



Executive summary

Training Systems Design: Bridging the gap between users and developers using storyboards



Report no.

NLR-TP-2011-175

Author(s)

A. Rankin
J.N. Field
R. Kovordanyi
M. Morin
J. Jenvald
H. Eriksson

Report classification

UNCLASSIFIED

Date

July 2011

Knowledge area(s)

Training, Simulatie en Operator Performance
Externe Luchtvaart Veiligheid en beleidsondersteuning

Descriptor(s)

Training Systems Design
Storyboarding
Crisis Management
Distributed Training Systems

Problem area

Crisis Management teams are made up of personnel from different organisations, and often consist of personnel that do not work together on a regular basis. This can be addressed with a training system that enables frequent team training, including distributed training. In designing such a system it is important to identify the requirements of each organisation. The training needs for each user must be translated into a single set of user requirements, and functional requirements for the shared training system.

Description of work

This paper presents the method that was applied in the CRISIS European Union research project. The ongoing project is developing

an interactive virtual reality environment for training crisis management personnel. During the requirements definition phase of the project the system design team worked together with the end-user stakeholders and software development team to define the system concept. The team used storyboards and low fidelity prototypes to create the system concept, share ideas and collaborate on the design. It is essential that during this initial phase all of the stakeholders have a shared understanding of the system design and the requirements to avoid potentially costly misunderstanding.

Results and conclusions

This paper describes the experiences defining the system concept, user and functional

requirements using this design approach. The scenario-based design that was applied during the project lends itself to the use of storyboards and prototypes to communicate and refine the concepts as they are being developed. During the requirements definition phase this method enabled the end-users to fully participate in the requirements design through the use of simple, office computer-based tools. Concepts were defined by the design team, and could be shared with the end-users, at each of their locations

The focus of the techniques used is on the importance of visualizations, and how these can be collectively created between stakeholders and partners, allowing ideas to be

circulated and approved from multiple users and perspectives.

Applicability

The method that is described in this paper is applicable to the general design of training systems. It applies to the cooperation between a mixed team of users, designers and developers, and can be applied when the teams are distributed in different locations.

The research leading to these results has received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement no. FP7-242474. As CRISIS is a collaborative effort the authors would also like to thank all CRISIS partners who might have indirectly contributed to this paper.



NLR-TP-2011-175

Training Systems Design: Bridging the gap between users and developers using storyboards

A. Rankin¹, J.N. Field, R. Kovordanyi¹, M. Morin², J. Jenvald² and
H. Eriksson¹

¹ Linköping University


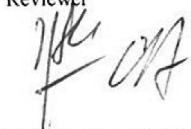
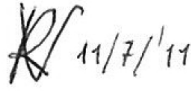
² VSL

This report is based on a presentation to be held at the European Conference on Cognitive Ergonomics 2011 –
Designing Collaborative Activities, Rostock, Germany, August 24-26, 2011.

The contents of this report may be cited on condition that full credit is given to NLR and the authors.

Customer	European Commission
Contract number	----
Owner	NLR + partner(s)
Division NLR	Air Transport
Distribution	Unlimited
Classification of title	Unclassified
	July 2011

Approved by:

Author	Reviewer	Managing department
		 11/7/'11

Abstract

Motivation – Designing distributed training systems for crisis management (CM) requires an approach with the ability to address a great variety of needs and goals. Crisis responses involve multiple agents, each with different backgrounds, tasks, priorities, goals, responsibilities, organizations, equipment, and approaches. Identifying the different user training needs and translating these into user and functional requirement therefore poses great challenges.

Research approach – In this paper we present experiences of how to enable the collaboration between multiple stakeholders and partners when creating and adapting ideas throughout the design phase. The technique has been used in a European project aimed at developing an interactive Virtual Reality (VR) environment for training crisis management.

Findings/Design – The focus of the paper is on the initial storyboard iterations and lo-fi prototypes, as this is a crucial stage for expressing ideas in a perceivable way without having to spend too much time and effort on creating detailed prototypes.

Take away message – Experiences using low-cost commercial software for creating storyboards are presented, as these provided the means to create, share, present, adapt and circulate ideas, facilitating the fusing of ideas, shared understanding and distributed working.

