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# A survey on state of the art of 3D Geographical Information Systems

Volker Walter

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**EuroSDR Final Project Report**

# A survey on state of the art of 3D Geographical Information Systems

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# A survey on state of the art of 3D Geographical Information Systems

## 1 Introduction

In recent years, substantial technological progress in managing 3D geospatial data could be observed. New technologies for the collection of 3D data (in particular airborne and terrestrial laser scanning) as well as an increasing performance of Central Processing Units (CPUs) and Graphics Processing Units (GPUs) allow for 3D data collection and handling on standard PCs. However, the managing and processing of 3D geospatial data is much more complex compared to the managing and processing of 2D geospatial data and the question is if existing 3D Geographical Information Systems are capable to handle the requirements of the users.

In order to investigate this situation in more detail, we conducted a survey to identify the state of the art of 3D Geographical Information System, the future requirements as well as existing problems. We are very pleased that 32 institutions all over Europe participated in this survey. This report summarizes the outcome of this survey. In the next chapter the participants are categorized into different groups. Then, the results of the questionnaire are discussed in detail. Finally, the main results are summarized and future work is discussed. The institutions which participated in the study are listed in Appendix A and the original questionnaire is attached as Appendix B.

## 2 Participants

Our main target group of this survey were National Mapping and Cadastral Agencies (NMCAs). However, we decided to open the survey also to other public and private institutions in order to get a full overview of the situation. A total of 32 institutions participated in the survey. Most of them (25) are public institutions (see Table 1). The public institutions can be further subdivided into:

- National Mapping and Cadastral Agencies (10)
- Regional Mapping and Cadastral Agencies (8)
- City Surveying Offices (7)

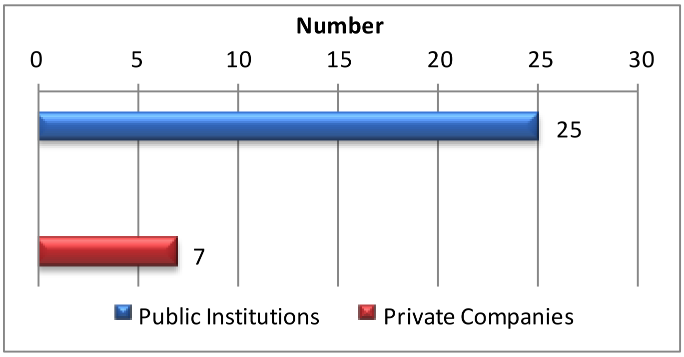


**Table 1:** Type of participating institutions

The answers from the public institutions and private companies were very similar and as such, the majority of answers are evaluated jointly. Only questions, where the answers were significantly different, were separately evaluated. This is the case for:

- The working areas of the institutions (Table 2)
- The number of employees (Table 3)
- The level-of detail of the data which is typically used (Table 14)
- The kind of data management (Table 15)

Table 2 shows the working areas of public institutions and private companies. The three top main working areas of public institutions are *Surveying* (88.0%), *Data Collection* (88.0%) and *Data Processing* (88.0%), whereas the three top main working areas of private companies are *Software Development* (85.7%), *GIS Products* (71.4%) and *GIS Services* (57.1%) or *Internet Solutions* (57.1%). This shows that the main tasks of public institutions are more focused on data acquisition, whereas the main tasks of private companies are more focused on data processing.

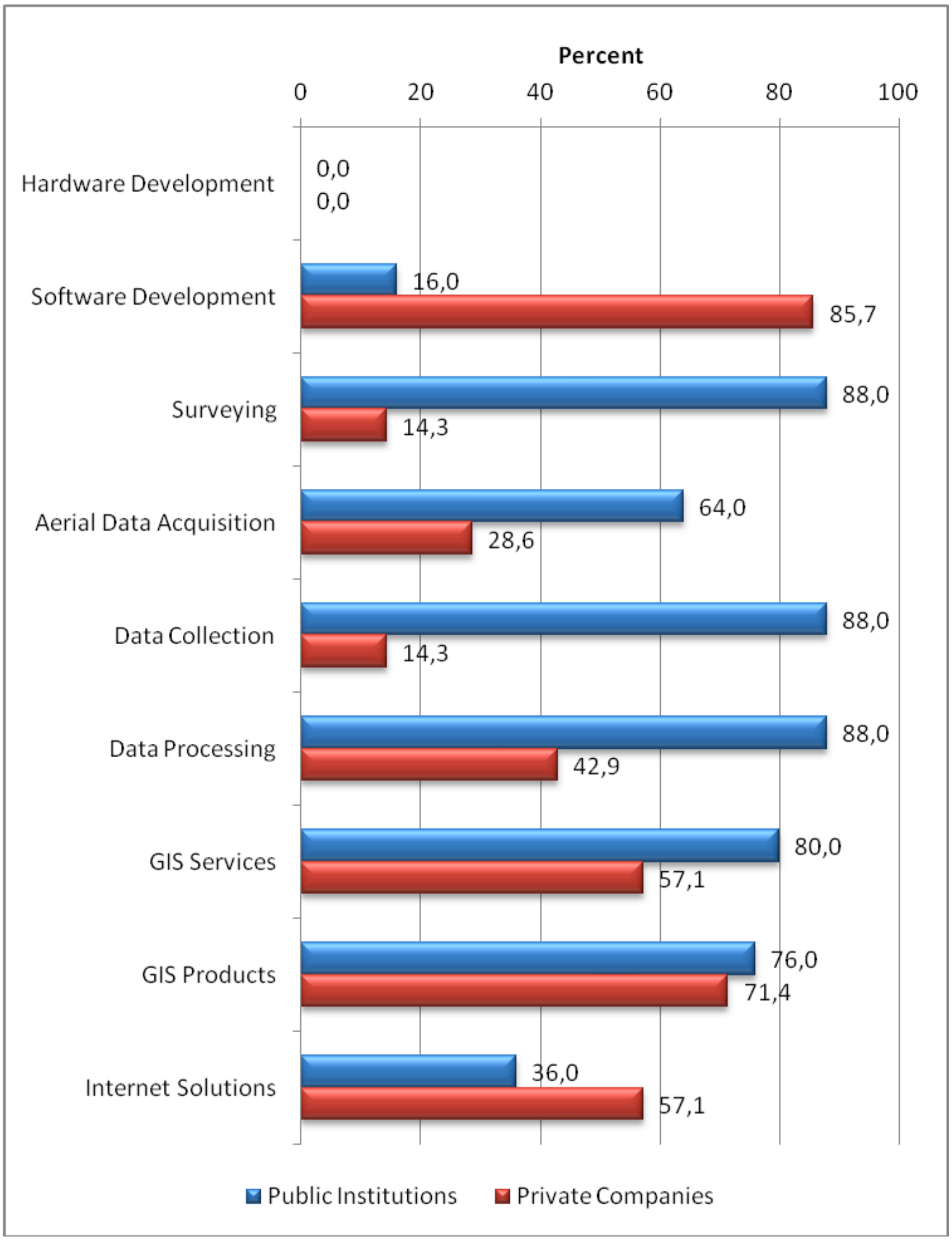


**Table 2:** Working areas of the institutions

Table 3 shows the number of employees in the public institutions and private companies. Most of the participating public institutions are national or regional mapping and cadastral agencies, which have typically several hundred employees. City surveying offices are normally smaller with 10-20 to 50-100 employees. The size of private companies, which participated in this study, ranges from 1-10 to 100-500 employees.

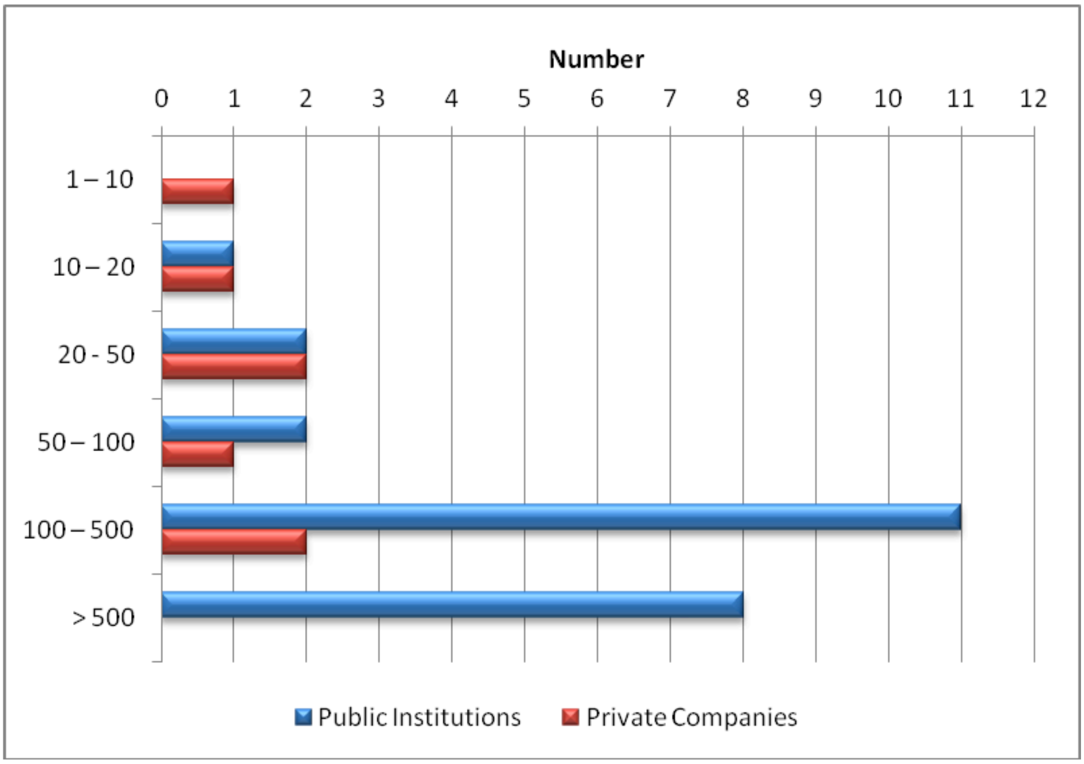


**Table 3:** Number of employees of the participating institutions

# 3 Evaluation of Questionnaire Part A

Questionnaire Part A contained questions about the market and the state-of-art of 3D data management. The questions could be answered by selecting one or more predefined answers. Optionally it was possible to add free-text for additional information or comments.

## 3.1 Question A.1: 3D Geographical Information Systems (3D GIS) can be defined in various ways. Which of the following definitions are applicable?

The evaluation of the answers showed that the participants have very different views about the definition of a 3D GIS. One participant suggested reformulating the question:

> *The question should rather be: 'What is your goal?' A normal user will not do editing or developing a system. That is the job of an expert. But a normal user has its own question and he wants answers.*

Table 4 shows the results of the evaluation of Question A1. The three definitions which have the highest consensus are: *A 3D GIS can handle 2D and 3D spatial data* (87.5%), *A 3D GIS must provide functionalities for the interactive input/modelling of new 3D data* (81.3%) and *A 3D GIS must provide functionalities for the interactive editing of already collected 3D data* (78.1%).

The three definitions with the lowest consensus are: *A 3D GIS can handle only 3D spatial data* (6.3%), *A 3D GIS should be one single software system* (18.8%) and *The realisation and implementation of a 3D GIS must be independent from the application* (34.4%).

