3D Geomodelling for Europe

Project number: GeoE.171.005

Deliverable 7.2

Data exchange report

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Version: 22-10-2021

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

Deliverable Data		
Deliverable number	D7.2	
Dissemination level	Public	
Deliverable name	Data exchange report	
Work package	WP7, Information Platform Interface	
WP Lead/Deliverable beneficiary	Lars Schimpf / LAGB	
Deliverable status		
Submitted (Author(s))	22/10/2021	Lars Schimpf, Alexander Malz
Verified (WP leader)	22/10/2021	Lars Schimpf [LAGB]
Approved (Project leader)	22/10/2021	Stefan Knopf [BGR]

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1 INTRODUCTION

1.1 Document Background and Scope

This document presents the 3DGEO-EU-Workpackage 7 ”Data exchange report” report. It provides an overview of the project geodata, which was transfered and published by the GeoERA-Information Platform (GIP) project. With respect to the particular and various data sets comprising 3D geomodels, new compilations and derived data sheets as well as project reports, guidelines and manuals, the report focuses on a clarification of associated data and requirements to efficiently ensure the maintenance, dissemination and sustainablity of the project results. This report represents the status in Oktober 2021 after the third project year.

1.2 Abbreviations

3DGEO-EU	Project ”3D geomodelling for Europe”
EGDI	European Geological Data Infrastructure
GIP	Project ”Geo-Information Platform”
WP	Workpackage

2 AMBITIONS AND EXPECTED IMPACTS

2.1 Ambitions

The main ambition of 3DGEO-EU is the harmonization of geological data across geological, topographical, but especially across national borders to allow reliable assessments of resource potentials and possible use conflicts on a pan-European scale. Due to a variety of thematic challenges associated with geological and geophysical parameters and characteristics (e.g. stratigraphy, geophysical models, structural interpretation) specific workflows for harmonization of geological information across borders need to be establishe and proofed. In the 3DGEO-EU project such methods were developed, described and prooved to ensure the availability of validated workflows for the geoscientific community in Europe. This work was done in three workpackages (WPs), which focus on the integration of geophysical potential field data, cross-border harmonization of fault data and the estimation and visualisation of uncertainties. Developed and established workflows were further applied in three WPs focusing on cross-border pilot areas. The methodologic advantages and the gain in experience on cross-border 3D harmonization work will be a keystone for further transnational harmonization efforts.

2.2 Expected impacts

The aim of 3DGEO-EU is to establish methods and workflows for cross-border harmonization of 3D geomodels and geodata, which will become applicable to other regions in Europe. The expected impacts are:

- The development of methods for semantic and geometric harmonization of geodata and geomodels.
- The establishment of advanced mapping and 3D geomodeling strategies for regional to pan-European data and model harmonization, improvement of consistency and model integration.
- The development of improved visualization methods for uncertainties and optimized reconstruction and restoration workflows to reduce uncertainty of geomodels.
- The establishment of consistent data and geomodels in cross-border regions, which can become the nucleus for further transnational harmonization projects.
- The harmonization of stratigraphic and structural modeling workflows to enhance the comparability of results in a pan-European scale.

2.3 Workpackage objectives

The main objective of the work package Information Platform Interface was to govern the interactions with the GeoERA-IP project and to manage all kinds of communication and data exchange between the 3DGEO-EU project and other GeoERA projects, especially the IP. Therefore, WP7 developed and evaluated all requirements of 3DGEO-EU WPs in dense accordance with the parts of the Project Data Management Plan relating to IP and EDGI to enable an efficient and consistent uptake and embedding of project results into the GeoERA-IP project. This also includes uploading 2D and 3D data to EGDI as well as editing the corresponding metadata (MicKA).

3 PROJECT DATA OVERVIEW

The 3DGEO-EU project is subdivided into eigth WPs (Figure 1) with various deliverables comprising manuals, reports, harmonized data as well as 3D geomodels, which were produced during the project. Three WPs (WP1, WP2 and WP3) produced mainly geodata and geomodels in the pilot areas while WP4, WP5 and WP6 focused on method development and example data. Two WPs (WP7 and WP8) took care of the dissemination of results and the project management. The following chapters will give a detailed overview of the WPs and the associated data.

