EUCLID: ESA'S DARK ENERGY 3-AXIS STABILIZED SURVEY MISSION AT THE NIGHT-SIDE SUN-EARTH LIBRATION POINT

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The paper will describe the general mission analysis and the launch window design together with the treatment of the perturbations on the trajectory caused by the step-and-stare implementation of the sky survey. This is necessary to reduce the station-keeping DeltaV allocation, which is a major part of the propellant budget.

The Euclid dark energy mission is one of the future missions in the framework of the ESA Cosmic Vision Programme 2015-2025. The mission's purpose is to map about 15,000 Deg2 of the sky region with galactic latitudes above 30 Deg and free of extinction in an effort to observe how weak gravitational lensing affects the shape of distant galaxies. This information is to be collected by imaging and spectroscopy of deep-sky objects in visible and/or near infrared wavelengths. The launch of Euclid is currently foreseen for the first quarter of 2020 and the lifetime is 7 years. In order to meet the scientific requirements, it is foreseen to cover the interesting sky regions staring in one direction with an approximately 0.5 Deg2 field of view at a time with fixed, three-axis stabilised attitude. Then the instrument is re-pointed at the next field by a slew manoeuvre.

Launch is assumed with Soyuz 2-1b Fregat from Kourou. Euclid is injected into a direct transfer towards the far side libration point L2 of the Sun-Earth system (SEL2). Only one Soyuz-Fregat flight program (FP) will be used to a fixed apogee altitude near the SEL2 and this FP will be optimized for maximum payload performance. Since the fixed velocity at separation is not necessarily the velocity required at a given date to insert the spacecraft onto the stable manifold of the SEL2, the deltaV allocation on the spacecraft for this first correction manoeuvre is one of the constraints on the launch window. An early correction of this deviation together with the launcher dispersion error is necessary due to the amplification of deviation from the velocity of the stable manifold. Any error is amplified by a factor of more than 8 on the second day after separation already. The launch window is constrained by eclipses and the illumination of the telescope. Since the S/C is launched towards SEL2, the launch is into the Sun direction such that the perigee is located on the day side of the Earth.

The motion around SEL2 is unstable and requires regular station-keeping manoeuvres. The deltaV required for the station keeping depends strongly on the perturbations acting on the spacecraft. The micropropulsion system installed on the S/C is unbalanced and thus every torque compensation performed with the micro propulsion system will cause a parasitic DeltaV which is amplified by the dynamics at the libration point. This must later be compensated by the station-keeping manoeuvres currently planned once every month.

The design of the strategy to cover the sky with exposures of the telescope is limited by the attitude constraints on the S/C. The telescope may not be pointed closer than 87 Deg to the Sun and the solar array main panel may not be pointed more than 31 Deg away from the Sun. While at any moment in time only a part of the sky can be observed, the entire sky becomes accessible during one year due to the natural motion of the libration point around the Sun. The limitation in the attitude during the survey has the advantage that the parasitic DeltaV of the micro propulsion system occurring during between the observations is also limited in its direction with respect to the synodic rotating frame of the SEL2 and thus its common part can be considered for the trajectory design and does not have to be treated as a perturbation. Dependant on the direction this can cause a significant reduction in the station-keeping DeltaV.

In addition to the mission analysis defining the deltaV requirements and the launch window calculation the problem of implementing and efficient sky survey are presented. With the constraints on the regions to be observed there are ecliptic longitudes with a large part of the latitude band to be scanned as well as ecliptic longitudes with only a very small part of latitudes to be scanned. Simple strategies would lead to science idle times, which should be avoided. The sky coverage strategy can have a significant impact on the required consumables to be carried for the micro propulsion system and the station-keeping budget.