

Roadmaps to Ocean Worlds

SBAG Update
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Congressional Direction

- From the Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2016
 - **“...The Committee directs NASA to create an Ocean World Exploration Program whose primary goal is to discover extant life on another world using a mix of Discovery, New Frontiers and flagship class missions consistent with the recommendations of current and future Planetary Decadal surveys.”**
- Connected to the view of Ocean Worlds as perhaps habitable and potentially inhabited worlds

OPAG Charge to ROW

- *OPAG chartered ROW; we are coordinating with SBAG since some “SBAG-owned” bodies could be ocean worlds*
- Identify and prioritize science objectives for Ocean Worlds
 - tied to the Decadal Survey
- Design roadmap to explore these worlds to address science objectives
 - Mission sequences, sustained exploration effort
- Assess where each Ocean World fits into the overall roadmap
- Summarize broad mission concepts
 - Considering mission dependences & international cooperation
- Recommend technology development and detailed mission studies in support of the next decadal survey
- Place exploration of Ocean Worlds into the larger context of Solar System exploration

Philosophy on Ocean Worlds

What is an Ocean World?

- We want to be inclusive!
- All bodies which plausibly can have or are known to have an ocean will be considered as part of this study
- A goal is to study the entire spectrum of Ocean Worlds... to understand life in the context of all Ocean Worlds.
 - If we focus on one target and find life, we won't be done!
 - Why would life evolve at one world at not another?
 - Why would life take a particular form at one world and a different one at another?
- It's important to consider ties to the Earth and Earth's ocean here too
- For each of these worlds, after we carefully consider overall/general science objectives, we will subdivide into groups to consider what questions need to be addressed at a target level, and potential mission plans
 - So we'll get into target-based discussions a bit later in the process

Team members

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Overarching Goal

- The ROW team has focused on a draft for the main goal for Ocean Worlds in order to start formulating driving science questions:

Identify ocean worlds, evaluate their habitability, and search for life

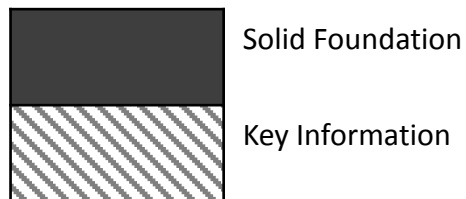
Ocean World Themes

- Four themes
 - Identify ocean worlds
 - Characterize Oceans
 - Assess Habitability
 - Search for Life
- Theme groups came up with an initial set of science questions for each theme
 - Ranging from high level to very detailed

Target teams

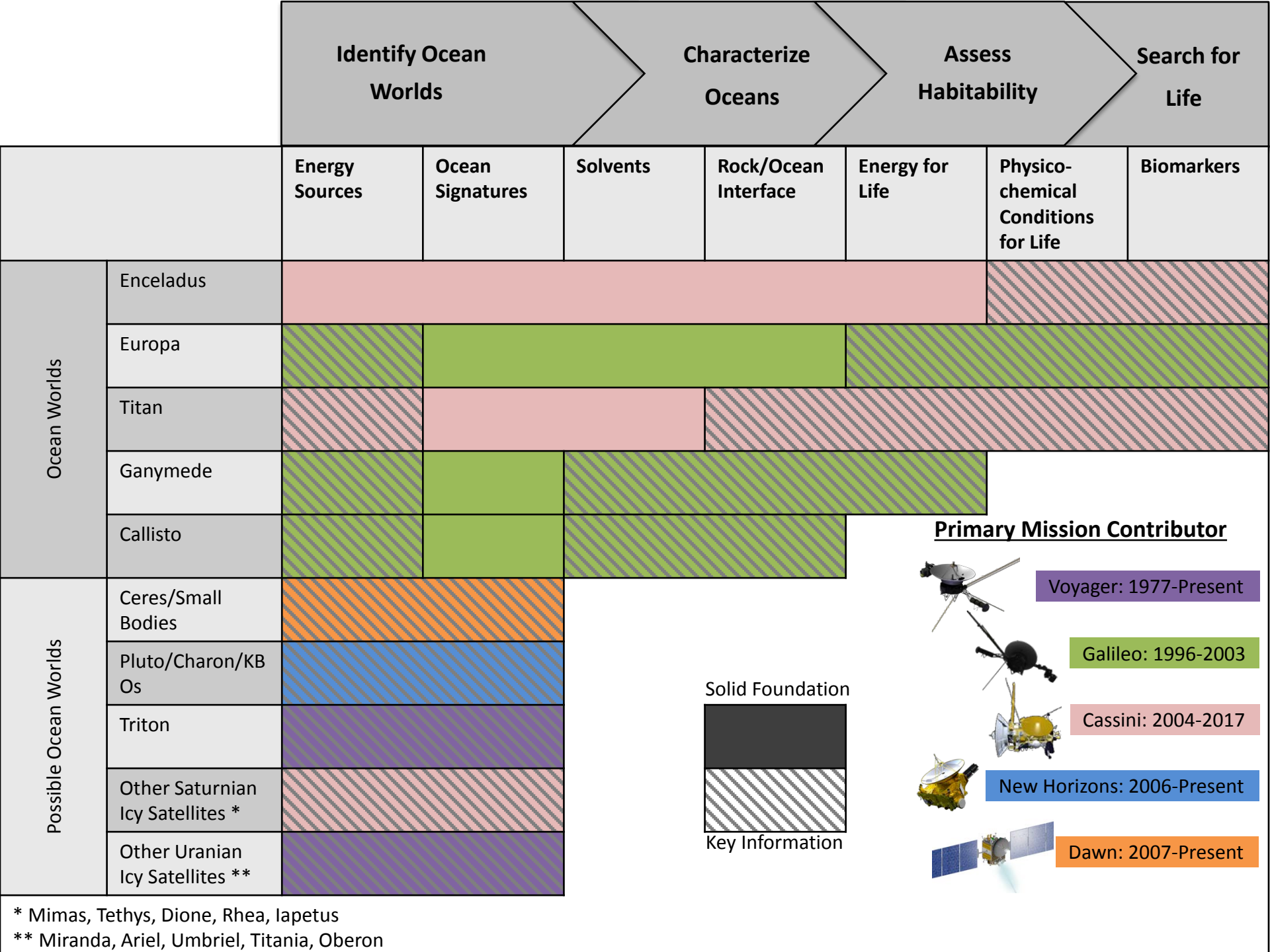
- We formed target teams for the following (groups of) targets
 - Enceladus
 - Europa
 - Pluto, Charon & KBOs
 - Ceres & small bodies
 - Ganymede and Callisto
 - Triton
 - Titan
 - Other satellites (“up and coming”)
- Target teams assessed the status of each target: how well are each of the Theme science questions known, what do we know about them, what is their level of their “ocean-worldness”

