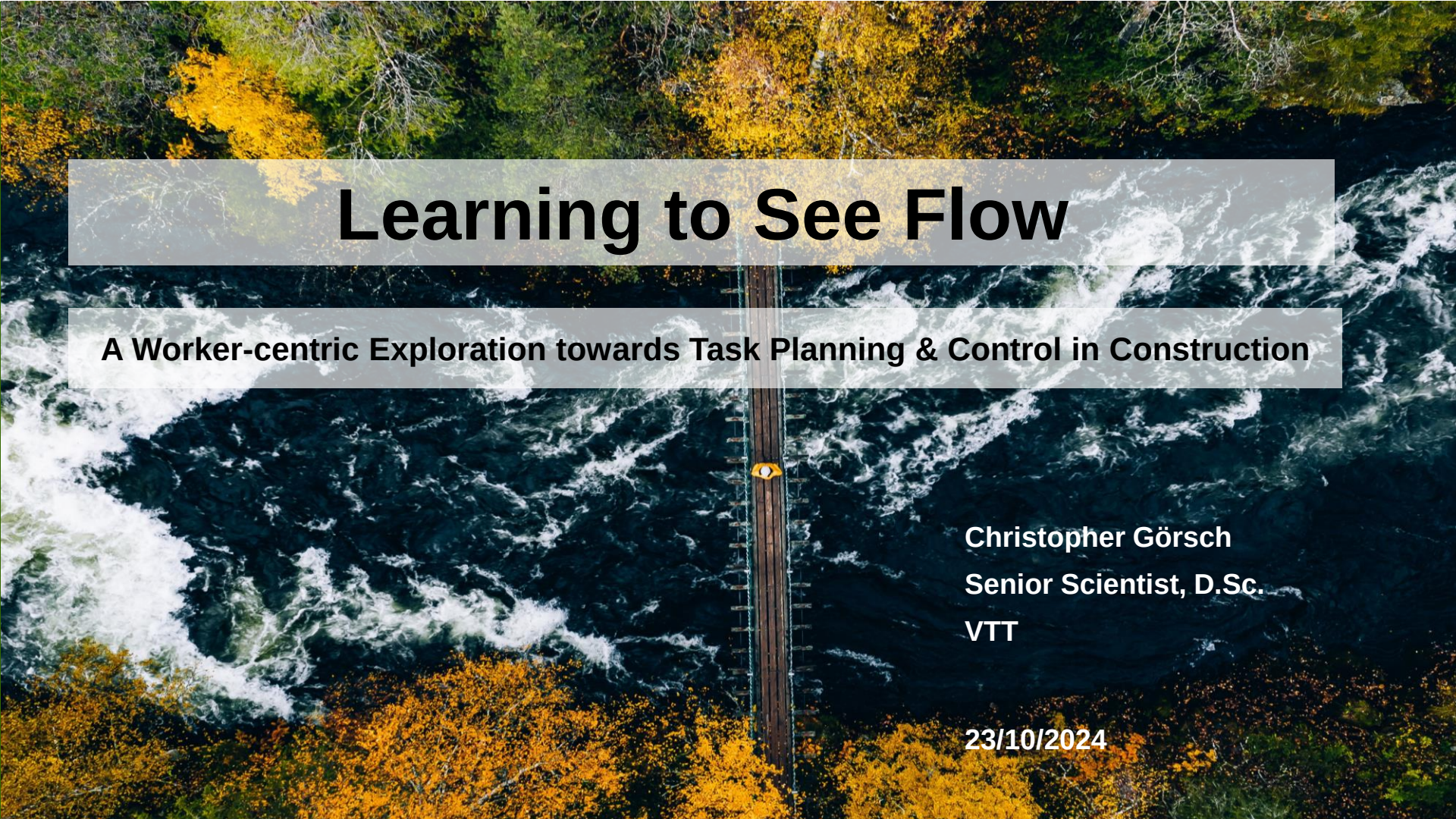

Learning to See Flow

A Worker-centric Exploration towards Task Planning & Control in Construction

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Senior Scientist, D.Sc.
