PREparing for the Domino effect in Crisis siTuations.

PREPARING FOR THE DOMINO EFFECT IN CRISIS SITUATION

D7.5 TRAINING METHODOLOGY REPORT

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EXECUTIVE SUMMARY

In many crisis management operations, decision makers and their team face serious difficulty to obtain reliable information on the state of the situation, let alone that they are able to predict how certain failures may propagate through a particular system and on to different systems, as compound failures usually manifest themselves in different organisations in various geographical locations. The integrated PREDICT Decision Support Tool (iPDT) supports this sense-making process by offering information on the context of the incident, on the particularities of the infrastructural issues and systems involved, on the interdependencies and cascading effects

The introduction of iPDT will change the structure and tasks of the crisis management organisations. Training is paramount for successful acceptance and implementation of technology in any organisation. The aim of this report is to present a training approach and considerations for the selection of tools for training of crisis management operations. More specifically, the focus of this report is on a general outline for introducing the integrated PREDICT Decision support Tool (iPDT) to the stakeholders (and users) and on the design of the training for end-users.

We have provided a stepwise methodology (Event Based Approach to Training - EBAT) to develop such necessary training and we have given examples how this method can be used for training of crisis managers using iPDT. The most important recommendations from the EBAT approach are:

1. to develop learning experiences or learning tasks based on learning goals and not on operational tasks
2. to specify and introduce specific events in any training session that elicit the behaviours that contribute to the acquisition of necessary knowledge and skills
3. to create a meaningful learning environment for trainees where they can experience consequences of correct and incorrect behaviours, and receive feedback on how to improve their behaviour.

The next step in the PREDICT project is to take this EBAT approach and develop a specific training session for a crisis managers and their teams while using iPDT support.

1. Introduction

In crisis management, high-level decision makers have to make sense of complex problems in non-routine situations for which no simple analogies, automated, or rule-based solutions exist. These decision makers and their team have to collect, analyse and synthesize information to build an understanding of what is happening, they have to generate options for action and consider the consequences of different courses of action. Often, they have to attend to information from different conceptual domains simultaneously and interactively. And across comparable crises the conceptual domains involved and the way they interact may differ, depending on the context or stakeholder-organisations involved.

Critical Infrastructure (CI) networks are extremely important in modern day societies and our growing dependency on them is accompanied by an increased sense of vulnerability. The complexity and tight coupling of CI networks allow relatively small disturbances to rapidly escalate into compound crises (Boin & McConnell, 2007) while the consequences of such cascading failures are hard to predict. In crisis management organisations, many decision makers or their team already face serious difficulty to obtain reliable information on the state of the situation, let alone that they are able to predict how certain failures may propagate through a particular system and on to different systems, as compound failures usually manifest themselves in different organisations in various geographical locations.

The integrated PREDICT Decision Support Tool (iPDT) supports this sense-making process by offering information on the context of the incident, on the particularities of the infrastructural issues and systems involved, on the interdependencies and cascading effects (e.g. how failure can propagate through a particular system and on to different systems). Furthermore, the iPDT can support 'what if' reasoning to predict and consider consequences of different possible courses of action.

The introduction of these technologies will change the structure and tasks of the crisis management organisations. A consequence of automated support may include a shift from active control to more passively monitoring, organized in more diverse and distributed teams that share information across domains. This involves competences such as situational awareness, collaborative decision-making, workload management, and teamwork ability. Education and training have to be designed that prepare for such concrete and predicted changes in crisis management. The aim of this report is to present a training approach and considerations for selection of training tools for training of crisis management operations. More specifically, the focus of this report is on a general outline for introducing the iPDT to the stakeholders (and users) and on the design of training for end-users.

2. Training and training methodology: Event Based Approach to Training

The introduction of the iPDT will impact the future structure, work and competences of the crisis management organisation. The effectiveness of any new support system will depend on successful training of such new competences: various categories of users need to understand its functional and/or technical capabilities and limitations, how it should be implemented in a crisis management organisation, how it should be used, how to interpret its output, how to maintain it, and so forth. Proper training and education can promote and stimulate use of the iPDT. Thus, it is not only important to train the end users, but also to train the support and development groups, so they will have a sufficient level of awareness of the future use of the iPDT in crisis management. Such training and education need to be geared towards the needs and specific context of the various user groups: the end-users, the technical support groups and the iPDT development team.

For each of these user groups, the necessary competencies are best to be developed using guided learning experiences that capture the critical aspects of real world experiences (Coultas, Grossman & Salas, 2012; Salas & Cannon-Bowers, 2001). The traditional framework for instruction and training, which is based on first learning theoretical knowledge followed by practical training in field exercises, has practical and didactic drawbacks (Bosch & Riemersma, 2004). An example of a didactic drawback is that in field exercises, the instructor has limited control over the learning environment. It is therefore difficult, or sometimes even impossible to structure the learning situations according to an optimal sequence. The vast organizational and logistic efforts required to conduct a tactical field exercise are a practical drawback. In contrast, another form of training, called scenario-based training (SBT), trainees prepare, execute, and evaluate exercises that are simplified simulations of the real-world. In this approach, the users can practice skills in a relevant context, learn to discover the important cues in various problem situations, and to generalize the acquired knowledge for achieving transfer to unpractised situations. The opportunity to practice in a meaningful learning context, i.e. a context that provides feedback about the adequacy of one's behaviour, is expected to create deeper learning than knowledge transfer in a classroom setting or through learning media (books, video, ICT). However, in any practice setting where students interact with the learning content and each other, there is a risk of creating 'free play' sessions, where situations may occur that are unexpected or even unwanted by the instructor (Peeters, Bosch, Meyer & Neerincx, 2011). Therefore, it is important to minimize 'free play' and control the training scenario to guarantee the occurrence of experiences that help acquire the learning goals. For the development of such training, we will follow the Event Based Approach to Training (EBAT). EBAT is preferred firstly because it is a systematic approach to develop and introduce specific events in training that target to elicit the behaviours that contribute to the aimed knowledge and skill acquisition and secondly because it stipulates that there is an explicit relationship between learning goals and learning events (Fowlkes et al, 1998; Salas & Cannon Bowers, 2011).

