CONCEPTUAL FOUNDATIONS FOR A NEW LEAN BIM-BASED PRODUCTION SYSTEM IN CONSTRUCTION

Paper ID: 106

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Funding

This work is part of BIM Simulation Lab - FESR 1086, a research project funded by the European Development Fund (ERDF) Südtirol/Alto Adige.

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Production Systems in Construction

What is a production system in construction?

"A framework of **methods** and **tools** to manage **construction processes** according to the three target variables **quality**, **time** and **costs**."
(Borrmann et al, 2018)

Motivation

Source: Financial times

Lean Construction

The Optimist

Lean Construction

The Optimist

The Pessimist

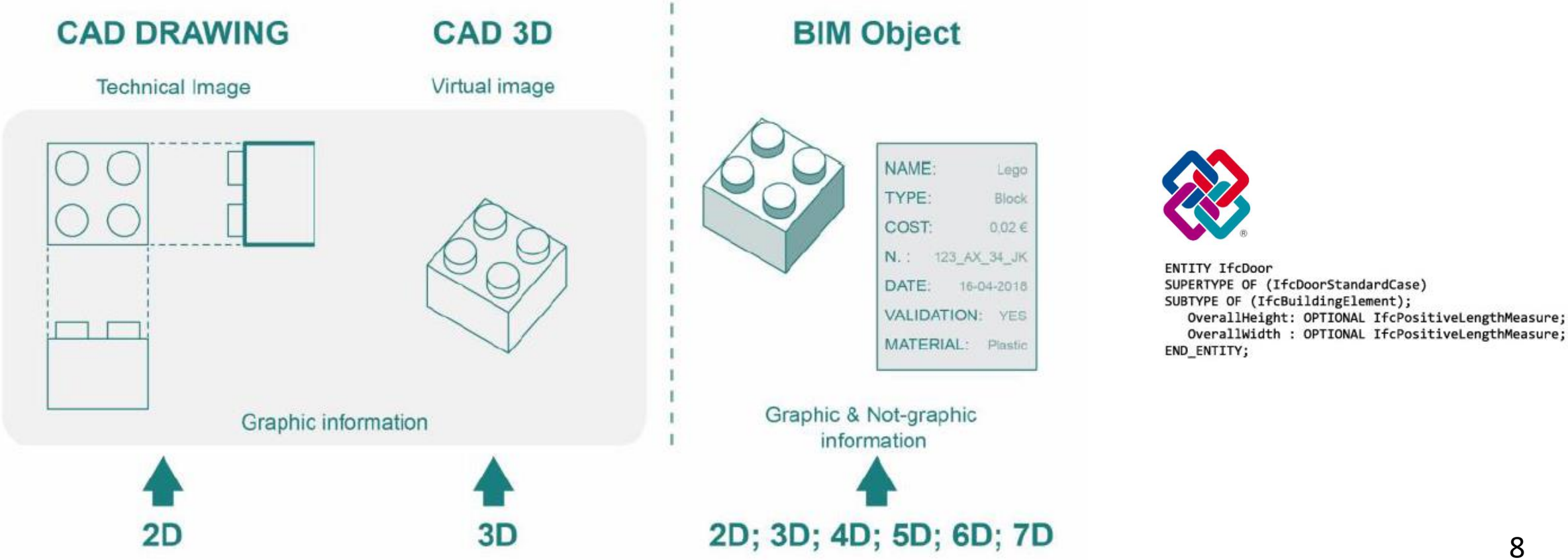
Lean Construction

Everything that is **not needed** is waste

BIM can help to define what **is needed**

Source: lean.org/leanpost

Building Information Modeling (BIM)




```
ENTITY IfcDoor
SUPERTYPE OF (IfcDoorStandardCase)
SUBTYPE OF (IfcBuildingElement);
   OverallHeight: OPTIONAL IfcPositiveLengthMeasure;
   OverallWidth : OPTIONAL IfcPositiveLengthMeasure;
END_ENTITY;
```

Goal: Shifting production system design efforts towards the digital prototype

- Integration of **BiM** and *Lean* on data processing level
- Storing Last Planner System (LPS) process information in the IFC file format
- Conceptualizing a new lean BIM-based production system:

Goal: Shifting production system design efforts towards the digital prototype

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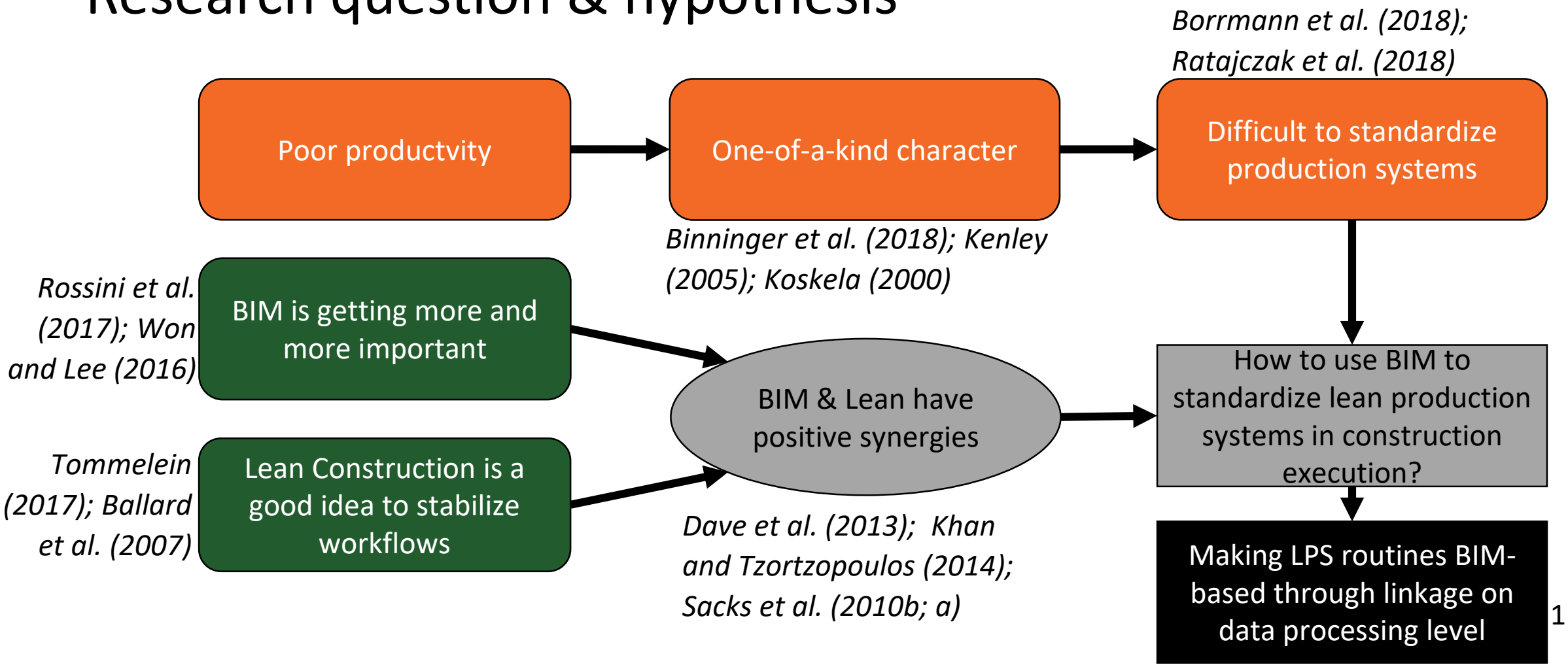
- Conceptualizing a new lean BIM-based production system:

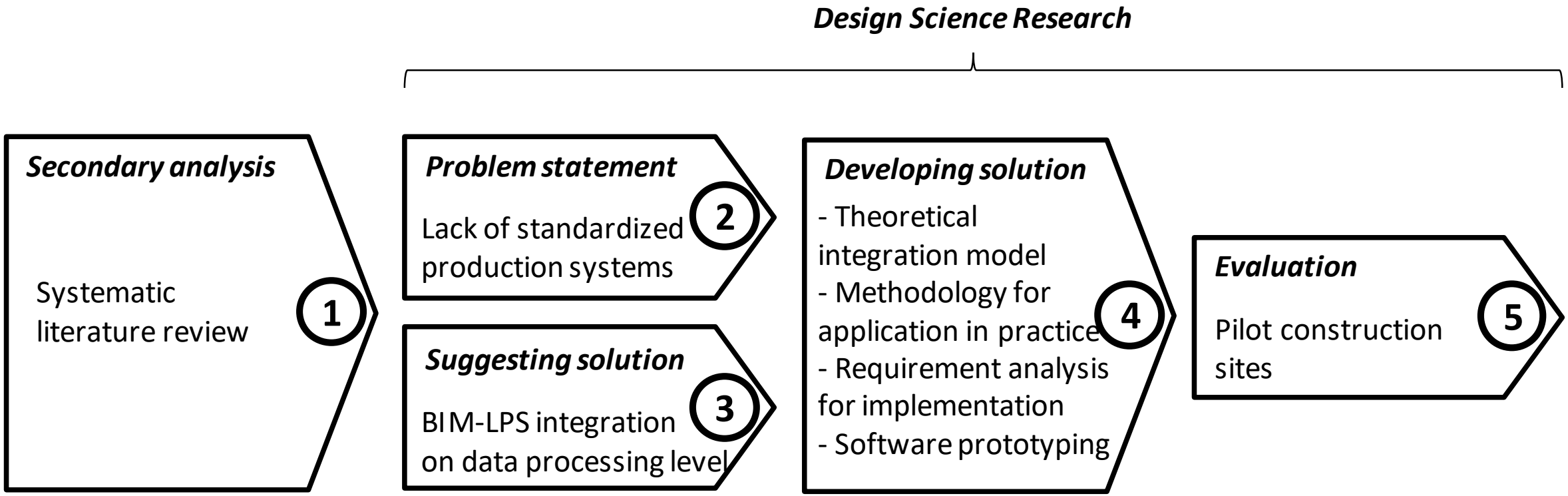
BiM + *Lean*

- Production System

Research question & hypothesis



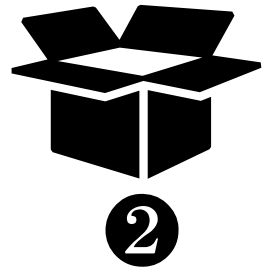
Research Methodology



Preliminary literature findings - Shortcomings

Frameworks of co-applications
(Guerriero et al. (2017); Scheer et al. (2014))

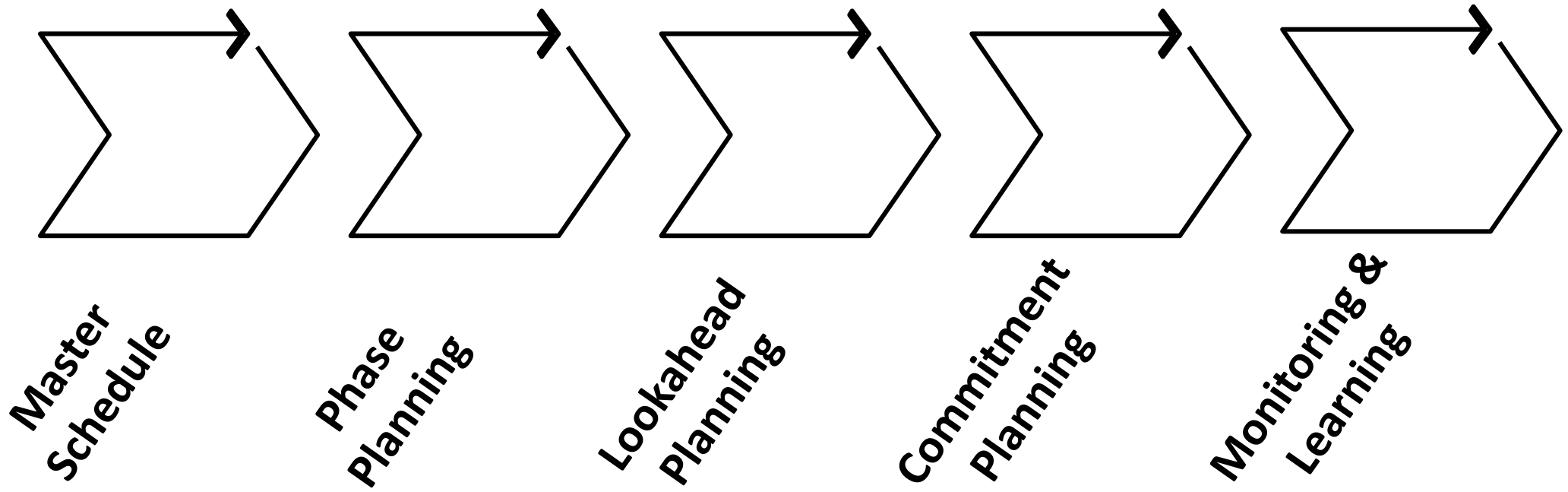
Partial implementation of LPS steps
(Bhatla and Leite (2012); Gerber et al. (2010))

