 DOI: 10.3217/978-3-85125-883-7-28

INCREASING SAFETY AND SECURITY BY USING MODERN INTERDISCIPLINARY APPROACHES FOR UNDERGROUND FACILITIES

[1]Nina Gegenhuber, [1]Robert Galler

[1]Montanuniversitaet Leoben/Chair of Subsurface Engineering, AT

ABSTRACT

In the last couple of years, the need for extended safety and security methods in underground facilities for users, operators and emergency services became more and more important. Especially when it comes to terroristic attacks or accidents in underground structures where toxic gases and hardly any visibility can be part of, emergency services need to be as good as possible supported and protected. Therefore, various projects starting with a robot for mapping, augmented/virtual and mixed reality applications or navigation systems are carried out at ZaB - Zentrum am Berg in Eisenerz, a tunnel research, development, training and education facility, belonging to the Montanuniversität Leoben. This enables safety-related research without prejudice to the necessary operating times and high availability of conventional traffic tunnels. For the generation of a situational picture, the 3D representation of the underground branches of the facility, the recording of the number, the whereabouts of the tunnel users and the effective range of the sensors integrated in the operational and safety systems (BuS) are necessary. The goals also include positioning systems that allow real-time position determination despite darkness, smoke and very high temperatures. The presentation deals with research projects in the above-mentioned fields and some first findings.

Keywords: emergency services, underground positioning, real-time, safety and security, ZaB

1. INTRODUCTION

Underground structures, such as tunnels, subways or underground stations, represent a major challenge for emergency services due to the extraordinary conditions, especially when it comes to complex scenarios. Poor visibility, smoke development, temperature, emissions, the use of explosives, released hazardous substances (CBRN substances) and structural hazards among the influencing factors, not only place special demands on the emergency services, but also push the equipment and devices to their limit.

Autonomously operating systems for reconnaissance and logistics tasks are currently not available due to the lack of sensors. It is therefore still necessary for the emergency personnel to go directly to the danger areas. Positioning must take place without external infrastructure, since its availability in the event of a disaster cannot be guaranteed. The same applies to any navigable a priori map information. It is therefore necessary to find a positioning system which, without external sensors or infrastructure and without available map data, determines the position of the robot or persons in the tunnel in darkness, smoke and great heat, precisely and reliably in real time, in order to automatically guide them on this basis.

The real-time availability of situation information is an essential prerequisite for optimized command support in underground crisis scenarios. Solutions offer mobile, flexible multi-sensor platforms, rapid data processing, data management and the integration of external information sources. Multi-sensor solutions, on the other hand, also use in-situ installed tunnel equipment such as video cameras. They can provide valuable additional information for the point in time before a dangerous situation occurs and improve the real-time capability of situation picture generation in order to be able to supply the emergency services with current data when they arrive. This data is intended to provide the number and location of infrastructure users prior to

the critical event. In addition, knowledge and models of human behaviour in underground crisis situations are essential prerequisites for the development of technical concepts and innovative assistance solutions. The organization and management of the emergency services must be coordinated in detail with the scenario requirements and structural/spatial framework conditions.

Therefore, research projects focusing on the support in safety and security in tunnels in emergency cases is essential. The Zentrum am Berg gives us the possibility to try and train within these projects in a 1:1 scale. In various projects positioning of people and a robot underground, bringing together virtual and augmented reality for training and emergency cases and testing sensors for smoke and heat are brought together to increase safety and security in tunnels.

2. ZENTRUM AM BERG

With the Zentrum am Berg on the Styrian Erzberg, the Montanuniversität Leoben operates an independent research infrastructure for the construction and operation of underground facilities which is unique in Europe. The facility consists of an extensive tunnel system and enables research and development on a 1:1 scale as well as education and training under real conditions.

The underground research facility consists of two parallel railway tunnels, two parallel road tunnels and a test tunnel (Fig. 1). The tunnels can be reached via three entry portals and are connected underground by a cavern. A total of five different tunnel tubes are therefore available for research and test purposes. The facility enables national and international research projects to be carried out on a wide range of issues along the entire life cycle of underground facilities:

- Geotechnical monitoring
- Numerical simulation in geotechnics
- Safety research, safety technology/ventilation, tests of fire detection and fire protection devices, risk management
- Rescue Conditions
- Thermo and aerodynamic issues
- Long-term stability and durability of materials
- Rehabilitation of underground structures
- Impact of climate change: mudslides, rock fall, landslides and forecasting technologies
- Innovative and low-vibration driving methods
- Equipment technology such as control systems, gate systems (tightness requirements vs. dirt) or electrical equipment in the railway tunnel

The fully equipped road, railway and test tunnels allow a wide variety of training options and test executions for emergency services, as well as for operating and maintenance personnel. This should make a decisive contribution to increasing the safety of users of underground transport systems.