EBAT starts with the identification of the skills required to perform the task. From that inventory a set of learning objectives for a particular (group of) user(s) is derived. Thus, real world tasks are not copied directly into the training exercise because this would be inefficient and sometimes ineffective for a number of reasons: First, different real world tasks may call upon the same skill, whereas other skills may hardly be called upon in real world tasks, creating risk of overtraining certain skills and undertraining others. Second, different users may each have their own individual level of knowledge and skill. This creates the need to introduce learning events that offer opportunity to practice a certain skill under different conditions: easy conditions for one user, difficult conditions for another, more experienced user. Therefore, although learning experiences should represent real world conditions, the design and scheduling of events in the training exercise have to be based on learning objectives rather than on real world tasks.

As argued, mere exposure to problem situations and practice is not enough to foster skill development. For learning to take place, deliberate or thoughtful processing of the context is required, as well as instructional cues to foster understanding and adequate skill acquisition. Feedback on behaviour and performance is of critical importance for the learning process. With EBAT, explicit links between the learning objectives, the exercise events, performance measures, and feedback are maintained. Performance measures are based on learning objectives and may deviate from real world operational performance standards. For example, during skill development the performance criteria may be set to a lower level than required under operational conditions. In contrast, when the goal of training is to achieve a level of mastery that protects the trainee against decay of skills and knowledge, performance standards during training may be set higher than operational performance standards (Arthur, Bennett Stanush, & McNelly, 1998; Driskell, Driskell & Salas, 2014).

In the following sections, we will describe each step of the EBAT approach in more detail. Where possible and relevant, we will use the given use case (the flooding scenario) to illustrate how EBAT can be applied for the training of the various user groups in using the iPDT. Therefore, we will start with a short overview of the different user groups and their generic training requirements.

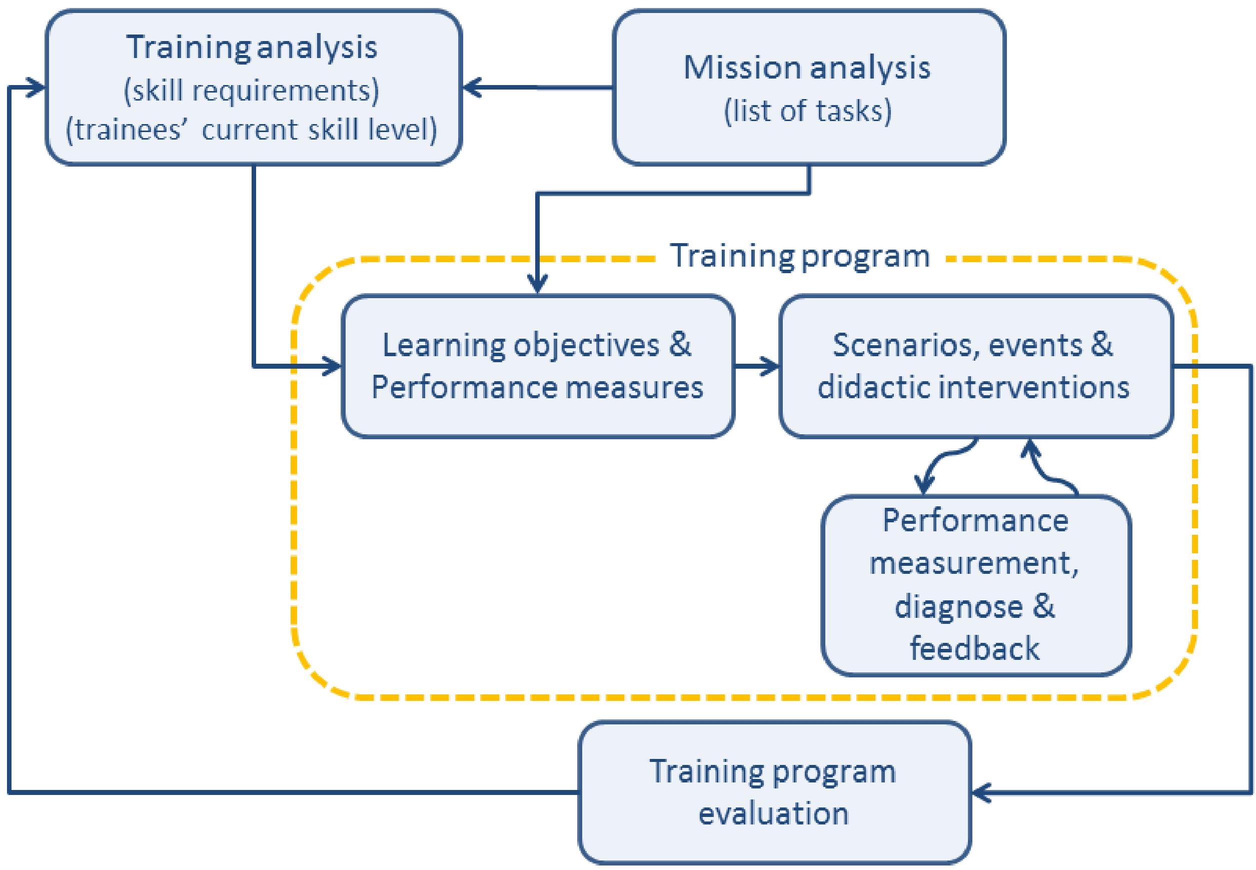

Figure 1: EBAT approach for training (inspired by Fowlkes et al. 1998)

