DURAARK - ENRICHING BIM AND POINT CLOUD DATA FOR THE USE IN BUILDING LIFECYCLES

28. MAY 2015 - LISBON- GEOSPATIAL WORLD FORUM - GEOBIM
CITA: Bridging Digital Design and its materialisation

http://cita.karch.dk
3D is ubiquitous in the Building profession - BIM
DENMARK
SINCE 2007: BIM DEMANDED FOR PUBLIC BUILDINGS

- State >2,5 mio Euro => BIM
- Municipalities >0,7 mio Euro => BIM

- Competition phase demands 3D model (IFC)
- Digital exchange of information via project web
- Quantity take-off from IFC model
- Digital handover of facility management information regutaed through Information and Communication Technology contracts (ICT-contracts)
UNITED KINGDOM
FROM 2016:

“...The UK Government has mandated that all public projects in the UK will be delivered using BIM by 2016. This is driving the private sector to adopt Building Information Modelling processes, which is now becoming a common requirement for all major projects....”
<table>
<thead>
<tr>
<th>Stakeholder - Interviews, Workshops, Datasets</th>
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<tbody>
<tr>
<td><strong>Architects</strong></td>
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<tr>
<td>Krydsrum Arkitekter (DK)</td>
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<td>Zeso Architects (DK)</td>
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<td>BIPS (DK)</td>
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<td>KRH (DK)</td>
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<td>DTU (DK)</td>
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<td>LE34 (DK)</td>
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<td>Plan3D (DE)</td>
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<td>COWI (DK)</td>
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<td>HCU Hamburg (DE)</td>
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<td>ATS (SE)</td>
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<td>FARO (DE)</td>
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<td>Bygningstyrelsen (DK)</td>
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<td>Copenhagen Properties (DK)</td>
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<td>Danish Technical University (DK)</td>
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<td>Bane Danmark (DK)</td>
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<td>Lufthavn København (DK)</td>
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<td>NTNI (DK)</td>
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<td>DSV (DK)</td>
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<td>Falun Kommun (SE)</td>
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<td><strong>Fortifikationsverket (The Swedish Fortifications Agency) (SE)</strong></td>
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<td><strong>Statens fastighetsverk (The National Property Board of Sweden)</strong></td>
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<td><strong>Statsbygg (NO)</strong></td>
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<td><strong>Direktoratet for byggkvalitet in Norway (NO)</strong></td>
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<td><strong>Contractors in the Netherlands (NL)</strong></td>
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<td><strong>Rijksgebouwendienst (NL)</strong></td>
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<td><strong>Dalux (DaluxFM)</strong></td>
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<td><strong>NTI (Mdoc / MdocFM)</strong></td>
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<td><strong>Catenda (NO)</strong></td>
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<td><strong>dRofus</strong></td>
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<td><strong>NExtFM (NL)</strong></td>
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<td><strong>Mainmanager (Is)</strong></td>
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<td><strong>Think project (DE)</strong></td>
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<td><strong>Building Owners</strong></td>
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<td><strong>National Archive of the Netherlands</strong></td>
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<td><strong>Statsbiblioteket - State and University Library, Aarhus (DK)</strong></td>
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<td><strong>Flemish Architecture Archive (NL)</strong></td>
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<td><strong>Riksarkivet (The National Archives) (SE)</strong></td>
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<td><strong>Riksantikvaren Norway (NO)</strong></td>
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<td><strong>Arkivverket (NO)</strong></td>
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<td><strong>Aarhus City Archive (DK)</strong></td>
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<td><strong>Cultural Heritage Institutions</strong></td>
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</table>
Life-cycle of BIM models

- Planning
- Production
- Operation / Archiving

Roles:
- Engineers
- Architects
- Land Surveyors
- Construction Companies
- Building Owners
- Cultural Heritage Institutions
Construction Engineer
BIM model

Owner/developer

Project Web

MEP Engineer
BIM model

Architect
BIM model

Lund Cristallen by DURAARK partner CCO architects

Building Practice with BIM in Denmark
Building Data in the Operational Phase of a building is a “live object”

- New building related data is constantly generated (and old data overwritten)
- Stakeholders consider a FM system as archive
- Stakeholders see a challenge to keep building data up to date

