



SCIENCE & SECURITY July 2015

CASRA NEWSLETTER – SPECIAL ISSUE 10

Three years ago, the first issue of Science & Security was published. Since then, the CASRA newsletter has taken you on a “tour d’horizon” of our research and development activities. We have shown you different facets of *what* we do and *why* we do it. We have also provided you with one or the other insight into *how* we work.

In the 10th issue of Science & Security, we decided to make the *how* our main focus. This newsletter takes you behind the scenes of our center and shows you how we do things to achieve our main objective: to increase security and facilitation at airports and in other environments involving people and technology. We are happy that several of our employees contributed short texts on their areas of expertise included in infoboxes.

We also took the opportunity to interview one of Switzerland’s most experienced security expert - Werner H. Wüest - the former head of Zurich State Police, Airport Division, Security Control Branch at Zurich Airport. He has cooperated with CASRA and its organizational predecessors over many years in different projects.

We would also like to use this opportunity to thank Dr. Sandrina Ritzmann for her work with us in the last four years. She has initiated and successfully realized the past 10 issues as editorial manager. After becoming mother recently, she has found a job five minutes from home so that she does not have to commute three hours everyday to work at CASRA. We thank Sandrina very much for her great work in several research projects and for the editorial management of the CASRA Newsletter.

We hope you enjoy this special issue!



Dr. Diana Hardmeier
Director



Prof. Dr. Adrian Schwaninger
Chairman

CASRA BEHIND THE SCENES: PROCESSES, PEOPLE, AND THE CASRA SPIRIT



CASRA summer team event, July 17, 2015

It is the last Friday of the month, two o'clock in the afternoon. The CASRA meeting room is densely packed, the latecomers have to bring their own chairs from their desks. It is the monthly CASRA meeting, where company news are discussed, project updates are given, and, in the knowledge transfer section, employees educate each other on specific topics that are relevant for everyone. Today, some time of the meeting is devoted to a brainstorming session in order to elicit different views on the unique elements that constitute CASRA and that make this organization successful. One very common statement is *"the CASRA spirit"*, and indeed, this elusive construct seems to play an important role. There is more to be told about it later - what can be said at this

point is that it seems to be the common ground of CASRA's staff with their different professional backgrounds, nationalities, and languages.

Another reason why CASRA is a successful, innovative, and dynamic organization is the particular combination of competencies and also a set of adaptive processes that are necessary for our research and development activities. What we do has been described in the previous issues of this newsletter and is summarized in Infobox 1: CASRA - A Short Portrait. The focus of this special issue will be on *how* we do it and *what competencies* come together at CASRA in order to meet the unique challenges and opportunities of research and development in the security sector.

'C' STANDS FOR CENTER

When speaking of CASRA's particular combination of competencies, this does not only refer to the set of knowledge, skills, and abilities of employees, but also to the different organizations that form CASRA. When Alex Kunz, responsible for marketing and sales, describes the organizational structure, he usually starts by explaining the acronym CASRA (Center for Adaptive Security Research and Applications): The "C" stands for *center* - a center that emerged from the Visual Cognition Research Group (VICOREG) of the University of Zurich, which was founded in 1999 and had a research focus on visual perception, recognition and attention. The security research team

INFOBOX 1: CASRA - A SHORT PORTRAIT



Dr. Diana
Hardmeier,
Director



Prof. Dr. Adrian
Schwaninger,
Chairman

The Center for Adaptive Security Research and Applications (CASRA) was founded in 2008. It emerged from the Visual Cognition Research Group (VICOREG) of the University of Zurich which was founded in 1999. Today, CASRA has a workforce of around 30 people, comprising among others psychologists, computer scientists, and aviation security experts, many of which have an academic degree. We are aiming at increasing security and facilitation at airports

and in other environments involving people and technology. CASRA is recognized internationally as one of the leading security research centers with a focus on X-ray screening. Some facts and figures about this: We published more than 100 scientific papers, supported 12 successful PhD theses, completed 30, and currently run 15 research projects (including two EU projects), involving hundreds of airports worldwide.

