



Delivering
Excellence
Together



*Andrea Sbaragli, PhD
15th October 2025*

Agenda



1

Introduction

*What is off-site construction?
What are the objectives of the project?*

2

Use case

*Manufacturing Operations
Overview of Steel Frame System area*

3

Digital system

Data driven solution to improve Steel Frame System area Monitoring, Planning & Scheduling

4

Conclusions

Remarks on the proposed system & Further Activities

Introduction



What is off-site manufacturing and why is gaining traction?

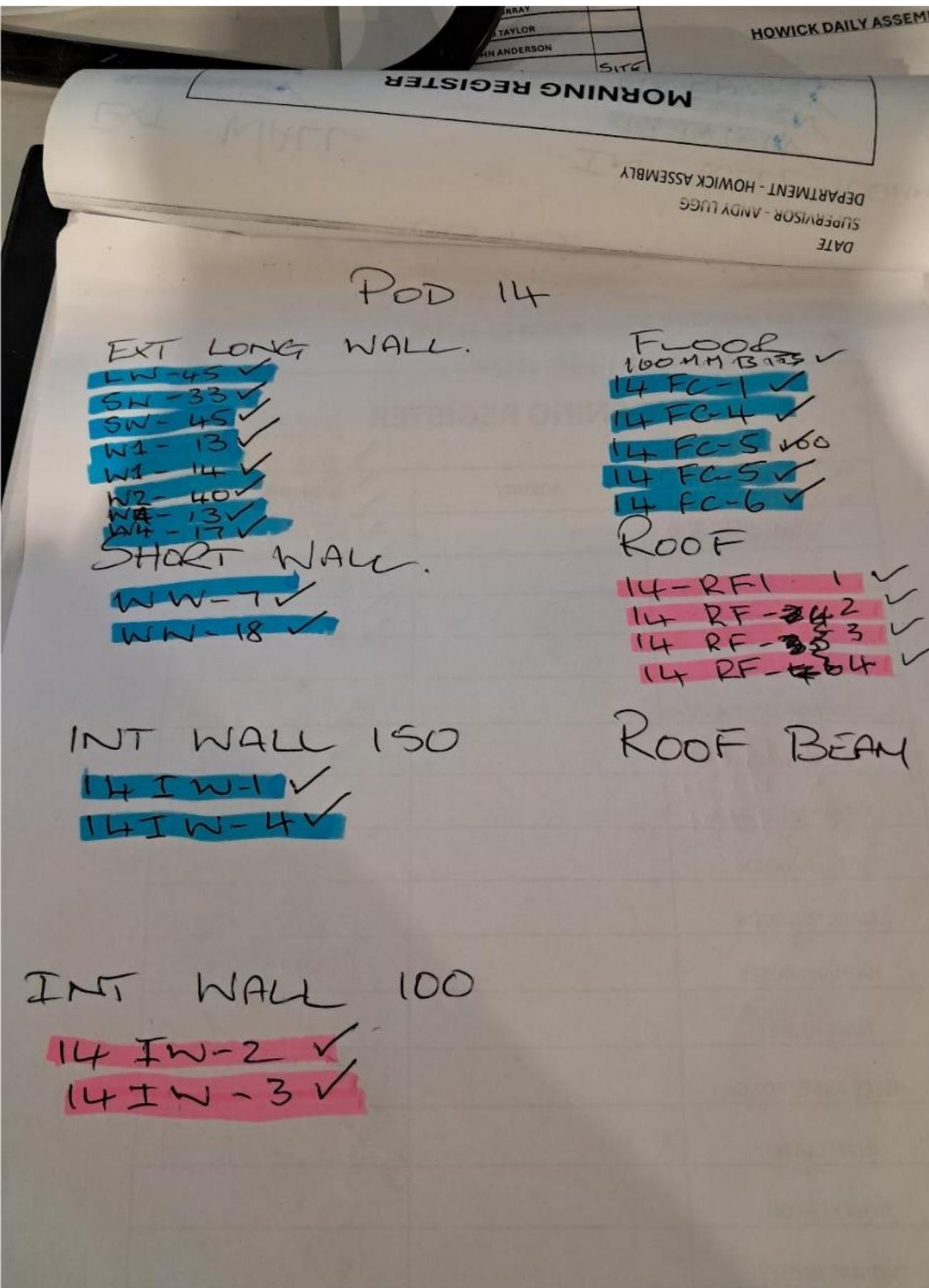


- » Innovative approach involving the design and production of structural components in a **factory** before being installed on **site**
- » Opportunity to **improve** project **planning** control, **productivity** and **delivery time**
- » Wide **variability**: geographical conditions, budget, building functions and client personalization
- » Due to **low standardization** construction has **very low** average **profit margins** compared to other sectors such as manufacturing (McKinsey and Company)

