2022

# 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 *2022 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 and the major results obtained during this financial year.
2022 has been a very positive year that has seen:

- the formal opening day of the new RaSS laboratories, including the Quantum Radar laboratory
- a consolidation of the personnel at RaSS with one new permanent and one new temporary research positions
- 28 active projects been carried out
- 39 publications published
- 14 participating members in 21 conferences, workshops and specialist meetings
- RaSS personnel leading three NATO activities and participating in one additional NATO activities
- 9 project proposals granted that will see new projects starting at the very beginning of 2022

This report has been kept concise and simple in order to give a brief breath of what RaSS has been concentrating its effort on in the last year. For any additional information, please feel free to contact me at rass@cnit.it.

2022 has also been my last year as Director of the RaSS Laboratory. After nearly five years, I will be stepping down from my position as Director in favour of Prof. Agostino Monorchio, to whom my sincere congratulations and best wishes go for a successful mandate.
Sincerely,
Marco Martorella
Director of RaSS

consorzio nazionale
interuniversitario
per le telecomunicazioni

National Lab
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 non-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 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 when possible 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 places itself between academia and industry with the aim to fill the gap existing 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 its effort 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 FREESPACE. The former focuses on the design and development of radar systems whereas the latter deals with the design and production of advanced antenna concepts and electromagnetic compatibility. Both ECHOES and FREESPACE improve the ability of RaSS to produce effective technological transfer.

# FINANCIAL STATS

The RaSS Laboratory budget comes from several sourcing of financing.

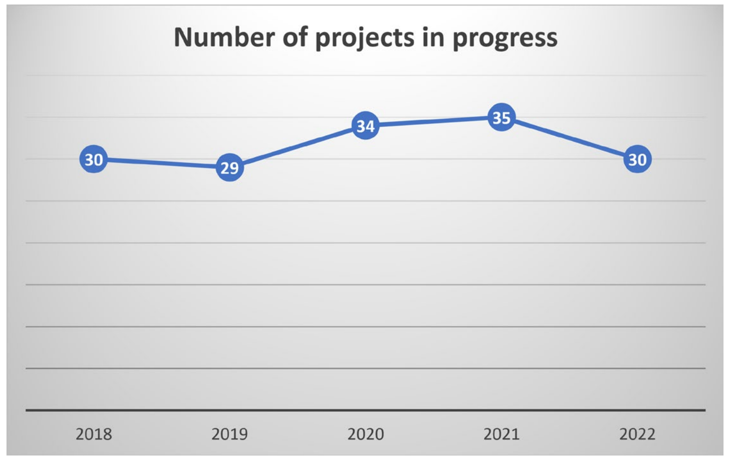



*Figure 1 - RaSS Lab number of projects in progress FY 2018 through FY 2022*

The following figure outlines the lab's financial trend from FY 2018 through FY 2022.

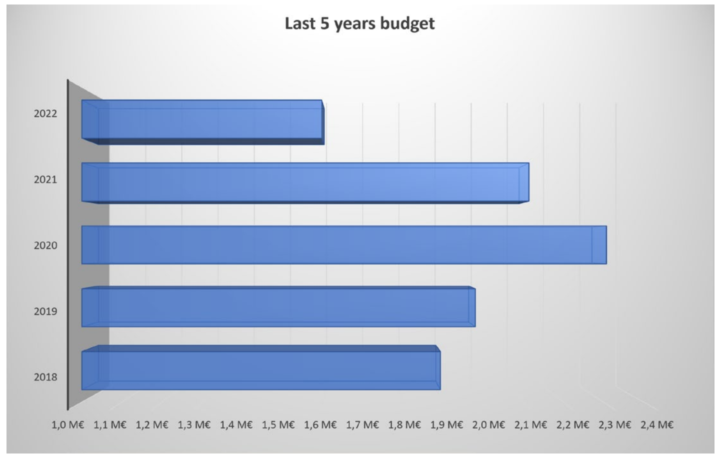



*Figure 2 - RaSS Lab financial trend from FY 2018 through FY 2022*

# ORGANISATION CHART

Figure 3 – shows the organisational chart of the RaSS Lab as on 31 December 2022.
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, antenna, electromagnetic modelling & materials.
RaSS also has an explorative research area, where promising basic research is internally funded, and instrumental laboratory.
On the administration side, RaSS is composed of a secretariat office, a quality control office, a safety and prevention office and a public relation office. RaSS governance is directed by the Steering Committee, which is chaired directly by the Director.

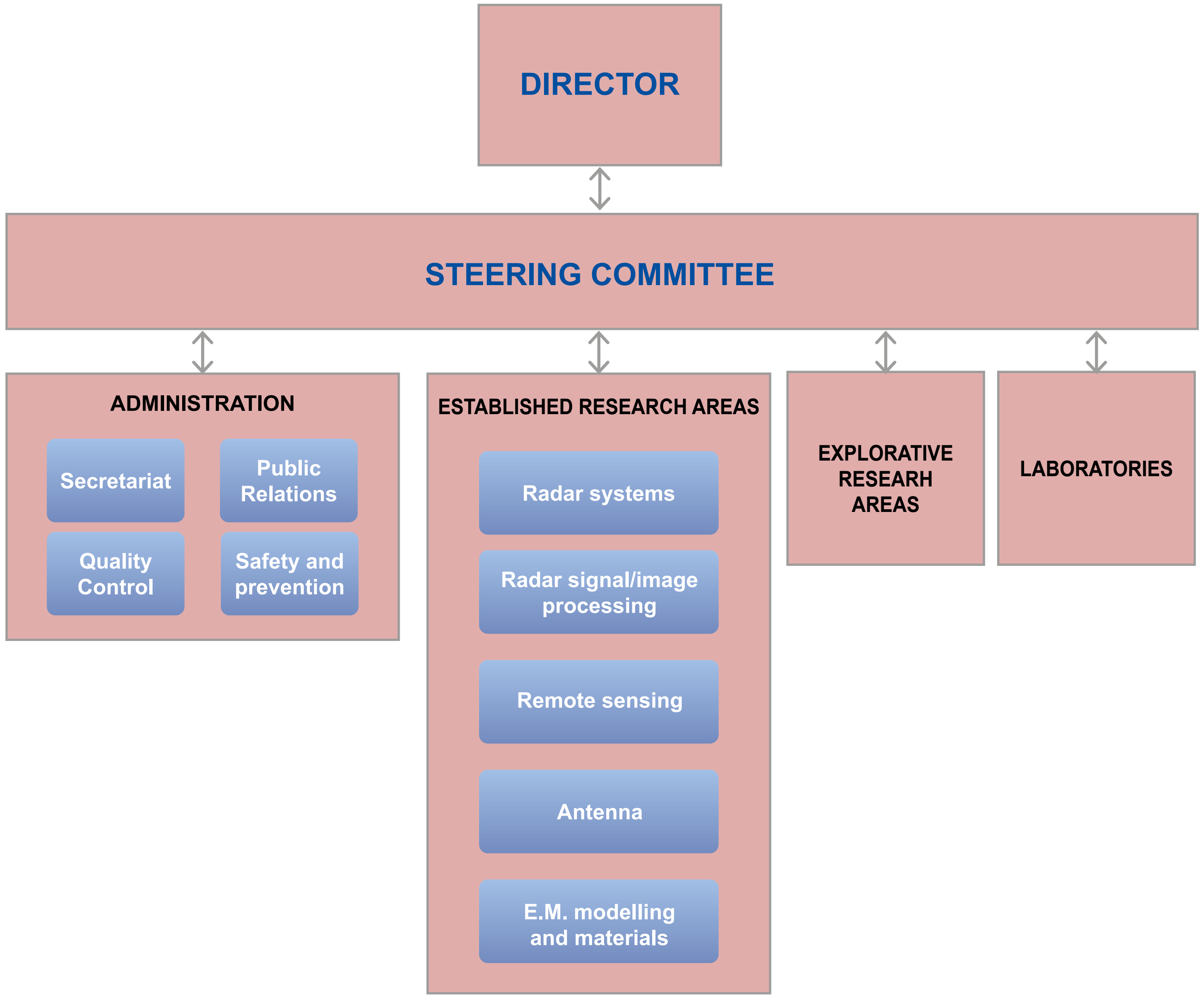



*Figure 3 – Organisational Chart.*

# DIRECTOR

Prof. **Marco Martorella** his Laurea degree (Bachelor+Masters) in Telecommunication Engineering in 1999 (cum laude) and his PhD in Remote Sensing in 2003, both at the University of Pisa. He is now an Associate Professor at the Department of Information Engineering of the University of Pisa and an external Professor at the University of Cape Town where he lectures within the Masters in Radar and Electronic Defence. Prof. Martorella is also Director of the CNIT's National Radar and Surveillance Systems Laboratory. He is author of more than 250 international journal and conference papers, 3 books and 19 book chapters. He has presented several tutorials at international radar conferences, has lectured at NATO Lecture Series and organised international journal special issues on radar imaging topics.

He is a member of the IEEE AES Radar Systems Panel, Vice-Chair of the NATO SET Panel and a member of the EDA Radar Captech. He has chaired several NATO research activities, including three Research Task Groups, one Exploratory Team and two Specialist Meetings. He has been recipient of the 2008 Italy-Australia Award for young researchers, the 2010 Best Reviewer for the IEEE GRSL, the IEEE 2013 Fred Nathanson Memorial Radar Award, the 2016 Outstanding Information Research Foundation Book publication award for the book Radar Imaging for Maritime Observation and three NATO Set Panel Excellence Award (2017, 2018 and 2021). He is a co-founder of ECHOES, a radar systems-related spin-of company. His research interests are mainly in the field of radar, with specific focus on radar imaging, multichannel radar and space situational awareness. He is a Fellow of the IEEE.

# INCOMING 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 activity is mainly 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.

# INCOMING DIRECTOR'S: PROF. AGOSTINO MONORCHIO

I am honored to have been appointed Head of the National Laboratory of Radar and Surveillance Systems (RaSS-Lab) by the CNIT shareholders' meeting of last January 2023. I was part of the initial group headed by prof. Enzo Dalle Mese, who founded the laboratory in 2010, providing my expertise in applied electromagnetics so you can understand my proud to be now the Head of the well-known and prestigious laboratory that has become. It is therefore my intention to continue the scientific tradition of the laboratory in the field of radar systems and applied electromagnetics: indeed, this is a huge privilege, but also a very big responsibility, which I can only hope to fulfill.
I am particularly thankful to my predecessor, Prof. Marco Martorella, for the superb job he performed so far, and I am pleased to have inherited the laboratory in very good shape (it will be difficult and challenging to overcome his results).
The long and traditional collaboration we have will ensure a smooth transition, without losing any specificity of the 'core business' of our research group. As a guideline to my tenure, I would like to stress the importance of being open and inclusive, especially to the extraordinary competences in our field offered by other national research units. I am eager to work with other CNIT colleagues, spread all over Italy, to provide novel and breakthrough (applied) solutions in radar and electromagnetic fields.

# Active Projects

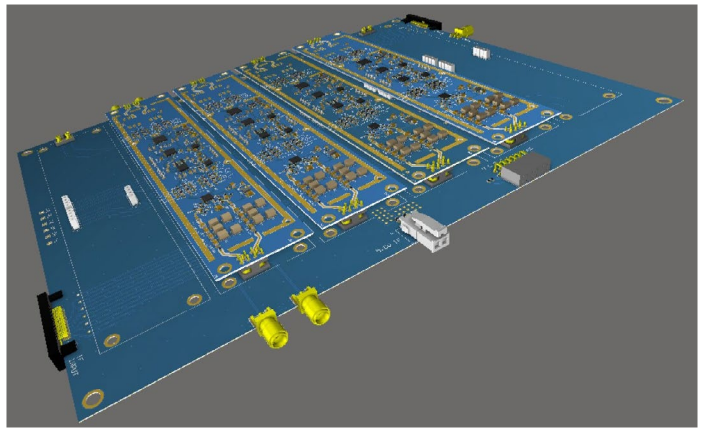
# PROJECT ANTI-DRONES

Innovative concept
to detect, recognize and
track "killer-drones"

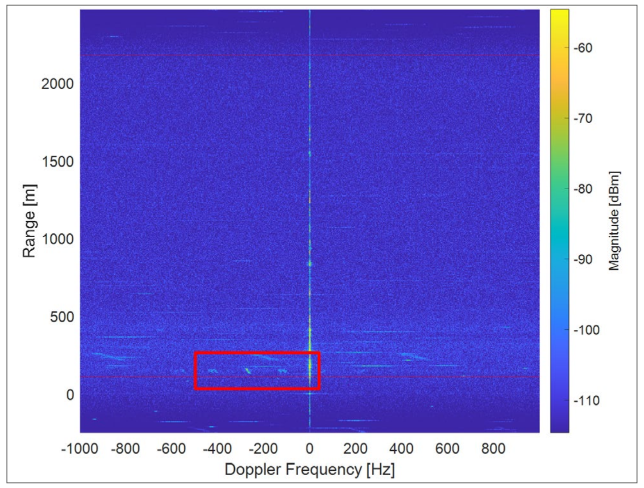
The project focuses on the development of a new concept of anti-drone system, which is able to detect, recognize and track killer-drones – mini/micro UAVs - in order to facilitate their neutralization and, at the same time, to minimise risks for people and assets. The realization of Anti-Drones' goal requires the integration of different competencies, such as system design and integration, design of antennas and transceiver, development of advanced signal processing algorithms, as well as development of software and firmware. The system is based on the use of software defined technologies and software engineering techniques to guarantee flexibility and re-use of existing technology.
Anti-drones will move forward the current state of the art of anti-drone systems through the use of mini-radar technology and signal processing, which will improve current system performances with minimal environmental impact (e.g. visual impact and EM pollution) to the urban environment.
The Anti-Drone's radar demonstrator has been tested during the measurement campaigns. The radar capabilities have been successfully verified through the detection of three different drones: DJI Spark, Sigma ingegneria HELIX, Sigma ingegneria horus (https://www.sigmaingegneria.com/robotica.php).

| Technical Sheet |
|---|
| **Funding institution:** |
| *NATO – ESCD – SPS Programme* |
| **Project partners** |
| *CNIT-RASS, Mother Teresa University (MTU), North Kazakhstan State University (NKSU)* |
| **Project duration** |
| *September 2019 - March 2023* |
| **Involved countries** |
| *Italy, North Macedonia, Kazakhstan* |

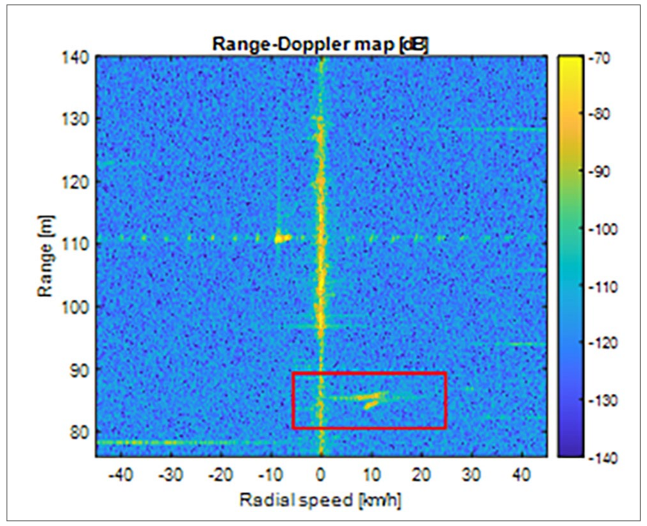

*(a) Anti-Drones project Conceptual Diagram*



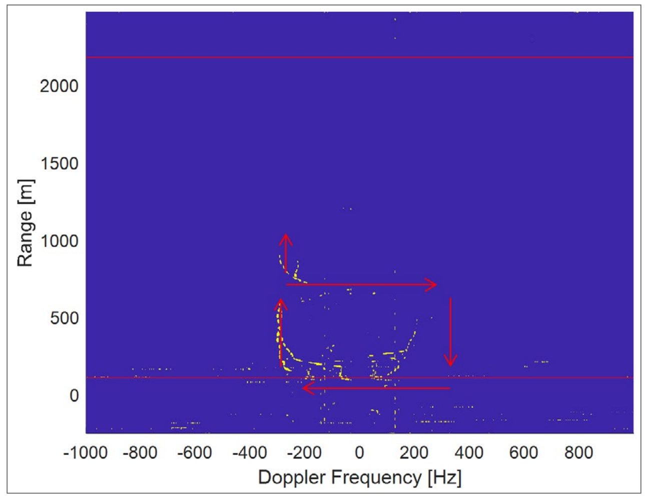
*(b) 3D View of the IF board*




*(c) Range Doppler map of a DJI Spark drone (weight 249g)*




*(d) Range Doppler map:*
*birds (red box) spread in Doppler dimension and bales signature*




*(e) Range Doppler map: target trajectory*

*(f) Final Trials at Krivolak NATO Training Center*

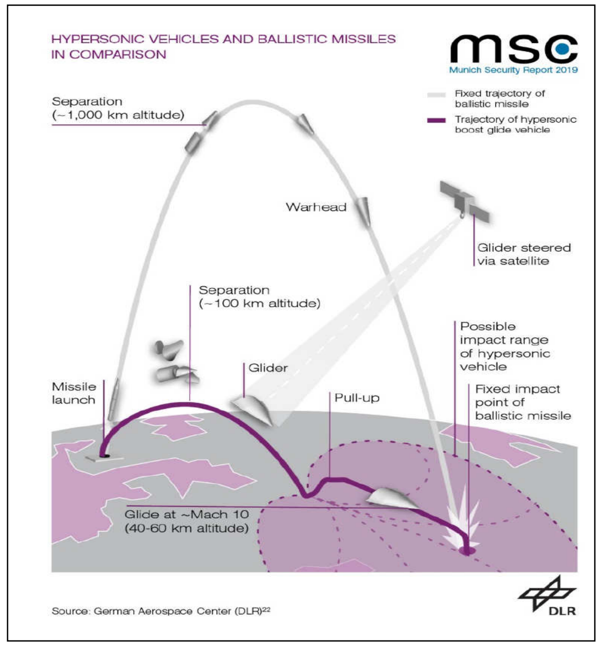
# PROJECT ARMA

Architettura Radar per la Minaccia ipesonicA

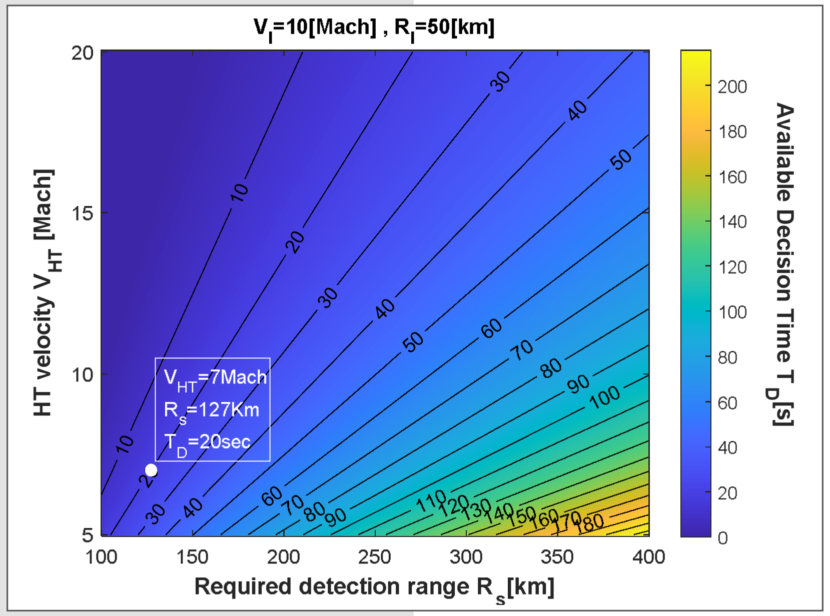
The aim of this project is to 1) define the essential and sufficient requirements to be able to detect and track next generation Hypersonic Threats (HT) for interceptor missile on-board radar and sensor systems and 2) to study radar and RF sensor architectures on board the interceptor missile in order 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*



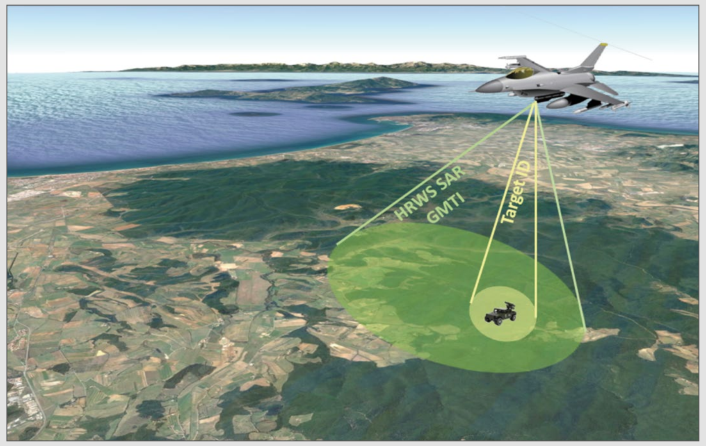

*(b) Decision Time as a function of Hypersonic Threat speed and required detection range*

The COGITO project represents one of the first attempts to apply a cognitive architecture to the problem of target recognition. Today, in fact, most of the "Cognitive Radar" architectures, either implemented or under study, are focused on the radar capability to automatically select the regions of the frequency spectrum that are free of either intentional or unintentional radio frequency interferences. It should be noticed that such a way of working resembles that of a cognitive radio system more than a cognitive radar system. The concept of cognitive radar for target recognition is based on the system's ability to understand the environment and to autonomously manage the radar system degrees of freedom (transmitted waveform and received signal processing parameters) as well as the target recognition algorithms. A cognitive radar that is specifically designed for automatic target recognition will aim at maximizing target recognition performances by exploiting a priori knowledge of the external environment as well as by learning from its successes and failures.

