Summary of Data Analysis of the YES2 Tethered SpaceMail Experiment

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The 2nd Young Engineers' Satellite (YES2) is a 36 kg student-built experiment that piggybacked on the Foton-M3 microgravity platform. It was launched in September 2007 with three objectives: 1. education, 2. deployment of a 32 km tether to accurately release a 6 kg spherical capsule into a re-entry trajectory, 3. landing of the capsule (Fotino) in Kazakhstan. YES2 thus intended to demonstrate SpaceMail, a concept for frequent sample return originally proposed for the International Space Station (ISS). Using a tether system rather than a rocket reduces complexity and cost, saves storage on-board the station and allows for a smaller and simpler capsule. This paper summarized the data analysis of the YES2 mission. The planned tether deployment included a unique two-stage approach, a tether swing of 45 degrees and a capsule release from the bottom of the tether for increased landing precision. Despite an electrical problem, the tether deployed fully (it overdeployed by 1.7 km) and was released at the proper time close to the nominal release point, sending Fotino in a trajectory towards the designated landing zone, some 800 km upstream of the nominal landing area. The capsule was not (yet) recovered.

The data analysis had the following objectives: reconstruction of the deployment trajectory, estimation of the capsule trajectory and projected landing spot, assessment of the closed-loop control performance and potential landing accuracy, assessment of the deployer hardware performance for the SpaceMail application, study of tether physics and suitability of simulations and testing for planning tether missions. All the tether mission objectives could be achieved, novel deployment features were successfully demonstrated. The quantity and quality of the data allows for improved understanding of tether dynamics and recommendation for future activities.

The primary source of data is the Optical Loop Detection (OLD) system from which tether length and length rate can be derived. Based on tether deployment dynamics, this data is used to reconstruct the deployment trajectory: length, velocity, in-plane angle and tension. Intermittent lack of OLD data near the end of deployment proved to be a challenge, yet the full deployment could be derived in sufficient detail, from which hardware and software performance could then be studied. Independent confirmation of in-plane angle, velocity and tension data could be obtained from accelerometer and magnetometer data from the DIMAC experiment on Foton-M3. This data also showed proper tether release. Derived hardware performance as well as measured tension shocks after deployment could be correlated to simulation results. The analysis was further supported by subsatellite data (to estimate Fotino dynamics), SSAU GPS/magnetometer data (further detailing of deployment) and NORAD measurements (confirmation of momentum transfer).