COPE – COMMON OPERATIONAL PICTURE EXPLOITATION

SEVENTH FRAMEWORK PROGRAMME

GRANT AGREEMENT No 217854

Collaborative project

Deliverable No D6.6

26/12/2010

COPE

Trial's Results and User Feedback

Authors:	Reinhard Hutter
Work package (WP, Task):	WP6, Task 6.6
Deliverable No:	D6.6
Delivery date (in Annex I):	Jan. 2011
Review date (in Annex I):	Jan. 2011
Responsible partner:	CESS
Dissemination level:	PU

COPE

Summary

This deliverable describes the results, findings and conclusions of the Final COPE trial held between 22-24 Sept. 2010 at the training site of the Finnish Emergency Services College in Kuopio.
The setup of the trial consisted of a large scale live-scenario in which the use and performance of the COPE components / technologies and the overall COPE system of systems was demonstrated and evaluated. In addition, a so called tabletop exercise was executed with the aim of giving the Cope C2 system additional load and tasks which would be necessary in a real incident but which could not be exercised to the full extent on the live site.

The COPE system of systems is the result of a research project and does not represent an operationally fielded system. Therefore, in view of the possible further development and marketing of the technologies, an analysis of deficiencies is as important as the positive results. The evaluation has to regard both, the innovation and system performance reached and demonstrated as well as the potential for the future.

Therefore, in addition to the direct, measurable trial exercise results, the potentials of the COPE solutions have been evaluated, including a comparison with the state of the art of COP development activities in various application domains (chapter 5.4).

Results in summary show performance rates of the COPE system and its components between good and excellent. So a full achievement of the COPE project goals can be concluded.

Object evaluated	**Performance**	**Limitations**
The overall COPE System	All components were operational and contributed to the COP as planned	Overall performance is hard to measure. Full exploitation would need repeated training and exercising; Local/temporary failures occurred but they did not jeopardize the overall results
The COPE Command & Control	Worked as planned; TSO, GIS and data repository very helpful	Some visualization functions and selectiveness should be improved
The COPE Decision Support System	Worked with FR who were familiar with the procedures	Should become an integrated C2 function also for higher level C2
The First Responder System-Control	Worked correctly and to requirements	Very partial outages
The Human Wearable equipment	Worked as planned and designed	Components must be integrated in first responder's wear
The Sensors/ SIPs	Worked to design	Customer adaptation if required
The Communication system	Worked	Some minor and temporary interference and overload problems with video streaming

Table 1: Overall summary evaluation

Contents

Terms and definitions

This list contains main terms frequently used in this report. The definitions apply to how these terms are used in COPE. In other circumstances, terms may be defined differently.

Term	Definition as used in this report
	The personal pronoun "he" is defined to stand for "he or she" whenever appropriate
Common Operational Picture (COP)	The description in time of the emergency situation that supports the emergency responders within and between different agencies to act appropriately. COP is described as the pool of information • that is registered and stored in a database • concerning past, present and expected future events • that is available for presentation in a user interface • that is suitable for emergency responder work • the form of presentation of which is consistent and unambiguous, but not necessarily similar to all stakeholders • the content of which is structured around operational processes of the emergency responders • that needs to be interpreted and acted upon by the emergency responders • that is meaningful in the context of emergency responder work
Conclusions	Consequential interpretations derived from results
COPE System or System of Systems (SoS)	The set and functionalities and interactions of all COPE Technologies
COPE Technologies	Components developed or improved in the project forming part of the COPE System
Evaluation	A more general term of assessing things, including V&V
Human Factors (HF)	Tasks and analyses dealing with understanding, usability and acceptance of COPE technologies from the user point of view
Key Performance Indicator (KPI)	A physical or logical unit in which the function of a system (e.g. availability) can be measured
Live exercise	An exercise with real actors in the field acting on real events and using real technologies, resources and aids
Measure of Effectiveness (MoE)	A physical or logical unit by which the contribution of a system to a task (e.g. incident management) can be measured
Results	Quantitative and qualitative outcomes derived from the trial
RTD	Research and Technology Development, use here as the typical work performed in FP7 projects
Scenario	An account or synopsis of a possible course of action or event to which persons, organizations, technologies resources and procedures are exposed to in the exercise(s)
Tabletop Exercise-TTE	An exercise of virtual roles, resources and events simulated by role players with technical aids only from the COPE C2 and the CDS
Trial; Exercise	The action / process to demonstrate, prove and evaluate the COPE technologies and their cooperation in the COPE system

V&V	Verification and Validation
Validation	Assurance that a system performs the task(s) it has been designed for (in COPE: the added value to emergency response)
Verification	Assurance that a system works according to specified requirements

Abbreviations:

Acronym	*Meaning*
AQUEST	Air Quality Estimator
BA	Breathing Apparatus
BAECO	Breathing Apparatus Entry Control Officer
C2	Command & Control
CDS	COPE Decision Support System
ConOps	Concept of Operations
COP	Common Operational Picture
COTS	Commercial off the Shelf
CSO	Command Support Officer
EMAS	Environment Monitoring and Analysis System
FF	Fire Fighter(s)
FR	First Responder
FRS-C	First Responder System Control
FRS-HW	First Responder System- Human Worn
FWF	Fireworks Factory
HazCon	HAZMAT Control
HAZMAT	Hazardous Material
HF	Human Factors
HUD	Head-up Display
IAMA	Incident Area Map Analysis (CDS function)
IC	Incident Commander
LIVEX	Live Exercise
LoS	Line of Sight
PSU	Power Supply Unit
QoS	Quality of Service
RSSI	Received Signal Strength Indicator (a measurement of the power present in a received radio signal)
RTD	Research and Technology Development
SAR	Search and Rescue
SC	Sector Commander
SIP	Sensor Integration Platform(s)
TETRA	Terrestrial Trunked Radio
TSO	Tactical Situation Object (ontology based data dictionary)
TTE	Tabletop Exercise
V&V	Verification and Validation
WLAN	Wireless Local Area Network
WMD	Wrist Mounted Display
WSN	Wireless Sensor Network

1 Introduction

This report contains a summary evaluation of the COPE[1] System of Systems. The report has been structured and formulated in a way to be as self-contained as possible. The reader should be able to gain the basic information of the COPE project and the efforts preformed to achieve a sound evaluation if its results without having necessarily to refer to the numerous other deliverables.
Some more detailed analyses are either referred to where documented separately, or put into the 6 annexes to this deliverable.

The evaluation of a complex system like that of COPE exposed to a complex environment, the COPE scenario, in the Finnish emergency training school is a manifold task. This report gives evaluations and assessments derived from various sources and analysed from different viewpoints, as already discussed in the methodology document D6.1.

In the final evaluation, evaluations were made mainly from 4 perspectives:

- The end-users of the COPE system and its components
  – on how they could work with the system
- The technology developers and providers
  – on how they saw their technologies working
- The present and future research challenges concerning the COP topic
  – on the scientific value of the project, and
- The comparison of the COPE achievements to other advanced COP systems or COP concepts evolving
  – on how COPE compares to the state of the art.

For the purpose of final demonstration and evaluation, the COPE system and its components have been exposed to an appropriate environment which allows the necessary investigations leading to final results. These components have been prepared, organized, scheduled and operated in the final COPE trial:

- The physical/geographical trial site
- The personnel and the technical resources
- The Scenario the COPE system has to be exposed to
- The planning and organizing processes and
- A suite of appropriate analysis and assessment methodologies

[1] Project name: Common Operational Picture Exploitation

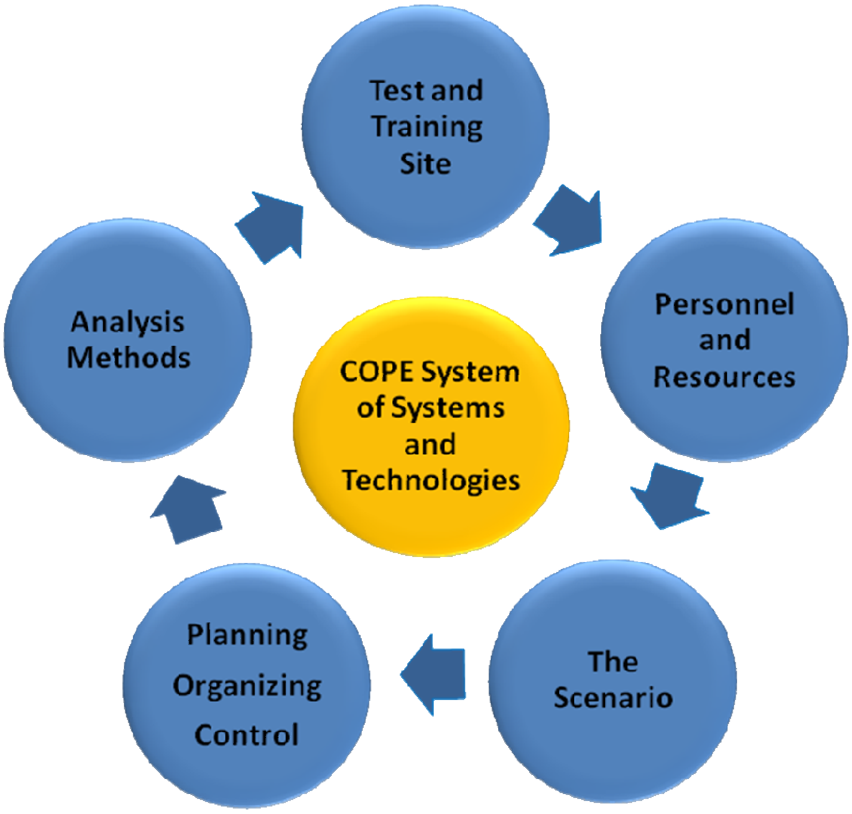


Figure 1: The Main Trial Elements

These elements have been designed, developed, harmonized and integrated into the COPE trial environment.

2 Goals

The overall Goal of COPE was to advance a spectrum of different existing or evolving technologies, in a way that they can be integrated into a system of systems. The focus of the work then was twofold:
a) to realize and prove the contributions of these technologies to an improved common operational picture, and
b) to show the capability to make use of and benefit from this advanced COP.

The goal of the final trial was to be the cornerstone for the final evaluation. It was designed and exercised to:

- Expose the COPE system to the complex environment
- Demonstrate its functionalities
- Generate an information base adequate for a sound overall evaluation of the COPE system
- Receive feedback from external stakeholders - directly involved stakeholders and observers

This together with some further analysis on innovation forms the basis for this final evaluation report.

3 Description of final trial setup 22-24 Sept. 2010

3.1 The trial site

The trial site was a sub-area of the Emergency Service College, Finland, in Kuopio. It comprised several buildings and infrastructure which could be set on fire, representing attacked scenario elements, an ammonium tank, which exploded, streets and distant housing areas. This was the scene of the so-called live exercise (LIVEX).
A part of the large scenario which could not be featured as live exercise was played as a so-called tabletop exercise (TTE) in a dedicated building located immediately adjacent to the live scene.

Details are described in deliverable D6.2, the scenario and the trial setup in chapters 3.2 and 3.4., respectively, of this report. The COPE system implemented and the resources used are described in Chapters 3.3 and 3.5, respectively.

The basic infrastructure of the ESC environment included the incident scene for the final trial, the basic freighting equipment, such as emergency services vehicles and manpower, resources from the Emergency Response Centre as well as police. The technical environment included laptops, TETRA network and radios as well as the ad hoc WLAN network provided by VTT.

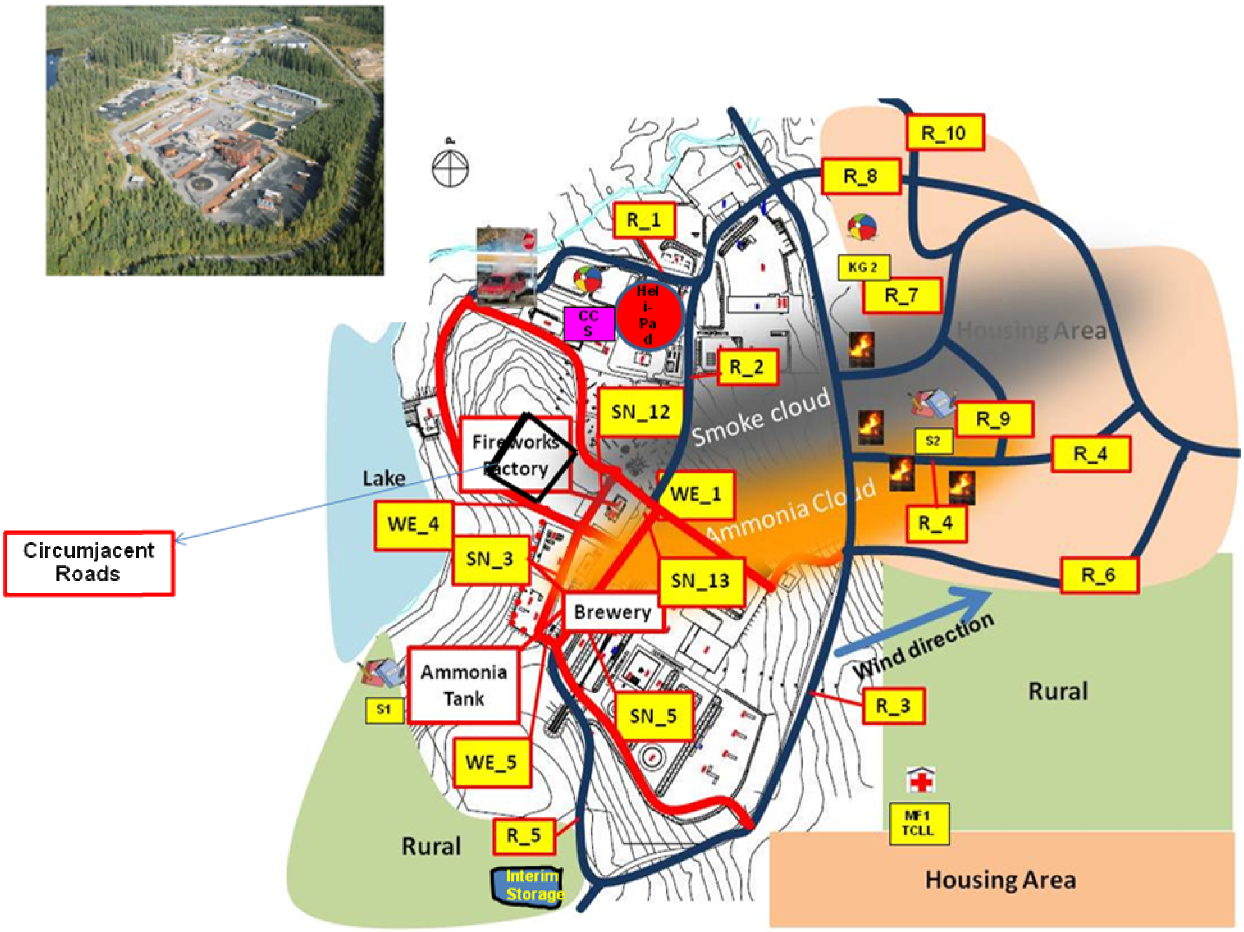


Figure 2: The Training Site

3.2 The Scenario

Scenario event(s) demonstrated:

The operational scenario describes and structures the sequence of events occurring during a major disaster incident or series of incidents which the COPE system and its components are exposed to during the COPE trial.
The scenario has been based on the real disaster of the huge fireworks factory explosion on 13 May, 2000, in Enschede at the Dutch-German border, where 23 people died, thousands were wounded, hundreds of buildings and major infrastructures destroyed. This scenario framework was chosen by 3 reasons:
a) This disaster was well documented and the data are publicly available,
b) The size and consequences have the appropriate complexity and dimension for the COPE trial
b) The Enschede disaster really happened, so the team was not dragged into the usual but superfluous discussions on whether the scenario is realistic or too artificial.

The total scenario has been documented in detail in D 6.2.

The scenario starts with a bomb explosion in the factory and several subsequent explosions of fireworks containers. From there, the nearby brewery soon is set on fire. This leads to an emergency call (112). The emergency call will give an alert to the local fire brigade. The fighting teams are composed of local fire fighters and students. Meanwhile, the ammonia tower of the brewery is endangered and later on explodes.

Once arriving on the scene, the incident commander realises that additional recourses are needed and a request to the dispatching centre is be released. At the same time another explosion takes place at the nearby fireworks factory. Streets have to be cleared by special forces and equipment of the fire brigade with police support before the fire brigades can start their work of rescuing people and fighting the fires. The nearby housing area, mainly kindergarten, is also exposed to danger because of the ammonium cloud approaching. The media starts showing interest towards the incident. More scenario details can be found in Annex 6.

3.3 The COPE system and its components

The COPE system of systems is described in Deliverable D5.1.7 - Prototype Demonstrator to be used in WP6. The document also includes software manuals and hardware descriptions.
The document COPE Deliverable D5.1.6 - Test & verification protocol describes the system integration methodology and its results.
The picture below gives a system overview. It shows the roles of the users of the system and which technical equipment they have available to use.

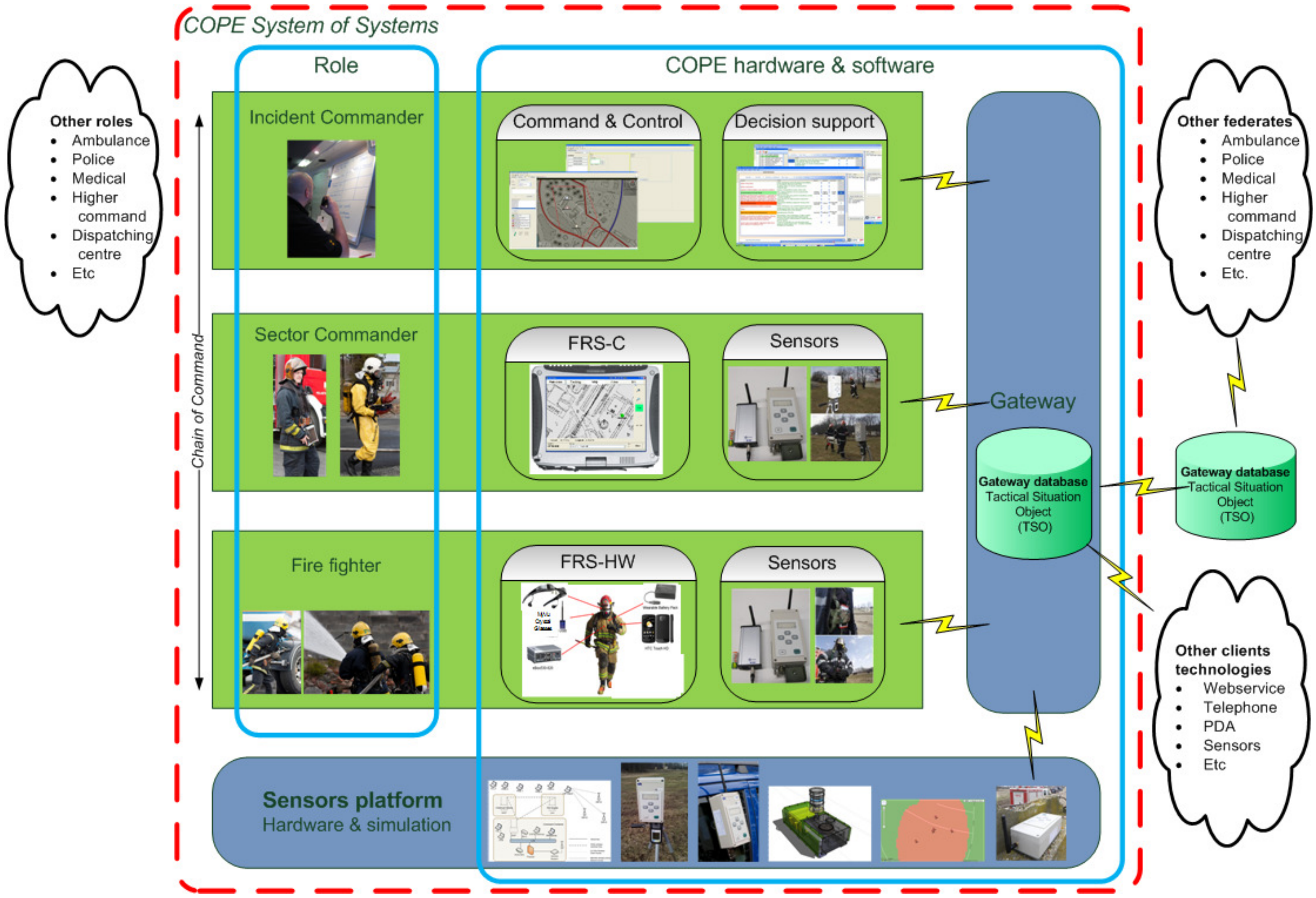


Figure 3: The COPE System

3.4 The trial setup

The scenario was of a size and complexity that the LIVE-setup in the training field could only cover a selected part with real hardware resources (e.g. vehicles, water) and persons acting upon the events. It covered mainly the phase of direct engagement of fire fighting and supporting and coordinating actions:

- Evacuation of injured and dead
- Containment of dangerous/ endangered areas
- Fighting of fires and leakage of the gas tank

The remaining part of the trial was simulated in the tabletop exercise which covered the elements that could not be portrayed in reality:
It included the phases of

- Initial alerting of dispatching centre
- Clearing of blocked streets in the area
- Early collection and transportation of injured to collection points
- Monitoring of the toxic cloud and alerting and –where necessary – evacuation of endangered housing areas

The whole exercise was conducted in real-time and lasted approximately 150 minutes real-time.
The live exercise was triggered by the TTE and lasted about 90 minutes.

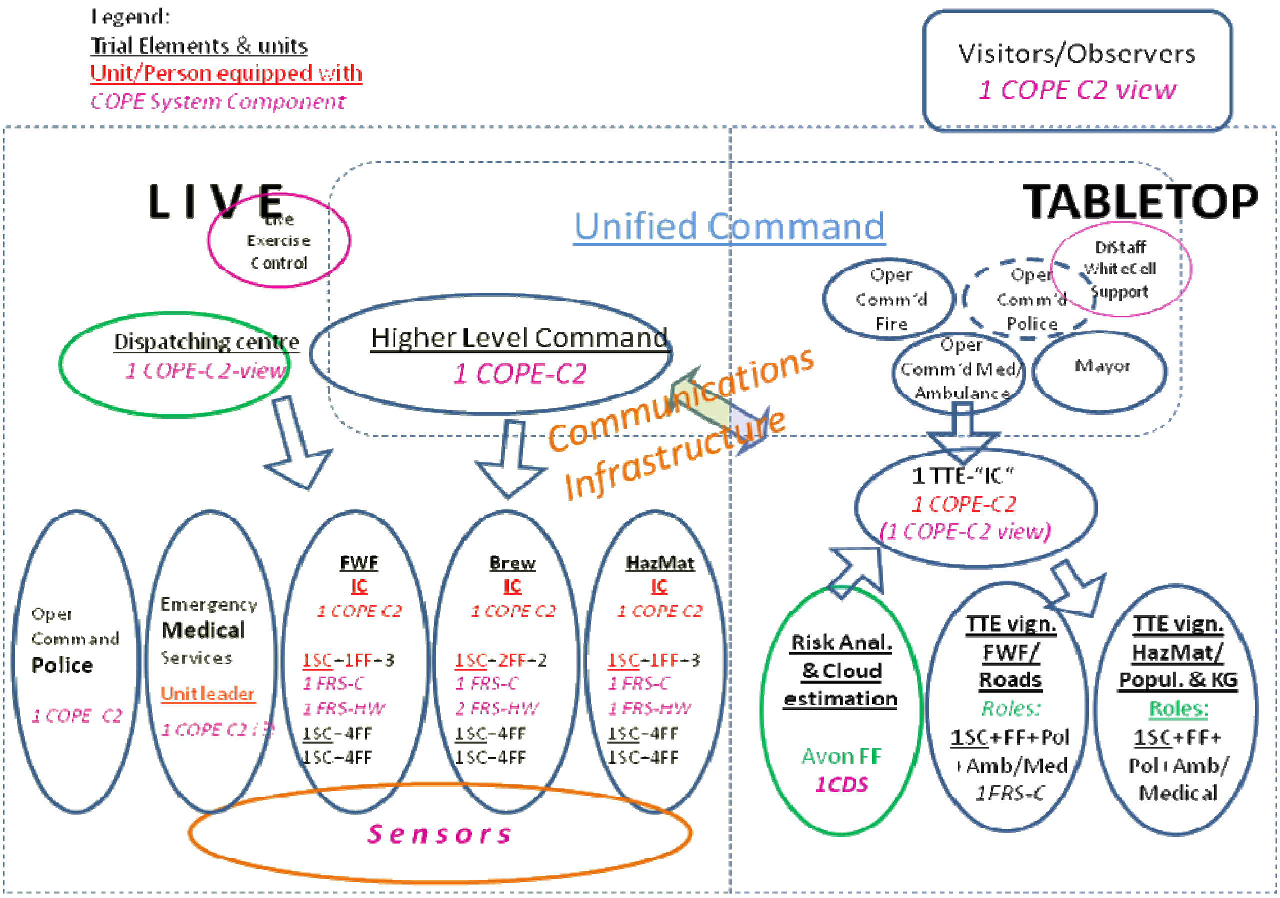


Figure 4: The trial setup

Figure 4 is a summary of the whole trial setup. It gives the total overview of the units represented and acting in the exercise, and how and where they were using COPE technologies (please refer to the legend).

3.4.1 The Live Exercise objectives and characteristics (LIVEX)

The objective of the Live exercise (LIVEX) was to expose the COPE system to a challenging environment which should be as real as possible. This way, the use and performance of the system and its components, including communications were to be shown and measured in real operation.
The "measurement", data collection and evaluation processes are described in chapter 4.2.

3.4.2 The Tabletop Exercise objectives and characteristics (TTE)

The TTE should add to a complex Common Operational Picture and generate a considerable additional load of information and tasks particularly to the C2 component and to the decision support component of COPE. It demonstrated the COPE functionality to a larger group of external players and observers. It could exercise to some extent the cross-service (fire fighters, police, medical & evacuation) coordination and show the capability, feasibility and benefits of combining a LIVEX with a TTE.
The scenario parts played in the TTE were scripted and fed into the system in real-time. Participants could adapt certain roles, could evaluate the scenario events

and give additional feedback (e.g. allocation of resources or decision on evacuations) into the system.
The detailed TTE scenario script is attached as Annex 6: The Scenario and TTE Script & data.

3.5 The Trial Staffing and Resources

3.5.1 COPE Hardware and Software Resources

Fig. 3 above already gave an overview of the technologies' configuration and how they work together in the trial.

The quantities of individual components, which comprise the total COPE system of systems of the Trial, are listed below:

COPE Component	Users	Qty.	Provider
COPE SIP W : The SIP wearable module with outdoor (GPS) localization capabilities	SC	4	UTI
COPE SIP W-DR : The SIP wearable module with outdoor (GPS) and indoor (dead reckoning) localization capabilities	SC/FF	3	UTI
COPE SIP D-G : The SIP deployable module suitable for ground deployment	SC	4	UTI
COPE SIP D-V : The SIP deployable module suitable for vehicle deployment	-	2	UTI
Standard PC Laptop (as alternative to the tablet PC)	-	1	UTI
Flash-OFDM @450 modem for mobile Internet Connections OR One (1) 3G/HSPA modem for mobile Internet Connections	-	1	VTT
WLAN Mesh Outdoor Access Points	All	3	VTT
Controller unit for Access Points	All	1	VTT
868 MHz radio units for deployable sensor network (up to ten (10) available if required)	Sensors	7	VTT
PC Receiver unit for deployable sensor network	Sensors	1	VTT
Standard PC Laptop (for testing purposes)	-	1	VTT
FRS-C (Panasonic Toughbook tablet PCs)	SC	3	BAE UK
FRS-HW (Only one will have a thermal camera) • Utility Vest: COPE designed vest for fire fighters for carrying the sensors, locators, batteries etc. • Cromwell F600 Fireman's helmet • Day camera (fitted to helmet) • Thermal camera (fitted to helmet – only for 1 FRS-HW) • Helmet Mounted Display (fitted to helmet) • Wrist Mounted Display (HTC touch HD smart phone) • Main processor • Battery • Wi-Fi transceiver	FF	4	BAE UK ESC (vest)
Spare batteries and battery chargers	-	-	BAE UK
Toughbook for the COPE Gateway	-	1	BAE UK
Standard PC Laptop (IC/CSO)	IC/CSO		BAE SWE
Standard PC Laptop (for demonstration)	-		BAE SWE ESC
Ruggedized PC Laptop	IC/CSO	1	GMV
EMAS sensor with gas and weather (temperature, wind speed/direction, humidity) sensing capability		1	Bofors

TETRA radios	All	apprx 40	ESC
TETRA network	all	1	ESC

Table 2: COPE Technical Resources

Most of this equipment was used in the LIVEX. The TTE was equipped with one COPE-C2 laptop and 2 supporting laptops for exercise control. The TTE-C2 was interlinked with the LIVEX system.
The CDS-Cope Decision Support System was also exercised on one computer in the TTE environment.
Almost 40 major COPE components were installed (not including TETRA radio, which was used but was not part of COPE by origin).

3.5.2 Personnel resources

A total of **74 persons** participated in the peak hours of the trial exercise. The trial participants were recruited or invited from different stakeholder groups. Beside the members of the COPE team responsible for proper preparation and conduct of the trial and the evaluation, there were a large number of external personnel participating in both, the LIVEX and the TTE.

Live Exercise participants

Quantity	Role	Organization	
1	Emergency response operator	ESC	
6	Incident Commanders	Northern Savo Fire Department and ESC	
9	Sector commanders	Northern Savo Fire Department and ESC	
21	Fire Fighters	Northern Savo Fire Department and ESC	
2	Police units (2+2)	Northern Savo Police	
Approx. 10-15	Supporting staff: instructors, security personnel, admin, tech. support, maintenance, provision etc.	ESC	

Table 3: LIVEX participants

Tabletop Exercise participants and availability

Role	Equipment to use	Name[2] /Nationality	Organization	Availability required		
Primary role/task during TTE				**COPE general Briefings Tue 21**	**TTE Briefg. & Rehearsal Wed. 22 11:45-17:00**	**TTE execution Thu 23 10:00-17:00**
Trials director	C2	DE	CESS	Yes	Yes	Yes
Trials scenario moderator		DE	CESS	Yes	Yes	Yes
Trials Discussion moderator		DE	CESS	a.m.	Yes	Yes
Mayor/ politician role	(C2)	FI	ESC	Yes	Yes	Yes
IC	C2	FI	ESC			yes
IC-Support	C2	IR	TCD		yes	yes
CSO/ C2-Operator	C2	S	BAE-CITS	Yes	Yes	Yes
FF Command	(C2)	RO	IGSU		Yes	Yes
Ambulance Command	(C2)	FI	ESC			Yes
Police Command	(C2)	FI	Police School Tampere			Yes
Virtual FB units	(C2)	IR	TCD		Yes	Yes
Virtual FB units	(C2)	RO	IGSU		Yes	Yes
Virtual Ambulance units	(C2)	FI	ESC		Yes	Yes
Virtual Police	(C2)	FI	Police School Tampere		Yes	Yes
TTE SC	(C2)	IR	Dublin FB	Yes	Yes	Yes
CDS/Risk assessment 1	CDS	UK	Avon FF		Yes	Yes
CDS/ Risk assessment 2	CDS	UK	Avon FF		Yes	Yes
CDS Support	CDS	PO	GMV		Yes	Yes
CDS Support	CDS	PO	GMV	Yes	Yes	No
CDS Support	CDS	UK	BAE-UK	Yes	Yes	Yes
				All others upon availability		Total: 19

Table 4: TTE participants [1]

Names have been deleted for data protection/privacy reasons

3.6 The Trial Schedule

The trial was scheduled in several phases:

- The general introductory briefing session to all
- The detailed preparation of the TTE and of the LIVEX in parallel
- The TTE phase
- The LIVEX phase which was synchronized with the TTE via a dedicated COP handover
- The post-trial debriefings, Q&A sessions and discussions with participants
- The final COPE-internal session on the major findings and steps ahead.
-

The detailed timing is given in the agendas below.

