KOΐOς

Research and Innovation Center of Excellence

2021

ACTIVITY REPORT

University of Cyprus

Imperial College London

Contents

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Forewords

Message from the Rector

> I am confident that the Center will continue its dynamic growth and transform its ideas into practical solutions, resulting in better ways of living.

Dear Reader,

Undoubtedly, 2021 was another year in which our lives and work were affected by the COVID-19 pandemic. Despite the significant operational disruptions posed by the pandemic, the University of Cyprus found new ways to overcome challenges, move forward, and lay the groundwork for future successes.

The University paid special attention to the health and safety of colleagues, students, and the broader academic community, while at the same time continued its operation, delivering a world-class education, enhancing its research and innovation activities, and making positive contributions to society at large. Our response to COVID-19 has also been significant, as our community supported the national efforts to track the pandemic and mitigate its effects.

Over the past year, the University of Cyprus achieved important recognition, since it was ranked among the #601-700 and #501- 600 best universities in the world for 2021, according to the widely recognized Shanghai Ranking List and the Times Higher Education World University Rankings respectively. Also, for the first time it was ranked 477th among the top 1.000 universities in the world, according to the QS World University Rankings.

In a rapidly changing environment, the University of Cyprus is constantly changing, adjusting, and evolving to manage challenges and ensure its operational continuity amidst crises. Within this context, we have reviewed and updated our Strategic Plan (2021-2025) towards accelerating our strategic development and producing excellent outcomes.

In this journey of knowledge, research, innovation, and the pursuit of excellence, the KIOS Research and Innovation Center of Excellence plays an important role in developing innovative solutions and making a difference in society both nationally and internationally. I am confident that the Center will continue its dynamic growth and transform its ideas into practical solutions, resulting in better ways of living.

I would like to express my sincere gratitude and offer my warmest congratulations to the Faculty and researchers of the KIOS Research and Innovation Center of Excellence for their hard work and collective effort in producing excellent research and innovative outcomes for the benefit of society.

Sincerely,

Professor Tasos Christofides Rector,
University of Cyprus

Message from the Director

> KIOS provides opportunities for motivated young people and makes a difference in society and our everyday lives, through research and innovation

I am pleased to introduce you to the 2021 Activity Report of the KIOS Center of Excellence, which summarizes the Center's most significant achievements in research and innovation.

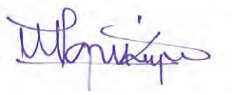
Over the past year, the Center continued its ambitious pursuit of excellence in research and innovation by producing new knowledge and technological tools for making critical infrastructure systems smarter, more efficient, greener, and more secure.

KIOS has continued to be highly successful in attracting competitive research funding at the European level and participating in several multidisciplinary research projects funded by international and national funding sources. Moreover, KIOS researchers have continued publishing their research work in high-impact journals and prestigious international conference proceedings.

The KIOS Innovation Hub has been very active in engaging and collaborating with industry and government organizations in Cyprus and abroad through new research and innovation projects. Moreover, the Center continued the development of technological tools to support national stakeholders in addressing the COVID-19 pandemic challenges and other infectious diseases, thus contributing to the digital transformation of Cyprus.

A great honor for the Center was the official visit to KIOS of the President of the European Commission, Ursula von der Leyen, and the President of the Republic of Cyprus, Nicos Anastasiades, during which KIOS researchers had the opportunity to showcase the Center's pioneering work, which is relevant to the goals of the NextNegerationEU and the Cyprus Recovery and Resilience Plan for a greener, more digital, and more resilient Europe.

In conclusion, I would like to take this opportunity to acknowledge the exceptional work of the KIOS personnel, for going above and beyond to ensure that the Center will continue doing what it does best: provide opportunities for motivated young people and make a difference in society and our everyday lives, through research and innovation. I would also like to extend my appreciation to the leadership and administration of the University of Cyprus for their continued support.



Prof. Marios M. Polycarpou,
Director, KIOS Research and Innovation Center of Excellence
Professor of Electrical and Computer Engineering, University of Cyprus
Visiting Professor, Imperial College London, U.K.
Member of the Cyprus Academy of Sciences, Letters, and Arts

In brief

The KIOS Research Center was established in 2008 at the University of Cyprus and was subsequently selected by the EU to advance into a Research and Innovation Center of Excellence in 2017.

The mission of the KIOS Research and Innovation Center of Excellence (KIOS CoE) is to conduct multidisciplinary research and innovation in the area of Information and Communication Technologies (ICT) with emphasis on the monitoring, control, management and security of critical infrastructures. These infrastructures include large-scale, complex systems such as power and energy systems, water systems, transportation systems, telecommunication networks, healthcare systems, and emergency management and response systems.

The Center's vision is to provide an inspiring environment for conducting excellent, cutting-edge research at a global scale, producing new knowledge and advanced engineering and management tools that can be applied to solve timely and real-life problems in the considered Critical Infrastructure Systems, bringing multiple benefits to society at large.

Research in high-tech areas important to Cyprus and the global economy

SCIENTIFIC FOUNDATIONS

- Control Theory, Automation and Robotics
- Artificial Intelligence, Machine Learning and Analytics
- Information Technology, Systems and Engineering
- Software/Hardware System Design & Integration
- Cyber-Physical Security

APPLICATION AREAS

- Power & Energy Systems
- Water Systems & Environmental Monitoring
- Intelligent Transportation Systems
- Telecommunication Systems & Networks
- Healthcare Systems
- Emergency Management & Response

RESEARCH OUTCOMES

- Intelligent Monitoring & Control
- Resilience, Adaptation & Reconfiguration
- Security, Safety & Trustworthiness
- Embedded Real-time Algorithms
- Big Data Analysis & Management
- Performance & Energy Optimization

Towards smarter, greener, and more secure Critical Infrastructures

Modern societies depend on the availability and smooth, efficient, proper, and uninterrupted operation of critical infrastructures systems. When properly functioning, critical infrastructures touch every aspect of human life by providing essential services to society, such as energy, water, food, transportation, health, and ICT systems, thus enabling economic growth and social well-being.

As the world's population increases and urbanization accelerates, the demand for service provisioning is rising rapidly. As a result, critical infrastructure systems worldwide are expanding and are becoming more complex, necessitating greater efficiency and improved capabilities in order to sustain their effective operation. Meanwhile, the effects of climate change, such as intense heatwaves, droughts, hurricanes, fires, and floods, pose direct threats to these systems, affecting their operation. Moreover, their dependance on technological advances and the high level of interconnectedness between them, increase the risk of malicious cyber-attacks.

Improving the resilience and reducing the vulnerabilities of critical infrastructure systems is a critical priority for all nations to meet current socio-economic and environmental challenges and ensure economic prosperity and social coherence. This is essential for achieving the UN's 2030 Sustainable Development Goals, the EU's policies on green and digital transition as well as the National Recovery & Resilience Plans.

The KIOS Research and Innovation Center of Excellence at the University of Cyprus embraces these challenges and develops new knowledge and technological solutions to improve the operation, efficiency, reliability, safety, and security of critical infrastructure systems. The goal is to make these infrastructures smarter, greener, and more secure. The Center's research achievements contribute to their transformation and bring major socio-economic and environmental benefits at the local and global level.

