Building an IT Platform for Strategic Crisis Management Preparation

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***Abstract*—.This paper presents the result of the work achieved by a European consortium, which has as goal to build an innovative system to assist security managers in the crisis preparation, training and management phases. The iterative approach of the consortium is presented, as well as the results. An novel interactive and shared Common Operational Picture is proposed which has been validated by three large scale demonstrations. On-going and future work focusing on the security of building interiors is moreover presented.**

I. Introduction

We live in a world of crises: whether we think about the latest terrorist threat or epidemic, the upheavals in the Middle East or a hostage situation, climate change or a factory explosion these events all force crisis managers to make critical decisions under conditions of stress, urgency and deep uncertainty. For crisis managers to perform effectively, they must address a set of political-administrative challenges that are hard to fulfill in the best of circumstances (think of making tough calls, crisis coordination, and crisis communication).

Perhaps the most vexing challenge for crisis managers is the collection, analysis and sharing of critical information [1]. Meeting this challenge is a condition for creating shared situational awareness, which simply means that key decision-makers operate with the same understanding of the situation at hand. The reality is that this challenge is rarely met in large-scale crises and disasters [2].

Many technological fixes have been proposed and developed, but few of these have made a real impact at the strategic level. While operators, such as police officers and firemen, have made technological leaps, the strategic crisis rooms remain remarkably low-tech, apart from the ubiquitous television screens that are routinely muted when critical decisions must be made.

This paper presents the results of the current state of the created crisis management system. Section II, provides an overview of the three iterative projects and explain how they are related. Section III describes the created Common Operational Picture and focuses on its sharing capabilities. Section IV provides an overview of the three demonstrations that were held to demonstrate the system's potential. Finally, future work on the automatic reconstruction of building interiors is presented in section V, which is followed by a conclusion.

II. Our approach to the problem

In the past years, we have participated in a multi-national consortium, funded by the European Commissions seventh framework program (FP7) for Security Research, that has developed a promising combination of tools and method to provide strategic crisis managers with situational awareness. These tools have been developed in three consecutive projects, namely CRIMSON, INDIGO, and currently VASCO. CRIMSON [3] created a platform for the 3D simulation of urban crises. INDIGO widened the platform, enabling inter-organisational preparation and response in any threat environment, enabling joint sense-making across managerial levels [4]. INDIGO facilitates interorganizational preparation and exercises; it also provides the basis for a real-time information management system. VASCO, which commenced in early 2014, will further enhance this platform by adding the possibility of 3D mapping of individual buildings. This allows for the development and testing of comprehensive security plans in an urban context.

The CRIMSON, INDIGO and VASCO projects are developed in close cooperation with End-User groups in France, The Netherlands, Greece and Sweden. At the outset, these groups mostly consisted of operative leaders and mid-level managers. As the potential of the CRIMSON/INDIGO platform grew, managers at the strategic level have become involved. We typically ran one-day scenarios with extended hot washes and debriefings to be able to validate separate functions of the platform. We found that the operative level had a much easier time of engaging with the functionality of the systems. For them it compared to an integrated command system that could be tweaked to do many more things.

The platforms were built with the primary purpose to train strategic teams. The system allows the trainer to store all the operative information and assists the trained in the controlled unfolding of the scenario. But it also has the capacity to help strategic decision-makers organize information and create a common operational picture. Interestingly, in the testing phase it turned out that end-users, such as the police and fire service, recognized the potential for real-time use of this platform.

One of the most key findings in the testing phases was that experienced crisis managers use the system to rapidly weed out tactical information but also to probe strategically important information. This was achieved without the need of system operators. The managers started working naturally with key personnel in the network, which can be contacted through the system, to get their assessment of the situation.

A. The first version - CRIMSON

The CRIMSON platform, developed in 2004-5, was based on the then revolutionary idea that crisis managers could use a 3D map to visualize their threat environment. It was built for an urban context and did not contain many ways to organize information other than geographically related data. It did provide the rudimentary means to build and run scenarios, allowing for media reports to be inserted into unfolding crisis scenarios.

