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Hydrogen safety virtual reality training tool Status

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Partner responsible for the deliverable: CRISE

Contributing partners: ALL

Authors:

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Document history

Revision	Date	Modifications made	Author(s)
V1	12 December 2013	First part: **VR Training Environments***	Eric Maranne
V2	08 March 2014	Second part: **VR Training Design***	Eric Maranne
V3	4 September 2014	Third part: **Virtual Exercises report after Workshop***	Eric Maranne
V4	20/03/2015	Final	Eric Maranne

** All intermediary documents produced are available on HyResponse webSite.*

Contents

INTRODUCTION

This document presents the **Hydrogen safety virtual reality training tool** and exposes work of CRISE in the HyResponse project.
In this document, this work will have to be evaluated against CRISE role and expectancies linked to Virtual Reality uses as defined in the HyResponse DOW.
Following is a shortlist of CRISE role and VR expectations within the HyResponse Project.

In WP2:
• Provide their requirements with regards to the description of the applications and to the formulation of hazard scenarios for subsequent implementation in virtual reality tools, • Validate pedagogic representations and operational scenarios per application, in the context of the Virtual Reality (VR) test bed.
In WP3:
• Review the format and the content of the educational training, • Customized 3D representations of FHC systems for pedagogic purpose, • Contribute to the D3.1. International Curriculum on hydrogen safety training for First Responders
WP5:
The goal of this WP is to develop a 3D Virtual Reality Serious Game environment in order to: • Test WP2 production from the first responder standpoint, • Evaluate pedagogic strategies for training against WP2 assessments, • Incorporate hydrogen exercises modelling in the different applications and test elaborated responses capabilities in ENSOSP 3D VR training tools, • Allow large scale, multi-agency validations and training sessions.
Three tasks are defined:
Task 5.1. Programming of thehydrogen virtual training platforms(Leader:CRISE) Task 5.2.Definition of the 3D Virtual Reality Serious Game exercises(Leader: ENSOSP, participants:CRISE, HELION, AL, UU) Task 5.3. Hydrogen phenomena input for virtual training exercises (Leader: UU, participant:CRISE)
Role of participants:
CRISE: • Carry out the 3D Virtual Reality hydrogen application and training tool and write D5.1, • Contribute to the elaboration of the virtual training exercises.
ENSOSP:
• Lead the elaboration of the virtual training exercises and write D5.2.
UU:
• Contribute to the elaboration of the virtual training exercises, • Provide inputs for the development of the virtual training tools • Lead the development of the D5.3.

HELION and ALwill review the design of the FCH systems and will participateto the elaboration of the virtual training exercises.
Three deliverables are expected within this WP:
D5.1: Hydrogen safety virtual reality training tool (Month 12) D5.2: Virtual reality educational exercises (Month 18) D5.3: Hydrogen phenomena input for virtual training scenarios(Month 24)

What stands out of this shortlist is the span of Virtual Reality activities in the project:

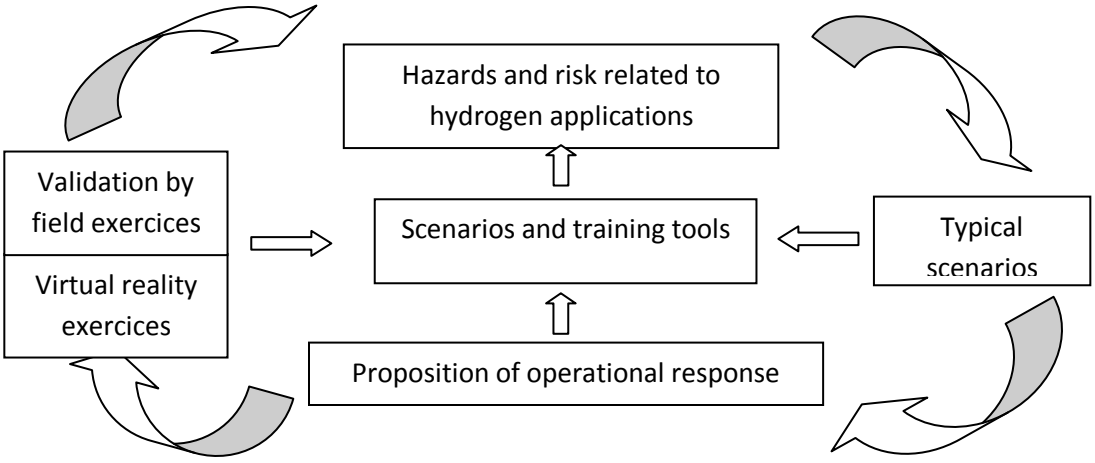
- from the very first stages, where it has been necessary to provide environments and representation support to other members,
- during best practices and doctrinal discussions in order to provide cross competencies representations
- during test exercises and workshop to support representation of SOPs (Standard Operatiing Procedures) and ROEs (Rules of Engagement) in a cross instituional (industrial vs frontliners) and in a cross cultural (different cognitive and doctrinal approaches at international level)
- during the curriculum content organisation
- it will be heavily used during pilot training sessions,
- it will have to support web based diffusion, training and rehearsal after the end of the project

