

Activity-Flow Work Structuring Method

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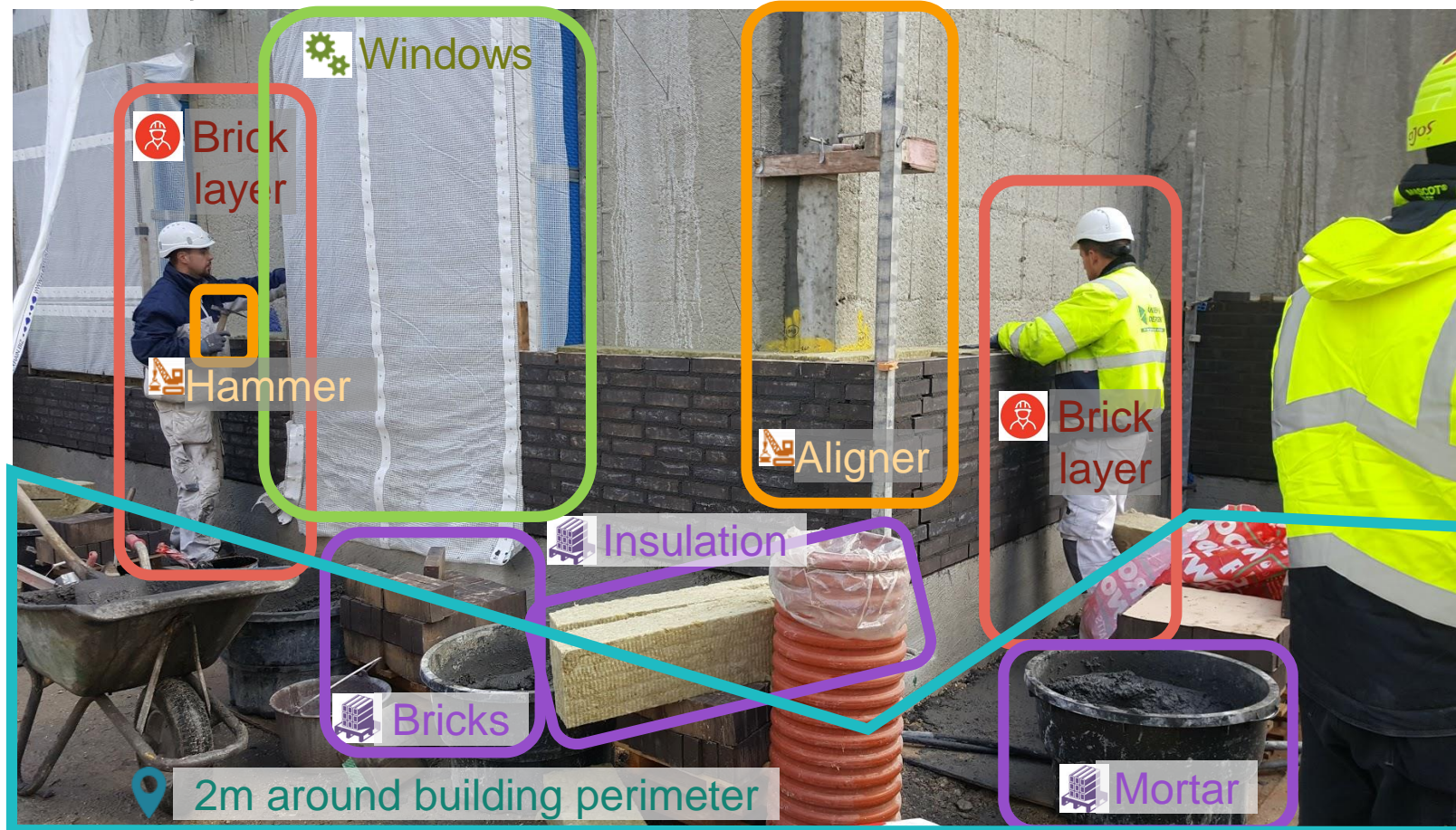
July, 2019

Activities require a set of flows to be executed

(Koskela 1999)
(Bertelsen et al. 2006)

Façade brick construction (Frederikskaj project)


-  Labor
-  Materials
-  Precedence
-  Workspace
-  Equipment
-  Information
-  External



Make-ready process = Ensure activities in plan are sound

(Ballard & Howell 1998)

- Make-ready increases planning reliability by:
 - Identifying and removing activity constraints
 - Committing to “sound” activities
- Case study make-ready process: \approx 80% of weekly meeting

		REGISTRO GESTIÓN DE PROYECTOS ANÁLISIS DE RESTRICCIONES			REVISION: 1	
CÓDIGO DE PROYECTO		1819 - EDIFICIO DE OFICINAS ICHMA			Página: 3	
NOMBRE DE PROYECTO		EDIFICIO DE OFICINAS ICHMA			NO. REGISTRO 1	
SEMANA : 67		FECHA : 4/11/2016			UBICACION SAN ISIDRO - LIMA	
AREA	ACTIVIDAD DEL LOOKAHEAD	RUBRO	DESCRIPCIÓN DE LA RESTRICCIÓN	FECHA LEVANTAMIE NTO	RESP.	ESTADO
				Nº TOTAL DE RESTRICCIONES		
				% DE RESTRICCIONES POR SEMANA		
ADMINISTRACION	Encofrados nucleo central	MANO DE OBRA	Ingreso de Capataz de Encofrado	3/22/2016	MR	SUPERADA
ADMINISTRACION	PERMISOS	DOCUMENTACION	Renovacion de permisos para horario extendido	4/12/2017	MR	EN PROCESO
ADMINISTRACION	PERMISOS	DOCUMENTACION	Permiso de USOS DE VIAS (Av. Derteano)	4/12/2017	MR	EN PROCESO
ALMACEN	ENCOFRADO PLACAS LATERALES P-04 Y P-05	MATERIAL	Fenótipo para placas laterales doble film negro	3/21/2016	ON	LEVANTADA
OFICINA TECNICA	COLOCACIÓN DE TABIQUES	MATERIAL	CERTIFICADOS DE CALIDAD DE TABIQUES PLYROCK	3/14/2016	CP	LEVANTADA
OFICINA TECNICA	LIMPIEZA DE SOTANOS	SUBCONTRATA	DETERMINAR SUB CONTRATA PARA ELIMINACION CON BOBCAT Y VOLQUETE DESDE PATIO MANIOBRAS	4/4/2016	KS	LEVANTADA

Can the field managers track readiness of all flows?