1. "Mission analysis": an *analysis* of the mission of PREDICT-supported crisis management. It produces a set of tasks (mission essential tasks list). For each task, the criticality for the mission is determined, and under what conditions the tasks need to be performed . This assessment is needed to define criteria for performance (see box "Learning objectives & Performance measures").
2. "Training Analysis": an analysis of the requirements for training. It produces the set of skills needed to be able to carry out the tasks (skill requirements). In addition, it also produces an assessment of what skills are already mastered by these students and what skills need further training (trainees' current skill level). Both outputs are used to define the learning objectives (see box "Learning objectives & Performance measures").
3. "Learning Objectives & Performance Measures": a document specifying the objectives of training and the criteria for performance.
4. "Scenarios, events & didactic interventions": a *document* that guides the delivery part of training: the scenarios, the events that elicit the behaviour required for skill acquisition and so on.
5. "Performance measurement, diagnose & feedback": a *document* guiding the measurement and diagnosis of training performance, the delivery of feedback[1].
6. "Training programme evaluation": an *analysis* assessing the effects of training (increase of skills after following the training programme). Results are used to update the "trainees' current skill level", and thus reveal whether training has been successful in bringing the trainee to the desired competence level, or whether further training is required.

2.1 Mission and task analysis

The tasks of crisis management are dependent on the type of mission or context: Depending on the nature of the crisis and the objectives of managing the crisis (e.g. to safely evacuate a community during a flood, or to minimize damage and casualties of a hurricane) different tasks will have to be executed. Therefore, a task analysis starts with decomposing the mission in terms of its goal(s), how these should be reached, with what equipment / means and under which conditions. An example description for crisis management mission could be:

> You are the National Disaster Response Staff at the Ministry of Interior and at 06:24 in the morning of May 6 2016 you have received an early warning of a breach in the ring dike at Hardinxveld. The forecasted flooding will affect an area from Dordrecht in the south-west to Lexmond in the north-east. Within the next 3 days, it is expected that residential areas in Dordrecht, Hardinxveld, Nieuw Lekkerland, Alblasserdam, Oud-Alblas, Bleskensgraaf and Sliedrecht will have 4-8 meters water. It is your mission to safely evacuate these areas within the next 36 hours. You can deploy 13 teams (a total of 422 persons) from the Armed Forces

[1] This may be feedback to the student, but it may also involve recommendations when to adjust the training program (e.g. "after two wrong decisions, the trainee does not yet master the skill at the required level, so provide more scenario's for training at this level.")

in six locations, as follows: five teams (174 persons) in Dordrecht, three teams (89 persons) in Sliedrecht, one team (33 persons) in Oud-Alblas, one team (29 persons) in Alblasserdam, one team (40 persons) in Nieuw-Lekkerland, one team (45 persons) in Hardinxveld, and one team (12 persons) at Bleskensgraaf.

From the analysis of the mission, a Mission Essential Tasks List (METL) can be formulated. These tasks can be defined in terms of: Onset criterion, input, operations, output, critical task cues, critical conditions, frequency of occurrence, consequences of failure, impact/effect measure (see Table 1 for more detailed information of all aspects). Some operations need to be further divided and analyzed. Thus, a task analysis provides a structured inventory of subtasks; the required input for the execution of these tasks; the necessary skills and knowledge for the task operations; the critical conditions under which these have to be performed, and the standards for operational performance.

Task a: Decision on evacuation of residential area in flood area							
Onset criterion	Input	Operations	Output	Critical cues	Critical conditions	Frequency	Failure consequence
Breach at point (x_0,y_0)	Radio: Information on breach. Computer model: expected timeline expansion of flooded area Maps of area Demographic information of residents	Activities such as *collect information, decide on deployment of police officers, plan optimal route, check predicted flood*	Decision to evacuate at T=X	Information on expansion of flood Weather information Time	Bad weather conditions Night time Elderly people or hospital in area	Once every 5 years	Evacuated when no flooding happens = waste of time and money Evacuation too late: extra time and money to get victims out of area, casualties
Subtask a.3	Plan optimal route for evacuation						
Expected expansion of flooded area at T=X	Roadmaps Traffic Weather information	Identify different areas and categories of evacuees Decide on route per category			Road closure Heavy traffic		Traffic jams Slow progress of evacuation Casualties

		and area Communicate routes to police officers in charge					
Subtask a.4	Check predicted expansion of flooded area						
Incoming communication of emergency services in area (x_1,y_1)	Communication with emergency services Computer model: expected timeline expansion of flooded area Maps of the area	Check for consistency Falsify computer predicted model	More certainty on computer predictions	Timely updates from the emergency services in the field	No reliable communications Ambiguous input from emergency services		Increased uncertainty on the unfolding situation and the quality of the evacuation plans

Table 1: Task analysis with examples of task and subtasks

2.1.1 Stopping rule for task analysis

A critical issue in task analysis is to decide when to stop: How to decide to continue breaking down a task into subtasks or to leave that at a certain level. In line with Ormerod (2000), we suggest to cease further analysis when a task describes a single goal that can be reached without specification of the technology required (technology independent).

