The Design Pipeline of the Milani Mission: Overview and Challenges After DART Impact

Mattia Pugliatti[0000−0002−1286−2594], Fabio Ferrari[0000−0001−7537−4996], Felice Piccolo[0000−0002−4611−325X], Antonio Rizza[0000−0003−3780−2974], Claudio Bottiglieri[0000−0002−6206−8479], Vittorio Franzese[0000−0002−2306−6315], Carmine Giordano[0000−0003−0833−4729], and Francesco Topputo[0000−0002−5369−6887]

Politecnico di Milano, Department of Aerospace Science and Technology, Milano, 20156, Italy mattia.pugliatti@polimi.it

Abstract. In this work, we present an overview of the design pipeline adopted for the Milan mission. The pipeline is presented as a generalized methodology that can be used to design any close-proximity mission about a small body. Its key elements are also addressed for the specific case of the Milani mission in relation to the changes that will need to be addressed following the updates from the DART mission.

Keywords: Milani · CubeSat · Didymos · Hera · Mission Design

Introduction

Milani[1] is a 6U CubeSat designed with both orbital and attitude control capabilities that will be released in the Didymos environment by the Hera mothercraft in early 2027. Milani will be released during a dedicated Hera operational phase after an early characterization of the binary system. The Didymos system is constituted by a primary and a secondary body called D_1 and D_2, respectively.

The main scientific and technological objectives of the Milani mission are to characterize the Didymos binary system, estimate its gravity field, characterize the dust environment, demonstrate inter-satellite communication capabilities with Hera, and demonstrate the use of CubeSat technologies in deep space.

The pipeline used for the design of the Mission Analysis (MA) and GNC subsystem of the Milani CubeSat is split into three components.

Mission analysis pipeline

The MA pipeline is structured as a sequence of 8 design blocks, as represented in Figure 1. The failure of one step to satisfy the requirement and analysis of the previous one requires a fallback and re-design. Updates from the DART mission are expected to affect the dynamical modeling of the system since better estimates about the masses of the bodies will be available as well as improved shapes for polyhedral gravity models. The dust environment surrounding the asteroid may also impact observability while the exact crate size may require an update in the payload analysis. All these changes can be accommodated by the current pipeline by tuning its input parameters.

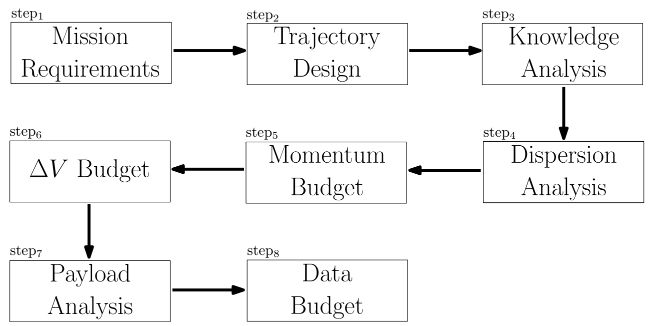

Fig. 1. High-level schematic of the MA pipepline.

Image processing pipeline

The image processing (IP) of Milani [2] has been designed since the early stages to accommodate large changes in the shape models of the bodies of the Didymos system expected after the DART and Hera missions. To enable that, the IP has been designed as a global data-driven method that updates itself through new datasets of images obtained in an artificial environment.

By design, the IP itself is thus a pipeline that uses coefficients that needs tuning through data obtained at different phases and from different missions. Additional changes are not expected in the IP algorithm if not for the tuning coefficients or for specific processing that may be required by the presence of dusty particles within the system after the impact.

Guidance, Navigation, and Control system pipeline

The Guidance, Navigation, and Control (GNC) system of Milani has also been designed from a generic GNC generator software [3] which has been written in a fully re-configurable way. Transition between the pipelines is ensured by CARONTE: an in-house developed application to generate all the necessary configuration files. Updates during successive phases of the mission are expected in the dynamical models used onboard for the filter as well as the ground ones used to simulate the environment.

References

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