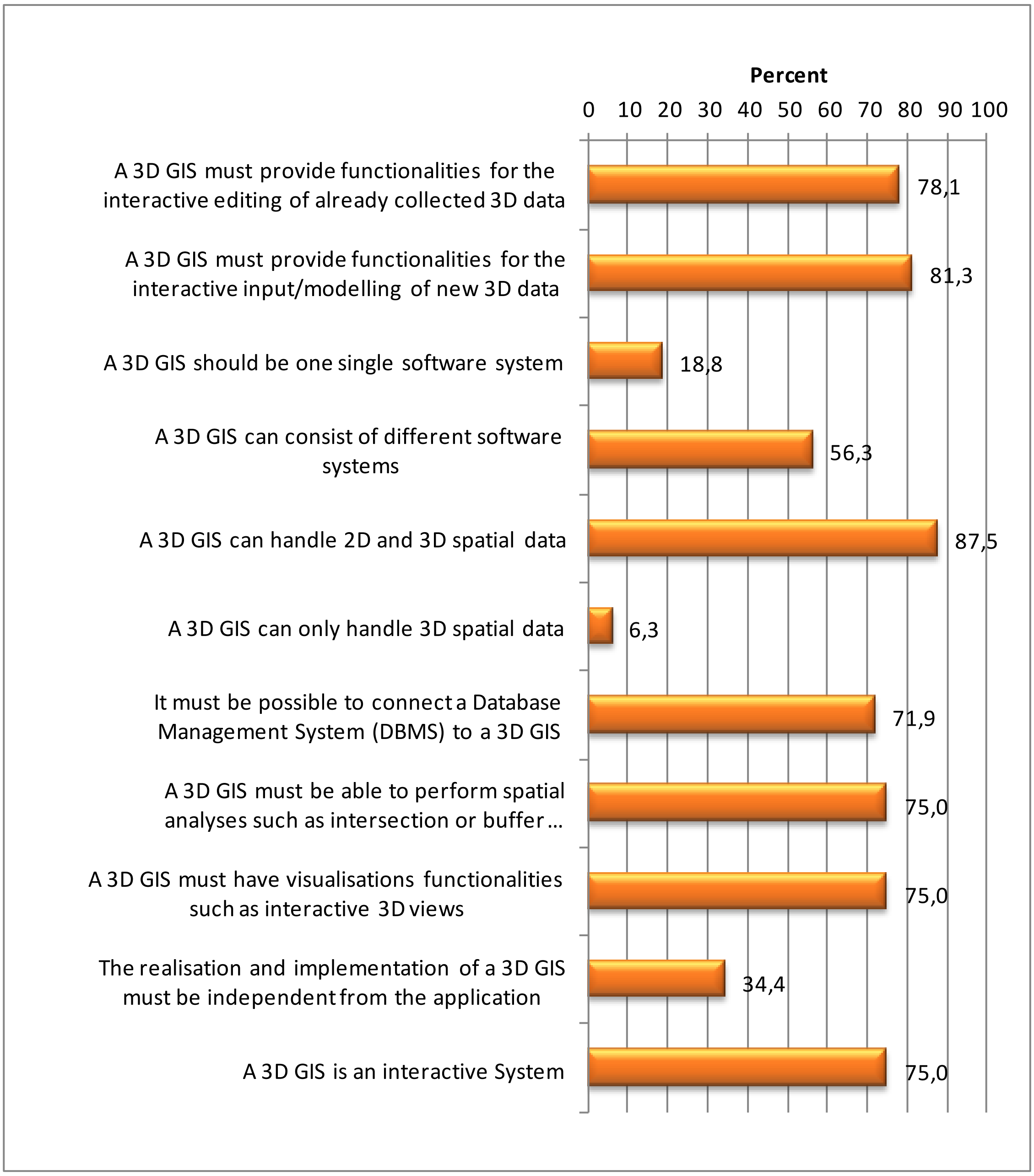


**Table 4:** Definition of a 3D GIS

One comment to Question A.1 was to define 3D GIS as a collection of different SDI Services:

> *Although the question refers to 3D GIS, I assume that modern architectures like SDI are appropriate to be considered in answering the question. Thus a 3D GIS in my understanding should be composed out of different SDI Services. Of course there is a need for visualization functionalities and 3D views in particular fields of application, but this shouldn't be a mandatory part of a 3D GIS definition.*

## 3.2 **Question A.2**: 3D GIS is often named a key technology. To which of the following statement do you agree?

There is a strong consensus that 3D GIS has the potential to become a key technology (84.4%) (see Table 5). No one of the participants believes that 3D GIS will never be a key technology, but 21.9% have the meaning that 3D GIS is already a key technology. Some participants selected both *3D GIS is already a key technology* and *3D GIS has the potential to become a key technology*. Therefore, the sum of both answers is higher than 100%.

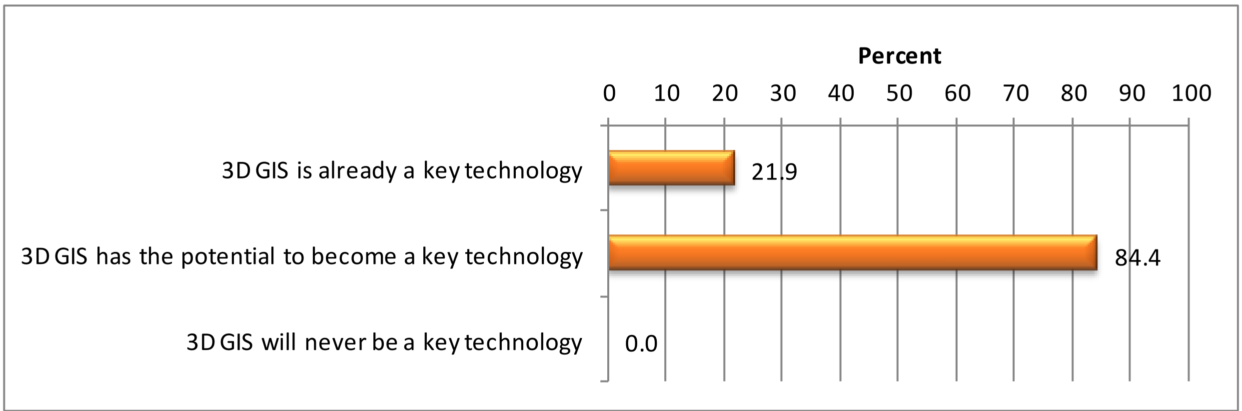


**Table 5:** Is GIS a key technology?

## 3.3 **Question A.3**: How do you see the availability of the following resources for 3D geospatial data? (1 = very good, 2 = good, 3 = satisfying, 4 = insufficient, 5 = not available)

Although the availability of the resources for 3D geospatial data are seen in average as satisfying, there is still room for improvement (see Table 6). *Data* is seen as the resource with the best availability (2.8), closely followed by *Technology* (2.9). The resource with the lowest availability is *Trained Personal* (3.4).

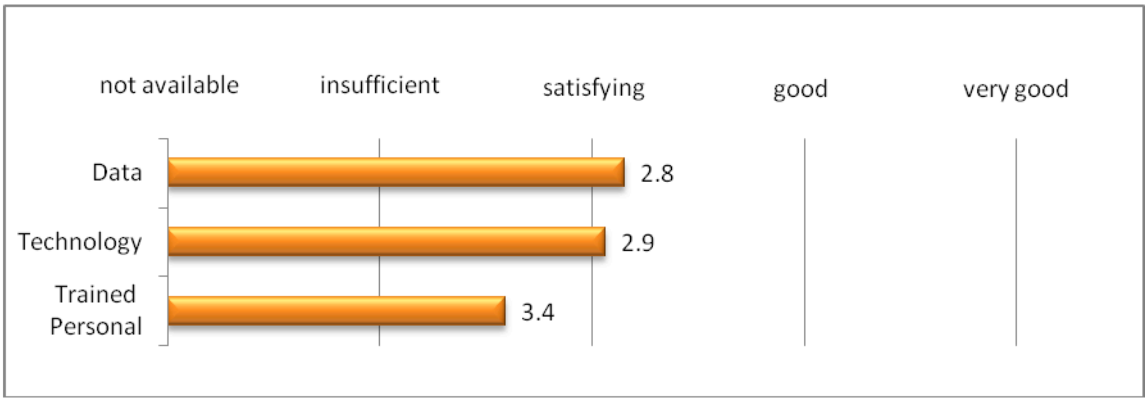


**Table 6:** Availability of resources for 3D geospatial data

## 3.4 Question A.4: How will the 3D geospatial market (for hardware, data, software and services) develop?

Hardware is the market segment with the lowest growth expectations (see Table 7). However, no more than 3.1% of the participants think that this market segment will shrink and only 6.3% think that it will stagnate. All other expect that this market segment will grow in the future (slowly 34.4%, medium 31.3%, fast 25.0%).

The market segments Services, Software and Data are seen by most of the participants as medium growing (Table 8-10). None of the participants expect that these segments will shrink. Especially the segments Data and Services are seen as strong segments: 34.4% of the participants think that these segments will grow fast in the future.

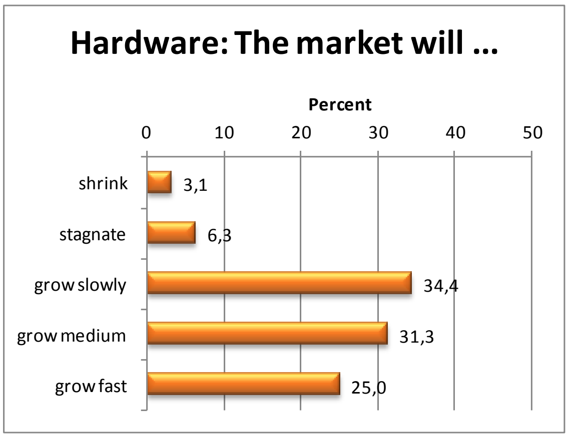


**Table 7:** Hardware development

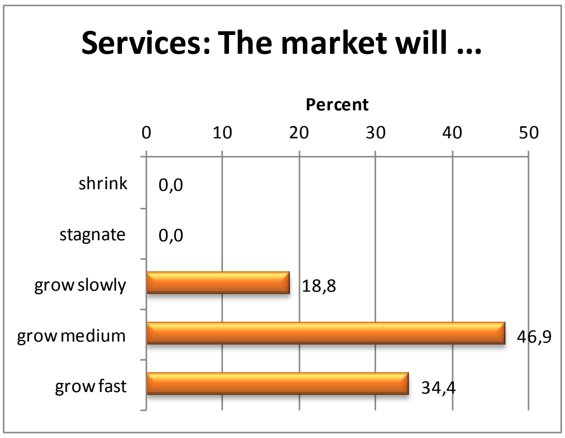


**Table 8:** Services development

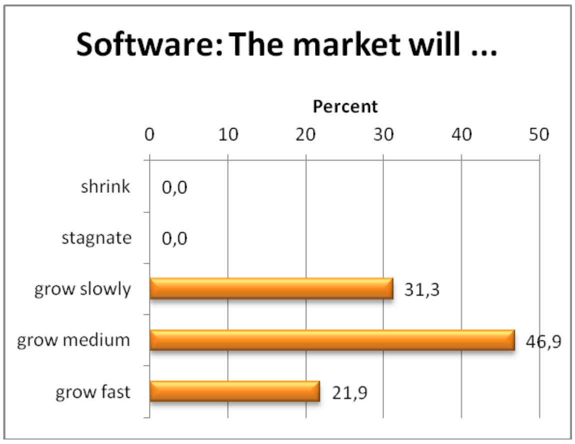


**Table 9:** Software development

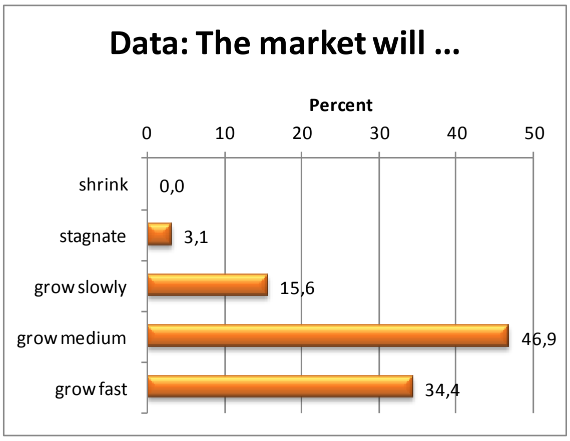


**Table 10:** Data development

## 3.5 Question A.5: What are your major customers of 3D geospatial data?

Table 11 shows that public institutions are at the moment the major customers (96.9%) of 3D geospatial data. Private companies are the second important customers (small companies 34.4%, medium companies 37.5%, and large companies 37.5%). Private individuals (6.3%) are at the moment not a significant customer base.