Introduction

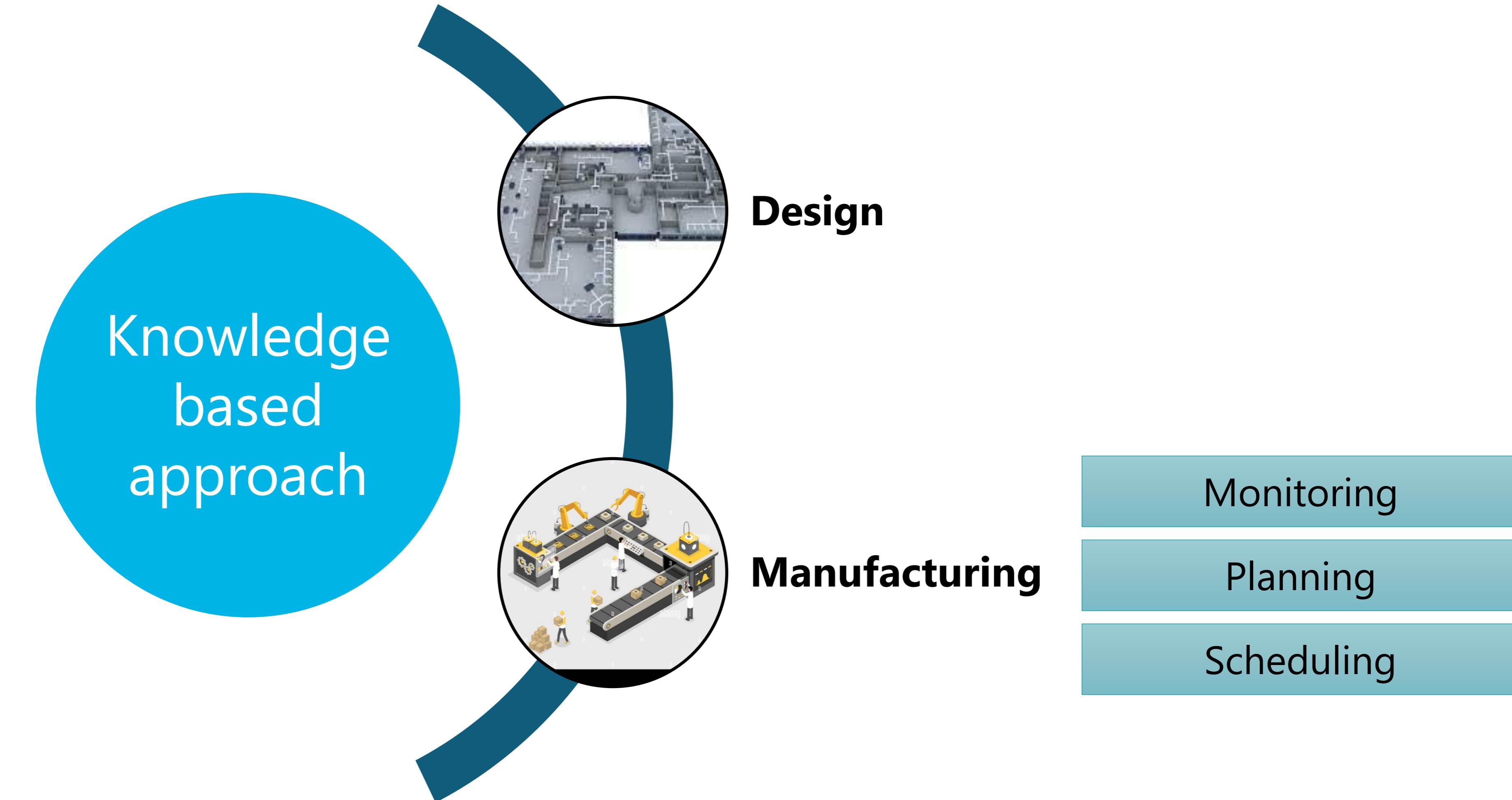


How off-site construction companies track production?



