

PSC EUROPE FORUM CONFERENCE

**Radars for long distance maritime surveillance
and SaR operations (RANGER): Serving the
need for safer European seas**

DIMITRIS KANAKIDIS, EXUS

- RANGER ID
- Consortium
- Objectives
- RANGER concept & pilots
- RANGER vision & impact

- BES-01-2015: Radar systems for the surveillance of coastal and pre-frontier areas and in support of search and rescue operations
- "RANGER: RAdars for loNG distance maritime surveillancE and Search and Rescue opeRations"
- Grant agreement no: 700478

- Start date: 1 May 2016
- End date: 31 October 2019

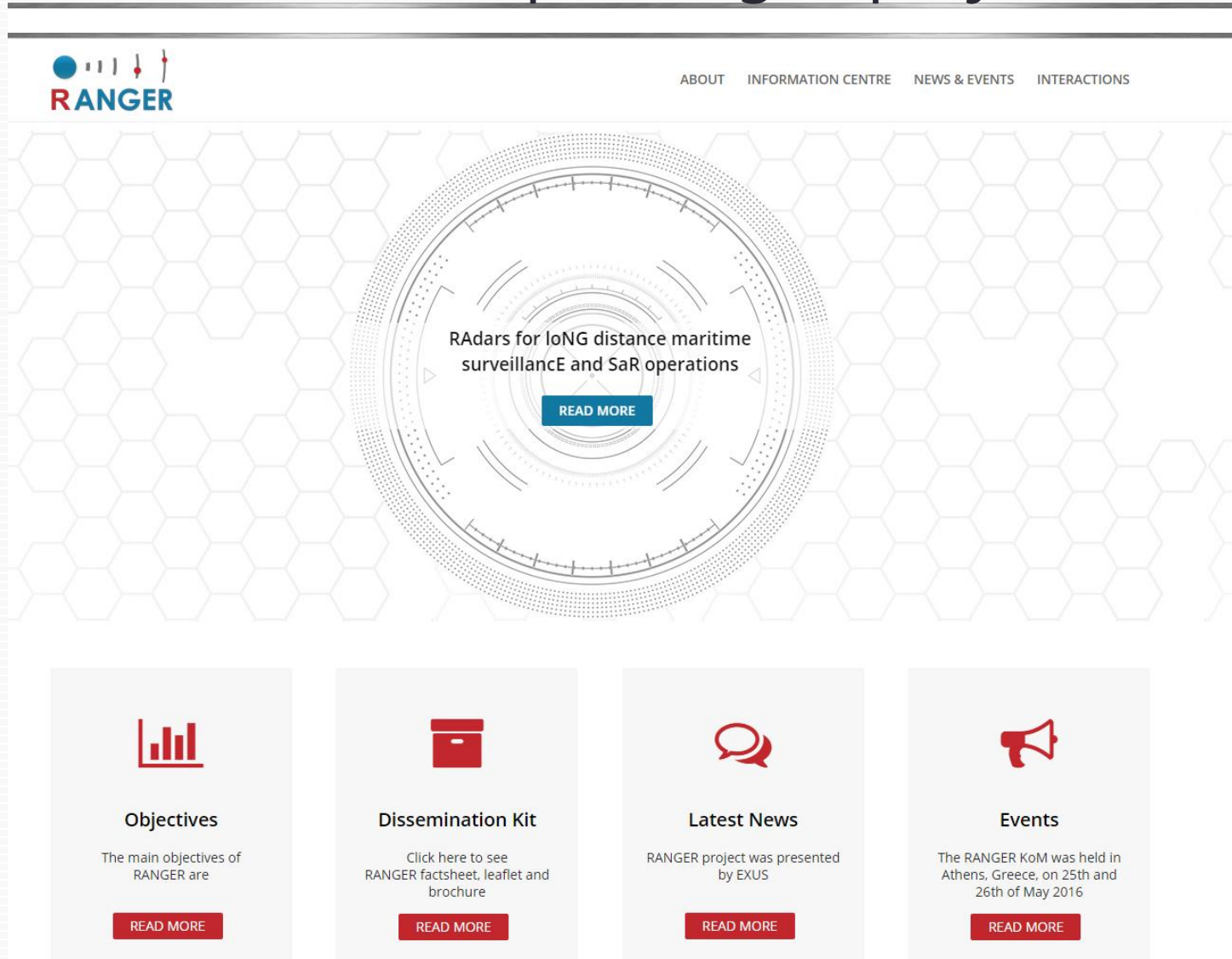
- Total budget: 7,992,312.50 €
- Total funding: 7,992,312.50 €