Keywords

Training Systems Design, Storyboarding, Crisis Management, Distributed Training Systems

Contents

1	Introduction	4
2	Scenario Based Design	5
3	User Requirements Analysis	7
3.1	Concept development using storyboards	7
3.2	Visualizations of user interactions	8
3.3	Interactive prototypes	10
4	Discussion	13
5	Summary	14
6	Acknowledgements	14
	References	15

1 Introduction

Crisis Management (CM) teams involve multiple participants from different agencies that do not necessarily work together regularly. Each agency and participant has a different approach to the crisis, different priorities, responsibilities, procedures, equipment, experience and background, and yet they must all come together rapidly in a team to address the crisis. Training together is an important step towards achieving this goal. Information technologies offer great opportunities for using simulation and gaming as tools in improving CM (Beroggi, 1995; Walker, Giddings, & Armstrong, 2011). However, in designing systems to meet such an array of requirements there are great challenges to interpret and unify the different needs and goals into a single set of requirements for the system. To define what parts of the context, communication systems and tools to simulate it is essential to also take into consideration contextual, cultural and socio-technical aspects. Retrieving this information from users can greatly be aided by visualizing techniques, as will be illustrated in this paper.

The elicitation of user and functional requirements is a critical phase in a project although, all too often, this part is not adequately addressed. It is essential that in this phase all stakeholders, from end-users to designers and developers have a shared understanding of the system design and the requirements. Misunderstandings at this stage can escalate and become costly and sometimes even irreversible at later stages in the project.

In this paper techniques used for eliciting system requirements and enabling the collaboration of the designers, developers and the end-users during the design phase of the training system will be presented. The method is being used in the European 7th Framework project CRISIS, aimed at designing an interactive virtual reality (VR) environment for crisis management training, such as for the management of an aircraft or public transportation accident. The VR training system is a desktop application and will encompass a collaborative and interactive simulation for individual and team training across multiple levels of an organization in both co-located and distributed environments.

In the phase prior to the one described in this paper, scenarios were written, a method commonly used in emergency-management training systems (Drury et al., 2009; Haynes, Purao, & Skattebo, 2009; Walker, Giddings, & Armstrong, 2011). These scenarios then formed the basis for communication within the design team, and for the definition of the user requirements. The design of the reference scenarios was based on existing live training exercises that illustrated the training needs for the VR system. These scenarios formed the basis for further workshops and interviews with end users to determine the user requirements.

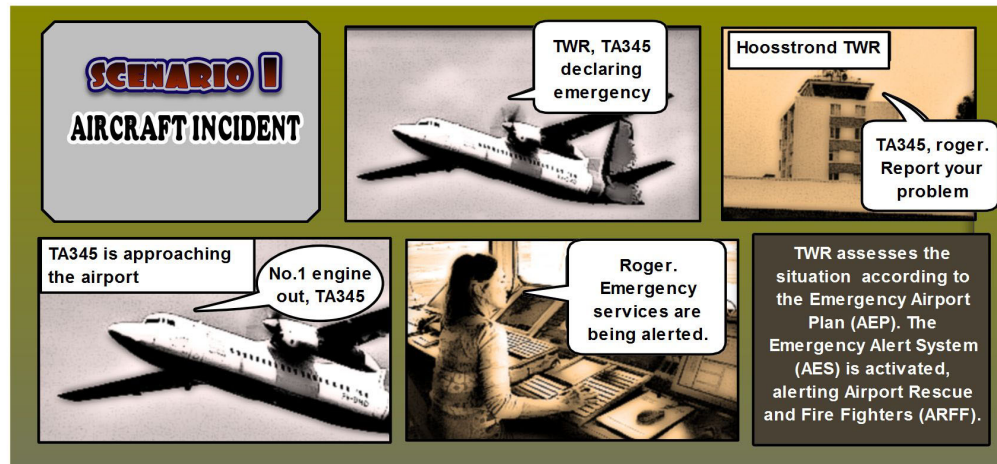


Figure 1 Storyboard images from the aircraft accident scenario

The techniques described in this paper are used to extract the functional requirements using storyboarding and prototypes. A scenario-based visualisation technique enabled the project partners to create, present, adapt, and circulate their ideas across the development team and end-users using simple-to-use low-cost commercial software. This initial step is followed by a more detailed phase of visualisation to refine the requirements and the user interactions, building use scenarios and prototypes to illustrate potential system functionality and use these as a basis for discussion. The final stage is identifying the technical aspects of the functional requirements for the system. The method of combining storyboards, scenarios and prototypes using simple commercial software is intended to ensure that the wide variety of participants in the design process, from end-users to software developers, training designers to project managers can be involved in the process and that uncertainties in the design can be addressed quickly.

