



## PIL testing of the Optical On-board Image Processing Solution for EO-ALERT

OBDP 2021

Authors: Francisco Membibre, Antonio Latorre, Alexis Ramos, Juan Ignacio Bravo, Robert Hinz, Álvaro Morón, Murray Kerr

Presented by Francisco Membibre

June, 2021



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776311



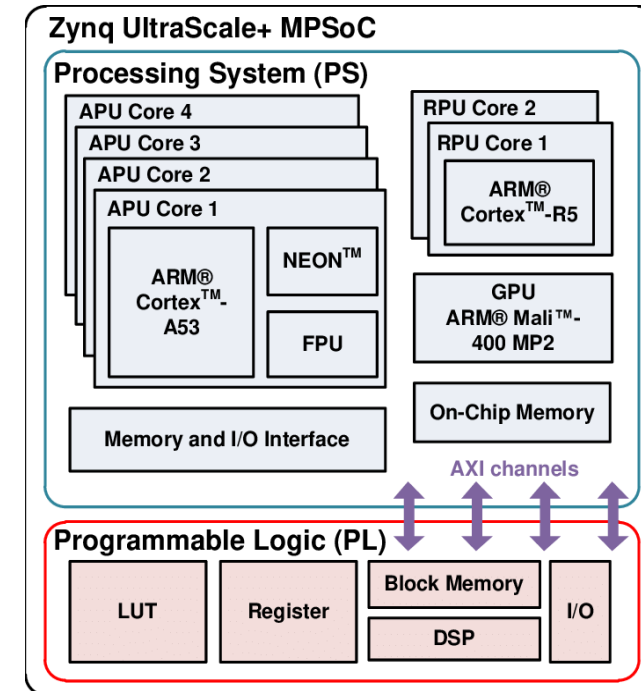
## Introduction

### EO-ALERT: Next generation satellite processing chain for rapid civil alerts

- **H2020** project: DEIMOS SPACE, DLR, OHB, Politecnico di Torino, TU-GRAZ, DMS IMAGING
- **Objective:** On-board low latency processing of EO products
- **DEIMOS SPACE** is **project coordinator** and responsible of **optical observables** for **Ship Detection** and **Extreme Weather** products
- The **tendency** is towards product latency of **15 to 30 min**
- Our latency is **< 1 minute**
- **Idea:** Move key EO data processing elements **from GS to FS** (using **ML** and **AI** on-board)
- Real image databases: from **DEIMOS-2 VHR optical** satellite and **MSG SEVIRI**
- Processing is done on a **Multi-board scheme** based on **COTS** to decrease processing time or cover more area
- Allowing to process 8400px x 12000px images (**100 km<sup>2</sup> per board**)



## COTS - Zynq® UltraScale+™ MPSoC



Shen, Zhuoxuan & Dinavahi, Venkata. (2018). Real-Time MPSoC-Based Electrothermal Transient Simulation of Fault Tolerant MMC Topology. IEEE Transactions on Power Delivery. PP. 1-1. 10.1109/TPWRD.2018.2866562.



# Single Event Effect (SEE) Protections

## Introduction of elements against radiation in COTS

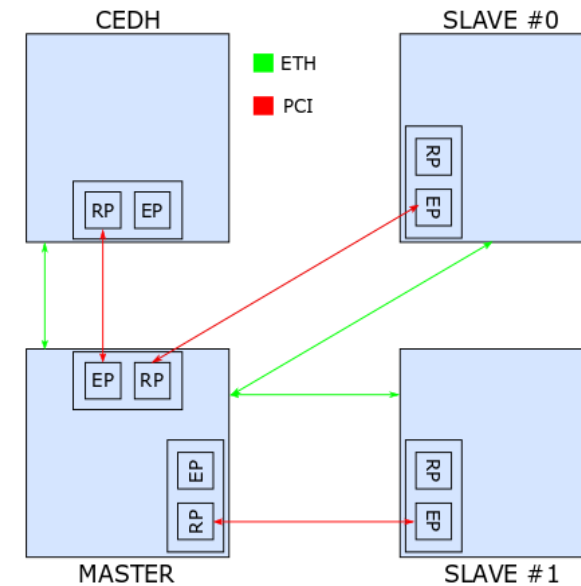
- Single Event Upset (SEU)
  - User Memory
    - Error Detection and Correction (EDAC)
  - Configuration Memory
    - Memory Scrubbing (Soft Error Mitigation (SEM) IP)
- Single Event Latch-up (SEL)
  - Watch Dog

