D7.3 Use case long term Archiving

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Executive Summary

This deliverable evaluates the fit of the proposed DURAARK methods and tools against existing practises, expectations and future visions of stakeholders with an interest in long-term availability and interpretability of building information data: building owners / facility maintenance, cultural heritage / research institutions and IT-software developers / system providers. As part of the evaluation, the deliverable analyzes emerging scenarios and evaluates the outcomes of stakeholder engagement and surveying through workshops, questionnaires and targeted interviews. The results from the evaluation process are used to assess the future of digital archiving of architectural 3D data in the three domains and to check if and where the DURAARK processes need to be adapted.

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1 Introduction

This deliverable builds on the stakeholder identification and procedural analysis as previously described in the DURAARK deliverables D2.2.1[1] and D7.7.1[2]. While D2.2.1 described all DURAARK stakeholders along the lifecycle of architectural 3D data, D7.7.1 put forth three stakeholder groups with an interest in long-term availability of this data:

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

Consequently, these three stakeholder groups form the target group for institutional preservation of architectural data, as they share the goal and the responsibility of facilitating long-term availability and usability of the respective information.

1.1 Building Information Models in the building profession

While the idea behind BIM can be traced back to the 1970s, it was only in 2002 that Jerry Laiserin contributed to a wider pick-up of the term Building Information modelling to describe the information centric chain that takes place in building-related processes, covering analysis, design as well as management tasks [62]. Over the following years these originally distinct areas have been chained and visualized in “BIM Wheels” (see Figure 1) which emphasise the linked but especially cyclic nature that building-related processes undergo. The understanding of a building as being in a constant cycle of planning, building and maintenance relates to the raising awareness of sustainability and its similar emphasis on cyclic processes.

[1] http://duraark.eu/wp-content/uploads/2014/02/DURAARK_D2.2.1.pdf
[2] http://duraark.eu/wp-content/uploads/2014/06/duraark_d7.7.1.pdf

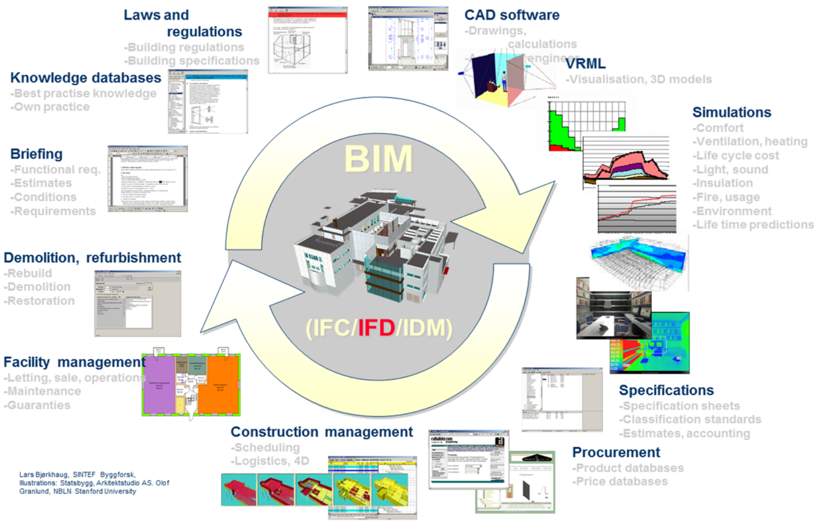

Figure 1: An early BIM Wheel from 2003 showing a potential lifecycle of a building using BIM tools [12]

The common BIM wheel, as presented by Bell and Bjørkhaug in 2003 [13] suggests a quite optimistic understanding of an ongoing enrichment of a single unified building model. Here, partners are working together either in one BIM model or hand over model(s) to the next partner in an ongoing chain.

The query among stakeholders from all areas of the building industry in Scandinavia conducted within the DURAARK Deliverable D7.7.1 shows that BIM is introduced in the Scandinavian context in a practical manner for the process of design and building.

Stakeholders in the design and construction phase of a building are engaging in a practice where BIM models are shared and edited collectively. Initial geometric data is enriched with further details and properties, which are stored as metadata in the 3D object's properties. This process is however not linear, but has breaking points and loops, for example, when responsibilities are handed over during the process or simply due to the meandering nature of the planning processes.

1.2 Building Information Models beyond the building phase

The investigations for D7.7.1 indicate that the concept of a unified building model which is edited by many stakeholders does not fit the actual current day practice. Instead many building models exist for the different stakeholders, which are only overlaid in certain intervals and eventually gathered in order to create an as-built documentation at the end of a building's construction phase. This is the status which is handed over to the building owners, who might use the model for Facility Management systems (FM) and furthermore pass it on to archival institutions.

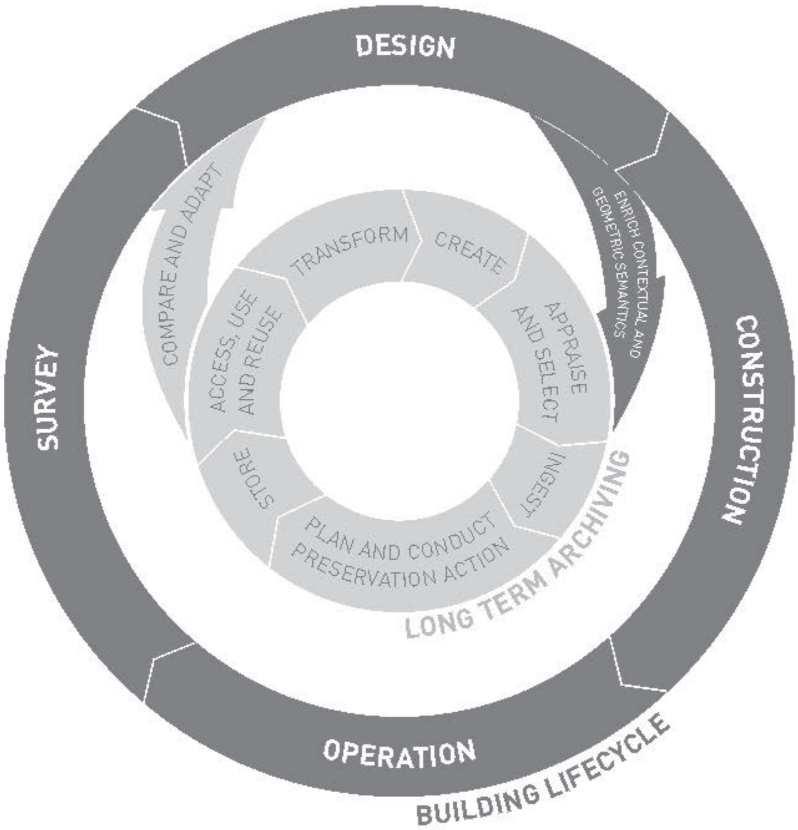

Figure 2: DURAARK Digital Building Information Lifecycle: The parallel lifecycles of digital building information in the context of the building profession and of long-term archiving

Furthermore, D7.7.1 indicates that building owners have only an interest in a limited set of data for the operation of buildings. This partial view is not dissimilar to all other stakeholders in the building process and covered within the concept of, for instance, the IFC model. Building owners are hence including only parts of the rich building information in the as-built BIM Models and through that into their FM systems. All further update and enrichment activities during the operational phase of a building focus are hence conducted on a subset of the original building information, while the original parts stay unchanged in the long-term archive. This leads to parallel cycles of building information emerging (see Figure 2): one at the building owners and their engineers and architects, which are concerned with maintaining and updating the physical building, and the other in a data archive, which is concerned with the long-term maintenance of building data. These two cycles typically intersect only when construction activities are finished or new ones are considered or planned.

However, the emerging lifecycle of building information poses challenges under the aspects of the long-term accessibility of the building data, as the link between different models has to be created in a durable way, maintained and eventually re-established.

1.3 Goal of the deliverable

The goal of this deliverable is to evaluate the fit of the proposed DURAARK system to the work practices of the aforementioned institutional stakeholders. This requires a focus on three different aspects:

- **Alignment with stakeholder processes:** D7.7.1 described processes in place at various stakeholders. These stakeholder processes need to be revisited for the institutional preservation groups, taking into account a special focus on maintaining long-term availability of the data.
- **Alignment with stakeholder needs:** Previous research and analysis conducted in DURAARK work packages 2, 6 and 7 has identified gaps in the curation and preservation handling of architectural 3D data. The use cases of the DURAARK project are centered on these gaps. Existing tools and processes for the curatorial comparison of plans and scans, for the semantic enrichment of objects to facilitate the preservation of knowledge over the long-term and for modular tools to assist preservation on a logical file format layer need to be presented to the stakeholders. To adequately evaluate how the proposed processes meet stakeholder demands, procedural, technical and organizational requirements and capabilities need to be detected. These shall form the basis of evaluation procedures to take place at later points in the project.
- **Alignment with stakeholder expectations:** Stakeholder expectations focus on the procedural quality as well as on technological integratability and usability of tools. The demonstration of the first prototype of the DURAARK toolset and

workbench shall be judged by the stakeholders against this set of criteria. A special focus shall be put on the integratability of tools into existing workflows as well as an assessment of how the proposed DURAARK tools align with stakeholders' visions of future archiving processes.

The evaluation process of the DURAARK methods and tools will be based on the re-analysis of emerging scenarios, which the DURAARK project is building on, as well as on stakeholder input to these aspects. The outcome of these two studies forms the basis for a three-fold evaluation focus:

- **Evaluation of our methods:** DURAARK methods are building on emerging scenarios of information handling of the respective stakeholder domains. At this point in the project it is therefore crucial to evaluate the stakeholders' visions of future practices and see if DURAARK methods need to be aligned.
- **Evaluation of our tools:** Understanding stakeholder processes allows us to understand how the software will be used within their workflows and what expectations exist for the tools. It allows evaluating if and where software development needs to be aligned with stakeholders' requirements.
- **Evaluation of the data content:** Methods and tools of the DURAARK project largely build on linked open data and vocabularies. As these vocabularies need to be linked, the resulting datasets in themselves need to be evaluated.

Engagement with stakeholders in the analysis process of the aspects mentioned above was facilitated through a workshop and through targeted interviews. The method and process behind the stakeholder engagement is further described in chapter 2. As mentioned above, an in-depth knowledge of emerging scenarios for the different stakeholder groups is necessary to understand expectations in future scenarios, but also to provide an updated benchmark, which methods and tools can be repetitively measured against. Chapter 3 describes the emerging scenarios for the stakeholder groups and also for the emerging role of vocabularies and of data assessment. Chapter 4 summarizes the findings of the stakeholder engagements, describing exemplary practice within the three groups building owner / facility maintenance, cultural heritage / research institutions and IT-service / software companies. Chapter 5 assesses the DURAARK methods, tools and data content against the stakeholders' expectations, drawing on the finding of the previous analysis of emerging scenarios, status quo and stakeholder expectations. Based on this, recommendations for future archival practice will be made in chapter 5 before the deliverable concludes with an outlook on further DURAARK work in chapter 6.

1.4 Status quo of the DURAARK development

The methods and tools developed in the DURAARK project are integrated into the DURAARK workbench (see Figure 3). The workbench is a modular system, which is available as an integrated web-based system. However, the individual modules are mostly microservices, which are containerized and can be integrated into existing workflows within other repositories or environments as well.

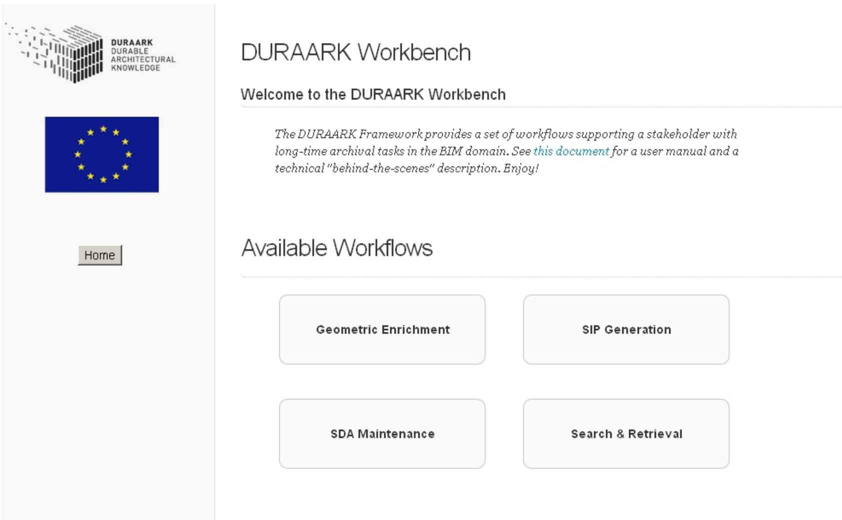

Figure 3: the DURAARK Workbench

The workbench supports the DURAARK use cases described in Deliverable D2.2.1:

- The user is able to search and retrieve objects as defined in the respective DURAARK use cases.
- "Planning, documenting and verifying retrofitting/energy renovation of buildings" and "Exploiting contextual information for urban planning" are access and re-use use cases that are supported through the semantic digital observatory (SDO) and the semantic digital archive (SDA).

- “Monitoring the evolution of a structure over time”, “Detecting the differences between the as-planned and the as-is state”, as well as, “Identifying similar objects within a point-cloud scan” are use cases that are supported through the geometric enrichment tools.
- In order to guarantee the long-term availability and understandability of the objects in the context of the use cases, the SDA needs to be maintained and the objects need to be archived in a digital preservation system.

Technical and functional details of the first prototype of the workbench are available in D2.4. The implementation of DURAARK tools and methods into digital preservation processes is discussed in D6.2.
In its current state, the workbench presents curation as well as preservation methods and tools. It incorporates DURAARK results such as metadata schemas as well as concrete enrichment and data comparison tools, enabling re-usability of the data. The importance of reusability of digital objects is further discussed in chapter 3.2.1, while the current status of the DURAARK results are evaluated against user expectations in chapter 6.

2 Methods and processes

A well-grounded analysis and evaluation of user requirements and expectations requires a structured approach. Both quantitative as well as qualitative research methods are valid approaches. In order to choose the approach best suited, the project had to determine whether a broad but possibly flat or a detailed but possibly not representative view leads to the results best suited for the process and prototype evaluation. While a broad quantitative approach leads to a more objective overview which can easily be presented in numbers and statistics, a qualitative approach rather represents detailed and highly subjective insight, which is best represented in a textual form. To reach a representative result in a quantitative approach, a large enough sample group needs to be available, whereas the sample group in the case of qualitative methodology may be significantly smaller, but shall form a good representation of the target [80].

In the case of the DURAARK use cases, the user group relevant for the evaluation of methods and processes is a highly specific one. While previous work conducted in WP2 had put forth a number of stakeholders, further research conducted in work packages 6 and 7 has established that only 3 specific stakeholder groups have put forth a strong interest in long-term availability of the content and fall into the institutional preservation group: building owners and facility maintenance, cultural heritage / research institutions with an archival mandate and the IT-service providers which either provide software or services enabling the first two groups to adequately meet their archival needs. These three domains form a heterogeneous group with different sub-sets of knowledge and requirements. Due to this a qualitative approach is preferred, as it allows for the questioner to become a participant in the process by stepping actively in, for example through needed further explanation or through inquiries. The risk of the qualitative method is the subjective view point of the interviewee as well as the interpretation of the interviewer. While no universal truth can be derived from an interview processes, the work package has defined the high level form and goal of the stakeholder and use case study as follows: A stakeholder study will be conducted in form of a workshop and targeted interviews and will deliver feedback of identified stakeholders on the methods and tools which have been developed in the DURAARK project so far. The sample group consists of institutions, which have been previously identified as stakeholders in deliverables 7.1 and 6.1 or of stakeholders which have voiced interest in the project as a response to dissemination activities.

2.1 Process, risks and technical decisions

This section will give a short overview of the process used for the stakeholder engagement and evaluation. It gives insight into how the data material which was used for the evaluation and assessment was gathered - namely, through a workshop and through a questionnaire used in targeted interviews. Two other research methods applied for this deliverable are desktop research conducted for the analysis of emerging trends and technologies reported on in chapter 3 and the description of software and process development connected to crowdsourced data evaluation, which have been conducted in conjunction with workpackge 3 and are further described in section 3.4. No technical decisions were made in the task associated with this deliverable. Technical decisions connected to the crowdsourcing are discussed in the WP3 Deliverable D3.4, respectively.

2.1.1 Sustainable Building Information Workshop

The “Sustainable Building Information Workshop” was held as a one-day event in Copenhagen on November 12th, 2014. It brought together 23 participants of the different stakeholder groups and the DURAARK consortium with the goal of discussing current practises and future scenarios in long-term usability of building information. To achieve this goal, the workshop was broken down into presentation as well as discussion segments, which followed common themes:[3] Current and emerging data practises, software and service infrastructures and an outlook and assessment of future scenarios.

As part of the presentation session, two building owners and facility managers presented their current data practises - Copenhagen Property shared the challenges in integrating BIM into their system and work practises and discussed what the right level of maintainable data is in a setting with 3.500 buildings. The Danish Technical University DTU presented their “from paper to BIM” strategy and highlighted accuracy and credibility as key factors to be addressed in the digital objects. For the software and services sector, the software companies DALUX, dRofus and Catenda were invited to give short insights into their existing system architectures in the facility maintenance domain - this presentation segment was directly followed by a presentation of the DURAARK workbench to allow for a direct discussion of how the DURAARK results can be integrated into existing system landscapes. The DURAARK project furthermore presented the different goals of the

[3] The presentations mentioned below are made available on the DURAARK website, under: http://duraark.eu/sustainable-building-information-workshop-12-november-2014-copenhagen-presentations-online/

Figure 4: Announcement of the Sustainable Building Information Workshop on the DURAARK webpage

project and introduced emerging challenges and scenarios as well as insights into how the project is addressing these.
The second half of the workshop was dedicated to break-out sessions. Here, pre-defined groups were set up to ensure an even mixture of DURAARK, building owner/facility maintenance, cultural heritage and software company representatives in each group. To steer the discussion, the DURAARK representatives in the groups were briefed prior to the workshop and each group was given the following list of questions as a discussion guideline:

1. Reflection past:
   - Where did system(s) not work in respect to lifecycle views and long-term archiving ?
   - Why did it not work? -or- Why did it work well?
2. Current practise:
   - What is your current / typical landscape of IT-system(s) ?
   - What data would you use / re-use in an emerging building lifecycle ?

3. Future practise:

   - What do you envision as challenges and potentials for your future practice ?
   - Where does your profession / sector need to change and with what requirements ?
   - Who is the driver behind new process implementation in your system (e.g., user-lead vs. software-vendor-lead process) ?
   - How can adaptable systems be developed ?
   - How could your system / process be used as - or extended towards - long-term archiving functionality ?

The DURAARK representatives within the groups took notes and audio recordings, while all presentations where as well videotaped. The entirety of the material was used for the evaluation discussed in chapters 4 and 5. The workshop concluded with a brief recapturing of the groups' discussion results.
The workshop was documented on the DURAARK webpage, where all, but one presentation delivered at the day are available, as well as a list of participants. The workshop received very positive feedback from the participating stakeholders.

2.1.2 Questionnaire and targeted interviews

In designing the questionnaire[4] standard procedure as recommended by literature [43][16] was followed. In a first step, the target group and distribution method was defined. It was decided that the questionnaire was to be given to the attendants of the workshop and in addition sent via e-mail to selected institutions of the three stakeholder groups relevant to the institutional preservation use case study. A focus should be put on institutions who either already work with 3D architectural data or are likely to be working with it in the near future. After the initial return of the questionnaire by the respondents, selected follow-up interviews were conducted where considered necessary.
The content of the questionnaire was designed using the overarching questions covered in this deliverable:

- **Information on participant**
  The intent of this section is to gather basic information about the respondent's

[4] The questionnaire including the different domain versions is described in the Appendix

organization in regard to stakeholder group, position in the market / institutional landscape, size of the institution in terms of the scale of employees and of clients / (digital) projects.

- **Information on current processes**
  The intent of this section is to gather information regarding the status quo of the organization's digital holdings (e.g., size, heterogeneity and 3D ratio), the organization's system landscape (e.g., client/server architecture, interface type, commercial/custom-made, archiving functionality), and the who and how of data production and consumption (e.g., deposit processes, indexes and metadata for description, why is data accessed, who accesses data).

- **Information on visions for future scenarios**
  The intent of this section is to gather information on emerging processes that the stakeholder considers necessary. These emerging processes may include methods already covered in DURAARK tools as well as methods currently not addressed in the project. Stakeholder expectations are queried for feasibility criteria and integration requirements in the system and process landscape. Questions cover the use of external catalogues or libraries, linked (open) data and go and no-go criteria for services and their potential providers.

The questionnaire combines multiple-choice with free-text question types. While questions dealing with rather limited scopes - this is in particular true for the "Information on participant" and holding-related "Information on current processes" questions - are best addressed in multiple-choice to allow for easy categorizations and comparisons of the results, the main focus of questions about processes and future scenarios is to gather detailed information and are therefore best addressed in free-text answer options.
As the three stakeholder groups come from different domains, they do not speak the same language in regards to processes. Furthermore, processes may be comparable in nature but effectively have different names or use different terminology in the respective domains. An example for this is the use of external vocabularies: while the buildingSMART dictionary may be well known and understood in organizations that already deal with BIM, such as facility maintenance and software providers of building information repositories, cultural heritage institutions may not know buildingSMART. To give an example of how this was addressed - question 6a "Do you use or will use catalogues, vocabularies or libraries from external sources to index your data?" listed different examples - for software vendors

and cultural heritage institutions the question text read "as for instance Getty AAT or the buildngSMART data dictionary", for building owners just the buildingSMART data dictionary example was included. The questionnaire was given test-runs by different DURAARK project members to ensure understandability and adequate length and form.

2.1.3 Risks

Risks associated with the process:

#	Risk Description	Risk Assessment	Contingency Solution	Project Relevance
1	The chosen methodology for the user analysis is too subjective, not allowing for a correct use case analysis	**Impact**: High **Probability**: Low. The subjectivity is a risk of any qualitative study and partially intended, as it allows for a direct dialogue on the surveyed material.	The risk of subjectivity falsifying the results is counteracted by three measures: (1) a detailed plan for the process (2) the study being executed and monitored by several project team members from different domains and (3) the review process of the deliverable, bringing in yet two more views.	Low Not observed

#	Risk Description	Risk Assessment	Contingency Solution	Project Relevance
2	The different versions of the questionnaire for cultural heritage, building owners / facility maintenance and software vendors differ too much to allow for exact comparability	**Impact:** Low **Probability:** Medium. As especially usage processes of cultural heritage / research differs from building owners / facility maintenance, no complete congruence of the processes mentioned in the questionnaire can be given. How these processes align and where they differ is actually one of the points this work shall address.	The results are first compared within their stakeholder group and then compared against other results. If results within a stakeholder group completely differ from other results of the same group, this is addressed in follow-up interviews. The inter-stakeholder comparison is conducted as part of the overall assessment in this deliverable. Where answers differ between stakeholder groups, it is analyzed whether this is due to how the question was asked or if this lies in the nature of the process as implemented by the respective domain.	Low Not observed

#	Risk Description	Risk Assessment	Contingency Solution	Project Relevance
3	Not enough feedback from stakeholders is available to conduct a use case analysis	**Impact:** High **Probability:** Medium. The DURAARK partners come from different domains, they have established networks within their areas, which includes contact to stakeholder groups analyzed in this deliverable. New contacts were established during DURAARK dissemination activities, e.g., through follow-up conversations to presentations given at conferences. As the project has peaked the interest of those dealing with building information data, it is unlikely that not enough stakeholders can be gathered for feedback.	If the initial list of stakeholders to address does not return a satisfying number of answers, a second list will be generated through the project members networks and matching multiplicators at the domain levels.	Low Not observed

#	Risk Description	Risk Assessment	Contingency Solution	Project Relevance
4	The use case analysis puts forth that the developed DURAARK methods and tools do not align with user expecations	**Impact:** High **Probability:** Low. The project regularly monitors the state-of-the-art development connected to DURAARK research and developments. In consortium-wide meetings and discussions, planned development is presented and discussed. The consortium includes representatives of the cultural heritage, software vendor and research domain. Furthermore, close connections to the facility maintenance domain eixst. Thefore, requirements and expectations of the relevant domains are well known to the consortium.	This deliverable is tasked with matching the existing institutional preservation use case against current DURAARK methods and tools. Different levels of granularity are to be captured - ranging from implementation scenarios and the modularity of the software to overall expectations regarding the methods used. This input is necessary for fine-tuning DURAARK development, e.g., in regards to their interfaces or usability.	Low Not observed

Table 1: **Risks identified and assessed.**

3 Emerging scenarios of information handling for institutional stakeholders

3.1 Role of information in the emerging building lifecycle

The DURAARK Deliverable D7.1 highlighted the emergence of an established practice with BIM in all areas of the Scandinavian building profession. Here, several information models are developed over the time of a project, synchronized in a shared model in the cloud and information is extracted and exchanged between the partners. Model View Definitions (MVD) introduced by the buildingSMART consortium describe procedures between data producers and receivers on structure and content of BIM models and outline procedures for handing over the models in Information Delivery Manuals [45]. This procedure pays tribute to the fact that stakeholders are mainly only interested in a certain type of information held within a BIM.

3.1.1 Building Information Models in the operational phase of buildings

Our earlier investigations came to the conclusion that BIM practice among the group of building owners, archives and cultural heritage institutions is way less established. These institutions are, however, responsible for the building and its data model (BIM) when the design and (re-)construction phase of a building is over and it enters the operational phase. This phase is the most expensive in a building's lifecycle where, depending on source, up to 560% of the initial building costs emerge [38].

As the operational phase of a building is the longest phase in the lifecycle, it is a key ingredient in any narrative about BIM. The operational phase of a building - the Facility Management (FM) - is until now not covered with the same set of established standards and interoperability of tools as for BIM in the design phase. Until now, research efforts and development of BIM standards, tools and aspects relating to their implementation have set a **focus on BIM in planning, design and construction processes** [56] - despite the fact that new works only account for 1-2% of the total building stock in a typical year [58].

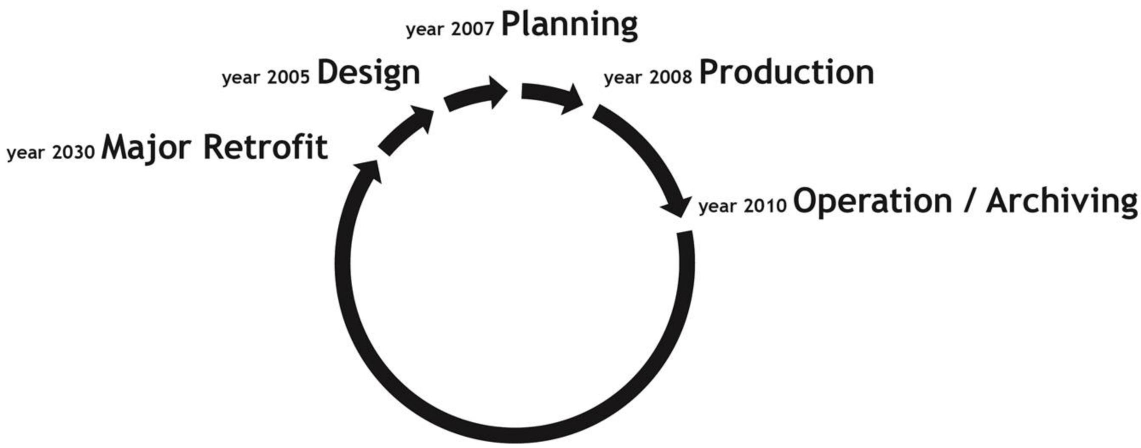

Figure 5: Hypothetical building lifecycle. The length of design and construction time is a fraction of the operational phase of a building

3.1.2 Standardisation efforts for BIM and FM

Several international organizations have invested tremendous efforts into attempts to establish standards for the information exchange between BIM and FM-related tools. These attempts are acknowledged by the field, but not broadly implemented.
In the US, the National Institute of Building Sciences (NIBS) released (in conjunction with the International Alliance for Interoperability (IAI) and many other facility-related associations and software companies) in December of 2007 the first version of a National Building Information Model Standard (NBIMS) [72]. On an international level, the buildingSMART organization already proposed a Basic FM Handover Model View to exchange data from the construction into the operational phase of a building in 2009 [61] and has several running projects on the interoperability of BIM and FM. Among these is the Open BIM / FMie project, which aims to enrich the IFC4 format to meet the needs for Facility Management purposes [2]. The Construction Operations Building Information Exchange (COBie) project is another example of the growing emphasis on capturing and transmitting digital building information so it can be reused during building operations [33].

3.1.3 Facility Management and BIM

A reason for the lacking exchange between BIM and FM might, besides general interoperability problems on the side of software [55], be the lack of knowledge of BIM-related techniques among those who are responsible for the operation of buildings [6] [79]. Other

frequently named reasons are the lack of easy-to-handle tools, the plethora of tools for FM from a wide range of local vendors[77] [57], as well as the underlying fact that **operation and design of buildings are fundamentally different parts of a building's lifecycle**. Due to this, FM is at present time often referred to as the final frontier of BIM from a life cycle perspective [57].
FM is holistic in nature, covering tasks as diverse as the following [5] [100]:

- Health and safety
- Fire safety
- Security
- Maintenance, testing and inspections
- Cleaning
- Operational
- Tendering
- Commercial property management
- Business continuity planning
- Space allocation and changes

The underlying data models therefore have to span activities from the daily cleaning of the single building unit to the management of global real estate portfolios on enterprise or governmental level. The aims of the stakeholders to use FM systems may vary in detail, but are surely driven by the overarching idea to enhance the performance of a facility [31] (see also Figure 6).

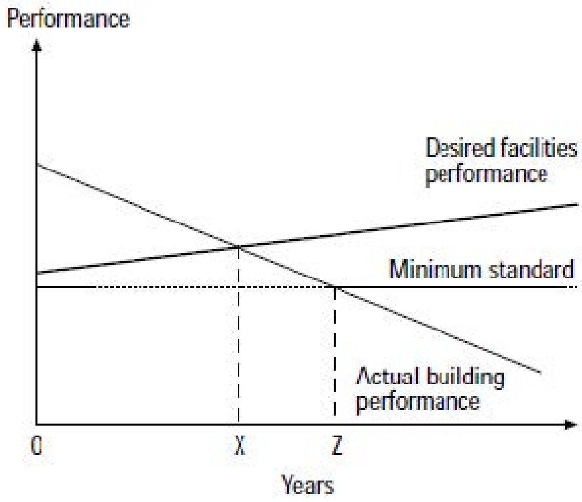

Figure 6: The driver to use FM systems is to increase a facilities performance over time.[31]

In general, a diverse range of FM tools, object types and databases are used in the profession:

- Paper documents
- Spreadsheets
- Computer-Aided Facility Management (CAFM) tools. Examples: FM:Interact (by FM:Systems), Archibus, AiM Space and Facilities Management (by AssetWorks)
- Computerized Maintenance Management Systems (CMMS). Examples: FAMIS by Accruent, IBM Maximo, Corrigo, WebTMA (by TMA Systems), and AiM Maintenance Management (by AssetWorks)
- Document Management Systems (DMS)
- Building Management Systems (BMS)
- Building Automation Systems (BAS)

3.1.4 Motivation to engage with BIM in FM

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 [50]. Hence, the **role and outreach of FM systems increases**, and is being paralleled by a growing need for precision within the systems. 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 [78]. 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 [25] [6] [56] [58] [7]. Research on buildings with BIM implemented in FM systems has also shown a substantial gain in performance, where for instance significant energy savings of 75% could be accomplished in a period over just three years [78].
Governments have hence taken legislative action and mandate the use of BIM in the design and construction phase including the handover of digital data required for the operational phase. Accordingly, **requirements for BIM and FM on all public building projects** were set into action in Denmark in 2007 [59] and will be leveraged in the UK from 2016 on [46]. These requirements meet a building-related sector where an awareness of the benefits, approaches and techniques of BIM related to FM is only just emerging.