Off-site flows










Delivered to the jobsite



On-site flows

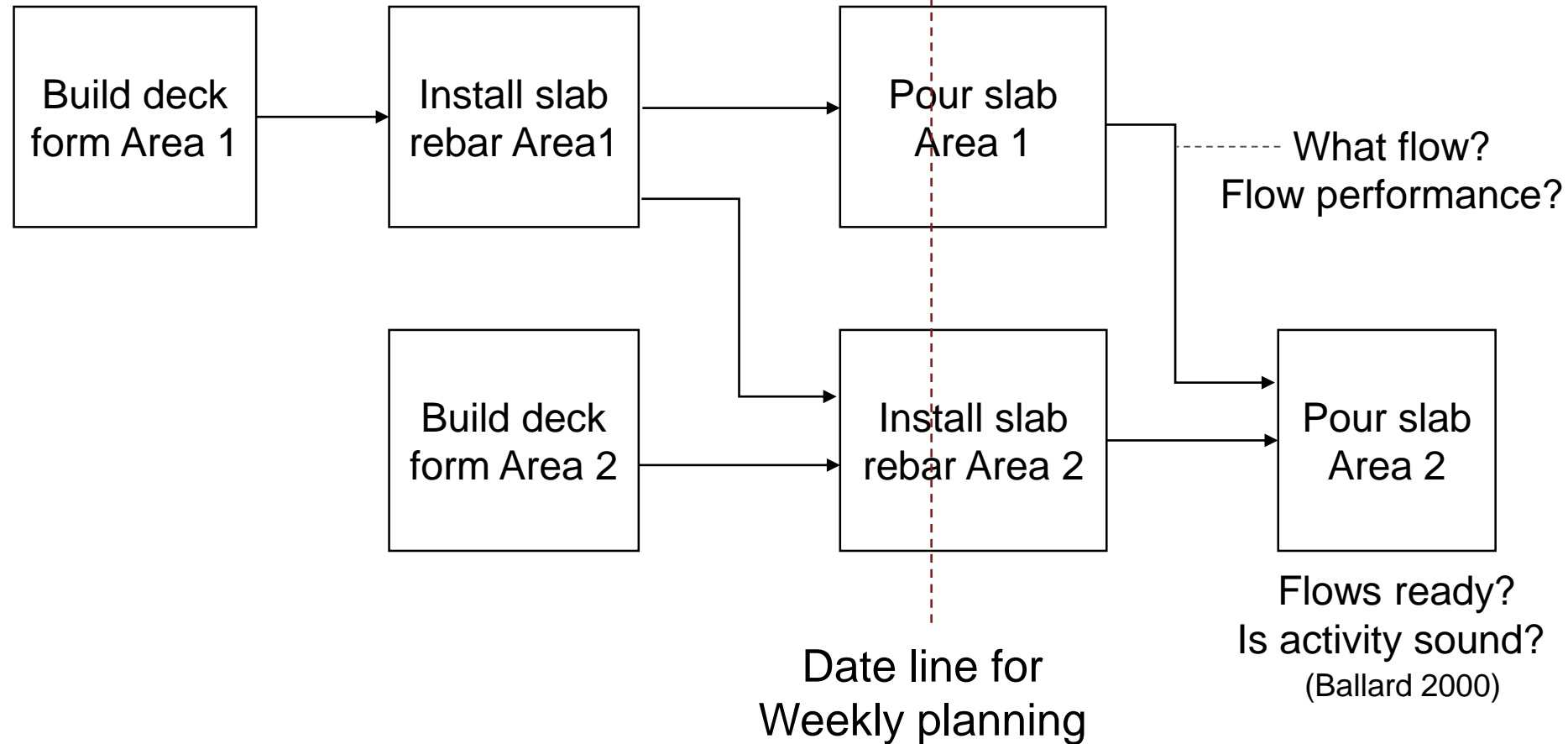
Released by upstream activities



Reason for non-completion		% related to flow	
		Off-site	On-site
	Predecessor		50.60%
	Labor availability	4.50%	14.54%
	Change of priority		13.90%
	Equipment availability	8.23%	
	Equipment overcapacity		3.90%
	Information unavailable	1.73%	
	Quality inspection failed		1.73%
	Materials delivery	0.43%	
	Underestimated		0.43%
Total		14.89%	85.10%

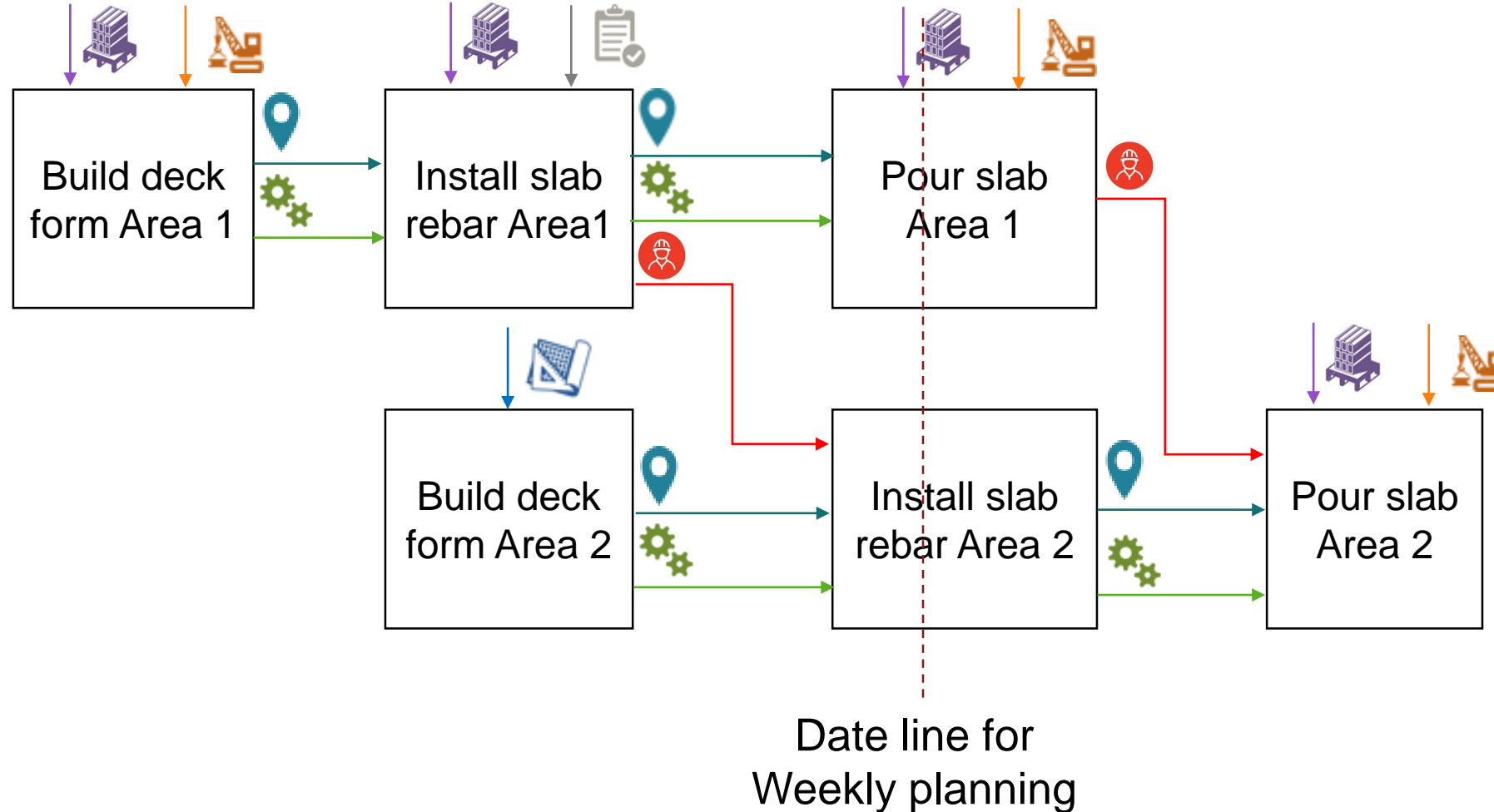
Most reasons for non-completion relate to on-site flows