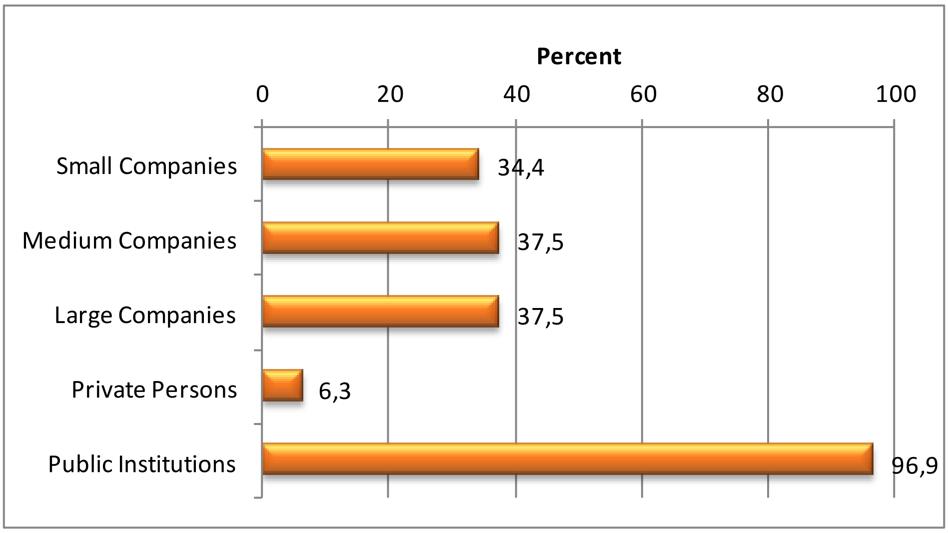


**Table 11:** Major customers of 3D geospatial data

## 3.6 Question A.6: Are your customers aware of the potential of 3D data?

The main answer to this question could be: *some are aware and some are not*. This can be seen also in Table 12: 53.1% of the participants selected *Yes* and 56.3% selected *No*. Some participants selected both *Yes* and *No*. Therefore, the sum of both answers is higher than 100%.

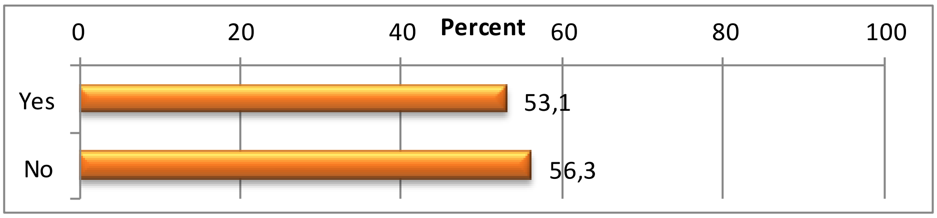


**Table 12:** Market awareness of customers

Some individual comments to Question A.6 are:

> *The awareness is slightly improving, a lot of clarification and information transfer is necessary to convince the customers.*
>
> *It would be necessary to invest in dissemination and marketing processes.*
>
> *Although 3D is universally understood in concept, and despite the fact that there is a near-universal expectation for 3D, many/most customers struggle to define exactly how they would benefit from 3D.*
>
> *People are aware of the potential of 3D data as a geometric data to produce rendering. But very few are aware of the potential of 3D GIS as an analysis tool. Furthermore, there are a lot of different levels of awareness between customers.*
>
> *Demonstrations of 3D data have been given to key customers, awareness is still low.*

## 3.7 Question A.7: What is the market potential for 3D geospatial data of different applications? (1 = very high, 2 = high, 3 = medium, 4 = low, 5 = not existing)

The two applications with the highest market potential for 3D geospatial data are *3D City Models* (1.4) and *Town Planning* (1.4) (see Table 13). The market potentials of all other applications are estimated a little bit lower, but even the lowest estimation is still between medium and high.

Many participants added additional applications with high market potential to the predefined answers. These applications and others will be discussed below together with the answers of Question B.5 (*Which will be the main application areas of 3D geospatial data in the future?*).

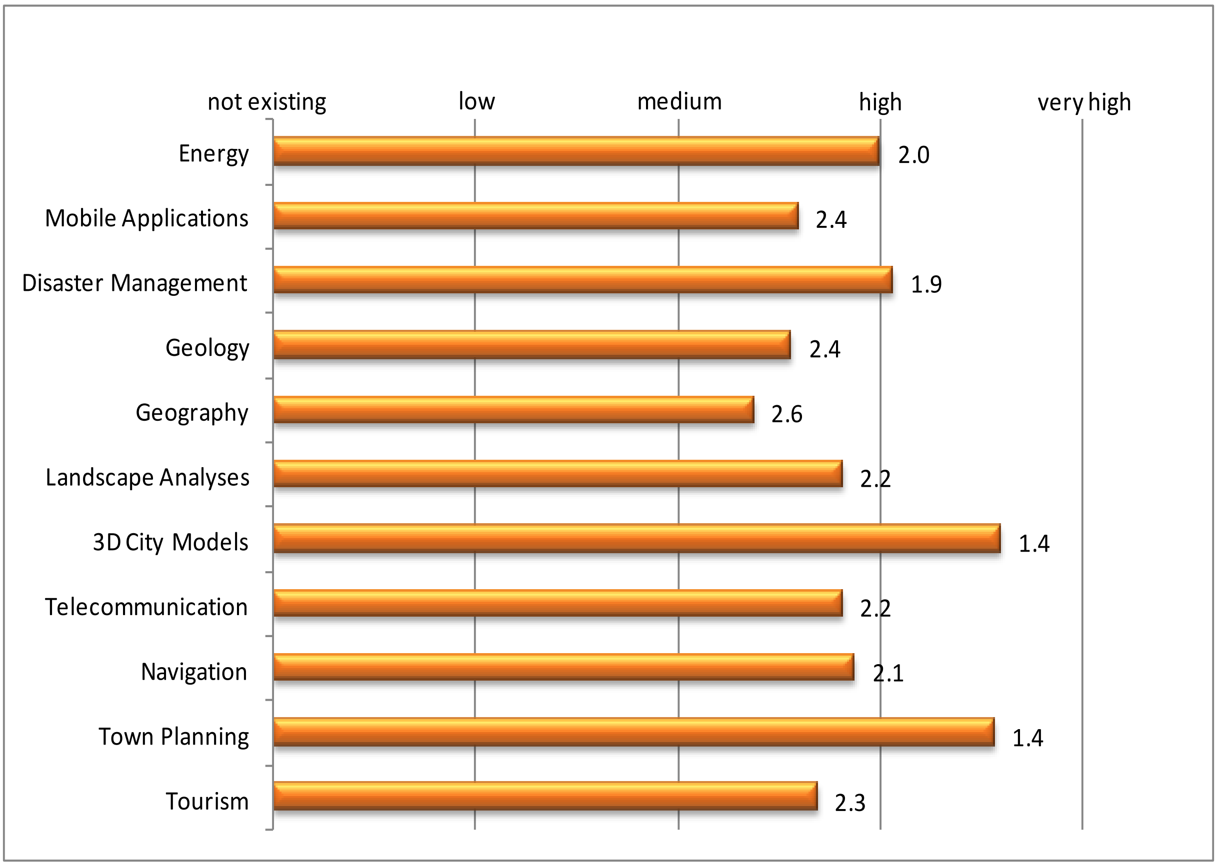


Table 13: Market potential of 3D applications

## **3.8 Question A.8**: Which level-of-detail of 3D geospatial data do you handle in your organization?

The answers of public institutions and private companies to this question were significantly different. The results can be seen in Table 14.

The most basic level-of-detail of 3D geospatial data, which is used by all participants, is *2.5 DTM*. For public institutions the next two important levels-of-detail are *Houses as Block Models without Roof Structures without Textures* (64.0%) and *Houses with Roof Structures without Textures* (60.0%). For private companies the next two important levels-of-detail are *Houses with Roof Structures with Textures* (71.4%) and *Vegetation* (71.4%).

One trend that can be seen in Table 14 is, that public institutions are typically working with less complex levels-of-detail (the answers in the upper part of the table) whereas private companies are typically working with more complex levels-of-detail (the answers in the lower part of the table).

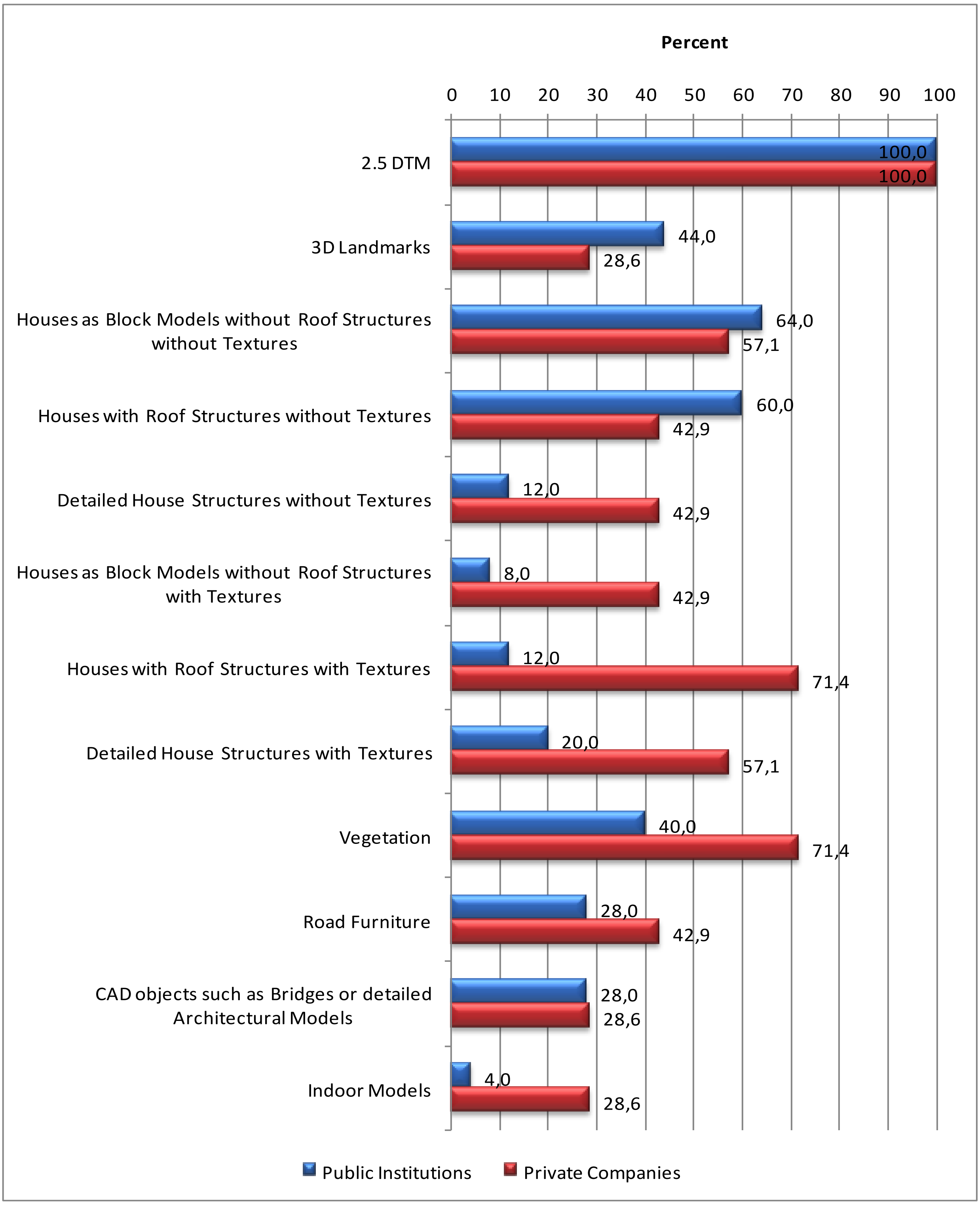


**Table 14:** Level-of-detail of 3D geospatial data

## 3.9 Question A.9: How do you store and process 3D geospatial data in your organization?

Table 15 shows the data management of public institutions and private companies: 88.0% of the public institutions use Database Management Systems (DBMS) for storing their data in comparison to 42.9% of the private companies. The reason for this is probably that National and Regional Mapping Agencies have to handle very large datasets.

