



Digital preservation of information models for the built environment - *an overview of the DURAARK project & preservation of semantically enriched BIMs*



Technische Universiteit
Eindhoven
University of Technology

Jakob Beetz (Eindhoven University of Technology, NL) & DuraArK consortium



DURAARK
DURABLE
ARCHITECTURAL
KNOWLEDGE



Nature

[Air, ground, water]

Society

[Individuals, Groups, Users, Creators]

Governance

World > Country > State > Region > Municipality > Plot

small
fine
[mm]

Infrastructure [Energy, Transport, Water, Communication, Waste]

Linear > Node > Facility

big
coarse
[km]

Building

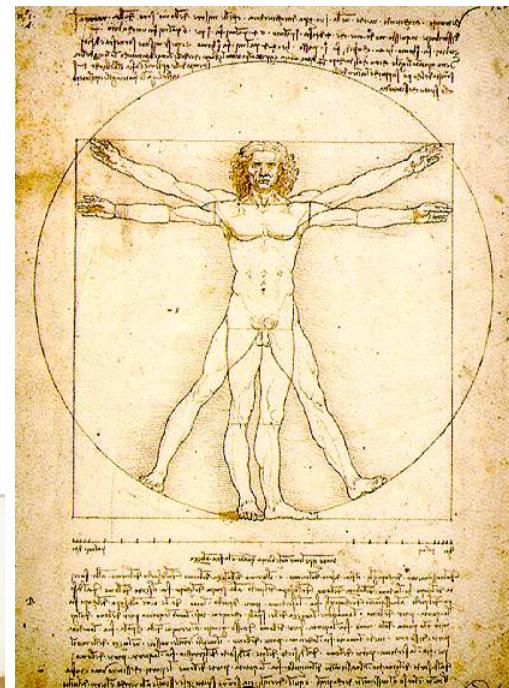
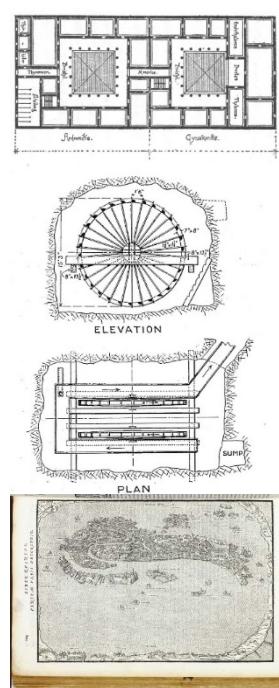
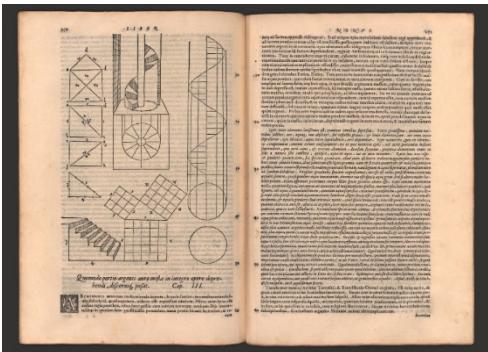
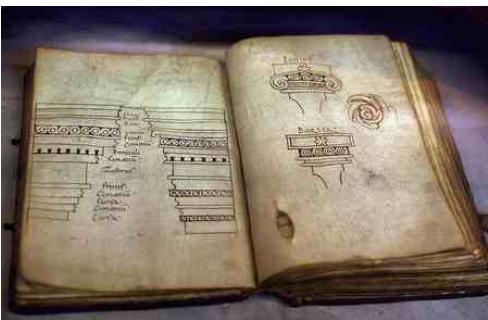
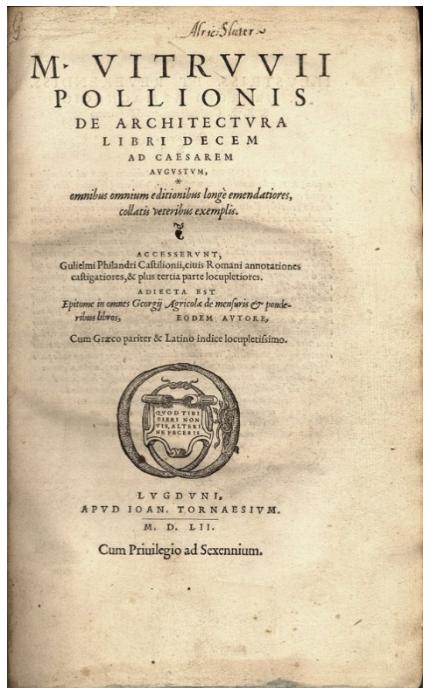
Building > Storey > Space > Element > Component
Infrastructural construction > Structure > Building Element > Component

GIS

Infra

BIM

Building Information - the spectrum



Building Information - then

Master Builder

Building Information - in the meantime

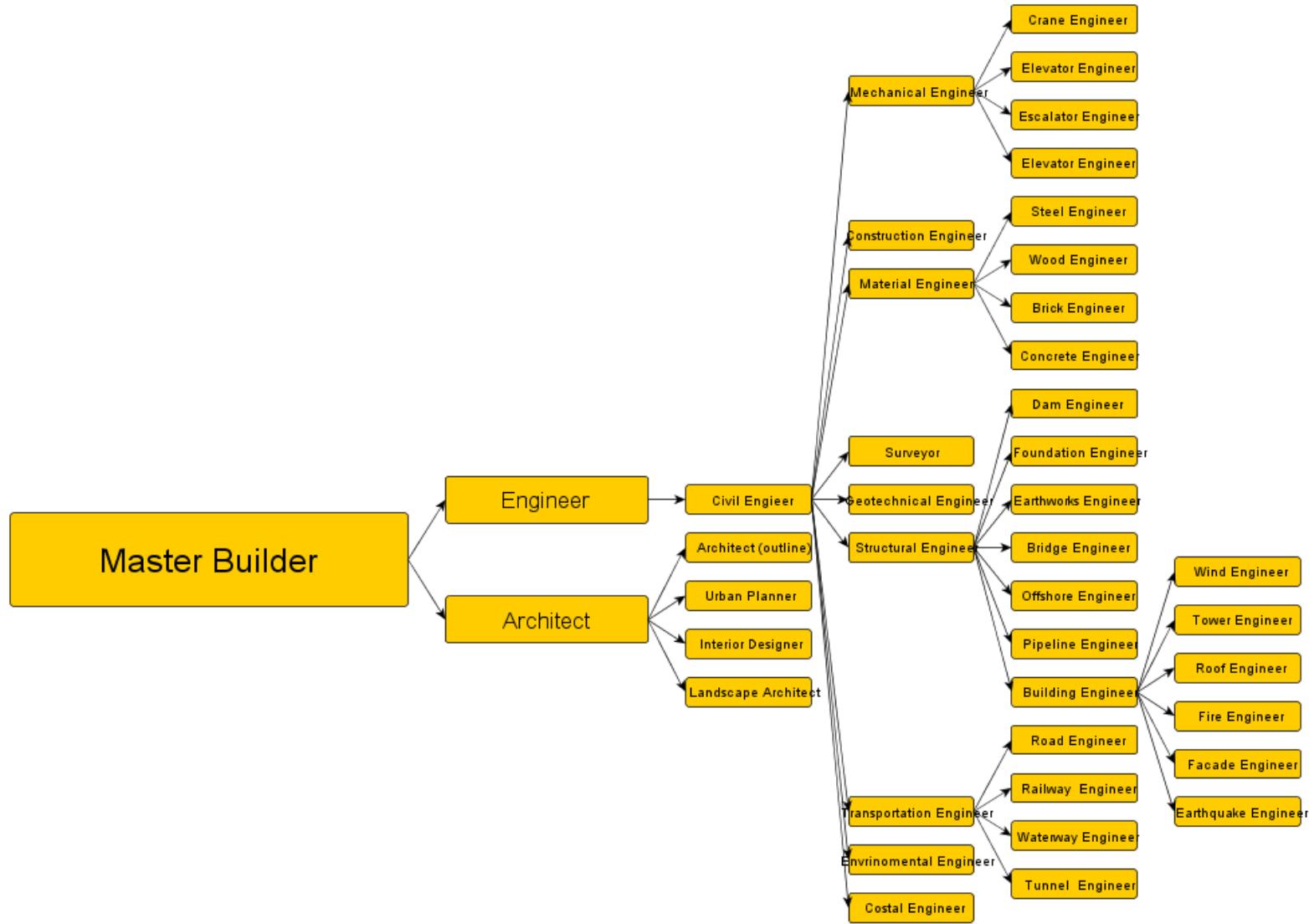


DURAARK
DURABLE
ARCHITECTURAL
KNOWLEDGE





Building Information - in the meantime



Relevance

- Approx 30% of energy use goes into building

[AIE, 2009]

Diversity

- Building stock in EU: ca. 40 % pre-1960, 42 % 1960-1990, 18% post 1990

[BPIE, 2011]

Fragmentation and heterogeneity

- 11 million jobs, 2 million companies
- 93% of companies less than 10 employees
- Only 100 companies with more than 2000 employees

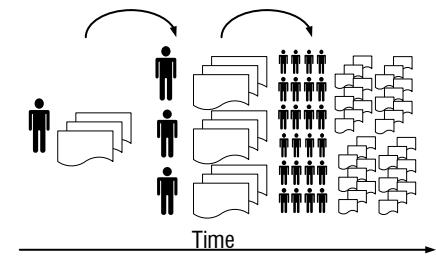
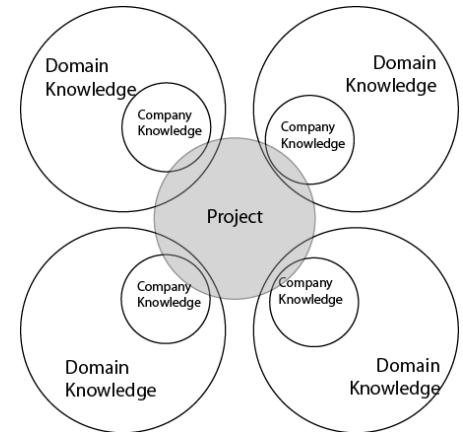
[EU in 2000, Kiviniemi]

- Often more than 200 actors and domains involved

Inefficiency

- \$ 15,4 Billion loss *per year* for *capital facilities alone* in the US due to interoperability and communication issues

[NIST: Gallaher et al, 2004]



Characteristics of the building sector

Building Information Modeling (BIM): Covering the complete lifecycle of a building

- design drafts
- design development
- construction documentation
- production
- documentation of the current condition
- building operation