The system is protected by hardware redundancy (Spare Boards)



## Multi-board Scheme – Test Bench Validation

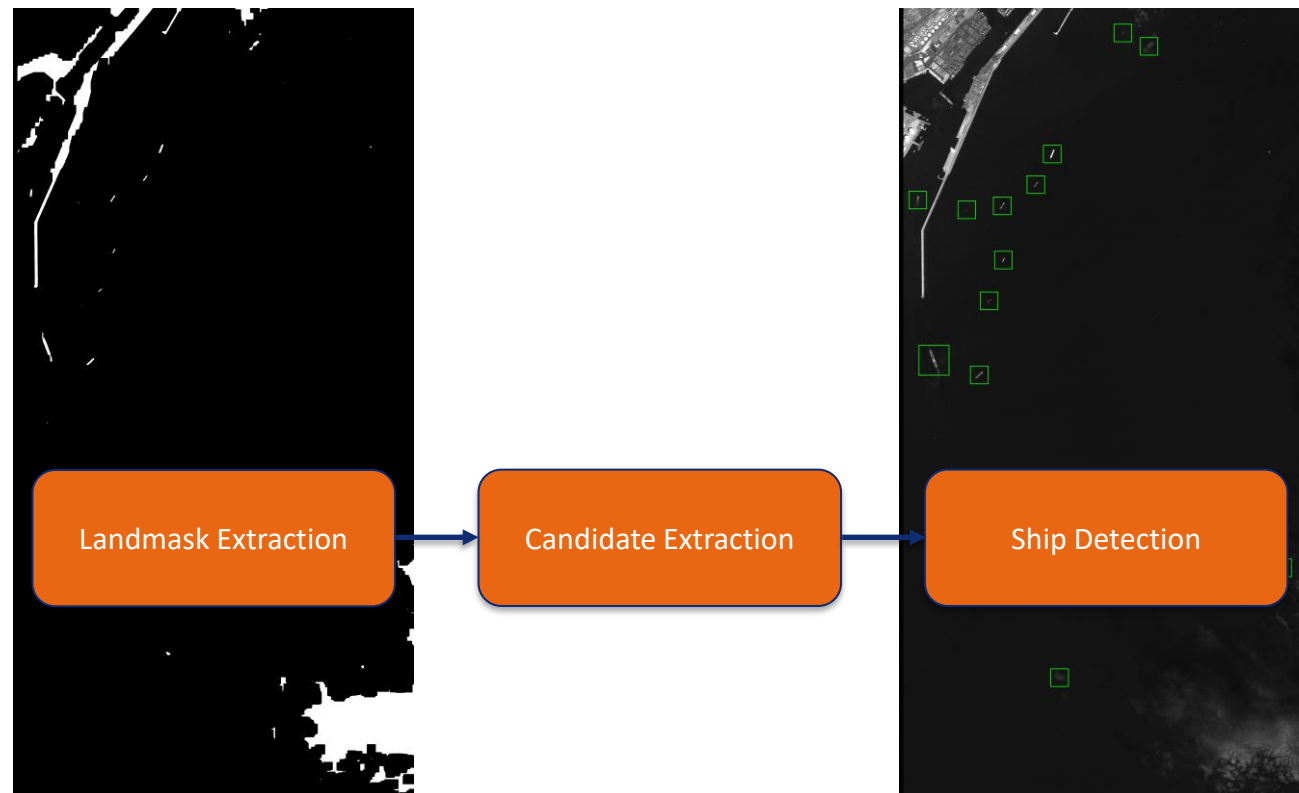
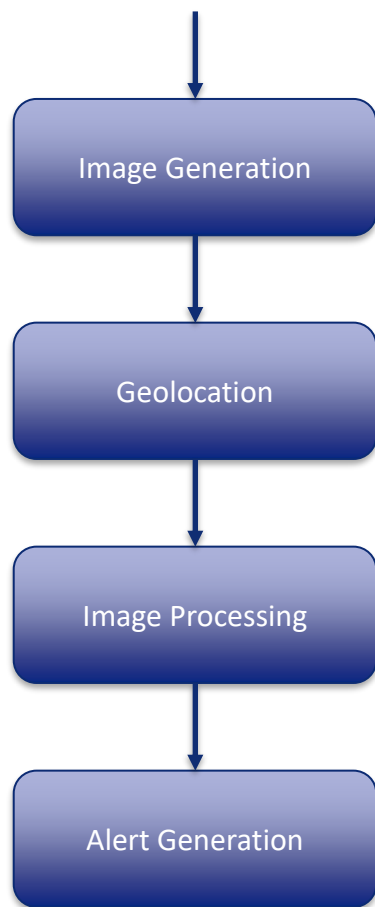
- Data Storage & Transfer
- Interfaces
  - PCIe – Data transfers
  - Ethernet – Manage Data Transfers (Telecommands)
    - *Will be replaced by CAN bus*