Sustainable Energy Infrastructures

Transforming the energy sector is essential to attain global targets for climate and energy. KIOS researchers develop and implement intelligent monitoring and control solutions to support the green and digital evolution of the electricity grids. These solutions improve the efficiency and the cost-effective operation of the energy systems, reduce energy consumption, and maximize the penetration of renewable energy sources and storage technologies in power grids and smart buildings. KIOS researchers, in collaboration with the local energy authorities, have integrated the developed tools into the Cyprus' energy infrastructure system, enhancing its stability, reliability, and power quality, and at the same time contributing towards the reduction of greenhouse gas emissions.

The Center's research achievements contribute to the **transformation of critical infrastructures** and bring **major socio-economic and environmental benefits** at the local and global level

Our researchers transform **new knowledge** into tangible results, to make critical infrastuctures **smarter, greener, and more secure,** for the benefit of society at large

Smart Water Distribution Systems

Sustainable management of water resources and access to clean water for all people are at the heart of the UN Sustainable Development Goals. KIOS researchers develop smart water technologies and real-time water quality monitoring and decision support tools to transform the water distribution systems in the cities of the future. The KIOS team, in collaboration with major water operators and wastewater organizations in Cyprus and abroad, deploys technologies to reduce water losses, detect and mitigate contamination events, improve water quality monitoring, and increase the efficiency of the water distribution systems.

Intelligent Traffic Management Solutions

Intelligent transportation systems are a top priority for climate action since they can help to reduce greenhouse gas emissions and road traffic deaths. Researchers at KIOS are working towards the development of intelligent monitoring and control algorithms to better manage traffic congestion within large scale urban areas as well as well as techniques for detecting cyber-attacks against vehicles. These solutions contribute to traffic congestion relief, reduction of travel time, reduction of fuel consumption and emissions as well to the improvement of road safety. The KIOS CoE has an ongoing research collaboration with the Cyprus Ministry of Transport, Communications and Works, through which technological solutions are being developed, aiming at the green and digital transformation of Cyprus' transportation network.

Innovative Emergency Response Technologies

Emergency response technologies play an essential role in preventing loss of life, minimizing impact to the ecosystems, and decreasing cost to property and critical infrastructures. Researchers at the Center develop artificial intelligence based-tools that can help first responders (e.g., Civil Defence, Police, Fire Service) to manage emergency operations efficiently and effectively. By using these technologies, first responders can enhance their decision support, the real time surveillance, and the monitoring during emergencies. In addition to its turn-key technological developments, KIOS delivers training courses on the use of remotely piloted aerial systems for emergency management to key stakeholders at an international level.

In current times, with increased climate and energy challenges at the local and international levels, the role the KIOS CoE plays in tackling some of the world's most pressing challenges becomes more important than ever. Our researchers collaborate with over 250 organizations in Cyprus and abroad to transform new knowledge into tangible results, to make critical infrastuctures smarter, greener, and more secure, for the benefit of society at large.

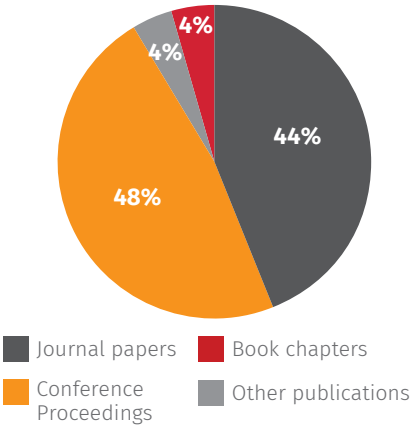
Research Activities

Scientific dissemination

Scientific dissemination is an important and integral part of the KIOS CoE, since it fosters the transfer of knowledge and results in international scientific communities.

In 2021, the KIOS Faculty and the wider KIOS research team have published 85 journal and conference papers, 4 book chapters, and 4 other publications.

KIOS CoE Publications 2021



• Peer-reviewed journal publications

Academic journals serve as one of the principal forums for researchers to disseminate their research work within the scientific community. The KIOS CoE researchers continue to target high-quality and high-impact journals, whose topics of interest cover the research activities of the Center. In 2021, the KIOS research team has published 41 peer-reviewed journal papers in academic journals within their areas of expertise.

• Conference proceedings

Conference proceedings facilitate fast scientific dissemination, allowing researchers to present their research at conferences, workshops, and symposia, aiming at the fast and wide adoption of their research ideas by their peers in the scientific community. In 2021, the KIOS research team has published 44 peer-reviewed papers in scientific conference proceedings.

KIOS CoE Open Science Activities

The KIOS CoE has recognized the significance of openly disseminating scientific results. Towards that goal the KIOS Open Knowledge Portal[1] was launched in 2017. This is an online repository hosted on Zenodo that stores and manages all research-related papers, open research data and open-source code produced at the KIOS CoE. The majority of the Center's journal and conference publications are available to the scientific community following the "green" open access model through this Portal.

In addition, the KIOS CoE Repository on Github[2] is another channel for making the software code and associated datasets available to the research community.

Finally, the KIOS CoE follows the best practices in Open Science and actively contributes to reproducible research initiatives. To this end, a number of scientific results produced at KIOS CoE can be easily reproduced online by other researchers using the relevant software code and accompanying data that are publicly available on the KIOS CoE Reproducible Research Platform on Code Ocean[3].

1. https://zenodo.org/communities/kios-coe/
2. https://github.com/KIOS-Research
3. https://codeocean.com/explore/capsules?query=kios

KIOS CoE Mobile Application

The KIOS CoE developed a mobile application where crowdsourcing data collection tools are provided to engage different communities around the globe such as the general public, researchers and scientists. Through these tools the citizens are able to easily visualize and share their data, to connect with other communities, and engage in new type of collaborations, collect data in specific digital formats, and facilitate the process of finding specific scientific data.

The application is already available on Google Play Store and will soon be released on Apple App Store.

Scientific Conference

During 2021, the KIOS CoE co-organized the inaugural Europe, Middle East, and Africa (EMEA) Technical Forum on tiny Machine Learning (tinyML), which was held online on June 7-10, 2021. The Forum featured an exciting blend of tutorials, keynote talks, panels, industry and policy-maker perspectives, and a student research forum, addressing an abundance of topics related to machine learning technologies.

The co-organization of such major event helps to increase the reputation of KIOS CoE as a center that promotes excellence in research and innovation.

KIOS CoE participation in EU level networks

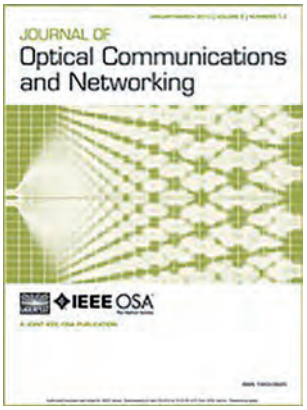
In 2021, the KIOS CoE research team participated in several EU level networks, platforms, and strategic partnerships, aiming to increase the visibility of the Center and to exploit future collaborations. This enables the KIOS CoE team to reach potential partners and increase access to proposal consortiums.