B. The second version - INDIGO

The INDIGO project's goal, the CRIMSON follow up, free and was to provide an IT-system that integrates 3D-mapping, simulation tools and a highly effective method of information display. INDIGO was developed to display a strategic representation of a crisis situation that is as complete and as easy as possible to understand. To enable this, INDIGO graphically displayed operational information on a 3D map; It also enables the creation and deliver evolving scenarios for planning, training, and anticipating future developments. Moreover, it provides replay of events after the crisis for analysis. In addition, it allows first responders and field units to be involved in simulated exercises.

INDIGO enables both the 2D and 3D interactive visualization of available geographic, cartographic, and architectural information about the crisis environment, such as buildings, infrastructures, roads, maps, terrain, aerial pictures, statistics, documentations, etc., from a global scale to the local level. This visualization can be updated in real-time with data collected from the field, such as location and movements of units, situation reports, pictures, alerts, sensor measures, state of incidents, levels of resources, weather data, ect. Figure 1 shows a screenshot of a Common Operational Picture achieved with the INDIGO system.

The 2D/3D representation of the crisis environment offers a way of sharing and communicating complex information, which, in turn, facilitates coordination between users across organizational boundaries with very different cultural and experiential backgrounds. In addition, the INDIGO consortium has proposed a free and open source European reference for 2D/3D emergency symbology (symbols, indicators, colours) on 2D and 3D maps with the support of the European Committee for Standardization. This reference fills an important gap by offering a common visual reference that can be used to facilitate the immediate and general understanding of a crisis situation, thus improving a common understanding for decision making, command and control across organizational boundaries. The

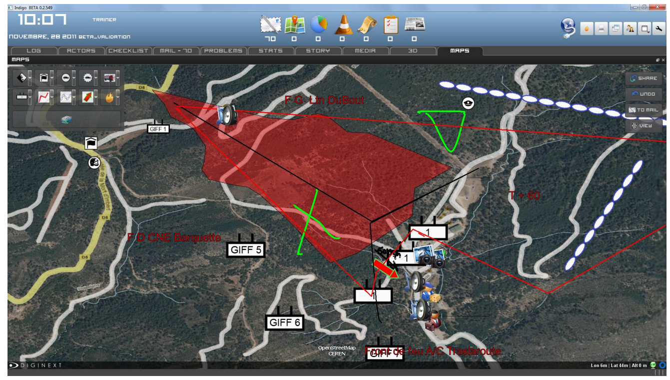

Fig. 1. **INDIGO.** Interactive visualisation and annotation of the geographic environment.

Fig. 2. **INDIGO device.** Intuitive manipulation of information.

proposed reference takes into account its equivalent defined by the US Homeland Security Working Group.

INDIGO makes use of an interactive devices, for displaying, editing and sharing the constructed picture of the situation. The devices screen can be projected on the wall, which allows all in the room to see it. Figure 2. The information can, of course, be shared with other centers and with first responders and operational units in the field. It enables the exchange of real-time information (situation reports, pictures) with field units. It allows trainers to develop open-ended scenarios, which can be revisited to make learning easier.

Strategic actors found the multitude of information options initially distracting, but they quickly learned to use the information filters to suit their needs. One of the strong points of the platform is its capacity to integrate decision logs, geodata with operative information, media picture, video and audio communications in one interface. The system comes with a method of information management, which helps to speed up the sense-making process while maintaining adaptive.

As the capacity of the system grew, we began to develop scenarios that generate more complex strategic challenges. We presented participants escalating events that had value complexity at its core and that challenged the capacity to multi-task between sense-making, meaning-making and decision-making.

Fig. 3. **VASCO Concept.** Collaboration and building security knowledge sharing.

As these scenarios were implemented, the coordination and collaboration side of the event became paramount and tested the platform as well as the involved organizations.

C. The third and future version - VASCO

The goal of the VASCO system is to provide added value to the Public Safety and Security agencies by enabling security managers to share security concepts and measures.The current development of VASCO will further integrate the information sharing between operational and strategic levels. By introducing a method to quickly build a 3D picture of a building and its environment, strategic and operational managers can work together to understand and assess complex situations, which will not just enable shared sense-making but more effective decision-making before and during crisis situations.

Given VASCOs unique approach this effectively translates into a 3D rendition of the building illustrating the threat that has been manifested as a security incident as well as the mobilized forces acting on it, both outside and inside a building. This view can be considered the most accurate and intuitive for responding agents as it produces output that is ready to be used cutting back on the need for mental calculations, path-finding identification, etc. All locations, assets, actors, simultaneously occurring events and conditions can be represented and visually fed to the user while keeping the burden-of-knowledge requirements to a bare minimum.