2.2 Training analysis

The tools of the iPDT are developed to support crisis managers in their situation assessment, option generation, what-if reasoning and decision-making. They constitute the primary target group for training. In order to be able to successfully exploit the tools' features, the trainees need to learn how to incorporate the tools into their work-flow. That means that they have to be skilled in executing the operation procedures: To use the tools for queries and checks. However, more importantly, they have to learn when and how to use the tools and how to use, that is understand and interpret, its output. This involves determining in what situations they can expect to profit from the system and when it is unlikely that the system will contribute to judgement and decision-making. Trainees must also learn to have an open eye for both the opportunities of a particular tool, but also for its potential weaknesses.

This requires learning how to evaluate the reliability of a tool's output, how to weigh it against their own assessments, and so forth. Another issue that also needs to be addressed in a training programme for end-users is that the introduction of automated support may change a crisis manager's role from active control to more passive monitoring and information management (planning). This is, in itself, not a significant change. It requires that the user is aware of this, remains vigilant at all times, and has the cognitive flexibility to switch roles if the circumstances demand to do so.

A second group of users to be trained are persons of the Administrative and Technical Units that support the end-users. They have to install, integrate and maintain the tooling in the operational environment of their respective organizations. Trainees of this group need to acquire the technical skills and knowledge to be able to work with the systems. For optimal integration of these tools in a crisis management organisation, they need to be aware of what type of crises can occur, and how the tools will be used by the end-users. A certain level of cross-training (Cannon-Bowers, Salas, Blickensderfer & Bowers, 1998; Lacerenza, Zajac, Savage & Salas, 2015) is needed for the staff of the Administrative and Technical Units to become familiar with the context and tasks of the end-users.

A third group of users to be trained are the system developers. They are responsible for the functional development and technical integration of the tools under development. This group also has to have a certain level of awareness on how the end-users will be working with the tools.

A final group to be identified for needing training in using the iPDT are the instructor/trainers. After all, they have to be able to point out the features of the system to the end user trainees, and how the output of the tools needs to be incorporated into judgment and decision-making processes. These instructor/trainers have to learn how to develop and deliver such training in the most optimal way. The focus of such a 'train-the-trainer' programme should lie upon how to instruct end users in the operation of the tools, how to teach their students to make optimal use of the tools, but also how to make them aware of the limitations of the tools, and how to evaluate the validity of a tool's predictions and advice.

Large scale flooding scenario's with cascading events typically involve several groups of stakeholders from various sectors and with different levels of responsibility. For training purposes, different choices can be made: a large-scale training involving all stakeholders as (primary or secondary) trainee groups can be set up. The learning goals then involve coordination and communication between these stakeholders. However, such a large-scale operation with more than one primary trainee group may create too many difficulties in the scheduling and control of learning events and feedback. Certain groups find themselves waiting while other trainees are collecting information or planning. For more efficient use of training time, one trainee group can be the target group, with other stakeholders being simulated. Coordination and communication procedures can still be trained with simulated agents or training support staff. Thus, if the mission and subsequent training goals involve coordination and communication between multiple stakeholders, it doesn't necessarily mean that all stakeholders need to be trained at the same time. Especially in preliminary sessions, with rather novice trainees, large scale-training sessions can not only be inefficient but also prove to be ineffective, because trainees do not deliver necessary input for next level trainees, depriving them of a learning opportunity. Large scale training sessions probably have more value with more advanced trainees, to prepare and test the whole organization – rather than train individual trainees – for operational missions.

2.3 Learning Objectives and Performance Measures

The mission and task analysis has provided a list of operations that have to be executed under different conditions. These form the basis for the learning objectives. Important here is to establish whether or not the training audience is capable of executing these operations under the specified conditions, i.e. possesses the necessary skills and knowledge, or whether some skills and knowledge are lacking. It may be that user groups do not possess the skill completely, or do not have the required level of mastery of a skill, or have never applied the skill under the specific (required) conditions.

Learning objectives specify what has to be learned during training. They should be formulated in terms of observable behaviour so that it can be established whether or not they are met. Learning objectives can include a description of the skill (e.g. formulate alternative evacuation route), the conditions under which that skill has to be performed (e.g. for evacuation of a residential area in case of flood) and a standard for observable behaviour (e.g. at least three contingency routes).

2.3.1 Learning Objectives for Crisis Management

Studies have shown that experts in crisis management have large collections of schemas, enabling them to recognise a large number of situations as familiar (Van den Bosch & Helsdingen, 2007). These schemas facilitate recognition and categorization of problem situations, thus guiding the selection of an appropriate response (Klein et al, 1994). Being able to interpret a crisis situation adequately requires the recognition and judgement of relevant factors (e.g. weather, time of day, etc.). Novices do not (yet) have elaborated mental tactical schemas. They are therefore more inclined to focus on isolated cues and tend to take these at face value. Further, they are often not aware of assumptions they implicitly adopt to fill in missing parts; hence, they cannot be critical about them, and are more likely to “jump to conclusions”. If we want novices to become experts, training in crisis management therefore needs to address two components: (a) Expansion and refinement of mental schemas, and (b) practice in solving complex and unfamiliar problems.