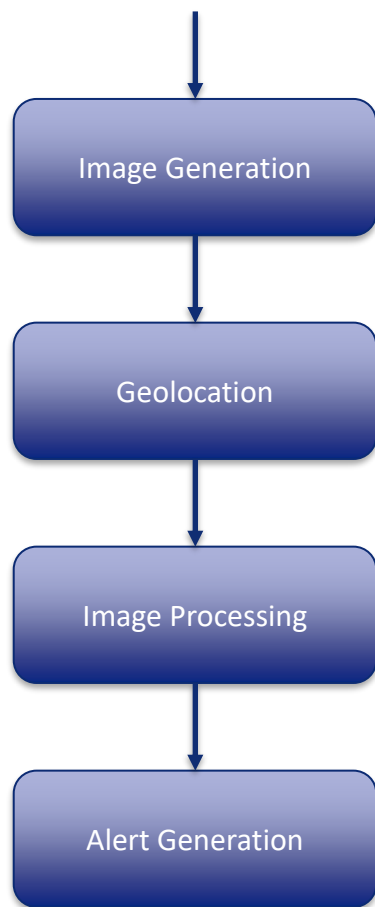
# Algorithms: Ship Detection



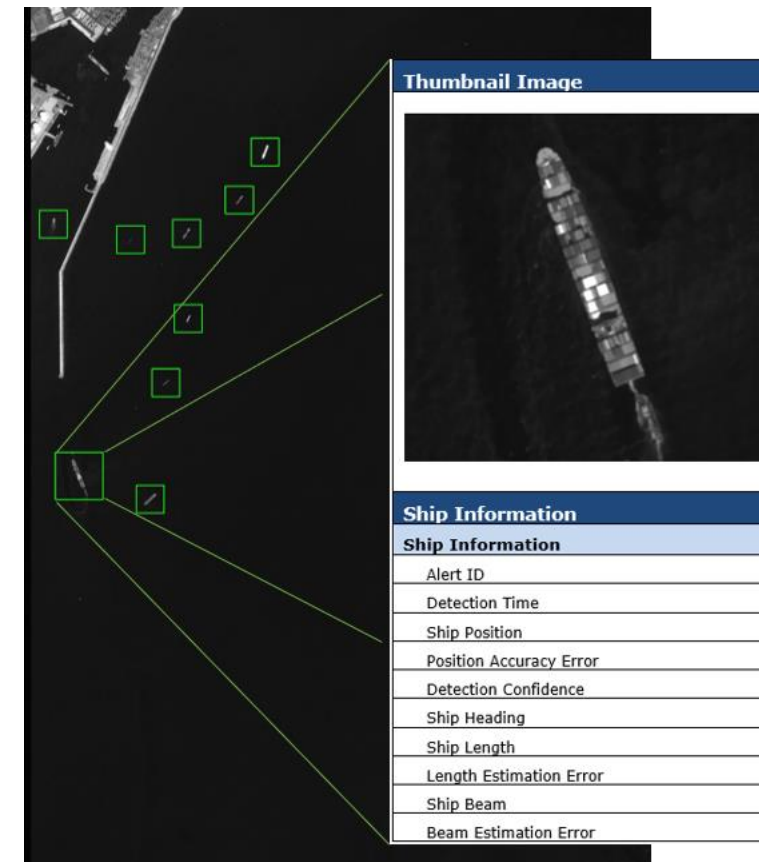
# Algorithms: Ship Detection



# Algorithms: Ship Detection

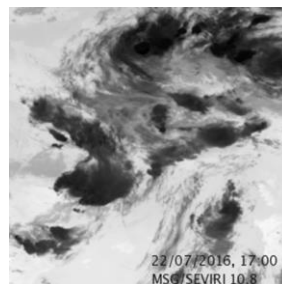


Thumbnail + Information

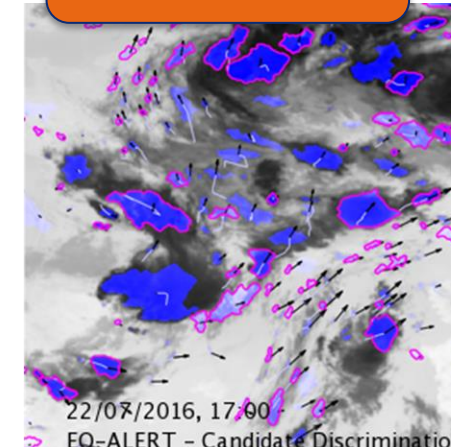