Current construction models do not represent all the flows

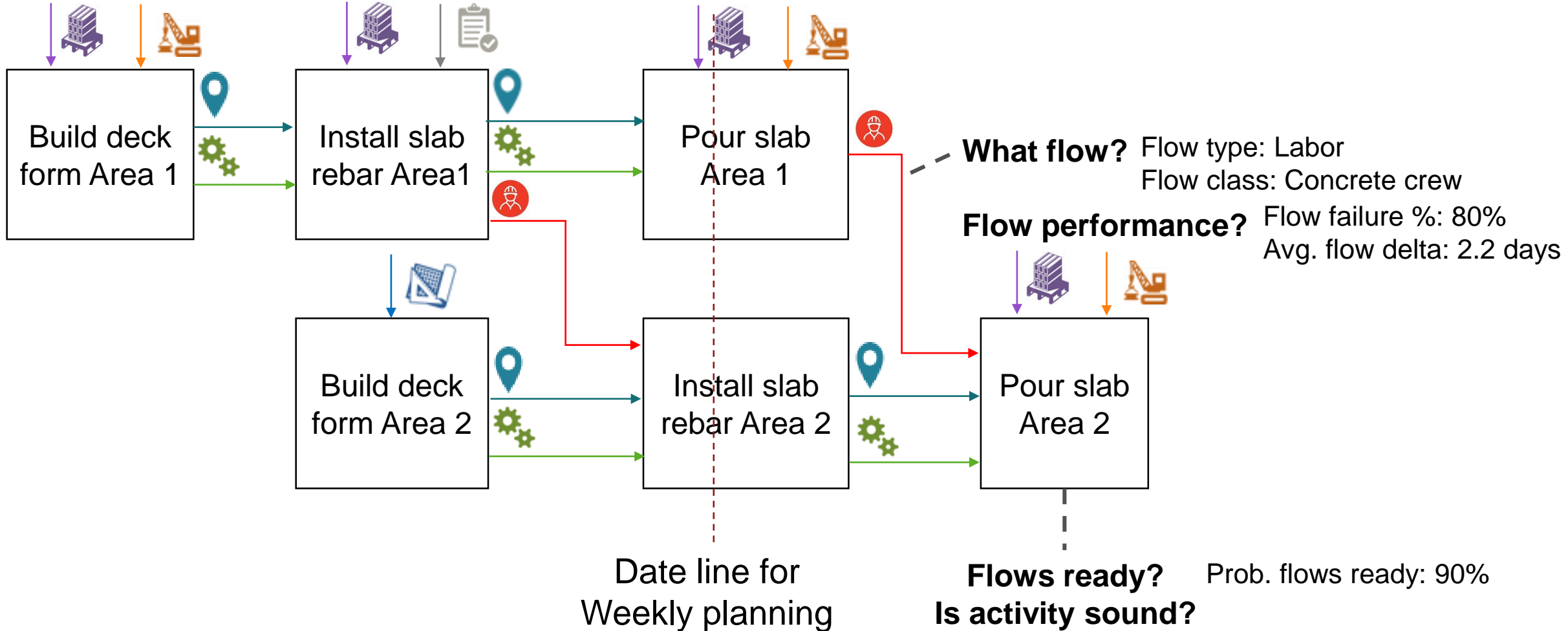


Field managers commit to activities based on readiness “perception”
(Pikas et al. 2012)

Proposed activity-flow construction representation



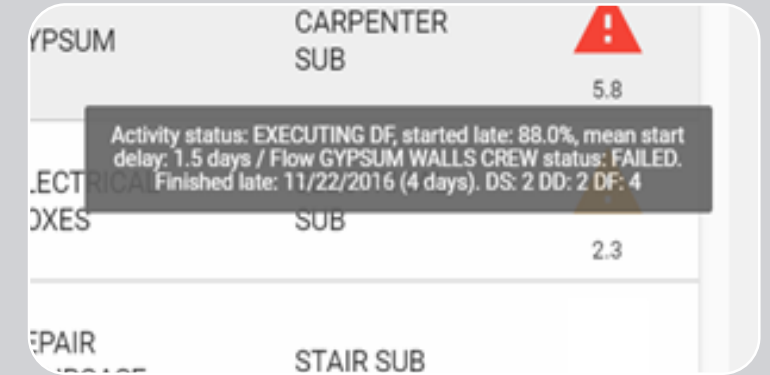
Proposed activity-flow construction representation



Objective - Develop activity + flow - based model to:

Look-ahead

Activity name	Status	Planned start	Planned finish	Actual start	Actual finish	Days	Reason for variability	DS	DD	DF	Activity Type	Sub	Risk
2ND FLOOR RESIDENT MEET	EXECUTING DF	11/08/2016	11/16/2016	11/17/2016		2M 27.2	PRECEDER	6	0	0	FLOOR RESIDENT MEET	FLOORING SUB	2
2ND FLOOR ELECTRICAL FLOOR	EXECUTING DF	11/08/2016	11/16/2016	11/17/2016		2M 27	PRECEDER	6	0	0	ELECTRICAL FLOOR	ELECTRICAL SUB	2
40.1ST GYPSUM	EXECUTING DF	11/11/2016	11/16/2016	11/16/2016		4G 27	SLOWER THAN ANTICIPATED	3	0	0	GYPSUM	CARPENTER SUB	1.3
2ND FLOOR ELECTRICAL FLOOR	EXECUTING DF	11/14/2016	11/16/2016	11/16/2016		2M 1	PRECEDER	4	0	0	ELECTRICAL FLOOR	ELECTRICAL SUB	1.3
7E PAINTING STAIRS	DELAYED START	11/16/2016	11/21/2016			7E		0	0	0	PAINTING STAIRS	PAINTING SUB	2
40.1 GYPSUM	EXECUTING DF	11/16/2016	11/16/2016	11/17/2016		4G 1	SLOWER THAN ANTICIPATED	2	0	0	GYPSUM	CARPENTER SUB	1.3
2ND FLOOR ELECTRICAL FLOOR	DELAYED START	11/16/2016	11/17/2016			2M 2	PRECEDER	0	0	0	ELECTRICAL FLOOR	ELECTRICAL SUB	1
7E.7 ELECTRICAL BOXES	DELAYED START	11/16/2016	11/16/2016			7E.7	PRECEDER	0	0	0	ELECTRICAL BOXES	ELECTRICAL SUB	1
7E.7 PAINT	DELAYED	11/16/2016	11/17/2016			7E	PRECEDER	0	0	0	PAINT	PAINTING SUB	1



