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D4.5 Implementation of services of the 'what if' analysis demonstrator for the CIPRNet web portal

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1 Introduction – Rationale of this document

As part of its activities for creating a Virtual Centre of Competence and Expertise in CIP[1] (VCCC), CIPRNet has planned deploying a number of services to its target audiences via its website. Offering these services has more than purpose. First, the services shall demonstrate CIPRNet's new added-value capabilities. Second, the services shall extend CIP related contents of the Web portal and thus form a transition from a pure project website to a Web portal for the VCCC.

The VCCC services include amongst others:

- CIPedia©, an online glossary of CIP related terms[2] [D2.31][D2.32][D2.33][D8.110].
- "Ask the expert", an interactive service for asking CIP related questions to experts from CIPRNet and external experts [D5.3].
- CIPRNet's Decision Support System services [D4.6] which provide access for registered users to CIPcast [D7.4].
- A demonstration service for CIPRNet's 'what if' analysis capability based on federated modelling, simulation and consequence analysis, manifested in the application CIPRTrainer [D6.5][D6.4].

This deliverable D4.5 documents the latter service, i.e. the Web-based 'what if' analysis demonstration service of the VCCC or more conveniently named CIPRTrainer demonstration service. The service is accessible to registered users only. A user feedback mechanism will be implemented that allows improving the service (based on results of [D6.6+D6.7]). The service includes access to a tutorial of the usage of the interactive Web-based CIPRTrainer demonstration, derived from the experiences with the training material provided in [D9.40].

1.1 Context: the current status of the VCCC services

The first three services have already been deployed earlier. CIPedia© has become quite popular for such a highly specialised website. It currently receives more than 1,000 views per day, in total more than 398,000 views by the time of drafting this deliverable. Besides CIPRNet, the H2020 project RESIN has become a major contributor of CIPedia© contents.

For technical, security and license reasons, the services currently cannot be hosted on a single web server. The CIPRNet website bundles the access to the VCCC services. Users get routed in the following way:

- CIPedia© runs on Fraunhofer's Wiki farm
- 'Ask the Expert' is based on access to a database hosted by ENEA
- CIPcast is also hosted by ENEA
- The web-based 'what if' analysis demonstration service demonstration service is hosted on a Fraunhofer server

With the exception of CIPedia© that follows a Wikipedia like look and feel, the service access has a common look following the visual appearance design of the CIPRNet website.

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[1] CIP: Critical Infrastructure Protection

[2] www.cipedia.eu

1.2 'What if' analysis as a new capability for crisis management

The management of a disaster or crisis typically consists of cycles of situation update, decision taking, planning, and execution of response actions, sometimes under severe time pressure. At decision points, crisis managers often do not have just one option for action, but several. The challenge is to take a well-informed and most effective decision. Insufficient awareness of the role of Critical Infrastructures [Luiijf09] and incomplete information on consequences of crisis or disaster evolution [Klaver16] contribute to that challenge. In most cases, it is not possible to revert a decision or an action already taken – in reality. However, in *simulation* it is possible to do exactly this: 'go back in time' and explore a different course of action. This constitutes an unprecedented training opportunity that complements standard command post, table-top, or physical exercises. The expected benefits would be increased awareness of crisis managers of the role and behaviour of interconnected Critical Infrastructures in disasters, emergencies, and crisis situations, and a better understanding of possible consequences of scenario evolution and the influence of own actions.

CIPRTrainer is the software system that enables crisis managers to train decision-making in crises involving cascading effects of Critical Infrastructures. It is a new application that provides a new capability for training crisis management (CM) staff at the tactical level: Exploring different courses of action and comparing their consequences ('what if' analysis), based on federated modelling, simulation and analysis (fMS&A). At the front end, the prototypical training system presents itself to the user as a single-page web application. Its back end includes a federated simulation of three Critical Infrastructure simulators, a scenario database, a consequence analysis module, a complex event processor, and a threat simulation (flooding) [D6.4].

1.3 Relation to other deliverables and document structure

Work package 5 coordinates all the activities related to concrete and direct end-user support, and the design of the VCCC services started there. Deliverable D5.2 [D5.2v2] includes the initial requirements for the four VCCC services mentioned above. Deliverable D6.4 [D6.4] describes the implementation of CIPRTrainer, and deliverable D6.5 [D6.5] contains the documentation / user manual of the CIPRTrainer system. Deliverable [D6.6+D6.7] contains questionnaires that would be the basis of the user feedback mechanism. Finally, deliverable D9.4 [D9.40] contains training material prepared for the first training event on CIPRTrainer in Rome, July 15, 2016 [D9.83].

The remainder of this document is structured in analogy to [D4.6] as follows. In Section 2, we describe the design of the CIPRTrainer demonstration service and its implementation as CIPRNet/VCCC Web portal service. Section 3 elaborates on the CIPRTrainer demonstration service tutorial. We conclude in the summary section by highlighting the main points of the service.

