8th IAA Planetary Defense Conference
3 - 7 April 2023, Vienna, Austria

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

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8th IAA Planetary Defense Conference
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Historical Note

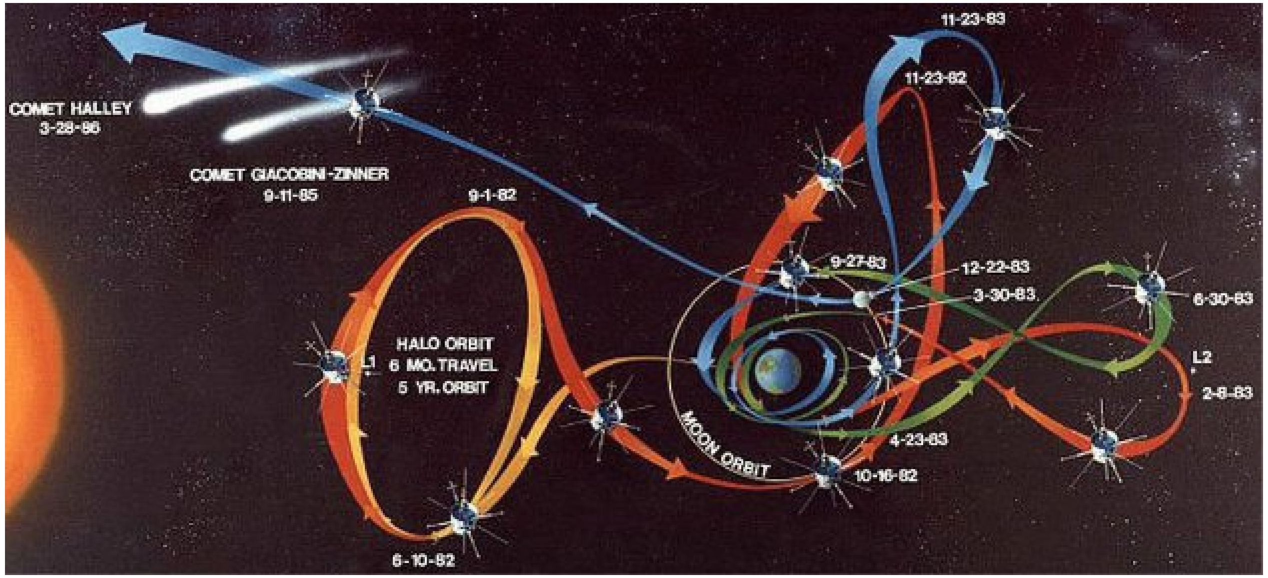

Figure 1. Mission of the ISEE-3 spacecraft[1]

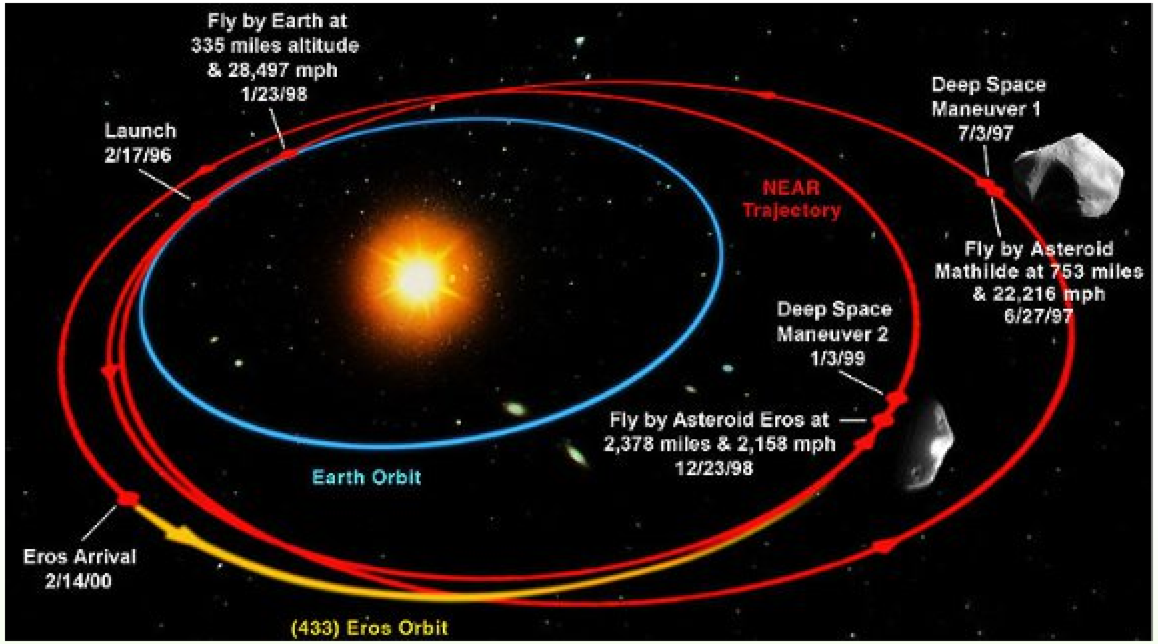

Figure 2. Mission of the NEAR Shoemaker interplanetary station[2]

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[1] **D.W. Dunham, R.W. Farquhar et al, The 2014 Earth return of the ISEE-3/ICE spacecraft, Acta Astronautica, Vol. 110, 2015, pp. 29–42.**
[2] **Discovery is NEAR. URL: https://near.jhuapl.edu/**