VTT

23/10/2024

Operations Flow Coordination

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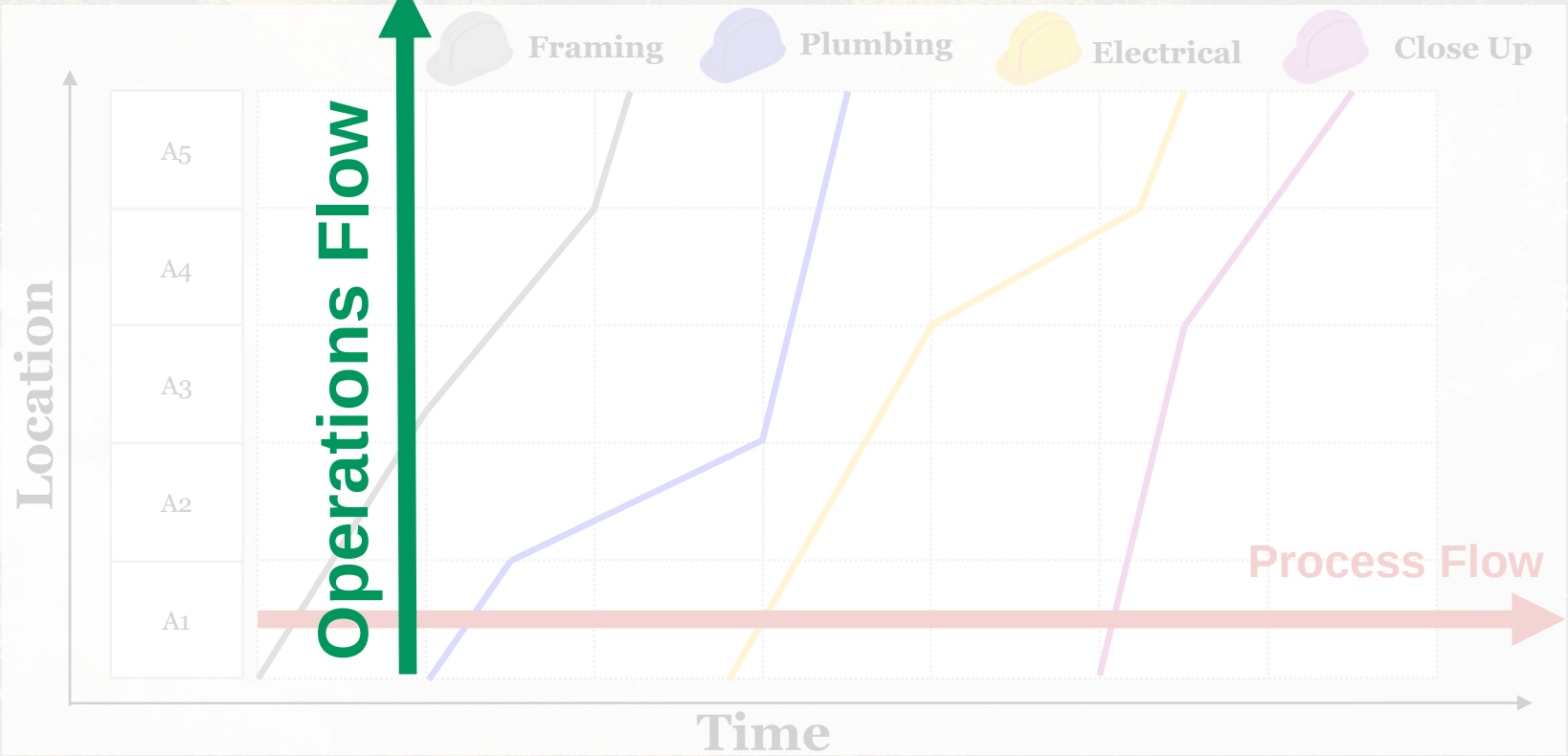
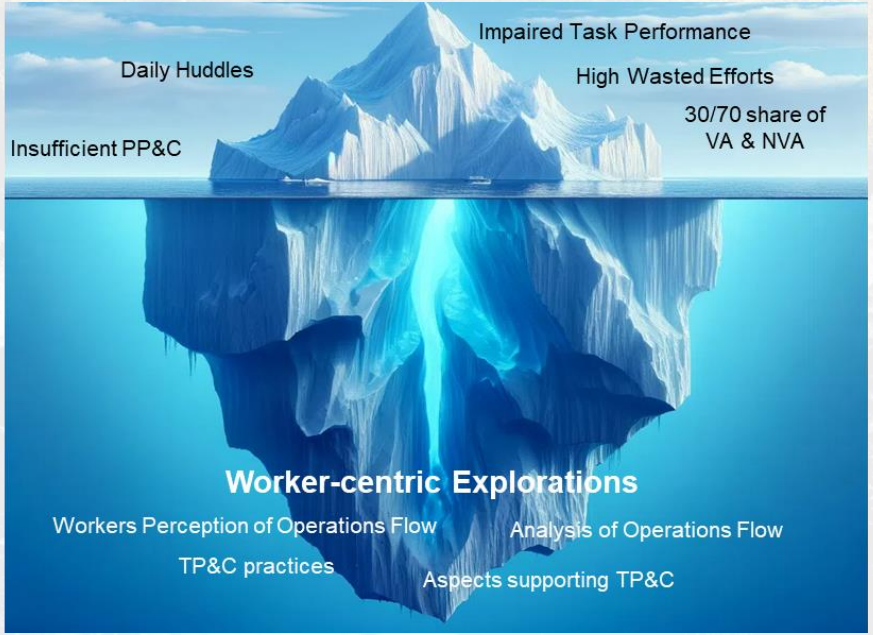
Workers Task Performance