This interactive visualisation and manipulation of information can be used for all fundamental phases of security management; from the planning phase of multi-agency operational measures to emergency response, as well as training of the involved staff in addition to real-time operations management.

Taking advantage of VASCOs unique features, the system has as goal to provide a user-friendly, accurate, innovative, helpful, information-rich and time-efficient tool available for security teams to share security concepts and measures. An illustration showing the VASCO concept is displayed in Figure 3.

III. COMMOM OPERATIONAL PICTURE

The concept of common operational picture is the capacity to provide a unified view of a particular situation to all actors involved. Although it is a seemingly simple concept, achieving it can be a challenging task. Many factors come in effect while attempting to feed all individual responders with a common operational picture and this has led to various approaches being developed using anything from voice-communications to Heads Up Displays.

A state of the art on crisis management systems [5] and interviews of end users highlighted a need for sharing information, but also highlighted the need to have a system tailored for operativeness efficiency. Conclusions showed that more information should be shared among multiple organisations involved into a crisis.

The consortium designed a Common Operational Picture to fit both training and operational purposes, as encouraged by [6]. The training main features are to enable the monitoring of trainees performance as well as to have a constant direct communication link for scenario injects. Operational use cases are to monitor the environment, sensor information, first responders position and status as well as to be able to add custom annotations. Sharing the content and filtering for report purposes is also a key need of such a Common Operational Picture. The results presented in the next subsections are the outcome of the INDIGO project[1].

A. Common Operation Picture Visualisation & Interaction

The Common Operational Picture gathers information from various in-the-field sources such as sensors and first responders reports. Maps is an efficient mean to assist the understanding of a situation at a glance and is key to strategical decision support. The INDIGO Common Operational Picture enables an interactive visualisation of the geographical environment with information layered and gathered on top. The visualisation of the geographical theather is available in 2D and also in 3D, enabling to visualise altimetric information. This has been achieved using DIGINEXT VIRTUAL GEO SDK[2] which enabled the design of custom software on top of an Geographical Information System (GIS) technology.

This technology allowed a high graphical refresh frequency, around 60 Hz in most cases, which was necessary to obtain confortable natural interactions, such as tactile maps manipulation and annotation using a stylus. Indeed to make a Common Operational Picture efficient in operational situations, natural user interfaces have been implemented. The goal was to design a system that is accessible with a smallest as possible learning curve.To do so, we had the idea to bring all the "analogous tools" to digital. Alike a paper map, a user is able to move the maps with its fingers. This has been achieved with a tactile sensor, were collaborativness allows multiple users to manipulate the map simultaneously, with a technological limit to 32 points -fingers- for the current devices. As a user would do using a whiteboard, a stylus -a digital pen- has been designed and allows the user to write annotations on the map. Moreover, a physical ruler with digital interaction, called a

[1] http://indigo.diginext.fr/

[2] http://www.virtual-geo.com/en/

Fig. 4. **INDIGO Tangible Ruler.** Users are able to mesure digital maps with a tangible ruler. The digital scale around the objects automatically adapts to the maps scale.

tangible object, enabled users to measures distances with a real ruler with the distances displayed on screen. These distances are dynamic and scale simultaneously with the maps scale. The tangible ruler is shown in figure 4.

B. *Common Operational Picture Sharing*

The Common Operational Picture sharing has to take into account the organisation infrastructure and hierarchy. The system must not be a terminal system; it has to allow the process input information, such as sensors, and to be able to have meaningful outputs, for reporting purposes to a higher level for example, were human simplications and explanations will always be indispensable.

To adapt to as many as possible organisations infrastructures, the Common Operational Picture has been designed to work in parallel of existing systems -using its own networks and sensors- but also allows the connection to existing systems thanks to the use of many open standards.

Sharing information inside one organisation's hierarchy but also across multiple organisations involved into the crisis response is the main feature of this system. Designing a system that could handle the mapping of one organisation and multiple organisations altogether has been very difficult, as each organisation contains very specific roles and rules. Uncountable back and forth interviews were necessary to capture the smallest common denominator.