So, training should focus on practice in a variety of relevant problem situations. This is necessary to develop the elaborate schemas needed for crisis management in real life. In addition, training should incorporate practice in exercising critical thinking strategies needed for thorough situation assessment during the crisis management process. The iPDT can be used to support this critical thinking: The tools help the user to identify how a crisis situation may develop, and thus help the user in acknowledging the possibility of cascading events. Furthermore, the tools may support the user in evaluating possible interventions before these are implemented by predicting the outcome of alternative courses of action. At the same time, with the introduction of such tools and the changes in crisis management that it brings about – for example by providing information on cascading consequences propagating through different domains and geographical areas, it is even more important that end-users have situational awareness, collaborative decision-making skills and are able to manage workload and teamwork. And to reduce the risk of overreliance on automated support tools, training could prepare users to stay vigilant in their monitoring role and actively reflect upon available information and the systems’ predictions.

2.4 Scenarios, events & didactic interventions

The inventory of learning objectives is used to select and design the learning environment appropriate for the objectives. EBAT uses Scenario-Based Training (SBT) as the learning environment. In SBT, trainees prepare, execute, and evaluate exercises that are simplified and especially designed simulations of the real world. SBT is considered to be an appropriate approach for training competencies required in complex task environments (e.g. Fowlkes, Dwyer, Oser, & Salas, 1998; Hoffman, Ward, Feltovich, DiBello, Fiore, & Andrews, 2013; Oser, 1999). It focuses, on the development of practice, diagnosis and feedback in a meaningful learning environment (Korteling, Helsdingen & Theunissen, 2013). In meaningful learning environments, specific critical elements of the real world are represented to provide a high amount of ambient information and feedback to support active practice and learning. For certain psychomotor skills, this means that certain physical characteristics of the real world have to be represented with high fidelity, i.e. does a training steering set mimic the real world vehicle in such a way that the forces experienced during training are the same as in the real vehicle. But for other types of skills, it is not the degree of realism of the physical characteristics that provide meaningful environment, but rather the psychological validity of the context. This means that for the end-users of the iPDT, critical elements of the crisis management task environment have to be represented, including critical elements from their interaction with the iPDT. Not the physical characteristics of these tools will be important, but typical output of the system should be modelled in the training scenario: e.g., the systems' prediction of propagation of a flood, or information from the iPDT on the status of critical infrastructure in the flooded area. This will provide the users with an opportunity to learn how to incorporate this type of information in their situation assessment and decision-making in a crisis. It may even be considered to represent one of the tools with a lower level of reliability than in the real world, so users experience problems during training when they blindly follow the system and are thus triggered to critically reflect on the accuracy of the systems' output.

2.4.1 Learning from events

In EBAT, learning takes place as a result of events, purposely introduced in the scenario to trigger particular behaviour of a trainee. It is this behaviour that brings about the acquisition of the necessary knowledge and skills. Such events may be used to trigger the same activities as used in the operational environment, but they may also be used to elicit activities such as reflection or other processes that will contribute to learning.

Important in the specification of an event is its correspondence to a learning objective, the onset of the event's cue in the training session, and the desired trainee's response. This information can be taken from the task analysis (onset criterion and/or critical cues) and from the learning objectives (standard for observable behaviour). Table 2 provides an example of events appropriate for learning crisis management with the use of iPDT.

Learning objective	Learning event	Onset or trigger cue	Critical conditions	Required response
Route planning	iPDT Assessment: Residential area will be within flooded area	PREDICT Tool assessment Time (flooding) at Location (residential) = T0+60	Severe weather Heavy traffic on one of the main roads	Identify 3 areas. Plan different route for each area Have contingency ready for each area Secure free route for emergency services
Check predicted expansion of flooded area	Incoming communication from the field contradicts the systems predictions	Communication from the emergency services	Ambiguous communications from the emergency services Communications lost	Actively check status of area to falsify computer prediction Communicate with different geographical areas

Table 2: Specification of learning events for learning objective

2.4.2 Scenario and didactic interventions

A scenario consists of a description of the background of the task or problem the trainee has to solve, a starting point, and the specification of events. Scenario-based training programmes have the advantage that they present real world problems, embedded within a realistic context, and often with some level of interaction and time constraints that resemble real world situations (see Table 3 for a typical scenario flow).

Successful scenarios for crisis management training have the following characteristics:

- Dilemma: The scenarios represent a fundamental property of crisis management: uncertain and incomplete information about the situation at hand.
- Uncertainty: Information on the situation is limited and time to solve the problem is limited, thus, decisions have to be made before all information is collected.
- Unexpected events: During the training, unexpected or surprising events (from the viewpoint of the trainee) are introduced to encourage reflection upon the situation and upon the anticipated effects of alternative solutions. Furthermore, this also fosters discussion with the other team members.

- Irrelevant events: Trainees have to learn to recognize important cues and how to act appropriately. However, if all events and cues in a scenario are relevant to the situation, the trainee does not have a chance to learn to distinguish between relevant and irrelevant information and events. Therefore, scenarios also have to contain irrelevant information.

A strength of scenario-based training is that it provides trainees with a structured learning environment representing the actual task environment. This helps the trainee to acquire the required knowledge and skills in an active fashion. As argued before, scenario-based training is not limited to experience and practice. It also emphasizes reflection, feedback and discussion. This aspect is very important as it facilitates elaborate processing of the learning experiences, resulting in knowledge representations that allow trainees to use that what has been learned in similar other tasks and situations (transfer of training).

It has been shown that variability of practice is very important for skill acquisition (Soderstrom & Bjork, 2013). Variability of practice enables trainees to discover variants and invariants between situations, and relate these to the effects of their behaviour. Variability of practice helps trainees to develop elaborate mental representations of situations and of the task.