2 Scenario Based Design

Using scenarios for design of human-centred systems can be a powerful instrument as it allows designers and analysts a simple way of exploring and testing new ideas. By describing the sequence of information exchange, actions and results it forces designers and analysts to reflect on human experiences, human behaviour and their implications on the system. According to Carroll (2000) scenarios are “the language of all stakeholders” (p. 58). Storytelling is a familiar narrative structure since childhood – giving people the advantage of already being experts at applying their imagination and overloading meaning into the story (Carroll, 2000; McCloud, 2006). A scenario is initiated by an event, and followed by a sequence of actions. For example, the “aircraft incident” scenario portrayed in Figure 1 describes how an airplane pilot reports to the air traffic control tower that “one engine is out”. The air traffic control tower immediately

alerts the airport emergency services, which are on-site when the plane crashes on the runway as it is coming in for landing. This alert is followed by a large rescue operation involving multiple organizations. The scenario ends when the fire is extinguished and all casualties have been transported from the scene of the accident.

Another advantage of using scenarios is that they can be used collaboratively. They can easily be circulated to end-users and other stakeholders such as project managers, software architects or graphical designers who can provide new ideas and directive feedback (i.e. providing hands-on suggestions for further ideas or refinement). This flexibility provides the freedom for innovative explorations of design requirements and alternative views without having to commit to one particular solution (Carroll, 2000).

Storyboarding is a visualization technique in scenario-based design used to represent interactions based on a number of sketches or still images portraying significant actions, often with a matched-up dialogue or other textual description (Goodwin, 2009). Storyboarding has its origins in the movie industry where a storytelling style of comic books to depict the storyline of a movie is used to visualize the actions pre-production (Saffer, 2006).

Traditionally sketching is done by hand and therefore requires some drawing skills. Lacking this skill could be a huge disadvantage for designers, users or any other stakeholders who need to express their ideas in a perceivable way. The landscape for this activity may be changing as easy-to-use and inexpensive software tools that can aid the “artists” are becoming increasingly available. These tools can be found at a range of different complexity levels: from simpler tools like *Bubblr*¹, which supports basic adding of captions to photos in *Flickr*², to more complex (and more expensive) tools like *The Tarquin Engine*³, which is a flash template for dynamic navigation during user system interaction. Tools, or a combination of these, are chosen depending on what type and level of visualizations and interactivity the designer wants.

In the CRISIS project the software program *ComicLife* was used for storyboarding. *ComicLife* integrates photos, pictures, captions and lettering to create comic like images (see Figure 1). Our motivations for choosing this particular piece of software were that:

- 1) No prior skills are required such as sketching or programming competencies
- 2) Suggestions and ideas can be sent around and altered by all stakeholders via internet.
- 3) Pictures and sketches from various sources can be employed and made to look coherent

¹ <http://www.pimpampum.net/bubblr/>, Retrieved April 16, 2011

² www.flickr.com, Retrieved April 16, 2011

³ www.webcomicsnation.com/tarquin, Retrieved April 16, 2011

- 4) The level of fidelity can be adjusted at different stages in the process by simple “style” – editing
- 5) Actions and events can easily be added or removed throughout the whole design process
- 6) The images can be reused later on in the scenario or in an altogether different scenario

Figure 1 illustrates an example of a storyboard developed using ComicLife. Here, images are based on real photographs that have been modified using style and colouring. The reason for making the storyboard “comic-style” is to help the reader “experience” the story (McCloud, 2006). Keeping the story “comic-style” allows focus to stay on the story rather than on details in the picture, which may bias the viewer’s interpretation and imagination. The reader, i.e. the user, is guided by storytelling principles such as pace, clarity and communication, which can help clarify ambiguities and contradictions in the story making the scenarios more realistic (McCloud, 2006).

