DEMASST
Mass transportation security

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Current technological solutions and relevant research

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Executive Summary

This document gives an overview of security technologies that are currently in use in European mass transportation, and technologies that represent recent or ongoing research. This document will serve as a foundation for later deliverables in this work package, and serves to highlight areas in which new research may be needed.

The content of this document primarily reflects the competence and background of the contributing partners, which implies that there is a strong focus on information fusion, detection of explosive devices and other dangerous substances, and human performance. Other ongoing and recently finished research projects which are relevant for mass transportation security are also briefly described.

This deliverable is primarily targeted toward the DEMASST partners, but it may also be of interest to stakeholders.

CONTENTS

1 Introduction

This document contains an enumeration of security solutions for mass transportation that are in use, available or part of ongoing research. A common course of events in a provoked accident case is as follows:

Normal management ⇨ Hostile activity ⇨ Hazard ⇨ Consequences

In this overview we have categorized possible technologies after which hostile activities they are intended to prevent or which consequences they are intended to reduce.

Based on potential consequences, we have used the following solution categories:

- Prevention
  - Detect suspicious person, object or delivery (i.e. delivery of objects made for damaging mass transportation)
  - Reaction capacity/capability when suspicious object or delivery is detected
  - Prevent availability of access (i.e. access to delivering objects made for damaging mass transportation)
  - Prevent detailed knowledge of vehicle and infrastructure (this also covers ICT security measures, and by extension, ICT Intrusion Detection Systems)
  - Reaction capacity/capability when suspicious person is detected
- Reduce impact
  - Detect hazard (i.e., detection of an unwanted situation as it is happening – to reduce impact)
  - Reduce down time of transport services
  - Reduce damage to vehicles or infrastructure
  - Reduce injuries to passengers or personnel
  - Reduce damage to environment

The potential consequences we have identified are:

- Impact damage to vehicles or infrastructures
- Damage to the environment
- Fire
- Explosion
- Biological
- Chemical
- Radioactivity
- Injury

The consequences are not necessarily distinct, in that a bomb can cause an explosion, which in turn may cause a fire, which in turn may cause injury to passengers and damage to the environment. However, we have decided to use these consequence categories for now, in order to make it easier to distribute solutions.

We have identified whether the security technologies are of strictly technological nature, or whether administrational or human behaviour aspects are also addressed. We also indicate whether the security technologies are in use, part of ongoing research or a topic for future research.

Notice that some technologies prevent a potential hazard, some reduce possible consequences, and some technologies do both.

This report describes current solutions for security of mass transport, as well as emerging solutions and current research. In the following chapters, these solutions are described in a manner where they are grouped by theme (explosives, information fusion, etc.), followed by an appendix where solutions are grouped according to the classification defined above.

2 Existing technological security solutions

This chapter describes technological security solutions that are already employed in European mass transportation.

The project partners are primarily research oriented, which implies that the majority of input has been related to the state of the art in high-technology solutions. In turn, this means that more established solutions such as surveillance/CCTV, fire protection systems, and general ICT security solutions are not covered here.

2.1 Improvised explosive devices

Detecting explosive devices deployed in a transport system is a challenging task. The dense crowds of people, the small volumes of an Improvised Explosive Device (IED) and thereby the possibility for hidden transport, the short time allowed for detection of weak signals in a noisy environment are all part of the problem. The different detection techniques should therefore be considered with the following questions in mind:

- How fast is the response of the detection system?
- Is the detection system mobile?
- What is the selectivity of the detection system to different substances?
- Is it possible to use the solution for stand-off detection?

The first step in the detection process is to identify a possible IED. It is necessary to determine whether or not the object is an IED and which substances it contains and in which amounts, i.e. if it contains explosive materials and/or other CBRN materials. Since an IED might easily blend in with the surrounding, for instance by being hidden in bags, it can be very difficult to detect. Camera surveillance, where trained staff uses camera equipment to regularly scan an area in search for newly placed objects such as bags or parcels, is a method for finding suspicious objects. For detection of delivery, however, this technique is not sufficient. In such situations there is a need for detection equipment that can check people and luggage at stationary or temporary checkpoints.

2.1.1 Detection of delivery and suspicious objects

Methods used to detect suspected explosive devices are based on detecting material such as wiring, metal and electrical circuits inside objects. Possible solutions are metal detectors, X-ray and nuclear quadrupole resonance techniques, and radio waves which can be used detect electrical circuits. One risk with the latter method is that the radio waves trigger a possible explosive to detonate. The detectors are further described in section 2.1.2.1.

2.1.2 Detection of explosives

When a suspicious object is detected, the next step is to determine whether or not the object is an IED and which substances it contains and in which amounts, i.e. if it contains explosive material and/or other CBRN materials. The detection of explosives can be divided into two groups: bulk detection methods and trace detection methods. Bulk detection means that the explosive in the IED is directly detected, and it therefore has to be visible for the method to work in current methods. Trace detection focuses on finding the trace amounts of explosives as gases or particles around an object containing explosive materials. This can for example be packing material, bags or a person who has handled the IED. Studies have shown that it is very difficult to avoid leaving traces when handling explosive material.

The methods available today are generally able to detect only a few explosives and markers, and they are not fast enough to allow for example screening of passengers at airports, subway stations or buses. For a screening system to be useful it has to be fast and be able to identify more substances with a low risk of false alarms.

2.1.2.1 Bulk detection methods

2.1.2.1.1 X-ray methods

X-rays penetrate most material deeply, and X-ray scattering is therefore a convenient way to scan through for example bags and briefcases without opening them. In combination with imaging, the contents of the scanned object will appear as a visual picture on a screen that can be studied by trained staff. With some X-ray systems, the so-called EDS systems, it is also possible to detect explosives by viewing the object, e.g. the bag, from several different angles. Then the density of the material inside the bag can be estimated, and if the density is found to be close to the density of a known explosive the system gives a warning.

X-ray diffraction, XRD, is a method combining the EDS systems with X-ray diffraction in order to identify the chemical structure of the suspected material. The system first uses EDS to find a suspect object, and then XRD to identify what substance the object contains. The number of false alarms is thus reduced compared to the EDS system. X-ray technology might be a promising technique for future stand-off detection. A large problem in using the technique, however, is the health risk following X-ray exposure to humans.

EXDEP, Explosives detection with energetic photons, K. W. Habinger et al. [4], is an experimental technique which uses intense 13.5 MeV electron-generated X-rays to activate nitrogen, which is present in most explosives. By studying the decay of the nitrogen and the activity one can get indications of explosive material. This method is, however, at the experimental stage, it is time consuming and has poor resolution, and at the present stage it is not considered a promising technique.

2.1.2.1.2 Neutron and gamma ray based techniques

Neutrons and gamma rays are able to penetrate materials, and can be used to examine volumes, for example bags. By bombarding a sample with neutrons and observe the emitted gamma radiation, the chemical composition and abundance can be estimated. Both neutrons and gamma rays pose health hazards, which make these techniques only applicable to luggage.

2.1.2.2 Trace detection methods – existing

Trace detection includes techniques to find and identify the trace amounts of explosives present in gas phase or as particle around an object, such as packing material or on the hands of a person who has handled explosives. Such traces are very difficult to avoid when handling explosives. To be able to take advantage of trace detection methods, sampling of vapors and particles is essential.

2.1.2.2.1 Sampling and collection

Many explosives have very low vapor pressure, and therefore there is not always enough explosives vapor available to enable gas phase sampling. In these cases it is necessary to collect explosives particles instead of vapor. Even when one tries very thoroughly to avoid leaving traces, handling explosives will give residuals on for example hands and clothes. There might also be residuals on briefcases, passports and wallets, for instance. With 10% collection efficiency a tenth generation fingerprint contains enough material to be detected by current trace detection technology [10]. Collection or sampling of explosives differs widely depending on what type of environment is of interest. Detection in a mass transport situation requires an extremely fast collection and detection.

Figure 1: Swiping a bag for particles for detection with Smiths Detection IonScan 400B (Courtesy of Smiths Detection)

Most trace detection systems used today have particle sampling by swipes. This is a time consuming procedure in which a swab is used on a piece of luggage and the swab is then analyzed for traces of explosives. Today the demand for a faster collection system is high, and it is desired to be able to analyze an object without touching it, i.e. stand-off detection. A system designed for screening at e.g. an airport has been presented in a patent [11]. It is a walk in inspection apparatus for production of air samples containing vapors of explosives, drugs or other substances carried by a person. Puffs of air are blown on the person inside the inspection booth, and a blower outside the booth sucks in a large volume of air both form around the person and horizontally through the funnels in the end wall and through ducts. This air is then analyzed.

2.1.2.2.2 Chemical reaction detection

Test kits are avaliable for rapid identification on an unknown powder. These tests result in colored reaction products when nitro-aromatic and nitramine compounds are reacted with alkali or acidic solutions. The operator can visually determine the presence of various compounds by the color development of the extract. The absorbance at a specific wavelength can also be measured and correlated to the compound concentration. The level of sensitivity is in the nanogram range. The testing procedure is fast and efficient, and the result appears in seconds.

2.1.2.2.3 Photoluminescence and Organic polymers detectors

Photoluminescence detection can be used to provide sensitive, selective detection of one or a few target chemicals at the time. This can be done using semi conducting organic polymers (SOPs), which fluoresces when illuminated by ultraviolet light. This fluorescence is changed when the SOP is exposed to nitro aromatic vapour. The detection levels are given as 5 ppb for TNT and 100 ppb for DNT and the detection time 1 second [15]. The simultaneous response for both TNT and DNT (and other nitro aromatic compounds) can be an advantage since the concentration of DNT and other degradation products are present to a larger extent than the pure TNT.