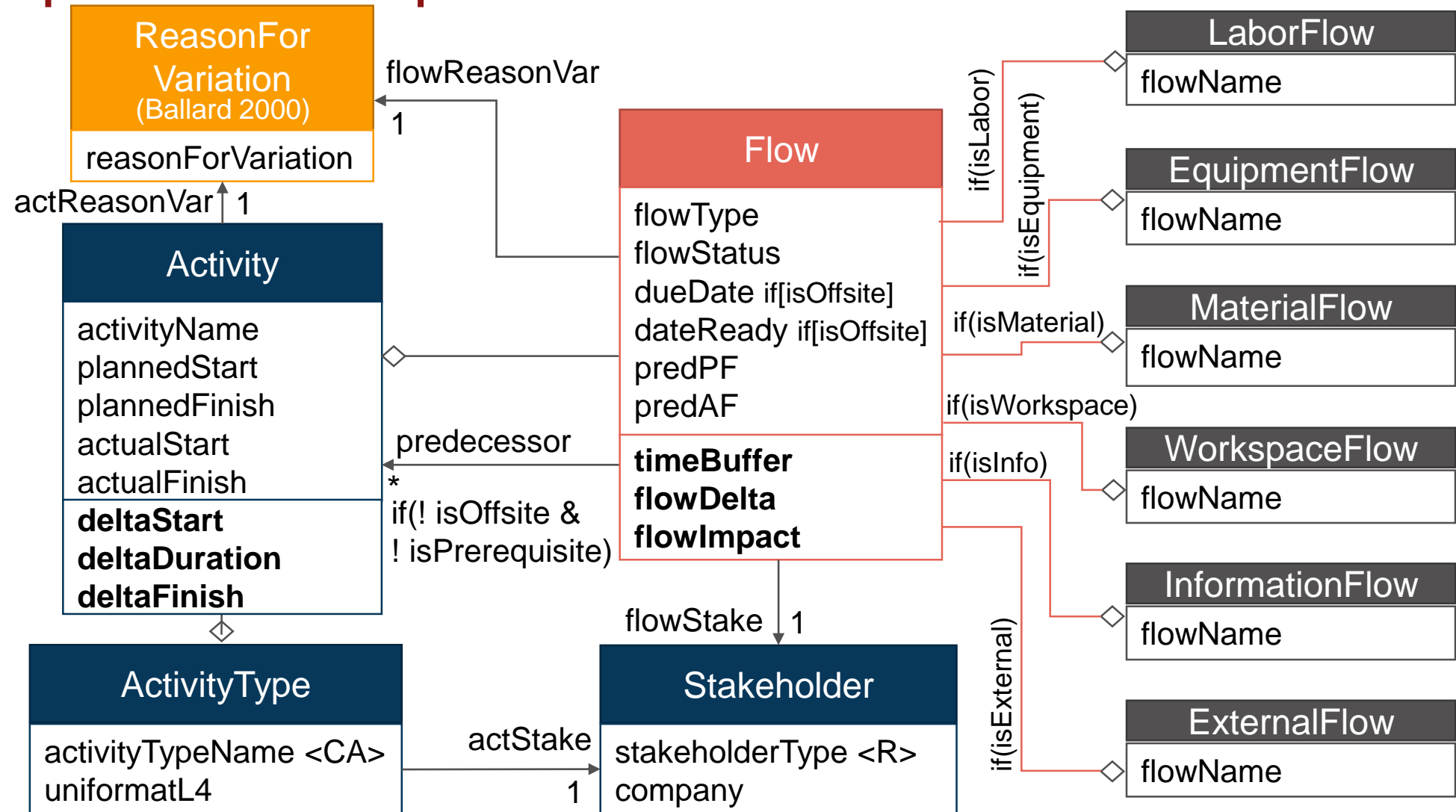
Formally manage activities and flows

Make data-driven decisions
e.g., Resource and buffer sizing

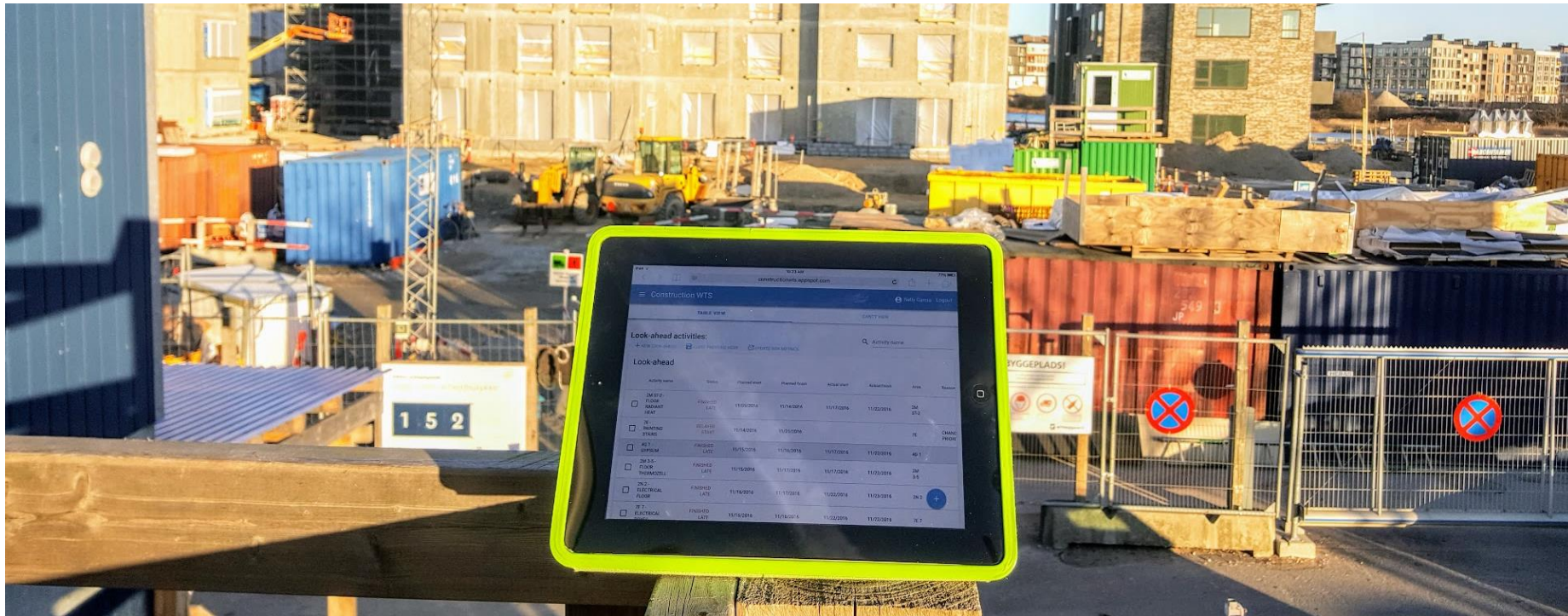
Predict delays in downstream activities

Computational representation of the AFM

Garcia-Lopez 2016



Developed Activity-Flow App



Work structuring + Production control

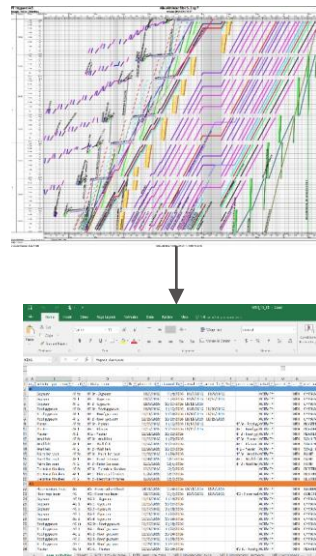
Work structuring

Activity + Flow
Structuring
Method

Transform
schedule into
Activity-Flow
representation



Set-up meeting on
Fredrikskaj project

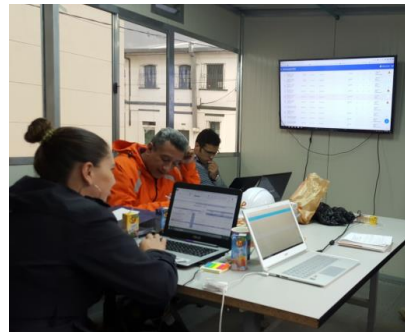


Weekly planning and control

Update look-
ahead and
weekly plan

Carry out daily
tracking

Present analytics
in weekly
planning meeting



