POLITECNICO
MILANO 1863

CISLUNAR DEPARTURE EXPLOITATION FOR PLANETARY DEFENSE MISSION DESIGN

7° IAA Planetary Defense Conference – PDC 21

A. Pasquale, M. Lavagna, F. Renk

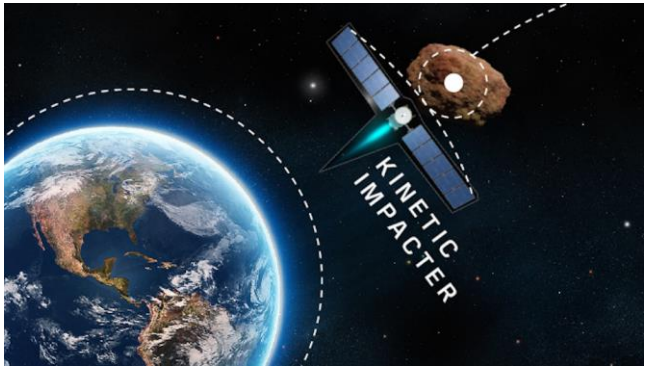
esa

DIPARTIMENTO DI
SCIENZE E TECNOLOGIE
AEROSPAZIALI

Context, Motivation & Objectives

International Space Exploration Coordination Group (ISECG) agencies increased interest in **cislunar** space.

Lunar Gateway (LOP-G)



Increasing concerns about **planetary defense** issues:

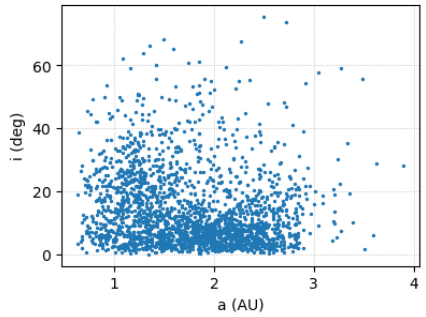
- Early **detection** of potentially hazardous objects;
- **Tracking** and characterization of PHOs;
- Issue **warnings** of the possible effects of potential impacts;
- Study strategies and technologies for **mitigating** PHO.

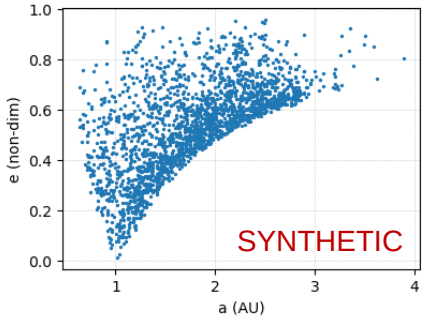
Preliminary assess the feasibility to exploit the cislunar space as a departing point for planetary defense missions.

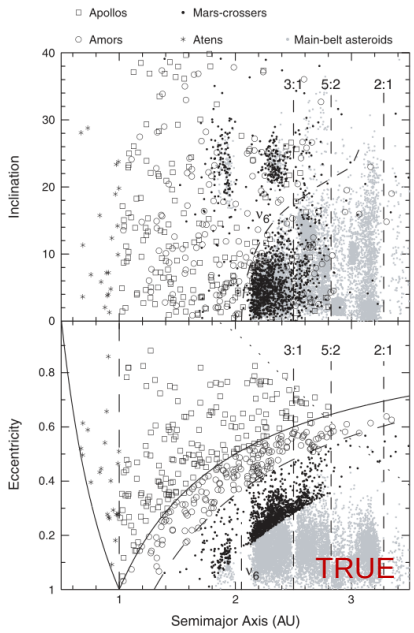
NEA/PHA Modelling

- Generation of an arbitrary-sized NEO/PHO **synthetic** distribution
- Extraction of **tracked** object database *(merge NASA JPL Small Body and Minor Planet Center databases).*

Target region defined.