Time	Agenda 22 Sept	
09:00	COPE-internal Discussions	COPE team
11:00	Lunch	
11:45	COPE Project Briefing	Coordinator
11:55	The COPE System and Technologies	BAE-S
12:10	The Scenario	CESS
12:30	The Trial Plan and Setup	CESS
12:45	Human Factors Analysis & Evaluation	VTT
13:00	End of Introduction Session	all
13:30	LIVE: Technology Verification; Walk Through;	VTT/ESC +…
13:30	TTE: Preparation; Introduction to C2 etc; Rehearsal	CESS+ TTE-players
16:30	End of Sessions	

Time	TTE Preparation Agenda 22 Sept	All TTE Staff
13:30	TTE Objectives and course of action	CESS
14:00	Tasks and roles in the TTE	CESS
14:40	Explanation of the Script	CESS
15:20	Use of the COP-C2 System in the TTE	BAE-S
15:40	The Evaluation	CESS
15:50	TTE-Rehearsal	all
16:15	End of Session	

	Agenda 23 Sept	
09:00	Preparatory measures	COPE-internal
10:00	Handouts and final arrangements TTE	All TTE participants
10:00	Prep LiveEx	LIVE Ex. participants
11:00	Start TTE	All TTE participants
12:15	TTE People to watch LiveEx from Tower and on site	TTE participants
12:00	Start LIVE Exercise	All LIVE participants
14:00	Luncheon for TTE people	
	Coffee for Live Ex people	
14:00- 16:00	Debriefings Live Interview sessions & self evaluations LIVE	SBAE/TCD Selected LIVE-Players
14:00 16:00	Feedback TTE (parallel) Questionnaire	CESS+ TTE Players

Time	Agenda 24 Sept	
09:00	Statement on Trial Findings	Each COPE Partner
10:00	Discussion	All
10:30	Way ahead Evaluation from HF p.o.v. Evaluation from WP6 p.o.v. Structure of final results Input to D&E activities	VTT CESS VTT / CESS Rob
11:30	Next steps and deadlines	Jari
12:00	Lunch	
13:00	Checkout/ leave	

Figure 5: The Trial Schedule

4 Analysis and Evaluation Processes and Methods

4.1 Data and information acquisition

The evaluations are based on a variety of data and information sources

- The COPE data repository which contains all trial setup, situation development and events information according to the COPE data dictionary based on the COPE modified TSO[3]-based ontology. For details see COPE Deliverable D5.1.6 - Test & verification protocol.

- The repository replay function which allows to track back all events of the whole exercise (LIVE and TTE) which caused any change in the C2 data set.
- Reports, debriefings; discussions (noted comments)
- Interviews (notes)
- Debriefing with all participants of the LIVEX (audio recording) and the TTE
- Recordings (audio and video) (TETRA network communications, 4 Video recordings of the activities of 3 Incident Commanders' and the activity of the Higher Level Commander)
- Questionnaires (structured scoring system)
    - For LIVEX on system V&V and human factors (HF) analysis
    - For TTE and selected LIVEX players on overall system performance
- Additional comments in the questionnaires

The HF oriented evaluation methods are described in 4.2.1 and 4.2.2.

The TTE questionnaires (Annex 1: Questionnaire Template) includes 3 sections:

1. Questions on evaluating the overall setup of the cope trial and of the COPE system
2. Evaluation of the operational performance of the COPE applications (see 4.2.3) and
3. Questions on assessing the market chances and recommended improvements

4.2 The evaluation Methods

4.2.1 The evaluation approach in the HF-oriented analysis of LIVEX

The analysis of the functionality and usability of the COPE technologies in the LIVEX was a rather complex task. The exercise involved up to 65 professional emergency responders. Out of these, 19 emergency responders utilised COPE technologies. These persons were experienced professionals from the nearby towns. The rest were last course students of the Emergency Services College.

The aim of the evaluation was to evaluate the COPE technology concept on the basis of the end users' actual performance with the COPE technologies and their expert opinions about the technologies,. In earlier Deliverables (D4.4) the evaluation approach has been described to comprise of two levels, i.e. the verification and the validation levels. Verification is to check whether the COPE system complies with the specifications imposed at the start of the development process. Verification focuses on specific work tasks and the key performance indicators (KPI) defined with regard to their fulfilment. The validation seeks answers to the broader question whether the designed technology provides added value to the emergency response activity. For this evaluation of the fulfilment of

[3] TSO=Tactical Situation Object & ontology, containing the most important information pieces which are managed by the emergency responders:
1. the description of the emergency itself
2. the description of the resources which could be used to support the operations
3. the description of the activities which are part of the operations
A complete description of the OASIS TSO can be found in the [AD01] and its annex (the TSO data dictionary).
http://www.oasis-fp6.org/documents/OASIS_TA21_ICD_063_DSF_1_1_pub.pdf and
http://www.tacticalsituationobject.org/

the technology promises a more comprehensive reference than single task accomplishment is needed. The reference is that the technology fulfils the intrinsic work demands, i.e., the core-task demands of the work in which it should be applied. In this analysis validation is focused on the cognitive demands that developing and maintaining a common operational picture COP might put (see D.2.1 and D2.2). In D2.3 it is explained in more detail how the reasoning about the achievement and potential achievements[4] of capabilities of the COPE technology concept was accomplished.

In order to achieve reasonable evaluations of a new complex set of technologies, it is very important to acquaint the users with the technology to be tested. As part of the HF-oriented V&V evaluation, training material of the COPE technology was developed. One professional emergency responder from ESC trained the professionals using the COPE technology in a three hour session during which they had the opportunity and duty to try out the COPE applications. The training took place in the week and days before the trials.

4.2.2 The methods used in HF-oriented verification and validation

Verification

1) Walkthrough protocol for verification (before the trial) was conducted during the pre-trial training. Each role (IC, SC and FF) representative was asked to perform according to the walkthrough protocol, step by step, the performance of which video is recorded and evaluated.

2) Verification interview (before the trial) was conducted during the training after walkthrough and was based on methods described in D4.4.

Validation

1) Validation questionnaire which was filled in during debriefing/self-evaluation.

2) Dialogical Group Discussion, validation of which was conducted during debriefing/self-evaluation and including:
- Introduction to the session
- Division into three groups (FWF, Brewery, Hazmat)
- Each group discusses the incident and the technology use while the other two actively listen.
- No commenting by the other groups during the discussion.
- Each discussion about 30 minutes long
- Content of the discussions:
    - Topic 1: Performance of the emergency response activity
    - Topic 2: Technology and common operational picture

3) In addition to the above mentioned data acquisition methods, the performance of COPE technology users (IC and higher command from video recordings and the discussions) and communications (from TETRA) is analysed. Conclusions are drawn on the existing and the potential capabilities of the COPE technology concept.

[4] We sometimes use the artificial word „Promisingness“

Beyond this, second to second formation of the COP and the share of each tool in the formation of COP is analysed using all validation-related data. These results will be reported later in scientific publications.

Synthesis

The detailed results of the verification and validation will be presented in D2.3 in which also earlier V&V results will be synthesised into a final evaluation of the capabilities and the potential of the COPE technology concept.

4.2.3 Performance of the COPE functional applications

The COPE system functionality has been defined by a set of 14 “Applications”. They have been designed and specified in detail in the deliverables of D3.3, including the functional flowcharts, and in D4.3 where they have been used as a basic reference for the process of technology screening and application in the first responder environment.

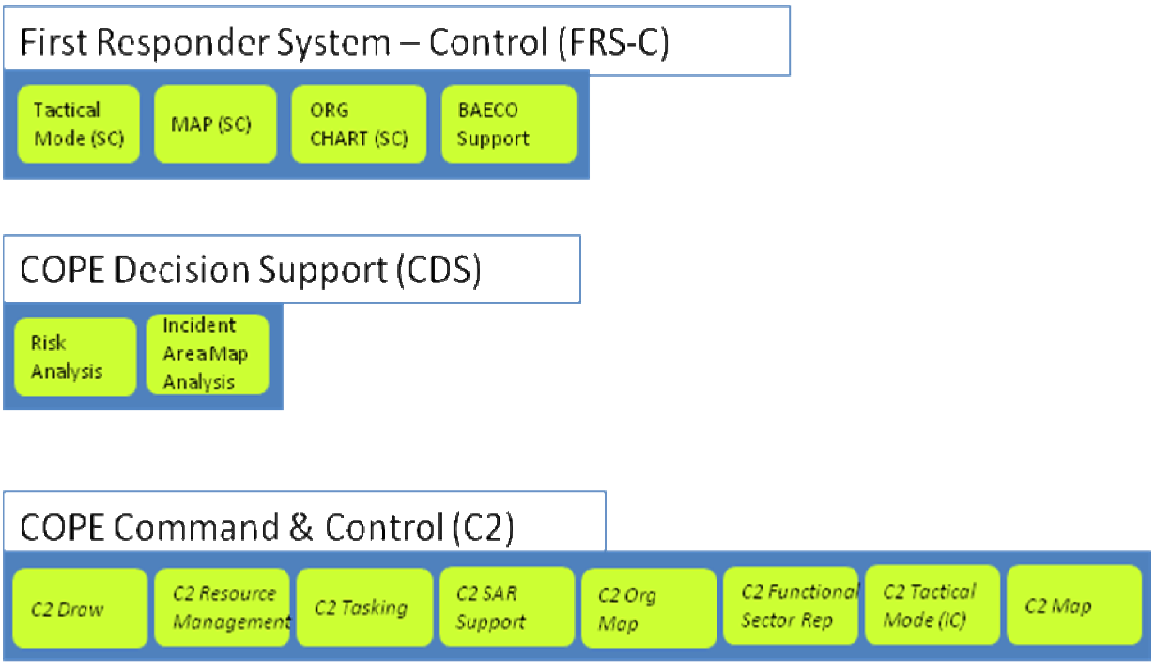


Figure 6: Designed COPE applications

Out of these COPE applications, a selection was realized, implemented into the COPE system and exposed to the COPE trials. They are briefly described in Table 5 below. (For details see D3.3 and D4.3.

Ref No.	COPE Application	Main Application Functions
	On Sector Command level, the SC can use the so called FRS-C with the:	
1a	**FRS-C Map function** showing functional and/ or geographical	• Location of people and assets • Send info to FRs

	sectors, areas of interest, items of interest etc. (not used in tabletop exercise)	• Receive Information from FRs • Monitor & control Sensor deployment • Send information to COPE-C2 (e.g. current location of resources
1b	**FRS-C Tasking Function** provides the SC with task handling between the IC and the sector	• Receive tasks from the IC • Acknowledge tasks • Change task status • Receive incident tactical mode • Receive IC's statement of intent
1c	**FRS-C Breathing Apparatus Function** providing the SC with the ability to assign breathing apparatus to fire fighters and monitor	• Assign breathing apparatus • Monitor remaining air time • Alert the SC when remaining air thresholds are reached
	On Incident Command level, the IC is supported by several applications of the so called COPE C2:	
2.	**C2 Draw** for generating symbols, items of interest, areas etc.	• Use drawing technology (pen; touch-screen) • Generate drawings information • Communicate to relevant users
3.	**C2 Tasking** for creation, assignment and acknowledgement of tasks	• Identify data required for tasking function • Develop tasking options • Communicate tasking decisions to the SCs • SC to give orders to frontline FFs
4.	**C2 Functional Sector Map** for creation and assignment of operational sectors	• Identify critical areas and/ or functions • Generate operational sectors; display sectors • Communicate to relevant users, esp. SCs
5.	**C2 Map** as the common reference to display the Common Operational Picture (COP) and perform planning and distribution tasks	• Provide the basic map information • Update changes • Display the Common Operational Picture (COP)
	Further, mainly on IC level, the ***Cope Decision Support System*** can be used, with its functions	
6.	**Risk Analysis**, based on a manual risk card system used by UK FFs, and automated for COPE	• Select objects at risk (e.g. shortage of resources; level of threat; Risks to FRs) • Identify data for risk assessment • Apply "Risk Card" logic • Evaluate risk result • Communicate to IC (and possibly other users)
7.	**HAZMat: Cloud Estimation**, display and decision support concerning HZMAT (Also named **IAMA**= incident area map analysis)	• Receive sensor data • Identify HazMat area/ event • Request cloud estimation from cloud estimation software • Visualize cloud as estimated • Communicate to C2/ IC (and possibly other users)

Table 5: Implemented COPE functional applications

Evaluations based on the questions of the questionnaire allowed scoring at a scale of 1 to 5 points, and included verbal comments. Both have been considered in the evaluations in Chapters 5 and 6.

The scale of points range to be attributed was defined as
5 = excellent
4 = very good
3 = good
2 = fair
1 = failed or very low performance

All scoring input to the questionnaire by participants was statistically evaluated. The numerous verbal inputs as comments and recommendations were interpreted and incorporated in the conclusions of this report (Chapter 6).

4.2.4 COPE and COP state of the art and trends

This part of the final evaluation work goes beyond the scope of the final trial exercise. It comprises an evaluation of the COPE achievements in comparison to the state of the art in the development of advanced Common Operational Picture systems and an attempt to figure out basic trends in future COP requirements, concepts and technologies. For this purpose, a survey of recent advanced COP developments and applications has been performed (see Annex 3: COP State of the Art and Trend Analysis). This includes generic capabilities and application requirements as well as analyses of a selected number of concrete COP projects, military and civil, and their markets.

From these and from expert knowledge, a catalogue of COP parameters has been derived which can be used as a reference for the COPE COP system (Annex 4: COP Sate of the Art and Trend Criteria). It goes without saying that not all these characteristics, functionalities and technologies listed in this catalogue could ever be implemented in a single COP system.

First, COP systems as core C2 elements will differ greatly between different applications: A tsunami warning system requires a different COP than the control centre of a globally operating chemical industry group.

Second, implementing too many, not to say all, features in one system will be neither economic nor would it be operationally applicable.
This evaluation therefore has to regard several steps as follows:
a) Identify those properties/technologies/functions etc. from the catalogue which have been implemented in COPE
b) Identify those which were of minor or no relevance to COPE
c) Give a qualitative evaluation of how these COPE features compare to the state of the art
The results of this analysis are described in Chapter 5.4

5 Evaluation Results

The evaluation is done from different perspectives ("views"):
5.1: The provider view: Chapter 5.1 gives an evaluation of the individual technologies or groups of technologies by the technology providers.
5.2: The operational view: Chpt. 5.2 gives an assessment by the exercise participants of the operational performance as supported by the COPE system
5.3: The trial view: 5.3 evaluates the overall COPE achievements of the trial
5.4: The research and technology view: 5.4 gives a comparison of the COPE achievements to the wider state-of-the-art in COP related RTD.

A further most important view, however, is the end-user view. It has been analyzed in great detail and its results are separately documented in C2.3, and some conclusions are given in chapter 6.1 of this report D6.6.

This multi-view evaluation does not only address the different aspects of a complex project like COPE, it also implies some self correction mechanisms by avoiding that individual assessments may be biased.
Evaluations are made as honest as possible not only reporting the "goodies" but also discussing things which did not work to satisfaction.

5.1 Evaluation of the individual technologies

5.1.1 COPE Gateway

The COPE Gateway enables communication between different subsystems in COPE. It is a "web service", based on the "service oriented architecture" paradigm (SOA). SOA is essentially a collection of distributed services that communicate with each other using some connection technology. A "service" is a well-defined, self-contained, function that does not depend on the context or state of other services. A "web service" is one of several connection technologies that can be used for communication and data exchange between services. Other examples of service connection technologies are DCOM and CORBA. The use of a web service as the connection technology in preference of DCOM or CORBA makes it easy to implement clients in very different environments.

Gateway communication uses TSO, which stands for Tactical Situation Object and is a proposed EU standard for exchanging information during emergency management. Information is sent using XML and it supports interoperability between both computers and humans. (see also Chapter 4.2.1).

The Gateway saves all data received and afterwards this can be used for evaluation and replay of the events in the scenario.
During the trial the COPE Gateway was operational at all times. All data from the trial was saved and is available for evaluation and replay.

5.1.2 Command and Control System

The purpose of the C2 (Command and Control) application was to provide the user with

- A map window showing positions of resources, hazards etc. in a map of the place of the emergency event
- A tasking window used for task allocation for sector commanders
- Additional information such as direction and speed of wind

The primary user of the C2 in COPE is the Incident Commander. The application is run on a laptop placed in a vehicle or at a fixed position near the place of the emergency event.

If the Incident Commander is not able to run the C2 then it is used by the Command Support who verbally communicates with the Incident Commander. The C2 is developed with the need of the Incident Commander in focus. There is however no technical limitation for other roles to use the C2. In the COPE trial several roles used the C2 such as the police, the medical services, higher command and other Incident Commanders.

The purpose of the C2 is to present the data in the system as the Common Operation Picture. The C2 receives information from the COPE Gateway and presents it in the C2 map and tasking window.

Functionality in the C2

- Map support – Map layers, zooming, panning,
- Map icons – Using icon for displaying HAZMATS, resources, injuries etc.
- Drawing – Using the map for showing sectorization, hazardous areas
- Resource management – Displaying resources in the map
- Tasking – To define and distribute tasks, both for physical and functional sectors

During the trial of the C2 the following results were derived from a technical point of view:

1. The COPE-C2 worked with all its implemented functionality
2. The C2 occasionally lost contact with the network (WLAN). Then data was not updated which made the application to freeze until network connection was found again.
3. There are no reports or evidences about the C2 application not working as intended (apart from point 2 above).

During tests prior to the final trial the C2 itself was working without any errors. It is therefore reasonable to assume that the problem with the network as described in point 2 above is the only reason for the problems of the C2.

5.1.3 COPE Decision Support (CDS)

The COPE Decision Support is a software application that runs in a ruggedized laptop. Its purpose is to assist the user in performing risk analysis which is a procedure used manually by the AVON/UK fire fighters.

This procedure is based on the use of Risk Cards which serve as memory aids for the Incident Commander (IC) with the purpose of making his decision more efficient. There are several Risks Cards and each of them applies to a specific scenario piece. Within each of the cards, hazards are listed which the IC is likely to encounter in that scenario type and for each of them a set of controls are listed and those proposed to mitigate the hazards.

There are two separated steps in this procedure:

- Dynamic Risk Analysis (DRA)
- Analytical Risk Analysis (ARA)

The Dynamic Risk Analysis is based on the selection of the different Risk Cards that apply to the incident and the correspondent HazCon[5] pairs that he wishes to address. The Analytical Risk Analysis basically prioritizes the HazCons by quantitatively assigning Likelihood and Severity of the expected consequences of the hazards.

The CDS tool makes this process very efficient through a software interface tailored to the user needs. Furthermore, on top of assisting the existing procedure of the AVON fire fighters it also allows the operator to insert the result of the analysis into the Common Operational Picture (COP). This is done by placing the resulting HazCons in the COPE Gateway through its site maps feature and all systems connected to the Gateway can see them.

The tool was fully used in the final trial in Kuopio and the resulting assessment concludes that the tool has the potential it has been designed for. It was recommended that the system to be tailored also to address Risk Analysis at a higher operational level. Currently it is designed for Risk Analysis at the sector level. Further evaluation of the CDS tool resulting from the final trial is available in chpt. 5.2.3 and in Annex 5: CDS Evaluation.

5.1.4 HazMat - Gas Cloud estimation

The gas cloud estimation (Air Quality Estimator, AQEST) was operating as a separate software in the background during the trial. Its purpose was to give an estimate of the gas cloud distribution and concentration in the incident area. The software received the gas concentration information from the sensors via the SIP and the wind data from EMAS through the COPE gateway. Based on this information a gas cloud estimation algorithm working on a majority voting logic between the sensors was run and the results were sent to the COPE gateway. This whole process was fully automated and did not need any user interaction. An update of the cloud estimate was sent in every 45 seconds. The result was then displayed on the map views of C2 and CDS. The users of these two applications were then able to see where the gas cloud was currently estimated to be and in addition the gas levels inside the clouds.

Most of the time the AQEST was working as expected during the trial. The estimator was able to receive the data sent by SIP and EMAS, calculate the cloud estimate correctly and submit it to the COPE gateway. The gas levels of the clouds were reasonable considering the gas sensor values (SIP) when observed during the

[5] HAZMAT Control

trial. Some problems occurred when pieces of the information from SIP were not received. SIP sent the information in several TSO-messages, one message defining the sensor position and then one message for each gas type defining the gas concentration at the sensor.

A couple of times the gas concentration information was received by AQEST but the position message from two or more gas sensors was not received due to network delay (or possibly some other unidentified reason). This caused AQEST to send gas cloud estimates where the position and gas concentration were incorrect to the COPE gateway. This issue would have been relatively easy to fix by including a more precise sanity check to the AQEST for received SIP data. However, similar situations had not occurred during the earlier tests, so a flaw in the software was not noticed. If only one position message was missing, incorrect functionality in AQEST did not occur and missing gas concentration messages from SIP did not cause any errors. No problems occurred with the received wind information from EMAS. AQEST was always able to use the latest available wind information and use it correctly when calculating the estimate.

As an overall finding, the design and functionality of AQEST was in a good condition during the trial. Fixing the problem with missing position messages requires only one minor change to the AQEST software. For more information, detailed technology and algorithm description & validation see Appendix 6.3 of D5.1.7.

5.1.5 First Responder System Human Wearable (FRS-HW)

The FRS-HW provides the fire fighter with two basic functions; the ability to capture data and transmit it back to the COPE database as well as the ability to view data using two display devices. The FRS-HW integrates one or more sensors to capture data from the environment around the fire fighter. For the trials the FRS-HW used the following sensors:

- helmet mounted thermal camera
- helmet mounted day camera
- GPS / inertial position sensor
- toxic gas sensor

The FRS-HW provides the fire fighter with a non see-through Helmet Mounted Display (HMD) that provides him or her with a level of situational awareness by displaying real-time video from the thermal and day cameras as well as a building map. The building map has a number of real-time symbol overlays that allow the user to see his/her own position as well as the positions of other personnel, resources and hazards in the viewable area. The FRS-HW also provides the fire fighter with a small level of control using the touch-screen on the Wrist Mounted Display (WMD). It provides the user with the ability to toggle the display on the HMD between the video and the building map views, and it provides him with the ability to tag a location. Location tagging allows the user to record a short audio/video clip using the currently selected video sensor and microphone. This video clip is attached to an item of interest symbol drawn on the map at the location of the user. The tag is sent back to the SC. The WMD also has an outdoor map as well as the same building map that can be displayed on the HMD. Both maps have a number of real-time symbol overlays that provide the user with the location and information about personnel, resources and hazards in the viewable area.

The FRS-HW contributes to the COP by providing sensory information from the fire fighter to users higher up the command chain. It also allows the fire fighter to view a subset of data that all other users of the COP could view.

The FRS-HW took the physical form of a webbing jacket with two large pockets. One pocket contained the battery Power Supply (PSU) and the other contained the main processor. The fire fighter's helmet (which was attached to the vest with an umbilical containing the camera and display feeds) contained the video sensors and the HMD.

In general the system performed successfully from a functional point of view. The real-time video was visible on the HMD and the user's position was successfully updated on the outdoor map. There were a few issues during the trials both of which were anticipated:

- Compatibility of the HMD with the user's BA mask
- Experience with the system

Currently the HMD is attached to the brow of the fire fighter helmet and the only adjustment for the display is in rotation up and down. When the fire fighter is wearing BA equipment then the gap between the helmet visor and the BA mask leaves very little room to be able to adjust the HMD such that it is visible to the fire fighter.

Due to the logistical issues involved in providing the FRS-HW in advance of the trial the users had no training time with the system, which meant that they were not confident in using the system and did not know how to use the system to improve their operational efficiency.

5.1.6 First Responder System Control (FRS-C)

The FRS-C provides the SC with the ability to assign/de-assign personnel to/from a group of FRS-HW units. It also controls the consolidation of data from all FRS-HW units assigned to its sector, uploads that data to the COPE database, and distributes data from the COPE database to each of its FRS-HW units. The FRS-C provides the SC with a level of situational awareness based upon data in the COPE database and data from the FRS-HW units. This data is displayed to the user in the form of a tasking window and outdoor/building maps. The tasking window displays tasks for the sector that have been issued by the IC as well as the incident tactical mode and the IC's statement of intent. It also allows the SC to change the status of issued tasks. The maps are similar to the maps used by the FRS-HW, however, they provide the user with more control capabilities in terms of zooming and moving the map, and the symbology overlays are tailored to the SC's role. The FRS-C also provides the SC with the ability to assign/de-assign BA sets to personnel, then monitor how much remaining time they have on their current air supply. The system will trigger alarms when the remaining time reaches certain threshold limits. The FRS-C also allows the SC to view real-time video from the active helmet mounted video sensor on each fire fighter assigned to the sector and wearing a FRS-HW.

The FRS-C contributes to the COP by consolidating all data output from the FRS-HWs within a sector and uploading it to the COPE database for all other users to view. It uploads the position of the SC to the COPE gateway and allows him to view the positions and details of other personnel, resources and hazards in the viewable area using the common map data available to all COPE users. Finally it allows the SCs to interact with the IC with task hand-shaking allowing the IC and other interested parties to view task details and status.

For the trials the FRS-C application was hosted on a Panasonic CF-19 “Toughbook” worn across the body. It was also connected to a body mounted GPS/toxic gas sensor worn on a webbing jacket on the chest.

Most functions on the FRS-C worked correctly, however, due to a last minute change to the configuration that had to be made before the start of the trial, an error in the configuration meant that the SC in charge of the sector tackling the brewery incident was unable to view any streaming video from the fire fighters wearing the FRS-HW units. When working outdoors, data appeared to update on the FRS-C in a timely manner, however it was noticed that due to an un-defined issue with network traffic (see 5.1.6 below) there were times when data was moving across the Wi-Fi network very slowly, hence there was a delay in the update of data. When the fire fighters wearing the FRS-HW units moved inside the brewery building they lost connection to the COPE Wi-Fi network very quickly. This was anticipated as the attenuation of Wi-Fi signals by walls is very high.

Although significant training was conducted on the FRS-C before the trial, a functional flaw remained unidentified, and just before the start of the trial the SCs appeared very unsure of how to use the FRS-C, e.g. tasks sent to the SCs from the IC were never acknowledged. From a technology perspective it is unclear at this time whether this is down to a fault in the FRS-C application or whether this is due to a lack of training/experience. Previous testing before the start of the trial, however, suggests that the tasking functionality was working correctly.

5.1.7 COPE Communications technology

COPE System of Systems consists of several different parts which need to share data wirelessly to form the Common Operational Picture. There is a need to have different levels of communication and data sharing between Command Level, Field and Unit Level and Sensor Level.

The COPE technologies are designed to support the actions on the emergency operation field and this is why also the COPE Communication System’s main focus was on the Field Communications utilizing WLAN and WSN (Wireless Sensor Networks). Voice communication was not considered as COPE technology; however TETRA network was used for voice communication in the COPE demonstration. For detailed communication technology description and evaluation, refer to the D5.5.2 and D5.5.3 documents.

In the demonstrations WSN was used for sensor data transfer from the deployable sensor nodes to the first responders and command centres. Deployable sensors were used at the hazmat incident for gas and GPS data transmission. WSN radio interface utilized low power embedded 868 MHz radio technology.

WLAN Mesh Network was used to cover the incident area with wireless infrastructure to enable communications between First Responders, Local Servers, COPE Gateways and CDS- and C2 platforms. There were a total of three mobile mesh access points to cover the incident area which acted as routers to deliver all the data that was sent through the network to the end users through the COPE gateway.

The COPE Communication infrastructure was utilized at all times during the final demonstration. WSN including seven wireless sensors was used for deployable sensor data transmission from the chemical accident. According to the recorded data and analysis the sensor network infrastructure worked as expected. The following table depicts statistical results of the sensor network.

Sensor ID	RSSI Rx	Packet Loss	Std Deviation	Distance to receiver	Lat (WGS-84)	Lon (WPGS-84)
1	-63	0.0 %	0.00	287	62.82929722	27.51376389
2	-81	2.6 %	0.94	370	62.82862413	27.51517466
3	-83	0.7 %	0.65	404	62.82830833	27.51583611
4	-81	0.4 %	0.49	376	62.82886111	27.51684167
5	-86	8.4 %	1.91	364	62.82871667	27.51596944
6	-85	1.8 %	0.83	336	62.82942778	27.51689444
7	-76	4.7 %	1.58	269	62.82972222	27.51573611

The above table shows the RSSI levels, packet loss and its standard deviation, distance to the receiver and GPS-position. The table indicates that the lower the RSSI level the higher the packet loss is. Obstacles as buildings and forest might have negatively affected the signal strength and consequently the packet loss has increased. Node number 5 was behind a metal structure and did not have LoS to the receiver. It is worth mentioning that packet loss was quite low under the given circumstances and the required information was received with proper frequency even though retransmissions were not used. To summarize, functionality and reliability of the WSN and sensor technology were adequate for this purpose of use.

The WiFi network was used between all users. The following discussion concerning WiFi has to be considered as analytical speculation. According to signal strength tests before the trial, the network covered the whole incident area with proper QoS properties. Although the network was tested to be functional beforehand it seemed that the network could not provide sufficient QoS during the whole trial. There are several reasons which might have affected the network. The TETRA traffic during the trial was quite intense, which might have had effects to 802.11 signal quality. We did not have the ability to test this in advance because of lack of TETRA radios.

The main reason the network did not support the functions all the time could have been the amount of data transmitted in the network. The maximum theoretical data rate of the network is 54 Mbits/s, which is shared with all the users. The 54 Mbits/s data rate will decrease to 24 Mbit/s if one hop occurs and accordingly to 9

Mbits/s with two hops (hops between the access points). The data rate is also proportional to the signal strength and it seemed that the signal strength varied because of obstacles (in building) and end user's receiver sensitivity. This is why the individual user might have had bandwidth available even lower than 1Mbit/s sometimes during the trial (depending where the end user was). The biggest bandwidth 'consumers' were the FRS-HW and FRS-C platforms with thermal video cameras and video cameras installed. In the beginning of the trial the latency of the network increased when the FRS-platforms seemed to have fallen down. It could be that these platforms flooded data through the network during the booting time. The network infrastructure could not handle this amount of data and that is why the latency increased and bandwidth decreased in the whole network. However the network recovering mechanisms prevented the network to crash completely and the data communication could continue with lower capacity. Also during the trial there were time instances the network was sluggish. The most likely reason for this was the unpacked video streams sent from the end users to each other through the network.

It has to be noted also that the C2 application ran on the P3 laptops and at the command vehicles we were utilizing standard PC WiFi network interface cards with quite poor sensitivity. Also the PC capacity (memory, processor capacity etc.) may affect the performance of the application although the network capacity would be enough.

