D8.7 Market Study and Exploitation Plan v2.0

DURAARK

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Executive summary

The DURAARK project has produced a large number of research outputs- in a range form software artefacts to knowledge, best practices and datasets. This outcome represents together a significant contribution to the ongoing efforts for securing long-term access to building data across a wide range of communities and disciplines. These are inherently linked and represented by the many disciplines, that are part of DURAARK.
The constant contact that the research consortium had to stakeholders and related research communities, allowed us to identify the best strategy for the outcome, to create a sustainable impact. The applied actions can be summarized in four areas:

- Further research through Community Building
- Further development through commercialisation
- Further use through Standardisation
- Establishment of a sustainable organisational framework

These actions guided the activities of Workpackage 8 and the whole consortium. The first version of this deliverable "D8.5 Market Study and Exploitation Plan v1.0" drafted the above mentioned strategies. This second version of the deliverable provides a further development and refinement and reports on the specific actions undertaken by the consortium. For these a special focus was set on the creation of a sustainable outcome of the software artefacts from DURAARK, which demonstrates the potential of the research in the best possible way to third parties and motivates pick-up and further development.
Notable examples of the success of this strategy are the DURAARK workbench prototype and the successful VOLVOX plug-in. Further community oriented activities, were the release of www.data.duraark.eu, a repository for all building related datasets, which were collected and created through the course of DURAARK. These datasets from real life practice fill a gap, as communities of stakeholders from professional and research practice, which were missing this type of data for test and evaluation purposes. With more than 403 GB of point cloud datasets and 298 IFC BIM models publicly available it contributes massively to Architectural, Engineering, Computer Science and other interested research and stakeholder communities.
Especially in year 3 DURAARK produced many tangible outcomes, which mad the desired engagement with commercial stakeholders and related researchers easier. DURAARK could raise the amount of associated Commercial companies, with whom we collaborate for instance in terms of evaluation and who express a desire for further research collaborations or commercialisation by 293% in comparison to Year2. DURAARK has furthermore ten active collaborations with 13 related research projects, which produced joint papers and new initiatives for research application.
The formation of the "Durable Building Data Association (DBD)" and the agreement of all partners on ways to manage the foreground of the DURAARK research after the

funding period, provide not only the organisational and legal framework, but means to maintain and enlarge the interested communities of researchers and practitioners, with whom DURAARK is currently in contact with.

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1 Introduction

The DURAARK project has produced a large number of research outputs- in form of software artefacts, over knowledge and best practice to datasets. This outcome represents together a significant contribution to the ongoing efforts for securing long-term access to building data across a wide range of communities and disciplines. These are inherently linked and represented by the many disciplines, that are part of DURAARK.

This deliverable describes the approach taken by the project to ensure that its outputs are adopted by stakeholders and the broader scientific community and how this approach has lowered barriers to on-going collaboration, availability and maintenance of the research outcome after the end of the project.

The previous deliverable D8.5, which was developed in the second year of DURAARK, identified the possible research outcomes and matched these to stakeholder groups. Linked markets were studied and described and exploitation and sustainability strategies discussed. This led to a plan to ensure the sustainability of the research outcome. The focus of this deliverable is given to how this was actually further developed, implemented and linked to the range of DURAARK research outcomes.

This deliverable reprises in this **first introductory section** the previously defined aims for sustainability and exploitation of the research outcome in subsection 2.2,the identified stakeholders with vested interest in subsection 2.1 and the Exploitation and Sustainability Strategy in section 2, which has been developed to make these pick-up and further the developments of the consortium .

The section 3 **Identified Exploitable outcomes of DURAARK and related Markets** matches the outcomes of the DURAARK consortium to stakeholders and the linked markets and explains the chosen exploitation strategy.

The following sections document the main efforts of the consortium to ensure sustainability of the outcome through **Software Sustainability activities**, section 4, **Standardisation activities** section 5 and **Community building and Commercialisation**, section 6. The section 7 **Organisational sustainability** illustrates the legal and organisational framework that was created by the partnership in order to continue the work and discussion started in the project. These efforts are organised through the foundation of the “Durable Building Data Association – DBD” linked with an application to the European Commission in order to start a thematically related COST network.

2 Exploitation and sustainability strategy

The partners in DURAARK shrive to sustain the results of the project by supporting long-lasting communities of practice in adopting and maintaining the research outcome. They have adopted the strategies described in this deliverable and committed to maintain the access to the research results for a minimum of five years after end of the funding period.

The activities in this third year of the DURAARK project focused on the assurance of high sustainability of the heterogeneous research outcome. For this we further developed the sustainability and exploitation strategy outlined in the previous Deliverable D8.5 "Market Study and Exploitation Plan V1". We revisited the stakeholder communities and the related markets in subsection 2.1 and updated the planning of the exploitation and sustainability actions in subsection 2.2, which led to three general approaches to employ. How and where we do so is explained in detail and on the level of specific research outcomes in the section 3.

2.1 Stakeholders

The groups of stakeholders that are addressed by the DURAARK project in terms of exploitation and sustainability have been described and analysed in depth in the previous deliverables D2.1 "Requirement Document", D6.1"Current state of 3D object digital preservation and gap-analysis report" and the previous version of this document D8.5 "Market Study and Exploitation Plan V1". This knowlegde was furthered through Deliverable D7.1 "Current state of 3D object processing in architectural research and practice", D7.2 " SME Use Case - Design and Retrofitting" and "D7.3 Use case long term Archiving", which all investigated the stakeholders processes with building-related information. This in depth knowledge, which was acquired through the ongoing exchange of the project partners with stakeholders and communities in an international context is the base of the sustainability and exploitation actions described in this document.

In the beginning of the research period the following stakeholders have been identified as groups, that are interested in the pick-up and further use of outcomes of DURAARK:

1. Architects and engineers
2. Construction companies

3. Building owners and real estate managers
4. Suppliers of software and IT services for building industry and facility managers
5. Public administrations/ Public planning / Policy makers
6. Knowledge base maintainers
7. Researchers and lawyers
8. Cultural heritage institutions
9. Research communities in areas such as digital preservation, building information modelling and semantic web/linked data

What was challenging for the management of the outcome of DURAARK in year 3, was that the stakeholder communities are not homogeneous consumers of tools. They consist in themselves of large groups, with different preferences for the exploitation of the outcomes of DURAARK. The consideration of these subgroups within stakeholder communities is important for the sustainability of the research outcomes:

- **users** of software or services want typically finished products with guaranteed productivity.
- **developers or communities** creating software or services within the stakeholder group are typically interested in picking up software on component level, when it is well documented and has credentials.
- **companies** developing software or services for the stakeholder group pick-up software libraries or research approaches described in papers, if they seem beneficial and the licensing situation is defined.
- **researchers** from related fields, such as Computer Science, who pursue research in the area of the stakeholder, pick-up research outcomes, if they seem relevant, beneficial, novel and well documented.

Considering that the DURAARK stakeholders, who are addressed by DURAARK developments, are not only placed across the whole spectrum of the building industry (pos. 1-4 in the list above), but as well in disciplines, which are at best peripherally linked to the profession, thoughtful planning of the exploitation actions is required. The aim of

DURAARK is furthermore not to develop finished products, but at the most prototypical implementations. The overall aim is to trigger adoption and further development of research results. We discuss therefore in section 3 the maturity of each developed artefact and dataset in relation to possible stakeholder communities and propose one of the developed exploitation and sustainability approaches.

2.2 Planning for exploitation & sustainability

As the funding of DURAARK is not aiming at the creation of developed products, the sustainability and exploitation strategy has to target stakeholders and related communities, which are able to pick-up and continue the developed research - ideally towards product maturity.
According to D8.5 the main aim concerning exploitation and sustainability can be grouped in these main areas:

- providing long-term access to DURAARK results
- stimulate take-up and reuse of DURAARK results
- enabling third parties to benefit from DURAARK results
- growing the user base and the community built around the DURAARK project
- providing DURAARK results as a foundation for business models (from third parties or consortia)

The success of these exploitation and sustainability tasks for DURAARK outcome is depending on the observation of a number of complementary approaches. We have found five principles, whose application onto specific project outputs informs the sustainability actions.

1. **Quality**
   Ensuring that project outputs conform to standards-driven quality assurance.
2. **Visibility**
   Providing integrated outreach to multiple audiences to maximise discoverability.
3. **Documentation**
   Enabling pick-up through good documentation of code and context.

4. **Open licensing**
   Using open licences to encourage the adoption and reuse of project outputs.

5. **Community integration**
   Integrating project outputs into commercial and non-commercial products, services and ongoing developments of communities.

2.2.1 Quality

Quality ensures the development of project outputs in line with the needs of stakeholder communities. The consortium has been striving throughout the whole project period to ensure a high quality of output in terms of precision, relevance, quality and utility. All research output has therefore been thoroughly evaluated. The report of this process is found in deliverable D7.4 Evaluation.

2.2.2 Visibility

Visibility ensures the provision of appropriate information for different audiences to support discovery and take-up of project outputs. This approach is aligned with the dissemination effort undertaken during the lifetime of the project and includes offline and online media. The related dissemination tools and their impact in this year are described in the Deliverable D8.8 *Dissemination report Year 3*. Several complementary activities implement this:

- ensuring outputs address explicit and well-defined audience needs;
- publishing outputs using open infrastructure;
- designing for good user experience (information architecture, interaction and visual design).

2.2.3 Documentation

Stakeholders will only pick-up research outcomes, if sufficient documentation is provided for implementation and further development. DURAARK has implemented standards and procedures to ensure code quality and reported on this in Deliverable D1.6 Quality Assurance & Risk Management Plan v3. The ability to integrate research results was

subject to the evaluation activities in D7.4, where i.e. the ease of implementation of major software components was measured.

2.2.4 Open licensing

All DURAARK outputs, including software and non-software, will be released under open licenses to encourage their adoption, reuse, and the contribution of further enhancements back to the community where possible by encouraging derivative works to be made available under similar licensing conditions (although this will not prevent commercial integration and further development remaining privileged).

2.2.5 Community integration

Internal and external stakeholders will be encouraged to collaborate on development and sustainability, through various approaches designed to deliver efficiency and consistency. Founding the "Durable Building Data Association – DBD" and linking it with an application to the European Commission to start a thematically related COST network is a further means to attract, interest and bind communities around DURAARK outcomes.

2.3 Exploitation & sustainability actions

Following the above mentioned aims and objectives, the exit and sustainability strategy of the project focused on how to keep the outcomes of the project alive for the next five years and beyond, increase the user base and set forth a structured approach that will enable researchers and other stakeholders interested in further expanding the research in the area. For this purpose the DURAARK consortium has developed further the exploitation approaches from D8.5 into three main directions. Each of these represents an action, that shall ensure further development and use of research outcome.

- Further research through Community Building - section 6
- Further development through commercialisation - section 6
- Further use through Standardisation - section 5
- Establishment of a sustainable organisational framework - section 7

The actions are not mutually exclusive. They give a main direction when applied to each of the research outcomes.

2.3.1 Further research through Community Building

Research output, which is ready for further development or is in itself a resource for further research, such as datasets and reports, is best picked up, when it becomes part of a vivid community. Disseminating it with low hurdles in terms of licensing, a good documentation and credentials through prototypical implementations and extensive evaluation motivate communities to pick-up research ideas, concepts and artefacts. Communities exist around established platforms like GitHub or Grasshopper3d and attract pick-up of the data.The foundation of the "Durable Building Data Association – DBD" and the application for a related COST action at the European Commission are steps to keep the consortium together after the end of the project and to attract further interested partners.
The DURAARK consortium has decided unanimously to provide the research output for free to the scientific community, release only open source code and put all research reports online. Wherever possible well frequented dissemination platforms are used. DURAARK establishes furthermore it own channels, as through data.duraark.eu, which allows a single entry to all software and dataset related research output of DURAARK.

2.3.2 Further development through commercialisation

Near to application level research can find further development in collaboration with stakeholder. The have to be identified among the Stakeholder communities (see Section 2.1) and ideally convinced for a further collaborative development within and beyond the runtime of the project. The dissemination activities in WP8 and the strong linkage, that WP7 has developed through exchange and collaboration to many stakeholders has succeeded in documented intention to further the research in joint projects.

2.3.3 Further use through standardisation

Research results, which are met by an unambigious consent of communities can become standards. Standardization is seen as the ultimate way to create a sustainable

impact on stakeholder communities. Within DURAARK we have successfully started standardisation processes, which are reported on in the section **Standardisation activities**5.

2.3.4 Establishment of a sustainable organisational framework

Following and furthering the use and development of the DURAARK research outcomes necessitates a solid organisation to allow for continued communication, monitoring and decision making within the partnership.

3 Exploitable outcomes of DURAARK & relation to markets and sustainability actions

The exploitable outcomes from the DURAARK project is composed of[1],

- Knowledge and best practices (in the form of reports and publications)
- Software artefacts and tools with prototypical implementations
- Extensive datasets from practice

As a research project DURAARK has created a multitude of content, see Figure 1, all of it digital. Outcomes are not solely the prototypes, which are the main subject of the Deliverables, but as well tools and techniques, which were eventually only intended for project-internal use. This section asks: what has been produced that has value outside the project and after the project has finished?
This chapter is matching the outcome, which is related to several disciplines, to the key stakeholders and their related market situations, these are described first. The following chapter reasons which of the introduced Exploitation and sustainability strategies, see section 2 will be applied for each outcome.

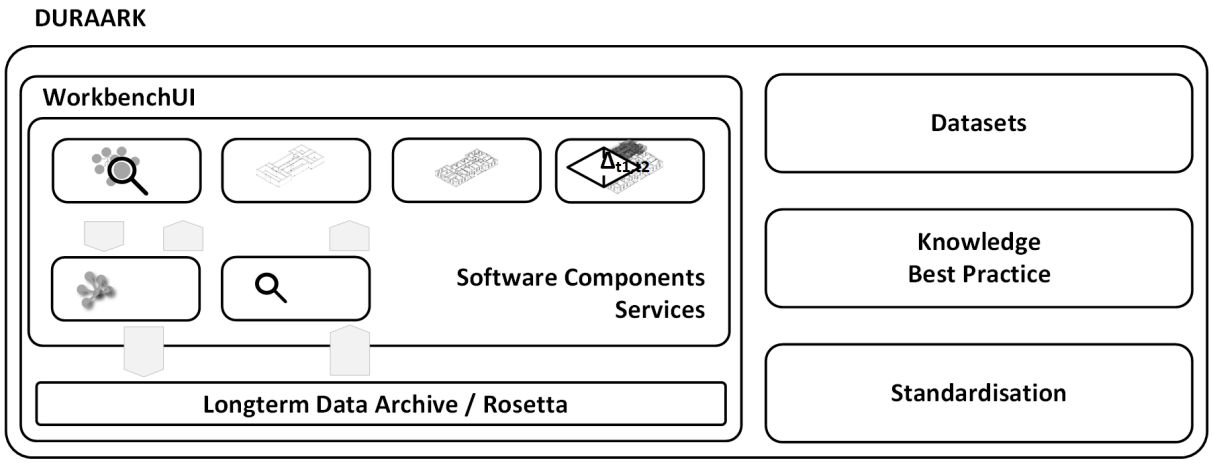


Figure 1: Overview of principal research outcomes created in Duraark.

[1] As defined in the IPR Management Plan (deliverable D1.7)

3.1 Overall market situation

This section provides an update to the overall market situation, which was described in Deliverable D8.5. We can conduct the markets of the stakeholders with vested interest in DURAARK research outcomes, as BIM and Digital Asset Management Market, are growing. Combined with the increasing proliferation of laser scanning and related technologies a demand for long-terms storage and modes to connect data models is already exsiting and can be expected to grow. The market for cultural heritage was described in D7.3.

The stakeholders of DURAARK will typically be users of modern forms of digital storage for architectural data. The main inputs for the workflow are open BIM (IFC) and/or point cloud files (E57). Included in the workflow is a tool to convert a laser scan set (E57) to a simplified model in IFC format. This means that the size of the markets for BIM and laser scanning products/services are the most relevant when estimating the market demand for DURAARK. Another related market is the market for Long Term Digital Storage (LTDS).

3.1.1 Size of BIM related market and focus on BIM for Facility Management

The increase of size and importance of BIM related markets, has been subject of a large number of studies. These describe the adoption of (open) BIM have been made available in the last few years. Here is a selection describing a few of the biggest markets.

Situation in the UK market An interesting source of information about the market situation related to BIM in the UK is the report series "National BIM report".[2] The most recent at the time of writing is the 2015 version. The series looks at how UK building design professionals are adapting to the use of BIM. Results suggest we are now reaching a stage where BIM is becoming the norm among stakeholders in most markets. We can read about increased used of openBIM in the UK and a push for use of collaborative BIM in governmental projects in the UK. [3]

[2] NBS national BIM report 2015: http://www.thenbs.com/pdfs/NBS-National-BIM-Report-2015.pdf

[3] http://www.bre.co.uk/enews/bre/bsUKI/bsUKI_aug14.html

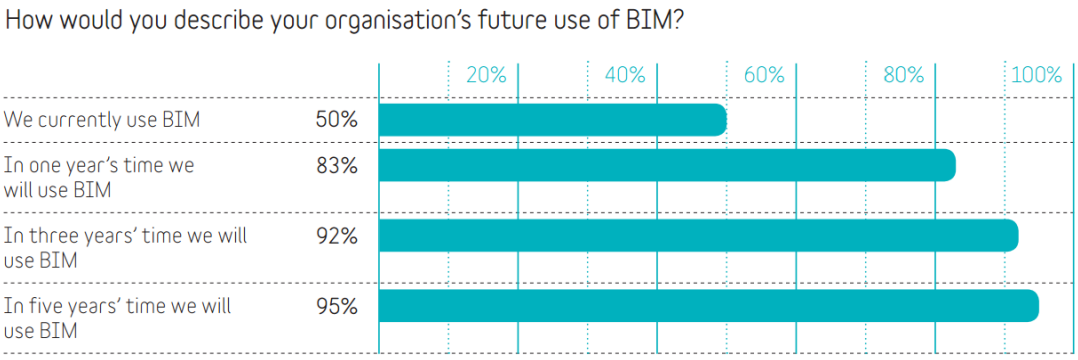


Figure 2: When will respondents in the UK start to use BIM. Source: National BIM Survey 2015

The 2015 edition of the national BIM report indicate that the awareness of BIM is strongly growing.

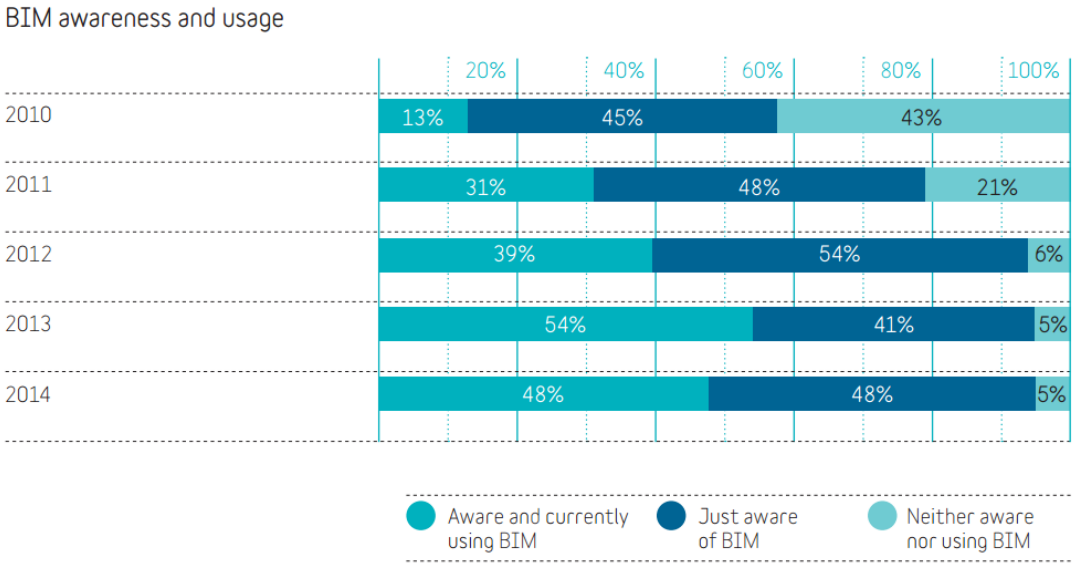


Figure 3: BIM awereness timeline. Source: National BIM Survey 2015

From 2012 to 2014 the percentage of respondents who have used IFC rose from 39 to 49 percent.

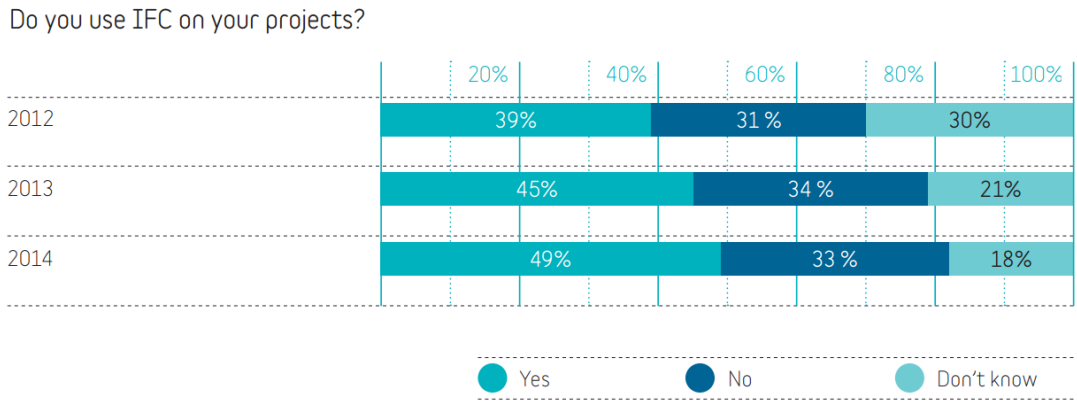


Figure 4: Share of respondets that use IFC. Source: National BIM Survey 2015

In comparison Cobie[4] usage does not see the same increase.

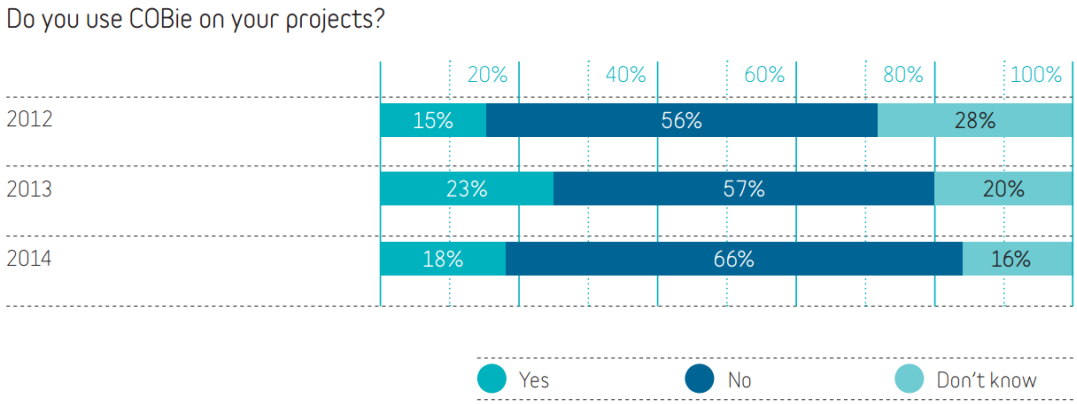


Figure 5: Share of respondents that use Cobie. Source: National BIM Survey 2015

Size of the BIM related market in Canada

Included with the 2013 edition of National BIM report[5] was a study for the Canadian market. The template was the third National BIM Survey (NBS) and it was modified slightly for the Canadian market. It was carried out between February and March 2013, 78 people from a range of disciplines and company types responded. Quoting from the report:

"BIM activity: Today, 66% of respondents indicated that they currently use BIM. A high percentage of respondents indicated that they are hearing more about BIM and believe

[4] https://en.wikipedia.org/wiki/COBie

[5] http://www.buildingsmart.no/sites/buildingsmart.no/files/nbs-international-bim-report_2013.pdf

BIM is the future of project information, and 97% believe that they will be using BIM in five years. With regard to the success of BIM (in today's environments and tools), more than half feel that there is not enough good information yet about what BIM really is. Only 24% of respondents believe what they hear about BIM, and 10% believe that BIM is just a synonym for 3D CAD. The fact that 26% of respondents feel that models only work in the software they were built on suggests that BIM 'silos' are still common. Silos are two or more software applications, collaborating to communicate between themselves – to the exclusion of others. There is still a great deal of distrust that two or more software programs can successfully exchange BIM data. This is confirmed in a later question where only 52% of respondents reported exporting their data to an open format". We actually think that this is a relativly high number and indidates that the position for open BIM is quite strong in Canada.

Situation in the German market

Frauenhofer recently made available a market study[6] (in German). The study is recent, data was gathered in March and April 2015, and is based on the input from 378 persons. It indicates that the position for open BIM is currently not as evolved in Germany as it is in the Nordic countries or in the UK. When asked, in what formats exchange of planning data was carried out between project participants, 87% of the participants exchanged, often or always, the formats .dwg or .dxf. 2.6% of respondents frequently exchange planning data with the exchange format IFC (Industry Foundation Classes) 72.5% never use the IFC format.

However, it seems that a large share of the respondents were not into modern design and collaboration tools since every fifth respondent had not heard about BIM. Other studies (below) indicate that the larger European countries are slow at adopting BIM, the exception being UK.

Situation in the North American market "The Business Value of BIM in North America"[7] is a market study from McGraw Hill. The subtitle is Multi-Year Trend Analysis and User Ratings (2007-2012). It report that in 2008 the adaption of BIM was 28%,

[6] Franuenhofer market study: http://www.detail.de/fileadmin/uploads/BIM-Studie_CKH__150706.pdf

[7] http://www.bimformasonry.org/pdf/the-business-value-of-bim-in-north-america.pdf

5 years later it had grown to 71%. It states that 90% of large and medium-to-large organizations were engaged with BIM, compared to 49% of small ones.

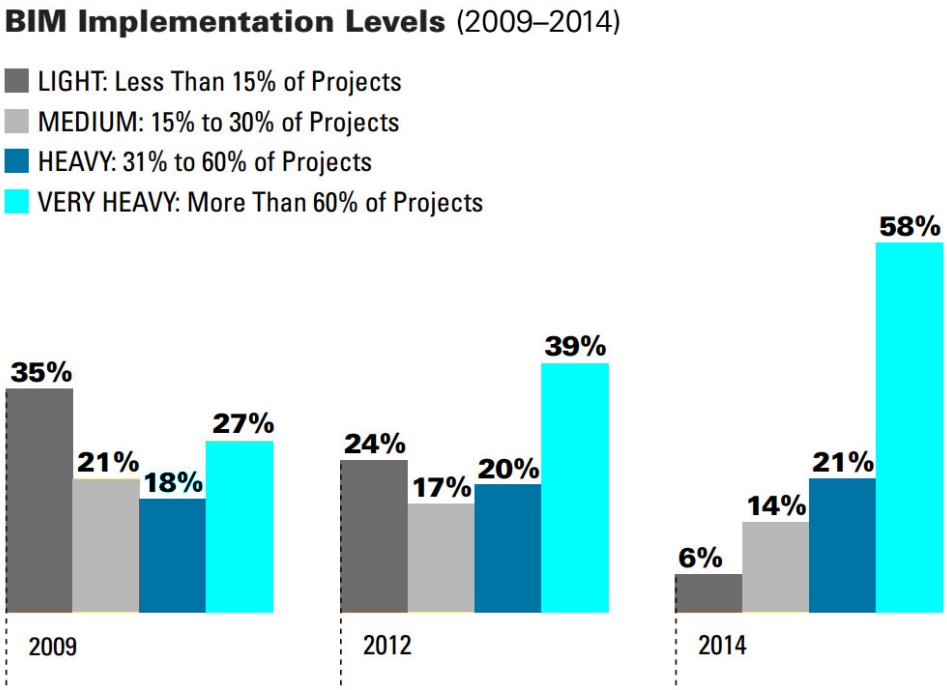


Figure 6: **BIM-implementation in North America.**

Figure 6 by McGraw-Hill from 2012 [8] indicates the massive shift towards BIM technologies and processes in the building industry in the last five years. More than 60% of companies are using now BIM for the dominant part of their projects. A number, which might even be higher in markets, such as Scandinavia, where BIM was made mandatory by government decree already in 2006 (see D7.1).

Situation in the Chinese market The size of the Chinese economy makes it an interesting market. The growth rate has been reduced in the last few years,[9] but China is still a growing economy.

Plans exist for national BIM standard in China in 2016.[10] There is a popular website[11]

[8] http://www.bimformasonry.org/pdf/the-business-value-of-bim-in-north-america.pdf
[9] http://data.worldbank.org/country/china
[10] http://planet.vectorworks.net/2014/09/promoting-national-bim-standards-in-china/
[11] http://chinabim.com/

dedicated to BIM in China, naturally in Chinese language – but it seems to translate well using Google Translate. There is also an article[12] available on the website indicating that moving towards open BIM has governmental support, but it will take time.

Situation in the Indian market

The state of BIM adaption in India is the topic of this conference proceeding[13]. It was carried out in 2014, and was based on the input from 400 respondents. It indicated that the degree of BIM usage was lower in India (estimated to be 22%, but this estimate might have an upward bias) than in economically more developed countries.

Comparison of the BIM adaption across different countries Juszczyk et al [14] presents meta-study with comparison of different countries/regions BIM adaption. The study indicates that North America has a larger degree of BIM adaption than Europe, but it did not differentiate between open BIM (IFC) and proprietary BIM.

[12] Chinesearticle:http://www.chinabim.com/school/knowledge/standard/2014-08-18/6669.html

[13] https://www.fig.net/resources/proceedings/fig_proceedings/fig2014/ppt/ss36/ss36_kavanagh_7434.pdf

[14] http://2015.creative-construction-conference.com/CCC2015_proceedings/CCC2015_79_Juszczyk.pdf

Regions / Countries	Year	Rate of overall BIM adoption
North America (including the USA and Canada)	2012	72%
South Korea	2012	58%
India	2014	22%
The Middle East	2011	25%
Australia	2012	19%
New Zealand	2012	34%
Western Europe (average)	2010	36%
Countries of Western Europe (variations):		
France	2010	38%
Germany	2010	36%
The United Kingdom	2010	35%

Figure 7: Metastudy BIM adaption worldwide.

The source for Figure 7 are the proceedings [15] to the Creative Construction Conference 2015 in Poland.

The market adoption is however driven by governmental policies, as an examination by Autodesk shows (Figure 8). It can be expected, that markest with a low BIM adoption will grow exponentially, when either their governments enforce BIM policies or the specific markets try to catch up with other countries increased efficiency due to BIM.

