European Civil Protection

upsafety

EDUCATION, TRAINING AND EXERCISE PROGRAMME FOR UNDERGROUND INFRASTRUCTURES

This is the final result of the project Up Safety, published in June 2011

PREFACE

With great pride we present this handbook to assist authorities, emergency services and training centres in organising and executing the whole range of education, training and exercise activities for incident command teams that have to deal with crisis situations in underground infrastructures. Safety officers from the underground facilities are also included in this programme.

The main goal of the project Up Safety has been to jointly develop a multidisciplinary approach for improving safety in underground facilities. The most important way to achieve an effective and coordinated multidisciplinary approach in case of an emergency is to train all actors of the incident command team in a realistic setting together, so that they learn and practice to cooperate, communicate and work together effectively in practice. This appears to be the most crucial problem in effectively handling emergencies according to the evaluation of many (complex) emergencies internationally.

To improve the effectiveness of civil protection organizations in underground scenarios we have developed an Education, Training and Exercise Programme (ETE-programme) for road tunnels, metro stations and underground parking lot. This programme meets current demand in Europe. Part of the ETE-programme is a newly developed virtual reality tool that can be used in education and training, but also as an assisting tool when organising table-top exercises.

In the developing process of the ETE-programme we invited experts who could advise on the programme. There were experts from the field of operators, from emergency services and other civil protection organisations, and from public authorities. We also organised a session to instruct trainers that had to bring the instruction into practice by guiding a team through the education and training part. This again gave input for improving the ETE-programme. And with the improved programme we again instructed the trainers in order to work out three table top exercises: one with a scenario in a road tunnel, one in a metro station and one in parking lot. These exercises with teams from the Netherlands, Belgium and Romania, together with a realistic exercise in a parking lot situation, were the finalisation of our project.

Lead partner was the Province of Zeeland (Middelburg; the Netherlands). The lead partner delivered the project management team. This team organised all events, communications with the Civil Protection Policy Unit of the European Committee, finances, and website-actuality.

The other partners were the Fire Brigade Ghent (Ghent; Belgium), Studiengesellschaft für unterirdische Verkehrsanlagen (STUVA) (Cologne; Germany), N.V. Westerscheldetunnel (Goes; Netherlands), Amsberg Infraestructuras S.A. (Madrid; Spain), General Inspectorate for Emergency Situations Bucharest (Bucharest; Romania) and Falck AVD (Best; the Netherlands).

We recommend this ETE-programme to improve the effectiveness of civil protection organisations in underground infrastructures in case of an emergency. The Up Safety project team also hopes this ETE-programme will be an inspiration for all who are responsible in improving the safety in underground facilities.

Contents

1 INTRODUCTION

1.1 SCOPE AND AIMS

The European Infrastructure consists of many underground facilities. These facilities fall into three major categories: road tunnels, metro stations and parking lots. Underground facilities bring along specific safety risks that need to be managed during the design, construction and operation of the infrastructure. In case of an emergency the civil protection organisations will need to act in close cooperation with the facility-staff to conduct an efficient and effective response. Within Europe there are no standard Education, Training and Exercise (ETE) programmes yet, that prepare these organisations in dealing with emergency situations in underground facilities.

The overall aim of the project Up Safety is to improve the effectiveness of civil protection organisations in underground infrastructures in case of emergency. By establishing a new European network on specific knowledge and scenarios for underground facilities, cooperation and coordination between public civil protection organisations and staff-members of these facilities will be enhanced.

Within the project the following objectives are met:

- To gain insight on the specific nature of underground facilities with regard to special requirements and considerations when dealing with incidents in this environment;
- To identify possible, unwanted effects in time and space as a result of incidents inside and in the immediate vicinity of underground facilities that require multidisciplinary action from emergency services, staff personnel and possible other agencies;
- To develop EU-proof guidelines on the conduct of multidisciplinary operations inside and in the immediate vicinity of underground facilities to effectively counter these effects;
- To contribute to a mutual understanding of the monodisciplinary responsibilities and tasks of emergency services and staff personnel when incidents in underground facilities occur;
- To develop a methodology for educating, training and exercising for that can be used when planning and executing multidisciplinary ETE-activities for the three major categories;
- To identify the possibilities of Virtual Reality (VR) in multidisciplinary ETE-activities and to make optimum use of a selected VR-tool within the ETE-programme.

The overall result is this document, which includes an ETE-programme that can be used for each of the three categories: road tunnel, metro station and parking lot. The document provides designated trainers with the tools that enable them to plan, organise and execute activities necessary to educate, train and exercise personnel of emergency services and operators that are involved in multidisciplinary response operations in these facilities.

This document is not intended to be prescriptive or to function as an operational manual as there is no single approach that will meet the needs of every object in relation to possible incident scenarios. It is a common framework that provides enough flexibility to be adapted by the countries to local circumstances and specific problems.

1.2 FOCUS GROUP

This document is aimed at a multidisciplinary training audience. It focuses on the multidisciplinary response and does not provide specific advice for each emergency service or for the staff of the underground facilities. However, this document is useful to anyone who is likely to be involved in the preparation and/or execution of emergency response operations in underground facilities. National academies and institutes in the public safety sector might have an interest as well, as their single-service programmes regarding the topic should be congruent with this document.

The main target audience can be divided into two focus groups. The first group are the training teams on which the ETE-programme is focused. The second group consists of the trainers that are responsible to plan, organise and execute all activities within the ETE-programme.

1.2.1 TRAINING TEAMS

The primary focus is on the incident commanders and their team that are responsible for the command, control and coordination of multidisciplinary emergency response operations at the incident location (on-scene). The team consists of the representatives of the civil protection organisations (police service, fire and rescue services and ambulance services) and representatives of underground facilities (operators, managers).

The secondary focus is on the higher level commanders and their team that are responsible for the command, control and coordination in relation to the larger effects that occur with major incidents, including the coordination with public offices. These commanders are routinely not located near the incident location (off-scene).

1.2.2 TRAINERS

The category of trainers that are responsible for the ETE-activities within the Up Safety programme are the same trainers that are normally responsible for training incident commanders and their teams and higher level commanders. It is important to understand that the ETE-programme for underground infrastructures is merely an addition to the regular multidisciplinary ETE-programmes for emergency command teams. Just as the training audience needs a certain proficiency-level at the start of the ETE-programme for underground infrastructures, so do the trainers.

1.3 READING GUIDE

This document consists of two parts. Part I describes the guiding principles for emergency response operations in underground facilities and is characterised by a strong conceptual approach. In chapter 2 it provides a framework of working definitions around the theme of emergency response operations, so all countries and services within the EU share the same vision around this concept. In a certain way this chapter is also philosophical in nature as it lays down a certain thought process to which the incident commander and his or her team should adhere to.

Chapter 3 describes the general aspects of underground facilities from the viewpoint of an incident commander. It provides the commanders and their teams with general knowledge in relation to these infrastructures, that may influence their decisions and actions when an incident takes place. It looks beyond the physical characteristics of an object and describes as well, in broad terms, the behaviour of fire and smoke and the human behaviour and self-

reliance. A general course of action in case of emergency provides insight in the reaction of the staff of an underground facility to an incident.

Chapter 4, 5 and 6 deliberate on the previous chapter respectively by looking at road tunnels, metro stations and parking lots in detail. Each chapter deals with one of the three objects and provides more background on each specific underground facility. It provides knowledge about legislation and the safety organisation that is in place. It also describes the different safety measures and installations that can be in use and their contribution to an emergency situation. Having an understanding of their mitigating effects is important for incident commanders, especially when safety measures and/or installations fail to do what they are designed for.

Chapter 7 integrates the previous chapters of Part I and describes the multidisciplinary response to an emergency situation in an underground facility. It provides an educational model of how civil protection units work alongside the facility staff, with the different processes depicted during an emergency situation. Secondly it describes how the incident command team works together in such situation, by going through a cycle of creating situation awareness, developing courses of action, making decisions and putting these decisions into action.

Part I provides the conceptual background and knowledge against which the ETE-programme is developed. In Part II the methodology behind this programme is explained as well as the didactics to turn the programme into concrete activities. It describes the philosophy behind the ETE-programme and provides guidance and direction to trainers that are responsible for planning, organising and executing the ETE-activities for multidisciplinary teams. Some boundary conditions are set at the beginning and the conceptual approach behind the programme is explained. Subsequently, guidance and direction is given to the proposed content of the programme. At the end a generic but complete ETE-programme is presented, leaving room for local circumstances to fill in the details.

PART I

2 EMERGENCY RESPONSE

2.1 EMERGENCY MANAGEMENT

Emergency management is a holistic approach to prevent and deal with emergencies, which involves four major phases: mitigation, preparedness, response and recovery. Figure 2.1 shows a graphic representation of these four phases.

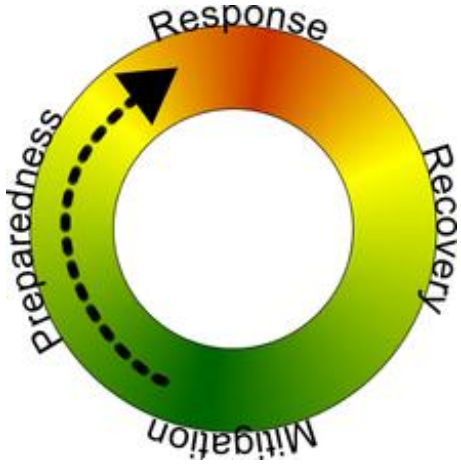

Figure 2.1 *Four phases of emergency management*

To have an understanding of how the phases fit into the overall concept of emergency management, a basic knowledge of the activities within the different phases is necessary.

Mitigation efforts attempt to prevent hazards from developing into emergencies altogether, or to reduce the effects of the emergencies when they occur. The focus of the mitigation phase is on the long-term measures for reducing or eliminating risks. The first activity therefore is the identification and analysis of potential risks. Mitigation measures can be structural or non-structural. Structural measures are taken from the earliest stage when designing a new infrastructure, for instance a new tunnel or metro station, and make use of technological solutions. Non-structural measures may include activities such as legislation and inspection.

Preparedness is a continuous cycle of planning, organising, educating, training, exercising and equipping activities. The aim of this phase is to ensure effective cooperation and coordination and the enhancement of capabilities to prevent, protect against, respond to, recover from and mitigate the effects of emergencies. During the preparedness phase, emergency managers develop plans of action to manage and counter the perceived risks and take action to build the necessary capabilities needed to implement such plans.

Response encompasses the decisions and actions taken to deal with the immediate effects of an emergency. Depending on the situation, this phase normally lasts for several hours or days. The effects of an emergency can be direct effects (loss of life, injured people, material damage) as well as indirect effects (environmental issues, public disorder, media attention). The response phase includes the mobilisation of the necessary emergency response services, such as police, fire-fighters and ambulance crews.

Recovery has a twofold aim. The first objective is to restore the situation to its previous state, if possible, by providing aid to the persons involved (physically as well as mentally) and by rebuilding and repairing destroyed infrastructure. The second objective is to evaluate what has happened, how the emergency was handled during the response phase, why it happened and what has to be done to prevent it from happening again. This is also the moment that the question of accountability is raised. The recovery phase can take weeks, months, even years to complete. It is important to understand that actions that are taken during the response phase may influence the longer-term outcomes for a community. The recovery should therefore be regarded as an integral part of the response phase from the very beginning.

Emergency management is a continuous process that takes place within governmental as well as non-governmental organisations. Effective emergency management therefore relies on thorough integration of emergency plans at all levels of civil protection organisations and public/private institutions as part of the preparedness phase. Individuals and groups involved in responding to an emergency have to be educated, trained and exercised to put these plans to the test. The focus should be on the multidisciplinary cooperation and coordination when working together in the response phase.

This joint approach is key to success when dealing with emergencies. A single service can be trained to the highest standards, but when its people do not understand the role of the other players in the field, or are unable for other reasons to work alongside sister services, the outcome can be disastrous. This explains furthermore why the focus of the ETE-programme for underground infrastructures is on the incident commanders and their team, including representatives of the underground facility.

Although the aim of the project is geared towards an effective response, in itself the ETE-programme is an integral part of the preparedness phase. In this chapter the principles of an effective response to an emergency are described. In part II of this document will be explained what this means for preparing civil protection organisations and the staff of underground facilities.

2.2 ANTICIPATION VERSUS RESILIENCE

Anticipation is an integral part of the mitigation phase during which risks and potential emergencies are identified and analysed. But risks can only be inventoried to a certain degree and numerous combinations of factors of influence are possible that will create a unique situation every time an emergency occurs. Therefore, detailed plans and standard solutions often do not hold during the response phase. Anticipation however is still the dominant strategy in our risk-avoiding society and is primarily aimed at the reduction of insecurity.

Thinking about risks and possible scenarios that may occur, is important in preparing for emergencies. But it is just as important to understand that these are merely best guesses of what might happen. Emergencies therefore require a more resilient approach during the response phase. Commanders and managers of civil protection organisations must be able to react in a flexible manner to unexpected events.

When responding to an emergency, the focus should be on the immediate consequences and wider impacts rather than their causes. This effects-based approach asks for flexible and adaptable arrangements that will enable an effective multidisciplinary response.

As a consequence the ETE-programme for underground infrastructures is geared more towards resilience than anticipation. Scenarios that are drafted within this document are examples how to develop activities within the ETE-programme.

2.3 AGENCIES INVOLVED IN RESPONDING TO EMERGENCIES

This paragraph describes what the responsibilities and tasks are of the different emergency services. The main focus is on the police, fire and rescue and ambulance services, but in “others” is explained which agencies also can play a role during an emergency in an underground facility. The responsibilities and tasks of members of the staff of the different underground facilities is explained in the upcoming chapters.

2.3.1 POLICE SERVICE

For the police, as for the other services, the saving and protection of life is the priority. But they also have to ensure that the scene is preserved, to safeguard evidence for subsequent enquiries and possible criminal proceedings. This is not the case when the incident occurs from a natural hazard and no element of human error or criminal intent is involved. When there is a possibility that an incident has been caused by terrorist action, than that will be the assumption until demonstrated otherwise.

Their main responsibilities lie with public order and corresponding tasks include the following.

- Establish and maintain cordons at appropriate distances, when necessary and practical. Cordons are established to facilitate the work of the emergency services and to protect the public and property. When a terrorist action is suspected, the police will take additional measures to protect the scene.
- Assist in redirecting traffic and providing motor escorts when the situation dictates such measures.
- Maintain and restore public order when civil unrest is present or originates.
- Identify and register in the case of fatalities. When people are missing, the police will normally co-ordinate search activities on land, with or without the help of the other services or volunteers.
- Intervene when criminal or terrorist activities such as hostage situations are taking place, with special intervention units that are trained for these kind of emergencies.
- Oversee any criminal investigation and facilitate inquiries by other agencies, for instance official investigations by governmental organisations.

2.3.2 FIRE AND RESCUE SERVICE

The primary role of fire and rescue services during an emergency situation is the rescue of people trapped by fire, wreckage or debris. They will prevent further escalation of an incident by controlling or extinguishing fires, rescuing people and undertaking other protective measures. These include the following tasks.

- Deal with released dangerous goods and the effects of such incidents. This includes the recommendation of exclusion zones after detection and measurement. It also includes the decontamination of people, animals, vehicles and infrastructure.
- Provide assistance to the effects of large quantities of flood water or damage by other natural hazards such as storms.
- Provide assistance to ambulance services with casualty handling and the police with the recovery of bodies.
- Provide accessibility to the incident scene for the other services and agencies.

2.3.3 AMBULANCE SERVICE

The primary role of the ambulance service is the provision of emergency medical assistance and the transportation of injured people to hospitals. Crews have to be highly skilled and able to treat and stabilise patients before movement to hospitals without unnecessary delay.

It is important to understand that the involvement of the medical services in relation to the incident doesn't stop here. In the hospitals further medical treatment takes place and, if necessary, psychological treatment (aftercare) as well.

2.3.4 OTHERS

There is a whole range of other services that possibly can play a role during an incident in an underground facility. These comprise of public services as well as private companies such as utilities, telecommunications and transport providers. Private companies are not discussed in detail here, although they play an important role in the timely restoration of essential services to help minimise the wider impact on the community. What follows now is a listing of some of the public services that play a role in the response to emergencies.

