ON THE ROLE OF ARCHITECTURAL MODELS :

WHAT CAN WE LEARN FROM INFORMATION SYSTEM AND FROM CONSTRUCTION PROJECTS ?

ERIC DUBOIS

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY

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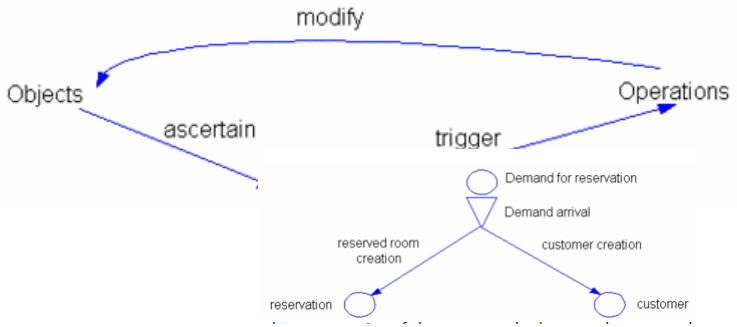
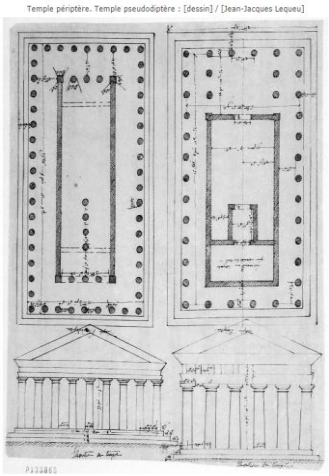
FROM ….

FROM ….. TO



ROLE OF MODELS and ARCHITECTURES in IS and Building domains



MOTIVATIONS FOR THIS PRESENTATION

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY

PERSONAL MOTIVATION: THE ‘BEAUTY OF THE MODELS’ ….

PROFESSIONAL MOTIVATIONS

Luxembourg Institute of Science and Technology

- **LIST** is the national RTO (Research and Technology Organisation), resulting from the merge of CRPs Henri Tudor et Gabriel Lippmann in 2015)
- Mission is to perform science-based technological innovation for the benefits of organisations and the society in general
- **ITIS** (IT for Innovative Services) is one of the three LIST departement with 140 people having expertise in
  - *Performance and quality of services*
  - *Information-intensive Interactive Services*
  - *IT Service Innovation Management*
- With applications in:
  - Logistics & Mobility (goods and persons)
  - eHealth
  - Finance eco-systems
  - **Construction**

PROFESSIONAL MOTIVATIONS

ACTIVITIES IN THE BUILDING SECTOR

Collaborative Research project with

naturhome made in wood

Needs for the re-engineering of part of the processes with the introduction of new I.S.

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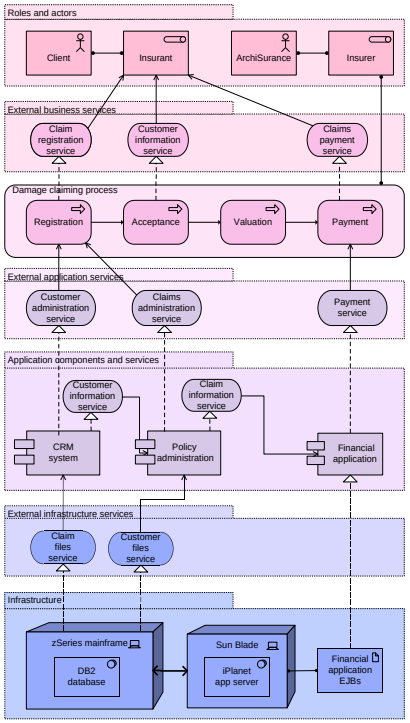
PROFESSIONAL MOTIVATIONS

ACTIVITIES IN THE BUILDING SECTOR

Use of EA for modeling the AS IS and the TO BE of the organisation

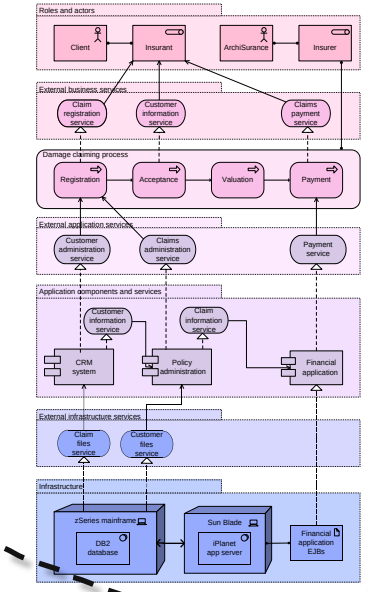


PROFESSIONAL MOTIVATIONS

ACTIVITIES IN THE BUILDING SECTOR

What are the benefits of using E.A. models?

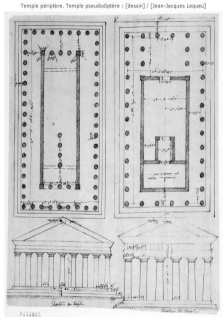
What are the benefits of using architectural models ?

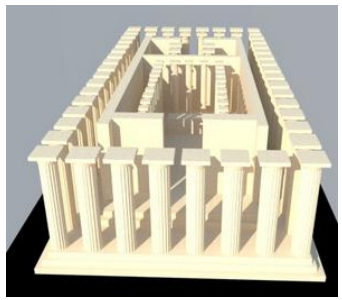


Can we build on top of experiences in Building and I.S. architectures ?

GOAL OF THE PRESENTATION

Towards a better intertwining of Building and IS domain





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Digital modelin the Buidling domain offer

new opportunities for IS supporting collaborative working

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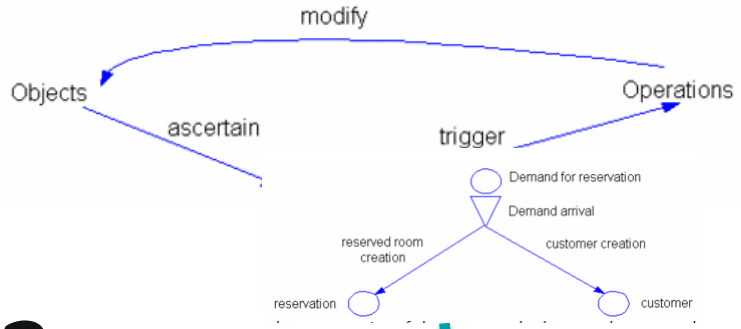
GOAL OF THE PRESENTATION

Towards a better intertwining of Building and IS domains



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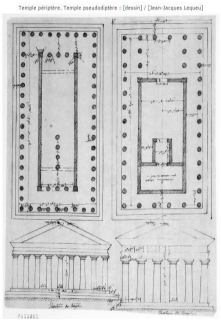
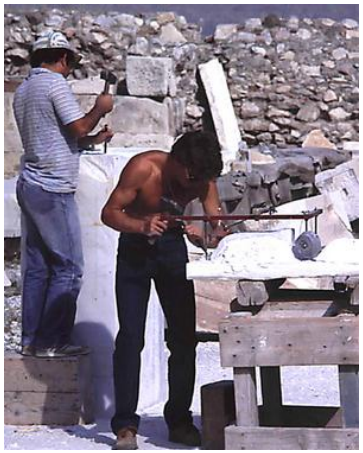


- IS-related Requirements Engineering methods and models can improve the Building development and maintenance lifecycle

GOAL OF THE PRESENTATION

Towards a better intertwining of Building and IS domains



Fiber optic sensor monitoring movement on a column

3

The new paradigm of SMART BUILDING asks for a joint approach regarding a better integration of the buidling and of the information systems

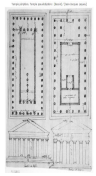
PRODUCT SERVICE SYSTEM

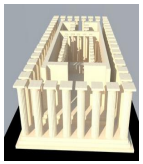
GOAL OF THE PRESENTATION

Towards a better intertwining of Building and IS domains

4

Cyber-physical critical systems ask for a systemic approach like e.g. in the safety and security domains





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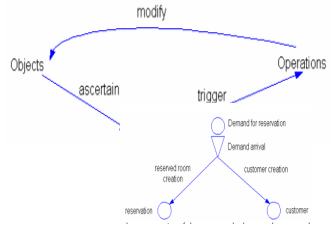

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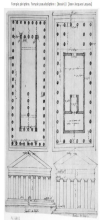

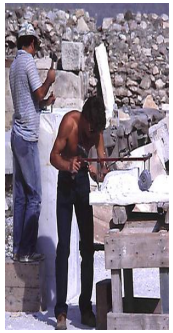

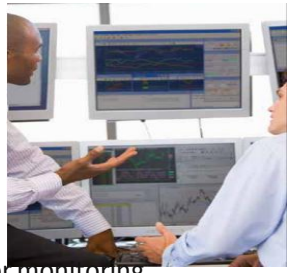

Fiber optic sensor monitoring movement on a column

3

4

DIGITAL MODELS FOR BUILDINGS

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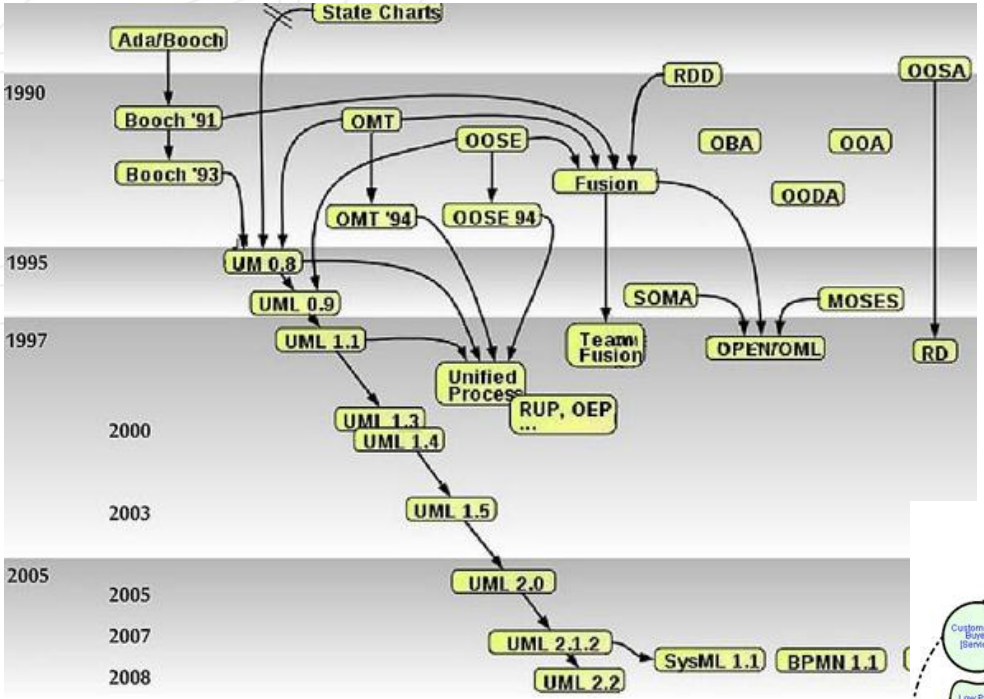
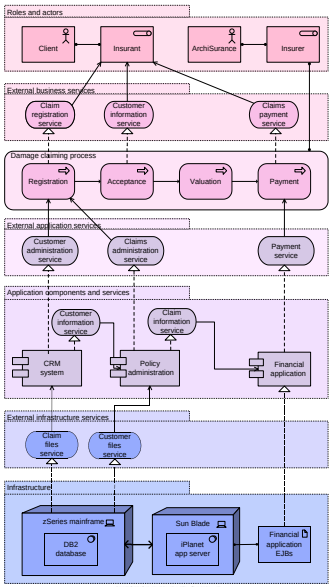
LIST

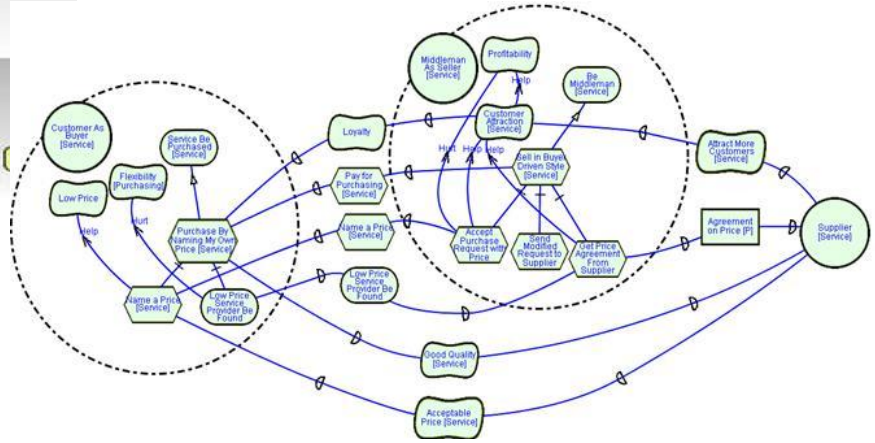
DIGITAL MODELS FOR IS

Open Group - ArchiMate



UML - OMG





ITU - User Requirements Notation (URN)

BUILDING MODELS

MODELS FOR SUPPORTING BUILDING ACTIVITIES

Conceptual Design Industrialisation Production Use .....

Architecture Construction Facility Mgt

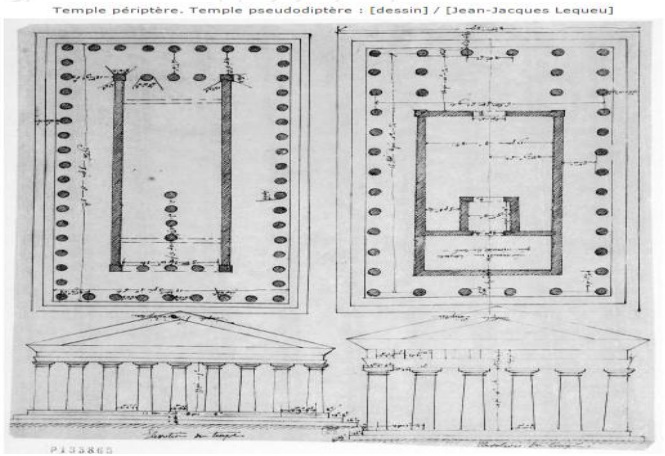
Models and documents are important for supporting the different phases

Facility Management is an phase including maintenance and possibly evolution tranformation

With the new circular economy, document is also important for the demolition phase

BUILDING MODELS

MODELS FOR SUPPORTING BUILDING ACTIVITIES

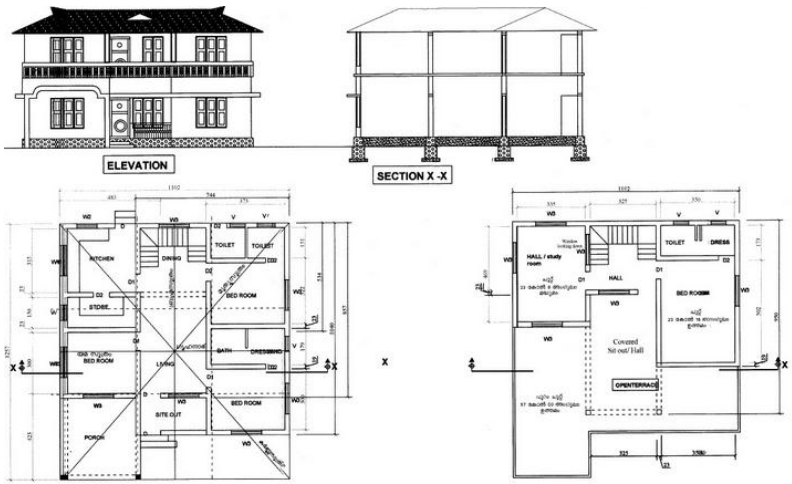


No question about the use of models for supporting Building activities

models are there for centuries !

