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BIRDY – SmallSat for NEO reconnaissance and exploration

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ESEP
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ODYSSEUS

l'Observatoire de Paris | PSL

Space missions to small bodies

- ***Reconnaissance objectives***
  - get mass + porosity
  - improve orbit

  ⇒ essential to risk assessment
  ⇒ essential to mitigation design/optimisation

- **About 25 small bodies visited**
  - asteroids / comets / small satellites including NEOs

  - mostly fly-by (*F*)
  - snapshot image…. *±complete*
  - mass estimate……. *seldomly*

⇒ ***Develop radio-science capabilities in a fly-by or a rdv***

Target	Mission		Mass	Date
Asteroids				
(10955) Bennu	OSIRIS-Rex	O+SR	Y	Jul. 2020
(486958) Arrokoth	New Horizons	Fly-by	N	Jan. 2019
(162173) Ryugu	Hayabusa2	O+SR	Y	Jul. 2018
(4179) Toutatis	Chang'E 2	Fly-by	N	Dec. 2012
(21) Lutetia	Rosetta	Fly-by	Y	July 2010
(2867) Steins	Rosetta	Fly-by	N	Sep. 2008
(25143) Itokawa	Hayabusa	Orbit+SR	Y	June 2005
(5535) AnneFrank	Stardust	Fly-by	N	Nov. 2002
(433) Eros	NEAR Shoemaker	Orbit+landing	Y	Feb. 2000
(2685) Masursky	Cassini/Huygens	Fly-by	N	Jan. 2000
(9969) Braille	Deep Space 1	Fly-by	N	Jan. 1999
(253) Mathilde	NEAR Shoemaker	Fly-by	Y	June 1997
(243) Ida	Galileo	Fly-by	N	Aug. 1993
(951) Gaspra	Galileo	Fly-by	N	Oct. 1991
Comets				
67P/Churyumov–Gerasimenko.	Rosetta	Orbit+landing	Y	Aug. 2014
103P/Hartley2	EPOXI(Deep Impact extended inv. DIXI)	Fly-by	N	Nov. 2010
9P/Tempel 1	Deep Impact, Stardust	Orbit+impact, Fly-by	N	Jul. 2005, 2011
81P/Wild 2	Stardust	Orbit+SR	N	Jan. 2004
19P/Borrelly	Deep Space 1	Fly-by	N	Sep. 2001
26P/Grigg-Skjellerup	Giotto	Fly-by	N	Jul. 1992
1P/Halley	Giotto, Vega 1&2, Sakigake, Suisei, ICE	Fly-bys	Y	March 1986,
21P/Giacobini-Zinner	ICE	Fly-by	N	Sep. 1985
Moons				
M1 Phobos	MEX, ODY, MGS, Phobos2, Viking1	Multiple fly-bys	Y	2004, 2001, 1997, 1989, 1976
M2 Deimos	MEX, ODY, MGS, Viking2	Multiple fly-bys	Y	2004, 2001, 1997, 1976

Nota : DAWN, New Horizons to dwarf planets not mentioned.
Ida's mass obtained from the Ida+Dactyl binary relative orbit

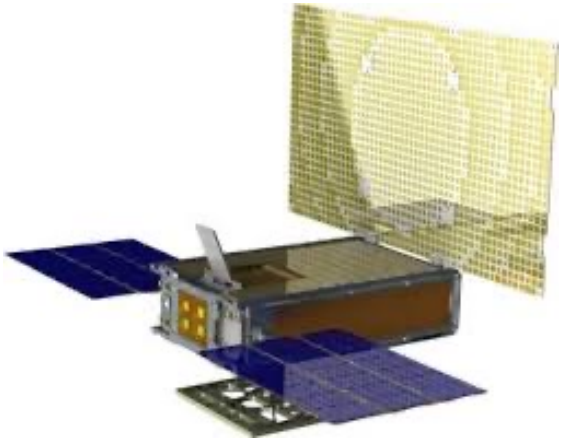
CubeSat/nanosatellites advantages

- vs. “traditional” satellite mission:

→ Reduction of launch and development costs

→ Reduction of development cycle time (standards)

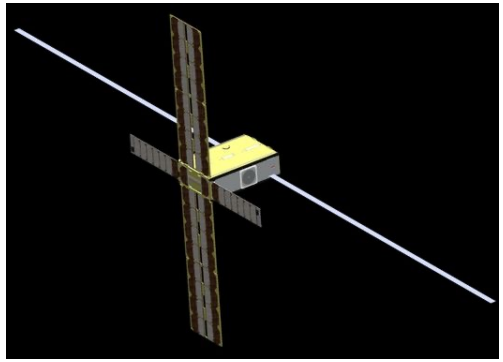
- Use of COTS components
- Dedicated subsystems
- More and more SmallSats 1U, 2U, 3U, 6U, …



MaRCO (JPL)

- interplanetary: stand-alone or companion to mothercraft/carrier

- **Advantages:**
  - **fast developments/readiness**
  - **simple specific tasks**
  - **multi-points measurements + relative measurements**



Hera/Juventas (ESA)

Planetary Defence - Reconnaissance

- A matter of warning time – **Two precursor baseline options**
  depending on alert situation
  - in-depth Exploration [best case rendez-vous]
  - quick Reconnaissance [worst case, likely… fly-by]

- **Mission objectives**
  - small fleet of 2 replicate CubeSats + S/C carrier
  - camera imaging shape, size, (binarity)
  - inter-satellite links (2way, radio-optical)
  - mass & porosity
  - refine orbit

- **Rendez-vous – low velocity encounters**
  - close to surface, and multiple flybys
  - deep knowledge, imaging & radio-science
  - + post-mitigation validation

- **Single fly-by – high velocity encounter**
  - 1st and last minute look
  - Imaging & radio-science
  - -> principle of NEOcore mission

- **Current developments**
  - Auto-navigation & Radio-science test-benches