SAFETY AND SECURITY STRATEGIES FOR SUB-SURFACE STRUCTURES PREPARING SECURITY FORCES FOR SUBSURFACE OPERATIONS

Peter Hofer
Theresian Military Academy / Institute for Advanced Officer Training

ABSTRACT

Along with the importance of subsurface structures for modern societies, the probability of operations in such an environment is increasing, too. Environmental factors and a skilled opponent require a deep understanding for this topic, and specially trained and equipped personnel aware of the risks and dangers. However, the mastering of subsurface environments will significantly improve military operational efficiency and inter-actor cooperation while at the same time minimising the risk of own losses or collateral damage.
The NIKE[1] Interdisciplinary Research Group was founded with the intent to develop a sub-surface operations concept, to train forces, to provide special advice by means of a Sub-Surface[2] Operations Cell and to develop a virtual reality environment for mission preparation and training. The first training cycle managed to provide highly valuable experience for the refining of further training and the development of necessary future capabilities.

Key Words: complex scenario, interdisciplinarity, Sub-Surface Operations Cell, virtual reality

1. INTRODUCTION

Against the background of increasing mobility requirements, a growing population and limited space, subsurface service structures are indispensable for modern societies: "*Existing underground service facilities include road and rail tunnels, urban subways, underground parking, canalisation, energy recovery, transport, and storage sites, but also structures out of sight as abandoned traffic systems, former air raid shelters or nuclear waste deposits are part of the subterranean environment.*" (Hofer 2019a, p. 497) The recently published report on Austrian military capabilities confirms the likelihood of hybrid scenarios and the necessity of military operations in vast rural but also in unclear urban areas, in buildings and – which is of uttermost importance for subsurface operation units – in tunnel systems (Bundesministerium für Landesverteidigung 2019, p. 80).

Within public life, multiple stakeholders are connected in a system of different responsibilities with, however, one common interest: to keep infrastructures accessible, operational and safe (Hofer 2018b, p. 542). Their interaction and (un)involvement has been identified as an emerging risk (Wietek and Wetzig 2010, p. 156). Security in the sense of *"the protection of a person, building, organization, or country against threats such as crime or attacks emerging from foreign countries"* (Cambridge University Press, security) has for example been addressed by iNTeg-Risk (Wietek and Wetzig 2010), by the London Underground (Cash 2016) and by the SKRIBT project (Vollmann et al. 2012). Growing hybrid threats using all instruments of power (Monaghan et al. 2019, pp. 12–15), the attractiveness of public transport – especially underground – as possible target and increasing terrorist skills (Fischer and Pelzer 2015, 105, 137) lead to a higher vulnerability of subsurface structures: *"Open and accessible by design and necessity, crowded with people, and key for the functioning of economic and daily life in the cities they serve, these systems represent both attractive and high-impact targets. Their openness and high usage also make them difficult to secure."* (Wilson 2008, p. 7)

[1] The acronym NIKE/uT refers to sustainable interdisciplinarity in complex subsurface operations („**N**achhaltige **I**nterdisziplinarität bei **K**omplexen **E**insätzen unter Tage").
[2] Within military terminology "subterranean" would be correct, but due to the fact that "subsurface" is more common amongst technicians, we will generally stick to this term.

Apart from rather generic approaches of risk management and preventive aspects of security, there still seems to be a lack of techniques, tactics and procedures involving all actors and integrating preventive and reactive aspects in tightly knit safety and security strategies created for complex scenarios. A cross-impact analysis of different risks, associated with reactions to attacks, identified the capability of conducting subsurface operations as a very critical one marked by a high level of risk (Hofer 2019a, p. 498). Environmental factors like rock mechanics and statics, water, hazardous material, natural ventilation patterns, and absolute darkness caused by power outages, combined with a dynamic opponent operating in wide-stretching underground facilities, constitute a complex scenario (Hofer 2018b, p. 540) in which – according to the definition of complexity (Feess) – **the interaction of all actors and factors in the system can cause an unpredictable momentum**.

2. SAFETY AND SECURITY STRATEGIES FOR SUB-SURFACE STRUCTURES

An impressive level of safety provisions has already been achieved in the past years; however, an optimum of safety can cause deficiencies in security and in well-balanced resilience. A skilful orchestration of stability and flexibility (Scharte et al. 2014, p. 17) can handle the contradiction between safety and security.