2.1.2.2.4 Immunoassay and biosensor detection

Immunoassays and biosensors take advantage of the ability of antibodies to selectively bind to a primary target analyte present in low concentrations in a complex matrix. A sample is mixed with an enzyme conjugate of the explosive and particles with antibodies specific to the explosive. Any explosives present in the sample will compete with the enzyme for the antibody binding sites on the particles. By adding an enzyme substrate and a chromogen it is possible to detect the presence of e.g. an explosive in the sample.

2.1.2.2.5 Surface acoustic wave sensors

The principle of surface acoustic wave sensors is that an acoustic wave confined to the surface of a piezoelectric substrate material is generated and allowed to propagate. If a vapor is present on the same surface, the wave and any substances in the vapor will interact to alter the properties of the wave. By measuring the changes in the surface wave characteristics it is possible to get an indication of the properties of the vapor [16].

SAW devices coated with a thin layer of chemo-selective polymer can provide highly sensitive detectors for identifying vapors. This type of detector has been evaluated by Houser et al for TNT and DNT [17].

2.1.2.2.6 Ion mobility spectrometry

Ion mobility spectrometry, IMS, is a detection technology commonly used today for screening of both people and luggage at air-ports. The best results with this method are found for TNT and other nitrotoluenes.

A development of this method is LIMS, where laser ionization is used. The advantages with this method are the increased selectivity and the reduced background.

2.1.2.2.7 FAIMS (high field asymmetric waveform ion mobility spectrometry)

FAIMS is an improvement or refinement of the IMS technique which further increase the selectivity. FAIMS is also known as IMIS (Ion mobility increment spectrometry) or Field ion spectrometry. A commercial detector based on FAIMS in combination with MEMS and microfabrication technology is the EGIS Defender from Thermo Electron Corporation [18]. They state nanogram detection levels of nitrates, EGDN/AN, NG, DNT/TNT, PETN, RDX, TATP, HMTD and tetryl in 10-12 seconds.

2.1.2.2.8 Mass spectroscopy

Mass spectrometry is a sensitive technique used to identify a molecule by its mass and fragmentation pattern, and it is often used in combination with other methods. It requires only trace amounts of sample.

2.1.2.2.9 Infrared and Raman spectroscopy

Fourier transform infrared spectroscopy is a characterization technique used to identify the composition of an inorganic or organic substance. Infrared radiation is absorbed by the vibrational modes in the sample molecule, these energy levels are specific for each substance and can serve as fingerprints in the identification.

Raman spectroscopy uses the in-elastically scattered light from a sample in the identification. The shift in energy between the incoming light and the scattered photons matches the Raman active vibrational levels in the molecules, and is species specific. Raman spectroscopy is extremely information rich and thus very interesting as a method to identify the chemical composition of unknown explosives. A visible quantity (ng) is required for this method to be useful.

2.1.2.2.10 Canine detection

The use of dogs in detecting explosive and other material is well established. In the last decade, dogs trained to detect flammable and ignitable liquid residues, called accelerant detector dogs, have become widely used, and their alert has proven to be admissible as evidence. A number of studies have been performed on detection dog-handler teams but in many cases the results are confidential and therefore note easily available. A review of this subject was published in 2001 by Furton and Myers [19]. The conclusion from this is that dogs still represent the fastest, most versatile, reliable real-time explosive detection device available.

3 Candidate security solutions and current research

This chapter describes security solutions for mass transportation security which are not yet widely deployed. There is much information on current FP7 Security Research projects in the brochure published by the EC [1]. Note that relevant research is also being performed in other research programmes that do not necessarily have the "security" label. In order to limit the scope, primarily European research initiatives are covered.

3.1 Network enabling of public transportation for increased security

The coverage of Wi-Fi hotspots is expanding, especially in urban areas, enabling the public to access the internet at virtually any place, such as bus-terminals, trains stations etc. The capacity and speed of mobile broad-band has also increased in the last few years and is expected to continue to do so when operators improve on existing software and hardware, and starting the roll-out of the next generation mobile network, Long Time Evolution (LTE), or 4G. LTE will allow 75-100 MBPS uplink speeds and 250-300 MBPS downlink speeds, to be compared with 3G offering 11.5 MBPS and 28 MBPS respectively [48].

Also, public transportation companies are planning to service their customers with Wi-Fi access onboard busses and trains, providing the passenger the possibility to get on-line while travelling. The network enabling of vehicles in the public transportation sector not only serves the purpose of providing the passenger access to the internet, but also has major implications for increased security and safety. Traffic control can monitor the state of individual vehicles in real-time, for example position, speed, fuel-consumption etc., and perform more sophisticated forms of traffic management. Also, this means that various surveillance systems can be deployed on busses, trains and at major stops in order identify suspicious behaviours, identify ongoing vandalism and more in real-time. In case of accidents, or criminal/terrorist acts, traffic control can cooperate efficiently with concerned agencies, and through the network, the response/rescue team can get access to live-video feeds, and/or data from other types of sensors, en-route to the target site. This will enable increased situational awareness at all levels. In addition to this, passengers with Internet access may in an easy way stay informed concerning travelling information in general, or regarding the evolution of a particular event that is taking place in their immediate surrounding. Moreover, they may use the connectivity to post information, related to a particular situation, on blogs, micro-blogs, etc., which may be utilized in a command and control context to gain an even better situational awareness.

There are several examples of public transportation companies rolling out, or testing, solutions for network enabling of their buss/train fleets. In 2008 SL (Stockholms Lokaltrafik) carried out a pilot demonstrating the possibilities of Wi-Fi connectivity onboard busses covering a route from Stockholm to Norrtälje (approximately 70 km) [49]. A number of real-time applications were demonstrated, including Wi-Fi access for passengers, pushing of commercials and travel information to various screens onboard the busses, environmental application, including for instance feedback to traffic control on CO_2 emissions per passenger etc. Further, feeding of surveillance images from busses to traffic control was tested (however, in this case pre-prepared images were used). There are several similar projects around the globe, see for example [50]. Several deployments of Wi-Fi video surveillance systems (for real-time applications) are being made, part of various homeland security initiatives [51]. All in all, the above indicates that network connectivity on public transportation will be a general commodity within the next few years, and given the increased capacity and speeds of these networks, more demanding services and application may be deployed for increased security and safety.

There are also other aspects of this evolution. Network enabling of vehicles, i.e. enabling of communication between individual vehicles, and from vehicle to infrastructure, is also bringing other types of opportunities concerning safety. For instance, within ERTICO – "*a multi-sector, public/private partnership pursuing the development and deployment of Intelligent Transport Systems and Services (ITS)*" [52], a number of safety-related research programs are being conducted within the EU. The SAFESPOT [53] and CVIS [54] projects aiming at the design of cooperative systems for increased road-safety based on vehicle to vehicle and vehicle to infrastructure communication. This would in the end enable features such as increased intersection safety, safe overtaking, reporting of road condition, head on collision warning, speed limitation, safety distance etc. Note, however, that increased automation and computerisation also potentially introduces new opportunities for attackers, which implies that further research is required to determine if these measures result in improved overall security and safety.

3.2 Information Technology for Protecting the Security of Mass Transportation

New threats towards mass transportation occur continuously and technology used to identify and protect against these threats becomes more relevant. When searching for the terrorists that bombed three underground trains and a bus in July 2005 in London, Scotland Yard, the headquarters of the Metropolitan Police Service responsible for policing Greater London, reviewed hour after hour of footage. This proves the usefulness of video for investigating acts of terrorism and crime, but it also shows that it can only help investigate an incident, not prevent or mitigate a crime or attack.

To be able to prevent and foresee possible threats something more than just video is needed. Instead of using information from one source we can combine information from several different sources and use this combined information to foresee possible events that could threat the security of mass transportation.

3.2.1 Situation awareness

To understand the impact of information you obtain, events that occurs, and your own actions we need something called situation awareness. The goal of situation awareness is to provide a user with enough information so that they can achieve their objectives. Extensive research is done on situation awareness that deals with military situations, but it can easily be adapted to solutions to civilian uses, such as mass transport security.

Situation awareness can be described in several different ways. In [59] it is described as knowing what the opponent is doing and why they are doing it. In this paper they argue for the necessity of having automated situation awareness in order to achieve information superiority on the battlefield. The paper presents two different applications, one based on the build-up to the Kuwait war in 1991, and the other a network intrusion example. In both cases, the authors break down the situation into events that the system should look for. For example, an observation of troops moving closer to the border increases the level of aggression that the situational awareness systems believes that Iraq has against Kuwait.

Situation awareness that is used to forecasts regarding future events is called predictive situation awareness. Predicative situation awareness is useful to obtain mass transport security since it can be used to foresee dangerous situation and the opportunity to prevent that these situations occurs.

Situation awareness is obtained by combining, modelling and visualizing information from several differnt sources in a suitable way.

3.2.2 Plan recognition

Plan recognition is a complement to situation awareness that can be used to prevent attacks, accidents and crimes in mass transportation. Plan recognition differs from situation awareness in the sense that it is used to refer to the task of inferring another agent's plan or plans based on observations of the agent's actions or the effects of those actions [65][68]. The plan recognition problem consists of recognizing an agent's goal as well as the plan by which it attempts to achieve the goal based on observing the agent's actions.

In general, plan recognition relies on a *plan library* that consists of plans that can potentially be executed by the observed agent. The plan library usually consists of a set of top-level plans that are decomposed hierarchically. A plan recognizer is used to match observations to specific plan steps in the library and to infer possible top-level plans.

Plan recognition problems can be classified as either intended plan recognition or keyhole plan recognition [66]. In intended plan recognition the recognizer can assume that the agent is deliberately structuring his activities in order to make his intentions clear while in keyhole plan recognition this is not the case. Plan recognition problems can also be classified as obstructed plan recognition which is when the agent may try to perform erroneous plans [67].