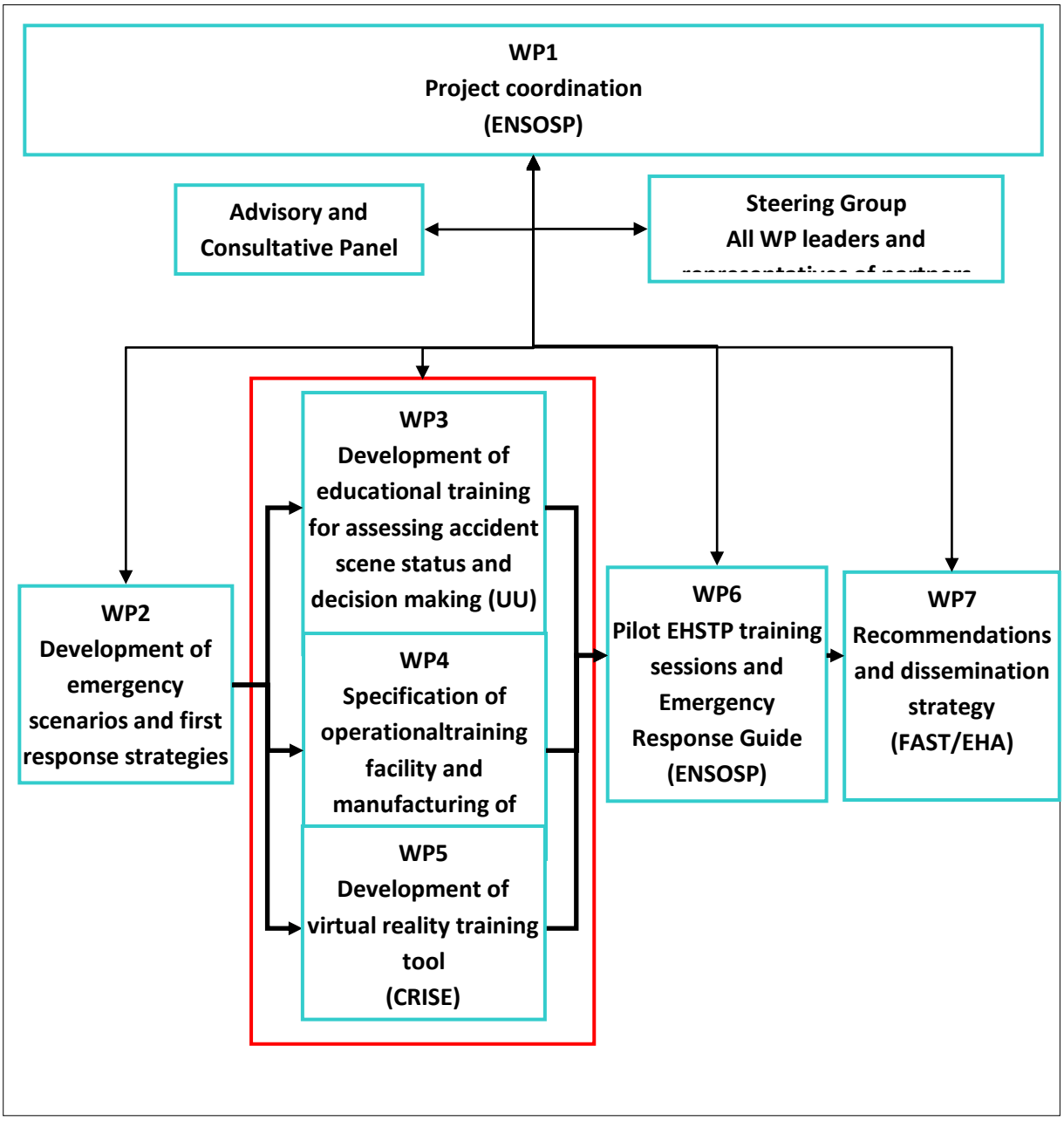
Besides, VR proved to have a wide functional span beyond a simple training tool:

- for shared representation of phenomena, SOPs and ROEs,
- as a common ground representation for team discussions and exercises,
- for shared representation of the physical simulator proposed setups

All HyResponse members have been concerned and have been providing input to build this VR tool.

This document is a condensed version of working documents already uploaded to the confidential area of project website : http://www.hyresponse.eu/members/documents_upload.php




WP1
Project coordination
(ENSOSP)
Advisory and
Consultative Panel
Steering Group
All WP leaders and
WP3
Development of
educational training
for assessing accident
scene status and
decision making (UU)
WP2
Development of
emergency
scenarios and first
response strategies
WP4
Specification of
operationaltraining
facility and
manufacturing of
WP5
Development of
virtual reality training
tool
(CRISE)
WP6
Pilot EHSTP training
sessions and
Emergency
Response Guide
(ENSOSP)
WP7
Recommendations
and dissemination
strategy
(FAST/EHA)

VR Training Environments

Complete VR Training Environments document is available on confidential area of project website : http://www.hyresponse.eu/members/documents_upload.php

The first task has been to produce virtual environments and assets dedicated to hydrogen risk mitigation. After some documentation and input from partners, some relevant infrastructures have been selected and inserted into a wide virtual area.

Example of such infrastructures are:

- tunnels (different types)
- driveways (roads and motorways)
- parkings (open, underground, private, public, ...)
- industrial production
- alternative energy production
- storages
- ...

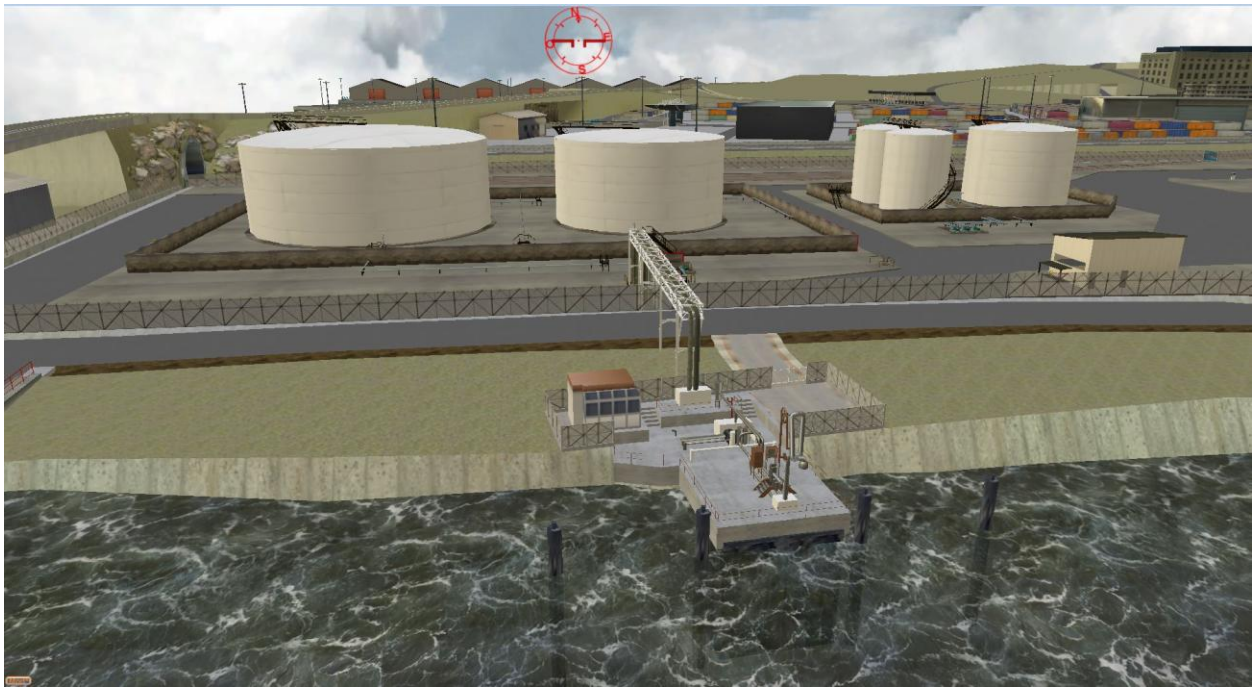
These infrastructures need to be inserted in different types of surrounding, in order to support significance to sound risk mitigation processes. These operationally interesting 'surroundings' have been compiled into an 'environment', suitable for a wide number of different scenarios story telling.