- 10 partners
- 7 countries
- 4 pilots
- 42 months



No	Participant organisation name	Type	Country
Technology providers			
1	EXUS Software Ltd (EXUS)	SME	UK
2	DIGINEXT (DXT)	IND	FR
3	Institute of Communications and Computer Systems (ICCS)	RTO	GR
4	Technische Universitaet Dresden (TUD)	RTO	DE
5	Laurea University of Applied Sciences (LAU)	RTO	FI
6	FINMECCANICA (FNM)	IND	IT
7	TELESTO Technologies (TEL)	SME	GR
8	NATO CMRE (NATO)	RTO	BE
Partner End-users			
9	Ministry of Defence (HMOD)	END USER	GR
10	Directorate of Maritime Affairs (DMA)	END USER	FR
Supporting End-users			
A	Italian Marina Militare	END USER	IT
B	European Coast Guard Functions Forum	END USER	BE
C	Direction générale des douane et des droits indirects	END USER	FR

- <http://ranger-project.eu/>



The screenshot shows the RANGER project website. At the top left is the RANGER logo. To the right of the logo is a navigation menu with the following items: ABOUT, INFORMATION CENTRE, NEWS & EVENTS, and INTERACTIONS. The main content area features a large circular radar graphic with the text "RADars for loNG distance maritime surveillancE and SaR operations" and a "READ MORE" button. Below this are four columns, each with an icon and a "READ MORE" button:

- Objectives**: The main objectives of RANGER are
- Dissemination Kit**: Click here to see RANGER factsheet, leaflet and brochure
- Latest News**: RANGER project was presented by EXUS
- Events**: The RANGER KoM was held in Athens, Greece, on 25th and 26th of May 2016

RANGER innovates by combining **novel and ground-breaking Radar technologies** with innovative supporting technological solutions for **early warning**, in view of delivering a **surveillance platform** that will offer detection, recognition, and identification as well as tracking of suspicious vessels capabilities far beyond existing legacy radar systems, seamlessly fitting and contributing to the CISE framework through the provision of on-demand **CISE compliant services**.

