Lean and integrated management process of temporary construction items (TCIs)

Alex Schlachter
MSc. Architectural Engineering, DTU

Agenda

I. Problem & Solution Space

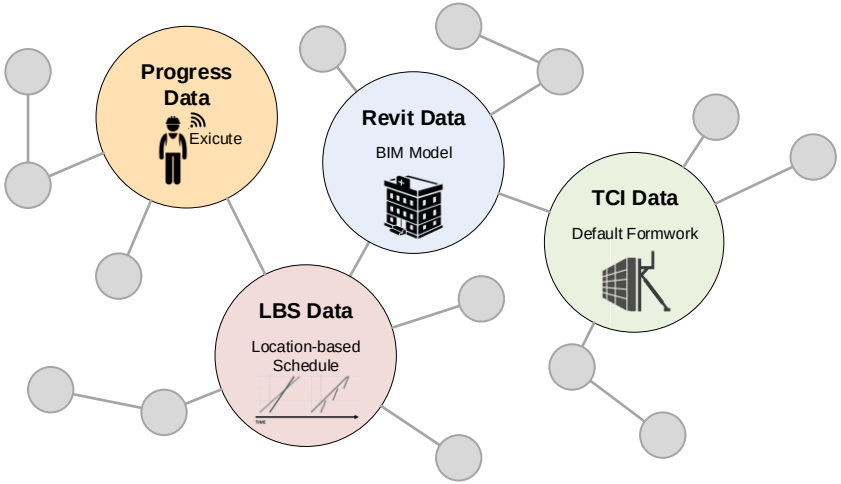
II. Proposed specific Solution

III. Linked Data in Construction

IV. Prototyping/ Demo Project
- Data Sources & Extraction
- Data Management
- Data Processing & Querying
- Data Visualization & Distribution

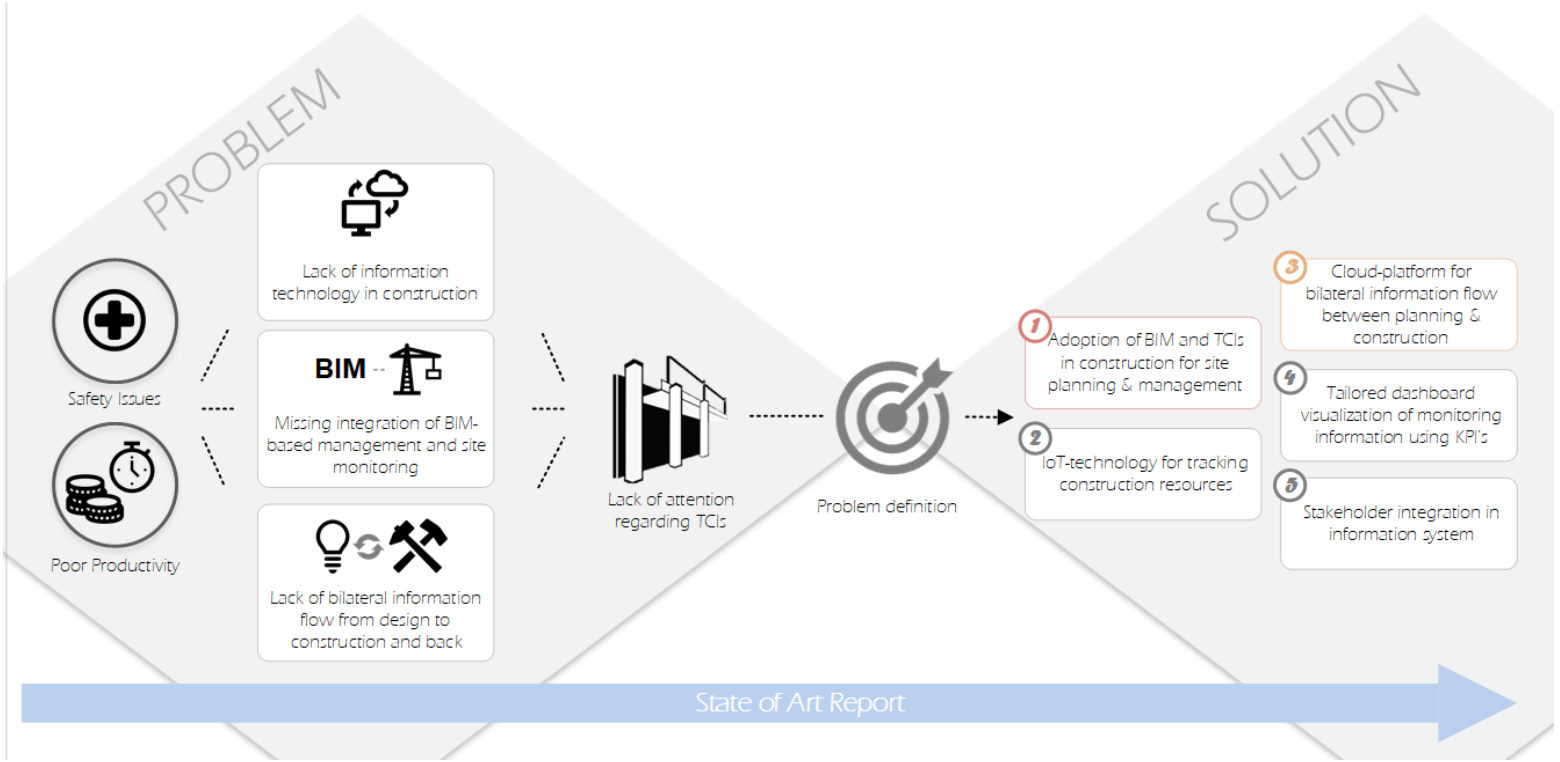
V. Case Study

VI. Ideal Future Scenario



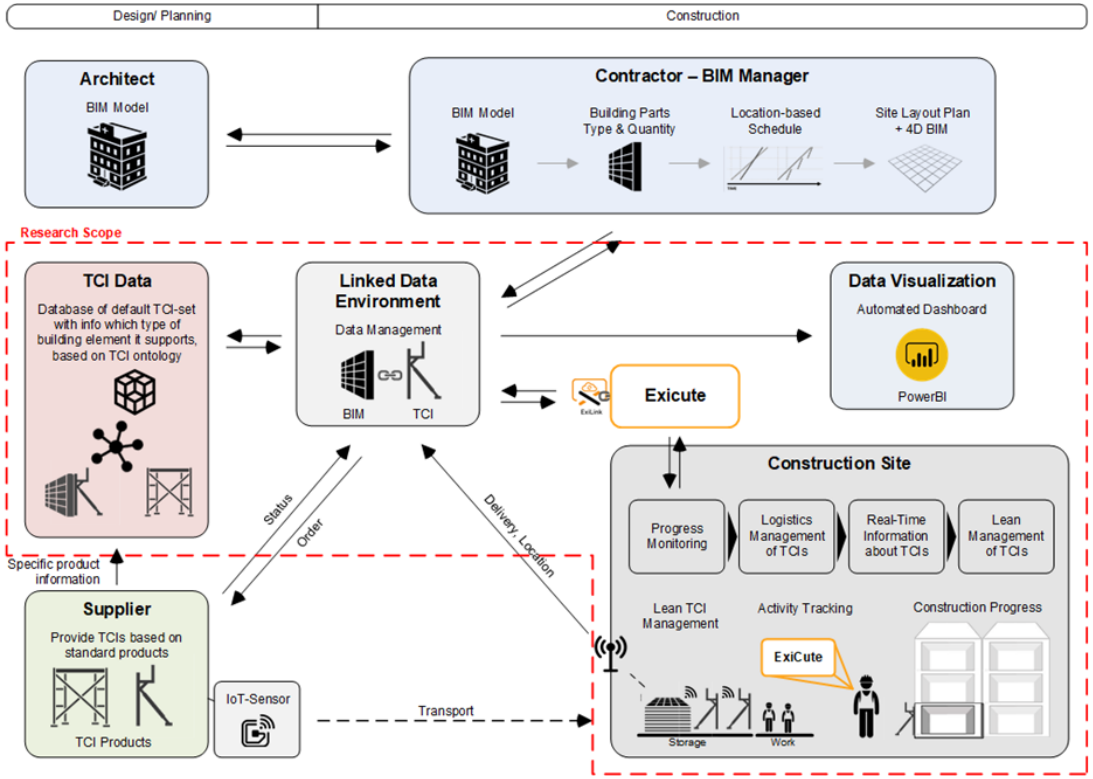
I. Problem & Solution Space

State of Art - Problem & Solution Space



II. Proposed specific Solution

Proposed Solution



Benefits

- Automatic planning of TCIs
- Goal to generate a TCI utilization plan
- Direct link of TCIs to permanents building elements supporting their construction
- Passive scheduling and monitoring of TCIs
- No additional planning effort
- Lean management of TCIs possible due to precise and updated data about TCI-utilization
- Possible extension with supplier software, product catalogues and IoT-tracking