2 CIPRTrainer demonstration Web service design

It should be noted that the CIPRTrainer demonstration service is different from the full CIPRTrainer system. This has a number of reasons. First, the full CIPRTrainer system is based on federated modelling and simulation of Critical Infrastructures (CI). One of the federate simulators, the commercial electricity network simulator SINCAL, uses a dongle for license protection. That is, at any one time only a single simulation can be run. In case of simultaneous access, only one user of the service could access and use the SINCAL simulator,

resulting in a rather frustrating experience to other users. The license costs (€ 10,800 list, € 2,160 academic) prohibit acquiring further licenses from the project's resources. Second, the full CIPRTrainer system requires training before using it.

Therefore, we decided to design the Web-based demonstration service such that a) more than one user can use it at the same time, and b) limit the interactions and provide guidance such that even a novice user can operate the demonstration service.

The goals of the demonstration service are a) demonstrating the user the added values of CIPRTrainer: exploring different courses of action; compare different consequences; experience the behaviour of CI under severe perturbations, and b) stimulating interest in using the full system.

Although the CIPRTrainer demonstration Web service is already implemented, we have written this design section such that it also shows alternative options for the implementation of certain features. This could be considered as a retrospective design description. The non-IT-expert reader may safely skip this section and continue with section 4.

2.1 Functional description of the demonstration service

The demonstration service of CIPRTrainer is provided as a Web application. Different functionalities are implemented as different Web views. Users are able to navigate between these views when using the demonstration service of CIPRTrainer and thus get an impression of the functions of the full CIPRTrainer system.

As stated in the beginning of this section, the demonstration service exposes only a part of the complete CIPRTrainer system due to the technical limitations mentioned above. The major goal of the demonstration service is providing an easy-to-use service demonstrating the highlights of the training rationale built inside the full CIPRTrainer system, not to replicate the whole CIPRTrainer system. The major functionalities of the demonstration service are:

- Exploring a set of predefined different courses of action.
- Comparing their different consequences.
- Experiencing the behaviour of CI under severe perturbations in these courses of action.

The functional differences between the CIPRTrainer demonstration service and the full CIPRTrainer system are listed in Table 1.

Table 1: Comparison of functionalities between the full CIPRTrainer system and the CIPRTrainer demonstration service

	Full CIPRTrainer system	CIPRTrainer demonstration Web service
Exploring different courses of action	Y	Y
Comparing different consequences	Y	Y
Experiencing the behaviour of CI under severe perturbations	Y	Y
Rollback of simulations	Y	N
Multi-session usage	N	Y
Use without intensive guidance	N	Y
GIS layers presentation	Y	N

2.1.1   Pre-defined decision options as videos and multi-session support

One of the core requirements of the demonstration service is that it must support multiple simultaneous sessions ("multi-session ready"). The reason for this requirement is that this service shall be widely available to authenticated users of the website / VCCC web portal. The user experience would not be optimal if only one demonstration session could be performed at a time. The full CIPRTrainer system is not multi-session ready, since the commercial electricity simulator SINCAL used in the CIPRTrainer prototype is a single-license version protected by a dongle, such that it can be used only in a single session at a time (see also introduction to Section 0). The direct consequence of this limitation is that we could not use the full CIPRTrainer system and we needed to find a different solution.

To overcome the lack of the real domain-specific simulators and reduce the complexity of the demonstration system, pre-calculated simulation results are being presented as videos to the user. The dynamics of the crisis situation is also shown in the videos. This greatly reduces the complexity of the Web demonstration service – the users only need to watch a series of video sequences with the option to repeatedly watch the presented situations and courses of actions in each video sequence and then make their decision at predefined interaction points. These video sequences are embedded in the `Demonstration` Web view in Section 2.2.

The implementation of the CIPRTrainer Demonstration Web Service (CWS) supports multiple simultaneous sessions. When a user logs in to the CWS, the CWS creates a new session. When interacting with the CWS, the user's Web browser creates HTTP requests that are sent to the CWS. The management of simultaneous sessions requires the correct assignment of each HTTP request to the corresponding session. For achieving this, the CWS uses a suitable mechanism, HTTP sessions based on cookies. This mechanism allows for identifying the training session that is currently active for a certain HTTP request.

2.1.2   Authentication

The CIPRTrainer demonstration service is designed to be only accessible for authorised users who are members of the VCCC audience. The technical implementation provides a mechanism for prohibiting unauthorised access to the demonstration Web service – both its Web views and its RESTful APIs[3] (in case we decide to deploy them as well; cf. Section 2.2.1).

2.2   Views and transitions of the Web application

To provide the functionalities described in Section 2.1, three basic types of Web views have been designed which are illustrated in Figure 1.