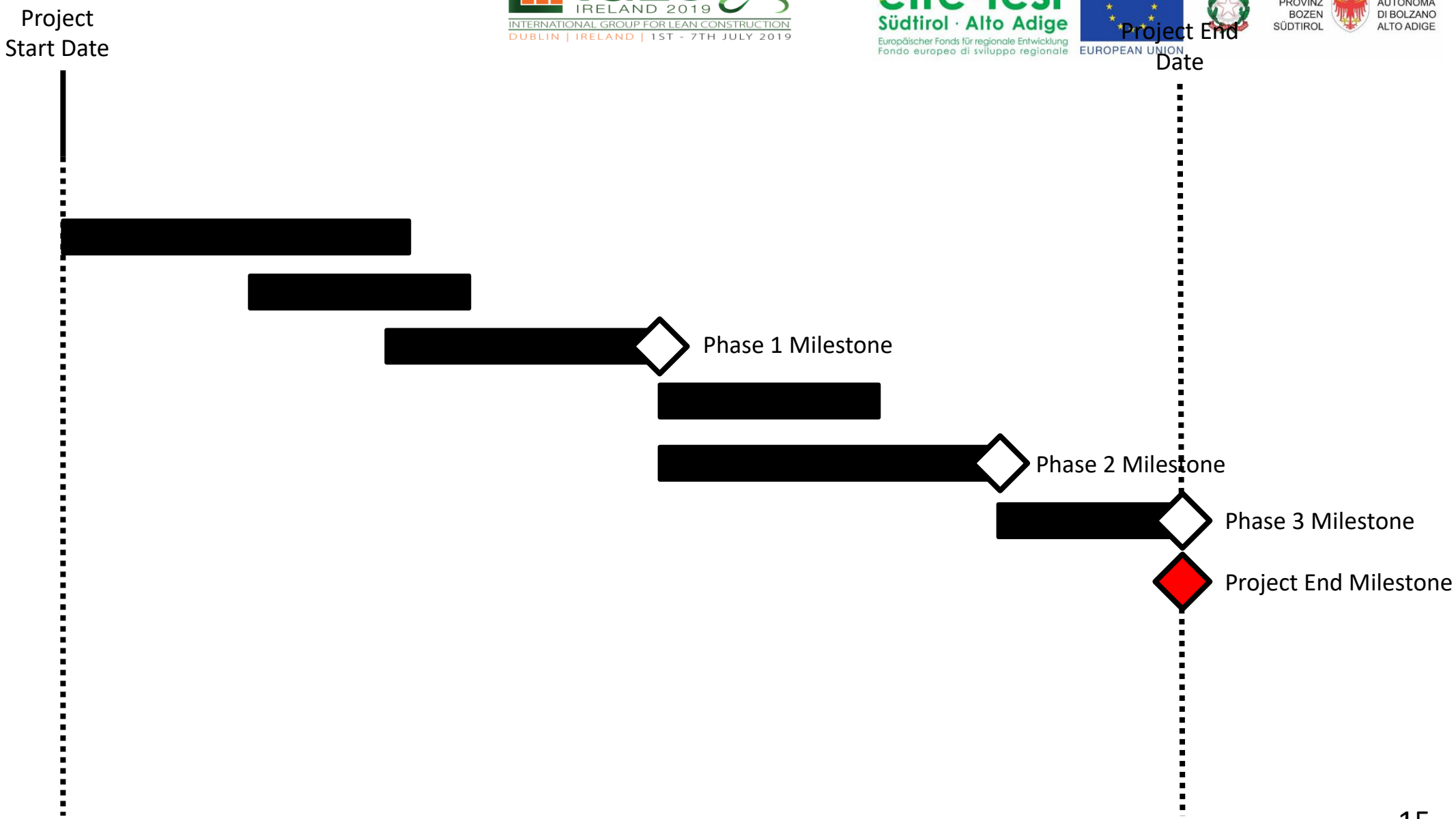


Need to add other functionalities:

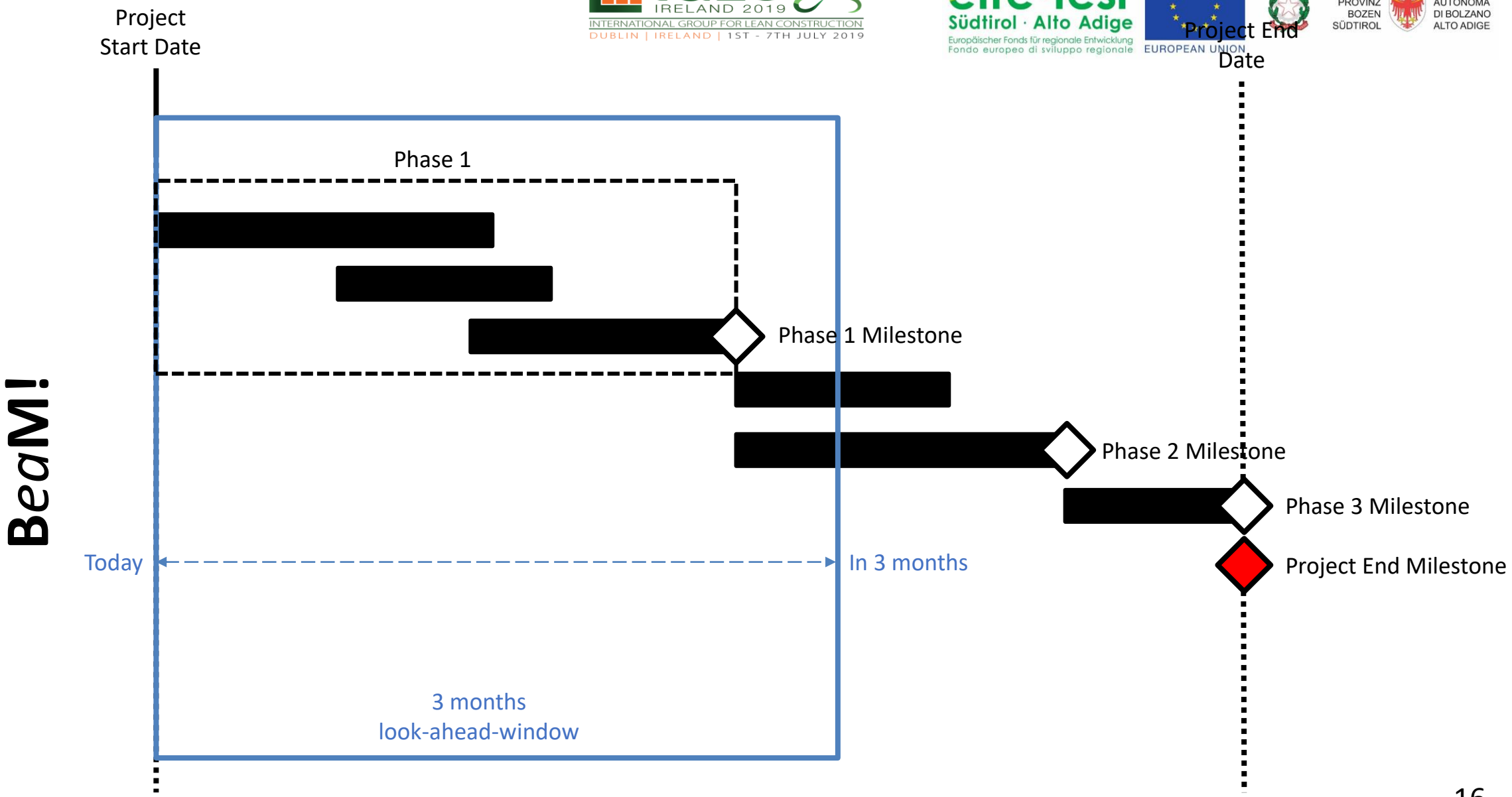
- Adding aspects of Scrum → Clear roles *(Dave et al. 2015)*
- Adding aspects of (digital) Kanban → *Visualisation, Pull-System, Digitize! (Mossman 2015; Rybkowski 2010)*
- Adding aspects of Earned Value Management → *Cost control (Novinsky et al. 2018; Zhang et al. 2018)*

The **B*ea*M!** process from LPS perspective

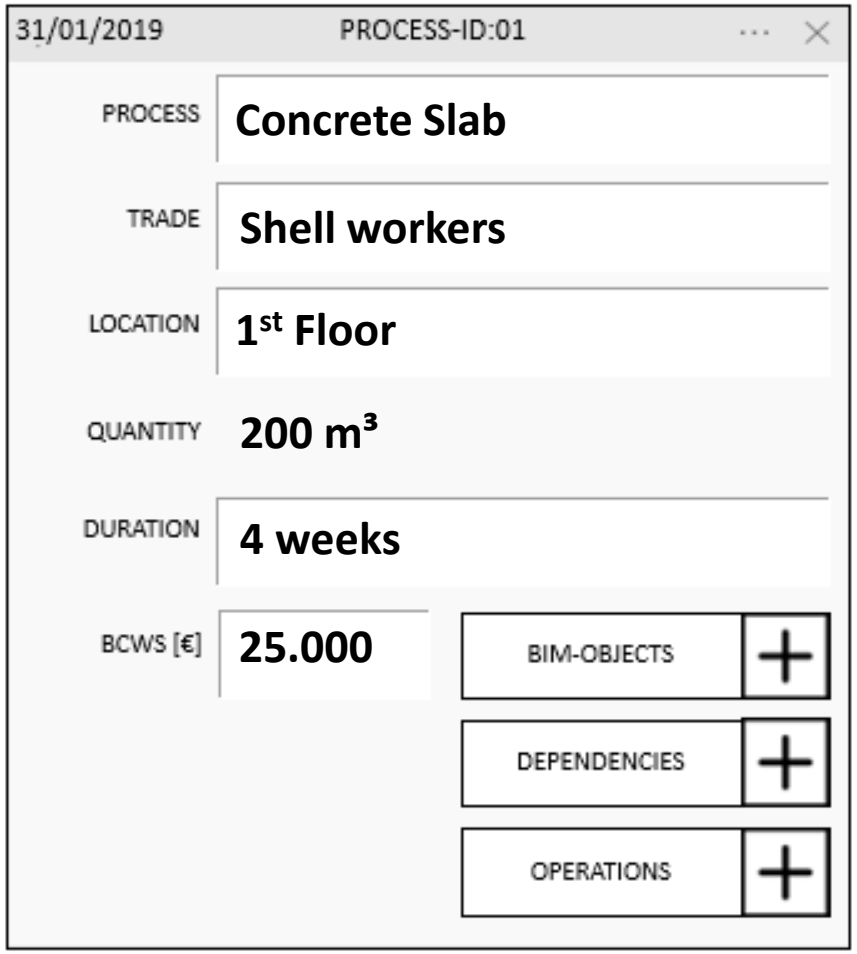



Project
Start Date
Project End
Date
Phase 1 Milestone
Phase 2 Milestone
Phase 3 Milestone
Project End Milestone

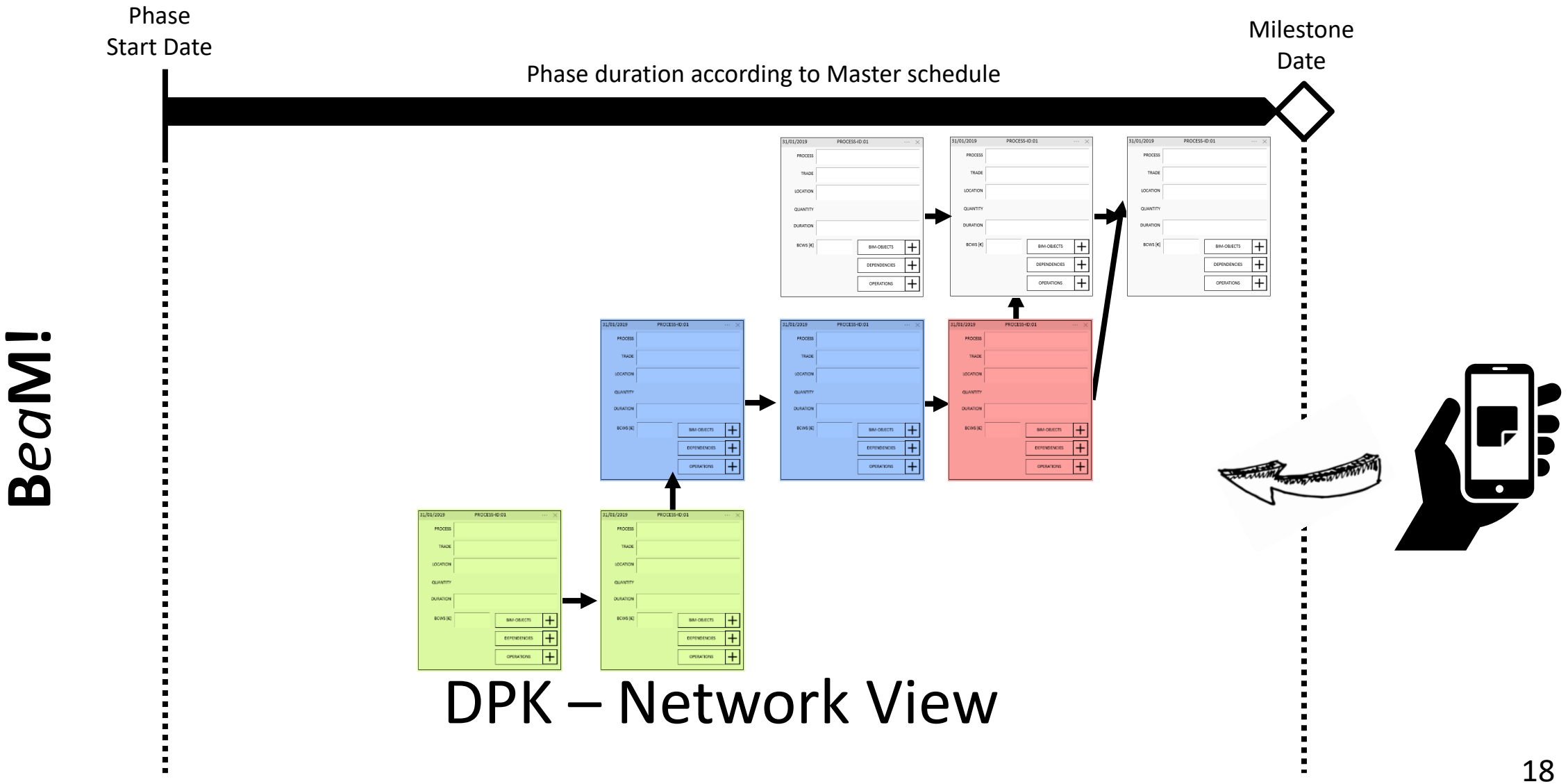
BeaM!


