VNREDSat-1 MISSION: TRANSFER AND FIRST MONTHS OF OPERATIONS

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Abstract for an oral presentation

The VNREDSat-1 Mission

VNREDSat-1 (**V**ietnam **N**atural **R**esources, **E**nvironment and **D**isasters monitoring **Sat**ellite) is the first Earth Observation space system operated by Vietnam. It has been launched on the 7th of May 2013 by a Vega rocket, from Kourou, French Guyana. It is currently operated by VAST teams. The transfer phase and early routine operations has been performed by EADS Astrium teams leading to a hand over to VAST team early September 2013. This was the starting point of VAST Flight Dynamics operational experience following a 2 years training period held both at Astrium premises and at VAST facilities in Hanoi before the launch and during LEOP and IOT operations.

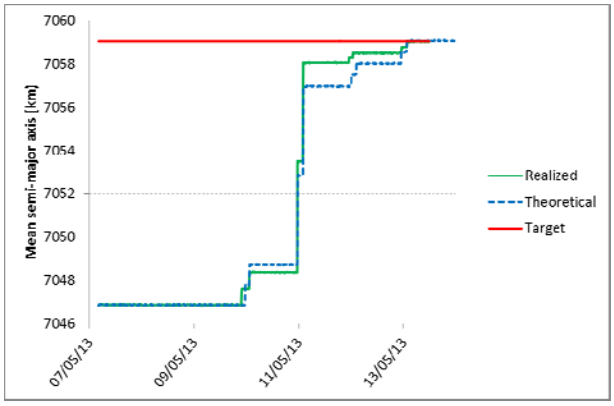
Reference orbit definition for VNREDSat-1

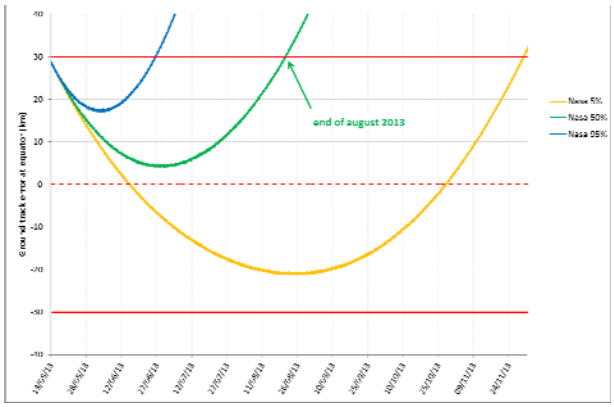
The design of the mission orbit shall cope with various constraints, such as revisit period of the system over Vietnam, ground lighting conditions for imaging, ground station visibilities, platform blinding constraints, and minimization of the orbit free drift. The choice made for the VNREDSat-1 mission is a phased Sun-synchronous orbit, with a Ground Track (GT) cycle of 14+18/29 revolutions per day (mean altitude above equator 681km, mean inclination 98.134°). The Local Solar Time (LST) of ascending node chosen for this mission is 22:32 ±10min. The eccentricity and argument of perigee are chosen to fit with frozen eccentricity conditions. As there was no particular phasing constraints, the reference grid was not defined a priori, which means that no phasing of the GT with respect to a reference grid had to be considered during the transfer phase. Targeted mean orbit to be reached at the end of the transfer phase has been optimized to postpone as far as possible the first station keeping Orbit Control Maneuver (OCM). The transfer phase, starting after spacecraft separation from the launcher, consisted in reaching these optimized targets.

Transfer realization: 8 maneuvers to correct semi-major axis and inclination

The injection orbit requested to Arianespace was 12 km lower than target altitude. The Vega injection accuracy was quasi-perfect. The transfer phase therefore consisted in rising up the semi-

major axis and correcting the weak deviations on both inclination and eccentricity, to reach the end-of-transfer targets (*a=7059.11km, ex=0, ey=0.0012, i=98.1335°*). Since the injection deviations were very weak, the nominal transfer strategy designed during the pre-launch mission analysis phase has been followed. The transfer lasted 8 days, timespan during which the satellite has been switched to normal mode (Day 1-2), first calibration image has been shot (Day 3), and 8 orbit control maneuvers have been performed. From Day 4 to 8, 2 manoeuvers per day were computed, uploaded, realized at relevant argument of latitude for eccentricity control, and then calibrated before the next computation. The transfer strategy was designed in order to have 2 small corrections at the beginning of the transfer (to state on the good behavior of the propulsion system) and 2 small corrections at the end, to limit the deviations while stopping the orbit drift on the targets. At the end of the transfer, the next OCM was expected around end of August 2013 (under typical 50-quantil solar activity conditions).





6 first months of operations as seen from VAST

Flight Dynamics Routine activities

The daily routine activities for FD operators start every morning when the GPS parameters and Doppler parameters production has been done by the Satellite Control Terminal (SCT), once the first morning satellite contact has been completed. All the FD activities are performed using the EADS Astrium FD software package Quartz LEO© which is developed and maintained by EADS Astrium, and has already been delivered to several LEO operators. The daily routine activities consist in:

- Orbit determination (OD) and maintenance activities (Doppler bias calibration, comparison of OD accuracy with GPS or Doppler data)
- FD Events Prediction (eclipses, ground stations visibilities, nodes crossings, platform polarities, collisions avoidances) and Station Keeping (SK) parameters evolution monitoring (GT and LST)
- Generating ephemeris files for the Mission Planning Terminal (MPT) team, in charge of the daily image plans computation

- Generating files for ground stations programming : Antenna Pointing Files for the X-Band antenna (image telemetry) and TLE for the S-Band antenna (platform telemetry + commanding)

Orbit Control Maneuver activities

The decision to perform an OCM stems from the daily monitoring of both GT evolution (within a ±30km wide mission window) and LST evolution (within a ±10min wide mission window). The first OCM was computed and executed autonomously by VAST teams on the 1st of October 2013. It consisted in correcting only the GT evolution (in-plane maneuver only). The next GT correction is expected around mid-December 2013 (depending on actual solar activity). The next LST correction (combined maneuver in-plane/out-of-plane) is expected around beginning of September 2014.

Pre OCM activities

Once the need of a maneuver has been established, the FD team computes the orbital increments required to control the GT and/or LST evolutions, then implements those increments to get the maneuver start epoch and duration. Finally, it generates the TC files to be uploaded to the spacecraft, including the start command, number of pulses, attitude guidance before, during and after maneuvers. Once checked, the TC files are sent to the SCT, in charge of the upload of the OCM plan.

Post OCM activities

Post maneuver activities consist in estimating the efficiency of the maneuvers based on the navigation measurements (GPS/Doppler) before, through and after the maneuvers. The calibration coefficient is used for the computation of the next OCM. It is also necessary to estimate the remaining propellant mass after thrust using the propulsion tank telemetry parameters (temperatures and pressure).

Conclusion

The transfer phase performed by EADS Astrium lead VNREDSat-1 spacecraft to reach its operational orbit within 8 days, taking into account a proper initialization of the SK cycle. Nowadays, VAST teams have taken the lead on the operations and autonomously conduct the routine activities that ensure the daily delivery of high level quality images to various Vietnamese partners. EADS Astrium is proud to have followed and supported the development of a new protagonist in the field of space flight operations.