EU-CIRCLE

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

D8.11 FINAL REPORT ON COLLECTED AND HARMONISED DATA AND METADATA

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Statement

This report, D8.11 Final Report on Collected and Harmonised Data and Metadata, provides approaches that were done in WP2, WP3 and WP4 for the development of methodologies to define metadata for EU-CIRCLE related datasets. The developed metadata will cover five type of data sets, Climate Hazards modelling, the Representation of Critical Infrastructures, the Damage Functions. the EU-CIRCLE analysis output and CI Resilience.

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Executive Summary

Metadata is a set of data able to describe the content and make a data set searchable and then shareable. This deliverable summarizes the guidelines for the development of the metadata files for the EU-CIRCLE Project covering data and metadata related with Climate Hazards, CI representation, Risk Model and Resilience.

The structure of metadata is based on a general template (baseline metadata) enhanced with specific fields for each type of data. As a result of this, at any given stage of the EU-CIRCLE analysis (i.e representation of CI assets, Resilience) a common metadata structure will be used.

Furthermore, data specifications for the used data is presented where details about the attributes, data types and ranges of acceptable data are given.

Contents

1 Introduction

The deliverable D8.11 *Final Report on Collected and Harmonised Data and Metadata,* presents approaches that were done in EU-CIRCLE project and work packages 2, 3 and 4 about the collection and development of metadata as well as to provide the data specifications including field names, attributes, data types and ranges for all the data of EU-CIRCLE Project. In particular, the work under this deliverable consolidates the individual work of each WP in one consolidated and harmonised document.

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 WP2 we identify two main data sets that will be accommodated with metadata.

- **Primary Climate Data:** the structure and content of metadata covering results of climate observations and modelling
- **Secondary Climate Data**: secondary climate products and results of the impact models.

In 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).

In WP4 we identify two main data sets that will be accommodated with metadata:

- **End-User Questionnaire:** There are two types of data within this data set: data related with the development of the questionnaire and data related with the collected responses. The second type of data will be used by the RAT (Resilience Assessment Tool, D4.5) for the calculation of the resilience index. For both types of data, the necessary fields and structures have been defined and included in the general EU-CIRCLE metadata approach.
- **Resilience Indicators:** The second dataset that this deliverable cover is related with the development of RAT tool and the structure of Resilience Indicators and sub-indicators.

The aim of this report is to present in a consistent framework for the development of metadata for each stage of the EU-CIRCLE analysis.

2 Methodology

2.1 EU-CIRCLE Metadata Development

Thu purpose of this document is to provide a final report on the collected data and metadata. The considered dataset includes data from WP2 related with climate hazards, WP3 for CI representation, risk and impact modelling and WP4 resilience data. The outcome of this deliverable is an EU-CIRLCE holistic approach for the definition and collection of metadata as well as the definition of data specifications following well-known existing and new proposed standards. Based on the level of usage of existing standard and methodologies, the development of data modelling and metadata can follow one of the three approaches: (a) use of existing standards and methodologies (i.e. NetCDF), (b) adapting and expanding existing approaches to meet the needs of EU-CIRCLE project (i.e. INSPIRE for CI Representation) and (c) proposed new data models and approaches to cover EU-CIRCLE special data cases (i.e Risk Modelling/Damage functions).

2.1.1 Adopting Existing Standards

The first part of data that EU-CIRCLE covers and aim to harmonize is related with climate hazards and particular the results of climate observations and modelling as well as the secondary climate products and results of the impact models. For this part of work, the usage of climate modelling metadata approach as done by the CF (Climate and Forecast) metadata conventions and applied in recent CMIP5 (Coupled Model Intercomparison Project Phase 5; https://cmip.llnl.gov/cmip5/) and CORDEX (Coordinated Regional Climate Downscaling Experiment; http://cordex.org/) programmes is adopted. To full fill the requirements of EU-CIRCLE project, slight enhancement of this standards may be considered.

Another example of existing standard that can be used by EU-CIRCLE for the modelling and visualization of CI is the CityGML, an open standardised data model and exchange format to store digital 3D models of cities and landscapes. Actually, CityGML defines ways to describe most of the common 3D features and objects found in cities (such as buildings, roads, rivers, bridges, vegetation and city furniture) and the relationships between them.

2.1.2 Adapting/Extending Existing Standards

In this paragraph we focused on the modelling and representation of CI representation and assets visualization based on well-known 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 EU-CIRCLE related attributes and fields.

2.1.3 EU-CIRCLE Proposed Standards

Beyond the usage of existing data, either by adopting them or adapting/enhancing where is applicable, the usage of new proposed data sets and metadata to cover other EU-CIRCLE needs is also considered in the specific tasks of the project and is summarized in this report. In particular, the definition of data models and metadata to cover the Risk Modelling (fragility curves, damage functions) is done within WP3, Task 3.6 and reported in D3.6 Risk Model Metadata. Similar, data and metadata related with resilience indicators and end-users questionnaire are used in WP4, Task 4.6 and reported in D4.8 CI Resilience Metadata.