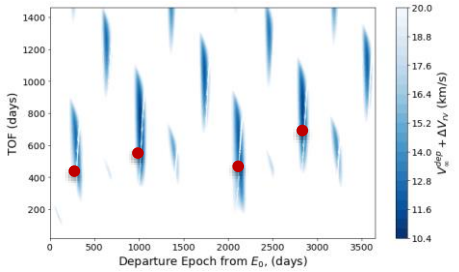
Mission Scenario Definition

Two-step optimization

RENDEZVOUS

The **total transfer energy** is minimized, i.e.

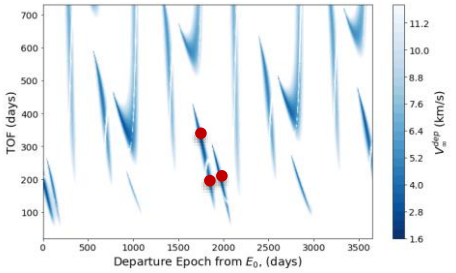
$$\min_{E_0,TOF} \sqrt{C_3} + \Delta V_{rv}$$



FLYBY

1. **Departure energy** minimization,

$$\min_{E_0,TOF} \sqrt{C_3}$$



2. Encounter **relative velocity** constrained minimization

$$\min|\boldsymbol{U}| \; s.t. V_\infty \in [0, cV_\infty^1]$$

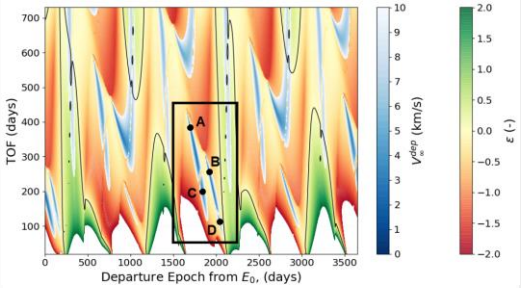
KINETIC IMPACT

1. **Departure energy** minimization,

$$\min_{E_0,TOF} \sqrt{C_3}$$

2. **Impact efficiency** maximization,

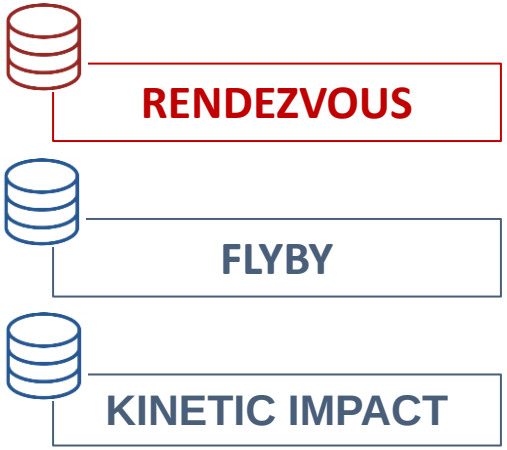
$$\min|1/\varepsilon| \; s.t. V_\infty \in [0, cV_\infty^1]$$



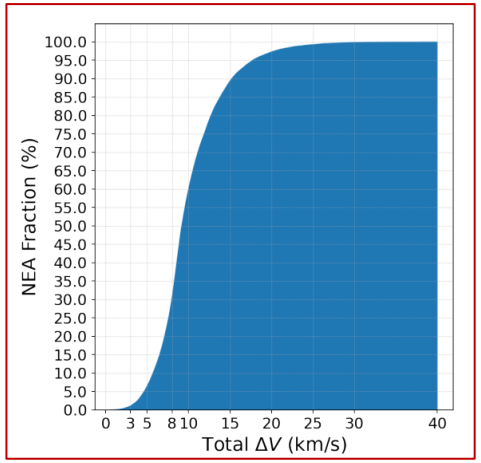
Large scale **Lambert**-based search.