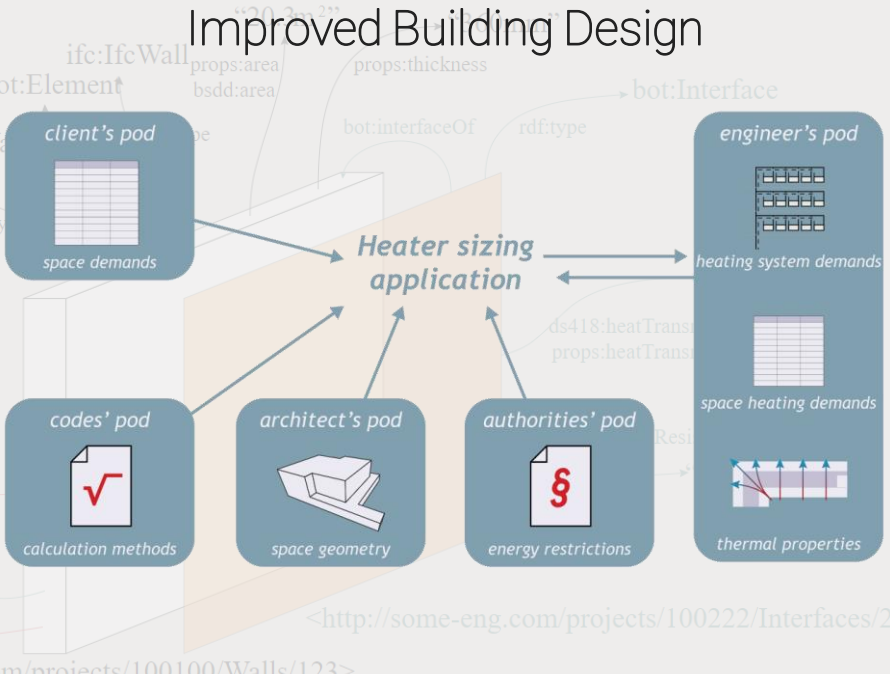
III. Linked Data in Construction

Linked Building Data (LBD) - Example

Data is stored and hosted by the stakeholder who generated it and is responsible for it

Data can be shared with authenticated people or be made publicly available

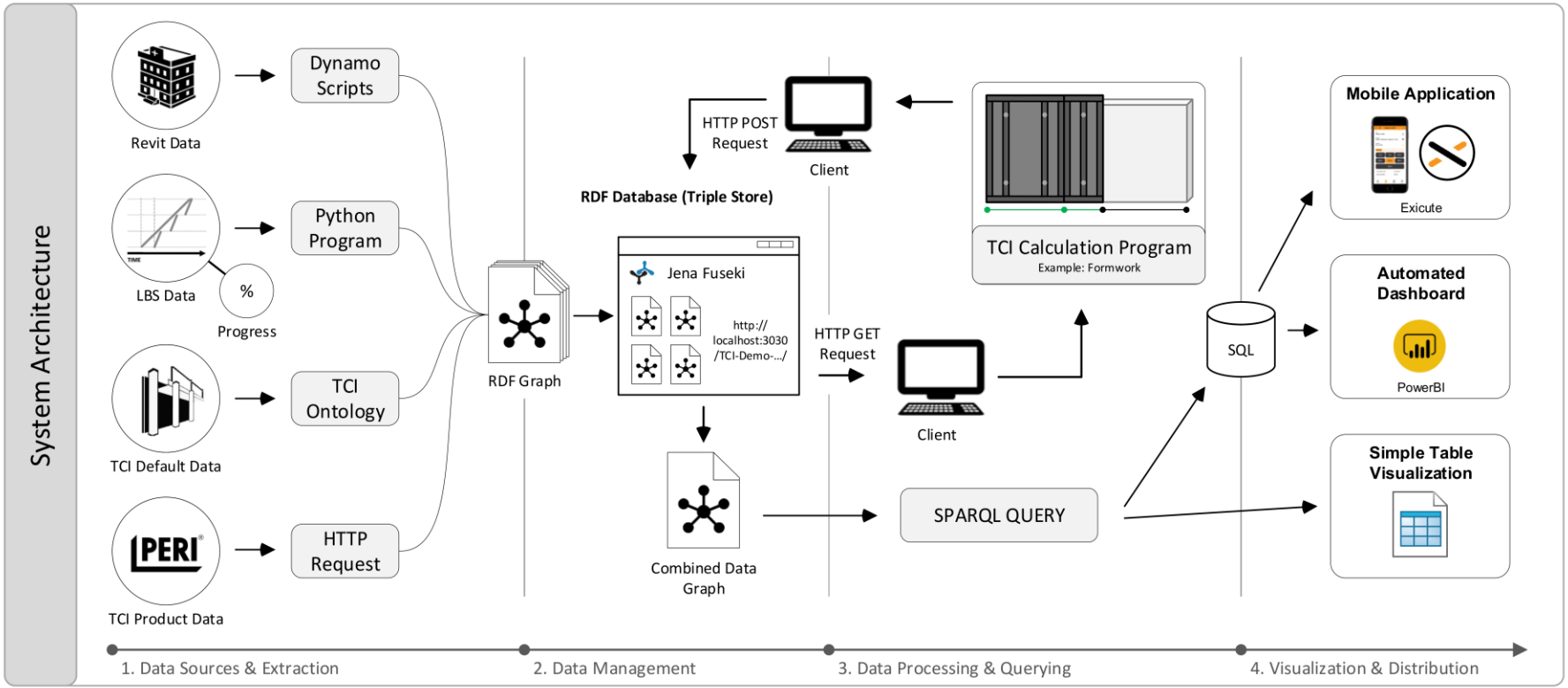
The model data can be extended with Linked Open Data (products, material properties, IoT, GIS)



Source: http://www.student.dtu.dk/~mhoras/presentations/20200305_bSNorway.html#/10/8