In ComicLife different styles can be adapted to the level of fidelity appropriate for each image, as well as using “mixed-fidelity”, i.e. when high fidelity is used on some dimensions and low-fidelity on others (McCurdy et al., 2006; Yasar, 2007). As specific functionalities of the system are determined, certain parts can be made to look increasingly authentic. Colouring of specific details can also be used to draw attention to the use of a specific event or tool.

3 User Requirements Analysis

The following section presents examples of the storyboards used in three main steps; (1) Concept development, (2) Visualization of user interactions and (3) Interactive prototypes. The three steps presented in this section describe how to get from generic scenarios (e.g. textual scenario descriptions) to the point where the levels of detail in the prototypes are sufficient to extract functional requirements. Examples are given from different user perspectives and interfaced. Prior to the three steps presented below user requirements have been gathered through interviews, workshops and site visits. These were performed in an iterative process over several months to produce a list of user requirements. The scenarios used for storyboarding are based on the results from these interviews and workshops (for a more detailed description see Rudinsky & Hvannberg, 2011).

3.1 Concept development using storyboards

In this first step we translate the textual scenarios into visual form. The purpose of the step is to capture and refine ideas and requirements from the users and with the system design team. The storyboards provide an overview of the flow of actions and interactions taking place in the

scenarios. They do not include any information on what goes on “behind the scene” in the system design, e.g. no information on the details of how the user will interact with the system is provided. At this point, the storyboards solely include “the story”. Working through each scenario helps determine whether the stated training requirements are unclear, incomplete, ambiguous or contradictory. Both the end-users and the system concept designers can refine the scenarios and identify potential system requirements during this step. Figure 1 illustrates the first two minutes of a scenario where an airplane reports engine problems to the air traffic control tower. In the example the air traffic controller raises the alert alarm. The storyboards are shared within the team and offer a fast and simple way to visualise the scenario and what the system will be used to train.

3.2 Visualizations of user interactions

Exploring how the user interacts with the virtual world is carried out by visualizing the user interactions. First, visualizations of how the users interact with the system are made (Figure 2).



Figure 2 Airport medical unit using interacting with the training system using keyboard and mouse

Ways of interacting and communicating with the system and other participants are illustrated such as keyboard, head set, radio or mobile phone. More than one storyboard can be made for each user-group to provide a variety of user interfaces that can be discussed with the end users. Figure 2 illustrates an airport medical unit receiving the airport emergency alarm. Interactions with the VR-system are performed using a keyboard, mouse and a mobile phone.

By using storyboarding to visualise and develop the use case examples of user interaction with the system, it was possible to illustrate several interaction concepts. The advantage of this approach was that an idea could be worked out by one member of the design team and included in a storyboard quickly and simply. This idea was then shared with the other members of the team (users, designers and developers combined) and could be further modified if required.

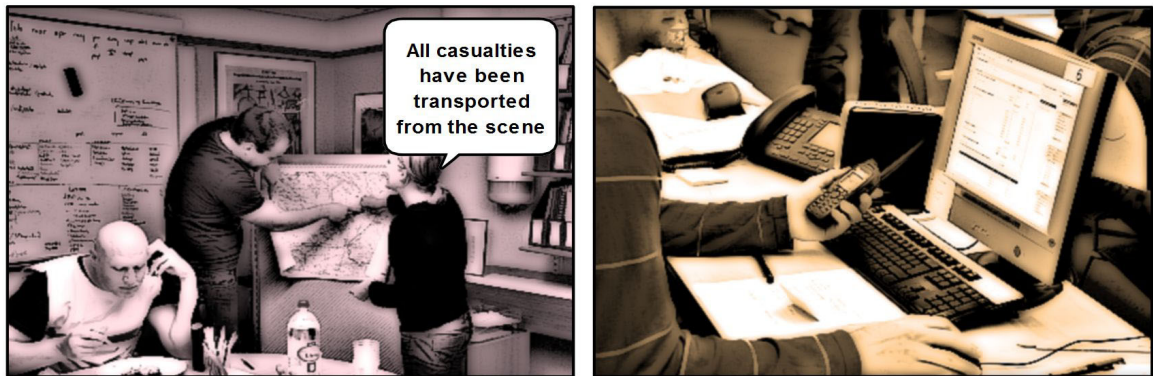


Figure 3 Command team working on strategic level utilizing maps, white boards etc (left). They receive information and interact with the VR system through telephone and radio communication (right)

Figure 3 demonstrates a *command level team*. These storyboards were created to discuss the work environment and the different types of users and what tools are used to support their tasks in a particular context. For example we see maps, magnets, white boards available in Figure 3. Information from the virtual world is provided through telephone and radio communication with the outside worlds, i.e. participants and simulation staff interacting with the virtual world. An additional way of providing the command team with information from the virtual world could be video surveillance from the accident scene.

