FP7 2013 Cooperation Work Programme
Theme 6: Environment (Including Climate Change)

Novel indicators for identifying critical *INFRA*structure at *RISK* from Natural Hazards

Deliverable D7.4

IDST System v2.0

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0.2	14/11/2016	Addressed internal review comments.	Panos Melas and Zoheir Sabeur (University of Southampton IT Innovation Centre)
1.0	17/11/2016	Final formatting and layout.	Panos Melas and Zoheir Sabeur (University of Southampton IT Innovation Centre)

Executive Summary

This document is a follow on complementary report to deliverable D7.3 in WP7 which was made available on the 31/03/2015. It provides user guidance on how to access and use the final version of the INFRARISK Decision Support Tool (IDST) software developed in the INFRARISK project. The document provides a "walk through" experience for the user to work with the IDST tool and perform an early version of risk management on critical infrastructure. With the final version of the IDST software, early implementations of geo-specified database information, processes and visualization methods with an intuitive graphical user interface in the system are demonstrated. The IDST is currently accessible on-line and directly using a web browser under the following URL: https://infrarisk.it-innovation.soton.ac.uk/.

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1 INTRODUCTION

The purpose of the INFRARISK Decision Support Tool (IDST) is to allow infrastructure owners and managers to assess the risks associated with a particular infrastructure network subject to natural hazards, such as earthquakes, landslides and flooding. The IDST will provide access to generated databases and scenario simulations results for a Northern Italy case study, in order to demonstrate how the methodology works. However, the user will also have the option to apply the methodology to any network of interest provided the necessary data is uploaded to the IDST. This document describes the final release of the IDST portal manual.

2 CONNECTING TO THE IDST

The IDST is designed to be used from any web browser. This includes mobile as well as desktop operating systems. The IDST has been tested in the following browsers:

- Linux: Firefox, Chromium
- Apple: Firefox, Safari
- Windows: Firefox, Chrome, IE9+
- Android tablets: Chrome
- iPad: Safari

In addition, the IDST will support most smart phones browsers with qHD (960x540 pixels) or higher display resolutions.

The IDST is directly accessible from a browser using the following URL:

https://infrarisk.it-innovation.soton.ac.uk.

3 PUBLIC VIEW OF THE PORTAL

The initial page of the portal (Figure 1) provides users a brief explanation of the IDST as well as the terms and conditions of the IDST portal. The initial page also allows authenticated users access INFRARISK datasets, i.e. databases, workflows, as well as to create and store their own stress tests.

Figure 1: IDST home page

Under the "Help" link there is a dropdown menu with two options, these are "IDST Help" and "About INFRARISK". The "IDST Help" provides the IDST User Manual. The "About INFRARISK" describes the objectives of the project and provides a URL where further information can be found.

4 PORTAL LOGIN

To log into the portal the user can click on the login button at the top right corner of the initial page. The user is presented with several authentication services (Figure 2), these are:

a) Mozilla Persona

b) Google

c) Yahoo

d) Linkedin

Once the authentication mechanism has been selected the user will be redirected to the respective site for the login. After a successful login the user is asked to allow the IDST portal to access the user's profile. This information is required for authentication. If permission is given then IDST portal will associate the user's profile with the provided account details. In case a different account is used this will be treated by the IDST portal as a different user.

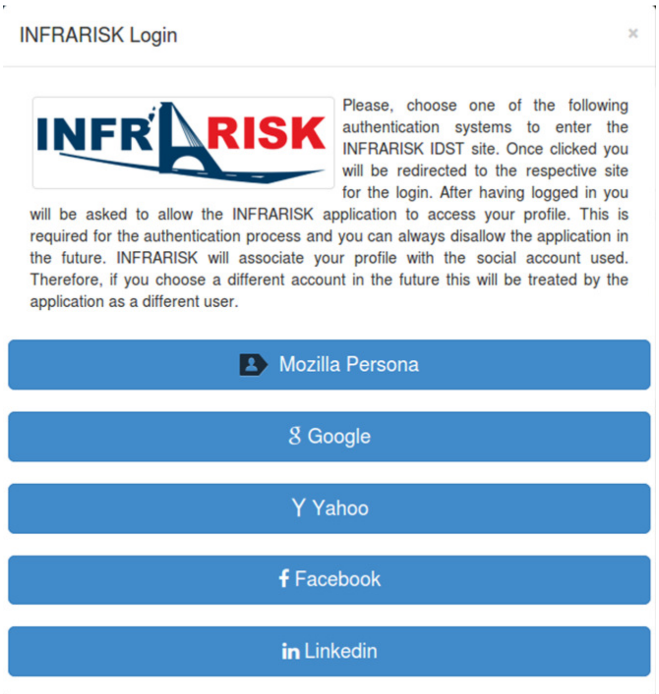

Figure 2: IDST login

4.1 Mozilla Persona Login

If users do not want to use for authentication their social media account, Mozilla Persona provides an alternative authentication mechanism. Creating a Mozilla Persona account is simple and requires a valid email address only.

For creating a Mozilla Persona login (Figure 3) we need to follow these registration steps:

1. Click on the "sign in" button
2. Enter a valid email address by which the account can be identified
3. Provide a password for the Mozilla Persona account

4. The user is then sent an email for validation purposes

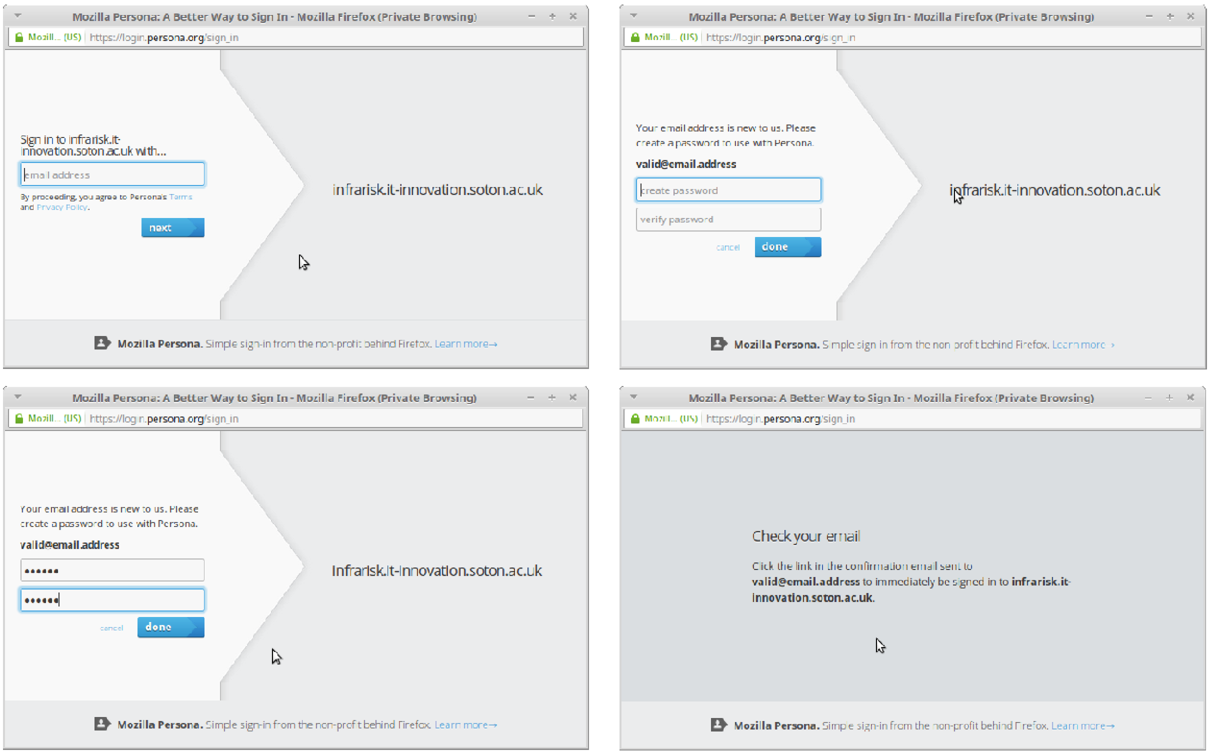

Figure 3: Login via Mozilla Persona

Once the account is created the sign-in into the IDST portal is simple. The user clicks on the login link, provides the registered email address and the Mozilla Persona password.

4.2 Google Login

By clicking on the “Google” option enables to use Google credentials for the IDST login (Figure 4).

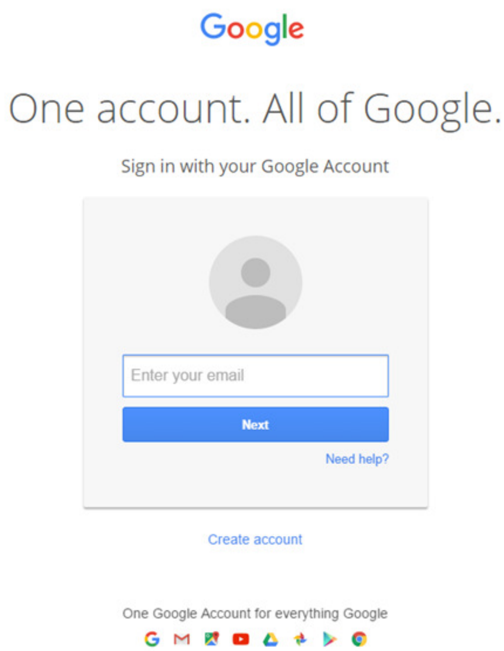

Figure 4: Standard Google login

4.3 Yahoo Login

By clicking on the “Yahoo” option enables to use the Yahoo credentials for the IDST login (Figure 5).

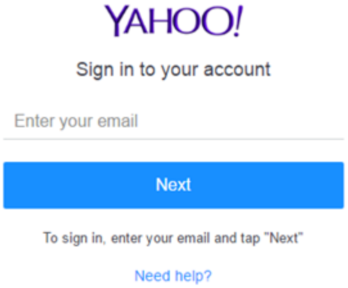

Figure 5: Yahoo login to IDST

4.4 LinkedIn login

By clicking on the “LinkedIn” option enables to use the LinkedIn credentials for the IDST login (Figure 6).

