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

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EXIGO

Agenda

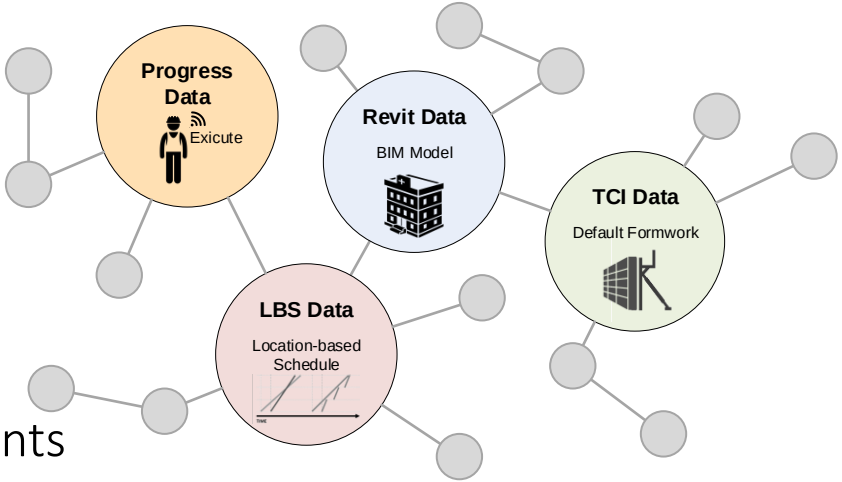
I. Problem & Solution Space

II. Propose specific Solution

III. Demo Project

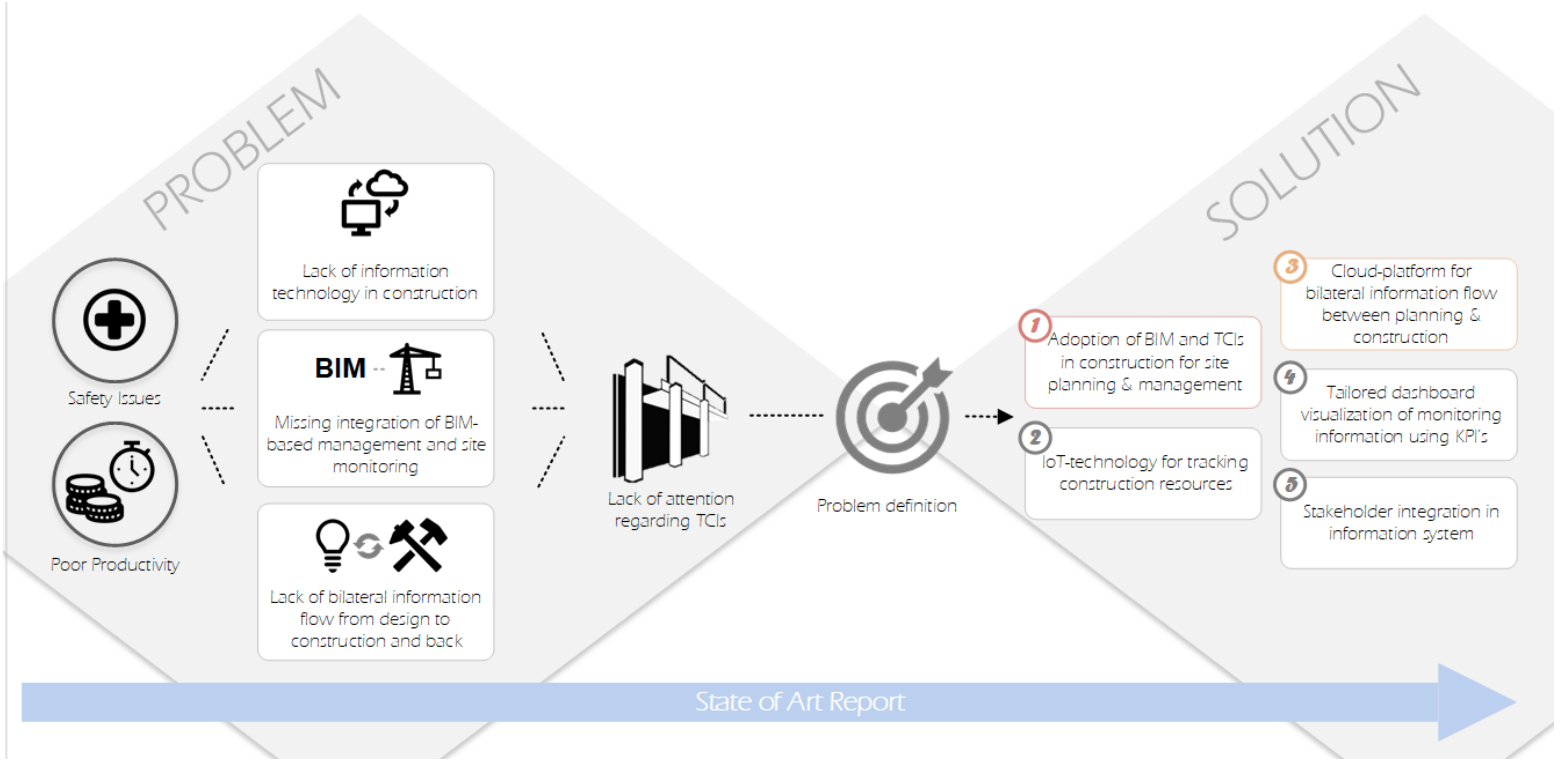
- Data Sources & Extraction
- Data Management
- Data Processing & Querying
- Data Visualization & Distribution