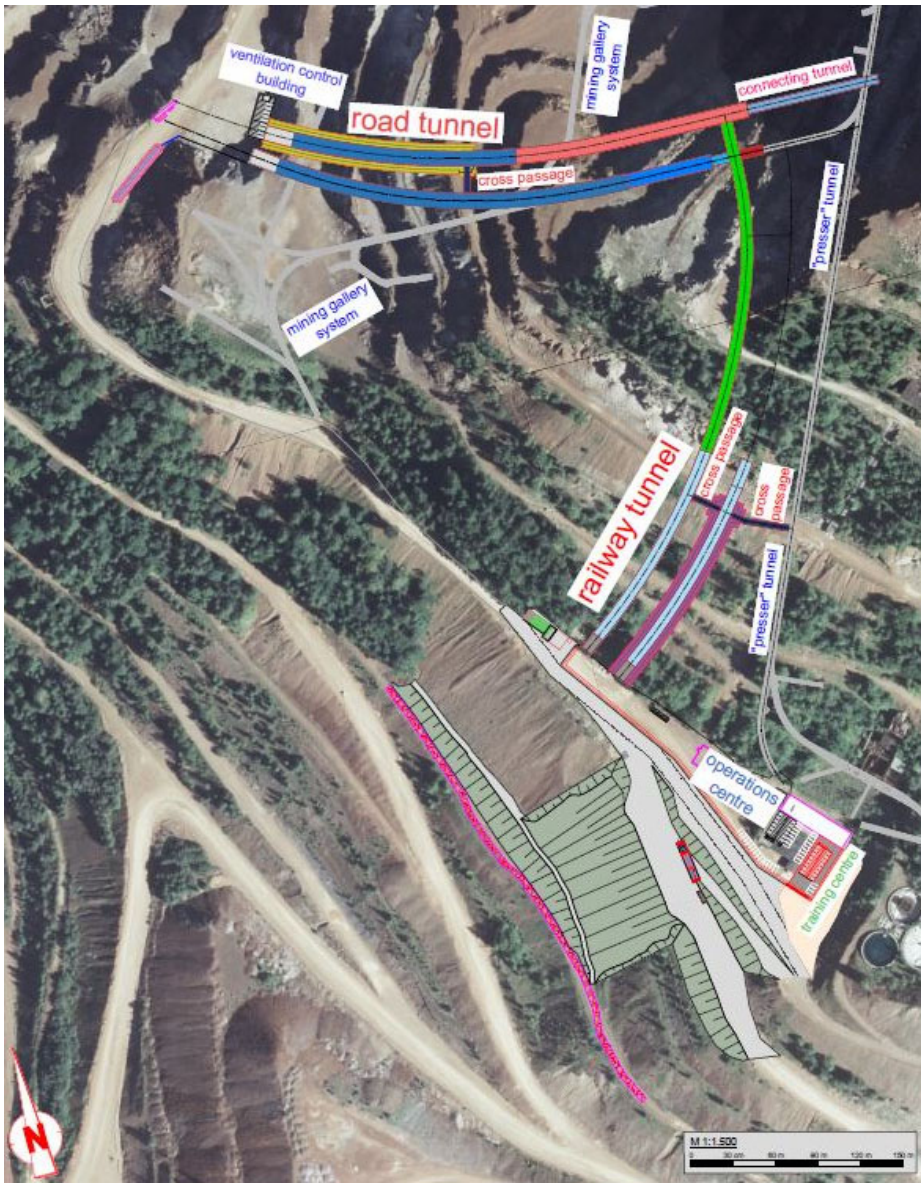

Figure 1: Overview Zentrum am Berg in Eisenerz (Styria)

The instruction of service and maintenance personnel should also take place on the basis of training courses and the practical training for relevant professions should be settled.

- Testing of evacuation scenarios using different protection and control devices, signaling technology and others
- Experiments with automated firefighting systems
- Training for very high fire loads (e.g. truck fire)
- Impact of different operating scenarios for plant and operating technicians and optimized handling of maintenance processes
- Training of relevant professions

The Zentrum am Berg serves researchers, students, emergency organizations, industry, as well as operators and users of the road and rail infrastructure as an event infrastructure and international hub. This is intended to initiate excellent, international and interdisciplinary cooperation in the field of underground research.

