MONITORING AND PROTECTION OF CRITICAL INFRASTRUCTURE BY UNMANNED SYSTEMS

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Preface

This book, Monitoring and Protection of Critical Infrastructure by Unmanned Systems, presents 15 papers delivered at the NATO Advanced Training Course (ATC) hosted in Chisinau, the Republic of Moldova, and held in hybrid format from 30 May to 5 June 2022. The event was attended by 31 speakers, among them 12 in-person, and 92 attendees, the majority of them in-person. This NATO ATC was indeed a wonderful experience for many who attended it, with speakers and attendees from 19 countries, all seeking innovative methods and best practice to use state-of-the-art technology to enhance the monitoring and protection of critical infrastructure by unmanned systems. The organizing committee worked closely with the NATO Liaison Office and the Information and Documentation Center on NATO in the Republic of Moldova.

The ATC explored the issues of monitoring and protecting critical infrastructure through an interdisciplinary approach. Over the past decade, the attention of many developed democratic countries has been drawn to the protection of vital objects. Science and research increasingly focus attention on security and critical infrastructure protection. Legal frameworks for the protection of critical infrastructure elements, with a focus on energy, transport and ICT, have gradually been developed in European countries, but such frameworks are still missing in some, mainly non-EU, countries. The protection of infrastructure objects is achieved by technical, technological, and organizational measures and the protection of soft targets appears set to become another key activity of modern states in the future.

The concept of critical infrastructure arose mainly because of the occurrence of unexpected events. To identify the key elements for efficient security management, it is necessary to define and describe the types of threat, as well as estimating the probability of their occurrence along with their expected consequences. When discussing critical infrastructure protection, the influence of the entire spectrum of possible threats should be considered. These threats are classified into three main types:

- natural events
- technical failure/human error
- intentional acts such as terrorism, crime, or war.

The ATC was divided into 4 blocks.

Block 1: *General aspects of Protection of Critical Infrastructure*

1.1 Protection of critical infrastructure in Moldova.
1.2 Protection of critical infrastructure in NATO countries.

Block 2: *Unmanned systems and sensor network technology for monitoring threats to critical Infrastructures.*

Block 3: *Monitoring, data analysis and structural modeling*

3.1 Monitoring and forecasting of natural catastrophes.
3.2 Modeling and data analyses.

Block 4: *Cybersecurity and protection of IT infrastructure plus one practical session: Practical training activities*.

A practical session was organized after the theoretical interdisciplinary presentations, during which the participants were taught practical skills related to the presented areas, such as using drones for building and critical infrastructure inspection; 3D mapping in the laboratory using the licensed software Pix4Dmapper; environmental monitoring platform Flying laboratory SOWA; and the building of information modeling and finite element modeling of critical infrastructure elements.

If critical infrastructure elements (physical and IT) must be protected, the essential task is prevention, i.e. discovering and predicting threats. The ATC aimed to cover this issue through an interdisciplinary and innovative approach, using advanced methods for monitoring and protection. The ATC was therefore focused on the new methodology (Unmanned Systems – USs, sensor networks, etc.) which can help with the recognition of various threats (terrorist explosions, criminal-cyber-attacks, natural events such as flooding, etc.) and on the modeling behavior of critical infrastructure elements under such threats and the consequent design of adequate means of protection, which may include USs, from new intentional actions.

USs have grown rapidly in popularity in recent years. Tactical USs are now used extensively by the military and various security services, while professional USs are becoming increasingly common in a variety of civilian fields. This expanding use of USs is due to advances in technology, to their improved versatility and smaller size, as well as to the reduction in risks and costs that remotely operated systems offer as a result of not having a pilot or operator on board. USs include ground control stations (GCS), data communication links, and a range of unmanned aerial (UAV), ground (UGV) and underwater (UUV) vehicles. USs are now used more and more in mainstream applications thanks to advances in technology. This increased use in turn leads to refining the way in which platforms are deployed and integrated into teams of workers.

Performance in autonomy mainly comes from the massive use of advanced IT technology as the core of USs, and operators should consider the security of data collected via a US as a critical part of their risk management program. Questions of cybersecurity in the domain of USs are crucial, and the potential misuse of small USs for criminal and other malicious purposes is another growing development that needs to be addressed in education and training, so that there are sufficient qualified personnel to engage these challenges.

