2023

Annual report

cnit consorzio nazionale interuniversitario per le telecomunicazioni

National Lab RaSS Radar and Surveillance Systems

Director's Introduction

This is our official edition of the *2023 Radar and Surveillance Systems (RaSS) Laboratory's Annual Report.*
This edition has been prepared with the aim of showcasing the research activities that have been conducted in our Lab and the major outcomes accomplished during this financial year.
2023, as last years, has been very positive due to the following achievements:

- a consolidation of the personnel at RaSS with one new permanent and one new fixed-term research positions
- 33 active projects carried out
- 39 publications published
- 15 participating members in 27 conferences, workshops and specialist meetings
- RaSS personnel leading three NATO activities and participating in one additional NATO activities
- 8 project proposals granted that will see new projects starting at the very beginning of 2024

This report has been kept concise and brief in order to give a glance of RaSS' main activities in the last year. For any additional information, please feel free to contact me at rass@cnit.it.

2023 has also been my first year as Director of the RaSS Laboratory, an astonishing journey thanks to the enthusiasm of researchers, colleagues and administrative personnel, that affected me so much: please, keep up with the great work!

Agostino Monorchio
Director of RaSS

cnit consorzio nazionale interuniversitario per le telecomunicazioni

National Lab RaSS Radar and Surveillance Systems

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THE RADAR AND SURVEILLANCE SYSTEMS LABORATORY IN A NUTSHELL

The Radar and Surveillance Systems (RaSS) is a National Laboratory of the National Interuniversity Consortium for Telecommunications (CNIT). CNIT is a no-profit consortium composed of 44 Research Units (38 Italian Universities, 7 Departments of the National Research Council-CNR) and 6 National Laboratories (https://www.cnit.it/en/). The RaSS Lab was founded in 2010 with the purpose of creating a critical mass of professionals to face research challenges in the field of radar and applied electromagnetics. Today, RaSS counts 32 people among researchers, technical and administrative staff. The RaSS Lab has participated in several national and international research projects (often as leader), funded by the Italian MoD (Ministry of defence), EDA (European Defence Agency), MIUR (Ministry of Education), MISE (Ministry of Economic Development), EU FP7, EU H2020, ESA (European Space Agency), EOARD (European Office of Aerospace Research and Development), NATO SPS (Science for Peace and Security), NCIA (NATO Communications and Intelligence Agency), ARMASUISSE, ASI (Italian Space Agency), Tuscany Region, Industries like LEONARDO, MBDA, VITROCISET, INTERMARINE, GEM, E-GEOS, TELEDYNE, among others. RaSS strives to maintain, and possibly to increase, the quality and excellence of the research activities and the results achieved. At the same time, it seeks to strengthen and consolidate its structure and to invest in basic research in new promising areas. RaSS activity is standing between academia and industry with the aim to fill the gap between them. Many research projects that have been carried out at RaSS have led to the development of fully integrated demonstrators with TRLs between 5 and 6. RaSS also focuses on dissemination activities, including journal and book publications, presentations at international conferences, training activities under the form of short courses, tutorials, seminars and lectures for industry, government and various research institutions. RaSS values all its collaborations nationally and internationally, counting today more than 50 partners across, industry, academia and both government and non-government research institutions. RaSS has a strong participation in both the NATO and the European Defence Agency (EDA) contexts, where its personnel hold key roles within Panels and CapTechs. RaSS has spun off two companies, namely ECHOES and FREE SPACE. The former focuses on the design and development of radar systems whereas the latter deals with the design and production of advanced antenna systems and electromagnetic compatibility. Both ECHOES and FREE SPACE improve the ability of RaSS to produce effective technological transfer.

FINANCIAL STATS

The RaSS Laboratory budget comes from several sourcing of financing.

The following figure outlines the lab's financial trend from FY 2019 through FY 2023.

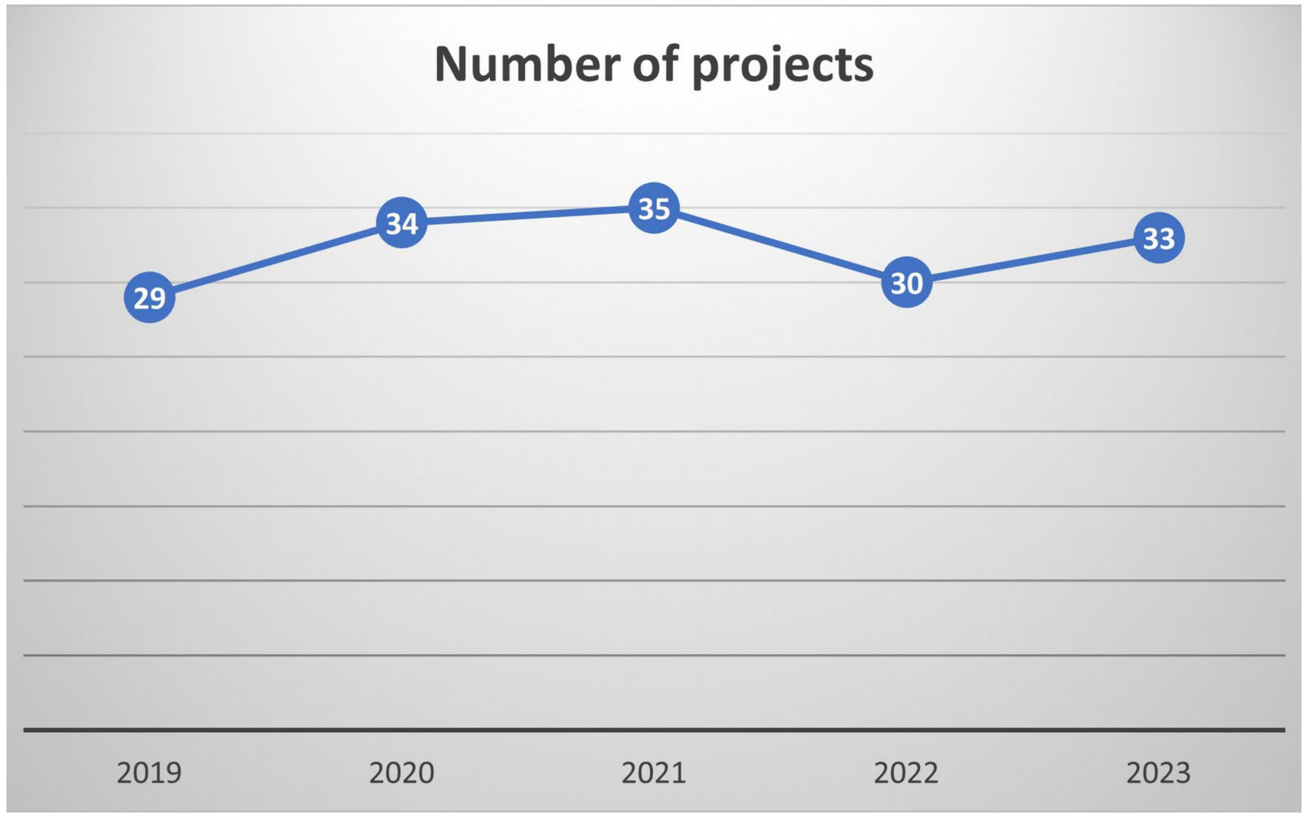


Figure 1 - RaSS Lab number of projects in progress FY 2019 through FY 2023

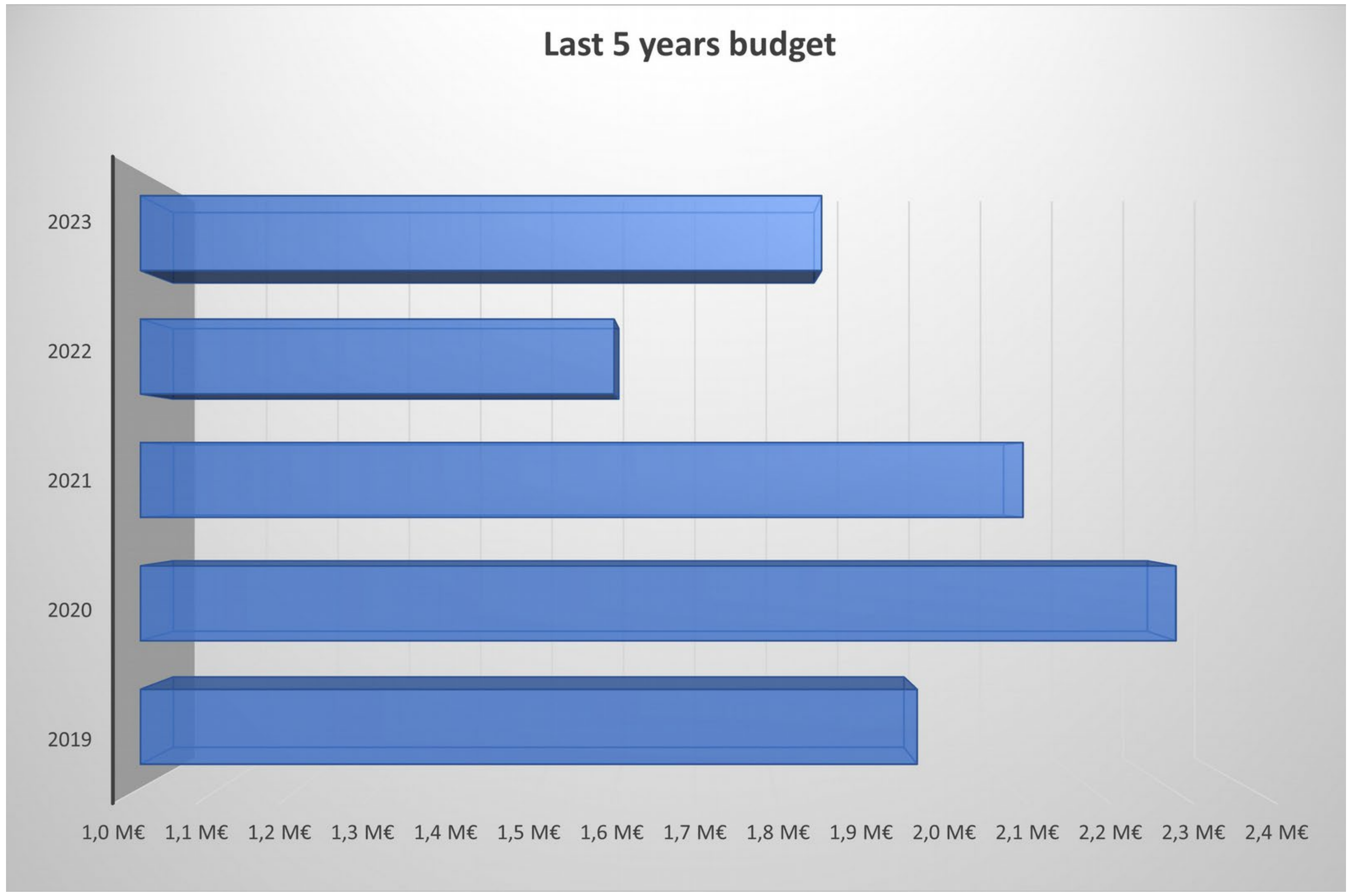
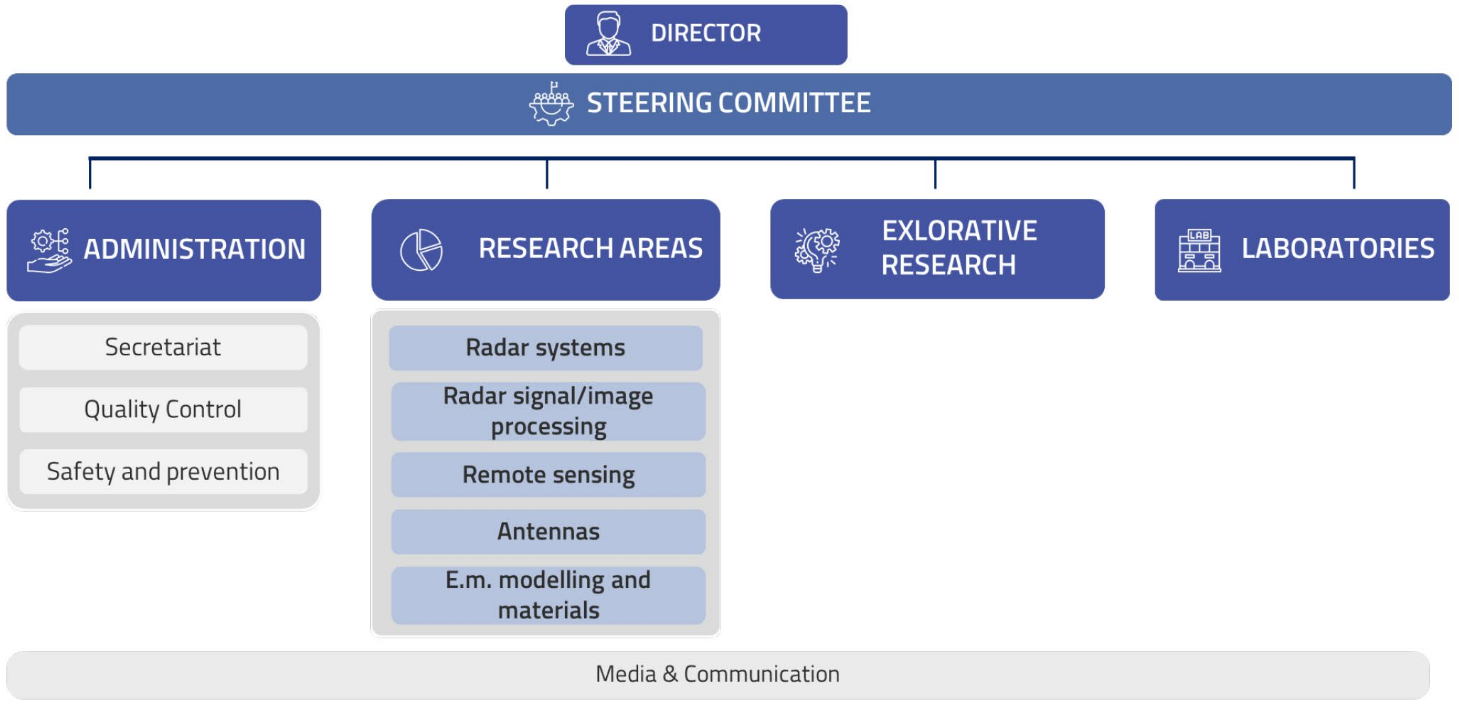


Figure 2 - RaSS Lab financial trend from FY 2019 through FY 2023

ORGANISATION CHART

Figure 3 shows the organisational chart of the RaSS Lab as on 31 December 2023. This diagram illustrates the structure of the organisation and the relationships of its governing bodies and positions. The RaSS Lab is organized in five research areas, namely radar systems, radar signal/image processing, remote sensing, antennas, electromagnetic modelling & materials. RaSS also has an explorative research area, where promising basic research is internally funded, and instrumental laboratories. On the administration side, RaSS is composed of a secretariat office, a quality control office and a safety and prevention office. RaSS activities are disseminated by the Media & Communication board. RaSS governance is directed by the Steering Committee, which is chaired directly by the Director.



DIRECTOR

Prof. **Agostino Monorchio** is Full Professor at the University of Pisa; he received the Laurea degree in electronics engineering and the Ph.D. degree in methods and technologies for environmental monitoring from the University of Pisa, Pisa, Italy, in 1991 and 1994, respectively. During 1995, he joined the Radio Astronomy Group, Arcetri Astrophysical Observatory, Florence, Italy, as a Postdoctoral Research Fellow, working in the area of antennas and microwave systems. He spent several research periods at the Electromagnetic Communication Laboratory at Pennsylvania State University (USA), both as a recipient of a scholarship (Fellowship Award) of the Summa Foundation, New Mexico (USA), and in the framework of CNR-NATO Senior Fellowship programme. He has carried out a considerable research activity and technical consultancy to national, EU and U.S. industries, coordinating, as principal scientific investigator, a large number of national and European research projects. He serves as reviewer for international journals, and he was Associate Editor of IEEE Antennas and Wireless Propagation Letters from 2002 to 2007. He has been an AdCom member from 2017 to 2019 and he is co-chair of the Industrial Initiative Committee of the IEEE APS. Prof. Monorchio is active in a number of areas including computational electromagnetics, microwave metamaterials, radio propagation for wireless systems, the design and miniaturization of antennas and electromagnetic compatibility, biomedical microwaves applications. The basic research activity is carried out at the Microwave and Radiation Laboratory of the Department of Information Engineering, University of Pisa, together with a large group of PhD students, Post-Docs and research associates. He is Head of RaSS National Laboratory of CNIT (Consorzio Nazionale Interuniversitario per le Telecomunicazioni). He is a member of the Scientific Advisory Board of Directed Energy Research Center of TII (Abu Dhabi, UAE) and affiliated with the Pisa Section of INFN, the National Institute of Nuclear Physics. His research results have been published in more than 180 journal papers and book chapters, and more than 260 communications at international and national conferences, he is co-author of 5 patents. In 2012 he has been elevated to Fellow grade by the IEEE for his contributions to computational electromagnetics and for application of frequency selective surfaces in metamaterials.

Active Projects

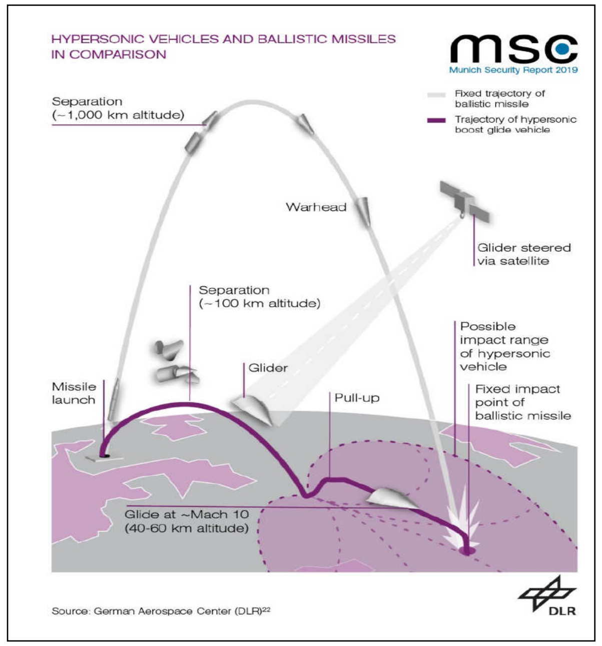
PROJECT ARMA

Architettura Radar per la Minaccia ipesonicA

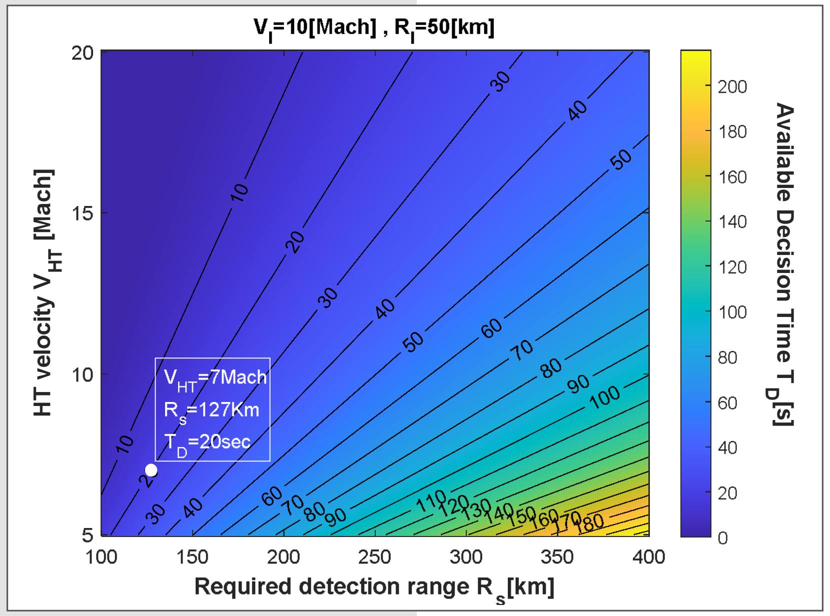
The aim of this project is to 1) define the essential and sufficient requirements to be able to detect and track next generation Hypersonic Threats (HT) for interceptor missile on-board radar and sensor systems and 2) to study radar and RF sensor architectures on board the interceptor missile in order to meet these requirements, taking into account the state of the art and current scientific and technological gaps. To achieve the aim of the project, the study will address the following topics:

- Analysis of the plasma layer around objects in hypersonic regime. The aerothermodynamic field around representative forms of MI will be simulated numerically through computational fluid dynamics in different conditions of hypersonic regime to verify the presence of plasma and calculate its eventual distribution.
- Interaction of the EM wave with the representative model of the object and the plasma volume for the determination of the RCS as the frequencies, angles of incidence, phase (and height) of the flight, hypersonic speed, etc. vary. (applied electromagnetism). Analysis of the distortion of the radar signature of the model due to the effect of timevarying plasmas at the various transmission frequencies.
- Study of the characteristics of existing radars: the performance of radar systems sized for "conventional threats" need to be re-evaluated in HT scenarios, where the threat, flying at lower altitudes, appears on the radar horizon at lower ranges and remains immersed in the superficial clutter.
- Study of the interaction of RF sensors, Seeker RF, on board the missile due to the presence of plasmas.
- Study of the architecture of the single radar sensor (ground sensors, seekers, sensors on air and space platforms) and of the radar networks (on various platforms) to meet the requirements necessary for the detection and tracking of HTs.

Technical Sheet
Funding institution:
Italian Ministry of Defence (MoD)
Project partners
LEONARDO S.p.A, MBDA, LINKS, POLITECNICO DI TORINO
Project duration
February 2022 - March 2023
Involved countries
Italy



(a) Trajectory Comparison between ballistic missile and hypersonic weapons



(b) Decision Time as a function of Hypersonic Threat speed and required detection range

PROJECT ARTURO

Advanced Radar Technology in eUROp

The ARTURO (Advanced Radar Technologies in eUROpe) project proposes a solution to fulfil future operational needs based on extended use of emerging technologies. More specifically, studies of ARTURO project will be focused on:

- Representing end-users vision in terms of needs and high-level requirements for the future most demanding scenarios and environments.
- Defining an innovative Sensor Architecture and the most efficient applicable technologies to be implemented in the future development.
- In-depth analysis of the new threats and the environment surrounding the radar which produces an accurate definition of the various operational scenarios (air, land and naval) the new class of radar is expected to cope with.
- Carrying out the study of modern HW (hardware) and SW (software) technologies that provide the constituent elements of the new class of radar. New approaches to design (i.e. cognitive) and modern technologies such as Artificial Intelligence will be disseminated within the design.
- Supporting the above topics by selecting a specific preliminary development of key components of the new architecture.
- Proposing a roadmap for future developments based on the results derived by the current research.
  The ARTURO research addresses the future defence needs (keeping in mind civil world as well) and proposes a new class of sensors based on feasibility studies and high level specifications. From an architectural point of view, the proposed approached is based on the scalability as a key driver of design, i.e. a modular design for extending the same components on different platforms with a consequent reduction of non-recurring and logistic costs. The design is then based on an elementary and fundamental component for all the new class of radars while the different sensors for different domain applications are formed via aggregation of the elementary component. As a matter of fact, the ARTURO project will analyse and study a wide set of technologies to evaluate the benefits they could bring in new generation of radar systems and to indicate which are relevant depending on the CONOPS. In particular, a roadmap for sensors will be elaborated based on the study results provided by various technological analyses. This roadmap will figure out the most appropriate sensors according to their domain and use cases, their class of performance, their level of maturity, their cost benefit analysis and their complementarity regarding other competing technologies.

Technical Sheet
Funding institution:
EU EDF
Project partners
Scalinix, Sentech Srl, Thales DMS France SAS, Thales Nederland BV, Totalforsvarets Forkskningsinstitut, Universidad de sevilla, Università degli Studi di Pavia, XY-Sensing, Leonardo SpA, Aalto Korkeakoulusaatio sr, Airbus defence and Space, Baltijos Pazangiu technologiju Institutas, CoreHW, Echoes srl, Hensoldt, Indra, Marduk Technologies, TNO, Pitradwar, Rheinmetall Italia, SAAB, SATWAYS
Project duration
September 2023 - August 2026
Involved countries
Italy, France, Germany, Netherlands, Sweeden, Spain, Poland, Finland, Lithuania, Estonia, Greece

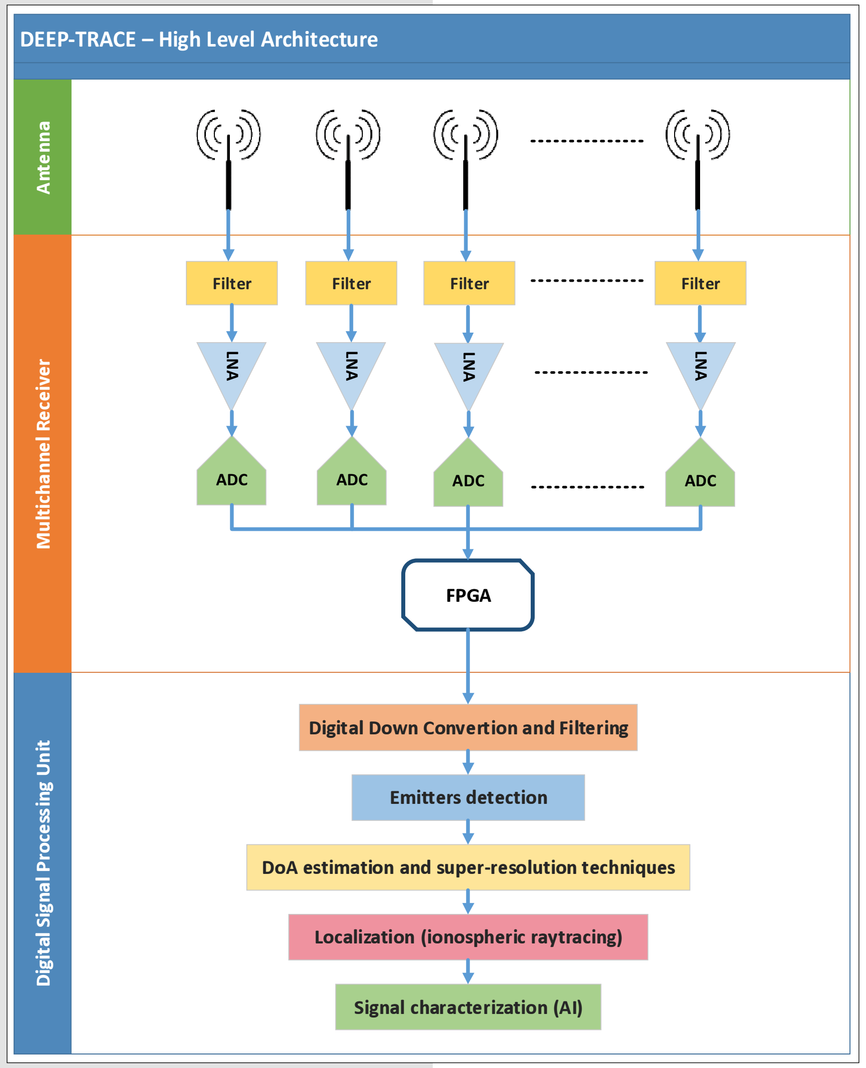
PROJECT DEEP-TRACE

Deployable performing HF radio goniometer compact system for C-ESM applications

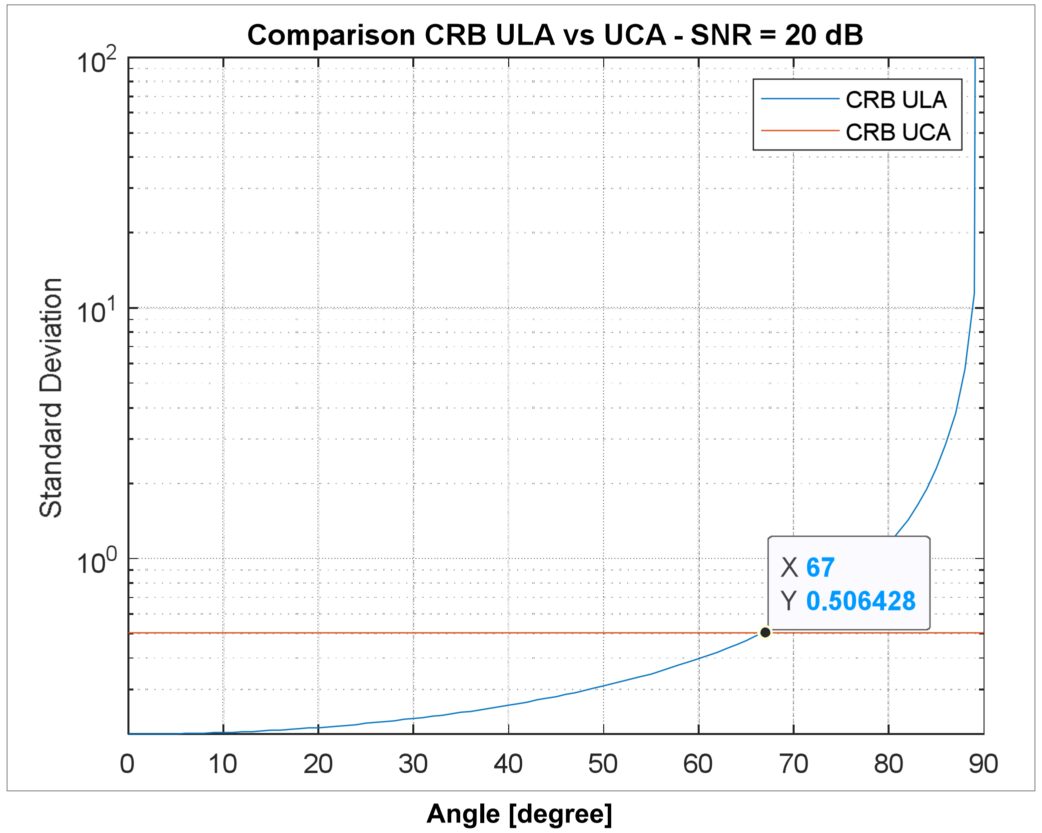
The DEEP-TRACE project aims at realizing a multi-channel system based on an array of compact receiving antennas for receiving, digitizing and analysing HF band signals for C-ESM applications. This configuration is conceived to cope with compactness, easy deployment, modularity and scalability requirements.
The proposed technological solution allows to estimate the direction of arrival (DoA) of the received signals, to characterize the signal through the use of Artificial Intelligence (IA) techniques and to localize the source making use of 3D ionospheric propagation models for the signals transmitted in sky-wave mode. This system could be used individually or in a multi-sensor / multi-platform configuration. This last configuration, appropriately dislocated, will allow the geolocation of the HF source, regardless of the type of propagation (sky-wave or surface-wave).
The main innovative aspects of this proposal are:

1) An accurate miniaturization of the antennas combined with the use of an active and flexible adaptation, able to use the radiating elements in array configuration to be deployed both in the terrestrial environment (urban or not) and naval;
2) Implementation of different DoA estimation techniques even in the presence of a limited number of sensors, and comparison of their performance in terms of mean square error of estimate and robustness to mismatches between design conditions and actual conditions determined by the ionospheric channel;
3) Positioning techniques of the individual receiving nodes in a sensor network configuration. The techniques adopted will optimize the spatial configuration of the nodes in order to minimize the Cramer-Rao limit on the DoA estimate;
4) Localization based on 3D ionospheric propagation models able to reconstruct the e.m. path from the receiver to the transmitter through the ionospheric channel;
5) Artificial Intelligence (IA) for classifying the detected signal (e.g.: type of propagation, continuous / pulsed wave, modulation, etc.).