Hidden Gaps

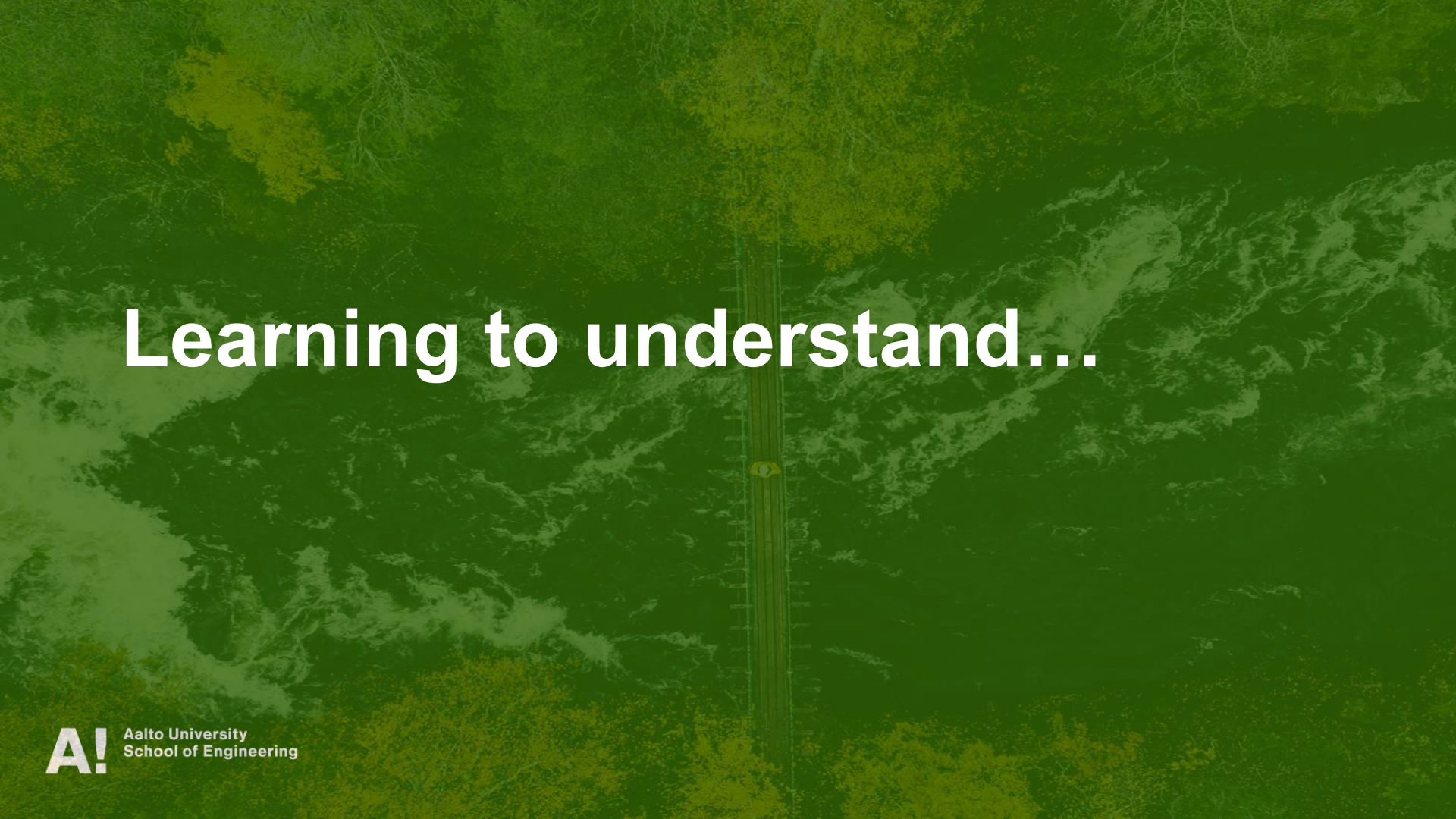
What is known?

What is unknown?



Research Questions

1. How do workers perceive operations flow in construction, and how can operations flow be analysed?
2. What TP&C aspects support operations flow and task performance?


Learning to understand…

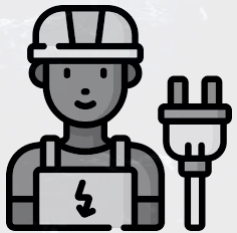
Survey

Why?

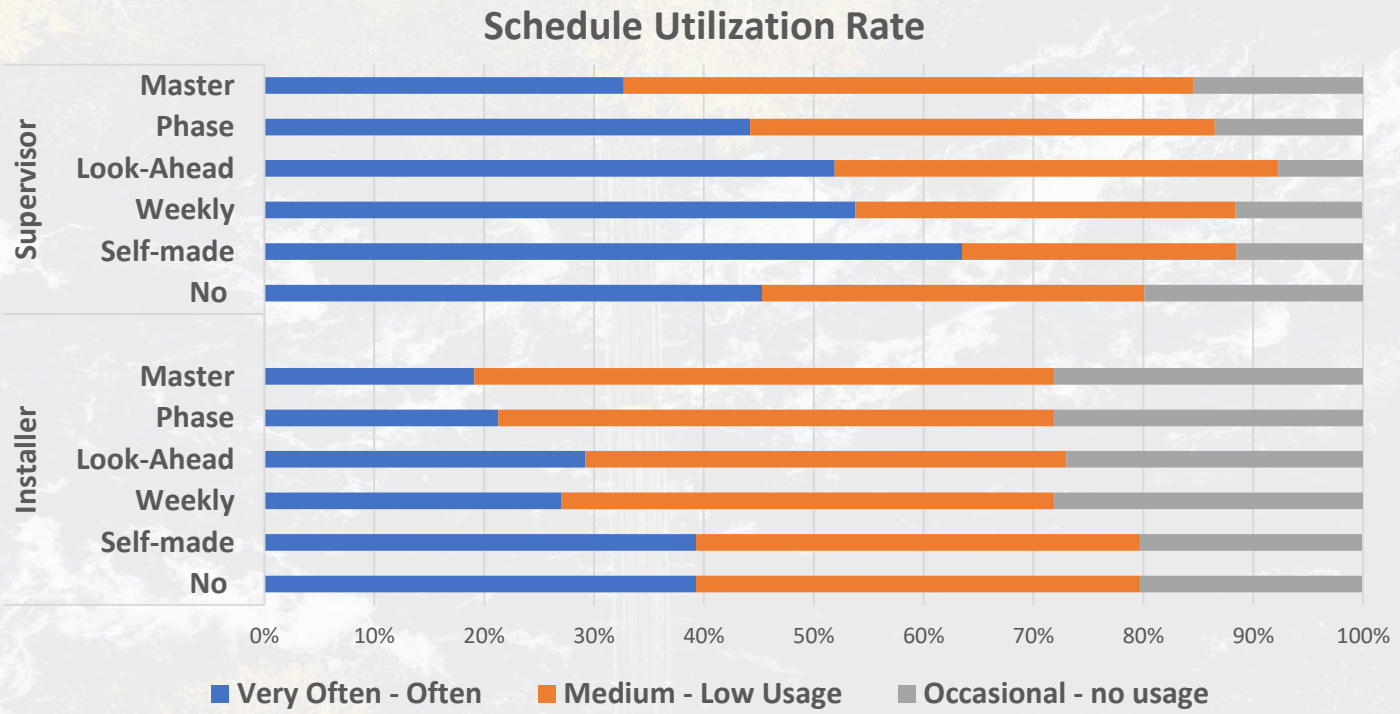
- To gain a comprehensive understanding of the information sources, planning, and control practices needed by workers
- To capture individuals' perspectives, subjective opinions and experiences