To fit the organisation hierarchy, a group information layer system has been developped. Each organisation is represented as a group, and may add information in this group layer. The organisation may also create subgroups, with a layer of information dedicated to each subgroups. Staff members are associated to groups, and are able to activate the visibility of other groups layer information. Moreover,the system enables a user to link information from other groups but also to share information to multiple organisations. This last is necessary for major incidents. As of today, this system proved to be efficient and was able to fit all the organisations hierarchy who used the system. A scheme explaining this group layering system is displayed in figure 5.

The content inside each layer that may be shared range from maps geolocalized information - such as symbols, text,

Fig. 5. **INDIGO Involved Organisation Layering.** Organisation involved in a crisis management have one or more dedicated layer of information, which can be shared across other organisations. The police layer, in blue, may be joined to firemen information, in red, ontop of GIS imagery.

photo reports, audio reports, sensor measures, video reports - to key lists information such as crisis narative, checklists, resources status, ect.

Crisis management staff are not always gathered in the same room to manage the crisis. They may be collaborating in seperated offices, and the need to create a ”virtual room” was expressed by the end users. A conference technology was integrated into the system and enabled users to talk and see distant collaborators directly mapped with the key staff and groups inside the system, without the need of external means.

During a crisis, one of the key issue is that all the networks are probably disabled. The most reliable ones are the civil security networks. Unfortunately, their network bandwith is very small and requires cutting edge algorithms to be able to communicate information. The INDIGO network technology was design to be compliant with the hard bandwith constraints. Each annotation and symbols are stored in a vectorial format, which is small by nature in size and moreover are even more reduced thanks to compression algorithms. In addition, smart algorithms have been developped to transfer only yhe small values that have been modified to other connected systems, which permits to reduce even more the bandwith occupancy. However, as of today, all the multimedia materials, such as videos and photos, require a higher bandwith network.

IV. Demonstrations

During the INDIGO project, three main demonstrations were held to show the project outcome. End users participated at each large scale exercises, and for two of the demonstrations, the INDIGO exercise even replaced their annual strategic training.

A. *Country side: Industrial site*

The first demonstration was held in the south of France, inside an industrial gaz site, which holds millions of meters cube of gaz. Three different organisations were involved: firefighters, police officers and the industrial site staff. The INDIGO system was used in parallel of their own crisis respond systems. The crisis respond members were able to operate their own tools while capturing all the necessary information into the INDIGO devices. First responders were in the field and operated anti-fire machines to prevent against a simulated fire. They reported to their hierarchy their status, and decision makers were able to visualized a shared Common Operational Picture across all three organisations.

Being able to train with their own tools highlighted some problems inside the organisation's machines; Moreover, a speed test comparison was made during the exercise between their tool and the INDIGO natural interactive devices to capture and annotate the Common Operational Picture. After one of the four hours of the training session, INDIGO proved to aggregate the necessary information more quickly. A video of this event can be visualized here[3].

B. Urban Environment: Stockholm

The second demonstration was held in Stockholm were a major man-made disaster led to many casualties, infrastructure damages and a paralyzing of the city traffic. Twenty trainers were involved, belonging to thirteen different civil security organisations.

First responders in the field were able to visualize a video of the man-made disaster from a mobile device. They reported the incident to the hierarchy who activated the crisis cell. The operational teams secured the area with roadblock and field units, while the decision makers were able to discuss and take decisions, assisted by the visualisation of the operational units actions and response. The decision makers had to report to high ranked officials about the situation.

The trainees were enthousiastic to be able to share quickly a Common Operational Picture across multiple organisation as well as to have a intuitive device which allowed collaboration. A video of this event can be found here[4].

C. Urban Environment: Leiden

The third demonstration involved two different organisations, each defined by three levels of hierarchy. A terrorist threat was at the heart of the training session. The hierarchy levels were collaborating from distant rooms and managing the information at their level. Conferences between the hierarchy levels were held at key moments of the training sessions by the trainees. The trainers were trying to overload the trainees with press events as one of the trainees' objectives was to make public reports. Three training sessions were held to enable the trainees to be familiar with the system.

The trainees enjoyed using this user-friendly system as they could easily enter information and visualise what they required. They also appreciated the after action analysis tool were they could step by step replay the training sessions. Results show that the trainees were familiar to the system after the first training session. In the next two sessions, the trainers could adapt the initial scenarios exactly to the trainees level and organisation structure. End users envision that this class of system will be standard in the coming years, and that our approach to build and tailor the system to their day to day need is key to a successful product. A video of this event can be found here[5].

