EU-CIRCLE

A pan-European framework for strengthening Critical Infrastructure resilience to climate change

D3.6 RISK MODEL METADATA

Contractual Delivery Date: 10/2017	**Actual Delivery Date**: 08/2018
Type: Document, report	**Version**: v0.5

Dissemination Level: Public Deliverable

Statement

This report, D3.6 Risk Model Metadata, provides approaches that were done in Task 3.6 for the development of methodologies to define metadata for WP3 related datasets. The developed metadata will cover three type of data sets, the Representation of Critical Infrastructures, the Damage Functions and the EU-CIRCLE analysis output.

EU-CIRCLE is a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653824. Please see http://www.eu-circle.eu/for more information.

Preparation Slip			
	Name	Partner	Date
From	Michael Skitsas	ADITESS	20/08/2018
Reviewer	Ralf Hedel	IVI	27/08/2018
Reviewer			
For delivery	Thanasis Sfetsos	NCSRD	28/08/2018

Document Log			
Issue	Date	Comment	Author / Organization
V0.1	31/10/2017	Deliverable Structure	ADITESS, NCSRD
V0.2		Definition of metadata format and encoding	ADITESS, NCSRD
V0.3		Data specifications	ADITESS, EUC
V0.4		Address comments based on internal feedback	ADITESS

Executive Summary

Metadata is a set of data able to describe the content and make a data set searchable and then shareable. This deliverable provides guidelines for the development of the metadata files for the EU-CIRCLE Risk Model and Critical Infrastructure Networks related data.

The guidelines aim to cover three type of data sets, the Representation of Critical Infrastructures, the Damage Functions (forming the EU-CIRCLE Risk Model) and the EU-CIRCLE analysis output (the result of CIRP software). The structure of metadata is based on a general template (baseline metadata) enhanced with specific fields for each type of data.

Furthermore, data specifications for the assets (CI networks) and damage functions are presented in this document in order to assist the development of the data sets and define the data structures for storage and access.

Contents

1 Introduction

The deliverable D3.6 *Risk Model Metadata,* presents approaches that were done in Task 3.6 from the WP3 of the EU-CIRCLE project. The main results of D3.6 are the development of methodologies in how to define metadata for the WP3 datasets. In general, metadata give information about the data, such as who made the data, what are the data dimensions, references to algorithms etc. Examples of relevant metadata attributes are also given in this deliverable.

The metadata is defined as structured information able to describe an information resource or data set. Metadata is often called data about data or information about information. The purpose of metadata is to make the data discovery easier, organise the data and eliminate the data duplication.

In EU-CIRCLE project and WP3 we identify three main data sets that will be accommodated with metadata:

- **Representation of Critical Infrastructures:** This dataset includes all the CI networks that are developed (or already existing) and are going to be used under the EU-CIRCLE Project. CI networks is one of the input of CIRP software.
- **Damage Functions**: The second main dataset of EU-CIRCLE and input the CIRP is the developed damage functions. These functions are related with the Risk Modelling and aim to represent the impact of a hazards over the assets of an infrastructures.
- **CIRP Analysis output:** The last data set covered in this deliverable is the output of EU-CIRCLE CIPR software. Generally, the output of the CIRP is similar with the input network enhanced with the analysis results (i.e. damages per asset).

As part of the metadata, this deliverable also presents the EU-CIRCLE data specifications for the assets and damage functions.

2 Methodology

2.1 Link with existing international standards

The official standards organizations like International Organization for Standardization (ISO) and Federal Geographic Data Committee (FGDC) define metadata standards especially for geospatial data.

INSPIRE Metadata

Data sets and the Spatial Data Services providing them need to be discoverable by the people requiring the provided information to be available. According the INSPIRE, To important things should be considered in order to have these resources discoverable: (a) description of resources by the data owners, and (b) online access to these repository. In particular, data owners should provide an accurate description of their resources based on predefined rules as provided by the INSPIRE Regulations. This description will form the metadata for the considered resources. While the data are well described in metadata, an online access to metadata repositories should be available to make the searching of data feasible. Beyond the creation and storage of metadata, the maintenance of them is another important process in order to have a functional and up-to-date system.

The technical requirements for providing Discovery Services are given in [INSPIRE TG DS 2011], and the requirements for the metadata content and structure in the document [INSPIRE TG Metadata 2017].

FGDC Content Standard for Digital Geospatial Metadata (https://www.fgdc.gov/metadata)

According to the FGDC [FGDC CS 1998], metadata are sets of information that describe the content of a geospatial data set. The FGDC has established content standards for metadata for the purpose of providing a common set of terminology and definitions for geospatial data documentation. Similar with INSPIRE, these metadata should be available for search by FGDC compliant data search tools.

EU-CIRLCE Metadata guidelines and structure is based on INSPIRE metadata enhanced with reference Risk Model (Damage Functions) and EU-CIRLCE Analysis data sets.