How?

- Survey followed an eight steps research design & targeted MEP workers
- Distributed via e-mail and in multiple languages to reach a broad and diverse audience of workers across Finland
- Questions focused on schedule utilization and information flows
- Attracted 146 participants



Emergence of Task Planning & Control



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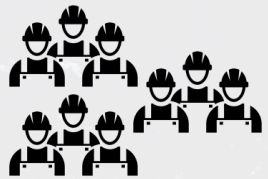
Differences in Workers´ Planning Practices

Early Planners	Late Planners
Main Information needs before arrival on-site, often not satisfied	Main Information needs when preparing tasks, often not satisfied
More often Plumbers/HVAC workers	More often Electricians
The smaller the crew size the higher the share of early Planners	The bigger the crew size the smaller the share of early planners



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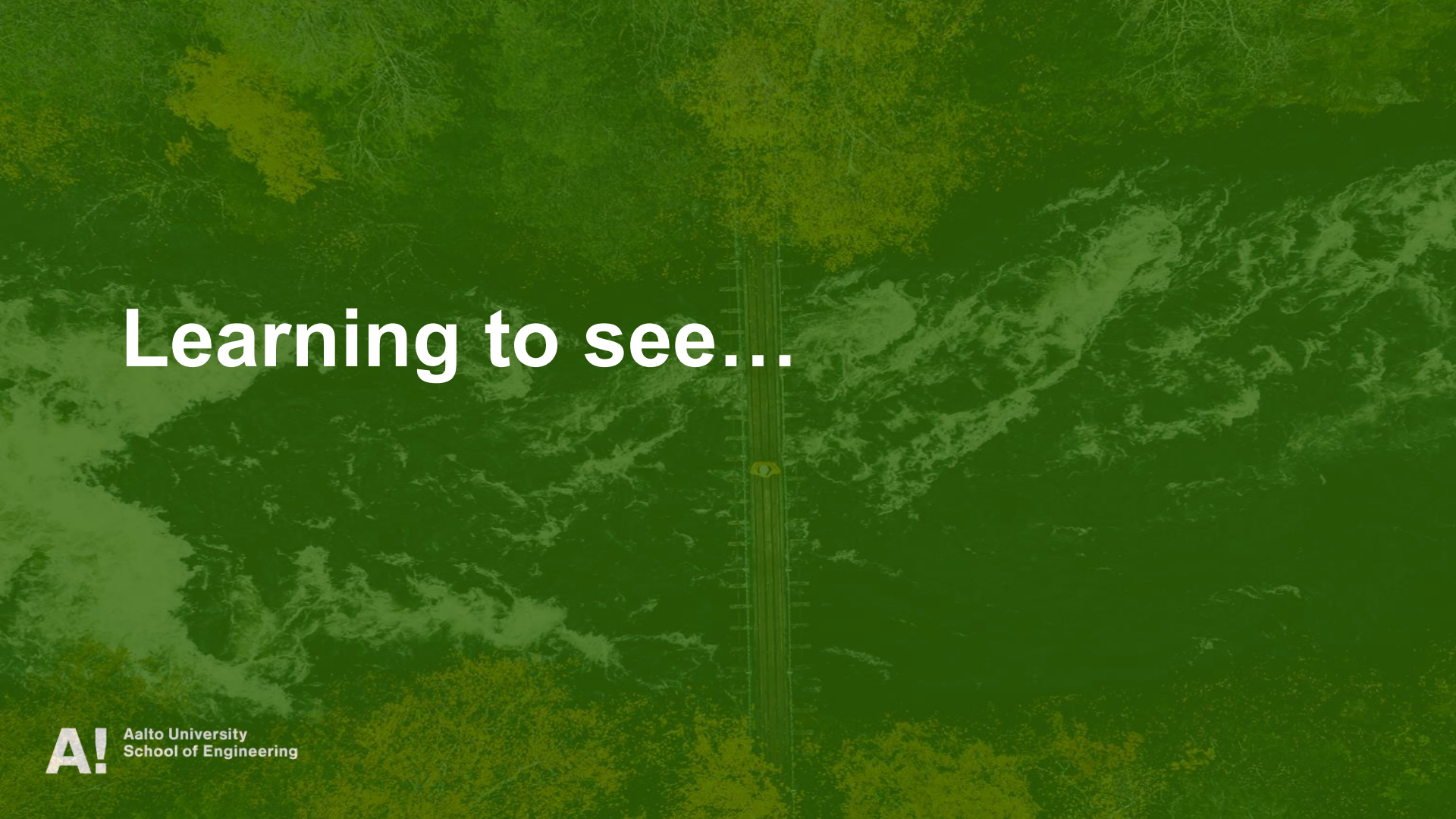
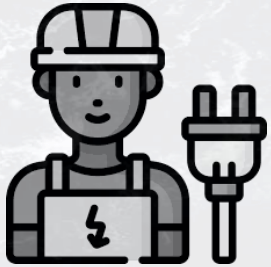
Learning to see…