Another measure that may be expected to enhance learning value of scenario is practice in the zone of proximal development (Clapper, 2015). For scenario design this means having a set of scenarios of different levels of complexity. Trainees may be practicing on scenarios that are somewhat too difficult for them, but in such scenarios support should be given. Trainees can benefit from such support by copying elements from an expert's approach, solution, or representation of the task.

A particular way to support trainees is by introducing scaffolds. Scaffolds may be in the form of augmented cues, when specific relevant cues in a situation or problem description are augmented to attract the trainees' attention and help the trainee distinguish between relevant and irrelevant information. Augmenting may be realized visually, for example, by increasing contrast values on a screen, or auditory, by presenting a warning signal.

Learning objective(s):	Communicate inbound free routes for emergency services
Background information	Here the story for the trainee is sketched with background information on the crisis and the conditions are described. Also, critical elements in the story are presented (usually not given to the trainee). E.g. Expected flooding of residential area (x_1,y_1) within 7 hours after breach in dike at point (x_0,y_0). Three separate routes for the different areas of the residential area are planned (see map). The trainees' job is to plot free inbound route for emergency services and communicate this to the emergency services. Critical conditions for variation: - Heavy traffic on A 27 prevents emergency services taking northern inbound route, alternatively, they can take A2, A15 for southern route or N 210 for

	northern route depending on traffic on the evacuation routes. - There's a football match in Feyenoord stadium, keeping the city's emergency services in the city. Alternatively, stand by services should come from Gouda or Breda.			
Time	Event	Input (information presented to the trainee)	Assessment that trainee should make	Reaction (observable behaviour that trainee is expected to display)
T = 0	Start scenario, all information provided to trainee. Request to plan inbound routes	Maps of the area with evacuation routes plotted List of emergency services that are on standby (where they are coming from, etc)		
T+15	Incoming call for asking emergency medical support from location (x_1,y_1) in the residential area		Identify correct team at correct geographical location Select correct route	Communicate inbound route (x,y) to standby emergency medical services in Rotterdam Haven Hospital within 2 mins
T+18	Incoming call from emergency services claiming part of route (x,y) is flooded	Maps of the area Computer model prediction of affected areas	Incoming information contradicts predictions from computer model.	Collect more information to falsify incoming information and/or computer predictions

Table 3: Example of a scenario script

2.4.3 On the frequency, variation and scheduling of learning tasks

The scheduling, variation or frequency of learning tasks during training does not have to correspond to reality. In pilot training for example, we can schedule several landing sessions at different airports after another, without any take off or cruise flight in between if the training equipment allows for that (a simulator). Although trainees may have some difficulty accepting the practising of separate flight segments without real-world order of take-off, cruise flight and landing, such a schedule may prove to be most efficient. Similarly, it is often opportune to practise certain emergency situations more frequently than they would happen in real life. If a skill or task is very important, then it needs to be trained frequently, even if the situations may seldom occur in the real world. Another consideration is to include practice variation. Practise variation has proven to be beneficial for learning. Even if that variability is not part of the required post-training performance, the variability during practice has been proven to enhance post training performance, compared to constant practice, on a number of different task types (Burke & Hutchins, 2007; Schmidt, 1975).

For effective and efficient use of training time, it may be required to accelerate certain processes to avoid idle waiting time, or to slow down other processes to provide more practice opportunity and prevent frustration. It is paramount to consider the consequences of these timeline alterations: trainees have to be informed, and if trainees are given more time to execute certain actions; the learning plan has to include steps to develop the trainee to the level where s/he can execute tasks at operational speed.

2.5 Performance Measurement, Diagnosis & Feedback

The next step in training design is the specification of performance measurement protocol. Effective performance measurement not only allow assessment of whether trainees achieve the learning objectives, but also they help to determine why performance occurred as observed and to diagnose any knowledge gaps or misconceptions. In crisis management, task performance relies for a considerable part on internal mental processes, such as reasoning, memory retrieval, and knowledge integration. For example, a situation assessment officer may be engaged in assessing the consequences of a cascading crisis situation, without showing any observable actions related to this process. This implies that measures are needed that reveal the trainees internal processes and strategies. This can be done best by an instructor, who monitors the behaviour of the trainees by, for example, asking them to “think aloud” about their task performance. After Action Reviews and post-training discussions may also shed light on the processes of assessment and decision making that took place during the training. It may also reveal how these processes were supported (or distorted) by the iPDT tools.

Another complicating characteristic of crisis management is that there is often no single “right” way to accomplish a task (Hutchins, Kemple, Porter, & Sovereign, 1999; Link, Meesters, Hellingrath & Van de Walle, 2014). Especially in cascading crisis situations there exist multiple threats, and interventions that may alleviate one threat may simultaneously worsen the consequences of another threat. This makes it hard to assess the quality of trainee performance in objective terms, as an action may be adequate from one perspective, but highly inappropriate from another. Therefore, domain-expert instructors are needed for evaluation of trainee behaviour and performance (Van den Bosch & Riemersma, 2004), because they have the expertise to:

- *Infer internal processes* from evaluating the covert relationship between events in the outside world, internal process, and observable behaviour.
- *Take the situational context into account* that is needed to interpret trainee behaviour.
- *Interpret subtle cues indicating internal processes*. Determining that a trainee is anticipating possible or likely events, or when he is considering alternative solutions.