The WiFi network worked in the trials as expected but was occasionally overloaded due to the reasons explained above.

5.1.8 Sensors Integration Platform (SIP)

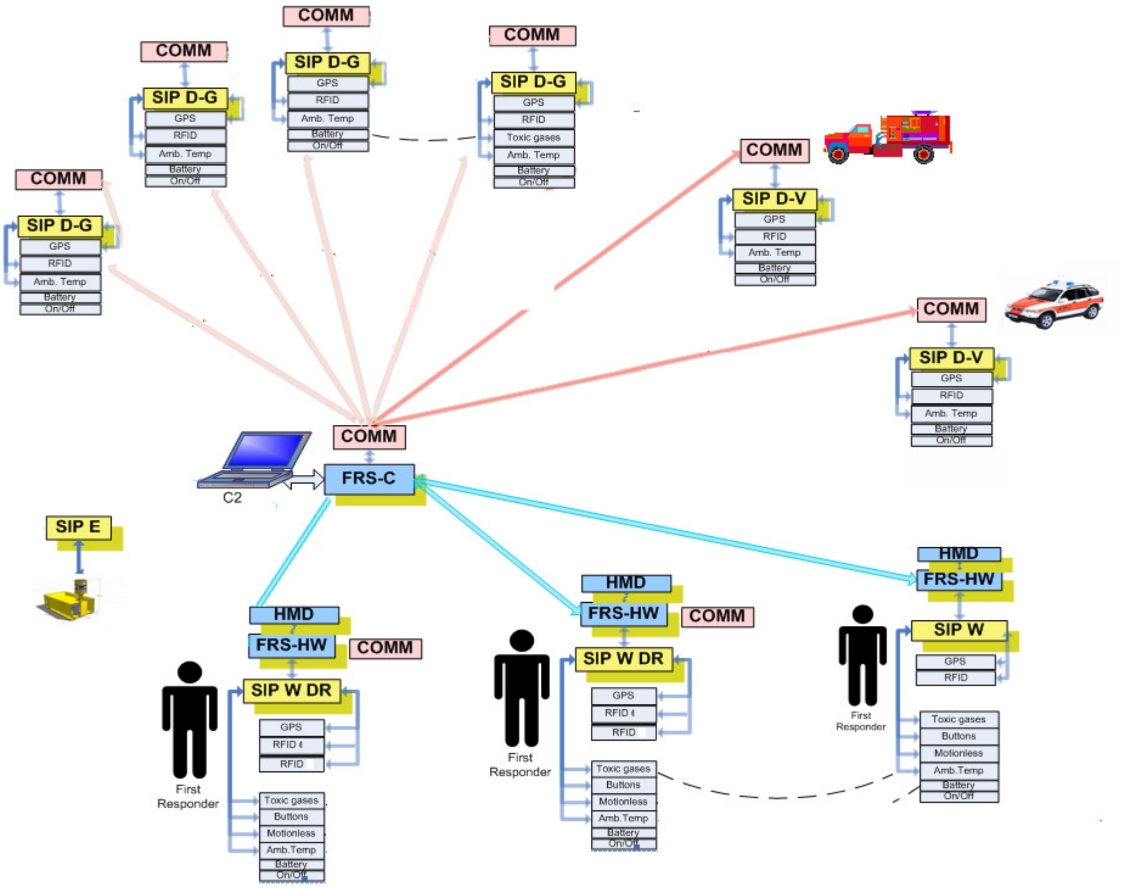


Figure 7: Sensor integration configuration diagram

The Sensors and the sensor integration platform, through the network, sends and receives information to/from first responders as well as the operational command and control centre (C2). The sensor platform is in charge of isolating the rest of the system from the "sensor" environment, so any data request will be issued / served in a standardized way.

5.1.8.1 COPE SIP W: The SIP wearable module with outdoor (GPS) localization capabilities

This is a wearable module for the First Responder sensors integration.

This module collects the information from the FR sensors and sends it through C2 or HMD modules to the COPE Gateway via the FRS system.

The main functions are:
- Establishment the FR outdoor localisation: GPS

- Position(Longitude & Latitude)
- Status (Valid, Not Valid)

- Resources – code identification
  - Resources Identification
- Obtaining the date regarding the Safety of FR
  - Dangerous gases detection
  - External Temperature
  - Motionless detection
- Support data:
  - Power status: On battery, Battery Discharged, Charging
  - Tamper alarm (Alarming upon unauthorized opening of the SIP-FR chasing)
  - SOS button (PANIC/EMERGENCY);

Using the product allowed us to obtain the information about the outdoor position and status (motionless detection) of the FR, the FR's identification code, data about the environment in which he operates (the presence of dangerous gases and external temperature), and data about the equipment status.

These data were used to complete the picture area of actions in the C2. During the trials held in Bucharest and Kuopio, the equipment worked properly and provided the necessary information to the C2. The end user reported the equipment was necessary and useful. Use of the equipment requires minimum training of the user.

5.1.8.2 COPE SIP W-DR : The SIP wearable module with outdoor (GPS) and indoor (dead reckoning) localization capabilities

This wearable module serves the First Responder sensors integration.

This module collects the information from the FR sensors and sends it through C2 or HMD modules to the COPE Gateway via the FRS system.

The main functions are:

- Establishment the FR position:
  - GPS for outdoor localisation
    - Position(Longitude & Latitude)
    - Status (Valid, Not Valid)
  - Dead Reckoning Module for indoor localization
    - The indoor localization is based on GPS and dead reckoning. The dead reckoning (DR) is the process of estimating the current position based upon a previously determined position, or fix and advancing that position based upon known or estimated speeds over elapsed time, and course.
    - Indoor use previous determined position by GPS receiver and provides independent position information based on user's stride and pace will take magnetic north and barometric altitude.
    - When good GPS data is available, the dead reckoning sensors are automatically and continuously calibrated. DR and GPS are

blended by an internal Kalman filter into a composite real-time position data output.
- When GPS data is unavailable, dead reckoning takes over. The position error characteristics are independent of time, and depend primarily on distance travelled.

- Resources – code identification
  - Resources Identification
- Obtaining the date regarding the Safety of FR
  - Dangerous gases detection
  - External Temperature
  - Motionless detection
- Support data:
  - Power status: On battery, Battery Discharged, Charging
  - Tamper alarm (Alarming upon unauthorized opening of the SIP-FR chasing)
  - SOS button (PANIC/EMERGENCY);

Using the product allowed us to obtain the information about the outdoor and indoor position and status (motionless detection) of the FR, its identification code, data about the environment in which it operates (the presence of dangerous gases and external temperature) and data about the equipment status.
These data were used to complete the picture area of actions in the C2.
SIP-W has been researched, designed and developed by UTI to meet system requirements.

During the trials held in Bucharest and Kuopio evidence was created that the equipment worked properly and provided the necessary information to the C2.

The end user judged the equipment was necessary and useful. Use of the equipment requires minimum training of the user.

5.1.8.3 COPE SIP D-G: The SIP deployable module suitable for ground deployment

This is a fixed module for ground deployment.

This module collects the information from the sensors and sends them through C2 or HMD modules to the COPE Gateway, through the communication system.

The main functions are:

- Establishment the SIP D-G outdoor localisation: GPS
  - Position (Longitude & Latitude)
  - Status (Valid, Not Valid)
- Resources – code identification
  - Resources Identification
    - each resource has a tag with ID attached.
    - has until 48 tags serial numbers enrolled in EEPROM memory
    - range for tag detection : 10m indoor.
    - generate events when tags enter or leave detection area, so the resources disposal are known to higher levels of command.

- Obtaining the date regarding the Safety of FR
  - Dangerous gases detection
  - External Temperature
- Support data:
  - Power status: On battery, Battery Discharged, Charging
  - Tamper alarm (Alarming upon unauthorized opening of the SIP-D-G chasing)

Using the product allowed us to obtain the information about the sensor position, its identification code, data about the environment in which it operates (the presence of dangerous gases and external temperature) and data about the equipment status.

These data were used to complete the picture area of actions in the C2.
SIP-W has been researched, designed and developed by UTI to meet system requirements.

During the trials held in Bucharest and Kuopio there is evidence that the equipment worked properly and provided the necessary information to the C2.

The end user judged the equipment as necessary and useful. Use of the equipment requires minimum training of the user.

5.1.8.4 COPE SIP D-V: The SIP deployable module suitable for vehicle deployment

This is a mobile module for vehicle deployment.

SIP-D-V has the same functions as a SIP-D-G but it has a mechanical interface for installation on vehicles.

This feature allows the transmission to C2 the information regarding the movement and the arrangement of vehicles participating in the interventions.

5.1.8.5 Standard PC Laptop (as alternative to the tablet PC)

This ruggedized computer is designed for developing modules integration software for tests and demonstrations. It used in the AT run Microsoft Windows XP Embedded or Microsoft Windows XP Professional SP2. During the demonstration specialized test software developed for this purpose was used.

Taking into consideration the final results of the analysis, inspections and tests resulting from the verification and demonstration activity, the whole system and its modules satisfied the requirements.

5.2 Operational Evaluation of System Performance

The main methodology used for this evaluation section has been discussed in chapter 4.2.3 and Annex 1: Questionnaire Template . The detailed statistical evaluation is attached as Annex 2: Statistical Evaluation of filled Questionnaires, and will be interpreted in this chapter. In addition, the numerous written comments and the verbal input from intermediate and final discussions will be analysed and combined with the statistical evaluation.

The basis for this is a set of questions related to the performance of the COPE system and its applications as defined. A total of 16 questionnaires were returned which gives an adequate representativeness for a statistical evaluation.

In this chapter, the Questions 1.6 and 2.1.x are evaluated. As most of the participants did not evaluate all 7 individual applications separately (Questions 2.1.x), we decided for evaluation purposes to group the operational applications into:

1. Map-supported applications: Sector & Incident Commander Support comprising
   a. Sector map function (Application # 1 according to table Table 5 above)
   b. C2 functional sector map (Application # 4) and
   c. C2 map (Application # 5)
2. Functional support applications: Incident Commander draw and tasking support, comprising
   a. C2 draw (Application # 2) and
   b. C2 tasking (Application # 3)
3. Decision support for the IC:
   Risk Analysis (Application # 6)
4. Decision support for the IC:
   HAZMAT (Toxic cloud estimation; Application # 7)
5. A summary evaluation of the overall COPE system from question No. 1.6

It should be noted, that the evaluation of the individual COPE applications was even broken further down into the sub-criteria

- Raising of awareness and COP understanding
- Acceleration of processes and decisions
- (Improvement of) quality of disaster management measures
- Intensity of use
- Communication and cooperation support
- Usability and understanding of the system

The following evaluation summarizes the scoring results and the written and verbal comments and discussion contents. They present a selection of a total of 66 histograms generated by the evaluation system.

In all statistical figures, the horizontal axes are the scores, the vertical axis gives the number of entries received from participants. Only selected histograms are presented here. The total of 66 histograms and the underlying numbers are contained in Annex 2: Statistical Evaluation of filled Questionnaires.

5.2.1 Sector/ Incident Command-Map support applications

Map support applications were scored at an average of 3.1, with the highest effects being created for awareness raising and good scores for all other criteria.

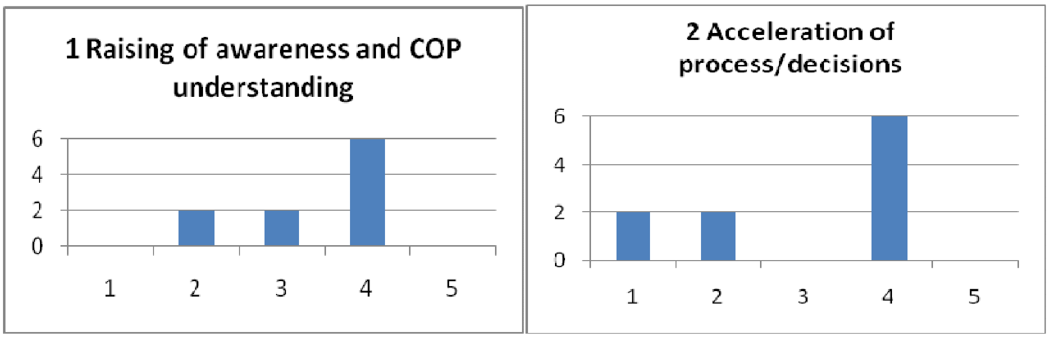


Figure 8: Map/Awareness raising and process acceleration

The acceleration potential of C2 and decision processes was scored very good, but there were few participants assessing the speed of the system to be effectively applied as too slow.

The improvement of the quality of disaster management (Fig. 10) through the application of COPE map technologies has been particularly attributed to the capability of sharing "map units", i.e. the transparency and unification of map information across hierarchical levels and between different user groups.

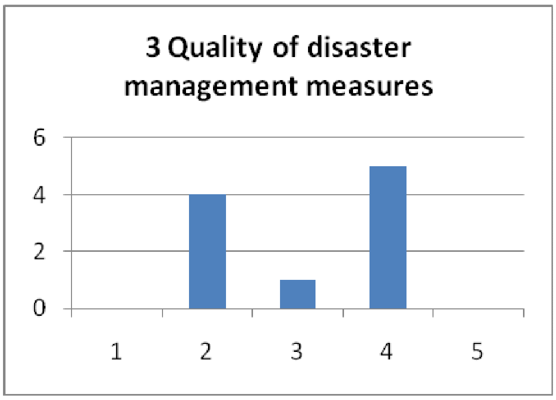


Figure 9: Map/Quality of disaster Mgmt

5.2.2 Functional support of the IC

The improvement of the quality of disaster management through the application of COPE C2 functions has been attributed by the participants to the

- Ease of use
- Video communication e.g. of and for smoke divers
- Early sharing of hazard information to incoming units

- Tasking and task control

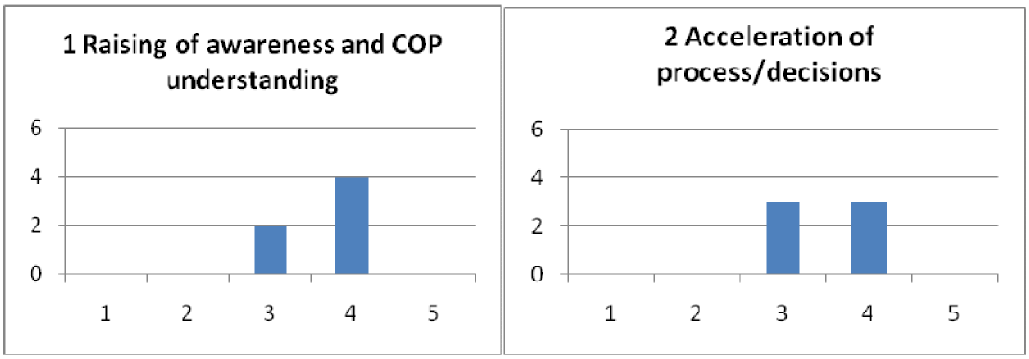


Figure 10: IC Support/Awareness and Acceleration

Suggestions were made to provide different views of the COP depending on the situation requirements, and also historical views. The latter is realized in COPE, at least for the purpose of lessons learned and evaluation of best practice, through a comfortable full-scale playback function of the data repository as recorded during the trial (or of course also and even more valuable) in real events.

5.2.3 Risk analysis

The sample size for this and the next (5.2.4) evaluations is only between 5 and 7, as only those participants could evaluate who worked with the Cope Decision support system CDS.

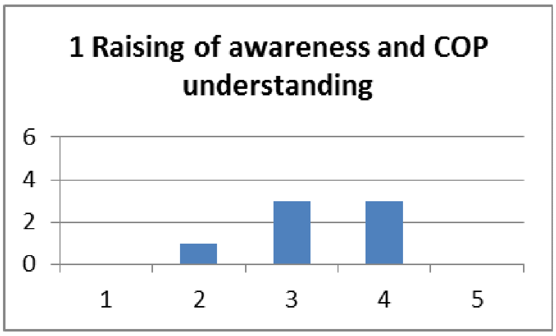


Figure 11: Risk Analysis/Awareness

The results from the chart above indicate that the there was a general recognition from the evaluators that the Risk Analysis provided very good means to increase awareness and understanding of the COP. Nevertheless, the efficiency of the application was considered average (good) and with room for improvement.

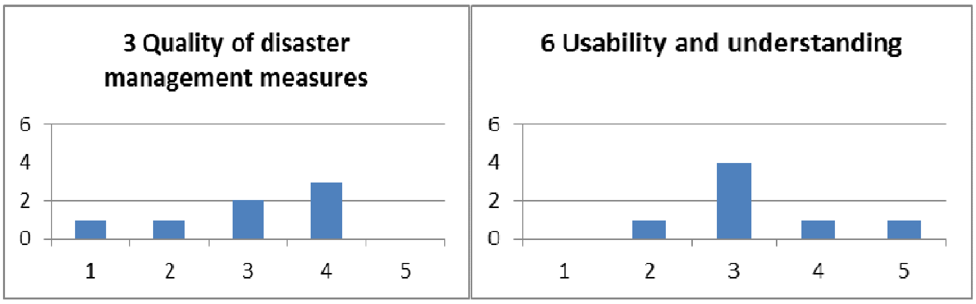


Figure 12: Risk Analysis - Quality and Usability

In terms of understanding whether what is provided meets the user needs, the chart on the left indicates that there is a difference in opinion about whether the application provides quality data or not. On the other hand, the chart on the right reflects that the application was well conceived in terms of easiness of manipulation and presentation of data. One may interpret this as the user to successfully be able to operate and navigate the tool but having difficulties on how he should use the information at hand. This may mean that the way the Risk Analysis is applied in the concept of operations (ConOps) should be further analysed.

The CDS was suggested to be directly integrated into the C2 system, and also become applicable at the higher crisis management and strategic level.

5.2.4 HAZMAT function

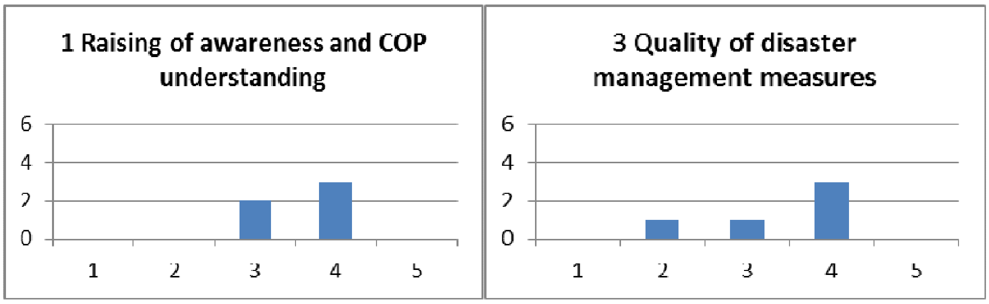


Figure 13: HAZMAT Application – COP Awareness and Quality

The results from Figure 13 indicate that there is a clear added value in the HAZMAT application in the COPE System. In fact, it addresses the very core objective of the project which is sharing information between systems in a Common Operational Picture. Nevertheless, it also shows that although the intended functionality of the application is most relevant and useful its implementation and resulting disaster management measures still have room for improvement, e.g. in the stability of sensor input information.

5.2.5 Summary evaluation of the overall COPE applications & functionality

The overall operational performance of the COPE system of systems received an average score of 3.2. This evaluation gives a summary evaluation by COPE application from question 1.5, and compares it to the evaluation of the individual applications in questions 2.1 as discussed in the chapters above.

The table and the graphic of fig. 16 show the overall performance of the COPE applications and a very good coincidence of the two separate ways of scoring (control function of the methodology).

Appl.#	Appl. Title	Eval. Summary Qest. 1.5	Indiv Eval. Qestns. 2.1.x
1	FRS-C Map function	3.2	3.1
4	C2 funct. Sector map	3.3	
5	C2 Map	3.3	
2	C2 Draw	3.1	3.3
3	C2 Tasking	3.2	
6	Risk Analysis	3.0	3.2
7	HAZMat: Cloud Estimation	3.1	3.3

Table 6: Summary evaluation of COPE applications

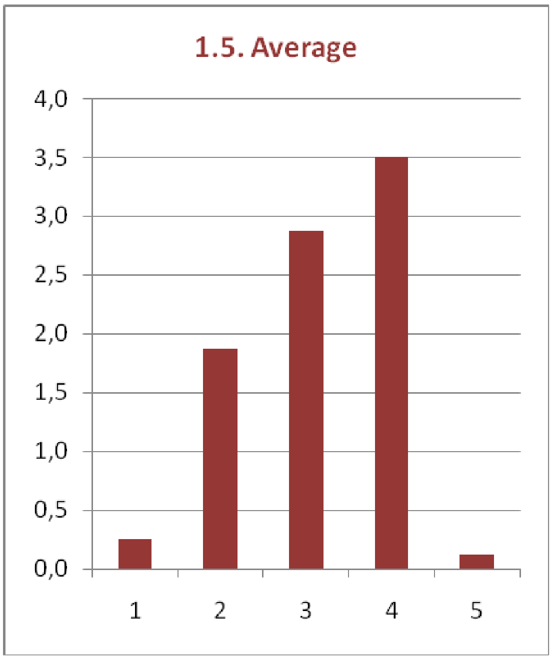


Figure 14: Overall performance of all COPE Applications

5.3 Evaluation of the overall COPE achievements and of the trial conduct

5.3.1 COPE System summary and innovation evaluation (Q. 1.6; 3.1; 3.2; 3.3)

The summary evaluation questions used the following evaluation criteria:

- Degree of technical innovation
- Degree of operational/functional innovation
- Quality of implementation

- Interoperation/cooperation of components
- Maturity of the COPE system and
- Ease of use

For COPE, being an applied research project, the degree of technical innovation on the one hand, and the quality of innovation on the other, are the most important criteria. Both were rated above average and commented as very convincing. (see Fig 16 below).

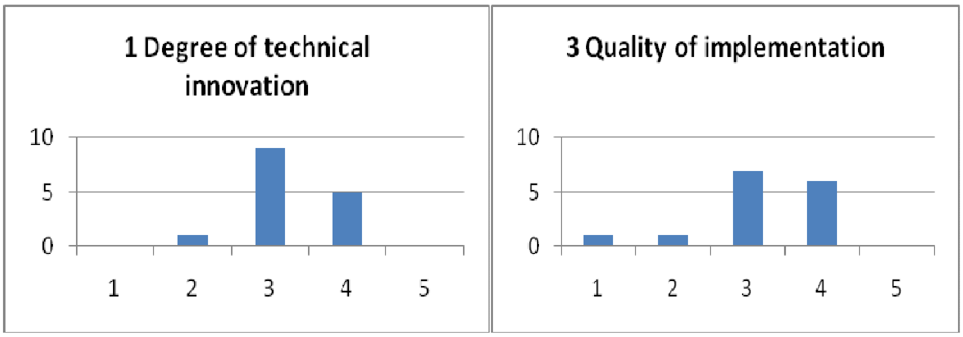


Figure 15: Overall technical innovation and implementation quality

The most convincing solutions presented were named to be
- The transfer of the Common Operational Picture across hierarchies, e.g. pictures and positions of fire, sensors and chemical accident (which was one of the key goals of COPE)
- The FF-worn GIS & GPS sensors and information on status and location of FFs
- The tasking and decision support functions at C2 level

Better integration of wearable components with the regular clothing and gear of the fire fighters was suggested as an important improvement. The extension of C2 and decision support functions from tactical up to strategic (crisis management) level was strongly suggested, as was the improvement of the interactive drawing capability in C2.

The CDS function of HAZMAT of cloud estimation worked sufficiently (see 5.1.3) but was obviously not transparent to the CDS users. Risk analysis should be directly integrated into the C2 system.

The innovation was considered to lie not so much in the individual components (some available at the market, some still immature), but rather in the cooperation of the various technologies integrated in the system of systems.

Almost surprisingly, the ease of use at IC level was positively evaluated, although the system is still in a demonstrator status.

5.3.2 The trial organization, setup and conduct (questions 1.1, 1.2, 1.3, 1.4, & 3.4/ 3.5)

The evaluation of the overall trial effort included the criteria of

- Preparation, accommodation, logistics processes
- Quality and understanding of the presentations
- Time Schedule
- Demonstration Equipment and presentation facilities
- Trial Event Premises
- Technical excellence of the whole setup
- General performance of trial support tools
- Performance of the team

In summary, the overall conceptual idea of COPE and of the trial concept, organization and conduct were assessed very positively. Highlights reported were the clear formulation of the goals, the quality of the presentations, the discussion and networking processes, and above all, the ESC facilities, operational support and hospitality.

Improvements (but no direct critique) were suggested for better involvement of visitors, particularly in the processes of the TTE participants' dialogue and interactions. This is a well known phenomenon because the TTE ran in real time whereas more intensive in-course discussions and interactions would require stretching of time to slow motion at least by a factor of 3. There should have been a more visible link between the TTE and the LIVEX. More C2 terminals for TTE users would have been helpful.

The higher-level orientation of and better reference to the COPE objectives were missed by some participants. This was due to the fact that they, unfortunately, could not participate in the full set of introductory and preparatory sessions. Some deficiencies occurred with actors playing certain roles, because they had not participated in the preparatory session's dry run. More intensive instruction dry runs could have increased the trial effectiveness

The figures below give a statistical overview and some selected criteria of trial setup and execution.

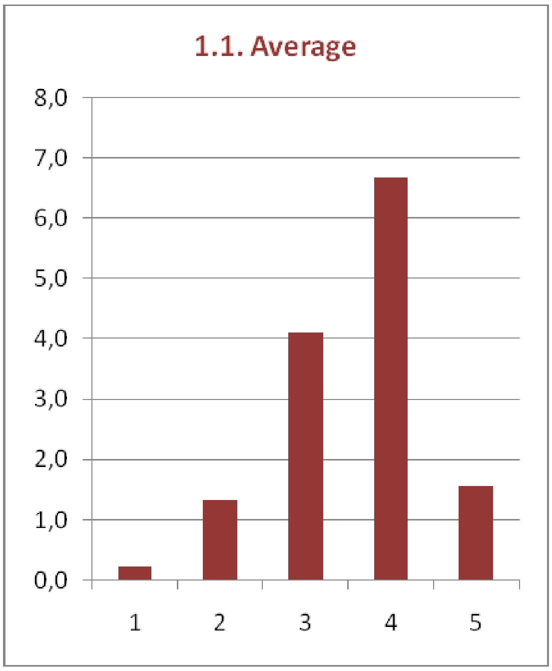


Figure 16: Overall trial organization, setup and conduct

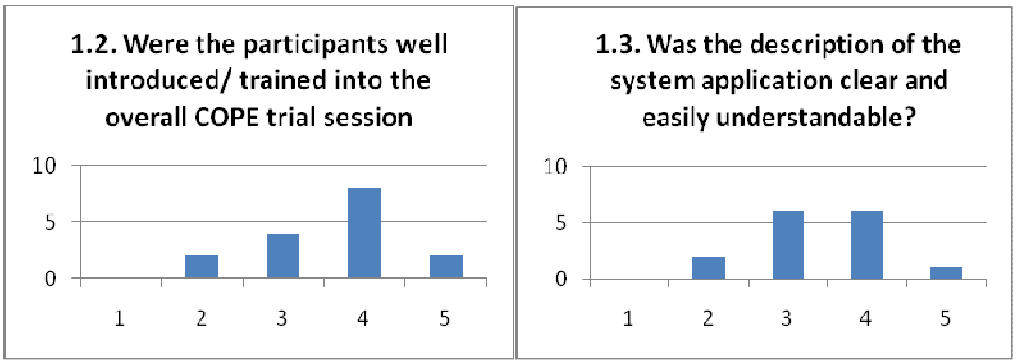


Figure 17: Quality of training and system descriptions

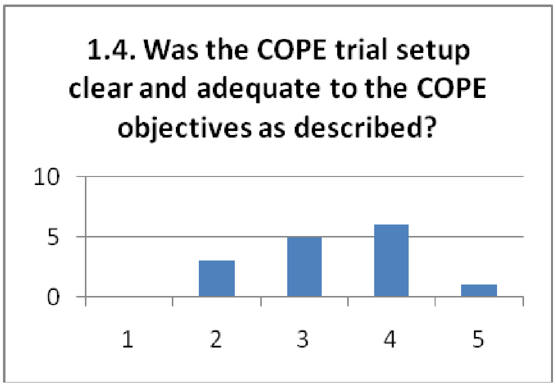


Figure 18: Adequacy of the Trial

Figure 19: Fulfilment of participants' expectations

5.4 General evaluation against the state of the art of COP programs

5.4.1 Survey of COP state of the art

Given that exploitation of the COPE System-of-System is a primary objective of the project, the range of applicability of COP capabilities, the market for COP systems and existing and developmental COP systems need to be understood in order to assess the potential for future application of COPE or COPE-based solutions. Annex 3 provides a preliminary survey of currently and developmental systems and areas of applicability. A detailed comparison requires a special research effort and would need further subsequent work to enhance the scope for applicability and the market for European COP systems.

At this stage COP developments mostly in the US are very advanced in terms of both, areas for possible applications and COP-relevant technologies. US drivers have been military requirements and the role of the DHL in the aftermath of 9-11 an in a technologically more complex environment. In addition to military COP systems, US COP capabilities have become expedient in areas like situation awareness, enhancing effectiveness of complex operations, ensuring the functionality of complex systems, enabling precision processes, enhancing planning and management of various resources and assets by partners in specified operations et al. Increasingly, application-specific COP systems are being introduced (e.g. for bio-surveillance).

A comparison of existing and developmental COP systems needs to review each system in terms of the purpose it is designed to meet and the complex systems into which given COP systems need to be integrated to help matching the respective challenges.

In Europe COP capabilities have primarily been developed and in part introduced to support fire brigades, police and other public services. Transferability of solutions as well as of application-specific systems is important to enhance COP solutions within the EU. The COPE project while confined to limitations of experiments was designed to help with both, European requirements to ensure future exploitation in an expanding European market, and eventually with generating competitiveness also in external markets. The list of criteria chosen for the evaluation of Systems-of-Systems should help guiding such efforts.

The COPE WP6 leader has performed a survey of 18 latest or current projects on Common Operational Picture development and implementation. It included 9 C2 systems using advanced COP technologies and 9 providers who offer COP solutions or major components. From this analysis and with the background knowledge of team members on Common Operational Picture requirements, programs, and use, we have developed a set of criteria which are of relevance for advanced COP systems.

5.4.2 The COPE & its COP in the global and future context

This chapter gives a summery on where the COPE results are ranging compared to the state of the art in common operational picture (COP) RTD .
The analysis is documented in Annex 3: COP State of the Art and Trend Analysis, and the list of criteria in Annex 4: COP Sate of the Art and Trend Criteria.

The criteria contain 3 major groups of generic criteria:

1. Requirements for a COP
2. Trends, primarily in ICT
3. Generic Measures of effectiveness for a COP

Altogether, a list of 72 criteria could be generated.

Of course the COPE solution cannot satisfy all of these criteria, advanced functions and technologies, respectively. Each COP system is limited to the set of tasks and services it is designed for and to the technologies the customer needs and is willing to pay for. The criteria in Annex 4 are therefore “generic” in a sense that they cover close to all characteristics of an aggregate of various COP systems.

This evaluation of COPE against this list, therefore, identifies which of the criteria have been strongly covered by COPE, which moderately covered by COPE, for which the COPE solutions offer further development potential, and which fell completely outside the scope o the COPE project.