Studies in the areas of aviation security human factors, human-machine interaction, cognitive and computational modeling, perception and recognition of objects have led to the development of applications for training and testing in the area of aviation security, installed in more than 40 countries at more than 900 airports and other sites worldwide. The computer-based training system X-Ray Tutor (XRT) is an individually adaptive training software for X-ray image interpretation. The CASRA Testing Platform (CTP) is our software solution to conduct pre-employment or certification tests. The selection of suitable employees is supported by the X-Ray Object Recognition Test (X-Ray ORT) that measures the aptitude and ability to become a good security screener. The X-Ray Competency Assessment Test (X-Ray CAT) is a highly reliable, valid, and standardized test designed for the certification and testing of X-ray image interpretation competency. Further, the CASRA Learning System (CLS) is an e-learning platform facilitating online training courses such as the X-ray Introduction (XRI). This course trains the basics of X-ray screening and the look of everyday objects in X-ray images.

Through research and development projects, we continuously adapt and advance software solutions, processes, and best practices in collaboration with experts and end users. A few examples of current and highly relevant research topics are the optimization of human-machine performance using automatic explosive detection in cabin baggage screening, behavior analysis, the use of intelligence information to advance operator competences, introduction of unpredictability measures, or the development of recommendations for optimizing the use of Threat Image Projection (TIP) using combined threat images and remote screening.

organizations is a highly notable characteristic of CASRA. A flat hierarchy and an open, creative culture enable all employees to bring in their ideas, in line with their individual competencies. "We have work and organizational psychologists, software developers, computer scientists, former airport security officers (screeners), IT infrastructure specialists, and people with a background in management or business administration. And quite a number of people possess a unique combination of skills, for example in psychology and X-ray screening", explains Dr. Stefan Michel, Senior Researcher of FHNW at CASRA. Bringing in their specific backgrounds and different competencies, people work together in the same projects to achieve common project goals.

In the last decades, an increasing number of organizations have realized that combining applied psychology with engineering and business competencies is a key factor for innovation in IT and service sectors. However, according to Stefan, the role of work and organizational psychologists sometimes needs a bit of explanation in certain engineering environments. "We as work and organizational psychologists use a socio-technical systems approach to optimize human, technology and process factors. The objectives are to increase system performance and reliability, improve working conditions, and to foster the continuous development of employees in their particular work settings. Many of these aspects are reflected in our projects in the field of aviation security", he says (see also Infobox 2: Research at CASRA).

On the one hand, CASRA initiates research projects to develop or evaluate new technologies in aid of human operators, to investigate the impact of technology such as automated threat detection on human performance, or to

of the *University of Applied Sciences and Arts Northwestern Switzerland (FHNW), School of Applied Psychology, Institute Humans in Complex Systems (MikS)*, has broadened the scope by conducting adaptive security research on humans, technology, and processes. *APSS Software and Services Ltd.*, a University of Zurich spin-off company, guarantees for *adaptive security applications (software and services)* that are

in line with and based on the research results. This set-up that unites different organizations in one center is one of the factors that make CASRA unique and support its adaptive and innovative approach that is strongly driven by science and research.

The fact that an observer in CASRA's offices in Zurich would not notice that there is staff present from different

conduct scientific groundwork in areas such as behavioral security screening, or work design in X-ray security screening. On the other hand, it is often the case that authorities or the industry approach CASRA with their particular operational issues in order to find solutions for actual problems or to foster innovation.

In short, research is core to CASRA's activities, but it is certainly not the only aspect that is vital for the organization's success.

THE "HOW" MAKES THE DIFFERENCE

We zoom back to the CASRA meeting room and the brainstorming session where CASRA employees are discussing which aspects are important for CASRA's success. Due to the center's particular structure with different organizations that work so closely together, it is no wonder that how we do project management is mentioned by the au-

