EO4LEAs: Advanced Geospatial Intelligence and AI for Enhanced Law Enforcement and Security Through Copernicus Integration, Multimodal Data Fusion and Digital Twins

#@APP-FORM-HERIAIA@#

List of participants

Participant No. *	Participant organisation name	Acronym	Country
1 (CO)	CENTER FOR SECURITY STUDIES	KEMEA	Greece
2	EUROPEAN UNION SATELLITE CENTRE	SATCEN	Spain
3	CDXI SOLUTIONS PC	CDXi	Greece
4	ETHNIKO ASTEROSKOPEIO ATHINON	NOA	Greece
5	ACCELIGENCE LTD	ACCELI	Cyprus
6	T4I ENGINEERING PRIVATE COMPANY	T4i	Greece
7	Serco (Czech Republic) SRO	SERCO	Czech Republic
8	DRAXIS RESEARCH VENTURES NON PROFIT SME	DREVEN	Greece
9	RADEXPERT CONSULTING & MANAGEMENT S.R.L	RAD	Romania
10	INSTITUT PO OTBRANA	BDI	Bulgaria
11	RESILIENCE GUARD SRL	RG	Italy
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13	LARNACA SEWERAGE AND DRAINAGE BOARD	LSDB	Cyprus
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1. Excellence #@REL-EVA-RE@#

1.1 Objectives and ambition #@PRJ-OBJ-PO@#

The EO4LEAs project aims to advance Copernicus Security Services, with a targeted focus on enriching surveillance capabilities across border, maritime, and critical infrastructure domains, as well as exploring their utility for civil security. This endeavour involves developing efficient processing chains, incorporating innovative data fusion and visualisation techniques, and applying artificial intelligence for real-time analysis to elevate the quality and efficiency of Copernicus services. The project's integrated approach is designed to enhance security and law enforcement responses to challenges such as climate change-induced migration, among others. In line with the visionary objectives of the Destination Earth (DestinE) initiative, the project aims to leverage digital twin technology for precise simulation and analysis of security threats. Additionally, it plans to utilise the Copernicus Data Space Ecosystem through ONDA Dias, enhancing the discoverability and interoperability of EO data. This ecosystem represents a significant evolution in EO data access, facilitating the creation of new applications and data products that leverage the extensive datasets available, including Sentinel images and commercial datasets. Following this strategic alignment with DestinE and the integration with the Copernicus Data Space Ecosystem, the project will introduce an innovative fusion of data sources, notably incorporating IoT data from Galileo-enabled devices and sensor data from UAVs. This data fusion is aimed to enrich and complement the already available offer of Copernicus data, enhancing the information available within the ecosystem and augmenting the digital twin models proposed by DestinE, offering a more comprehensive and detailed data layer for analysis. By seamlessly combining these diverse data streams, the project aspires to enhance the predictive analytics and situational awareness capabilities of security services, significantly contributing to an integrated, efficient, and responsive security framework. This will not only cater to the immediate surveillance needs of border, maritime, and infrastructure security but also anticipate and adeptly adapt to future security challenges, safeguarding Europe’s safety and strategic autonomy in an ever-changing global landscape. Aligned with the Copernicus Security Services Strategic Research Agenda, the project directly contributes to the overarching goals of enhancing the Copernicus Security Services through state-of-the-art data (SoA) technologies and tools, expanding service scope and user uptake, and fostering EU strategic autonomy and industrial competitiveness. This alignment ensures that the project's efforts are in sync with the strategic directions intended for the evolution and advancement of Copernicus Security Services, affirming its commitment to addressing the pressing and evolving security needs of Europe.

EO4LEAs provides a sophisticated, integrated security framework that leverages the full potential of Copernicus data, coupled with other data sources, through digital twin technologies, thereby enhancing European competitiveness and global security.

Through significant advancements in security surveillance and environmental monitoring, the project will contribute to developing resilient and adaptive security strategies, ensuring that Copernicus services remain responsive to the rapidly evolving security landscape.

1.1.1 Specific Objectives

EO4LEAs encompasses research and innovation objectives (RIOs) and impact-making objectives (IMOs), with respective research and innovation activities (RIAs) and impact-making activities (IMAs). Within this framework, each innovation endeavour is matched with key results (KRs), aiming to extend beyond the present SoA. Elevating beyond SoA is quantitatively determined by the benchmarks of the Key Performance Indicators (KPIs). The interconnected framework of EO4LEAs' objectives, activities, and anticipated impacts is illustrated in Figure *1*. More information regarding the KRs of EO4LEAs, their baseline Technology Readiness Levels (TRLs), and methodologies can be found in Sections 1.1.4 and 1.2.3, respectively.

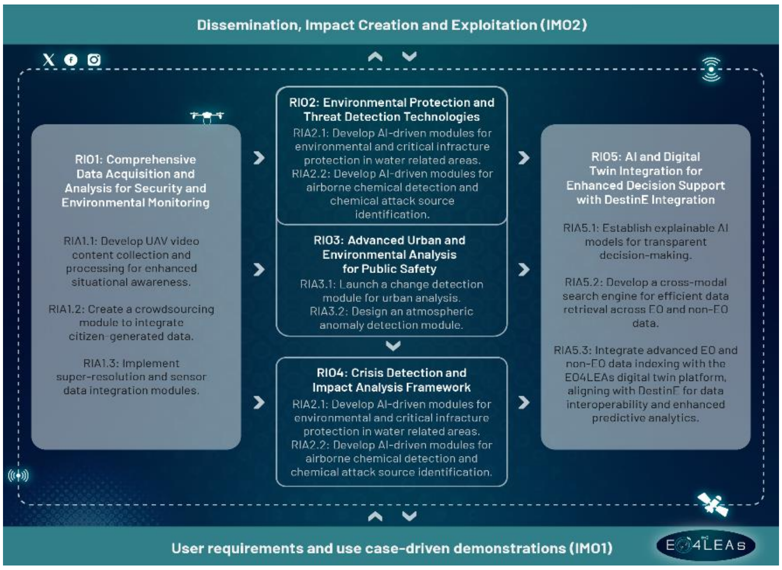


Figure 1: Schematic of EO4LEAs' Objectives and Activities Integration

RIO1: Data Acquisition and Analysis for Security and Environmental Monitoring			
The primary goal of **RIO1** is to harness comprehensive data acquisition and analytical methodologies for security and environmental monitoring applications. By integrating diverse data sources, including UAV video content, crowdsourced information, sensor data, and super-resolution imaging, this objective aims to enhance situational awareness and provide real-time responses to crises and environmental hazards. The focus is on developing robust modules that process and analyse data efficiently, ensuring that law enforcement agencies and environmental monitoring bodies have access to accurate and actionable intelligence. This multi-faceted approach seeks to improve the quality and speed of decision-making processes, thereby contributing to safer communities and healthier environments.			
RIA1.1: Develop UAV video content collection and processing for enhanced situational awareness.	**KR01:** UAV video content collection and processing	**KR01 KPIs:** Processing Power Requirements: ≤ 20% reduction during pilots Mean Time and Standard Deviation for Data Retrieval: ≤ 30% reduction during pilots	D4.1, D5.1
RIA1.2: Create a crowdsourcing module to integrate citizen-generated data.	**KR02**: Crowdsourcing module	**KR02 KPIs:** Crawling efficiency: timely collection of relevant data about real-word events	D4.2, D5.2

RIA1.3: Implement super-resolution and sensor data integration modules.	**KR03:** Sensor data wrappers **KR09:** Super resolution module	**KR03 KPIs**: Data Quality Assurance; Sensor Network Coverage; **KR09 KPIs**: +10% increase on accuracy in detection tasks with the super-resolved images	D4.1, D5.1 D6.1, D7.1

RIO2: Environmental Protection and Threat Detection Technologies

RIO2 focuses on advancing technologies for environmental protection and the detection of various threats, emphasising the development of innovative solutions for algae bloom monitoring, oil spill detection, and airborne chemical threat identification. Through the integration of AI-driven modules, this objective seeks to provide accurate forecasting, rapid identification, and effective mitigation strategies for environmental hazards and chemical threats. The aim is to enhance the capability of LEAs and other stakeholders in monitoring environmental health and responding to potential security risks with precision and efficiency. By leveraging state-of-the-art analytical tools and algorithms, RIO2 endeavours to safeguard natural ecosystems and public health, while also ensuring a proactive approach to threat detection and crisis management.

RIA2.1: Develop AI-driven modules for environmental and critical infrastructure protection in water related areas.	**KR04**: Algae bloom monitoring and forecasting module **KR05:** Oil spill detection module **KR06**: Early warning and monitoring system for geotechnical failures and landslide risks based on interferometric, GNSS, and UAV data	**KR04, KR05 KPIs**: +12% improvement in accuracy; +80% in detection probability **KR06 KPIs**: At least 3 critical assets are covered; At least 200 square km of area monitored	**D6.1, D7.1**
RIA2.2: Develop AI-driven modules for airborne chemical detection and chemical attack source identification.	**KR07:** Embedded AI for autonomous airborne chemical detection payload module **KR08:** Source localization of chemical attacks module	**KR07 KPIs:** Near real time discrimination of 2 partially co-eluting peaks (compounds) during the GC analysis KPIs:	**D6.2, D7.2**

RIO3: Advanced Urban and Environmental Analysis for Public Safety

RIO3 is dedicated to conducting advanced urban and environmental analysis to bolster public safety. It aims to merge cutting-edge urban analysis and change detection methodologies with atmospheric anomaly detection capabilities, facilitating comprehensive monitoring of urban development, environmental conditions, and potential safety threats. This objective underscores the importance of leveraging high-resolution data and sophisticated analytical tools to identify and assess factors affecting urban environments and public well-being. By providing actionable insights into urban growth patterns, environmental anomalies, and potential hazards, RIO3 supports informed decision-making and proactive public safety measures, ensuring communities are better prepared to respond to and mitigate risks associated with urbanisation and environmental changes.

RIA3.1: Launch a change detection module for urban analysis.	**KR10:** Change detection module	**KR10 KPIs**: +10% increase in F1, Precision and Accuracy, Time performance on the produced products	**D6.1, D7.1**
RIA3.2: Design an atmospheric anomaly detection module.	**KR11:** Atmospheric anomaly detection module	**KR05 KPIs**: +10% precision in identification; Reduction in false positive/negative rates by 20%	

RIO4: Crisis Detection and Impact Analysis Framework

RIO4 aims to establish a comprehensive framework for crisis detection and impact analysis, enabling early identification, assessment, and management of potential crises and their consequences. By developing a multimodal crisis detection module alongside risk and impact assessment tools, this objective facilitates a multidimensional approach to understanding the scope and severity of emergencies. The integration of diverse data sources enhances the capability to pinpoint emerging threats rapidly and assess their potential impact on communities and environments. This framework is designed to support stakeholders in making informed decisions, prioritising

response efforts, and implementing effective mitigation strategies. Through RIO4, agencies and organisations gain access to essential insights that drive proactive and effective crisis management, ultimately contributing to the resilience and safety of societies facing complex emergencies.			
RIA4.1: Develop a multimodal crisis detection module.	**KR12:** Multimodal crisis detection module	**KR12 KPIs**: + 10% Accuracy, Precision, Recall, F-score, Rating of usefulness (4/5 in Likert scale) on EO4LEAs' use cases	**D6.3, D7.3**
RIA4.2: Implement risk and impact assessment modules.	**KR13:** Impact assessment module **KR14:** Risk assessment module	**KR13 KPIs**: Estimates of loss within 1 million euros. **KR14 KPIs**: Spatial resolution <500m or city block level.	**D6.7, D7.4**

RIO5: AI and Digital Twin Integration for Enhanced Decision Support with DestinE Integration			
RIO5 aims to synergize all AI solutions and diverse data streams, including UAV footage, IoT sensor data, and social media insights from EO4LEAs, into a unified digital twin platform. This integration is meticulously designed to enhance decision-making processes for Law Enforcement Agencies (LEAs) and other stakeholders by providing a holistic view of environmental and security scenarios. By embedding advanced AI technologies and leveraging the comprehensive data streams within the digital twin framework, RIO5 enhances its role as a pivotal tool for scenario analysis, predictive analytics, and strategic planning in support of the Copernicus for Security services. The objective encapsulates the essence of marrying real-time and theoretical data flows with AI-driven insights, aiming to furnish LEAs and relevant entities with actionable intelligence for informed decision-making. The collaboration with the Destination Earth (DestinE) initiative further enriches this objective, ensuring interoperability with a broader geospatial data ecosystem and models, thereby driving innovative, data-led approaches to address the multifaceted challenges in crisis management, environmental protection, and public safety. Through RIO5, stakeholders are empowered with a dynamic and interactive simulation platform that mirrors real-world complexities, aligned with the goals of Copernicus for Security, to advance public safety and environmental monitoring initiatives.			
RIA5.1: Establish explainable AI models for transparent decision-making.	**KR15:** Explainable AI module	**KR15 KPIs:** Explainability Index: >80% stakeholder comprehension. Robustness to Attacks: Performance degradation <5%. Bias Reduction: Fairness improvement >20%. Decision Rule Accuracy: >85% expert alignment.	**D8.2, D9.1**
RIA5.2: Develop a cross-modal search engine for efficient data retrieval across EO and non-EO data.	**KR16:** Foundation model and question-answering interface for Copernicus security applications **KR17**: Cross-modal search engine	**KR16 KPIs**: >= 5 data modalities; >= 3 vision encoders and 1 LLM; Query answering time < 5 seconds; >= 3 different SSL architectures for Security related applications; >= 1 multimodal alignment algorithm **KR17 KPIs:** +10% for Mean Average Precision, Precision, Recall, F-score, Rating of usefulness (4/5 in Likert scale)	

RIA5.3: Integrate advanced EO and non-EO data indexing with the EO4LEAs digital twin platform, aligning with DestinE for data interoperability and enhanced predictive analytics.	**KR18:** Advanced EO and non-EO data indexing and DestinE. **KR19**: EO4LEAs digital twin platform	**KR18 KPIs:** Number of additional data sources to be indexed >3 modalities, Information retrieval time < 10%. **KR19 KPIs:** Reusability, scalability, interoperability, efficiency and security; Rating of usefulness (4/5 in Likert scale)	**D8.1, D8.3, D9.2**

The produced outcomes of EO4LEAs will also be evaluated, disseminated, communicated, and exploited by all partners. The KPIs of the following IMOs and IMAs are presented in Section 2.

IMO1. User requirements and use case-driven demonstrations	
IMA1.1 Use case design, stakeholder engagement user requirements.	**D10.1**
IMA1.2 Development of the validation scenario and evaluation methodology.	**D10.2**
IMA1.3 Pilot preparation, planning and user training.	**D3.2**

IMO2. Dissemination, Impact Creation and Exploitation	
IMA2.1 Communication, dissemination, clustering and standardisation activities.	**D10.2**
IMA2.2 Market analysis, industrial requirements and business models.	**D11, D12.1**
IMA2.3 Exploitation and Sustainability plan, Intellectual Property (IP) protection for the proposed solutions.	**D11, D12.2**

1.1.2 Ambition

EO4LEAs aims to make advancements and has a clear focus in three key domains (KDOs) in order to achieve its goals in regards to enhancing the Copernicus for Security services. The current state-of-the-art concepts and research relevant to each identified domain, as well as EO4LEAs's contribution that goes beyond the state-of-the-art, have been summarised as follows:

KDO1: Enhanced Data Retrieval, Curation, and Integration for Environmental and Copernicus for Security Applications
Objective: To advance the collection, organisation, preparation, and integration of multi-source data for environmental monitoring and security applications, focusing on EO, UAVs, IoT devices, and social media data, ensuring their readiness for analysis and decision-making processes.
SoA:
Data Curation and Preparation: Existing techniques handle diverse data sources for integration and analysis, emphasising automated data cleaning, integration, and transformation tailored to specific needs. **Social media and Web Crawling:** Current tools, such as Hootsuite[1] and Brandwatch[2], monitor social media for brand mentions and customer sentiment but lack specific features for security and environmental monitoring integration. **UAV Data Acquisition:** The use of UAVs with high-definition cameras and GNSS sensors, particularly enhanced by the Galileo system, illustrates the importance of UAVs in collecting georeferenced data for analysis. **IoT and In-situ Data Collection:** Utilisation of ground stations, like the T4i DOVER Ground Station, for data collection from airborne chemical detectors and other IoT devices, indicates the role of IoT in environmental and security data monitoring.
Beyond SoA:

[1] https://www.hootsuite.com/

[2] https://www.brandwatch.com/

EO4LEAs will enhance data retrieval and preparation frameworks to integrate diverse data sources effectively, including the application of AI for automated data processing and anomaly detection. The project will improve upon existing social media monitoring capabilities by adapting the crawling framework developed in the H2020-CALLISTO project for specific security and environmental monitoring needs. By incorporating Galileo-enhanced UAVs equipped with AI and middleware for real-time analytics and seamless data broadcasting, EO4LEAs aims to improve data acquisition, reliability, and processing throughput. Upgrading the T4i DOVER Ground Station reflects EO4LEAs' commitment to boosting IoT and in-situ data collection capabilities, facilitating robust data collection and integration for advanced analysis and decision support within the platform.

KD02: Advanced Geo-spatial AI for Enhanced Monitoring and Analysis for Copernicus for Security

Objective: EO4LEAs aims to advance Geo-spatial AI technologies to improve the monitoring and analysis of environmental and security-related phenomena. This effort will leverage comprehensive datasets, including those from Copernicus, UAVs, GNSS, IoT, and in-situ measurements, to address multifaceted challenges in these areas.

SoA:

Environmental Monitoring with AI: Current AI applications in environmental monitoring, such as Chl-a concentration analysis using satellite multispectral imaging (e.g., Chen et al., 2017; Nguyen et al., 2020; Henrichs et al., 2021; Huynh et al., 2022), exemplify the utilisation of remote sensing data for ecological assessments. These methods offer broad spatial and temporal coverage but face challenges in resolution and specificity for certain tasks. They usually capitalize on multispectral data along with techniques such as OBIA (Kolokoussis & Karathanassi, 2018), PCA and Gradient Boosting (Argamosa et al., 2022), SVM (Tysiąc et al., 2022), as well as more modern approaches such as Residual CNNs (Seydi et al., 2021), U-Net, SegNeXt and MariNeXt (Kikaki et al., 2024).
Threat Estimation and Infrastructure Monitoring: The surveillance of critical infrastructure currently involves a mix of periodic manual inspections and remote sensing technologies. Techniques like visual inspections, geotechnical monitoring (Prakash et al., 2022), and differential GB-InSAR (Aswathi, J., et al., 2022, Wang, Peng, et al., 2020) are standard but often lack the capability for real-time monitoring.
GeoAI for Climate Events Detection: The application of GeoAI models, specifically CNNs and GANs, on Sentinel-2 and Sentinel-5P data for detecting extreme climate events highlights existing efforts to enhance spatial resolution and atmospheric analysis capabilities.
CBRNe Detection and Atmospheric Modeling: The Weather Research Forecast (WRF) model and the FLEXible PARticle dispersion model (FLEXPART) are utilised for atmospheric data generation and substance trajectory simulation, respectively. The T4i DOVER airborne chemical detector plays a pivotal role in initial chemical threat identification, employing gas chromatography for hazard detection. While effective in certain scenarios, these methods often lack real-time adaptability and are constrained by predefined analytical parameters.

Beyond SoA:

EO4LEAs will deploy advanced GeoAI techniques, such as conditional Generative Adversarial Networks (cGANs), to improve environmental monitoring accuracy and timeliness significantly. This includes forecasting Chl-a concentrations using Sentinel-2 imagery, with methodologies aiming for higher spatial resolution and quicker detection capabilities.
By integrating Persistent Scatterer Interferometry (PSI) and GNSS data, the project proposes a novel approach to real-time infrastructure monitoring. This methodology aims for early detection (Bountos., et al., 2021) of structural changes (Federico., et al., 2022) and potential threats, leveraging the dynamic capabilities of these technologies for proactive risk management.
The project will also utilise GeoAI to enhance the detection of extreme climate events through improved Sentinel-2 imagery resolution and Sentinel-5P atmospheric anomaly detection. These efforts will be supported by employing CNNs for more refined analyses, aiming to identify subtle environmental and urban shifts indicative of climate events.
Advanced AI in T4i DOVER for CBRNe Detection: Integrating sophisticated AI algorithms into the T4i DOVER system, EO4LEAs enhances the detection and analysis of airborne chemical threats by enabling real-time analytical method optimization and autonomous operation. This development ensures dynamic adaptability to environmental changes and potential interferents, substantially reducing the risk of detector saturation and boosting the efficiency of the deployment and operational processes. The project innovates by utilizing dispersion models fed with drone-collected measurements for pinpointing the sources of hazardous substances accurately, marking a significant advancement in the management of atmospheric CBRNe threats.

