SEARCHING FOR INTERIOR TO EARTH ORBIT ASTEROIDS (IEO'S) BY USING SPACECRAFT STAR TRACKERS. H. Svedhem[1] and D. Koschny[2], [1]ESA/ESTEC, PB 299, 2200AG Noordwijk, The Netherlands, H.Svedhem@esa.int, [2]ESA/ESTEC, PB 299 2200AG Noordwijk, The Netherlands, Detlef.Koschny@esa.int.

Introduction: Only a few handfuls of objects on orbits entirely inside the orbit of the Earth are known to date. These objects are notoriously difficult to detect from ground as they only display a small crescent of light towards the observer and as they can only be observed at times near sunrise and sunset. A spacecraft in a position inside the orbit of the Earth, however, will have a much more advantageous position for observing such objects. These spacecraft can be interplanetary probes in heliospheric orbit, or Venus and Mercury orbiters. As at the moment there is no dedicated asteroid search mission in such orbits we have investigated what could be done by using the Star Tracker of a presently flying spacecraft, namely Venus Express.

Spacecraft Star Trackers are of course not the ideal instruments to search for asteroids as they have a small aperture compared to what a dedicated instrument would have, but they can have the advantage of being at the right place and look in the right direction, and they can be operating for extended periods. As there normally, for redundancy purpose, are at least two star trackers on any interplanetary spacecraft, and only one is used for navigation, at least one could be operating for the purpose of looking for asteroids as long it is not needed for navigation.

Initial tests: Venus Express carries two identical Star Trackers manufactured by Selex Galileo, Italy. They are each equipped with 1k by 1k CCD's with 13µm by 13 µm pixels, and optics with a 30 mm aperture and a Field of View of 16.6 degrees. The present software allows reading out only small sub frames of max 15 by 15 pixels and the present maximum software limits the integration time to 10 s. Using 10 s integration time and unprocessed images we reach a limiting magnitude of +12.1 on the raw images.

We have demonstrated the feasibility from Venus orbit by taking 3 by 3 such sub frames in order to get small images of 45 by 45 pixels centered on different main belt asteroids at different intervals. The motion against the backgrounds stars have been verified for 6 different asteroids.

Modeling: We have used the NEO model of Bottke [1] and synthezised about 100 artificial objects on orbits entirely inside the orbit of the Earth. We have used the real trajectory and pointing as experienced by the Venus Express spacecraft between May 2006 and July 2007. For 8 hours per day the spacecraft communicates with the Earth and thereby the Star Trackers point in an almost inertial attitude near the ecliptic plane, and always away from the Sun. For these 8 hour per day we have tested if any of these model objects has passed within the 16.6 degrees Field of view of the Star Tracker. If an object has appeared in three consecutive images (separated by 2 hours) a hit is registered.

Result: For an extrapolated integration time of 100s, and using an estimated limiting magnitude of +14.6 and the model and spacecraft parameters as described above, we predict that Venus Express will find 5 IEO's during the remaining 50 months of operation (assuming 8 out of 24 hour operation).

S/W modification: A study has been initiated in order to design a software patch to the Venus express Star Trackers that will allow an increased integration time up to 300 s, to allow reading out full frame images and to allow on board cosmic ray suppression. A potential difficult problem to solve is the limited amount of data memory available on the Venus Express Star Tracker. This problem may also be important on other models but future models could be adapted and be equipped with additional memory at a reasonable cost. If the software patch fro Venus Express will turn out well we may try this in orbit and get down between 10 and 30 images per 24 hours for further processing on Earth.

Conclusions: We have demonstrated feasibility of detecting IEO's from interplanetary spacecraft inside the orbit of the Earth. The results are far from those expected from a dedicated mission but by using many spacecraft together a reasonable result may be possible at a very low cost as no or only little new hardware will be needed. We predict that Venus Express will find 5 IEO's in 50 months with the present performance. Adding more spacecraft with possibly better instruments may enhance this number significantly.

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References:

[1] Bottke et al. (2002), Debiased orbital and size distribution of near-Earth-objects, Icarus 156, 399-433.