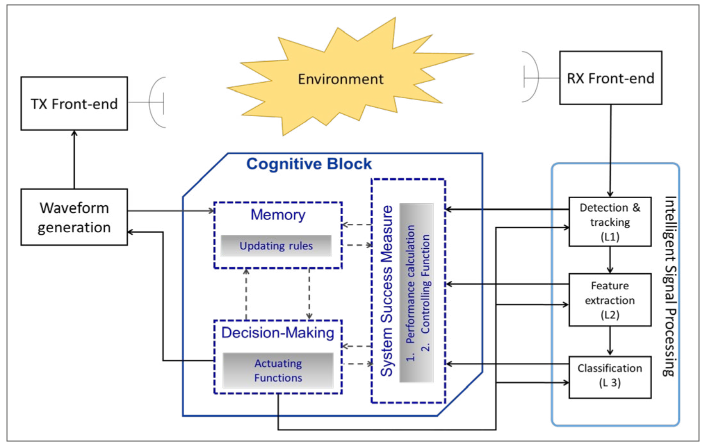
The aim of this project is to develop and test, both on simulated and real radar data, different cognitive radar architectures for automatic target recognition. The project will also provide a performance comparison between classical HRR/ISAR classifiers and the newly developed cognitive architectures. In order of appearance, the images below show an implementation of the COGITO system concept in an operative scenario, the overall system architecture, a more detailed classifier block diagram, where the feedbacks toward the system intelligence are highlighted with different colours, and preliminary results obtained by using a dataset composed of e.m. target models of 4 cars. Results are provided in terms of accuracy, error and precision and are meant to compare the advantage of using cognition when the external environment changes. In the example provided in Fig. 4, the environment changes in terms of SNR. In this case, the system adapts to the environment changes by applying the on-line learning approach proposed in the COGITO project. Other scenarios have been simulated to prove the classifier capability to drive the transmitter parameters (bandwidth, number of receiving spatial channels and full-pol acquisition).

[1] Martorella M, Gelli S and Bacci A (2021). "Ground moving target imaging via SDAP-ISAR processing: Review and new trends" Sensors. 21(7) ISSN: [DOI] [URL]

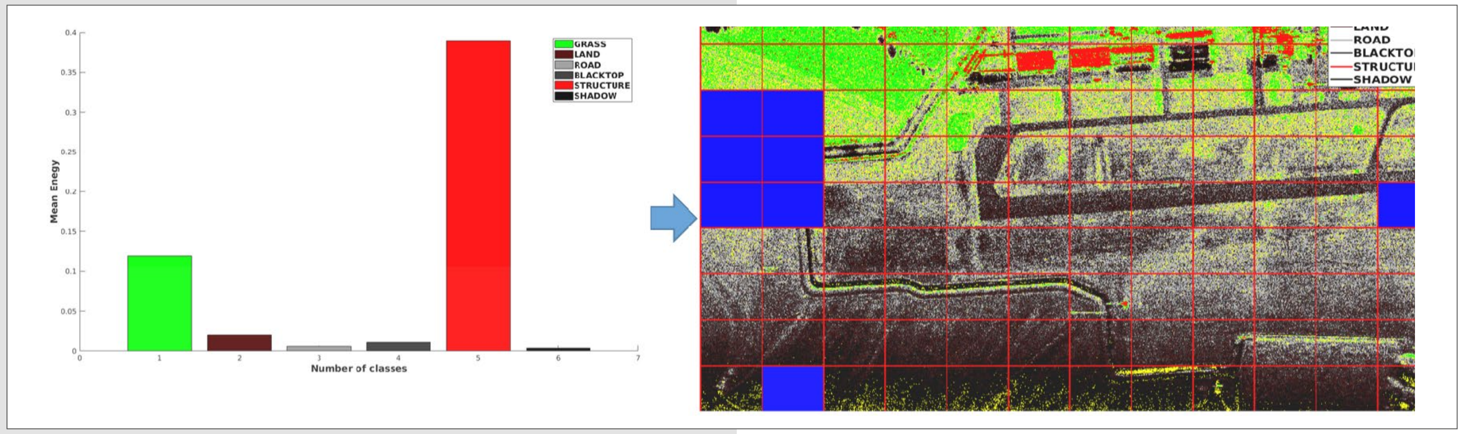
| **Technical Sheet** |
|---|
| **Funding institution:** |
| *European Defence Agency (EDA)* |
| **Project partners** |
| *IDS, FHR, MBDA* |
| **Project duration** |
| *January 2019 - January 2022* |
| **Involved countries** |
| *Italy, Germany* |



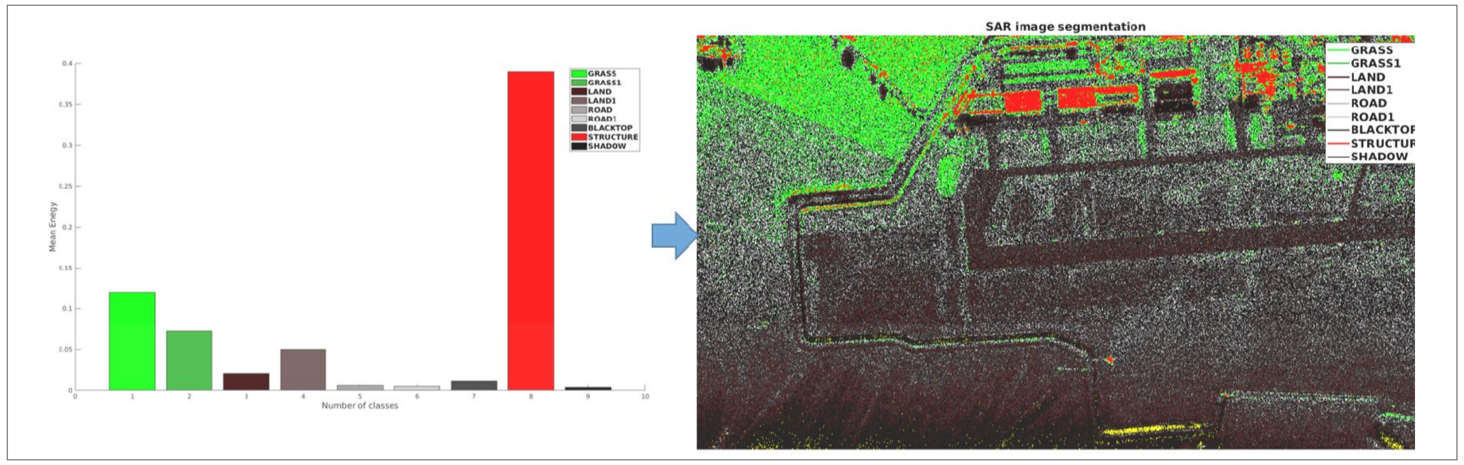

*(a) Cogito conceptual idea and operative scenario*



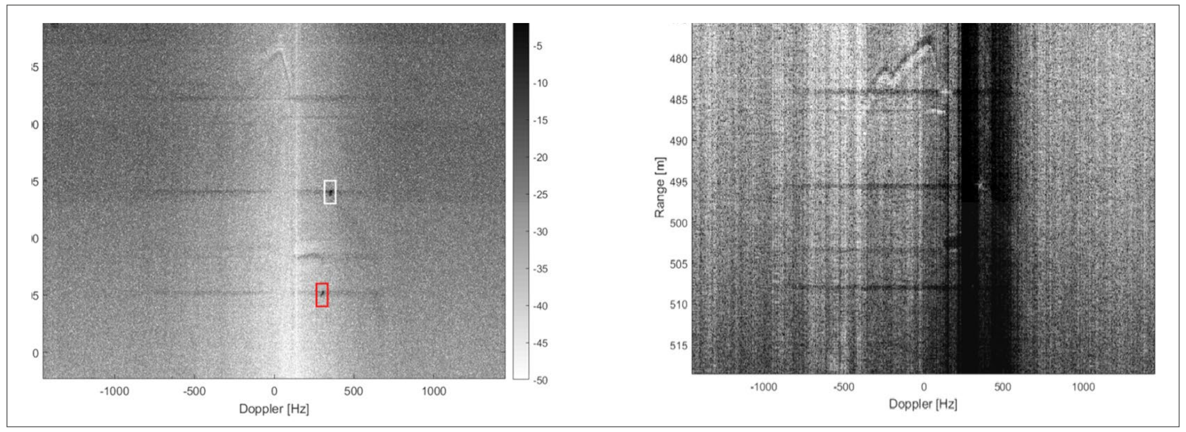

*(b) Block diagram for a cognitive radar high level architecture [2]*




*(c) Cognitive SAR image segmentation-first step: Blue squares are the areas for which the SAR segmentation algorithm shows uncertainties [2]*




*(d) Cognitive SAR image segmentation-second step: The SAR segmentation memory is updated using the new detected pixels and the SAR segmentation is performed again only on the blues areas that are now classified pixel by pixel without uncertainties [2]*




*(e) Cognitive SDAP for moving target detection (left) compared to the non cognitive SDAP algorithm (right). The results on the right side shows a worsts mitigation of the background clutter and the moving targets (those highlighted with the rectangles in the left figure) cannot be detected. This is a portion of the SAR image shown in (d) (below the landing strips of the airport) [2]*

## Simulation 1: fine tuning strategy against SNR

Performance comparison: SNR

Time

| Accuracy [%] | $28.52dB$ | $24.42db$ | $19.21dB$ | $16.57dB$ | $15.44dB$ | $12.30dB$ |
|---|---|---|---|---|---|---|
| Baseline classifier | 100 | 100 | 90.75 | 83.25 | 74.92 | 58.58 |
| Fine tuning at $28.52dB$ | 100 | 100 | 90.75 | 83.17 | 74.92 | 50.04 |
| Fine tuning at $24.42dB$ | 100 | 100 | 99.83 | 83.17 | 74.92 | 58.58 |
| Fine tuning $9.21dB$ | 100 | 100 | 100 | 83.25 | 74.92 | 52.63 |
| Fine tuning at $16.57dB$ | 100 | 100 | 100 | 83.17 | 74.92 | 66.31 |
| Fine tuning at $15.44dB$ | 100 | 100 | 100 | 83.17 | 83.17 | 66.47 |

Time

| Error rate [%] | $28.52dB$ | $24.42db$ | $19.21dB$ | $16.57dB$ | $15.44dB$ | $12.30dB$ |
|---|---|---|---|---|---|---|
| Baseline classifier | 0 | 0 | 4.62 | 8.38 | 12.54 | 20.71 |
| Fine tuning at $28.52dB$ | 0 | 0 | 4.75 | 8.42 | 12.54 | 24.98 |
| Fine tuning at $24.42dB$ | 0 | 0 | 0.839 | 8.38 | 12.54 | 23.09 |
| Fine tuning $9.21dB$ | 0 | 0 | 0 | 8.38 | 12.54 | 23.63 |
| Fine tuning at $16.57dB$ | 0 | 0 | 0 | 8.42 | 8.42 | 16.85 |
| Fine tuning at $15.44dB$ | 0 | 0 | 0 | 8.42 | 8.42 | 16.76 |

Time

| Precision [%] | $28.52dB$ | $24.42db$ | $19.21dB$ | $16.57dB$ | $15.44dB$ | $12.30dB$ |
|---|---|---|---|---|---|---|
| Baseline classifier | 100 | 100 | 92.87 | 89.97 | 87.48 | 84.18 |
| Fine tuning at $28.52dB$ | 100 | 100 | 92.72 | 89.94 | 81.64 | - |
| Fine tuning at $24.42dB$ | 100 | 100 | 99.83 | 89.94 | 81.64 | 83.97 |
| Fine tuning $9.21dB$ | 100 | 100 | 100 | 89.97 | 81.66 | 74.26 |
| Fine tuning at $16.57dB$ | 100 | 100 | 100 | 89.94 | 89.94 | 85.65 |
| Fine tuning at $15.44dB$ | 100 | 100 | 100 | 89.94 | 89.94 | 85.68 |

*(f) An example of how the system adapts the training set against SNR variations over time. The performances are measured in terms of accuracy, error and precision. The cognitive classifier, after the on-line learning process (last line of each table), is compared with a non-cognitive classifier (baseline classifier, first line of each table)*

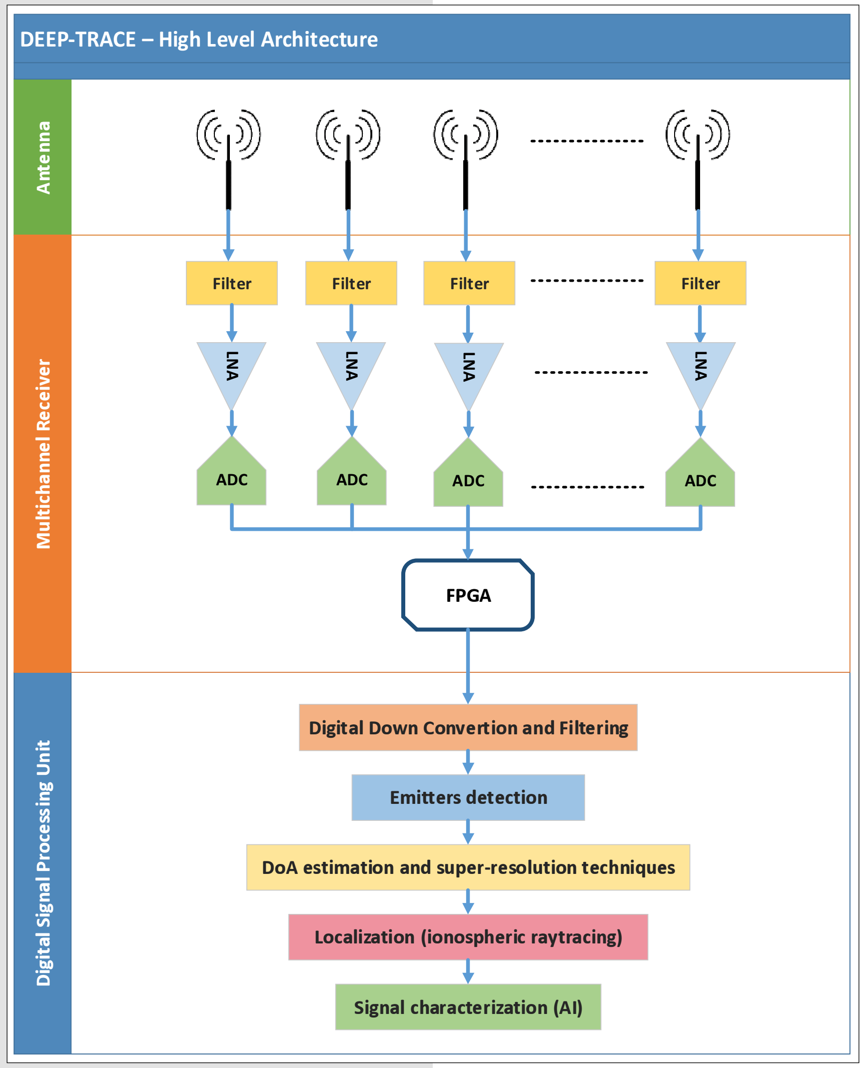
# PROJECT DEEP-TRACE

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

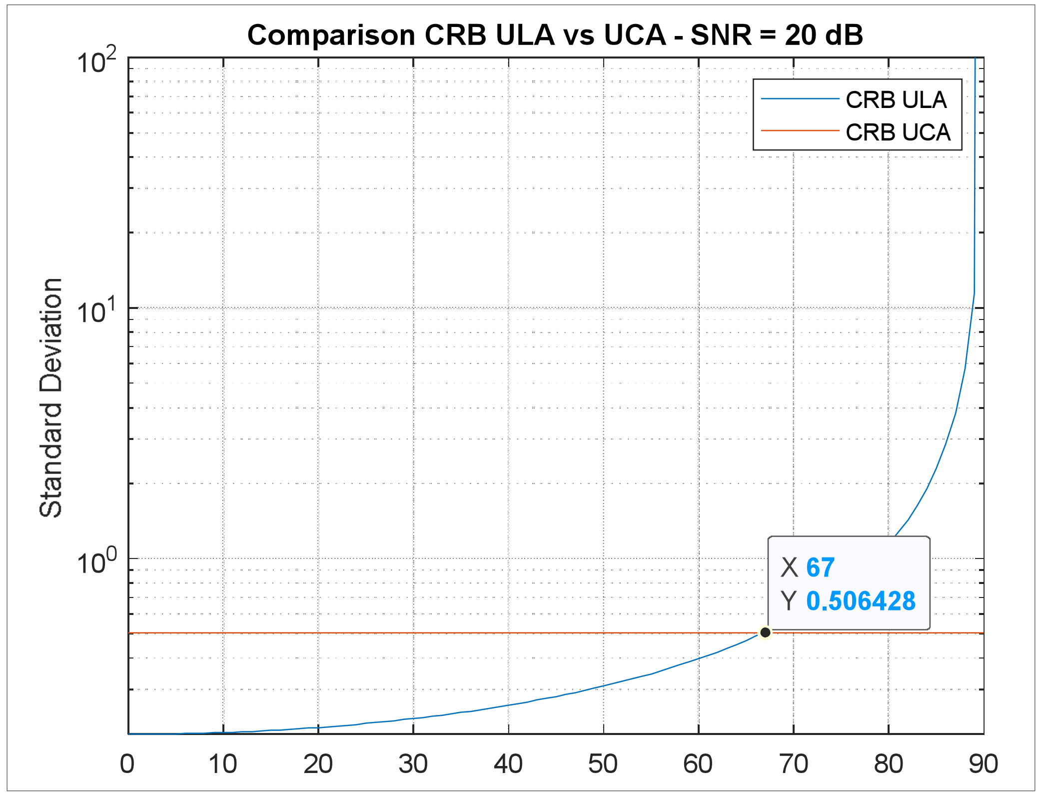
The DEEP-TRACE project aims at realizing a multi-channel system based on an array of compact receiving antennas for receiving, digitizing and analysing HF band signals for C-ESM applications. This configuration is conceived to cope with compactness, easy deployment, modularity and scalability requirements.
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.).