A sample of networks in which KIOS researchers participated:

- UNIMED Subnetwork on Safety and Security of Critical Infrastructures
- Crowdhelix Network
- The European Water Platform - WssTP (WATER EUROPE)
- Union Civil Protection Knowledge Network
- Disaster Risk Management Knowledge Centre
- AI Connect Network
- Connecting Education and Research Communities for an Innovative Resource Aware Society (CERCIRAS) COST ACTION

Research News

Optimal and Near-Optimal Alpha-Fair Resource Allocation Algorithms based on Traffic Demand Predictions for Optical Network Planning



This work examines proactive network optimization in reconfigurable optical networks based on traffic predictions. Specifically, the fair spectrum allocation (SA) problem is examined for a priori reserving resources aiming to achieve near-even minimum quality-of-service (QoS) guarantees for all contending connections. In this work, we consider predictive traffic distributions, allowing the exploration of several combinations of possible SAs. To find a fair SA policy, we resort to an α-fairness scheme, while QoS fairness is evaluated according to a game-theoretic analysis based on the coefficient of variations of the connections' unserved traffic metric. α-fair SA integer linear programming algorithms are proposed, showing that as parameter α increases, QoS fairness improves, along with connection blocking, resource utilization, and overprovisioning and under provisioning.

T. Panayiotou and G. Ellinas, "Optimal and Near-Optimal Alpha-Fair Resource Allocation Algorithms based on Traffic Demand Predictions for Optical Network Planning", *IEEE/OSA Journal of Optical Communications and Networking (JOCN)*, vol. 13, no. 3, pp. 1-16, 2021

Leakage detection and localization in water distribution systems: A model invalidation approach

A key challenge in the area of leakage diagnosis in water distribution networks is how model-based methods can deal with the high uncertainty of network parameters and consumer water demands, while at the same time using only a small number of sensor measurements compared to the system states.

Our work addresses these challenges by utilizing known bounds on demand and model parameter uncertainty to formulate a 'healthy' interval-model of the system. We introduce a novel methodology for leakage detection through interval-model invalidation and develop an optimization-based methodology for leakage localization using the proposed interval-model. This methodology has the advantage of using a non-linear model, thus avoiding linearization errors. Moreover, there is no need to calculate an optimal threshold for detection, as this is implicitly defined by the bounds on the uncertain parameters. This work paves the way for the use of set-based methods for dealing with uncertainty in water systems, by demonstrating their suitability and effectiveness.

Stelios G. Vrachimis, Stelios Timotheou, Demetrios G. Eliades, Marios M. Polycarpou, "Leakage detection and localization in water distribution systems: A model invalidation approach", *Control Engineering Practice*, 110, 104755, 2021.

TinyML: Current Progress, Research Challenges, and Future Roadmap

Tiny machine learning (tinyML) is a fast-growing field of machine learning technologies and applications including algorithms, hardware, and software capable of performing on-device sensor data analytics at extremely low power, hence enabling a variety of always-on use-cases and targeting battery-operated devices. tinyML systems are slowly adopted for multiple commercial applications and new systems on the horizon, and at the same time, significant progress is being made on algorithms, networks, and models. Further, what was initially considered low power applications, is now mainstream and commercially available. There is therefore a growing momentum demonstrated by the technical progress, ecosystem development and the need for benchmarking and evaluation methodologies. In this paper, we present an overview of the current state of the art, while we also identify challenges and opportunities. We also provide our vision for the road ahead.

M. Shafique, T. Theocharides, V. J. Reddy and B. Murmann, "TinyML: Current Progress, Research Challenges, and Future Roadmap," *2021 58th ACM/IEEE Design Automation Conference (DAC)*, 2021, pp. 1303-1306.

Digital subtraction of temporally sequential mammograms for improved detection and classification of microcalcifications

The aim of this study was to demonstrate that automated detection and classification of breast microcalcifications, a precursor of cancer, can be improved with the subtraction of sequential mammograms as opposed to using the most recent images only. One hundred pairs of mammograms were retrospectively collected from two temporally sequential rounds. However, mammograms cannot be directly subtracted, due to tissue changes over time and breast deformation during mammography. To overcome this challenge, optimized preprocessing, image registration, and postprocessing procedures were developed. Machine learning techniques were employed to classify the true microcalcifications as benign or suspicious. The classification resulted in 90.3% accuracy and 0.87 AUC, compared to 82.7% and 0.81 using just the most recent mammogram. Temporal subtraction is more effective in microcalcification detection and classification, compared to using only the most recent mammogram, and could play an important role in automated diagnosis systems.

K. Loizidou, Galateia Skouroumouni, Costas Pitris and Christos Nikolaou, “Digital subtraction of temporally sequential mammograms for improved detection and classification of microcalcifications,” *European Radiology Experimental*, vol. 5, no. 1, pp. 1–12, 2021.

Stability of power networks with time-varying inertia

A major transition in modern power systems is the replacement of conventional generation units with renewable sources of energy. The latter results in lower rotational inertia which compromises the stability of the power system, as testified by the growing number of frequency incidents. In this study, we consider how inertia variations, resulting from the application of control action associated with virtual inertia and fluctuations in renewable generation, may affect the stability properties of the power network within the primary frequency control timeframe. We consider the interaction between the frequency dynamics and a broad class of

non-linear power supply dynamics at the presence of time-varying virtual inertia and provide suitable conditions such that stability is guaranteed. In particular, we impose two conditions; a decentralized passivity-related condition on the power supply dynamics and a condition that associates the maximum rate of growth of virtual inertia with the local power supply dynamics. The presented conditions are locally verifiable and applicable to arbitrary network configurations. Our analytic results are validated with simulations on the Northeast Power Coordinating Council (NPCC) 140-bus system, where we demonstrate how varying virtual inertia may induce large frequency oscillations and show that the application of the proposed conditions yields a stable response.

A. Kasis, S. Timotheou and M. Polycarpou, "Stability of power networks with time-varying inertia," *2021 60th IEEE Conference on Decision and Control (CDC)*, 2021, pp. 2788-2793.

Energy management and control of a flywheel storage system for peak shaving applications

Peak shaving applications provided by energy storage systems enhance the utilization of existing grid infrastructure to accommodate the increased penetration of renewable energy sources. This work investigates the provision of peak shaving services from a flywheel energy storage system installed in a transformer substation. A lexicographic optimization scheme is formulated to define the flywheel power set-points by minimizing the transformer power limit violations and the flywheel energy losses. Convex functions that represent the flywheel power losses and its maximum power are derived and integrated in the proposed scheme. A two-level hierarchical control framework is introduced to operate the transformer-flywheel system in a way that handles prediction errors and modelling inaccuracies. At the higher level, a model predictive controller is developed that solves the lexicographic optimization scheme using linear programming. At the lower-level, a secondary controller corrects the power set-points of the model predictive controller using real-time measurements. A software platform has been developed for integrating the proposed controllers in an experimental setup to test their effectiveness in a realistic testbed setting, and the flywheel system characteristics are experimentally identified. Simulation and experimental results validate and verify the modeling, identification, control and operation of a real flywheel system for peak shaving services.

L. Tziovani, L. Hadjidemetriou, C. Charalampous, M. Tziakouri, S. Timotheou, E. Kyriakides, “Energy management and control of a flywheel storage system for peak shaving applications,” *IEEE Tran. Smart Grid*, vol. 12, no. 5, pp. 4195-4207, Sep. 2021.