3. PROJECTS OVERVIEW

The first important approach for safety is the position of people or a robot within the underground infrastructure. Navigation of the robot and the blue on blue problem from the military are just two issues, which need to be solved. Due to the multidimensional branching of underground structures and the limited view and the resulting difficulties in orientation, the precise positioning of one's own forces is essential for survival. Therefore, NIKE Bluetrack deals with a blue force tracking system (Fig. 2) that provides the location information of the own forces on a map to commanders. In underground structures (e.g. tunnels or subways), the localisation is challenging due to the lack of GNSS signals.

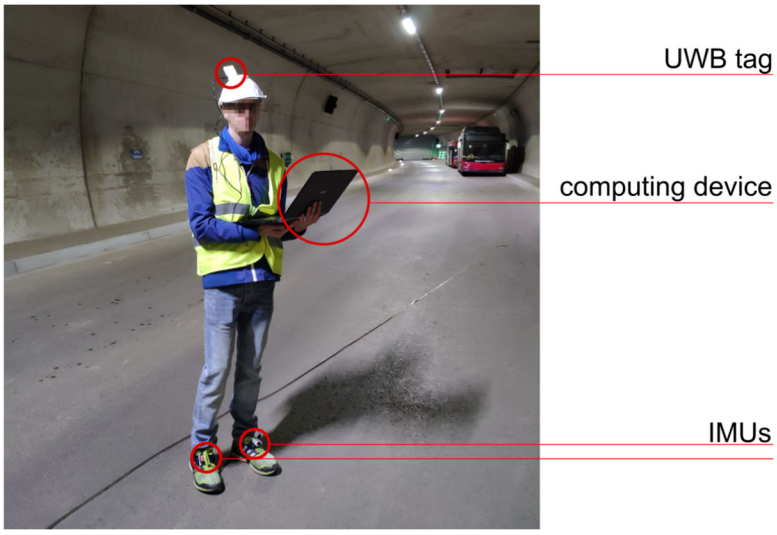

Figure 2: Test subject with sensors mounted on helmet and shoes. [1]

First outputs including detailed analyses of the tests, algorithms and analysis with IMU and UWB are summarized in [1]. Those first results are promising and the final tests are planned at ZaB in summer.

The multidisciplinary use of semi-autonomous robots equipped with sensors for supporting analysis tasks, on the one hand, enables situation-adapted deployment techniques and quick decision-making. On the other hand, intelligent, mobile and portable multi-sensor solutions directly on site and on the person, as well as the real-time generation of an overall situation picture, can provide support for the safety of the emergency services.

In the two KIRAS projects ROBO-MOLE and NIKE-SubMoveCon, this is considered from two different perspectives, one with an autonomous robot and the other with equipment for the emergency services and with installed tunnel equipment that meets current standards. [2]

Figure 3: Laser scan data by RIEGL at ZaB

Within ROBO-MOLE first measurements carried out, have been laser scan data by RIEGL Laser Measurement Systems GmbH at ZaB. The tunnel structure was scanned down to the centimetre in order to obtain an up-to-date inventory of the tunnel structure with all its installations (Fig. 3). Further experiments included fire tests to see, where the limitations of the various sensors for the robot (Fig. 4) are. The selected sensors are IMU, thermal cameras, laser scan, RGB camera, odometry and CBRN sensors for positioning of the robot and deliver further information for the emergency services. Especially the smoke from a fire is challenge for the various sensors. Final tests of the full robot system will be conducted in October.

Figure 4: Fire tests for the sensor evalution (railway tunnel, ZaB)

Further experiments with video cameras and thermal sensors from Joanneum Research were carried out. In order to be able to support the generation of a picture of the situation, a localization of the direction of movement and the position of individual people is a prerequisite for clarifying the situation, where and how many people were in the underground facility. The video cameras have different orientations and installation locations within the ZaB tunnel system, which must be determined metrologically.

Figure 5 shows those control points that are helpful in determining the orientation of a video camera and must be provided as a 3D position. Such thermal camera recordings serve as the basis for further tasks in generating situation images for any crisis scenarios. The technical implementation of converting the video cameras of the tunnel equipment into a measuring system is being carried out in cooperation with Joanneum Research Forschungsges.mbH. The areas of responsibility of the partners in NIKE-SubMoveCon break down into the provision of image material, control points and first approximate values for the camera parameters by the ZaB and the calculation of the camera parameters and image processing by Joanneum Research.