Spectrum-Roentgen-Gamma

Launch: July 13, 2019

Planned Mission duration: 6.5 years

Mass of propellant reserves[3]: ~271 kg

Characteristic velocity reserve: ~206 m/sec

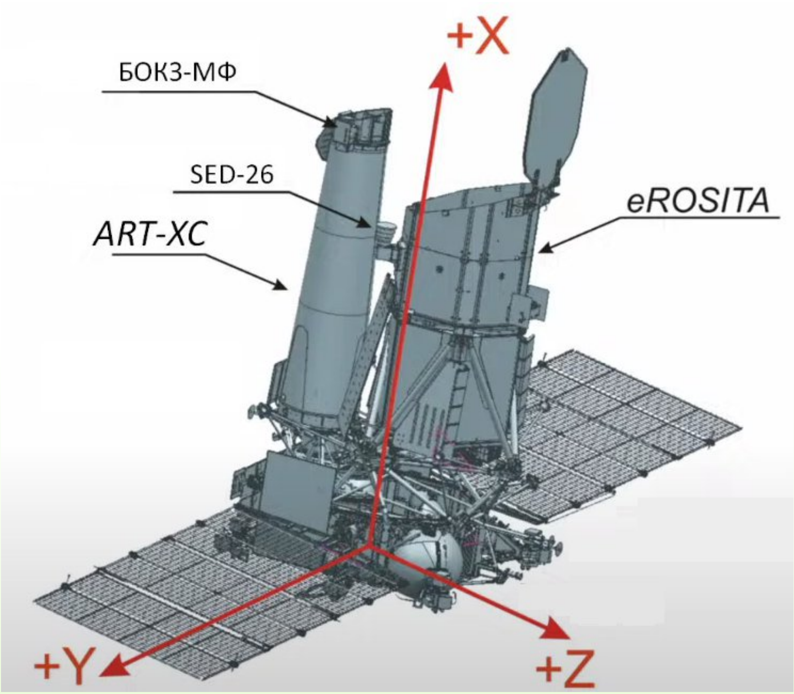

Figure 3. The SRG space observatory

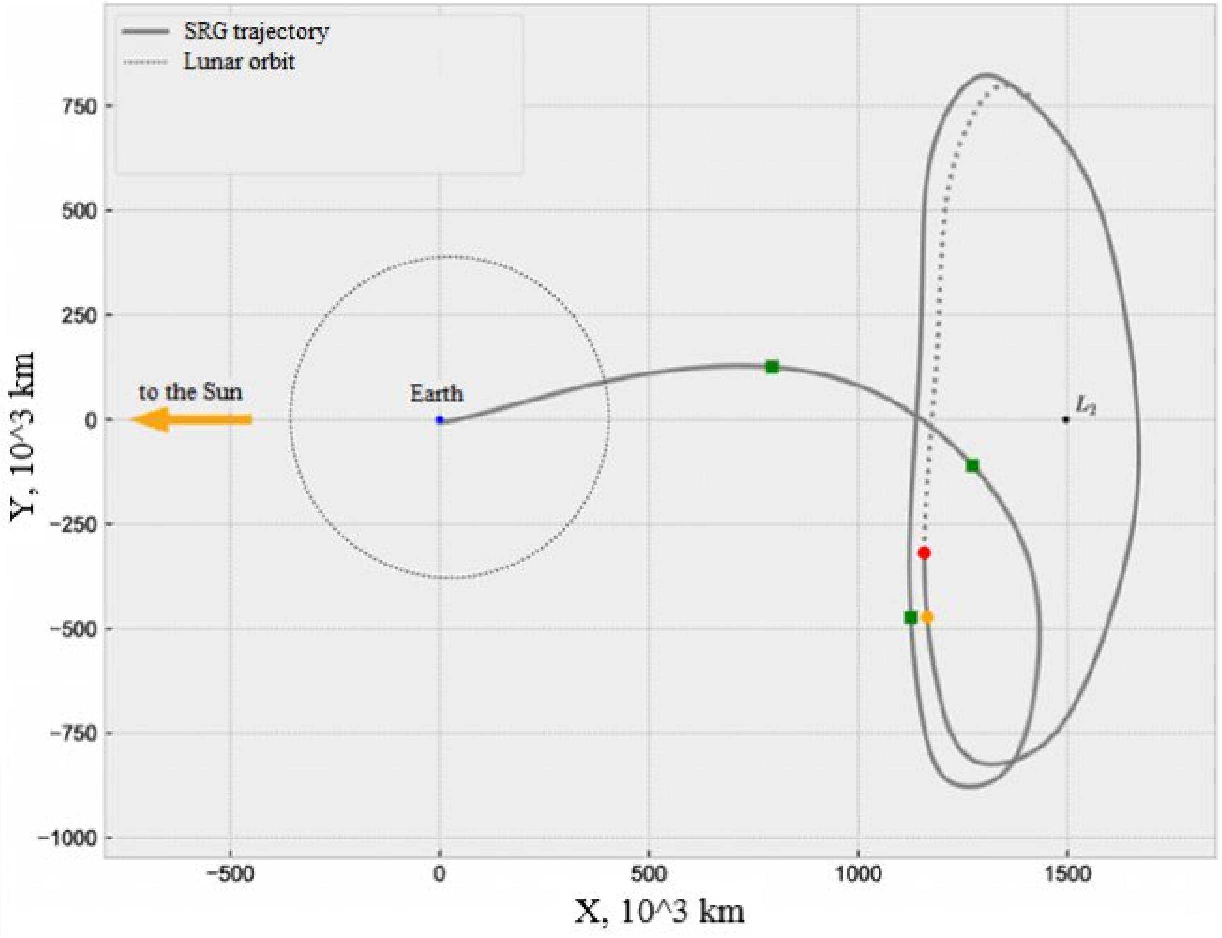

Figure 4. Trajectory of the SRG spacecraft[4]

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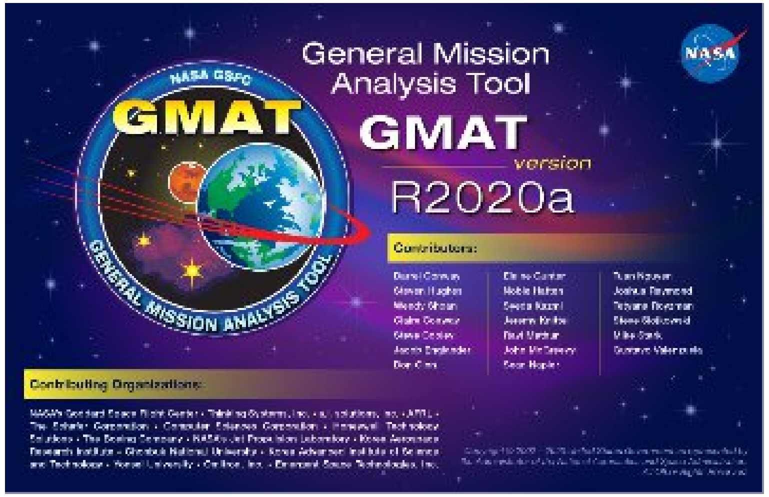
[3] High Energy Astrophysics Today and Tomorrow, A.V. Pogodin, Ballistic support for the flight of the «Spektr-RG» spacecraft

[4] Spectrum-Roentgen-Gamma, Astrophysical project. URL: https://iki.cosmos.ru/missions/spektr-rg

SRG Trajectory Simulating



The simulation was performed using NASA GMAT software package[5]