Building Information - Today

3D CAD

- Geometry along X-Y-Z axes



4D CAD

- Schedule time



5D CAD

- Cost-related information



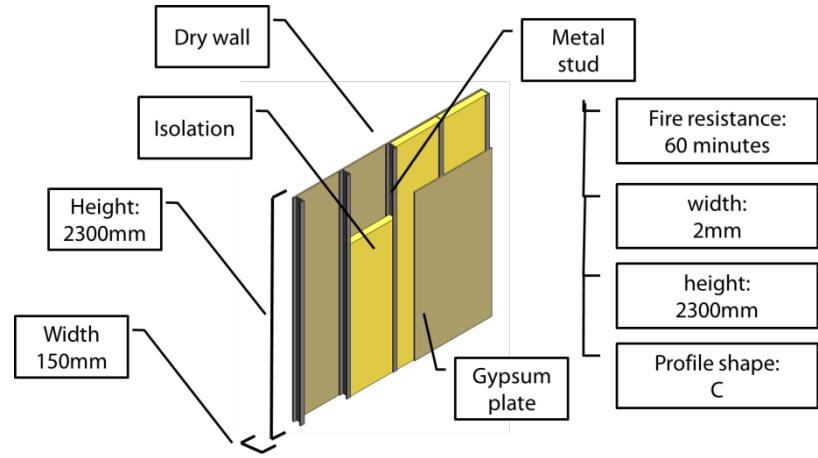
6D CAD

- Energy and sustainability

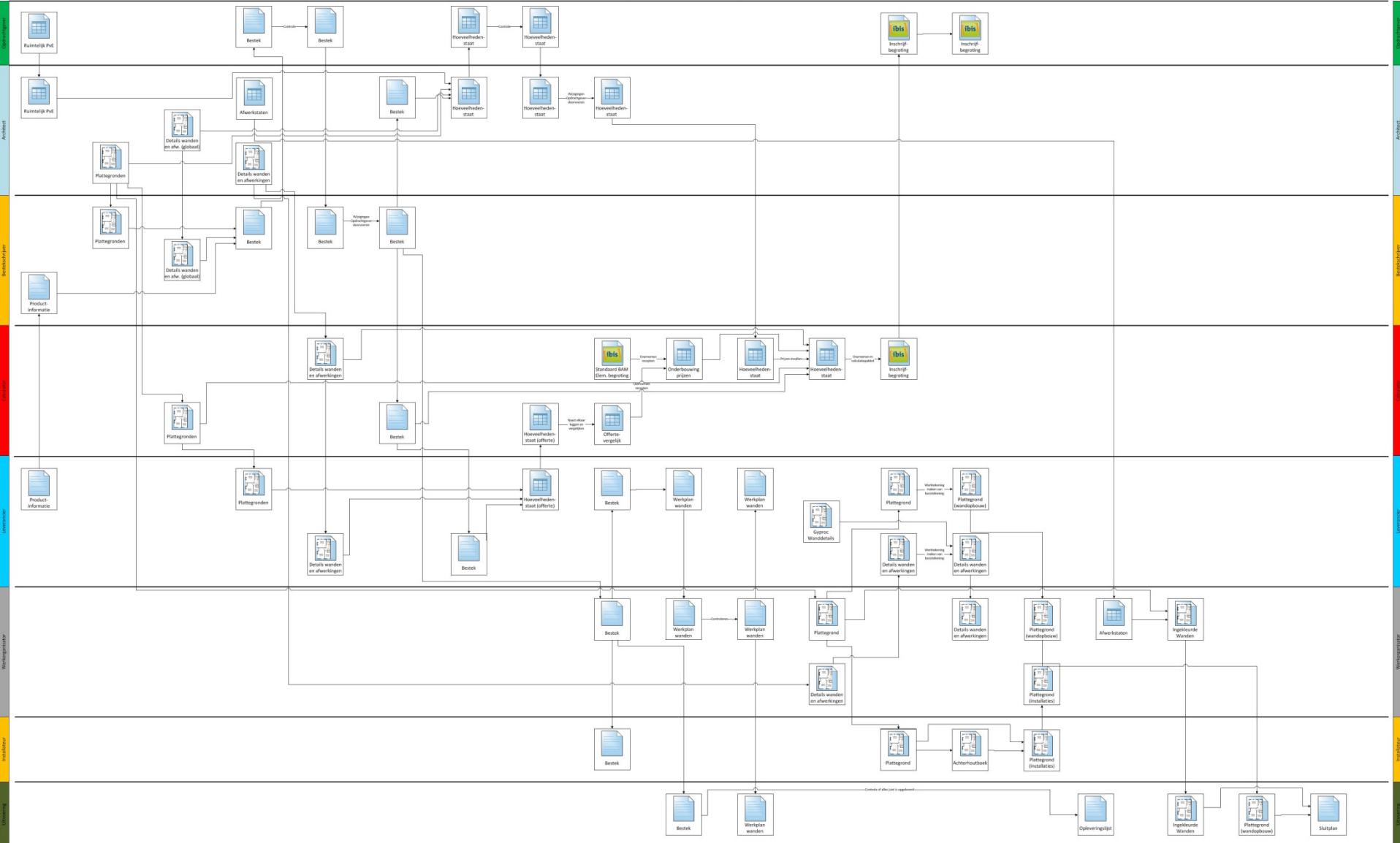


7D CAD

- Facility management



Provenance of Information: a simple example



Source: Royal BAM group, Daan Kuijsten

Flow of information during detail design

Datum 18 april 2011

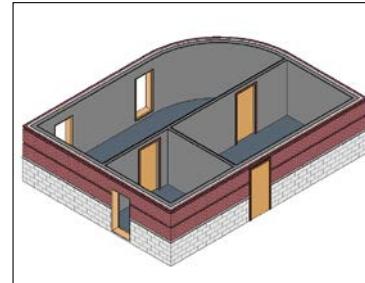
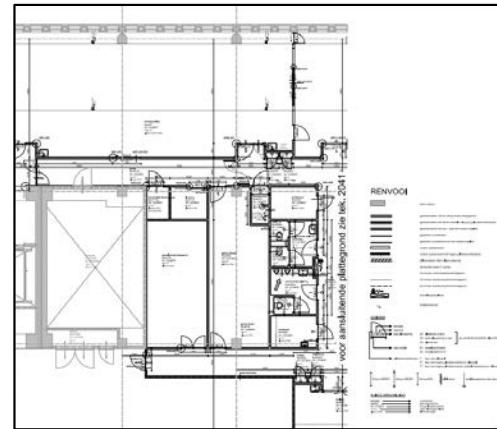
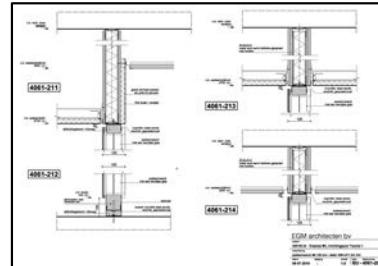
Titel: Programma van Eisen kliniek tranche I

[Handwritten signature]

4 Ruimtelijk Programma van Eisen

4.1 Samenvatting benodigde ruimtelijke voorzieningen

Voor de opbouw van de gevraagde voorzieningen per functioneel blok (1 tot en met 5) wordt verwezen naar het gedetailleerde ruimtelijke programma van eisen in paragraaf 4.2.



A 99100.24 PLAFOND- EN WANDSYSTEMEN 44
Erasmus MC te Rotterdam, afbouw werkbestek A, A1 en B1

44.41.21-e SYSTEEMWAND, REPLATING OP SKELET, METALEN WANDPROFIEL, GIPSPLAAT (vervolg)

WANDPROFIEL, GIPSPLAAT

Fabrikaat

- koudgeleerde stalen profielen met een dikte van ten minste 0,6 mm.

Opperlaagbehandeling: zandstruin verzuikt

Profielen:

 - volgens regels, standaard profielen
 - versterkings-tijlen aanbrengen naast in de wand opeennemen kozijnen, en waar overigens nodig voor een stabiele uitlevering, zoals bij vrije wandbeddingen; bij aan de wand bevestigen zwaar sanitair, waste inrichting en dergelijke;
 - bij een WBDBO-nis van 30 of 60 minuten (deurkozijn+wand) aan weerszijden van staten deur- en/of ramkozijnen een verticaal U-vormig versterkingsprofiel aanbrengen (van vloer tot bovenliggende vloerconstructie) aanbrengingen met een wanddikte van 2 mm; aantrekken bij niet-verdiepingse hoge kozijnen eenzelfde profiel aanbrengen boven het kozijn, gekoppeld aan de wandtijl;
 - kokerprofielen aanbrengen in de wanden ter plekke van de aanschutting op de brandwandend haakse aansnijpunt (conform tekening en TNO-report koker 60.64, zie detail 32.20 op tekening 66).

kokerprofielen boven gangzijde ([zie detail 462-017](#)),

Toebereken:

 - bevestigingsmiddelen
 - afdichtingsmateriaal zoals cellenband, kitafdichtingen en dergelijke, zoals aangegeven op tekening en/of voorgeschreven door de leverancier.

2. GIPSKARTONPLAAT (BRL 1009+w99)

Foto's achter: B9B

 - niet betegeld oppervlak : GKB standaard bouwplaat
 - betegeld oppervlak : GEET WR-plaat met vertraging wateropname

Materiaal: getrapte/gedrukte aipskarton.

Lengtekunsten: afgeschernde laag.

Dikte (mm): 17,5

44.41	Metastof boardoek ck 120 mm 30 mm. paneelvoering. 45 dB	0		134.931,00	7.733,132	0,00
44.41.216	Loodvrije dik 2 mm, van verloot 270+ weer.	450	m ²	12.500,00	625,000	178,80
	Loodvrije dik 2 mm, van verloot 270+ weer.	334	m ²	652.000,00	18.000,00	178,80
	afwerk-industrie A	640	m ²	12.000,00	10.600,00	0,00
	afwerk-industrie B	1.048	m ²	247.000,00	2.472,40	2.472,40
	Loodvrije LP sheet 25 mm met plastiek	0				
	hoekversteviging Industrie Comer Beta o.p.	420	m ²	1.000,00	400	400
	bevestigingsmateriaal t.o. penalen deelvlooi equivalent, blad, looptoegang/poorten	0				0,00
	bevestigingsmateriaal t.o. penalen deelvlooi equivalent, blad, looptoegang/poorten	0				0,00
44.41.216	Metastof boardoek ck 125 mm	0		501.962,000	501.962	0,00
	versteerd ingelast hoek rood, ca. 175 mm x 30 mm aansluiting	148	st	36.960,00	5.459,40	0,00
	versteerd ingelast hoek groen, ca. 175 mm x 30 mm aansluiting	148	st	36.960,00	5.459,40	0,00
	versteerd ingelast hoek wit, ca. 175 mm x 30 mm aansluiting	17	st	19.000,00	332,00	332,00
	Metastof boardoek boven-wandvoering, da, ca. 1900 mm	900	m ²	49.000,00	94.240,00	0,00
	Metastof boardoek boven-wandvoering, da, ca. 1900 mm	300	m ²	16.000,00	3.200,00	3.200,00
	Loodvrije dik 2 mm, van verloot 270+ weer.	1696	m ²	211.360,00	35.227,36	35.227,36
	afwerk-industrie A	1400	m ²	3.000,00	300,00	300,00
	afwerk-industrie B	0	m ²	954.000,00	9.544	9.544
	Loodvrije LP sheet 25 mm met plastiek	0				
	hoekversteviging Industrie Comer Beta o.p.	2200	m ²	1.000,00	2.200	2.200
	bevestigingsmateriaal t.o. penalen deelvlooi equivalent, blad, looptoegang/poorten	0				0,00
	bevestigingsmateriaal t.o. penalen deelvlooi equivalent, blad, looptoegang/poorten	0				0,00
	bevestigingsmateriaal t.o. penalen deelvlooi equivalent, blad, looptoegang/poorten	0				0,00
	paneelvoering t.o. st. squalini of vleugelschild	0				0,00
44.41.216	L					
	Metastof vank ck 125 mm	0		61.361,113,000	6.136.113	0,00
	versteerd ingelast hoek rood, ca. 350 mm x 30 mm aansluiting	730	st	36.000,00	25.200,00	25.200,00
	versteerd ingelast hoek groen, ca. 350 mm x 30 mm aansluiting	280	st	16.000,00	4.800,00	4.800,00
	versteerd ingelast hoek wit, ca. 350 mm x 30 mm aansluiting	300	st	36.950,00	11.085,00	11.085,00
	versteerd ingelast hoek wit, ca. 175 mm x 30 mm aansluiting	244	st	19.000,00	4.540,00	4.540,00
	versteerd ingelast hoek wit, ca. 175 mm x 30 mm aansluiting	190	st	19.000,00	3.210,00	3.210,00
	flexibele schroefverankerplaats 204, ca. 60 mm t.w.v. aansluit	6000	m ²	7.000,00	35.000	35.000
	flexibele schroefverankerplaats 204, ca. 60 mm t.w.v. aansluit	4000	m ²	4.000,00	16.000	16.000
	terugdoppen ontwerpstaal	4	m ²	4.000,00	19.200,00	19.200,00
	terugdoppen ontwerpstaal	0	m ²	112.000,00	25.440,00	25.440,00
	koekjes voor 204 x aansluitgat glijplaat t.p. 100	200	st	62.000,00	2.157.264,00	2.157.264,00
1	Metastof vank ck 125 mm standaardvorm	34475	m ²	62.000,00	2.157.264,00	2.157.264,00
2	Metastof vank ck 125 mm standaardvorm	2000	m ²	68.000,00	13.600,00	13.600,00
3	Metastof vank ck 125 mm standaardvorm, l.h. 300 mm	200	m ²	68.000,00	13.000	13.000
4	Metastof vank voordeurblad, één sluit deel	450	m ²	45.000,00	20.750,00	20.750,00
5	Metastof vank voordeurblad, één sluit deel	750	m ²	45.000,00	20.750,00	20.750,00
6	Metastof vank ck 125 mm, 2 zijkanten Winkelstaal	2500	m ²	66.000,00	166.350	166.350