Figure 5: Thermalvideo -camera with a person visible (NIKE Submovecon)

Two new projects started last autumn: NIKE DHQ-Radiv and NIKE Med. Both include first results from the other already existing projects and intertwine. NIKE DHQ-Radiv is an essential sub-project of the overall NIKE program and will develop the process of rapid data integration and visualization of this information in a truly comprehensive Common Operational Picture [3]. It is important to ensure the lateral continuity of different visualization systems in the entire reality - virtuality continuum (2D & 3D & Mixed Reality). Only individual applications are actually available, there is currently no collaborative collaboration option.

Figure 6: Usage of Virtual Reality (VR) for mission preparation. (Pictures: ÖBH/laabmayr)

NIKE Med evaluates the required and available emergency capacities, develops an application to optimize care for responders, and identifies development needs for building strategic reserve capacities. NIKE Med makes an essential contribution within the framework of the NIKE research and development program to achieving full operational readiness of a specialized task force with the capability to operate underground, thus adding essential value to state crisis and disaster management. At this stage of the project the needs of the various emergency services is evaluated as input for the planned app.

4. CONCLUSIO

The projects NIKE Bluetrack, ROBO-MOLE and NIKE-SubMoveCon complement each other perfectly and are a first example of interdisciplinary approaches in disaster management. The safety of the emergency services and optimal support for them in the event of a complex emergency is the top priority. The results of these projects will contribute to supporting emergency services and protecting lives in dangerous situations. Positioning within an underground structure is essential and can be realized with those projects for the future. All projects have various emergency service partners, to make the research output practical in operation. The new projects NIKE DHQ Radiv and NIKE Med, extend the already running projects and add new developments on the one hand with the various mixed, augmented and virtual reality applications, which already used for different training and on the other hand include the medical input which results in complex scenarios. The overall target is to make underground structures safer for users and emergency services, who risk their lives to safe others.

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6. ACKNOWLEDGEMENT

Significant parts of the developments presented are funded by the FFG in the following projects:

FFG-Nr. 879691, NIKE Bluetrack (Nachhaltige Interdisziplinarität bei Komplexen Einsätzen unter Tage / BLUE Force TRACKing), Partner: OHB Digital Solutions GmbH, IL-Ingenierubüro Laabmayr & Partner, BMLV, TU Graz

FFG-Nr. 879720, NIKE-SubMoveCon (Nachhaltige Inter-disziplinarität bei Komplexen Einsätzen unter Tage - Subsurface Movement Control), Partner: Joanneum Research Forschungsgesellschaft mbH, Montanuniversi-tät Leoben, Ingenieurbüro Laabmayr & Partner, IFR - Ing. Richard Feischl, Experience Research & Consulting, BMLV, ASB Stmk.

FFG-Nr. 879693, ROBO-MOLE (ROBOtik für 3D-Mapping, Orientierung und Lokalisierung bei untertägigen Einsatz-szenarien) Partner: Montanuniversität Leoben, AIT Aus-trian Institute of Technology GmbH, Berufsfeuerwehr Graz, Berufsfeuerwehr Innsbruck, Bundesfeuerwehr Linz, BMLV, CBRN Protection GmbH, DCNA, e-netic, IQSOFT Gesellschaft für Informationstechnologie m.b.H., JOANNEUM RESEARCH Forschungsgesellschaft mbH, RIEGL Research Forschungsgesellschaft mbH, Technische Universität Graz (Institut für Software-technologie und Institut für Geodäsie/Arbeitsgruppe Navigation)

FFG-Nr. 886340, NIKE Med (Nachhaltige Interdisziplinarität in Komplexen Einsätzen - MEDical treatment), Partner: SimCampus, Mindconsole GmbH, DCNA, IL Laabmayr &Partner, Universität Innsbruck, BMLV

FFG-Nr. 886302, NIKE DHQ Radiv (Digital Head Quarter-Entwicklung RApid Data Integration and Visualization als Kernprozess der Stabsarbeit), Partner: Syncpoint GmbH, Realsim, IL Laabmayr & Partner, Meixner Vermessung, BMLV, OHB Digital Solutions GmbH, JOANNEUM RESEARCH Forschungsgesellschaft mbH