



FY25 Strategic University Research Partnership (SURP)

Charting Trajectory Pathways in the Uranian and Neptunian Systems

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Objectives:

- Overall: Generate and examine trajectory trade spaces in Neptunian and Uranian systems using a motion primitive approach.
- Year 3:
- 1. Update the primitive-based trajectory design procedure to support the more complex dynamical environment
 - 2. Generate and examine the trade space for various itineraries (in progress)
 - 3. Updated technical approach to ensure generation of high-quality, feasible initial guesses.

Background:

Ice giants Uranus & Neptune are targets of next high priority science missions.

Mission objectives for a flagship mission to ice giant planets:

- Perform remote and in situ measurements of the planet’s atmosphere, interior, and magnetosphere
- Perform imaging of the rings and small satellites
- Flyby large satellites to study composition, gravity, surface features, and particle environment



Significance and Benefits to JPL and NASA:

Automated capability to generate trade space of pathways in a multi-body system

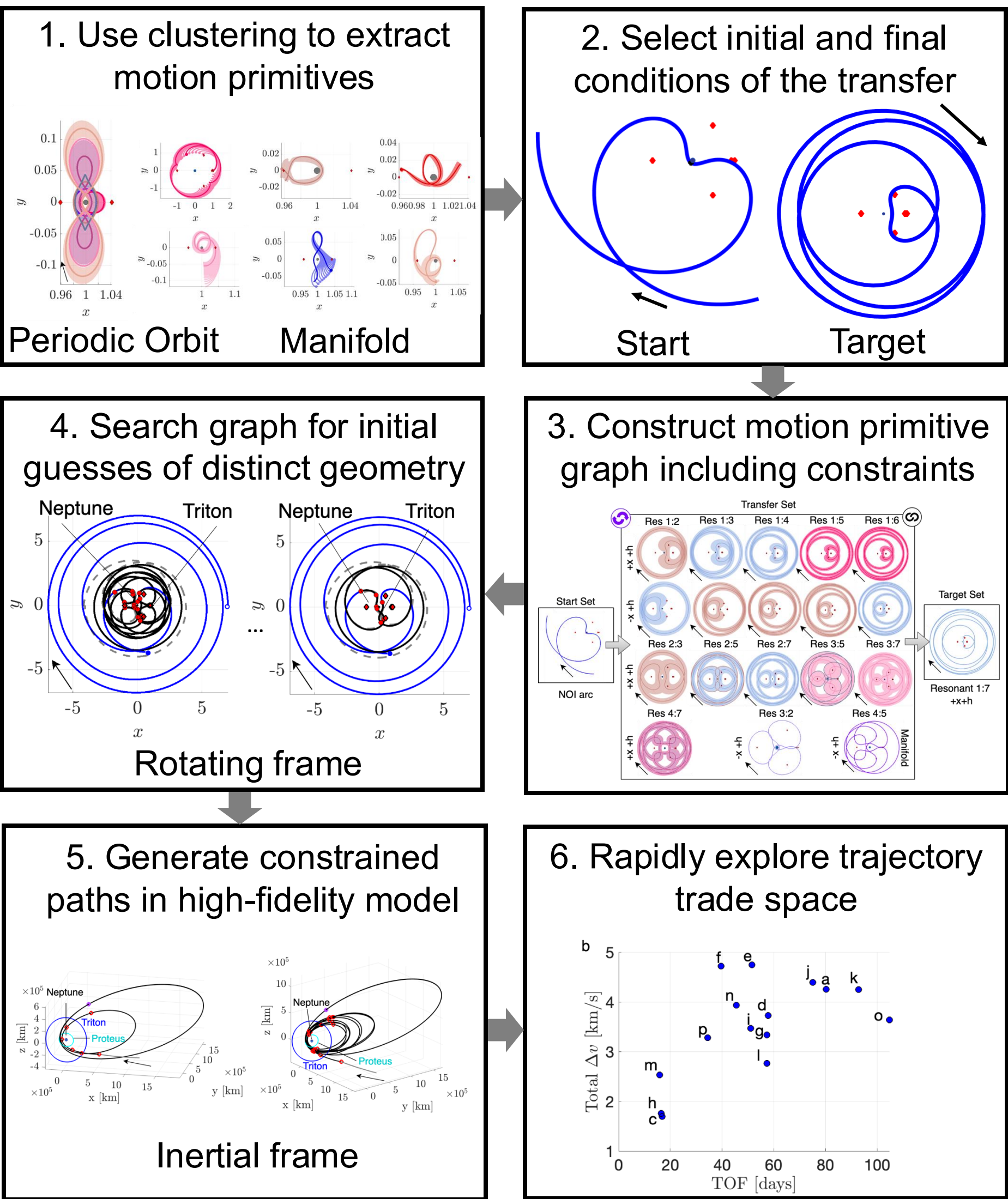
Benefits to trajectory design for ice giant missions:

- Addition of multi-body trajectory options to patched conic solutions
- Automated solution space search incorporating science return and operational constraints
- Possible multi-spacecraft design for increased science return

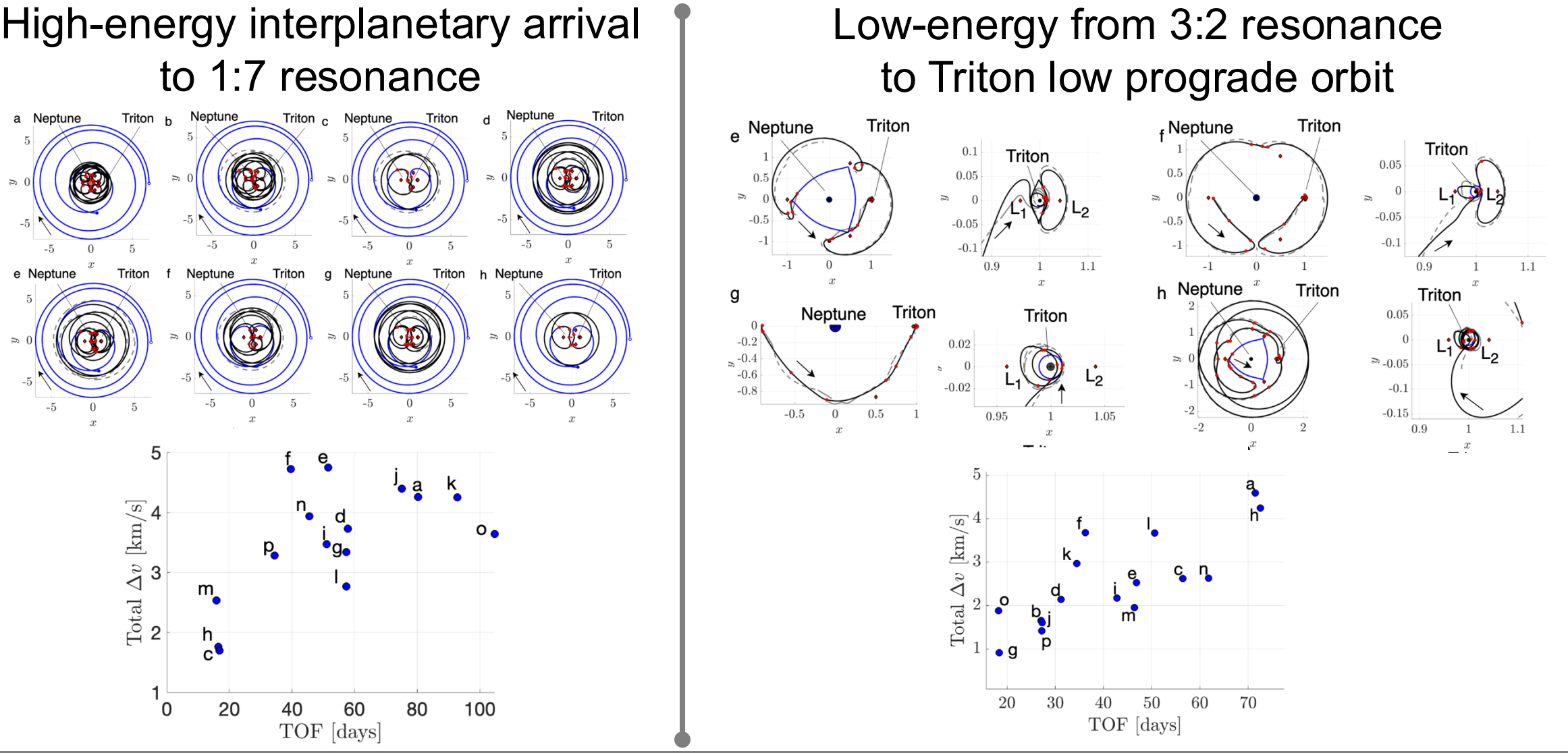
Benefits to other mission concepts

- Underlying algorithms readily adapted to other solar system destinations
- Supports concepts for planetary exploration, astrophysics, & heliophysics
- Suited for early concept formulation, enabling rapid iteration & maturation