IV. Further Development/ Improvements



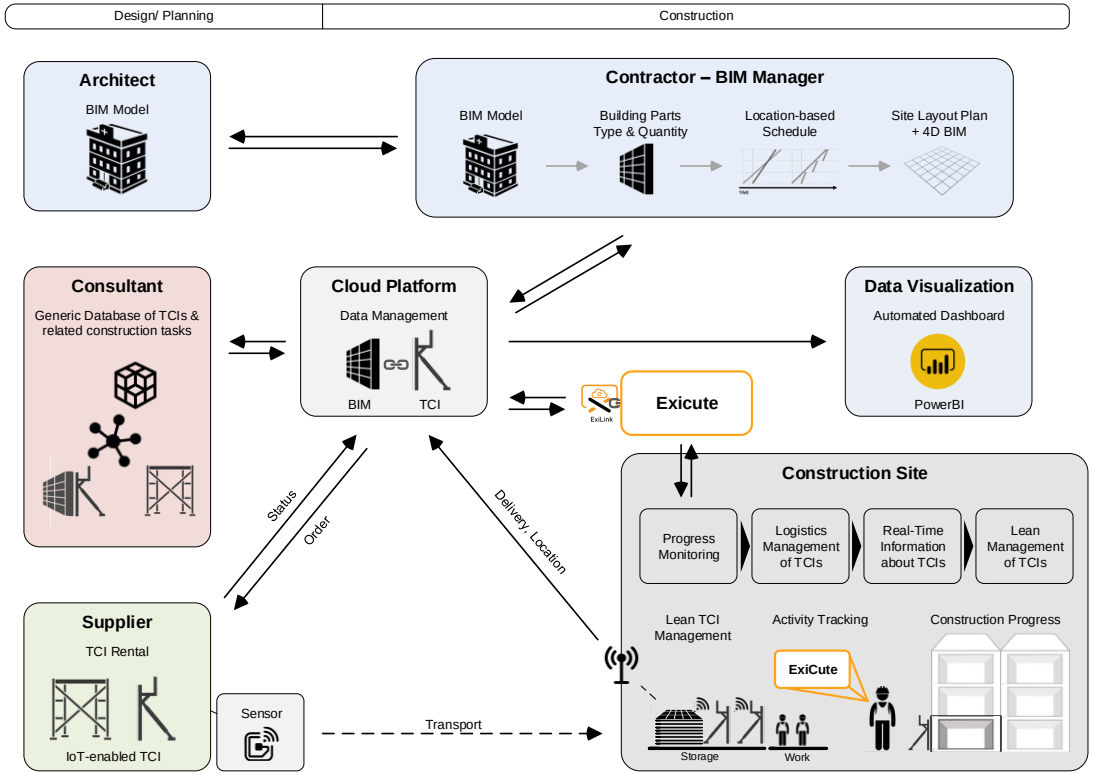
I. Problem & Solution Space

State of Art - Problem & Solution Space



II. Propose specific Solution

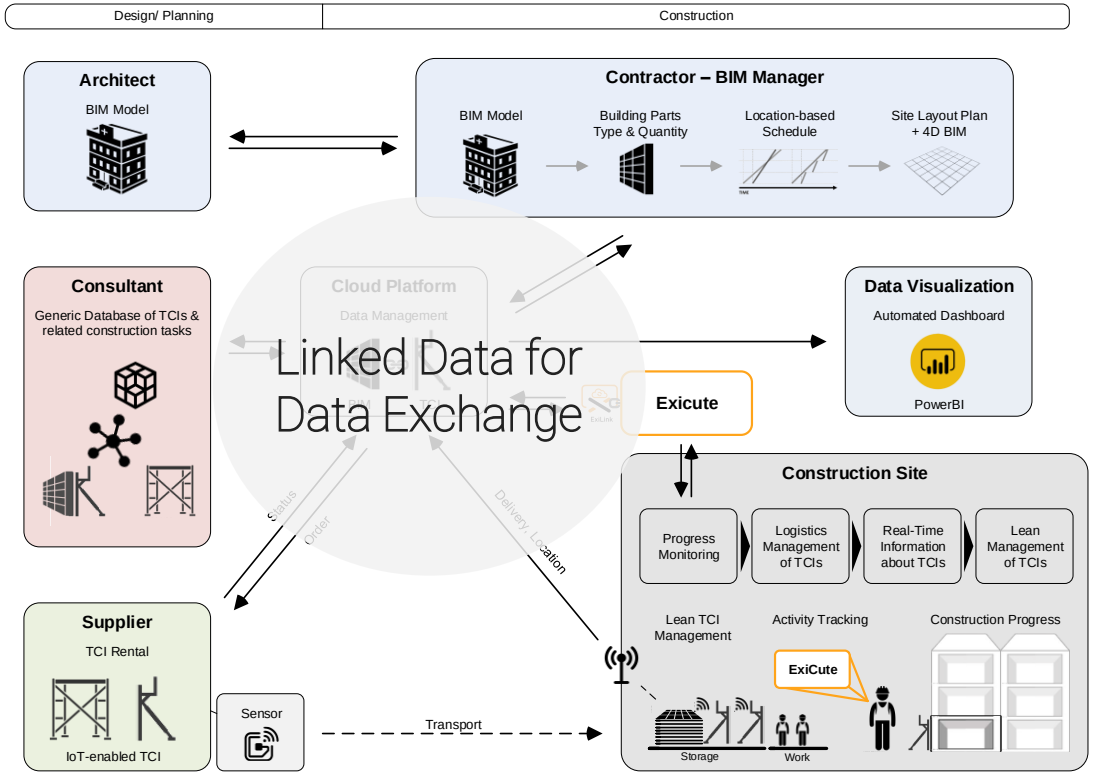
Proposed Solution



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

Proposed Solution



Benefits

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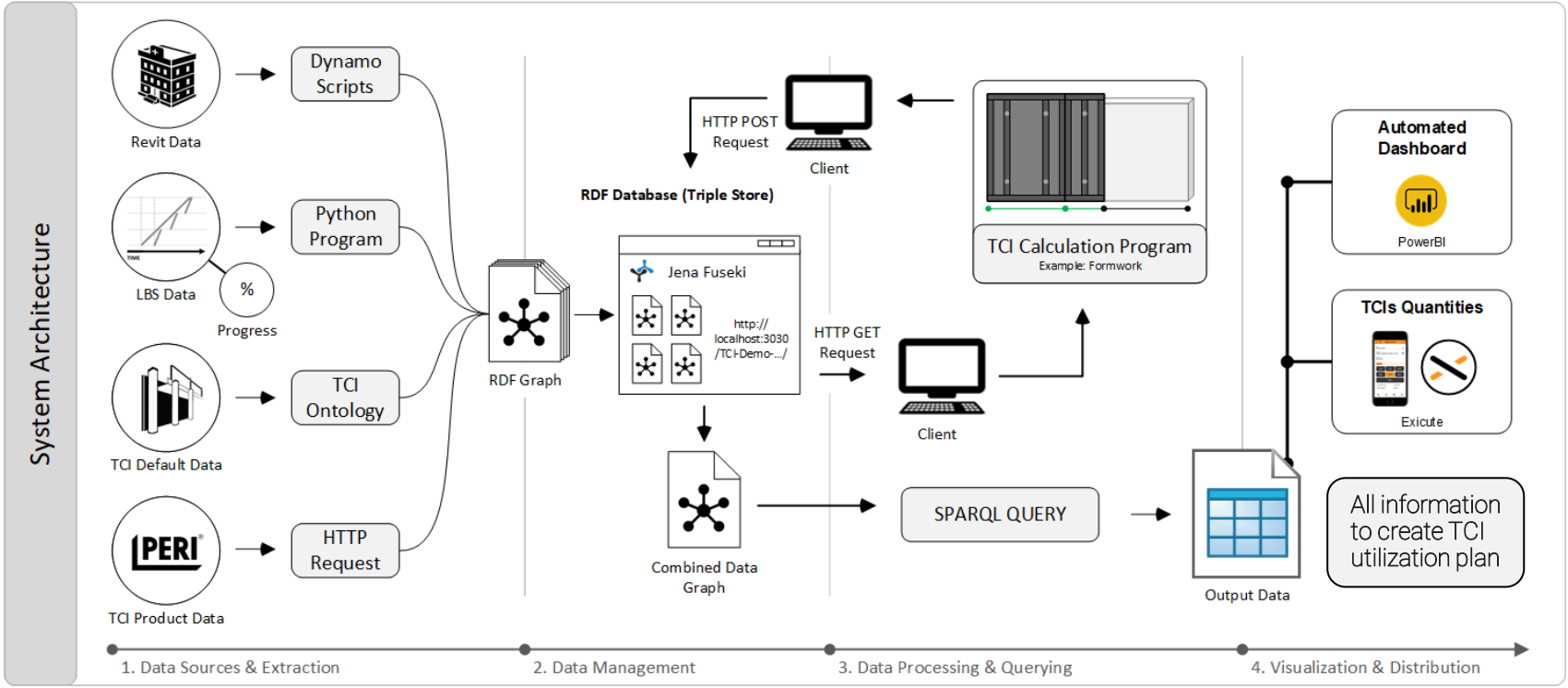
V. Demo Project

