User-centred semantic interoperability during disaster response: a novel approach from the EPISECC project enabling end-users to continue using their own terms while enhancing their mutual understanding

Source: EPISECC project[1]

Authors: Snjezana Knezić, Martina Baučić
University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Croatia

Abstract

During the disaster response phase semantic interoperability has always been an important part of the communication between first responders. Even though both technology and standardisation are constantly evolving, this part of the communication is still very challenging. The response phase usually includes many first responders using their own terminology and corresponding semantics. Existing standards related to disaster and emergency management help, particularly if they are created by international organisations like Red Cross, but countries' first responders still rely on their own semantics. EPISECC project developed Semantic Box Service which creates semantic annotations for the messages exchanged by first responders during the disaster response phase. They receive messages enhanced with semantic annotations, which provides receiver's own terms of main concepts included in the message. By introducing semantic annotations during the message exchange between first responders the solution fosters mutual understanding and thus the communication as whole. EPISECC Semantic Box Service is based on three semantic structures: EPISECC Taxonomy, EPISECC Semantic Repository, and Ontology model for the EPISECC use case. These structures are supported by two processes: Semantic Mapping and Semantic Matching. The proposed solution allows end users to enter, use and update their own semantic structures and performs automatic semantic matching of their concepts. A brief explanation of the service's concept as well as developed structures and processes is given in the paper.

Semantic heterogeneity in disaster response

When a disaster strikes many organisations take part in a response phase such as: police, medical emergency services, civil protection, humanitarian organisations like Red Cross etc. Having rather different roles and capacities in saving lives and property each of them usually uses its own terminology and corresponding semantics. In case of cross border or huge disasters involving international teams, first responders come from different countries and even though international organisations commonly use English language, the national ones use their terminologies in their own languages. Consequently, the communication during the response phase includes varieties of languages and terminologies, from national to international ones. Creation of comprehensive shared

[1] Project Efficient Communication & Access to Critical Information in Disaster Management. The project is funded by the European Community's Seventh Framework Programme (SEC-2013.5.1-1) through the Grant Agreement Number 607078. Figures are taken from publications, presentations or deliverables which were created during the course of the project EPISECC.

situational awareness picture and full semantic interoperability among the first responders is certainly very challenging task.

During the disaster response inaccurate understanding between first responders can cause more distress and sometimes can slow the process of saving lives and property. Even though automatic translation is getting more accurate and can be used in case when first responders belong to the same domain (like medical service) but come from different countries, it could cause misunderstandings because translated terms may stand for different concepts. When first responders use the same language but coming from different domains using the same terms for different concepts could cause misinterpretation, as well. For example, the term ‘safe zone’ for fire fighters does not have the same meaning as for medical service. The term ‘safe zone’ for fire fighters stands for the concept “an area in a building where fire could not spread” while for medical service it stands for “an area safe for triage”.

One possible solution is to agree on common terminology, which should be used by first responders from all domains speaking various languages. In that case first responders should reach consensus on the common set of concepts and corresponding terms, which is extremely challenging process and, if ever created, such set will presumably cover only a part of used concepts. Achieving agreement certainly takes time and updating of such set demands new agreement bringing another challenge, because new terms are introduced rather frequently and any set of agreed concepts and terms will soon become outdated. Moreover, such standard should be accepted and use by practitioners and they should be promptly acquainted with it, even practice to use it.

The solution explained herein aims to find the solution to the abovementioned challenges. It accepts semantics already used by different first responders, have a potential to undertake future concepts and corresponding terms being introduced as emergency services evolve, and include new first responders’ organisation at any time.

The EPISECC project solution

During the disaster response, first responders are acting according to their operational procedures, using their own ICT tools for communication and their own terminologies. To enhance interoperability between first responders, EPISECC project developed a concept of the Common Information Space (CIS). Instead of having a common ICT solution for all, CIS enables first responders to use their own ICT tools by installing a dedicated adaptor. Adaptors connect interfaces of ICT tools to the CIS and transform proprietary data formats into standardised messages that are exchanged within CIS. The only effort first responders have to undertake, prior to joining CIS, is the implementation and installation of a specific adaptor for their ICT tools.