KDO3: Digital Twins and AI-Enhanced Decision Support for Copernicus Security
Objective: This domain aims to develop a sophisticated framework that incorporates digital twins, cross-modal search capabilities, explainable AI, and advanced risk assessment methodologies. It seeks to provide a holistic view of environmental and security scenarios, facilitating informed decision-making through the integration of diverse data sources, including Earth Observation, UAVs, IoT, and social media data, within a digital twin environment.
SoA:
Digital Twins in Environmental and Security Applications: Current implementations of digital twins in environmental and security domains primarily focus on creating virtual replicas of physical entities for simulation, analysis, and prediction. However, these implementations often lack the integration of diverse data sources and advanced analytical capabilities to fully leverage the potential of digital twins for complex decision-making scenarios. **Cross-modal Search and Data Fusion:** Techniques like MuseHash (Pegia et al., 2023) offer adaptability across various data types but are yet to be fully explored in the context of security applications. Existing foundational models (Jakubik., et al., 2023) provide a basis for cross-modal data integration but require further development to meet the specific needs of security and environmental applications. **Explainable AI (XAI) for Decision Support:** While AI models, including deep learning, have been extensively applied to environmental monitoring and security, the emphasis on explainability remains limited. The need for AI models that provide understandable and interpretable results is critical for gaining trust and facilitating user-friendly decision-making processes. **Risk Assessment:** Risk and impact assessment methodologies (Fema, P. 2012) have significantly evolved to encompass broader scopes, transitioning from focusing solely on single assets to encompassing regional and local scales. The framework developed by Vamvatsikos and Chatzidaki (2022) represents a notable advancement, offering a near-real-time assessment of local/regional disasters. This approach integrates hazard, exposure, vulnerability, and sensor data into pre-computed scenarios for rapid assessment. Similarly, Tsarpalis et al. (2023) have expanded the application of these models to simulate core community functions and assess socioeconomic impacts comprehensively. Despite these advancements, the application of such frameworks at the Copernicus level remains unexplored, particularly concerning region-critical infrastructure and dynamic risk scenarios.
Beyond SoA:
Integrated Digital Twins with Advanced AI: By combining digital twin technology with advanced AI models, including GeoAI for enhanced monitoring and analysis, this domain aims to create comprehensive virtual environments that reflect real-world complexities. These digital twins will integrate data from Copernicus, UAVs, GNSS, IoT, and social media, providing a dynamic platform for scenario simulation and decision support. **Sophisticated Cross-modal Search for Security Applications:** Leveraging advancements in cross-modal search technologies, the project will develop foundation models that enhance the ability to search and retrieve relevant information across different data types. This capability will be crucial for analysing and synthesising information within the digital twin framework, enabling efficient decision-making based on comprehensive data analysis. **Risk Assessment and Decision Support with Digital Twins:** Incorporating advanced risk assessment methodologies into the digital twin environment, the project aims to provide real-time insights into potential threats and vulnerabilities. This approach will leverage dynamic exposure and risk analysis, supported by AI data flows and socio-economic models, to offer actionable intelligence for crisis management and preventive measures. EO4LEAs seeks to expand upon these foundations by developing a risk assessment framework that leverages Copernicus data for a dynamic and comprehensive evaluation of evolving disasters and threats. This initiative will address the gap in current methodologies by integrating AI data flows and fine-grained socioeconomic models, thus offering a novel approach to risk assessment that accounts for the dynamic nature of exposure and risks. By doing so, EO4LEAs aims to enhance the operational capability to assess and respond to crises, including man-made hazards such as CBRNe events, through the application of advanced data analytics and digital twin technologies. **Explainable AI for Enhanced Interpretability and Trust:** By integrating XAI techniques into the digital twin framework, EO4LEAs seeks to make AI-driven insights more accessible and understandable to end-users. This effort will focus on developing AI models that not only deliver high performance but also provide explanations for their outputs, enhancing transparency and trust in AI-assisted decision-making processes.

1.1.3 Relation to the Work Programme

EO4LEAs project proposal is submitted to the call HORIZON-CL4-2024-SPACE-01 "Strategic autonomy in developing, deploying and using global space-based infrastructures, services, applications and data 2024 – applications" and addressing the topic HORIZON-CL4-2024-SPACE-01-36 "Copernicus for Security". Overall, EO4LEAs is directly related to the Work Programme (Table *1*) by focusing on the enhancement of security capabilities through the Copernicus services infrastructure, with a particular emphasis on supporting the needs of border surveillance, civil security, law enforcement operations, and crisis management, amongst others.

Table 1: Relation to the Work Programme

Topic objectives (TOs) and their mapping with EO4LEAs' specific objectives	
TO1: *Enhanced fitness of the current services to better respond to evolving policy and user requirements.*	
RIO1, RIO3, RIO5, IMO1	**RIO1, RIO3, & RIO5** aim to enhance the fitness of services by leveraging advanced data acquisition and analysis technologies. **IMO1** ensures these innovations meet evolving user needs, directly contributing to this objective.
TO2: *Enlargement of current service scope through the inclusion of new, complementary elements and extended communities of users.*	
RIO1, RIO2, IMO2	The inclusion of innovative UAV and AI-driven environmental protection technologies in **RIO1 & RIO2** and market and business model exploration in **IMO2** effectively extend the service scope and community reach.
TO3: *Significant technological enhancement in detection capabilities, timely access to data or delivery of information, narrowing the gap between capabilities and the more stringent security observation requirements.*	
RIO2, RIO4	**RIO2 & RIO4**'s focus on developing cutting-edge threat detection and crisis management solutions directly addresses the objective of enhancing technological capabilities for security observations.
TO4: *Significant improvement in integration of non-space data along end-user intelligence supply chains, bringing added value at operational level also at regional at local levels, or in support to field campaigns.*	
RIO1, RIO3, RIO5	The integration of diverse data sources, including IoT, social media, and UAV footage in **RIO1, RIO3, & RIO5**, enriches end-user intelligence supply chains, aligning with the objective of improving non-space data integration.
TO5: *Development of processing chain(s) to handle an increasing volume of satellite data, keeping abreast with technology developments and include new paradigms in data fusion, processing, automation, as well as added-value information access and visualisation.*	
RIO1, RIO2, RIO4, RIO5	The development of advanced processing chains in **RIO1, RIO2, & RIO4,** and the integration of these technologies in a digital twin platform in **RIO5**, ensures keeping pace with technology developments and introducing new paradigms in data processing, for Copernicus for Security.
TO6: *Integration of the Geospatial Artificial Intelligence (GeoAI) and Earth Observation data analytics with a variety of other application-specific data sources like data from remote sensors accessed through IOT, as well as crowd-sourced data, high velocity transnational data and social media posts.*	
RIO3, RIO4, RIO5	**RIO3 & RIO4**'s efforts to merge GeoAI with Earth Observation data analytics, alongside **RIO5**'s focus on incorporating a wide array of data sources into a unified analysis platform, directly contribute to this objective by enabling comprehensive and sophisticated environmental and security analyses.

Crucially, EO4LEAs enhances collaboration between law enforcement agencies (LEAs) and stakeholders within the security and surveillance sectors, developing new, operational solutions that exploit the full potential of combined Copernicus and additional data sources through advanced AI and digital twin technologies. EO4LEAs also contributes to the expected outcomes of the HORIZON-CL4-2024-SPACE-01-36 topic (Section 2.1).

1.1.4 Positioning of EO4LEAs – Technology Readiness Levels

EO4LEAs has set specific objectives for each of its areas of focus, some of which are already technologically mature while others pose long-term challenges. By the end of the project, EO4LEAs aims to validate technologies in relevant environments reaching a technology readiness level (TRL) 6 at a minimum. The table below shows where EO4LEAs's key results fall on the "idea to application" spectrum and provides information on the current and expected TRLs.

Table 2: Key Results (KRs) and their TRL increase.

Key results	TRL	Justification

	Cur	Exp	
KR01: UAV video content collection and processing	4	6	Adapting SAITU controllers for EO4LEAs sensor integration on drones, enabling Computer Vision-driven data processing.
KR02: Crowdsourcing module	5	7	Based on SMAS, a social media dashboard, developed on H2020-CALLISTO project
KR03: Sensor data wrappers	5	7	Enhancements to T4i DOVER's chemical detection, integrating Symbiotic Engine software for advanced data processing.
KR04: Algae bloom monitoring and forecasting module	4	6	Leveraging PathoSAT from H2020-PathoCERT for algae bloom analysis and prediction
KR05: Oil spill detection module	5	6	Applying PathoSAT and insights from H2020- WQeMS for oil spill detection.
KR06: Early warning and monitoring system for geotechnical failures and landslide risks based on interferometric, GNSS and UAV data	4	6	Individual solutions developed in past projects fused into a unified framework
KR07: Embedded AI for autonomous airborne chemical detection payload module	3	6	Refining airborne chemical detection methodologies from H2020-TOXi-triage for enhanced capability with T4i DOVER.
KR08: Source localization of chemical attacks module	3	6	Based on research and development in H2020-SU-FCT04 ODYSSEUS project
KR09: Super resolution module	3	6	Incorporating super-resolution research from H2020-CALLISTO with a specific aim on researching its applicability on multiple downstream tasks.
KR10: Urban analysis and change detection module	3	6	Incorporating super-resolution research from H2020-CALLISTO.
KR11: Atmospheric anomaly detection module	3	6	Based on research from H2020-CALLISTO project.
KR12: Multimodal crisis detection module	4	7	Customizing multimodal crisis detection tools from H2020-CALLISTO for EO4LEAs' needs.
KR13: Impact assessment module	4	7	Improving impact assessment tools for operational deployment, building on past project achievements.
KR14: Risk assessment module	2	6	Enhancing and integrating risk assessment tools into EO4LEAs with a user-friendly interface.
KR15: Explainable AI module	3	6	Expanding explainable AI methodologies for security services with practical evaluation scenarios.
KR16: Foundation model and question-answering interface for Copernicus security applications	3	5	Optimizing an LLM and integrating it with a vision model for multimodal security applications.
KR17: Cross-modal search engine	3	6	Based on the well-tested multimedia search engine VERGE (https://mklab.iti.gr/verge/), which is extended to include satellite images and combine them with videos from UAVs and other social

			media images.
KR18: Advanced EO and non-EO data indexing and DestinE	3	7	H2020-CALLISTO insights and ONDA data catalogue for advanced data indexing for DestinE.
KR19: EO4LEAs digital twin platform	4	7	Developing EO4LEAs' digital twin platform using QGIS modules for comprehensive geospatial data simulation and analysis.

#§PRJ-OBJ-PO§#

1.2 Methodology #@CON-MET-CM@# #@COM-PLE-CP@#

1.2.1 Concept

EO4LEAs seeks to advance Copernicus Security Services through Geo-spatial Artificial Intelligence (GeoAI), digital twins, and integrated data analytics. The project, with its five Research and Innovation Objectives (RIOs) and two Impact Objectives (IMOs), aims to enhance environmental monitoring and security responses using diverse data sources like UAV footage, crowdsourced insights, and sensor data. RIO1 emphasises comprehensive data analysis for environmental and security monitoring, employing advanced imaging and data from various sources to inform law enforcement and environmental strategies. RIO2 develops AI modules for environmental hazard detection and threat monitoring, focusing on algae bloom forecasting, oil spill detection, and airborne chemical threat identification to safeguard environmental health. RIO3 concentrates on urban analysis and atmospheric anomaly detection to support public safety measures through detailed environmental and urban condition monitoring. RIO4 establishes a framework for crisis detection and impact analysis, using multimodal detection modules and risk assessment tools to manage emergencies effectively. RIO5 focuses on integrating AI solutions and various data streams into a digital twin platform, aiming to enhance decision-making for Law Enforcement Agencies (LEAs) and other stakeholders. This includes creating a dynamic simulation environment that mirrors real-world complexities and is aligned with the objectives of the Copernicus for Security services. The integration with the Destination Earth (DestinE) initiative is a key aspect of this objective, ensuring interoperability with broader geospatial data ecosystems and models, which is crucial for advancing Copernicus for Security. IMO1 focuses on aligning project solutions with end-user needs through validation scenarios, pilot preparations, and training, ensuring the relevance and applicability of project outcomes. IMO2 is dedicated to the sustainable dissemination and exploitation of project results, including market analysis, business model development, and intellectual property protection, to ensure a lasting impact on the Copernicus ecosystem. EO4LEAs addresses Copernicus Security Services challenges by extending the application of GeoAI, digital twins, and data analytics, thereby enhancing security and environmental monitoring capabilities.

1.2.2 Application and Validation

PUC1: Decision-Making Alert System (DMAS) for Climate Security in the Sahel Region

Context: The International Organization for Migration (IMO) defines climate migration as the movement of individuals forced or choosing to relocate due to climate change impacts. The [European Commission's Synopsis Report] highlights climate change and migration as key challenges for EU research and innovation investment in the coming years. Climate change affects migration patterns variably, often exacerbating existing trends or creating new migration flows. While some migrations are responses to immediate disasters, others result from gradual environmental changes. The relationship between climate change and migration is complex, influenced by local conditions and historical migration trends. Furthermore, predicting migration flows, including the number of people affected and the nature of their displacement, is fraught with uncertainties (Bijak, J. & Czaika, M. 2020).

Before EO4LEAs: Currently, Copernicus Security Services portfolio provides a set of services for Border and Maritime Surveillance and the Support to EU External and Security Actions. Moreover, Copernicus provides as well other thematic such as Climate Change Service or Copernicus Land Monitoring Services, which could support analysis and predictions related to climate change. However, it does not offer different modules to provide decision-makers with relevant information related not only with climate datasets but also with geopolitical risks in the affected area. Moreover, the current services do not provide a risk scale factor based on the predictions in regard to how climate change and extreme weather events may affect migration flows in specific regions. Capabilities to predict climate change scenarios in the short and medium terms, 3 and 5 years respectively, are of utmost importance to support not just local and regional authorities but also EU institutions, bodies and agencies, in better planning their policies, activities and resources.

After EO4LEAs: The advantage of this PUC will be the exploitation possibilities in an operational context (based on the users' requirements), a geospatial context based not only in climate datasets, satellite imagery provided by the Sentinel missions and the Copernicus Contribution Missions (upon request), but also in geopolitical factors, and with a perspective of evolution from previous methods and methodologies by offering a risk scale factor. The implementation and outcomes of this use case shall be beneficial for improving monitoring capabilities of EU Agencies and Institutions, such as Frontex or some of the DGs in the EU Commission interested in having a higher level of awareness in relation to how climate changes may be affecting migration flows within Third countries and towards the EU territory.

Applications: The DMAS for Climate Security marks a significant advancement in addressing climate-induced migration. It consists of:

- **Early Warning Module**: Designed to provide real-time alerts for extreme events (floods, droughts, wildfires etc.), incorporating social media analytics and official disaster reports into its risk assessment framework. This dynamic system updates risk evaluations based on the latest satellite imagery (Sentinel missions and the Copernicus Contributing missions) and service data (social media and in-situ data, whenever available and delivered by international organisation with deployed missions in the affected AOI), aiding emergency institutions in timely decision-making.
- **Prediction Module:** Focuses on identifying areas at risk of forced migration due to climate change, employing deep learning to analyse spatial diffusion processes which could potentially forecast displacement zones. This module utilises a comprehensive dataset, including satellite imagery (Sentinel missions and the Copernicus Contributing missions) and climate projections (Climate Data Store (CDS) Application Program Interface (API**))**, to generate a risk scale factor for different regions, particularly valuable in pre-event scenarios (3/5 years).

Integrating these modules into the Digital Twin enhances their utility, allowing users to visualise and combine insights for strategic planning. The EO4LEAs initiative thus stands as a pivotal solution for managing the complexities of climate-induced migration, offering a scalable, data-driven framework to support local authorities, international organisations, and EU missions in proactive and reactive measures against migration crises.

Objectives: The objective of this system is to support the decision-making process of local authorities, international organisations and the several EU missions in the Sahel region, namely the EUCAP Sahel Mali and EUMPM Niger. Moreover, the capability to estimate, predict and to provide quick reaction geospatial information is a considerable added value to support European Union policies/regulations such as the new asylum and migration management regulation and the new rules governing migration and force majeure situations.

PUC1 Key Performance Indicators:

- The proportion (%) of people displaced due to an extreme event.
- The proportion (%) of people experiencing long-term displacement because of climate change.
- The proportion (%) of people affected by forecasted high-risk scenarios.
- The proportion (%) of people displaced within their own country.
- The proportion (%) of people displaced to another country.

At least **8** of the following **11** Key results will be evaluated in PUC1**: KR02, KR09, KR10, KR11, KR12, KR13, KR14, KR15, KR16, KR18, KR19**

PUC2: Civil Security

Context: With more organisations gaining access to industrial technologies, modern weapons, and chemicals, CBRNe (Chemical, Biological, Radiological, Nuclear, and Explosive) threats in urban areas are expanding. The Council of Europe has recently adopted a Counter-terrorism Strategy for 2023-2027 which offers new tools and concrete responses to continuous and emerging challenges faced by state authorities. However, there are still several gaps in the areas of prevention, readiness, response, and recovery from both unintentional and purposeful CBRNe incidents. The main objective of this Use Case is to enhance the detection and monitoring of large-scale CBRNe events (involving dangerous substances, an epidemic or nuclear accident) in urban areas using EO data and other terrestrial technologies like thermal imaging sensors, explosion detection systems and chemical detectors on UAVs. Institutional venues such as EU or national parliaments, public buildings, health buildings and education buildings are types of public spaces that can be specifically vulnerable to attacks, either terrorist or because of an accident. PUC2 will run in the "Markopoulo Training Facility" which is located close to "Eleftherios Venizelos" International Airport. The area is used as "Multi-purpose Training and Technology Test Bed Facility" for LEAs and Emergency Responders since it provides a controlled and safe environment for both testing and validation.

Before EO4LEAs: Even though there are limitations on satellites specifically designed for CBRNe detection and monitoring right now, there are several ways that satellite data can be used to contribute to this field, including cloud cover, land mapping, surface property measurements, atmospheric composition, and chemical detection. Moreover, and most of the time, the latency or resolution of the available data is not adequate enough to meet the demanding standards of CBRNe modelling for incident management. As platforms and technologies advance (e.g. in terms of better onboard processing, optical data transfer, new constellations and novel platforms operating at varying altitudes), the resolution and latency are increased, increasing the viability of satellite and non-EO data in the realm of CBRNe control.

After EO4LEAs: This PUC will significantly enhance the operational capabilities of Law Enforcement Agencies (LEAs) by providing Copernicus-enabled services for detecting, monitoring, and analysing CBRNe threats. Utilising high-resolution EO data along with in-situ detection technologies, the service aims to offer precise CBRNe threat assessments.

Applications:

- **EO data analysis**: Urban density estimation through change detection on satellite imagery to for risk assessment; Atmospheric anomaly detection to explore the applicability of Sentinel-5P data on detecting CBRNe threats.
- **UAV Missions:** Equipped with advanced sensors and AI-driven analytics, our UAVs will conduct surveillance missions to identify and monitor CBRNe threats in real-time. These missions are crucial for the initial detection of hazardous substances and the assessment of affected areas, providing timely data for immediate response actions.
- **Source Detection through Modelling**: Utilising air dispersion and atmospheric models, we will accurately trace the origin of detected hazardous substances. These models will take UAV-collected data and simulate the spread of contaminants, enabling precise source location identification, critical for containment and mitigation strategies.
- **Social Media Data Fusion**: Crowdsourced data from social media platforms will be integrated with air quality data from the Copernicus Atmosphere Monitoring Service (CAMS) using advanced multimodal fusion event detection algorithms. This integration aims to enhance early warning systems by correlating public observations with scientific measurements, improving situational awareness and response readiness.

Objectives: The primary objective of this Use Case is to enhance the decision-making capabilities of Law Enforcement Agencies (LEAs) by equipping them with tools for improved situational awareness, which involves providing a detailed and accurate depiction of CBRNe threats. This aims to enable LEAs to respond swiftly and effectively, leveraging reliable data and forecasts to improve their readiness and response strategies. Additionally, the initiative seeks to support EU policies and regulations by offering tools that align with EU strategies on civil security, focusing particularly on the management and mitigation of CBRNe risks. Ultimately, this Use Case is dedicated to establishing a comprehensive and integrated framework for CBRNe threat management. By combining advanced technologies and diverse data sources, it aims to protect civil society and bolster the security resilience of urban environments against the potential occurrence of CBRNe incidents.

PUC2 KPIs

- Improvement of detection, modelling and monitoring of CBRNe incidents in urban areas by 30%.
- Reduce the threat and damage from CBRNe incidents of accidental, natural and intentional origin by 50%.
- Reduce the CBRNe detection and identification time by 40% and improve the response time of LEAs by 70%
- Increase situational awareness and support CBRNe threat assessment by 80%.
- Improve civil security and local control of CBRNe incidents by 40%.

At least **10** of the following **15** Key results will be evaluated in PUC2: **KR01, KR02, KR07, KR08, KR09, KR10, KR11, KR12, KR13, KR14, KR15, KR16, KR17, KR18, KR19**

PUC3: Maritime Environmental Monitoring and Security

Context: The Black Sea, one of the most isolated seas globally, is under threat from various environmental challenges due to its large drainage basin and limited connectivity with global oceans. Its ecological balance is fragile, with the Danube Delta acting as a critical link between the Danube River and the Black Sea's state. Over the years, anthropogenic activities, including industrial runoff and illegal maritime activities, have led to significant water quality degradation and ecosystem damage. Trans-border waterways, similarly, face the complex challenge of pollution that does not respect geographical boundaries. The Struma (Strymonas) river, for instance, showcases how industrial accidents and natural events can lead to widespread environmental and public health crises across borders. Both scenarios underline a pressing need for advanced, integrated monitoring and response mechanisms capable of addressing these environmental threats effectively and swiftly. The maritime domain also grapples with "ghost ships" that evade detection by turning off communication systems to engage in illegal dumping within territorial waters, posing significant risks to marine ecosystems and human health. Such activities, coupled with the challenges of bio-indicator-based ecosystem monitoring, exemplify the complex environmental and security challenges faced by maritime and trans-border waterway regions.

Before EO4LEAs: Before the advent of EO4LEAs, monitoring environmental threats in crucial areas like the Black Sea and trans-border rivers faced notable challenges. Traditional monitoring methods were often slow and costly, lacking in both reach and efficiency, especially against pollution transcending borders. While satellite data offered some insights, the absence of sophisticated analysis tools limited its effectiveness. This gap in capabilities was especially problematic in dealing with elusive "ghost ships," which could dump pollutants undetected. Authorities' reliance on basic satellite imagery and direct assistance requests led to reactive measures, often too delayed to prevent environmental damage. The lack of advanced technologies for vessel tracking and risk profiling further hampered proactive environmental and maritime security efforts.

After EO4LEAs: EO4LEAs significantly improves environmental monitoring in the Black Sea and trans-border waterways. By using AI and big data, it enables precise tracking of "ghost ships" and pollution sources, leading to timely alerts and predictive actions against illegal dumping. In situations like the Struma River flooding, the integration of satellite imagery, UAV surveillance, and social media analysis allows for quick hazard identification and response. This approach enhances the accuracy and efficiency of monitoring efforts, safeguarding both the environment and public health, and improving the effectiveness of relevant agencies.

Applications:

- **Predictive Analytics and Change Detection for Vessel Tracking:** Uses analytics to predict vessel routes and change detection for early identification, improving maritime surveillance.
- **Satellite Surveillance with Copernicus Data:** Leverages Copernicus data for wide-area maritime monitoring, enhancing pollution detection and search and rescue efforts.