First there are the local authorities that do not only have a responsibility from an administrative point of view, but also operational with regard to the public works department. This department holds a wide range of functions that are likely to be called upon in support of the emergency services. The local authority will also play an enabling role in close cooperation with a wide range of organisations which are routinely not involved in emergency response operations. The following tasks can be distinguished.

- Inform the population and co-ordinate all press activities.
- Evacuate people and providing immediate shelter and welfare to the evacuees and to provide medium to long-term welfare as well if the situation dictates
- Register victims and liaise with coroners to provide emergency mortuary capacity in the event that existing mortuary provision is exceeded.
- Provide for crush barriers or other material to create a physical cordon or to aid traffic management efforts.
- Provide catering facilities, toilets and rest rooms for the welfare of all emergency response personnel in the event of a protracted emergency.
- Lead the recovery effort, which is likely to carry on for a considerable amount of time and is likely to involve many organisations.

It is important that during the preparation phase these tasks are written down in plans and procedures, so that there is no misunderstanding of who is doing what in the hectic period right after an incident occurs.

The second group of public services that is discussed in this paragraph are the agencies that are on a lower alert than the first responders that are mentioned before. These can include (national) organisations that only come into place when an incident is considered a disaster. Examples are the *Civiele Bescherming* ("Civil Protection") in Belgium or the *Bundesanstalt Technisches Hilfswerk* ("Federal Agency for Technical Relief") that only come into action when regular units of the emergency services do not have the capacity or the material to act in an effective way to an emergency.

Other public services can play a role in incidents with underground infrastructures, including the Armed Forces, Search & Rescue units, bomb squads et cetera. It is obvious that the involvement of these services depends very much on the situation.

2.4 ORGANISATION

Flexibility and scalability are the two guiding principles during emergency response operations. This creates a response system that is able to withstand all hazards independent of the scale or complexity of an incident. Flexibility does not mean that there is no form of standardization necessary whatsoever. When a multidisciplinary response is required, it is obvious that the emergency services know what to do, have to know exactly what to expect from each other and understand how to work side by side in a coordinated and effective manner. Emergency plans foresee in the necessary procedures and instructions to make an effective multidisciplinary response possible and education, training & exercise will prepare individuals and teams on their respective roles. But the organisation of the response provides the structural backbone of the emergency response operation. Apart from being flexible, this organisation has to be easy scalable as well.

2.4.1 EFFECTS IN TIME AND SPACE

The effects of an incident determine the extent of the response by the civil protection organisations and the level of scaling-up. This can best be explained by the following figure.

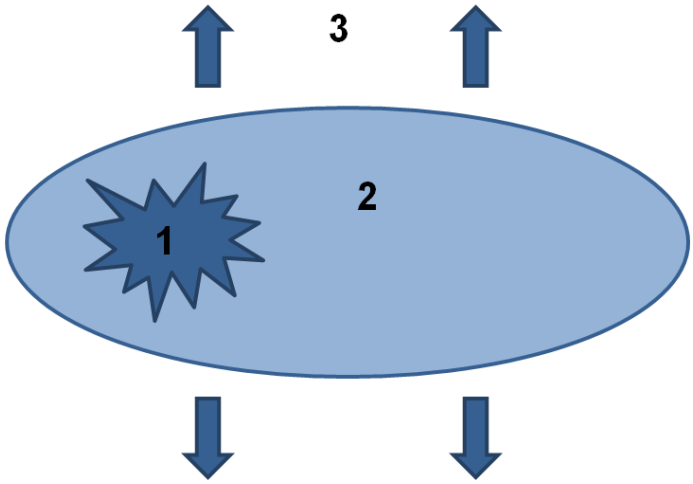

Figure 2.2 *Graphic explanation of effects in time and space*

When an incident occurs, there are in concept three possible effects related to space:

1. The effects of the incident are confined to a relatively small area close to the source of the incident and there are hardly any effects to the surroundings. An example is a truck having an accident in a tunnel with the driver only slightly hurt. The emergency response services are able within their own means to provide first aid to the injured driver and arrange the traffic management.
2. The effects of the incident are having a wider impact on the surroundings. In the example above, the same truck is catching fire while carrying toxic material and there is emission of dangerous gasses. The emergency response services that are directly operating on the location of the incident are unable to oversee the wider impact of this situation and might not have the capabilities within their own means to cope with the situation.

3. The effects of the incident do not only have a wider impact to the surroundings that require an operational response, but also (might) have political and administrative consequences. For instance the well-being of the local population or the political sensitivity of an incident. Taking the same example again, a thick cloud of poisonous gas is exiting the tunnel and threats a village close by. At the same time there has been a discussion for years now on the question if the transportation of dangerous goods should be forbidden on that road. These issues will draw the public office into the emergency situation as well.

It is obvious that there is a time aspect involved as well. Most of the time incidents start small and grow in severity and/or geographically as time evolves. There is always the chance of domino effects or interrelated effects and it is not always easy to distinguish between direct and indirect effects in a certain situation.

In paragraph 2.2 an effects-based approach is mentioned as part of a more resilient and flexible response to emergencies. The key to this approach is to be able to make a prediction of the future based on the situation as it is now. By defining how a scenario might evolve in the (near) future and by predicting the possible effects in time and space, measures can be taken on forehand to counter these effects when they occur. When there is more time to analyse the situation, more scenarios can be formulated (for instance a most likely scenario and a worst case scenario). This “scenario-thinking” will form the base of the ETE-programme.

2.4.2 LEVELS OF COMMAND

It is important to distinguish between the respective functions of single services (monodisciplinary) and multidisciplinary response teams. Single services have the authority to exercise a command function over their own personnel and assets. The single service command levels are often described as bronze, silver and gold , which originates from the police service within the UK. However, it is ambiguous to use the same terms within a multidisciplinary setting, as there might be no command authority delegated over all the emergency response services to a single responding service.

The amount of command and control that is delegated will depend on the arrangements that are made in each member state within the national civil protection organisation. At the least there should be an agreement on the cooperation and coordination between the different emergency response services. Within this document “command” is used for all actions related to command, control and coordination.

There are three levels of command: operational, tactical and strategic.

- **Operational**. The operational level corresponds to the normal operational response provided by the emergency services where the management is of routine tasks. Operational commanders will concentrate their efforts and resources on the specific tasks within their areas of responsibility. Each service must liaise and coordinate with all other agencies involved to ensure a coherent and integrated effort. Individual responder agencies may refer to the operational level as bronze.
- **Tactical**. The purpose of the tactical level is to ensure that the actions taken by the operational level are coordinated, coherent and integrated in order to achieve maximum effectiveness and efficiency. It also includes determining priority in allocating resources. This level often consist of a layered system of two separate command teams: one located near the incident location (on-scene command) and a higher level command team that is routinely not located at the place of an incident (off-scene command). Individual responder agencies may refer to the tactical level as silver.
- **Strategic**. At the strategic level the emergency is considered in its wider context and the longer-term and wider impact of the situation is determined. The purpose is to formulate

the overall strategy and objectives for the emergency response and establish the framework from a political and administrative perspective. A strategic command team normally exists of representatives of the public office and senior commanders of the emergency services. Individual responder agencies may refer to the strategic level as gold.

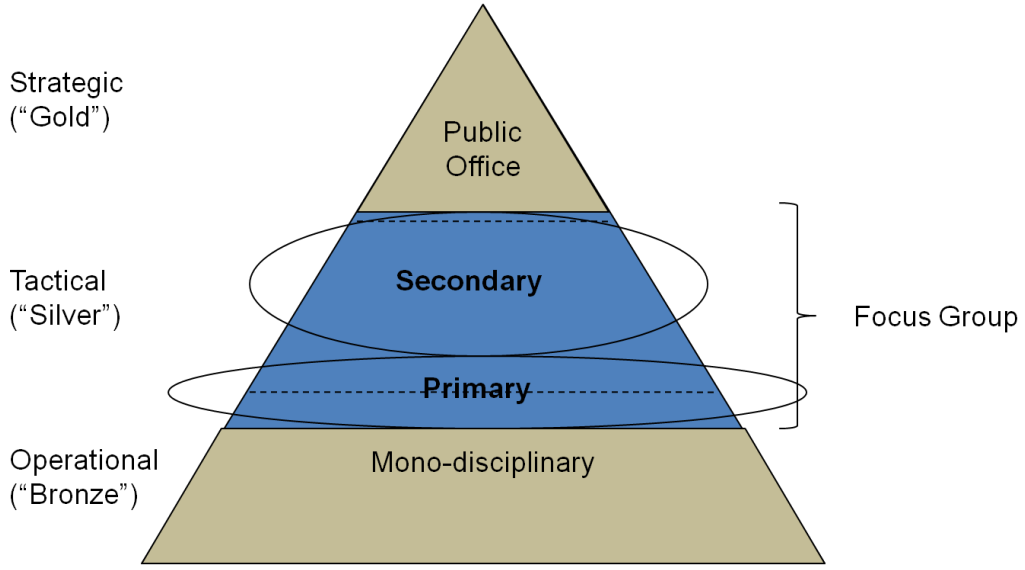

Figure 2.3 *Levels of command and position of the focus group*

In the above figure the levels of command are graphically depicted and the position of the focus group of the ETE-programme for underground infrastructures is included. It is difficult to give an exact definition of the levels and their functions as there is no common doctrine available in the EU. But it should be clear that the ETE-programme is not aimed at the monodisciplinary actions of the single services at the operational level, nor is it aimed at the strategic level where the public office is involved. It is aimed at the tactical level of command where the operational multidisciplinary actions are taken with a strong focus on the incident command teams that are operating on-scene at the incident location.

The levels of command within civil protection organisations are more or less related to the effects in time and space as they are described in paragraph 2.4.1. Emergency management normally start at the operational level and it is a key function of operational commanders to advise their superiors if the situation requires the involvement of a next higher command level.

2.4.3 ON-SCENE ORGANISATION

When an incident requires a multidisciplinary response, the emergency services will be alarmed to head for the incident site. The first coordination efforts between the services will start immediately from the beginning. At a certain point all duty officers of the police, fire & rescue service and the ambulance service will be present, as well as the designated incident commander. From that moment on there will be a formal command, control and coordination relationship established.

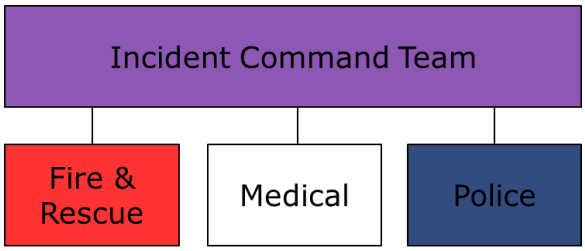

Figure 2.4 *Basic command structure including the three main services*

Figure 2.4 shows the basic command structure, where the three main services operate under a single incident command team. In the case that others are involved there will be a relation established with the incident command team as well. This will be the case with incidents in underground facilities when staff members work alongside the emergency services.

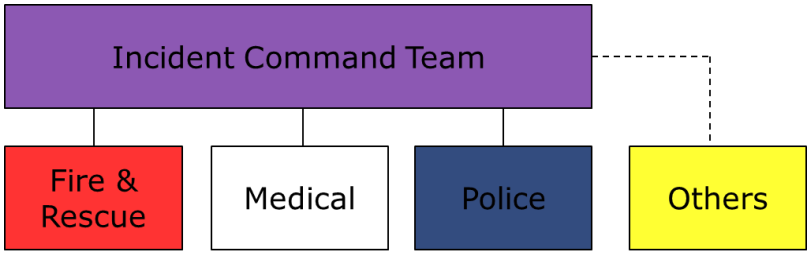

Figure 2.5 *Relationship of the incident command team with others*

The line from “others” to the incident command team in the figure above is dotted, because the relationship is not always the same. This depends again on the amount of command, control and communications is delegated within the arrangements that are agreed upon. There is always some form of coordination and cooperation, but it is not automatically the case that the incident commander has command and control over all assets operating on the incident area.

When an incident becomes larger and scaling-up takes place, the organisation dealing with the incident will grow larger as well. Other organisations may be involved, such as public works, and there will be a next higher hierarchy layer of command and control established. This can be on-scene or off-scene, dependent on the normal modus operandi within the countries.

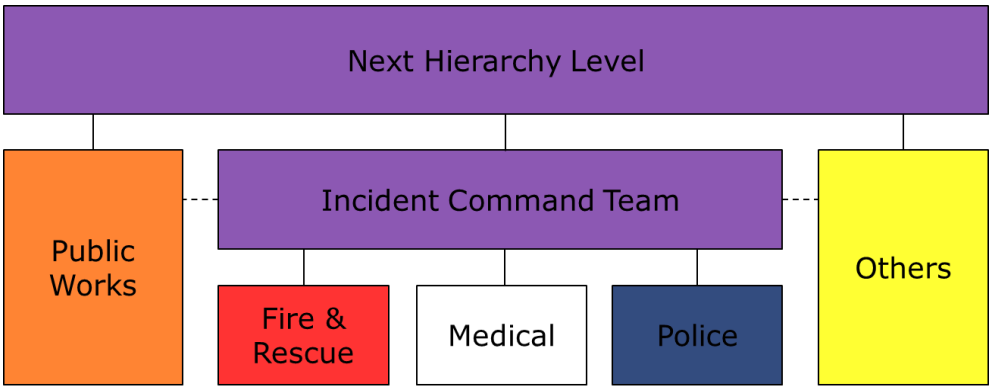

Figure 2.6 *Position of the incident command team after scaling-up*

The incident command team has to deal with other organisations in all directions in this situation. It has to instruct the units that are under its control, it has to coordinate with all organisations working alongside and it will have to inform the next hierarchy level as well as executing their instructions.

3 GENERAL ASPECTS OF UNDERGROUND FACILITIES

Emergency services do not operate on a day-to-day basis in underground facilities. It is important that they gain an insight at the challenges of these facilities in case of an emergency. So are the environmental conditions in enclosed spaces very much different to more common environments. Special attention is needed to the behaviour of fire and smoke, two of the most common effects, as this is different in relation to “normal” structures. The same applies to the human behaviour and self-reliance when an incident occurs in a tunnel, metro system or parking lot. Emergency services should also be aware of the general course of action that is taken by the facility management in case of an emergency. Bottom line is that incident commanders have knowledge about the general aspects of underground facilities that may influence their decisions and actions when responding to an incident. In chapter 4, 5 and 6 the specific safety measures and installations that are present in the modern versions of each of the three infrastructures are discussed.

3.1 SPECIAL CONDITIONS OF UNDERGROUND FACILITIES

Emergency services need to be aware of the special conditions that underground facilities present when an incident occurs. Although there may be large differences between size, shape and lay-out, there are several similarities between road tunnels, metro systems and parking lots that must be considered.

- **Confined spaces and enclosures**. All underground facilities are confined spaces with limited exit and access possibilities. When an incident occurs this makes the options for fleeing the hazardous area limited to users of a facility. At the same time it makes the options for the emergency services to approach the source limited as well. Some areas in an underground facility might be enclosed completely.
- **Elevation differences and gradients**. The elevation differences in an underground facility may be large. A metro system is good example of a network of stations and tunnels over different levels and located at different depths. This has an effect on how smoke develops and what this means for the direction people will flee. It also has an effect on how water runs and gathers. The same applies when there are large differences in gradients.

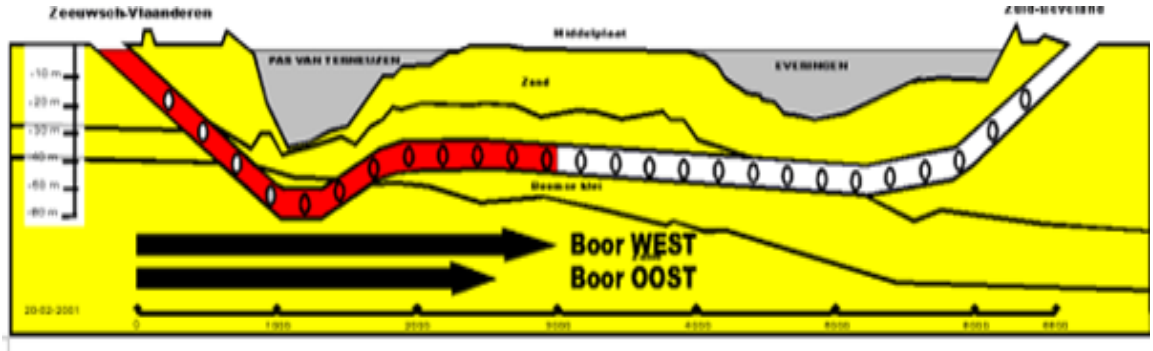

Figure 3.1 *Graphic display of gradients in the Westerscheldtunnel in the Netherlands*

An example is the steep gradients that often exist in tunnels (see figure 3.1). These have an effect on how smoke develops, that is to the highest point. As a result people will try to flee in opposite direction, that is to the lowest point. Drainage of water creates an issue as well, independent if it is caused by floods or by extinguishing water.

