Jet Propulsion Laboratory
California Institute of Technology

Pluto Orbiter Study

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Objectives

Answer Jim Green's question, "Is it possible to put a New Horizons spacecraft into orbit around Pluto?"

Evaluate the range of ELVs currently available, and the capability afforded by the SLS

Identify enabling technology

Study Guidelines

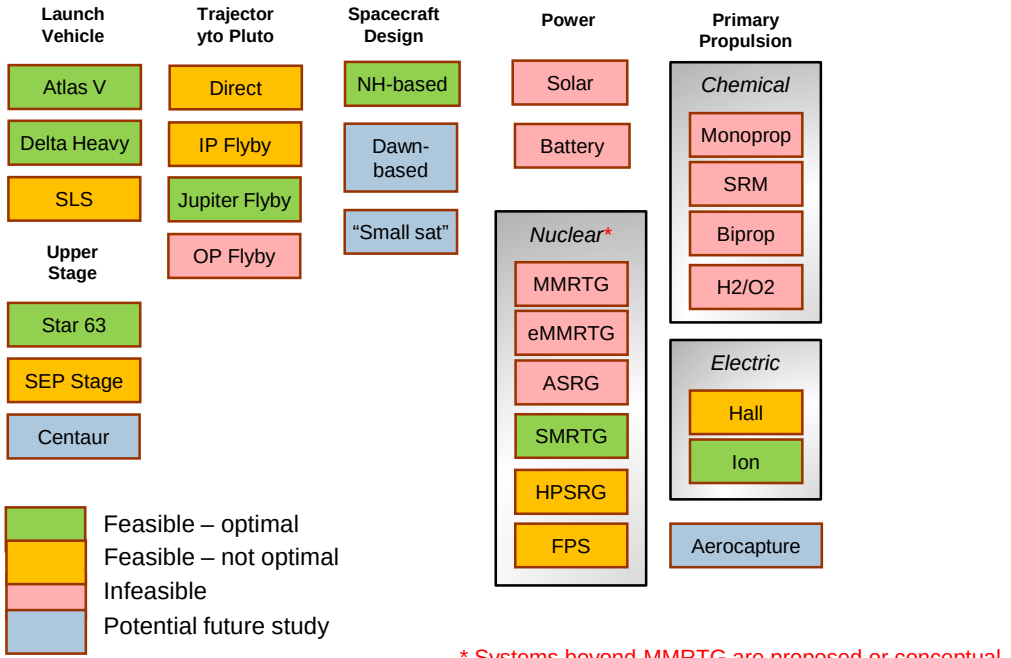
Assumptions

- Mission should achieve orbit at Pluto
- New Horizons mass spacecraft with New Horizons mass payload
- Trip time <15 years

Derived Requirements

- Use radioisotope electric propulsion (REP)
- >1 kW electric power available at Pluto

Trade Tree



* Systems beyond MMRTG are proposed or conceptual.

Mission Length

Getting to Pluto is doable with current technology (New Horizons)

- 9.5 year flight time
- ~400 kg dry mass
- ~200 W at encounter supplied by GPHS RTG

Stopping at Pluto (getting into orbit) is the challenge

- NH flew by Pluto at nearly 14 km/s
- Longer trip times can reduce approach velocity
  - 15 year trip time = ~10 km/s
  - 50 year trip time = ~2-3 km/s
- Transits longer than ~15 years likely not attractive
  - Begins to push the limits of RPS and other systems

Propulsion

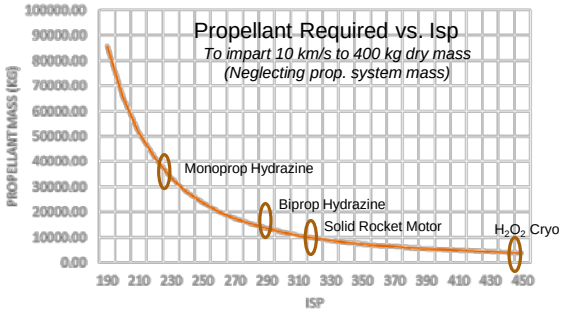
Assuming ~400 kg dry mass (New Horizons) s/c