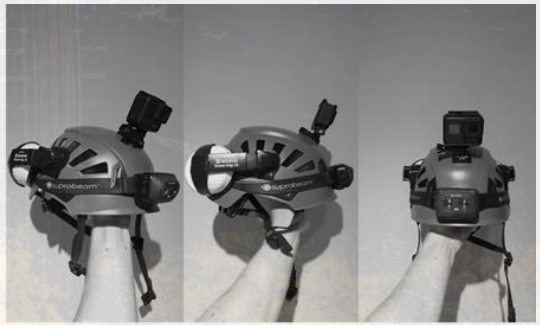


Time-Motion Study

- To incorporate qualitative and quantitative data of individual task performance
- systematic activity, waste, precondition observation and classification of 14 workers
- Observation conducted throughout 5 workdays in 4 different projects
- Approx. 10.000 activities analysed from electrician, plumbers and HVAC workers



1-Ear protection
2-Head Lamp
3-Go Pro
4-Power Bank



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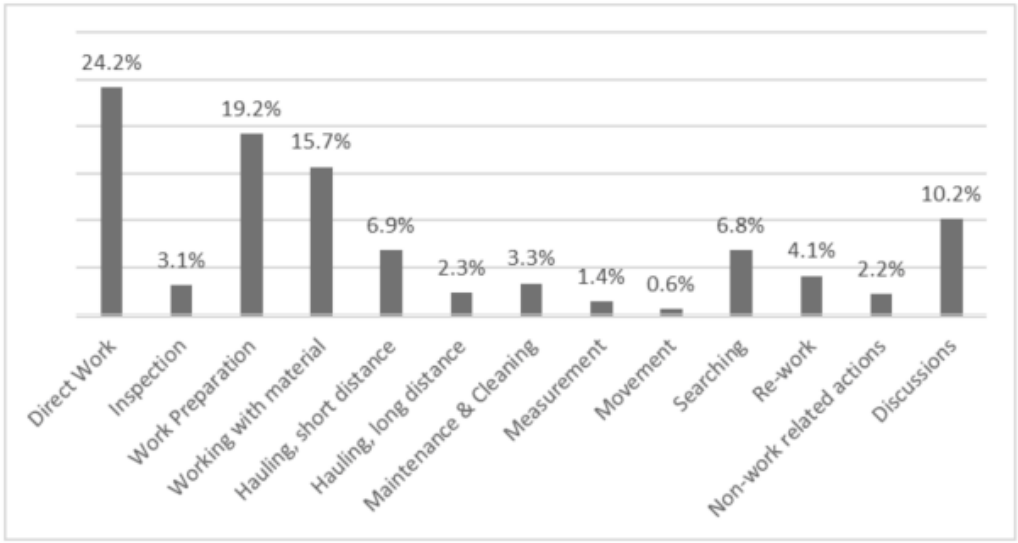
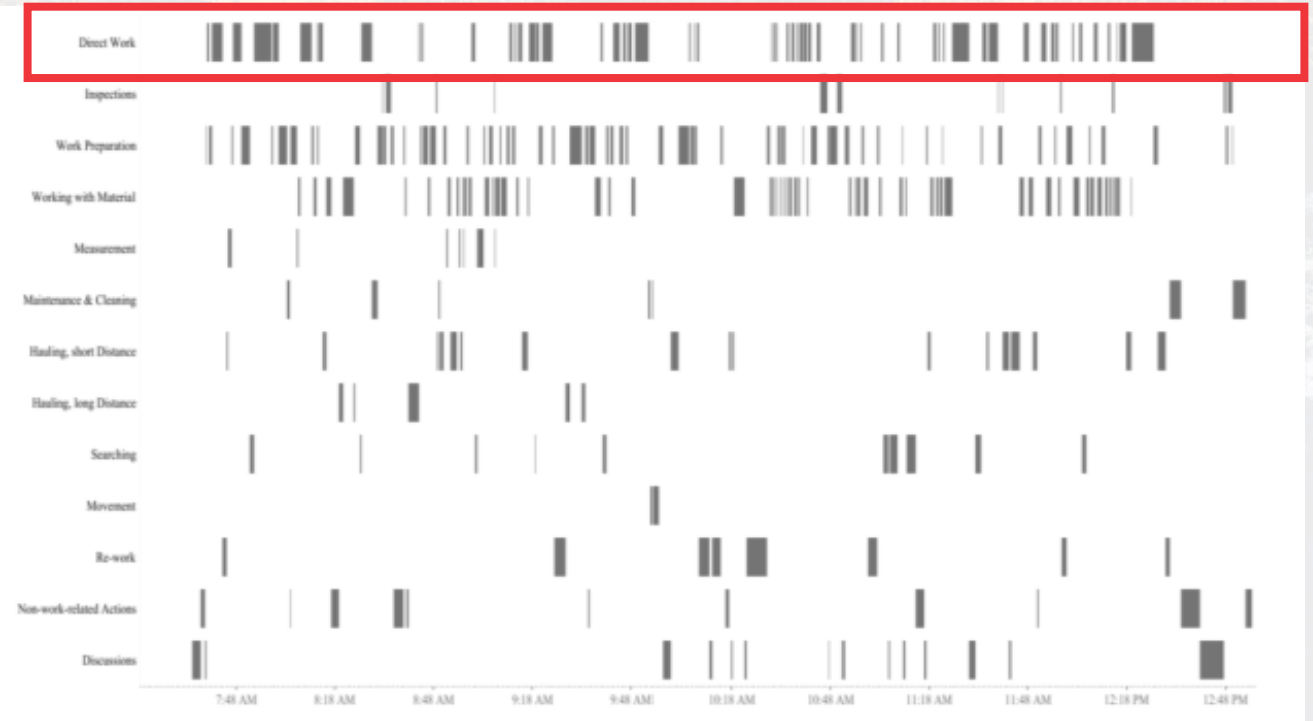
Quantifying Plumber's Working Activities