2.2 Coordinates Referencing System

A spatial reference system (SRS) or coordinate reference system (CRS)[1] is a coordinate-based local, regional or global system used to locate geographical entities. One of the main purposes of the CRS is to define a specific map projection. In particular, these systems are used for a uniquely referencing spatial information in space as a set of coordinates (x, y, z) and/or latitude and longitude and height, based on a geodetic horizontal and vertical datum.

The standard [ISO 19111] describes the conceptual schema and defines the description for two cases. The first case is given by a coordinate reference system to which a set of coordinates is related. The second case consists of a coordinate operation (coordinate transformation, coordinate conversion, concatenated coordinate operation) to change coordinate values from one coordinate reference system to another.

The **World Geodetic System (WGS)**[2] is a standard coordinate system for the earth that is used in cartography, geodesy, and satellite navigation including GPS.

Map Projection

A map projection is a systematic transformation of the latitudes and longitudes of locations from the surface of a sphere or an ellipsoid into locations on a plane (a plane is a flat, two-dimensional surface). This process is a required in the creation of plane maps. The projection a map from sphere to a plane surface always imposed a kind of distortion. This distortion can be varies from and depending on the purpose of

[1] https://en.wikipedia.org/wiki/Spatial_reference_system
[2] https://en.wikipedia.org/wiki/World_Geodetic_System

the map and the requirements some distortions are acceptable or not. To mitigate this and minimize the distortion, different map projections exist. There is no limit to the number of possible map projections.

A CRS then defines, with the help of coordinates, how the two-dimensional, projected map in your GIS is related to real places on the earth. The CRS that EU-CIRCLE project will follow is the standard WGS84 (EPSG:4326)[3].

2.3 Metadata Structure and Encoding

As we already mentioned, metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource [NISO 2004]. The challenge is to define and name standard metadata fields so that a data consumer has sufficient information to process and understand the described data without the need to access the actual data sets. INSPIRE, provide a comprehensive guideline including the rules for the creation of metadata for geospatial related data sets.

INSPIRE XML Encoding of ISO metadata

In INSPIRE, the encoding of metadata is based on the ISO Standards [ISO 19115], [ISO 19119] and [ISO 19139]. The abstract standards [ISO 19115] and [ISO 19119] provide a structural model and specify the content of the set of metadata elements used in INSPIRE while the [ISO 19139] standard specifies the XML encoding of [ISO 19115].

Metadata File Format – JSON

Another metadata file format that can be found is the JSON format. JSON is a lightweight data-exchange format that is very easy to read, parse and generate. Based on a subset of the JavaScript programming language, JSON is a text format that is optimized for data interchange. JSON is built on two structures: (1) a collection of name/value pairs and (2) an ordered list of values. JSON format is required by the Open Data Policy for the development of metadata.

EU-CIRCLE Encoding

In EU-CIRCLE project metadata will follow an XML encoding based on INSPIRE guidelines with the addition of specific fields to fulfil the requirements of the project.

Regarding the data specification and the specific data models that are using in EU-CIRCLE project (i.e. Assets Class Repository) other formats can be used. In particular, for the asset class repository, a JSON encoding will be followed.

[3] http://spatialreference.org/ref/epsg/wgs-84/

3 EU-CIRCLE CI and Risk Model Metadata

Every dataset within EU-CIRCLE should be accompanied with a metadata file following the guidelines described in this chapter. Currently, the file that represents the metadata is in an XML format with filename as DATAFilename_metadata.xml.

As we already mentioned, for the WP3 we identified three main data set. The first one is the Critical Infrastructure files which represent a network of assets. The second type of data is related with risk model and particularly describes the damage functions. Both the first two types (CI Networks and Risk Model) together with the climate hazard model (D2.4) constitute the input of the CIRP software. The last type of data set that we include in this deliverable is the analysis output of CIRP (EU-CIRCLE analysis). This dataset is similar with the CI network enhanced with the occurred damage on the assets (as a result of the analysis).

In the work under the Task 3.6 of WP4, we define a common approach to develop the metadata regardless the purpose of the data. This approach has a general template for metadata (baseline metadata) that applies in all the types of datasets and then for each type, user will be able to fill the specific topics related with the type of data. For example, an EU-CIRCLE analysis will include the base line metadata and all the extra fields that include information about the geospatial data, risk model and the EU-CIRCLE analysis.

3.1 Baseline Metadata

This section of metadata should be competed in all cases of data.

3.1.1 Naming Convention

This element will include details about the filename and the meaning of the structure. From the filename, user should be able to identify the type of data as well as further details about the sector/subsector and the organization.

