SPACE DEBRIS SYMPOSIUM (A6)
Modeling and Risk Analysis (2)

Author: Dr. Carmen Pardini
ISTI-CNR, Italy, carmen.pardini@isti.cnr.it

Dr. Luciano Anselmo
ISTI-CNR, Italy, luciano.anselmo@isti.cnr.it

USA-193 DECAY PREDICTIONS WITH PUBLIC DOMAIN TRAJECTORY DATA AND ASSESSMENT OF THE POST-INTERCEPT ORBITAL DEBRIS CLOUD

Abstract

Our Laboratory was involved in re-entry predictions of potentially risky space objects since 1979. In all cases analyzed so far, the Two-Line Elements (TLE) determined by the US Space Surveillance Network (SSN) were openly available and constituted a fundamental source of orbit data on which most of the analysis was carried out.

At the beginning of 2008, however, the need arose to predict the orbital decay of the American spacecraft USA-193, whose characteristics, function and orbit were classified. With no SSN orbit data and independent Italian tracking capability, we turned our attention, for the first time, to the orbits determined by a worldwide network of about 20 very dedicated and competent visual satellite observers. The TLE of USA-193 obtained from such visual observations, freely distributed through the Visual Satellite Observer's and the Heavens-Above web sites, were therefore used as the sole source of orbit information.

From our point of view, this situation was truly interesting and represented a perfect test case to investigate several aspects of the problem: the accuracy and the reliability of the orbital data provided by amateur satellite observers, the limits of visual tracking applied to very low earth satellites, the capabilities of present day non professional telescopes and cameras to characterize a large space object and, last but not least, our ability to extract and deduce the maximum amount of usable information, and a coherent picture of the situation, only from public domain sources.

Contrary to our expectations, this exercise was extremely successful and we learned a lot in the process. The TLE provided by the visual observers resulted to be very accurate for a so low satellite (even though the minimum and very stable level of solar activity helped a lot), but data gaps of a few days were sometime possible, due to unfavorable pass geometry or weather and illumination conditions. In particular, the orbital period and the semimajor axis were so accurate that very good decay fits were possible with a special perturbation software, including various atmospheric density models together with the other relevant perturbing accelerations. It was therefore possible to estimate accurate values of the ballistic parameter and the resulting decay and reentry predictions were extremely stable.

Amateur optical observations and images of USA-193 were also able to estimate roughly the shape and sizes of the satellite, showing that the solar arrays were never deployed. With this information, and taking into account our estimates of the ballistic parameter, we obtained reasonable and consistent values of the spacecraft mass. Then, based on previous reentry fragmentation analyses, it was possible to guess the expected USA-193 casualty area, casualty expectancy, debris ground footprint, probability of impact in Italy and so on.

After the decision by the US Government to destroy the satellite, it was possible to estimate in advance the interception time windows and the post-event ground tracks. Following the successful spacecraft breakup, the resulting debris cloud was simulated and compared with the cataloged fragments. Its evolution was analyzed and the adverse impact (very limited, indeed) on the circumterrestrial environment was assessed.