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POSSIBILITIES OF USING A SPACECRAFT LOCATED IN THE VICINITY OF THE LIBRATION POINT FOR NEAR-EARTH OBJECTS EXPLORATION

Maxim Pupkov, Natan Eismont, Vladislav Zubko and Konstantin Fedyaev
Space Research Institute of Russian Academy of Sciences, 84/32 Profsoyuznaya Str, Moscow, 117997, Russia, m.pupkov@iki.rssi.ru

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Extended Abstract—

The current study shows various possibilities for extending the mission of a spacecraft located in a vicinity of a Sun-Earth libration point to determine physical characteristics of near-Earth objects. Such an extension is possible if the main onboard systems of the spacecraft function properly after the completion of the planned part of the mission, as well as there is enough amount of propellant in the fuel tanks to carry out the necessary impulses. A similar task was successfully solved in the ICE-3 project [1], in which the spacecraft was successfully redirected to the Giacobini-Zinner and the Halley comets from the vicinity of the Sun-Earth libration point L_1.

Presently, there are a number of spacecraft that operate in vicinities of the Sun-Earth collinear libration points. These include the Spectrum-Roentgen-Gamma space observatory (SRG) [2], which was successfully launched in July 2019 and is currently in an orbit around the Sun-Earth libration point L_2. Its trajectory, simulated in the NASA GMAT software system, is shown at Figure 1.

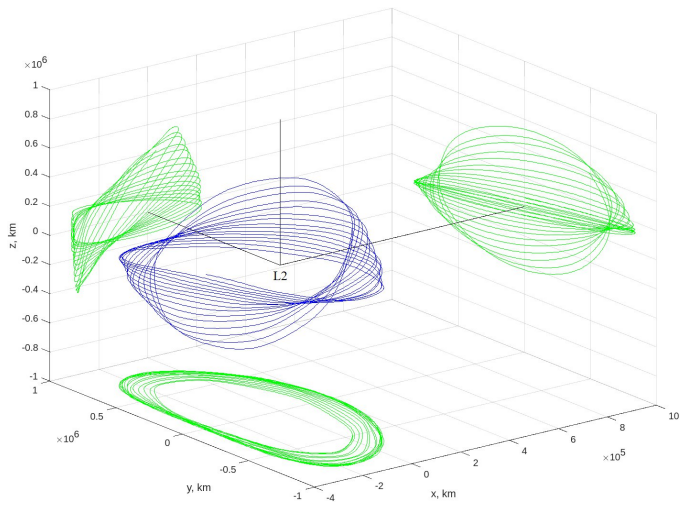

Figure 1. Trajectory of the SRG space observatory

According to preliminary estimates [3], by 2029, after the completion of the main mission, there will be enough fuel to supply impulses necessary for redirecting the spacecraft to a trajectory of a close approach to some asteroids. 2029 is of particular interest, since this year the next close approach to the Earth of the Apophis asteroid [4] takes place.

Figure 2 shows a simulated trajectory of the SRG spacecraft after redirection to Apophis. The encounter date is April 11, 2029. The estimated relative velocity of the asteroid flyby at the moment of the close approach is almost two times less than in the case of the passage of the asteroid Matilda by the interplanetary station "NEAR Shoemaker" in June 1997 [5].

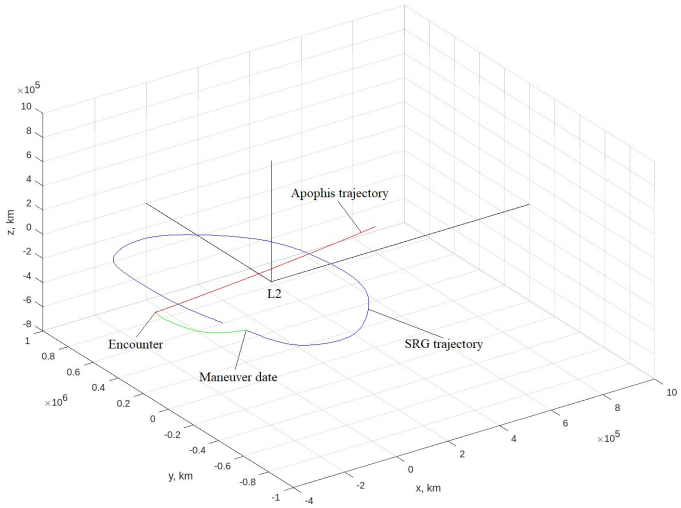

Figure 2. Transfer trajectory of the SRG space observatory to a close approach to Apophis

As the results of the simulation show, after approaching Apophis the SRG spacecraft may be

returned back to a restricted orbit in a vicinity of the L_2 libration point (see Figure 3).