The `Home` and the `Tutorial` views are singletons, i.e. there is always only one instance of both views inside the implementation of the demonstration Web service. The last view – `Demonstration` – can have multiple instances, depending on the number of active sessions.

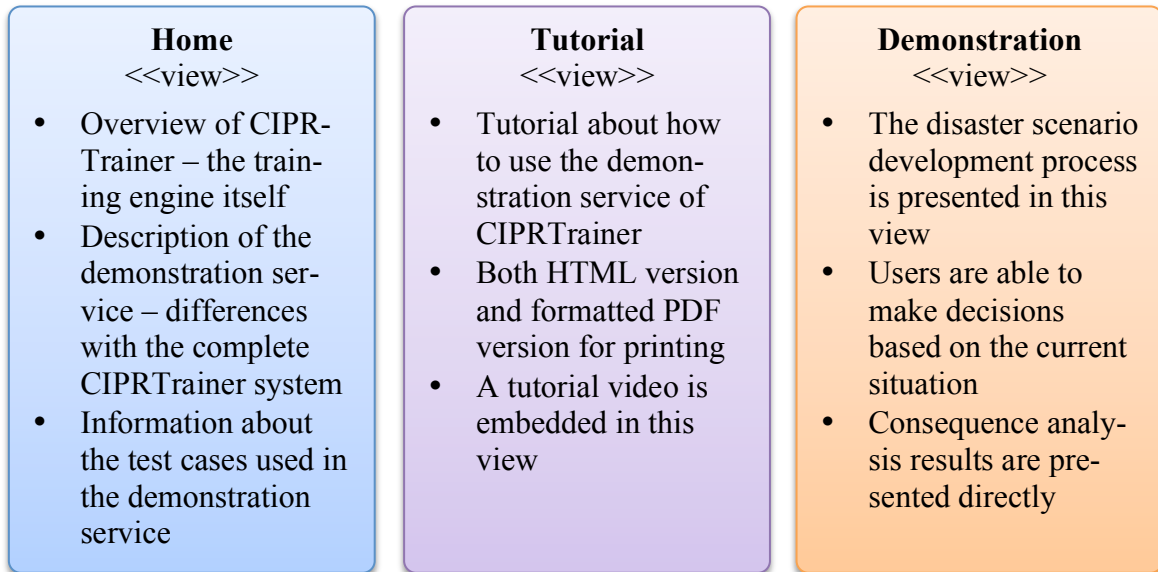[3] REST: representational state transfer; API: Application Programming Interface

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<table>
<tr><td>**Home**
<<view>></td><td>**Tutorial**
<<view>></td><td>**Demonstration**
<<view>></td></tr>
<tr><td>
• Overview of CIPR-Trainer – the training engine itself
• Description of the demonstration service – differences with the complete CIPRTrainer system
• Information about the test cases used in the demonstration service
</td><td>
• Tutorial about how to use the demonstration service of CIPRTrainer
• Both HTML version and formatted PDF version for printing
• A tutorial video is embedded in this view
</td><td>
• The disaster scenario development process is presented in this view
• Users are able to make decisions based on the current situation
• Consequence analysis results are presented directly
</td></tr>
</table>

Figure 1: Web view types in the CIPRTrainer demonstration Web service

2.2.1 URL structure for stateless design

Stateless design is critical for large Web applications. One of the prominent advocates of the stateless design paradigm is the RESTful design, a paradigm for high performance and scalability. The demonstration service per se is not purely stateless due to the fact that users need to be authenticated. However, the stateless design is applied after the user is logged in.

The URL structure for the demonstration service is presented in Figure 2. The node $ROOT is the base context path of the demonstration Web service application. Depending on the deployment, e.g. behind a reverse-proxy or not, this could change. The /home node represents the Home view defined previously: if an authorised user tries to access the URL $ROOT/home, then the Home view would be rendered and delivered. Similarly, the Tutorial view is mapped to the URL $ROOT/tutorial.
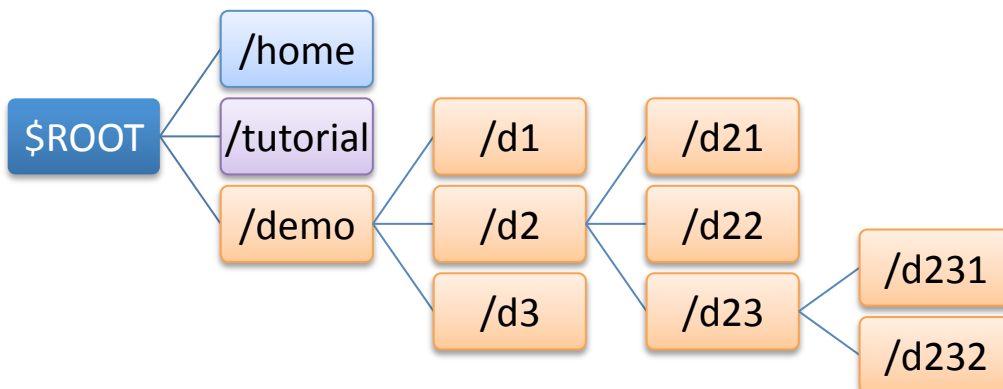
Figure 2: URL structure of the CIPRTrainer demonstration Web service

The Demonstration view is more complex. Depending on the current location in the URL structure and the user decisions, different views should be redirected to the corresponding URLs. This kind of redirection is currently hard-coded in the test case. The views will be rendered and delivered either from the server or by the client Web browser (isomorphic design, further explained in Section 2.3).