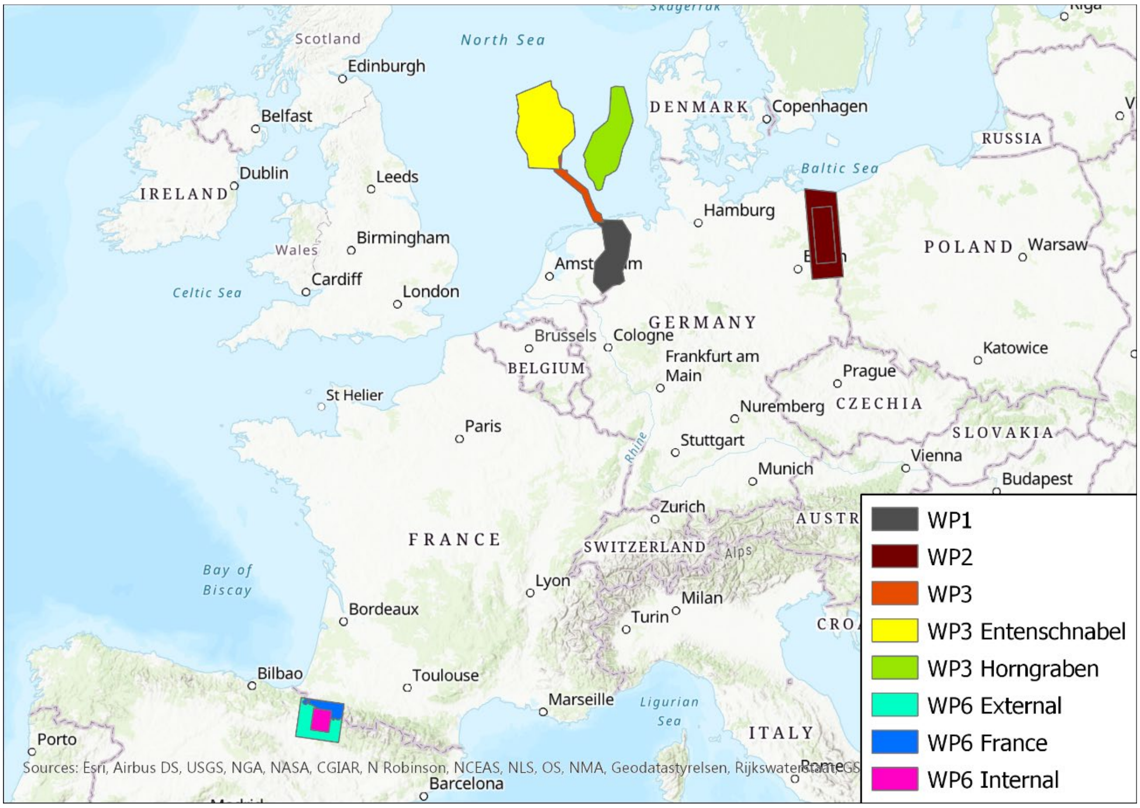

Figure 1: Location of the different work areas of the work packages.

3.1 Cross-border pilot areas

3.1.1 WP1: Harmonization of Cenozoic and Mesozoic layers in the northern onshore Dutch-German cross-border region for assessment of underground usage

This pilot area work package developed a cross-border 3D geomodel consisting of 10 stratigraphic horizons (top Neogene-base Triassic), the NLS3D model. Another aim was to identify, describe and attribute potential geothermal units (depth, thickness and its properties) in Cenozoic strata and to produce a decision support map of the Rupel-Formation in the northern onshore, cross-border region of the Netherlands and Germany (Lower Saxony). This work package produced harmonized data and geological structures of the subsurface in an area that is intensively used for both energy and groundwater purposes. The data-exchange-relevant deliverables of this workpackage are listet in Table 1.

Table 1: Deliverables of WP1 containing digital data (no reports)

Deliverable number	Deliverable name	Deliverable data (in month)	Type of deliverable	Data formats
D1.2	NLS3D: A harmonized 3D model of 10 main Cenozoic and Mesozoic horizons with a supporting report	M24	3D model	ESRI ASCII grid
D1.3	Harmonized distribution, depth and thickness maps of Cenozoic layers	M33	Digital data	ESRI ASCII grid
D1.4	Harmonized map of hydraulic barrier between fresh groundwater and the deep salt groundwater system as a decision support tool for planners	M33	Digital data	ESRI ASCII grid

3.1.2 WP2: Cross-border harmonization of selected horizons and structures in the Polish-German border region

The aim of WP2 was the development of harmonized geological 3D models (see Table 2) for selected horizons and structures in the Polish-German cross-border region (horizons and structures in the Mesozoic and Permian strata; for energy storage, geothermal use, partially potential hydrocarbon reservoirs). The work focused on two pilot areas of the Polish - North German Basin System covering a broad area of the Polish-German border:

1) the Gorzów-block and
2) the near border part of Szczecin Trough and its extension to the German side.