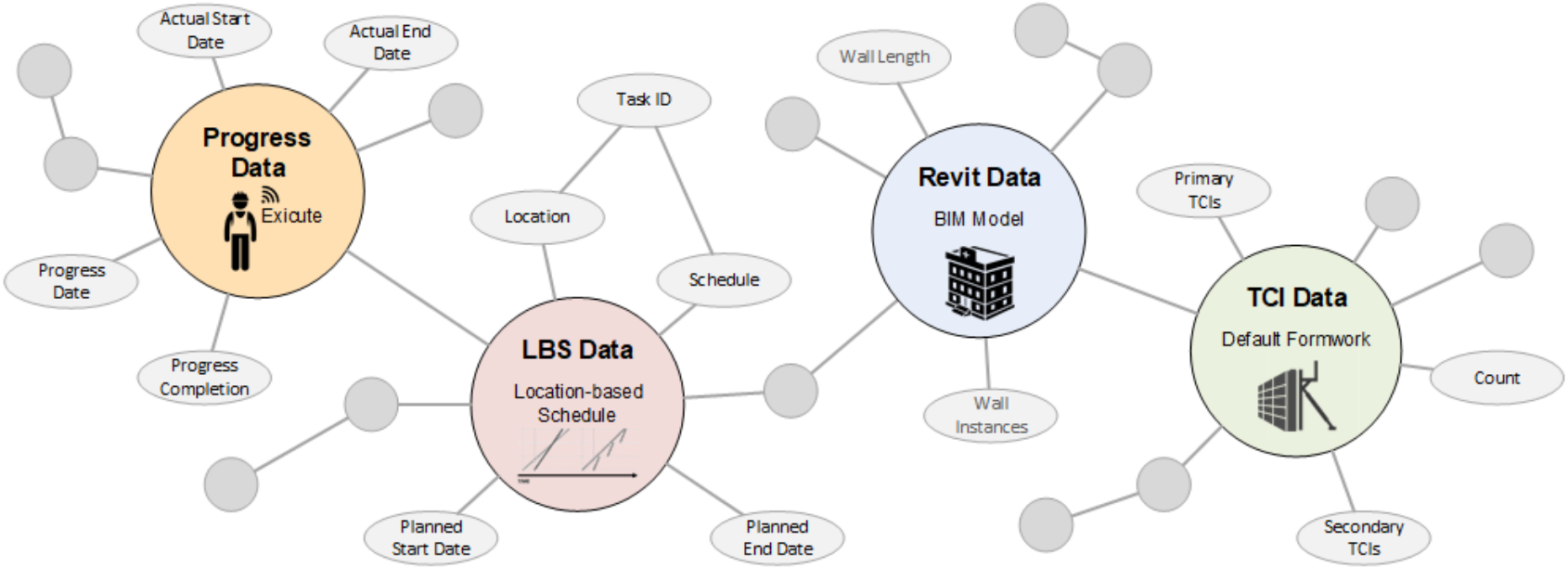
System Architecture



Data Sources

Formwork Example

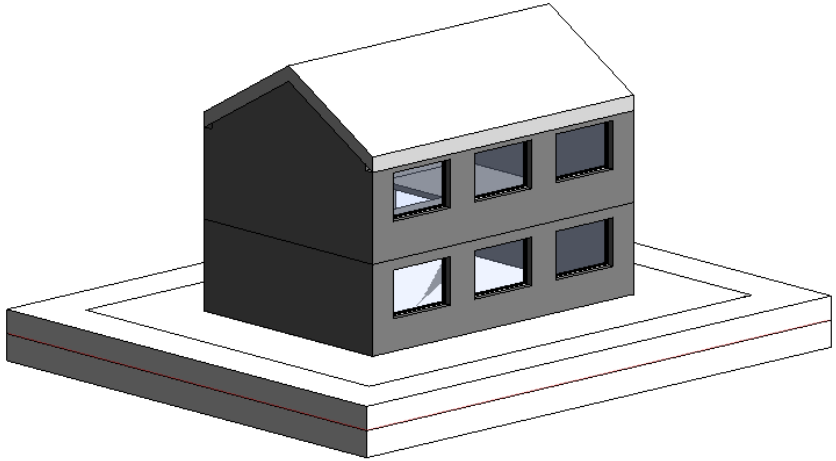
... Important parameter for TCI utilization



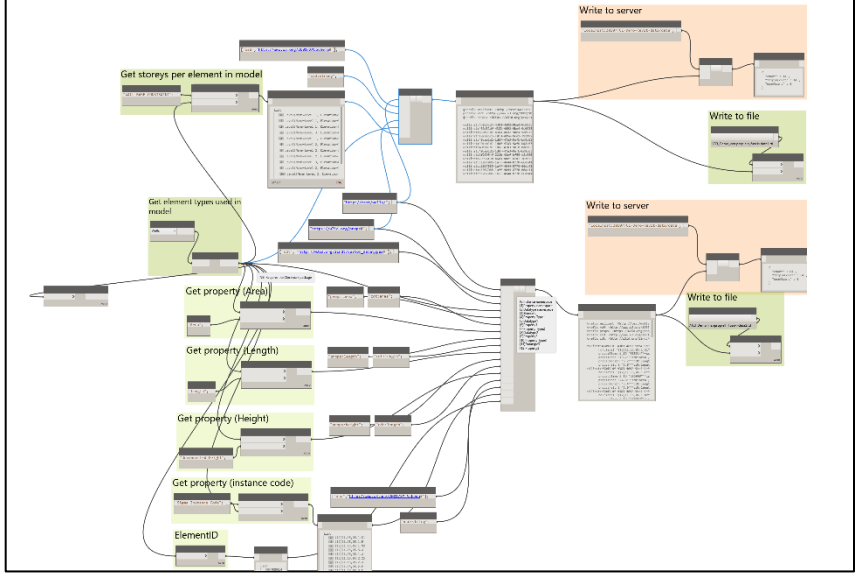
Building Model - **Revit**

Revit Data
BIM Model

Data Generation in Revit



Data Extraction in Dynamo

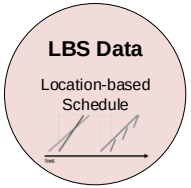


Building Model - **Revit**

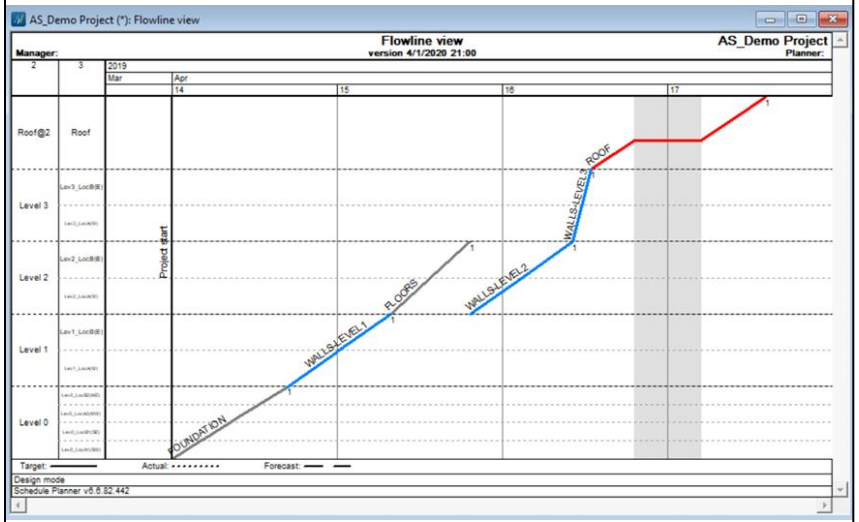
Revit Data Graph

```
wallinst:450d31df-4383-4692-9be4-9c0935e083ef-0008f0ba
        a                   product:Wall , ont:Concrete400MmCastInPlace ;
        rdf:label           "(12)11.15,05.1.S1" ;
        bot:adjacentElement wallinst:40cab1d1-1d6f-47a3-9afb-bd8c6300ff7e-0009c504 , wallinst:c1037085-1aff-4644-8770-66dc41edbf0b-0009d67e ;
        props:Element_ID    "585914" ;
        props:Revit_GUID    "450d31df-4383-4692-9be4-9c0935e083ef-0008f0ba" ;
        props:angle         0.0 ;
        props:area          19.2 ;
        props:height        3.0 ;
        props:length        6.2 ;
        props:level_simple  "Level1" .

wallinst:450d31df-4383-4692-9be4-9c0935e083ef-0008f0f0
        a                   product:Wall , ont:Concrete400MmCastInPlace ;
        rdf:label           "(12)11.15,05.1.E" ;
        bot:adjacentElement wallinst:450d31df-4383-4692-9be4-9c0935e083ef-0008f14f , wallinst:c1037085-1aff-4644-8770-66dc41edbf0b-0009d67e ;
        props:Element_ID    "585968" ;
        props:Revit_GUID    "450d31df-4383-4692-9be4-9c0935e083ef-0008f0f0" ;
        props:angle         90.0 ;
        props:area          24.0 ;
        props:height        3.0 ;
        props:length        8.4 ;
        props:level_simple  "Level1" .
```