- Analysed and classified 5.3 hours of plumbing work video (one working day)
- High on-site customization led to 19.2% work preparation and 15.7% working with materials
- 6.8% Search activities resulted from insufficient materials and disorganized storage
- 9.2% was spent on transporting tools and materials
- High NVA caused operational fragmentation

Erratic Heartbeat of Operations Flow?



- 284 activities in one day
- 283 activity changes in just 5,3 hours
- In average approx. every minute work activities change
- Overall, DW paused & continued 61 times, mostly due to work preparation & working with materials

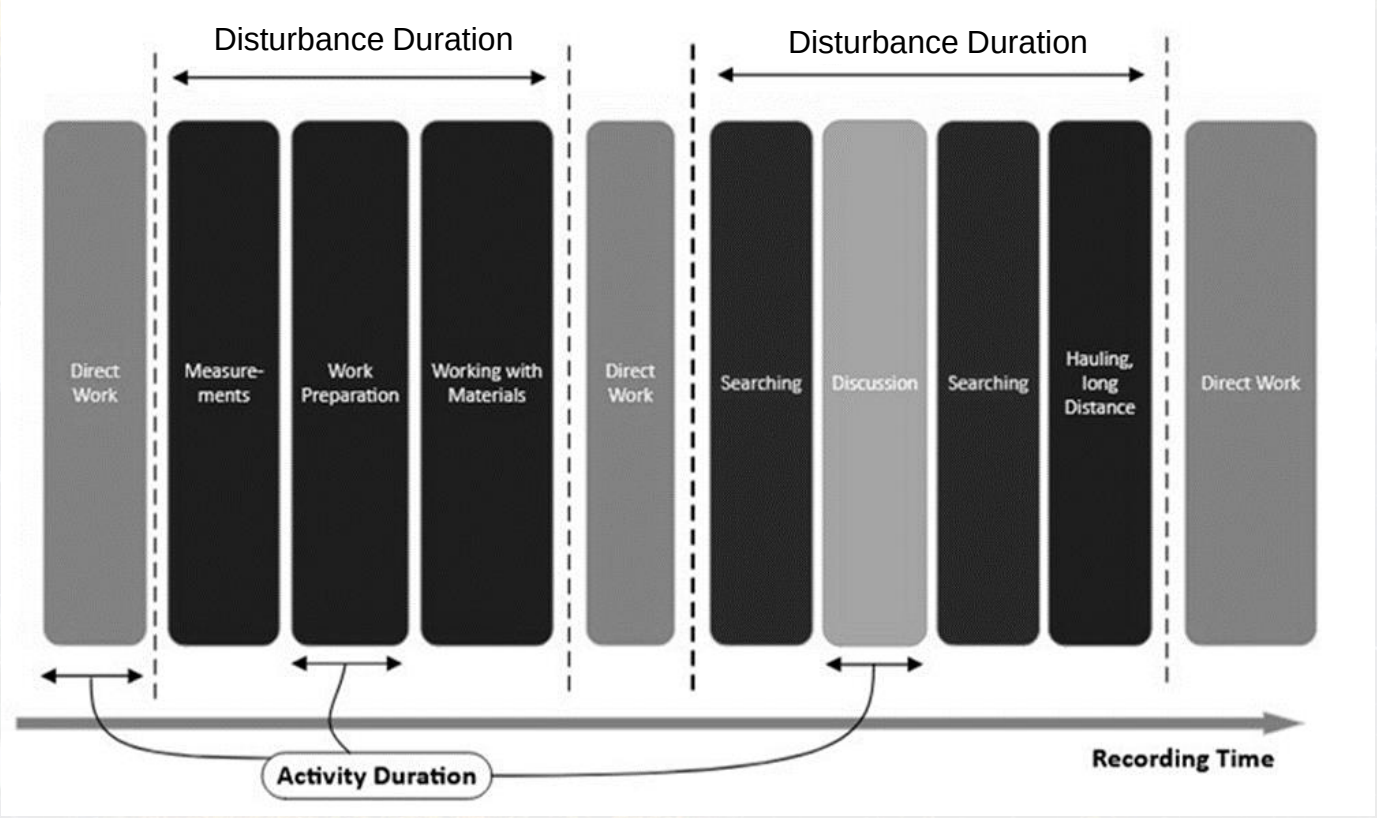
Learning to analyse…

Activities analysed

Activities	Time (h)			Share of time (%)			Counts		
	Overall	Electrician	Plumber/ HVAC	Overall	Electrician	Plumber/ HVAC	Overall	Electrician	Plumber/ HVAC
Direct work	29:35	19:17	10:17	18.9	24.0	13.6	1,735	1,179	556
Inspection	5:12	2:52	2:20	3.3	3.6	3.1	371	193	178
Work preparation	27:17	14:51	12:26	17.5	18.5	16.4	2,209	1,270	939
Working with material	21:15	12:37	8:37	13.6	15.7	11.4	1,267	843	424
Long-distance hauling	8:04	2:37	5:26	5.2	3.3	7.2	274	87	187
Short-distance hauling	6:40	3:48	2:52	4.3	4.7	3.8	503	303	200
Measurement	4:52	1:53	2:59	3.1	2.4	3.9	491	183	308
Maintenance and cleaning	5:21	3:24	1:56	3.4	4.2	2.6	344	230	114
Non-work-related actions	15:48	7:43	8:04	10.1	9.6	10.7	657	312	345
Searching	6:18	1:36	4:42	4.0	2.0	6.2	265	64	201
Rework	3:05	1:26	1:39	2.0	1.8	2.2	169	96	73
Movement	6:33	2:18	4:14	4.2	2.9	5.6	481	226	255
Discussion	16:09	6:01	10:07	10.3	7.5	13.4	798	324	474
Total	156:16	80:30	75:46	100	100	100	9,564	5,310	4,254

- Share of DW is higher for electricians than for plumber/HVAC workers
- Overall, only 20% is spend on DW, which means approx. 80 % of the time is spend on NVA
- 8-hour workday has in average 455 activity changes

What is disturbing Operations Flow?



“No work gets done when on the run”

Short-term Disturbance	Medium-term Disturbance	Long-term Disturbance
Average Time 00:01:31	Average Time 00:08:46	Average Time 00:20:15
Most of them within electrical work	More in plumbing/HVAC work	More in plumbing/HVAC work
Not Wasteful	Wasteful – Very high in Motion	Wasteful – Motion & Transportation

What causes Disturbances?

Missing Precondition	Short-term	Medium-term	Long-term
Total count	54	725	514
Building design & specifications	0%	2%	5%
Directives	0%	2%	2%
Components & materials	19%	42%	31%
Workers	0%	5%	8%
Equipment & machinery	15%	20%	21%
Sufficient space	13%	3%	11%
Connecting works	2%	21%	16%
External conditions	0%	2%	2%
Working conditions	52%	2%	5%

- Medium- and long-term disturbances were mainly due to missing components, materials, equipment issues, and challenges with connecting work, Workers handled logistical tasks themselves to address these issues
- Short-term disturbances: 67% were due to poor working conditions and lack of space, Short-term issues also involved missing components, materials, and equipment, Some short-term disturbances occurred even when all preconditions were met.

TP&C Aspects Enhancing Operations Flow

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Planning Aspects

Operations Design

- Collaborative planning integrating workers
- Clear design & schedules relevant to workers
- Optimized for operations *(space allocation, logistics, constructability, etc.)*

Enhanced Information Systems

- Track & analyze data in real-time
- Integrated data & systems
- Continuously accessible & updated information

Visual Management

- Providing individualized situation picture
- Enhancing transparency & overcoming visual barriers *(from frog to bird-eye view)*
- Task execution aids

Control Aspects

Work process Standardization

- Use mobile workstations, improve task predictability, and streamline processes
- Human-robot collaboration for site logistics
- Pre-designed off-site construction