1

seidenwand MS. 125/2.75.2

Source: Royal BAM group, Daan Kuijster



3D Object Acquisition

BIM

- *prescriptive* CAD
- shaping the future

3D Object acquisition:

- *descriptive* CAD
- documenting the current state
- preparing retro-fit / renovation



Tremendous progress in the last 10-15 years:

- Various methods: Laserscanning, photometric stereo, multiview reconstruction, structured light
- Fast
- Accurate
- Cheap... well, kind of like...

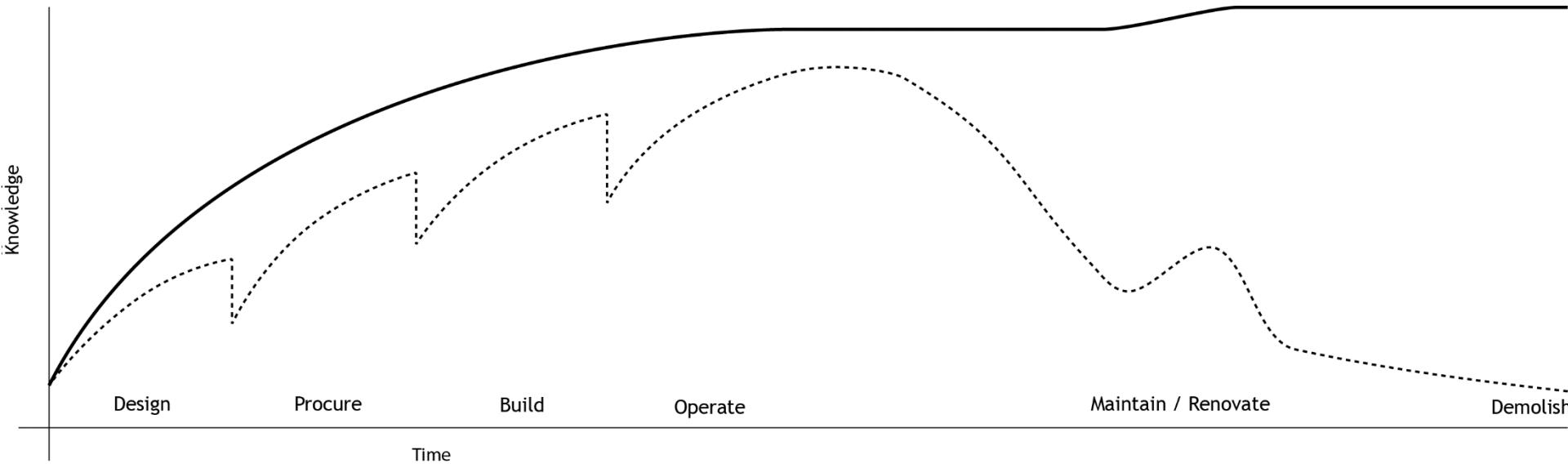


'Archival system' for project hand over

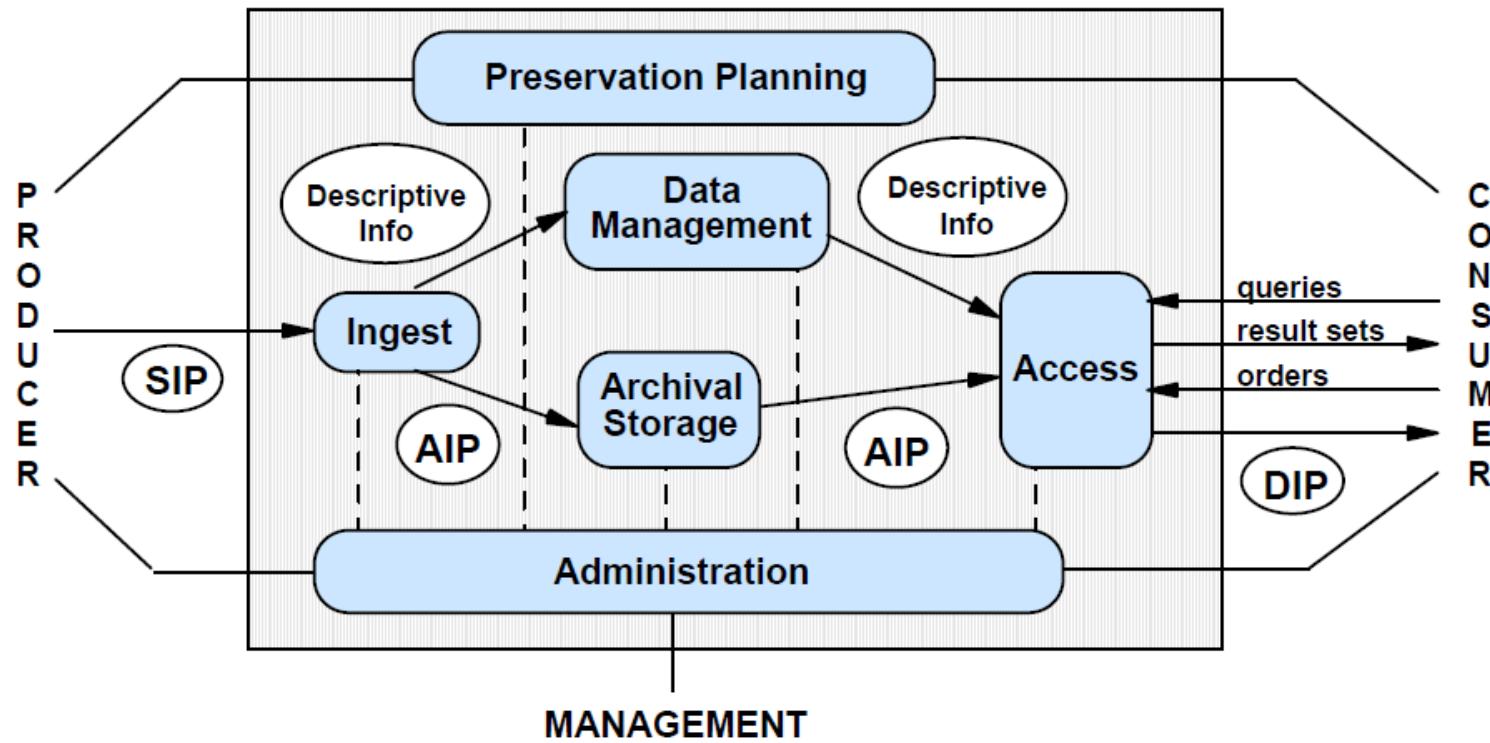


DURAARK
DURABLE
ARCHITECTURAL
KNOWLEDGE





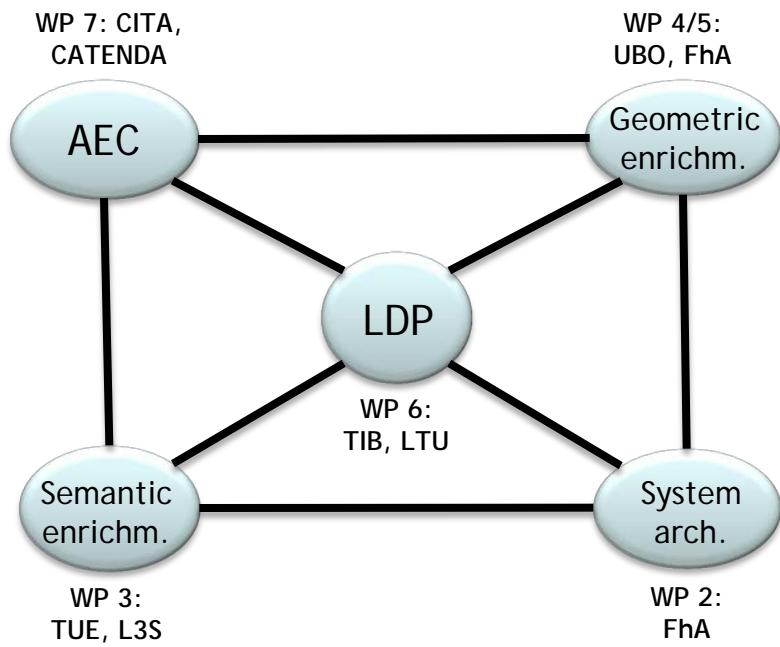
Information and knowledge loss and decay



