TRAINING AND SUPPORTING FIRST RESPONDERS BY MIXED REALITY ENVIRONMENTS

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Abstract

The perception and awareness of the possibilities of *chemical, biological, radiological, and nuclear ("CBRN")* emergencies is constantly growing. These dangers are in most cases not directly detectable by human senses and as a consequence no inborn or trained refle- xes of reaction exist. One has to explicitly design and validate(!) special procedures ('Best Practices') to detect and to counter such dangers. These Best Practices have to be specifi- cally trained, especially under near-realistic yet safe conditions. Modern technology allows to *simulate* actual situations (including the use of simulated tools) and the consequences of various courses of action in a realistic way.

The overall goal of the SimRad.NCB project is the development and utilization of trai- ning tools for First Responders for all aspects of an intervention in emergency situations, including technical procedures, management, team coordination, etc.

By taking a process view these interventions can be dissected into individual emergency processes and their subprocesses. This allows a pin-pointed substitution of some individual activities by a simulation, ranging from coarse approximations up to near-realistic simula- tions using Mixed Reality technology.

This paper is an evolution and expansion of [Chroust et al., 2008] and will specifical- ly emphasize the process point of view of these response actions and the corresponding simulation possibilities.

1 Responding to CBRN-emergencies

1.1 Problems of CBRN-emergencies

The perception and awareness of the possibilities of *chemical, biological, radiological, and nuclear ("CBRN")* accidents is constantly growing. In case of an emergency professional re- sponse groups, so-called First Responders (e.g. fire brigade, ambulance services, police forces) together with voluntary helpers who are initially in charge of handling the emergency situation, with later support from specialists (e.g. chemists, laboratory personnel, civil protectdion forces). They have to take appropriate rescue actions in order to minimize the negative effects.

An important part of the problem concerning these dangers is that we do not have any inborn, natural "sensors" to recognize them, let alone natural, semi-autonomous reactions. This requires adequate training with respect to the emergency and properly operating the equipment and tools for identifying and interpreting these dangers, drawing the correct conclusions, and initiating the appropriate reactions. The appropriate actions might even be counter-intuitive and, if not well chosen, might negatively interfere with one another.

This requires especially First Responders to be well trained under realistic and practical condi- tions, involving considerations of human factors, reactions and cooperation.

As learnt from business and software engineering, a key to effective management of various situations is the process view.

We consider the various processes involved in a first response, performed by different First Responders. In analogy to similar approaches in software engineering we will pave the steps for analyzing and assessing the capability and maturity of the involved processes, and thus build a basis for improving them.

Up to now a realistic reproduction of emergency situations without creating real dangers (similar to flight simulators) for training under 'safe conditions' on a larger scale was usually infeasible due to a lack of appropriate environment. Modern Information and Communication Techno- logy allows to *simulate* such situation, both based on past actual situations ("play-back") and imagined ones. Such simulations have numerous advantages beyond eliminating dangers and problems from usual outdoor exercises. The availability of various simulation approaches also gives us a chance to establish some *systematic and standardized* training programmes, where specific individual pieces of training can be enacted in their proper context. To support this approach it is of advantage to take a *process oriented* approach to analyze emergency inter- ventions and orient the individual training situations on the holistic process view of the whole intervention.

The rest of the paper is structured as follows: After a general discussion of First Responders' issues and the concept of process in chapter 1. Chapter 2 discusses the individual process cate- gories and the processes and subprocesses with respect to interventions. This leads up to chapter

3 where the possibilities of replacing various subprocesses by simulation are discussed in view of improving the safety and intensity of training. Chapter 4 sketches the project SimRad.NBC in which these ideas are elaborated and concepts and their feasibility are studied.

1.2 Needs of First Responders

A recognized emergency situation causes some so-called First Responders (e.g. fire brigades, ambulance services, police, security organizations and voluntary helpers) who are initially in charge of handling the emergency situation, with later support from specialists to respond to the emergency call. They are usually generalists, knowing *most* hazards but only to a certain depth. Obviously these processes will be to some extent iterative and error prone (fig. 1).

- As our basis of thinking we assume that the kind of emergencies we consider are cau- sed by the appearance of some kind pollutant, be it that a container leaks, be it that the dangerous agent came from somewhere else (e.g. airbound).

- First Responders must be able to identify, analyze and interpret symptoms and indicators.
  Preferably their analysis should be based on available indicators (measurable data). Un-
  fortunately most CBRN- materials are only detectable by appropriate technical devices.
  With respect to the different emergencies various Best Practices of behavior (also called
  'Standard reactions') exist. These Best Practices have been identified out of experience
  of the past to be the most appropriate actions *under a given set of circumstances*. Based on the analysis First Responders have to make the appropriate decisions with respect to tactics and strategies (choosing an available/feasible Best Practice, etc., see fig. 4.