- **Visibility**. Without artificial lighting there is hardly any to none visibility. When an incident occurs and the emergency lighting goes on the sight is limited and this might cause a feeling of disorientation. In case of smoke or dust the visibility will get worse.
- **Air circulation**. Pure natural ventilation is not possible in an underground facility. For this reason there is always some form of mechanical ventilation present. In tunnels and parking lots this is necessary to get rid of the cars exhaust gasses. The ventilation system plays an important role when there is the need for the smoke exhaust in the case of fire.
- **Long distances**. The distances can be long in underground facilities, horizontally as well as vertically. The longest road tunnel in Europe is the Gotthard tunnel that is almost 17 kilometres long. The world's deepest metro station is the Admiralteyskaya in Saint Petersburg, with its deepest point 105 meters underground. It does not need much explanation that these distances present some difficulties for emergency services. Heavy loads have to be carried long ways where trucks cannot come or many water hoses are necessary to get the required length in case of a fire.

3.2 BEHAVIOUR OF FIRE AND SMOKE

Fires in underground facilities differ in various ways from fires that occur in more regular building types. The most important characteristics of underground fire and smoke behaviour are summarized in this paragraph.

First of all the design and use of underground facilities entail specific fire risks. For reason of practical use (road tunnel, metro station) and/or public safety and safety perception (parking lots) these building types are characterized by large, open spaces and limited or no fire compartmentalization. Once a fire starts, there is no physical blockade that prevents the heat and smoke from spreading freely through the facility.

In comparison to normal building stock, the use of the facility by traffic (cars, trains) contains a very different (ignition) risk as well as fire load. In tunnels for instance a traffic accident or technical failure of a vehicle might result in a fire situation. Vehicles in parking lots in addition are sometimes exposed to malicious intentions. High voltage railway tracks possess specific risks like sparks or short-circuiting. The fire load will be much higher through the availability of highly combustible material.

A third characteristic can be found by looking at the different fire curves. In office buildings the development of a fire is characterized by the *cellulosic fire curve* whilst in tunnel safety considerations the so called RWS curve is widely used. This curve was developed by the Rijkswaterstaat, Ministry of Transport in the Netherlands and is based on the assumption that in a worst case scenario, a 50 m^3 fuel, oil or petrol tanker fire with a fire load of 300MW could occur, lasting up to 120 minutes. The RWS curve knows a higher peak temperature and faster fire development in comparison to the cellulosic fire curve. As an example, during the fire in the Gotthard tunnel in Switzerland in 2001, the temperature raised to 1200 ºC.

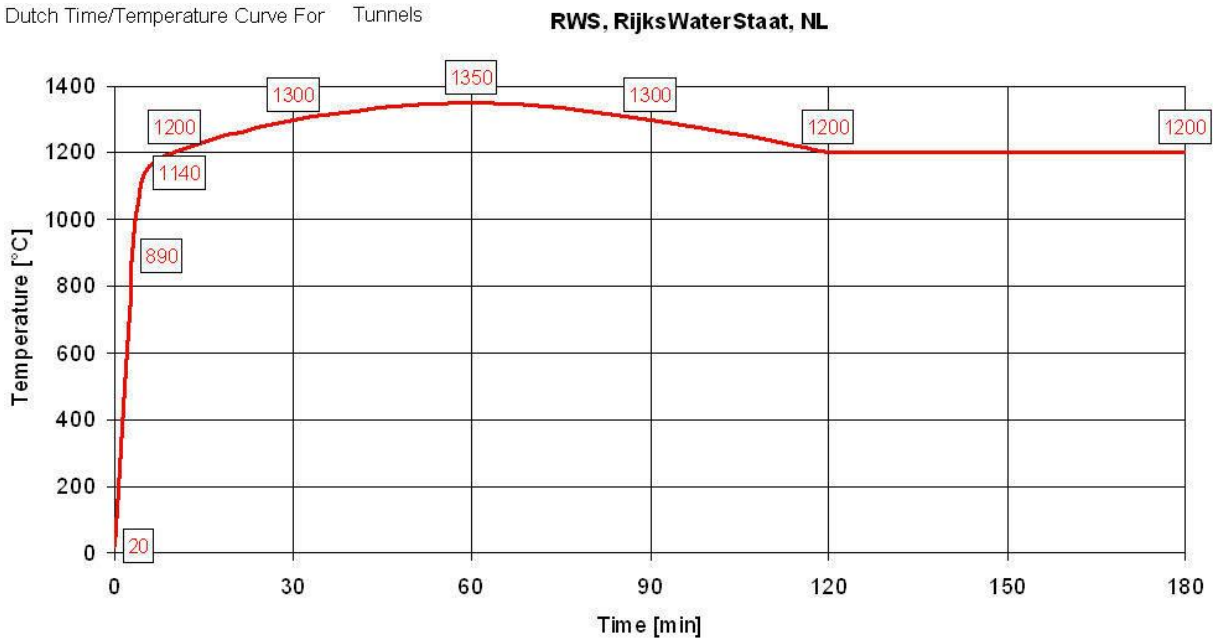

Figure 3.2 RWS curve

Apart from the different fuel type, the temperature effect is magnified due to some other characteristics. Tunnels and car parks have limited height and no windows, resulting in decreased heat dissipation to the surrounding atmosphere. The hot smoke layer spreads throughout the ceiling and radiates heat to nearby combustible object (for instance other cars). This induces fire spread and flash over conditions.

The hot smoke layer also will affect unprotected ceiling structures causing *concrete spalling* (due to evaporation of water) and sometimes, but mainly after significant exposure time, decreased structural quality. The effect of concrete spalling however tends to be higher in open, unheated car parks and near the ends of a tunnel (increased humidity).

Except for fire spread due to the smoke layer, burning fuel floating away from the vehicle can ignite nearby objects. Also, after approximately eight to ten minutes of exposure (at 500°C) asphalt burns, adding to the fire load and releasing toxic gases and soot. Concrete at its turn is incombustible and emits no harmful gases.

The smoke spread depends on:

- Facility dimensions and geometry;
- Gradient (in tunnels);
- Airflow conditions;
- Smoke-cooling processes (wall surfaces and roughness, humidity);
- Presence of smoke barrier.

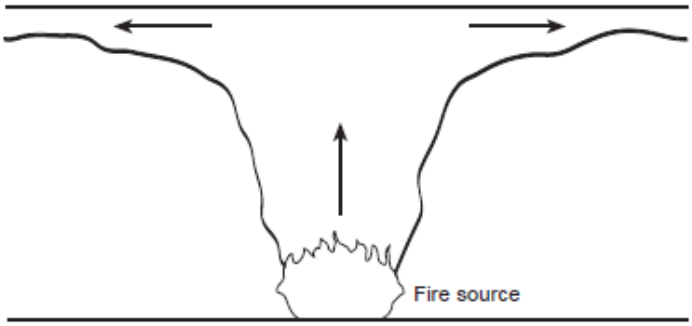

Figure 3.3 *The behaviour of smoke in confined spaces*

The behaviour of smoke therefore is a very complex process, but most strongly depends on the smoke management system in use. When no mechanical ventilation is activated, the natural driving forces (wind, buoyancy) cause pressure differences and, as a result, smoke movement form high pressure locations to low pressure zones. In underground facilities of limited height this results in a stratified smoke layer spreading away from the fire.

Smoke management systems in underground facilities can roughly be divided in two main principles:

- Capturing and removing smoke (transverse ventilation);
- Pushing smoke in a desired direction (longitudinal ventilation).

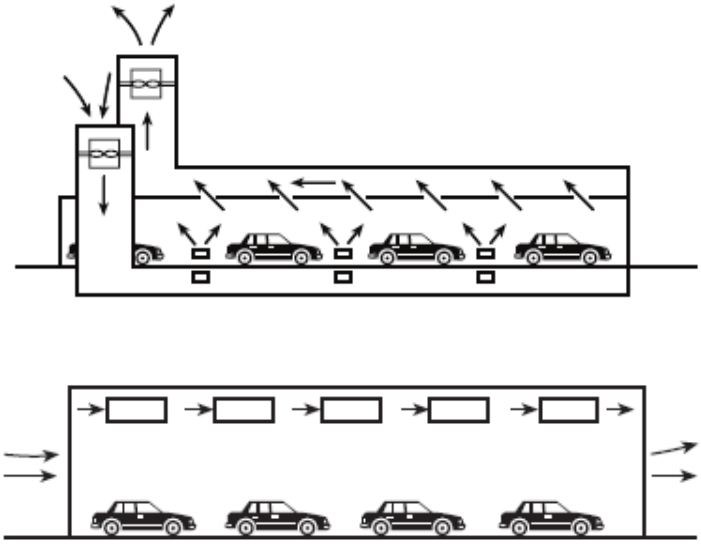

Figure 3.4 *Transverse (above) and longitudinal ventilation (below)*

All types of smoke movement, both natural and mechanical induced, bring about mixing and increased turbulence. As a result, the smoke volume expands, but the smoke itself is dispersed. The dispersion cools down the smoke and increases sight which at first instance appears to be a positive effect. However, hot smoke sticks to the ceiling and cooling down the layer will make it descend toward the roadway. For reason of safe egress, most smoke management systems are activated with several minutes of delay.

3.3 HUMAN BEHAVIOUR AND SELF-RELIANCE

There has been extensive research how people react in case of emergencies, especially in relation to fires and smoke in buildings. Research shows that their natural response is to exit through the way they came in and they hardly follow the signs to make use of the closest emergency exits. Although most people are aware of the fact you should not try to flee through smoke, almost everybody does so. In general people wait too long before they start evacuating the incident area, often to an extent that escape is no longer possible.

This is even more so in surroundings where they don't feel themselves familiar with, for instance a tunnel. They have an affiliation with their vehicle that makes them feel safe to stay inside (see the boxed text on the Mont Blanc tunnel).

"Of the 39 people who died after fire swept through the Mont Blanc tunnel on 24 March 1999, all but 7 had stayed in their cars. Most drivers rolled up their windows and waited for rescue. Eventually the ventilation system in the tunnel drove toxic smoke back down the tunnel faster than anyone could run to safety. These fumes quickly filled the tunnel and caused vehicle engines to stall; they needed oxygen to run. Many drivers near the blaze who attempted to leave their cars and seek refuge points were quickly overcome. They were poisoned by fumes from the fire."

Underground facilities often are perceived by their users as complex and unfamiliar, almost alien, environments, where they feel confined. These are generally places where people would rather not be, in contrast with buildings which people use daily. Therefore the reactions of people to emergencies within underground facilities are slightly different. The review of the relatively few tunnel fire incidents shows the following observations:

- People often don't perceive themselves to be in immediate danger;
- Safety systems can and do fail;
- Fire and smoke can spread rapidly in tunnels;
- People may exhibit property/vehicle affiliation;
- Egress routes for vehicles and personnel will become blocked;
- People do not evacuate immediately;
- Traffic will continue to enter tunnels experiencing emergencies unless they are prevented physically or otherwise;
- Rescue services may not be able to reach entrapped people because of the severity of the fire and road traffic chaos (for example, drivers attempting U-turns);
- Refuge areas may not have the fire endurance necessary in order to ensure the survivability of their occupants;
- Users are not familiar with the safety systems.

Some additional observations of incidents dealing with rail tunnels show that:

- Staff is not well trained;
- Reluctance to raise the alarm;
- Staff were afraid that they might cause passengers to panic.

The last observation is interesting, because it is a myth that people panic when a fire, or other type of emergency, occurs.

The self-reliance of people is dictated by human characteristics, building characteristics and emergency characteristics. An example of the latter is that when people are informed that there is a potential explosion-hazard, they tend to start moving quicker than in case of a fire.

Incidents related to the detection of fire and smoke rely heavily on the self-reliance of road users. Time is crucial because fire and smoke develop much quicker in confined spaces than in the open (see former paragraph).

The level of self-rescue is determined by the time it takes for people to react to an emergency and by the actions and decisions taken by others around them. Technical fire safety measures are important, but the organisational aspects are just as important. A quick response by trained personnel of an underground facility can reduce the time that people react in a proper way up to ten times. People are strongly influenced by the behaviour of others and tend to follow instructions from others, especially from people with authority.

Experiments with different forms of alarming lead to different responses. Normal alarms, like an alarming bell, have much less effect than a spoken message over a sound system. When an alarm is stopped in the middle of an evacuation, people stop as well with escaping.

3.4 GENERAL COURSE OF ACTION IN CASE OF EMERGENCY

Underground facilities have their own organisation in place that will react immediately when an incident occurs. This is obviously not true for smaller objects such as short tunnels or unmanned parking lots. The organisation's staff consists of operators that work in (centralized) control rooms as well as managers, maintenance personnel et cetera. This staff will therefore play an essential role in the early moments when an incident evolves and has to work closely together with the first responders of the different civil protection organisations when they arrive at the scene. Staff personnel receives periodic training regarding routine operation procedures to ensure the safety of the users of their facility.

The following general course of action can be considered a standard operating procedure for all underground infrastructures that have one or more operators on site. It consists of eight general steps that guide a facility operator through an evolving situation.

1. Detect;
2. Secure;
3. Communicate;
4. Support;
5. Redirect or detour;
6. Check and repair;
7. Release;
8. Aftercare, report and evaluate.

During these steps the following actions are taken.

- **Detect**. An incident in an underground facility can be detected in various ways depending on the technical installation that is available. First notifications often come from this technical installation, such as the fire or smoke detection system. Furthermore the operator can detect abnormal behavior on the Closed Circuit Television (CCTV) system. Facility users can call the operator via voice connection that is installed in the facility or by telephone on the European emergency number 112. Another option is that an inspecting agency finds an abnormality during periodic inspection or daily maintenance

and reports this to the control center. Depending on the type of incident the internal procedure starts and, when required, the emergency services are alarmed.

- **Secure**. After the first detection it is important that the situation will be secured as fast as possible. This means in most cases that the entry to a facility is closed in order to prevent any additional traffic or persons going to the incident location.
- **Communicate**. Depending on the evolving scenario and type of facility, the operator will communicate with the emergency services. The operator will instruct and assist by means of the public address system and/or visual and audio beacons the users of a facility, especially when they have to be evacuated to a safe area. Other staff members can also play a role here by assisting the facility users, thereby enhancing the level of self-rescue that will take place.
- **Support**. If emergency services are present, the facility operator will have a supporting role to the emergency services. The operator has detailed knowledge about the infrastructure and knows and understands the current situation. The overview from the control center, ideally supported by CCTV system, can be shared with the emergency forces on-scene. Support can also include opening road barriers and adjusting the ventilation scheme when and where available.
- **Redirect or detour**. This step is only applicable to tunnels and metro stations. If the incident takes a significant amount of time to restore to normal operation, the operator can choose to redirect traffic over detour routes. This is especially important when the tunnel (tube) will be closed for a long time. The detour routes can be controlled and/or monitored from a Traffic Control Center. It is eminent that the emergency services should be aware of the detour routes.
- **Check and repair**. Check and repair is a stage that starts once the emergency services have completed their work. The facility staff checks for damage and when necessary starts repair works.
- **Release**. The staff determines whether the facility is ready for release and will be made available for normal operation. The staff first receives a release signal from the emergency services. Once a tunnel or station is re-opened the detour routes will be cancelled.
- **Aftercare, report and evaluate**. Aftercare, report and evaluate form the final step in handling incidents. It is important and mandatory that all data is logged. Together with reports and technical investigations by the emergency services, the reporting and evaluating structure makes it possible to evaluate the multidisciplinary response and cooperation between the emergency response units and recommend lessons learned. In case of extreme events it may also be necessary to include aftercare for the tunnel operator and other staff (trauma care).

