PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Filippo Ferrandino

Cycle: XXXIX

Training and Research Activities Report
PhD Year: Second

student signature

Tutor: prof. Alessandro Cilardo

tutor signature

Co-Tutor: Gabriella Gentile

Date: November 10, 2025

1. Information:

- ➢ **PhD student:**   **Filippo Ferrandino**   **PhD Cycle: 39**

- ➢ **DR number:**   **DR997213**

- ➢ **Date of birth:**   **25/7/1996**

- ➢ **Master Science degree:** Computer Engineering

- ➢ **University:** University of Naples "Federico II"

- ➢ **Scholarship type:** *DM 117/2023*

- ➢ **Tutor: Alessandro Cilardo**

- ➢ **Co-tutor: Gabriella Gentile**

- ➢ **Period abroad:** *Cira 12 mounths spents and 0 mounths to be spent*

2. Study and training activities:

Activity	Type	Hours	Credits	Dates	Organizer	Certificate
Can we Rely on AI? Reliability Issues in Artificial Neural Networks and Potential Solutions for Autonomous Vehicles	Seminar	**1**	**0.2**	**16.1.2025**	**Prof. Paolo Rech**	**Y**
High Performance and Quantum Computing	Courses		**6**	**18.12.2024**	**UniNa**	**Y**
The Good, the Bad, and the Ugly in Quantum Computing: Computational Power, Intrinsic Noise, and Transient Faults	Seminar	**1**	**0.2**	**16.1.2025**	**Prof. Paolo Rech**	**Y**
Design methodologies for digital circuits and systems oriented to FPGA	Courses		**2.4**	**27.2.2025**	**Gennaro De Meo**	**Y**
AI @ The Deep Edge	Courses	**21**	**4.2**	**29-31.1.25**	**STmicroelectronics**	**Y**
CIRA PhD Days	Research		**2**	**7-8.4.2025**	**CIRA**	**Y**
Dynamic Risk Assessment in Industrial Applications:Leveraging Bayesian Inference for Enhanced Decision-Making	Seminar	**1**	**0.2**	**4.3.25**	**UniNa**	**Y**

CINI HPC Summer school	Doctoral School		3	16-20.09.2025	**CINI**	Y
Sovranita Digitale cos'è e quali sono le principali minace al cyberspazio nazionale	Seminar	1	0.2	23.06.2025	**Prof./Dr. Roberto Baldoni**	Y
TAROT Summer school	Doctoral School		4	30.6/4.7.2025	**UniNa**	Y
ACACES Summer school	Doctoral School		5	13-19.07.2025	**Hipeac**	Y
AI Powered User interface design	Seminar	4	0.8	24.10.2025	**Prof Antonio Origlia**	Y
Safety Critical Systems for Railway Traffic Management	Courses		4	3-30.10.2025	**UniNa**	Y
Nextcomm	Courses (type C)		3	9-30.10.25	**CESMA**	Y

2.1. Study and training activities - credits earned

	Courses	**Seminars**	**Research**	**Tutorship**	**Total**
Bimonth 1	**6**	**0**	**7**		**13**
Bimonth 2	**6.6**	**0.4**	**6**		**13**
Bimonth 3	**0**	**0.2**	**11.8**		**12**
Bimonth 4	**3**	**0.2**	**6.8**		**10**
Bimonth 5	**9**	**0**	**5**		**14**
Bimonth 6	**7**	**0.8**	**5.2**		**13**
Total	**31.6**	**1.6**	**41.8**	**-**	**75**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

The research is conducted in the broader context of developing autonomous and intelligent technologies for the next generation of aerospace systems, as part of a European collaborative project. The activities range from hardware-level optimization on FPGA platforms to AI model deployment on embedded systems and the integration of perception and situational awareness modules for autonomous aircraft operations.

Multipliers Approximate for Neural Network
The first step involved a state-of-the-art analysis of approximate multipliers specifically for FPGA. Encouraged by promising results from the literature, I replicated experiments based on the few publications that provided open-source code for approximate multipliers. In these studies, all comparisons were made either against exact multipliers cited in previous research or those provided by the tools used. I compared these to the best-performing exact multiplier designed for FPGA, the results

showed that some of the most optimized approximate multipliers in the literature consume more power than this exact multiplier.

Physical Unclonable Function for FPGA

Another experimental effort was in developing a Physical Unclonable Function (PUF) by programming specific FPGA LUT configurations. In the context of ensuring that the hardware processing the data remains authentic and unaltered, PUF technology is emerging as a robust solution. I implemented key PUF metrics, and while many achieved values close to an ideal PUF, Uniqueness remained relatively low. Future research will focus on improving this metric, testing on a broader range of boards, and evaluating performance across varying environmental conditions.