Project Start Date
Project End Date
Phase 1
Phase 1 Milestone
Phase 2 Milestone
Phase 3 Milestone
Project End Milestone
Today
In 3 months
3 months
look-ahead-window
BeaM!

BeaM!

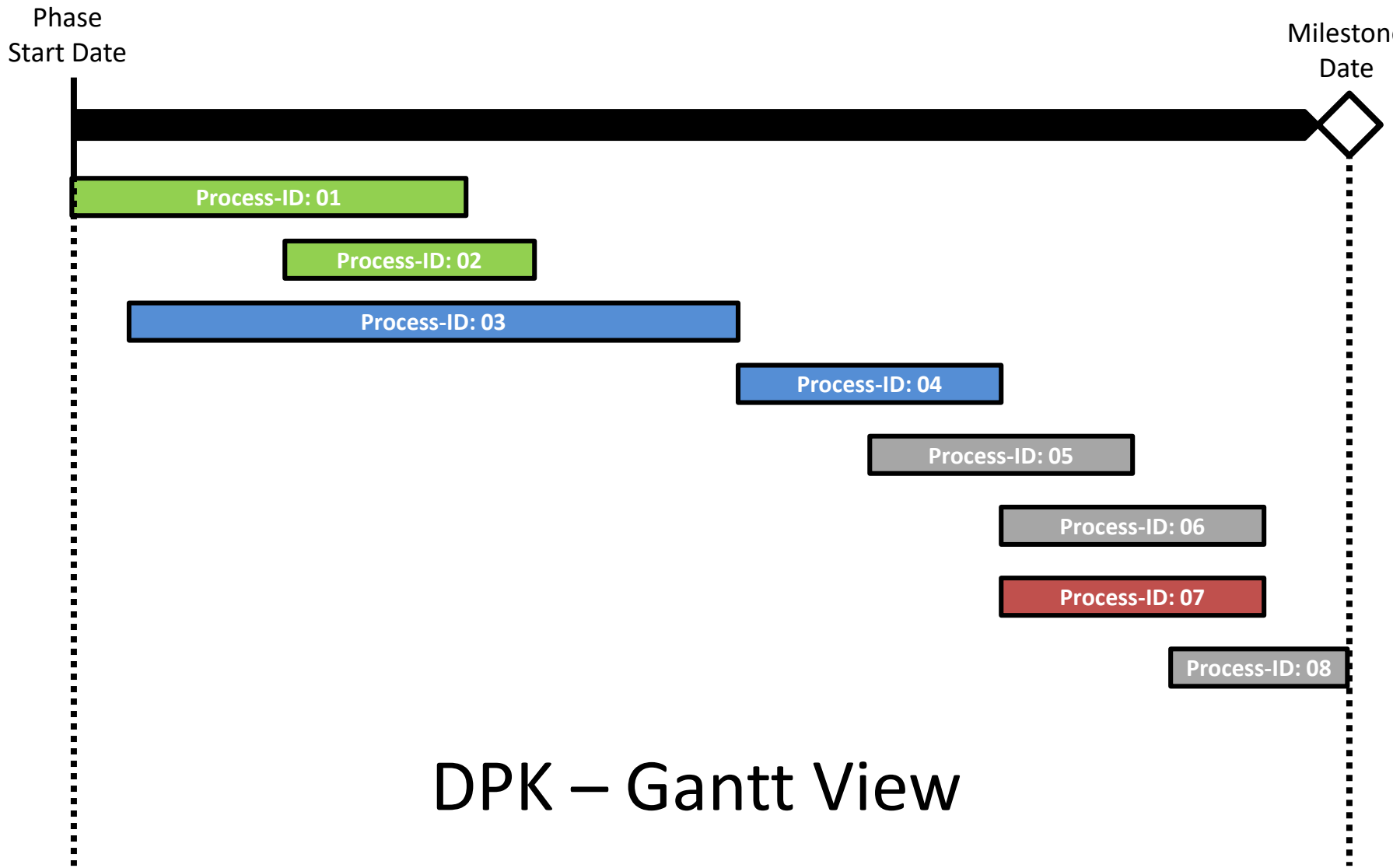


Digital Process Kanban (DPK)

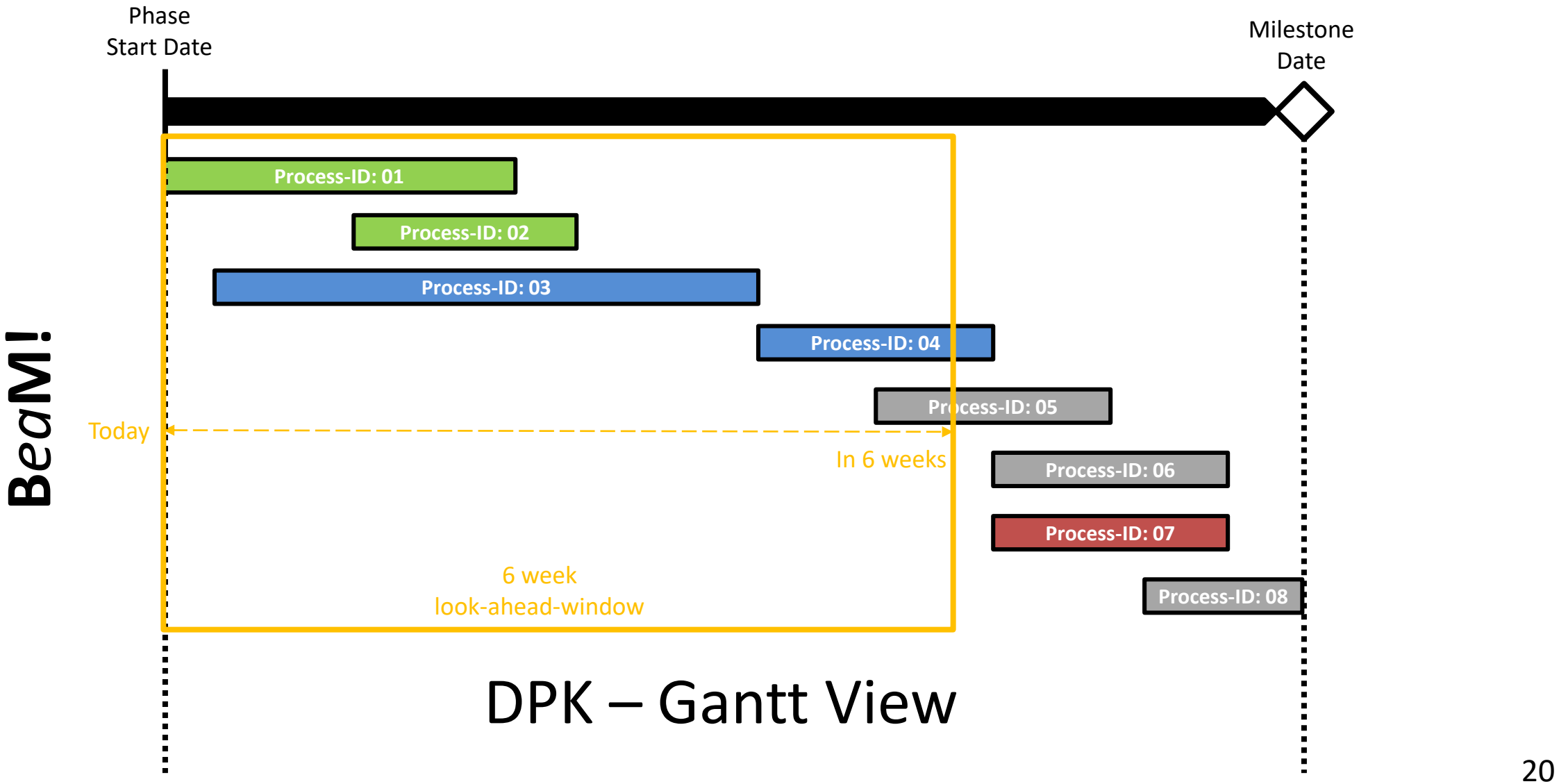


DPK – Network View

BeaM!

