JAXA's Solar System Exploration Program with Small Satellites: From PROCYON and EQUULEUS to Outer Solar System Exploration

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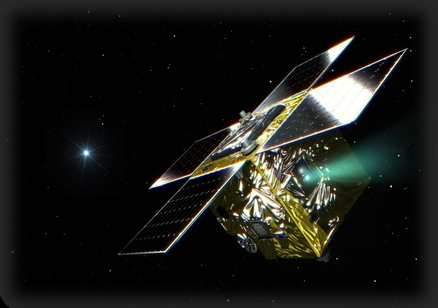
PROCYON (2014) with U. of Tokyo

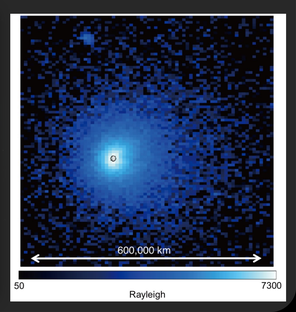
Size / Weight 55cm / 65kg

Orbit Interplanetary (Earth-resonant)

Achievements

- ✓ Demonstration of 50 kg-class deep space exploration micro-spacecraft bus including:
  - Deep space X-band communication system
  - X-band GaN SSPA (>32.7%, world's highest efficiency)
  - Xe-based ion / cold gas integrated propulsion system
- ✓ Science mission in deep space (Geocorona observation., etc)





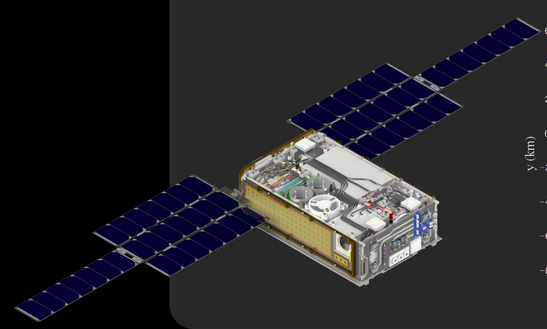
EQUULEUS (2022) with U. of Tokyo

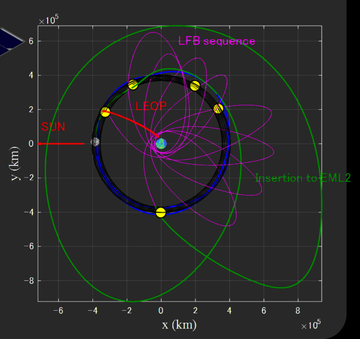
Size / Weight 6U / 10.5kg

Orbit Cislunar (Earth-Moon system)
(launched as Artemis-1 CubeSat)

Achievements

- ✓ Demonstration of deep space exploration CubeSat bus including miniature deep space X-band transponder
- ✓ Efficient / precise trajectory control demonstration withing the Sun-Earth-Moon region
- ✓ World's first orbital maneuver beyond LEO using water-based propulsion system





Comet Interceptor with ArkEdge Space

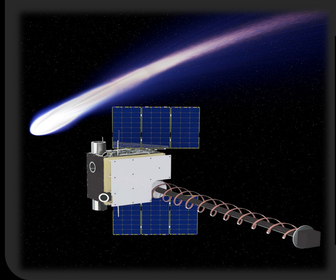
(planned delivery to ESA: 2026)

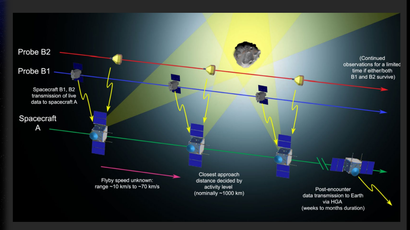
Size / Weight 24U / 35kg (one of the three S/C)

Orbit SEL2 → Comet flyby trajectory

Mission

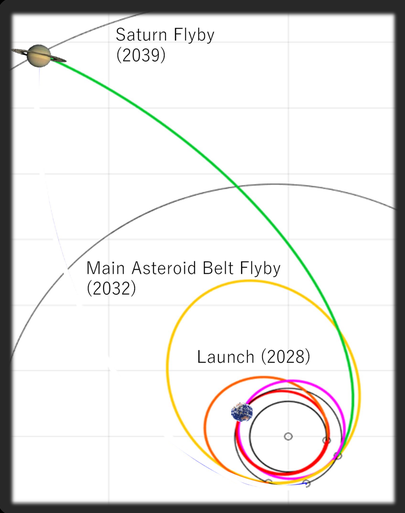
- ✓ First-ever observation of a long-period comet by ESA and JAXA, which will be performed by main S/C + two small probes (one of them contributed by JAXA)
- ✓ Autonomous flyby observation by a CubeSat-class probe
- ✓ Mission assurance/reliability approach using COTS units
- ✓ Techology transfer and support for start-up company