- **Environmental Hazard Detection through social media and Satellite Data:** Combines social media insights and satellite analysis to identify and respond to environmental threats quickly, aiding in early hazard detection and response coordination.

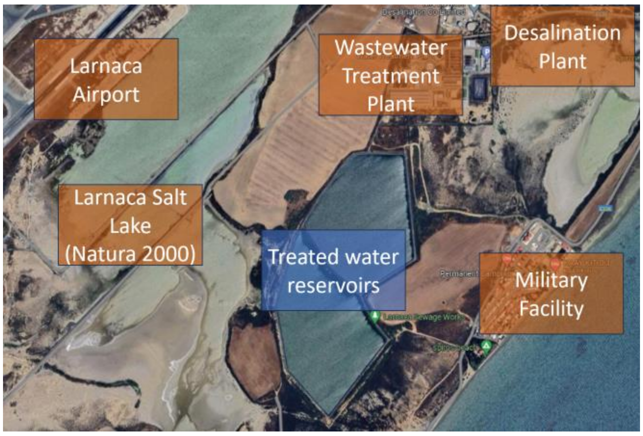
Objectives: The main objective of this Use Case is to enhance environmental monitoring and maritime security through improved detection and management of water pollution and search and rescue missions in the Black Sea region. Utilising EO4LEAs technologies, including advanced data analytics, AI-driven predictive modelling, and integrated Copernicus satellite data, the project aims to significantly boost the identification of pollution sources and operational efficiency of search and rescue activities. This initiative supports the decision-making processes of maritime authorities and environmental protection agencies by offering timely, accurate, and actionable insights. It also aligns with EU policies and regulations aimed at safeguarding marine ecosystems and ensuring maritime safety. Ultimately, this Use Case strives for a collaborative and technologically advanced approach to environmental protection and maritime security, enhancing resilience against anthropogenic threats and natural disasters.

PUC3 KPIs

Scenario 1: Black Sea Water Pollution and Search & Rescue	Scenario 2: Trans-border Water Pollution Source Identification
• Increase detection accuracy of unauthorised maritime activities by 40%. • Reduce response time to marine pollution incidents by 30%. • Elevate pollution event detection rate by 50. • Improve efficiency in resource allocation for surveillance and intervention by 20%.	• 30% increase in source identification precision. • 20% reduction in identification time. • 35% more environmental hazard signals detected. • 25% improved intervention efficiency.

At least **10** of the following **14** Key results will be evaluated in PUC3: **KR02, KR04, KR05, KR07, KR09, KR10, KR11, KR12, KR13, KR14, KR15, KR16, KR17, KR18, KR19**

PUC4: Critical Infrastructure Surveillance



Context: The city of Larnaca has a unique ecological and infrastructural ensemble, comprising the Larnaca Salt Lake, protected under the Natura 2000 framework, as well as critical entities nearby such as the main national airport, Larnaca's wastewater treatment plant, and a desalination plant. During its operation, the LSDB's wastewater treatment plant stores the treated water in two adjacent reservoirs situated between the airport, the salt lake, and the wastewater infrastructure. The Water Development Department of the Ministry of Agriculture manages the water from these reservoirs for irrigation purposes. Given the sensitive surrounding areas, the integrity and security of these reservoirs are paramount. Monitoring and safeguarding them and associated infrastructure against potential threats, such as structural failures or environmental hazards, is crucial for maintaining ecological balance, public health, and safety.

Before EO4LEAs: Traditional monitoring methods for structural and environmental security in such critical and sensitive areas are often reactive, with limited predictive capabilities. Existing technologies have limited resolution, frequency, and analytical depth to effectively anticipate and mitigate risks, leading to delayed responses to threats such as structural instabilities, e.g., after an earthquake.

After EO4LEAs: The introduction of EO4LEAs revolutionises the approach to monitoring and securing the treated water reservoir and surrounding critical infrastructure. By harnessing the power of advanced EO technologies, including InSAR, GNSS, and UAV data, combined with cutting-edge analytical techniques and machine learning models, this use case will establish a comprehensive early warning and threat estimation system, coupled with a digital twin. This system will provide high-precision, real-time insights into structural geotechnical stability and potential environmental threats, enabling proactive management and response strategies.

Applications:

- **Structural Integrity Monitoring:** Utilising InSAR and GNSS-enabled sensor data, alongside high-resolution SAR imagery, this application focuses on monitoring the structural health of critical assets of the reservoirs. It identifies both immediate and gradual geotechnical instabilities, leveraging machine learning to differentiate between normal and abnormal patterns, for timely interventions.

- **Environmental Threat Detection:** Advanced algorithms will monitor key environmental indicators such as Chlorophyll-a levels, using hyperspectral satellite imagery and deep neural networks. This application aims to pre-emptively identify and address ecological threats such as algal blooms, ensuring the preservation of water quality and ecological balance.
- **Evaluate consequence risk**: Using the digital twin what-if functionalities, to evaluate the consequences of the various emergencies which could cause a cascading effect on other infrastructures or the environment.

Objectives:

The key objective is to enhance the monitoring of the structural integrity of the critical infrastructures in a neuralgic location in Larnaca, focusing on the treated wastewater reservoirs. Through the integration of EO technologies, coupled with the analytical tools and digital twins, the project aims to foster a proactive, data-driven approach to risk management, for reducing the impacts on structural failures.

PUC4 KPIs:

- Reduction in the detection time of structural instabilities by 50%.
- Increase in the accuracy of environmental threat predictions, such as algal blooms, by 70%.
- Improvement in the effectiveness of early warning systems for structural and environmental threats by 60%.

All the following **9** Key results will be evaluated in PUC4: **KR03, KR04, KR09, KR10, KR13, KR14, KR15, KR18, KR19**

1.2.3 Overall approach and methodology

The overall approach and methodology for each of the abovementioned Key Results KR01-KR19 are presented in Table 3.

Table 3: Key Results (KR) and corresponding brief implementation methodology.

Key results	Methodology
KR01: UAV video content collection and processing	UAVs with advanced imaging and GNSS, enhanced by Galileo precision, capture georeferenced video for real-time analytics.
KR02: Crowdsourcing module	Advanced search and geo-referencing integrate social media data for enhanced situational awareness through a comprehensive dashboard.
KR03: Sensor data wrappers	Expansion of T4i DOVER and a GNSS sensor network for advanced environmental and structural stability monitoring.
KR04: Algae bloom monitoring and forecasting module	DNN and GANs detect Chlorophyll-a levels for algal bloom monitoring and forecasting, with additional oil spill detection algorithms.
KR05: Oil spill detection module	Oil spill detection algorithms using EO data, supported by a deep learning benchmark dataset.
KR06: Early warning and monitoring system for geotechnical failures and landslide risks based on interferometric, GNSS and UAV data	Integration of PSI, GNSS, and UAV imagery with machine learning for early warning of geotechnical instabilities and landslide risks.
KR07: Embedded AI for autonomous airborne chemical detection payload module	AI-enhanced T4i DOVER for autonomous operation and optimized chemical threat detection.
KR08: Source localization of chemical attacks module	Specialised algorithms accurately detect and pinpoint chemical attack sources, enhancing rapid response capabilities.
KR09: Super resolution module	Deployment of GANs for SuperResolution to provide detailed observation of environmental and urban landscapes
KR10: Change detection module	GeoAI methodologies for change detection in urban and maritime environments using Sentinel-2 imagery.
KR11: Atmospheric anomaly detection module	CNNs analyse Sentinel-5P data for atmospheric anomaly detection, focusing on early climate condition warnings.

KR12: Multimodal crisis detection module	Integrates social media with EO and non-EO data for comprehensive crisis detection using advanced algorithms.
KR13: Impact assessment module	Assesses economic losses and effects on populations from disasters, supporting informed decision-making and recovery.
KR14: Risk assessment module	Combines hazard, exposure, vulnerability, and AI data for risk assessment of catastrophic events.
KR15: Explainable AI module	Transparent AI models for Copernicus Security Services, emphasizing model robustness and operational clarity.
KR16: Foundation model and question-answering interface for Copernicus security applications	Self-supervised learning for multimodal data integration, developing a user-friendly UI for querying Copernicus Security datasets.
KR17: Cross-modal search engine	Researches cross-modal search techniques for efficient satellite imagery and video data retrieval through a user-friendly interface.
KR18: Advanced EO and non-EO data indexing and DestinE	Integrates diverse data sources for enriched analytics, ensuring DestinE framework compatibility for data utilisation.
KR19: EO4LEAs digital twin platform	Develops a digital twin for relevant agencies, integrating real-time EO and non-EO data for evaluating what-if scenarios, assessing the current situation, as well as enhancing operational planning and response.

1.2.4 Research and innovation activities linked with the EO4LEAs project

Table 4: Research and Innovation projects that are relevant to EO4LEAs.

Project Name	Project Goal	Contribution to EO4LEAs	Partner(s)
H2020 TOXI-triage	CBRN emergency response technologies	T4i DOVER detector design and development.	T4i
H2020 GIDPROvis	Visualisation of volatile chemicals	Adaptation of T4i SMS for Gas Ion Distillation and SIPRO tech.	T4i
H2020 HYPERION	Risk assessment of cultural heritage cities	Socioeconomic impact assessment.	RG
H2020 7SHIELD	Cyber and physical threat framework for crisis management	Knowledge and technologies for managing cyber and physical threats, enhancing EO4LEAs with a robust Business Continuity Module and insights into sensor, IoT, and UAV data integration for crisis management.	RG, CDXi*, SERCO, NOA, KEMEA, ACCELI
Horizon PLOTO	Risk assessment of inland waterways	Risk Assessment Engine development.	RG, SORECC, NTUA
H2020 ODYSSEUS	Enhanced understanding and management of explosives and precursors, developing advanced tools for LEAs	Expertise in explosives and precursors enriches EO4LEAs' prognostic, detection, and forensic tools, bolstering security measures.	BDI, T4i, KEMEA, CDXi
H2020 CALLISTO	AI-powered Big Data platform connecting Copernicus Data with end-users	Social media data analysis and multimodal retrieval service for Security applications.	DREVEN, SERCO, CDXi, NOA, ACCELI
H2020 PERIVALLON	Combating environmental crime with AI and geospatial intelligence	Extension of the AI models	DREVEN, KEMEA, CDXi
H2020 ISOLA	Enhancing ship security with innovative technologies	Heterogeneous data indexing and retrieval.	CDXi, ACCELI, T4i
H2020 beAWARE	Decision support in extreme	Tailoring on around air quality events	CDXi

	weather events		
H2020 aqua3S	Advanced water safety technology for detection and alerts	EO data processing for AI algorithms and expertise on water related applications	CDXi, DREVEN, BDI
H2020 PathoCERT	Enhancing first responders' coordination in water contamination events	Algal bloom monitoring with atmospheric correction updates and social media analysis.	CDXi, UCY
H2020 WQeMS	Satellite-based water quality monitoring system	Oil spill detection module satellite data processing and handling.	CDXi, SERCO
Horizon FUELPHORIA	Demonstrating Value Chains for advanced biofuels	Algae monitoring and forecasting algorithm optimizations.	CDXi
H2020 INGENIOUS	Next generation integrated toolkit for collaborative response	Social media data analysis on emergency events.	CDXi
H2020 DeepCube	Explainable AI pipelines for Copernicus data	Explainable AI for question answering and EU Data Spaces integration.	NOA

*CDXi is a spin-off company of CERTH (https://www.certh.gr, one of the larger public non-profit research organisations of Greece), is detailed further in Section 3.2.1

1.2.5 Advancing Copernicus for Security with Ethical AI

EO4LEAs is committed to advancing Copernicus Security Services through the responsible development and deployment of AI technologies, adhering strictly to the EU's forthcoming AI Act. This ensures all AI solutions within EO4LEAs meet the highest standards of ethical, technical, and social robustness within the European Union, emphasising the specific needs of LEAs and environmental monitoring. **Technical Robustness**: EO4LEAs aims for at least a 10% improvement in performance indicators across AI modules, ensuring accuracy, consistency, and robustness against failures, crucial for environmental and security applications. **Social Robustness**: By integrating LEA feedback through questionnaires and engagement, EO4LEAs ensures AI systems are attuned to security and environmental contexts, promoting sustainable and responsible practices. **Reliability**: The project emphasises the creation of reliable AI systems that deliver dependable insights across diverse applications, from maritime surveillance to urban security, enhancing LEAs' operational capabilities. **Explainability**: Adopting Explainable AI (XAI) principles, EO4LEAs enhances the transparency of decision-making processes in AI systems, enabling LEAs and stakeholders to make informed decisions based on clear, understandable insights. Through these efforts, EO4LEAs sets a benchmark for AI applications within security services, aligning with regulatory expectations and enhancing the operational efficiency and situational awareness of LEAs and other stakeholders.

1.2.6 Social sciences and humanities

Social sciences and humanities in EO4LEAs are aiming to provide a better understanding of the dynamic interplay of human, and technological factors, which play a key role in safety, reliability and change in the critical infrastructures systems, especially regarding AI and automation. The focus will be dedicated to improving performance, efficiency and safety by providing tools and methodologies to comprehend the dynamic of human behaviour, performance & organisational systems, to establish learning communities, to promote better practices and to bridge the gap between operations and design. Moreover, key stakeholders will be engaged in knowledge generation and development and the impact of human, technological and organisational interventions upon operational performance and user acceptability. All of these methods will aim to achieve a long-term sustainability change. Concluding, implementation planning will be addressed in order to ensure the efficient incorporation of the developed solutions in real-life bearing in mind socio-technical and behavioural issues.

1.2.7 Sex and Gender Analysis

To enhance the quality and integrity of EO4LEAs and prevent the emergence of gender biases in our methodologies, the consortium systematically incorporates gender and sex considerations throughout the research process. This integration occurs across all stages, including use case design, hypothesis formulation, data collection, analysis, documentation, and dissemination. Specifically, within WP1, the gender and sex dimensions are seamlessly integrated into quality control, risk management, and contingency planning activities. Additionally, we analyse the intersectionality of gender and sex with other pertinent social factors such as ethnicity, age, and socioeconomic status, where applicable. Utilising tools like the Garcia Toolkit, we ensure that gender and sex dimensions are accounted for in explanations and visualisations to aid decision-making and crisis intervention processes. Furthermore, we are dedicated to achieving gender balance in research and implementation efforts to mitigate potential, yet undetected, biases in research and innovation endeavours.

1.2.8 Open science practices

Transparency and openness will be emphasised in order to guarantee that EO4LEAs will have a concrete impact on society's trust and engagement towards science and R&I. In this way the Consortium aims to improve the reproducibility of results and minimise duplication of work among the research community. More specifically, EO4LEAs, will focus on the reproducibility of its final outcomes (i.e., publications, datasets, models, ontologies, algorithms) by implementing the strategy explained in the following section that is based on an Open Science by Design approach. The specific data used will be clearly described by the Consortium to facilitate the process of inclusion/exclusion of data (-sets) in future studies. Statistical inference results will be explained by adding in the produced deliverables the timely process followed to make analytical decisions, alongside with a confirmation on whether the study is exploratory or confirmatory. In case of identification of implemented methods and processes that did not serve their purpose to the core, an analysis of them will be included in deliverables and reports, to be avoided by future researchers. Possibly uncertainty and constraints of results on the generalisation of outcomes will be discussed in all relevant deliverables. ORE (Open Research Europe) platform is going to be used by the Consortium to publish open access materials to fellow researchers that will also be peer-reviewed. Additional open access venues are going to be considered based on the content of results to maximise impact to the most relevant stakeholders (such as OpenAIRE). Preliminary findings are going to be discussed/presented to peer reviewers, as an attempt to further enhance the Consortium's practices and ways of operation, in the framework of dissemination of project's results in Conferences. Relevant standards and guidelines (e.g., FAIR) will be followed for the creation and processing of data and metadata to ensure the easy access and reusability of outcomes from future researchers.

1.2.9 Data Management Plan

Within the EO4LEAs work plan, numerous technology-focused tasks are outlined for processing both open and closed source data, all while adhering to the regulations set forth by the General Data Protection Regulation (GDPR) regarding the handling of personal data. The consortium is committed to establishing a robust organisational and technical data protection framework to ensure compliance, encompassing criteria such as lawful processing, secure storage, and anonymization where applicable. Prior approval from the project's Ethics Committee is mandatory before implementing this framework. Moreover, Task 1.3 & Task 2.3, a dedicated component of WP1&WP2, is tasked with meticulously addressing data collection, management, and access aspects throughout and post-project. This task culminates in the development and delivery of the EO4LEAs Data Management Plan, elucidating data sources, flows, access protocols, security measures, and strategies for public data dissemination after the project's conclusion, including licensing and infrastructure considerations.

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2. Impact #@IMP-ACT-IA@#

2.1 Project's pathways towards impact

2.1.1 Project's pathways towards the topic's expected impact

EO4LEAs' project proposal is submitted to the call HORIZON-CL4-2024-SPACE-01-36, Strategic autonomy in developing, deploying and using global space-based infrastructures, services, applications and data 2024.

EO4LEAs develops R&D activities to support an increase in service performance, outreach and scope, aiming particularly at fostering:

Innovative methods and technologies to explore new and enlarged data sets and the development of applications addressing requirements not currently tackled by the current services.

By leveraging advanced GeoAI techniques and digital twin technology to process and analyse heterogeneous data sources, including Copernicus satellite imagery, UAV footage, and IoT sensor data. This approach enhances environmental monitoring and security surveillance capabilities, offering innovative solutions to unmet user needs and expanding the operational scope of existing services.

Actions in support to the evolution and scope of the security services, namely increasing user reach, responding to specific regional needs and increasing service added value in user operational scenarios.

By integrating the developments from EO4LEAs into Copernicus Security Services, the project directly contributes to broadening the scope and effectiveness of these services. Specifically, through the deployment of our pilot use cases—ranging from decision-making support systems for climate-induced migration in the Sahel region to enhanced CBRNe detection and response in urban environments, and advanced maritime environmental monitoring and security. This targeted approach ensures that the EO4LEAs project addresses the urgent and specific needs of different regions and user groups, thereby significantly enhancing the added value of security services in various operational scenarios. By providing tailored, AI-enhanced solutions that incorporate the latest in satellite and sensor technology, EO4LEAs empowers law enforcement agencies and other stakeholders with actionable insights, enabling more efficient and informed decision-making in critical situations. This not only increases the reach of security services to new user communities but also deepens the impact and relevance of these services in addressing complex security challenges across Europe and beyond.

2.1.2 Project's pathways towards the destination's expected impact

Open strategic autonomy in developing, deploying and using global space-based infrastructures, services applications and data, including by reinforcing European independent capacity to access space, securing the autonomy of supply for critical technologies and equipment, and fostering the EU's space sector competitiveness.

EO4LEAs directly contributes to achieving open strategic autonomy in space-based infrastructures, services, applications, and data by pioneering advancements in GeoAI and digital twin technologies tailored to the Copernicus Security Services. This initiative not only demonstrates a commitment to leveraging European space assets for critical environmental and security applications but also strengthens Europe's independent capabilities in accessing and utilising space. Firstly, by integrating these innovative technologies with Copernicus, EO4LEAs ensures that the EU can independently monitor, analyse, and respond to environmental and security challenges. This reduces reliance on non-European technologies and services, bolstering Europe's strategic position in global space endeavours. Secondly, the development and deployment of EO4LEAs' solutions are rooted in European innovation, contributing to securing the supply chain for critical space technologies and equipment within the continent. By fostering homegrown technological advancements, the project underpins the EU's autonomy in maintaining and enhancing its space infrastructure. Moreover, EO4LEAs acts as a catalyst for the EU's space sector competitiveness by introducing advanced analytical capabilities and decision-support tools that are anticipated to set new standards in space-based service delivery. The project's emphasis on open-source software and broad dissemination of results encourages widespread adoption and further innovation, creating a dynamic and competitive space sector in Europe. Finally, EO4LEAs strengthens the Copernicus Security Services by offering more precise, reliable, and actionable insights through enhanced data processing and analysis. This improvement in service quality and scope ensures that Europe remains at the cutting edge of space-based environmental monitoring and security surveillance, maintaining its leadership and autonomy in global space affairs.

2.1.3 Contributions to Key Strategic Orientations from the topic's destination

This proposal contributes mainly to KSO A and KSO D as follows:

KSO A, 'Promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations.'

By leveraging security and climatic knowledge, Copernicus data along with novel AI, HPC, and Big Data technologies, EO4LEAs aims to develop new and innovative services, addressing efficiently and effectively the diverse and emerging requirements of the European security sector. This combination of high-level technology with Copernicus data will support safety and security. The project is anticipated to increase the competitiveness of businesses and organisations that provide EO and ICT-related services to the security sector. This will allow the latter to take advantage of the technological innovations and economically viable solutions produced in order to develop new security-related products and services and explore new business opportunities. This can support the goals of the European Digital Economy Strategy and result in higher economic growth, the creation of jobs, and enhanced innovation and competitiveness within the market segment. EO4LEAs dissemination, communication & exploitation strategy, plan and activities will constitute the steppingstone for creating a wider outreach and for fostering the competitiveness of the EU space sector, through the developed solutions addressed to law enforcement agencies. EO4LEAs developed technologies, as part of the project's scientific outcomes, will act as an impact booster for creating cooperation links in both European and international level, as well as for enhancing the technical, scientific and educational background of all involved stakeholders.

Furthermore, EO4LEAs will offer a modular architecture that will incorporate elements to realise Digital Twins for the security ecosystem (which encompass all levels, including data, application, and knowledge tiers). The Copernicus Data Space Ecosystem will be leveraged to simplify access to Copernicus Sentinels via a common API through ONDA Dias and to enable their use through data standardisation and interoperability tools.Additionally, EO4LEAs will contribute to the evolution of Copernicus Security services, by enhancing decision-making processes

through advanced predictive analytics and risk assessment models, incorporating digital twins and GeoAI for comprehensive environmental and security analysis. Utilising heterogeneous data sources, including Copernicus satellites, UAVs, social media, and IoT devices, EO4LEAs develops tailored solutions for critical use cases, significantly enhancing the operational capabilities of law enforcement agencies and stakeholders in the security sector.
The adoption of Galileo and EGNOS services, as well as the creation of downstream EGNSS applications, can all be aided by the technological innovation of EO4LEAs, guaranteeing better system efficiency and cost performance. In addition, the project presents innovative multisensory data fusion methods that make it possible to use Copernicus (EO) data in conjunction with other non-spatial (in-situ) data to provide higher-value services and goods with more accurate temporal and spatial resolution.
Finally, EO4LEAs can establish a direct connection with emerging technologies like quantum computing, supporting connections to these new computing paradigms that use quantum features to provide computational capability.