INFOBOX 2: RESEARCH AT CASRA



Dr. des. Marcia Mendes, Research Scientist MikS

Automation and other technological changes are leading to increasingly complex working and living conditions. In this context, work and organizational psychologists focus on individuals and groups facing such complexity and are concerned with the design and reliability of socio-technical systems. To illustrate these rather abstract notions, let us look at the example of technologies that enable remote screening of carry-on passenger baggage and their implications for human operators. From the perspective of work and organizational psychologists, numerous questions arise: How do X-ray screeners react to this new technology and procedures? What impact does remote screening have on performance and job satisfaction? Which psychological work design principles need to be considered to successfully introduce remote screening? These and other, similar questions guide the research process in CASRA's projects. Within the scope of these projects, a number of employees pursue their doctoral studies, which also leads to added value for the customers and project partners: Research results are scientifically well-founded and receive further visibility through publications in scientific journals and presentations at international conferences. Currently, three doctoral students are working on their theses: Marcia Mendes, who just successfully defended her dissertation "Human factors in aviation security X-ray screening," Nicole Haettenschwiler, and Yanik Sterchi. Their dissertations include topics such as human-machine interaction using new X-ray technology, X-ray image interpretation training, or evaluations of work settings at security checkpoints and their impact on X-ray screener performance. CASRA's doctoral students highlight the aspect of on-the-job project management training at CASRA as a valuable aspect of their doctoral studies: They are gradually introduced to project management by full-time professional project managers, which allows them to develop project management skills in addition to their academic qualifications.

INFOBOX 3: PROJECT MANAGEMENT AT CASRA



Christoph Meier, Vice Director

Our research and development projects with integrated resources from different organizations must be planned, managed, and evaluated in an effective and efficient way in order to meet the requirements of a changing environment at all times. The project portfolio management (PPM) is a valuable instrument, which gives input to CASRA's steering committee (consisting of director, vice director, chairman, and senior project managers). It comprises a prioritized list of all current projects, including strategic and financial information, to help us allocate our time and personnel resources. Project managers inform each other in a bi-weekly project manager meeting, and in quarterly project reports. Based on these inputs and targeted project presentations within the steering committee, the PPM is updated regularly. The project durations of our ventures can vary from several weeks up to multiple years. In most cases, the members of CASRA work on several projects at the same time, which makes it important to have a detailed time reporting in our SAP system. On this basis, CASRA's project portfolio controller can track regularly whether our project portfolio is properly adjusted to the current resource situation and take action if necessary. All in all, with this system, we have created an organizational instrument which optimally reflects the challenges we encounter in our research and development environment in the context of aviation security.

dience. Christoph Meier, vice director and project portfolio controller, explains it like this: "As a center that integrates employees from different organizations and that is working mainly on a project basis, CASRA aligns its work efforts in a so-called project portfolio management (PPM). Basically, the PPM is a prioritized list of all current projects including strategic importance, financial budget and other information." Its objective is to enable decisions when it comes to prioritization of projects and to help allocating CASRA's time and personnel resources in an optimal way (see also Infobox 3: Project Management at CASRA).

Our software development process resulted as another key element from the brainstorming exercise on impor-

INFOBOX 4: SOFTWARE DEVELOPMENT AT CASRA



Wicher Visser,
Senior Software
Developer / Project
Manager



Claudia Lüchinger,
Product Manager

CASRA services the market by providing companies and authorities with scientifically based software solutions for training and testing. These solutions need to adhere to high standards, which require thoughtful analysis before adjustments and extensions can be made. At the same time, our research is a more fast-paced environment and custom software prototypes are often necessary to verify and execute scientific studies. The need for these prototypes may arise spontaneously, and consequently may call for short development windows. Prototypes commonly do not impose requirements, such as scalability, that are critical for market-ready solutions. Yet they may provide a basis which can be further pursued and developed, and occasionally even be integrated into CASRA software solutions.

In order to integrate the needs of research and industry projects alike, CASRA has adopted a special flavor of *Scrum* - an agile methodology for software development. The bases of Scrum are prioritized "wish lists" for products called *product backlogs*. What is implemented when is decided by taking into account short, mid, and longterm product management perspectives. These are regularly updated by taking into account regulatory requirements and changes, end user needs, and innovative ideas emerging from applied research projects. The development process takes place in *sprints* - time slots of two to four weeks - in which the team works on a small chunk of items from the top of that wish list and decides how to implement those pieces. Along the way, the team meets each day to assess its progress. The person responsible to overview the process, the *scrum master*, keeps the team focused on its goals.

Scrum at CASRA allows for agility to changing requirements and provides the necessary flexibility to integrate project requirements and feature requests from project partners and customers as they come to our desk. A strong emphasis is put on being able to adapt to changes, while ensuring short time-to-market trajectories. Not an easy task to accomplish by any length, and this is mainly achieved by combining results of research, strategic evaluation, product management, and agile software development. With a flat hierarchy, special skill sets and bright minds, we are able to efficiently convert even challenging ideas into reality.

tant aspects of CASRA. Our software development is strongly focused on the end user, but at the same time, it is interwoven with our research endeavors. There are many opportunities but also challenges to this dual foothold in academics and industry. One such challenge is how to integrate requirements from these two fields into the software solutions. The requirements originating from both fields can vary significantly and are often influenced by different timelines, budgets, and perspectives. CASRA has adopted Scrum as an agile software development framework and other processes to meet this challenge. More information on this can be found in Infobox 4: Software Development at CASRA.