This evaluation was done independently from the COPE trial. Nevertheless, there is a good coincidence between the state-of-the-art evaluation performed by the trial participants (Chapter 5.3.1) and this independent analysis. In table 7, the assessments in Annex 4 are added up. Of course this is only a very crude and generic summary because the different criteria will have different weightings in general and different importance in the specific application case.

Markings:
Strong representation in COPE: Was required according to COPE objectives
Partial representation in COPE: Was useful but not mandatory
Development potential: Was not required but can be implemented
Not addressed in COPE: Is out of scope of COPE

Class of criteria	Aggregated conclusions	Total Criteria	strong	part	pot	not
1. Key drivers of COP projects from a customer point of view	A large portion of important future characteristics of a COP have been implemented in COPE	47	18	11	11	11
2. Future trends	Many innovative technologies have been fully or partially	17	5	5	2	6

	implemented in COPE					
3. High level Measures of Effectiveness	The COPE solution satisfies most of the high-level MoEs which characterize modern C2/ COP systems	8	5	4	0	0
Total[6]		72	28	20	13	17

Table 7: State of the art summary

Nevertheless Table 7 shows a good summation of criteria and how they were met by COPE in the three categories above. It gives a good indication on where the COPE system stands in the realm of on-going COP developments and the state of the art reflected therein.

The summary gives a clear trend: The COPE project has met a large subset of these criteria, fully or partially (pink and green), and it offers the potential for further expansion of its functionality and / or use of advanced technologies (yellow). A reasonable subset of criteria lies out of scope of the project and were not addressed (grey).

As can be seen from this coverage in Annex 4, COPE represents a good standing compared to the global state of the art and trends. In addition, it should be seen that the main objective of COPE goes beyond the pure use of advanced technology. The most dominating issue of COPE according its mission is the combination and integration of various technologies in a system of system of COP information sources and sinks in a complex, multi- technology, multi-level and multi- service environment.

5.4.3 The prospects for exploiting the COPE System-of-Systems

The variety of advanced COP for security purposes has increased during the last 10 to 15 years and it is further evolving.

- authorities requiring COP capabilities
- providers of COP solutions
- purposes and functionalities of COP systems,
- special applications (MCOP, BCOP) etc.,
- types of structures of and access to COP information
- hierarchical and/or functional systems and architectures with critical COP components,
- types of information sources usable for COPs (geo spatial, environmental, biological, political, public, etc.),
- avenues for future advancements

And last but not least: The huge uncertainties of future threats to and vulnerabilities of human societies represent a continuous and growing challenge to technological and operational requirements and the flexibility of future COP solutions.

COP systems for fire fighting are among the more widely used applications.

[6] There are 6 double-counts from Annex 4 in the coloured columns

A comparison of existing and developmental COP systems needs to review a number of reference systems, above all in terms of the purpose they are individually designed for to meet, and the complexity of systems for coping with, this variety of future needs (see also and Annexes 3 and 4).

In this context comparing chosen technologies for realizing COP capabilities will be critical in view of the purpose of the COP system under consideration. This requires a case-by-case review that will above all need to be done by systems developers and producers.

Given this purpose-orientation for the comparison, two complementary assessments are important:

(1) the extensiveness of COP solutions, i.e. the transferability to other areas of application, and
(2) the scope for more user-specific applications and improvements.

This should direct efforts to assess the scope for further advancements of COP capabilities which will undoubtedly continue in both military and non-military areas of application. The COPE System-of-Systems should thus be evaluated in regard to the range of COP systems for fire-fighting, the transferability of COP solutions to other applications and the transferability of other COP solutions or solution components to advancements of the COPE System-of-Systems.

6 Conclusions

6.1 Conclusions concerning usability and acceptance

The results concerning the usability and acceptance of the COPE technology concept by the end-users were reported in the D2.3. The results indicate that it is possible to test the technology already in its concept phase and still gain important evidence of its quality. In this case, even though the implementation of the COPE technology was still in a demonstrator status, the end users were able to deliver important feed back to the design.

The verification evaluation that tested the fulfilment of the COPE applications of the certain tasks indicated that the requirements were fulfilled and the tasks to be accomplished could be fulfilled with the designed technology.

The validation evaluation reported the direct feedback but also focused on the potential of the CPE technology concept in the future emergency response work, especially concerning the added value for *Common Operational Picture.* In the evaluation process the researchers abstracted the three main *concept requirements* that could be seen to support COP. These features could be considered the innovative features of COPE concept:

- *Forming a model of the situation,*
- *Presenting a model of the situation* and
- *Sharing the model.*

These concept requirements should be supported by four *concept solutions* i.e.

- *Actors terminals for participation*
- *Sensors for extending human senses,*
- *Semantic information system for abstraction of relevant information and*
- *Availability of information in a gateway on WLAN*,

all equipped with several *functional solutions*. Claims concerning the functional solutions' ability to support concept requirements and work demands were formulated. These were tested with the evidence gained in the final trial and in two earlier large-scale trials.

On the bases of analysis of the evidence it may be concluded that concerning the above mentioned concept solutions positive evidence for capability and potentials was gained as follows:

- *Actors terminals for participation*: clearly positive evidence of the visual map presentation, partly positive with regard to managing tasks.
- *Sensors for extending humans senses*: clearly positive evidence with regard to camera solutions, chemical sensors, and locating objects and persons.
- *Semantic information system for abstraction of relevant information:* an innovative feature of the COPE technology concept but hidden from the end-users. The significance of this innovative feature for controlling of information flow and alarming in relevant situations were identified as relevant features. The concept appears to require more work to meet some context dependent information demands of the users.
- *Availability of information in a gateway on WLAN* also gained positive evidence concerning its potential. In particular, the users found the in-time presentation of information and retrieval of stored information very promising features.

Overall evidence supporting the potential of the concept came from the users in response to two questions:

- Do the emergency responders feel that their understanding of the emergency situation would improve if the COPE technology would be implemented, and
- Would the COPE solutions, if finalized, fit in their professional work?

All responders reacted positively to these questions, either strongly supporting or supporting the statements, i.e. **COP would improve, and COPE technology would fit into their professional use.**

6.2 Conclusions concerning performance of individual COPE sectors

6.2.1 The Command and Control and Decision Support System-C2 and CDS

The trial was the right basis for showing and validating the COPE achievements in the very complex and challenging scenario. Objective of the final COPE exercise was to show how the COPE technologies contribute to a COP. Purpose of the TTE was to show how CC2 and CDS can be used and how they contribute to improve the COP step by step. In the COPE trial the COP was limited mainly to an operational picture of fire brigade. Keeping that in mind, the final trial was a successful proof of the C2/COP concept, supported by numerous statistics on evaluation criteria and comments from participants given in discussions and in writing.

Full integration of the CDS, higher command level C2 applications and cross-agency support should be the top candidates for COPE-C2 improvement. Then a development status would be reached which allows support of coordination at international level.

6.2.2 First Responder System (FRS-C and FRS-HW)

From a technical perspective we know that the digital map with its dynamic overlays provides the first responder with an intuitive method of viewing the scene of an incident. It allows the user to view the state of hazards as well as the positions of personnel, resources and items of interest around the incident ground.

The significant benefit of the COPE system over other more independent systems is that the data is common across all sub-systems, i.e., the data that is viewed by the first responders comes from the same source as the data viewed by the IC. This makes understanding of the incident by all parties simpler, consistent and hence will increase efficiency.

The FRS performed reasonably well. Various comments by interested parties at the trials have helped to re-affirm a point that has been discussed regularly within the field of emergency response technology. Reliability and confidence are keys to the usefulness of the system. If the first responder using the FRS does not have confidence in the system then he/she will be very reluctant to use it. In order for the first responder to develop confidence in the system it must perform its designated functions reliably within the operating environments of the various incident grounds.

During the trials reliability was good, when considering the system as a technology concept demonstrator, however when considering it as a potential production system, more maturity, both for the hardware and software, is required. The Wi-Fi communications standard has proved very useful, from the perspective of the first responder, when the system is used outside of buildings. When the first responder was operating inside the building the Wi-Fi connection was lost very quickly. This is unacceptable for the FRS and an improved architecture for communicating with the COPE Gateway must be developed. This may involve using a different communications standard or may involve using mobile repeaters within the buildings or even hose mounted communications cabling etc.

6.2.3 Sensors/SIP

SIP taken together, and also the modules and components taken separately, have met the operational requirements established for such a system.

Because SIP offers real-time data about the position, identification, composition and actions of assets (human and material), the hazards, positions etc. can be measured in the area where a disaster occurs, Leading to benefits in management of the intervention actions, such as:

- management of the activities in real time;
- reducing the alerting and intervention time;
- reducing the means of intervention;
- reducing the human and material losses.

6.3 Conclusions concerning state of the art, research challenge and innovation.

6.3.1 Command and Control System

The project used the TSO (Tactical Situation Object), which was developed by the EU project OASIS and is subject to intended EU standardization. It provided the project with a process to follow for the development of the interfaces to the COPE Gateway. The COPE Gateway could be reached through the internet which enabled remote integration. This reduced the time needed for live integration and also reduced the integration risks.

As discussed in chapter 5.4.2 and Annex 4, the COPE system of systems and its components addressed, exploited and implemented a number of innovative concepts and technologies. Its focus according to the objectives, however, was not primarily on highly innovative technologies per se, although quite a selection could be shown. The core idea of COPE was to integrate the large set of different technologies in a way that all of them contribute to a powerful enhanced Common Operational Picture. In the other direction, most of the technologies, depending on their function, could also make use of information received from this COP.

There was a limited demonstration of cross-service C2 support capability by including – beside the main fire fighting environment – police, the dispatching centre and some simulated higher level command, the “Unified Command”.

6.3.2 First Responder System

Looking at the individual items that make up the FRS, the levels of state of the art and innovation were not required to be extremely high. Most of the equipment used in the FRS has been on the market in some fashion for a period of time. The innovation in COPE, according to its goal, becomes apparent when assessing how the different components of the FRS have been put together and used for the benefit of the first responder.

The HMD takes a low cost binocular display and mounts it in a convenient but discrete location where it is always visible to the first responder but does not impede his peripheral vision. This concept of an offset display means that useful information can complement the view from the user. The displayed data is not permanently in the users’ field of view, however it is there for the user to view when he or she wishes to view it without the need to move anything or interact other than just to look up.

The wrist-mounted display provides the user with a simple and intuitive touch screen display that allows the user to perform some very simple yet powerful functions by using one or two button presses. This architecture provides the user with a non-intrusive display system that requires minimal interaction and provides information to the user when he/she needs it.

The GPS-denied localisation demanded the most innovation within the FRS and provided the biggest research challenge. This is a technology that many different parties have tried to solve over the years with very little reliable success. The biggest issue with this type of inertial navigation is drift inherent in the inertial sensors. The trials did not really focus on this aspect of the system in enough detail to provide conclusive results as to how well this element of the system performed. But we do know that however well it did perform it will become more and more inaccurate over time. That means it must be re-aligned periodically. We believe that this can be achieved using data fusion from multiple sensors. E.g. human mounted range finders may be able to accurately determine a person's position when coupled with data from a vector map of the building interior.

The other major research challenge that has been started but still requires more effort is the challenge of providing reliable, high-bandwidth communications within a large building without requiring large amounts of expensive and unwieldy infrastructure.

6.3.3 Sensors

The sensor networks, developed for the COPE project, are seen as a new class of devices having the potential to revolutionize the capture, processing, and communication of critical data for use by first responders integrated sensor nodes and other wireless devices into a disaster response setting. This provides facilities for ad hoc network formation, resource naming and discovery, safety, and in-network aggregation of sensor-produced data. Additionally, a robust localization system would let rescuers determine their location and track victims even within a building.

6.4 Conclusions concerning maturity

6.4.1 C2 System

There is a market for applications like the C2 and there are already several applications available. To develop the COPE C2, although to a large extent based on COTS technologies, into a product would nevertheless require improvement in several areas. The most important are

- Software functionality – Further development and extension of the existing functions and services
- Robustness, usability etc. – Further development of the usability of the system including manuals and training
- Hardware – Investigate the possibility to use other hardware than a laptop for accessing the COPE C2

- Interfaces and interoperability – Develop interfaces to existing systems

6.4.2 First Responder System

The FRS was always intended to be a technology concept demonstrator and as such is a long way from being mature enough to be a marketable product. The FRS equates to Technology Readiness Level (TRL) 5 on the TRL scale (see Figure 20) where TRL9 is a marketable system.

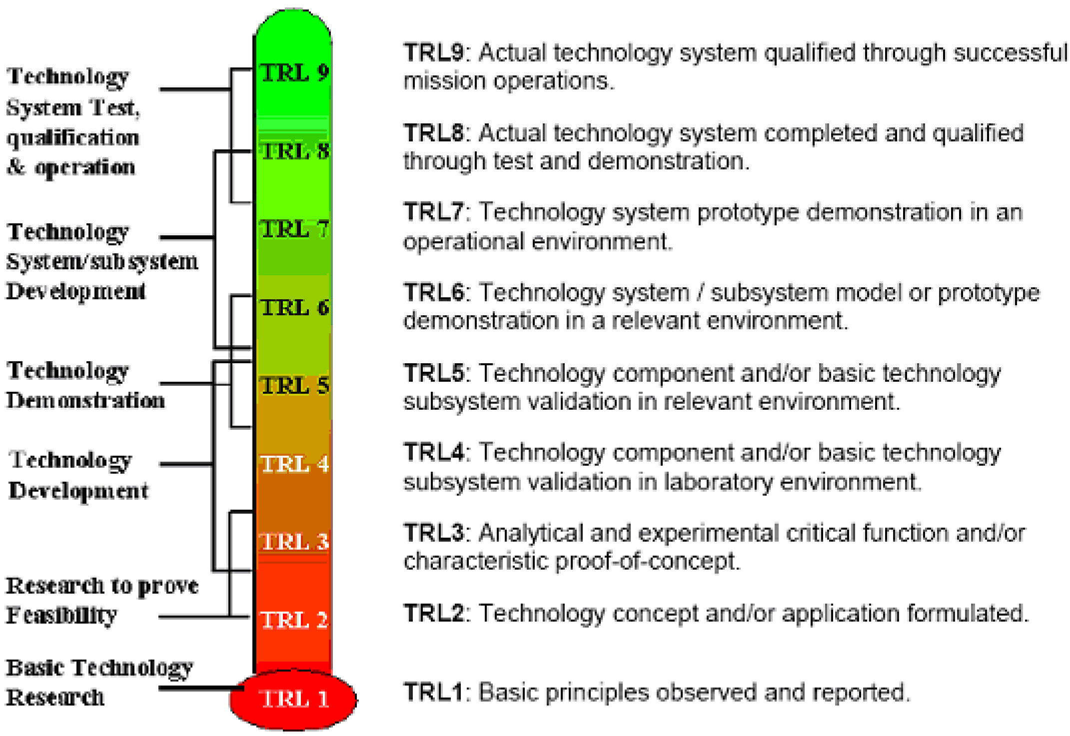


Figure 20: Technology Readiness Levels

To move the FRS forward towards being a marketable system the following tasks would need to be performed:

- Processing hardware would need to be designed to miniaturise the system and ruggedize it.
- The HMD would need to be re-packaged and ruggedized.
- The helmet-mounted sensors would need to be integrated within the fire fighter helmet.
- The system cabling would need to be integrated into the fire fighter clothing with the possible option of providing a wireless connection between the main processing unit and the helmet.
- Further design and user feedback iterations are required for the software applications.

The FRS does have some obvious dual use opportunities for dismounted soldiers on the military battlefield. With some modifications to the software applications the FRS could provide situational awareness to soldiers and commanders alike including functions such as blue force tracking etc.

6.4.3 Sensors/SIP

The COPE Sensor Integration Platform, with an easy deployable structure, and open to further development could be a starting point of a future EU “First Responders Support-Actions Network” that would gather at low costs regional flexible modular platforms.

Also, segments developed and designed in this project can be used in further RTD projects and they may directly be used in different disaster missions like determining positions, detecting hazardous gas, identifying persons and resources, monitoring systems movement, etc.

6.5 Conclusions concerning integration and interoperability

The COPE Gateway was implemented using a Service Oriented Architecture. During development the gateway could be reached and used remotely via the internet. This enabled all partners to perform the major part of the integration work at their own sites.

During the final trial the Gateway was hosted locally and was accessed on the local area network used during the trial.

From a functional and technical point of view, during the trial a high degree of integration between the C2 system, the decision support system CDS, the FR-HW wearable components, the sensors and their integration platform (SIP) and the underlying communication system could be achieved. Not everything cooperated to perfection in this complex environment of a large catastrophic scenario, in a partially live and partially simulated environment.

Better integration at some places of the COPE architecture might be advisable but the effort should only be invested if specific customer requirements profiles and the underlying market chances would justify.

6.6 Summarizing conclusions on the COPE project as a whole

Quoting the first sentence of the abstract of the Description of Work:

“The Common Operational Picture Exploitation (COPE) project will integrate COTS solutions and novel technologies to achieve a step change in information flow both from and to the first responder in order to increase situational awareness across agencies and at all levels of the command chain.”

This goal could be fully achieved by

- The identification evaluation/screening and selection of a set of different technologies adequate to this task
- The in-depth analysis of requirements for building the COPE innovative solutions,
- Several development activities in modifying and adapting the technologies for the purpose of COPE

- An intensive effort in regarding the Human Factors of the end-users in all processes of technology development and verification, and in trial exercise design and validation
- The integration of all components into a demonstrator “System of Systems” and the setup of a large scenario based mixed live and tabletop type trial exercise.

According to the judgement of the first responder end-users and external stakeholders, the system and its components worked to the satisfaction level “good” to “very good”. Some temporary failures and reductions in functionality were at a level usual for such a complex research project, and did not derogate the detailed and overall result as planned.

The COPE solutions form a basis for advanced COP solutions and its status of advancement can be compared to other highly advanced COP projects in the western world. Efficient use of the COPE results will require further customization efforts and intensive training of the end-users.

Annex 1: Questionnaire Template

Annex 2: Statistical Evaluation of filled Questionnaires

Annex 3: COP State of the Art and Trend Analysis

Annex 4: COP Sate of the Art and Trend Criteria

Annex 5: CDS Evaluation

Annex 6: The Scenario and TTE Script

Annex 1 to COPE D6.6

Trial Questionnaire Template

SEVENTH FRAMEWORK PROGRAMME

THEME 10: SECURITY

Common Operational Picture Exploitation

Questionnaire (double sided)

Please fill in your (Voluntary)
Name:
Country:
Organization:

Introduction:
The COPE System of Systems is composed of a large number of technologies which have been integrated technically to make them interoperable, and operational in order to contribute to a number of defined so called **COPE** operational **Applications**.
The total COPE evaluation process consists of a detailed Human Factors oriented evaluation of the individual components of COPE technology, and an **aggregated operational evaluation** of these applications **with this questionnaire**.

Each addressee is asked to answer the Questions below to the best possible.

1. The questionnaire consists of a **general** section on the overall trial organization and performance,
2. a section addressing the individual COPE "**applications**", and
3. Some questions concerning the possible **future** of the COPE results

Summary Description of the COPE applications:

Ref No.	COPE Application	Main Application Functions
	On Sector Command level, the SC can use the so called FRS-C with the:	*Acronyms: SC= Sector Commander* *FRS-C= First Responder System Control*
1.	**FRS-C Map function** showing functional and/ or geographical sectors, areas of interest, items of interest etc. (not used in tabletop exercise)	• Location of people and assets • Send info to FRs • Receive Information from FRs • Monitor & control Sensor deployment • Send information to COPE-C2 (e.g current location of resources
	On Incident Command level, the IC is supported by several	*Acronyms: IC= Incident Command* *C2= command and Control* *FF=firefighter*

	applications of the so called COPE C2:	*COP= Common Operational Picture*
2.	**C2 Draw** for generating symbols, items of interest, areas etc.	• Use drawing technology (pen; touchscreen) • Generate drawings information • Communicate to relevant users
3.	**C2 Tasking** for creation, assignment and acknowledgement of tasks	• Identify data required for tasking function • Develop tasking options • Communicate tasking decisions to the SCs • SC to give orders to frontline FFs
4.	**C2 Functional Sector Map** for creation and assignment of operational sectors	• Identify critical areas and/ or functions • Generate operational sectors; display sectors • Communicate to relevant users, esp. SCs
5.	**C2 Map** as the common reference to display the Common Operational Picture (COP) and perform planning and distribution tasks	• Provide the basic map information • Update changes • Display the Common Operational Picture (COP)
	Further, mainly on IC level, the ***Cope Decision Support System*** can be used, with its functions	*Acronyms:* *HAZMat= Hazardous Material*
6.	**Risk Analysis**, based on a manual risk card system used by UK FFs, and automated for COPE	• Select objects at risk (e.g. shortage of resources; level of threat; Risks to FRs) • Identify data for risk assessment • Apply "Risk Card" logic • Evaluate risk result • communicate to IC (and possibly other users)
7.	**HAZMat: Cloud Estimation**, display and decision support concerning HZMAT (Also named **IAMA**= incident area map analysis)	• Receive sensor data • Identify HazMat area/ event • Request cloud estimation from cloud estimation software • Visualize cloud as estimated • Communicate to C2/ IC (and possibly other users)
?	**Other:**	•

Rating: We use a general rating scheme (points) to be assigned by you to the individual subjects in question:

1= failed or very low performance,
2=fair
3=good
4=very good
5= Excellent,

Please also fill the fields in the tables where you are asked for **free text/ Remarks** information. Please use clear handwriting.

1. COPE trail organization and general assessment

1.1. How was the overall organization of the COPE trial

Evaluation of the overall Trial - Event?							
Your Rating	**Failed**	**1**	**2**	**3**	**4**	**5**	**Excellent**
Preparation, accommodation, logistics processes		☐	☐	☐	☐	☐	
Quality and understanding of the presentations		☐	☐	☐	☐	☐	
Time Schedule		☐	☐	☐	☐	☐	
Demonstration Equipment and presentation facilities		☐	☐	☐	☐	☐	
Trial Event Premises		☐	☐	☐	☐	☐	
Technical excellence of the whole setup		☐	☐	☐	☐	☐	
General performance of tools		☐	☐	☐	☐	☐	
Performance of team		☐	☐	☐	☐	☐	
Other?		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
What did you like most? What did you miss?							

1.2. Were the participants well introduced/ trained into the overall COPE trial session

Failed	**1**	**2**	**3**	**4**	**5**	**Excellent**
	☐	☐	☐	☐	☐	
Remarks						

1.3. Was the description of the system application clear and easily understandable?

Failed	1	2	3	4	5	Excellent
	☐	☐	☐	☐	☐	
Remarks						

1.4. Was the COPE trial setup clear and adequate to the COPE objectives as described?

Failed	1	2	3	4	5	Excellent
	☐	☐	☐	☐	☐	
Remarks						

1.5. Please give an overall rating of the functionalities/applications of the COPE system you were able to work with or watch (an evaluation by components will follow in part 2.)

Your Rating	**Failed 1**	**2**	**3**	**4**	**5 Excellent**
1.FRS-C Map	☐	☐	☐	☐	☐
2.C2-Draw	☐	☐	☐	☐	☐
3.C2 Tasking	☐	☐	☐	☐	☐
4.C2 Functional Sector Map	☐	☐	☐	☐	☐
5.C2- General Map; COP Quality	☐	☐	☐	☐	☐
6.CDS- Risk Assessment	☐	☐	☐	☐	☐
7. HAZMAT-Cloud estimation	☐	☐	☐	☐	☐
Others functions I have identified (please name)	☐	☐	☐	☐	☐

1.6. How do you rate the overall characteristics of the COPE System as you have seen them?

Evaluation of the overall quality of the COPE solutions							
Your Rating	**Failed**	**1**	**2**	**3**	**4**	**5**	**Excellent**
Degree of technical innovation		☐	☐	☐	☐	☐	
Degree of operational/ functional innovation		☐	☐	☐	☐	☐	
Quality of implementation		☐	☐	☐	☐	☐	
Interoperation/ cooperation of components		☐	☐	☐	☐	☐	
Maturity of the COPE system		☐	☐	☐	☐	☐	
Ease of use		☐	☐	☐	☐	☐	
Other?		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
Please name the **most** convincing COPE tool/technology/function							
Please name the **least** convincing COPE tool/technology/function							

2. Evaluation of individual COPE – Applications / Functions

Please **tick** one **COPE application** you evaluate in the following table.
You can also combine (mark) 2 applications which you think belong closely together. There is one sheet for each individual application you want to evaluate.
If you need more sheets, please ask the COPE team.
Please number your sheets in the top line.

2.1. Individual COPE- Application evaluation sheet No. ____ of___

Please tick in column 1 the one (or two) applications you evaluate here

Your tick	Ref.No. to chpt.1.	COPE Applications
		Sector Commander support (SC)
	1.	**Map function** showing functional and/ or geographical sectors, areas of interest, items of interest etc.
	?	**Other SC**-support (please specify)
		Incident Commander support (IC)
	2	**C2 draw** for generating symbols, items of interest, areas etc
	3.	**C2 Tasking** for creation, assignment and acknowledgement of tasks
	4.	**C2 functional** sector map
	5.	**C2 map** as the common reference to display the Common Operational Picture (**COP**) and perform planning and distribution tasks
	?	**Other C2-IC**-support you realized; please specify
		COPE Decision Support System (CDS)
	6.	**Risk analysis**, based on a manual risk card system used by UK FFs, and automated for COPE
	7.	**HAZMat: Cloud estimation**, display and decision support concerning HAZMAT

Operational evaluation of the individual COPE solution/application

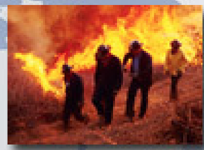
Your Rating: The COPE application solution improved	**Failed**	**1**	**2**	**3**	**4**	**5**	**Excellent**
Raising of awareness and understanding of situation		☐	☐	☐	☐	☐	
Acceleration of processes/decisions		☐	☐	☐	☐	☐	
The quality of disaster managem't processes/decisions		☐	☐	☐	☐	☐	
Intensity of use (permanently, sporadically, seldom, not?)		☐	☐	☐	☐	☐	
Communication and cooperation		☐	☐	☐	☐	☐	
Usability and ease of understanding		☐	☐	☐	☐	☐	
Other qualities realized, please name:		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	

Please describe the main positive feature(s)

Please describe essential failures & drawbacks

Where do you see best improvement potential



2.2. Individual COPE- Application evaluation sheet No. ____ of___

Please tick in column 1 the one (or two) applications you evaluate here

Your tick	Ref.No. to chpt.1.	COPE Applications
		Sector Commander support (SC)
	1.	**Map function** showing functional and/ or geographical sectors, areas of interest, items of interest etc.
	?	**Other SC**-support (please specify)
		Incident Commander support (IC)
	2	**C2 draw** for generating symbols, items of interest, areas etc
	3.	**C2 Tasking** for creation, assignment and acknowledgement of tasks
	4.	**C2 functional** sector map
	5.	**C2 map** as the common reference to display the Common Operational Picture (**COP**) and perform planning and distribution tasks
	?	**Other C2-IC**-support you realized; please specify
		COPE Decision Support System (CDS)
	6.	**Risk analysis**, based on a manual risk card system used by UK FFs, and automated for COPE
	7.	**HAZMat: Cloud estimation**, display and decision support concerning HAZMAT

Operational evaluation of the individual COPE solution/application

Your Rating: The COPE application solution improved	**Failed**	**1**	**2**	**3**	**4**	**5**	**Excellent**
Raising of awareness and understanding of situation		☐	☐	☐	☐	☐	
Acceleration of processes/decisions		☐	☐	☐	☐	☐	
The quality of disaster managem't processes/decisions		☐	☐	☐	☐	☐	
Intensity of use (permanently, sporadically, seldom, not?)		☐	☐	☐	☐	☐	
Communication and cooperation		☐	☐	☐	☐	☐	
Usability and ease of understanding		☐	☐	☐	☐	☐	
Other qualities realized, please name:		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	

Please describe the main positive feature(s)

Please describe essential failures & drawbacks

Where do you see best improvement potential

2.3. Individual COPE- Application evaluation sheet No. ____ of___

Please tick in column 1 the one (or two) applications you evaluate here

Your tick	Ref.No. to chpt.1.	COPE Applications
		Sector Commander support (SC)
	1.	**Map function** showing functional and/ or geographical sectors, areas of interest, items of interest etc.
	?	**Other SC**-support (please specify)
		Incident Commander support (IC)
	2	**C2 draw** for generating symbols, items of interest, areas etc
	3.	**C2 Tasking** for creation, assignment and acknowledgement of tasks
	4.	**C2 functional** sector map
	5.	**C2 map** as the common reference to display the Common Operational Picture (**COP**) and perform planning and distribution tasks
	?	**Other C2-IC**-support you realized; please specify
		COPE Decision Support System (CDS)
	6.	**Risk analysis**, based on a manual risk card system used by UK FFs, and automated for COPE
	7.	**HAZMat: Cloud estimation**, display and decision support concerning HAZMAT

Operational evaluation of the individual COPE solution/application

Your Rating: The COPE application solution improved	**Failed**	**1**	**2**	**3**	**4**	**5**	**Excellent**
Raising of awareness and understanding of situation		☐	☐	☐	☐	☐	
Acceleration of processes/decisions		☐	☐	☐	☐	☐	
The quality of disaster managem't processes/decisions		☐	☐	☐	☐	☐	
Intensity of use (permanently, sporadically, seldom, not?)		☐	☐	☐	☐	☐	
Communication and cooperation		☐	☐	☐	☐	☐	
Usability and ease of understanding		☐	☐	☐	☐	☐	
Other qualities realized, please name:		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	

Please describe the main positive feature(s)

Please describe essential failures & drawbacks

Where do you see best improvement potential

2.4. If you want to evaluate more individual applications, please ask for additional evaluation sheets

3. Outlook & Chances

3.1. How do you assess the chances to bring COPE products to market/into operation? Please name promising components and reasons

3.2. Where would you concentrate further R&D resources to improve market/ acceptance chances?

3.3. Could you/ would you support follow-up action of future use? How?

3.4. Your final Remarks/ Comments

3.5. Have your expectations been satisfied?

Your Rating	Not at all	1	2	3	4	5	absolutely
Satisfaction of expectations in summary		☐	☐	☐	☐	☐	
Remarks:							



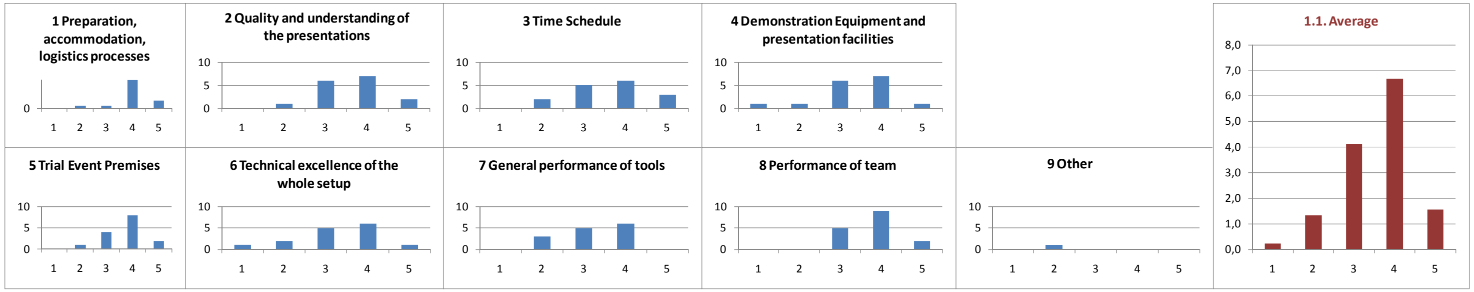

Room for Comments

!! Thank you very much for your cooperation !!