Open Archival Information System (OAIS) Framework



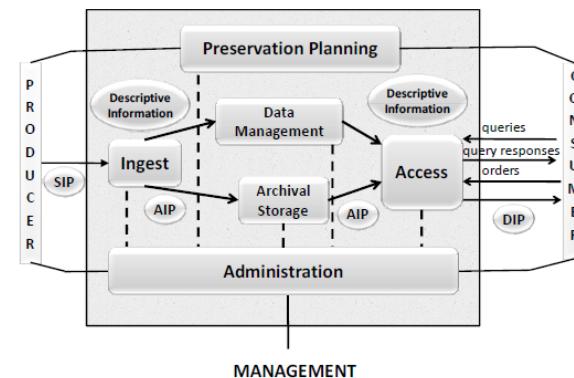
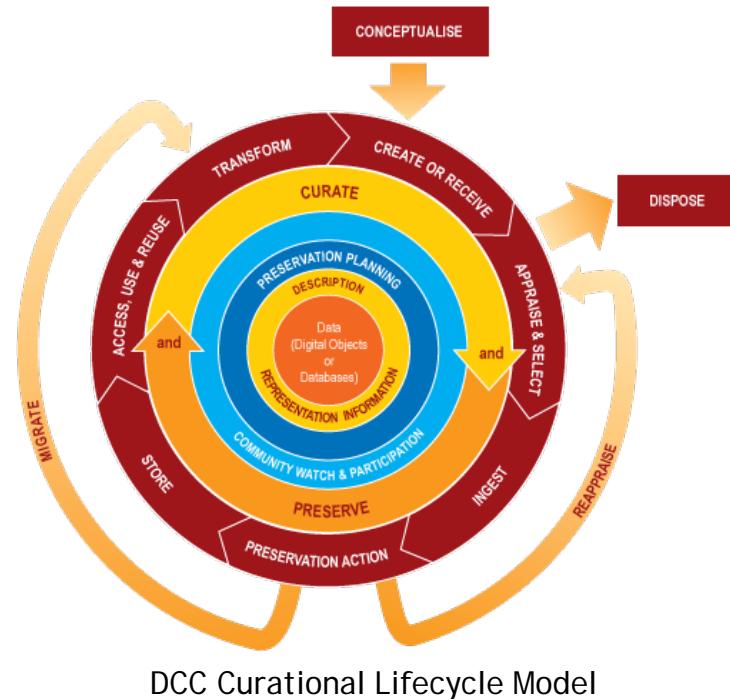
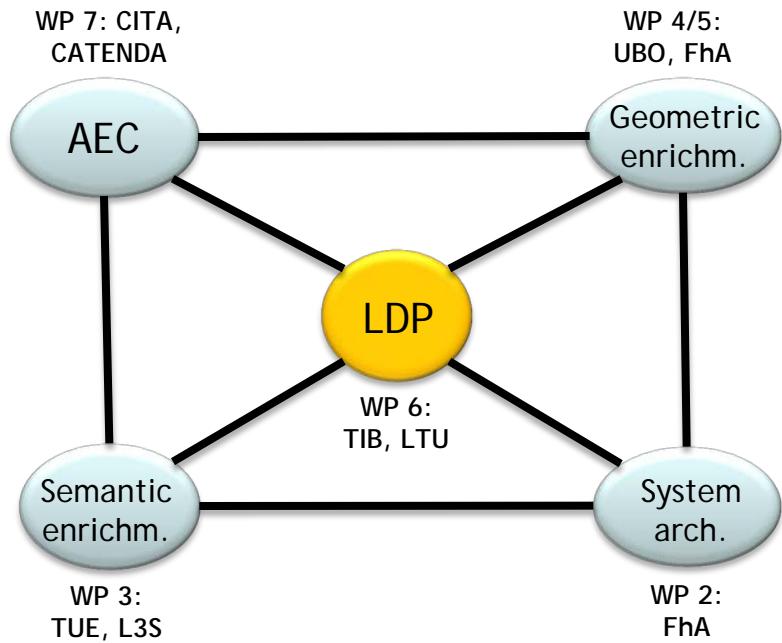
DURAARK Structure and Overview



DURAARK Structure and Overview

WP 6 (TIB, LTU):

- Enable LDP for BIM and point cloud datasets
- Evaluation of LDP requirements (data formats, risk analysis, ingest, storage, etc.)

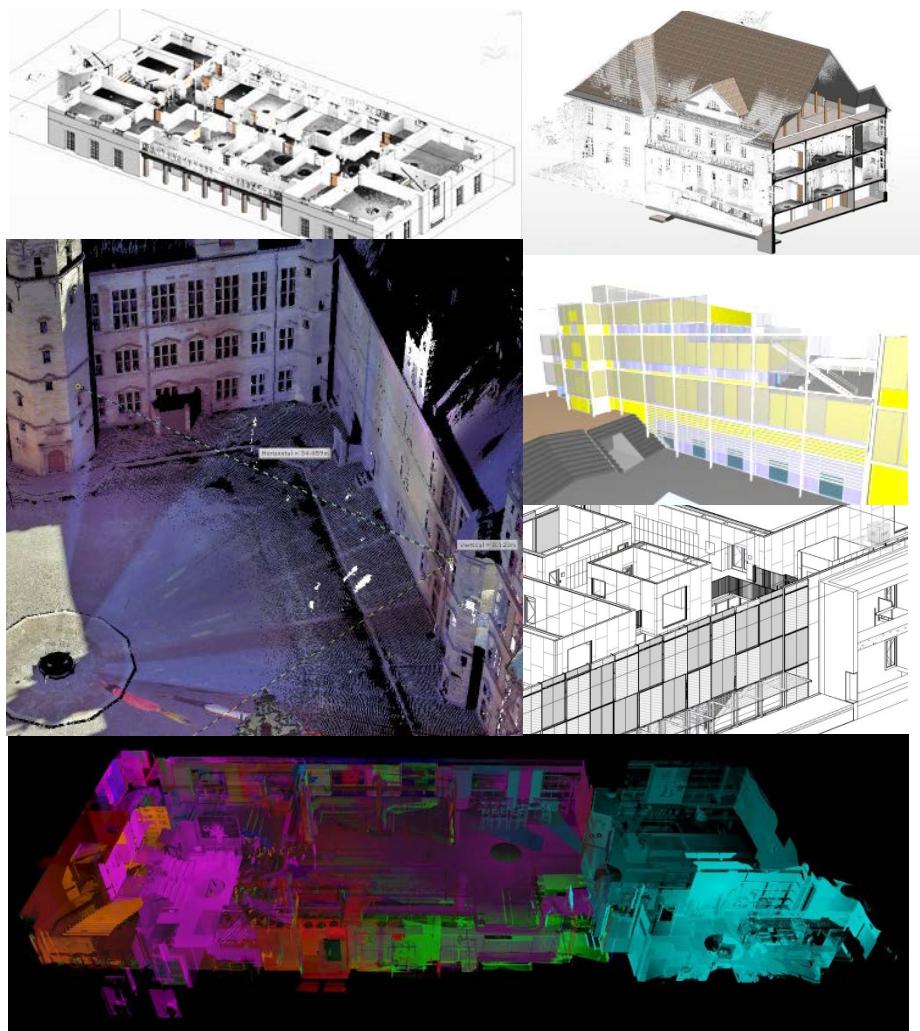
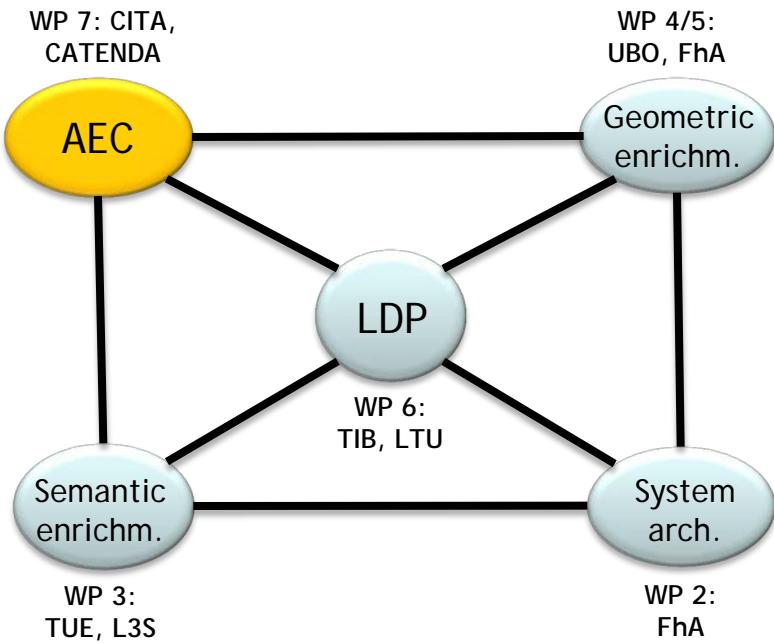


OAIS model overview

DURAARK Structure and Overview

WP 7 (CITA, CATENDA):

- Acquired many IFC and point cloud datasets
- In touch with stakeholders, practitioners and experts
- Evaluation of needs and outcomes



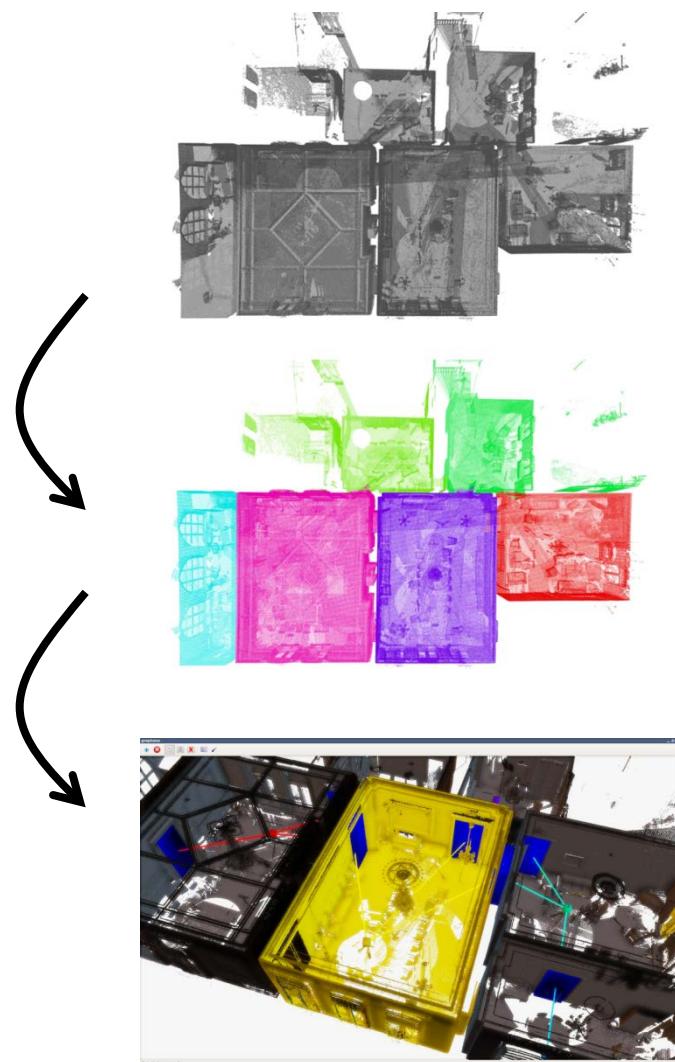
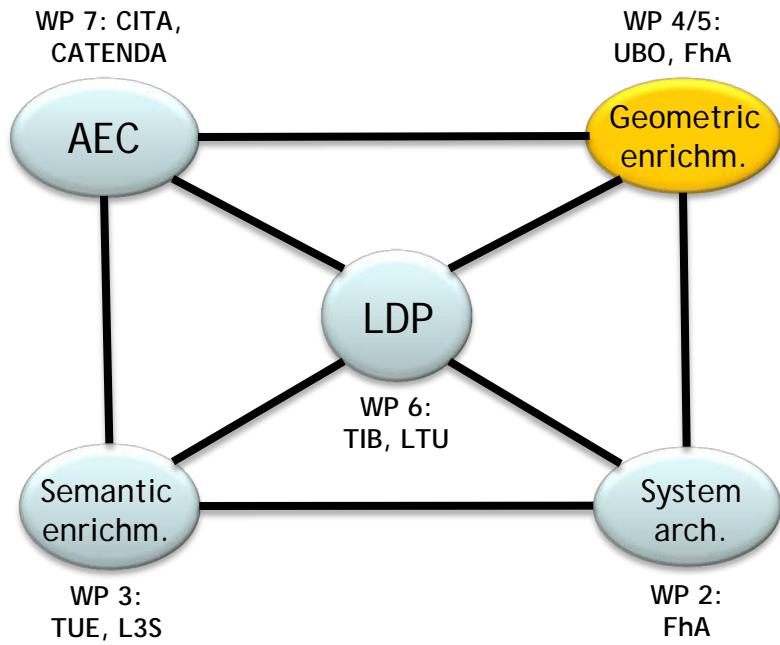
DURAARK Structure and Overview