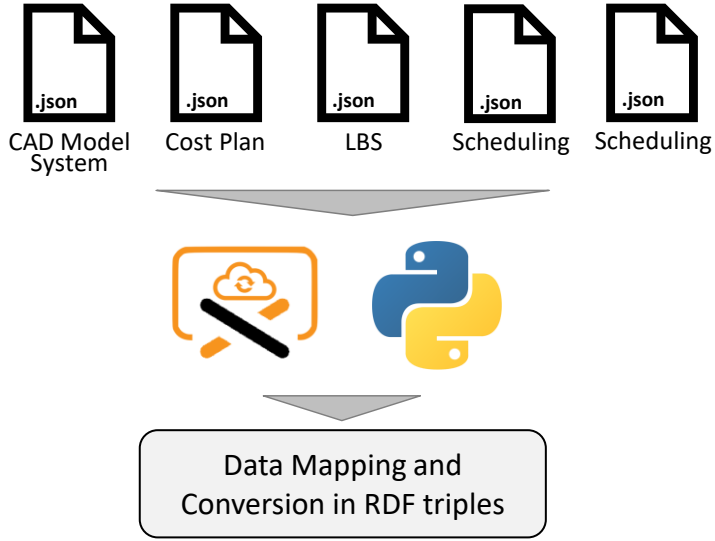
Location-Based Schedule – VICO Office



Data Generation in VICO



Data Extraction in ExiLink/ Program



Location-Based Schedule – VICO Office

LBS Data Graph

```
inst:1000.0.145882  a                lbs:CompLoid , product:Wall ;
        lbs:hasCompLoid              "1000.0.145882" ;
        lbs:hasLocation              "Lev1_loca(w)" ;
        lbs:haslocLoid               "1000.0.355001" ;
        lbs:hasschedLoid             "1000.0.321768" ;
        lbs:hastaskLoid              "1000.0.358588" ;
        lbs:taskActualEndDate        "NULL"^^xsd:dateTime ;
        lbs:taskActualStartDate      "NULL"^^xsd:dateTime ;
        lbs:taskPlannedEndDate       "2019-04-08 07:28:48.000"^^xsd:dateTime ;
        lbs:taskPlannedStartDate     "2019-04-04 11:00:00.000"^^xsd:dateTime ;
        lbs:taskProgressCompletion   "0.0"^^xsd:nonNegativeInteger ;
        lbs:taskProgressDate         "NULL"^^xsd:dateTime ;
        props:Element_ID             "585914" ;
        props:Revit_GUID             "450d31df-4383-4692-9be4-9c0935e083ef-0008f0ba" .
```

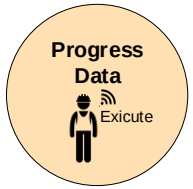
Location-Based Schedule – VICO Office

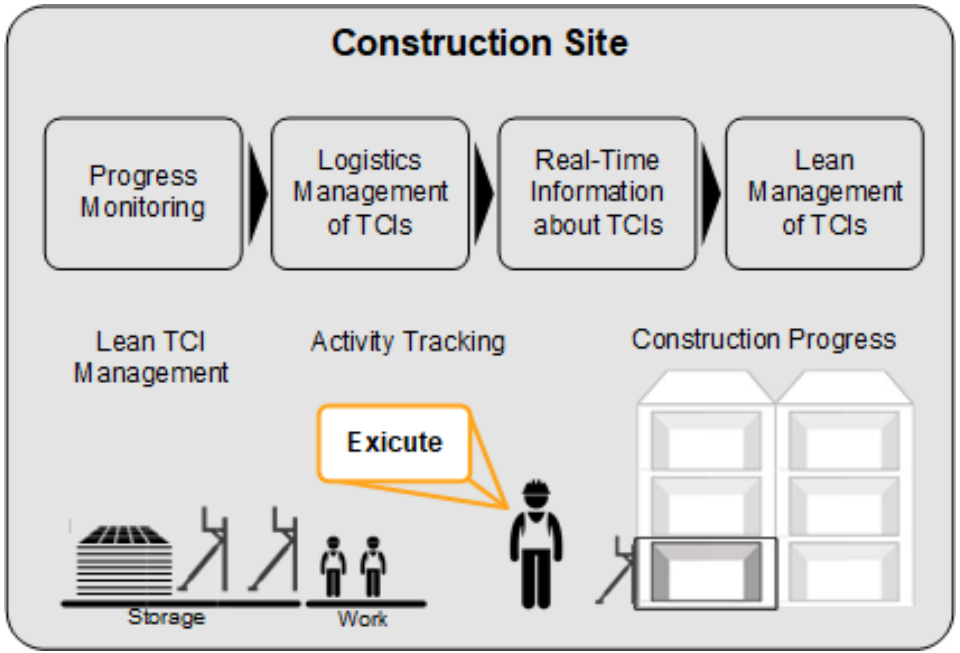
LBS Data Graph

```
inst:1000.0.145882  a                  lbs:CompLoid , product:Wall ;
        lbs:hasCompLoid                "1000.0.145882" ;
        lbs:hasLocation                "Lev1_loca(w)" ;
        lbs:haslocLoid                 "1000.0.355001" ;
        lbs:hasschedLoid               "1000.0.321768" ;
        lbs:hastaskLoid                "1000.0.358588" ;
        lbs:taskActualEndDate          "NULL"^^xsd:dateTime ;
        lbs:taskActualStartDate        "NULL"^^xsd:dateTime ;
        lbs:taskPlannedEndDate         "2019-04-08 07:28:48.000"^^xsd:dateTime ;
        lbs:taskPlannedStartDate       "2019-04-04 11:00:00.000"^^xsd:dateTime ;
        lbs:taskProgressCompletion     "0.0"^^xsd:nonNegativeInteger ;
        lbs:taskProgressDate           "NULL"^^xsd:dateTime ;
        props:Element_ID               "585914" ;
        props:Revit_GUID               "450d31df-4383-4692-9be4-9c0935e083ef-0008f0ba" .
```

