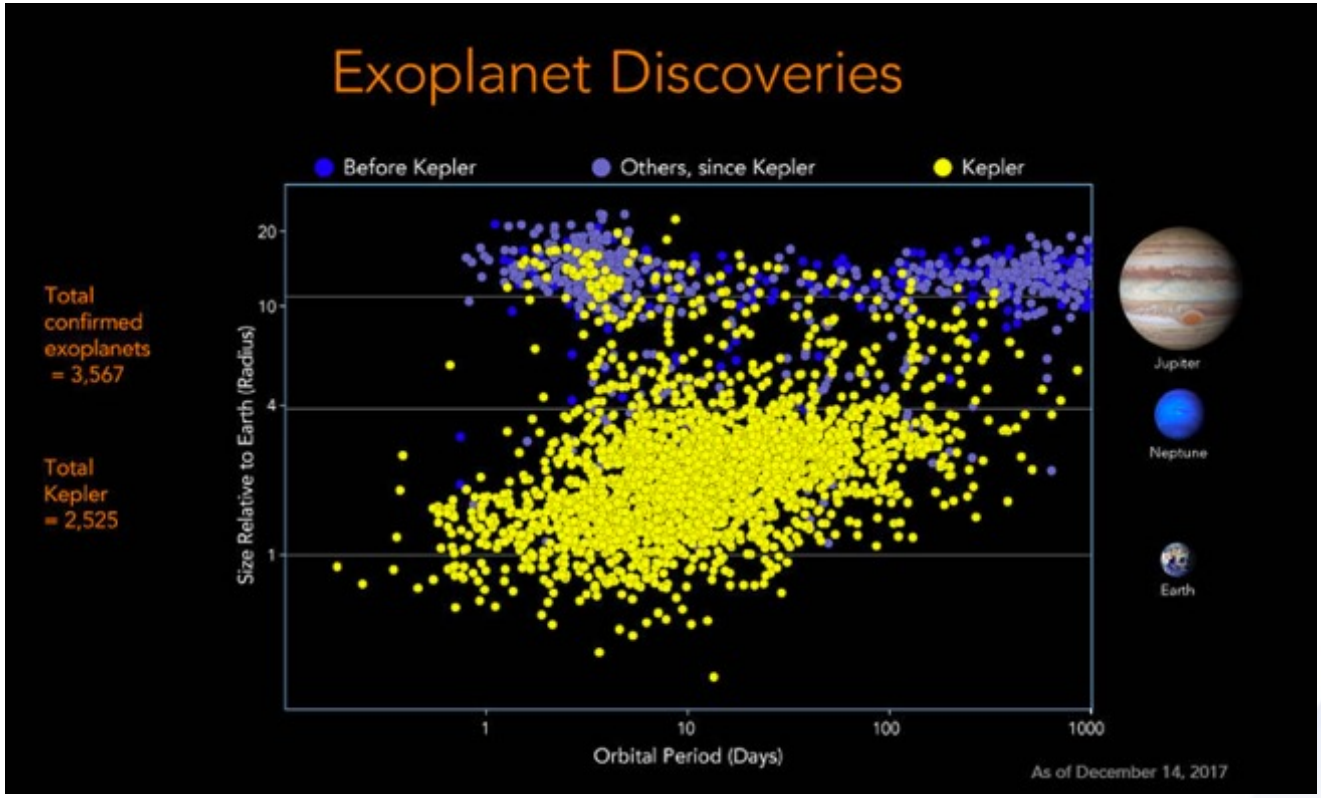
# Early Career Initiative Proposal FY23

# Aerocapture as an Enabling Technology for Ice Giants Missions

**Project Principal Investigator: Soumyo Dutta**

# Why the Ice Giants?

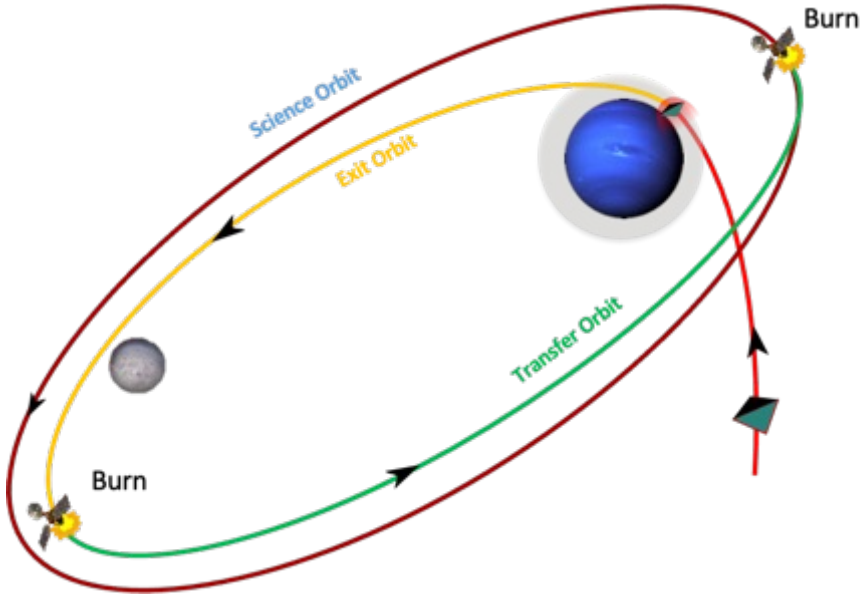
- Uranus and Neptune (Ice Giants) have only been visited by Voyager 2 through a flyby
- Uranus has interesting obliquity; Neptune has interesting moon: Triton
- Many exoplanets are Uranus/Neptune like
- **Uranus is the top flagship class mission destination in the 2023-2032 Planetary Science Decadal Survey**