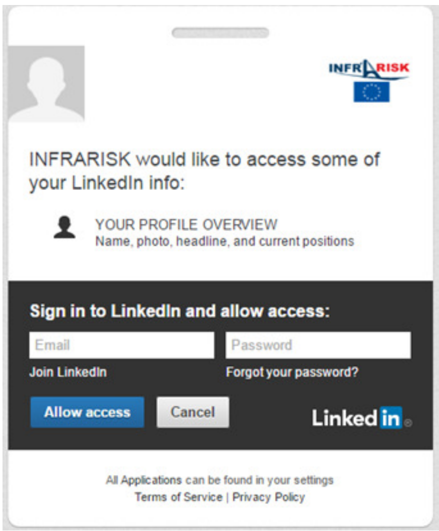

Figure 6: LinkedIn login to IDST

5 IDST DASHBOARD

After a successful login the user is presented the IDST Dashboard page (Figure 7). This dashboard represents a step-by-step process that allows multiple cascading hazards to be defined, geospatial coverage, infrastructure elements and natural hazards. The user can access datasets, profile, usage statistics tools and information associated with case studies.

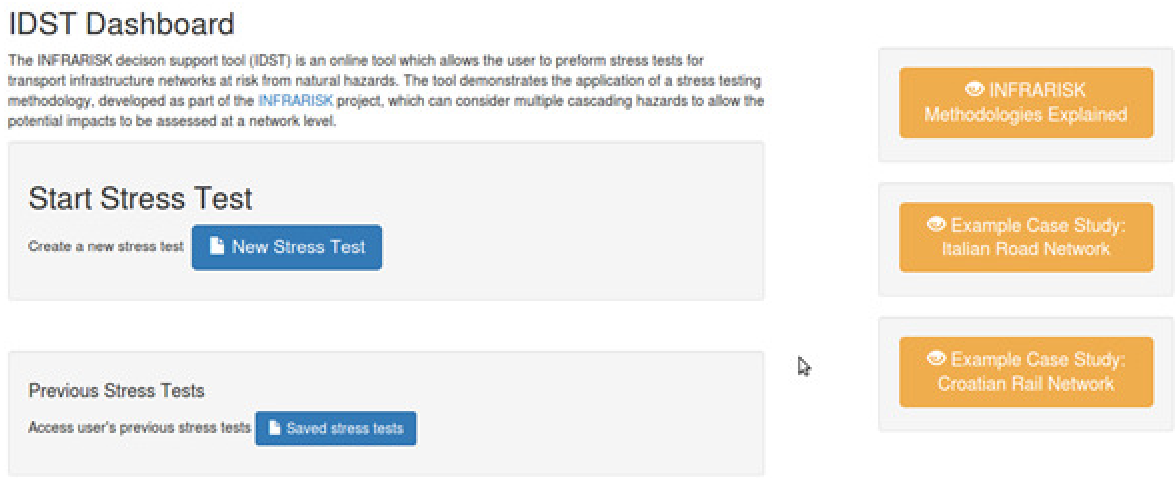

Figure 7: IDST dashboard

The IDST dashboard provides the following links:

a) In the top right corner: Help, IDST, Tools¸ Logout
b) The buttons on the right side are: INFRARISK Methodologies Explained, Example Case Study: Northern Italy Road Network and Example Case Study: Croatian Rail Network.
c) The central part of the dashboard represents the starting point of the workflow. By clicking on “New Stress Test” the user can start a new evaluation study. The “IDST Stress Test Summary List” provides access to previously defined cases studies. The user can re-visit these case studies, modify parameters and re-run the simulations.

In the following sections we provide a detailed description of each of these functions.

5.1 IDST User Profile

The IDST link provides information about the User Profile, Activity statistics and User defined datasets (Figure 8). The User Profile includes fields for: Status, User Email, User ID, Roles, Date joined and Last login. The Activity statistics keeps track of the reports generated by the user.

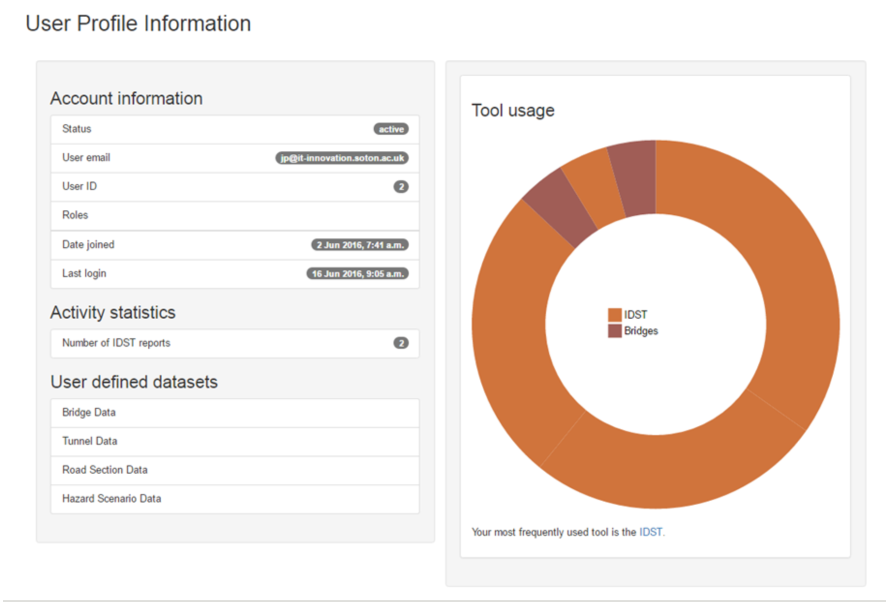

Figure 8: IDST User related information

5.2 Other Tools

The Tools menu contains links to other tools developed in the INFRARISK project. The current links to those tools include:

- Link to the Knowledge Base, (https://infrarisk.datagraft.net/) provides information about road infrastructure elements of a geographical area (Figure 9).
- The ORT-application[1] will give insight in the three projects which are developed for the INFRARISK project. A Croatian case study rail network and the exposure to flood hazards.

[1] https://www.veilig.in

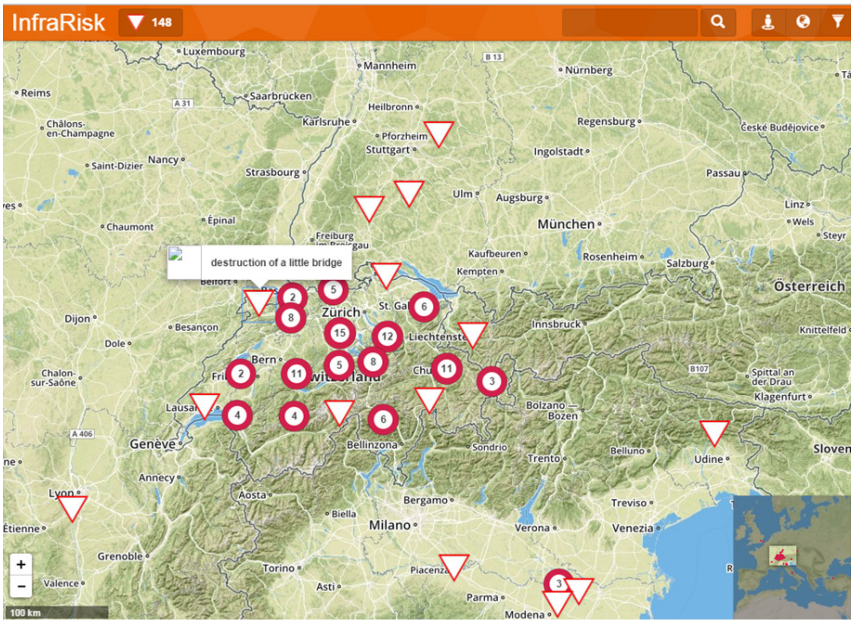

Figure 9: INFRARISK Knowledge Base tool

5.3 IDST Overarching Risk Management Framework Workflow

In this section we provide a brief description of individual steps of the IDST implementation of the Overarching Risk Management Workflow (ORMF) (Hackl et al., 2016). Further details about the IDST implementation of the ORMF workflow can be found in Melas et al. (2016).

6 DEFINE STRESS TESTS

An ORMF workflow run in IDST is described as a stress test. Users can define and run their own stress tests. By clicking on the "New Stress Test" button on the IDST Dashboard the user can define a new stress test (Figure 10). Alternatively, the user can choose a predefined stress test based on the two INFRARISK case studies, i.e. Italian case study road network or the Croatian case study rail network (Clarke et al., 2016).

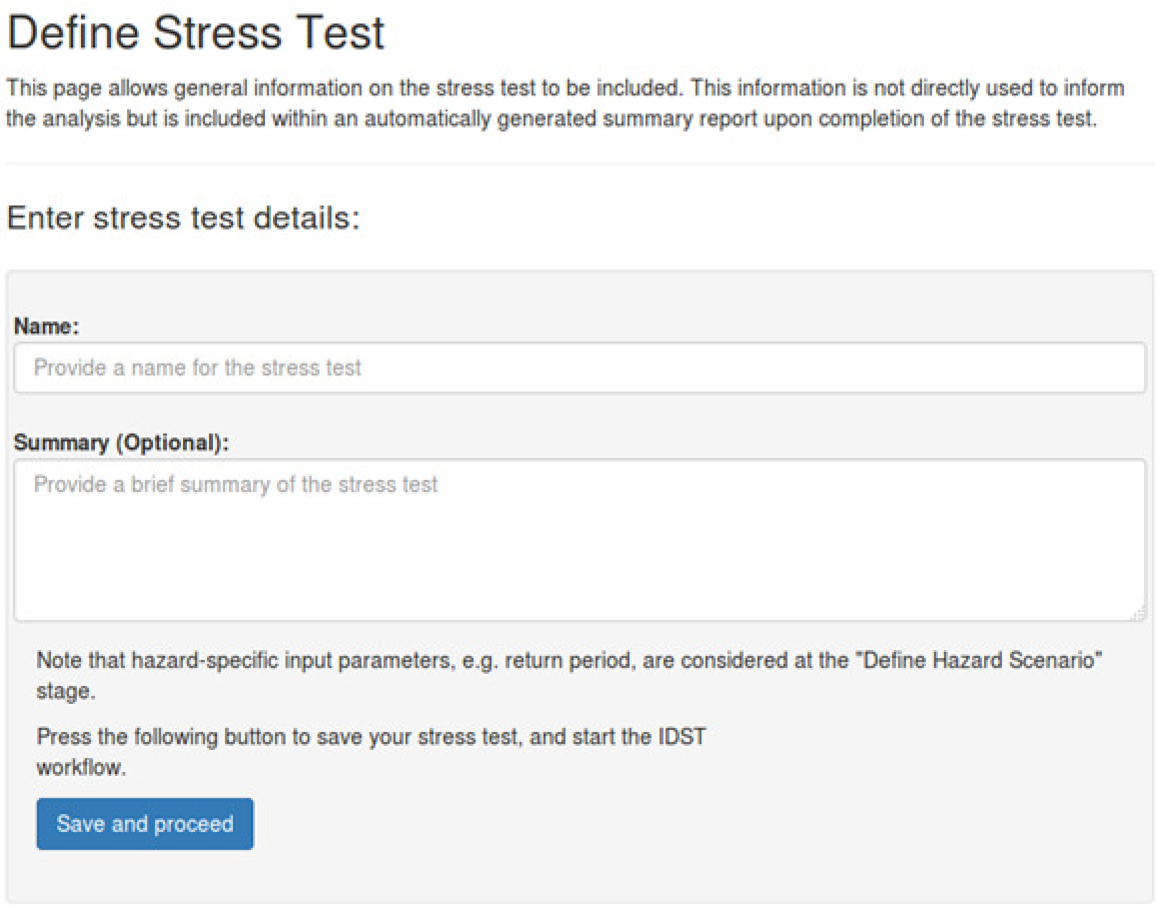

Figure 10: Problem identification

When all information is provided the user saves the information by clicking on the "Store and proceed" button.