WP 4 (UBO):

- Synchronization and comparison of BIM and point cloud datasets

WP 5 (UBO, FhA):

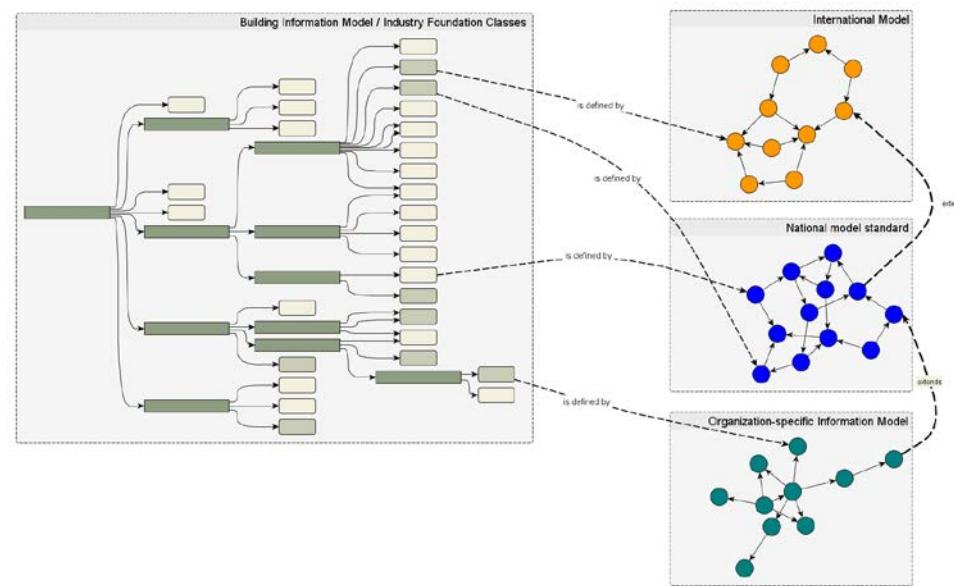
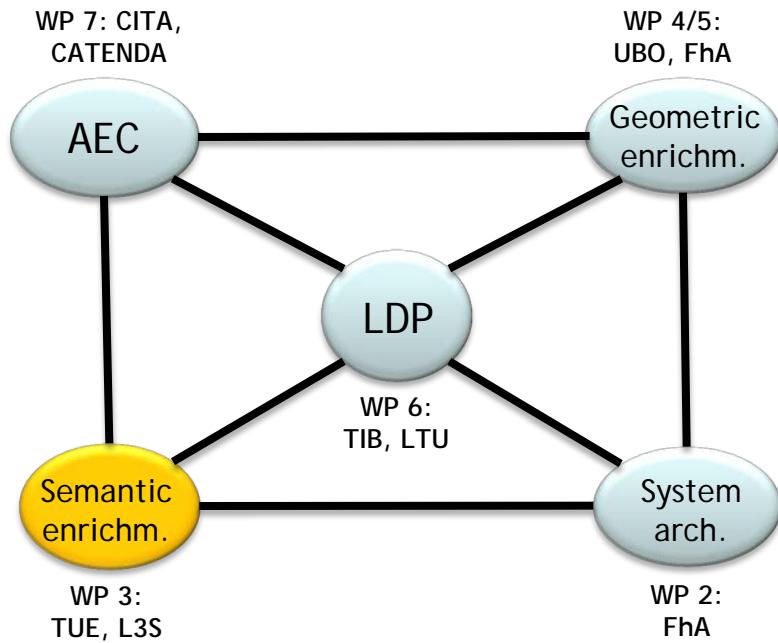
- Geometric enrichment of "low-level" datasets (i.e. point clouds)



DURAARK Structure and Overview

WP 3 (TUE, L3S):

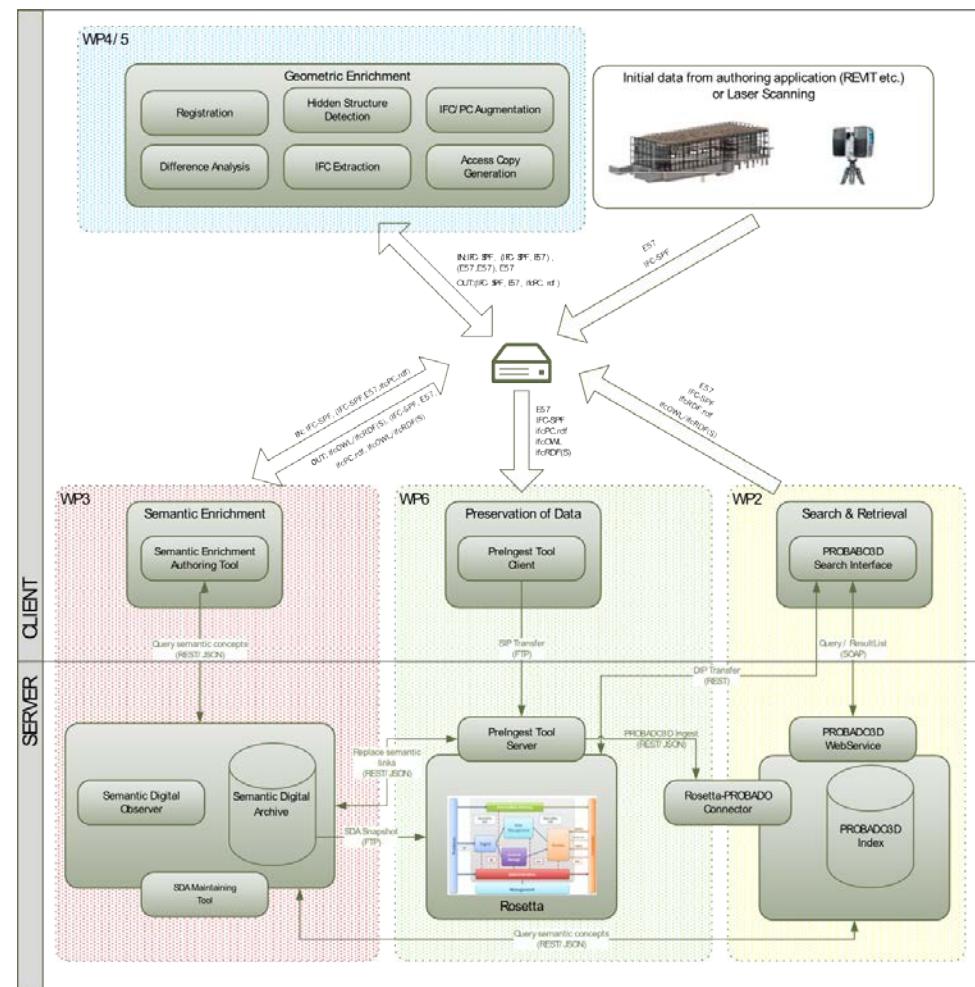
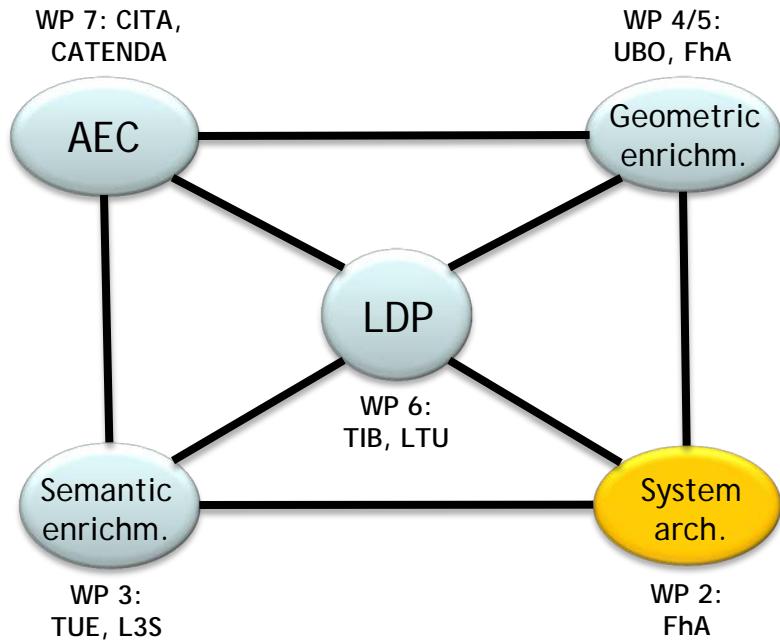
- Complementing datasets with semantic attributes
- Development of self-sustained knowledge database (semantic digital archive, SDA)

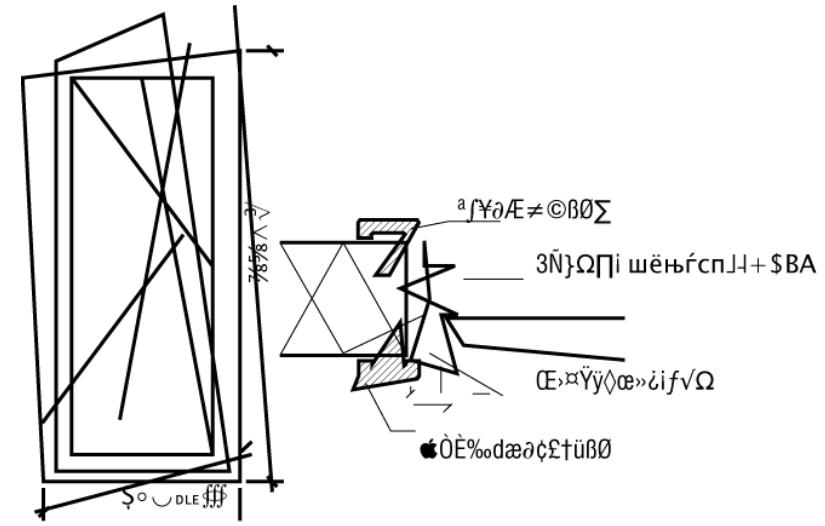
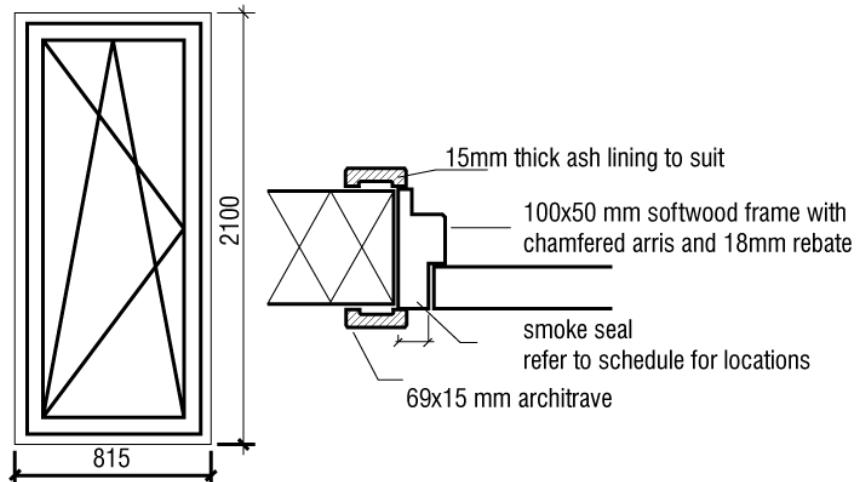


