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Processing of Optical Telescope Observations with the Space Object Catalogue BACARDI

Authors: Martin Weigel (1), Michael Meinel (2), Hauke Fiedler (1)
(1) DLR – German Space Operation Center (GSOC)
(2) DLR – Simulation and Software Technology

martin.weigel@dlr.de
Presenting Author: Martin Weigel

Abstract:
In a joint project of the DLR the Institutes for Simulation and Software Technology and DLR Space Operations and Astronaut Training develop methods for space surveillance. The aim of the project is to develop an orbital database for objects in Earth orbit – called the Backbone Catalogue of Relational Debris Information (BACARDI). The main research topics are object identification from different sensor observations, orbit determination and orbit propagation including state vector and state uncertainty. Main applications of the orbital database will be close approach prediction for collision avoidance - further on re-entry prediction, detection of satellite manoeuvres and on-orbit fragmentations.
An introduction is given to the software architecture of BACARDI. A self-developed middleware provides the functionality for distributed computations on a scalable network of hardware devices. A relational database is used for data storage and access. The data are structured in more than 100 tables, e.g. for space surveillance and tracking sensors, sensor observations, orbit parameters in different dynamic models, object properties, on-orbit events like manoeuvres and fragmentation, etc. Provenance data allow for tracing back the sources of information for each data product. One example question is which sensor provided information that was used for orbit determination and prediction and subsequent generation of a close approach warning a satellite operator has to deal with. Past states of information can be reconstructed by evaluation of metadata and processing logs. Sharing of space surveillance data has a great potential under the assumption that different level of confidentiality are respected. Therefore, in BACARDI every data record and processors are linked with configurable rights and different user roles for usage and transfer in accordance to defined rules.
The data processing chain consists of a multi-staged algorithm of observation correlation and subsequent orbit determination. In a first correlation step, new measurements are compared against existing orbital information of already known objects, for example previously generated or imported database records. In case of an unambiguously and reliable correlation result, the orbit record is updated by the new observations. The remaining uncorrelated measurements are passed to an object identification algorithm that filters out multiple observations that are connected by an elliptical Earth orbit. In this way, new candidate objects are discovered and initial orbits are determined. The association of further observations increases the orbit accuracy and may lead to an object candidate confirmation and generation of a new catalogue record.
The first sensor network contributing observation data to BACARDI is the Small Aperture Robotic Telescope Network (SMARTnet). The network is used for monitoring the geostationary Earth orbit and is subject to a proposed second presentation at ISSFD 2015. Since August 2014, a robotic telescope is tested at Zimmerwald Observatory of the Astronomical Institute of the University of Bern. Once testing is finished, the telescope will be deployed at the Sutherland Observatory in South Africa. Optical observation of GEO and MEO objects where gathered since the beginning of the test campaign. Thereby, it is possible to present the first results of BACARDI processing algorithms based on real measurements. The core steps of the processing chain will be demonstrated for passive optical observations that provide short series of line of sight measurements from geostationary objects.