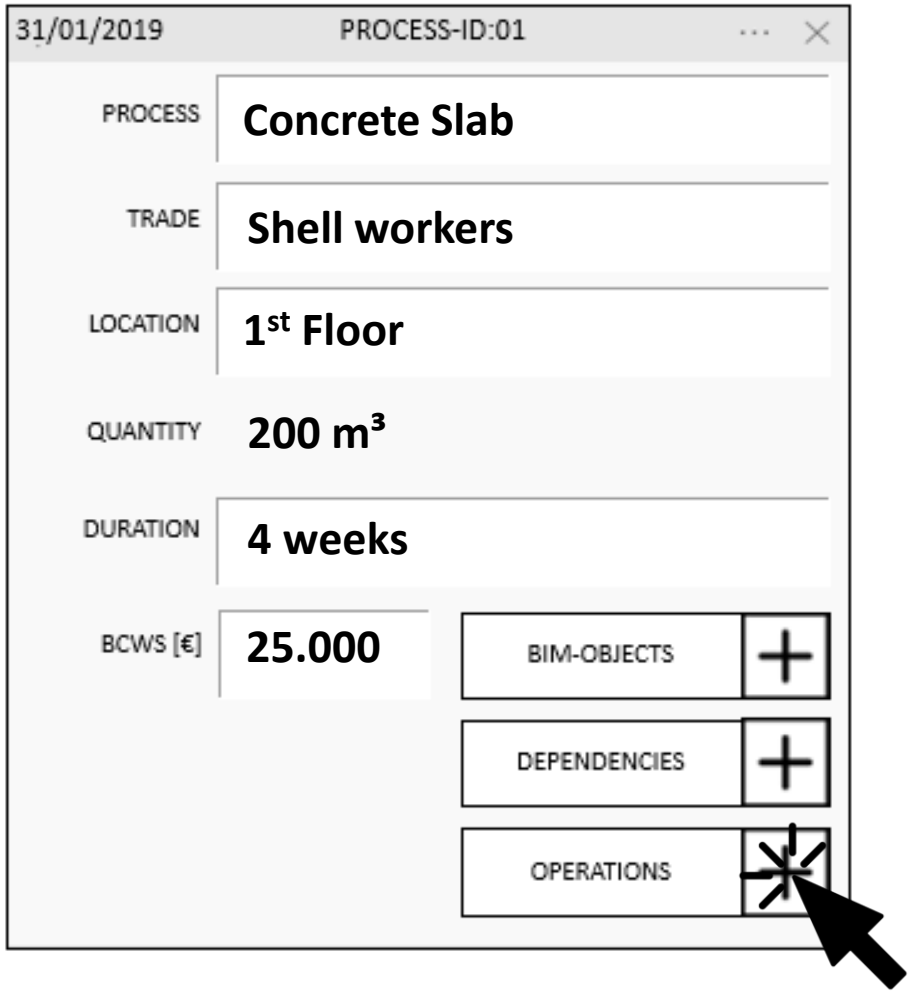


DPK – Gantt View



DPK – Gantt View

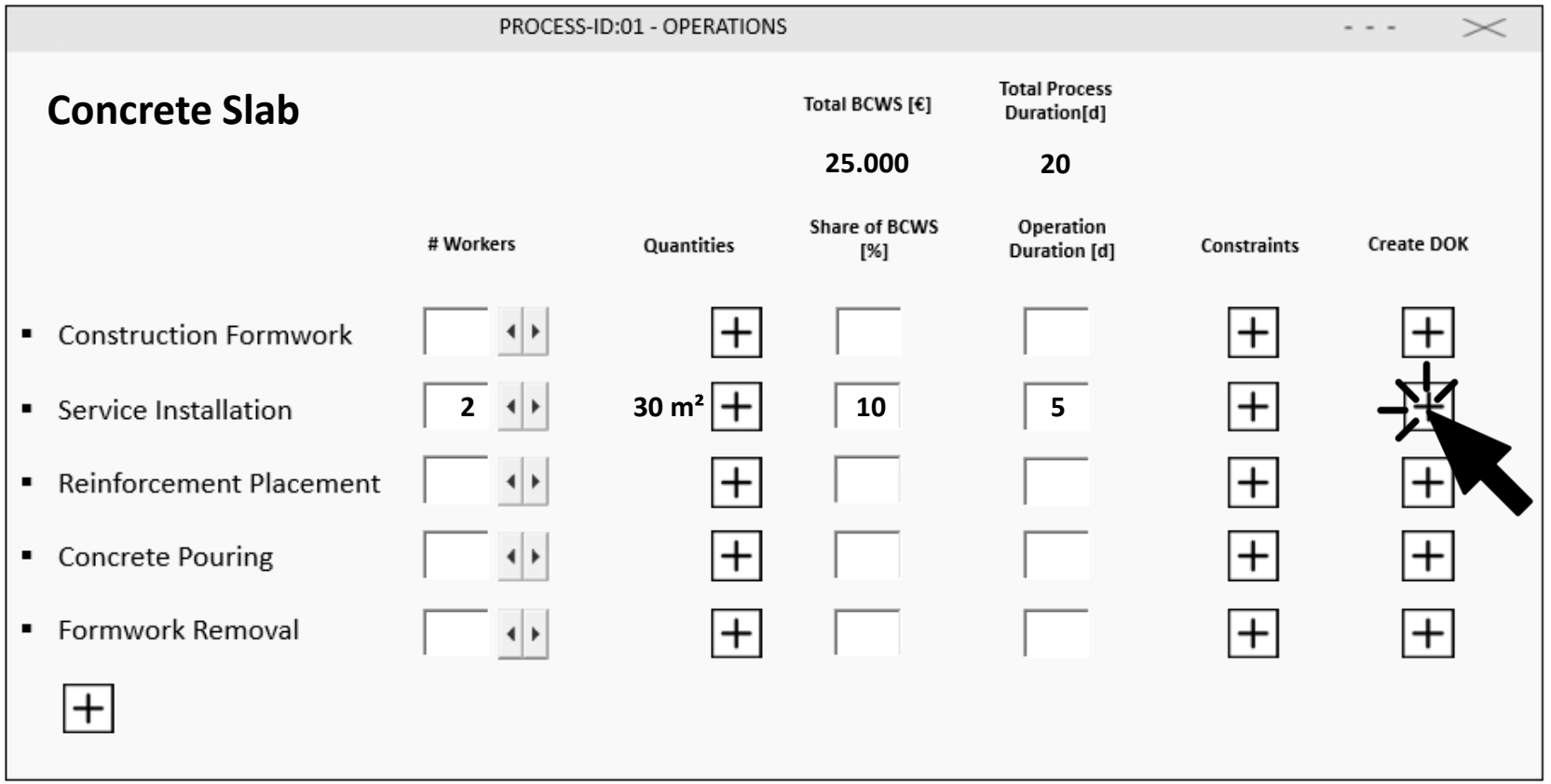
BeaM!



Designing Operations

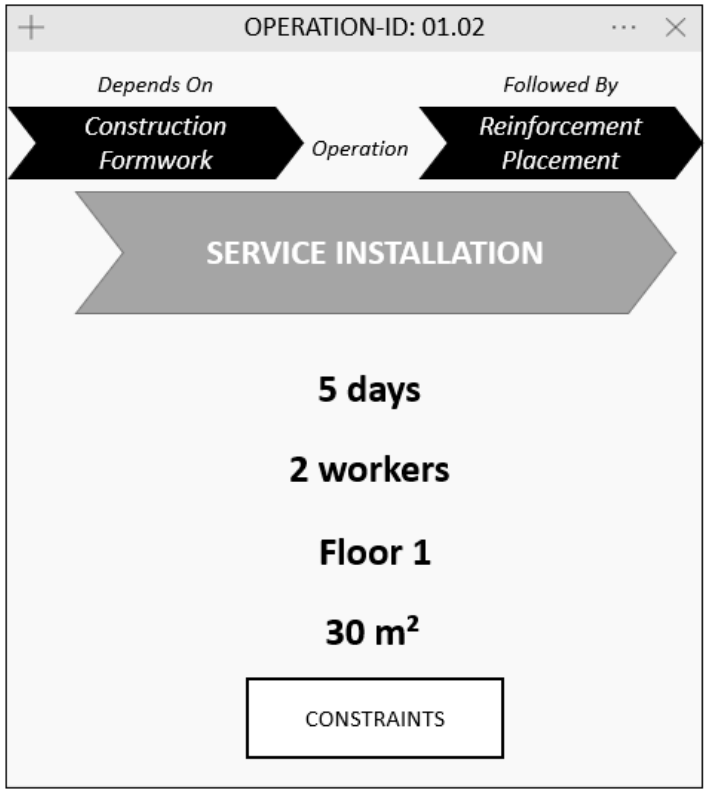
Creating Digital Operation Kanban (DOK)

BeaM!

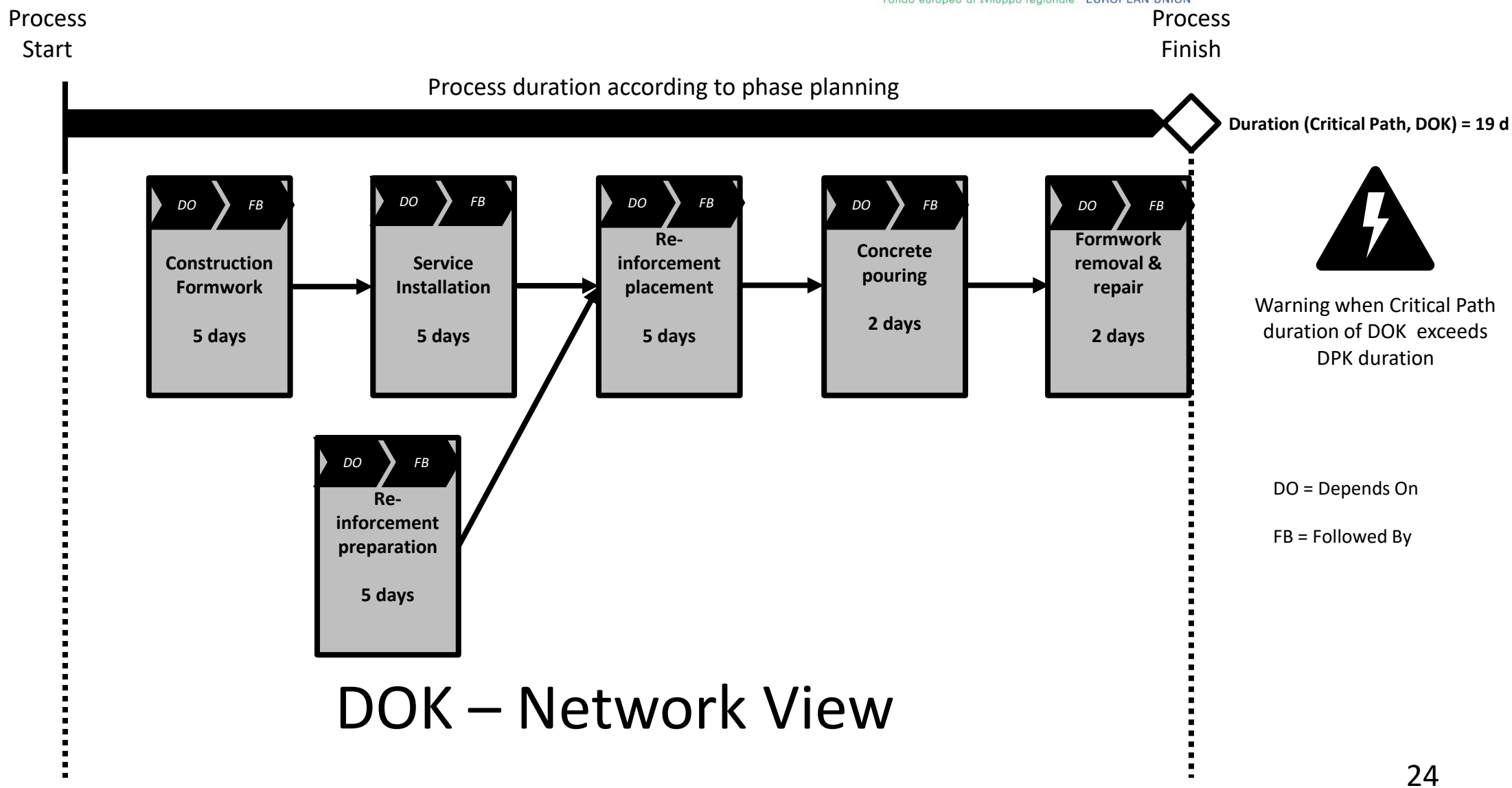


Digital Operation Kanban (DOK)

BeaM!

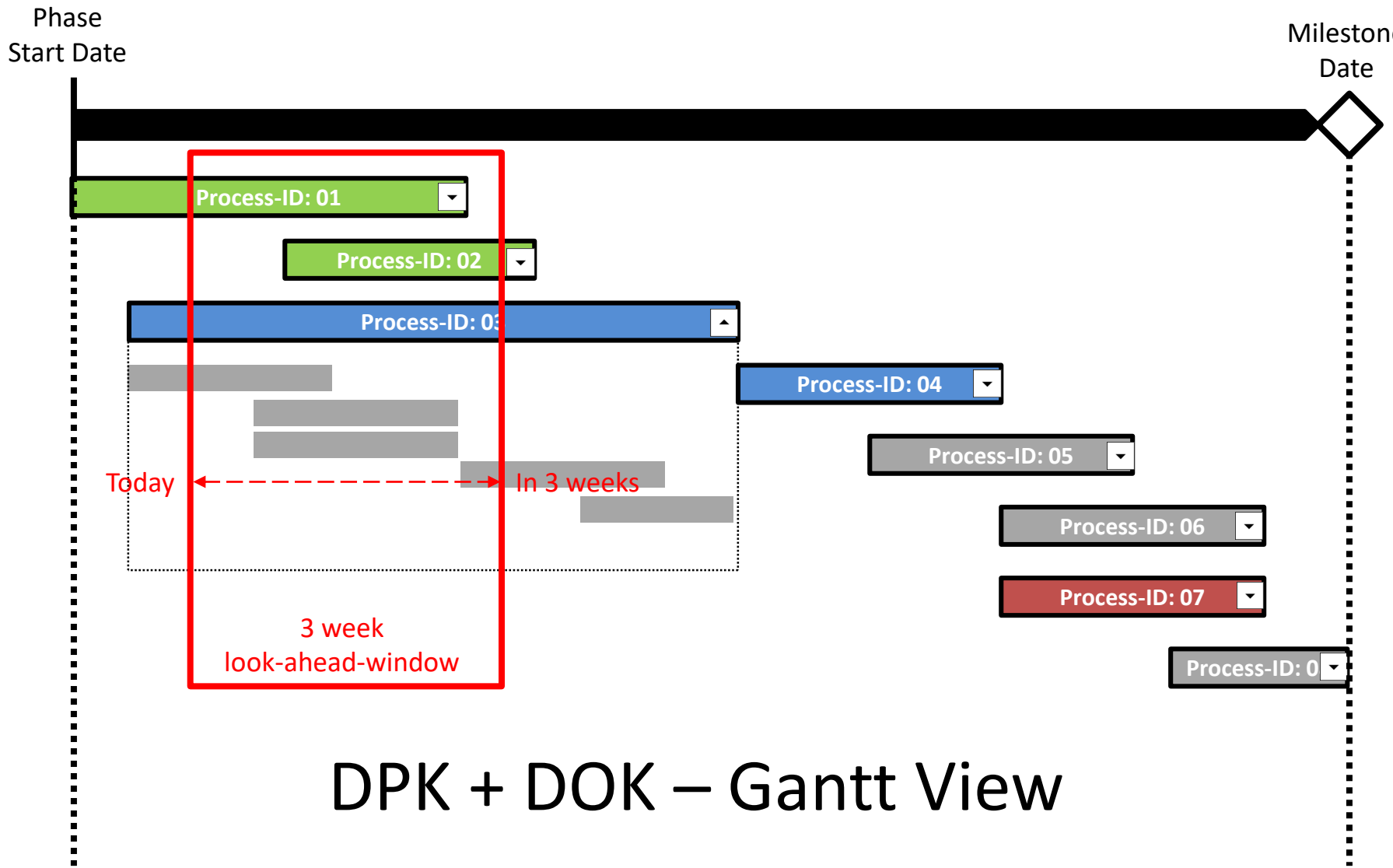


BeaM!