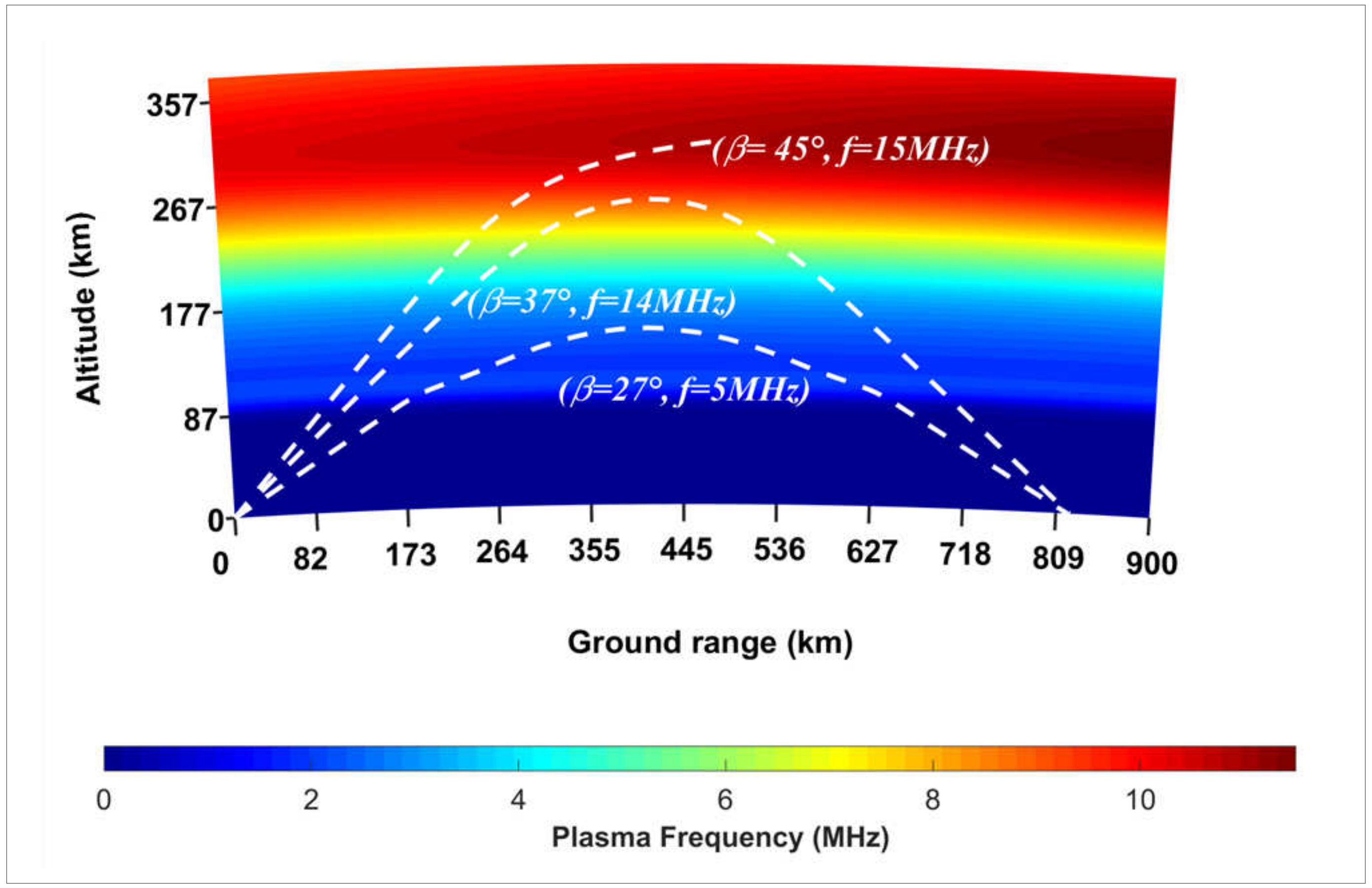
Technical Sheet
Funding institution:
Italian MoD
Project partners
ECHOES s.r.l., FreeSpace s.r.l
Project duration
June 2021 – June 2024
Involved countries
Italy



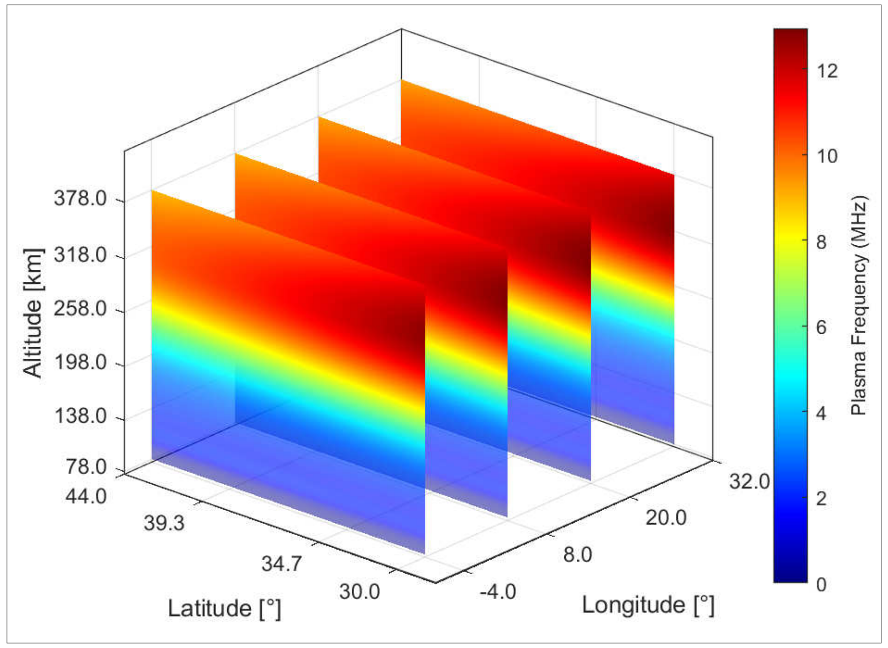
(a) DEEP-TRACE High-level architecture



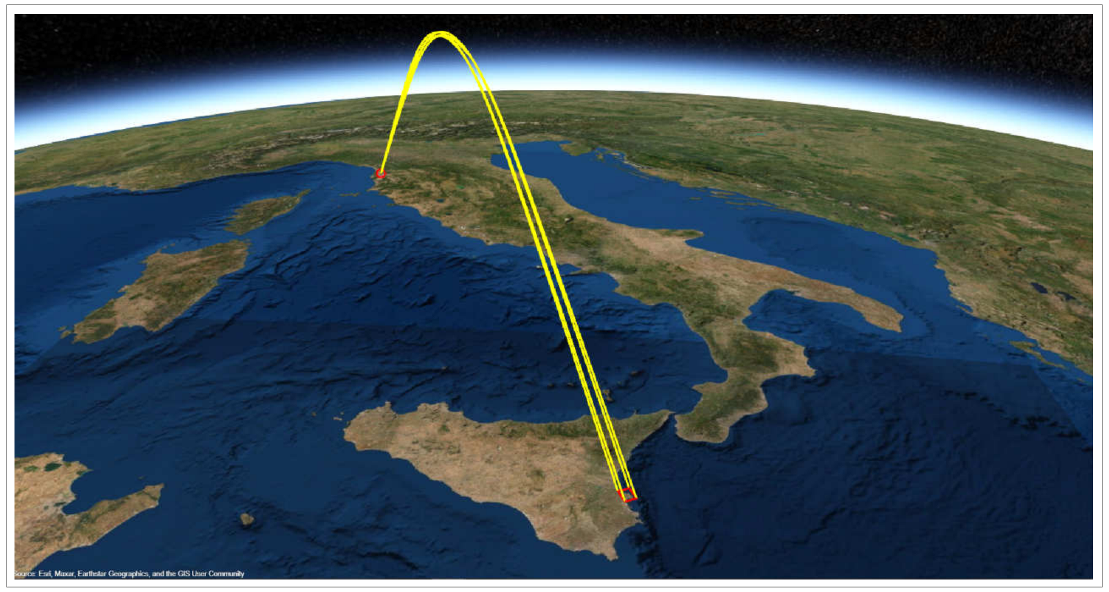
(b) Beamforming performance comparison: Uniform Linear Array (ULA) vs Uniform Circular Array (UCA) (SNR=20 dB)



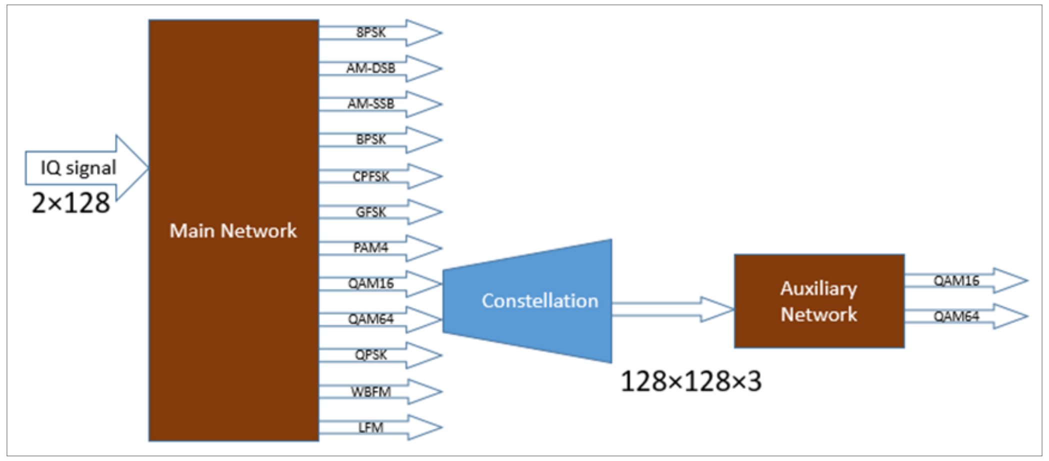
(c) Electron density profile and ray-paths formation related to the reference scenario



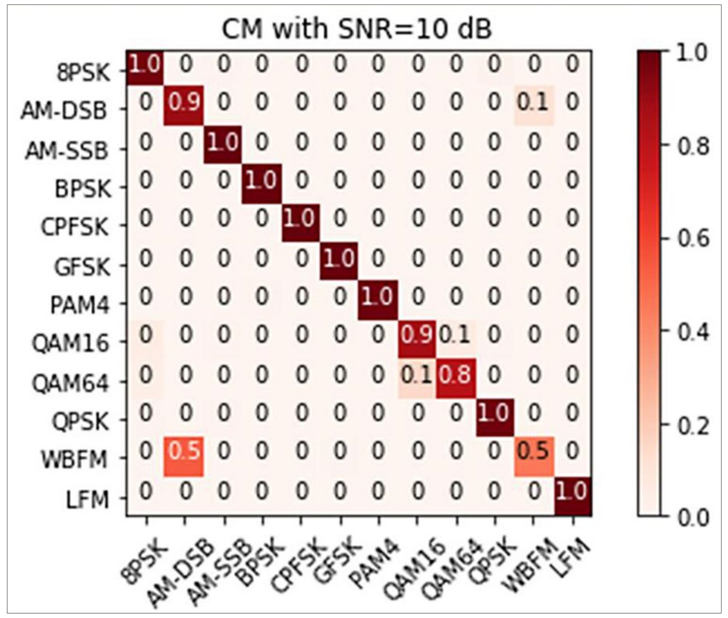
(d) Longitude slices of the 3D Electron density related to the reference scenario



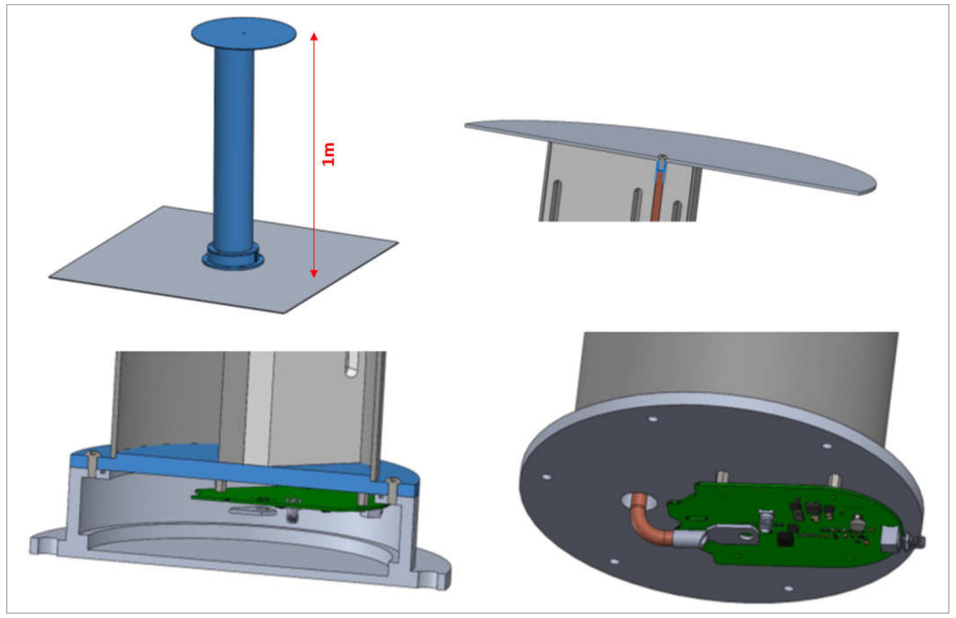
(e) 3D ray tracing outcome for the transmitter localization in the reference scenario



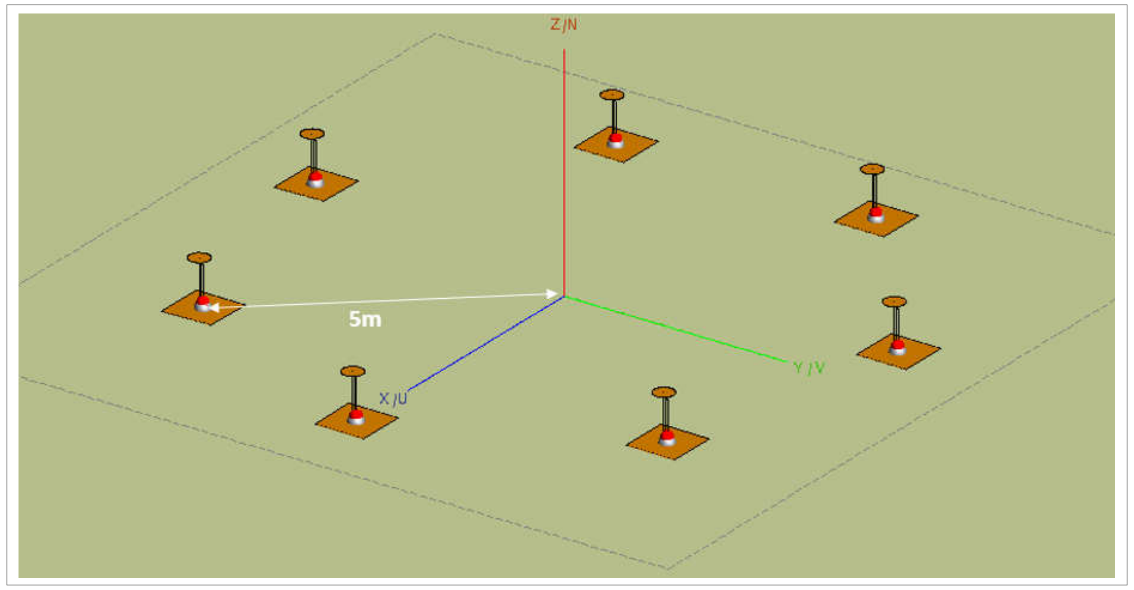
(f) The CNNbased automatic modulation classification architecture. The auxiliary network resolves the ambiguity between the two similar modulations (QAM16, QAM64) to enhance the overall accuracy



(g) The confusion matrix of the proposed automatic modulation classification architecture at SNR=10dB



(h) Preliminary mechanical project of the antenna (single element of the array) including, at the bottom, the PCB of the amplifier performing the matching with the front-end of the receiver. The antenna is very compact having an overall dimension of about 1m



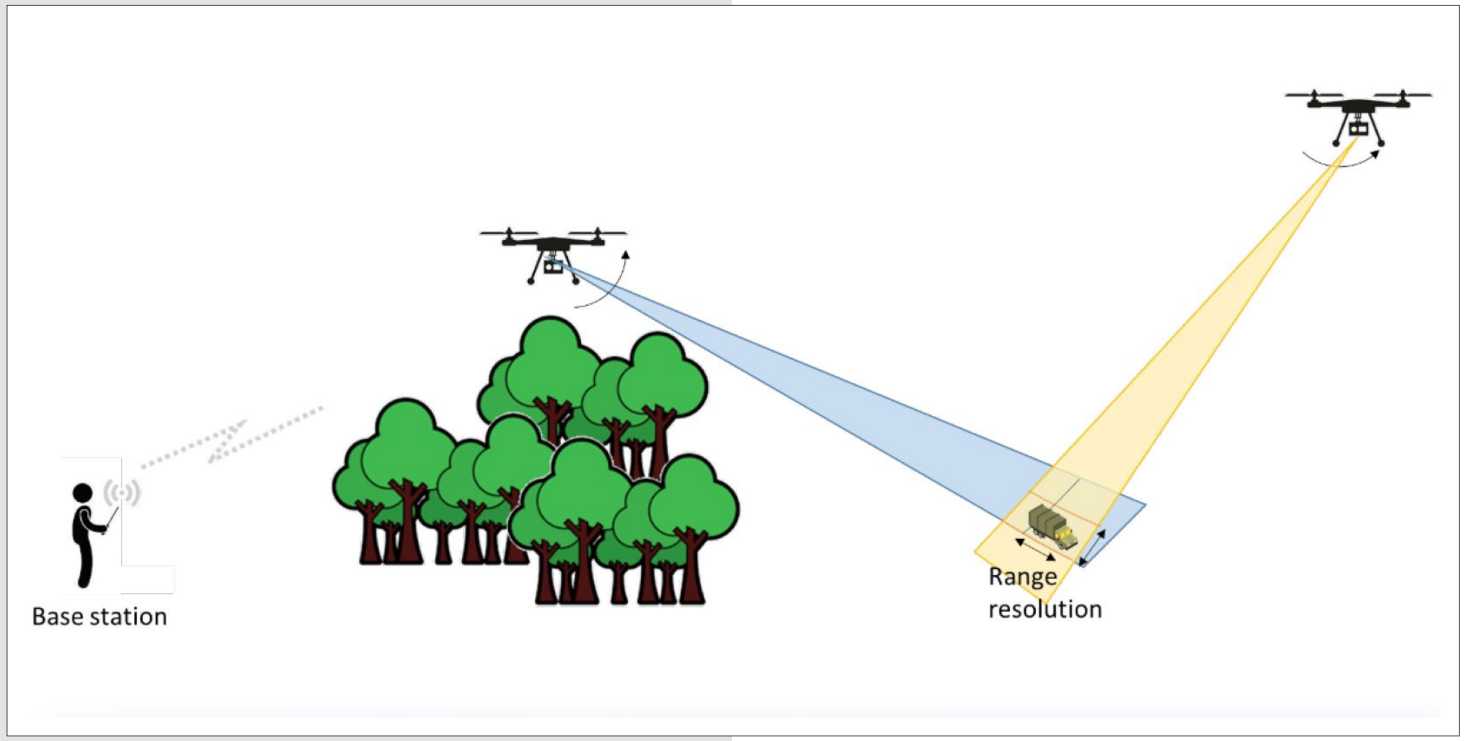
(i) EM model of the circular array for the DOA estimation. The array diameter is about 10m and it can be easily deployed in the operative scenario due to the compact antennas

In tactical environments, the need for a swift and adaptable surveillance system is evident for small ground troops and medium-sized coastal vessels. Ground troops on the move and boats navigating coastal waters require real-time updates on their surroundings and timely alerts about potential threats or nearby movements. Existing communication systems often fail to provide comprehensive details or timely updates, leading troops to rely on semi-fixed surveillance tools like portable radars, which are limited by terrain obstacles and lack adaptability in dynamic situations. Similarly, coastal naval operations face challenges due to obscured threats from coastal topography and potentially insufficient commandprovided information, increasing associated risks. There is a clear need for an innovative, cost-effective, and versatile surveillance system not currently available in the market.

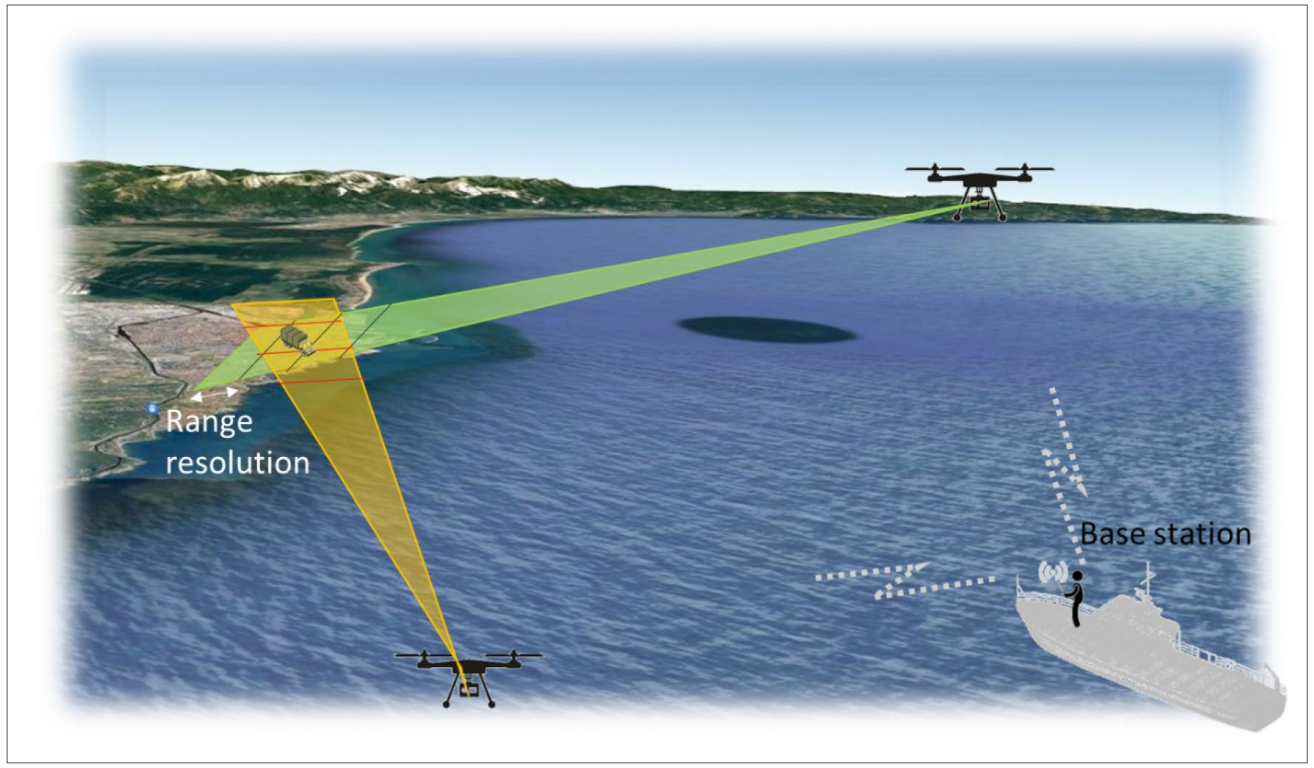
The proposed solution involves deploying easily launched drones equipped with sensors from various ground points or small boats. These drones offer lightweight, portable systems for continuous perimeter surveillance. Their dynamic surveillance capabilities allow for the detection of threats both in the air and on land, adapting to changing scenarios. Equipped with radar sensors, these drones operate independently of lighting or weather conditions, unlike electrooptical systems. This solution also enhances naval tactical scenarios by transforming shipboard radars into multi-static systems, enabling obstacle scouting and improved target detection, tracking, and recognition.

The project's primary goal is to demonstrate drone swarm technology, focusing on developing and integrating surveillance and collision avoidance systems, and creating algorithms for efficient drone-based surveillance in both land and maritime tactical operations. This initiative aims to overcome current surveillance limitations, providing a dynamic and adaptable solution for tactical scenarios on land and at sea.