The reported methodology of collecting metadata within EU-CIRLCE project aims to provide a harmonized metadata structure for all the dataset used by the components of EU-CIRCLE either as an input to the analysis tools either as analysis results. For each EU-CIRCLE related analysis, the holistic metadata file will keep information about the CI representation and climate hazards, the damage functions as well as the results of EU-CIRCLE analysis tools and the Resilience Assessment Tool.

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 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

[1] https://en.wikipedia.org/wiki/Spatial_reference_system
[2] https://en.wikipedia.org/wiki/World_Geodetic_System
[3] http://spatialreference.org/ref/epsg/wgs-84/

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 EU-CIRCLE Metadata Structure

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

In the work, we summarize the work done in WP2, WP3 and WP4 and presented in deliverables D2.4, D3.6 and D4.8 respectively. The approach of collecting information and developing the metadata file 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	Text	Free Text

	summary of the content of the resource		
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 Climate Hazards Metadata and Standards

3.2.1 Primary climate data

Primary climate data in this section refers to following types of the information: (1) results of the station observations, (2) interpolated station data to the regular grid, (3) remote sensing (e.g. by satellites) data available at the climate periods, (4) results of the global and regional climate models (cf. EU-CIRCLE D2.1). All types of data can be produced by the research communities and national and international bodies (often following community driven efforts for the common formats and conventions), and user generated data (often needs additional work to format specific data before sharing). Common format to share these data is NetCDF. Further the NetCDF and other standards, the EU-CIRCLE climate hazards will follow the proposed metadata development methodology as well. This extra section of metadata will keep information about the global metadata describing details about the algorithms, infrastructure or models that produced the data. The following table presents details about the Climate Hazards related metadata.

Field Name	Field Description	Field Type	Acceptable Values
typeFormat	The type format of the data set	String	i.e CF-1.4
title	A succinct description of the data set	Text	Free text
institute	The organisation where the data were produced	Array (String)	EU-CIRCLE CI Sectors
source	How the data were produced, e.g. model type, run number and circumstances	Text	
history	An audit trail of data set processing	Array (Text)	
references	Web page or reference to the report and/or scientific publication	Array (URL)	
comment	Other useful information not covered elsewhere that adds value	Text	Free text
filename	Typical filenames and content	String	Filename
author	The person(s) who generated the data	String	

Climate data will follow an additional filename convention with more information/details about the data processing and algorithms appears in the filename. The following example presents the fields that are used for the construction of the filename:

tas_EUR-11_CNRM-CERFACS-CNRM-CM5_rcp45_r1i1p1_SMHI-RCA4_v1_day_20060101-20101231.nc

tas: variable saved: near-surface air temperature

EUR-11: domain: European domain at the 0.11° (~12.5 km) horizontal resolution.

CNRM-CERFACS: institution that performed global climate model (GCM) simulation

CNRM-CM5: specific GCM

rcp45: greenhouse gases concentration scenario

r1i1p1: additional details of the GCM simulation related to the model physics and initialization method.

SMHI: institution that performed regional climate model (RCM) simulation

RCA4_v1: specific RCM

day: frequency of data: daily data

20060101: first simulated time event in this file YYYYMMDD

20101231: last simulated time event in this file YYYYMMDD

Also, based on the provided guidelines, the spatial information about the climate analysis will be covered by the specific section (Geospatial Metadata) following the INSPIRE guidelines.

3.2.2 Secondary climate data

In this section we provide an overview of the metadata need for the secondary climate data.

Field Name	Field Description	Field Type	Acceptable Values
inputData	Dimensions and global metadata as in Primary climate data.	Reference	This field can be a reference to primary metadata
algorithm	Details about the algorithm to be used	Text	Free text
command	Details about the command (if applicable) that is executed	String	
tool	Details about the tool	Text	
comment	Other useful information not covered elsewhere that adds value	Text	Free text
filename	Filename and path of the results	String	Filename
author	The person(s) who generated the data	String	
institute	The organisation where the data were produced	Array (String)	
source	How the data were produced, e.g. model type, run number and circumstances	Text	
history	An audit trail of data set processing	Array (Text)	
references	Web page or reference to the report and/or scientific publication	Array (URL)	
title	Title of the secondary data		
climaticModel	Description of the climatic model	Text	
climaticScenario	Description of the climatic scenario	Text	
datasetDescription	Description of the used datasets	Text	

More details as well as examples about the climate change metadata can be found on deliverable D2.4 EU-CIRCLE climate hazards metadata and standards.

3.3 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.

3.3.1 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	String (ENUM)	The values are within the

	the data represents		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 the data (in the form of interconnections)	Array (String)	EU-CIRCLE CI Sectors
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>
```

3.3.2 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>
```

3.3.3 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>
```

3.3.4 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 reference System	String	URL

XML Example:

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

3.4 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.

3.4.1 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>
```

3.5 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.