User-friendly and performant software solutions are the vessel to deliver value for research projects, governments, and the industry. At the same time, the *creation of image content* for the CASRA applications is also an important aspect to achieve the objective of increasing security and facilitation at airports and in other environments. For example, X-ray images of containers such as bags, cargo shipments, or mail need to be selected and processed. Also, images of prohibited items such as weapons or improvised explosive



Selected pictures from the numerous social and sports events of CASRA members

INFOBOX 5: CONTENT CREATION



Slavtcho
Groshev,
Project Manager

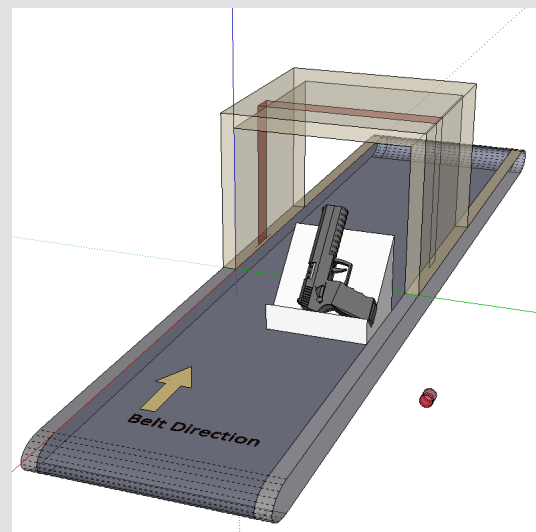
Creating image content poses challenges which require a combination of scientific expertise, operational experience, and solid knowledge of image processing algorithms. The first stage of creating image content is the recording of original *X-ray images of containers*, such as passenger bags, mail, or cargo shipments. These original images need to be of a sufficiently high quality (low image distortion, high resolution etc.). Furthermore, the images need to conform to specific standards regarding their content. For example, images of passenger bags should not contain any liquids. These images then need to go through post-processing and be converted into a proprietary image format.

Apart from the images of containers, we also need to maintain a *database of prohibited items*, recorded in a variety of views according to standardized procedures and processes. What items are prohibited depends on the context of X-ray screening. At airports, these are guns,

knives, improvised explosive devices, and other objects, such as for example electric shock devices. At prisons, all types of electronic items are prohibited. The prohibited items database is continually extended with new and emerging threats, based on a well-established systematic threat assessment regularly conducted by CASRA (see CASRA Newsletter Issue 9).

The final stage of content creation is the *creation of complete training courses or tests*. Training and testing require different approaches. Our training system XRT uses its sophisticated built-in merging algorithm to automatically generate unique combinations of containers (e.g. bags) with prohibited items adapted to the individual competency level of the user. Specific libraries of containers and prohibited items need to be composed and customized to the X-ray screening context.

To create reliable and valid image interpretation tests, such as CASRA's X-Ray CAT, it is necessary to manually and systematically create a large number of images where prohibited items are merged into images of containers. These images then need to be pretested scientifically to be able to obtain statistical measures of item difficulty and power to discriminate proficient from less proficient X-ray screeners. The analysis of these data is the basis for the selection of the images that are finally included in a test.



Recording of a gun in a rotated position
(The dark brown L-shaped detector is shown inside the machine, the red cylinder below the belt depicts the X-ray source position)

devices need to be recorded and go through post-processing as well. Finally, complete training courses or tests are created based on the two libraries consisting of containers and prohibited items respectively. More details on this process are provided in Infobox 5: Content Creation.

THE CASRA SPIRIT

Coming back from the more tangible elements that constitute CASRA to the prevailing answer of the brainstorming session, the CASRA spirit merits a closer look. Even though most people working at CASRA are Swiss, there are

in total ten different nationalities including quite diverse ones like Argentinian or Swedish and, consequently, also different cultures. It is hard to tell whether it is *despite* this high level of diversity or *because* of it that everybody's expertise and unique viewpoints are valued and bring an important input to CASRA's projects and products.