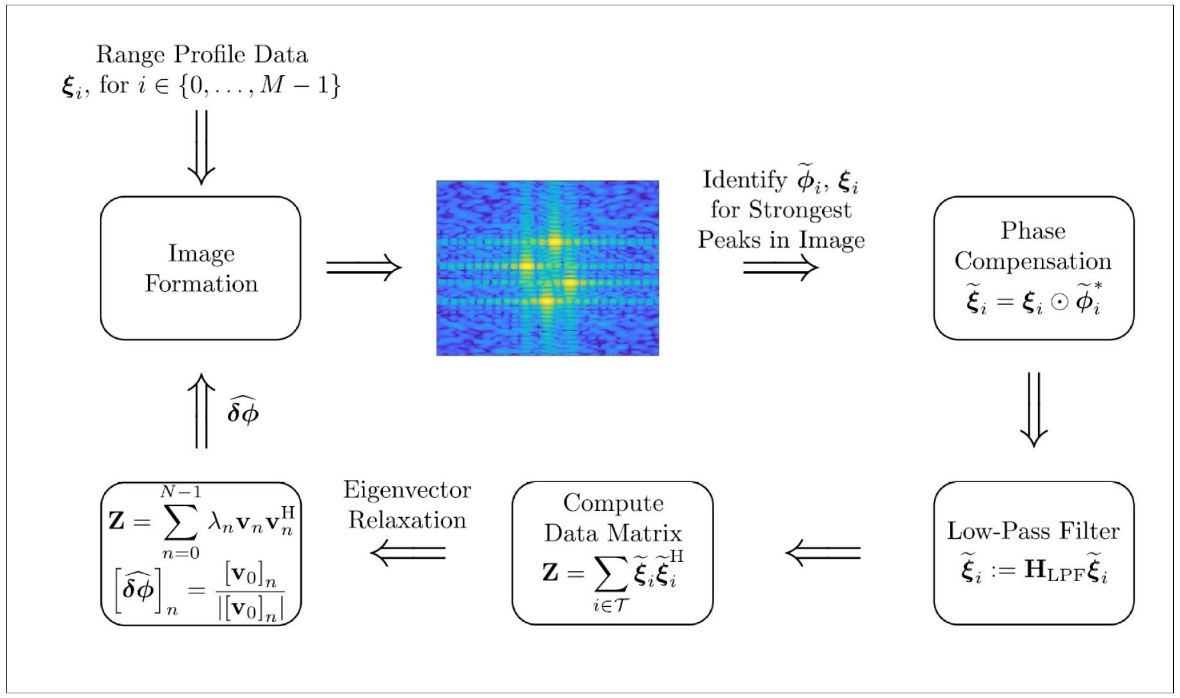
Technical Sheet
Funding institution:
Italian MoD
Project partners
Echoes srl, ARESYS, SIGMA INGEGNERIA S.R.L.
Project duration
October 2022 - October 2025
Involved countries
Italy



(a) Ground tactical surveillance: detection and localization of moving targets



(b) Maritime tactical surveillance: detection and localization of movng targets



(c) Generalized Phase Gradient Algorithm for SAR imaging

PROJECT 3D-ISAR

ATR by means of Polarimetric ISAR Images and multi-view 3D InISAR

Both homeland security and asset protection in military scenarios require high performing modern surveillance systems in terms of accuracy and response times. Examples are the protection of ports, airports, critical infrastructures, immigration monitoring and prevention, maritime and air surveillance from various types of platforms (land, sea, air and space). In this variety of applications there is the need to have a support for the recognition of the threat produced by an approaching target.
The aim of the project 3D-ISAR is twofold:

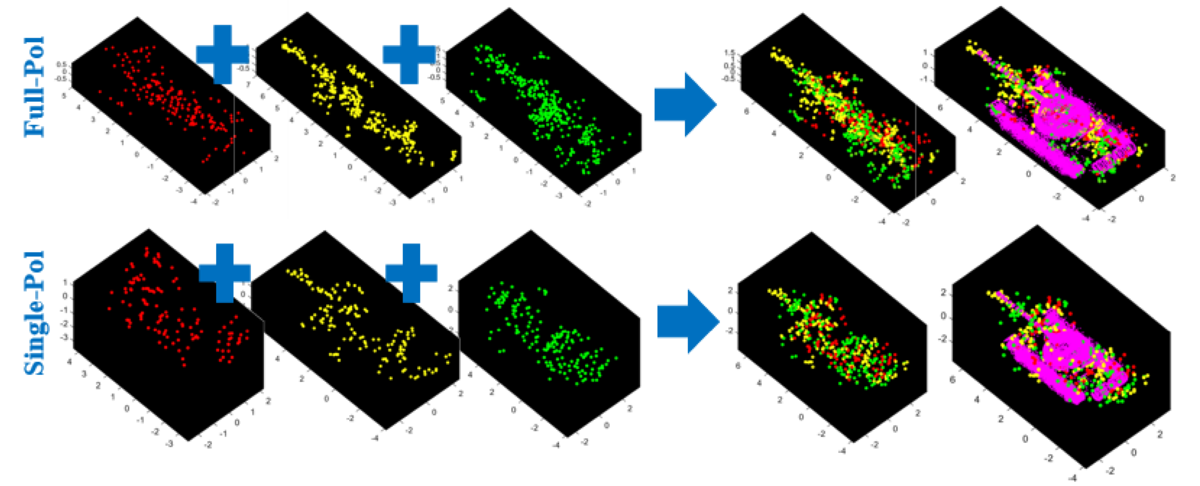
- Demonstrate that the use of polarimetry may enhance the performance of 3D Interferometric ISAR imaging systems. 3D InISAR has been proven effective to generate a 3D point target model of non-cooperative moving targets. To further enhance its performance, a fully polarimetry 3D InISAR algorithm is under development that will be able to combine the advantages of fully polarimetry radar over single polarisation radar and those of 3D InISAR over 2D ISAR imaging.

- Develop a non-cooperative target recognition algorithm that exploits fully polarimetric 3D InISAR results.
  The use of 3D target reconstruction instead of 2D ISAR images may overcome the problem of creating large and costly databases as 3D reconstructed images can be compared directly to geometrical target CAD models or simulated 3D e.m. CAD models. Moreover, the use of machine learning will be also investigated in this work for the implementation of NCTR algorithms.

Figure (a) the 3D InISAR results obtained by using multiple views (both in elevation and azimuth) of the a real target superimposed to its CAD model. The same figure also reports the estimated target size and size ratios to show that the use of polarimetry permits to reach an improved estimate of the target size and preserve the target shape more faithfully.
Figure (b) shows the results in terms of classification and recognition of the CAD mode based algorithm. The algorithm compares the 3D InISAR reconstructions of the T72 obtained using different polarimetric channels with a set of CAD models of cars, trucks and tanks. The algorithm follows a two steps procedure, firstly the class is identified (figure b - (left)), then the target model within the identified class is recognized (figure b -(right)).
As it is possible to observe the SPAN-based approach provides the best results in terms of classification but the coherence-based algorithms is the only one which is able to correctly identify the target type Figure (c) shows the results in terms of classification and recognition of the PCT-based algorithm.
The algorithm makes
use of a database of 3D InISAR reconstruction of targets, (cars, trucks and tanks) simulated from their CAD models.
Again the target to be classified is the T72 and its 3D InISAR reconstructions are used as input of the classifier. The algorithm follows a two steps procedure, firstly the class is identified (figure c -(left)), then the target model within the identified class is recognized (figure c - (right)). In this case the recognition procedure requires a fine tuning of the training set, which consist of fine tune the network weights using a portion of the T72 3D reconstructions, which has been divided into three sets, namely training, validation and test set.

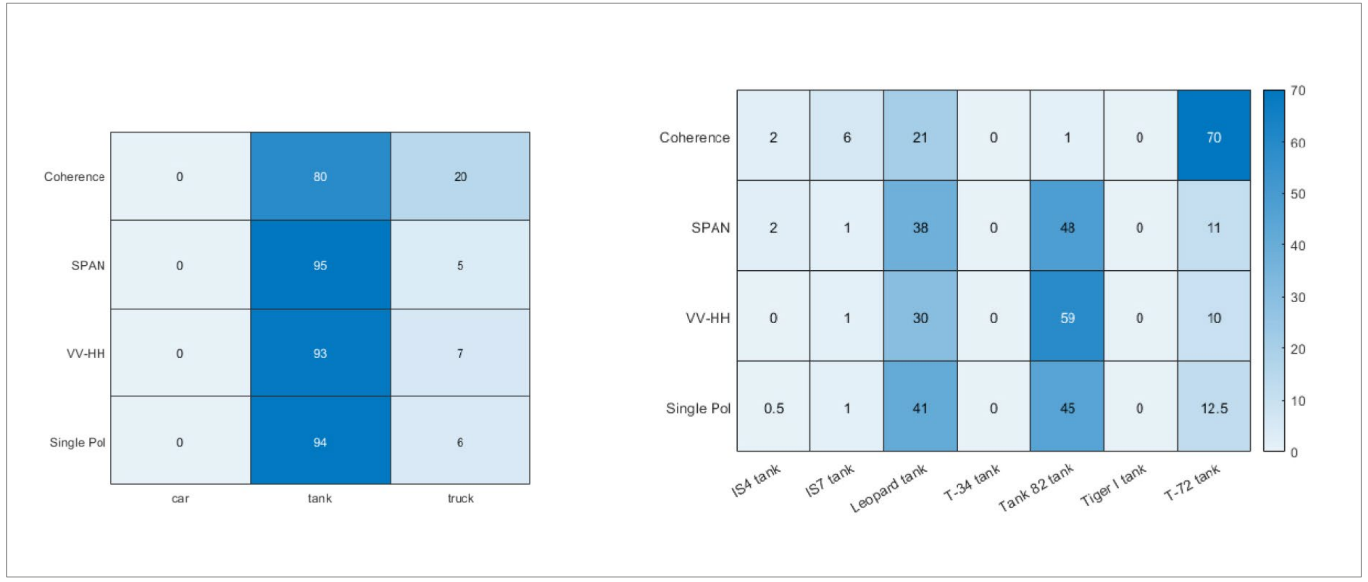
[1] E. Giusti, A. Kumar, F. Mancuso, S. Ghio and M. Martorella, "Fully polarimetric multi-aspect 3D InISAR," 2022 23rd International Radar Symposium (IRS), 2022, pp. 184-189, doi: 10.23919/IRS54158.2022.9905018

Technical Sheet
Funding institution:
ONR GLOBAL
Project partners
CNIT RaSS
Project duration
September 2020 - September 2023
Involved countries
Italy

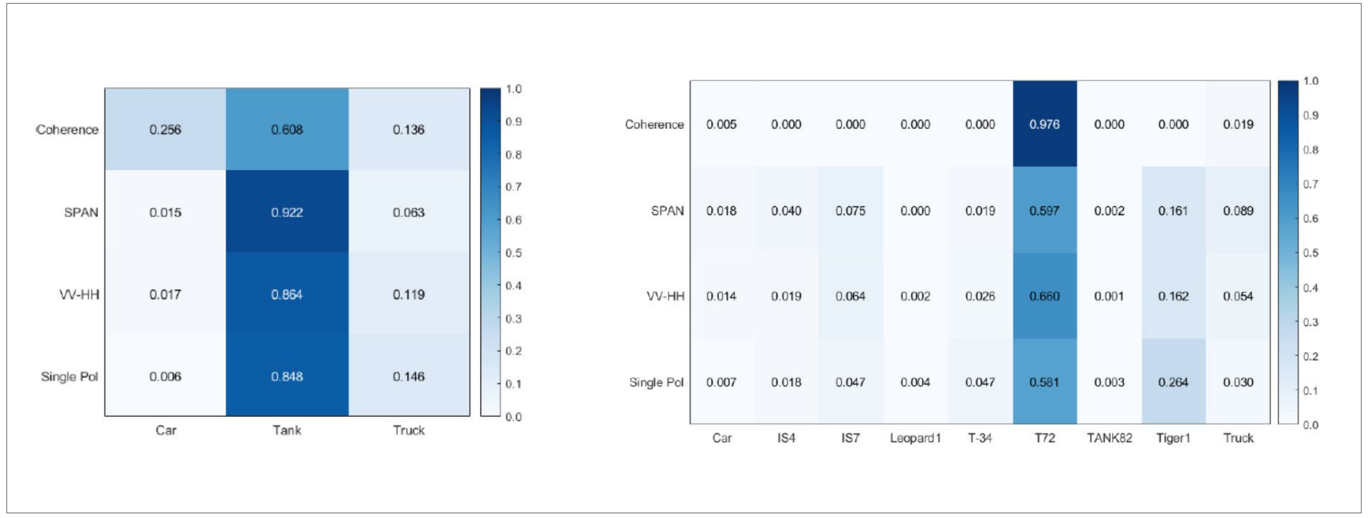


Tank/Size	L	W	H	L/W	L/H	W/H
Actual	9.24 m	3.4 m	2.37 m	2.72	3.89	1.43
Full-pol 3D InISAR	11.22 m	4.20 m	2.57 m	2.67	4.36	1.63
Single-pol 3D InISAR	11 m	6.52 m	6.62 m	1.68	1.66	0.99

(a) 3D target reconstruction using fully polarimetric radar data of a tank [1]



(b) Comparison of the classification performance of the CAD model based obtained using full-pol and single-pol 3D InISAR algorithms. The Classification results have been obtained based on the RMSE (left), Recognition performance of the CAD model based classifier (right)



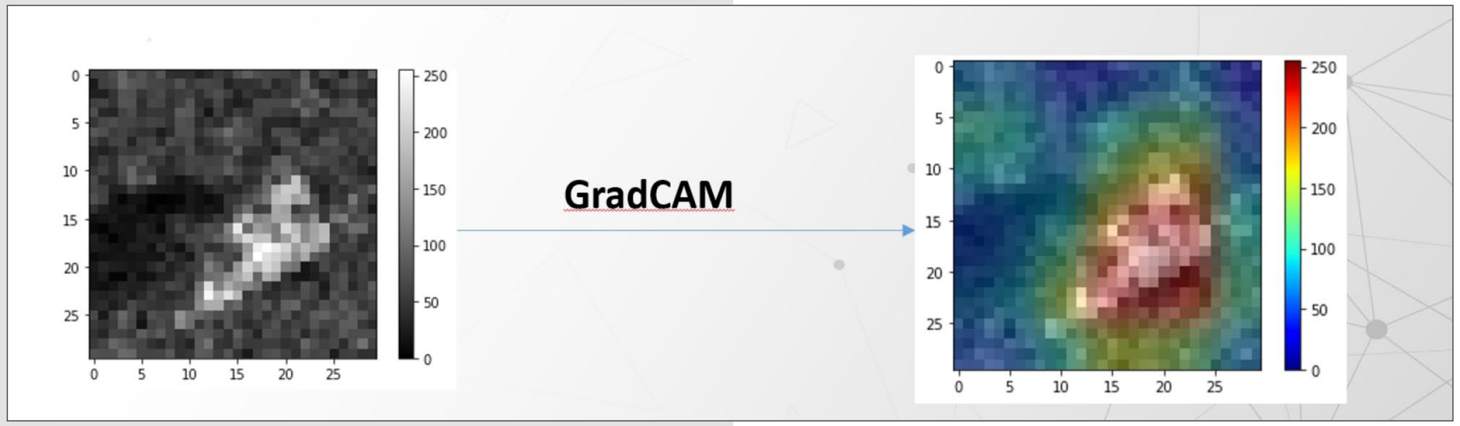
(c) Comparison of the classification performance of the PCT- based algorithm obtained using full-pol and single-pol 3D InISAR T72 reconstructions (left), Recognition performance of the PCT-based classifier after fine tuning (right)

PROJECT FARADAI

Frugal and Robust AI for Defence Advanced Intelligence

The project "Frugal and Robust AI for Defence Advanced Intelligence" (FaRADAI) focusses on frugal learning, i.e. the ability of a system to adapt and learn from its' environment, including from user supervision, for a reasonable cost and without intervention from expert developers. An important cross-cutting need for Artificial Intelligence is to create technologies for reliable, autonomous and frugal learning, i.e. the ability of a system to adapt and learn from its environment, including from user supervision, at a reasonable cost and without ' intervention of expert developers nor regression. Such technologies can be highly disruptive and have a high impact on many capabilities, especially when the information to be managed is highly variable or unpredictable and high adaptability is required.
These technologies can also alleviate the current need to provide data to system developers to achieve improvements depending on that data, which can be critical when the data is sensitive, and is therefore critical for defense. They can improve technological independence more generally. Selected actions should include the organization of technology challenges that address well-defined objectives in order to initiate and drive progress towards addressing identified defense needs, while simultaneously leveraging civilian research and generating spillover effects.
As part of the FaRADAI project, current advances in artificial intelligence technologies will be thoroughly studied in parallel with a detailed study of the main challenges imposed by a defense system. Aiming for significant breakthroughs in artificial intelligence, the models will accelerate their wider application and deployment in defense systems, increasing their impact and overall performance.

Technical Sheet
Funding institution:
EU EDF
Project partners
ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS, ANAPTYXIS - CERTH, BALTIJOS PAZANGIU TECHNOLOGIJU INSTITUTAS, BIANOR SERVICES EOOD, C&V CONSULTING, COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES, DEFSECINTEL SOLUTIONS OU, E-GEOS SPA, EXUS SOFTWARE MONOPROSOPI ETAIRIA, PERIORISMENIS EVTHINIS, FLYSIGHT SRL, FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER, ANGEWANDTEN FORSCHUNG E.V., FUNDACION TECNALIA RESEARCH & INNOVATION , HENSOLDT OPTRONICS GMBH, INDRA SISTEMAS SA, INFILI TECHNOLOGIES SOCIETE ANONYME, INSTITUT PO OTBRANA, LEONARDO - S.p.A., LINK CAMPUS UNIVERSITY, MARINTRAFIK OPEREISONS ANONYMI, ETAIREIA PLIROFORIKIS, MBDA ITALIA SPA, NATIONAL CENTER FOR SCIENTIFIC, RESEARCH "DEMOKRITOS", NAVAL GROUP, NEDERLANDSE ORGANISATIE VOOR TOEGEPAST, NATUURWETENSCHAPPELIJK ONDERZOEK TNO, OKTAL SYNTHETIC ENVIRONMENT, RHEINMETALL ELECTRONICS GMBH, RIGAS TEHNISKA UNIVERSITATE, SAFRAN ELECTRONICS & DEFENSE, SATWAYS, SKA POLSKA SPOLKA Z OGRANICZONA, ODPOWIEDZIALNO, STAM SRL, SZAMITASTECHNIKAI ES AUTOMATIZALASI KUTATOINTEZET, THALES France, THALES PROGRAMAS DE ELECTRONICA Y COMUNICACIONES SA, THALES SIX GTS FRANCE SAS, UNIVERSIDAD POLITECNICA DE MADRID
Project duration
December 2022 - August 2026
Involved countries
Lithuania, Bulgaria, Belgium, Estonia, Germany, Spain, Greece, France, Netherlands, Germany, Latvia, Poland, Italy, Hungary



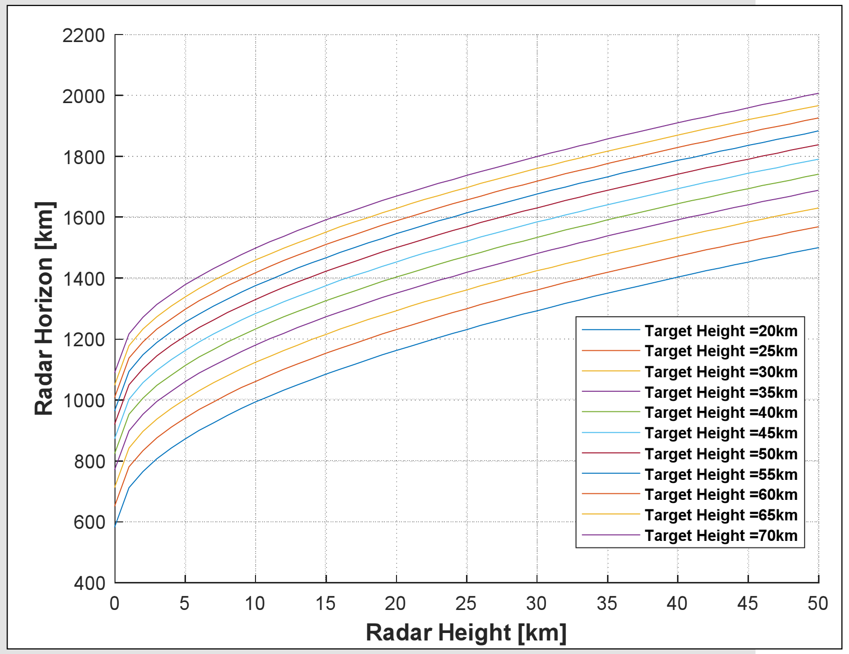
(a) XAI results based on Grad-Cam

PROJECT HYPOTENUSE

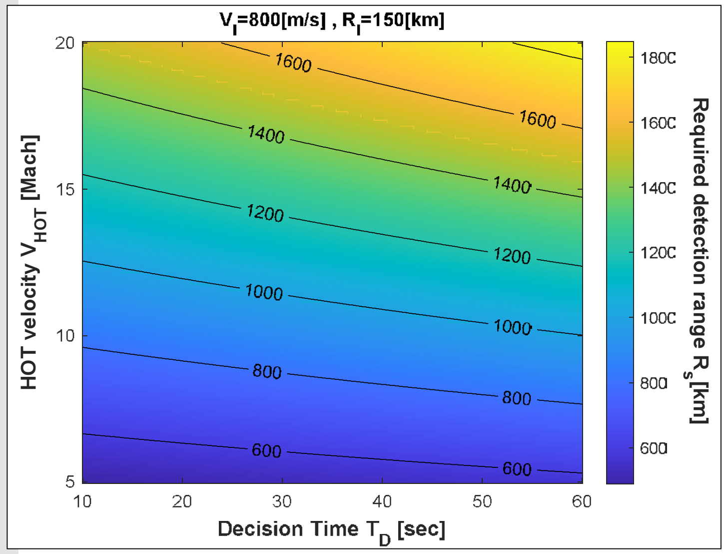
HYPersOnic Threat dEtection aNd coUntermeaSurEs

Hypersonic missile threats are considered a game-changing military technology. Specifically, hypersonic missiles can fly between approximately 5,000 and 25,000 km/hour, they fly at unusual altitudes of between tens-of-kilometres to in excess of 100 km, their manoeuvrability enables them to evade even the most sophisticated layered missile defence infrastructures. Their speed, unusual altitudes and manoeuvrability combine to render hypersonic missiles extremely elusive to detect and to intercept. A hypersonic strike would unfold more rapidly than a conventional strike and would significantly compress the timelines for an attacked party to respond. The purpose of this study is not to analyse hypersonic missile developments per se, but rather to identify and study the state-of-the-art sensor and intercept (hard- and soft-kill) technologies that constitute a robust Hypersonic Missile Defence (HMD) mechanism. It is clear that no one sensor, or class of sensors, will be able to fully observe hypersonic threats throughout their various phases from launch, glide, cruise to impact. Rather a constellation or layer of technologies will need to be deployed that comprise different types of radar operating with IR sensors and associated intercept (hard- and soft-kill) measures. The layers of electronic sensors including different types of radar and IR sensors represent a stand-alone OODA-loop (Observe–Orient–Decide–Act). For example, the sensor-constellation "holistically" observes the threat, then the constellation Orientates sensing and/or intercept assets toward the threat corridor. All the while, the layer of sensors is providing data to enable the Decide and Act steps of the OODA-loop.

Technical Sheet
Funding institution:
European Defence Agency (EDA)
Project partners
ONERA, FHR, Flysight, HENSOLDT, Leonardo, ISL, MBDA It, LINKS, WUT
Project duration
April 2022 – April 2023
Involved countries
France, Italy, Germany, Poland



(a) Radar Horizon for different radar and target height



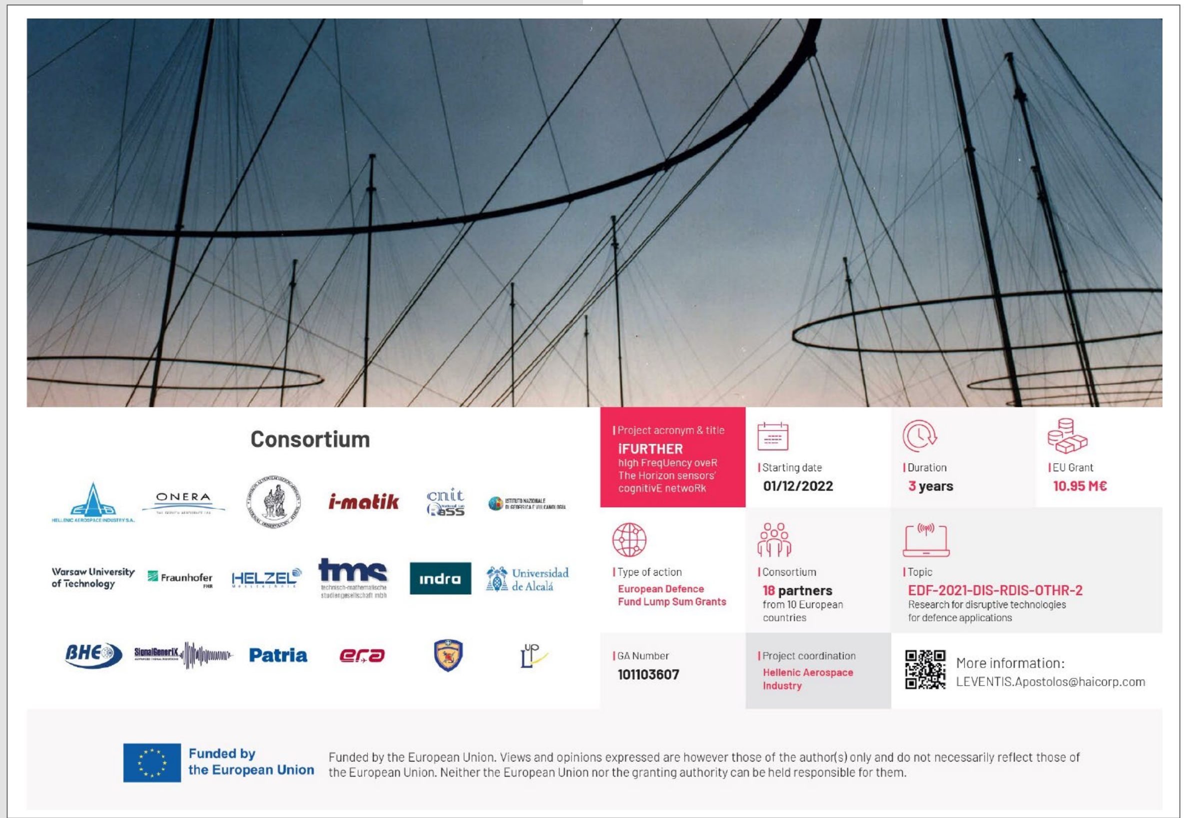
(b) Required detection range as a function of Hypersonic Threat speed and Decision Time

iFURTHER

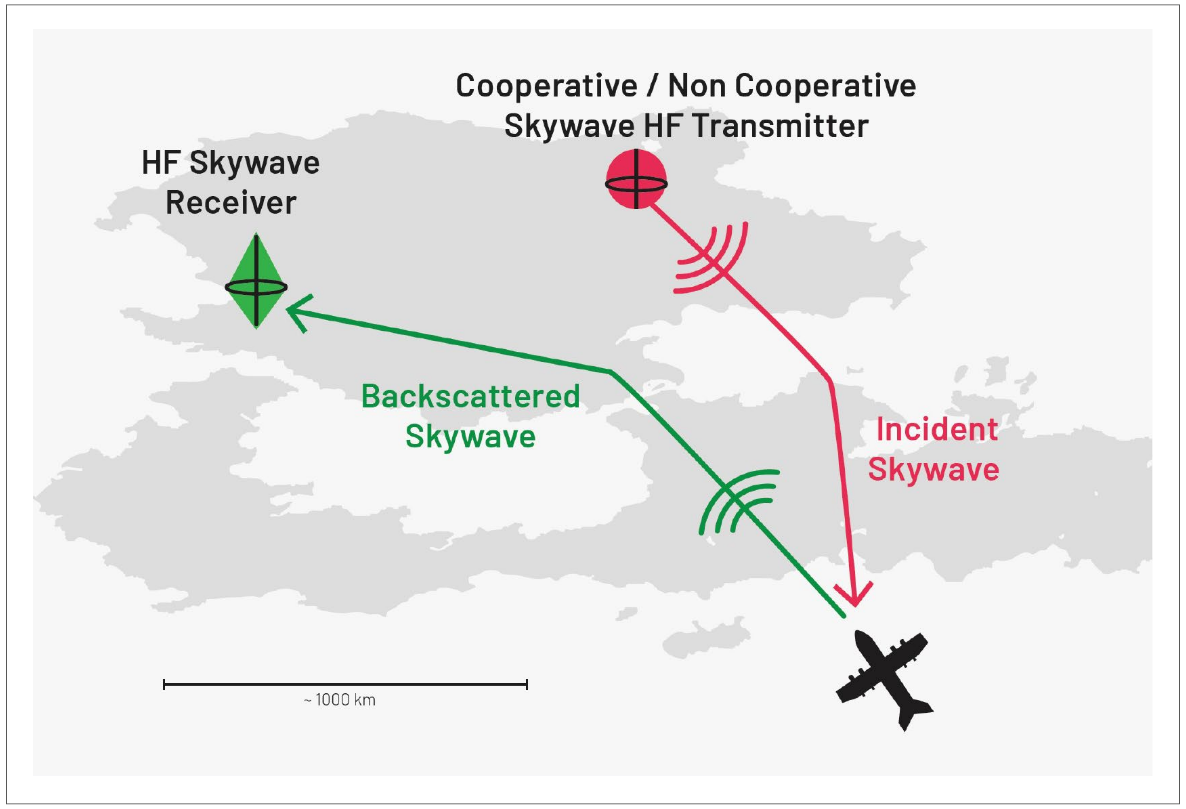
The iFURTHER project aims to address wide area air and sea covert surveillance, by developing new concepts of Over-The-Horizon radar to be integrated into a collaborative network of high-frequency sensors. This project will therefore focus on a cognitive network of high-frequency radars as a disruptive future defence capability to protect the EU. The main objectives of this project are:

- Detect and track air and sea targets at long range (over the horizon), far beyond currently existing systems, by using the reflections of skywave and surface-wave propagated signals.
- Fill gaps and extend the current EU air and sea radar coverage by introducing a multistatic sensor configuration supported by ad-hoc network protocols and an appropriate infrastructure for synchronisation and coordination of sensors (e.g., C2).
- Implement cognitive radar management systems to optimise operational parameters in real time and as a function of environmental conditions (e.g., the state of the ionosphere), based on robust ionospheric models and sounding protocols (not excluding the development of ionospheric sensors).
- Implement advanced signal processing techniques to improve over-the-horizon detection and track performance as well as target localisation capabilities.
- Utilize available non cooperative illumination and apply cognitive features at network level to develop new techniques for optimized use of the electromagnetic spectrum and passive processing.