In addition to syntactical interoperability CIS provides the Semantic Box Service, which enhances common understanding of the exchanged information and provides certain level of semantic interoperability for first responders. Semantic Box Service creates portions of text called semantic annotations, which are attached to the messages exchanged during disaster response. When first responders receive messages, the semantic annotations provide them explanations of key terms included in the message. The explanations are their own terms having best possible match with sender’s terms, no matter if the message is written in foreign or their own language. Therefore, by attaching semantic annotations to the messages the solution provides better mutual understanding between first responders.

The example below shows the situation when the message sent by an Italian first responder includes the concept "pompe idrovore". The EPISECC Semantic Box service creates annotated message for the Croatian receiver including semantic annotations for the key concept "pompe idrovore": "Hidraulična crpka" and "Klipna crpka". Semantic annotations are terms for receiver's concepts which semantically match concepts of the sender, either as exact or broader semantic match. Semantic annotations are placed right after sender's concepts, inside brackets and start with the label "SA". Additional label, placed after terms, indicates the matching type retrieved by Semantic Box Service: "E" (exact) is assigned to the concepts which exactly match the sender's ones, and "B" (broad) is assigned to the concepts which broadly match the sender's ones in cases when there are no results for exact match.

Italian sender: <instruction>Necessarie attività di aspirazione acqua con ***pompe idrovore*** ed attività di pulizia fango e detriti</instruction>

Croatian receiver: <instruction>Necessarie attività di aspirazione acqua con ***pompe idrovore*** **(SA *Hidraulička crpka* B *Klipna crpka* B)** ed attività di pulizia fango e detriti</instruction>

An example of semantically annotated message, extraction from Common Alerting Protocol (CAP) free text part

The EPISECC solution, briefly explained above, represents an user-centred approach for semantic interoperability in disaster response, which allows users to continue using and developing their own tools and terminologies while enhancing mutual understanding among them. The following text concisely explains the logic and structure of EPISECC Semantic Box.

EPISECC semantic features

The EPISECC solution includes semantic structures and processes, which are the basis of EPISECC Semantic Box. The semantic structures are the following:

- EPISECC Taxonomy,
- EPISECC Semantic Repository, and
- ontology model for the EPISECC use case.

The semantic interoperability processes are:

- semantic mapping, and
- semantic matching.

EPISECC Taxonomy, EPISECC Semantic Repository and the abovementioned semantic interoperability processes provide data for the EPISECC Semantic Box, which creates semantic annotations for first responders' messages. The ontology model is developed to allow ad-hoc users to participate in shared situational awareness during disaster response as an extension to be implemented in next development phase of CIS.