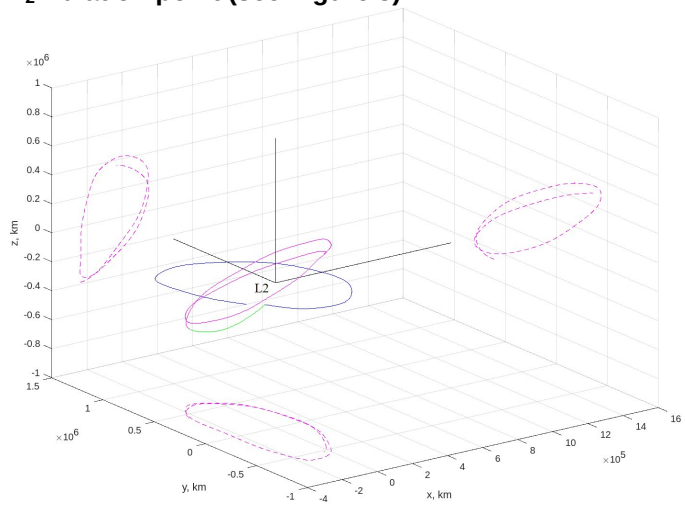

Figure 3. The trajectory of the SRG space observatory after the close approach to Apophis

Also other possible targets for an extended mission of the SRG observatory can be found. In particular, the asteroid 1990 MU is considered as a candidate for such a mission. The next close approach of the asteroid to the Earth takes place in 2027. Figure 4 shows the corresponding simulated trajectory of the SRG spacecraft.

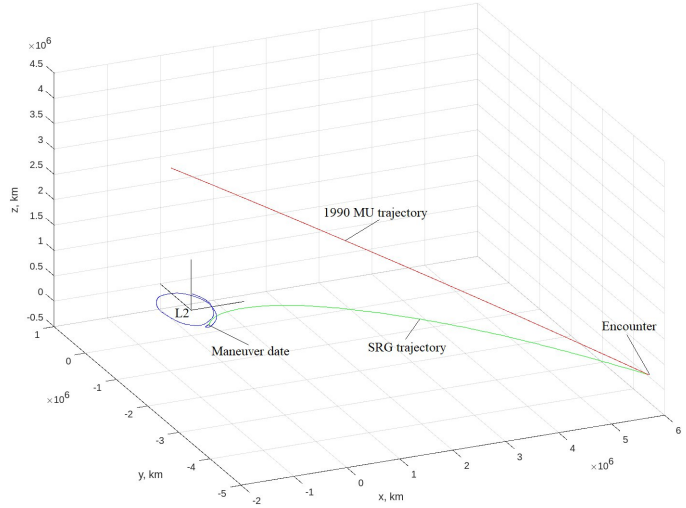

Figure 4. Transfer trajectory of the SRG space observatory to a close approach to the asteroid 1990 MU

The SRG observatory is not the only spacecraft that can be redirected to approach near-Earth objects. As an alternative example we considered the DISCOVR satellite [6] launched in 2015 and currently positioned in the vicinity of the Sun-Earth libration point L_1. Among possible objects for an extended mission of the DSCOVR spacecraft we found the asteroid 1997 XF_{11} (see Figure 5). This celestial body may be approached under the same restrictions on the total required ΔV as for the SRG space observatory.

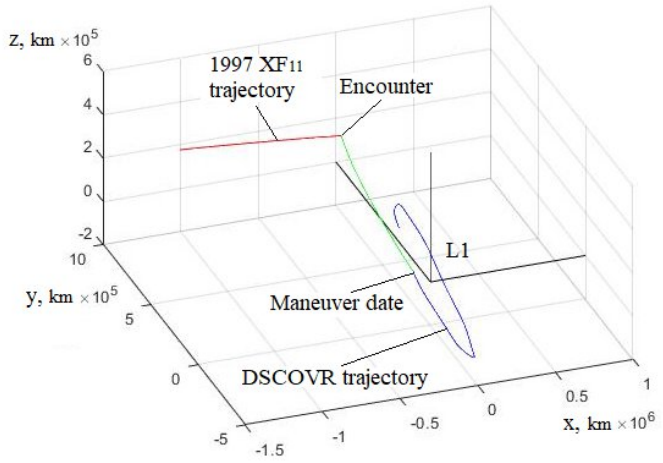

Figure 5. Transfer trajectory of the DSCOVR satellite to a close approach to the asteroid 1997 XF_{11}

Another possible example of applying the described approach may be given for the GAYA space telescope [7] launced in 2013 and is expected to operate until 2025 in an orbit around the Sun-Earth libration point L_2. We considered an example of redirecting the telescope to a close approach to the asteroid 1997 NC_1 after completing its main mission (see Figure 6).

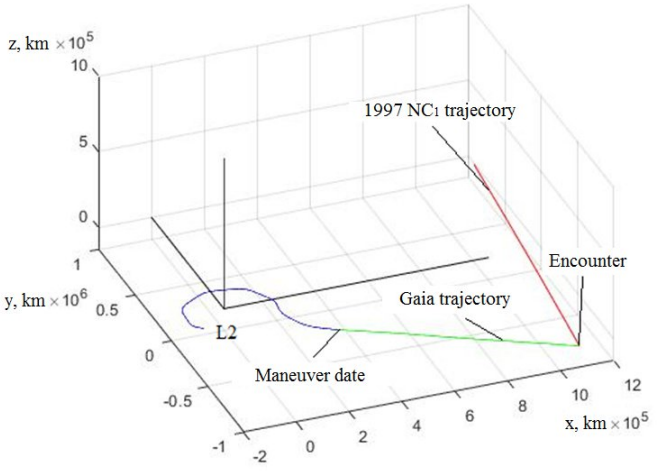

Figure 6. Transfer trajectory of the Gaia spacecraft to a close approach to the asteroid 1997 NC_1

The possibility of using a spacecraft equipped with a low-thrust engine for the study of near-Earth asteroids is also discussed. Several examples of such a mission are considered.

Preliminary calculations show the prospects of the described approach. The main advantages are efficiency of such missions and saving of resources.

References

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