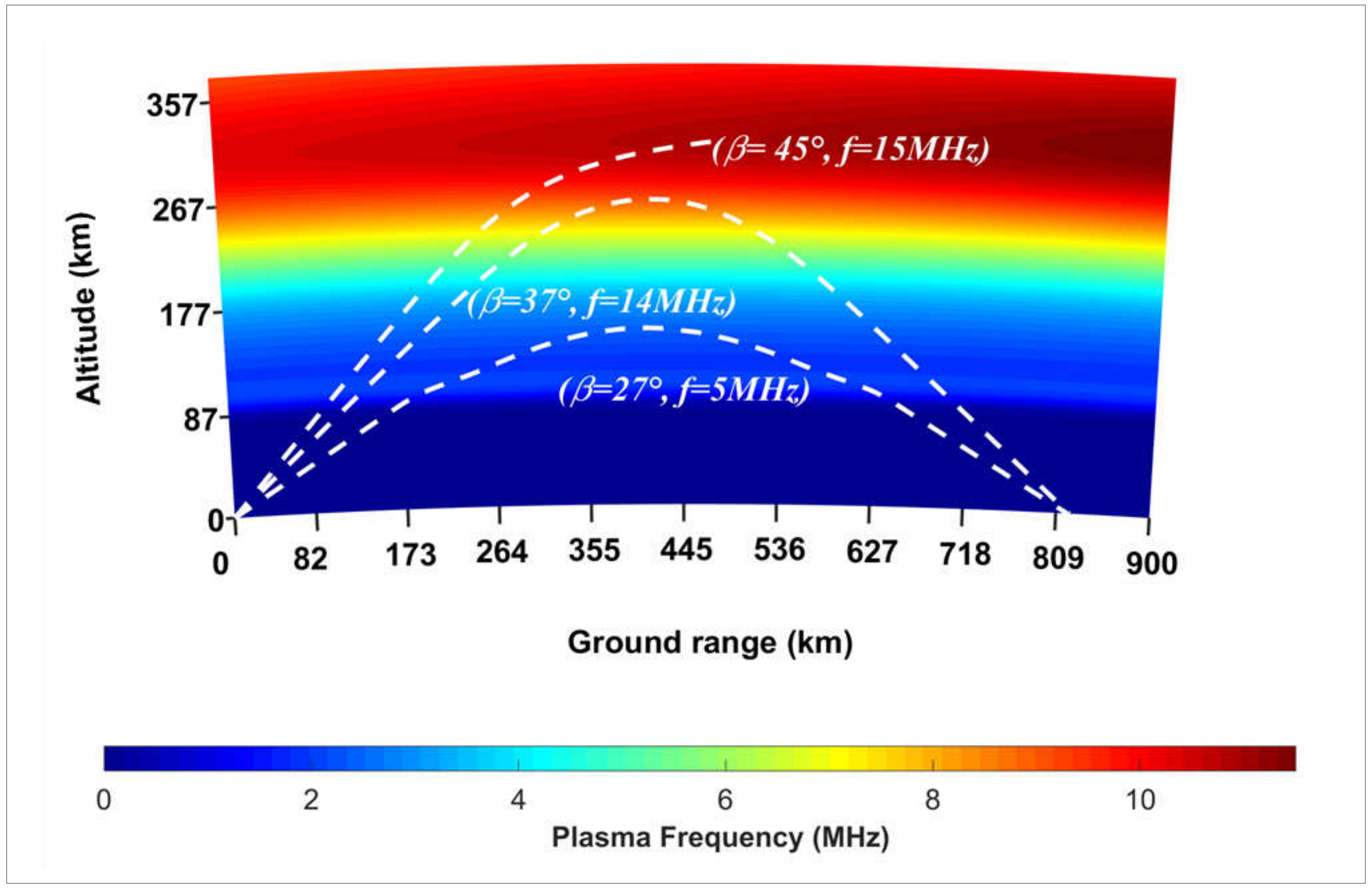
| Technical Sheet |
|---|
| **Funding institution:** |
| *Italian MoD* |
| **Project partners** |
| *ECHOES s.r.l., FreeSpace s.r.l* |
| **Project duration** |
| *June 2021 – June 2024* |
| **Involved countries** |
| *Italy* |



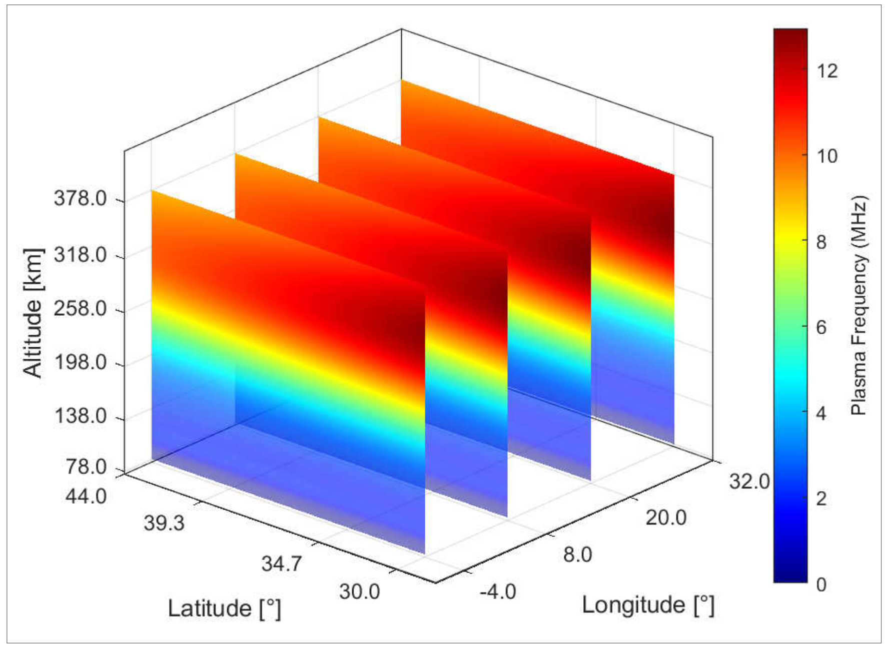

*(a) DEEP-TRACE High-level architecture*



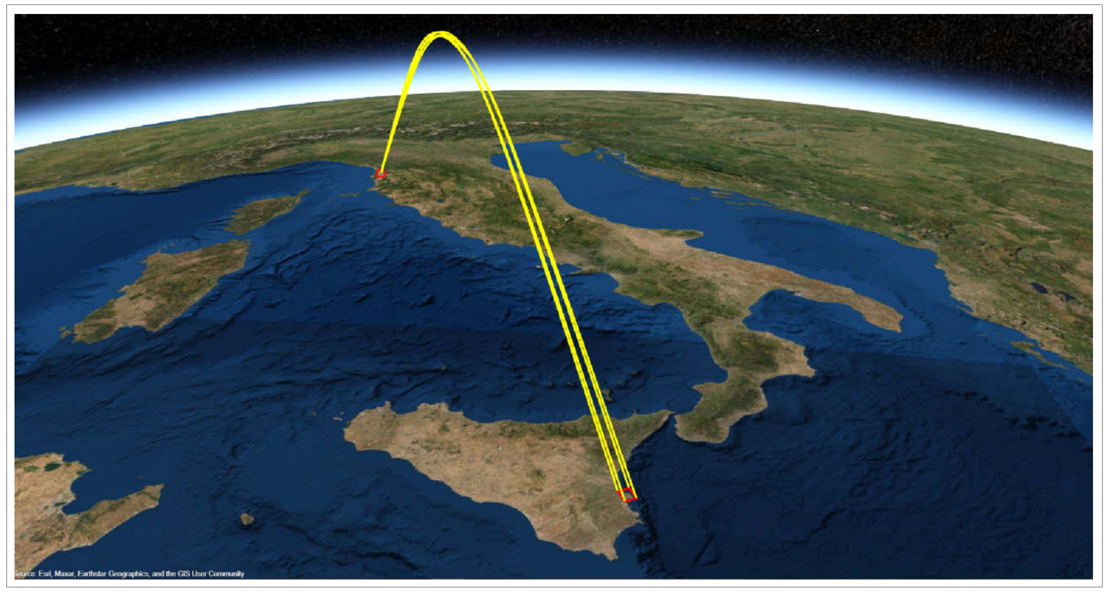

*(b) Beamforming performance comparison: Uniform Linear Array (ULA) vs Uniform Circular Array (UCA) (SNR=20 dB)*



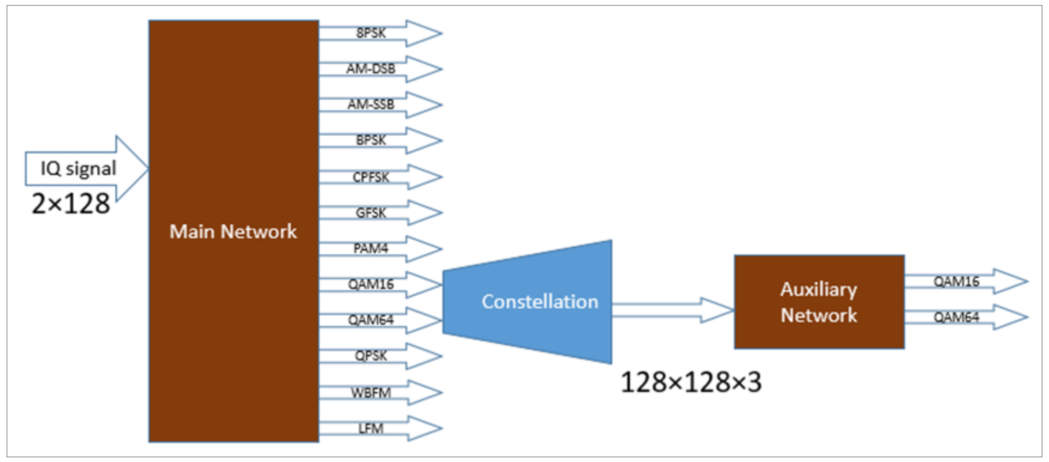

*(c) Electron density profile and ray-paths formation related to the reference scenario*




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

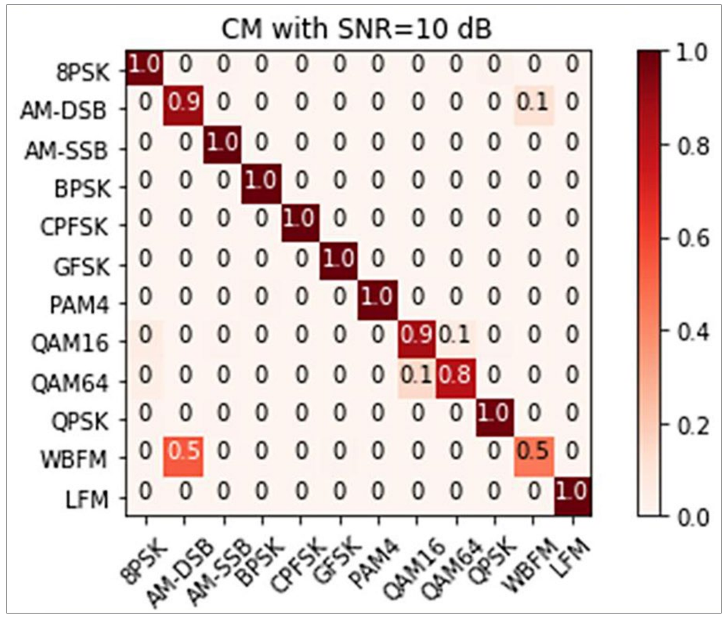


((e) 3D ray tracing outcome for the transmitter localization in the reference scenario

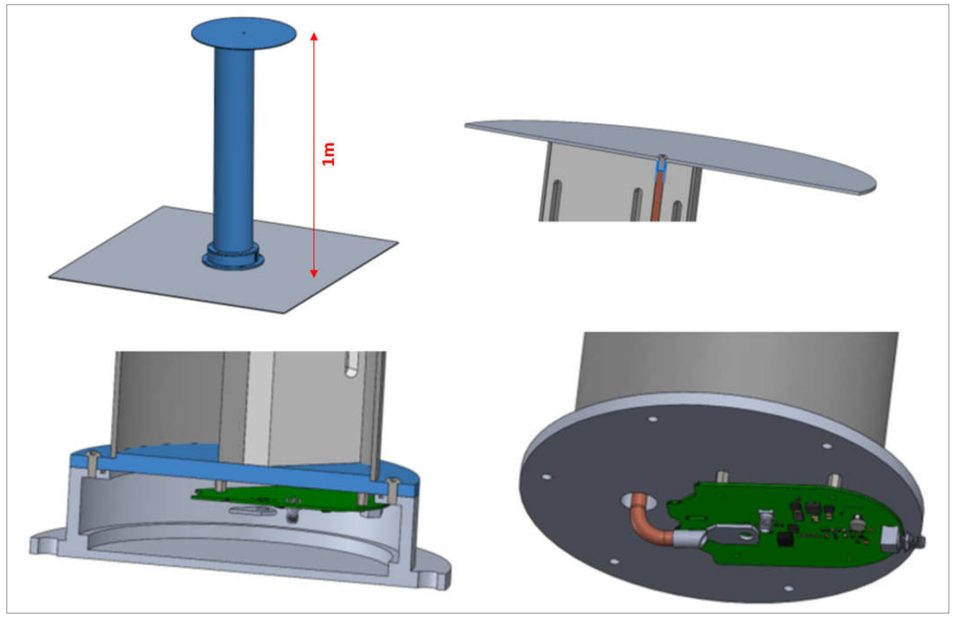



(f) The CNNbased automatic modulation classification architecture. The auxiliary network resolves the ambiguity between the two similar modulations (QAM16, QAM64) to enhance the overall accuracy

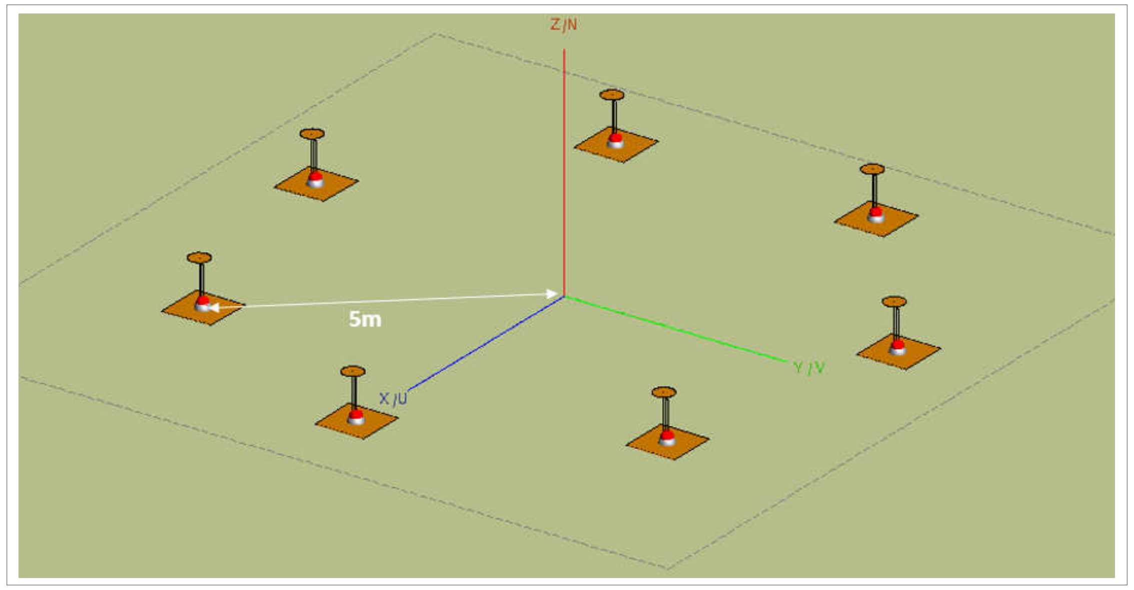





(g) The confusion matrix of the proposed automatic modulation classification architecture at SNR=10dB




(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

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

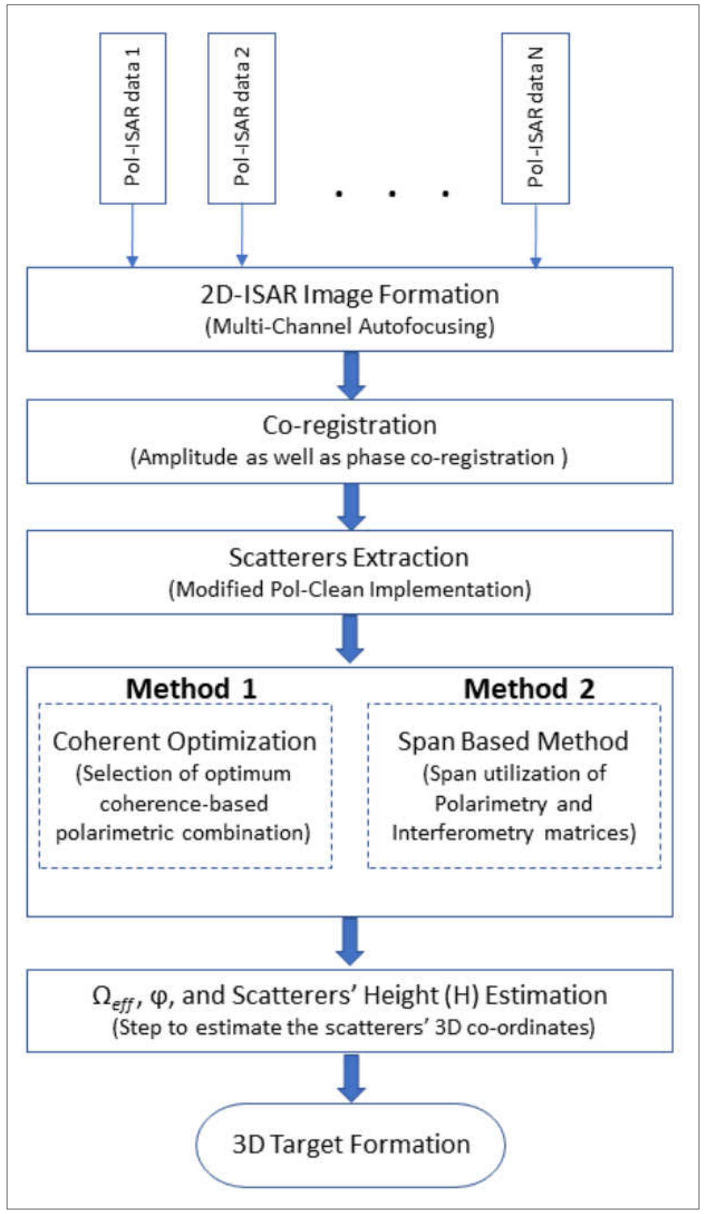
Both homeland security and asset protection in military scenarios require high performing modern surveillance systems in terms of accuracy and response times. Examples are the protection of ports, airports, critical infrastructures, immigration monitoring and prevention, maritime and air surveillance 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.

