EOD FUTURE IN THE LIGHT OF THE NATO EOD DEMONSTRATIONS AND TRIALS 2014

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The NATO EOD Demonstrations and Trials series facilitates multinational capabilities through the Defence against Terrorism Programme of Work in support of the Smart Defence Initiative. The main idea of the 2014 year's event was 'New technologies – assistance and limitation of the EOD in the post-ISAF era' as a challenge for EOD/IEDD experts, scientists, producers, industry and Subject Matter Experts involved in the fight against terrorism. As the EOD Demonstrations and Trials is open also for Partner countries, the event demonstrates practical dimensions of cooperation and partnership.

EXECUTIVE SUMMARY

Background

The NATO Explosive Ordnance Disposal Demonstrations and Trials (DaT) series has been established as a good way to accelerate the fielding of counter-measure technological solutions in order to equip better our armed forces and civilian response agencies towards new challenges. The main objective of this biennial event is to offer a common platform for companies, researchers, development institutes and NATO bodies to present the needs and latest technological solutions for improvement of the EOD operator's capability to EOD operational and armament community.

The DaT14 was organised by the NATO EOD COE (NATO Explosive Ordnance Disposal Centre of Excellence) under the auspices of NATO Emerging Security Challenges Division in conjunction with the Programme of Work for Defence against Terrorism (POW DAT). It was held in Trenčín, Slovakia, from 30 September to 02 October 2014. More than 43 exhibitors from 17 countries – excluding those who were part of NATO – took part in the event. In addition, several partner nations presented their technological approaches.

The DaT14 was more than just a simple exhibition; it was accompanied by the conference, two seminars, and several working meetings attended by more than 117 SMEs (Subject Matter Experts) and distinguished guests from 21 countries.

It is believed that a number of EOD (Explosive Ordnance Disposal) key players and related technology business were present.

The importance, direction, goals and outputs of the DaT14 are the subject of this article in order to familiarise readers with some achievements, challenges and ways ahead.

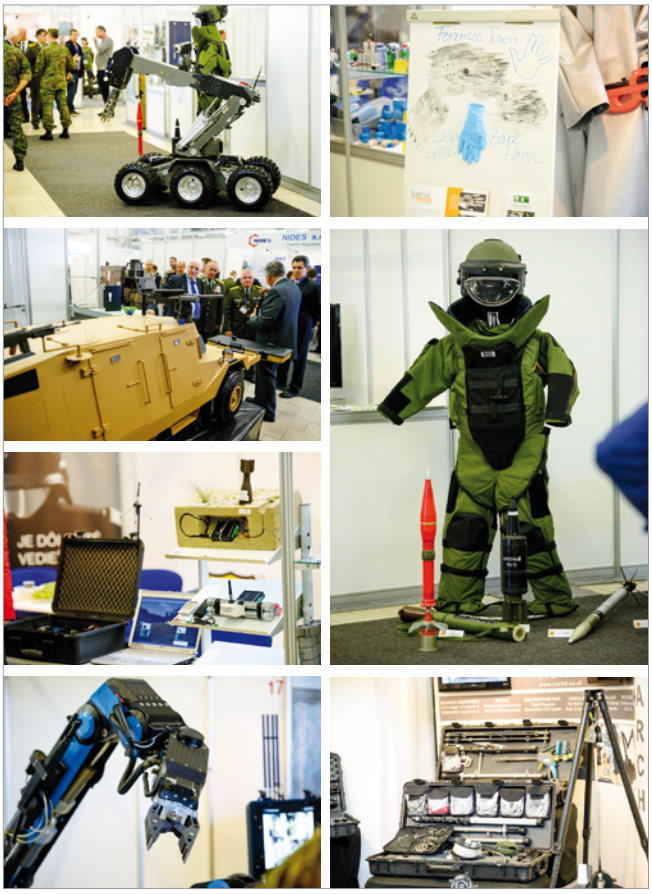
Opening Ceremony (from left) LtGen Peter Gajdoš, 2nd Deputy Chief of the General Staff of the Slovak Armed Forces, COL Michael Clark, NATO ACT, COL Ľubomír Mrváň, Director EOD COE.