KSO D, 'Creating a more resilient, inclusive and democratic European society, prepared and responsive to threats and disasters, addressing inequalities and providing high-quality health care, and empowering all citizens to act in the green and digital transitions.'

By bolstering Copernicus and offering added value services for sustainably managing security challenges within the frameworks of border surveillance, civil security, maritime surveillance, and critical infrastructure, EO4LEAs aims to contribute to a resilient green economy and society.
EO4LEAs can have a major impact on local, regional, or national economies by implementing cost-effective processing chains, utilising cutting-edge data fusion and visualisation techniques, and utilising artificial intelligence for real-time analysis to improve the calibre and effectiveness of Copernicus security services.
In addition to enhancing security, the project will raise public awareness of threats pertaining to the environment, the economy, society, and general health and wellbeing. EO4LEAs innovations and results will be explained to non-technical stakeholders, such as law enforcement agencies, civil society, local stakeholders, and policy makers, in an appropriate language as part of the project's participatory activities that will take place in the context of the PUCs. This will help them understand the multipurpose and benefits of Copernicus data, IoT, and sensor data in European and global security.
Through these initiatives, the public will be made aware of the importance of Copernicus and the ways in which security services can assist LEAs in addressing challenges like population displacement, safeguarding critical infrastructure, and monitoring the environment in the face of natural or man-made disasters, as well as climate change.

2.1.4 Scientific and Technological Impact at scale

The EO4LEAs project aims to advance Copernicus services to more effectively address evolving security requirements by developing streamlined processing chains, incorporating cutting-edge data fusion and visualization techniques, and leveraging artificial intelligence for real-time analysis. A key focus is enhancing surveillance of borders, maritime areas, and critical infrastructure through the integration of advanced technologies, including digital twin technology from the Destination Earth initiative, within the Copernicus Data Space Ecosystem. This integration aims to improve the accessibility and interoperability of Earth Observation (EO) data, bolstering security efforts. The project's scientific and technological impact is projected to be extensive, with dissemination efforts including contributions to at least 10 scientific or academic articles and at least 5 open access publications. These will be showcased in top EO and security-related venues, organized as follows:

Conferences: IEEE International Geoscience and Remote Sensing Symposium (IGARSS); European Space Agency's (ESA) Big Data from Space conference; ESA Living Planet Symposium; International Conference on Multimedia Modeling; Cyber Security for Critical Assets Europe; International Conference on Critical Information Infrastructures Security; Critical Infrastructure Protection & Resilience Europe; IFIP Working Group 11.10 on Critical Infrastructure Protection; International Defense and Homeland Security Simulation Workshop.

Journals: Journal of Applied Topics in Earth Observation; IEEE Transactions on Geoscience and Remote Sensing; International Journal of Protective Structures; International Journal of Information Security; Springer's International Journal of Critical Infrastructure Protection; Security Journal.

An additional aim is to fortify the predictive analytics and situational awareness capabilities of security services, fostering the development of an integrated, efficient, and responsive security framework. This enhancement will result from the innovative fusion of diverse data sources, including IoT data from Galileo-enabled devices and sensor data from UAVs. Consequently, EO4LEAs will emerge as a comprehensive, integrated security framework that maximizes the potential of Copernicus data, thus elevating European and global security and contributing to the formulation of resilient and adaptive security strategies.

2.1.5 Economic Impact

EO4LEAs will offer a variety of modules and services showcasing innovative solutions, for detecting, extending, and enriching surveillance capabilities, levering Copernicus services, thereby enhancing the operational capabilities of security practitioners such as Police and Border Guard Authorities, along with other pertinent public entities engaged in combating environmental crisis management. The EO4LEA's advanced solutions present significant opportunities for commercialization. Based on the active end-user engagement, the EO4LEAs project will highlight how those solutions will collaboratively address surveillance, security and environmental threats, inviting prospective users and customers to collaborate as co-innovators in the process. As a key point, collaboration will begin in the early stages of service development, addressing user needs and specifications, collaboratively crafting compelling value propositions, and jointly defining use cases tailored to operational requirements. Through this holistic approach, value propositions will be refined and tested in real-world scenarios, ensuring seamless integration with existing operational frameworks by international standards. This approach aims to foster widespread acceptance of EO4LEAs solutions within the market.

2.1.6 Societal impact

The societal impact of EO4LEAs is aligned with the UN sustainable development goals (specifically SDGs 3,6,11,12,13,16 and 17) and will contribute to multiple levels for a better understanding of the scale, scope, and impact that surveillance, civil security, and environmental crisis management has on society at large which will feed through policy recommendations that can be delivered at EU and Member States levels. The impact of the aforementioned threats has detrimental effects on society at the micro-, meso- and macro-levels, from harming individuals, distorting market opportunities for legitimate business, and reducing the quality of life of inhabitants of cities to the destruction of natural ecosystems and public health, as well as long term impacts on climate change. Furthermore, in the field of civil security, crisis occurrence provides fertile ground for the wider organized crime networks, and the illegitimate use of proceeds of crime leads to further societal concerns related to the trafficking of drugs, weapons, human beings, and corruption across both businesses and public organizations. Moreover, since society's awareness of the effect of the surveillance capabilities across border, maritime, and critical infrastructure in civil security is limited and so, the EO4LEAs dissemination/communication actions will focus on enhancing citizen engagement, building awareness of the scale of the problem, and providing opportunities for them to recognize potential indicators, and thus contributing to real-time detection.

2.1.7 Barriers and obstacles to impact

Policy, Ethics, and Legislation
Barrier: Ethical and data protection concerns related to the automated online data collection
Mitigation Measure: Legal and ethical analysis and requirements specification towards ensuring transparency in data collection processes
Barrier: EO4LEAs methodology and solutions don’t align with the current Police and Border Guard Authorities practices and legal requirements
Mitigation Measure: EO4LEAs will leverage the multi-disciplinary consortium for integrating the processes of LEAs, border guards, and environmental agencies, to ensure the compliance of the technological solutions with both the requirements and restrictions
Barrier: Deliver of datasets containing sensitive data (people, geolocations)
Mitigation Measure: The EO4LEAs digital tools will be preprocessed to remove sensitive data, by means of obfuscation techniques (people detection and removal, spatial obfuscation) preserving the knowledge content while enforcing privacy and confidentiality
Technical
Barrier: Lack of integration of data and technologies from heterogeneous sources
Mitigation Measure: EO4LEAs will focus on ensuring interoperability among the different modules
Barrier: Current hardware constraints and AI module performance inadequacy for mass-scale data analysis

Mitigation Measure: AI architecture optimization to boost the inference throughput and grant applicability at a mass-scale	
Barrier: The end-user systems might not support hosting and integrating the EO4LEAs solution	
Mitigation Measure: The intended service-oriented modular architecture will enable easy and secure integration with existing infrastructure, as well as end-user security policy enforcement	
Economic	
Barrier: Limited end-users' budget that prevents the adoption of EO4LEAs holistic digital platform as a whole	
Mitigation Measure: The EO4LEAs modular architecture permits end users to adopt subsets of provided services, in terms of budget constraints	
Barrier: Volatile, fast-developing market of competing technologies using EO and non-EO data	
Mitigation Measure: EO4LEAs will prepare a detailed market analysis from the early phase of the project implementation, which will be continuously enriched	
Societal	
Barrier: Lack of expert training and development	
Mitigation Measure: Expert training will take place during the field trials	

2.2 Measures to maximise impact - Dissemination, exploitation and communication #@COM-DIS-VIS-CDV@#

2.2.1 Dissemination of project results

The major focus of the EO4LEAs dissemination strategy is on ensuring that the project research and practical outcomes are widely communicated to each target community, at appropriate timing, via appropriate channels.

Table 5: Dissemination Plan timeline

Phase	Objective	Approach
Beginning of the project (period 1)	Raise Awareness. Address the target audience and their needs. Start recruiting users.	Website development and content update, including social media account creation. Publication of support material, mass media Attendance to events with similar EU Cluster 3 projects (FCT and INFRA).
Project going-on (period 2)	Active involvement of UG. Continue engaging users. Training of Pilot Users.	Organization of Focus Group workshops Pilot Users training through info days. Enrich website and all mass media channels.
Results & Beyond (period 3)	Solicit 1st business interest to customers. Promote the exploitation of the EO4LEAs product/service. Promote the findings to key stakeholders.	Organization of a pan-European Workshop. Continue Focus Group with the UG. Enrich website and all social and mass media channels. Submit scientific papers to journals & conferences.

Dissemination channels: In order to reach all target audiences previously defined and communicate the key message to each target group, the following dissemination tools & channels will be used.
A **Project website**, to provide a dissemination path for the project outputs and documentation. Through the project site, information concerning the project and its progress will be presented. The site will be available by the end of Month 3 of the project, and it will be maintained and updated regularly, for at least 3 years after the end of the project.
Social Media. The project will be visible soon after its beginning in a wide range of social networks, such as, X, and LinkedIn. The social media activity will follow a social media strategy that will be developed as part of the dissemination strategy as outlined in D11-12.1.
An electronic **newsletter** will be published covering the latest updates of the project, addressing the general research community, as well as the target audiences of the project, and will be updated and disseminated bi-annually.
Brochures and Posters will be produced to present the benefits and impact of the project to the general public, with easy-to-read content. Brief information regarding the different technologies involved will be offered in the brochures, and results will be presented.
A **project video** to present EO4LEAs and its objectives and findings to first responders and authorities related to

space ground segment. The project video will be displayed in events where EO4LEAs will be presented and will also be available online on the project website and social media.

At a partner level, the dissemination activities are grouped based on the type of each beneficiary in Table 6 below:

Table 6: Specific dissemination activities per category.

	Main dissemination activities	Target audience
RTOs	Research organisations disseminate EO4LEAs through publications in scientific journals related to the technology advancements of the project. RTOs will organise and participate in workshops and conferences dedicated to critical infrastructure protection. They leverage their international research community network for building awareness, and for sponsoring the project's activities and results for further expansion and interfacing. RTOs contribute to the dissemination material so as to appeal to a wider audience and promote clustering and collaboration activities between the project and other EU-wide initiatives.	Scientific community and practitioners in critical infrastructure protection; operators of critical infrastructures in energy, water, healthcare, logistics, banking, telecommunications and transport; Open source research community.
Large Industries	Large industries contribute to the dissemination of the project by using their commercial profile and expertise to reach potential stakeholders through their existing portfolio and marketing tools (website, social media, newsletter). EO4LEAs will also benefit from the large network of collaborators that large industries have built through the years.	Potential stakeholders in critical infrastructure. Practitioners in protection of critical infrastructure.
SMEs	SMEs will have an active role in the dissemination of EO4LEAs by using the company's website and social media accounts. Dissemination will include the project's objectives and results. SME's will also contribute to the content of the dissemination material and to promote the project in relevant workshops (European Safety and Reliability Conference, International Conference on Natural Hazards & Infrastructure).	Clientele list of SMEs, security professionals.
Public bodies	Public bodies disseminate the results of the project amongst the respective critical infrastructure protection representatives. In addition, they will distribute the results amongst interrelated infrastructure operators to raise awareness of the project and highlight the potential benefits. They will also target experts within the policy sector of each infrastructure to frame future iterations of policies.	Public and private CIs, Emergency services/ operation centres, Policymakers

2.2.2 Communication activities

To ensure efficient communication of EO4LEAs to a wider audience, the following communication activities have been defined. The presented communication plan is a first approach of the communication strategy that is going to be finalised in the beginning of the project in the framework of Task 11.1 & Task 12.1 Communication and Dissemination actions.

Communication activities of Y1
The first year of the project will focus on the launch of the project's website and social media to familiarise the audience with the project. The content of the website will be developed and continuously updated, at least twice a month. Google Analytics will help to assess the website's traffic. A project newsletter will be designed that is going to be accessible through the website and social media of EO4LEAs. All the official project templates are going to be compiled and a brochure and roll-up banner giving an overall presentation of the project are going to be designed and printed. In order to facilitate the dissemination of the projects material a press kit will be distributed to news providers and a publication of a press release will be organised. Lastly, participation in conferences, workshops, and other events where printed material of the project could be distributed will be encouraged.

Communication activities of Y2
The communication activities of the second year will focus on keeping updated the previously defined website, social media, and newsletter channels. A new brochure is going to be circulated with more information aiming primarily at the pilot users. A video preparation will be scheduled regarding the first year of the project and the upcoming pilot use cases. Participation in conferences, workshops and other events will again be encouraged and the consortium is going to schedule Info Days related to demonstrations. Two Info-Day events of 10 days in total, will be organised for each PUC, targeting the familiarisation of pilot users with the objectives of pilots and the EO4LEAs platform. Lastly, the consortium is aiming to deliver at least 6 peer-reviewed papers by the end of the second year of the project.

Communication activities of Y3
In the final year of the project, all communication channels will be updated with the latest news and outcomes of the project. 2 newsletters are expected to be distributed. Conferences, workshops, peer reviewed publications and other event participation will disseminate further the project results. A publication of a press release will be scheduled to mark the end of the project, along with the final and updated press kit to news providers. A conclusive project workshop will be organised in one of the EU countries. The core objective of the workshop will be to inform stakeholders about the outcomes and lessons learned during the project implementation. The workshop will include presentations and discussions with members of the consortium but also from invited specialised speakers.

Table 7, displays the dissemination and communication KPIs that will be monitored and measured in the lifetime of the project.

Table 7: Dissemination and Communication targets.

Tool	Metric	Target
EO4LEAs website	Number of i) visits/views; ii) downloads of publicly available online material, iii) website audience	i) Measurement: Google Analytics; 10% visits increase every year; ii) 100 downloads; iii) Total visits: 7000
Stakeholder Forum	Number of LEAs	> 6 organizations
Synergies	Number of Synergies with related projects and initiatives	> 5 synergies
Workshops	Number of i) workshops, ii) participants/workshop (by target group)	i) 4 workshops: 1 scientific workshop collocated with a Rank A conference with > 20 participants and 3 workshops (roadshow events) focusing on the project demonstration to security authorities
Social Media	Number of i) groups joined, ii) active discussion forums, iii) views (LinkedIn), iv) tags and followers (Twitter), v) comments, likes, favorites and retweets	i) 1 discussion forum on X/ LinkedIn, ii) 400 views, iii) 300 followers, iv) at least 1 post per week across all social media platforms
Publications	Number of i) publications in technical and scientific conferences and journals, ii) publications in industry-led magazines and websites	At least 10 scientific or academic open access publications
User Group	i) Number of users, ii) diversification	i) At least 50 users
Newsletter	i) Frequency, ii) no. of readers	i) Bi-annual, ii) at least 200 readers in total

2.2.3 Exploitation

Ensuring the project's results are effectively exploited is a key point for EO4LEAS to maximise its added value and enhance competitiveness. In essence, the EO4LEAS exploitation strategy will consist of three building blocks:
Building Block 1: Initial Market Analysis and Business Model(s) Market analysis: The identification of the potential market will align with the project's objectives and utilise the most up-to-date market data available. The global satellite broadband communication in the public safety market size serves as a benchmark for Copernicus Security

Services, as it endeavours to augment its surveillance capabilities within the security sector. The global satellite broadband communication in public safety market size was valued at $1.36 billion in 2020 and is projected to reach $10.76 billion by 2030, growing at a CAGR of 23.1% from 2021 to 2030.. Through the detailed market analysis, potential opportunities for various solutions developed within the project will be defined. The EO4LEAS business models will be designed based on the findings of the market analysis, outlining how EO4LEAS will generate and deliver value. Customised business models will then be devised, taking into consideration factors such as value propositions, revenue streams, and cost structures. Stakeholder engagement and validation will be integral throughout this process, allowing for refinement of the models to align with stakeholders' requirements and preferences, ultimately yielding resilient and flexible business solutions.

Building Block 2: IPR Management IP Management Plan: A specific IP Management Plan will be elaborated to protect the property of the project's background and results, also addressing the management and distribution of IP rights and ownership among project partners. Both the activities and methodology defined in the IP Management Plan will be fine-tuned and agreed upon among all partners towards the project end when final project outcomes have been generated.

Building Block 3: Strategy for market take-up and long-term sustainability: The third building block will comprise three modules, each serving distinct functions: i) Marketing Plan Definition: The marketing plan will articulate the marketing strategy, incorporating elements such as pricing, promotion, and distribution strategies. It will be informed by the comprehensive analysis and synthesis of the project's exploitable assets. This phase aims to identify the optimal positioning for products by assessing their capacity to meet user needs relative to competitors' offerings. Subsequently, coherent positioning decisions, encompassing branding and product description, will be designed and seamlessly integrated into all communication endeavors; ii) Standardization Roadmap Establishment: A roadmap delineating standardization efforts will be crafted based on the standardization requirements identified in preceding phases. This roadmap will establish timelines for standardization activities and identify the relevant standardization bodies for engagement and iii) Business Plan Development: The business plan will be meticulously developed, encompassing identified expenses, market analysis findings, and refined business models. This comprehensive plan will emphasize critical aspects such as value proposition, business models, target markets, timelines, competitors' analysis, and risk assessment. Additionally, estimated costs will undergo quantitative analysis to assess the financial viability of EO4LEAS. Various scenarios, including optimistic, realistic, and pessimistic, will be explored to ensure robustness and adaptability.

The **exploitation plan** for EO4LEAs will be formulated according to the guidelines outlined in WP11&WP12, delineating suitable targets for leveraging the project's outputs. This plan will encompass strategies for building upon and reusing the progress attained, along with the development of a commercial and business strategy for the project results. It will span the entirety of the project's duration, persisting beyond its conclusion, and will be crafted, composed, and implemented by the EO4LEAs Exploitation Manager, drawing upon the foundational elements previously mentioned. By the end of the project, the exploitation plan will cover in detail the following topics:

- **Objectives:** Detailed definition of the aims of the Exploitation Plan including (a) the mapping out of the way the Consortium can derive commercial benefits during and after the project from the work conducted under EO4LEAS and (b) the definition of the way the technical work should be conducted to maximise commercial benefits.
- **Strategy:** EO4LEAS has potential application in a number of different areas that access the EO4LEAS data but differing needs in the use of it. The exploitation pan will describe these sectors (size, changes required to address their problems, cost of accessing the sectors, main actors etc.). The Exploitation Plan will also cover market research on competitor technology.
- **Mechanisms**: Once the Strategy is defined, the mechanisms for implementing such strategy (marketing actions, demonstrations to main actors etc.) will be defined.
- **Plans of Action:** After markets are defined in detail and mechanisms have been chosen and preliminary contacts established, we will be in a good position to assess the costs and benefits of the exploitation. We already have a clear picture of where benefits are to be found. Benefits can however only be secured after some investment is made. To secure that investment (whether it comes from partners' resources, outside sources of financing or new partnerships) detailed costings have to be provided. Thus, the information presented here needs to be broadened into detailed business plans for partners showing P&L and Cash-Flow forecasts, sensitivity analyses etc.
- **Impact:** Customer contacts, the results of market research and the definition of Plans of Action will lead to suggested modifications in the research direction of the project to maximise its commercial impact. At pre-defined points during the project, the implications of the developing Exploitation Plan on research will be

considered by the Project Board.

- **Scope of Commercial Agreement**: Though a Consortium Agreement will be signed early in the project, the detailed definition of the commercial implications of development can only be properly considered once actual products have started to take shape. Then the Consortium Agreement will be revisited and expanded
- **Future Actions**: The project is only planned to last 3 years, but the exploitation will persist after this period. It is therefore important that all future actions are clear and well-defined before the research project ends.

The exploitation strategy for EO4LEAS aims to maximise the utilisation and impact of research and development (R&D) outcomes within operational environments, particularly within the framework of the EU Copernicus program. Key elements of this strategy include technology transfer to Copernicus implementers through targeted outreach efforts, knowledge-sharing workshops, and collaboration agreements to ensure seamless integration into operational workflows. Additionally, an Intellectual Property Rights (IPR) management framework will be established to govern the licensing and utilisation of project results, prioritising accessibility and flexibility. Open licensing policies will be advocated for to promote widespread adoption and re-use of project deliverables, enabling Copernicus implementers to freely install, copy, and adapt solutions to meet their specific operational needs. Furthermore, ongoing capacity building and support will be provided to Copernicus implementers through training sessions, technical assistance, and documentation, facilitating seamless integration and maximising operational impact. Regular monitoring and evaluation activities will be conducted throughout the exploitation phase to assess the uptake and impact of R&D outcomes within operational environments, informing iterative improvements and refinements to the exploitation strategy to ensure continued relevance and effectiveness.

By prioritising technology transfer, embracing open licensing principles, and providing ongoing support to Copernicus implementers, the aim is to catalyse the transformation of R&D innovations into tangible operational benefits within the EU Copernicus programme.

Individual Exploitation Plans: Each partner will provide an Individual Exploitation Plan outlining their intentions for exploiting each asset in accordance with their business and research strategies. Partner motivations will be assessed and organised into target exploitation action categories, including advancing and broadening TRL, marketing promotion, redistribution, internal exploitation, third-party assignment or licensing, further research, and integration into existing business lines or networks. Each category will entail specific actions and plans, as provided by Table 8.