The assessment of complex scenarios of hybrid origin in selected subsurface service structures has led to the following conclusions (Hofer 2019b):

- In general, the initiative is with the opponent: at the beginning, it is him who can exploit existing safety precautions for his own purposes. Consequently, own forces must quickly (re)gain freedom of action because the environment and the presence of (un)involved third parties could lead to a race against time.
- Subsurface structures are growing and offer multiple possibilities for an attack. Bifurcations and expansion create multidimensional and complicated subsurface service structures requiring concise databases offering detailed information to enable the planning and the conduct of operations.
- Subsurface operations are driven by technical parameters: they enforce inter-actor cooperation, which takes place under the risk of an opponent being well informed about the strengths and weaknesses of friendly forces. Besides that, all operators must be familiar with the specific risks and dangers and know how to adapt to the environment.
- Significant pieces of information on subsurface structures are available from open sources and, thus, can also be useful for an opponent. Therefore, critical, and detailed information must be protected from unauthorized access.
- Evildoers will select own forces as objectives. Coping with complex scenarios requires a shift from – generally high-speed – operations, with the focus on damage, to a concentration on the cause of an incident to reduce own losses.
- Technical assistance is an advantage, but the possibility of failure must be considered at any time. This applies to both training and equipment of forces.

Security has not been to the same extent part of the considerations on subsurface service structures as has been safety. Preparation and inter-actor cooperation have primarily reflected the experience of first responders. To improve interaction across disciplines and to involve all stakeholders for more demanding tasks, the Embracive Leadership Model has been developed (Hofer 2018b, p. 543). The S^6-Model (**S**afety and **S**ecurity **S**trategies for **S**ub-**S**urface **S**tructures) was designed to fit into this Embracive Leadership Model and encompasses activities and principles to succeed in an extremely challenging, complex underground scenario by considering six activities (columns) describing WHAT to do and six principles (triangle) HOW to act. Although originally designed for subsurface environments, it goes without saying that the S^6 – Model is applicable to every kind of service structure that is of strategic interest[3]