DURAARK Structure and Overview

WP 2 (FhA):

- Performed requirement analysis
- Specified system architecture ->
- LDP system prototype
- Tools for browsing the archive

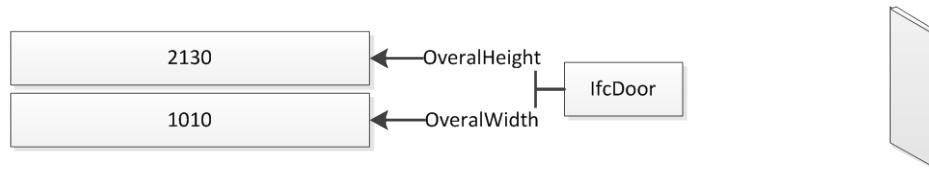




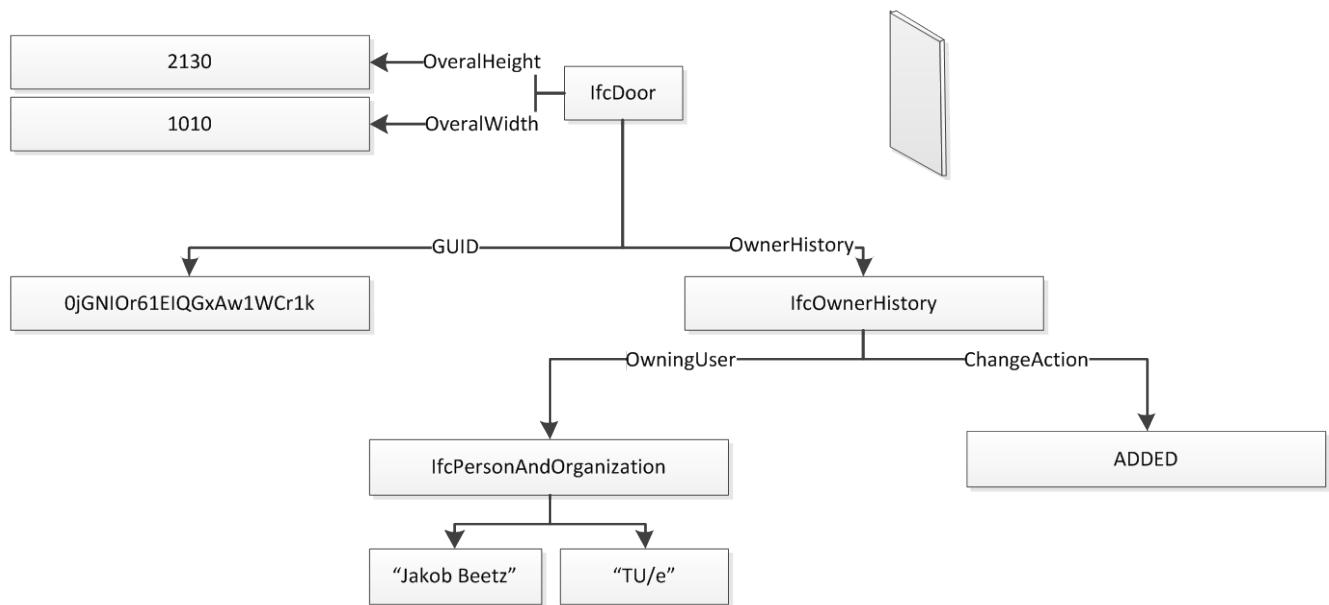
Lack of semantic information in CAD



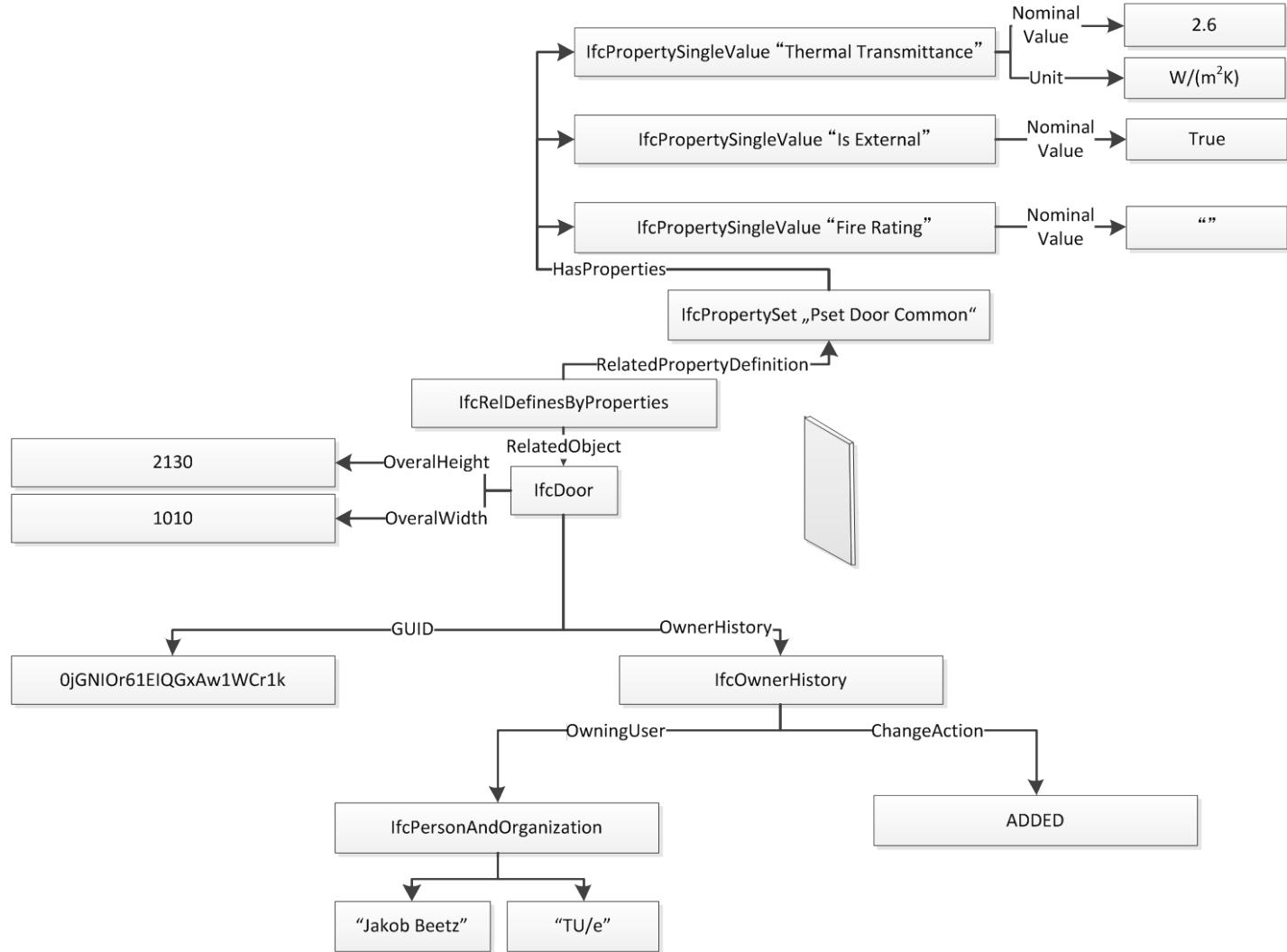
Semantic Definition in IFC



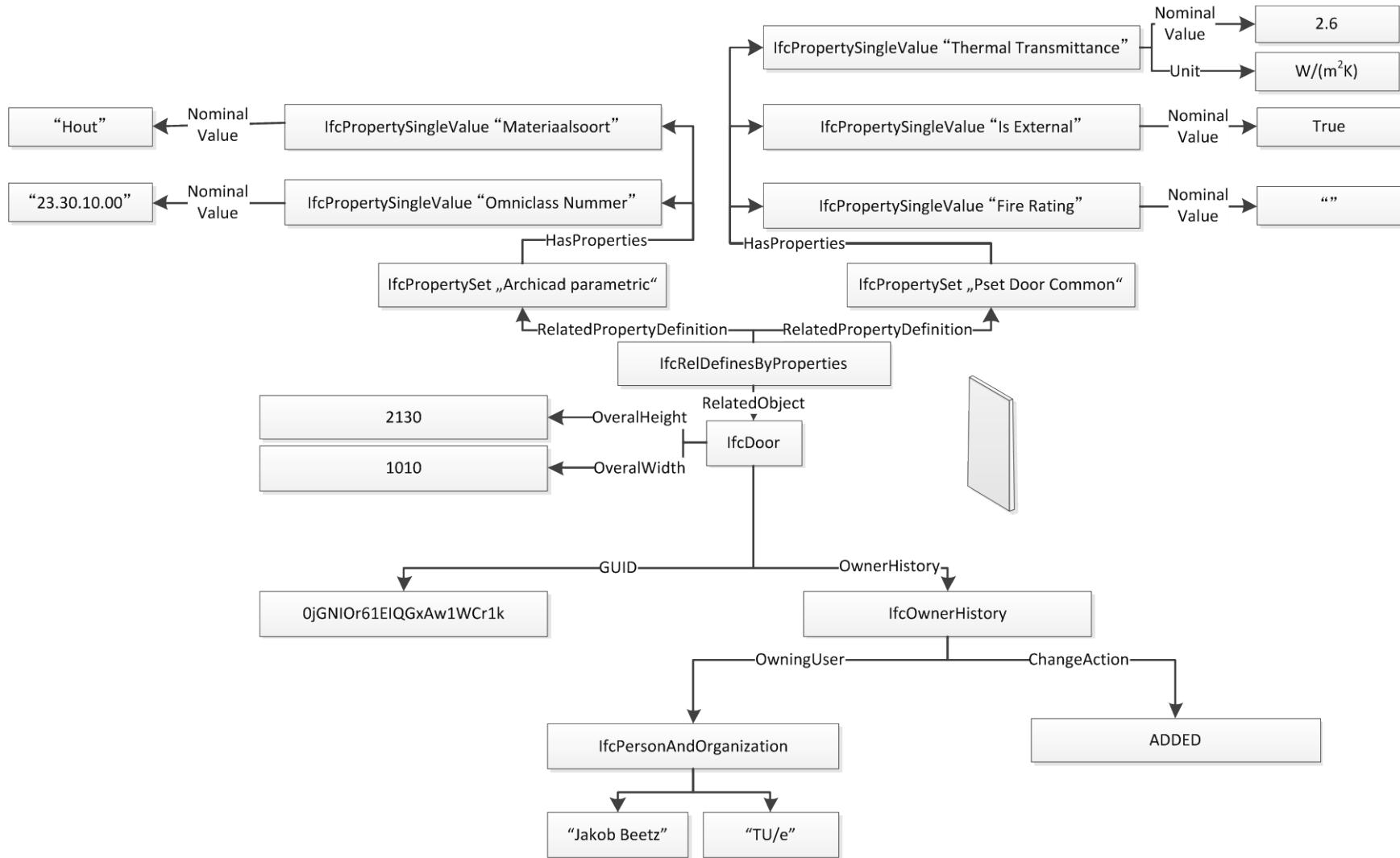
Definition by attributes



Definition by standardized properties



Definition by ad hoc properties

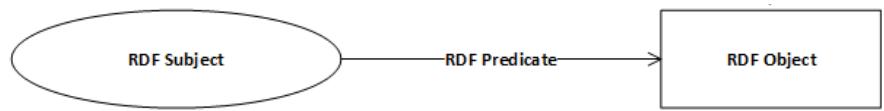




