An Updated Process for Automated Deepspace Conjunction Assessment

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Abstract: *There is currently a high level of interest in the areas of conjunction assessment and collision avoidance from organizations conducting space operations. Current conjunction assessment activity is mainly focused on spacecraft and debris in the Earth orbital environment (reference 1). However, collisions are possible in other orbital environments as well (reference 2). This paper will focus on the current operations of and recent updates to the Multimission Automated Deepspace Conjunction Assessment Process (MADCAP) used at the Jet Propulsion Laboratory for NASA to perform conjunction assessment at Mars and the Moon. Various space agencies have satellites in orbit at Mars and the Moon with additional future missions planned. The consequences of collisions are catastrophically high. Intuitive notions predict low probability of collisions in these sparsely populated environments, but may be inaccurate due to several factors. Orbits of scientific interest often tend to have similar characteristics as do the orbits of spacecraft that provide a communications relay for surface missions. The MADCAP process is controlled by an automated scheduler which initializes analysis based on a set timetable or the appearance of new ephemeris files either locally or on the Deep Space Network (DSN) Portal. The process then generates and communicates reports which are used to facilitate collision avoidance decisions. The paper also describes the operational experience and utilization of the automated tool during periods of high activity and interest such as: the close approaches of NASA's Lunar Atmosphere & Dust Environment Explorer (LADEE) and Lunar Reconnaissance Orbiter (LRO) during the LADEE end of mission, multiple spacecraft performing Mars Orbit Insertions (NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) and the Indian Space Research Organization's (ISRO) Mars Orbiter Mission (MOM)), and the close approach of comet Siding Spring at Mars. The situation of several new spacecraft appearing in Martian Orbit and desire to avoid debris from the comet provided unique challenges to the automated conjunction assessment process. In addition, special consideration was required for the treatment of missions with rapidly varying orbits and less reliable long term downtrack estimates; in particular this was necessitated by perturbations of MAVEN's orbit induced by the Martian atmosphere. In order to analyze such cases using the existing MADCAP tool, it proved more useful to focus on orbit crossing distances and event timing in place of absolute close approach distances of the spacecraft. A variable threshold scheme was implemented based on the predicted time until a conjunction event. In the absence of covariance data in trajectory files, this method allows events to be categorized by threat level based on an uncertainty level which changes as predictions are carried further in time. The application of special techniques to non-operational spacecraft with large uncertainties is also studied. Because there is no Mars surface-based radar space surveillance network, non-operational spacecraft cannot be reliably tracked as is done for Earth orbiting spacecraft and debris. Thus, a conjunction assessment method for deepspace non-operational spacecraft must rely on long*

term propagation of last known trajectory information. This introduces large uncertainties and interesting challenges to the automated conjunction assessment process. Other methods for dealing with the distinctive issues of non-operational spacecraft are explored and future work in this area described. Strategies for inclusion of covariance estimates and probability analysis in the automated deepspace tool are discussed. Although the applications discussed in this paper are in the Martian and Lunar environments, the techniques are not unique to these bodies and could be applied to other orbital environments.

1. Lauri K. Newman, "Conjunction Assessment Risk Analysis (CARA) Program Overview", https://foiaelibrary.gsfc.nasa.gov/_assets/doclibBidder/tech_docs/CARA%20overview%20briefing.pdf, 7 August 2013.

2. David S. Berry, Joseph R. Guinn, Zahi B. Tarzi, and Stuart Demcak, "Automated Spacecraft Conjunction Assessment at Mars and the Moon", AIAA SpaceOps 2012 Conference, Stockholm, Sweden, 11 June 2012.