Source Dalux FM
Life-cycle of BIM models
Life-cycle of BIM models in relation to lifetime
Change of data during operational phase of building
Evolution of building data
Future Re-use of Building Data
• How to find the right information?
• How to trust the information?
• How to use the information?
DURAARK (Durable Architectural Knowledge) is a collaborative project developing methods and tools for the semantic enrichment and long-term preservation of architectural knowledge and data. It is funded through the European Commission’s FP7 Programme and is running between 02/2013 — 01/2016. www.duraark.eu
Architectural Data in DURAARK

BIM/IFC

Scan/E57

Image
Connecting and Compare
Motivation: Enrich Architectural data, preserve meaning
Integration of Data into Design & Retrofitting Workflow

Geo Data

Linked Data Cloud

Neue Heilanstalten Berlin / Architekt: Ludwig Hoffmann 1900-1914
DURAARK Longterm Archiving system

As-planned BIM BIM software
As-built Point Cloud scanner | point software
Enriched BIM with Point Cloud BIM software

Search & Retrieve
Comparison Point Clouds and BIM in time
Δt1,t2

Preservation System
Long time archive

SIP Container

DURAARK Workbench UI + Service Platform
Restful Interface, Docker

Semantic Digital Archive
Organize, archive, expose

Metadata extraction and enrichment

BIM from Point Clouds

Difference Detection as-built <-> as-planned

As-planned BIM

BIM software

http://workbench.duraark.eu

DURAARK

Semantic Digital Observatory
crawl, link, align

http://workbench.duraark.eu

Martin Tamke (CITA) / Copenhagen
Objects - Properties - Machine Search in 3d Model
Search: Semantic Web technology

Now... *that* should clear up a few things around here

© Horrocks, Oxford University
Linking Data - World Wide Web - Linked Open Data Cloud
Semantic Digital Archive (SDA) consists of three components:

1. Meta Data Extraction and Semantic Enrichment

   - Industry Foundation Classes (IFC), STEP Physical File Format (SPFF)
   - created with native BIM Software (e.g. ArchiCAD, Nemetschek, Revit)
SDO: Crawling relevant data sets for enrichment
Existing models and vocabularies

Connectedness

Specific to the Built Environment

Semantic Digital Observatory
crawl, link, align

DBpedia

yago
select knowledge

Linked Open data
GETTY VOCABULARIES

freeclasseu
Die freie Klassifikationsstruktur

Connectedness

Specific to the Built Environment

Existing models and vocabularies
Semantic Digital Archive (SDA) consists of three components:

1. Meta Data Extraction and Semantic Enrichment
   - Extract meta data from E57 and IFC files submitted to the archive.
   - Enrich by curator and automated methods

2. Semantic Digital Observatory (SDO)
   - Discover relevant data sets for semantic enrichment
   - Cluster similar data based on initial seed list

<table>
<thead>
<tr>
<th>Named Entity</th>
<th>Disambiguated DBPedia URI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower 185</td>
<td>dbp:Tower_185</td>
</tr>
<tr>
<td>Fountain Place</td>
<td>dbp:Fountain_Place</td>
</tr>
<tr>
<td>1540 Broadway</td>
<td>dbp:1540_Broadway</td>
</tr>
<tr>
<td>US Bank Tower</td>
<td>dbp:US_Bank_Tower</td>
</tr>
<tr>
<td>Die Pyramide</td>
<td>dbp:Die_Pyramide</td>
</tr>
<tr>
<td>One America Plaza</td>
<td>dbp:One_America_Plaza</td>
</tr>
<tr>
<td>777 Tower</td>
<td>dbp:777_Tower</td>
</tr>
<tr>
<td>Mellon Bank Center</td>
<td>dbp:Mellon_Bank_Center</td>
</tr>
<tr>
<td>One Worldwide Plaza</td>
<td>dbp:One_Worldwide_Plaza</td>
</tr>
<tr>
<td>Comcast Center</td>
<td>dbp:Comcast_Center (Philadelphia)</td>
</tr>
<tr>
<td>Museum Tower</td>
<td>dbp:Museum_Tower (Dallas)</td>
</tr>
<tr>
<td>Two Prudential Plaza</td>
<td>dbp:Two_Prudential_Plaza</td>
</tr>
<tr>
<td>Enterprise Plaza</td>
<td>dbp:Enterprise_Plaza</td>
</tr>
<tr>
<td>Thanksgiving Tower</td>
<td>dbp:Thanksgiving_Tower</td>
</tr>
<tr>
<td>Acn Center</td>
<td>dbp:Acn_Center (Chicago)</td>
</tr>
<tr>
<td>Tower Life Building</td>
<td>dbp:Tower_Life_Builder</td>
</tr>
<tr>
<td>900 North Michigan</td>
<td>dbp:900_North_Michigan</td>
</tr>
<tr>
<td>Chrysler Building</td>
<td>dbp:Chrysler_Building</td>
</tr>
<tr>
<td>One Museum Park</td>
<td>dbp:One_Museum_Park</td>
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</tbody>
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<tr>
<th>Relevant Candidate Entity</th>
<th>Cosine Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbp:Renaissance_Tower</td>
<td>0.1566</td>
</tr>
<tr>
<td>dbp:Nicholas_Tower</td>
<td>0.1169</td>
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<tr>
<td>dbp:38_Hudson_Street</td>
<td>0.1143</td>
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<tr>
<td>dbp:Alcide_de_Gasperi_Building</td>
<td>0.0945</td>
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<tr>
<td>dbp:Nebraska_Township_Livingston_County_Illinois</td>
<td>0.0897</td>
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<tr>
<td>dbp:Hotel_des_Indes (Batavia)</td>
<td>0.0606</td>
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<tr>
<td>dbp:Recordando_Otra_Vez</td>
<td>0.0582</td>
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<tr>
<td>dbp:Eric_Bloom</td>
<td>0.0461</td>
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<tr>
<td>dbp:Eastern_State_Penitentiary</td>
<td>0.0407</td>
</tr>
<tr>
<td>dbp:Inez_Courtney</td>
<td>0.0353</td>
</tr>
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   - Discover relevant data sets for semantic enrichment
   - Cluster similar data based on initial seed list
   - Allow manual validation of discovered links through crowdsourcing