[15] https://www.fig.net/resources/proceedings/fig_proceedings/fig2014/ppt/ss36/ss36_kavanagh_7434.pdf

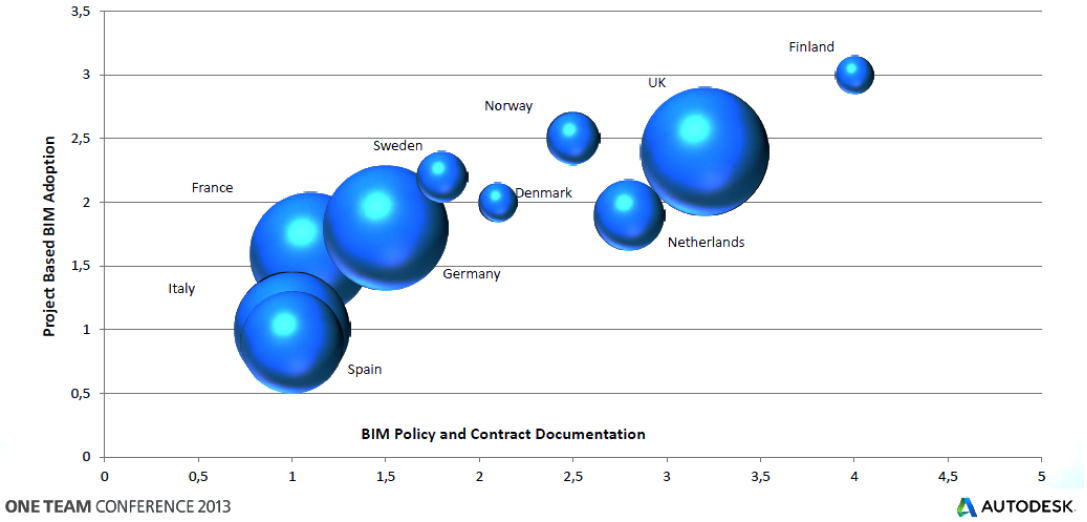


Figure 8: BIM Policy stage by adoption rating EMEA / Different governments bim policy requirements.

The source for Figure 8 is an Autodesk presentation at the One Team conference[16] in 2013.

The increase of the BIM market necessitates tools and techniques to create interoperability between the different data models used by stakeholders. Several resources highlight that problems with interoperability with a group of stakeholders using BIM is a major obstacle to unleash the full productivity of the technology [13] [12] [11].

The DURAARK deliverable D7.3 reported similar notions for the interoperability with in the digital chain from the production to the operation of a building. To transfer and maintain the knowledge encaspulated in BIM is a major obstacle and provides a market for DURAARK developments.

The D7.3 concluded as well, that Facility Management is the area with the most interest in the longterm access of BIM files. The Facility market is hence one of the most important field within the BIM sector for the general DURAARK outcome and is described here in short:

According to the report “Facility Management Market by Solutions (CAFM, IWMS,

[16]http://www.nti.dk/media/1289410/nti-april2013-final.pdf

CMMS, BIM, IWMS) & Services – Worldwide Market Forecasts and Analysis (2014-2019),"[17] infrastructural development and technological advancements are the primary factors driving the growth for the facility management market.

The requirements of facility management have increased tremendously during the recent years. Among those are the demands to save energy and capital spent on buildings, which have commonly been tackled through the implementation of computerized support. However, growing numbers of computerized elements inevitable lead to more demanding facility management operations [7]. Hence, the **role and outreach of FM systems increases**, and is being paralleled by a growing need for precision within the systems.

This precision can help to accomplish the demands for more energy efficient buildings, where BIM implemented in FM systems has also shown a substantial gain in performance, and significant energy savings of 75% could be accomplished in a period over just three years [10].

The quality of FM systems depends, however, on the underlying data models and their content. As this information does not exist for many existing buildings, it has to be generated and then fed into FM systems to enable FM processes. Current data input methods applied for conventional Computerized Maintenance and Management Systems (CMMS) are prone to duplicate information entries and to information loss [10]. Intelligent and interoperable tools and techniques which fully expel manual data entry and retrieval work are hence in high demand and the transfer or even **link of FM data with BIM is considered a logical and necessary step** towards this aim [3] [1] [8] [9] [2].

3.1.2 Size of the laser scanning market

The size of the point cloud market is growing, which can be read in the increase of sales and growth of the companies that produce laser scanning. We found this quote, stating that the leading producer of 3d laser scanners "had a track record of growth for a number of years. From 2009 to 2014, Faro was growing at 18 percent per year." [18]. This is supporting our strong impression that the laser scanning market is growing quickly.

[17] http://www.marketsandmarkets.com/Market-Reports/facilities-management-market-1030.html

[18] http://www.bizjournals.com/orlando/news/2015/11/19/faro-technologies-ceo-talks-layoffs-challenges-and.html?ana=yahoo

A market study[19] that looks at laser scanning, independent of industry, predicts that the total market size will grow to usd 7.7 billion by 2018, and at that time having a 47.9 percent compound annual growth rate(CAGR).[20]

The afore mentioned market study states furthermore, that "It was concluded that North America will remain the chief market for the technology, yet Europe will see rapid expansion, with the region expected to have a CAGR of 43.2 percent and could account for more than one-third of the global market by 2018."
Studies point however at a significant lack of automatisation in the creation of data from 3d scanning for stakeholder workflows. Hullo and Thibault [6] describe for instance, that more than 90% of the effort with 3d scanning goes into the refinement and extraction of information from the data. Any technology, that reduces this amount of mostly manual work by experts will have great chances on the market.

3.1.3 Size of the Long Term Digital Storage market

The Long Term Digital Storage market is sometimes referred to as the "Digital Asset Management Market". Although this relates to many forms of digital assets, not only architectural, it is very large and expected[21] to be growing in the near future. The storage of architectural information is a part of that. Matching aspects are hence the technical, practical and economical consequences of physically storing the data. IFC models can be moderately large, but to work with them practically the larger ones are usually not much bigger than 500 MB. Laser scan sets can be much larger, and several of laser scan datasets we have been using in DURAARK are larger than 25 GB. Fortunately the capacity and unit costs for storage has been continually improving [22].

[19] http://www.smartgeometrics.com/blog/surveyors/3d-laser-scanning-modeling-market-expanding/
[20] Definition of CAGR: http://www.investopedia.com/terms/c/cagr.asp
[21] link: http://www.prnewswire.com/news-releases/digital-asset-management-dam-market-worth-412-billion-by-2019-293809471.html
[22] http://www.forbes.com/sites/tomcoughlin/2014/06/29/keeping-data-for-a-long-time/

3.2 Software components and services

This section concisely describes the software components and services (artefacts) which were implemented during the course of the DURAARK project. The artefacts are related to the potential stakeholders and communities we are addressing. Moreover, we discuss the readiness of the artefacts in terms of their usage as a product. For each artefact the market situation is shown, together with the envisioned exploitation direction (i.e. community oriented, commercial oriented, standardization effort).
The text is partly an update of the version presented in D8.5, Section 2.2.

3.2.1 WorkbenchUI

Stakeholder Communities:	**Building owners and real estate managers** **Public administrations/Public planning/** **Policy makers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The WorkbenchUI serves as the reference implementation for accessing the functionality developed in DURAARK via a graphical user interface. The WorkbenchUI is a web application that runs in a browser either locally on the stakeholders computer, or as web service in a private or public cloud.
The functionality of the WorkbenchUI is divided into two main areas: the Pre-ingest and the Retrieval workflow. With the pre-ingest workflow a stakeholder can pre-ingest building data into a long-term archival system (i.e. ExLibris Rosetta). The WorkbenchUI provides the following steps within the workflow:

Create Building Session A new building session is created that serves as a container for the data that is created during the pre-ingest workflow. BIM models as IFC files and point clouds as E57 files can be uploaded into this session via the GUI.

Manipulate Metadata Metadata gets extracted from the uploaded files and can be manipulated by the stakeholder.

Geometric Enrichment The WorkbenchUI provides the tools IFC Reconstruction, Detect Power Lines and Difference Detection which allow a stakeholder to add geometric enrichments to the files in the session.

Semantic Enrichment Via the GUI semantic information of different topics can be added and browsed through for the building in the session.

Digital Preservation The uploaded 3D files, metadata, semantic and geometric enrichments available in the session can either be ingested into the Rosetta DPS or they can be downloaded as a BagIt file to the local harddisk.

The retrieval workflow allows stakeholders to search the archive for buildings in a) utilizing the developed metadata schema and b) in comprising the semantic enrichments gathered in the pre-ingest workflow. This combination allows for complex queries to satisfy the needs of the stakeholder group.
The functionality behind the steps listed above is provided by the *Service Platform*. A detailed description of the WorkbenchUI can be found in D2.5.
As a reference and show-case implementation of DURAARKs functionality the WorkbenchUI is addressing all of the stakeholders described in D2.2.1. The target audience for future development are both, the scientific research community and commercially oriented stakeholders. The WorkbenchUI consists of UI-modules which can be used and developed independently of each other. This has the advantage that researchers and commercial companies alike can choose which parts are interesting for them and develop them further. This modular approach in combination with the open source development on Github[23] will help to attract future collaborative development for the WorkbenchUI.
Market situation: From a market perspective the Workbench and Service Platform (next section) can be seen as one system. The following comments relate to the core system (the subcomponents are commented separately). They glue the components of DURAARK together and present them to the user based on an integrated workflow. The best commercial possibility for the WorkbenchUI & Service Platform would be a company that provide LTDA software and/or service decides to use it as a basis for their solution. The evaluation in D7.4 shows that the WorkbenchUI and Service Platform is very flexible and powerful and that will provide a flying start for those who decides to base their business on it.

[23] https://GitHub.com/duraark

Conclusion

The workbench is prototypical and addresses many stakeholders. A clear identification of a single market is difficult. Special efforts were put in place in year 3 in order to demonstrate the potential of the workbench in terms of functionality and technological base, ref section 4.

3.2.2 Service Platform

Stakeholder Communities:	**Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The Service Platform is a service oriented layer which provides a web-based application programming interface (API) to access its functionality. The platform consists of five services, which group together related software components developed in the project. For stakeholders it is possible to pick a single or multiple service(s) to use distinct functionality which was developed in DURAARK. It is not necessary to use the complete Service Platform. This modularity allows DURAARK to be integrated into the workflows and applications of stakeholders in a flexible way. Providing DURAARK's functionality via a web-based API further enhances this flexibility, as the API can be generically accessed from all major programming languages.

As the Service Platform is providing functionality comprised of all components it is addressing all stakeholders defined in D2.2.1. A more distinct differentiation on which component is targeted for which stakeholder is available in this section in the description of the different components themselves.

The Service Platform provides a technological basis for projects in the AEC/BIM domain. DURAARK has contributed the infrastructure for working on BIM and point cloud files, edit metadata and add geometric and semantic enrichments before persisting the data into a long-term preservation system. Each functionality is modularized on a service

level, which can be accessed via a web-based API and on a component level, which means that most of the components can also be directly used via their command line interface. This architecture allows future projects to contribute to the existing functionality on different layers, where each layer boundary is strictly defined. Together with the open source nature of the project and the provided documentation the Service Platform forms a sound research platform for external parties to add functionality to or use or extend the existing one. The components and services developed within the DURAARK project already provide sophisticated functionality in the domain and at the same time serve as examples on how to utilize the Service Platform to integrate new functionality.

The service platform is using state-of-the-art web technologies to serve DURAARK's functionality via its web-based API. The deployment uses the Docker[24] containerization technology, which is an open platform for distributed applications. The Docker-based deployment allows for robust deployments of the system in private and public clouds or at stakeholder premises and makes it very easy for developers to test the system. Docker is a cross-platform system, where Linux and Mac were first class citizens from the beginning on. Therefore, we consider the Service Platform itself as stable and scalable when used on Linux and Mac systems. On Windows the Service Platform is working, the installation robustness of the Docker pre-requisite has to be improved, though. The Docker team is heavily working on making the Windows support rock-solid, we expect to have a more robust installation experience in the next six months. The robustness of the installation of the Service Platform is therefore determined by the robustness of the Docker support on Windows.

Conclusion

The Service Platform has its biggest potential in using it as a research platform in the AEC/BIM domain, were research groups can contribute new technology in the field to a coherent platform to extend its functionality. We also see potential for commercialisation, where companies can use (parts of) the open source services and components and carve a product out of the current state. The "Durable Building Data Association – DBD" will serve as a contact point for commercial companies, as well as for research facilities, to utilize the platform for commercial or research oriented future work.

[24] https://www.docker.com/

The following services are available and list the components which are powering the services[25]. The components are described in the remainder of this section. A more detailed description of the Service Plaform can be found in D2.5. The most relevant outcomes are described separately below.

duraark-metadata

The duraark-metadata service extracts metadata from BIM models (IFC format) and point clouds (E57 format). The actual extraction is done by *pyIfcExtract* (subsubsection 3.2.7) and *E57Extract* (subsubsection 3.2.8).

duraark-semanticenrichment

The duraark-semanticenrichment service provides an API for querying the data collected in the pre-ingest workflow to search for buildings and it allows to enrich buildings with context-aware semantic information. The service is powered by *SDAS* (subsubsection 3.2.4) and *Focused Crawler* (subsubsection 3.2.5) components.

duraark-geometricenrichment

The duraark-geometricenrichment service provides a toolset that allows to reconstruct a BIM model (as IFC file) from a point cloud, detect hidden power lines from a point cloud with panorama images and also allows to detect differences between point cloud and point cloud and point clouds and BIM model. The responsible components are *pc2bim* (subsubsection 3.2.13), *RISE* (subsubsection 3.2.15), and a combination of components for the *difference detection* (subsubsection 3.2.14).

duraark-digitalpreservation

The duraark-digitalpreservation service is responsible for storing the data in a building session into a long-term preservation system, which is Rosetta in our case. It also allows to download the session data to your local harddrive. The components used in this service are *sip-generator* (subsubsection 3.2.12) for creating a Rosetta-compliant SIP and *rosetta-connector* (subsubsection 3.2.12) for ingesting a SIP into Rosetta and for retrieving files back from the archive.

[25]The "duraark-sessions" service is omitted here, as it is only responsible for holding the session state.

3.2.3 Duraark point cloud viewer

Stakeholder Communities:	**Suppliers of software and IT services**
	Research communities
Sustainability Strategy:	**Further research through Community Building**

3D viewer for E57 files (including viewing and data API). It is based on Potree, a three.js backed point cloud viewer.

Conclusion

The point cloud viewer is an adaptation of an existing open source tool. It demonstrates the potential for web based point cloud visualisation and will be disseminated as a demonstrator of this to communities of developers via GitHub. The repository for the source code is `https://GitHub.com/DURAARK/duraark-pointcloud-viewer`.

3.2.4 SDAS: Storage & Retrieval

Stakeholder Communities:	**Architects and engineers**
	Suppliers of software and IT services
	Public administrations/Public planning/
	Policy makers
	Knowledge base maintainers
	Cultural heritage institutions
	Research communities
Sustainability Strategy:	**Further research through Community Building**

In this section, the main functionalities of the Semantic Digital Archive Storage (SDAS) within the DURAARK system are described. The SDAS serves as central storage for all semantic and geometric metadata within DURAARK, and as such, contains a continuously growing *knowledge graph* of buildings, their digital models and their context, where the latter covers geometric information as well as semantic information about, for instance, the

geographic, historic or legal context. Data within the SDAS can be roughly categorised into the following three categories:

1. **Primary metadata of digital objects and physical assets:** the SDAS serves as a repository of metadata describing the physical assets (buildings) and their context themselves as well as the data object representing them. As such, it is an index and catalogue providing information about the buildings preserved in the DURAARK system as a Linked Data set.

2. **Geometric metadata:** the SDAS captures some baseline geometric information about the shapes and structures captured by the described digital assets, as provided by WP3, WP4 and WP5.

3. **Semantic enrichments:** targeted crawls retrieve related background knowledge from the Linked Data graph about data captured in the SDAS. This includes specifically data further describing the geographic, environmental or structural context of the captured physical assets. Cross-domain reference graphs such as DBpedia and Freebase are used together with more focused datasets with clear temporal or regional focus. While external datasets evolve, crawling is the method of choice for capturing related information within the SDAS.

Schema

Each of the categories described above adheres to a different schema. While the first category (*base metadata for digital and physical assets*) is expressed using a well-defined vocabulary, namely the *buildM* schema introduced in D6.2, the *semantic enrichments*, i.e. crawled context graphs are following arbitrary vocabularies used in their source datasets, for instance, the DBpedia ontology[26] or the Geonames ontology[27].
The *buildM* schema, a central vocabulary for annotating digital models and physical structures, primarily describes the concepts *Digital Object*[28] and *Physical Asset*[29], where suitable vocabulary terms are derived from a number of existing vocabularies (see D6.2). As such, the population of *buildM* instances defines the core of the SDAS and serves as central registry of buildings and their digital models, which are further enriched with

[26] http://dbpedia.org/ontology/
[27] http://www.geonames.org/ontology
[28] http://data.duraark.eu/vocab/buildm/DigitalObject
[29] http://data.duraark.eu/vocab/buildm/PhysicalAsset

contextual background knowledge from our focused crawling/enrichment functionalities. The overall combination of a set of *buildM* instances describing a particular asset and their corresponding context graphs (crawls) is referred to as *buildM+* (D6.2).

Implementation

The SDAS prototype implementation is based on a *triple store*, i.e. a NoSQL graph database for RDF data[30]. Specifically, due to its performance and scalability, the SDAS uses the OpenLink Virtuoso [31] triple store as the database backbone for the SDAS. It provides a mechanism for persistent storage and access of RDF graphs. The triple store supports RDF data serializations such as RDF/XML as well as N3/N-triples.
The SDAS is being populated primarily with data produced by the metadata extraction and geometric/semantic enrichment components provided by the project. Data can be divided in the following categories: (a) buildM instances, i.e. metadata of digital objects or physical assets, including geometric features and (b) semantic enrichments in the form of focused crawls, which describe additional contextual knowledge about a building or structure. A dedicated API has been provided, which allows the versioning of instances in the SDAS and simplifies the communication between workbench and SDAS, specifically when updating or adding instances in the SDAS. In addition, the DURAARK WorkbenchUI provides a GUI to manually configure crawls for enriching data in the SDAS. The crawling process is initiated by first providing a seed list that encodes the *information need*. The seed list is in the form of entity URIs, usually coming from publicly available knowledge bases (i.e. DBpedia). The crawler is triggered through the APIs described in the following section.

Querying the SDAS

The data stored in the SDAS can be queried using the following SPARQL endpoint: `http://data.duraark.eu/sparql`. The SPARQL endpoint is exposed both as visual web interface and as a REST API, where queries are directly transmitted as part of a HTTP GET request. The Semantic Digital Archive Service is proxying requests from the WorkbenchUI (or 3rd party software) to this endpoint. Having the SDAS as a remotely

[30] The term 'quad store' on the other hand includes an additional context column per RDF triple that allows the fine grained capturing of context, provenance and named graphs. These however can also be employed using the more common triple stores

[31] `http://virtuoso.openlinksw.com/`

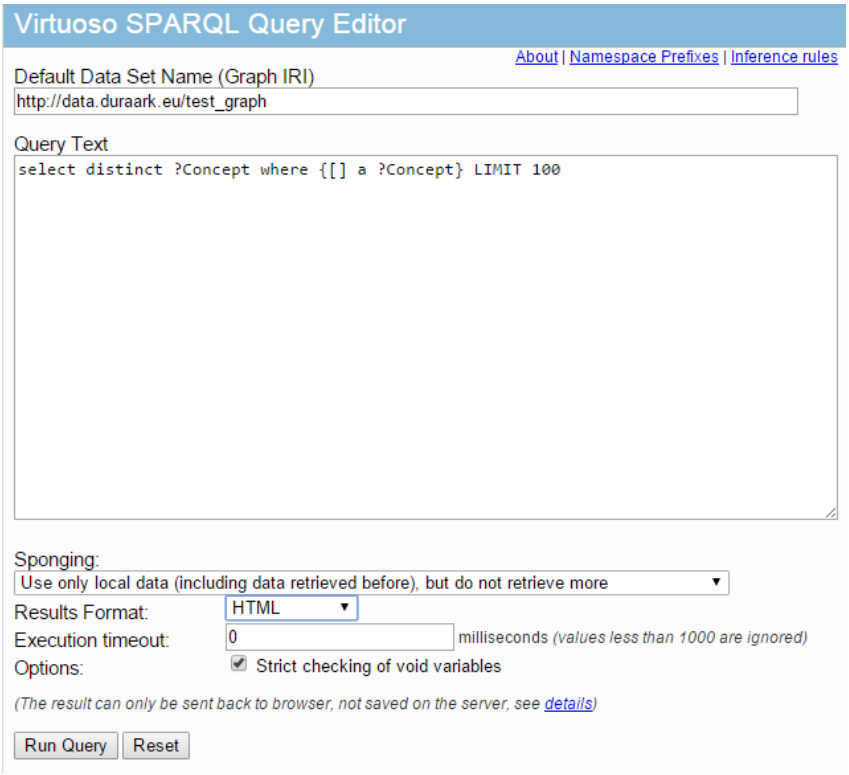


Figure 9: **The Virtuoso SPARQL query editor.**

accessible component allows the Service Platform to be installed locally (e.g., when using the Grasshopper® components) and still have access to the SDAS knowledge graph[32]. Figure 9 shows the corresponding SPARQL query editor GUI, where the graph IRI can be specified alongside the query itself. The query in the figure retrieves all IFC files that describe buildings in *Chicago*.

More example queries showcasing the potential of the SDAS prototype, can be found at `http://data-observatory.org/sdas/`.

Conclusion

The SDAS Storage & Retrieval component introduces a novel technological approach into stakeholder communities from BIM and Long Term Archival. These communities have to have time to explore, eavluate and test the approach. A further development through community building is hence the chosen sustainability action for this DURAARK research

[32]The same principle holds true for the remote Rosetta DPS component. In this case the Digital Preservation Service is communicating with the remote Rosetta DPS.

outcome.

3.2.5 Semantic Enrichment (Focused Crawler)

Stakeholder Communities:	**Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Knowledge base maintainers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

This section describes the second version of the *Focused Crawling* component[14] which is implementing the *semantic enrichment* functionalities of the SDA. With respect to the initial prototype, significant improvements have been designed and implemented. Specifically, we introduce a focused crawler for linked data (detailed description in D3.6), which replaces the previously developed crawling environment with a more targeted and hence scalable approach. Crawls are either based on (a) manually defined seed lists, for instance, to retrieve relevant linked data subgraphs about the geographic, historical or infrastructural context of buildings and their model or (b) automatically extracted seeds, directly derived from existing *buildM* instances. Based on experimentally defined crawl configurations, we introduce an efficient means to crawl linked data of relevance to the specific instances in the SDAS. The focused crawler is exposed via the Semantic Digital Archive Service to the WorkbenchUI and other 3rd party software. The Semantic Digital Archive Service is internally using the API of the *Focused Crawling* component.

Conclusion

The Focused Crawler introduced a targeted and scalable approach for linked data. This approach becomes very relevant for the BIM community, where for instance the buildingSMART community founded a "Semantic Building Data" working group. Obstacles occur however through the closed nature of most building data and related Ontologies, as described in D7.4. The Focused Crawler serves hence as a technology demonstrator

and best practice, disseminated to research communities among stakeholders for further development.

3.2.6 IFC - point cloud schema

Stakeholder Communities:	**Architects and engineers**
	Construction companies
	Building owners and real estate managers
	Suppliers of software and IT services
	Public administrations/Public planning/
	Policy makers
	Knowledge base maintainers
	Researchers and lawyers
	Cultural heritage institutions
Sustainability Strategy:	**Further use through Standardisation**

In the IFCpoint cloud related reppository[33] an extension to the Industry Foundation Classes schema is introduced with the capabilities to efficiently describe and store point cloud data. The repository contains schemas, prototype tools and documentation. The prototype tool is capable of associating external point clouds and describing them parametrically according to IFC building surfaces. As such, a unified format of IFC building data is obtained that represents point cloud data more efficiently than prevalent point cloud formats. The decomposition and association between the two data sources enriches the semantics of both. The point clouds are labelled with the building elements they describe and can be navigated according to the spatial subdivision structure of IFC. IFC building elements obtain an additional detailed representation that describes surface characteristics and the exact as-built physical form. A binary serialization is introduced that writes IFC files (with or without point clouds) in an efficient hierarchical structure for efficient partial retrieval. This binary serialization format is based on ISO-13030-26 and uses the HDF5 file format. More info about HDF5 can be found here: https://www.hdfgroup.org/why_hdf/

[33] https://GitHub.com/DURAARK/IFCPointCloud/

Conclusion

The IFC point cloud schema is undergoing Standaridation efforts. It is in the pipeline to be endorsed as an schema extension for the Industry Foundation Classes model by the buildingSMART organization. Once standardized, software vendors will be able to exchange combined as-built and as-planed data by using both point cloud data sets that are tagged with semantic information or have explicit geometry representation in parallel to the implicit point representation.

3.2.7 IFC metadata extractor

Stakeholder Communities:	**Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Knowledge base maintainers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The IFC metadata extractor is a tool to retrieve descriptive aggregate and per-component information from IFC files. The management of large numbers of different building models (for both intermediate and long-term archival purposes) currently is done in ad-hoc and most often manual fashion, which contributes to the incoherence of processes. This is a problem that the metadata extractor has the potential to address. It is used today in the DURAARK workflow to automatically extract some of the information needed to populate the "BuildM" schema. It has the potential to work as both: **a)** a standalone tool to retrieve information from large sets of IFC models to quickly get numbers describing count and size of different components; and to **b)** be used as a basis for querying one or more IFC files for a set of properties. It can be used for instance to discover if there are outside-facing walls, windows or doors that does not contain thermal transmittance information (based on checking the properties of the components). It can be used directly in a command line workflow or integrated in other software on source code level.

Conclusion

It probably does not have a direct commercial market, but as it is a useful tool expected to be used by the building industry to automate the management of building data. Efforts are employed to disseminate and activate related BIM communities of developers in research and practice of stakeholders.

3.2.8 E57 Metadata extraction

Stakeholder Communities:	**Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Knowledge base maintainers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The E57 Metadata extraction is a utility to extract metadata from E57 point cloud files The URL for the code repository is `https://GitHub.com/duraark/E57extract`.

Conclusion

The tool can be picked up by related BIM communities of developers in research and practice of stakeholders.

3.2.9 Interlinking component

Stakeholder Communities:	**Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Knowledge base maintainers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The Interlink component is a web based component where the user can easily provide a assessment of if and how two semantic web terms relate to each other. This is very useful functionality since keeping vocabularies tidy and removing duplicates is important for quality.

Conclusion

The evaluation of the tool in D3.6 showed, that it is a useful and user friendly tool which serves an important role in the DURAARK software architecture, but that it is most likely not something that will be sold as a separate product. It can however be used as an integrated part of a larger package in order to maintain the ontologies.

3.2.10 java-rdf-updater

Stakeholder Communities:	**Suppliers of software and IT services**
	Cultural heritage institutions
	Research communities
Sustainability Strategy:	**Further research through Community Building**

The java-rdf-updater is a small Java tool to update RDF triples in Virtuoso (with authentication).

Conclusion

The tool can be part of a stand-alone product. Like the other components it is available on Github.[34]

[34] https://GitHub.com/DURAARK/java-rdf-updater

3.2.11 IFC contextual Enrichment

Stakeholder Communities:	**Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The IFC contextual Enrichment tool is a java based command line tool. The user provides the file path to an IFC file and which parts of the IFC file (for instance IFCPOSTALADDRESS, IFCBUILDING, IFCORGANIZATION) the tool should look at in order to extract possible location names. Given this input it initiates crawling and interacts with the Semantic Digital Observatory. A detailed description of this tool can be found here.[35]

Conclusion

A useful tool to get location names from IFC files, but not designed to be a stand-alone product. Like the other components it is available on Github.[36]

3.2.12 SIP generator / Connection to Rosetta Ingest

Stakeholder Communities:	**Suppliers of software and IT services** **Cultural heritage institutions** **Research communities**
Sustainability Strategy:	**Further research through Community Building**

The SIP Generator supports producers of digital material with its organization and packaging as Submission Information Packages (SIP). The provided *SIP Generator* is a Java tool which is capable of generating both, Rosetta-compliant SIPs and BagIt files. It provides the possibility to include more than just one representation, for instance an

[35] http://duraark.eu/wp-content/uploads/2015/03/DURAARK_D3_4.pdf
[36] https://GitHub.com/DURAARK/java-rdf-updater

additional Modified Preservation Master or one respectively multiple Derivative Copies. With the help of the by Ex Libris provided web services it is furthermore possible to ingest and retrieve the SIPs into and from the System.

Conclusion

Cultural heritage institutions which have digital preservation system in place and want to preserve their 3D data within this system can benefit from this software service. This functionality addresses furthermore Rosetta users which want to preserve their 3D data into a Rosetta system. For users of other digital preservation systems (e.g. Archivematica) the provided BagIt packages are a fitting solution.
The tool will be offered to the LTDA community for furtehr development and integartion as apoart of a community action.

3.2.13 Geometric Enrichment Components

Stakeholder Communities:	**Architects and engineers** **Construction companies** **Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Research communities**
Sustainability Strategy:	**Further development through commercialisation**

The main identified outcome of the geometric enrichment components developed by UBO as part of WP5 is the software prototype for the automatic reconstruction of parametric building models from indoor point cloud datasets. In addition to the generation of IFC files consisting of the building's floor, ceiling and wall structure, the detection of meaningful architectural features such as openings and columns further enrich the resulting models. These models may be imported into widely used architecture modelling software such as e.g. Autodesk Revit for further processing and analysis.
In addition to disseminating the developed methods to the scientific community (see D8.8), potential industry stakeholders include architects, facility management providers,

and surveyors who use point cloud scans as a means to quickly and easily gather the geometry of existing buildings. In these domains, point cloud datasets are increasingly used as a basis for generating BIM models. Since the model generation process is often a highly manual and time-consuming task, automating this process will be beneficial to stakeholders from the aforementioned domains.

While the developed software tools are prototypical, they have been tested and evaluated on many complex, real-world datasets during the DURAARK project. This evaluation and feedback from stakeholders received during the project period helped to improve robustness of the software components and quality of the resulting models. UBO is planning to further develop the components in collaboration with industry partners after the end of the DURAARK project.

Conclusion

A tool that is able to semi- or even fully- automatically create a valid IFC file from a point cloud data is a desired feature among BIM related communities. D7.2 and D7.4 point at the lack of existing commercial applications. Implementing the developed technology in PointCloud-to-BIM applications can save the end user significant time and effort. The core technology might have relevance in other domains to. This tool has very likely the greatest immediate commercial value of the research outcome created in DURAARK.The project is currently in contact with more than one large commercial company that is interested in the technology.