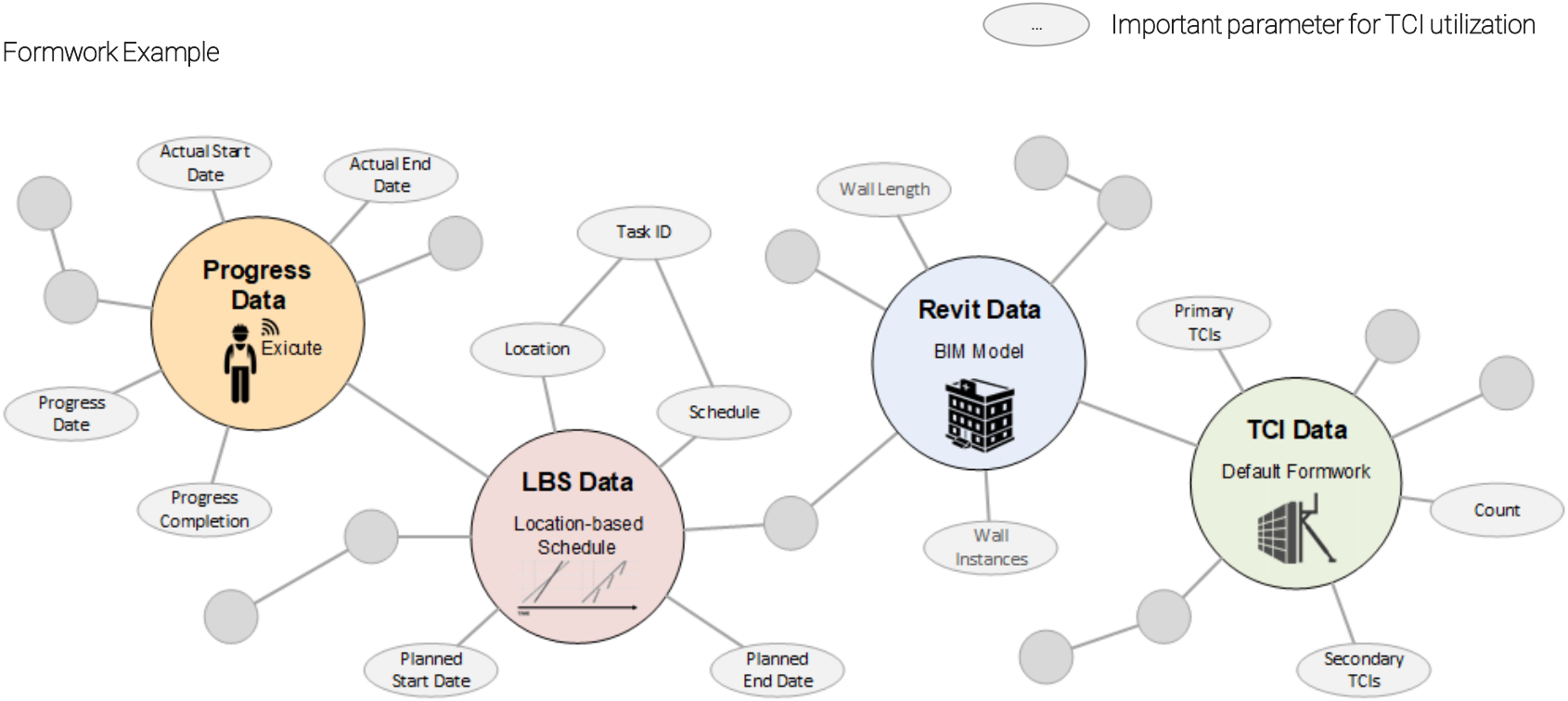
IV. Prototyping/ Demo Project

System Architecture



Data Sources

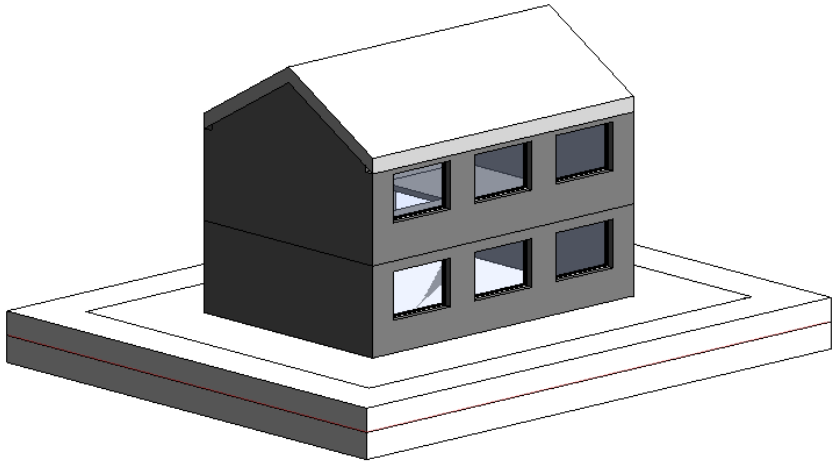
Formwork Example



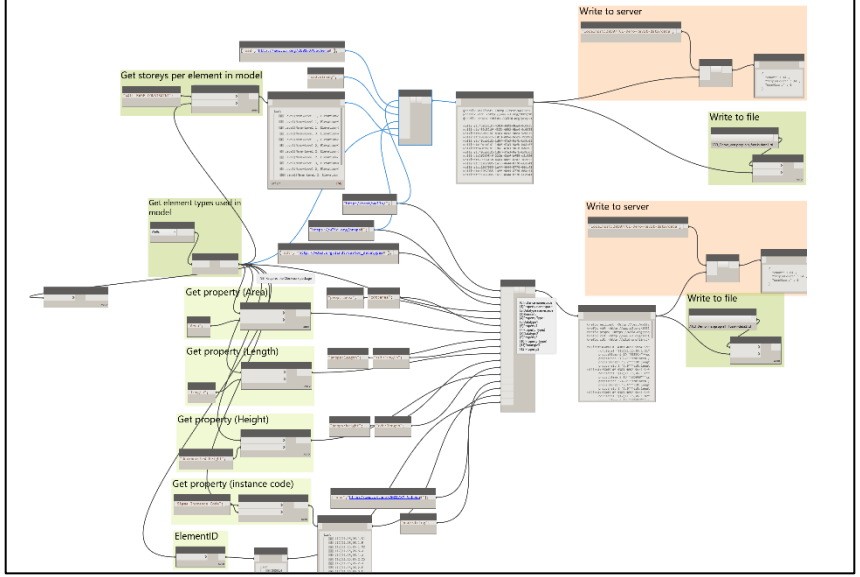
Building Model - **Revit**

Revit Data
BIM Model

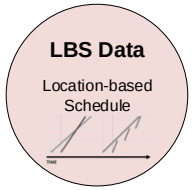
Data Generation in Revit



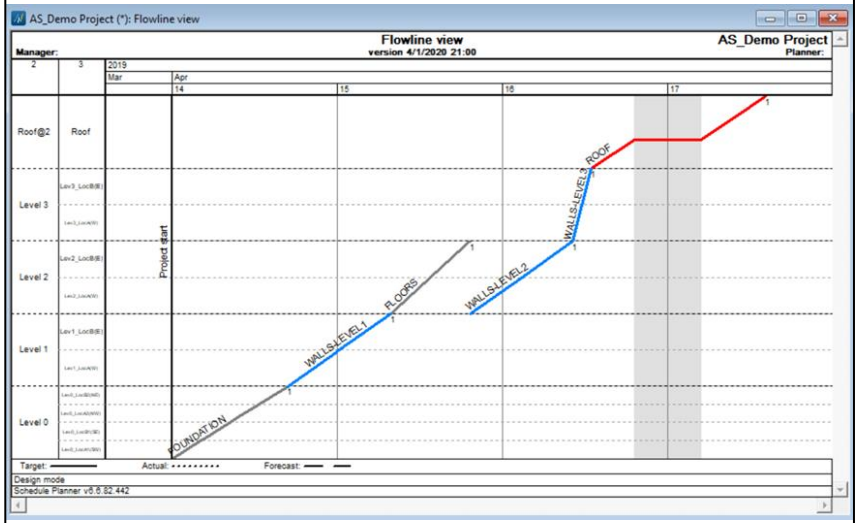
Data Extraction in Dynamo



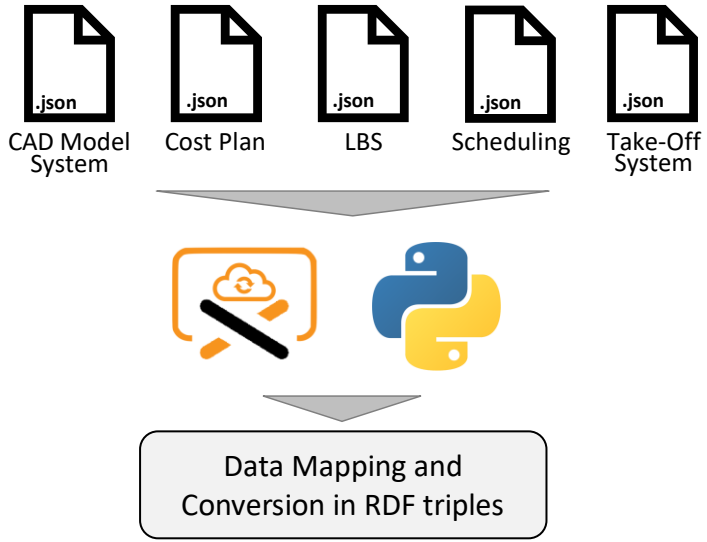
Location-Based Schedule – VICO Office



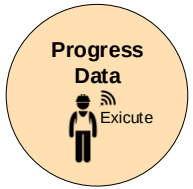
Data Generation in VICO

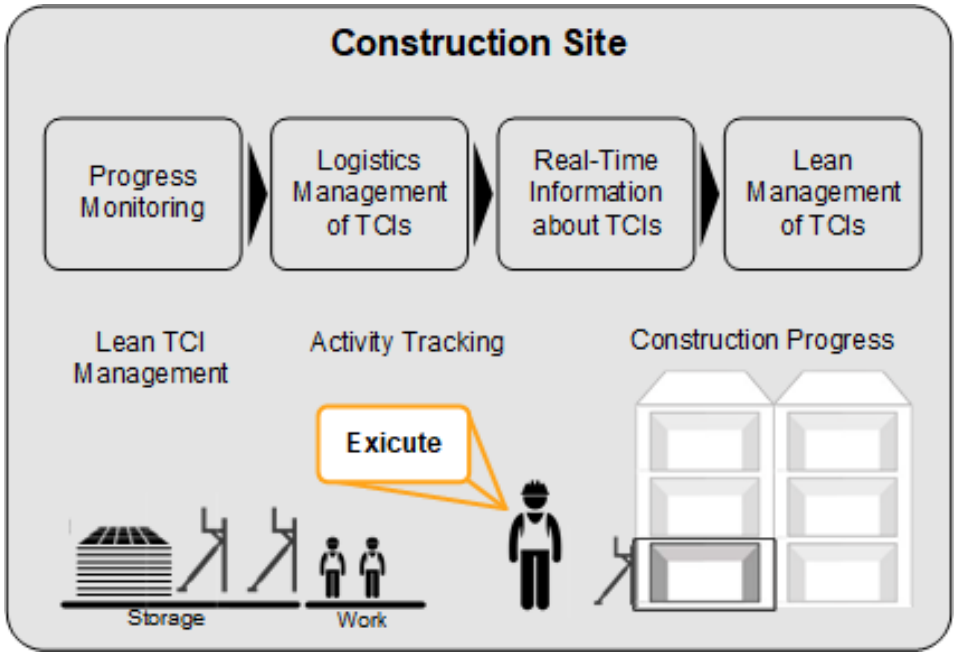


Data Extraction in ExiLink/ Program



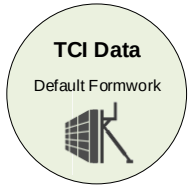
Progress Monitoring – **Exicute**





Temporary Construction Items – **TCI**

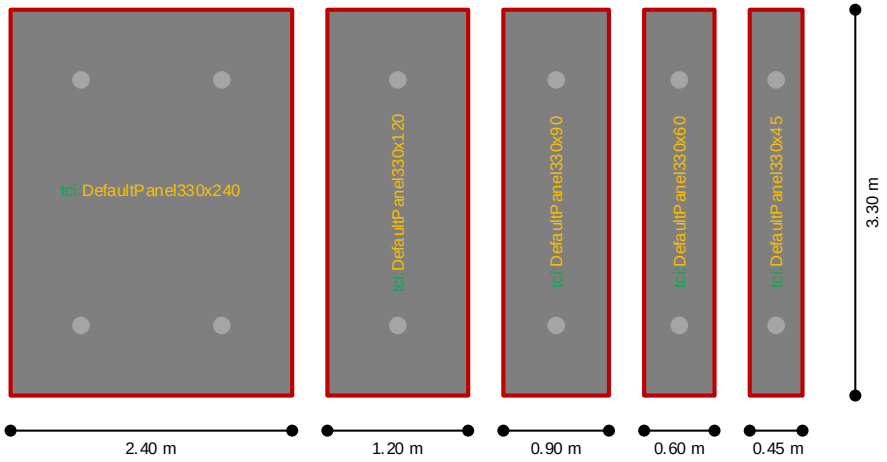
- TCI Ontology Creation describing the TCI context