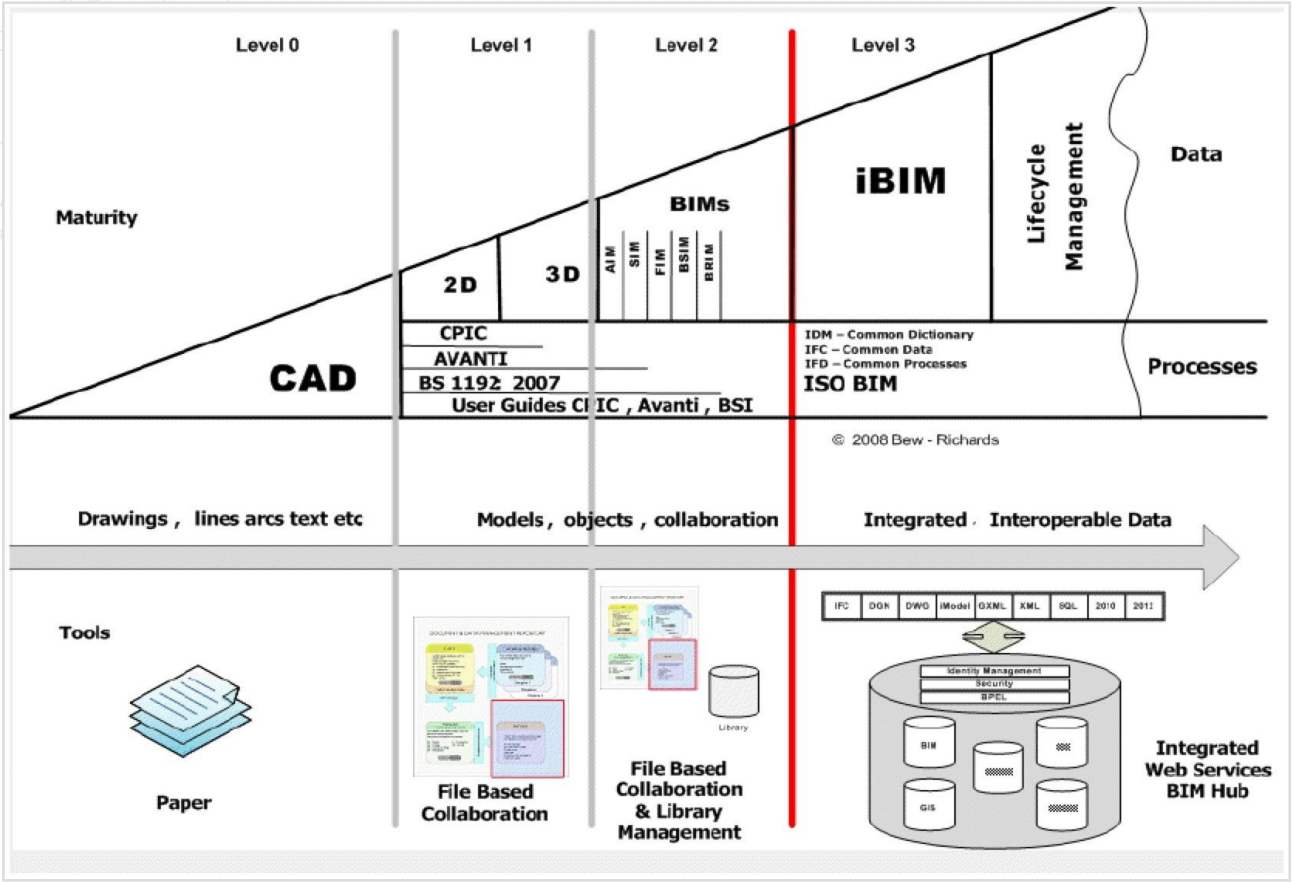
But paper based

Or digitally based but with proprietary formats



BUILDING MODELS

MOTIVATIONS FOR BIM: BUILDING INFORMATION MODEL



Bew & Richards, 2008

BUILDING MODELS

BIM: BUILDING INFORMATION MODEL, PERIMETER

Modelling
shaping
forming
presenting,
scoping

Information
an organised
set of data:
meaningful,
actionable

to **virtualy construct** a
to **extend the analysis** of a
to **explore the possibilities** of
to **study what-if scenarios** for a
to **detect possible collisions** within a
to **calculate** construction **costs** of
to **analyse constructability** of a
to **plan the deconstruction** of a
to **manage** and **maintain** a

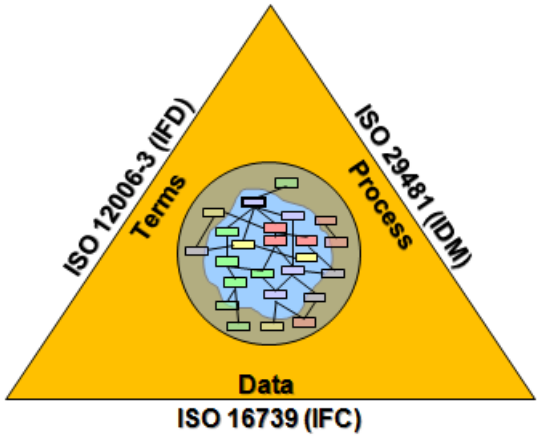
Building
a structure, an
enclosed space,
a constructed
environment
(Succar, 2008)

Succar, 2009

BUILDING MODELS

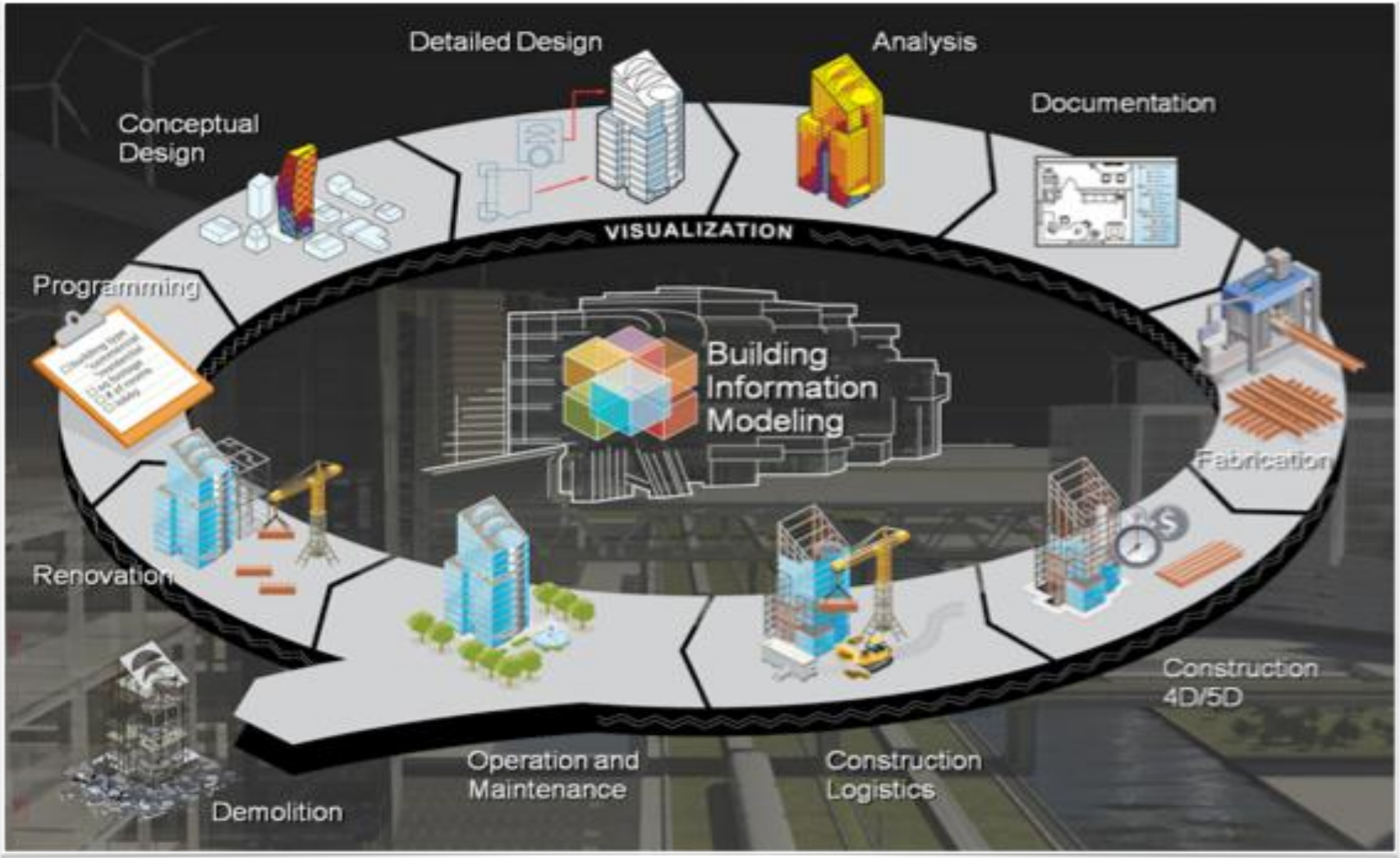
BIM: BUILDING INFORMATION MODEL

- **BuildingSMART** standards for BIM
  - International data dictionary framework (IFD)
    - International Framework for Dictionaries
    - **bSDD** (buildingSMART Data Dictionary)
  - A data model for building elements
    - **IFC**, ISO 16739
    - **COBie**, Facility Management Handover data sche
  - Processes modeling standard (IDM)
    - Information Delivery Manuals