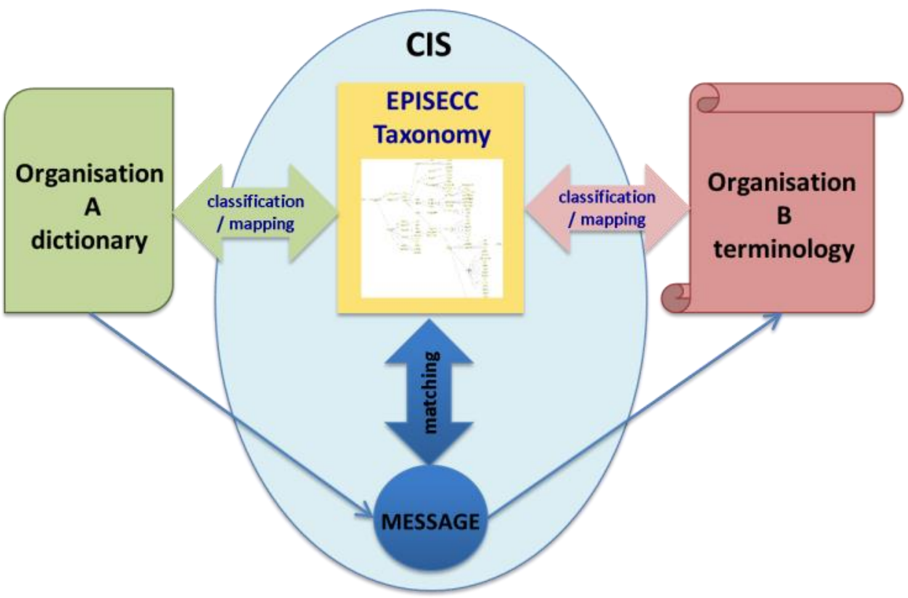
EPISECC Taxonomy

The taxonomy is a core of the EPISECC solution's semantic interoperability structure. Considering classification or categorisation as the most common cognitive processes, a generic taxonomy is developed and used to serve as an interface between first responders' terminologies. Each concept is precisely described and has a label called term. EPISECC Taxonomy is built with concepts which belong to the universe of discourse defined as: "A response to a critical event". It combines facets (multidimensional classification) with hierarchy and contains 317 concepts and 44 facets providing a common classification system for the particular universe of discourse. By combining facets into multidimensional space the number of concepts is much higher than 317. Such ad-hoc created concepts using facets are called compound terms. The EPISECC Taxonomy is built on variety of inputs from end users including the concepts identified from the EPISECC Inventory, thus presenting a common structure which could be effortlessly accepted by practitioners despite different culture, practice or expertise.

Semantic mapping and semantic matching

Semantic mapping is the step first responders have to undertake to be semantically connected to CIS. Basically, it is the classification of first responders' concepts against EPISECC Taxonomy. The first responders' concepts are usually stored in their dictionaries, taxonomies, terminologies and similar structures or simply they are any other concepts used throughout disaster response. During semantic mapping first responders have to find concepts in the EPISECC Taxonomy having either same or broader meaning to their own concepts. For example, according to the description in EPISECC Taxonomy an organisation's concept 'water tank' could be classified as 'specialised vehicle'. Consequently, connected to the taxonomy first responders' organisation is semantically connected to others who preformed the same process. The results of the semantic mapping process are stored in EPISECC Semantic repository.

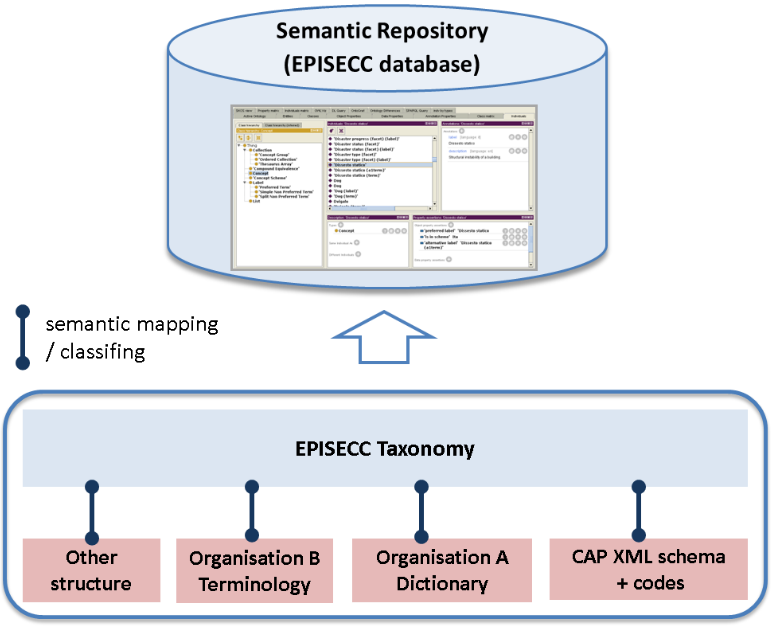
Semantic matching is a process of retrieving the concepts of an organisation that receives the message which semantically match the concepts of an organisation that sends the message. This process uses results of the classification process, namely semantic mapping.