Default Formwork Set

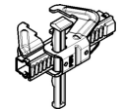
Primary Formwork Elements

tci:PrimaryTCI



Secondary Formwork Elements

tci:SecondaryTCI


tci:DefaultCoupler

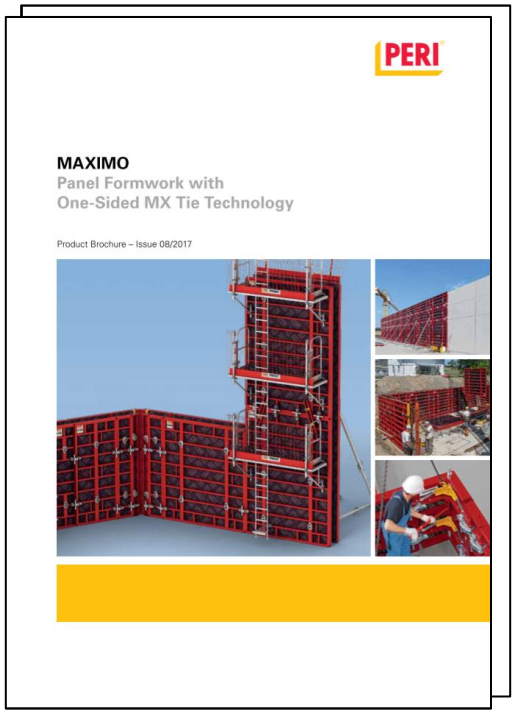

tci:DefaultTieRod

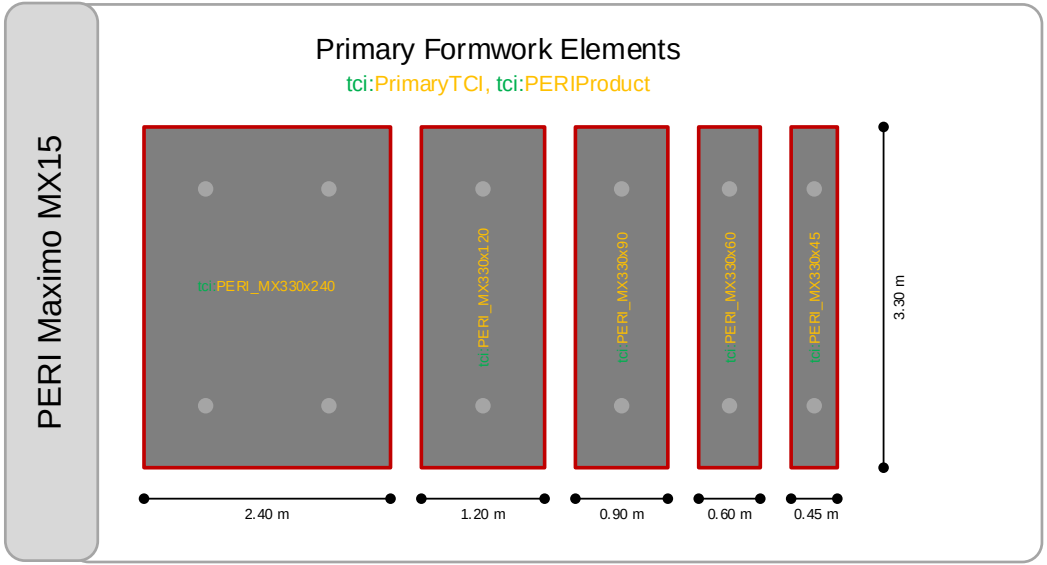

tci:DefaultWingnut


tci:DefaultPushPullProp

Specific Product – **PERI MAXIMO MX15**

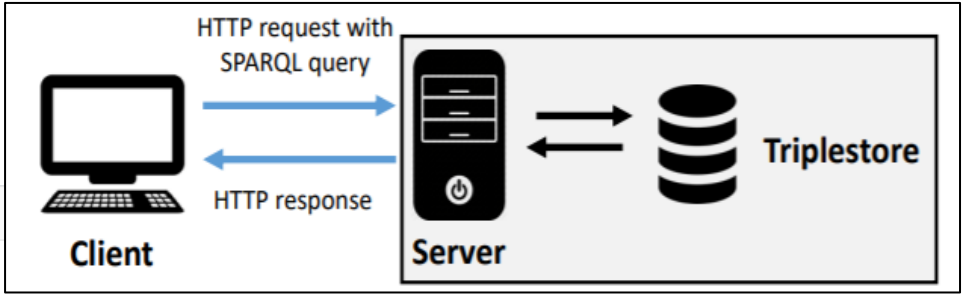
- Product Catalogue

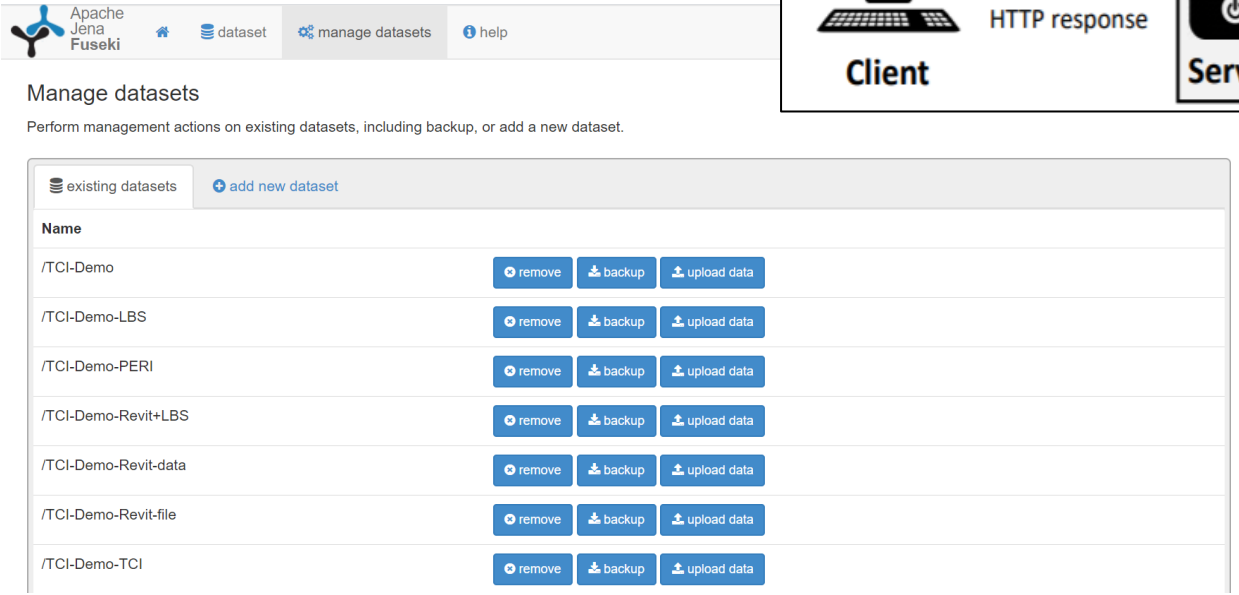




Data Management

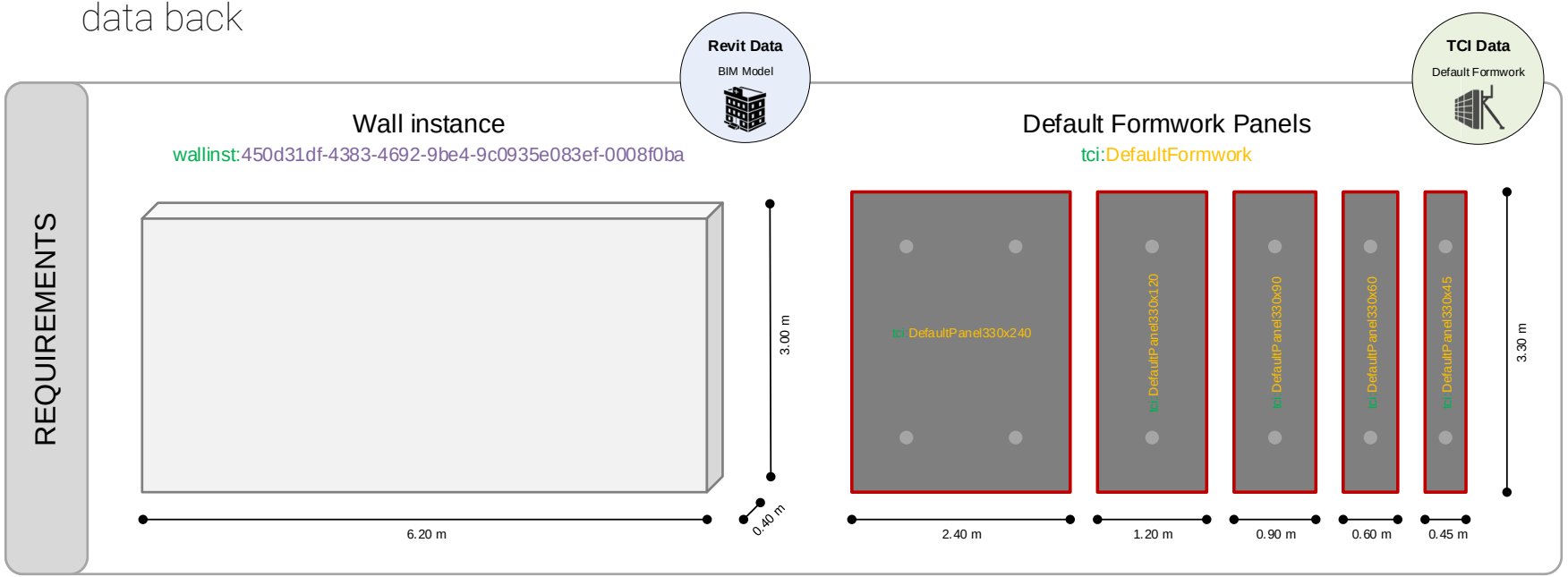
- Storage in triple store Jena Fuseki
- Access through localhost:3030