The target was to harmonize and update existing data inventories and interpretations in Poland and Germany, to establish harmonized (stratigraphical, seismostratigraphical, structural, geometrical) geological 3D models at the Polish and German border region using existing data inventories and (in close connection to WP6) employing potential field methods (gravimetry, magnetics) in addition to seismic investigations in less explored areas (cooperation with IGME and 3DGEO-EU-WP6).

Table 2: Deliverables of WP2 containing digital data (no reports)

Deliverable number	Deliverable name	Deliverable data (in month)	Type of deliverable	Data formats
D2.3a	Improved and harmonized geological 3D model at the Polish-German border region for the pilot area 1	M18	3D model	Gocad TSurf
D2.3b	Improved and harmonized geological 3D model at the Polish-German border region for the pilot area 2	M39	3D model	Gocad TSurf

3.1.3 WP3: North Sea area Netherlands-Germany-Denmark

In this area the existing national (and regional) subsurface geomodels were integrated by harmonizing the stratigraphic boundaries, interpreted lithostratigraphic horizons based on seismics, structural concepts and the velocity parameters of the layers. To find and to exemplarily test efficient workflows for harmonization or the consistent translation between the established national concepts was a main task of this work package. Workpacke 3 developed 3 3D models which are listed in Table 3.

Table 3: Deliverables of WP3 containing digital data (no reports)

Deliverable number	Deliverable name	Deliverable data (in month)	Type of deliverable	Data formats
D3.2	A generalized 3D depth model of (a part of) the Entenschnabel region	M10	3D model	ESRI ASCII grid
D3.6	Summary of the harmonization work on time model.	M35	3D model	ESRI ASCII grid
D3.8	Harmonized depth models and structural framework of the NL-GER-DK North Sea	M39	3D model	ESRI ASCII grid

3.2 Method development

3.2.1 WP4 Method development – Uncertainty in geomodels

3D geological models are often created from ambiguous and uncertain data which are subject to error propagation during measurement and interpretation. Further they are often scarce and heterogeneous, so that the modeler depends on model-based interpretation, e.g. by assuming a certain tectonic regime or deformation style. Apart from the small scale reservoir models of the resource industries, these uncertainties are often neither evaluated nor shown to the users and stakeholders. Within this work package different sources of uncertainty were compiled, a classification of the different types of uncertainty was formulated and test data sets for the different types of uncertainty were provided. Subsequently these test data sets (Table 4) were used to test the state of the art visualization methods from computer graphics and may act as a basis for developing new methods. However the data transfer, testing processes etc. were carried out by the workpackage itself with only little support of WP7.

Table 4: Deliverables of WP4 containing digital data (no reports)

Deliverable number	Deliverable name	Deliverable data (in month)	Type of deliverable	Data formats
D4.4	Publicly available data sets/geomodels from the pilot areas (including documentation	M39	Parameterized 3D models	Gocad TSurf

3.2.2 WP5 Method development – Faults

This work package is closely connected to the GeoERA project HIKE and focussed on consistent cross-border fault mapping- and characterization in all pilot areas of this project. For all harmonization areas, described in the workpackages 1, 2, and 3, one main task was to meet the requirements and specifications put forward by the Fault Database development under project HIKE. An important aspect of the project was to define common standards and methodologies to convert data between different fault formats and vintages, and to define a common way to model and characterize faults by building on best experiences. Through joint meetings with the experts of the HIKE project, these activities were synchronized. Initially a deliverable "3D fault objects with metadata and attributes" was planned as a result for the HIKE project. However, HIKE did not require any 3D fault data and the deliverable was discarded.

3.2.3 WP6 Method development – Optimizing reconstructions of the subsurface to reduce structural uncertainty in 3D models

Achieving reliable and harmonized reconstructions across Europe needs sharing, discussing and finding agreements among the existent workflows used by the different geological surveys in order to:

1) overcome methodological problems (lack of seismic data, structural consistency, etc.),
2) tackle cross-border harmonization (as an affordable and reliable way) and
3) face future challenges (agreement on best practices).