Semantic mapping and matching via the EPISECC Taxonomy

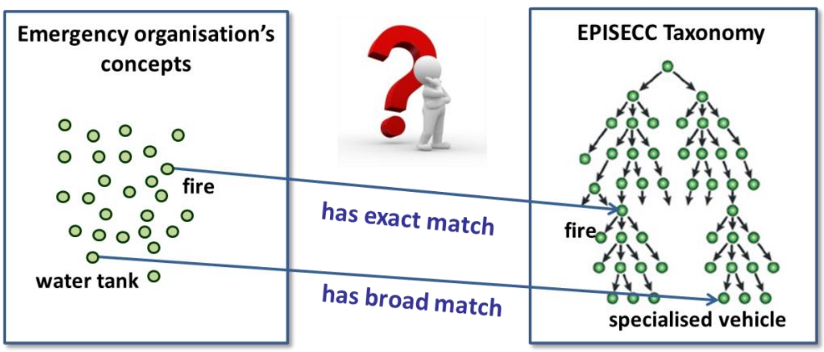
EPISECC Semantic Repository

The second semantic structure is developed to provide a permanent store of concepts, their semantic descriptions and mutual relations. Semantic Repository's structure is based on the Resource Description Framework (RDF) data model (as state-of-the-art for the semantic interoperability) and the Simple Knowledge Organization System-thes (SKOS-thes) model able to store various semantic structures, from taxonomies and ontologies to unstructured sets of concepts. The structure of the EPISECC Taxonomy is stored into the Semantic Repository as well as first responders' concepts and semantic mappings to the EPISECC Taxonomy. The processes of Semantic Mapping and Matching, and consequently interpretation of meanings of exchanged information between the organisations by creating the semantic annotations, are than performed automatically.



The EPISECC Semantic Repository: storage of the EPISECC Taxonomy, first responders'' semantics and semantic relations

The EPISECC Taxonomy's elements are represented by the following SKOS-thes classes: Concept, Concept Scheme, Label, Preferred Term and Thesaurus Array. Two SKOS-thes properties were used to represent the taxonomy's hierarchies: 'has narrower' and 'has broader'. Semantic mappings are represented by the SKOS-thes properties: 'has exact match' and 'has broader match'. Organisations' concepts are represented by the SKOS-thes classes: Concept, Concept Scheme, Label and Preferred Term.



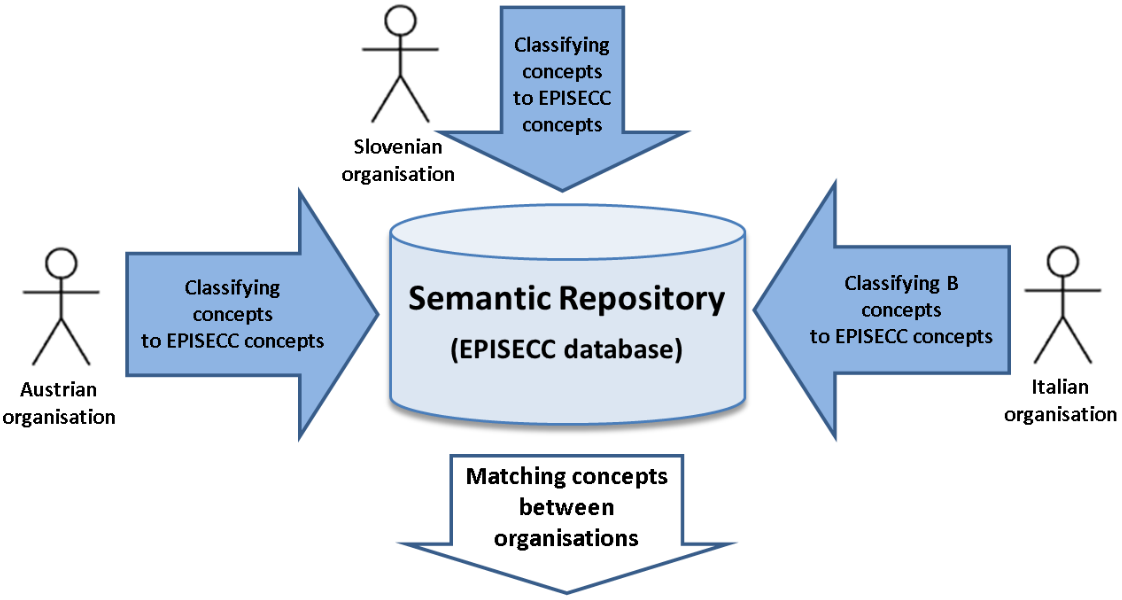
Semantic mappings by the SKOS-thes properties: 'has exact match' and 'has broad match'.

Terms and standards used by first responders are ever emerging and the semantic models developed within the project are able cope with that. The Semantic Repository, as a central place for storage of semantics, has a significant role because semantics becomes independent of application codes and there is no need for upgrading ICT tools every time it changes. Use of the RDF database model for the implementation of the Semantic Repository made that central place distributed over the web, bringing a new perspective: semantics can be maintained by a common effort of all end users.