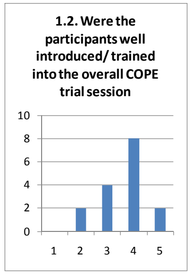
Annex 2 to COPE D6.6

Trial Qiesitionnaires and statistical Evaluation

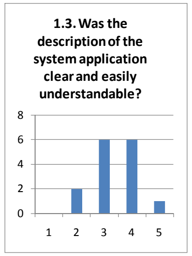
1.1.	How was the over	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Preparation, accon	0	1	1	11	3	16	4,0
2	Quality and unders	0	1	6	7	2	16	3,6
3	Time Schedule	0	2	5	6	3	16	3,6
4	Demonstration Eq	1	1	6	7	1	16	3,4
5	Trial Event Premise	0	1	4	8	2	15	3,7
6	Technical excellen	1	2	5	6	1	15	3,3
7	General performar	0	3	5	6	0	14	3,2
8	Performance of te	0	0	5	9	2	16	3,8
9	Other	0	1	0	0	0	1	2,0
10		0	0	0	0	0	0	-
	Sum	2	12	37	60	14	125	**3,6**
	Avg.	0,2	1,3	4,1	6,7	1,6		3,6



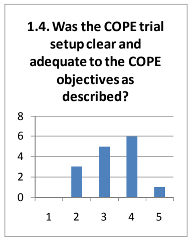
1.2.	Were the participants well introduced/ trained into the overall COPE trial session	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
		0	2	4	8	2	16	3,6



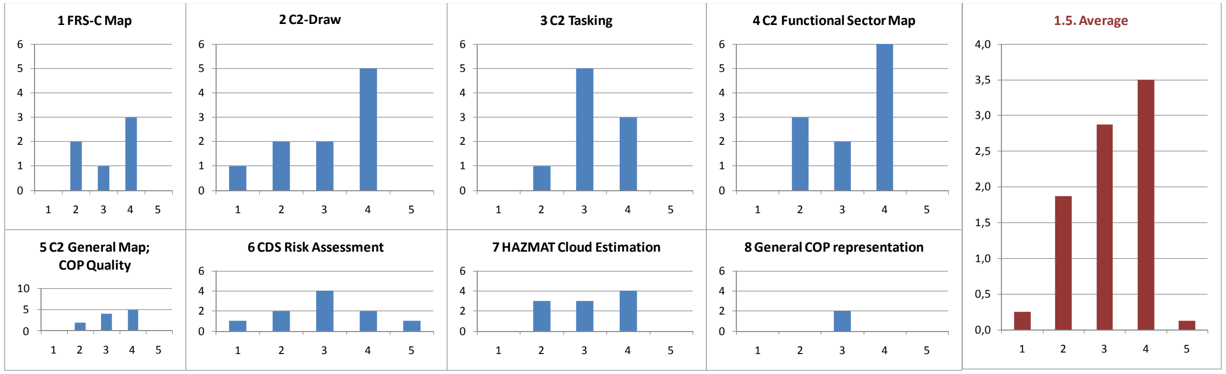
1.3.	Was the description of the system application clear and easily understandable?	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
		0	2	6	6	1	15	3,4



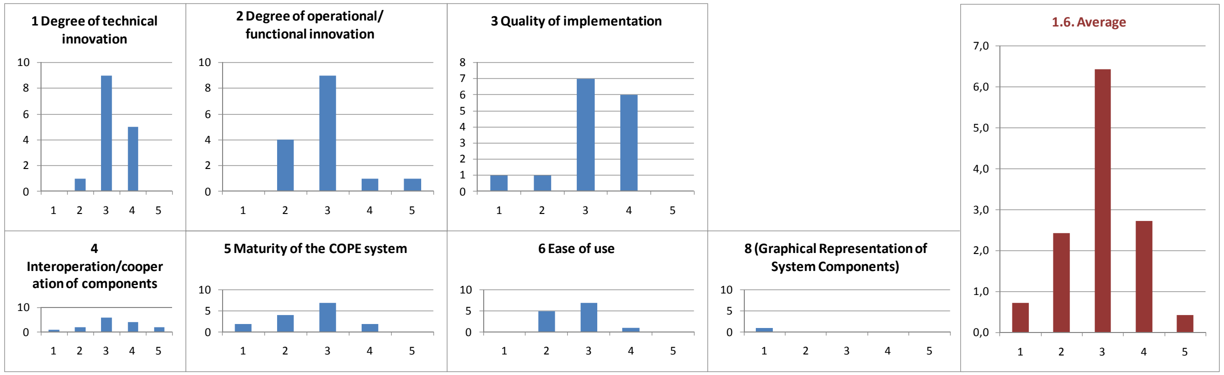
1.4.	Was the COPE trial setup clear and adequate to the COPE objectives as described?	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
		0	3	5	6	1	15	3,3



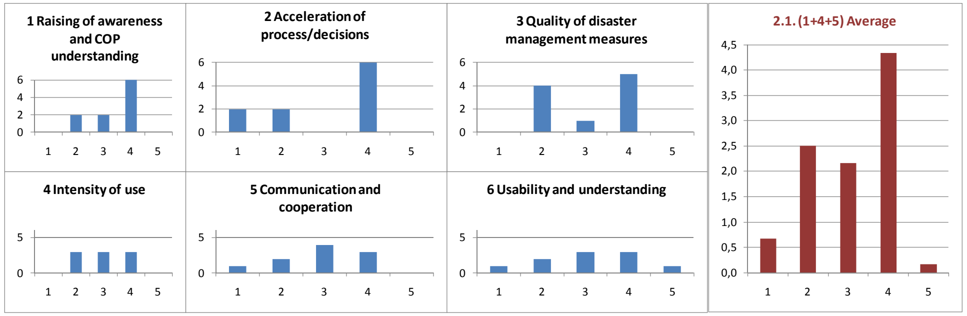
1.5.	**Please give an overall rating of the functionalities/applications of the COPE system**	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	FRS-C Map	0	2	1	3	0	6	3,2
2	C2-Draw	1	2	2	5	0	10	3,1
3	C2 Tasking	0	1	5	3	0	9	3,2
4	C2 Functional Sect	0	3	2	6	0	11	3,3
5	C2 General Map; C	0	2	4	5	0	11	3,3
6	CDS Risk Assessme	1	2	4	2	1	10	3,0
7	HAZMAT Cloud Est	0	3	3	4	0	10	3,1
8	General COP repre	0	0	2	0	0	2	3,0
	Sum	2	15	23	28	1	69	**3,2**
	Avg.	0,3	1,9	2,9	3,5	0,1		3,2



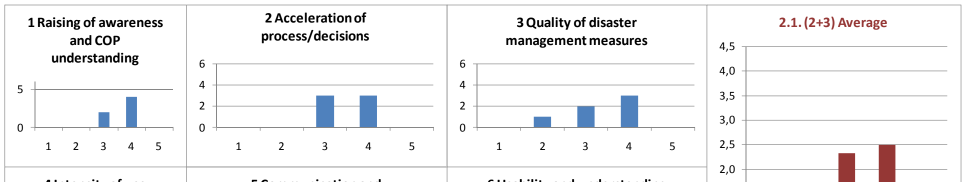
1.6.	**How do you rate the overall characteristics of the COPE System as you have seen them?**	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Degree of technica	0	1	9	5	0	15	3,3
2	Degree of operatio	0	4	9	1	1	15	2,9
3	Quality of impleme	1	1	7	6	0	15	3,2
4	Interoperation/coo	1	2	6	4	2	15	3,3
5	Maturity of the CO	2	4	7	2	0	15	2,6
6	Ease of use	0	5	7	1	0	13	2,7
7	Other	0	0	0	0	0	0	-
8	(Graphical Represe	1	0	0	0	0	1	1,0
	Sum	5	17	45	19	3	89	**3,0**
	Avg.	0,7	2,4	6,4	2,7	0,4		3,0



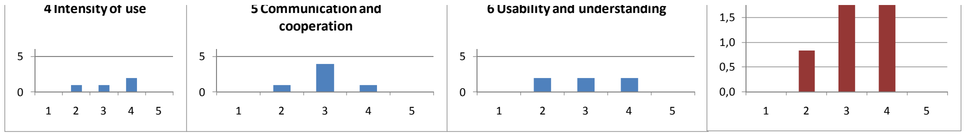
2.1.a	**COPE Applications Sector/Incident Commander support**	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Raising of awarene	0	2	2	6	0	10	3,4
2	Acceleration of pro	2	2	0	6	0	10	3,0
3	Quality of disaster	0	4	1	5	0	10	3,1
4	Intensity of use	0	3	3	3	0	9	3,0
5	Communication an	1	2	4	3	0	10	2,9
6	Usability and unde	1	2	3	3	1	10	3,1
7		0	0	0	0	0	0	-
8		0	0	0	0	0	0	-
	Sum	4	15	13	26	1	59	**3,1**
	Avg.	0,7	2,5	2,2	4,3	0,2		3,1



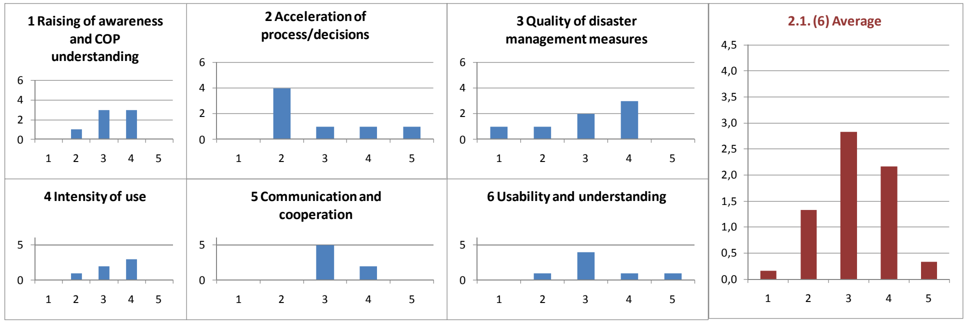
2.1.b	**COPE Applications / Incident**	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Raising of awarene	0	0	2	4	0	6	3,7
2	Acceleration of pro	0	0	3	3	0	6	3,5
3	Quality of disaster	0	1	2	3	0	6	3,3
4	Intensity of use	0	1	1	2	0	4	3,3
5	Communication an	0	1	4	1	0	6	3,0



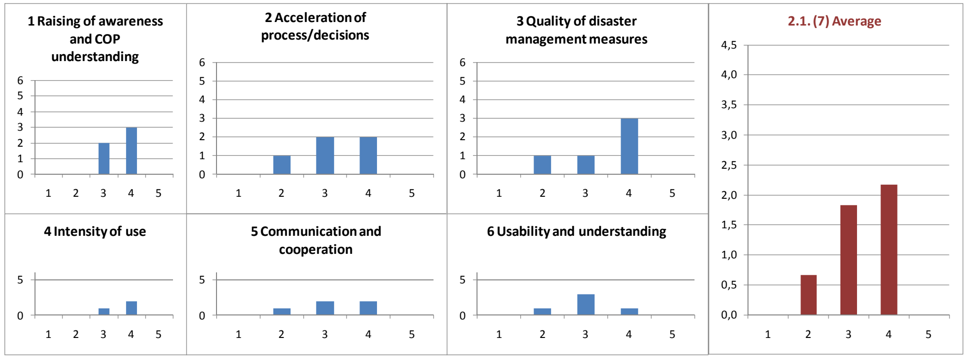
		1	2	3	4	5	Ticks	Avg.
6	Usability and unde	0	2	2	2	0	6	3,0
7		0	0	0	0	0	0	-
8		0	0	0	0	0	0	-
	Sum	0	5	14	15	0	34	**3,3**
	Avg.	0,0	0,8	2,3	2,5	0,0		3,3



2.1.c	COPE Decision Support System 6, Risk analysis	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Raising of awarene	0	1	3	3	0	7	3,3
2	Acceleration of pro	0	4	1	1	1	7	2,9
3	Quality of disaster	1	1	2	3	0	7	3,0
4	Intensity of use	0	1	2	3	0	6	3,3
5	Communication ar	0	0	5	2	0	7	3,3
6	Usability and unde	0	1	4	1	1	7	3,3
7		0	0	0	0	0	0	-
8		0	0	0	0	0	0	-
	Sum	1	8	17	13	2	41	**3,2**
	Avg.	0,2	1,3	2,8	2,2	0,3		3,2



2.1.d	COPE Decision Support System 7, HAZMat: Cloud estimation	Failed				Excellent	Ticks	Avg.
		1	2	3	4	5		
1	Raising of awarene	0	0	2	3	0	5	3,6
2	Acceleration of pro	0	1	2	2	0	5	3,2
3	Quality of disaster	0	1	1	3	0	5	3,4
4	Intensity of use	0	0	1	2	0	3	3,7
5	Communication ar	0	1	2	2	0	5	3,2
6	Usability and unde	0	1	3	1	0	5	3,0
7		0	0	0	0	0	0	-
8		0	0	0	0	0	0	-
	Sum	0	4	11	13	0	28	**3,3**
	Avg.	0,0	0,7	1,8	2,2	0,0		3,3



3.5.	Have you expectations been satisfied?	Not at all				absolutely	Ticks	Avg.
		1	2	3	4	5		
		0	0	3	10	1	14	3,9

Annex 3 to COPE D6.6

Survey of the state-of-the-art and advanced COP projects

1. Prerequisites for the evaluation of the COPE System-of-Systems

The purpose of the COPE Project is to develop an advanced common operational picture capability (COP) and to realize the associated information flow from and to advanced technologies and person actors and to integrate the components into a “System-of-Systems”. The main goal was to demonstrate these COP capabilities and to evaluate them in an operational environment.
This evaluation will be undertaken on the basis of an experiment and a TTE which will consider the results in a more complex scenario. It will be done by COPE participants and invited guests not involved in the preceding RTD process. An essential part of the project is to assess the possible exploitation of the COPE product. Given the limitations of the operational environment, this will require a methodology which will still suffice to identify applicabilities of the COPE product.

To help preparing the final operational evaluation three preparatory steps are important:

- The selection of evaluation criteria for COP products, that are particularly relevant for assessing the functionality and applicability of the COPE System-of Systems. Criteria will be chosen to assess the effectiveness of the COPE product in an operational environment compared to the effectiveness in case of an operational picture used by the same actors in the same scenario, but without the technologies (WSN technologies) used in COPE (i.e. through parallel augmented exercises/PAE).
- A review of the COPE process, i.e. the RTD process, w.r.t. special conditions, changed testing goals, employed technologies, failures and/or missed opportunities resulting from the reduced scope ot the experiment, consequences for future applicability, need for subsequent work etc.
- A survey of relevant COP developments and applications to allow comparisons of COPE System-of-Systems with available or developmental advanced systems and with requirements for advanced COP systems and most successful applications. To that end a variety of existing COP systems with a variety of applications and operational environments will be enlisted and briefly discussed.

2. Survey of COP developments and applications

2.1 Definition of COP capabilities

COP capabilities are information management tools that have been in use for the last but 20 years in a widening range of military and increasingly also non-military applications. They can be critically important whenever a common display of information is needed by several independent actors, e.g. headquarters, to achieve a specified common result.

Conventional operational pictures typically fail to provide sufficient information that allows needed timeliness and coordination of responses, identical or at least comparable information and its shared availability and visualization, precision of data that serve to shape decisions and interactions aiming at common objectives. Such capabilities may not always be critically needed. But the criticality of such requirements, i.e. the comprehensive and possibly differentiated release of integrated information, is rapidly increasing. Timely, precise, comprehensive, continuous information available to independent actors seeking to achieve common results are increasingly critical for the effectiveness of systems and operations thus widening the scope of systems functionalities and of effective complex operations (e.g. coalitions operations), but also increasing their IT dependence and vulnerability.

Definitions of COP systems vary. We use the following: COP systems are designed to provide a common display of information from different sources to a set of independent actors to enhance the chances for timely and/or effective coordination and responses to achieve specified common outcomes.

2.2 Applicability of COP Systems

COP requirements are least demanding and the easiest to meet in the least challenging circumstances (low level, limited escalatory potential etc). Given the relatively simple structure of the COPE trial case and the emphasis on exploitation and thus applicability, the conditions for transferability of COPE solutions will need special attention. The key question will be where COP capabilities could make critical differences, and, w.r.t. the COPE System-of-Systems, whether it will be needed or least be applicable in effective and cost-effective ways.

Areas where COP capabilities have been successfully applied are e.g.

- enhancing situation awareness in civilian or military conditions;
- enhancing the effectiveness of complex operations like military multi-service-and/or coalitions, search- and rescue operations, maritime emergency management (e.g. maritime emergency management), resource management, personnel and asset management under crisis conditions.
- ensuring the functionality of complex systems, through continuous up-dating and surveillance, e.g. of airport operations like for O'Hare/Chicago, (through Intergraph), of metropolitan railway systems like the Washington Metro, Los Angeles Regional Railway, the Ansaldo Chicago Railways, of air-traffic control, custom control and border protection (CBP), etc.;
- enabling required precision in processes, e.g. for the production of A 350 Airbus where 3-D models in various and disparate production sites configure elements from more than 90 suppliers in view of extreme demands for precision;
- Enhancing the planning and conduct of managing manpower resources, capabilities, logistics, financial assets etc. by partners involved in possible specified common operations.

- The first two – enhancing situation awareness and the effectiveness of operations – were the first areas for COP applications.

2.3 Advanced military COP Systems

In retrospect the lack of COP capabilities has initially been evident in military campaigns, i.p. during Desert Storm when not only allies, but also US military services and forces involved were unable to communicate, i.p. on the basic of shared information, i.p. common operational pictures. Since then COP capabilities for military applications to improve interoperability and to allow force integration and joint and combined operations became a prime objective for defence planning, i.p. in the US. But the further development of COP capabilities for military applications continues along with both changing and increasingly demanding military requirements and newly available technologies.

Three key criteria dominate these developments:

- dynamicity in view of escalatory potentials of crisis situations, needs for mobility etc.;
- complexity in view of requirements for multi-level, multi-service, multi-nation-, multi-jurisdiction etc. coordination of activities (above all responses);
- uncertainty in view of increasingly blurred dividing lines and distinction and the increasing involvement of new types of actors/opponents.

Advancement of military COP capabilities are above all driven by these three criteria (see Annex 1). Obviously the more the three key criteria – dynamicity, complexity and uncertainty – apply, the more the need for COP capabilities will increase.

2.4 Development of COP Systems for civilian applications

The increasingly blurred distinctions between defence and homeland security and the impact of 9-11 and Katrina have accelerated the development of COP capabilities for non-military security objectives. Specific security requirements have developed that required specific COP developments. They typically differ from military COP applications in several ways:

- They are aiming at coping with critical conditions rather than with deciding competitive situations with hostile, non-cooperative opponents.
- Their risk-exposure differs from military situations in that military opponents would tend to blind or disable own capabilities or at least to interfere. While this could become increasingly relevant also for homeland security along with new typical vulnerabilities of non-military COP capabilities, this is not yet a dominant consideration.
- In complex future conflict situations involving military and non-military needs for responses requirements for COP would tend to become more demanding still since mixed COPs would be needed by a wider range of authorities (see e.g. the OASIS COP System-of-Systems, annex 2).

COP developments will thusrequire continued developments. The most demanding conditions arise with the need for high-level involvement. In the aftermath of 9-11 and Katrina the US is most advanced with the establishment of the DHS's National Operations Center (NOC) where COP capabilities were introduced more systematically in 2006 as a situational awareness tool for strategic, operational and tactical purposes.

2.5 Advancement of US COP Systems: DHS as driver

In Spring of 2009 the DHS invited US industry to propose more advanced COP capabilities: "second generation COP". DHS is increasingly working with other agencies in areas like geospatial information, federated search engines, service-oriented architecture etc. Current COP developments by DHS aim at a capacity to determine the kind of information needed. Upgraded COP capability will include advanced visualization of data and analysis from multiple intelligence sources, faster fusion of information and better interfaces with legacy networks and databases. It will be designed to meet also the needs of state and local authorities that share information with DHS – mostly through a nation-wide network of intelligence fusion centres. This is expected to not only improve decision-making, but also the willingness and preparedness of other agencies to cooperate (see Henry McDavid, Chief Information Officer, DHS Office of Operation Coordination and Planning, CDW-G March 6, 2009).

2.6 European state-of-the art

Within the European Union no comparable system like the DHS-NOC exists so far that combines top-down- and bottom-up requirements and capabilities for COP on all levels, and it will take developments for which at this stage essential preconditions are missing. On the other hand, IT-dependent capabilities could ease bypassing subsidiarity requirements if governments agree to do so.

In this vein it is doubly important to develop COP capabilities for local and wider regional requirements across a widening range of areas: The need exists on the spot in view of possible contingencies, e.g. fire or industrial disasters, and in many instances the escalatory potential, the cross-border effects, the possible spill-overs into other service sectors etc. render bottom-up capabilities ever more desirable, if not necessary.

The extent of Australian fires (2009) and Russian (2010) may exceed likely contingencies within the EU, but fire-fighting in EU Europe should be seen not only in terms of local, but also of wider regional, state, national and even EU-wide responsibilities and requirements.

2.7 International market for COP Systems

By now an international market for COP capabilities has developed driven primarily in view of widening applications to public services, i.p. lower-level needs, and wider ranges of areas of applicability. This is again most advanced within the US. Some specific COP capabilities are confined to US users, but a widening range of systems and operations in public services has come into use also in Europe and Asia.

In Spring 2009 the DHS initiated several requests for information (RFI) for upgrading the COP capabilities activated in 2006 to make the DHS NOC more accessible to state and local authorities and to eventually build a second-generation COP capability that allows for improved visualization and increased users (see Original Synopsis March 30, 2009, Solicitation Number ROOP-09-000003, on requirements and constraints). Customs and Border Protection (CBP) issued an RFI to determine whether market research can provide available or developmental open architectures solution for CBC COP/C2 capabilities. The attached DHS Exhibit 300 Public Release for COP displays how elaborate the procurement process has become (Annex 4). In January 2010 DHS conducted a comprehensive program review of the NOC COP program to reduce risks associated with the current model. Development of a solution which allows for continuously refining requirements is the intended success.

In addition to continuous improvements of military COP capabilities, e.g. a Mobility COP (see Annex 5), user- and application-specific COP capabilities are being developed, e.g. a bio-surveillance COP developed for DHS National Bio-surveillance Integration Center (FAZD Center, 2010) for assessing biological events at national and global scales on a real-time basis.

In recent years state and local authorities in the US and elsewhere are also activating own COP capabilities with or without links to the NOC. See the FEMA list:

Typical users on state and/or local levels are airports (e.g. O'Hare) authorities, municipal railway systems (e.g. in Chicago or Los Angeles), large commercial facilities (e.g. Exxon- or Dupont-sized firms), shipyards, and by now widely available fire-brigades. Reinforced by 9-11 and Katrina a number of major companies have produced a variety of COP capabilities. These are some of the most successful and/or promising COP systems:

- <u>Command Support System</u> (Vector Command), specialized on exercising and with specified applications for fire brigades and partner services (police, ambulance, hospitals) by (1) Berkshire Fire and Rescue, (2) South Yorkshire Fire and Rescue, (3) London Fire Brigade (by far the largest with stations) and (4) South Australian Metropolitan Fire Service. One important characteristic of these capabilities is that they are intended for use in major catastrophes. COP capabilities are an essential element of the Command Support System (see Annex 5).
- <u>OASIS</u> (BAE Systems Advanced Technology Center), developed within the EU FP 6 program, intended to allow military/civilian information-sharing between UK Fire, policy and ambulance services (see Annex 2).

- Intergraph Solutions, integrated solutions available for both critical infrastructure protection (O'Hare Airport, German Federal Police, Washington Metro, Calgary Tri-Services, Melbourne Emergency Services etc.) and emergency responses: computer-aided emergency dispatch enabling new levels of efficiency in communication between police, fire, and emergency and security forces.
- Public Safety Resource Center COP Template (ESRI), geo-processing tool, allows e.g. to include current wind directions.
- LuciadMap ™, provides the framework and functionalities for achieving high situational awareness applications in aviation (see Annex 7).
- Life Ring, supports first responders, fire-fighters, police and military commanders. Newest version of Life Rings SuperCOP ™ capabilities is ResQdraw, a command-and rescue GPS screen-drawing function currently used by the US Cost Guard and US Navy, incorporated into a mobile collaboration COP software (see Annex 8).
- Pace, a COP application consisting of three types of modules: information gathering sources and reporting to a C2 module that allows decisions based on from those sources and autonomous peers, and display units at the emergency location. Special attention is given to trust management (see Annex 9).
- ESRI Situational Awareness, seeks to integrate existing GIS and IT infrastructures to provide COPs across multiple organizations.
- Bio-surveillance COP (BCOP), for assessment of biological events at national and global scales on real-time basis, primarily for supporting analysis and presentation to higher-level decision-makers (see Annex 10).

2.8 The prospects for exploiting the COPE System-of-Systems

At this stage an increasing variety exists of

- authorities and companies providing and requiring COP capabilities
- purposes and functionalities of COP systems,
- special applications (MCOP, BCOP) etc.,
- types of access (incl. user-specific COP capabilities),
- hierarchical and/or functional systems with critical COP components,
- types of information sources (geo spatial, biological etc.),
- avenues for future advancements

COP systems for fire fighting are among the more widely used applications.

A comparison of existing and developmental COP systems needs to review each system above all in terms of the purpose it is designed to meet and the complex systems for coping with a challenge into which given COP systems need to be integrated to help matching the challenge.

In this context comparing chosen technologies for realizing COP capabilities will be critical in view of the purpose of the COP system under consideration. This requires a case-by-case review that will above all need to be done by systems developers and producers.

Given this purpose-orientation for the comparison, two complementary assessments are important: (1) the extensiveness of COP solutions, i.e. the transferability to other areas of application, and (2) the scope for more user-specific applications and improvements.

This should direct efforts to assess the scope for further advancements of COP capabilities which will undoubtedly continue in both military and non-military areas of application. The COPE System-of-Systems should thus be evaluated in regard to the range of COP systems for fire-fighting, the transferability of COP solutions to other applications and the transferability of other COP solutions for fire-fighting to advancements of the COPE System-of-Systems.

The following matrix which relates a selection of existing and developmental COP systems and capacities should help achieving this task of the COPE Project.

Annex 4 to COPE D 6.6

State of the Art and Trends in Common Operational Picture Development

- Basis for a generic COPE-COP evaluation –

-

Definition from COPE D6.1

Common Operational Picture (COP)	**COP systems are designed to provide a common display of information to a set of independent actors to enhance the chances for timely and/or precise and/or effective coordination and responses to an event or situation to achieve specified outcomes**. **COP is described** as the pool of information • that is registered and stored in a database • concerning past, present and expected future events • that is available for presentation in a user interface • that is suitable for emergency responder work • the form of presentation of which is consistent and unambiguous, but not necessarily the same to all stakeholders or levels of command • the content of which is structured adequate to operational processes of the emergency responses • that can be interpreted and acted upon by the emergency responders • that is meaningful and applicable in the context of emergency responder work

From a COP survey and the background knowledge of team members on Common Operational Picture requirements analysis, other COP projects and programs, we have developed a set of criteria which are of relevance for advanced COP systems.
The analysis is documented in Annex 3 and the list of criteria in this Annex 4, including an evaluation of the COP capabilities and characterisics as they were developed in the COPE project..
It of course cannot be expected that the COPE COP will cover, be capable of and use all these advanced characteristics, functions and technologies. They represent the collectivity of criteria identified in a total of 18 COP or COP-related projects with differing missions, requirements and capabilities. No project of the COPE size will ever be able to nor is it reasonable from an operational and cost-effectiveness point of view to incorporate all in one system.

This evaluation, therefore, identifies which features of this catalogue have been chosen for and implemented in COPE, to what extent, and why or why not.

The catalogue covers the perspectives of

1. Customer expectations and requirements
2. High level measures of effectiveness of a COP
3. Trends in COP technologies

The interesting COP-related projects we have identified are listed at the end of the tables.