There two common approaches to solve the plan recognition problem: *symbolic plan recognition* and *probabilistic plan recognition.* Symbolic plan recognition [66][69] is based on the idea of checking consistency of the plans in the plan library while probabilistic plan recognition [70][71] is based on the idea of selecting the plan that has a high probability based on a set of observations. Symbolic and probabilistic plan recognition can also be combined with decision-theoretic plan recognition [72] which is based on the idea of maximizing a known utility function.

When only the goal of an agent is of interest, the plan recognition problem reduces to goal recognition. Plan recognition is very similar to activity recognition, intent recognition, and behaviour recognition since they all involve making inferences about other agents based on observations of their behaviour. We use term activity recognition as a collective name to describe plan recognition, goal recognition, intent recognition and behaviour recognition since it covers all of them.

Activity recognition is an important issue in several areas and applications. For example, the ability to automatically detect activities is of increasing importance in applications such as bank security, airport tarmac security, baggage area security and building site surveillance. A concrete example of where plan recognition technology is used is given in [73] where the aim is to identify terrorist activity.

3.2.3 Information Fusion

Information fusion is the act of merging information from different sources with differing conceptual, contextual and typographical representations. This is an important technology that is used to obtain situation awareness as well as input for plan recognition and activity recognition.

Information relies more and more on multimedia documents mixing at the same time text, images, speech, video, geographically based information systems, dense or scarce sensory data etc. Fusion of these different kinds of information could be important for mass transportation security, since analysis of, e.g., open source text from the web could enable analysts to detect weak signals that give early warnings about terrorist attacks. Thus, information fusion has to be able to handle all kinds of information. Up to-date techniques create a semantic representation of the concept represented in the diverse media, in order to allow a fusion of the data at this semantic level.

These techniques are ontology based, raising problems like the continuous maintenance of these ontologies in order to allow them to integrate new concepts and always be close to the evolution of the world. Setting and maintenance of large ontologies needs huge computing capabilities.

There are several technologies that can be used to process data in an intelligent way so that it can be used for information fusion.

3.2.4 Techniques for processing data

Several techniques are available for processing data. Processed data is then merged using information fusion and used as input for situation awareness and plan recognition. A mentioned before, data can come from several different sources such as images, videos and sensors.

One example of data that can be used is text. Text can come from many different sources, like deployed sensors in the system, newspapers, weblogs or from the transport passengers, microblogging about what they are doing and what is happening at the moment. Since text is unstructured, it is important to have proper tools than can analyse it and extract the relevant information to the user.

Searching is an example of an important technology to extract information that is relevant from large amount of text. Text mining is another important technique for processing text since large amount of text can be analyzed automatically. A paper by [57] discusses some problems inherent to mining the internet for open source intelligence information. Such mining can be an important input to both plan recognition and situation awareness. Of particular interest is the large number of newspapers that also provide web access to their articles.

3.2.5 Mixed-initiative approaches

Mixed initiative interaction[1] is a recently introduced paradigm for systems where several agents interact in a flexible manner, i.e., where there is no fixed structure that determines whose turn it is to "control" the reasoning process. Most often, such systems consist of two agents: a human operator and a computer system that assists the human in some task. In principle, the same methods could be used also for systems consisting of many computer tools that interact with each other and/or with humans. Mixed initiative interaction is a paradigm that is useful for secure mass transportation since the idea with a mixed-initiative interaction, is that each agent does what it does best.

For instance, a human could supply intuition and experience to a situation while the computer uses its computing power to retrieve, search and calculate. In some parts of the process, it will be the human who has the initiative and control, while in others the computer will take over and show results to the user.

Mixed-initiative approaches combine the strengths of the user and the computer and allow them to reason in dialogue with each other. This can be used to obtain better results in both situation awareness and plan recognition since the human intuition can be used in combination with knowledge/computations/retrieval from the computer.

3.3 Protection against airborne toxic agents

An intentional release of chemical or biological toxic agents in enclosed spaces like in stations or vehicles may rapidly lead to lethal concentration levels because the contaminants are diluted into relatively small air volumes. Unlike in outdoor releases, the indoor concentrations can also remain high for relatively long periods of time. Attacks may involve fast-acting agents (generally chemicals), causing victims' symptoms to appear within seconds to minutes, or slower acting agents (generally biological toxins or microorganisms) for which the onset of symptoms may begin after a delay of hours to days. Vulnerability to biological agents exists mainly because of the current inability to detect their presence in time for prompt response actions.

In case of a terrorist attack, where the warning time is zero, permanent protection must be available continuously. A promising protection solution consists of an advanced high-efficient particle filtration operating continuously combined with chemical agent detector to recognise the threat and trigger additional protective measures. Additional protective measures not only guard against the primary threat from CBR, but also improve indoor air quality and reduce passengers' exposure to airborne microbes. [74]

[1] An article by Allen[64], which is part of a special section devoted entirely to mixed-initiative interactions, gives a readable overview of the subject.

3.4 Explosive devices

3.4.1 Bulk detection methods – emerging

3.4.1.1 Millimeter wave imaging and THz spectroscopy (emerging)

Millimeter-wave imaging is a technique used to look through materials. Special sensors detect naturally emitted or from objects reflected waves with a wavelength of approximately 3 mm (frequency 100 GHz). This wavelength can pass through clothing, but dense objects reflect a clear profile by blocking the body's natural radiation. Each type of material has its own frequency response, which may be useful for material identification in the future. The system can also be operated in an active mode [8], where high frequency radiation (100 GHz) is emitted from a source, and the reflected waves are detected. The technique is completely harmless to humans, which makes the technique applicable for screening people.

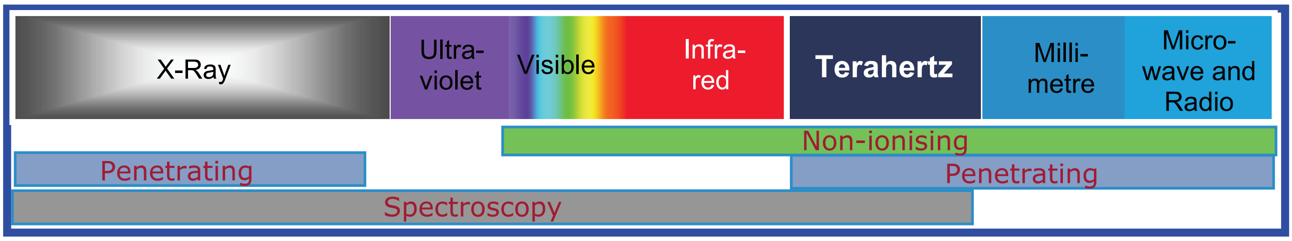

Figure 2: Illustration of the electromegnetic spectrum showing the THz-region. (From Kemp [9])

THz spectroscopy is an emerging technique used to detect explosives and other substances in sealed, non-metallic containers. Clothes and many other materials become nearly transparent to electromagnetic waves with a wavelength longer than 300 µm, corresponding to appr. 1 THz. This frequency regime enables imaging of substances hidden under for example clothes without the harmful ionizing radiation, and since it is not harmful to humans it is possible to screen people for hidden objects.

Kemp [9] has investigated several common explosives, TNT, HMX, PETN, RDX, PE-4 and Semtex, and found that they all show characteristic features in the range 0.5 to 3 THz. It was also found that there was no significant confusion between the explosives and harmless materials.

3.4.1.1.1 Magnetic techniques – NMR and NQR

Nuclear magnetic resonance, NMR, can be used to distinguish between different chemical species. It is today straightforward to observe magnetic resonance signals for a large number of explosives in a laboratory setting, but it is not possible to identify these materials in the field. For these measurements strong magnetic fields are needed, which is a severe problem. Even if this difficulty could be overcome, applying strong homogeneous magnetic fields would destroy many other materials, such as magnetic recordings. Nuclear quadrupole resonance, NQR, is another method to observe magnetic resonance without the use of magnetic fields. With NQR it is possible to detect buried landmines [5], which is an indication of the possibilities to detect other hidden explosives.

3.4.2 Trace detection methods – emerging

3.4.2.1 DESI (Desorption electrospray ionization)

DESI has been used in trace detection of RDX, HMX, TNT, PETN and their corresponding Composition C4, Semtex-H, Detasheet [20]. In the analysis of RDX, HMX and TNT, additives were used to increase the selectivity. The limit of detection of the neat explosives was sub-nanogram in all cases, and sub-picogram in the case of TNT. With DESI it was also possible to detect explosives in complex matrices, for example household cleaners and diesel fuel [20]. Recently the same researchers were also able to detect TATP on paper, metal and brick as well as in methanol, vinegar and diesel [21].

3.4.2.2 MALDI (Matrix assisted laser desorption) and Ion mass spectrometry

Matrix assisted laser desorption is a soft ionization technique followed by mass spectrometry. It is widely used for analysis of both organic and biological polymers. One of the disadvantages with MALDI is that it is not possible to analyze compounds that decompose in the presence of acid. Another problem is a reduced sensitivity when analyzing samples with low molecular weight. Several solutions have been proposed to overcome these problems, including the use of high-molecular weight matrices [22]. There have also been experiments with no matrix at all and with other types of matrices.

Using MALDI in trace detection of explosives has been proposed in a patent [23], but no experimental evidence has been found.