Defining the system on which the calculations are performed is a four stage process that includes the definition of: boundaries, network elements, hazard scenarios, network scenario and network element datasets.

6.1 System Boundaries

The definition of system boundaries allows the geographical area for which the risk assessment will be performed to be specified (Figure 11).

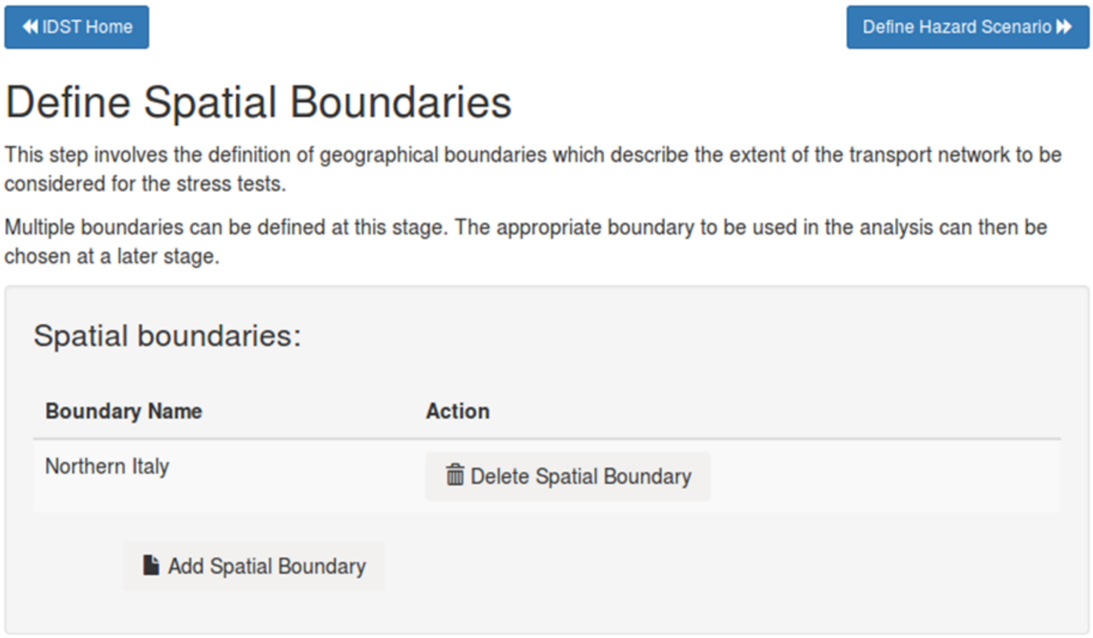

Figure 11: Definition of system boundaries

By clicking on the "Add Spatial Boundary" the user can highlight the area of interest. There are several options for defining boundaries in the IDST, these are:

a) User defined boundaries
   - Manually defined spatial borders
   - User can also upload spatial borders defined in a separate file

b) Pre-defined boundaries
   - Northern Italy, case study borders
   - Croatia railway, case study borders (currently disabled)

6.2 Define Hazard Scenario

After defining the spatial boundaries the "Define Hazard Scenario" button gets enabled. The definition of the hazard scenario involves specifying the following:

a) the hazard source
b) list of associated, primary or secondary, hazard events
c) list of hazard models associated with hazard events

Currently, the implemented hazard sources are precipitation and earthquake (Figure 12). The selection of the hazard source is saved by clicking on the "Store Scenario Hazard Source" button.

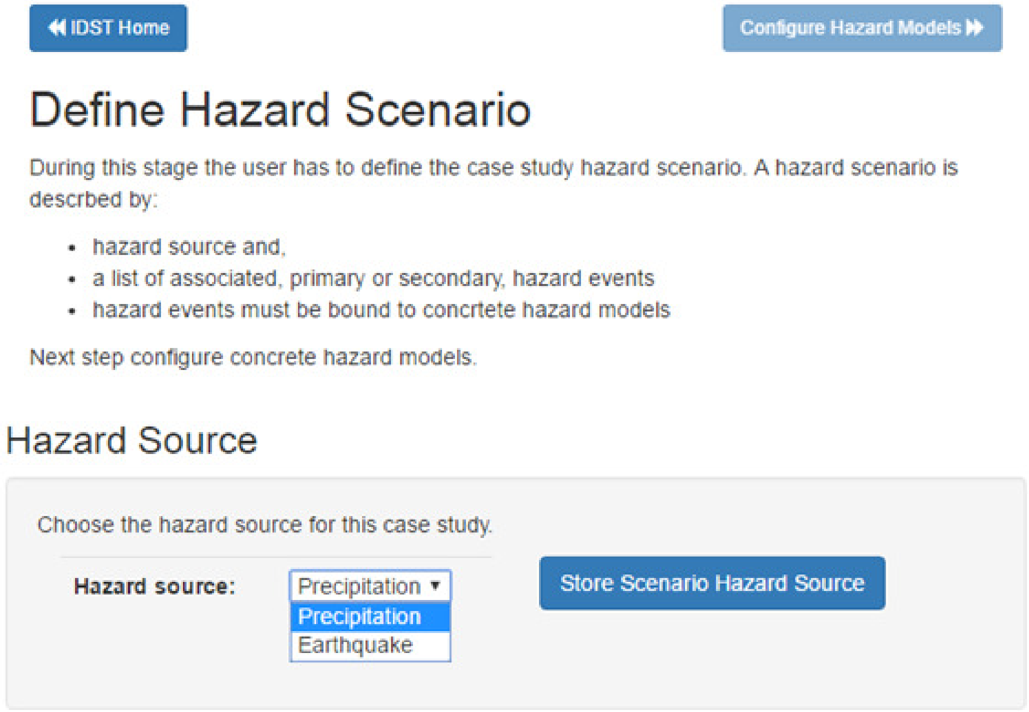

Figure 12: Defining hazard source

After defining the hazard source hazard events can be created and added by clicking on the "Add Hazard Event" button (Figure 13). The selected configuration is saved by clicking on the "Stored Hazard Event" button.

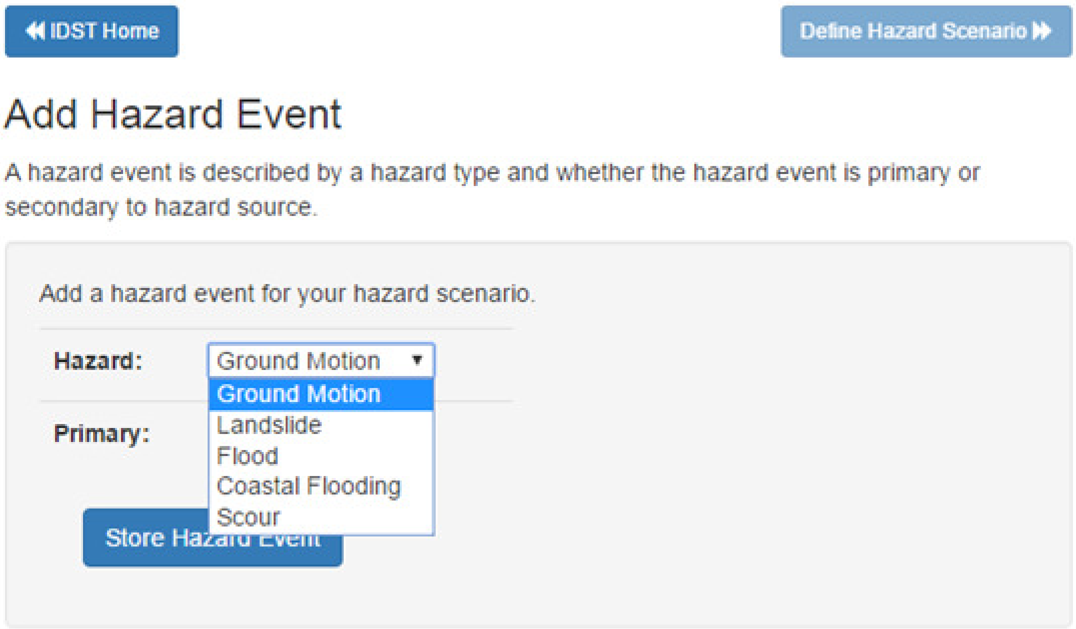

Figure 13: Defining a hazard event

Both the hazard source and the event must be bounded to a hazard model (Figure 14). By clicking on the "Assign to Model" allows to select from several hazard models that are applicable for the given hazard event.

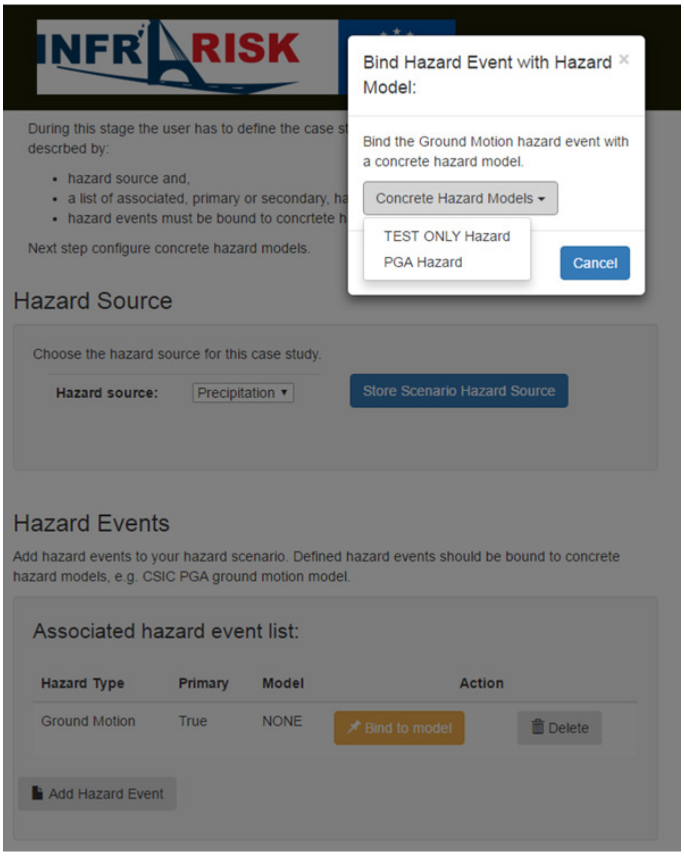

Figure 14: Assigning hazard models to hazard events

Once the hazard source and the hazard events are defined the following step is the configuration of the associated hazard models. This step is activated by clicking on the "Configure Hazard Models" button.

