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Preliminary planification for solar sail trajectory project

This document contains the initial proposals for the *Solar-Sail Trajectory Design for Near-Earth Binary Asteroid Flyby Mission* project. First, a rough methodology and projected time frames are proposed, followed by a quick summary of the background research completed for the project, as well as the most important references.

Methodology

The project will follow the following rough outline:

1. Construction of a **trajectory optimisation tool**, providing certain constraints and boundary conditions, and calculated using a Bézier curve shape-based method.

   The calculation tool has the following sections:

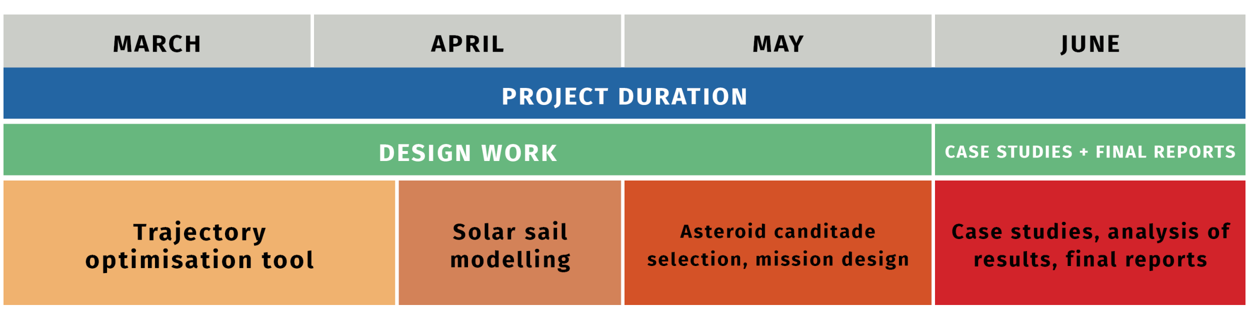
   (a) Constraints and reference frames
   (b) Equations of motion
   (c) Problem description
   (d) Bézier functions
   (e) Trajectory optimisation

2. **Modelling of the solar sail** thrust vector for inclusion in the trajectory design tool.

3. Background research on **near-earth binary asteroids**, reviewing similar missions and selecting candidates for study.

4. Final **case studies** of trajectory calculations for solar sails visiting the asteroid systems, as well as result analysis.

Projected time frames



References

An extensive literature review has been completed for the project, and a variety of sources will be useful int he final project. A quick summary is made so as to simplify process down the line, and a commentary made on the most pertinent documents used as reference.

Solar sail technology review

Several sources are used as reference for current solar sail technologies, mathematical modelling of the thrust produced, and models of the solar radiation pressure. While these papers also contain information on the structural dynamics, materials, and deployment of solar sails, these are beyond the scope of this project.

In [Fu et al., 2016], a comprehensive review of the state of the art of solar sails is made, including a quick summary of the physical phenomenon, a variety of attitude control methods, orbital equations of motion, structural dynamics and deployment. In particular, section 2.2 *Solar radiation pressure force modelling* will be useful for the second stage of this project. Additionally, section 4.3 contains an exhaustive list of studies concerning solar-sail mission trajectories, which may be useful in mission design.

Another paper, [Gong and Macdonald, 2019], follows much the same lines. A useful addition is found in section 4, where the characteristics of the non-Keplerian orbits followed by solar sails around the sun, where the thrust force is generated by SRP.

When the solar sail modelling commences, a variety of sources may be consulted, in addition to those mentioned here–the mathematical particulars of the problem have been extensively approached. A large part of the modelling process will be selecting an appropriate model for the trajectory calculation tool.

Bézier curves for shape-based trajectories

An approach developed mostly at Harbin Institute of Technology, these authors have developed a tool which uses Bézier curves to model the trajectory.

The principal source used is [Huo et al., 2019a], which contains the most extensive description of the trajectory calculations, and is additionally already applied to an electric sail. This paper will be the most common reference in the first part of the project.

Other papers by the same authors are also useful to complement this paper: [Fan et al., 2020] and [Huo et al., 2019b].

Other papers can also be mentioned: a project which uses Bézier curves to approximate real trajectories (nearly the inverse problem) [de Dilectis et al., 2016], a commentary on elliptical approximations (since perfect ellipses cannot be described using Bézier curves, approximations are made and the errors studied) [Maisonobe, 2003], and yet another paper has a practical matrix form of Bézier coefficients [Jusko, 2016].

References

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