3.4.2.3 Electronic noses

An electronic nose is an instrument which consists of an array of electronic chemical sensors with partial specificity and an appropriate pattern recognition system, which is capable of recognizing simple or complex odors [24]. In the ideal case every vapor that the electronic nose is exposed to will cause some or all of the sensor elements to respond different, producing unique response patterns that encode each vapor. By computational analysis these patterns can then be correlated with specific vapors. The use of such response patterns provides a combinatorial advantage that allows the discrimination of more odors than there are types of sensors[25]. There are many types of electronic noses, and they will not be presented here. An overview can be found in [26].

3.4.2.4 Surface Plasmon Resonance

Surface Plasmon Resonance is based on optical refraction, and the competition between reflection and absorption of a meterial. The method works best for heavier molecules, and is commonly used for determining properties of proteins, sugars and DNA. To detect explosives, which are relatively small molecules, a binding antibody of larger molecular mass can be used to increase the weight [27] [28]. With this method TNT concentrations in the range 60 ppt to 1000 ppb have been measured [27].

A study focusing more generally on NO- containing species gives detection limits of 1.2 nmol/l (29 ppb) for NO2, 7.6 nmol/l (184 ppb) for C6H5NO2 and 0.17 nmol/l (4.1 ppb) for DNT [29].

3.4.2.5 Quantum cascade lasers and IR spectroscopy

Quantum cascade (QC) lasers work in the mid-IR region (3-20 µm). Methods that are currently being explored for explosives detection in the mid IR range are for example continuous wave CRDS based methods [30], absorption spectroscopy and evanescent field spectroscopy [31]. To this point, however, no evidence of explosives detection has been found.

3.4.2.6 LI-MS (Laser ionization mass spectrometry)

LI-MS has been demonstrated for nitrobenzene, 1,3-dinitrobenzene, o-nitrotoluene, 2,4-dinitrotoluene and 2,4,6-trinitrotoluene as well as the peroxide based explosive triacetone triperoxide in gas phase [32].

A more selective method is Jet-REMPI-MS, which combines optical spectroscopy and mass spectroscopy. This method can be applied to for example security screening of personnel, hand-carried baggage, checked baggage. Presently this method is being developed to increase the sensitivity and reliability, in order to detect trace amounts of explosives.

3.4.2.7 SERS (Surface enhanced Raman spectroscopy)

The Raman scattered light from a surface is a unique "fingerprint" of the chemistry of the surface. Raman spectroscopy is an insensitive method, but there are variations to Raman spectroscopy to make the technique more sensitive. One of these is Surface enhanced Raman spectroscopy, which has been used to detect vapor from TNT at room temperature in laboratory environment [77].

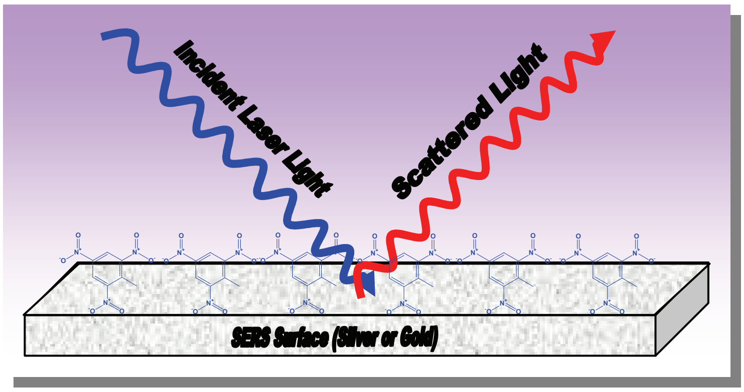

Figure 3: Schematic illustration of SERS

3.4.2.8 Electrochemistry

Electrochemistry is an analytical method useful for analysis of trace amounts of a substance in an electrolyte. Two examples of electrochemical sensors have been presented by Sakovich et al. [34] and by Wallenborg and Bailey [35]. The sensitivity of at least these forms is far too low for detection of low vapor pressure explosives.

Spectro-electrochemistry is a combination of electrochemistry with a spectrometric method such as Raman spectroscopy, SERS, IR absorption or UV-Vis spectroscopy for identification. By a suitable combination of techniques it might be possible to improve the sensitivity.

3.4.3 Stand-off techniques for Trace detection

3.4.3.1 LIBS (Laser induced breakdown spectroscopy)

Laser induced breakdown spectroscopy, LIBS, is a detection method that uses a laser with high enough energy to break down the sample into plasma. The atoms, molecules and ions in this plasma emit light with characteristic frequencies, which can be detected with a spectrometer. In this way the elemental composition can be determined.

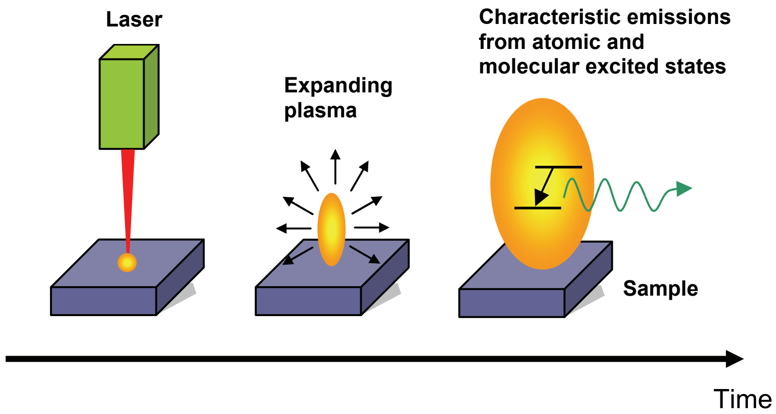

Figure 4: Illustration of the LIBS principle

In a real environment there will be many interfering substances present, and the explosive surface might not be directly exposed to the detector. Among the advantages of LIBS systems are the large stand-off distances possible by using a laser. Lopez-Moreno et al. [38] used LIBS in stand-off detection of explosive residues on a car at a distance of 30 m. It also has relatively low purchase and maintenance cost. Since all materials have a LIBS signature, no sample preparation and no consumables are required. Among the disadvantages is need for strong focused high energy required to form the plasma, which also ablates the surface material.

No study has been found that describes the LIBS sensitivity in relation to the available amount of substance, and it is unclear how easily particle detection is handled at a distance.

3.4.3.2 CARS (Coherent Anti-Stokes Raman spectroscopy)

Coherent anti-stokes Raman spectroscopy (CARS) is a variant of Raman spectroscopy that has been investigated in several studies concerning the identification of explosive material. Portnov et al. [40] use CARS for detection of fingerprint particles of e.g. RDX, and Katz et al. [41] has demonstrated stand-off detection of trace amounts of solid explosives (KNO_3, RDX) at ranges up to 12 m. Li et al. [42][43] report the detection of several chemicals from a 12 m stand-off distance..

3.4.3.3 PLP/LIF or PF/LIF

For nitrogen compound based explosives, it is possible to combine photo fragmentation and the detection of photo dissociated NO radicals. This is not a selective method, but will rather alert for any nitrogen containing compound. Since NO is frequently present in the atmosphere, interference of background NO can cause problem. Detection limits for TNT of 15 ppb at near ambient conditions and at a range of 15 m Has been reported [44]. Other publications have reported sensitivities of 40 ppb [45] or low ppm [46] levels. This technique has potential for remote detection, but the sensitivity has to be increased.

3.4.3.4 LIDAR

Light detection and ranging, LIDAR, is similar to RADAR (radio detection and ranging) with the use of laser pulses instead of radio waves. Typically LIDAR is used for environmental monitoring. The detected substances are then present in much higher concentrations than explosives vapor around an object. LIDAR has, however, been mentioned as a possible detection method for explosives provided that the sensitivity can be improved [47].

3.4.3.5 Resonant Raman spectroscopy

Standard Raman spectroscopy have problem with low sensitivity and fluorescence. In resonant Raman spectroscopy [75], however, these factors are greatly improved. By resonant enhancement the signal is increased, which leads to significantly lower detection limits. Enhancements close to 60.000 times has been reported for TNT in vapour phase, which led to detection limits of around 30 ppm. [76]

3.4.4 Conclusion on explosives detection

To conclude the detection methods mentioned in the previous chapters, some methods are more suitable than others in a mass transportation scenario. The existing techniques described in section 2.1.2, such as x-ray techniques and chemical analysis of swiping samples are time consuming but can still be useful. Some of the most promising techniques to screen people and luggage with higher sensitivity than the present methods could be THz imaging (see section 3.4.1.1), laser based stand off techniques, such as Raman spectroscopy (see section 3.4.3.5), and area surveillance schemes, such as described in the LOTUS project (see section 3.10.11).

3.5 Detection and identification

This section contains a short description of the state of the art of technologies in the domain of “Detection and Identification” with regard to security of mass transport, with subtopics: smart sensors / sensor networks, situational awareness, biometrics, tracking and tracing of goods and persons. This concerns technology development activities which lead to demonstrable capabilities, not consultancy oriented knowledge.

Detection and Identification technologies are typically projected on (partially) automating of the capabilities that used to be performed by humans:

- Collecting and presenting raw data in context (human as sensor);
- Situational awareness (data fusion, information fusion, filtering and searching);
- Detection of hazardous materials and objects (CBRNE agents, including explosives, weapons, drugs, alcohol, smoke);
- Measuring of physical human attributes (body heat, heartbeat, gait);
- Detection, recognition and localization of certain persons, groups of persons or cars;
- Behavior detection and analysis (lost luggage, loitering aggressive behavior, fear, vandalism, evasive behavior, response to triggers);
- Passenger flow analysis;

- Tracking (combining observations over time and place)

This section gives a short overview of the state of the art for these capabilities. The status is communicated with a short description and a current TRL (Technology Readiness Level, see Table 1 below).