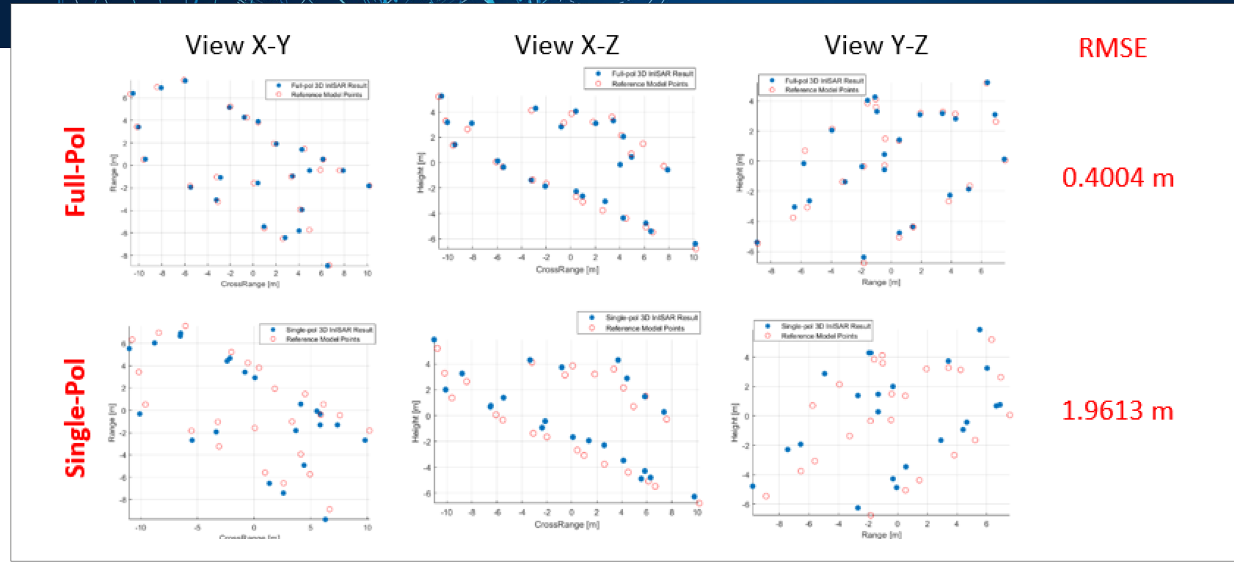
Figure 1 shows the proposed 3D-InISAR imaging algorithm. Specifically we have implemented and tested two different approaches, the coherent optimization and the span based methods.
Figure 2 shows an example of results using simulated data, in which the advantage of using fully polarimetric information can be appreciated either visually as well as numerically. In fact the RMSE calculated between the coordinates (true and estimated) of each scatterer is provided to be much lower when using polarimetry.
Figure 3 shows results obtained by using multiple views (both in elevation and azimuth) of the same target superimposed to the target CAD model. The same figure also reports the estimated target size and size ratios to show that the use of polarimetry permits obtaining a better estimate of the target size and preserve the target shape more faithfully.

*[2] 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*

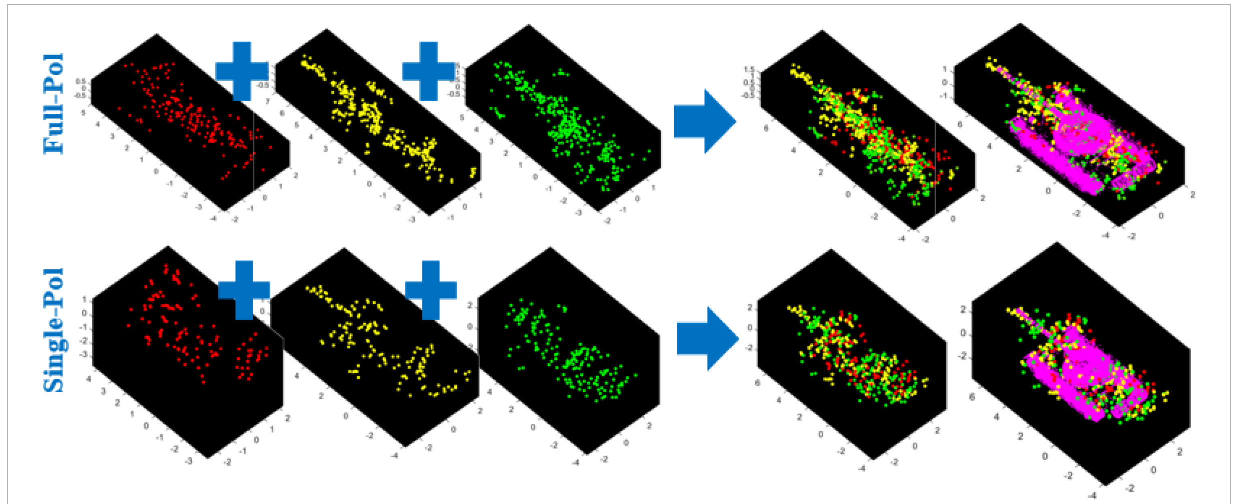
| Technical Sheet |
| --- |
| **Funding institution:** |
| *ONR GLOBAL* |
| **Project partners** |
| *CNIT RaSS* |
| **Project duration** |
| *September 2020 - September 2023* |
| **Involved countries** |
| *Italy* |




*(a) 3D-InISAR imaging algorithm*

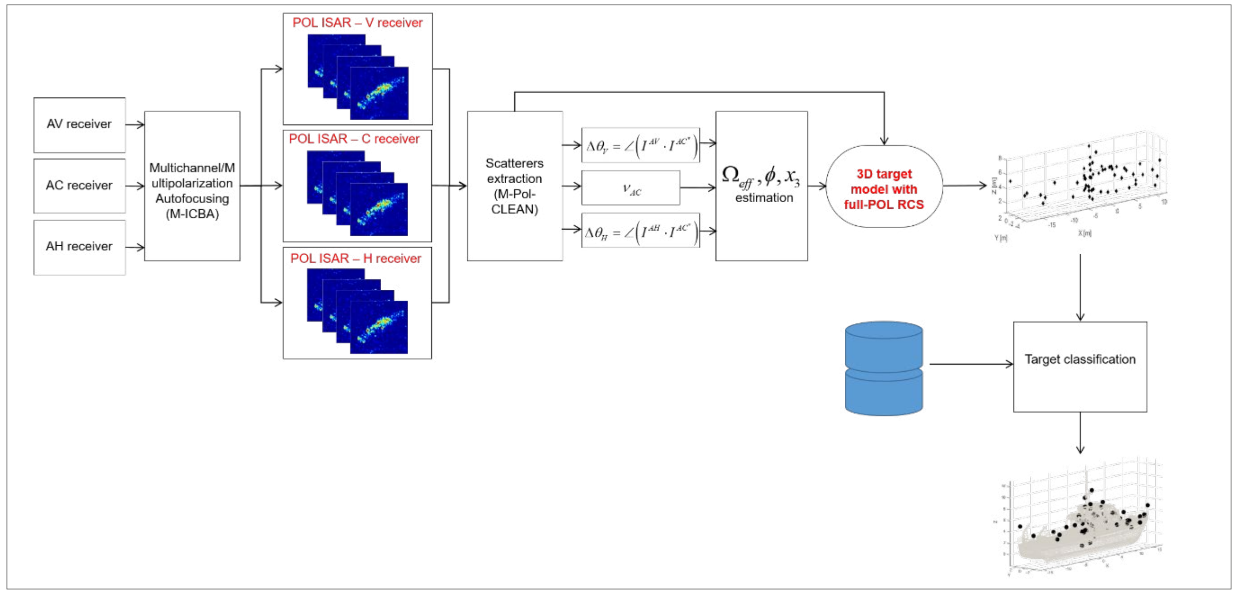



*(b) An example of 3D InISAR image reconstruction obtained by processing simulated data and either fully polarimetric and single polarimetric data*




| Tank/Size | L | W | H | $\frac{L}{W}$ | $\frac{L}{H}$ | $\frac{W}{H}$ |
| --- | --- | --- | --- | --- | --- | --- |
| 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 |

*(c) 3D target reconstruction using fully polarimetric radar data of a tank [2]*



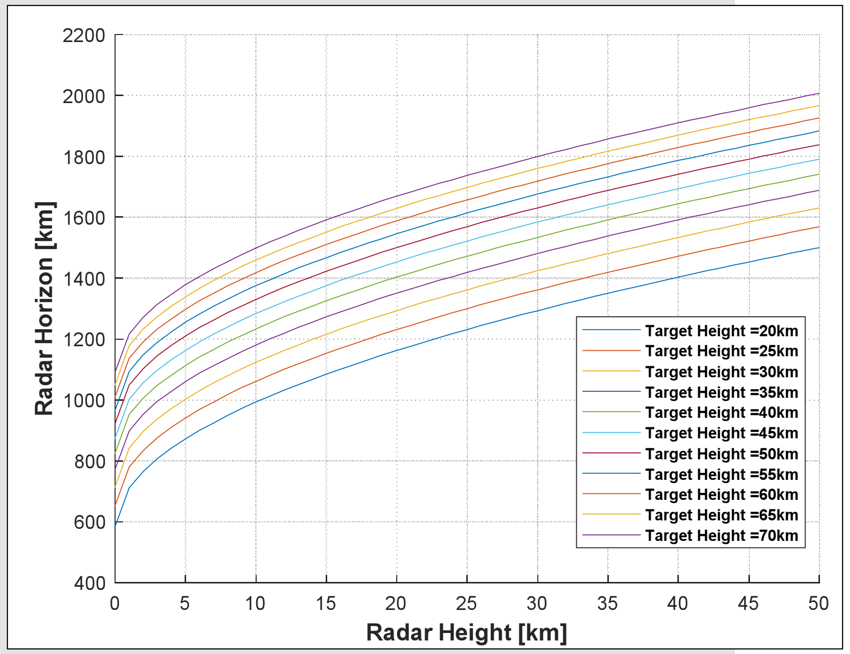

*(d) A high level block diagram of the software algorithm that we implemented.*
*The project activities will focus on the development of the multichannel/multipolarization CLEAN algorithm and on the development of a target classifier*

# PROJECT HYPOTENUSE

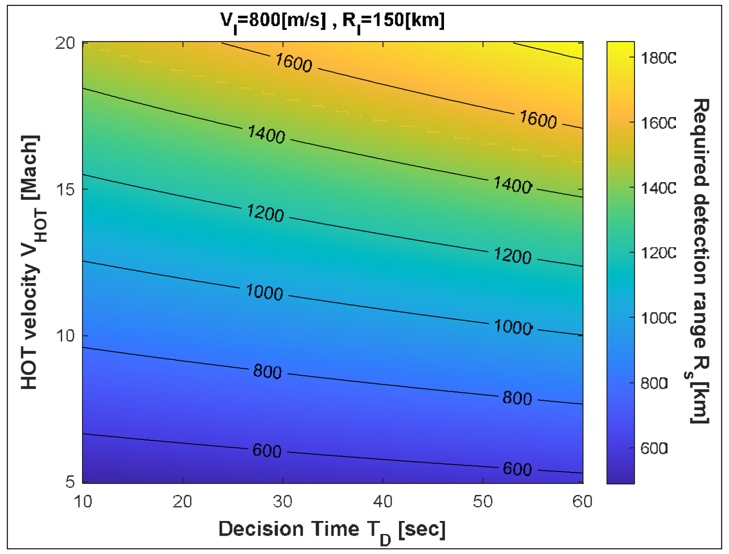
HYPersOnic Threat dEtection aNd coUntermeaSurEs

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*

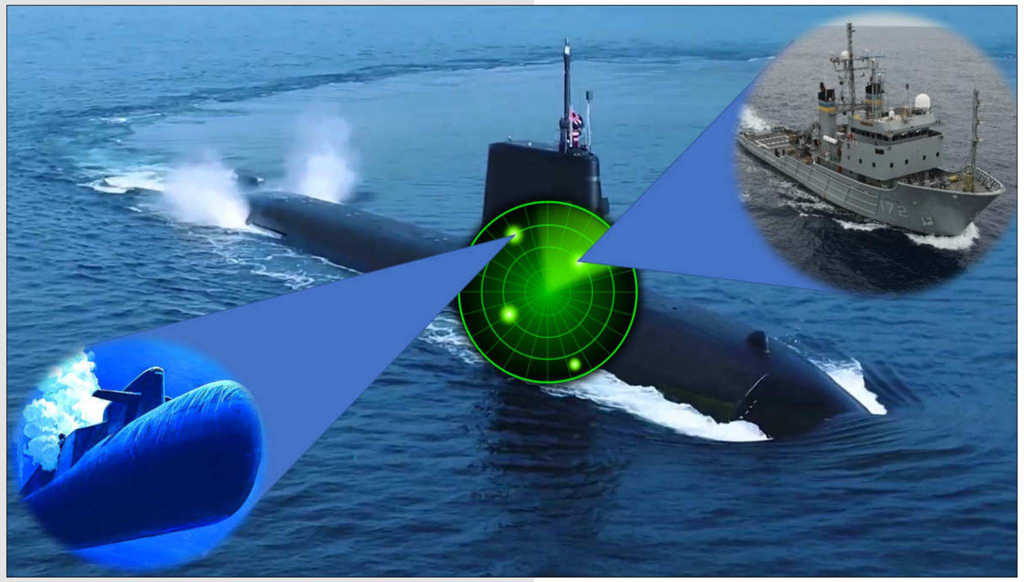


# PROJECT ISS DRASS

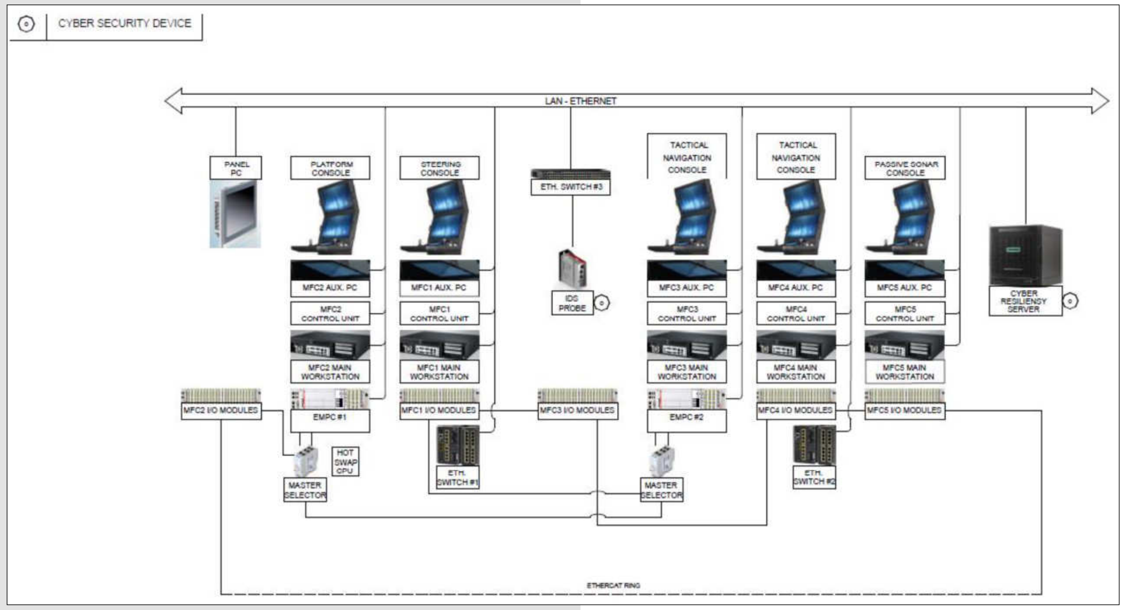
Integrated Submarine System with DRASS

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** |
| -- |
| **Project duration** |
| *January 2021 – October 2021* |
| **Involved countries** |
| *Italy* |



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




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

# PROJECT NORMA

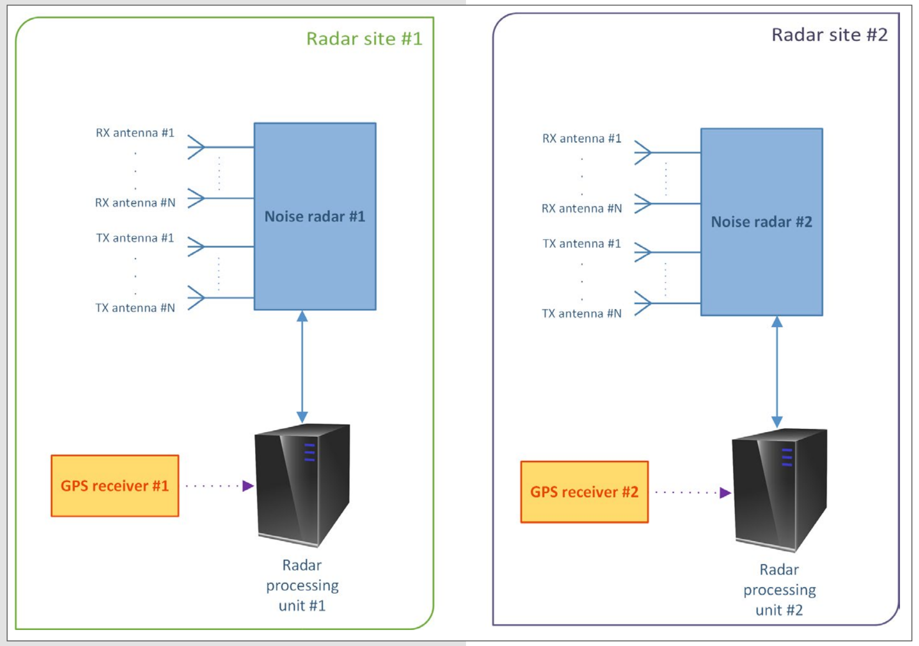
## NOise imaging Radar network for covert air and MAritime borders Security

The project proposes the study, design, analysis and demonstrator realization of a wideband noise imaging radar network for air and sea border surveillance. The single radar sensor will be designed to work in three different modes: target RCS measurement, high range resolution profiling (HRRP or 1D imaging) and 2D-SAR and ISAR imaging.
The main novelties of the NORMA system are:

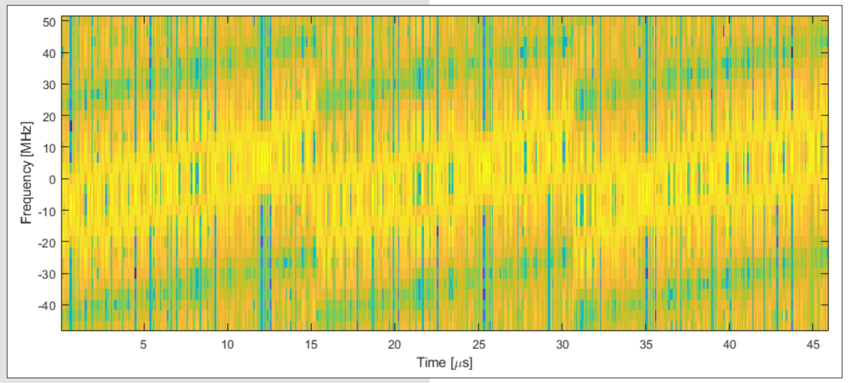
- use of random/noise and noise-like waveforms, which enable Low Probability of Intercept (LPI) characteristic and, hence, covert surveillance operational mode
- radar imaging capability with noise waveforms, more specifically, high resolution range profiles and 2D- images of targets to be used for recognition and classification
- ability to transmit stepped frequency continuous waveforms, which enable the detection of slow aerial (especially drones) and sea target in strong clutter environment
- advanced signal processing, which provides the ability to detect targets floating in sea clutter environment
- radar network, which enables bistatic, multistatic and Multiple Input Multiple Output (MIMO) RCS and 1D- 2D imaging for better target characterization and identification

A technological demonstrator composed of a network of two noise imaging radar systems will be designed and developed.
The demonstrator will be designed to produce monostatic and bistatic, RCS measurements, high range profiling and 2D ISAR imaging. Test and validation will be performed in two scenarios: 1) The surveillance of the Russian-Ukraine air border around the area of Kharkov, as a practical real problem; 2) The surveillance of the sea area around the Livorno harbour (Italy) for monitoring illegal and threatening activities. Special attention will be paid to the detection of floating small size objects in sea clutter.