3.1.5 Challenges for BIM in Facility Management

As practices of BIM and FM are gaining momentum it is important to understand the principal approaches and the challenges that have been identified in the field. Facility management systems are database systems that typically provide access to the building-related data to many users, allowing them to perform work in a broad range of categories, such as maintenance and repair, security and energy management and commissioning [98]. A list of identified issues with BIM and current Facility Management and Operation information systems (FM&O) reads like this [78]:

- Issues with as-designed and as-built information
- Issues with the identification of the data's importantance for FM&O
- Issues with specifying LODs required for the FM model

- Varying information requirements according to the organizational role of the FM&O actors
- Non-useful information coming from design- and construction-intent models
- Non-uniform naming, due to a variety of industry-wide standards, local naming conventions and data classification structures, as well as established colloquial names deployed in various FM&O information sources of the facility
- Proprietary database systems not allowing for customization
- Lack of knowledge for specifying a CMMS early in the design phase
- Information fields in the CMMS's not matching those in the BIM authoring tool
- Lack of direct integration or linking among the CMMS data with the BIM model
- Lack of interoperability among the CAFM (computer-aided facilities management) system and the CMMS
- Manual and time-taking querying and updating routines in CAMF systems such as overlaying polygons on 2D drawings
- The BIM systems and models not fully integrating with the FM&O workflow
- Issues with updating as-built models after construction

The **ingest of data and the update of the underlying database is the core problem for the information handling of Facility Management systems**. The use of more secure and automated approaches is hence a primary aim for the use of BIM in FM.

3.1.6 Handover of data between BIM and FM

The **handover of data** from planning tools to CAFM is today still dominated by manual entry and the use of 2D drawings extracted from CAD or even scans of paper drawings [6]. Processes to exchange data between BIM and FM have been developed and implemented. These can be classified in five different solutions (see Table 2).

Solution	Technical approach(es) for linking information
Using spreadsheets as simple document indexing tools	Hyperlinking
Using spreadsheets according to COBie guidelines	Hyperlinking, exchanging and synchronizing data
Using the IFC format for exchanging building information among BIM and FM&O systems	Exchanging and synchronizing data (embedding and integrating data to the recipient system)
Coupling CMMS's with BIMs via Application Programming Interfaces (API)	"Portal solution"
Using proprietary middleware such as EcoDomus,Onuma Systems, FM:Interact	"Portal solution"

Table 2: Today's technical solutions for optimizing information transfer from BIM to FM software [78]

These approaches present different levels of integration of FM and BIM. Some are manual or semi-automatic processes, only allowing **uni-directional transfer of data**, while other represent approaches that allow a **bi-directional transfer of data**. The latter points at BIM as an integral component, where it is part of the live and dynamic FM data-environment, while the former represents BIM as a sole data carrier, which has no or only little role within the FM system.

3.1.7 Definition of data to transfer between BIM and FM

As FM systems are tailored to the specific needs and IT environments of customers, the definition of data taken from BIM into FM systems is often customer specific. This demands good planning as well as expertise in both, the area of FM and BIM. Related knowledge and expertise is not too established in the FM-related parts of the building industry [55]. Building information models delivered at project completion are however a rich information source for FM, but not all of the information is valuable on a day-to-day basis within the broad range of an FM practice, where data retrieval, change management, and tracking costs and work executed are operational costs for the building owner [90]. The evolution of hardware and software tools makes it increasingly tempting for an owner to want "everything" in the final model. This bears the risk of creating a specification requirement that is overly costly and exceeds the ability to leverage the data [25]. Hence all processes from BIM to FM extract or link only to a limited set of information in the

source BIM data.
The consideration of the amount and type of data to take from BIM are as well decisive for the technical solution to choose for this process. Duane Gleason writes, for instance, that in general COBie provides a framework for organizing and reporting FM data using an Excel-based format but owners should be realistic when deciding if an Excel spreadsheet will be sufficient, as the final project deliverables may be much more elaborate than a COBie-compliant form [25]. Current practices often still require the handover of paper documents containing equipment lists, product data sheets, warranties, spare part lists, preventive maintenance schedules, and other information. This often leads to incomplete and inaccurate information that is difficult to access and utilise for the purpose of increasing FM efficiencies [55].

3.1.8 Definition of processes and roles for transfer between BIM and FM

The process of information handover has to be defined. This demands definitions and contracts that delimit not only the data and formats, but especially the process of their generation and handover. This is especially important as the **handover of data coincides with the greatest incision in the building lifecycle**, when building and construction work ceases and the responsibility is handed over to the building owner and facility management team. The handover phase hence demands a close collaboration and exchange between different parties with different interests and modes of working. Facility managers have traditionally been distant to the planning process of buildings and joined only in a very limited way and often only at the late stage of facility handover to clients [7]. **An understanding of the others processes related to data, work and decisions are hence often limited.**

How to curate the process of creating BIM for FM is an important point of discussion, connected to the question who is best placed in the role of data input and maintaining the model [11]. Where some suggest to separate the processes, meaning that construction contractors complete their documents at the end of construction - and produce a separate set of data for the maintenance contractor survey [34], other experiences with BIM to FM processes suggest a more **integrated way of enriching data for FM processes**. Here, data in BIM should be enriched in an incremental and pragmatic way so as to keep the process manageable and valuable to all [25]. BIM objects are from the start setup in a way that accommodates later use in FM, but hold only a limited amount of

FM-related information. More detailed information, such as make, model, design size, etc., can be put into the models as the submittal gets approved. Finally, commissioning specific information such as serial number, date installed, approved performance date and asset acceptance date can be put into the model when closer to final inspections [25].

3.1.9 Feedback - Role of FM for BIM and design of buildings

The previous section points to the underlying conflict that FM information is typically not integrated into BIM processes in building practice. On the contrary, it creates additional costs on the side of stakeholders involved in the building process, which building owners finally have to be willing to pay for in order to see the **added value of the engaging FM and BIM**. Despite the fact that 70% to 80% of a project's lifecycle costs are determined during the design phase [67], design decisions are not usually challenged for their impact on operational cost or maintenance. The link to FM practices could lead to design decisions that incorporate operational demands in a better way [73]. For the designer, who today has only a limited set of means to asses and communicate the impact of design decision on facility management [7], the facility manager could provide post-occupancy evaluation of facilities for the design team as feedback [98].

3.1.10 Updating of FM and BIM

As FM models are used to steer processes and to take decisions, the use of outdated documents is among the most serious loss-making factors for building owners during the post-construction era [35] [88]. **Means to keep FM models up-to-date with the current state of the building** are hence a major consideration in the operational phase of a building. An FM system, as well as a linked BIM model, requires continuous maintenance to remain valuable to the building itself as well as to its owners [11].
Technological advancements make FM systems ubiquitous and shift the modes of how they interact with users and how these retrieve and change data. Mobile devices such as tablets and smartphones extend not only the reach of FM systems to the facility itself and inform workers on site, but provide as well means to get feedback and updates on the status of the site through photos, annotations or means to register 3D geometries [48]. Mobile devices are here not only replacing printed forms for collecting data but enhance the automation of FM and provide further added value to integrated FM:BIM applications [78].

The linkage of FM systems and physical assets can be bi-directional, when for instance barcode systems are incorporated into BIM and ease the accessibility of commissioning documents [98]. Such **concepts reach towards the web of things and require more intelligent FM:BIM tools**. A need which is further increased through the advent of sophisticated operational equipment, namely Building Automation Systems (BAS) [83] and recent advances in pervasive computing and wireless sensors. Exemplary applications span from security and surveillance to monitoring of consumption of facility resources (e.g., measuring, logging and comparing water and electricity consumptions). Novel types of building performance measurement methods, such as sensor network systems, generate extensive, heterogeneous information within facilities, providing valuable information about the current state of a building.

While extensive sensor data is collected from different environments, there are still significant challenges in converting such data into useful information needed by different facility stakeholders [42]. The **utilization of semantic technologies** facilitates the management and interpretation of data collected from facilities. For example, the use of resource describing metadata enables more intelligent machine-to-machine interactions, such as reasoning, deduction and semantic searches [10] [4]. Here, the integrated implementation of IFC-compliant and semantic web technologies (e.g., RDF and OWL) seems to be beneficial, though the potential of semantics is still yet to be fully realized [85].

3.1.11 System architectures for BIM and FM

The limited compatibility between BIM technologies and FM technologies (e.g., CAFM, BAS, etc.) can be exacerbated by the huge difference among the lifecycle of BIM technologies, FM technologies and buildings. Today, the architecture of FM systems is under development. A move from proprietary and vendor-specific solutions to FM systems that are compatible with **open standards for building data** is a central requirement [89]. According to this an efficient integrated FM:BIM system would most probably be composed of a set of loosely coupled software applications with web-based interfaces where the FM application is capable of bi-directional exchange of data with updated as-built BIM applications [89].

3.1.12 Risks for building-related information

Whatever solution is chosen, a lifecycle approach to building information has to take into consideration the **fundamentally different perspectives on data for the design-to-build on the one side and the operational phase of a building on the other side**. The shift between the phases poses the biggest risk for building information to be damaged or lost - a need for preservation of data emerges.
This is due to the fact that the operation of a building focuses only on certain aspects of building information, while a huge amount of fabrication and design-related information is disregarded. The process of **information handover between BIM and FM is potentially lossy**, as the subsequent party is only interested in and working with certain information of the dataset. A need emerges to preserve this rich information for future (re-)use in the building cycle, when buildings need to undergo renovation and retrofitting or investigations into specifics of the previous process which have to take part, as in the case of accidents or legal disputes. These use cases for building information are currently not in the view of scholars.

3.1.13 Shift in nature of building information

The expansion and increasing integration of computational systems, their extension through linkage to a wide array of data sources, as building automation and sensors, as their seemingly pervasive character, reaching out to the site and its user through mobile applications, points towards an upcoming massive shift in the relation between the physical asset and its data model. A change in practice is taking place, where the **digital building model is no longer a representation of the physical asset, but becomes an integral part of it**. However, during the transition to the operational phase the model shifts scope and nature. It is no longer the instruction for a building process, as in BIM or the traditional practices of architectural 2D drawing and 3D modelling. These **formerly central means of architectural representation are now a mere supplement or even derivative** of a “live” operational building information model.

3.2 Future of archiving for research and cultural heritage

3.2.1 Towards data re-use in research

While research of any domain is based on data production, it is only in the past few years that a slow shift from the mere production of scientific data towards taking full data-lifecycle implications into consideration has taken place. In 2007 Jim Gray coined the term of the fourth paradigm, describing a shift in the practice of scientific research from experimental, theoretic and purely computational models to data-intensive driven practices. He outlined the need for tools to cover full-lifecycle activities, ranging from capturing and validation of data over curation and analysis to permanent archiving and re-use [44].
Much of this data is produced in scientific research - which in return is a culture largely driven by internal measurements such as peer-review processes, citation rates and new funding. While the data may contribute to these factors, it has little long-standing impact within the scientific community itself, leading to an inevitable gap between scientific data practices and the need for data and new knowledge in the private and governmental sectors [3].
The European Union's High Level Expert Group on Scientific Data addressed exactly this gap in its 2010 final report "Riding the wave - How Europe can gain from the rising tide of scientific data". The report outlines the clear goal of the availability of an e-infrastructure by the year 2030, which will allow researchers and practitioners of any domain to find, use and re-use the data they require for their work. Three main pre-requisites to achieve this goal are a general awareness of the importance of sharing and preserving data, the existence of reliable repository infrastructures which enable researchers and practitioners alike to find, access and re-use data from every domain, and lastly the reliability, interpretability and trustworthiness of the data itself [60].
In a response to the "Riding the Wave" report, four national funding bodies - the German Research Foundation (DFG), the Joint Information Systems Committee (JISC, United Kingdom), the SURFfoundation (Netherlands) and Denmark's Electronic Research Library (DEFF) - collaborated in a knowledge exchange on a joint high-level action program. The program focuses on three areas [95]:

- incentives such as dataset citation and published codes of conduct for data sharing shall ensure that data sharing will become a part of the academic culture

- training of future "data scientists" shall ensure that data logistics will become a main aspect of the academic professional life
- data infrastructures need to close present-day gaps between generating, (re-)using and preserving data while being based on solid funding

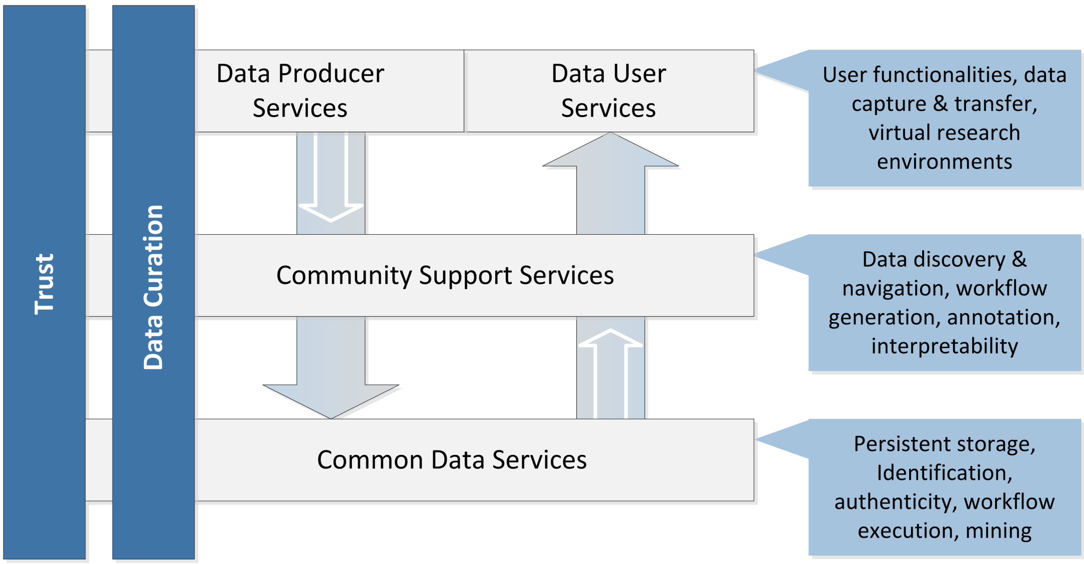

Figure 7: A future collaborative data infrastructure as envisioned by the "Riding the Wave" Report

Image 7 shows a high level view of a global scientific data infrastructure as envisioned in the "Riding the Wave" report. While the overarching principles of the infrastructure need to be trust and the full lifecycle support of data curation, data services can be roughly divided into three layers. The most refined level is the usage layer, which meets the needs of the individual data producer or user in delivering functionality to capture, transfer or re-use data, e.g., in virtual research environments. Often, the user draws upon community support services of their respective domain, for instance through subject specific search interfaces. The most generic layer is that of common data services, which provides the long-term storage and allows the data to be mined and passed on via the community support services to the user [60].

Funders in the UK have been at the forefront of a push towards open scientific data – in 2009 the majority of the UK funding bodies already required long-term curation of the research data and at least partially included funding for data centers [52]. The German

Research Foundation (DFG) requests information on planned data availability for re-use as part of the grant proposal, pointing out that existing standards, data repositories and archives of the respective domain should be used, where possible [40]. In an in-depth analysis of US funding bodies, Dietrich et al. point out that policies frequently do address access requirements, but should address preservation issues more clearly to close the gap between the goals of data management and the implementation realities they face [29]. Research institutions and universities have yet to pick up data management and sharing policies. As Horstmann points out, today only 1% of German universities have a research data policy in place [47].

3.2.2 The landscape of research data repositories

Today's research data landscape is best described through the availability of cross-domain and domain-specific research data repositories. R3data[5] is a registry of research data repositories, which captures information about the location, domain, content type and archiving status of the respective data repository. The registry started in August 2012 and went online with 23 entries [76] – as of November 2014, 1,093 data repositories are registered with r3data.org [1].
Figure 8 shows the repositories registered in r3data by country. As a single repository can have multiple nodes with an international spread, multiple country hits per repository are possible. Countries with less than 20 registered repositories are summarized in "other". The United States clearly dominates the repository landscape with most of the registered repositories being highly disciplinary, such as the "State of the Salmon" [6] repository, which stores data about the wild salmon population or RGD - the Rat Genome Database[7].

[5] http://www.r3data.org
[6] http://www.stateofthesalmon.org
[7] htto://rgd.mcw.edu

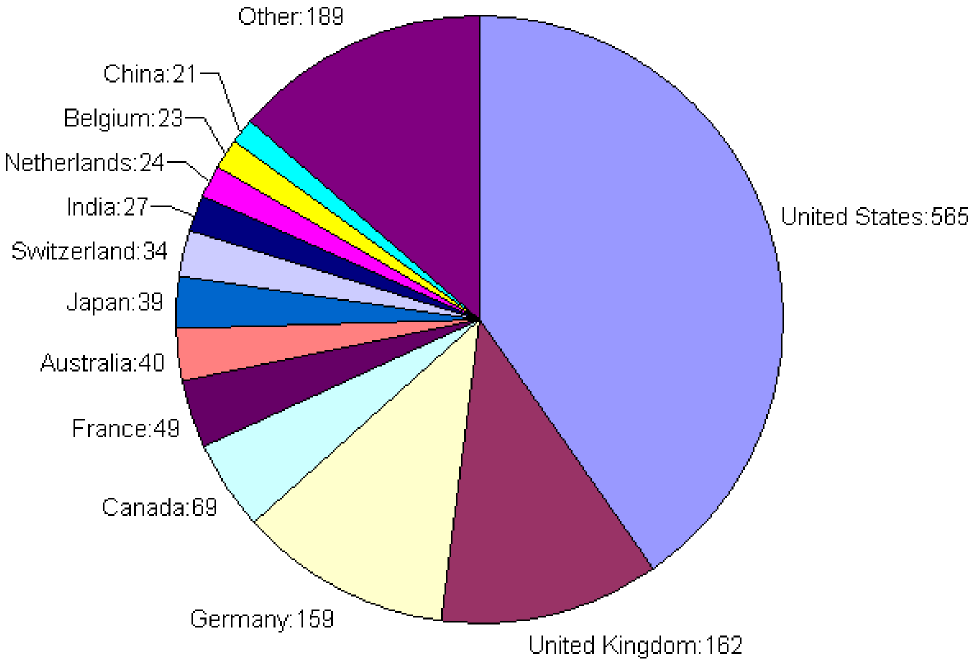

Figure 8: Research data repository nodes in r3data by country

While the majority of the repositories located in Germany and the United Kingdom are still disciplinary, a fair share of interdisciplinary repositories exist at the institutional levels, such as the Max-Planck society's Edomond[8] or the University of Cambridge's DSpace@Cambridge[9]. This trend continues through all countries – however, disciplinary repositories are often spread over nodes in several countries, an advantage which institutional repositories rarely have. An analysis of the repositories by domain has shown a clear dominance of the natural sciences and life sciences over humanities and engineering sciences (see Figure 9). Across all domains about 20% of the registered repositories identify as long-term archives for their respective data. Regarding long-term archiving and long-term availability it is interesting to note that out of 249 repositories which stated to be archiving, only 91 identified as using persistent identifiers (PI). It is unclear in how many cases this is due to the information not being available or PIs not being in place – which would be surprising in an environment which supports long-term availability of the information.

[8] http://edmond.mpdl.mpg.de/imeji/
[9] htpps://www.repository.cam.ac.uk

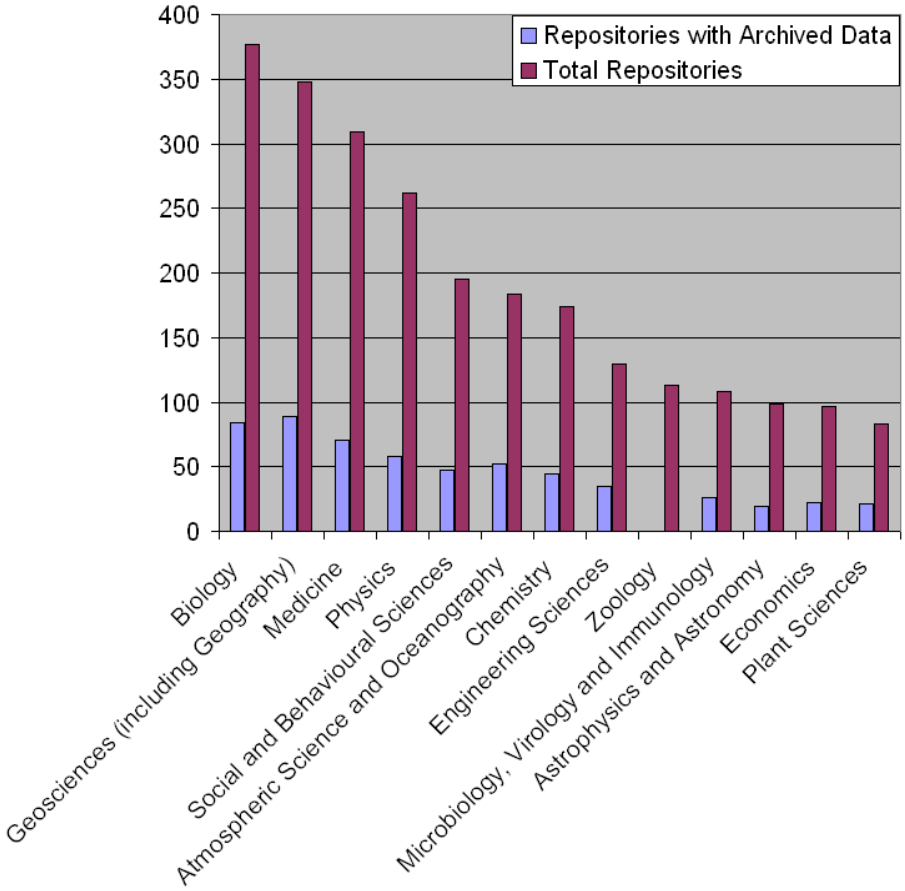

Figure 9: Research data repositories in r3data by domain (including interdisciplinary repositories)

R3data currently lists 9 repositories that store data of the domain "Construction Engineering and Architecture". A full listing is included in table 3. For one of the hits (Woods Hole Oceanographic Institution – Data & Repositories) no connection to the domain could be detected and it should be regarded as a false positive. 3 repositories are interdisciplinary, containing research data from various domains, 2 repositories contain travel survey information, 1 contains standards documents, 1 repository contains energy information and 1 images from wall and ceiling paintings. Most information contained in the repositories is textual information, no 3D objects / BIM objects / 3D scans could be identified.

Repository Name	Archived Data	Repository Type	Discussion
Wand- und Deckenmalerei in Lübecker Häusern 1300 bis 1800[10]	No	Disciplinary	Contains images of the 1,600 wall- and ceiling paintings found in houses in Lübeck, Germany, built between 1300 and 1800
Metropolitan Travel Survey Archive[11]	No	Disciplinary; instiu-tional	Includes raw data and documentation of transportation survey conducted in 47 US cities
ETH Travel Data Archive[12]	No	Other; data provider	Repository contains 40 surveys conducted by the Institute for Transport Planning and Systems (IVT)
U.S. Energy Information Administration[13]	Yes	Other; data provider	Includes ca. 500,000 files of US energy information such as regulation documentation and survey information, e.g., commercial buildings energy consumption surveys

[10] http://www.wandmalerei-luebeck.de/
[11] http://www.surveyarchive.org/
[12] http://www.ivt.ethz.ch/vpl/publications/ethtda/index_EN
[13] http://www.eia.gov/

ASTM International[14]	No	Institutional; disciplinary per r3data description, however, the range of domains covered (all sciences) should lead to interdisciplinary classification; data provider	Repository includes ca. 12,000 standards (structured text) of ASTM International, covering all sciences
Publicdata.eu[15]	Yes	Multi-disciplinary service provider	Includes open and freely reusable datasets from various public bodies at local, regional or national levels across Europe. Currently contains 57 datasets tagged "architecture", including specification information, statistics on living conditions and information about monument and conservation areas.

[14] http://www.astm.org/Standard/index.html
[15] http://publicdata.eu/

3TU.Datacentrum[16]	Yes	Institutional disciplinary per r3data description, however, the range of domains covered (all but humanities) should lead to interdisciplinary classification; data provider	Repository size: 5,875 datasets. Supports all sciences of the 3 Dutch Technical Universities (natural sciences, life sciences, engineering).
UCD Digital Library[17]	Yes	Multi-disciplinary; data provider	Digital Library of the University College of Dublin's James Joyce Library, includes mainly digitized representations of analogue content (print, photographs, 2D plans, maps)

[16] http://datacentrum.3tu.nl/en/home
[17] http://digital.ucd.ie/

Woods Hole Oceanographic Instiution – Data & Repositories[18]	No	Institutional; disciplinary	Collection of different disperse datasets and repositories of the Institution. While "construction engineering and architecture" is explicitly stated in r3data it is unclear how it connects.

Table 3: Overview of r3data.org repositories tagged as containing "Construction, Engineering and Architecture" data

3.2.3 Facilitators and drivers in research data management

Funders and policy makers requesting the re-usability and availability of research data has lead to a broader research data repository landscape. Furthermore, umbrella organizations like the Research Data Alliance (RDA)[19] try to address cross-domain needs. This is supplemented by a growing training opportunity for scientists in research data management practises. Institutions specializing in data curation and preservation, such as the UK-based Digital Curation Centre (DCC) have been offering tools and guidelines for data management for several years now. DCC's offerings include paper based checklists[20], but also DMPonline[21], a web-based tool which shall aid researchers of any domain in writing their data management plan. In addition to cross-domain offers, there have been many disciplinary efforts targeting the needs of their respective scientists, such as DataONE for environmental sciences[22] or CESSDA Training Centers focusing on research data management for the social sciences[23].

[18] http://www.whoi.edu/data/
[19] https://www.rd-alliance.org/node
[20] http://www.dcc.ac.uk/resources/data-management-plans/checklist
[21] https://dmponline.dcc.ac.uk/
[22] https://www.dataone.org/data-management-planning
[23] http://www.gesis.org/archive-and-data-management-training-and-information-center/training-center-home/

Formulated at a high level, data management plans shall include the following actions:

- considering format and extent of the data and understanding how the process influences or even becomes part of the data
- deciding which data needs to be kept and preserved and which doesn't
- considering legal and ethical implications of the data, including property rights and third-party restrictions
- considering the storage and backup of the information to meet preservation needs
- adding administrative data such as persistent identifiers, project and funding information to the data
- planning and regulating data sharing, taking possible restrictions into consideration and assigning responsibilities and resources to the task

A driver for scientists to engage in data management planning and action is certainly the citability of datasets, as given through, e.g., DataCite's[24] digital object identifier (DOI) assignments to data sets, journals such as Nature[25] requiring datasets to be included alongside the publications and repositories like DRYAD[26] allowing its depositors to understand how their datasets have been re-used and cited.
Figure 9 has shown that the high value of research data re-usability has already reached the natural science and life science domains - the adoption of research data management in the engineering and architecture domains are certainly on the horizon. Here, discipline-specific repositories need to be implemented and the needs of the domain on the community and user service levels, as shown in figure 7 need to be evaluated and addressed.

3.2.4 From research data to cultural heritage

The UNESCO "Charter on the Preservation of the Digital Heritage" defined the scope of digital heritage in 2003, describing it as "unique resources of human knowledge and expression" including "cultural, educational, scientific and administrative resources, as well as technical, legal, medical and other kinds of information". The charter clearly stated

[24] www.datacite.org
[25] http://www.nature.com/authors/policies/availability.html
[26] http://datadryad.org/

that digital heritage can be both – born digital meaning initially created in the digital domain, as well as data converted into the digital form from an analogue equivalent [93]. With digital heritage therefore including everything format and content wise, the difference between data in general and digital heritage in particular clearly lies in the scope of "unique resources of human knowledge and expression". Neither the charter, nor policy makers define more clearly what this is – the decision is rather left to collection and archival mandates of heritage institutions who can look back on hundreds of years of experience in selecting analogue materials.

But how can these institutions face the amount of digital data that exists today? The digital universe of 2013 is estimated at 4.4 zeta byte and expected to be doubling in size about every two years. This means that by 2020, the digital universe will span 44 trillion giga bytes, or 44 zeta bytes [92].

While semi- and full-automatic classification systems are already in use in many libraries to automatically classify and tag selected information resources [99], automatic selection processes remain far less common. Especially in the selection of resources to be archived, (semi-)automatic selection processes are currently only in place on a subscription basis, for example in web harvesting of resources – either in form of full web-site crawls or in partial crawls such as event-based twitter crawls [9]. However, selection processes can only work well if enough structured information about content and context is available.

In general, cultural heritage institutions receive data in 3 different ways:

- as legal deposits, e.g. in form of the regulated transfer of information from public institutions on regional, state and national level or in form of other mandatory deposits regulated by law or decree, e.g. for publications to a national library or dissertations to an academic library
- as negotiated deposits, e.g. in form of deposits of significant individuals or companies to an archive such as the Frank Lloyd Wright collection at the Avery Architectural and Fine Arts Library [27]
- through active acquisition, e.g. in form of purchasing material or collecting ephemeral information such as un-published information

All categories can include classical textual information, but also non-textual information, such as 3D data. In regards to digital data, research data repositories often form an

[27] urlhttp://library.columbia.edu/locations/avery/da/FrankLloydWrightCollection.html

intermediate layer between production and long-term data storage. Figure 9 showed that only about 20% of the repositories consider archiving a core functionality – meaning that either the data will be inevitably lost or another layer will need to pick up the data. A close cooperation between research data repositories and cultural heritage archives could ensure early on that a responsibility chain for the data exists.

While scientific data shall be re-usable to ensure a maximized economic impact of public funding and to adequately document the research behind claims, these benefits may only hold true for a certain time-span. Data may eventually become outdated or be directly or indirectly included in newer datasets. One of the key challenges of cultural heritage research of the future will be the appraisal of data to decide if it is indeed "unique resources of human knowledge and expression", an invaluable asset, or whether it needs to have a retention period assigned to it. Re-appraisal of data which is once included in the archive is currently not a common practice among archives. It is, however, imaginable that this may become necessary in the future as more and more digital data is produced and eventually archived.

3.3 Future development of vocabularies

Within the building industry, a growing interest in and need for vocabularies can be observed in classification taxonomies for documentation and process coordination. A recent example of a consortium-lead initiative to provide a framework ontology exchange can be seen in the buildingSMART International Framework for Dictionaries (IFD)[28] initiative and its buildingSMART Data Dictionary (bsDD)[29] implementation. A detailed overview of the origin of the bsDD can be found in Appendix A of D3.2.

Within the context of the DURAARK project, Linked Open Data (LOD) vocabularies are used to semantically enrich buildings models, as has been described in earlier deliverables D3.1[30] and D3.2[31], and to document the state and perception of the built environment, described in D3.4.

The developments described in chapter 3.1 demand an adaptation of the high level

[28] http://www.ifd-library.org
[29] http://bsdd.buildingsmart.org
[30] http://duraark.eu/wp-content/uploads/2014/02/duraark_d3.3.1_final.pdf
[31] http://duraark.eu/wp-content/uploads/2014/02/duraark_d3.3.2_final.pdf

vocabularies, developed by international organizations such as buildingSMART to the national and institutional level of individual stakeholders. The Cuneco standard CCS [23] is one of these localized approaches. While it has strong ties to the buildingSMART consortium, it is itself widely used among Danish stakeholders, as an orientation mark for the development of their own internal vocabularies. Stakeholders as such as DTU and Bygningstyrelsen (see chapter 4) develop these general concepts further for their internal needs - deviations and incompatibilities to the base vocabularies can here be assumed. And while these do not pose a problem for the today often isolated working stakeholders, it poses problems when data enters an archival or stronger interconnected context.

At the same time, well-established vocabularies exist close to the tight framework of the building industry, that document successful a domain specific set of products or concepts. A non-exhaustive list of examples of such vocabularies is provided below to allow for a general understanding of their wide range of applications. In addition, many institutions have their own taxonomies or vocabularies and often base procurement text on their internal definitions.