3.5.1 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>
```

3.6 EU-CIRCLE Resilience Assessment

The EU-CIRCLE resilience assessment has three types of data: the end-user questionnaire, the EU-CIRCLE analysis output (CIRP software) and the indicators that are used for the calculation of the Overall Resilience Index. The EU-CIRCLE analysis is already covered in D3.6.

3.6.1 End-User Questionnaire

Each CI that want to use the RAT tool for the calculation of Resilience Index, will be asked to fill the end-user questionnaire related with resilience. Details about the development and the sample responses are presented in the next section of this deliverable. In this paragraph, we provide the required fields for the development of the metadata file to describe the questionnaire.

Field Name	Field Description	Field Type	Acceptable Values
questionnaire	The ID of questionnaire in the system	Integer	

name	The name of the author (user) that fill the questionnaire	String	
position	The position of this person in the organization	String	
dateType	The type of the date. New response, update existing questionnaire	String	
date	The date of filling the questionnaire	Date	ISO 8601
description	The description of the questionnaire. This field will be field by the operator in order to describe within a single paragraph the purpose of the questionnaire	Text	Free text
associateFile	Include any files as outcome of the analysis	Filename and locator	

Additional, several fields related with the questionnaire can be also included in this section.

Field Name	Field Description	Field Type	Acceptable Values
questionnaire	The ID of questionnaire in the system	Integer	
name	The name of person (contact person) that is responsible for this instance of questionnaire. The main author	String	
position	The position of this person in the organization	String	
email	Contact details of this person	String	Valid email
creationDate	The date of creation of the questionnaire	Date	ISO 8601
revision	The revision number of the questionnaire	Integer	
revisionDate	The date of last revision	Date	ISO 8601
title	The title of the questionnaire	Text	
description	A short description of the content and the purpose of the questionnaire	Text	Free text
keywords	Several keywords that characterize the questionnaire	List (String)	
questions	The number of questions	Integer	
time	The estimated required time for completion of the questionnaire	Integer	Minutes

XML Example

```
<eucircle-resilience>
    <end-user-questionnaire>
        <questionnaire>1</questionnaire>
        <name>John Smith</name>
        <position>Business Continuity</position>
        <dateType>Creation</dateType>
        <date>2018-07-15T15:53:00</date>
        <description>
        Short description about the questionnaire
    </description>
        <associateFile>n/a</associateFile>
    </end-user-questionnaire>
</eucircle-resilience>
```

3.6.2 EU-CIRCLE Resilience

The second part of resilience metadata section is the indicators and the execution of RAT for the calculation of resilience index. After each exercise, the user will be asked to fill the fields below in order to have a record of the activity as well as the possibility to search among resilience assessment exercises that held previously.

Field Name	Field Description	Field Type	Acceptable Values
questionnaire	The ID of questionnaire that is used. Note, this ID refers to the response that is captured and not to the questionnaire as definition.	Integer	
analysis	The ID of the analysis that is executed and used in the resilience assessment.	Integer	
date	The execution date of RAT tool	Date	ISO 8601
description	The description of the analysis	Text	Free text
purpose	The purpose of the analysis	Text	Free Text
index	The overall index value	Decimal	Range 0 to 10
capacity	The capacity indices. An array that holds the five considered capacity indices.	Array (Decimal)	Range 0 to 10

XML Example