6.2.1 Configuring the hazard model

The reason for configuring the hazard model is that each model can take different parameters and values, these models can represent layers over a certain area. A stress test in IDST can have one hazard source and several events, for example an earthquake that triggers a landslide. The configuration of the PGA model is activated by clicking on the "Setup PGA" button (Figure 15).

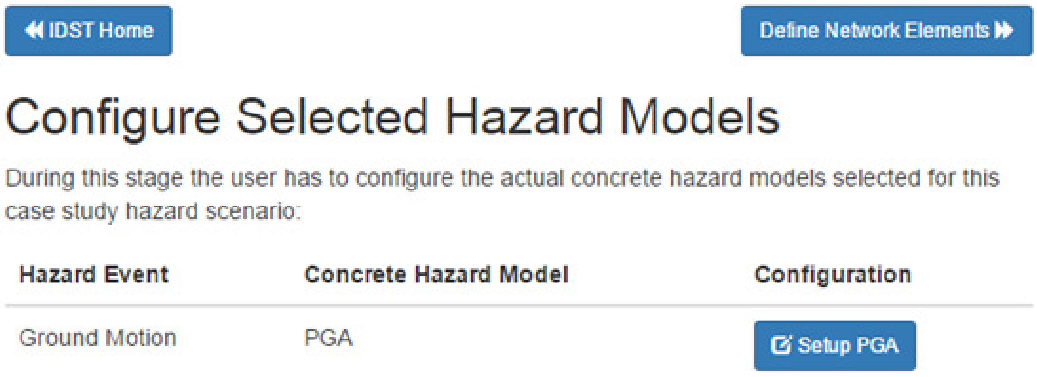

Figure 15: Configuring the PGA model

6.2.2 Define Network Scenario

The hazard scenario at this stage of the IDST workflow is specified only in generic terms, it is not yet mapped to a particular area. The configuration of the network scenario and elements (Figure 16) is a three step process consisting of:

a) Network infrastructure
b) List of network infrastructure elements, or network event types (road network, bridges, tunnels etc.)
c) Spatial boundaries

Table 1 summarises the type of structural elements of the network and the associated hazards.

Network Element	Hazard Event
Bridges	Ground Motion
Tunnels	Ground Motion
Road sections	Ground Motion-triggered landslides

Table 1: Network elements and hazards considered

The damage for bridges, tunnels and road section was classified according to five states: no damage, slight/minor damage, moderate damage, extensive/major damage, and complete damage. Additional parameters such as the, indicative restoration times and repair costs for the individual network elements were also obtained. For roads the length of sections is 10m, the values for bridges and tunnels are given per individual structure.

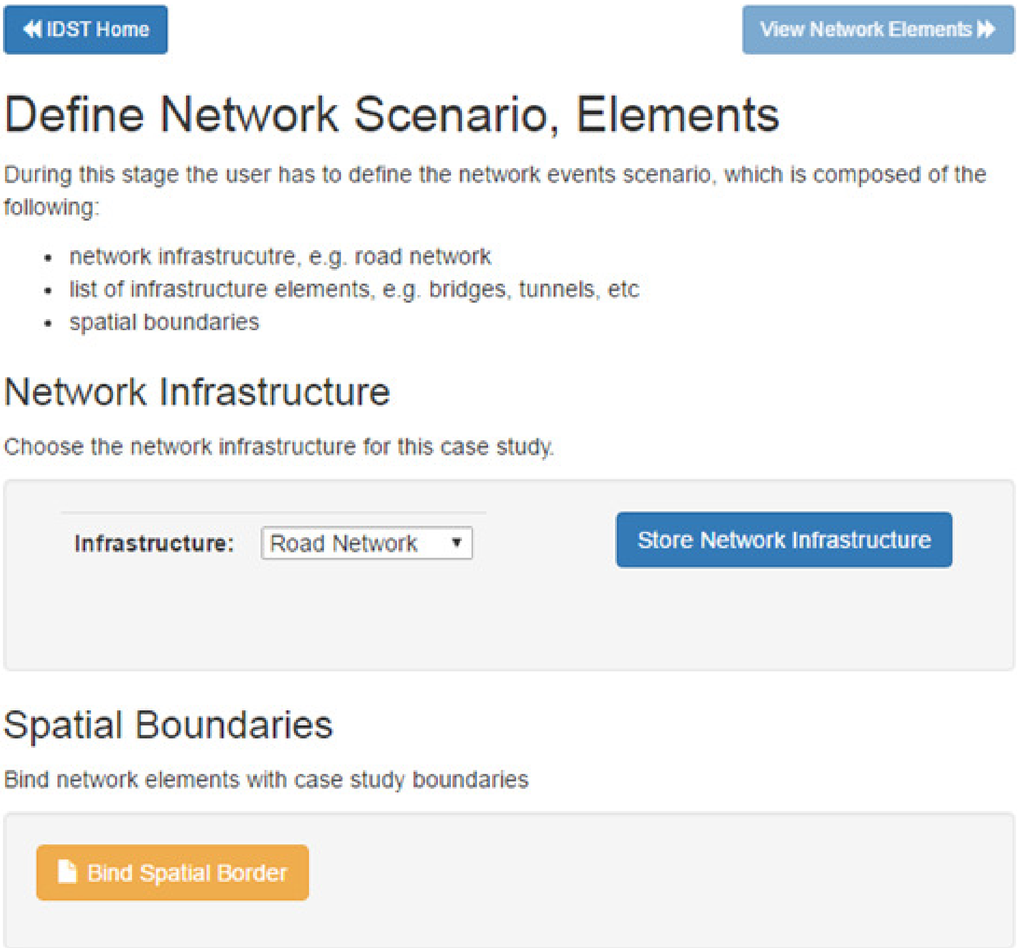

Figure 16: Define network scenario and elements

6.2.3 Define Network Event Type

After clicking on the "Store Network Infrastructure" the user can add more infrastructure elements to the scenario (Figure 17). Each network element type should be assigned to network model and also to a hazard event that affects the specified network element type.

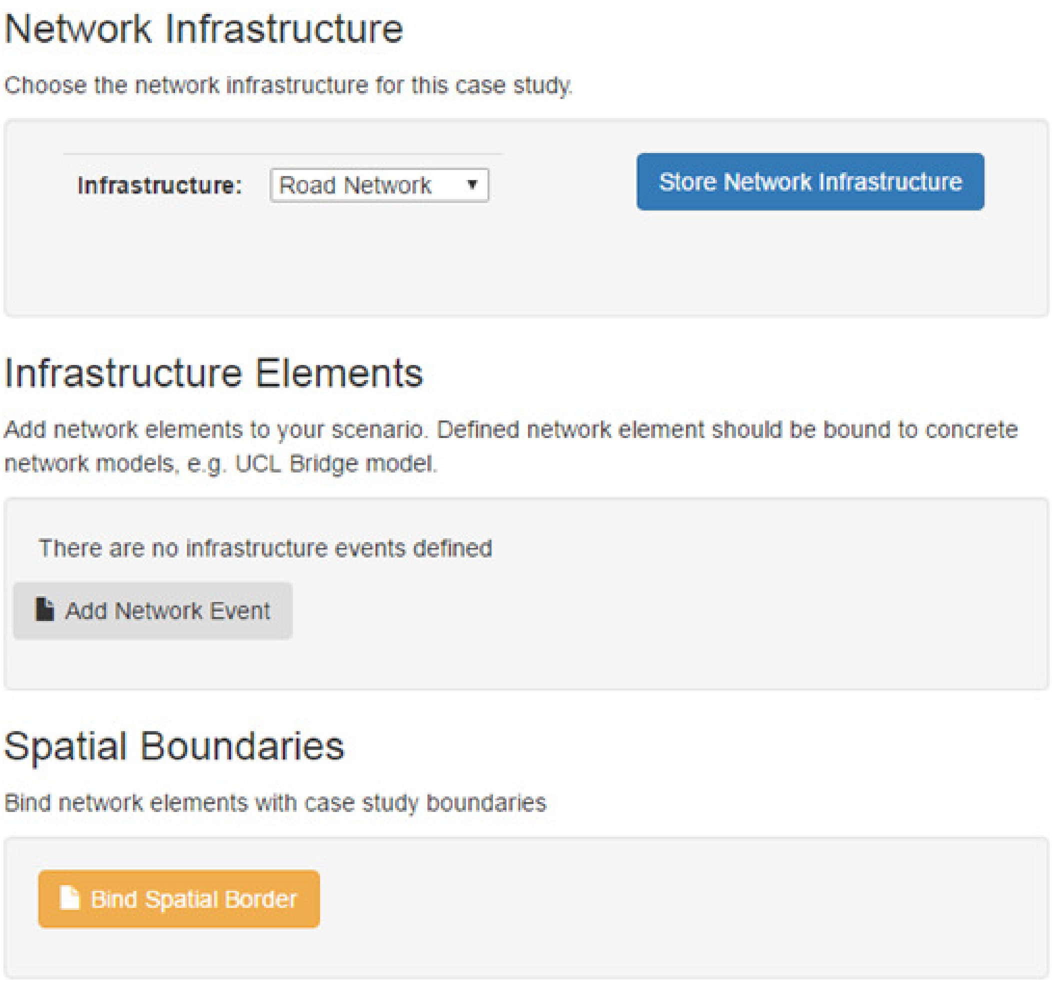

Figure 17: Defining infrastructure characteristics

By clicking on the “Add Network Event” we can associate the given network element with a specific hazard event defined earlier (Figure 18).