- Getty **AAT**, the Art and Architecture Thesaurus[32]
- **ETIM**[33], the European Technical Information Model, a product classification for technical products within HVAC, MEP and naval applications
- **ISO 13501-2** provides a classification of fire resistance behaviour for building materials
- **POSC/CAESAR** provides data interoperability primarily used in the oil and offshore industries
- **ISO 261** is an example of a widely used international standard to describe nuts, bolts and screw threads

These vocabularies form a central and integrated part of business processes within the niche markets these vocabularies describe. Hence, costs associated with moving to new taxonomies or different technologies, i.e., with the aim of integration into the building industries vocabularies, are high. As a consequence, opportunities emerge through a trend

[32] http://vocab.getty.edu/aat
[33] http://etim-international.com

that constitutes a shift towards relying on Linked Open Data (LOD) modeling techniques to map these distinct islands of concepts onto each other to provide an interlinked network of vocabularies, rather than to design everything from the ground up in a centralized manner.

An example of such an initiative on a regional level is the CB-NL initiative[34] in the Netherlands, which strives to provide an umbrella ontology onto which more specific well-established ontologies can map their concepts so that these currently disjoint worlds can exchange information using a harmonized model. Work on this mapping ontology is still in progress, but it is clear that the DURAARK consortium will settle on RDF/OWL[35] technology to constitute this mapping. This signifies the trend in the industry to embrace LOD technologies as has been outlined in the DURAARK description of work.

The DURAARK project facilitates and investigates aforementioned processes such as the ontology mapping tasks. As part of the D3.4 deliverable a visual tool for the human verification of automatically suggested relations between disjoint vocabularies has been presented. Tools already exist to suggest these automated mappings, for example the Silk Workbench, which can suggest mappings based on for example the Levenshtein distance between label literals. Lastly, in the subsequent section crowdsourcing initiatives for vocabulary alignment are presented and ways to validate crowd contributions by means of comparing them to experts' assessments are presented.

[34] http://public.cbnl.org/61
[35] http://wiki.cbnl.org/xwiki/bin/view/2.+Accessing+the+CB-NL/WebHome

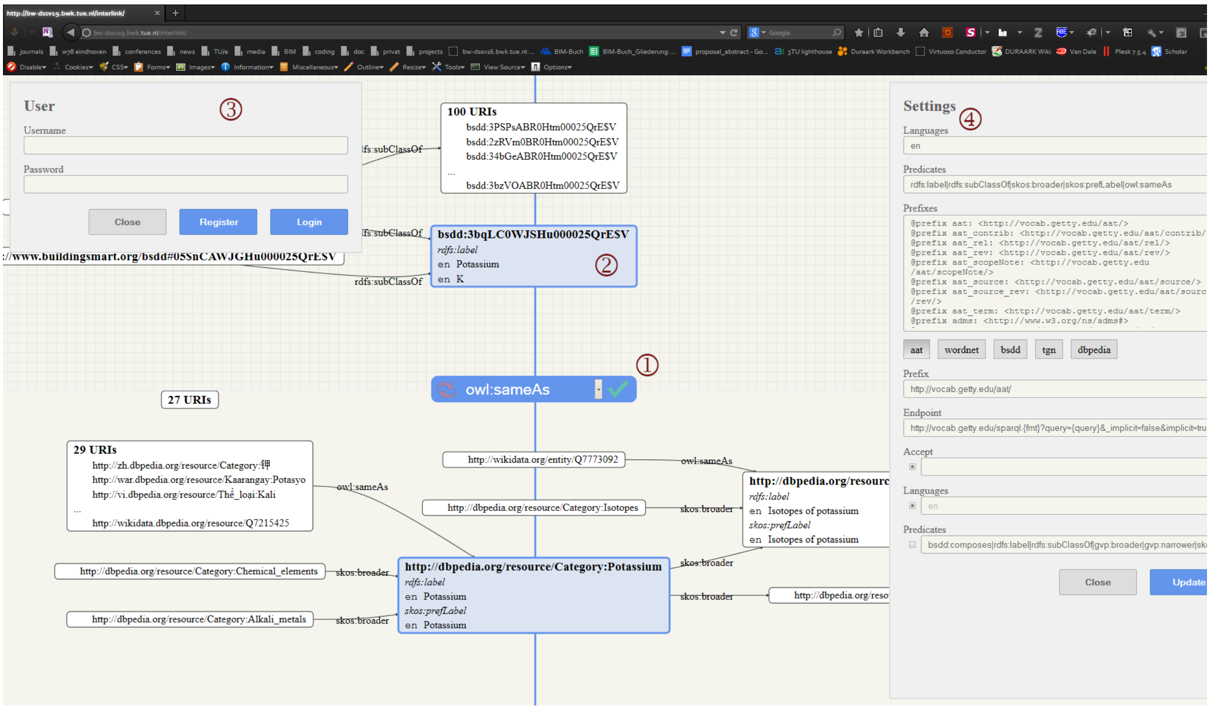

Figure 10: Screenshot of the Manual Interlinking Prototype (delivered as of D3.4) showing two concepts being linked. 1) Relation widget with vertical alignment axis. 2) Node widget showing the labels of the selected node. 3) Register/Login dialog. 4) Configuration Dialog

3.4 Crowdsourced data assessment

Within the DURAARK context, as presented in earlier deliverables D3.2, D3.3 and D3.4, we embrace the Linked Open Data cloud as well as existing vocabularies in order to overcome several challenges regarding the enrichment of archival data. In this section we describe the recent progress made by various research communities, towards abridging semantic web technologies within a multitude of realms. We focus on solutions that exploit crowdsourcing in order to overcome certain emerging challenges, such as the scalability of involving experts and the concomitant costs. First, we present exemplary works that portray the applicability of crowdsourcing for a wide variety of purposes ranging from data collection and enrichment to results evaluation and validation. Next, we discuss in detail the key challenges that are concomitant with crowdsourcing; (i) reliability of workers, and (ii) the quality of results produced.

3.4.1 Confluence of crowdsourcing and the Semantic Web

Due to the nature of semantic web technologies, the need for human input or intervention is apparent. In recent times, *crowdsourcing* and *gamification* have been adopted as a means to solve several problems emerging in the Semantic Web and to engage workers within such tasks.
Ontology alignment is one domain that has profited from dedicating atomic microtasks to the crowd. Demartini et al. [28] leverage crowdsourcing techniques with an aim to achieve large-scale entity linking. Sarasua et al. introduced CrowdMap [84], a model to acquire human input via crowdsourcing in order to solve the problem of ontology alignment. In other works, researchers have used gamification in order to collect human input. Thaler et al. developed a game called SpotTheLink with an aim to solve the problem of ontology alignment [91]. Thaler et al. also used gamification for image annotation and interlinking. Keeping up with the tradition of 'semantic games with a purpose' [87], Markotschi et al. developed a game in order to collect contributions to the creation of formal domain ontologies from Linked Open Data [64].

3.4.2 Quality of results and reliability of workers

There has been a lot of work related to the quality and reliability of crowd workers. Researchers in the field have acknowledged the importance and need for techniques to deal with inattentive workers, scammers, incompetent and malicious workers. Marshall et al. profile Turkers who take surveys, and examine the characteristics of surveys that may determine the data reliability [65].
Kazai et al.[54] use behavioural observations to define the types of workers in the crowd by type-casting workers as either *sloppy*, *spammer*, *incompetent*, *competent*, or *diligent*. By doing so, the authors expect their insights to help in designing tasks and attracting the best workers to a task. While the authors use worker-performance in order to define these types, we delve into the behavioral patterns of untrustworthy workers. Ross et al. [82] study the demographics and usage behaviors, characterizing workers on Amazon's Mechanical Turk. Complementing such existing works, our work focuses on worker modeling.
Baba et al. report on their study of methods to automatically detect improper tasks on crowdsourcing platforms [8]. The authors reflect on the importance of controlling the quality of tasks in crowdsourcing marketplaces. Through their work, Ipeirotis et al. motivate the need for techniques that can accurately estimate the quality of workers,

allowing for the rejection or blocking of low-performing workers and spammers [49]. The authors present algorithms that improve the existing techniques to enable the separation of bias and error rate of the worker.
In the realm of studying the reliability of crowd workers, and gauging their performance with respect to the incentives offered, Mason et al. investigate the relationship between financial incentives and the performance of the workers[66]. They find that higher monetary incentives increase the quantity but not the quality of work of the crowd workers.
Eickhoff et al. aim to identify measures that one can take in order to make crowdsourced tasks resilient to fraudulent attempts in their work [36]. The authors conclude that understanding worker behavior better is pivotal for reliability metrics. Dow et al. present a feedback system for improving the quality of work in the crowd [32]. Oleson et al. present a method to achieve quality control for crowdsourcing, by providing training feedback to workers while relying on programmatic creation of gold data [74]. However, for gold-based quality assurance, task administrators need to understand the behavior of malicious workers and anticipate the likely types of worker errors with respect to different types of tasks.
Difallah et al. reviewed existing techniques used to detect malicious workers and spammers and described the limitations of these techniques [30]. Buchholz and Latorre propose metrics for the post-hoc exclusion of workers from results [17]. In another related work, Wang et al. present a detailed study of *crowdturfing systems*, which are dedicated to organizing workers to perform malicious tasks [97]. In yet another relevant work by Eickhoff et al., the authors propose to design and formulate microtasks such that they are less attractive for cheaters [37]. In order to do so, the authors evaluate factors such as the type of microtask, the interface used, the composition of the crowd, and the size of the microtask.
Yuen et al. present a literature survey on different aspects of crowdsourcing [101]. In addition to a taxonomy of crowdsourcing research, the authors present a humble example list of application scenarios. Their short list represents the first steps towards task modeling. However, without proper organization regarding types, goals and workflows, it is hard to reuse such information to devise strategies for task design. In a step forward, Gadiraju et al. [41] propose a comprehensive and exhaustive taxonomy for the different types of microtasks.

3.4.3 Crowds and experts

Over the last decade, there has been some work in the direction of combining the 'wisdom of the crowd' with knowledge from experts in order to overcome problems emerging from noisy crowdsourced labels, in addition to other machine learning settings [53, 81]. *Nichesourcing* has been introduced by de Boer et al., to combine the strengths of the crowd with those of professionals and experts, thereby improving the outcome of human-based computation for certain appropriate tasks [27]. Shankar et al. exploit geo-tweets from Twitter users to learn about places, and show that their proposal to create a crowdsourced location-based service returns results that match current approaches (i.e., experts) [86]. It is a costly endeavour to involve experts in the process of data assessment and curation tasks, especially in the context of large amounts of data. Therefore, crowdsourcing can play a pivotal role to overcome these challenges.

4 Exemplary digital archival practice and operation process of institutional stakeholders

This section describes exemplary digital archival and operation processes of building information data as found in the three stakeholder groups. As described in chapter 2, this deliverable used questionnaires (see Appendix 7.6), interviews and a workshop held in Copenhagen, to gain first hand knowledge about the actual processes and challenges that stakeholders from the groups of institutional building owners/facility maintenance, cultural heritage/research institutions and software companies/service providers encounter when working with building information. The deliberate is especially interested in their practice under aspects of long-term availability of data - a concern that most of the stakeholders share. The study for this deliverable cannot claim to be exhaustive or representative for the general trend in the building profession. Within the ongoing work in the project, the DURAARK consortium could however identify stakeholders that have established practices with building information data. These can be seen as early adopters in the general context of the three stakeholder groups under investigation. The experience from them can hence be a guide to a good practice for the ones to follow.

4.1 Institutional building owners

The group of building owners under investigation in this deliverable all have an institutional background - meaning they are either a part of the state, as property organizations on state, region or municipal level, or building owners which are fully or to the biggest extend state-owned, such as airport or municipal real estate organizations. The owners under investigation are all large in size with over 100 employees and can usually look back on a long history. However, almost none of the institutions existed in the same organizational setup over the whole period of time. They rather shifted organizational form and link to super-ordinate institutions or ministries.

The portfolio of buildings they take care of is often extremely large and valuable. Stakeholders like Copenhagen property (KeJD) or the Swedish Fastighets Verket are among the 4 largest building owners in their countries. The portfolio includes usually a mix of historically extremely valuable buildings, as well as very mundane living units and utilitarian buildings. The stakeholders' building stock is thereby dynamic and might split or merge with the institutional relations or political times. Due to this background all

stakeholders can be sure that their occupation with the building mass in their possession is long-lasting. This occupation includes the tasks of the operation and maintenance of buildings through, i.e., inspections, cleaning and repair. Building owners also develop their portfolio further and adapt it to new needs and regulations, as they demolish old buildings and build new ones. Hence, hundreds of building and renovation projects are executed by the investigated stakeholders every year. These are manifold in nature, ranging from a quick dealing with a simple renovation of a space to the upgrade of the complete building portfolio over years, in order to accommodate new energy regulations. Due to their tight relations with the political institutions, their position in the market provides these large building owners with a special prominence. This weight has been used in the past to introduce advancements into the profession. As described in the DURAARK deliverable 7.7.1 Denmark used for instance the strategic position of the state owned building property organizations to push the digitalisation of the whole building profession. The 2007 "Bekendtgørelse om anvendelse af informations- og kommunikationsteknologi (IKT) i offentligt byggeri" [59] regulated here only the way that public building owners would organize the way they manage construction and facility management related processes. This regulatory act moved however the whole Danish building industry, as shown in D7.7.1.
Institutional building owners are forerunners of the industry and often act as sites to test and develop new solutions, as Mette Carstadt from Universitets- & Bygningsstyrelsen stated [21]. The "University and Buildings ministry" is nowadays called Byggestyrelsen and is Denmark's second largest property owner. The large amount of building assets and annual turnover of institutional building owners - KeJD has for instance 2.6 billion Danish Kroners (DKK) annual turnover, the Danish Technical University 1.6 billion DKK - requires simultaneously a professional approach towards all processes related to building management on the technological and process level. Hence, the building owners have a specialized organizational structure, with specialists responsible for construction and design, maintenance, financial and juridical regards, as well as IT-related questions. Specialized units are here dealing with questions of Building Information Models, their creation, management and integration into the processes and systems of the institution. Among most stakeholders the organization of building information and the related communication processes have been identified as key components of the day-to-day businesses.

4.1.1 General processes around buildings and their data

All processes that building owners engage with are replicated in their digital processes:

- management of buildings (FM)
- update / change of building data
- planning of retrofitting of existing building stock
- planning of new buildings / addition to existing building stock
- presentation / information about buildings to external persons / organizations
- assessment (security, fire, usage, energy) of existing building stock

The processes involve the whole organization, with several departments dealing with data related to buildings. The access to data is here regulated and predominantly internal. External companies and stakeholders from all building-related fields can have access on a case by case basis, for instance in order to ingest FM data for new buildings into the FM systems. Access is however only granted, when contractual relations exist. A general access of the public to the building information cannot be granted due to the sensitivity of the future - and it is not planned or foreseeable that this will change in the future.

4.1.2 Datatypes of building owners

The type of data the stakeholders are dealing with is diverse and covers 2D (dwg, dng, pdf, dwf), 3D (dgn, dwg) and BIM data (ifc,dgn,rvt). Furthermore, point-clouds in various formats (fls, las, txt, e57) are not uncommon to the stakeholders. 2D data is still most common in the day-to-day practice (40-90%), while the percentage of BIM files is increasing. Stakeholders describe that the BIM objects they receive are semantically not as rich as they potentially could be or the stakeholders imagined or wished them to be. BIM objects are rather poor in terms of metadata and only hold information on the most general classification levels - furthermore often when explicitly demanded by the building owners. This observation is in line with the findings in the DURAARK deliverable D7.7.1 which found as well that BIM models are mostly used to coordinate the planning of engineers and designers or to perform quantity takeoff. The description of building elements and installations and their technical and product data takes predominantly place through external files (pdf, xls, doc). These are linked to the individual building elements through unique IDs and are delivered in organized folder structures or similar methods at the point of handover.

4.1.3 Initial creation and handover of data

The responsibility for the initial generation of building information or their modification and extension during design and construction processes is usually not situated at the building owner, but external companies. The handover of data to the stakeholders and their systems is always occurring and crucial, even in cases where the stakeholders are highly involved in data creation. This is for instance the case in Falun Kommune, who conduct the 3D scanning of all their properties by themselves or in the case of KeJD, who digitizes their complete building portfolio in a short period of time.

Upon retrieval, the data is usually checked by the building owner and, after eventual revisions, accepted. The data is typically handled by specialized departments of the stakeholder, who ingest the data in central IT systems or distribute the data to other departments which have their own systems, for instance for management of facilities maintenance, rental contracts etc. The IT departments are also responsible for the internal storage or archiving of original building data and the submission of refined data to archives as described in D7.7.1.

The processes after the handover often require an adaptation of the data, the enrichment of metadata, further refinement and indexing or the modeling of stakeholder specific assets. For this purpose, the stakeholder holds a set of BIM and CAD tools as well as specialists to work with them. The duration of the process to ingest data into IT systems ranges from hours to weeks depending on the task. All stakeholders describe it as tedious, prone to error, too slow and complicated.

4.1.4 Organizing the use of building information across stakeholders

It was previously described in section 3.1.8, that the building owners' IT systems for FM are not working with the same data models as used in the building process, which is indeed a major issue. Extending this description, we found that all investigated stakeholders have different systems to index and create metadata for building-related data coherently across their whole organization. Respective indexes can be purely internal, referencing to an overarching geo system, single buildings, their spaces and the assets within those, standards, such as A104 (Danish document management standard)[14] or the Swedish Construction Classification system (BSAB 96)[20], or internal systems that are derivatives from national standards, such as the Danish BIPS A104 or Cuneco CCS[23], which orients itself against the buildingSMART standard.

In order to increase the sustainability of data and the ease of interoperability with their own IT systems, stakeholders spend a large amount of time to define the type, format, quantity and quality of data as the way these are communicated and delivered during and at the end of a business relation with external companies and institutions. These definitions are in the Danish context called *Information og Kommunikation Aftale* (IKT - Information and Communication Agreements). They are legally binding and part of the contract that stakeholders have with, for instance construction work. The IKTs include often a set of documents defining each specific area: e.g., CAD standards, standards for as-built documentation, tender, process (i.e., consistency control) and delivery. They are developed by the stakeholder - often adapting previous own or existing national and international standards - and will be adopted for the specificity of each construction case. Extending on the more general description in D7.7.1 (chapters 2.1 and 2.3) the IKTs templates under investigation for this deliverable [94] [39] show that stakeholders demand in general three sets of data upon completion of a building:

1. as-built documentation
2. documentation specific to the stakeholders' maintenance operations and FM systems
3. documentation of the building process

The **as-built documentation** includes BIM files with specified formats (i.e. IFC 2x3 and original format), as well as technical documents in pdf format. The BIM formats have to follow defined structures, as for instance those defined by the Danish BIPS standard (bips lagstruktur 2005, bips CAD-manual 2008). The standards established here are as well related to the documentation of existing buildings and may go quite deep into detail. The DTU defines for example the precision of elements (say on a scale from 1-5, where 1 is 25 cm and 5 is 0.5 cm 7.1, the informationlevel (1-6) 7.2 and introduced as well a classification of accuracy of data levels from 0-4 (Danish Informationsnøjagtighed) 7.2. The latter refers to the source of the data, ranging from measurement by hand (level 0) up to laser-scans (level 4). All this information shall be attached to the specific building elements in the BIM model.
Stakeholder-specific information is needed for each file in order to reference the models and other information to geographical and internal systems. This includes, for example, information of the Danish Building ministry about the geo-system used for coordinates and height (according to bips F103, objektstruktur 2008), as the respective values. For internal purposes further metadata is required:

- Matrikelnummer (a kind of unique ID)
- Ejerlav (owner)
- BBR ejendomsnummer (Owners number)
- BBR bygningsnummer (building number)
- BBR kategori (category)

BBR is the Bygnings- and Boligregister (Building and Real-Estate register)[68] of Denmark, where all buildings are listed in an online database run by the government. The system is based on geo referencing (see Figure 11). This information should as well be included in the delivered IFC files. However, this information could not be identified in the dataset that was handed to the DURAARK consortium from the respective stakeholder.

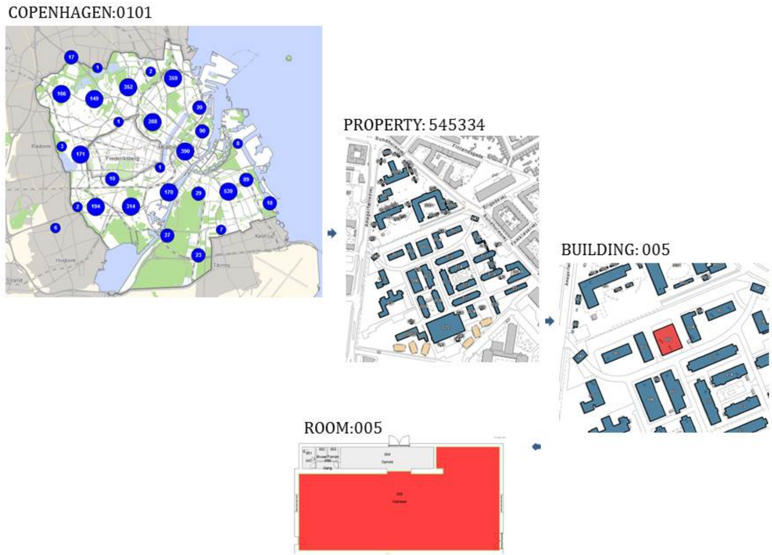

Figure 11: KeJD uses the Danish BBR system to identify spaces and buildings in a georeferenced way.

Documentation specific to the stakeholders' maintenance operations and FM systems are demanded by most of the stakeholders' IKT and shall allow a seamless import of the BIM data into maintenance and other IT systems. The respective parts of the contracts are using standards to define the exchange. In the case of the Bygningsstyrelsen, (see Annex 7.3) a schema developed by buildingSMART Denmark is used in order to describe the way spaces and areas are defined in the respective IFC model:

- Global ID (IfcBuilding.GlobalId, IfcBuilding.Name)
- storey (IfcBuildingStorey.GlobalId, IfcBuildingStorey.Name)
- room number (IfcSpace.GlobalId, IfcSpace.Name,IfcSpace.LongName)
- area (IfcElementQuantity.GrossFloorArea)
- roomtype (IfcPropertySet(DkGovRoom).DkGovRoomFunction)
- room function (IfcPropertySet(DkGovRoom).DkGovRoomFunction)
- alternative room function (IfcPropertySet(DkGovRoom).DkGovRoomAltFunction)

This set of information is sufficient for room planning tasks. However, stakeholders demand more data for the management of their portfolio, as KeJD for instance generates BIM data, which holds information such as openings and wall qualities, as well as the use and amount of people in a space (see Figure 12). This allows them to estimate the energy use of their buildings and compare it with the real numbers in order to decide about the priority of renovation tasks in their portfolio.

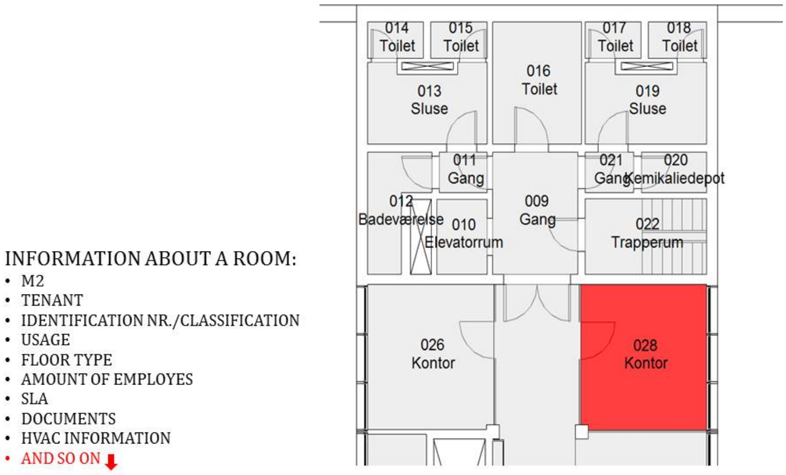

Figure 12: Information linked to a single space in the data model of KeJD

Especially building information models from the construction phase are potentially rich in information and show all assets within a building. This completeness is interesting for the following maintenance of a building, when the BIM objects are enriched or linked to related information. Pioneering stakeholders, such as the DTU, endeavour into this area and demand very detailed information (see Annex 7.4 and Table 4) from building contractors or other experts who are engaged in the final phases of a construction project.

Level	Purpose	Information/data	Delivery format
ARK1	Recognition and order of assets	Active/passive fire system	Mark with "P"/"A"/"-"
		Amount (m, m2, m3, pcs)	Document [xls]
		Fire Classification (REI)	Numeric value and text
		Building Number	Numeric value and text
		Contractor	Text
		Assurence Contact (CVR-Number)*	Numeric value
		Supplier	Text
		Location (e.g. LYN=Lyngby)	Text

		Producer	Text
		Space Number	Numeric value and text
		Sfb-Number Code level 3, description and type	Numeric value and text
		Material Type	Text
		Submission Date	Date [yyyy-mm-dd]
ARK2	Maintenance of assets	Recommendations for maintenance check	Document [word]
		Recommendations for maintenance check	Interval [months]
		Recommendations for cleaning	Document [word]
		Recommendations for cleaning	Interval [months]
		Recommendations for maintenance	Document [word]
		Recommendations for maintenance	Interval [months]
		Acquisition and Assurance	Date [yyyy-mm-dd]
		Color (RAL)	Numeric value and text
		Directory of positions (hidden installations)	Drawing [dwg]
		U-value	Numeric value
ARK3	Operation of assets	List of doors and windows	Document [xls]
		Product / Data Sheet	Document [pdf, ocr, word]
ARK4	Full management of assets	Certificates	Document [pdf, ocr, word]
	planning own production	Product photos	Photo [jpg]
		Product specific descriptions	Document [pdf, ocr, word]

Table 4: Information for architectural objects required by DTU at handover of data to FM systems (see Annex 7.4)

Building contractors or other experts engaged in the final phases of a construction are as well demanded to deliver a **documentation of the building process**. This process is in the Scandinavian context taking place online at platforms hosted by external companies, as for instance byggeweb [19] (from 2015 onwards RIB). These platforms are contracted by the building owners and become over the course of the construction process a repository for building models and all related communication and documentation. While stakeholders, such as the Bygningsstyrelsen demand the handover of a complete documentation of the process (see 7.5), practice shows that the handover and archiving of this online repositories takes place through the further operation of the web-platform. This poses challenges to the integrity and accessibility of the stored documentation when a migration of data might be necessary due to an evolution of the platform or a vendor lock-in.

4.1.5 Challenges and alternative ways of delivering BIM:FM data

Despite all efforts to define interfaces, the handover of data from BIM to FM remains challenging. Stakeholders report about inconsistencies of metadata and classification which are not due to IFC export problems, but systematic errors or carelessness from the side of the companies delivering the data. Cause for this might be the lack of appropriate tools as well as the lack of knowledge about the later use of the data.
Stakeholders have hence challenges to enrich data, as they have a hard time validating the incoming data for consistency and quality. The current practice includes manual inspections of parts or errors that occur during the ingest into the FM system. Stakeholders report about lengthy cycles between them and contractors until the data reaches the quality defined in the IKT agreements. Other stakeholder report that this level is not reached at all or that the exchange of FM data is stopped due to budget constraints.
Alternative means to structure the process of data input into an FM system are hence highly demanded. As the information about maintenance is quite extensive and includes many different types of data (see Table 4), which are simultaneously often only available when the building is finished - as for instance photos of the assets - stakeholders are shifting the input of data into the FM system from their side to the contractors. In case of DTU or Bygningsstyrelsen the contracts for the handover of data include the ingest of all FM relevant data into the respective FM systems. These tasks can again be subcontracted to specialized companies, who receive access to the web-frontends of, i.e., FM systems such as Dalux [26] (used by DTU) or VISTA FM [96] (used by Bygningsstyrelsen) in order to ingest data. According to the stakeholders, structuring the ingest process this

way combines the competence and knowledge at the contractor level with the virtues of a structured system - now a synonym of FM systems. The base for the ingest of data is however still the BIM model in the IFC 2X3 format. This provides all information about the building and its assets, which hence needs to be meta-tagged according to the data organization of the stakeholder, in order to allow for interoperability between BIM and FM systems for the initial and eventual later ingests.

4.1.6 Purpose, organization and architecture of IT systems for the operational phase of Building Information

The role of the building-related data is reflected in the organization of building owners' IT systems as well. These are often the result of historic developments and the internal organization of the stakeholders.

One important observation is the existing split between the stakeholders design and construction departments and the ones that take care of the operation of buildings. This demarcation mirrors the general setup of the building discipline and the way BIM evolved, as described earlier in section 3.1 of this deliverable. Until now this division is the state of the art in the organization of construction and operation. The modes of thinking seem to be very different on the two sides: the construction side is driven by an idea to operate with a big team of specialists and reach certain goals in time, while the operational side is working in long time frames, with a less specialized workforce and immediate feedback from users. The handover of data is therefore not only a technical issue. Coupling the insights gained in the use of buildings with the capability to handle and control big amounts of data in the building phase is a vision that all stakeholders share.

Facility Maintenance and BIM data are however just parts of the bigger picture and not necessarily the focus of the whole organization. However, they become relevant whenever information from the general building portfolio has to be broken down into finer granularity. Questions, such as "how many kitchens do we have in our childcare institutions?" or "which appliance require the most energy in our buildings?", require the link of different information sources in a common data model. These questions are often politically motivated and require a substantial amount of resources to be answered today, as the data required to answer these questions has to be pulled in and combined from many different sources.

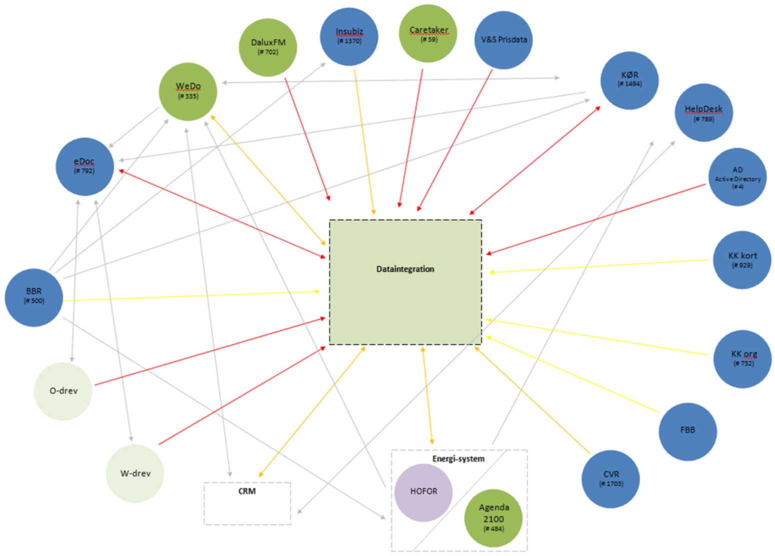

Figure 13: The IT system of KeJD includes more than 20 subsystems. The integration of these is a vision of the stakeholder.

Institutional stakeholders are working today with networks of specialized IT systems, which exchange data about buildings in varying forms and extents. KeKJD alone counts more than 20 internal IT systems that work with building information (see Figure 13). While the data between these systems should be easily exchangeable, as they share the same organization and identifiers for the held objects, the daily practice shows that the integration of these systems is a tedious process (see Figure 13).