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Table 1: Technology Readiness Levels in the Department of Defense [78]

3.5.1 Collecting and presenting raw data in context

- Together with a SME, TNO has developed the SpotShot for automating a periodic visual inspection of an area. It is currently deployed in the ADO Soccer Stadium. TRL=9

- The concept “hearing without listening” is under development. This concept masks sounds such that an operator can hear what happens, but can not listen into speech. TRL=4

3.5.2 Collecting and presenting situational awareness to humans

The reason for detection and identification is the collection of situational awareness. Current research projects on this subject are:

- The concept “3D Audio” offers sounds in 3d to the operator, in order to enhance his situational awareness. TRL=4
- Data-fusion and information-fusion based on people tracking is under development. TRL=2
- The Early Warning System of TNO which aims to give hypotheses and warnings about probable vehicle trajectories and behavior. TRL=5
- Mainport Security is being developed. In this concept technologies are developed to monitor transfer of persons and goods on quays. TRL=5
- The concept Smart Observation of TNO is based on showing sensor data, such as video, on a 3d map of the surroundings. TRL=6
- Development of computer vision technologies and presentation technologies to find persons in non overlapping cameras, based on appearance such as clothing. (not face recognition) TRL=3-5

3.5.3 Detection of hazardous materials and objects

A lot of research is performed on the subject of detection of hazardous materials. Amongst them are:

- Development and test of sensors to detect explosives and chemical and biological agents TRL=4-9
- Development of mmwave scanners for hidden object detection. TRL=4

3.5.4 Measuring of physical human attributes

If people are intending to carry out criminal acts, the human body gives some information about it. Several research projects are looking into this subject:

- Development of a Human Gait Analysis with radar. This makes detection possible of heavy objects, or classification of gender or abnormal movement. TRL=2
- Development of aggression detection with radar. TRL=2
- Development of life sign detection with radar (for example for detection of abnormal heartbeat and respiration) TRL=3
- Development of IR detection of body temperatures. TRL=4

3.5.5 Detection and localization of certain persons, groups of persons or cars

There are several ways to detect and localize persons, groups and cars. Knowing where people, groups and cars are gives you a better situational awareness and a better feeling about what is going on. Technologies under research are:

- Mmwave scanners for biometrics. TRL=4
- Computer vision technologies to track persons in non overlapping cameras, based on appearance such as clothing (not being face recognition), TRL=3-5
- Multi-camera tracking of persons. TRL=6
- High-accuracy (cm) car-tracking with cameras (not base don license plates) TRL=8-9
- Car-tracking with radar. TRL=5
- Development of detection and localization of cars from a moving vehicle (TRL=6) and more general detection and localization of moving objects from a moving object. TRL=3

In line with the traceability of goods in a 3D environment research is going on regarding the use of passive and active tags to track objects and (exact) locations using stand-off radar technologies. The passive tags use no battery and transmit an identification code. The active tags/transponders use a battery which in addition allows for the possibility of transmitting data of connected/integrated sensor(s). With existing RFID technologies in mind we have tried to overcome limitations in exactly locating these tags, locating them through walls and trying to avoid expensive fabrication methods. As a result there are several ongoing patent applications and demonstrable tags. For the passive type tags the current TRL level is between 1 and 2 as all the comprising technologies exist or have been researched, however have not yet been combined to function as a whole. The active type tags/transponders are within the range 4 and 5 and have been demonstrated in a number of different contexts.

3.5.6 Behavior detection and analysis

On the subject of behavior detection much is research is currently going on. Behavior detection and analysis is a key element for the security of mass transport. Examples of technologies that are developing are:

- Technologies for detection of a hostile intent. TRL=3
- Technologies to detect aggression (within the EU project ADABTS). TRL=2
- Technologies for localized aggression detection based on audio. TRL=6
- Technologies for lost luggage detection. TRL=3
- Technologies for proximity detection of persons. TRL=3-4
- Technologies for suitcase-carrying-detection. TRL=3-4
- Technologies for loitering detection. TRL=3-4
- Technologies for group splitting detection TRL=3-4
- Technologies for wild-movement detection. TRL=3-4

3.5.7 Passenger flow analysis

- TNO is developing crowd-detection. TRL=3-4
- Within the EU project AMIDA technologies are developed for anomaly detection in people flow. TRL=4
- Another way to look at flows is against-the-flow-detection. TRL=3-4

3.5.8 Relevant other information sources:

TNO did a study for the Dutch coordinator for counter terrorism (NCTb) which resulted in list of 150 types of behavior that are relevant for public transport camera operators.

Within the PASR project ISCAPS several relevant scenarios were identified and several capabilities were demonstrated:

- Demonstration of detection of unattended luggage, find the moment it was put there and by whom, find the entrance and route of that person and tracing the person in order to locate him.
  - Luggage remains unattended for some period of time
  - Select from the video stream the moment that a person put down the luggage or walked away from it.
  - From that moment in time trace back the person and the luggage, in order to see through which entrance they entered and the route they took.
  - From that moment in time trace forward the person, in order to see where he is now.
- Demonstration that several human behaviours might lead to suspicion, including both terrorist and criminal intentions.
- Demonstration of early detections of a chemical attacks and the capability to see into darkened and smoke filled areas, an important assets for planning rescue operations.
- Demonstration that in a limited geographical area how cars can be followed and how people getting in and out of cars can be linked to parked vehicles.
- Connection of luggage to a biometric of a person

3.6 Critical infrastructure protection

Modern societies are increasingly dependent on a set of products and services which comprise the Critical Infrastructure (CI). CI are those assets and parts thereof which are essential for the maintenance of critical societal functions, including the supply chain, health, safety, security, economy or social well-being of people (European Commission, 2006). In many counties the transport system has been established as one of the main parts of the CI, together with energy and ICT. Failing CI may have serious consequences to citizens and society as a whole. Therefore, Critical Infrastructure Protection has received a lot of attention from policy makers and operators in recent years.

One type of threat consistently identified as a key challenge for Critical Infrastructure Protection is that of dependencies and interdependencies among different critical infrastructures. The topic of critical infrastructure (CI) dependencies is of high interest to society due to the possibility of cascading effects that may seriously harm society as a whole.

Research is going on on models and tools in support of risk and dependency analysis, and on developing innovative technologies for protection. In this research area European level project like ACIP, VITA, CI^2RCO, EURAM, IRRIIS, DIESIS and EURACOM are carried out.

Tools and models that have been developed include:

- Methods and tools for performing risk assessment and contingency planning (EURAM, EURACOM);
  These tools support in identifying interdependencies of the transport system with other

critical infrastructures and analyzing the risks attached.

- A research infrastructure to allow federated simulations of critical infrastructure, making it possible to study the effects that failures in one infrastructure (e.g. the energy sector, or ICT sector) may lead to incidents in other sectors (e.g. the transport system).
  TNO works on this modeling environment both internationally (DIESIS) and nationally. Nationally, we combine the effects of explosives to build objects (e.g. stations, tunnels) with the cascading effects to vital functions like electricity or transport. To model the urban surroundings, the model Urban Strategy is used.

Development of technology is mainly done with respect to detection and monitoring (see before). Furthermore, methods are developed to indicate what the threat is to a certain object: who is interested in the object (motivation and capability), what are his possibilities to attack the object (means and capabilities). Based on this, vulnerability studies are carried out in order to obtain information on the amount of damage and number of injuries. Advice is given how to prevent the attack, to protect the object, to minimize the effects and consequences of an attack and finally how to restore to normal business as fast as possible.

3.7 Human performance

The interaction between technology, organization and human capabilities in order to achieve optimal system performance, is at the heart of the human factors expertise. With respect to mass transportation, the following capabilities, exemplified by illustrative projects, are relevant.

3.7.1 Detection of abnormal behaviour

One of the safety measures frequently used at this moment are surveillance cameras. It is however unclear whether camera surveillance can be effective in detecting terrorist behavior. Before behavior detection techniques for cameras or other sensors can be developed further, research on the determinants of behavior that are characteristic for terrorist behavior is needed.

Some research projects (e.g. for the Dutch National anti-terrorist agency and within the FP7 project ADABTS) aim to identify behaviors that are specific for terrorist behavior in public spaces. First of all, terrorist behavior can be detected (by man) in every phase of the terrorist attack (preparation phase, attack, after the attack). However, not all the collected behaviors can be linked to only terrorism – some are also relevant for everyday crimes like pick pocketing or drug dealing. Therefore, a general term for this is “deviant behaviors”, behavior that indicates an individual’s hostile intent instead of “terrorist behavior.” Second, the differences between specific deviant behaviors collected at different public places (metro/tram/train stations) are minimal. The exception concerning locations is behavior at airports. A specific type of behavior can be normal at a train station, while it is deviant at an airport and the other way around. Also, cultural differences can influence a small sample of the assembled deviant behaviors. Third, experts state that at this moment 6% of the assembled deviant behaviors can be automatically detected, 40% can be detected by cameras or other sensors within 3 years and 54% of the assembled deviant behaviors can ‘never’ be detected by cameras or other sensors.

3.7.2 Perceptions of Security and Interventions by citizens

Besides the technological quality of security measures, the perception of these measures by citizens and passengers is also important. The goal of the FP7 project CPSI (Changing Perceptions of Security and Interventions) is to provide governments and related organizations with a methodology to increase insight into the determinants of actual and perceived security, and into which interventions are effective for increasing security. The deliverables of this project represents a practical and ready-to-use tool, which can be employed by policy makers and other end-users to formulate policy regarding security. This project has developed 1) a conceptual model of actual and perceived security and their determinants, 2) a methodology to collect, quantify, organize, analyse and interpret security-related data, 3) a data warehouse to store and extract for analysis data amassed using the methodology, and 4) carried out a validation study to test the model, methodology and data warehouse. The project deliverables can be used by end-users to assess security at the international, national and local levels and to draw conclusions regarding such issues as:

- What are the levels of actual and perceived security in specific locations?
- Which interventions work where?
- Which interventions should be implemented in which locations?