Besides of common methods (integration of geological mapping, structural and stratigraphic data, seismic sections, wells, etc.) this transversal WP payed special attention to the integration of potential field geophysical data (GravMag), structural balanced sections and the application of restoration techniques as validation tools. This WP has tight connections with WP2, WP4 and WP5. The data-exchange-relevant deliverables of this workpackage are listet in Table 5.

Table 5: Deliverables of WP6 containing digital data (no reports)

Deliverable number	Deliverable name	Deliverable data (in month)	Type of deliverable	Data formats
D6.2	3D model of the South western Pyrenees; digital files	M40	Digital data	GeoTIFF/GRD/ ESRI ASCII/ESRI shapefile files

3.3 Project management and result dissemination

3.3.1 WP7 Information Platform Interface

The main objective of the work package Information Platform Interface was to govern the interactions with the GeoERA-IP project and to manage all kinds of communication and data exchange between the 3DGEO-EU project and other GeoERA projects, especially IP. Therefore WP7 developed and evaluated all requirements of the 3DGEO-EU WPs in dense accordance with the parts of the Project Data Management Plan relating to IP and EDGI to enable an efficient and consistent uptake and embedding of project results into the GeoERA-IP project. This also includes uploading 2D and 3D data to EGDI as well as editing the correpsonding metadata (MicKA). This workpackage did not create any 2D or 3D-data.

3.3.2 WP8 Project Management and Coordination

This work package governed the overall coordination and management of the project, especially the preparation and implementation of the work plan, monitoring of project progress and the coordination of obligatory meetings and deliverables as defined by the GeoERA guidelines. The work included to ensure communication among work packages, between partners and with the EC, as well as conflict and risk management and the interaction with the GeoERA Executive Board. This workpackage did not create any 2D or 3D-data.

4 REQUIREMENTS FOR TECHNICAL IMPLEMENTATION OF RESULTS

The requirements for the technical implementation substantially comprise three main topics, which evolved from the different needs of the two different partners (GIP & 3DGEO-EU):

- spatial reference,
- data exchange formats,
- EGDI functionalities

However these topics will represent questions and needs which result on the current status of the project work.

4.1 Spatial Reference

Since GeoERA is a pan-European project dealing with transnational projects the necessity of using proper spatial reference systems becomes evident. Following the technical guidlines prescribed by *INSPIRE Thematic Working Group Coordinate Reference Systems & Geographical Grid Systems (2014)* two spatial reference systems would be suitable for this purpose: On the one hand Lambert Conformal Conic (ETRS89-LCC) for conformal mapping at scales smaller or equal to 1:500,000 (EPSG 3034) and on the other hand Lambert Azimuthal Equal Area (ETRS89-LAEA) for spatial analysis and displaying information (EPSG 3035). Using this reference system within the 3DGEO-EU project was heavily discussed and criticized as it turns out that ETRS89-LAEA is more suitable because true area projection is required: WP1 analyzed the result of the projection of a 3D-model from ETRS89-LAEA into ETRS89-LCC in an early project stage. The distortion of the resulting data led to the decision that it is not recommendable to use ETRS89-LCC.

4.2 Data Exchange Formats

As mentioned above the 3DGEO-EU-project produces harmonized cross-border three- as well as two-dimensional data, which will mainly consist of derived information based on existing primary data (e.g. well data) and national or regional 3D models. This led to the necessity of finding appropriate data exchange formats for 2D, 2.5D and 3D data. The criteria for these formats highly depend on the data type itself. Besides the georeferenced data a few different formats will be used: Excel or CSV for all kind of properties and PDF for reports.

4.2.1 2D- and 2.5-D Data

Inside the huge amount of possible 2D-data a distinction should be made between raster and vector data:

4.2.1.1 Raster Data

Two and 2.5-dimensional raster data was exchanged in three data formats: ESRI ASCII grid, CPS-3 and GeoTiff depending if the data should be visualized as 3D model or in a 2D map (GeoTiff).

4.2.1.2 Vector Data

Since the project members usually used one of the most common GIS (e.g. ArcGIS, QGIS) the exchange format of vector data is limited to constraints given by the mentioned software. As a result of technical limitations and outdated data formats the exchange format for all kind of vector data was the OGC GeoPackage v1.2.1.