4.1.7 Keeping building information up to date

The use and integration of building information in the operational workflow has a wide proliferation among the investigated stakeholders. Implementation and integration levels we found ranged from:

- BIM as a one way information carrier - uni-directional transfer
- BIM as a repository for spatial information - BIM data is linked into the system, updates in BIM take place manually
- BIM as a repository for spatial information - bi-directional link for selected data
- Building Information as a central repository (3D scan of the as-built)

As buildings are dynamic and change all the time, the way of updating the building information comes immediately into focus after the initial ingest. The main task with an FM system is hence to assure the reliability of the data. The stakeholders face the challenge that existing information, whether on paper or as legacy CAD and 3D files, is not directly usable in information systems. Different strategies are used and combined in order to generate the up-to-date information:

- ad-hoc generation of data from existing legacy data and check against the as-built
- ad-hoc generation of data through on-site measurement
- sequential update of information through intake of as-Built BIM data whenever an asset is built or refurbished (demand to use BIM)
- update of existing BIM through on-site inspection

The majority of stakeholders are using BIM models as the preferred carriers of information. 3D scans are here solely a means to obtain up-to-date information and abstract them into BIM. Some stakeholders observe this type of data as a means to continuously receive updates about the state of their buildings. Scans are here seen as the richest of possible information sources and are considered to be well suited to answer questions about buildings and plan activities, as they make time consuming and exhausting site visits unnecessary for an ageing workforce - as in the case of Falun Kommune in Sweden. A challenge is however that the resulting amounts of data are overwhelming and the interpretation of these by means of machines is lacking until today.
An approach to outfit on-site personnel with the capability to work on the FM database and retrieve, comment, enrich and change localized information in the FM systems is a further approach to increase the speed and reliability of data in the systems. The IT systems become here both central and necessary to the execution of FM-related work. Hence, systems such as Dalux FM offer mobile apps, that allow on-site workers access to the FM system and provide general as well as task-specific information in a combination of textual, 2D, 3D and image based information (see Figure 14).

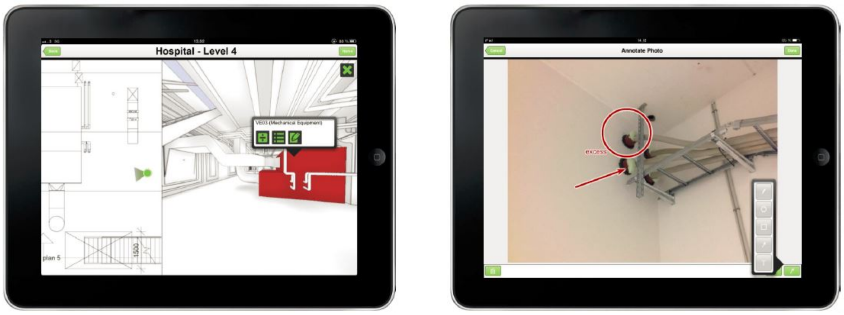

Figure 14: IT systems, as Dalux FM, are extending the reach and interoperability of FM through Mobile apps

4.1.8 Risks for stakeholders' building information

Most stakeholders are aware of the long-term risks that their building data is exposed to. They are however often of the opinion that the regular use of the data in a live FM:BIM system will overcome problems such as the change of software versions, etc. This thinking might be true for all FM-related data, if the system is able to work bi-directional with BIM data and updates of BIM data is highly automated. However, semi-manual integration such as in uni-directional links of BIM and FM data include many time consuming manual steps that are prone to error or neglect, due to overload, incompetence or prioritizing of tasks through workers' choices.

The stakeholders' perspective is often not capturing the long-term aspect (50 years plus) of information. Only some of the responsible IT managers, such as at the Copenhagen Airport, have experienced several radical shifts of paradigms related to building information. As today's generation of workers cannot understand how organizations could only work with 2D paper information, future generations might have the same view of current high-end integrated FM:BIM systems - including the same problems of interoperability.

How endangered data can be, becomes evident in situations of system upgrades. The Danish Bygningsstyrelsen is for instance discussing an upgrade of the online Building management system (byggeweb). The extent to which the therein stored ("archived") construction process documentation will be transferred is under negotiation. Budgetary parameters are here an important point of consideration and might lead to discarding some of the "old" data in the byggeweb.

A similar risk can be identified for the as-built documentation. This is often the base for the live FM system at the stakeholders' side. Their current workflows store the data, while no archiving of the as-built BIM data and their related files is set in place.

4.2 Cultural heritage and research institutions

As discussed in section 3.2, data repositories for construction and architectural data are still rare. However, the work of deliverable D7.7.1 highlighted that massive amounts of architectural 3D data are produced in practice and research and that at the same time policies exist on national levels which demand the deposit of building information models to a policy maker after the completion of publically funded buildings. However, these objects have not reached the cultural heritage archives yet. The goal of the use case study for research and cultural heritage institutions is an evaluation of where these institutions currently are in regards to curation and preservation processes for 3D building information and how they envision future scenarios. The cultural heritage and research institutions whose feedback was gathered through the workshop, through questionnaires and interviews included institutions at different levels:

- national level, e.g., in form of national archives
- regional level, e.g., in form of municipality archives
- institutional level, e.g., in form of research institutions

Two of the institutions stated to double as building owner / facility maintenance and cultural heritage institution. However, the team which responded to this section of the analysis was the digital archiving and preservation unit of the respective organizations. These stated that they are aware of Building Information being available within their institution, but have not yet integrated it into their regular digital preservation activities. We specifically targeted institutions of various market positions and sizes from within our networks who were either previously identified as having architectural 3D data in their holdings or were actively preparing for information being passed to them in the near future.

4.2.1 Producers and users - the stakeholders of our stakeholders

Based on the answers given to questions about the data producers depositing information and the reasons why the data is accessed, three different levels of producer-consumer support could be derived.

The **national archives** have a common profile, only accepting information from municipalities, government agencies and royal commissions and having no guidelines in place which for example regulate requirements in format or accompanying information. This may be surprising, as it is common archival practice to have these in place for other types of objects (mainly text, still images and audio-visual materials)[36]. However, the content type is too new and rare for standard procedures to have been established already. Instead, individual transfer planning is conducted[37]. As for the consumer side of the digital object, all archives stated that the information is not stored for specific reasons such as the planning of new buildings, but to support "general access by the public to the archival record". Contextually, the **object is therefore not seen as a living object, but as a discrete piece of information**.

The **municipal institutions**, on the other hand, receive or expect to receive their information from architects and land surveyors. In that regard, their 3D collection profile is similar to that of the research institutes, who expect to receive a growing number of 3D data from the same producers. Like the national archives, municipal institutions don't have specific guidelines for their producers available yet. Both institution types also serve similar types of consumers - most of the archived data is either made available to the general public or to specific external persons / organizations connected to the building. Both institution types - municipal archives as well as research institutes - name researchers from the fields construction / architectural history as their predominant designated community for architectural 3D data. While the municipal archive is mainly focusing on the presentation and basic information layer about the building stock, the research institution wants to keep the 3D representation at a level of granularity which also allows for facility management or retrofitting actions, where available.

A third group was found in **institutions acting at a national as well as a research level, but with a special focus on archaeological and conservation aspects**. The survey included two representatives from this group. Both listed land surveyors, external companies producing scans and external contractors producing tender information as their

[36] For example the guidelines of The National Archives UK: http://www.nationalarchives.gov.uk/information-management/manage-information/selection-and-transfer/

[37] For example at Archives New Zealand:
http://archives.govt.nz/advice/guidance-and-standards/appraisal-and-disposal-information/transfer-physical-records-archives

depositors. Furthermore, both institutions have deposit guidelines for 3D data in place, which address the digital object in regards to its format, accompanying metadata as well as in regards to the data carrier / transfer method to the archive. It is not surprising, that these two institutions are also the respondents with the highest percentage of 3D data in their digital holdings. Both institutions also gave the same answer regarding future usage scenarios to be supported - they envision access scenarios for facility maintenance as well as future retrofitting projects and consequently they are the only representatives of the surveyed cultural heritage institutions which included updating and changing the building data as an access reason. With all of the similarities of these two institutions the designated community is indeed a surprise - one of the institutions sees a closed group of conservationists as the main community and has the clear purpose of supporting a specific set of physical buildings and monuments - the other lists researchers as the main designated community, supporting any intended purpose of that domain through publicly available data. Despite the different consumers, this group of institutions provided a polar opposite to the discrete information view of the national archives, regarding the **digital object in its connection to a physical asset which is in constant flux**.

4.2.2 Existing archival processes amongst cultural heritage stakeholders

A main focus of the structured interviews and questionnaires was to understand the status quo of digital collections and archival processes for cultural heritage institutions already dealing with or preparing to deal with building 3D data. A surprising result regarding the overall digital holding size was that no correlation between the level of the institution (national / regional / institutional) and the size of the digital holdings could be detected. We had expected national archives' holdings to far surpass regional and institutional ones, but instead could see an even spread. Over 75% of the stakeholders are dealing with holdings > 10 TB size, over 50% of the stakeholders are dealing with holdings > 100 TB size. The information reaches the institutions through internal or external projects or producers, whose numbers vary from 10 to 100+ per year. As expected, 3D information only makes up for a very small part of the overall collection, coming in at about 0-5% of the overall digital holdings the institutions are responsible for. We expect this to be the biggest difference between the cultural heritage stakeholders and the institutional building owners. As expected for the comparatively small percentage of 3D data in the overall holdings, the institutions stated that these objects are currently seeing little usage, as opposed to, for example, 2D objects, which are accessed frequently.

For most institutions[38] only one internal system exists to deposit, process and store the data over the long-term. Other systems, however, do exist for processing connected to organization internal use and re-use of the data - such as data mining or active data re-use. In these cases, the organization may access the data through front-ends and load it into other systems. Public access may either be granted via flexible front-ends to the archival system or through separate access systems. All institutions use in-house server-based solutions for their archival IT systems, the split between self-created / bespoke and adapted commercial systems is about half-half. While cloud based system services were unanimously not seen as a choice, one institution uses an external but local storage provider for archival storage in addition to internal operational and back-up storage. There were two interesting opposing positions regarding how "archiving" differs from regular storage: one statement regarded the "archival storage" as a secure layer with no direct day-to-day connection to the operational/access layer - the other position is to regard "archival storage" as a means to easy access (for internal and external use) by moving objects from disperse deep storage locations into a manageable system.
As for digital preservation processes, adding descriptive information and metadata during ingest and updating the contextual as well as technical information about the files over the course of time are accepted as standard processes and conducted by all institutions. All institutions stated that no separate processes for 3D data exist and it is handled in the same processes as other data. Processes mentioned in addition to the metadata gathering on the descriptive and technical levels were integrity checking, migration and OAIS compliance.

Since the institutions do not treat 3D data differently than other data within their ingest and preservation workflows, they are also described through the same descriptive metadata schema as other information. The research institutions dealing with a lot of building-related content mentioned domain relevant vocabularies. One institution mentioned the Getty AAT in connection with descriptive information. Two institutions mentioned extensive use of external schemas / linked data sources for descriptive information - vocabularies and data sources mentioned here were Geonames[39], Midas[40], the Library of

[38] Statements about the system landscape of the respondents exclude those who either stated that they are currently implementing a new system and those who could not answer system-related questions.
[39] http://www.geonames.org
[40] http://www.heritage-standards.org.uk/midas/docs/meta/index.html?url=/midas/docs/

Congress Subject Headings [41], Ordinance Survey [42] and the SENSCHAL vocabularies [43]. Possibly not surprisingly, the two institutions making use of these sources are the institutions with a special focus on archaeology and conservation.
Some of the respondents provided information about the file formats of the 3D objects in their holdings. For 3D plans, in particular the proprietary formats AutoCAD CAD (cad), Geomagic 3D Wrap File (wrp) and Agisoft Photoscan (psz) were mentioned, as well as the open formats PDF/E (also referred to as 3D PDF), Wavefront object (obj), Virtual Reality Modeling Language Objects (vrml) and Extensible 3D graphics (x3d). For 3D scans the proprietary formats Trimble RealWorks (rwp) and PTC Faro Cloud format for AutoCAD (ptc) were mentioned, as well as the availability of 3D scan information in open formats such as ASCII text files or comma separated value files (csv). Institutions that did list file formats included both - proprietary as well as open - and pointed out that data producers are asked to deposit the information in both: the native format as well as an open file format for archival purposes. While the listed formats mainly contain only geometric information, **only one stakeholder stated that they foresee BIM objects entering their holdings in the near future**.

4.2.3 Expectations in future preservation scenarios for 3D data

The second focus of the stakeholder study was a discussion on future scenarios for the usage and preservation of 3D data. In regards to external service providers for all or parts of the preservation workflows, users were asked to state their "go" and "no-go" criteria. Requirements on the user experience side were the availability of a web-interface and the availability of guidelines and support - for the process as well as for the day to day use of the system, e.g., in form of a help desk. On a process level, the service would have to support full data preservation on bit and file format level and ideally make data available as open access. Main inhibitors to the use of an external service or software provider are the lack of transparency, lack of data availability and the lack of preservation processes. Major concerns were cost, especially for public institutions, and concerns about trust as well as legal issues such as the privacy laws of different countries. While the institutions listed open access to the data as an important plus factor, which is in-line

meta/http___www_heritage-standards_org_uk_midas_schema_2_0.html

[41] http://id.loc.gov/authorities/subjects.html

[42] http://www.ordnancesurvey.co.uk/

[43] http://www.heritagedata.org/blog/vocabularies-provided/

with the research data repository guidelines discussed in section 3.2, they also stated that not all data could be made available to the public. Concerns regarding open access included the fact that some information may compromise site or operational security as well as the objects potentially including personal information about individuals which may breach privacy laws.
While the use of linked data sources is not necessarily high up on the priority list of cultural heritage institutions, they do see the potential benefit of tapping this resource, in particular in regards to an improved user experience and in enriching building management data to be ingested in the future. The current wishes of a dream scenario for future preservation workflows are, however, much more on the contextual and logical level of the digital object. Most frequently the wish for a light-weight industry accepted archival standard file format was mentioned. A further requirement of this file format would be a wide support by proprietary software in form of consistent and stable export routines into the archival format. Furthermore, the format should allow for extraction routines to support automatic metadata extraction for descriptive and technical information. Further expectations were well-formedness of data and a better support for easy retrieval and display of 3D building data to improve preservation processes but also user search and discovery routines. Lastly, the objects should document the trustworthiness of their content and context - their content should document/allow the ability to reproduce the physical asset to accurate scale - their context should document and allow easy detection and differentiation of private and public data held within.

4.3 Software companies and service providers

Software companies and service providers consult, develop and implement the BIM and FM solutions for institutional building owners. The specialized requirements of the customers often lead to a requirement for customized solutions, as discussed in section 4.1, hence leading to a special position of the software companies and service providers in the market. The software and IT companies contracted by the building owners are predominately small to middle sized. They are working together tightly with a limited amount of often local customers and develop highly innovative solutions for and with the customers. Companies such as DALUX, Catenda or dRofus furthermore have close links to research. The companies are here not necessarily developing solutions from scratch, but utilize and adapt existing solutions. For instance, the open-source BIM server [75],

the viewer API of Catendas BIMsync [22] or the commercial EDM model server [51] are often found as core parts for the handling of BIM models in FM systems.
The companies' expertise is key to the development of IT solutions, as they listen to their clients' needs. As the clients are seemingly engaging with BIM formats, all software companies and service providers have some kind of BIM to FM integration embedded in their products. The offered solutions follow here the approaches described earlier (see Table 2). Most of these are **uni-directional links** between BIM and FM, where the BIM model is used as an input channel for BIM data. Updates of a building's layout require here the re-ingest of IFC data and the manual update of the FM database. The IT systems developed by software companies and service providers vary in the way they engage with BIM. For the internal view on the spatial layout of the building some systems use the BIM file only once to derive dwg 2D drawings, while others generate the necessary 2D overviews of buildings more or less constantly or whenever a BIM file is updated in the model server. Some solutions, such as DALUX FM [26], access the BIM model in the 3D model server to generate on the fly 3D views on stationary computers and mobile apps (see Figure 14). These views allow users to, e.g., describe and track issues in a building with geo-referenced textual and photo input. Some companies, such as DALUX FM [26], use open standards such as the BCF: BIM Collaboration Format, developed by buildingSMART in order to exchange topics, such as issues, scenes, etc. between different BIM software [18]. Within approaches that constantly query and use the underlying IFC model, the BIM model becomes central to the operation of the FM system. In this scenario a constant maintenance of the BIM is implemented on the process level. This should guarantee a high sustainability of the building information, as long as such an FM system is used.
Solutions with a **bi-directional link** mechanism read data from BIM models as they write data into these. The solutions offered by the inspected stakeholders predominantly write object properties into the BIM file. These properties are generated or updated in the FM database through the users of the FM system [26] [63]. A change of a building's geometry is usually not triggered or executed through the FM portal and, according to some of the stakeholders, not a business case for building owners at all, but rather for the commissioned architects and engineers or specialists in the design and construction departments of the building owner's organization.
The stakeholders see the challenge that the constant update of FM solutions necessitates, as they are aware of the complexity of ingest of dozens of FM-related properties per

building object. The linkage of external product information is here a considered solution. Mainmanager FM integrates for instance the product information that are offered by the third party company Cobuilder [24]. Their constantly maintained and extended library offers on-line information about thousands of materials and products. Maintaining a copy of the library entry in the FM system or a constant check of availability, as measures to counter loss of functionality during the third parties' downtime or disappearance from the market, are not implemented in the FM solution yet.

5 Assessment of a future digital archival practice of institutional stakeholders

5.1 Process and systems in the lifetime cycle of building information

This chapter contains an assessment of the DURAARK approach for institutional preservation stakeholders in two ways: it evaluates if and how the DURAARK methods and tools implement the emerging scenarios discussed in chapter 3 and it evaluates how the DURAARK methods and tools fit into the systems and processes of the analyzed stakeholders presented in chapter 4. The stakeholder group of the IT software companies and IT service providers are not included in detail in this assessment, as they are essentially an intermediate - they develop the software which supports the processes, but do so based on either specific customer requests or because they are following state-of-the-art practices.

A key question to assess the fit of the proposed DURAARK methods and tools into existing and evolving stakeholder processes is the question of compatibility, i.e., does the sub-set of stakeholders included in the “institutional preservation use case” group have comparable processes, visions and requirements.

For building owners / facility maintenance, the building information is without a doubt a living object, which always needs to represent the actual state of the physical asset. However, the frequency at which the stored information is accessed and/or updated may vary, depending on the underlying maintenance processes at the respective organizations. Especially as-is representations, such as point-cloud scans or derived BIM models of the physical asset, may play an important role in retrofitting processes but as these processes do not occur frequently, the data might differ at the time of re-use in environments which have been updated since the last access occurred. The building owner / facility maintenance group shares a common interest, which focuses on the current and up-to-date version of the physical asset description in building information. Original objects of previous states are of main interest only at the initial ingest stage, where they may be exploited for existing information on various description levels. These stakeholders put forth different practices and expectations in regard to the *semantic information richness*. For FM processes the required information is often substantially different from that required for construction.

Stakeholders from building owners and facility maintenance filter and hence enrich the original data. What happens to the original files differs depending on the software solution in use and the process of the stakeholder, but so far never reaches the level of state of the art digital archiving or even long-term archiving. The *integration levels of BIM* into the stakeholders workflows is as well heterogeneous- ranging from uni-directional transfer, over bi-directional transfer to the integration of a central repository. Despite these differences, the stakeholder group of building owners / facility maintenance can be described as being **process-centric** with long-term availability and usability requirements being drawn predominantly from the day-to-day actions they perform.

The vast majority of cultural heritage / research institutions, on the other hand, consider the digital building information object as a discrete information object. In this context every building information item is seen as a representation of a physical asset in a temporal and spatial relation - and each digital representation in itself may be relevant for archiving. For most stakeholders in this group, use and re-use of the object takes place through consumers located outside of the organization, such as the general public or specific research groups. Usage scenarios may produce new objects with their own spatial and temporal dependencies. A third dimension introduced through the disconnection of re-use scenarios taking place outside of the responsibility of the archiving organization / system is information richness. It is well imaginable that the only difference between an original archived object A and a new object stemming from re-use B is not the temporal or spatial dependency of the representation in connection to the physical asset, but rather the information richness in form of further description or tagging of respective parts of the building information. The archive may consider this a new discrete information object - it may be linked to the physical asset or to other objects through descriptive metadata or collections, but it will most likely be archived alongside other representations of the same building. The stakeholder group of cultural heritage / research institutions can therefore be described as being mainly **object-centric** with long-term availability and usability requirements being almost exclusively drawn from the availability and understandability of each object in its own right at any given point in time.

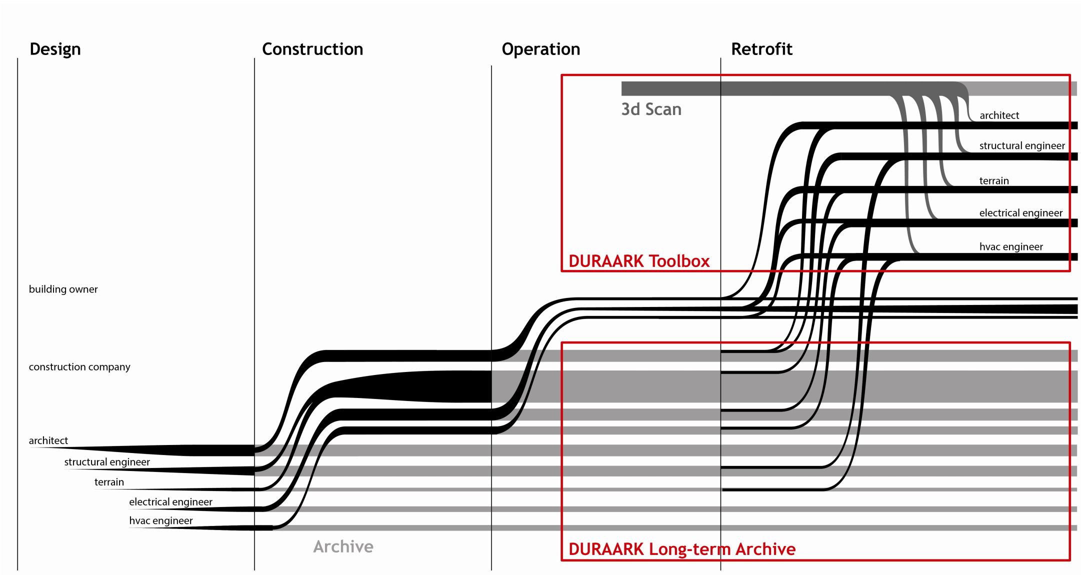

Figure 15: DURAARK tools and methods between use, re-use and archiving

While historically these two viewpoints represented opposite ends of the spectrum, growing availability of digital information, growing complexity of processes and growing awareness of policy makers and funders of the benefits of long-term availability for active re-use set these two viewpoints in closer connection to each other. It could be observed that forerunners of the building owners / facility maintenance domain are increasingly concerned about long-term availability of their digital objects, especially in regards to long-term understandability on a semantically rich level, while forerunners of the cultural heritage / research domain - here currently especially those directly collaborating with conservation or archaeology - are starting to explore ways of integrating building information for Facility Management into their processes.

DURAARK methods and tools are aiming to be a connection layer between process-centric and object-centric views. The geometric and semantic enrichment processes of the DURAARK workbench address concrete use cases of the building owner / facility maintenance group - as discussed in chapters 3 and 4. In bridging process and long-term availability, the processes and methods are introducing emerging scenarios to the institutional stakeholder group.

The stakeholder engagement described in chapter 4 has granted a good understanding of the stakeholders' system architectures and integration requirements. Interoperability of

systems for access and use, but also for archiving, is a common worry for all stakeholder groups alike.
The methods used for geometric enrichment within DURAARK allow for the in D7.1 detected need for the validation of archived data, both in terms of creating trust on the side of the potential user into the material, as well as in terms of integrating it into stakeholders' workflows. The DURAARK methods for comparison of different 3D-scans, of 3D-BIM models and scans as well as for the automatic generation of BIM models from scans are here of high relevance. For the building owner / facility maintenance stakeholders, these are tasks that are required in day-to-day processes, as only scans may be available and 3D-models are currently generated manually, or as a scan of the current state of a building might be compared to earlier scans in order to evaluate changes. However, the methods behind these plans may be used in the archiving context of cultural heritage institutions as well - newly deposited scans may be checked against existing scans in an archive to evaluate the deviance and make an appraisal decision for archiving, or plans may be compared against scans to evaluate migration processes.
The DURAARK methods for semantic enrichment allow for the identification of external linked data sources to be harvested and observed for changes, for the enrichment of digital objects using the harvested datasets and thus for a monitoring of changing concepts linked to the building information. For the building owner / facility maintenance stakeholders, semantic enrichment is an already emerging scenario within their internal and external environments seemingly being interconnected. A need emerges to link their existing internal vocabularies to external sources such as the buildingSMART data dictionary and its national derivatives. However, stable methods to exploit these information sources as well as mechanisms to monitor and update the enriched information are not yet available, but highly desirable, as the stakeholder analysis has put forth. Cultural heritage / research institutions, on the other hand, saw the use of linked data more as a future scenario, however, they all stated a need for solid descriptive and technical metadata accompanying the object, carrying on by describing that an automated extraction would be beneficial. As the semantic enrichment routines can be used to semi-automatically generate descriptive metadata, the methods may well fit the requirements of the institutions in areas currently not envisioned by the stakeholder.
The DURAARK methods for archiving take the overall lifecycle requirements and the different preservation levels of the object into consideration. While both, building owners / facility maintenance as well as cultural heritage / research institutions build their

processes on archival functions, they do so with a different emphasis. The process-centric facility maintenance domain believes that preservation issues may not be necessary due to frequent use, going by a sort of "preservation-by-access" philosophy. Cultural heritage, on the other hand, puts much effort into digital preservation processes, rather implementing a "preservation-for-access" philosophy. While facility maintenance currently partially neglects implications on the logical file format level of digital objects, the cultural heritage approach is often very static in connection to the digital object, neglecting the connection between physical and digital objects in regards to spatial and temporal dependencies. The DURAARK methods address both needs, thus functioning as a bridge between the two approaches, by combining tasks such as descriptive metadata extraction / generation and file format identification in the SIP-generating process. During the stakeholder evaluation, several institutions of the facility maintenance domain stated that archiving is necessary, but that tasks to address the problem need to be low-level in entry and not overly complicated. In an ideal world, it should be "as easy as pushing a button". Stakeholders are as well in need of a definition of events that necessitate archiving. The stakeholders' understanding of projects that take place within a building can provide a threshold and point in time to define an archival action. Upon completion of a project the newly created dataset might be archived. This understanding might set a stop to the current confusion about effort and timing of archival actions. The proposed time is in sync with the shift between the building- and the operational phase of a building, as proposed in the DURAARK building information lifecycle (see Figure 2).
Regarding the interoperability of DURAARK tools, the availability of the integrated workbench as well as the availability of the single processes wrapped in the workbench as stand-alone tools provide different usage scenarios, allowing the stakeholders to integrate the tools into existing repositories and workflows as seen fit. The stakeholder analysis has shown that this is a major requirement. It has further put forth that system architecture and workflows vary greatly - not just between the two stakeholder groups at large, but also between institutions of the same stakeholder group. Interoperability and modularity are therefore key requirements for the DURAARK tools.

5.2 Expert-based and crowdsourced data evaluation

Crowdsourcing as an emerging scenario has been presented in section 3.4, where it was also pointed out that this method may be used for the time-consuming and expensive task

of ontology mapping. The stakeholder responses have shown that this is indeed a concern, especially to the facility management domain where processes are still in flux and new vocabularies and data sources are evolving. Concrete examples that exemplify the use of ontology mapping can be seen for example in the use of product ontologies. For maintenance and replacement scenarios it is imperative to have up-to-date information on the products used within the facility, along with information on its compatibility, compliance and suppliers. This information is often based on national standards. Furthermore, the catalogs of the suppliers are continuously evolving. The ontology mapping of linked data vocabularies, among others, harmonizes the heterogeneous information and facilitates the decision making around product replacement and maintenance.
In this subsection we first describe our approach of using crowdsourcing for the evaluation of relevance assessment mechanisms, introduced in the earlier deliverable D3.4. As a next step we draw a comparison between using experts and crowds for evaluation.

5.2.1 Crowdsourcing evaluation: relevance assessment of focused crawls

We refer the reader to deliverable D3.4, where a detailed explanation of the focused crawler has been presented.

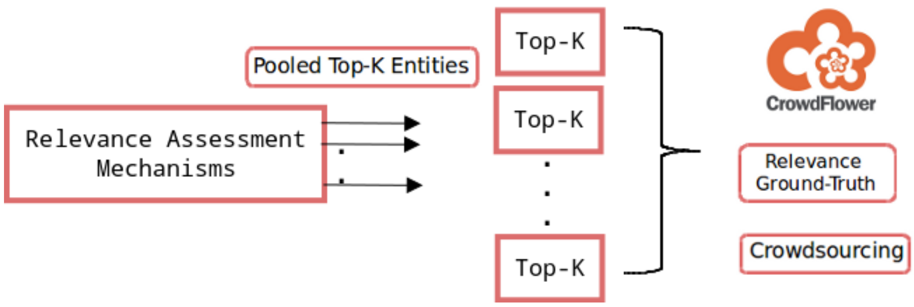

Figure 16: Generation of ground-truth for evaluation of relevance assessment measures.

We leverage crowdsourcing as a means to establish the ground-truth for the most relevant entities within a specified n-hop neighborhood of a focused crawl, using a seed-list S. We adopt the following steps in order to establish the ground-truth for evaluation.

- First, we pool the top-k[44] entities within the n-hop neighborhood of seed-entities $e_i \in S$, $i = 1...n$, as obtained by using the different relevance assessment measures.

[44] In this case we pooled the top-100 entities obtained from each relevance assessment measure.

- We model the activity of assessing the relevance of an entity to the seed-list, as an atomic microtask that can be deployed on a crowdsourcing platform such as CrowdFlower.
- Next, we present the seed-list and each entity gathered from the neighborhood of the seed-list to workers in the crowd, and request judgments of relevance based on a 5-point Likert-scale.
- By aggregating the judgments from the workers, we rank all the entities within the n-hop neighborhood of the focused crawl, thereby generating our ground-truth of relevant entities to the seed-list S. Note that, in cases when the worker's judgments do not converge to agreement, i.e., when the crowd does not reach a clear consensus, we deploy those units as microtasks again until an agreement is reached.
- Finally, we use the ground-truth thus established to evaluate each of the relevance assessment methods across the top-k entities.

5.2.2 The case of Link Prediction

The task of *link prediction* refers to the creation of explicit links between resources on the Semantic Web at the instance level. This implies the challenge of entity resolution by creating appropriate links between resources. Different types of links such as `owl:sameAs`, `skos:relatedMatch`, `skos:narrowMatch` and so forth can be used for linking various resources. However, this task is more complex than it seems owing to two primary reasons; (i) sparsity of additional metadata, and (ii) possible ambiguity between resources, requiring disambiguation. Human input is crucial with respect to the link prediction, more so in the absence of context and knowledge regarding the type of data. In the last few years, there has been a lot of work in the field of link discovery and prediction [70][71][69].

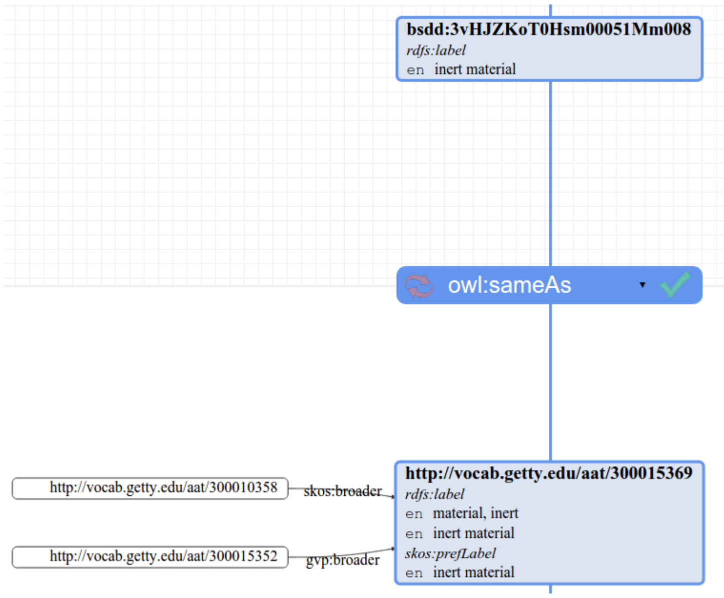

Figure 17: An example of linking equivalent instances from different vocabularies using the *Interlink* interface for experts.

Link Prediction by Experts

As mentioned in section 3.3, deliverable D3.4 presented a visual tool called *Interlink*, for the human verification of automatically suggested relations between disjoint vocabularies. As a part of our experimental setup, we deploy this tool and request experts within the DURAARK consortium to align a fixed number of resources using a list of pre-defined relationships.