- This means that First Responders must have available some own knowledge to distinguish the applicability of the appropriate Best Practices, be it based on memory or on access to an information source (fig. 1).

- Additionally they must be able to request ad-hoc and just-in-time additional information on the specific situation (fig. 1).

- They have to make decisions which are often irreversible on the Best Practices. For these decisions computer-support could be highly useful.

- CBRN-emergencies usually also involve persons as victims. It is necessary to give them medical, technical, or psychological support and help.

- They also have to consider potential or existing damage to objects-at-risk and environ- ment and the effects of the chosen Best Practice.

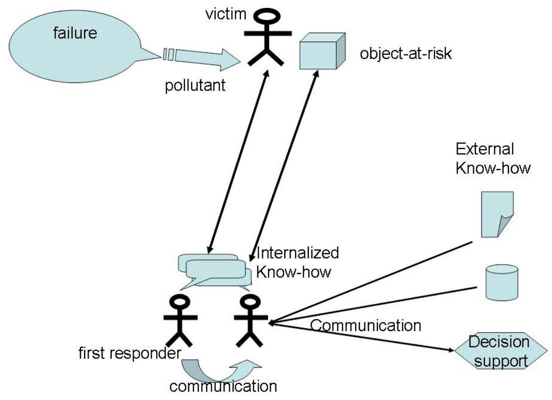

Fig. 1: First Responders' information need

In order to train First Responders a simulation framework is provided for them with several technologies for teaching and training on several levels of understanding and detail.

2 Emergency-Responses - a Process View

2.1 What is a Process?

An intervention due to an CBRN-incident is a highly complex undertaking. Reasons are the invisibility of dangers and the comparative newness of the challenges. A process view, i.e. a view which concentrates on the *whole* process and its subprocesses to be per- formed has proven to be effective and helpful in many other complex undertaking li- ke in business [Scheer, 1998, Ould, 1995] and in software development [Humphrey, 1989, El Emam et al., 1998, Wang and King, 2000]. A process view is also a key to understanding the *whole* challenge and a basis of improvement. The more complex the task is, the more a process view is needed.
The statement by [Chroust and Schoitsch, 2009] *"Industrial maturity demonstrates itself in the ability to abstract the development process from the specifics related to the production of the individual product. ..."* is also valid for emergency intervention (replacing 'development' by 'in- tervention', 'production' by 'performance' and 'product' by 'intervention'). Such an abstracted process acts as a template, process model, for future development processes, called "instan- tiation" (fig. 2). This abstraction is not straight-forward, since it is necessary to decide which features of an individual process are considered to be specific to an individual product and which features are to be considered relevant for the process model and thus for future proces- ses. Conceptually we separate the WHAT (individual product one wants) from the HOW (this should be done in a general fashion).
Obviously one has to choose a compromise between too general a process description - covering all types of situations but lacking any specifics about an individual situation - and too narrow a description which cannot be applied to a large enough class of situations.

Simple processes like building a chair are usually learnt once and for all in apprenticeship, more complicated ones (e.g. assembling a cupboard from prefabricated parts or cooking an unknown dish) need guidance by a written, formalized description, i.e. a Process Model. The notion of process models is actually our daily routine: cooking recipes, instructions on how to operate the video recorder, the car, etc. are essentially process models describing (in more or less detail) a necessary processes. For unknown or complicated processes

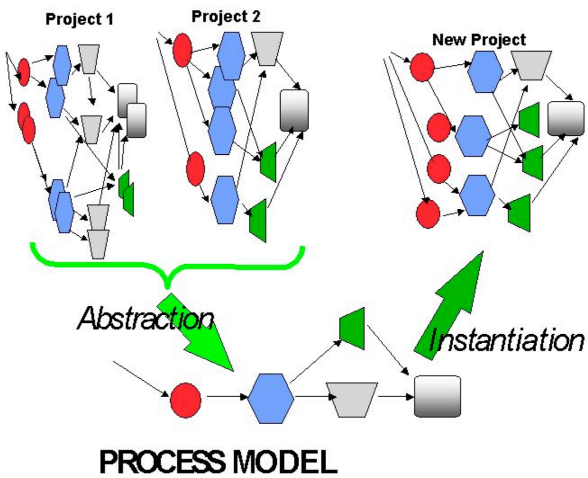

Fig. 2: Process Abstraction and Instantiation

Once the process model is established by abstraction from many processes (fig. 2) it offers numerous advantages:

- All processes, all subprocesses and their interaction can be identified and described to a certain depth.
- The whole intervention, from its very beginning to its (hopefully successful) end can be viewed, taught, and analyzed.
- The same process model can be applied to different interventions.
- One can "reason about the process", about advantages and disadvantages of certain me- thods and activities.
- One can gradually improve the process based on past experience [El Emam et al., 1998] by adding newly detected process know-how to the process model to be utilized by future interventions.