3.2.14 Difference Detection

Stakeholder Communities:	**Architects and engineers** **Construction companies** **Building owners and real estate managers** **Suppliers of software and IT services** **Public administrations/Public planning/** **Policy makers** **Research communities**
Sustainability Strategy:	**Further development through commercialisation**

The detection of differences between concurrent representations of the same building measured at different points in time (for instance before and after a renovation or retrofitting has taken place) or generated by different parties for different purposes (e.g. an as-planned model and as-built measurements of the constructed building) are an important ingredient for verifying and monitoring the changing state of a building.
The software prototype for the transfer of structure and semantics developed by UBO in WP4 tackles these use-cases by providing means to determine correspondences (or missing correspondences) between different building representations. This information can subsequently be used for e.g. visualizing differences between the datasets in order to highlight deviations between them.
The envisaged target community for the aforementioned software tools includes companies performing renovation or retrofitting tasks on already existing buildings, facility management providers who need to monitor intentional or unintentional changes made to buildings, as well as the long-term preservation community for which the verification of datasets after e.g. migration is an important part of the LDP workflow for ensuring data integrity.

The current prototypal version of the software has been integrated into the DURAARK system prototype which demonstrates its usage as part of an LDP workflow.

Conclusion

This tool has interesting market potential among BIM relates stakeholders as a tool for quality detection of point cloud to Bim processes, as-build and in construction processes, as well as for other stakeholders, that want to compare different states of a building. The evaluation within D7.4 showed limitations and potentials of the current state of development of the tool. This can be taken further with commercial partners.

3.2.15 RISE Component

Stakeholder Communities:	**Architects and engineers**
	Construction companies
	Building owners and real estate managers
	Research communities
Sustainability Strategy:	**Further research through Community Building**
	Further development through commercialisation

The RISE component is a geometric enrichment tool working on point cloud scans and imagery of the scanned room(s). It utilizes as-built BIM data from scans of indoor spaces in order to provide a hypothesis of paths of electrical lines. The system assumes that legal requirements and standards exist for defining the placement of power supply lines. This prior knowledge is formalized in a set of rules, using a 2D shape grammar that yields installation zones for a given room. Observable endpoints (sockets and switches) are detected in indoor scenes of buildings using methods from computer vision. The information from the reconstructed BIM model, as well as the detections and the generated installation zones are combined in a graph that represents all likely paths the power lines could take. Using this graph and a discrete optimization approach, the subgraph is generated that corresponds to the most probable hypothesis. The result of the tool is an IFC file that has the most probable hypothesis encoded and which can be used in other software to process the result further. The WorkbenchUI provides a graphical user interface that allows to display the results as an interactive 3D graphic, as well as a 2D representation of the results.
The target stakeholders for this component are those who have to work with electrical wiring during the lifecycle of a building. Architects and planners will us the tool to get a suggestion for the optimal location of power lines based on the position of light switches, switches, etc. in terms of shortest wire length. In the reconstruction phase RISE helps to estimate the costs for a replacement of the electrical wiring based on the calculated wire length. With RISE civil engineering stakeholders have a tool at hand to design rules and standards on how to build up electrical wiring in building based on different constraints. RISE is not yet ready for the use in real world scenarios. We estimate the wire length based on direct connections between endpoints with respect to the allowed installation zones, which equals the estimation of cable funnels. To make the algorithm usable for real

world scenarios it is necessary to put more expert knowledge into the real behaviour of the cables within the funnels. That said, the component provides a sound infrastructure from gathering information of visible endpoints out of a point cloud with imagery data. Endpoints can be modified and the power source root point can be arbitrarily chosen. The definition of installation zones is very flexible and can be based on existing specifications or on specific building scenarios.

Market situation

A study conducted on the productivity of the construction industry in North America shows that it is struggling with a lack of coordination, in particular the electrical construction companies. The study points at the implementation of Building Information Modelling (BIM) in these fields as a solution for this problem. Its application in this field would reduce conflicts and improve coordination. However, the study simultaneously points at little actual implementation of BIM in the electrical construction field. This is supported by the finding that 59% of the companies, who actually use BIM, have only three or less years of experience with this technique (Hanna et al., 2014).
Another survey conducted in the USA (Azhar, 2009) gives a ranking of BIM features for this field (e.g. clash detections, visualization of electrical design, space utilization), however, 79% of the participating companies responded that they are not using BIM, with the main reasons being not knowing about BIM, lack of technological experience, software incompatibility, and implementation costs. However, the 21% that use BIM reported positive savings in time and cost.
While these studies show that there is an interest in the utilization of BIM for electrical construction, this interest is currently not fulfilled in the area of as-built documentation and renovation projects - which makes for 75% of the EU building market share (Atanasin et al., 2011).

Past and current work practices of companies installing the electrical wiring of buildings are still based on 2d drawings as a base for the work on site 10. These drawings contain the necessary information for workers to execute the work in the building, such as the position of switches, fuse boxes, as well as the principal connection between these. The workers themselves know about the height, that switches are to be mounted in the walls and the way, that cables shall be laid. These rules are setup by the national authorities and today harmonized on i.e. European level. Technical norms, as the DIN 18015 in

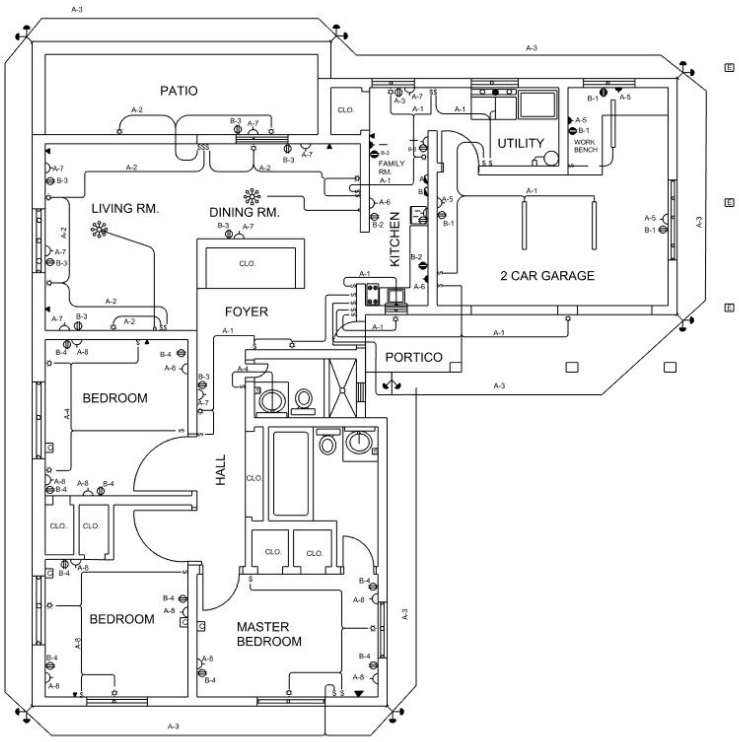


Figure 10: Typical electrical plan for a small one family house. The drawing dates from 2015 and was received from from the Organisation of the American states Code section. http://www.oas.org/pgdm/document/codedraw/sectiong.htm

Germany or the Starkstrømbekendtgørelsen[37] , provide so called installation zones, for the routing of the cables. Workers might adapt the routing of cables to special features on local level, but will generally follow the concept of the norms.
This current situation is challenging, as a documentation of the electrical system of a legacy building, is if at all, only present as 2d drawing which is hard to read and does not provide information about the actual routing of cables in three dimensions. The general compliance of electrical installation to the framework build by the norms, provides on the other hand side a relatively secure ground for professionals to estimate, where wires would ideally be routed.
The application of our approach in a retrofitting scenario for buildings has been positively evaluated in D7.4. Although practitioners stated, that they would recommend to check the generated data before its use, they can see the value in terms of estimation of cable length, and rough positions.
However looking at the established practices on communicating electrical systems to building site and the obvious lack of adoption of BIM in the electrical sector, we see, that this feature would have even more value for the design of new building. Practitioners could use their BIM models to estimate the cable length and the attached costs. RISE can provide an estimate, that could, factored with the regular security measures, help managing the costs for electrical installation.
The feature with the most valuable contribution is however the developed approach for the recognition of 3d elements using a combination of 3d Laserscan data and correlated images, that is part of RISE. We see a big potential, in this combination of data from different sensors and the use of advanced search algorithms.The direct use in practice is however limited, as the photo sensors build into cameras are not providing sufficient resolution, as shown in the evaluation in D7.4. This will however change in future and the advent of image based mobile scanning solutions on consumer level, asin the google project tango device[38], will provide a potentially strong user base.

Conclusion

The tool can be of great help for the Architectural planning BIM community. The implementation into a commercial product is the recommended sustainability strategy for overall RISE component. The parts, that deal with the combination of 3d point cloud and

[37] https://www.sik.dk/Virksomhed/El-for-fagfolk/Love-og-regler-om-el/Staerkstroemsbekendtgoerelsen
[38] https://developers.google.com/project-tango/

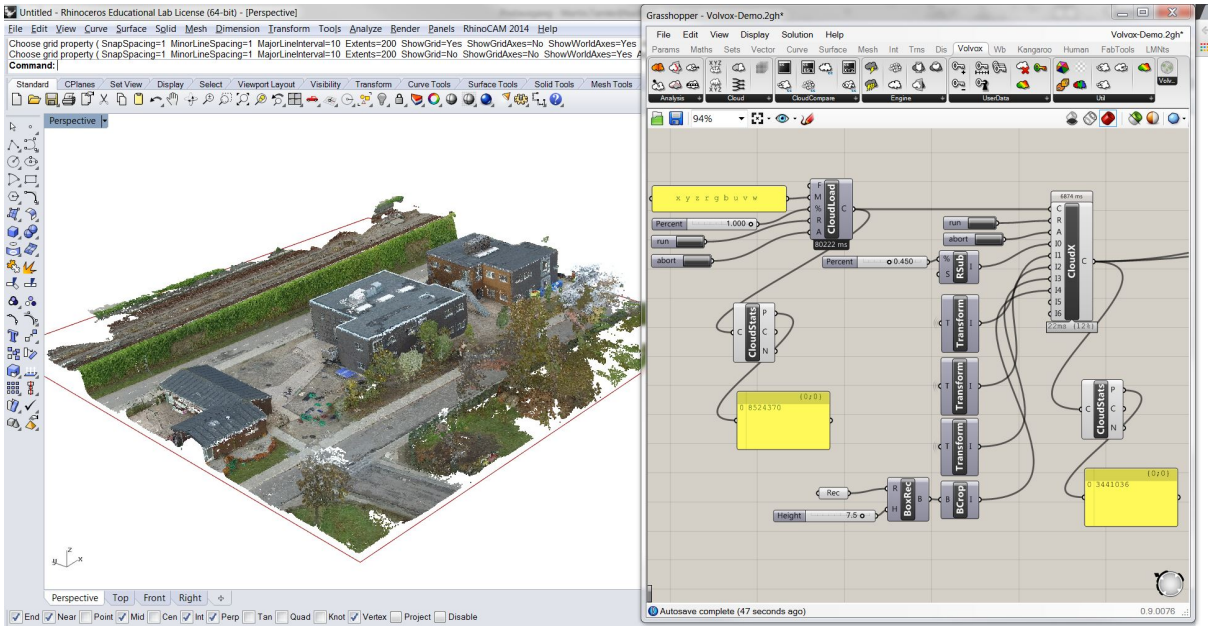


Figure 11: The Rhino Volvox Plugin provides basic functionality for working with point Clouds in a parametric CAD environment, as here for instance reorientation, subsampling and cropping. It is multihreated, fast and requires little computer resources.

image based searches show however a great potential, which should be further explored in through further research efforts. The tools is hence provided for further exploration and development to the community via GitHub through combination of 3d point cloud and image based searches.

3.2.16 Volvox PointCloud Plugin for Rhino

Stakeholder Communities:	**Architects and engineers**
	Construction companies
	Research communities
Sustainability Strategy:	**Further research through Community Building**

The Volvox Plugin [39] integrates point cloud functionality into the popular Rhino3D

[39] http://www.food4rhino.com/project/volvox?etx

CAD [40] environment. Users can import E57 and other point cloud files, transform and crop them, minimize the amount of points through different subsampling algorithms and compare the point clouds for instance in regards to meshes or BIM models of building designs. Volvox is multithreaded and provides access to the individual points and attached properties in a point cloud. Users can amend and attach properties and are in general enabled to actively engage with the point cloud, rather to use it as a simple means of representation.
Volvox has been developed in order to evaluate the implementation of DURAARK tools into stakeholder working environments (see D7.4) and to promote DURAARK research in stakeholder communities. It is currently in a beta state, released as version 0.2.0.0.
Volvox serves for user and developer communities as a demonstrator for the benefit of an integration of point cloud manipulation functionality into stakeholder design and work environments. Current point cloud software, as Bentley Pointtools[41] or Autodesk ReCap[42] is conceived as a processor of datasets before their ingestion into stakeholders design software. In here users have currently hardly any means to manipulate the point clouds. Not even a further transformation cropping or sub- or upsampling is possible. Volvox provides all of this and even more, as for instance user defined colouration, freeform cropping and the manipulation of single points. The tools provides means to emancipate the user and promote him to an author and creator of data, rather than a sole consumer of data -the place, that current point cloud software reserves for him or her.

Addressed Stakeholders and Communities

Volvox uses the Rino CAD environment, which is popular with stakeholders such as:

- **Architects and engineers**
- **Construction companies**
- **Suppliers of software** and IT services for building industry and facility managers
- **Research communities** in areas such as digital preservation, building information modelling and semantic web/linked data

[40] http://www.rhino3d.com/
[41] https://www.bentley.com/en/products/product-line/reality-modeling-software/bentley-pointools
[42] http://www.autodesk.com/products/recap/overview

Market situation

Volvox is programmed for the highly popular Grasshopper visual scripting environment [43] with over 40.000 members [44]. Tools for Grasshopper address professional users, consultants and developers, who need a high control over workflow with building data and resulting outcome. Grasshopper is used to develop automated solutions for specific design and construction cases.

Plenty of plugins are available for Grasshopper (GH) and Rhino. More than 140 are only available for GH through the official marketplace [45]. Of the total number of 253 available plugins, only 9 are pay only plugins. These 9 have a range from 29€ - 499€.

The current market of point cloud software is oriented towards professionals from Engineering and Land surveying. The leading software such as FARO scene [46], Bentley Pointtools [47] or Autodesk ReCap [48] come with a high price. Faro Scene costs for instance 11.127€ [49]. The functionality of these tools is mature, especially in comparison to Volvox, which i.e.doesn't have the advanced Graphic pipelines of the professional software.

These are however not integrated into the design environment, but produce solely data for a later use in the actual stakeholder software. Volvox proves that an integration of such functionality is possible in the actual design environments of professionals (see D7.4) and that it might be beneficial for design to assess point clouds.

The market for point clouds software seems however quite limited at the moment. The production of point clouds is still an expensive endeavour, where 3D scanners with reliable precision are not available for under 20.000€ [50]. The proliferation of low cost scanners such as Microsoft Kinect [51] raises however awareness and creates an interest into point cloud in stakeholder communities.

Conclusion

The software artefacts has a limited functionality in comparison to mature point cloud packages, it allows however communities to create new ways to work with point clouds

[43] http://www.grasshopper3d.com/
[44] http://www.grasshopper3d.com/profiles/members/
[45] http://www.food4rhino.com
[46] http://www.faro.com/en-us/products/faro-software/scene/overview
[47] https://www.bentley.com/en/products/product-line/reality-modeling-software/bentley-pointools
[48] http://www.autodesk.com/products/recap/overview
[49] http://www.3dscannerstore.co.uk/software/
[50] http://www.faro.com/products/3d-surveying
[51] https://dev.windows.com/en-us/kinect

and motivates a further engagement and later development of these approaches. The Volvox plugin will be induced into related communities in order to instigate pick-up and foster further research.

3.3 Knowledge and best practices: reports and publications

Stakeholder Communities:	**Architects and engineers**
	Construction companies
	Building owners and real estate managers
	Suppliers of software and IT services
	Public administrations/Public planning/
	Policy makers
	Knowledge base maintainers
	Researchers and lawyers
	Cultural heritage institutions
	Research communities
Sustainability Strategy:	**Further research through Community Building**

This category includes all IP covered in written reports and documents, including:

- scholarly publications[52],
- technical reports, and
- deliverables[53], most notably deliverables of type R (report) and the accompanying reports provided along with software deliverables (type P, prototype).

With respect to scholarly publications, the consortium has published altogether 30 publications (at the time of writing) in major conferences and journals, covering the whole range of disciplines and stakeholder communities, including computer graphics, building information modeling, long-term preservation, semantic technologies and Web science. For a complete overview of publications we refer to the DURAARK Website and the projects dissemination reports (D8.4, D8.6 and D8.8). With respect to deliverables, the project has produced 43 deliverables, 15 of which were prototype deliverables, containing both a software prototype as well as corresponding report.
Reports typically provide the theoretical background and documented knowledge related to other outcomes, such as software and data, and ensure the reproducibility of project results. As such, they provide and convey the knowledge gained throughout the project

[52] http://duraark.eu/publications/
[53] http://duraark.eu/deliverables/

and the expertise required to use, reproduce, exploit or implement techniques, data or software produced in the technical work packages of DURAARK.

3.3.1 Long term archiving policies

DURAARK has developed preservation policies and presented them within Deliverable D6.3. This policies help to maintain a digital archive and to formalize processes within an organization. These policies are developed upon best practice efforts which were conducted by the project 'SCAlable Preservation Environments' (SCAPE) within the SCAPE Policy Framework.[54] DURAARK has developed on policies with regards to preservation of architectural 3D data as well as the preservation of RDF snapshots from the SDA / SDO. Within the evaluation activities for Deliverable D7.4, a questionnaire was creative to question stakeholders about their current usage and requirements with regards to policies. Even though long term preservation seems to play a bigger role within the organizations of the stakeholders, hardly no services or functions have been established to ensure the long term preservation.

3.3.2 Future digital archival practice of institutional stakeholders

The Deliverable D7.3 identified three main staheholder groups for institutional preservation of architectural data, which share the goal and the responsibility of facilitating long-term availability and usability of the respective information:

1. governmental or large scale building owners as well as the facility management in charge of the maintenance of these holdings
2. cultural heritage and research institutions with an archival mandate for architectural data
3. companies and consultants involved in creating and implementing IT-systems to manage facilities

The investigation of their practices and a match of the outcomes of this resulted in best practices descriptions, how these groups can proceed towards a secured long term access of their building data.

[54] http://wiki.opf-labs.org/display/SP/SCAPE+Policy+Framework

Conclusion

Especially the chapters 4 *Exemplary digital archival practice and operation process of institutional stakeholders* and chapter 5 *Process and systems in the lifetime cycle of building information* of the report provide information, that is relevant for stakeholders among a set of fileds, such as Building owners and real estate managers, Suppliers of software and IT services for building industry and facility managers, Public administrations/ Public planning / Policy makers, Knowledge base maintainers, Cultural heritage institutions and Research communities in areas such as digital preservation, building information modelling and semantic web/linked data.
The reports are disseminated publicly in order to enable further use and development in many communities.

3.4 Datasets

Stakeholder Communities:	**Architects and engineers**
	Construction companies
	Building owners and real estate managers
	Suppliers of software and IT services
	Public administrations/Public planning/
	Policy makers
	Knowledge base maintainers
	Researchers and lawyers
	Cultural heritage institutions
	Research communities
Sustainability Strategy:	**Further research through Community Building**

DURAARK has collected a substantial amount of building related datasets throughout its runtime ranging from point clouds and IFC files, combinations of these to semantic metadata for building models. These datasets can full fill in building related communities purposes similar to:

- the **'Stanford Bunny'** and other geometric test datasets extensively used by the Computer Graphics research and development community for the validation and comparison of algorithms[55]
- the **Common Building Information Model Files and Tools**[56] and the **Open IFC Model Repository**[57] for the BIM research and standardisation community to test and validate files.
- the **Lehigh University Benchmark (LUBM)** [58] datasets for the evaluation of RDF triple stores and SPARQL queries

Conclusion

The datasets have a value outside of the DURAARK project, providing examples as well as test and validation data to all stakeholder groups. These dataset have been published

[55] http://graphics.stanford.edu/data/3Dscanrep/
[56] http://www.nibs.org/?page=bsa_commonbimfiles
[57] http://openifcmodel.cs.auckland.ac.nz/
[58] http://swat.cse.lehigh.edu/projects/lubm/

through a dedicated webpage www.data.duraark.eu for the basis of a public repository of datasets.
The webpage contains additionally, a range of structured RDF datasets – Linked Data – and related vocabularies are provided as part of WP3 and in detail listed and described in deliverable D1.7.
In the following sections, an overview of the four main categories of datasets is provided, which are made available by the consortium. The success of the publication of the repository is described in a dedicated section 6.2.

3.4.1 Introduction to available datasets

The DURAARK project has collected and produced a considerable amount of 3D datasets in BIM and point cloud formats - this totals in extensive documentation of 91 building projects at the time of writing. While the focus was set on the collection of files in open standards (E57 and IFC), several files also exist in proprietary formats such as vendor specific point clouds (`Bentley Pointtools`, `Faro Scene`) or BIM-formats (`Autodesk Recap`, `Autodesk Revit`, `Bentley Microstation`, `ArchiCAD`). These files can be used to test the derivation of the Open formats, but neither their conversion nor their preservation are within the scope of the DURAARK projects. The collection of datasets emanates from all phases of building design, ranging from the early conceptual design stages to construction documentation and facility management.
While the datasets were useful for directing the course of the DURAARK project and provided the consortium with real world data, to assess research methods and software prototypes, many of the files cannot be shared publicly as they contain data sensitive to the owners and the security of buildings. Often they are the results of considerable amounts of work and in many cases owners of the files hesitate to share these for free. An exception are datasets from public authorities, and academic environments which can be shared publicly.

3.4.2 point cloud Datasets

A large number of 3d Scans in the open E57 format where collected from stakeholders or produced within the DURAARK consortium. The total number of these accounts now to 1042 on the DURAARK server. This is about 10 times as much as the recorded amount

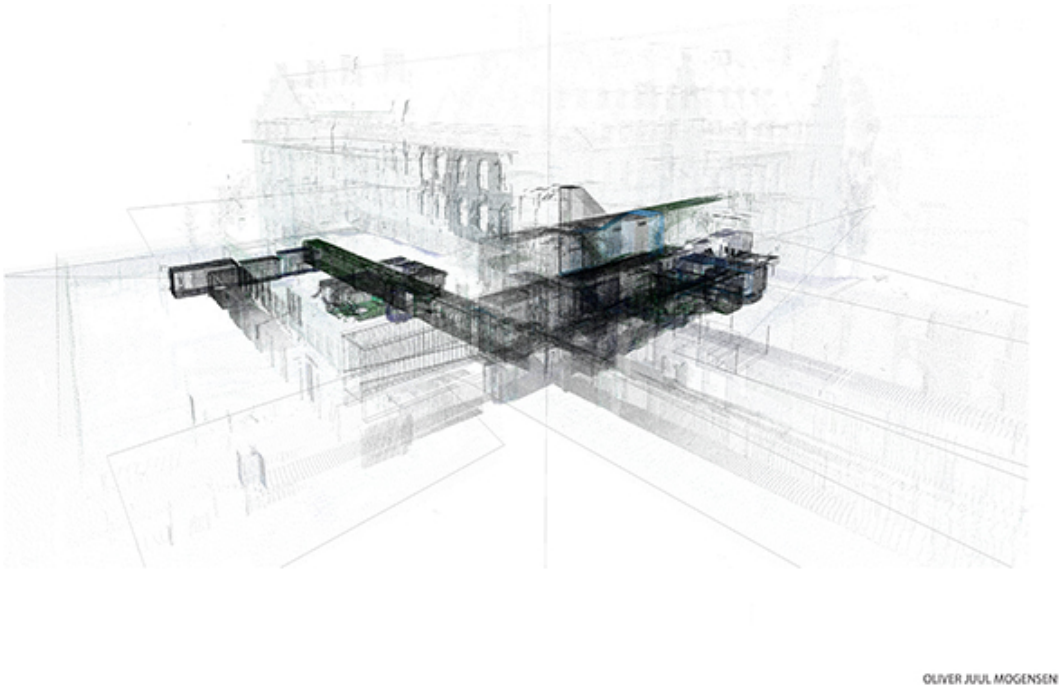


Figure 12: The Diakonissen dataset consists of 16 E57 point clouds acquired in a 10 hours scan marathon with two 3d laserscanners by CITA and a student team in the start of 2015.

Confidentiality	total [GB]	Number Files Year 3	Number Files Year 2
Confidential	2.180	958	61
Public	403	84	36
Total	2.583	1.042	97

Table 1: Overview of public and confidential point cloud E57 files in use and published.

from year 2. The total number of collected E57 is around 2.18TB. The datasets were instrumental for the internal evaluation of tools and approaches, as documented in D7.4. As many of the collected point clouds are confidential, as they reveal areas, which are not opened to public and should not be - according to their owners. However almost 20% of the total amount of data could be made available to the general public for other academic, standardisation and testing purposes through `data.duraark.com`. A detailed overview of all datasets is provided in the Appendix A.5.

3.4.3 Building Information Model datasets

The amount of Building Information models available within the project and for the public rose by 176% in the third year of DURAARK with around 50% of these now publicly available through *data.duraark.eu*.

Confidentiality	total [MB]	Number Files Year 3	Number Files Year 2
Confidential	8.750	296	5
Public	282	298	210
Total	9.032	594	215

Table 2: Overview of public and confidential IFC STEP Physical Files in use and published.

As highlighted in the introduction, the availability of common datasets for quality assurance and reference implementation in the fields of interoperability is of utmost importance. The DURAARK activities with regard to Building Information Modelling and particularly with regard to IFC models have been focused on reusing the existing established reference datasets and making new datasets available.

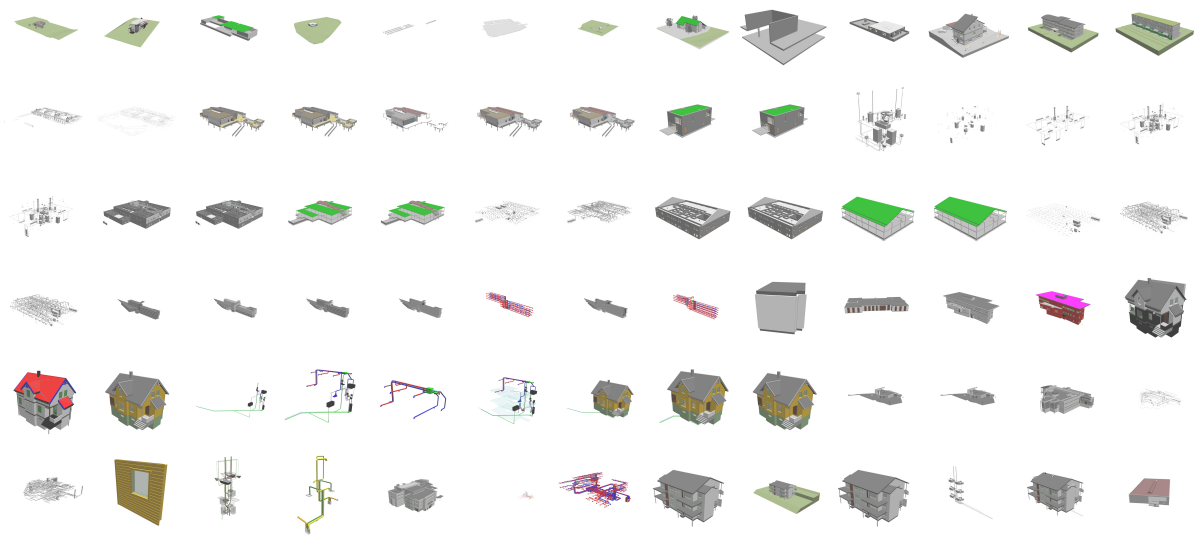


Figure 13: A view on 80 of the collected IFC models from stakeholder practice.

Datasets listed here only have their explicitly modelled representations and mostly stem from planning and early design stages. A subset of the models is illustrated in Figure 13,

an overview of the number is provided in Table 2 and the complete listings can be found in Appendix A.4.

3.4.4 Hybrid point cloud and BIM datasets

Hybrid models have both an explicit representation in the form of at least one IFC file and additional point cloud datasets that have been acquired in the existing building. These datasets have been used in particular to test automated object recognition and registration of scanned data with modelled data. For the remaining activities these datasets played an important role in the extension of the IFC model schema with point cloud data sets (deliverable D3.5), where they served as test and validation datasets.

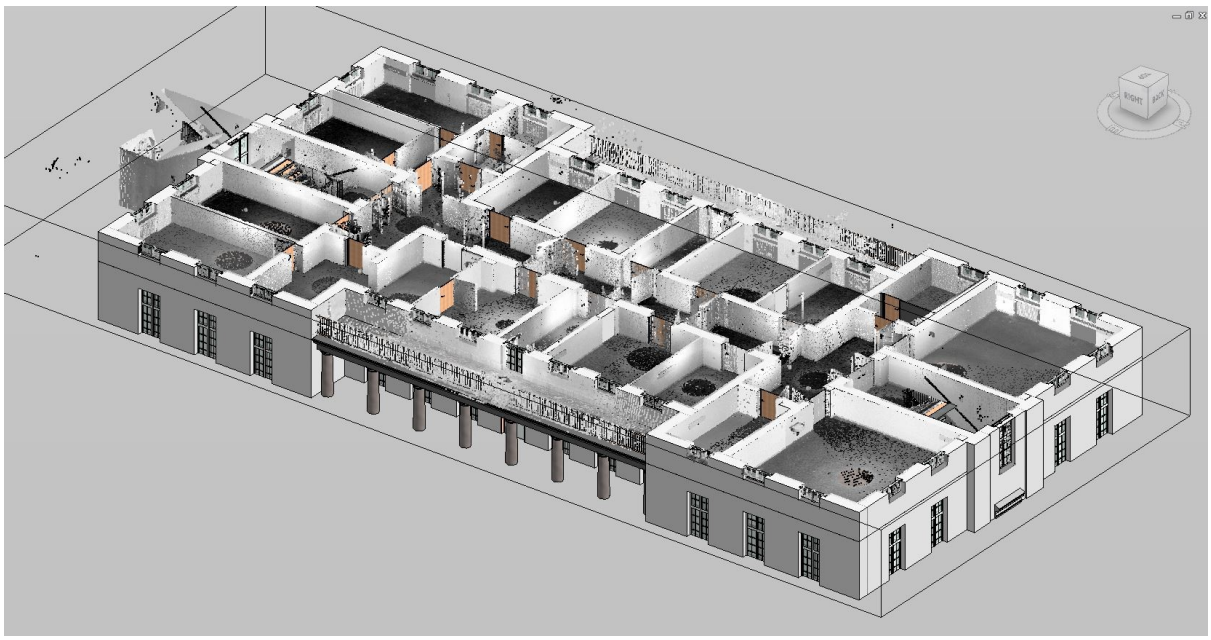


Figure 14: The hybrid "House 30" dataset demonstrates the integration of the explicitly modelled building overlaid with the laser scan point cloud datasets.