Evaluating AI Model Support on Embedded Systems

As part of a collaborative task between my research work and CIRA, I investigated which components might best support AI models on embedded systems. After extensive optimization and measurements, GPU-based devices emerged as the most effective in my scenario, particularly due to their scalability and energy efficiency. If higher power is required, the same optimized engine can be adapted to high-performance Nvidia devices or cloud systems. Meanwhile, in applications that demand exceptionally low power consumption, even at the expense of some quality metrics, AI models on microcontrollers or directly on sensors allow for an energy efficiency that other platforms cannot match, though their energy-per-frame metric may not be the lowest.

4. Research products:

Filippo Ferrandino, Daniele Lombardi, Alessandro Cilardo
A novel ultra-compact FPGA-based Physical Unclonable Function
IEEE Transactions on Computers - **Q1 Journal**
Submitted on 6/2025

Salvatore Bramante, **Filippo Ferrandino**, Alessandro Cilardo
Energy-Efficient AI Deployments at the Urban Edge: Lessons from Hardware Profiling
Smart Cities - Q1 Journal in rewriting

Mario Barbareschi, Salvatore Barone, **Filippo Ferrandino**
Optimizing Accuracy-Loss in Approximate Neural Network via GPU-Driven Bit-Width Emulation
Transactions on Computer-Aided Design of Integrated Circuits and Systems - Q1 Journal
Submitted on 10/2025

Filippo Ferrandino, Angelo Manco, Gabriella Gentile, Alessandro Cilardo
"Enhancing Situational Awareness in the Airport Environment: A Use Case Approach"
In writing

5. Conferences and seminars attended

Participation to CIRA PhD Days: event organized by the Italian Aerospace Research Centre (CIRA) to promote collaboration and knowledge exchange among PhD students and researchers in the aerospace field. Participants presented their research activities through talks and posters, fostering discussion and networking opportunities with experts from academia and industry.

6.   Periods abroad and/or in international research institutions

This research is framed within the SESAR Strategic Research Agenda for the Digital European Sky [Single European Sky ATM Research 3 Joint Undertaking, Digital European Sky – Strategic Research and Innovation Agenda, Publications Office of the European Union, 2020]. The agenda addresses various pillars and research topics aimed at meeting the growing demands of air transport while ensuring a high level of sustainability. Two key needs are particularly relevant to this work: (i) the development of new Air Traffic Management ATM technologies through SESAR projects to enhance ATM performance, and (ii) smart management of airport capacity to align it with air transport demands. Within this context, the research focuses on specific enabling technologies related to automatic take-off and landing.

A crucial aspect of ensuring safety and efficiency in these automated processes is situational awareness. As automation levels rise in aviation, the ability to maintain a clear understanding of the surrounding environment becomes increasingly important. Situational awareness enables both human operators and automated systems to perceive relevant factors, comprehend their implications, and anticipate future developments, facilitating timely and effective decision-making. This is especially critical in high-stakes environments like air traffic management, where complex, dynamic, and safety-critical operations are routine.

Situational awareness is the ability to perceive, understand, and anticipate the environment in real-time to support decision-making, crucial in automated, complex, and safety-critical contexts like aviation and air traffic control.

The concept of situational awareness can be broken down into three key components:

Perception: Gather relevant information from the environment, such as objects, events, or people around the system.

Comprehension: Analyze the gathered data to assess the current situation, identifying potential obstacles and classifying them by type.

Projection: Predict future developments based on current information, including estimating the speed and direction of obstacles to determine potential collisions and triggering alerts as needed.

During the Task Analysis, I classified Ground Movements into five macro-categories: Bird, Person, Plane, Other Vehicles, and FOD (objects larger than a standard carry-on bag). Each category was associated with a specific risk coefficient, useful for prioritizing alerts and mitigation actions. Based on this analysis, I created an object detection dataset primarily composed of a combination of several public datasets, each carefully distilled and adapted to fit our specific use case.

The task addressed is object detection over large areas with soft temporal constraints. We set a reference inference time of approximately 33 ms per network, which requires architectures capable of real-time execution on embedded devices. For this reason, the target hardware selected was the Jetson AGX Orin. Regarding the models, I chose YOLOv11s and YOLOv11m—at the time considered state-of-the-art (SOTA)—for their balance between accuracy and computational efficiency.

For proper situational understanding, identifying all surrounding objects is not sufficient; it is also necessary to estimate their position, direction, and velocity. Even if these estimates are not extremely precise, they are essential, when combined with object type, to assess potential hazards. The position estimation, was implemented using stereoscopic vision systems. In the demo project, two separate cameras were employed, allowing a configurable baseline during installation. The configuration can also be extended to a group of cameras to provide 360° coverage of a wider area.

The final system detects hazards using YOLOv11. Detected objects are assigned unique IDs through tracking algorithms such as ByteTrack and BoTSORT. Stereoscopic data provide spatial localization, and by combining position, unique ID, and temporal information, the system can estimate the direction and speed of each potential hazard. These data are then used to assess risk levels and trigger appropriate alerts or operational responses.

CIRA(*PNRR - DM 117/2023*): 12 months expected

Abroad Tutor: Gigante Gabriella

Period abroad completed: 12 months

Period remaining: 0 months

7. Tutorship

Not yet.