- **Decadal Survey also mentions aerocapture as a technology that should be incentivized**




Credit: https://www.nasa.gov/image-feature/ames/exoplanet-discoveries

# What is Aerocapture?

Uses aerodynamic forces within an atmosphere to decelerate and achieve orbit insertion




**Typical Fully-Propulsive Mission**

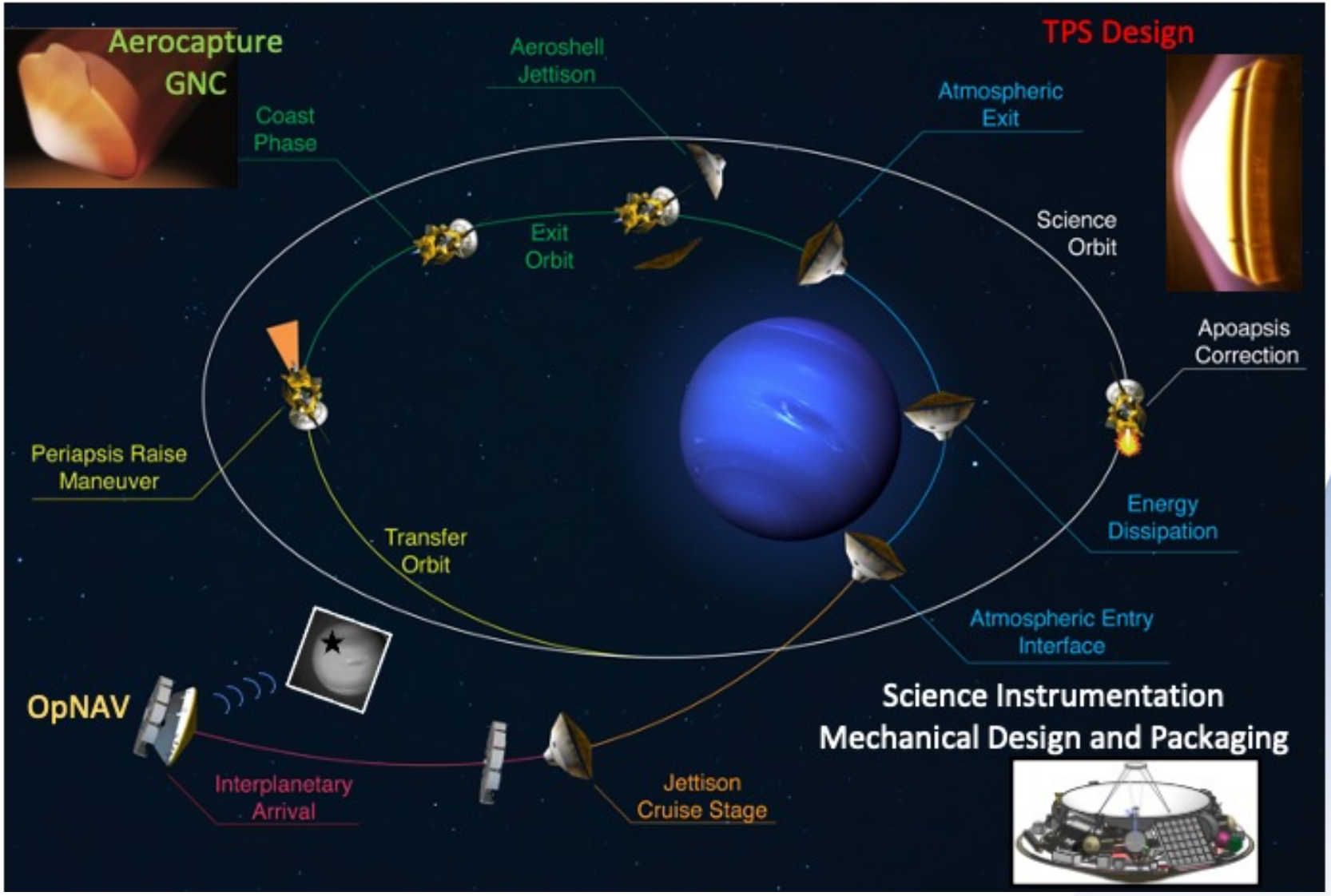
- Fast interplanetary speeds for outer planets
- **Need 50% or more mass** for fully-propulsive orbit insertion (requires ΔV of 1-2 km/s)
- Typical mission **require long cruise phase** (13-17 years)

