POINTING ERROR ENGINEERING FRAMEWORK FOR HIGH POINTING ACCURACY MISSIONS

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ABSTRACT

Pointing error engineering covers the engineering process of establishing system pointing error requirements, their systematic analysis throughout the design process and eventually compliance verification. For technical as well as historical reasons, pointing error engineering in the European space community has long been implemented on the basis of engineering practices that were often tailored on a case-by-case basis and no standard practice was in place. This situation has been changed by the initiative of the European Cooperation for Space Standardization (ECSS): the ECSS Control Performance Standard E-ST-60-10C, published in November 2008, provides solid and exact mathematical elements to build up a performance error budget. However, an additional document that provides guidelines and summation rules based on the top level clauses gathered in this ECSS-E-ST-60-10C standard was considered necessary by ESA to provide ESA projects with a clear pointing error engineering methodology. This methodology is the basis for a step-by-step process with guidelines, recommendations and examples consistent with and complementing the ECSS standard.

The answer to this necessity is the ESA Pointing Error Engineering Handbook (PEEH) that was published in 2011 as ESA applicable document with the reference ESSB-HB-E-003. The ESA PEEH builds upon previous analytical work that introduced a mathematically well-founded approach to pointing error engineering. An accompanying SW tool that supports the ESA PEEH users in compiling pointing budgets was also considered beneficial in promoting dissemination and enhancing application of the Handbook. Such Pointing Error Engineering Tool (PEET) was envisaged to assist system engineers and control engineers both for the pointing requirements allocation activities, typically taking place in early phases of a project, and for the pointing error budget verification activities, taking place in later phases.

ESA initiated and coordinated the development of a PEET prototype, carried out by Astos Solutions GmbH with the support of the Institute of Flight Mechanics and Control of the University of Stuttgart. The objective was to implement the step-by-step methodology proposed in the PEEH for early feasibility studies (Concurrent Design Facility-type pre-phase A studies)

and phase A studies. This approach is intrinsically capable of minimizing the margins and uncertainties in pointing budgets and therefore is expected to prove extremely valuable especially for high pointing accuracy missions. Indeed, it is for this class of missions that the accurate analytical results that can be obtained using PEET could make the difference in taking the correct design decisions.

PEET has been extended to relative position error budgeting and is released under the ESA Software Community License. An operational software, targeting use in Phases B and C, is under development for ESA to be released under the same license type as PEET. This will permit processing complex calculations for high accuracy pointing, frequency domain techniques introduced in the handbook, provision of traceability and a common platform for exchange of information between the various entities.

ESA is currently using PEET for the pointing error engineering analyses of a number of missions, including Euclid, MetOp-SG, and Proba-3.

The paper will provide a detailed summary of the pointing error analysis and evaluation methodology according to the PEEH. The implementation and features of the PEET prototype will then be described. An application of the use of PEET in pointing error budgeting activities for high pointing accuracy missions will be presented. Conclusions and an overview of the foreseen future developments will complete the paper.