3.4.5 Semantic Building Metadata - Linked Datasets and Vocabularies

Semantic metadata for building models is produced in WP3, following Linked Data principles. There are different categories of Linked Data and related RDF vocabularies

that have been collected and produced in the context of the DURAARK project. These are made available via `http://data.duraark.eu` as well.

- Vocabularies such as the `buildM` metadata schema[59] for the description of archived building models, scans and physical assets. The `buildM` vocabulary is the central schema for the description of semantic metadata in the SDA. It covers technical as well as descriptive metadata.
- **Metadata of physical and digital assets** in the form of `buildM` instances. The population has been gained by the extraction and enrichment of the BIM datasets described in 3.4.3. The population of the datasets currently consists of ca. 5000 triples and is further described in the appendix.
- **Snapshots and profiles of datasets** from the Linked Data Cloud that have been gathered, compiled and generated by SDO components like the focused crawler (further details in the appendix).
- **Links and enrichments** of `buildM`-based metadata. This **mappings between building-related vocabularies** such as the buildingSMART Data Dictionary (bSDD), the Getty Arts and Architecture Thesaurus (AAT), the FreeClass ontology that have been extensively described in the report D3.2. The interlinking curation and reinforcement is based on a number of automatic pre-alignments of some of the vocabularies mentioned above as well as re-informcements and confirmations of these links by both domain experts and crowds (see D3.4). It also includes links with external data, i.e. the semantic enrichments described in earlier deliverables (D3.2) and the ones generated through crawling, interlinking and clustering described in deliverables D3.4 and D3.6. Further details can be found in Appendix.

[59] `http://data.duraark.eu/vocab/buildm/`

4 Software sustainability activities

The goal of especially the last six months of the project (M30 to M36) was to provide the range of software artefacts and especially the integrated software prototype in a maintainable and documented state in order to provide a low entry hurdle for developers to adapt and extend the artefacts and the system prototype and so that third parties have a sound environment to use the system for their own projects and workflows.
The actions to achieve that goal in terms of the integrated software prototype are described in the first of the following subsection 4.1. It describes changes in the WorkbenchUI (Figure 15) to enhance the user experience and acceptance of stakeholders. The Service Platform was generalized to give system integrators and software developers a sound and broad base to use the platform in their own projects and workflows. Alongside with these enhancements a documentation to deploy the system on Microsoft Windows and Linux hosts was created. To allow potential stakeholders to try the DURAARK System a "playground" environment that we set up which sets up the DURAARK System in a "single click" experience.

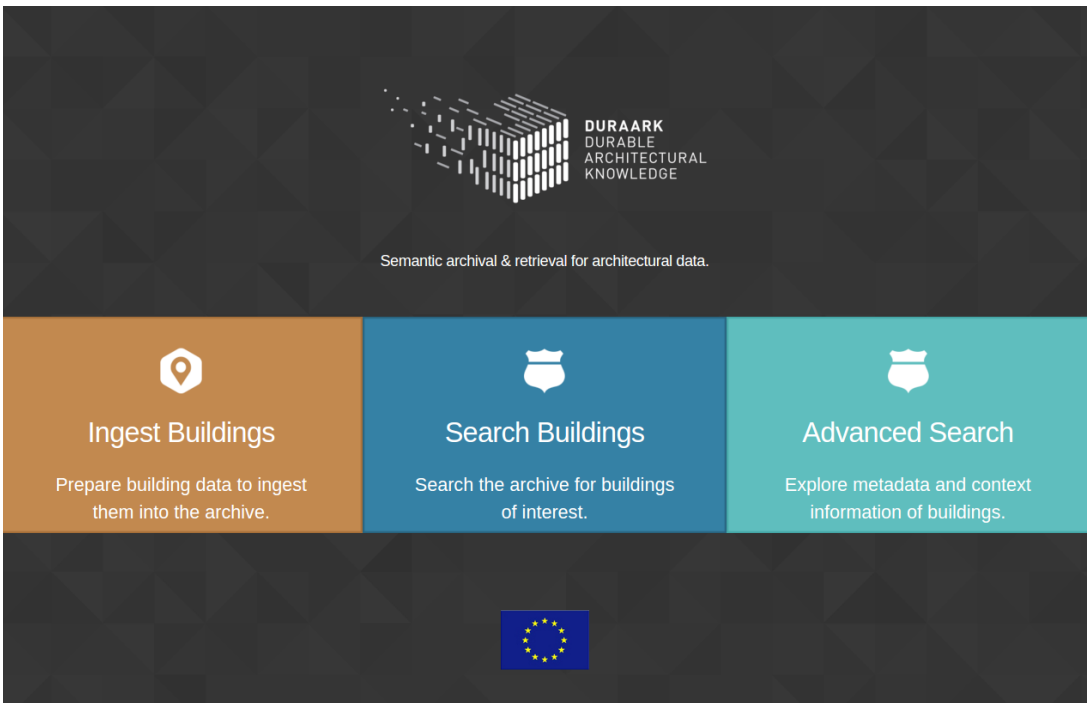


Figure 15: Screenshot of the WorkbenchUI landing page.

The software environment to process the 3D content produced in the project, which perfectly complements the longtime preservation aspect of DURAARK with the practical needs of stakeholders to work with point cloud and BIM models alike, converged into the release of *Volvox*, a plugin for the domain software Rhino3D (see subsection 4.5). The combination of those activities is helping the DURAARK project to have a sustainable impact and afterlife.

4.1 WorkbenchUI Improvements

The WorkbenchUI was released as v0.9.0 in January 2016 (end of project), shows a screenshot of the landing page which is available at `http://workbench.duraark.eu`. Since D2.5 (last official WP2 deliverable), which contained v0.7.0 of the software, the following features have been added or enhanced:

Session support (new) The WorkbenchUI now supports *sessions*. A stakeholder can add a new session which is the container for the files making up a building. All files created during the pre-ingest workflows are stored within the session. It is possible to store the content of the session into the Rosetta DPS or to download the session as a BagIt file.

File Upload (new) It is now possible to upload files into a session via a drag'n'drop feature.

Search interface (new) To support the retrieval workflow a distinct search functionality was introduced. It allows to filter the buildings stored in the knowledge database by criteria defined in the buildM schema.

RISE Integration (new) The RISE component is now fully integrated and allows to detect power lines within point clouds. The GUI provides a textured 3D preview of the model with the detected power lines, as well as a 2D preview for each wall of a room.

Difference Detection Integration (new) The Difference Detection functionality (see D4.3) is now integrated and allows a stakeholder to compare multiple scans of a building over time in a 3D viewer.

IFC Reconstruction Integration (enhancement) The IFC Reconstruction interface was enhanced and now supports the preview of the reconstructed model, the download of the IFC file and also the download of an intermediate representation which contains the floor plan of the building with the entities doors and windows. This representation is e.g. used in the RISE tool as a base for the power socket detection.

Design (enhancement) The design of the application was updated to provide stakeholders with a more modern design that visually helps to keep an overview on which workflow is currently active.

4.2 Service Platform Improvements

Since the M30 version, which was v0.7.0, the Service Platform has been updated to v0.9.0. This latest version is now fully compliant with the layered software stack which is depicted in Figure 16. This layered software stack is what we call the DURAARK System. It is a composition of the WorkbenchUI on top and the Service Platform underneath, where the WorkbenchUI is the reference implementation of a graphical user interface for the Service Platform.

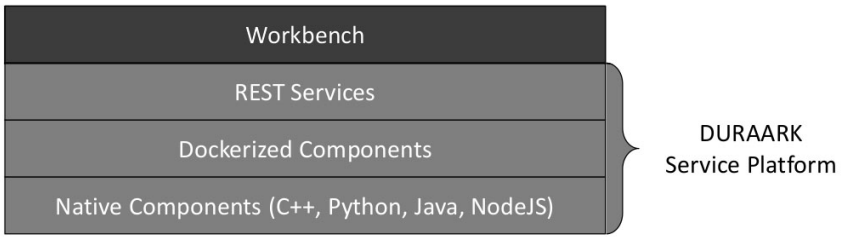


Figure 16: Services of the Service Platform with associated components, which are powering the services. Services and components are all available as Docker images for easy installation.

The Service Platform is the work horse of the system. It holds (most of) the functionality developed in DURAARK and makes it accessible on three layers. The *REST Services* allow to interface with the system with a decoupled, network-based approach. The REST Services are a thin layer on top of the *Dockerized Components*, which allow the different components (see below) to be easily run on a Docker-enabled host. Third party applications can directly use these components via their command line interface.

Finally, the components can be integrated into other software stacks in using their native implementation directly, e.g. to use the respective Python script, C++ executable or Java application. This lowest layer needs to setup the compilation environment (if the component is compiled) and the dependencies manually.

The REST Services are also provided as Docker images, which allows easy installation of all or individual services on a Docker-enabled host. The dockerized services are:

- duraark/duraark-sessions
- duraark/duraark-metadata
- duraark/duraark-geometricenrichment
- duraark/duraark-sda
- duraark/duraark-digitalpreservation

Since v0.9.0 the following components are packaged as Docker images as well:

- duraark/ifc-metadata
- duraark/duraark-sdas
- ochi/duraark_pc2bim
- ochi/duraark_autoreg
- paulhilbert/E57-processor
- paulhilbert/E57-metadata
- paulhilbert/ifc-mesh-extract
- paulhilbert/duraark_assoc
- paulhilbert/compress_E57n

The availability of the dockerized components allows them to be directly used by third parties on Docker-enabled hosts. That means that stakeholders do not have to go through the native compilation process of the respective components and/or that an installation of dependencies are not necessary anymore. The only dependency to use the components is the Docker runtime environment, which is available for Microsoft Windows, Linux and Mac.

4.3 Microsoft Windows Deployment

The software stack for the DURAARK System has its native roots in the Linux operating system and its design is tailored to be installed on a Linux server which is available in the stakeholder's network. The main technology used for the deployment of the system is Docker, which started its existence on Linux. The majority of our target stakeholders, though, are working on the Microsoft Windows operating system. Additionally, for many of the stakeholders their size is not large enough to have a dedicated server environment running (which is normally Linux based).

To enable the seamless deployment of the DURAARK System on Microsoft Windows hosts we created a setup for this platform and added a step-by-step documentation[60] (see Figure 17) to deploy DURAARK on Windows hosts. The documentation is accompanied by the *duraark-installer*[61], which automates most of the deployment procedure on Windows.

The main partner to test the Windows deployment was CITA. They were using this deployment type to connect their Rhino3D Volvox to the DURAARK System. See D7.4, Section 4.1 and 4.7 for the evaluation of the deployment and integration with the system.

[60] Windows Installation Instructions: https://GitHub.com/DURAARK/duraark-installer/wiki/Windows-Installation-Instructions

[61] duraark-installer: https://GitHub.com/DURAARK/duraark-installer/releases

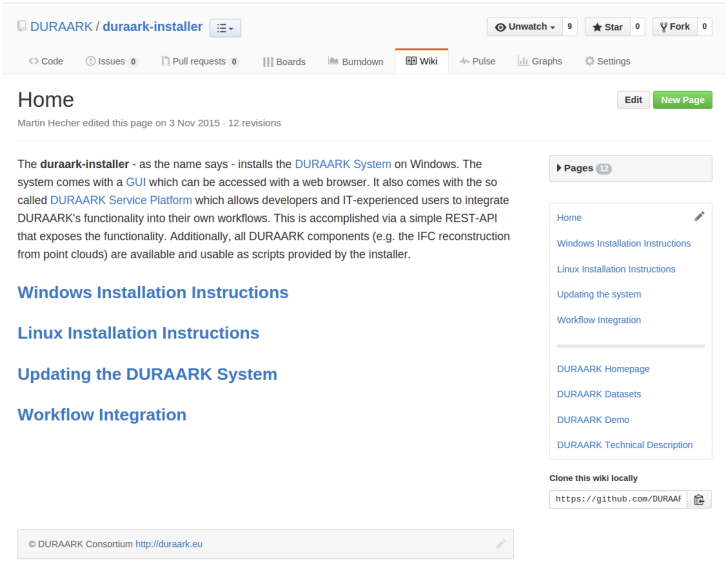


Figure 17: Screenshot of the Windows deployment documentation page.

4.4 DCHQ Cooperation

DCHQ is a company for the "Deployment Automation & Life-Cycle Management Platform For Container-Based Applications". This is a perfect match for the DURAARK System architecture, which is composed of multiple Docker containers. In close cooperation with the founder of DCHQ, Amjad Afanah, we were able to deploy the different services of the DURAARK Service Platform via their online platform. The result of this cooperation is a promotion page[62] (see Figure 18) provided by DCQH, where the DURAARK services are available as so called "Blueprints". A blueprint describes the deployment of a service and can be used as is by a stakeholder or to adjust the deployment to their needs. With the DCHQ cooperation we show a proof-of-concept on how to utilize DURAARK's web-focused architecture to enable private and public cloud installations of the DURAARK system.

DCHQ is promoting the DURAARK as official customer[63] and linking and promoting a

[62] DCHQ DURAARK page: https://www.dchq.io/landing/products.html#/library?org=DURAARK

[63] DCQH Customer Page: http://dchq.co/customers.html

blog post[64] describing the technical setup of DURAARK with their system through their channels (e.g. Google+, LinkedIn, etc.).

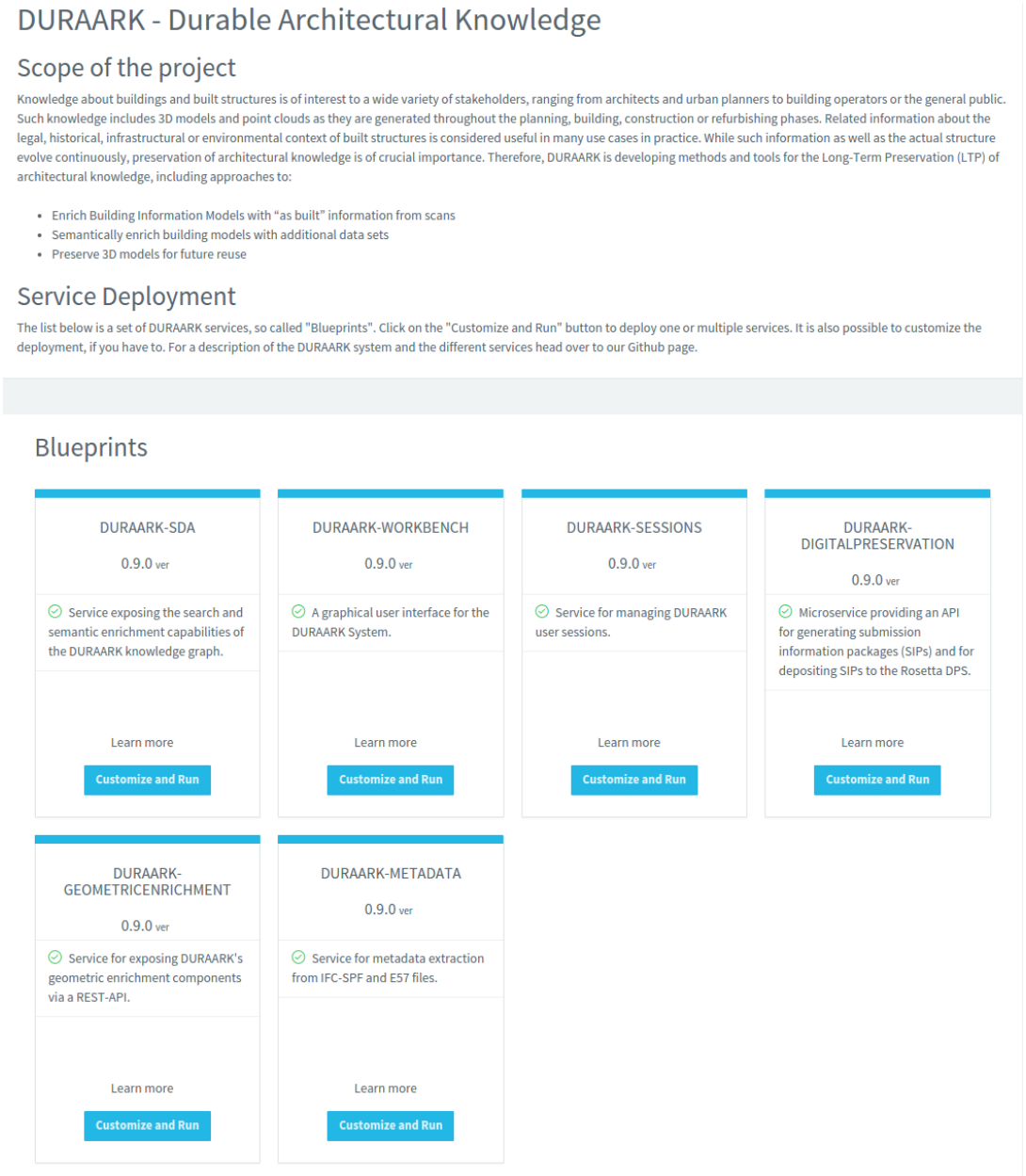


Figure 18: Screenshot of the DURAARK promotion page on DCHQ.

[64] DURAARK DCHQ blog post: http://dchq.co/2/post/2015/09/docker-based-application-stack-for-the-archival-of-architectural-data-with-dchq.html

4.5 Release of Volvox Plugin

Figure 19: Screenshot of the community wepage of Volox.

The first beta release of the Volvox plugin was published on a dedicated page on the community platform for Rhino plugins Food4Rhino.com `www.food4rhino.com/project/volvox?etx` website on 14th of September 2015. Across the 5 following months it was downloaded almost 800 times, constituting a large user group among the Grasshopper community. Currently the official user group[65] on the Grasshopper forum has almost 100 members, illustrating the engagement of the users into the development of the plugin. The community itself is composed of different professions such as: architects, structural engineers, artists, researchers etc. This variance is derived from the huge popularity of Grasshopper (approximately 40,000 members on the user forum across multiple CAD-dependent disciplines), which at the moment is the most popular parametric design software.

Volvox also enabled a link to the Duraark docker system, particularly the geometric

[65] www.grasshopper3d.com/group/volvox

enrichment containers. Through the implementation of point cloud editing tools in Rhino Grasshopper by Volvox a prototypical setup for the connection between a BIM environment and the geometric enrichment containers was possible (see Figure 20).

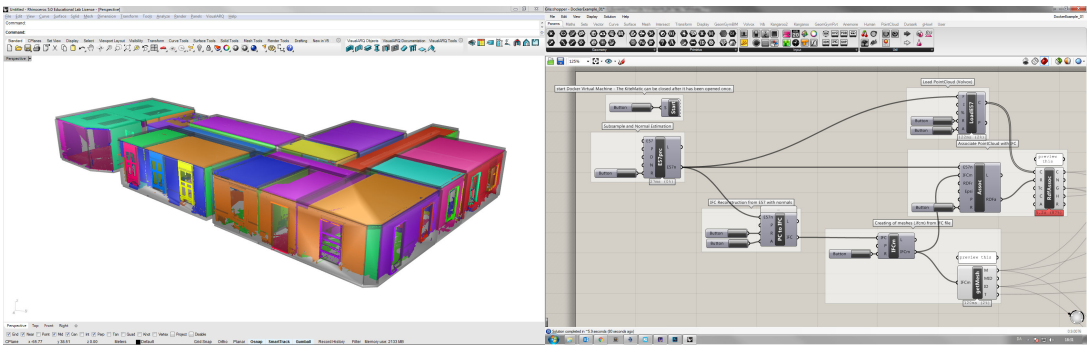


Figure 20: Geometric Enrichment Containers run through Rhino Grasshopper as prototypical BIM implementation.

There are over 140 Grasshopper plugins with various applications, and Volvox fits well in an area occupied so far by relatively few BIM and landscape design oriented tools (such as GeometryGym[66] , VisualArq[67] , Elk[68]) adding to the pool of information management tools. Nevertheless Volvox is the first Grasshopper plugin which enables the users to manipulate and analyze 3d scans, therefore it has no direct competitor.

After the initial release a close collaboration with the users was established, which resulted in many new features as a response to their needs. A good example of this process is the development of the multithreaded part of the plugin – which was made at first to speed up the text parsing of .xyz and .txt 3D scan files. After the creation of a proper multithreaded framework for the tool, it was possible to speed up other features of Volvox (i.e. subsampling tools). Another profit coming out from having such an engaged user group is that each of the users becomes an active beta-tester. Thanks to the user response we were able to debug Volvox efficiently, given specific bug-generating use cases. This input enabled us to find and debug memory leaks and display issues.

As of today, the plugin is partially open source, but it is planned to become completely open source as soon as the first stable release is published. The parts which are open

[66] www.geometrygym.blogspot.com
[67] www.visualarq.com
[68] www.grasshopper3d.com/group/elk

source at the moment enable users to use the base Volvox library to create and edit point clouds within grasshopper.

5 Standardisation activities

From the activities in the DURAARK workpackages, a number of standardization and harmonization efforts have been initiated and supported by the consortium members. In the following section these activities in towards a standardized ifcOWL (Figure 21), an point cloud extension for IFC, the Pronom file format registry for SPF files and the W3C Linked Data efforts are described.

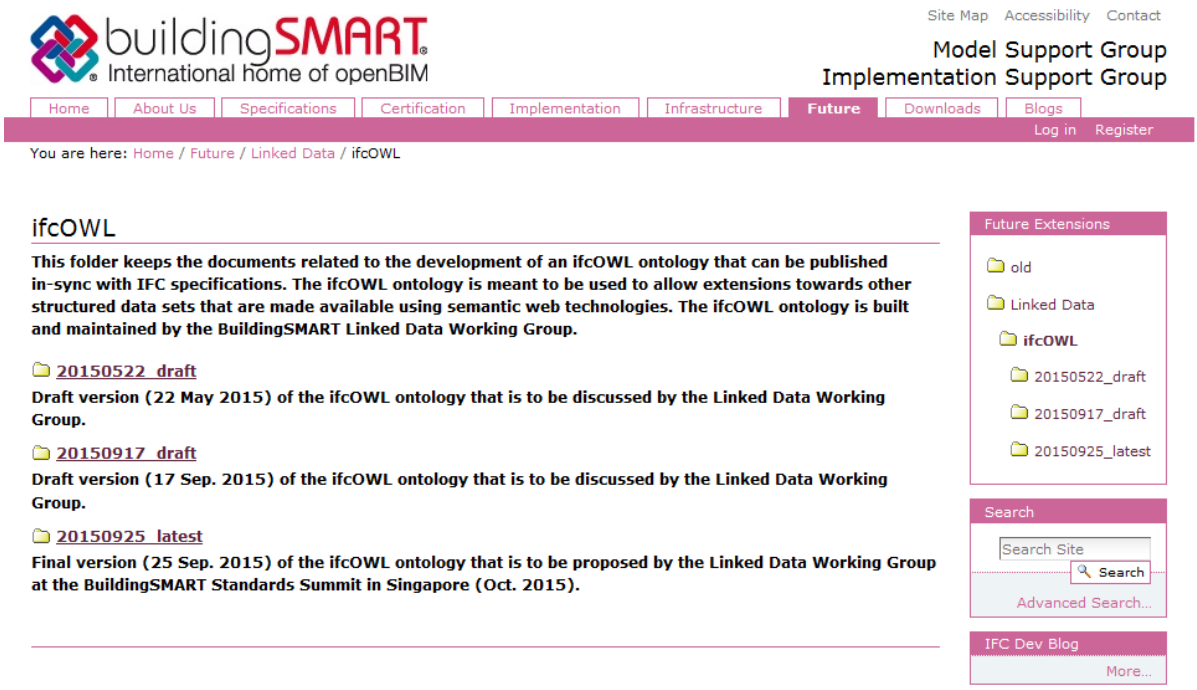
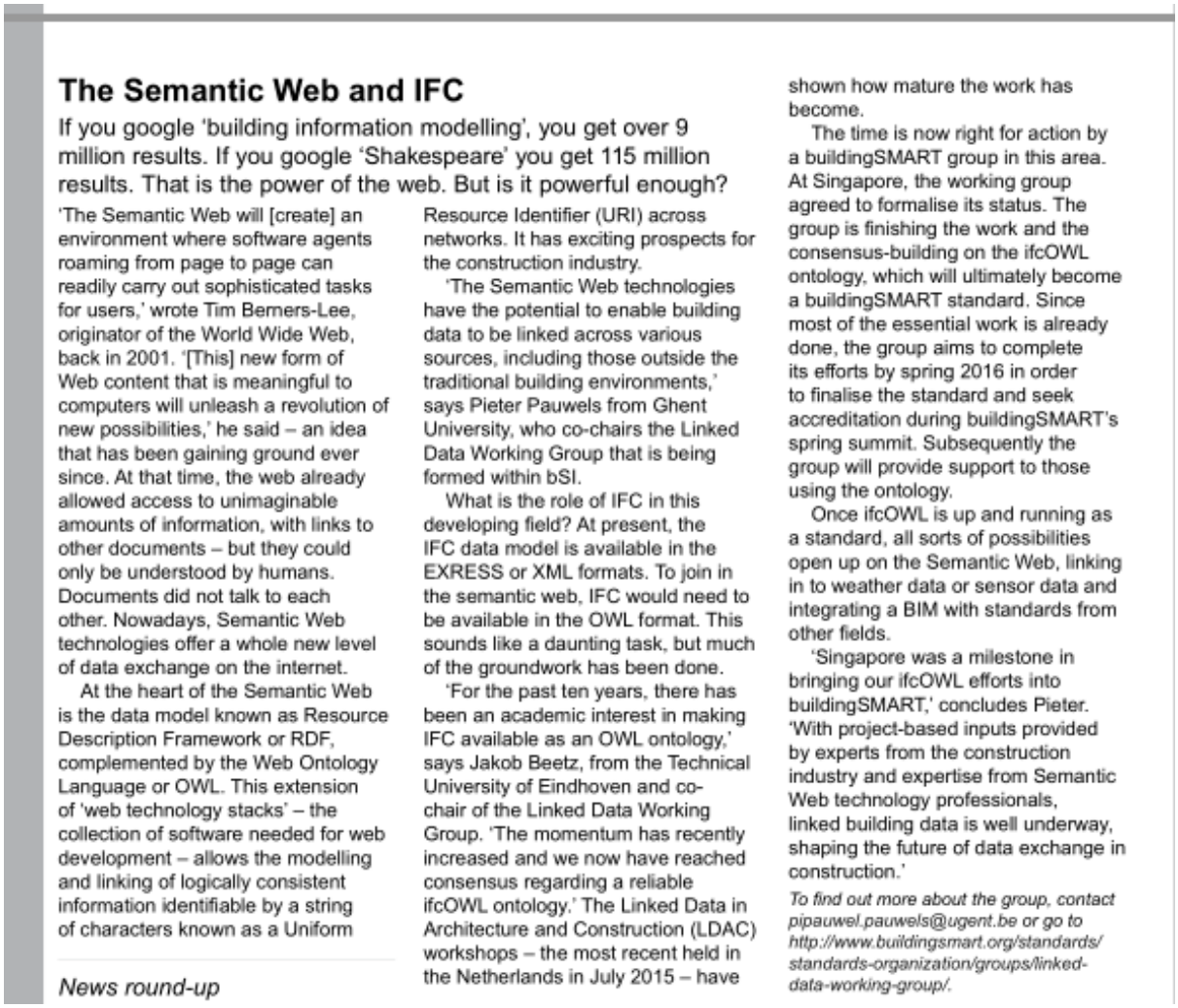


Figure 21: Screenshot the official Model Support Group web page of the buildingSMART organization regarding the standardization of the ifcOWL specification

5.1 ifcOWL

As a novel way to relate and integrated building-related datasets, the standardization of RDF/OWL representations of Building Information Models has been proactivley supported and pushed by the DURAARK project. The first suggestions for the creation of an ifcOWL schema file have been made a number of years ago already. The concensus-building among a critical mass of supporters from both academic and industry stakeholders however took of in the last years of the DURAARK project. Events crucial for making final pushes

towards such standardization have been the physical meetings during the 3^{rd} Linked Data in Architecture and Construction workshop in Eindhoven (detailed technical negotiations and voting, see D7.4) as well as the buildingSMART summits in London in the spring of 2015 (initial pitch) and the fall summit in Singapore in October 2015 (official ingestion into the buildingSMART standardization pipeline, see also figure 22).



The Semantic Web and IFC

If you google 'building information modelling', you get over 9 million results. If you google 'Shakespeare' you get 115 million results. That is the power of the web. But is it powerful enough?

'The Semantic Web will [create] an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users,' wrote Tim Berners-Lee, originator of the World Wide Web, back in 2001. '[This] new form of Web content that is meaningful to computers will unleash a revolution of new possibilities,' he said – an idea that has been gaining ground ever since. At that time, the web already allowed access to unimaginable amounts of information, with links to other documents – but they could only be understood by humans. Documents did not talk to each other. Nowadays, Semantic Web technologies offer a whole new level of data exchange on the internet.

At the heart of the Semantic Web is the data model known as Resource Description Framework or RDF, complemented by the Web Ontology Language or OWL. This extension of 'web technology stacks' – the collection of software needed for web development – allows the modelling and linking of logically consistent information identifiable by a string of characters known as a Uniform Resource Identifier (URI) across networks. It has exciting prospects for the construction industry.

'The Semantic Web technologies have the potential to enable building data to be linked across various sources, including those outside the traditional building environments,' says Pieter Pauwels from Ghent University, who co-chairs the Linked Data Working Group that is being formed within bSI.

What is the role of IFC in this developing field? At present, the IFC data model is available in the EXRESS or XML formats. To join in the semantic web, IFC would need to be available in the OWL format. This sounds like a daunting task, but much of the groundwork has been done.

'For the past ten years, there has been an academic interest in making IFC available as an OWL ontology,' says Jakob Beetz, from the Technical University of Eindhoven and co-chair of the Linked Data Working Group. 'The momentum has recently increased and we now have reached consensus regarding a reliable ifcOWL ontology.' The Linked Data in Architecture and Construction (LDAC) workshops – the most recent held in the Netherlands in July 2015 – have shown how mature the work has become.