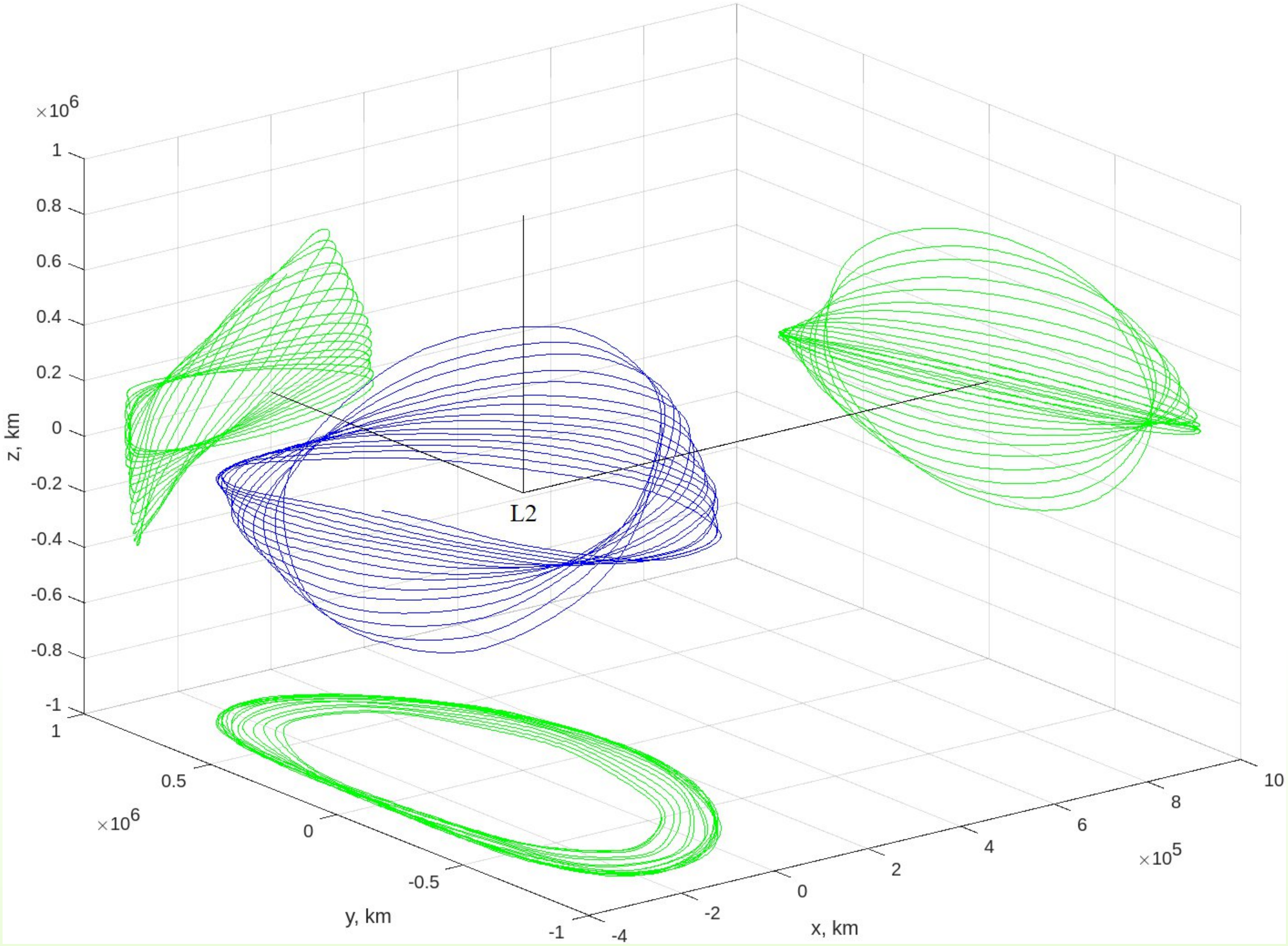


Figure 5. Simulated trajectory of the SRG spacecraft[6]

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[5] General Mission Analysis Tool (GMAT) Mathematical Specifications, NASA Goddard Space Flight Center, Greenbelt RD, Greenbelt, MD 20771, 2020, pp. 206.

[6] S.A. Aksenov, S.A. Bober, Calculation and Study of Limited Orbits around the L2 Libration Point of the Sun–Earth System, Cosmic Research,Vol. 56, No. 2, 2018, pp. 144–150.

Transfer Trajectory to the Apophis Asteroid

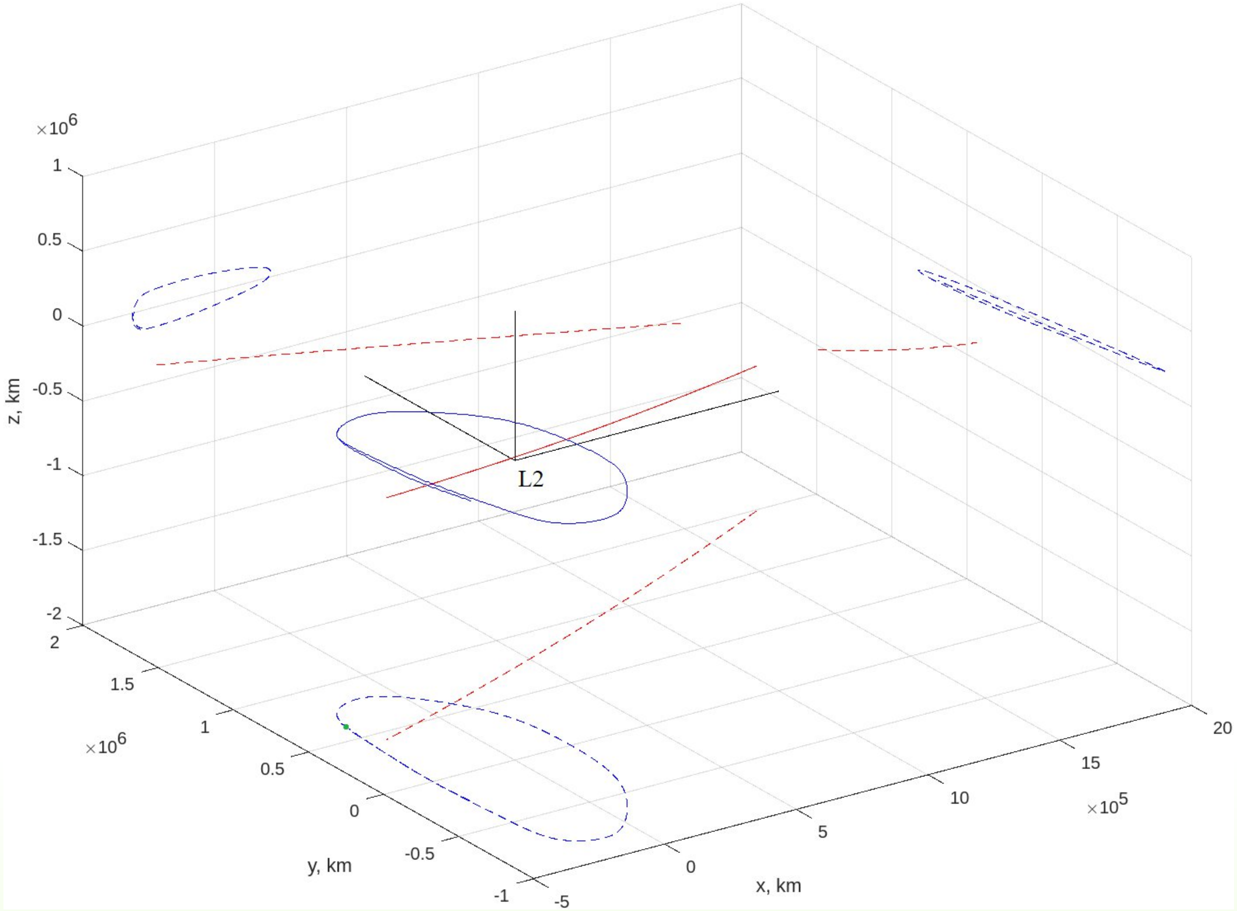

Figure 6. Trajectories of the SRG spacecraft (shown in blue) and the Apophis asteroid[7] (shown in red)