BUILDING MODELS

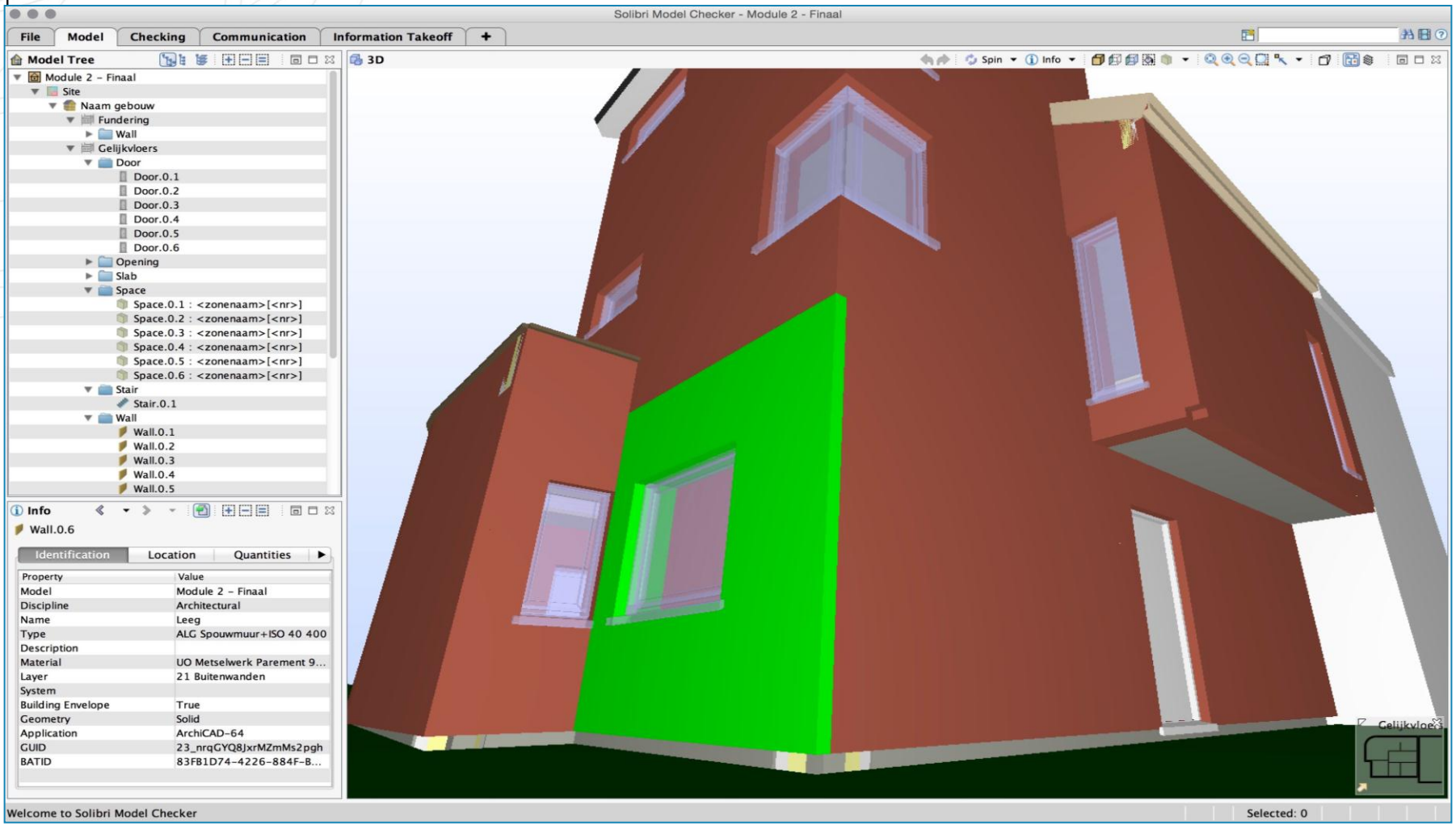
BIM: BUILDING INFORMATION MODEL



BIM FOR SUPPORTING ALL THE PHASES OF A BUILDING PROJECT

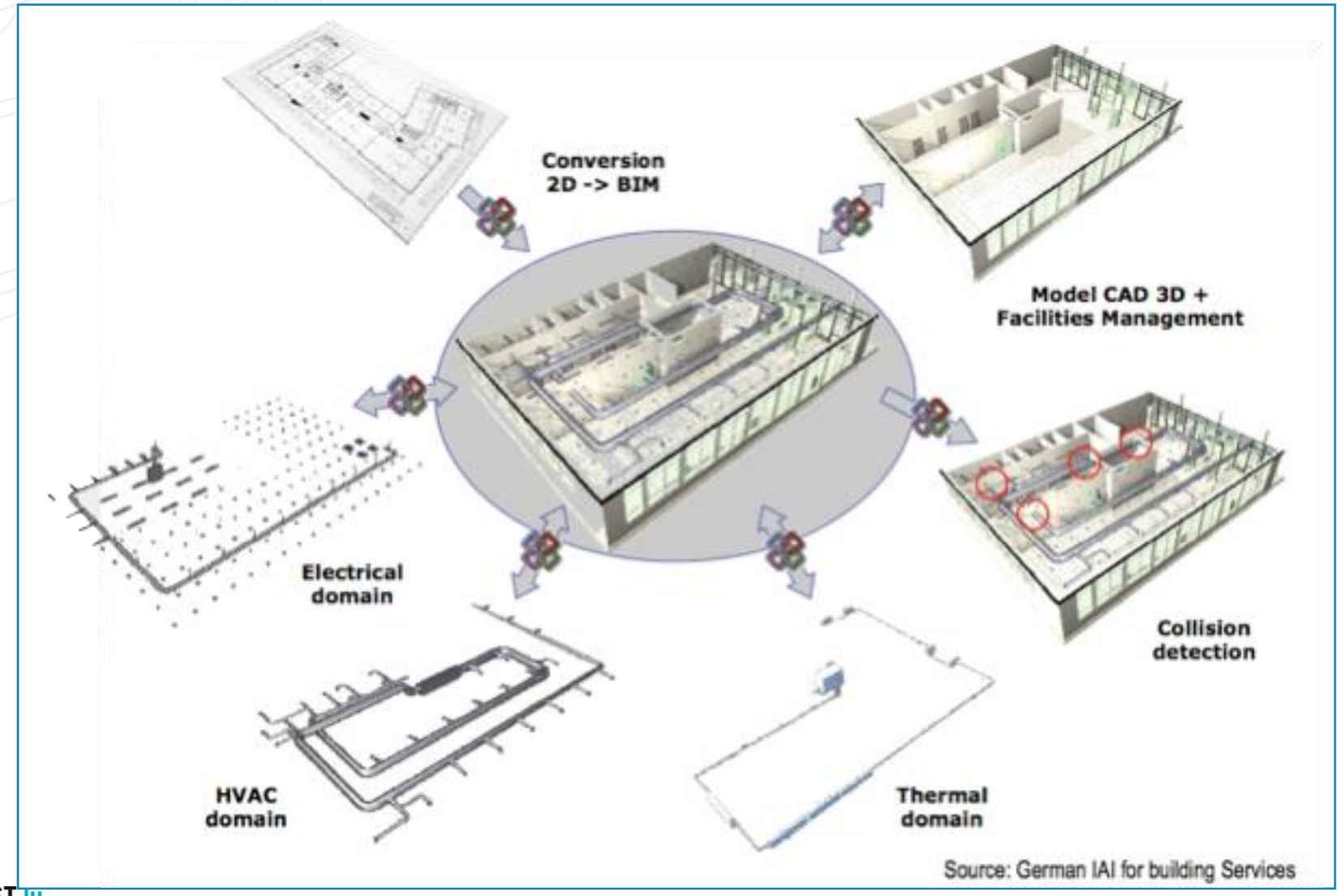
BUILDING MODELS

BIM: BUILDING INFORMATION MODEL



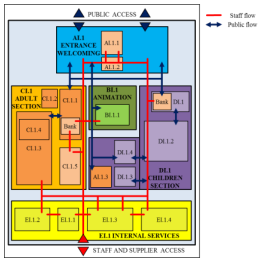
BUILDING MODELS

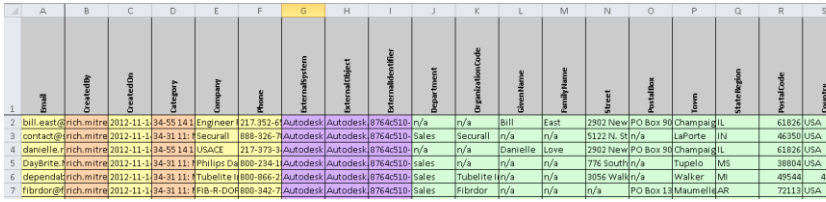
BIM: BUILDING INFORMATION MODEL



BUILDING MODELS

BIM: BUILDING INFORMATION MODEL





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3	contact@rich.mitre		2012-11-1	34-31 11:	Securall	888-326-7	Autodesk	Autodesk	8764c510-	Sales	Securall	n/a	n/a	5122 N. St	n/a	LaPorte	IN	46350	USA
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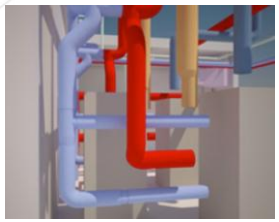
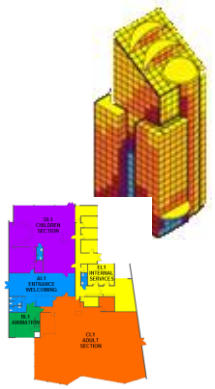
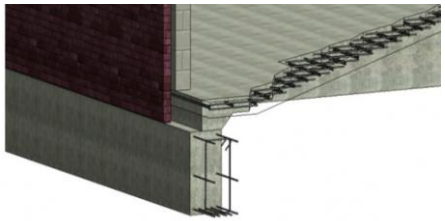
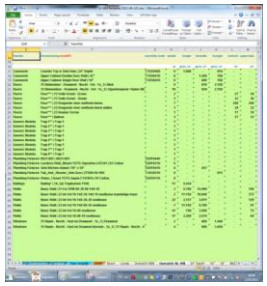
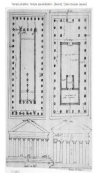


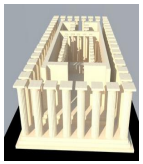
BiMserver™
Open source Building Information Modelserver











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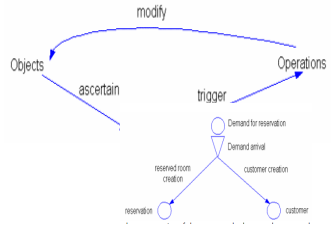

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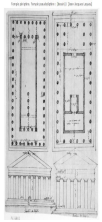
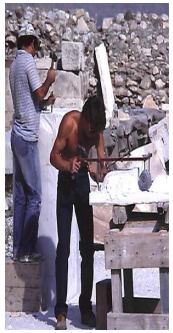
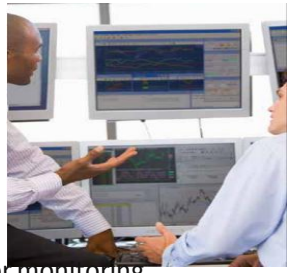




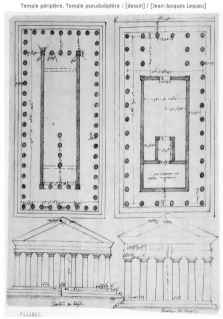


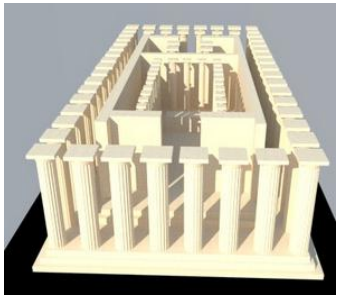
Fiber optic sensor monitoring movement on a column

3

4

TOWARDS A BETTER INTERTWINING OF BUILDING AND IS DOMAIN





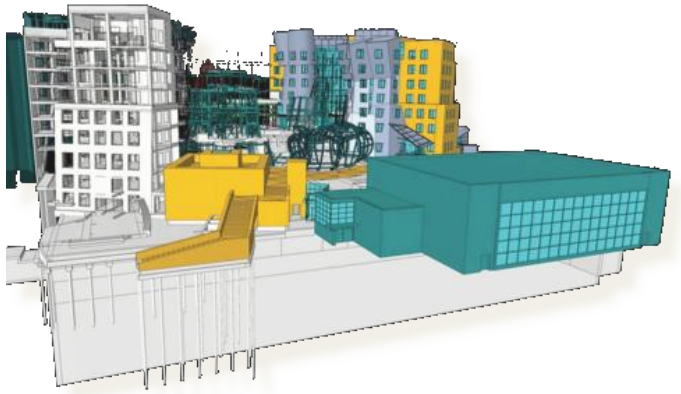
1

Digital models in the Buidling domain offer new opportunities for IS supporting collaborative worki

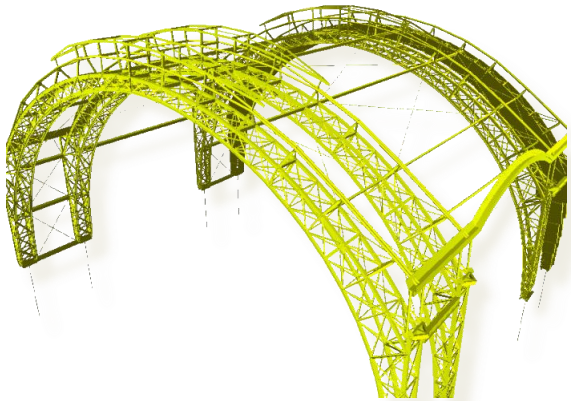
LIST RESEARCH AND INNOVATION IN CONSTRUCTION

Main characteristics of the construction sector

- Only one object produced
- Short-lived teams
- Independent and heterogeneous actors
- Wide range of models and methods
- Many different viewpoints
- Restricted areas of responsibility
- Internal strategies vs. project strategies



"Ray & Maria Stata Center for CIIS, MIT"
Arch. Gehry Partners



Dresden station, Germany
Arch. Foster and Partners

LIST RESEARCH AND INNOVATION IN CONSTRUCTION

- Cooperation is essential
  - To ensure project success
  - Difficulties
    - Low predictable environment
    - Communications not standardized
    - Low interoperability between CAD software
  - IS solutions remain under-used

THE ISSUE OF DOCUMENT MANAGEMENT

- State of the Art
  - Existing IS solutions are under-used in construction projects
- 2 types of limits
  - Human limits related to cooperative behaviours
    - Structuring of documents not efficient, exchanges not enough described, too much documents/releases produced…
  - Technological/IT limits
    - Still a lot of paper-based plans, no interoperability between tools , no connection with internal management system…
- Consequences
  - Wasted time (financial impact)
  - Difficulty to have latest documents on site (impact on quality of works)

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Participative elicitation of requirements for a new IS

- Series of workshops with practitioners
- Identifying consensual best practices…

Supported by the development of models

- Formalisation of requirements as
  - In a data model (BIM compatible)
  - Collaboration models following our collaborative practices metamodel
  - HCI Models

Supported by the development of

- MDE Development Approach supported by a SOA-based platform
- Integration of a BIM server

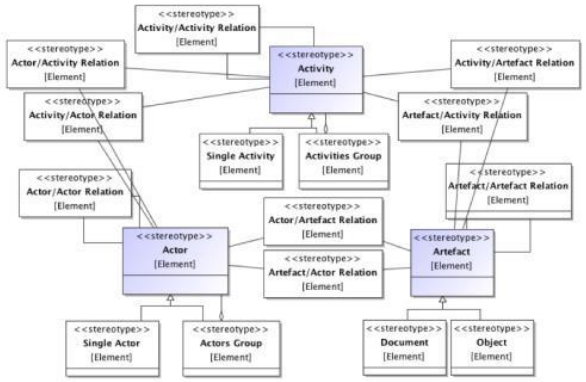


Fig. 1. Cooperation Context MetaModel CCMM – M2 (extract)

Validation through Lab and pilot projects experiments

School project, Luxembourg Cents

Offices/Hotel project, Luxembourg Kirchberg

School project, Nancy

School project, Nancy

 ©

CRTI-weB®

Document Exchange Best Practices

1. To use a standardized name for document files

2. To describe and to localize the modifications done on a document release

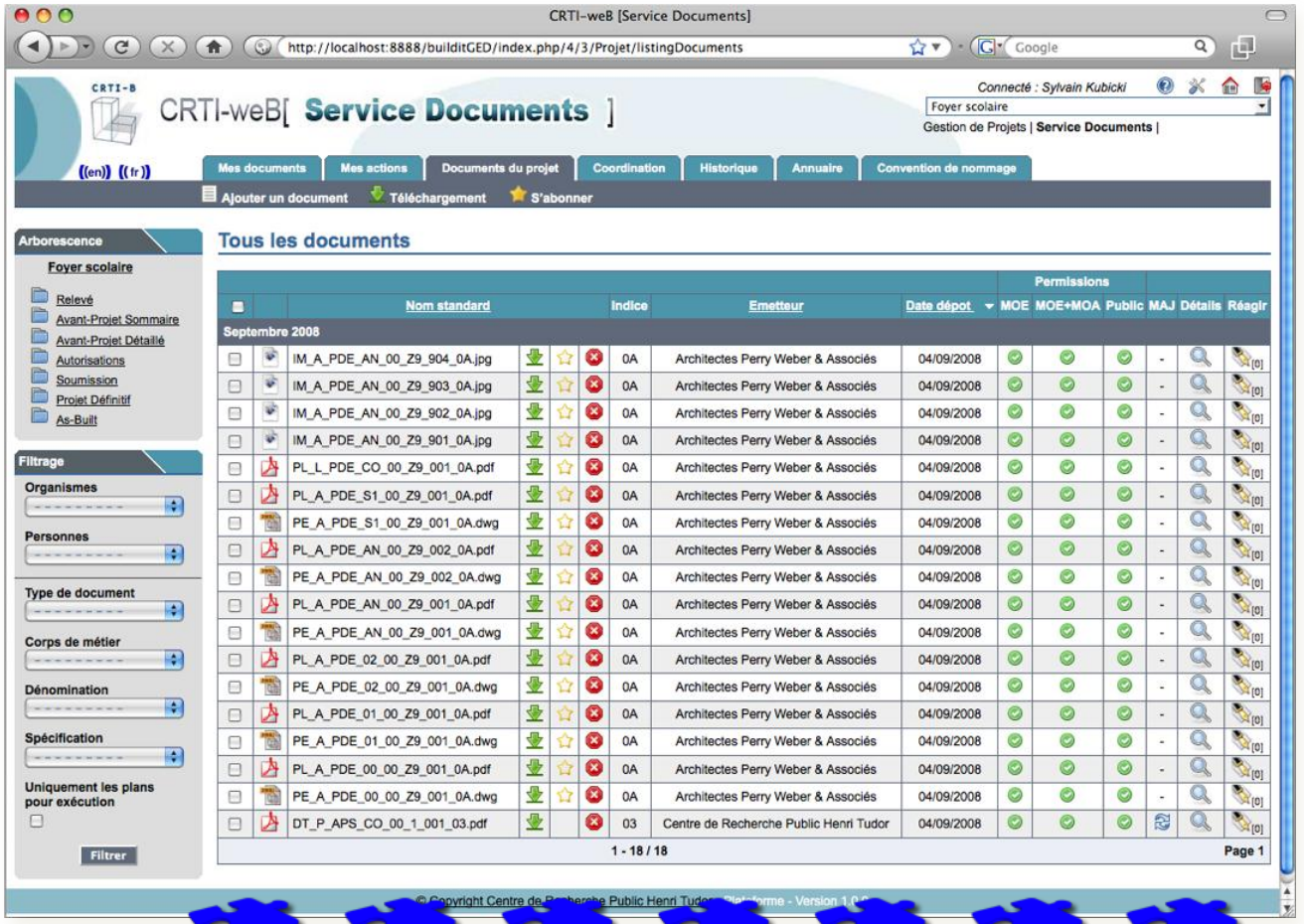
3. To inform the other participants when a document is uploaded or modified

4. To send and record the requests to the other participants

5. To react and to trace the reactions about a document

6. To monitor the access to share documents for the different participants in a project

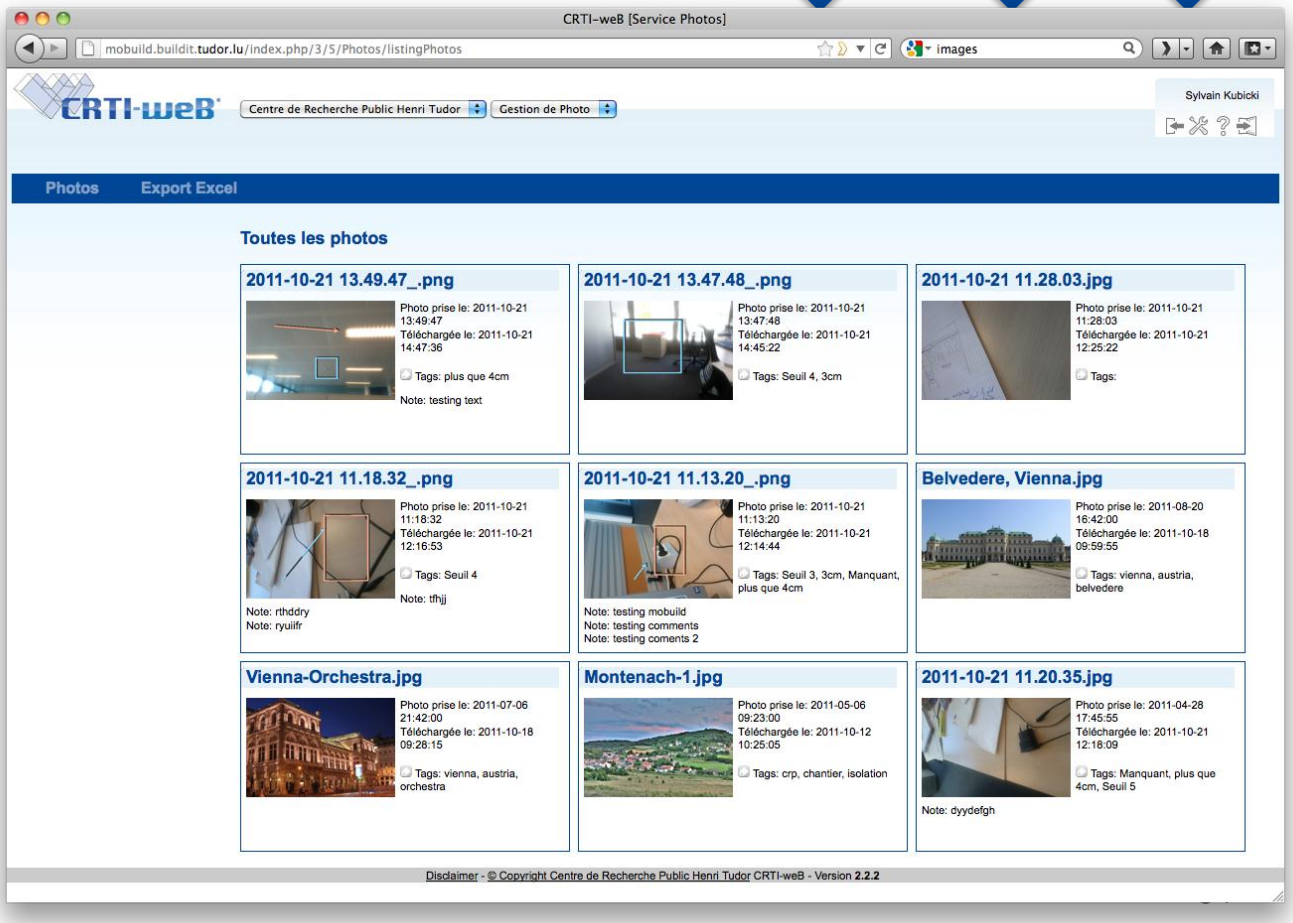
7. To monitor the document exchange



1. Service "Document name management"
2. Service "Document update"
3. Service "Notification"
4. Service "Action"
5. Service "Reaction"
6. Service "Areas"
7. Service "Document Exchange Dashboard"