The time is now right for action by a buildingSMART group in this area. At Singapore, the working group agreed to formalise its status. The group is finishing the work and the consensus-building on the ifcOWL ontology, which will ultimately become a buildingSMART standard. Since most of the essential work is already done, the group aims to complete its efforts by spring 2016 in order to finalise the standard and seek accreditation during buildingSMART's spring summit. Subsequently the group will provide support to those using the ontology.

Once ifcOWL is up and running as a standard, all sorts of possibilities open up on the Semantic Web, linking in to weather data or sensor data and integrating a BIM with standards from other fields.

'Singapore was a milestone in bringing our ifcOWL efforts into buildingSMART,' concludes Pieter. 'With project-based inputs provided by experts from the construction industry and expertise from Semantic Web technology professionals, linked building data is well underway, shaping the future of data exchange in construction.'

To find out more about the group, contact pipauwel.pauwels@ugent.be or go to http://www.buildingsmart.org/standards/standards-organization/groups/linked-data-working-group/.

News round-up

Figure 22: Clipping of the official buildingSMART newsletter no. 22[69] reporting on the progress of the ifcOWL standardization effort.

At present (December 2015), the specification is up for a request for comments. A prospective final balloting will take place during the Spring Summit in March 2016 to be held in Amsterdam. The efforts are bundled through the buildingSMART *Linked Data*

Working Group[70], where DURAARK members were the key initiators and Jacob Beetz (TUE) is currently one of the two chairs of the working group.

5.2 Extension of the IFC Schema with point cloud data structures

The results of the WP3 activities towards the standardization of an extension to the Industry Foundation Classes model with point cloud data strcutures has been introduced into the buildingSMART pipeline by distributing work results among the community. Due to a current restructuring of the standardization pipeline within the buildingSMART organization (see figure 23) and the late stage of the project in which this deliverable was produced, the standardization is still its early stages. It will be continued after the project end in parallel to the advancement of the HDF5 serialization that is ongoing. The aim is to deliver a working reference implementation alongside the specification text that will allow software vendors, researchers and other stakholders to use the recommended approach. So far individual feedback on the proposal and schema text by various experts has been mostly positive. A paper reporting on the further progress is submitted to the ICCCBE 2016 conference in Tokyo.

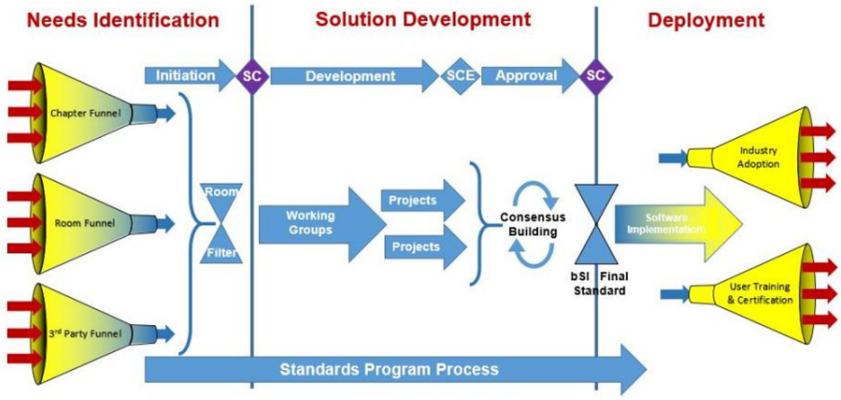


Figure 23: buildingSMART Standardization Pipeline

[70]http://www.buildingsmart.org/standards/standards-organization/groups/linked-data-working-group/

5.3 WC3 community group for Linked Building Data

To exchange information on various activities sourrounding Linked Data in the Built Environment, the W3C "Linked Building Data Community Group"[71] has been established in 2014 with members of different DURAARK partners as co-founders. The group (see figure 24) currently consists of 26 members from 10 countries that are often asscociated with other EU- and national funded research and development projects in the area. 10 live meetings an 19 virtual meetings have been organized by the group from its inception including two meetings at project partners locations[72]. The activity of the group is the gathering of use-cases and requirements for the application of Linked Data in the Built Environment. By the end of 2015 more than 60 use cases have been defined, categorized and documented on the wiki pages[73] of the group.

[71] https://www.w3.org/community/lbd/

[72] during the Linked Data in Architecture and Contruction meeting in Summer 2015 in Eindhoven and the CIB W78 conference in Eindhoven

[73] https://www.w3.org/community/lbd/wiki/Main_Page

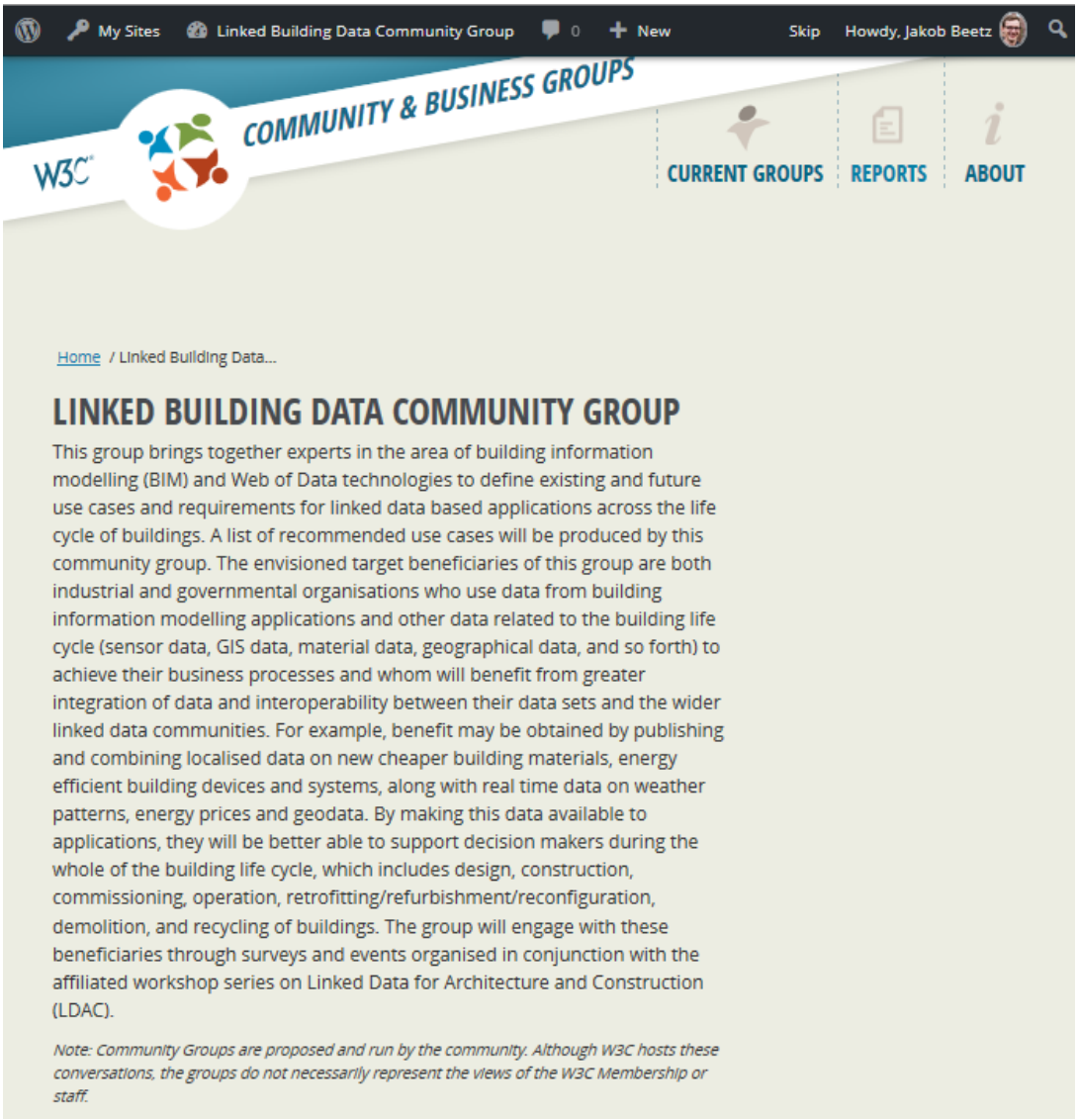


Figure 24: W3C community group on Linked Building Data

6 Community building and commercialisation

The third year of DURAARK saw an increased engagement with research and stakeholder communities in order to stipulate pick-up and further development of research outcome. The engagement took place in four areas, described in the following sections.

6.1 Clustering with projects

An active exchange with related research projects creates room for discussion and cross-fertilisation of ongoing work in the project, as well as fields, where DURAARK research outcomes might be picked up and further developed.
The clustering activities of DURAARK took place on different levels, which range from the loose exchange with projects, that have similar interest (KNOWeSCAPE subsection 6.1), the alignment of content, through overlap of researchers between projects (ForgetIT subsection 6.1) or the active collaboration, expressed through joint papers (Harvest4D 6.1) up to targeted collaborations in order to pursue identified common research interests in joint applications of partners (D3D subsection 6.1). In the third year of DURAARK partners reached out and exchanged with the following 13 projects:

Digital 3Dimensional objects for reuse (D3D)

D3D[74] is a planning project (a pre-study project), partly financed by VINNOVA[75] under the programme "SEEDS — For greater innovation in public funding".
The goal with D3D is an application and a project plan adapting DURAARK processes and tools for preservation of 3-dimensional objects of buildings for future reuse in property and heritage for Swedish stakeholders. Hamid Rofoogaran of LTU participated in this work which also involves the Swedish National Archives, the National Property Board of Sweden, and the Swedish Fortifications Agency. Falu municipality also joined as a discussion partner.
The pre-study project started in August 2014 and ended in March 2015 with a project proposal for an implementation project that would involve adapting and adopting DURAARK

[74] http://www.vinnova.se/sv/Resultat/Projekt/Effekta/2012-01393/D3D---Digitala-3Dimentionella-objekt-for-ateranvandning/ [sv]

[75] VINNOVA is Sweden's innovation agency – http://www.vinnova.se/en/ – and is a major funder of needs-driven research

processes and tools into a Swedish context. Submission of proposal is pending due to structural changes at some partners.

DEDICATE

At the final seminar of 'DEDICATE' (Design's Digital Curation for Architecture)[76], the DURAARK project was presented at the University of Glasgow in October 2013. The Royal Commision on the Ancient and Historical Monuments of Scotland and CyArk Europe had a high interest in the DURAARK project and its results. Therefore the contact for exchange and discussion on further developments was established.

RADAR

The DFG funded project 'RADAR' (Research Data Repository)[77] works on a interdisciplinary infrastructure for research data with regards to availability, preservation and publication. Exchange between DURAARK and RADAR took place on research data management and the development of information infrastructures.

MIT FACADE

The project 'MIT FACADE' (Future-Proofing Architectural Computer-Aided Design)[78] was from the beginning of DURAARK one of the most important reference projects with regards to long term preservation of architectural 3D data. The MIT requested information from the DURAARK project for extending their work which was conducted during FACADE.

IANUS

The DFG funded project 'IANUS'[79] establishes functions and services for supporting digital research information within classical studies. After a presentation of the DURAARK project on the 'Kooperation Langzeitzugriff 2015' in June 2015 in Berlin, IANUS requested further information of the DURAARK project with regards to long term preservation of three dimensional data. This was the starting point of an ongoing exchange.

[76] http://architecturedigitalcuration.blogspot.de/
[77] http://www.radar-projekt.org/display/RE/Home
[78] http://libraries.mit.edu/news/facade-project/457/
[79] http://www.ianus-fdz.de/

District Information Modelling and Management for Energy Reduction (DIMMER)

The DIMMER[80] system integrates BIM and district level 3D models with real-time data from sensors and user feedback to analyse and correlate buildings utilisation and provide real-time feedback about energy-related behaviours. It allows open access with personal devices and Augmented Reality (A/R) visualisation of energy-related information to client applications for energy and cost-analysis, tariff planning and evaluation, failure identification and maintenance, energy information sharing.

Mapping on Demand and Harvest4D

UBO has collaborated with the *Mapping on Demand*[81][82] and *Harvest4D*[83][84] projects, especially during the second and third year of the DURAARK project. The goal of this collaboration was the exchange of expertise regarding point cloud compression techniques and the development of novel ideas in this field. Two papers [5, 4] have been published in collaboration with the respective partners from UBO during the timeframe of the DURAARK project which present improved compression schemes on architectural point cloud data. A variant of the method presented in [4] has been implemented in the third software prototype for point cloud compression documented in Deliverable 5.4.
Furthermore, the versatile and fast WebGL-based *Potree*[85] point cloud viewer which is being developed under the Harvest4D project has been adopted by the DURAARK project for visualization of point cloud data in the WorkbenchUI.

Distributed Transactional Building Information Management (DRUM)

DRUM[86] develops software to make building information modelling (BIM) more usable in practical building projects. The semi-open, heterogeneous, and fragmented nature of building projects as well as the contractual boundaries, need to protect expertise, and the danger of legal disputes makes the naive notion of a centralised BIM database

[80] http://dimmer.polito.it/project
[81] http://cg.cs.uni-bonn.de/en/projects/mapping-on-demand/
[82] Funding: DFG Research Unit 1505
[83] http://cg.cs.uni-bonn.de/en/projects/harvest4d/
[84] Funding: European Commission, 7th Framework Programme
[85] http://potree.org/
[86] http://cse.aalto.fi/en/research/groups/distributed_systems/projects/drum

unrealistic. Instead, there is a need for distributed information management solutions that recognise the reality that BIM consists of multiple partial models (e.g., architectural model, structural model, mechanical model, construction process) that have complex relationships (one model being an elaboration of another, two models having spatial clashes, and so on).
DURAARK members presented research results to DRUM partners.

ForgetIT

ForgetIT[87] deals with the urgent problem of selecting web data and knowledge for preservation as well as targeted "forgetting".
ForgetIT combines three new concepts to ease the adoption of preservation in the personal and organizational context:
- Managed Forgetting models resource selection as a function of attention and significance dynamics.
- Synergetic Preservation makes intelligent preservation processes an integral part of the content lifecycle in information management
- Contextualized Remembering targets keeping preserved content meaningful and useful

The topics are of high relevance for DURAARKs preservation efforts and via LTU DURAARK has collaborated with ForgetIT by exchanging knowledge and information concerning structures for packaging information and software solutions for this.
L3S and LTU are participating in both ForgetIT and DURAARK.

KNOWeSCAPE

KNOWeSCAPE[88] is a European COST Action dealing with the mapping, discovery and analysis of knowledge across the web. KNOWeSCAPE tackles this urgent problem through networking.
DURAARK coordinator Stefan Dietze has earlier given an invited talk where he introduced DURAARK. Since than a regular exchange on an informal baisis took place.

[87] http://www.forgetit-project.eu/en/start/
[88] http://knowescape.org

Ready4SmartCities

The READY4SmartCities[89] project intends to increase awareness and interoperability for the adoption of ICT and semantic technologies in energy system to obtain a reduction of energy consumption and CO2 emission at smart cities communities level through innovative relying on RTD and innovation outcomes and ICT-based solutions.
The goal of the project is to support:
A new energy data ecosystem that will accommodate cross-domain data (climatic, occupation, pollution, traffic, activity, etc.) and will allow the exploitation of such data at a global scale; by identifying the set of ontologies relevant to energy-efficiency in Smart Cities and the different requirements and guidelines on how to use (publish and interchange) data described according to those ontologies.
By allowing feasible step-by-step action plans for city authorities and other relevant stakeholder groups to develop and use ICT-based solutions for energy system in urban and rural communities towards future Smart Cities, the vision of the project is that this will lead to reduced energy consumption and CO2 emissions.
Collaborations with DURAARK are manifold. DURAARK representatives participated in a Ready4SmartCities Summer School, discussions and collaborations were held for further exchange of infrastructure and data and the joint organisation of a summer school.

Timeless Business Processes and Services (TIMBUS)

The TIMBUS[90] project focuses on resilient business processes. It will make the execution context, within which data is processed, analysed, transformed and rendered, accessible over long periods. TIMBUS considers the dependencies on third-party services, information and capabilities that will be necessary to validate digital information in a future usage context – continued accessibility is otherwise often considered as a set of activities carried out in the isolation of a single domain.
TIMBUS will deliver activities, processes and tools that ensure continued access to services and software to produce the context within which information can be accessed, properly rendered, validated and transformed into knowledge.
Andreas Rauber, who is part of the TIMBUS Project Coordination Committee, is also a member of the DURAARK Advisory Board.

[89] http://www.ready4smartcities.eu/home
[90] http://timbusproject.net

6.2 Release of Datasets, Code, Software Artifacts and Plugins

Establishing communities, which pick-up results from DURAARK, is an important part of the Sustainability Strategy of DURAARK, as described in subsubsection 2.3.1. DURAARK created many artefacts, which are of interest for communities of stakeholders and researchers. These are publicly available through established platforms, such as GitHub (Code and libaries, see subsection 4.3), Grasshopper3d (Volvox plugin, see subsection 4.5) or DCHQ] have been (DURAARK Docker, see subsection 4.4). An established share for building related datasets was however missing. This is why DURAARK created a data repository of its own, which provides access to the DURAARK data, connects to both professionals and researchers and is an important legacy of DURAARK.
The use of a wide variety of publication platforms proved already useful, as stakeholders, who get aware of one platform, but might not find the right content can be directed to others ones with more akin code. We experienced a related case, where a developer from Optiréno contacted us through the GitHub page, as he was interested in the IFC reconstruction component. His level of expertise, was however better fitting to the Volvox plug-in. We could redirect him to this and he became an early tester of the developed DURAARK Docker integration in Rhino/Grasshopper. We document the exchange with Optiréno in Appendix B.

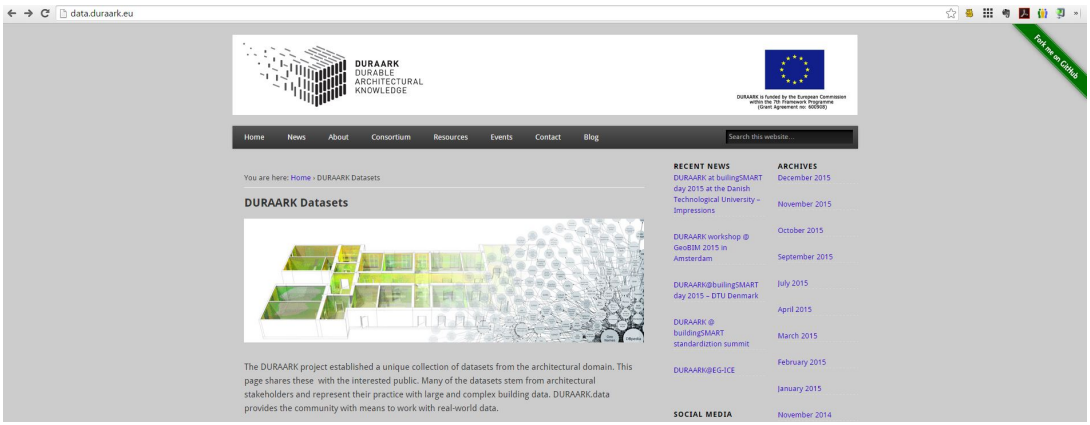


Figure 25: Data.Duraark.eu shares a unique collection of datasets from the architectural domain with the interested public.

The DURAARK dataset repository went online in October 2015 http://data.duraark.eu/. It shares a unique collection of datasets from the architectural domain with the interested public. A dominant part of the datasets, especially among the point cloud

datasets, stem from architectural stakeholders and represent their practice with large and complex building data. data.DURAARK.dk provides the community with means to work with real-world data.
This site contains links to the following datasets, which are all shared to the public domain according to Creative Commons CC0:

1. IFC Models and point clouds – 3d representations of buildings as BIM models (.ifc) and/or point clouds (E57) mainly from 3d Laser scanning
2. RDF Metadata – Graph based representation of architectural data and its internal and external relations. accessible through a common SPARQL Endpoint
3. Schemas & Vocabularies – Data schemes developed within DURAARK to describe the heterogeneous architectural data through a homogenous metadata
4. Application Programming Interfaces (APIs) – Services developed by DURAARK to access and handle architectural data

The page is continuously updated, when new datasets are acquired. The page is promoted through social media, postings on the project website and promotion by DURAARK partners on their mailings, talks on conferences and presentations.
Feedback from users led to the introduction of automatically generated thumbnails for all IFC and point cloud datasets, see Figure 26. This raised the legibility of the datasets and made the page more attractive to visitors.
A dedicated banner relates these as well to the DURAARK presence of GitHub, where the source code to the APIs exposed on data.duraark.eu can be found.

6.3 Creating sustained research action - COST action

A COST action proposal is a major part of the sustainability strategy of DURAARK, as outlined in the section *Exploitation & sustainability actions* 2.3. A related application has been prepared and submitted to the COST Open call procedure.

The COST action has been scoped slightly broader than the scope of the DURAARK project, in order to make sure that we reach a critical mass of researchers in the COST

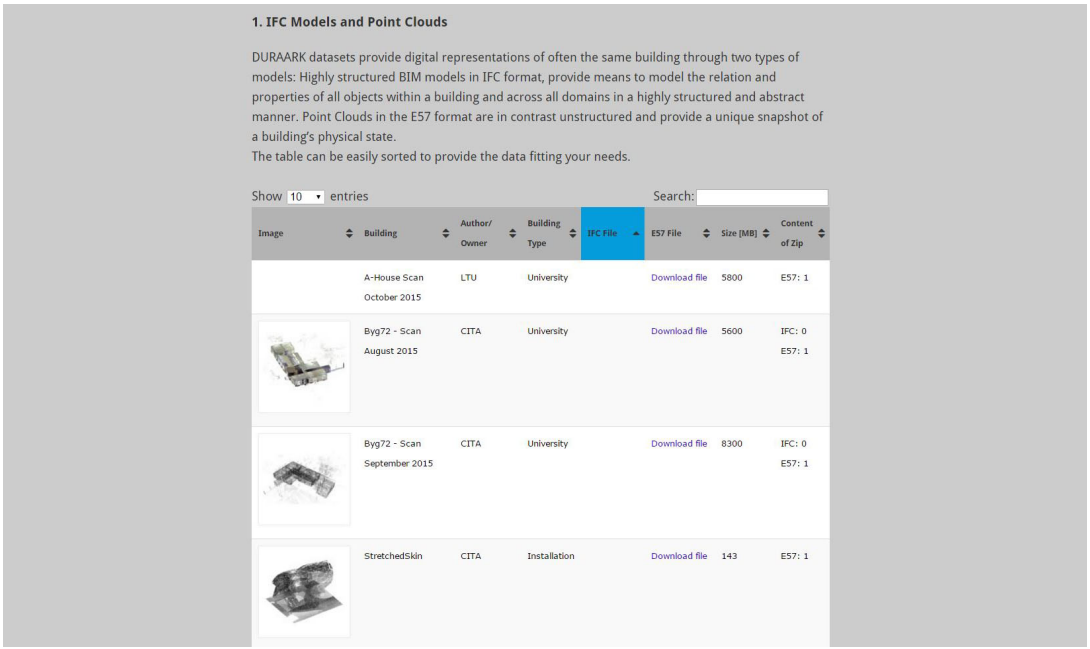


Figure 26: The datasets can be identifed and sorted by a set of criteria, such as type, size and whether both IFC and E587 data is present.

network but also for the possibility to have a knowledge exchange between related topics. In the application the scope of the COST action has been expressed as:

> Data about architectural structures is of relevance in a variety of domains such as urban planning, cultural heritage preservation and reconstruction, architecture or building operation. Historically buildings are documented in a multitude of ways, with early documentations, for instance of cultural heritage, in unstructured and analogue forms, at one end of the spectrum and and current 3D models, point cloud and Building Information Models (BIM) at the other end of the spectrum. Given that diversity, interpretation, search, discovery, analysis and preservation of such data are crucial tasks of interests to all sorts of stakeholders such as architects, urban planners, historians, building operators or cultural heritage experts.
>
> - Interoperability between heterogeneous models and data
> - Geometric analysis and enrichment of 3D models: shape recognition
> - Semantic enrichment of unstructured data and models (documents, 3D models)

- Long-term preservation of multimodal architectural data and models

Therefore, this COST Action aims to form a network of researchers in a range of involved disciplines and application areas, including:

- Semantic technologies and Linked Data
- Long-term preservation
- Information Extraction and Natural Language Processing (NLP)
- Building Information Modelling
- Cultural Heritage Preservation
- Urban planning
- Computer Graphics

The overall aim is to foster and facilitate research addressing the aforementioned challenges by creating an unprecedented network of researchers and practitioners and facilitating exchange and transfer of knowledge.

The work with a COST application has been led by partner LTU that will act as main proposer. All partners have contributed by searching in their respective networks for potential members of the COST proposal.

All partners of DURAARK are expected to participate in the COST action which means that the criteria of at least five COST member countries is fulfilled, but there are several additional participants in the proposal. The proposal should be coordinated by a Main Proposer from a COST member country and DURAARK partner LTU will act as this. The proposal has been submitted for the next COST collection date, which is expected to be 9 February 2016. Therefore, the final outcome of the COST evaluation will probably not be known when the DURAARK project ends.

6.4 Commercialisation activities

The engagement with companies and other stakeholders, who have the potential to pick-up and further develop the research outcome from DURAARK, has been a concern of the project since it first day. The continued efforts in the dissemination of research results to stakeholders, the acquisition of datasets from them and the alignment of the research

to their needs have been documented in the deliverables of the Workpackages 7 and 8. These efforts resulted today in a strong and throughout positive feedback from companies on the DURAARK developments, the expression of interest and joint initiatives to pursue further research.
This chapter reports on the efforts and results of this important part of the sustainability actions of DURAARK.

6.4.1 Engagement with commercial stakeholder groups

DURAARK developed a set of actions, which are coined to identify and get in contact with stakeholders central to the field. These actions are documented in the Dissemination report D8.8 and include:

- participation in stakeholder events
- organisation of stakeholder events
- presentation for individual stakeholders
- areas in which the consortium is actively exchanging with stakeholders i.e. for evaluation activities

6.4.2 DURAARK Info materials

We have developed a set of media conceived to communicate especially to stakeholders like:

- Flyers
- Banners
- Presentations

A complete overview of DURAARK communication media is provided in D8.8.

Figure 27: Stakeholder oriented communication materials include the DURAARK webpage, Flyers, Posters, the DURAARK Facebook presence and presentations made especially for stakeholder events.

6.4.3 Association and activities with commercial stakeholders

DURAARK partners are currently in contact with a series of companies and pursue with them activities to establish further research collaborations on the base of DURAARK results. We have collected a series of letters of expression of interests and appraisal for the relevance of the conducted research. Initial interests of companies, especially into the Geometric enrichment components and the service platform, led to presentations and the exchange of datasets as a fist step for further collaboration. This created "Associated Companies", which were documented in the Deliverables D7.1, D7.2 and D8.8.

The processing of the stakeholders dataset with the DURAARK tools provided opportunities for evaluation and feedback for the further development in the research project, but as well to the stakeholders. These received the results and could evaluate them themselves. The reaction were throughout positive to frenetic: *"Whoa, this is awesome!"* was for instance the reaction of Daniel Davis, Lead researcher at wework, a New York based real estate company, which offers co-working places on a global scale.

The evaluation and collaboration efforts created vested relations to specific stakeholders, with whom DURAARK partners wrote i.e. research applications (Scalypso) or made regarding agreements (Faro, see Appendix). An overview over expressions of interests and datasets have been received from the following companies and organisations. The reaction and expressed interest is documented for some of these in the Appendix B.

- ATP
- Autodesk -App. B
- CCO
- CAD-Q -App. B
- FARO -App. B
- FOJAB
- Haier -App. B
- Hexagon
- KEJD

- Laser Scanning Architecture -App. B
- laserscanning-europe
- LE34
- leica-geosystems -App. B
- optireno -App. B
- Plan3D
- PLH
- scalypso
- WeWork -App. B
- White -App. B
- ZESO

7 Sustainable organisational framework

DURAARK has created an organisational framework (fig. 28), that will enable the partnership to maintain access to and promotion of the research outcomes for a period that lasts at least for the promised period of 5 years. The framework guarantees the access to the software artefacts, as well as further development, the ability to initiate events and research initiatives and to deal with eventually emerging questions of IPR, licensing and use of the foreground created in DURAARK.

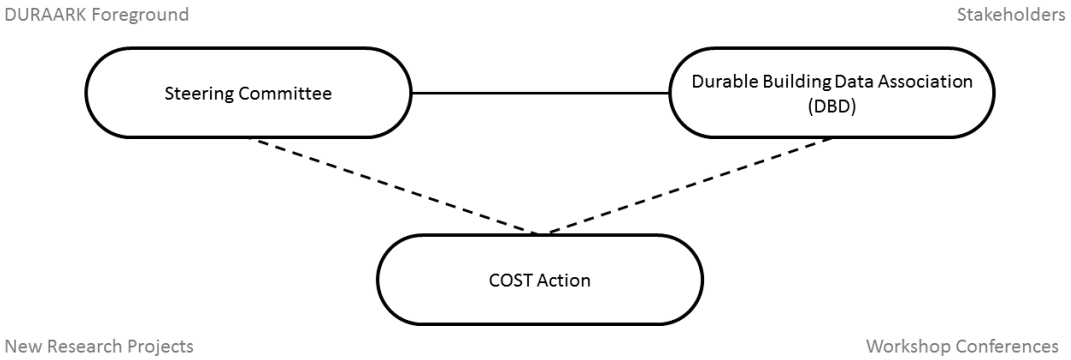


Figure 28: The three parts of the Sustainable organisational framework of DURAARK in relation to their indented purposes. The top two parts are necessary and established. The COST action is under evaluation by the EU commission.

The framework is operative with two already already established parts and will gain an ideal state, when the consortium wins the COST action it applied for. See the following listing for a distinction between the three parts:

Durable Building Data Association (DBD) DBD is a foundation to create and maintain a network of stakeholders around tools and methods related to semantic enrichment and preservation of building-related data. The DBD has a budget financed by its members, a detailed description is available in Section 7.1.

Management of foreground after EU funding period (Steering Committee) The Steering committee is governing the scientific future and exploitation of the DURAARK outcomes with all current project partners, e.g. in striving for new research projects. It has no budget on its own. The Steering Committee is described in 7.2, it has no budget on its own.

COST Action The COST Action additionally provides a publicly funded way of participating in or in the organization of workshops or conferences regarding the DURAARK scientific activities. In that, it could support activities of the DBD. The COST Action is described in Section 6.3.

7.1 Foundation of the "Durable Building Data Association (DBD)"

As part of the organisational sustainability activities the DURAARK consortium is in the process of founding the "Durable Building Data Association (DBD)". The association will be initially funded by the current consortium partners and will constitute at the General Assembly meeting in Graz end of January 2016. The DBD will be located in Graz, Austria. The two founders of the association are Martin Hecher from FhA and Jakob Beetz from TUE.