Common Operational Picture Generic Criteria

Markings:
Strong representation in COPE: Was required according to COPE objectives
Partial representation in COPE: Was useful but not mandatory
Development potential: Was not required but can be implemented
Not addressed in COPE: Is out of scope of COPE

Criteria	strong	partial	Pot	Not	Comments
1. Generic Requirements to a COP: The drivers and possible customers' expectations to an advanced COP					
Question for COPE evaluation: How relevant were these "drivers" for the design and implementation of the COP?					
• Dynamicity/ real time capability: Fast reaction to situation changes	x				
• Multi-media, multi-source-capability					
○ GIS/geographical	x				

○ Graphics	x				
○ Data	x				
○ Video	x				Between FF and SC; not part of the C2 Gateway
○ Voice/audio			x		
○ Input from various sensors	x				
• Adaptive to situations & tasks, differing in type, size, character					
○ Flexible to multiple situations		x			
○ Switching/ changeover mechanisms to different applications			x		
○ Configurability: A set of applications to select from				x	
○ Configurability/ hardware		x			
○ Applicability for different security services/tasks			x		
○ Applicability at different C2 levels		x			
○ Scalability: Adaptation in size and complexity		x			
○ (Degree of) automation of selection processes				x	
• Usability					
○ Easy learning				x	
○ Easy handling	x	x			High focus in C2 system
○ Physical user interfaces (screen/touchscreen, keyboard, functional keys, joystick, voice etc.)	x				Specific interfaces like joystick etc. were never a COPE requirement
○ Menu concept and menu guidance; self-explanatory			x		
○ Multi-lingual	x				
• Standards & COTS technologies					
○ Architecture (COE; SOA;...); modularity; ...			x		
○ GUI	x				
○ GIS	x				
○ Data base concept & structure; data dictionary; ontology	x				
○ Standard interfaces to other systems				x	

○ Interoperability with other systems				x	
• Supportive services/ functions					
○ Support/ automation of system adaptation and reconfiguration				x	
○ Task dependent information processing (interpretation, fusion, aggregation, presentation; alerting on special events or information,...)			x		
○ Basis for or containing integrated decision support tools	x				
○ Allows/ supports prioritizing/ ranking of objects, tasks, decisions		x			
○ Forecast capability (estimation, propagation, forecast of consecutive or consequential events, ...)				x	
○ performance under uncertainty / vague information				x	
○ Use of open services and information (Internet)		x			Used during decelopment; not required during trial
○ Easy interfacing with other systems				x	
○ Multiple application interfaces: Map, symbology, foreground and background data, functional menus	x	x			
○ Automated report generation	x	x			Capabilities available but not used in trial
○ Layering technology (Map, weather buildings, streets, topology, foliage, statistics, patterns,	x	x			Capabilities available but not used in trial
○ Dynamic display of resources...			x		
○ Scaling of functionality to actual application			x		
○ Training, exercising, rehearsal mode			x		
○ Replay function	x				
• Resilience					
○ IT security			x		
○ Physical robustness		x			Not necessary to be fully achieved in a

					demonstrator version for all components
○ Resistance to sabotage				x	
○ Mobility /Transportability	x				
○ performance under degradation (fail safe)			x		
○ recovery functions				x	
• Adequacy of cost:					Cost and cost-effectiveness, in a procurement and operations sense, are completely outside the COPE project and therefore not considered in the evaluation
○ Development to a marketable system					
○ Implementation					
○ Maintenance					
○ Training cost of staff					
2. Trends, primarily Information Technologies (Note: There is some unavoidable overlap with the criteria under 1.)					
Question for COPE evaluation: How far could these trends be regarded in the RTD-process of COPE?					
• Advanced user interface:					
○ VR-technologies				x	
○ HUD	x				Head up Display; Helmet mounted Display
○ acoustic/audio support			x		
○ 3-D				x	

o Interactive screens/displays				x	
• Interaction functions: Touch-screen, drag& drop, joystick, direct draw function,...		x			
• Context-dependent visualization	x	x			
• Context dependent menus and user guidance		x			Was not in the requirements
• Advanced Multi-media capability		x			
• Use of public information & services (internet etc. public safety feeds; geo-RSS feeds; Google earth/ maps; incident repositories; ...)			x		
• (Easy) integration of COP into legacy C2 systems	x				When TSO becomes EU standard, integration or interoperability will be easy
• Viewing, transforming of COP (tilt, rotate, zoom, cut, select, layer,....)		x			
• Integration of specialized applications, e.g.					
o CBRN / hazards behaviour	x				
o LOS/ eLoS in terrain				x	Line of Sight was not a COPE functional requirement
o LOS/ eLoS in urban areas/ buildings				x	
o Weather forecast				x	
• Multi-sensor environment integration (Chemical, environmental, positioning, weather, ...)	x				
3. Generic Measures of Effectiveness **Question for COPE evaluation:** How did the COPE COP contribute to these measures of performance?					The detailed evaluations are given in chp.5 of D6.6, and in D2.3
• Creates / attracts situation awareness	x				
• Saves time	x				

• Leads to quality decisions	x				
• Saves and /or supports optimum use of resources (personnel; space (?)		x			
• Keeps the manager “on track” (does not divert him from his duties)	x				
• Helps avoid casualties and/or damages		x			
• Supports coordination with other services (peer, subordinate, superior)	x	x			
• Eases/supports training and exercising		x			
4. Cases of advanced COP systems/projects					
This is a selection of COP projects which were viewed for generating a general set of COP criteria (see 1.-3. Above)					
Dedicated operational systems					
• O’Hare Airport					
• Washington Metro					
• Melbourne Emergency Services Telecommunication Authority					
• Ansaldo Chicago Railways					
• GIS Safety Resource Center					
• Calgary Tri-Services					
• FAZD Center					
• You Tube Calgary Wildfire					
• LA Regional Railways					
COP solutions/components available on the market					

• OASIS		
• Command Support system (Vector Command)		
• Intergraph solutions		
• Safety Resource Center COP Template (ESRI),		
• LuciadMap ™,		
• Life Rings Super COP ™		
• Pace		
• ESRI Situational Awareness		
• Bio-surveillance COP (BCOP)		
•		
•		

Some sources:
http://blogs.esri.com/Dev/blogs/publicsafety/archive/2010/03/09/Public-Safety-Resource-Center-Common-Operational-Picture-Template-Updated_2100_.aspx
http://msnbcmedia.msn.com/i/msnbc/Sections/News/UnifiedDefenseJuly2004.pdf http://www.ansaldo-sts.com/AnsaldoSTS/EN/Business/SupervisionTrafficControl/WA/COP/index.sdo

Annex 5 to COPE D6.6

COPE Decision Support System (CDS) and the Kuopio Table Top Exercise – Evaluation Report

Scope

This report describes the evaluation of the COPE Decision Support (CDS) developed by GMV Skysoft in WP5.3 and evaluated during the Kuopio Evaluation as part of the Table Top Exercise (TTE) on September 23, 2010 at the Emergency Services College, Kuopio. Finland. It is limited to the qualitative observations and interviews.

Limitations on Validation

Our ability to conduct a full validation of the CDS tool was limited due to two primary factors. Firstly, the nature of the TTE meant that there was limited opportunity for the Avon Fire Fighter users to interact with the system in the way that was intended. Secondly, the Risk Analysis Cards functionality on the CDS was intended to be used by an incident commander or sector commander on first arriving at the incident ground (Dynamic Risk Assessment) and assessing risks to deployed firefighters on the ground. However, the Finnish fire fighters procedures do not foresee this rik card functionality. Therefore the CDS had to be implemented in the TTE in a command post function for which it was not designed for. Thus the risks that the CDS identified and the hazard-control pairs were more appropriate to front line firefighting than to the more strategic TTE goals. We consider this effort to be closer to a verification of the CDS rather than validation. Therefore, most of the deficiencies discussed below cannot be blamed to the CDS but rather to this (unavoidable) artificiality of the trial setup.

Despite these two major limitations, we were able to gather data with respect to the utility and usability of the CDS from our two firefighter SMEs. We took the opportunity to gather feedback on the tool at several points during the exercise[1]: firstly, prior to the start of the exercise (after the initial training on the tool), secondly from observing the CDS in action during the TTE (with the caveats identified above), thirdly from further feedback on the use of the tool during the TTE debrief, and finally from two evaluation surveys used to collect data from all of the COPE technologies[2].

Evaluators

The two evaluators were from the Avon Fire & Rescue Service (United Kingdom). Major aspects of the CDS were based on user requirements analysis conducted with these users and based on their approach to risk assessments. Therefore we asked them to provide feedback on the tool, given that the Finnish Fire Service did not conduct risk assessments in the same way (this is an issue for cross-national interactions and a problem for a unified Concept of Operations). Our firefighters were both experience incident commanders. One is a Watch

---

[1] It should be noted that the CDS concept has been reviewed on two occasions with firefighters from Avon Fire & Rescue Service (UK) prior to this exercise, providing feedback into the iterative design of the system concept and the interface itself.

[2] The survey data has been collected by CESS (following the TTE debrief) and by VTT (based on usability questions for all the COPE technologies used in the field. These data are held by CESS and VTT and are included in the quantitative data analysis.

Manager at a central Bristol fire station, and is an experienced trainer and incident commander. The other is a senior officer at the South West Command Development Centre, and is a trainer on the Incident Command development course, training fire fighters to be incident commanders.

Quantitative Data
The quantitative survey data collected after the TTE using the CESS and the VTT data forms is reported in the main part of this report.

Interview/Observation Data
The following evaluation is based on comments made by the evaluators as part of a formal evaluation interview, comments and observations made during the TTE, and comments made by the evaluators as part of the TTE debrief.

Unified CONOPs and Tying in to Multinational Operations. A further issue was that the risk card aide memoire was pulled from UK doctrine and developed with UK firefighters. We later found out that the Finnish emergency Services do not have any similar process and were unable to accommodate the introduction of a new way of working to the training exercise that we were using to evaluate the COPE technologies. This resulted in the CDS being placed in Table Top Exercise at the operational level, rather than at the originally intended tactical level.

CDS to appply to "Strategic" Risk Assessment Task. Due to this unfortunately unavoidable placement of the CDS it was inappropriately exercised during the evaluation. The CDS was developed for the sector commander or a first responder (en route and on arrival) arriving on the scene with the risks and controls focused on a tactical level. During the TTE, however, the CDS was placed at a more operational level. The outputs from the CDS, however, were not intended to support more strategic risk assessment. The possibility of using a "Risk Card" approach (see D5.3.2) at a strategic level was discussed. The question was raised whether there was an equivalent of the operational risk cards for higher level strategic risk assessment. The answer was that for large scale incidents at large facilities, many of these risks are identified in emergency planning and in site-specific risk information which is often accessible by the control centre. It might therefore be possible to allow a user of the CDS to access these documents themselves, however there is the possibility that these documents are not presented in an easy to read way that could act as an "aide memoire" or decision support to the incident commander or his Command Support Officer (CSO).

This problem meant that the CDS outputs had limited applicability in the TTE and a full validation of the tool's utility could not be assessed.

Need for a Real Risk Assessment or Decision Making due to TTE Script.
On top of the inappropriate location of the CDS in the "system", there was also no need to assess the risk in the TTE because the script already identified the primary hazards that needed to be considered as well as the assessment of risk and the actions that the incident commander took to manage the whole situation. Therefore the use of the CDS was not requested by the IC and the users of the CDS were sometimes not sure what they were supposed to do as part of the exercise and therefore also found it hard to envision how the CDS might be used in a real operational/tactical setting.

Given where it was exercised in the TTE, the primary comment from the evaluators was that a competing system, Vector Command Ltd's Command Support System (CSS) did comparable things that the CDS and COPE C2 did in the TTE.

However, in early discussion in the COPE project we already recognized CSS as a primary competitor and tried to emphasise that the COPE tools should focus at the lower levels of command (tactical), and emphasize added value of COPE as the inclusion of real time sensor data flowing to and from the front line emergency responders. The evaluators' comments with regard to the CDS as used in the TTE were appropriate, however CDS was not intended to be used at that level and therefore the primary value of the CDS as envisioned in the COPE program could not be fully highlighted or exercised during the TTE.

System Functionality Exercise in the TTE
To review, the following is a brief description of the functionality of the CDS system (See D5.3.2?? for a more in depth description of the CDS technology):

1) **Dynamic Risk Assessment (DRA)** – the purpose of this part of the system is to pull up a "risk" card based on an initial classification of the incident (often based on the dispatch/control centres classification). Once the risk card has been brought up, the user sees a list of primary hazards to consider as well as a list of potentially related risk cards with other associated hazards. The purpose of this risk card is to act as an aide memoire to an incident commander when he first arrives on the scene.

2) **Analytical Risk Assessment (ARA)** – once the initial size up of the incident has occurred, the risk cards provide the incident commander with a set of control measures which could be put in place to mitigate the risks. The incident commander is also able to allocate qualitative assessments of the likelihood and severity of the risks which in turn are turned into an overall risk assessment with respect to whether the firefighters are facing an "intolerable risk" (and should probably pull back) or "acceptable risk with control measures in place" or "trivial risk", the table below summarises the outputs from the risk analysis.

	Highly Unlikely	Unlikely	Likely
Slightly harmful	Trivial Risk	Tolerable Risk	Moderate Risk
Harmful	Tolerable Risk	Moderate Risk	Substantial Risk
Extremely Harmful	Moderate Risk	Substantial Risk	Intolerable Risk

The incident commander can then select when certain control measures have been put in place. Selecting different control measures may reduced the perceived risk to firefighters. If all control measures that can be put in place for each Haz-Con (hazard-control pair), then the risk is minimized as far as possible by the incident commander.

3) **Hazard Picture** – Once the risk assessments have been conducted, the incident commander can look at the incident picture on a map based interface. The map pulls information from the COPE C2 system, indicating the location of various resources. The CSO can open up the map and the list of hazards identified during the risk assessment can be added as icons on the map. In addition, data from the chemical sensors and cloud prediction

software provide an indication of the extent of a hazardous gas cloud, or area hazard. The hazard icons are shared with the COPE C2 system so that hazards are shared across the COP.

When the TTE started the evaluators began to look at the risks associated with building collapse, but the IC directed them to look at the risk of further explosion first. They easily found the risk card for explosion, which indicated “no firefighting except life saving, evacuate all personnel”. This advice did not match how the incident evolved in the script so the controls for this risk were ignored. An “exclusion zone” for the explosion risk could not be put on the map due to a lack of “area hazard” representation or use of the drawing tool.

Specific Usability Issue

With respect to the specific functionality of the tool, the following usability issues were identified:

1) **Generic Control Measure Descriptions.** The firefighters asked if they could access chemical data from the system so that they could identify the specific control measures for the specific chemical. The control measures identified on the risk cards are very generic and there is not enough support on the CDS (for example, in the form of data bases) to support the identification of specific controls for every occasion. Chemical Hazard data bases do exist and are currently available to the fire services either on their mobile data terminals on an appliance or via “reach-back” capabilities to their control centre or to a hazmat expert who has access to those data.

2) **Creating Area Hazards.** It was requested that the system generate a representation of smoke/limited visibility as a hazard on the incident ground, but neither the COPE C2 nor the CDS can create “area hazards”. Related to this, the potential for an explosion needed to be represented as an area hazard, but it could not be on the current system.

3) **Fire Service-centric Hazards.** hazards are very fire service –centric, are there specific hazards or hazard controls pairs that relate specifically to ambulance, police, military, other organizations in addition to those relating to the fire service?

4) **Are the risks pre- or post implementation of controls?** It was not clear whether the assessment of risk was supposed to be identified before control measures are implemented or after the control measures are implemented. Implementation of a control measure may change the significance of a specific hazard to the incident ground and therefore impact the risk estimates.. It should be made clear that the initial assessment is based on the hazard before any control is put in place. But, the assessment and the control measures should be linked so that the actual impact of the hazard on the assessment is reduced if control measures are put in place.

5) **Locating Haz-Con Pairs.** There may be several locations affected by the existence of a hazard and the control measures put in place to mitigate it. For example, identifying moving traffic as a hazard to firefighters may be a potential hazard at multiple locations around the incident ground. The hazard mapping function needs to be able to allow for multiple icons to represent the hazard, not just one.

6) **Hazards have different risks depending on other factors.** The control measures for the same hazard may be different depending on the circumstances. The Haz-Con pairings need to be flexible enough to be able to represent different Haz-Con pairings for the hazard in different parts of the incident ground.

7) **Multiple Levels of Risk Analysis.** The sector commanders do their own risk assessments for their area of responsibility. It was not clear how the different risk assessments from multiple different sector commanders would feed into the risk assessment by the incident commander and how those would be represented in the COP. This is important because the IC may allocate limited resources and will want to see conflicting control strategies and overlapping resource requirements. The same hazard may be important at the Sector level, but less important at the IC level. CDS only appears to have one level of description which may not be able to handle the different levels of description even within the operational level, never mind between operational, tactical and strategic levels. It was suggested that maybe, like Vector Command Ltd's Command Support System (the major market competitor, previously identified in the project), a sector area could be separated from the main map for use by the sector commander, with hazards added at the lower levels and then combined at a higher level.

8) **Support vs. Audit Tool.** CDS provided an audit function not a support function as demonstrated in the TTE. It was used to document decisions and assessments, not supported the making of those assessments.

9) **Where does it sit?** It was not finally cleared where CDS should fit into the CONOPS nor who the specific user were to be, although it had been suggested in the project that a CSO would be the primary user in support of an incident commander. It was felt that this tool probably was better situated in a command vehicle. In addition, it was identified that this is a tool that would be useful on the way to an incident especially if it was also tied to resources and tasking. After having identified a hazard it was unclear who was responsible for controlling that hazard, or even who was aware that the hazard had been identified (even though it appeared on the map, there was no confirmation from other users that they had seen it). However, there was also feedback later in the evaluation that indicated that the Sector Level may be more appropriate (which contradicts the use of the tool in a command vehicle). This issue has not been resolved during this project.

10) **CONOPs.** The users of the CDS did not want to add icons without conformation from the IC who was not available. The filtering and decisions of whether to add icons onto the map and whether they would be more clutter than help is an issue for the implementation of the tool and a CONOPs. In addition, a major output of the DRA and ARA processes in UK doctrine are the identification of a "tactical mode" which provides the general stance of all emergency personnel to the current hazards. It is a mechanism for SCs to communicate to ICs and vice versa. This was not implemented in the TTE and therefore a major potential benefit colud not be exercised or tested, although available in principle.

11) **Initial Response Phase vs. Future Phases**. The tool did not fit the phase of the incident in the TTE and therefore it was exercised only with limited effectiveness. This was, however, due to the exercise artificialities and not an inherent deficiency of the CDS.

12) **Control conflicts.** There was no guidance on how to resolve conflicts in controls for different hazards. This still comes down to the judgment and skill of the incident commander.

13) **Readability of Text.** Some of the text did not fit into the windows or cells in which it was represented. This meant that the user could not read the full labels and not all functionality was transparent. This was somewhat mitigated with drop down menus and redundant colour coding of the risk assessments once completed, however this should be addressed more effectively in future iterations. The evaluators themselves did not comment specifically on this issue during the exercise or debrief interviews.

14) **Positive Functionalities.** The Table of Contents was good and useful, especially with it being alphabetical and numerically organized. It was easy to navigate around the tool. Being able to share the hazard icons with the COPE C2 system was considered a plus.

Overall Comments

The TTE showed some of the mechanical aspects of supporting a COP, but did not illustrate how COP/CDS might support the actual emergency response activities, decisions, assessments and judgments that are required to conduct emergency response. This was mostly due to the way that the CDS was included in the evaluation exercise because of the lack of knowledge of the "real" Finnish fire fighters with the CDS doctrines.

Suggestions for Future

It is recommended that the following are examined in future efforts related to the CDS work:

1) If a CDS is to be conducted as part of a TTE, conduct the TTE in slower time, so that participants can actually explore the role of the CDS in the emergency response process and attempt to solve real dilemmas and assessment requirements using the tool without the clock of the script ticking.

2) In future, SMEs should be allowed to express their questions, views, and opinions about the potential applications of the various tools without the script driving the event. The script needs to be viewed as a support to the exercise not the driver. The expertise of the SMEs in their respective fields was not allowed to be expressed in the TTE as executed. We should have done the TTE as a verification process with non-emergency responders as an initial run through before inviting experts to use the systems in the TTE.

Annex 6 to COPE D6.6:

The Scenario and TTE Script

Introductory Remark

The operational scenario describes and structures the sequence of events occurring during a major disaster incident or series of incidents which the COPE system and its components are exposed to during the COPE trial. The scenario has been based on the real disaster of the huge fireworks factory explosion on 13 May, 2000, in Enschede at the Dutch-German border, where 23 people died, thousands were wounded, hundreds of buildings and major infrastructures destroyed. This scenario framework was chosen by 3 reasons:
a) This disaster was well documented and the data are publicly available,
b) The size and consequences have the appropriate complexity and dimension for the COPE trial
b) The Enschede disaster really happened, so the team was not dragged into the usual but superfluous discussions on whether the scenario is realistic or too artificial.

The total scenario has been documented in detail in D 6.2.

A6.1 TTE Script

A6.1.1 Phase 1: Chaotic Phase

Roles:	FF command Ambulance command Police command Mayor IC(TTE)

General situation:	confusion, panic, fear, crowd behaviour, lack of leadership
Disabled casualties:	wait for help; great risk of death
Ambulant casualties:	uncoordinated inflow into the nearest hospitals; Absorption of medical resources
Volunteers:	arrive at the disaster scene hindering relief efforts of emergency services
First responders:	arrive at the disaster area: fire, debris caused by the Explosion; casualties on the roads; arriving volunteers and emergency services can cause gridlock
Aim:	to gain a common operational picture as soon as possible

Step 1: to get a general idea of the situation
Step 2: to register the resources available at the disaster area

Time frame: 10:40 – 11:01

Course of events:

Time	Message		Content
	From	To	
10:40			Bombs explode in the fireworks factory, ignites chemicals and containers filled with fireworks
10:42			Fireworks factory is burning; local fires at the neighbouring brewery
10:47	Emergency centre	FB and Ambulance	**Situation:** Heavy explosions in the industrial area; Fireworks Factory is burning; local fires in Brewery; intensive black smoke; chaos on the roads; debris everywhere; dead and injuries; demolished cars all about. **Order:** Fire Brigade: FB3, FB4, FB5, FB6 , FB7, FB8 and Ambulance: A_1 - A_5 resort to disaster area via R1, R2, R5
10:53	A_2_E	Ambulance command	A_2_E arrived at junction WE_1 / SN_13 via R2; intensive black smoke everywhere, moving towards north-east. Very limited visibility. Strong heat radiation. WE_1 and SN_13 impassable: debris and burning cars on the roads. Impossible to stay here for longer time without protecting clothes. Propose to turn back to R2 and wait in some distance from junction for further instructions.
10:54	A_1_E	Ambulance command	A_1_E arrived at WE_4 West; WE_4 West impassable because of debris, twisted metal pieces and large concrete fragments. Victims everywhere. Burning and demolished cars along the road cannot drive on beyond junction WE_4/SN_12. Brewery and Fireworks Factory burning. Intensive smoke moving North-East. Expect further instructions.
10:57	A_3_E	Ambulance command	A_3_E arrived at junction WE_4 / SN_13 via R5; SN_13 impassable because of debris, burning cars and victims everywhere. Black biting smoke from burning Brewery. Expect further instructions.
10:59	FB3_CU1	FF command	FB3_CU1arrived at WE_4 West; SN_12 and WE_4 filled up with by debris and blocked by burning and demolished cars. In between many injuries. No way to drive closer to Fireworks Factory. Brewery burning. Fire fighters, paramedics, ambulances and heavy equipment needed for SAR and to clear roads.

			Recommend to install RCP (resources collection point) and CCP (casualty collection point).
10:59	FF command	FB3_CU1	FB3_CU1 commander gets the IC authority "circumjacent roads" (= IC(TTE)), his deputy becomes CSO of TTE
10:59	FB4_CU1	IC(TTE)	FB4_CU1 is arrived at WE_4 / SN_13 via R3. Fireworks Factory fully burning, strong heat radiation. Brewery window front demolished after explosions, fire penetrating Brewery. SN_13 and WE_4 blocked by debris, burning cars and injuries on the road, as far as can be seen because of smoke from Brewery. Need fire fighters, heavy equipment, fire brigades as many as can be made available and ambulances.
11:01	FB5_CU	IC(TTE)	FB5_CU arrived at WE_1 / SN_13 via R2. WE_1 and SN_13 blocked by debris and damaged cars. Probably many injuries on the roads. Very limited visibility because of smoke. Strong heat radiation from Brewery. Need reinforcements in great numbers. Need to advance backwards towards R2 until reinforcements are available.
11:01	FB6_CU1	IC(TTE)	FB6_CU1 arrived at SN_3/WE_4 via R5. WE_4 and SN_12 blocked by demolished cars and debris. Many injuries on the road. Fireworks Factory fully burning. Brewery burning, fire moves towards Ammonia Tower. Allocation of fire brigade urgent.
11:01	IC(TTE)	CSO	Keep up to date the list of arrived resources in the CC2 system
11:01	Heavy detonation: A further container exploded		
11:01	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • DA (Disaster Area) What: • IOI “ Initial Situation” Put Icon “Kindergarten” on the Map Put Icon “School” on the Map Put Icon “Hospital” on the Map Put Icon “Explosion Incident” on Fireworks Factory Put Icon “Fire” on Brewery Put Icon “Fire Engine” at the junction WE_4/SN_3 Put Icon “Fire Engine” at the junction WE_4/SN_13 Put Icon “Fire Engine” at the junction WE_1/SN_13 Put Icon “Fire Engine” at the junction WE_4/SN_3 Put Icon “Fire Engine” at the junction WE_1/SN_12 Put Icon “Ambulance” at the junction WE_4/SN_3 Put Icon “Ambulance” at the junction WE_1/SN_13 Put Icon “Ambulance” at the junction WE_4/SN_13
11:01	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • DA (Disaster Area) Task: Distribute the status report at all: • Fireworks Factory fully burning, strong heat radiation. Brewery window front demolished after explosions, fire penetrating Brewery. SN_13 and

			WE_4 blocked by debris, burning cars and injuries on the road, as far as can be seen because of smoke from Brewery. • WE_1 and SN_13 blocked by debris and damaged cars. Probably many injuries on the roads. Very limited visibility because of smoke. Strong heat radiation from Brewery. • SN_12 and WE_4 filled up with by debris and blocked by burning and demolished cars. In between many injuries. Fireworks Factory fully burning. Brewery burning, fire moves towards Ammonia Tower. Request: • Allocation of fire brigade urgent. • Need reinforcements in great numbers. • WE_4 and SN_12 blocked by demolished cars and debris. Many injuries on the road. Requirements: • Fire fighters, heavy equipment, fire brigades as many as can be made available and • ambulances.

A6.1.2 Phase 2: Initial Response

Role Players: FF command
Ambulance command
Police command
Mayor
IC(TTE)

General situation: This phase is mainly devoted to the analysis and assessment of the current situation and aims at establishing chain of command

Fire Brigade: Analyse the situation concerning size and character of the disaster
Analyse the needs of resources
Establish their chain of command

Medical service: based on the current assessment of situation, the medical service has to pre-estimate the potential amount of casualties and to activate its surge capacity to expand medical resources to accommodate casualties in a mass casualty situation

Aim: Organisation and realisation of the task "establish the chain of command for the TTE

Command chain: FB commanders have to organise and establish the chain of command and to allocate the SC authority to the different CU commanders.

Resources: Allocation of resources to the different areas of responsibility of the TTE

Time frame: 11:02 - 11:10

Course of events:

Time	Message		Content
	From	To	
11:02 – 11:10	Ambulances	Ambulance command	A_4_M arrived at WE_4 West; A_5_M arrived at WE_1 / SN_13;
11:03	IC(TTE)	FB4_CU1	Order: FB4_CU1 responsible for WE_4
11:04	IC(TTE)	FB5_CU	Order: FB5_CU is responsible for sector "WE_1"
11:04	IC(TTE)	FB6_CU1	Order: FB6_CU1 is responsible for sector "SN_12"
11:05 – 11:09	FB´s	IC(TTE)	FB7_CU1 arrived at WE_1/SN_13; FB8_CU is arrived at WE_4 / WE-1; FB3_LU1 arrived at RCP;FB3_HU1 arrived at RCP; FB4_LU1 arrived at RCP; FB4_HU1 arrived at RCP; FB3_USAR1 arrived at RCP; FB6_USAR arrived at RCP; FB5_LU arrived at RCP; FB5_HU arrived at RCP; FB6_LU1 arrived at RCP; FB6_HU1 arrived at RCP;
11:05	IC(TTE)	FF comm´d, Virtual FB units	Report 1: ”Status Report” (1) Fireworks Factory (FF) completely destroyed and burning; (2) Brewery burning (3) Roads SN_12, SN_13, WE_1 and WE_4 around FF

			impassable (4) Disaster area must be sealed off by Police
11:06	IC(TTE)	FF command	Report 2: "Risk Assessment": Explosion of Ammonia Tower puts unacceptable risk on first responders, not rescued casualties and housing area. Probability of explosion very high. Measures to be taken immediately: (a) put sensors in place (b) provide rough assessment of cloud propagation (c) initiate early warning in the housing area (d) Take measures to evacuate Kindergarten
11:06	IC(TTE)	CSO	Enter Report 1 "Review of the situation" and Report 2 "Assessment of the situation" into CC2 Task ID: DA_1 Unit: DA Task: Review of the situation To: FF command Review of the situation: Free text: (1) – (4) Assessment of the situation: Free text: (a) – (d)
11:07	IC(TTE)	FB7_CU1	Order: FB7_CU1 is responsible for street "SN_13"
11:07	IC(TTE)	FB8_CU	Allocated to FB8_CU is responsible for RCP (Resources Collection Point)
11:09	IC(TTE)	FB3_USAR1	Allocated to FB3_USAR1 allocated to WE_4
11:10	FF command	IC(TTE)	Measures (a) - (d) approved
11:10	IC(TTE)	CSO	Enter into CC2: Task DA_1 approved by FF command
11:10	IC(TTE)	FB4_LU1	Allocated to: FB4_LU1 allocated to WE_4
11:10	IC(TTE)	FB4_HU1	Allocated to FB4_HU1 allocated to WE_4
11:10	IC(TTE)	Police command	Request: Police establish access roads (R1, R2, R5), seal off the disaster area, direct the rescue vehicles to the RCP
11:10	IC(TTE)	FB3_LU1	Allocated FB3_LU1 establish RCP
11:10	IC(TTE)	FB3_HU1	Allocated FB3_HU1 establish CCP

A6.1.3 Phase 3: Site Clearing

Role Players: FF command
Ambulance command
Police command
Mayor
IC(TTE)

General situation: After command authority has been established, a thorough inspection and assessment of damage have to be done and the plan for removing of debris, rescuing casualties has to be executed. The earlier a strong leadership and command authority is installed at the scene, the less risk exists for injuries and damages.

Fire Brigade: FB clears the disaster area in order to facilitate SAR operations
FB secures the area in order to prevent immediate dangers represented by

- Secondary structural collapse
- Chemical, radiation contamination

Police: Police

- Restricts access to the disaster area,
- Sets cordon around the disaster area
- Grants access routes for ambulance service
- Maintains order among first responders, casualties and volunteers
- Ensures security of victims and first responders.

Strict control of access to the disaster area by the command authority is needed. If needed, traffic lanes will be opened to ensure adequate flow of resources and casualties.

Time frame: 11:15 – 12:22

Course of events:

Time	Message		Content
	From	To	
11:00 – 11:15	DiStaff	Unified Command	Presentation of the situation at the end of • Chaotic Phase and • Initial Response Phase
11:15	IC(TTE)	WE_4 SC: FB4_CU1	Order: Clear WE_4 with heavy equipment (FB3_USAR1) and SAR
11:15	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB4_CU1 (WE_4) Task: • Clear WE_4 and SAR Means allocated since: • 11:09: FB3_USAR1, • 11:15: FB4_LU1, • 11:15: FB4_HU1 Results:
11:15	IC(TTE)	Police command	Request: Open access roads for Rescue Ops and seal the disaster area off.

11:17	WE_4 SC: FB4_CU 1	IC(TTE)	Status report: Casualty Position CP1with 19 casualties at junction WE_4/SN_12 Request: additional fire fighter crews needed to rescue the casualties and to transport them by means of stretchers to the CCP
11:17	FF command	IC(TTE)	Order: IC(TTE) provide rough assessment of cloud propagation for threat assessment for fire fighters and endangered housing area
11:17	IC(TTE)	FF command	Prognosis of potential cloud propagation: Urgent! Poisonous cloud expected to Housing Area. Immediate deployment of Forces in Housing Area requested to alert people to stay in their houses, close windows and doors and wait for further announcements. Request for public address system vehicles, HazMat equipment for house-to-house alert
11:17	IC(TTE)	Police command	Initiate immediate alert by local TV and Broadcasting stations. Poisonous cloud expected to threaten Housing Area. People stay in their houses, close doors and windows
11:19	FF command	Police command	Initiate protective measures in hospital to seal building against penetration of poisonous gas
11:19	IC(TTE)	WE_1 SC: FB5_CU	Resources allocation: FB6_USAR, FB5_LU and FB5_HU allocated to WE_1. Rationale: WE_1 should also provide a 2nd access to SN_13, where many casualties are assumed.
11:19	IC(TTE)	SN_12 SC: FB6_CU1	Resources allocation: FB6_LU1 and FB6_HU1 allocated to SN_12
11:19	WE_1 SC: FB5_CU	IC(TTE)	Status Report: casualties at different places of WE_1
11:19	IC(TTE)	CSO	Enter into CC2: Functional Sector: • FB5_CU" (WE_1) What: • IOI " CP5" as icon "injured person" at junction WE_1/SN_12 • 1 casualty
11:19	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • FB4_CU1 (WE_4) What: • IOI " CP1" as icon "injured person" at junction WE_4/SN_12 • 19 casualties
11:21	IC(TTE)	SC WE_1: FB5_CU	Order: Clear WE_1 and SAR
11:21	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB5_CU" (WE_1) Task: • Clear WE_1 and SAR Means allocated since:

			• 11:04: FB6_USAR • 11:04: FB5_LU • 11:04: FB5_HU Results:
11:21	FB3_CU	IC(TTE)	FB3_CU2 arrived at RCP
11:23	IC(TTE)	FB3_CU2	Order: FB3_CU2 responsible for CCP
11:23	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • DA Task: • Establish casualty collection point CCP Means allocated since: • 11:07: FB3_HU1 • 11:23: FB3_CU2 (SC CCP)
11:23	SC WE_1: FB5_CU	IC(TTE)	Message: CP 5 at WE_1 West with 1 casualty
11:23	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • FB5_CU (WE_1) What: • IOI " CP5" as icon "injured person" at WE_1 near junction WE_1/SN_12 • 1 casualty
11:23 – 11:25	FB7_USAR1, FB7_LU1, FB7_HU1, FB8_LU, FB8_HU	IC(TTE)	FB7_USAR1, FB7_LU1, FB7_HU1, FB8_LU, FB8_HU all arrived at RCP
11:25	FB3_LU2, FB3_HU2, FB3_USAR2	ICC(TTE)	All arrived at RCP
11:25	SC WE_1: FB5_CU	IC(TTE)	Status Report: • WE_1: Junction WE_1/SN_12 cleared; • 1 casualty rescued • as SN_12 is impassable for fire fighters with stretcher, an ambulance vehicle is needed at the junction WE_1/SN_12 Request: Ambulance vehicle at junction WE_1/SN_12 needed
11:25	IC(TTE)	Ambulance command	Request: ambulance vehicle needed at WE_1/SN_12
11:25	Police command	IC(TTE)	Police has ordered protective measures for hospital by hospital administration
11:25	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • DA (disaster area) What: • IOI: put " MedicalPoint" as icon "endangered hospital" on Hospital in the Housing.