4.2.2 3D-Data

Most of the three-dimensional data (3D-models) will be developed with the SKUA- Gocad Software Suite which generates the Gocad ASCII format (*.ts) by default. But there was also 2.5D data which was exchanged in raster formats. In most cases the data conversation and preparation were done by this workpackage. There was also an intensive data testing phase at the end of the project runtime which revealed a few problems within the data import capabilities of the EGDI-platform

4.2.2.1 EGDI Functionalities

A very interesting part of the work done was the discussion about the different EGDI functionalities. These included searching, data access and different visualization methods for 2D, 2.5D as well as 3D. However most of these functionalities were also desired by other projects but in the following the special 3DGEO-EU relevant ones are discussed.

4.2.2.2 Uncertain data

Uncertainties are a well-known problem in modelling geological data due to the fact that different input data with an often widely varying spatial distribution is used within the modeling process. These uncertainties can be determined and then be used to parametrize the 3D model (e.g. scalar field).

4.2.2.3 Glyphs

Glyphs or some kind of 3D primitives (e.g. cubes, spheres) may be useful to visualize different parameters. As they are real 3D objects their vertices can be multiplied by matrix defined by the individual parameter: A tensor of second order (3x3 matrix) for each vertex can be used to transform a sphere into an ellipse in order to indicate a strain- stress- or permeability-tensor or to indicate the anisotropic uncertainty of a vertex position. This functionality could not be realized by the EGDI project.

4.2.2.4 Option to display objects

These additional (textured) objects are similar to the glyphs mentioned above. However these objects don't need to be matrix manipulated during runtime (e.g. by a shader) depending on model parameters. The idea behind it is to represent buildings or drilling rigs for orientation purposes. This functionality could not be realized by the EGDI project.

5 METADATA, DATA UPLOAD AND TEST-DATA

Creating and managing metadata is a very important task to describe and to publish any type of spatial data and models. So it was mandatory to create a metadataset inside the EGDI metadata catalogue for every dataset which should be uploaded into EGDI. This was done using the EGDI metadata system (MicKA, see Figure 2). Workpackage 7 developed and provided a document where the different workpackages could fill out the corresponding metadata. Later on, this file was used to import the metadata into MicKA.

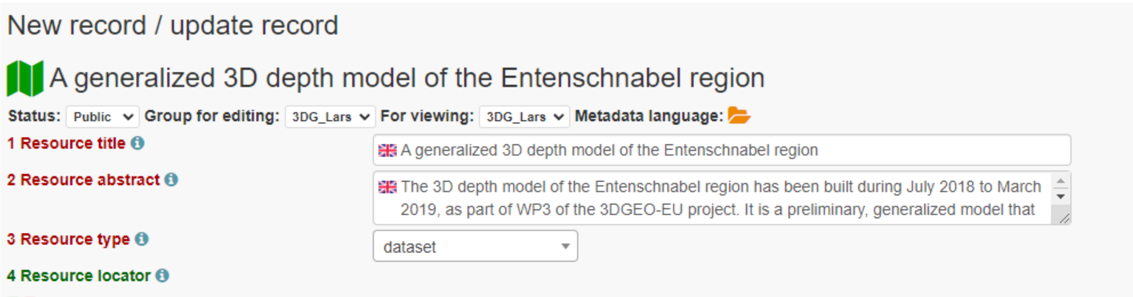

Figure 2: Webfrontend of the EGDI metadata system

Uploading data to the EGDI plattform differed depending on the data dimensions itself. The two dimensional data which should be visualized using standard map functionalities was uploaded by WP7 using the EGDI administration module (Figure 2). The data given to WP7 by the other workpackages was manipulated before it was uploaded to EGDI. This includes the following tasks:

- Projection into the spatial reference system 3034
- Creation of legend images
- Convertion into OGC GeoPackage or GeoTiff