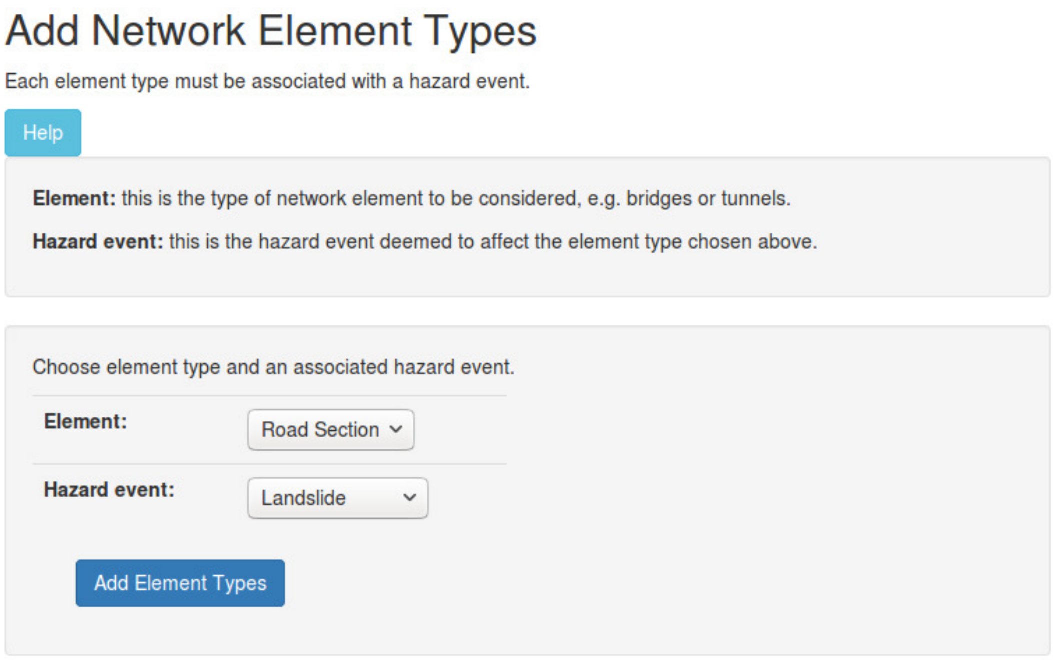

Figure 18: Linking network element types with events

6.2.4 Assign network event to the damage model fragility functions

Once the network event is selected by clicking on the "Choose Model" button the user can assign this event to a network model (for example Bridge Model) (Figure 19).

For the network bridges and tunnels, the IDST has adopted the median fragility functions with lower and upper confidence bounds. Information about the application of the SYNER-G database to the network bridges and tunnels can be founded in INFRARISK Deliverable D3.2 (D'Ayala and Gehl, 2015). Information about assigning fragility functions to road sections built on slopes can also be found in INFRARISK Deliverable D3.2.

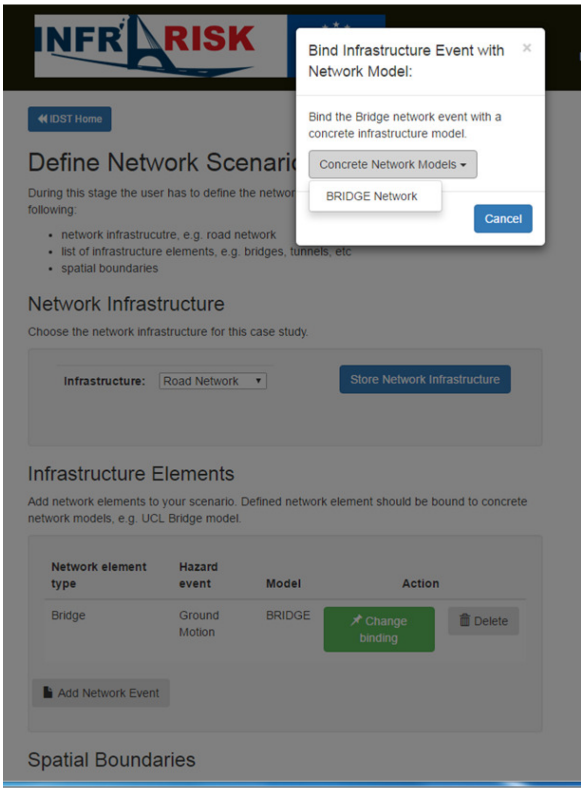

Figure 19: Assigning infrastructure event to a network model

After selecting the Network Model the next step is defining the spatial boundaries applicable to network elements.

6.3 Adding network dataset elements (datasets)

At this step of the workflow the user defines the actual network element datasets (bridges, tunnels, road sections) for each network event type defined earlier. Multiple datasets of network elements can be associated with a network event by clicking on the “Add Network Dataset” (Figure 20).

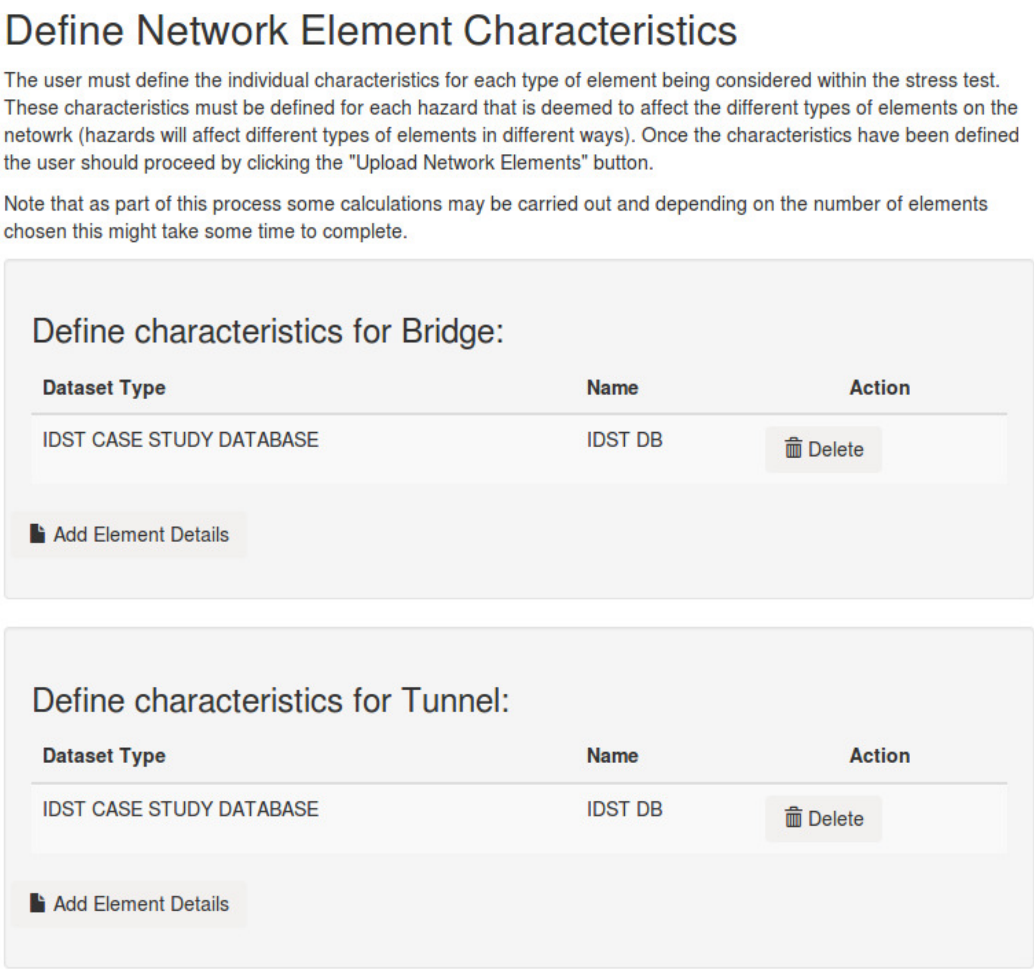

Figure 20: Network element datasets

Currently there are three different dataset formats of network elements supported by IDST (Figure 21):

a) Network element datasets already preloaded in IDST databases
b) User defined network element datasets in a shape-file format.
c) User defined network element datasets in a CSV format.

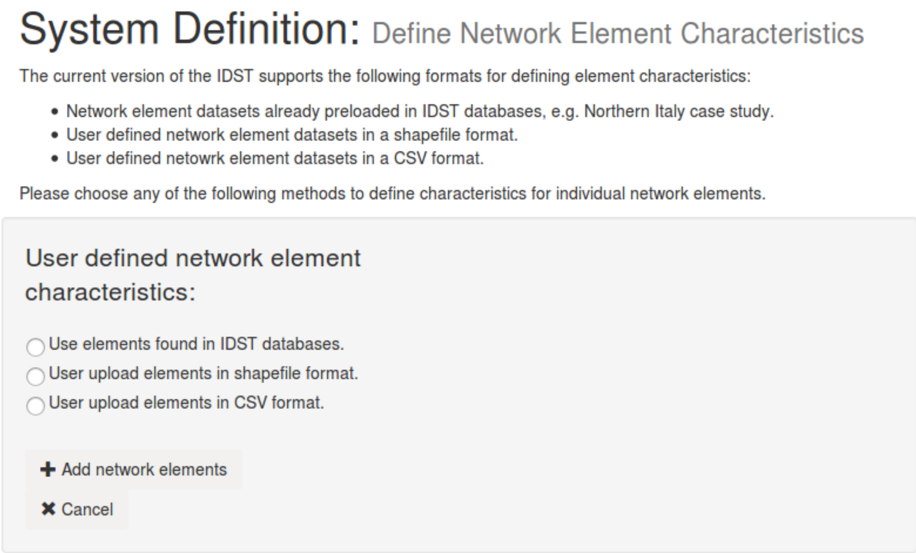

Figure 21: Selecting network elements

After selecting the relevant datasets for the Bridge and Tunnels the "Analyse Network Element" can be activated (Figure 22).