172
RESEARCHERS EMPLOYED
by KIOS CoE at the end of 2021

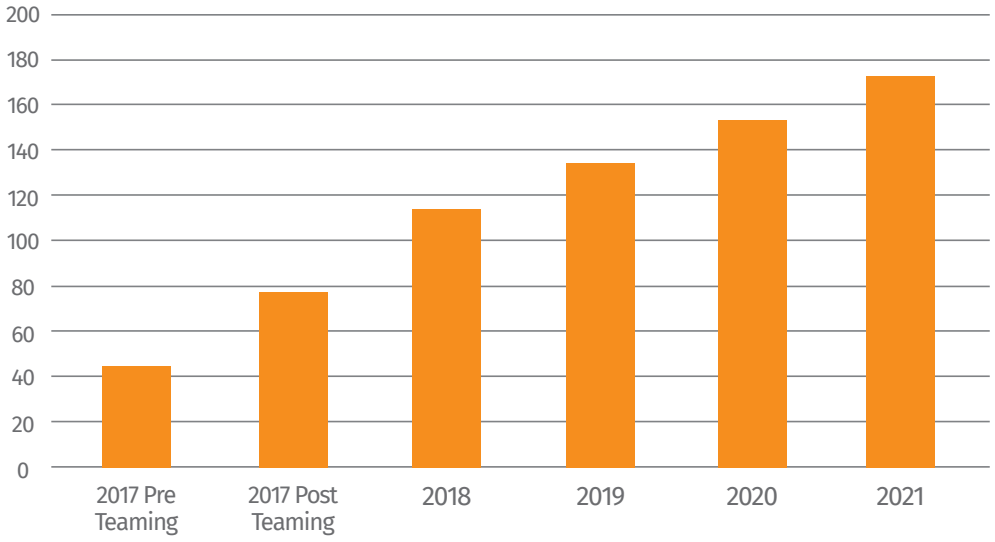
KIOS CoE Personnel

The human capital is the most important asset of an organization. Thus, the KIOS CoE places particular emphasis on recruiting high-caliber researchers who will contribute significantly to the development of the Center.

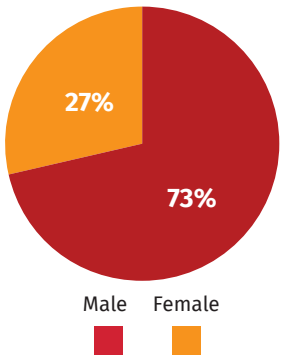
The KIOS CoE places also particular emphasis on promoting diversity, equal opportunities, and gender balance at all levels of its research and innovation teams. Towards this end, the Center aims to increase gender balance among its research personnel by offering female researchers an attractive working environment. In addition, the KIOS CoE has developed recruitment initiatives to attract highly-qualified personnel from Europe and the Middle East - North Africa (MENA) region.

At the end of 2021, 172 researchers were employed by the KIOS CoE including full-time and part-time employees. This number includes Faculty, Affiliated Faculty, Research Faculty, Postdoctoral researchers, PhD Students, Research and Software Engineers, Interns and Administrative Personnel. At the KIOS CoE spoke at Imperial College London 13 Researchers were employed. Finally, the KIOS Alumni network comprises 229 people.

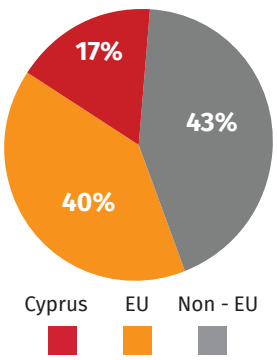
Personnel Growth Per Year



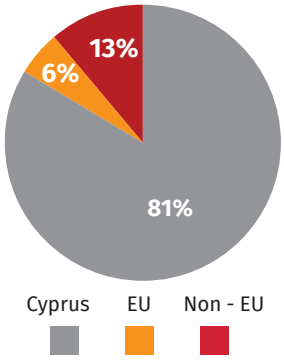
Gender



Country of Highest Academic Degree



Country of Origin



Competitive R&I Funded Projects

In 2021, the KIOS CoE participated in a number of collaborative research and innovation projects funded by various competitive funding programmes, including Horizon H2020, the Cyprus Research and Innovation Foundation, other EU funding programmes, such as INTERREG and SolarEranet Co-fund, as well as EU funding programmes tackling specific EU policy and objectives, such as emergency response. These projects which involve multidisciplinary international consortiums address important global challenges for critical infrastructure systems such as power and energy systems, water networks, transportation networks, telecommunication networks, and emergency management and response systems.

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FUNDED
RESEARCH PROJECTS
in 2021

	ACRONYM	FULL TITLE	FUNDING SOURCE	KIOS ROLE
1	KIOS CoE*	The KIOS CoE project focuses on the significant development of KIOS into a world-class research and innovation Center of Excellence. The project which is part of the EU's strategic program "Spreading Excellence and Widening Participation', is being implement in collaboration with Imperial College London	EU - H2020 TEAMING*	Coordinator
2	Water-Futures	Development of a new theoretical framework for the allocation and development decisions on drinking water infrastructure systems, so that they are socially equitable, economically efficient and environmentally resilient	EU - H2020 - ERC Synergy Grant	Coordinator
3	ARTION	Development of a world class network for knowledge sharing in the area of Artificial Intelligence (AI) for disaster management	EU CIVIL PROTECTION	Coordinator
4	THISEAS	Development of an electronic situational awareness and decision support system to improve the Cyprus National Guard's operational capabilities.	Cyprus Ministry of Defence	Coordinator
5	PathoCert	Development of technologies for detecting and managing pathogen contamination events during emergency response situations	EU - H2020	Coordinator
6	EMPOWER	Empowering the Cyprus power system with sustainable and intelligent technologies to enhance its stability and reliability, under high penetration of renewable energy sources	Cyprus RIF[1]	Coordinator

7	FAULT LEARNING	Design and development of an online learning-based fault diagnosis engine with adaptation capabilities - MSCA Research Fellowship	EU - H2020 MSCA	Coordinator
8	BITS	Development of Bayesian statistical methodologies and tools in the area of Intelligent Transportation Systems - MSCA Research Fellowship	EU - H2020 - MSCA	Coordinator
9	C-AVOID	Development of a realistic fully-fledged transportation architecture based on the new generation of cellular networks (5G) - MSCA Research Fellowship	EU - H2020 - MSCA	Coordinator
10	SmarTher Grid	Design of control schemes for thermostatic loads to provide effective, efficient, and reliable ancillary support to the power network - MSCA Research Fellowship	EU- H2020 - MSCA	Coordinator
11	GLADIATOR	Next-generation theranostics of brain pathologies with autonomous externally controllable nanonetworks: a trans-disciplinary approach with bio - nanodevice interfaces	EU - H2020 FET OPEN	Coordinator
12	REALFLON	Design and development of innovative optimization algorithms for resource allocation, scalability, and security in flexible optical networks	Cyprus RIF	Coordinator
13	GLADIATOR Complementary	Complementary infrastructure to support the development of a working prototype of a complete, autonomous and clinically applicable, nanonetwork-based, Molecular Communications platform	Cyprus RIF	Coordinator
14	CAPACIDI	Building the capacity of researchers to coordinate and participate in EU funded project	Cyprus RIF	Coordinator
15	SESAME	Development of a new generation of Multi-Robot Systems (MRS), utilizing AI/ML among other approaches, to design dependable and secure multi-robot systems for key European sectors including Healthcare, Manufacturing, Agri-food, and Infrastructure Inspection	EU-H2020	Partner
16	EnerMan	Create an energy sustainability management framework collecting data from the factory and holistically process them to create dedicated energy sustainability metrics	EU-H2020	Partner
17	ELECTRON	Development of a new-generation platform for Electrical Power and Energy Systems, capable of empowering the resilience of energy systems against cyber, privacy, and data attacks	EU - H2020	Partner

