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Author: Ms. Laia Lopez Llobet
International Space University (ISU), France, laia.lopez.llobet@community.isunet.edu

Prof. Chris Welch
International Space University (ISU), France, chris.welch@isunet.edu
Dr. Andreas Hein
Initiative for Interstellar Studies, United Kingdom, andreas.hein@i4is.org
Ms. Giulia Costella
International Space University (ISU), France, giulia.costella@community.isunet.edu
Ms. Cato Meaker
International Space University (ISU), France, cato.meaker@community.isunet.edu

OPTIMUM LOCATION TO INTERCEPT INTERSTELLAR OBJECTS WITH BUILD-AND-WAIT MISSIONS

Abstract

Since the detection of the first interstellar objects (ISOs) passing through the Solar System, the scientific community has been working on different approaches to study them. The first ISOs ever detected were 1I/'Oumuamua in October 2017, followed by 2I/Borisov in August 2019 which were classified as an interstellar asteroid and an interstellar comet, respectively. Such ISOs present high scientific interest because they could provide more insight into the composition of other stellar systems, planetary formation and the hypothesis of panspermia.

However, although astronomical observations can be performed by telescope, in order to further analyze these objects, in-situ data gathering by spacecraft is required. Such objects are usually detected late in their passage through the Solar System and possess high heliocentric velocities (v_∞ >25 km/s). Their detection frequency is low and the observation window is typically short. These obstacles make both reaching these scientifically promising objects and also designing an appropriate spacecraft challenging.

Beginning the mission design and spacecraft manufacture only after ISO detection would significantly lower mission success probability. Consequently, "build-and-wait" is a very appealing mission concept. This type of mission consists of building a spacecraft beforehand and then storing it on Earth ready to launch when required or sending it to a specific location in space to wait for its target.

This paper assesses the best mission approach for missions to ISOs. The main characteristics, detectability and incoming frequency of ISOs are assessed for the determination of the best mission approach and its characteristics. A trade-off is conducted between build-and-wait missions on Earth and in space, based on cost, risk, response time and spacecraft lifetime. It is determined that, currently, due to constraints regarding logistical challenges, build-and-wait missions in space are the best approach for the interception of ISOs. In addition, the optimal location to place a spacecraft in space for future missions to ISOs is assessed by creating, using integration numerical methods, random potential trajectories of ISOs based on their characteristics.