4 ROAD TUNNEL

4.1 LEGAL ASPECTS AND REGULATIONS

4.1.1 EU DIRECTIVE 2004/54/EC

The EU directive 2004/54/EC aims at ensuring a minimum level of safety for road users in tunnels in the European network by the prevention of critical events that may endanger human life, the environment and tunnel installation as well as by the provision of protection in case of an emergency. The EU directive takes into account that:

- The conduct of road users is a decisive aspect of tunnel safety. Safety measures should be aimed at self-rescue and allow road users to act immediately so as to prevent more serious consequences.
- Safety in tunnels requires a number of measures relating, amongst other things, to the geometry of the tunnel and its design, safety equipment (including road signs), traffic management, training of the emergency services, incident management, the provision of information to users on how best behave in tunnels and better communication between the authorities in charge and the emergency services.

The EU directive emphasizes the importance of emergency response preparedness through the introduction of mandatory training and exercises. A set of procedural requirements must be met during the design and commissioning of a tunnel and during modifications and periodic exercises. The EU directive also has a set of minimum safety requirements that must be met, for instance uniform signing for tunnels.

4.1.2 STANDING SAFETY ORGANISATION

The EU directive introduces four entities that have their own role to play in ensuring safety in tunnels as part of the mitigation and preparedness phase:

- **Administrative Authority**. This authority shall have responsibility for ensuring that all aspects of the safety of a tunnel are assured and which shall take the necessary steps to ensure compliance with this directive. It is responsible for putting in place organisational and operational schemes, including emergency response plans, for the training and equipping of emergency services.
- **Tunnel Manager**. For each tunnel located on the territory of one of the member states, whether it is in the design, construction or operating stage, the Administrative Authority shall identify as Tunnel Manager the public or private body responsible for the management of the tunnel at the stage in question. The Administrative Authority itself may perform this function.
- **Safety Officer**. For each tunnel, the Tunnel Manager shall, with the prior approval of the Administrative Authority, nominate one Safety Officer who shall coordinate all preventive and safeguards measures to ensure the safety of users and operational staff. The Safety Officer may be a member of the tunnel staff or the emergency services, shall be independent in all road tunnel safety issues and shall not be under instructions from an employer in respect of those issues. A Safety Officer may perform his tasks and functions at several tunnels in a region. The Safety Officer verifies that tunnel staff and emergency services are trained, and he shall take part in the organization of exercises held at regular intervals.

- **Inspection Agency**. Evaluations and tests are carried out by an Inspection Agency. The Administrative Authority may perform this function. Any entity performing the inspections, evaluations and tests must have a high level of competence and high quality procedures and must be functionally independent from the Tunnel Manager.

4.2 SAFETY MEASURES AND INSTALLATIONS

The Westerscheldetunnel in the Netherlands is taken as an example here to illustrate the safety measures and installations of a large, modern tunnel. The tunnel is designed with an exceptionally wide range of safety measures to prevent unsafe situations from occurring, while preventive measures limit the potential consequences of a disaster. It is important that civil protection organisations understand how these measures work and what the consequences are if there is a failure in the safety system.

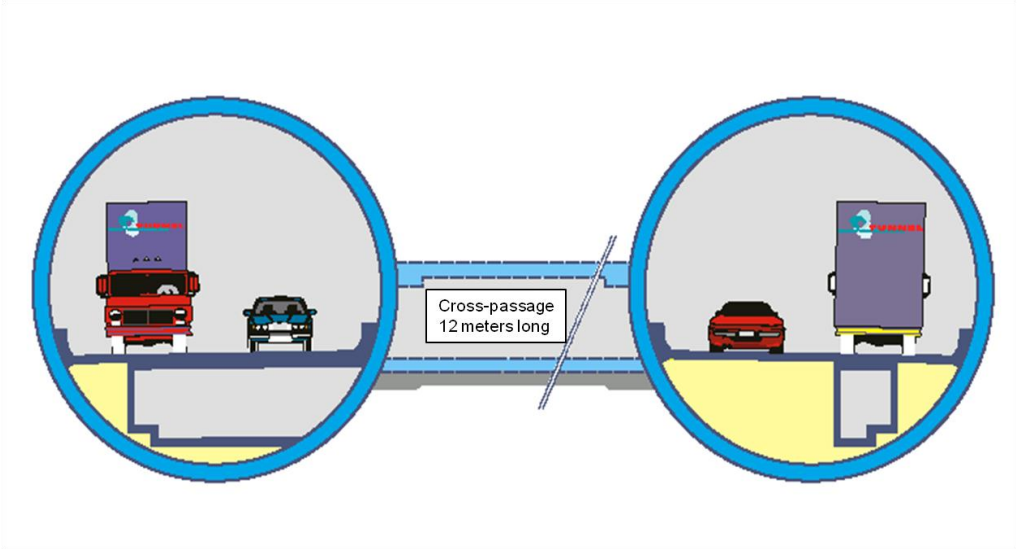

Figure 4.1 *Cross-section of the Westerscheldetunnel*

The Westerscheldetunnel is an example of a tunnel with modern facilities. It has two tubes, each carrying one-way traffic. This makes head-on collisions in the tunnel almost impossible. Cross-pasages can be found at every 250 meters that can be used as an escape route to get away from the incident. At the same time emergency response units can use the cross-passages to enter the incident area. Within each tunnel tube the following safety measures and installations can be found.

- Traffic management system;
- Communications system;
- Fire-resistant cladding;
- Emergency exits;
- Ventilation system;
- Emergency units;
- Central sumps and dumps.

The operator in the control room is able to monitor the situation with a Closed Circuit Television (CCTV) installation.

- **Traffic management system**. The aim of the traffic management system is to exercise traffic control in case of vehicle breakdown or emergencies. Lanes can be blocked, traffic can be slowed down, or stopped completely, or the tubes can be closed. Matrix signs are used to vary the travelling speed or warn traffic of upcoming events. The traffic management system can be used in conjunction with the communications system.
- **Communications system**. Intercom systems that are connected with the control room are present in the tubes as well as in the cross-passages. The control room can also communicate through loudspeakers to give instructions to the users of the tunnel.
- **Fire-resistant cladding**. The fire-resistant cladding on the tunnel walls serves to protect the concrete and keep the tunnel intact during a fire. It can at a minimum resist a two-hour fire with a maximum temperature of 1350 °C. There is however the possibility that the lining will be detached from the wall during an intensive fire, but it will still hold its resistant capacities. When the lining breaks, there is a high risk of rocks and wreckages falling down.
- **Emergency exits.** In the event of a serious incident in the tunnel, emergency exits are clearly marked. Emergency doors are positioned every 250 meters to allow all travellers to quickly escape to the other tunnel tube when necessary. The exit doors are fire and smoke resistant for at least one hour. A light overpressure is created by the ventilation system so that smoke and other gasses are kept outside.
- **Ventilation system**. In case of fire, the ventilation system is capable of drawing off smoke and gasses. The direction is in the length of the tunnel and the airstream is reversible (longitudinal ventilation). People can escape in the opposite direction and it gives the emergency services the change to approach a fire from a direction that is free of smoke. In the situation that one or some of the ventilators cease operating, this will hardly have any effect on the ventilation capacity as a whole. There is however a perverse effect to ventilation. In case of a fire, the ventilators provide for more oxygen that increases the intensity of the fire.
- **Emergency units.** At 50-meter intervals, emergency units have been placed, each one equipped with an intercom and a fire extinguishing system. When an emergency unit is opened, it will directly be registered in the control room and a camera will have the emergency unit visible.
- **Central sumps and dumps**. At the lowest point of both tunnel tubes are central sumps and pump units located. The sumps can hold up to 80m³ of water. Water from the tunnel and portals drains through pipelines into the sumps and is pumped out into the Westerschelde.

4.3 POSSIBLE RISKS AND EFFECTS

Safety measures and installations as described above are taken to lower the change of an incident to take place and to mitigate its impact when an incident occurs. But no matter how extensive and sophisticated the safety system is developed, possible risks will stay to exist (see paragraph 2.2). As a general rule, risks can be divided in three major categories:

- Man-made incidents;
- Natural disasters;
- Terrorist and criminal acts.

The difference between terrorist acts and the other two categories is the deliberate intention to create a (potential) dangerous situation. In relation to possible incidents within a road tunnel, the following risks and effects are identified per category.

4.3.1 MAN-MADE INCIDENTS

The most common incidents with regard to road tunnels are accidents that are caused by human error (accidents) or vehicle/material failure. On a daily basis incidents occur in (larger) tunnels that effect normal tunnel operation and require action from the tunnel staff. These so-called *traffic management incidents* include:

- Broken down vehicle;
- Accident with material damage;
- Accident including damage to tunnel infrastructure;
- Loss of fluids/liquids (non-dangerous goods);
- Loss of cargo and/or material on the road;
- Pedestrians, animals and/or bicycles in the tunnel;
- Wrong way driver;
- Height restricted vehicle.

In most cases these incidents do not require a coordinated response from the civil protection organisations, but may include support from the tunnel or road inspector or from the police. The incidents are managed by the tunnel staff and focus on creating a safe place for the road users in the tunnel as well as for response teams, such as wrecker service, tunnel inspector, incident management crew. This can be done through traffic management interventions such as lane closure, reduction of speed limits and tunnel closures. People that are inside the tunnel can be informed by the operator about the required response and actions they have to perform.

Another subcategory is *maintenance incidents*. Depending on the operational procedures during maintenance works, the tunnel can be open or closed for traffic. In case of a closed tunnel the emergency response is geared towards rescuing the maintenance crew. Where the tunnel is open during maintenance works, the incident scenarios can be more complex.

When the direct effects of a man-made incident become larger, a coordinated response from the civil protection organisations is required. These effects may include:

- Loss of life;
- Serious injuries;
- Trapped maintenance personnel;
- Detection of fire and/or smoke;

For tunnels that allow passage of dangerous goods, according to the stipulations of European agreement concerning international carriage of dangerous goods by road (Accord européen relatif au transport international de marchandises Dangereuses par Route (ADR)), incidents can be separated into different subcategories having different effects:

- Pressured gasses can result in explosions and in case of flammable gasses increase the magnitude of fire.
- Leakage of toxic goods will seriously effect climatologic conditions in the tunnel.
- Leakage of flammable liquids can cause a rapidly spreading fire when ignited.

All incidents with dangerous goods require fast response from emergency services. The big difference with the major incidents mentioned above is the wider impact they can have on the environment and on the surroundings outside the tunnel. In other words, the effect area can be much larger.

4.3.2 NATURAL DISASTERS

A natural disaster is the consequence of a natural hazard. In relation to tunnels the following natural hazards might form a threat to the normal operations of a road tunnel:

- Flood;
- Earthquake;
- Avalanche;
- Land- or mudslide;
- Blizzard;
- Wild fire.

Natural disasters are greatly location depended and occur on a much smaller scale than man-made incidents. So the chances are low, but the impact might be high. The effects of a natural disaster are trapped people inside the tunnel, limited access to tunnels, severe damage to the infrastructure, large water masses inside the tunnel et cetera. Malfunctioning equipment will make it very difficult for the tunnel staff to get an overview of the situation.

4.3.3 TERRORIST AND CRIMINAL ACTS

Tunnels are essential infrastructure objects with great economic value and are therefore a potential target for activists, pressure groups and terrorists. Possible incidents are:

- Occupation;
- Destruction;
- Crime;
- Threat.

"Sunday 24 September 2006 the British newspaper the Observer reported the Channel tunnel has been targeted by a group of Islamic militant terrorists aiming to cause maximum carnage during the holiday season, according to French and American secret services.

The plan, which the French foreign intelligence service became aware of earlier this year, is revealed in a secret report to the French government on threat levels. The report, dated December 19, indicates that the tip-off came from the American CIA. British and French intelligence agencies have run a series of checks of the security system protecting the 31-mile tunnel but the threat level remains high. British security services remain on high alert throughout the holiday period."

As explained, the difference between terrorist acts and the other two categories is the deliberate intention to create a (potential) dangerous situation. The direct effects however can be more or less the same. For example, the explosion of a truck with pressured gas in a tunnel can have the same destructive effect as a car filled with explosives. But the indirect effects will be different, as a terrorist attack will create a different involvement from the authorities and/or special units. At the same time, the media and the society will react completely different to such an event and there is a possibility for a domino-effect like civil unrest and/or public disorder.

5 METRO STATION

5.1 LEGAL ASPECTS AND REGULATIONS

Concerning the topics of operation in case of incidents, emergencies, fire safety and execution of training, numerous regulations exist within Europe. But these are only partly valid for metro systems.

5.1.1 EUROPEAN REGULATIONS

The EU directive 2004/54/EC refers to road tunnels and is therefore explained in more detail in chapter 4. The stipulated basic safety rules can be transformed to a limited degree into the field of public transport tunnels and metro stations. This directive aims at ensuring a minimum level of safety for road users in tunnels in the Trans-European Road Network (TERN) by the prevention of critical events that may endanger human life, the environment and tunnel installations as well as by the provision of protection in case of accidents. It emphasizes the importance of emergency response preparedness through the introduction of mandatory training and exercises. A set of procedural requirements must be met during design and commissioning of a tunnel and during modifications and periodic exercises.

The European Commission has also set in force a Technical Specification of Interoperability (TSI) relating to safety in railway tunnels in the trans-European conventional and high-speed rail system. This specification relates only to long distance railways and is not valid for metro systems. However, some general statements can be assigned to metro systems too. In relation exercises can be read that prior to opening of a single tunnel or a series of tunnels, a full-scale exercise comprising evacuation and rescue procedures, involving all categories of personnel defined within the emergency plan, shall take place. The emergency plan shall define how all organisations involved can be familiarised with the infrastructure and how often visits to the tunnel and table top or other exercises have to take place.

5.1.2 STANDING SAFETY ORGANISATION

Metro systems are considerably different from road tunnels or parking lots. The rolling stock, the train, is driven by specially educated and trained personnel, where as cars in road tunnels and parking lots are driven by individuals. Against this background, metro stations and tunnels must be examined separately. Under normal operating conditions individuals are not allowed in the tunnels, but only access the platforms.

The operator is the person, or a group of persons, responsible for all traffic management aspects of the metro system. The operator is working from a centralized control room that is equipped with communication devices such as CCTV screens, telephone and radio communication to steer the metro system and the metro staff. Drivers and inspectors report all relevant safety information to the operator and receive instructions from the operator.

Depending on how the emergency response plans are designed, the metro operator plays an essential role in the early stage of the response to an incident. The staff receives education and training for daily/normal operation procedures to ensure safe operation of the metro system.

The role of the driver, as being part of the operating team, can be highly important in critical situations. The driver might be the first responder to any incident and the only field help for the passengers, until the emergency response units arrive on the scene.

5.2 SAFETY MEASURES AND INSTALLATIONS

As with road tunnels, metro stations are designed and equipped with a large range of safety measures and installations and become more and more sophisticated. Most of these are related to the prevention of the effects of fire and smoke or to the security of the facility and its passengers. Security measures aimed against harmful intent fall outside the scope of the Up Safety programme.

Figure 5.1 *Artist impression of a modern metro station facility*

In relation to fire and smoke, the following measures and installations are in place:

- Ventilation system;
- Compartmentalisation;
- Sprinkler and water mist systems;
- Emergency exits and safe areas.

Furthermore there are the fire detection sytems, communication systems and emergency units (fire hydrants and portable fire extinguishers) that are functionally not different from these in road tunnels (see paragraph 4.2). A closer look at the four measures and installations leads to the following conclusions.

- **Ventilation system**. In underground passenger transport facilities the enabling of self-rescue is of vital importance in the event of a fire. As a minimum, during the time required for self-rescue from the endangered section (approximately fifteen minutes) the smoke must be prevented from reaching the area of the escape route and sufficient visibility in the lower smoke layer must be provided. The most effective measure to keep the smoke level of underground stations low for as long as possible in the key areas, is the correct arrangement and dimensioning of smoke and/or heat exhaust shafts to the open. Shafts can work naturally based on the thermal current or be equipped with mechanical ventilation systems.

- **Compartmentalisation**. To minimize injury and damage in case of fire, different preventive measures for structural fire protection are implemented in underground public transport systems. Examples are structural separation by fire-resistant and non-combustible walls and ceilings, smoke barrier and gas-proof self-closing doors and flaps.
- **Sprinkler and water mist systems**. If the transport area itself is to be divided into fire areas or zones, only measures can be considered that restrict fire and smoke but are also permeable for trains and passengers. That is the case with the application of conventional sprinkler systems and water mist systems. In the public transport field so far, such water mist systems have been used for example in the metro system of Milan, where the safety zones for passengers are protected by water curtains. Furthermore in the Madrid metro the areas of escalators, shops, offices, ticket counters et cetera have such equipment.
- **Escape routes and safe areas**. Escape routes can be long in large metro stations. In case of a deep underground station, which causes very long evacuation times, a safe space can be provided by overpressure in the stairwells. In this way passengers will be protected against the effects of fire and smoke. Some metro tunnels have emergency exits as well.