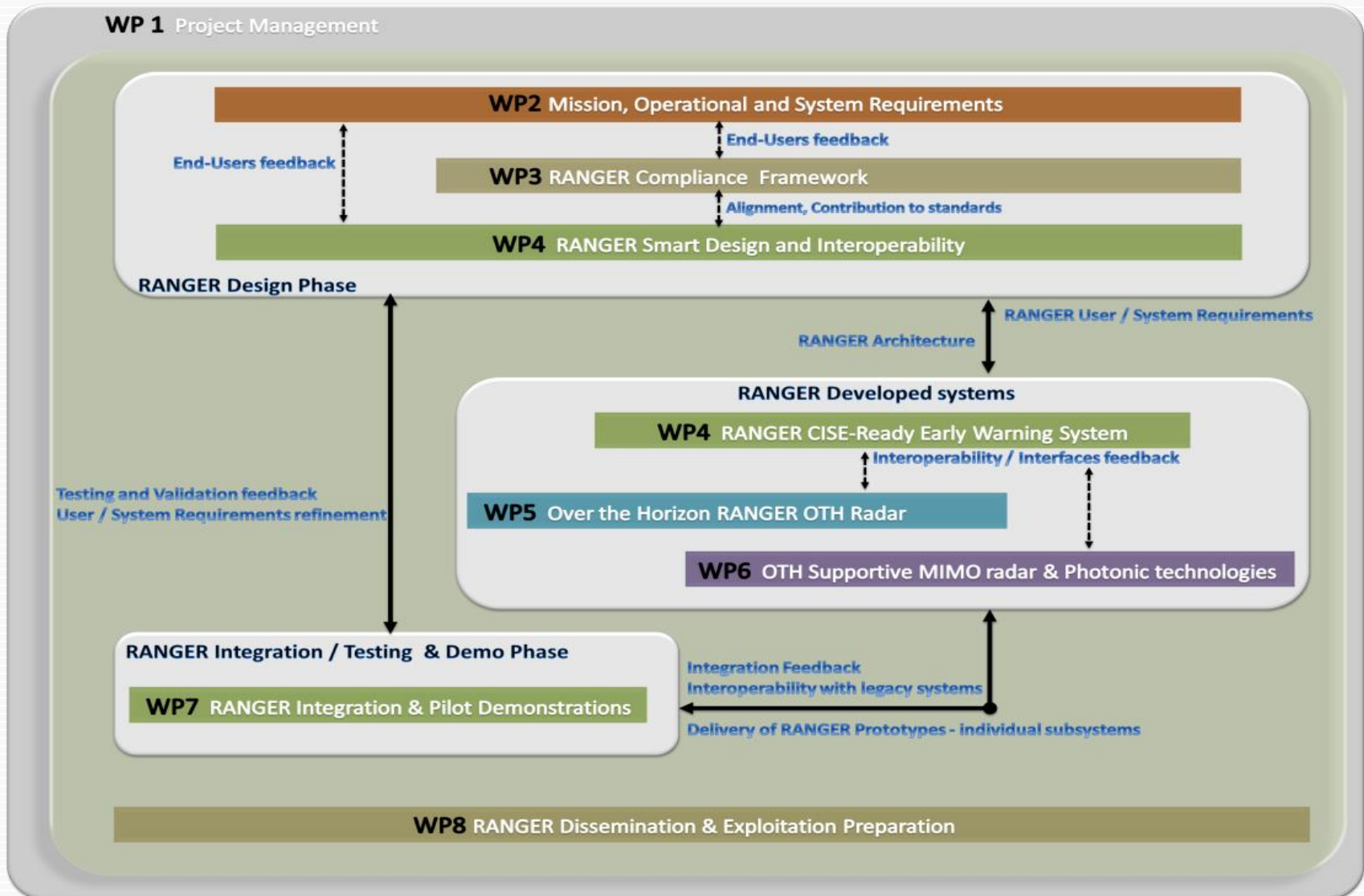
- **High-level Objective 1:** To provide a complete solution for traffic surveillance and search and rescue operations offering **vessel detection, recognition, and identification** capacities far beyond existing radars in terms of both target size and range for traffic surveillance and search and rescue operations
 - improving the detection range for smaller boats of the new Stradivarius Over-The-Horizon (OTH) Radar system
 - design and develop a novel Photonically Enhanced MIMO Radar configuration that will increase resolution and detectable target speed by order of magnitude
 - To design and develop a novel Early Warning System (EWS) that exploits deep and adaptable machine learning schemes able to Automatically Detect radar Targets