18	Smart5Grid	Development of 5G solutions for building innovative and high performance smart grids able to feature online monitoring data and enable efficient, fast, and secure operation	EU - H2020	Partner
19	OneNet	Development of new generation of grid services able to fully exploit demand response, storage and distributed generation	EU-H2020	Partner
20	CORONASENSE	Development of an innovative software to assess in real-time the Indoor Air Quality specifically for conditions that enable the spread of COVID-19 in large public indoor spaces	Cyprus RIF - Seed-COVID	Partner
21	Malloc	Development of a software solution that protects users' data by safeguarding their mobile devices against unauthorised or unattended data recordings or transmissions	NextGenerationEU - Pre-Seed	Partner
22	WiseStorage	Development of an innovative web-based solution to optimize the operation of Battery Energy Storage Systems (BESS) installed in buildings and maximize the prosumers' profit.	NextGenerationEU - Pre-Seed	Partner
23	AIDERS	Deployment of artificial intelligence techniques for the improvement of emergency response	EU CIVIL PROTECTION	Partner
24	MariSense	Development of a maritime cognitive decision support system	Cyprus RIF	Partner
25	Control4COVID	Development of an intelligent emergency information management platform for controlling COVID-19	Cyprus RIF - Seed-COVID	Partner
26	CovTracer-EN	Development of the CovTracer - Exposure Notification tracing application in collaboration with the CYENS CoE	EU-ESI	Partner
27	AURA	Development of an innovative software for the improvement of the indoor air-quality monitoring in large, energy efficient buildings	NextGenerationEU - Pre-Seed	Partner
28	SWIFTERS	Enable local and international security organizations to build, manage, and scale their drone programs, and leverage the full capabilities of drones in their own missions	Cyprus RIF - Pre-Seed	Partner

29	KIOS CoE - HUAWEI	Development of an information fusion radio location algorithm with Tango-aided floor plan and signal mapping	"HUAWEI Technologies Ltd"	Partner
30	DiMPAH	Aggregate, connect, and make widely available, novel open education resources on selected digital methods	EU-ERASMUS	Partner
31	AIRMOS	Implementation of intelligent real-time drone monitoring tactics to safeguard sensitive facilities	Cyprus Seeds	Partner
32	CUREX	Address the protection of the confidentiality and integrity of health data by producing a novel, flexible, and scalable situational awareness-oriented platform	EU - H2020	Partner
33	DOMOGNOSTICS +	Conduct industrial research, develop and evaluate an innovative low-cost intelligent software/hardware solution designed for building operators to better monitor and control their building systems	Cyprus RIF	Partner
34	CARAMEL	Address the cybersecurity challenge of the next generation mobility, contributing to the long-term vision of safer roads with zero fatalities	Cyprus RIF	Partner
35	EnergyXchange	Conduct industrial research to develop and evaluate a novel product to facilitate the introduction of stakeholders to the new liberalized energy market	Cyprus RIF	Partner
36	Pvgnosis	Development and demonstration of technical novel solutions to advance the operation, maintenance, and lifetime of photovoltaic plants	Cyprus RIF and EU -SOLAR ERANET[2]	Partner
37	CERETAB	Utilization of new, state-of-the-art border surveillance technologies for border monitoring and security	EU Internal Security Fund Borders and Visa	Partner
38	CybPhys	Upgrade bachelor/master-level curricula and study programs in Belarusian and Ukrainian universities in the area of cyber-physical systems modelling and simulation	EU - ERASMUS+	Partner

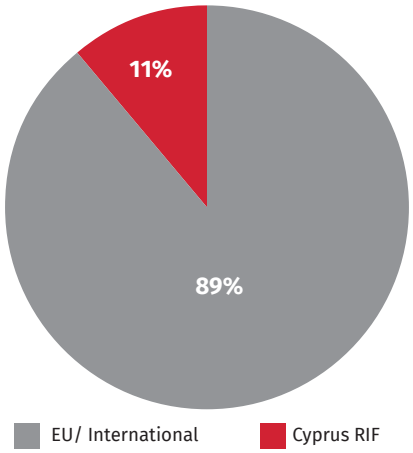
39	FLEXITRANSTORE	An integrated platform for incresed flexibility in smart transmission grids with storage entities and large penetration of renewable energy sources	EU - H2020	Partner
40	FLOBIT	Smart water usage and savings enablement metering system, supported by artificial intelligence and machine learning methods, for building environments	Cyprus RIF	Partner
41	RONDA	Help transport stakeholders better assess the condition of the roadway network and its vulnerabilities, mitigate associated risks, and manage transport networks	Cyprus RIF	Partner

* Complementary funding for the KIOS CoE is provided by the Government of the Republic of Cyprus through the Deputy Ministry of Research, Innovation, and Digital Policy,, by the University of Cyprus and Imperial College London.

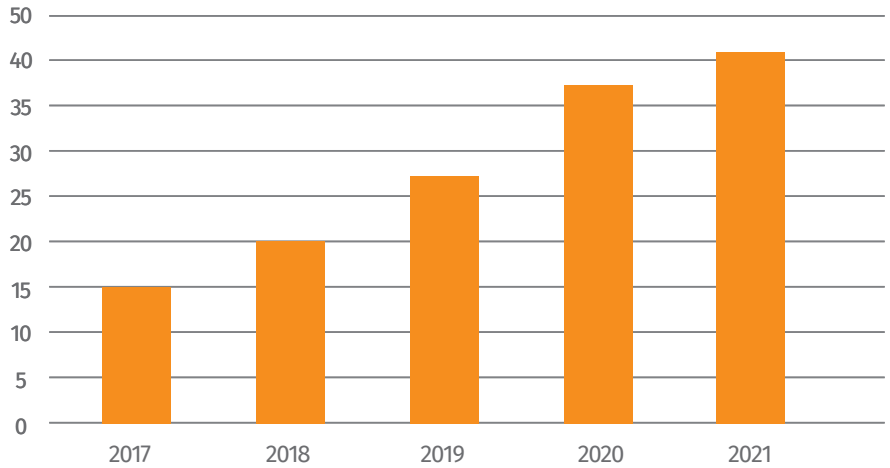
(1) Cyprus RIF - Cyprus Research & Innovation Foundation

(2) Horizon 2020/FP 7 SOLARERA.NET Cofund and the Cyprus Research and Innovation Foundation"

Funding sources for Research and Innovation projects for 2021



Competitive funding projects per year



A Sampling of New Projects in 2021

SMART WATER FUTURES: Designing the Next Generation of Urban Drinking Water Systems

The "Water-Futures" project, funded by an ERC Synergy Grant, aims “Water Futures” aims to develop a new theoretical framework for the allocation and development decisions on drinking water infrastructure systems, so that they are socially equitable, economically efficient, and environmentally resilient, in line with the Sustainable Development Goals of the United Nations Agenda 2030. These next-generation water systems will utilize new technologies to integrate real-time monitoring and control with long-term robustness and flexibility.

The project is funded by the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme.

THISEAS: A defence research project to enhance the operational capabilities of the Cyprus National Guard

The “THISEAS” project aims at developing an electronic situational awareness and decision support system to improve the Cyprus National Guard’s operational capabilities. By using the integrated THISEAS system, mission leaders will have a better view and understanding of the area of operation and the current conditions, thus contributing significantly to operational planning and decision making.

The project is funded by the Cyprus Ministry of Defence.

