orbital and in-situ science options at Enceladus?

- Cross-pollinating ideas between RMA team members stimulate new mission design concepts to achieve Enceladus orbit
- Provide the right mix of people to identify and resolve the "tall tent poles"



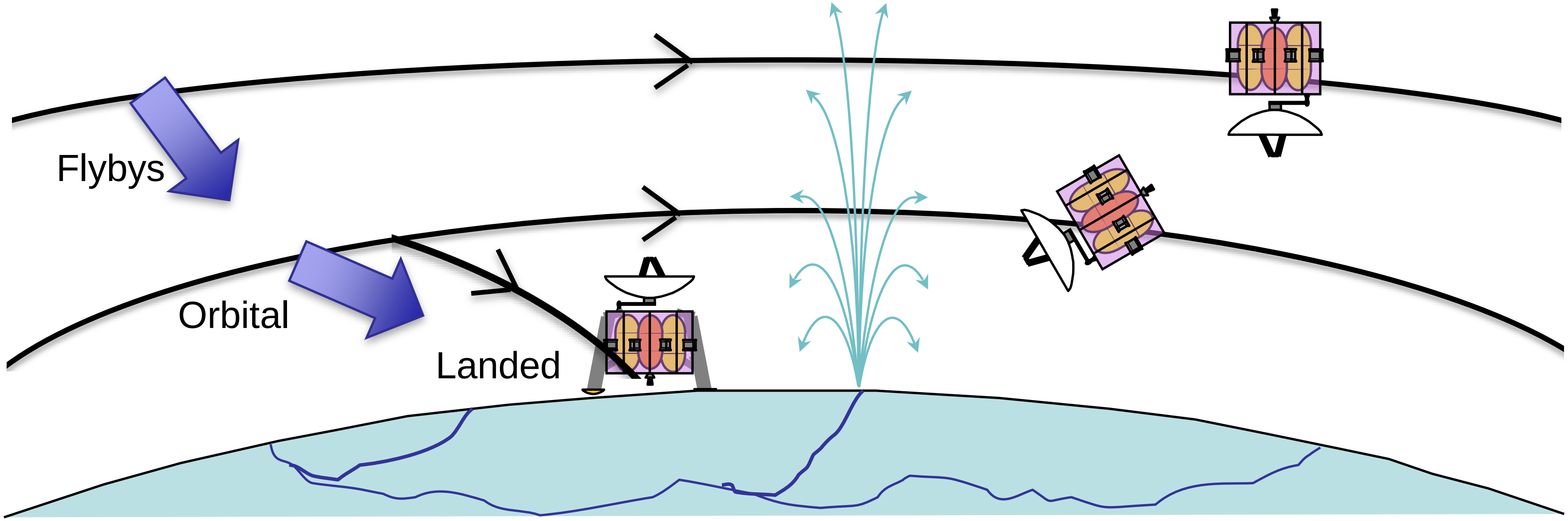


Result: Innovative pump-down trajectories deliver significant mass to Enceladus to achieve science beyond Cassini

Combine existing concepts in new ways to extend science capabilities

How to achieve a greater range of science goals through a new architectural combination?

- Concurrent interactions in RMA infuse ideas across science, systems engineering, mission design, operations, and cost/risk