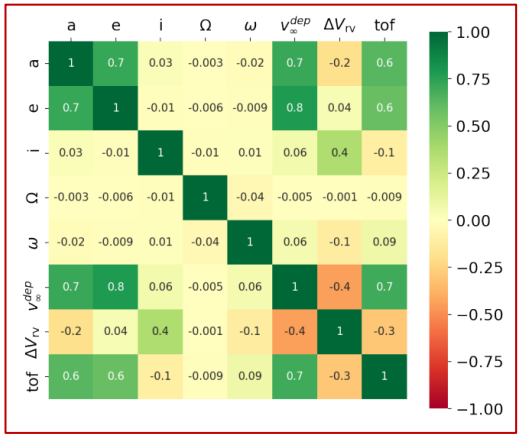
Reachability Analysis

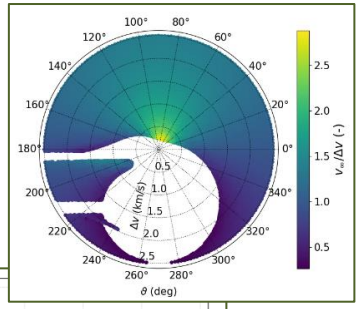
- A database of **transfers** is generated.

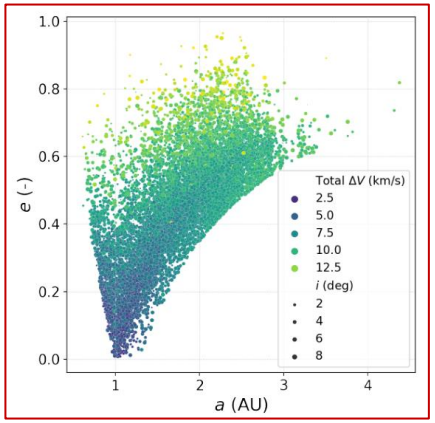


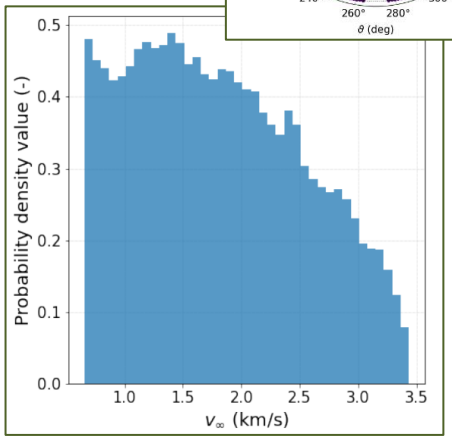
- A database of **escape conditions** is created.

