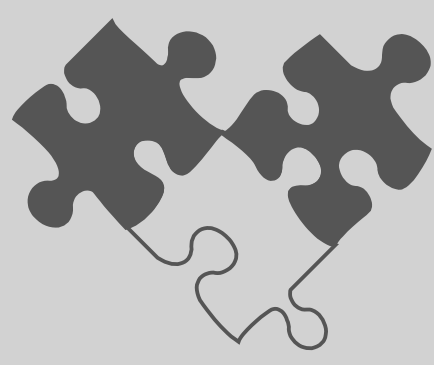
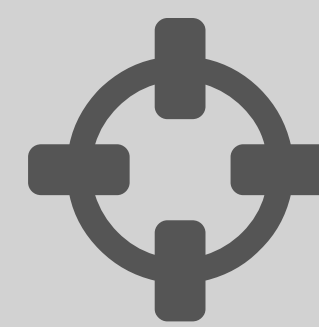


# FPGA-based Artificial Intelligence Approach for a Cyber-Physical Embedded System Architecture

## BACKGROUND

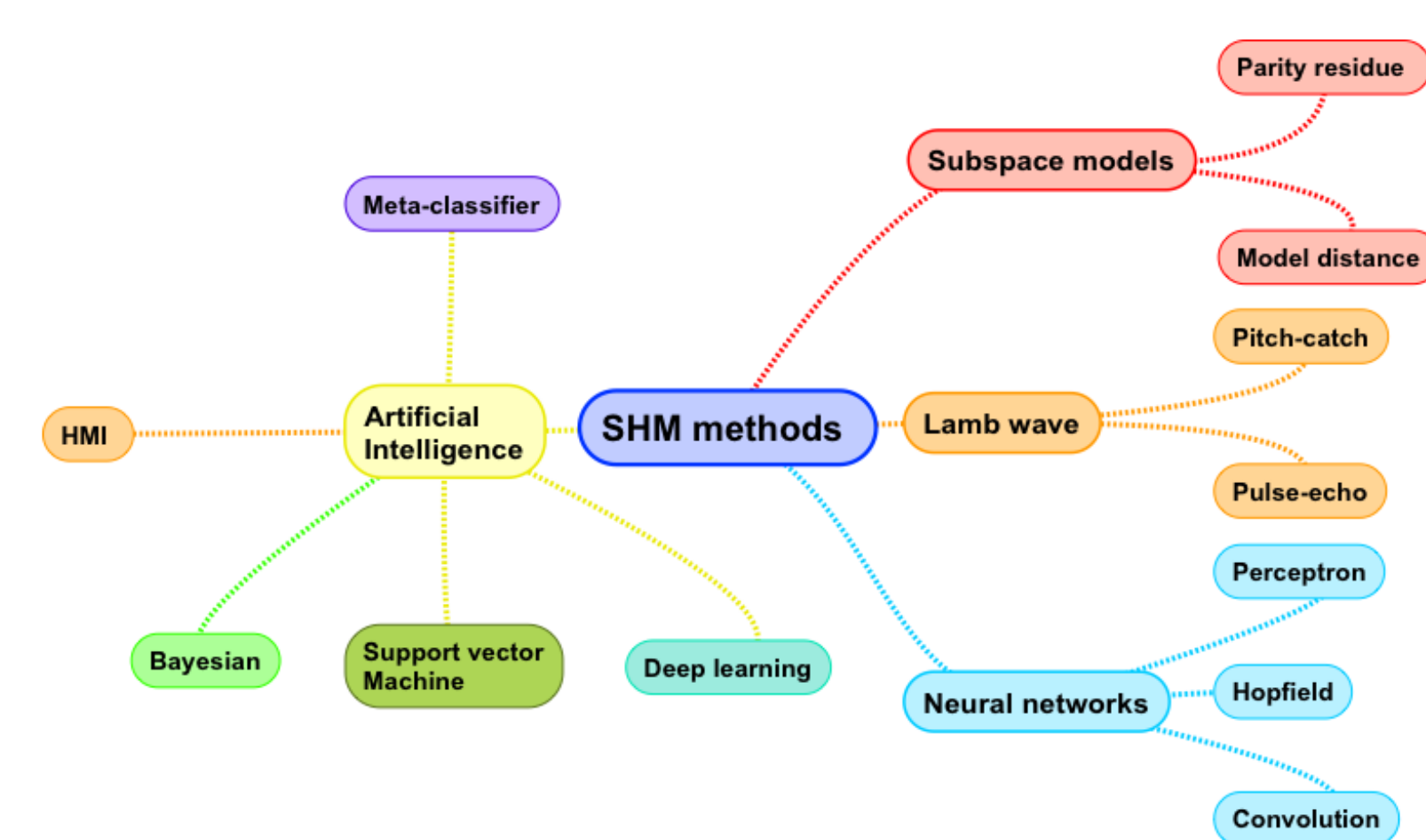


- Fault detection and diagnostic functions need to be fully addressed in the next avionic generation.
- The new concept of Cyber-Physical Systems (CPS) deals with physical/computation system integration.
- Several well-studied Structural Health Monitoring (SHM) methods are ready to be incorporated in avionic systems as a fundamental real-time function.
- However, as a complex embedded CPS, a fully automatic runtime SHM system presents significant challenges.
- FPGA boards can encapsulate Artificial Intelligence (AI) hardware implemented diagnostic methods.
- SoS (System of Systems) abstract models are needed to govern reconfiguration mechanisms to provide fault detection and tolerance.
- It is here proposed an architecture to deal with the complexity, real-time demands and embedded energy restrictions.



## GOALS

- *The objective is to propose and test a new AI-controlled CPS architecture focusing on automatic FPGA-based fault detection and diagnosing SHM system. It comprises three levels of a distributed processing network:*
  - Physical level with intelligent sensors and actuators;
  - Mathematical level with FPGA hardware algorithms;
  - High-end FPGA level with machine learning methods.

