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Modeling and Risk Analysis (2)

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## SWOT REENTRY: MANEUVERS STRATEGY AND RISK COMPUTATION

**Abstract**

The Surface Water Ocean Topography (SWOT) mission is a joint NASA/CNES mission to be launched on November 2022 dedicated to oceanography and continental hydrology. Once the scientific mission is over, SWOT will have to perform a controlled re-entry to comply with the French Space Operation Act (FSOA). Indeed, the launch authorization is subject to the respect of the FSOA, fully applicable since 2020. The main requirement applying to the end of life of the satellite consists in limiting the casualty area and then the probability of having a victim on ground under the threshold of  $10^{-4}$  in case of a natural reentry. With a mass over two tons and a casualty area of about  $170\text{m}^2$ , SWOT can't comply with this requirement. Thus, the platform has been designed with a specific propulsion system to carry out end-of-life manoeuvres leading to an atmospheric re-entry and impact in the SPOUA (South Pacific Ocean Uninhabited Area). CNES is in charge of defining re-entry manoeuvres strategy, performing end-of-life operations and evaluating the risk of casualties in case of failure during nominal strategy. This paper will address these three topics. The computation of the ten manoeuvres used to lower the perigee and finally target the SPOUA is performed using DOORS tool. Before describing the manoeuvres strategy, this paper presents an overview of the current functionalities of this tool which has been already used during the five ATV missions and ASTRA-1K de-orbit twenty years ago! DOORS is mainly used for mission analysis purposes, but for end-of-life operations, it will be activated by the operational system FDS (Flight Dynamics System). Thus, fine comparisons between FDS propagators and DOORS computations have been performed. Finally, the estimation of casualty risk relies on the use of two other CNES tools: DEBRISK and ELECTRA whose methods will be presented. The list of surviving fragments has been computed using new DEBRISK-V3 methodology in case of controlled and uncontrolled reentry. The risk of human casualty is evaluated using ELECTRA and its Monte Carlo simulations. This tool generates numerous trajectories of the satellite and its fragments with various dispersed variables. The impact locations on an up-to-date grid of world population leads to the probability of victims. The complete risk of SWOT controlled re-entry encompasses both the risk related to a failure during the last re-entry manoeuvre and the risk associated with the natural re-entry in case a failure occurs before this last burn (during the mission or during the first re-entry manoeuvres). Both of them are weighted by their probability of occurrence.