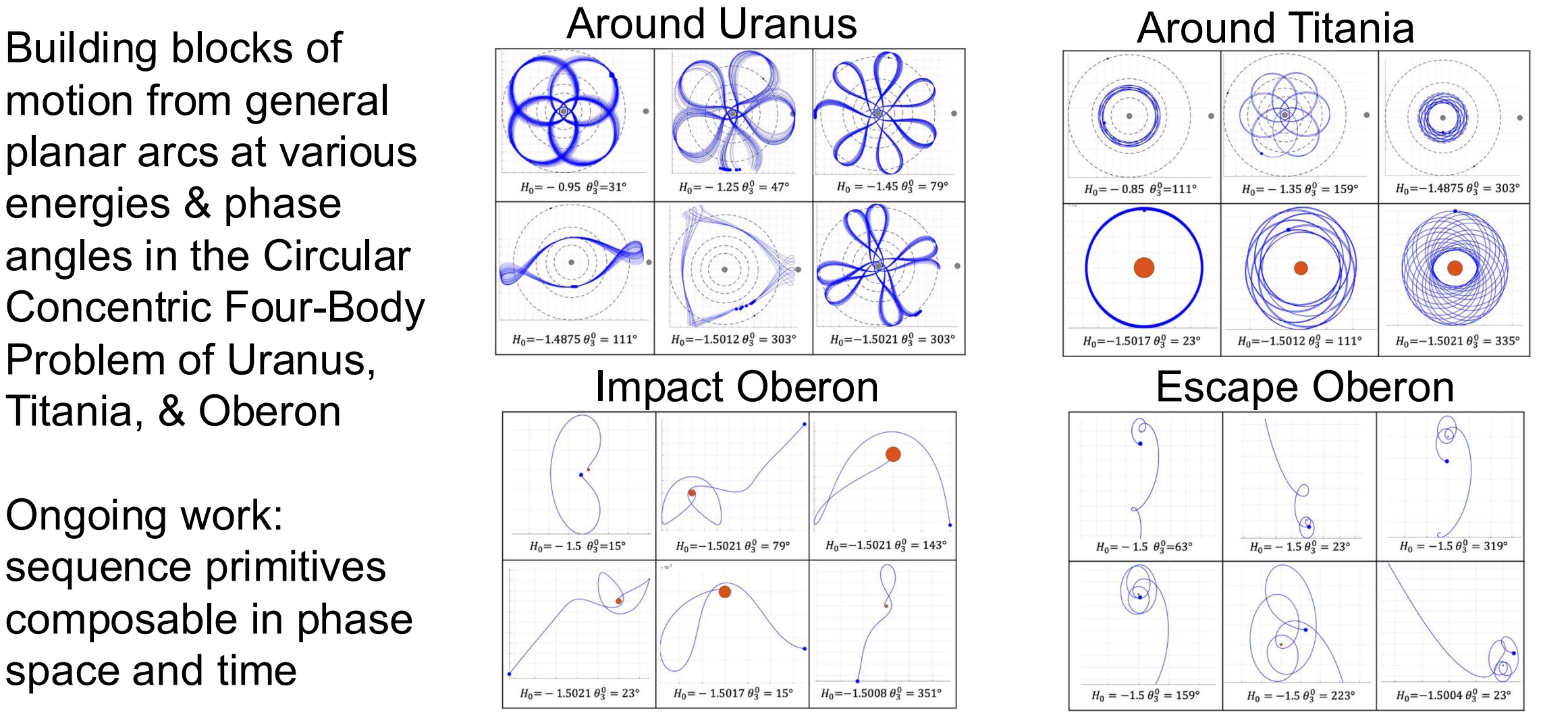
Trajectory Design Approach:



Planar Transfers in the Neptunian System:



Planar Motion Primitives in the Uranian System:



National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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Publications:

- [1] Miceli, G.E., Bosanac, N., ‘Generating Planar Trajectories for Neptunian System Exploration Using Motion Primitives’ Under Review
- [2] Miceli, G.E., ‘Data-Driven Spacecraft Trajectory Design for Planetary System Exploration,’ Ph.D. Dissertation, University of Colorado Boulder, August 2025
- [3] Giuliana Miceli, Natasha Bosanac, Reza Karimi, “Generating the Trajectory Design Space for Neptunian System Exploration” 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO, August 2024

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