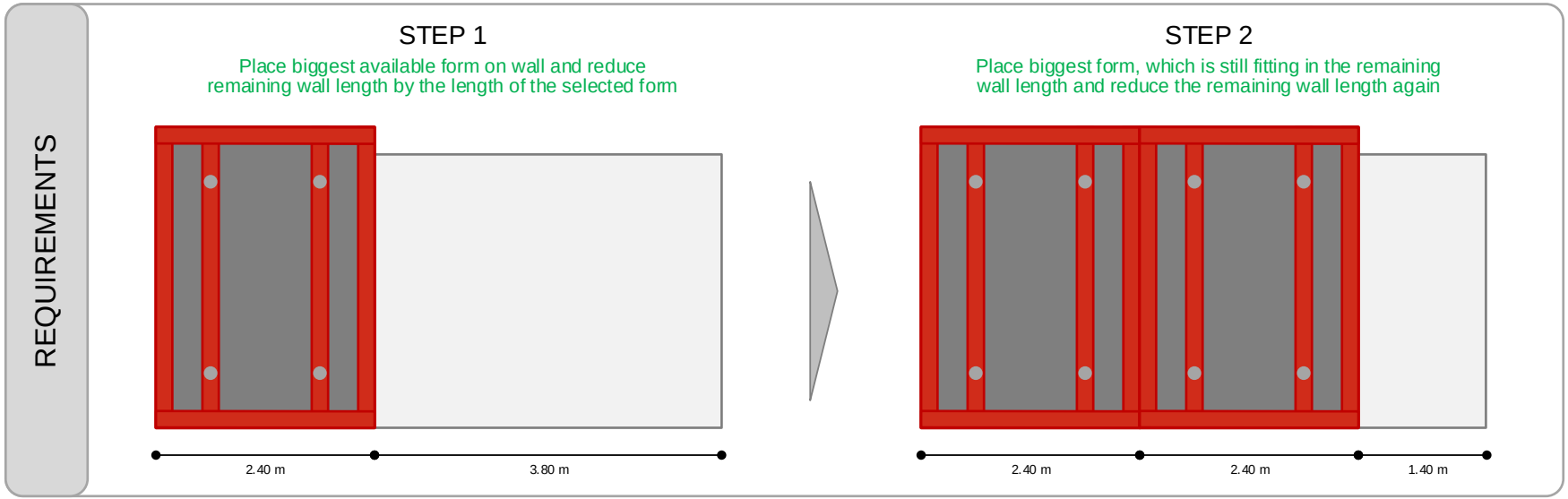
Data Processing & Querying

- Demo project for the calculation of formwork layout on wall elements
- Formwork calculation program that receives data from triple store and write processed data back



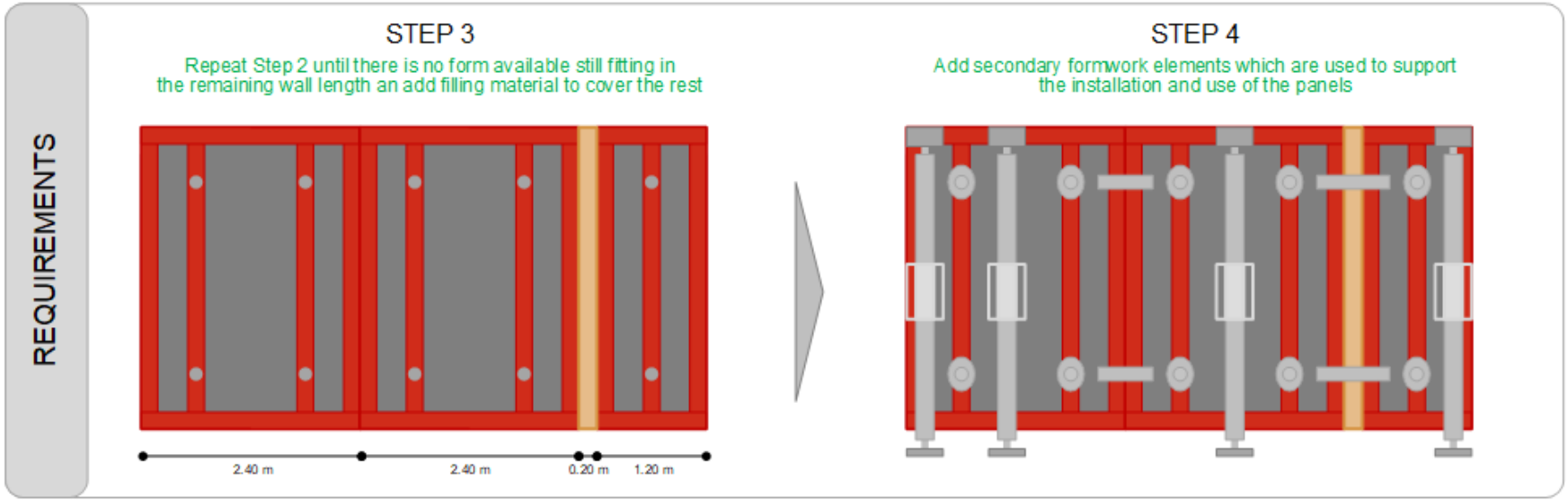
Data Processing & Querying

- Logic of Formwork Calculation Program



Data Processing & Querying

- Logic of Formwork Calculation Program



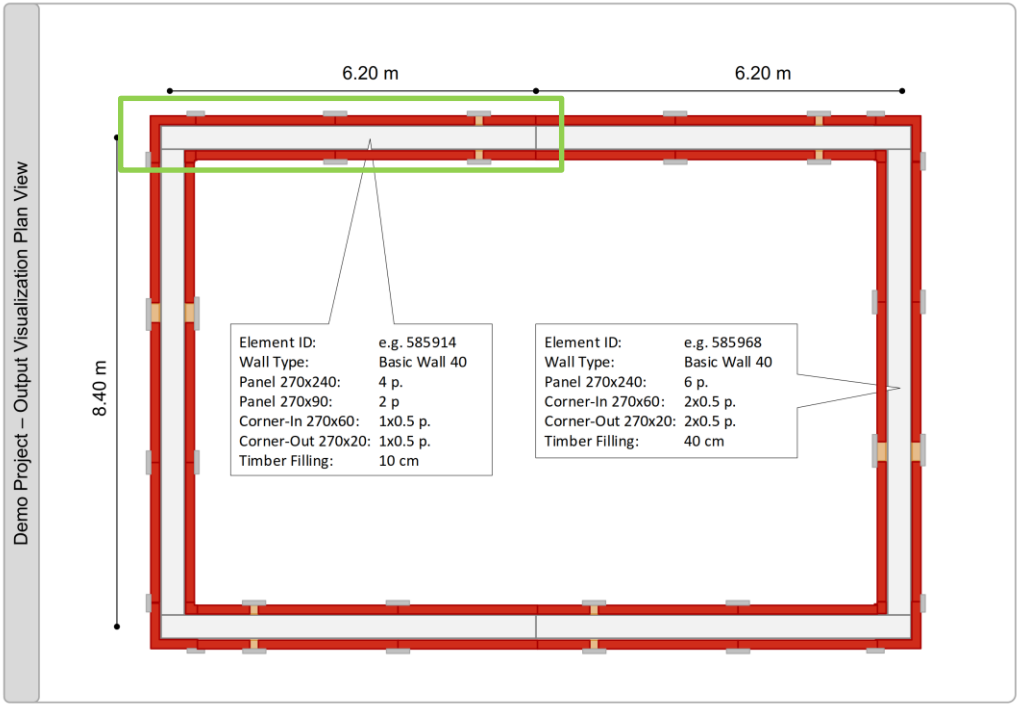
Data Processing & Querying

Desired Data to develop a TCI utilization plan

Revit		TCI					VICO		Exicute			
ElementID	props: length	Primary Formwork	Count	props: length	Secondary Formwork	Count	taskPlanned StartDate	taskPlanned EndDate	taskProgress Date	taskProgress Completion	taskActual StartDate	taskActual EndDate
string	*m*	*string*	*integer*	*m*	*string*	*integer*	*DateTime*	*DateTime*	*DateTime*	*%*	*DateTime*	*DateTime*
585914	6.20	Default Panel 330x240	4	2.40	Default Wingnut	12	2019-04-04 11:00	2019-04-08 07:28	2019-04-06 11:00	70.0	2019-04-04 11:00	NULL
		Default Panel 330x120	2	1.20	Default Tie Rod	12						
		Wooden filling material	2	0.20	Default Coupler	16						
					Default PushPull Prop	6						
					Default Waler	0						
644734	6.20	Default Panel 330x240	4	2.40	Default Wingnut	12	2019-04-08 07:28	2019-04-09 11:57	2019-04-08 16:00	100.0	2019-04-08 11:00	2019-04-08 16:00
		Default Panel 330x120	2	1.20	Default Tie Rod	12						
		Wooden filling material	2	0.20	Default Coupler	16						
					Default PushPull Prop	6						
					Default Waler	0						

Data Processing & Querying

- Demo Project - Output Data

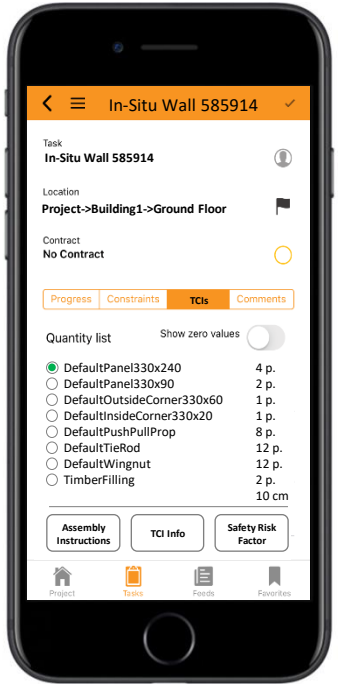


ElementID	VICOinst	TCIs	Quantity
585914	1000.0.351404	DefaultCoupler	8
585914	1000.0.351404	DefaultOutsideCorner330x60	0
585914	1000.0.351404	DefaultPanel330x240	4
585914	1000.0.351404	DefaultPanel330x90	2
585914	1000.0.351404	DefaultPushPullProp	8
585914	1000.0.351404	DefaultTieRod	10
585914	1000.0.351404	DefaultWingnut	10
585914	1000.0.351404	TimberFilling	2
585968	1000.0.351451	DefaultInsideCorner330x20	1
585968	1000.0.351451	DefaultPanel330x120	0
585968	1000.0.351451	DefaultPanel330x45	0
585968	1000.0.351451	DefaultPanel330x60	0
585968	1000.0.351451	DefaultPanel330x90	0
585968	1000.0.351451	DefaultWaler	0
585968	1000.0.351451	DefaultCoupler	12
585968	1000.0.351451	DefaultOutsideCorner330x60	1
585968	1000.0.351451	DefaultPanel330x240	6
585968	1000.0.351451	DefaultPushPullProp	10
585968	1000.0.351451	DefaultTieRod	14
585968	1000.0.351451	DefaultWingnut	14
585968	1000.0.351451	TimberFilling	2