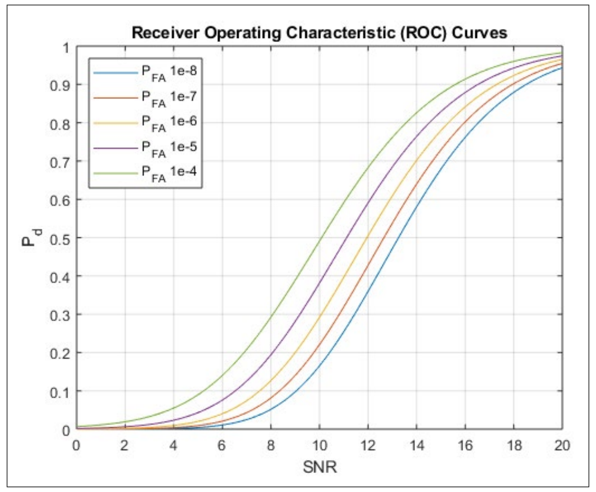
| Technical Sheet |
| --- |
| **Funding institution:** |
| *NATO Emerging Security Challenges Division, SPS Programme* |
| **Project partners** |
| *IRE NASU with the participation of Echoes s.r.l* |
| **Project duration** |
| *May 2018 – May 2021* |
| **Involved countries** |
| *Italy, Ukraine* |



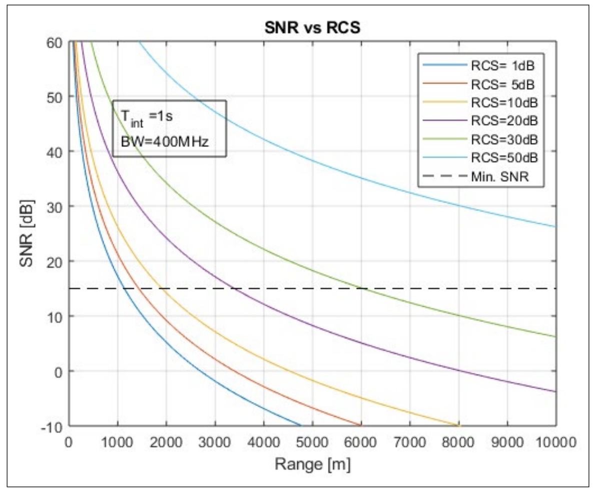

*(a) NORMA high level system architecture including two noise r*



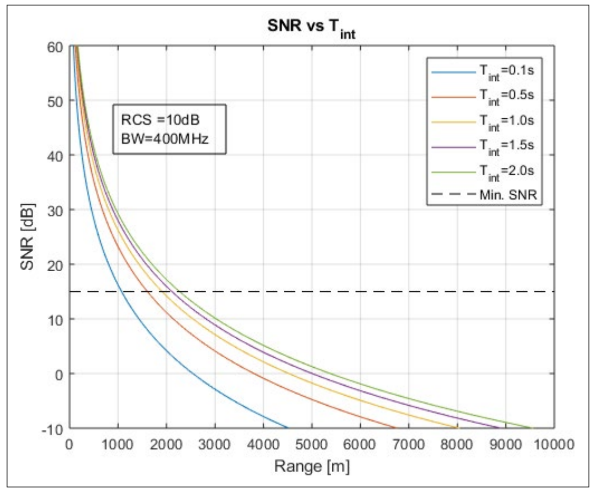

*(b) PRBS (pseudorandom binary sequences) modulated FMCW waveform, 30MHz noise bandwidth. The typical "ramp" of FMCW signal is completely masked by the noise, leading to pseudo random noise like waveforms and, hence, LPI operations © [2020] IEEE. Reprinted, with permission, from [S. Tomei et al., "NORMA - A noise radar network for covert border surveillance," 2020 21st International Radar Symposium (IRS), 2020];*



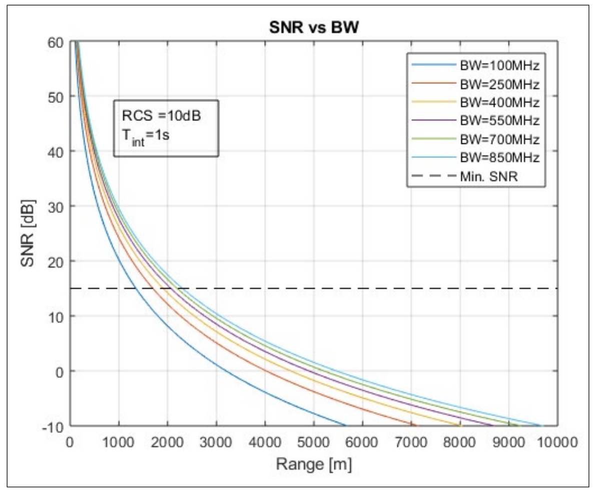

(c) ROC curves for Swerling III model



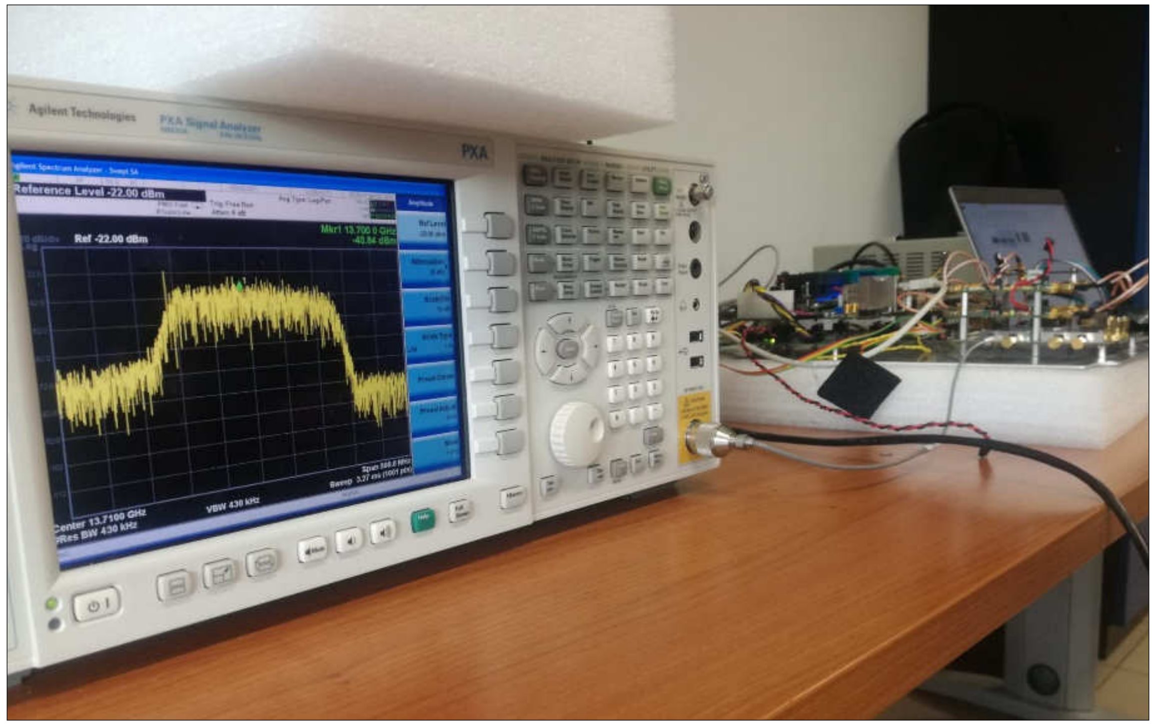

(d) SNR with respect to range distance with the varying of the target RCS



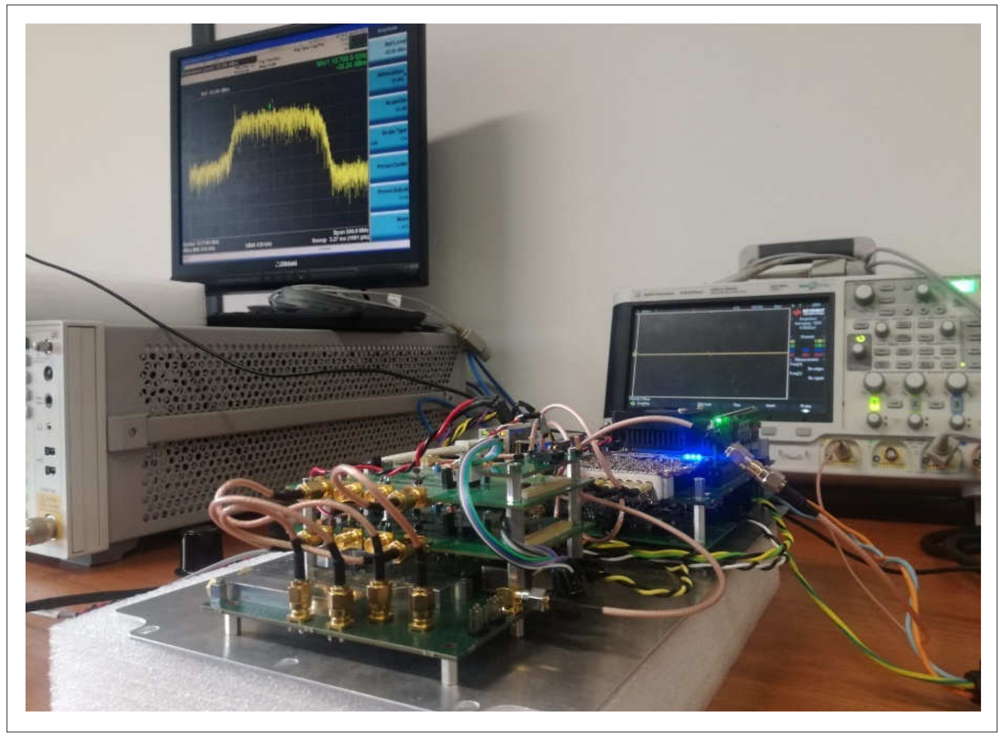

(e) SNR with respect to range distance with the varying of the coherent processing interval



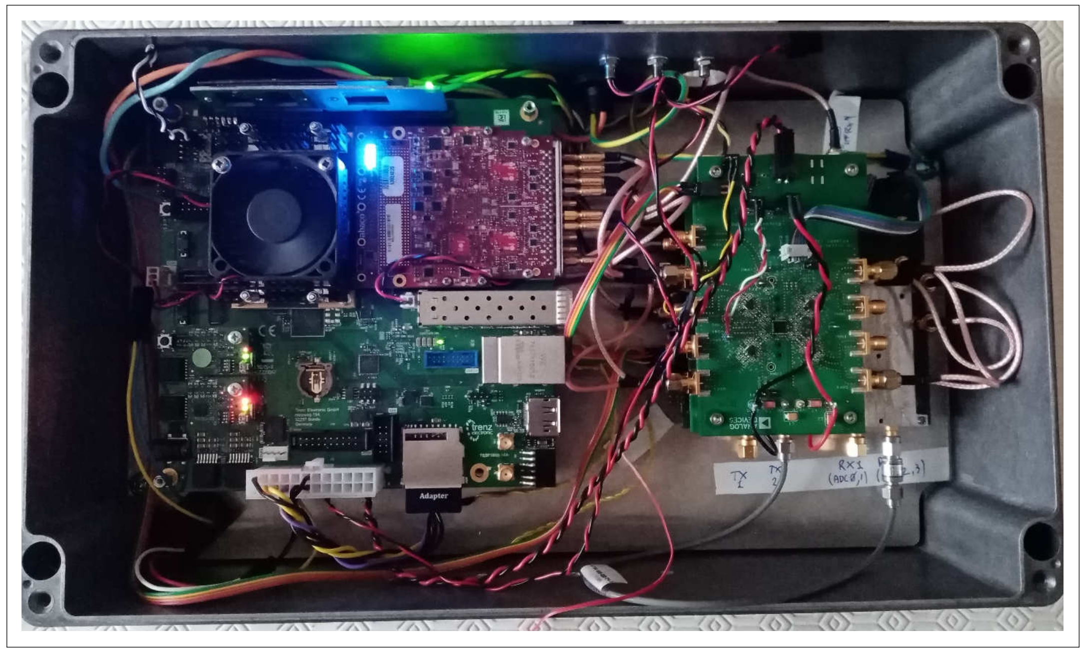

(f) SNR with respect to range distance with the varying of the transmitted waveform bandwidth




(g) Mesurement testbench: spetrum Analyser



(h) Mesurement testbench Oscilloscpe and radar out of the box



(i) Radar Box for loopback test

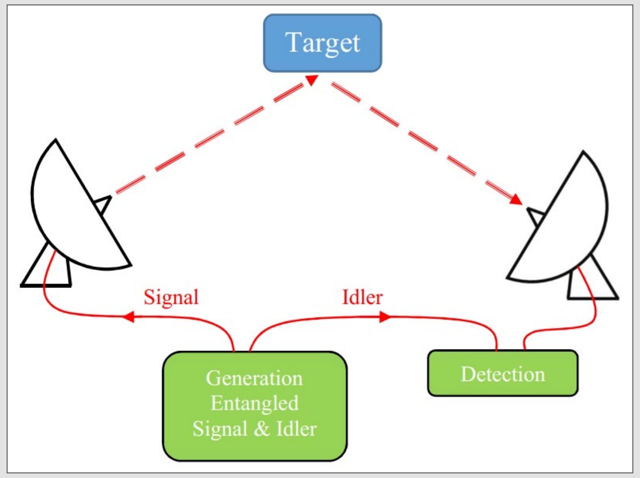
# PROJECT QUANDO RF



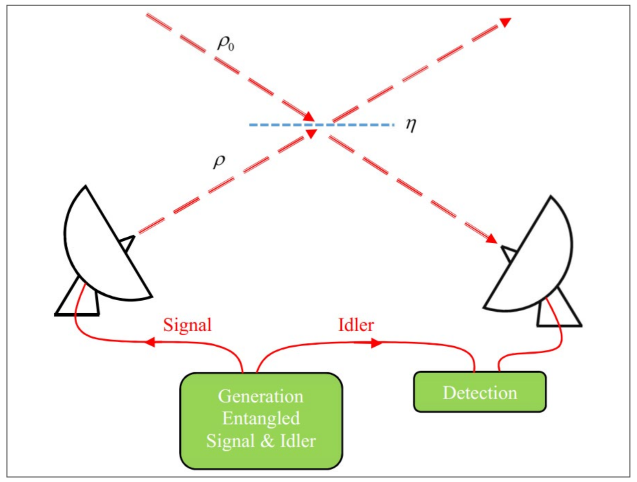
The First Quantum Revolution shaped the world we live in today: without mastering quantum physics, we could not have developed computers, telecommunications, satellite navigation, smartphones, or modern medical diagnostics.
Now a Second Quantum Revolution is unfolding, exploiting the enormous advancements in our ability to detect and manipulate "single quanta" (atoms, photons, electrons). The market availability of Quantum Sensors could lead to a paradigmatic shift in the design of future systems revolutionising Defence capabilities.
For the FWC QUANDO we assembled a consortium carefully structured to cover the entire value chain of innovation (from research organisations to innovative small and medium companies, including technology developers and integrators) with knowledge of state-of-the-art quantum sensing technologies and competences in military and defence applications.
To answer this novel service request, we have brought-in an additional subcontracting RTO with expertise in the application of quantum technologies to radar and surveillance systems.
As requested, we will perform a state-of-the-art analysis regarding quantum technology applications in the RF domain drawing on our consortium knowledge and expertise. Following we will concentrate on detection, tracking and recognition of challenging targets identifying and selecting the most promising quantum technologies. We will analyse the improvement brought about by these techniques with respect to naval based use cases. Building on our results from the FWC QUANDO we will assess common hardware and processing between quantumbased optronics and RF sensors. Our study will allow the definition of a clear roadmap for new project initiatives in both the field of RF sensor and optronics systems.

| Technical Sheet |
|---|
| **Funding institution:** |
| *EDA* |
| **Project partners** |
| *CNR, ONERA, TNO, FLYBY, HENSOLDT, LEONARDO, TECNOBIT, THALES, DLR, CNIT* |
| **Project duration** |
| *July 2021 - July 2022* |
| **Involved countries** |
| *Italy, France, Germany, Netherlands, Spain* |

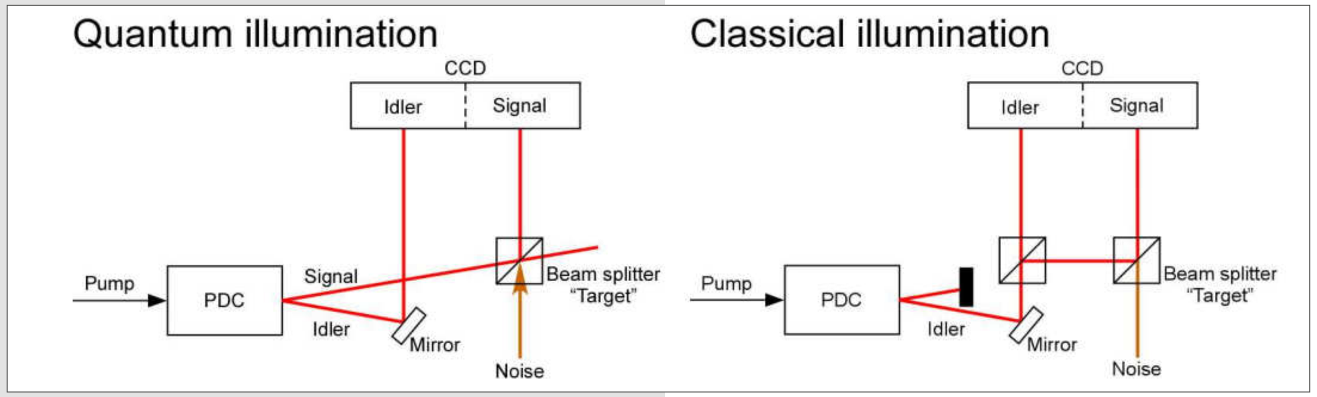
*[3] M.Höijer, T. Hult and P. Jonsson, "Quantum Radar, a survey of the science, technology and literature". Technical report, December 2019, Swedish Defence Research Agency (FOI)*




*(a) Principal sketch of a quantum radar. The difference to a classical radar is the signal and idler being entangled. The entanglement creates an enhanced correlation between (the part of) the signal being reflected back and the idler [3]*




*(b) A mathematical treatment of the quantum radar in (a) [3]*




*(c) The schematics of the setup used by Lopaeva et al. The signal and idler paths are arranged so they are equally long so the photons reach the CCD detector at the same time independently which path they took. CCD – charge-coupled device, PDC – parametric down-conversion [3].*



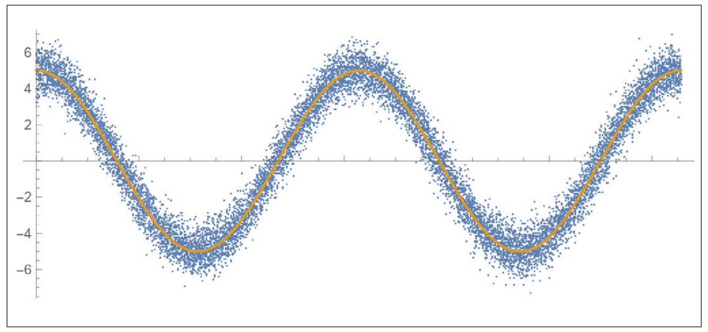
# PROJECT QUANTUM RADAR



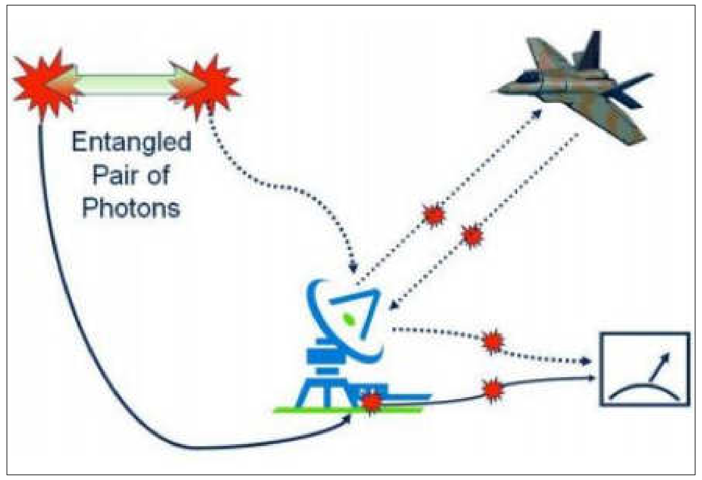
The project will investigate new techniques based on quantum states of microwave radiation in the range 1-10GHz, in particular regarding entanglement, for the realization of a prototype of a "Quantum Radar" with enhanced precision in interferometric measures with low SNR, mandatory to detect non-cooperating targets. With respect to optical systems, an active radar system can be quite expensive. We need to realize compact radar systems with the desired performances.
The project has 3 phases

- Phase 1: Quantum Metrology: Design, characterization and preliminary testing
- Phase 2: Quantum Design: design of the quantum radar system
- Phase 3: Quantum detection: detection of a stealth target with a Quantum Illumination Radar in the microwave range.