2.2 Process Categories

Following ISO/IEC 12207 [ISO/IEC, 2007] we can distinguish three essential categories of processes (see fig. 3):

Primary Life Cycle Processes consist of processes that serve primary purposes and goals of the intervention, in our case resolving an emergency.

Supporting Life Cycle Processes consist of processes that support another process as an inte- gral part with a distinct purpose and contribute to the success and quality of the interven- tion. A supporting process is employed and executed, as needed, by another process.

Organizational Life Cycle Processes consist of processes employed by an organization to establish and implement an underlying structure made up of associated life cycle pro- cesses and personnel and continuously improve the structure and processes. They are typically employed outside the realm of specific intervention; however, lessons from such projects and contracts contribute to the improvement of the organization.

In the sequel we will (still incompletely) identify different processes and subprocesses within the categories.

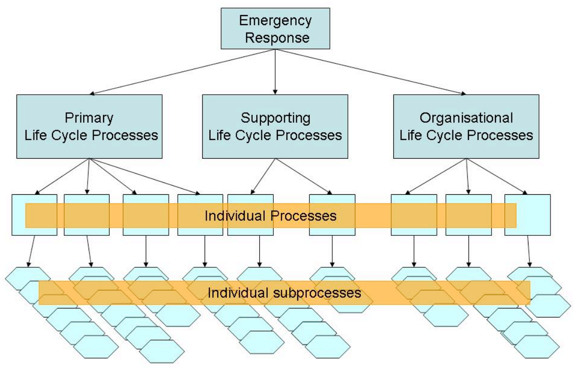

Fig. 3: Hierarchy of Processes

2.3 Primary Processes

Reaction to an Alarm This is the actual starting point for the set of intervention processes.

Key subprocesses are accepting an emergency call, decision on trustworthiness and re- liability of call, mobilize appropriate First Responder units, coordinate with other First Responder units,

In-situ Analysis A serious problem in CBRN-emergencies it the lack of 'inborn' sensors for the danger, even recognizing that it is a case of an CBRN-emergency might sometime be difficult.

Key subprocesses are: Causal Analysis, analysis of the total situation, identification of secondary and emergent Dangers

Evaluation of Situation, tactical and strategic decisions Having acquired a certain knowled- ge about the emergency situation it is necessary to decide on the appropriate 'responses', both short-time immediate tactics and longer-term strategies.

Key subprocesses are: assess available resources and their availability over time, tactical and strategic planning and decisions, define a strategic roll-out plan, communicate the strategic roll-out plan, etc.

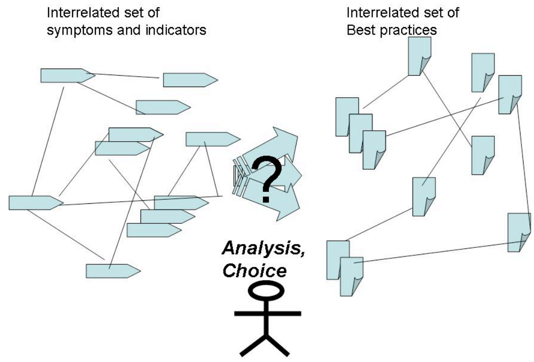

Fig. 4: Choosing a Best Practice

Actual Intervention Probably the most obvious need is to understand and learn Best Practices for 'technically' handling the individual emergency situations. This means mostly tech- nical knowledge of how to behave and to act, but management etc. are equally important.

Key subprocesses are: consider safety and security of First Responders, help and treat vic- tims and endangered persons, Manage Risk, secure and protect objects-at-risk, consider and handle secondary and emergent dangers

Terminate Intervention At some point the intervention end for the First Responders.

Key subprocesses are: successful termination of emergency, hand-over to specialists, Re- porting and Feedback

2.4 Supporting Processes

Besides the key processes described above, which depend on one another and have to be per- formed in a certain sequence (but with iterations and refinement steps) there are global subpro- cesses which cover the whole process.

Communication A key to a successful intervention is obviously the communication between different First Responders, even across organizational boundaries. In many cases direct communication might be hampered or obstructed by physical (noise, smoke, visibility), physiological gaps (hard hearing, or cultural barriers (language, taboos, ...). A fuller dis- cussion can be found in [Chroust, 2008a].

Key subprocesses are: communicate with your co-responders, communicate with victims, communicate with central command, communicate with information sources (knowledge data bases),

Management and Coordination is concerned with organizing the interplay between diffe- rent units from different organizations (Red Cross, emergency medical support teams, fire brigade, police, military, ...), considering different views on education, their pur- pose, organizational culture, member types, equipment, group dynamics [Parfitt, 2004, Katzenbach and Smith, 1993, Stewart and Joines, 1987], cultural differences etc. Espe- cially stress situation, adverse physical conditions, cultural gaps and bias multiply the chances for misunderstanding [Dörner, 2006, Chroust, 2008b]).