Collaborative look-
ahead update on
Equilibrium project



Tracking using mobile
device on Fredrikskaj
project



Weekly planning
meeting on Ichma
project

Work Structuring: Definition + Gaps

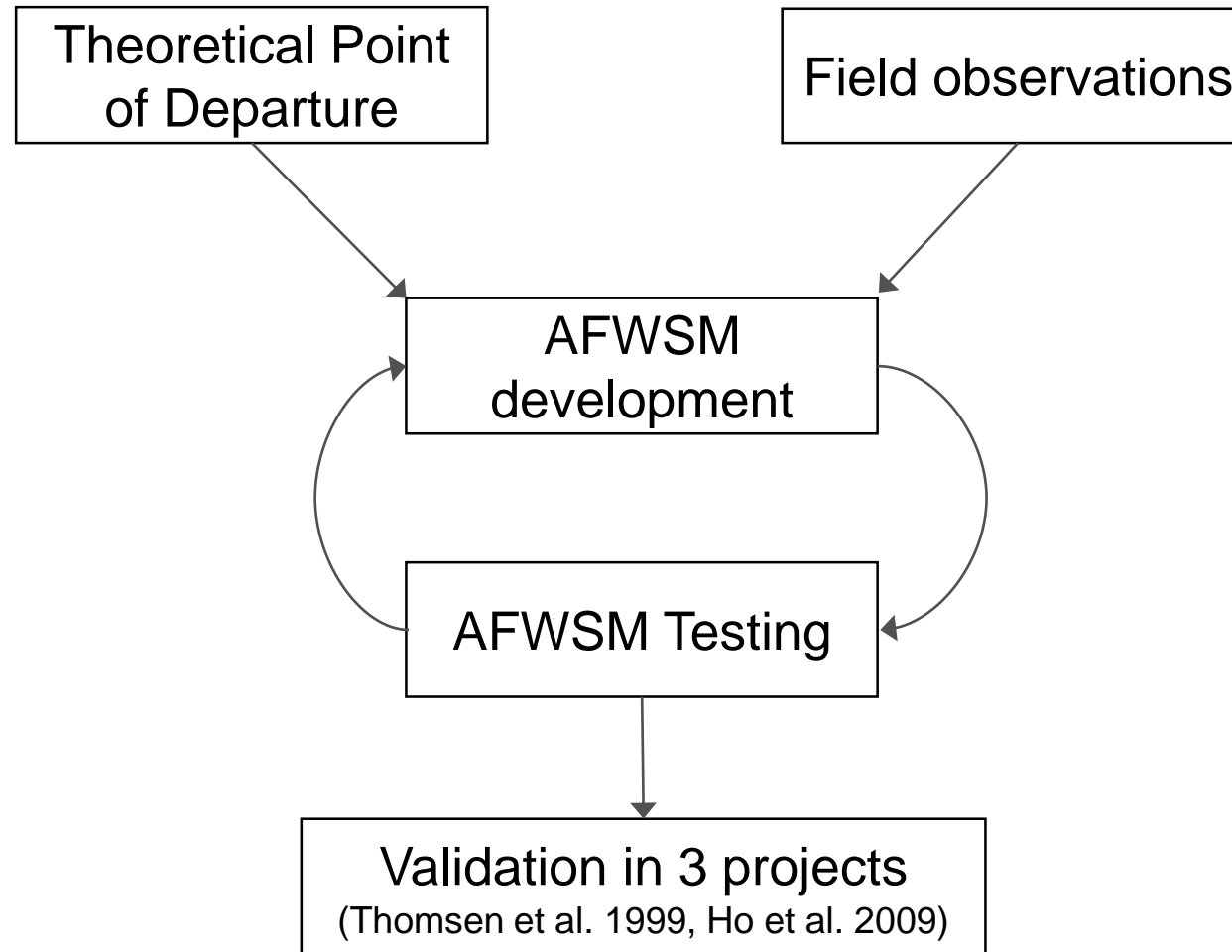
Definition:

- Work structuring entails connecting the facility design (product) with the processes, typically in the form of schedules, used to deliver the physical facility (Ballard et al. 2001; Tsao et al. 2004)

Research Question:

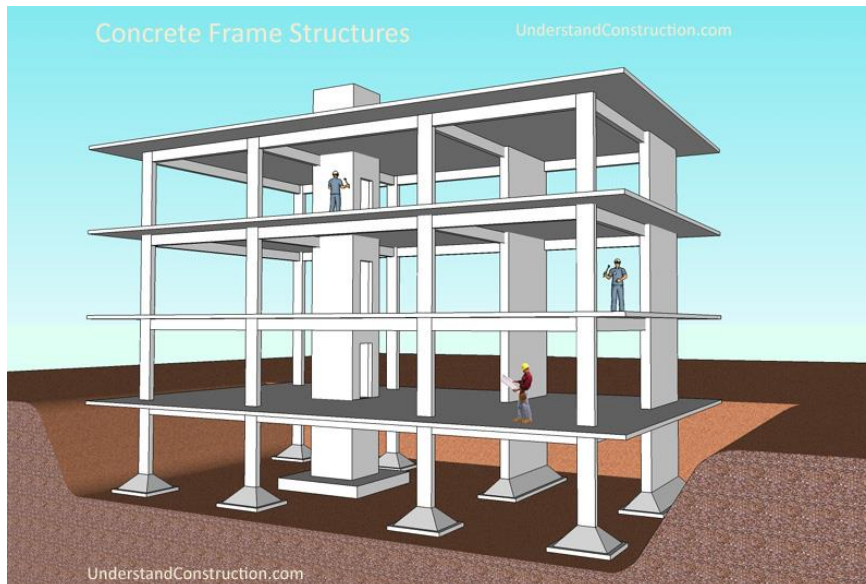
- How can we extend existing work structuring methods (e.g., Takt planning and Ballard's Lean method) to enable field managers to structure all the construction flow types and generate activity-flow schedules?