2.3 Isomorphic design of the demonstration service

The idea of "isomorphic design" has emerged recently. It aims at handling the problem that modern HTML5 applications have – JavaScript's heavy dependency on the client processing and functional capabilities. That means if the client system, e.g. the Web browser, does not have JavaScript support enabled then the Web page will not get rendered correctly.

The solution is quite intuitive, namely server-side rendering. After the Web server has detected that the HTTP request comes from a client that has limited support for JavaScript, the server will spawn a "virtual" client to render the Web pages and then send the rendered results to the (real) client system. The challenge however is the implementation – no one wants to implement the coding twice: one for the real client and the other for the "virtual" client. To solve this dilemma, at least partially, several frameworks have been developed. More details will be given in Section 2.4.

Isomorphic design is critical for modern Web sites, especially for those HTML5-based websites with high demands on Search Engine Optimisations (SEO). With this in mind, the CIPRTrainer demonstration Web service will be search engine friendly and thus support its own promotion and dissemination.

2.4 Recommendations for technical implementation

To facilitate the technical implementation, several recommendations regarding the programming languages, software frameworks and server infrastructures have been provided.

To keep it simple, we recommended not using a Content Management System (CMS) for building the demonstration Web application. CMS are good for collaborative editing of the Web contents (e.g. using template structures), which is not the case for the demonstration service of CIPRTrainer. It would be overkill to use some heavy CMS for building the demonstration service.

In principle, the main programming language for developing the demonstration service could be JavaScript. Modern JavaScript engines are quite efficient for the backend and a huge ecosystem (coding environment, syntax checking, building automation, deployment, etc.) has already been developed on top of NodeJS, which is a modern JavaScript engine. Other candidates would be Java or Python, both have a huge community as well. Depending on the skills of the developers, either one could be used. For the front-end, JavaScript is the only native language that is supported by modern browsers; however, trans-compilers for other programming languages like Java or Python do exist.

Isomorphic design is specific for developing the service with JavaScript. Several frameworks exist already that reduce the effort of supporting isomorphic design: Meteor[4], DerbyJS[5] and Feathers[6], etc. Finally, the authentication can be done with HTTP basic authentication on top of HTTPS. Other authentication mechanisms like OAuth, i.e. login with Google, Facebook accounts, etc. could also be provided depending on the available development resources. However, it is recommended not to use sophisticated ones in order to keep the demonstration service simple and concise.

The demonstration service should be secured as well. Different views will be protected by checking if the HTTP request is authorised or not. Technically, either HTTP cookies or token-

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[4] https://www.meteor.com/

[5] http://derbyjs.com/

[6] http://feathersjs.com/

based authentication could be used. The service developer can choose one. A dedicated authentication Web page should be provided for the user to login into the system.

3 CIPRTrainer demonstration Web service

This section comprises details about the user interface and the interaction possibilities of the CIPRTrainer Demonstration Web Service.

3.1 CIPRTrainer demonstration Web service interface

The CIPRTrainer Demonstration Web Service (CWS) is a Single Page Application (SPA), which provides a continuous user experience by dynamically changing the DOM-tree[7] using JavaScript. CWS offers a home page, a tutorial, and a service demonstration page.

3.1.1 Home page

The landing or home page of CWS contains a brief description of the key features of CWS, and links to other documents such as the official CIPRNet website (ciprnet.eu), public deliverables and other services (see Figure 3).

Figure 3: Landing page of CWS

3.1.2 Tutorial page

By clicking on the link "Web Service Demonstration", the user is introduced to an interactive tutorial, which comprises three steps and gives instructions on how to use CWS (see Figure

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[7] DOM: Document Object Model

4). By completing the tutorial, the user is redirected to the demonstration page. The tutorial is not obligatory and can be skipped by clicking on the button "Skip Tutorial" on the bottom side.

Figure 4: Tutorial page of CWS

3.1.3 CIPRTrainer demonstration Web service page

The crisis scenario chosen for the demonstration is a dramatic cargo train derailment incident in Germany. After the virtual training session for the chosen derailment scenario has commenced, the user can see the situation display of CIPRTrainer. The Web service then plays a video sequence showing the evolution of the incident up to a certain point where a decision is required/needs to take place by the user as trainee. When the trainee enters a decision, the situation advances to the next interaction moment. This evolution is shown in video sequences. The video sequences show the map of the area in which the incident takes place, show how events and additional information are displayed in CIPRTrainer's trainee view, and how actions are taken or initiated in the simulated crisis management.