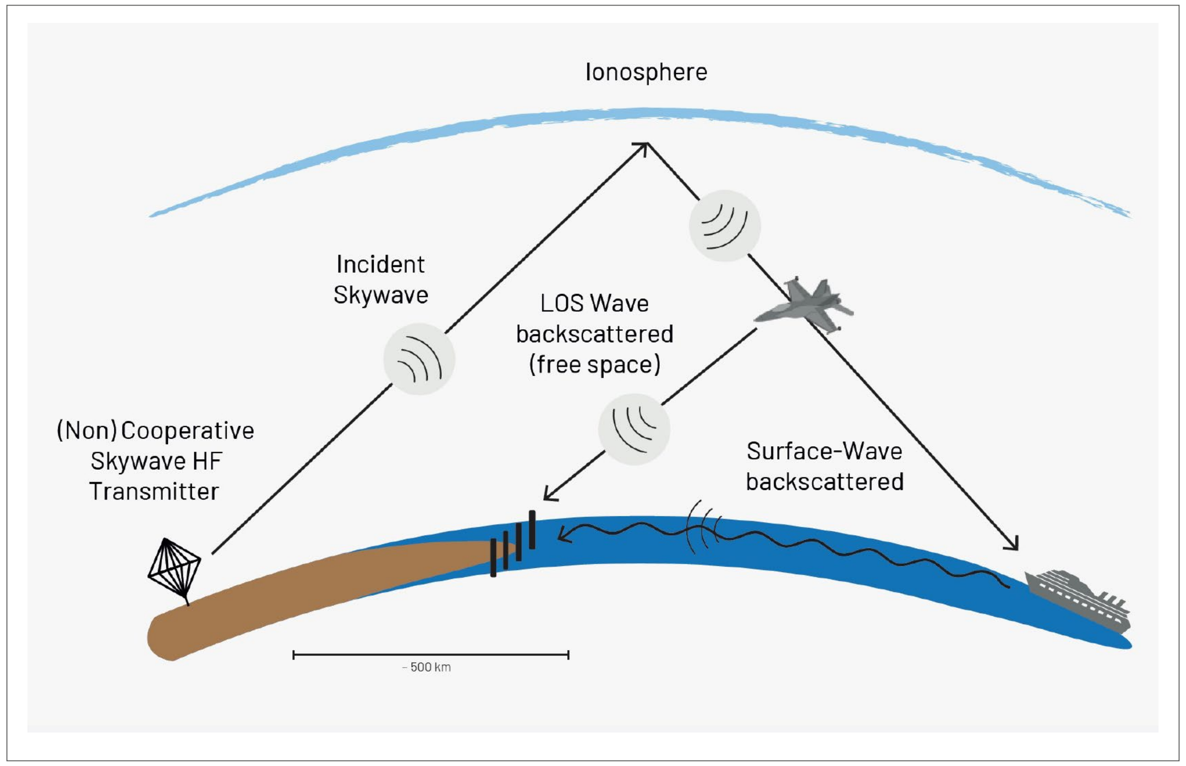
Technical Sheet
Funding institution:
iFURTHER is a research project funded by the European Defence Fund under EDF-2021-DIS-RDIS-OTHR-2 "Research for disruptive technologies for defence applications" - Grant Agreement No. 101103607 Funded by the European Union *Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the grantingauthority can be held responsible for them.*
Project partners
Hellenic Aerospace Industry SA, Office National D'etudes Et De Recherches Aerospatiales, Ethniko Asteroskopeio Athinon, Imatik - Efarmoges Ypsilis Texnologias Etaireia Periorismenis Efthinis, Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Istituto Nazionale di Geofisica e Vulcanologia, Politechnika Warszawska, Fraunhofer Gesellschaft Zur Foerderung Der Angewandten Forschung E.V., Helzel Messtechnik GmbH, Technisch-Mathematische Studiengesellschaft Mit Beschrankter Haftung, Indra Sistemas SA, Universidad De Alcala, SignalGenerix Limited, Patria Aviation Oy, Era AS, Ministry Of National Defence, Greece, L - up SAS
Project duration
December 2022 - November 2025
Involved countries
Italy, Greece, Germany, Czech Republic, Spain, France, Finland, Poland, Cyprus



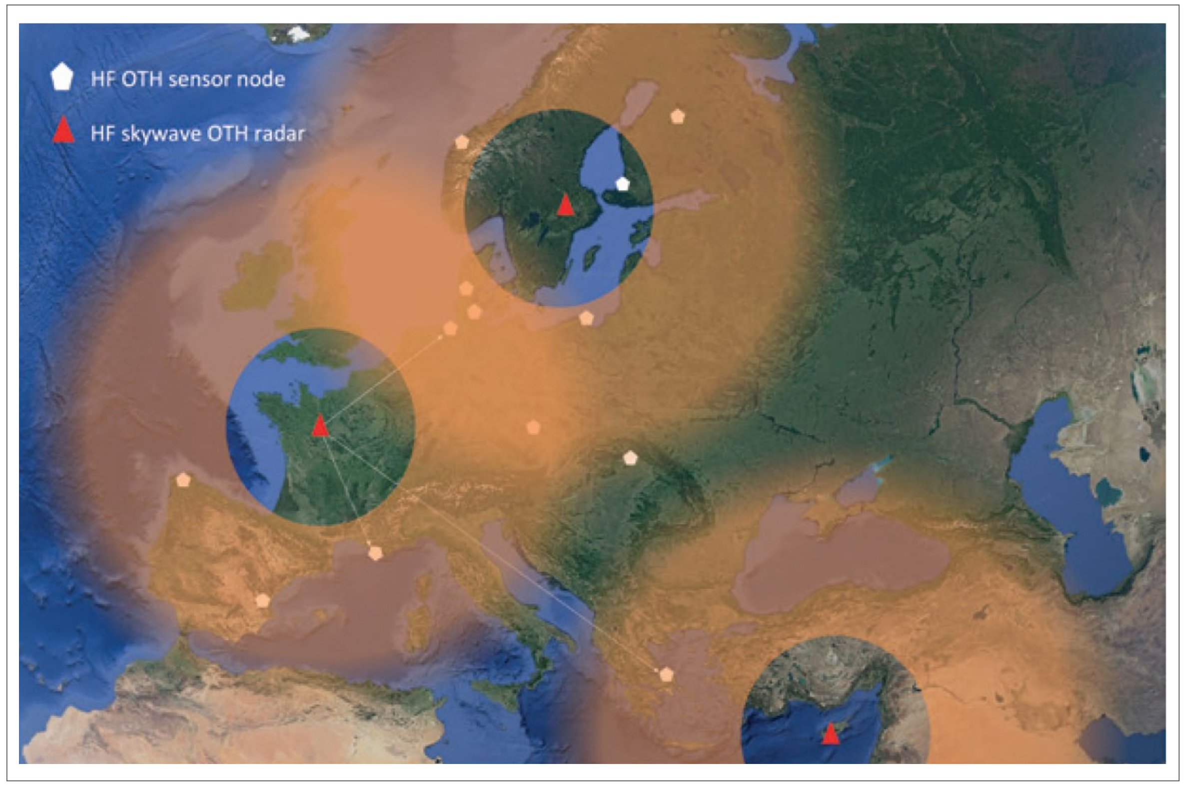
(a) iFURTHER overview



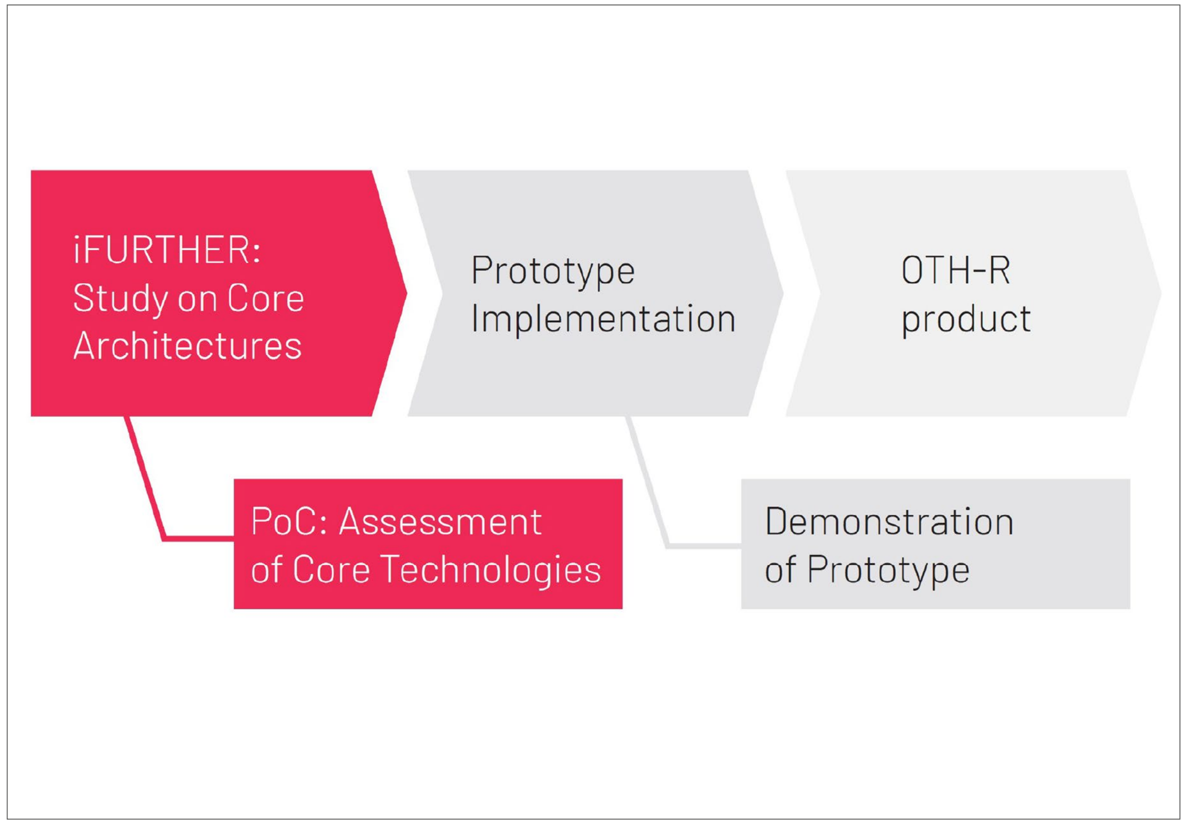
(b) Multistatic Skywave OTH-R system with long baseline: Concept



(c) Multistatic Hybrid (Skywave - LOS/Surface-wave) OTH-R system: Concept



(d) Envisioned EU wide surveillance



(e) Implementation Roadmap towards an OTH Radar product

PROJECT ISS

Integrated Submarine System

The aim of this project is to analyse the technological and algorithmic solutions for a Target Motion Analysis (TMA) system for submarines. Particularly, a software-defined architecture is proposed to host a wide spectrum of software applications dedicated to the management of on-board systems. Using a distributed shared server architecture, data can be available from multiple users at the same time, without the need of execution on dedicated consoles. The proposed architectural approach allows to limit the space required for the HW, for which an architecture has been proposed, introducing energy saving factors and minimizing the need for heat dissipation. The modularity of the architecture makes it easy to integrate possible updates both HW (to increase system computational capabilities) and SW (to update automatic information analysis capabilities) and ensure interoperability with solutions from any future developments.
Given the software-defined nature of the system, a particular focus has been the cybersecurity aspects, adopting a security-by-design strategy, which provides the integration of special security systems in each element of the developed system.

In addition, advanced artificial intelligence algorithms were taken into account to allow the identification and mitigation of any cyber attacks. Finally, TMA and data fusion algorithms have been analysed, focusing on the integration of different type of sensors in the system without the need to modify the software.

Technical Sheet
Funding institution:
DRASS
Project partners
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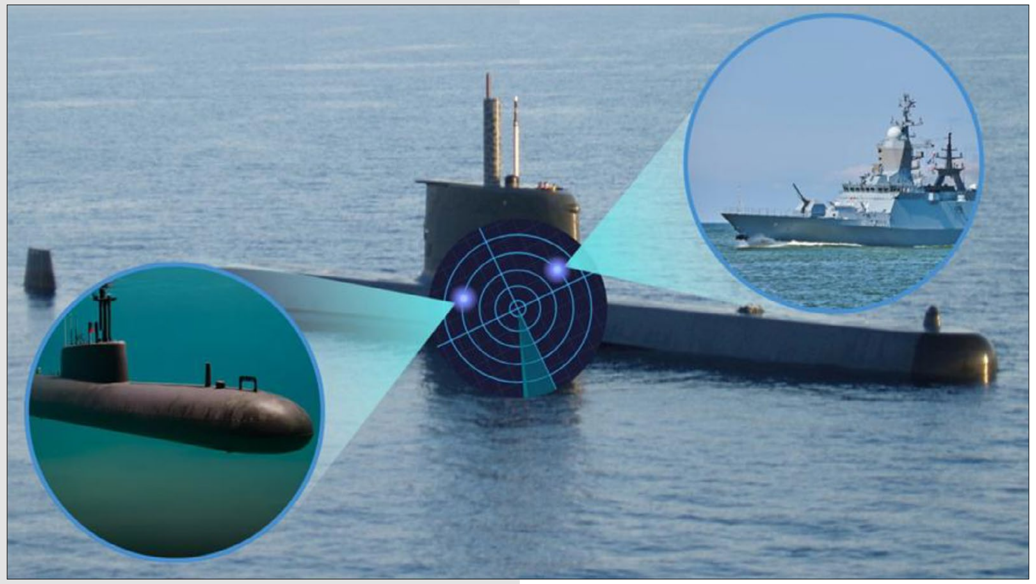
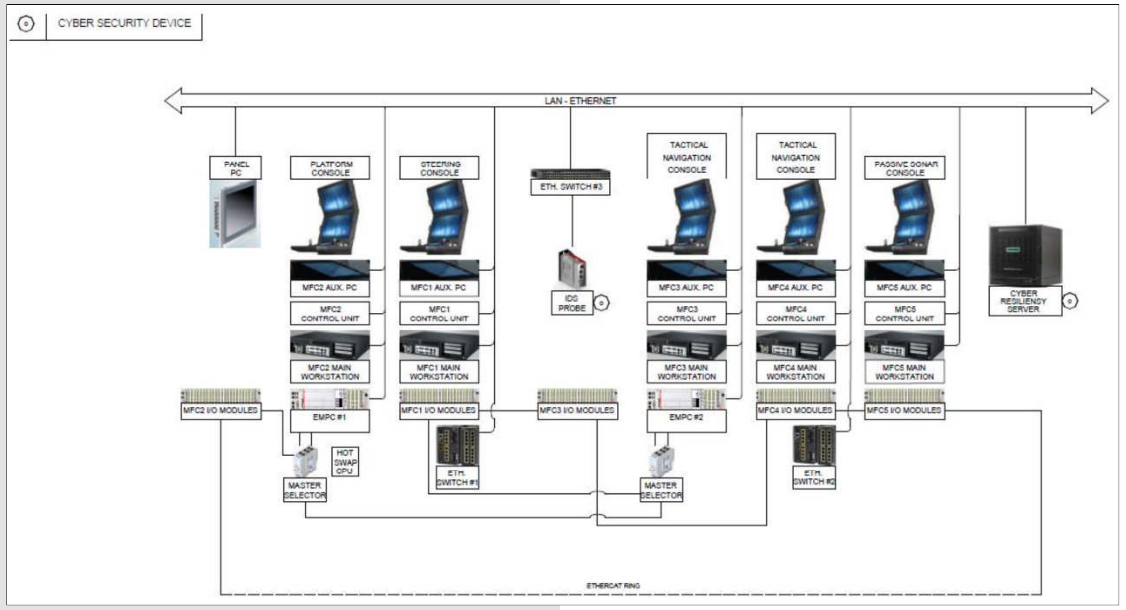
Project duration
January 2021 – October 2023
Involved countries
Italy



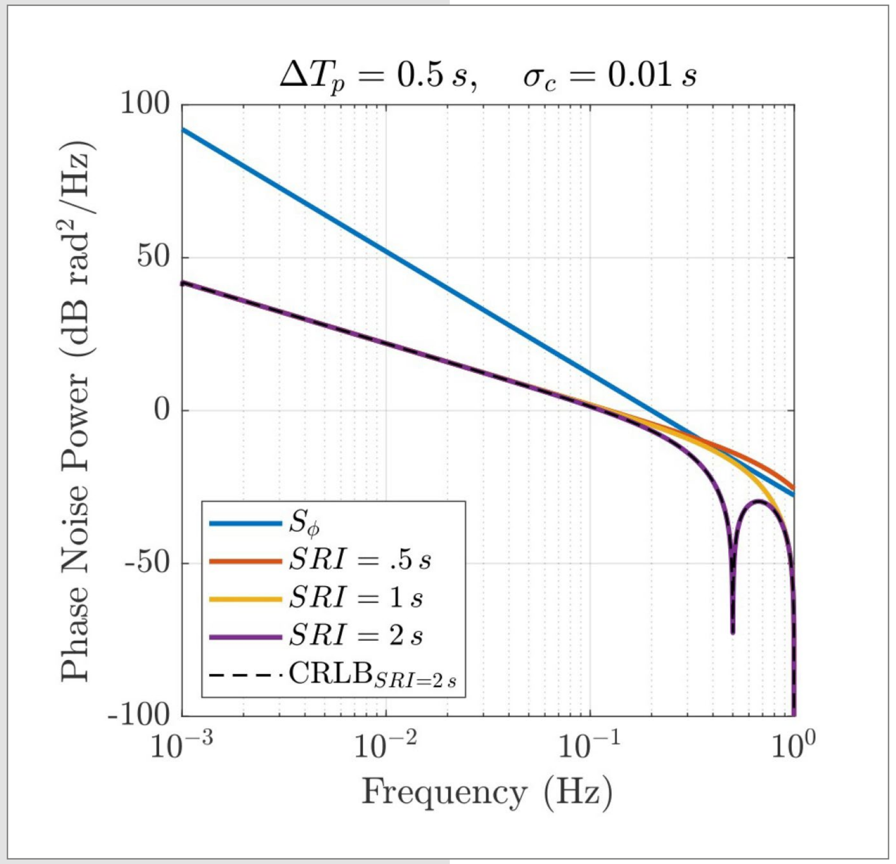
(a) The system will track both surface and underwater target



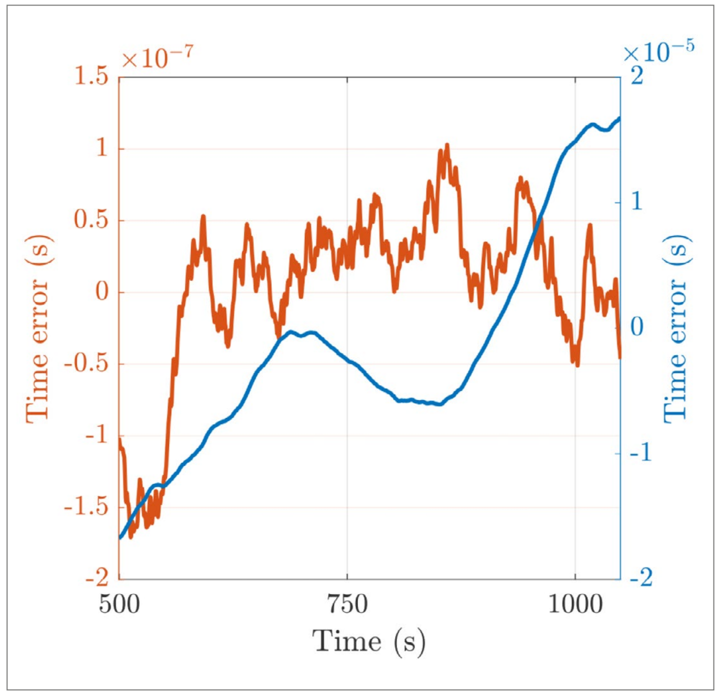
(b) Possible hardware configuration of a command and control system

Modern warfare is increasingly relying on autonomous Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs). As a result, enhancing Situational Awareness capabilities has become crucial for executing effective military operations. The MoMuRaN project aims to tackle this problem by studying and developing a Mobile Multistatic Radar Network for surveillance applications in urban environments to provide support to military operations. The key feature of this system is its adaptive nature, which is needed to deal with the highly dynamical battle scenarios. The network, being mobile, will have its radar nodes installed on Unmanned Ground Vehicles (UGVs). This mobility brings forth significant challenges in terms of the system's size and power requirements. The network's mobile nature and the unique characteristics of operational environments also affect the quality of the wireless channel, hence appropriate modulation techniques must be adopted to address these challenges. Furthermore, as the system is multistatic, it requires stringent synchronization across the network to enable coherent processing and maintain a certain standard of performance.
Our laboratory's research is focused on the task of synchronization, which in radar applications often imposes very precise timing. This is typically accomplished using optical fibres. However, for this particular and demanding application, only wireless synchronization protocols have been investigated. Initial simulations indicate that combining these protocols with highly stable oscillators could deliver the necessary performance. During this first year of the project, the research has been focused on a comparative analysis of the results achieved by using the proposed approach with different oscillator models.

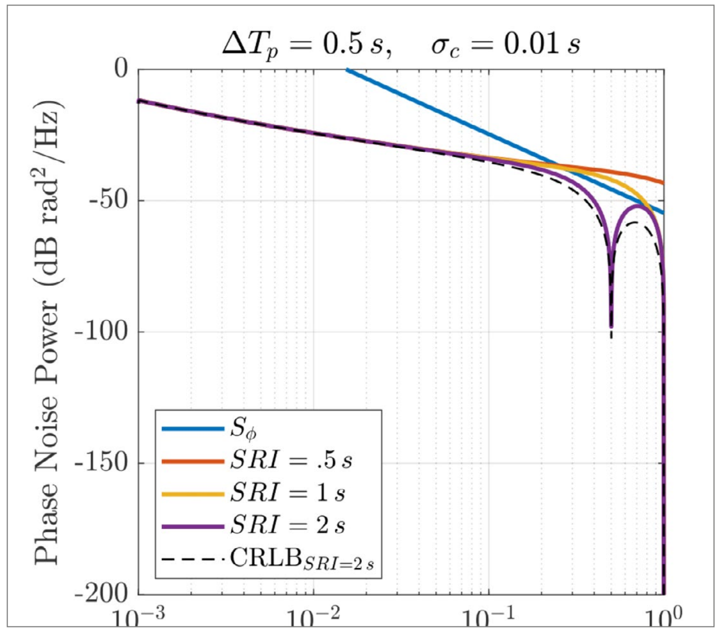
Technical Sheet
Funding institution:
Rheinmetall S.p.A.
Project partners
Rheinmetall S.p.A.
Project duration
November 2022 - November 2025
Involved countries
Italy



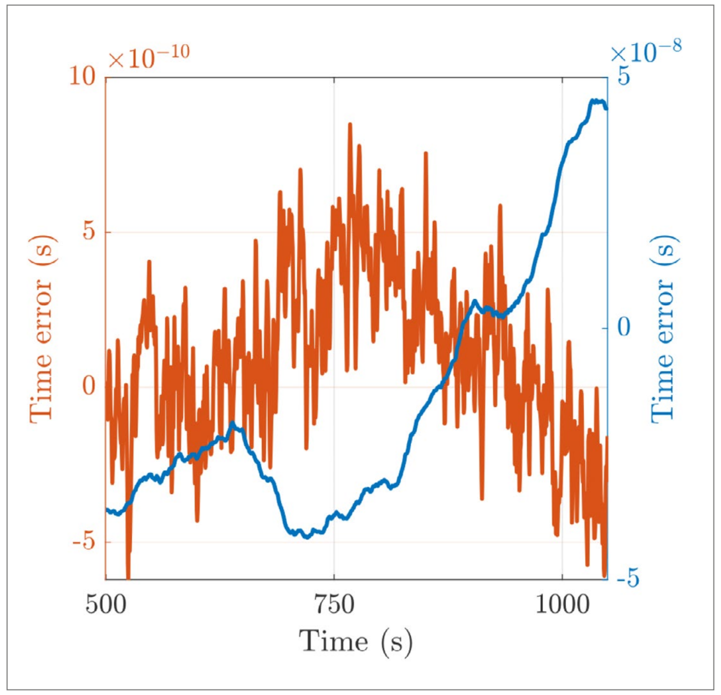
(a) Phase Noise Power Spectral Density (PSD) of the USRP E312 oscillator (blue curve) compared to the Phase Noise PSD post-synchronization by adopting the proposed approach. The Synchronization Repetition Interval (SRI) indicates the time between two consecutive synchronization epochs



(b) Timing error realizations obtained by using the USRP E312 oscillator model (blue curve) and the same model postsynchronization (orange curve)



(c) Phase Noise Power Spectral Density (PSD) of the ULN-8R oscillator (blue curve) compared to the Phase Noise PSD post-synchronization by adopting the proposed approach. The Synchronization Repetition Interval (SRI) indicates the time between two consecutive synchronization epochs



(d) Timing error realizations obtained by using the ULN-8R oscillator model (blue curve) and the same model post-synchronization (orange curve)

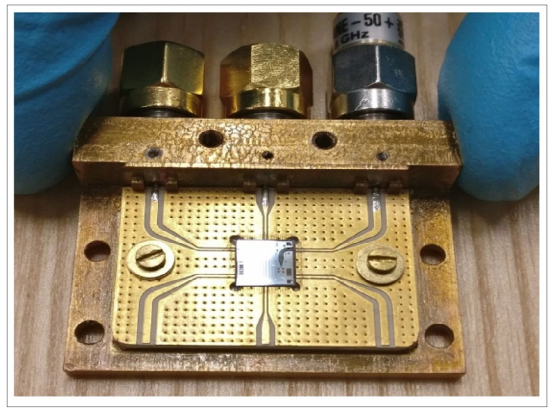
PROJECT QUANDO SC3

QUANtum technologies for Defence with application to Optronics

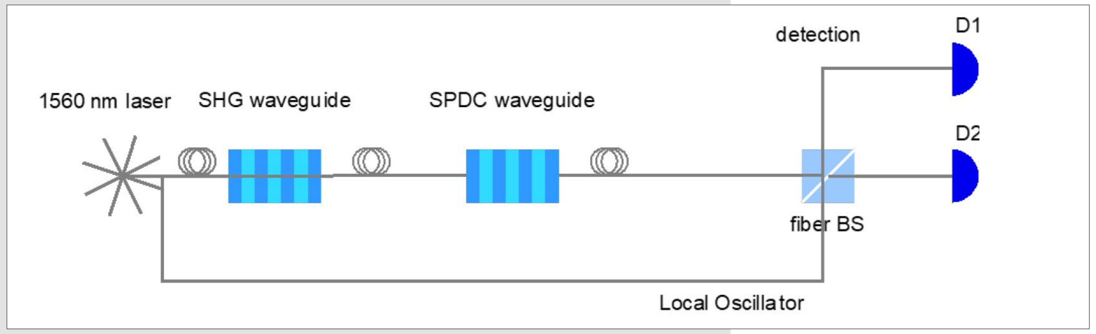
Quantum sensors harness fundamental quantum principles like superposition and entanglement to approach the inherent measurement limits set by physics. They promise significantly enhanced precision and accuracy, revolutionizing scientific, industrial, and commercial applications. These sensors excel in measuring various physical quantities—magnetic, electric, and gravitational fields, times, frequencies, temperatures, and pressures—with unparalleled accuracy.
Typically, a quantum sensor employs discrete quantum states (qubits) dependent on the parameter being measured.
A protocol initializes the system in a known quantum state, interacts it with the measured system, and measures the qubits. This iterative process significantly improves accuracy compared to traditional sensors by utilizing entanglement techniques, quantum control, or squeezing protocols that surpass the Heisenberg limit.
Quantum sensor advancements are poised to transform defense domains like C4ISR and navigation, with the potential to disrupt defense operations. The QUANDO Consortium, under EDA's directive, investigates quantum technologies for defense, focusing on quantum sensing. Collaborators across research organizations, large industrial partners, and SMEs are involved in this initiative, investigating quantum technologies' potential in optronics and radio frequency domains.
The current phase aims to synthesize an Electro Optical/Radio Frequency (EO/RF) quantum technology to solidify earlier studies and outline a potential EU defense quantum sensing roadmap. The project's objectives encompass technology identification, demonstrator design, realization, experimental testing, and result analysis, aligning with EDA's directive for an EO/RF quantum sensing proof-of-concept demonstrator.
The project evaluates EO and RF quantum sensing technologies, exploring non-classical light sources, Optical Parametric Oscillators for mid-IR radiation, cryogenic Josephson Parametric Amplifiers, and Nitrogen-Vacancy centers in diamond for compact antenna receivers. Quantum Radar, utilizing quantum properties to enhance signal processing and counteract stealth properties, stands as a promising technology offering superior target detection capabilities and resilience against electronic countermeasures.