3.7.3 Control room design

Control rooms play a major role within traffic management, the operation of bridges and sluices, public safety and security and countless other applications. The functioning of these control and monitoring rooms depends on many factors. A good layout of the workplace is important, but so are the workload and operator competence.

It is important to base the work on an integral vision of the optimal cooperation between organization, man and technology. The basis for lay-out, workplace, application and user interface are optimized working methods and task performance in the control room. The design should be deducted from the aims and mission of the organization, the (working) processes and the collaboration with other parties inside and outside the control room. Also other relevant aspects, such as measuring the workload, the optimal crew size and operator training and education should be part of the design.

Many companies work on control room design. Two of them are TNO and the Norwegian firm IFE. TNO has worked on many (inter)national projects within various domains (control rooms, emergency rooms, surveillance rooms, crisis centres, call centres and operations rooms). IFE is working on the Halden Reactor Project, which looks at control rooms design and man-machine systems for control rooms in nuclear plants.

3.7.4 Training and simulation

The task of traffic managers will become more dynamic in the near future. The environment is more diverse, combining and integrating different modes of transport. In case accidents and crises occur, traffic managers need to act, in a distributed team setting, appropriately. This shift in tasks and environment poses different demands on the training of this personnel.

One way of training is the area of automated simulator-based training by means of Computer-Assisted Instruction (CAI). Traditionally, a CAI system does not enable a true dialogue between the learner and the virtual instructor. Most frequently, the system acts like a human expert, and authoritatively provides feedback and ways to improve the task performance.

TNO has developed a training simulator that enables the operator to train incident situations. Currently, the simulator is being improved by developing intelligent agents that support a qualified operator, who trains himself, without the presence of a human instructor. This intelligent, educational agent enables a dialogue between the learner and the agent.

3.8 Information management

Important issues concerning Intelligence and policing are related to build up standard situations and to spot or derive suspicious activities. In that way, organizations are able to take (counter) measures in time and direct personnel to areas that require specific actions or attentions (risk management chain). An important issue is to be able to predict possible activities as soon as possible. The activities not only relate to the development and application of new technology and techniques, but also to improve working processes supported by this technology.

The complete Intelligence chain of Direction, Collection, Processing, Dissemination and Taking measures should be integrated. Issues within this chain are:

- to direct and manage available sensors and sources to collect relevant information
- to develop models with indicators that define normal and abnormal behavior
- to process large volumes of documents and databases
- to analyse the information, i.e. to quantify the environment and threats/risks, given the available (collected) information

The last results give direction (again) to direct and manage sensors and sources to collect missing information, and to direct personnel in case measures have to be taken.

Prototypes and methodologies are available, but need to be adapted and improved for mass transportation security.

The following Programs and projects are examples of working in this field of Intelligence and Policing.

3.8.1 Research Program on Intelligence, Dutch Ministry of Defense, 2000 – ongoing

Projects within this program consists of subjects regarding the improvement of processing of information into intelligence, from the processing of documents to functionalities in order to quantify threats and risks (hypotheses management). Threat models are developed regarding terrorism and criminality as input to the hypotheses management module, to be able to support analysts in their effort to predict threats. Functionalities are tested with real operational data from current military missions.

Results:

- Evaluated functionality, implemented in the research framework (PARANOID = Program for Analysis and Retrieval On Intelligence Data)
- Description of threat models

3.8.2 Development of methodologies for information directive policing, Dutch Ministry of Internal Affairs and Defense, 2006 – 2008.

The goal of this project was to develop methodologies to define indicators and sources in the complete information and intelligence chain in order to improve the direction of police personnel to carry out their tasks. Environments were maritime border patrol and transport security (human trafficking, drugs, illegal waste).

3.8.3 Concept Development and Experimentation on Intelligence, Ministry of Defense, 2007 - 2009.

The goal of this project is to carry out experiments with Intelligence personnel in an operational environment to improve intelligence processes and to improve their skills and the usage of tooling within these processes. Experiences are carried out with intelligence personnel during exercises in general and during their preparation for missions abroad.

The processes and tooling to support intelligence personnel for their mission are tested and evaluated. The results are an overview of usable indicators in different stages of the information and intelligence chain to direct police personnel as soon as possible.

3.9 Mass Transportation Security Relevant Projects

3.9.1 TRIPS

Transport Infrastructures Protection System

For more information, see:
http://ec.europa.eu/enterprise/security/doc/project_flyers_2007/TRIPS.pdf

3.9.2 ISCAPS

The Integrated Surveillance of Crowded Areas for Public Security (ISCAPS) project was funded under the first call for proposals for the Preparatory Action on the Enhancement of the European Industrial Potential in the Field of Security Research (PASR 2004). The main goal of ISCAPS was to reinforce security for the European citizen and to downsize the terrorist threat by reducing the risks of malicious events. This was undertaken by providing efficient, real-time, user-friendly, highly automated surveillance of crowded areas which are significantly exposed to terrorist attacks.

For more information, see:
http://www.iscaps.reading.ac.uk/about.htm

3.9.3 TERASEC and the European Security Research Programme PASR

One of the fundamental roles of government is to help ensure the security of its citizens. Studies show the threat of terrorism, organised crime, and natural disasters are among Europeans' worst fears. The goal of European Security Research is making Europe more secure for its citizens while increasing its industrial competitiveness By co-operating and

coordinating efforts on a Europe-wide scale, the EU can better understand and respond to risks in a constantly changing world. The Preparatory Action on "Enhancement of the European Industrial Potential in the field of Security Research 2004-2006" (PASR) constitutes the Commission's contribution to the wider EU agenda for addressing key security challenges facing Europe and her partners. It focuses in particular on the development of a security research agenda to bridge the gap between civil research, as supported by EC Framework Programmes, and national and intergovernmental defence programmes.
In response to the first call for proposals in the frame of PASR 2004 a proposal "Active Terahertz Imaging for Security (TeraSec)" was submitted by a consortium of 14 European research organizations, universities and industrial partners. The proposal was selected for funding in July 2004. The key parameters of the project are:

- Project in the frame of PASR 2004
- 179 applications in PASR 2004
- TeraSec selected for funding in July 2004 (one out of 6 funded projects)
- Duration: 24 months (01.01.2005 -31.12.2006)
- Mission: Protection against terrorism
- Coordination: German Aerospace Center (DLR)

The TeraSec mission can be summarized as follows:
Suicide bombers and anonymous mail attacks have become serious threats world wide. Since X-ray is difficult to apply for personnel scans due to radiation safety regulations, new technologies for remote detection of threats are required. Also fast and reliable technologies are needed to detect threats hidden in mail or similar. Due to their unique properties terahertz (THz) rays offer an alternative inspection method which can cope with these new challenges. The goal of this project is to improve homeland security by developing a new technology which will allow detecting threats, explosives, pathogens and chemicals hidden by a person or inside an object such as letters or luggage. The new technology is based on THz radiation and advanced sensor concepts. In combination with existing sensors this will lead to an increased level of security at public places for example airports. This new class of sensors will support governments, agencies and public authorities in their effort to protect the public against terrorism

For more information see:
http://solarsystem.dlr.de/terasec/

3.9.4 HAMLeT

Human model MATROSHKA for radiation exposure determination of astronauts.

The European Space Agency's project MATROSHKA (MTR), dedicated to determine the radiation load on astronauts in- and outside the International Space Station (ISS), launched in Jan. 2004 and is currently in its experimental phase 3. MTR is an anthropomorphic upper torso phantom containing over 6,000 radiation detectors to determine the depth- and organ dose distribution in the body. It is the largest international research initiative performed in the field of space dosimetry, combining the expertise of leading research institutions all over the world.

Consequently it generates a huge pool of data of immense value. Aiming at optimal scientific exploitation, the project ***HAMLET*** will bring together a European expert committee, consisting exclusively of members of the MTR consortium, to process and compile the data acquired individually. Based on experimental input as well as on radiation transport calculations, a three-dimensional model for the dose distribution in an astronaut's body will be built up. The results describe the exposure conditions both for extra-vehicular activities (MTR-1:2004 05) and inside the ISS (MTR-2A/B:2006 08). The project goes beyond essential data analysis and incorporates a modelling approach to guide new experimental measurements and strengthen the predictive capacity. This allows further utilization of the data, particularly with respect to detailed modelling of radiation interactions in the human body. The scientific achievements contribute essentially to radiation risk estimations for future interplanetary human missions, putting them on a solid experimental and theoretical basis. The synthesis of data, considerably extending previous knowledge, constitutes a major accomplishment by which Europe can establish worldwide leadership in this special branch of space radiation research.

For more information, see:
http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_ES&ACTION=D&DOC=1&CAT=PROJ&QUERY=0123cd9658ad:df24:5da46595&RCN=89359

3.9.5 ISOTREX

ISOTREX - Integrated System for On-Line Explosives Trace Detection In Vapor And Solid State

The European ISOTREX Project, coordinated by ENEA, focuses on the development of laser equipment that can detect hidden explosives starting from their tracks released into the environment (gaseous emissions, particles scattered on land or clothes) to be used in Transit areas, where there is a large flow of people and goods (airports, railway stations, banks, post offices). Within ISOTREX will be realized: a) the subsystem based on LIBS (Laser Induced Breakdown Spectroscopy), which allows the detection of liquid and particles of explosives, b) the subsystem based on IR absorption methods (cavity ring-down or laser photo - acoustic spectrometer) for the detection of gaseous emissions of explosives.