This 6km*6km environment encompasses for example:

- old and new style dense city quarters
- sparse homes and highrise buildings
- schools, hospitals, and other public buildings
- commercial centers
- industrial estates (from artisanal to heavy petrochemical)
- harbour, airport, leisure
- floodable area and mountain remote location
- motorways, tunnels
- ...

In the following screenshot are presented some places in this training environment, ready to be personalised for any specific operational scenario.

.The complete environment, including fully customisable areas.

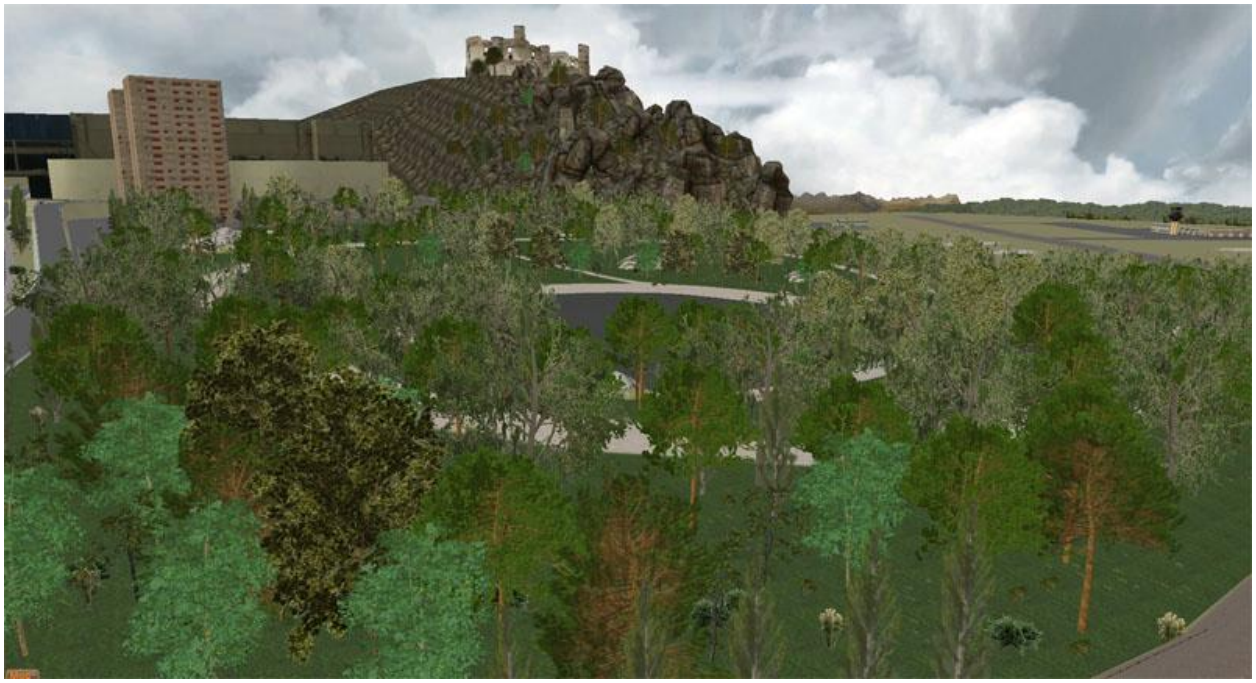


Energy storage and industrial estate.

70ies urban style, with open air parking lots.

Old city, historical center. Ready for Hydrogen Bus incident ...

Old city center, from above, with underground parking, city bridges, ...



Remote location, ready to receive a green cell powered antenna

Of Course the environment isn't sufficient, and it must be populated with hydrogen risk related assets.

The VR tool has been designed so that assets can simply be dragged and dropped into the 3D in order to build specific environments.

For example, a green cell, near a solar electrical production unit, situated on the roof of a nearby commercial center.

Environments when populated by designed objects enable to obtain an interactive 3D virtual environment in which trainees may interact between themselves, and with surrounding objects and equipment.

For example, it's possible to extinguish a fire, using a hose and a nozzle, and this will trigger automated management of water level in the fire engine, eventually the pressure at hydrant level, and, of course, heat generated by the fire will impact objects and people (virtually of course)

A very simple vehicle fire.

or, more complex to mitigate, in a tunnel:

VR Training Design for HyResponse

Complete VR Training Design for Hyresponse document is available on confidential area of project website : http://www.hyresponse.eu/members/documents_upload.php

Pedagogic concepts for developing HyResponse training

The aim of this document is to present the different types of training that may be designed in the context of the HyResponse project. For each training type, some specific considerations and material design are presented.