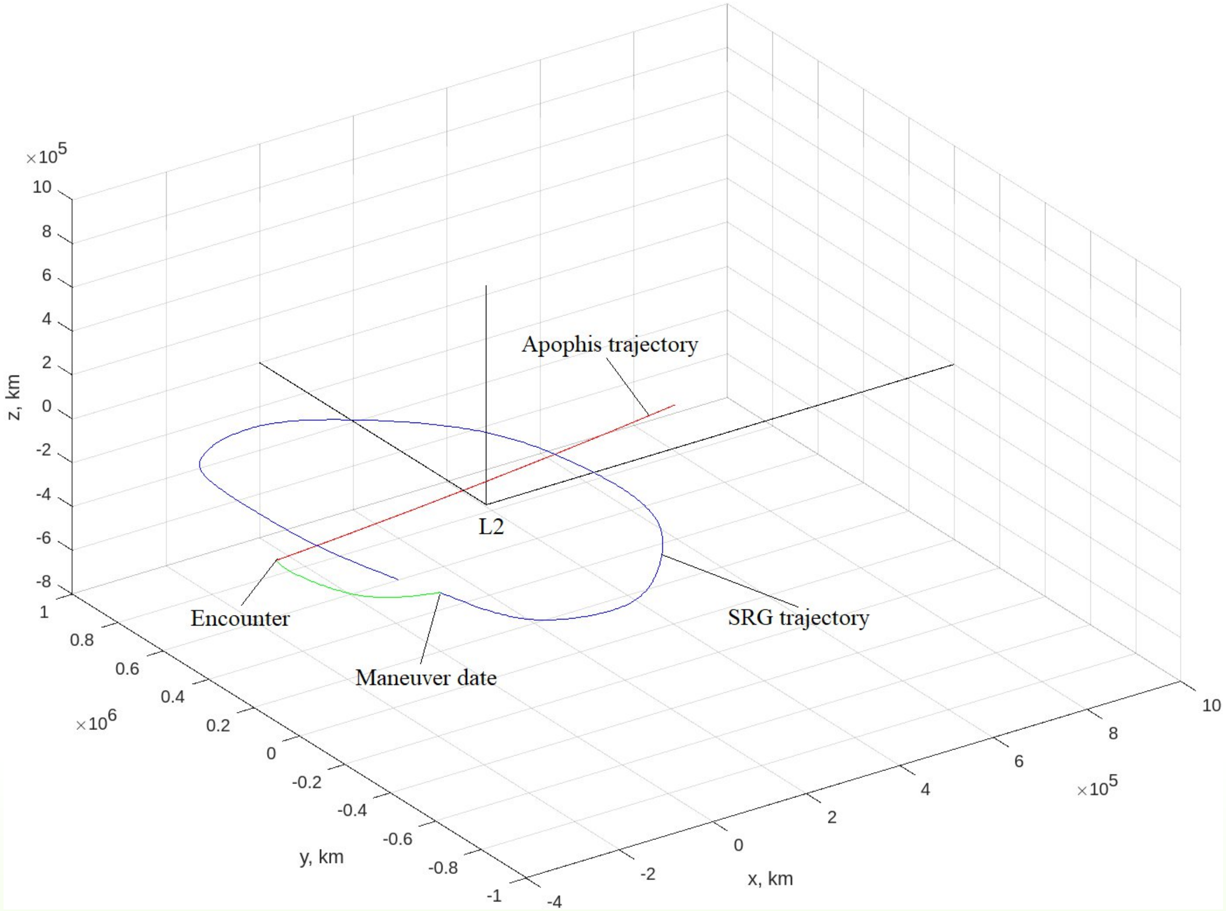

Figure 7. Transfer trajectory of the SRG spacecraft to a close approach to the Apophis asteroid in 2029

Maneuver date: 01.03.2029

$\Delta V \approx 171.7$ m/sec

Encounter: 11.04.2029

$V_{rel} \approx 6$ km/sec

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[7] **NEO Earth Close Approaches: Center for Near Earth Object Studies. URL: https://cneos.jpl.nasa.gov/ca/**

Transfer Trajectory to the Apophis Asteroid

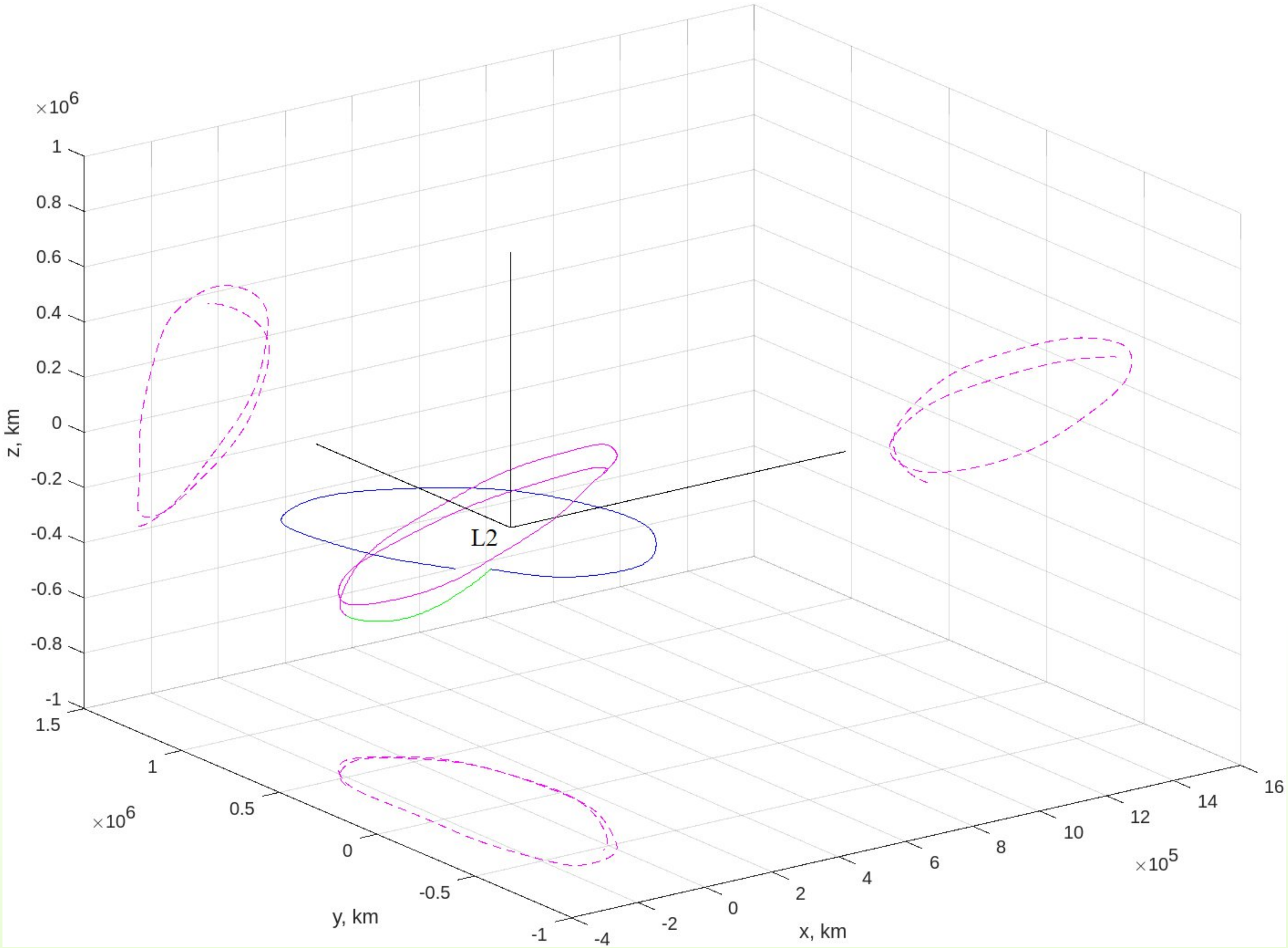

Figure 8. The trajectory of the SRG spacecraft (shown in purple) after the close approach to the Apophis asteroid