Data Visualization & Distribution

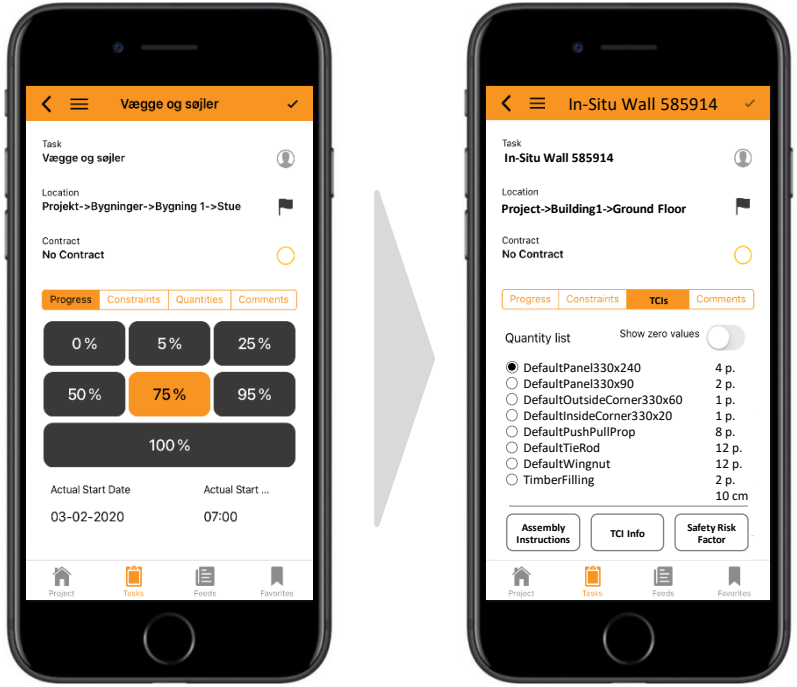
Information for Project Manager

Information for Construction Worker



Data Visualization & Distribution

Option 1: Exicute Cloud Platform

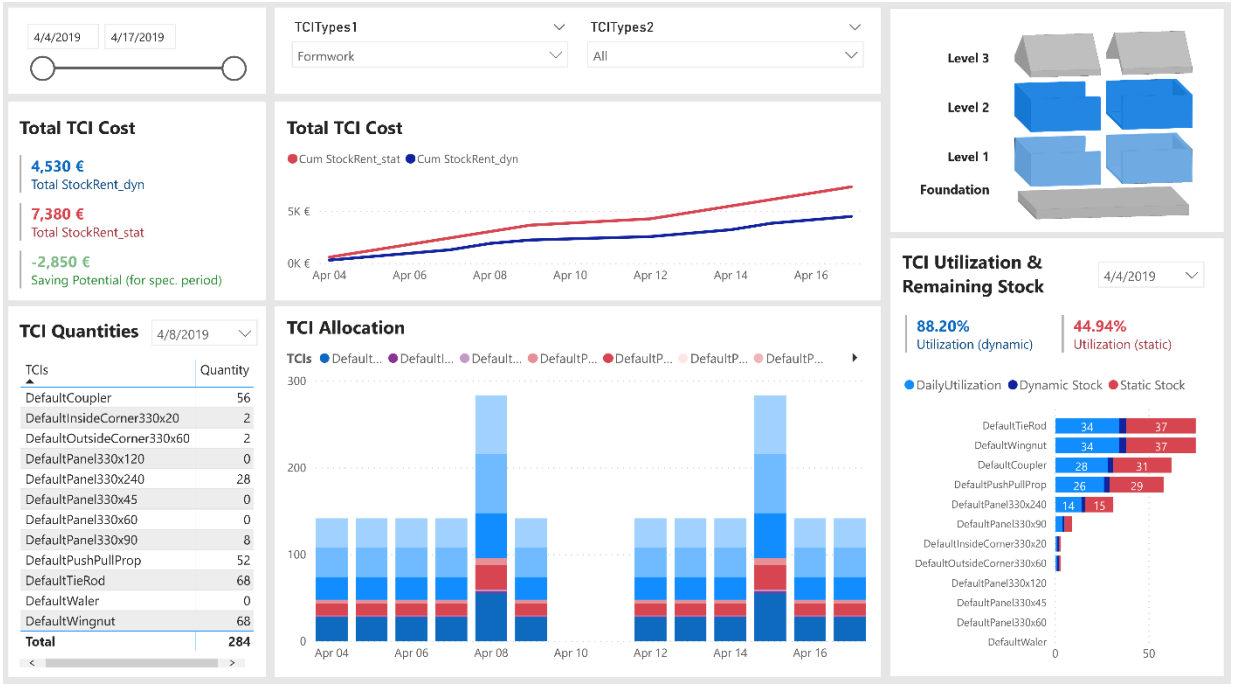


Integration in existing App

- Implementation of the proposed solution in practice
- Extension of the existing application "Ëxicute"
- New tab "TCI Quantities"
  - TCI quantities per task
  - Parameters of TCIs (weight etc.)
  - Installation time
  - Storage location before and after use
  - Safety Risk Factor
- Conversion of output data into SQL format in order to implement it in Exicute
- Could be an additional feature that can be sold to contractors

Data Visualization & Distribution

Option 2: Power BI Dashboard Visualization



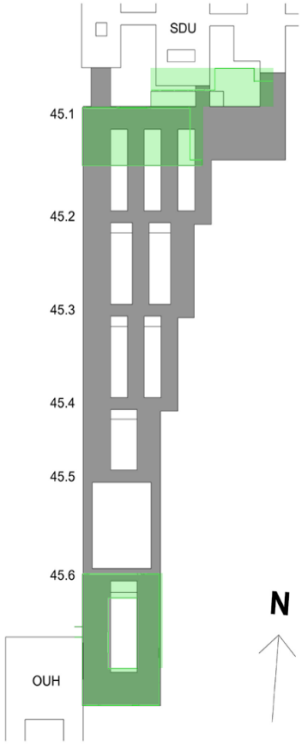
Automated Dashboards

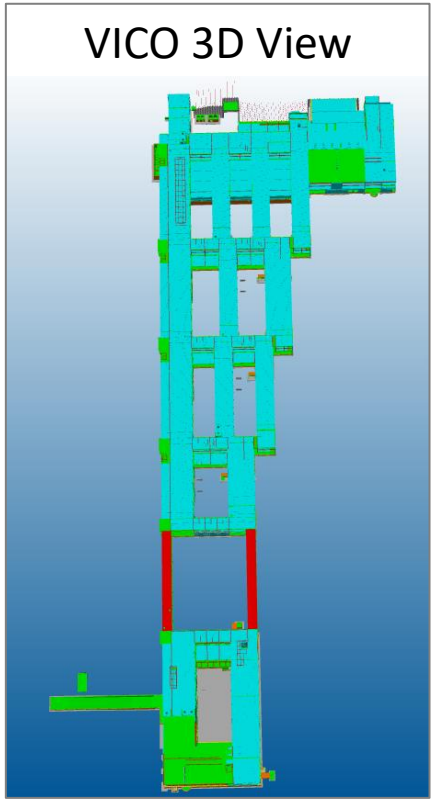
- Direct link between triple store and Power BI
- TCI utilization plan over time
- Utilization of exploded model view to locate tasks
- Quantities & Types for upcoming tasks
- Current stock on site
- Etc.