Figure 17 presents an example of linking equivalent instances from different vocabularies using the *Interlink* interface for experts. Here, we can see that an expert can align the `inert-material` resource instance from the *BSDD* vocabulary with that from the *Getty AAT* vocabulary.

The Figure 18 presents the relations that one can use to link various resources.

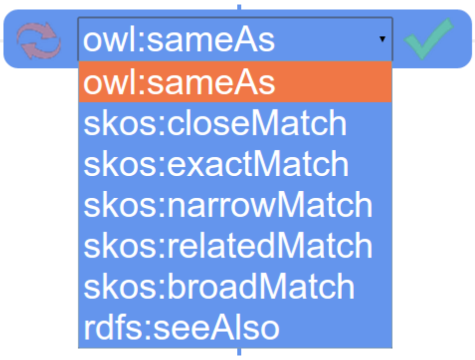

Figure 18: An expert can use these different relations in order to link various instances using the *Interlink* tool.

Link Prediction by the Crowd

As mentioned earlier, getting experts to link resources with appropriate relationships on a large scale is an expensive process. In order to reduce the costs, yet sustain the quality of the linking, we aim to turn towards crowdsourcing.

We will break the process of accessing possible relations between different resources from varying vocabularies into atomic microtasks that can be deployed on a crowdsourcing platform such as CrowdFlower[45]. During the design phase of these microtasks, we will employ state-of-the-art design methods to ensure high quality of results and the reliability of workers. Each pair of resources is judged by 5 different workers, so that a consensus over the most suitable relation between the pair of resources can be reached. By aggregating the results from the crowdsourcing tasks, we shall aim to investigate whether or not microtask workers in a crowd can replicate the quality of links produced by experts.

[45] http://www.crowdflower.com

6 Conclusion and Impact

6.1 Best practice for BIM in FM

The analysis of the stakeholders' practices has shown that the understanding of the role of Building Information Models change when they enter the operational phase of a building. As the domain is a data intensive and more importantly a process driven one, the BIM objects are no longer "frozen states" of an object which is handed to a new player, as for example in the case of the architect-construction company process chain. Instead, BIM in the operational building phase is a "live object", where the data in the repository needs to reflect the constant changes and updates to a building. In order to support this, most FM users and software vendors currently take a pragmatic approach, where the FM system is positioned at the heart of the FM operation. Up to recently BIM was exclusively considered an input channel into the FM system. However, this process is slowly changing and ways and methods to exchange data between FM and BIM are advancing. This processes enriches the BIM models with information, as it keeps them on par with the physical building.

A major risk remains at the point of the handover phase from the completed construction project to facility maintenance. In current practice, a new and slimmer FM:BIM model is created and the information rich original BIM model is often simply shelved. There are several reasons for this - one being that the maintenance and update between the operational FM:BIM model and the original BIM is too laborsome, as it requires specialist knowledge. Another reason lies in the well established internal indexing systems of FM software, using stable and well established indexes which provide good means to re-identify spaces and elements across the datasets that describe buildings across their existence. The wish and vision of all players in the field is, however, to make the interchange more fluent and establish a practice where the distinction vanishes between digital building models in the operational phase of a building and those for the design and construction phase.

With current practice in BIM and FM starting to focus on building data in one format (IFC), the future will very likely bring more complete datasets describing a building. These datasets will consist of interlinked data entities rather than a single file and will be adapted to the process of stakeholders. It is also safe to assume that BIM objects of the future will not only include the description of the building, but furthermore capture procedural data on an information genesis instead of focusing on only one state.

6.1.1 Best Archival Practices

While cultural heritage and research institutions have long-standing experience in the preservation of analogue as well as digital objects, the objects reach the archives in a time-delayed manner. The evaluation has shown that despite the fact that BIM objects are commonly used in the AEC (Architecture, Engineering and Construction) and the FM domains and policy makers have passed regulations regarding the use of BIM and IFC for publically funded buildings, the objects have not reached the cultural heritage archives yet. Simultaneously, D7.7.1 has also shown that BIM and 3D scanning are indeed used in architectural research. However, research data management and the availability and public sharing of these objects in research data repositories has not reached the architectural research domain yet.

While standard digital preservation processes exist, these have to be adapted for each object type. The gaps for 3D architectural preservation have been presented and discussed in DURAARK deliverable D6.6.1 and re-confirmed by the feedback of the stakeholders in the evaluation presented in this deliverable. Furthermore, standard and open file formats play an important role in cultural heritage digital preservation - for BIM IFC is a very complex file format and data schema which still needs to make its way into the digital preservation domain. The biggest challenge, however, is the dichotomy of the object-centric archiving view of cultural heritage institutions and the process-centric archiving view of building information in general. We foresee future archives having to move away from a static digital object view towards a more process-oriented view. In this process, cultural heritage archives shall not parallel facility maintenance systems in regard to consistent updates to the project - rather, archives will keep regular snapshots of the objects, which need to be closely connected. Similarly, BIM repositories commonly are database systems, where the respective parts of the model are stored in various tables. Only at the point of export are flat files such as IFC written out of the database. It is likely that in the future the process will remain in the database and the snapshots will remain in the IFC files for true archival images - however, it may also be considered to archive both the database and the IFC file to enable a holistic contextual approach.

6.2 Recommendations for future archival practice among stakeholders

The following points could be identified as overarching recommendations for institutional archiving processes of 3D architectural objects with the goal of active and ongoing object re-use for scenarios such as facility maintenance:

- **Use open standards** - Open standards help avoid vendor lock-ins, as the wide user-base provides a network of like-minded and through that higher chances for future support. The longevity of open standards was impressively demonstrated by stakeholders during the DURAARK Sustainable Building Data workshop, where more than a decade old IFC 1.5 files were successfully accessed. The importance of sustainability factors in open standards has been discussed in deliverable D6.6.1.
- **Choose FM systems that can use as-built BIM models** - Stakeholders report that the general quality and hence the value of BIM models improves when they are not only used during construction, but as well for the operation phase of buildings where they provide information for FM processes.
- **Archive the original BIM models** - The current BIM:FM practice extract only a subset of the available information in BIM models. all other parts can however provide valuable information for, e.g., future retrofitting events of a building. The original BIM models should hence be archived rather than shelved.
- **Use systems that allow for a bi-directional transfer of information between FM and BIM** - FM systems that edit and enrich existing BIM files and keep them up-to-date with the changing physical building guarantee the longevity of models.
- **Use BIM as information HUB** - The active use of BIM data in FM processes (i.e., for the generation of 2D and 3D views in maintenance and reporting processes) secures ongoing use and attention to digital building objects.
- **Have clear requirements for delivery of BIM data for FM system** - The information needed from BIM objects differ massively between the construction and operation phase of a building. The transition requires an enrichment and filtering of data. The planning of this phase and the preparation of all stakeholders for this event is the basis for a smooth and automated process.

- **Use a consultant during the process of the BIM creation** - Stakeholders report that partners in BIM processes have a hard time coordinating the ongoing use of BIM. A contractual formalization of this process and the monitoring of it through external consultants helps to avoid planning problems - through, e.g., regular collision detection, as it creates a neutral instance that takes care of the data quality and can help to increase the sustainability of data, through test exchanges with the building owners FM systems.

- **Tools to check validity of input** - A re-use of archived data is only possible, if standards, requirements and expectations are kept.

- **Differentiate between nice-to-have and must-have** - The creation and maintenance of data is a laborsome process. Stakeholders report that an overload of requirements for the delivery of BIM data lowers the quality and with that the chances for use and re-use of BIM data in later stages of a building's life cycle. It might as well be an overload when archives try to provide data for the daily facility management.

- **Define archival events and motivations** - A good understanding of the purpose of archiving is necessary and will as well clarify the timing of archival actions.

6.3 Impact on DURAARK and outlook to future work

The work in this deliverable has presented a first general evaluation of the DURAARK use case for institutional preservation. It does not intend to be a detailed and exhaustive evaluation of the DURAARK workbench, but rather an in-depth description of our understanding of the evaluation of stakeholders' requirements along their present-day practises, future visions and emerging scenarios of their respective domains, as well as a high-level use case study of how the proposed DURAARK methods and developed tools fit these requirements and visions.

The work in this deliverable has underlined that DURAARK project results are indeed highly relevant to the stakeholders. It has also shown that the modularity of the tools is indeed a key criteria to allow for the integration of tools into the contemporary system landscapes and workflows.

The development of software prototypes and demonstrators within the DURARAK project takes place within the framework of a STREP project. The DURAARK consortium has however formulated a series of criteria, which will help to evaluate the work in the different disciplines and work packages constituting the DURAARK project, as it helps to align the work with the questions which were raised by the stakeholders and presented in this deliverable:

- **Relevance**: This deliverable demonstrates that the processes of all stakeholders are seemingly information based. BIM and 3D scan data are here major contributors to information about buildings - however, other sources exist as well, as the investigation of FM processes showed. As the processes of the field are only emerging, the DURAARK project has to base the question of relevance on predictions that are based on the observation of trends, such as the general shift among stakeholders from manual to automated processes. This shift could be observed for several processes, including enrichment, linkage, ingest or validation of archival building data. The observation and identification of stakeholders with novel and highly relevant interests (e.g., the Swedish municipality of Falun, who has a huge repository of 3D scans, but little means to extract semantically rich data from these on architectural structures, which in return can be used by commissioned companies) or questions (e.g., such as the Danish Bygningsstyrelsen that has to decide whether it wants to keep data archived in cloud based storages, when the underlying proprietary system will be updated) can indicate whether and where DURAARK processes are of relevance. The use cases developed in WP2 so far provided a sufficient base.

- **Utility**: Especially this point has to be seen in the light of DURAARK being a STREP Project: the developed solutions are prototypical and cannot have the same effort as developed products with a clear vision for the target group. The DURAARK solutions can however be evaluated in terms of interoperability and modularity. The utility of the semantic enrichment and cloud-based processes within the DURAARK project can be assessed through an evaluation of the used vocabularies connection to the building domain (i.e., whether they use already established standards such as the buildingSMART data dictionary and can be used as well on localized implementations and derivatives of these). The evaluation should as well cover both the archival actions necessary to ingest, as well as to retrieve and re-use building data in the building information lifecycle.

- **Precision**: A qualitative evaluation of the precision of developed DURAARK methods can be used for instance for the automated linkage of data, detection of architectural structures within point-clouds and their relation and transformation to BIM models. The DURAARK datasets have to suffice for these needs.
- **Usability**: The assessment of the usability of the prototypes focuses on questions such as whether the developed approaches fit into existing workflows of users and into their changing technological environments. Questions of GUI and interaction with users are of concern, a detailed evaluation on a qualitative level is however not within the scope of a STREP project.
- **Quality**: A qualitative assessment is proposed for the approaches developed in WP3, at the level of the Semantic Digital Archive / Observatory or the semantic data enrichment.

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7 Appendix

7.1 DTU - IKT technical BIM/CAD specifications

Author: Denmark's Technical University

Language: Danish

Original title:

IKT-teknisk BIM/CAD-specifikation

Based on the IKT template by bips [15] with DTU's additions and adoptions

IKT Tekniske specifikationer:

Baseret på bips IKT tekniske specifikationer med DTU's tilføjelser og ændringer.

BILAG IKT-01
Ydelsesspecifikation

BILAG IKT-02 Teknisk kommunikations-specifikation	**BILAG IKT-03** Teknisk BIM/CAD-specifikation	BILAG IKT-04 Teknisk udbuds-specifikation	BILAG IKT-05 Teknisk Afleverings-specifikation

DTU IKT standarder:

BILAG IKT-06 FIL-navngivning og struktur	BILAG IKT-07 Nulpunkt	BILAG IKT-08 Arealkategorier og rumnavngivning	BILAG IKT-09 2D Autocad specifik
BILAG IKT-10 3D objekter og egenskaber	BILAG IKT-11 Visualiserings-model	BILAG IKT-12 3D Revit specifik for som udført	BILAG IKT-13 Projektweb specifik
BILAG IKT-14 IKT organisations-diagram	BILAG IKT-15 FM informationer til driften		

Indhold

1. Orientering

bips C202, CAD-manual 2008, basisbeskrivelse, er sammen med denne projektspecifikke beskrivelse gældende for byggesagen, medmindre der i denne projektspecifikke beskrivelses kapitel 1 – 7 er afvigelser til bips C202.

Alle krav, der i denne beskrivelse stilles til fælles- og fagmodeller, er alene møntet på bygningsmodeller, der udveksles mellem byggesagens parter.

1.1 Formål

Denne manual er udarbejdet for at optimere udnyttelsen af BIM og CAD-data, som skabes i forbindelse med projektering af bygninger og ombygninger af ejendomme for Danmarks Tekniske Universitet (DTU).
I manualen beskrives de retningslinjer, som eksterne Rådgivere/Totalentreprenøre/entreprenører skal følge vedrørende form og indhold af de data, som efter et projekts afslutning skal afleveres til DTU ved bygherren - Campus Service (CAS) til brug for drift og vedligeholdelse i henhold til bilag IKT-05, *IKT-teknisk afleveringsspecifikation*.

1.2 CAS' anvendelse af CAD

CAS opdeler CAD-data i følgende to grupper:

Projekttegninger, -informationer og fagmodeller
Er i mellemafleveringerne og slutafleveringen dokumentation af informationer produceret i forbindelse med en projekterings- og/eller udførelsesopgave.
Under projektering kan CAS have interesse i at modtage projekteringstegninger som Cad-tegninger eller fagmodeller. Da disse tegninger kun benyttes til orienteringsformål, og ikke skal vedligeholdes af CAS, aftales omfang og grundlag for sådanne med bygherren.

Som udført tegninger, modeller og informationer
Alle relevante informationer, som aftales sammen med bygherren før afleveringen af bygningen Det gælder som udgangspunkt for alle gældende informationer og tegninger, som blev produceret under projekteringen. Disse informationer afleveres på "som udført" niveau 3, i henhold til FRI / PAR's Ydelsesbeskrivelse for "Som udført", til brug for den daglige drift og vedligeholdelse af DTU's bygningsmasse. For nærmere beskrivelse se bilag IKT-05, *IKT-teknisk afleveringsspecifikation*.

1.3 CAS' CAD-systemet

CAS benytter i driften som CAD-modelleringsværktøj Autodesk REVIT og AutoCAD MEP.
Generelt skal der anvendes objektorienteret projektering med fagmodeller.

2. Grundlag for CAD-produktionen

2.1 Fil- og mappestruktur

Fil- og mappestruktur udføres i henhold til DTU standard, afhængig af opgavens art:
- Renovering, om- og tilbygning anvender IKT bilag 06
- Nybyg anvender bips A104 og IKT bilag 06a - 06g

CAS skelner som nævnt i indledningen, afsnit 1.2 mellem projekttegninger og -modeller udarbejdet til en projekterings- og udførelsesfase og som udført tegninger og -modeller, der skal indgå i drifts- og vedligeholdelsesarbejdet.

2.2 Koordinat-, højde og modulsystemer

2.2.1 Generelt

2.2.2 Overordnet referencesystem

Til projektering anvendes system DKTM, såfremt andet ikke er aftalt. Der kan efter aftale med bygherren, anvendes et andet system, såfremt dette vurderes mere fordelagtigt (f.eks. Plankoordinatsystem UTM/EUREF89 og højdesystem DVR90).

2.2.3 Projektspecifikt koordinatsystem

Hvis bygningens placering i terræn ændrer sig under projekteringen, ændres referencepunkternes definition i forhold til referencesystemerne.
DTU koordinatsystem beskrevet i bilag (IKT-07 DTU nulpunkt) er gældende for alle aktive filer samt modeller. Det skal anvendes til "som udført" modeller og dokumentations fagmodeller.

2.2.4 Modulnet

Som modulsystem/modulnet skal anvendes modulnetsfilen ved navn: <xxxxxxx> //Udfyldes af BIM/CAD projektkoordinator//.

2.2.5 Enhedssystem

Mindste enhed er < mm>

2.2.6 Referencepunkter

Der anvendes følgende referencepunkter i henhold til BILAG IKT-07 *DTU nulpunkt*.
// Udfyldes af BIM/CAD projektkoordinator//

Referencepunkt	Placering	Plankoordinat- og højdesystem	Projektspecifikke koordinater
1			
2			

2.2.7 Indsættelsespunkt

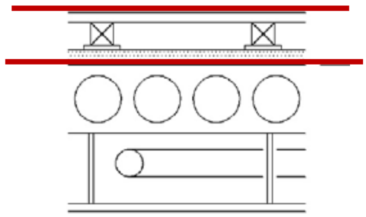
I henhold til DTU standard IKT-07 Nulpunkt

2.2.8 Bygningens placering i koordinat- og højdesystem

Defineres af BIM/CAD projektkoordinator i henhold til bilag IKT-07 Nulpunkt.

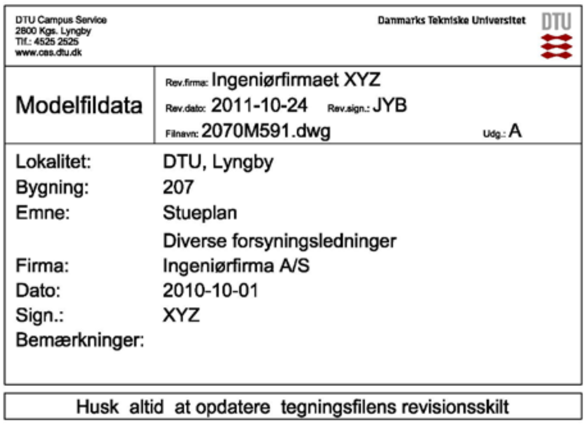
2.3 Sektionering

På nye bygninger udarbejdes princip for sektionering af den BIM/CAD projektansvarlige sammen med projekteringsledelsen og dokumenteres i nærværende afsnit. Til aflevering gælder overkante færdig gulv



På eksisterende ejendomme anvendes bygningernes aktuelle sektionering.

2.4 Modelskilt



Der skal anvendes DTU's standard modelskilt, der sendes som dwg.
Efter aftale med bygherren anvendes et 3D objekt med egenskabsdata, som forbliver synlig også i IFC fag modellen.

Alle attributter skal udfyldes.

Størrelsen og indsættelsespunkt defineres af BIM/CAD projektkoordinatoren og godkendes af bygherre.

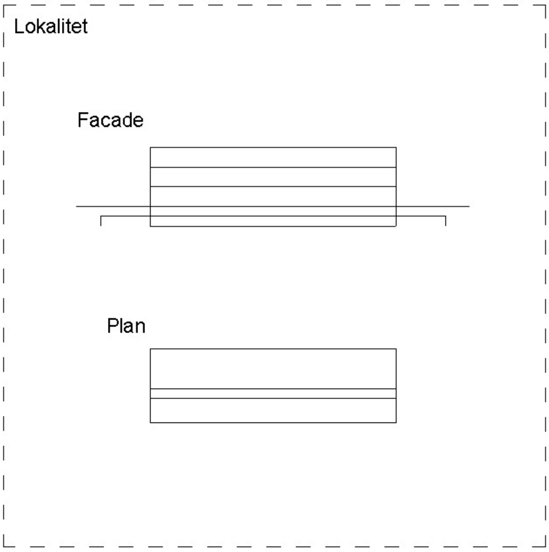
Modelskiltet skal indeholde: Se modelskilt

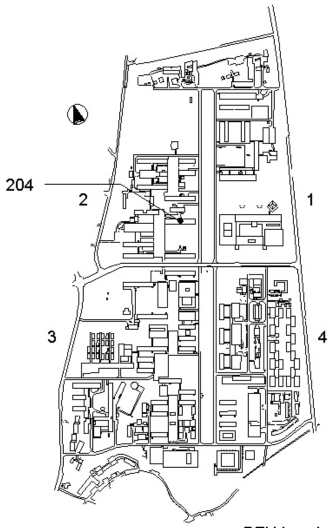
Indhold / attributnavn	Datatype
Se RVT / DWG skabelon	**Se RVT / DWG skabelon**

2.5 Tegningsskilt = Tegningshoved

Tegningsskilte skal udformes som vist herunder og fremsendes af bygherren som dwg fil. Alle attributter skal udfyldes.

Tegning
LLYN.B204_E1_K01_F01_H1





DTU Lyngby

• DTU Campus Service	Nils Koppels Allé, bygning 402	2800 Kgs. Lyngby	www.cas.dtu.dk	Tlf. 4525 4525	Sag.
o Cowi A/S	Parallelvej 2	2800 Kgs. Lyngby	www.cowi.dk	Tlf. 5640 0000	Sag. A017401
o CCO A/S	Bragesgade 10b	2200 København N.	www.christensenco.dk	Tlf. 7244 4440	Sag. 125
o Rørbæk og Møller Arkitekter ApS	Jægersborg Allé 1A	2920 Charlottenlund	www.r-m.dk	Tlf. 3940 1011	Sag. 1534
o Wessberg A/S	Herlev Bygade 14	2730 Herlev	www.wessberg.dk	Tlf. 4488 2000	Sag. 11.6435
o Schul Landskabsarkitekter	Pasteurvej 24, 4 sal	1798 København V.	www.schul.dk	Tlf. 4542 5090	Sag.

Rev.	Dato	Ansv.	Tegn.	KS	Godk.	Tekst
2	2013-07-02	EFJ	EFJ	MLA	MLA	used only for example
1	2013-07-01	EFJ	EFJ	MLA	MLA	used only for example
–	2013-06-24	EFJ	EFJ			–

DRIFT

Udfyld Campus · Udfyld Bygningsnr
1. sals plan

Format: 30x147 **Skala:**

1M 2M 3M 4M 5M

Danmarks Tekniske Universitet · Campus Service
2800 Kgs. Lyngby · T: +45 4525 4525 · www.cas.dtu.dk

DTU

Tegning
LLYN.B204_E1_K01_F01_H1

Tegningshovedet er altid placeret i nederste højre hjørne af tegningsrammen. Revisionsfeltet er inkl. i tegningshovedet.
Til flere siders dokumenter (f.eks. detaljemapper) anvendes DTU's skabelon.

2.5.1 Tegningsformater

Alle tegningsformater har stående A4 som grundmodul. Tegninger skal KUN være A1 (f.eks. 1:100) eller A3 format.
Undtagelse: DTUs 100m bygninger bibeholdes i aflang A4 / A3 format.

2.6 Tekster og målsætning

Logisk sammenhængende tekst udføres som én tekstblok og må ikke bestå af flere delelementer. Der skal konsekvent for hele projektet arbejdes med stort begyndelsesbogstav i alle tekster. Der skal anvendes Ariel, og teksthøjder er 2 - 2,5 – 3,5 og 5 mm. Andre tekstfonts skal godendes af DTU.

Generelt gælder, at teksten skal placeres således, at der opnås acceptabel læsbarhed, også ved nedskalering til A3 format.

2.7 Tegningsprincipper

Generelt: Nye tegninger erstatter gamle håndtegninger, som udgår.

2.7.1 Tegningsenheder

• Alle tegningselementer skal indtegnes i 1:1, så 1 ”drawing unit” = 1 mm.
• Til situationsplanen anvendes meter, så 1 ”drawing unit” = 1 m.

2.7.2 Dimensioner og mål

• Al målsætning (undtagen koter) angives i hele mm med 1.000 separator "." .
• Koter angives i m med 2 decimaler.
• Vinkler angives indenfor 360° med 1 decimal.
• Arealer angives i m^2 med 1 decimal.

2.7.3 2D Tegningsnummerering

I henhold til bilag IKT-06 Fil-navngivning og struktur.

2.7.4 Tegningsopsætning

Tegningsenheden er mm. Vinkler angives i 360° systemet. Koter angives i meter. Alle øvrige mål i mm.

2.7.5 Henvisninger, signaturforklaring, noter m.v.

Disse placeres i fold over tegningshoved med DTU kort, til venstre for tegningshoved eller på side 2 ved A4 tegninger. Henvisninger til andre tegninger placeres over revisionsfelt og tegningshoved. Overskriften for henholdsvis NOTE og SIGNATUR skrives i teksthøjde 3,5 med store bogstaver og med understregning. Selve teksten skrives i teksthøjde 2,5 med små og store bogstaver. Teksten lægges på laget V09-NT- for VVS og E09-NT- for EL o.s.v.

2.8 Rumnumre / rumnavngivning

Alle rum skal nummereres efter DTU standard, Bilag IKT-08 *Arealkategorier og rumnavngivning*

3. Strukturering af bygningsmodeller

3.1 Geometri og byggeobjekt

Hvis der skal arbejdes objektorienteret og med egenskabsdata på byggeobjekter, skal der tages stilling til, om egenskaberne skal beskrives på det enkelte objekt i bygningsmodellen, eller om egenskabsdata skal håndteres udenfor modellen i en fil eller database med et link mellem modellen og dets tilhørende egenskabsdata.
Valg af rumdatabase for håndtering af egenskabsdata på rum i henhold til IKT 01

Ydelsesspecifikation afsnit 6 stk. 6.

Hvis der arbejdes med eksterne egenskabsdata, skal der defineres et filformat, som er fælles for de parter, der skal tilgå informationerne.

3.2 Bygningsmodel

3.3 Tema

Bygningsobjekter, indeholdt i bygningsmodeller, der udveksles med andre parter, skal være struktureret og klassificeret iht. IKT ydelsesspecifikationen afsnit 2.4 Klassifikation.

3.4 Informationsniveauer

Fagmodeller, som udveksles med andre parter, skal have et informationsniveau svarende til det, som er angivet i *Bilag IKT-10a Projektdokumentation.*
Informationsniveauer beskrives i særskilt dokument af hver rådgiver med små illustrationer og godkendes af bygherren. BIM/CAD projektkoordinator er ansvarlig for koordinering mellem rådgivere.

3.5 Lag

Se bilag IKT-09 DTU 2D Autocad/program specifik.

3.6 Egenskabsdata

Defineres i BILAG IKT-10 DTU 3D objekter og egenskaber og bilag IKT-10a Projektdokumentation

3.7 Revisionsmarkeringer

Krav til revisionsstyring er angivet i *IKT-teknisk kommunikationsspecifikation.*

3.8 Reference til andre bygningsmodeller

Beskrives af BIM/CAD projektkoordinator, efter aftale med bygherren..

3.9 Modelleringsdisciplin

//Udfyldes af BIM/CAD projektkoordinator// .

3.10 Opdeling af modellen

Der aftales mellem rådgivere hvordan modellen opdeles i mindre enheder for koordinering af fællesmodellen. Dette sker senest 8 uge efter projekts opstart.
Bygningsmodellerne opdeles som udgangspunkt i en fagmodel pr. fag.
//Projektspecifik opdeling udfyldes af BIM/CAD projektkoordinator//

3.11 Definition af præcisionen

Under hele projekteringen dokumenteres objekternes præcision i en property per bygningselement.
Inddeling af præcisionen (f.eks. 1 til 5, hvor 1 er 25cm og 5 0,5cm) aftales mellem rådgiverne og godkendes af bygherren senest 8 uger efter projektopstart.

4. Brug af bygningsmodeller

Processen beskrives af BIM/CAD Projektkoordinator efter aftale med bygherren og godkendes af bygherren.
Bygningsmodellerne anvendes til kommunikation på projekteringsmøder og til kommunikation med bygherre, koordinering, konsistens- og kollisionskontrol, udtræk af mængder, grundlag for simuleringer og visualiseringer

4.1 Generelt

4.2 Tegningsproduktion
Der henvises til BILAG IKT-09 DTU 2D autocad specifik.

4.3 Simulering
Processen beskrives af BIM/CAD projektkoordinator, efter aftale med bygherren.

4.4 Konsistenskontrol
Processen beskrives af BIM/CAD projektkoordinator, efter aftale med bygherren.

4.5 Visualisering
Processen beskrives af BIM/CAD projektkoordinator, efter aftale med bygherren.

4.6 Dataudtræk
Processen beskrives af BIM/CAD projektkoordinator, efter aftale med bygherren. I ODS eller database format efter aftale med bygherren.

5. Dokumentation

5.1 Tegningsliste
Udfyldes DTU's standard skema (regneark udleveres af DTU).

5.2 Fagmodelliste
Udarbejdes af //Totalrådgiver//. Godkendes af bygherren.

5.3 Krydsreferenceskema
Ved anvendelse af referencefilsteknik (XREF) udfyldes DTU's standard skema (regneark udleveres af DTU).

6. Udveksling

6.1 Generelt
Fagmodeller stilles til rådighed for bygherren og byggesagens øvrige parter som specificeret i *IKT-ydelsesspecifikation (bilag IKT-01).*
Udveksling i projektweb skal ske i de filformater, som er specificeret i *IKT-teknisk kommunikationsspecifikation (bilag IKT-02).*

6.2 Formål
Herunder specificeres til hvilke formål, der udveksles på byggesagen.

Udvekslingsformål	Anvendes (X)
Grundlag for modtagerens fagmodeller	x
Underlag for modtagerens tegningsproduktion	x
Viderebearbejdning indenfor et andet fagområde	x
Overdragelse til anden part	x
Underlag for tværfaglig konsistenskontrol	x
Visualisering i 2D eller 3D	x

Dataudtræk for mængdegrundlag	x
Koordinering med bygherren	x

6.3 Formater

Generelle udvekslingsformater

Udfyldes sammen med BIM/CAD projektkoordinator.

Data	Format og version	Udveksles (kryds for ja)
Fagmodel		*x*
Fællesmodel		*x*
Udtræksfiler		*x*
Dataudtræk		*x*
Digitale plot		*x*
Tegninger		*x*
Anden Dokumentation		*x*

Udveksling skal ske i de filformater, som er specificeret i *IKT-ydelsesspecifikation.*

Til visuel analyse anvendes IFC eller Navisworks / 3D-PDF efter aftale med bygherren.

For udveksling af "aktive" modeller med bygherren gælder: DTU Campus Service anvender internt programpakken Autodesk Revit MEP Suite. CAD data som leveres til DTU campus Service skal være fuldt ud kompatibel til DTU's drift systemer.

Opgavespecifikke formater

IKT 01 Teknisk Ydelsesspecifikation sætter de overordnede retningslinjer for udvekslingsformater.
Skemaet herunder specificerer filformat for CAD-data efter formål.
Udfyldes af BIM/CAD projektkoordinator.

Udvekslingsformål	CAD-data	Filformat og version
Grundlag for modtagerens fagmodeller		
Underlag for modtagerens tegningsproduktion		
Viderebearbejdning indenfor et andet fagområde • Grundlag for brandsimulering • Grundlag for varmetabsberegning		
Overdragelse til anden part		
Underlag for tværfaglig konsistenskontrol		
Visualisering i 2D eller 3D		
Dataudtræk for mængdegrundlag		
I forbindelse med flere af ovenstående formål		

Hver part skal for modeller, der henholdsvis modtages og leveres, foretage en afprøvning af, at de er i aftalte udvekslingsformater.

6.4 Procedurer

Afprøvningen af udvekslingsproceduren skal være foretaget inden *8* uger efter opstart.

I nedenstående skema angives det, hvornår der skal udveksles CAD-data til hvilket formål, mellem hvilke parter dette sker og det informationsniveau CAD-dataene skal have. Skemaet udfyldes af BIM/CAD Projektkoordinator.
BIM/CAD projektkoordinatoren udarbejder et grafisk procesdiagram som godkendes af bygherren.

Tidspunkt	Formål	Part	Info.
Løbende udveksling			
-			
-			
Ved afslutning af faser			
Forprojekt 10 dage før aflevering			
Hovedprojekt efter udbud			
Faste terminer			
x			

Uformel udveksling af CAD-data mellem de enkelte parter forventes at ske ca. hver uge.

6.5 Dokumentation

7. Kontrol / kvalitetssikring

Generel dokumenteres og kvalitetssikres informationer i en ensartet form (eventuelt med grafiske illustrationer).
Beskrives af BIM/CAD projektkoordinator . Godkendelse af bygherren.

7.1 Generelt

7.2 Fil- og mappestruktur

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.3 Fagmodeller

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.4 Tegningsfiler

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.5 Simulering

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.6 Dataudtræk

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.7 Dokumentation

Beskrives af BIM/CAD projektkoordinator. Godkendelse af bygherren.