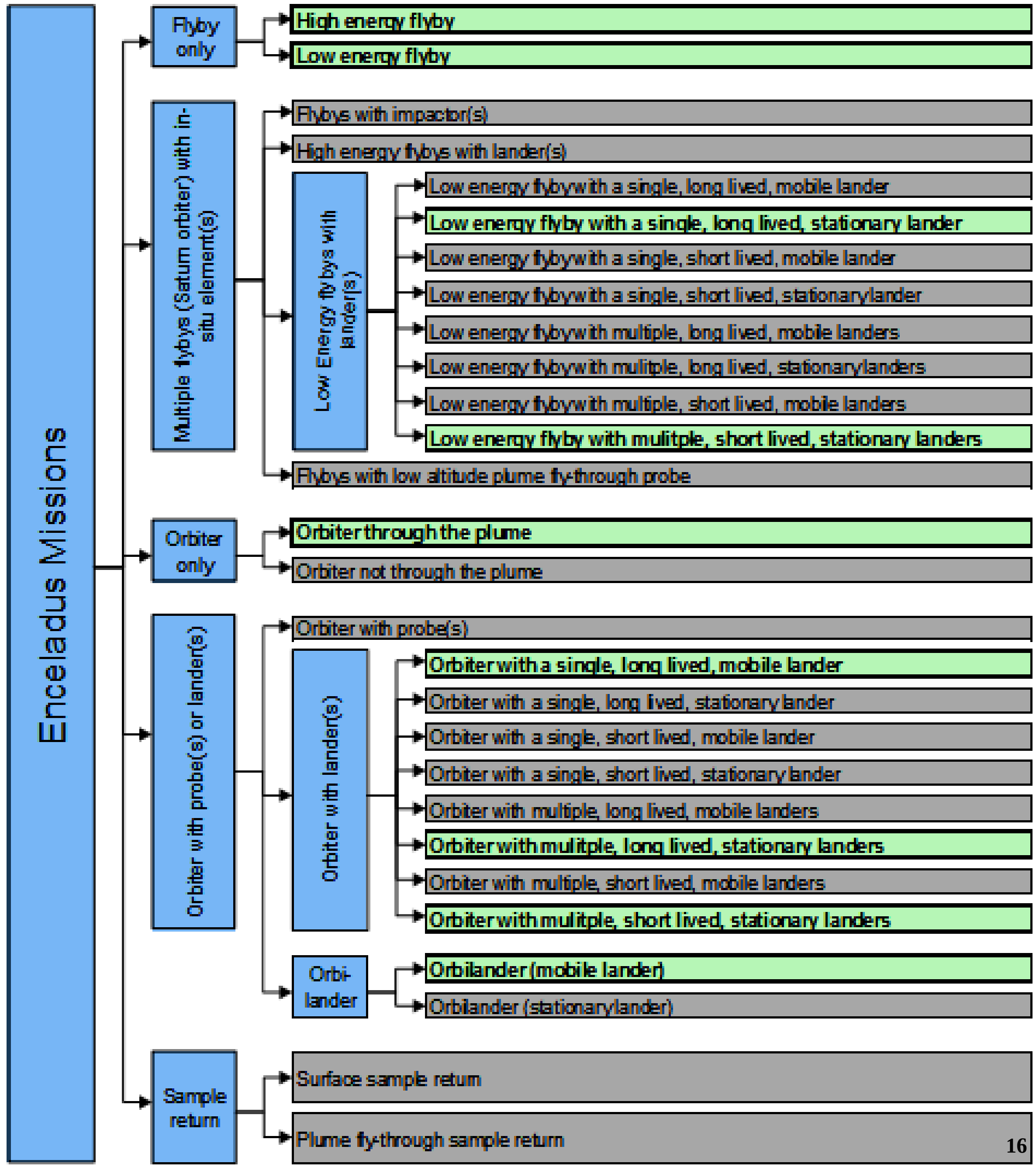
Result: "Orbi-lander" integrates multiple science objectives into a single solution spanning Saturnian system to Enceladus global to local in-situ

Select architectures for integrated assessment

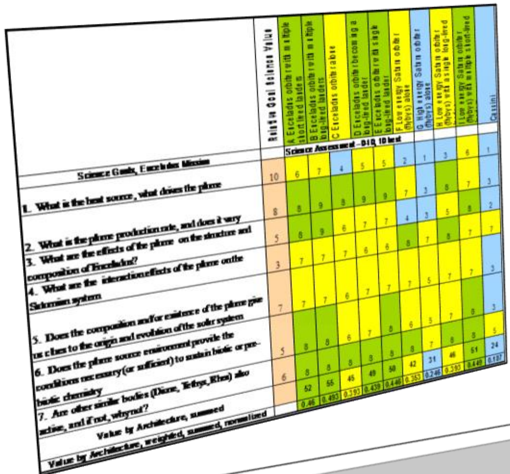
Prune and assemble trade space elements into selected mission architectures

9 mission architectures proceed to integrated analyses

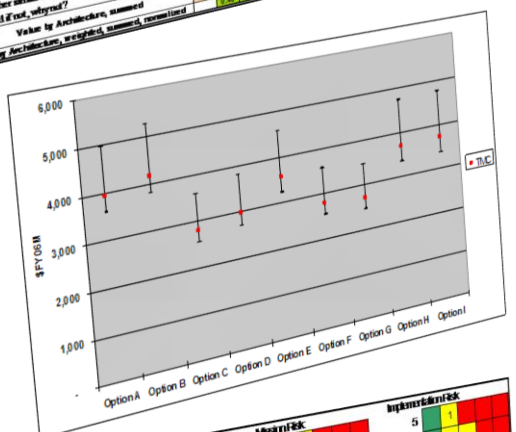
Documented decision-making and rationale