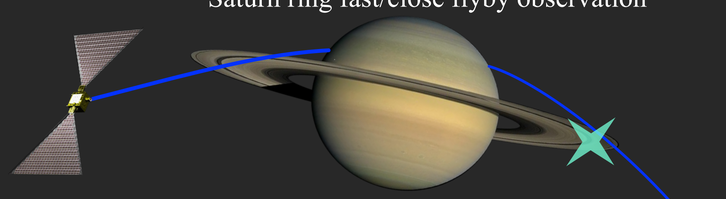


(credit: ESA)

OPENS-0: the first mission of OPENS (Outer Planet Exploration by Novel Small Spacecraft) program

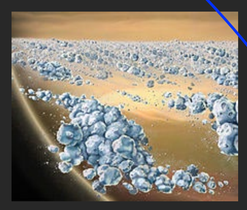


Saturn ring fast/close flyby observation



Mission Sequence Plan

2028：Launch by a small launcher
2029：Earth Swing-by #1
& Cruising Sciences Start
2030：Venus Swing-by & Observation
2031：Earth Swing-by #2
2034：Earth Swing-by #3
2039：Saturn Flyby



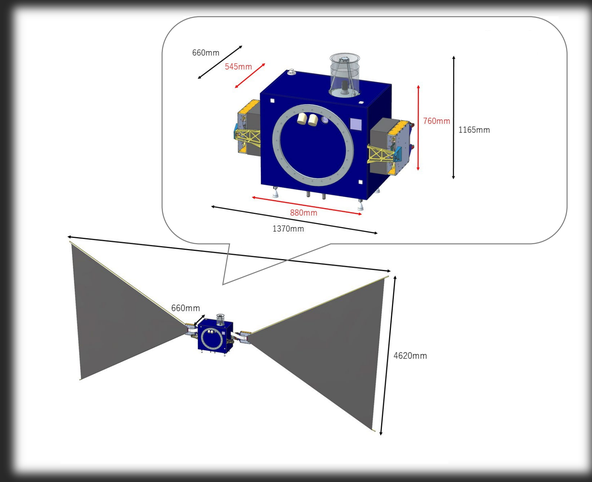
(credit: NASA)

Primary mission objective

Demonstration of key technologies to enable outer planet exploration with low-cost small (100kg-class) spacecraft that can be launched by small launch vehicles

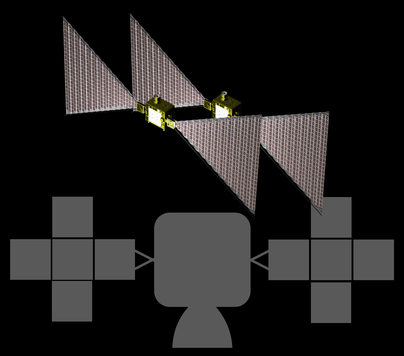
Key technologies to be demonstrated

- ✓ Light-weight membrane-based solar array paddle
  - 50W@9AU, 9m², 24kg without gimbals, equivalent to >150W/kg at Earth distance
- ✓ Thermal design to minimize the required heater power in the outer planet region
- ✓ Cost/weight effective reliability approach to survive long term deep space environments while using COTS units (e.g., hibernation operation)

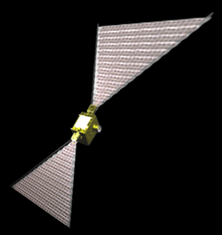


Programmatic approach for higher frequency outer planet exploration in the 2030s after OPENS-0 (OPENS-1,2,…X)

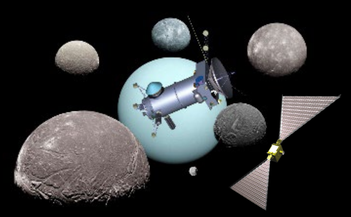
Large launcher and/or orbital transfer vehicle
+ multiple missions (constellations of small spacecraft)



Small launcher
+ stand-alone independent small spacecraft



Mothership-daughtership collaboration within an international flagship mission



(image source: NASA)

(credit: NASA)