7.2 DTU - IKT instructions for parameters for the definition of levels and base of BIM

Author: Denmark's Technical University

Language: Danish

Original title:

IKT-10d Parametre for stade og grundlag

Based on the IKT template by bips [15] with DTU's additions and adoptions

Danmarks Tekniske Universitet DTU

IKT Tekniske specifikationer:

Baseret på bips IKT tekniske specifikationer med DTU's tilføjelser og ændringer.

BILAG IKT-01
Ydelsesspecifikation

BILAG IKT-02 Teknisk kommunikations-specifikation	BILAG IKT-03 Teknisk BIM/CAD-specifikation	BILAG IKT-04 Teknisk udbuds-specifikation	BILAG IKT-05 Afleverings-specifikation

DTU IKT standarder:

BILAG IKT-06 Filnavngivning og -struktur	BILAG IKT-07 Nulpunkt	BILAG IKT-08 Arealkategorier og rumnavngivning	BILAG IKT-09 2D Autocad specifik
BILAG IKT-10 3D objekter og egenskaber	BILAG IKT-11 Visualiserings-model	BILAG IKT-12 3D Revit specifik for som udført	BILAG C-13 Projektweb specifik
BILAG IKT-14 IKT organisations-diagram	BILAG IKT-15 FM informationer til driften		

1. PARAMETRE FOR STADE OG GRUNDLAG, VEJLEDNING

1. Formål og modtager

Formålet med notatet er at fastlægge en metode til at kommunikere objekters nøjagtighed og grundlag for modelleringen.

- **Objekt nøjagtighed**, skal forstås i forhold til hvorvidt et givent objekt, f.eks. en væg er modelleret på baggrund af scannede tegninger, eller baseret på en opmåling på stedet. Dette påføres på det enkelte objekt i modellen.
- **Objekt stade**, det vil sige hvilket stade er objektet i forhold til eksisterende, nyt, eller nedrivning. Dette påføres det enkelte objekt i modellen.
- **Objekt ejer** (modelejer) - hvem har modelleret bygværket f.eks. bygherre, der har modelleret eksisterende forhold, eller rådgiver, der på skitseringsniveau har tilføjet objekter. I denne sammenhæng er det konkluderet, at der ikke skelnes på ejer på objektniveau, men for modellen som helhed.

2. Forudsætninger

DTU anvender p.t Revit version 2013 til håndtering af bygningsmassen. Derfor vil det beskrevne løsningsforslag tage udgangspunkt i Revits muligheder.

2. TEORI

1. Parametre

I Revit er der mulighed for at oprette parametre på to måder:

- Projekt parametre (Project Parameters)
- Delte parametre (Shared Parameters).

Project parameters kan bruges i lister, men ikke i tags. *Delte parametre* kan bruges på tværs af projekter, objekter og kan bruges i *lister* og *tags*. Ydermere kan selve parameterets data type defineres som et nummer, tekst, vinkel m.fl..

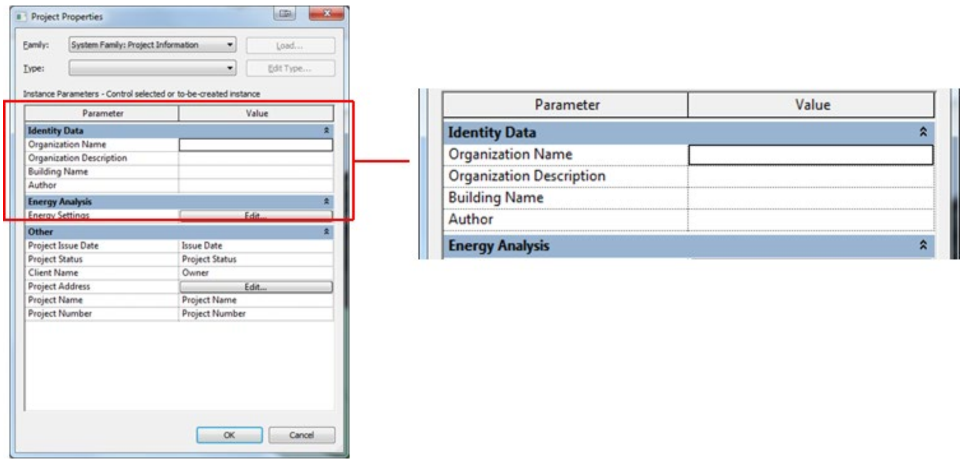
Parametre kan knyttes til tre overordnede kategorier.

- Selve projektet/bygningen.
- Objekttypen. For eksempel alle vægge af en bestem type.
- Det enkelte unikke objekt (instansen), for eksempel en specifik væg.

2. Projekt parametre:

De parametre, der knytter sig til projektet (Project Parameters) er parametre som f.eks. bygherre, forfatter, adresse og bl.a. bygningsnavn. Netop bygningsnavn er vigtigt at bemærke, hvis det ønskes at bygnings navn skal overføres til f.eks. IFC. Bygningsnavn er en indbygget (standard) parameter i Revit, som ikke kan ændres. Derfor kan det vise sig besværligt at tegne mere end én bygning pr. projektfil.

Muligheden for at angive en forfatter for modellen, gør det nemt at identificere modelens "ejer". Informationen om et objekts oprindelse kan bl.a. bruges som gruppering i lister (Schedules).



3. Typeparameter:

Typeparameter knytter sig til *typen*. F.eks. alle vægge af en bestem type. En anvendelse af dette kunne være til angivelse af u-værdi. Denne regnes ud fra væggens sammensætning af materialer, som deles på type niveau og uafhængig af den enkelte væg og i hvilken kontekst den optræder. *Typeparameter* kan tilknyttes på tværs af objekttyper. F.eks. kan u-værdi godt tilknyttes både vægge og vinduer. Rettes et *Typeparameter* rettes det for alle objekter af den type, som parameteren er knyttet til. Objekter af samme type, kan derfor ikke have individuelle værdier i en *Typeparameter*.

4. Unik parameter

Unikke parametre knytter sig til også selve typen (vinduer, døre, osv.), men rettes værdien af parameteren, ændres det kun for det enkelte objekt. Dette kan f.eks. være identifikation i form af dør- eller rumnummer, som er relateret til instansen.

5. Model opbygning

Der findes mange måder at opbygge modeller på. Ofte findes der ikke én rigtig og forkert måde, men derimod flere metoder.

Dette gør sig især gældende når det drejer sig om kombinationen af nybyg og eksisterende forhold.

Revit indeholder muligheden for at angive hvilken fase et objekt tilhører. Som udgangspunkt arbejdes der i Revit med faserne ”Eksisterende” og ”Nyt”, men flere faser kan oprettes efter behov (***anbefales ikke***).
Faserne gør det muligt at sætte et nyt vindue i en eksisterede væg og efterfølgende kan den grafiske visning tilpasse sådan at kun nye objekter vises, eller f.eks. objekter som rives ned osv.

Faser fungerer på mange måder godt, men netop faserne gør f.eks. at samlinger mellem en eksisterede væg og en ny væg, kan være svære at få rigtige.

Dette gør at det grafiske udtryk ofte kan være svært at få rigtigt.

6. Løsningsforslag

Til angivelse af et objekts nøjagtighed oprettes et *Typeparameter* (tekst) ved navn *”Information accuracy”*, under gruppen ”Identity Data”, som knyttes til alle objekter i alle modeller. Værdiliste for parameter fremgår af selvstændigt notat. Der kan f.eks. skelnes mellem ”Scannet”, ”Visuelt tjekket” ”Opmålt” og ”As built”.

Til angivelse af objektets ejerskab anvendes projektparameteret Forfatter / Author for hele modellen. Der skelnes således ikke mellem ejere på objektniveau.

Det anbefales at der ikke anvendes faser, men at der derimod oprettes en model over eksisterende forhold, hvor nøjagtigheden at det enkelte objekt angives. Rådgiver der skal buge modellen kan linke modellen ind i deres egen og bruge den eksisterende model som underlag. Skulle der være objekter i den eksisterende model, som ikke er nøjagtige nok for rådgiverne, må de indtegne det nye objekt oven i det eksisterende objekt og angive en passende værdi for nøjagtigheden. Da niveauet for nøjagtighed i sådanne altid vil være stigende, vil det ved samling af modellerne være nemt at se hvilket af de to objekter der er gældende.

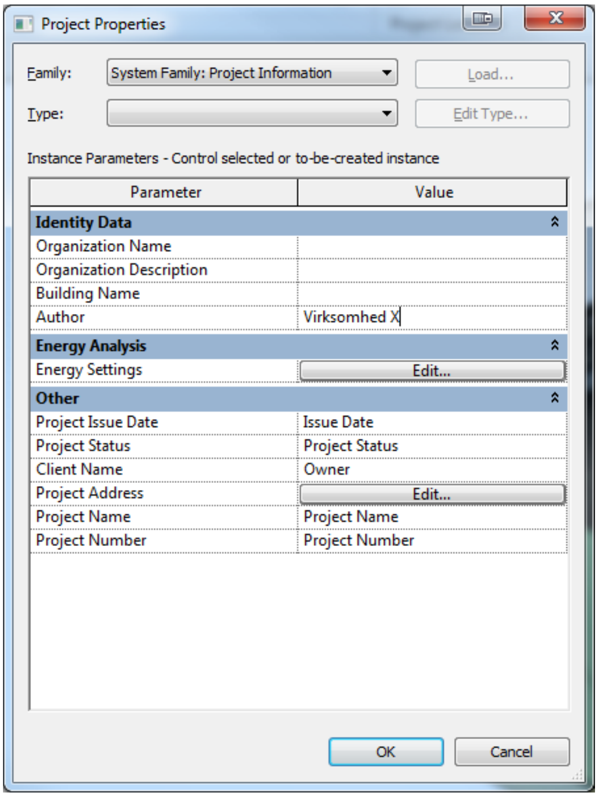
Se i øvrigt nedenstående illustration, som eksempel på brug af parametre i processen.

3. PARAMETRE FOR STADE OG GRUNDLAG, VÆRDILISTE

1. Teknisk løsning

Det anbefales at *bips A104's* retningslinjer for metadata følges, i det omfang det er muligt. Denne vejledning forholder sig kun til de absolut nødvendige metadata. Der kan tilknyttes flere metadata hvis det skulle vise sig nødvendigt.

Til angivelse af ejerskab anbefales at alle objekter har samme ejer, så det styres ved projektparameteret forfatter (Author) *(se bips A104. side 31)*.



2. Stade

Til angivelse af stade (eksisterende, nyt, nedrivning), bruges Revit "Phasing" i form af egenskaberne "Phase created" og "Phase Demolished" på objektniveau. Der må ikke tilføjes yderligere faser end Revits standard.

3. Informationsnøjagtighed (Grundlag)

Til angivelse af et objekts nøjagtighed oprettes et unikt "Shared parameter" som Instance:

Property	Value
Name	*Information accuracy*
Discipline	Common
Type of parameter	Text
Parameter Group	Identity Data

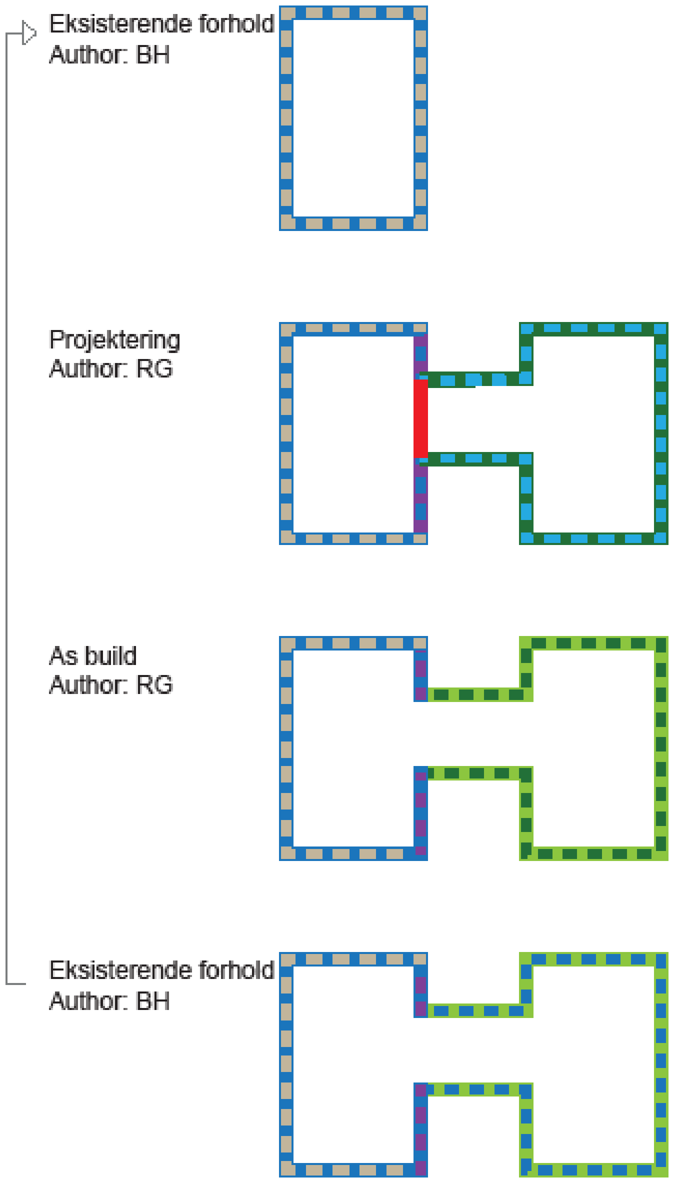
4. Værdiliste for Informationsnøjagtighed (Information accuracy) (ikke fra A104)

Kode som angiver nøjagtigheden for et givet objektets geometri. Informationsnøjagtighed er et obligatorisk metadataelement. Værdierne i listen er bundne og må ikke afviges.

Nærværende liste anvendes også i dokumentationsmodul for tegninger (Kvalitetssikringsniveau).

Metadataværdi DK	Metadataværdi EN	Værdi Kode	Definition	Eksempler
Informationsnøjagtighed 0	Information accuracy 0	**JA0**	Objekt dannet ud fra en opmåling af analogt tegningsgrundlag.	Anvendes hvor objektet er oprettet direkte ud fra et scannet grundlag
Informationsnøjagtighed 1	Information accuracy 1	**JA1**	Objekt dannet på baggrund af overordnet kontrol af bygningsdeles indbyrdes placering på stedet. Objektet er ikke opmålt.	Anvendes hvor objektet er tjekket visuelt, men ikke opmålt, på pladsen. For eksempel ruminddeling eller vinduesplacering.
Informationsnøjagtighed 2	Information accuracy 2	**JA2**	Objektet er dannet på baggrund af gældende projekteringsgrundlag.	Anvendes for objekter ændret eller tilføjet i forbindelse med projekteringen. Nøjagtighed afspejler projekteringens aktuelle fase.
Informationsnøjagtighed 3	Information accuracy 3	**JA3**	Objektet er dannet på baggrund af den fysisk realiserede bygning, med de bygningsdele, komponenter og egenskaber, som er resultat af produktion.	Anvendes til dokumentation for det færdige byggeri. Svarer til As built / Som udført.
Informationsnøjagtighed 4	Information accuracy 4	**JA4**	Objekt dannet ud fra en opmåling på stedet med minimum tolerance.	Anvendes hvor objektet er opmålt på stedet f.eks. af landmåler eller lign.

vILLUSTRATION AF PARAMETRE FOR INFORMATIONSNØJAGTIGHED OG STADE



EKSISTERENDE FORHOLD
Drift / BIM kontor har modelleret eksisteren de forhold på baggrund af scannet grund lag. Phasing er sat til "Created, Existing" og informationsnøjagtighed til "JA0".
Bygherre (BH) er opført som "Ejer" (Author) af modellen.

PROJEKTERING
I projektering er eksisterende forhold (Created, Existing), overdraget til rådgiver, som nu er "ejer".
Eksisterende forhold, mod tilbygning, er delvist opmålt (JA2), mens gennembryd ning i væg er markeret som Nedrives" (Demolished, New Construction). Objekter på Ny bygning er sat til "Created, New Construction", informationsnøjagtighed "JA2" for Projektering.

AS BUILT
Byggeriet er udført og nye objekter mark eres som "As built" (JA3).
Rådgiver er "Ejer".
Modellen overdrages til Bygherre som "As built" materiale.
Tilbygning / Nybygning er i overdragelsen stadig markeret som "Created, New Construction", mens opmålt væg er mark eret som "Created, Existing", opmålt på stedet (JA4)

EKSISTERENDE FORHOLD
Modellen er overdraget til Bygherre, som i sin proces for modtagelse ændrer den nye bygning til "Eksisterende forhold, As built", "Created, Existing", JA3.
Bygherre er nu "Ejer" af modellen som nu indgår som modeldokumentation / tegningsdokumentation for eksisterende forhold for bygningen.

PHASING
- Created, New Construction
- Created, Existing
- Demolished, Existing
- Demolished, New Construction

INFORMATIONSNØJAGTIGHED
- JA0 Scannet grundlag
- JA1Visuelt tjekket
- JA2 Projekt
- JA3 As built
- JA4 Opmålt på stedet

DTU/ 07-10-2013

7.3 Instructions for the delivery of area calculations

Author: buildingSMART Nordic Denmark

Language: Danish

Original title:

Vejledning for aflevering af digital arealinformation

Document id	Title	Organisation /Author	Date	Status
DK-GOV-Area	Arealinformation fra projekt til FM	buildingSMART-DK	20100816	App

Udarbejdet efter international standard ISO/DIS 29481-1 Information Delivery Manual (IDM)

Vejledning for aflevering af digital arealinformation

Denne vejledning beskriver formål, procedure og specifikation for aflevering af digitale arealdata via en bygningsinformationsmodel (BIM) I IFC-format.

Formål

I forbindelse med arealforvaltning i de statslige styrelser er det af stor værdi at have overblik over alle bygningernes arealer. Arealer er selve formålet med bygningerne og er styrende i en lang række af forvaltningsprocesserne. Arealer danner således grundlag for konkurrencer, husleje, rengøring, energivurdering, indberetninger, benchmarking og lignende.

Derfor er det af vital betydning, at arealinformation efter nybygning, renovering og ombygning, hurtigt bliver registeret korrekt i centrale systemer hos driftsherren. Derfor stilles der med denne vejledning konkrete krav om aflevering/udveksling af arealinformation i de relevante processer.

Specifikationen vil blive benyttet af de statslige bygherrer i Danmark.

Det er udelukkende rum og den rumlige struktur i bygningen, der stilles krav til og som skal afleveres.

Læsevejledning

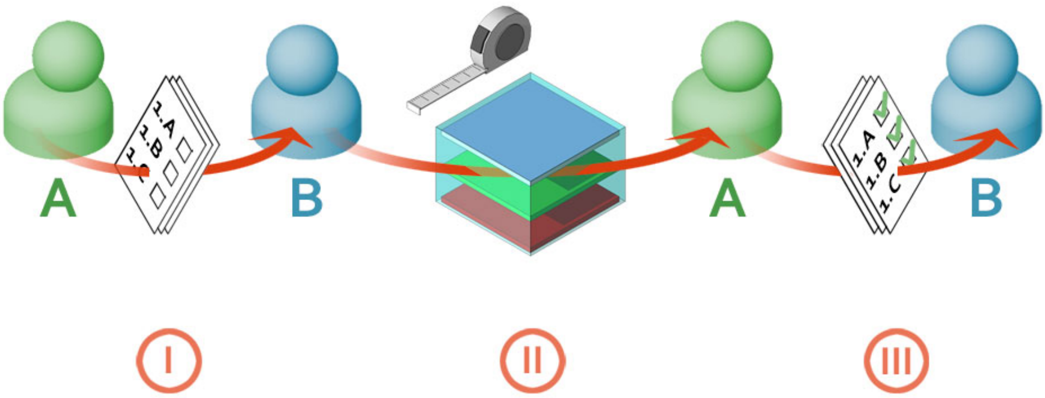
Afsnittene Formål, Leveranceoversigt og Procesoversigt er rettede mod projektledere og beslutningstagere.
Øvrige afsnit omhander specifikationer for dataleverancen, og er derfor rettede mod teknikere.

Udarbejdet af buildingSMART Danmark
på initiativ af Slots- og Ejendomsstyrelsen

I samarbejde med Universitets- og Bygningsstyrelsen
og Forsvarets Bygnings- og Etablissementstjeneste

Leveranceoversigt

Leverancen foregår mellem A) en modtager (initator) i det følgende kaldet bygningsejer/driftsansvarlig og B) en leverandør (executer) i det følgende kaldet rådgiver. I det følgende er de roller og transaktioner/interaktioner denne vejledning omhandler kort beskrevet:

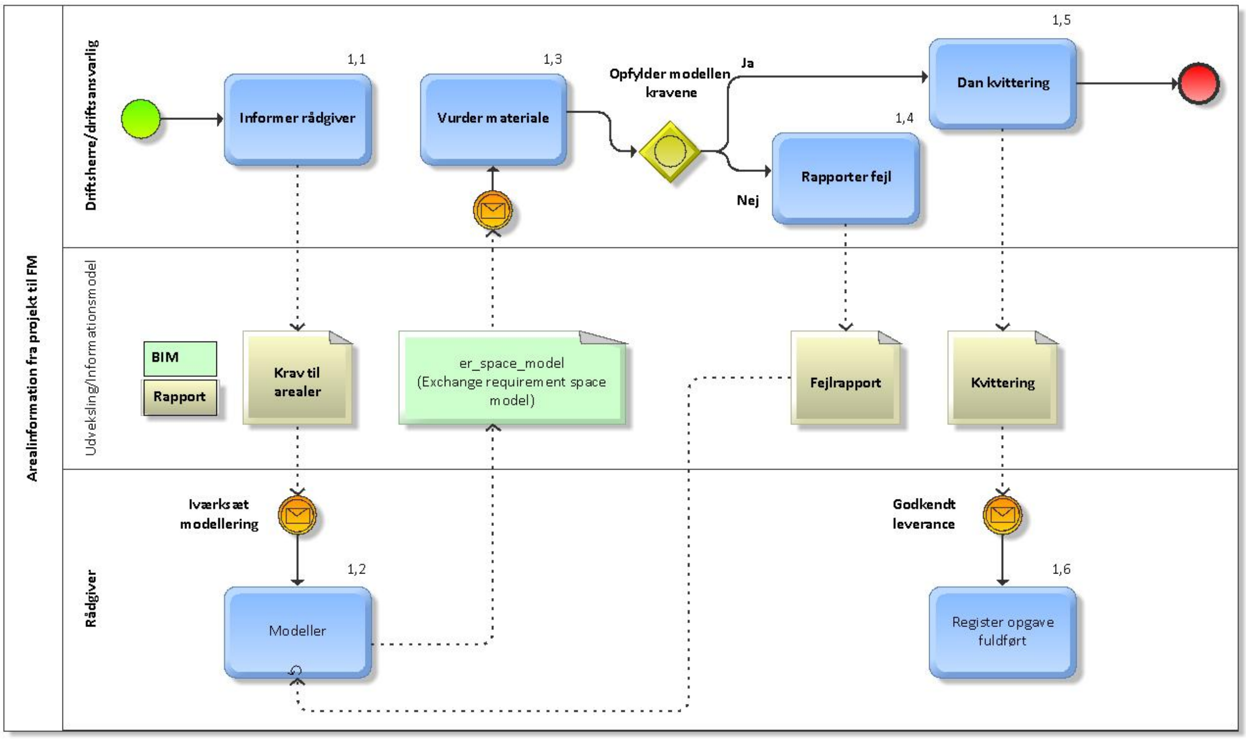


Interaktionsforløb mellem bygningsejeren/driftsansvarlige (initator) og rådgiveren (executor).

Roller
A) Bygningsejeren/driftsansvarlige (initator) som har et behov for modtage data.
B) Rådgiveren som udfører projekteringen eller registreringen på den givne ejendom er leverandør (executor).

Leverancer / Transaktioner
(I) Bygningsejeren/driftsansvarlige skal specificere eksakt, hvad der skal afleveres (nærværende Vejledning / IDM)
(II) Rådgiveren skal i henhold til denne IDM aflevere en datafil til bygejeren (II) (IFC) med de specificerede informationer på det angive tidspunkt.
(III) Bygningsejer/driftsansvarlige skal ved modtagelsen kvittere (III) med en godkendelse for korrekt modtagelse.

Procesbeskrivelse



Specifikation af processer	Type	Dokumentation
[1,1] Informér rådgiver	Subproces	Bygningsherren/driftsansvarlige fremsender afleveringskrav til rådgiveren, som skal indberette arealinformation vedrørende et eller flere byggerier.
[1,2] Modellér	Subproces	Rådgiveren modellérer de aftalte bygninger baseret på krav fra driftsherren/driftsansvarlige.
[1,3] Vurdér materiale	Subproces	Bygningsherren/driftsansvarlige sikrer at det af rådgiveren fremsendte materiale bliver kontrolleret i forhold til de opstillede krav til informationsmodelleringen.
[1,4] Rapportér fejl	Subproces	Driftsherren/driftsansvarlige sikrer at der udarbejdes og fremsendes en rapport til rådgiveren med fejl og mangler til det af rådgiveren afleverede materiale i det omfang at materialet ikke indfrier de opstillede krav.
[1,5] Dan kvittering	Subproces	Bygningsherren/driftsansvarlige sikrer, at der udarbejdes en kvittering på at informationsleverancen er godkendt.
[1,6] Registér opgave fuldført	Subproces	Rådgiveren registrerer at opgaven med informationsleverancen er fuldført.

Specifikation af dataobjekter

Krav til arealer	Data object	Nærværende information delivery manual (IDM) som udleveres af bygningsejeren/driftsansvarlige til rådgiveren, der skal forestå arealinformationsleverancen.
Fejlrapport	Data object	Rapport med fejl og mangler registreret i det af rådgiveren fremsendte materiale.
Kvittering	Data object	Kvittering med information om at informationsleverancen fra rådgiveren opfylder de opstillede krav til informationsleverancen.

Specifikation af udvekslingsindhold

er_space_model	Exchange requirement	Bygningsinformationsmodel som indeholder rum modelleret som spaces i IFC. Rum skal være tilknyttet en bygning og etagen, hvor gulvet befinder sig. Arealer skal opmåles i henhold til DS13000 suppleret med evt. retningslinjer, som bygningsejeren/driftsansvarlige udleverer. Rumfunktion baseret på SES-standardlister over rumfunktion (LINK eller versionsangivelser eller DBK table 20/20a) Alternative rumfunktioner skal angives særskilt, såfremt at rummet har flere funktioner. Rumnummer i henhold til projektspecifikke specifikationer Klassifikationkode svarende til rumfunktion skal baseres på gældende version af Tabel 20 og 20a i "DBK Resultatdomænet 1, Struktur og klassifikationstabel for bebyggelser,bygninger og rum" udgivet af bips, hvor intet andet er angivet. Foruden brugsrum skal der oprettes et rum, som svarer til etagens bruttoetageareal. Disse rum skal navngives, så navnet på rummet starter med navnet på etagen de angiver.

Specifikation af koordinationspunkter

Opfylder modellen kravene?	Coordination point gateway	Beslutning om hvorvidt rådgiverens informationsleverance kan godkendes eller om den skal revideres.

Specifikation af aflevering / Model View Definition (MVD)

Navn	er_space_model
Identifikation	DK-GOV-Area_er01
Fase	Fase 05 i Danske Ark / F.R.I-modellen fra DBK Procesdomænet, Klassifikationstabeller og faser, bips, version 1,0, 2006-08-01, ISBN-87-91340-63-2 og til stage 9 i ISO 22263 Lifecycle stages.

Nærværende specifikation er påregnet brugt i forbindelse med overførsel af ruminformation fra rådgivere til bygningsejere og driftsansvarlige i forbindelse med drift af bygninger. Formålet med specifikationen er at understøtte en digital overførsel af rum dannet i bygningsinformationsmodeller til bygningsejeren/driftsherren med henblik på efterfølgende nyttiggørelse af data til driftssituationen.

Som beskrevet i procesbeskrivelsen kan bygningsejeren/driftsherren udføre analyser for at undersøge om informationsleverancen opfylder de opstillede krav.

Informationskrav

Udarbejdet efter IFC 2x3

Bygning IFCBuilding (element)

Propertyname	Beskrivelse	Data type	IFC name	Tilvalg
GlobalId	Unique ID	String	IfcBuilding.GlobalId	x
Name	Navn	String	IfcBuilding.Name	x

Etage IFC BuildingStorey

Propertyname	Beskrivelse	Data type	IFC name	Tilvalg
GlobalId	Unique ID	String	IfcBuildingStorey.GlobalId	x
Name	Navn	String	IfcBuidlingStorey.Name	x

Rum IFCSpace

Propertyname	Beskrivelse	Data type	IFC name	Tilvalg
GlobalId	Unique ID	String	IfcSpace.GlobalId	x
Number	Rumnr.	String	IfcSpace.Name	x
Name	Navn	String	IfcSpace.LongName for rum IfcSpace.Name for rum,som angiver bruttoetageareal	x

Areal	Nettoareal for rum og bruttoareal for rummet, som repræsenterer etagens bruttoetageareal	Area unit	IfcElementQuantity.GrossFloorArea	x
DkGovRoomType	Kode/Rumtype	String	IfcPropertySet(DkGovRoom).DkGovRoomFunction Om nødvendigt kan det accepteres, at produktnavnet på applikation til at generere data med, indgår i navnet på property set'et sammen "other".	x
DkGovRoomFunction	Rum funktion	String	IfcPropertySet(DkGovRoom).DkGovRoomFunction Om nødvendigt kan det accepteres, at produktnavn på applikation til at generere data med, indgår i navnet på property set'et sammen "other".	x
DkGovRoomAltFunction	Alternativ rumfunktion	String	IfcPropertySet(DkGovRoom).DkGovRoomAltFunction Om nødvendigt kan det accepteres, at produktnavn på applikation til at generere data med, indgår i navnet på property set'et sammen "other". Hvis der optræder flere alternative rumfunktioner skal variablen suppleres med _n for hver alternativ funktion.	x

Forretningsregler

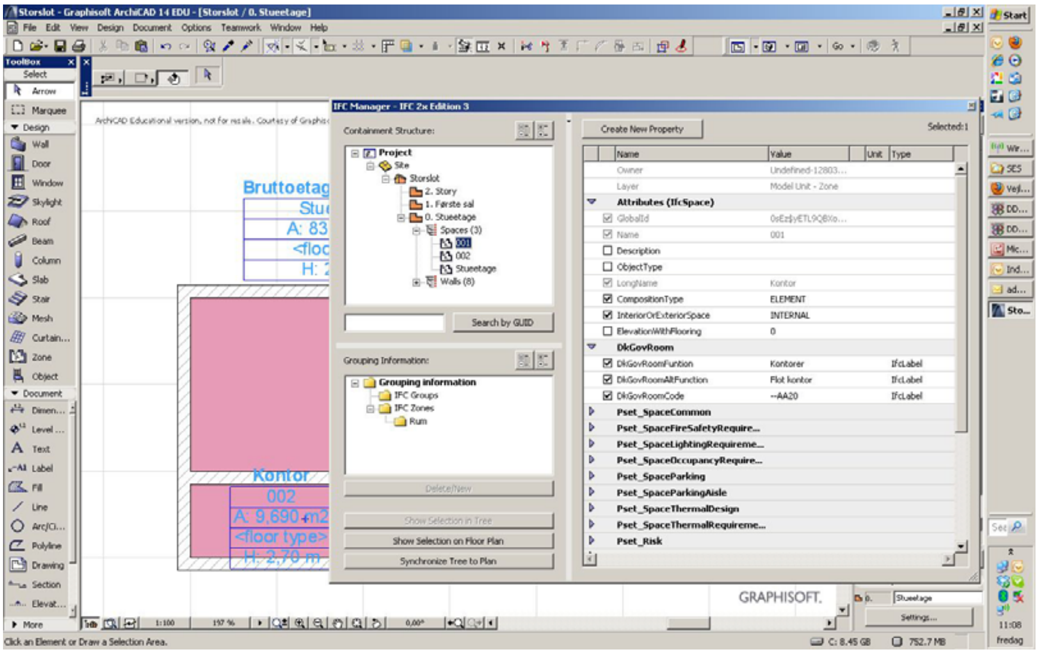
SpaceMustContainValidClassifikation

Type	Business rule
Identifikation	DK-GOV-Area_Rule01
Navn	SpaceMustContainValidClassifikation
Formål	Sikre at det kun benyttes gyldige værdier for klassfikation.
Tilladte værdier	SES-standardlister over rumfunktion

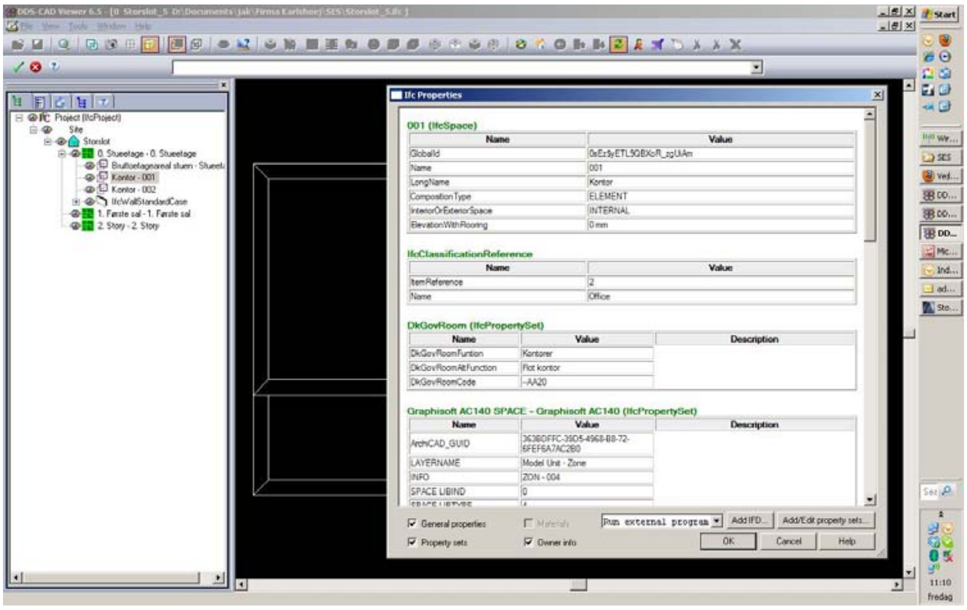
Bilag: Eksempler

I dette afsnit er der givet lidt eksempler på, hvordan IFC spaces kan afleveres.