ARTION: Development of Artificial Intelligence Knowledge Network to assist with Disaster Management

The “ARTION” project aims to develop a world class network for knowledge and data sharing in the area of Artificial Intelligence for disaster management. The network will promote the development and use of Artificial Intelligence tools that can help first responders to manage disasters, such as forest fires, floods, and earthquakes, efficiently and effectively.

The project is funded by the European Union’s Call for proposals in the field of Civil Protection under the Union Civil Protection Knowledge Network.

SESAME: Development of Safe and Secure Multi-Robot Systems

The “SESAME” project aims to develop a new generation of Multi-Robot Systems (MRS), utilizing Artificial Intelligence/Machine Learning among other approaches, to design dependable and secure multi-robot systems for key European sectors including Healthcare, Manufacturing, Agri-food, and Infrastructure Inspection.

The project is funded by the European Union’s Horizon 2020 Research and Innovation Programme.

A Sampling of Projects' Outcomes

AIDERS: Design and Development of a novel AI toolkit for emergency response

A novel Artificial Intelligence (AI) toolkit was developed within the context of the AIDERS project that provides relevant, reliable, and timely information from data collected through sensors onboard drones. It uses real-time data analytics and AI algorithms to enable informed decision-making by first responders during emergencies. The AI toolkit was tested and evaluated through infield exercises and real operations.

EMPOWER: Deployment of cutting-edge solutions to evolve the Cyprus Power System

The project's partners have developed intelligent monitoring and control solutions, using cutting-edge technologies, in order to modernize the Cyprus power system. These include: 1) the installation of measurement devices in key transmission substations of the Electricity Authority of Cyprus (EAC), to render the Cyprus power system fully observable by synchronized measurements, 2) the development of intelligent wide area monitoring and control solutions based on the measurements to enable the real time monitoring of the power system operating condition every 20 millisecond, and 3) the deployment of different energy storage solutions to increase the penetration level of renewable energy resources. These solutions have been integrated in the EMPOWER platform, to enhance the situational awareness and the control capabilities of the system operators.

CUREX: Innovative solutions for the protection and security of health data

To address the protection of the confidentiality and integrity of health data, the project's partners developed GDPR compliant tools and applications targeted towards healthcare professionals and individuals. In particular, they developed eight software tools and two medical patient and health professional applications, cyber and privacy risk assessments, a decision support tool for recommending optimal combinations of cyber controls, cyber hygiene controls to defend against social attacks, as well as a private blockchain network to record and distribute cyber risk-related data among health organizations.

CARAMEL: Artificial Intelligence-based Cybersecurity for Connected and Automated Vehicles

The CARAMEL project partners have developed several innovative tools and solutions based on machine learning and artificial intelligence for holistically enhancing the cybersecurity aspects of connected and autonomous vehicles across multiple pillars. The solutions ranged from machine learning algorithms to protect against malicious attacks on various sensors that are used by a vehicle to perceive its environment, detection of attacks on message exchanges between vehicles, detection of spoofing attacks on external sources of information such as GPS, defense mechanisms against electromobility infrastructure abuse, and anomaly detection algorithms for remotely connected vehicles. The solutions have been integrated in embedded platforms and real autonomous vehicles and validated both experimentally in the field and in simulated environments

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ACTIVE PROJECTS
with the
INDUSTRY
in 2021

KIOS Innovation Hub:
Collaboration with Industry

The KIOS Innovation Hub was created in 2017 with the aim to enable the technology transfer of the core research competencies of KIOS CoE in the area of ICT to organizations involved in the monitoring, control, security and management of critical infrastructure systems (CIS).

Its vision is to promote collaboration between academia, industry, operators of critical infrastructure systems, regulators, as well as governmental organizations with the ultimate goal to create an ecosystem that spans the entire innovation cycle from conception of an idea to its commercialization.

A significant activity of KIOS during 2021 was its contribution towards the preparation of the Cyprus Recovery and Resilience Plan 2021-2026, aiming to address the socioeconomic impacts caused by the coronavirus pandemic. In the forthcoming years, KIOS, in collaboration with its industrial partners, will participate in several national projects that support Cyprus' green and digital transition.

Innovation Hub Partners

Deputy Ministry of Research Innovation and Digital Policy

Power and Energy

Electricity Authority of Cyprus

cyprus energy regulatory authority

ieit

ΔΣΜΚ

Transportation

Ministry of Transport, Communications and Works

Department of Public Works

Water

Water Board of Lemesos

WDD TAY

Emergency Response

Emergency Response Unit

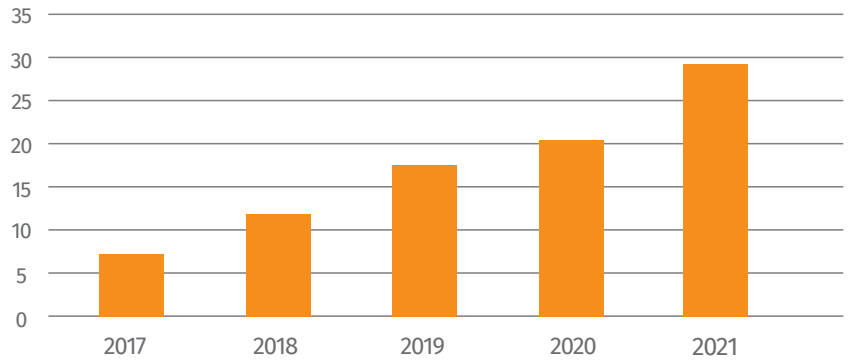
Police Border Marine

Telecommunications

cyta

Health

Industrial projects per year



Industrial Collaboration Outcomes

Study for the redesign of the Cyprus Electricity System

The KIOS research team, in collaboration with the Electricity Authority (EAC) and the Transmission System Operator of Cyprus (TSO), led the effort for a study on the «Redesign of the Cyprus Electricity System ahead of 2021-2030". This study will enable the EAC and TSO to address significant challenges related to the high penetration of Renewable Energy Sources into the country's electric power system, the improvement of energy efficiency, and the reduction of gas emissions.

Public Transport Monitor Toolbox

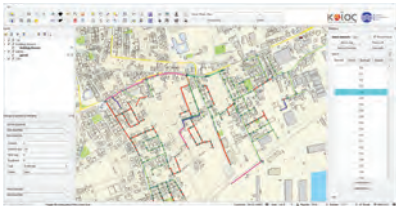
The Public Transport Monitor Toolbox (PT Monitor) was developed within the framework of the collaboration agreement with the Ministry of Transport, Communications, and Works to easily monitor the service quality and performance of public transport providers by public transport inspectors. It consists of a web-platform and mobile application that enable data collection, management, and analysis.

RESPOnse Decision Support System

The RESPOnse decision support platform was implemented in collaboration with the Cyprus Port and Marine Police to improve resource management and enhance situational awareness at operational level. The platform includes digital tools for monitoring the use of assets for the particular police units, automate alerts and reporting, and optimize their emergency response capacities.

OCEANOS

The platform "Oceanos" has been developed by the KIOS researchers within the research collaboration agreement between the KIOS Innovation Hub and the Water Board of Limassol. This integrated platform gathers, stores, and accesses data from water networks, thus becoming a useful decision-making tool for the Water Board of Limassol. Utilizing this platform, the Board will be able to better monitor and detect any leaks in Limassol's water network, aiming to reduce the response time for the restoration of faults.