5.3 POSSIBLE RISKS AND EFFECTS

The same concept applies to all underground facilities: no matter how good the safety measures and installations are designed and implemented, there is always a chance at incidents. For metro systems, the following risks and effects are identified within the three categories of man-made incidents, natural disasters and terrorist and criminal acts.

5.3.1 MAN-MADE INCIDENTS

As with road tunnels, *traffic management incidents* require primarily action from the operating staff. The frequency at which these subcategory of incidents occur however, is much lower than in road tunnels. Traffic management incidents in metro systems include:

- Loss of primary power source resulting in stalled trains, loss of lighting and switching to emergency power;
- Disabled, stalled or stopped trains due to adverse personnel or passenger emergency condition;
- Broken down train;
- Minor accident of a metro carriage, for example derailment, without personal injuries;
- Pedestrians, animals or bicycles in the tunnel.

This subcategory of incidents effects normal metro operation, but in most cases do not require a coordinated response from the civil protection organisations. The incidents are mostly managed by action from the metro staff only and are aimed at the safety of operation for users and staff. Ensuring smooth operation avoids delays and inconvenience for the passengers as customers of the metro system.

To cope with the incidents mentioned above, actions of traffic management interventions are undertaken, for instance redirecting trains on other tracks and closures of respective tunnel sections. Additionally the passengers sitting in the train involved in the incident must be informed by the operator about the response. If the delay exceeds a defined period of time de-boarding might be required.

Another subcategory is *passenger related incidents*. These incidents include:

- Evacuation of passengers from a train, where assistance is required;
- First aid or medical care for passengers on trains due to illness;
- Accidents with injured people.

Again, in most of the cases the metro staff is able to cope with these kinds of incidents. As long as the affected persons are located inside an operable train, the train will always stop in the next station to provide the ambulance team easy access to the train. Intervention by other services is normally not needed.

When the direct effects of a man-made incident becomes larger, a coordinated response from the civil protection organisations is required. These effects may include:

- Loss of life;
- Serious injuries;
- Train can't reach the station;
- Detection of fire and/or smoke.

A worldwide analysis of major fire incidents in tunnels and stations used by local public transport shows that large fires with high damage to property and personal injury are rare events, but they cannot be ruled out altogether. Fires in public transport vehicles and facilities can have different causes, but in the majority of cases they occur due to arson (see paragraph 5.3.3) or technical defects.

"On 18 November 1987 a fatal fire broke out at King's Cross St. Pancras metro station that killed 31 people. The escalator on which the fire started had been built just before World War II. The steps and sides of the escalator were partly made of wood, which meant that they burned quickly and easily. Although smoking was banned on the subsurface sections of the London Underground, the fire was most probably caused by a traveller discarding a burning match, which fell down the side of the escalator onto the running track. The running track had not been cleaned since the escalator was constructed in the 1940s and was covered in grease and rubbish.

The lack of visible flames and relatively clean wood smoke produced brought the emergency services into a false sense of security, especially as firemen had attended more than 400 similar metro fires over the previous three decades. Firemen later described the fire as around the size and intensity of a campfire. Many people believed that the fire was small and thus not an immediate hazard."

In a metro system, a fire can take place in the following locations:

- Platform inside the station;
- Shopping area inside the station;
- Technical installations area;
- Tunnel;
- Metro train stopping inside the station;
- Metro train stopping inside the tunnel.

Every incident with a detection of fire and smoke requires a detailed investigation of the cause. Even a small fire can grow within a short time to a serious incident and the fire service has to be alarmed as soon as possible.

When the detection occurs inside a train, a fast reaction by the metro driver is of high relevance. The driver has to follow the general instruction to reach the next station, because the situation for evacuation and fire fighting is much better there. After the station is reached the driver has to prompt the passengers to disembark the train and to move to a safe place if possible outside the station. Afterwards the driver should try to extinguish the fire until the fire serviced has arrived.

Only if the train is forced to stop in the tunnel and thus reaching the next station is not possible, the driver should locate the fire and try to extinguish it with the fire extinguisher available in the train. In parallel the evacuation of passers in the effected carriage should be triggered by giving clear instruction through announcement via loud speakers. If the fire extinction does not succeed the evacuation of all persons in the tunnel (passengers and staff) to the nearest emergency exit must be started using the emergency paths beside the track. The tunnel operation command room starts the procedure to evacuate the respective tunnels system and alarms the fire service.

5.3.2 NATURAL DISASTERS

As with road tunnels, the natural environmental and weather conditions can cause a threat to the normal operations of a metro system (station and tunnel):

- Extreme weather conditions, such as heavy snow;
- Flood;
- Earthquake;
- Avalanche;
- Land- or mudslide.

The possible threats to metro stations are limited to the first three of the above, due to the fact that metro stations are located in urban areas where avalanches and land- or mudslides normally don't have any effect. The trains however can commute over a larger distance, so at the tunnel entries effects by avalanches or land- or mudslides can occur.

The effects of a natural disaster will be more or less the same as with road tunnels.

5.3.3 TERRORIST AND CRIMINAL ACTS

Metro systems are essential infrastructure objects with great economic value and therefore a potential target for activists, pressure groups and terrorists. Possible incidents are:

- Occupation;
- Destruction;
- Crime;
- Threat.

"The Madrid train bombings consisted of a series of coordinated bombings against the commuter train system of Madrid, Spain on the morning of 11 March 2004, killing 191 people and wounding 1800. The official investigation by the Spanish Judiciary determined the attacks were directed by an al-Qaeda-inspired terrorist cell although no direct al-Qaeda participation has been established.

The bombings occurred three days before general elections. Controversy regarding the handling and representation of the bombings by the government arose with Spain's two main

political parties, accusing each other of concealing or distorting evidence for electoral reasons. Nationwide demonstrations and protests followed the attacks. The predominant view among political analysts is that the Aznar administration lost the general elections as a result of the handling and representation of the terrorist attacks."

When a terrorist attack takes place on a metro system, people will panic and civil unrest en public disorder can be major effects of such an incident. As the Madrid train bombings show, the political implications can be enormous.

Threats from terrorism can come in many forms. The Sarin incident in the Tokio metro system in 1995, killing 15 people, proves that even the unthinkable can happen and that it is impossible to predict every scenario that can take place. The above listing of possible incidents is therefore mere an example.

6 PARKING LOT

6.1 LEGAL ASPECTS AND REGULATIONS

6.1.1 EU DIRECTIVES

Where strong regulations exist for the safety in road tunnels, and deductions of these apply to metro systems as well, there are no European directives available in relation to parking lots. Between the nations there are large differences regarding safety measures and installations that should be in place. Sprinkler installations for instance are obligatory in some countries, but not in all. Even within countries there are large differences between how cities handle parking lot safety during the design and building of it. Most of the time there are no specific regulations in place and parking lots are regarded the same as normal building structures above ground level. Even simple emergency assets like fire extinguishers are sometimes not present, as there is no obligation and the risk of theft or vandalism is deemed to high.

6.1.2 STANDARD SAFETY ORGANISATION

Parking lots may or may not have a facility staff present that operates from a control room. If this is not the case, the safety in a parking lot can be monitored from a central emergency room. A mixture is also possible, when then parking lot is closed during a certain period at night. When a facility staff is present, they are responsible for the operational exploitation of the parking lot. Their focus is as much on safety as it is on security.

Figure 6.1 *Picture of a modern parking lot with a large range of safety measures*

6.2 SAFETY MEASURES AND INSTALLATIONS

Modern parking lots are designed with a large range of safety measures to prevent unsafe situations from occurring and to mitigate the effects of a possible incident. Older structures often can be ill-equipped or have aged installations that are not up to standard in a modern society. With the absence of uniform international and national rules and regulations, every standard between bare minimum and highly sophisticated is possible.

This paragraph will consider the more advanced safety measures and installations that might be present as the picture on the previous page shows. The following can be identified.

- Parking installation;
- Emergency routes and exits;
- Ventilation system;
- Fire suppression system.

Other systems that are standard present are the fire alarm system and gas detection system (carbon monoxide and liquefied petroleum gas). These are discussed here not in further detail as they will primarily play a role before the actual response by the emergency services. The ones mentioned are explained below.

- **Parking installation**. When an incident takes place, the barriers at the entrance gates should be closed and the exit gates opened. Therefore the parking installation should be an integral part of the overall safety system. This applies to emergency exits, speed gates and overhead doors as well. Emergency buttons are placed on escape routes so that doors and gates can be opened by fleeing pedestrians.
- **Emergency routes and exits**. Emergency routes can run via several features. Elevators will normally cease operating or stop at a designated floor in case of emergency. Escalators and moving walkways can be part of the route as well and will stay operationally or are shut down. In stair wells and lift shafts an overpressure is normally created to create a smoke-free emergency route.
- **Ventilation system**. In modern parking lots the ventilation system is connected with the fire alarm system. This creates an intelligent smoke exhaust system, which makes it possible for users of the facility to flee without an immediate danger of smoke. At the same time it provides the fire service the opportunity to fight the fire in a relatively smoke-free environment. The perverse effect that we talked about earlier when discussing the topic in relation to road tunnels, is also present here. Therefore the ventilation system is sometimes (partly) shut down, to prevent the heart of the fire from spreading rapidly. It is important to understand that the smoke has to come out somewhere and within build-up areas will create a reaction of the public.

  In older parking lots the method of compartmentalisation is still used a lot. The unwanted effect of this method might be that pedestrians and drivers have difficulty finding the exits or getting away from the hazardous area at all.
- **Fire suppression system**. The presence and direct availability of fire extinguishers and hoses, and other active means for direct suppression of fires, differ greatly between different parking lots. An interesting discussion is if laymen should try to prevent a fire from spreading or should make alarm and flee to safety as soon as possible. Facility staff members are trained in the use of fire extinguishers.

  Another discussion is revolving around the topic of the use of sprinklers. Advocates of the use of sprinklers will argue that this is the only way to prevent a starting fire from spreading rapidly through a parking lot. Cars will be cooled as well as the area as a whole, that provide the fire services with the opportunity of operating close to the heart of the fire. Opponents will point out that using sprinklers will have an effect on the proper

working of the smoke exhaust system. Another disadvantage they will say, is the fact that burning liquids (gasoline) will spread more easily through the facility as the burning liquid floats on the water.

From the control room the facility staff can monitor the situation in a parking lot with CCTV cameras. These cameras can be linked to a central emergency room as well. From the control room the staff can communicate with voice messages to the users of a parking lot over the sound system. It is important to notice that the control room of a parking lot always has an overpressure to keep the car exhaust out. This will also keep the smoke out in case of a fire.

6.3 POSSIBLE RISKS AND EFFECTS

Possible risks will stay to exist and have a certain effect on parking lots and their direct and indirect environment. As for road tunnels and metro stations, the same three major categories apply:

- Man-made-incidents;
- Natural disasters;
- Terrorist and criminal acts.

The following risks and effects are identified within the three categories.

6.3.1 MAN-MADE INCIDENTS

Incidents that are caused by human error or vehicle/material failure do not come in so many different forms. They include:

- Collisions with material damage or damage to the structure;
- Persons becoming unwell;
- Vehicle malfunction;
- Release of dangerous gasses.

In most cases these incidents will not require a coordinated response from the civil protection organisations, but may include involvement of the police, ambulance or fire and rescue service. Other (privately operated) services might be called in as well, for instance a wrecker service. The facility staff available will be able to cope with these kind of incidents and assist where and when necessary.

When the direct effects of a man-made incident become larger, a coordinated response of the civil protection organisations might be required. These effects may include:

- Loss of life;
- Serious injuries;
- Detection of carbon monoxide or liquefied petroleum gas (above a certain level);
- Detection of fire and smoke.

Especially the latter two require a fast response from the emergency services. The ventilation has to work in a proper way and the parking lot has to be evacuated as soon as possible. The assistance of the facility staff is of great value as they have detailed knowledge about the structure’s design and the safety measures and installations available. Images from the control room can contribute to a better understanding of what is happening.

"On 26 October 2010 a fire broke out on the second layer of an underground parking lot in the centre of the city of Haarlem in the Netherlands. The fire started in one of the parked vehicles and the owner of the car reacted quickly. After she was not able to find a fire extinguisher, she called 112 and warned other users of the facility. The fire spread rapidly and the smoke became so thick that the firemen were not able to enter the parking lot and could only use their water cannons from the outside in.

As a result of the smoke development the police had to evacuate the area, including the courthouse, two theaters and several hotels and cafes. Because of the enormous heat that the fire produced it was not possible to enter the parking lot within 24 hours after the fire started. A total of twenty cars took fire and the salvage of all vehicles took many days to accomplish."

6.3.2 NATURAL DISASTERS

The threat of natural environmental and weather conditions to the normal operation of a parking lot is relatively low due to the fact that this kind of underground structure is located in urban areas. Possible hazards are limited to:

- Extreme weather conditions, such as heavy snow;
- Flood;
- Earthquake.

The effects can respectively lead to trapped personnel inside the parking lot, large water masses inside the parking lot and serious damage to the infrastructure or collapse.

6.3.3 TERRORIST AND CRIMINAL ACTS

Parking lots can be a potential target for terrorist and criminal acts. Possible incidents are:

- Criminal assault;
- Public disorder and/or looting;
- Destruction;
- Bomb threat.

Criminal acts are normally a matter for the police. When there is a threat of imminent danger, for instance a bomb threat, all civil protection organisations will respond as well as the public administration. When a terrorist attack takes place on a parking lot, people will panic and civil unrest and public disorder will be major effects of such an incident.

7 INCIDENT COMMAND TEAM

In chapter 2 the on-scene organisation is discussed in case an incident happens that requires a multidisciplinary response. It is explained that the first coordination efforts between emergency services start immediately after they arrive at the scene. At the same time the members of the incident command team are alarmed to command, control and/or coordinate all activities at the incident site. Independent of the level of scaling-up that will take place, the incident command team is always organised in the same way and its members have certain tasks to fulfil. This chapter explains this organisation and these tasks and focuses on the decision-making process that takes place within the team.

7.1 ALARMING

The incident command team will become operational when the situation dictates a close coordination between the civil protection organisations to ensure an effective response. It is obvious that somebody has to take the initiative to alarm the team based on his or her judgement of the situation and unfolding events. It is very much country-depended who will have the authority to do so and the alarming can be done by:

- The duty officers of one of the emergency services that are present at the incident-scene.
- In absence of the duty officers by one of the commanders of the operational units that are on-scene.
- By one of the officers of one of the emergency services that are informed directly by their own people about the situation but are presently off-scene.
- The chief of the emergency room that handles the incident.

Again, it is a responsibility for each of the European countries to develop a standard operating procedure on this matter. The same applies to other aspects of the alarming-procedure such as the means that are used and the reaction times that should be met.

The way this is done in the Netherlands for instance can be used as an example for such a procedure. Here the alarming-procedure is normally set in motion by one of the duty officers that are present at the scene, but any of the above options is possible. The general emergency room, that handles all emergencies within one of the so-called safety regions, will alarm the necessary personnel and material to head to the incident site. The normal routine is that the core-members of an incident command team (see paragraph 7.3) are required to arrive at the scene within 30 minutes from the time they are alarmed on their pager. Other members, for instance a representative from the public works department, may have a longer response time.

7.2 LOCATION

Once the incident command team is alarmed and present at the scene, they have to decide on a location to work from. The incident commander, who leads the incident command team, will choose the best option after discussing it with the other team members. Depending on the level of preplanning that is done, and the level of detail of the emergency plans that are available in relation to a specific object, some spots may be already explored during the mitigation or preparation phase. In case of larger road tunnels for instance, there are normally certain areas designated for the treatment of victims, the storage of car wreckages and for location of the command post (on both sides of the tunnel entrances).

It very much depends on the available means within a country how a command post is set up and equipped. A large communication vehicle of one of the services might be the first choice or a dedicated command vehicle might be called in. Some countries make use of specially equipped containers that are brought to the incident site by truck. Another option is the use of a building or something similar close to the site, but communications will normally cause a problem in doing so. In case of an underground infrastructure it might be tempting to use the control room, because of the advantage of the real-time footage provided by the CCTV. There might be disadvantages however that outweigh this advantage by far.