V. Case Study

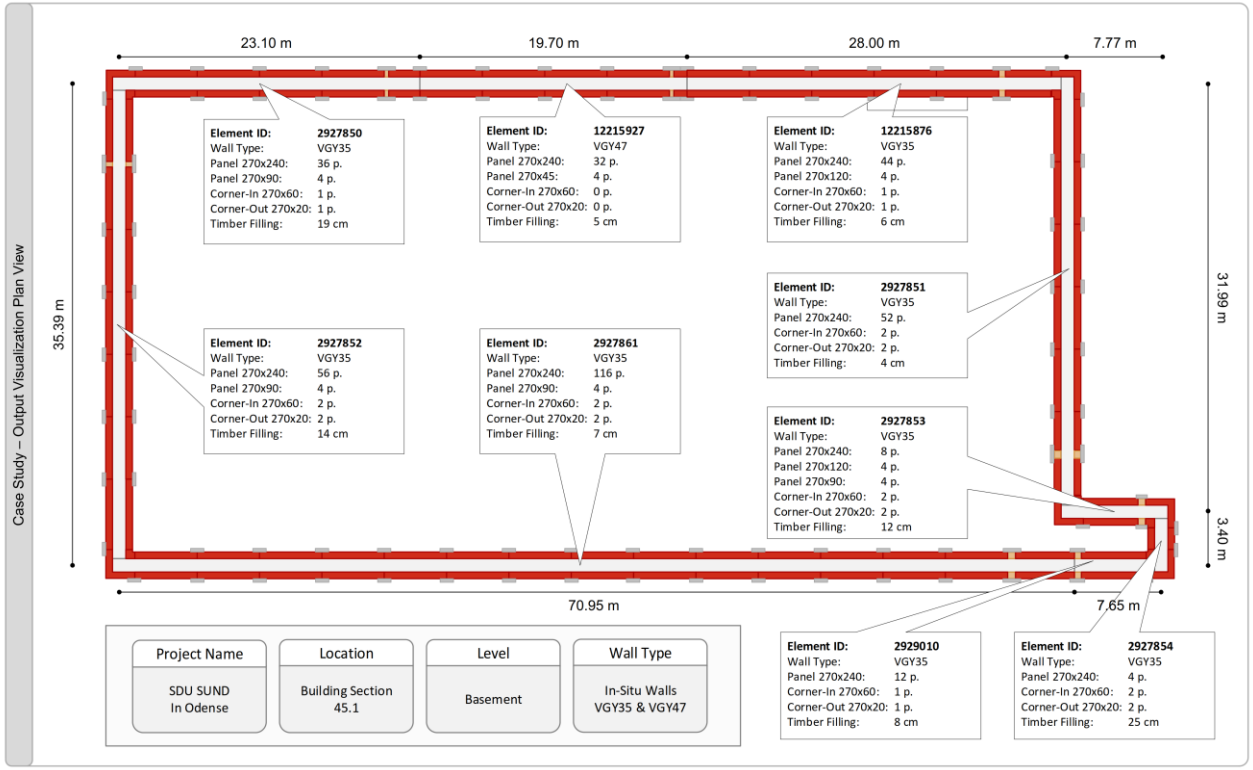
Case Study – Project Information

Project Name	SDU SUND
Location	Odense
Project Type	Public, New Construction, Rural
Building Type	Healthcare Science Faculty
Building Size	50.740 m² brutto
Levels	Basement, Level 1-4
Building Sections	45.1 – 45.6
Value for Case Study	In-situ concrete walls are installed in the basement and serve as an application field for the developed prototype solution, creating a utilization plan for the required formwork
Used Data	• 3D-model (rvt-file) • Location-based schedule (vico-file)





Case Study – Results

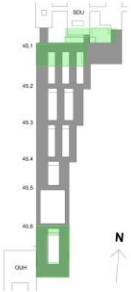


Case Study – Results

Power BI Dashboard Visualization – Page 0: Project Overview

Project Information

Project Name:	Nyt SDU SUND
Location:	Odense
Project Type:	Public, New Construction, Rural
Building Type:	Healthcare Science Faculty
Building Size:	50.740 m² brutto
Levels:	N-1, N00, N01, N02, N03
Building Sections:	45.1, 45.2, 45.3, 45.4, 45.5, 45.6

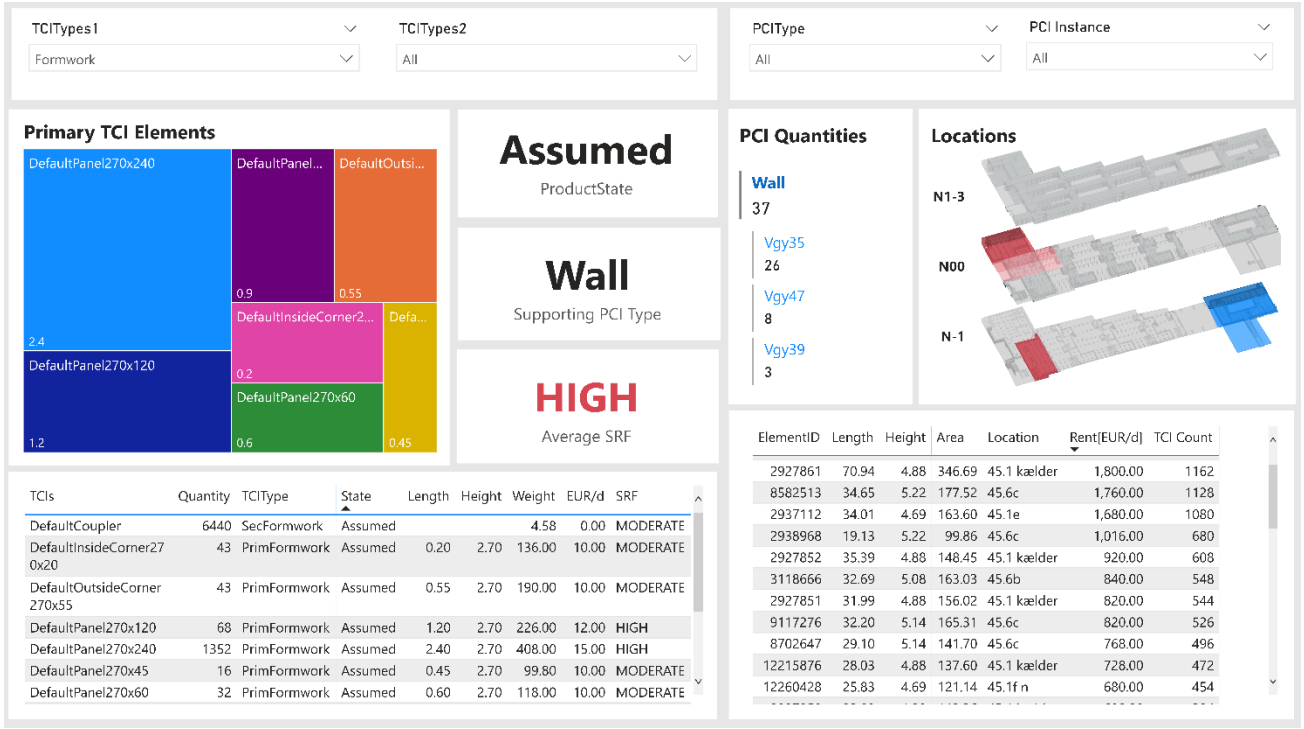


Content of the Dashboard

TCIs/PCIs	TCI Information with specifications and quantitites PCI information with specifications and quantitites Location Slicer for PCIs
TCI Utilization	TCI allocation over time Daily TCI quantities Daily TCI utilization compared to stock Comparison between static stock (current practice) and dynamic stock Cost information
TCI Tasks	Gantt diagram, showing all tasks which involve TCIs TCI utilization time and timber filling per task TCI quantities per task and safety-risk-factor