CYTA Chatbot

The KIOS research team has developed a chatbot software in collaboration with the Cyprus Telecommunications Authority (CYTA) to enhance its operational capabilities and increase the overall customer satisfaction. Within this framework, innovative algorithms have been created and implemented to address the complexity and uniqueness of the Greek-Cypriot dialect.

COVID-19 Emergency Management Support

The KIOS researchers, in collaboration with the Cyprus Ministry of Health and the Deputy Ministry of Research, Innovation and Digital Policy, have developed innovative digital solutions (COVERP, SNOW, EARLY, PHASE, and BRIGHT platforms, the Cyprus Digital COVID Certificate and the contact tracing app CovTracer-EN) to assist the public authorities in Cyprus to control the spread of the virus and overcome the challenges that arose due to the pandemic.

Entrepreneurship Activities

5 STARTUPS gain SUPPORT from KIOS

KIOS CoE contributes towards the transformation of the research and innovation culture of Cyprus by enhancing its entrepreneurial ecosystem. For this reason, the Center supported the creation and development of startups by partnering with them in research projects related to the Center's application areas.

The startups, founded by KIOS Alumni, received pre-seed and seed funding, and turned their ideas into actions by developing new products and services in order to solve real-life problems, thus bringing multiple socioeconomic benefits to citizens.

Startup Highlights

• The startup Malloc, developing technologies on data privacy and security, has raised close to $2 million in seed funding from Y Combinator and the Urban Innovation Fund. Malloc developed a software solution that protects users' data by safeguarding their mobile devices against unauthorized or unattended data recordings or transmissions (www.mallocprivacy.com).

• The startup Lelantus Innovations, offering indoor environment quality solutions, has received seed funding from the Cyprus Research and Innovation Foundation to develop an innovative software for real-time spatiotemporal assessment of the Indoor Air Quality, specifically for conditions that enable the spread of COVID-19 in large public indoor spaces (www.lelantusinnovations.com).

• The startup WiseWire Energy Solutions, offering innovative solutions and consultancy services in the area of smart grids and energy efficient buildings, has won its participation in the OneNet H2020 project in collaboration with the KIOS CoE (www.wisewiresolutions.com).

• The startup Esmene is working on the development of Artificial Intelligence tools for drone-based operations and has reached the prototype demonstration phase (TRL-7), a step before the product enters the market (www.esmene.com).

• The startup PHOEBE Innovations, offering intelligent monitoring solutions for industrial systems, secured seed funding for developing PandoraSeal, an intelligent ICT platform for managing epidemiological data and offering policy decision support to governments and other authorities. In addition, Phoebe Innovations participates as a partner in a number of research and innovation projects led by KIOS CoE (www.phoebeinnovations.com).

KIOS CoE Research Infrastructures

The KIOS CoE, together with Imperial College London, develop physical and virtual research infrastructures for conducting rigorous and transparent testing on methodologies, tools, and new technologies related to the monitoring, control, management and security of large scale and complex critical infrastructure systems (CIS). These environments allow researchers to examine the reliability, safety, security, and resilience of a wide range of cyber-physical systems and add value to their research and innovation activities. Furthermore, these infrastructures can be utilized by the Center's collaborators and partners to advance the technological readiness levels of new concepts and tools, as well as promote the efforts towards the co-creation of new products and services.

Power Systems

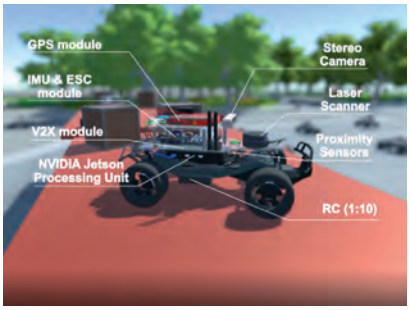
The Power Systems Research Infrastructure targets high penetration of renewable energy sources to reduce greenhouse gas emissions. It aims towards modeling, simulation, emulation, and experimental validation of energy systems, with capabilities in the development of smart technology for the efficient and reliable integration of renewable resources both at the building and grid level. A real-time simulator is used to develop digital twins of actual power systems (i.e., the entire Cyprus power system) and investigate the interaction with smart grid controllers and actual power devices in hardware in the loop framework. Three different energy storage pilots and a wide deployment of sychrophasor measurement units in Cyprus power substations are integrated to facilitate the development of intelligent monitoring and control solutions for smart grids. Further capabilities include the development of real-time control algorithms for power electronic converters to advance the grid integration of renewable energy sources, as well as testing of cyber security solutions in active distribution grids and in digital substations.

Smart Water Systems

The Water Security Research Infrastructure is a small-scale representation of an urban water transport system, and is composed of a network of tanks, pumps, valves, as well as hydraulic and quality sensors. A key feature is the ability to reconfigure the topology and to emulate realistic water demands through its controller. This infrastructure can be used as a benchmark to generate datasets that can be used by researchers to demonstrate results in the area of real-time monitoring, control, management, and cyber-physical security. In addition, it is complemented with a virtual city water distribution system, corresponding to 10,000 consumers, to be able to demonstrate, in a realistic environment, the impact of these technologies, for instance, in reducing water losses, improving security, and reducing greenhouse gas emissions.

Intelligent Transportation Systems

The Transportation Research Infrastructure is a small-scale physical plant that tests and evaluates Connected Autonomous Vehicle (CAV) technologies under real-life traffic conditions. The CAVs will play a significant role in future transportation systems and will provide enormous societal and environmental benefits in terms of reducing traffic accidents and greenhouse emissions, improving the efficiency, reliability, and costs of transportation systems and enhancing quality-of-life. The Transportation Research Infrastructure comprises various sensors installed to collect real-time measurements that allows the development and evaluation of novel monitoring, management and control schemes related to the recently introduced CAVs within a low-cost, controlled, and safe environment.



Emergency Response, Sensors, and Robotics

The KIOS CoE develops state-of-the-art tools and methodologies for emergency response management, as well as monitoring and inspection of critical infrastructures through the utilization of Unmanned Aerial Vehicle (UAVs), sensors, and robotics technologies.

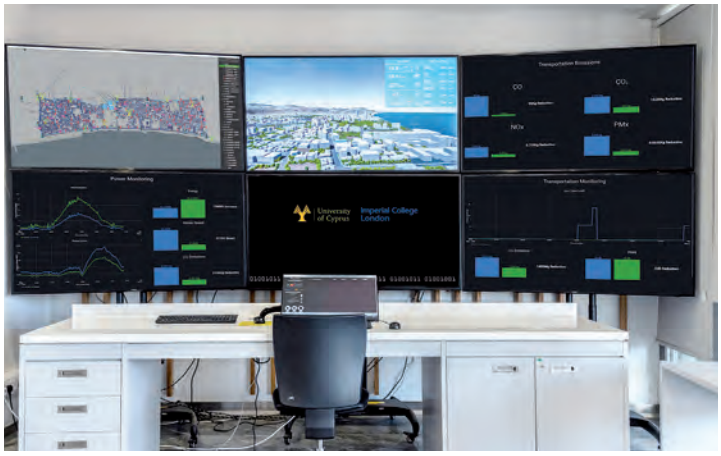
These technologies are used for the development of intelligent functionalities including automated path-planning, real-time image analysis, and object detection and coordination architectures for multi-drone systems that ensure scalable and robust operations. The key benefits of such systems include the enhancement of public safety, improvement of CIS efficiency, safety of operations and hazards avoidance, reduction of person-hours and costs.