Exicute

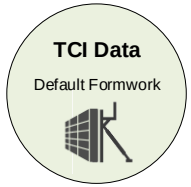
Progress Monitoring – **Exicute**

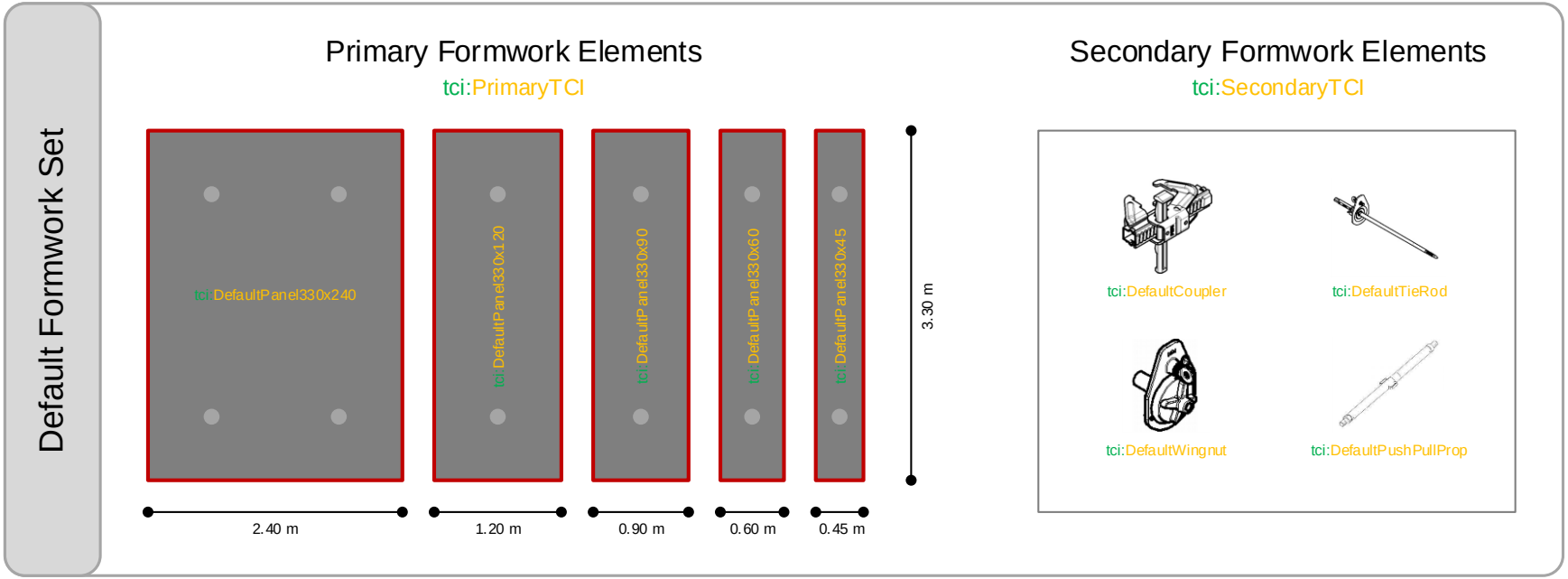




Temporary Construction Items – **TCI**

- TCI Ontology Creation describing the TCI context





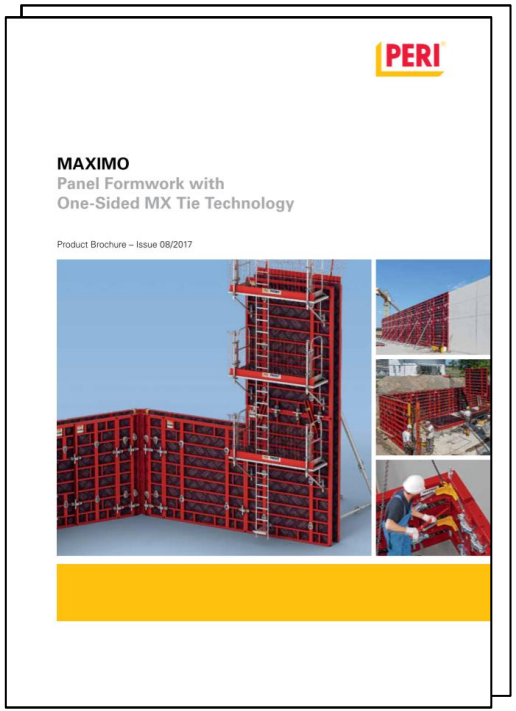
Temporary Construction Items – **TCI**

TCI Data Graph

```
tci:PrimaryTCI  a          owl:Class ;
        rdfs:subClassOf    tci:TCI ;
        owl:disjointWith   tci:SecondaryTCI .

tci:SecondaryTCI  a       owl:Class ;
        rdfs:subClassOf   tci:TCI .


tci:DefaultPanel330x240
        a             owl:NamedIndividual , tci:DefaultFormwork , tci:FormworkVertical , tci:Panel ;
        rdf:label     "Default Panel 330x240" ;
        props:area    7.29 ;
        props:height  3.30 ;
        props:length  2.40 ;
        props:weight  408.0 ;
        props:width   0.12 .

tci:DefaultCoupler  a  tci:SecondaryTCI , owl:NamedIndividual , tci:DefaultFormwork , tci:Coupler ;
        rdf:label     "Default Coupler" ;
        props:weight  4.58 .
```