EPISECC Semantic Box

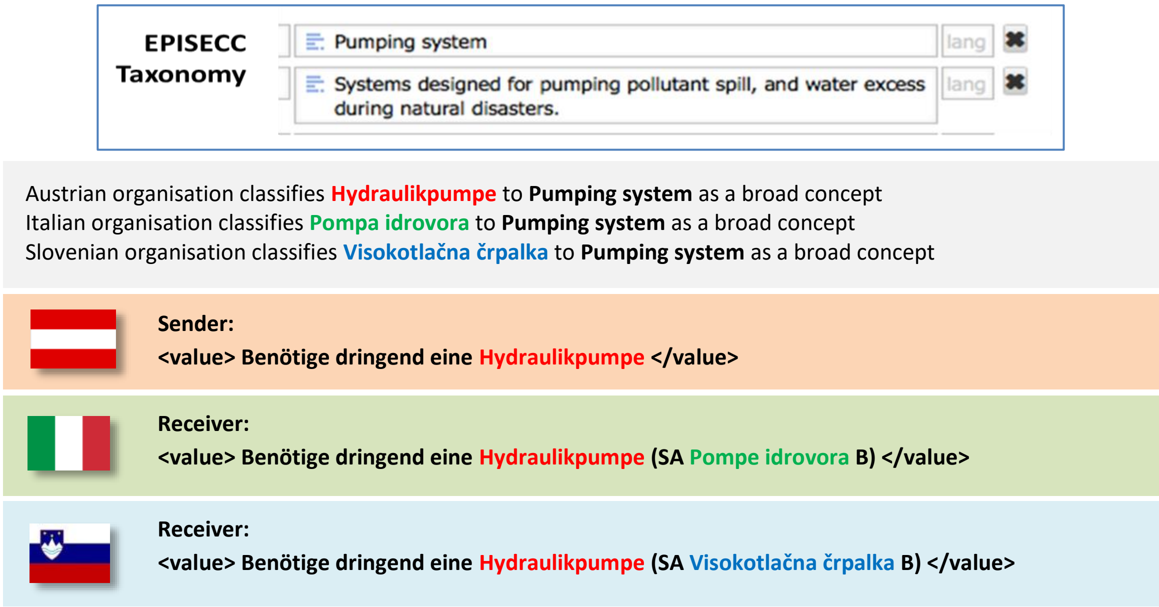
For the creation of semantically annotated messages, the EPISECC Semantic Box was prototyped and implemented, offering to the end users the following:

- entering and storing the first responders' concepts, their description and other properties;
- semantic mapping of the first responders' concepts to the EPISECC Taxonomy's concepts;
- creation of semantic annotations (via semantic matching process).



Semantic Repository and the processes of semantic mapping and matching

Semantic mapping of first responders' concepts against the EPISECC Taxonomy must be done before the information exchange among first responders begins. During semantic mapping, the first responders perform classification of their concepts to the EPISECC Taxonomy's concepts and, if needed, creates compound terms from the EPISECC Taxonomy facets' values. Semantic matching is a process of retrieving concepts of first responders who receives the message which semantically match the concepts of the first responder who sends the message. The semantic matching between the concepts of different first responders is performed via the EPISECC Taxonomy in the case when they mapped their concepts to it prior to response action. The mappings are stored in the EPISECC Semantic repository and the semantic matching process includes querying of the database for the concepts satisfying the conditions defined by the SPARQL queries. If necessary, by using reasoning mechanism new semantic mappings between concepts could be inferred.