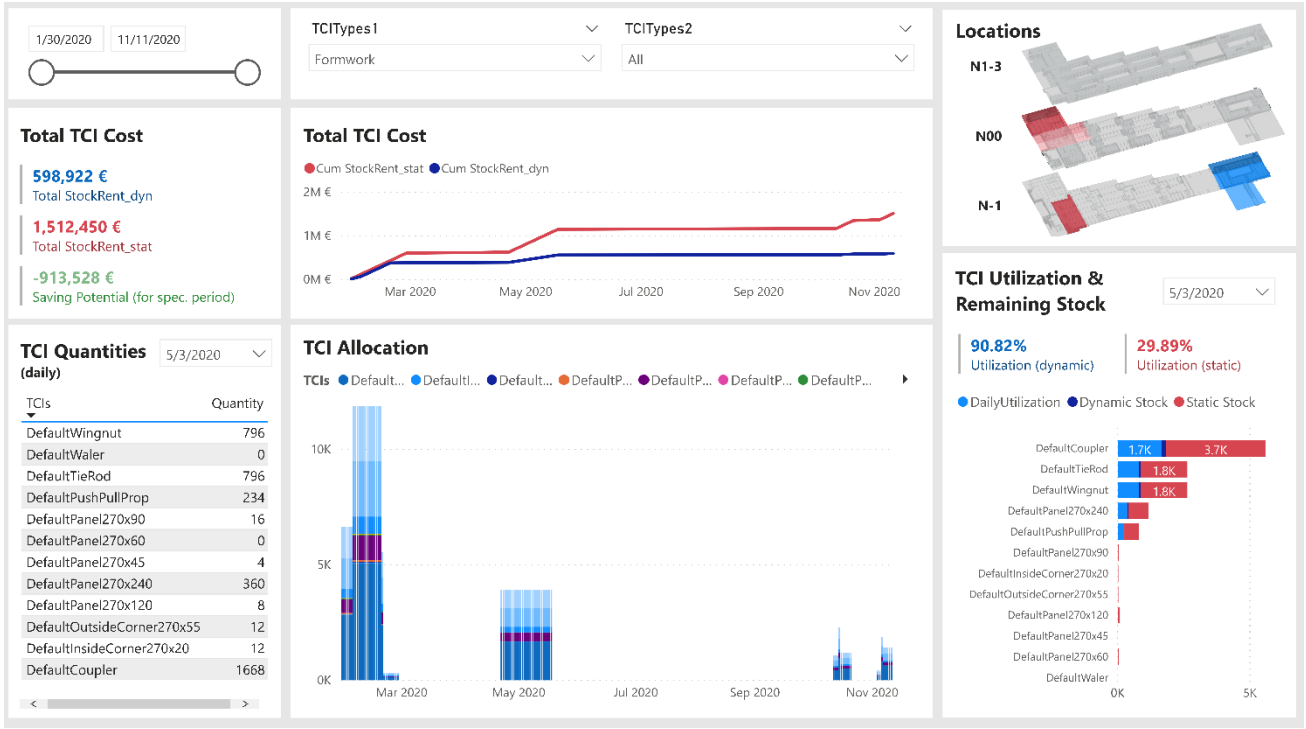
Case Study – Results

Power BI Dashboard Visualization – Page 1: TCI/PCI Information



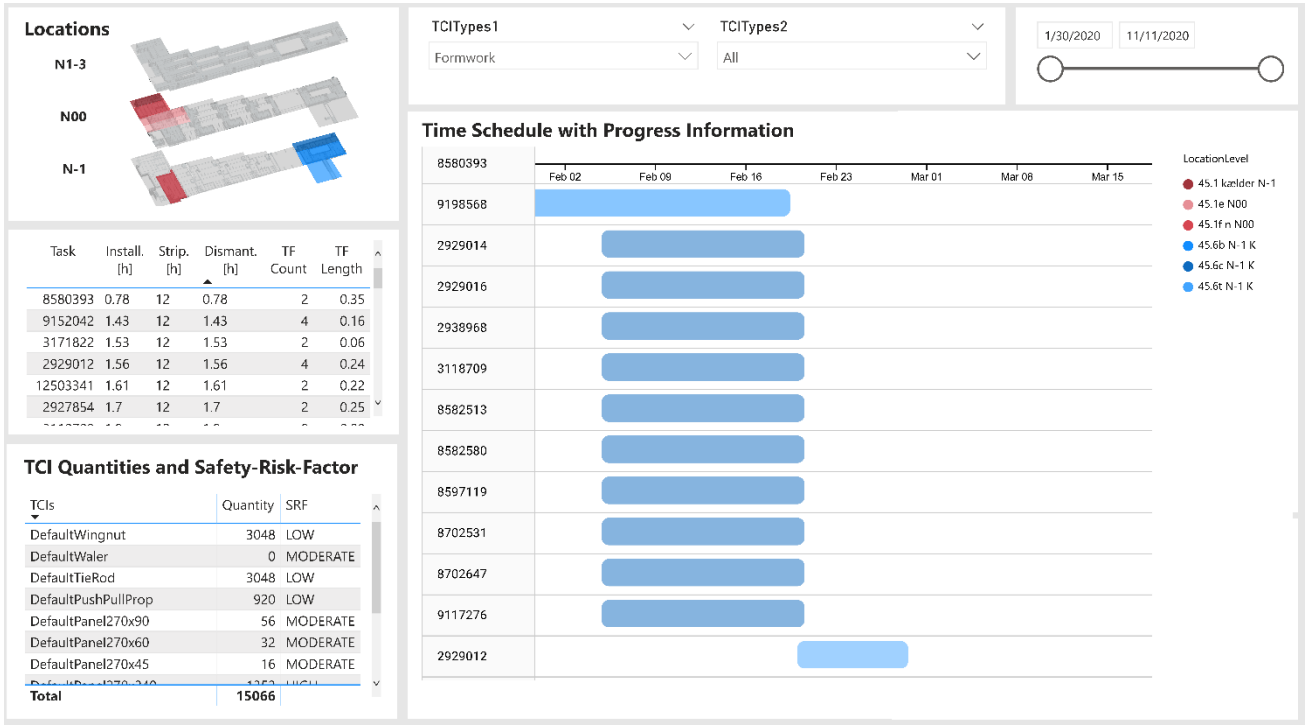
Case Study – Results

Power BI Dashboard Visualization – Page 2: TCI Utilization



Case Study – Results

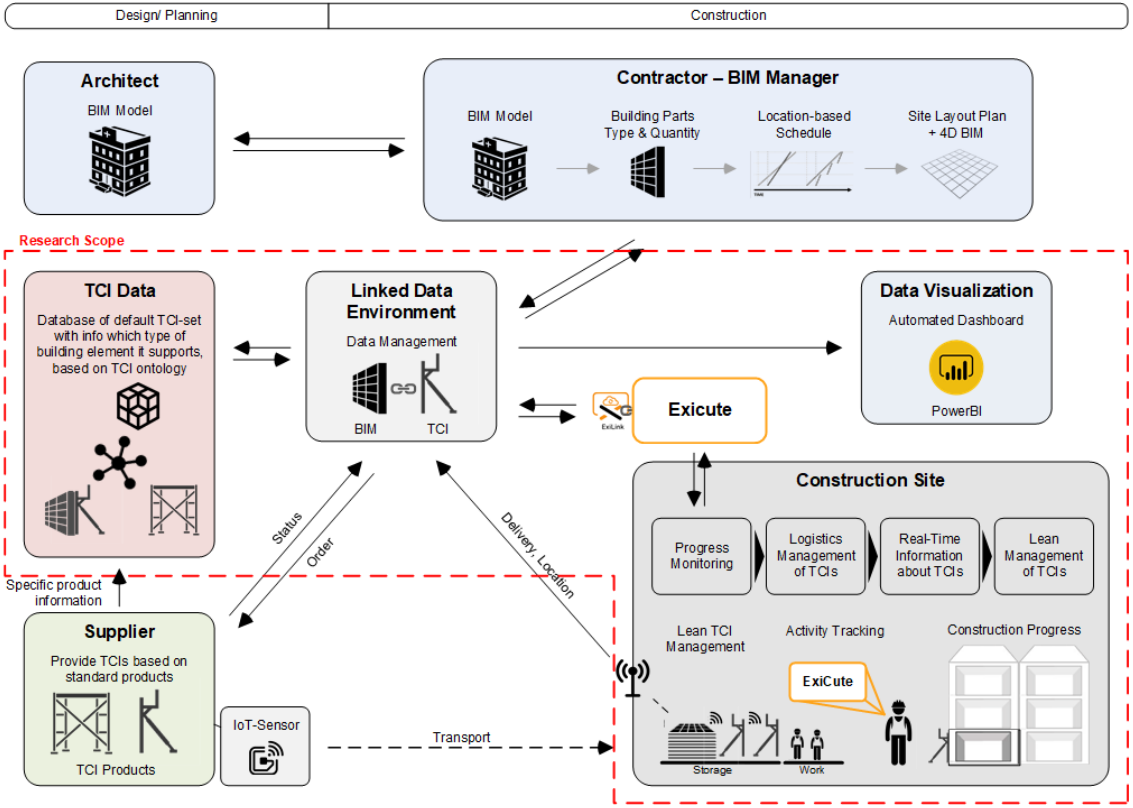
Power BI Dashboard Visualization – Page 3: TCI Task Information



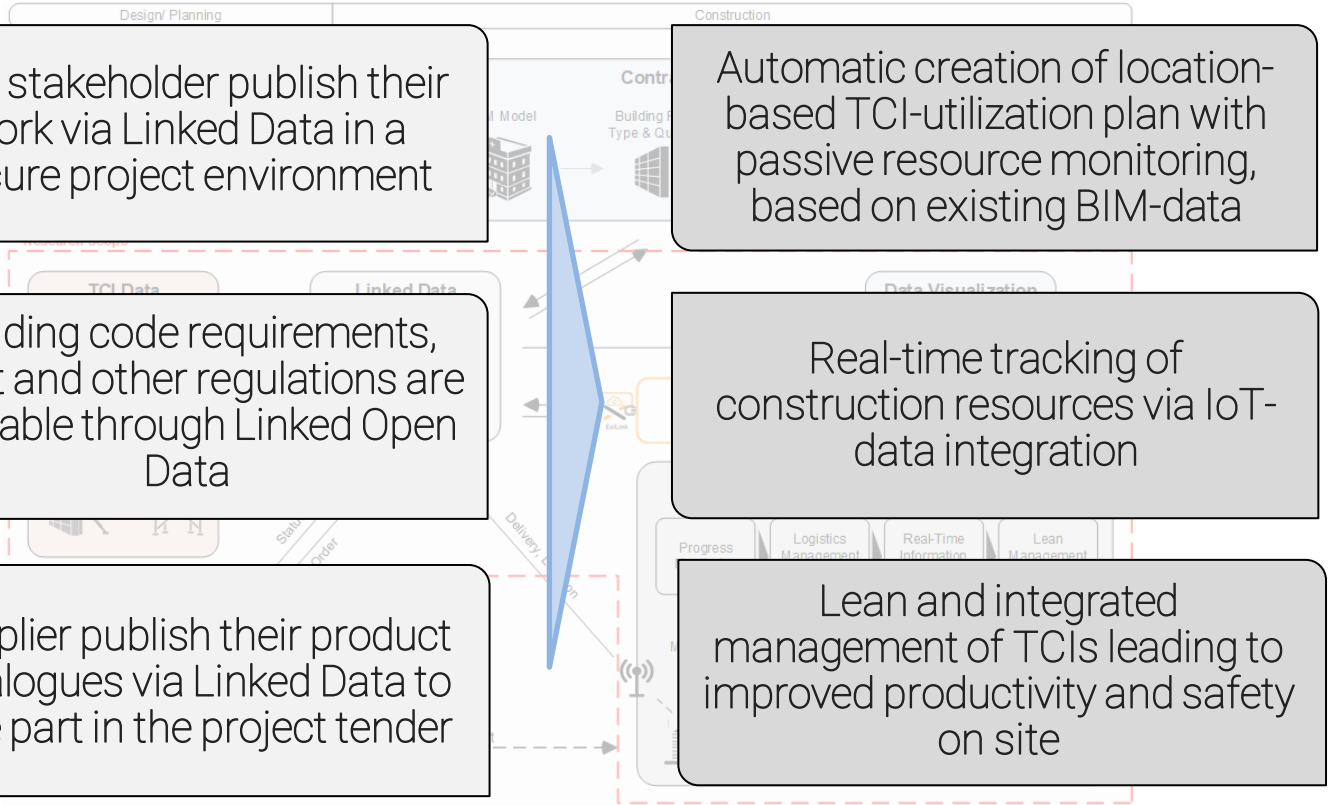
Task	Install. [h]	Strip. [h]	Dismant. [h]	TF Count	TF Length
8580393	0.78	12	0.78	2	0.35
9152042	1.43	12	1.43	4	0.16
3171822	1.53	12	1.53	2	0.06
2929012	1.56	12	1.56	4	0.24
12503341	1.61	12	1.61	2	0.22
2927854	1.7	12	1.7	2	0.25

VI. Ideal Future Scenario

Ideal Future Scenario



Ideal Future Scenario



1. AEC stakeholder publish their work via Linked Data in a secure project environment
2. Building code requirements, client and other regulations are available through Linked Open Data
3. Supplier publish their product catalogues via Linked Data to take part in the project tender

Automatic creation of location-based TCI-utilization plan with passive resource monitoring, based on existing BIM-data

Real-time tracking of construction resources via IoT-data integration

Lean and integrated management of TCIs leading to improved productivity and safety on site

Questions/

Feedback?