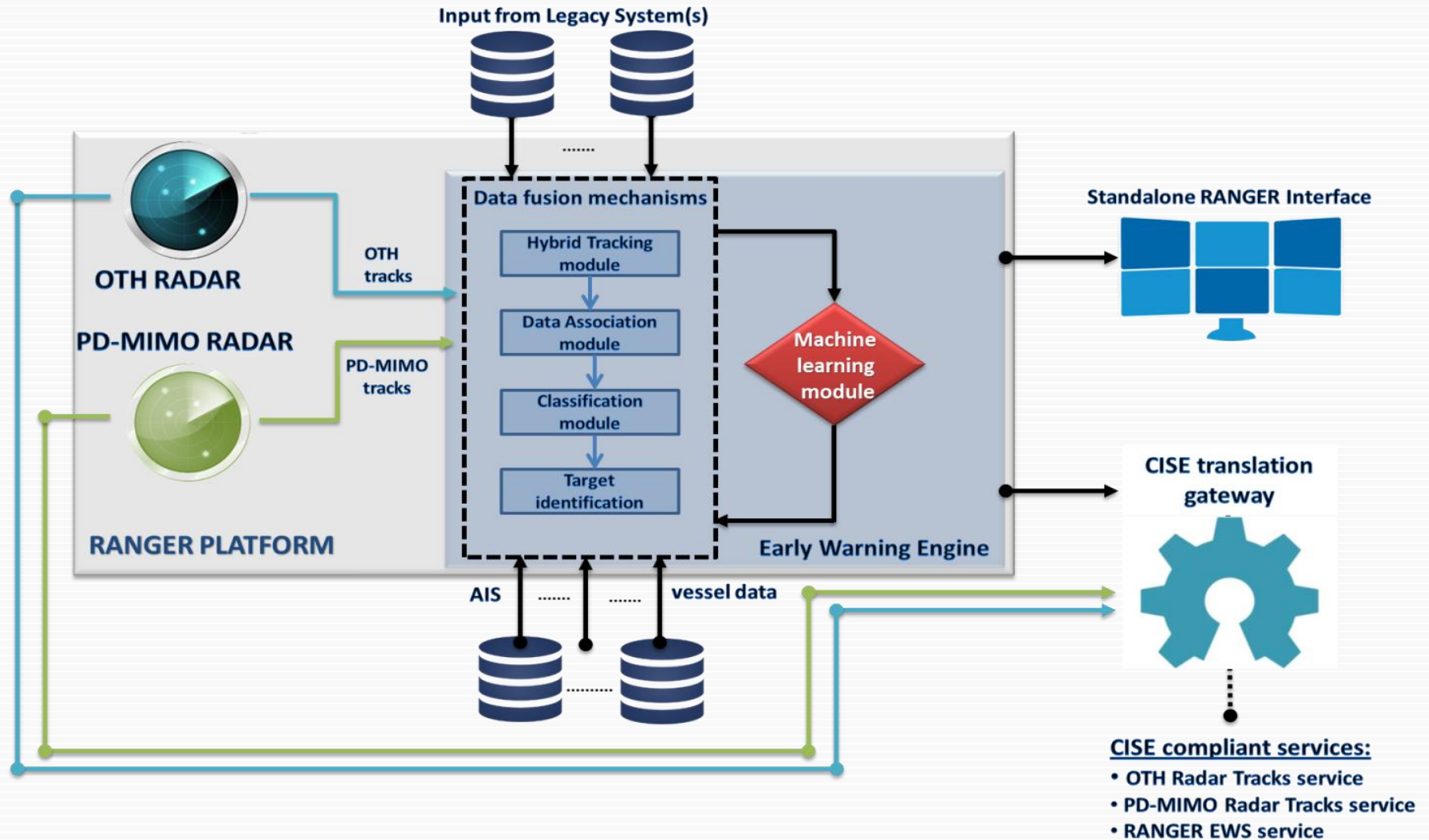
- **High-level Objective 2:** To **lower the total cost of ownership** (acquisition, installation, operation and maintenance) compared to existing radar solutions
 - To evaluate the benefits of trade-off on system design (e.g. use of a carrier frequency close to 9 MHz, use of new antenna array layout or antenna shape), in order to reduce antenna array size, antenna's number, and transmitted power
 - design radar systems with individual performances equivalent or superior to those obtained by using multiple legacy radar systems, resulting as such to cost effective solutions

- **High-level Objective 3:** To ensure **compatibility of the RANGER platform with CISE**, already from the design phase in order to safeguard seamless interoperability in line with the CISE compliance framework through a scalable set of CISE-ready RANGER services
 - Incorporate information with regard to the CISE framework from the design and architectural phase of the RANGER platform through close interaction loops, basically with EUCISE 2020 project
 - Develop a CISE translation gateway as an aggregator of interfaces that will allow the RANGER services to operate in a CISE compliant framework
 - Develop at least three CISE compliant RANGER services (the OTH Radar tracks, PE-MIMO Radar tracks, and Early Warning System) validated in a cross-country demonstration environment.