Now... *that* should clear up a few things around here

© Horrocks, Oxford University

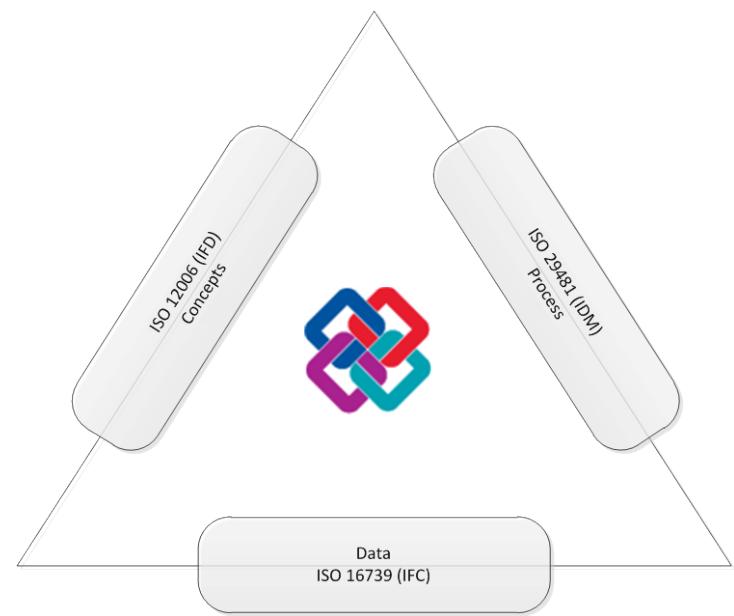
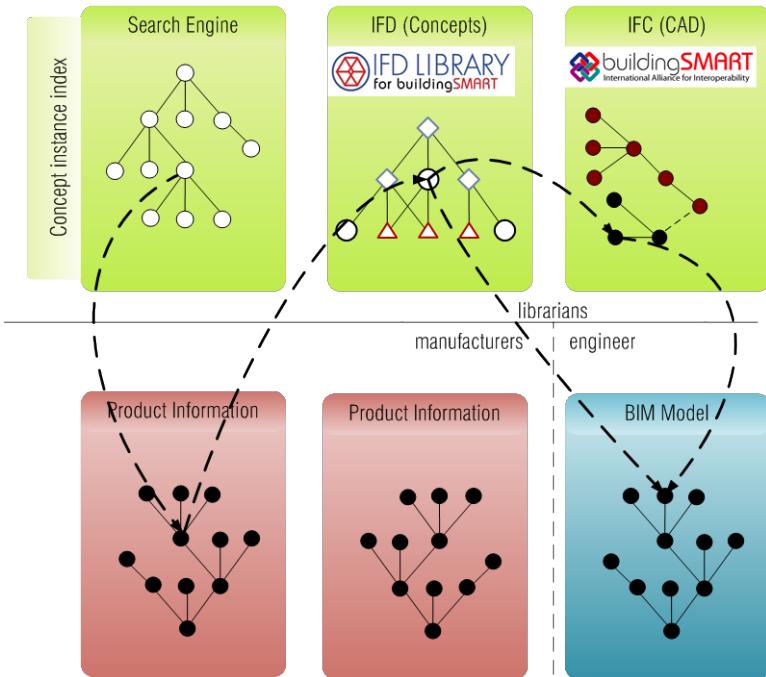
The Semantic Web



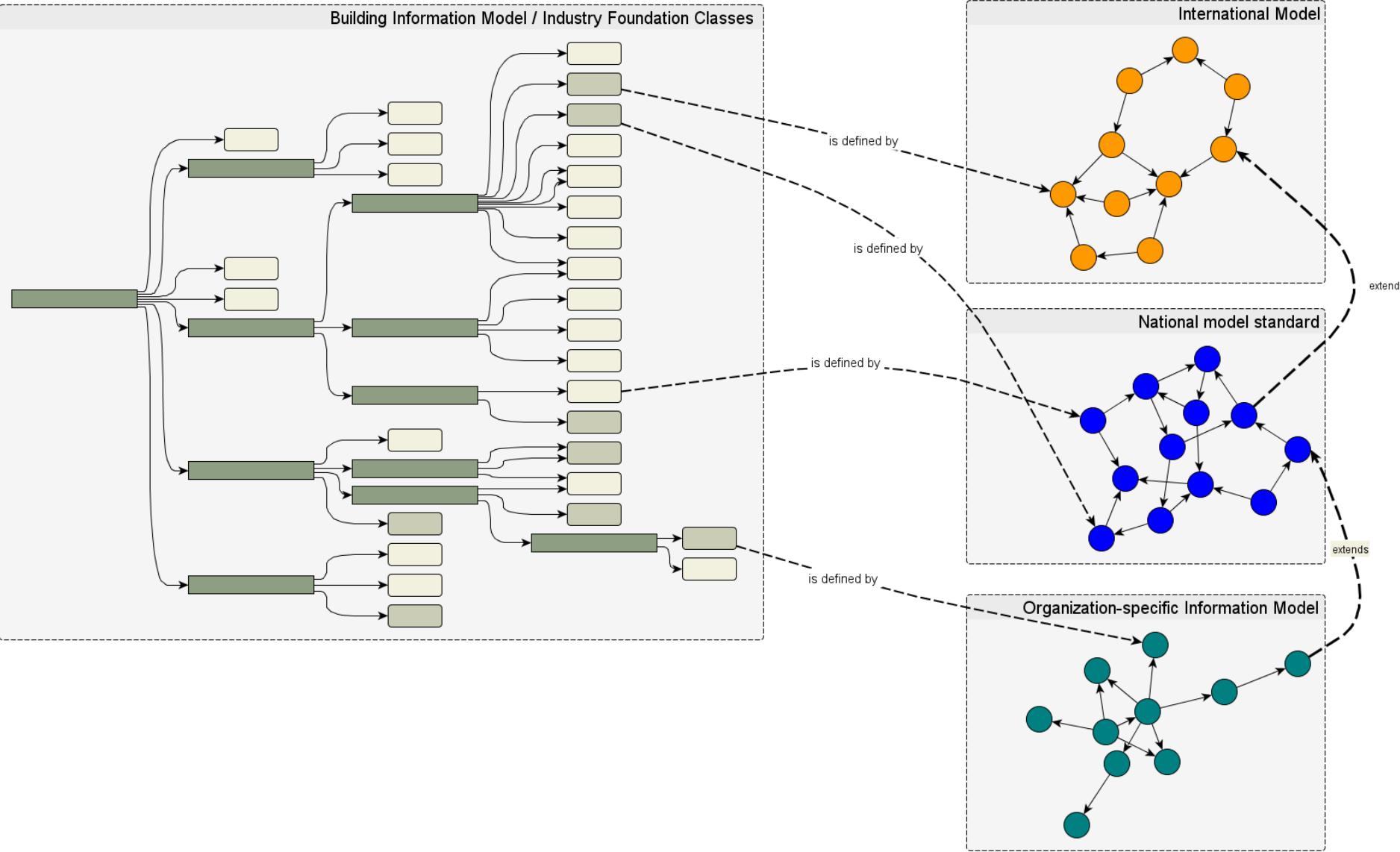
Legacy part 21 enrichment with RDF

Increase semantic scope:

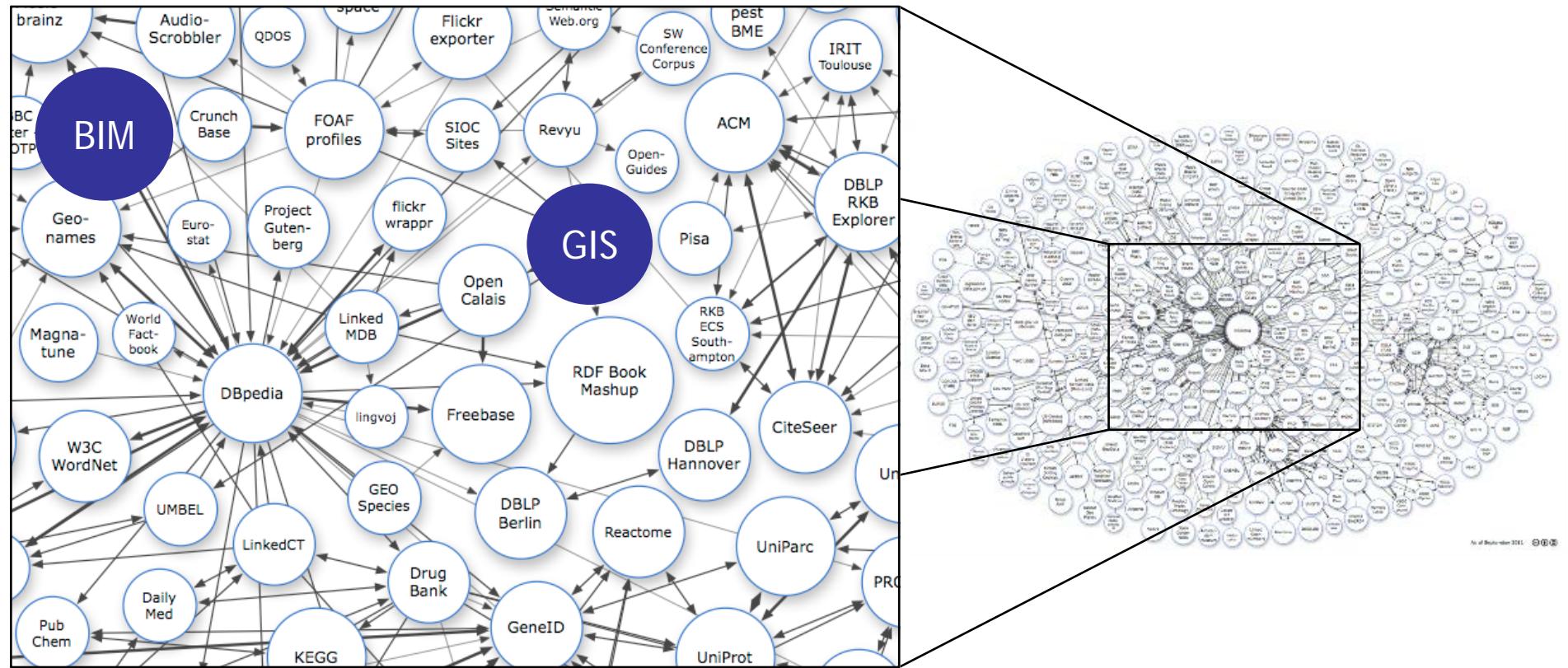
- International Framework for Dictionaries (IFD, ISO 12006):
 - Data structure to captures concepts, properties and relations
- buildingSMART Data Dictionary (bSDD)
 - Reference instance of IFD, currently filled with ca. 50,000 concepts