Another difference is the number of software systems which are needed in order to process the data. None of the public institutions are able to realize their workflows with only one software system in comparison to 42.9% of the private companies. On the other hand, 80.0% of the public institutions need several software systems in comparison to 14.3% of the private companies.

One similarity of data management of public institutions and private companies is that roughly half of the public institutions (48.0%) and half of the private companies (57.1%) store at least parts of their 3D geospatial data also in file systems.

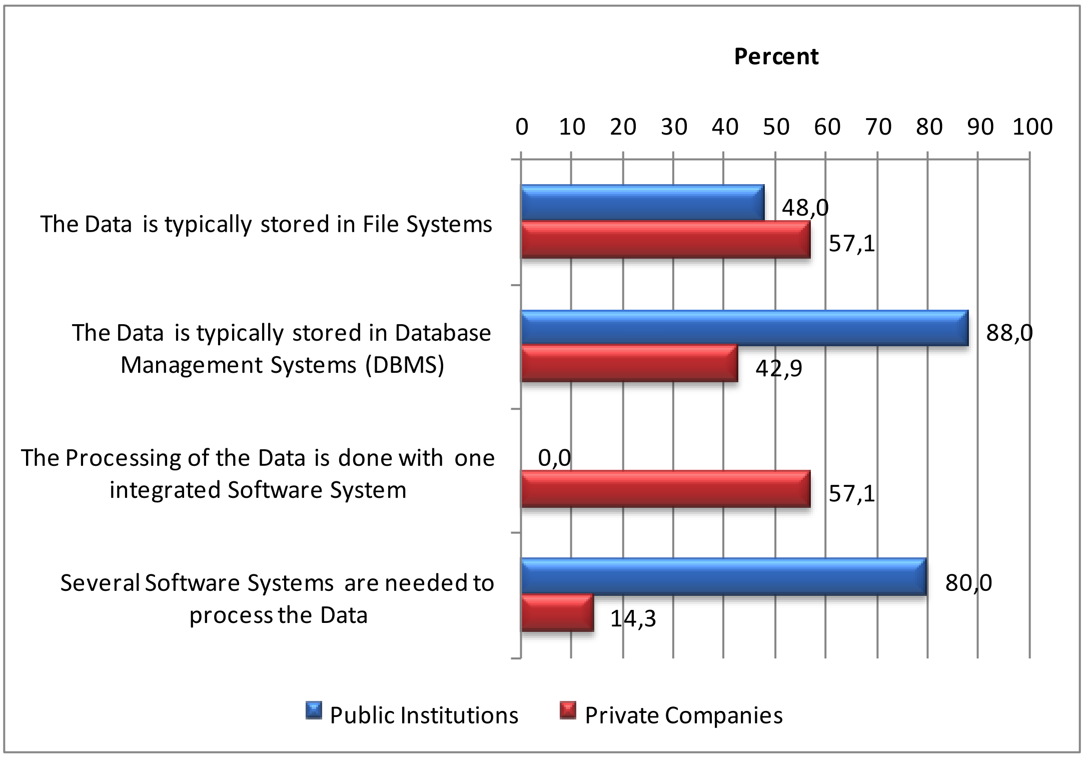


**Table 15:** Data management

## 3.10 Question A.10: Which software systems do you use for the work with 3D data?

Table 16 shows the diverse software systems which are used by the participants. Even though, only 32 institutions participated in this study, 40 different software systems are used. It has to be mentioned that the original questionnaire contained only eleven different software systems that could be selected. All other systems were added by the participants in the category: *others*. Therefore it could be that some of the systems are used by more participants as Table 16 indicates, because it is possible that some participants selected only the predefined answers - even though they work with more systems.

The most used software system is *ArcGIS 3D Analyst* (21), followed by *Microstation Bentley* (19), *LandXplorer* (6), *novaFACTORY 3D* (6), *Autodesk Map 3D* (5), *Global Mapper* (5), *GeoMedia Terrain* (4) and *inpho Stoftware* (4). All other systems are used only by one or two participants.

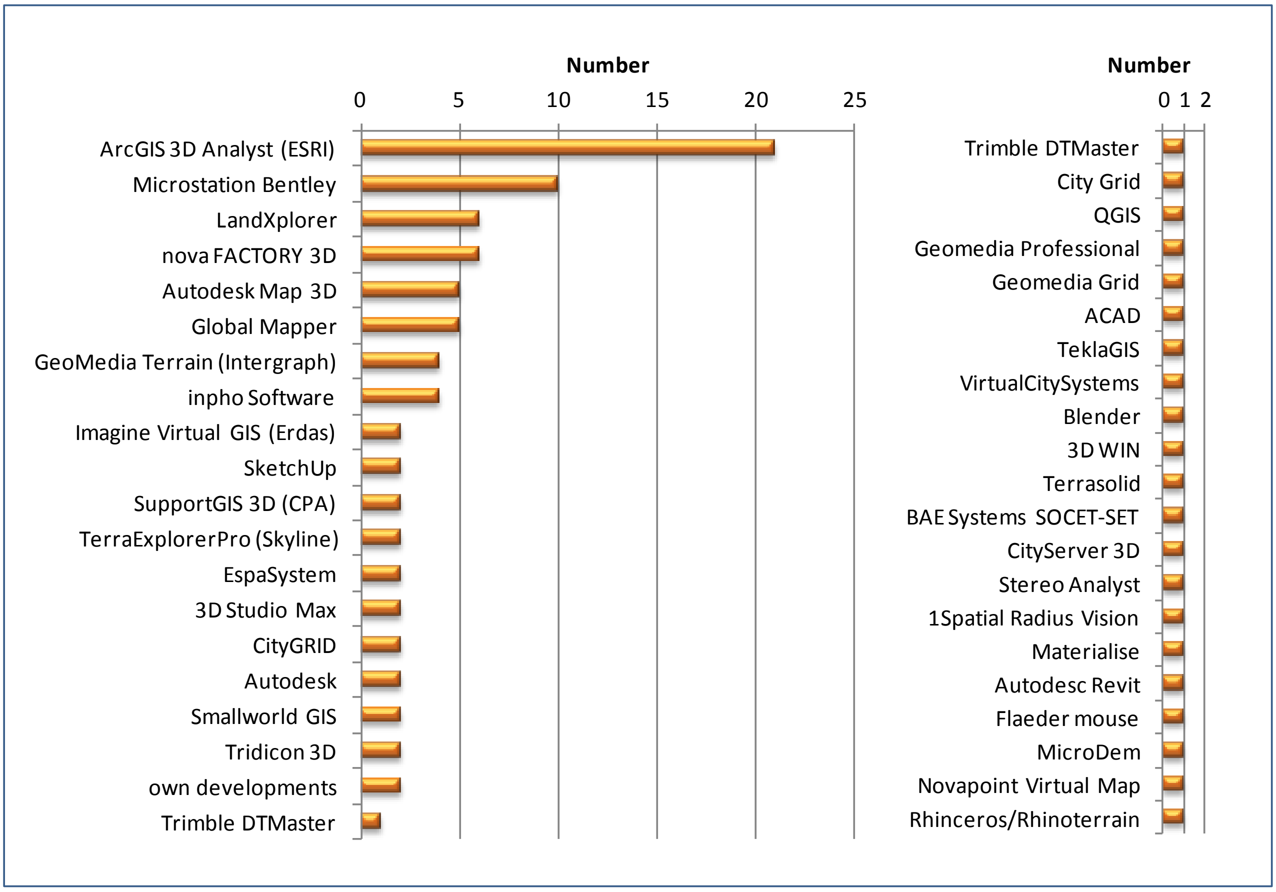


**Table 16:** Used software systems

## 3.11 Question A.11: Which 3D data models do you use for managing 3D geospatial data in your organization?

The most used data model is *2.5D GRID* (93.8%), followed by *3D Point Clouds* (81.3%), *2.5D Vector Data* (71.9%) and *2.5D TIN* (68.8%) (see Table 17). It can be seen that 2.5D models are dominating 3D models. Complex 3D models, such as *BREP* or *CSG* are only used by a minority group. Cell based methods, such as *Cell Decomposition*, *Voxel*, *Octtree* or *Tetrathedron* and mathematical models such as *Parametric Instancing* or *Sweep Representation* play no or only an unimportant role.

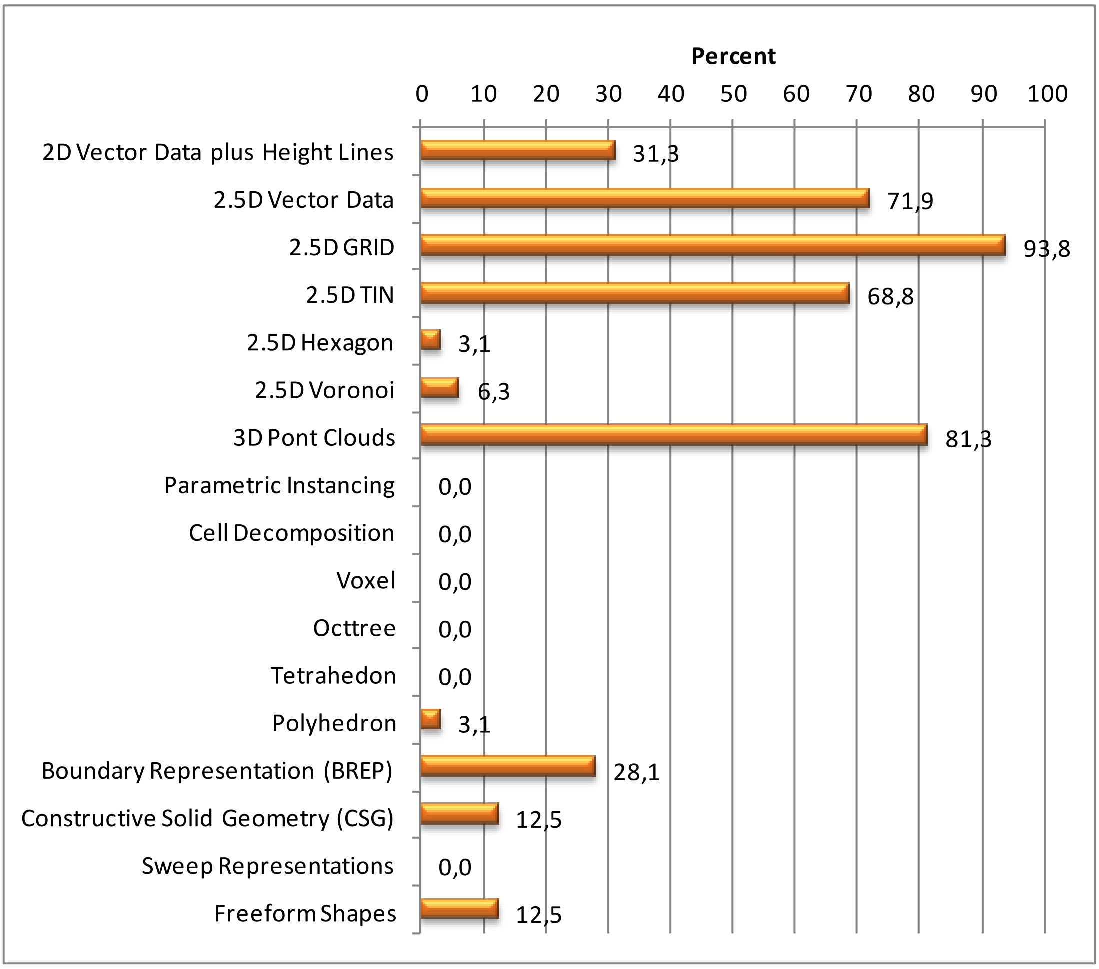


**Table 17:** Used data models

## **3.12 Question A.12**: Which 3D data formats do you use for managing 3D geospatial data in your organization?

Table 18 shows that 26 different 3D data formats are used by the participants. One reason for this is the high number of different software systems (see Question A.10) which are used. The other reason is that at the moment no single format is available that can fulfil the requirements of all participants (see also Question B.6: *What are your major problems in the field of 3D data handling?*).