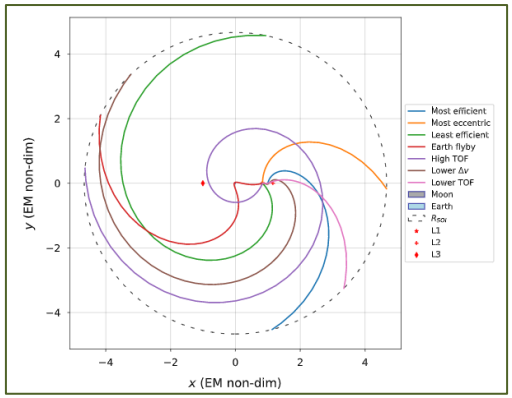




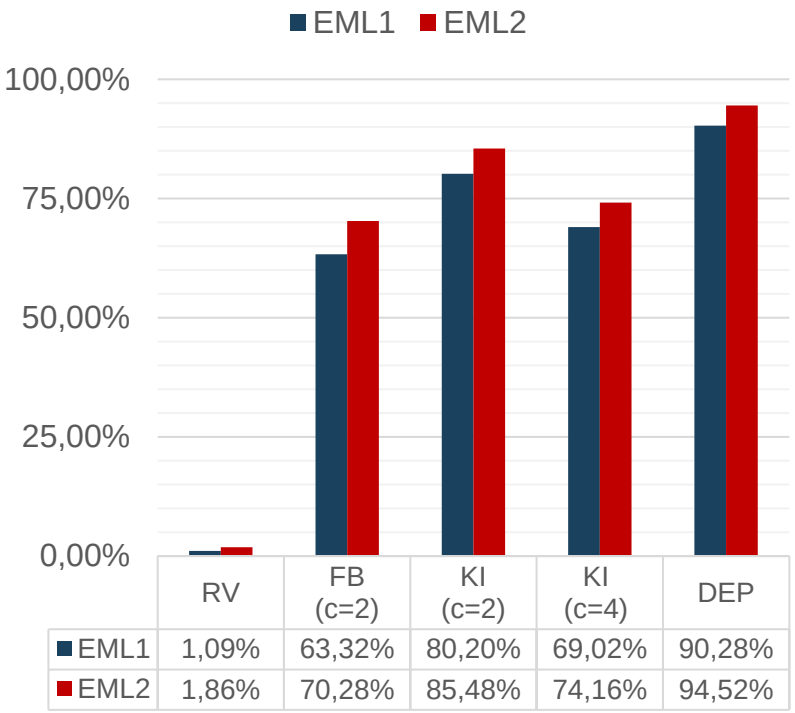






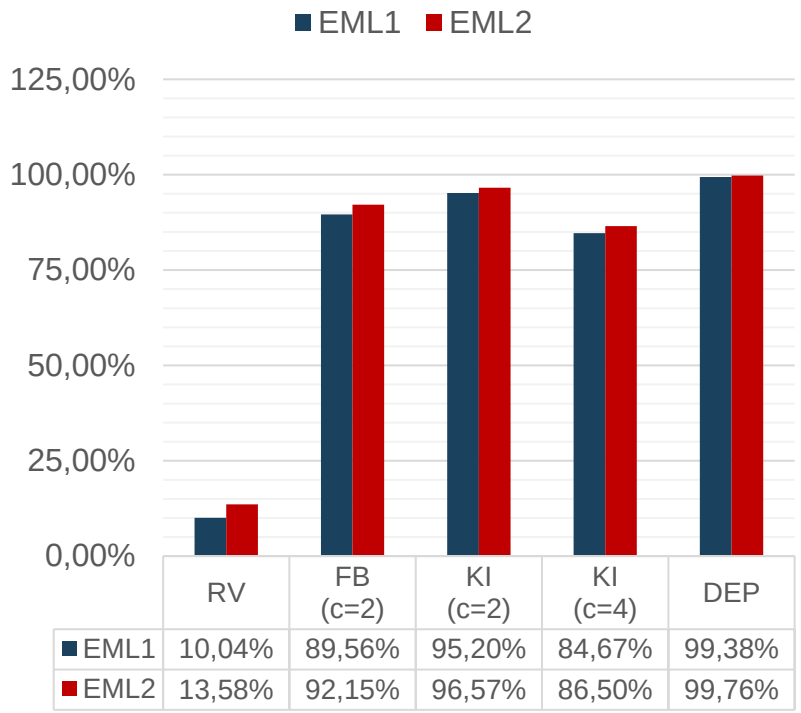


Envelope Of Reachable NEA From EML1/EML2



	RV	FB (c=2)	KI (c=2)	KI (c=4)	DEP
EML1	1,09%	63,32%	80,20%	69,02%	90,28%
EML2	1,86%	70,28%	85,48%	74,16%	94,52%

ΔV budget of 2,5 km/s



	RV	FB (c=2)	KI (c=2)	KI (c=4)	DEP
EML1	10,04%	89,56%	95,20%	84,67%	99,38%
EML2	13,58%	92,15%	96,57%	86,50%	99,76%

ΔV budget of 5,0 km/s

POLITECNICO
MILANO 1863

CISLUNAR DEPARTURE EXPLOITATION FOR PLANETARY DEFENSE MISSION DESIGN

7° IAA Planetary Defense Conference – PDC 21

A. Pasquale, M. Lavagna, F. Renk

esa

DIPARTIMENTO DI
SCIENZE E TECNOLOGIE
AEROSPAZIALI