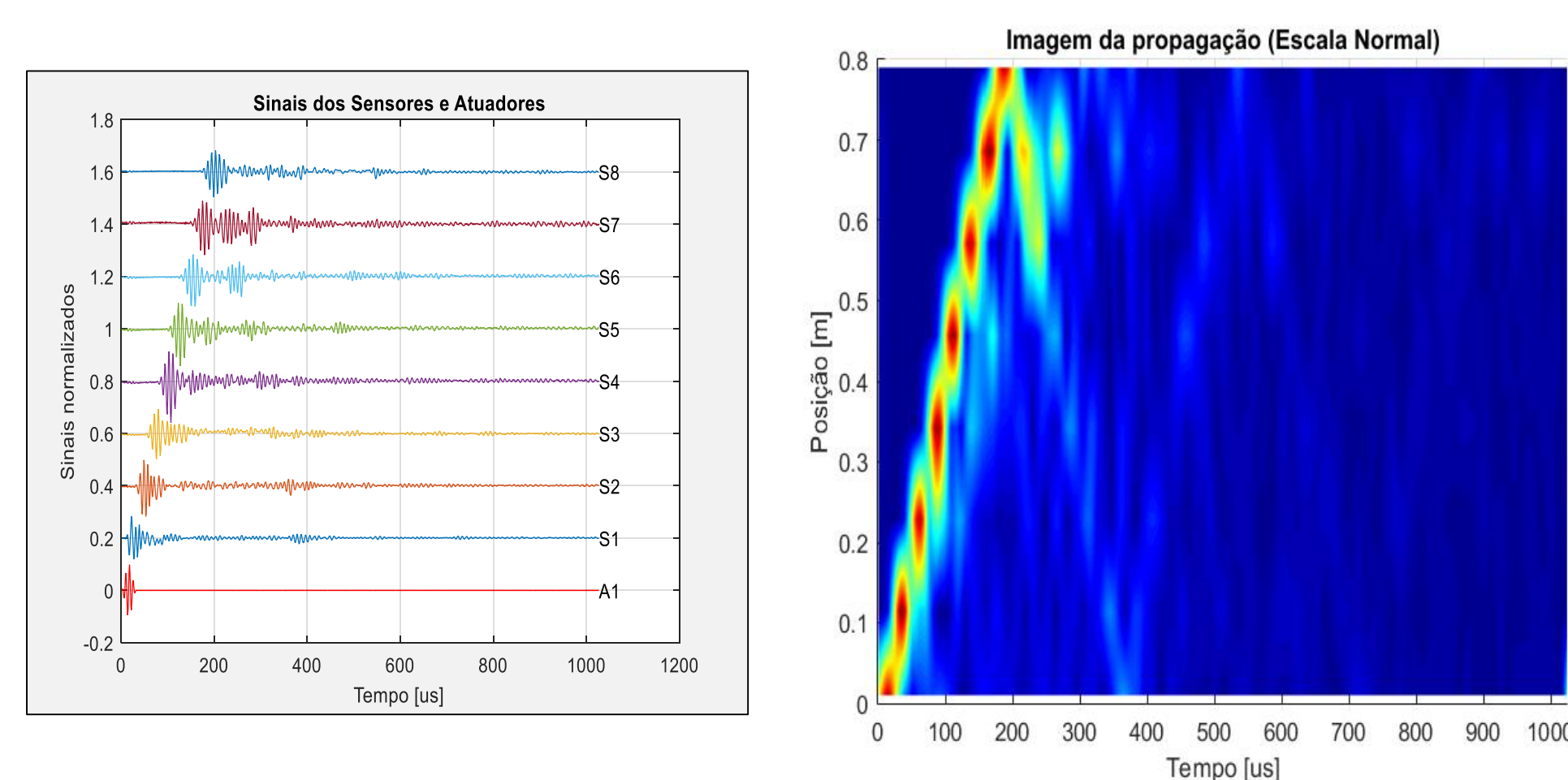


CPS/SHM concept and methods

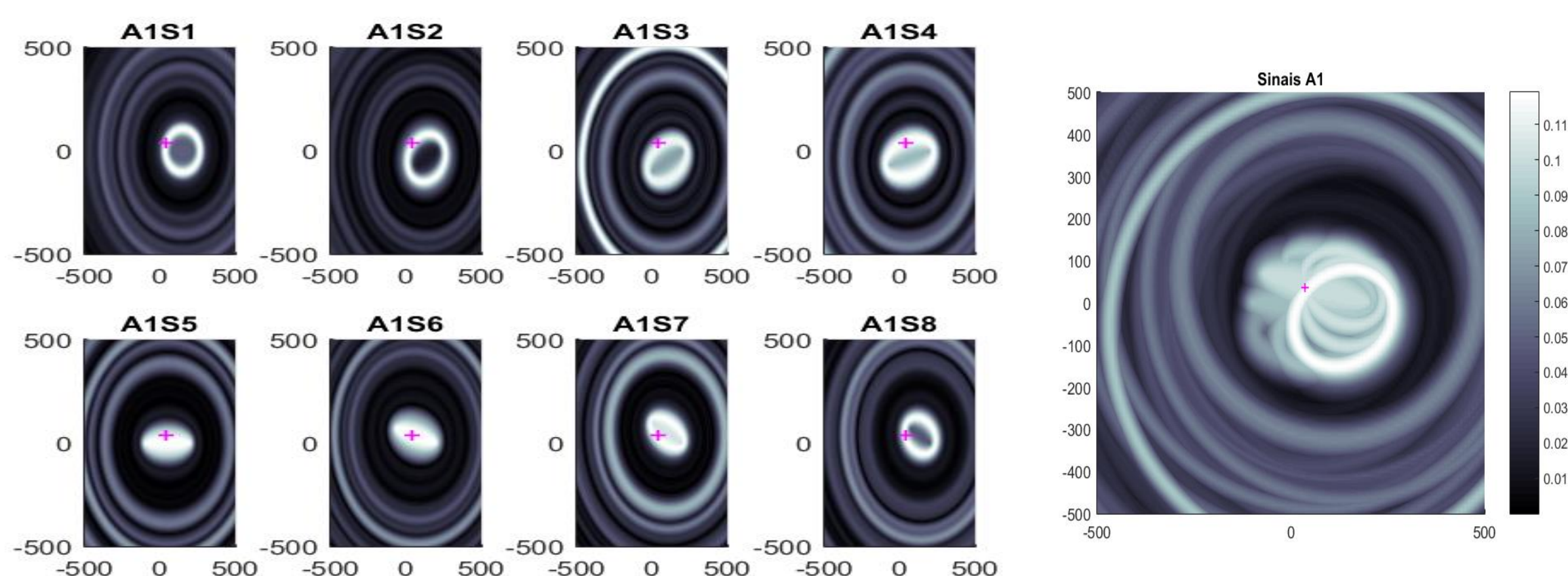
## APPROACH



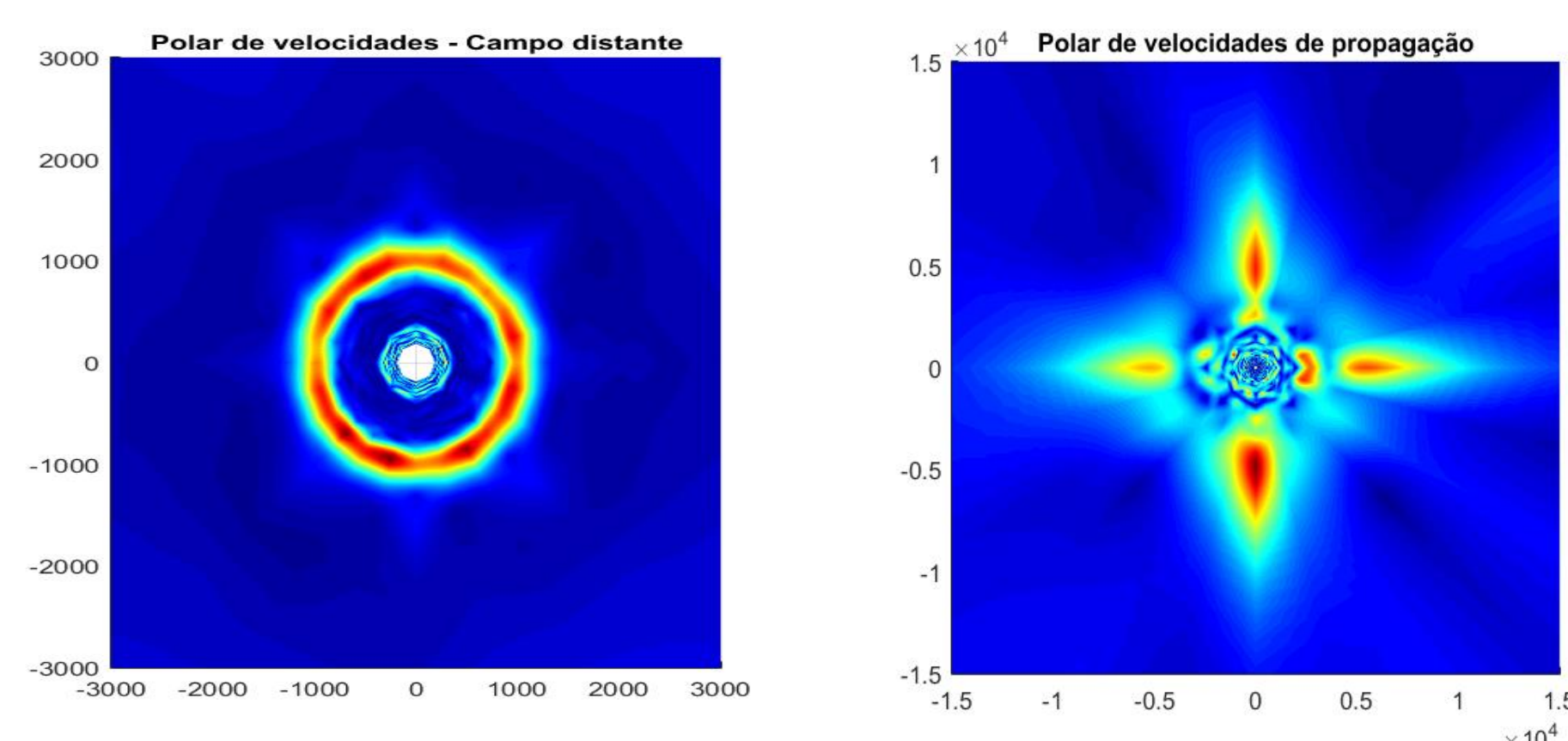
A FPGA-based embedded CPS laboratory prototype is under construction incorporating several SHM methods in a hierarchical distributed network, which could be adopted to monitor an aircraft. The proposed generic architecture will provide the framework for hardware implementation of AI-controlled classification strategies and signal processing techniques through runtime reconfiguration of computational resources.



Example of Lamb wave based SHM method



Machine vision classification of structural damage



Wave propagation on aluminum and composite plates