Research Methodology



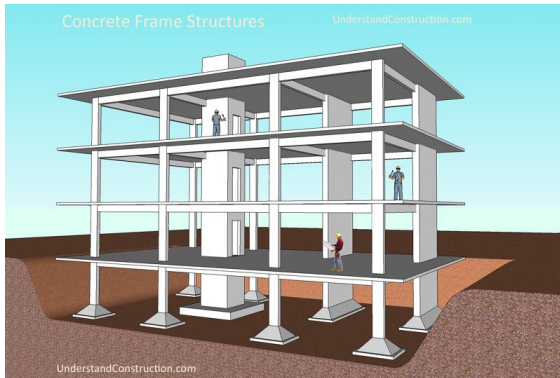
Activity-Flow Work Structuring Method (AFWSM)

- Consists of **7 steps** that allow field managers to visually represent activities and flows in a construction fragnet or process
- Example:



Fragnet: Build concrete structure

AFWSM: Step 1 – Define fragnet's prototypical activities



EXAMPLE:
Fragnet: Build concrete structure

Install column rebar

Install column forms

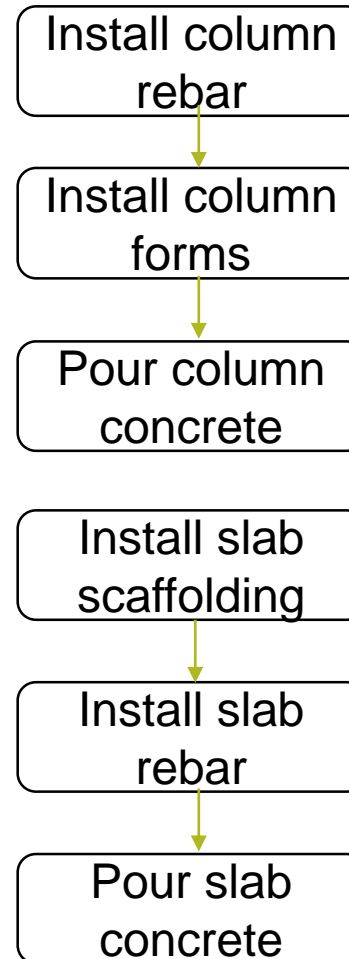
Pour column concrete

Install slab scaffolding

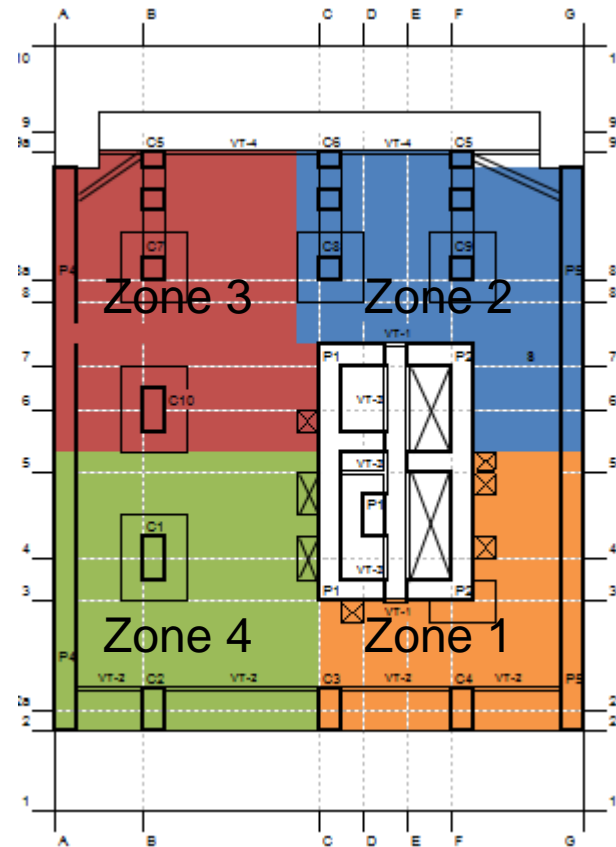
Install slab rebar

Pour slab concrete

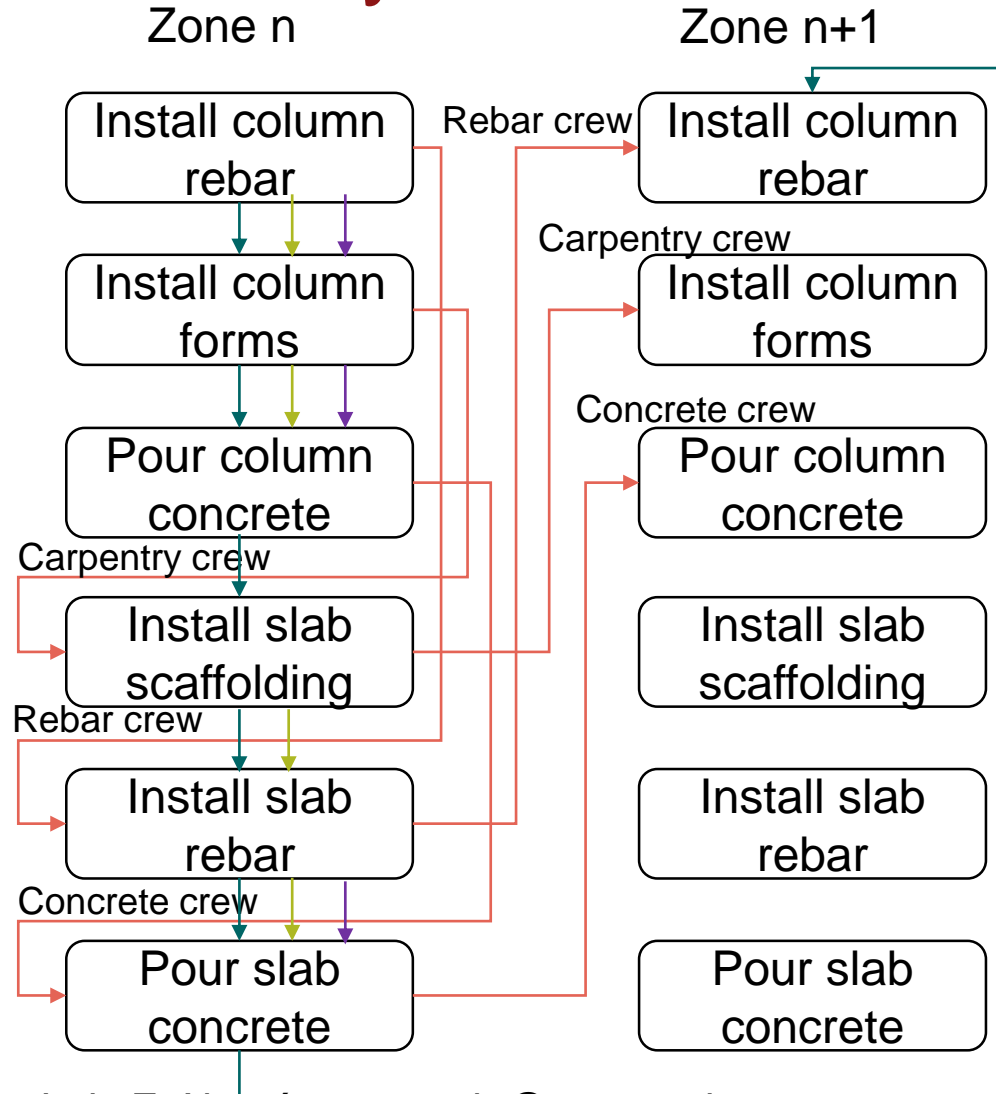
AFWSM: Step 2 - Sequence fragnet's prototypical activities based on precedence constraints



