Detection performance of L1-based NEO surveys

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Introduction

Space based asteroid surveys offer various advantages that make them valuable complements to ground based observations. Among these are:

- Less restricted observation times
- Potentially favorable positions to observe currently sparsely known asteroids groups (Atiras).

Dedicated telescopes are expensive, however, and enough time on large space telescopes is difficult to obtain for time-intensive surveys. A considerable potential might lay in the use of compact sensors or smaller devices already installed on spacecraft that have spare operating time.
Even though the discovery rate of these sensors would be considerably lower compared to larger missions, the lower cost and a potentially large number of instruments on different spacecraft might make them worthwhile.

Sensors and Orbit

Sensors

Main sensor characteristics:

- Visible range sensors
- Maximum instrument mass: 3 kg
- Based on existing instruments

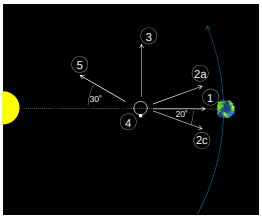
Three sensors were chosen in order to allow a trade-off between field of view and limiting magnitude.

Simulated sensors			
	SPOSH (SP)	**Terma Star Tracker (ST)**	**Telecam (TC)**
FoV [deg²]	140x140	22x22	5x5
Limiting magnitude [mag]	9	14	16
Aperture diam. [mm]	6.5	22	50

Orbit and Pointing

- Spacecraft on L1-orbit
- 7 different pointing scenarios:

1 - centered on Earth
2 - 20 deg offset to Sun-Earth vector
3 - 90 deg offset to Sun-Earth vector in the Ecliptic
4 - 90 deg offset to Sun-Earth vector perpendicular to the ecliptic
5 - 150 deg offset to the Sun-Earth vector

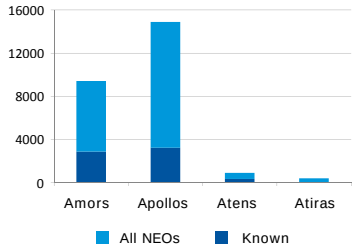


Underlying NEO-Population

- Based on the 2015 NEO model of Granvik, Morbidelli, Bottke and collaborators
- Subset with absolute magnitude H < 22 (25,653 objects)

Known shares brighter than 22nd magnitude (estimates):

- Amors: 31 %
- Apollos: 22 %
- Atens: 39 %
- Atiras: 3 %



Simulation Tool

- Uses 2015 NEO population model of Granvik, Morbidelli, Bottke and collaborators
- Allows generation, analysis, and visualization of NEO populations
- Allows simulation, analysis, and visualization of observations, using built in optical and radar sensor performance models

Results

Detected objects in modelled population (10 years)								
Sensor	***Scenario***	***1***	***2a***	***2b***	***2d***	***3***	***4***	***5***
SP	Mean	0.3	0.3			0.1		
	StdDev	*0.5*	*0.5*			*0.3*		
ST	Mean	17.6	12.2	11.3	13.2	7.9	5.7	8.9
	StdDev	*3.7*	*3.2*	*3.1*	*3.1*	*2.4*	*2.4*	*1.3*
TC	Mean	17.3	16.6	14.3	15.1	12.8	5.8	18.6
	StdDev	*4.3*	*3.8*	*4.0*	*3.9*	*3.4*	*2.5*	*2.7*

The results clearly similarly good performances of the ST and the TC sensors.

In order to obtain a better indication of the performance to discover new objects, an observation simulation was carried out on the known population. The difference between the two simulations gives an indication of how many new discoveries may be expected. This perspective clearly shows the advantage of a more sensitive sensor over less sensitive sensors with a larger field of view.

Estimate of new discoveries (10 years)							
Scenario:	***1***	***2a***	***2b***	***2d***	***3***	***4***	***5***
ST		0.0			0.0	1.2	
TC	1.5	1.6	0.1	1.7	1.2	1.6	0.6

Given the relatively few discoveries, it might be interesting to use more sensitive sensors. The following table shows how the performance could be improved if the ST and the TS sensor both had a limit improved by two magnitudes.

Estimate of new discoveries with better sensors (10 years)							
Scenario:	***1***	***2a***	***2b***	***2d***	***3***	***4***	***5***
ST $H_{v,Lim} = 16$		13.6			7.6	15.5	
TC $H_{v,Lim} = 18$	13.8	15.6	15.4	9.1	20.0	11.6	21.0

Conclusions

The simulations showed a relatively weak discovery performance for the original sensors that fitted the defined mass envelope of 3 kg. The results thus strongly suggest to employ more sensitive sensors in order to achieve a better survey performance if deployed as a single sensor. Within the scope of the considered values, they also indicate that an improvement in sensitivity should be preferred over an improvement in field of view.
Given the relatively low mass of the sensors, though, it might be worth to consider them as payloads distributed on several missions, or in case of the Star Trackers, to use flying hardware during otherwise idle time.

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