For more details see:
http://ec.europa.eu/enterprise/security/doc/project_flyers_2007/ISOTREX.pdf

3.9.6 SAFEE

Security of air transportation; SP1, dedicated to the cabin of an aircraft, is to a large extent directly applicable to the cabin of other transport means.

Final demonstration with actors in a full size mock up at AIRBUS confirmed that the real problems usually pop-up when implementing the system in a real environment with real human beings!

[Ref 3] 1

3.9.7 SIC

SIC is a French national project dedicated to the protection of critical infrastructures with a demonstration in one administrative building and one commuter train station (project is midway); RATP and SNCF (French Railways) are involved.

[Ref 3] 4

3.9.8 VideoID

VideoID is a French national project involving RATP and UIC to assess feasibility of identification through non-cooperative video.

[Ref 3] 5

3.9.9 DESCARTES

DESCARTES is a French national project dedicated to crisis management, lead by Thales.

3.9.10 MARIUS

This PASR 2005 project lea by Thales aims at developing a pre-operational autonomous command post which can be deployed very quickly to monitor crisis management operations.. The CEA has demonstrated the use of a micro-drone as a mobile sensing system to be used inside a metro tunnel.

3.9.11 AIRSECURE

The AIRSECURE project (EU FP6) was concerned with risk based detection and protective filtration system for airports against airborne CBR hazards, and developed a system that consists of filtration and detection solutions against airborne threats at airports. The design and operation of the system is based on risk analysis and risk management. The complete AIRSECURE system can be divided into three main components: Risk management, filtration solutions, and detection solutions.

More information may be found at: http://www.3gfilters.com/airsecure/index.html

3.9.12 SECUREMETRO

The aim of the SECUREMETRO project is increased safety and security of metro vehicles from terrorist attacks by explosives and firebombs through materials choices and design, thereby increasing resilience and reducing the impact of attacks on passengers, staff, infrastructure and property.

The SecureMetro project will consider threats from conventional explosives and firebombs. The four project objectives are:

1. To increase metro vehicle resilience to terrorist bomb blast through selection of vehicle materials and structural design. This will reduce injuries from fragments of

vehicle materials and improve structural integrity in blast situations, offering greater security to passengers and staff. This includes enhancing the ability of a vehicle to remain on the track and keep moving so that underground rescue is not required. Contribution to structural integrity standard EN12663 will allow wide and interoperable implementation of vehicles offering security by design.

2. To increase security against a firebomb attack through design of fire barriers and fire suppression technology while also contributing to passenger safety from accidental or vandalism fires. Design of features to prevent the spread of fire and fumes will contribute to standards compliance (prEN 45545 and TS 45545) for fire protection of railway vehicles.
3. Through increasing resilience of vehicles to blast and fire attacks and reduced damage to adjacent vehicles and infrastructure, speed up recovery following attack, allowing the rail system to "bounce-back" to normal operation quickly.
4. Reduce the attractiveness of metro systems as a target for attack by reducing deaths and injuries, increased resilience, reducing economic impact and making recovery faster. This will be achieved through wide dissemination of the findings of SecureMetro, and promotion of transfer to high speed rail of the vehicle design and technology developed for metro systems.

The project is coordinated by the University of Newcastle-upon-Tyne, with the participation of INASMET-TECNALIA.

3.9.13 MIPMaDe

Modelling of Infrastructure Protection- From Materials To Devices
The latest trends on terrorist attacks involve the use of new explosives as well as new attacking strategies. Currently, there are design tools available to evaluate the behaviour and the damage experienced by a conventional structure when facing a fire or expansive waves as a result of an explosion.

What is missing are intelligent dynamic tools able to evaluate the degree of vulnerability of Critical Infrastructures, tools that can also help determine the most appropriate materials to design physical protection barriers.

A tool as the one mentioned above, will help identify the vital areas of the buildings susceptible of passive protection systems (e.g. armour systems, elastic structures) and the ones where an active protection system is required (e.g. sensor networks, video surveillance, alert systems).

Increasing security of a building to a terrorism bomb attack requires new simulations tools that can help also design (or re-design) the building's structures so that the damage to people and good are minimized.

Intelligent protection systems will provide a greater effectiveness and rapidness in alert systems and evacuation protocols. To achieve this target, this project proposes to develop a software tool for the intelligent design of Public Infrastructures which:

- optimizes the existing technologies as well as those under development
- tests new physical protection barriers

3.9.14 Nanosecure

The Nanosecure (IPPME) project aims to develop technologies for advanced nano technological detection and detoxification of harmful airborne substances for improved public security.

3.9.15 DITSEF

The full name of the FP7 DITSEF project is Digital & Innovative Technologies for Security & Efficiency of First responder operations.

3.9.16 Eritr@C

The Eritr@C project aims at extending the operation of a neutron based inspection system system (EURITRACK) to improve the data analysis and transfer the technology to UE Custom Agencies

3.9.17 SRIP

SRIP is a French national project dedicated to developing a robot for first responder.

3.9.18 BOOSTER

BOOSTER is a capability project designed to research and develop new bio-dosimetric tools in order to quickly evaluate the level of potential casualties

3.9.19 SEDUCE

Seduce stands for "Systems for explosives detection on centers and public infrastructures". The project aim is the increase of the security level on critical public centers such as ports, airports, rail stations and metro stations. This Spanish initiative has a high industrial participation. (Funded project in the call CENIT of CDTI).

3.9.20 CUSTOM

CUSTOM (FP7-SEC 2009-2) is a collaborative project for the development of sensor technologies in the field of drug detection

The objective of the project is to develop a drug precursor sensor demonstrator, implementing two main techniques. The first is low cost, high data throughput sensing technique, based on UV-Vis-NIR fluorescence. Fluorescence will be enhanced by development of Organic macro-molecules sensitive to specific classes of compounds of interest (ephedrine, pseudoephedryne, P2P, …) in the domain of drug detection. That first technique will be combined with a highly sensitive and selective, compact and low weight, spectroscopic sensing technique in Mid-IR optical range, based on Laser Photo-Acoustic Spectroscopy (LPAS). INASMET-TECANALIA main role is the fluorescence sensor development.

3.9.21 DECOTESS

The DECOTESS project is an FP7 Coordination and Support Action aimed at developing an CBRNE roadmap for the identification of existing technologies and the gap analysis to improve future development.

3.9.22 FBB

The aim of the Fluorescence based biosensor for microbial/life detection project is to develop a biosensor for microbial life detection (FBB) capable of providing information of the infestation status of an enclosed facility. The instrument will allow assessing the quality of food, water and surfaces of MISS-ISS payload before and after cleaning operations, the FBB project was funded by the European Space Agency.

3.9.23 ASPIC

ASPIC is a French national project (just completed) intended to generate a model of contamination of a structure receiving the public (this was done for an airport terminal, but would apply to a railway station as well).

For more information, see:
http://www.systematic-paris-region.org/fr/securite/UserFiles/File/ASPIC.pdf
(in French)

3.9.24 ASPIS

The recently started FP7 project ASPIS aims to develop a network of self-healing communications and security nodes capable of surviving major destructions. RATP (Paris transportation) is also a partner and is interested in hazard-proof video black-box. ASPIS is a last chance situation assessment tool that will be able to pass video and other sensor data after event if the communication infrastructure has collapsed. RATP has confirmed that they want to rely on the results of ASPIS in Phase II.

For more information, see: http://ipsc.jrc.ec.europa.eu/showca.php?id=86

3.10 Relevant projects where no further information has been provided

No additional information has been provided by the partners on these projects.

3.10.1 ADABTS

Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces

[Ref 1] 6

3.10.2 BeSeCu

Human behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication.

[Ref 1] 10

3.10.3 CAST

Comparative assessment of security-centered training curricula for first responders on disaster management in the EU.

[Ref 1] 12

3.10.4 COCAE

[Ref 1] 14

3.10.5 EFFISEC

Efficient Integrated Security Checkpoints
[Ref 1] 30

3.10.6 FRESP

Advanced First Response Respiratory Protection

[Ref 1] 44

3.10.7 iDetecT 4ALL

[Ref 1] 48

3.10.8 IMSK

Integrated Mobile Security Kit

[Ref 1] 50

3.10.9 INDECT

Intelligent information system supporting observation, searching and detection for security of citizens in urban environment

[Ref 1] 52

3.10.10 INFRA

Innovative & Novel First Responders Applications

[Ref 1] 56

3.10.11 LOTUS

Localization of Threat Substances in Urban Society

[Ref 1] 58

3.10.12 NMFRDisaster

[Ref 1] 60

3.10.13 OPTIX

Optical Technologies for Identification of Explosives

[Ref 1] 66

3.10.14 SAMURAI

Suspicious and Abnormal behaviour Monitoring Using a netwoRk of cAmeras & sensors for sItuation awareness enhancement

[Ref 1] 70

3.10.15 SUBITO

Surveillance of Unattended Baggage and the Identification and Tracking of the Owner
[Ref 1] 88

4 Technology overview

In Table 2 below, we present an overview where technologies and projects are mapped to technology categories and consequences. The mappings are explained in more detail in appendix A. Each cell in the overview has a different colour that illustrates the current status of the projects or technologies, structured as follows:

cell.number	Green colour: Technology exists and is in use.
cell.number	Yellow colour: Technology represents ongoing research
cell.number	Red colour: Technology gap identified.

Figure 5: Color coding of status of solutions

Each column in the overview is a threat category (e.g. Fire), while each row is a consequence (e.g. Reduce down time). This is shown below, with an excerpt of cell 3.10 as an example. Cell 3.10 is about reducing down time in connection with fires. The cell number maps to section numbers in the appendix, where more information about each cell can be found.

	...	Fire	...
Reduce down time	...	3.10	...