The goal of the association is to promote the topic of semantic enrichment and preservation of building-related data, attract new members and maintain a competence network. The DBD will also maintain the DURAARK Service Platform as open source platform with documentation updates, code maintenance, feature development and consulting on the integration of new functionality for members and other stakeholders.

The statutes of the foundation can be found in Appendix C.1. This document lists as well the partaking institutions and the further members of the board of the Association. These were defined in the founding meeting of the Association in Graz on the 26.01.2016. They are formulated in German, as the association will be registered in Austria.

7.2 Management of foreground after EU funding period (Steering Committee)

As a structure for managing foreground after the funding period the DURAARK consortium has established a steering committee. The steering committee does not have a budget on its own. For activities which need a budget (e.g. marketing material, see points below) the Durable Building Data Association (DBD, see Section 7.1) organization can be used to finance this necessities. This is possible as the members of the steering committee are also members of the DBD organization.

The committee takes care of post project activities in the following form (for the full text of the agreement see Appendix C.2):

- The steering committee (SC) consists of one representative per consortium partner.
- One of these members has the function of the single "face to the customer". This "face" is the first contact for emails and calls.
- Role of the "face to the customer": If an institution shows interest for scientific DURAARK outcomes, it will address the contact point. The "face" will send a first notice to partners, react to general requests, answer general questions and provides general information about the project.
- More technical or specialised questions will be forwarded to the respective partner in the steering committee and an answer will be send. If applicable the request will be forwarded to the DBD.
- Decisions on activities like regular updates of the webpage, marketing material, marketing activities can be financed via the Durable Building Data Association, if necessary.
- Meeting frequency: The SC should meet once per year. The meeting can be virtual by video conference. If necessary additional meetings can be scheduled.
- Profit: If any of these requests ends up in business that leads to profit, the profit has to be split between the partners/can be invested in further activities.

The official document containing the above content together with legal necessities was approved by the Fraunhofer legal department and by all project partners on the last General Assembly of the Project on 26.01.2016 at FhA in Graz. The complete document signed by all partners can be found in Appendix C.2.

8 Risk analysis

Each partner has a good overview of suitable dissemination activities in their domain. In contrast to other projects, DURAARK, however, has a high potential for involvement in standardisation processes. As touched upon in the introduction 1, we are actively studying the feasibility of involving existing communities as a means to assume sponsorship of the output of DURAARK.

To actively engage in these processes, the right partners need to be identified and collaboration needs to be actively developed to achieve success.

8.1 Failing to make an impact on standardisation and establishment of defact standards

Risk: The consortium might have missed important partners and initiatives (collaborations) in order to generate the best impact on standardisation.

Risk assessment – Impact: High, **Probability:** Low

Description: Dissemination activities are planned according to the best opportunities which are identified at this stage.

Contingency solution: A plan for how the work is and will be carried out exists, but all available communication channels need to be monitored carefully to ensure that no crucial existing or new initiative – for standardisation or other collaborations - are missed. The state of the art and ongoing research developments will be monitored through ongoing clustering activities, via network activities and through regular attendance of scientific and industrial conferences. Furthermore, WP8 and the DURAARK coordination will keep a close contact with the DURAARK Advisory Board in order to ensure input is taken into account from all communities of relevance for DURAARK. Should new initiatives emerge which are so far unrecognised, the WP8 team will assess any collaboration opportunities and, if applicable, will plan new dissemination activities involving the new entities. The status of our efforts will be examined and, if needed, further plans adjusted during regular WP 8 meetings.

8.2 Failing to appropriately address all target communities

Risk: Given the high diversity of the project, there is a risk of missing out on important exploitation targets and communities.

Risk assessment – Impact: Medium, **Probability:** Medium

Description: A critical mass of users and take-up by key target audiences is crucial for the sustainability of the project. Given the high diversity of the project, addressing communities in a balanced way and reaching out to the right venues, working groups and communities is a constant challenge.

Contingency solution: As contingency actions, partners closest to so far under-represented community will be involved by WP8 leader LTU and targeted actions will be conducted. Constant monitoring of dissemination and exploitation action will help to alleviate and detect such issues early.

8.3 Biased stakeholder concern

Risk: Attention to different stakeholder groups gets out of balance (i.e. biased towards certain communities).

Risk assessment – Impact: Medium, **Probability:** Low

Description: The project has stakeholders in many areas which have to be reached through different activities at different times. While this involves a risk to under-recognise certain communities in favour of others, a certain focus might also emerge throughout the course of the project.

Contingency solution: While the DURAARK consortium involves partners from all key areas relevant to the project (digital preservation, building information modelling, semantic web), individual activities of partners are assumed to contribute to a balanced dissemination approach and will be complemented through additional dissemination actions. WP8 will permanently monitor dissemination activities and orchestrate joint dissemination activities which specifically target the identified dissemination needs.

8.4 Failing to successfully set-up a COST action

Risk: We fail to achieve a COST action concerning durable access to and use of building information.

Risk assessment – Impact: Low, **Probability:** Medium

Description: The consortium's exploitation and community-building strategy foresees the setup of a dedicated COST action, covering the inter-disciplinary topics of DURAARK. While COST Actions undergo a review and approval process, there is no guarantee, that even a well-prepared COST Action will finally received funding.

While we are not depending on this funding, it would to some extent affect the possibilities for post-project work and for expanding a community.

Contingency solution: The COST action is seen as an added pillar of the exploitation and sustainability strategy, which complements the overall set of activities. To this extent, it is not a mandatory element which can be complemented through other community-building activities.

9 Conclusions and impact of the sustainability actions

DURAARK has been working on creating a sustainable impact on stakeholder and research communities throughout the project period. It has formulated sustainability goals and actions, which are resting on several columns ranging from creating sustainability of the research outcomes through adress and build up of interested communities, commercialisation and standardisation. These actions have not been exclusive, but were often applied simultaneously. Publishing the source code of software components did for instance not prohibit the collaboration with industry partner in forming new research groups, that pick-up DURAARK research after the funding period in order to develop it further and implement it into commercial products.

The success in standardisation actions and the pick-up of developed software components, as i.e. the VOLVOX plugin, are futher indicators for the impact, that DURAARK made on communities. The longterm archiving communities received finally knowledge and tools in form of guidelines, best practices description, components and awareness in stakeholder communities, that enable them to address this most urgent goal of the DURAARK project. The formation of the "Durable Building Data Association (DBD)" and the agreement of all partners on ways to manage the foreground of the DURAARK research after the funding period, provide finally not only the organisational and legal framework, but as well a mean to maintain and enlarge the interested communities of researchers and practitioners, which DURAARK is currently in contact with.

References

[1] Autodesk. Bim and facilities management.

[2] S. Azhar. Building information modeling: Trends, benefits, risks, and challenges for the aec industry. 11(3):241–252.

[3] Gleason D. Getting to a facility management bim. In editor, editor, *booktitle*.

[4] Tim Golla and Reinhard Klein. Real-time point cloud compression. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2015.

[5] Tim Golla, Christopher Schwartz, and Reinhard Klein. Towards efficient online compression of incrementally acquired point clouds. In *Vision, Modeling & Visualization*. The Eurographics Association, October 2014.

[6] J.-F. Hullo, G. Thibault, and C. Boucheny. Advances in Multi-Sensor Scanning and Visualization of Complex Plants: the Utmost Case of a Reactor Building. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, pages 163–169, February 2015.

[7] U. Isikdag, J. Underwood, and M. Kuruoglu. *Building Information Modelling*. Wiley Blackwell.

[8] G. Kelly, M. Serginson, and Lockley S., editors. *BIM for Facility Management*. Technology Futures Institute, Teesside University, Middlesbrough, UK, 13th International Conference on Construction Applications of Virtual Reality, 30-31 October 2013, London, UK.

[9] D. Kincaid. *Adapting buildings for changing uses: guidelines for change of use refurbishment*. London and New York.

[10] P. Parsanezhad and V. Tarandi. Is the age of facility managers' paper boxes over? In S. Kajewski, K. Manley, and K. Hamspon, editors, *Proceedings of the World Builidng Congress 2013 (CIBWBC2013).*

[11] Eduardo Toledo Santos. Building information modeling and interoperability. In editor, editor, *SIGraDi 2009 - Proceedings of the 13th Congress of the Iberoamerican Society of Digital Graphics, Sao Paulo, Brazil, November 16-18, 2009.*

[12] Budimir N. Svetel I., Jaric M. Bim: Promises and reality. 32:34–38.

[13] Golabchi A.; Kamat V. Evaluation of industry foundation classes for practical building information modeling interoperability. In Shigeo Kitahara Kenichi Fujino Shigeomi Nishigaki, Katsutoshi Saibara, editor, *2013 Proceedings of the 30th ISARC, Montréal, Canada.*

[14] Ran Yu, Ujwal Gadiraju, Besnik Fetahu, and Stefan Dietze. Adaptive focused crawling of linked data. In *The 16th Web Information System Engineering Conference*, 2015.

Appendices

Appendix A

Detailed dataset listings

A.1 Schemas & Vocabularies

In Table A.1 we list all Schemas and Vocabularies, published through DURAARK are listed. They are available for download on `http://data.duraark.eu`

schema	description
buildm	the DURAARK **build**ing descriptive **m**etadata schema intended to be dropped into PREMIS records describing `premisowl:IntelectualEntity` items
ifcm	the DURAARK **IFC** technical **m**etadata schema capturing information describing IFC object representations.
E57m	the DURAARK **E57** technical **m**etadata schema describing E57 point clouds.

Table A.1: Schema and Vocabularies used in DURAARK.

A.2 RDF Metadata

`#type`	`#resources`	`#triples`
`duraark:DigitalObject`	74	730
`duraark:PhysicalAsset`	61	726
`geonames:Feature`	39	512
`Total`	174	1968

Table A.2: Initial `buildM` instances generated by DURAARK as part of the SDA.

In the Table A.2, all RDF Metadata, published through DURAARK are listed. They are available for download on http://data.duraark.eu As part of the SDA, data has been generated generated by the different modules within DURAARK to produce an initial set of `buildM` instances, describing digital objects (e.g. IFC files) and physical objects (the actual buildings). From the initial process the data in the SDA is summarised by the following statistics. The generated resources are accessible through SDA's dereferencing mechanism, e.g. http://data.duraark.eu/resource/0721677.
While the focused crawler deals with creating snapshots of building-related Web data, initial crawls (see deliverables D3.2 and D3.3) have been produced covering specifically geodata and energy sustainability metadata (statistics below). More targeted **focused crawls** are currently under development as part of D3.6.
In addition to this, the SDA also contains information about the dataset generated for our work regarding contextual semantic enrichment (presented in D3.3, D3.4). Here, we investigated the perception of architectural structures within the dataset (for more details regarding the architectural structures within the dataset, see http://data-observatory.org/building-perception/. This data can be queried at the following Graph IRI in the SDAS: http://data.duraark.eu/structures/. Table A.3 presents some statistics regarding this data.

#type	#resources	#triples
Airports	100	1100
Bridges	59	600
Churches	139	1490
Halls	72	729
Skyscrapers	179	1800
Total	549	5719

Table A.3: Statistics regarding the perception of architectural structures (airports, bridges, churches, halls, skyscrapers) in USA and Germany.

A.3 Application Programming Interfaces (APIs)

The DURAARK project has developed a set of services which provide means to access and handle architectural data in digital repositories. The services is accessible via a REST API so that (parts of) the functionality can be integrated into the workflow of stakeholders.

We provide an overview of the services here, together with additional links to the service's homepage, its API documentation and installation instructions.

The listing of the APIs is also available online at http://data.duraark.eu/#apis.

API Listing

Name:	**duraark-sessions**
License:	MIT
Description:	Service for managing DURAARK user sessions
API documentation:	http://data.duraark.eu/services/api/sessions/
Source code:	http://github.com/DURAARK/duraark-sessions

Name:	**duraark-metadata**
License:	MIT
Description:	Service for metadata extraction from IFC-SPF and E57 files
API documentation:	http://data.duraark.eu/services/api/metadata/
Source code:	http://github.com/DURAARK/duraark-metadata

Name:	**duraark-sda**
License:	MIT
Description:	Service exposing the search and semantic enrichment capabilities of the DURAARK knowledge graph
API documentation:	http://data.duraark.eu/services/api/sda/
Source code:	http://github.com/DURAARK/duraark-sda

Name:	**duraark-geometricenrichment**
License:	MIT
Description:	Service for exposing DURAARK's geometric enrichment components via a REST-API
API documentation:	http://data.duraark.eu/services/api/geometricenrichment/
Source code:	http://github.com/DURAARK/duraark-geometricenrichment

---

Name:	**duraark-digitalpreservation**
License:	MIT
Description:	Service providing an API for generating submission information packages (SIPs) and for depositing SIPs to the Rosetta DPS
API documentation:	http://data.duraark.eu/services/api/digitalpreservation/
Source code:	http://github.com/DURAARK/duraark-digitalpreservation

---

Name:	**Focused Crawler**
License:	LGPL
Description:	Service for direct access to the "Focused Crawler" component to gather semantic information on topics (this API is integrated into the "duraark-sda" service)
API documentation:	https://github.com/bfetahu/focused_crawler
Source code:	https://github.com/bfetahu/focused_crawler

A.4 IFC files

In the following table, all IFC datasets used in the DURAARK project, including their size in MB, IFC Schema version and availability are listed.
The table intentionally starts on the next page.

IFC Files	Public				
	Preview				
	Confidential				

Owner / Author	Project Name	Disclosure Agreement	IFC File Name	Number of files	Size of files (mb)
Academic	Academic	Public	Academic_Barcelona-Pavillon_Arch.ifc Academic_DDB-Kingo_Arch.ifc Academic_DDB-KUA-ContextMassing_Arch.ifc Academic_DDB-Massing_Arch.ifc Academic_DDB-Soeholm_Arch.ifc Academic_DDB-Uhrskov_Arch.ifc	6	5.4
Autodesk	Academic_Autodesk	Public	Academic_Autodesk-AdvancedSampleProject_Arch.ifc Academic_Autodesk-BasicSampleProject_Arch.ifc	2	41.4
GeometryGym	PlanarPanels	Public	GeometryGym_131116-PlanarPanels.ifc	1	0.7
Karlsruhe Institute of Technology	FJK	Public	KIT_FJK_Arch.ifc	1	13.9
Karlsruhe Institute of Technology	Institute	Public	KIT_Institute_Arch.ifc	1	2.7
Karlsruhe Institute of Technology	Smiley-West	Public	KIT_Smiley-West_Arch.ifc	1	3.2
UK National Building Specification	Lakeside	Public	NBS_LakesideAC01_Arch.ifc NBS_LakesideAC10_Arch.ifc NBS_LakesideRVT01_Arch.ifc NBS_LakesideRVT10_Arch.ifc NBS_LakesideVW00_Arch.ifc	5	160.0
UK National Building Specification	Duplex	Public	NBU_Duplex-Apt_Arch.ifc NBU_Duplex-Apt_Arch-Optimized.ifc NBU_Duplex-Apt_Eng-HVAC.ifc NBU_Duplex-Apt_Eng-MEP.ifc NBU_Duplex-Apt_Eng-MEP-1.ifc NBU_Duplex-Apt_Eng-MEP-2.ifc NBU_Duplex-Apt_Eng-MEP-Optimized.ifc NBU_Duplex-Apt-COBie_Arch-Design.ifc NBU_Duplex-Apt-COBie_Arch-Handover.ifc NBU_Duplex-Apt-COBie_Arch-ProductInstall.ifc NBU_Duplex-Apt-COBie_Arch-ProductSelect.ifc NBU_Duplex-Apt-COBie_Arch-Programming.ifc	12	74.7
UK National Building Specification	MedicalClinic	Public	NBU_MedicalClinic_Arch.ifc NBU_MedicalClinic_Arch-Optimized.ifc NBU_MedicalClinic_Eng-CON.ifc NBU_MedicalClinic_Eng-CON-Optimized.ifc NBU_MedicalClinic_Eng-ELE.ifc NBU_MedicalClinic_Eng-HVAC.ifc NBU_MedicalClinic_Eng-MEP.ifc NBU_MedicalClinic_Eng-MEP-Optimized.ifc	8	422.0
UK National Building Specification	OfficeBuilding	Public	NBU_OfficeBuilding_Arch-1.ifc NBU_OfficeBuilding_Arch-2.ifc NBU_OfficeBuilding_Arch-Optimized.ifc NBU_OfficeBuilding_Eng-CON.ifc NBU_OfficeBuilding_Eng-CON-Optimized.ifc NBU_OfficeBuilding_Eng-ELE.ifc NBU_OfficeBuilding_Eng-HVAC.ifc NBU_OfficeBuilding_Eng-HVAC-Optimized.ifc NBU_OfficeBuilding_Eng-MEP.ifc	9	142.0
Nemetschek VectorWorks	DCR-LOD	Public	NVW_DCR-LOD100_Arch.ifc NVW_DCR-LOD200_Arch.ifc NVW_DCR-LOD200_Eng-CON-1.ifc NVW_DCR-LOD200_Eng-CON-2.ifc NVW_DCR-LOD200_Eng-HVAC.ifc NVW_DCR-LOD300_Arch.ifc NVW_DCR-LOD300_Eng-CON.ifc NVW_DCR-LOD300_Eng-HVAC.ifc	8	374.0
Selvaag Gruppen / DDS Data Design System	BARD	Public	SGD_BARD_Arch.ifc SGD_BARD_Merged.ifc	2	52.7
Selvaag Gruppen / DDS Data Design System	Blueberry	Public	SGD_Blueberry_Arch-1.ifc SGD_Blueberry_Arch-2.ifc SGD_Blueberry_Arch-3.ifc SGD_Blueberry_Eng-HVAC.ifc SGD_Blueberry_Eng-HVAC-Plumbing-1.ifc SGD_Blueberry_Eng-HVAC-Plumbing-2.ifc SGD_Blueberry_Eng-HVAC-Ventilation.ifc SGD_Blueberry_Merged-Plumbing-1.ifc SGD_Blueberry_Merged-Plumbing-2.ifc SGD_Blueberry_Merged-Ventilation_.ifc	10	121.0
Selvaag Gruppen / DDS Data Design System	BODO	Public	SGD_BODO_Arch-1.ifc SGD_BODO_Arch-2.ifc SGD_BODO_Arch-3.ifc SGD_BODO_Eng-HVAC-Plumbing.ifc SGD_BODO_Eng-HVAC-Ventilation.ifc	5	273.0
Selvaag Gruppen / DDS Data Design System	CDB	Public	SGD_CDB-2010_Eng-HVAC.ifc	1	2.9
Selvaag Gruppen / DDS Data Design System	DDS	Public	SGD_DDS-CAD_Eng-CON.ifc	1	0.2
Selvaag Gruppen / DDS Data Design System	Duplex	Public	SGD_Duplex_Eng-HVAC-Plumbing.ifc SGD_Duplex_Eng-HVAC-Ventilation.ifc	2	91.6
Selvaag Gruppen / DDS Data Design System	HiTOS	Public	SGD_HiTOS_Arch.ifc SGD_HiTOS_Eng-ELE.ifc SGD_HiTOS_Eng-HVAC.ifc	3	75.1
Selvaag Gruppen / DDS Data Design System	Munkerud	Public	SGD_Munkerud_Arch-1.ifc SGD_Munkerud_Arch-2.ifc SGD_Munkerud_Arch-3.ifc SGD_Munkerud_Eng-ELE.ifc SGD_Munkerud_Eng-HVAC-Sanitary.ifc SGD_Munkerud_Eng-HVAC-Ventilation.ifc SGD_Munkerud_Merged.ifc	7	72.9
CITA	Byg72 Scan June 2015	Public	Byg72_BasedOn_1st_Scan.ifc	1	0.4
Plan3D	Haus30	Public	Plan3D_Haus30.ifc	1	20.6
Autodesk research	210-King	Public	Autodesk-Research_210-King_Merged.ifc	1	147.0
CITA	Foundation-EDF	Public	CITA_Foundation-EDF_Arch.ifc	1	35.1
LTU	A-House Scan June 2014	Public	LTU_A-House_current_conditions.ifc	1	89.8
LTU	A.House Scan September 2014	Public	LTU_A-House_Air.ifc LTU_A-House_Cooling.ifc LTU_A-House_Ducting.ifc LTU_A-House_Heating.ifc LTU_A-House_K-model.ifc LTU_A-House_Plumbing.ifc LTU_A-House_redesign.ifc LTU_A-House_Sanitation.ifc LTU_A-House_VOIDS.ifc	9	418.0
Statsbygg	HIBO	Preview	Statsbygg_HIBO_ARK-20080410_PREVIEW.ifc	1	65.3
CCO	DTU-Building127	Preview	CCO_DTU-Building127_Arch_PREVIEW.ifc CCO_DTU-Building127_Eng-CON_PREVIEW.ifc CCO_DTU-Building127_Eng-HVAC_PREVIEW.ifc	3	70.9
Faro	Apartment_MEP	Preview	Faro_Apartment_MEP_PREVIEW.ifc	1	3.4
LE34	Carlsberg	Preview	LE34_Carlsberg_SG-265-Building-1_PREVIEW.ifc LE34_Carlsberg_SG-265-Building-2_PREVIEW.ifc LE34_Carlsberg_SG-265-Building-2-Exterior_PREVIEW.ifc LE34_Carlsberg_SG-265-Building-3_PREVIEW.ifc LE34_Carlsberg_SG-265-Tower-1-2_PREVIEW.ifc	5	433.0

Statsbygg	Risløkka trafikkstasjon	Preview	Statsbygg_Rislokka_B1-Arch.ifc Statsbygg_Rislokka_B2-Arch.ifc Statsbygg_Rislokka_M-Arch.ifc Statsbygg_Rislokka_MEP.ifc Statsbygg_Rislokka_Terrain-Land.ifc	5	93.3
Laser Scanning Architecture	Barrack 2OG	Preview	LaserScanningArchitecture_preview.ifc	1	0.3
ATP	PR	Confidential	ATP_PR_Arch_CONF.ifc	1	24.0
KEJD	Haveje	Confidential	KEJD_Haveje_Arch_CONF.ifc	1	49.7
KEJD	Kastelsvej	Confidential	KEJD_Kastelsvej_FM_CONF.ifc	1	24.4
PLH	DSV	Confidential	PLH_DSV_Arch_CONF.ifc	1	129.0
FOJAB	Landsarkivet	Public	FOJAB_Landsarkivet_IFC.zip	1	169.0
FOJAB	Isblocket	Preview	FOJAB_Isblocket.ifc	1	29.6
CAD-Q	Hosjoskolan	Preview	HOSK_Leverans_20151123.ifc	1	38.1
CCO	DTU-Building-204	Confidential	CCO_DTU-Building-204_FM_CONF.ifc	1	36.9
CCO	DTU-Building324_Construction	Confidential	CCO_DTU-Building324_Construction_Architectural.ifc CCO_DTU-Building324_Construction_Electrical.ifc CCO_DTU-Building324_Construction_Structure.ifc CCO_DTU-Building324_Construction_Ventilation.ifc	4	194.0
CCO	DTU-Building324_Tender	Confidential	DTU-Building324_Tender_Architectural.ifc DTU-Building324_Tender_Structural.ifc	2	111.0
CCO	Lund_Kristallen	Confidential	CCO_Lund-Kristallen_Arch_Conf.ifc	1	200.0
NCC	Carlsby	Confidential	NCC_Carlsby-detailed_Arch_Conf.ifc NCC_Carlsby-tender_Arch_Conf.ifc	2	96.1
			Total	**132**	**4,408.3**

A.5 E57 files

In the following table, all E57 datasets used in the DURAARK project, including their size in MB, their number of scans and number of points are listed.
The table intentionally starts on the next page.

E57 Files	Public				
	Preview				
	Confidential				
Owner / Author	**Project Name**	**Disclosure Agreement**	**E57 File Name**	**Number of files**	**Size of files (mb)**
Acadia	Office	Public	Acadia_Acadia_Office.e57	1	487
CITA	Dermoid	Public	CITA_DermoidI.e57 CITA_DermoidIII.e57	2	12,580
CITA	DesignHub	Public	CITA_DesignHub.e57	1	23,500
CITA	Fraunhofer	Public	CITA_Frauenhofer.e57	1	59,800
CITA	IAAC	Public	CITA_IAAC_University.e57	1	15,500
CITA	Kronborg	Public	CITA_Kronborg.e57	1	16,000
CITA	Marés	Public	CITA_Marés.e57	1	4,330
CITA	PersistentModelling	Public	CITA_PersistentModelling02_PUBLIC.e57	1	980
CITA	KADK-Festsalen	Public	CITA_KADK-Festsalen_QualityOfScan-Cleanness-DarkPoints300_PUBLIC.e57 CITA_KADK-Festsalen_QualityOfScan-Cleanness-StandardFilters_PUBLIC.e57 CITA_KADK-Festsalen_QualityOfScan-Cleanness-StandardFilters-DistanceBased_PUBLIC.e57 CITA_KADK-Festsalen_QualityOfScan-Cleanness-StrayPoints3-0-002-50_PUBLIC.e57 CITA_KADK-Festsalen_QualityOfScan-Cleanness-Unclean_PUBLIC.e57 CITA_KADK-Festsalen_ReferenceScans_QualityOfPlanning-Poor_PUBLIC.e57 CITA_KADK-Festsalen_ScanPrecision_000-Res1-5-Qua3x_PUBLIC.e57 CITA_KADK-Festsalen_ScanPrecision_001-Res1-4-Qua3x_PUBLIC.e57 CITA_KADK-Festsalen_ScanPrecision_002-Res1-2-Qua3x_PUBLIC.e57 CITA_KADK-Festsalen_ScanPrecision_003-Res1-4-Qua4x_PUBLIC.e57 CITA_KADK-Festsalen_ScanPrecision_004-Res1-4-Qua6x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_QualityOfPlanning-Better_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-005-Res1-5-Q2x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-006-Res1-5-Q3x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-007-Res1-5-Q4x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-008-Res1-5-Q6x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-009-Res1-20-Q4X_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-010-Res1-20-Q6X_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-011-Res1-20-Q8x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-012-Res1-16-Q3x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-013-Res1-10-Q3x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-014-Res1-8-Q2x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-015-Res1-5-Q2x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-016-Res1-4-Q1x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-017-Res1-2-Q1x_PUBLIC.e57 CITA_KADK-Festsalen-QualityOfScan_ScannerSettings-017-Res1-2-Q1x_PUBLIC.e57	26	24,600
CITA	Room-24_7	Public	CITA_20131108-Room-24-7_PUBLIC.e57	1	985
CITA	CITA_Deleuran AA VisitingSchool Aarhus	Public	CITA_Deleuran_AAVisitingSchoolAarhus.e57	1	97
CITA	Tower	Public	CITA_Tower.e57	1	1,170
CITA	StretchedSkin	Public	CITA_StretchedSkin_e57.zip	1	183
CITA	DesignMuseum	Public	CITA_DesignMuseum.e57	1	5,480
CITA	Byg72 Scan June 2015	Public	CITA_Byg72_1st_Scan.e57	1	7,640
CITA	Byg72 Scan August 2015	Public	CITA_Byg72_2nd_Scan.e57	1	8,930
CITA	Byg72 Scan September 2015	Public	CITA_Byg72_3rd_Scan_09-2015.e57	1	13,400
Plan3D	Haus30	Public	Plan3D_Haus30_1st.e57 Plan3D_Haus30_2nd.e57 Plan3D_Haus30_3rd.e57 Plan3D_Haus30_Basement.e57 Plan3D_Haus30_Outdoor.e57	5	91,800
Autodesk research	210-King	Public	Autodesk-Research_210-King_Office.e57	1	53
CITA	Foundation-EDF	Public	CITA_Foundation-EDF-01.e57 CITA_Foundation-EDF-03.e57	2	14,400
LTU	A-House Scan June 2014	Public	LTU_A-House_2014-06-25.e57	1	7,940
LTU	A.House Scan September 2014	Public	LTU_A-House_-2014-09-25.e57	1	8,300
LTU	A-House Scan October 2015	Public	LTU_A-House_2015-12-21.e57	1	10,000
ATS	Restaurant	Preview	ATS_Restaurant_PREVIEW.e57	1	7,130
LE34	Gormsgade	Preview	LE34_Gormsgade_1_PREVIEW.e57 LE34_Gormsgade_3-1-Floor_PREVIEW.e57 LE34_Gormsgade_3-2-Floor_PREVIEW.e57 LE34_Gormsgade_3-GrFloor_PREVIEW.e57 LE34_Gormsgade_3-Outside_PREVIEW.e57	5	17,800
LE34	Højbroplads	Preview	LE34_Højbroplads_1_PREVIEW.e57 LE34_Højbroplads_2-Floor_PREVIEW.e57 LE34_Højbroplads_3-Floor_PREVIEW.e57 LE34_Højbroplads_4-Floor_PREVIEW.e57 LE34_Højbroplads_Facade_PREVIEW.e57	5	64,500
LE34	Kloak	Preview	LE34_Kloak_PREVIEW.e57	1	671
LE34	Norsgade	Preview	LE34_Norsgade-Gade_PREVIEW.e57 LE34_Norsgade-Norsgade_PREVIEW.e57	2	38,000
LE34	Vestergade72	Preview	LE34_Vestergade72_Afleveret-1-Floor-1_PREVIEW.e57 LE34_Vestergade72_Afleveret-2-Floor-1_PREVIEW.e57 LE34_Vestergade72_Afleveret-2-Floor-bagtrappe-1_PREVIEW.e57 LE34_Vestergade72_Afleveret-3-Floor-2_PREVIEW.e57 LE34_Vestergade72_Afleveret-4-Floor-2_PREVIEW.e57 LE34_Vestergade72_Afleveret-5-Floor-2_PREVIEW.e57 LE34_Vestergade72_Afleveret-6-Floor-2_PREVIEW.e57 LE34_Vestergade72_Afleveret-kaelder-1_PREVIEW.e57 LE34_Vestergade72_Afleveret-stue-1_PREVIEW.e57	9	174,000
ZESO	Nygade	Preview	ZESO_Nygade_PREVIEW.e57	1	30,000
CCO	DTU-Building127	Preview	CCO_DTU-Building127_CITA-Clean_PREVIEW.e57 CCO_DTU-Building127_CITA-Sub5x5_PREVIEW.e57 CCO_DTU-Building127_CITA-UnClean_PREVIEW.e57	3	37,900
Faro	Apartment_MEP	Preview	Faro_Apartment_MEP_PREVIEW.e57	1	5,410
LE34	Carlsberg	Preview	LE34_Carlsberg_Byg-1-1-Floor-1_PREVIEW.e57 LE34_Carlsberg_Byg-1-1-Floor-2_PREVIEW.e57 LE34_Carlsberg_Byg-1-2-Floor-1_PREVIEW.e57 LE34_Carlsberg_Byg-1-2-Floor-2_PREVIEW.e57 LE34_Carlsberg_Byg-1-3-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-1-Kaelder_PREVIEW.e57 LE34_Carlsberg_Byg-1-Stuen_PREVIEW.e57 LE34_Carlsberg_Byg-1-Trappe_PREVIEW.e57 LE34_Carlsberg_Byg-2-1-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-2-2-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-2-3-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-2-4-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-2-5-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-2-Kaelder_PREVIEW.e57 LE34_Carlsberg_Byg-2-Stue_PREVIEW.e57 LE34_Carlsberg_Byg-3-1-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-3-2-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-3-3-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-3-4-Floor_PREVIEW.e57 LE34_Carlsberg_Byg-3-Kaelder_PREVIEW.e57 LE34_Carlsberg_Byg-3-Stue_PREVIEW.e57 LE34_Carlsberg_Byg-3-Trappe_PREVIEW.e57 LE34_Carlsberg_Exterior-1_PREVIEW.e57 LE34_Carlsberg_Exterior-3_PREVIEW.e57 LE34_Carlsberg_Exterior-4_PREVIEW.e57 LE34_Carlsberg_Tag_PREVIEW.e57	26	635,820
Statsbygg	Rislokka trafikkstasjon	Preview	Statsbygg_Rislokka-Trafikkstasjon_PREVIEW.e57	1	20,300
Laser Scanning Architecture	Barrack 2OG	Preview	LaserScanningArchitecture_collected_preview.e57	1	21,300
WeWorks	240 Bedford	Confidential	WeWorks_240bedford_CONF.e57 WeWorks_240bedford_IndoorONLY_CONF.e57	2	15,000
WeWorks	255 Butler	Confidential	WeWorks_255butler_CONF.e57	1	31,500
FOJAB	Landsarkivet	Public	FOJAB_Landsarkivet_1900_1970.e57 FOJAB_Landsarkivet_2014.e57	2	9,110
FOJAB	Villa Pierce	Preview	Villa_Pierce_basement.e57 Villa_Pierce_1Floor.e57 Villa_Pierce_2Floor.e57	3	10,700
FOJAB	Isblocket	Preview	Isblocket_5thFloor.e57	1	6,990