For sure, the flat hierarchy plays an important role. Everybody with the necessary skills and motivation is encouraged to take on responsibility, explore new areas and participate in developing new ventures for the organization. This freedom for potential triggers creative

ideas and fosters the drive to develop innovative projects and solutions.

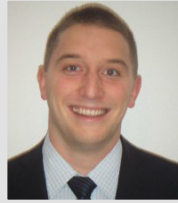
It is also quite usual to find CASRA members undertaking leisure activities together and outside of the office hours. There are regular tennis tournaments, lunch-break swimmers, squash-games, boat outings, and other activities. This spring, more than half of CASRA's employees participated in the bike-to-work challenge, committing to come to work by bike at least 50% of the working days for one month. In addition to the sports activities, there is of course also one or the other after-work beer. Taken together, it can be said that

the core of the CASRA spirit is a culture of trust, nurtured on and also off the job, and the common motivation to strive for the best possible solutions in CASRA's endeavors.

Last but not least, regarding knowledge, skills, and abilities, it should be mentioned that several CASRA employees have an airport security screener background. This is essential for developing high quality training and testing solutions, but also to guide applied research regarding its practical relevance. More on this can be found in Infobox 6: CASRA's Airport Security Officers (Screeners).

In summary, it can be concluded that CASRA's competencies and the set of adaptive processes tailored to research and development in the field of security are central to the organization's success. Over and above, the glue that holds everything together are the unique working atmosphere and the CASRA spirit. Based on this combination of constituting elements, CASRA will continue its efforts to advance security and facilitation at airports and in other environments involving people and technology.

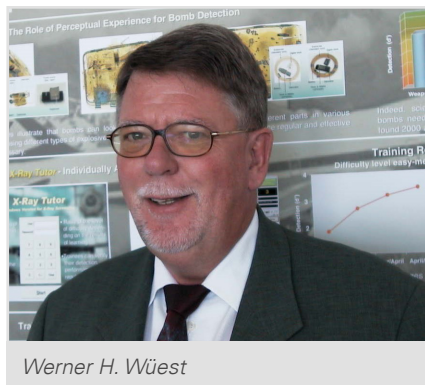
INFOBOX 6: CASRA'S AIRPORT SECURITY OFFICERS (SCREENERS)



Alex Kunz,
Manager
Marketing & Sales

Some of CASRA's staff (among them the vice director and the marketing and sales manager) used to work for Zurich State Police, Airport Division, Security Control Branch at Zurich Airport as airport security officers (screeners) during their university studies. Hence, they know what it takes to work at a security checkpoint. This *screener knowledge*, combined with the knowledge acquired at their university studies, is essential in many projects and in the development process of the different software solutions that CASRA provides. Our former screeners ensure the high quality of the X-ray image content in training tools and tests. For instance, they develop content such as threat images for competency assessment tests that are then subject to a scientific validation procedure in extensive pretests. They also record new threats, or choose suitable bags for different training libraries. Their work is always double-checked by another screener with a "second set of eyes". Profound knowledge on airport security screening is also very important for research projects in which human-machine interaction and screening processes are optimized, or new checkpoint designs are developed and evaluated. This is so important to us that, yes, even the vice director cannot get away from the legacy of being a former screener when talking about quality assurance, consultancy, and innovative research projects.

INTERVIEW WITH WERNER H. WÜEST, 02.06.2015



Werner H. Wüest

In the early 90's, long before regulations for computer-based training (CBT) of airport security X-ray screeners were in place, you introduced such training at Zurich airport. Can you please summarize in a few words why and how you did this?

We knew that there were differences between screeners regarding their detection performance. Through simple tests, we had the feeling that there were large differences regarding the recognition of prohibited objects and even of everyday objects in X-ray images. But we could neither find out the reason nor prove it scientifically.

Adrian Schwaninger – at the time a young researcher – and I got to know each other in 2000. As the Head of the Visual Cognition Research Group (VICOREG) of the University of Zurich, he was specialized in visual perception, recognition, and attention. Through information by an attentive screener, we met each other, and I told him about our problems with X-ray screening and the large differences in detection performance between screeners. That was the initial spark: He immediately saw an interesting application of his research work and its opportunities.

With a lot of verve and commitment there were solutions developed and im-

plemented to find out where the problems were and how to solve them to improve the quality of screening.