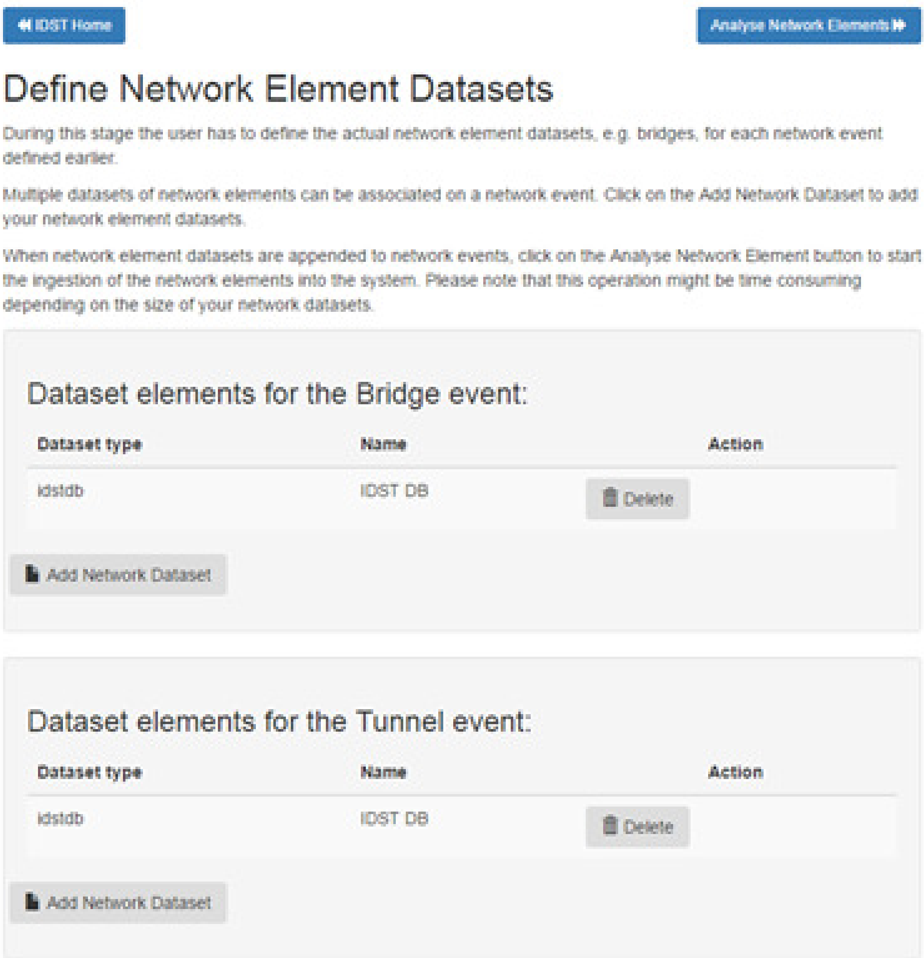

Figure 22: Defining network element datasets

The main functions of “Analyse Network Element” are data ingest and filtering the elements inside the area boundary (Figure 23). This operation can be time consuming depending on the size of datasets.

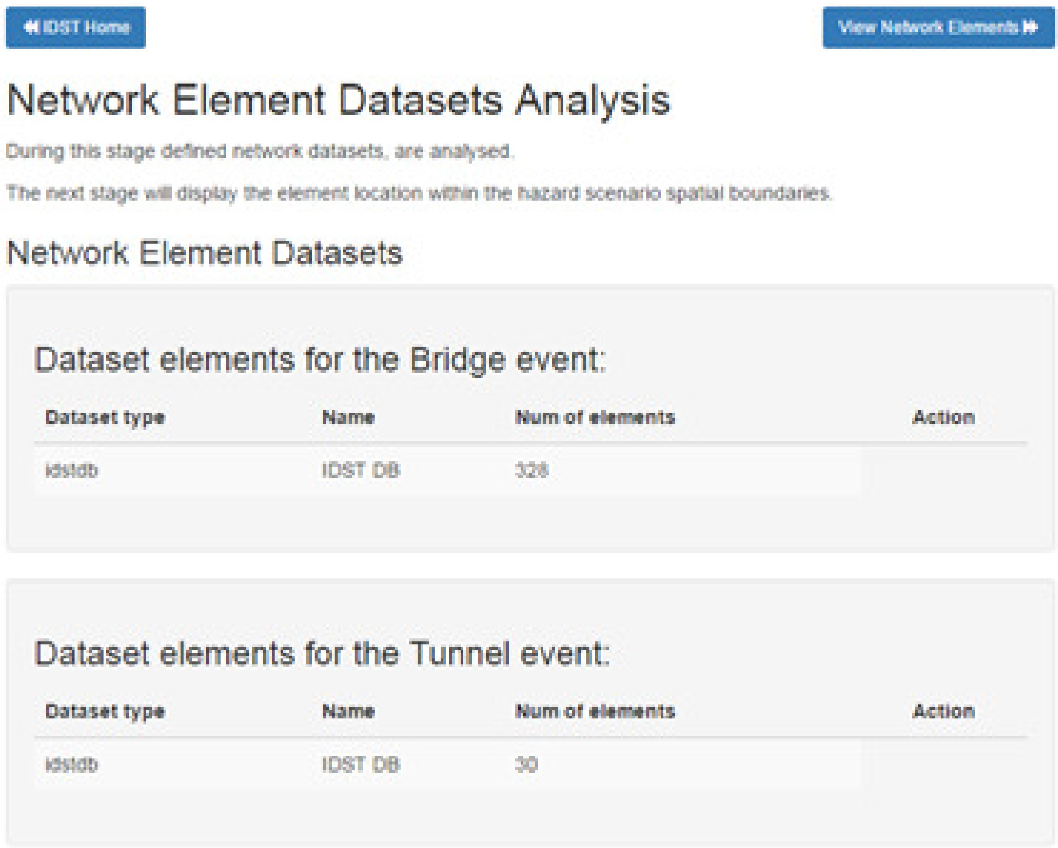

Figure 23: Analysing network elements

6.3.1 View network elements

Once all components of the network scenario are specified the user can click on “View Network Elements” button for checking the parameters of elements (Figure 24).

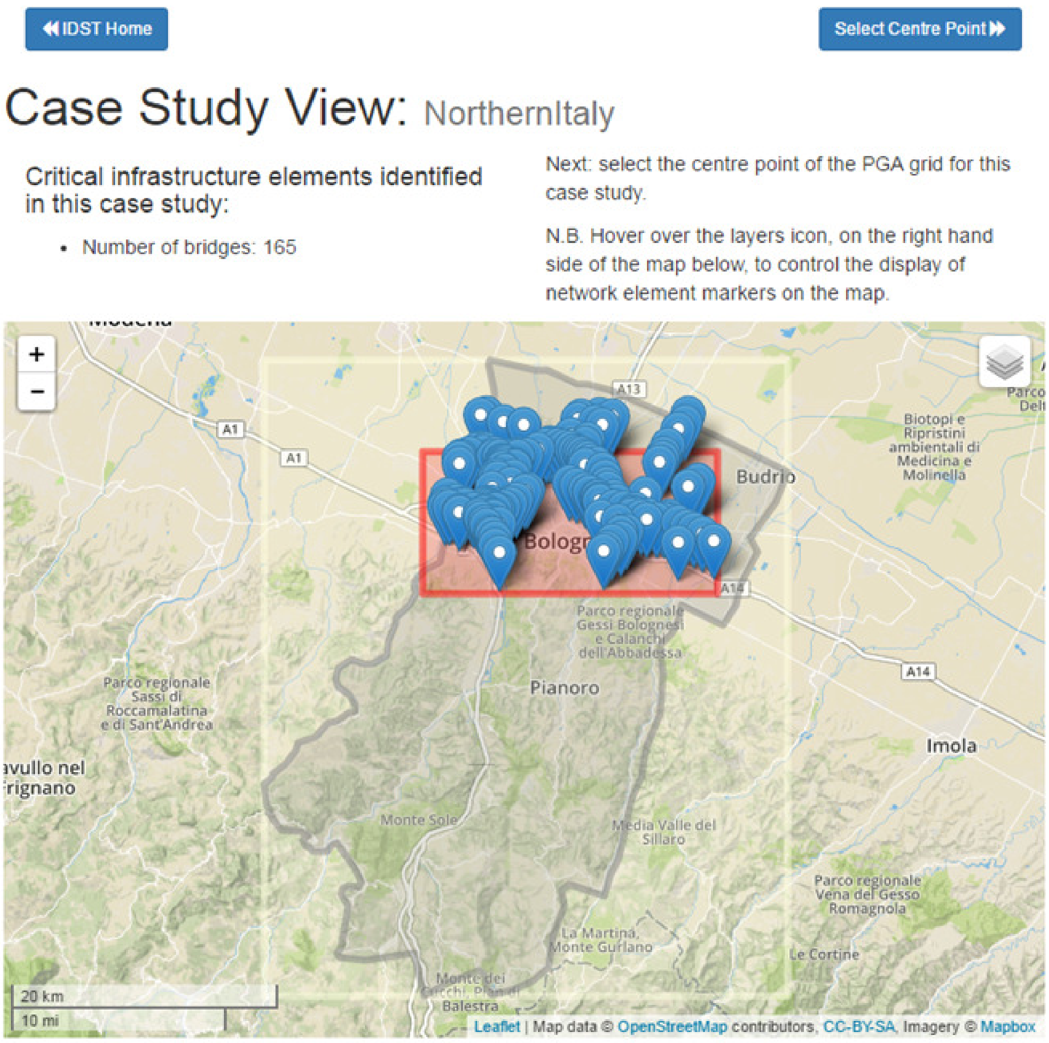

Figure 24: Viewing network elements

6.3.2 Inspecting individual network elements

By clicking on individual network elements the user can obtain additional information about the location, construction material, architecture details, fragility curves etc. (Figure 25). To each of the network element (e.g. bridges, tunnels and roads) a fragility curve is assigned.

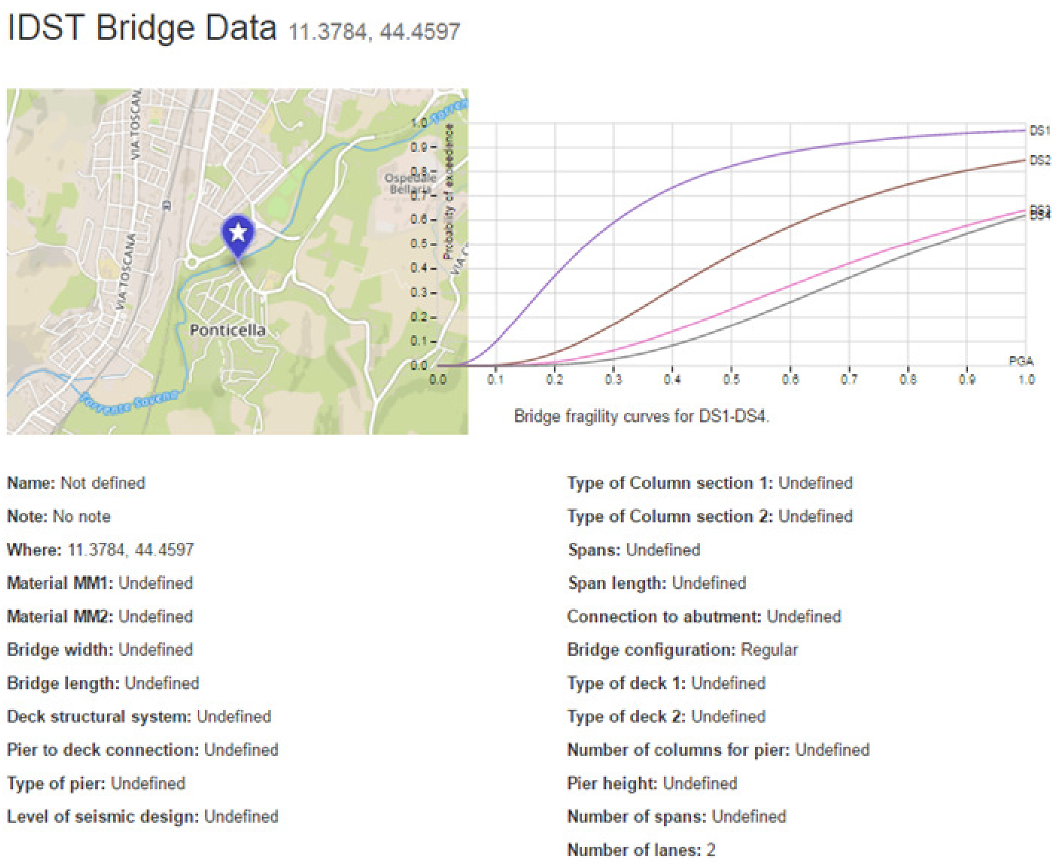

Figure 25: Inspecting individual network elements

6.3.3 Finalising Hazard Model Configurations

This is an optional step that might be required to finalise the configuration of previously selected hazard models with extra parameters that were not available during the initial configuration of that hazard model. Such parameters are usually spatial boundaries, or actual network objects.