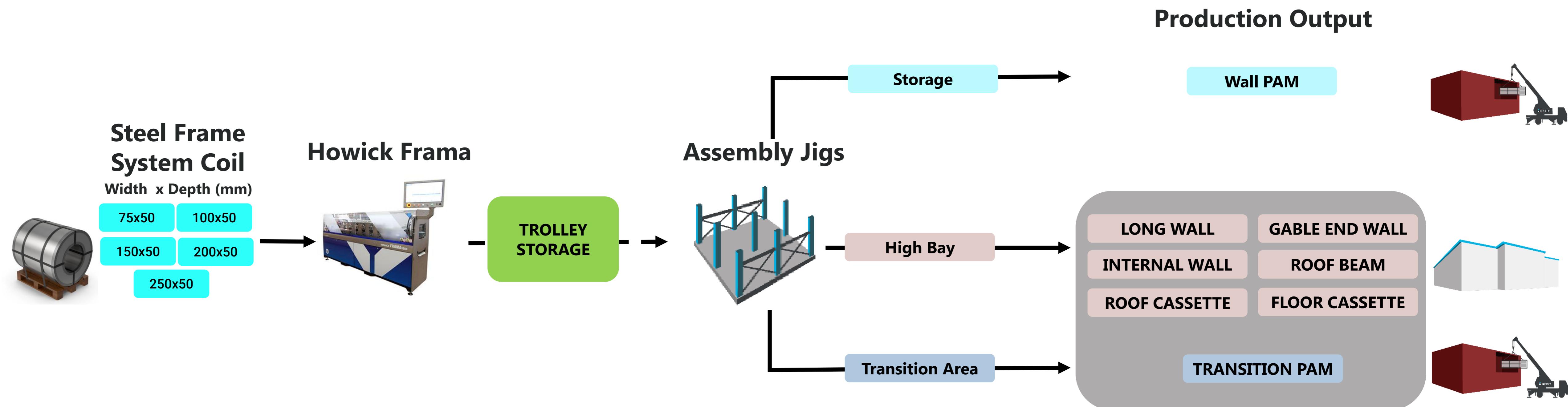
- »»» **Low adoption** of established **manufacturing standards** and **principles**
- »»» **Limited digital footprint** to monitor factory operations
- »»» **Ripple effects** on:
 - Cost evaluations
 - Resources dimensioning and efficiency
 - Project deadlines

Introduction



»»» Which manufacturing job shop is considered?