KIOS Virtual City

The KIOS Virtual City is a specially designed virtual platform to assist with the management and operation of interdependent critical infrastructures systems (e.g., water, power, telecommunications, transportation, and health systems) and can be used to assess the cascading effects of natural or man-made disasters (e.g., flooding, power blackouts) which can seriously impact people's everyday lives, affecting their safety and well-being.

The Virtual City emulates the actual operation of critical infrastructure systems (CIS) within the urban and sub-urban environment and offers a virtual decision support facility for assessing the security and efficiency of a city as well as its environmental footprint and operational costs.

This platform is ideal for use by policy makers, CIS operators, and other stakeholders to assist them towards their decision making with respect to the management of a smart city environment. It is accessible through the KIOS Control Room with custom interfaces and it is also available as a research tool to be downloaded by researchers.



Education & Training Activities

Education and training activities are essential for building and maintaining scientific excellence at the Center. During 2021, the MSc Program in Intelligent Critical Infrastructures run successfully for the third consecutive year. In addition, a number of activities have been implemented such as the 2-Day Training Course on Cyber-Security, the Distinguished Lecture Series, workshops, and seminars.

MSc Program in Intelligent Critical Infrastructure Systems

Master of Science in
INTELLIGENT CRITICAL
INFRASTRUCTURE SYSTEMS

The innovative MSc Program in Intelligent Critical Infrastructure Systems is offered by the Department of Electrical and Computer Engineering at the University of Cyprus in collaboration with the KIOS Research and Innovation Center of Excellence and Imperial College London.

It is designed to train high-qualified engineers on the newest ICT approaches, in order to be able to deal with the challenges in monitoring, control, management and security of critical infrastructure systems, namely power systems, water distribution networks, telecommunication networks, and transportation systems. The coursework provides a blend of the necessary theory, tools, applications, transferable skills, and practical/research experience, in a holistic approach which provides students with knowledge, skills, competencies and experiences relevant to the topic of the program. Furthermore, the program takes advantage of the state-of-the-art buildings and laboratory/testbed infrastructure facilities at the University of Cyprus campus.

The duration of the program is 3 semesters (1.5 years) and is also available for part-time students (6 semesters / 3 years). Courses are delivered by academics from the University of Cyprus and Imperial College London.

For more information about the program please visit the website: www.msccis.ucy.ac.cy

2-Day Training Course on Cyber-Security

In September 2021, the KIOS CoE in collaboration with Imperial College London organized an online 2-day training course on Cyber-Security, which attracted postgraduate students, researchers and engineers who wanted to expand their knowledge in related areas. The course was delivered by two world-recognized experts in their fields, Prof. Bruno Sinopoli (Washington University in St. Louis, USA), and Prof. Mihalis Maniatakos (New York University in Abu Dhabi).

KIOS CoE Distinguished Lecture Series

During 2021, the KIOS CoE hosted two internationally recognized scientists who gave talks on cutting-edge research and innovation advances in their respective fields. Professor Stavros Zenios from the University of Cyprus gave a talk on “The risks from climate change to sovereign debt in Europe” and Professor Contantine Dovrolis from Georgia Institute of Technology presented the topic “From the Brain to Graphs, Neural Networks and back to the Brain”.

Communication and Dissemination Activities

> KIOS CoE gained significant national and international visibility through high-profile visits

The KIOS Research and Innovation Center of Excellence places special emphasis on communication and dissemination activities in order to make its research activities and results accessible to its stakeholders, partners, and the general public.

For the year 2021, the Center's dissemination and communication activities included:

High-profile visits, short videos, networking events with the industry , outreach activities , online presence, media publicity

High-Profile visits

In 2021, the KIOS CoE gained significant national and international visibility through high-profile visits from national policy and decision makers, international experts, and enterprise and innovation experts.

Examples include: 1) The visit by the President of the European Commission Ursula von der Leyen and the President of the Republic of Cyprus Nicos Anastasiades (photo 1), 2) the visit by the Chief Executive of the European Defence Agency Mr. Jiří Šedivý, and 3) the visit by the Ambassador of the United States of America in Cyprus, Ms. Judith G. Garber.

1

Networking Events with the Industry

During 2021, the KIOS CoE organized two press conferences to announce its research and innovation collaborations with Larnaca' s public authorities (Municipality, Water Board, and Sewerage and Drainage Board) and the Ministry of Transport, Communications and Works (photo 2).

In addition, the Center organized workshops with the Public Works Department and the Port and Marine Police, to present the developed Public Transport Monitor System and the RESPOnse Decision Support System respectively. Finally, an event on the use of Geographic Information Systems (GIS) was organized, involving all stakeholders of critical infrastructures that use GIS as a tool to enhance and improve their operations.


2

Outreach activities

Cyprus Forum 2021

The KIOS CoE Director participated in the Cyprus Forum 2021 and discussed with the Limassol Water Board Manager, Mr. Socrates Metaxas, about the prestigious ERC Synergy Grant "Water-Futures" project, which focuses on the future of water distribution systems in relation to the impacts of climate change.

Undergraduate Research Opportunities Program (UROP 2021)

The Undergraduate Research Opportunities Program (UROP) for young students was organized for the 13th consecutive year. The selected students had the opportunity to work with KIOS faculty and researchers on innovative research projects for 2 months.

European Researcher's Night 2021

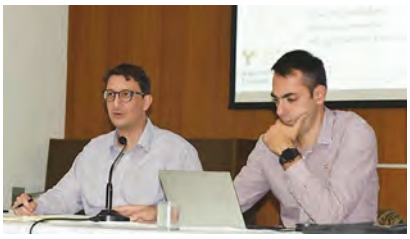
The KIOS CoE participated in the European Researcher's Night 2021, which was held online. Visitors to the KIOS virtual booths had the opportunity to learn about renewable energy technologies and smart water systems; how Artificial Intelligence improves drones for emergency response; and how smart technologies can be used for traffic management.

European Cyber Security Challenge 2021

KIOS PhD Students Christos Makridis and Leonidas Stylianou were part of the Cyprus national team which ranked 6th in the European Cyber Security Challenge 2021. Our students had the opportunity to engage in a number of security-related challenges.

Free University Lecture Series

KIOS CoE Research Lecturers Lenos Hadjidemetriou and Christos Laoudias delivered presentations on "Renewable Energy Sources and Smart Electricity Grids" and "Digital Contact Tracing" respectively at Zinonio Free University in Larnaca.



School Visits

During 2021, young students visited KIOS premises and learned about the research and technology being undertaken at the Center. In addition, KIOS Researchers gave lectures to pupils at schools in various areas of Cyprus.

Online presence

The KIOS CoE uses a number of online communication mediums to disseminate the Center's research results, news and events, achievements, etc. Examples include the KIOS CoE website, newsletter, as well as our social media pages (Facebook, Twitter, LinkedIn, and YouTube).

Media publicity

The research activity undertaken at the KIOS CoE has been widely published in the printed and electronic media. This includes a number of articles in newspapers and websites with large readership numbers.


The KIOS Center of Excellence has received funding from the European Union's Horizon 2020 recearch and innovation programme under the grant agreement No. 739551 (KIOS CoE).


The KIOS Center of Excellence has received funding from the Government of the Republic of Cyprus through the Deputy Ministry of Research, Innovation and Digital Policy.

Complementary funding for the KIOS CoE is also provided by the University of Cyprus and Imperial College London.