Accounting for Human Reaction Humans are a key to emergency calls. It is important to foresee and influence how individual First Responders react in a emergency situation in view of essentially invisible dangers. Different views on education, organizational culture, member types, equipment, group dynamics [Parfitt, 2004, Katzenbach and Smith, 1993, Stewart and Joines, 1987], cultural differences etc. have to be considered.

Utilizing Electronic Decision Support For complex, systemically balanced decision in such complex situations access to extensive background information (background database fig. 1) is necessary. Computer support in the sense of electronic performance support sy- stems and expert systems [Chroust, 2000, Banerji, 1995, Burgess, 2000, Cole et al., 1997, Fischer and Horn, 1997, Racine et al., 2004, Rasmussen, 1993] would be helpful.

2.5 Organizational Processes

Organizational processes are usually employed outside the realm of a single intervention. They are concerned with long-term consideration. They consist of processes employed by an organi- zation to establish and implement and improve the infrastructure.

Training The main concern of training is to enhance suitability and effectiveness of the per- formed action. Training is one of the key processes; section 3 is devoted to this. Key training areas are: measurement tool training, equipment training, coordination training, individual behaviour training, risk evaluation and decision making, group behaviour and cooperation training

Process Evaluation and Optimization During the operation First Responders will also noti- ce suboptimal situations and behavior. Such observations are very helpful for improving future interventions. People need to be trained to recognize and report such observati- ons. The feed-back would improve the collection of Best Practices. Details on Process Evaluation and Optimization can be found in relevant software engineering books, e.g. [SPIRE Project Team, 1998, van Loon, 2004, El Emam et al., 1998, Dangle et al., 2005].

Reporting Reporting can be fruitfully used to collect further experience and to feed this expe- rience back to the processes of the First Providers.

Failure Prevention Although not directly connected to First Responses, proposals for preven- tion of emergencies could be collected and passed on. This is similar to process optimiza- tion but is stronger oriented towards the environment and not directly related to the actual emergency.

3 Simulation and Training

Many of the processes described above cannot be trained ’life’ due to many reasons: too dan- gerous, too costly, too little learning effect (missing feedback and reproducibility) insufficient speed of computers, no chance for instructor’s intervention, no collection of data, etc. Modern IC-technology allows to *simulate* an actual situation, i.e. providing a models which is able to behave - in essential parts - like the real world.
There are numerous way of simulation a process. For the current discussion we will restrict our- selves to so-called Mixed Realities (cf. section 3.3) where the real-word processes are somewhat modelled but with a varying degree of accuracy and with a varying degree of non-real-world add-ons.

3.1 Modelling

A model is usually a reduced abstraction of some essential aspects of some real or imagined object or situation. Simulation means to execute (animate, enact) such a model. Models can be used (fig. 5) to resolve problems in an abstract fashion and to re-introduce a found solution into the real world environment. In the case of intervention by First Responders simulation (i.e."enactment") will be used for demonstrating, training, analyzing, evaluating, verifying, and validating approaches to intervention in a CBRN-environment.

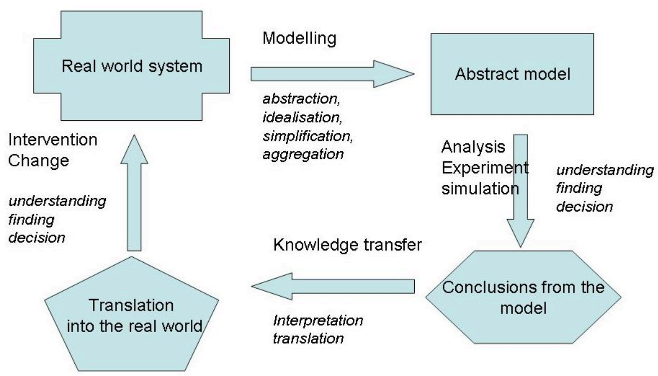

Fig. 5: Problem Solving with models

When abstracting the real world to a model various aspects have to be considered.

- What are the essential active elements (actors, e.g. humans, tools, machines)
- What are the essential passive elements (buildings, nuclear source, data bases, ...)

- To what detail should the simulation go (cf. [Flynn, 1977])
- Which part of the process should be replaced (fig. 6).