Use Case



Use Case



Howick Machine



Trolleys



Assembly jigs



Stillages



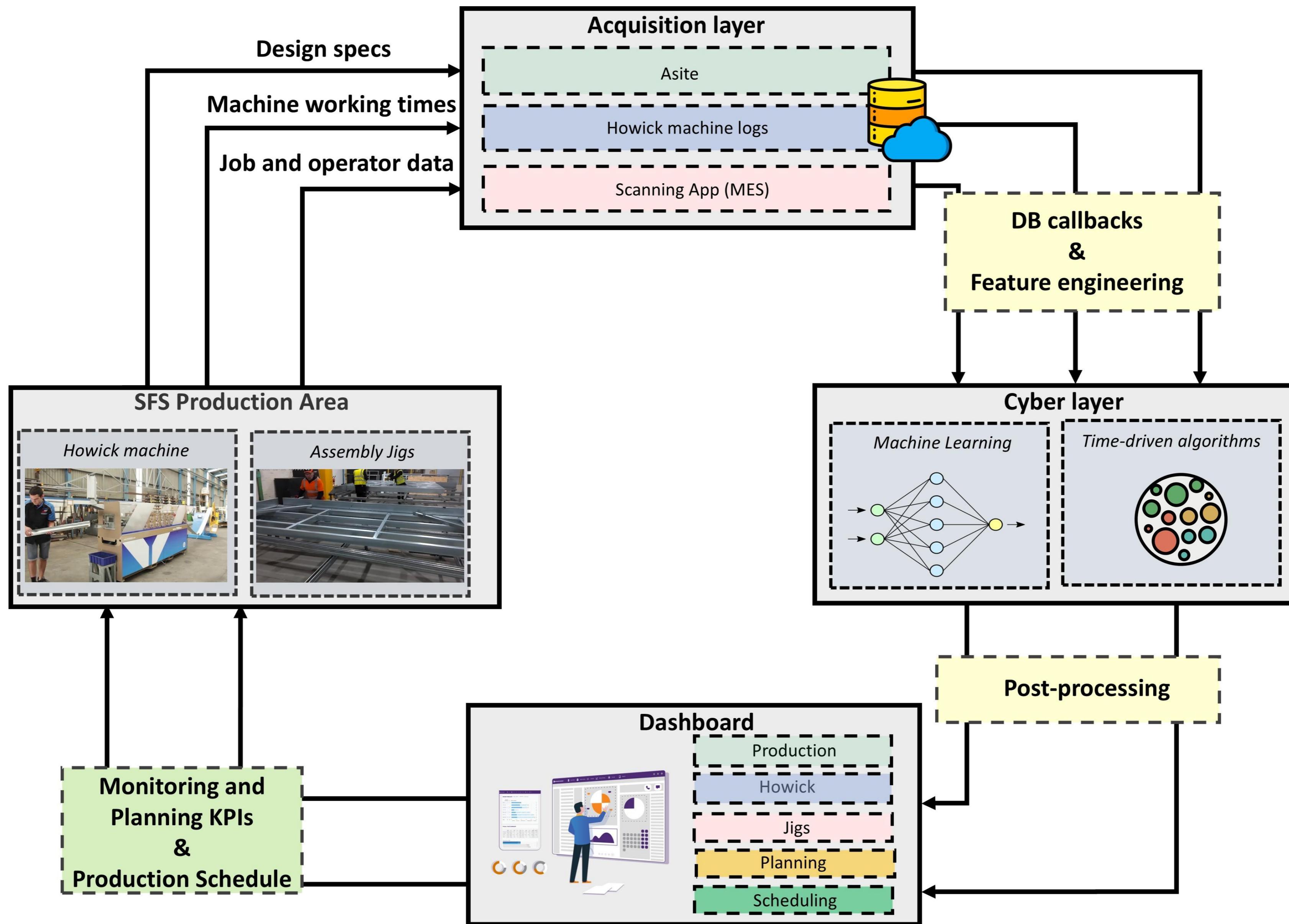
- 1 dedicated operator:
- Run manufacturing sequence
- Machine set ups for coil changes
- Admin and Quality jobs
- Material Handling into trolleys

- Structured into 2 sides and 4 levels for storing up to 8 frames
- Each frame has a traveller pack containing Audit Sheet, Assy Drawing and Green Tag
- Material Handling is manual

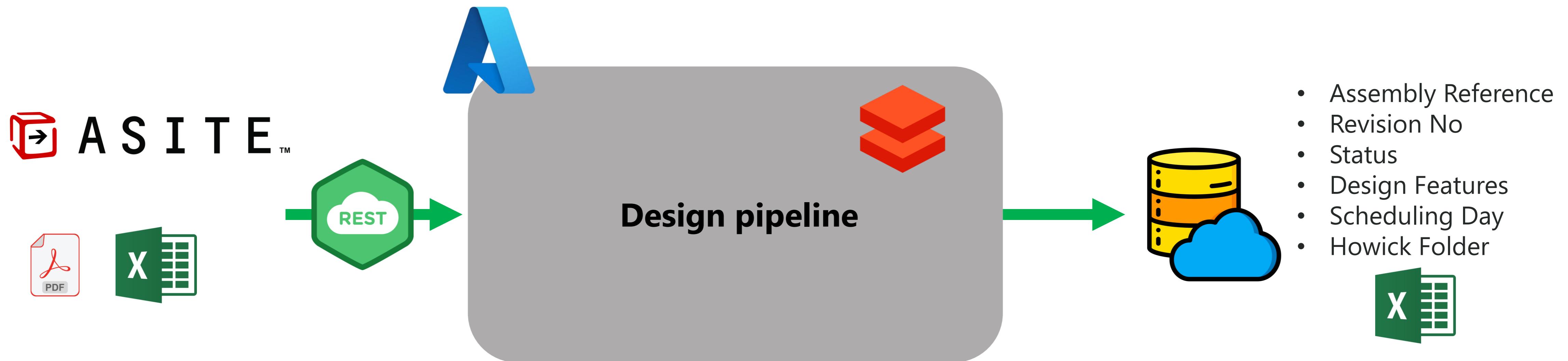
- Up to 4 assembly workers for 2D assembly
- **BathPod** and **UltraPod** to the High bay
- **WallPams** into Stillages
- **Transition PAM** frames to transition manufacturing cell