The most commonly used formats are *3D-Shapefile* (23) (because of the most used software system is *ArcGIS 3D Analyst* - see Question A.10), followed by *DXF* (22), *CityGML* (19), *KML/KMZ* (14), *3D PDF* (10), *3DS* (9), *GML3* (8), *VRML* (8). All other formats are used in most of the cases only by one organization.

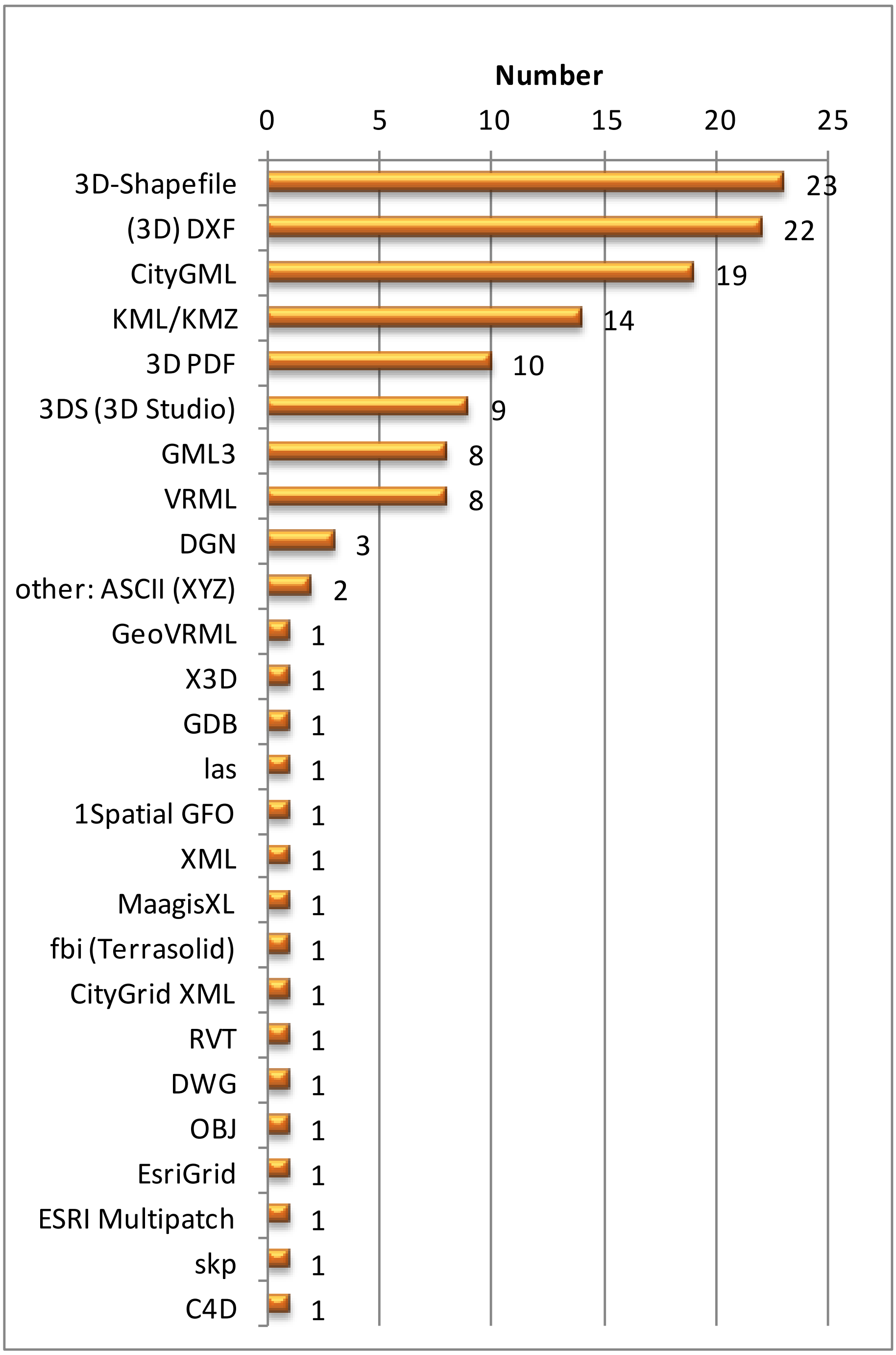


**Table 18:** Data formats

## 3.13 Question A.13: Which kind of 3D analysis functions do you use today and which will need presumably in 5 years? Multiple answers are possible.

Today, the most used 3D analysis functionalities are *2.5 Terrain Analyses* (Slope, Orientation, Height Lines, Lighting, etc.) (84.4%), followed by *3D Geometrical Calculations* (40.6%), *3D Selection* (37.5%) and *3D Intersection* (34.4%) (see Table 19). The analysis functionalities *3D Buffers* (15.6%) and *3D Route Planning* (9.4%) are only needed by a minority of the participants.

The analysis functionalities requirements to 3D GIS will presumably increase in the next five years. For all functionalities in Table 19 a strong increase is expected.

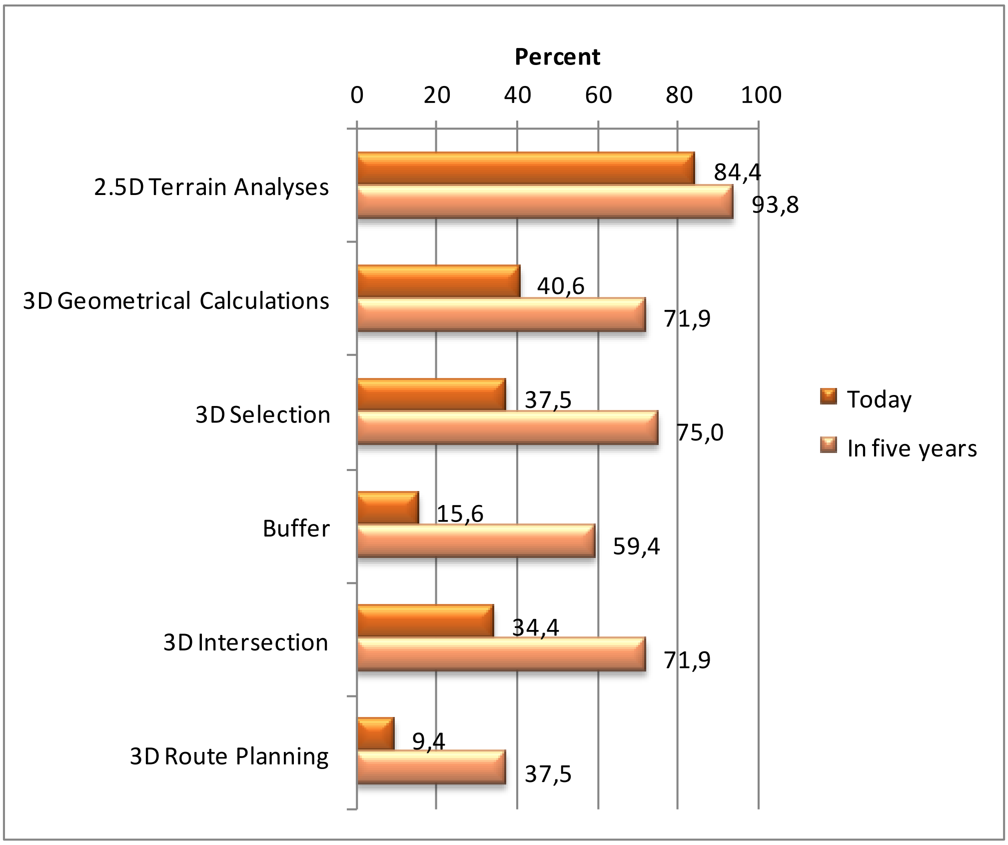


**Table 19:** Data analysis functionalities

**3.14 Question A.14**: Which kind of 3D visualization functionality do you use today and which will need presumably in 5 years? Multiple answers are possible.

Today, the most used visualisation functionality is *Stereo Visualisation* (65.6%), followed by *High Resolution Images* (56.3%), *2D Textures* (46.9%), *2D Views and 3D Views at the same time* (37.5%), *Camera Movements* (34.4%), *3D Symbols* (31.3%) and *Complex 3D symbols* (31.3%) (see Table 20). All other visualisation functionalities are used by less than 20 percent of the participants.

Like analysis functionalities, the visualisation functionalities requirements to 3D GIS will presumably increase in the next five years. For all functionalities in Table 20 a strong increase is expected.

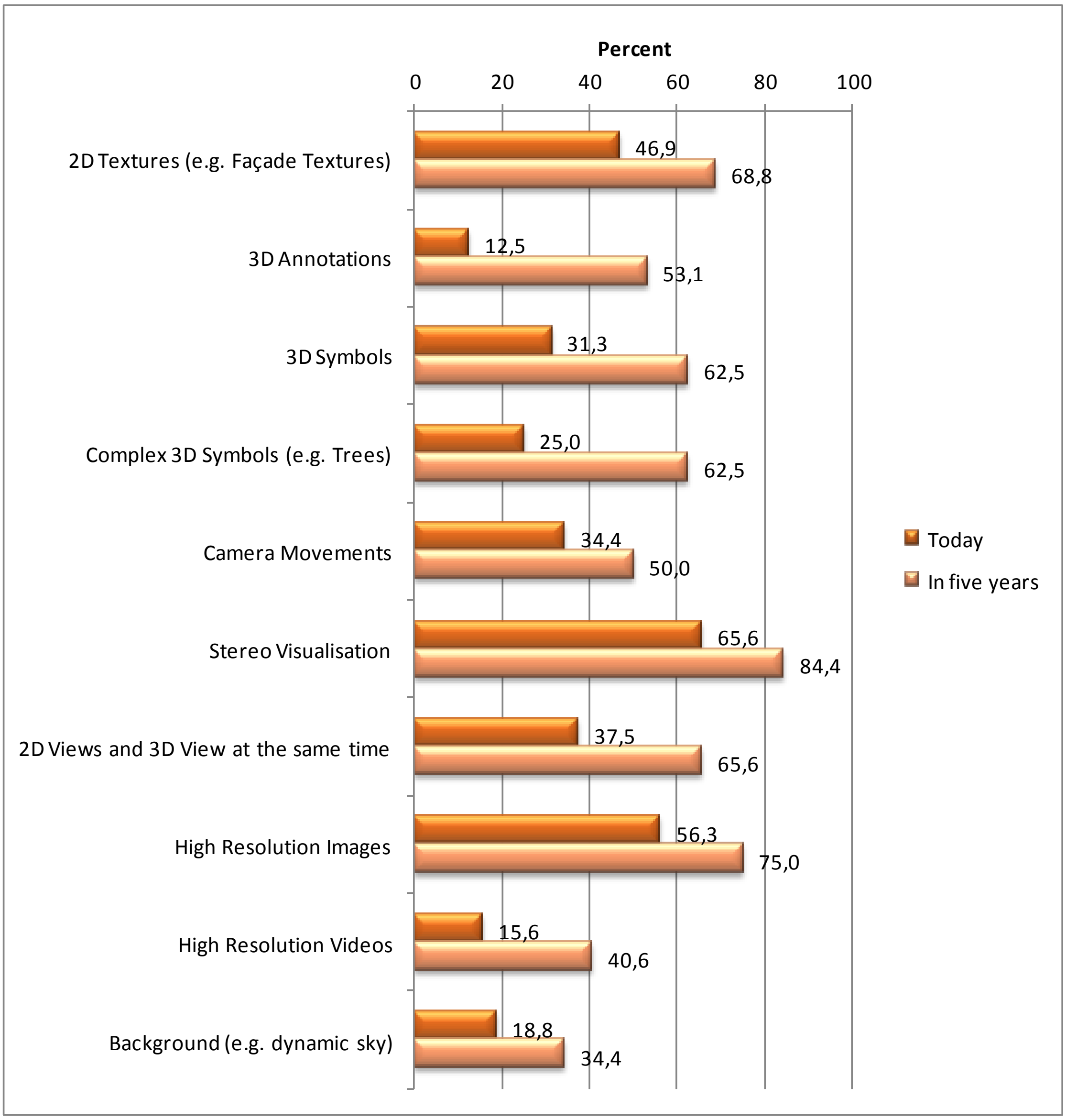


**Table 20:** Data visualisation functionalities

# 4 Questionnaire Part B

This part of the questionnaire contained general questions about 3D data management. The questions could be answered with free-text.

