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Author: Mr. Volker Maiwald
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, volker.maiwald@dlr.de

APPLICABILITY OF THE TISSERAND CRITERION FOR OPTIMIZATION OF GRAVITY-ASSIST SEQUENCES FOR LOW-THRUST MISSIONS

Abstract

Mission for space exploration are becoming more ambitious and gravity-assist maneuvers act as one enabler for them. The "free energy" associated with this technique is often vital for conducting a mission in the first place. Consequently, new methods for sequencing and optimizing gravity-assist maneuvers and sequences are investigated and further developed – for missions involving impulsive and low-thrust propulsion alike. The System Analysis Space Segment department of the German Aerospace Center (DLR) in Bremen is currently conducting research to combine gravity-assist sequence with low-thrust optimization. One technique, which is prominently used to sequence gravity-assist maneuvers are Tisserand Graphs, based on the Tisserand Criterion, which states that a function of certain orbit parameters of a comet (for mission design purposes spacecraft) remains approximately constant even after a close encounter with a planetary body. However one condition for the validity of the Tisserand Criterion is that the only force acting on the spacecraft is gravity, which obviously would not be the case for a low-thrust mission. By investigating approximations and simplifications necessary for deriving the Tisserand Criterion, e.g. non-constant spacecraft mass, and the deviation they cause from the real situation in the solar system, this paper analyses how well suited the Tisserand Criterion is for use in low-thrust mission design. Furthermore a correction term is presented that allows inclusion of thrust into the criterion and thus reducing the accompanied error.