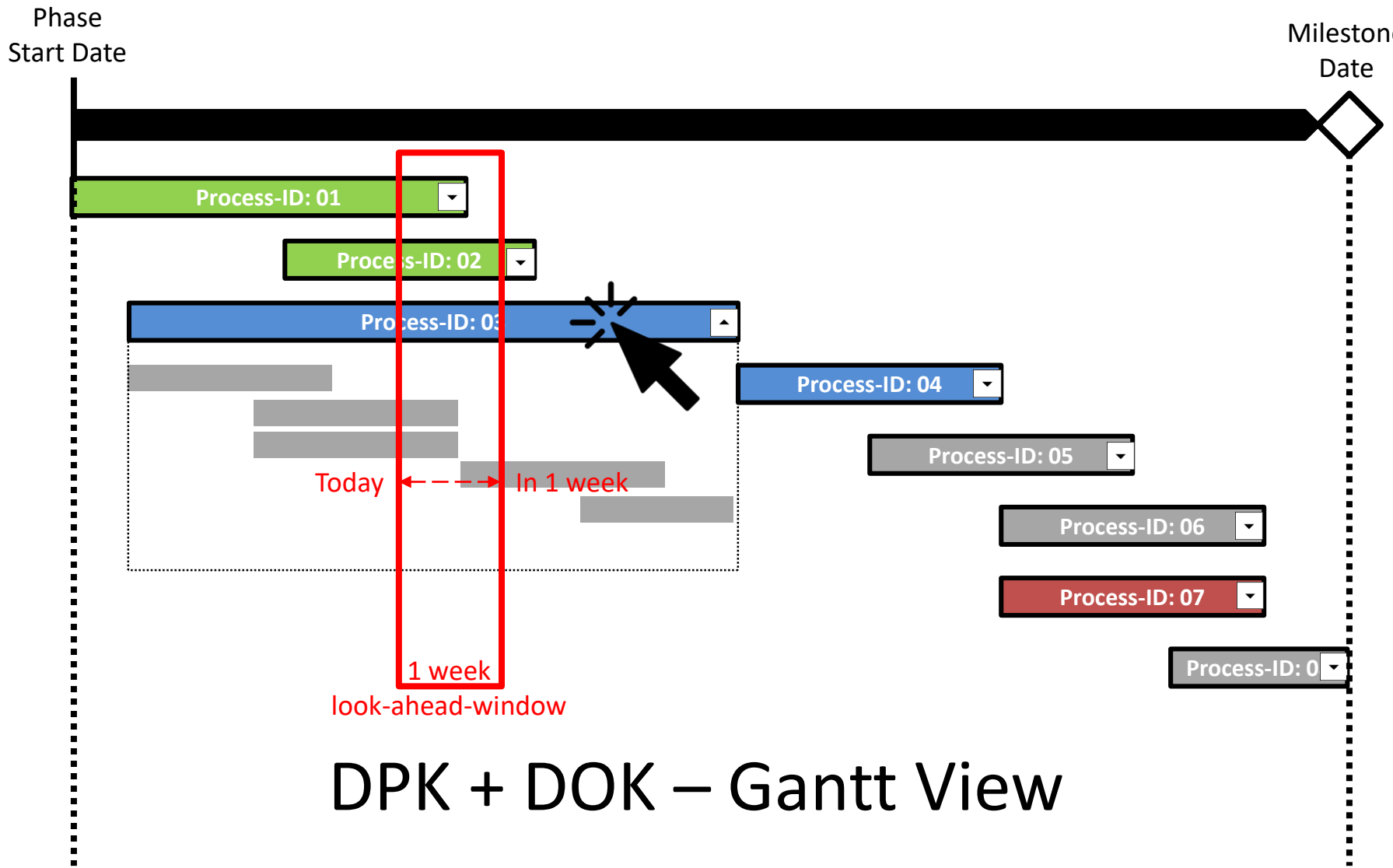
DOK – Network View

BeaM!

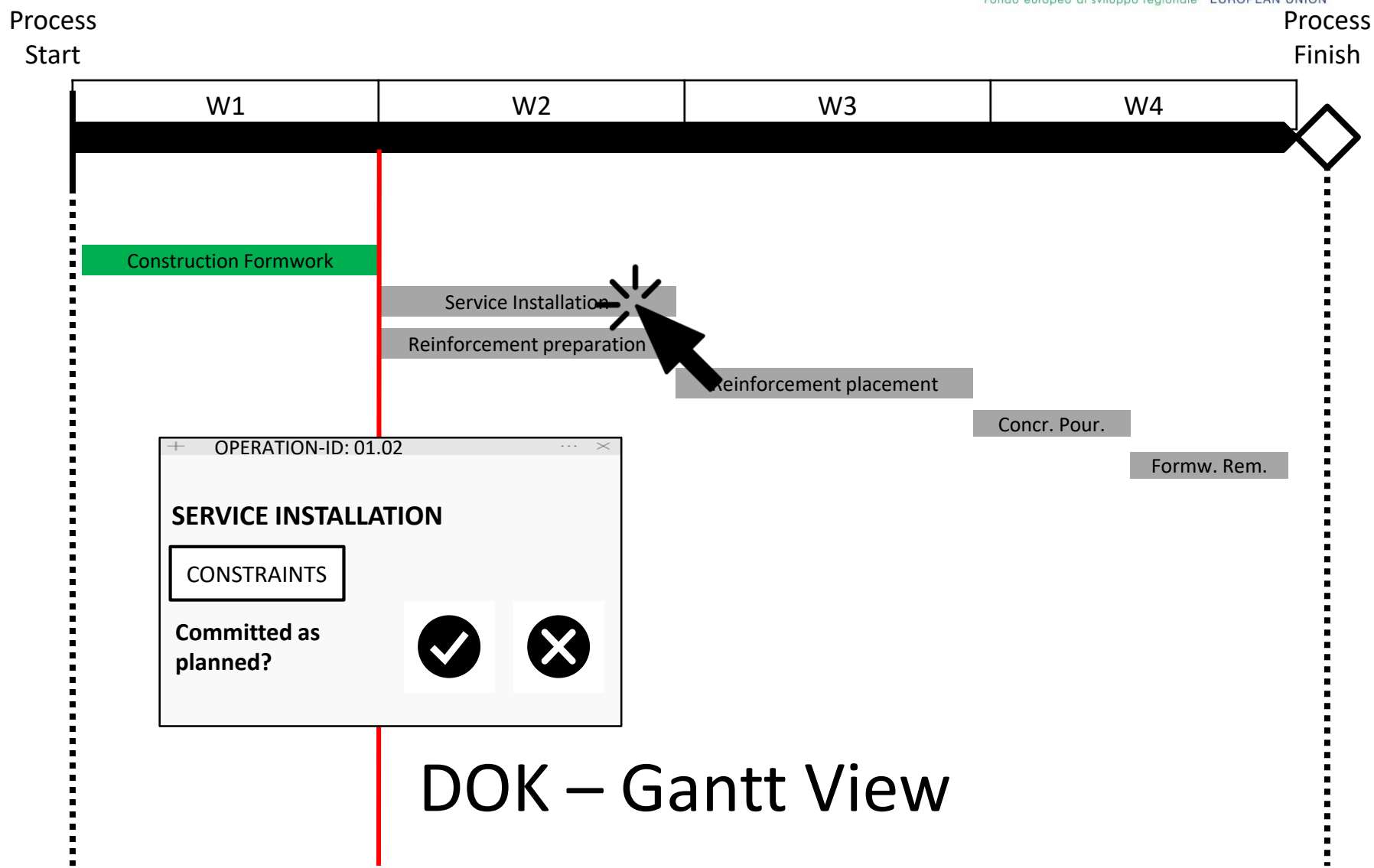


DPK + DOK – Gantt View

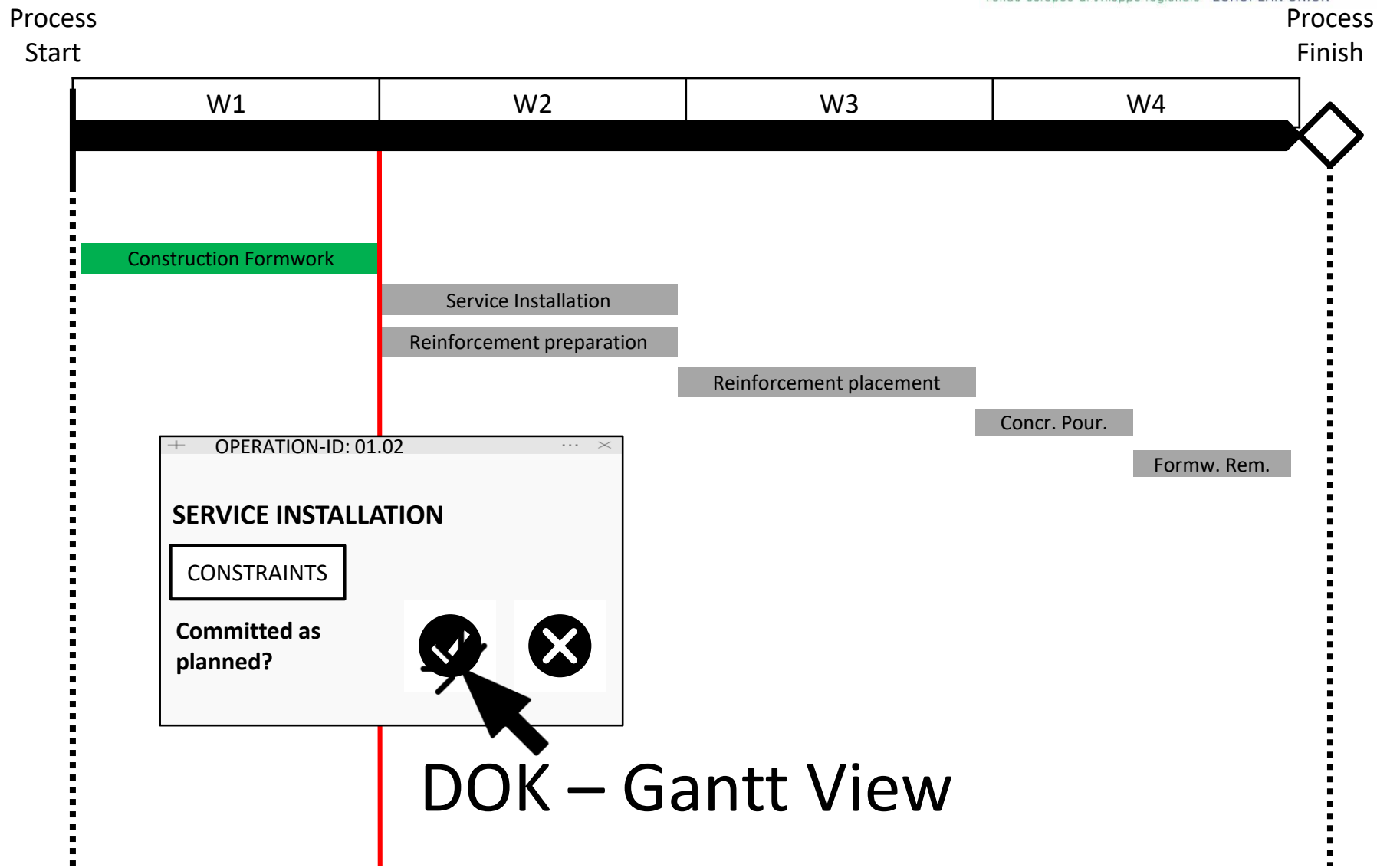
BeaM!