Field Name	Field Description	Field Type	Acceptable Values
dataType	The type of the data that metadata refers for.	String (ENUM)	Network, Damage Function, CIRP Analysis [Acceptable values can be extended based on the needs of EU-CIRCLE project]
sector	The CI sector that data refers for.	String (ENUM)	List of available CI Sectors
fileType	The format type of the file. For example can be		Shapefile, XML, GeoJSON [Acceptable values can be extended based on the needs of EU-CIRCLE project]

Filename Example:

ICT_Network_CYTA_05May2018.shp

XML Example:

```
<naming-convention>
    <dataType>Network</dataType>
    <sector>ICT</sector>
    <filename>ICT_Network_CYTA_05May2018.shp</filename>
    <filetype>shp</filetype>
</naming-convention>
```

3.1.2 Metadata Reference Information

This section of metadata can be characterized as metadata of metadata. In particular, it contains details about the metadata such as the language, the point of contact and the creation date.

Field Name	Field Description	Field Type	Acceptable Values
pointofContact	The Point of Contact of the organization responsible for the development and the updating of the metadata	String	n/a
date	The date of last revision of the metadata content. Initially, this field refers to the creation date.	Date	ISO 8601 format
dateType	Defines the type of the above date	String (ENUM)	Creation Date, Publication Date, Revision Date
language	The language which the metadata are expressed	String	The value of this field can be limited in the official languages of the community (ISO 639-2)

XML Example:

```
<reference-information>
    <pointofContact>Full Name</pointofContact>
    <date>2018-05-05T15:53:00+05:00</date>
    <dateType>Creation Date</dateType>
    <language>EN</language>
</reference-information>
```

3.1.3 Resource Identification

Resource identification section contains information about the content. Through this set of fields, the interested party (potential user of the data) can get a quick overview about the content and the purpose of the data.

Field Name	Field Description	Field Type	Acceptable Values
title	Resource Title	Text	Free Text (example: Power Network Poles in a City)

abstract	The abstract field contains a brief summary of the content of the resource	Text	Free Text
purpose	The purpose of the resource	Text	Free Text
locator	This field defines the link(s) to the resource and the additional information that may exists about the resource.	String	URL or File directory
language	The language that is used within the data (resource)	String	

XML Example:

```
<resource-identification>
    <title>Mobile Communication Network of Nicosia</title>
    <abstract>This is the abstract of the network...</abstract>
    <purpose>Identify the risk due to extream winds</purpose>
    <locator>URL or File directory</locator>
    <language>EN</language>
</resource-identification>
```

3.1.4 Keyword

Keywords is one of the most useful sections of formal metadata. The keyword value is a commonly used word, formalized word or phrase used to describe the subject. While the topic category is too coarse for detailed queries, keywords help narrowing a full text search and they allow for structured keyword search. For the EU-CIRCLE project, in metadata keywords can be found as a "Free Keyword" in the form of string. Additionally, if the keyword originates from a controlled vocabulary specific fields to include this are existing.

Field Name	Field Description	Field Type	Acceptable Values
value			
vocabulary	The citation of the originating controlled vocabulary	Object	Vocabulary object (Table…)

Field Name	Field Description	Field Type	Acceptable Values
title		String	
date		Date	ISO 8601
dateType		String (ENUM)	Creation Date, Publication Date, Revision Date

XML Example:

```
<keywords>
    <keyword>
        <value>Antenna</value>
        <vocabulary>
            <title>n/a</title>
            <date>n/a</date>
            <dateType>n/a</dateType>
        </vocabulary>
    </keyword>
    <keyword>
        <value>Tower</value>
        <vocabulary>
            <title>n/a</title>
            <date>n/a</date>
            <dateType>n/a</dateType>
        </vocabulary>
    </keyword>
</keywords>
```

3.1.5 Temporal Reference

This section addresses the requirement to have information on the temporal dimension of the data. Based on EU-CIRCLE needs, initially we record three fields, the creation date, the last revision and the valid period of the data. More important dates can be included in the future based on the needs of EU-CIRCLE (i.e date of publication).

Field Name	Field Description	Field Type	Acceptable Values
creationDate	The date of creation of the data.	Date	ISO 8601
lastRevision	The date of the last revision. In metadata there is no need to keep revision history.	Date	ISO 8601
validPeriod	The period that the data are still valid. This period can be expressed in a due date. After that date, the data should be revised.	Date	ISO 8601

XML Example:

```
<temporal-reference>
    <creationDate>2018-05-05T15:53:00+05:00</creationDate>
    <lastRevision>2018-05-05T15:53:00+05:00</lastRevision>
    <validPeriod>2019-05-05T15:53:00+05:00</validPeriod>
</temporal-reference>
```

3.1.6 Data Quality

The processing history of result data set or data set series can provide valuable information about the applicability of the data for a particular use. This information may include information on the source data used and the main transformation steps that took place in creating the current data set or data set series.