Users at different organizational levels will have a different set of requirements to execute their task during a crisis. This may create the need for different interfaces to support the different tasks in the best way possible. For instance, at regional and national levels, command tasks are more abstract and concern strategic decision making. Usually Chief Commanders are present in the same room and utilize tools such as white boards, paper, pens and maps to create and overview and analyse the situation (as in Figure 3, left image). Immersing this type of work completely into a VR system provides some challenges as this affects the fundamental



Figure 4 Left image illustrates the command post immersed in a 3D virtual world. The right image illustrated an overview of the functions of the command post interface



Figure 5 Images from the CRISIS accident scene interface mock-up illustrating examples of the radio and clipboard use

principles of teamwork and training (Jenvald, Morin, & Eriksson, 2010). Therefore different options of system interface were presented in the storyboards (Figure 4). In the left image the command room is immersed in a 3D world and in the right image a 2D interface is presented, providing an overview of the functions used by the command staff such as maps, GPS systems, news up-dates, log reports, radio, telephone etc. In the 2D world monitors and displays are built into the VR-system and provide information from the virtual world. A head-set integrated with the system is used for phone and radio communication. Each function and its interactions with the user were further developed in illustrations that visualise particular aspects of system use.

Similarly for developing the concept for the training instructor's interface, mock-ups were developed to illustrate how the requirements that the end-users identified could be interpreted in the design (Figure 5). Instructors impose a whole set of system requirements which are different from those of other users. This includes an exercise planning tool, an after action review tool and a "bird's eye" perspective of an on-going training session. To understand in what ways the instructor might want to influence the events taking place in the virtual environment requires an understanding for training objectives and methods. The after action review system will aid the instructor to evaluate the outcome of the training session. For this, training objectives have to be clearly specified by the end-users and traceable within the system. In these illustrations it is emphasised that these are mock-ups to promote and aid the design and development process, as the software is developed it will be possible to share and consider mock-ups and prototypes that are derived from the system development.

3.3 Interactive prototypes

The aim of this step is to translate the user requirements into more concrete examples that can be discussed with the end-users in more detail. Prototypes are developed in Microsoft Office PowerPoint for elements of the system where interactivity is required to generate better

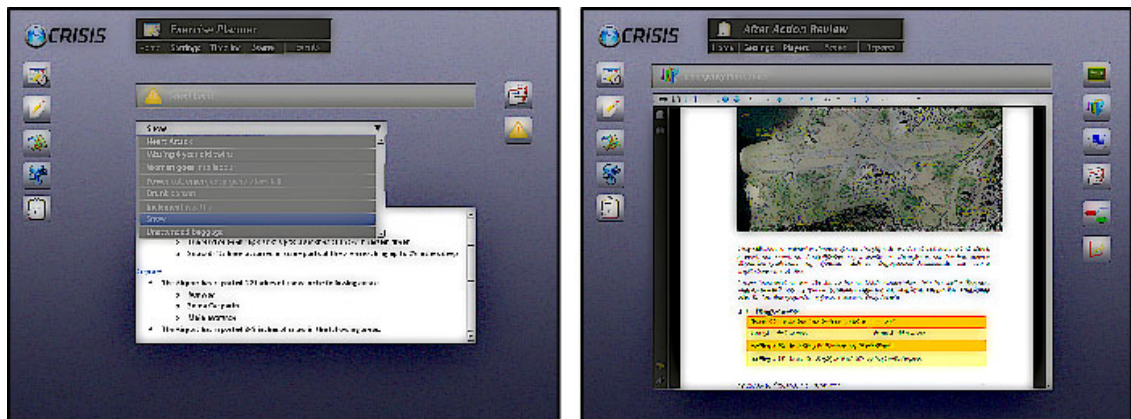


Figure 6 Images from the CRISIS Instructor Interface mock-up illustrating how events can be created and accessing reference documents

