ABACO, AN AUTONOMOUS BOARD FOR AVOIDING COLLISIONS

Dario Modenini[1[0000-0002-1517-3938]], Giacomo Curzi[2[0000-0001-6015-1538]],Alfredo Locarini[3[0000-0002-0259-6747]],Paolo Tortora[1[0000-0001-9259-7673]], Stefano Cicalò[4], AlessiaBertolucci[4],FrancescaGuerra[4] and Mauro Cardone[5]

[1]Department of Industrial Engineering and Interdepartmental Center for Industrial Research in Aerospace, Alma Mater Studiorum Università di Bologna, via Fontanelle 40, 47121, Forlì, Italy.
[2]Interdepartmental Center for Industrial Research in Aerospace (CIRI-AERO) Alma Mater Studiorum Università di Bologna, via Baldassarre Carnaccini 12, 47121, Forlì, Italy.
giacomo.curzi2@unibo.it
[3]Department of Industrial Engineering, Alma Mater Studiorum Università di Bologna, via Fontanelle 40, 47121, Forlì, Italy.
[4]SpaceDys s.r.l., Via Mario Giuntini 63, 56023 Navacchio di Cascina (PI), Italy.
[5]Italian Space Agency, Via del Politecnico, 00133 Roma, Italy.

Abstract. The increasingly crowded space environment is demanding for autonomous and efficient Collision Avoidance solutions.ABACOis an onboard device able to perform late Collision Avoidance, aided by a ground companion for maneuver negotiation and data retrieval.

Keywords: Collision Avoidance, Space Traffic Management,Autonomy.

1 ABACO Context

While space-based solutions are generating growing interest in service providers (internet, surveillance, etc.), there is a strong push in making access to space cheaper. The overall effect is an expected dramatic increase in space traffic to be handled. Parts of the larger Space Traffic Management discipline, Conjunction Assessment and Risk Analysis (CARA) and Collision Avoidance (COLA) are crucial to ensure a safe operational environment.
An autonomous collision avoidance infrastructure is therefore highly desirable[1][2].

In this context, and in the framework of a project funded by the Italian Space Agency, we propose an onboard-satellite subsystem (ABACO) able to improve COLA maneuvers effectiveness while mitigating the ground workload. ABACO is heading towards autonomous lateCOLA to yield a paradigm shift in the current process.
At the moment we are in the detailed design phase;the project goal of integration and testing of a TRL4 elegant breadboardshould be achieved in mid-2023.

1.1 Motivation

For autonomous systems like ABACO, there is typically a tradeoff about whether the autonomy shall be placed onboard or inground [3]. The main driving factor is the availability of better data quality to perform a given task.

While high-level coordination i.e., Space Traffic Management is a good candidate for on-ground automation thanks to global SSA availability, the CARA process might be more effectively automated onboard. In fact,when performed on-ground, CARA is prone to false alarm because it must decide for maneuvering early enough in time to design/negotiate and *upload* the maneuver, thereby relying on older measurements for orbit determination of the involved objects.When performed onboard, assuming GNSSdata to be available in near-real time for the hosting spacecraft, a late-maneuver policy can be implemented by updating the risk estimate closer to the conjunction. This reduces the number of unnecessary maneuvers with negligible magnitude changes [4].

If on one hand, we recognize that the onboard advantage with respect to on-ground is significant only when both objects' orbits would be available with comparable (GNSS-class) uncertainty, the number of active objects sharing their GNSS positions is going to increase. Therefore, we expect ABACO to provide a significant advantage for many conjunctions in the near future, especially for intra-constellation collision avoidance (e.g., Starlink).

2 Concept of Operation and Architecture

ABACO works in synergy with the current surveillance ground segment using a companion ground application. The ground counterpart is in charge of Space traffic management, negotiating high-riskevents for maneuvers while gathering also SSA information needed by the ABACO board in orbit. Eventually, the ABACO board has to make the ultimate choice about the maneuver optimizing it to account for tertiary objects as well.
This allows mitigation actions to be conducted efficiently with minimal human supervision.

Our efforts are in i) adopting a safe risk metric usable without supervision needs, ii) using Machine Learning to conveniently optimize against post-maneuver conjunctions and iii) develop a quasi-real time orbit determination algorithm with cutting-edge accuracy.

From a hardware point of view, ABACO features a navigation unit, devoted to the autonomous orbit determination and prediction for the hosting spacecraft, plus a collision avoidance unit, which provides conjunction screening, risk assessment, and mitigation functionalities (such as the computation of evasive orbital maneuvers), supported by Artificial Intelligence.

3 Conclusion

The full paper describes the concept of operations and architecture of the ABACO board. It also gives a roadmap of the development process within the project funded by ASI, ultimately aiming at the manufacturing of a TRL 4 prototype of ABACOto be tested in a laboratory environment.

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