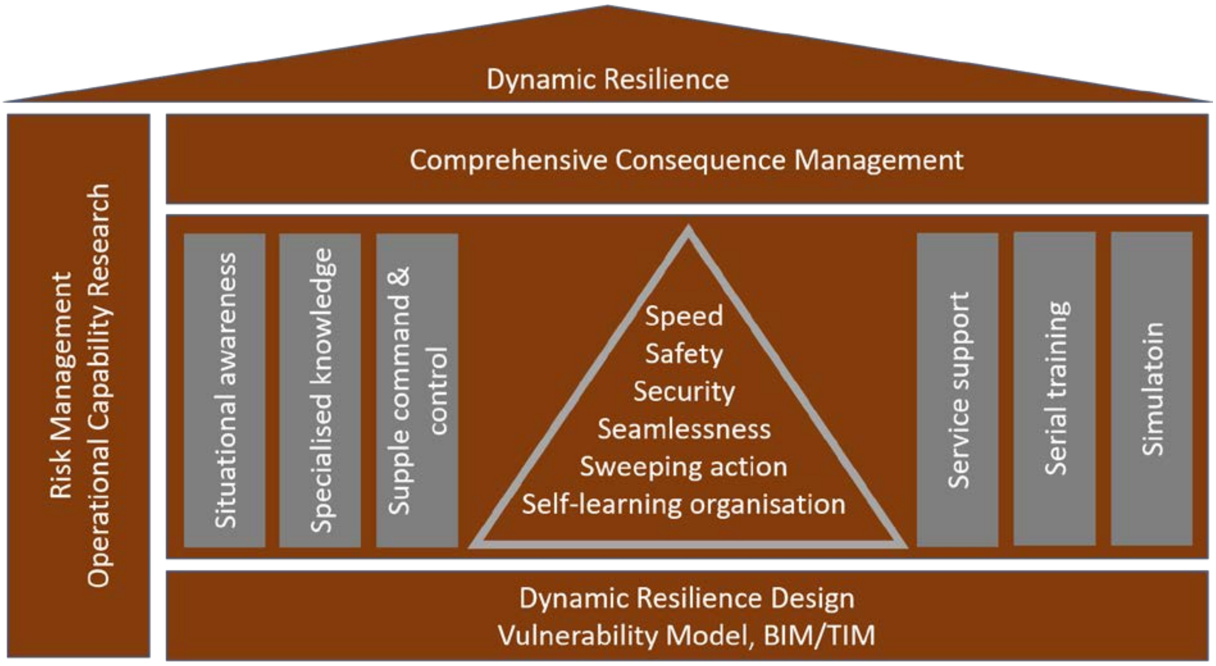

Figure 1: Safety and Security Strategies for Sub-Surface Structures are embedded into the Embracive Leadership Model and describe activities and principles for successful operations in subterranean environments. (Hofer 2019a)

All activities and principles strive for **Dynamic Resilience** combining Dynamic Resilience Design and Comprehensive Consequence Management. They perform analyses on how to create infrastructures, organisations, and networks to quickly regain their functionality after a crisis. They also offer proposals on how to cope with hybrid threats as well as technical, natural, or man-made disasters by using inter-actor planning, coordinated prevention and reaction (Hofer 2018a, p. 455) - complemented by Risk Management and Operational Capability Research. Within the **Dynamic Resilience Design**, a **vulnerability model** is used to describe infrastructures, including their vulnerabilities, operational and technical parameters, and possible (re)actions either with main effort on damages or on the cause of a damage. All this is meant to take place in accordance with prepared data bases like for example Building or Tunnel Information Modelling. Activities within the **Comprehensive Consequence Management** are driven by inter-actor cooperation aiming to maintain the capabilities needed for mission accomplishment. Dynamic Resilience Design and Comprehensive Consequence Management are linked by **Risk Management and Operational Capability Research** because only the identification of risks and related research thereon can close identified capability gaps. The embedded principles and activities ensure proper planning, service, and reaction to crises. All activities and principles are interrelated and heavily depending on each other:

<u>Activities (WHAT)</u>

Situational Awareness is extremely time-sensitive and should provide the forces with all important information on actors and factors. **Specialised Knowledge** is required to understand the subsurface operational environment. **Supple Command & Control** can adapt requirements and needs for a specific situation. **Service Support** is a key element. It will be the more stressed the larger underground facilities are. **Serial Training** is necessary to maintain operational readiness for specific types of environment. **Simulation Training** is conducted in a virtual infrastructure to maximize the efficiency of planning, training, and operation.

[3] Content wise it must be adapted to the relevant structure's particularities.

Principles (HOW)

As complex subsurface operations constitute a race against time, **Speed** is crucial to gain and retain the initiative. **Safety** and **Security** are ubiquitous twins and must always be considered, planned, and executed in a well-balanced manner. The term **Seamlessness** describes the smooth transition from preparation to action. **Sweeping Action** is achieved by a comprehensive approach integrating all actors and committing them according to their specific strengths. Permanent improvement and the adaption to new challenges can be achieved by a **Self-Learning Organisation** based on a maximum of innovation.

3. THE "NIKE 2020" RESEARCH AND DEVELOPMENT CAMPAIGN

Driven by identified capability gaps and in the spirit of the S^6-model, the research group NIKE initiated development activities and started to form and train units of the Austrian Armed Forces for subsurface operations. However, only a combination of civil and military competences made it possible to achieve the range of knowledge and skills needed to cope with the complexity of subterranean challenges. The NIKE research group, funded by the Austrian Ministry of Defence, serves as an umbrella organisation for several subprojects and it is an affiliate to the Montanuniversität (Mining University) of Leoben, Austria. This partnership provides the Armed Forces with specific knowledge (Hofer and Skupa 2018), thus enabling a quick build-up of expertise. By means of a team consisting of experts from various university chairs, specialists from Mine Rescue Service as well as from the Austrian Armed Force's engineer, CBRN[4] defence and infantry branches, together with geospatial specialists, in-depth knowledge can be provided in a comprehensive, experimental research and development hub. The NIKE I/2020 R&D campaign was based on three lines of development (figure 2).