Static exhibition

Static exhibitions were organised throughout the whole event and provided detailed insights on specific technologies which respond to modern markets. It is believed that DaT formed one of the largest EOD-related exhibitions in Europe as a number of highly respected producers were present. Statistically, the following forty-three companies introduced their solutions:

Armtrac Ltd, BAAINBw U6.2, BLÜCHER GmbH, Delta Business Media Limited, DOK-ING, DSA DETECTION, DynITEC GmbH, Elta Systems Ltd, RAMTA Division, FY-Composites Oy, GARANT Sicherheitstechnik AG, HP Marketing & Consulting Wurst GmbH, HQH Systems spol. s. r., Chemring Technology Solutions – EOD, IAI, ICM X-ray, Industrial Research Institute for Automation & Measurements PIAP, Institute of Mathematical Machines, Military University of Technology (Poland), Institute of Robotics and Cybernetics, FEI STU, INWARD DETECTION s.r.o., iRobot Corporation, JAKUSZ Sp. z o.o., Logos Imaging LLC, Med-END, NC EOD Novaky, NIC INSTRUMENTS Ltd., NIDES s.r.o., Proytecsa Security S.L., PYRA s.r.o., QinetiQ North America, Quanser Consulting Inc., Roboteam Ltd, Scanna Msc Ltd, SEMA WORLD, SlovCert s.r.o., Smiths Detection, Taurob GmbH, TECNOBIT, S.L.U., Thermo Fisher Scientific, University of Zilina, URDAN - Metal & Casting Industries, US Army RDECOM-TARDEC.

The participating producers did not only present their products (robots, handy tools for EOD operators, EOD detection, neutralisation, and disposal equipment…) but also contributed to recognising a number of EOD future challenges as they took an active part in the discussions during the conference and seminars.



EOD team during live demo.

Live demo

As an essential part of DaT14, live demonstrations gave the companies producing special EOD equipment the opportunity to present their products in real life conditions. While it is possible to learn a great deal of information concerning a product by reading about it, seeing it in action is usually the best way to get a clear picture of its abilities and liabilities. During the three days of live demonstrations many producers took the chance to exhibit their merchandise in the field.

The first day of DaT14 was dedicated to invited VIPs and distinguished visitors only. The live demonstrations started with a showcase of IED incident response performed by the EOD team from the Slovak EOD National Centre with the support of Special Forces Unit from Žilina. The procedures were reflecting the current TTPs (Tactics, Techniques and Procedures) used in the ISAF operation.

The scenario illustrated a daily patrol checking a vulnerable point (a culvert). Although the culvert appeared clear, the GPR (Ground Penetrating Radar) operator found a pressure plate over the culvert, marked it and requested EOD support. The responding EOD team sent an ROV (Remote Operating Vehicle) to confirm the threat and subsequently dismantled the device. While performing the disruption, the operator noticed a secondary device intended to target the first responders. After taking care of the primary device, the operator searched the suspicious area and found a DFC (Directional Fragmentation Charge) aimed at the pressure plate. Using the ROV he pulled the device to the surface. However, due to its robust construction, he was unable to disconnect the firing system of device. Therefore the team leader decided to use a water charge to disrupt the IED (improvised explosive device). After disruption, the team leader inspected the result using the ROV at first, then performing a manual check of the device and surrounding area. When the area was clear, he requested the assistance of another team member to perform site exploitation for potential intelligence data.

These types of incidents occur on a daily basis and EOD teams are therefore used to their full capacities often going from one incident to another. EOD support is absolutely essential to maintain the freedom of movement of coalition forces and to prevent casualties caused by UXOs (unexploded ordnance) and IEDs.

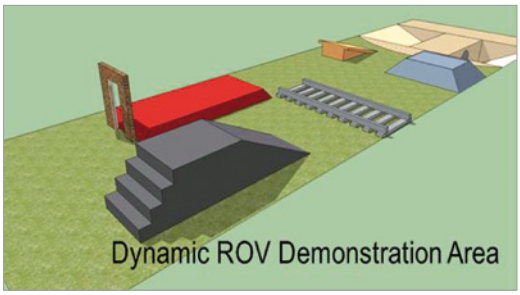
The second and the third day of live demonstrations were open to the public which meant the audience could see that things can go wrong even during a simple demonstration. Performing EOD tasks in battlefield conditions is often extremely complicated and time consuming as the enemy is trying to make your job as difficult as possible.

The presented equipment and its capabilities can be divided into several categories:

Remotely operated vehicles

The focus of presenting companies during DaT14 concerning ROVs was mostly on improvements in communication technologies, interoperability, improved controllers and meshing technology that enables the

Remote operating controller.