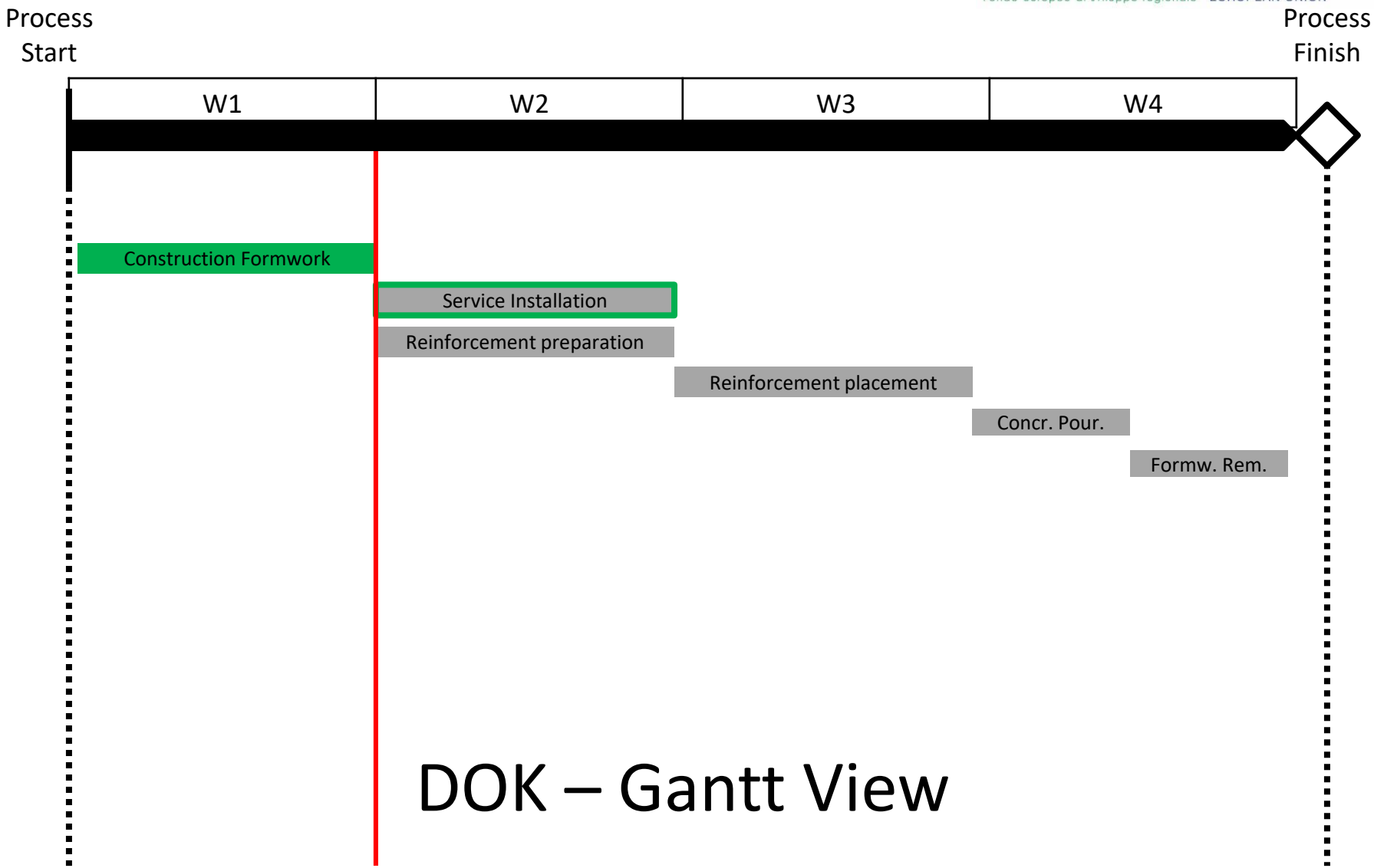
DPK + DOK – Gantt View



DOK – Gantt View



DOK – Gantt View



DOK – Gantt View

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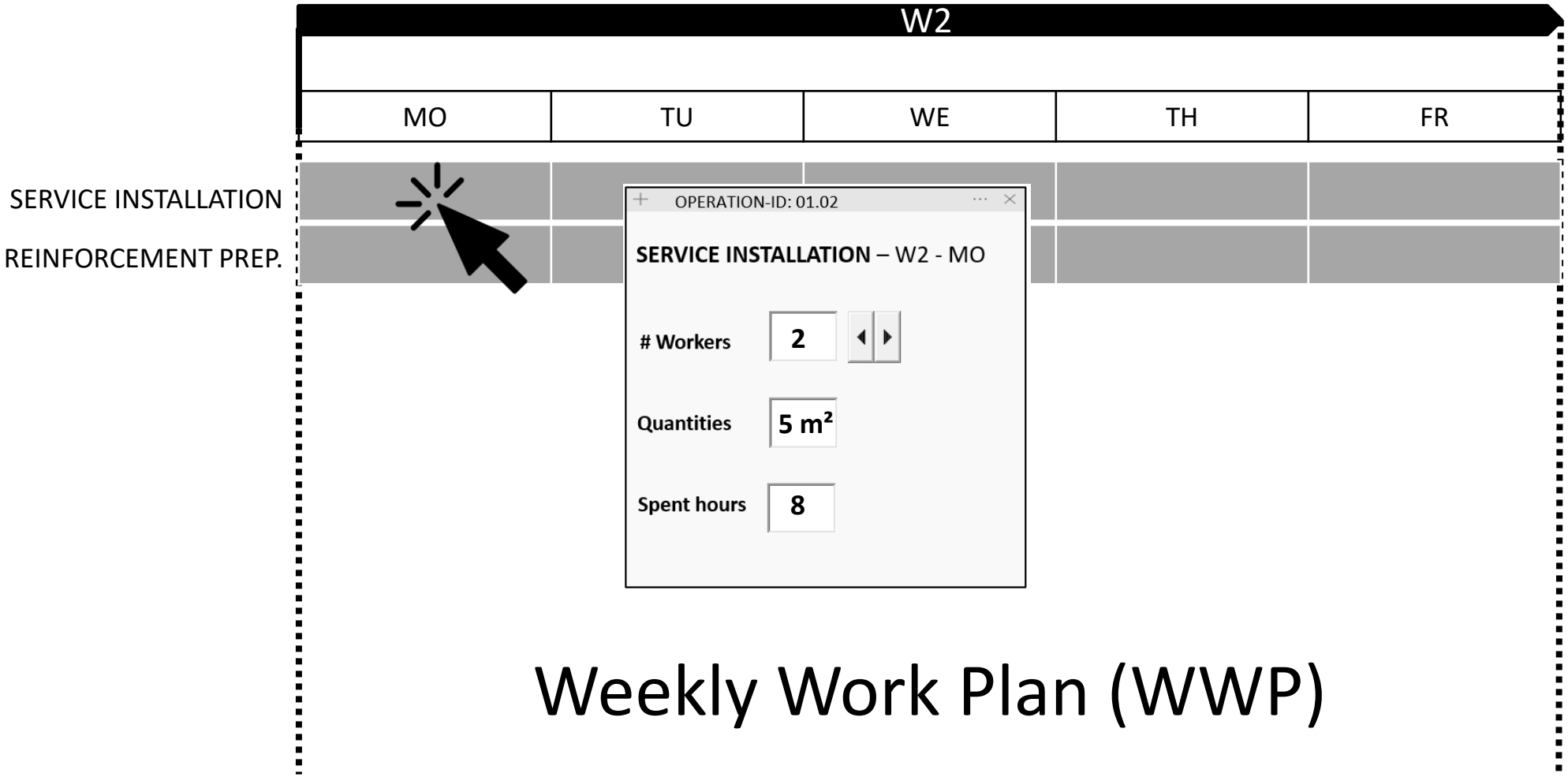
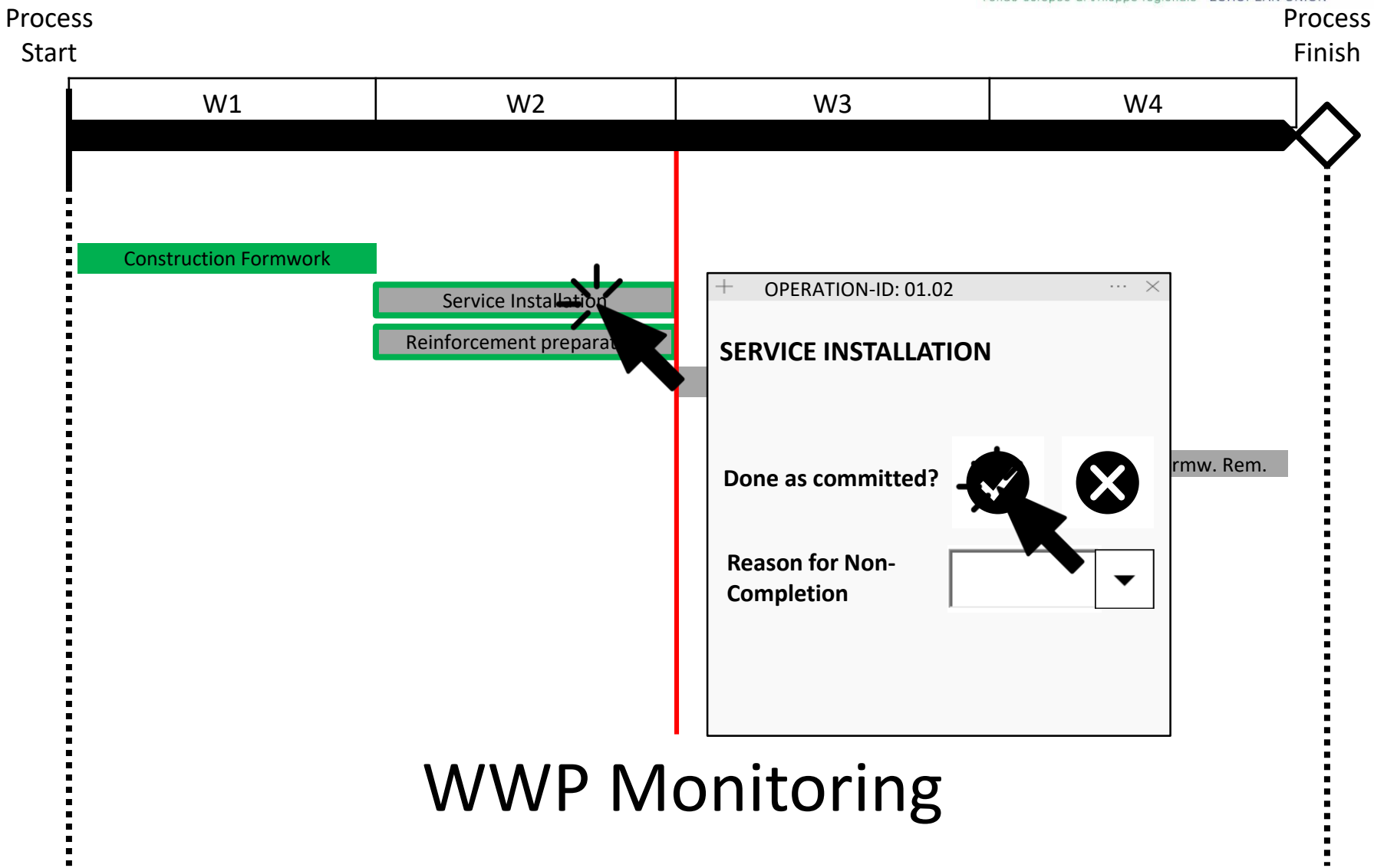
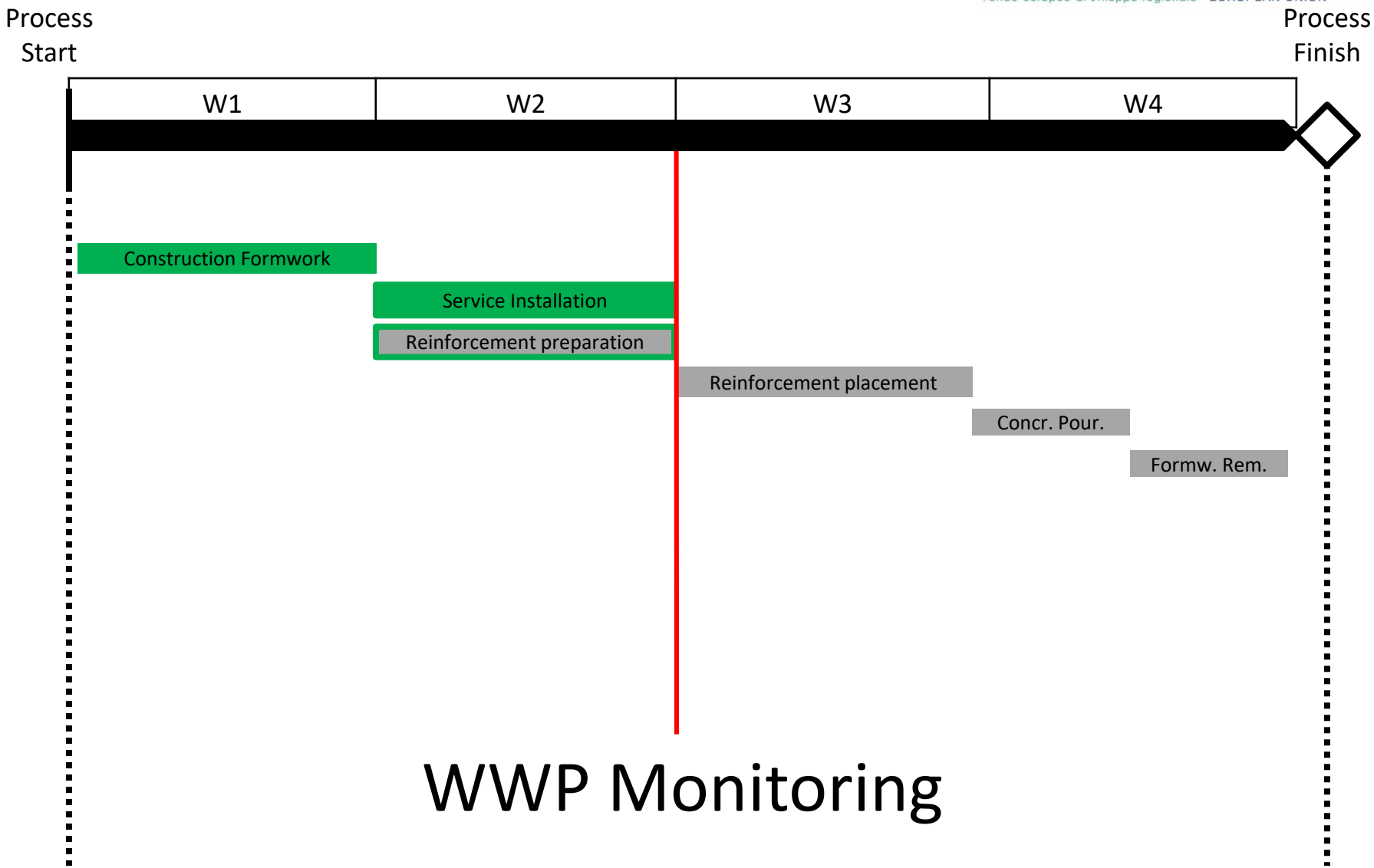


Weekly Work Plan (WWP)