Table 8: Individual exploitation plans

Exploitable Assets	Owner	Exploitation options & potential customers	Licence
EO4LEA Digital Twin	**UCY**	*LEAs, International security agencies, ICT companies*	Open Source (GPL)
Video content collection and processing	**UAV**	*LEAs, ICT companies*	
Crowdsourcing module	**CDXi**	*LEAs, International security agencies, Border guards, National security organisations, Environmental agencies*	Open source (CC BY-NC-SA 4.0)
Monitoring and forecasting Chlorophyll-α levels using satellite imagery	**CDXi**	*Environmental agencies, National security organisations*	Open source (CC BY-NC-SA 4.0)
Mapping of oil spills utilizing Copernicus Sentinel-2 data	**CDXi**	*Environmental agencies, international security agencies, National security organisations,*	Open source (CC BY-NC-SA 4.0)
Crisis detection module	**CDXi**	*LEAs, International security agencies, Border guards, National security organisations, Security equipment manufacturers, Environmental agencies*	Open source (CC BY-NC-SA 4.0)
Cross-modal search engine	**CDXi**	*LEAs, International security agencies, Border guards, National security organisations, Security equipment manufacturers, Robotic systems manufacturers*	Open source (CC BY-NC-SA 4.0)
Software P-PSI	**NOA**	*LEAs, International security agencies, Border guards, National security organisations, Security*	GNU LESSER GENERAL

		equipment manufacturers, Robotic systems manufacturers	PUBLIC LICENS
Socioeconomic Impact Assessment	**RG**	*LEAs, Border guards, international security agencies, National security organisations*	Proprietary
Organizational Business Continuity Module	**RG**	*LEAs, Border guards, international security agencies, National security organisations*	Proprietary
Risk Assessment Engine	**RG (partial)**	*LEAs, Border guards, international security agencies, National security organisations*	Proprietary (RG holds license for research exploitation)
T4i DOVER Ground Station	**T4i**	*Environmental agencies, LEAs, International security agencies, Border guards, National security organisations, Security equipment manufacturers*	Proprietary (T4i holds license for research exploitation)
T4i DOVER	**T4i**	*Environmental agencies, LEAs, International security agencies, Border guards, National security organisations, Security equipment manufacturers*	Proprietary (T4i holds license for research exploitation)

A **Joint Exploitation Plan** will also be developed to encompass continuous testing and validation of EO4LEAs tools and services, ensuring alignment with State-of-the-Art (SoA) benchmarks, Key Performance Indicators (KPIs), user requirements, and the outcomes of the four use cases. Dissemination and communication activities will aim to foster connections between the consortium and external stakeholders, raising awareness of the EO4LEAs solution. Implementation of the exploitation strategy will proceed in alignment with project objectives and timelines. Synergies with other EU projects and international networks/initiatives will be sought through collaboration and relationship-building with relevant associations, projects, programs, and networks to expand outreach efforts. Open access dissemination of research findings will be facilitated via platforms like Zenodo. The fully developed EO4LEAs solution will be made available for immediate deployment, with access facilitated through licensing arrangements with the service provider.

2.2.4 Management of knowledge and intellectual property rights strategy

Intellectual Property Rights (IPR) Strategy: EO4LEAs is committed to adhering to the European Commission's policies regarding intellectual property rights (IPR), focusing on the ownership, exploitation rights, confidentiality, and commercial utilisation of results. This commitment ensures the protection and strategic use of project results, fostering innovation while allowing for wide dissemination and impact. Key facets of our IPR strategy include:

- **Ownership and Access Rights**: Consistent with EC policies, research publication rights will belong to the originators of the work, promoting an environment of open access and wide dissemination of project findings. EO4LEAs prioritises making its scientific outputs available through open access channels, enhancing the visibility and accessibility of its innovations.
- **Open Source Software**: Aligning with the drive towards open innovation, EO4LEAs plans to release most of its software developments under open source licences. This approach lowers barriers to adoption for end-users, such as law enforcement agencies and environmental monitoring bodies, by minimising upfront costs and fostering community-based enhancements and reliability.
- **Expertise and Background Knowledge:** Consortium partners will contribute their pre-existing expertise and knowledge to the project without additional costs, retaining full ownership of their respective intellectual property. This shared foundation of knowledge and technology facilitates a collaborative innovation environment within EO4LEAs.
- **Development of New Technologies**: Innovations and technologies developed within EO4LEAs will be owned by the contributing consortium members. In cases of joint development where specific contributions cannot be discerned, arrangements for joint ownership will be established, ensuring a fair and equitable distribution of intellectual property rights among partners.

EO4LEAs will implement a comprehensive IP strategy in stages, from initial analysis to execution and positioning, to safeguard IP assets and align them with the project's commercialization and exploitation strategies. This includes:

IP Analysis: Identification and inventory of IP assets, assessing their relevance to the project's objectives and

potential commercial pathways.
IP Strategy Definition: Harmonisation of individual IP strategies into a cohesive plan.
IP Operations: Establishment of IP goals and monitoring mechanisms.
IP Execution: Implementation of defined IP actions and communication among stakeholders.
IP Positioning: Evaluation of market and competitor IP strategies, with iterative realignments as necessary to minimise risks and enhance market uptake.

The project will continuously monitor and revise its IP strategy, incorporating SWOT analysis to align with market needs and competitive landscapes. This dynamic approach ensures the effective exploitation of innovations, contributing to the strategic autonomy of the EU in space-based services. By embedding a robust IPR strategy from the outset and ensuring continuous management, EO4LEAs lays the groundwork for sustainable impact and commercial success. This strategic approach not only safeguards project outcomes but also secures market visibility and exploitation opportunities. During the project, a dedicated IPR management procedure will develop an IP registry reporting Foreground IP in alignment with open Science and FAIR principles. A clear legal framework that will be established in the Consortium Agreement will regulate IP ownership, access rights, and other related issues. Towards the project's end, a comprehensive plan will address IP assessment, legal risk management, exploitation, and enforcement, ensuring strategic IP use beyond the project lifecycle.

Knowledge Management: EO4LEAs is deeply committed to maximising the impact and reach of its generated knowledge both during and after the project's lifespan. The project has developed a detailed strategy for knowledge management aimed at broad dissemination and easy access to its insights, innovations, and results. This strategy targets a wide audience including stakeholders, researchers, and the general public, ensuring that EO4LEAs's contributions are widely available and beneficial. Here is an overview of how EO4LEAs plans to manage and share its knowledge:

- **Project Documents:** EO4LEAs will ensure wide access to its knowledge base by publishing the public sections of formal documents, including deliverables and milestones, on its website. These documents will be archived in an open-access repository, with final versions released under a Creative Commons "CC BY" licence, facilitating maximum reuse.
- **Project Reporting:** To keep stakeholders informed of our progress, EO4LEAs will produce quarterly and periodic progress reports as required by the European Commission. While these reports may contain sensitive information and not be fully public, summaries of developments and accomplishments will be shared on the project's website. Press releases and announcements will further highlight project advances.
- **Publications:** EO4LEAs encourages the dissemination of research findings through publications in journals and conferences, with a particular focus on open-access platforms. A dedicated budget supports open access publishing (gold open access) for each research and technology organisation within the consortium. Submissions to journals that offer green open access or require an embargo period will be considered on a case-by-case basis, ensuring compliance with open access mandates.
- **Presentations**: Presentations delivered as part of the EO4LEAs project will be made publicly available on the website, licensed under Creative Commons to promote knowledge reuse. Additionally, a concise presentation summarising the key outcomes of each public deliverable will be uploaded, providing an accessible overview of the project's results and achievements.

Through these measures, EO4LEAs commits to an open and transparent sharing of knowledge, ensuring that the project's contributions to environmental monitoring, security surveillance, and the broader Copernicus initiative have a lasting and wide-reaching impact. This strategy not only adheres to the principles of open science but also facilitates the engagement and collaboration of diverse communities with the project's outputs.
#§COM-DIS-VIS-CDV§#

2.3 Summary

SPECIFIC NEEDS	EXPECTED RESULTS	D & E & C MEASURES
• Current security services lack real-time, comprehensive environmental and situational awareness, crucial for timely and effective law enforcement and emergency response. • Traditional Earth Observation (EO) data processing and analysis methods fall short in meeting the urgent and complex needs of Law Enforcement Agencies (LEAs) due to their inability to integrate and analyze diverse, multi-source data streams efficiently. • LEAs require advanced simulation and digital twin technologies for predictive analytics and scenario planning, which are not fully integrated into existing security services. • There is a significant gap in the operational integration of non-space data (e.g., social media, IoT sensors) with EO data, limiting the effectiveness of current security and surveillance efforts. • The absence of sophisticated GeoAI solutions in current security services restricts the capability to automatically detect, categorize, and respond to emerging threats or incidents. • Limited access to customized, user-friendly tools for data visualization and decision support systems challenges the operational efficiency of LEAs in field and strategic operations.	**KR01**: UAV video content collection and processing; **KR02:** Crowdsourcing module; KR03: Sensor data wrappers; **KR09:** Super resolution module; **KR04:** Algae bloom monitoring and forecasting module; **KR05:** Oil spill detection module**; KR06:** Early warning and monitoring system for geotechnical failures and landslide risks based on interferometric, GNSS, and UAV data; **KR07:** Embedded AI for autonomous airborne chemical detection payload module; **KR08:** Source localization of chemical attacks module; **KR10:** Change detection module; **KR11:** Atmospheric anomaly detection module; **KR12:** Multimodal crisis detection module; **KR13**: Impact assessment module; **KR14:** Risk assessment module; **KR15**: Explainable AI module; **KR16:** Foundation model and question-answering interface for Copernicus security applications; **KR17:** Cross-modal search engine; **KR18:** Advanced EO and non-EO data indexing and DestinE; **KR19:** EO4LEAs digital twin platform.	**Dissemination (D) & Communication (C):** • Scientific or academic open access publications > **10** • **4** Workshops**:** 1 scientific workshop collocated with a Rank A conference with > 20 participants and 3 workshops (roadshow events) focusing on the project demonstration to security authorities. • Website and social media: 1 discussion forum; 400 views; 300 followers; ≥1 post per week. • User group ≥ 50 users • Newsletters: ≥ **200** readers; bi-annual. • Project Brochure and Roll-up banner • Short Project Film • Project Fact Sheet **Exploitation (E):** • Open-source release of select software modules. • Commercial licenses for specialized technologies to LEAs and security sectors. • Training programs for LEAs on technology application in operational settings. • Development of a business model for service offerings • Scientific advances/re-use; Other EU funding programs; Policy making; Open EC exploitation platforms.

<table>
<tr><th>TARGET GROUPS</th><th>OUTCOMES</th><th>IMPACTS</th></tr>
<tr><td>A. Law Enforcement Agencies (LEAs)
B. International Security Agencies
C. ICT Companies
D. Border Guards
E. National Security Organizations
F. Environmental Agencies
G. Security Equipment Manufacturers
H. Robotic Systems Manufacturers</td><td>• Improved Situational Awareness: Enhanced decision-making for LEAs and environmental agencies through advanced data analytics and real-time monitoring.
• Increased Security & Protection: Notable advancements in managing environmental and security threats via AI and digital twins.
• Space Autonomy: Strengthened European independence in space with GeoAI and digital twin integration into Copernicus.
• Sector Competitiveness: Innovation boost in the EU space sector through open-source initiatives and result dissemination.
• Technology Adoption: Wider use of EO4LEAs technologies, driving forward European space capabilities through user-driven innovation and collaboration.</td><td>• Scientific Impact: EO4LEAs pushes the boundaries in GeoAI and digital twin technologies, enhancing Earth Observation data analytics for security and environmental monitoring.
• Economic Impact: The project catalyzes the growth of the EU space and security sectors, promotes innovation, opens new business avenues, and strengthens Europe's strategic autonomy in space-based services.
• Societal Impact: It improves public safety and environmental protection through advanced monitoring and analysis, thereby contributing to a more informed, resilient, and secure society.</td></tr>
</table>

#§IMP-ACT-IA§#

3. Quality and efficiency of the implementation #@QUA-LIT-QL@# #@WRK-PLA-WP@#

3.1 Work plan and resources

3.1.1 Work Packages and EO4LEAs structure

The EO4LEAs implementation plan is structured around twelve (12) interrelated Work Packages (WPs) (Figure 2): WP1 & WP2 are responsible for both managing and administering the project effectively, including adhering to the ethics appraisal procedure in Horizon Europe, as well as ensuring compliance with the Commission contract and the Consortium Agreement. WP3 focuses on designing pilot use cases and scenarios for EO4LEAs, defining pilot KPIs for evaluation, specifying user, ethical, and legal requirements, and analysing data models and their compatibility with existing standards. WP4 & WP5 are dedicated to the collection, organisation, and preparation of multimodal data from a variety of sources to facilitate its integration, further analysis, and visualisation through the digital twin technology. These work packages prioritise ensuring the quality and fusion-readiness of data for subsequent processing steps, serving as a foundational layer for WP6 & WP7 activities. WP6 & WP7 focus on the integration of Geospatial Artificial Intelligence (GeoAI) for analysing geospatial data. Their goal is to derive valuable insights, identify patterns, and make predictions based on the heterogeneous data prepared in WP4 & WP5, enhancing the project's analytical capabilities. WP8 & WP9 aim to develop digital twin models in line with the Destination Earth (DestinE) initiative, leveraging the data fusion and GeoAI algorithms outcomes from the project. They concentrate on building scalable, accurate digital representations of the Earth that are relevant to the EO4LEAs' pilot use cases. By incorporating Explainable Artificial Intelligence (XAI), WP8 & WP9 ensure that the decision-making process is transparent and understandable. These work packages also seek to improve the interaction between users and digital twins, making simulation, analysis, and the extraction of actionable insights more intuitive. WP10 is focused on evaluating the EO4LEAs framework in four (4) use case scenarios, implementing operational tests and demos, and training end-users towards the efficient use of EO4LEAs. Finally, WP11 & WP12 ensure effective communication, dissemination and exploitation of the project activities and sustainability of its results.

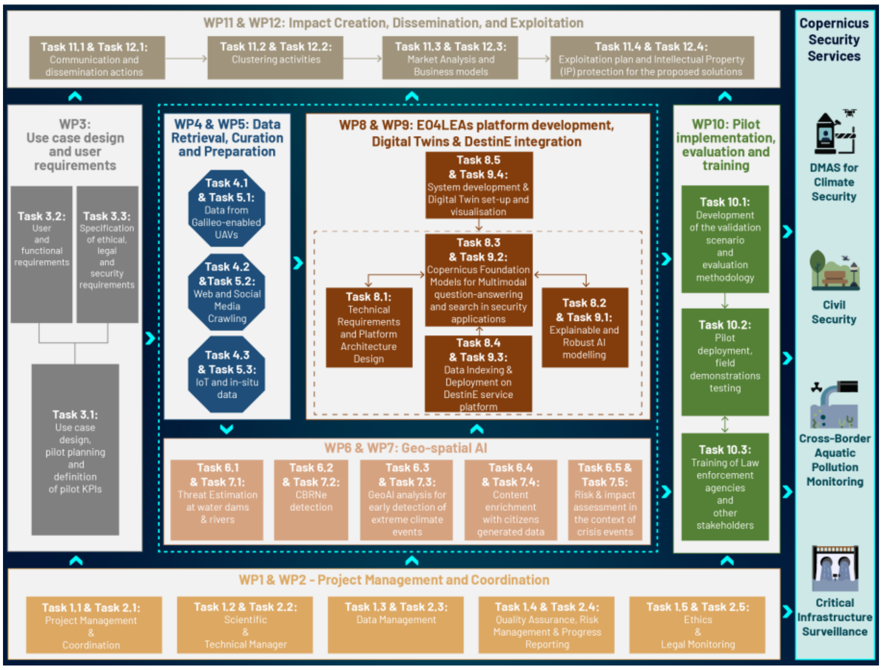


Figure 2: EO4LEAs WP and Task dependencies.

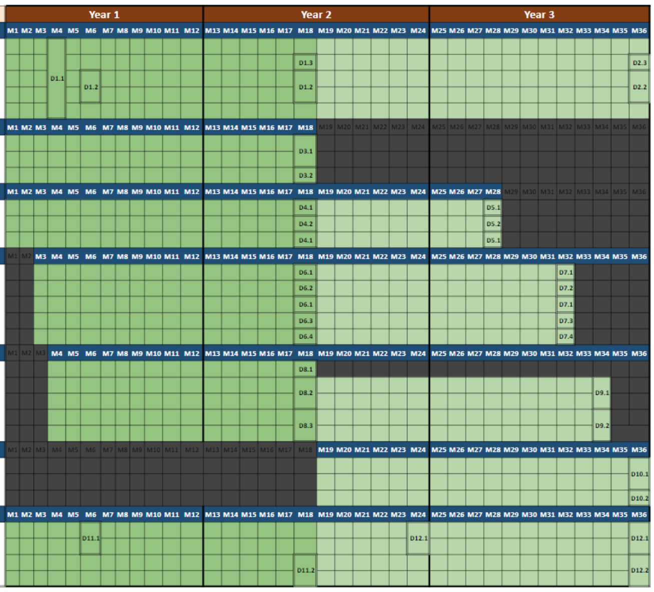
3.1.2 List of work packages

Work Package	Work Package Title	Leader	PMs	Start	End
WP1	Project management & coordination (v1)	**KEMEA**	33.6	M1	M18
WP2	Project management & coordination (v1)	**KEMEA**	36.5	M19	M36
WP3	Use case design and user requirements	**NOA**	112.3	M1	M18
WP4	Data Retrieval, Curation, and Preparation (v1)	**ACCELI**	35.1	M3	M18
WP5	Data Retrieval, Curation, and Preparation (v2)	**ACCELI**	35	M19	M28
WP6	Geo-spatial AI (v1)	**CDXi**	61.5	M3	M18
WP7	Geo-spatial AI (v2)	**CDXi**	61.4	M19	M32
WP8	EO4LEAs platform development, Digital Twins & DestinE integration (v1)	**UCY**	74.5	M4	M18
WP9	EO4LEAs platform development, Digital Twins & DestinE integration (v2)	**UCY**	75	M19	M34
WP10	Pilot implementation, evaluation and training	**SATCEN**	104.2	M19	M36

WP11	Impact Creation, Dissemination, and Exploitation (v1)	**DREVEN**	39.4	M1	M18
WP12	Impact Creation, Dissemination, and Exploitation (v2)	**DREVEN**	40.4	M19	M36

3.1.3 Timing of Work Packages, Tasks and Deliverables

Work Packages and Tasks	Leader	Start	End
WP1 & WP2 - Project Management and Coordination	**KEMEA**	**M1/M19**	**M18/M36**
Task 1.1 & Task 2.1 Project Management & Coordination	KEMEA	M1/M19	M18/M36
Task 1.2 & Task 2.2 Scientific & Technical Manager	CDXi	M1/M19	M18/M36
Task 1.3 & Task 2.3 Data Management	KEMEA	M1/M19	M18/M36
Task 1.4 & Task 2.4 Quality Assurance, Risk Management & Progress Reporting	KEMEA	M1/M19	M18/M36
Task 1.5 & Task 2.5 Ethics & Legal Monitoring	RAD	M1/M19	M18/M36
WP3 - Use case design and user requirements	**NOA**	**M1**	**M18**
Task 3.1 Use case design, pilot planning and definition of pilot KPIs	NOA	M1	M18
Task 3.2 User & functional requirements	SATCEN	M1	M18
Task 3.3 Specification of ethical, legal and security requirements	KEMEA	M1	M18
WP4 & WP5 - Data Retrieval, Curation, and Preparation	**ACCELI**	**M3/M19**	**M18/M28**
Task 4.1 & Task 5.1 Data from Galileo-enabled UAVs	ACCELI	M3/M19	M18/M28
Task 4.2 & Task 5.2 Web and Social Media Crawling	CDXi	M3/M19	M18/M28
Task 4.3 & Task 5.3 IoT and in-situ data	T4i	M3/M19	M18/M28
WP6 & WP7 - Geo-spatial AI	**CDXi**	**M3/M19**	**M18/M32**
Task 6.1 & Task 7.1 Threat Estimation at water dams & rivers	NOA	M3/M19	M18/M32
Task 6.2 & Task 7.2 CBRNe detection	T4i	M3/M19	M18/M32
Task 6.3 & Task 7.3 GeoAI analysis for early detection of extreme climate events	CDXi	M3/M19	M18/M32
Task 6.4 & Task 7.4 Content enrichment with citizens generated data	CDXi	M3/M19	M18/M32
Task 6.5 & Task 7.5 Risk & impact assessment in the context of crisis events	RG	M3/M19	M18/M32
WP8 & WP9 - EO4LEAs platform development, Digital Twins & DestinE integration	**UCY**	**M4/M19**	**M18/M34**
Task 8.1 Technical Requirements and Platform Architecture Design	UCY	M4	M18
Task 8.2 & Task 9.1 Explainable and Robust AI modelling	DREVEN	M4/M19	M18/M34
Task 8.3 & Task 9.2 Copernicus Foundation Models for Multimodal question-answering and search in	NOA	M4/M19	M18/M34
Task 8.4 & Task 9.3 Data Indexing & Deployment on DestinE service platform	SERCO	M4/M19	M18/M34
Task 8.5 & Task 9.4 System development & Digital Twin set-up and visualisation	UCY	M4/M19	M18/M34
WP10 - Pilot implementation, evaluation and training	**SATCEN**	**M19**	**M36**
Task 10.1 Development of the validation scenario and evaluation methodology	SATCEN	M19	M36
Task 10.2 Pilot deployment, field demonstrations testing	KEMEA	M19	M36
Task 10.3 Training of Law enforcement agencies and other stakeholders	BDI	M19	M36
WP11 & WP12 - Impact creation, dissemination and exploitation	**DREVEN**	**M1/M19**	**M18/M36**
Task 11.1 & Task 12.1 Communication and dissemination actions	ACCELI	M1/M19	M18/M36
Task 11.2 & Task 12.2 Clustering activities	KEMEA	M1/M19	M18/M36
Task 11.3 & Task 12.3 Market analysis and Business models	DREVEN	M1/M19	M18/M36
Task 11.4 & Task 12.4 Exploitation plan and Intellectual Property (IP) protection for the proposed solutions	DREVEN	M1/M19	M18/M36



3.1.4 Work package description

WP1 & WP2	**Project management & coordination (v1, v2)**

Objectives: The primary objectives focus on overseeing the project's administrative and technical dimensions. Administrative oversight includes tracking adherence to grant requirements, handling risk management, conducting internal meetings, safeguarding intellectual property rights, and overseeing budgetary spending. In the technical realm, the emphasis is on maintaining high standards of quality while tracking the project's scientific and technical progress. The aim of managing data is to guarantee that all project-related data, whether acquired or generated, is managed with strict adherence to privacy, confidentiality, FAIR, and ethical standards. The overarching objective of this work package is to ensure the project is carried out successfully, characterised by efficient management and adherence to ethical standards.