The ATC was also focused on data analysis and modeling, addressing in particular the application of computer modeling software for forecasting dangerous natural hazards such as the 3D mapping of the current state of risk factors, etc., as well as the procedure for defect detection through the data fusion of processed images and vibration measurements, automation in defect image acquisition by UAV, automatic data storage in bridge management systems, the embedding of sensor systems to revalorize and transform elements and structures into self-diagnostic elements, and data-driven automatic procedures for alerts in monitored structures.

The practical training activities of the ATC took place in the teaching laboratory "Educational for Drone" (Erasmus+ eDrone project OED) and the research laboratory Environmental Physics and Modeling Complex Systems (ePhysMCS Lab) at the Moldova State University (MSU), home to the environmental monitoring platform Flying laboratory SOWA, the SmartCity *eALERT* platform, air quality sensors, etc.

The trainees were researchers and students specializing in the area of security of infrastructures (security studies, infrastructural engineering, electrical engineering, etc.) from Moldova State University, Military Academy Alexandru cel Bun, Alecu Russo Balti State University, State Agrarian University of Moldova, Technical University of Moldova, and the Academy of Sciences of Moldova, together with local government

security experts from the Ministry of Internal Affairs of the Republic of Moldova, the Ministry of Defense of the Republic of Moldova, and the General Inspectorate for Emergency Situations of the Ministry of Internal Affairs of the Republic of Moldova. Also present were security officers who deal with security challenges of critical infrastructure, stake holders, experts who deal with terrorism or other violent threats looking for specialized knowledge, and experts who deal with problems related to the protection of critical infrastructure.

There were two very significant benefits for attendees.

- Acquaintance with and knowledge of the development of modern technologies for technical protection systems that can provide safety and security for critical infrastructure, concentrated on civil engineering objects.
- The sharing of knowledge and ideas for future scientific and technical activities in the field of research and development for the protection of critical infrastructure using elevated monitoring systems and high-performance structural materials.

Following the impact that the Russian invasion of Ukraine and the pandemic have had on every individual and in every aspect of life, the ATC talks began with Moldovan security in the light of the war in Ukraine, and emphasized general aspects of the protection of critical infrastructure in the Republic of Moldova and NATO countries, including the technology used for counter-terrorism, tactics and strategies to prevent support for breakaway regions, as well as the current energy security situation in Europe and how it affects the Republic of Moldova.

The event provided attendees with the opportunity to consider the many ways in which unmanned systems and sensor network technology can be used to monitor threats to critical infrastructure. Sessions on the monitoring, data analysis and structural modeling monitoring and forecasting of natural catastrophes, as well as on cybersecurity and the protection of IT infrastructure, were also of special interests for local students and experts studying and working in the ICT field.

Students from the Military Academy Alexandru cel Bun took part with great interest in the onsite practical training activities on using drones for building and critical infrastructure inspection, such as 3D mapping in the MSU ePhysMCS research laboratory using the licensed photogrammetry software Pix4Dmapper for professional drone mapping, and the civil application of the environmental monitoring platform Flying laboratory SOWA.

The event included an official visit to the Academy of Sciences of Moldova. Also, several presentations took place. These were from DANAERO, a Moldovan company located in Chisinau, for UAV solutions for industry; from JSW Innowacje S.A., a Polish research and development company located in Katowice, Poland, for an automatic UAV system as an enhancement for critical infrastructure protection; from Selelgroup, an Italian company located in Rome, for an innovative unmanned vehicle suitable for the monitoring of critical infrastructures in an amphibious environment; and from MSU ePhysMCS research laboratory for the development of the *eALERT* environmental monitoring platform. These added to the substantial impact of this workshop on speakers and attendees, and it is hoped that the follow-on activities, such as joint research projects, innovative courses, and the design, development and testing of new Unmanned Vehicle Systems (UVS) applications will have a similar impact on the broader scientific communities of the participants.

ATC website: https://ephysimlab.usm.md/spsatcg5816/.

Contents