Related eServices

Sending photos to CRTI-weB



CRTI-weB®

- Today, CRTI-weB has been used in about 60 large construction projects
- It is recommended by the
  - national sectorial association (CRTIB)
- It is transferred to software company
- We are in charge of
  - Assessment
    - Gathering feedbacks of users, of service provider
    - Tracking real-time feedbacks, regular questionnaires, workshops
  - Managing evolutions
    - Technical side (Software architecture)
    - Functional evolutions (specification, development management, tests)

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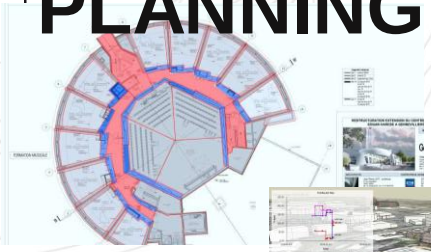
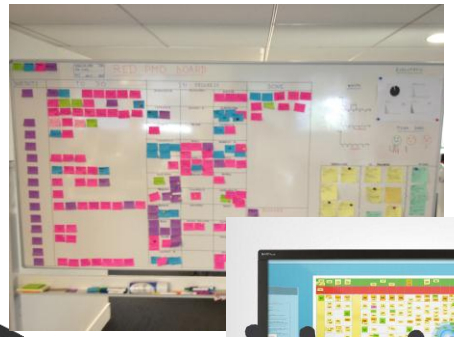
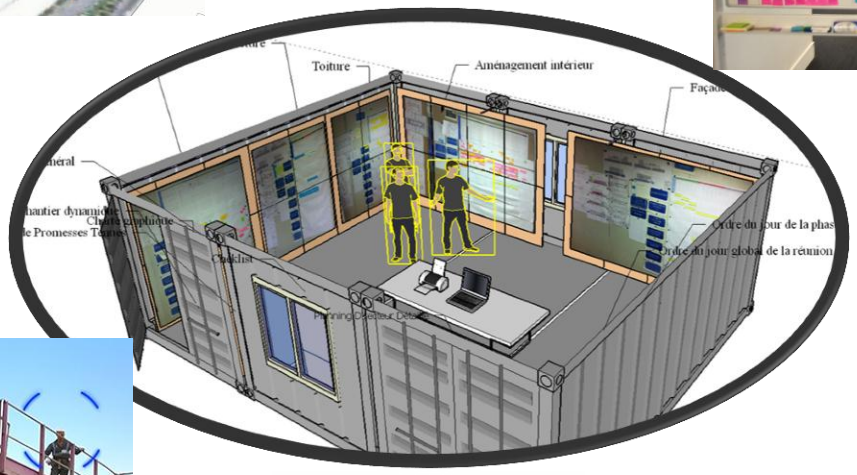
THE FUTURE: TOWARDS A FULLY INTEGRATED PLANNING AND MONITORING I.S.







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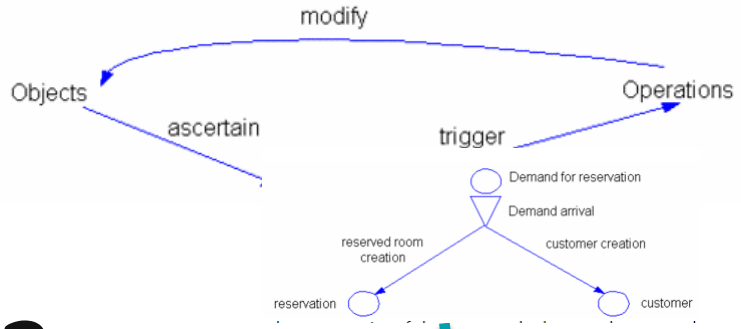
TOWARDS A BETTER INTERTWINING OF BUILDING AND IS DOMAIN



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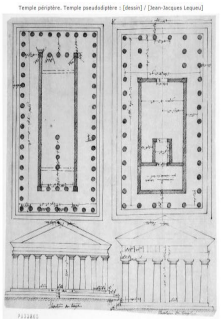


IS-related Requirements Engineering methods and models can improve the Building development and maintenance lifecyle

REQUIREMENTS ENGINEERING AND BUILDING LIFECYCLE

Conceptual Design Industrialisation Production Use

Architecture Construction Facility Mgt

The SPECIFICATIONS of the BUILDING

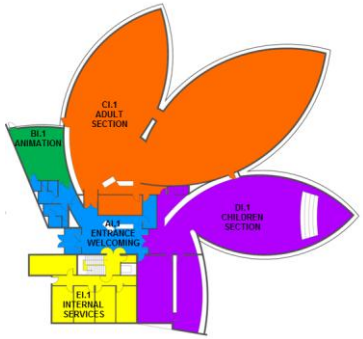
The REQUIREMENTS for the BUILDING

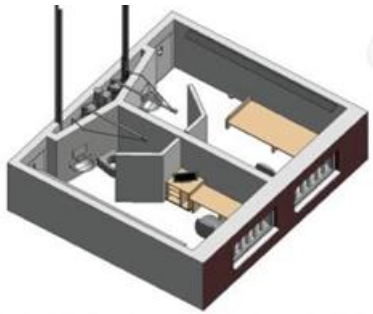
THE SPECIFICATIONS OF THE BUILDING

A multimedia library case

The Design phase

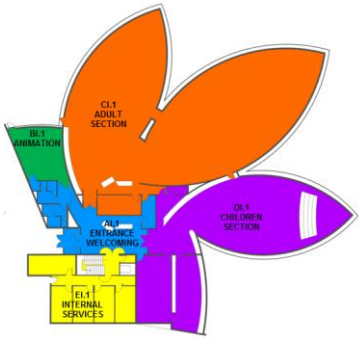
The specification of the structure is made of spaces and resources as well as
a building configuration
which defines the size, shape and proportions of the three dimensions associated with the building.



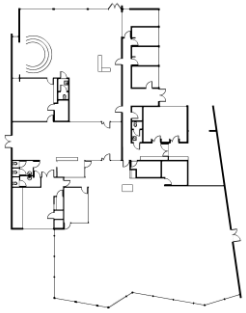


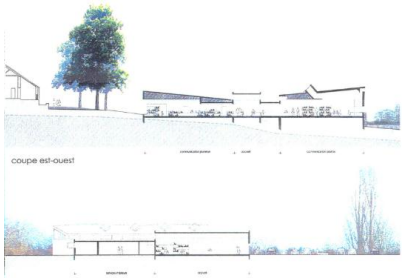
THE SPECIFICATIONS OF THE BUILDING

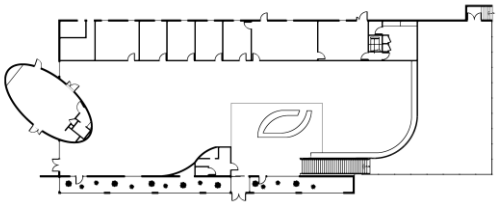
Often many different Design (solutions) for a same problem



REQUIREMENTS SHOULD ALLOW TO EVALUATE THE BEST SOLUTION







THE REQUIREMENTS PROBLEM

➔ **The Conceptual Phase is mainly experienced-based**

- Optional part of architects' education
- Experienced during on-the-job training
- Most of the programmers are former architects

➔ **Requirements elicitation based on principal activities**

- Main focus on the building (too much solution oriented)
- Few details on clients' business needs and operations
- Lack of documentation
- Fuzzy and implicit requirements

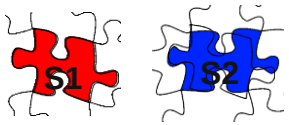
➔ **Lack of requirements management**

- Mainly human and paper based brief
- ICT solutions limited to project and building requirements
- Programmer = memory of the project

THE REQUIREMENTS PROBLEM

Copy-paste of “poor/standard” solutions or definitions

[SC-Construct 1; Interview]

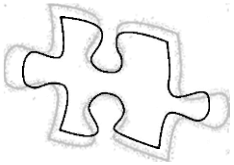


Conflicts between requirements

[Tzortzopoulos et al. 2006; Barrett & Stanley 1999]

Lack of accuracy in requirements

[Barrett & Stanley 1999; Tzortzopoulos et al. 2006]



Implicit requirements

[SC-Construct 1; Interview; Barrett & Stanley 1999]

Lack of comprehensiveness

[Shen et al. 2004; Yu et al. 2006; Kamara et al. 2002; Barrett & Stanley 1999; Yahya et al. 2007]

Absence of formalism / standardization / systemic / systematic

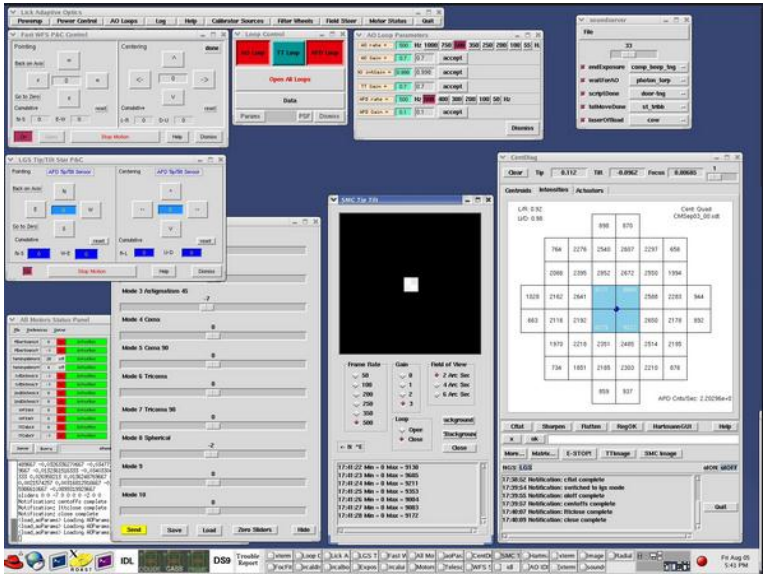
[Professional Architectural Programming Training 2011; Interviews]

Absence of languages, methods and tools

THE REQUIREMENTS PROBLEM

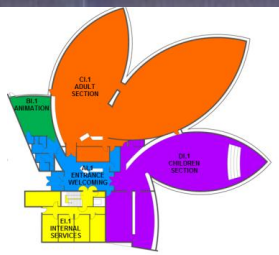
Last but not least the Architect which is often privileging the aesthetics of the building and less its utility. The 'look and feel' of the building can be great but in practice, it may happen that the building does not offer the adequate spaces, layout, or resources needed for activities.

This could be compared with an IS where the GUI is excellent but functionalities are missing



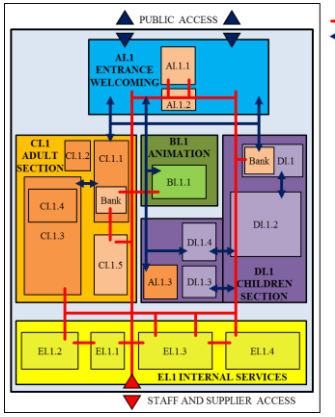
REQUIREMENTS PRACTICES

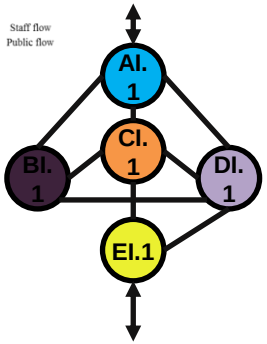
- :

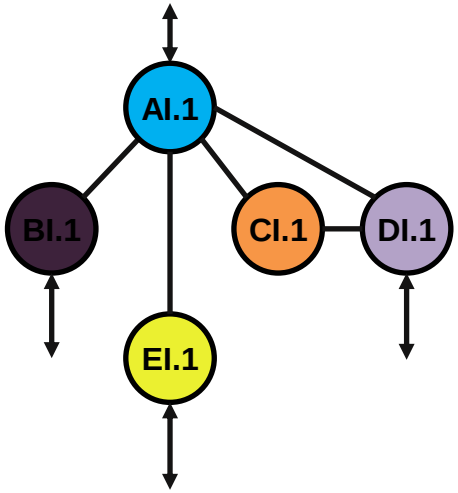


Requirements Production

Identify spaces, transition between spaces and resources required for activities (1 space par activity)



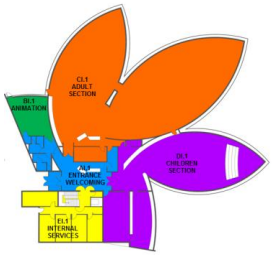


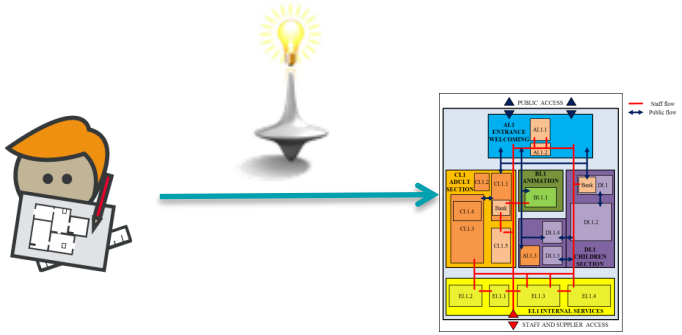


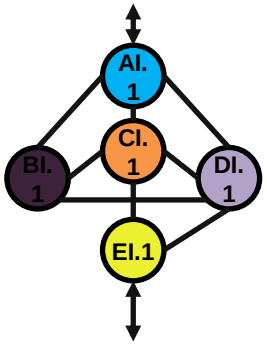
Check if the specification of the solution verifies the requirements

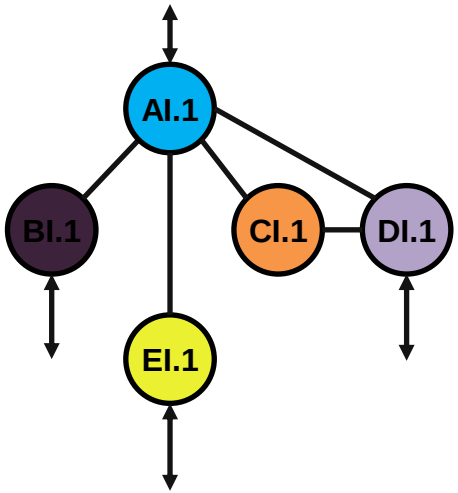
REQUIREMENTS PRACTICES

- :