Field Name	Field Description	Field Type	Acceptable Values
processHistory	This field will include information about the process history.	Text	Free Text Example: Input for CIRP… for the analysis of…]

XML Example:

```
<data-quality>
    <processHistory>
        <record>This is a sample record of process history</record>
    </processHistory>
</data-quality>
```

3.1.7 Access and Use level

The technical restrictions applying to the access and use of the data shall be documented in the metadata as well. Currently, for the EU-CIRCLE demands we include the conditions applying to access and use and the limitations on public access. Later more restriction can be included in this area based on the needs of EU-CIRCLE project.

Field Name	Field Description	Field Type	Acceptable Values
accessConditions	Access and use conditions of the data	String	*The element must have values. If no conditions apply to the access and use of the resource, "no conditions apply" shall be used. If conditions are unknown, "conditions unknown" shall be used.*
accessFees	*Information on any fees necessary to access and use the data*	String	Information on fees if is applicable. Link to a URL can be also used
publicAccess	Definition of any limitations in case of public data	String	*If there are no limitations on public access, this metadata element shall indicate that fact.*

XML Example:

```
<access-level>
    <accessConditions>No conditions apply</accessConditions>
    <accessFees>No fees apply</accessFees>
    <publicAccess>No limitations</publicAccess>
</access-level>
```

3.1.8 Responsible Party

In addition to the information about the organisation responsible for the data, the metadata for shall contain the information about the responsible party for the service. The responsible party accepts accountability and responsibility for the data and ensures appropriate care and maintenance of them.

Field Name	Field Description	Field Type	Acceptable Values
organizationName	The name of the organization responsible for the establishment, management, maintenance and distribution of the data	String	Free Text
email	The email of the contact point of the responsible party	String	Valid email

XML Example:

```
<responsible-party>
    <organizationName>Name of the organization</organizationName>
    <email>email@organization.com</email>
</responsible-party>
```

3.2 Geospatial Metadata - CI Networks

This part of metadata is required only for data that contains geospatial information. As the main geospatial data of EU-CIRCLE (with respect to WP3) is the representation of Critical Infrastructure networks (based on the registry of assets) related fields have been included in this section.

3.2.1 Classification of Spatial Data

This section includes information about the classification of the spatial data. The information is highly related with the purposes of EU-CIRCLE and thus, is update to cover the CI sector that data belongs.

Field Name	Field Description	Field Type	Acceptable Values
sector	The Critical Infrastructure sector that the data represents	String (ENUM)	The values are within the list of sectors that EU-CIRCLE project covers.
subsector	The Critical Infrastructure sub-sector that the data represents	String (ENUM)	The values are within a list of sub/sectors that EU-CIRCLE project covers. The list is dependent on the choice of sector.
crossSectors	List of other sectors that included in	Array (String)	EU-CIRCLE CI Sectors

	the data (in the form of interconnections)		
content	The content of the specific data with respect to CI representation	String (ENUM)	The acceptable values are: Asset (in case that data represents a specific asset), Network (in case that date represents a specific network), Complex Network (in case that network contains interdependencies with other sectors)

XML Example:

```
<spatial-classification>
    <sector>ICT</sector>
    <subsector>TELECOM</subsector>
    <crossSectors>
        <sector>ENERGY</sector>
        <sector>WATER</sector>
    </crossSectors>
    <content>Complex Network</content>
</spatial-classification>
```

3.2.2 Geographic Location

According the INSPIRE metadata and ISO 19119 this section is the extent of the data in the geographic space, given as a bounding box. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals.

Field Name	Field Description	Field Type	Acceptable Values
nLat	North Bound Latitude	Decimal	Decimal representation of coordinate with a precision of two decimals.
eLon	East Bound Longitude	Decimal	Decimal representation of coordinate with a precision of two decimals.
sLat	South Bound Latitude	Decimal	Decimal representation of coordinate with a precision of two decimals.
wLon	West Bound Longitude	Decimal	Decimal representation of coordinate with a precision of two

			decimals.
countries	List of countries that the data covers	Array (String)	Country names
Format	The format of the Bounding Box that is followed	String	i.e. ISO 19139

XML Example:

```
<geolocation>
    <bbox>
        <nLat>35.1499686675</nLat>
        <eLon>33.4003730416</eLot>
        <sLat>35.0128634585</sLat>
        <wLon>33.0793265</wLon>
    </bbox>
    <countries>Cyprus</countries>
    <format>ISO19139</format>
</geolocation>
```

3.2.3 Spatial resolution

Spatial resolution section refers to the level of detail of the (geospatial) data set. It shall be expressed as a set of zero to many resolution distances or equivalent scales.

