## Short note on orbital manoeuvres in LEO with TriaXOrbitaL

*For both cases below, assume drag. Ram area = 0.03 m^2, CD = 2.5. Assume 10,000 sec ISP.*
*1) **Case BOB4** Starting orbit: 350 km circular orbit.*
*Burn for 20 minutes at 350 km until perigee = 170 km*
*Thrust = 5.5 mN*
*Spacecraft mass = 15 kg*
*Final orbit = 170 km perigee, apogee = 350 km. I know the apogee won't remain at 350 km. What is the new apogee?*

*What is the time to go from 350km circular to 350 km apogee, 170 km perigee. Number of orbits, total burn time?*

### Run Case BOB4

121 pulses of 20 minutes are needed to lower perigee from 350 down to 170 km. Time to go is 7.6 days. Apogee (with help of the drag at perigee) decreases from 350 to 325 km (aerodynamic forces are "moderate", not high, not "low"). Total burn time 121 x 20 minutes. DeltaV =53.2 m/s (thrust orientation during the burn: in the horizontal --i.e. perpendicular to the radius vector to Earth-- opposite to the velocity).
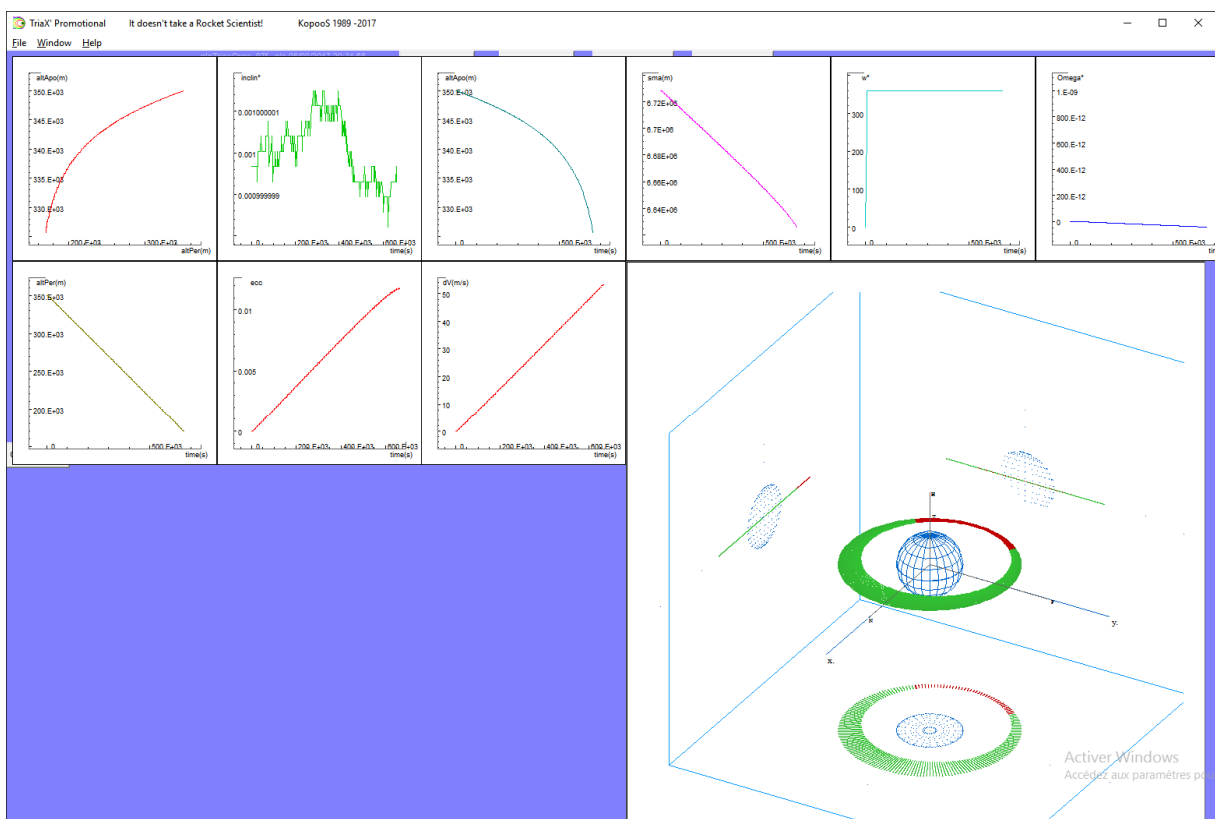