- Store variable number of WallPams
- Used for on-site delivery

Digital System - Overview



Digital System – Acquisition Layer



How to schedule data to production and send CSV files to the Howick Machine?

Digital System – Dashboard: Scheduling

Schedule Selected Clear Selection

	ProjectID	AssemblyRef	ProductionRef	RevisionNo	Status	ScrewCount	Coil	DirectLink	SchedulingDay	Len
■	10734	10734-MRT-ZZ-02-DR-S-09-1006	02-09-1006	C01	Approved IFC	42	150.0	https://adoddleleak.asite.com/lnk/oLKR867fodpA6xupAndM	—	25490.2
■	10734	10734-MRT-ZZ-02-DR-S-09-1007	02-09-1007	C01	Approved IFC	42	150.0	https://adoddleleak.asite.com/lnk/oLKR86rsodpA6aspAndM	—	26768.6
■	10300	10300-MRT-Z3-01-DR-S-3039-02	Z3-01-3039-02	C01	Approved IFC	122	100.0	https://adoddleleak.asite.com/lnk/XM49LBjH6LkxdsLXXKn	—	44183.8
■	10752	10752-MRT-ZZ-01-DR-S-6518-18GW1	18GW-1	C03	Approved IFC	124	150.0	https://adoddleleak.asite.com/lnk/67Ur4LatKapaRKCegebLk	—	48808.6
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW1	18IW1	C04	Approved IFC	136	100.0	https://adoddleleak.asite.com/lnk/M9oxeRqudBekpUnBMea	—	49850.2
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW2	18IW2	C04	Approved IFC	180	100.0	https://adoddleleak.asite.com/lnk/R79goELCE6rb9uk6rdG	—	52119.3
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW3	18IW3	C04	Approved IFC	117	100.0	https://adoddleleak.asite.com/lnk/zaKgpxGlxrdopyu7kpab	—	43291.3
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC1	19FC-1	C02	Approved IFC	80	250.0	https://adoddleleak.asite.com/lnk/9AypKo7lp58eddspAx7k	2025-09-12 14:15:00	41442.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC2	19FC-2	C02	Approved IFC	160	250.0	https://adoddleleak.asite.com/lnk/XM569rMS60pg5RhLzydj	2025-09-12 14:15:00	49505.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC3	19FC-3	C02	Approved IFC	144	250.0	https://adoddleleak.asite.com/lnk/RayE9rgUEq8njohk6rdG	—	44235.2
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC4	19FC-4	C02	Approved IFC	144	250.0	https://adoddleleak.asite.com/lnk/aMydKklCdo8ggGFbz5Ar	—	45123.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC5	19FC-5	C01	Approved IFC	308	100.0	https://adoddleleak.asite.com/lnk/Bn8xB80lnGkrqKFk54L	—	72628
■	10300	10300-MRT-Z3-00-DR-S-3066-03	Z3-00-3066-03	C01	Approved IFC	44	100.0	https://adoddleleak.asite.com/lnk/oRngz5xuooj8ytpAAEX	—	21565
■	10300	10300-MRT-Z3-00-DR-S-3067-01	Z3-00-3067-01	C02	Approved IFC	80	100.0	https://adoddleleak.asite.com/lnk/aMz67XSSddLegAlBkkKj	—	23442.6
■	10300	10300-MRT-Z2-00-DR-S-2158-02	Z2-00-2158-02	C01	Approved IFC	60	100.0	https://adoddleleak.asite.com/lnk/aM86j97HdR9xfBkkKj	—	24312.1
■	10300	10300-MRT-Z2-00-DR-S-2159-01	Z2-00-2159-01	C01	Approved IFC	58	100.0	https://adoddleleak.asite.com/lnk/XMqz5Eouk4ogkhLXXKn	—	23104.5
■	10300	10300-MRT-Z2-00-DR-S-2160-01	Z2-00-2160-01	C01	Approved IFC	64	100.0	https://adoddleleak.asite.com/lnk/eMqzyEkSkXoglRHBrKL	—	28785.5