Field Name	Field Description	Field Type	Acceptable Values
eqScale	An equivalent scale is generally expressed as an integer value expressing the scale denominator	Integer	n/a
resDistance	A resolution distance shall be expressed as a numerical value associated with a unit of length	Decimal	n/a
units	The unit of measure for the resolution distance.	Decimal	n/a

XML Example:

```
<spatial-resolution>
    <resDistance>500</resDistance>
    <units>m</units>
</spatial-resolution>
```

3.2.4 Coordinate Reference Systems

Description of the coordinate reference system

Field Name	Field Description	Field Type	Acceptable Values
csrCode	Coordinate Reference System Code	String	i.e EPSG:4326
csrName	Coordinate Reference System name	String	i.e. WSG84
csrRefLink	Reference link for coordinate	String	URL

	reference System		

XML Example:

```
<crs>
    <crsCode>EPSG:4326</crsCode>
    <crsName>WSG84</crsName>
    <crsRefLink>http://spatialreference.org/ref/epsg/wgs-84/</crsRefLink>
</crs>
```

3.3 Risk Model – Damage Functions

Risk modeling is a very important aspect of EU-CIRCLE project and a mandatory input of CIRP for the execution of scenarios. The development of damage functions for different assets with respect to hazards is part of the risk modeling. Damage functions (or fragility curves) are appeared in the form of XML files compatible with the CIRP software. For each XML file a complementary metadata will be developed as well. Beyond the baseline information additional fields (that are presented in this section) will be included.

3.3.1 Damage Assessment Approach

The main characteristics of the developed damage functions have been defined in this section. These fields are related with the damage assessment approach that is followed.

Field Name	Field Description	Field Type	Acceptable Values
damageType	The type of damage function.	String (ENUM)	The damage types as defined by the EU-CIRCLE project (i.e structural, loss of performance, functional)
method	The damage assessment method that is considered	String	The damage assessment methods as defined by the EU-CIRCLE project (i.e. Input-Output Model, Multivariate models, Damage Functions, etc.)

XML Example:

```
<risk-model>
    <damageType>Structural</damageType>
    <method>Damage Function</method>
</risk-model>
```

3.4 EU-CIRCLE Risk Analysis

The last part of EU-CIRCLE specific metadata sections is related with the output of CIRP software. The purpose of this section is to enhance the baseline metadata with several fields describing the executed analysis.

3.4.1 EU-CIRCLE Analysis

Generally, the output of EU-CIRCEL CIRP software is similar with the input file of critical infrastructure (i.e shapefile of a network) enhanced with columns as calculated during the analysis. Such columns can be the occurred damage of every asset as well as the economical or performance cost of the infrastructure.

Field Name	Field Description	Field Type	Acceptable Values
analysisType	The type of the analysis	String (ENUM)	
date	The date of the execution of the analysis	Date	ISO 8601
description	The description of the analysis	Text	Free text
Purpose	The purpose of the analysis	Text	Free text
associateFile	Include any files as outcome of the analysis	Filename and locator	

XML Example

```
<eucircle-analysis>
    <analysisType>Type of the analysis</analysisType>
    <description>Short description of the analysis</description>
    <purpose>The purpose of the analysis</purpose>
    <associateFiles>
        <file>
            <filename>results.xml</filename>
            <locator>URL or Path</locator>
        </file>
    </associateFiles>
</eucircle-analysis>
```

4 EU-CIRCLE Data Specifications

EU-CIRCLE WP3 deals with two main dataset families, the one related with CI assets and networks [D3.1] and the risk modelling (Damage Functions) [D3.3].

This deliverable also defines the structure of this data. For each class we define the basic fields as well as the definition of the details (i.e units, type of field)

4.1 CI Assets and Networks

One major task of EU-CIRCLE project is the definition of CI assets and the development of the Asset Class Repository (ACR). For the definition of a class a number of specific fields must be completed. The data of each class are divided in four main categories: (a) information about the asset and the sector, this can be consider as the metadata part of the class, (b) the input section describing the several inputs of the specific asset, (c) the output part, and (d) the list of attributes that characterize the considered asset.

4.1.1 Asset Classification

Each asset is classified in a CI sector and service following the hierarchy below:

- Sector
  - Subsector
    - Critical Services
      - Asset Type

Field Name	Field Description	Field Type	Acceptable Values
sector	The critical infrastructure sector that asset belongs	String (ENUM)	EU-CIRCLE CI Sectors (i.e. ICT Sector)
subsector	If applicable, the sub-sector of the CI sector	String (ENUM)	EU-CIRCLE CI Sub-sectors (This field is dependent on the selected sector) (i.e Telecom)
service	Description of the services that asset is involved	String	Free text (i.e Mobile Telephony)
assetType	The type of the asset	String (ENUM)	Selected from a predefined list: Physical, Functional, Link

Additional details about the identification and description asset class are presented in the following table.