## 4.1 Question B.1: What are the driving forces for managing 3D geospatial data in your organisation?

Four different driving forces can be identified:

- **Customer's needs**: Private companies as well as public institutions collect 3D data because they have customers who need 3D data. Most of these customers are public institutions (see also Question A.5). Existing 3D applications are typically in the fields of *Urban Planning*, *Visualisation*, *3D City Models* and *Energy*. One participant answered that they collect 3D data because they *anticipate* the customer's future needs.

- **Mandate by law**: Many of the public institutions have a legal mandate to collect, process and provide 3D geospatial in order to support administration, politics, business and science in their decisions and processes.

- **Technical developments:** The progresses in landscape survey make it possible to collect 3D data. Since our environment is 3D, it has also to be collected in 3D. It is a natural progression in data management: analogue data → digital 2D data → digital 3D data.

- **Internal processes**: 3D data is needed for internal processes such as Orthophoto Production, Digital Terrain Models, etc.

## 4.2 Question B.2: How strong is the 3D market affected by international organisations (such as OGC, EuroSDR, EUROGI, AGILE, etc.)?

The participants can be separated into two groups: The first group (about one-third of the participants) answered that they are not able to answer this question or that they think that these organisation have no or only very small influence to the 3D market. The other group attest these organisations strong influence in terms of providing international standards for 3D data and web services. Especially the engagement in standardisation of the Open Geospatial Consortium (OGC) was mentioned by several participants.

Some individual comments to Question B.2 are:

> *All the named bodies above influence our thinking around data standards. Our greatest external engagement concerning 3D is OGC.*
>
> *The 3D market is affected quite strongly by the mentioned organizations. Without any centralized organization, the development of different data standards and data transfer standards, the management and market of 3D data wouldn't be as far as it is now.*
>
> *Our work is affected by the Open Geospatial Consortium (OGC), in terms of providing international standards for data and web-services. The other mentioned organizations provide platforms for the exchange of information, connecting administration, business and research.*

*The market is most strongly affected by large corporate players like Google and ESRI but also companies like Bentley and Mapinfo. For standardization primarily OGC drives the market.*

*They are creating initiatives to normalize and model the acquisition, processing, applications and 3D services.*

*Several institutions and organizations are activating the market for 3D geospatial information. They are linking public bodies such as national mapping and cadastral agencies with research institutes and universities and companies dealing with geospatial data. This often results in applied research in spatial data provision, management and delivery. From our point of view, it cannot be assessed clearly, how strong the impact of these activities result in specific market activities.*

## 4.3 **Question B.3**: How do you evaluate the future development of the 3D market in your country / in the EU?

Most of the participants think that the 3D market will grow moderately or strongly in the future. It is expected that the EU market will grow in the same way as the home market. However, many participants assume that the prerequisite for a strong market growth is that existing problems first have to be solved (see also Question B.6: *What are your major problems in the field of 3D data handling?*)

Some individual comments to Question B.3 are:

*There is clear need for it. When technology gets cheaper and modelling easier, there will be more use and users.*

*From our point of view it can be assumed that the market will grow rapidly with the increasing availability of sufficient data (in terms of data model, coverage of the data, costs of data), low-cost and easy-to-use software products. With the knowledge, how this kind of data has to be managed and how it can be used, the development of the market for 3D geospatial data will continuously grow in the coming five years.*

*Growing with customer awareness of existing 3D geospatial products*

*It is the future - younger people don't see the point with using 2D when 3D is around*

## 4.4 **Question B.4**: Will 3D geospatial data create new customers for your organisation? Who will be the new customers?

About half of the participants do not expect that 3D geospatial data will create new customers. They assume that the customers of 3D geospatial data will be the same as that of 2D geospatial data.

The other half of the participants anticipates that 3D geospatial data will create new customers. These customers will come mainly from the public sector. Only few participants expect customers from the private sector and only one participant expects private individuals as new customers.

## 4.5 **Question B.5**: Which will be the main application areas of 3D geospatial data in the future?

Table 21 shows the future application areas of 3D geospatial data which were identified by the participants (in alphabetical order). In principle, these application areas cover all existing application areas of 2D geospatial data. Figure 1 shows a Word Cloud of all named application areas (a Word Cloud is a visual representation which shows how frequent specific words are contained in a list).

| | |
|---|---|
| Agriculture | Internet Presentation |
| Airport Mapping | Lakeside Mapping |
| Asset Management | Landscape Planning |
| Building Planning | Law Enforcement |
| Cadastre | Marketing |
| City Models | Mobile Applications |
| City Planning | Modelling |
| Civil Security and Services | Monitoring |
| Coastal Mapping | Nature Protection |
| Country Planning | Navigation |
| Disaster Management | Noise Analyses |
| Ditching | Peat Estimates |
| Emergency Management | Property Management |
| Energy | Public Utilities |
| Entertainment | Regional Planning |
| Environmental planning | Renewable Energy Resources |
| Fire Maps | Risk Management |
| Flood Modelling/Mapping | Security |
| Forest Management | Simulation |
| Games | Social Media |
| Geography | Solar Cadastre |
| Geology | Subsoil Applications |
| Hydro-Geological Monitoring | Telecommunication |
| Image Classification Support | Topographic Analyses |
| Infrastructure Planning | Tourism |
| Insurance Industry | Town Planning |

**Table 21:** Potential future application areas of 3D geospatial data


**Figure 1:** Potential future application areas of 3D geospatial data

## 4.6 Question B.6: What are your major problems in the field of 3D data handling?

The problems most frequently identified in the field of 3D data handling are:

- **Interoperability**: Many different software systems are needed which are often not interoperable.

- **Software**: Existing software solutions are not efficient enough. The tools and algorithms are not mature enough. The programs are difficult and can be used only by experts.

- **Standardisation**: Missing or inconsistent standards for 3D data.

- **Amount of data**: The handling of large 3D datasets is difficult.

- **Integration**: The fusion and handling of existing 2D data with new 3D data is problematic.

# 5 Summary

In order to identify the state of the art of 3D data management, the future requirements as well as existing problems a survey on 3D geospatial data handling was conducted. The following list highlights the main results of this study:

- The answers of public institutions were not much different to the answers of private companies. Significantly different answers were only given to the question concerning typical working areas (public institutions: data acquisition; private companies: data processing) and to questions concerning data management (public institutions: less complex data models but more complex software systems; private companies: more complex data models but less complex software systems).

- The participants have no consistent definition of a 3D GIS. The definition of a 3D GIS is dependent on the underlying application. However, this is also true for 2D GIS.

- The main customers of 3D geospatial data are currently public institutions. Private companies represent at the moment only a small market segment, but it can be expected that this segment will grow in the future.

- Private individuals are at the moment and presumably in the near future not a significant customer base for 3D geospatial data.

- The application areas of 3D geospatial data are manifold. Nearly all areas, where 2D geospatial data are used, are also potential working areas of 3D geospatial data. The simple reason for that is that our world is three-dimensional and therefore people want to work with three-dimensional representations.

- The software market for processing 3D geospatial data is at the moment very heterogeneous. Many different software products are in use and very often one specific product is only used by one or two institutions. This leads to problems, because the different systems are often not interoperable.

- The same situation holds true for the standardisation of 3D geospatial data: many different data formats are in use and very often one specific format is only used by one or two institutions.

- The existing software products are not powerful enough. Not all requirements of the participants can be fulfilled. Nearly all participants expect that the requirements will increase in the next five years.

- It is expected that 3D GIS will be an important key technology in the near future. However, the problems which were identified in this study have first to be solved.

# 6 Conclusions and Outlook

The survey shows that 3D GIS is a very complex field with manifold aspects in different directions. In addition, 3D data modelling is much more complex compared to 2D modelling. In the 2D world data models are less complex, while in 3D a variety of data models are being used (see Figure 2).

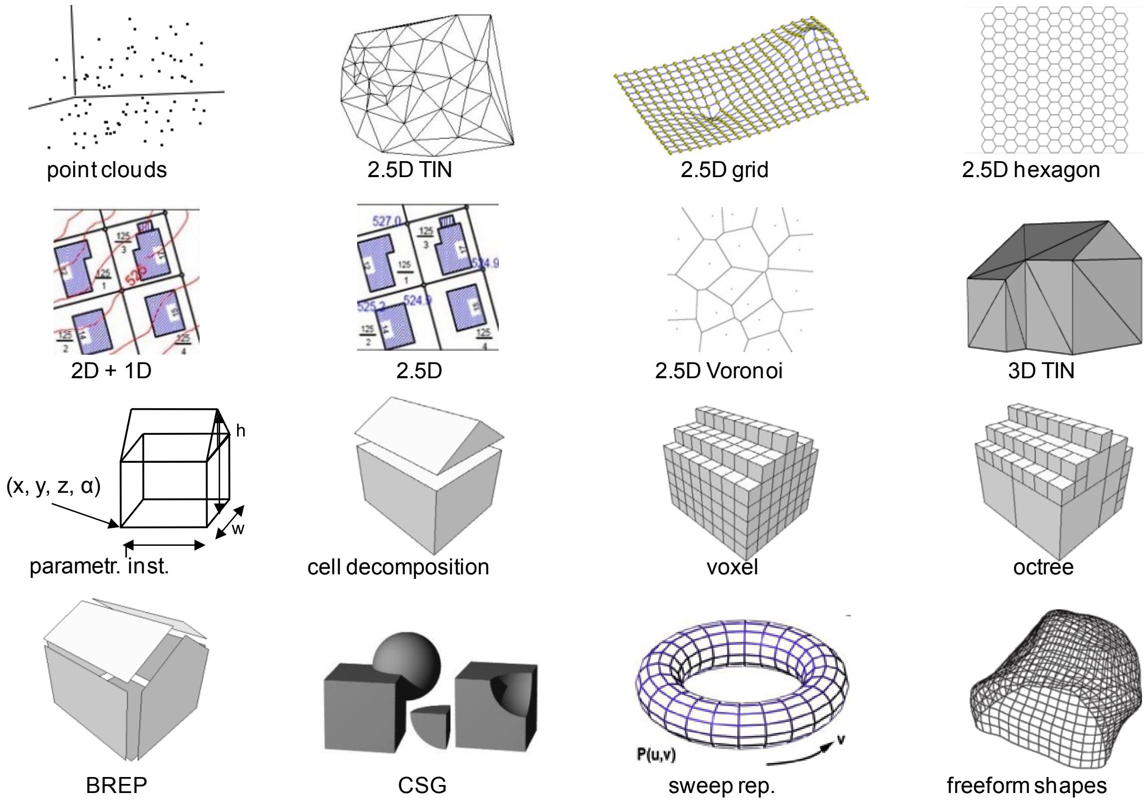


**Figure 2:** Different data models for representing 3D data

In order to overcome the discussed problems of 3D geospatial data handling, it is necessary to invest mainly into three fields:

- **Research**: There are still problems in the 3D world which need fundamental research. Research topics are for example:
    - 2D data and 3D data integration
    - Integration of different 3D models
    - Parallelization of 3D analysis functionalities on GPUs or multi-core CPUs
    - Handling of very large 3D spatial datasets
    - 3D Portrayal in Web services
- **Development**: The software manufacturers have to develop more powerful software systems. Future systems must have:
    - More analysis and visualisation functionalities.
    - Easy-to-use interfaces which can be used also by non-specialists
    - Integrated workflows (Input, Management, Analysis and Presentation with one system)
- **Standardization**: Consistent standards and services are needed to exchange and access 3D data.