At a certain point, the user can interact by choosing between two different outcomes: the scenario evolution with and without cascading effects of critical infrastructures. Based on the decision, one out of two available video sequences is started. When the selected video sequence is finished, the user is presented information about calculated aftermaths or consequences in form of tables and diagrams (see Figure 6), and a list of crisis management related actions that led to the result. It should be noted that the user has no influence what actions are performed. Figure 5 illustrates the demonstration web page, which consists of three sections:

- CIPRTrainer Introductory Video,
- CIPRTrainer Web Service including the interaction possibility,
- Result view including consequences and list of actions being performed.
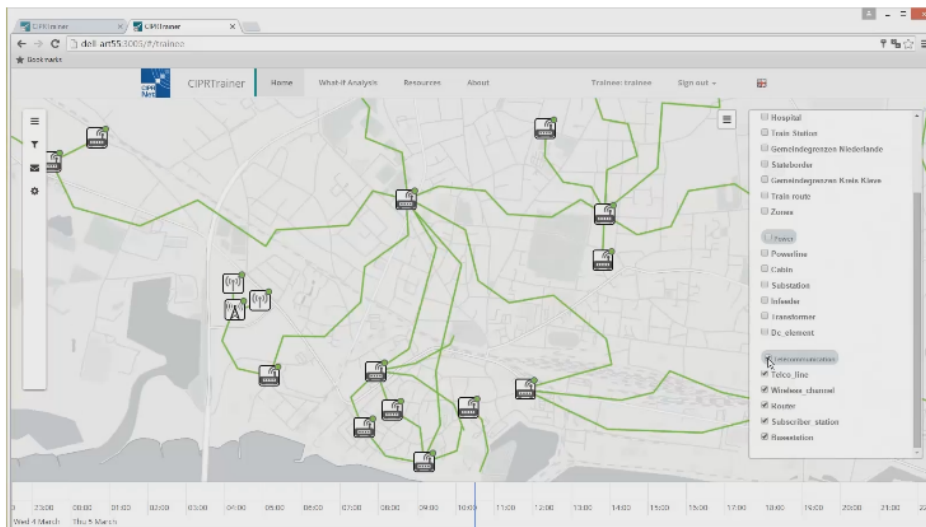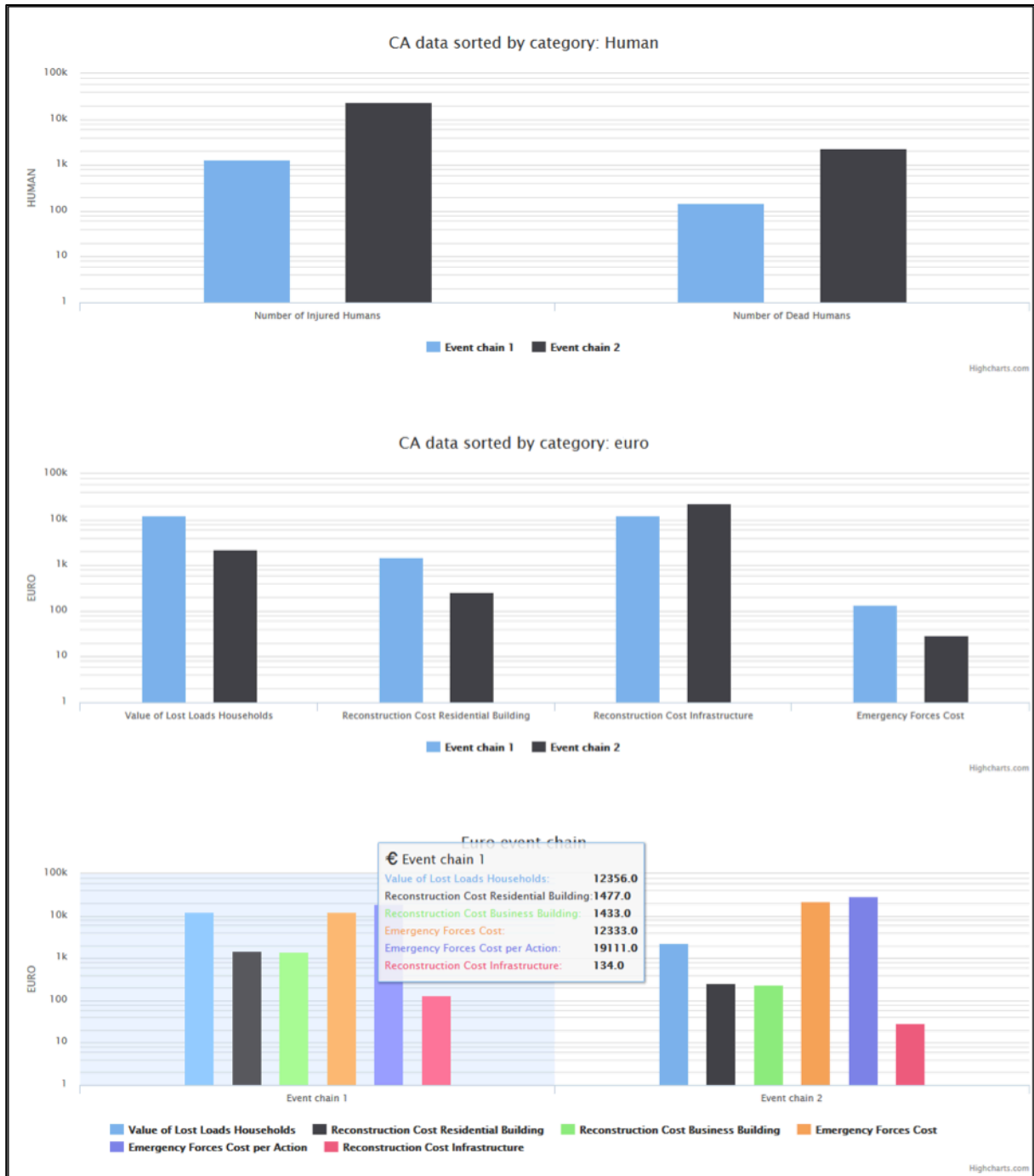
Figure 5: Demonstration page of CWS