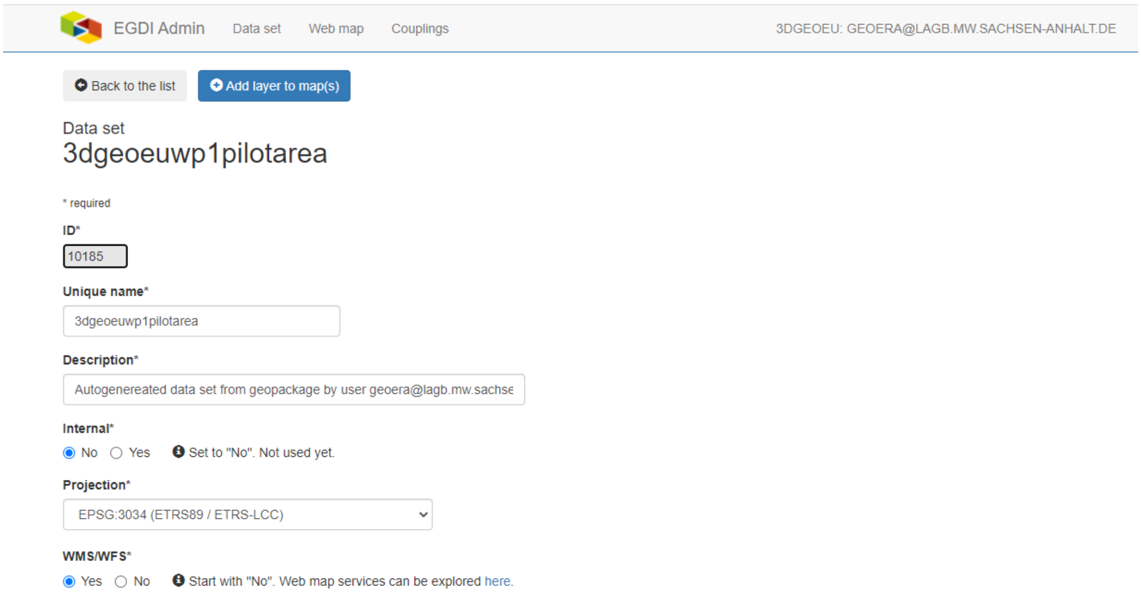

Figure 3: EGDI administration module with some test data

A very welcome feature was the test environment provided by the EGDI project. Here it was possible to upload 2D data, edit the different information and examine the data in a test environment as an exact copy of the EGDI web viewer before uploading it to the productive environment.
Uploading threedimensional data was a little bit more complicated. The process required to send the data together with some additional information like colouring, descriptions, layer names etc. to a member of the EGDI development team and then to wait till the import was finished. The EGDI development team here also provided a test environment with some basic 3D-viewer functionalities to examine and check the model before uploading it into the productive environment.

6 RESULTS AND CONCLUSIONS

Although 3DGEO-EU and its different work packages are very ambitious and highly sophisticated projects, most of the produced data follows the state of the art in 2D and 3D geological data processing. The outcome of this is the used data formats and the special needs of the WPs. Communicating these needs and discussing them with the GIP was often not that easy. Sometimes it took very long to get an answer to a certain question. After launching the GitHub issue tracker, the response time decreased significantly and the communication got better.
During the testing and uploading processes to EGDI a few problems arose which need to be solved by the individual developer team: The EGDI import tools need some extension and bugfixing. It turns out that some necessary information described in the header of a ts- and zmap-file will not be read and processed during the import of these files. This includes the coordinate reference system as well as the direction of the z-axis (Figure 4). Ignoring the direction of the z-axis results in an upside-down model and is not acceptable.

```
GOCAD_ORIGINAL_COORDINATE_SYSTEM
NAME "gocad Local"
PROJECTION Unknown
DATUM Unknown
AXIS_NAME X Y Z
AXIS_UNIT m m m
ZPOSITIVE Depth
END_ORIGINAL_COORDINATE_SYSTEM
GEOLOGICAL_FEATURE 3D-MV_Z1
```

Figure 4: Screenshot of a ts-file with information about the direction of the z-axis. In this case the z-axis points downwards.

Another problem is the interface between EGDI and the new 3D-viewer. The 3D viewer is not able to visualize the 3D-data (ESRI ASCII filed) uploaded into EGDI.
In contrast to the active development and discussion of the visualization and the data exchange, the metadata system (MicKA) was developed to such an extent that the creation and editing was very easy. Only the documentation and explanation of some of the metadatafields is sometimes confusing and needs some user-friendly revision.

7 REFERENCES

INSPIRE Thematic Working Group Coordinate Reference Systems & Geographical Grid Systems (2014): D2.8.I.1 Data Specification on Coordinate Reference Systems – Technical Guidelines, 30 p.