		Identify Ocean Worlds		Characterize Oceans		Assess Habitability		Search for Life
		Energy Sources	Ocean Signatures	Solvents	Rock/Ocean Interface	Energy for Life	Physico-chemical Conditions for Life	Biomarkers
Ocean Worlds	Enceladus	Solid Foundation					Key Information	
	Europa	Key Information		Solid Foundation		Key Information		
	Titan	Key Information		Solid Foundation		Key Information		
	Ganymede	Key Information		Solid Foundation		Key Information		
	Callisto	Key Information		Solid Foundation		Key Information		
Possible Ocean Worlds	Ceres/Small Bodies	Key Information						
	Pluto/Charon/KB Os	Key Information						
	Triton	Key Information						
	Other Saturnian Icy Satellites *	Key Information						
	Other Uranian Icy Satellites **	Key Information						



* Mimas, Tethys, Dione, Rhea, Iapetus

** Miranda, Ariel, Umbriel, Titania, Oberon



Identify Ocean Worlds

Characterize Oceans

Assess Habitability

Search for Life

Energy Sources

Ocean Signatures

Solvents

Rock/Ocean Interface

Energy for Life

Physico-chemical Conditions for Life

Biomarkers

Ocean Worlds

Enceladus

Europa

Titan

Ganymede

Callisto

Possible Ocean Worlds

Ceres/Small Bodies

Pluto/Charon/KB Os

Triton

Other Saturnian Icy Satellites *

Other Uranian Icy Satellites **

Primary Mission Contributor

Voyager: 1977-Present

Galileo: 1996-2003

Cassini: 2004-2017

New Horizons: 2006-Present

Dawn: 2007-Present

Solid Foundation

Key Information



* Mimas, Tethys, Dione, Rhea, Iapetus
 ** Miranda, Ariel, Umbriel, Titania, Oberon

Goals, Objectives, Investigations report

- Goals, Objectives and Investigations (GOI) report/document
- Target Teams provided text covering what is known, and what still needs to be learned about each body, for the GOI document

GOI Document

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Ocean Worlds Missions Scenarios, Roadmaps & Technologies

- Target Teams provided input on key measurements needed to move our understanding of each target forward
- Also provided input on future mission types needed

Current & Future Activities

- In the future:
 - Collate and vet mission concepts and measurements needed to address science questions
 - Ocean Worlds Missions Scenarios, Roadmaps & Technologies document
 - Preliminary results on mission planning presented at OPAG Feb 2017
 - Provide draft GOI document to OPAG committee (Jan 2017)
 - Does it fulfill the ROW charge?
 - Provide draft GOI document to OPAG for initial feedback (Feb 2017)
 - Provide draft GOI document to community for additional feedback and further refinement (Mar 2017)