Semantic Enrichment with distributed Vocabularies



Semantic Enrichment with distributed Vocabularies



Linked data for engineering purposes

3D Table

NL

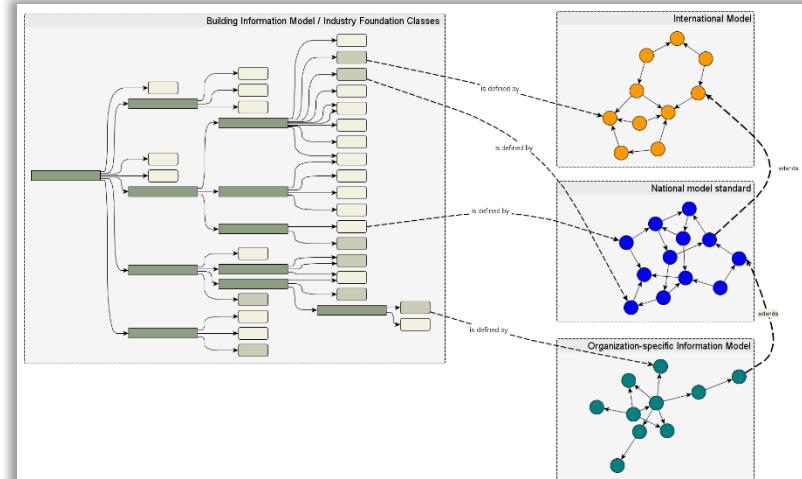
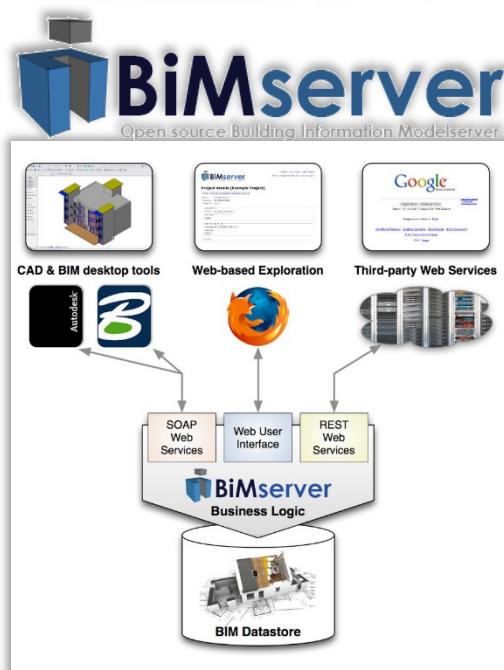
EN

▶ Start Transaction

Download IFC

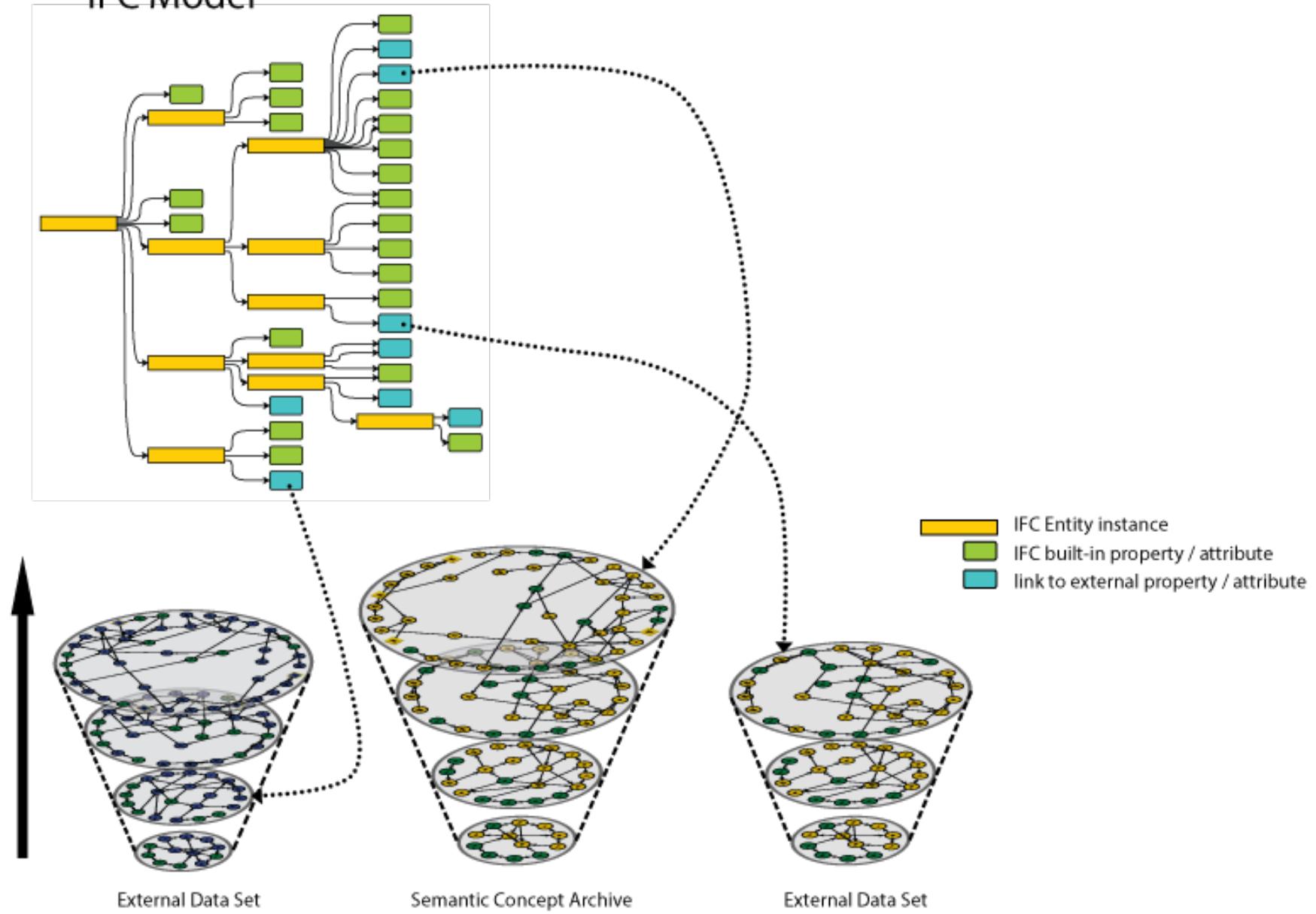
Objects

Type	Name	GUID
Beam	BEAM Verankering-staal-trompet in betonprop(128)	BMBVvbk5NY6000000000000000
Beam	BEAM Verankering-staal-trompet in betonprop(2)	BMBVvbk5NY6000000000000001
BuildingElementProxy	BUILDINGELEMENTPROXY Betonwerk prop in buispaal(30)	BMBVvbk5NY6000000000000002
Column	COLUMN Buispaal-staal-1524x18(3)	BMBVvbk5NY6000000000000003
Column	COLUMN Slot-staal-C6(114)	BMBVvbk5NY6000000000000004
Beam	BEAM Verankering-staal-trompet in betonprop(83)	BMBVvbk5NY6000000000000005
BuildingElementProxy		BMBVvbk5NY600L00K0000000006
Column	COLUMN Buispaal-staal-1524x18(38)	BMBVvbk5NY6000000000000007
BuildingElementProxy	BUILDINGELEMENTPROXY Trekput kabels-put-beton(3)	BMBVvbk5NY6000000000000008
Beam	BEAM Verankering-Jetmix-101 6x17.5-Groutichaam 8m(11)	BMBVvbk5NY6000000000000009



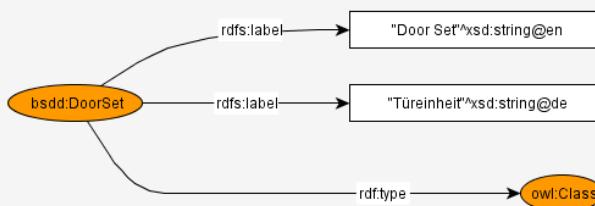
Semantic Enrichment prototype demo

IFC Model



Use of evolving vocabularies





change:additions
change:removals

<http://duraark.eu/data/archive/bsdd/2013-12-01/removals#>

:CS → change:changeset

dc:date → "2013-12-01"xsd:date

change:additions

change:removals

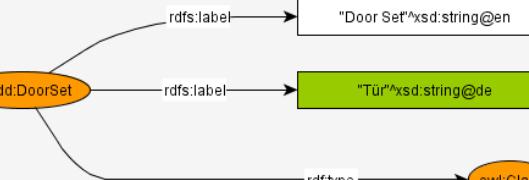
:CS → change:changeset

dc:date → "2014-01-01"xsd:date

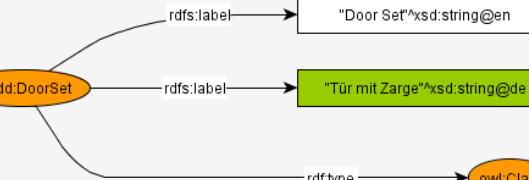
t_0

Δ_{t_1}

Δ_{t_2}



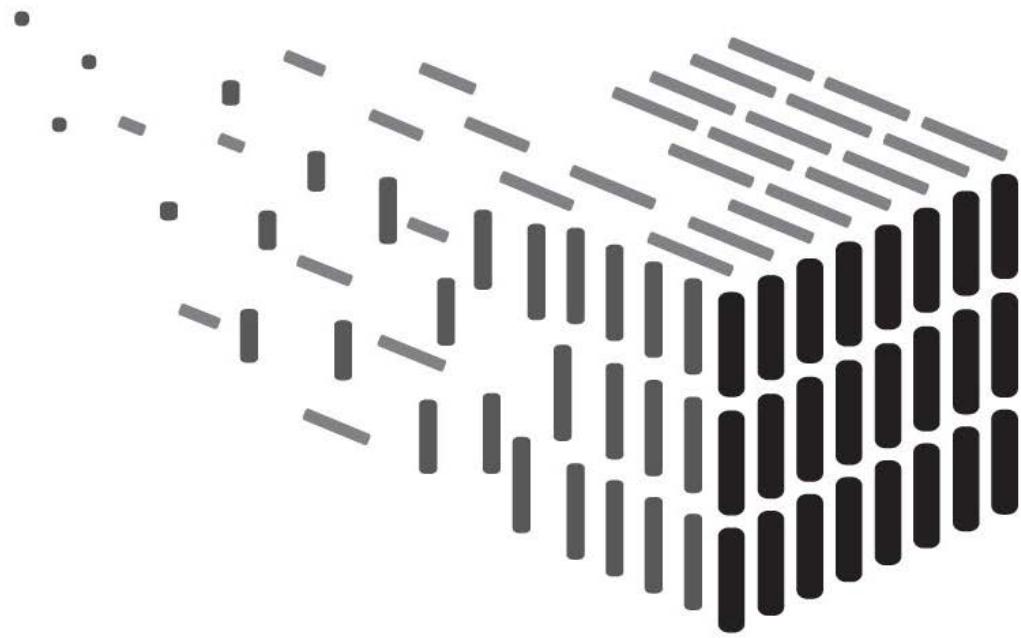
A_{t_1}



A_{t_2}

Versioning evolving vocabularies





DURAARK
DURABLE
ARCHITECTURAL
KNOWLEDGE

<http://www.duraark.eu>