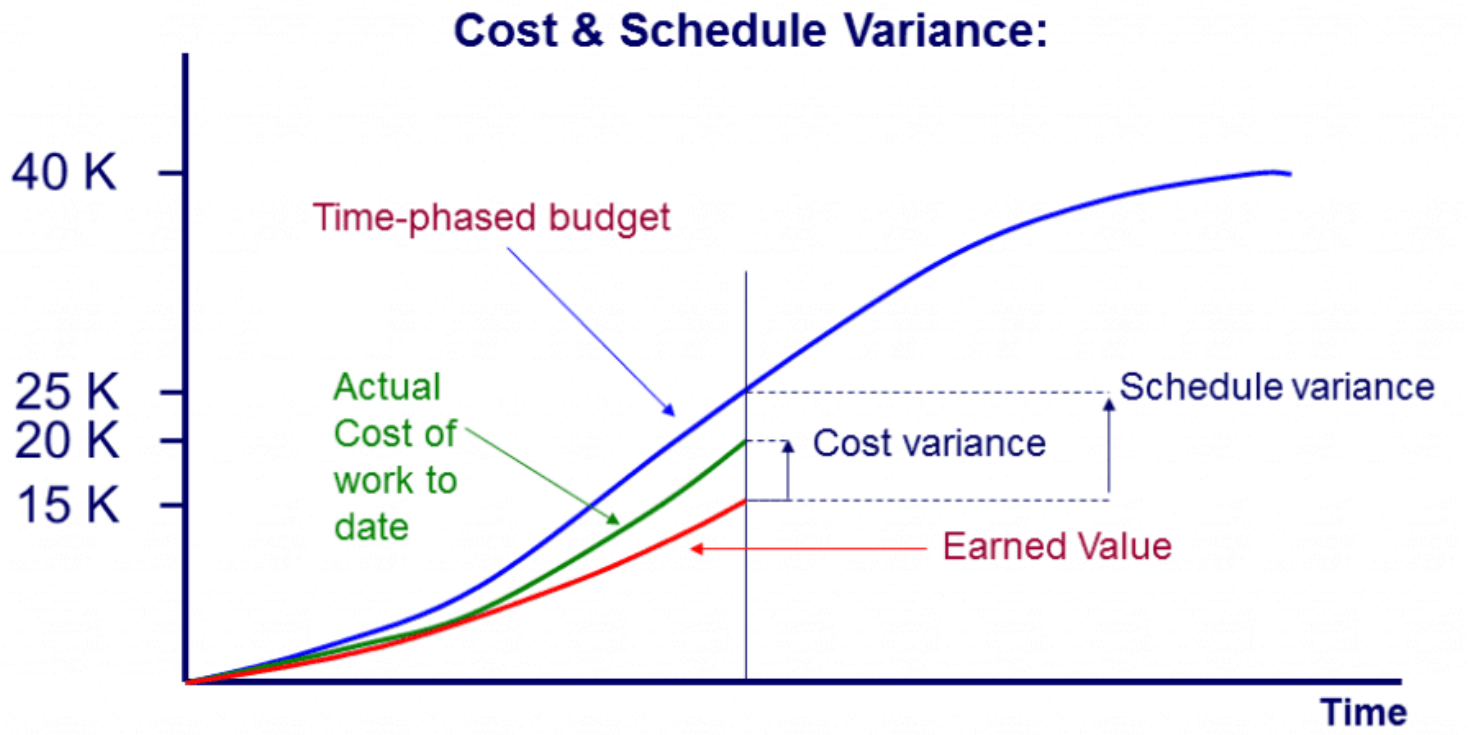
WWP Monitoring



WWP Monitoring

KPIs

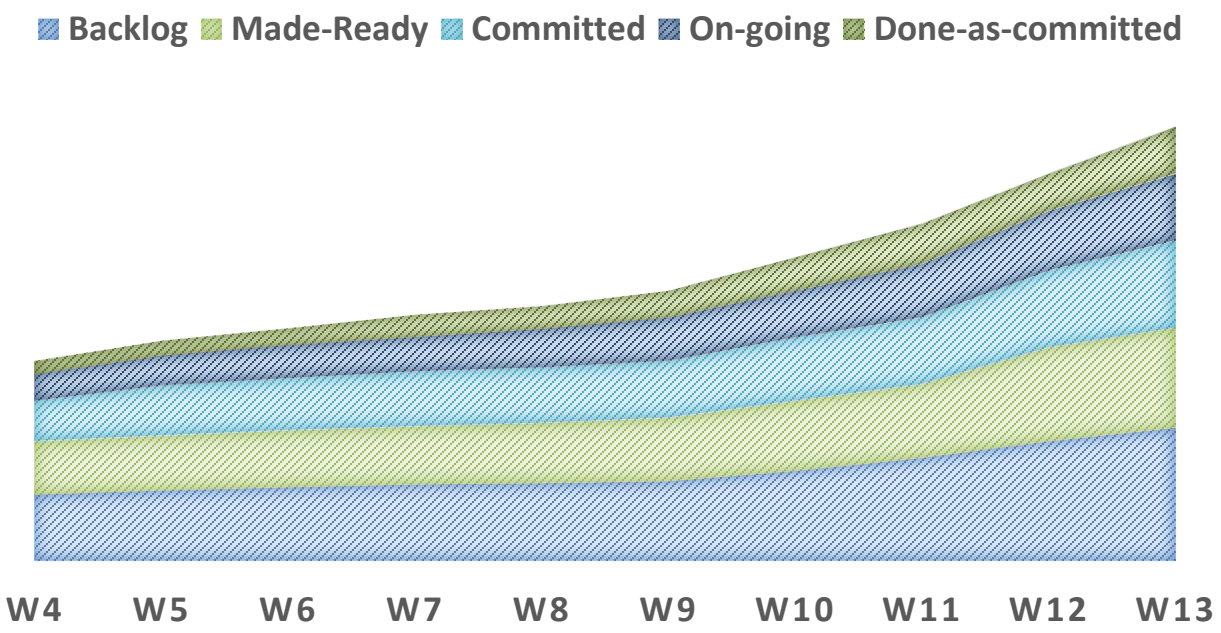
- LPS metrics (PPC, TMR, TA)
- EVM metrics (EV, AC, PV)



Source: PMIS Consulting Limited

KPIs

- LPS metrics (PPC, TMR, TA)
- EVM metrics (EV, AC, PV)
- Kanban metrics (CT, LT)



KPIs

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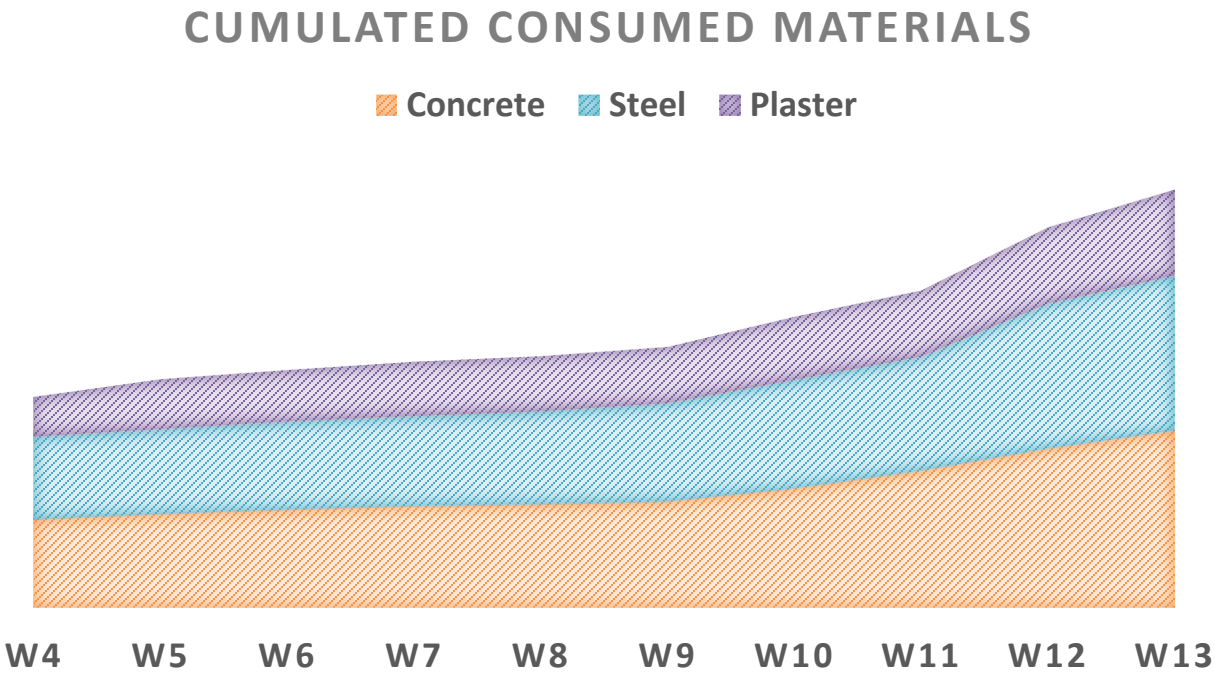
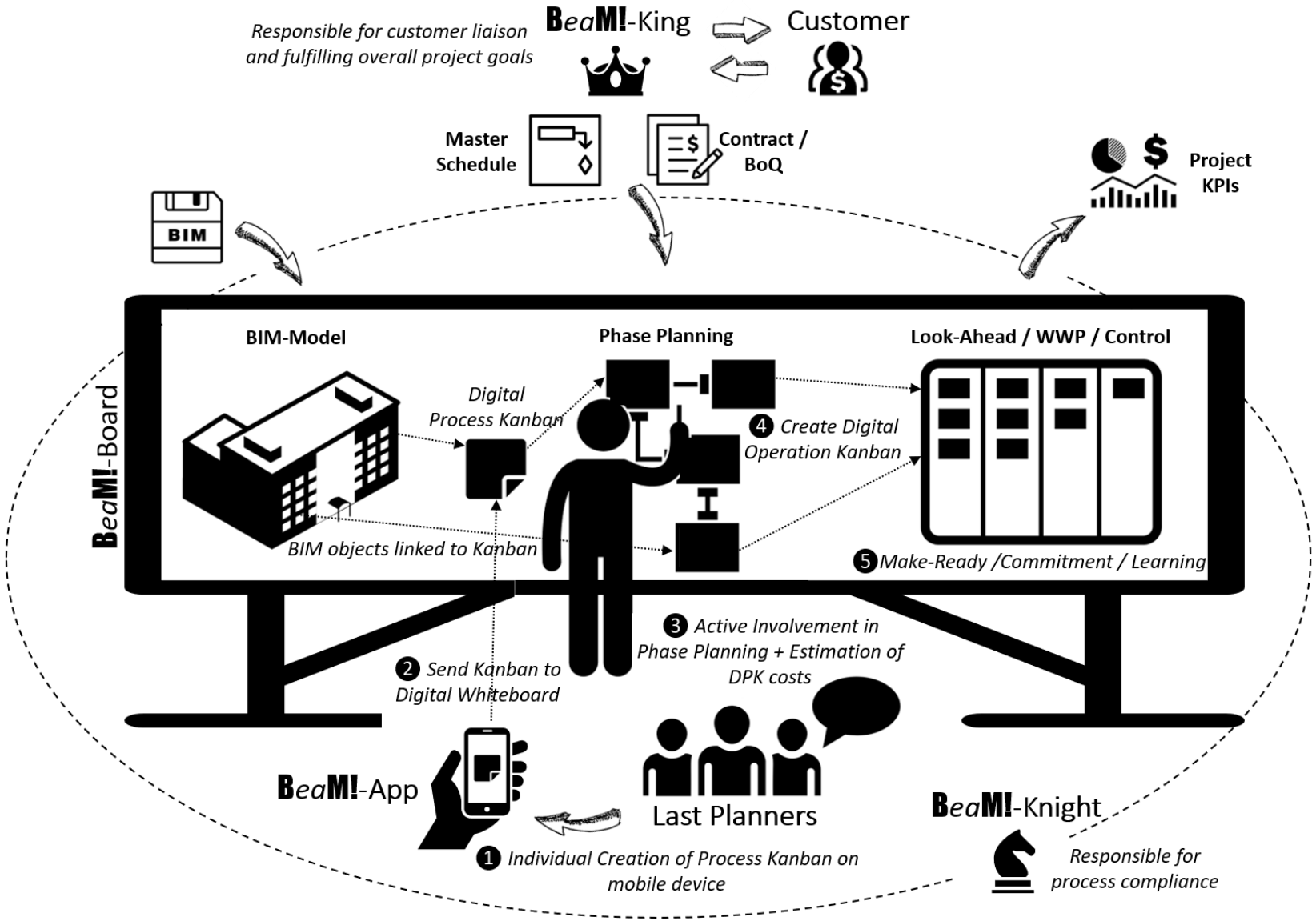
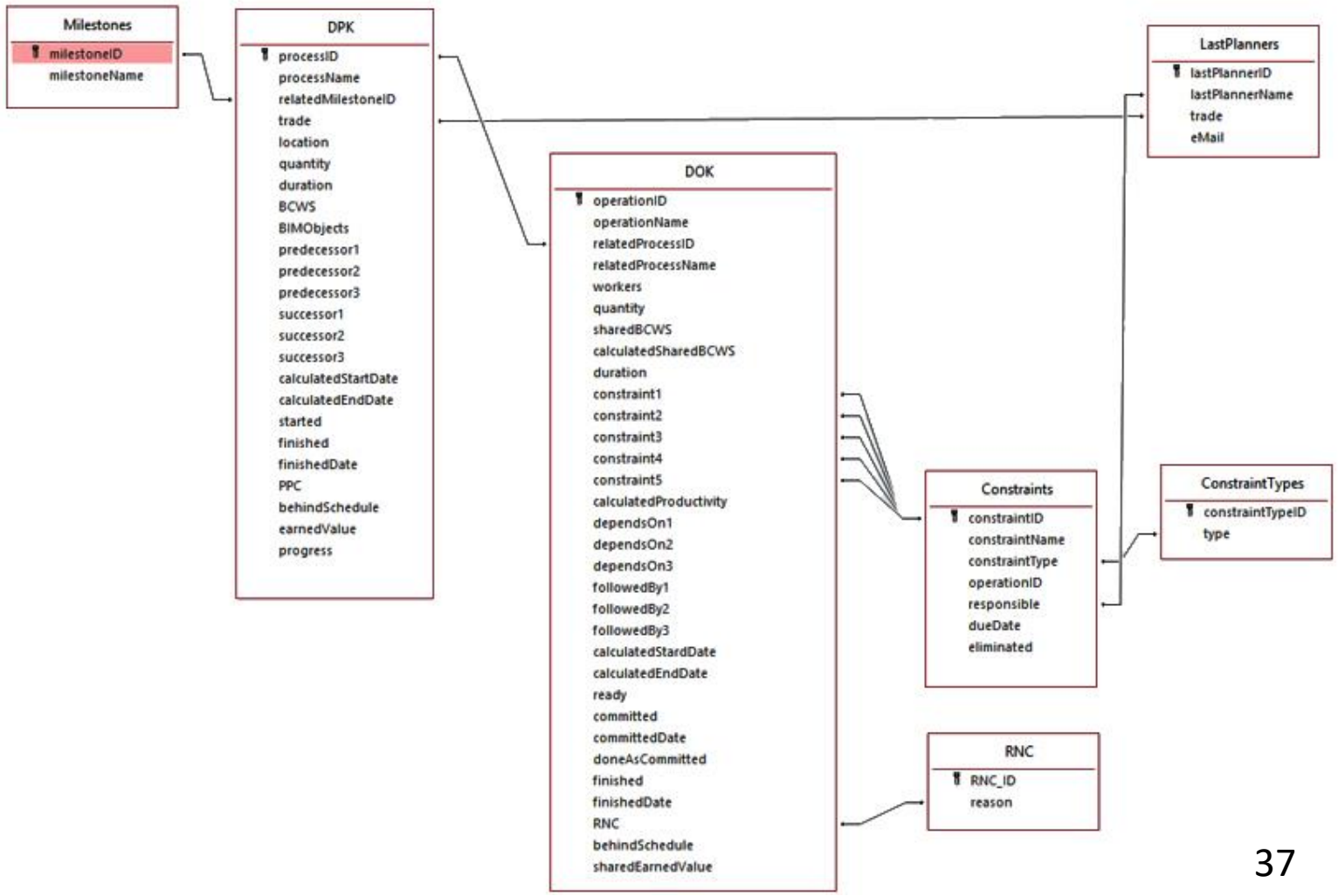