Field Name	Field Description	Field Type	Acceptable Values
id	A unique ID of the asset class	String	UUID value
userId	Creator of the asset class	String	UUID value

assetName	The name of the asset	String	Free Text
description	A short description about the asset class	String (ENUM)	Free Text
version	The current version of the asset class. This field can be extended to keep the versioning history as well (if necessary)	String	Version
creationDate	The date of creation of the asset class	Date	ISO 8601
revisionDate	The date of last revision of the asset class	Date	ISO 8601
accessLevel	The access and use level of the asset.	String (ENUM)	Private, Public, Restricted
notes	A text field that can keep additional information about the asset class.	Text	Free text (i.e. details of the current version: weight attribute is added)

JSON Example:

```
{
  "id" : "adeb5b4a-86a0-11e8-adc0-fa7ae01bbebc",
  "userID" : "adeb5b4a-86a0-11e8-adc0-fa7ae01bbeb1",
  "sector" : "ICT",
  "subsector" : "TELECOM",
  "service" : "Mobile Telephony",
  "assetType" : "Physical",
  "assetName" : "Cell Antenna",
  "description" : "Antenna for mobile telephony",
  "version" : "1.0",
  "creationDate" : "2018-05-05T13:31:15+00:00",
  "revisionDate" : "2018-05-05T13:31:15+00:00",
  "accessLevel" : "Private",
  "notes" : "Notes area"
}
```

4.1.2 Asset Inputs

This section of data describe the inputs to the CI asset. In the definition of the class, the input field is an array of object where each object has the following information.

Field Name	Field Description	Field Type	Acceptable Values
name	The input name	String	n/a
type	The type of the field	String	One of the available data types (Integer, Decimal, String, …)
units	If applicable, the units of the value of input	String	i.e m/sec
description	A brief description about the input	String	Free text

JSON Example:


```
{
  "inputs": [
    {
      "created_at": "2017-09-13T05:09:43Z",
      "description": "Number of incoming connections",
      "id": 1,
      "input_type": "Integer",
      "name": "Connections",
      "updated_at": "2017-09-13T05:09:43Z"
    }
  ]
}
```


4.1.3 Asset Outputs

Similar with inputs, outputs of the specific asset should be defined in the asset class.

Field Name	Field Description	Field Type	Acceptable Values
name	The input name	String	n/a
type	The type of the field	String	One of the available data types (Integer, Decimal, String, …)
units	If applicable, the units of the value of input	String	i.e m/sec
description	A brief description about the input	String	Free text

JSON Example:


```
{
  "outputs": [
    {
      "created_at": "2017-09-14T06:50:27Z",
      "description": "Output data bandwidth",
      "id": 3,
      "name": "Bandwidth",
      "output_type": "Double",
      "updated_at": "2017-09-14T06:50:27Z"
    }
  ]
}
```


4.1.4 Asset Attributes

The last category of data that define an asset class is the list of attributes. Similar with inputs and outputs, an array of attributes will be included in the definition of the class. Each attribute is defined as an object with the fields given below.

Field Name	Field Description	Field Type	Acceptable Values
name	The name of the attribute	String	n/a
description	The description of the attribute	Text	Free text
type	The type of the field of attribute	String	One of the available data types (Integer, Decimal, String, …)
static	Declare if the value of the attribute remains static throughout the lifetime of the asset	Boolean	True/False
units	If applicable, the units of the value of input	String	i.e m/sec
default	Default value of the attribute	Type is depending on the attribute	

JSON Example:

```
{
  "attributes": [
    {
      "created_at": "2017-09-13T05:09:43Z",
      "updated_at": "2017-09-13T05:09:43Z",
      "name": "weight",
      "description": "Antenna weight",
      "id": 1,
      "type": "Double",
      "static" : True,
      "units" : "Kilograms",
      "default" : "n/a"
    }
  ]
}
```

4.1.5 CI Design thresholds and requirements

Additionally, to the asset attributes and based on EU-CIRCLE scope, a special class of data about the CI design thresholds and requirements is added.

Field Name	Field Description	Field Type	Acceptable Values
name	The name of the threshold	String	n/a
type	The type of the field of the threshold	String	One of the available data types (Integer, Decimal, String, …)
units	If applicable, the units of the value of input	String	i.e m/sec
hazard	The hazard that this asset/property is exposed	String	EU-CIRCLE considered hazards

Impacts	Short description on impacts	Test	Free text

JSON Example:

```
{
  "thresholds": [
    {
      "created_at": "2017-09-13T05:09:43Z",
      "updated_at": "2017-09-13T05:09:43Z",
      "name": "windResistance",
      "description": "Antenna resistance in wind",
      "id": 1,
      "type": "Double",
      "units" : "m/s",
      "hazard" : "wind",
      "impacts" : "Summary of impacts"
    }
  ]
}
```

4.1.6 Asset Instance

After the definition of the Asset Class and the development of the ACR, users can create instances of assets. To create a new instance (this will be assisted by a user interface) user should select an asset class and then to provide the specific attributes about the new instance.