- **High-level Objective 4:** To **validate** and **demonstrate** the effectiveness of the **integrated RANGER** platform in **relevant environments** by the actual public authorities/end-users in **two terrain-diverse operational scenarios** that will be implemented in two phases each, accomplishing at the end of the project a TRL-6 level for the entire RANGER platform.
- To validate the integrated RANGER platform (in 2 phases) by the public authorities/ end-users in both Greece and France in conjunction with Italian Marina Militare (Italian Navy)

- **High-level Objective 5:** To define a **multilevel compliance framework** that RANGER solution will be aligned with.
 - To define Societal/Ethical/Legal constraints and establish the procedures that are needed to comply with current ethical, societal and legal frameworks
 - To smoothly integrate with landscape, while minimizing the environmental footprint
 - To gather currently used procedures, best practices and technical standards that should be followed during development phase to ensure system compatibility and interoperability with legacy systems
 - To be aligned with CISE/EUROSUR roadmaps
 - To analyse Drug Trafficking and Irregular Immigration trends and practices to gain knowledge and understanding of trafficking and irregular immigration in order to clarify the behaviour of the maritime surveillance targets





- **RANGER Over-The-Horizon Radar**



▪ RANGER Over-The-Horizon Radar

Existing OTH radar from Diginext

- above 25m long, up to 200Nm

Target OTH in Ranger

- down to 2m ASL (Above Sea Level); up to 150Nm

•Capabilities :

- High range detection radar (150 to 200 Nm)
- Continuous detection on the area of interest
- Limited power : between 400 W and 2 kW
- Limited environmental footprint



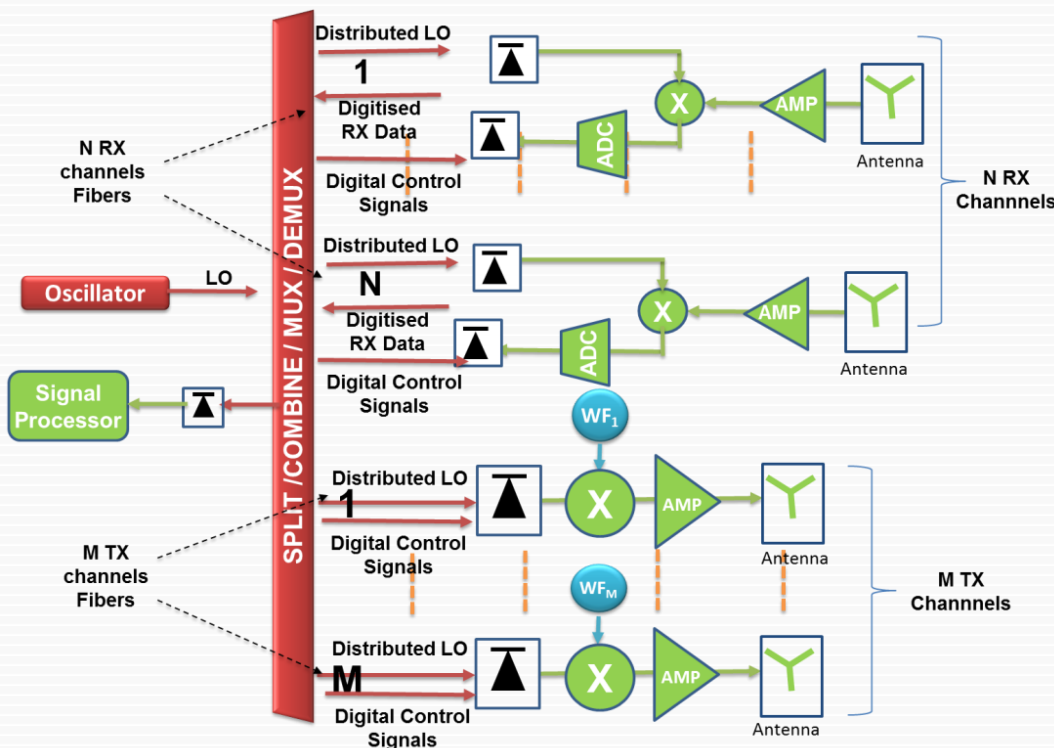
**RANGER OTH Radar detecting >25m long ships up to 200Nm from coastline (sea state 3)*