```
<eucircle-resilience>
    <end-user-questionnaire>
        <questionnaire>1</questionnaire>
        <name>John Smith</name>
        <position>Business Continuity</position>
        <dateType>Creation</dateType>
        <date>2018-07-15T15:53:00</date>
        <description>
            Short description about the questionnaire
        </description>
        <associateFile>n/a</associateFile>
    </end-user-questionnaire>
    <resilience>
        <questionnaire>1</questionnaire>
        <analysis>3</analysis>
        <date>2018-07-19T13:23:00</date>
        <description>Short description about the resilience exercise</description>
        <purpose>This exercise is contacted for the needs of new adaptation measures</purpose>
        <index>8.5</index>
        <capacity>
            <anticipatory>8.01</anticipatory>
            <absorptive>7.3</absorptive>
            <coping>9</coping>
            <restorative>8.9</restorative>
            <adaptive>8.6</adaptive>
        </capacity>
    </resilience>
</eucircle-resilience>
```

4 EU-CIRCLE Data Specifications

EU-CIRCLE Project deals with four main dataset families, the one related with CI assets and networks [D3.6], the risk modelling (Damage Functions) [D3.6], the Climate Hazards data and metadata [D2.8] and CI Resilience [D4.8]

In this document, we also summarize the definitions of these datasets presenting the main attributes of variables, the data types and giving some examples.

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 Climate Data Specifications

4.3.1 Variables and Local Attributes in NetCDF specific

Variable	Units	Details
height	double	height:axis = "Z" ; height:long_name = "height" ; height:positive = "up" ; height:standard_name = "height" ; height:units = "m" ;
time	double	time:long_name = "time"; time:units = "h since 1998-4-19 6:0:0"; time:bounds = "time_bnds"

pressure	double	pressure:long_name = "pressure"; pressure:units = "kPa";
maxtemp	double	maxtemp:long_name = "temperature"; maxtemp:units = "K"; maxtemp:cell_methods = "time: maximum";
ppn	double	ppn:long_name = "depth of water-equivalent precipitation"; ppn:units = "mm";
TS_var	double	TS_var:long_name="surface air temperature variance" TS_var:units="K2"; TS_var:cell_methods="time: variance";
precipitation	double	precipitation:long_name="Accumulated precipitation"; precipitation:cell_methods="time: for each day time: maximum"; precipitation:units="kg";
temperature	double	temperature:long_name="surface air temperature"; temperature:cell_methods="time: minimum time: mean over years; temperature:units="K";
rlon	double	rlon:standard_name = "grid_longitude" ; rlon:long_name = "longitude in rotated pole grid" ; rlon:units = "degrees" ; rlon:axis = "X" ;
rlat	double	rlat:standard_name = "grid_latitude" ; rlat:long_name = "latitude in rotated pole grid" ; rlat:units = "degrees" ; rlat:axis = "Y" ;
rotated_pole	char	rotated_pole:grid_mapping_name= "rotated_latitude_longitude" ; rotated_pole:grid_north_pole_latitude = 39.25 ; rotated_pole:grid_north_pole_longitude = -162. ;
lon	double	lon:standard_name = "longitude" ; lon:long_name = "longitude" ; lon:units = "degrees_east" ;
lat	double	lat:standard_name = "latitude" ; lat:long_name = "latitude" ; lat:units = "degrees_north" ;

4.3.2 Climate indices as implemented in the CDO tool[4]

CDO Command	Short Description
eca cdd	Consecutive dry days index per time period
eca cfd	Consecutive frost days index per time period
eca csu	Consecutive summer days index per time period
eca cwd	Consecutive wet days index per time period
eca cwdi	Cold wave duration index w.r.t. mean of reference period
eca cwf	Cold-spell days index w.r.t. 10th percentile of reference period
eca etr	Intra-period extreme temperature range
eca fd	Frost days index per time period
eca gsl	Growing season length index
eca hd	Heating degree days per time period
eca hwdi	Heat wave duration index w.r.t. mean of reference period
eca hwf	Warm spell days index w.r.t. 90th percentile of reference period
eca id	Ice days index per time period
eca r75p	Moderate wet days w.r.t. 75th percentile of reference period
eca r75ptot	Precipitation percent due to R75p days
eca r90p	Wet days w.r.t. 90th percentile of reference period
eca r90ptot	Precipitation percent due to R90p days
eca r95p	Very wet days w.r.t. 95th percentile of reference period
eca r95ptot	Precipitation percent due to R95p days
eca r99p	Extremely wet days w.r.t. 99th percentile of reference period
eca r99ptot	Precipitation percent due to R99p days
eca pd	Precipitation days index per time period
eca r10mm	Heavy precipitation days index per time period
eca r20mm	Very heavy precipitation days index per time period
eca rr1	Wet days index per time period
eca rx1day	Highest one day precipitation amount per time period
eca rx5day	Highest five-day precipitation amount per time period
eca sdii	Simple daily intensity index per time period
eca su	Summer days index per time period
eca tg10p	Cold days percent w.r.t. 10th percentile of reference period
eca tg90p	Warm days percent w.r.t. 90th percentile of reference period

[4] https://code.mpimet.mpg.de/projects/cdo/embedded/cdo_eca.pdf

eca tn10p	Cold nights percent w.r.t. 10th percentile of reference period
eca tn90p	Warm nights percent w.r.t. 90th percentile of reference period
eca tr	Tropical nights index per time period
eca tx10p	Very cold days percent w.r.t. 10th percentile of reference period
eca tx90p	Very warm days percent w.r.t. 90th percentile of reference period

4.3.3 Climate hazards: Impact model's data

Variables related to Flood Characteristics

CF Standard name	Units	CF Description
flood_water_speed	m s-1	"Speed is the magnitude of velocity. Flood water is water that covers land which is normally not covered by water."
northward_flood_ water_velocity	m s-1	"A velocity is a vector quantity. "Northward" indicates a vector component which is positive when directed northward (negative southward). Flood water is water that covers land which is normally not covered by water."
eastward_flood_ water_velocity	m s-1	"A velocity is a vector quantity. "Eastward" indicates a vector component which is positive when directed eastward (negative westward). Flood water is water that covers land which is normally not covered by water."
flood_water_duration_ above_threshold	s	"The quantity with standard name flood_water_duration_above_threshold is the time elapsed between the instant when the flood depth first rises above a given threshold until the time falls below the same threshold for the last time at a given point in space. If a threshold is supplied, it should be specified by associating a coordinate variable or scalar coordinate variable with the data variable and giving the coordinate variable a standard name of flood_water_thickness. The values of the coordinate variable are the threshold values for the corresponding sub-arrays of the data variable. If no threshold is specified, its value is taken to be zero. Flood water is water that covers land which is normally not covered by water."
flood_water_thickness	m	"The flood_water_thickness is the vertical distance between the surface of the flood water and the surface of the solid ground, as measured at a given point in space. The standard name ground_level_altitude is used for a data variable giving the geometric height of the ground surface above the geoid. "Flood water" is water that covers land which is normally not covered by water."
time_of_maximum_ flood_depth	s	"The quantity with standard name time_of_maximum_flood_depth is the time elapsed between the breaking of a levee (origin of flood water simulation) and the instant when the flood depth reaches its maximum during the simulation for a given point in space. Flood water is water that

		covers land which is normally not covered by water.“
time_when_flood_water_ falls_below_threshold	s	“The quantity with standard name time_when_flood_water_falls_below_threshold is the time elapsed between the breaking of a levee (origin of flood water simulation) and the instant when the depth falls below a given threshold for the last time, having already risen to its maximum depth, at a given point in space. If a threshold is supplied, it should be specified by associating a coordinate variable or scalar coordinate variable with the data variable and giving the coordinate variable a standard name of flood_water_thickness. The values of the coordinate variable are the threshold values for the corresponding sub-arrays of the data variable. If no threshold is specified, its value is taken to be zero. Flood water is water that covers land which is normally not covered by water.”
time_when_flood_water_ rises_above_threshold	s	“The quantity with standard name time_when_flood_water_rises_above_threshold is the time elapsed between the breaking of a levee (origin of flood water simulation) and the instant when the depth first rises above a given threshold at a given point in space. If a threshold is supplied, it should be specified by associating a coordinate variable or scalar coordinate variable with the data variable and giving the coordinate variable a standard name of flood_water_thickness. The values of the coordinate variable are the threshold values for the corresponding sub-arrays of the data variable. If no threshold is specified, its value is taken to be zero. Flood water is water that covers land which is normally not covered by water”.