Dynamic ROV Demonstration Area - obstacle track.

use of mesh nodes (in some cases the ROV itself functions as a mesh node); these extend the range of the ROV or enable it to operate in areas with difficult access (tunnels, big buildings, complex urban areas).

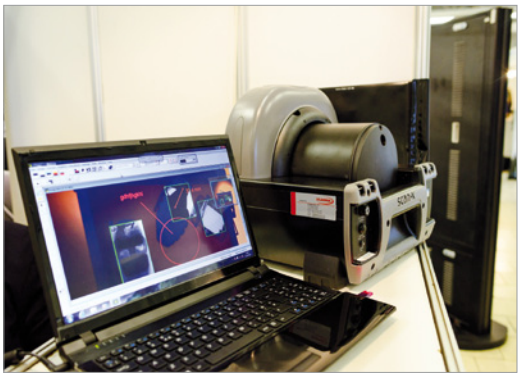
Other capabilities demonstrated by ROVs were working in tandem (two robots cooperating to complete a task) and even ROV with two arms. The operators could also test the ROVs manoeuvrability and their own skills on an unforgiving obstacle track.

Identification and detection

Various detectors and X-rays can considerably enhance the operator's effectiveness in the field. The presented technologies covered identification of substances, enhanced ROV sensoring and real time mapping systems. Some companies preferred to present these products in an indoor environment because they were in the prototype stage of development and were not waterproof.

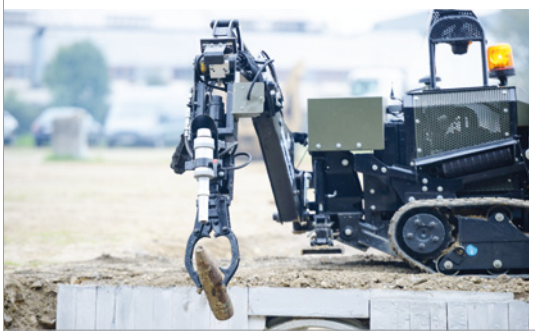
Company	Country	Product	Website
QinetiQ North America	USA	ROV	www.qinetiq.com
iRobot Corporation	USA		www.irobot.com
Thermo Fisher Scientific	USA	Portable analytical instruments	www.thermofisher.com www.ahurascientific.com
DynITEC GmbH	Germany	Remote initiation system	www.dynitec.com
Roboteam	Israel	ROV	www.robo-team.com
Chemring Technology Solutions – EOD	United Kingdom	Disrupter	www.chemringeod.com
Industrial Research Institute PIAP	Poland	ROV	www.piap.pl/en
Taurob GmbH	Austria	ROV	http://taurob.com
Armtrac Ltd	United Kingdom	ROV/demining robot	www.armtrac.net
DOK-ING	Croatia	ROV	http://dok-ing.hr
Med-Eng	Canada	Hook and line	www.med-eng.com
Proytecsa Security S.L.	Spain	ROV	www.proytecsa.net

List of companies participating in live demonstrations.



Miscellaneous EOD devices and tools

Certain situations cannot be resolved just by using unaided ROVs and require a little help either by mounting additional tools on the ROV or by manually approaching the device. This is where various disruptors, hook and lines, bomb suits and similar equipment come into play. During DaT14 live demonstrations, the companies presented remote firing devices, disruptors, hook and line kits and even a camera system that provides a live feed from the EOD operators helmet for the purposes of data collection and information support for the operator.



ROV (remote operating vehicles) during demonstration.

Jamie Shea, Deputy Assistant Secretary General for ESCD, during his address.

Conference and seminars

The NATO EOD DaT series of centric exhibitions can be seen mainly as producers' centric exhibitions but in reality the focus is on perspectives of subject matter experts and academics. There is normally a space allocated for a conference and two seminars within the EOD DaT series. In 2014, the conference served as a theoretical ground for the topic *'Future of military robotics and its potential in EOD unmanned systems*', while the Seminar Nr.1 was searching for the answers to the question *'What are the limits of technologies in replacing EOD operator's abilities*?'. The Seminar Nr.2 stimulated discussions on two topics: *'Roles and procedures for the testing of technologically advanced EOD equipment' and 'Development of EOD equipment linked with real testing procedures'.* These meetings and their objectives provided not only platforms for networking but also established a solid base for sharing knowledge and information in several dimensions. A number of speakers presented a great deal of interesting views and raised some provocative questions related to the EOD issues. Most of these ideas and concerns were analysed within the EOD COE (Explosive Ordnance Disposal Centre of Excellence) post-event feedback process and partly summarised for the use of EOD community of interest in the section *'Some EOD considerations in the light of DaT14'.*

SOME CONSIDERATIONS IN THE LIGHT OF DAT14

This part is aimed to provide some considerations and perspectives to the EOD community as presented by the speakers within the NATO EOD DaT 14 conference and two seminars which were subsequently analysed, structured, brainstormed, and outlined by the EOD COE working group.