**RANGER OTH Radar detecting <12m long ships up to 150Nm from coastline (sea state 3)*

▪ RANGER Photonics-Enhanced MIMO Radar

- Detection of small and fast maneuvering vessels
- Extremely high resolution and very frequent scanning refresh cycles



OPT path	
EL path	
Waveform	
OPT-to-EL or EL-to-OPT Transducer	

▪ RANGER Photonics-Enhanced MIMO Radar

Core advantages: MIMO technology vs Standard Phased Array:

- Highly increased aperture size and resolution
- Increased probability of detection due to suppression of the Radar Cross Section (RCS) fluctuation problem
- Increased probability of detection due to higher SNR
- Number of targets detectable increased M_t times

Core advantages: PE-MIMO technology vs MIMO:

- Increase detection range due to photonic oscillators with minimum phase noise
- Massively increased aperture size due to additional transmit arrays
- By order of magnitude increased probability of detection due to strongly increased suppression of RCS fluctuation problem
- Further increased probability of detection due to higher SNR
- Enhanced spatial resolution due to usage of distributed antenna arrays
- By order of magnitude increased number of targets detectable

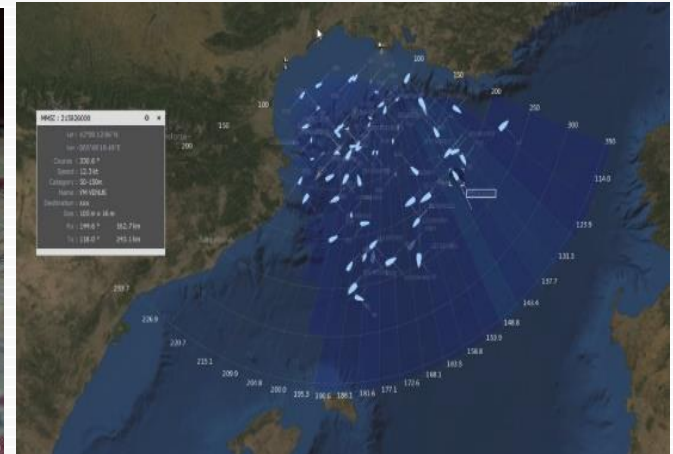
▪ RANGER Early Warning System (EWS)

EWS will be built upon **advanced Data fusion** algorithms and architectures as well as **novel deep machine learning** structures to provide:

- A **threat classification** of all simultaneously detected targets based on AIS data, historical data in available databases as well as maneuvering patterns of detected and tracked vessels.
- **Automatic Target Recognition (ATR)** through cross correlation of Radar and AIS data.
- **Target Continuous Tracking**, especially valuable for high-threat vessels.
- **Alarms** including collision warning, boundary violation and proximity alerts.
- **Recommendations on required interventions** based on risk assessment and self-training of threat detection models.



■ RANGER Advanced User Interface



Left: An example of an adaptive multimodal interface developed in DXT's INDIGO project for crisis management using a tactile surface and tangible interactive objects. Center: a physical ruler is placed on the table to define a zone and display the scale. Right: An example of a maritime surveillance interface developed with VirtualGeo.