11:29	IC(TTE)	SC SN-13: FB7_CU1	Resources allocation: • FB7_USAR1 allocated to SN_13 • FB7_LU1 allocated to SN_13 • FB7_HU1 allocated to SN_13
11:30	IC(TTE)	SC RCP: FB8_CU	Resources allocation: FB8_LU allocated to RCP
11:30	IC(TTE)	SC SN_13: FB7_CU1	Order: Clear SN_13 and SAR
11:30	IC(TTE)	CSO	Enter Task into CC2: Functional sector : • FB7_CU1" (SN_13) Task: • Clear SN_13 and SAR Means allocated since: • 11:29: FB7_USAR1 • 11:29: FB7_LU1 • 11:29: FB7_HU1 Results:
11:32	IC(TTE)	SC SN_12: FB6_CU1	Resources allocation: FB3_USAR2 allocated to SN_12
11:32	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB6_CU1" (SN_12) Task: Clear SN_12 and SAR Means allocated since: • 11:30: FB3_USAR2, • 11:19: FB6_LU1 • 11:19: FB6_HU1 Results:
11:32	IC(TTE)	SC WE_4: FB4_CU1	Resources allocation: • FB3_LU2 allocated to WE_4 • FB3_HU2 allocated to WE_4
11:34	Mayor	Ambulance command	Eastland provides upon request: 6 ambulance vehicles • 2 helicopters • 4 land vehicles
11:34	Mayor	IC(TTE)	Periodical cloud warning by TV and Broadcast in place
11:34	IC(TTE)	FF command	Maps show ammonia cloud propagation with 3 levels of concentration: • Level "red: danger of life • Level "yellow": medical treatment required • Level "green": no sustainable effect
11:44	Police command	IC(TTE)	Evacuation of Kindergarten ordered, bus and police personnel on route to Kindergarten Housing Area North
11:44	FB4_CU1	IC(TTE) / FF command	Fire spread on Ammonia Tower. Situation out of control.
11:46	FF command	IC(TTE)	Order: immediate retreat of all firemen engaged around the ammonia tower
11:48	FB6_CU1	IC(TTE)	Confirmation of operation: • SN_12 cleared • 2 casualties rescued
11:48	IC(TTE)	CSO	Enter Task into CC2:

			Functional sector: • FB6_CU1 (SN_12) Task: • finished Means allocated since: • 11:33: FB3_USAR2, • 11:19: FB6_LU1 • 11:19: FB6_HU1 Results: • SN_12 cleared • 2 casualties rescued
11:48	IC(TTE)	Police command	Request: Sealing of Housing Area by Police requested to avoid public movements during expected penetration of poisonous cloud into Housing Area
11:54	SC WE_4: FB4_CU 1	IC(TTE)	Confirmation of operation: • WE_4 cleared • 29 casualties rescued
11:54	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB4_CU" (WE_4) Task: • finished Means allocated since: • 11:09: FB3_USAR1, • 11:15:FB4_LU1, • 11:15: FB4_HU1 • 11:33: FB3_LU2 • 11:33: FB3_HU2 Results: • WE_4 cleared • 29 casualties rescued
11:56	IC(TTE)	Unified command	Ammonia tower exploded
11:56	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • DA (Disaster Area) What: • IOI " Ammonia Explosion" • Draw Icon "Explosion Incident" at Ammonia Tower
11:58	IC(TTE)	White cell "risk assessment"	Immediate information from sensor measurements required for risk and propagation calculation by VTT model and visualisation on CDS map for risk assessment
11:58	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • DA (disaster area) What: IOI: enter the endangered area as "Area of Interest" into the map
11:58	IC(TTE)	Police command	Order: Police, seal Housing Area from 12:32 until 13:42 to avoid public movements during chemical cloud

			penetration into Housing Area
11:58	FF command	IC(TTE)	Order: provide status report until 12:02
12:00	SC WE_1: FB5_CU	IC(TTE)	Confirmation of operations: • WE_1 cleared • 2 casualties rescued
12:00	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB5_CU" (WE_1) Task: finished Means allocated since: • 11:19: FB6_USAR • 11:19: FB5_LU • 11:19: FB5_HU Results: • WE_1 cleared • 2 casualties rescued
12:02	FB7_CU1	IC(TTE)	Confirmation of operations: • SN_13 cleared • 12 casualties rescued
12:02	IC(TTE)	CSO	Enter Task into CC2: Functional sector: • FB7_CU1" (SN_13) Task: • finished Means allocated since: • 11:29: FB7_USAR1, • 11:29: FB7_LU1 • 11:29: FB7_HU1 Results: • SN_13 cleared • 12 casualties rescued
12:02	FF command	IC(TTE)	Housing Area North: public address system vehicles, HazMat equipment for house-to-house alert and public observation in place
12:02	IC(TTE)	FF command	Status Report: (1) Disaster Area: ammonia cloud threat: status red until11:56; • status yellow until 12:06; • status green expected until 12:22 (2) Housing Area: • status red expected from 12:34 until 13:02 • status yellow expected from 13:02 until 13:22 • status green expected from 13:22 until 13:52 (3) No cloud related casualties reported so far (4) Regular TV/Broadcasting warning in place (5) Patrolling firemen and police, wearing protective clothes in place (6) Evacuation of Kindergarten expected before 12:22 (7) Status of SAR and road clearing: • WE_1 cleared, 2 casualties rescued;

			• WE_4 almost cleared, 27 casualties found; • SN_12 cleared, 2 casualties rescued; • SN_13 nearly cleared, 12 casualties found
12:22	Police command	IC(TTE)	Evacuation of Kindergarten in Housing Area accomplished
12:22	IC(TTE)	CSO	Enter IOI into CC2: Functional Sector: • DA (disaster area) What: IOI: put “ X” as icon on school symbol

A6.1.4 Phase 4: SAR

Role Players: FF command
Ambulance command
Police command
Mayor
IC(TTE)

General situation: After removing of debris, rescuing casualties has to be executed. The earlier casualties can be rescued, the less risk exists for injuries.

Fire Brigade: Fire Brigade

- Removes rubble in order to retrieve victims
- Searches for victims and
- Rescues the detected victims

Police: Police

- Restricts access to the disaster area,
- Sets cordon around the disaster area
- Grants access routes for ambulance service
- Maintains order among first responders, casualties and volunteers as well as
- Ensures security of victims and first responders.

Strict control of access to the disaster area by the command authority is needed. If needed, traffic lanes will be opened to ensure adequate flow of resources and casualties.

Medical Service: after the search phase:
first triage at the disaster area and evacuation to medical facilities

Time frame: 12:25 – 14:40

Course of events:

Time	Message		Content
	From	To	
12:25	FB4_CU1	IC(TTE) / CSO	Info: • WE_4 cleared • FB3_USAR1is waiting at RCP for new tasks
12:25	Police command	IC(TTE) / CSO	Evacuation of Kindergarten in Housing Area accomplished
12:26	FB4_CU1 / IC(TTE)	Ambulance command	Info: • 2 casualties R13F, R19F have been stretchered from CP3 at WE_4 to CCP and • are waiting for evacuation
12:26	FB4_CU1	IC(TTE) / CSO	Info: • WE_4 cleared • all casualties of WE_4 stretchered to CCP
12:30	Police command	IC(TTE)	Sealing of housing area in place
12:30	FB7_CU1 / IC(TTE)	Ambulance command	Info: the 4 casualties R22M, R23M, R26F, R27M have been stretchered to junction WE_1/SN_13
12:40	Emergency Coordina	Ambulance comman	Emergency call from Housing Area: difficulty in breathing, ambulance required

	tion Centre (ECC)	d	
12:40	IC(TTE)	FF command	Status report: (1) status per road (WE_1, WE_4, SN_12, SN_13) (2) SAR success
12:41	Ambulance command	IC(TTE)	Info: • all available ambulance units are engaged. • Free capacity not until 14:20
12:55	Emergency Coordination Centre (ECC)	Ambulance command	Emergency call from Housing Area: difficulty in breathing, 2 ambulance vehicles required
13:40	IC(TTE)	Police command	all-clear signal for ammonia cloud in Housing Area requested. Recommendation: keep windows and doors closed because of fire smoke from disaster area
13:45	Police command	IC(TTE)	all-clear signal for poisonous cloud threat: (1) restrictions to stay in houses are abolished (2) Alert team ordered to make respective announcements by loudspeakers until 15:30 (3) TV/Broadcast stations were requested to periodically announce all-clear signal, but recommend to keep doors and windows closed because of smoke from disaster area (4) Operation of Kindergarten recommended not before next morning because of fire smoke from disaster area (5) Sealing of Housing Area abolished
13:45	Police	IC(TTE)	Alert teams ordered to withdraw and contact their units; announcements of TV-/Broadcast Stations concluded
14:40	IC(TTE)	all	Mission completed; end of TTE

A6.2 TTE Actors and their Tasks

ID	Name	Actor	Task
DiStaff	Directing staff	Script Organiser	Directs the TTE via predefined script
		CC2 Operator	Enters tasks and Items of Interest (IOI) into CC2 on request of IC
		CDS Operator	Supports the IC by using the COPE Decision System (CDS)
UC	Unified Command	Mayor	Organises the cross-border cooperation on the political level
		Fire Fighting Command	Asks for additional fire units from neighbour state on request of IC and organises the cross-agency collaboration
		Police Operations Command	Organises the cross-agency collaboration
		Ambulance Operations Command	Asks for additional ambulance units from neighbour state on request of IC and organises the cross-agency collaboration
IC (TTE)	Incident Commander of the Table Top Exercise	Professional Fire Fighter	IC (TTE) is responsible for both vignettes “Circumjacent Roads” and “HazMat”. He has to organise the rescue operations, the recovery of injured persons, and to clear the situation. He will be supported by SCs and First Responders. He requests police actions such as barricading the disaster area, blocking and clearing of road traffic, installing access routes, preventive evacuation measures, managing the disaster tourism etc. He also requests initially ambulance support after having cleared the situation. The IC (TTE) will also request and obtain additional resources from the “Unified Command”, a body composed of representatives, respectively expert knowledge of Fire Brigade, Police, Ambulance and Public Authorities.
SC (TTE)	Sector Commander “Circumjacent Roads” and “HazMat” respectively	Professional Fire Fighter	Responsible solely for the vignette “Circumjacent Roads” respectively “HazMat”. He has to organise the rescue operations, the recovery of injured persons, and to clear the situation in agreement with the IC (TTE). He will be supported by First Responder Units allocated to him by the IC(TTE). He has to ask the IC (TTE) for additional support (FB, Ambulance, Police).
FB units	Virtual Fire Brigade units	1 member of the White Cell	All fire brigade units allocated to the TTE will be simulated by the respective member of the white cell according to the orders of the IC(TTE)
	There are different types of FB units which are:		
	FB_CU	Command Unit	1 command vehicle manned with 3 people (= 1 crew) and equipped with the appropriate communication equipment needed in major incidents
	FB_LU	Ladder Unit	1 ladder vehicle manned with 2 crews à 3 men and equipped equipped with ladder, hoses, cutting equipment, portable generator, lightweight

			portable pump, water-packs, inflatable air bags, road signs, floodlights, medical kit, hose ramps, general tools, chemical suits, breathing apparatus, first aid equipment including defibrillators.
	FB_HU	Hose Layer Unit	1 vehicle manned with 2 crews à 3 men and equipped with a large-capacity of high-pressure hose wagons to respond to incidents where hydrants or other water sources are not close enough to the fire ground and fire fighters are hampered by a lack of water.
	FB_USAR	Urban SAR Unit	2 heavy trucks, each manned with 2 crews à 3 men. The first heavy-rescue truck is carrying apparatus to gain access to and explore voids/spaces after a structural collapse, as well as binoculars, digital cameras, core drills, electrical tools, angle grinders, search cameras, communications equipment, life detectors, timber cutters, and lighting. The second truck is carrying a black Bobcat multi-purpose vehicle for removing debris from a disaster site.
Amb units	Virtual Ambulance units	1 member of the White Cell	All ambulance units allocated to the TTE will be simulated by the respective member of the white cell according to the orders of the IC(TTE)
	There are different types of ambulance units which are:		
	A_E	Evacuation vehicle	It is not able to provide on-board medical treatment and can transport 1 casualty
	A_M	Medical Ambulance	It is able to provide on-board medical treatment and can transport 1 casualty
	A_H	Helicopter	It is able to provide on-board medical treatment and can transport 1 casualty
Police units	Virtual Police units	1 member of the White Cell	All police units allocated to the TTE will be simulated by the respective member of the white cell according to the orders of the IC(TTE). Police activities are: barricading the disaster area, blocking and clearing of road traffic, installing access routes, preventive evacuation measures, managing the disaster tourism etc.

A6.3 Infrastructure

A6.3.1 Disaster Area

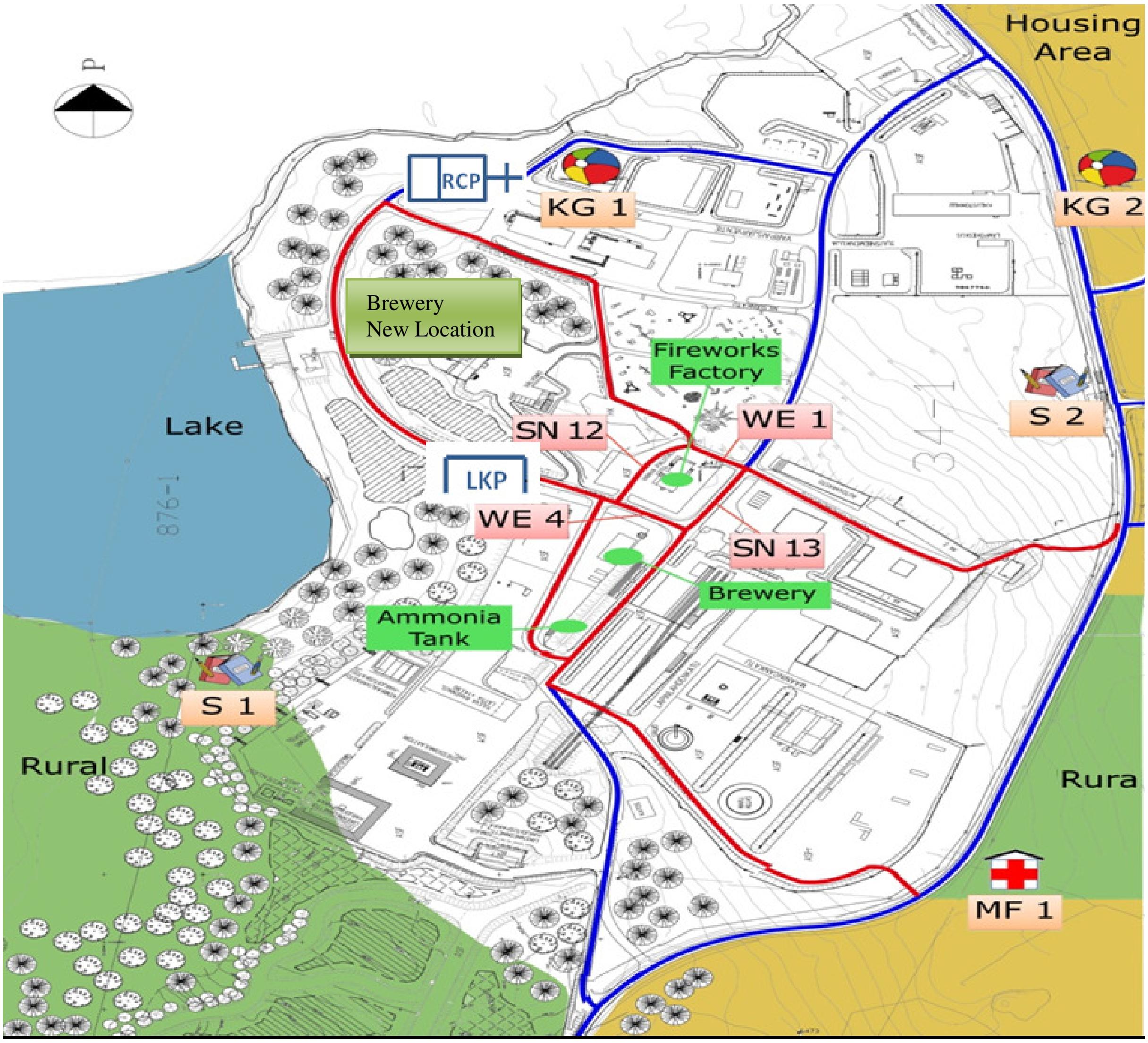


Figure 1: Infrastructure of the Disaster Area[1]

---

[1] The brewery, by a „last-minute“ decision of the emergency colledge, had to be moveaout 200 meters to the North-West.

A6.3.2 Distances from the Disaster Area to Fire Brigade Stations

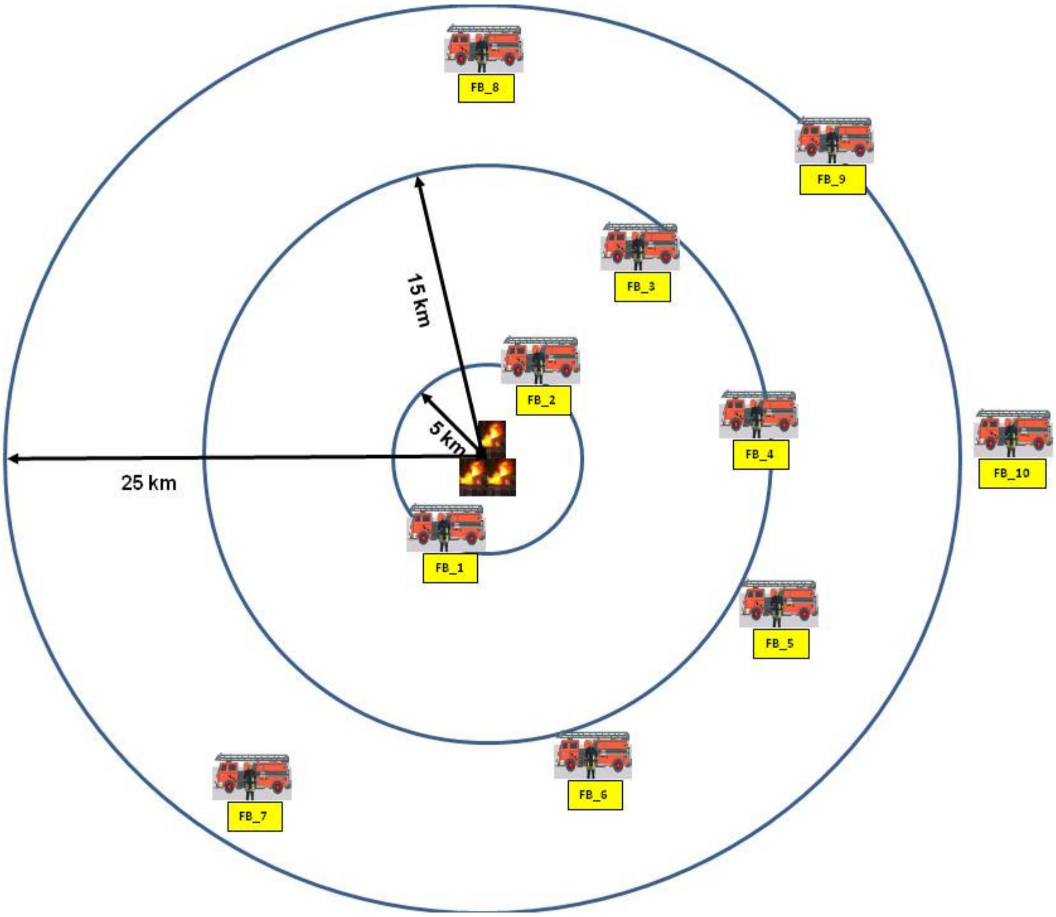


Figure 2: Fire Brigade Distances to the Disaster Area

A6.3.3 Distances from the Disaster Area to Hospitals

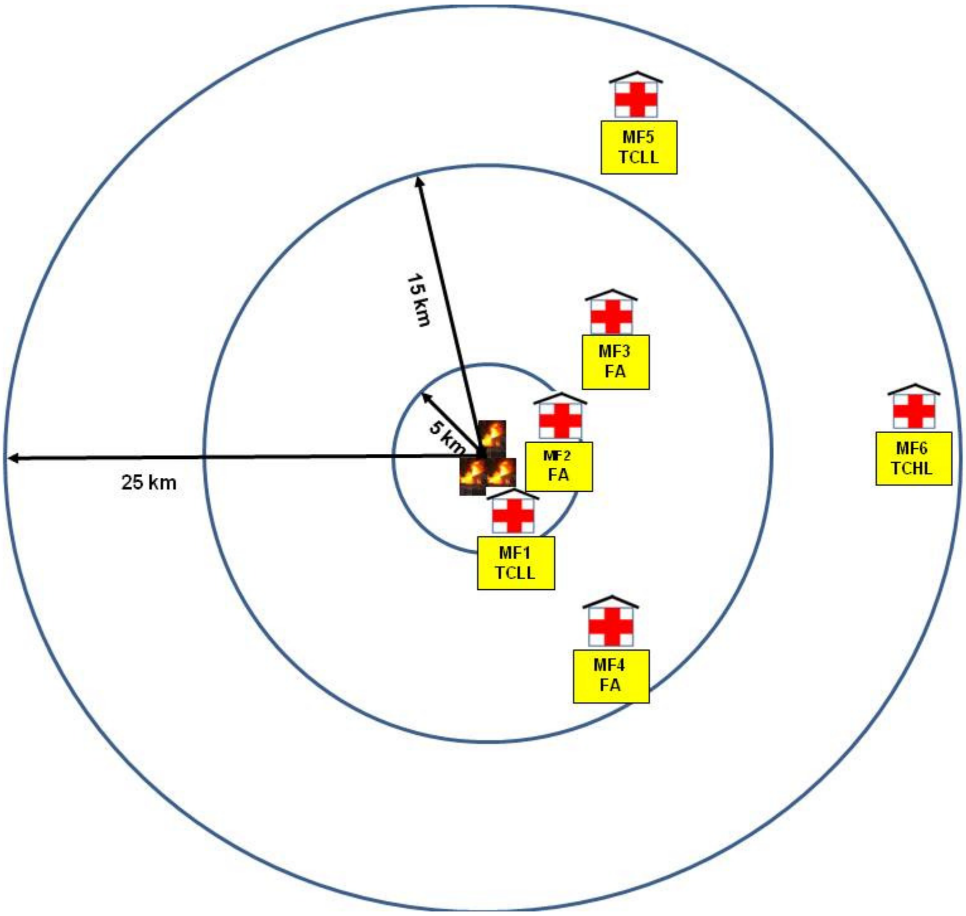


Figure 3: Distances from the Disaster Area to the Hospitals

A6.3.4 Distances from the Disaster Area to Ambulance Stations

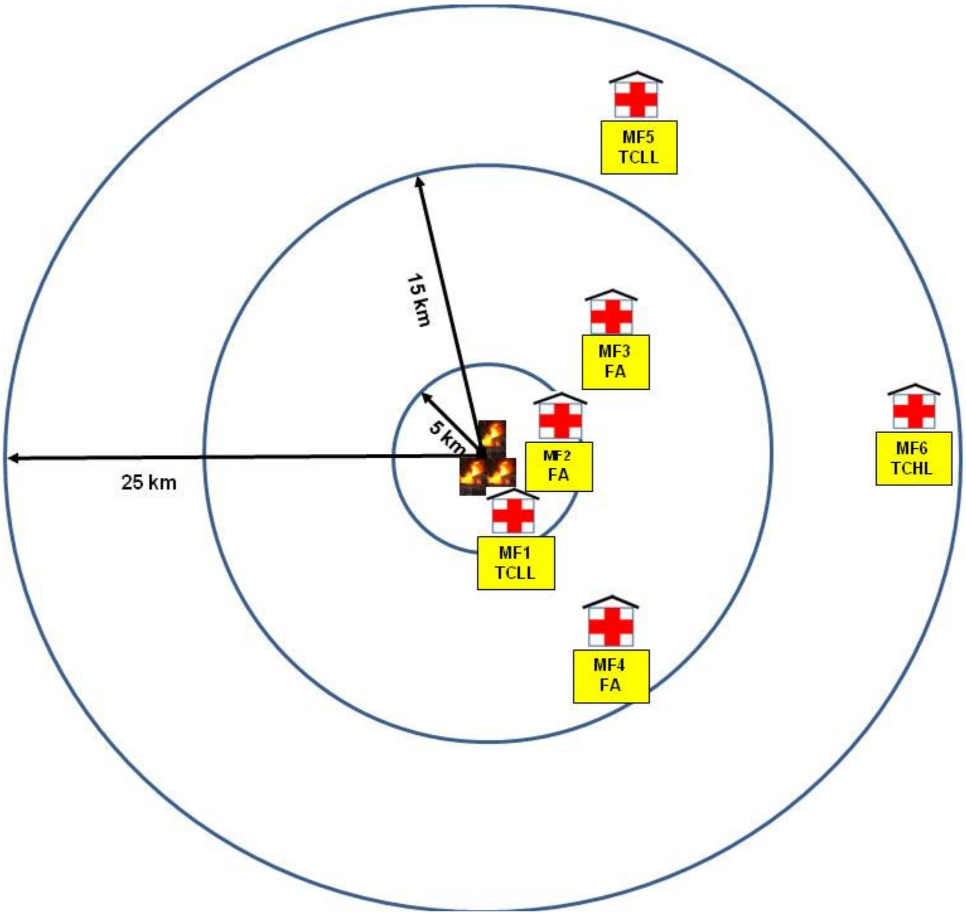


Figure 4: Distances of the Ambulances to the Disaster Area

A6.4 TTE Objects

		Geography		Organisation	
Unit	Arrival Time at DA[2]	Arrived at	Allocated to sector	Allocated to Functional Sector	Allocation Time
FB3_CU1	10:59	WE_4 West	TTE	IC(TTE)	FF command
FB5_CU	11:01	WE_1/SN_13	WE_1	FB5_CU	12:34
FB6_USAR	11:05 – 11:09	RCP	WE_1	FB5_CU	12:42
FB5_LU	11:05 – 11:09	RCP	WE_1	FB5_CU	12:42
FB5_HU	11:05 – 11:09	RCP	WE_1	FB5_CU	12:42
FB4_CU1	10:59	WE_4/SN_13	WE_4	FB4_CU1	12:33
FB3_USAR1	11:05 – 11:09	RCP	WE_4	FB4_CU1	12:39
FB4_LU1	11:05 – 11:09	RCP	WE_4	FB4_CU1	12:40
FB4_HU1	11:05 – 11:09	RCP	WE_4	FB4_CU1	12:40
FB3_LU2	11:25	RCP	WE_4	FB4_CU1	12:49
FB3_HU2	11:25	RCP	WE_4	FB4_CU1	12:49
FB6_CU1	11:01	SN_3/WE_4	SN_12	FB6_CU	12:34
FB3_USAR2	11:25	RCP	SN_12	FB6_CU	12:49
FB6-LU1	11:05 – 11:09	RCP	SN_12	FB6_CU	12:42
FB6-HU1	11:05 – 11:09	RCP	SN_12	FB6_CU	12:42
FB7_CU1	11:05 – 11:09	WE_1/SN_13	SN_13	FB7_CU1	12:37
FB7_LU1	11:23 – 11:25	RCP	SN_13	FB7_CU1	12:47
FB7_HU1	11:23 – 11:25	RCP	SN_13	FB7_CU1	12:47
FB7_USAR1	11:23 – 11:25	RCP	SN_13	FB7_CU1	12:47
FB8_CU	11:05 – 11:09	WE_4/WE_1	RCP	DA	12:37
FB8_LU	11:23 – 11:25	RCP	RCP	DA	12:48
FB8_HU	11:23 –	RCP	RCP	DA	12:48

[2] Disaster Area

	11:25				
FB3_LU1	11:05 – 11:09	RCP	RCP	DA	12:40
FB3_CU2	11:21	RCP	CCP	DA	12:44
FB3_HU1	11:05 – 11:09	RCP	CCP	DA	12:40

A6.5 Command Chain & Sector Organisation

A6.5.1 Geographical Sector Organisation

Without limitation of the number of functional sectors

Geographical Sector	Sector Commander	Functional Sector Name	Allocated Resources
WE_1	FB5_CU	FB5_CU	FB6_USAR, FB5_LU, FB5_HU
WE_4	FB4_CU1	FB4_CU1	FB3_USAR1, FB4_LU1, FB4_HU1, FB3_LU2, FB3_HU2
SN_12	FB6_CU1	FB6_CU1	FB3_USAR2, FB6_LU1, FB6_HU1
SN_13	FB7_CU1	FB7_CU1	FB7_USAR1, FB7_LU1, FB7_HU1
RCP	FB8_CU	FB8_CU	FB3_LU1, FB8_LU, FB8_HU
CCP	FB3_CU2	FB3_CU2	FB3_HU1
DA (disaster area)	FB3_CU1 (= IC(TTE))	FB3_CU1	

A6.5.2 Functional Sector Organisation

Number of TTE functional sectors <= 5

Geographical Sector	Sector Commander	Functional Sector Name	Allocated Resources	Remarks
WE_1	FB5_CU	FB5_CU	FB6_USAR, FB5_LU, FB5_HU	
WE_4	FB4_CU1	FB4_CU1	FB3_USAR1, FB4_LU1, FB4_HU1, FB3_LU2, FB3_HU2	
SN_12	FB6_CU1	FB6_CU1	FB3_USAR2, FB6_LU1, FB6_HU1	
SN_13	FB7_CU1	FB7_CU1	FB7_USAR1, FB7_LU1, FB7_HU1	
DA (disaster area)	IC(TTE)	FB3_CU1	FB3_CU2, FB3_HU1, FB8_CU, FB3_LU1, FB8_LU, FB8_HU	RCP, CCP, CCP2, DA merged to DA