Transfer Trajectory to the Asteroid 1990 MU

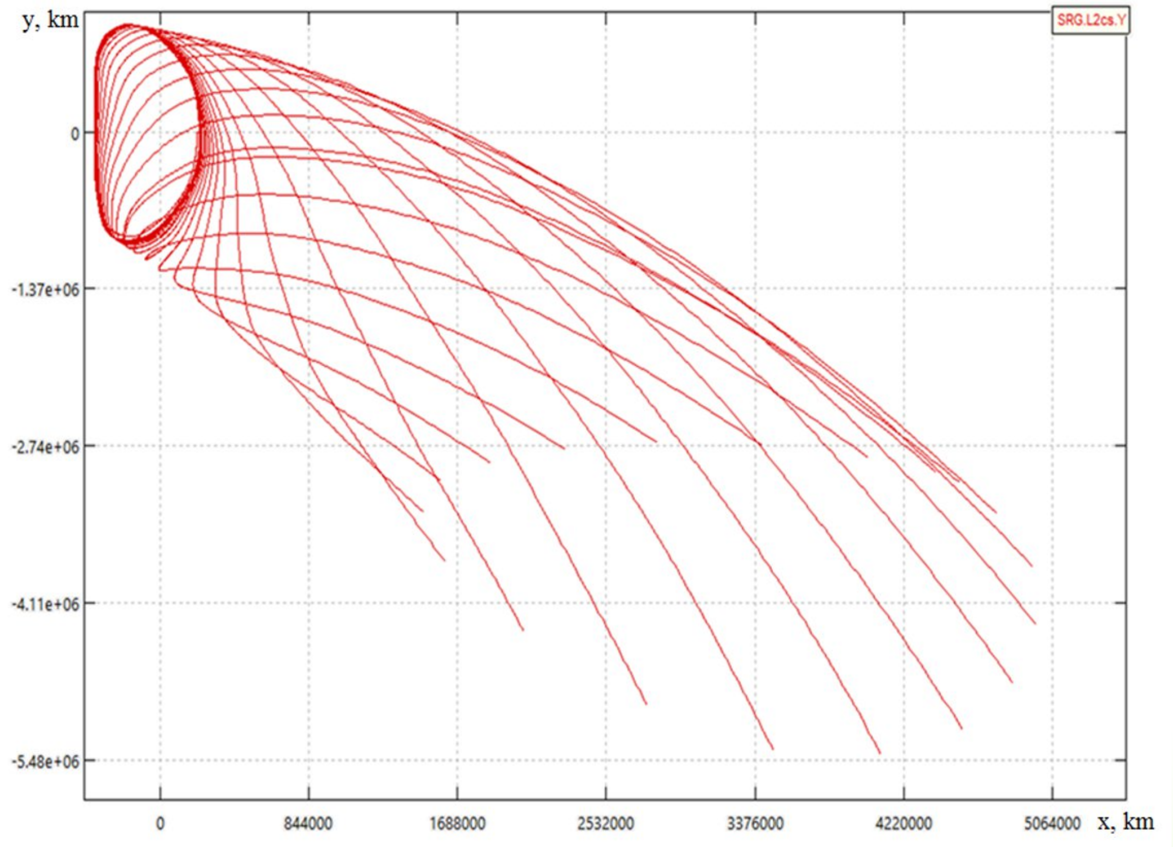

Figure 9. An example of an unstable manifold

Encounter: 10.06.2027

$\Delta V_{1\ (small)} \approx 6$ mm/sec

$\Delta V_2 \approx 126.1$ m/sec

$V_{rel} \approx 22$ km/sec

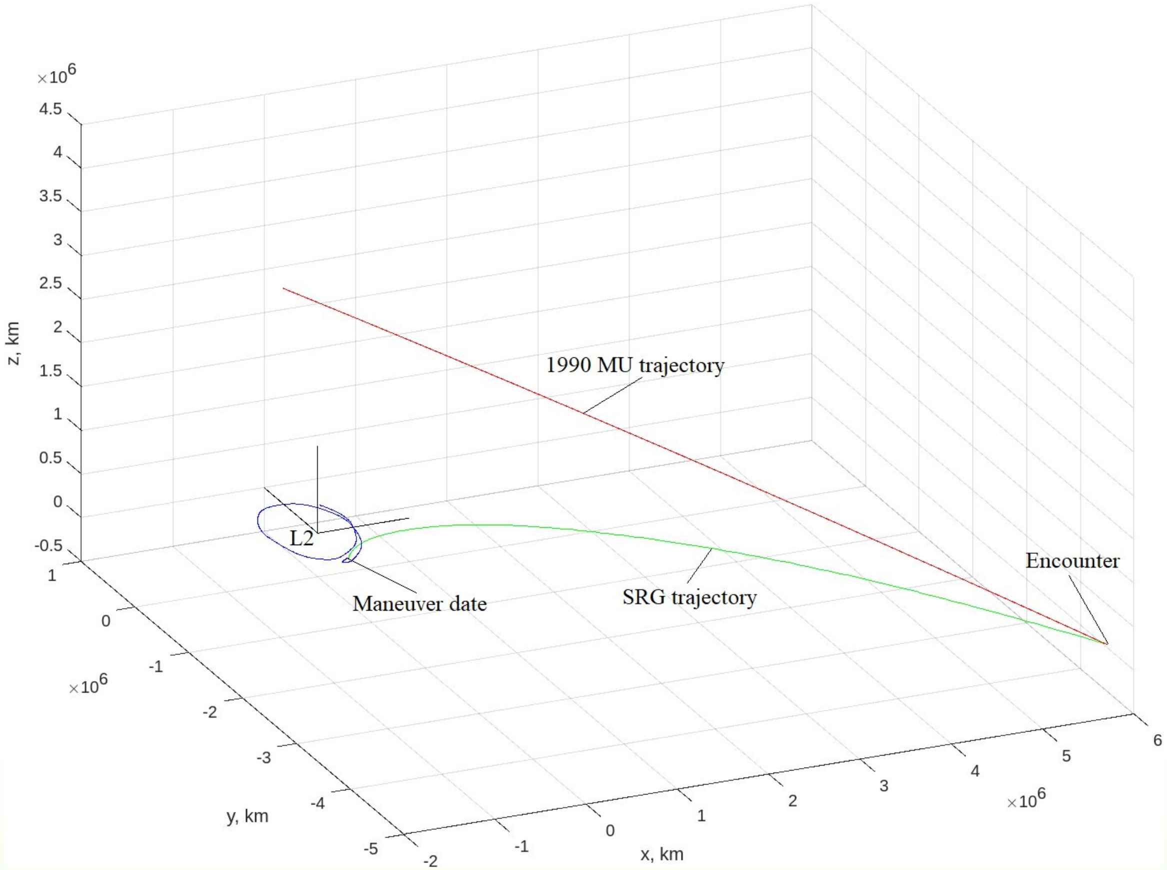

Figure 10. Transfer trajectory of the SRG spacecraft to a close approach to the asteroid 1990 MU in 2027

Dates of maneuvers:

ΔV_1 - 10.06.2026 (for the first small impulse),

ΔV_2 - 21.03.2027

The DSCOVR Spacecraft and the Asteroid 1997 XF_{11}

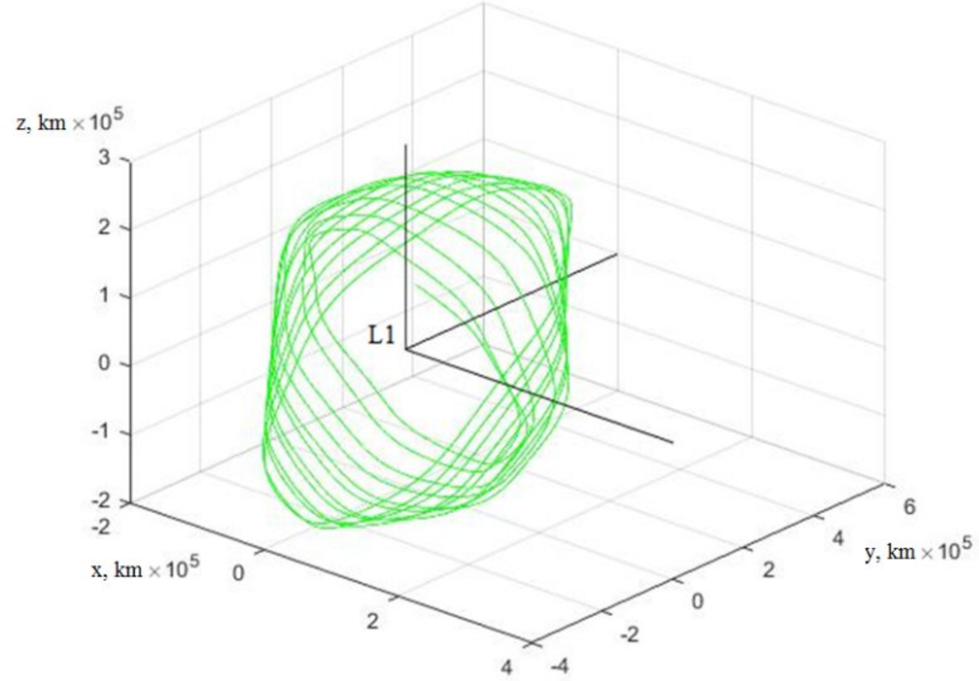

Figure 11. Simulated trajectory of the DSCOVR[8] spacecraft

Maneuver date: 25.09.2028

$\Delta V \approx 178$ m/sec

Encounter: 25.10.2028

$V_{rel} \approx 14$ km/sec

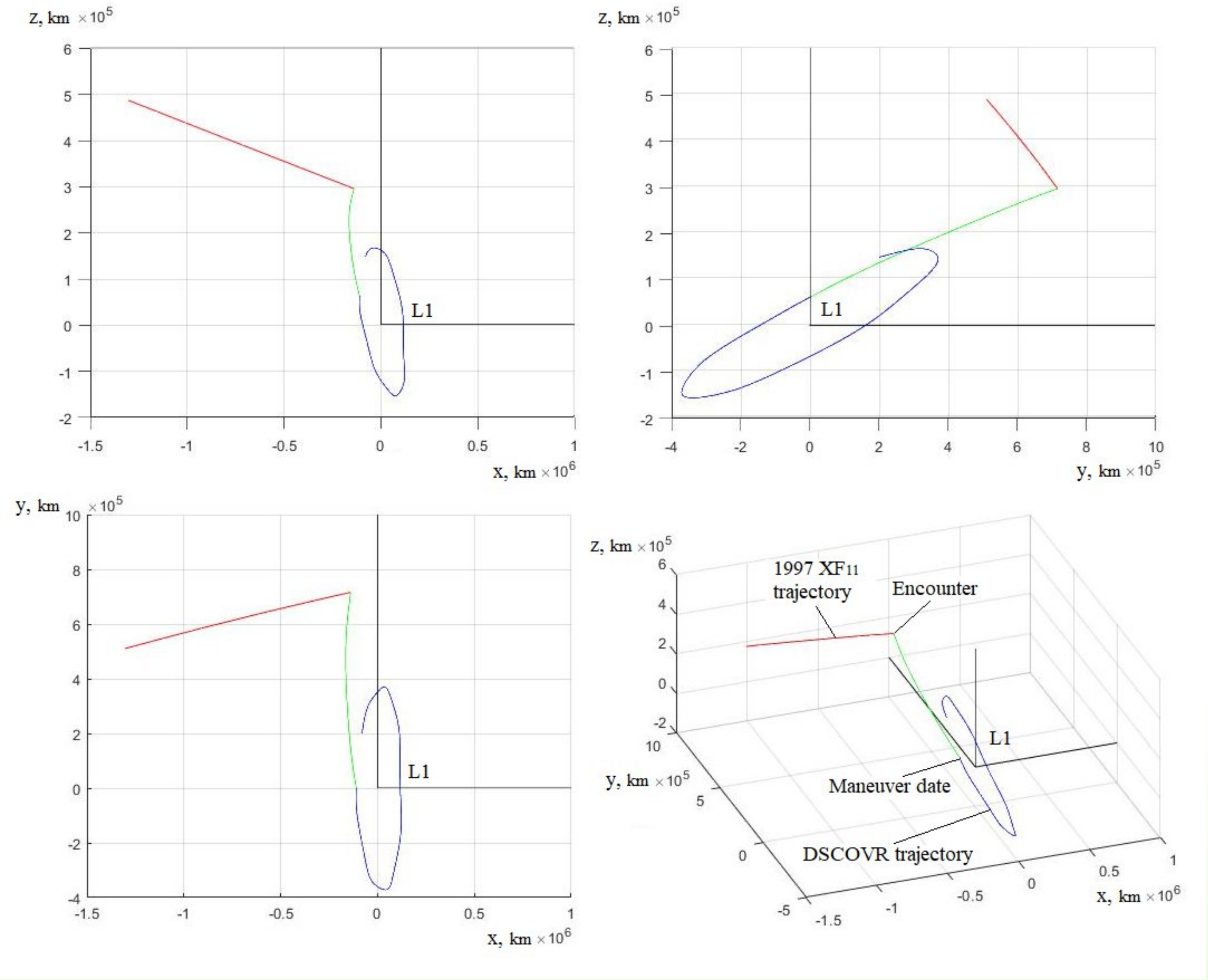

Figure 12. Transfer trajectory of the DSCOVR spacecraft to a close approach to the asteroid 1997 XF_{11} in 2028

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[8] DSCOVR: Deep Space Climate Observatory. URL: https://www.nesdis.noaa.gov/current-satellite-missions/currently-flying/dscovr-deep-space-climate-observatory