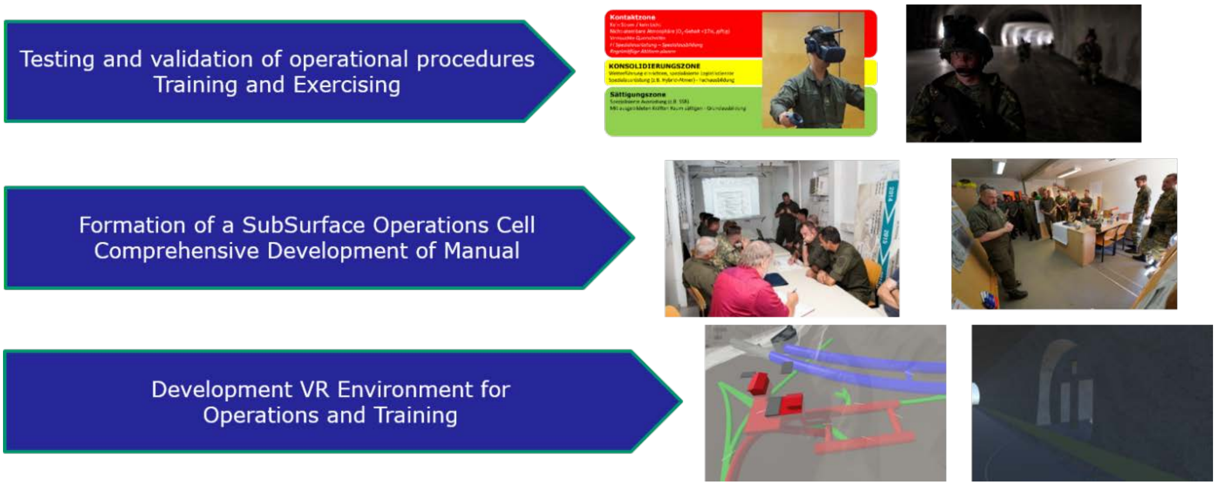

Figure 2: The lines of development frame the R&D approach within the NIKE project.

As comprehensiveness is a key factor of the S^6 – Model, the research group interacts with a wide range of actors and programs. NIKE represents an added value for the EIT[5]-funded PhD-project called "SafeMine", which strives for attractive and safe workplaces in the mining industry (Hutwalker et al. 2018). The ETU-ZaB venture of the national Austrian security research program KIRAS (KIRAS Sicherheitsforschung 2018) aims at a standardization of training requirements. The project's affiliation with planning and construction enterprises and national authorities is a further advantage. During the next months, an increased international exchange is planned because subterranean operations are gaining interest and momentum in the Armed Forces around the globe.

[4] Chemical, Biological, Radioactive, Nuclear
[5] European Institute of Innovation and Technology

Developing an operational concept was the most decisive prerequisite because it defines the necessary capabilities by using the term “complex”, which refers to the scenario and not to the infrastructure. The procedures had to be tested with trainings and exercises because simplified notional layouts had proven inappropriate for the validation. This concept (Fig. 3) is organised around three overarching, functional zones requiring sound and comprehensive knowledge from several disciplines. Security forces in the red **“Contact Zone”** face the most adverse and difficult circumstances. Therefore, a periodic relief of these forces must be planned. With an increasing depth of penetration, the yellow **“Consolidation Zone”** must follow the red zone to enable the relief of forces and to ensure logistic support and communication. The green **“Saturation Zone”**, which connects the operation to the outer world and denies the opponent to access the rear area, completes the underground operational concept (Hofer 2019a, pp. 501–502). The concept breaks down complex situations with simultaneous threats of different kinds into interconnected areas with changing requirements and enables command and control elements to adapt to these circumstances and to reduce complexity.