To support instructors in conducting performance evaluation systematically, protocols and instruments are useful (Van Berlo & Schraagen, 2000). This is also recommended for the crisis management training with the iPDT. This can be achieved, for example by tallying whether or not a particular behaviour was shown (see Table 4). Standards can be drawn up for their training performance: for novices standards may be lower (e.g. 75% correct identification) than for advanced students. Another solution would be to have the standards the same as for experienced trainees but to support novices (with scaffolds or worked out examples).

Learning objective	Time	Trigger event	Assessment	Observable behaviour	Evaluation (by instructor/evaluator)
Communicate inbound routes for emergency services	T +15	Incoming call for emergency medical support at residential area	Identify correct team at correct geographical location Select correct route	Communicate inbound route (x,y) to standby emergency medical services in Rotterdam Haven Hospital	Correct communication Performance too slow, call made at T +21

Table 4: Scoring form for trainee evaluation during scenario

2.5.1 Feedback

For learning, feedback on the effects of one's behaviour is indispensable. Within psychology and educational sciences a lot of research has been done on the efficiency and effectiveness of feedback for learning (see e.g. Hattie & Timperley, 2007; Kluger & DeNisi, 1996). Several types of feedback have been identified, such as positive and negative feedback, process feedback, outcome feedback, cognitive feedback, delayed feedback, peer feedback, to name a few. In general it has been concluded that positive feedback is more effective than negative (Balzer, Sulsky, Hammer & Sumner, 1992) and delayed and infrequent feedback (Klayman, 1988) generates better post-training performance than frequent and immediate feedback.

Outcome feedback only provides information on the correctness of a decision; cognitive feedback concerns the person's cognitive processes in relation to the task. In complex tasks like crisis management, cognitive feedback is often appropriate and effective.

In providing feedback to the trainees, it is important not only to focus on the 'what' but also on the 'why' of performance. Why did certain things go well, why were certain mistakes made? A good After Action Review with the trainees and a facilitator helps to diagnose mistakes and to come up with solutions to overcome these a next time.

Providing cognitive feedback is closely tied to performance measurement (see previous section), because feedback can only be based on some kind of evaluation of the underlying processes. In the development of a novice to expert level there is ideally a shift from external evaluation and feedback to self-evaluation and learning through reflection. In the early phases of training the domain-expert instructor guides the trainee's acquisition of skill by pointing out in his/her feedback the relationships between the context, the environment, actions, and outcomes. In the more advanced phases of training, trainees should no longer be entirely dependent upon their instructor for performance evaluation and diagnosis: They should be provided with tools for self-assessment and correction, and should be encouraged to discuss solutions with other trainees. Here lies an opportunity for using the iPDT. The tools may be used by the trainee to deliver feedback on the situation assessment and on the outcomes of actions under consideration. This demands, of course, a critical attitude of the trainee towards the reliability and validity of the tools' output.

2.6 Training Programme Evaluation

A method for designing a training programme needs to include a procedure for evaluating its effectiveness. It is important to establish whether training crisis managers in using support tools has the desired effects. Outcomes may be used to refine, replace or modify selected training methods and content. The success of a training programme can be evaluated at different levels (Kirkpatrick, et al. 1994): At the level of trainee' experiences, at the level of training effectiveness, at the level of transfer of skills and knowledge to the job, and at the level of organisational impact (see Table 5).

Level	Description
Reaction	Which were the trainees' thoughts and feelings about the training
Learning	Increase in knowledge/skills/attitudes during, and as a result of training
Behaviour	Transfer of learned knowledge/skills/attitudes from the training situation to the real world situation
Results	Improvements of training on the organisational level (increased sales, less failure in operations, increase in production)

Table 5: Levels of evaluation of a training programme (from Kirkpatrick et al, 1994)

Trainee's experiences may be collected through questionnaires after the training, or observations during the training. However, most trainees, and especially novices, are poor judges of their own learning and progress. Oftentimes, what they experience as effective training is the training where their performance is good and where they make few mistakes. However, many studies have proven that this type of training does not guarantee good learning. It has been shown that performance during training and performance after training are inversely correlated (Schmidt & Bjork, 1992). Thus, when trainees struggle during training and make mistakes, they tend to benefit more in terms of learning and post-training performance than when instructional support, scaffolding or easy training problems makes the training session smooth and easy. In this respect, Bjork (1994) refers to the concept of "desirable difficulty", as something that should be strived for to prevent illusions of competence on the one hand, and frustration on the other.

The second level of training evaluation, learning, is evaluating whether the training objectives are met. In the context of this report, this refers to the objective of training persons in making use of iPDT in their crisis management task. An appropriate measure of effectiveness would be to compare end-of-training performance of the trained group with another group (e.g. a non-trained group, or a group following another training programme).

The third level concerns the transfer of knowledge and skill to the job. A measure of effectiveness for a training in the use of support tools (PREDICT) would be to assess how in a real crisis the trained group use the iPDT and how this affects the quality of their assessments and decisions (as post-hoc determined by a group of experts in an evaluation session). Although it is difficult to compare performance in real life situations, an attempt could be made to compare this to a group who hasn't been trained. Because measuring performance in real life is difficult and expensive, it is not often done. A first reason for this is that not all jobs allow for such measurement, especially when the tasks concerned are rare or dangerous, as is the case with crisis management. Secondly, even if changes in job behaviour are found, it is often difficult to relate them unequivocally to the training interventions.

The fourth level of evaluation is the organisational impact of the training. This is even harder to measure objectively, but experiences of superiors or measurements over longer periods of time (e.g. performance of trained teams across a series of crises) may give an indication of the training's impact. This information combined with the lessons learned on the other levels can prove to be fruitful to reflect on and to improve a training programme.