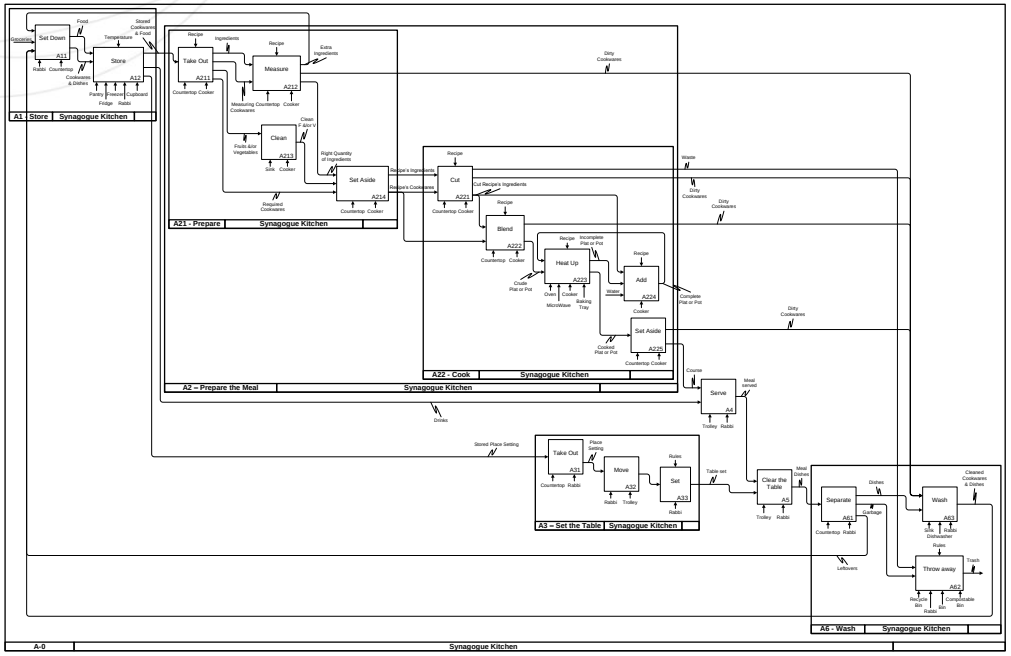


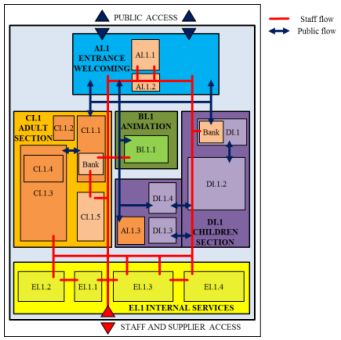
No standards for representing the brief
No requirements methods for producing it

INTRODUCING IS RE TECHNIQUES

PhD C. Mauger

- :



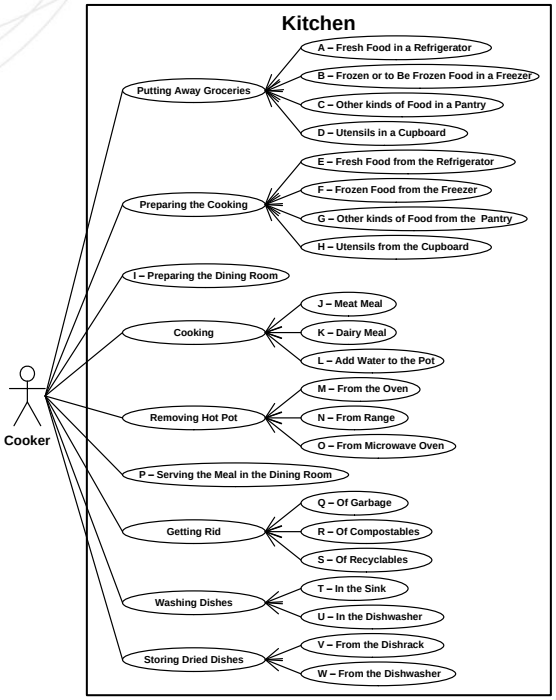


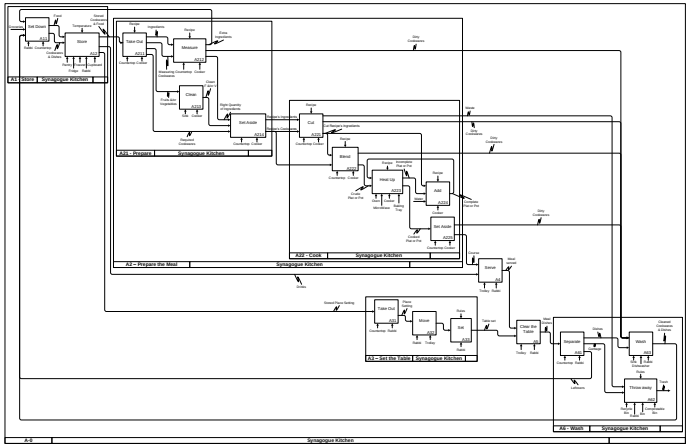
Understanding the need for spaces and ressources by understanding thaectivities that have to be performed in the building

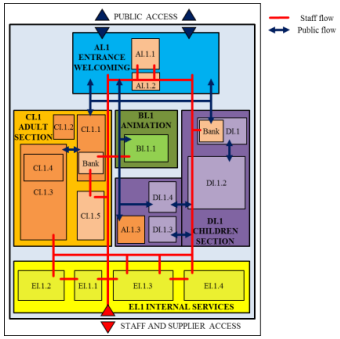
INTRODUCING IS RE TECHNIQUES

Joint work C. Mauger & D. Berry

- :







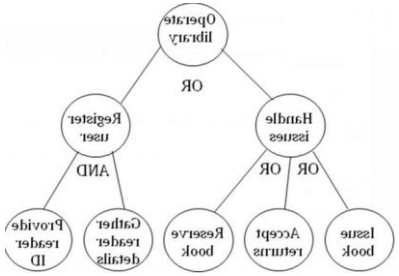
Use of use cases for understanding the services to be delivered

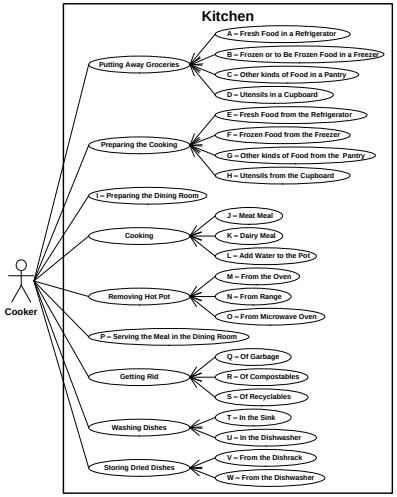
INTRODUCING IS RE TECHNIQUES

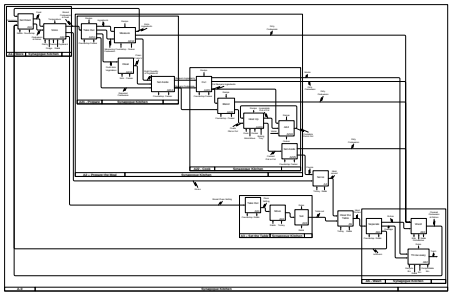
PhD C. Mauger

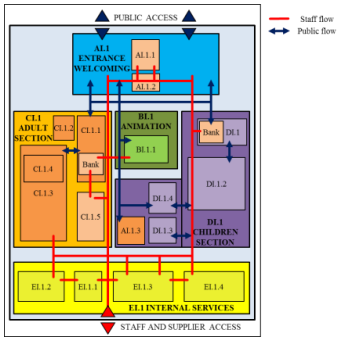
- :

Use of GORE for understanding the goals of a building

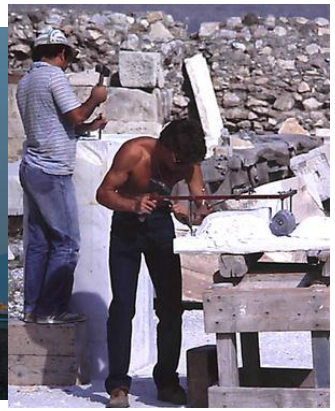








TOWARDS A BETTER INTERTWINING OF BUILDING AND IS DOMAIN



3

The new paradigm of SMART BUILDING asks for a joint approach regarding the integration of the buidling and of the information systems

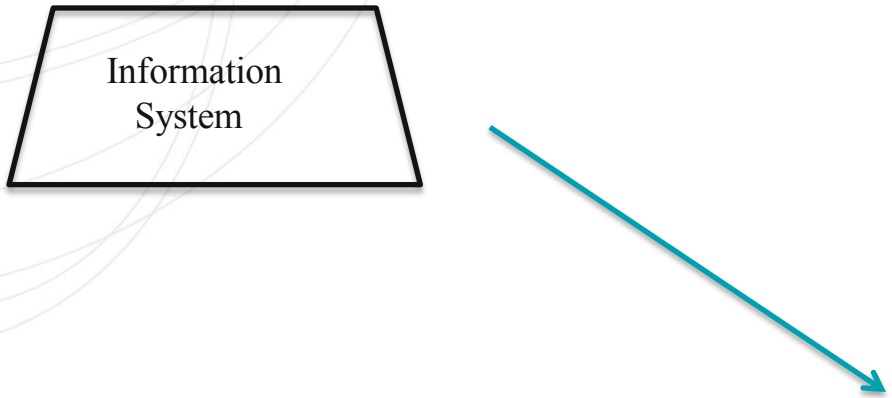
PRODUCT SERVICE SYSTEM

EVOLUTION OF INFORMATION SYSTEM

EVOLUTION OF BUILDING

INFORMATION SYSTEM

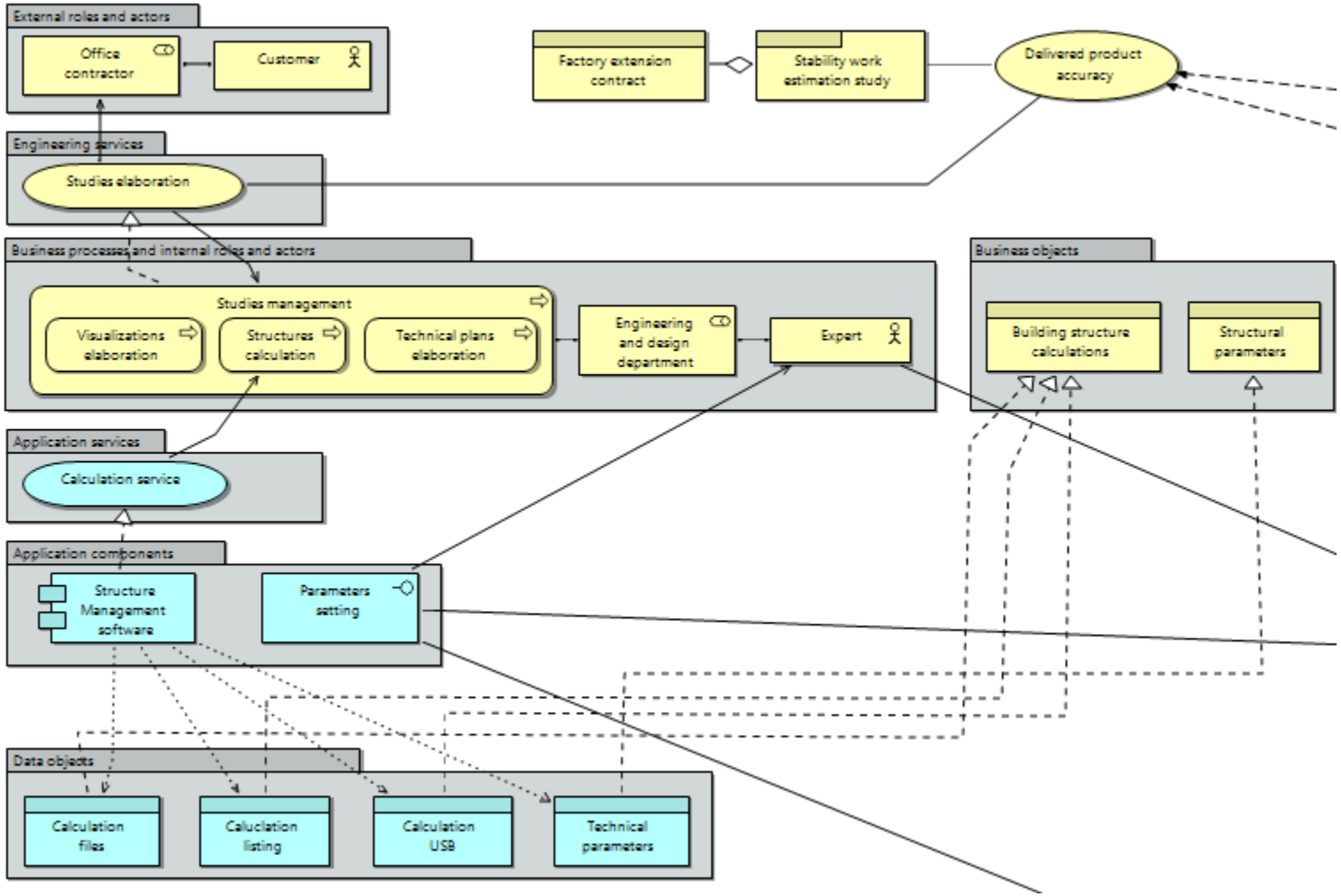
From I.S. to Service System



Service system is defined as a configuration of people, processes, technology and shared information connected through **a value proposition** with the aim of **a dynamic co-creation of value** through the participation in the exchanges with customers and external/internal service systems

from [Spohrer, Maglio, 2007]

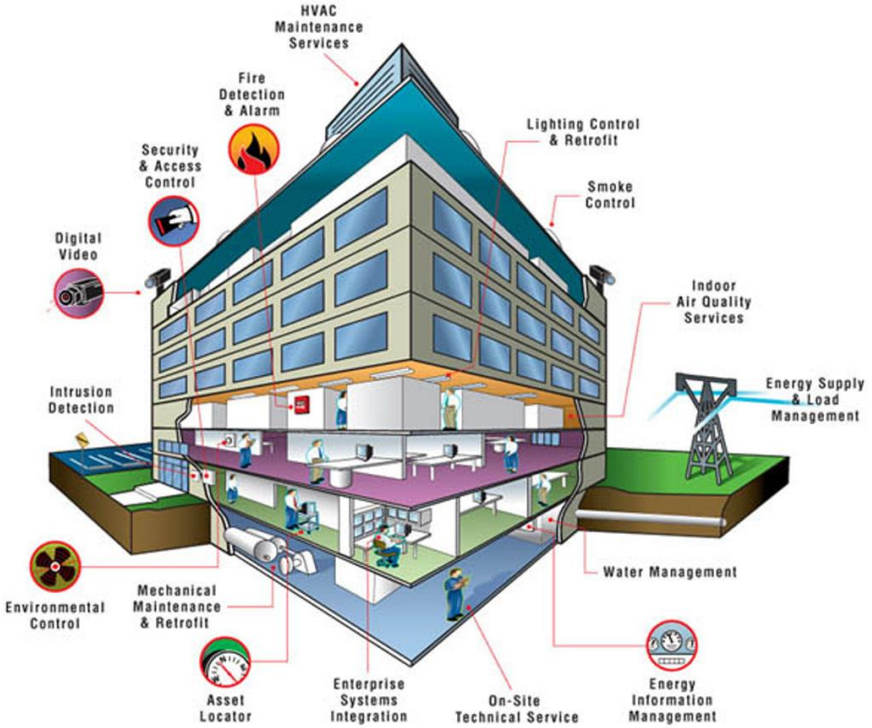
SERVICE SYSTEM AND E.A.