Since the market potential of 3D GIS is huge it can be expected that much money will be invested in this market in the near future by software and hardware manufacturers and that it will be possible to overcome the problems which were identified in this study in the coming years.

# Annex A: Participating Institutions

## National Mapping and Surveying Agencies

Dutch Kadaster & University of Technology, Delft, The Netherlands
Federal Agency for Cartography and Geodesy, Germany
Kort & Matrikelstyrelsen, Denmark
Lantmäteriet, Sweden
National Geographic Institute Belgium
National Land Survey of Finland
National Geographic Institute Spain
Ordnance Survey Great Britain
Ordnance Survey Ireland
Swiss Federal Office of Topography

## Regional Mapping and Surveying Agencies

Agency for Geoinformation and Surveying, Baden Württemberg, Germany
Agency for Geoinformation and Surveying, Brandenburg, Germany
Agency for Geoinformation and Surveying, Hamburg, Germany
Agency for Geoinformation and Surveying, Lower Saxony, Germany
Agency for Geoinformation and Surveying, Munich, Germany
Agency for Geoinformation and Surveying, Rheinland-Pfalz, Germany
Agency for Geoinformation and Surveying, Wiesbaden, Germany
Insiel SpA ICT Company of Friuli Venezia Giulia Region, Italy (owned by FVG Region Italy)

## City Mapping and Surveying Agencies

City of Espoo, Finland
City of Frankfurt, Germany
City of Geneva, Switzerland
City of Graz, Austria
City of Stuttgart, Germany
City of Tampere, Finland
City of Vienna, Austria

## Private Companies

AED-SICAD AG, Bonn, Germany
Basepoint Oy, Kajaani, Finland
Geofly GmbH, Magdeburg, Germany
GIS Consult GmbH, Haltern am See, Germany
imp GmbH, Halle, Germany
M.O.S.S. Computer Grafik Systeme GmbH, Taufkirchen, Germany
Vianova Systems Finland Oy, Espoo, Finland

# Annex B: Original Questionnaire

## Questionnaire
## 3D Data Management in Urban Areas

# Title page

| | |
|---|---|
| Institution / Company: | |
| Name of responsible person: | |
| Email of responsible person: | |
| Date: | |

**Please complete this questionnaire until 3rd February 2012.**

**If you have any question please contact Volker.Walter@ifp.uni-stuttgart.de for assistance.**

**Type of Institution:**

| ✓ | **Type** |
|---|---|
| | Public Institution |
| | Private Company |

**Please indicate the Working Areas of your Institution (several answers are possible):**

| ✓ | **Working Areas** |
|---|---|
| | Hardware development |
| | Software development |
| | Surveying |
| | Aerial Data Acquisition |
| | Data Collection |
| | Data Processing |
| | GIS services |
| | GIS products |
| | Internet solutions |
| | *Other:* |
| | *Other:* |
| | *Other:* |

**Size of Institution:**

| ✓ | **Number of Employees** |
|---|---|
| | 1 – 10 |
| | 10 – 20 |
| | 20 - 50 |
| | 50 – 100 |
| | 100 – 500 |
| | > 500 |

# Questionnaire

# 3D Data Management in Urban Areas

# Part A

*This part of the questionnaire contains questions about the market and the state-of-art of 3D data management. The questions can be answered by selecting one or more predefined answers. Optionally it is possible to add free-text for additional information or comments.*

**Question A.1**: 3D Geographical Information Systems (3D GIS) can be defined in various ways. Which of the following definitions are applicable?

| ✓ | **Definition** |
|---|---|
| | A 3D GIS must provide functionalities for the interactive editing of already collected 3D data |
| | A 3D GIS must provide functionalities for the interactive input/modelling of new 3D data |
| | A 3D GIS should be one single software system |
| | A 3D GIS can consist of different software systems |
| | A 3D GIS can handle 2D and 3D spatial data |
| | A 3D GIS can only handle 3D spatial data |
| | It must be possible to connect a Database Management System (DBMS) to a 3D GIS |
| | A 3D GIS must be able to perform spatial analyses such as intersection or buffer generation |
| | A 3D GIS must have visualisations functionalities such as interactive 3D views |
| | The realisation and implementation of a 3D GIS must be independent from the application |
| | A 3D GIS is an interactive System |

Please use the following text field, if you want to add additional information:

**Question A.2**: 3D GIS is often named a key technology. To which of the following statement do you agree?

| ✓ | **Statement** |
|---|---|
| | 3D GIS is already a key technology |
| | 3D GIS has the potential to become a key technology |
| | 3D GIS will never be a key technology |

Please use the following text field, if you want to add additional information:

**Question A.3**: How do you see the availability of the following resources for 3D geospatial data?
(1 = very good, 2 = good, 3 = satisfying, 4 = insufficient 5 = not available)

| **Availability (1-5)** | **Resources** |
|---|---|
| | Data |
| | Technology |
| | Trained Personal |

Please use the following text field, if you want to add additional information:

**Question A.4**: How will the 3D geospatial market (for hardware, data, software and services) develop in the next 5 years?

| ✓ Hardware | ✓ Data | ✓ Software | ✓ Services | **Development** |
|---|---|---|---|---|
| | | | | The market will shrink |
| | | | | The market will stagnate |
| | | | | The market will grow slowly |
| | | | | The market will grow medium |
| | | | | The market will grow fast |

Please use the following text field, if you want to add additional information:

**Question A.5**: What are your major customers of 3D geospatial data?

| ✓ | **Major Customers** |
|---|---|
| | Small Companies |
| | Medium Companies |
| | Large Companies |
| | Private Persons |
| | Public Institutions |

Please use the following text field, if you want to add additional information:

**Question A.6**: Are your customers aware of the potential of 3D data?

| ✓ | **Market awareness** |
|---|---|
| | Yes |
| | No |

Please use the following text field, if you want to add additional information:

**Question A.7**: What is the market potential for 3D geospatial data of different applications?
(1 = very high, 2 = high, 3 = medium, 4 = low, 5 = not existing)

| **Market Potential (1-5)** | **Application** |
|---|---|
| | Tourism |
| | Town Planning |
| | Navigation |
| | Telecommunication |
| | 3D City Models |
| | Landscape Analyses |
| | Geography |
| | Geology |
| | Disaster Management |
| | Mobile Applications |
| | Landscape Analyses |
| | Energy |
| | *other:* |
| | *other:* |

Please use the following text field, if you want to add additional information:

**Question A.8**: Which level-of-detail of 3D geospatial data do you handle in your organization? Multiple answers are possible. Estimate the percentage of use.

| ✓ | **Level-of-Detail** | **Percentage of use** |
|---|---|---|
| | 2.5 DTM | |
| | 3D Landmarks | |
| | Houses as Block Models without Roof Structures without Textures | |
| | Houses with Roof Structures without Textures | |
| | Detailed House Structures without Textures | |
| | Houses as Block Models without Roof Structures with Textures | |
| | Houses with Roof Structures with Textures | |
| | Detailed House Structures with Textures | |
| | Vegetation | |
| | Road Furniture | |
| | CAD objects such as Bridges or detailed Architectural Models | |
| | Indoor Models | |

Please use the following text field, if you want to add additional information:

**Question A.9**: How do you store and process 3D geospatial data in your organization?

| ✓ | **Data Storage and Processing** |
|---|---|
| | The Data is typically stored in File Systems |
| | The Data is typically stored in Database Management Systems (DBMS) |
| | The Processing of the Data is done with one integrated Software System |
| | Several Software Systems are needed to process the Data |

Please use the following text field, if you want to add additional information:

**Question A.10**: Which software systems do you use for the work with 3D data? Multiple answers are possible. Estimate the percentage of use. If your software systems are not listed below, please specify them in the rows other.

| ✓ | **Software** | **Percentage of use** |
|---|---|---|
| | ArcGIS 3D Analyst (ESRI) | |
| | LandXplorer | |
| | TNTmips | |
| | Autodesk Map 3D | |
| | WinGrass | |
| | Imagine Virtual GIS (Erdas) | |
| | GeoMedia Terrain (Intergraph) | |
| | PAMAP GIS Topographer (PCIGeomatics) | |
| | nova FACTORY 3D | |
| | Microstation Bentley | |
| | Global Mapper | |
| | *other:* | |
| | *other:* | |

Please use the following text field, if you want to add additional information:

**Question A.11**: Which 3D data models do you use for managing 3D geospatial data in your organization? Multiple answers are possible. Estimate the percentage of use.

| ✓ | **Data Model** | **Percentage of use** |
|---|---|---|
| | 2D Vector Data plus Height Lines | |
| | 2.5D Vector Data | |
| | 2.5D GRID | |
| | 2.5D TIN | |
| | 2.5D Hexagon | |
| | 2.5D Voronoi | |
| | 3D Pont Clouds | |
| | Parametric Instancing | |
| | Cell Decomposition | |
| | Voxel | |
| | Octtree | |
| | Tetrahedon | |
| | Polyhedron | |
| | Boundary Representation (BREP) | |
| | Constructive Solid Geometry (CSG) | |
| | Sweep Representations | |
| | Freeform Shapes | |
| | *other:* | |
| | *other:* | |

Please use the following text field, if you want to add additional information:

**Question A.12**: Which 3D data formats do you use for managing 3D geospatial data in your organization? Multiple answers are possible. Estimate the percentage of use.

| ✓ | **Data Standard** | **Percentage of use** |
|---|---|---|
| | GML3 | |
| | VRML | |
| | GeoVRML | |
| | X3D | |
| | CityGML | |
| | KML/KMZ | |
| | 3DS (3D Studio) | |
| | DXF | |
| | 3D-Shapefile | |
| | PDF | |
| | *other:* | |
| | *other:* | |
| | *other:* | |

Please use the following text field, if you want to add additional information:

**Question A.13**: Which kind of 3D analysis functions do you use today and which do you will need presumably in 5 years? Multiple answers are possible.

| **Today ✓** | **In 5 Years ✓** | **Analysis Functions** |
|---|---|---|
| | | 2.5D Terrain Analyses (Slope, Orientation, Height Lines, Lighting, etc.) |
| | | 3D Geometrical Calculations |
| | | 3D Selection |
| | | 3D Buffer |
| | | 3D Intersection |
| | | 3D Route Planning |
| | | *other:* |
| | | *other:* |
| | | *other:* |

Please use the following text field, if you want to add additional information:

**Question A.14**: Which kind of 3D visualization functionality do you use today and which do you will need presumably in 5 years? Multiple answers are possible.

| **Today** ✓ | **In 5 Years** ✓ | **Visualisation Functionality** |
|---|---|---|
| | | 2D Textures (e.g. Façade Textures) |
| | | 3D Annotations |
| | | 3D Symbols |
| | | Complex 3D Symbols (e.g. Trees) |
| | | Camera Movements |
| | | Stereo Visualisation |
| | | 2D Views and 3D View at the same time |
| | | High Resolution Images |
| | | High Resolution Videos |
| | | Background (e.g. dynamic sky) |
| | | *other:* |
| | | *other:* |
| | | *other:* |

Please use the following text field, if you want to add additional information:

## Questionnaire

## 3D Data Management in Urban Areas

# Part B

*This part of the questionnaire contains general questions about 3D data management. The questions should be answered with free-text.*

**Question B.1**: What are the driving forces for managing 3D geospatial data in your organisation?

Please use the following text field for your answer:

**Question B.2**: How strong is the 3D market affected by international organisations (such as OGC, EuroSDR, EUROGI, AGILE, etc.)?