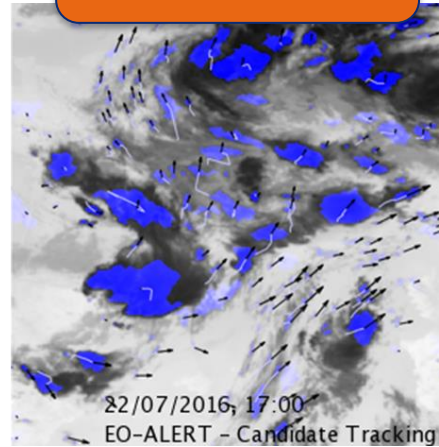
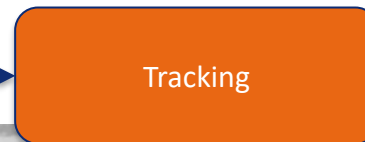


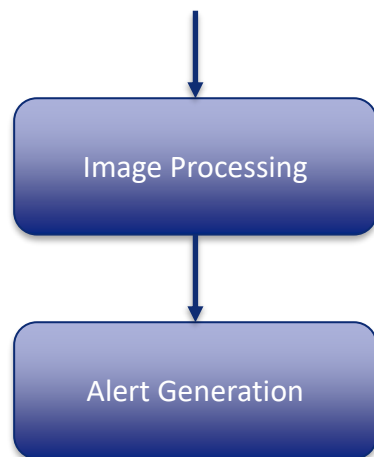
Ship Information	
Alert ID	
Detection Time	
Ship Position	
Position Accuracy Error	
Detection Confidence	
Ship Heading	
Ship Length	
Length Estimation Error	
Ship Beam	
Beam Estimation Error	



