ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (4)

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AN APPROACH TO ESTIMATE THE TOTAL PROBABILITY OF IMPACT WITH THE GALILEAN SATELLITES GIVEN FAILURE FOR THE EUROPA MISSION

Abstract

The Europa Mission baseline design would conduct detailed reconnaissance of the Jovian moon Europa and investigate whether the icy moon could harbor conditions suitable for life. The Mission Concept would send a highly capable, radiation-tolerant spacecraft into an orbit around Jupiter to perform repeated close flybys of Europa.

In our contribution to the IAC Congress we will detail the approach taken by the Europa Project for estimating the probability of unintended impact with Europa and other Galilean moons.

This estimate constitutes the first of several steps needed to demonstrate how the Mission Concept can comply with NASA's Planetary Protection Requirements, which impose an upper bound on the probability of inadvertent contamination of an icy satellite. If the probability of unintended impact is small, cleanliness requirements may be reduced, otherwise constraints are placed on the total biological burden in the flight system.

Our approach can be briefly described as follows:

1. The Mission Design team produces a nominal trajectory with orbital maneuvers placed at strategic locations.
2. The Orbit Determination team models the maneuver execution error and ephemerides uncertainties to produce a covariance matrix associated with every maneuver.
3. Assuming no future maneuvers after having executed a given maneuver (and before having executed the following maneuver), we perform a large-scale Monte Carlo simulation of the dynamical system modeling the spacecraft motion; the initial conditions are sampled from the corresponding covariance matrix and the outcomes are grouped into categories.

The categories considered for enumeration are:

- Impact with Io, Europa, Ganymede, or Callisto
- Entry into Jupiter
- Escape from Jupiter

- Reaching a prescribed final time
- Reaching a prescribed total ionizing dose

This process is repeated for every maneuver in every trajectory considered for the Europa Mission Concept.

The outcome of the Monte Carlo simulation provides the means to estimate various trajectory statistics, their distributions, and corresponding confidence intervals. Specifically, it provides an estimation of the probability of impact given failure after every maneuver.

Our contribution will detail the selection of forces to include in the dynamical system, the choice of numerical integration software, the multi-threaded implementation, the deployment of the simulator in JPL's supercomputers and Cloud Computing resources, and a discussion of preliminary results.