Specific Product – **PERI MAXIMO MX15**

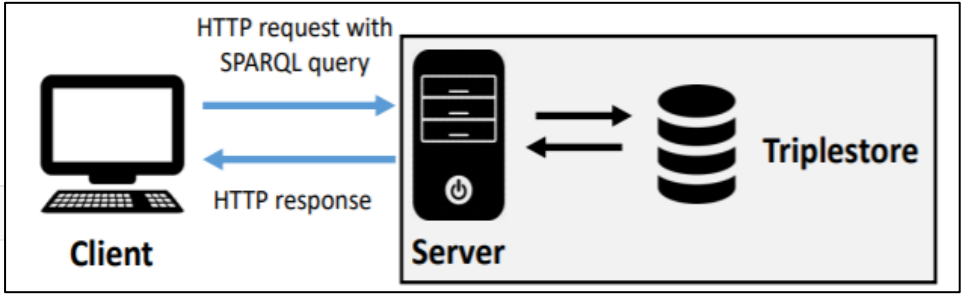
- Product Catalogue

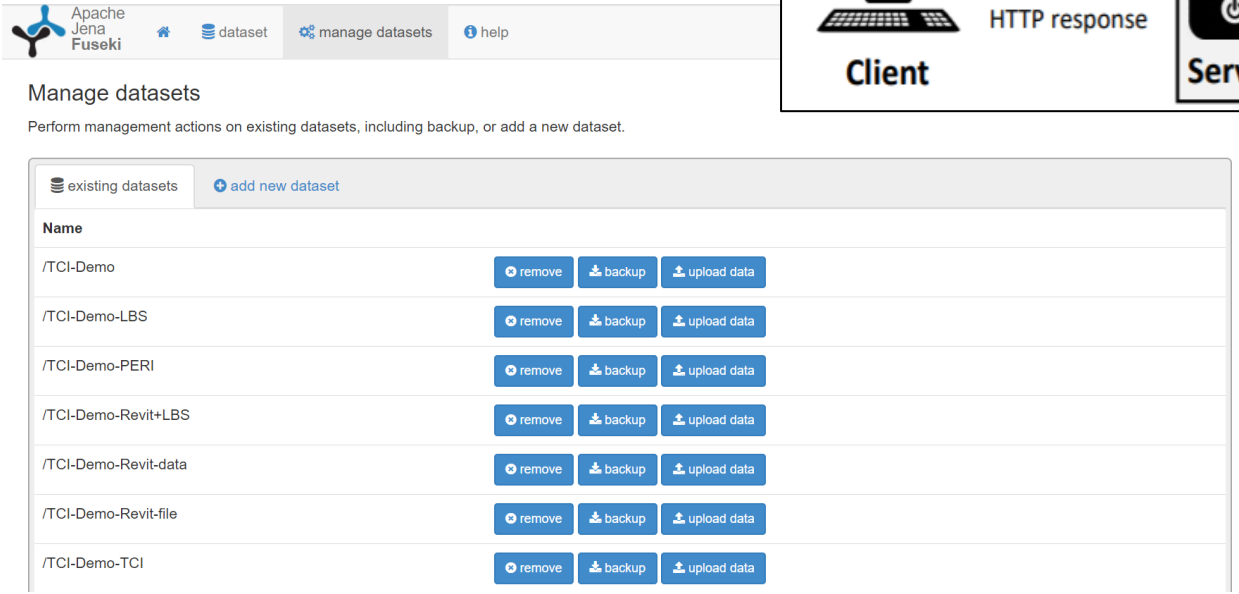



```
peri:MAXIMO_MX15   a  peri:PERIProduct ,
                      tci:FormworkVertical ;
                   rdf:label "MAXIMO MX15 Panel Formwork"^^xsd:string ;
                   tci:hasProducer "PERI GmbH"^^xsd:string ;
                   tci:hasProductCatalogue "MAXIMO MX 15, 270 _ 330 Instructions for Assembly and Use"^^xsd:string ;
                   tci:consistsof peri:PERI_MXM330x60, peri:PERI_MXI330x60, peri:PERI_MXI330x50x20, peri:PERI_MXA330x45,
                   peri:PERI_MX330x90, peri:PERI_MX330x60, peri:PERI_MX330x45, peri:PERI_MX330x30, peri:PERI_MX330x240,
                   peri:PERI_MX330x120, peri:PERI_MXA330x35, peri:WDAMX330x10, peri:PERI_WingnutMX15, peri:PERI_WingnutDW15_Pivot,
                   peri:PERI_WalerMAR853, peri:PERI_Waler85, peri:PERI_TieT5_TrioBulkhead, peri:PERI_TieMX15_3040,
                   peri:PERI_AlignmentCouplerBFD .

peri:PERI_MX330x240 rdf:type  owl:NamedIndividual ,
                              peri:MAXIMO_MX15 ,
                              tci:Panel ;
                    tci:hasArtNo  "114426"^^xsd:string ;
                    rdf:label   "PERI MX 330x240"^^xsd:string ;
                    props:length  "2.40"^^xsd:decimal ;
                    props:height  "3.30"^^xsd:decimal ;
                    props:area  "7.29"^^xsd:decimal ;
                    props:width    "0.12"^^xsd:decimal ;
                    props:weight    "408.0"^^xsd:decimal .

peri:PERI_MX330x120 rdf:type  owl:NamedIndividual ,
                              peri:MAXIMO_MX15 ,
                              tci:Panel ;
                    tci:hasArtNo  "114248"^^xsd:string ;
                    rdf:label   "PERI MX 330x120"^^xsd:string ;
                    props:length  "1.20"^^xsd:decimal ;
                    props:height  "3.30"^^xsd:decimal ;
                    props:area  "3.96"^^xsd:decimal ;
                    props:width    "0.12"^^xsd:decimal ;
                    props:weight    "226.0"^^xsd:decimal .
```