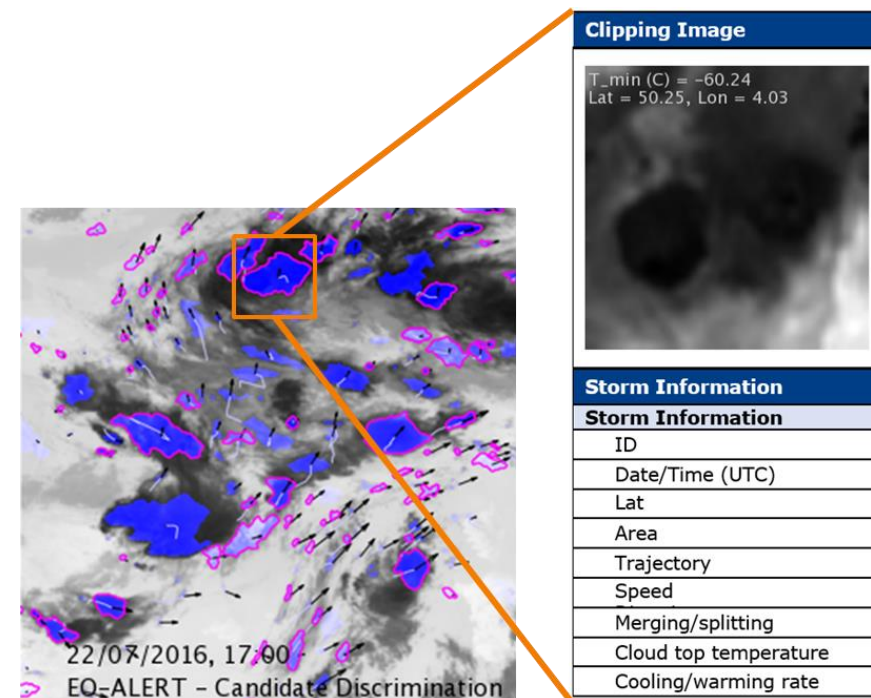


L1.5 MSG/SEVIRI data

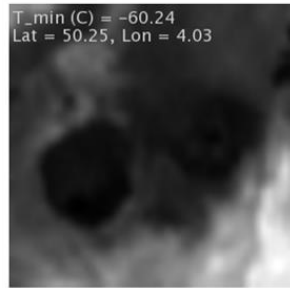




Thumbnail + Information

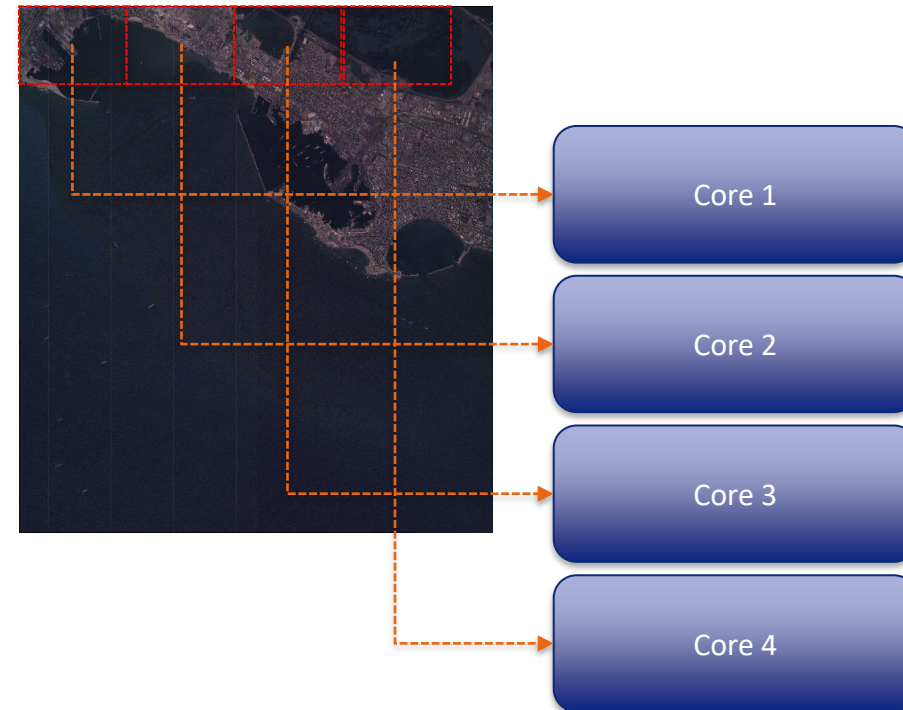


22/07/2016, 17:00  
EQ-ALERT - Candidate Discrimination

Clipping Image	
T_min (C) = -60.24	
Lat = 50.25, Lon = 4.03	
	
Storm Information	
Storm Information	
ID	
Date/Time (UTC)	
Lat	
Area	
Trajectory	
Speed	
Merging/splitting	
Cloud top temperature	
Cooling/warming rate	