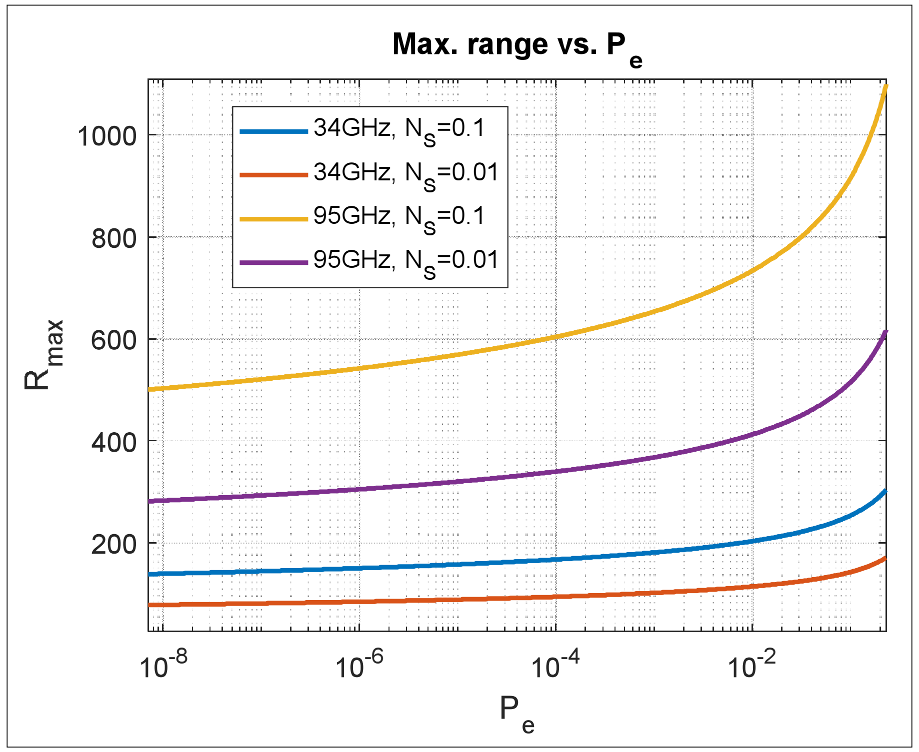
| Technical Sheet |
|---|
| **Funding institution:** |
| *Italian MoD* |
| **Project partners** |
| *CNIT, UniCAM, INRIM* |
| **Project duration** |
| *July 2021 - July 2025* |
| **Involved countries** |
| *Italy* |




*(a) Orange curve is ideal measurement according to classical physics. Blue dots are noise due to quantum effects*




*(b) Qualitative scheme of a two-photon quantum illumination radar*




*(c) Quantum Radar maximum range vs. Error Probability*

# PROJECT RING

## 3D Radar Imaging for Non-Cooperative Target Recognition

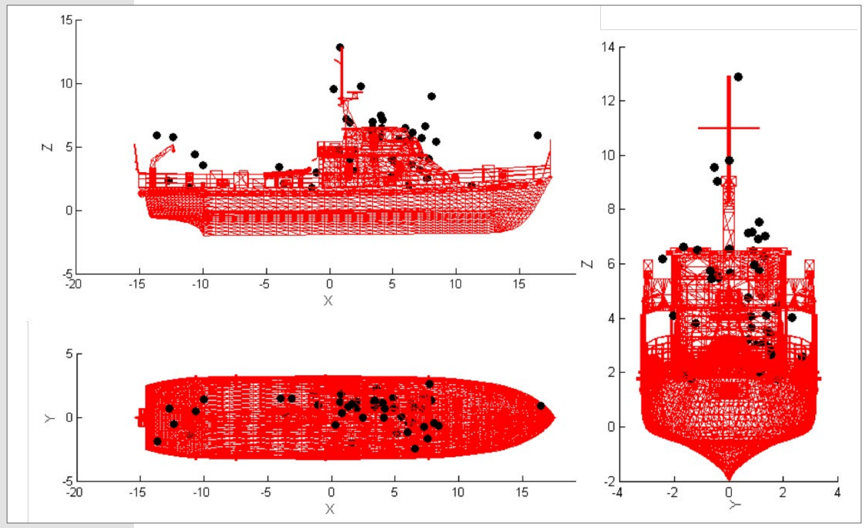
RING aims at developing a new system for Non-Cooperative Target Recognition (NCTR) based on 3D radar imaging. The core of this project is the development of a system for 3D radar image formation based on the use of a dual orthogonal baseline interferometric radar and the associated target recognition architecture and algorithms. The operative needs that have led to this proposal concern both tactical and strategic operations where target identification is a required capability. Use of this technology has also been considered in scenarios of civil/homeland security.
State-of-the-art radar systems employ a basic target recognition system, which is based on an identification friend of foe (IFF) approach. This technology, though, is based on target's cooperation. Some modern systems employ noncooperative target recognition systems that are based on the use of 2D radar images, mainly Inverse Synthetic Aperture Radar (ISAR). 2D ISAR images, unfortunately, suffer of several issues, which may be overcome by employing 3D radar imaging technology. 3D information of a target, in fact, leads to a more refined target identification and prioritization for operational and tactical purposes. The precise target identification can be used for recognizing and prioritizing detected target. For example, the developed technology will provide vital information, including cases where it must be decided whether a detected target can be treated as an attacking plane, or whether it is fighter or bomber (with precise brand assignment), if it is armed (in case of externally attached missiles or bombs), and so on so forth. This project aims at developing and validating such technology to make it available to future radar systems.
The proposed technology could also be used in homeland security scenarios, in order to enhance maritime and border surveillance where it is important to recognize and classify detected targets. Examples are the protection of ports, airports, ships, critical infrastructures, coastal control, immigration monitoring and prevention, including maritime, air and space surveillance from different types of platforms (ground, naval, air and space). In all aforementioned applications, there is the need to recognize a threat produced by a non-cooperative target, which can be significantly enhanced by using recognition techniques based on a novel 3D radar imaging technology.
The project partners will develop three different demonstrator that will be tested during the third year of the project:

- A ground based interferometric radar system
- A Ship borne interferometric radar system
- A drone based interferometric radar system using 4 drones flying in formation.

During the second year of the RING project, we have realised the three technological demonstrators and developed algorithms for the recognition of non-cooperative targets that are based on 3D radar images. More specifically, two database-free approaches have been proposed that compare the 3D target reconstruction with the "reference" target saved in the system database. The first one directly compares the 3D target reconstruction with a target CAD model. The second one compares specific 2D views obtained from both the reference geometrical target model and the 3D target reconstruction.
Figure (b) shows an example of 3D InISAR reconstruction obtained by using a ground-based system previously developed by RaSS (2016).
Figures (c,d,e) illustrate the drone-based demonstrator main components.
Figures (f,g,h) show an example of database-free classification

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

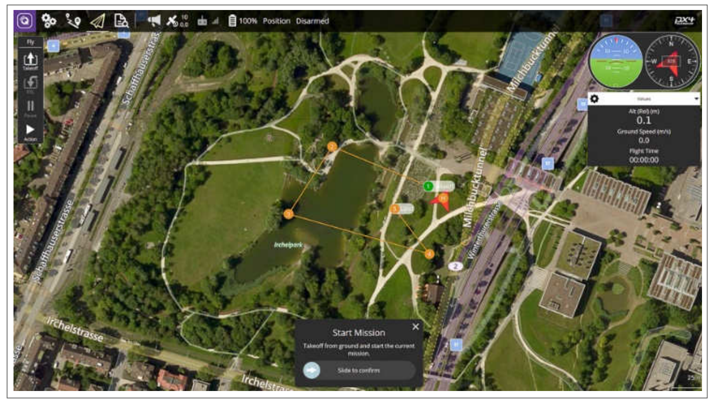

*(a )The first ground based interferometric radar system developed at the RaSS laboratory in 2016 - PIRAD demonstrator*



*(b) An example of 3D InISAR results using real data acquired using PIRAD system. the results of the 3D InISAR is a cloud of points in the 3D space and is compared in this figure with the target CAD model*


*(c) Drone selected for the drone-based demonstrator*

*(d) Drone Futaba T10J radio controller;*


*(e) Drone Qground control software*


*(f) Radar antenna - 20dBi gain*


*(g) A picture of the measurements*

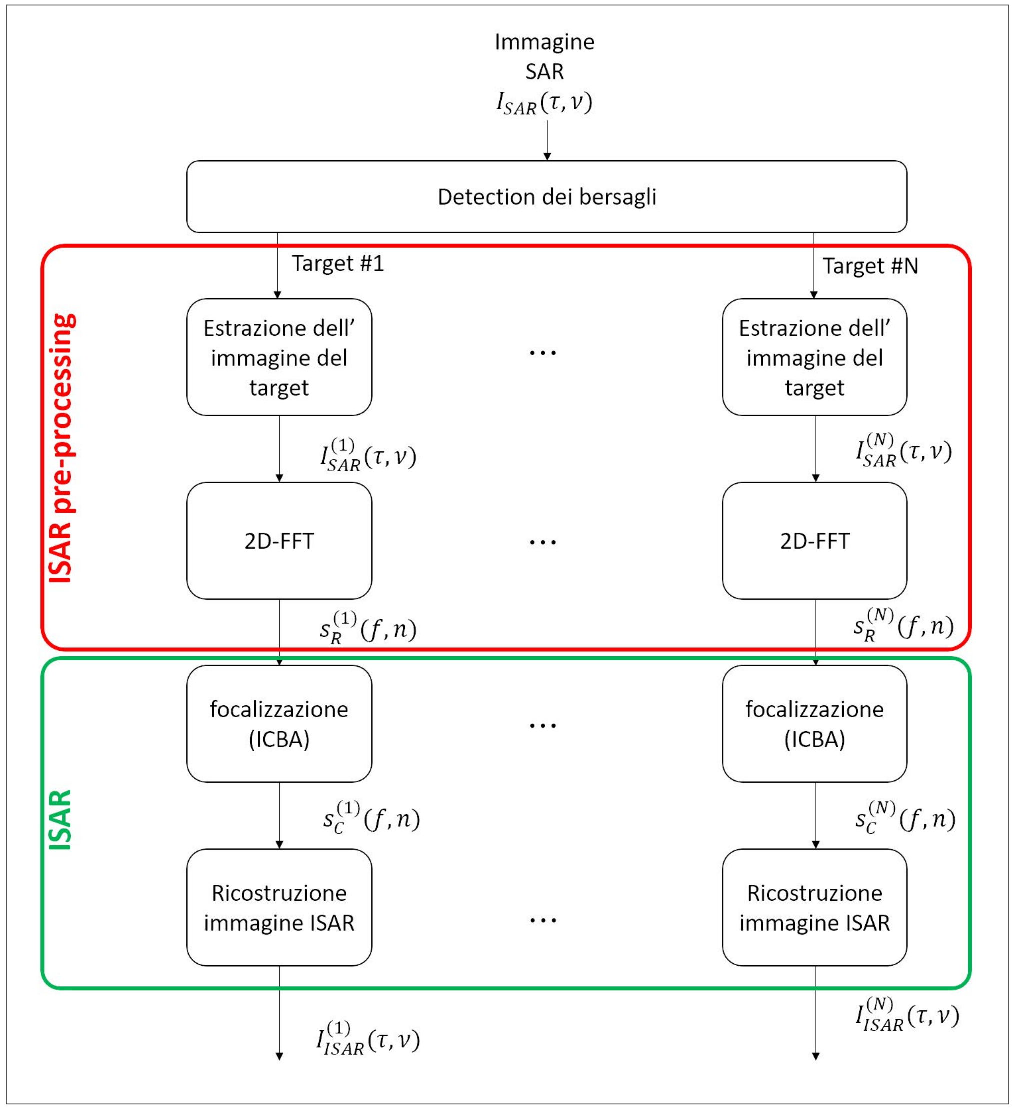
*(h) A picture of the cooperative target used in the measurements.*

# PROJECT SAMBA-X

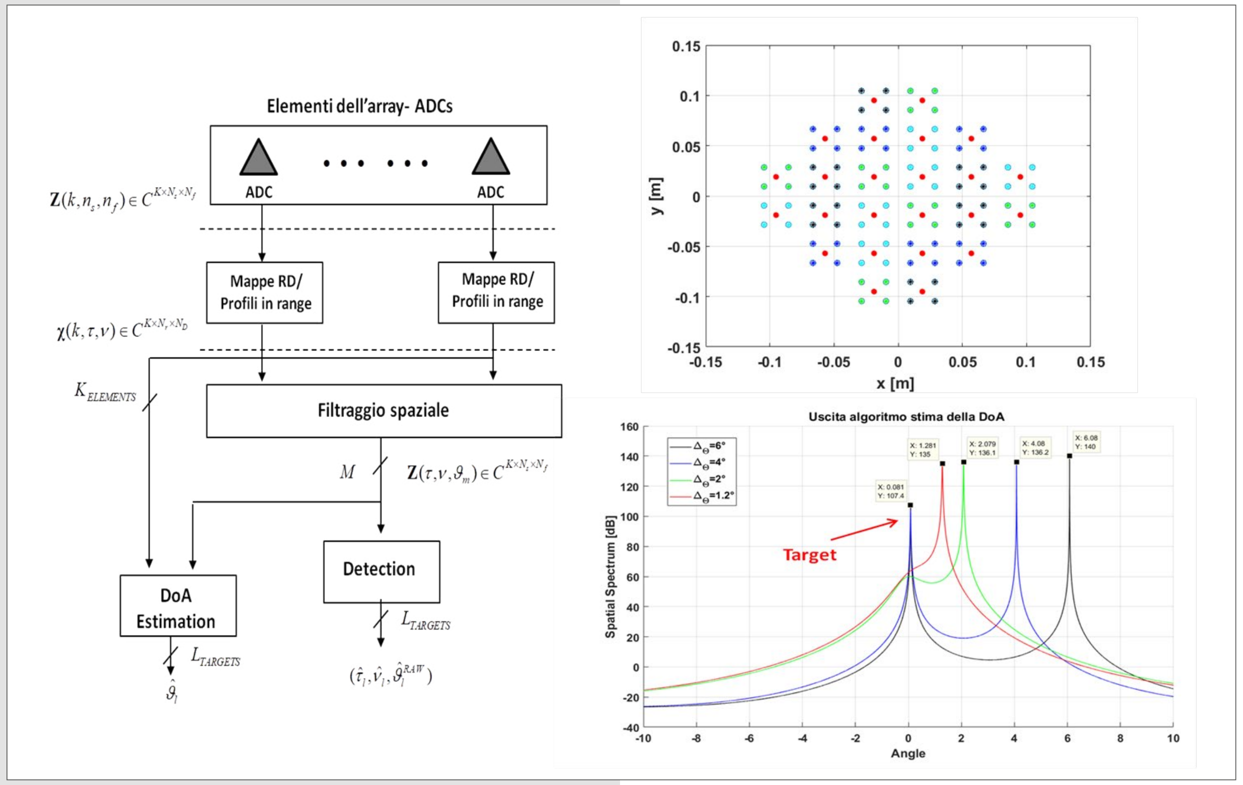
Seeker AESA multiruolo a basso costo in banda X per applicazioni navali

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.

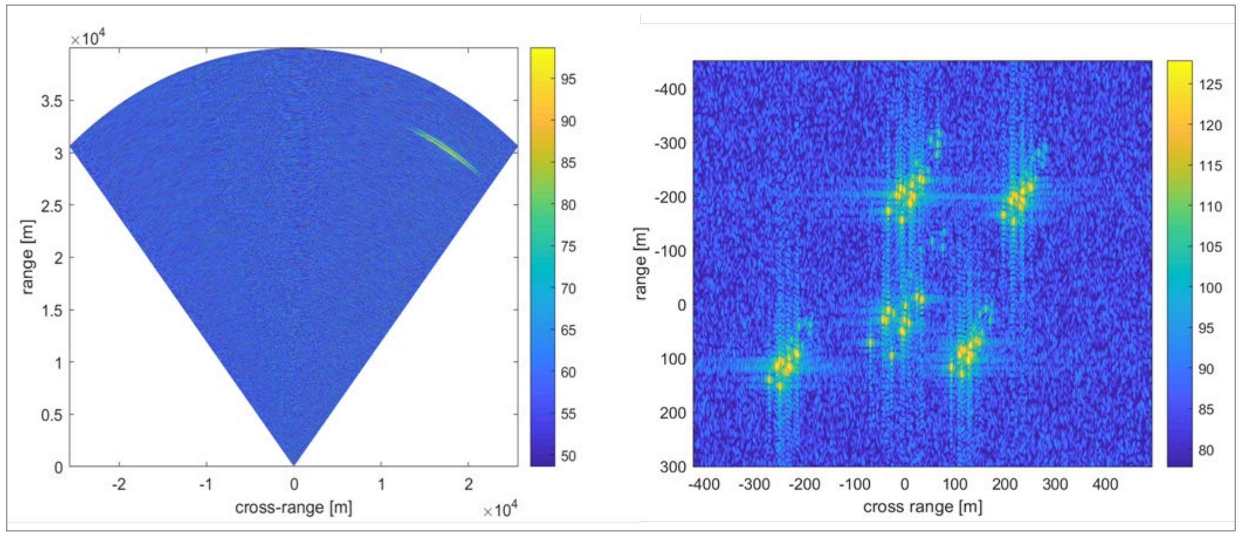
| Technical Sheet |
|---|
| **Funding institution:** |
| *Italian MoD* |
| **Project partners** |
| *ELDES s.r.l* |
| **Project duration** |
| *February 2020 - February 2022* |
| **Involved countries** |
| *Italy* |




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




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




*(c) Preliminary results on the radar imaging technique application*

# PROJECT SARAI

## SARAI - SAR signature simulation of targets

The objective of the project is to develop a simulated operating environment IMINT (Imagery Intelligence). This will be done through the formation of a multilevel deep learning network in order to “understand” the SAR images and time series by learning the functionalities without technical supervision and to carry out specific detection, classification and / or recognition tasks by specializing the technologies developed for the identified scenario. The objective of the activity is to support the execution of the tasks planned for Phase 1 of the SARAI project. In detail, the activity includes the following activities:

Task 1: • Development, calibration and test of a SAR signature simulator with the following functions:

- Exploitation of 3D CAD geometric models characterizing the target and the surface where the target is located.
- Exploitation of the physical parameters characterizing the target materials (directly or indirectly through the definition of the diffusion and reflection coefficients).
- Modeling of the SAR backscattering mechanism including the geometric configuration and reflection parameters of the material.

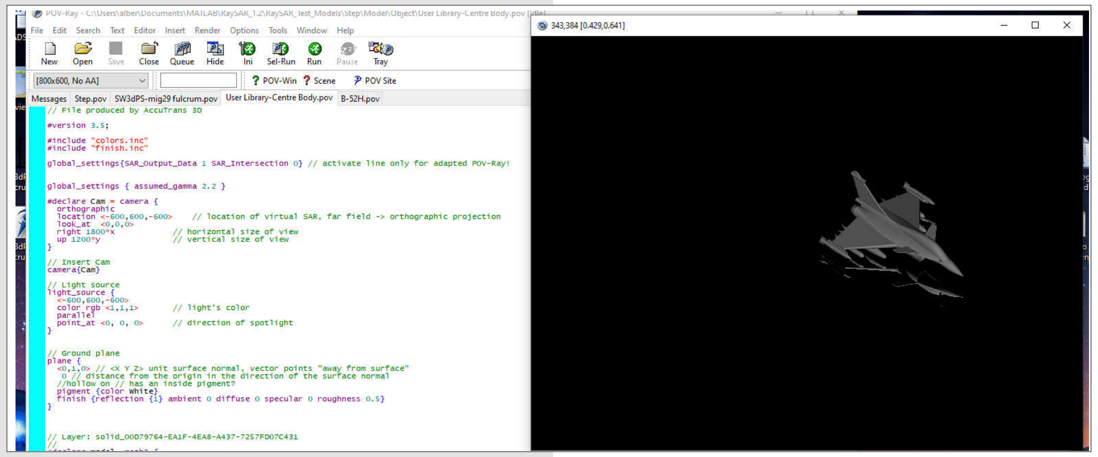
Task 2: • Identification, selection and collection of 3D geometric models of the targets of interest both open source and from commercial suppliers.