6.3.4 Selecting a Centre Point for the Ground Motion hazard

The Seismic Hazard PGA model is an example of such a hazard model as it requires the selection of a network object to be defined as the anchored point of its PGA grid. The purpose of this step is to overlay (anchor) the Ground Motion PGA grid on a certain geographical area.

The user selects one of the network elements on the map, then by clicking on "Make Central Point" button. As a result the central point is anchored on the map of the specified region (Figure 26).

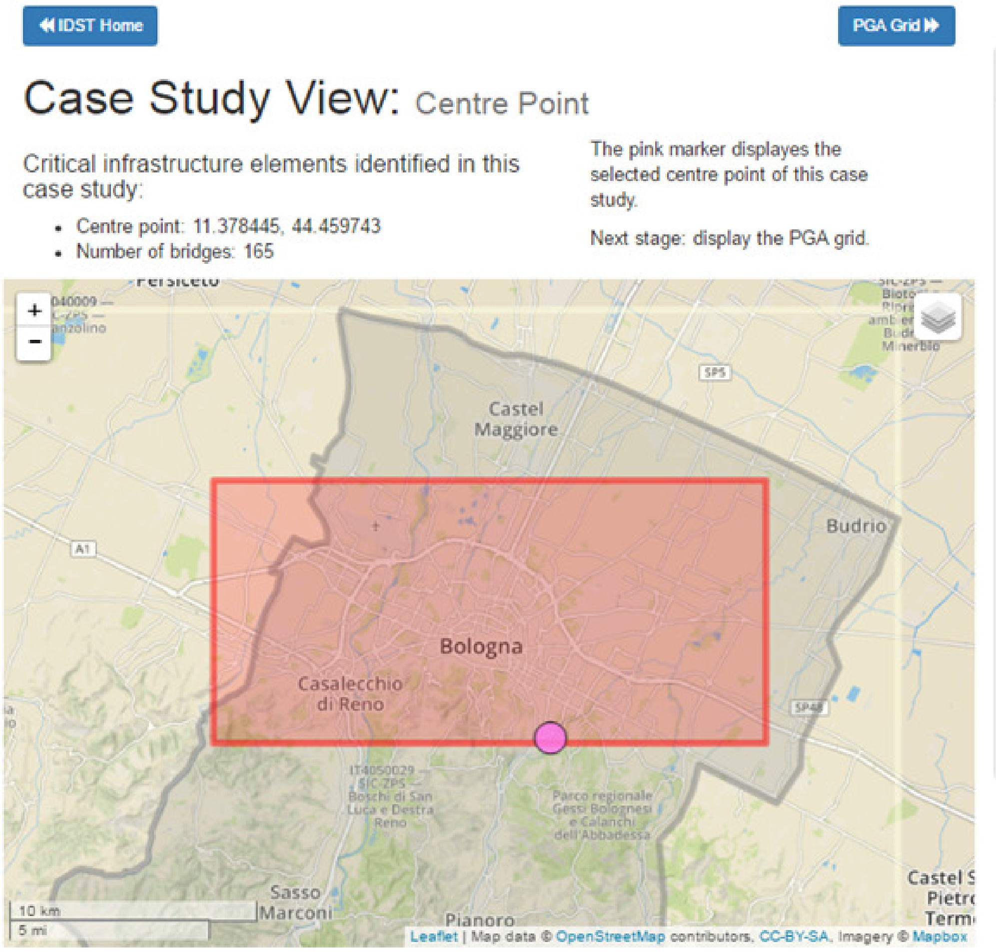

Figure 26: Selecting a centre point

After selecting the central point, the PGA grid can be overlaid on the map. By clicking on the PGA grid button, a coloured map (a heatmap) of the region, where the colours represent the distribution of PGA data in relation to the central point (Figure 27). In this case the brighter areas represent higher values. By clicking on the “Download PGA Grid” the user can obtain the PGA values in CSV format.

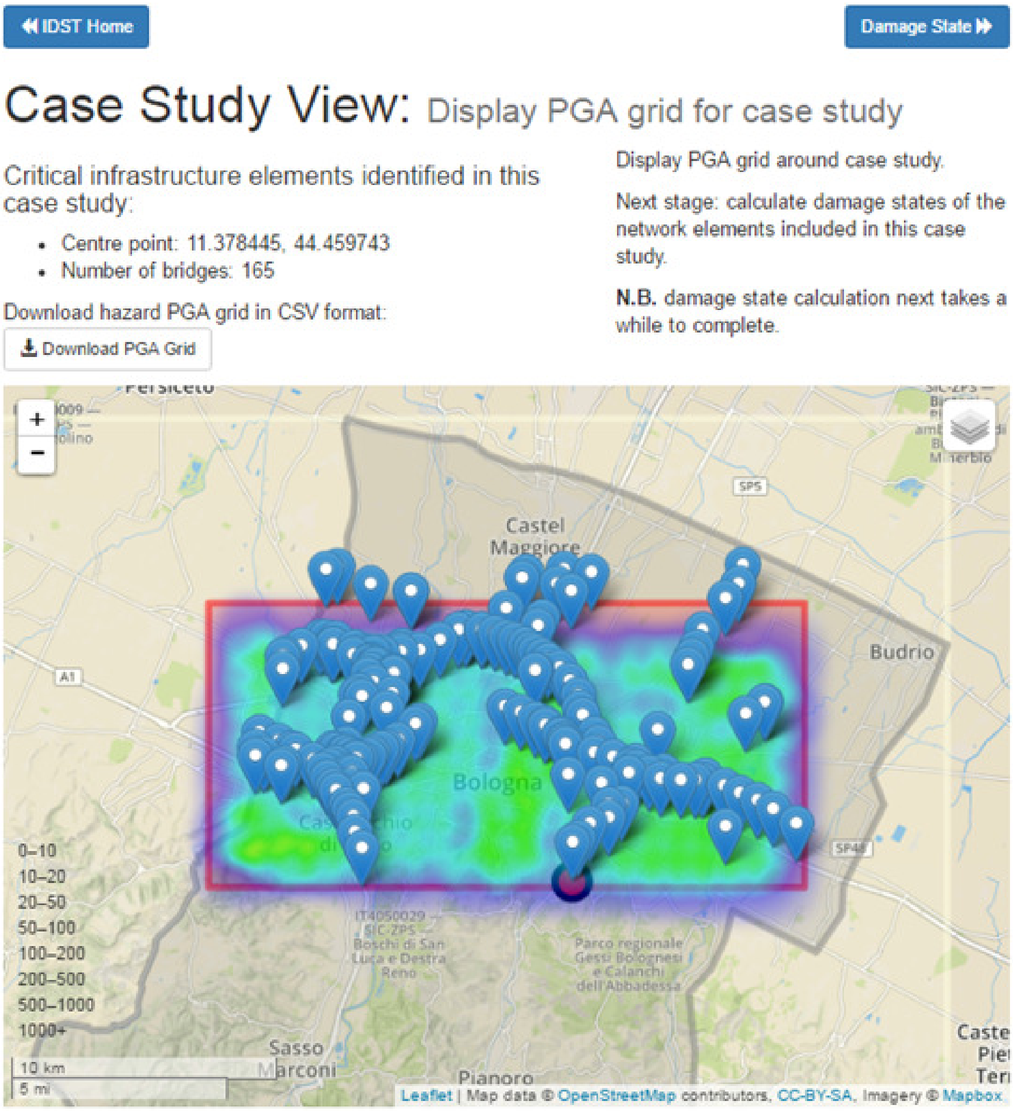

Figure 27: Displaying PGA grid

6.4 Calculating damage state

By clicking on the "Damage State" button on Figure 27 the IDST calculates the predicted damage for the dataset elements (see also Figure 28). The panel provides information about the type of dataset, source, and the number of element objects identified.