Please use the following text field for your answer:

**Question B.3**: How do you evaluate the future development of the 3D market in your country / in the EU?

Please use the following text field for your answer:

**Question B.4**: Will 3D geospatial data create new customers for your organisation? Who will be the new customers?

Please use the following text field for your answer:

**Question B.5**: Which will be the main application areas of 3D geospatial data in the future?

Please use the following text field for your answer:

**Question B.6**: What are your major problems in the field of 3D data handling?

Please use the following text field for your answer:

# Index Table



# Index Figure

LIST OF OEEPE/EuroSDR OFFICIAL PUBLICATIONS

State – March 2013

1 Trombetti, C.: „Activité de la Commission A de l'OEEPE de 1960 à 1964" – Cunietti, M.: „Activité de la Commission B de l'OEEPE pendant la période septembre 1960 – janvier 1964" – Förstner, R.: „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960–1964)" – Neumaier, K.: „Rapport de la Commission E pour Lisbonne" – Weele, A. J. v. d.: „Report of Commission F." – Frankfurt a. M. 1964, 50 pages with 7 tables and 9 annexes.

2 Neumaier, K.: „Essais d'interprétation de »Bedford« et de »Waterbury«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" – „The Interpretation Tests of »Bedford« and »Waterbury«. Common Report Established by all Participating Centres of Commission E of OEEPE" – „Essais de restitution »Bloc Suisse«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" – „Test »Schweizer Block«. Joint Report of all Centres of Commission E of OEEPE." – Frankfurt a. M. 1966, 60 pages with 44 annexes.

3 Cunietti, M.: „Emploi des blocs de bandes pour la cartographie à grande échelle – Résultats des recherches expérimentales organisées par la Commission B de l'O.E.E.P.E. au cours de la période 1959–1966" – „Use of Strips Connected to Blocks for Large Scale Mapping – Results of Experimental Research Organized by Commission B of the O.E.E.P.E. from 1959 through 1966." – Frankfurt a. M. 1968, 157 pages with 50 figures and 24 tables.

4 Förstner, R.: „Sur la précision de mesures photogrammétriques de coordonnées en terrain montagneux. Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE" – „The Accuracy of Photogrammetric Co-ordinate Measurements in Mountainous Terrain. Report on the Results of the Reichenbach Test Commission C of the OEEPE." – Frankfurt a. M. 1968, Part I: 145 pages with 9 figures; Part II: 23 pages with 65 tables.

5 Trombetti, C.: „Les recherches expérimentales exécutées sur de longues bandes par la Commission A de l'OEEPE." – Frankfurt a. M. 1972, 41 pages with 1 figure, 2 tables, 96 annexes and 19 plates.

6 Neumaier, K.: „Essai d'interprétation. Rapports des Centres de la Commission E de l'OEEPE." – Frankfurt a. M. 1972, 38 pages with 12 tables and 5 annexes.

7 Wiser, P.: „Etude expérimentale de l'aérotiangulation semi-analytique. Rapport sur l'essai »Gramastetten«." – Frankfurt a. M. 1972, 36 pages with 6 figures and 8 tables.

8 „Proceedings of the OEEPE Symposium on Experimental Research on Accuracy of Aerial Triangulation (Results of Oberschwaben Tests)“ Ackermann, F.: „On Statistical Investigation into the Accuracy of Aerial Triangulation. The Test Project Oberschwaben“ – „Recherches statistiques sur la précision de l’aérotriangulation. Le champ d’essai Oberschwaben“– Belzner, H.: „The Planning. Establishing and Flying of the Test Field Oberschwaben“ – Stark, E.: Testblock Oberschwaben, Programme I. Results of Strip Adjustments“ – Ackermann, F.: „Testblock Oberschwaben, Program I. Results of Block-Adjustment by Independent Models“ – Ebner, H.: Comparison of Different Methods of Block Adjustment“ – Wiser, P.: „Propositions pour le traitement des erreurs non-accidentelles“– Camps, F.: „Résultats obtenus dans le cadre du project Oberschwaben 2A“ – Cunietti, M.; Vanossi, A.: „Etude statistique expérimentale des erreurs d’enchaînement des photogrammes“– Kupfer, G.: „Image Geometry as Obtained from Rheidt Test Area Photography“ – Förstner, R.: „The Signal-Field of Baustetten. A Short Report“ – Visser, J.; Leberl, F.; Kure, J.: „OEEPE Oberschwaben Reseau Investigations“ – Bauer, H.: „Compensation of Systematic Errors by Analytical Block Adjustment with Common Image Deformation Parameters.“ – Frankfurt a. M. 1973, 350 pages with 119 figures, 68 tables and 1 annex.

9 Beck, W.: „The Production of Topographic Maps at 1 : 10,000 by Photogrammetric Methods. – With statistical evaluations, reproductions, style sheet and sample fragments by Landesvermessungsamt Baden-Württemberg Stuttgart.“ – Frankfurt a. M. 1976, 89 pages with 10 figures, 20 tables and 20 annexes.

10 „Résultats complémentaires de l’essai d’«Oberriet» of the Commission C de l’OEEPE – Further Results of the Photogrammetric Tests of «Oberriet» of the Commission C of the OEEPE“ Hárry, H.: „Mesure de points de terrain non signalisés dans le champ d’essai d’«Oberriet» – Measurements of Non-Signalized Points in the Test Field «Oberriet» (Abstract)“ – Stickler, A.; Waldhäusl, P.: „Restitution graphique des points et des lignes non signalisés et leur comparaison avec des résultats de mesures sur le terrain dans le champ d’essai d’«Oberriet» – Graphical Plotting of Non-Signalized Points and Lines, and Comparison with Terrestrial Surveys in the Test Field «Oberriet»“ – Förstner, R.: „Résultats complémentaires des transformations de coordonnées de l’essai d’«Oberriet» de la Commission C de l’OEEPE – Further Results from Co-ordinate Transformations of the Test «Oberriet» of Commission C of the OEEPE“ – Schürer, K.: „Comparaison des distances d’«Oberriet» – Comparison of Distances of «Oberriet» (Abstract).“ – Frankfurt a. M. 1975, 158 pages with 22 figures and 26 tables.

11 „25 années de l’OEEPE“
Verlaine, R.: „25 années d’activité de l’OEEPE“ – „25 Years of OEEPE (Summary)“ – Baarda, W.: „Mathematical Models.“ – Frankfurt a. M. 1979, 104 pages with 22 figures.

12 Spiess, E.: „Revision of 1 : 25,000 Topographic Maps by Photogrammetric Methods.“ – Frankfurt a. M. 1985, 228 pages with 102 figures and 30 tables.

13 Timmerman, J.; Roos, P. A.; Schürer, K.; Förstner, R.: On the Accuracy of Photogrammetric Measurements of Buildings – Report on the Results of the Test “Dordrecht”, Carried out by Commission C of the OEEPE. – Frankfurt a. M. 1982, 144 pages with 14 figures and 36 tables.

14 Thompson C. N.: Test of Digitising Methods. – Frankfurt a. M. 1984, 120 pages with 38 figures and 18 tables.

15 Jaakkola, M.; Brindöpke, W.; Kölbl, O.; Noukka, P.: Optimal Emulsions for Large-Scale Mapping – Test of “Steinwedel” – Commission C of the OEEPE 1981–84. – Frankfurt a. M. 1985, 102 pages with 53 figures.

16 Waldhäusl, P.: Results of the Vienna Test of OEEPE Commission C. – Kölbl, O.: Photogrammetric Versus Terrestrial Town Survey. – Frankfurt a. M. 1986, 57 pages with 16 figures, 10 tables and 7 annexes.

17 Commission E of the OEEPE: Influences of Reproduction Techniques on the Identification of Topographic Details on Orthophotomaps. – Frankfurt a. M. 1986, 138 pages with 51 figures, 25 tables and 6 appendices.

18 Förstner, W.: Final Report on the Joint Test on Gross Error Detection of OEEPE and ISP WG III/1. – Frankfurt a. M. 1986, 97 pages with 27 tables and 20 figures.

19 Dowman, I. J.; Ducher, G.: Spacelab Metric Camera Experiment – Test of Image Accuracy. – Frankfurt a. M. 1987, 112 pages with 13 figures, 25 tables and 7 appendices.

20 Eichhorn, G.: Summary of Replies to Questionnaire on Land Information Systems – Commission V – Land Information Systems. – Frankfurt a. M. 1988, 129 pages with 49 tables and 1 annex.

21 Kölbl, O.: Proceedings of the Workshop on Cadastral Renovation – Ecole polytechnique fédérale, Lausanne, 9–11 September, 1987. – Frankfurt a. M. 1988, 337 pages with figures, tables and appendices.

22 Rollin, J.; Dowman, I. J.: Map Compilation and Revision in Developing Areas – Test of Large Format Camera Imagery. – Frankfurt a. M. 1988, 35 pages with 3 figures, 9 tables and 3 appendices.

23 Drummond, J. (ed.): Automatic Digitizing – A Report Submitted by a Working Group of Commission D (Photogrammetry and Cartography). – Frankfurt a. M. 1990, 224 pages with 85 figures, 6 tables and 6 appendices.

24 Ahokas, E.; Jaakkola, J.; Sotkas, P.: Interpretability of SPOT data for General Mapping. – Frankfurt a. M. 1990, 120 pages with 11 figures, 7 tables and 10 appendices.

25 Ducher, G.: Test on Orthophoto and Stereo-Orthophoto Accuracy. – Frankfurt a. M. 1991, 227 pages with 16 figures and 44 tables.

26 Dowman, I. J. (ed.): Test of Triangulation of SPOT Data – Frankfurt a. M. 1991, 206 pages with 67 figures, 52 tables and 3 appendices.

27 Newby, P. R. T.; Thompson, C. N. (ed.): Proceedings of the ISPRS and OEEPE Joint Workshop on Updating Digital Data by Photogrammetric Methods. – Frankfurt a. M. 1992, 278 pages with 79 figures, 10 tables and 2 appendices.

28 Koen, L. A.; Kölbl, O. (ed.): Proceedings of the OEEPE-Workshop on Data Quality in Land Information Systems, Apeldoorn, Netherlands, 4–6 September 1991. – Frankfurt a. M. 1992, 243 pages with 62 figures, 14 tables and 2 appendices.

29 Burman, H.; Torlegård, K.: Empirical Results of GPS – Supported Block Triangulation. – Frankfurt a. M. 1994, 86 pages with 5 figures, 3 tables and 8 appendices.

30 Gray, S. (ed.): Updating of Complex Topographic Databases. – Frankfurt a. M. 1995, 133 pages with 2 figures and 12 appendices.

31 Jaakkola, J.; Sarjakoski, T.: Experimental Test on Digital Aerial Triangulation. – Frankfurt a. M. 1996, 155 pages with 24 figures, 7 tables and 2 appendices.

32 Dowman, I. J.: The OEEPE GEOSAR Test of Geocoding ERS-1 SAR Data. – Frankfurt a. M. 1996, 126 pages with 5 figures, 2 tables and 2 appendices.

33 Kölbl, O.: Proceedings of the OEEPE-Workshop on Application of Digital Photogrammetric Workstations. – Frankfurt a. M. 1996, 453 pages with numerous figures and tables.

34 Blau, E.; Boochs, F.; Schulz, B.-S.: Digital Landscape Model for Europe (DLME). – Frankfurt a. M. 1997, 72 pages with 21 figures, 9 tables, 4 diagrams and 15 appendices.

35 Fuchs, C.; Gülch, E.; Förstner, W.: OEEPE Survey on 3D-City Models.
Heipke, C.; Eder, K.: Performance of Tie-Point Extraction in Automatic Aerial Triangulation. – Frankfurt a. M. 1998, 185 pages with 42 figures, 27 tables and 15 appendices.

36 Kirby, R. P.: Revision Measurement of Large Scale Topographic Data.
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