The Gaia Spacecraft and the Asteroid 1997 NC_1

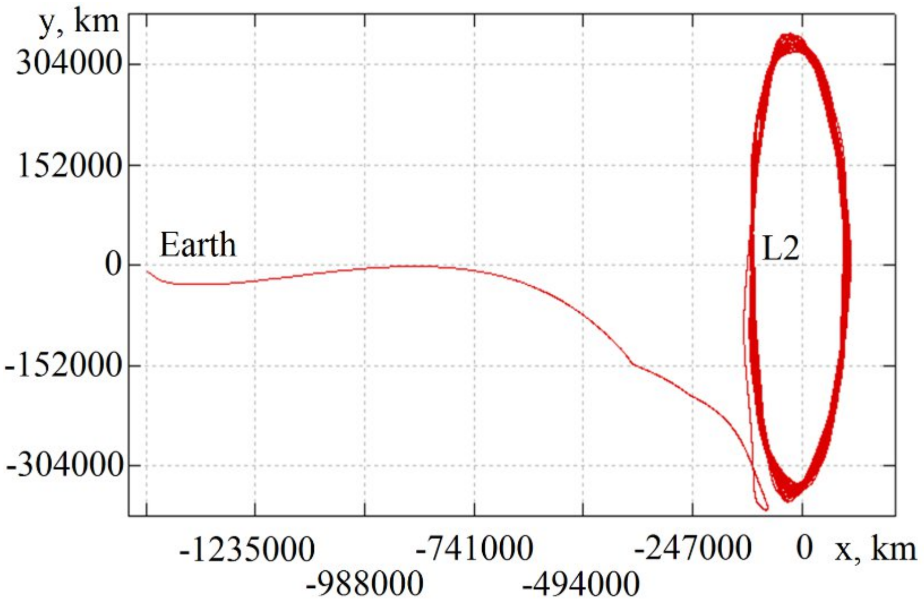

Figure 13. Trajectory of the Gaia[9] spacecraft

Dates of maneuvers:

ΔV_1 - 23.11.2025 (for the first small impulse),

ΔV_2 - 25.05.2026

Encounter: 28.06.2026

$\Delta V_{1\ (small)} \approx 0.8$ m/sec

$\Delta V_2 \approx 29.5$ m/sec

$V_{rel} \approx 9$ km/sec

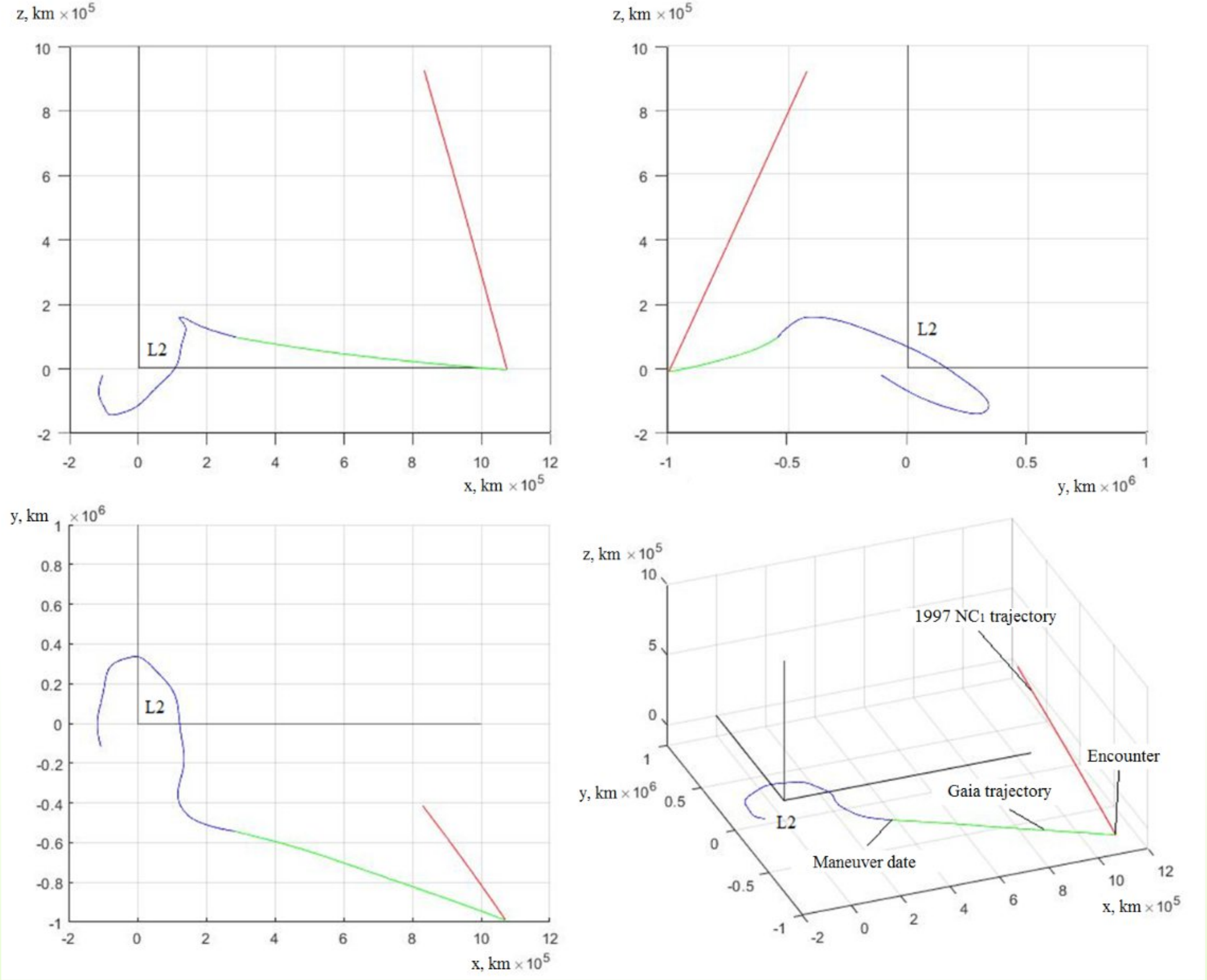

Figure 14. Transfer trajectory of the Gaia spacecraft to a close approach to the asteroid 1997 NC_1 in 2026

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[9] ESA Science and Technology – Gaia. URL: https://sci.esa.int/web/gaia/

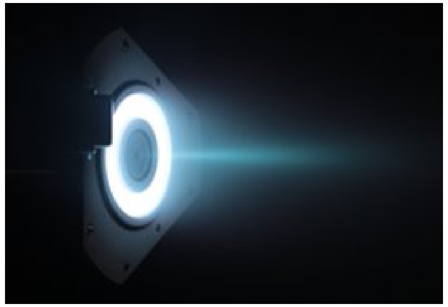
Spacecraft equipped with a low-thrust engine

3 small spacecraft were considered:

1) SSC №1 with a mass of 100 kg;
2) SSC №2 with a mass of 200 kg;
3) SSC №3 with a mass of 400 kg.