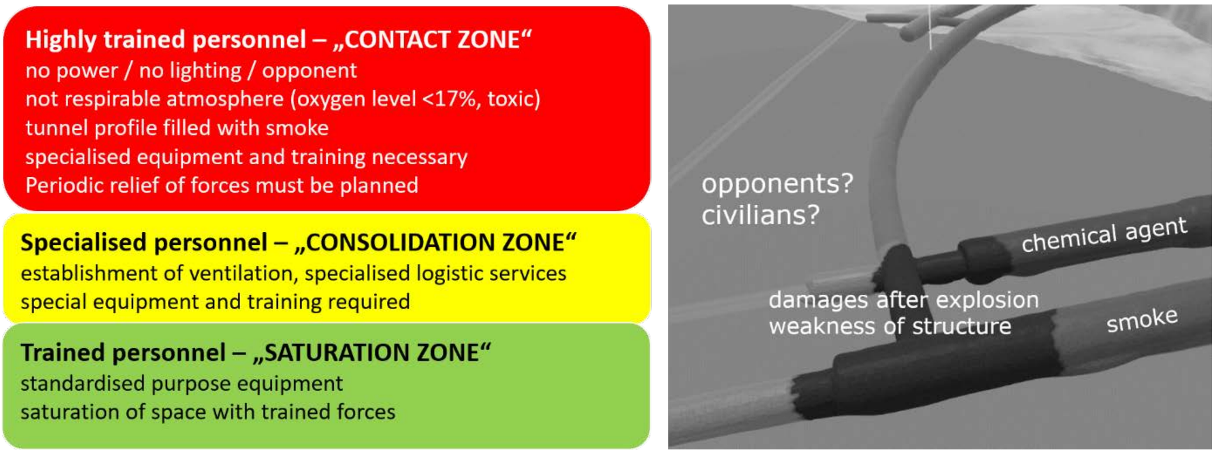

Figure 3: The operations concept is organised around three zones and takes a variety of challenges into consideration. (Hofer 2019a, p. 502)

Training activities and exercises were organised in seven modules and in accordance with the concept of operations. The research group was also the core for a Sub-Surface Operations Cell (SSOC), specialised in subterranean operations and aiming at offering advice for military commanders and civil heads of operations on demand. Again, civil-military interaction is of paramount importance for success. Experimental training and exercises, expertise coming from the SSOC and national as well as international experiences made it possible to write a manual on this topic.

As entering a subsurface structure under the beforementioned circumstances is a heavy burden, technical assistance for the committed personnel is a top research priority. The Subsurface Operations Tool (SOT), which is currently under development, will be a special support instrument for the planning, command and control, training, and simulation to enable proper preparation and action by a quick fusion of available but still highly heterogenous data.

4. CONCLUSIONS UND OUTLOOK

The NIKE 2020 R&D campaign has provided a bundle of important experiences and results with the aim to master the subterranean challenge. The “Zentrum am Berg” (www.zab.at) offers a unique and versatile infrastructure with a wide range of different subterranean facilities enabling high-intensity research and training in different cross-sections and development stages.

The following conclusions could be drawn from the “NIKE 2020” Research and Development Campaign:

- The operations concept was tested and validated. The equipment, forces required and procedures (e.g. establishment of zone junctions) were primary topics of research.
- Inter-actor interaction could be improved, and comprehensive trainings standards were developed. Training levels and modules proved to be applicable.
- Virtual reality-assisted command and control procedures and possibilities for “Rapid VR Modelling” could be developed.
- Conducting operations in a highly life-threatening environment must be the benchmark for the subsurface operations forces. Logistic and communication are key for success and must follow constantly.
- Aspects of health and safety in training were observed at any time, and standards for future training could be developed.
- The establishment of a Sub-Surface Operations Cell by integrating required experts will significantly increase the operational readiness of the community of the subsurface troops.

Further experimental research must be conducted to achieve progress in the areas of blue force tracking, the effects of explosions in confined infrastructure, treatment of mass casualties, and crowd management within a complex scenario. So far, all those aspects have not been developed within the common framework of a complex operation conducted in a subsurface service structure. One of the biggest challenges for the future will be the merging of singular research activities to a more common approach.

5. REFERENCES

Bundesministerium für Landesverteidigung (2019): Unser Heer 2030. Die Antwort auf künftige Bedrohungen. Wien. Available online at https://www.bundesheer.at/archiv/a2019/unserheer2030/pdf/unserheer2030.pdf, checked on 9/25/2019.

Cambridge University Press: Cambridge Dictionary Online. Available online at https://dictionary.cambridge.org/, checked on 9/28/2019.

Cash, Anthony A. J. (2016): Safety and Security Issues in Complex Underground Infrastructures. In Anders Lönnermark, Haukur Ingason (Eds.): Proceedings from the Seventh International Symposium on Tunnel Safety and Security. Montréal, Canada, March 16-18, 2016. Borås, Sweden: SP Technical Research Institute of Sweden (SP report, 2016:01), pp. 37–49.