A6.6 Chemical Cloud Propagation

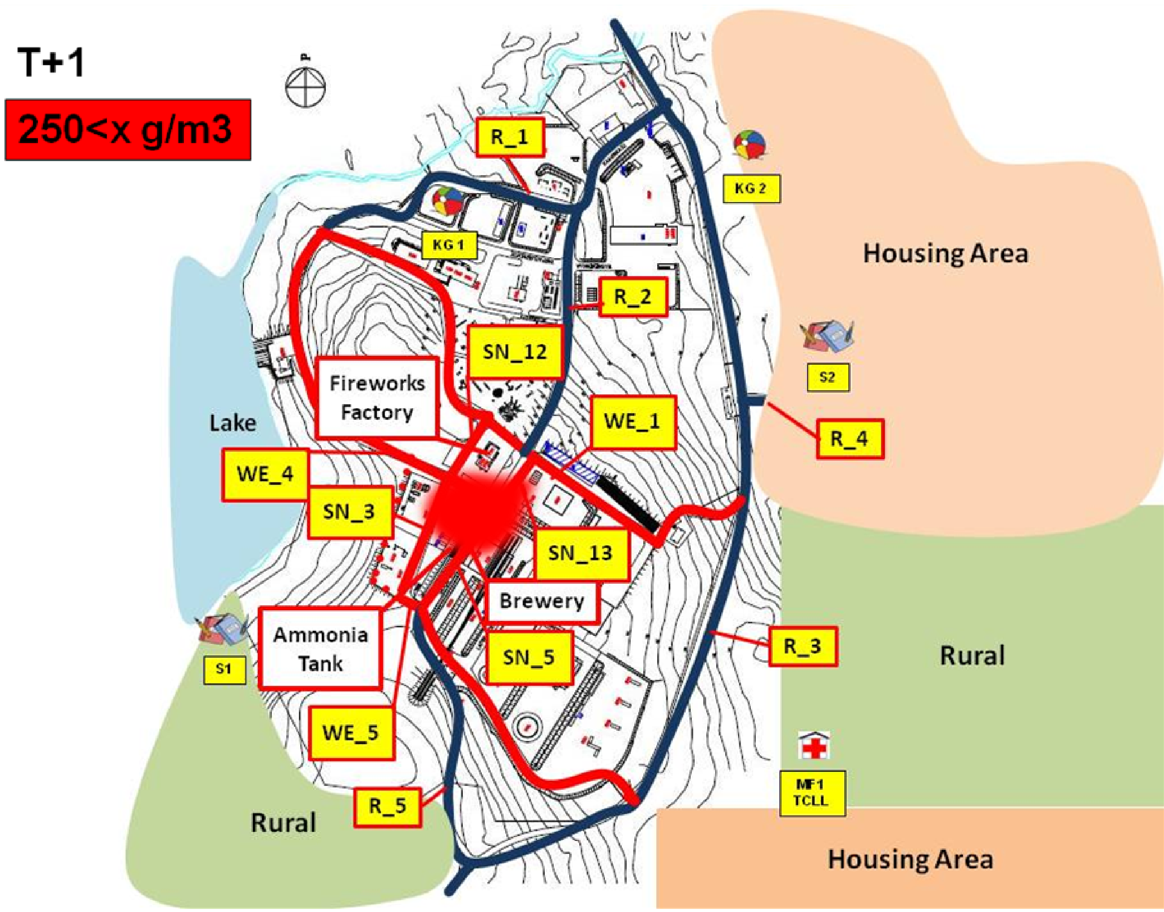


Figure 5: Chemical Cloud Propagation: Step 1

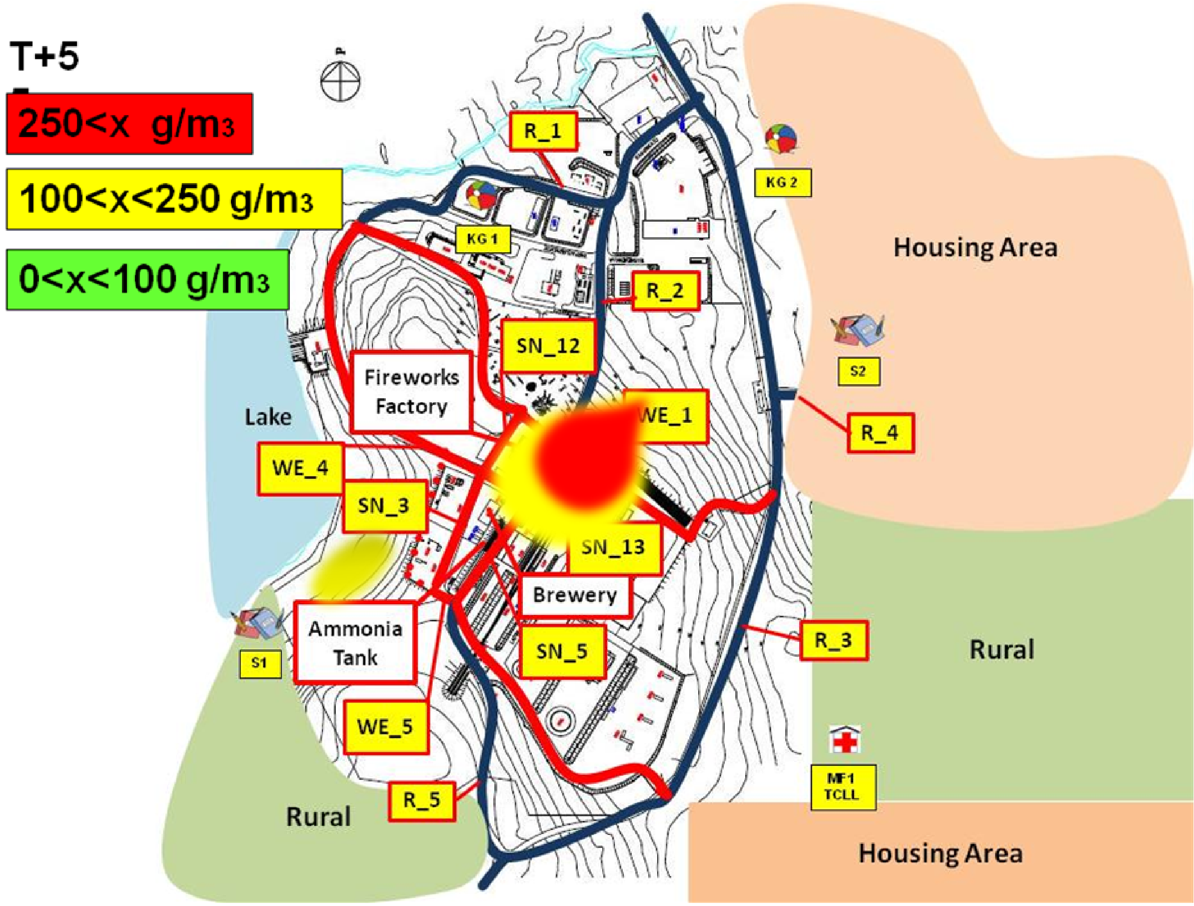


Figure 6: Chemical Cloud Propagation: Step 2

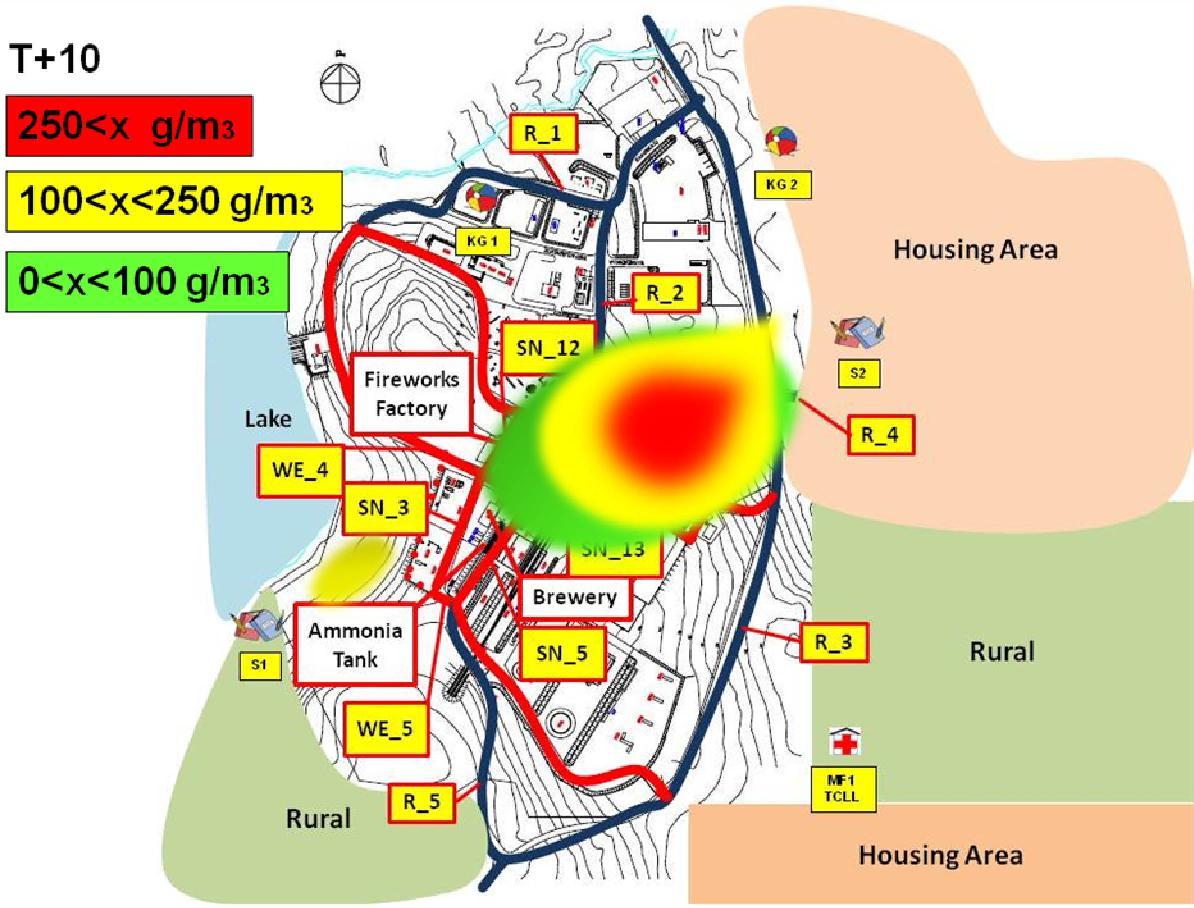


Figure 7: Chemical Cloud Propagation: Step 3

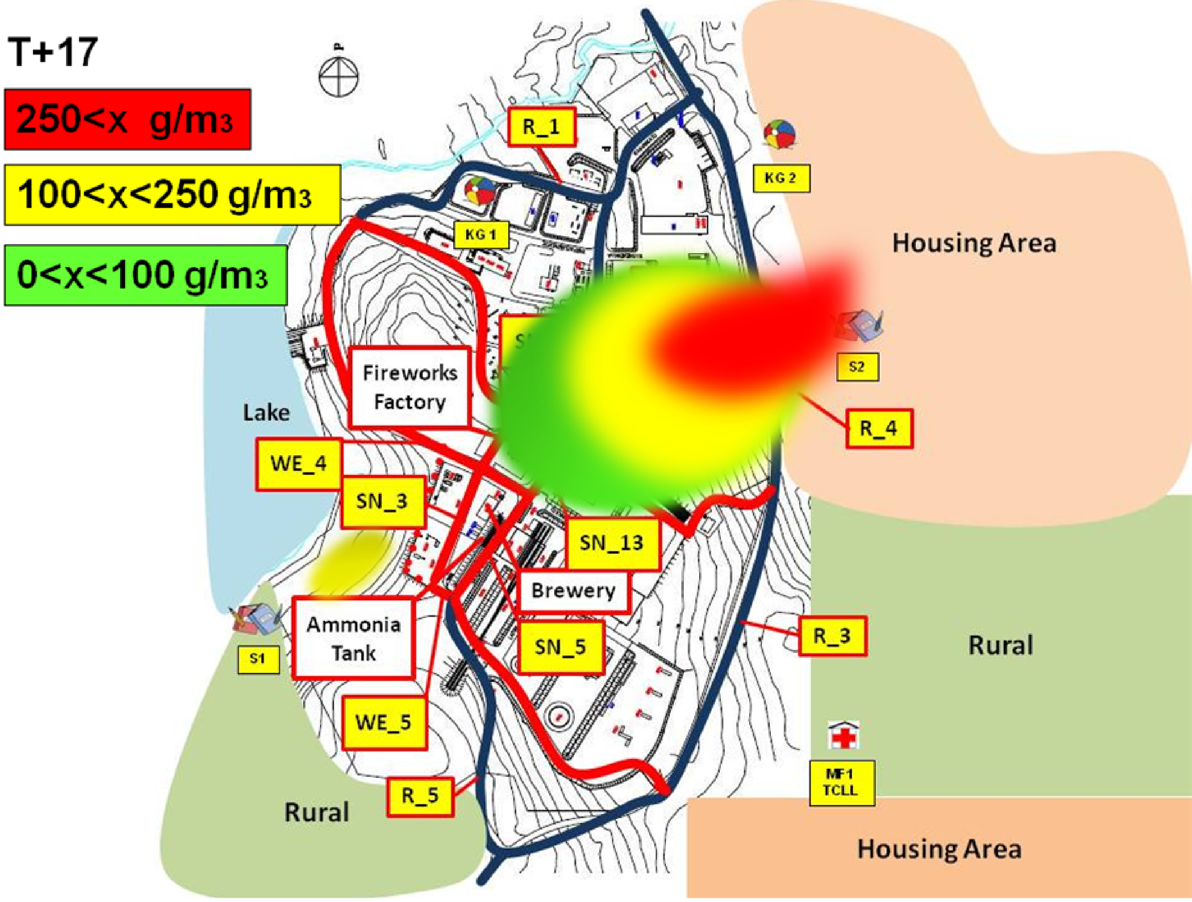


Figure 8: Chemical Cloud Propagation: Step 4

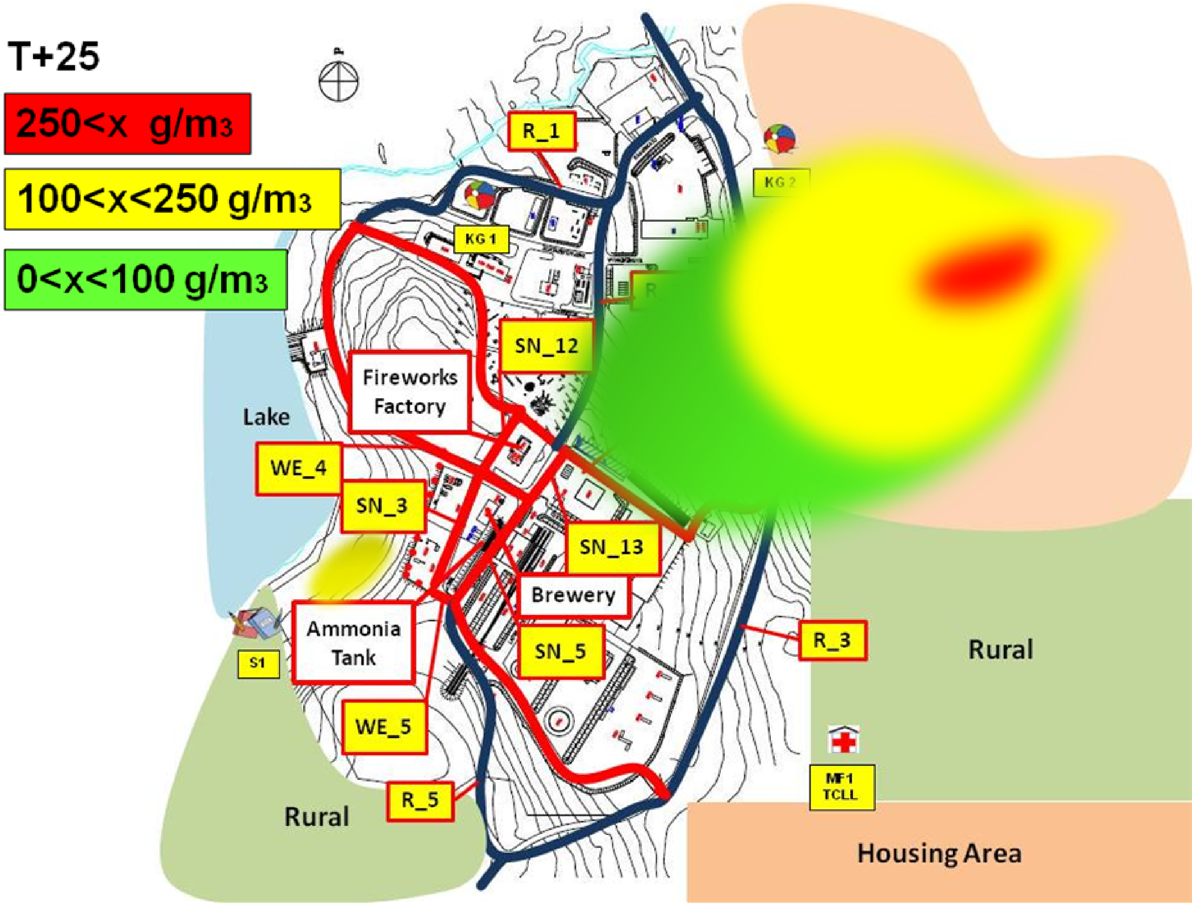


Figure 9: Chemical Cloud Propagation: Step 5

A6.7 Technical Data

A6.7.1 Fire Brigade

FB-Unit	Subunit	Name of Subunits	Number of Persons	Number of Vehicles	Distance to disaster area [km]	Cruise speed [km/h]	Journey Time [minutes] from initial position to disaster area	Call-in Time [minutes]	Total Time [minutes] from initial position to disaster area
FB3	Command Unit (CU) (Standard)	FB3_CU1	3	1	14	80	11	1	12
FB3	Ladder Unit (LU) (Standard)	FB3_LU1	6	1	14	60	14	5	19
FB3	Hose Unit (HU) (Standard)	FB3_HU1	6	1	14	60	14	5	19
FB3	Urban SAR Unit (USAR)	FB3_USAR1	12	2	14	60	14	5	19
FB3	Ladder Unit (LU) (Standard)	FB3_LU2	6	1	14	60	14	15	29
FB3	Hose Unit (HU) (Standard)	FB3_HU2	6	1	14	60	14	15	29
FB3	Urban SAR Unit (USAR)	FB3_USAR2	12	2	14	60	14	15	29
	Sum Persons FB3		51	9					
FB4	Command Unit (CU) (Standard)	FB4_CU1	3	1	15	80	11	1	12
FB4	Ladder Unit (LU) (Standard)	FB4_LU1	6	1	15	60	15	5	20
FB4	Hose Unit (HU) (Standard)	FB4_HU1	6	1	15	60	15	5	20
	Sum Persons FB4		15	3					
FB5	Command Unit (CU) (Standard)	FB5_CU	3	1	17	80	13	1	14
FB5	Ladder Unit (LU) (Standard)	FB5_LU	6	1	17	60	17	5	22
FB5	Hose Unit (HU) (Standard)	FB5_HU	6	1	17	60	17	5	22
	Sum Persons FB5		15	3					
FB6	Command Unit (CU) (Standard)	FB6_CU1	3	1	17	80	13	1	14
FB6	Ladder Unit (LU) (Standard)	FB6_LU1	6	1	17	60	17	5	22
FB6	Hose Unit (HU) (Standard)	FB6_HU1	6	1	17	60	17	5	22
FB6	Urban SAR Unit (USAR)	FB6_USAR	12	2	17	60	17	5	22
	Sum Persons FB6		27	5					
FB7	Command Unit (CU) (Standard)	FB7_CU1	3	1	22	80	17	1	18
FB7	Ladder Unit (LU) (Standard)	FB7_LU1	6	1	22	60	22	5	27
FB7	Hose Unit (HU) (Standard)	FB7_HU1	6	1	22	60	22	5	27
FB7	Urban SAR Unit (USAR)	FB7_USAR1	12	2	22	60	22	5	27
	Sum Persons FB7		27	5					
FB8	Command Unit (CU) (Standard)	FB8_CU	3	1	23	80	17	1	18
FB8	Ladder Unit (LU) (Standard)	FB8_LU	6	1	23	60	23	5	28
FB8	Hose Unit (HU) (Standard)	FB8_HU	6	1	23	60	23	5	28
	Sum Persons FB8		15	3					
	Sum Persons Total		150	28					

A6.7.2 Ambulances

Ambulance-Unit	Vehicle Type	Name of Subunits	Transport Capacity	belonging to Hospital	Distance to the disaster area [km]	Cruise speed [km/h]	Call-in Time [minutes]	Time [minutes] from initial position to disaster area	Time [minutes] from disater area to hospital and back
Westland									
A_1	EVAC	A_1_E	1	MF1_TCLL	5	60	2	7	14
A_2	EVAC	A_2_E	1	MF2_FA	4	60	2	6	12
A_3	EVAC	A_3_E	1	MF2_FA	8	60	2	10	20
A_4	MED	A_4_M	1	MF2_FA	13	60	3	16	32
A_5	MED	A_5_M	1	MF5_TCLL	20	60	3	23	46
A_6	HELICOPTER	A_6_H	1	MF6_TCHL	23	240	5	11	22
Eastland									
A_7	EVAC	A_7_E	1	MF7_FA	27	60	2	29	58
A_8	MED	A_8_M	1	MF8_TCLL	27	60	3	30	60
A_9	HELICOPTER	A_9_H	1	MF9_TCHL	30	240	5	13	25
A_10	EVAC	A_10_E	1	MF10_FA	27	60	2	29	58
A_11	MED	A_11_M	1	MF11_TCLL	27	60	3	30	60
A_12	HELICOPTER	A_12_H	1	MF12_TCHL	30	240	5	13	25

A6.8 Casualties

A6.8.1 Places of discovery at the disaster area

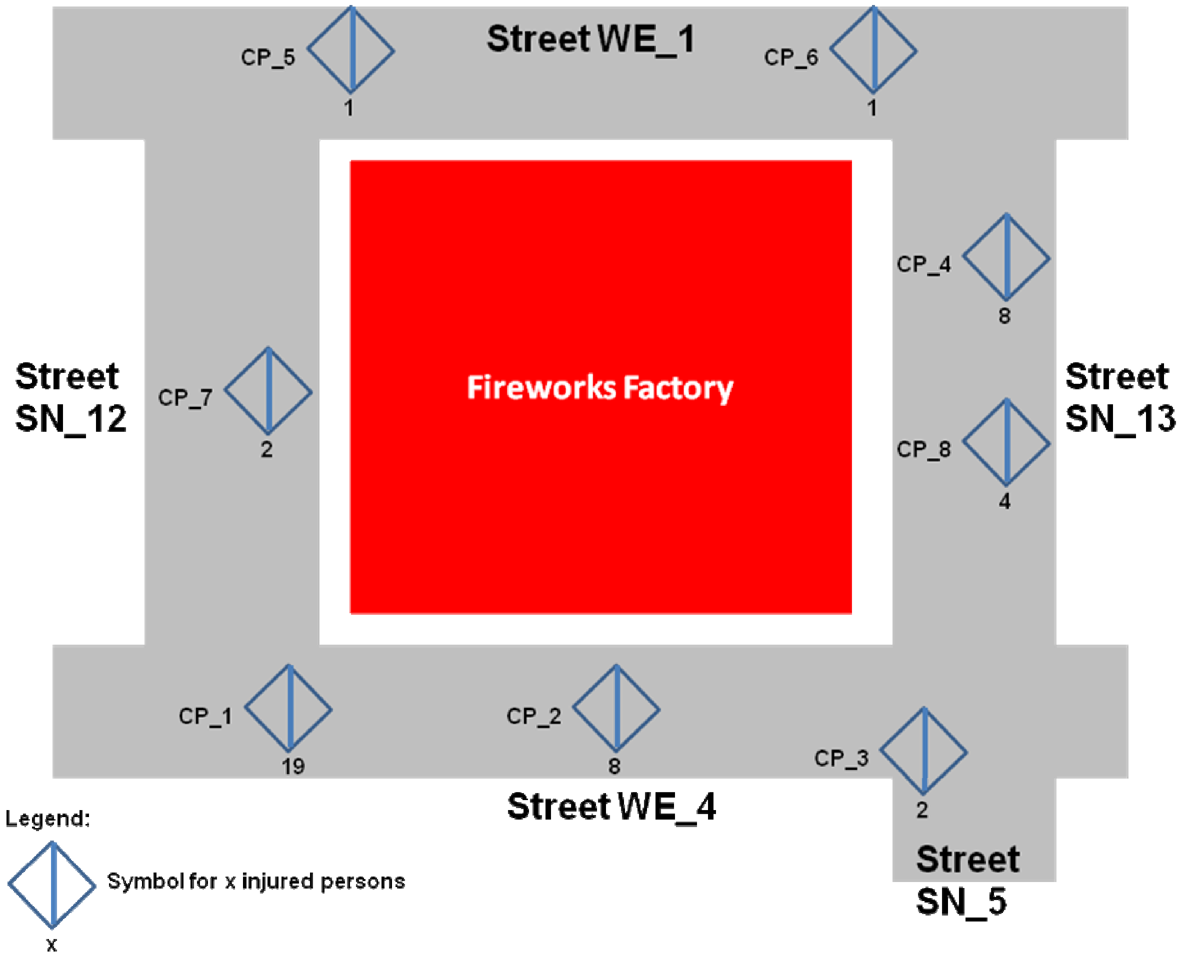
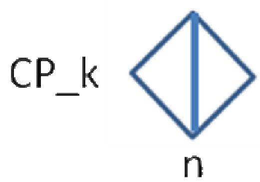


Figure 10: Places of casualty discovery at the disaster area

Legend:



Symbol for: n injured people have been discovered at the kth Casualty Position CP_k

A6.8.2 Rescued Casualties

Rescue Time	**Casualty Position (CP)**	**Road**	**SAR Unit**	**Number of Casualties**
12:41	CP1	WE_4 (WE_4/SN_12)	FB3_USAR1	19
12:44	CP5	WE_1 (WE_1/SN_12)	FB6_USAR	1
12:50	CP2	WE_4 (Brewery)	FB3_USAR1	8
12:53	CP8	SN_13 (midway)	FB7_USAR1	4
12:55	CP7	SN_12 (midway)	FB3_USAR2	2
13:00	CP3	WE_4 (East)	FB3_USAR1	2
13:03	CP6	WE_1 (East)	FB6_USAR	1
13:05	CP4	SN_13 (FF)	FB7_USAR1	8

A6.8.3 Health Status

Casualty Name	member of	Location	IOI	Status description	Category
F010M	Fireworks Factory	WE_4 / SN_12	IOI_1	gash, fractured arm, major burns	T1
F011M	Fireworks Factory	WE_4 / SN_12	IOI_1	smashed face, chemical burns	T1
F01F	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F02F	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F03F	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F04F	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F05M	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F06M	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F07M	Fireworks Factory	WE_4 / SN_12	IOI_1	smoke poisoning, cuts and contusions	T2
F08M	Fireworks Factory	WE_4 / SN_12	IOI_1	broken ribs, fracture of the skull	T4
F09M	Fireworks Factory	WE_4 / SN_12	IOI_1	burns, head violations	T1
R01M	Pedestrian	WE_4 Bus stop	IOI_1	head smashed by fragment	T5
R02F	Pedestrian	WE_4 Bus stop	IOI_1	burnt	T5
R03M	Pedestrian	WE_4 Bus stop	IOI_1	face and head hit by fragments	T4
R04M	Pedestrian	WE_4 Bus stop	IOI_1	circulatory collapse	T1
R05F	Pedestrian	WE_4 Bus stop	IOI_1	broken leg, burns	T1
R06M	Pedestrian	WE_4 East	IOI_2	pelvic fracture, burns	T2
R07M	Pedestrian	WE_4 East	IOI_2	broken leg, burns	T2
R08M	Pedestrian	WE_4 East	IOI_2	spine injury, inability to walk	T2
R09F	Pedestrian	WE_4 East	IOI_2	head injuries, blackout	T2
R10F	Pedestrian	WE_4 FF	IOI_2	head smashed by fragment	T5
R11C	Pedestrian	WE_4 FF	IOI_2	third-degree burns	T4
R12F	Pedestrian	WE_4 FF	IOI_2	face and head hit by fragments	T1
R13F	Pedestrian	WE_4/SN_5	IOI_3	broken leg, cuts, , burns	T1
R14M	Pedestrian	WE_4/SN_13	IOI_4	smashed lower legs, cuts	T2
R15C	Pedestrian	WE_4/SN_13	IOI_4	eye injury, burns	T2
R16M	Pedestrian	WE_4 West	IOI_1	heavy fractions of head and body	T4
R17M	Pedestrian	WE_4/SN_13	IOI_4	head injuries, spine injury	T1
R18M	Pedestrian	WE_4 Brewery	IOI_2	arm loss by glass plate	T1
R19F	Pedestrian	WE_4/SN_5	IOI_3	broken collarbone, head injury	T2
R20M	Pedestrian	WE_4 West	IOI_1	burned in car after fragment hit	T5
R21M	Pedestrian	SN_13 FF	IOI_4	deadly hit by bricks	T5
R22M	Pedestrian	SN_13 FF	IOI_4	deadly hit by bricks	T5

R23M	Pedestrian	SN_13 FF	IOI_4	Third-degree burns	T4
R24M	Pedestrian	SN_13 N	IOI_6	severe head injuries	T1
R25M	Pedestrian	SN_13 midway	IOI_6	smashed leg	T1
R26F	Pedestrian	SN_13 FF	IOI_4	spine injury, inability to walk	T2
R27M	Pedestrian	SN_13 FF	IOI_4	smoke poisoning, blackout	T2
R28M	Pedestrian	SN_13 midway	IOI_6	trapped in burning car	T1
R29M	Pedestrian	SN_13 midway	IOI_6	severe burns	T2
R30M	Pedestrian	SN_13 midway	IOI_6	severe head injuries	T1
R31F	Pedestrian	SN_12 N	IOI_5	third-degree burns	T4
R32F	Pedestrian	SN_12 midway	IOI_5	concussion, burns, cuts	T1
R33M	Pedestrian	SN_12 midway	IOI_5	broken ankle	T2
R34M	Pedestrian	SN_12 S	IOI_1	burns, smashed knee	T2

Statistic:		
	T1 =	14
	T2 =	19
	T3 =	0
	T4 =	6
	T5 =	6
	Sum =	45

Category	Meaning	Consequences	Examples
T1	acute danger of life	immediate treatment, transport as soon as possible	arterial lesions, internal haemorrhage, major amputations
T2	severe injury	constant observation and rapid treatment, transport as	minor amputations, flesh wounds, fractures and dislocations
T3	minor injury or no injury	treatment when practical, transport and/or discharge when possible	minor lacerations, sprains, abrasions
T4	no or small chance of survival	observation and if possible administration of analgesics	severe injuries, uncompensated blood loss, negative neurological assessment
T5	deceased	collection and guarding of bodies, identification when possible	dead on arrival, downgraded from T1-4, no spontaneous breathing after clearing of airway