FARO	Tiergartenstrasse	Preview	Villa_EG_.e57 Villa_OGT_.e57 Villa_HK.e57 Villa_KG.e57	4	37,820
Faro	Small Building	Preview	Faro_SmallBuilding_E57.zip Faro_SmallBuilding_2x2_E57.zip	2	41,000
WHITE	LimhamnsLæge	Preview	1Floor.e57 2Floor.e57	2	7,870
CAD-Q	Hosjoskolan	Preview	CADQ_Hojskolan_E57.zip CADQ_Hojskolan_2x2_E57.zip CADQ_Hojskolan_5x5_E57.zip	3	220,000
CITA	KADK Courtyard	Public	CITA_KADK_Courtyard.E57	1	4,540
MortenMyrup	Loft_and_Roof	Confidential	MortenMyrup_Loft_Roof.E57	1	4,150
CITA	KADK_Exhibition_UMTS	Public	CITA_UMTS_Exhibition.E57	1	13,800
CITA	Nyborg Strand	Public	CITA_Nyborg.E57	1	898
ATS	Nyborg Strand	Preview	ATS_NyborgStrand.E57	1	297
HCU	Nyborg Strand	Preview	HCU_NyborgStrand.e57	1	713
CITA	Diakonissen	Public	CITA_Diakon_1stFloor.e57 CITA_Diakon_Basement.e57 CITA_Diakon_GroundFloor.e57 CITA_Diakon_Outside.e57 CITA_Diakon_Staircase.e57	5	30,500
CITA	KADK-Reception	Public	CITA_KADK_Reception.E57	1	142
Stattsbyg	Oslo Bispegaard	Preview	Stattsbyg_OsloBispegaard.E57	1	27,600
LE34	Facade	Confidential	LE34_Facade.e57	1	2,450
ATS	Bohus_Fortress	Confidential	ATS_BohusFortress.E57	1	945
CITA	Nikolaj Kunsthal	public	CITA_NikolajKunsthal.e57	1	3,520
			Total	**107**	**1,690,319**

Appendix B

Stakeholder reactions

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B.1 Faro

FARO

FARO 3D Software GmbH
Zweigstelle Dresden, Tiergartenstraße 79, 01219 Dresden, Deutschland

CITA | Centre for Information Technology and
ArchitectureThe Royal Danish Academy of Fine Arts,
Schools of Architecture, Design and Conservation
Martin Tamke, Associate Professor
Philip de Langes Allé 10 / Postal address:
Takkelloftsvej 2
1435 Copenhagen K
Denmark

Dresden, 14.12.15
2549/252246

DURAARK - Components for automated PointCloud to BIM workflow

Sehr geehrter Herr Tamke,

Ihre Ergebnisse im Forschungsprojekt „DURAARK - Components for automated PointCloud to BIM workflows" beeindrucken uns.
Gerne bestätigen wir Ihnen, dass wir zukünftig mit Ihnen gemeinsame Forschungsaktivitäten durchführen wollen.

Als Hersteller von Scannern und vor allem Punktwolken-Interpretationssoftware sehen wir uns als natürlichen Partner.
Da wir selbst für Domänen wie Rohrleitungssysteme, Architektur und Archäologie Mustererkennungssysteme entwickeln, können wir Ihren Ansatz zur Erkennung der wesentlichen Architekturelemente (Wände, Türen, Fenster etc.) in Gebäuden nachvollziehen und halten ihn für aussichtsreich. Wir konzentrieren uns aktuell auf halbautomatische Ansätze, um eine manuelle Prüfung und Nachbereitung zu vermeiden. Für den relativ regelreichen und strukturierten Bereich (Neubau-)Architektur können wir erkennen, dass ein Vollautomat im Bereich des Möglichen liegt.

Anwendungen während der Planung im Bestand sowie die Etablierung eines Regelkreises für den Bauprozess sind sehr relevant. Sie können zu einem signifikant höheren Automatisierungsgrad in dieser Industrie beitragen.

Zweigstelle Dresden: FARO 3D Software GmbH, Tiergartenstraße 79, 01219 Dresden
Hauptsitz: FARO 3D Software GmbH, Lingwiesenstr. 11/2 • 70825 Korntal-Münchingen
Registergericht Stuttgart • HRB 751952 • UST-ID-Nr: 70006/01979
Geschäftsführung: Joseph Anthony Arezone
(ISO 9001:2008) • Bank: HypoVereinbsbank • BIC/Swift: HYVEDEMM497
IBAN: DE74870200860007444052

www.faro-3d-software.com

Telefon: +49 (0) 351 418 880 0
Telefax: +49 (0) 351 418 880 29
info@faro-3d-software.com
Nasdaq: FARO

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B.2 wework

From: Daniel Davis
To: Martin Tamke
Cc: Jason Andersen; Thad Wester; Henrik Leander Evers
Subject: Re: Laser scans
Date: 15. december 2015 18:19:50

Whoa, this is awesome! It works really smoothly on my computer. And thanks for sending through the settings, it looked pretty sad to begin with but now it looks fantastic.

Daniel

On Tue, Dec 15, 2015 at 11:58 AM, Martin Tamke <Martin.Tamke@kadk.dk> wrote:

> Hello all
>
> As promised three stories from the 255_Buttler dataset as weblink.
>
> http://134.119.46.108/potree/examples/diff_1.html
>
> http://134.119.46.108/potree/examples/diff_2.html
>
> http://134.119.46.108/potree/examples/diff_3.html
>
> The potree viewer looks best, if you have these settings:
>
> - Turn "max. points(m)" to maximum
>
> - lower "Appearance" > "PointSize" a bit
>
> - Enable "Appearance" > "Eye-Dome-Lighting"
>
> - Lower "Appearance" > "Eye-Dome-Lighting" > "Strength"
>
> - Lower "Appearance" > "Eye-Dome-Lighting" > "Radius"
>
> - Clipping might be useful; to realize that do:
>
> 1. Look from above, click the right-most tool ("clipping volumes") and
>
> place the box roughly somewhere
>
> 2. You can edit this box by pressing "e", "r" or "t" to activate
>
> different transformations
>
> 3. Setting "Settings" > "Clip Mode" to "Clip Outside" actually clips
>
> using the box which allows you to restrict the view.

Good fun

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
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1435 Copenhagen K
Denmark
tel +45 4170 1500 / direct +45 41701731
http://cita.karch.dk

http://duraark.eu

http://innochain.net

http://www.complexmodelling.dk

KADK - CVR nummer DK18975734

EAN 5798009814210

From: Jason Andersen [mailto:jason.andersen@wework.com]
Sent: 14. december 2015 17:37
To: Daniel Davis <daniel.davis@wework.com>
Cc: Martin Tamke <Martin.Tamke@kadk.dk>; Thad Wester <thad.wester@wework.com>
Subject: Re: Laser scans

Martin,

Here is the 255 Butler existing conditions model as we do them.

https://app.box.com/s/d7z19tqbv1rw40neocrpuhgdkqxas1yv

WeWork | Jason Andersen
Associate, Director of Project Integration
Physical Product

wework.com

Create Your Life's Work

On Tue, Dec 8, 2015 at 3:09 PM, Daniel Davis <daniel.davis@wework.com> wrote:

> Hi Martin,
>
> Lets discuss this more on Monday. I'm sure we can give you the right files, we might need to take some of the proprietary information out of them, but it should be okay.
>
> Daniel
>
> On Tue, Dec 8, 2015 at 1:15 PM, Martin Tamke <Martin.Tamke@kadk.dk> wrote:
>
> > Hello Daniel
> >
> > Thanks a model of the current state would as well be interesting, as the analysis should show all new and all remaining walls.
> >
> > Best Martin Tamke
> >
> > Martin Tamke, Dipl. Ing. MAA
> > Associate Professor
> >
> > CITA | Centre for Information Technology and Architecture
> > The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
> > Philip de Langes Allé 10 / Postal address: Takkelloftsvej 2
> > 1435 Copenhagen K
> > Denmark
> > tel +45 4170 1500 / direct +45 41701731
> > http://cita.karch.dk

,

B.3 Haier

From: HAIER (IMAP)
To: Martin Tamke
Subject: CITA/Tamke - Info und Fragen
Date: 27. maj 2015 07:47:18

Sehr geehrter Herr Tamke!

Danke für Ihre Antwort.

Ich sende Ihnen als ZIP das stationierte Projekt aus Scene und zusätzlich die direkten Scans aus dem Scanner FARO X130.

Ich stelle diese Dateien auf Onedrive (eine Freischaltung folgt) zum Download zur Verfügung.
Sollte es damit Probleme geben, ersuche ich um Info, dann versuche ich es mit wetransfer.

Da das Internet in unserer Gegend nicht das Schnellste ist, kann es einige Zeit dauern, bis Sie die Daten herunterladen können.

Ich spezialisiere mich auf die Lieferung der Grundlagen für die Weiterplanung.

Für das Ergebnis strebe ich folgende Möglichkeiten an (je Anforderung der Kunden):

- 3D-Modell des bestehenden Gebäudes (Geländes), auch von Vegetation als DWG z.B. für AutoCad

oder

- 2D-Schnitte, Grundrisse und Ansichten (wie aus PointCab) die aber wahrscheinlich wirtschaftlicher aus vorher erstellten 3D-Modellen zu gewinnen sind.

Für mein Verständnis:
Sind Teile der angestrebten Ergebnisse nicht schon in z.B. PointSense erreicht ?
Was soll DURAARK außer die Umwandlung von Punktwolken in BIM-Modelle erreichen?
Ich habe etwas im Internet recherchiert, aber dort eigentlich nur sehr allgemeine Beschreibungen gefunden.

Mit freundlichen Grüßen
Andreas Haier

Von: Martin Tamke [mailto:Martin.Tamke@kadk.dk]
Gesendet: Dienstag, 26. Mai 2015 18:58
An: HAIER (IMAP)
Betreff: RE: Faro - Confernece - Gespräch

Hallo Herr Haier

Vielen Dank fuer Ihre Nachricht. Ich erinner mich natuerlich noch gut an Sie und Ihre Firma. Unsere Software laueft zu Zeit nur im Prototypenstatus. Einen Installer fuer Windows platformen hat es leider noch nicht.

Gerne wuerden wir aber mit Ihnen an der weiteren Entwicklung zusammenarbeiten und schauen, dass wir Ihre Anforderungen in die Software implementieren uns bald auch mit Ihnen testen koennen. Ein guter Einstieg in die Zusammenarbeit wäre, wenn Sie uns einen typischen Scan Datensatz zur Verfuegung stellen wuerden. Wir koennten diesen dann durch unseren Prototypen laufen lassen und

sehen, ob er Ihren Erwartungen entspricht und natuerlich diskutieren, wie wir geeignete Daten erstellen koennen.

Vielleicht koennen Sie uns eine Datensatz von einem Haus zusenden, an dem Sie schon gearbeitet haben. Wo Sie also die original Scans und die Daten, die Sie fuer Planungsprozesse erstellen, haben. Am besten fuer den Transport von groesseren Datenmengen zu uns ist https://www.wetransfer.com/ geeignet.

Ich freue mich auf einen weiteren Austausch

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
Philip de Langes Allé 10
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Denmark
tel +45 4170 1500 / direct +45 41701731
http://cita.karch.dk

http://duraark.eu
http://innochain.net
http://www.complexmodelling.dk

KADK - CVR nummer DK18975734
EAN 5798009814210

From: HAIER (IMAP) [mailto:haier@ahabau.at]
Sent: 24. maj 2015 15:28
To: Martin Tamke
Subject: Faro - Confernece - Gespräch

Sehr geehrter Herr Tamke!

Sie werden Sich vielleicht an unser Gespräch nach Ihrem Vortrag auf der FARO-Conference in Stuttgart erinnern.

Da haben wir besprochen, dass ich als User bei der Weiterentwicklung Ihrer Software mithelfen könnte.

Ich ersuche Sie daher um Information, wie das ablaufen könnte und eventuell um einen Link Ihre Software herunterladen zu können.

Mit freundlichen Grüßen
Ing. Andreas Haier
Baumeister

Diese E-Mail wurde von Avast Antivirus-Software auf Viren geprüft.
www.avast.com

Diese E-Mail wurde von Avast Antivirus-Software auf Viren geprüft.
www.avast.com

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B.4 Laser Scanning Architecture

From: Laser Scanning Architecture
To: Martin Tamke
Subject: Re: DURAARK - Components for automated PointCloud to BIM workflows - Our talk during FARO 3D Documentation Conference in Stuttgart
Date: 24. november 2015 16:29:32

Hallo Martin,

nun habe ich geschafft, Euch ein Set eines Grundrisses zusammenzustellen.
Einmal der FARO Workspace und zum Vergleich die acad dwg.
Bin gespannt auf Eure Auswertung!

Downloadlink (2 GB):
https://www.hidrive.strato.com/lnk/FZsPHbBt

Mit herzlichen Grüßen,
Dipl.-Ing. Johannes Rechenbach
Architekt BDA

Laser Scanning Architecture
Lüerstraße 16
D-30175 Hannover

fon +49 511 81 40 60
mobil +49 160 855 45 55

mail@laser-scanning-architecture.com
www.laser-scanning-architecture.com

Am 04.11.2015 um 14:35 schrieb Martin Tamke:

> Hallo Johannes
>
> Hier nun das von uns unterschriebene NDA .
> Ich freue mich auf den weitern Asutausch und deine Meinung zu den Modlelen, die wir dir nach erhalt der Revit und Scene daten schnellstmoeglich zusenden werden.
>
> Best Martin Tamke
>
> Martin Tamke, Dipl. Ing. MAA
> Associate Professor
>
> CITA | Centre for Information Technology and Architecture
> The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
> Philip de Langes Allé 10 / Postal address: Takkelloftsvej 2
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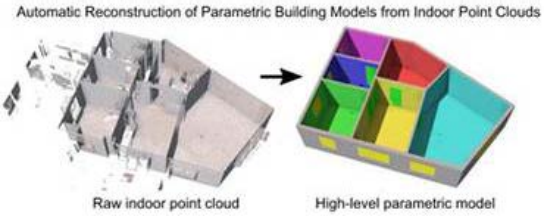
> http://cita.karch.dk
>
> http://duraark.eu
> http://innochain.net
> http://www.complexmodelling.dk

KADK - CVR nummer DK18975734
EAN 5798009814210

From: Martin Tamke
Sent: 13. oktober 2015 13:00
To: 'mail@lsa3d.com' <mail@lsa3d.com>
Subject: DURAARK - Components for automated PointCloud to BIM workflows - Our talk during FARO 3D Documentation Conference in Stuttgart

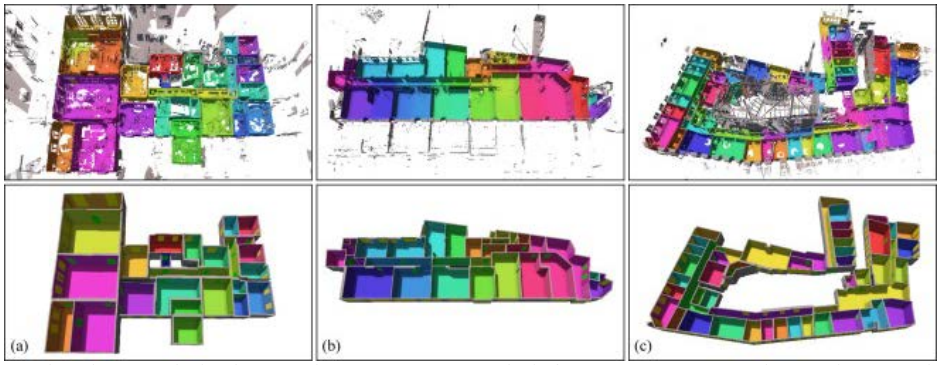
Dear Johannes Rechenbach,

I hope this mail reaches you well. We got in contact during your FARO 3D Documentation Conference in Stuttgart earlier this year and we spend some time waiting for the trains to Stuttgart. Here we were discussing, how Point Clouds are often hard to implement into the AEC related workflows, as these are centered around BIM models. I told you about an early prototype of our tools to automatically generate BIM models from Point Clouds and you expressed an interest in testing these with some of your architectural datasets.



Today we would like to pick up this conversation and hope, that you are interested in an exchange. We have matured the tools within the project. These prototypes center on the geometric and semantic enrichment of Point Clouds. We have now good working processes for the automated PointCloud to BIM processes and automated registration and detection of differences between Point Clouds and existing BIM models. These have been published in papers (as in this Special Issue on CAD/Graphics 2015 - http://www.sciencedirect.com/science/article/pii/S0097849315001119) .

We have as well a video, which might interest you. It demonstrates the creation of BIM models from simple and more complex Point Clouds. http://0x00.cc/pc2bim-cad-graphics-2-720.mp4 . Our tools are at the moment able to automatically remove clutter and outliers within Point Clouds and detect spaces, wall, doors and windows. These are than transformed into parametric BIM models in the open-standard IFC format.



Example results on point clouds with 33, 43, and 67 scans. Upper row: point clouds after segmentation step; most ceiling points (i.e. points with downwards-facing normals) are removed for visualization. Lower row: generated BIM models; detected windows are shown in yellow, doors are shown in green. Most wall elements are faithfully reconstructed; some excess walls have not been removed (see e.g. the large room in the lower-right corner of the second column).

We hope, that you see a benefit of these approaches for your workflows and are still interested in a collaboration with research. Our tools, which we developed together with our colleagues from Computer Science in the frame of the European Research project DURAARK, are however still research prototypes. In Stuttgart we discussed, how these might eventually support some areas of your workflows in generating building models.

A first step for an exchange, might be, besides an initial call, to receive some architectural Point Cloud datasets and the derived BIM models from you. We could than test the DURAARK prototypes on these and have a discussion on the resulting BIM models with you. We have developed a Non-Disclosure Agreement, which should make this as well easy on a juristically level.

I hope, that we raised some interest and look forward for future exchange with you.

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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EAN 5798009814210

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B.5 Leica

From: Tahir.Sharif@leica-geosystems.com
To: Martin Tamke
Subject: RE: Articles
Date: 12. december 2015 20:45:49

thanks please can you send me the link to the opensource code on github as well..

From: Martin Tamke <Martin.Tamke@kadk.dk>
To: "Tahir.Sharif@leica-geosystems.com" <Tahir.Sharif@leica-geosystems.com>
Date: 12/12/2015 14:38
Subject: RE: Articles

Hello Tahir

No problem, please find attached. I really look forward for the further exchange.

Thre paper attached:
. The underlying principals of our method - Grapp Paper - Ochmann, S, Vock, R, Wessel, R, Tamke, M and Klein, R 2014 'Automatic Generation of Structural Building Descriptions from 3D Point Cloud Scans', Proceedings of GRAPP 2014 - International Conference on Computer Graphics Theory and Applications, LisBon
. A more contextualizing and somewhat speculative paper for the Ecaade conference - From Point Clouds to Definitions of Architectural Space
. Paper on a process, that we developed to search in images from 3d scans for objects (here sockets) and relate them back to the 3d model.

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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KADK - CVR nummer DK18975734
EAN 5798009814210

-----Original Message-----
From: Tahir.Sharif@leica-geosystems.com [mailto:Tahir.Sharif@leica-geosystems.com]
Sent: 11. december 2015 15:01
To: Martin Tamke <Martin.Tamke@kadk.dk>
Subject: Articles

Hi Martin

Please can you send through the articles you mentioned.

Regards
Tahir

Sent from my iPhone

[attachment "paper_web_rc1.pdf" deleted by Tahir Sharif/EMEA/Leica] [attachment "ecaade2014_138.content.pdf" deleted by Tahir Sharif/EMEA/Leica] [attachment "GRAPP_2014_54_CR.PDF" deleted by Tahir Sharif/EMEA/Leica]

,

B.6 Autodesk

From: Ramtin Attar
To: Martin Tamke
Cc: Azam Khan
Subject: RE: DURAARK components
Date: 16. april 2015 18:07:19

Hi Martin,
It was great chatting with you at SimAUD. Finally I got some response back from our team in San Fran so I can set up a meeting. Please let me know how flexible your schedule is over the next couple of weeks. Also, who will be attending on your side. Autodesk team will be very technical, so it might help if you have a technical representative on your side. My understanding is that you are primarily asking for help on the SDK /API.

Best
Ramtin

From: Martin Tamke [mailto:Martin.Tamke@kadk.dk]
Sent: Friday, March 27, 2015 3:15 PM
To: Ramtin Attar
Cc: Azam Khan
Subject: DURAARK components

Hello Ramtin

Azam and me had some dialogue about our ongoing research on Point Clouds and BIM models and, as you are as well engaged in this area you might help us here.
Over the last years we have been investigating related workflows for the building profession and created a set of components for difference detection, reconstruction, registration etc. The components have been developed within the EU DURAARK project wwww.duraark.eu, which is aiming at granting longterm accessibility to building data. Within this scope a set of tools are looking into semantic and geometric enrichment – which implies for instance the automated identification of spaces and architectural elements. The developed components can be addressed in a web environment or from software packages. We find that the tool works already quite nicely and offer support for architectural practice.

We wonder, whether Autodesk would be interested in a further exchange and collaboration on the development? Azam said that you might know how to proceed, or whom to approach.

I attach some screenshots of two of the developed components in the nice graphicstyle of our collaborators from Computer Science. The work here is just in the process of publication – I would hence ask you to keep it confidential.

We have as well tried an experimental implementation of the components in Rhino - mainly, as the plug on the PointCloud API of Revit was pulled just when we wanted to test it. Another question of ours would be, whether there is a documented way to address the PointCloud engine in Revit.

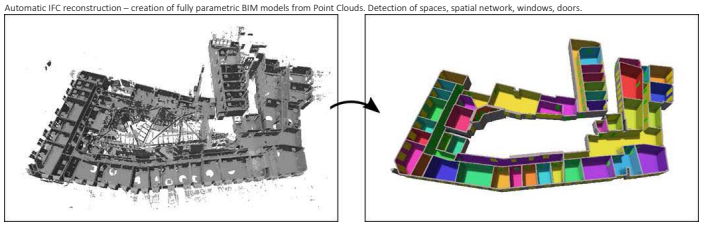
However we were able to establish a prototypical and very experimental workflow from a pointcloud to an editable BIM Model in Rhino. We have a video of this on vimeo. Its again unpublished work (and pretty rough ☺) the link is https://vimeo.com/123438344 - the password: DURAARK . The components we use here do not represent the state of the art of the component development – but might give an idea of the degree of achieved automatisation and act as proof of concept.

I look forward for further exchange and hope you have a great day together with Azam.

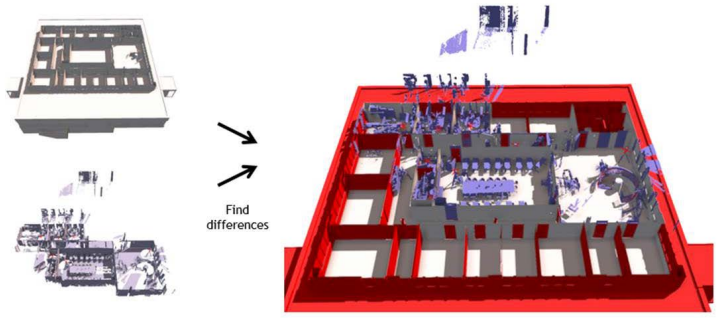
Best from Copenhagen

martin

Automatic IFC reconstruction – creation of fully parametric BIM models from Point Clouds. Detection of spaces, spatial network, windows, doors.



Difference detection – here BIM against Point Clouds. Detection and monitoring of (un)intentional deviations - incorrectly placed walls, torn down walls. The approach is able to work with potentially incomplete representations and is able to detct semantic relations of walls and points, and hence differentiate between interior objects, scanned BIM objects with deviations and those without.



Martin Tamke, Dipl. Ing. MAA
Associate Professor

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http://www.complexmodelling.dk

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EAN 5798009814210

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B.7 BIM hub

From: Tahir Sharif
To: Martin Tamke
Cc: mohammed@thebimhub.com
Subject: Follow Up
Date: 8. januar 2016 12:49:46

Dear Martin

Please can we arrange a time for an online demo of what we discussed at GeoBIM.

FYI, I left Leica Geosystems at the end of Dec.

Regards
Tahir Sharif

The BIM Hub LTD
Scotgate House
2 Scotgate Road
Honley, Holmfirth,
England
HD9 6GD
http://www.thebimhub.com

The BIM Hub Fz-LLc
Office 51,
DMC Building No. 8,
Dubai Media City, Dubai
United Arab Emirates,
P.O. Box 502068

,

B.8 CAD-Q hub

From: Daniel Davies
To: Martin Tamke; Henrik Munk Madsen; Samir Balicevac; Tore I Marthinsen; Shahab Khalaj; Anders Moberg
Subject: SV: Automation of Pointcloud to BIM - DURAARK
Date: 4. november 2015 16:07:10
Attachments: image001.png
image002.png
image004.png

The image looks really cool and useful for quality assurance of modelled vs cloud data and identifying what is necessary for deviation checking.
Martin, maybe you should consider just printing these images and selling them for a high price to a gallery as abstract digital art ☺

Anders & Samir
Will you be sending a data set. Cloud and model to Martin for testing purposes?

Best Regards

CAD-Q
ADDNODE GROUP

Daniel Davies
BIM Application Engineer

Direct +45 44 22 14 19
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Mobile +45 40 76 64 66
e-mail daniel.davies@cad-q.dk

2300 Copenhagen
Denmark
Visiting address: Robert Jacobsens Vej 70.1

NAVIATE
bimeye

Fra: Martin Tamke [mailto:Martin.Tamke@kadk.dk]
Sendt: 4. november 2015 15:52
Til: Daniel Davies <Daniel.Davies@cad-q.dk>; Henrik Munk Madsen <Henrik.Munk.Madsen@cad-q.dk>; Samir Balicevac <samir.balicevac@cad-q.se>; Tore I Marthinsen <Tore.Marthinsen@cad-q.no>; Shahab Khalaj <shahab.khalaj@cad-q.se>; Anders Moberg <anders.moberg@cad-q.se>
Emne: RE: Automation of Pointcloud to BIM - DURAARK

Hello Anders, Henrik, Samir, Tore, Shahab and Daniel

Daniel Davies and me had a quick call today and he updated me on the status of the conversation. I'm very happy to hear about your interest and the possibility to receive a dataset for some tests on ourside. What I didn't illustrate in my last email is the "Semantic Difference detection", which we developed. This tool displays the differences between a BIM model and a pointCloud with regards to clutter (such as Furniture) and exteriors of the scan (such as neighboring buildings, trees etc.). I attach a screenshot with a colour code (Purple = Exterior & Indoor Clutter, Grey = Matching BIM elements, Red = Deviating BIM elements (& openings)).

We would be happy to provide you with some sample output of the tool as well, if you have a dataset with a BIM model (ifc or revit) and Point Cloud scan (FARO scene or e57 format) for us. The e57 should contain

the single scans including scanner locations.

All the best from Copenhagen. We look forward for the further exchange and discussion of possibilities and potentials.

Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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From: Martin Tamke
Sent: 28. oktober 2015 12:02
To: 'Daniel Davies' <Daniel.Davies@cad-q.dk>
Subject: RE: Automation of Pointcloud to BIM - DURAARK

Hello Daniel

Thank you very much for forwarding this and the instant feedback. We would be more than happy to get into a closer exchange and you are completely right, that the solution is in a research state. With good results however.

Concerning the questions:

1) The tool creates at the moment ifc format as an output. As it is internally working with parametric elements the output doesn't really matter too much and an integration into other BIM descriptions shouldn't be a problem.
2) The point cloud related tools necessitate a good pointcloud / BIM environment before and after and there are quite good ones already. We have done a prototypical implementation in Rhino with the VisualArq BIM plugin and have as well a webplatform, where the tool is integrated on serverside. But overall we consider it better, that the tool get integrated into existing workflows and look here for project collaborations.
3) It would be great to discuss this further. There might as well be areas in the process of working on a project, where the developed difference detection of BIM to pointclouds, could serve well for quality control etc.

I would propose, that we have a call together with the group in Stockholm. Best possibly after a test on a dataset from yours? Than we could talk about results.
Today I´m in a project kickoff, but maybe you and me can have a call tomorrow? Would you have time around lunch time?

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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http://www.complexmodelling.dk

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EAN 5798009814210

From: Daniel Davies [mailto:Daniel.Davies@cad-q.dk]
Sent: 27. oktober 2015 13:07
To: Martin Tamke <Martin.Tamke@kadk.dk>
Subject: VS: Automation of Pointcloud to BIM - DURAARK

Hi Martin
Here is the reply I received from our FM business unit manager. They seem very interested in a meeting with you. See email underneath.