2.7 Considerations and limitations

EBAT is a systematic way to design scenario-based training for complex task performance. By specifying events that elicit certain critical behaviours, it is expected to have a higher training value than when a scenario would just be free-play scenario in which events occur by chance. And because in EBAT scenario events are predetermined (in time or order) performance can be monitored and evaluated for discussion afterwards. Nevertheless, there are limitations of the EBAT approach to consider:

First of all, not all complex skills are best trained using scenario-based training. The meaningful learning environment capturing lots of critical (physical or psychological) elements from the real world job will only be an efficient training vehicle when the trainee needs to have this explicit presentation of rich context. This is usually the case with novices lacking contextual knowledge and experience. In contrast, experienced professionals that need to further their (academic) knowledge or higher-order generic skills (such as academic writing or people management), may be better served with written documentation or classroom instruction because these skills are relatively context-independent, conceptual, and abstract.

Secondly, research has shown that activities that occur prior to training may even have a greater impact on how effective training turns out to be (Tannenbaum, Cannon-Bowers & Mathieu, 1993) than activities during or after training. These factors fall into three general categories: (a) what trainees bring to the training setting, (b) variables that engage the trainee to learn and participate in developmental activities, and (c) how the training can be prepared so as to maximize the learning experience.

Considering these limitations, it is important to have insight into the characteristics of the trainees: their skill levels and personal characteristics. In this document, we have focused mainly on the end-users, but similar efforts should focus on the administrative, technical and training staff user groups.

3. Next Steps

> "*In spite of the conceptual momentum generated by public discourse on network-centric operations or perhaps because of it, it is important to consider the consequences of relying too heavily on technology in the process of decision making, and in other processes central to command and control (C2). The idealised potential for sensors, computers and communications to support a Revolution in Military Affairs should not be accepted unquestioningly. It needs to be recognised that a strategically useful leverage of technology will require talented, highly trained personnel as well as the development of appropriate tactics and doctrine to deliver the expected benefits (O'Hanlon, 2000). These considerations are often easily dismissed in rhetorical arguments by the advocates of technological solutions."* (p 192 from *A history lesson on the use of technology to support military decision making and command and control*. Bolia, Vidulich, Nelson & Cook, 2007)

Training is paramount for successful acceptance and implementation of technology in any organisation. We have provided a stepwise methodology (EBAT) to develop such necessary training and given examples how this method could be used for development of training crisis managers using iPDT in cascading flood crises. The most important recommendations from the EBAT approach are:

1. to develop learning experiences or learning tasks based on learning goals and not on operational tasks
2. to specify and introduce specific events in any training session that elicit the behaviours that contribute to the acquisition of necessary knowledge and skills
3. to create a meaningful learning environment for trainees where they can experience consequences of correct and incorrect behaviours, and receive feedback on how to improve their behaviour.

Within the context of the PREDICT project, the next steps are to use this methodology and guidelines to develop specific training programmes for the different operators that make use of the iPDT.

In order to do that properly, the six steps from EBAT training methodology approach are to be followed. Taking the PREDICT cases as a starting point, different positions and parties can be identified that have a role at specific steps. Table 6 shows a first attempt to assign these roles.

Step	Name	Short description	Responsible	Contribution from PREDICT Tool Development
1	Mission analysis	Analysis of the situations in which crisis management teams are likely to use tools from the iPDT to manage the crisis. The analysis produces requirements in terms of a set of tasks and the set of associated skills to be able to carry out the tasks	Policy-making officials; mayors; experienced crisis managers; project manager PREDICT-tools Suite	The mission is, of course, formed by the type of anticipated crisis in the future. The mission of the CM-team is to be able to manage these situations, thereby assisted by the iPDT: what kind of input do the PREDICT tools require, what kind of output do they deliver; what is the level of validity and certainty, etc.
2	Training analysis: Skill requirements and training group analysis	First specify the skills needed to be able to perform the mission task, and constitute the learning objectives: which competencies need to be mastered by the trainees Secondly assess the skills that the target trainee group already masters and which skills need further training	Training developer / instructor / Mission Leader (+) (project manager PREDICT is needed to shed light on the skills required to operate the systems and to process its output)	This will mainly be dependent on how the use of the iPDT changes the crisis management tasks.
3	Learning Objectives & Performance Measures	The activity of specifying the assessed skills in terms of operationally defined learning objectives that can be measured	Mission Leader & Trainer	Specify the behaviours that one has to be able to perform during and after training, including the use of the iPDT.
4	Scenarios, events &	This constitutes the structuring of	Training	Tool Developers to prepare

	didactic interventions	the learning objectives in a set of scenarios, to define the events that will evoke the required skills, to define and implement the didactic interventions to foster learning from these scenarios. It also involves the actual delivery of training	developer with Mission leader	their tools for use, in particular to the events introduced in the training scenarios
5	Performance measurement, diagnose & feedback	Measuring and diagnosing training progress, and providing data for the decision on possible adjustments of training	Trainer	Tool developers are required to provide information on how trainees should be informed about the system and its use, as well as after correct use as incorrect use of the tools
6	Training programme evaluation	This assesses the effects of training (increase of skills after following the training programme, in particular on skills involving the use of iPDT) to reveal whether training has successfully achieved the desired competence level, or further training is required.	Mission Leader with Trainer	Tool developers use the results of these analyses to modify their system, and/or the interface to the tools (e.g. the way the tool presents its output to the user).

Table 6: The steps involved in developing EBAT-training in PREDICT-supported crisis management, the responsible positions and/or parties involved, and the implications for PREDICT Tool development.

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