[2] D. Luong, C. W. S. Chang, A. M. Vadiraj, A. Damini, C. M. Wilson and B. Balaji, "Receiver Operating Characteristics for a Prototype Quantum Two-Mode Squeezing Radar," in IEEE Transactions on Aerospace and Electronic Systems, vol. 56, no. 3, pp. 2041-2060, June 2020.

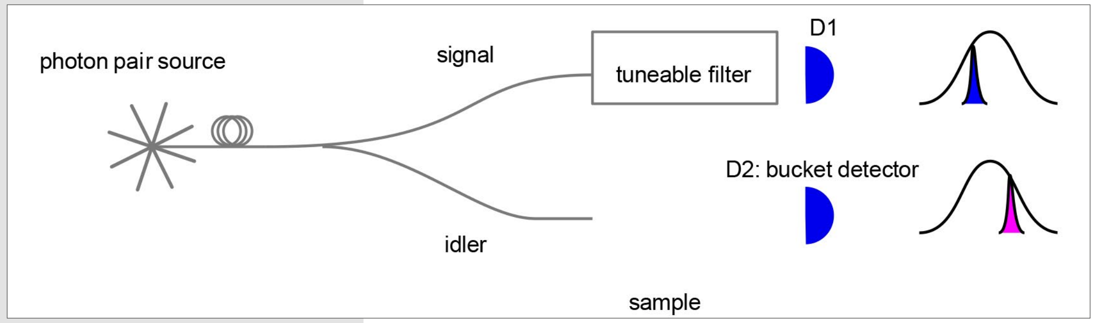
Technical Sheet
Funding institution:
EDA
Project partners
CNR, FLYBY S.R.L., LEONARDO S.PA., TECNOBIT, THALES R&T, DLR
Project duration
December 2022 - December 2023
Involved countries
Italy, France, Germany, Spain



(a) Josephson Parametric Amplifier [2]



(b) Demonstrator components



(c) Demonstrator high-level scheme

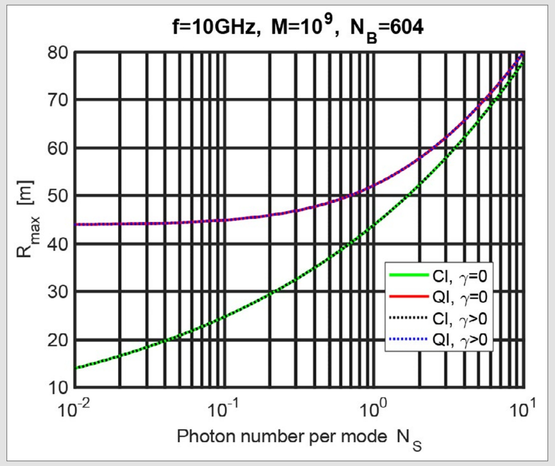
PROJECT QUANTUM RADAR

Quantum Radar

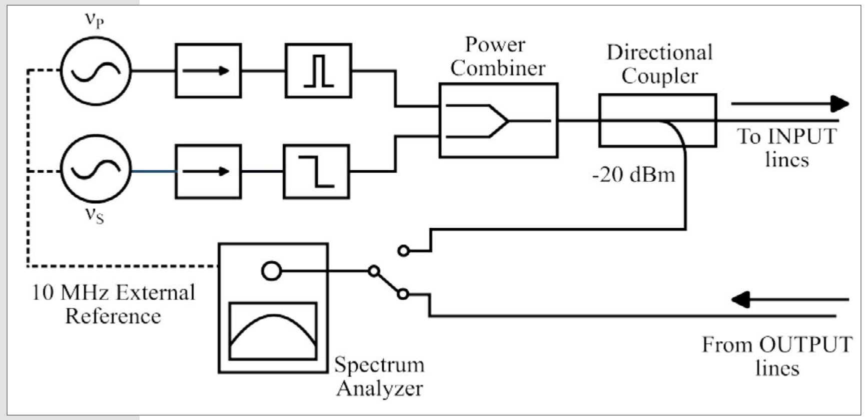
The project focuses on exploring novel quantum techniques using microwave radiation states (1-10 GHz) to develop a prototype Quantum Radar. This radar aims to enhance precision in interferometric measurements by employing entangled microwave beams, reducing destructive effects from environmental noise when detecting non-cooperative targets.
The specification outlines a three-phase plan: Phase 1 involves design and testing, Phase 2 includes quantum design at contingent on Phase 1 success, and Phase 3 focuses on quantum detection upon Phase 2 achievements.
While the contract is for Phase 1, subsequent phases rely on funding confirmation, operational interest, and meeting prior phase objectives.
The overarching research objectives aim to experimentally verify a 6 dB Signal-to-Noise Ratio (SNR) increase using quantum illumination compared to classical Radar protocols. This involves generating twin signals in a Two-Mode Squeezed Vacuum (TMSV) state, where one signal is retained while the other, affected by environmental interactions, rapidly loses its entanglement.
The project seeks to harness quantum properties like superposition, entanglement, and photon indistinguishability to create robust experimental models for improved detection in both microwave and optical domains. By optimizing detection methods, post-processing, and developing a superconducting parametric amplifier, the goal is to create a Quantum Radar prototype with superior SNR, power, and target distance capabilities compared to current scientific benchmarks.

[3] D. LuongarXiv:2108.10151 [quant-ph]
[4] S. Barzanjeh et al. Microwave quantum illumination using a digital receiver. Sci. Adv.6,eabb0451(2020)

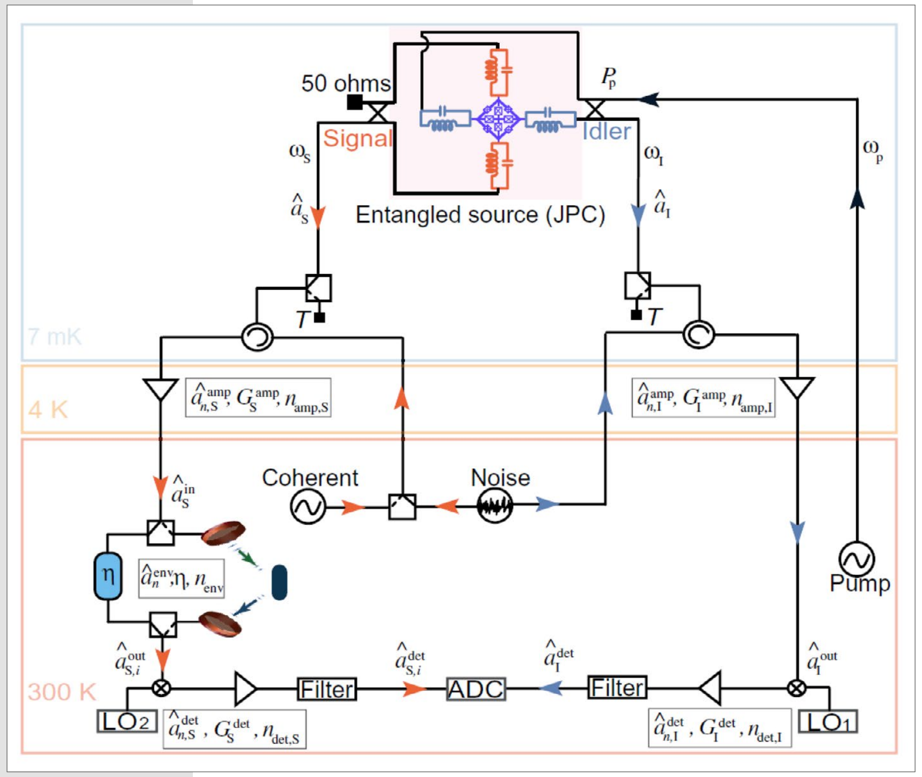
Technical Sheet
Funding institution:
Italian MoD
Project partners
UniCAM, INRIM
Project duration
July 2021 - July 2025
Involved countries
Italy



(a) Quantum gain in ranging with power w.r.t. Coherent Illumination



(b) Schematic representation of the roomtemperature microwave circuit used for characterizing the JTWPA prototype [3]



(c) Description of the apparatus for implementing a PCR (Phase Conjugated Receiver [4])

RING is dedicated to innovating Non-Cooperative Target Recognition (NCTR) through 3D radar imaging. This entails creating a 3D radar image system using a dual orthogonal baseline interferometric radar, along with associated target recognition architecture and algorithms.
The practical requirements of the RING project cover both tactical and strategic operations requiring the ability to identify targets for both civil and national security scenarios.
Cutting-edge radar systems currently employ a fundamental target recognition system rooted in the Identification Friend or Foe (IFF) approach. However, this approach relies on the cooperation of the target. Some contemporary systems opt for non-cooperative target recognition, utilizing 2D radar images, particularly Inverse Synthetic Aperture Radar (ISAR).
Unfortunately, 2D ISAR images encounter several issues, which 3D radar imaging technology can address. The acquisition of 3D information about a target enhances precise identification and prioritization for operational and tactical purposes.
The technology proposed in RING holds potential in homeland security scenarios, elevating maritime and border surveillance by improving the recognition and classification of detected targets. Across all mentioned applications, there exists a crucial need to identify threats posed by non-cooperative targets, a challenge that can be significantly addressed by leveraging recognition techniques based on innovative 3D radar imaging technology;
Project partners designed and built three separate demonstrators for testing in the third year of the project:

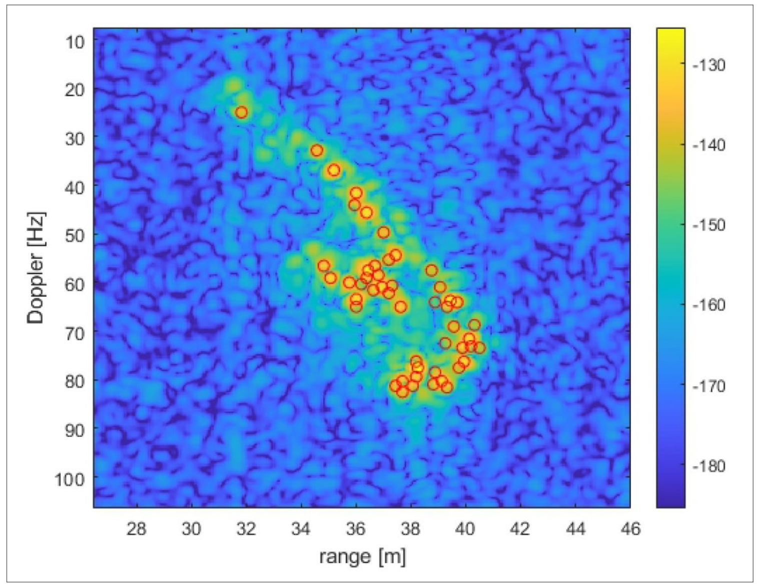
- A ground based interferometric radar system
- An on-board interferometric radar system
- A drone-based interferometric radar system employing four drones flying in formation

During the third year, three measurement campaigns were carried out to demonstrate the operational concepts of these demonstrators and collect three sets of real data for testing the algorithms. Figure 1 shows a snapshot of drone-based tests with two cooperative targets, while Figure 2 illustrates both 2D and 3D target reconstructions of the pilot boat, serving as an example of the 3D InISAR results.

Technical Sheet
Funding institution:
MoD (IT)
Project partners
GEM, ECHOES, WUT, PIT-RADWAR
Project duration
January 2020 - October 2023
Involved countries
Italy, Poland

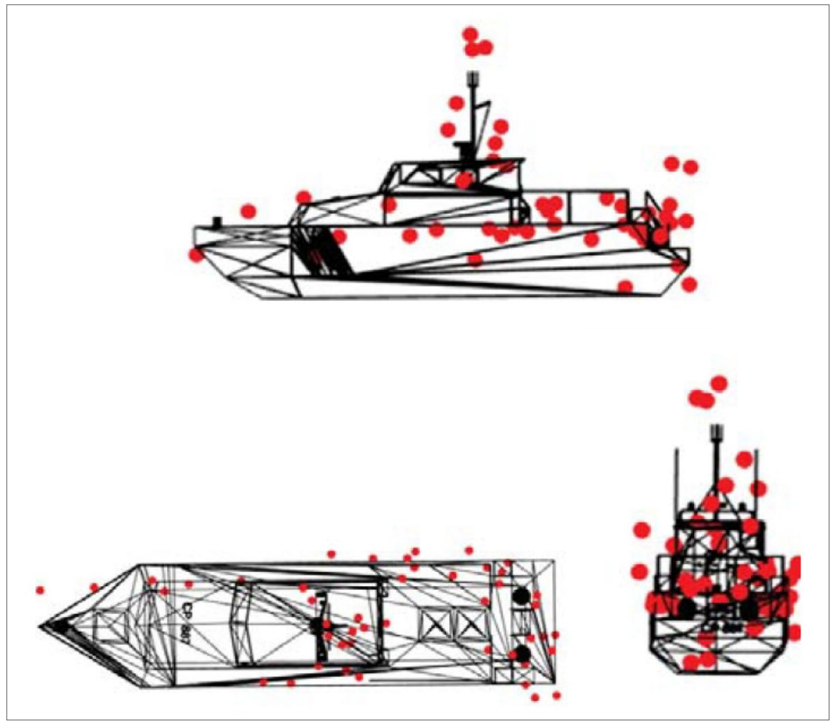

(a) A picture of the measurements

(c) A picture of the cooperative target used in the measurements



(d) 2D ISAR image of the pilot boat. The red dots are the main scatterers extracted by means of the CLEAN algorithm


(b) A picture of the cooperative target used in the measurements

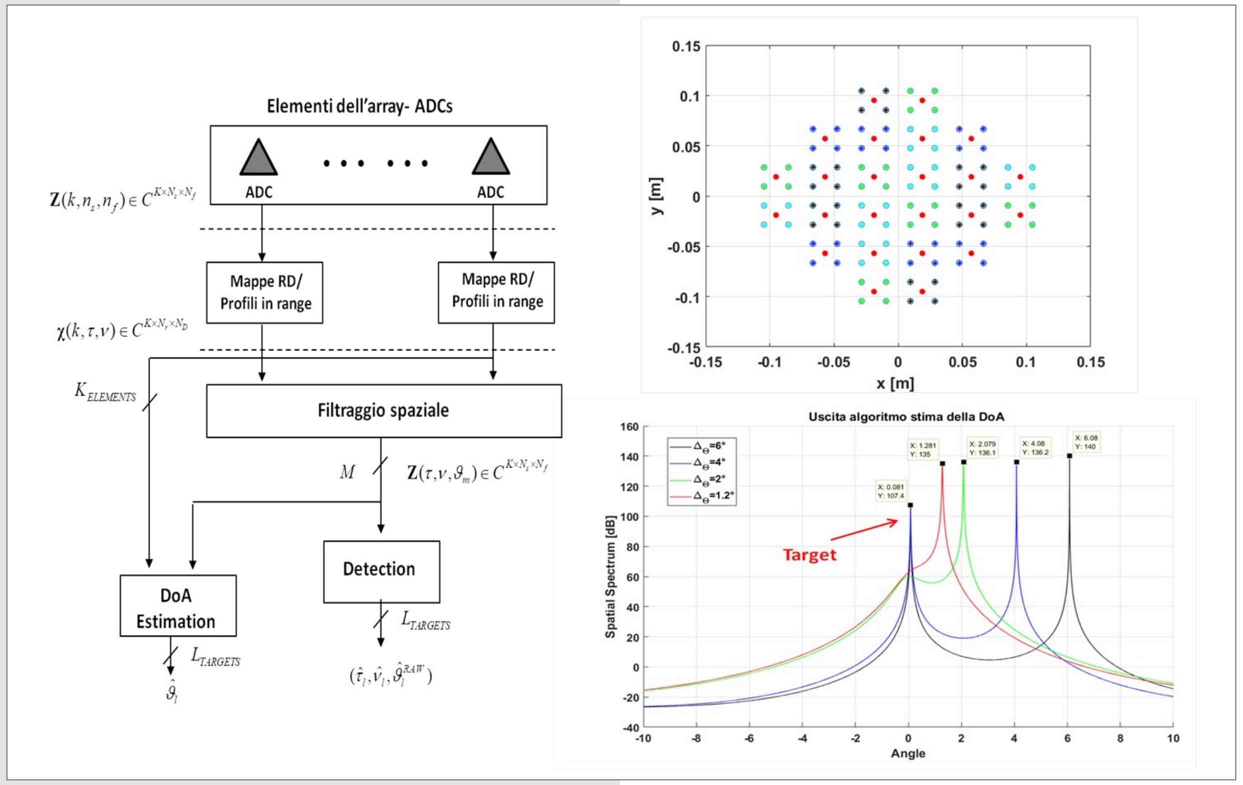

(e) 3D InISAR reconstruction of the pilot boat compared to the target geometrical CAD model

PROJECT SAMBA-X

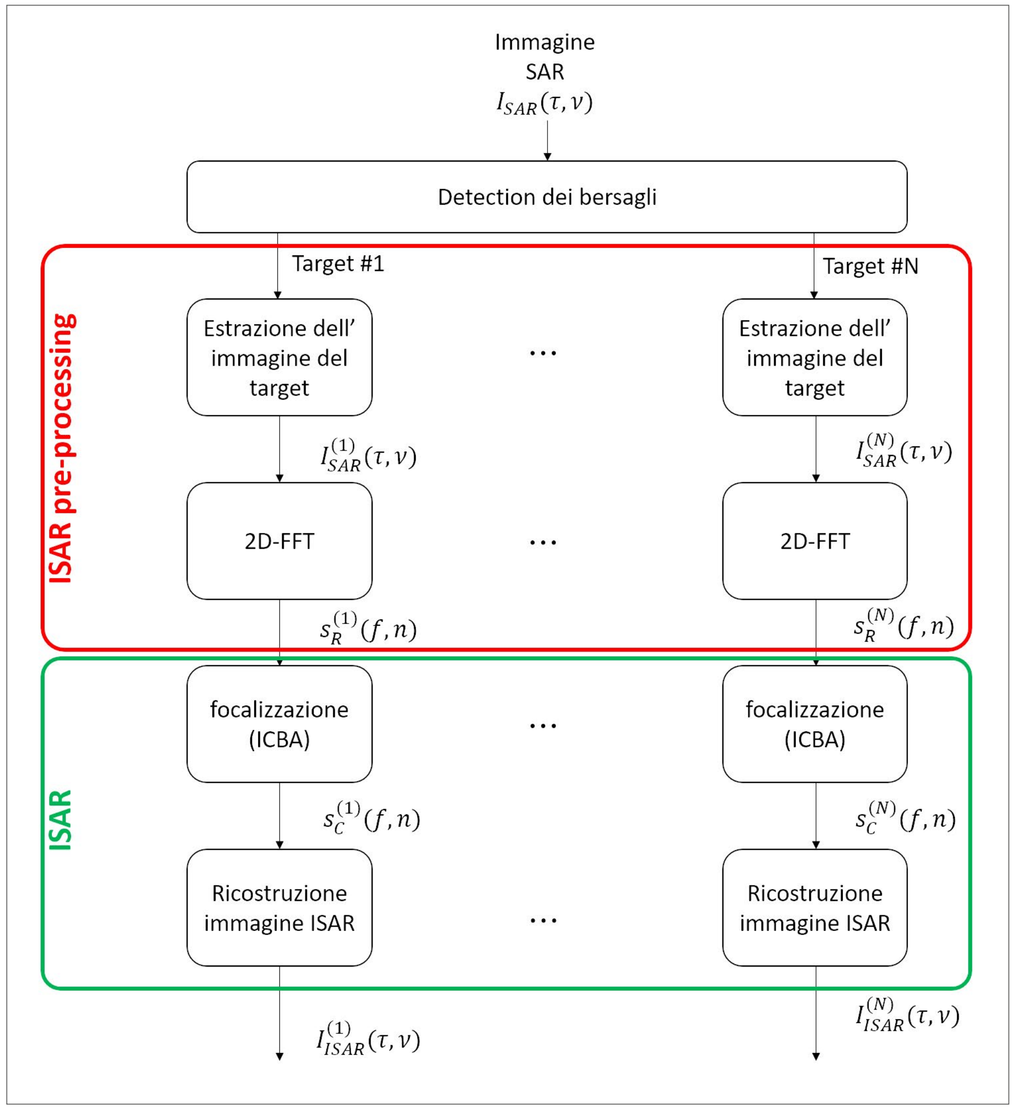
Seeker AESA multiruolo a basso costo in banda X per applicazioni navali

Traditional seekers use a mechanical scanning antenna, which limits the overall system performance. With the improvement of the latest microwave device technologies, Active Electronic Scanned Array (AESA) has become implementable in seekers. This allows for substantial performance improvements, which result in a significant increase of seeker's operational capabilities. In particular, SAMBA-X aims to improve seeker's performances with regard to increased target discrimination, resistance to ECM (ECCM) and greater longevity thanks to the improved Mean Time Between Failure (MTBF) obtainable with this technology.
In summary, this project focuses on the study and development, for the first time in Italy, of a low-cost seeker demonstrator equipped with an ITAR-free AESA X-band antenna.
The seeker under consideration has multirole capabilities, that is, it could also be used as a fire direction system on smaller ships. As part of this project, a demonstrator based on AESA technology will be built and validated in laboratory. Such demonstrator will implement a digital version of the classic "monopulse".
The demonstrator will also be able to record "raw" data and make it available for offline verification of newly developed algorithms. Once validated, these algorithms will be available for future implementations (upgrades) either on the same demonstrator or on a possible, higher TRL, prototype.