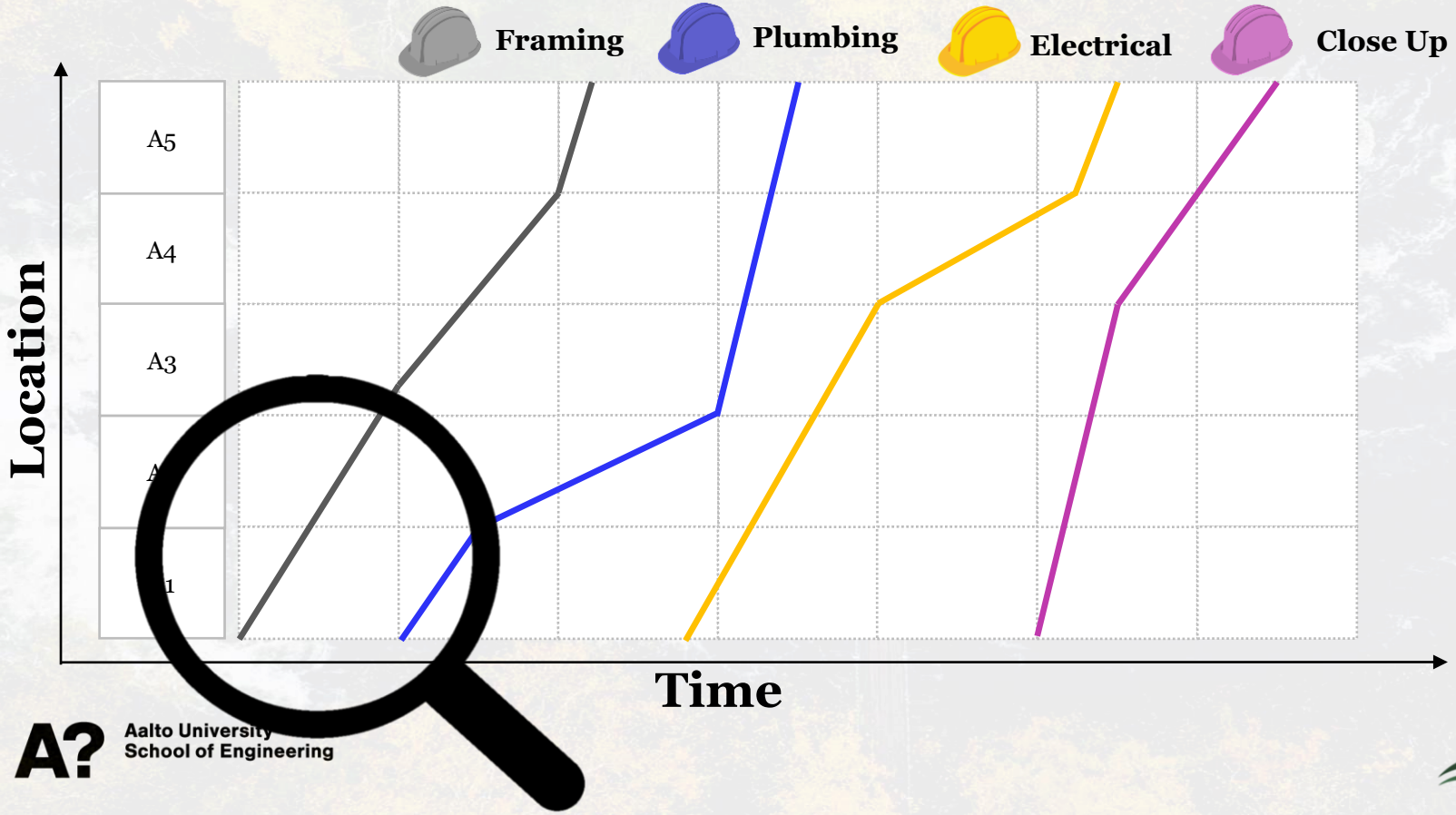
Automated On-site Tracking & Analysis

- Current methods do not capture dynamics
- Movement, disturbances and waste tracking based on tracking location, pedometer, time data (as-performed)
- Automated progress capturing (as-built)
- Flow simulation and prediction of next tasks on individual level

Visualizing Operations Flow

- Improve management & workers awareness by identifying disturbances & waste