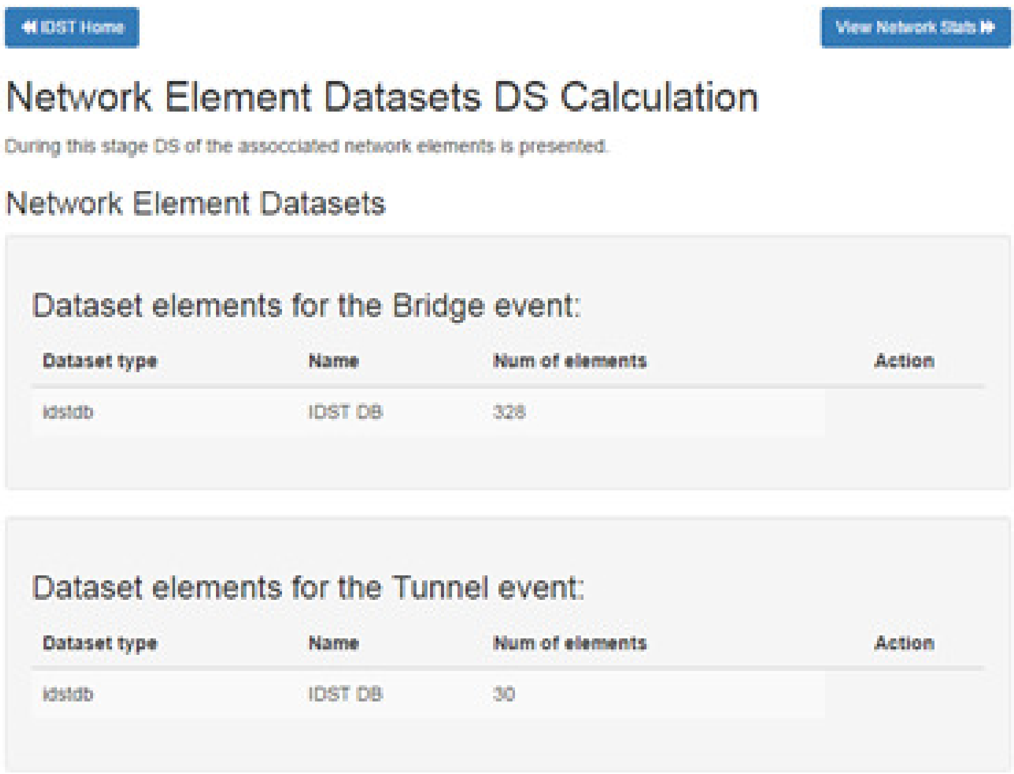

Figure 28: Damage state calculations

6.5 Risk Estimation

The risk for the road network caused by earthquakes and earthquake-triggered landslides is calculated, while the network repair cost, repair duration and indirect consequences can potentially be estimated. Currently they are only indicative but they can further developed for more accurate estimation in the future.

Following the above, the user can obtain the summary of the stress test study by clicking on the “Damage States Stats” button. This will spawn the damage state statistics (Figure 29).

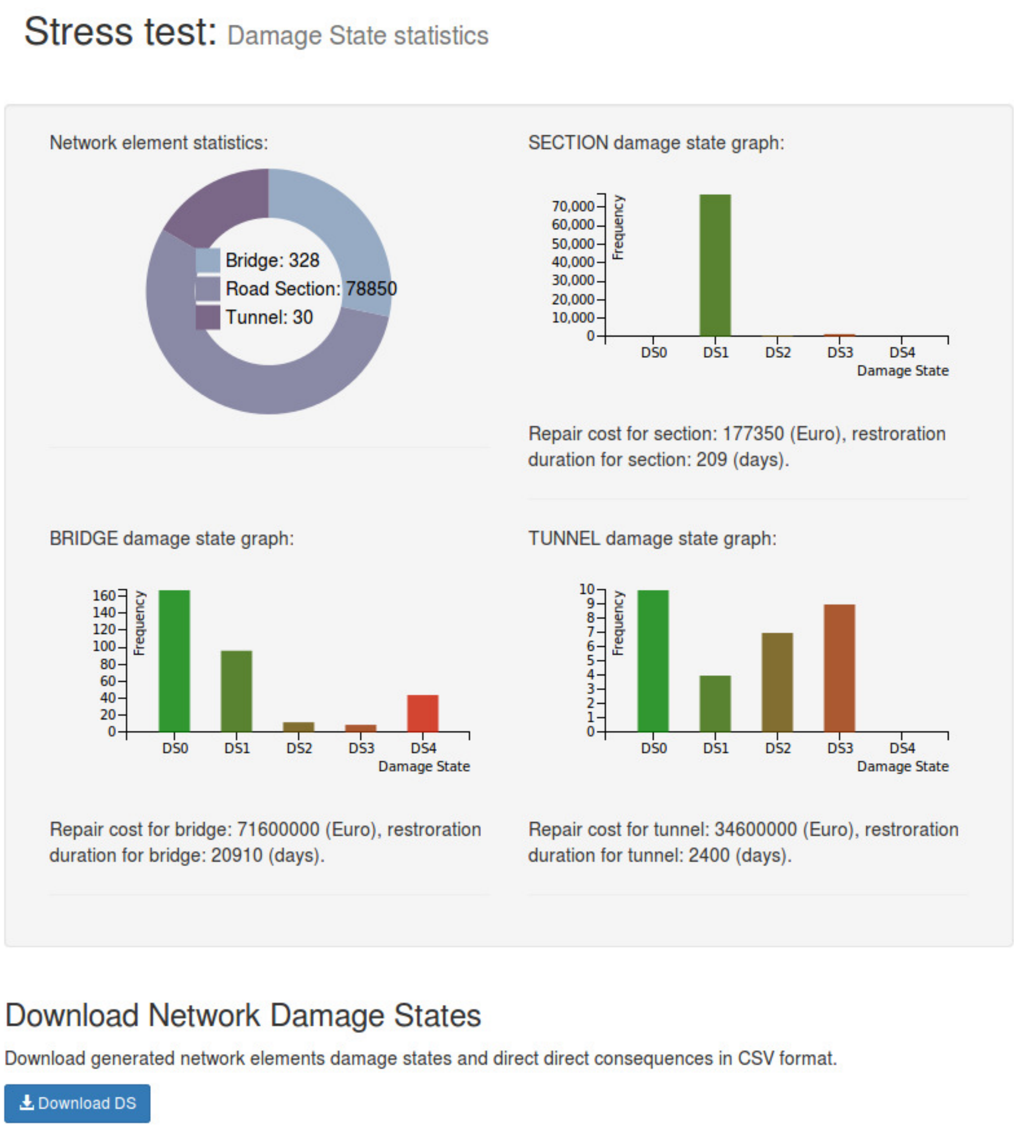

Figure 29: Damage state statistics

6.6 Report generation

By clicking on the “Stress Test Report” button the user can obtain a detailed account of the entire case study describing each stage of the IDST workflow and the relevant parametric values (Figure 30-Figure 32). The main categories included in the report are:

a) System Stress Tests
b) System Boundaries
c) Hazard Scenario
d) Network Elements
e) Risk Estimation

Case Study: Report

Problem Identification

System representation

- Case study name: NorthernItaly
- Summary:
- Addressee:
- Questions this case study is trying to answer:

System Stress Tests

System stress tests defined for this case study include:

- **Return period:** 1000
- **Failure criteria:** 10

System Boundaries

Spatial and temporal boundaries set for this case study:

Spatial Boundaries:

Spatial boundary name	Surface area (Km2)
BolognaAirport	241.7615

Temporal Boundaries:

Temporal boundary name	Temporal boundary value
earthquake	12

Figure 30: Stress test report – part 1

Hazard Scenario

This case study main hazard scenario is defined with:

Primary hazard source: Precipitation

Hazard central: 11.3784, i 44.4597

Identified hazard events:

Hazard event	Primary type	Binding hazard model
Ground Motion	True	CSIC PGA Seismic Model

Associated Concrete Hazard Model Setup

The PGA hazard model used in this case study is configured with the following parameters:

Seismic activity: Low activity

Ground-motion prediction model: Low attenuation

Hazard level (annual probability of ground motionn exceedance): 2500y mean Return Period

Fractile of extreme gound-motion: Extreme value at reference site exceeded by 50% of values

Random field: 6

Download hazard PGA grid in CSV format.

Download PGA Grid

Network Elements

The network infrastructure examined for this case study is the Road Network.

Network elements:

Network element	Associated hazard event	Binding network model
Bridge	Ground Motion	UCL bridge concrete model

Associated spatial boundaries: BolognaAirport.

Figure 31: Stress test report – part 2

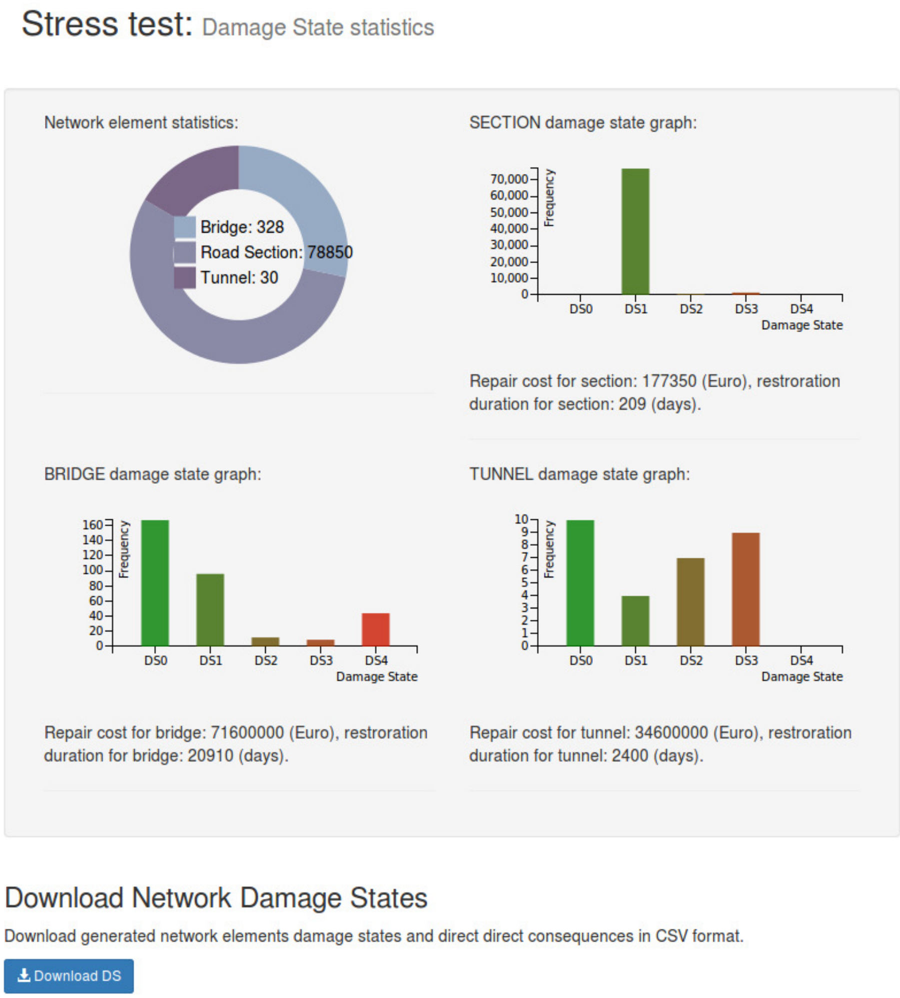

Figure 32: Stress test report – part 3

7 CONCLUSION

In this document we have described the functionality of IDST portal and provided a detailed account of ORMF workflow implemented in the IDST. This workflow supports the core stages of the overarching risk management workflow. IDST users can define and run their own stress tests.

The output of IDST workflow is the estimated damage state of individual network elements. This information allows specialists to assess the expected damage under various hazard scenarios.

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