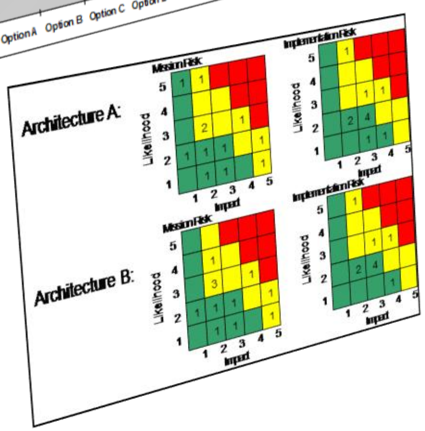
Analyze architectural options to identify the best candidates for follow-on study



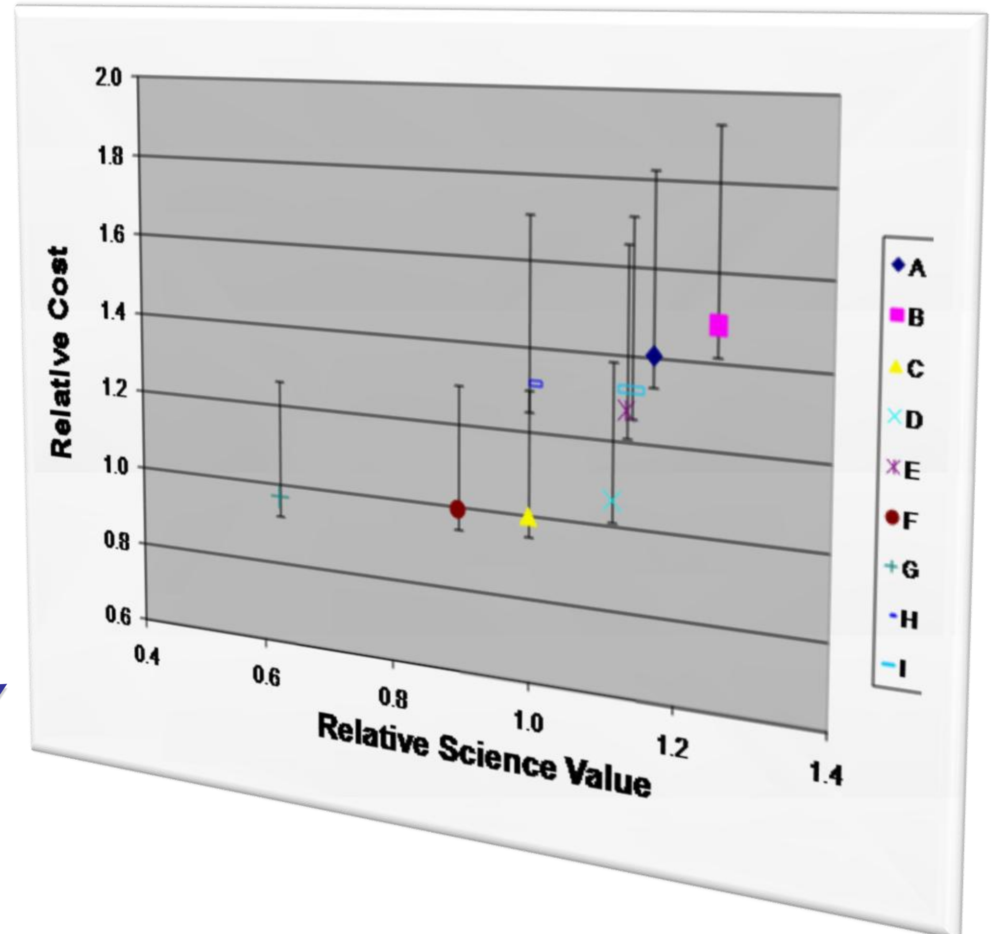
Science Value



Cost



Risk



Reveal the “sweet spots” through integrated assessment of multiple Figures of Merit

RMA addresses key needs for Decadal Survey decision-making

RMA provides an effective and consistent approach to:

- **Generate and assess early concepts in a broad trade space driven by science objectives**
- **Bring concepts of varying maturity (CML 1, 2) to common footing at CML 3**
- **Identify preliminary cost class bins (e.g., Flagship, New Frontiers, Discovery) for a set of science mission architectures**
- **Provide Decadal Survey the necessary information to identify best candidate architectures to proceed to detailed point design studies**