FROM BUILDING TO ‘SMART BUILDING’

Smart Building can be defined as a building hosting several information systems (IS) providing services about energy management, safety, welfare, communication, etc.

[Anglés, S. M., Ganah, A., Santos, A. G., & Leube, F. J. J.]



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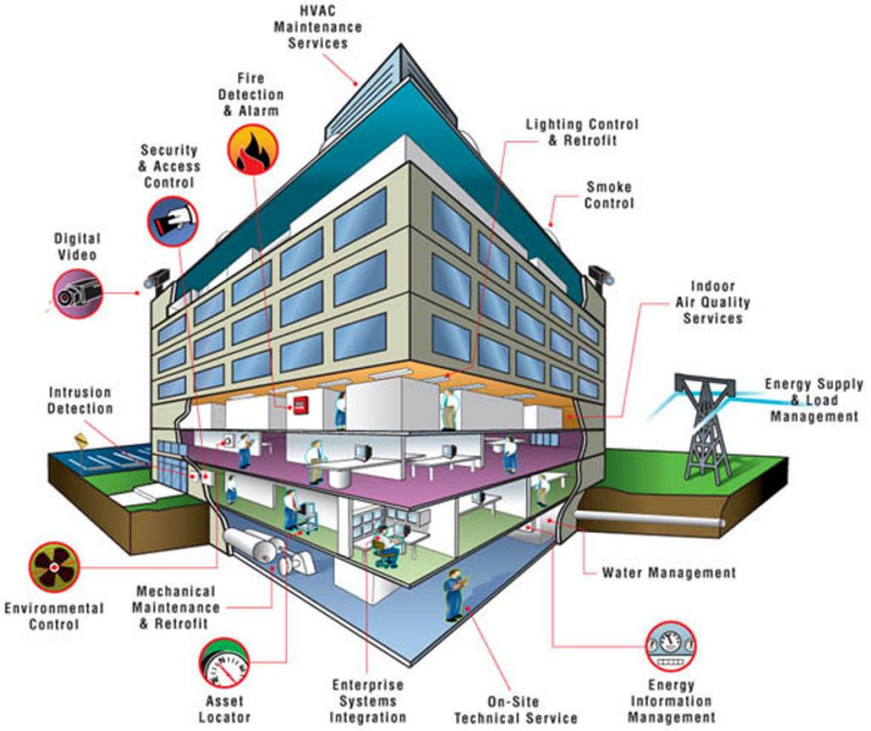
‘SMART BUILDING’

a SMART BUILDING like another buidling delivers services but there are now alternatives regarding the way services are implemented



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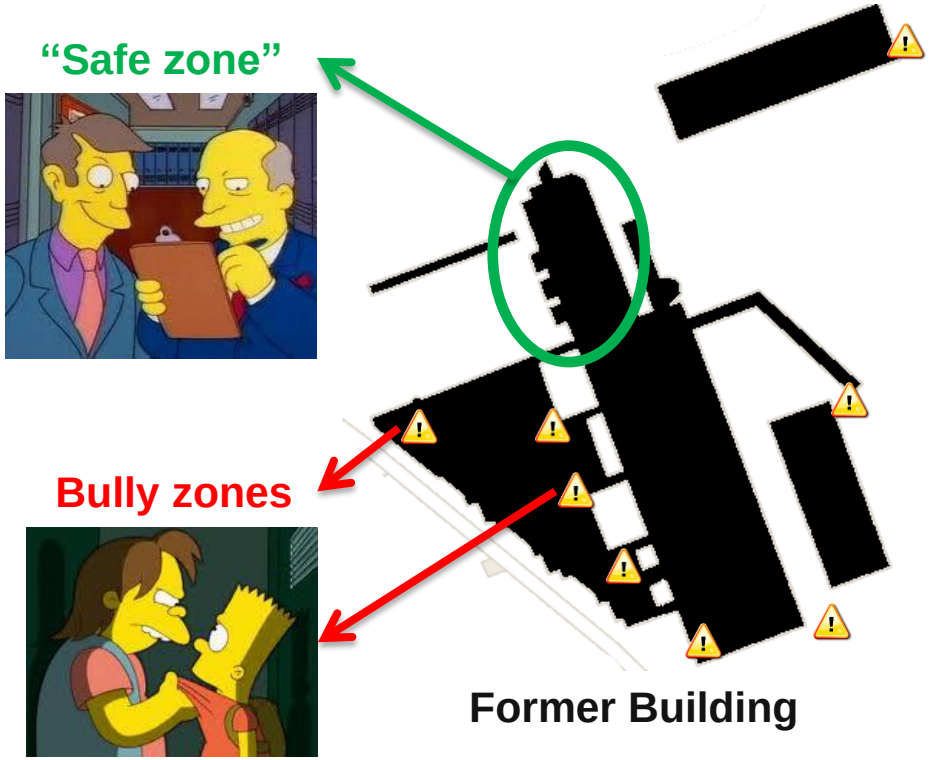
EXAMPLE

A Requirement Goal associated with a School in Luxembourg

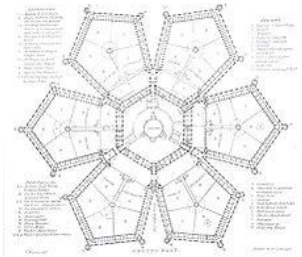
Group Work Session on a specific topic: Pupils' safety



EXAMPLE

Several possible requirements associated with the goal realization

Architecture Positioning



Transparent Materials

Teachers + Rounds

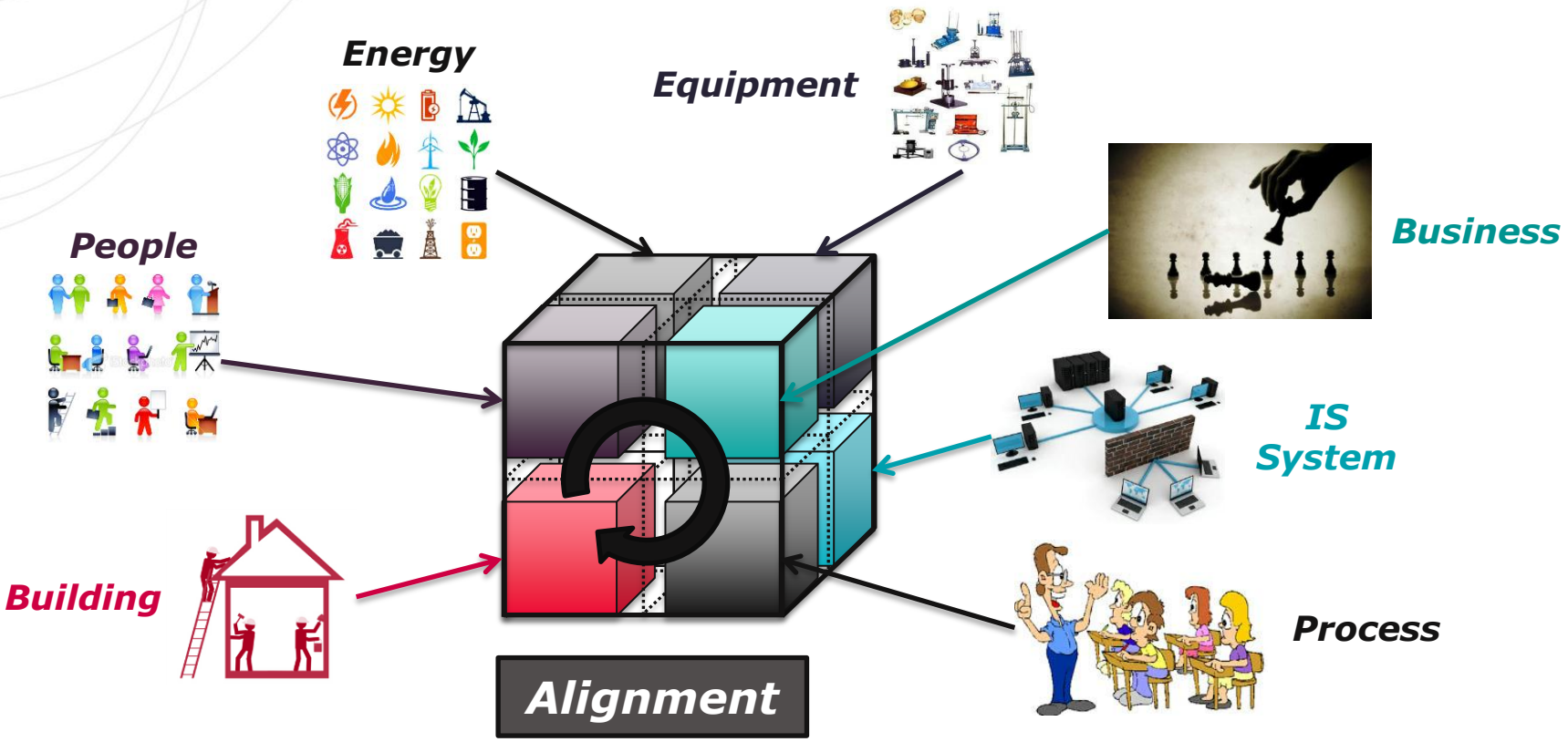
CCTV + Guard

Combination

1. Building
2. Materials
3. Organisation + Equipment
4. IS + People + Room
5. "Org." + Materials + Building

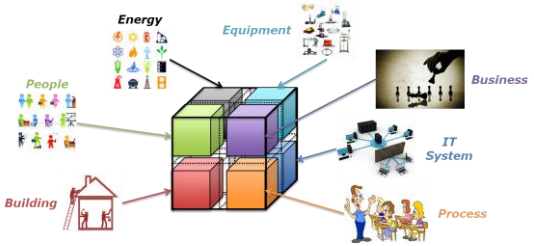
Different Requirements on different hard/soft solutions!

A SMART BUILDING IS A BUILDING SYSTEM



A SMART BUILDING IS A BUILDING SYSTEM

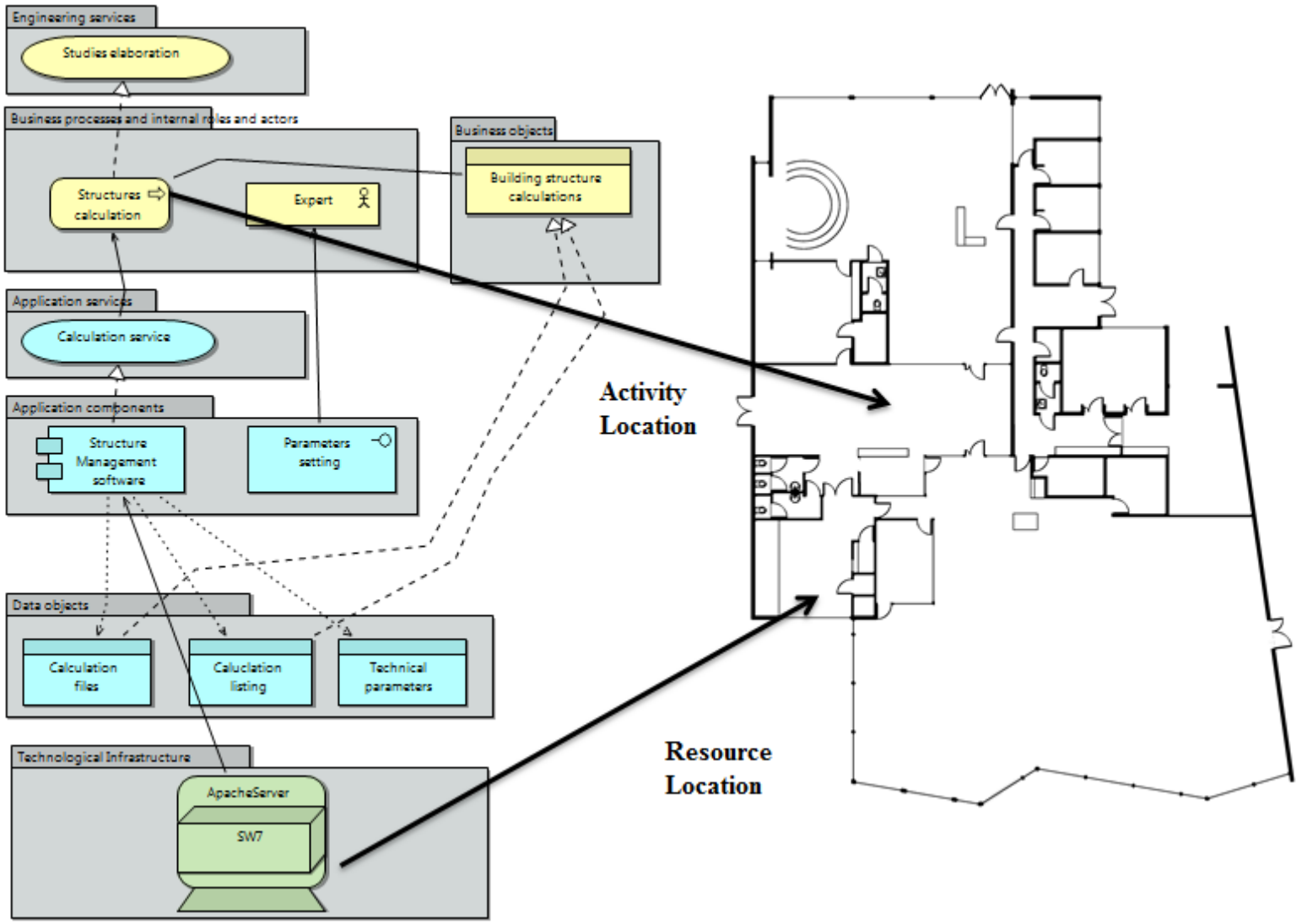
The system is a product-service system (PSS)



“Building as a PSS’	
Product part	*Service part*
• Building • Equipment & Furniture • IT Infrastructure • … → **Physical (static) artefacts**	• Business and Support Services (e.g. Administration, Maintenance) • Service Systems • … → **Soft (dynamic) artefacts**

Alignment

PSS LIKE BUILDINGS REQUIRE AN INTEGRATED MODELLING APPROACH

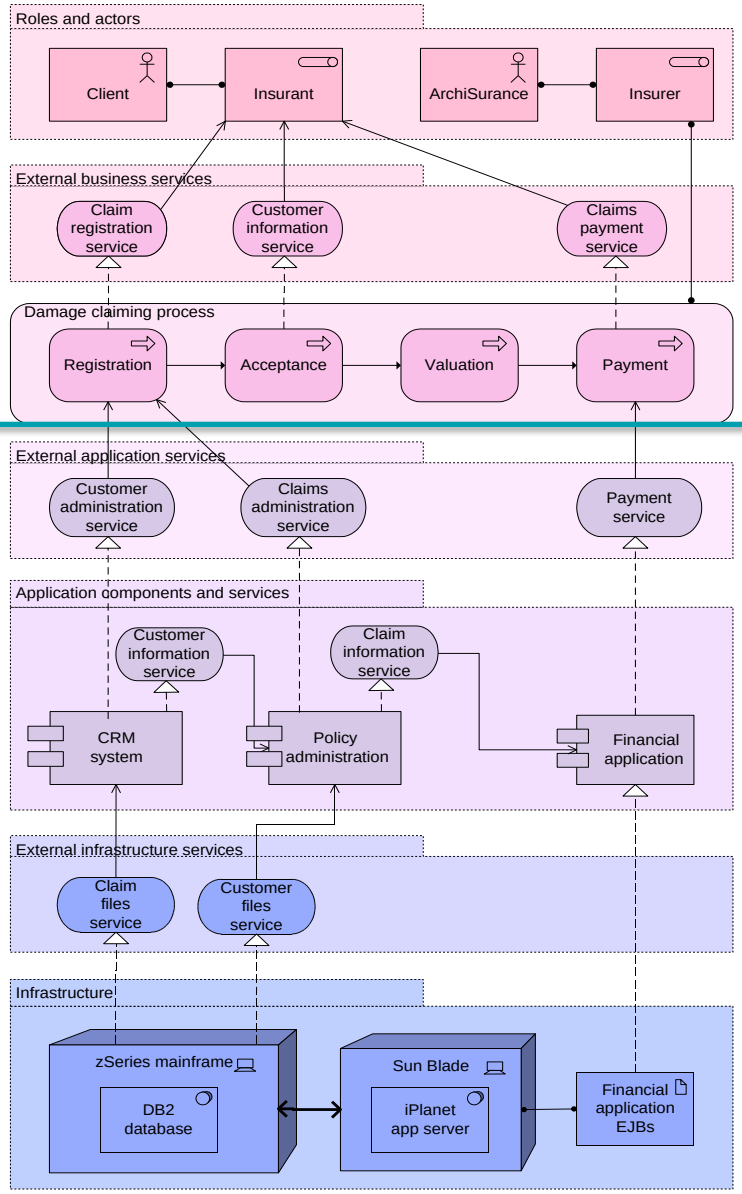


TOWARDS A BETTER INTERTWINING OF BUILDING AND IS DOMAINS

4

Cyberber-physical critical systems ask for a systemic approach like e.g. in the safety and security ares