T1.1 & T2.1 Project Management & Coordination [M1-M18; M19-M36] (KEMEA)

This task involves the necessary administrative and financial steps to execute the project and meet its goals. Administrative duties cover: a) ensuring the project meets the EU Commission Grant Agreement's requirements; b) identifying and planning for potential risks; c) setting up and holding project meetings, including those of the General Assembly, technical teams, and the Advisory Board; d) establishing and overseeing the Project Management Board (PMB) and Advisory Board (AB); e) monitoring intellectual property rights (IPR), data protection, and the dissemination of knowledge generated by the project. Financial tasks encompass: a) overseeing the allocation and use of project funds and monitoring expenses; b) conducting an internal financial monitoring; c) keeping accurate financial records and accounts within specified deadlines; d) gathering and organising financial reports from project partners. To guarantee the project adheres to the Grant Agreement's scientific quality standards, a Project Handbook detailing all necessary procedures will be created and shared with all partners, facilitating the project's seamless execution.

Outputs: D1.1

T1.2 & T2.2 Scientific & Technical Management [M1-M18; M19-M36] (CDXi)

This task ensures EO4LEAs achieves the highest quality in research and development by implementing robust quality assurance protocols and risk management strategies. The formulation of a comprehensive quality assurance strategy is central to this task, aimed at ensuring project outputs and technical efforts meet excellence standards. A centralised risk log, maintained by the Project Management (PM) team, will document, analyse, and strategize on potential risks, with routine reviews to keep it current. In addition to upholding scientific and technical quality norms and addressing discrepancies, this task involves monitoring Key Results (KRs) through technical teleconferences to align them with Pilot Use Cases (PUCs) requirements. This ensures deliverables are not only high-quality but also closely match user needs. Furthermore, an internal quarterly technical report will track the project's progress and alignment, focusing on three main goals: ensuring compliance with quality standards, monitoring the quality of scientific and technological outputs, and managing deviations from the plan efficiently. This structured approach supports EO4LEAs in delivering impactful outcomes that enhance Copernicus Security Services.

Outputs: D1.1, D1.3, D2.3

T1.3 & T2.3 Data Management [M1-M18; M19-M36] (KEMEA, All**)**

This task is designed to monitor the privacy and confidentiality of data generated or collected by EO4LEAs, ensuring compliance with established standards for data production, use, preservation, and dissemination; this includes applying technical standards for data representation as well. It will also assess which data can be released as part of the open data initiative. Following the FAIR principles, EO4LEAs will create a Data Management Plan (DMP) detailing the handling of data throughout and beyond the project's lifespan. The DMP will address data training, record-keeping, provision of information, and data robustness and accuracy. With Copernicus data being extensively utilised, EO4LEAs will request additional datasets from Copernicus Contributing Missions via the Data Warehouse mechanism managed by ESA to enrich the project with high-resolution data. Furthermore, this task commits to ensuring that the project's developments are in line with existing laws, ethical standards and guidelines by paying special attention to the management of personal data as part of the project.

Outputs: D1.1, D1.2, D2.2

T1.4 & T2.4 Quality Assurance, Risk Management & Progress Reporting [M1-M18; M19-M36] (KEMEA, All**)**

This task is focused on establishing quality assurance guidelines for the research and development activities within EO4LEAs, identifying potential risks, and implementing necessary corrective measures. EO4LEAs will develop a comprehensive quality assurance plan to guarantee the excellence of project outputs and oversee the technical work's quality. Additionally, a risk log will be created, featuring risk descriptions, analyses, and mitigation strategies, to be managed and regularly updated by the PM team. This task also includes ensuring that the project's advancements adhere to current ethical standards and guidelines. Moreover, it aims to certify that EO4LEAs meets the required scientific and technical quality benchmarks, tracks the quality of scientific and technological achievements, and rectifies any deviations from the established plan.

Outputs: D1.1, D1.2, D2.2

T1.5 & T2.5 Ethics & Legal Monitoring [M1-M18; M19-M36] (RAD, KEMEA, CDXi, BDI, UCY, ANR)

This task aims at identifying and addressing legal and ethical challenges that may emerge during the EO4LEAs project. EO4LEAs is committed to ensuring that all project endeavours comply with legal and ethical norms relevant to the technology in use and its applications. To facilitate this, an internal ethics board will be established at the beginning of the project to tackle any concerns related to ethics. The designation of a Data Protection Officer (DPO) will secure adherence to GDPR mandates, encompassing the implementation of privacy-by-design practices.

A key priority will be the management of risks tied to the personal data processing and the use of disruptive technologies such as AI, aiming to protect individuals' fundamental rights by following an ethics-, security- and privacy-by-design approach. The insights gained from these evaluations will be consolidated into a legal and ethical framework, detailing precise risk mitigation approaches. This framework will incorporate a thorough review of legal and ethical regulations at both the European and pertinent national levels, mindful of the evolving regulatory landscape.

Moreover, this task entails the responsibility of compiling templates of information sheets and informed consent forms for human participation and processing of personal data as well as developing privacy notices for all tools and systems crafted and evolved by EO4LEAs and examining the necessity for a data protection impact assessment prior to the operation of technologies and tools that are likely to result in high risks to the rights and freedoms of the data subjects (such as web and social media crawling), to ensure these innovations are in strict compliance with data protection standards. This task will ensure that all research activities and dissemination activities are conducted in an ethical and lawful manner and will place emphasis on the pilot use case demonstrations, respecting all participants' rights, and adhering to established ethical principles and legal requirements.

Outputs: D1.1, D1.2, D2.2

WP3	Use case design and user requirements
Objectives: The primary objectives of WP2 encompass the design, finalization, and evaluation of the EO4LEAs pilot use cases, alongside establishing their implementation, ethical, and legal frameworks. In shaping these elements, WP2 will actively incorporate feedback and guidance from the Copernicus Security Services Strategic Research Agenda (CSS-SRA). This approach ensures that the development and assessment of the pilot use cases are aligned with the strategic priorities and ethical guidelines outlined in the CSS-SRA, facilitating a project that is both responsive to user needs and adherent to the highest standards of ethical and legal compliance within the scope of Copernicus Security Services.	
T3.1 Use case design, pilot planning and definition of pilot KPIs [M1-M18] (NOA, KEMEA, SATCEN, ACCELI, BDI, UCY, LSDB, ANR) This task involves EO4LEAs' use case leaders working in partnership with the involved end-users to collaboratively design the pilot use cases. The objective is to create a detailed framework for each Pilot Use Case (PUC) that clearly outlines its objectives, the benefits it brings in line with end-users' operational needs, the expected outputs including product or service specifics, the designated Area of Interest (AOI) for pilot demonstrations, and a high-level summary of the technical execution plan. In addition to these components, this task will develop the demonstration scenarios that are slated for execution as part of WP6's pilot operations. These scenarios will detail the services being provided, the roles of all participants involved, and visual diagrams to guide the sequence of events. To conclude, a structured plan along with identifiable and quantifiable Key Performance Indicators (KPIs) will be established to ensure each pilot demonstration can be evaluated effectively, focusing on its alignment with the project's aims and user engagement strategies. **Outputs: D3.1**	
T3.2 User & functional requirements [M1-M18] (SATCEN, All**)** In this task, the objective is to gather and collect the functional and non-functional requirements for the EO4LEAs project. The requirements development for user requirements & functional requirements and non-functional requirements includes four phases: elicitation, analysis, specification and validation through co-creative practices with EO4LEAs practitioners, consortium members and relevant stakeholders. This iteration aims to achieve a successful inter-relationship between the users' needs and the objectives of this project. Furthermore, through engagement with end-users and analysis of their operational contexts, this task will delineate the specific requirements that EO4LEAs must meet to ensure effectiveness and usability in real-world scenarios. It involves a thorough investigation into how satellite data and additional sensor information can be optimally utilised within the contexts of Border Surveillance, Civil Security, Maritime Surveillance, and Critical Infrastructure Surveillance. The EO4LEAs end users will translate the technical gaps, which they face daily, in the commensurable definitions making the link between the use cases activities and the project technical developments. **Outputs: D3.1**	
T3.3 Specification of ethical, legal and security requirements [M1-M18] (KEMEA, SATCEN, CDXi, NOA, ACCELI, RAD, BDI, UCY, LSDB, ANR) The objective of this task is to formulate the requirements for EO4LEAs taking into account ethical, legal and security aspects. The ethical, legal and security requirements that will be extracted, according to three tasks (Knowledge acquisition; Identification of legal and ethical sources; Definition of requirements), will shape the design and development of services and tools in EO4LEAs. The legal requirements will include the EU and Member States legislation relevant for the project, with special focus given to the fundamental right to privacy and data protection, cybersecurity and the use of AI-enabled technologies. Regarding the national legislation, information will be collected from all relevant partners (mainly PUC leaders and technology providers) via a dedicated questionnaire. In line with the recommendations of T1.5, this task will ensure that an ethics-, security- and privacy-by-design approach will be followed. **Outputs: D3.2**	

WP4 & WP5	Data retrieval, curation and preparation (v1, v2)
Objectives: The primary goal of WP3 is to systematically gather, curate, and prepare multimodal data from an	

array of sources, including UAVs, social media, and IoT devices, to ensure its readiness for integration, analysis, and visualisation using digital twin technology. This includes ensuring data quality, facilitating effective data fusion, and supporting the seamless execution of subsequent analytical processes in WP4 and WP5. WP3 aims to establish a robust foundation for the project's data infrastructure, optimising the utilisation of georeferenced video content, web and social media insights, and IoT-generated data to advance the EO4LEAs' pilot use cases.
T4.1 & T5.1 Data from Galileo-enabled UAV [M3-M18; M19-M28] (ACCELI, NOA, T4i, SERCO, RG**)** This task encompasses the manufacturing and deployment of UAV equipped with embedded processor (eg GPU), high-definition cameras and GNSS sensors, pivotal for capturing georeferenced video data within the EO4LEAs project. This UAV, leveraging the precision of the Galileo system, will gather video footage annotated with accurate geographical coordinates. The proposed initiative aims to enhance the on-board application of AI and functional execution processes, thereby improving reliability and throughput for real-time data analytics. In addition to data acquisition, the task will involve the development of a comprehensive software infrastructure that ensures seamless data broadcasting and task allocation across a distributed network. This will be achieved through the implementation of middleware for effective data distribution and an application layer that facilitates the deployment and operation of parallel algorithms. These algorithms are designed to be dynamically distributed and executed across the network's nodes, optimising the use of distributed GPU resources for efficient parallel processing. The envisioned architecture for this infrastructure will be modular and feature well-defined layers to accommodate scalable and flexible processing of the EO4LEAs project's georeferenced video content, thereby fulfilling the project's requirements for UAV-provided data. **Outputs: D4.1, D5.1**
T4.2 & T5.2 Web and Social Media Crawling [M3-M18; M19-M28] (CDXi, NOA, SERCO, RG, LSDB**)** The task aims to collect relevant social media posts for EO4LEAs' use cases using tailored search criteria, focusing on areas of interest and event detection. By employing geo-referencing and geo-location techniques, it will extract geo-information from posts lacking coordinates, ensuring integration with EO data and location identification. Additionally, web scrapers will extract more data from selected websites. The results will be visualised on a dedicated dashboard, providing a comprehensive view of the monitored areas as delineated by the specific requirements of EO4LEAs' pilot use cases. **Outputs: D4.2, D5.2**
T4.3 & T5.3 IoT and in-situ data [M3-M18; M19-M28] (T4i, NOA, ACCELI, SERCO, RG, UCY, LSDB**)** This task is pivotal in collecting, preparing, and distributing IoT and sensor data throughout the project, thereby augmenting AI development for critical applications such as civil security and infrastructure monitoring. The T4i DOVER Ground Station used for collecting data from the airborne payload will be expanded to collect data from other sources, such as weather or ground sensor data. The upgraded ground station will act as an IoT hub that will be wirelessly connected to a local network and/or the internet, in order to transmit data to the cloud repository and EO4LEAs platform for further processing and visualisation. For monitoring critical infrastructures, a network of sensors enabled by GNSS will be produced and installed, offering high precision data related to the position. After collaboration with the stakeholders, the position of the IoT devices will be identified. Sensors will measure various parameters related to the dam stability, focusing on the possible displacement. This may include accelerometers, inclinometers, etc, for measuring accelerator or tilt. A local data acquisition system will be established through a communication infrastructure. Data analysis of these sensors will be conducted at a suitable platform, and alerts will be produced. New innovative IoT sensors with GNSS capabilities will be evaluated, as well as machine learning models on the edge. **Outputs: D4.1, D5.1**

WP6 & WP7	**Geo-spatial AI (v1, v2)**
Objectives: The main objectives of this WP are the development and deployment of advanced AI technologies and algorithms for threat estimation, CBRNe detection, GeoAI analysis, content enrichment with citizens generated data, and risk & impact assessment, to enhance early detection, monitoring, and response to various crises and extreme events.	
T6.1 & T7.1 Threat Estimation at water dams & rivers [M3-M18; M19-M32] (NOA, CDXi, DREVEN, BDI, RG, UCY, LSDB, ANR)	

In this task we focus on two distinct activities. First, we will use InSAR, GNSS and UAV data to monitor the structural geotechnical stability and potential threats for critical assets such as dams, bridges, and power plants, at fine spatial and temporal scales towards establishing an automated early warning system for potential failures. We will use Persistent Scatterer Interferometry (PSI) data either directly from the Copernicus European Ground Motion Service and we will analyse via our in-house PSI chain high-resolution Synthetic Aperture Radar (SAR) X-band imagery from TerraSAR-X and/or COSMOS-SkyMed, to identify either instabilities directly on the assets, or instabilities (e.g. landslides) in the natural environment in the vicinity of the dams that may pose a risk to the asset. Our monitoring system shall be able to discern between abrupt and evolving ground displacements, while the integration of GNSS data from Galileo alongside Copernicus data enables real-time monitoring of dams and associated assets, ensuring proactive risk management. Our early warning systems will be based on a machine learning model that fuses photogrammetric products from UAV images and very high-resolution satellite multispectral images, with PSI and GNSS measurements, alongside historical structural failure data, to enhance our ability to detect deformations, geometric changes, and structural alterations promptly. With this advanced monitoring framework in place, we can swiftly identify potential threats, issue early warnings, and take decisive action to prevent disasters, thereby safeguarding vital infrastructure and ensuring the safety and integrity of water dams and rivers.

Furthermore, this task also includes advanced algorithm development for environmental monitoring. A state-of-the-art and fully automated algorithm will be utilised for the detection and monitoring of Chlorophyll-a (Chl-α), which is an important indicator of algal blooms. Moreover, DNN techniques and Generative Adversarial Networks (GANs) will be employed for the forecasting of Chl-α levels using hyperspectral satellite imagery and improved atmospheric correction approaches along with reanalysis climatological data for the atmospheric parameters. In addition, this task will deal with the development of oil spill detection algorithms based on EO data leveraging established and novel deep learning architectures. Alongside, a novel oil spill detection benchmark dataset dedicated for deep learning purposes will be created or built upon existing ones.

Outputs: D6.1, D7.1

T6.2 & T7.2 CBRNe detection [M3-M18; M19-M32] (**T4i,** KEMEA, CDXi, ACCELI, DREVEN, RG, ANR**)**

These tasks address enhanced automation of the T4i DOVER airborne chemical detector by embedding multivariate data analytics capabilities for advanced operation and self-configuration. Appropriate firmware will be developed and tested that will utilise AI techniques for serving autonomous operation, analytical method selection on-the-fly (e.g. sampling time, GC oven temperature and thermal programming, analysis time etc), protection of the detector from saturation as well as optimization of its power autonomy. Data generated by the upgraded T4i DOVER detecting toxic threats will feed into a dispersion model that will visualize the contaminated zone and predict further contamination based on other types of data. Specifically, the dispersion model accompanied with an atmospheric one will enable the source location of a gas that is the result of an illegal activity. The atmospheric model generates the meteorological conditions, i.e. wind, temperature, humidity and atmospheric pressure, and the dispersion model reads the meteorological data and simulates the evolution of the gas in space and time.

Outputs: D6.2, D7.2

T6.3 & T7.3 GeoAI analysis for early detection of extreme climate events [M3-M18; M19-M32] (**CDXi,** SATCEN, DREVEN, RG**)**

This task leverages advanced GeoAI techniques, specifically CNNs and Generative Adversarial Networks (GANs), to enhance the analysis of Copernicus Sentinel-2 and Sentinel-5P data for the early detection of extreme climate events. This involves two focused sub-tasks: A) Resolution Enhancement of Sentinel-2 Imagery: Deploying GANs to improve the spatial resolution of Sentinel-2 imagery will allow for a more detailed observation of both environmental and urban landscapes (SuperResolution). In this enhanced imagery, change detection for ship detection as well as urban density analyses will be conducted, utilising self-supervised learning techniques to expand the AI networks' learning capacity. The goal is to identify subtle shifts in the environment (e.g, ships at sea) and urban areas indicative of impending security events. B) Atmospheric Anomaly Detection with Sentinel-5P: Applying CNNs to analyse Sentinel-5P data focuses on identifying atmospheric anomalies. This analysis is essential for detecting early signs of extreme climate conditions, leveraging Sentinel-5P's ability to monitor atmospheric gas concentrations. The insights gained will directly contribute to T6.4 & T7.4 (Content Enrichment with Citizens Generated Data) and T6.5 & T7.5 (Risk & Impact Assessment in the Context of Crisis Events) and support all four EO4LEAs'use cases.

Outputs: D6.1, D7.1

T6.4 & T7.4 Content enrichment with citizens generated data [M3-M18; M19-M32] (**CDXi,** SATCEN, DREVEN, BDI, RG, UCY, LSDB, ANR)

These tasks will work on detecting real-world events through the analysis of anomalous patterns within citizen-generated data from social media platforms. Initially, this task involves monitoring social media platforms for specific keywords, hashtags, and geo-referenced posts enabling the detection of emerging crises and fast response. Through the analysis of the citizen-generated content, a better understanding of the extent of a damage before, during and after an extreme event will be gained, assigning relevance scores to extracted information. As these methods form the baseline, this work will build upon the insights and results obtained from them. An event detection will follow on non-EO data, employing outlier detection based on daily fluctuations and the ST-DBSCAN spatial and temporal clustering algorithm. While EO data will offer valuable imagery of affected areas, social media posts can verify and validate the accuracy and the severity of the detected events supported by visual concept extraction techniques. To ensure reliability, a correlation analysis will be conducted between non-EO and EO data. This foundation allows for refining and broadening methodologies based on initial outcomes. The outcome of this task will involve the fusion of non-EO and EO data to provide insights and support risk assessment from the perspective of citizens' digital footprint.

Outputs: D6.3, D7.3

T6.5 & T7.5 Risk & impact assessment in the context of crisis events [M3-M18; M19-M32] (RG, SATCEN, DREVEN, ANR)

Risk and impact assessment models will be developed for the probabilistic assessment of the socioeconomic impact of local/regional disasters and their effect on population. These can be employed in the context of further WP4 tasks to: (a) support prediction of migration patterns and potential flows of people; (b) assess the impact of CBRNe/chemical events to support short-term prediction of losses; (c) quantify the risk of dam, water reservoir, and surrounding slope stability & integrity, considering short-term actions of pertinent natural hazards (e.g., earthquake, rainfall).

Outputs: D6.4, D7.4

WP8 & WP9	**EO4LEAs platform development, Digital Twins & DestinE integration (v1, v2)**

Objectives: Construction of a robust architecture for the EO4LEAs platform, which integrates diverse data sources, AI, and digital twins, aimed at enriching Copernicus Security Services. This includes developing explainable AI models to ensure transparency and robustness in decision-making processes and creating foundation models for intuitive multimodal question-answering. The work aims to make Copernicus data more accessible and actionable for LEAs, enhancing security applications through advanced analytics and interoperability with the DestinE platform.

T8.1 Technical Requirements and Platform Architecture Design [M4-M18] (**UCY,** CDXi, NOA, ACCELI, T4i, SERCO, DREVEN, RG)

In this task, we will organize workshops with technical stakeholders to translate the outputs from WP3 (Output D3.1), into the functional and non-functional requirements, the technical specifications, and the architectural design of the EO4LEA platform, following the Systems and Software Engineering ISO/IEC/IEEE 29148-2011. During the first phase of this task, surveys and semi-structured interviews will take place to document the needs and the gaps. The task will identify the scope, critical infrastructure system models (geospatial, computational), analytics and AI tools, data spaces, the links with DestinE as well as algorithms and simulators, for establishing Digital Twins. Moreover, this task will investigate and validate with experts' questions that the digital twins could answer, in the context of "what-if" scenarios. The results will be documented in a comprehensive technical specification document.

Outputs: D8.1

T8.2 & T9.1 Explainable and Robust AI modelling [M4-M18; M19-M34] (**DREVEN**)

This task focuses on developing AI algorithms and models specifically designed for Copernicus Security Services. The models will undergo the integration of eXplainable Artificial Intelligence (XAI) techniques, such as feature importance analysis, model visualization, and decision rule extraction, to enhance their explainability. This will ensure that the relevant stakeholders will understand the rationale behind the output of the ML models, leading to more effective decision-making. Additionally, the task aims to enhance the models' robustness against various real-world challenges, including adversarial attacks, data distribution shifts, and biases. The implementation of the task will be built upon four interrelated modules: i) The development of AI algorithms and models, ii) the integration of explainability, iii) the enhancement of robustness, and iv) the evaluation and validation to assess their performance, explainability, and robustness using diverse datasets and scenarios relevant to Copernicus Security Services. The explainable and robust AI models developed in T5.2 will later be integrated into the digital twin framework through its APIs (T5.3), contributing to data-driven decision-making, transparency, reliability, and thus the effectiveness of the DSS.