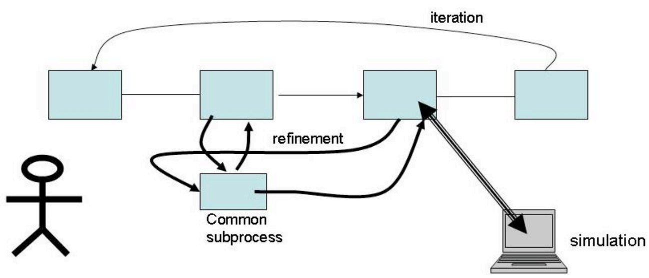

Fig. 6: Substituting real-world processes by simulated ones

3.2 Substitution of Processes by Simulation

An intervention by First Responders is a combination of several intertwined processes (see secti- on 2). For various reasons some of these (sub)processes cannot be performed/trained reasonably in safety while others preferably should be performed in the real world.
Adopting a process view suggests that we *replace* certain of these 'untrainable' (sub)processes (fig. 6), by a simulated process which performs the *essential functions* of the replaced functions in one way or another.
This means that we have to create a dynamic environment which *simulates* some of the original processes. by "enactment", i.e. by performing in some real or abstract way the necessary steps. This is also true for in-action replacing real subprocesses by simulations, allowing projections, planning and what-if evaluations. There is a more or less seamless continuum from true, un- modified reality to the Virtual Reality. Using a simulation instead of the 'real-world' process entails additional advantages than just the removal of danger, see section 3.4.
In [Schönhacker and Chroust, 2009] we identified three software-intensive modelling techni- ques (Virtual Reality and Augmented Reality) which are of special interest for the training of First Responders only became feasible for individual First Responders thanks to the enormous growth of computing power within the last few years.

3.3 Mixed Reality

Simulation can be done with more or less similarity to actual environments. We take a broad view of 'Mixed reality' (fig. 7) to cover the complete spectrum between 'pure' real-word envi- ronments and completely abstracted, virtual representations.

Taking a closer look we actually see a continuous spectrum of these techniques with some intermediate techniques (fig. 7).

- a *real-world environments*

- *real-world environment extended by real word objects*, e.g. added markers and signs (e.g road signs, flags, warning icons, etc.)
- *Augmented Reality*, see section 3.3.2 for details.
- *Virtual Reality*, see section 3.3.1 for details. and
- *Complex Mathematical Simulations* (=abstracted virtual reality), completely abstracting from any resemblance to the reality and just providing mathematical models (e.g. System Dynamics Models).

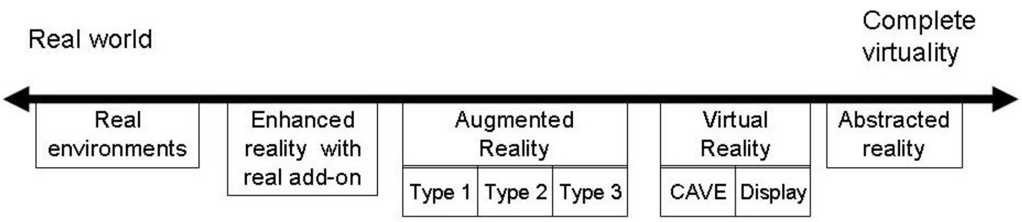

Fig. 7: Continuum from real world to full virtuality

3.3.1 Virtual Reality

These environments do not have to have any correspondence to an existing environment
[Billinghurst and Kato, 2002, Ramesh and Andrews, 1999, Rheingold, 1992, Stone, 1992]. They can be implemented on their own and are in that sense independent of changes to of their presumably real counterpart and also independent of any geographical changes of the user. An older version were CAVEs ("Cave Automatic Virtual Environment ") which gave a immer- sive effect but at a high technological effort, usually without any mobility.
The modern equivalent for CAVEs Reality are computer programs with near-realistic rende- rings. Many users can take part in the virtual environment. All users are represented by virtual figures ("avatars") which they can form, dress etc. to their liking and which move and behave on behalf of their owners, controlled by the owners.
The most well-know version of these games is "Second Life" [Cross et al., 2007, Linden Lab, 2008]. The most outstanding feature is the personal interaction of many players partners can be simulated, which offers interesting training feature of interaction and coopera- tion for larger groups of people.
Despite all realistic pictures, the user is always somewhat an observer or bystander. No actual immersion usually occurs.

3.3.2 Augmented Reality

The most promising approach is Augmented Reality technology [Chroust and Hoyer, 2004, Fleischmann and Strauss, 2001, Tarumi et al., 2000]. It is a field of computer research which deals with the combination of real-world and computer-generated data, usually with the help of translucent glasses or head-displays to

overlay images over a real world scenario (fig. 8). It offers both the aspect of a field experiment but allow to introduce aspects which cannot (or should not) exist in reality. Augmented Reality offers the aspect of a field experiment but allows introducing aspects which can (or should) not exist in reality. Thus, it seems to be the most promising approach for training purposes because actions can be taken in a real surrounding, supported by modern technology. Augmented Reality technologies are difficult to implement since a coordination between the overlaid pictures and the real world has to be provided.
Also some undesirable side-effects can occur which never would probably be modelling, e.g. an area becoming inaccessible due to water used by the parallel working fire brigade, disturbing noise, but also amusing effects of an uninformed passer-by stepping through the image of a supposedly hot image of a fire.
Some of the applications of Augmented Realities can be:

- One can "show" simulated hazardous materials etc. projected over a real environment, without running into any real danger (e.g. in ultraviolet visible powder to simulate con- tamination, or replacing a radioactive source with a blue-tooth sender and making the complimentary changes in the sensor tools).
- One can show the effects of existing but invisible dangers (e.g. radioactivity) by Augmen- ted Reality with data derived from sensors and tools (e.g. showing the heat emanation), overlaid on the real images (cf. fig. 8).
- One can augment the reality with further virtual persons to simulate group behavior etc.

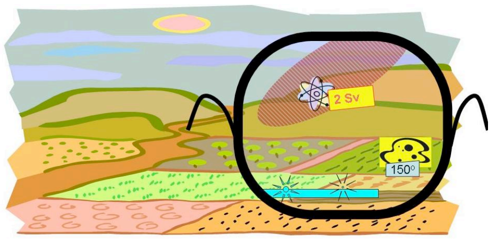

Fig. 8: Augmented Reality - adding information in the glasses

Fig. 8 shows an ocular which is able to identify contaminations in a landscape and adding quantitative information for the user.
The overlay of computer simulated pictures and the real world can be achieved in basically three ways

- Type 1: a locally existing image can be superimposed on a distant object. This is usually achieved by appropriate semi-transparent glasses (fig. 9). In the simple case the picture in the glasses is NOT correlated to the object. It could provide some general information not directly linked to one object.

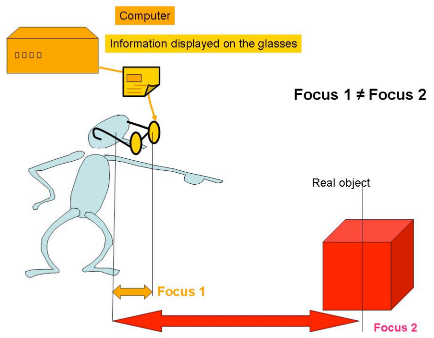

Fig. 9: Focus-situation at augmented Reality

- Type 2: the information is generated in the distance and is electronically attached to the real-world object and thus can be seen from everywhere. It does not need a specific outfit of the user (fig. 10).

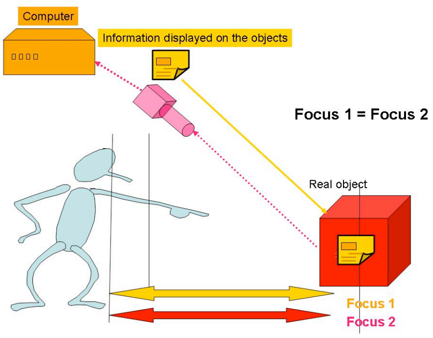

Fig. 10: Add-on Reality displayed on the real world objects

- Type 3: a locally existing images superimposed and correlated with the real object. This more useful, sophisticated, and expensive version needs information which is correlated to the relative position of the user to the real objects and has to reflect changes in position of both the object and the user (cf. fig. 8 and fig. 11).

3.4 Advantages of Simulation

The use of simulation brings several advantage to the training of First Responders. Some of the more salient advantages are:

- Subprocesses of the complete process can be simulated
- Dangers scenarios can be replaced by safe ones.
- Training Sessions can be arbitrarily often repeated, considerable data can be collected, compared and analyzed

- Playback of training sessions can be done, allowing analysis of behaviour, identification of subtle reactions etc.
- Alternative approaches ('practices') can be tried out as simulations
- Seasoned practitioners can comment on various Best Practices according to the 'SIK'- principle (*"Seeing Is Knowing"*).
- Gradual substitution of some of the subprocesses can make training more or less realistic, consistent with the growing knowledge of the trainees
- Many of the simulated processes can be successfully used in real interventions, especially for prediction and 'what-if' analysis and post-mortem learning.