Obviously we want to enquire about the commercial potential of your work and what commercial intentions or application this research is heading in. We (CAD-Q) are of course in the business of software solutions and development of related services.

Best Regards

CAD-Q
ADDNODE GROUP

Daniel Davies
BIM Application Engineer

Direct	+45 44 22 14 19	2300 Copenhagen
SwitchB	+45 70 10 71 10	Denmark
Mobile	+45 40 76 64 66	
e-mail	daniel.davies@cad-q.dk	Visiting address: Robert Jacobsens Vej 70.1

NAVIATE ROOM FOR THE PROFESSIONAL bimeye

Fra: Anders Moberg
Sendt: 26. oktober 2015 16:42
Til: Daniel Davies <Daniel.Davies@cad-q.dk>; Shahab Khalaj <shahab.khalaj@cad-q.se>
Cc: Henrik Munk Madsen <Henrik.Munk.Madsen@cad-q.dk>; Samir Balicevac <samir.balicevac@cad-

,

B.9 optireno

From:	Yanni Roua
To:	Martin Tamke
Cc:	Henrik Leander Evers; Martin Hecher; Stefan Dietze; Raoul Wessel; Sebastian Ochmann (ochmann@informatik.uni-bonn.de)
Subject:	Re: DURRARK project
Date:	17. december 2015 14:08:29
Attachments:	image007.png image001.png image005.png

Hi Martin,

Glad to hear that you are planning further development in an open source framework as started !
Also could be interested in further collaboration (e.g mobile scanner laser application).

Best,

Yanni ROUA

Responsable développement ERP et innovation BIM

Ingénieur ESTP

optiréno

Bât. A 213 rue de Gerland

69007 LYON

Tel fixe : 04.78.84.29.92

Portable : 06.72.73.20.49

2015-12-16 16:01 GMT+01:00 Martin Tamke <Martin.Tamke@kadk.dk>:

> Hello Yanni
>
> Henrik is working on the renewed code for the Docker implementation in Grasshopper.
>
> And thanks for your question of how we keep the project outputs alive and develop it further – this is indeed a major part of our current efforts.

We plan to uphold the code after the end of the project and are in progress of founding an Association, in order to have a legal framework for this.

However we are for sure majorly interested in continuing the research and developing the components further. We have ideas, but maybe you or your company are interested in a further collaboration?

Best Martin Tamke

Martin Tamke, Dipl. Ing. MAA
Associate Professor

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http://www.complexmodelling.dk

KADK - CVR nummer DK18975734

EAN 5798009814210

From: Yanni Roua [mailto:yanni.roua@optireno.fr]
Sent: 15. december 2015 14:35

To: Henrik Leander Evers <heve@kadk.dk>
Cc: Martin Hecher <martin.hecher@vc.fraunhofer.at>; Stefan Dietze <dietze@l3s.de>; Martin Tamke <Martin.Tamke@kadk.dk>; Raoul Wessel <wesselr@cs.uni-bonn.de>; Sebastian Ochmann (ochmann@informatik.uni-bonn.de) <ochmann@informatik.uni-bonn.de>
Subject: Re: DURRARK project

Hi Henrik,

Yes last week I managed to install and run the docker system, but after trying to restart it, it is crashing, so I need to uninstall and re-install again ...

So if I get it right, if the docker is well installed later on I will be able to run it through Grasshopper and so try the work flows of D7.2 ?

I was wondering as the DURRARK project shall end in January 2016, which parts will be maintained and which might have further development ?

Best,

Yanni ROUA

Responsable développement ERP et innovation BIM

Ingénieur ESTP

optiréno

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69007 LYON

Tel fixe : 04.78.84.29.92

Portable : 06.72.73.20.49

2015-12-15 14:22 GMT+01:00 Henrik Leander Evers <heve@kadk.dk>:

> Hi Yanni
>
> This case sounds very interesting. And your work case is very much related to the research we do in duraark. So very interesting. And I would love to get some feedback from you. ☺ We will though probably not at this stage come to the implementation of Zeb1 scanner data. But who know maybe in the future. ;)
>
> Do you have the Duraark Docker System up and running like described here:
>
> https://github.com/DURAARK/duraark-installer/wiki/Windows-Installation-Instructions

,

B.10 White Architects

From: Ola Dellson
To: Martin Tamke
Subject: Revit to built to pointcloud to Revit
Date: 16. oktober 2015 17:04:11

Hi Martin!

Good to see you the other day, as always. :)

I think I could provide you with a Revit-designed project that you can 3D-scan. It's a project of rowhouses in Limhamn, Malmö. Built by NCC, and they are finishing them (48 in all) in stages, about 10 at a time. So if you time it right you could have access to some houses after they are finished but before the inhabitants arrive.

Are you interested? Let me know, so I can arrange it with NCC. I haven't asked them yet, but I don't think they would say no.

Cheers,
Ola

Ola Dellson, White arkitekter, Malmö, 040-660 93 45

Appendix C

Sustainable organisational framework

C.1 Durable Building Data Association (DBD) Statutes

The statutes intentionally start on the next page.

Statuten des Vereins
Gesellschaft zum nachhaltigen Management von Gebäudedaten

§ 1: Name, Sitz und Tätigkeitsbereich

(1) Der Verein führt den Namen ”Gesellschaft zum nachhaltigen Management von Gebäudedaten“.

(2) Er hat seinen Sitz in Graz und erstreckt seine Tätigkeit auf die ganze Welt.

(3) Die Errichtung von Zweigvereinen ist nicht beabsichtigt.

§ 2: Zweck

Zweck des Vereins ist der Aufbau eines forschungsorientierten Netzwerks zum Thema nachhaltige Datenhaltung für Gebäudedaten. Das Netwerk fördert den wissenschaftlichen Austausch und die Zusammenarbeit von Akteuren im Bereich Architektur, Planung, Konstruktion und Wartung von Gebäuden mit den inhaltlichen Schwerpunkten Langzeitarchivierung von Gebäudedaten, semantische Datenhaltung, Visualisierung von Gebäudedaten und Datenverarbeitung.

Die Tätigkeit des Vereines ist gemeinnützig und nicht auf Gewinn gerichtet.

§ 3: Mittel zur Erreichung des Vereinszwecks

(1) Der Vereinszweck soll durch die in den Abs. 2 und 3 angeführten ideellen und materiellen Mittel erreicht werden.

(2) Als ideelle Mittel dienen

a) Laufende Dokumentation schon bestehender Kontakte und Initiativen im Sinne des Vereinszwecks
b) Aufbau von Kontakten im In- und Ausland
c) Erarbeitung neuer Projekte in Zusammenarbeit mit Forschungseinrichtungen und Unternehmen
d) Bereitstellung von Informationen über vollzogene Projekte und neue Projektvorschläge
e) Durchführung eigener Veranstaltungen (Vorträge, Webinare, Seminare, u.a.) zur Förderung des Vereinszwecks
f) Bereitstellung einer gemeinnützigen und öffentlich zugängliche Software-Platform zur nachhaltige Datenhaltung für Gebäudedaten

(3) Die erforderlichen materiellen Mittel sollen aufgebracht werden durch

a) Beitrittsgebühren und Mitgliedsbeiträge
b) Zuwendungen privater und öffentlicher Stellen
c) Erträge aus Veranstaltungen und Dienstleistungen des Vereins
d) Spenden, Sammlungen, Darlehen, Förderungen und sonstige Zuwendungen und Erträge aus Kapitalanlagen
e) Sachspenden

(4) Der Verein kann, soweit die materiellen Mittel und der Vereinszweck dies zulassen, Angestellte haben und sich überhaupt Dritter bedienen, um den Zweck zu erfüllen. Auch an Vereinsmitglieder, darin eingeschlossen Vereinsfunktionäre, und Vorstandsmitglieder kann Entgelt bezahlt werden, sofern dies auf Tätigkeiten bezogen ist, die über die Vereinstätigkeiten im engsten Sinn hinausgehen; derartiges Entgelt hat einem Drittvergleich standzuhalten. Wird ein Rechtsverhältnis mit einem Vorstandsmitglied abgeschlossen ist die Unterschrift eines weiteren Vorstandsmitglieds notwendig.

§ 4: Arten der Mitgliedschaft

(1) Die Mitglieder des Vereins gliedern sich in ordentliche, außerordentliche und Ehrenmitglieder.

(2) Ordentliche Mitglieder sind jene, die sich voll an der Vereinsarbeit beteiligen. Außerordentliche Mitglieder sind solche, die die Vereinstätigkeit vor allem durch Zahlung eines erhöhten Mitgliedsbeitrags fördern. Ehrenmitglieder sind Personen, die hiezu wegen besonderer Verdienste um den Verein ernannt werden.

§ 5: Erwerb der Mitgliedschaft

(1) Mitglieder des Vereins können alle physischen Personen sowie juristische Personen und rechtsfähige Personengesellschaften werden.

(2) Über die Aufnahme von ordentlichen und außerordentlichen Mitgliedern entscheidet der Vorstand. Die Aufnahme kann ohne Angabe von Gründen verweigert werden.

(3) Bis zur Entstehung des Vereins erfolgt die vorläufige Aufnahme von ordentlichen und außerordentlichen Mitgliedern durch die Vereinsgründer, im Fall eines bereits bestellten Vorstands durch diesen. Diese Mitgliedschaft wird erst mit Entstehung des Vereins wirksam. Wird ein Vorstand erst nach Entstehung des Vereins bestellt, erfolgt auch die (definitive) Aufnahme ordentlicher und außerordentlicher Mitglieder bis dahin durch die Gründer des Vereins.

(4) Die Ernennung zum Ehrenmitglied erfolgt auf Antrag des Vorstands durch die Generalversammlung.

§ 6: Beendigung der Mitgliedschaft

(1) Die Mitgliedschaft erlischt durch Tod, bei juristischen Personen und rechtsfähigen Personengesellschaften durch Verlust der Rechtspersönlichkeit, durch freiwilligen Austritt und durch Ausschluss.

(2) Der Austritt kann nur zum ersten des Monats erfolgen. Er muss dem Vorstand mindestens drei Monate vorher schriftlich mitgeteilt werden. Erfolgt die Anzeige verspätet, so ist sie erst zum nächsten Austrittstermin wirksam. Für die Rechtzeitigkeit ist das Datum der Postaufgabe maßgeblich bzw. das Absendedatum im Falle einer Bekanntgabe per E-Mail. Der Mitgliedsbeitrag bzw. Beitrittsgebühr werden bei einem Austritt nicht rückerstattet.

(3) Der Vorstand kann ein Mitglied ausschließen, wenn dieses trotz zweimaliger schriftlicher Mahnung unter Setzung einer angemessenen Nachfrist länger als sechs Monate mit der Zahlung der Mitgliedsbeiträge im Rückstand ist. Die Verpflichtung zur Zahlung der fällig gewordenen Mitgliedsbeiträge bleibt davon unberührt.

(4) Der Ausschluss eines Mitglieds aus dem Verein kann vom Vorstand auch wegen grober Verletzung anderer Mitgliedspflichten und wegen unehrenhaften Verhaltens verfügt werden.

(5) Die Aberkennung der Ehrenmitgliedschaft kann aus den im Abs. 4 genannten Gründen von der Generalversammlung über Antrag des Vorstands beschlossen werden.

§ 7: Rechte und Pflichten der Mitglieder

(1) Die Mitglieder sind berechtigt, an allen Veranstaltungen des Vereins teilzunehmen und die Einrichtungen des Vereins zu beanspruchen. Das Stimmrecht in der Generalversammlung sowie das aktive und passive Wahlrecht steht den ordentlichen und den Ehrenmitgliedern zu. Das passive Wahlrecht ist nicht auf ordentliche Mitglieder oder Ehrenmitglieder beschränkt.

(2) Jedes Mitglied ist berechtigt, vom Vorstand die Ausfolgung der Statuten zu verlangen.

(3) Mindestens ein Zehntel der Mitglieder kann vom Vorstand die Einberufung einer Generalversammlung verlangen.

(4) Die Mitglieder sind in jeder Generalversammlung vom Vorstand über die Tätigkeit und finanzielle Gebarung des Vereins zu informieren. Wenn mindestens ein Zehntel der Mitglieder dies unter Angabe von Gründen verlangt, hat der Vorstand den betreffenden Mitgliedern eine solche Information auch sonst binnen vier Wochen zu geben.

(5) Die Mitglieder sind vom Vorstand über den geprüften Rechnungsabschluss (Rechnungslegung) zu informieren. Geschieht dies in der Generalversammlung, sind die Rechnungsprüfer einzubinden.

(6) Die Mitglieder sind verpflichtet, die Interessen des Vereins nach Kräften zu fördern und alles zu unterlassen, wodurch das Ansehen und der Zweck des Vereins Abbruch erleiden könnte. Sie haben die Vereinsstatuten und die Beschlüsse der Vereinsorgane zu beachten. Die ordentlichen und außerordentlichen Mitglieder sind zur pünktlichen Zahlung der Beitrittsgebühr und der Mitgliedsbeiträge in der von der Generalversammlung beschlossenen Höhe verpflichtet.

§ 8: Vereinsorgane

Organe des Vereins sind die Generalversammlung (§§ 9 und 10), der Vorstand (§§ 11 und 12), die Rechnungsprüfer (§ 13) und das Schiedsgericht (§ 14).

§ 9: Generalversammlung

(1) Die Generalversammlung ist die „Mitgliederversammlung" im Sinne des Vereinsgesetzes 2002. Eine ordentliche Generalversammlung findet alle vier Jahre statt.

(2) Eine außerordentliche Generalversammlung findet auf

a. Beschluss des Vorstands oder der ordentlichen Generalversammlung,
b. schriftlichen Antrag von mindestens einem Zehntel der Mitglieder,
c. Verlangen der Rechnungsprüfer (§ 21 Abs. 5 erster Satz VereinsG),
d. Beschluss der/eines Rechnungsprüfer/s (§ 21 Abs. 5 zweiter Satz VereinsG, § 11 Abs. 2 dritter Satz dieser Statuten),
e. Beschluss eines gerichtlich bestellten Kurators (§ 11 Abs. 2 letzter Satz dieser Statuten)

binnen vier Wochen statt.

(3) Sowohl zu den ordentlichen wie auch zu den außerordentlichen Generalversammlungen sind alle Mitglieder mindestens zwei Wochen vor dem Termin schriftlich per E-Mail (an die vom Mitglied dem Verein bekanntgegebene E-Mail-Adresse) einzuladen. Die Anberaumung der Generalversammlung hat unter Angabe der Tagesordnung zu erfolgen. Die Einberufung erfolgt durch den Vorstand (Abs. 1 und Abs. 2 lit. a – c), durch die/einen Rechnungsprüfer (Abs. 2 lit. d) oder durch einen gerichtlich bestellten Kurator (Abs. 2 lit. e).

(4) Anträge zur Generalversammlung sind mindestens drei Tage vor dem Termin der Generalversammlung beim Vorstand per E-Mail einzureichen.

(5) Gültige Beschlüsse – ausgenommen solche über einen Antrag auf Einberufung einer außerordentlichen Generalversammlung – können nur zur Tagesordnung gefasst werden.

(6) Bei der Generalversammlung sind alle Mitglieder teilnahmeberechtigt. Stimmberechtigt sind nur die ordentlichen und die Ehrenmitglieder. Jedes Mitglied hat

eine Stimme. Die Übertragung des Stimmrechts auf ein anderes Mitglied im Wege einer schriftlichen Bevollmächtigung ist zulässig.

(7) Die Generalversammlung ist ohne Rücksicht auf die Anzahl der Erschienenen beschlussfähig.

(8) Die Wahlen und die Beschlussfassungen in der Generalversammlung erfolgen in der Regel mit einfacher Mehrheit der abgegebenen gültigen Stimmen. Beschlüsse, mit denen das Statut des Vereins geändert oder der Verein aufgelöst werden soll, bedürfen jedoch einer qualifizierten Mehrheit von zwei Dritteln der abgegebenen gültigen Stimmen.

(9) Den Vorsitz in der Generalversammlung führt ein Vorstandsmitglied das die übrigen Vorstandsmitglieder dazu bestimmen. Ist sich der Vorstand über den Vorsitz der Generalversammlung uneinig, so führt das an Jahren älteste anwesende Vorstandsmitglied den Vorsitz.

§ 10: Aufgaben der Generalversammlung

Der Generalversammlung sind folgende Aufgaben vorbehalten:

a) Beschlussfassung über den Voranschlag;
b) Entgegennahme und Genehmigung des Rechenschaftsberichts und des Rechnungsabschlusses unter Einbindung der Rechnungsprüfer;
c) Wahl und Enthebung der Mitglieder des Vorstands und der Rechnungsprüfer;
d) Genehmigung von Rechtsgeschäften zwischen Rechnungsprüfern und Verein;
e) Entlastung des Vorstands;
f) Festsetzung der Höhe der Beitrittsgebühr und der Mitgliedsbeiträge für ordentliche und für außerordentliche Mitglieder;
g) Verleihung und Aberkennung der Ehrenmitgliedschaft;
h) Beschlussfassung über Statutenänderungen und die freiwillige Auflösung des Vereins;
i) Beratung und Beschlussfassung über sonstige auf der Tagesordnung stehende Fragen.

§ 11: Vorstand

(1) Der Vorstand besteht aus mindestens zwei Mitgliedern.

(2) Der Vorstand wird von der Generalversammlung gewählt. Der Vorstand hat bei Ausscheiden eines gewählten Mitglieds das Recht, an seine Stelle ein anderes wählbares Mitglied zu kooptieren, wozu die nachträgliche Genehmigung in der nächstfolgenden Generalversammlung einzuholen ist. Fällt der Vorstand ohne Selbstergänzung durch Kooptierung überhaupt oder auf unvorhersehbar lange Zeit aus, so ist jeder Rechnungsprüfer verpflichtet, unverzüglich eine außerordentliche Generalversammlung zum Zweck der Neuwahl eines Vorstands einzuberufen. Sollten auch die Rechnungsprüfer handlungsunfähig sein, hat jedes ordentliche Mitglied, das die Notsituation erkennt, unverzüglich die Bestellung eines Kurators beim zuständigen Gericht zu beantragen, der umgehend eine außerordentliche Generalversammlung einzuberufen hat.

(3) Die Funktionsperiode des Vorstands beträgt vier Jahre; Wiederwahl ist möglich. Jede Funktion im Vorstand ist persönlich auszuüben.

(4) Der Vorstand wird von einem Vorstandsmitglied schriftlich oder mündlich einberufen.

(5) Der Vorstand ist beschlussfähig, wenn alle seine Mitglieder eingeladen wurden und mindestens die Hälfte von ihnen anwesend ist. Besteht der Vorstand aus zwei Mitglieder, ist er beschlussfähig wenn beide anwesend sind.

(6) Der Vorstand fasst seine Beschlüsse mit einfacher Stimmenmehrheit; bei Stimmengleichheit wird der Tagesordnungspunkt verschoben. Besteht der Vorstand aus zwei Mitglieder müssen Beschlüsse einstimmig gefasst werden.

(7) Den Vorsitz führt jenes Vorstandsmitglied, das die übrigen Vorstandsmitglieder mehrheitlich dazu bestimmen; bei Stimmengleichheit obliegt der Vorsitz dem an Jahren älteren Vorstandsmitglied.

(8) Außer durch den Tod und Ablauf der Funktionsperiode (Abs. 3) erlischt die Funktion eines Vorstandsmitglieds durch Enthebung (Abs. 9) und Rücktritt (Abs. 10).

(9) Die Generalversammlung kann jederzeit den gesamten Vorstand oder einzelne seiner Mitglieder entheben. Die Enthebung tritt mit Bestellung des neuen Vorstands bzw Vorstandsmitglieds in Kraft.

(10) Die Vorstandsmitglieder können jederzeit schriftlich ihren Rücktritt erklären. Die Rücktrittserklärung ist an den Vorstand, im Falle des Rücktritts des gesamten Vorstands an die Generalversammlung zu richten. Der Rücktritt wird erst mit Wahl bzw. Kooptierung (Abs. 2) eines Nachfolgers wirksam.

§ 12: Aufgaben des Vorstands

Dem Vorstand obliegt die Leitung des Vereins. Er ist das „Leitungsorgan“ im Sinne des Vereinsgesetzes 2002. Ihm kommen alle Aufgaben zu, die nicht durch die Statuten einem anderen Vereinsorgan zugewiesen sind. In seinen Wirkungsbereich fallen insbesondere folgende Angelegenheiten:

(1) Einrichtung eines den Anforderungen des Vereins entsprechenden Rechnungswesens mit laufender Aufzeichnung der Einnahmen/Ausgaben und Führung eines Vermögensverzeichnisses als Mindesterfordernis;
(2) Erstellung des Jahresvoranschlags, des Rechenschaftsberichts und des Rechnungsabschlusses;
(3) Vorbereitung und Einberufung der Generalversammlung in den Fällen des § 9 Abs. 1 und Abs. 2 lit. a – c dieser Statuten;
(4) Information der Vereinsmitglieder über die Vereinstätigkeit, die Vereinsgebarung und den geprüften Rechnungsabschluss;
(5) Verwaltung des Vereinsvermögens;
(6) Aufnahme und Ausschluss von ordentlichen und außerordentlichen Vereinsmitgliedern;
(7) Aufnahme und Kündigung von Angestellten des Vereins.

§ 13: Rechnungsprüfer

(1) Zwei Rechnungsprüfer werden von der Generalversammlung auf die Dauer von 4 Jahren gewählt. Wiederwahl ist möglich. Die Rechnungsprüfer dürfen keinem Organ – mit Ausnahme der Generalversammlung – angehören, dessen Tätigkeit Gegenstand der Prüfung ist.

(2) Den Rechnungsprüfern obliegt die laufende Geschäftskontrolle sowie die Prüfung der Finanzgebarung des Vereins im Hinblick auf die Ordnungsmäßigkeit der Rechnungslegung und die statutengemäße Verwendung der Mittel. Der Vorstand hat den Rechnungsprüfern die erforderlichen Unterlagen vorzulegen und die erforderlichen Auskünfte zu erteilen. Die Rechnungsprüfer haben dem Vorstand über das Ergebnis der Prüfung zu berichten.

(3) Rechtsgeschäfte zwischen Rechnungsprüfern und Verein bedürfen der Genehmigung durch die Generalversammlung. Im Übrigen gelten für die Rechnungsprüfer die Bestimmungen des § 11 Abs. 8 bis 10 sinngemäß.

§ 14: Schiedsgericht

(1) Zur Schlichtung von allen aus dem Vereinsverhältnis entstehenden Streitigkeiten ist das vereinsinterne Schiedsgericht berufen. Es ist eine „Schlichtungseinrichtung“ im Sinne des Vereinsgesetzes 2002 und kein Schiedsgericht nach den §§ 577 ff ZPO.

(2) Das Schiedsgericht setzt sich aus drei ordentlichen Vereinsmitgliedern zusammen. Es wird derart gebildet, dass ein Streitteil dem Vorstand ein Mitglied als Schiedsrichter schriftlich namhaft macht. Über Aufforderung durch den Vorstand binnen sieben Tagen macht der andere Streitteil innerhalb von 14 Tagen seinerseits ein Mitglied des Schiedsgerichts namhaft. Nach Verständigung durch den Vorstand innerhalb von sieben Tagen wählen die namhaft gemachten Schiedsrichter binnen weiterer 14 Tage ein drittes ordentliches Mitglied zum/zur Vorsitzenden des Schiedsgerichts. Bei Stimmengleichheit entscheidet unter den Vorgeschlagenen das Los. Die Mitglieder des Schiedsgerichts dürfen keinem Organ – mit Ausnahme der Generalversammlung – angehören, dessen Tätigkeit Gegenstand der Streitigkeit ist.

(3) Das Schiedsgericht fällt seine Entscheidung nach Gewährung beiderseitigen Gehörs bei Anwesenheit aller seiner Mitglieder mit einfacher Stimmenmehrheit. Es entscheidet nach bestem Wissen und Gewissen. Seine Entscheidungen sind vereinsintern endgültig.

§ 15: Besondere Bestimmungen

(4) Der Verein bedient sich fur die interne Kommunikation aller zum gegenwärtigen Zeitpunkt und in der Zukunft verfügbaren Mittel der elektronischen Kommunikation.

(5) Vereinsintern gilt elektronische Post (E-Mail) als Schriftform. Eine Einladung gilt als zugestellt, wenn sie innerhalb üblicher Fristen nicht an die/den AbsenderIn zurückgeschickt wurde.

(6) Alle Protokolle, die Statuten, die Geschäftsordnung und sonstige Schriftstücke gelten vereinsintern als veröffentlicht, wenn sie in geeigneter Form im elektronischen Netzwerk öffentlich zugänglich gemacht wurden oder per E-Mail an die Vereinsmitglieder zugestellt wurden.

§ 16: Freiwillige Auflösung des Vereins

(1) Die freiwillige Auflösung des Vereins kann nur in einer Generalversammlung und nur mit Zweidrittelmehrheit der abgegebenen gültigen Stimmen beschlossen werden.

(2) Diese Generalversammlung hat auch – sofern Vereinsvermögen vorhanden ist – über die Abwicklung zu beschließen. Insbesondere hat sie einen Abwickler zu berufen und Beschluss darüber zu fassen, wem dieser das nach Abdeckung der Passiven verbleibende Vereinsvermögen zu übertragen hat.

(3) Bei Auflösung des Vereins oder bei Wegfall des bisherigen begünstigten Vereinszwecks werden die geleisteten Einlagen anteilsmässig an die Mitglieder verteilt. Das verbleibende Vermögen wird, soweit dies möglich und erlaubt ist, einer Organisation zufallen, die gleiche oder ähnliche Zwecke wie dieser Verein verfolgt, sonst für gemeinnützige, mildtätige Zwecke im Sinne der §§ 34ff BAO.

C.2 Steering Committee Agreement

The agreement intentionally starts on the next page.

Agreement on Cooperation

Parties:

1. **Stefan Dietze, Gottfried Wilhelm Leibniz Universität Hannover**
   registered office: Welfengarten 1, 30167 Hannover, Germany
2. **Reinhard Klein, Rheinische Friedrich-Wilhelms-Universität Bonn**
   registered office: Regina-Pacis-Weg 3, 53113 Bonn, Germany
3. **Eva Eggeling, Fraunhofer Austria Research GmbH**
   registered office: Theresianumgasse 27, 1040 Wien, Austria
4. **Jakob Beetz, Technische Universiteit Eindhoven**
   registered office: De Rondom 70, 5612 AP Eindhoven, Netherlands
5. **Martin Tamke, Center for Information Technology and Architecture**
   registered office: Philip de Langes Alle 10, 1435 Copenhagen, Denmark
6. **Anders Lundkvist, Luleå University of Technology**
   registered office: SE-971 87 LULEÅ, Sweden
7. **Dag Fjeld Edvardsen, Catenda**
   registered office: Forskningsveien 3b, NO-0373 Oslo, Norway

The aforementioned organizations developed methods and tools for the Long-Term Preservation (LTP) of architectural knowledge, subsequently called „the DURAARK platform". The work was funded by the European Commission within the 7th Framework Programme (Grant Agreement No. 600908).

The parties want to focus their knowledge and research to further develop methods and tools for Long-Term Preservation (LTP) of building data after the project ending on January 31st, 2016. Therefore, they sign the following agreement to manage general questions regarding the cooperation. Concrete projects and results evolving from this agreement are to be treated in independent agreements.

§ 1. Clarification

1. Clauses in this Steering Committee Agreement do not override the DURAARK Grant Agreement and the DURAARK Consortium Agreement clauses.

§ 2. Agreement Goals

Partners have the following goals on their own accounts:

1. Cooperate to enhance and exploit the tools and methods developed in DURAARK.
2. A non-exclusive joining of forces and the creation of synergies regarding research in the area of Long-Term Preservation of architectural data.

§ 3. Objective of the Agreement

1. The agreement defines the frame to achieve the goals defined in §2.
2. A steering committee is instantiated to guide the cooperation and to uphold the mutual communication between partners.

§ 4. Steering Committee

1. All parties name a representative. This person is the official contact for other parties. The representatives form the Steering Committee which is the decision-making body of the cooperation.
2. The steering committee meets once a year at a minimum, either personally or virtually. The management of the steering committee is done by the speaker of the cooperation. The speaker is elected yearly by the members of the steering committee (by vote majority).
3. Major decision must be taken by consensus, each partner has a single vote. If no consensus is reached, the decision is deferred.

§ 5. Steering Committee Duties

1. The steering committee steers the cooperation. Parties are informing each other on topics and projects regarding the cooperation.
2. The steering committee discusses and reaches decisions on possible concrete project cooperations in the context of §3. Binding arrangements, especially regarding tasks, services, work and time plans and any remunerations remain subject to a separate agreement between the respective parties.

§ 6. Financial

1. If a party is providing services to another party or other parties in form of a sub-project, a financial compensation shall be agreed on in an additional agreement.
2. Parties strive to gain additional funding for sub-projects, e.g. in the form of research projects.

§ 7. Deliverables and Rights

1. Rights on DURAARK outcome are regulated in the DURAARK Consortium Agreement.

§ 8. Contacts for Licensing Issues

1. Contacts for licensing and usage issues of the tools of the DURAARK platform or the DURAARK platform itself are the respective representatives of the former project partners in the steering committee.

§ 9. Confidentiality

1. Information declared as confidential between parties will be treated as confidential by all parties for 3 years after the termination of this agreement.

§ 10. Agreement Start, Duration, Termination

1. The agreement enters into force after all parties signed the agreement and is valid until the January 31st, 2017. It is prolonged automatically for another year unless terminated with a notice period of one month before the 31st of January of the year.
2. Each party is entitled to terminate the agreement without statement of reason.
3. The termination of the agreement by a party does not affect the agreement for the remaining parties.

§ 11. Final provisions

1. Alterations and additions to this contract must be made in writing. Concrete sub-projects shall be agreed separately.
2. Should individual provisions of this agreement be ineffective or non-executable or become ineffective or non-executable after the conclusion of the agreement, the effectiveness of the agreement remains otherwise unaffected. If any provision of this agreement is found to be invalid or otherwise unenforceable, the further conditions of this agreement will remain fully effective and the parties will be

bound by obligations that approximate, as closely as possible, the effect of the provision found invalid or unenforceable, without being themselves invalid or unenforceable. The existing provisions apply accordingly in the event that the contract is shown to have omissions.

Date

(Stefan Dietze)

28.01.2016
Date

(Reinhard Klein)

28.1.2016
Date

(Eva Eggeling)

26.01.2016
Date

(Jakob Beetz)

26/01/16

Date

(Martin Tamke)

26/01/16

Date

(Anders Lundkvist)

26/1 - 2016

Date

Dag Fjeld Edvardsen

(Dag Fjeld Edvardsen)