Task 3: • Management, adaptation and conversion of 3D geometric models as input from the SAR simulator.

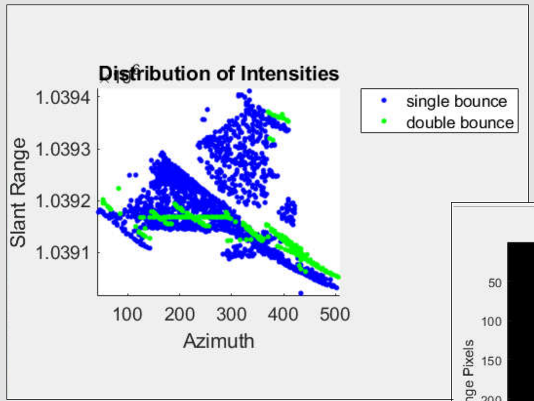
Task 4: • Generation of SAR signatures

Task 5: • Contribution to the project documentation relating to the SAR signature simulator.

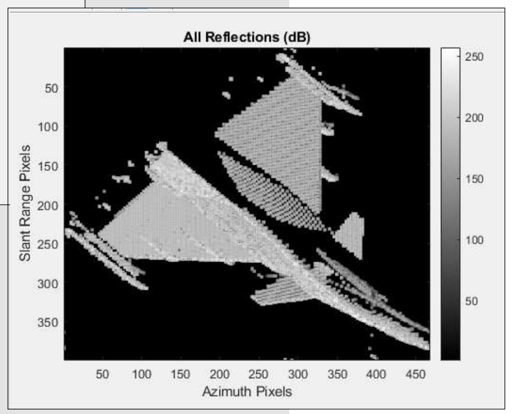
| Technical Sheet |
| --- |
| **Funding institution:** |
| *E-GEOS S.p.a* |
| **Project partners** |
| *E-GEOS S.p.a* |
| **Project duration** |
| *February 2021 - February 2022* |
| **Involved countries** |
| *Italy* |



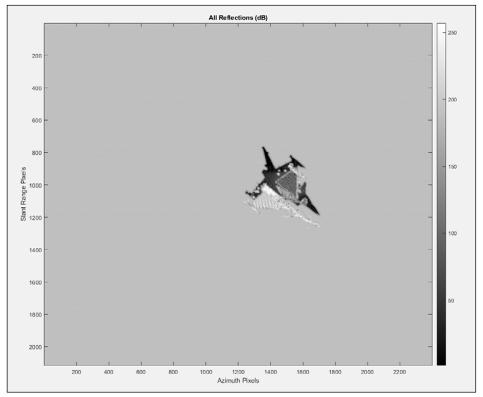
*(a) Ray - raytracing simulation environment*



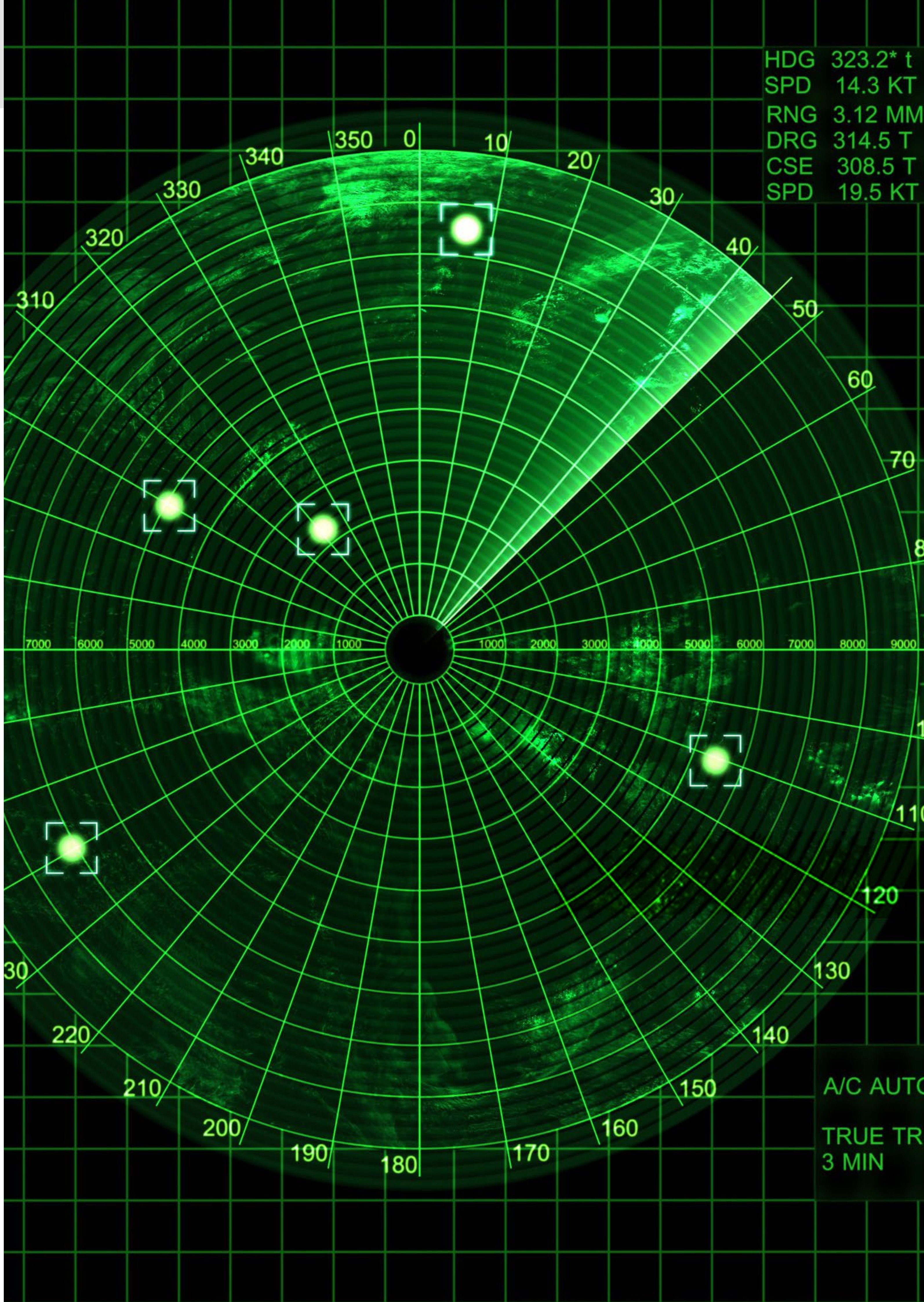

*(b) Reflection behaviour after SAR image simulation*




*(c) Simulated intensity of SAR image*




*(d) Simulation of SAR image in presence of clutter*



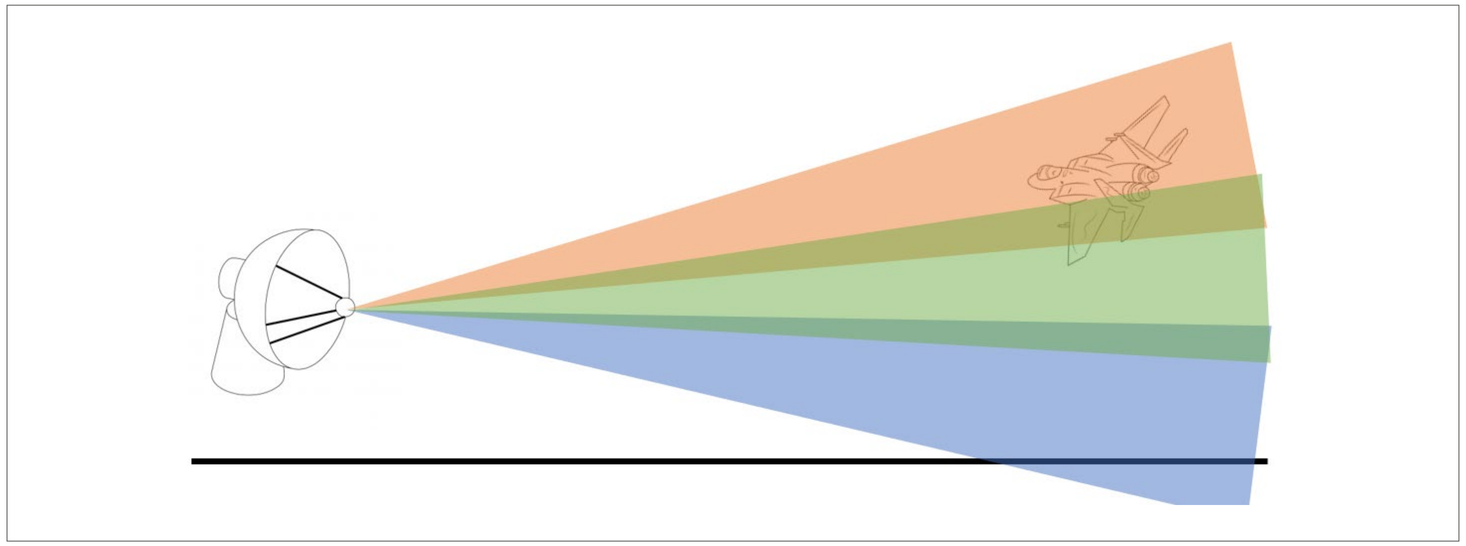
The objectives of this project are:

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, therefore in L band (1 GHz - 2 GHz) and 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.

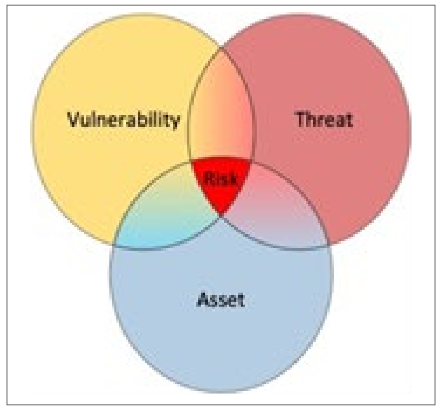
The proposed architecture will have characteristics of scalability, flexibility and adaptability that will allow future multifunction radar systems that will be based on it to:

- 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).

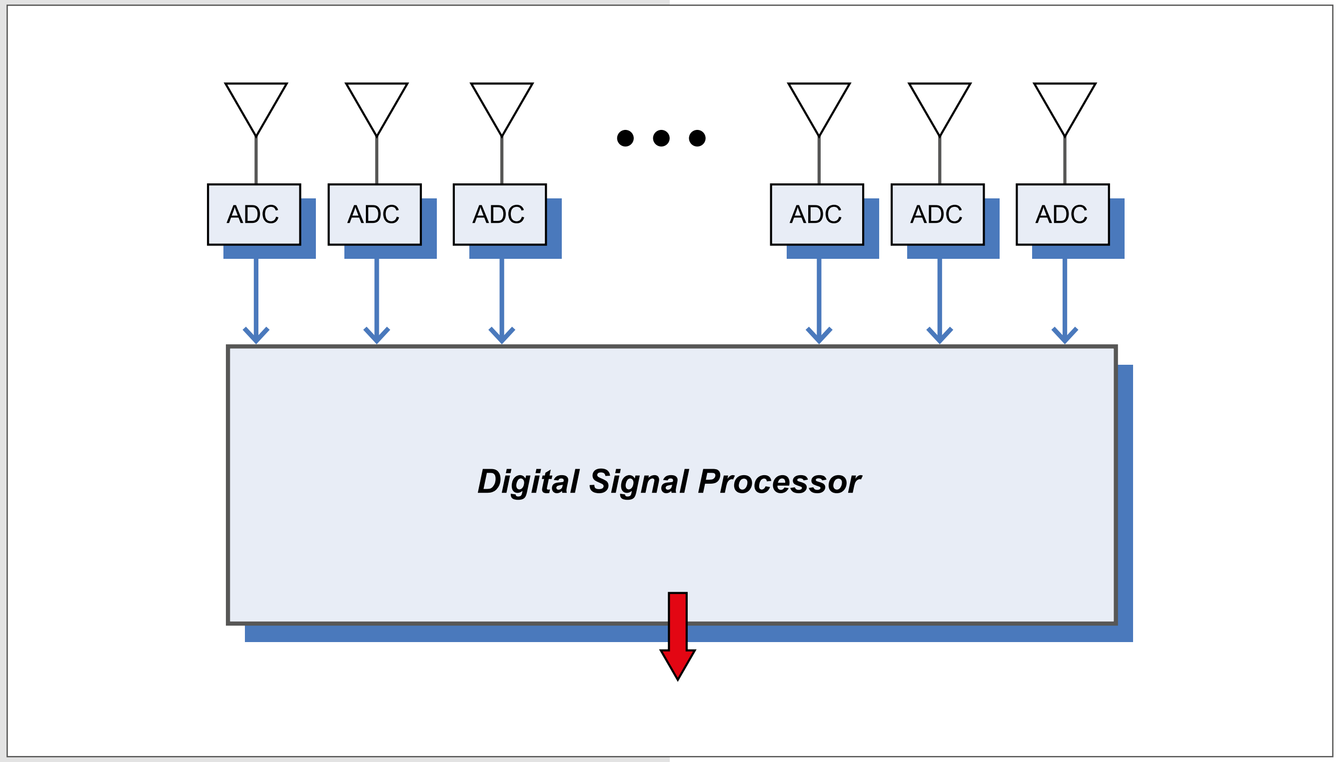
| Technical Sheet |
|---|
| **Funding institution:** |
| *Italian MoD* |
| **Project partners** |
| *Leonardo spa, Echoes srl* |
| **Project duration** |
| *April 2020 - April 2023* |
| **Involved countries** |
| *Italy* |



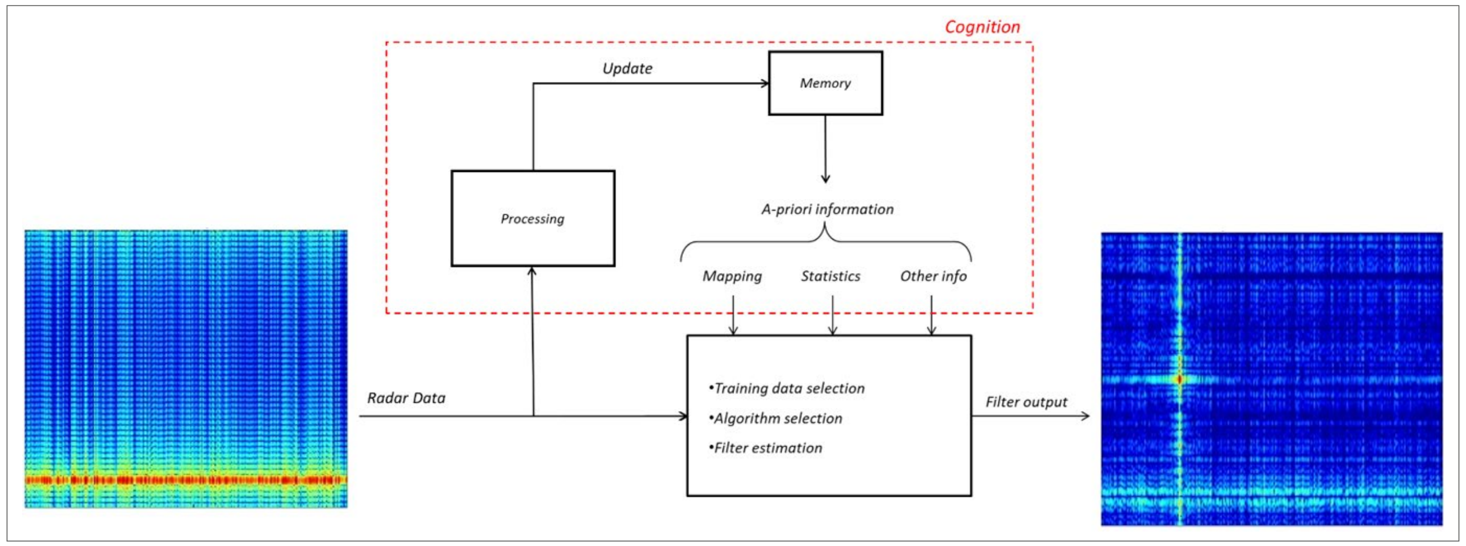
*(b) Simulated multiple fan-beam geometries*




*(c) Cyber risk concept representation*




*(a) Digital Array Radar Architecture*



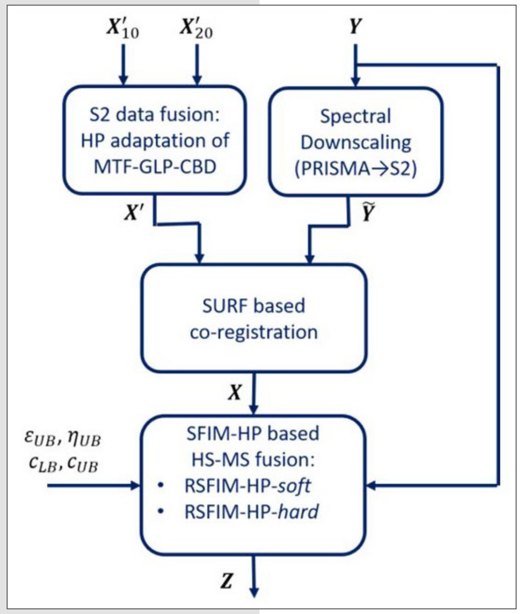

*(d) High level block diagram of the cognitive adaptive filter*

# PROJECT SR4IS

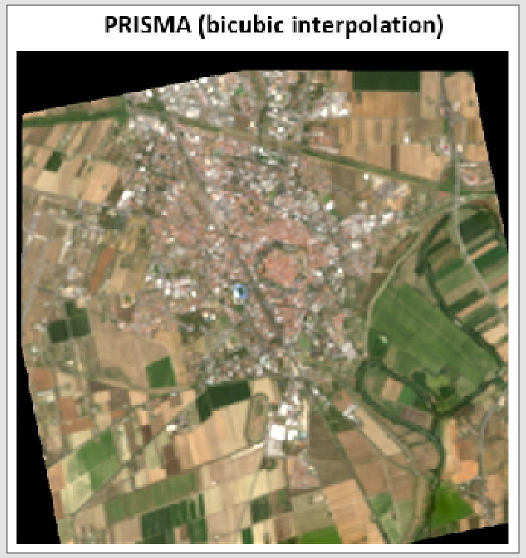
Super Risoluzione spaziale per immagini Iperspettrali Satellitari

The SR4IS project deals with the problem of improving the spatial resolution of hyperspectral data from the PRISMA mission of the Italian Space Agency. For this purpose, higher spatial resolution data from the Sentinel-2 (S2) mission are exploited. S2 is a wide-swath and fine spatial resolution satellite multispectral imaging mission of the European Space Agency (ESA) developed in the framework of the European Union Copernicus program.
S2 images include ten bands at 10 m and 20 m spatial resolution that are used to accomplish the PRISMA superresolution (SR) task. Specifically, during the project a new end-to-end procedure, called PRISMA-SR has been developed, that starting from the S2 data and the low resolution PRISMA image, provides a super-resolved image with a spatial resolution of 10 m and the same spectral resolution as the PRISMA hyperspectral sensor.
The first step of the PRISMA-SR procedure consists in fusing S2 data at different spatial resolutions to obtain a synthetic MultiSpectral image with 10 m spatial resolution and 10 spectral bands. Then, an unsupervised procedure is applied to co-register the fused S2 image and the PRISMA image. Finally, the two images at different spatial resolutions are properly combined in order to obtain the super-resolved hyperspectral image. Solutions for each step of the PRISMA-SR processing chain have been defined and analysed during the project. The effectiveness of the PRISMA-SR scheme has been tested on simulated data. Furthermore, real S2 and PRISMA images have been finally considered to test the PRISMA-SR procedure in a real application domain.