Figure 6: Diagrams enable the user to compare different training results

3.2 CIPRTrainer Web service interactions

The following section contains a short guide to the interaction possibilities of the CWS. It includes a section about the tutorial, which introduces the use of CWS in three steps, and the interaction possibilities for the demonstration.

3.2.1   Interactive tutorial

3.2.1.1   Step ONE – Getting familiar with the added value of CIPRTrainer

The aim of the first step is to familiarise the user with the key features and added value of CIPRTrainer. Technical or specialist terms are intentionally left out to provide a simplified view of the innovative features of CIPRTrainer (see Figure 7). To continue with step two, the user has to click on the bottom button ("Continue with STEP TWO", appears below text describing "What, if …" analysis, not shown in Figure 7).
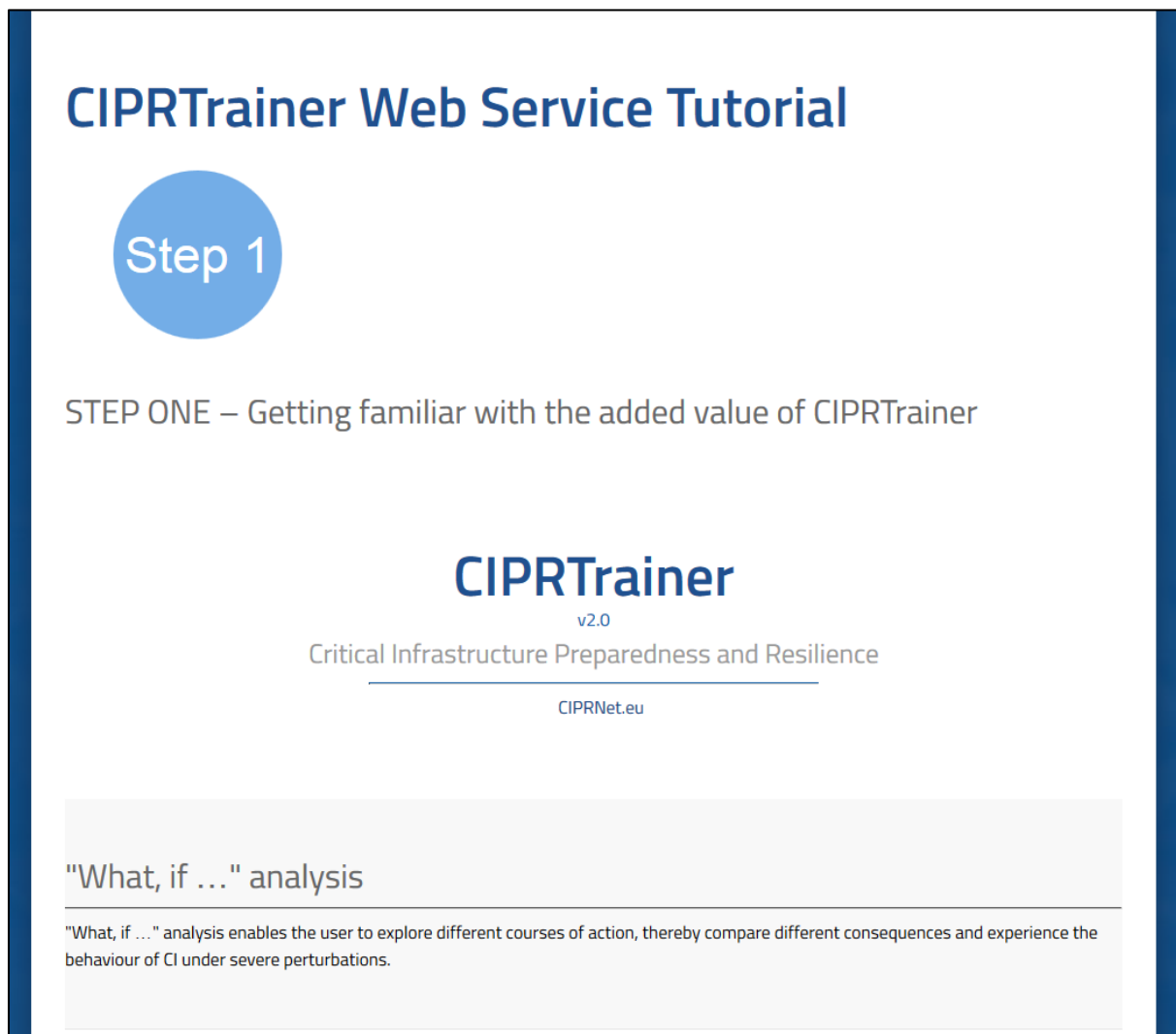
Figure 7: Step one gives an overview of key features and added value of the CIPRTrainer

