EO-ALERT: A Satellite Architecture for Autonomous Maritime Monitoring in Almost-Real-Time

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***Abstract*—This paper presents an overview of the maritime monitoring satellite architecture and results achieved by the EO-ALERT H2020 project. EO-ALERT proposes the definition and development of the next-generation Earth Observation (EO) data processing chain, based on a novel flight segment architecture that moves EO data processing elements from the ground segment to on-board the satellite, with the aim of delivering the EO products directly to the end user with very low latency; in almost-real-time, e.g. within 1 minute. This paper presents the EO-ALERT architecture, its performance and hardware, with a focus on its application to maritime scenarios. Performances are presented for multiple reference user scenarios; autonomous ship detection, for a service similar to the EMSA VDS, and extreme weather monitoring, for wind and wave. The ground test results using EO data show that the proposed architecture can deliver maritime EO products to the end user with latency lower than one-point-five minutes, for both SAR and Optical Very High Resolution (VHR) missions, demonstrating the viability of the architecture for almost-real-time maritime monitoring.**

Keywords— On-Board Processing, AI, Low Latency, Security

I. INTRODUCTION

The classical EO data chain generates a severe bottleneck problem, given the very large amount of EO raw data generated on-board satellites that must be transferred to ground, reducing responsiveness and increasing latency. EO-ALERT (http://eo-alert-h2020.eu/) proposes to solve this problem through the definition and development of the next-generation EO processing chain, that delivers globally and directly the EO products to the end user, with very low latency (in almost-real-time), with latencies below 1 minute.

Achieving this goal poses great challenges on the flight system. This is addressed through a combination of innovations in the on-board elements of the data chain and the communications link. As such, this goal necessitates innovation in several critical technological areas, namely: satellite on-board reconfigurable data handling, on-board image generation, on-board image processing for the EO products generation, high-speed on-board avionics, on-board data compression and encryption, and reconfigurable high data rate communication links to ground, while also exploiting machine learning (ML)/artificial intelligence (AI).

The paper presents the project results with application to very low latency and responsive maritime monitoring.

II. EO-ALERT OVERVIEW

Data latency has become a key requirement in the EO market. Current market trends are moving beyond Near Real-Time (NRT) applications, to applications with latencies in the order of 15 minutes to 30 minutes. The latency performance concept behind EO-ALERT is to achieve, for the EO products delivery globally to the end user, a **goal latency of less than one minute** and require a maximum latency of less than 5 minutes. This is demonstrated in EO-ALERT for the complete data chain from the payload to the ground reception and decryption of the EO products. This is verified and experimentally validated on an avionics test-bench (ATB), allowing the achievement of TRL 4/5 for the concept and technologies. This verification uses both archive data from multiple satellites (e.g. TerraSAR-X for SAR, DEIMOS-2 for Optical) and experimental EO data acquired specifically for EO-ALERT.

Current ground test results using TerraSAR-X EO data and DEIMOS-2 EO data show that the proposed architecture can deliver maritime EO products to the end user with latency lower than **one-point-five minutes**, with accurate detection of the ships and estimation of wind speed and wave height, in the areas of interest.

III. ACKNOWLEDGEMENTS

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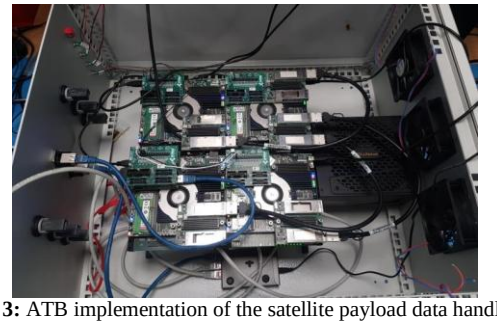

Fig. 3: ATB implementation of the satellite payload data handling unit (PDHU).

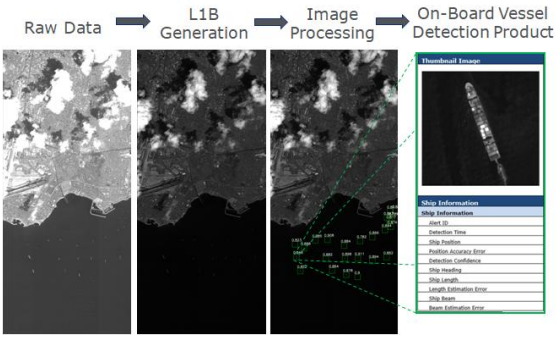

Fig. Optical on-board ship detection processing chain tested on DEIMOS-2 VHR EO payload data for the provision of EMSA VDS-like EO products (alerts).

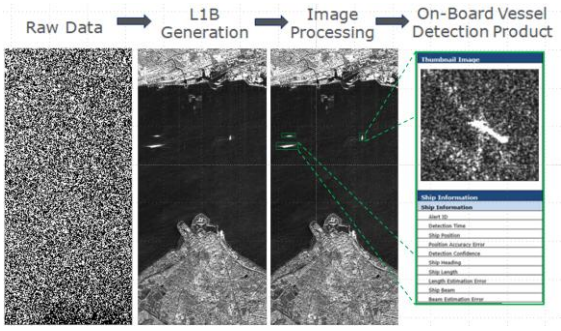

Fig. SAR on-board ship detection processing chain tested on TerraSAR-X EO payload data for the provision of ship detection alerts.