Each spacecraft is supposed to have an SPT-50 engine[10]

SPT-50M



	SPT-50	SPT-50M	
Propellant	Xe	Xe	Xe
Discharge voltage, V	180	180	300
Discharge current, A	1,25	1,25	1,0
Discharge power, W	225	225	300
Thrust, mN	14,0	14,8	18,0
Specific impulse, s	860	930	1200
Power-to-thrust ratio, W/mN	16,1	15,2	16,7
Lifetime, h Lifetime (cycles)	>1217 >3011	>5000 >11000	>5000 >11000
Mass, kg	1,23	1,32	
Dimensions, mm	160×120×91	169×120×88	
Development level	FM	FM	

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[10] **Fakel. Productions. Plasma thrusters. URL: https://fakel-russia.com/en/productions**

Spacecraft equipped with a low-thrust engine

Encounter - 11.04.2029

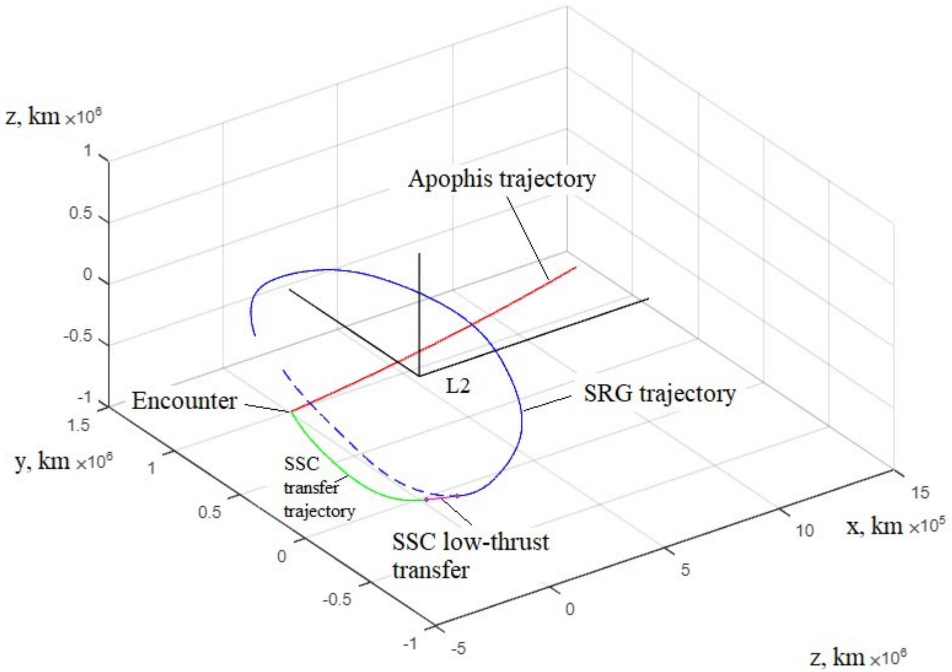

Figure 15. Transfer trajectory of the SSC №1 (100 kg) to a close approach to Apophis

Start of the maneuver:
24.02.2029
Engine operating time:
9.5 days

Start of the maneuver:
20.02.2029
Engine operating time:
19 days

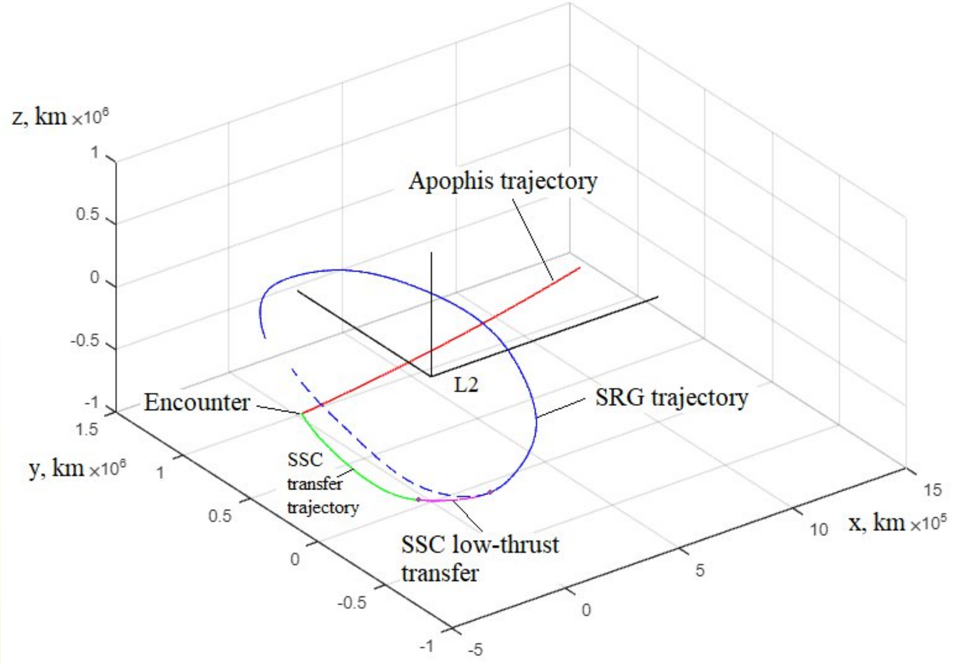

Figure 16. Transfer trajectory of the SSC №2 (200 kg) to a close approach to Apophis

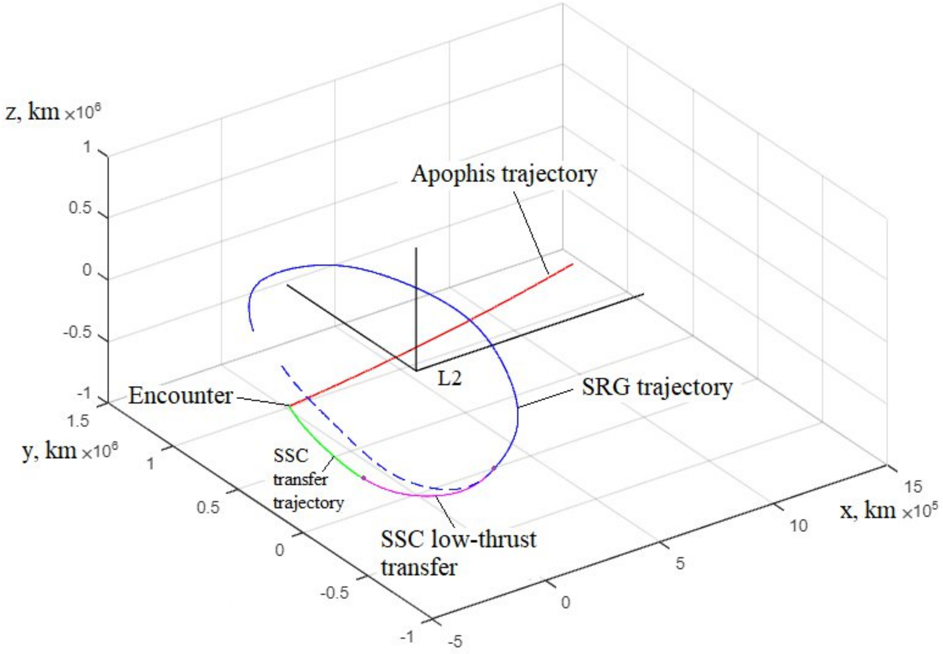

Figure 17. Transfer trajectory of the SSC №3 (400 kg) to a close approach to Apophis

Start of the maneuver:
11.02.2029
Engine operating time:
38 days

Conclusion

1. The technical feasibility of extending the mission of the SRG spacecraft to study near-Earth objects is shown.

2. It is demonstrated that with the existing propellant reserves, various scenarios of an extended mission are possible.

3. Examples of using this approach for the DSCOVR and the Gaia spacecraft are given.

4. The possibility of using a spacecraft equipped with a low-thrust engine is discussed.

5. The main advantages of such an approach are the efficiency of the mission and the economy of terrestrial resources.

Thank you for attention!

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