Variables related to Fire Characteristics

CF Standard name	Units	CF Description
fire_area	m2	““X_area" means the horizontal area occupied by X within the grid cell. The extent of an individual grid cell is defined by the horizontal coordinates and any associated coordinate bounds or by a string valued auxiliary coordinate variable with a standard name of "region". "Fire area" means the area of detected biomass fire.”
fire_radiative_power	W	“The product of the irradiance (the power per unit area) of a biomass fire and the corresponding fire area. A data variable containing the area affected by fire should be given the standard name fire_area.”
fire_temperature	K	“The overall temperature of a fire area due to contributions from smouldering and flaming biomass. A data variable containing the area affected by fire should be given the standard name fire_area.”

Variables related to Smokes Characteristics

CF Standard name	Units	CF Description
surface_upward_mass_ flux_of_carbon_dioxide_ expressed_as_carbon_due_ to_emission_from_fires	kg m^{-2} s^{-1}	"The surface called "surface" means the lower boundary of the atmosphere. "Upward" indicates a vector component which is positive when directed upward (negative downward). In accordance with common usage in geophysical disciplines, "flux" implies per unit area, called "flux density" in physics. The phrase "expressed_as" is used in the construction A_expressed_as_B, where B is a chemical constituent of A. It means that the quantity indicated by the standard name is calculated solely with respect to the B contained in A, neglecting all other chemical constituents of A. The chemical formula for carbon dioxide is CO2. The specification of a physical process by the phrase "due_to_" process means that the quantity named is a single term in a sum of terms which together compose the general quantity named by omitting the phrase. "Emission" means emission from a primary source located anywhere within the atmosphere, including at the lower boundary (i.e. the surface of the earth). "Emission" is a process entirely distinct from "re-emission" which is used in some standard names. The term "fires" means all biomass fires, whether naturally occurring or ignited by humans."
from_fires_excluding_ anthropogenic_land_ use_change **from_litter_in_fires** **from_natural_fires** **from_vegetation_in_fires**	kg m^{-2} s^{-1}	
surface_upward_mass_ flux_of_nitrogen_ compounds_expressed_ as_nitrogen_due_ to_emission_from_fires	kg m^{-2} s^{-1}	"The surface called "surface" means the lower boundary of the atmosphere. "Upward" indicates a vector component which is positive when directed upward (negative downward). In accordance with common usage in geophysical disciplines, "flux" implies per unit area, called "flux density" in physics. The phrase "expressed_as" is used in the construction A_expressed_as_B, where B is a

		chemical constituent of A. It means that the quantity indicated by the standard name is calculated solely with respect to the B contained in A, neglecting all other chemical constituents of A. "Nitrogen compounds" summarizes all chemical species containing nitrogen atoms. The list of individual species that are included in this quantity can vary between models. Where possible, the data variable should be accompanied by a complete description of the species represented, for example, by using a comment attribute. The specification of a physical process by the phrase "due_to_" process means that the quantity named is a single term in a sum of terms which together compose the general quantity named by omitting the phrase. "Emission" means emission from a primary source located anywhere within the atmosphere, including at the lower boundary (i.e. the surface of the earth). "Emission" is a process entirely distinct from "re-emission" which is used in some standard names. The term "fires" means all biomass fires, whether naturally occurring or ignited by humans."
tendency_of_ atmosphere_mass _content_of_alcohols_ due_to_emission_ from_forest_fires	kg m^{-2} s^{-1}	""tendency_of_X" means derivative of X with respect to time. "Content" indicates a quantity per unit area. The "atmosphere content" of a quantity refers to the vertical integral from the surface to the top of the atmosphere. For the content between specified levels in the atmosphere, standard names including "content_of_atmosphere_layer" are used. The mass is the total mass of the molecules. The specification of a physical process by the phrase "due_to_" process means that the quantity named is a single term in a sum of terms which together compose the general quantity named by omitting the phrase. "Emission" means emission from a primary source located anywhere within the atmosphere, including at the lower boundary (i.e. earth's surface). "Emission" is a process entirely distinct from "re-emission" which is used in some standard names. Alcohols include all organic compounds with an alcoholic (OH) group. In standard names "alcohols" is the term used to describe the group of chemical species that are represented within a given model. The list of individual species that are included in a quantity having a group chemical standard name can vary between models. Where possible, the data variable should be accompanied by a complete description of the species represented, for example, by using a comment

		attribute. The "forest fires" sector comprises the burning (natural and human-induced) of living or dead vegetation in forests. "Forest fires" is the term used in standard names to describe a collection of emission sources. A variable which has this value for the standard_name attribute should be accompanied by a comment attribute which lists the source categories and provides a reference to the categorization scheme, for example, "IPCC (Intergovernmental Panel on Climate Change) source category 5 as defined in the 2006 IPCC guidelines for national greenhouse gas inventories". “
Similar variables as upper in cells and includes: **1.** **alcohols_due_to_** **emission_savanna_** **and_grassland_fires** **2.** **2.1 ammonia** **2.2 benzene** **2.3 butane** **2.4 carbon-monoxide** **2.5 chlorinated hydrocarbons** **2.6 dimethyl sulphide** **2.7 elemental (or black) carbon dry aerosol** **2.8 ethane** **2.9 ethene** **2.10 ethers** **2.11 ethyne** **2.12 formaldehyde** **2.13 isoprene** **2.14 ketones** **2.15 methane** **2.16 molecular hydrogene** **2.17 nitrogene dioxide**	kg m^{-2} s^{-1}	

2.18 nitrogene monoxide **2.19 NMVOC** **2.20 NOx** **2.21 organic acids** **2.22 particulate organic matter dry aerosol** **2.23 pentane** **2.24 propane** **2.25 propene** **2.26 sulfur dioxide** **2.27 terpenes** **2.28 toluene** **2.29 xylene** **from (A) forest and from (B) savanna&grassland fires.**		

4.4 Impact Classification Specifications

4.4.1 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

4.4.2 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	< 2%	2 - 5%	5 - 15%	15 - 40%	> 40%

	(node / link)					
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%

4.5 EU-CIRCLE Resilience Data Specifications

In this section we summarize the data structures of the data required for the development of the Resilience Assessment Tool. The methodology is based on resilience indicators that are classified in five categories: Anticipation, Absorption, Coping, Restoration and Adaptation. Additionally, to execute the resilience analysis the input from end-user questionnaire and EU-Circle analysis tools is required as well.

For the implementation of the Resilience Data Specifications model and the developing of the RAT tool (as a web tool or other software tool) additional system fields such as object type, timestamps (insert, update), system id, user, etc. will be stored as well.

The first part of collected data for the calculation of CI resilience is the end user questionnaire. In this paragraph, we aim to define the structure of the questionnaire and give the user a guideline to prepare the questionnaire. The table below summarizes the required fields for each one of the questions.

4.5.1 End User Questionnaire

Questions

Field Name	Field Description	Field Type	Acceptable Values
questionID	The question ID. This id is unique for each question within a questionnaire.	Integer	Auto Increment number
parent	If the question is a sub-question the parent question ID should be given.	Integer	
category	Resilience category	enum	Anticipation, ….
question	The description of the question.		Free text
answerType	To describe the type of answer	enum	i.e. multiple choice, multiple answers, free text, numeric…)
choices (id, des)	A tuple that contains the id and the description of a possible answer (multiple choice type)	(integer, text)	
answer	Depending on the field type, the answer can be vary.	answerType	value of the answer
units	In case of metrics, this field will	text	

	described the units where the answer should be given		
excluded	This field indicates the exclusion of the question during the calculation of the resilience indicator	Boolean	True/False

JSON Example: Questionnaire