Example of Attributes

ID	Name	Description	Type	Static	Units	Default
1	maxflow	Maximum Flow	int	False	litres/hour	None
2	efficiency		double	False	percent	
3	poweroutput	Power Output	double	False	MW	
4	poweroutput	Power Output	double	False	kV	
5	averageflow	Average Flow	int	False	Vehicles/Lane/hour	
6	averagevelocity	Average Velocity	int	False	kms/hour	
7	capacity	Capacity in road networks	int	False	Cars/hour	
8	capacity	Capacity in railways	int	False	Trains/hour	
9	area	Area size	int	True	square meters	
10	volume	Volume Size	int	True	cubic meters	
11	width	Width	double	True	meters	
12	weight	Weight	double	False	kilograms	

4.2 Damage Functions

For the development of a damage function, users should follow the approach as presented in deliverables D5.1 and D5.4 and according the guidelines of the CIRP software.

4.2.1 Damage Function Properties

The following table presents the basic fields that user should provide during the implementation of the damage function.

Field Name	Field Description	Field Type	Comments
ID	Unique value identifier in the damage functions dataset	String	N/A
Author	Identifies the person(s) who provided each damage function	String	N/A
Structure Type	Structure Type this damage fuction is designed for	String	N/A
Description	A textual description providing information about the derivation of this damage function	String	N/A
Code	Design code for the damage function	String	N/A
Damage Type	The type of the damage of this function (Damage Class)	String	Structural
Demand Type	The demand type required by the damage function	String	I.e Wind Speed
Demand Units	The units of the demand type	String	i.e m/sec
Limit States	The limit states of the damage function curves, CIRP expects 4 limit states. This tells CIRP how many damage curves to expect.	String	Slight: Moderate: Extensive: Complete
Curve Type		String	i.e. InterpolatedFragilityCurve
Fragility Curve Type		String	I.e. interpolation
Points	Demand, Damage Class	Double, Double	i.e. <point>50,3<point>

XML Example:

```
<fragility-dataset>
    <fragility-dataset-sets>
        <fragility-set>
            <fragility-set-properties Description="Tropical cyclone windspeed-destruction scale
                for the tropical pacific" DemandUnits="m/sec" DamageType="Damage Class"
                StructureType="Residential Wood Building" Author="None" ID
                ="WIND_RESIDENTIAL_WOOD_BUILDING" DemandType="Wind Speed" Code="Wind Damage
                Curve for Residential Wood Buildings"/>
            <fragility-set-labels>
                <fragility-set-label>Wind Damage Curve for Residential Wood Buildings</fragility
                    -set-label>
            </fragility-set-labels>
            <fragility-set-fragilities>
                <fragility-curve curve-type="net.satways.cirp.fragilitycurves
                    .InterpolatedFragilityCurve" fragility-curve-type="interpolation">
                    <point>0.0,0.0</point>
                    <point>13.4112,1</point>
                    <point>21.90496,1</point>
                    <point>22.352,2</point>
                    <point>32.63392,2</point>
                    <point>33.08096,3</point>
                    <point>42.4688,3</point>
                    <point>42.91584,4</point>
                    <point>49.1744,4</point>
                    <point>49.62144,5</point>
                    <point>58.1152,5</point>
                    <point>58.56224,6</point>
                    <point>69.2912,6</point>
                    <point>69.73824,7</point>
                    <point>86.72576,7</point>
                </fragility-curve>
            </fragility-set-fragilities>
        </fragility-set>
    </fragility-dataset-sets>
</fragility-dataset>
```

4.3 Impact Classification Specifications

4.3.1 Bottoms-Up methodology

In EU-CIRCLE, the calculation of the overall impact is based on a bottoms-up methodology. In this section, we are presenting the list of indicators that are defined within EU-CIRCEL project and used for the calculation of impact. Additionally, we present the four levels that constitute bottoms-up methodology.

Level 3: Indicators

Class ID	Class Name	Values
1	Negligible	Percentage (Range)
2	Small	Percentage (Range)
3	Medium	Percentage (Range)
4	High	Percentage (Range)
5	Severe	Percentage (Range)

Level 2: Impact Categories (Groups) / Level 1: Aggregate Direct & Indirect

Category ID	Class Name	**Aggregate Direct & Indirect** (Level 1)
1	Physical damage to CI assets	Direct
2	Damage to CI performance	Direct
3	Casualties	Direct
4	Economic & Finance	Direct
5	Environmental	Direct
6	CI reputation	Direct
7	To societal groups	Indirect
8	Casualties	Indirect
9	Economic & Finance	Indirect

4.3.2 EU-CIRCLE Impacts

The following tables presents the value ranges that form the class for each type of considered impact. For each category of Level 2 a separate table is created.