3. Semantic Digital Archive Storage (SDAS)
   - Store meta data of archived content and expose as Linked Data

http://mimas.cvg.tugraz.at/search
Semantically Poor and Rich Data
3D is ubiquitous - Faster and Automated
Global Time allocation for creation of Architectural Data from 3D Laserscans

Why Automatic Detection Of Semantic Information?
Automatic Reconstruction - Point Cloud to BIM
Here we show some comparisons of the reconstructed model and the point cloud.
Semantically enriched Point Cloud

Surplus - Properties of Spaces / Room Connectivity
Definition of Spaces (use in Facility Management)
Definition of Connections: Search in Graph
Integration of Point Cloud data in the IFC schema
• Submitted to buildingSMART for standardization

Implementation of Semantic capabilities into the iFC Schema (BIM)
• buildingSMART linked data working Group (Jacob Beetz TUE)

The future of BIM is semantic
• How to find the right information?
• How to create trust into the information?
• How to use the information?
Point Cloud Analysis (Deviation & Difference)
Semanticaly aware Difference Detection
DURAARK Prototype - Semantic Difference Detection

source: Statsbyg Risløkka
Building and Building Data Lifecycle

• How to find the right information?
• How to create trust into the information?
• How to use the information?
Prototype Evaluation in Architectural Workflows
Current manual Approach
Measured during Nygade Use Case with Zeso Architects

- Manual Measurements: 12h
- Registration of materials and object classification: 4h
- BIM Modelling: 25h

Total: 41h

WP7 Duraark Prototype workflow

- LaserScanning: 9h
- Point cloud post-processing & registration: 12h
- Reconstruction of BIM model: 1h
- Manual Adjustment of model to drawing conventions: 4h
- Registration of materials and object classifications: 4h
- Quality Control with Difference-Analysis: 0.1h

Total: 30h

Use Case Nygade / Copenhagen with Zeso Architects - 107 Scans
Find more data

Detecting Information through combination of Approaches
DURAARK component: Reconstruction of Geometry
Projection & Orthophotogeneration
Detection of electrical appliances
Supervised Learning on generated Orthophotos
Referencing of detection in 3d Model
Comparing As Built - Difference Detection
Find Deviations - Geometrical or over Time
Automatised Detection of Architectural Meaning
Find Deviations - Geometrical or over Time
Prototype Evaluation with Stakeholders

LE 34 / Facade / Copenhagen

Statsbyg / Rikslokka / Oslo

Plan 3D / Haus 30 / Berlin

Zeso Architects / Nygåde / Copenhagen

LE 34 / Højbro Plads / Copenhagen

Hotel Nyborg Strand / Nyborg Strand

KADK / Diakonissenstiftelsen / Copenhagen
CITA Research Method - Demonstrators
3D Registration - Laser Scanning