Figure 6: Example excerpt from the overview table

To continue our example, in appendix A 3.10 (reproduced in Figure 7), more information on the project CAST is provided; it is specified whether the project is about technology; administrative measures and routines; or human behaviour. Further, the development stage of the project is classified as either in use or research.

A 3.10 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the EU [ref 1]		x			x
...					

Figure 7: Example of project description in the appendix.

Table 2: Technologies (available, or ongoing research)

	Physical damage at the vehicle or infrastructure	**Damage to environment**	**Fire**	**Explosion**	**Biological**	**Chemical**	**Radioactivity**	**Injury**
Detect delivery, suspicious object or suspicious person	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1
Reaction capacity/capability when delivery, suspicious object or person is detected	1.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2
Prevent availability	1.3	2.3	3.3	4.3	5.3	6.3	7.3	8.3
Prevent detailed knowledge of vehicle and infrastructure	1.4	2.4	3.4	4.4	5.4	6.4	7.4	8.4
Detect hazard	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
Reduce down time	1.6	2.6	3.6	4.6	5.6	6.6	7.6	8.6
Reduce damages to vehicle or infrastructure	1.7	2.7	3.7	4.7	5.7	6.7	7.7	8.7
Reduce injuries	1.8	2.8	3.8	4.8	5.8	6.8	7.8	8.8
Reduce damages to environment	1.9	2.9	3.9	4.9	5.9	6.9	7.9	8.9

5 Summary and Conclusion

This deliverable has presented an overview of security technologies that are currently in use in European mass transportation, and technologies that represent recent or ongoing research. There is a strong focus on information fusion, detection of explosive devices and other dangerous substances, and human performance. Other ongoing and recently finished research projects which are relevant for mass transportation security have also been briefly described.

From the table on the previous page we see that few of the technologies described can truly be considered ”in use”, which may be a somewhat surprising result. The main reason for this must be attributed to the composition of partners who contributed to this deliverable, since they were predominantly research organisations. Obvious existing technologies such as fire-extinguishers and closed-circuit camera surveillance have not been covered, for the same reason. Also note that gaps are also identified where there are projects listed, but when there is insufficient information about the projects. This may thus change in later revisions.

This document will serve as a foundation for later deliverables in this work package, and serves to highlight areas in which new research may be needed.

6 Terms and Abbreviations

3G - 3rd generation mobile telephony (UMTS)
CARS - Coherent Anti-Stokes Raman spectroscopy
CBRN - Chemical, Biological, Radiological, and Nuclear
COTS - Commercial Off-The-Shelf
CRDS - Cavity Ringdown Spectroscopy
DARPA - Defence Advanced Research Programs Agency
DESI - Desorption electrospray ionization
DIAL - differential absorption LIDAR
DNT - Dinitrotoluene
FAIMS - high field asymmetric waveform ion mobility spectrometry
IED - Improvised Explosive Device
IMS - Ion mobility spectrometry
IR - InfraRed
LIBS - Laser induced breakdown spectroscopy
LIDAR - Light Detection and Ranging
LIMS - laser ionization mobility spectrometry
LTE - Long Time Evolution
MALDI - Matrix assisted laser desorption
MBPS - MegaBit Per Second
NMR - Nuclear magnetic resonance
NQR - Nuclear quadrupole resonance
PASR - Preparatory Action on Security Research
QC - quantum cascade
RFID - Radio Frequency IDentification
SERS - Surface enhanced Raman spectroscopy
SL - Stockholms Lokaltrafik
SOP - Semi conducting Organic Polymer
TNT - Tri-Nitro Toluene
TRL - Technology Readiness Level
UIMA - Unstructured Information Management Architecture
UMTS - Universal Mobile Telephone System
UV - UltraViolet
Wi-Fi - Wireless Fidelity, or IEEE 802.11 wireless networking

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Appendix A - Tables of technologies and projects

A 1 Physical damage to the vehicle or infrastructure or part of either of them

A 1.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1, p6]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observation, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
THALES VideoID [ref 3, #5]	x				x
Bulk detection methods See section 2.1.2.1	x			x	
Trace detection methods See section 2.1.2.2	x			x	
Situation awareness See section 3.2.1	x		x		x

A 1.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x

A 1.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x

A 1.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

A 1.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
Detection and identification See section 3.5	x			x	x
Situation awareness See section 3.2.1	x		x		x

A 1.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the EU [ref 1]		x			x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 1.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x

TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x
SECUREMETRO Sec section 3.9.12	x				x

A 1.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
SGL for USaR Second Generation Locator for Urban Search and Rescue Operations [ref 1]	x				x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 1.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 2 Damage to environment

A 2.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x
Bulk detection methods See section 2.1.2.1	x			x	
Trace detection methods See section 2.1.2.2	x			x	
Situation awareness See section 3.2.1	x		x		x

A 2.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x

A 2.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x

A 2.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

A 2.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
Situation awareness See section 3.2.1	x		x		x

A 2.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the EU [ref 1]		x			x

A 2.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the EU [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x

THALES SIC [ref 3, #4]	x	x			x

A 2.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
SGL for USaR Second Generation Locator for Urban Search and Rescue Operations [ref 1]	x				x

A 2.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x

A 3 Fire

A 3.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x
Situation awareness See section 3.2.1	x		x		x

A 3.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x

A 3.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x

A 3.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

A 3.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x

A 3.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 3.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x

SECUREMETRO Sec section 3.9.12	x				x

A 3.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 3.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x

INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 4 Explosion

A 4.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
LOTUS					
OPTIX Optical Technologies for Identification of Explosives [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
THALES VideoID [ref 3, #5]	x				x
Bulk detection methods See section 2.1.2.1	x			x	
Trace detection methods See section 2.1.2.2	x			x	
Situation awareness See section 3.2.1	x		x		x

A 4.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x

A 4.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x

A 4.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

A 4.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x

A 4.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 4.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x
SECUREMETRO Sec section 3.9.12	x				x

A 4.8 Reduce injuries

name and description	Category	Development stage

	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
SGL for USaR Second Generation Locator for Urban Search and Rescue Operations [ref 1]	x				x
ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 4.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
INFRA Innovative & Novel First Responders Applications [ref 1]	x				x

ASPIS Autonomous Surveillance in Public transport Infrastructure Systems See section 3.9.24	x				x

A 5 Biological

A 5.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x

A 5.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x
Protection against airborne toxic agents See section 3.3	x				x

A 5.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 5.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 5.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 5.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 5.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 5.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

Protection against airborne toxic agents See section 3.3	x				x

A 5.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6 Chemical

A 6.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
LOTUS Localization of Threat Substances in Urban Society [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x

A 6.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x
Protection against airborne toxic agents See section 3.3	x				x

A 6.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x

ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 6.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x

ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
Protection against airborne toxic agents See section 3.3	x				x

A 6.9 *Reduce damage to environment*

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7 Radioactivity

A 7.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
COCAE Cooperation Across Europe for Cd(Zn)Te based security [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x

A 7.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x

A 7.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x
HAMLeT Human model MATROSHKA for radiation exposure determination of astronauts. See section 3.9.4	x				x

A 7.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x

ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
FRESP AdvancedFirst Response Respiratory Protection [ref 1]	x				x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 7.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
ASPIC Tool for simulating contamination of public buildings. See section 3.9.23	x				x

A 8 Injury

A 8.1 Detect delivery, suspicious object or suspicious person

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
ADABTS Automatic Detection of Abnormal Behaviour and Threats in crowded Spaces [ref 1]	x				x
EFFISEC Efficient Integrated Security Checkpoints [ref 1]	x	x			x
INDECT Intelligent information system supporting observatio, searching and detection for security of citizens in urban environment [ref 1]	x				x
SAMURAI Suspicious and abnormal behaviour monitoring using a network of cameras & sensors for situation awareness enhancement [ref 1]	x		x		x
SUBITO Surveillance of Unattended Baggage and the Identification and Tracking of the Owner [ref 1]	x				x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Human performance • Human behaviour analysis [ref 2, #10]			x		x
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x
TNO Inspection and monitoring • Identification [ref 2, #17]	x				x
THALES VideoID [ref 3, #5]	x				x

A 8.2 Reaction capacity/capability when delivery, suspicious object or person is detected

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
IMSK Integrated Mobile Security Kit [ref 1]	x				x
TNO Inspection and monitoring • Alerting [ref 2, #18]	x	x	x		x
TNO Behaviour • Detention [ref 2, #41]		x			x
Protection against airborne toxic agents See section 3.3	x				x

A 8.3 Prevent availability

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
iDetecT 4ALL Novel Intruder Detection and Authentication Optical Sensing Technology [ref 1]	x				x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES FP6 SAFEE [ref 3, #1]	x				x

A 8.4 Prevent detailed knowledge of vehicle and infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research

A 8.5 Detect hazard

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
TNO Detection and identification • Smart sensors / sensor networks [ref 2, #1]	x				x

A 8.6 Reduce down time

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x

A 8.7 Reduce damage to vehicle or infrastructure

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
TNO Operational performance • Infrastructure protection [ref 2, #7]	x	x	x		x
THALES SIC [ref 3, #4]	x	x			x

A 8.8 Reduce injuries

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the eu [ref 1]		x			x
NMFRDisaster Identifying the Needs of Medical First Responders in Disaster [ref 1]		x			x
Protection against airborne toxic agents See section 3.3	x				x

A 8.9 Reduce damage to environment

name and description	Category			Development stage	
	technical	admin and routines	human behaviour	technology in use	research
BeSeCu Human Behaviour in crisis situations: A cross cultural investigation in order to tailor security-related communication [ref 1]			x		x
CAST Comparative assessment of security-centered training curricula for first responders on disaster management in the EU [ref 1]		x			x