feedback from the end users (Figure 6 and 7). This approach enables basic interface and software design without requiring programming competence. While advanced animations can be demonstrated using other tools, such as *Adobe Flash Professional*⁴, these tools are not as widespread and hence not as accessible for editing in a team collaboration environment. The static interaction that is possible within *PowerPoint* is sufficient for the majority of prototype applications. The use of *PowerPoint* also enables editing on site to incorporate comments and demonstrate their effect immediately.

Crisis management teams include a wide range of different personnel, from the national commanders and coordinators to rescue personnel. The use of prototypes to refine the requirements aims to ensure that all users understand the system concept, and how it applies to their task and training. This approach allows the user requirements to be further refined, and functional requirements can then be derived. The aim of this step is to develop basic prototypes quickly and allow users to see and understand the system as it is designed and developed.



Figure 7 Images from a CRISIS interactive prototype of the interface

⁴ www.adobe.com, Retrieved April 18, 2011

A concept that has been discussed with the stakeholders during initial development discussions can be translated into a set of presentation slides using photos and screen mock-ups put together in *PowerPoint*. By using the same storyboarding software on the graphics, a uniform, “storyboard” appearance can be given to the prototypes as well. Creating an image of the system “screenshot” enables elements of the screen to be highlighted where the user can interact with the system. For example, a button on a screen, or stepping through a syllabus, can be implemented through the interaction capabilities of *PowerPoint*. This approach enables a relatively complete prototype of the system to be developed, and gives the user the ability to step through the screens.

When creating a prototype that is based on a relatively simple level of interaction it is important to be aware of the level of realism that a user may interpret in the wrong way. A user may believe that the functionality that is being demonstrated is already fully available, while it is only a concept that is yet to be translated into technical requirements. Therefore an element of “storyboarding” is useful in the interactive prototyping stage as well to reduce the apparent realism.

Although the three steps were presented in a sequential order they should be viewed as parts of an iterative process. Questions will arise during the storyboarding process and as uncertainties become less uncertain the storyboards will become increasingly detailed. The first sets of storyboards include a variety of different design-options that can be tested in prototypes that are increasingly advanced and interactive. As the development moves forward the storyboards are refined and when necessary, tested again. Likewise the interactive prototypes will be refined as the requirements become more defined, and the feedback from the different users is combined. Although not covered in this paper, the next step of the system development is to elicit a list of functional requirement, which can be implemented by the developer teams (see e.g. Goodwin, 2009, Carroll, 2000).

4 Discussion

To summarize, we see four major benefits of the storyboard technique used.

- 1) Allow quick and easy development of storyboards and prototypes.

Easy-to-use commercial software allowed all partners to take part in creating and re-creating ideas. Tools such as these facilitate creativity without the need for drawing or sketching competencies, which often hinders other partners and stakeholders than the designer to create the visualizations.

- 2) Work can easily be distributed, permitting the involvement of all stakeholders and partners. Keeping all project stakeholders, from the end users to the technical developers, involved in the design process is a key to success. Using a visualization technique such as storyboards ensures accessibility to all stakeholders and partners. As the storyboard format is electronic, it provides the opportunity for circulating ideas easily, allowing all partners (not just the designers or partners with sketching competencies) to alter, adapt or try new ideas and to share them with others without having to spend a lot of time and money.

- 3) Create shared understanding of the system between all stakeholders and partners. This is important for eliciting the right kind of information from the users and for reducing the risk for misunderstandings.

Using visualisation techniques for expressing ideas has the benefit of easily providing a context for questions and discussions. Although the visualisations only where early prototypes the visualisations of system functions provided a different type information as a common view of the system was created. Although user observations and interviews had been carried out prior to the first storyboards, a large amount of critical information was passed on during the initial storyboard sessions. As a shared view of the system emerged, so did the need for specific details of the users work situation. Further, details about function requirements and their priorities were identified. For example, the end-users felt that all functions of a real-life mobile phone were not necessary for the training system. Simulating the function of making a call using just one click on the mouse or keyboard was sufficient. Likewise, replicating the look and feel of the phone was not seen as important. On the other hand, it was agreed that background noise and other disturbances in using the phone was important to include in the final system in as a realistic way as possible.