- Operations flow can be visualized through incremental flowcharts

Reminder Flowline



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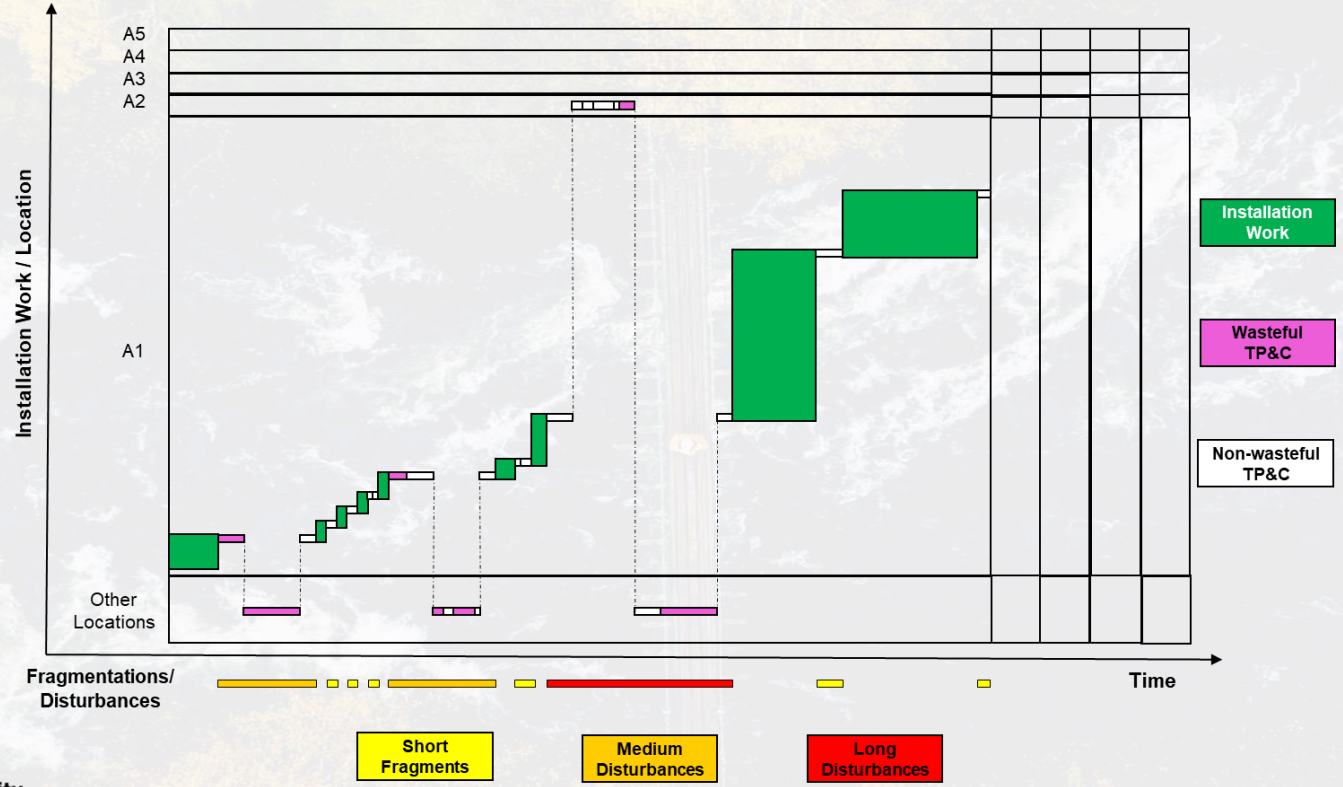
From Flowlines to Incremental Flowcharts



Interested in the Topic and Data?

Get the whole data set for free and reach out to collaborate https://zenodo.org/records/13867877

Thank You for Your Attention!

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