Result table for traceability:

| time(s) | ecc | ecc | altPer(m) | altApo(m) | inclin° | Omega° | w° | phi° | O+w+p° | w+p° | period | dt(s) | mass(kg) | thrust(N) | halfArc-t° | beta-t° | moon° | AnoExc° | n°Arc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 350000 | 350001 | 0.001 | 0 | 0 | 0 | 0 | 0 | 5492.3 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7638.8 | 0.000001 | 0.000001 | 349977 | 349985 | 0.001 | 0 | 256.923 | 243.777 | 140.7 | 140.7 | 5492.3 | 30.6 | 15 | 0.006 | 39.3 | 90 | 0 | 243.777 | 1 |
| 8838 | 0.000106 | 0.000106 | 348498 | 349921 | 0.001 | 0 | 359.178 | 220.122 | 219.3 | 219.3 | 5491.3 | 30 | 15 | 0 | 0 | 0 | 0 | 220.126 | 1 |
| 663646.5 | 0.011746 | 0.011746 | 170000 | 325663 | 0.001 | 0 | 359.516 | 51.849 | 51.4 | 51.4 | 5367.7 | 29.5 | 14.992 | 0 | 0 | 90 | 0 | 51.321 | 121 |

| O+w° | mid-t° | alpha-t° | Eclip(s) | sma(m) | dV(m/s) | Lo° | ra_sma° | d_sma° | e_x | e_y | i_x° | i_y° | TimeJD | MeanLo° | HourDN | ActAlt(m) | ActV(m/s) | Focus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 180 | 0 | 0 | 6730000 | 0 | 91.094 | 180 | 0 | 0 | 0 | 0.001 | 0 | 2458655.5 | 91.094 | 18 | 350000 | 7697.001 | Earth |
| 256.9 | 180 | 270 | 0 | 6730000 | 0 | -160.121 | 76.923 | 0.001 | 0 | -0.000001 | 0.001 | 0 | 2458655.59 | -160.121 | 18 | 349982.586 | 7697.009 | Earth |
| 359.2 | 180 | 0 | 0 | 6730000 | 0.4 | -86.532 | 179.178 | 0 | 0.000106 | -0.000002 | 0.001 | 0 | 2458655.6 | -86.524 | 18 | 349753.35 | 7696.83 | Earth |
| 359.5 | 180 | 270 | 0 | 6630000 | 53.2 | -109.47 | 179.516 | 0 | 0.011746 | -0.000099 | 0.001 | 0 | 2458663.18 | -110.528 | 18 | 199190.316 | 7813.263 | Earth |

*2)* ***Case BOB5*** *At an orbit of 170 km perigee, 350 km apogee, start burning for 20 minutes at perigee on each orbit.*
*Thrust = 3.5 mN*
*Just thrust at perigee.*
*Raise apogee to 500km.*
*What is the time to go from 170 perigee, 350 km apogee to 170 km perigee to 500 km apogee. Need number of orbits, total burn time and total transfer time. Of course, the perigee will change during this operation. What is the final perigee?*
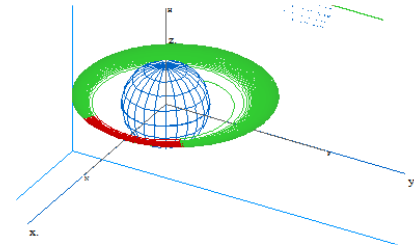
### Run Case BOB5

With aerodynamic forces "moderate", the thrust 3.5 mN is not enough for enabling perigee raising, the apogee slowly drop then both apsides decrease and deorbit occurs fast (13 days).