```
[
  {
    "id" : 1,
    "parent" : null,
    "category" : "ANTICIPATION",
    "question" : "Select the all hazards that for the time being included in your resilience plans",
    "answerType" : "Multiple",
    "choices" : [{
      "id" : 1,
      "decription" : "Heat waves",
      "type" : "boolean"
    },
    {
      "id" : 1,
      "decription" : "Heat waves",
      "type" : "boolean"
    }],
    "units" : null,
    "excluded" : false
  },
  {
    "id" : 2,
    "parent" : null,
    "category" : "ANTICIPATION",
    "question" : "Equipment and procedures for hazard mitigation exist",
    "answerType" : "Boolean",
    "units" : null,
    "excluded" : false
  },
  {
    "id" : 3,
    "parent" : 2,
    "category" : "ANTICIPATION",
    "question" : "How many climate related hazards (defined in scenario) it covers",
    "answerType" : "Integer",
    "units" : "Number",
    "excluded" : false
  }
]
```


Response

Field Name	Field Description	Field Type	Acceptable Values
questionID	The question ID that answer is for	Integer	
answer	The value of answer, in case of multiple answers, this field will be an array with the tuple of answer (id, answer)	answerType (or array)	

(choiceID , answer)	For multiple answer questions	tuple	

While the table in section 4.1.1 gives a guideline for the development of end-user questionnaire, the table in this paragraph gives the required fields to collect the response of a questionnaire.

JSON Example: Questionnaire Response