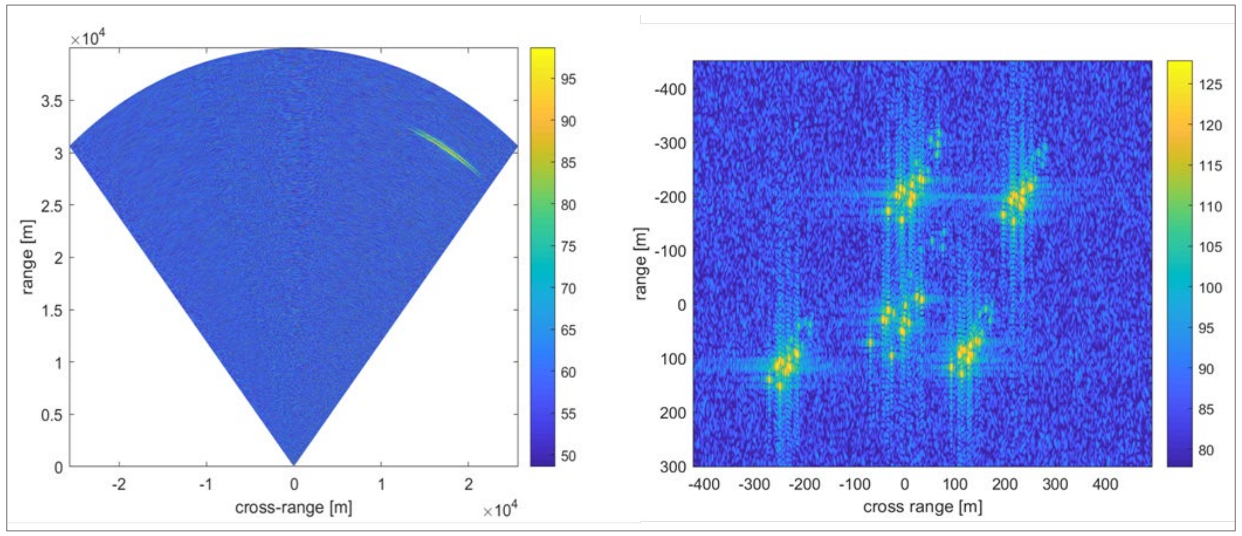
Technical Sheet
Funding institution:
Italian MoD
Project partners
ELDES s.r.l
Project duration
February 2020 - February 2022
Involved countries
Italy



(a) Preliminary DBF architecture and results obtained by applying DBF on AESA antenna divided into sub-arrays



(b) The block diagram of the ISAR algorithm applied to the SAR, also called "ISAR from SAR"



(c) Preliminary results on the radar imaging technique application

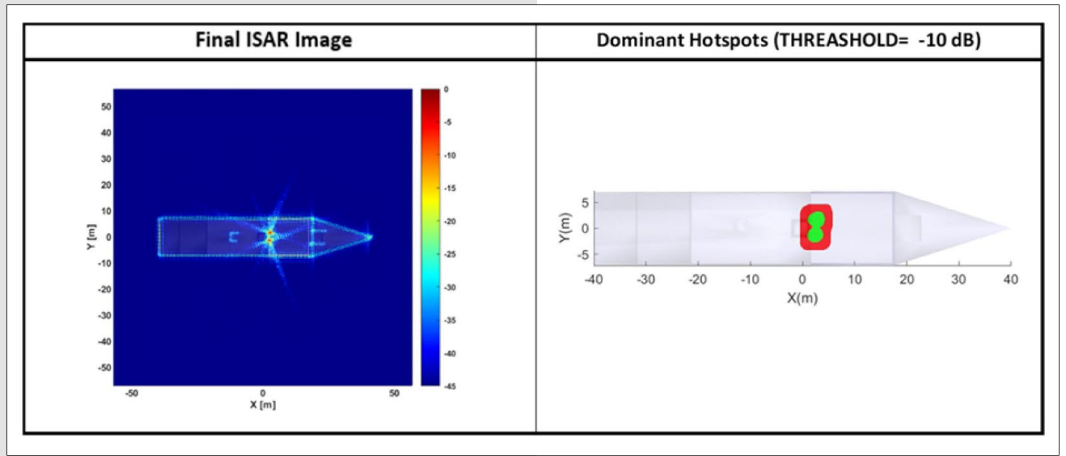
PROJECT SEPROM

Smart Electronic PROtection Me

The project purpose is to analyze the possibility of developing a new generation of intelligent electronic warfare means for platform self-protection and to study the development and testing of components necessary for EW platform protection.
In particular, the goal of the consortium members is to develop and analyze the possibilities of deploying future solutions of intelligent electronic protection measures on the modern (future-oriented) electronic warfare. The work includes analyses, design and experiments. The demonstrators are expected to be developed and used in field trials to demonstrate technology/technological capabilities, readiness and advancement.
CNIT contribution:

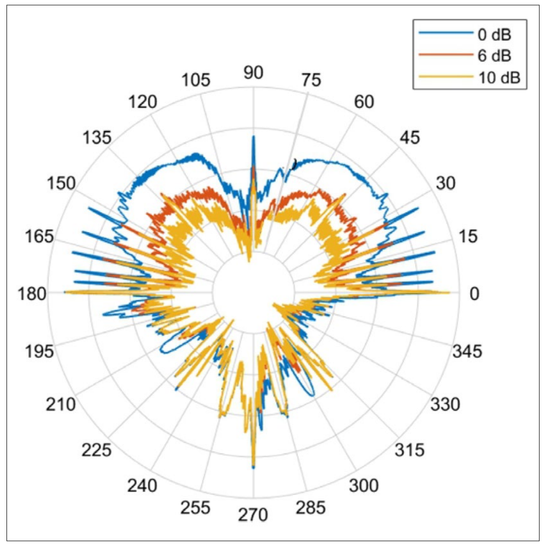
- The survivability of a complex platform in an operational environment increases with the reduction of its radar cross section. A platform with a smart 'skin' or coating, able to instantaneously modify the RCS, would be a very clever solution especially in conjunction with other EW protection systems for example chaffs or active chaffs, deployed at the same time.
- The main hotspots contributing to the RCS value can be treated separately, in order to obtain the variation of the RCS. An important issue to be deeply analysed is the arrival direction of the menace. Indeed, in such directions a subset of hotspots can be identified that contribute to RCS value, therefore mainly treating the necessary parts, with a clear advantage in terms of complexity reduction and higher technical feasibility.
- The use of active and passive metasurfaces has been proposed to improve the defense of a naval unit.
- The use of active and passive metasurfaces have been proposed to improve the defense of a naval unit.
- Various solutions have been studied and designed for the construction of passive and active metasurfaces.
- The dynamic RCS measurement system was defined in the basic logic blocks and the related technical specifications have been defined.

Technical Sheet
Funding institution:
EDA
Project partners
Warsaw University of Technology, Fraunhofer Institute for High Frequency Physics and Radar Technique, Leading Innovation and Knowledge for Society (LINKS Foundation), EM Techn. Company FreeSpace Srl
Project duration
April 2021 - October 2024
Involved countries
Italy, Germany, Poland

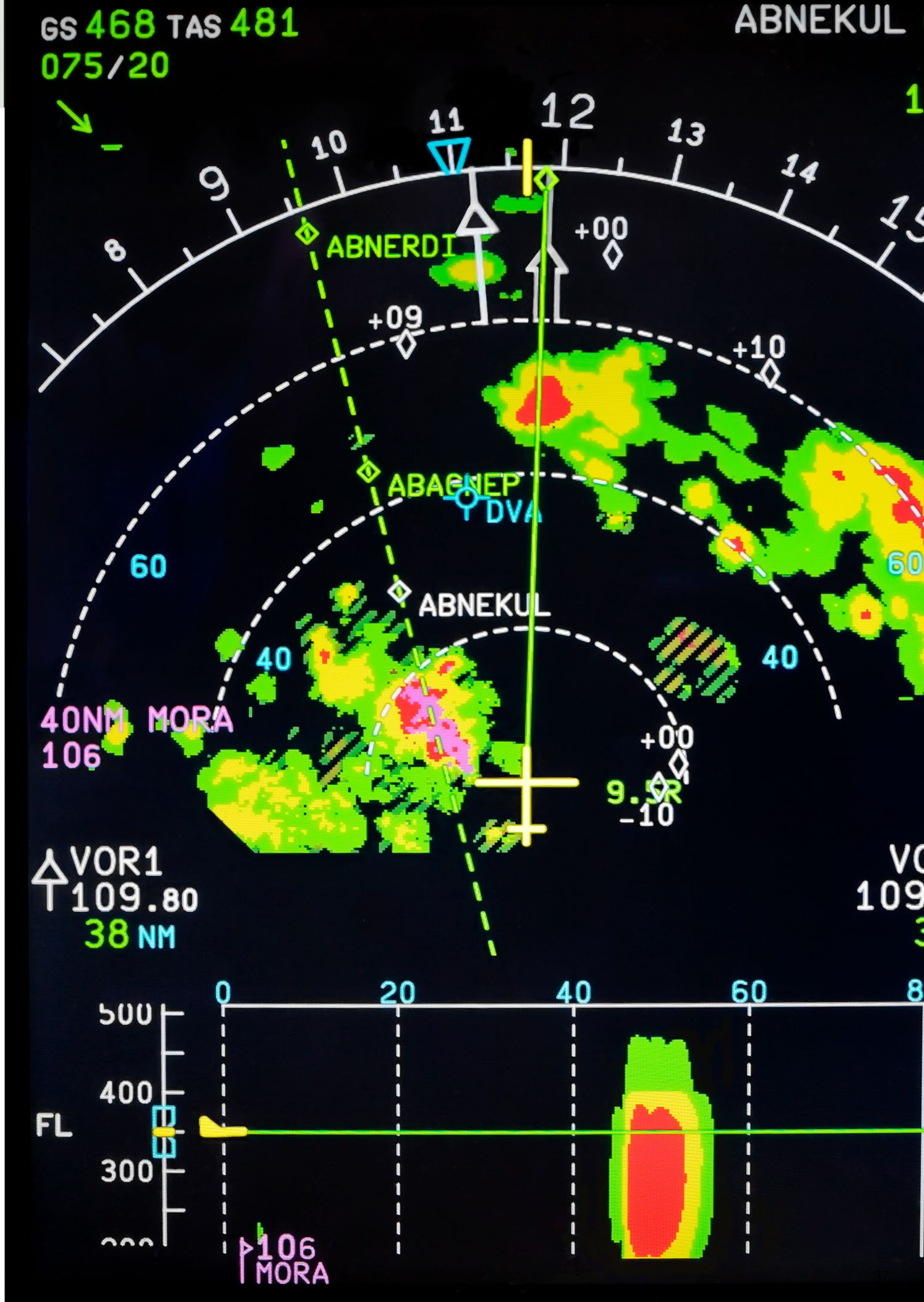


(a) Dominant hotspot localization of a naval model

(b) Measurement of the reflection coefficient of a passive metasurface panel



(c) Simulated RCS reduction of a naval unit in the azimuthal plane due to the use of a metasurface applied on the main hotspots of the target. The legend reads 0 dB for no attenuation and 6 or 10 dB of attenuation when the metasurface is applied



PROJECT SMARTAESA

Scalable & Multifunction SW defined RADAR and fuTure AESA

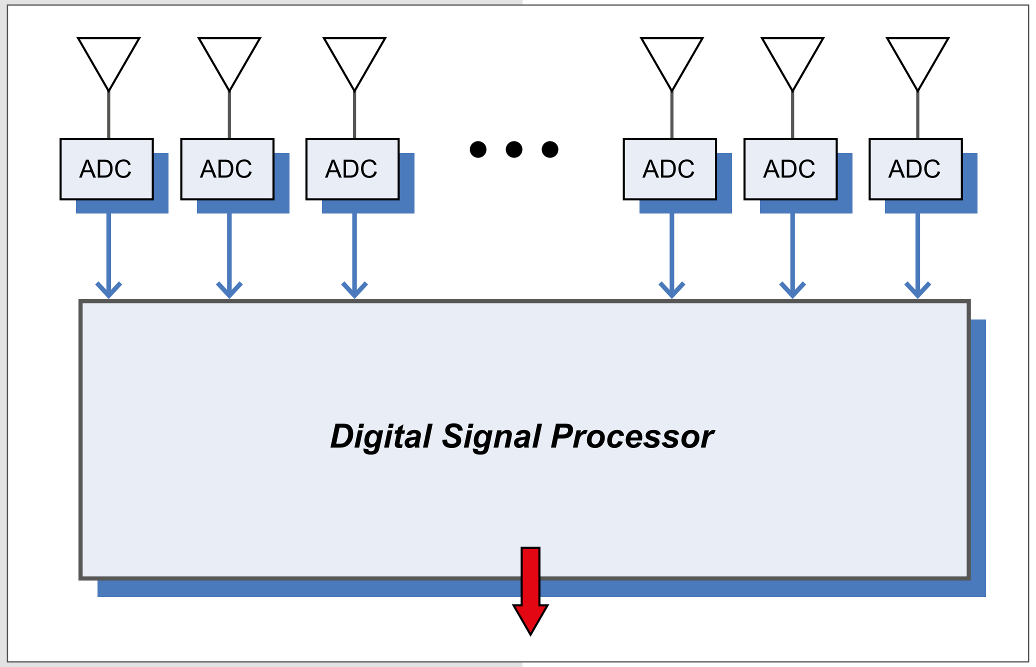
The objectives of this project are:

1. Study and design of a full digital beamforming radar architecture for open and SW defined multifunction radars. As a case in point, for design purposes only, a radar type MAESA-L, perating in the L-band (1 GHz - 2 GHz) and equipped with about a thousand transceiver channels, will be considered.
2. The realization of an L-band demonstrator, scaled and of suitable geometry, which uses the full digital beamforming techniques and with the aim of carrying out surveillance activities of appropriate scenarios of interest.

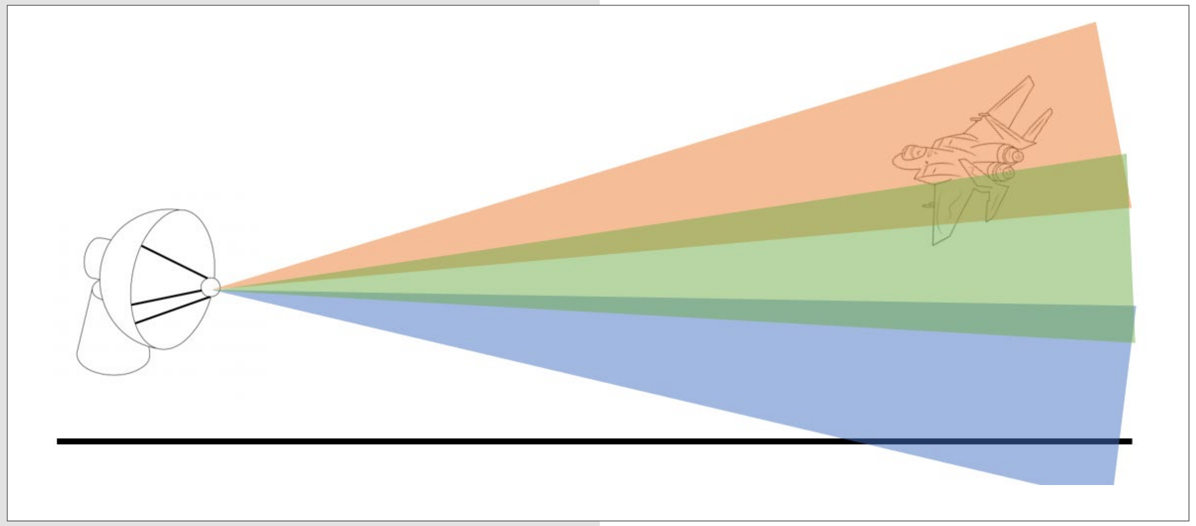
The proposed architecture will have characteristics of scalability, flexibility and adaptability that will allow future multifunction radar systems that will be based on it to:

- Avoid becoming rapidly obsolete with respect to the evolution of the threats they must counter.
- Be easily improved / upgradeable by means of firmware / software upgrades (e.g. implementation of accessory functions and / or the implementation of advanced signal processing based on Artificial Intelligence algorithms).

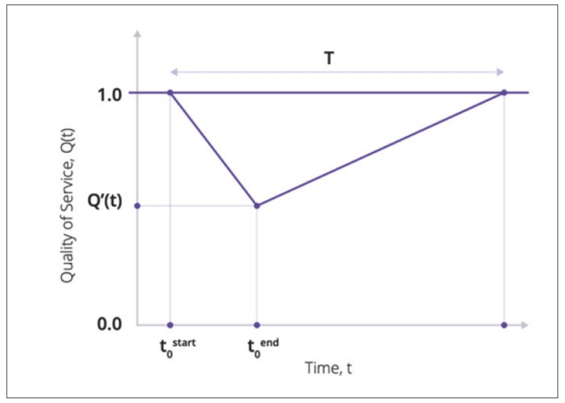
Technical Sheet
Funding institution:
Italian MoD
Project partners
Leonardo spa, Echoes srl
Project duration
April 2020 - April 2023
Involved countries
Italy



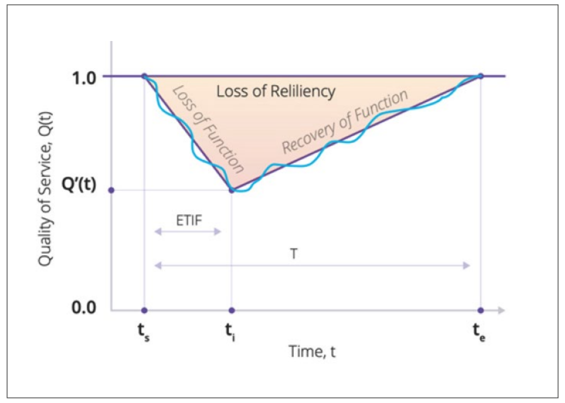
(a) Digital Array Radar Architecture



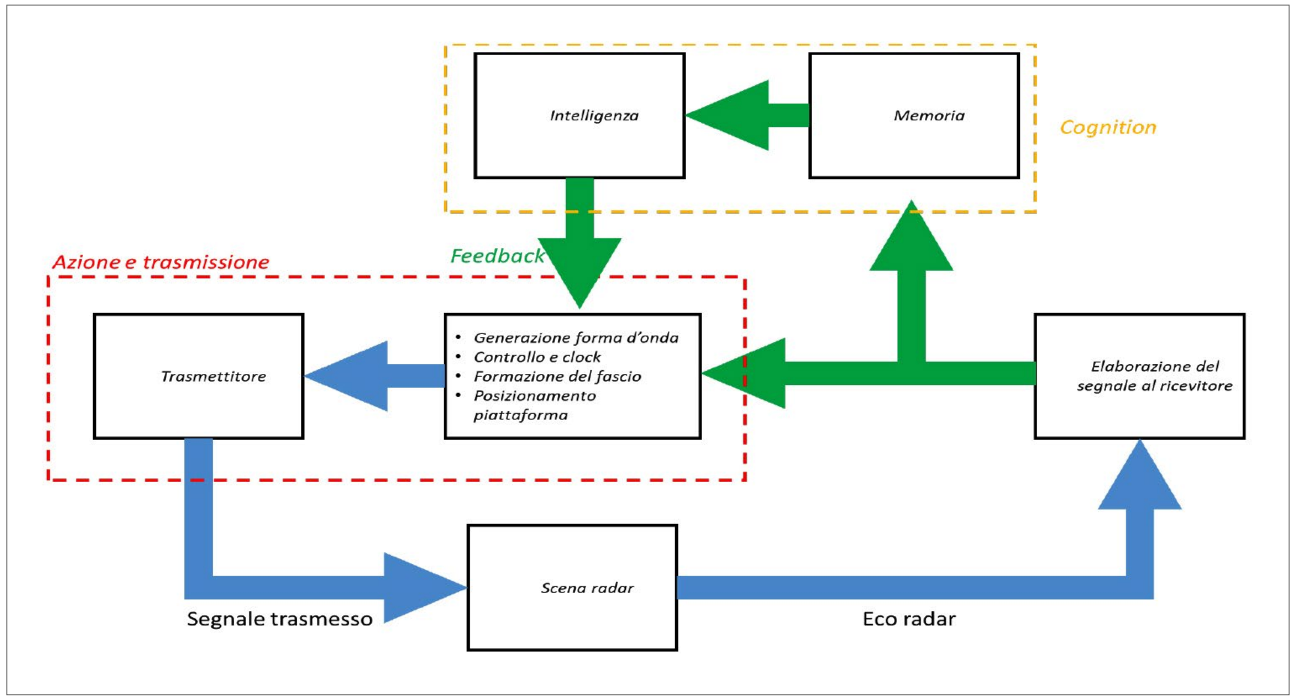
(b) Simulated multiple fan-beam geometries



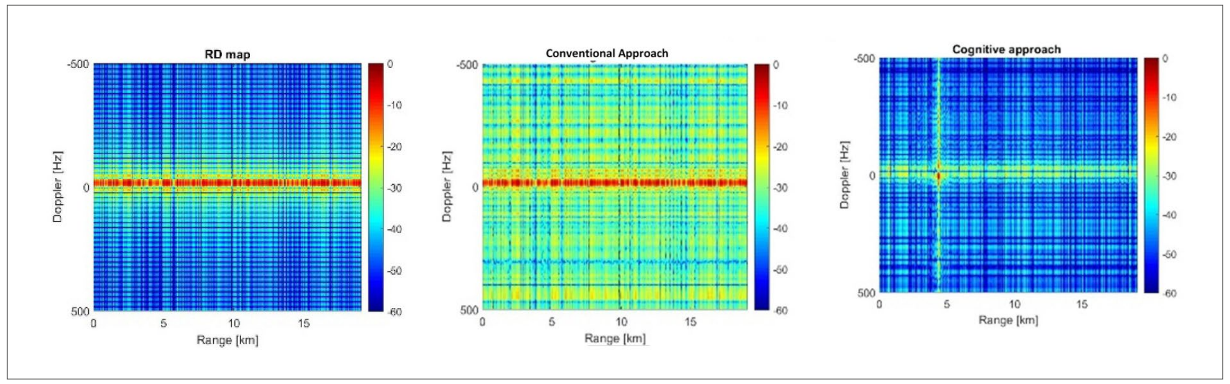
(c) Zobel model of cyber resilience



(d) Reference model of cyber resilience



(e) High level block diagram of cognitive processing for clutter cancellation



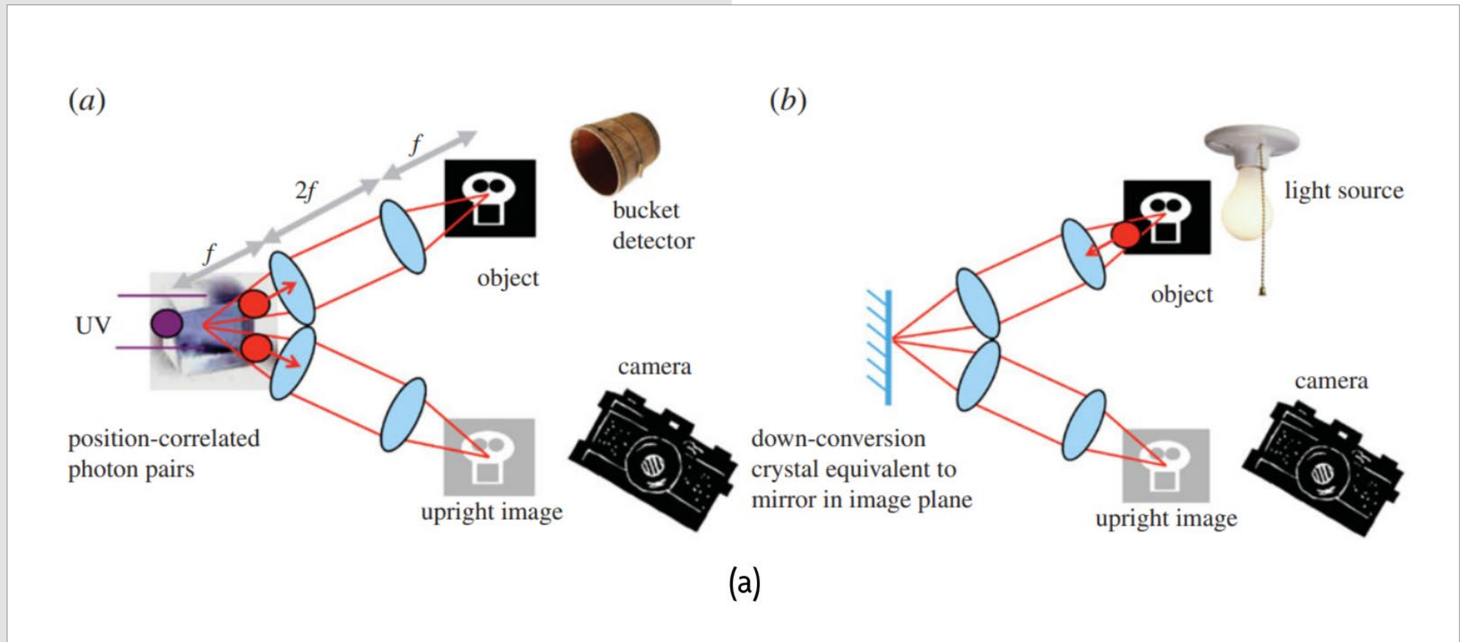
(f) Results of cognitive clutter cancellation vs conventional techniques

The research related to this collaboration is aimed at the study of Quantum technology Radar (both in the optical and RF domains), with particular attention to applications of imaging, to evaluate the feasibility, possible fields of application and advantages with respect to the technology of classic radar. The research consists of a first part, aimed at gathering information on the state of the art of technology and application scenarios; and a second part, aimed at construction of a mathematical model of quantum imaging radar and a model for its classical counterpart, in order to compare its performances. Their final result, will be the development of a source code, containing the implementation of this model in order to conduct tests and simulations on well-defined scenarios.
The following results are expected from the research (including both the optical and the RF):

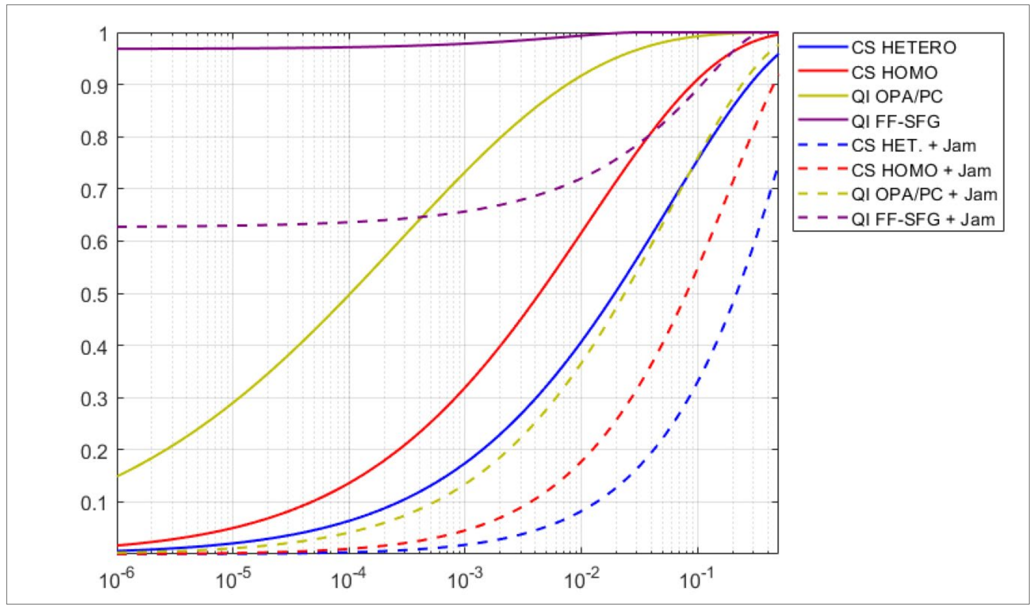
- Analysis of the state of the art of single pixel QI protocols and imaging QI protocols
- Analysis of the state of the art of the calculation methods of the performances related to the protocols
- Analysis of the state of the art of the technologies currently used in Quantum Illumination to generate and measure quantum signals
- Choosing a quantum imaging radar model deemed promising for a given application scenario, technology and/or performance
- Development of a quantum radar imaging model for the evaluation of performances according to operational requirements and environmental parameters
- Development of a classic imaging radar model, similar to the previous one, to evaluate the performance difference and demonstrate the possible benefit of quantum technology
- Source code, developed based on the templates in 5. and 6. to be used for an analysis of comparative performance of classical and quantum radar
- Identification of operational scenarios and conditions that present advantages significant from the application of the quantum solution, starting from the comparative analysis.