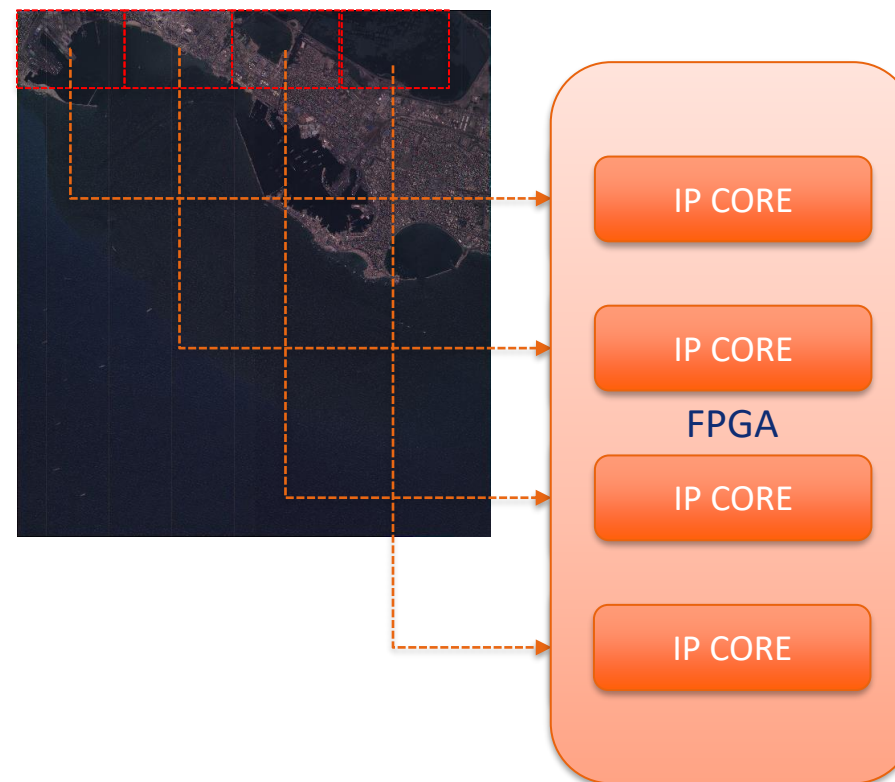
## HW/SW Processing Codesign

- **Multi-core**
  - Flexibility
  - Rapid development
- **FPGA**
  - Parallelism
  - Computing Power
  - Fixed Point Models - MATLAB®
    - *Overflows*
    - *Unaligned*
  - HW libraries – SDSoc™/Vitis™
    - *OpenCV*
    - *Xilinx® IP COREs*
  - Avoid HW-SW dependencies