7.3 COMPOSITION

The incident command team is normally composed of the following core-members:

- **Incident commander**. He has the mandate to command, control and/or coordinate all activities at the incident site and is a senior officer of one of civil protection organisations. Apart from the countries' protocols that might be prescriptive, it makes sense to let the situation determine which "colour" the incident commander should have (a security incident might be led by a police officer for instance, while an officer from the fire & rescue service might be a better option when dealing with a large fire or an emergency with dangerous goods).
- **Duty officer fire and rescue service**. The highest ranking officer of the fire & rescue service at the scene.
- **Duty officer medical**. The highest ranking medical official at the scene.
- **Duty officer police**. The highest ranking officer of the police service at the scene.
- **Press officer**. A representative of one of the services specially trained to handle the press that will be present at the scene.

Other members can join the team, such as ad hoc advisors, depending on the type of incident and the effects that take place:

- Representatives from public institutions such as the public works department or other organisations as mentioned in paragraph 2.4.3.
- Representatives from private parties such as railway operators, electricity companies or large chemical industries.

In case of an incident with an underground infrastructure, that has their own organisation in place, the facility staff will sent one of their employees to the incident command team as their representative. This employee will act as the incident manager of the facility and is the linking pin between the actions taken by the facility staff and the actions of the emergency services.

7.4 DECISION-MAKING PROCESS

The focus of the incident command team is to provide guidance and direction to the operational processes that take place at the incident site. In order to do so, the incident command team has to decide which actions should be taken by the emergency services. At the same time the incident command team has to make sure that their actions are coordinated with other organisations that are operating at the scene, to be sure that all activities are in line to achieve the desired effect. And not in the last place, higher level commands and authorities as well as designated stakeholders have to be informed continuously of the progress that is being made on-scene.

All of this can only be achieved by going methodically through a decision-making process that is normally executed under time pressure. Again, every country will have its own formats to go through this process in a structured way. But looking at it from a conceptual point of view, all will have the phases and/or steps incorporated in them as are shown in the model below.

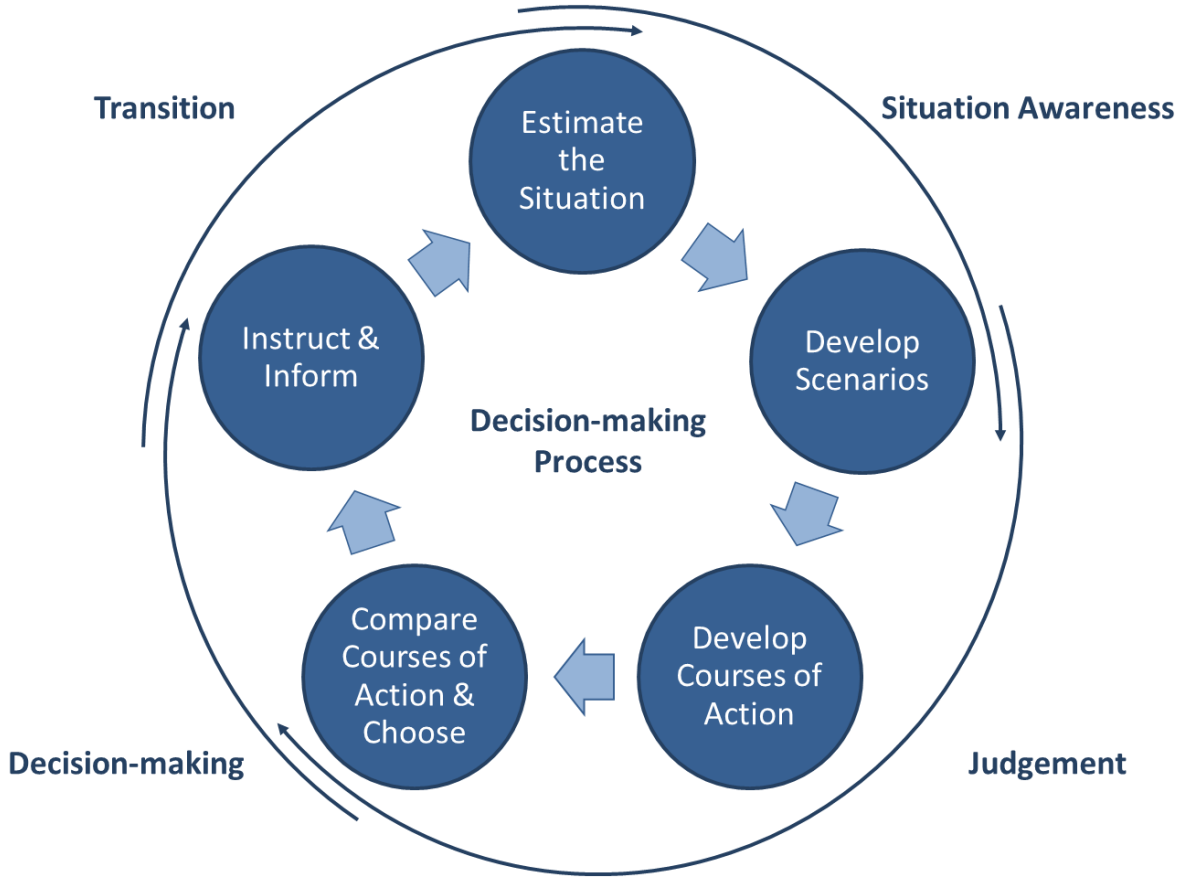

Figure 7.1 *Model of the decision-making process*

The four phases of this model are situation awareness, judgement, decision-making and transition. The phases don't have a clear cut beginning and ending and gradually shift from one to another as an never-stopping wheel that roles forward. This is in contrast with the steps to be taken within the process, that are clearly separated from each other. Each step is a process in itself with an input generated by the previous step and an output that sets the next step in motion. Following the steps will guide an incident command team 'automatically' through the decision-making process. So the phases explain what has to be done within the process and the steps explain how to do it.

7.4.1 SITUATION AWARENESS

The process is initiated by creating situation awareness in the first planning cycle that the incident command team conducts. In the following cycles this will shift to maintaining and improving situation awareness as the situation alters in time. Situation awareness is an estimate of environmental elements and other factors of influence within a volume of time

and space, the comprehension of their meaning, and the projection of their status in the near future. Simply stated, every member of the command team has the same perception of what is happening and why and what the consequences will be (risks and effects) of that present situation.

There are two steps to be taken to create this state of mind. Step 1 is to estimate the current situation. Based on the information that is available the incident command team will build a picture of what is happing at that moment based on facts. Therefore they will take the following elements and factors into account (the list is not exhaustible).

- Type and cause of the incident;
- Environmental elements (weather, terrain, infrastructure, civilians et cetera);
- Direct and indirect effects (in time and space);
- Emergency personnel and other means available (logistics, communications et cetera);
- Current actions taken by the emergency services and others.

Step 2 is to extrapolate this current situation to the (near) future. Paragraph 2.4.1 describes the theory behind this step where the incident command team will visualize how a scenario might evolve into the future, by predicting possible effects in time and space. More scenarios can be developed when time is available, for instance a most likely scenario and a worst case scenario. Further on in the process, the decision has to be made which scenario will be taken to work from.

This is the phase that requires a lot of knowledge from the team members about the environment they work in. In relation to underground facilities, this means knowledge about the general aspects as described in chapter 3 and possible risks and effects as described in the chapters 4, 5 and 6.

7.4.2 JUDGEMENT

During the step 2 of creating situation awareness, the judgement-phase already starts running. It is not difficult to realise that judgement is necessary to predict the future. The incident command team is now to the point where it should have answers formulated on the next questions:

- What is happening and why?
- What are the effects of the incident at the moment?
- What do we have available to solve this problem and what are we doing now?
- What will (possibly) happen next?
- What will the extension of the impact area be, how fast will it go and how long will it last?

In relation to an incident in an underground facility, this is the moment to look deeper into the actions that are taken by the standing safety organisation and the effects of all safety measures and installations that are available and, hopefully, are already working. The question is of these are all working in a way that help the emergency services in what they want to achieve. This comes down to true knowledge and experience about how preventive and mitigating efforts can positively contribute to emergency response operations and vice versa. A representative of the facility will be the most important source of information at this point.

At this point a lot of judgement is already done. The next move will be to start finding solutions to the problem in a structured way. The third step in the decision-making process therefore is to develop courses of action. This step depends a lot on the level of expertise

and creativity of the team members to come up with one or more solutions that work. To structure the thought process, this should be done in the following way.

First, the incident command team should define its aims: “What do we want to accomplish?” To define these aims, it is necessary to start thinking in effects again, but from a problem-solving point of view. Maybe we want to contain the incident to a small area first, or remove people from a (possible) impact area, or prevent building from collapsing. Contain, remove, prevent are all effects that an incident command team wants to achieve and are the aims that we are looking for.

The second question will be to define how we are going to realise these aims. This relates to the tasks of the agencies involved in responding to emergencies as described in paragraph 2.3. In several countries these tasks are translated into standard processes and procedures already. When the example above of containing an incident is taken, the “how” is rolling out automatically as all services know on forehand what is expected of them.

Finally the desired result should be defined. Defining this “end state” makes sure that it is clear to everybody when a certain aim is achieved.

So the triad of “aim-method-end state” is a methodical way to start develop courses of action and during this step a lot of issues will start getting visible. Not enough man power, not having all the necessary equipment available and missing certain expertise are just some of the issues that will roll out of the planning process. The incident command team has to come up with solutions for these problems or should drop a course of action in an early stage when it is obvious that it will impossible to execute it.

Depending on the time available the incident command team will develop one or more courses of action. It is desirable to have at least two courses of action to choose from instead of developing only one. The latter can cause a form of myopia where the whole team is thinking in the same direction, discarding anything that is not in line with that one and only solution. If the command team comes up with more than one scenario after step 2, every scenario should be the starting point for two courses of action.

Step 4 of the decision-making process is to compare the courses of action and choose the one that is considered best to counter the incident. This can be done by evaluating the courses of action against a set of pre-established criteria, with or without allocating a certain weight to each of the criteria.

Due to heavy time pressure on the process, especially in the initial stage of an incident, it is common practise to make a quick decision after step 2 (develop scenarios) to start working from the most likely or worst case scenario. The same applies to step 3 and 4. Instead of going through an analytical process of decision-making, the judgement phase is quickly passed by experienced decision-makers in dynamic conditions (naturalistic decision making). However, when time is available and the incident is complex and the stakes are high, it is recommended that the incident command team should aim for a more methodical way of working with a different set of options as described above.

7.4.3 DECISION-MAKING

There is not always a clear cut between the moment the judgement phase runs into the decision-making phase, as decisions are made constantly to get to a solution that works. But at the end of step 4 (compare courses of action and choose) the final decision is made to follow the course of action of choice. It is important that the incident commander makes absolutely clear what he wants to do by summarizing his decisions before proceeding with the process.

The next thing to do is turning decisions into concrete actions and to make one of the emergency services responsible for each of the actions. At the same time the incident commander has to decide which actions cannot be taken by the units under his control and which organisations should be informed of the situation and decisions/actions that are taken under his responsibility. He also has to make sure that it is clear how the public should be informed through the media with the help of the press officer.

7.4.4 TRANSITION

This may be considered as the most crucial phase of the decision-making process. At the end of step 4 all of the information still exists only in the command post. It is now time to disseminate the results of the decision-making process to the outer world. This is step 5 of the process, instruct and inform. The duty officers of the emergency services, and others that might be present at the table, have to instruct their units/personnel in the field on the tasks they have to accomplish. The press officer will start the information campaign towards the media/public and the incident commander will inform higher echelons and other network-partners on his estimate of the situation and his intentions for the next period of time.

All of these actions will have an effect on the course of the incident. The situation will alter when units start acting with the guidance and direction that is provided by the incident command team. The media will make up their stories that will influence the perception, and with that the reaction of the public. The higher echelons will start their own planning process with the information that is handed to them by the incident commander. If an incident grows larger, politics will start to play a more important role and more stakeholders will get involved.

One of the decisions that will be taken is the time of the next meeting with the incident command team. The altered situation and new information will drive the next cycle of the decision-making process.

7.5 TASKS

In the previous paragraph a lot of the tasks of an incident command team are already mentioned. The most important ones are listed below.

- Estimate the situation at the scene of the incident and the possible developments.
- Determine the actions necessary for a fast and coordinated response.
- Secure the scene.
- Inform higher echelons about the situation and recent developments.
- Coordinate with organisations not under command/control.
- Guide and direct the emergency units at the scene.
- Request for (extra) personnel and equipment if necessary.
- Request for specialised units if necessary.
- Provide information to the public and media.

PART II

8 EDUCATION, TRAINING AND EXERCISE

8.1 INTRODUCTION

The Up Safety ETE-programme is set up as a reference tool for trainers for the preparation of incident command teams, including designated staff members of an underground facility. This chapter describes the philosophy behind the ETE-programme and provides guidance and direction to trainers that are responsible for planning, organising and executing the ETE-activities for multidisciplinary teams. It is aimed at trainers that have already experience with educating, training and exercising teams and individuals in multidisciplinary response operations.

First the boundary conditions are listed to make clear what requirements must be met before starting with the ETE-programme. The programme is developed for members of incident command teams and can only be successfully employed when other preparative actions are already taken regarding mono-disciplinary operations, command structures and emergency plans. As well trainers as trainees should already be experienced to a certain level at the start of the programme.

Secondly the conceptual approach behind the programme is explained, so it is clear why the ETE-programme is designed in the way it is presented. The principles of the programme lay in a balanced mix of theory and practice as well as both focus on content and process and make sure that education, training and exercise make up a logical sequence that strides along in the right pace.

After setting the conditions and clarifying the concept behind the programme, the next step is to give guidance and direction to the proposed content of the programme. It makes clear what topics should be educated to the trainees and what should be trained when operating as incident command team. It also explains what is needed to organise full-scale exercises in terms of formulating goals, choosing the right working method and writing scenarios and scripts. Special attention is given to the aid of virtual reality as a simulation tool.

At the end a generic but complete ETE-programme is presented, leaving room for local circumstances to fill in the details. This programme is based on the use of the virtual reality tool ADMS, but can be executed with simulation tools of other suppliers as well. Even more, it can be executed without the use of virtual reality by using different working methods. This creates a versatile and flexible programme that can be used for each of the three objects, road tunnel, metro station and parking lot, independently of the geographical location of such objects in Europe and the specific situation that goes along with it.

8.2 BOUNDARY CONDITIONS

8.2.1 BASIC ENTRY LEVEL

Within the project Up Safety the focus is on the incident command team that is responsible for the command, control and/or coordination of multidisciplinary emergency response operations. The core-members of the incident command team are therefore the primary target group of the ETE-programme. On an individual level the core-members should already have knowledge of and practical experience with multidisciplinary operations before starting with the programme. They must also be aware of the processes and tactics that will be dealt with by the operational units of the service they represent. So a duty officer of the fire and rescue service must be able to explain to the other members of the team what the units are

doing, or are able to do, and what the effects of their actions will be when dealing with an incident in an underground facility.

As a team they should have knowledge of and practical experience with the decision-making process, based on national standard operating procedures. They should be already up to the standard that they can deal with incidents in a “normal” environment. The Up Safety ETE-programme is just an add-on to this basic level of experience, that focuses solely on the special circumstances and scenarios that underground infrastructures present.

The same applies to the facility staff members and other members that can join the incident command team as ad hoc advisors (see paragraph 7.3). The organisation they belong to is responsible for preparing these advisors within their own discipline to what they can expect and what is expected of them when joining the team.

8.2.2 MONO-DISCIPLINARY PREPARATION

All members of the incident command team that need specific knowledge and skills related to the fulfilment of their role and tasks, will receive education and training in a mono-disciplinary setting. These specialist requirements do not require collaboration and cooperation with the other members of the incident command team and are a responsibility of the agency they belong to. Therefore the mono-disciplinary preparation is not a part of the ETE-programme. As explained in the former paragraph, the members of the incident command team must already be prepared to a certain degree on the individual and team level before starting with the Up Safety ETE-programme.

8.2.3 COMMAND STRUCTURE

In paragraph 2.4 it is made clear that the organisation of the response forms the backbone of the emergency response operation. Organising the response should be done in a flexible and scalable manner, but it should be absolutely clear how the levels of command interact which each other and how command, control and coordination is organised. During an emergency it is too late to find out who should be alarmed and how roles, tasks, responsibilities and mandates are divided between the players on- and off-scene. Without a clear command structure, chaos and confusion will certainly lead to unwanted effects. If such is the case, the question of accountability will be very hard to answer and will probably lead to discussions on a political level.