- 4) Consolidate a large amount of user needs into one system design.

Unifying the different user-organizations needs is one of the greatest challenges a design project has to face. In our case, the ability to tailor each training session to a particular end-user was a

key issue in the design phase. For instance, this meant having functions that were configurable to suit different communication hierarchies. The initial storyboards were generic and presented multiple solutions and ideas of functions to be used in the training system. This allowed each end-user organization to discuss their individual needs and wishes and still ensure common ground between designers, users, technical partners, and other stakeholders. The user's requirements could easily be compared as they were based on the same visualizations. For example, log sheets had a different appearance and different use in the various response organizations. This led to a more detailed discussion on how the different users use logs during real life responses and what parts needed to be captured and simulated in the system.

It may also be necessary to go further in the interactive prototyping and develop more advanced prototypes to demonstrate particular aspects of the system or virtual environment – either by using other tools (such as Adobe Flash Professional) or by starting the software development process itself.

5 Summary

An essential part of developing new systems is to understand the users' needs and being able to transform these into functional requirements. This process can be particularly challenging when there are many partners and users involved. However, it is a critical step that is often rushed, which can create substantial problems at later stages in the development. In this paper we have summarized the steps used for facing the challenges faced at the initial part of the design phase. The focus of the techniques used is on the importance of visualizations, and how these can be collectively created between stakeholders and partners, allowing ideas to be circulated and approved from multiple users and perspectives.

6 Acknowledgements

We would like to thank all partners in the CRISIS project for contributing to the work presented in this paper. The research leading to these results has received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement n° FP7-242474.

References

- Beroggi, G. (1995). Employing virtual reality to support decision making in emergency management. *Safety Science*, 20(1), 79-88.
- Carroll, J. M. (2000). *Making Use: Scenario-Based Design of Human-Computer Interactions*. The MIT Press.
- Drury, J. L., More, L., Pfaff, M., & Klein, G. L. (2009). A Principled Method of Scenario Design for Testing Emergency Response Decision-Making. In Proceedings ISCRAM (Gothenburg, SE, 2009).
- Goodwin, K. (2009). *Designing for the Digital Age: How to Create Human-Centered Products and Services*. Indianapolis, IN, USA: Wiley Publishing, Inc.
- Haynes, S. R., Purao, S., & Skattebo, A. L. (2009). Scenario-Based Methods for Evaluating Collaborative Systems. *Computer Supported Cooperative Work*, 18(4), 331-356.
- Jenvald, J., Morin, M., & Eriksson, H. (2010). Challenges for user interfaces in VR-supported command team training. In Proceedings of NordiCHI (Reykjavik, ICE, Oct 2010).
- McCloud, S. (1994). Understanding Comics: The Invisible Art. *IEEE Transactions On Professional Communication*, 41(1), 66-69.
- McCloud, S. (2000). *Reinventing Comics : How Imagination and Technology Are Revolutionizing an Art Form*. Harper Paperbacks.
- McCloud, S. (2006). *Making Comics: Storytelling Secrets of Comics, Manga and Graphic Novels*. Harper Paperbacks.
- McCurdy, M., Connors, C., Pyrzak, G., Kanefsky, B., & Vera, A. (2006). Breaking the fidelity barrier: an examination of our current characterization of prototypes and an example of a mixed-fidelity success. In Proceedings of CHI' 06 (Quebec, CA, April 2006).
- Rudinsky, J., & Hvannberg, E. T. (2011). Consolidating models of requirements analysis for crisis management training simulator. In Proceedings of ISCRAM (Lisbon, PO, May 2011).
- Saffer, D. (2006). *Designing for Interaction: Creating Smart Applications and Clever Devices* (p. 231). Peachpit Press.

Walker, W. E., Giddings, J., & Armstrong, S. (2011). Training and learning for crisis management using a virtual simulation/gaming environment. *Cognition, Technology & Work*, 13(1).

Yasar, A.-U.-H. (2007). Enhancing experience prototyping by the help of mixed-fidelity prototypes. In Proceedings of *Mobility 07* (Singapore, September 2007).