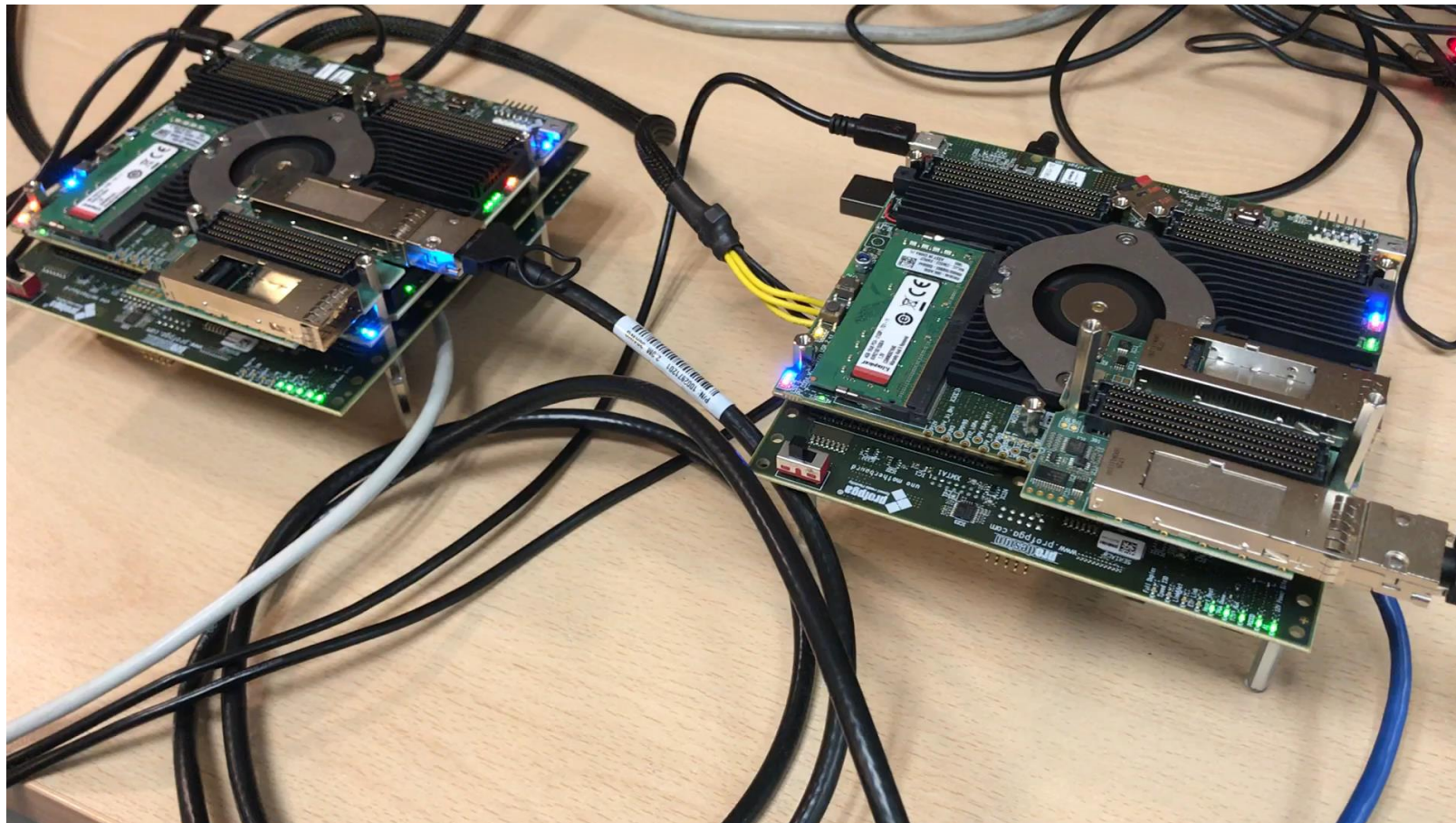


## HW/SW Processing Codesign

- **Multi-core**
  - Flexibility
  - Rapid development
- **FPGA**
  - Parallelism
  - Computing Power
  - Fixed Point Models - MATLAB®
    - *Overflows*
    - *Unaligned*
  - HW libraries – SDSoc™/Vitis™
    - *OpenCV*
    - *Xilinx® IP COREs*
  - Avoid HW-SW dependencies



## Tests: Dual-board Scheme (Video)





## Conclusions

- Next generation satellite processing chain for rapid civil alerts is the correct tendency to decrease product latency.
- These kinds of devices are increasingly used in space projects and contribute to put more computation power than ever before.
- Rapid prototyping allows developing from a global perspective.
- The time requirements have been validated on the TB:
  - 38 sec. (100 km<sup>2</sup>) – One processing board. -> (8400 x 12000 px)
  - 115 sec. (900 km<sup>2</sup>) and 154 sec. (1200 km<sup>2</sup>) – Three processing boards -> (3x3x8400x12000)px and (4x3x8400x12000)px
- There are several points that can be improved such as additional functions to the FPGA.
- This project is focus on Ship Detection and Extreme Weather but can be used for many other applications which use ML and AI.
- With these techniques (AI and ML), normally used on ground, it is possible to send results to the end user using near real time links with global coverage.





# Thank you



<http://www.eo-alert-h2020.eu/>



EO ALERT H2020 Project



@EOALERT



[francisco.membibre@deimos-space.com](mailto:francisco.membibre@deimos-space.com)

DEIMOS Space, Spain - an ELECORNOR Company  
[www.elecnor-deimos.com](http://www.elecnor-deimos.com)