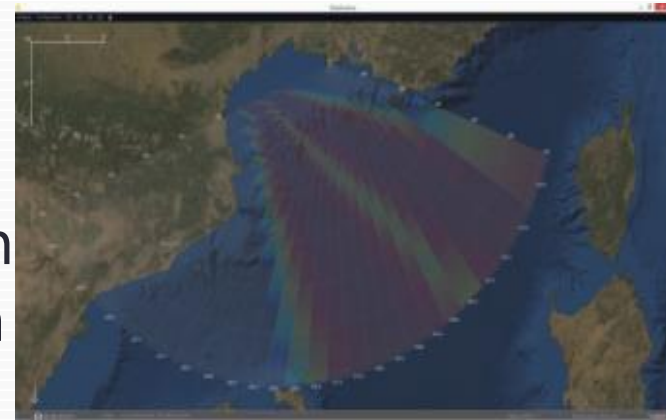
■ CISE translation Gateway

The CISE translation gateway is a layer that:

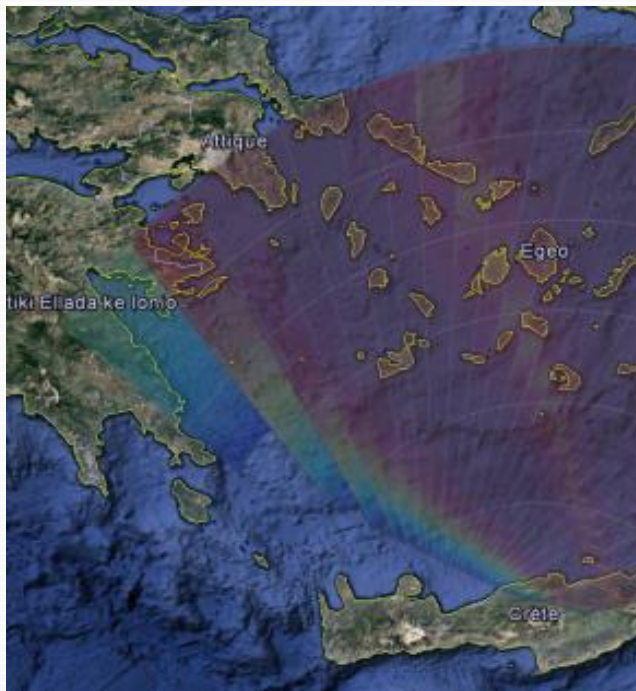
- will **serve as the connecting link** between the RANGER architecture's resources (RANGER platform and RANGER sensors) and the framework which implements the CISE concepts.
- will **serve as an aggregator of interfaces** that is responsible for receiving and collecting data from the field sensors (OTH, MIMO radar) as well as retrieving resources from the overall RANGER framework
- collectively translates the resources (data and metadata) into a **unified format that is CISE compliant** so that it is forwarded to the upper layer of CISE architecture (i.e. services) using a common CISE model.



- **Pilot Case 1:** Cross-country collaboration to confront drug trafficking and/or irregular immigration incidents in between French and Italian waters.
- **Challenges:**
 - Detect /track /identify non cooperative vessels travelling from South Mediterranean (Balearic Islands) towards Central Mediterranean and French/Italian shorelines.
 - Classify these vessels according to their threat level, based on cross-correlation and analysis of data originating from various sources (OTH Radar, PE-MIMO Radar, AIS, ATR using deep learning algorithms)
 - Get an early warning capability on Lion Gulf
 - Sharing of information between **French / Italian Authorities**
 - Fusion of real-time updated information to enhance situation awareness and efficient cooperation among neighbouring countries.



- **Pilot Case 2:** Cross country collaboration to face irregular immigration case that turns into a sea Search and Rescue Operation in Greek Archipelago and in between Italian/Greek waters



Scenario with OTHR in Crete



Scenario with OTHR in Aktio - Preveza complex

- **Pilot Case 2:** Cross country collaboration to face irregular immigration case that turns into a sea Search and Rescue Operation in Greek Archipelago and in between Italian/Greek waters
- **Challenges:**
 - Detect /track /identify non cooperative vessels travelling from Eastern Mediterranean (Greek coastlines) towards Central Mediterranean and Italian shorelines.
 - Classify these vessels according to their threat level, based on cross-correlation and analysis of data originating from various sources (OTH Radar, PE-MIMO Radar, AIS, ATR using deep learning algorithms)
 - Get an early warning capability before entering the Italian National waters
 - Exchange of information in real time between **Italian / Greek Authorities**
 - Fusion of real-time updated information to enhance situation awareness among neighbouring countries