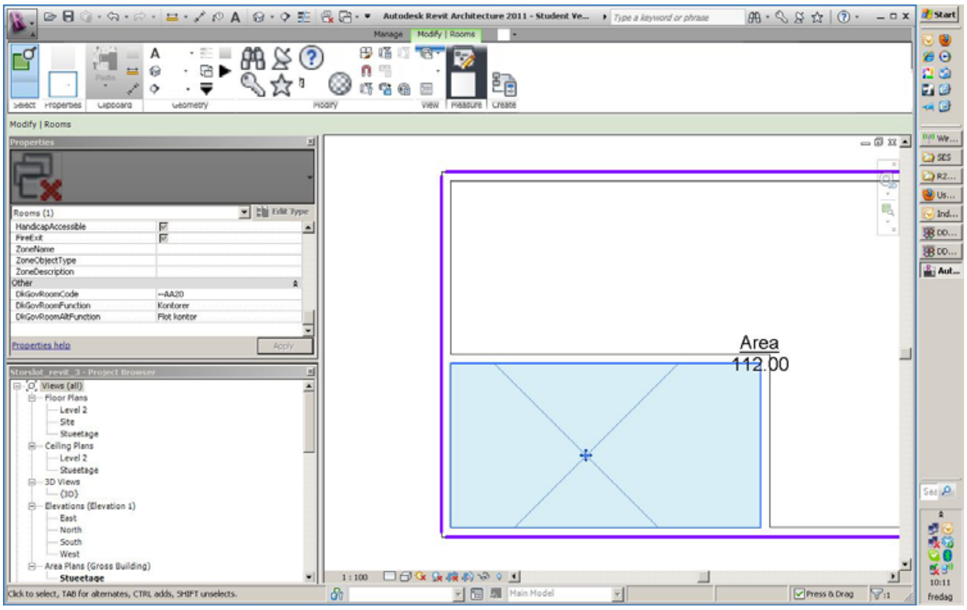
På baggrund af vægobjekter og andre BIM-objekter genereres der spaces/arealer, der tildeles de beskrevne egenskabsdata. I nødvendigt omfang jf. opmålingsreglerne justeres de automatisk genererede spaces/arealer. Herefter defineres etageobjektet og nødvendige egenskaber tildeles manuel eller automatisk.



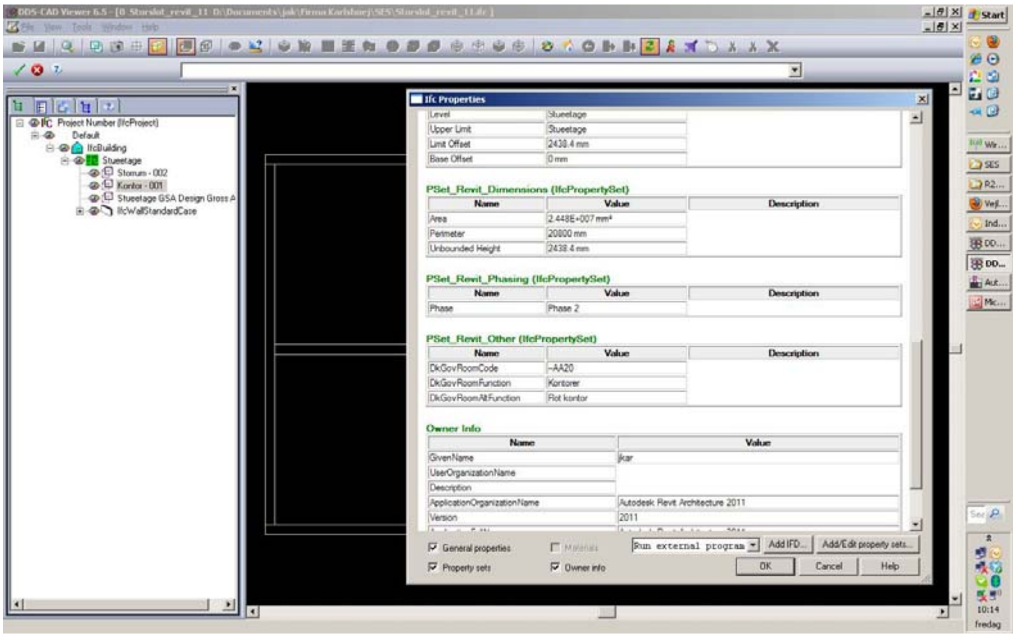
Rum oprettet som Zone i ArchiCAD 14 og tilføjet information om rumfunktion.



IFC-fil eksporteret med rum fra ArchiCAD og indlæst i DDS IFC-vieweren



Rum oprettet som Room i Revit Architecture 2011 og tilføjet information om rumfunktion.



IFC-fil eksporteret med rum fra Revit og indlæst i DDS IFC-vieweren.

7.4 DTU - IKT information for operational BIM models

Author: Denmark's Technical University

Language: Danish

original title:

IKT-15 FM informationer til driften, projektspecifik beskrivelse

Based on the IKT template by bips [15] with DTU's additions and adoptions

IKT-15 FM informationer til driften, projektspecifik beskrivelse

IKT Tekniske specifikationer:

Baseret på bips IKT tekniske specifikationer med DTU's tilføjelser og ændringer.

BILAG IKT-01
Ydelsesspecifikation

BILAG IKT-02
Teknisk kommunikations-specifikation

BILAG IKT-03
Teknisk BIM/CAD-specifikation

BILAG IKT-04
Teknisk udbuds-specifikation

BILAG IKT-05
Afleverings-specifikation

DTU IKT standarder:

BILAG IKT-06
Filnavngivning og -struktur

BILAG IKT-07
Nulpunkt

BILAG IKT-08
Arealkategorier og rumnavngivning

BILAG IKT-09
2D Autocad specifik

BILAG IKT-10
3D objekter og egenskaber

BILAG IKT-11
Visualiserings-model

BILAG IKT-12
3D Revit specifik for som udført

BILAG C-13
Projektweb specifik

BILAG IKT-14
IKT organisations-diagram

BILAG IKT-15
FM informationer til driften

IKT-15 FM informationer til driften, projektspecifik beskrivelse

Indhold

1. Orientering

Nærværende dokument beskriver indhold og teknik for aflevering af driftsinformationer til Campus Services BIM-database. Det være sig f.eks. anbefalet vedligehold, dokumenter, tegninger og informationer for bygningsdelstyper.

2. Formål

Drift og vedligeholdsinformationer skal afleveres efter, processer og tidsfrister beskrevet i IKT-05 ”*Afleveringsspecifikation*”. Det er vigtigt at tidsfrister overholdes, så driften har mulighed for at kigge informationerne grundigt igennem, FØR aflevering af bygningen. Hvis informationerne ikke er indberettet rigtigt, eller ikke er fyldestgørende, vil de blive betragtet som mangelfulde.

Indlevering af driftsinformationer vil ske igennem en IFC model til DaluxFM (se afsnit. 5 *Afleveringsmetode*). Projektspecifik journaliseringsdokumentation uploades, med egenskaber og links, til projektwebben.

3. Brugergrænsefladen i DaluxFM

DaluxFM er den database der håndterer driftsherres dokumentation, f.eks. anlægs- og tegningsdokumentation.
DaluxFM stiller en enkel, grafisk brugerflade til rådighed. Informationer til driften indberettes i denne BIM-database, så vidt mulig gennem (i prioriteret rækkefølge):

1. Indlæsning af modellen (IFC)
2. Indlæsning af en Excel-filer (Skabelonen udleveres af DTU)
3. Manuel indtastning

3.1. DaluxFM Digital Afleverings-modul

Modulet "Digital Aflevering" i DaluxFM, har til formål at opsamle alle nødvendige informationer og tegninger til driftsafdelingen. Driftsherre specificerer i modulet alle de informationer, tegninger og informationer, der skal forelægge når byggeriet står færdigt og skal overdrages. Den ansvarlige for den digitale aflevering hos entreprenør, eller totalrådgiver (se IKT-14 "*Organisationsdiagram*"), kan derefter i DaluxFM-modulet se en oversigt over egne afleveringsmangler i projektet og kvalitetssikre disse.

3.2. Information til aflevering

I DaluxFM skal følgende indlæses og indtastes, f.eks.:

- Den digitale bygningsmodel (IFC) samt etageplaner skal være defineret
- Bygningsdelstyper med tilhørende informationer (producent, typenummer m.v.)
- Dokumenter; produktblade, datablade, drift-og vedligeholdsvejledninger
- Tegninger og diagrammer
- Anbefalinger om vedligehold, rengøring og eftersyn
- Relationer mellem eksempelvis rum og ventilationsanlæg

Disse er beskrevet i IKT aftalen og i nærværende dokument under afsnit 7 "*FM Niveauskemaer*".

4. Tidspunkt for aflevering af dokumentation

Følgende ændring træder i kraft i forhold til IKT afleveringsspecifikationen (IKT-05):
"Aflevering af DV informationer" herunder tegninger forgår løbende parallelt med opførelsen af bygningen. Dette betyder, at når der fremsendes faktura på det udførte arbejde, på de forskellige fagetaper, udleveres tillige den dertilhørende dokumentation, i henhold til nærværende beskrivelse "*Digital aflevering i DaluxFM*" indeholdende det udførte arbejde.

Fysisk vil dokumentationen blive placeret i særskilt importafsnit, som ved modtagelsen skal prægodkendes af DTU driftsherres:

- BIM-ansvarlige
- CAS fagansvarlige
- Projektleder (eller udpeget af CAS, ledelsesrepræsentant)

5. Afleveringsmetode

Den digitale-afleveringsansvarlig (Se IKT-14 "*Organisationsdiagram*"), sørger for at al nødvendig information indsamles og indlæses i DaluxFM til driftsherre. Indlæsning af information og modeller i DaluxFM kan gøres af den digitale-afleveringsansvarlige alene, eller vedkommende kan vælge at "uddelegere" afleveringsopgaver til flere – evt. de udførende. Alle afleveringsopgaver godkendes endeligt af, som derefter ligger "klar" til driftsherre ved overdragelse.

IKT-15 FM informationer til driften, projektspecifik beskrivelse

5.2. Indlæsning af Digital Bygningsmodel (IFC)

De præcise krav til den digitale drift-bygningsmodel i Revit format er specificeret i bilag "12 IKT 3D Revit specifik". Revit-drift modellen eller den sidst gældende opdaterede projekterings/udførelses BIM-model, kan danne grundlag for IFC modellen.

Her gøres dog særlig opmærksom på, at der skal være et entydigt link, i form af en klassifikation efter CUNECO standarden, mellem objektet i modellen og de indberettede og indlæste informationer i Campus Services BIM-database.

Alle bygningsdele til drift, som forefindes i drift Revit-modellen, skal klassificeres efter type. Dalux stiller et plugin til Revit til rådigheden, hvor et check mellem modellen og de i DaluxFM indberettede bygningsdele kan foretages.

Når IFC modellen indlæses i DaluxFM vil alle bygningsdele, kunne ses og behandles i DaluxFM. De informationer, tegninger, dokumenter, relationer m.v. som er indtastet i DaluxFM for bygningsdelstypen er dermed knyttet sammen med den konkrete bygningsdel i drift modellen (Revit).

Indlæsning/indtastning af informationer (egenskaber) for en bygningsdelstype

5.3. Indlæsning af Excel-fil / regneark

For yderligere forklaring kontakt DTU/BIM-kontoret
Skabelon vedlægges som bilag IKT-15a "*FM skemaer*"

5.4. Manuel indtastning i Dalux FM

Såfremt informationerne, af forskellige årsager, ikke kan indlæses igennem modellen til BIM-databasen, tastes informationerne manuelt ind.

DaluxFM stiller også en enkel, grafisk brugerflade til rådighed, hvor indtastning af informationer, f.eks. anbefalet vedligehold, dokumenter og tegninger for en bygningsdelstype kan udføres. Man vælger bygningsdelstypen, og indtaster derefter de manglende informationer, som eksempelvis producent, leverandør, serienummer, uploader dokumenter, vælger anbefalet vedligehold osv.
Relationer kan eksempelvis angives mellem en bygningsdel og rum. Her kan man både vælge forsyningsrum på listeform eller grafisk via en etageplan, hvis modellen er indlæst.

6. Særlige forhold

DTU/driftsherre kan til en hver tid ubetinget kræve, at ovennævnte dokumentation og informationer udleveres indtastet i Microsoft Excel og nævnte filer vedlagt i dedikeret mappestruktur, uden meromkostninger og heraf følgende tidsforsinkelser. Dette kan foregå via projektweb, hvor leverandører og udførende parter tildeles adgang.

Niveauet for data kan til enhver tid ændres af DTU, uden yderligere omkostning.

7. FM Niveauskemaer

Alle bygningsdele SKAL have et entydigt link til bygningsdelen i modellen (f.eks. klassifikation eller typenr).

7.2. Indtastning af bygningsdele og komponenter

Hver bygningsdel / komponent indtastes i FM Skemaet, svarende til bygningsdelskort, med et indhold bestemt ud fra fagdisciplin og et detaljeringsniveau for bygningsdelen / komponenten defineret ud fra DTU's driftsafdelings behov. Detaljeringsniveau af driftsinformationer om emnet betegnes *FM Niveau.*

Ved afleveringen anvendes skabelonen i IKT-15a "*Bygningsdele*". I skabelonen IKT-15a er de enkelte fagdiscipliner opdelt på faner En bygningsdel / komponent indtastes således i rækker, én række pr. bygningsdel / komponent.
Under kolonnerne udfyldes informationer om bygningsdelen / komponenten. Antallet af kolonner der udfyldes, afhænger af det angivne FM Niveau for bygningsdelen / komponenten.

I forbindelse med afleveringen samles alle fagdiscipliner til ét Excel dokument, opdelt i faner svarende til skabelonen. Der må ikke afleveres flere faner pr. fagdisciplin.

7.3. FM Niveauer, definition

Skemaerne er under hver fagdisciplin opdelt efter *FM Niveau*, der angiver detaljeringen af driftsinformationer vedr. komponenten. For hvert niveau er formuleret en sætning, som udtrykker det behov for information niveauet dækker, f.eks. er "*Ventilation FM Niveau 1*" (VENT1), defineret ud fra "*Kan vi genkende og bestille en..*", mens behovet for FM Niveau 2, VENT2, er defineret som "*Kan vi vedligeholde en..*".

FM Niveauer er inddelt i en skala fra 1 til 4, hvor 1 er det laveste detaljeringsniveau og 4 det højeste.

Skalaen er inddelt således at højere niveauer "arver" underliggende niveauer. Således består niveau 2 af hele indholdet af Niveau 1, samt alle punkter under Niveau 2, mens FM Niveau 3 består af Niveau 1 + Niveau 2 + Niveau 3. Der skal med andre ord indtastes alle informationer fra og med niveau 1 til og med valgte niveau.

Det individuelle indhold af FM niveauer for de respektive fagdiscipliner er vist i skemaform under afsnit 7.5. "*FM niveauskemaer*".

7.4. Afleveringsformat

For hver information under de respektive niveauer er yderligere en beskrivelse af hvilken information der skal afleveres, samt "*Afleveringsformat*".

Afleveringsformat beskriver formatet, f.eks. tekst, tal, interval, dato m.m., for informationen der skal tastes ind i Excel skemaet, for den pågældende bygningsdel eller komponent.

Afleveringsformat for information om "*Entreprenør*" er således "*Tekst*" i det der er tale om et firmanavn og kan indeholde alle tegn, tal og bogstaver, mens "*Garanti kontakt (CVR-nummer)*" er "*Talværdi"* og må således kun indehold tal.

Det skal særligt bemærkes, at for Afleveringsformat af typen "*Dokument*" gælder, at der skal afleveres et selvstændigt dokument, parallelt med skemaet *Bygningsdele*, samt indtastes

dokument / filnavn i den respektive kolonne, under den pågældende bygningsdel eller komponent.
Dokumenter placeres i en undermappe pr. fagdisciplin og navngives som:
[FAG]\[*Klassifikationskode*]_[*Komponentnavn*]_[*Produkt*]_[*Dokumenttype*].

Eksempel:
Et "Reguleringsspjæld" tilhører fagdisciplinen "VENT" og er i *Bygningsdelsskemaet* angivet til at være FM Niveau 2 (VENT2).

Der skal således i henhold til FM Niveauet "VENT2" bl.a. afleveres information om "*Funktionsbeskrivelse*", hvilket under *Afleveringsformatet* er angivet som "Dokument [Word]".

For *Reguleringsspjæld* skal der således afleveres et selvstændigt dokument (fil) i Word, placeret i undermappen "VENT" navngivet:"
VENT\(57)2.4.01_Reguleringsspjæld_Netavent_Funktionsbeskrivelse.docx
Mappe | Klassifikation | Komponentnavn | Produkt | Dokumenttype | Ext.
Dokument / filnavn anføres i Excel skemaet i kolonnen "Funktionsbeskrivelse", så det er muligt at finde dokumentet.

Bemærk, at klassifikationskoden "*(57)2.4*" er bestemt ud fra *Bygningsdelsskema* (IKT-15a), mens ".01" er projektspecifikt løbenummer for dette reguleringsspjæld i projektet.

7.5. FM niveauskemaer

FM Niveauskemaer er inddelt efter følgende fagdiscipliner:

Init	Fagdisciplin
ARK	Arkitekt
AUT	Bygningsautomatik
EL	El installationer
LAND	Landskab (grøn vedligehold)
TERT	Ledninger i terræn
VENT	Ventilation
VVS	VVS

I det efterfølgende vises oversigter over FM Niveauer for de respektive fagdiscipliner
Hvert skema viser de respektive FM niveauer 1 til 4 for hver af fagdisciplinerne.

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema Arkitekt (ARK)

Niveau	Beskrivelse	Information / data	Afleveringsformat
ARK1	**Kan vi genkende og bestille en xxx**	Aktivt/passivt brandsystem	Markeres med "P"/"A"/"-"
		Antal (m, m2, m3, stk)	Dokument [xls]
		Brandklassifikation (REI)	Talværdi og tekst
		Bygningsnummer	Talværdi og tekst
		Entreprenør	Tekst
		Garanti kontakt (CVR-nummer)	Talværdi
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Producent	Tekst
		Rumnummer	Talværdi og tekst
		Sfb-nummer kodeniveau 3, beskrivelse og type	Talværdi og tekst
		Materialetype	Tekst
		Afleveringsdato	Dato [åååå-mm-dd]
ARK2	**Kan vi vedligeholde en xxx**	Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om rengøring	Dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Anskaffelse og garanti	Dato [åååå-mm-dd]
		Farve (RAL)	Talværdi og tekst
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
		U-værdi	Talværdi
ARK3	**Kan vi drifte en xxx**	Liste for døre & vinduer	Dokument [xls]
		Produkt- / datablade	Dokument [pdf, ocr, word]
ARK4	**100% håndtering af en xxx Projektering egenproduktion**	Certifikater	Dokument [pdf, ocr, word]
		Produktfotos	Foto [jpg]
		Produktspecifikke beskrivelser	Dokument [pdf, ocr, word]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema Ventilation (VENT)

Niveau	Beskrivelse	Information / data	Afleveringsformat
VENT1	**Kan vi genkende og bestille en xxx**	Afleveringsdato	Talværdi
		Aktivt/passivt brandsystem	Markeres med "P"/"A"/"-"
		Antal (m, m2, m3, stk)	Tekst og talværdi
		Betjeningsområde (rum nr./ etage)	Tekst og talværdi
		Bygningsnummer	Talværdi
		CE-mærkning	Dokument [pdf, ocr, word]
		Dimensioner (højde, bredde, dybde,Ø indre)	Tekst og talværdi
		Entreprenør	Tekst
		Garanti kontakt (CVR-nummer)	Talværdi
		ID-nummer	Tekst og talværdi
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Materialetype (datablad)	Tekst
		Producent	Tekst
		Rumnummer	Talværdi
		Sfb-nummer kodeniveau 3, beskrivelse og type	Tekst og talværdi
		Type	Tekst og talværdi
		Typenummer	Tekst og talværdi
VENT2	**Kan vi vedligeholde en xxx**	Alarmbeskrivelse og vejledning	Dokument [word]
		Beskrivelse af indstillinger og justeringsmuligheder	Dokument [word]
		Brugermanual på dansk / betjeningsvejledning	Dokument [word]
		Certifikater	Dokument [pdf, ocr, word]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning [dwg]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Dokument [xls]
		Funktionsbeskrivelse	Dokument [word]
		Funktionstest	Interval [måneder]
		Funktionstest	Dokument [word]
		Komponentoversigt	Dokument [xls]
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
		PI funktionsdiagram	Tegning [dwg]
VENT3	**Kan vi drifte en xxx**	Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om rengøring	Dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Dimensionerings-/designparametre	Dokument [xls]
		Effektforbrug (foto af mærkeplade)	Foto [jpg]
		Filterliste	Dokument [xls]
		Spjældtypeliste	Dokument [xls]
		Ventilatortypeliste	Dokument [xls]
		Anlægstegninger	Tegning [dwg]
VENT4	**100%**	Liste over anbefalede reservedele	Dokument [xls]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

håndtering af en xxx	Lyd-, temperatur- og lufthastighedsmålerapport for berørte rum, for verificering af rumkrav	Dokument [xls]
Projektering egenproduktion	Måle- og indreguleringsrapporter	Dokument [xls]
	Produktfotos	Foto [jpg]
	Risikovurdering iht. Arbejdstilsynets gældende regler	Dokument [word]
	Tegning af kanalføring	Tegning [dwg]
	Teknisk dossier	Dokument [word]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema Bygningsautomatik (AUT)

Niveau	Beskrivelse	Information / Data	Afleveringsformat
AUT1	**Kan vi genkende og bestille en xxx**	Aktivt brandsystem	Markeres med "P"/"A"/"-"
		Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om rengøring	Dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Bestillingsnummer (datablad)	Dokument [pdf, ocr, word]
		Billede (datablad)	Dokument [pdf, ocr, word]
		Bygningsnummer	Talværdi
		Dimensioner (højde, bredde, dybde,Ø indre)	Dokument [pdf, ocr, word]
		Effektforbrug (datablad)	Dokument [pdf, ocr, word]
		Entreprenør	Tekst
		Farve (datablad)	Dokument [pdf, ocr, word]
		Garanti kontakt (CVR-nummer)	Talværdi
		ID-nummer	Talværdi
		Kapslingsklasse (datablad)	Dokument [pdf, ocr, word]
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Materialetype (datablad)	Dokument [pdf, ocr, word]
		Monteringsvejledning	Dokument [pdf, ocr, word]
		Producent	Tekst
		Rumnummer	Talværdi
		Terminalbeskrivelser (datablad)	Dokument [pdf, ocr, word]
AUT2	**Kan vi vedligeholde en xxx**	Brugermanual på dansk / betjeningsvejledning	Dokument [word]
		Firmware	Dokument [pdf, ocr, word]
		Forbindelsesdiagram	Tegning [dwg]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning [dwg]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning [dwg]
		Forsyningshenvisning	Dokument [xls]
		Funktionsbeskrivelse	Dokument [xls]
		Hastighed	Talværdi
		I/O liste	Dokument [word]
		Kommunikation	Tekst
		Komponentoversigt	Dokument [pdf, ocr, word]
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
		Tekniske adresser	Tekst

IKT-15 FM informationer til driften, projektspecifik beskrivelse

Niveau	Beskrivelse	Information / Data	Afleveringsformat
AUT3	**Kan vi drifte en xxx**	BAC net ID (ikke switch)	Talværdi og tekst
		IP Kategori	Talværdi og tekst
		IP type	Talværdi og tekst
		Parameterliste for indstillingsværdier og justeringsmuligheder	Dokument [word]
AUT4	**100% håndtering af en xxx Projektering egenproduktion**	Certifikater	Dokument [pdf, ocr, word]
		Liste vedr. placering	Dokument [xls]
		Liste vedr. switch samt port/komponent	Dokument [xls]
		Placering på etage-/plan-tegning	Tegning [dwg]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema El installationer (EL)

Niveau	Beskrivelse	EL	Afleveringsformat
EL1	**Kan vi genkende og bestille en xxx**	Afleveringsdato	Dato [åååå-mm-dd]
		Aktivt/passivt brandsystem	Markeres med "P"/"A"/"-"
		Antal (m, m2, m3, stk)	Dokument [xls]
		Bygningsnummer	Talværdi
		EAN-nummer	Talværdi
		Entreprenør	Tekst
		Garanti kontakt (CVR-nummer)	Talværdi
		Gruppenummer	Talværdi
		ID-nummer	Talværdi og tekst
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Producent	Tekst
		Rumnummer	Talværdi
		Serienummer	Talværdi og tekst
		Sfb-nummer kodeniveau 3, beskrivelse og type	Talværdi og tekst
		Terræn (placering?)	Tegning [dwg]
		Type	Talværdi og tekst
		Årgang	Talværdi og tekst
		EL-nummer (identifikation for genbestilling)	Talværdi
EL2	**Kan vi vedligeholde en xxx**	Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om rengøring	Dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Brugermanual på dansk / betjeningsvejledning	Dokument [pdf, ocr, word]
		Funktionsbeskrivelse	Dokument [pdf, ocr, word]
		Komponentoversigt	Dokument [xls]
		Materialetype (datablad)	Tekst
EL3	**Kan vi drifte en xxx**	Apparatliste	Dokument [xls]
		CE-mærkning	Dokument [pdf, ocr, word]
		EF-oversensstemmelseserklæring	Dokument [pdf, ocr, word]
		Produkt- / datablade	Dokument [pdf, ocr, word]
		Nøgleskema	Tegning [dwg]
		Måle- og prøverapporter	Dokument [pdf, ocr, word]
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
EL4	**100% håndtering af en xxx Projektering egenproduktion**	Certifikater	Dokument [pdf, ocr, word]
		Produktfotos	Foto [jpg]
		Produktspecifikke beskrivelser	Dokument [pdf, ocr, word]
		Sikkerhedstest (Faldprøver på elevatorer)	Dokument [pdf, ocr, word]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning [dwg]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema Terræn (TERT)

Niveau	Beskrivelse	Information / data	Afleveringsformat
TERT1	Kan vi genkende og bestille en xxx	Afleveringsdato	dato [åååå-mm-dd]
		Antal (m, m2, m3, stk)	Hvis ikke i modellen
		Autorisationsnummer	Talværdi
		Bundkoteniveau	Talværdi
		Bygningsnummer	Talværdi
		CE-mærkning	dokument [pdf, ocr]
		Dandasgraf brøndnummer	Tekst og talværdi
		Dækselkote	Talværdi
		Entreprenør	Tekst
		Garanti kontakt (CVR-nummer)	Talværdi
		Idnummer	Talværdi
		koordinater (GPS)	Tekst og talværdi
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Materialetype (datablad)	Tekst
		Placering oversigtskort	Markering på kort dwg
		Producent	Tekst
		Sfb-nummer kodeniveau 3, beskrivelse og type	Tekst og talværdi
		Trykledning	Tekst
		Vandtype (kloak-/regn-/kemispildevand)	Tekst
TERT2	Kan vi vedligeholde en xxx	Anbefalinger om eftersyn	dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om rengøring	dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Brugermanual på dansk / betjeningsvejledning	dokument [word]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning[dwg]
		Funktionsbeskrivelse	dokument [xls]
		Liste over anbefalede reservedele	dokument [xls]
		Liste over indstillinger og justeringsmuligheder	dokument [xls]
		Liste over nødvendigt værktøj	dokument [xls]
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
TERT3	Kan vi drifte en xxx	Alarmbeskrivelse og vejledning	dokument [pdf, ocr]
		Parameterliste for indstillingsværdier og justeringsmuligheder	dokument [xls, word]
		Produkt- / datablade	dokument [pdf, ocr]
		Pumpeliste	dokument [xls]
TERT4	100% håndtering af en xxx Projektering egenproduktion	Anlægstegninger	Tegning[dwg]
		Beregninger på aggregater og rør	dokument [pdf, ocr]
		Certifikater	dokument [pdf, ocr]
		Konstruktionstegninger	Tegning[dwg]
		Måle- og indreguleringsrapporter	dokument [pdf, ocr]
		PI diagram	Tegning[dwg]
		Produktfotos	Fotos [jpg]
		Produktspecifikke beskrivelser	dokument [pdf, ocr]
		Tegning af rørføring	Tegning[dwg]
		Teknisk dossier	dokument [word]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema VVS (VVS)

Niveau	Beskrivelse	Information / data	Afleveringsformat
VVS1	**Kan vi genkende og bestille en xxx**	Afleveringsdato	Dato [åååå-mm-dd]
		Aktivt brandsystem	Markeres med "P"/"A"/"-"
		Antal (m, m2, m3, stk)	Talværdi og tekst
		Autorisationsnummer	Talværdi
		Bygningsnummer	Talværdi
		CE-mærkning	Dokument [pdf, ocr, word]
		Dimensionering (DN)	Talværdi
		Entreprenør	Tekst
		VVS-nummer (identifikation for genbestilling)	Talværdi
		Garanti kontakt (CVR-nummer)	Talværdi
		ID-nummer	Talværdi
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Producent	Tekst
		Rumnummer	Talværdi
		Sfb-nummer kodeniveau 3, beskrivelse og type	Talværdi og tekst
		Tryktrin (PN)	Talværdi
VVS2	**Kan vi vedligeholde en xxx**	Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om rengøring	Dokument [word]
		Anbefalinger om rengøring	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Brugermanual på dansk / betjeningsvejledning	Dokument [word]
		Forsynes fra/ forsyner(diagram, tegning, beskrivelse)	Tegning[dwg]
		Funktionsbeskrivelse	Dokument [xls]
		Identifikation (mærkning)	Dokument [pdf, ocr, word]
		Komponentoversigt	Dokument [pdf, ocr, word]
		Liste over anbefalede reservedele	Dokument [xls]
		Liste over indstillinger og justeringsmuligheder	Dokument [xls]
		Liste over nødvendigt værktøj	Dokument [xls]
		Oversigt over placering (skjulte installationer)	Tegning [dwg]
		PI diagram	Tegning [dwg]
VVS3	**Kan vi drifte en xxx**	Alarmbeskrivelse og vejledning	Dokument [pdf, ocr, word]
		Parameterliste for indstillingsværdier og justeringsmuligheder	Dokument [word]
		Produkt- / datablade	Dokument [pdf, ocr, word]
		Pumpeliste	Dokument [xls]
		Radiator / konvektorliste	Dokument [xls]
		Ventilliste	Dokument [xls]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