Changes in the environment

As EOD matters occur within the current situation and evolving changes in our environment, it could be that new circumstances and conditions after ISAF mission may affect some EOD perspectives.

The first thing to consider is that **IEDs will continue to be a weapon of choice** – not only for insurgents but also for new radical groups. In addition, it must be taken into account that new threats will appear and **CBRN** (chemical, biological, radiological, nuclear) will definitely be one of them. Likewise, the theatre of organised IED attacks might **move from failed states to the developed world**. Moreover, with the shift of theatre, further sophistication of terrorist groups will provide a breeding ground for **misuse of new technologies** for IEDs. It is no secret that even an ordinary student could bring new technological innovations. It now looks like **information management** (situational awareness) will be important if a response to the IED threat is appropriate and fast enough.

It is highly probable that the tendency to cut the military budget in developed countries will continue. It can be assumed that only those countries that will

During the conference.

allocate appropriate resources for their security can make a difference.

In the light of these changes in the environment, some **EOD challenges** have to be tackled. First of all, relocation of 'defeat the device' operations to **'homeland' means to put emphasis on neutralisation**. In most cases, detonation on site might not be acceptable. Inevitably, in CIED operations, it will be necessary to keep in mind that potential enemies will use further **sophisticated technologies** and have **more time to observe** our own TTPs (not only EOD procedures). Furthermore, not only the EOD operator, but also the appointed **incident commander have** to contemplate **cooperation with national and international authorities** (firefighters, police, health services, other agencies) when acting. Additionally, it has to be taken into consideration that any EOD mission on the domestic scene will be rigorously scrutinised by civilians.

As mentioned previously, it is clear that responses to these changes and challenges will have to be addressed from technological, human and procedural perspectives. It is obvious that these perspectives are overlapping. DaT14 was predominantly focused on technological aspects as far as robotics were concerned.

Standardisation

At the conference and seminars it was clear that there is still no common understanding of robotics. Strangely, there is no standard definition of what a robot or level of robotics means. Not only must linguistic definitions be unambiguous, but also standardisation must be addressed from technical and other points of view.

Non-standardised terminology relating to robotics revealed that even at a theoretical level there are different interpretations and understanding specifically in the use of terms in the field of robotics. Interaction between 'the robot' 'and the operator provides much room for different definitions what 'the robot' actually is. It begins as a remotely controlled device up to a fully autonomously acting device, which is virtually independent of the EOD operator's decision-making process. In connection with the aforementioned,

Remote Control Vehicle.

categorisation of these 'robots' reflects terminological problems that need to be resolved. When terminology and categorisation are addressed properly, testing and certification can become more transparent. This transparency will provide the EOD operator with a more accurate picture of currently available robotic capabilities.

Current status

A quotation by Dr Dowling from Defence Academy of the United Kingdom says 'Where we are is not where we want to be'. It means, specifically in EOD robotics, that only a certain level of robotisation has been reached. There are several indications that progress in robotics in general is so rapid that many of newly developed features are not implemented in robots for the EOD area. If we look closely at specifically designed robots for EOD missions, we can summarise their current abilities as follows:

- Obtaining **certain visual** information (new sensors can provide a better picture)
- **Picking and placing** objects
- **Rough manipulation** with tool and weapons
- **Bringing sensors closer** to analyse and detect explosives.

As mentioned previously, the development of new robot abilities (haptic, swarming robots, etc.) is such that procedural, legal and training issues are in the position of chasing rapid progress in technologies. It means that the status of training only partially reflects this headway in the EOD area.

Some of EOD operators requirements

This article doesn't intend to list all the requirements for the robot, which the EOD operator can imagine. However, in general we can outline the necessary requirements:

- Reliability
- User friendly
- Mobility and manoeuvrability
- Modularity
- Communication
- Object detection.

Reliability is considered a basic requirement. It is clear that any failure of the EOD robot can have disastrous consequences. As the robot neither **provides reliable information**, nor can reach the IED, the EOD operator might get incorrect information.

ROV during live demonstration.