| Technical Sheet |
| --- |
| **Funding institution:** |
| *Italian Ministry of Defence (MoD)* |
| **Project partners** |
| *University of Pisa, National Research Council* |
| **Project duration** |
| *June 2021 - June 2022* |
| **Involved countries** |
| *Italy* |



*(a) Block diagram of the PRISMA-SR fusion scheme*

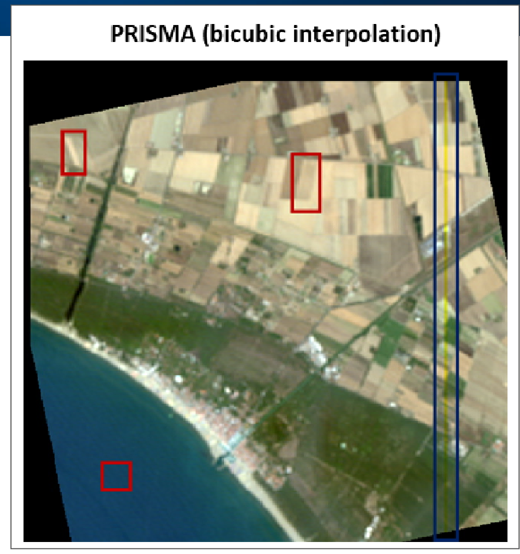


*(b) False Colour representation of PRISMA image*

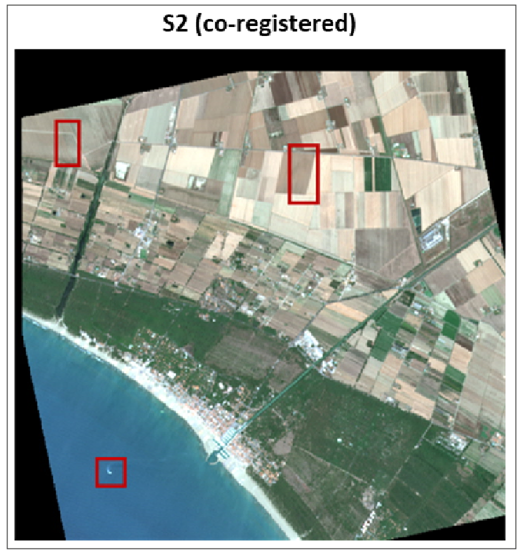
*(c) False Colour representation of S2 co-registered image*



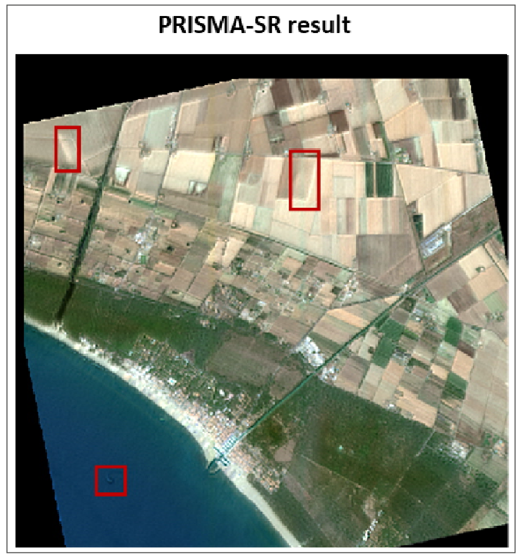
*(d) result of the PRISMA-SR procedure*



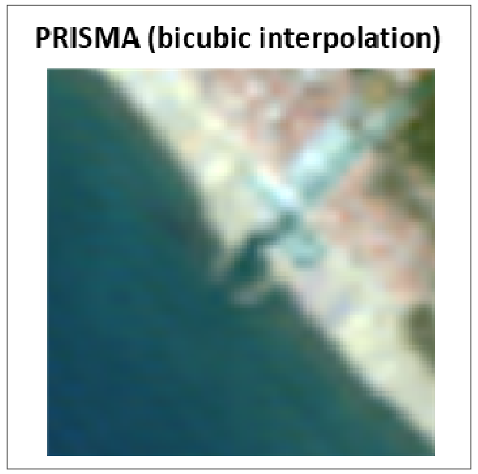
*(e) False Colour representation of PRISMA image*



*(f) False Colour representation of S2 co-registered image*



*(g) result of the PRISMA-SR procedure*



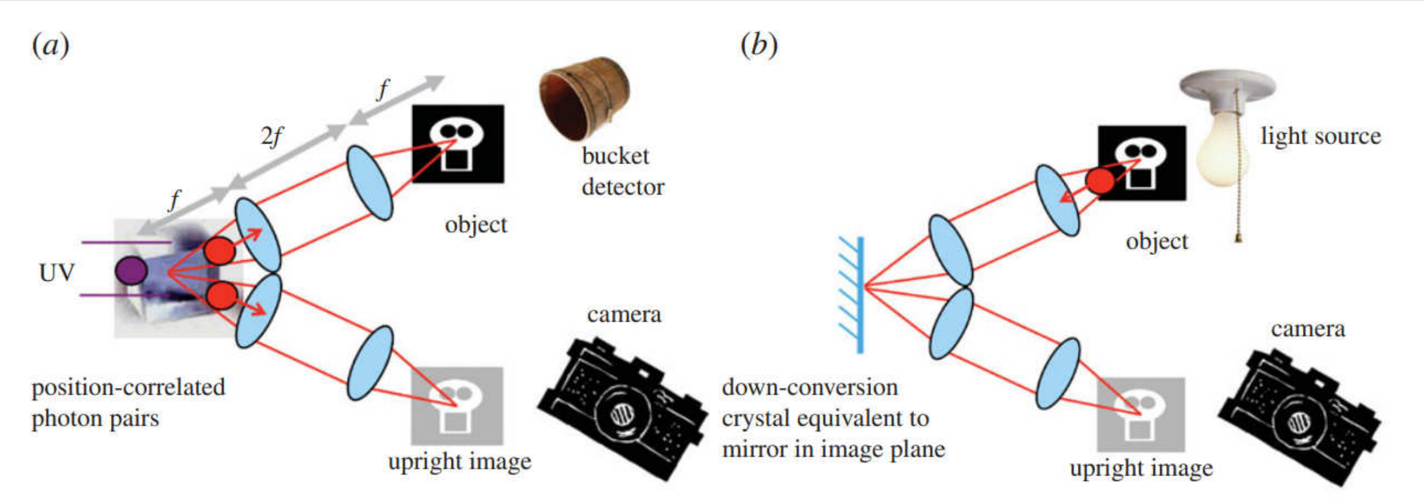
*(h) False Colour representation of PRISMA image*

*(l) result of the PRISMA-SR procedure*

*(i) False Colour representation of S2 co-registered image*

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.




*(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 [4]*

*[4] 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)*

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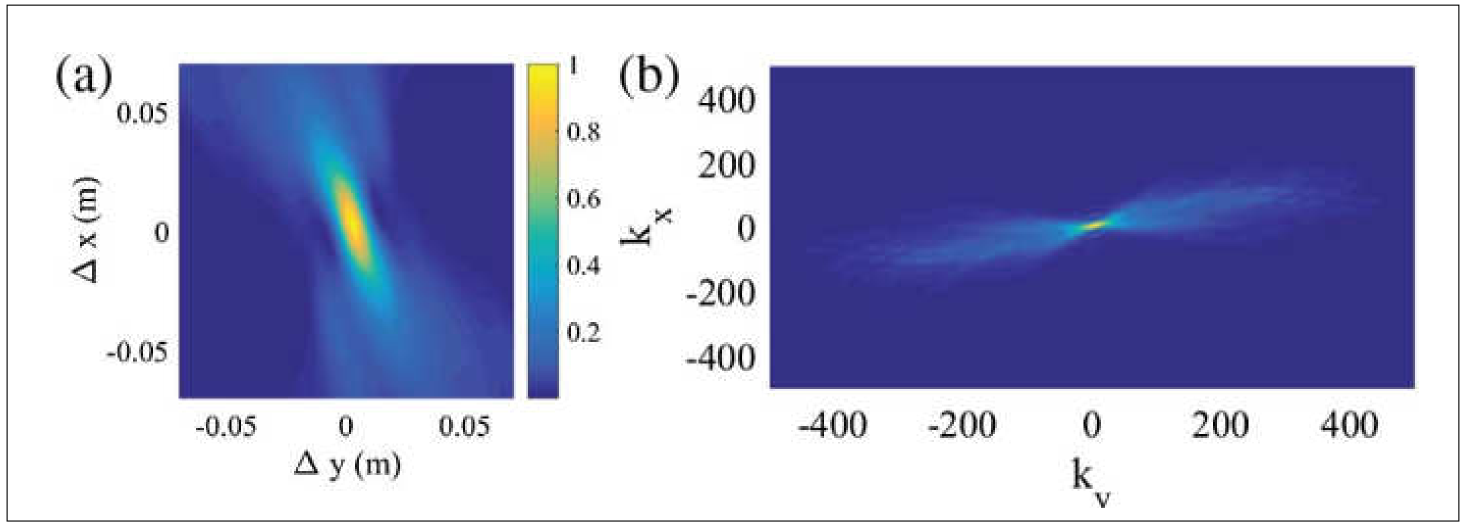
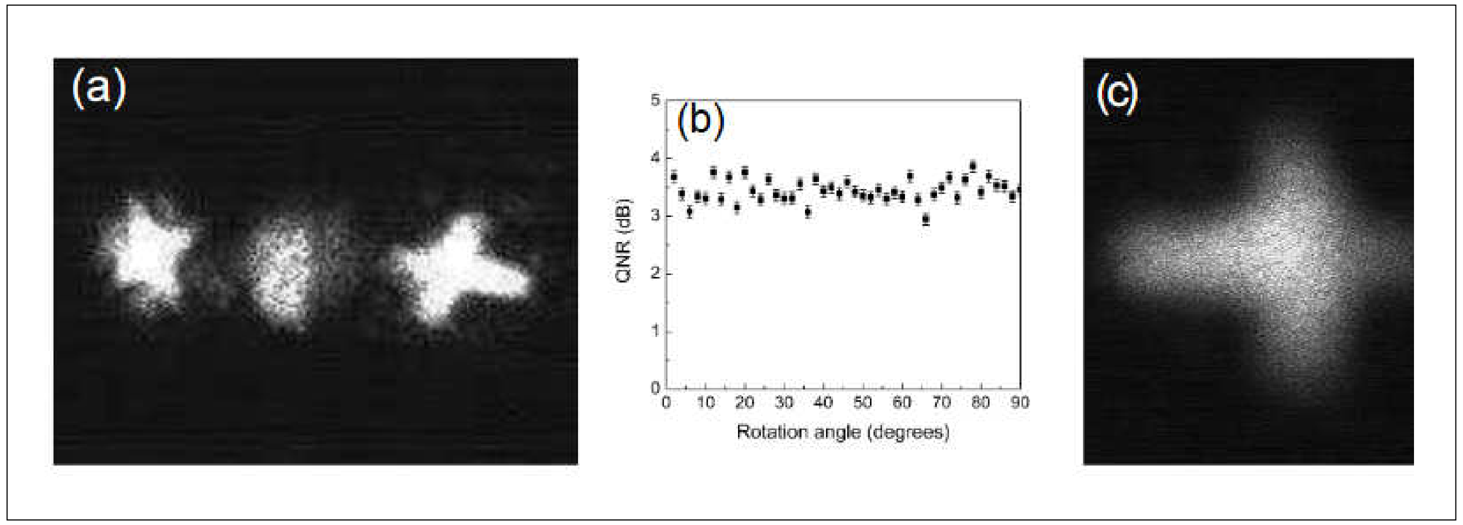
*[6] B. J. Lawrie e R. C. Pooser, «Toward real-time quantum imaging with a single pixel camera», Opt. Express, vol. 21, fasc. 6, p. 7549, Mar. 2013,*

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




*(b) right figure: 2D space-invariant approximation of incoherent PSF, for experimentally measured fields, left figure: Incoherent/optical transfer function corresponding to fields from a transmitting DMA displaced along the y axis by 30 cm[5]*




*(c) right figure: Image of conjugate, pump and probe beam profiles from left to right at the probe image plane; middle figure: quantum noise reduction as a function of cross rotation angle; left figure: a corresponding image of the conjugate in the conjugate image plane [6].*

# PROJECT WATER4AGRIFOOD



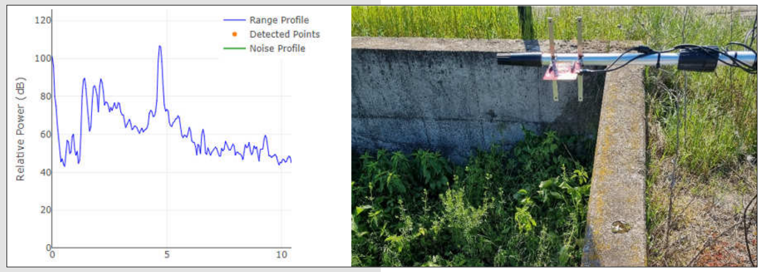
The water crisis: Global warming is the cause of climate change, weather anomalies and reduced rainfall. Over the last 50 years, the Mediterranean area has lost 100 millilitres of water per year.
Agriculture in distress: The unpredictability of the rains is putting agriculture, especially rainfed agriculture that relies solely on rainwater, in crisis. The risk is that it will not be possible to ensure water in quantity and quality to the agri-food chain.
No agrifood without water. Global warming is the cause of climate change which, in turn, leads to weather anomalies that we can all experience. What we observe is the unpredictability of rainfall. Without effective rainfall, it is not possible to ensure water in quantity and quality to the agri-food chain.
The project was set up to understand how to use and exploit water in farming systems in the South.
Public research bodies and private companies have formed a partnership to finalise industrial research actions and experimental development insights to innovate the water use in farms from which the raw materials for the agri-food chains originate. Possible solutions: It is urgent to find a remedy, or rather a range of solutions. A sort of tool box in which to choose the most suitable tool for farms.
Improving Mediterranean agri-food production under conditions of water scarcity seeks to find a solution to the problem of the lack of water available to farms and, more generally, to highlight its value for production purposes.

The Water4Agrifood project brings together expertise from industry and academic knowledge to build the right tools to make the best use of the water resources available to farms.
Regarding the development of sensors and data processing techniques for the remote monitoring of the geometry and water levels of the irrigation canal network, CNIT-RaSS performs the analysis and measurements acquired with a radar demonstrator exploiting some car-maker's hardware.

Water4AgriFood

| Technical Sheet |
| --- |
| **Funding institution:** |
| *Progetto Codice ARS01_00825 - Area di Specializzazione "Agrifood", PON R&I 2014-2020 e FSC* |
| **Project partners** |
| *UniCT-Di3A, Suez, Planeta, Irritec, CREA, ISEA, Tecno.El, CER, Polyeur, Bonifiche Ferraresi, Agriservice.* |
| **Project duration** |
| *November 2020 - May 2023* |
| **Involved countries** |
| *Italy* |

*(a) Signal acquired in real environment (irrigation channel)*




*(b) Signal received. The central peak corresponds to the power received from the water surface, the main peaks on the left correspond to the power received from the concrete abutment of the bridge*


*(c) Signal received. The central peak corresponds to the power received from the water surface, the main peak on the left correspond to the power received from the reflecting panel placed on the concrete abutment of the bridge.*



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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·GL

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Certificate No: 211274-2016-AQ-ITA-ACCREDIA | Initial certification date: 19 January 2017 | Valid: 20 January 2020 - 19 January 2023

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This certificate is valid for the following scope:
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*Figure 4 - Lab RaSS ISO 9001/2015 DNV certificate.*

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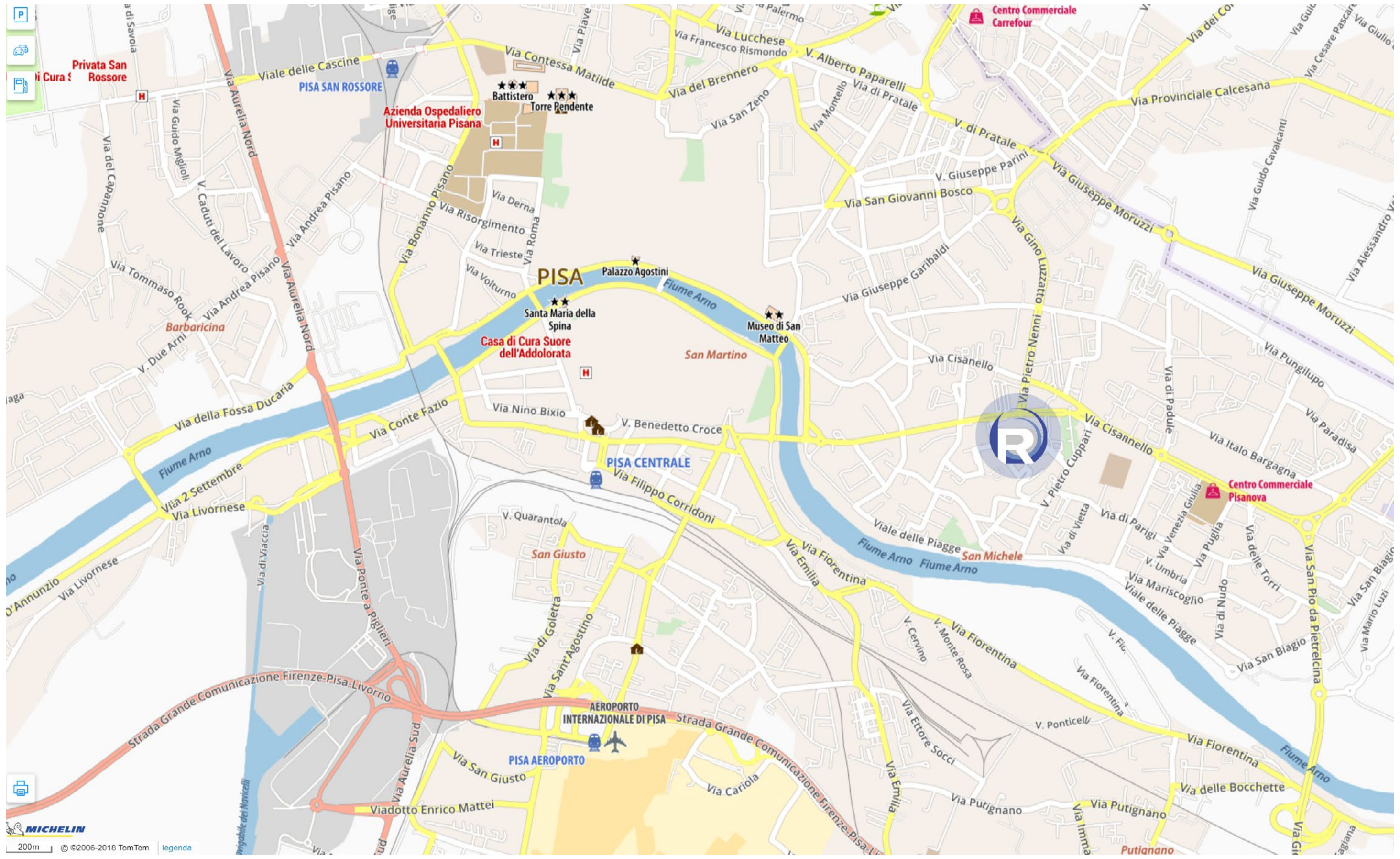

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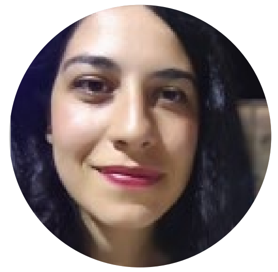

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