V. Future challenge: Automatic Reconstruction Of Indoor Environments

The presented work focus on outdoor environment and on Common Operational Picture Sharing. Many incidents

Fig. 6. **Indoor capturing.** The system to capture building interiors and automatically generate floor plans scaled to their metric dimensions.

occur indoor, efficient tools to understand the situation and to prepare missions are needed. In this scope, the VASCO project first goal is to research, implement and evaluate an innovative system that will enable security professionals to study, assess, and present security concepts and measures, which gives rise to an evidence-based, all-risk approach, for the protection of government buildings of critical importance. The VASCO project second goal is to research and assess security concepts and measures and build a knowledge and best practice database, which captures dynamic and visual reference scenarios that have been created and studied with the VASCO system during the different evaluation phases of the project, and beyond[6].

The geographical environment that INDIGO enables to work with does not address the interiors of buildings. Creating such interiors is a difficult and time-consuming activity. VASCO will enable users to rapidly and automatedly create a 3D digital model of a building, including interiors, and its environment from series of photographs.

The automatic reconstruction of architectural scenes is a challenging research problem in both outdoor and indoor environments. Automated solutions exist fo urban outdoor environments [7], [8], [9], [10], [11], as well as hybrid approaches have proven to be effective in security field [12], [4]. Compared to building exteriors, the reconstruction of interiors is complicated by a number of factors. For instance, visibility reasoning is more problematic since a floor plan may contain several interconnected rooms, in addition interiors are often dominated by structures that lack visual and geometric details to perform an automatic reconstruction. For example standard approaches [13], [14] produce high resolution 3D models, but are strongly time comsuming and basically an overkill for a large branch of applications. As highlighted by the recent presentation of *Google Project Tango* [15], the use of mobile devices to create a 3D map of an indoor environment is instead a growing and promising approach, especially for applications focused on the structure of a building rather than the details of the model.

Following this trend we adopt an innovative method (see [16] for details) to easily capture building interiors and automatically generate floor plans scaled to their metric di-

[3] https://www.youtube.com/watch?v=R8G4vgblO58
[4] https://www.youtube.com/watch?v=pa7DFv0E0iE#t=17
[5] http://vimeo.com/78160946
[6] http://vasco.diginext.fr

mensions. The proposed approach is able to manage scenes not necessarily limited to the *Manhattan World* assumption, exploiting the redundancy of the instruments commonly available on commodity smartphones, such as accelerometer, magnetometer and camera. Without specialized training or equipment, our system can produce a 2D floor plan and a representative 3D model of the scene accurate enough to be used for simulations and interactive applications (see Fig. 6). This kind of multi-room mapping enables non-technical people to create models with enough geometric features for simulations and enough visual information to support location recognition. To capture the scene the user walks between the rooms, ideally drawing an ideal trajectory to the wall upper or lower boundary, just aiming the phone camera at it. During the acquisition a video of the environment is recorded and every frame spatially indexed with the phone's sensors data, storing thousands of samples for every room. Through a specialized method we merge all individual samples exploiting their strong redundancy and obtaining the walls direction and position in metric coordinates, ready for the next floor merging step without any manual editing. The final result is 2D floor plan scaled to real-world metric units, ready for simulation and virtual browsing (see Sec. VI).

VI. Future challenge: Virtual Browsing and Rendering of Indoor Environemnts

A. Virtual Browsing

The most common interaction mode for browsing indoor environments is found in first person shooter video games and it consists of a combination of keyboard and mouse. The keyboard is used to control the position of the user avatar in the scene (with commands such as "walk forward", "run", "jump") and the mouse to control the gaze or aiming direction. Although this paradigm is now a *de facto* standard in video games, that does not imply it is also practical in other contexts. For example non-gamers persons found it too demanding to have to use both hands to explore a virtual scene, especially if it is not the primary task, such during a security emergency [**?**]. Furthermore, with the now pervasive touch devices, keyboard and mouse are simply unavaiable and therefore other forms of controls must be used (see [17] for a survey).