Data Management

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





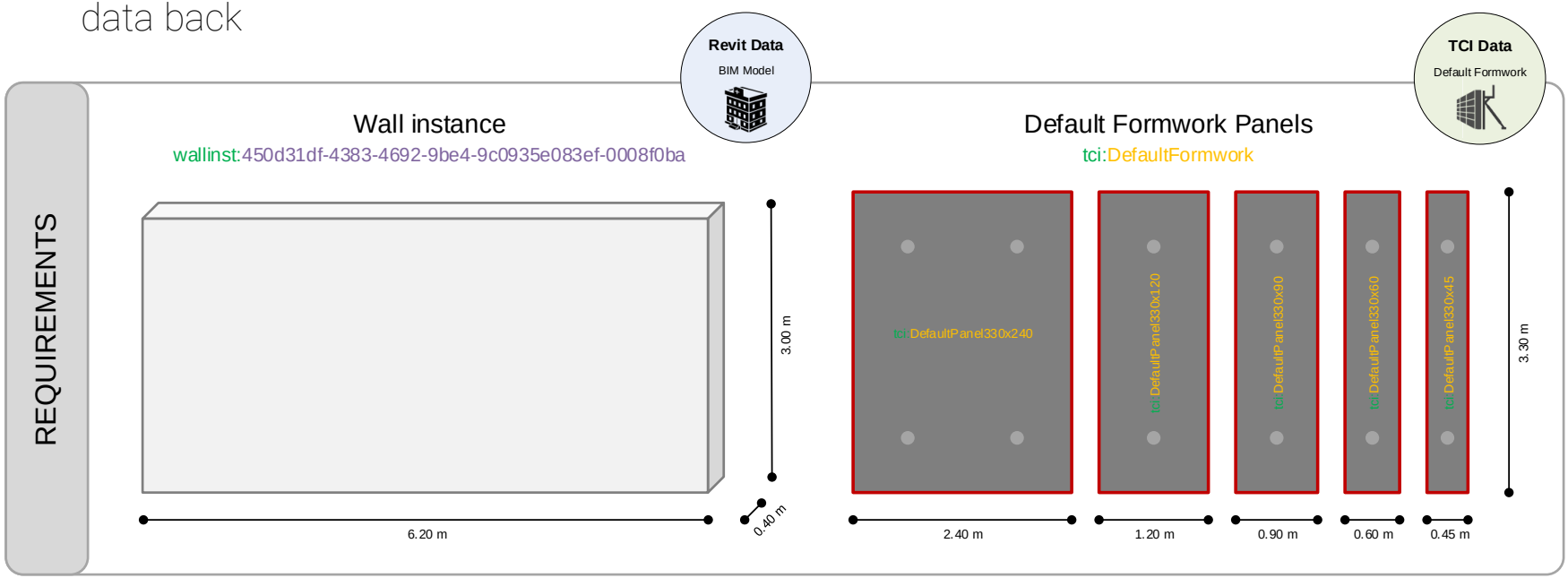
Data Processing & Querying

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						

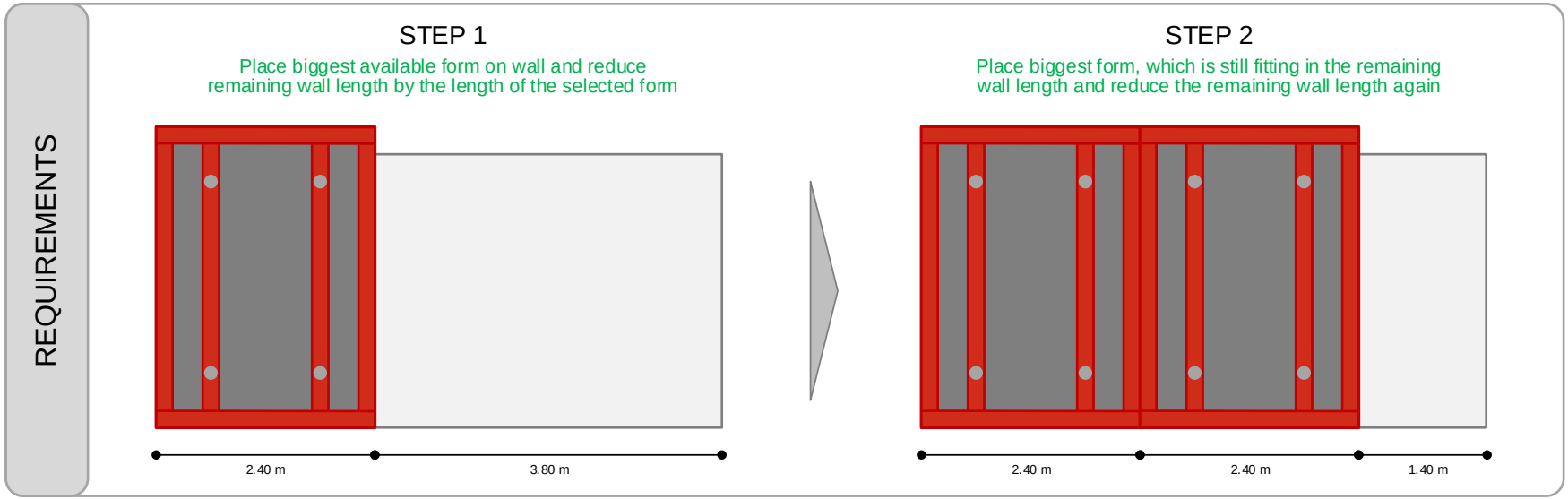
Data Processing & Querying

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



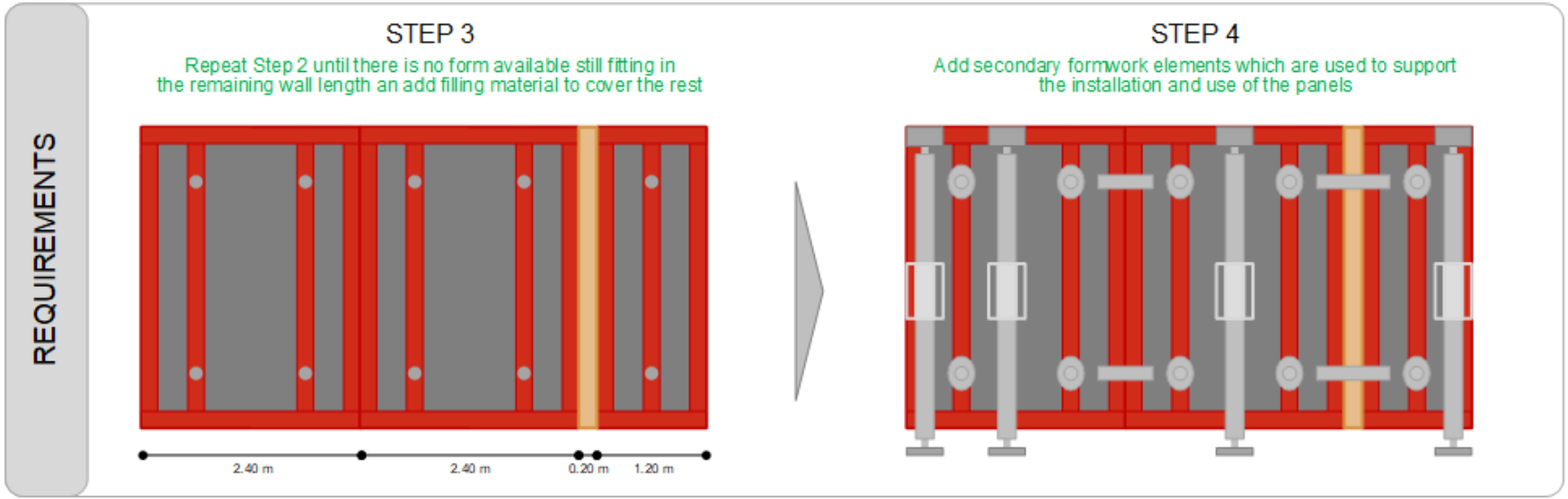
Data Processing & Querying

- Logic of Formwork Calculation Program



Data Processing & Querying

- Logic of Formwork Calculation Program



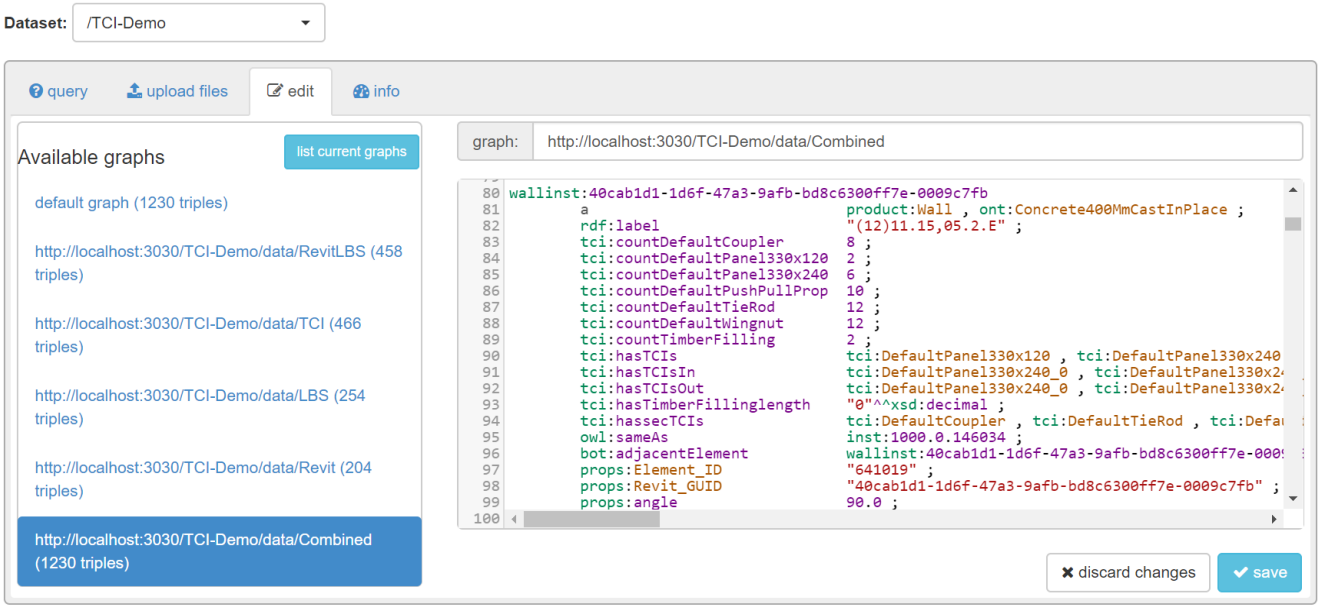
Data Processing & Querying

Output Data of Program


```
{"wallinst": "http://test/walls/450d31df-4383-4692-9be4-9c0935e083ef-0008f0ba",
   "length": 6.2,
   "TCIsIn": [
          {"TCIinst": "http://test/tci/DefaultPanel330x240_0", "length": 2.4},
          {"TCIinst": "http://test/tci/DefaultPanel330x240_1", "length": 2.4},
          {"TCIinst": "http://test/tci/DefaultPanel330x120_0","length": 1.2}],
   "TCIsOut": [
          {"TCIinst": "http://test/tci/DefaultPanel330x240_0", "length": 2.4},
          {"TCIinst": "http://test/tci/DefaultPanel330x240_1", "length": 2.4},
          {"TCIinst": "http://test/tci/DefaultPanel330x120_0","length": 1.2}],
   "secTCIs": [
          {"TCIinst": "http://test/tci/DefaultCoupler", "weight": 4.58},
          {"TCIinst": "http://test/tci/DefaultTieRod", "weight": 4.43},
          {"TCIinst": "http://test/tci/DefaultWingnut", "weight": 2.58},
          {"TCIinst": "http://test/tci/DefaultPushPullProp", "weight": 22.8}],

   "TCIsCount": [
          {"TCIinst": "http://test/tci/DefaultPanel330x240", "Count": 4},
          {"TCIinst": "http://test/tci/DefaultPanel330x120", "Count": 2},
          {"TCIinst": "http://test/tci/TimberFilling", "Count": 2},
          {"TCIinst": "http://test/tci/DefaultCoupler", "Count": 4},
          {"TCIinst": "http://test/tci/DefaultTieRod", "Count": 8},
          {"TCIinst": "http://test/tci/DefaultWingnut", "Count": 8},
          {"TCIinst": "http://test/tci/DefaultPushPullProp", "Count": 8}],
   "TimberFilling": [
          {"TCIinst": "http://test/tci/TimberFilling", "Length": 0.2},
          {"TCIinst": "http://test/tci/TimberFilling", "Length": 0.2}]},
```