Feess, Eberhard: Komplexität. Edited by Gabler Wirtschaftlexikon. Online. Available online at https://wirtschaftslexikon.gabler.de/definition/komplexitaet-39259, checked on 8/26/2019.

Fischer, Michael; Pelzer, Robert (2015): Die Logik des Anschlags. 1. Aufl. Frankfurt am Main: Campus.

Hofer, Peter (2018a): Dynamischer Schutz. Embracive Leadership im Rahmen der experimentellen Fähigkeitsentwicklung der Landstreitkräfte. In *Österreichische Militärische Zeitschrift* 56 (4), pp. 451–461.

Hofer, Peter (2018b): Security unter Tage – eine Fähigkeitslücke im Wirkungsverbund der Anspruchsgruppen. In *Berg Huettenmaenn Monatsh* 163 (12/2018), pp. 540–544. DOI: 10.1007/s00501-018-0795-8.

Hofer, Peter (2019a): Coping with Complexity. The Development of Comprehensive SubSurface Training Standards from a Military Perspective. In *Berg Huettenmaenn Monatsh* 163 (12), pp. 497–504. DOI: 10.1007/s00501-019-00915-9.

Hofer, Peter (2019b): Safety and Security in Untertagebauwerken - ein Widerspruch? Seminararbeit. Montanuniversität Leoben, Leoben. Subsurface Engineering.

Hofer, Peter; Skupa, Erhard (Eds.) (2018): Gemeinsam voran. Partnerschaftsstrategie Montanuniversität Leoben und Kommando Landstreitkräfte. Erstfassung. With assistance of Matthias Müller, Christine Adacker. Montanuniversität Leoben; Kommando Landstreitkräfte. Graz.

Hutwalker, Alexander; Binder, Angela; Langefeld, Oliver; Galler, Robert; Johansson, Jan; Weimer, Lucas et al. (2018): SafeMine PhD-Programme – Educating the Mine Health and Safety Workforce of Tomorrow. SafeMine – Doktorandenausbildung im Bereich Arbeitssicherheit und Gesundheitsschutz im Bergbau. In *Mining Report* 154, 2018 (5/2018), pp. 400–405. Available online at https://mining-report.de/wp-content/uploads/2018/10/MRG_1805_ISSA_SafeMine_PhD_181005.pdf, checked on 10/12/2019.

KIRAS Sicherheitsforschung (2018): ETU-ZAB. Available online at https://kiras.at/index.php?id=173&L=728&tx_ttnews%5Btt_news%5D=1249&cHash=a78952526d182b60895e973d0355aefa.

Monaghan, Sean; Cullen, Patrick J.; Wegge, Njord (2019): MCDC Countering Hybrid Warfare Project. Countering Hybrid Warfare. Multinational Capability Development Campaign. Available online at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784299/concepts_mcdc_countering_hybrid_warfare.pdf, checked on 10/11/2019.

Scharte, Benjamin; Hiller, Daniel; Leismann, Tobias, Thoma Klaus (2014): Einleitung. In Klaus Thoma (Ed.): Resilien-Tech. "Resilience-by-Design" ; Strategie für die technologischen Zukunftsthemen. München: Utz (acatech Studie), pp. 9–18.

Vollmann, Götz; Thewes, Markus; Heimbecher, Frank (2012): Safety and Security of Underground Infrastructure. New Concepts for Evaluating and Mitigating Risks of Tunnels. In Anders Lönnermark, Haukur Ingason (Eds.): Proceedings from the fifth International Symposium on Tunnel Safety and Security,. New York, USA, March 14-16 2012. Borås: SP Technical Research Institute of Sweden (SP report, 2012:10), pp. 243–251.

Wietek, Maximilian; Wetzig, Volker (2010): iNTeg-Risk ERRA A5. Safety and Security of Underground Hubs. In Anders Lönnermark, Haukur Ingason (Eds.): Proceedings from the fourth International Symposium on Tunnel Safety and Security. Frankfurt am Main, Germany, March 17-19, 2010. Borås, Sweden: SP Technical Research Institute of Sweden (SP report, 2010:08), pp. 153–158.

Wilson, Jeremy M. (2008): Securing America's passenger-rail systems. Santa Monica, CA: RAND Corporation.