BeaM!


Responsible for customer liaison and fulfilling overall project goals
BeaM!-King
Customer
Master Schedule
Contract / BoQ
Project KPIs
BIM
BIM-Model
Phase Planning
Look-Ahead / WWP / Control
BeaM!-Board
Digital Process Kanban
4 Create Digital Operation Kanban
BIM objects linked to Kanban
5 Make-Ready /Commitment / Learning
3 Active Involvement in Phase Planning + Estimation of DPK costs
2 Send Kanban to Digital Whiteboard
BeaM!-App
Last Planners
1 Individual Creation of Process Kanban on mobile device
BeaM!-Knight
Responsible for process compliance

Preliminary Results

- Database schema



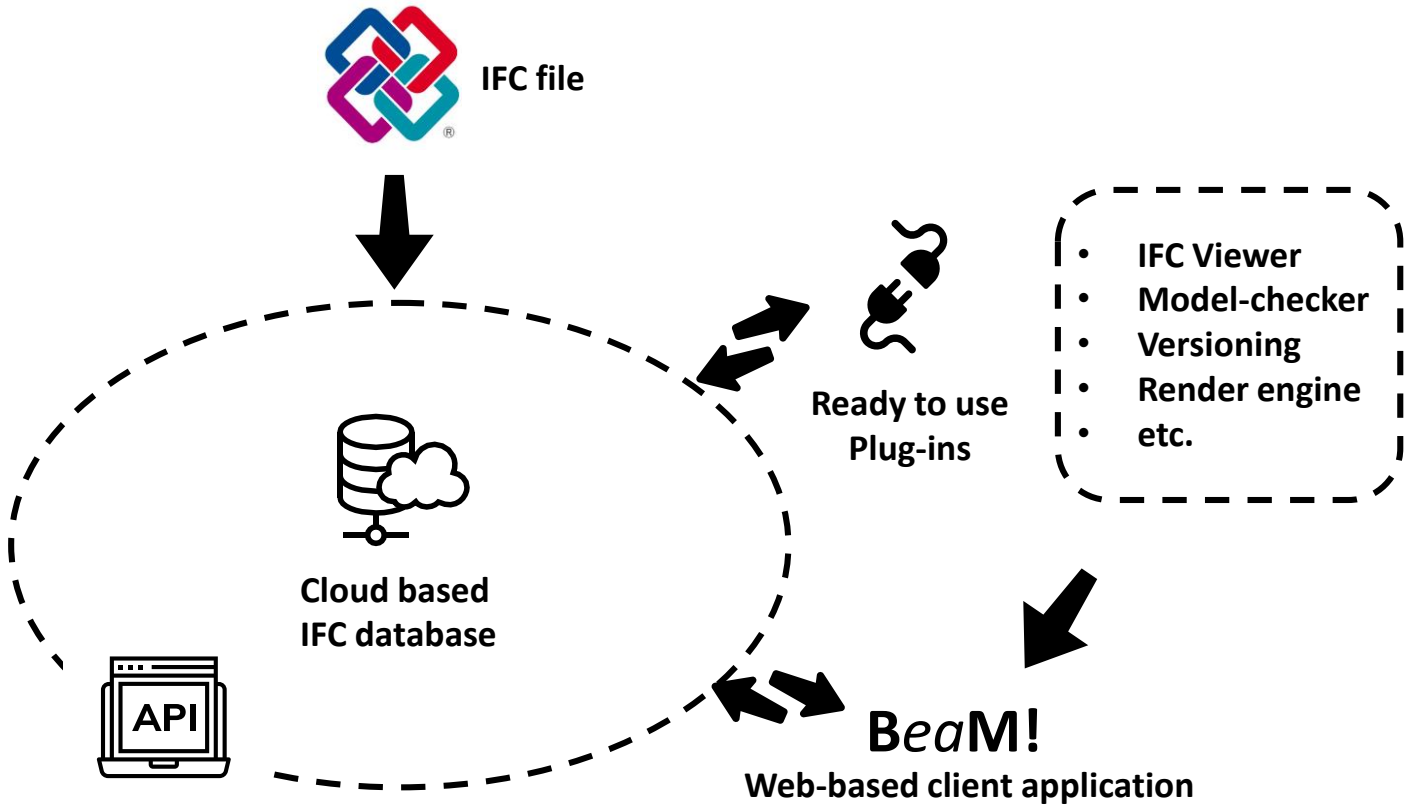
Preliminary Results

- Database schema
- Integration model

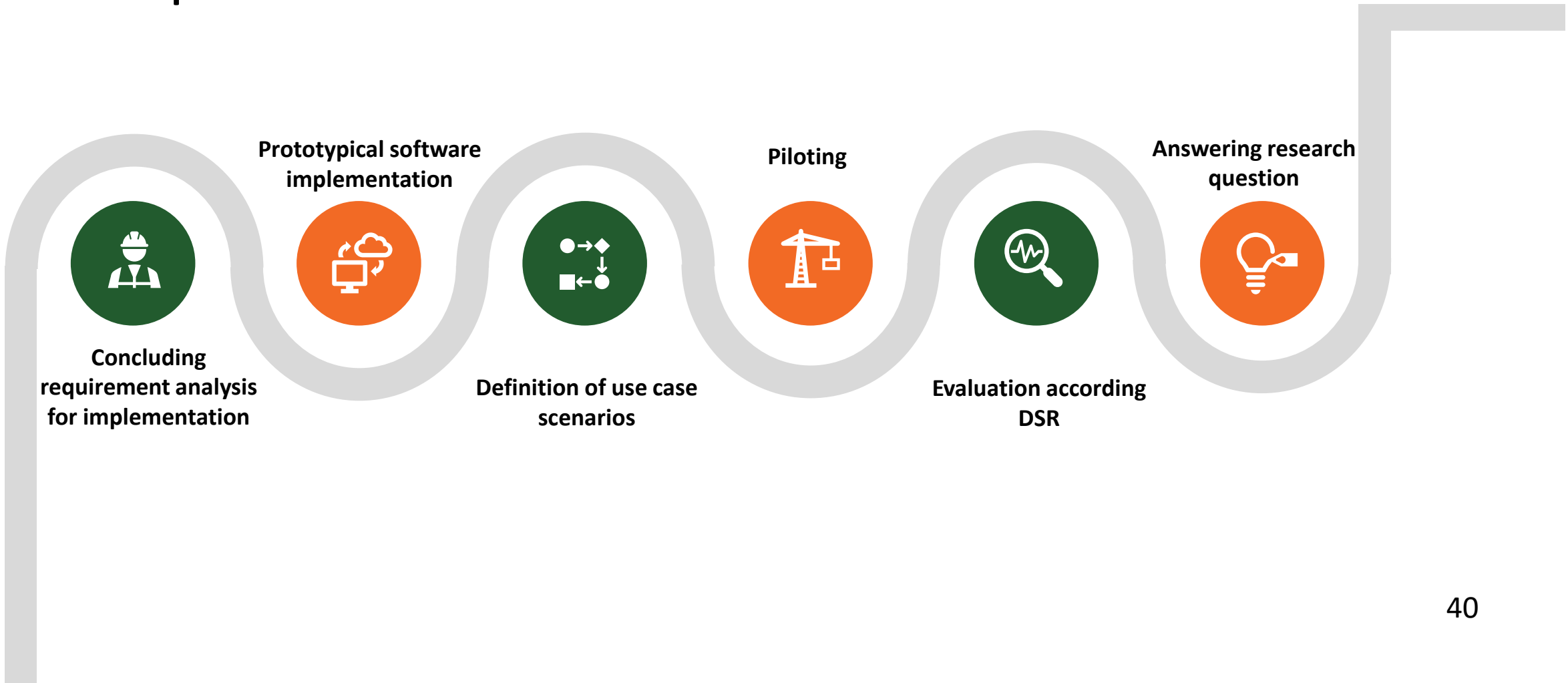
Step	Phase scheduling steps 1-6 by *Ballard (2000b)*	Digital Kanban-Board functionality	BIM: IFC manipulation
0	Have master schedule as starting point and identify milestones	Select BIM-Objects in IFC Viewer and press "create Milestone" button	Instantiate *IfcTask* object and set boolean *IsMilestone* to true
1	*"Define the work to be included in the phase; e.g., foundations, building skin, etc."*	Select BIM objects in IFC Viewer and press "create *Digital Process Kanban* Button" **OR** create corresponding Digital Process Kanban on mobile device and send it to **B***ea* **M!**-Board and then link to BIM objects	Kanban trigger instantiation of *IfcTask* objects which are linked to selected BIM objects (*IfcElements*) through *IfcRelAssignsToProduct* objects
2	*"Determine the completion date for the phase, plus any major interim releases from prior phases or to subsequent phases."*	Click on respective milestone and set finish date	Set attribute *LateFinish* of Type *IfcDateTime* in entity *IfcTaskTime* and relate to milestone *IfcTask* objects in step 0
3	*"Using team scheduling and stickies on a wall, develop the network of activities required to complete the phase, working backwards from the completion date, and incorporating any interim milestones."*	Arrangement of Kanban via touch control on **B***ea* **M!**-Board defines dependencies	Manipulate the *IsSuccessorFrom* and *IsPredecessorOf* attributes of *IfcTask* objects defined in step 1
4	*"Apply durations to each activity, with no contingency or float in the duration estimates"*	Click on respective Kanban and set duration	Assign duration through type *IfcDuration* and relate to *IfcTask* objects defined in step 1
5	*"Reexamine logic to try to shorten the duration."*	Collaborative re-arrangement of Kanban via touch control on **B***ea* **M!**-Board	Update of dependencies in *IfcTask* objects defined in step 1 according to re-arrangement
6	*"Determine the earliest practical start date for the phase"*	Click on first *Digital Process Kanban* of the phase and set start date	Set attribute *EarlyStart* of Type *IfcDateTime* in entity *IfcTaskTime* and relate to first arranged *IfcTask* object in step 5

Preliminary Results

- Database schema
- Integration model
- IT architecture



Next Steps


Concluding requirement analysis for implementation
Prototypical software implementation
Definition of use case scenarios
Piloting
Evaluation according DSR
Answering research question

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THANK YOU FOR YOUR ATTENTION

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