With aerodynamic forces "low", the thrust 3.5 mN is enough: 258 pulses of 20 minutes are needed to raise apogee from 170 up to 500 km. Time to go is 16.2 days. Perigee increases a bit from 170 to 175 km. Total burn time 258 x 20 minutes. DeltaV =72.1 m/s (thrust orientation during the burn: in the horizontal --i.e. perpendicular to the radius vector to Earth-- along with the velocity).
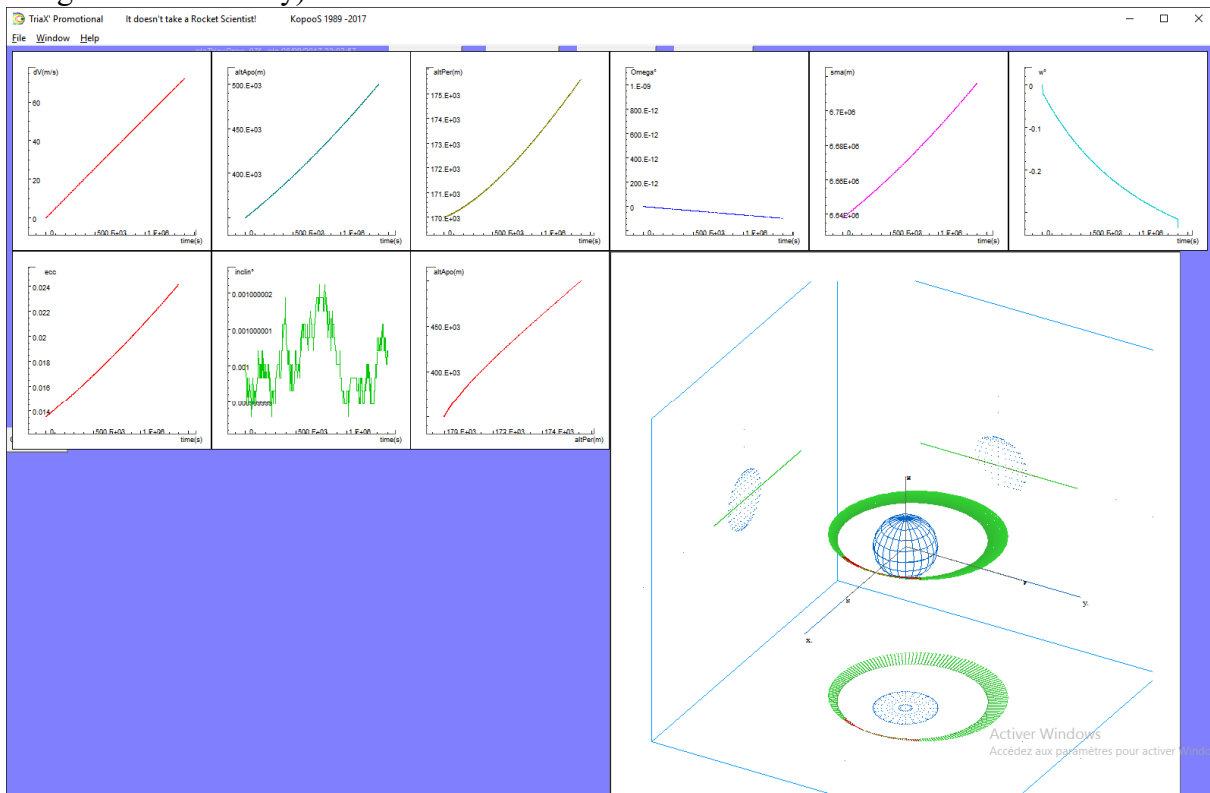


Result table for traceability:

| time(s) | ecc | altPer(m) | altApo(m) | inclin° | Omega° | w° | phi° | O+w+p° | w+p° | period | dt(s) | mass(kg) | thrust(N) | halfArc-t° | beta-t° | moon° | AnoExc° | n°Arc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.013558 | 170000 | 350001 | 0.001 | 0 | 0 | 0 | 0 | 0 | 5382.5 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4781.6 | 0.013541 | 169976 | 349742 | 0.001 | 0 | -0.018 | -41.172 | -41.2 | -41.2 | 5382.3 | 30.1 | 15 | 0.004 | 41.19 | 90 | 0 | 319.336 | 1 |
| 5983 | 0.013577 | 170003 | 350258 | 0.001 | 0 | -0.02 | 41.21 | 41.2 | 41.2 | 5382.6 | 29.3 | 15 | 0 | 0 | 0 | 0 | 40.7 | 1 |
| 1399728.5 | 0.024152 | 175588 | 500000 | 0.001 | 0 | -0.337 | -18.047 | -18.4 | -18.4 | 5477.3 | 29.2 | 14.989 | 0.004 | 41.19 | 90 | 0 | 342.377 | 258 |

| O+w° | mid-t° | alpha-t° | Eclip(s) | sma(m) | dV(m/s) | Lo° | ra_sma° | d_sma° | e_x | e_y | i_x° | i_y° | TimeJD | MeanLo° | HourDN | ActAlt(m) | ActV(m/s) | Focus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 6640000 | 0 | 91.094 | 180 | 0 | 0.013558 | 0 | 0.001 | 0 | 2458655.5 | 91.094 | 18 | 170000 | 7854.786 | Earth |
| 360 | 0 | 90 | 0 | 6640000 | 0 | 29.926 | 179.982 | 0 | 0.013541 | -0.000004 | 0.001 | 0 | 2458655.56 | 30.947 | 18 | 191678.298 | 7829.091 | Earth |
| 360 | 0 | 0 | 0 | 6640000 | 0.3 | 107.287 | 179.98 | 0 | 0.013577 | -0.000005 | 0.001 | 0 | 2458655.57 | 106.262 | 18 | 191802.576 | 7829.102 | Earth |
| 359.7 | 0 | 90 | 0 | 6720000 | 72.1 | -14.239 | 179.663 | 0 | 0.024152 | -0.000142 | 0.001 | 0 | 2458671.7 | -13.382 | 18 | 183200.806 | 7883.418 | Earth |