3.2.1.2   Step TWO – Explaining outcome of the demonstrated scenario evolution

This step provides meta-information of the outcome of the two possible scenario evolutions – the one with and without cascading effects. The result includes information about direct and indirect consequences, and a list of actions that has been performed. To continue with step three, the user has to click on the bottom button ("Continue with STEP THREE").

Figure 8: Step two of the CWS tutorial enables the user to understand the results of the simulation

3.2.1.3   Step THREE – Preparing for the use of interactive CIPRTrainer Web service

This step includes information on what the video is about and a guide on how to interact with demonstrator (see Figure 9). Video sequences and animations are incorporated to provide a clear understanding. The user can now launch the demonstration page by clicking on the bottom button ("Continue with the Web Service demonstration"). Basically, the user can choose between two courses of action: one course of action that includes failing CI elements and cascading effects, and another course of action that avoids cascading effects.

Figure 9: Step three explains the interaction possibilities of CWS
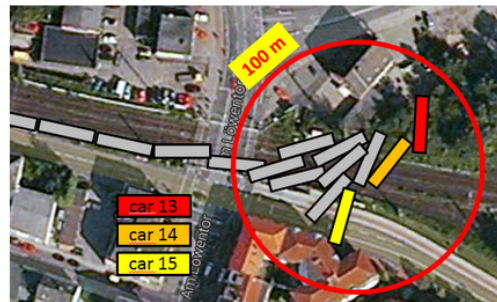
3.2.2 Interactive CIPRTrainer demonstration

The interactive demonstration Web service is built as simple as possible for the following reasons:

1. It is dedicated for users with low technical qualifications in order to gain a basic idea of what CIPRTrainer is about and what features are provided.
2. Since CIPRTrainer is a multi-user training system, we simplified the multi-user aspect by demonstrating the video sequence including different actors performing crucial decisions within the scenario simulation.

The demonstration page starts with an introductory video. As illustrated in Figure 10, the user can start the video sequence of the scenario. The video is being played up to a certain point in the scenario evolution, where a decision has to take place. The user is asked whether he or she wants to explore a simulation that ends with cascading CI effects or without (see Figure 11). Based on the decision, the video continues with actions that correspond to the outcome. When the simulation is finished, the user can examine the calculated results of the impact outcome on the web page. The results include a list of actions and the results of the consequence analysis embedded tables and diagrams (cf. Figure 6).
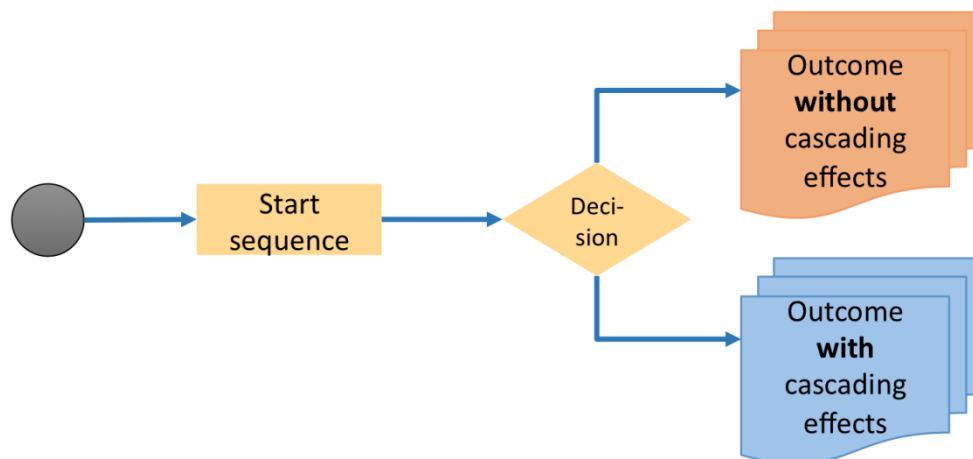