Outputs: D8.2, D9.1

T8.3 & T9.2 Copernicus Foundation Models for Multimodal question-answering and search in security applications [M4-M19; M19-M34] (**NOA,** CDXi)

In this task, our goal is to develop a foundation model that will allow the design of visual and text question-answering applications focusing on non-expert users and addressing security related challenges within Copernicus. The foundation model will incorporate a Large Language Model (LLM), fine-tuned to Copernicus security semantic concepts, and an aligned vision foundation models that is able to capture the semantics from multimodal sources: i) EO datasets in this project, including satellite, UAV, GNSS, IoT and in-situ measurements, ii) Copernicus higher level products, like the European Ground Motion Service product portfolio, iii) social media streams, and iv) specialised products in WP4. This includes threat Estimation at water dams & rivers, CBRNe detection, Extreme Climate Event Detection, Content enrichment with citizen-generated data, and Risk & impact assessment in crisis events. The task will be implemented in four distinct phases. First, we will employ self-supervised methods (pre-text tasks, contrastive learning, masked autoencoders) for training encoders (transformers) for the individual modalities above. Multimodal fusion methods will be examined to map all modalities to a common representation space. Then, a multimodal alignment algorithm will be used to align the LLM with the other modalities. Based on this unified foundation model, a question answering for Copernicus Security applications will be implemented and fine-tuned. Finally, a user-friendly interface (UI) will be developed to allow non-expert users to easily navigate the vast datasets and products, using various search queries, such as visual, spatial, or even textual descriptions, and retrieve the most relevant results.

This task will also explore the use of multimodal data hashing techniques to enable efficient cross-modal search in tasks involving satellite imagery and video sequences. The study aims to develop foundational models capable of generating hash codes for satellite imagery and video data, rapid and accurate retrieval based on multimodal inputs. This task will be supported by a user-friendly interface (UI), which will be designed to provide end-users with the ability to search a shot as a query and a search type (like, visual or spatial) and present the most similar results in a grid format.

Outputs: D8.2, D9.1

T8.4 & T9.3 Data Indexing & Deployment on DestinE service platform [M4-M18; M19-M34] (SERCO, SATCEN**)**

This task is designed to achieve two primary goals essential for the EO4LEAs project. The first goal is to integrate diverse data sources to broaden the project's analytical capabilities. This includes incorporating a) geo-referenced social media data to provide insights into human activities across various locations; b) data from UAV videos/images, enabled by Galileo, for high-resolution surveillance; c) chemical sensor data for real-time urban security threat detection; and d) scientific ensemble models to enhance predictive analytics and decision-making processes. By processing these varied information sources, the task aims to cultivate a richer analytical ecosystem for EO4LEAs, facilitating more complex analyses and informed decisions across different project use cases. The second goal is to ensure that the technologies developed for the digital twin, covering all aspects from pre-processing and analytics to planning, decision-making, sensor integration, and effectors, adhere to the DestinE framework. This compliance will ensure that EO4LEAs's technologies are fully compatible and interoperable with the DestinE platform, promoting seamless integration within the broader ecosystem. This task will thus contribute to the creation of a standardised and interoperable environment, enabling efficient data sharing, analysis, and operational execution within the digital twin's application scope.

Outputs: D8.3, D9.2

T8.5 & T9.4 System development & Digital Twin set-up and visualisation [M4-M18; M19-M34] (UCY, CDXi, NOA, ACCELI, T4i, SERCO, DREVEN, RG**)**

This task deals with the design, implementation, testing, and evaluation of an EO4LEA Digital Twin. The

implementation will follow a hybrid agile-waterfall software engineering design. The Digital Twin will be built atop the OCEANOS Digital Twin Platform, which is currently being used by critical infrastructure operators. This is an open QGIS-based platform, which supports the development of different modules and facilitates the interaction with different data sources.
Based on the technical specifications and other modules outlined in D8.1-8.3, the work will be segmented into the following: 1) develop modular components integrated functionality, ensuring comprehensive coverage of all aspects related to critical infrastructure systems security, including geospatial data analysis, AI-based predictive modelling, real-time data integration from various sensors, as well as advanced scenario simulation capabilities. 2) Implement data connectors to receive and process data from diverse data sources (e.g., GNSS sensors for dam monitoring), georeferenced social media, UAV images, chemical sensor data, as well as computational models of the environment and infrastructure. Efficient data indexing and compatibility with the DestinE service platform will be implemented for interoperability and data exchange. 3) Integrate AI and analytic tools, to provide insights into threats, anomaly detection, and risk assessment. Integrate multimodal foundation models for advanced Q&A interactions. 4) Develop a simulation engine capable of modelling complex "what-if" scenarios, such as the impact of a dam break on surrounding critical infrastructures and the environment in general. Create intuitive visualisation tools using QGIS and other frameworks, to represent simulation outcomes, risk assessments, and other relevant information in an accessible way (e.g., maps, animations, etc.). 5) Design a user-friendly interface to support interaction with the Digital Twin and evaluate its functionality in user studies. 6) Ensure rigorous testing of the different modules and workflows and evaluate its use as part of relevant PUC. 7) Finalise the deployment and release of the platform, ensuring that components are integrated and operational. Organise training sessions for stakeholders to ensure the effective utilisation of the platform for decision-making.
Outputs: D8.3, D9.2

WP10	**Pilot implementation, evaluation and training**

Objectives: This WP is aimed at evaluating the implementation of EO4LEAs' digital twins within the contexts of four pilot use cases: Border Surveillance, Civil Security, Maritime Surveillance, and Critical Infrastructure Surveillance. These digital twins are comprehensive systems that not only simulate real-world scenarios but are also enhanced by GeoAI algorithms developed within the project. These algorithms are integral to the digital twins, facilitating real-world data connectivity, preprocessing, analysis, and decision-making processes. The objective is to showcase through operational tests and demonstrations how these integrated systems improve security operations, addressing specific challenges in each pilot scenario. Moreover, the WP is designed to train law enforcement agencies and relevant stakeholders in using EO4LEAs' Key Results (KRs), enabling them to leverage the full potential of GeoAI-enhanced simulations for strategic decision-making and operational efficiency across the identified security domains.

T10.1 Development of the validation scenario and evaluation methodology [M19-M36] (SATCEN, KEMEA, BDI, RG, UCY, LSDB, ANR**)**

This task is focused on orchestrating the real-time demonstration of EO4LEAs' digital twins within the project's pilot use cases: Border Surveillance, Civil Security, Maritime Surveillance, and Critical Infrastructure Surveillance. The objective includes the assessment whether the WP2 requirements are fulfilled (1), technical benchmarking of each use case (2), creating detailed validation scenarios for each use case (3), and formulating evaluation criteria to conduct an independent assessment of the EO4LEAs system (4) and to test and evaluate the project's technologies and analyse the data gathered during evaluation in terms of system performance (e.g., satisfaction ratings, task completion times, error rates) (5). The PUC´s leaders will aim for an experimental pilot implementation and validation phase that thoroughly evaluates the effectiveness and applicability of EO4LEAs' digital twins and integrated GeoAI algorithms in real-world security operations. Moreover, feedback from external users will be collected on the effectiveness of the developed platform and tools.

Outputs: D10.1

T10.2 Pilot deployment, field demonstrations testing [M19-M36] (KEMEA, All**)**

This task is critical for demonstrating the capabilities of EO4LEAs' digital twins and the GeoAI technologies developed earlier in the project. Utilising the scenarios and use case narratives drafted in WP2, this phase will involve comprehensive real-world exercises that encompass all four pilot use cases: Border Surveillance, Civil Security, Maritime Surveillance, and Critical Infrastructure Surveillance. The evaluation will proceed through multiple avenues: a) Simulations employing established evaluation protocols, particularly in scenarios impacting

critical infrastructure like drinking water supply networks. b) On-site demonstrations at designated pilot locations to assess the operational effectiveness of the digital twins and GeoAI technologies in real-life settings. c) Workshops and user evaluation sessions, employing questionnaires tailored for stakeholders such as law enforcement agencies, to gather qualitative feedback on the technology's utility and user experience. d) Simulated events specific to the challenges addressed in the PUC1 and PUC2, to test the system's responsiveness and accuracy. Through these diverse testing and evaluation methods, the task aims to benchmark EO4LEAs' technology against the current state of the art, gaining insights into both the quantitative performance and subjective preferences of decision-makers and end-users. The gathered data will inform further refinements to ensure EO4LEAs meets the highest standards of effectiveness and user satisfaction. Each PUC leader will be responsible for coordinating the deployment, testing and evaluation of its own pilot use case supported by the involved technical partners and end-users. **Outputs: D10.1**
T10.3 Training of Law enforcement agencies and other stakeholders [M19-M36] (**BDI,** KEMEA, SATCEN, RAD, UCY, LSDB, ANR) A key deliverable of the EO4LEAs project is the development of a comprehensive training manual designed to empower end-users, particularly law enforcement agencies and other relevant stakeholders, with the knowledge and skills to effectively utilize EO4LEAs' digital twins and integrated GeoAI technologies. This manual will serve as an exhaustive resource for mastering the use of these systems, facilitating an understanding of their operational benefits and enhancing the efficiency of security operations across the pilot use cases. The training program, developed with assistance from experienced partners, will encompass both instructions and simulation-based exercises. These modules aim to impart the findings, operational insights, and strategic frameworks that have emerged from the project, ensuring participants gain a hands-on understanding of EO4LEAs' functionalities. Additionally, the training content will be integrated into the project's broader capacity-building efforts, playing a pivotal role in promoting the long-term adoption and effectiveness of the EO4LEAs approach and technologies among law enforcement and security professionals. **Outputs: D10.2**

WP11 & WP12	**Impact creation, dissemination and exploitation (v1, v2)**
Objectives: The main objectives of WP11 & WP12 are to create the dissemination, communication, and exploitation plan of EO4LEAs, along with the long-term data preservation plan, and to identify potential synergies and seek collaboration with other projects. Opportunities will be examined in the worldwide market.	
T11.1 & T12.1 Communication and dissemination actions [M1/M19; M18/M36] (**ACCELI,** All) In this task, initially the communication & dissemination plan of EO4LEA will be defined. A clear communication & dissemination policy will be established early in the project lifetime that will identify the relevant audiences and stakeholders to target along with the appropriate channels to use for such purposes. Project Web Site (www.EO4LEA-project.eu): It will include the project description, prospects, news & events related to the EO4LEA topics and announcements. The project website will also include a usable content management system (i.e., in the form of Wiki), where partners can put articles about intermediate project results. Furthermore, it will contain public documents available for download, including all project publications. All the intermediate results of the project (internal management/ progress reports, deliverables, presentations, papers, data sets, software, etc.) will be available through this website. Dissemination Material: Material to be created will include: a) The EO4LEA logo; b) Exploitation of popular web 2.0 channels and social media (such as X, LinkedIn and YouTube); c) A short project film ((3-4 minutes long) will be created (One year to 6 months before the end of the project) in order to make the project understandable for the public; d) An electronic newsletter will be issued every six months; e) Official project templates: a journalistic description of the project understandable for the public, a PowerPoint presentation will be prepared to promote project concept and innovations; f) A project brochure (leaflet) presenting project objectives, expected results and profiles of partners; g) Generation of project Fact Sheet, which will be widely disseminated by the EC. **Outputs: D11.1, D12.1**	
T11.2 & T12.2 Clustering activities [M1/M19; M18/M36] (KEMEA, All) This task will seek out synergies with other projects and organisations in security and space domains to establish a research & user community interested in the project's results. The project will capitalize on the well-established network of project partners in order to create an active Stakeholder Forum which will be composed mainly of	

external LEAs from additional EU member states or associated countries. Specifically, it is aimed to facilitate the dialogue between related EU-funded Actions for technological, operational, policy and ethical issues related to security and help to implement the project and formulate future research & policies. To this end, the Stakeholder forum will be formulated during the first six months of the project and will contribute towards the implementation of WP3 activities aiming at collecting requirements and feedback from a broader user group. Additionally, EO4LEAs partners will seek the participation and collaborative activities of our project in European research and innovation clusters on secure societies and Copernicus aiming at externalising project's results to external stakeholders, like law enforcement agencies, industries, academia, and policy makers. **Outputs: D11.1, D12.1**
T11.3 & T12.3 Market analysis and Business models [M1/M19; M18/M36] (DREVEN, CDXi, NOA, ACCELI, T4i, SERCO, RAD, BDI, RG, UCY, LSDB, ANR) This task focuses on the implementation of market analysis and development of the business models within the project, targeting the understanding of the landscape of target users and customer segments, along with new business opportunities. Based on the thorough analysis of both macro and micro levels, the task will gather and interpret data regarding market trends, competitors, and potential customers. This data will enable the project team to identify suitable approaches for leveraging the project results effectively. By exploring various business models derived through the integration of the project's technology providers into the potential revenue streams, the task will ensure its alignment with stakeholders' needs and preferences. The Triple Layered Business Model Canvas will be used for the development and visualisation of the business models, complemented by lean value proposition design. Direct interviews with stakeholders participating in the project's pilot activities, potential customers, and other relevant parties will generate valuable feedback on these models, aiding in their refinement and the formulation of a robust approach. **Outputs: D11.2, D12.2**
T11.4 & T12.4 Exploitation plan and Intellectual Property (IP) protection for the proposed solutions [M1/M19; M18/M36] (DREVEN, CDXi, NOA, ACCELI, T4i, SERCO, RAD, BDI, RG, UCY, LSDB, ANR) This task aims to define and design the project's exploitation plan at both partner and consortium levels, based on the insights generated from both the market analysis and the business models. By identifying the key results and outlining strategies for long-term sustainability, including revenue generation and scalability, the task will aim to ensure a coordinated effort toward commercialization. Additionally, individual plans for exploitable products will be developed, enabling partners to capitalize on their contributions. The task will also deal with the management of project knowledge, ensuring proper implementation and maintenance of the legal aspects of the partnership as described in the Consortium Agreement (CA), and monitoring the adherence to the CA and IPR management strategy (Section 2.2.2), following the appointment of an IPR Manager for the whole project. **Outputs: D11.2, D12.2**

3.1.5 List of Deliverables

No	Deliverable name	Lead participant	Type	Diss.	Del. date
D1.1	Project management & quality assurance plan	**KEMEA**	**R**	**SEN**	**M4**
Comprehensive plan that outlines the project management and quality assurance strategies to ensure the successful implementation of EO4LEAs					
D1-2.2	Self-Assessment, Data Management Plan and Progress Reporting	**KEMEA**	**DMP**	**SEN**	**M6, M18, M36**
Three iterations of self-assessment, data management, and progress reports reflecting the project's stages.					
D1-2.3	DWH request & use	**CDXi**	**R**	**SEN**	**M18, M36**
Documentation of data warehouse requests and usage across the project lifecycle.					
D3.1	Pilot use cases formation and user requirements	**SATCEN**	**R**	**EU RES**	**M18**
Detailed definition of each pilot use case and specification of user requirements					

D3.2	Ethical, Legal and Security Requirements Report	**KEMEA**	**R**	**EU RES**	**M18**
Assesses the ethical, legal, and security requirements within the project's context.					
D4-5.1	Sensor, in-situ, UAV data collection	**ACCELI**	**R**	**PU**	**M18, M28**
Reports on the acquisition, processing, and initial analysis of georeferenced video data from UAVs, sensor data, and in-situ measurements, reflecting progress in enhancing data collection methodologies					
D4-5.2	Social media data collection and dashboard	**CDXi**	**R**	**PU**	**M18, M28**
Presents findings and advancements in collecting, analyzing, and visualizing social media data relevant to EO4LEAs' objectives, including the development and implementation of a dashboard for real-time event detection and monitoring.					
D6-7.1	GeoAI analysis of water, land, and atmospheric conditions using copernicus and heterogeneous data sources	**NOA**	**R**	**PU**	**M18, M32**
Documents the development and application of GeoAI techniques for analysing water, land, and atmospheric conditions, showcasing the integration and analysis of Copernicus and other data sources.					
D6-7.2	Airborne chemical tracking and atmospheric modelling	**T4i**	**R**	**PU**	**M18, M32**
Reports the progress in developing airborne chemical tracking and atmospheric modeling capabilities, including advancements in sensor technology and analytical methods for detecting and modelling chemical threats.					
D6-7.3	Multimodal fusion for event detection	**CDXi**	**R**	**PU**	**M18, M32**
Describes the implementation of multimodal data fusion techniques for improved event detection, incorporating social media, sensor, UAV, and EO data.					
D6-7.4	Risk & Impact assessment of detected events	**RG**	**R**	**PU**	**M18, M32**
Provides an overview of the development and application of risk and impact assessment models for detected security relevant events.					
D8.1	Technical Requirements and Platform Architecture Design	**UCY**	**R**	**SEN**	**M18**
Outlines the architectural design and technical specifications for the EO4LEAs platform based on user requirements and project objectives, reflecting the foundational work for platform development.					
D8.2-9.1	Explainable AI & Cross-Modal Search	**NOA**	**R**	**PU**	**M18, M34**
Reports on the progress in developing explainable AI models and cross-modal search capabilities, aiming to enhance the transparency, reliability, and effectiveness of AI-driven analyses within EO4LEAs.					
D8.3-9.2	System development Digital Twins & DestinE integration	**SERCO**	**DEM**	**SEN**	**M18, M34**
Details the development and integration of digital twins and the DestinE platform within the EO4LEAs framework, documenting advancements in simulating and visualizing environmental and security scenarios for decision support.					
D10.1	Pilot implementation and prototype evaluation report	**SATCEN**	**DEM**	**EU RES**	**M36**
Comprehensive reporting/assessment on the overall implementation/application of the first prototype system and assessment under development					
D10.2	User training framework	**BDI**	**R**	**EU RES**	**M36**
Develop a framework based on which end-users will be trained on as well as user training manuals					
D11-12.1	Communication, Dissemination plan & Synergies	**ACCELI**	**R**	**PU**	**M6, M24, M36**
Plan and reporting for communication, dissemination, and clustering activities of the project, with three versions where the first serves as the foundational strategy and the subsequent versions update and report on progress and activities.					
D11-12.2	Market Analysis and Business Model	**DREVEN**	**R**	**SEN**	**M18, M36**

Market, exploitation and initial sustainability plan. Strategies to maximise the commercial / societal impact of the project (incl. market penetration, intellectual property management, and long-term sustainability plan)

3.1.6 List of milestones

No	Milestone name	WPs	Date	Means of verification
MS1	Project setup	1, 11	M6	MS1 signifies the launch of the EO4LEAs website, project management and quality assurance, initial data management, self-assessment, and communication plans. Associated deliverables: **D1.1, D1.2, D11.1.**
MS2	EO4LEAs framework v1	1, 2, 3, 4, 6, 8, 11	M18	MS2 marks the presentation of EO4LEAs' early outcomes from data collection to GeoAI algorithms, finalises technical requirements for the platform, and initiates integration. It highlights preliminary findings on the digital twin and compatibility with DestinE. MS2 also introduces the initial market analysis, business models, and EO4LEAs' exploitation strategy. Associated deliverables: **D1.2, D1.3, D3.1, D3.2, D4.1, D4.2, D6.1-D6.4, D8.1-D8.3, D11.2.**
MS3	EO4LEAs framework v2	5, 12	M28	MS3 signifies the end of the data collection phase and the midpoint of integration. It highlights updates to the dissemination and communication plan and summarizes project clustering activities thus far. Associated deliverables: **D12.1, D5.1, D5.2.**
MS4	EO4LEAs Completion and Operational Readiness	2, 5, 7, 9, 10, 12	M36	MS4 celebrates the completion of EO4LEAs, finalizing the digital twin platform. It confirms the full support of pilot use cases by EO4LEAs' technological and scientific achievements. Alongside, training materials such as videos and manuals have been created and are readily available, empowering LEAs to effectively learn and utilize EO4LEAs' results. The final version integrates comprehensive data preprocessing and preparation chains, utilized by all tools and AI systems within a unified digital twin platform, ensuring full interoperability and potential integration with DestinE. Associated deliverables: **D2.3, D2.2, D5.1, D5.2, D7.1, D7.2, D7.3, D7.4, D9.1, D9.2, D10.1, D10.2, D12.1, D12.2**

3.1.7 Critical risks for implementation #@RSK-MGT-RM@#

Description of risk (indicate level of (i) likelihood, and (ii) severity: Low/Medium/High)	Work package(s) involved	Proposed risk-mitigation measures
Diverging orientations (Low / Low)	WP1 & WP2	To mitigate the risk of diverging orientations, structured project management practices and a detailed work plan are in place to ensure effective collaboration. WP leaders are tasked with regularly aligning project goals among partners through structured meetings and communication channels, ensuring all efforts are directed towards common objectives.
Conflict in the Consortium (Low / Medium)	WP1 & WP2	The risk of conflicts within the consortium is addressed by the careful selection of partners with a history of successful collaborations. The Consortium Agreement includes a conflict resolution strategy to handle disagreements amicably. Regular team-building activities and clear communication protocols further mitigate this risk.

A consortium member is not responsible enough (Medium / Medium)	WP1 & WP2	The consortium's selection was based on recognized expertise and reliability. However, should this risk materialize, the Project Management Board (PMB) is prepared to swiftly reassign the tasks of the underperforming partner to more reliable consortium members to ensure project continuity.
Rapid technological advancement outpacing project developments (Medium / Medium)	WP1 & WP2, WP4 & WP5, WP6 & WP7, WP8 & WP9	The project will maintain flexibility in its development approach to incorporate or adapt to new technological advancements. Regular technology review meetings will be scheduled to assess and integrate relevant innovations, ensuring the project remains at the cutting edge and beyond.
Technical challenges in integrating diverse data sources into the digital twin platform (i.e. compatibility issues between IoT devices, satellite data and the EO4LEAs platform) (Medium / High)	WP8 & WP9	To address compatibility issues and technical challenges in integrating diverse data sources, the project will engage technology providers early to ensure compatibility and establish clear data exchange protocols. A flexible data ingestion framework is being developed to adapt to various data formats and sources, allowing for seamless integration within the digital twin platform.
Business model does not match the needs of technology providers (Low / Medium)	WP11 & WP12	An iterative, stakeholder-driven co-design process ensures the development of business models that align with the needs of technology providers and users. This process includes continuous feedback loops and, if necessary, multiple iterations to redesign the business model to meet all stakeholders' requirements successfully.
Disagreement in the exploitation of the project outputs (Low / Low)	WP11 & WP12	A robust Exploitation Plan agreed upon by all consortium members early in the project serves as a foundational document to prevent disagreements on output exploitation. This plan clearly outlines the rights and responsibilities related to the Background and Foreground IPs of each partner, facilitating consensus.
Underestimation of the required time for the development of the prototype (Low / High)	WP1 & WP2, WP8 & WP9	The project timeline has been carefully planned with realistic milestones to manage time effectively. Internal collaboration and leveraging past experiences from similar projects are crucial strategies to mitigate potential time deviations and ensure a smooth implementation of the work plan.
Inaccessibility or absence of critical field observations (Medium / Low)	WP4 & WP5, WP6 & WP7	Partners will leverage their extensive networks and close contacts with external entities to access necessary data. In cases where field observations are not available, the project is prepared to use simulated data, alternative satellite data, or modify methodologies to compensate for the lack of specific field data.