8.2.4 EMERGENCY PLANS

In the general introduction in chapter 1 is explained that this document is a common framework that provides enough flexibility to be adapted by the countries to local circumstances and specific problems. A “one-size-fits-all” solution would not render justice to the diversity that exists between different underground facilities, which have all their own unique risk profile that can lead to the same unique incident scenarios. A road tunnel of twenty kilometres running through a mountain in the Alps cannot be compared with the Westerscheldetunnel in the Netherlands that runs under water.

That means that within countries, regions and cities the risk profile will be different in relation to underground infrastructures that are present in a certain area. The preparation for each underground facility will be different and will be laid-down in emergency plans. The outline, procedures and instructions in these plans are applicable to all emergency services, and others, that might be involved when an incident occurs.

Emergency plans form the base for any ETE-programme dealing with an underground infrastructure. If there is no specific plan available for a certain object, the general emergency plan on a lowest level covering this object should be used.

The same applies to the specific standard operating procedures and other preparations that are done by the emergency services. This should all be done on forehand and the results of these preparations should be written down in a way that they fit into the emergency plan and are merely a particularisation of these plans. A pre-planned location for the incident command team (see paragraph 7.2) is an example of such a preparation. Other examples are fire pre-attack plans and maps that indicate the accessibility for emergency services to the incident site.

8.3 CONCEPTUAL APPROACH

8.3.1 THE TRIAD

Personnel of the emergency services and facility staff members need to acquire the desired knowledge and skills that are necessary to act in an effective way when an incident occurs and they have to be prepared for their respective roles and tasks when such happens. When the question is raised how to prepare people for an emergency, the standard triad of education, training and exercise will automatically be mentioned. At the same time these three words are many times mixed up and to prevent any confusion, its purposes are given below within the scope of the project.

The purpose of education is to acquire basic knowledge on the safety of underground facilities and the mono- and disciplinary processes that will take place when an emergency occurs in such a facility. It is important that this knowledge is secured over long periods of time, for instance by refreshment courses.

The purpose of training is to acquire and maintain individual and team skills that are necessary to accomplish the roles and tasks within a multidisciplinary response organisation.

The purpose of exercising is to put the acquired knowledge and skills into practice in a realistic setting. An exercise will expose weak spots in the emergency response organisation and will leave the organisation with some recommendations in the end. Exercises can therefore also be used to test the quality of the organisation or to experiment with new procedures.

In essence this triad can easily be explained by the metaphor of a little kid that starts exploring the world around him or her. It will crawl before it can walk and walk before it can run. The same applies to education, training and exercise. You cannot train before you have acquired the necessary knowledge and cannot exercise before you have acquired the knowledge and skills to do so. This sequence has to be obeyed to sort maximum effect in preparing people.

Education, training and exercise programmes can be executed in many different ways, using different didactics and methods, individual or in groups, with or without time pressure et cetera. In principle, the possibilities to prepare people for their roles and tasks within an emergency response organisation are almost inexhaustible. But the approach and concept behind it is always more or less the same. Basically there is a shift of responsibility taking place in the learning process from the teacher to the trainee.

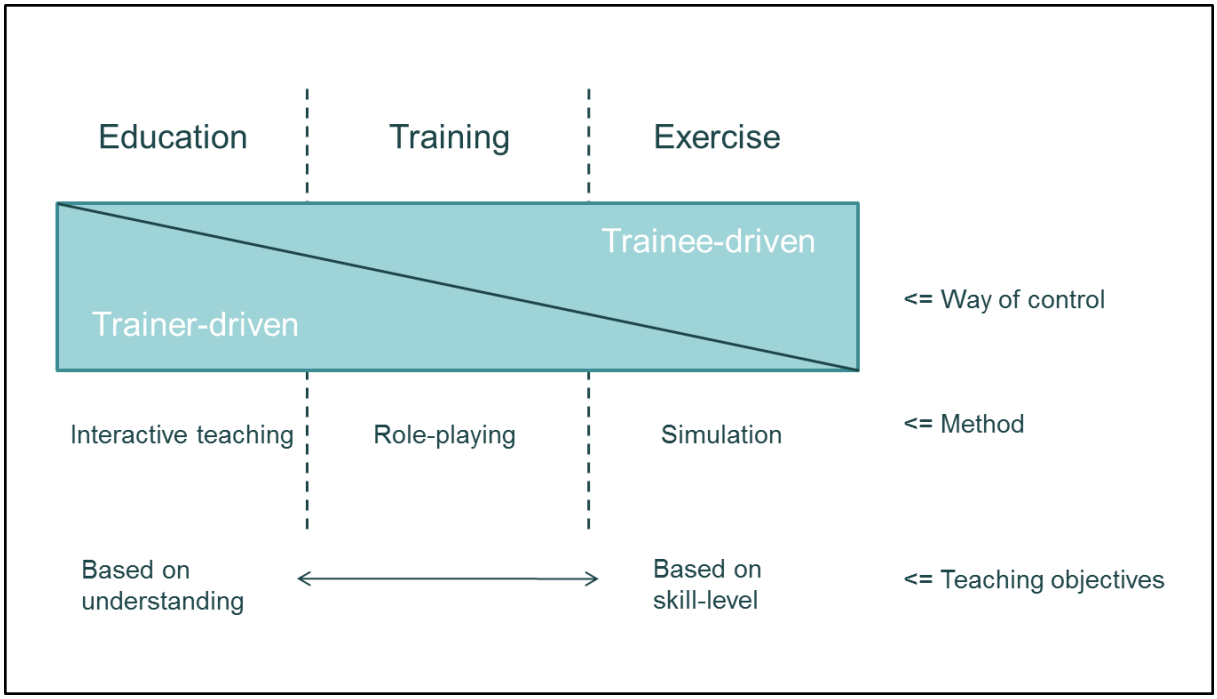

Figure 8.1 *Shift of responsibility in the learning process*

During the education phase the responsibility rests almost completely with the teacher that hands over knowledge by telling and demonstrating. The influence of the teacher gradually decreases via training until the trainees can use the acquired knowledge and skills independently when exercising.

The Up Safety ETE-programme is in line with this concept of controlling the learning process with a general shift from education to training to exercise and the responsibilities for the teacher and the trainees that shift with it.

8.3.2 CONTENT VERSUS PROCESS

Everything that is explained in part I of this document will come together in the ETE-programme. Looking closer at part I, content and process can be distinguished from each other. An example of the content is chapter 3 that talks in detail about the general aspects of underground facilities. The members of the incident command team must be familiarised with these aspects to develop an understanding of the particular environment they are working in and what it means for the response in case of an incident. When looking at chapter 7 it is obvious that this is more about the process at the table and the interaction between the members of the incident command team and the interaction with the outside world. These members should understand what is expected of them in this process and how their specific knowledge and skills should be used.

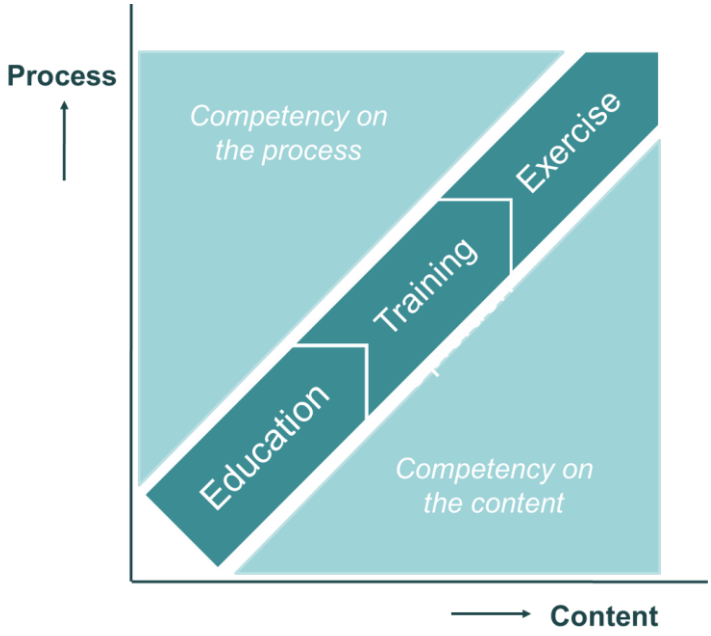

Figure 8.2 *Development of competencies on both process and content*

During the response phase, process and content are equally important and should go hand-in-hand together. Therefore, the members should develop their competencies on both. That means that in the ETE-programme there should be a balance between process and content as well. The figure above graphically explains this approach within the project.

8.3.3 THEORY VERSUS PRACTICE

Just as there is a balance between content and process, there should be a balance between theory and practice in the ETE-programme. It is important not to mix things up. Content does not equal theory and practice does not equal process. Theory is more related to education with the purpose of acquiring knowledge, but every training or exercise normally begins with a short refreshment of the theory as well. At the same time, practical teaching methods such as using case studies or discussion periods prevent that trainees just passively listen and the teacher speaks all the time.

Within the ETE-programme there is a balanced mix between theory and practice and the theory is used as an introduction to the next step in the programme.

8.4 EDUCATION, TRAINING AND EXERCISE

8.4.1 EDUCATION

As explained earlier, the purpose of education is to acquire basic knowledge on the safety of underground facilities and the mono- and multidisciplinary processes that will take place when an emergency occurs in such a facility. Part I of this document contains all the necessary basic information to build theory blocks that can be taught to the trainees.

It is up to the teacher to use this basic information and turn it into a learning plan based on the goals he or she wants to achieve. As a minimum the following should be presented.

- **General aspects of underground facilities**. Trainees have to develop an understanding of the special conditions of underground facilities and gain a general insight in the behaviour of fire and smoke and human behaviour and self-reliance. Trainees should also understand the reaction by facility staff members when confronted with an incident, as they are the first to react.
- **Safety measures and installations**. Trainees have to gain insight in safety measures and installations present in underground facilities to a degree that they understand how preventive and mitigating efforts can positively or negatively contribute to emergency response operations and vice versa.
- **Risks and effects**. Trainees must be able to assess the types of incident that can occur in relation to an underground facility and what the possible effects might be in time and space. When an emergency plan is available, most of the times a scenario-analysis has already been done.
- **Emergency response organisation**. Trainees must understand the structure of the response organisation as well as the actions taken by the emergency services and others and how these interfere with and support each other.
- **Incident command team operations**. Trainees must understand how the incident command is alarmed and how it will operate when arriving at the location of the incident, including their own role and tasks. They have to understand the ratio behind the decision-making process, that is the chronological order of situation awareness, judgement, decision-making and transition.

It is evident that the local situation dictates what should be presented to the trainees in detail, because there is no use in teaching something that is irrelevant to a specific situation. A lot depends on the content of the emergency plans of an underground facility and how detailed certain procedures and instructions are written down. But even more it depends on the professionalism of the teacher to reach the trainees and challenge them. Different teaching methods can be used, such as case studies using photo and video material or story-telling, preferably by experienced guest speakers.

The education phase can be concluded with a visit to an actual tunnel, metro-station or parking lot. During this visit the specific safety measures, installations and procedures can be discussed. It is recommended that a visit takes place after the trainees have acquired the basic knowledge as mentioned above, so they know what to look for and can ask the right questions.

8.4.2 TRAINING

Where education is focussed on transferring knowledge, training is about acquiring and maintaining skills. It is geared towards familiarisation with roles, tasks, procedures and instructions. Instructors will aim to create a safe environment, where trainees can make mistakes and the instructor can stop a training anytime to discuss results and give feedback, and by doing so gradually improve the performance.

It is difficult to present a detailed direction of what should be trained and what the best method would be. A lot of the training items require real plans and procedures, a real location, real people and real equipment and cannot be done in a classroom environment. The ETE-programme focuses on the training of the incident command team as a group, more than its individual members. From this perspective the following items should be trained in a realistic setting.

- **Alarm procedures**. Aim of this training is to check if the alarming lists are up to date and if all personnel required in case of incident can be reached in time. This applies to the personnel of an underground facility that have a role in the emergency response organisation as well as the external agencies, such as the emergency services and others that are mentioned in the emergency plans. It may include a check if all personnel involved is aware of their roles and tasks in case an emergency occurs.
- **Reaching the incident scene**. In addition to testing the alarm procedures, an incident can be "played" up to the moment that all personnel necessary is available at the right place at the incident scene. An important aspect and aim of this training will be the accessibility of the incident site, which is for instance a prominent issue regarding large road tunnels. One or both of the tubes might be unusable which requires entering the site from the right direction or otherwise becoming stuck on the wrong site. The moment that the incident command team is complete the training can be stopped and the results, such as total time required, can be evaluated.
- **Evacuation procedures**. The aim of this training is to execute all plans, procedures and instructions in relation to evacuating the incident area. When an incident occurs in an underground facility, the users initially have to react with the support of the facility staff to move away from the scene to a safe area. When the emergency services arrive, their first focus has to be to assist the evacuation of the site and by doing so assist in the self-reliance of the users.
- **Communications and interoperability of information systems**. The aim of this training is to make sure that all communication and information systems work properly and provide the users with what they need. This will also dictate the discussion what will be the best place to work from for the incident command team. When the images of the CCTV cannot be made visible in the command post, it might be tempting to start working from the control room. At the same time, the control room might be far away from the incident-site, or have certain communications restraints, which makes it not suitable to do so. This has to be tested in real.

The training items as mentioned above show already a lot of characteristics of an exercise. By cutting the overall emergency response action up in smaller bits and pieces however, it can be controlled by an instructor to a degree that he or she can interfere at any moment. It also gives the possibility of discussing certain results the moment a learning experience reveals itself.

What can actually be trained in a classroom environment is the training of the incident command team regarding their core-task, the decision-making process. By methodically going through the decision-making process, members of the incident command team familiarise themselves with the ratio behind the process. In a step-by-step approach, the team learns how to:

- Estimate the situation.
- Develop one or more scenarios based on this situation.
- Develop one or more courses of action.
- Reach a decision on the course of action to follow.
- Turn decisions into concrete actions.

After each step, the performance of the team as a whole can be evaluated as well as the performance of each individual member on its role and tasks within the process. The ETE-programme follows this approach and will be explained in greater detail in paragraph 8.5.

8.4.3 EXERCISE

Planning, organising and executing an exercise requires a lot of skill and experience of a trainer and is not something that can be described on a few pages. What follows below should be regarded as a refreshment for trainers rather than aiming at presenting something new.

Exercises can be organised in many ways within the learning process of individuals, teams and organisations. It is about putting the acquired knowledge and skills into practice in a realistic setting and can be used for testing and experimenting as well. Exercises can be organised in many forms ranging from a two hour paper exercise without any role-playing, up to full-scale exercises involving multiple organisations that run for days or weeks. It is important to realise that all exercises are a simulation of the real world, no matter how realistic their design is. Realism is often regarded as being the most important thing, but this is frequently overrated. It also requires a lot of time and money to organise full-scale realistic exercises and it is not always feasible or desirable to close an underground facility for the purpose of exercising. What follows are the steps that should be taken when planning an exercise, regardless how complicated or real the eventual exercise will be.

- **Goal formulation**. First step is the formulation of goals. In the ETE-programme this is done by establishing aims and learning objectives. The aim of an exercise is related to the purpose of the steps in the decision-making process, for instance “estimate the situation” (see former paragraph for this step-by-step approach). The learning objectives are related to knowledge, roles and tasks, processes and procedures and are more specified. For instance, within the aim of estimating the situation a learning objective can be “to develop understanding of the special conditions of underground facilities”.
- **Target group**. Next step is to decide who needs to be exercised. Within the project Up Safety this is the on-scene commander and his or her team, including all members that take place within the incident command team when an incident with an underground facility occurs.
- **Method**. The method to choose from should be very much related to the goals you want to accomplish. These methods can range from simple to complex and from abstract to real. As a rough guideline a trainer can choose between paper exercises without role-playing (case or dilemma), paper exercises with role-playing (interactive case, table top), computer simulation (virtual environment) or real life exercises.
- **Scenario**. Every exercise needs a setting and a plot that together make up the scenario. This should create a certain situation that requires action from the participants. Realistic combinations of events should lead to certain effects in time and space that create dilemmas that have to be solved. A scenario should contain the elements of threat, uncertainty and urgency that leads to a certain escalation point where more and more stakeholders are involved, as well public as private.
- **Events and incidents**. An exercise normally begins with a start setting and needs input to evolve over time and space. This is done by scripting, what means that certain events are brought into play by injects from outside. The total script is often called a main event list and main incident list (MEL/MIL) and is build up by serials in time. Exercise leaders can play with the time component to either increase or decrease the time pressure on the participants. Depending on how tight a script is written there is room left for free-play.
- **Supporting organisation**. Around the target group a supporting organisation is built. First objective of this supporting organisation is that the exercise runs smoothly and that the learning points are taken from it to be able to evaluate the exercise. This is done by the exercise leader and trainers that form “exercise control” and by observers/evaluators that look particularly at the performance of the participants. Second objective is to make sure that the target group is operating in the same environment with other units or organisations as they would do in real life. This is done by establishing a higher, lower

and flank control. In relation to Up Safety, lower control are the operational units, flank control are organisations working alongside the incident command and higher control are higher echelons within the command system, including public administration.