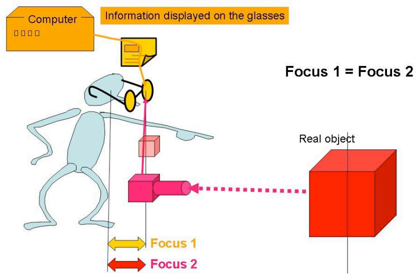

Fig. 11: Focus-situation in Imaged Reality

4 The SimRad.NBC Simulation Framework

At the moment practically no system exist which provides a near-reality training for *all* classes of First Responders from different fields. Single organizations train their personnel in *their* field individually. The exchangeability of real and simulated processes in SimRad.NBC will allow the exchange of processes for different types of First Responder groups, using the same look and feel of the simulation platform. The SimRad.NBC project uses these techniques to

1. explore, evaluate, and verify the feasibility and interdependencies of processes and their supporting tools:
   - interplay/interference/compatibility of tools (wireless telephones), e.g. is the system really working when hundreds of voluntary helpers use the existing equipment?
   - applicability of tools in adverse situations like poor visibility, high noise, electro- magnetic disturbances.
2. explore human dependencies on important influencing factors: stress, adverse environ- ment (poor visibility, high noise, heat, ...). Typical questions are: How does ambulance personnel really react in case of a CBRN incident?. Are they able to use the CBRN- detection devices?

3. experiment with new, integrated tools and software systems to professional as well as non-professionals.

Summary and Outlook

Up to now no near-reality simulation system existed which allowed the training of larger groups of First Responders, beyond the available training in individual, regional organization in special domains. SimRad.NBC will allow to train (or at least to make aware) First Responders of other fields to understand and be able to interact with colleagues from other fields in a variety of different ways.
The generalized structure of the framework would make it possible to utilize it also for other types of problem situation (e.g. climate, ozone, gas, smog, pollen, ...). A key in this project is the possibility to model and analyze human and environmental factors concerning emergencies and catastrophes using Augmented Reality. It will be possible to evaluate the efficiency of existing emergency plans and to suggest improvement, especially in the interface of different systems. Thus we believe that SimRad.NBC will be a contribution for improving and structuring First Responders' training as well as missions and will allow quantifiable improvement of the effi- ciency and efficacy of First Responders.

Acknowledgement

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References

[Banerji, 1995] Banerji, A. (1995). Electronic performance support systems. *Proceedings of International Conference on Computers in Education (ICCE '95) pg 2. Application Track*.

[Billinghurst and Kato, 2002] Billinghurst, M. and Kato, H. (2002). How the virtual inspires the real - collaborative augmented reality. *CACM vol. 45 (2002), no. 7*, pages 64–70.

[Burgess, 2000] Burgess, V. (2000). Changing nature of electronic performance support sy- stems. *http://scholar.coe.uwf.edu/students/vburgess/ChangingEPSS/tsld001.htm, Dec 2000*.

[Chroust, 2000] Chroust, G. (2000). Electronic performance support systems - challenges and problems. In *P. Kopacek (ed.): Computer Aided Systems Theory - EUROCAST'99, Vienna, Sept., Springer 1999*, pages 281–284. Springer 2000.

[Chroust, 2008a] Chroust, G. (2008a). Bridging gaps by cooperation engineering. In Kotsis, G., Taniar, D., Pardede, E., and Khalil, I., editors, *Proc. of the 10th Int. Conference on Infor- mation Integration and Web-based Applications and*

Services (iiWAS2008), pages 382–389. OCG (Austrian Computer Sociey) and ACM 2008.

[Chroust, 2008b] Chroust, G. (2008b). Localization, culture and global communication. In *Goran D. Putnik and Maria Manuela Cunha: Encyclopedia of Networked and Virtual Orga- nizations, vol II*, pages 829–832. Information Science reference, IGI Global, Hershey, USA, 2008.

[Chroust and Hoyer, 2004] Chroust, G. and Hoyer, C. (2004). Bridging gaps in cooperative environments. In *Hofer, C. and Chroust, G.: IDIMT-2004, 12th Interdisciplinary Information Management Talks, Sept, 2004, Budweis, Verlag Trauner Linz,2004, Linz*, pages 97–110.

[Chroust et al., 2008] Chroust, G., Roth, M., Ziehesberger, P., and Rainer, K. (2008). Trai- ning for emergency responses - the simrad-project. In Balog, P., Jokoby, B., Magerl, G., and Schoitsch, E., editors, *Mikroelektroniktagung ME08, Oct. 2008, Vienna*, pages 327–334. ÖVE, öst. Verband für Elektrotechnik.

[Chroust and Schoitsch, 2009] Chroust, G. and Schoitsch, E. (2009). Motivating smes to soft- ware process improvement a retrospective at the spire-project of 1998. In Höhn, R. and Linssen, O., editors, *Vorgehensmodelle und Implmenmtierungsfragen - Akcquisition - Lo- kalisierung - soziale Maßnahmen - Werkzeuge, 16. Workshop d. FG WI-VM der Ges. für Informatik, April 2009*, pages 177– 199. Shaker Verlag Aachen 2009.

[Cole et al., 1997] Cole, K., Fischer, O., and Saltzman, P. (1997). Just-in-time knowledge deli- very. *Comm ACM vol. 40 (1997), no. 7*, pages 49–53.