EA AND SECURITY RISK



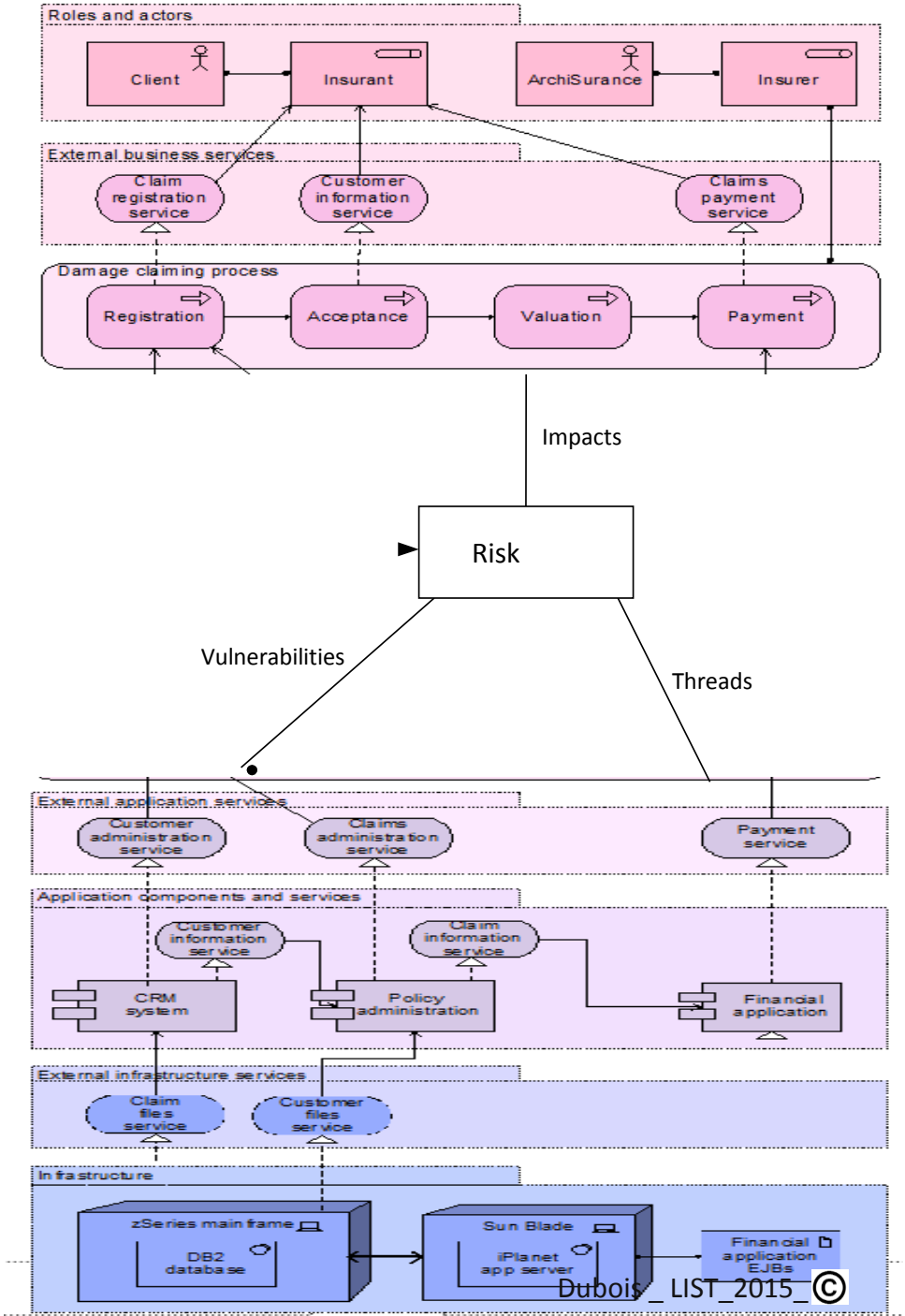
Enterprise Architecture is about, a.o.,

Business

Alignment

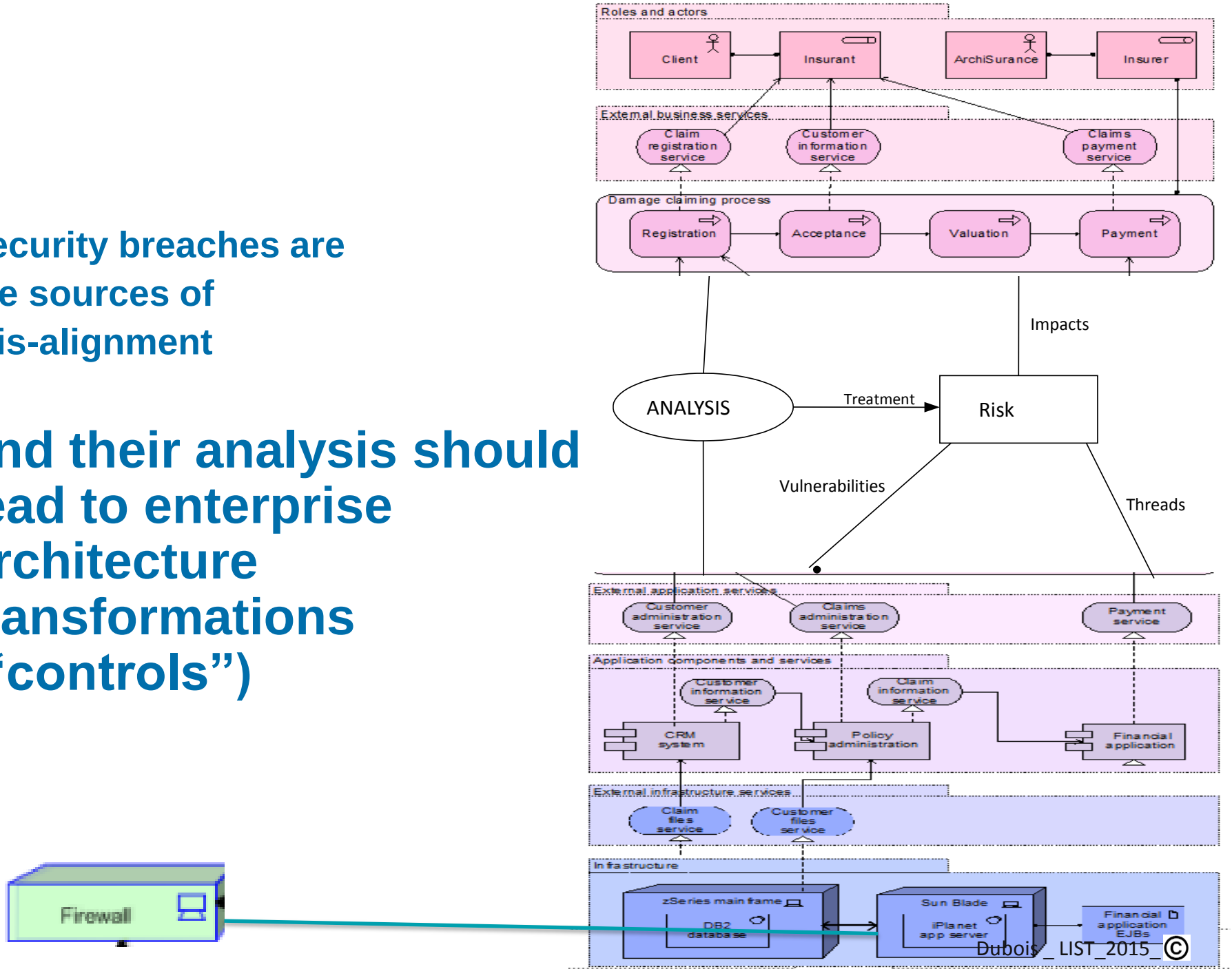
IT

Security breaches are the sources of mis-alignment



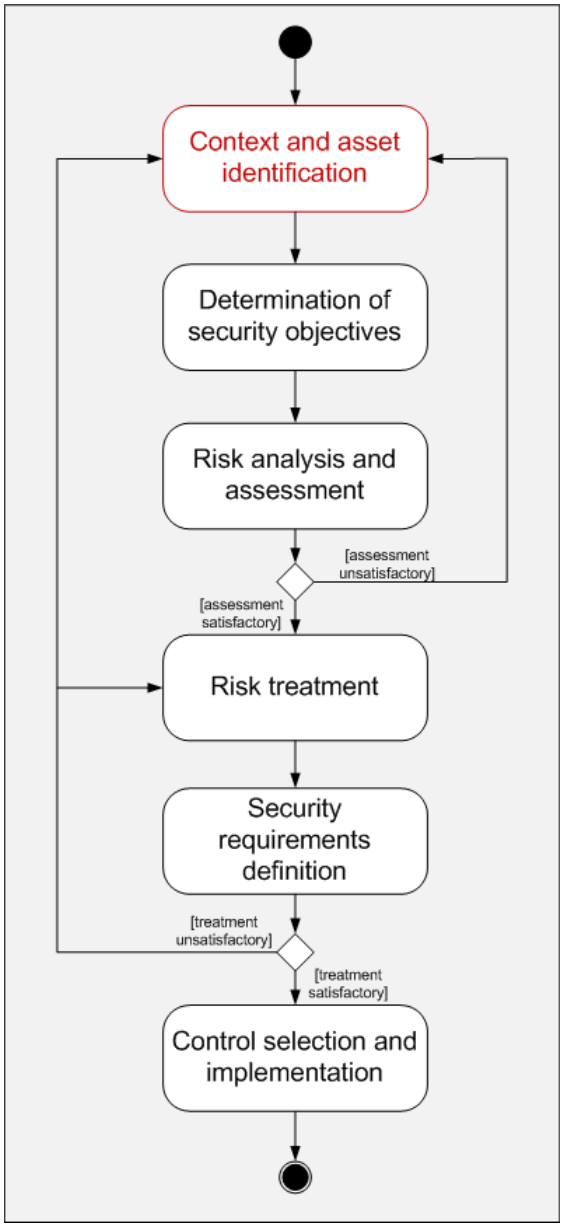
Security breaches are the sources of mis-alignment

and their analysis should lead to enterprise architecture transformations (“controls”)



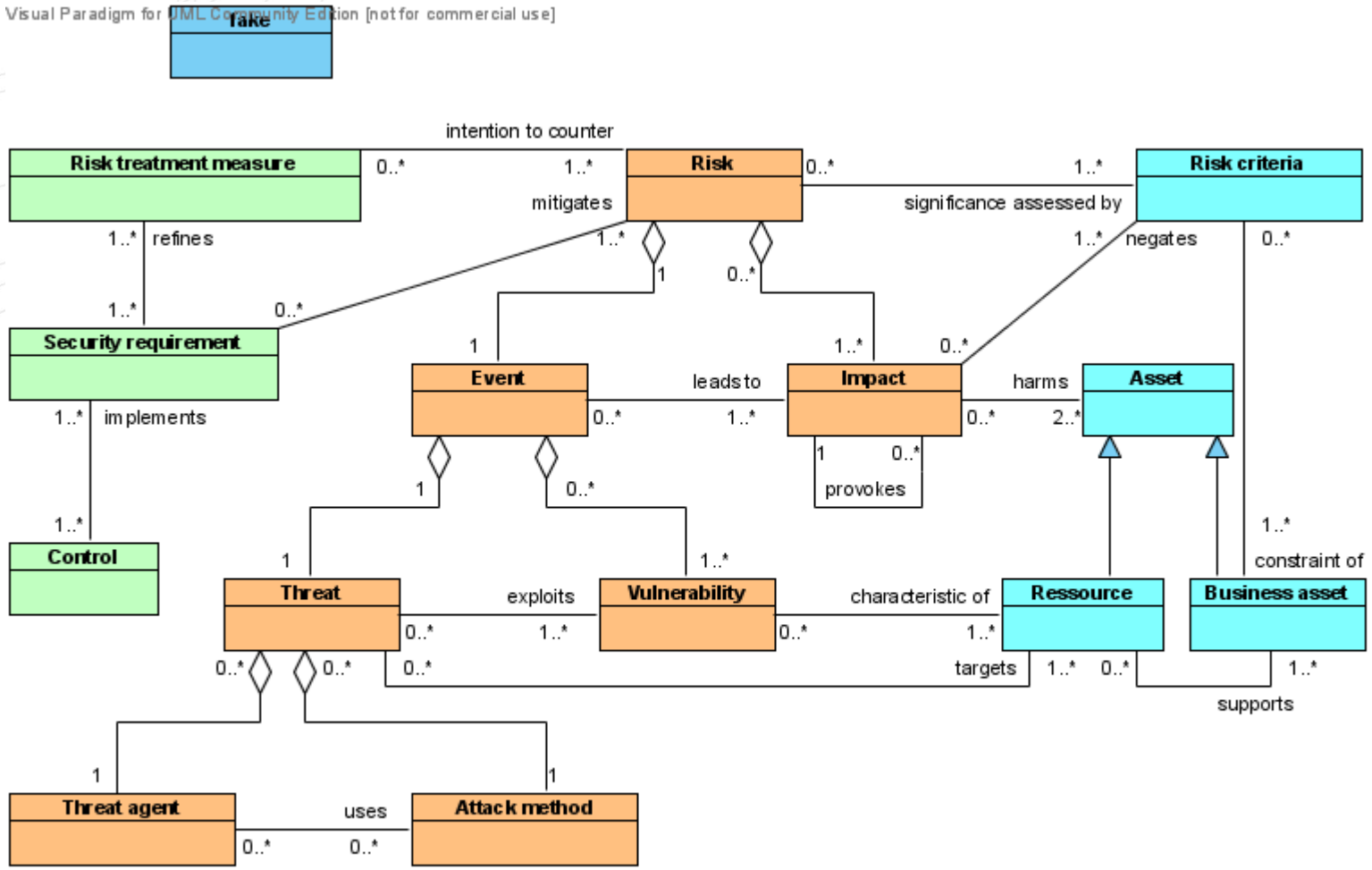
A SHORT INTRODUCTION TO SECURITY RISK ANALYSIS