Niveau	Beskrivelse	Information / data	Afleveringsformat
VVS4	**100% håndtering af en xxx Projektering egenproduktion**	Anlægstegninger	Tegning [dwg]
		Beregninger på aggregater og rør	Dokument [pdf, ocr, word]
		Certifikater	Dokument [pdf, ocr, word]
		Konstruktionstegninger	Tegning [dwg]
		Lyd-, temperatur- og lufthastighedsmålerapport for berørte rum, for verificering af rumkrav	Dokument [word]
		Måle- og indreguleringsrapporter	Dokument [pdf, ocr, word]
		Produktfotos	Foto [jpg]
		Produktspecifikke beskrivelser	Dokument [pdf, ocr, word]
		Risikovurdering iht. Arbejdstilsynets gældende regler	Dokument [word]
		Tegning af rørføring	Tegning [dwg]
		Teknisk dossier	Dokument [word]

IKT-15 FM informationer til driften, projektspecifik beskrivelse

FM Niveauskema Landskab (LAND)

Niveau	Beskrivelse	Information / data	Afleveringsformat
LAND1	Kan vi genkende og bestille en xxx	Afleveringsdato	Dato [åååå-mm-dd]
		Antal (m, m2, m3, stk)	Talværdi og tekst
		Bygningsnummer (N/S/Ø/V -for)	Talværdi og tekst
		Entreprenør	Tekst
		Garanti	Dato [åååå-mm-dd]
		Garanti	Dokument [word]
		Garanti kontakt (CVR-nummer)	Talværdi
		Idnummer	Talværdi og tekst
		Leverandør	Tekst
		Lokation (f.eks. LYN=Lyngby)	Tekst
		Producent (identifikation for genbestilling)	Tekst
		Risikotræ	Markeres med "*"
		Rumnummer	Talværdi og tekst
		Sfb-nummer kodeniveau 3, beskrivelse og type	Talværdi
		Standard for Danske Anlægsgartnere	
		Stednavn	Tekst
		Aktiv/passivt Brandsystem	Markeres med "*"
LAND2	Kan vi vedligeholde en xxx	Anbefalinger om eftersyn	Dokument [word]
		Anbefalinger om eftersyn	Interval [måneder]
		Anbefalinger om renholdelse	Dokument [word]
		Anbefalinger om renholdelse	Interval [måneder]
		Anbefalinger om vedligeholdelse	Dokument [word]
		Anbefalinger om vedligeholdelse	Interval [måneder]
		Brugermanual på dansk / betjeningsvejledning	Dokument [word]
		Anlægstegning	Tegning [dwg]
		Funktionsbeskrivelse	Dokument [xls]
		Identifikation (mærkning)	Dokument [pdf, ocr, word]
		Elementoversigt	Dokument [pdf, ocr, word]
		Udførelseskrav	Dokument [pdf, ocr, word]
		Oversigt over placering	Tegning [dwg]
LAND3	Kan vi drifte en xxx	Trafiksikkerhed	Dokument [pdf, ocr, word]
LAND4	100% håndtering af en xxx Projektering egenproduktion	Certifikater	Dokument [pdf, ocr, word]
		Konstruktionstegninger	Tegning [dwg]
		Produktfotos	Foto [jpg]
		Produktspecifikke beskrivelser	Dokument [pdf, ocr, word]

8. Bilagsoversigt

IKT-15a FM skema

7.5 Bygningsstyrelsen - Definitions for technical deliverables for universities

Author: Bygningsstyrelsen Denmark
Language: Danish
original title:
IKT-teknisk afleveringsspecifikation - Universiteter

IKT-teknisk afleveringsspecifikation
Bygningsstyrelsen

Universiteter

Bilag til BYGST IKT Ydelsesspecifikation
Dato 2013-12-19

Projekt:

Byggesag:	Dato:
Projektledelse:	
IKT Leder:	Revision:
	Revision dato:
Modtaget:	
________________________	___________
Underskrift	*Dato*

Indhold:

1. Orientering

Denne *IKT-tekniske afleveringsspecifikation* specificerer den digitale aflevering af D&V-dokumentation og "as built" projektmateriale på byggesagen.

Digital aflevering indeholder aflevering ved byggeriets afslutning

IKT Lederen skal udfylde og vedligeholde *IKT-teknisk afleveringsspecifikation*, herunder indhente bygherrens godkendelse.

Alt materiale afleveres på projektweb og i drift- og vedligeholdelsesdatabase og iht. aftale med bygherren.

2. Stamdata

Stamdata udfyldes af bygherren.

Objekt	Dataindhold		Bemærkninger
Ejendom	Matrikelnummer:		
	Ejerlav:		
	BBR ejendomsnummer:		
	BBR bygningsnummer:		
	BBR kategori:		
Adresse	Adresse:		
	Betegnelse/navn:		
	Bygningsafsnit:		
	BYGST Benk nr.:		
Terræn	Nummer:		
	Betegnelse:		
Sagsoplysninger	Sagsnummer:		
	Sagsnavn:		
Rum	Rumnummer:		
Organisation	Organisationsnummer:		
	Organisationsnavn (Ejer):		
Areal / mængde	Mængdekategori:		
			Tilvalgt
Bygningsdel	Klassifikation	CCS - (Cuneco Classification System)	

3. Digital aflevering.

Bygherre, rådgivere og driftsorganisation fastlægger tidligt i byggeprocessen de data der er relevante til D&V formål og målretter data til driftorganisationens IKT-værktøjer.

Driftsorganisationens afleveringsbilag:

3.1. Datastruktur

Strukturen i den digitale aflevering følger bips A104, seneste revision, eller efter aftale med Driftsorganisationen.

3.1.2. Datamodel for aflevering

Datamodellens relationer følger IFC 2x3 og indeholder som minimum følgende objekter:

Emne	Omfang	Tilvalgt
Bygning		X
Terræn		X
Rum		X
Bygningsdele		x

Anvendes IDM på projektet til brug for aflevering udleveres denne af bygherren.

3.2. Digital aflevering ved faseskift

Aflevering af byggesagens digitale materiale ved faseskift som procesdokumentation.
Indeholder dokumenter og bygningsmodeller.

Der henvises til Bygningsstyrelsens IKT-Ydelsesspecifikation, hvor det i afsnit 3 fremgår af fasemodellen, hvad der skal afleveres i hver fase.

Dokumenter og bygningsmodeller afleveres på projektwebben. Afleveringsfrist iht. byggesagens tidsplan.

3.3. Digital aflevering af byggesag

Aflevering af byggeri omfatter:

- Procesdokumentation
- As built - Produktdokumentation
- Drifts- og vedligeholdsinformation
- Forvaltningsinformationer

3.3.1. Procesdokumentation

Procesdokumentation gældende for hele byggesagsforløbet.
Indeholder dokumenter og eventuelle 3D bygningsmodeller.

Oversigt over dokumentering af byggesagsforløbet

Emne	**Formål**	**Filformat**	**Info. niveau**	**Omfang**
Oversigt over dokumenter				Dokumentliste genereres i projektweb.
Beslutningsreferater				
Ansøgning og tilladelser				
Notater				
Digitale bygningsmodeller				
Dokumenter				
Tegninger				
Andet(beskriv)				

Er projektweb anvendt og struktureret korrekt kan projektwebben indgå som procesdokumentation.

Iht. Bygningsstyrelsens projektwebstruktur d. 01.11.2012 benyttes følgende arkivering:
Procesdokumentation lægges/udgives i mappen *D1 Grundlag*
Godkendt materiale lægges/udgives i mappen *D2 Aflevering*

3.3.2. Drifts- og vedligeholdsinformationer.

Bygherre, rådgivere og driftsorganisation fastlægger tidligt i byggeprocessen de data der er relevante til D&V formål og målretter data til driftsorganisationens IKT-værktøjer.

Der redigeres og tilføjes i nedenstående skema.

Nr.	Dokumenttype	Beskrivelse	Filformat	Afleveres af
0	**Indhold**			
0.1	Indholdsfortegnelse	Samlet dokumentliste over afleveret driftsdokumentation	PDF	Rådgiver/ entreprenør

0.2	Indledning	Beskrivelse af D&V dokumentation	PDF	Udførende	
0.3	Adresse-, telefon-, e-mail- og hjemmesidelister	For entreprenører og leverandører	PDF	Udførende	
1	**Bygningsdele og tekniske anlæg**				
1.1	Anlægsoversigter	Oversigt over de tekniske anlæg	PDF / D&V-system	Udførende/ Rådgiver	
1.2	Datablade for drift og vedligehold pr. bygningsdelstype og teknisk anlæg	Producenten/leverandørens datablade skal som minimum indeholde stamdata for komponenten og krav til vedligeholdelse og udskiftning, periodisk eftersyn samt tiltag og intervaller for almindelig vedligeholdelse.	PDF / D&V-system	Udførende/ Rådgiver	
1.3	Funktionsbeskrivelse	Beskrivelse af de tekniske anlægs opbygning og funktion	PDF / D&V-system	Udførende/ Rådgiver	
1.4	Brugsanvisninger, driftsvejledninger	Brugsanvisninger og driftsvejledninger for bygningsdele og alle tekniske anlæg.	PDF / D&V-system	Udførende/ Rådgiver	
1.5	Specifikationer/fakta	Specifikationer på anvendte komponenter, eksempelvis produktblade indeholdende dimensioner, materialetype, ydelse m.v. for de anvendte produkttyper.	PDF / D&V-system	Udførende/ Rådgiver	
1.6	Reservedels- og komponentlister	Liste over kritiske reservedele til brug for drift og vedligehold	PDF / D&V-system	Udførende/ Rådgiver	
1.7	Rengøringsvejledning	Vejledning i anbefalet rengøringsmetode og materialer mv. Der ønskes kun rengøringsvejledning for samtlige synlige overflader som skal rengøres og hvis der kræves særlig rengøring for at opfylde entreprenørens garantistillelse for den enkelte bygningsdel.	PDF / D&V-system	Udførende/ Rådgiver	
1.8	Garantibeviser	Oversigt over garantibeviser og kopi af de enkelte garantibeviser. Hvis der jf. krav i udbudsmaterialet eller tilbuddet stilles en garanti på den enkelte bygningsdel så skal den fremgå af drifts- og vedligeholdelsesinformationsmaterialet (databladet) for den enkelte bygningsdel og være vedhæftet som fil.	PDF / D&V-system	Udførende/ Rådgiver	
1.9	Garantikrav/mindstekrav til vedligeholdelse	Krav til bygherre for opretholdelse af den stillede garanti på produktet	PDF / D&V-system	Udførende/ Rådgiver	
2	**Rapporter**				
2.1	Indreguleringsrapporter, målerapporter	Projekterede, målte og indstillede værdier	PDF	Udførende	
2.2	Øvrige rapporter	F.eks. fra brandmyndigheder, godkendelse af kantine, levnedsmiddelkontrol m.v.	PDF	Udførende	
3	**Tegninger og bygningsmodeller**				
3.1	Tegningsliste	Samlet tegningsliste over afleverede tegninger	PDF samt rediger-bart format ODF	Rådgiver	
3.2	Hoved- / driftstegninger	Som minimum: - Oversigts- og lokaliseringsplaner	PDF og som CAD-	Rådgiver	

	(as built)	- Etageplaner - Loftplaner - Hovedsnit - Facader - Konstruktionsplaner - Brandplaner - Kloakplan - VVS-planer - Ventilationsplaner - El, føringsvej og tavler, planer - El, lys, planer - El, kraft, planer - El, svagstrøm, planer - El, sikringsanlæg, planer	tegningsfiler i anvendt proprietær format	
3.3	Bygningsudsnit og detaljer	- Bygningsdetaljer - Rumtegninger - Teknikrum - Skakte	PDF	Rådgiver/ entreprenører
3.4	Princip og funktions-diagrammer (as built)	Som minimum for: - Afløb - Brugsvand - Køling - Varme - Ventilation - Hovedledninger - Tavler - CTS	PDF	Rådgiver/ entreprenører
3.5	Arbejds- og produktionstegninger (as built)	Entreprenørens arbejds-, detail- eller supplerende tegninger	PDF og som CAD-tegningsfiler i anvendt proprietær format	Udførende
3.6	Bygningsmodeller (as built)	Fællesmodel og fagmodeller	IFC samt original format	Rådgiver/ entreprenør
4	**Beregninger**			
4.1	Oversigt	Oversigt over beregninger der er relevante for byggeriet (fra rådgiver og entreprenør) – både dem som er indsendt til myndigheder og øvrige – f.eks. akustik, belysning mv.	ODF	Rådgiver
4.2	Rådgiverberegninger	Rådgivers beregninger, se pkt. 4.1	ODF	Rådgiver
4.3	Entreprenør-beregninger	Entreprenørens beregninger, se pkt. 4.1	PDF	Udførende
5	**Øvrig dokumentation**			
5.1	Byggesags-beskrivelser	Fra udbudsmaterialet	PDF	Rådgiver
5.2	Arbejdsbeskrivelser	Fra udbudsmaterialet	ODF	Rådgiver
5.3	As-built fotos/videos	Fotodokumentation af udførelsen (fra fagtilsyn mv.) herunder også TV-inspektion af afløbsledninger	PDF / original format	Rådgiver/ Udførende
5.4	Mangellister	Mangellister fra afleveringer	PDF	Rådgiver/ Udførende

3.3.3 As built – produktdokumentation

Digital dokumentation af det opførte byggeri.
As built dokumentationen afleveres digitalt til bygherren, og vil – medmindre andet er specificeret – bibeholde den struktur, der har været gældende under projektforløbet.
Projektledelsen udarbejder en oversigt over de dokumenter, der indgår i produktdokumentationen.

"As built" dokumentation afleveres i informationsniveau 4-6, svarende til *bips C202, CAD-manual 2008.*

Emne	**Formål**	**Filformat**	**Info. niveau**
Oversigt over produktinformation			
Byggesagsbeskrivelse			
Arbejdsbeskrivelser			
Ansøgninger og tilladelser			
As built tegninger Detailtegninger og diagrammer.			
CAD tegningsfiler			
Digitale bygningsmodeller		IFC samt originalt format	
Mangellister			
Arealer			
Andet			

3.3.4 Forvaltningsinformationer

Informationer for ejendomsadministration og økonomistyring.

Emne	**Formål**	**Filformat**	**Info. niveau**	**Omfang**
Energi – og driftsbudgetter.				
Kort & Matr.				
BBR				
Arealer				
Rumskema				
As built tegninger				
3D bygningsmodel		IFC samt originalt format		
Andet				

4. Afleveringsform

Dokumenter og datamodeller af byggesagens aflevering, afleveres på projektweb og til institutionens/lejers driftsdatabase < *navn* >.
Dokumenter afleveres i de mapper som angivet i strukturen for projektweb.

Bygningsmodellen afleveres som fag – og fællesmodeller i udvekslingsformat IFC 2x3 og i originalformat.

Aflevering af D&V - data fra de *udførende* foretages via projektwebben iht. den i projektet anvendte struktur.

Projekteringsledelsen og IKT ledelsen tilser at data bliver kvalitetssikret, og at data overdrages samlet eller i etaper til bygherren på projektweb.
Ved aflevering i etaper foretages denne ved etaper: A, B og C af dato XXXXXX eller overdrages dato: XXXXXX.

Adresse på projektweb til aflevering af forvaltningsdata: <   >

5. Procedure for digital aflevering

Aflevering af data skal foregå i følgende trin.

	Opgave	**Ansvar**	**Tidsfrist (jf. tidsplan)**
1	Specifikation af krav og ønsker til D&V-dokumentation		
2	Levering af stamdata		
3	Tilrettelægge aflevering af D&V-dokumentation		
4	Godkendelse af D&V og KS		
5	Aflevering af procesdokumentation		
6	Aflevering af D&V-dokumentation		
7	Aflevering af as-built dokumentation		
8	Aflevering af forvaltningsinformationer		
9	KS af entreprenørens aflevering		
10	Overdragelse til bygherren		
11	Granskning		
12	Andet		

6. Mangellister

Der anvendes digitale mangellister.
Mangellister udarbejdes, revideres og distribueres i henhold til *bips U104, seneste revision.*
Mangellister afleveres på projektweb.

7.6 Questionnaire

7.6.1 Introduction

Software Vendors General:
Questionnaire Sustainable Building Information Workshop 12. November 2014 - Copenhagen
This questionnaire intends to collect information about all people partaking in participants

Facility Maintenance / Building Owner:
DURAARK Questionnaire
This questionnaire intends to collect information about the state of the art and the direction of Building information-related facility management systems

Cultural Heritage:
DURAARK Stakeholder - Cultural Heritage and Research
The goal of this survey is to collect information on how cultural heritage and research institutions currently process and store architectural data and how they envision those processes to change in the future. The results of the questionnaire will be used by the DURAARK project in tailoring developed methods and tools towards the stakeholders' needs.

7.6.2 Information on Participant

Question 1:
Software Vendors / General; Cultural Heritage: Please provide a description of your organization
Facility Maintenance / Building Owner: Please provide a description of your organizations engagement with building profession

Question 1a *(multiple choice)*:
Software Vendors / General; Cultural Heritage: Type of organization (multiple answers possible):
Facility Maintenance / Building Owner: Please provide a description of your organizations engagement with building profession
All:

- building owner / facility maintenance
- architecture
- engineering
- construction company
- research institution
- government / public administration
- cultural heritage
- building industry-related consultant / software development
- other

Question 1b *(free text)*:
Software Vendors / General; Cultural Heritage: What is your role within the organization
Facility Maintenance / Building Owner: Who are you typically talking to in this organization

Question 1c *(free text)*:
Software Vendors / General; Facility Maintenance / Building Owner: What is the position in the market or institutional environment of your country?
Cultural Heritage: What is your organization's position in the market or institutional environment of your country?

Question 1d *(chosen one)*:
All: Approx. number of Employees

- 1-5
- 5-10
- 10-20
- 20-50

- 50-100
- $>$ 100

Question 1e*(chosen one)*:
Software Vendors / General; Facility Maintenance / Building Owner: Approx. number of projects / clients per year
Cultural Heritage: Approx. number of internal or external projects or producers (e.g. digitization projects, external customers such as universities) who deposit data with your institution per year
All:

- 1-5
- 5-10
- 10-20
- 20-50
- 50-100
- $>$ 100

Question 1f*(free text)*:
All: What is your annual turnover (if commercial)

7.6.3 Processes

Cultural Heritage: *Overall Archival Processes*

Question 2:
Software Vendors / General; Cultural Heritage: Please provide some information about the data you hold.
Facility Maintenance / Building Owner: Please provide some information about the data your systems are involved in

Question 2a*(chosen one)*:
All: What is the approx. overall size of your institution's digital holdings?

- < 1 TB
- 1-10 TB
- 11-100 TB
- 101 TB - 1 PB
- > 1 PB

Question 2b *(free text)*:
Software Vendors / General: What is the relation between 3D and 2D information in your data?
Facility Maintenance / Building Owner; Cultural Heritage: What is the relation between 3D and other information in your data (approx, in %)?

Question 2c *(combined multiple choice, chosen one, free text)*:
All: What types of data do you work with? Please specify the original format and how often your system accesses the data (for example: 2d data, 3d models, 3d scans, BIM models, technical datasheets, product sheets,. . .) (multiple answers possible)

- 2D Data; often / sometimes / rarely; formats
- 3D models; often / sometimes / rarely; formats
- 3D scans; often / sometimes / rarely; formats
- BIM models; often / sometimes / rarely; formats
- technical data sheets; often / sometimes / rarely; formats
- product sheets; often / sometimes / rarely; formats
- others; often / sometimes / rarely; formats

Question 2d *(free text)*:
All: How big are the individual files you are dealing with (approx. size in MB or GB)?

Question 3:
Software Vendors / General; Facility Maintenance / Building Owner: Please describe the IT system and processes that you are using to store building-related data.
Cultural Heritage: Please describe the IT system and processes that you are using to store data, including building-related / architectural data:

Question 3a ***(chosen one)*****:**
All: What description best fits your system?

- in-house server-based commercial solution
- in-house server-based commercially tailored solution (built by a vendor to your needs)
- cloud-based system with online interface
- **Software Vendors / General; Facility Maintenance / Building Owner:** self-created solution
- **Cultural Heritage:** self-created / bespoke solution
- Others

Question 3b ***(free text)*****:**
Software Vendors / General: Please name your commercial system (e.g. NextFM, Dalux, dRofus,...) or briefly describe your self-created solution:
Facility Maintenance / Building Owner: Please name the system your solution is based (i.e. SQL) or briefly describe your self-created solution:
Cultural Heritage: Please name your commercial system (e.g. Rosetta, Preservica, archivematica, NextFM, Dalux, dRofus,...) or briefly describe your self-created solution:

Question 3c ***(multiple choice)*****:**
All: How do you as a user interact with the system?

- web interface
- client side software
- data is exported and delivered to user

- **Software Vendors / General; Facility Maintenance / Building Owner:** others
- **Cultural Heritage:** other method

Question 3d*(chosen one)*:
All: How Does your system archive building data (3D, 2D) or do you move it to a different system for that? "'Archiving"' here means to store data over the long-term.

- yes, the data remains in the system over the long-term
- no, the data is moved out of the system and stored elsewhere for the long-term
- no, the data is eventually deleted out of the system
- unsure

Question 3e*(chosen one)*:
All: Does the "‘archiving"' functionality differ from the regular storage / operational system?

- Yes
- No
- unsure
- If "yes", please describe how

Question 3f *(multiple choice)*:
Software Vendors / General; Cultural Heritage: Who is using your system inside and outside your organization?
Facility Maintenance / Building Owner: Who is using your system when deployed in an organization?

- **Software Vendors / General; Cultural Heritage:** Specialists within my team
- **Facility Maintenance / Building Owner:** Specialists within their team

- **Software Vendors / General; Cultural Heritage:** certain departments in your organization
- **Facility Maintenance / Building Owner:** certain departments in their organization
- **All:** the entire organization
- **Software Vendors / General; Cultural Heritage:** certain users / external organizations outside my organization
- **Facility Maintenance / Building Owner:** certain users/external organizations outside their organization"
- **All:** the public (www)
- **All:** not applicable
- **All:** others

Question 3g *(multiple choice)*:
Software Vendors / General; Cultural Heritage: If companies outside your organization are using your system, do you (multiple answers possible):
Facility Maintenance / Building Owner: If multiple companies are using the system, do you (multiple answers possible):

- **All:** host the system for external users as a service
- **Software Vendors / General; Cultural Heritage:** offer access to users who have a system installed in their own IT
- **Facility Maintenance / Building Owner:** install the system at a client in a way that third parties can access it

Question 3h *(multiple choice)*:
Software Vendors / General; Facility Maintenance / Building Owner: What are typical data workflows within your organization's IT systems concerning building data?
Cultural Heritage: What are typical data workflows within your organization's IT / archiving systems concerning (building) data? (multiple answers possible)

- Software Vendors / General; Facility Maintenance / Building Owner: ingest new building data into your system
- **Cultural Heritage:** ingest new data into your system
- **All:** create tags, descriptors and metadata for the ingest
- Software Vendors / General; Facility Maintenance / Building Owner: maintain buildings and building data
- **Cultural Heritage:** maintain data by updating semantic information, e.g. descriptive metadata
- **Cultural Heritage:** maintain data by updating technical information, e.g. file format information
- **Software Vendors / General; Facility Maintenance / Building Owner:** maintain the integrity of the building data
- **Cultural Heritage:** maintain the integrity of the data
- **Software Vendors / General; Facility Maintenance / Building Owner:** gather and process data to prepare and decide on major tasks in and on buildings (i.e. renovation/retrofitting)
- **Cultural Heritage:** for building data: gather and process data to prepare and decide on major tasks connected to the buildings described in the data (i.e. renovation/retrofitting)
- **All:** others not mentioned here

Question 3i ***(free text)*****:**
Software Vendors / General; Cultural Heritage: How much time is (roughly) needed to maintain your digital archive?
Facility Maintenance / Building Owner: How much time is (roughly) needed to maintain their digital archive?

Cultural Heritage: *3D Archival Processes*

Question 4:
Software Vendors / General: Please tell us something about the ingest processes - who produces the data and how is it deposited into your system?
Facility Maintenance / Building Owner: Please tell us something about the ingest processes - who produces the data and how is it usually deposited into your systems?
Cultural Heritage: Please tell us something about the ingest processes - who produces the 3D data in your holdings and how is it deposited into your system?

Question 4a *(multiple choice)*:
Software Vendors / General; Cultural Heritage: From which external parties do you receive 3D data (multiple answers possible)? Facility Maintenance / Building Owner: From which external parties do your clients typically receive 3D data (multiple answers possible)?
All:

- Land surveyors
- Companies producing scans
- Municipalities
- Architects
- Contractors 3D description for tender or production
- We don't receive 3D data from external parties
- Others

Question 4b *(multiple choice)*:
Software Vendors / General; Cultural Heritage: If you accept 3D data from external producers, do you have guidelines for the data you accept? (multiple answers possible)
Facility Maintenance / Building Owner: If your clients accept 3D data from external producers, do they have guidelines for the data you accept? (multiple answers possible)
All:

- No guidelines available

- unsure
- Yes, guidelines on metadata (e.g., specific set of descriptive data needs to be supplied)
- Yes, guidelines on data formats (e.g., only certain data formats accepted)
- Yes, guidelines on data carriers / transfer (e.g., only transfer on CD-R accepted)
- Others

Question 4c *(free text)*:
Software Vendors / General; Cultural Heritage: Please describe in some keywords the process of treating 3d data for use in your system/ storage, after it is received/ generated?
Facility Maintenance / Building Owner: Please describe in some keywords the process of treating 3d data for use in their system/ storage, after it is received/ generated?

Question 4d *(free text)*:
All: How much time is (roughly) needed to do this ingest of an asset into your system?

Question 4e *(multiple choice)*:
All: Please describe how the building-related data is indexed and which metadata are created within your processes?

- **Software Vendors / General:** we do not index the data we receive (i.e. storage in folder system on server)
- **Facility Maintenance / Building Owner:** users do not index the data we receive (i.e. storage in folder system on server)
- **Cultural Heritage:** we do not index / describe the data we receive (i.e., storage in folder system on server)
- **Software Vendors / General:** we have our own index for the system
- **Facility Maintenance / Building Owner:** users have their own index for the system

- **Cultural Heritage:** We have our own index adapted from standards (i.e Denmark: cuneco)
- **Software Vendors / General:** we have our own index for the system
- **Facility Maintenance / Building Owner:** user have their own index adapted from standards (i.e Denmark: buildingSMART, cuneco)
- **Cultural Heritage:** we have our own index / metadata system adapted from standards (i.e., Cultural Heritage Domain: Dublin Core, CARARE; AEC domain Denmark: cuneco)
- **Software Vendors / General:** we use standard indexes
- **Facility Maintenance / Building Owner:** they use standard indexes
- **Cultural Heritage:** we use standard metadata schemas / indexes
- **All:** others

Software Vendors / General; Cultural Heritage: if you use / adapt standards, which?
Facility Maintenance / Building Owner: if they use / adapt standards, which?

Question 4f*(chosen one)*:
Software Vendors / General; Cultural Heritage: Is this index used coherent across your organization?
Facility Maintenance / Building Owner: Is this index used coherent across their organization?
All:

- Yes
- No

Question 4g*(chosen one)*:
Software Vendors / General: Is the index linked to outside systems/ontologies?
Facility Maintenance / Building Owner; Cultural Heritage: Is the index / metadata schema linked to outside systems/ontologies? (as for instance SENESCHAL, the

buildingSMART Data Dictionary (bSDD), or public catalogues of for instance national classification systems?
All:

- Yes
- No
- If 'yes' which

Question 5:
Software Vendors / General; Cultural Heritage: Please tell us something about your access processes
Facility Maintenance / Building Owner: Please tell us something about the access processes you system(s) provide

Question 5a *(multiple choice)*:
All: Who accesses the data?

- **Software Vendors / General; Cultural Heritage:** Specialists within your team
- **Facility Maintenance / Building Owner:** Specialists within teams
- **Software Vendors / General; Cultural Heritage:** certain departments in your organization
- **Facility Maintenance / Building Owner:** certain departments in client organization
- **All:** the entire organization
- **Software Vendors / General; Cultural Heritage:** certain users/external organizations outside your organization
- **Facility Maintenance / Building Owner:** certain users/external organizations outside their organization
- **All:** the public (www)
- **All:** not applicable
- **All:** others

Question 5b *(multiple choice)*:
All: For what reason is the data accessed?

- Management of buildings (FM)
- Update/ change of building data
- planning of retrofitting of existing building stock
- planning of new buildings / addition to existing building stock
- presentation / information about buildings to external persons/organsiations
- assessment (security, fire, usage, energy) of existing building stock
- others

Question 5c *(multiple choice)*:
Software Vendors / General; Cultural Heritage: How old is the archived data you typically need to access? (multiple answers possible)
Facility Maintenance / Building Owner: How old is the archived data they typically need to access? (multiple answers possible)
All:

- Up to 1 year
- 1-3 years
- 3-5 years
- 5-7 years
- 7-10 years
- 10-15 years
- Older than 15 years

Question 5d *(multiple choice)*:
All: For what purposes does access to archived data occur? (multiple answers possible)

- Active reuse of data for the same object / projects
- Active reuse of data for other objects / projects
- Viewing only (e.g., for reference reasons)
- Later inquiries by building owners
- Legal reasons
- Preservation of the cultural heritage
- Others

7.6.4 Future developments/expectations

Question 6:
Software Vendors / General; Cultural Heritage: Please tell us something about how you see future developments of your workflows and of ways you would like to access the data.
Facility Maintenance / Building Owner: Please tell us something about how you see future developments of the professions workflows and of ways data will be accessed.

Question 6a*(chosen one)*:
Software Vendors / General; Cultural Heritage: Do you use or will use catalogues, vocabularies or libraries (as for instance Getty AAT or the buildings smart data dictionary) from external sources to index your data?
Facility Maintenance / Building Owner: Do users will engage with catalogues or libraries (as for instance the buildings smart data dictionary) from external sources to index your data?
All:

- yes, already in use
- yes, planning to use
- no plans to use

- unsure

Question 6b ***(free text)*****:**
Software Vendors / General; Cultural Heritage: In case you will provide public access via the web to your stored building data, which parts of the building-related data would be still need to be non-public?
Facility Maintenance / Building Owner: In case your system (will) provide public access via the web to your stored building data, which parts of the building-related data would be still need to be non-public?

Question 6c ***(free text)*****:**
Software Vendors / General; Cultural Heritage: What are the "'go's"' and "'no-go's"' criteria to use an external service provider?
Facility Maintenance / Building Owner: What are the "'go's"' and "'no-go's"' criteria to use an external service provider (e.g., encryption, privacy laws in the respective country, data availability, backup, etc.)?

Question 6d ***(free text)*****:**
All: Building-related information is seemingly offered online (i.e. product catalogues, Building Smart Dictionary). Do you see your organization linking your system to this data? What would be the main benefit for your organization in doing so and what has to be overcome in order to get there?

Question 6e ***(free text)*****:**
All: What would be your dream scenario when it comes to the handling of building-related data?

7.6.5 Cultural Heritage: Comments

Additional question ***(free text)*****:**
Cultural Heritage: Anything else you would like to share with us about existing processes, problems or expectations in archiving 3D data?