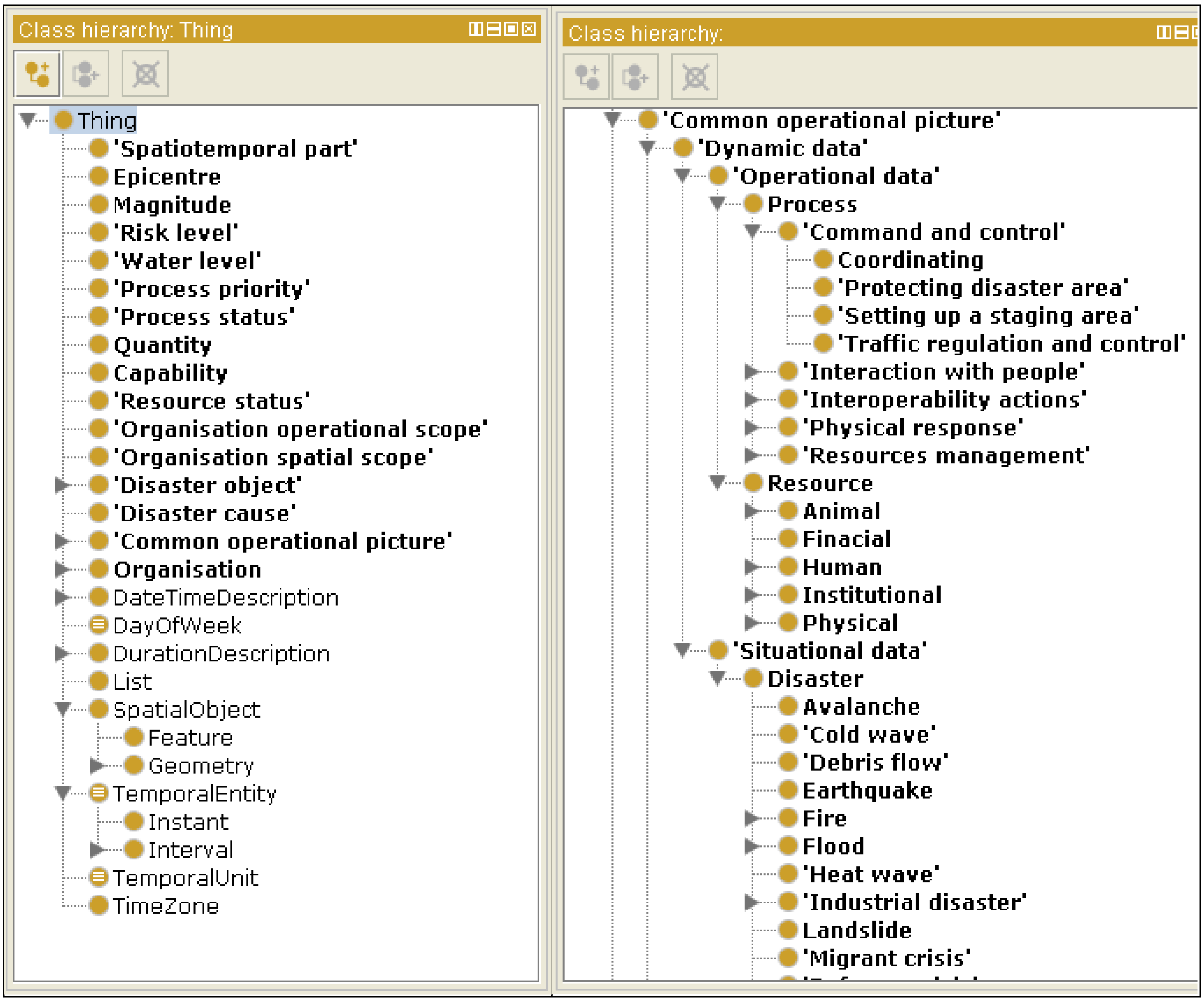
Semantic mappings of first responders’ concepts against the EPISECC Taxonomy concepts and annotated messages

Ontology model for the EPISECC use case

Previously described solution satisfies security requirements over information exchange in disaster response, usually imposed by certain first responders. Authorized first responders have to adapt their tools and enter semantics into the Semantic Repository prior to a disaster.

However, to enable ad-hoc users, like citizens, to participate in the common operational picture together with first responders, the EPISECC Ontology model is developed but not implemented as a part of CIS. The model enriches the EPISECC Taxonomy towards semantics for the spatial and temporal concepts. It describes the EPISECC use case as a model of domain knowledge with references to the upper ontologies what enables dynamic merging of data. The intention is to automatically classify spatio-temporal data coming from different end users and to merge them into a common operational picture. The added value of introducing the ontology model is that solution becomes open to ad-hoc participants and creates entirely shared situational awareness during disaster response.

Scope of the Ontology model



Protégé Desktop interface showing the class hierarchies of the Ontology model

Acknowledgement

*Thanks to the EPISECC consortium especially to Brugger J., Delprato U., Grüner R., Humer H., Huysmans K., Jasmontaite L., Lichtenegger G., Linke H., Neubauer G., Obritzhauser T., Preinerstorfer A., Ratanga RJ., Tusa G., Vorraber W. & Zuba G.

Figures are taken from publications, presentations or deliverables created during the course of the project EPISECC.