Solar Electric Propulsion for Jovian Capture

Principal Investigator: Nathan Strange (312)
Damon Landau (343), Try Lam (343)

Project Objective:

This spontaneous concept study investigated the feasibility of using Solar Electric Propulsion (SEP) to reduce a spacecraft's Jupiter approach energy enough that it would be possible to capture the spacecraft into Jupiter orbit ballistically using flybys of the Galilean Satellites.

Ballistic capture at Jupiter then eliminates the need for a chemical propulsion orbit insertion burn. This could potentially enable a Jovian mission using only low power (~1kW at Jupiter) electric propulsion.

FY09 Results:

We have found SEP trajectories that deliver 700-1200 kg more mass than possible with chemical propulsion trajectories. This mass benefit accounts for the inert mass of the Ion Propulsion System (IPS) and solar arrays. These 7-8 year SEP trajectories with a 25 kW array (at 1 AU) can outperform all chemical trajectories with a flight times of 10 years or less.

In addition, such a system would provide ~1 kW at Jupiter , which would be sufficient to operate the IPS at Jupiter.

Benefits to NASA and JPL:

This new technique will provide exciting new capability to future NASA and JPL Jupiter missions:

- Enabling more mass for Jupiter missions
- Enabling electric propulsion missions to Jupiter to forgo the addition of a chemical bi-prop system without a lengthy spiral capture
- Greater robustness to increases in flight system mass, as a given SEP trajectory can be lengthened to allow more mass without a larger launch vehicle
- Enabling JIMO-like low-thrust Jovian tours with solar power instead of a nuclear reactor

SEP Provides High Mass at Low Approach Energies

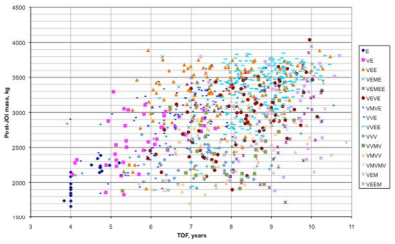
Chemical trajectories (on an Atlas V 551) to Jupiter max out at 3800-4000 kg of post Jupiter Orbit Insertion (JOI) mass.

If more mass than this is required with a chemical trajectory, a larger launch vehicle would be needed.

We have found 7-8 year SEP trajectories that deliver significantly more mass to Jupiter than even a 10 year chemical trajectory (on an Atlas V 551). This is even true if the larger inert mass of the Ion Propulsion System (IPS) and solar arrays are accounted for.

Moreover, the SEP trajectories provide additional robustness in that the delivered mass can be increased by lengthening the flight time to Jupiter.

Chemical Propulsion Trajectories
(Launch on Atlas V 551 w/ Inert Mass Subtracted)



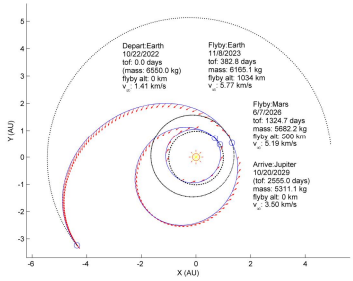
Chem. inert mass estimated by 10% of fuel mass for tankage + 50 kg

Example SEP Trajectories
(Launch on Atlas V 551 w/ Lunar GA)

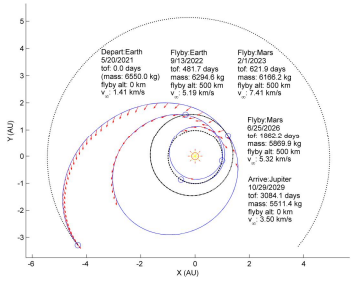
Path	Flight Time [yrs]	Array Power @ 1 AU [kW]	Number of Engines	Fuel Mass [kg]	Arrival Mass [kg]	Inert Mass Next / Ultraflex [kg]	(Arrival) - (Inert) [kg]	G-I Capture Period [mo]
EM	7.0	25	3+1	1239	5311	551	4760	8
EM	7.2	25	3+1	1160	5390	543	4847	8
EMM	8.4	25	3+1	1039	5511	531	4980	8
EMM	8.1	25	3+1	729	5821	500	5321	12
EMM	8.1	15	2+1	1157	5372	402	4970	12

SEP inert mass estimated by 10% of fuel mass + (Power)/(110 W/kg) + (50 kg)X(# of engines)

Example: 7 yr. EM Trajectory

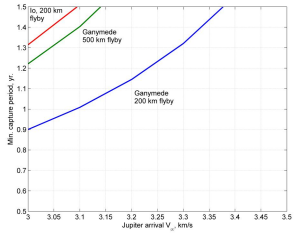


Example: 8.4 yr. EMM Trajectory

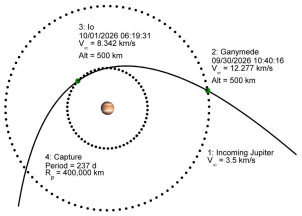


Galilean Satellites Enable Ballistic Capture

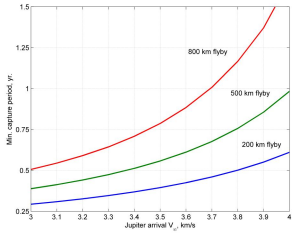
Single Ganymede or Io Flyby Jupiter Capture



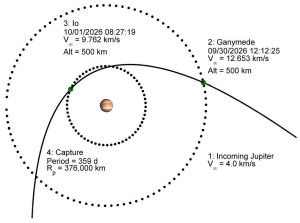
Ganymede-Io Capture into 8 mo orbit from 3.5 km/s V_∞



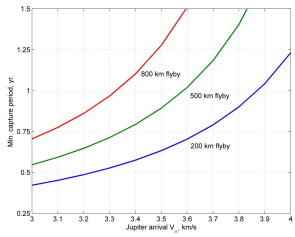
Jupiter Capture with Ganymede and Io Flybys



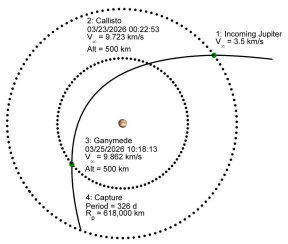
Ganymede-Io Capture into 12 mo orbit from 4.0 km/s V_∞



Jupiter Capture with Callisto and Ganymede Flybys



Callisto-Ganymede Capture into 11 mo orbit from 3.5 km/s V_∞



National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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