It took a good deal of persuasion and encouragement to raise the funds for this new project. At the same time, we spread our ideas in the Technical Task Force of the European Civil Aviation Conference (ECAC).

What were your biggest challenges as Head of Zurich State Police, Airport Division, Security Control Branch?

A major challenge throughout my work was the balancing act between the general quality of security, the quality of employees, the quality of equipment on one side, and on the other side, the costs caused by the security measures. My view has always been that security controls are a very demanding job and therefore, the staff should also satisfy these requirements – which is of course a cost factor. With the development of the computer-based training system X-Ray Tutor (XRT) and its installation at Zurich Airport in the year 2001 a most exciting question arose: How successful would this new training be with the screeners? We were amazed how happily the screeners completed their training sessions and how much their detection of prohibited items improved as a result of training. Part of the research and development project was also the development of reliable, valid, and standardized computer-based tests to measure X-ray image interpretation competency with the goal to certify screeners. After implementing such tests, and through applied research, we found out that some screeners did not have the necessary visual-cognitive abilities to achieve high levels of detection performance. This has led to the development

and implementation of pre-employment and assessment tests (like the X-Ray Object Recognition Test), which are now used at airports worldwide.

What are the most prominent differences between security screening as it is carried out today compared to when you started to work in this sector?

In former times, the detection focused on apparent dangerous items such as pistols, revolvers, and large knives. The inspected person was included in the evaluation. Today, many objects are considered to be threats and political decisions sometimes play a greater role than sensible regulations. Due to this trend, it has become more difficult to include the passenger in the evaluation – screening has become very standardized and predictable. Sometimes I have the feeling it would be advantageous to find the way back to evaluate the overall picture including risk information.

Which role does the human factor play in security controls?

In my opinion, the human operator still plays the most important role in the entire range of security controls – my estimation would be 70% human factor, 30% technical assistance. Do not forget: Almost in all areas of aviation, from technology to the cockpit, the 4-eyes principle applies. Not so at the security checkpoint: Within a few seconds, a decision has to be taken by a single person. During the entire working time the utmost concentration is required by this person, wrong decisions can have fatal consequences. For this reason, it is extremely important to continue to strengthen the human factor. From my

point of view, it will take much time before technology can completely replace humans in this area.

What do you think is the key to have a capable and productive screener workforce?

The quality of the screening must be further promoted: Selection, education and training must be further improved. In my opinion, screening should be a recognized profession with a certificate of proficiency. This in consequence includes the appropriate benefits provided by the employer. Thus we are back to the cost factor.

Meanwhile screening is no longer just an airport-matter, but extends to various other areas such as prisons, post offices, nuclear power plants, banks, etc. The requirements for the screeners are similar. Raising the screener activity into a recognized profession with a certificate of proficiency and standardized education with a focus on image recognition would have a positive impact on the social position of the screening personnel, which is so far considered by many as "a job with low demands".

What do you think are currently the biggest challenges that the aviation security industry is facing?

Still many of the activities at the security checkpoints are considered to be simple unskilled labor – which it is not. Many people think that technology solves all problems. That the equipment has to be operated and that the machine will always let the screener have the final decision, is hardly realized by most people.

Moreover: X-ray machines have been in use for more than 40 years for the purpose of security checks - the technical progress made during this time I

find rather disappointing. The images are certainly better and easier to interpret thanks to color indicating different materials. The devices however do not offer a consistently reliable support for the screener's final decision. When in doubt, the decision is passed to the screener and from them - quite unlike the equipment - a 100 percent detection of prohibited items is expected.

What do you think will the checkpoint of the future look like?

From my point of view, security checkpoints must move away from the image of being "congestion points". The process must get smoother.

The current trend towards analyzing the behavior of the passenger – as in former times - and also his background is interesting. Advanced cabin baggage screening technology with automated explosive detection, multiple views, or 3D rotatable images are important technological developments. Smart(er) checkpoints might use risk information, be less predictable, and hopefully more outcome-focussed than it is the case nowadays. The screener job will become even more demanding, which should not be underestimated. Most importantly, technology and processes need to be designed to help screeners to do a good job and not the other way around.

WERNER H. WÜEST

1974 – 2007:

Head of Zurich State Police, Airport Division, Security Control Branch; former member of the ECAC Technical Task Force; ICAO and ECAC Auditor

2007 – Today:

Security Consultant and Trainer

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