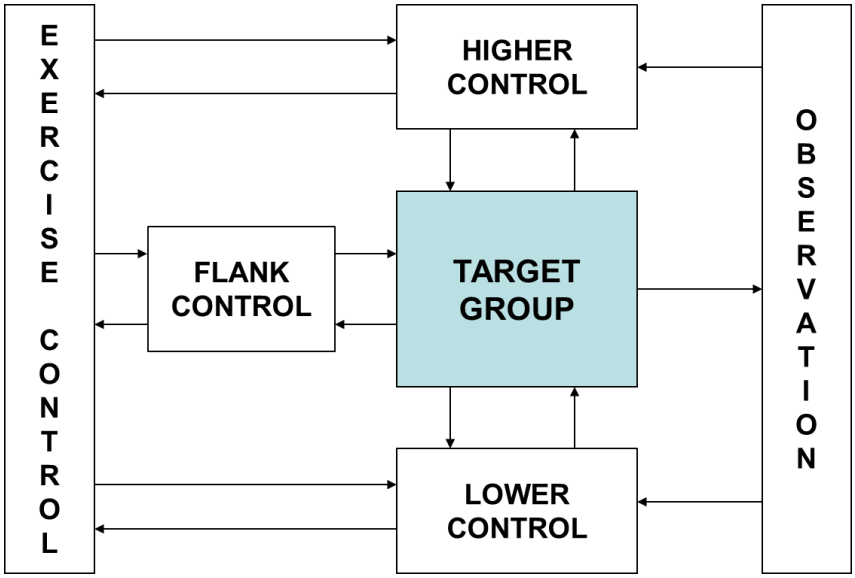

Figure 8.3 *Supporting organisation*

There is only a thin line between training and exercises in relation to teams. A training environment is more controlled and trainers can more or less interfere at any moment to give additional guidance or feedback to the trainees. Exercises are different from training in the way that the whole incident scenario is played without interference of the trainer and the evaluation is done afterwards.

The evaluation therefore is a crucial part of any exercise. Based on the observation during an exercise the participants will get feedback on their performance as a team, but also on their individual performance. Without a proper evaluation, there will be no good learning experience and this will hamper continuous improvement of the team. An evaluation is always linked to the objectives as they are established in the beginning.

8.4.4 VIRTUAL REALITY TOOL

Within the Up Safety project the decision is made to develop a virtual reality tool that can be a supporting aid to training and exercises. The virtual tool used within the project is ADMS, Advanced Disaster Management Simulator, which is a produced by a company based in the United States. The choice for a virtual reality tool is made because of several reasons.

- Training with virtual reality is cost and time effective and is a good preparation for live exercises.
- Training with virtual reality is flexible and can be used at any time and place with a difficulty level that is easily adjustable.
- Training can be standardised by giving the same training to each participant.

ADMS offers three realistic environments for road tunnel, metro station and parking lot, which can create different settings and various incident scenarios. It can look at an incident site from different angles, inside and outside a facility or in bird eye view.

8.5 GENERIC ETE-PROGRAMME

The Up Safety ETE-programme consists of a flexible and versatile two day education and training package and suggestions for exercises. It is a generic programme that can be used for the preparation of incident command teams, including facility staff members, regarding road tunnels, metro stations and parking lots. Because it is generic, it requires trainers to modify it to the local situation and build their specified programme using the content of part I of this document added with information that is applicable to this local situation.

8.5.1 EDUCATION AND TRAINING PACKAGE

The education and training package is covering a two day period and is divided into six blocks of approximately 90 to 120 minutes. With the exception of block 4, this is all done in a classroom environment which makes it cost and time effective.

Day 1	Day 2
Block 1: Education (theory) General aspects of underground facilities (chapter 3) ▪ Special conditions of underground facilities ▪ Behaviour of fire and smoke ▪ Human behaviour and self-reliance ▪ General course of action in case of emergency Specific situation regarding object (chapters 4, 5 and/or 6) ▪ Standing safety organisation and procedures ▪ Safety measures and installations ▪ Risks and effects Multidisciplinary response operations (chapters 2 and 7) ▪ Emergency response ▪ Incident command team	**Block 4: Education (practice)** Depending on object in area of responsibility, visit to: ▪ Road tunnel ▪ Metro ▪ Parking Lot
Block 2: Training 1 – Situation awareness (1) Related to step 1 of the decision-making process: Estimate the situation (chapter 7) Method: Interactive case without role-playing, supported by virtual reality tool	**Block 5: Training 3 – Judgement** Related to step 3 of the decision-making process: Develop courses of action (chapter 7) Method: Table top training with role-playing, supported by virtual reality
Block 3: Training 2 – Situation awareness (2) Related to step 2 of the decision-making process: Develop scenarios (chapter 7) Method: Interactive case with role-playing, supported by virtual reality tool	**Block 6: Training 4 – Decision-making** Related to step 4 and 5 of the decision-making process: Compare courses of action & choose and instruct and inform (chapter 7) Method: Table top with role-playing supported by virtual reality

The education part consists of block 1 and 4. Block 1 is the theory part aiming at acquiring basic knowledge on the safety of underground facilities and multidisciplinary operations as explained in paragraph 8.4.1. This block should focus on the specific situation at the

underground facility that is present in the area of operations of the incident command team. Block 4 is the practice part aiming acquiring practical knowledge on this facility. The suggestion is to do this at the second day of the package when the trainees have good knowledge of what they should be looking for. It can also be moved to day 1, but should always be done after the theory block.

The training part consists of block 2, 3, 5 and 6 and is built around the decision-making model that is presented in chapter 7. It follows the steps of this model chronologically and thereby increasing the level of difficulty and the time pressure on the incident command team. In annex A is a set of training worksheets presented covering aim, objectives, target group, level of experience, method, time and organisation for all four training blocks. Block 6 can be considered to be an exercise already. It runs a complete cycle of the decision-making process on real time, covering information gathering, process on the table and reporting the results to the operational units, higher commands and media.

Virtual reality is used to support all training blocks, but other supporting aids can be used as well such as photographs, video's and other imagery. Tools that are necessary to conduct each of the training blocks are:

- Emergency plans.
- Maps of the surrounding area.
- Maps of the object area with the underground facility shown in detail.
- Building plans with the safety measures and installations displayed.

Again, the education and training package can be adjusted in many ways to the preference of a trainer and the supporting aids that are available. The same applies to each of the training blocks that can adjusted as well.

8.5.2 FURTHER TRAINING AND EXERCISES

When an incident command team has completed the education and training package as described above, the team is ready to conduct further training and exercises. Before going through a full-scale exercise on a real facility covering an incident scenario from the beginning till the end, it is better to do some practical training on certain aspects of the response to a calamity. The most important training topics are presented in paragraph 8.4.2 and include:

- Alarm procedures.
- Reaching the incident scene.
- Evacuation procedures.
- Communications and interoperability of information systems.

It is advisable not do a full-scale exercise without taking these smaller steps in between, because of the risk of doing too much at one time. There might be too much room for errors which can lead to domino-effects which will in their turn lead to not reaching the aim and objectives of an exercise. It is also desirable to do one or more table tops on different scenarios, in the way training block 6 is designed, to get more experience with the decision-making process before doing a full-scale exercise on a real location, with real units and real equipment.

9 SUMMARY

Underground infrastructures are complex environments and when an emergency occurs, a lot of things will happen at the same time that interfere with each other. First, the specific environmental conditions will present a challenge to users, facility staff members and emergency services. Road tunnels, metro stations and parking lots are confined spaces with limited exit and access possibilities. Large elevation differences, reduced visibility, artificial air circulation and long distances add to the complexity of such facilities. Fire and smoke will behave differently in such an environment and show specific characteristics. Humans also will behave in different ways as they would do in “normal” surroundings and they have to rely heavily on the aspect of self-rescue. Facility staff members will play a crucial role in the first minutes after an incident takes place.

Secondly, all kind of safety measures and installations will start working that will have an effect upon the incident as it evolves in time. Civil protection organisations must understand what the mitigating effects are of such measures and installations and what their positive as well as negative influences are on the situation at hand. It should also be clear what might happen when these measures and/or installations fail to do what they are designed for during an incident.

Last but not least, all human activity in the vicinity has to be coordinated to prevent (more) casualties. Users of a facility need to be evacuated as quickly as possible from the danger area with assistance of the facility staff. At the same time emergency services will arrive at the scene to further assist with the rescue of people while preventing the effects of an incident from getting larger.

Multidisciplinary incident command teams play an important role in commanding, controlling and coordinating all activities at the incident scene. Their members have to understand how the environment, the measures and installations and the human activity interact with and relate to each other to create situation awareness. They also have to know how to judge such a situation and how to conduct relatively fast decision-making to turn decisions into concrete actions. This can only be done by education, training and exercising as part of the preparation phase.

No emergency scenario will ever be the same and it would be pointless to capture all possible scenarios. The scenario will depend very much on the location and type of object and therefore on the risk profile of an underground facility in relation to its surroundings. At the same time, a certain philosophy and methodology behind how to educate, train and exercise incident command teams can be developed that does not depend on a certain situation. This can be translated to a generic ETE-programme, that only has to be adapted to a specific location. Up Safety provides such an ETE-programme based on a resilient conceptual approach. The programme provides guidance and direction to designated trainers that are responsible for planning, organising and executing the ETE-activities for incident command teams, including facility staff members. The ETE-programme therefore is a flexible and versatile programme that can be used for each of the three objects, road tunnel, metro station and parking lot, independently of the geographical location of such objects in Europe.

ANNEX A: TRAINING BLOCK WORKSHEETS

TRAINING 1: SITUATION AWARENESS (PART 1)
Aim
Estimate the situation
Objectives
▪ Develop understanding of the special conditions of underground facilities ▪ Gain a general insight in the behaviour of fire and smoke in underground facilities ▪ Gain a general insight in human behaviour and self-reliance ▪ Take into account the reaction by the facility staff of an underground facility ▪ Visualise the incident on a map and/or sketch and present the team estimate ▪ Introduce the virtual reality tool ADMS
Target group
Incident Command Team (core members plus facility staff member)
Level of experience
• Individuals should have knowledge of and practical experience in multidisciplinary operations • Team should have knowledge of and practical experience in the decision-making process (based on national standard operating procedures)
Method
Interactive case without role-playing, supported by the virtual reality tool
Time
90-120 minutes
Organisation
• Plenary introduction to the training (15-30 minutes) • One or more teams working from different locations in the same room with support of two trainers per team. Scenario is presented on a central large screen with the aid of ADMS and starts running 15 minutes after the start of the incident (20 minutes) • Team discussion based on answering the following five questions (40 minutes): ▪ What is happening (type and cause of the incident) and what are the effects? ▪ What are the special environmental and infrastructural conditions in and around the underground facility presented? ▪ How will fire and smoke behave in such an environment? ▪ How will people react in such an environment and what does it mean for self-reliance? ▪ What actions are taken in the first moments by the emergency services and others (including the facility staff)? • Plenary presentation of the results of the estimate by one of the groups and short evaluation (15-30 minutes)

TRAINING 2: SITUATION AWARENESS (PART 2)
Aim
Estimate the situation and develop the most likely scenario based on the information provided
Objectives
• Develop further understanding of the general aspects of underground facilities • Gain insight in safety measures and installations present in underground facilities • Gather information through mono-disciplinary channels • Assess type of incident and possible risks and effects in time and space • Visualise the incident on a map and/or sketch and present the current and future situation
Target group
Incident Command Team (core members plus facility staff member)
Level of experience
• Individuals should have knowledge of and practical experience in multidisciplinary operations • Team should have knowledge of and practical experience in the decision-making process (based on national standard operating procedures) • Training 1 should be completed satisfactory
Method
Interactive case with role-playing, supported by the virtual reality tool
Time
90-120 minutes
Organisation
• Plenary introduction to the training (15-30 minutes) • One or more teams working from different locations in the same room with support of two trainers per team. Scenario is presented on a central large screen with the aid of ADMS and starts running 15 minutes after the start of the incident. Scenario runs on real time. • Role-players (police, fire & rescue service, medical, facility) have complementary information and make use of different monitors in the room. • Team members make contact with their counterparts; that is members of all teams go to the same role-players per discipline to gather information. Incident commander and press officer stay at the table (20 mins) • Team will do an estimate of the situation and will develop the most likely scenario, considering all environmental elements, safety measures and installations and current actions taken (40 minutes) • Plenary presentation by one group and short evaluation (15-30 minutes)

TRAINING 3: JUDGEMENT
Aim
Develop courses of action
Objectives
• Understand the importance of good situation awareness before developing courses of action • Understand all actions taken by the emergency services and others and how they interfere and support each other • Understand how preventive and mitigating efforts can positively contribute to emergency response operations and vice versa • Make use of a methodological way to develop a course of action • Visualise the course of action on a map and/or sketch and present this in a clear way
Target group
Incident Command Team (core members plus facility staff member)
Level of experience
• Individuals should have knowledge of and practical experience in multidisciplinary operations • Team should have knowledge of and practical experience in the decision-making process (based on national standard operating procedures) • Training 1 and 2 should be completed satisfactory
Method
Table top training with role-playing, supported by the virtual reality tool
Time
90-120 minutes
Organisation
• Plenary introduction to the training (15-30 minutes) • One or more teams working from different locations in the same room with support of two trainers per team. Scenario is presented on a central large screen with the aid of ADMS and starts running 15 minutes after the start of the incident. Scenario is the same as in training 2 and runs on real time. • Role-players (police, fire & rescue service, medical, facility) will have complementary information • Team members make contact with their counterparts to receive final information; that is members of all four teams go to the same role-players per discipline to gather latest information. Incident commander and press officer stay at the table (10 mins) • Team will re-do the estimate of the situation, will develop a worst case scenario and will develop one or more courses of action (40 minutes) • Presentation per group (10 minutes) • Plenary evaluation (15-30 minutes)

TRAINING 4: DECISION-MAKING
Aim
Complete the decision-making process
Objectives
• Understand the chronological order of situation awareness, judgement and decision-making • Weigh the consequences of each option before taking a final decision • Turn decisions into actions and make somebody responsible for each of the actions • Know who to inform about the situation and decisions/actions that are taken • Develop a public/media information campaign
Target group
Incident Command Team (core members plus facility staff member)
Level of experience
• Individuals should have knowledge of and practical experience in multidisciplinary operations • Team should have knowledge of and practical experience in the decision-making process (based on national standard operating procedures) • Training 1, 2 and 3 should be completed satisfactory
Method
Table top with roleplaying, supported by the virtual reality tool
Time
90 minutes
Organisation
• Plenary introduction to the training (10 minutes) • One or more teams working from different locations in the same room with support of two trainers per team. Scenario is presented on a central large screen with the aid of ADMS and starts running 15 minutes after the start of the incident. Scenario runs on real time. • Role-players of lower echelons (police, fire & rescue service, medical, facility) make use of different monitors in the room. Role-players of higher echelons can be reached by walkie-talkie. • Team members are to gather information; that is members of all teams go to the same role-players per discipline to gather information. Incident commander and press officer stay at the table and prepare first meeting (20 minutes) • Team will go through the decision-making process at the table (20 minutes) • Team decisions are reported to emergency services face-to-face (role-players lower echelons) and reported to higher commands by walkie-talkie (role-players higher echelons). Press officers draft first press reports for public/media information campaign (20 minutes) • Plenary presentation of one incident team commander and one press officer (10 minutes) • Plenary evaluation (10 minutes)