**Aerocapture Enabled Mission**

- Reduced propellant need; **increase on-orbit mass by 40%**
- Aerocapture less sensitive to faster interplanetary trajectories – **reduce trip time by 3-5 years**
- Savings used for launch vehicle choice or increased on-orbit science payload
- Fit a larger cap mission into smaller cap. e.g., **Flagship class mission in New Frontiers cap**

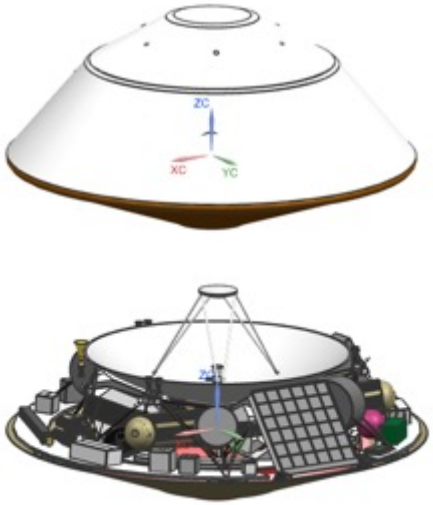
Ref: Lockwood 2004

# Areas of Research Needed for Ice Giants Aerocapture

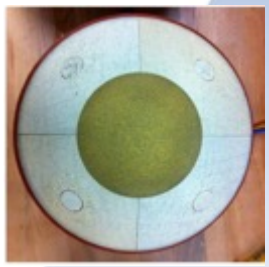


# Two Year Work Plan

- **Year One:** Development of a closed aerocapture design using the current state-of-the-art of the aerocapture subsystems
  - Provide a complete design for the goal of the proposal
  - Highlight the robustness in the design and the actual technical maturity of each subsystem
  - Goal is to provide a feasible end-to-end design of an aerocapture system
  - A probabilistic risk assessment will quantify actual risk of aerocapture
- **Year Two:** Technological maturation of subsystem design for alternatives and risk mitigation
  - Identification of ways to lower risk for each subsystem flagged at the end of the year one efforts
  - Do development to improve the maturity of the subsystem
  - Show existing feasible alternatives for subsystems with risk
  - Explore if the risk can be lowered and feasibility can be enhanced for the full aerocapture design
  - Focus will be on identifying mechanisms to improve the TRL of subsystems



Credit: Elliot et al. 2020



Conformal TPS – Credit: R.Beck, 2014

# Gathering a Team

PI: Som Dutta (LaRC)
Flight Mechanics Lead: Rohan Deshmukh (LaRC)
OpNAV Lead: Matt Smith (JPL)
TPS Design Lead: Ben Libben (ARC)
Mechanics Design Lead: Andrew Gomez (LaRC)

## Other Team Members


Dr. Rafael Lugo (EC)
Flight Mechanics Simulation (LaRC)


Eli Shellabarger (EC)
Aerodynamics (LaRC)


Dr. JB Scoggins (EC)
Aerothermodynamics (LaRC)


Dr. Ricardo Restrepo
Mission Design (JPL)


Declan Mages (EC)
Optical Navigation (JPL)


Jonathan Morgan
Thermal Protection System Design (ARC)


Daniel Matz
GNC Design (JSC Lead)


Breanna Johnson
GNC Design (JSC)

## Mentors

Dr. Neil Cheatwood
NASA Senior Technologist for Planetary Entry, Descent, and Landing

Karl Edquist
Senior Aeroscientist

Dr. Raj Venkatapathy
NASA Senior Technologist for Entry System Technologies

Dr. Shyam Bhaskaran
Group Supervisor, Outer Planet Navigation Group

## External Partners

Charles Stark Draper Laboratory, Inc.
GNC Design and Maturation, OpNAV

Intuitive Machines, LLC
GNC Algorithm Design

Booz Allen Hamilton
Agile Project Management, Probabilistic Risk Assessment