Scope and concepts

In the scope of HyResponse we're interested both in 'dissemination', 'education' and 'experience acquisition', which need slightly different approaches, but may rely on some common principles and materials.

First of all, Andragogy : we're not aiming at initial education, but at adults firefighters. Andragogy, as known as 'adults oriented pedagogy' implies a more self directing learner, less didactic and more hands on approaches, real life application focused and based on previous and acquired experience.

Andragogy has few principles (from Knowles (1984, Appendix D)):

(1) There is a need to explain why specific things are being taught (e.g., certain commands, functions, operations, etc.)
(2) Instruction should be task-oriented instead of memorization -- learning activities should be in the context of common tasks to be performed,
(3) Adults are most interested in learning subjects that have immediate relevance to their job or personal life.
(4) Instruction should take into account the wide range of different backgrounds of learners; learning materials and activities should allow for different levels/types of previous experience,
(5) Instruction requires helping them overcome inhibitions, behaviors, and beliefs about learning.

We can easily see that all those points are both related to each of our interest (dissemination, education and experience acquisition), and are to be considered globally.

Using virtual reality technology (VR) enables to help answering several expectations:

(1) explanation and explicitness: the production of real life foreseen problematic of H2 wide use enables to picture, and explicitly expose why specific protocols, functions, operations, etc. are needed
(2) task orientation and interaction: VR is the perfect tool for this.
(3) relevance and real/personal life relation will have to be designed through the choice of environments, operational problem, and scenarios. This will be discussed in the next chapters.

(4) the low cost of VR scenarios creation enables to provide a rich set of scenarios fitting learners experience diversity as extensively as possible.
(5) VR may provide training schemes ranging from single user to full blown multi agency set ups, providing many inhibition avoidance strategies, and provides a fresh approach to learning that may overcome existing beliefs or reluctance.

Typology of training

We may consider 5 different approaches in HyResponse scope:

- orientation exercises,
- tabletop exercises (TTX),
- drills,
- functional exercises (FE),
- full-scale exercises (FSE).

Orientation exercises

Orientation exercises are designed to 'guide' the user towards a problematic. This should be understood both as an explanation of 'why' it is necessary to train to H2 specifics, but, as well, as an orientation towards the different contents of the proposed trainings. We want the public to be self- directing into following the training, so we need to provide orientation.

The purpose to focus is to:

- familiarize newcomers to H2 incidents management specifics (Why, How)
- introduce interested persons to training offer

Examples are:

- dissemination material on a website (pictures, VR presentations)
- workshop or seminars presentation material gathering
- animation of constructive and explicit problem exposure and solving (performed usually by a single instructor/presenter, in a face-to-face to an **homogeneous** participants group (film, VR presentations, etc.)

Tabletops exercises (TTX)

A TTX is a low-stress exercise to stimulate discussion on a simulated event. Designed to expose the 'why' and 'how', discussion enables to discuss issues in depth, in the context and experience of participants, and to make decisions using slow-paced problem solving methods, driven by the instructor, in contrast to the spontaneous, fast-paced typical of actual or simulated emergency conditions. TTX are designed to

comfort the participant in understanding the problem and the protocols/functions/operations designed to deal with it. It enables to explicitly understand how these protocols are fitting in their everyday life and organisation (or what are the conditions in order for them to fit in).

Constructive problem solving, organisation/material bound limitation identification are the goals of these exercises. A TTX **may involve multi agencies** participants, as it enables to understand each other limitations, expectations, needs and capabilities, forces and weaknesses.

The scenario is generally invented and describes an event or emergency incident, bringing participants up to a simulated "present moment" in time.

VR is used to provide the realistic material and vision suitable to expose the subsequent interactive pacing of events decisions and effects.

TTX shouldn't be though as 'real time', some events may be accelerated if not conveying interest for the discussion, others may be slowed down in order to expose inner mechanisms, or to simply provide enough time for discussion.

Constructive and interactive problem solving is usually performed by a single instructor in front of a group of **heterogeneous** participants.

Drills

The purpose of a drill is to use repetition to instruct thoroughly.

Drills can be used to test and optimize personnel training, response time, and workforce and equipment capabilities. Drills optimally take place after TTX or orientation, staff should have an understanding of the function that will be tested in the drill.

A drill is usually focused on a segmented functional part of a protocol, like 'immediate response', or 'operative answer'.

Achieving drills goals implies performing a lot of exercises. Here, repetition, operational diversity, and participants' real life relevance are keys.

VR is used to provide shared operational exposure and understanding, to expose the interactive pacing of decisions, actions and effects, and to sustain the drill action with spontaneous or planned events. Messages, both planned and spontaneous are usually used too to sustain the drill action.

Functional exercises (FE)

The purpose of an FE is to test and evaluate the capabilities of an emergency response system, interagency cooperation and resources. Events and situations that would actually occur over an extended period of time are exposed explicitly using VR or described. Unlike Drills, an FE encompasses more complete system, mixing typically functional and commandment levels.

VR is used in much the same way as in drills, but scenarios are different and longer, enabling to encompass a function and commandment wide systemic response. Fewer scenarios are to be provided than in drills situation, but the material to create is much the same.

Full Scale Exercises (FSE)

The purpose of an FSE is to test and evaluate a major portion of the emergency operations plan in an interactive manner over an extended period. FSEs typically involve more than one agency. As with an FE, the objectives of an FSE must be specified.

The goal here typically is to validate interagency cooperation and coordination.

VR use, and material to design are much the same as in FE exercises. The difference is that other agencies participants' experience, cognitive representation of the events, organisation and response is to be taken into account to build a shared representation of the operational context.

Roles and responsibilities of exercise players

It is necessary to define who will participate in the exercise. The number of participants, both as trainees or trainers impact on the aim, objectives of the exercise.

Typically, the same exercise might be used with a single instructor in the context of 'orientation exercise' or for 'TTX', but won't have the same aim, objectives and applicability.