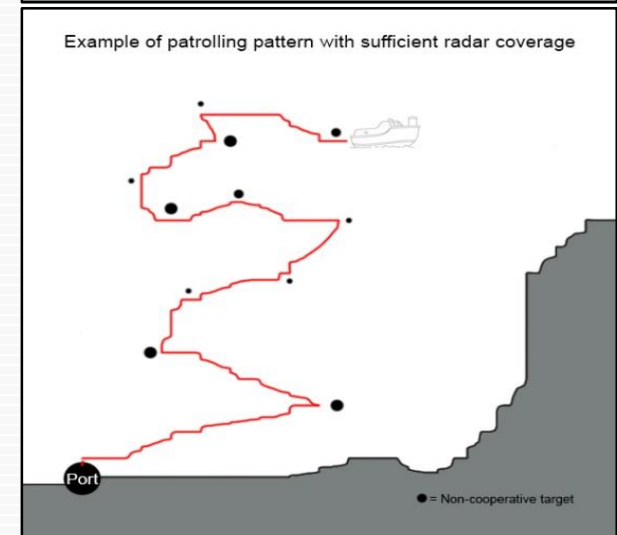
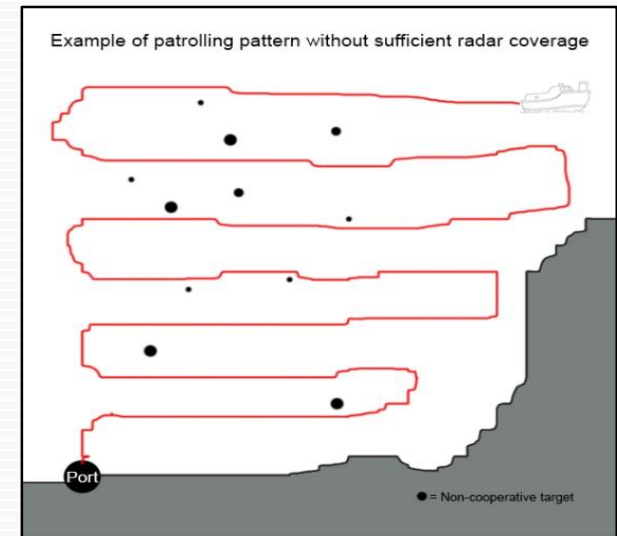
Gaps

- Traditional methods (VHF, radars) → lack of accuracy and time delays
- Illegal actions with small vessels:
 - Difficult to be detected
 - Abandoned or sank
 - Loss of lives

Expectations

- Complete solution
 - Improve the detection range with the OTH radar
 - Improve the performance of existing radars with MIMO technology
 - Design and develop a novel Early Warning System
- Lower the cost of ownership
- Compatibility between RANGER platform and CISE
- Close co-operation between end-users- research institutes-industry

- **Research and Innovation impact**
 - OTH Radar
 - PE-MIMO Radar
 - Deep Machine Learning
- **Impact on Maritime Surveillance and Operations**
- **Impact on Search and Rescue (SaR) operations**
 - Early detection of vessels with unusual behaviour allowing interventions to occur before any incident occurs
 - Optimization of end-user resources under SaR Operations
 - Efficient coordination of SaR Operations



Patrolling pattern examples

- **Impact on Irregular Immigration prevention**
 - a fully automated and self-learning platform
 - generate early warnings and detection alerts of “potentially suspicious” vessels
- **Impact on Illegal actions confrontation**
 - Comply with the CISE environment
 - Generates a common situational picture, improved detection and on-time identification of non-collaborative/suspicious small boats
 - Support enhanced and increasingly automated detection of abnormal vessel behaviours
- **Impact on the Maritime Surveillance Market**
- **Environmental impact**
 - Airspace is not affected
 - Land Use does not change
 - Local Wildlife Ecosystems Annoyance is expected to be minimum
 - Small Footprint and visual impact

Thank You!

DIMITRIS KANAKIDIS, EXUS
dkan@exus.co.uk