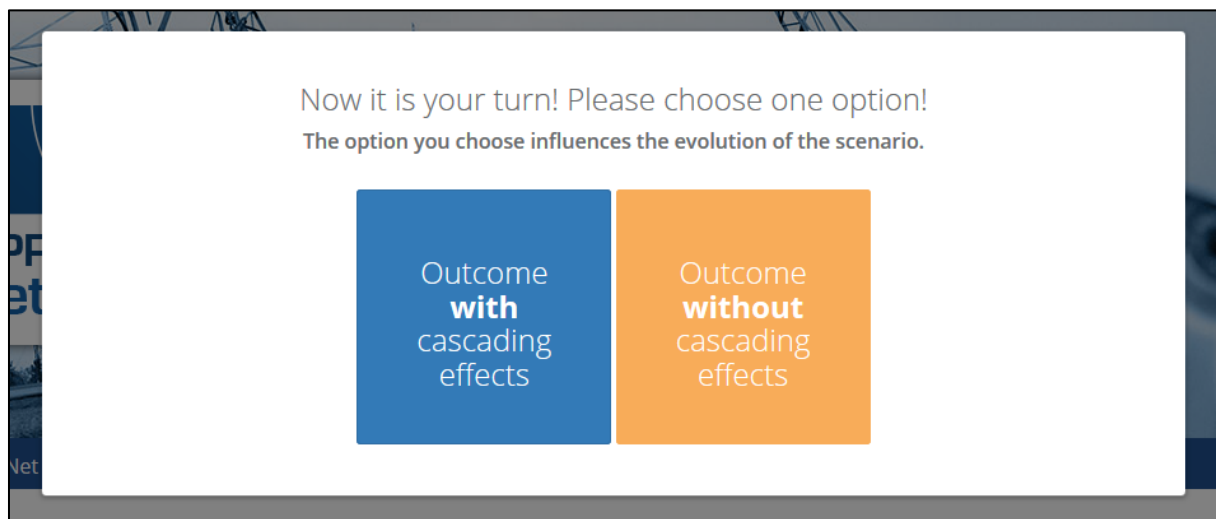**Figure 10: CIPRTrainer demonstration Web service flowchart**

Figure 11: The user is asked to choose between two scenario options with different outcomes

4 Summary and outlook

In this deliverable we have presented the CIPRTrainer Demonstration Web Service. The service has been designed such that it could demonstrate the added value of the new CIPRNet 'what if' analysis capability to a wider target audience. By using video sequences of two predefined courses of action recorded in CIPRTrainer, the Web service shows:

- How to explore different courses of action;
- How to compare the different consequences of the different scenario evolutions;
- The behaviour of CI under severe perturbations; and
- How to avoid cascading CI failures in the cargo train derailment scenario.

The CIPRTrainer Demonstration Web Service is a one page Web application that is decoupled from the full CIPRTrainer system. This setup allows multiple simultaneous accesses to the Web service, whereas the full CIPRTrainer system allows only one training session at a time due to license restrictions of one commercial CI simulator, where a single license costs € 10,800. Multiple licenses might be feasible for a later professional usage of the tool, but are in this case prohibitive for a demonstrator of a research project. Another advantage is that using the Web service requires little prior knowledge, delivered here by the tutorial part of the Web service, whereas using the full CIPRTrainer requires an introductory lesson.

Next steps are

- Advertising the demonstration service to CIPRNet's target audience and tracking the usage of the service via the CIPRNet website's statistics tools; and
- Implementing a user feedback mechanism including a questionnaire containing a subset of the questions contained in the questionnaires of forthcoming deliverable D6.6+D6.7.

List of acronyms

API	Application Programming Interface
CA	Consequence Analysis
CI	Critical Infrastructure
CIP	Critical Infrastructure Protection
CM	Crisis Management
CMS	Content Management System
CWS	CIPRTrainer demonstration Web Service
DOM	Document Object Model
GIS	Geographical Information System
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technologies
IP	Internet Protocol
REST	Representational State Transfer
SEO	Search Engine Optimisations
SPA	Single Page Application
URL	Uniform Resource Locator
VCCC	Virtual Centre of Competence and Expertise in CIP
WIA	'what if' analysis
XML	Extensible Mark-up Language

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[GA]   European Commission, represented by REA: Grant Agreement FP7-312450-CIPRNet

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