AFWSM: Step 3 – Identify workspaces and their sequencing

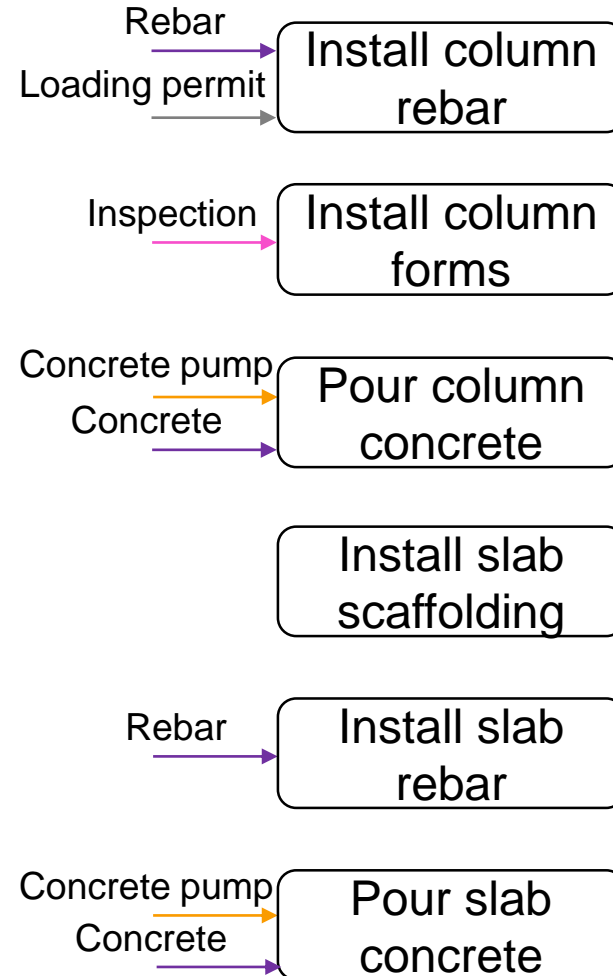


AFWSM: Step 4 – Identify on-site flows

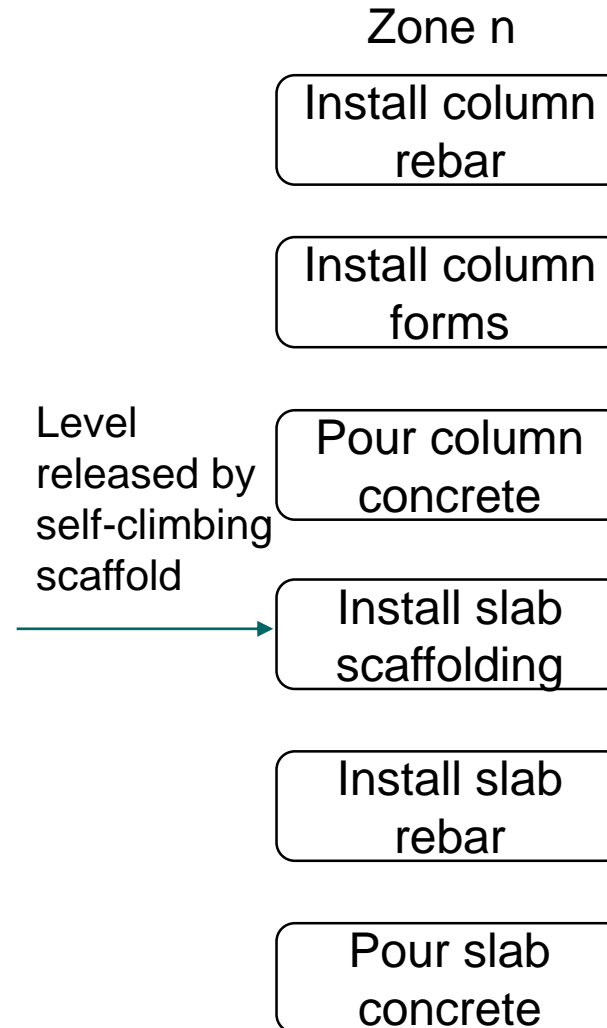


AFWSM: Step 5 – Identify off-site flows

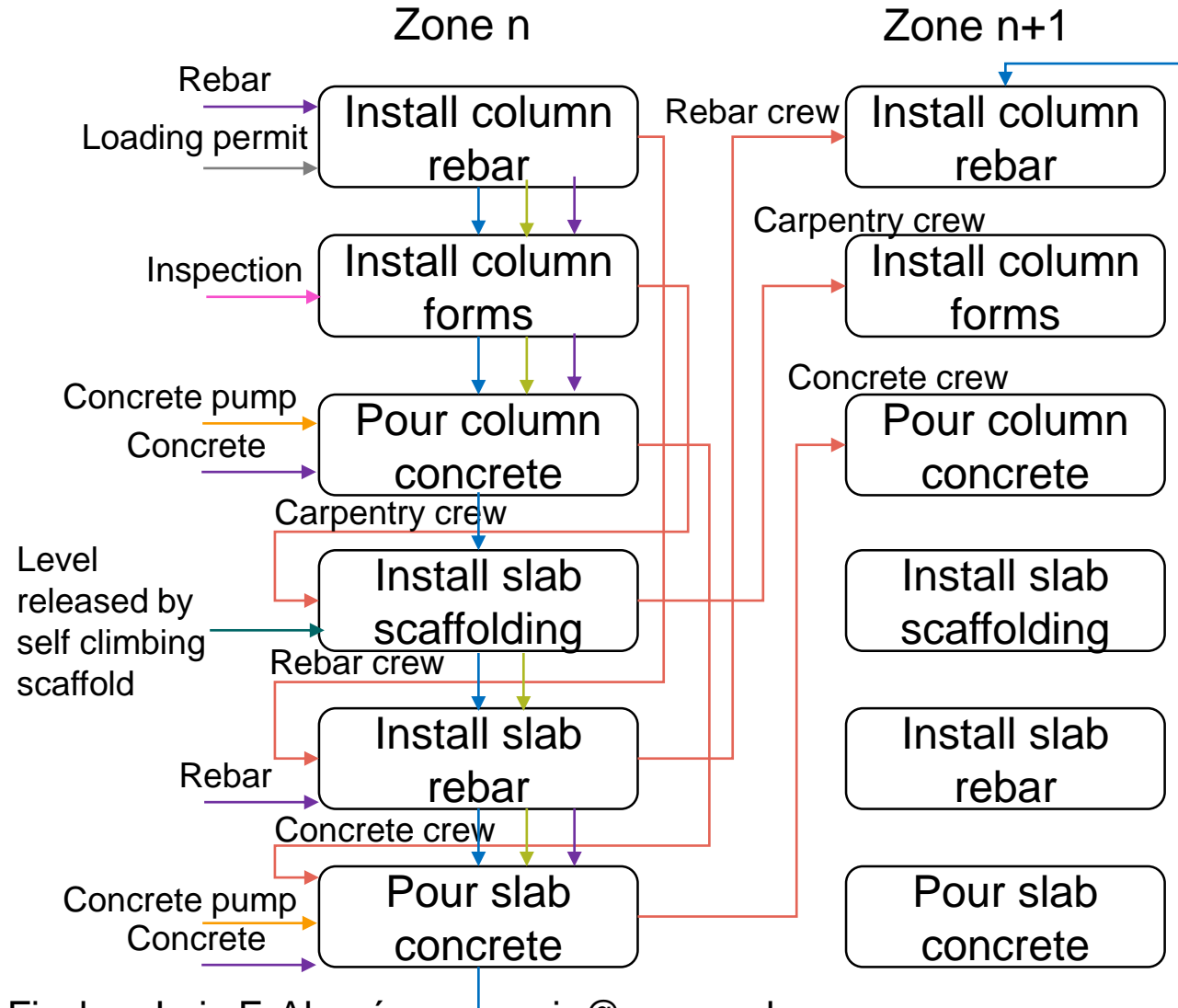
Zone n



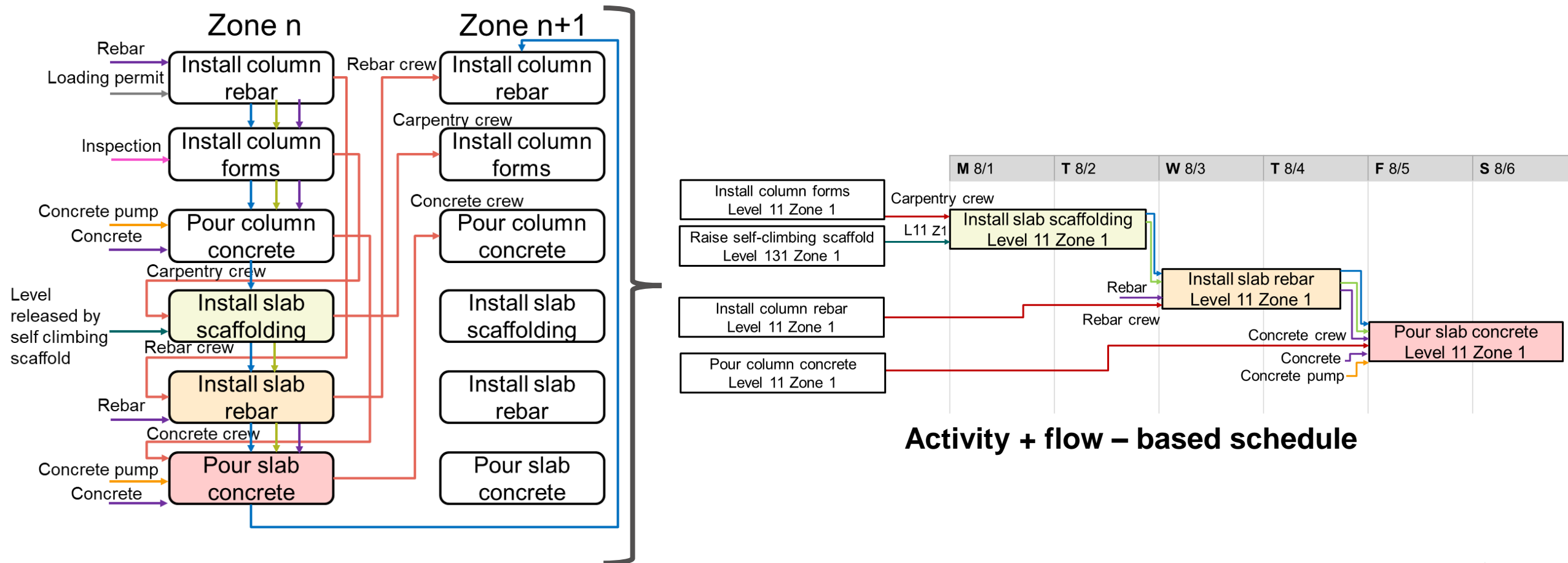
AFWSM: Step 6 – Identify interfaces with other fragnets



AFWSM: Step 7 – Identify stakeholders responsible for the flows



Field managers can use the AFWSM's outcome to create activity and flow-based schedules



AFWSM implementation results



Project	Ichma	Equilibrium	Frederikskaj	Total
Building type + phase	Office/Structural	Residential/Foundations	Residential/Finishes	
Test period	18 weeks	4 weeks	4 weeks	
# Fragnets	5	3	3	9
# Activity types	26	11	28	65
# Flows	85	31	80	196
Avg. Time (mins)	17	10	18	15

Feedback from field management teams



“It's very useful that we now have a tool that formally maps the flows that are needed to execute an activity ... we think about these things, but there is no formal tool that allows us to check that all the flows are ready so the activity is not in danger.”

Project Engineer Ichma

“Keeping track of the historical flow performance is key. We might have a hunch about what flows are consistently late, but we don't have the data to identify performance issues.” *Project Engineer Ichma*



“Identifying and mapping the flows in a visual way allows all of the contractors to be on the same page and understand the plan better” *Project Superintendent Frederikskaj*

Conclusions and Future Work

Conclusions:

- Considering flows during work structuring enables better **understanding and communication** of the plan among stakeholders
- The Activity-Flow Work Structuring Method (AFWSM) enables field managers to formally represent and manage flows
- The AFWSM should lead to schedules with higher planning reliability since flows should be better synchronized between activities

Future Work

- Testing effect of work structuring method on schedule performance
- Developing methods for automating / speeding transformation from work structuring to activity-flow-based schedules

Questions?

Thank you!

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