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3.1.8 Summary of staff effort

Partner	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	Total
KEMEA	11,5	11,5	13,0	0,0	0,0	1,5	1,5	0,0	0,0	16,0	4,5	4,5	64,0
SATCEN	0,3	0,3	4,0	0,0	0,0	1,0	1,0	0,5	0,5	3,5	0,5	0,5	12,1

CDXi	7,8	7,8	4,9	5,7	5,7	17,4	17,4	11,2	11,2	3,2	2,1	2,1	96,5
NOA	0,6	0,6	16,7	1,7	1,7	9,0	9,0	10,7	10,7	2,3	1,6	1,6	66,2
ACCELI	1,0	1,0	4,9	11,8	11,8	0,0	0,0	2,0	2,5	5,0	9,0	10,0	59,0
T4i	1,0	1,0	3,5	7,0	7,0	10,0	10,0	3,0	3,0	5,0	2,0	2,0	54,5
SERCO	0,7	0,8	4,1	2,5	2,5	0,0	0,0	16,9	16,9	3,4	3,0	3,0	53,8
DREVEN	0,8	0,6	4,9	0,0	0,0	5,6	5,6	11,7	11,7	3,2	10,2	10,2	64,5
RAD	5,0	8,0	6,0	0,0	0,0	0,0	0,0	0,0	0,0	4,0	1,0	1,0	25,0
BDI	1,5	1,5	10,5	0,0	0,0	1,3	1,2	0,0	0,0	13,0	1,0	1,0	31,0
RG	0,5	0,5	3,0	2,0	2,0	8,0	9,0	1,0	1,0	2,0	1,5	1,5	32,0
UCY	0,9	0,9	19,0	1,2	1,1	2,3	2,3	17,5	17,5	19,5	0,8	0,8	83,8
LSDB	0,6	0,6	6,8	3,2	3,2	2,4	2,4	0,0	0,0	13,1	1,2	1,2	34,7
ANR	1,5	1,5	11,0	0,0	0,0	3,0	2,0	0,0	0,0	11,0	1,0	1,0	32,0
TOTAL	**33,7**	**36,6**	**112,3**	**35,1**	**35,0**	**61,5**	**61,4**	**74,5**	**75,0**	**104,2**	**39,4**	**40,4**	**709,1**

'Purchase costs' items (travel and subsistence, equipment and other goods, works and services)

BE1/ KEMEA		
	Cost (€)	**Justification**
Travel and subsistence	2,650 €	Required participation in plenary and pilots (6 meetings x 2 participants x 1,000 € = 12,000 €)
Remaining purchase costs (<15% of pers. Costs)	52,800 €	
Total	55,450 €	

BE5/ ACCELI		
	Cost (€)	**Justification**
Other goods, works and services	38,974 €	Purchase of consumables for UAV manufacturing: (2x 15,000 = 30,000€); Organization of user group meetings and final event (5 x 2,600 = 13,000€)
Remaining purchase costs (<15% of pers. Costs)	37,026 €	
Total	76,000 €	

BE13/ LSDB		
	Cost (€)	**Justification**
Equipment	19,391 €	Purchase of sensors (2 x 10,000 = 20,000)
Remaining purchase costs (<15% of pers. Costs)	12,609 €	
Total	32,000 €	

BE14/ ANR		
	Cost (€)	**Justification**
Travel and subsistence	10,600 €	Required participation in plenary and pilots (6 meetings x 2 participants x 1,000 € = 12,000 €)
Remaining purchase costs (<15% of pers. Costs)	14,400 €	
Total	25,000 €	

3.2 Capacity of participants and consortium as a whole #@CON-SOR-CS@# #@PRJ-MGT-PM@#

3.2.1 EO4LEAs Key Competences Analysis

Information of the EO4LEAs consortium is identified in the full partner profiles which are detailed in Part A. Beyond the full profile information provided in such section, EO4LEAs, through this section, will show the suitability of the consortium.

The EO4LEAs consortium comprise 14 participants with different roles: research & development (**R&D**) and technology provider (**TECH**) partners will be responsible for innovation activities, designing and building the EO4LEAs technologies, end users (**USER**) will provide real needs and validating EO4LEAs technologies.

- **KEMEA** (**CO**) (**USER**): As the project coordinator and the end user for PUC2 of EO4LEAs, KEMEA applies its extensive experience in coordinating security research and EU-funded projects as well as they bring their connections with LEAs, KEMEA's leadership ensures EO4LEAs aligns with law enforcement and security requirements, facilitating practical and impactful outcomes.
- **SATCEN** (**USER**): The European Union Satellite Centre serves as a crucial end-user, playing a pivotal role in defining user and business requirements, and validating tools and services for EO4LEAs. As an agency with a strong connection to FRONTEX and profound insights into border surveillance, SATCEN ensures the project's solutions align with the operational realities and needs of law enforcement and security agencies across Europe. Their expertise in using satellite data for security purposes is invaluable, driving the project towards practical, impactful outcomes.
- **CDXi** (**TECH**): Originating from CERTH's Information Technologies Institute, CDXi directly leverages expertise in Earth Observation, AI, and data fusion. This expertise is critical for developing EO4LEAs' innovative solutions, with CDXi playing a key role in multitude of space and security projects.
- **NOA** (**R&D**): NOA's leading role in Earth observation research, exemplified by projects like DeepCube H2020 and SeasFire with ESA, contributes advanced machine learning, satellite image fusion, and risk assessment capabilities to EO4LEAs.
- **ACCELI** (**TECH**): Specializing in UAV technology, ACCELI contributes aerial data collection and processing expertise, enhancing EO4LEAs’ surveillance and monitoring capabilities. Their involvement in projects like H2020-ISOLA showcases their capacity to integrate UAV technology with Earth Observation data effectively.
- **T4i** (**TECH**): T4i adds a crucial layer to EO4LEAs by providing innovative sensor technologies for chemical threat detection and environmental monitoring, drawing on their development work in projects such as H2020-TOXI-triage and H2020 GIDPROvis.
- **SERCO** (**TECH**): Leading the consortium for the Destination Earth Core Service Platform (DESP), Serco is pivotal to EO4LEAs, developing a secure, flexible cloud-based system that provides decision-making tools and services. Awarded by the ESA, this role ensures the interoperability of EO4LEAs' digital twin platform with DestinE. Additionally, Serco brings expertise in Earth Observation and space technologies, including the delivery of Data Management platforms like DHuS and DIAS, which is invaluable to the project's success. Their contribution is central to integrating cutting-edge data management and enhancing the project's capabilities.
- **DREVEN (R&D)**: DREVEN contributes its extensive expertise in environmental informatics and data analysis to EO4LEAs, positioning it for successful development of the explainable AI component and exploitation. Their work in projects like H2020-PathoCERT and H2020-aqua3S underlines their capability in sustainable technology development.
- **RAD (USER)**: RAD brings a wealth of expertise in project management and consultancy across various funding mechanisms, including European and public funds. Their extensive experience in overseeing projects from conception to commissioning, particularly in the domains of security and crisis management, positions them as a vital asset to EO4LEAs. Collaborating with partners like CERTH in HE-VANGUARDS and H2020-PERIVALLON, RAD enhances EO4LEAs with its knowledge in explosives, contributing to the development of advanced prognostic, detection, and forensic tools. Their close ties with law enforcement agencies underscore their crucial role in translating the project's innovations into practical tools for enhancing public safety and operational efficiency.
- **BDI** (**USER**): BDI leverages its network within public organizations and first responders to enhance EO4LEAs' tools for crisis management, drawing from their collaboration in H2020-ODYSSEUS. Their focus on supporting Bulgarian Police Services and Fire Brigades showcases their commitment to applying EO4LEAs' results in real-world scenarios.
- **RG** (**R&D**): RG brings its expertise in risk assessment and crisis management from Horizon PLOTO and H2020-

7SHIELD to EO4LEAs, enhancing the project's business continuity module and sensor data integration for comprehensive crisis management.

- **UCY** (**R&D**): UCY's forefront position in digital twin technologies and simulation models, crucial for the EO4LEAs platform development, is strengthened by their innovative work in projects like Horizon Europe's ThinkingEarth and MeDiTwin, focusing on digital twins and AI for Earth Observation.
- **LSDB** (**USER**): LSDB's expertise in infrastructure management and environmental conservation contributes to grounding EO4LEAs' solutions in sustainability and real-world application, ensuring the project's environmental monitoring solutions are effective and comprehensive.
- **ANR** (**USER**): ANR provides regulatory insight and operational expertise in maritime affairs, ensuring EO4LEAs' maritime surveillance and environmental monitoring solutions are industry-aligned and comprehensive, enhancing the project's scope in addressing maritime security challenges.

3.2.2 Previous Collaborations

The EO4LEAs consortium capitalizes on a robust history of collaboration among its partners, highlighting a collective commitment to innovation and security enhancement through technology. KEMEA has previously joined forces with multiple consortium members across a range of impactful projects, ensuring a strong foundation for collaborative success in EO4LEAs. Notably, KEMEA, DREVEN, and CDXi (CERTH) have collaborated in the H2020-PERIVALLON project, focusing on combating environmental crimes with advanced AI and geospatial intelligence, demonstrating their collective expertise and capability to tackle complex security challenges.
Further collaborations include the work between SERCO, DREVEN, NOA, ACCELI, and CDXi in H2020-CALLISTO, where the consortium developed an AI-powered Big Data platform to connect Copernicus Data with end-users, showcasing the consortium's strength in social media data analysis and multimodal retrieval for security applications. CDXi's partnerships extend to SATCEN in H2020-PERIVALLON and with other members in H2020-ISOLA, enhancing ship security through innovative technology solutions.
The project also builds on the foundations laid by H2020 7SHIELD, involving RG, CDXi, SERCO, NOA, and KEMEA in creating a cyber and physical threat framework for crisis management. The expertise in explosives and precursors developed through H2020 ODYSSEUS by BDI, T4i, KEMEA, and CDXi enriches EO4LEAs' suite of prognostic, detection, and forensic tools, bolstering the consortium's security measures.
These previous collaborations, spanning areas from AI-driven EO services and data management to environmental crime combating and security enhancement, not only demonstrate the partners' ability to work together effectively but also their dedication to leveraging each other's strengths. This collective experience forms a solid base for the ambitious goals of EO4LEAs, aiming to enhance European and global security through advanced surveillance capabilities and technological innovation.

3.2.3 Management Structure

The EO4LEAs project's management structure is strategically crafted to ensure effective collaboration and decision-making across all consortium members. It delineates clear responsibilities and establishes a well-structured process for decision-making and information sharing, as illustrated in Figure 3.

- **KEMEA,** with its leadership role solidified by its success in the H2020-FORESIGHT project, coordinates the project, overseeing WP1 & WP2 for Project Management and Coordination. KEMEA's role is pivotal, ensuring project objectives are met while maintaining high standards of quality assurance and risk management.
- **NOA** leads WP3, focusing on Use Case Design and User Requirements,

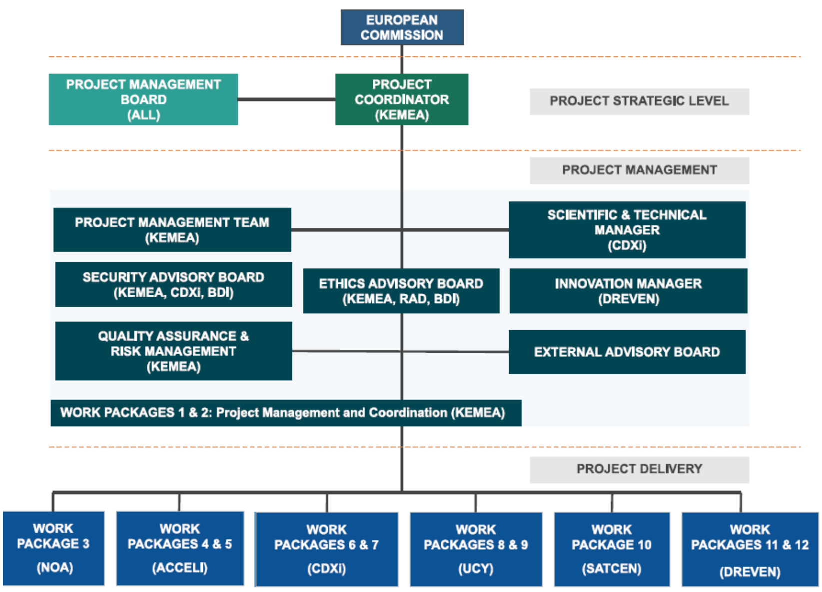

Figure 3: EO4LEAs' Management Structure.

leveraging its extensive experience in coordinating and implementing pilot demonstrations and validations.

- **ACCELI,** with its expertise in data retrieval, curation, and preparation, heads WP4 & WP5. This critical role underpins the project's success by ensuring data quality and readiness for subsequent integration and analysis.
- **CDXi (CERTH),** known for its significant contributions to geo-spatial AI and various EU-funded projects, leads WP6 & WP7. CDXi's role involves the development and integration of state-of-the-art GeoAI technologies, driving the project's innovative edge.
- **UCY** spearheads WP8 & WP9, focusing on EO4LEAs platform development, including the integration of Digital Twins and the DestinE initiative. UCY's technical expertise is key to advancing the project's infrastructure and ensuring interoperability with Copernicus services.
- **SATCEN** is responsible for WP10, Pilot Implementation, Evaluation, and Training, bringing its extensive knowledge in security applications to guide the practical deployment and assessment of project outputs.
- **DREVEN** leads WP11 & WP12, dedicated to Impact Creation, Dissemination, and Exploitation. DREVEN's experience in market analysis and the commercialization of research outputs ensures the project's findings reach the intended audiences and stakeholders effectively.

This comprehensive management structure leverages the unique strengths and expertise of each partner, positioning EO4LEAs for success and ensuring its contributions significantly impact European security and beyond**.**

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References

Bijak, J. & Czaika, M. Assessing Uncertain Migration Futures: A Typology of the Unknown. 30 http://www.quantmig.eu/res/files/QuantMig%20D1.1%20Uncertain%20Migration%20Futures%20V1.1%2030Jun2020.pdf (2020).

European Commission, Directorate-General for Research and Innovation, *Gendered innovations 2 – How inclusive analysis contributes to research and innovation – Policy review*, Publications Office of the European Union, 2020, https://data.europa.eu/doi/10.2777/316197

Hangan A, Chiru C-G, Arsene D, Czako Z, Lisman DF, Mocanu M, Pahontu B, Predescu A, Sebestyen G. Advanced Techniques for Monitoring and Management of Urban Water Infrastructures—An Overview. *Water*. 2022; 14(14):2174. https://doi.org/10.3390/w14142174

Phiri D, Simwanda M, Salekin S, Nyirenda VR, Murayama Y, Ranagalage M. Sentinel-2 Data for Land Cover/Use Mapping: A Review. *Remote Sensing*. 2020; 12(14):2291. https://doi.org/10.3390/rs12142291

Lefebvre G, Davranche A, Willm L, Campagna J, Redmond L, Merle C, Guelmami A, Poulin B. Introducing WIW for Detecting the Presence of Water in Wetlands with Landsat and Sentinel Satellites. *Remote Sensing*. 2019; 11(19):2210. https://doi.org/10.3390/rs11192210

AAWA Alto Adriatico Water Authority. (2021). *Flood Risk Management Plan of the Eastern Alps Hydrographic District - 1st revision 2021-2027*. Decree of the President of the Italian Council of Ministers of December 1, 2022 (published in the Offical Gazette n. 31, of Febbruary 7, 2023). Retrieved from https://sigma.distrettoalpiorientali.it/portal/index.php/direttiva-alluvioni/

Ferri, M., Monego, M., Norbiato, D., Baruffi, F., Toffolon, C., & Casarin, R. (2012). *AMICO: la piattaforma previsionale per i bacini idrografici del nord est adriatico (I e II)* [AMICO: the forecasting platform for the north-eastern Adriatic watersheds (I and II)]. In XXXIII National Conference on Hydraulics and Hydraulic Structures "IDRA 12", Brescia, Italy, September 10-15, 2012.

Mazzoleni, M., Verlaan, M., Alfonso, L., Monego, M., Norbiato, D., Ferri, M., & Solomatine, D. (2017). *Can assimilation of crowdsourced data in hydrological modelling improve flood prediction?* Hydrol. Earth Syst. Sc., 21, 839–861. https://doi.org/10.5194/hess-21-839-2017

Lioumbas, J., Christodoulou, A., Katsiapi, M., Xanthopoulou, N., Stournara, P., Spahos, T., Seretoudi, G., Mentes, A., & Theodoridou, N. (2023). *Satellite remote sensing to improve source water quality monitoring: A water utility's perspective*. *Remote Sensing Applications: Society and Environment*, *32*, 101042. https://doi.org/10.1016/j.rsase.2023.101042

Chen J, Zhu W, Tian YQ, Yu Q, Zheng Y, Huang L (2017). Remote estimation of colored dissolved organic matter and chlorophyll-a in Lake Huron using Sentinel-2 measurements. J Appl Remote Sens 11:1. https://doi.org/10.1117/1.JRS.11.036007

Fema, P. (2012). 58-1, Seismic performance assessment of buildings volume 1-methodology. Applied Technology Council. California: Redwood City.

Pegia, M., Jónsson, B. Þ., Moumtzidou, A., Gialampoukidis, I., Vrochidis, S., & Kompatsiaris, I. (2023, June). MuseHash: supervised bayesian hashing for multimodal image representation. In Proceedings of the 2023 ACM International Conference on Multimedia Retrieval (pp. 434-442). https://doi.org/10.1145/3591106.3592228

Prakash, Guru, et al. "Recent advancement of concrete dam health monitoring technology: a systematic literature review." Structures. Vol. 44. Elsevier, 2022. https://doi.org/10.1016/j.istruc.2022.08.021

Aswathi, J., et al. "InSAR as a tool for monitoring hydropower projects: A review." Energy Geoscience 3.2 (2022): 160-171. https://doi.org/10.1016/j.engeos.2021.12.007

Bountos, Nikolaos Ioannis, et al. "Self-supervised contrastive learning for volcanic unrest detection." IEEE Geoscience and Remote Sensing Letters 19 (2021): 1-5. https://doi.org/10.1109/LGRS.2021.3104506

Federico Ricciuti, Alessio Rucci, Chiara Gervasi, Ioannis Papoutsis, Roberto Acerbis, "Multimodal InSAR Reliability Prediction using Graph Neural Networks (H2020 DeepCube project)", Living Planet Symposium 2022

Jakubik, J., Roy, S., Phillips, C. E., Fraccaro, P., Godwin, D., Zadrozny, B., ... & Ramachandran, R. (2023). Foundation models for generalist geospatial artificial intelligence. arXiv preprint arXiv:2310.18660. https://doi.org/10.48550/arXiv.2310.18660

Henrichs, D. W., Anglès, S., Gaonkar, C. C., & Campbell, L. (2021). Application of a convolutional neural network to improve automated early warning of harmful algae blooms. Environmental Science and Pollution Research, 28(22), 28544–28555. https://doi.org/10.1007/s11356-021-12471-2

Huynh, N. H., Böer, G., & Schramm, H. (2022). Self-attention and generative adversarial networks for algae monitoring. European Journal of Remote Sensing, 55(1), 10–22. https://doi.org/10.1080/22797254.2021.2010605

Nguyen, H.-Q., Ha, N.-T., & Pham, T.-L. (2020). Inland harmful cyanobacterial bloom prediction in the eutrophic Tri An Reservoir using satellite band ratio and machine learning approaches. Environmental Science and Pollution Research, 27(9), 9135–9151. https://doi.org/10.1007/s11356-019-07519-3

Tsarpalis D., Karaferi E., Vamvatsikos D., Kohrangi M., Zeppos J. (2023). A socioeconomic model for estimating indirect consequences of earthquake hazards to cultural heritage communities. Proceedings of the SECED 2023 Conference, Cambridge, UK.

Vamvatsikos D., Chatzidaki A. (2022). The HAPI sensor-aware framework for infrastructure risk and resilience assessment. Proceedings of the 3rd International Conference on Natural Hazards & Infrastructure ICONHIC 2022, Athens, Greece.

Wang, Peng, Cheng Xing, and Xiandong Pan. "Reservoir dam surface deformation monitoring by differential GB-InSAR based on image subsets." Sensors 20.2 (2020): 396. https://doi.org/10.3390/s20020396

Kolokoussis P, Karathanassi V. Oil Spill Detection and Mapping Using Sentinel 2 Imagery. Journal of Marine Science and Engineering. 2018; 6(1):4. https://doi.org/10.3390/jmse6010004

Argamosa, R. J. L., Blanco, A. C., and Reyes, R. B.: MAPPING OIL SPILLS ON SEA SURFACE FROM SENTINEL 2 IMAGES USING PRINCIPAL COMPONENTS AND CATEGORICAL BOOSTING, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVI-4/W3-2021, 33–38, https://doi.org/10.5194/isprs-archives-XLVI-4-W3-2021-33-2022, 2022.

S. T. Seydi, M. Hasanlou, M. Amani and W. Huang, "Oil Spill Detection Based on Multiscale Multidimensional Residual CNN for Optical Remote Sensing Imagery," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 14, pp. 10941-10952, 2021, doi: 10.1109/JSTARS.2021.3123163.

Tysiąc P, Strelets T, Tuszyńska W. The Application of Satellite Image Analysis in Oil Spill Detection. Applied Sciences. 2022; 12(8):4016. https://doi.org/10.3390/app12084016.

Kikaki, K., Kakogeorgiou, I., Hoteit, I., & Karantzalos, K. (2024). Detecting Marine pollutants and Sea Surface features with Deep learning in Sentinel-2 imagery. ISPRS Journal of Photogrammetry and Remote Sensing, 210, 39-54, https://doi.org/10.1016/j.isprsjprs.2024.02.017.

#§QUA-LIT-QL§# #§WRK-PLA-WP§#