```
[
  {
    "questionID" : 1,
    "answers" : [{
      "choiceID" : 1,
      "answer" : true
    },
    {
      "choiceID" : 2,
      "answer" : false
    }]
  },
  {
    "questionID" : 2,
    "answer" : true
  },
  {
    "id" : 3,
    "answer" : 3
  }
]
```

4.5.2 EU-CIRCLE Analysis Tool Input

The second part of required input for the analysis is about the results of the EU-CIRCLE analysis tools (i.e CIRP). In order to achieve the integration with the RAT (i.e output of CIRP as input to RAT) we define the structure below.

Field Name	Field Description	Field Type	Acceptable Values
fieldID	The id of the field	integer	Auto increment number
source	Indicate whether the analysis is done using CIRP or other tool	String	Enum with available and acceptable sources
category	Resilience category if available	enum	Anticipation, ….
description	Description of the field	test	
valueType	The value as a result of the analysis tool		
unit	The units of the value		

The definition of a data instance is presented in the table below.

Field Name	Field Description	Field Type	Acceptable Values
fieldID	The id of the field	integer	
value	The value as result of the EU-CIRCLE	valueType	

	analysis tools	(from table above)	

JSON Example: CIRP Input Definition


```
[
  {
    "id" : 1,
    "source" : "CIRP",
    "category" : null,
    "description" : "Number of climate related hazards impacting area of CI (according to scenario)",
    "valueType" : "Integer",
    "unit" : "Number"
  },
  {
    "id" : 2,
    "source" : "CIRP",
    "category" : null,
    "description" : "Time that asset is not able to serve its intended function",
    "valueType" : "Integer",
    "unit" : "Hours"
  },
  {
    "id" : 3,
    "source" : "CIRP",
    "category" : null,
    "description" : "Cost of asset damage",
    "valueType" : "Decimal",
    "unit" : "EUR"
  },
  {
    "id" : 4,
    "source" : "CIRP",
    "category" : null,
    "description" : "Loss of performance for certain hazards level",
    "valueType" : "Integer",
    "unit" : "Percentage"
  }
]
```


JSON Example: CIRP Input Values

```
[
  {
    "fieldID" : 1,
    "value" : 4
  },
  {
    "fieldID" : 2,
    "value" : 20
  },
  {
    "fieldID" : 3,
    "value" : 10000
  },
  {
    "fieldID" : 4,
    "value" : 80
  }
]
```


4.5.3 Resilience Indicators

The core functionality of the RAT tool is the calculation of several resilience indicators (based on user's input, either from Questionnaire or EU-CIRCLE analysis tools).

As already mentioned, the structure of the RAT tool is based on five resilience categories: Anticipation, Absorption, Coping, Restoration and Adaptation. For each category, a resilience indicator will be calculated and the final resilience indicator will be a function of these categories. The following tables present the approach to define and develop the methodology for the calculation of such indices.

Resilience Index (i.e. Anticipatory Index)

Field Name	Field Description	Field Type	Acceptable Values
id	"Resilience Indicators": This field will contain the description of the resilience indicator	String	
class	The classification of the resilience indicator	enum	Anticipation, …
description	The description of the indicator	Text	
indicator	This field contains an object that describes the categories and subcategories among with the calculation of sub-indices.	Resilience Category	
weighType	Describe the methodology that is followed to set the weights between the sub-indices for the calculation of resilience index	String	Among available methods, i.e. UNIFORM, CUSTOM, etc..

Resilience Indicators

Field Name	Field Description	Field Type	Acceptable Values

id	The id of the field	integer	Auto increment number
description	A text description of the resilience indicator	Text	Free text
index	The calculated resilience index	Decimal	Range 0 to 10
weight	Based on the definition of the weight type a value will be assigned. User will give the rank if required	Integer	Values from 1 to the number of indicators in the same object
real	The real value of the index based on the weight	Decimal	Range 0 to 10
subindicators	List of all sub-indicators that used for this resilience indicator	Array	

Resilience Sub-Indicators / Categories

Field Name	Field Description	Field Type	Acceptable Values
id	The id of the field	integer	Auto increment number
description	A text description of the sub-indicator	Text	Free Text
source	Indicates the source of the field (i.e. end-user questionnaire, analysis tool)	Integer	Reference to input data
subcategories	This array field contains a list of objects [id, description, value] of all the sub-categories (with indicators) that constitute this indicator. The value of the sub-indicator will be the average among the values within this list.	Array [] (id, description, source, value)	id: the unique id of subcategory description: the description of the indicator in sub-category source: indicates the id of the input (questionnaire or analysis) that the value is calculated value: the index value
value	The value as a result of the analysis tool	Decimal	If subcategories: Value is the averaged of all sub-values Otherwise: Value is calculated based on the input
weight	A field that indicates the weight of the current sub-indicator	Integer	Rank value
real	The real value of index after the usage of weight	Decimal	Index

The following example presents part of the Anticipatory Index and how is calculated for the EU-CIRCLE project. Similar with this, the RAT (D4.5) presents all the considered index that are used for the calculation of the CI Resilience Indicator.

The Overall Resilience Index is a function of the five used indicators (Anticipatory index, Absorptive index, Coping Index, Restorative Index and Adaptive Index). Based on the weights and the real indicator as included in the structure of each indicator the overall resilience index is calculated.

JSON Example:


```
{
  "id": 1,
  "class": "ANTICIPATION",
  "description": "Anticipatory Index",
  "index": 5.9,
  "indicator": [
    {
      "id": 10,
      "description": "Awarenes of potential hazards",
      "index": 6,
      "weight": 5,
      "real": 0.42,
      "subindicators": [
        {
          "id": 11,
          "source": "ENDUSER",
          "description": "Users awareness of the number of hazards that may threaten an asset",
          "index": 6,
          "weight": 1,
          "real": 6
        }
      ]
    },
    {
      "id": 20,
      "description": "Quality/extent of mitigating features",
      "index": 4.81,
      "weight": 4,
      "real": 0.63,
      "subindicators": [
        {
          "id": 11,
          "description": "Equipment and procedures for hazard mitigation exist",
          "source": "ENDUSER",
          "index": 6,
          "weight": 1,
          "real": 6,
          "subcategories": [
            {
              "id": 22,
              "description": "Procedures are documented",
              "index": 7
            },
            {
              "id": 23,
              "description": "Procedures are regulary revised",
              "index": 5
            }
          ]
        }
      ]
    }
  ],
  "weighType": "RANK"
}
```

Resilience Levels

The following table presents the different levels that are used for the development of the Resilience Assessment Tool. The final result is the Overall Resilience Index which is a function of the 2nd, 3rd, and 4th level.

Level	Description	Abbreviation
1	Overall resilience index	ORI
2	Capacity Index	
-	Anticipatory capacity resilience index	C-ant
-	Absorptive capacity resilience index	C-abs
-	Coping capacity resilience index	C-cop
-	Restorative capacity resilience index	C-rest
-	Adaptive capacity resilience index	C-adapt
3	Resilience index	R
4	Resilience sub-index	I

Weights Table

The last part of Resilience Data specification is the weights table. As we mentioned in the tables above, the weights are used for the calculation of the several indices at each one of the levels of the Resilience Assessment Tool. The table below, presents the weights that are used in the RANK method.

Rank	Number of Items									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1.00	0.67	0.50	0.40	0.33	0.29	0.25	0.22	0.20	0.18
2		0.33	0.33	0.30	0.27	0.24	0.21	0.19	0.18	0.16
3			0.17	0.20	0.20	0.19	0.18	0.17	0.16	0.15
4				0.10	0.13	0.14	0.14	0.14	0.13	0.13
5					0.07	0.10	0.11	0.11	0.11	0.11
6						0.05	0.07	0.08	0.09	0.09
7							0.04	0.06	0.07	0.07
8								0.03	0.04	0.05
9									0.02	0.04
10										0.02
SUM	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**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 document summarize and presents the guidelines to prepare the metadata for EU-CIRCLE Datasets as a result of WP3, WP4 and WP5. The purpose of D8.11 is to prepare a standard approach to create a metadata file for all the datasets in a harmonised way.

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 dataset types that are considered in this work (Climate Hazards, Representation of Critical Infrastructures, Damage Functions and EU-CIRCLE analysis output, Resilience) is based on a general template (baseline metadata) enhanced with specific fields for each type of data.

Finally, the second part of this report presents the EU-CIRCLE data specifications data result of the work in WP2, WP3 and WP4. More specifically, this data is about CI assets and Network representation, Climate Hazard, Damage Functions, EU-CIRCLE Analysis, impact assessment and CI Resilience covering both end-user's questionnaire and resilience indicators.

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