It is needed to ensure that all needed / involved / concerned levels and organisations are represented (as trainees and/or trainers). Including the right players increases realism and running cost of the exercise.

Player roles can involve:

- Full participation – trainees playing their role
- Partial participation – observer,
- Simulated – A.I. taking in charge some operational levels, trainer masquerading a character

Virtual Exercises Report after September 2014 WorkShop

Complete VR Exercises Report after September 2014 WorkShop document is available on confidential area of project website :http://www.hyresponse.eu/members/documents_upload.php more screenshots and a complete film from the virtual events are available too.

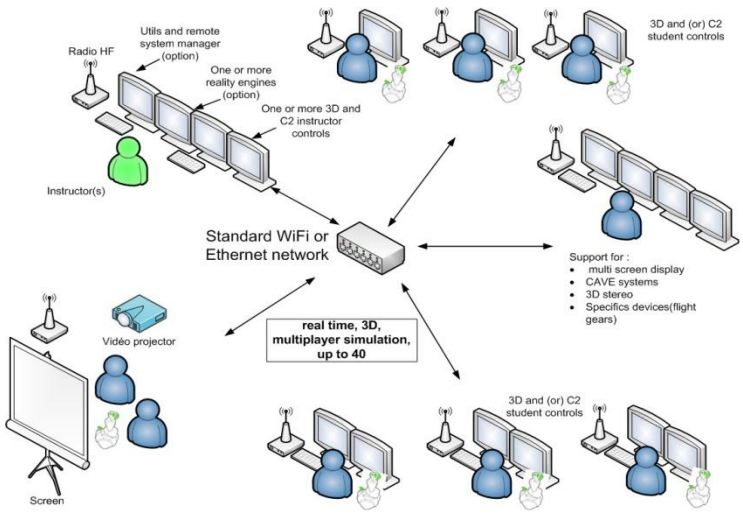
In the September 2014 introductory workshop, the Virtual Reality Training tool has been used for the first time to run two exercises.

One idea during the workshop was to demonstrate the tools capabilities, as a multiuser virtual reality framework, the other was to explicit the difficulties that may arise due to different perceptions of the danger, different cultures, different SOPs and ROEs.

Hyresponse – Workshop I - Virtual exercises

Set up as used in ENSOSP functional training exercices :

The usual Ensosp set up for fire fighters training is the following :



In this setup, many trainees are concurrently managing an emergency response. Those trainees may be fire fighters first responders, medics, or other kind of first responders (multi agency), or may be a full hierarchical deployment of first responders to IC, including media and institutions.

Ensosp provides a virtual training facility that may encompass very complex setup, like multi agency, joined forces operations, involving multiple, intricated commandment levels, from field operators up to high level commandment.

In the frame of the first Hyresponse workshop, a simple presentation set up has been provided as a tabletop exercise (cf TTX in preceding chapter), where the workshop attendees played the role of H2

‘Experts’. The aim of those exercises was to demonstrate the use of VR for HyResponse, and to ‘ignite’ a few discussions and remarks.

The setup was designed around three virtual access points:

- the first responders team, had access to virtual reality from their own point of view, performing proactive information gathering, making sense of the events and mitigating risk under tactical control,
- Tactical control was performed collaboratively and explicitely by the assembly of workshop attendees (TTX set up) in a different room. They were provided with a projected view, issued from a virtual camera (CCTV) located nearby the incident,
- finally a virtual helicopter was available for the attendees, ready to fly, with a real pilot at disposal.

First exercise : A multiple car crash on a motorway involving a H2 vehicle (Symbian equiped Kangoo).

In this simple set up, the forces involved where first responders team, backed by a manned IC Post (at county crises management center). First responders had access to the virtual incidents, and were able to perform actions.

When first responders arrive on the virtual scene, they find a vehicle on fire, and they extinguish it. They manage to call police for to stop motorway traffic. Then, they're scouting the cars to search for victims and find an intricated victim in a kangoo H2 car. An helicopter, certainly medias, is turning round in the sky over the incident.

First responders refers to the central IC, and have to describe the situation, ask for more fire engine (first is empty by now). Central IC ask to 'Experts' about H2 car incident.

IC proposes to start rescue victim (rescue shears & jaws of life handling).

This is the first time experts are asked for :

- Any danger with H2 ?
- Should we enforce a safe perimeter for victims and pedestrians?
- What about an helicopter circling above ?

Here discussion started in the experts pool (workshop attendees).

Before discussion settled (a workshop could be held on safe distances metrics), a poolfire broke under the kangoo, from a conventional vehicle oil leak.

First responders reacted immediately with an urgent extraction of the victim, and evacuated the scene.

Kangoo burned, safety valve triggered, H2 was released.

Fire engines arrived on scene. Fire was extinguished.

Ex. Over

Following screenshots have been realised during the Exercises.

Initial conditions. Multiple car incident, fire on conventional vehicule. Several victims, two urgencies, one trapped into a H2 kangoo. Media helicopter circling above. Motorway patrol, police, fire fighters and medics on their way.

Conventional car fire extinguished, meds scouting, H2 vehicule discovery, jaws of life use attempt, fire engine leader asks for experts advice :

Pool fire outbreak under conventional vehicule, and progresses towards Kangoo, emergency victim extraction, evacuation starting:

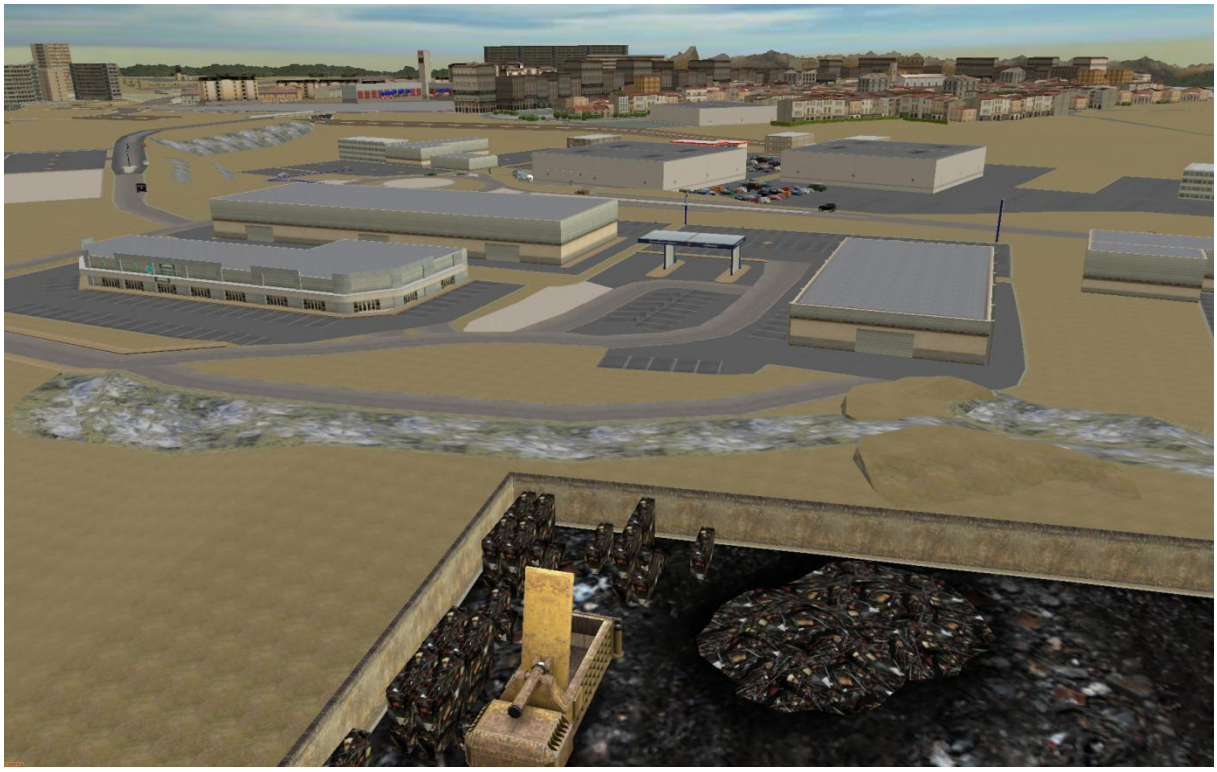
Fire extends to Kangoo itself, still evacuating :

H2 release (note vertical plume of Kangoo fumes oxydised by otherwise invisible H2 flame). Loud hiss burning sound. Evacuation not terminated yet.

Second exercise : liquefied H2 trailer incident.

In this simple set up, the forces involved where first responders team, as well as a specialised chemical team unit. First responders had access to the virtual incidents, and were able to perform actions.

Initial conditions : 5 PM, Saturday afternoon in a commercial area. A Chalugaz trailer incident near a store. The trailer contains liquefied H2 and is lying on the side off the road, leaned against the shop wall.



Initial conditions seen from the ground. No leak – no sound, no cryogenic whitish fumes. Driver is extracted. Trailer danger notices confirm content : liquid H2.

Workshop attendees are discussing about evacuation perimeter, wether to lift the truck back on road, or to empty it (opening valves), or transboarding contents into another trailer.

Decision is taken to trigger specific French procedure, involving the help of hydrogen industry experts. Decision to burn the H2 locally is taken, a special torch is delivered by helicopter.

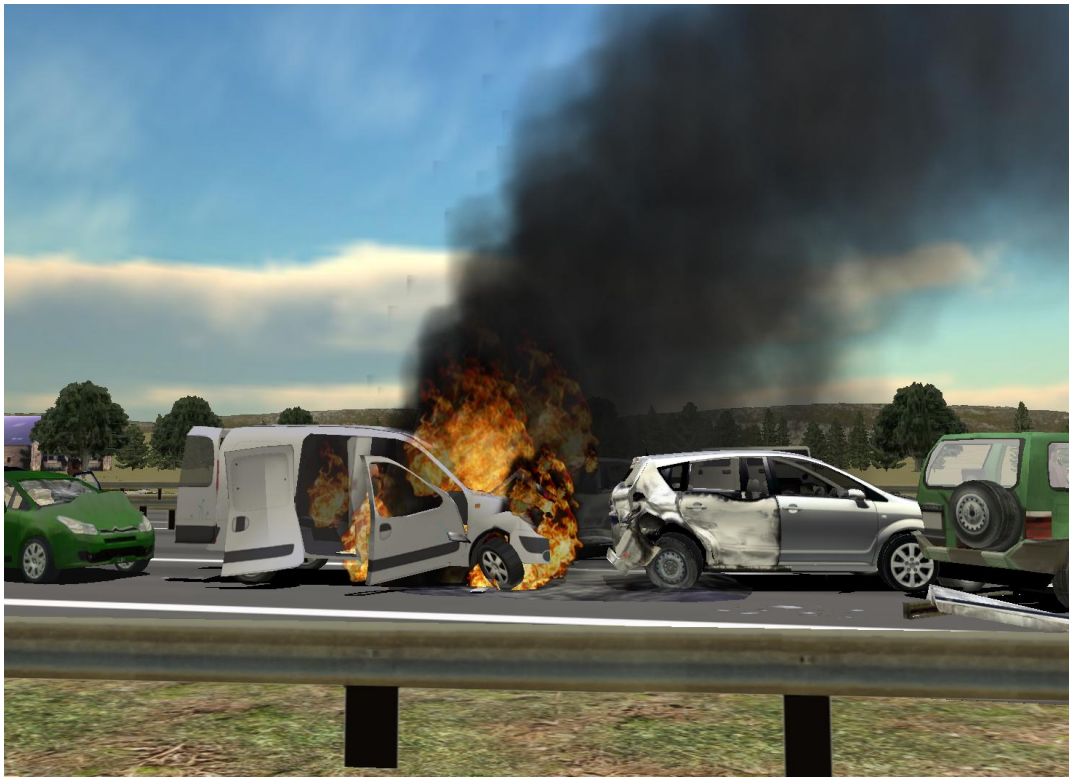
Torch deployed, connected, lit up (invisible flame), loud hiss burning sound.

