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SOLAR-SAILING TRAJECTORY DESIGN FOR CLOSE-UP NEA OBSERVATIONS MISSION

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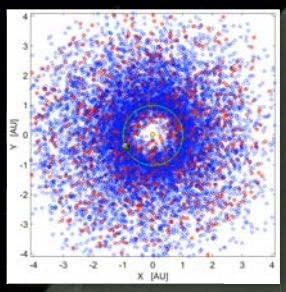
Why a multiple NEA rendezvous mission through solar sailing?

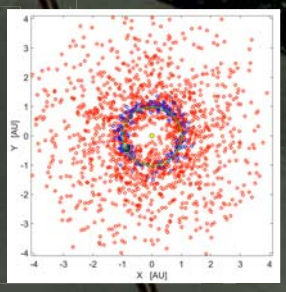
A good knowledge of chemical and physical properties of NEAs is needed in order to plan any mitigation mission. In order to improve our knowledge about NEAs, a rendezvous with these objects is better than ground-based observations, although more expensive. Moreover, the number of possible NEAs to visit is very large.

Multiple NEA rendezvous missions can be a way to visit as many objects as possible within one single mission, thereby reducing the cost for a single rendezvous.

Because of the high Δv required, solar sailing can be a good way to perform this kind of mission.



Heliocentric view of the positions of all NEAs (blue) and PHAs (red) on 13 April 2015



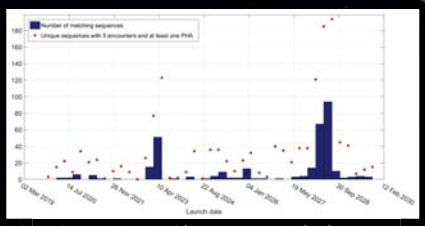
Heliocentric view of the positions of all objects in the database taken into account (NHATS asteroids in blue and PHAs in red) on 13 April 2015

- A tree search algorithm has been developed in order to find as many sequences of NEAs as possible within the mission requirements underlined in the DLR/ESA Gossamer roadmap [1].
- An automatic tool has been developed in order to optimize the sequences chosen from the previous output.
- A solar sail with a lower area-to-mass ratio, with respect to Ref. [1], has been taken into consideration, so that more payload can be carried on or a smaller sail can be used, raising the TRL.

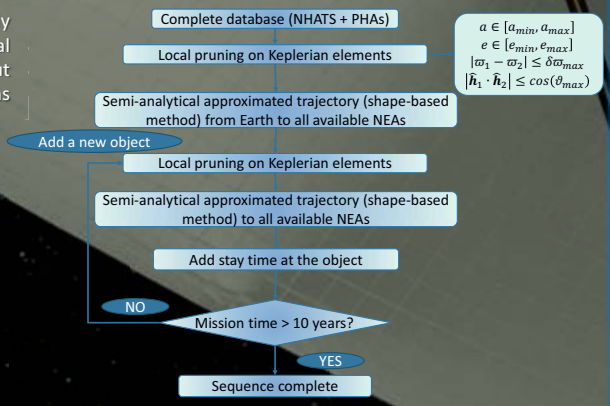
Sequence search

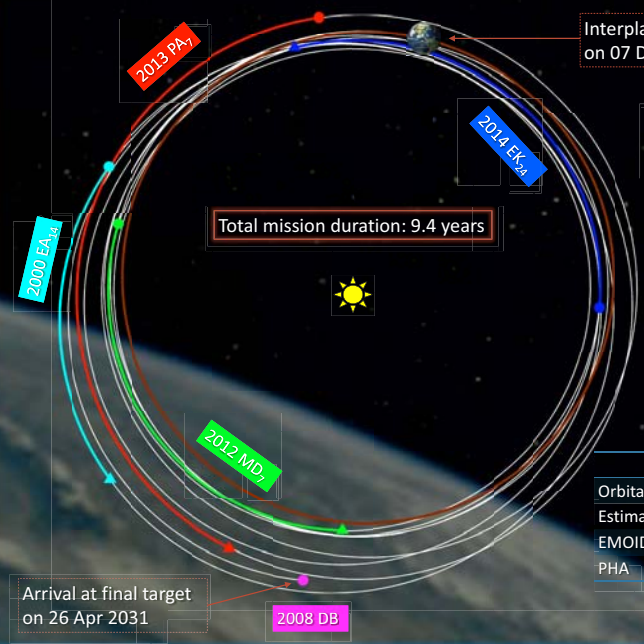
Starting from a database made of NHATS† asteroids and PHAs only and pruning the temporary database by means of astrodynamical considerations, a systematic search of sequences has been carried out with launch dates from 28 Nov 2019 for 10 years with 3 months intervals.

†Near-Earth Object Human Space Flight Accessible Targets Study (http://neo.jpl.nasa.gov/nhats/)



Unique sequences with 5 encounters and at least one PHA found by the sequence finder algorithm





Optimized sequence test case

Mission properties and an overview of the overall mission profile are shown for one of the sequences found by the sequence finder algorithm and optimized through the automatic algorithm developed. Note that all the objects are NHATS asteroids except 2000 EA_{14}, which is classified as PHA.

Image credit: NASA/JHUAPL

	2014 EK_{24}	2013 PA_7	2012 MD_7	2000 EA_{14}	2008 DB
Orbital type	Apollo	Amor	Aten	Apollo	Apollo
Estimated size [m]	65 – 150	85 – 190	40 – 95	170 – 370	20 – 50
EMOID [AU]	0.034	0.091	0.018	0.043	0.002
PHA	NO	NO	NO	YES	NO

References

[1] Dachwald, B., Boehnhardt, H., Broj, U., Geppert, U. R. M. E., Grundmann, J.-T., Seboldt, W., Seefeldt, P., Spietz, P., Johnson, L., Kührt, E., Mottola, S., Macdonald, M., McInnes, C. R., Vasile, M. and Reinhard, R., "Gossamer Roadmap Technology Reference Study for a Multiple NEO Rendezvous Mission," *Advances in Solar Sailing*, edited by M. Macdonald, Springer Praxis Books, Springer Berlin Heidelberg, 2014, pp. 211-226.

Image credit: NASA