[5] Padgett, Miles J, and Robert W Boyd. "An introduction to ghost imaging: quantum and classical." Philosophical transactions. Series A, Mathematical, physical, and engineering sciences vol. 375,2099 (2017)

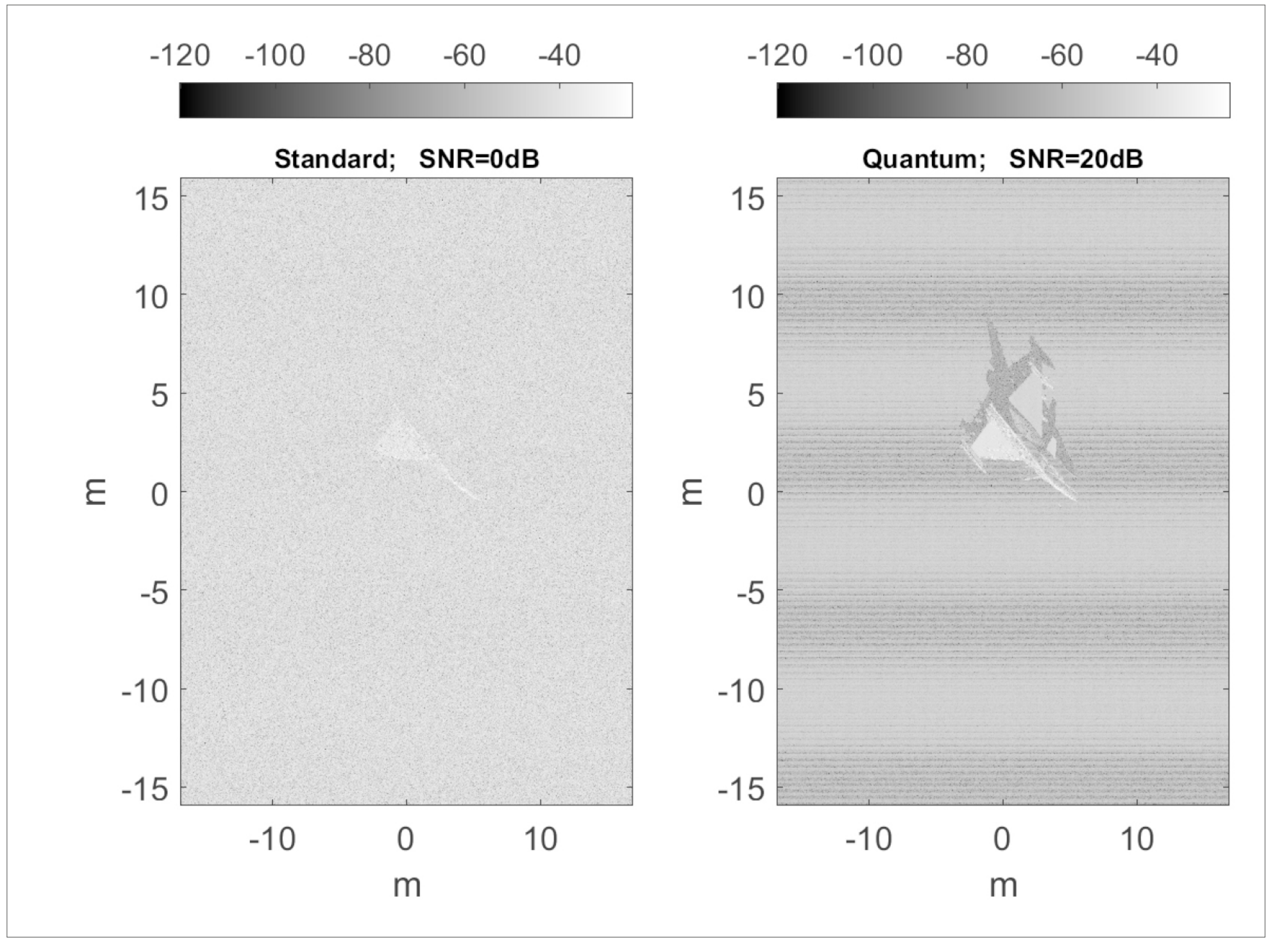
Technical Sheet
Funding institution:
LEONARDO
Project partners
LEONARDO
Project duration
July 2022 - July 2023
Involved countries
Italy



(a) The images produced by a ghost imaging system based on spontaneous parametric down-conversion (SPDC) are equivalent to those that could be produced by a classical imaging system and albeit the ghost imaging system has a different time sequence of events [5]

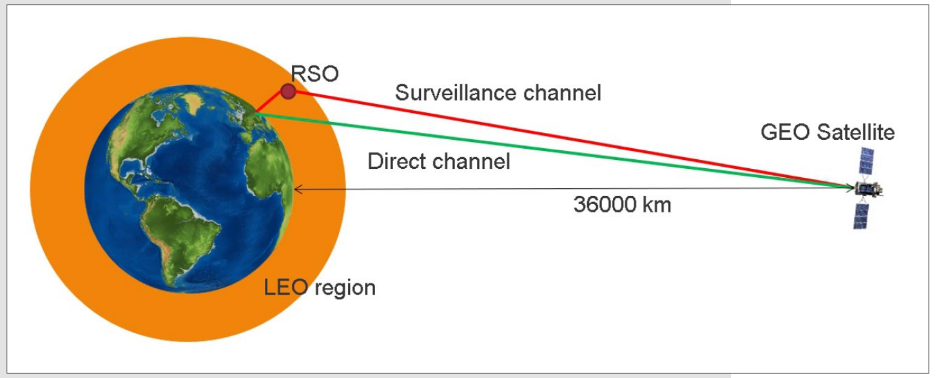


(b) ROC for different quantum receivers with jamming



(c) Microwave quantum imaging simulation (left) compared with classical, microwave imaging, demonstrating a 2dB increase in SNR

The proposed technological solution is focused on the use of a passive radar based on an array antenna that uses signals transmitted from satellite platforms (e.g.: DVB-S/DVB-S2) as illuminators of opportunity. This approach represents an opportunity of particular interest for the detection of space debris, thanks to the very wide coverage that transmitters in geostationary orbit can guarantee. The passive radar architecture allows for continuous surveillance (24 hours a day, 7 days a week), without the use of any own transmitters, thereby minimizing costs and energy consumption. In order to improve the radar detection performance, we propose the adoption of an array antenna formed by a high number of receive-only elements, therefore limiting the realization costs. Moreover, a single receiving element will be equipped with a flexible reception system capable of digitizing high-bandwidth signals. The ability to acquire broadband signals will allow the system to exploit a large part of the energy radiated by the satellite in order to improve the level of SNR. The use of an array of antennas and digital beamforming techniques can enable the achievement of a sufficient gain and the possibility to scan electronically the volume under surveillance.

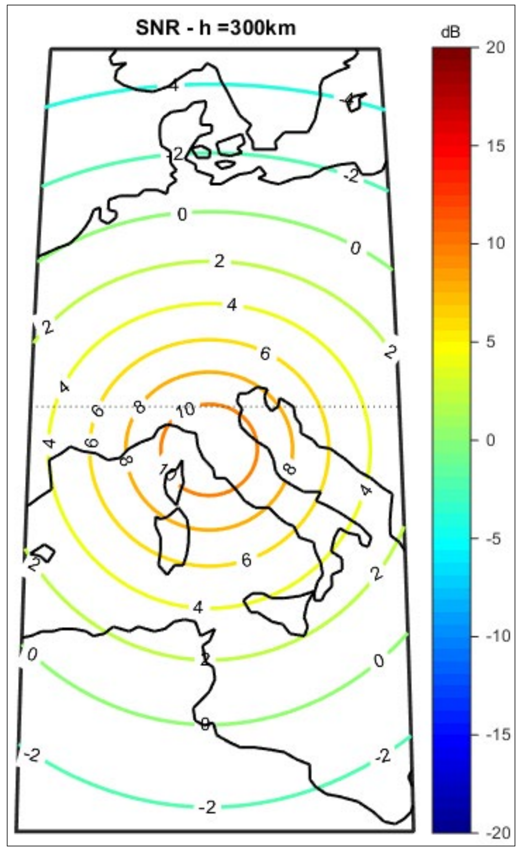


(a) Geometry of a satellite-based passive bistatic radar © [2020] IEEE. Reprinted, with permission, from [L. Gentile, A. Capria, A. L. Saverino, Z. Hajdaraj and M. Martorella, "DVB-S2 Passive Bistatic Radar for Resident Space Object detection: preliminary results," 2020 IEEE International Radar Conference (RADAR), 2020]

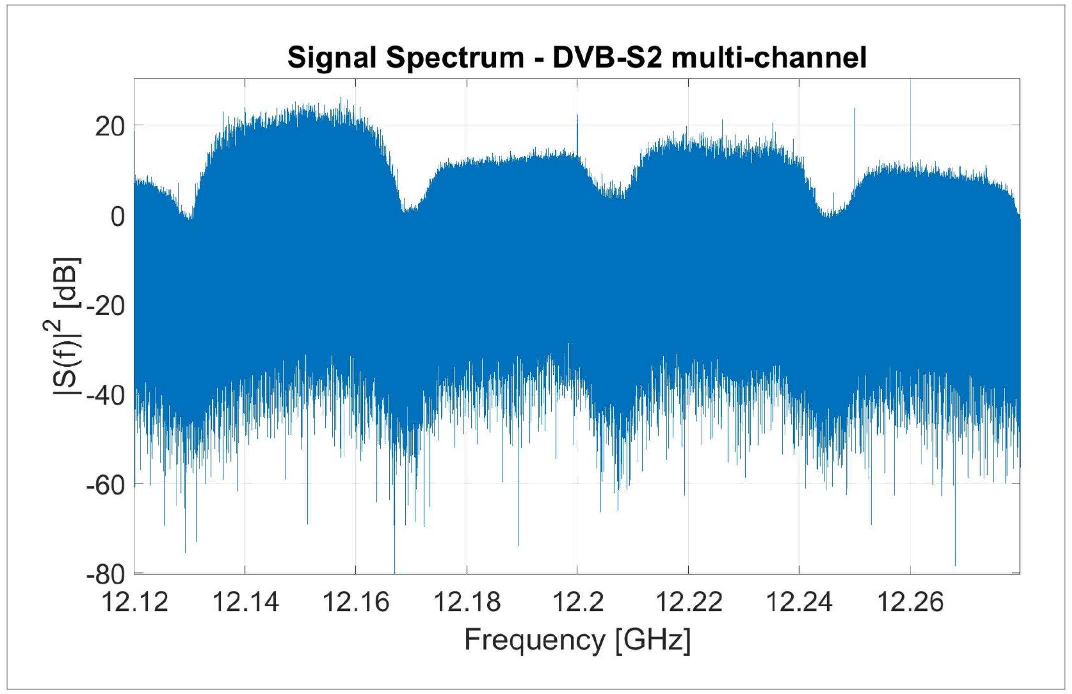
The main objectives of the Phase 1 (first year) of the project are:

- Definition of system requirements;
- Study and definition of the receiver antenna array geometry configuration;
- Study and definition of digital beamforming techniques;
- Study and definition of the signal processing system.

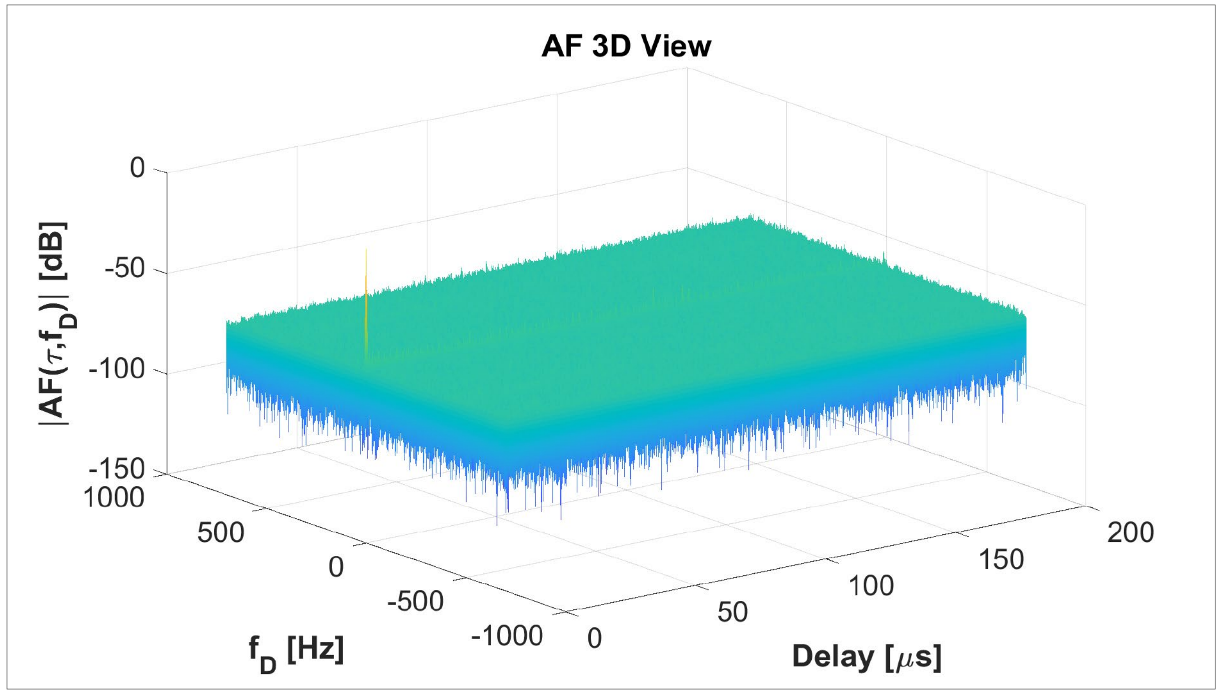
Technical Sheet
Funding institution:
Italian MoD
Project partners
ECHOES S.r.l.
Project duration
February 2020 - November 2020
Involved countries
Italy



(b) Expected SNR map obtained for a target with RCS=20 dBsm at a height=300 km



(c) Measured signal spectrum containing four transponders (Eutelsat Hotbird 13B real data)



(d) Four transponders DVBS/DVB-S2 AF as a function of time delay and Doppler frequency (Eutelsat Hotbird 13B real data)

The TAN-TOM project, funded under the Fund for Sustainable Growth of the Ministry of Enterprise and Made in Italy (MISE), focuses on non-invasive analysis techniques for leather processed in the tanning sector. It employs new multispectral optical and electromagnetic tomographic acquisition systems, utilizing artificial intelligence-based processing.
The project involves five partners, including three key companies operating in diverse industrial sectors:

- Barnini srl: Lead Company, specialized in automated systems
- SIRIO Lavorazione Conciaria srl: Expertise in tanning processes for third parties.
- TECNOCREO Engineering: Operates across various national industrial sectors.

Additionally, two Research Organizations contribute:

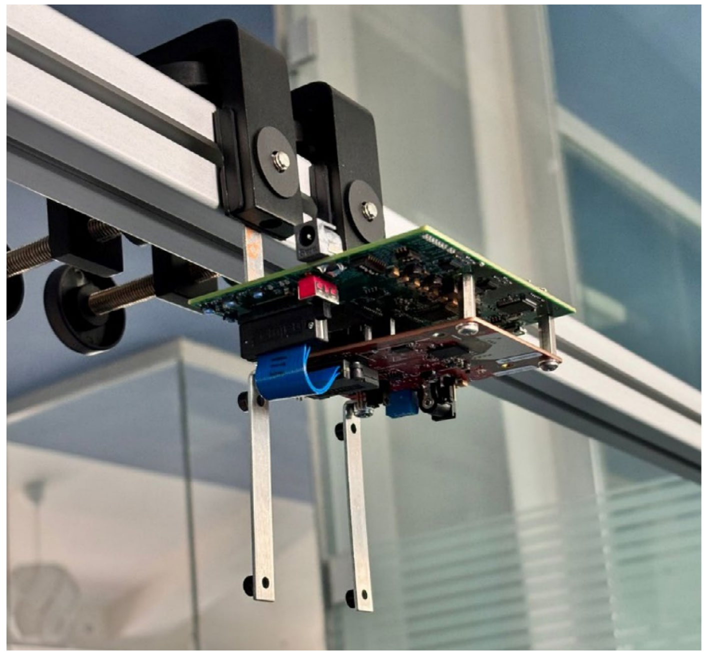
- National Inter-university Consortium for Telecommunications (CNIT): An ICT-focused non-profit research body.
- Experimental Station for the Leather and Tanning Materials Industry srl (SSIP): A National Research Body for the leather supply chain, serving as the Scientific Coordinator of the Project.

Furthermore, four high-profile companies contribute as consultants:

- COMPOLAB: An engineering firm skilled in multidisciplinary development of advanced solutions, from ideation to industrialization.
- FREE SPACE: An innovative startup dedicated to researching, designing, and producing systems and devices for electromagnetic signal generation, control, and transfer.
- BCN: A tanning company with over 80 years of experience, specializing in managingìcomplex R&D projects, combining craftsmanship, technological innovation, and eco-sustainability in its third generation.
- FLYSIGHT: An SME operating in the defense, aerospace, and infrastructure sectors, producing decision-support software solutions based on artificial intelligence and augmented reality.

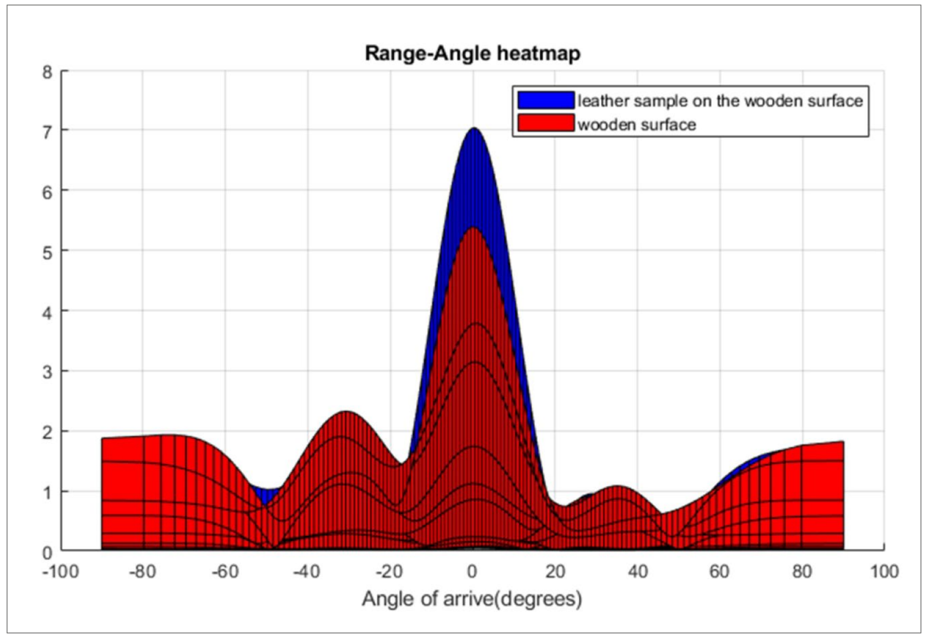
The project aims to create a "tomographic" leather inspection system (TAN-TOM) with high strategic potential for the development of the leather supply chain. This system will enable the analysis of leather quality during manufacturing processes, ensuring continuous monitoring and the development of advanced technological diagnostic systems for quality assurance.

Technical Sheet
Funding institution:
Ministero delle Imprese e del Made in Italy (MISE)
Project partners
Barnini srl, TECNOCREO srl., S.I.R.I.O srl, Stazione Sperimentale per l'Industria delle Pelli e delle materie concianti (SSIP)
Project duration
April 2023 - April 2026
Involved countries
Italy

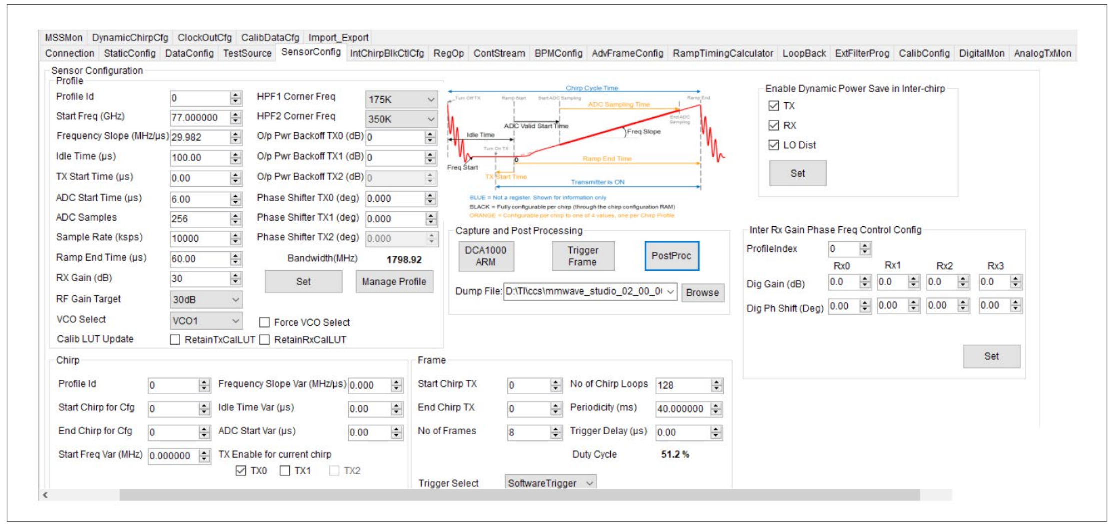


(a) Close-up view of the EHF radar (78 GHz) experimental setup: the red board is a TI AWR1642 mmWave FMCW automotive radar - the green board is a TI DCA1000 raw data capture card;

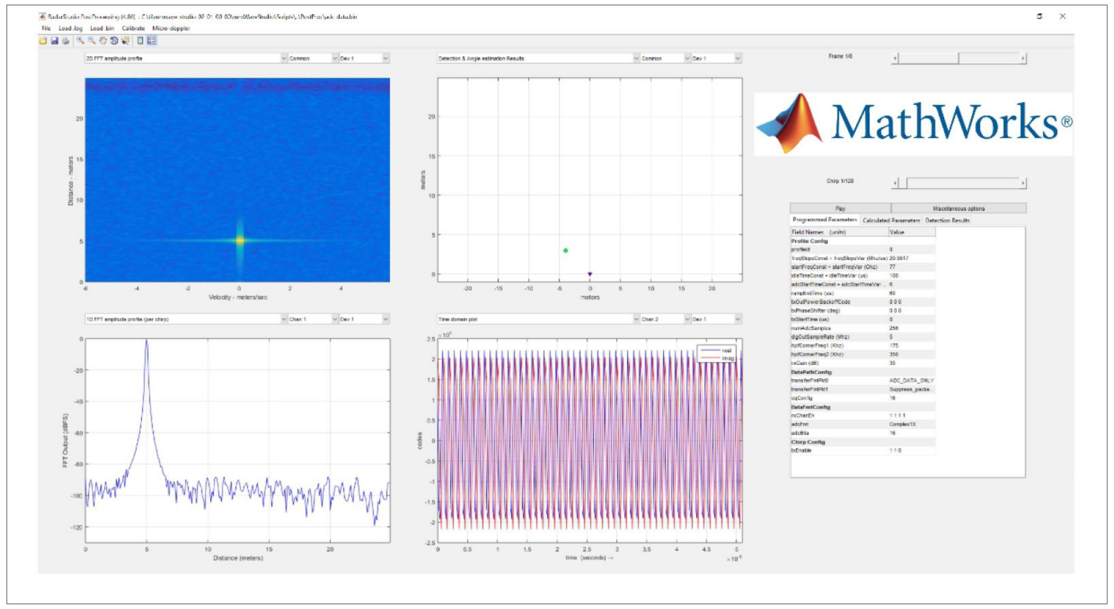
(b) Set of defected leather samples



(c) EHF radar (78 GHz) first experimental results on a leather sample: range-angle heatmap with and without the supporting surface



(d) Software support implementation: Texas Instrument mmWave Studio software (MMWAVE-STUDIO: https://www.ti.com/tool/MMWAVE-STUDIO)



(e) Software support implementation: MATLAB Runtime Eng (MATLAB Runtime Engine: https://www.mathworks.com/)

2022

[1] Brizi D and Monorchio A (2022), *"Magnetic metasurfaces properties in the near field regions"*, Scientific Reports. Vol. 12(1) [DOI] [URL]

[2] Cai J, Martorella M, Liu A, Giusti E, Huang Z and Huang L (2022), *"3D ISAR Imaging: ATR Based on the Alignment Between 3D ISAR Reconstruction and CAD Model"*, Proceedings International Radar Symposium. Vol. 2022-September, pp. 174-177. [URL]

[3] Canicatti E, Monacelli G, Sanchez-Bavuela D, Vispa A, Sani L, Monorchio A and Tiberi G (2022), *"Anatomical and Dielectric Tissue Mimicking Phantoms for Microwave Breast Imaging"*, 2022 16th European Conference on Antennas and Propagation, EuCAP 2022. [URL]

[4] Canicatti E, Sanchez-Bayuela D, Castellano C, Gonzalez R, Hernández L, Angulo P, Martín J, Monorchio A and Tiberi G (2022), *"Dielectric Characterization of Small Breast Biopsy Via Miniaturized Open-Ended Coaxial Probe"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1332-1333. [DOI] [URL]

[5] Canicatti E, Fontana N, Barmada S and Monorchio A (2022), *"Dielectric Characterization Improvement of Biopsy Samples Via a Coated Open-Ended Coaxial Probe"*, Mediterranean Microwave Symposium. Vol. 2022-May [DOI] [URL]

[6] Capria A, Saverino A and Martorella M (2022), *"Wideband DVB-S/DVB-S2 Passive Bistatic Radar for Resident Space Object detection"*, Proceedings International Radar Symposium. Vol. 2022-September, pp. 344-349. [URL]

[7] Corucci A, Canicatti E, Flamini R, Mazzucco C and Monorchio A (2022), *"An Efficient Approach for the Fast Isolation Assessment of Co-located 5G Antennas"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. pp. 1520-1521. [DOI] [URL]

[8] Dellabate A, Lazzoni V, Brizi D, Usai P and Monorchio A (2022), *"Customizing the Response of Conformal and Low-frequency Magnetic Metasurfaces"*, 2022 International Conference on Electromagnetics in Advanced Applications, ICEAA 2022. ,pp. 335. [DOI] [URL]

[9] Falchi M, Rotundo S, Brizi D and Monorchio A (2022), *"A Design Methodology for Response-controlled Passive Magnetic Metasurfaces"*, 2022 16th European Conference on Antennas and Propagation, EuCAP 2022. [URL]

[10] Falchi M, Rotundo S, Brizi D and Monorchio A (2022), *"Non-Destructive Sensing Evaluations by Using a Passive Magnetic Metasurface"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1384-1385. [DOI] [URL]

[11] Fontana N, Barmada S, Raugi M, Brizi D and Monorchio A (2022), *"Spiral Resonator Arrays for Misalignment Compensation in Wireless Power Transfer Systems"*, Applied Computational Electromagnetics Society Journal. Vol. 37(7), pp. 765-773. [DOI] [URL]

[12] Ghio S, Giusti E and Martorella M (2022), *"Low-cost database-free automatic target classification using 3D-ISAR"*, Proceedings International Radar Symposium. Vol. 2022-September, pp. 178-183. [URL]

[13] Giusti E, Gelli S and Martorella M (2022), *"A Parametric-Model-Based Approach for Atmospheric Phase Screen Removal in Ground-Based Interferometric SAR"*, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. Vol. 15, pp. 889-900. [DOI] [URL]

[14] Giusti E, Ghio S, Oveis A and Martorella M (2022), *"Proportional Similarity-Based Openmax Classifier for Open Set Recognition in SAR Images"*, Remote Sensing. Vol. 14(18) [DOI] [URL]

[15] Giusti E, Kumar A, Mancuso F, Ghio S and Martorella M (2022), *"Fully polarimetric multi-aspect 3D InISAR"*, Proceedings International Radar Symposium. Vol. 2022-September, pp. 184-189. [URL]

[16] Giusti E, Ghio S, Oveis A and Martorella M (2022), *"Open Set Recognition in Synthetic Aperture Radar Using the Openmax Classifier"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[17] Giusti E, Capria A, Saverino A, Gelli S, Munoz-Castaner J, Dosil R, Gonzalez I, Naya J and Menendez J (2022), *"A Compact Drone based Multisensory System for Maritime Observation"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[18] Jajaga E, Rushiti V, Ramadani B, Pavleski D, Cantelli-Forti A, Stojkovska B and Petrovska O (2022), *"An Image-Based Classification Module for Data Fusion Anti-drone System"*, Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). Vol. 13374 LNCS, pp. 422-433. [DOI] [URL]

[19] Kumar A, Giusti E, Mancuso F and Martorella M (2022), *"Polarimetric Interferometric ISAR Based 3-D Imaging of Non-Cooperative Target"*, International Geoscience and Remote Sensing Symposium (IGARSS). Vol. 2022-July, pp. 385-388. [DOI] [URL]

[20] Kumar A, Mishra V, Panigrahi R and Martorella M (2022), *"Hybrid-polarimetry Synthetic Aperture Radar for Oil-Spill Detection"*, 2022 URSI Regional Conference on Radio Science, USRI-RCRS 2022. [DOI] [URL]

[21] Lang P, Fu X, Feng C, Dong J, Qin R and Martorella M (2022), *"LW-CMDANet: A Novel Attention Network for SAR Automatic Target Recognition"*, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. , pp. 1-16. [DOI] [URL]

[22] Lazzoni V, Canicatti E, Brizi D, Rossi R, Moriondo M, Bindi M and Monorchio A (2022), *"Non-Destructive Olive Tree Dielectric Properties Characterization by Using an Open-ended Coaxial Probe"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1412-1413. [DOI] [URL]

[23] Lupidi A, Giusti E and Martorella M (2022), *"Polarimetric inverse synthetic aperture radar"*, Polarimetric Radar Signal Processing. , pp. 177-217. [URL]

[24] Lupidi A, Cantelli-Forti A, Jajaga E and Matta W (2022), *"An Artificial Intelligence Application for a Network of LPI-FMCW Mini-radar to Recognize Killer-drones"*, International Conference on Web Information Systems and Technologies, WEBIST - Proceedings. Vol. 2022-October, pp. 320-326. [URL]