Many specific assets have been designed specifically for the workshop, for example a Fuel cell vehicule, Kangoo type:

Kangoo screnshots :

After crash.

Burning :



Releasing (conventional fumes tint H2 flame):

Jaws of life opened

Cooled down …

Scenarios & project integration

Of course, such assets may be reused to compose any scene, and to create scenarios.

The virtual reality training tool has been used, in the project, to provide training, but it has been used to provide technical, operational and illustrative material.

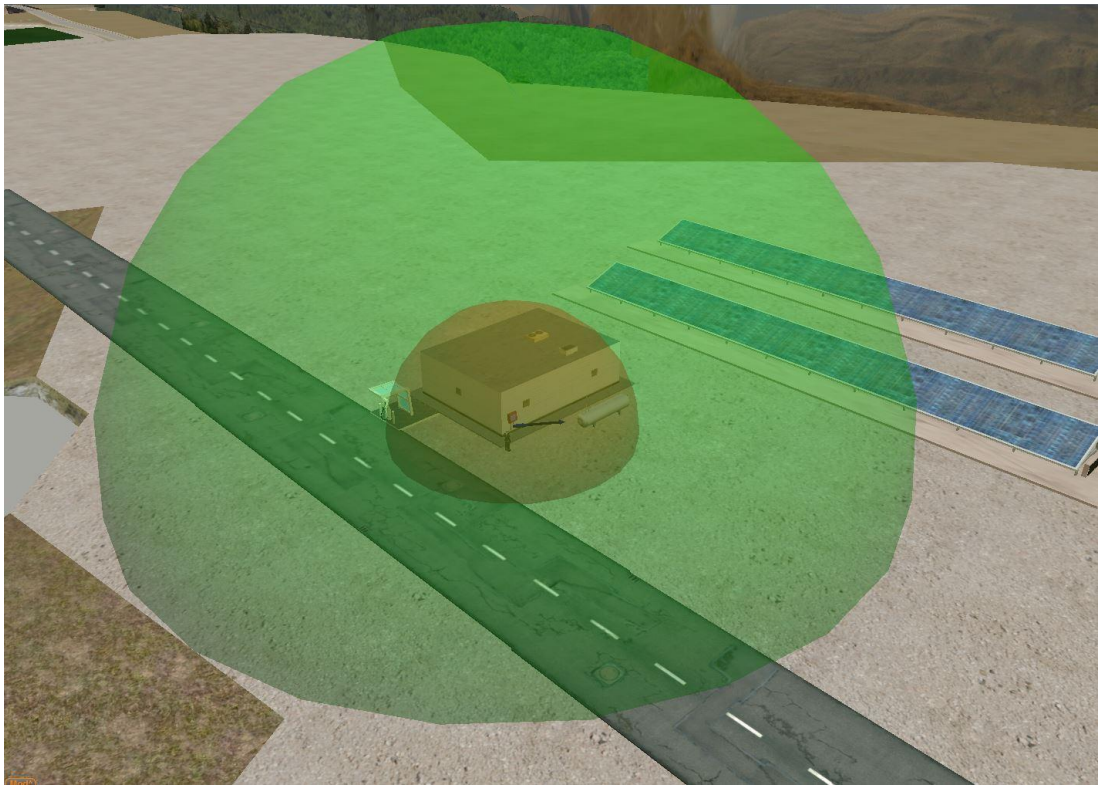
An illustration of this is a sample scene that has been provided on the 8th December 2014 to consortium members.

On this scene, are presented different types of storages, fuel cell bus, fuel cell vehicle, refilling station, storage area with fuel cell forklift, small house with fuel cell vehicle in garage, etc ...

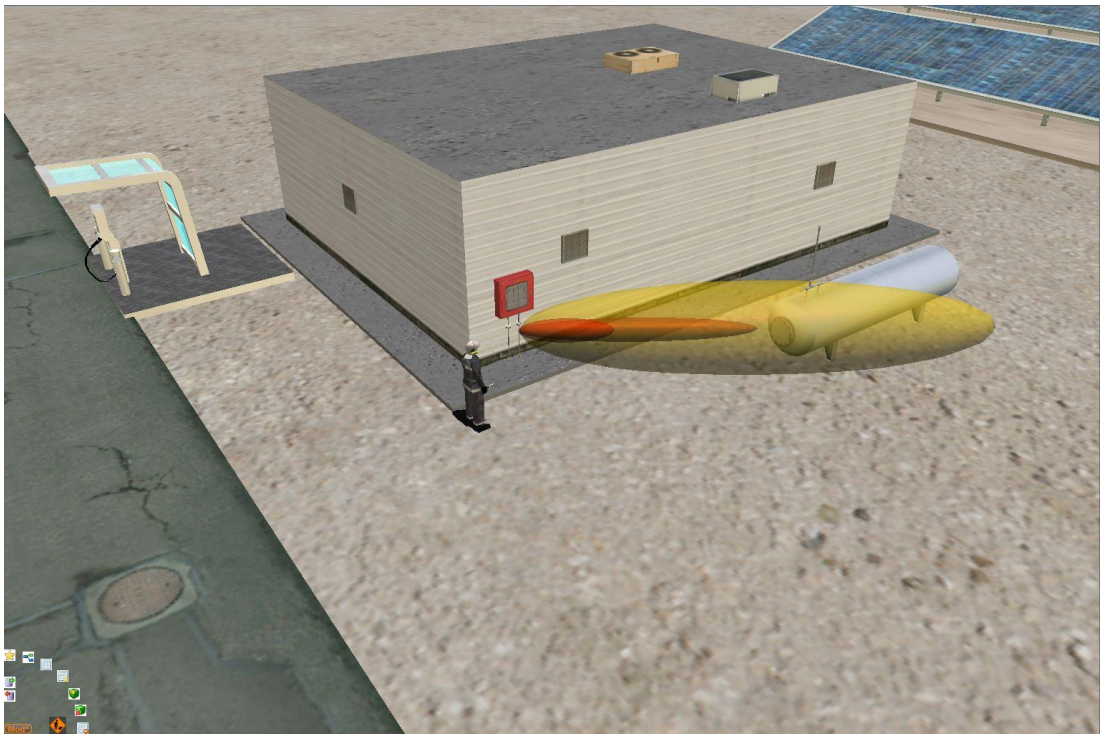

DEFENSE DE FUMER
RISQUE HYDROGENE
ZONE ATEX

Different types of visualisation and interactions are available:

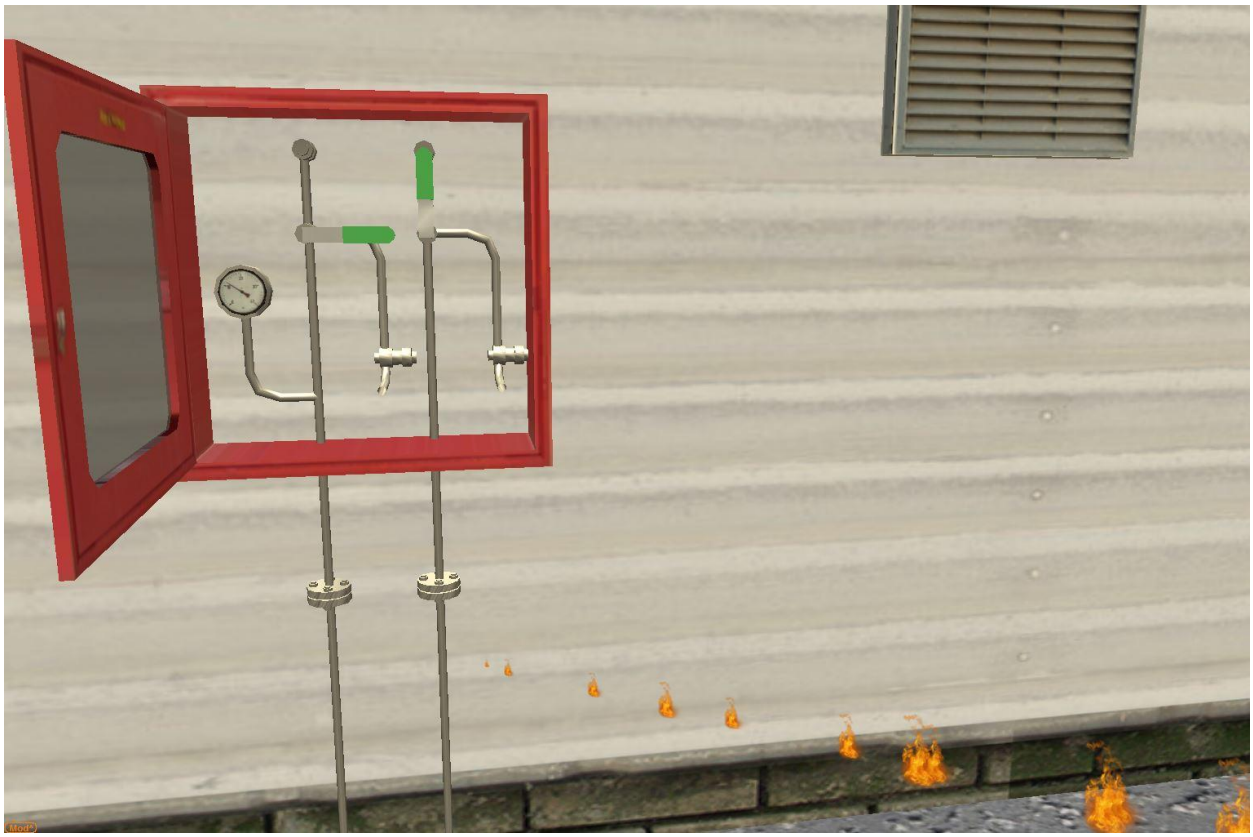
A pure operational, first responder level view of a pipe leaking.



At illustration level: sound envelopes representation at different levels ...



At technical / operational level: heat flux at operational thresholds



And always, interactive in the 3D and managed by AI and physics basic models

Distant Learning, eBook, pure HTML 3D, MOOC ...

This environment has been designed and delivered on the Virtual Reality training system, but not only.

It has been used for a demonstration online course on Hydrogen risk mitigation. This demonstration web site was composed with:

- a short introduction illustrated with an image gallery from this environment: a leaking storage, a represe,tation of the separation distance envelope, a representation of the sound, a representation of burning power thresholds, etc ...
- quizz on reflexive actions in front of a little scenes presented as screenshots
- a dynamic 3d representation of a leaking trailer and firefighters in action, exported from the VR training tool as 'pure HTML' not necessitating any software download or install on the client machine
- a little film, exported from the VR training tool exposing an attack lead on the trailer leak.

This webSite has been compiled, as a demonstration, as a stand alone epub **ebook**, readable on any computer or book reader (Kindle for example).

Those capabilities expand the use of the tool not only during training exercises, but as well to illustrate technical lectures, to provide material ,easily and at no residual cost, for designing online courses, online exercises, drills, and all the activity planned for the continuation of the HyResponse project.

The demonstration webSite, delivered on December 8 2014, is reachable on:

http://share.vr-vrisis.com/HyResponse/PresentationMilanoHTML/index.html

Conclusions

Current full content work documents are available on the members' zone of the HyResponse project website: http://www.hyresponse.eu/members/documents_upload.php).

The training tool has been designed to cover the needs of the HyResponse project, from the initial design, doctrinal evaluation phases, down to the after project dissemination and web based content.

Work is still going on, at the release date of this document. The integration of the physical platform, at ENSOSP, is planned, so that

- 'real' exercises may be rehearsed virtually,
- a virtual visualisation of danger zones, heat fluxes can be proposed
- safety concerns may be adressed in the classroom before going in the facility itself,
- a virtual version of 'real' exercises can be provided on the web for distant learning