One option is to design walkthroughts for synthetic 3D environments manually, as a sort o guided tours, essentially trading freedom of movement for easy-of-use. Since designing such walkthoughts manually is a hard and time-consuming task, automatic techniques have been proposed to explore the environments and find out the space of viable point of views [18]. There are other scenarios where the walkthoughts are simply derived by the acquisition path. A well known example is the Streetmaps by Google where the pictures are registered in a common (geographics) reference system and the user may essentially move along the point of views from which the photographchs were taken.

B. Rendering

Real time rendering is a well known topic in Computer Graphics and, although much has been done for high end machines, it is still prohibitive on the average mobile devices, especially if rendering is not the only task to do. Without expecting to include the boundless literature on the topic, we can state that solutions trade accuracy for speed, ranging from physically correct methods that simulate all the interaction between light and matter (referred to as Global Illumination techniques) to simple lighting models that adopt easy-to-compute *plausible* lighting effects. A class of solutions, named Image Based Rendering (IBR), aims at using images to "trick" the user in believing he/she is watching a 3D scene [19], [20]. Spatially indexed photographic imagery, popularized by Internet systems such as Google StreetView and Bing Maps StreetSide, can be considered as examples of IBR, as well as Photosynth [21] or Photocloud [22]. The advantage of these methods is that there is not actual light simulation and therefore are amenable to be implemented on low powered devices.

Fig. 7. Browsing with the system proposed in [23]. Left) Looking around the panoramic image. Right) Moving to another room. (Image courtesy of the authors)

C. Recent Advancements and Challenges

Recently, constrained navigation and an IBR rendering have been combined in a technique for browsing and rendering indoor environments [23]. With this approach the user acquires one panoramic image from the center of each room and a video when he/she moves from a room to the next. In this case the data consist on the panoramic images and video themselves and no 3D reconstruction is involved. Browsing the environment consists in looking around from the center of each room (that is, looking at the panoramic image) and moving from room to room by simple overlayed touch-and-go buttons. Figure 7 shows an example of navigation.

Anoter recent technique, presented in [24], applies a similar idea for virtual environments, by proposing an unassisted algorithm that in a preprocessing step "explores" the environment and shoots virtual photos and then proposes a similar interaction mode as [23]. Figure 8 shows the exploration graph for a model and a snapshot taken during the navigation.

Although advancements have been made both for reconstruction and for browsing, there are still problems to be solved. On the reconstruction side, state-of-the-art methods such as [16] are confined to extract only the footprint, while no practical solution exists for the furniture (tables, chairs etc.) that is, without requirig neither a range scanner nor a camera manouvred by a skilled operator. On the other hand, knowing the interior of a room, e.g. where tables and shelves are, may be

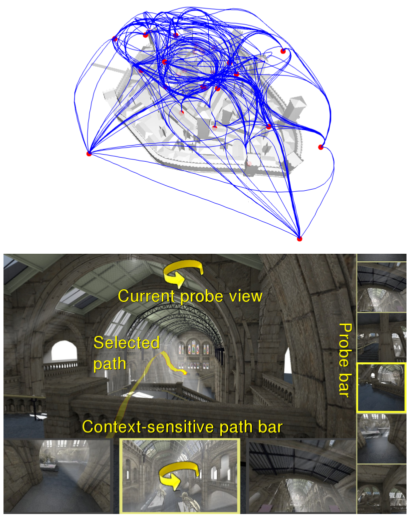

Fig. 8. The system proposed in [24]. Left) The exploration graph for a 3D model. Right) a snaphot taken during the navigation (Image courtesy of the authors)

necessary in security planning. Upcoming technologies as [15] may solve the problem for moderate-size room, but they work in a range of few meters and will not be practical for places like a train station or a parliament chamber.
For what concerns browsing and visualization, we see an important challenge in data fusion of videos and images (panoramic or not) into browsable 3D-like representations. The solutions proposed so far require a skilled operator to produce a data that can then be effectively browsed. The EploreMaps, for example, assume that one has a complete 3D model of the place. Instead, researchers should aim at making the input phase less demanding in terms or skills and hardware required.

VII. Conclusion

This paper presented an overview of the work achieved by a European consortium on information technology for security management needs. An iterative methodology has been presented, with emphasis on the results of the recently terminated second iteration. Three demonstrations were held to assess the need and use of the technological assistance in emergency situations. Results and feedbacks are more than encouraging. The third and current iteration is addressing indoor security concepts and measures, where the first results are expected in 2015.

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