[25] Mancuso F, Giusti E and Martorella M (2022), *"Polarimetric Three-Dimensional ISAR Imaging"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[26] Mancuso F, Giusti E, Kumar A, Ghio S and Martorella M (2022), *"Comparative assessment of polarimetric features estimation in fully polarimetric 3D-ISAR imaging system"*, IET Conference Proceedings. Vol. 2022(17), pp. 353-358. [DOI] [URL]

[27] Martorella M, Giusti E, Ghio S, Samczynski P, Drozdowicz J, Baczyk M, Wielgo M, Stasiak K, Julczyk J, Ciesielski M, Soszka M, Mularzuk R, Pizziol G, Stagliano D and Lischi S (2022), *"3D Radar Imaging for Non-Cooperative Target Recognition"*, Proceedings International Radar Symposium. Vol. 2022-September, pp. 300-305. [URL]

[28] Masi A, Rotundo S, Canicatti E, Molesti F, Brizi D and Monorchio A (2022), *"Microwave and Contactless Sensor for Millimeter Inclusions Detection in Biomedical Applications"*, 2022 16th European Conference on Antennas and Propagation, EuCAP 2022. [URL]

[29] Masi A, Rotundo S, Canicatti E, Brizi D and Monorchio A (2022), *"Experimental Study of Millimetric Inclusions Detection Through a Spiral Contactless Sensor for Biomedical Applications"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1328-1329. [DOI] [URL]

[30] Mazzinghi A, Cuccoli F, Argenti F, Feta A and Facheris L (2022), *"Tomographic Inversion Methods for Retrieving the Tropospheric Water Vapor Content Based on the NDSA Measurement Approach"*, Remote Sensing. Vol. 14(2) [DOI] [URL]

[31] Meucci G, Ghio S, Giusti E and Martorella M (2022), *"Radar target recognition based on open set YOLO"*, IET Conference Proceedings. Vol. 2022(17), pp. 377-382. [DOI] [URL]

[32] Mishra V, Brizi D, Violi V, Almansoori M, Banelli A, Vega F and Monorchio A (2022), *"Analysis of Microwave Absorbers for Electromagnetic Coupling Reduction Using Waveguide Method"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1246-1247. [DOI] [URL]

[33] Mishra V, Costa F, Brizi D and Monorchio A (2022), *"Surface Wave Attenuation in Salisbury Screen in TM0mode"*, 2022 IEEE USNC-URSI Radio Science Meeting (Joint with AP-S Symposium), USNC-URSI 2022 - Proceedings. , pp. 84-85. [DOI] [URL]

[34] Montomoli F, Macelloni G, Facheris L, Cuccoli F, Del Bianco S, Gai M, Cortesi U, Di Natale G, Toccafondi A, Puggelli F, Antonini A, Volpi L, Dei D, Grandi P, Mariottini F and Cucini A (2022), *"Integrated Water Vapor Estimation through Microwave Propagation Measurements: First Experiment on a Ground-to-Ground Radio Link"*, IEEE Transactions on Geoscience and Remote Sensing. Vol. 60 [DOI] [URL]

[35] Oveis A, Giusti E, Ghio S and Martorella M (2022), *"Extended Openmax Approach for the Classification of Radar Images with a Rejection Option"*, IEEE Transactions on Aerospace and Electronic Systems. , pp. 1-12. [DOI] [URL]

[36] Oveis A, Giusti E, Ghio S and Martorella M (2022), *"Moving and Stationary Targets Separation in SAR Signal Domain Using Parallel Convolutional Autoencoders with RPCA Loss"*, Proceedings of the IEEE Radar Conference. , pp. 1-6. [DOI] [URL]

[37] Oveis A, Giusti E, Ghio S and Martorella M (2022), *"Open set recognition in sar images using the openmax approach: Challenges and extension to boost the accuracy and robustness"*, Proceedings of the European Conference on Synthetic Aperture Radar, EUSAR. Vol. 2022-July, pp. 30-33. [URL]

[38] Park J, Raj R, Martorella M and Giusti E (2022), *"Multilook Polarimetric 3-D Interferometric ISAR Imaging"*, IEEE Transactions on Aerospace and Electronic Systems. , pp. 1-1. [DOI] [URL]

2022

[39] Park J, Raj R, Martorella M and Giusti E (2022), *"Simulation and Analysis of 3-D Polarimetric Interferometric ISAR Imaging"*, International Geoscience and Remote Sensing Symposium (IGARSS). Vol. 2022-July, pp. 2023-2026. [[DOI] [URL]

[40] Rotundo S, Brizi D and Monorchio A (2022), *"Bessel Beam Radiating System for Focused Transcranial Magnetic Stimulation"*, 2022 16th European Conference on Antennas and Propagation, EuCAP 2022. [URL]

[41] Rotundo S, Brizi D and Monorchio A (2022), *"A feasibility study of a radio-frequency theranostic device for tumor localization and treatment"*, 2022 16th European Conference on Antennas and Propagation, EuCAP 2022. [URL]

[42] Rotundo S, Brizi D and Monorchio A (2022), *"A Non-diffractive Radiating System for Safer Transcranial Magnetic Stimulation Treatments"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1330-1331. [DOI] [URL]

[43] Usai P, Brizi D and Monorchio A (2022), *"Fast Optimization Procedure for the Synthesis of Arbitrarily Conformable Magnetic Metasurfaces"*, 2022 International Conference on Electromagnetics in Advanced Applications, ICEAA 2022. , pp. 334. [DOI] [URL]

[44] Violi V, Brizi D, Mishra V and Monorchio A (2022), *"A Compact Wide-band Absorber Based on Resistive FSS and Magnetic Materials"*, 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, AP-S/URSI 2022 - Proceedings. , pp. 1086-1087. [DOI] [URL]

[45] Yu Q, Liu S, Monorchio A, Kong X, Brizi D, Wu C and Wen Y (2022), *"A Highly Selective Rasorber With Ultraminiaturized Unit Based on Interdigitated 2.5-D Parallel Resonator"*, IEEE Transactions on Electromagnetic Compatibility. , pp. 1-8. [DOI] [URL]

2023

[1] Bonicoli D, Giusti E and Martorella M (2023), *"Compressed Sensing: OMP2D Based Algorithm for Fully Polarimetric ISAR"*, Proceedings International Radar Symposium. Vol. 2023-May [DOI] [URL]

[2] Brizi D, Conte M and Monorchio A (2023), *"A Performance-Enhanced Antenna for Microwave Biomedical Applications by Using Metasurfaces"*, IEEE Transactions on Antennas and Propagation. Vol. 71(4), pp. 3314-3323. [DOI] [URL]

[3] Canicatti E, Ghavami N, Tiberi G and Monorchio A (2023), *"Accuracy Improvement of the Huygens' Principle-based Method for UWB Microwave Imaging"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[4] Canicattì E, Sánchez-Bayuela D, Romero Castellano C, Aguilar Angulo P, Giovanetti González R, Cruz Hernández L, Ruiz Martín J, Tiberi G and Monorchio A (2023), *"Dielectric Characterization of Breast Biopsied Tissues as Pre-Pathological Aid in Early Cancer Detection: A Blinded Feasibility Study"*, Diagnostics. Vol. 13(18) [DOI] [URL]

[5] Cantelli-Forti A, Colajanni M and Russo S (2023), *"Penetrating the Silence: Data Exfiltration in Maritime and Underwater Scenarios"*, Proceedings - Conference on Local Computer Networks, LCN. [DOI] [URL]

[6] Capria A, Saverino A, Giusti E and Martorella M (2023), *"SDR-based passive radar technology"*, Passive Radars on Moving Platforms. , pp. 265-289. [URL]

[7] Corucci A, Canicatti E, Flamini R, Usai P, Mazzucco C and Monorchio A (2023), *"An Efficient Ray-Tracing Approach for the Isolation Assessment of Co-Located Base Station Antennas at mmWave"*, IEEE Transactions on Electromagnetic Compatibility. , pp. 1-10. [DOI] [URL]

[8] Cuccoli F, Facheris L, Cortesi U, Del Bianco S, Gai M, MacElloni G, Barbara F, Baldi M, Montomoli F, Antonini A and Ortolani A (2023), *"Integrated Water Vapor Estimation Through Microwave Propagation Measurements: Second Experiment on A Ground-to-Ground Radio Link"*, International Geoscience and Remote Sensing Symposium (IGARSS). Vol. 2023-July, pp. 3788-3791. [DOI] [URL]

[9] Eliana C, Violi V, Brizi D, Flora F, Acerra F and Monorchio A (2023), *"On the Accuracy of Dielectric Characterization of Solid Materials by Open-Ended Coaxial Cable"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 1673-1674. [DOI] [URL]

[10] Facheris L, Antonini A, Argenti F, Barbara F, Cortesi U, Cuccoli F, Del Bianco S, Dogo F, Feta A, Gai M, Gregorio A, Macelloni G, Mazzinghi A, Melani S, Montomoli F, Ortolani A, Rovai L, Severin L and Scopa T (2023), *"Towards Space Deployment of the NDSA Concept for Tropospheric Water Vapour Measurements"*, Atmosphere. Vol. 14(3) [DOI] [URL]

[11] Falchi M, Brizi D and Monorchio A (2023), *"A Preliminary Study of a Conformal Electromagnetic Metasurface for Brain Tumor Detection"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[12] Falchi M, Rotundo S, Brizi D and Monorchio A (2023), *"Analysis and design of holographic magnetic metasurfaces in the very near field for sensing applications at quasi-static regime"*, Scientific Reports. Vol. 13(1) [DOI] [URL]

[13] Giusti E, Capria A, Saverino AL, Gelli S, Munoz J, Dosil R, Naya J and Menendez J (2023), *"A Drone-Based Multisensory Payload for Maritime Pollutants Detections"*, IEEE Aerospace and Electronic Systems Magazine. Vol. 38(3), pp. 4 – 18. [DOI] [URL]

[14] Giusti E, Ghio S and Martorella M (2023), *"Drone-based 3DInISAR: Experimental Results"*, Proceedings of the IEEE Radar Conference. Vol. 2023-May [DOI] [URL]

[15] Kang H, Li J, Guo Q, Martorella M, Giusti E and Cai J (2023), *"Robust Interferometric ISAR Imaging With UAMP-Based Joint Sparse Signal Recovery"*, IEEE Transactions on Aerospace and Electronic Systems. , pp. 1-19. [DOI] [URL]

[16] Kumar A, Mishra V, Panigrahi R and Martorella M (2023), *"Application of Hybrid-Pol SAR in Oil-Spill Detection"*, IEEE Geoscience and Remote Sensing Letters. Vol. 20 [DOI] [URL]

[17] Kumar A, Giusti E, Mancuso F, Ghio S, Lupidi A and Martorella M (2023), *"Three-Dimensional Polarimetric InISAR Imaging of Non-Cooperative Targets"*, IEEE Transactions on Computational Imaging. Vol. 9, pp. 210-223. [DOI] [URL]

[18] Kumar A, Giusti E and Martorella M (2023), *"Hybrid Polarimetry Inverse SAR"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[19] Lazzoni V, Rossi R, Brizi D, Ugolini F, Baronti S, Moriondo M, Bindi M and Monorchio A (2023), *"Implementation of a microwave sensor for the non-destructive detection of plant water stress"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[20] Lazzoni V, Brizi D and Monorchio A (2023), *"Spatial filtering magnetic metasurface for misalignment robustness enhancement in wireless power transfer*

2023

applications", Scientific Reports. Vol. 13(1) [DOI] [URL]

[21] Li H, Feng Y, Zhao M, Wang X, Brizi D, Fang X, Hu J, Sima B, Zong Z, Wu W and Monorchio A (2023), *"A Dual-Polarized and Wideband Switchable Absorption/Transmission Frequency Selective Surface With Multispectral Functionality"*, IEEE Open Journal of Antennas and Propagation. , pp. 1-1. [DOI] [URL]

[22] Masi A, Brizi D and Monorchio A (2023), *"Millimetric Inclusion Detection Through a Contactless Microwave Spiral Sensor for Biomedical Applications"*, IEEE Sensors Journal. , pp. 1-1. [DOI] [URL]

[23] Masi A, Brizi D and Monorchio A (2023), *"Wearable Radiofrequency Metasurface for Inflammatory Process Monitoring"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[24] Masi A, Brizi D and Monorchio A (2023), *"Wearable Radiofrequency Metasurface for Smart-Bandages"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 1119-1120. [DOI] [URL]

[25] Meucci G, Mancuso F, Giusti E, Kumar A, Ghio S and Martorella M (2023), *"Point Cloud Transformer (PCT) for 3D-InISAR Automatic Target Recognition"*, Proceedings of the IEEE Radar Conference. Vol. 2023-May [DOI] [URL]

[26] Meucci G, Karahoda B, Oveis A, Mancuso F, Jajaga E and Cantelli-Forti A (2023), *"Naval Cybersecurity in the Age of AI: deceptive ISAR Images Generation with GANs"*, Proceedings - Conference on Local Computer Networks, LCN. [DOI] [URL]

[27] Oveis A, Giusti E, Ghio S, Meucci G and Martorella M (2023), *"Incremental Learning in Synthetic Aperture Radar Images Using Openmax Algorithm"*, Proceedings of the IEEE Radar Conference. Vol. 2023-May [DOI] [URL]

[28] Oveis A, Giusti E, Ghio S, Meucci G and Martorella M (2023), *"LIME-Assisted Automatic Target Recognition with SAR Images: Toward Incremental Learning and Explainability"*, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. Vol. 16, pp. 9175-9192. [DOI] [URL]

[29] Oveis A, Capria A, Saverino A and Martorella M (2023), *"Convolutional Neural Network for Joint Communication and Radar Signals Classification"*, Proceedings International Radar Symposium. Vol. 2023-May [DOI] [URL]

[30] Oveis A, Giusti E, Meucci G, Ghio S and Martorella M (2023), *"Explainability In Hyperspectral Image Classification: A Study of Xai Through the Shap Algorithm"*, Workshop on Hyperspectral Image and Signal Processing, Evolution in Remote Sensing. [DOI] [URL]

[31] Oveis A, Giusti E, Ghio S, Meucci G and Martorella M (2023), *"Credible Recognition of Radar Images: Interpretability Metric and Classification Score"*, International Geoscience and Remote Sensing Symposium (IGARSS). Vol. 2023-July, pp. 1084-1087. [DOI] [URL]

[32] Pascarella F, Scarselli C, Novellis G, Nenna G and Monorchio A (2023), *"Genetic Algorithm Based Optimization for Concentric Circular Antenna Array Design"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 1365-1366. [DOI] [URL]

[33] Pui CY, Ghio S, Ng B, Giusti E and Rosenberg L (2023), *"Robust 3D ISAR Ship Classification"*, Proceedings of the IEEE Radar Conference. Vol. 2023-May [DOI] [URL]

[34] Qi X, Zhang Y, Jiang Y, Giusti E and Martorella M (2023), *"Optimized Nonlinear PRI Variation Strategy Using Knowledge-Guided Genetic Algorithm for Staggered SAR Imaging"*, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. Vol. 16, pp. 2624-2643. [DOI] [URL]

[35] Rotundo S, Lazzoni V, Brizi D and Monorchio A (2023), *"A Radio-frequency High-Q System for Biomedical Sensing Applications"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[36] Rotundo S, Falchi M, Brizi D and Monorchio A (2023), *"Non-Invasive Target Detection Enhanced Through a Low-Frequency Passive Metasurface for Biomedical Applications"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 1103-1104. [DOI] [URL]

[37] Rotundo S, Brizi D and Monorchio A (2023), *"On the Feasibility of a High-Sensitivity Imaging System for Biomedical Applications Based on Low-Frequency Magnetic Field"*, IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology. , pp. 1-8. [DOI] [URL]

[38] Rotundo S, Brizi D, Carluccio G, Lakshmanan K, Collins C, Lattanzi R and Monorchio A (2023), *"A Passive and Conformal Magnetic Metasurface for 3T MRI Birdcage Coil"*, 2023 International Conference on Electromagnetics in Advanced Applications, ICEAA 2023. , pp. 222-224. [DOI] [URL]

[39] Saillant S, Bok D, Molinie J-P, Leventis A, Samczynski P, Brouard P, Saverino A, Capria A and Paichard Y (2023), *"iFURTHER Project - A Cognitive Network of HF Radars for Europe Defence"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[40] Sánchez-Bayuela D, Canicattì E, Badia M, Sani L, Papini L, Castellano C, Angulo P, González R, Hernández L, Martín J, Ghavami N, Tiberi G and Monorchio A (2023), *"Automated Breast Tissue Classification through Machine Learning using Dielectric Data"*, 17th European Conference on Antennas and Propagation, EuCAP 2023. [DOI] [URL]

[41] Scarselli C, Pascarella F, Ciampalini C, Nenna G and Monorchio A (2023), *"Compact Slot-Patch Antenna with Dual Circular Polarization"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 907-908. [DOI] [URL]

[42] Semenyuk V, Kurmashev I, Lupidi A and Cantelli-Forti A (2023), *"Developing the GoogleNet neural network for the detection and recognition of unmanned aerial vehicles in the data Fusion System"*, Eastern-European Journal of Enterprise Technologies. Vol. 2(9-122), pp. 16-25. [DOI] [URL]

[43] Serrano A, Kobsa A, Uysal F, Cerutti-Maori D, Ghio S, Kintz A, Morrison R.L. J, Welch S, van Dorp P, Hogan G, Garrington S, Bassa C, Saunders C, Martorella M, Caro Cuenca M and Lowe I (2023), *"Long baseline bistatic radar imaging of tumbling space objects for enhancing space domain awareness"*, IET Radar, Sonar and Navigation. [DOI] [URL]

[44] Usai P, Brizi D and Monorchio A (2023), *"Low Frequency Magnetic Metasurface for Wireless Power Transfer Applications: Reducing Losses Effect and Optimizing Loading Condition"*, IEEE Access. Vol. 11, pp. 66579-66586. [DOI] [URL]

[45] Uysal F, Dorp P, Serrano A, Kobsa A, Ghio S, Kintz A, Bassa C, Garrington S, Cuenca M, Otten M, Hogan G, Welch S, Morrison R, Harrison P, Wrigley N, Martorella M and Usoff J (2023), *"Large Baseline Bistatic Radar Imaging for Space Domain Awareness"*, Proceedings of the IEEE Radar Conference. [DOI] [URL]

[46] Violi V, Brizi D, Almansoori M, Banelli A, Vega F and Monorchio A (2023), *"Design Guidelines for Fishnet Frequency Selective Surfaces"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 655-656. [DOI] [URL]

[47] Yuan H, Brizi D, Cao Q and Monorchio A (2023), *"A Switchable Transmission/ Absorption/Reflection Frequency Selective Surface"*, IEEE Antennas and Propagation Society, AP-S International Symposium (Digest). Vol. 2023-July, pp. 135-136. [DOI] [URL]

CERTIFICATIONS

From January 2017 the RaSS Lab has been certified ISO 9001/2015 by the international and independent body DNV GL. The certification refers to the "Design and development of technology systems and services in telecommunications, radar and electromagnetism and related computer aids and the design and manufacture of RF and microwave equipment and subsystems" (Figure 4).

DNV

MANAGEMENT SYSTEM CERTIFICATE

Certificate no.: 211274-2016-AQ-ITA-ACCREDIA
Initial certification date: 19 January 2017
Valid: 20 January 2023 – 19 January 2026

This is to certify that the management system of

Consorzio Nazionale Interuniversitario per le Telecomunicazioni - Laboratorio Nazionale RaSS - Radar e Sistemi di Sorveglianza

Galleria G.B. Gerace, 18 Sesto Piano - 56124 Pisa (PI) - Italy

has been found to conform to the Quality Management System standard:

ISO 9001:2015

This certificate is valid for the following scope:

Design and development of technology systems and services in telecommunications, radar and electromagnetics and related computer aids. Design and manufacturing of radiofrequency and microwaves equipments and subsystems (IAF 34, 19, 33)

Place and date: **Vimercate (MB), 09 December 2022**

ACCREDIA L'ENTE ITALIANO DI ACCREDITAMENTO

For the issuing office: **DNV - Business Assurance Via Energy Park, 14, - 20871 Vimercate (MB) - Italy**

Claudia Baroncini
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV Business Assurance Italy S.r.l., Via Energy Park, 14 - 20871 Vimercate (MB) - Italy - TEL: +39 68 99 905. www.dnv.it

Figure 4 – Lab RaSS ISO 9001/2015 DNV certificate.

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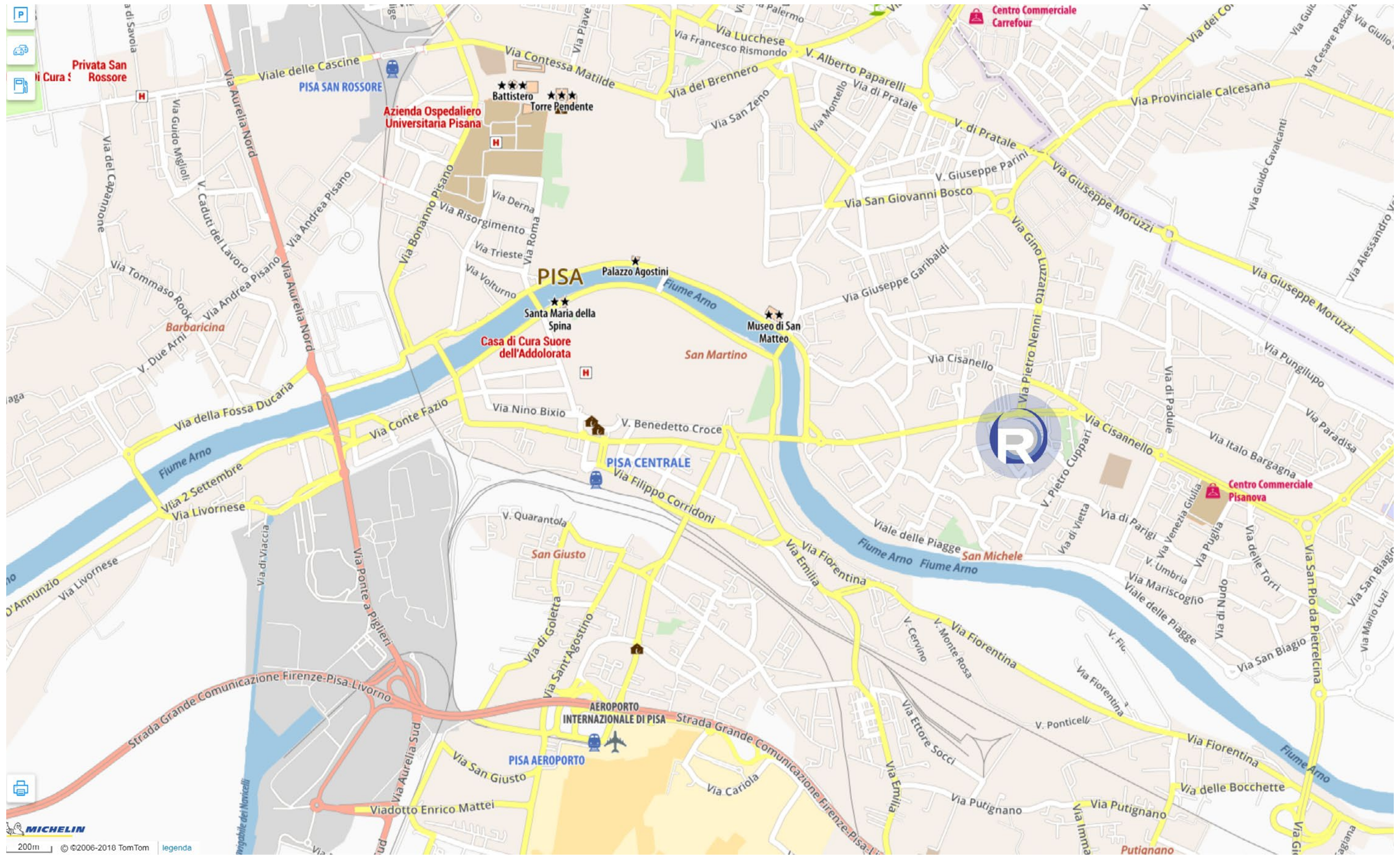


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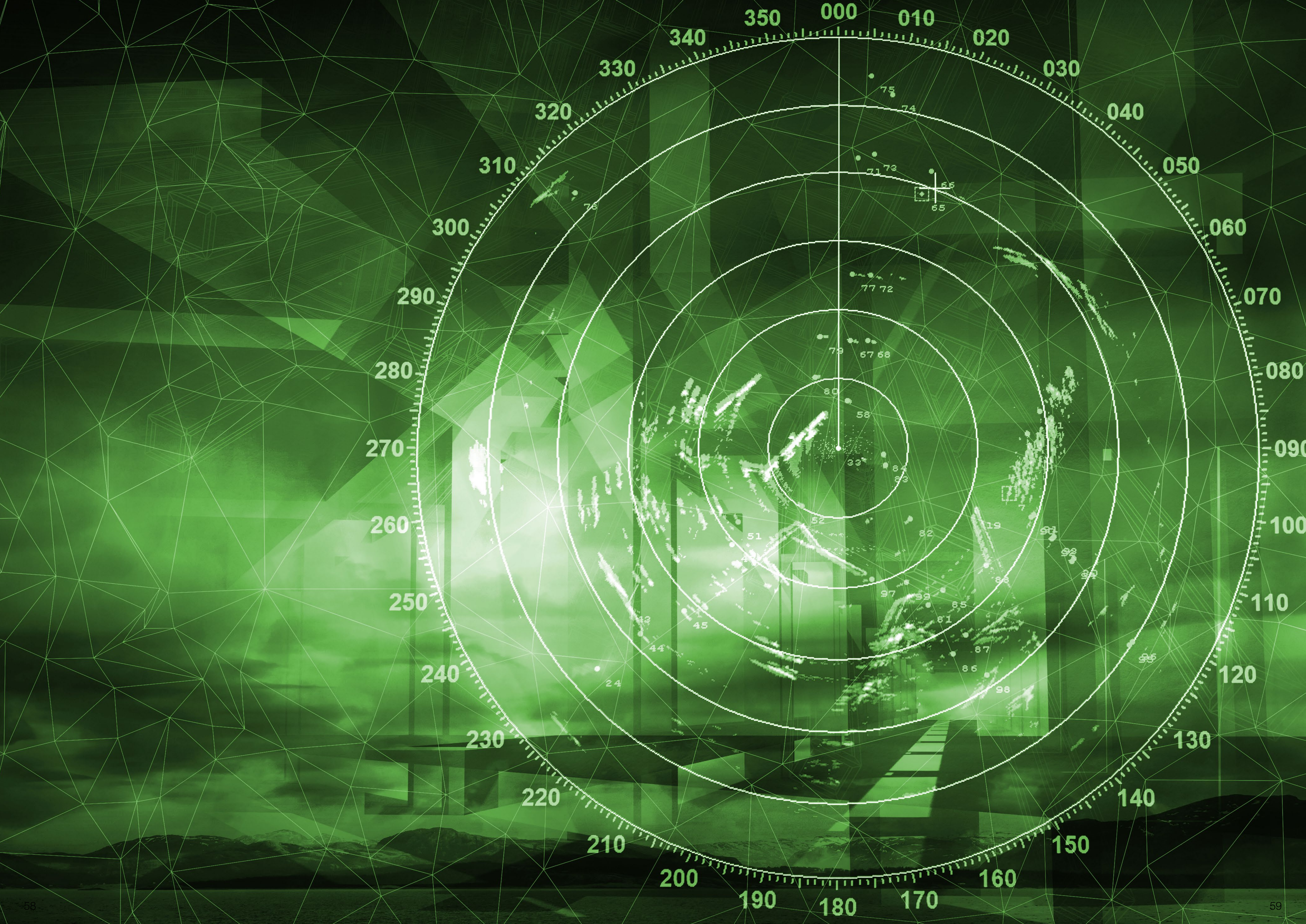
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