ISO 27005

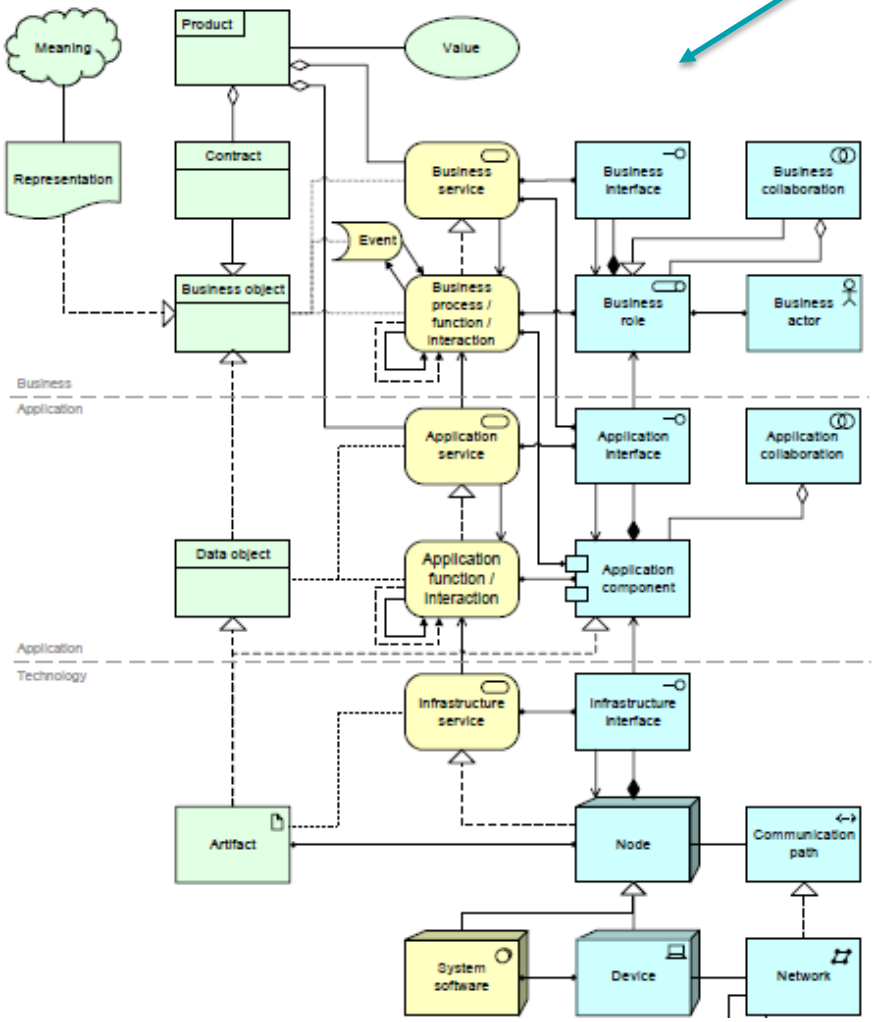


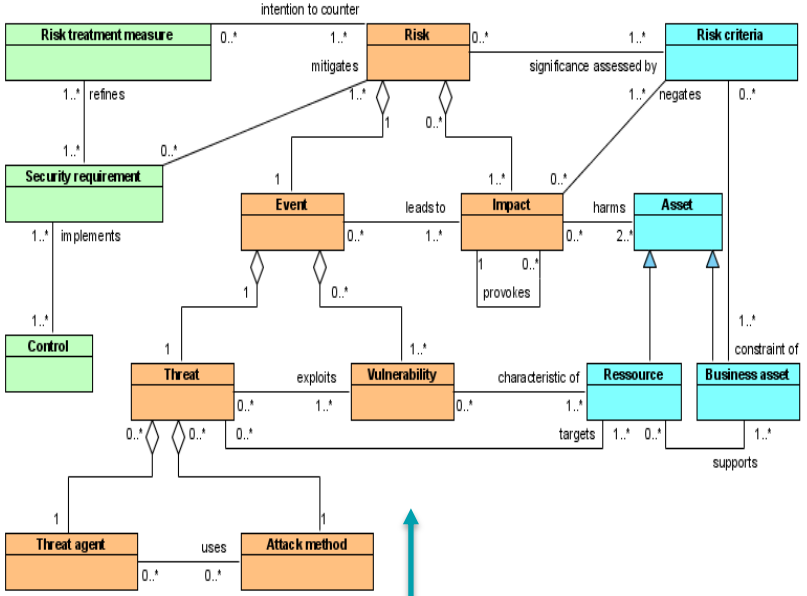
A SECURITY RISK ONTOLOGY

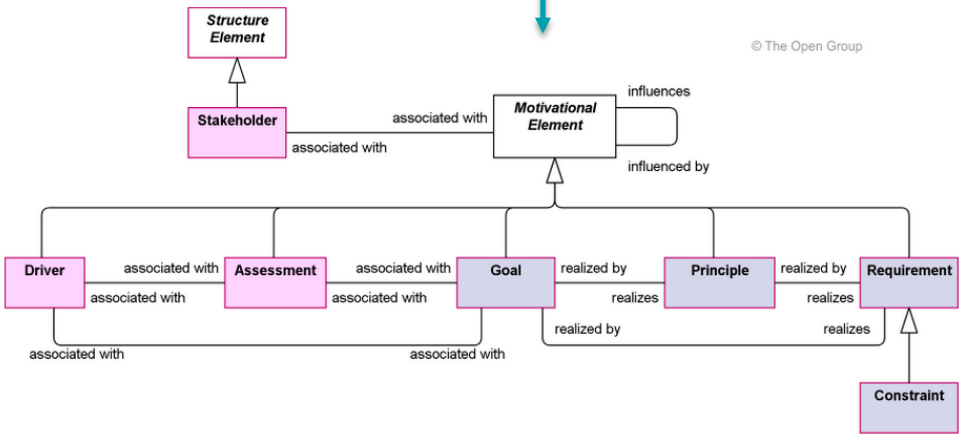
PhD work N. Mayer



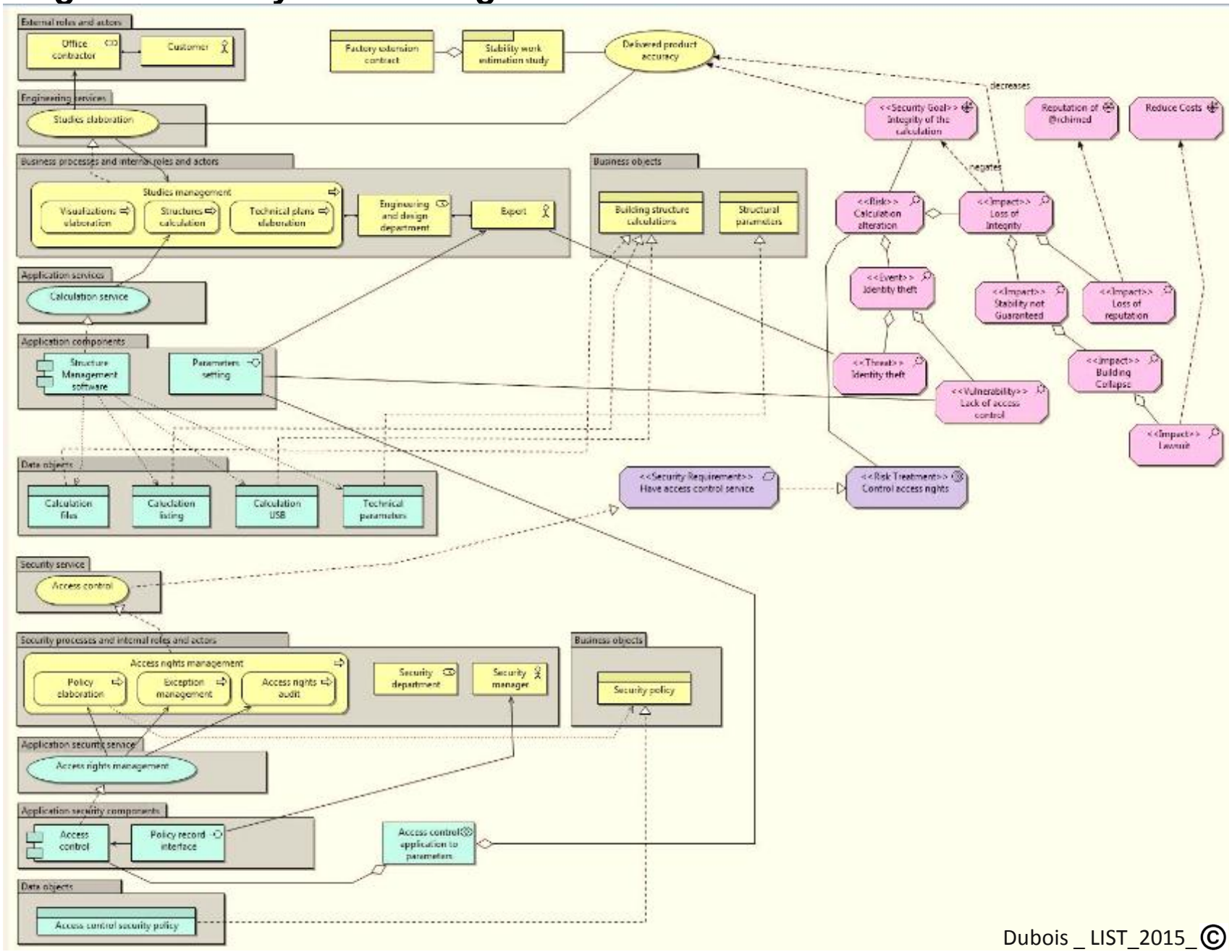
Integration with the ArchiMate meta-model





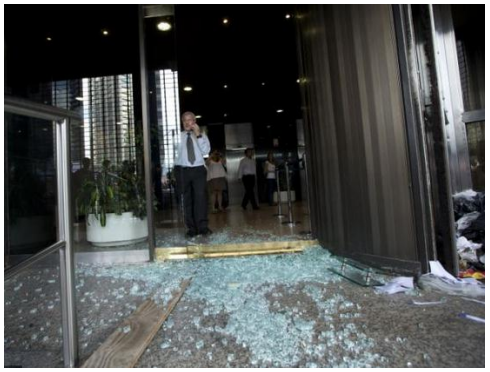


Using the security risk management ArchiMate extension

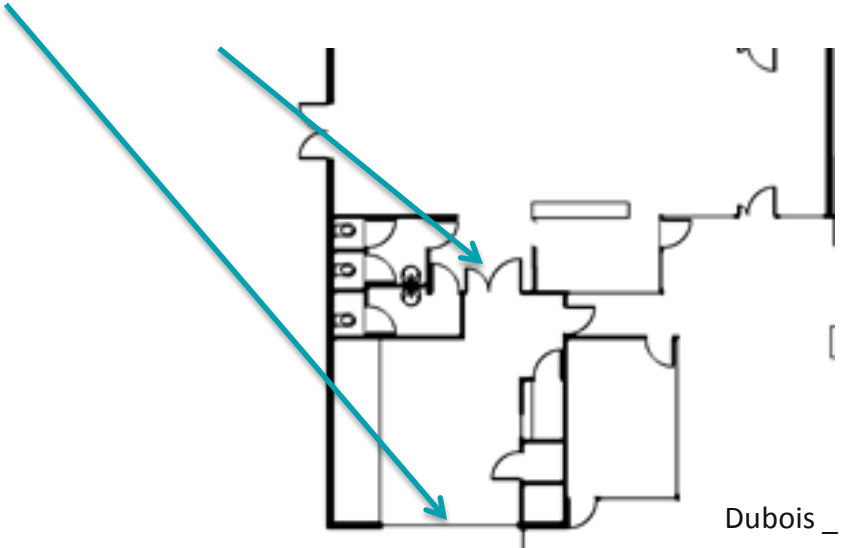


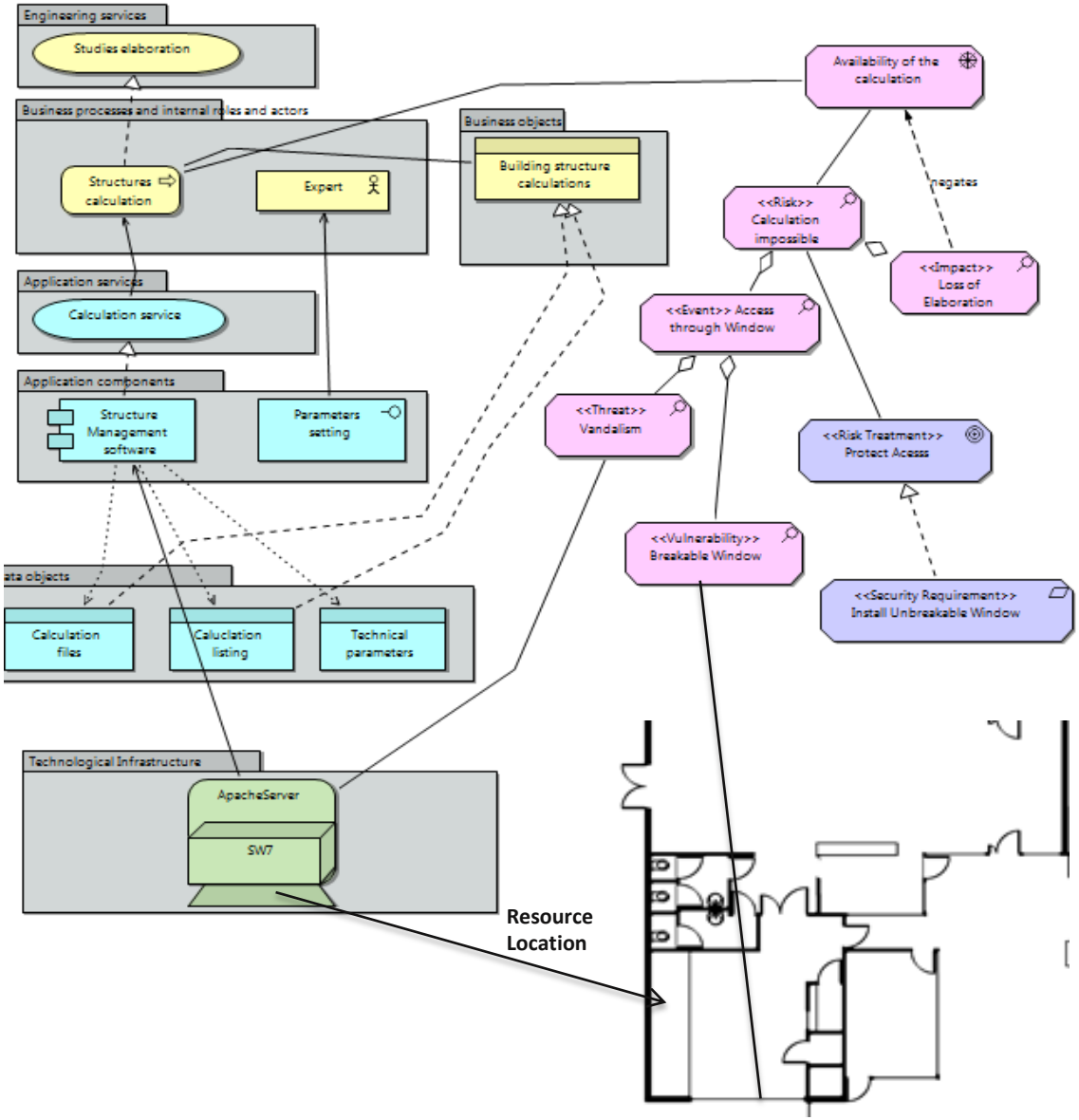
BUT SECURITY RISKS ARE ALSO RELATED TO PHYSICAL VULNERABILITIES

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY



Doors, Window, etc





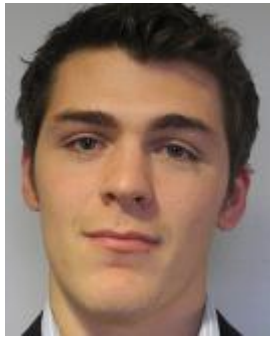
Need to jointly reason about the I.S. and the physical architecture

CONCLUSIONS

- **BIM opens new avenues for new I.S. supporting the building lifecycle and its different activities**

- **IS are everywhere and we need to adopt more systemic modelling approaches for capturing all the facets of a socio-cyber-physical system**

THE BUILDING TEAM @ LIST.LU



THANKS FOR ATTENTION

eric.dubois@list.lu