Data Processing & Querying

Combined Data Graph



Data Processing & Querying

Querying Output Data to create desired Data Table

```
SELECT ?Element_ID ?length ?PrimaryTCIs ?TCIsCount ?SecondaryTCIs ?2TCIsCount
?Location ?PlannedStartDate ?PlannedEndDate ?ActualStartDate ?ActualEndDate ?P
rogressDate ?ProgressCompletion

WHERE {GRAPH <http://localhost:3030/TCI-Demo/data/Combined>
{
?Revitinst a product:Wall ;
    props:Element_ID ?Element_ID ;
    props:length ?length ;
    tci:hasTCIs ?PrimaryTCIs;
    tci:hassecTCIs ?SecondaryTCIs .

?1Countprop tci:iscounting ?PrimaryTCIs .
?Revitinst ?1Countprop ?TCIsCount .
?2Countprop tci:iscounting ?SecondaryTCIs .
?Revitinst ?2Countprop ?2TCIsCount .

  ?VICOinst a lbs:CompLoid ;
    props:Element_ID ?Element_ID ;
    lbs:hasLocation ?Location;
    lbs:taskPlannedStartDate ?PlannedStartDate;
    lbs:taskPlannedEndDate ?PlannedEndDate;
    lbs:taskActualStartDate ?ActualStartDate;
    lbs:taskActualEndDate ?ActualEndDate;
    lbs:taskProgressDate ?ProgressDate ;
    lbs:taskProgressCompletion ?ProgressCompletion .

FILTER (?VICOinst != ?Revitinst)
}}
```

Data Processing & Querying

Revit		TCI					VICO		Exicute			
Element_ID	length	PrimaryTCIs	TCIs Count	SecondaryTCIs	2TCIs Count	Location	PlannedStartDate	PlannedEndDate	Actual StartDate	Actual EndDate	Progress Date	%
"645092"	"6.2"	"tci:DefaultPanel330x120" "tci:DefaultPanel330x240" "tci:TimberFilling"	"2" "4" "0.2"	"tci:DefaultCoupler" "tci:DefaultTieRod" "tci:DefaultWingnut" "tci:DefaultPushPullProp"	"4" "8" "8" "8"	"Lev1_loca(w)"	"2019-04-04 11:00:00.000"	"2019-04-08 07:28:48.000"	"NULL"	"NULL"	"NULL"	"0.0"
"585914"	"6.2"	"tci:DefaultPanel330x120" "tci:DefaultPanel330x240" "tci:TimberFilling"	"2" "4" "0.2"	"tci:DefaultCoupler" "tci:DefaultTieRod" "tci:DefaultWingnut" "tci:DefaultPushPullProp"	"4" "8" "8" "8"	"Lev1_loca(w)"	"2019-04-04 11:00:00.000"	"2019-04-08 07:28:48.000"	"NULL"	"NULL"	"NULL"	"0.0"
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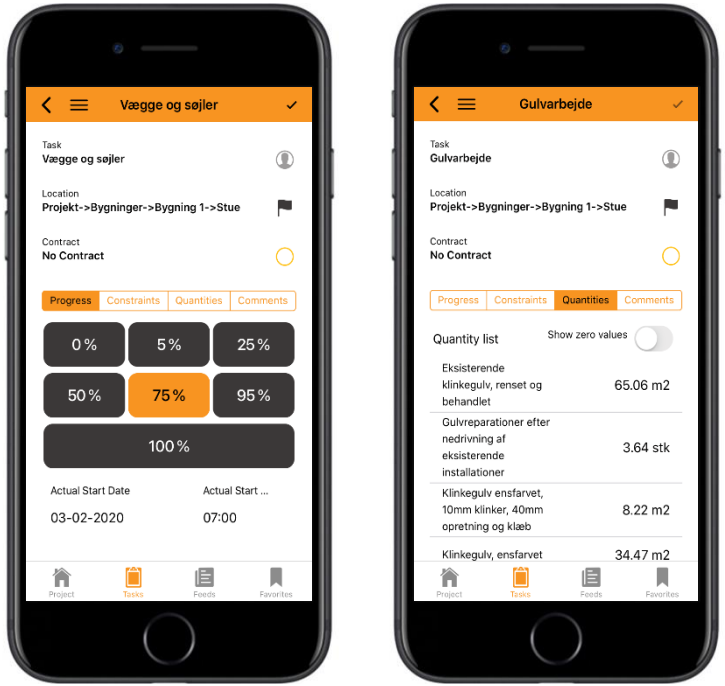
Data Visualization & Distribution

Exicute Cloud Platform

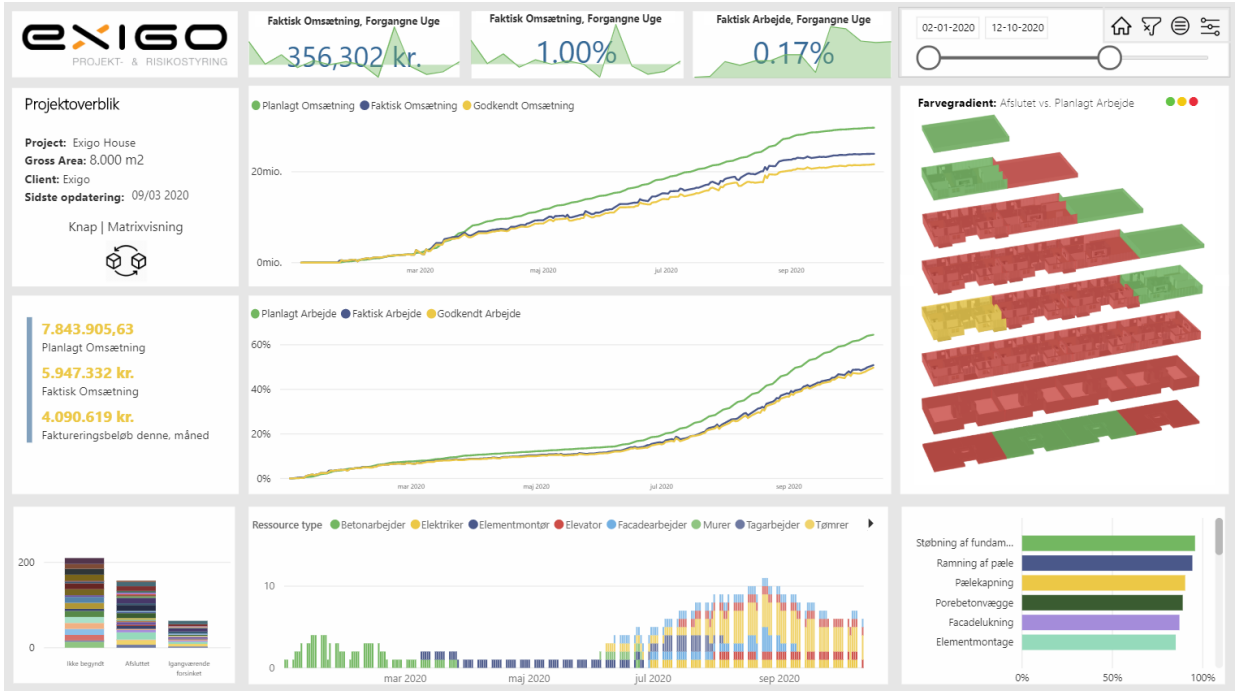


Integration in existing App

- Implementation of the proposed solution in practice
- Extension of the existing application
- 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

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.

VI. Further Development/ Improvements

Further Development/ Improvements

Improving formwork calculation program

Data Visualization & Distribution with Exicute & Power BI

IoT-Implementation for active resource tracking

Validate solution with case study on SDU project

Develop Program to export VICO data as an RDF data graph

Create business case for stakeholder to publish their information as Linked Open Data

Questions/

Feedback?