Physical damage to CI assets (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
1	Number of assets fully damaged over all assets (physical)	< 10%	10-25%	25-50%	50-75%	> 75%
2	Number of assets partially damaged over all assets (physical)	< 10%	10-25%	25-50%	50-75%	> 75%
3	Number of assets with a certain per cent (%) or range of damages (recommended threshold = 30% or 50%)	< 10%	10-25%	25-50%	50-75%	> 75%
4	Highest per cent (%) of physical damage of asset per network	< 10%	10-25%	25-50%	50-75%	> 75%
5	Average damage per network [%]	< 10%	10-25%	25-50%	50-75%	> 75%
6	Percentage of damaged assets over specific threshold over total number of assets P:property MT:Max Threshold	P < 0.02xMT	P > 0.02xMT and P < 0.05xMT	P > 0.05xMT and P < 0.15xMT	P > 0.15xMT and P < 0.40xMT	P > 0.40xMT

Physical damage to CI assets (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
7	Flow reduction in network asset (node / link)	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
8	Changes in network generation capacity	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
9	Changes in network demand capacity	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
10	Changes in network links capacities due to climate variability	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
11	Time that CI/asset/ is not able to serve its intended function	< 0.5 days	0.5 - 1 days	1 – 4 days	4 - 7 days	> 7 days
12	Connectivity Loss (CL)	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%

Casualties (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
13	Number of people affected over total (region) population	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
14	Person years lost over affected population	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%

Economic & Finance (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
15	Costs of damaged assets (of total value of CI)	< 0.5%	0.5 - 2%	2 - 10%	10 - 20%	20 - 30%
16	Loss of total income as a result of not servicing demand	< 0.5%	0.5 - 2%	2 - 10%	10 - 30%	30 - 40%
17	Costs for replacements, restoration & recovery (of regional GDP)	< 0,35%	0.35– 0.5%	0.5 – 1%	1 – 5%	5 – 15%
18	Maintenance costs after hazard (of regional GDP)	< 0,02%	0.02–0.05%	0.05-0.1%	0.1-0.3%	0.3-0.5%

Environmental (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
19	Max concentration of pollutant over region's threshold (data provided for daily pm10 concetration – µg/m3)	< 35	35 – 50	50 – 100	100 – 200	> 200

CI reputation (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
20	CI reputation (user defined according to the provided category)	n/a	n/a	n/a	n/a	n/a

To societal groups (Indirect)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
23	Percentage of people exposed / affected	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
24	Percentage of in-need societal groups (in people) not-served	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
25	Percentage of houses not-served	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
26	Percentage of enterprises not-served	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
27	Percentage of special facilities not-served (including emergency services)	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
28	Percentage of people annoyed (see Section 5)	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
29	Percentage of people been disruptive	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
30	Percentage of people been disturbed	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%
31	Percentage of people become dysfunctioned	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%

Casualties (Indirect)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
21	% of number of casualties ove total population of region	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%

Economic & Finance (Direct)

ID	Impact Description	Classes				
		Negligible	Small	Medium	High	Severe
22	Cost of damage for the entire economy (national/regional level)	< 0,1%	0.1–0.3%	0.3-0.6%	0.6-1%	> 1%

5 Conclusion

Metadata is a set of data able to describe the content and make a data set searchable and then shareable. This deliverable presents guidelines to prepare the metadata for EU-CIRCLE Risk Model and Critical Infrastructure Networks related data. The purpose of D3.6 is to prepare a standard approach to create the metadata files for WP3 datasets.

The methodology including the linking of EU-CIRCLE project (regarding the metadata) with existing international standards and encodings is presented.

The metadata structure of all the three dataset types that are considered in this work (Representation of Critical Infrastructures, Damage Functions and EU-CIRCLE analysis output) is based on a general template (baseline metadata) enhanced with specific fields for each type of data. Finally, this deliverable also presents the EU-CIRCLE data specifications for the assets and damage functions.

Bibliography

[INSPIRE TG Metadata 2017] Technical Guidance for the implementation of INSPIRE dataset and service metadata based on ISO/TS 19139:2007 (Version 2.0.1)

[INSPIRE TG DS 2011] Technical Guidance for the implementation of INSPIRE Discovery Services (Version 3.1)

[FDGC CS 1998] Metadata Ad Hoc Working Group Federal Geographic Data Committee, Content Standard for Digital Geospatial Metadata

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007) Part 2 to be published. (https://www.iso.org/standard/41126.html)

[NISO 2014] NISO Press, Understanding Metadata, ISBN: 1-880124-62-9

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003) (https://www.iso.org/standard/26020.html)

[ISO 19139] ISO/TS 19139:2007 Geographic information -- Metadata -- XML schema implementation (https://www.iso.org/standard/32557.html)

[ISO 19119] ISO 19119:2016 - Geographic information – Services (https://www.iso.org/standard/59221.html)