[Cross et al., 2007] Cross, J., O'Driscoll, T., and Trondsen, E., editors (2007). *Another life: virtual worlds as tools for learning*. eLearn Magazine, Volume 2007, Issue 3 (March 2007).

[Dangle et al., 2005] Dangle, K. C., Larsen, P., M., S., and Zelkowith, M. V. (2005). Software process improvement in small organisations: A case study. *IEEE Software vol. 22 (2005), no. 6*, pages 68–75.

[Dörner, 2006] Dörner, C. (2006). Rettung und notfallversorgung. In Sprengseis, G. and Lang, G., editors, *Vom Wissen zum Können - Forschung für NPOs im Gesundheits- und Sozialbe- reich*, pages 1992–200. Facultas Verlag, Wien 2006.

[El Emam et al., 1998] El Emam, K., Drouin, J.-N., and Melo, W., editors (1998). *SPICE, The Theory and Practice of Software Process Improvement and Capability Determination*. IEEE Computer Society, Los Alamitos.

[Fischer and Horn, 1997] Fischer, O. and Horn, R. (1997). Electronic performance systems. *Comm ACM vol. 40 (1997), no. 7*, pages 31–32.

[Fleischmann and Strauss, 2001] Fleischmann, M. and Strauss, W. (2001). Linking between real and virtual spaces: building the mixed reality stage environment. In *Proc. 2nd Australa- sian User Interface Conference (AUIC'01)*. IEEE Publishing 2001.

[Flynn, 1977] Flynn, M. (1977). Classes of emulators. *SIGMICRO Newsletter*, 8:4:34–35.

[Humphrey, 1989] Humphrey, W. (1989). *Managing the Software Process*. Addison-Wesley
Reading Mass. 1989.

[ISO/IEC, 2007] ISO/IEC (2007). Iso/iec 12207:2007 systems and software engineering - soft- ware life cycle processes. Technical report, Int. Org. for Standarization, ISO, Geneva 2007.

[Katzenbach and Smith, 1993] Katzenbach, J. and Smith, D. (1993). *The Wisdom of Teams*. Harvard Business School Press, Boston.

Linden Lab, 2008] Linden Lab (2008). Was ist second life?
http://en.wikipedia.org/wiki/Second_Life [2008-10-10].

[Ould, 1995] Ould, M. (1995). *Business Processes*. Wiley, Chicester 1995.

[Parfitt, 2004] Parfitt, W. (2004). Group integration. http://www.philhine.org.uk/ wri- tings/index_rituals.html.

[Racine et al., 2004] Racine, S., Kralick, K. E., and Yesuraja, S. (2004). Defining an effective electronic performance support system. *The Usability SIG Newsletter - Usability Interface, January 2004, vol 10, issue 3*, pages 1, 13,14.

[Ramesh and Andrews, 1999] Ramesh, R. and Andrews, D. H. (1999). Distributed mission training, teams, virtual reality, and real-time networking.

[Rasmussen, 1993] Rasmussen, J. (1993). Diagnostic reasoning in action. *IEEE Trans. on
Systems, Man and Cybernetics*, 23:4:981–992.

[Rheingold, 1992] Rheingold, H. (1992). Virtuelle Welten - Reisen im Cyberspace. *Rowohlt
Hamburg, 1992*.

[Scheer, 1998] Scheer, A. (1998). *ARIS - Vom Geschäftsprozeß zum Anwendungssystem*. Sprin- ger Berlin 1998.

[Schönhacker and Chroust, 2009] Schönhacker, S. and Chroust, G. (2009). Simrad.nbc - simu- lation and information system for rescue units at cbrn-disasters. In *submitted to IDC2009,
3rd International Symposium on Intelligent Distributed Computing, Cyprus, 2009*.

[SPIRE Project Team, 1998] SPIRE Project Team (1998). *The SPIRE Handbook - Better, Fa- ster, Cheaper - Software Development in Small Organisations*, page 250. Centre of Software Engineering Ltd, Dublin 9, Ireland.

[Stewart and Joines, 1987] Stewart, I. and Joines, V. (1987). *TA - Today, A new Introduction to*

Transactional Analysis. Lifespace Publ., Nottingham, Chapel Hill.

[Stone, 1992] Stone, R. (1992). Virtual reality and telepresence. *Robotica no. 10*, pages 461–467.

[Tarumi et al., 2000] Tarumi, H., Morishita, K., Ito, Y., and Kambayashi, Y. (2000). Commu- nication through virtual active objects overlaid onto the real world. In *Proceedings of the third international conference on Collaborative virtual environments*, pages 155–164. ACM Press.

[van Loon, 2004] van Loon, H. (2004). *Process Assessment and ISO/IEC 15504*. Springer, New Aork 2004.

[Wang and King, 2000] Wang, Y. and King, G. (2000). *Software Engineering Processes*. CRC Press 2000, Florida.