As a consequence, he has to discover for himself what brings the extra risk. Therefore, it is crucial to minimise failure that could lead to unintended engagements or to loss of control.

The **user friendly** requirement is a well known issue for everybody. However, this issue might be painful for producers. They have to come up with products which reflect the preferences of a vast majority of EOD operators for remote controllers.

Mobility and manoeuvrability requirements means building robots capable of performing tasks in environments that are either too dangerous or unsuitable for humans, e.g. to cross very difficult obstacles in dark rooms and underwater, which would be highly demanding or impossible for the EOD operator himself.

As mentioned before, reliability is crucial; therefore, having a high level of modularity is essential. **Modularity** requirement is understood in two ways: firstly, to attain different configurations for different missions and, secondly, when a component fails, its repair would be easy, mainly in the field, using spare modules.

Communication covers a number of sub requirements:

- new ways of data transmission up to smartphone,
- 24/7 support to the theatre,
- real-time information,
- networking of devices even in contaminated areas etc. (communication among robots).

Object detection requirements gives one the image of the EOD operator sitting in his office in his homeland in front of a screen; the robot deployed somewhere in the world and able to detect any kind of dangerous materials even well hidden under the surface. Afterwards, the operator gets a perfect multi-layered picture – what it is, what kind material it is made of, etc.

Technology related challenges

The EOD operator's requirements are just part of the development process as producers will note that there are several challenges related to meeting these requirements. It depicts what it embraces: for instance, there is a level of robot 'autonomy'. As discussed inter alia during DaT14, autonomy could stand for the robot and be able to:

- Reach the targeted area by itself without being remotely controlled by the EOD operator including incipient roll-over, own ECM (electronic counter-measure) capability, etc.,
- have 'E.T. come home' function (when communication with the operator is lost, it is able to return),
- reconfigure autonomously the parameters of sensors depending on the real time detection,
- be capable to evaluate independently the object´s behaviour,
- have some cognitive abilities, etc.

There is one more challenge relating to the autonomy of robots. Fully autonomous robots raise serious **legal and psychological aspects** that concerns which need to be addressed. Imagine there were innocent victims because of failed situation assessment by the robot; who is guilty? Who is the actual subject of law? The man or the robot? Or how would a man feel on being confronted by the robot in front of him somewhere in a forest? Safe or unsafe? Is the robot going to help him or kill him?

Dr Hillmann from the European Defence Agency said in his presentation, '… the main weapon will still be a human brain'. This statement was confirmed by a handful of producers. They highlighted that to **transfer all experience and tacit knowledge** of the

Producer vs. military – in discussion.

EOD operator was not and would not be so easy in the near future. This is because the operator's decision-making process includes self-knowledge from previous experience and he has learned from it. There are much more valuable problem-solving tools than any amount of explicit or recorded information/materials can provide.

*'There is no **silver bullet** solution'* sounded several times during NATO EOD DaT14. This statement reflects that many requirements are inconsistent with a technological point of view. It is not possible to transform itself from a heavy robot to a light one when a particular situation demands. Another example would be that the EOD suit provides protection from both fragmentation and blast. On the other hand, its weight will hamper the movement of the operator. The tailoring of devices for specific EOD tasks and searching for acceptable compromise will be the permanent issue not only for EOD operators but also for planners and producers.

Among others, some discussions centred around the networking of robots. This topic includes inter alia common information resourcing via interconnected databases. As stated by several subject matter experts, networking with all of its related issues is a very wide and a relatively unexplored field. Future projects will shed more light on this and provide more satisfying answers.

Some conclusions and ways ahead

The NATO EOD DaT 14 neither tackled nor predicted the complete and comprehensive lists of issues relating

to current and future EOD challenges. However, discussions and subsequent analysis provided some ideas which one should bear in mind when participating directly or indirectly in particular EOD projects as listed below:

- The **more mutually cooperative the robots,** the more capabilities available (tandem, swarming, clouds, etc.). It has already been registered that the number of robots used in military areas (the EOD is one of the top users) is gradually increasing. It is expected that the next step will be a higher level of mutual cooperation between robots with limited interference from the EOD operator.
- Insertion and **implementation of a larger amount with the EOD operator´s tacit knowledge** will be a growing requirement (i.e. producers already track the movement of the eye to get a better understanding of the acting and thinking process).
- With the development of new technologies, one has to deal with the question of **interface improvement between the EOD operator and the robot**. Nowadays, there are already technologies that support smoother communication and interaction between the operator (from play station generation, internet native generation) and the robot in a more natural way (e. g. haptisation of robots or goggles, etc).
- As developments of robots should not be limited to the ground, uphill progress has to be stimulated in the air (military unmanned aerial vehicles – specifically tailored drones, etc.) or underwater. This further robotisation in the three environments connected with new sensors brings it to **complex sensor network capabilities** (CSNCs). Heading to these CSNCs will trigger exponentially growing capability to better detection (pre-emptive IED detection), re-identification of detected targets etc. On the other hand, it should be expected that these new capabilities will be targeted by insurgents or terrorists as they will launch new responding tactics (fakes, hoaxes, etc. to confuse the multiplied or complex sensors).
- **Modularity** has already proved to be a good tool to satisfy at least two requirements. Firstly, it ensures easy maintenance. Secondly, maybe more relevant, it gives more freedom to tailoring of devices or networks based on missions assigned. Specifically, modularity enables open structures that a number of settled capabilities can be altered or multiplied (e.g. a robot can be equipped with several sensor modules or with more universal modules; perhaps even two robots can be interconnected via specific modules and provide required wider/advanced capability).
- Concerning some aspects of a **higher level of robot autonomy**, it is known that the autonomy of robots is not only a technological solution but also brings new legal and psychological queries. The future will come up with the answers to these queries.
- **Situational awareness** – permanent refreshment: this means that for the EOD operation to be successful it is crucial to provide the EOD operator with very good situational awareness. It has to be updated permanently, referring to a change of situation. Therefore, this requirement has to become an integral part of the training. Training of the EOD operator should reflect technological progress and tactics – of both 'friend' and 'foe') in order to implement them into his acting.
- Consequently, new and/or **innovated training tools** should be applied. During the NATO EOD Demonstrations and Trials of 2014, several innovative ideas and projects appeared as data fusion-semantic maps, real-time touch, real scenarios, Manual Neutralisation Techniques (MNT) scenarios, etc. Just to mention one of them – MNT scenarios should be taken very seriously as changes in our environment indicate that IED threat will increase as a result of terrorist know-how proliferation from failed states.
- There is a boom of robotic products around the world. So it is believed that certain standardisation specifically for EOD robots could be beneficial for both customers and producers. **Testing standards** are really supportive for robot standardisation. Testing itself has a handful of challenges. Usually, it begins with questions:

- Is there a real need for standardised testing?
- Who needs it?
- What about some extra problems related to overregulation and restrictions as producers will have to follow extra regulations related to testing?

Moreover, there is a number of following challenges such as:

- Standalone and field testing requirements
- Repeatability of testing
- Lessons learned feasibility (who is willing to share results either positive or negative and who is not afraid of misusing the results of testing)
- Some dependency of the EOD operator on technologies was recognised. It is believed that this dependency is beginning to cause what could be harmful from long-term perspectives (too autonomous robots vs EOD operator's decision-making process; the EOD operator should not lose his space for decision, etc.). A significant number of DaT14 contributors shared and highlighted that the need for proper **balance between technology and the operator's skills** has to be seriously maintained and taken into account in the future.

IN CONCLUSION

The most modern EOD techniques, equipment, together with a conference, seminars and live demonstrations – all of these took place during the NATO EOD demonstrations and trials of 2014.

The EOD demonstrations and trials facilitate multinational cooperation on capabilities through the Defence against Terrorism Programme of Work in support of the Smart Defence Initiative. The event sponsored by the NATO Emerging Security Challenges Division offered a tangible and visual example of this cooperation at work, in addition to improving interoperability and offering the opportunity to see innovative technologies. The support of the NATO Emerging Security Challenges Division to the DaT series is recognised as a crucial one and without its great help and assistance such an excellent and successful event would not be possible to organise. ■

ABOUT THE AUTHOR

During his military tour **Col Ľubomír Mrváň** served as an engineer officer at different commanding posts. He was deployed to UNTAES mission in Eastern Slavonia, later to Bosnia and Herzegovina at the Headquarters SFOR in Sarajevo. In the Iraqi Freedom operation, he took over the leading position as a demining company commander. He was assigned as a senior officer to the Joint Engineer Operations Branch at the Allied Joint Force Command in Naples, Italy, for three years. After serving at the General Staff, Staff for Operations, he took over the position of the Engineer Battalion Commander of Land Forces. In 2014 he assumed a command of the NATO EOD Centre of Excellence in Trenčín, Slovakia.