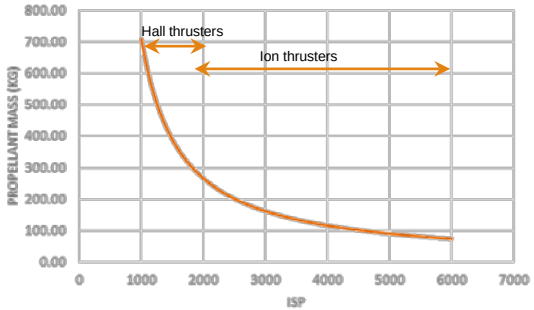
- Monoprop (Isp~230 s) would require >33,000 kg of propellant
- SRM (Isp~290 s) would require ~13,000 kg
- BiProp (Isp~320 s) would need ~9300 kg
- H2/O2 (Isp~450 s) would need ~3500 kg

Adding propulsion system mass to s/c dry mass quickly pushes all chemical options out of range of feasibility

Electric propulsion provides fuel efficiency needed to achieve high DV requirement

- Thrusters operating at Isp ~2000 s could reduce fuel requirement to <300 kg
  - Caveat that low thrust trajectory will increase DV requirement over impulsive burn





Power

Radioisotope power would be required; Solar is not an option at this distance

Trajectory analyses indicate that effective mission could be performed with ~ 1kW EP system

- Could be done with notional SMRTG (three 18-GPHS units at ~180 kg total), or four notional 8-GPHS SRGs at ~260 kg
  - Three unit configuration demonstrated on Cassini
  - SMRTG solution would use same amount of heat source plutonium as Cassini
- MMRTGs or eMMRTGs are not feasible
  - Would require 10 or more eMMRTGs at a total mass of ~450 kg
  - High heat source plutonium requirement: *~50% more than that used on Cassini*

Three-SMRTG power system assumed in modeling for this study

- ~1170 W available at Pluto arrival

Telecom

Higher power available from 1 kW SMRTG system could be exploited to increase data rates

Ka-band

- System using 100 W RF TWTA could return about 8 kbps to a 34m DSN station or 40 kbps to a 70m station using NH 2.1 m HGA
  - New Horizons predicts about 1 kbps with 12 W RF TWTA in X-band to 70m DSN station

Optical Comm

- Preliminary look at optical communications indicates possibility of data rate increase 1 to 2 orders of magnitude over Ka-band with comparable mass and power system
  - Dependent on link parameters chosen and assuming advanced technology laser

Results

Atlas V 551 could enable Pluto orbit in ~15.1 years

Delta IVH could enable Pluto orbit in ~15 years

SLS could enable Pluto orbit in ~14.9 years

Mission analysis assumes Jupiter flyby

- Launch dates end of 2028 or early 2029

Dry mass of s/c (minus propellant tanks) ~ 560 kg

- Includes 30 kg allocation for instruments (same as NH)
- Accounts for mass of power and propulsion system
- Propellant tank mass scaled with propellant

SLS

For the assumed flight system design SLS only cuts the flight time by ~30-50 days

- Trajectory is thrust limited for given power level
- SLS is underutilized for a 1 kW system

Higher EP power would enable either shorter trip time or higher delivered payload mass, or a combination of the two

- Increasing EOL power to 2 kW could decrease flight time from 15 to ~13 years using SLS
- Preliminary analysis indicates 10 kW provided by FPS using NEXT IPS could enable ~11.8 year flight time for NH mass spacecraft or increase delivered payload mass by ~900 kg over NH mass for a 14 year flight time
  - 20 kW could cut another year or add ~2000 kg payload mass

Conclusion

A New Horizons-mass Pluto orbiter with New Horizons-mass science payload appears feasible using currently available launch systems

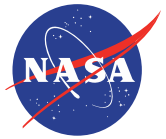
The lowest-cost option includes:

- Atlas V 551 launch vehicle
- EP system using commercially available XIPS 25 cm ion engines
- 1 kW of RPS power

SMRTG would be enabling technology

Optical Comm could enable significant increase in science return

A good candidate for future study would be a lower-mass spacecraft and science payload (*à la* smallsat)



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