Schedule Selected Clear Selection

	ProjectID	AssemblyRef	ProductionRef	RevisionNo	Status	ScrewCount	Coil	DirectLink	SchedulingDay	Len
■	10734	10734-MRT-ZZ-02-DR-S-09-1006	02-09-1006	C01	Approved IFC	42	150.0	https://adoddleleak.asite.com/lnk/oLKR867fodpA6xupAndM	—	25490.2
■	10734	10734-MRT-ZZ-02-DR-S-09-1007	02-09-1007	C01	Approved IFC	42	150.0	https://adoddleleak.asite.com/lnk/oLKR86rsodpA6aspAndM	—	26768.6
■	10300	10300-MRT-Z3-01-DR-S-3039-02	Z3-01-3039-02	C01	Approved IFC	122	100.0	https://adoddleleak.asite.com/lnk/XM49LBjH6LkxdsLXXKn	—	44183.8
■	10752	10752-MRT-ZZ-01-DR-S-6518-18GW1	18GW-1	C03	Approved IFC	124	150.0	https://adoddleleak.asite.com/lnk/67Ur4LatKapaRKCegebLk	—	48808.6
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW1	18IW1	C04	Approved IFC	136	100.0	https://adoddleleak.asite.com/lnk/M9oxeRqudBekpUnBMea	—	49850.2
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW2	18IW2	C04	Approved IFC	180	100.0	https://adoddleleak.asite.com/lnk/R79goELCE6rb9uk6rdG	—	52119.3
■	10752	10752-MRT-ZZ-01-DR-S-6518-18IW3	18IW3	C04	Approved IFC	117	100.0	https://adoddleleak.asite.com/lnk/zaKgpxGlxrdopyu7kpab	—	43291.3
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC1	19FC-1	C02	Approved IFC	80	250.0	https://adoddleleak.asite.com/lnk/9AypKo7lp58eddspAx7k	2025-09-12 14:15:00	41442.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC2	19FC-2	C02	Approved IFC	160	250.0	https://adoddleleak.asite.com/lnk/XM569rMS60pg5RhLzydj	2025-09-12 14:15:00	49505.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC3	19FC-3	C02	Approved IFC	144	250.0	https://adoddleleak.asite.com/lnk/RayE9rgUEq8njohk6rdG	—	44235.2
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC4	19FC-4	C02	Approved IFC	144	250.0	https://adoddleleak.asite.com/lnk/aMydKklCdo8ggGFbz5Ar	—	45123.4
■	10752	10752-MRT-ZZ-01-DR-S-6519-19FC5	19FC-5	C01	Approved IFC	308	100.0	https://adoddleleak.asite.com/lnk/Bn8xB80lnGkrqKFk54L	—	72628
■	10300	10300-MRT-Z3-00-DR-S-3066-03	Z3-00-3066-03	C01	Approved IFC	44	100.0	https://adoddleleak.asite.com/lnk/oRngz5xuooj8ytpAAEX	—	21565
■	10300	10300-MRT-Z3-00-DR-S-3067-01	Z3-00-3067-01	C02	Approved IFC	80	100.0	https://adoddleleak.asite.com/lnk/aMz67XSSddLegAlBkkKj	—	23442.6
■	10300	10300-MRT-Z2-00-DR-S-2158-02	Z2-00-2158-02	C01	Approved IFC	60	100.0	https://adoddleleak.asite.com/lnk/aM86j97HdR9xfBkkKj	—	24312.1
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■	10300	10300-MRT-Z2-00-DR-S-2160-01	Z2-00-2160-01	C01	Approved IFC	64	100.0	https://adoddleleak.asite.com/lnk/eMqzyEkSkXoglRHBrKL	—	28785.5

Mirror all Asite Activity. Jobs can be send to the Howick if the following are true:

» Status = 'Approved IFC'

» SchedulingDay=NULL

Upon Assembly Reference selection the system asks:

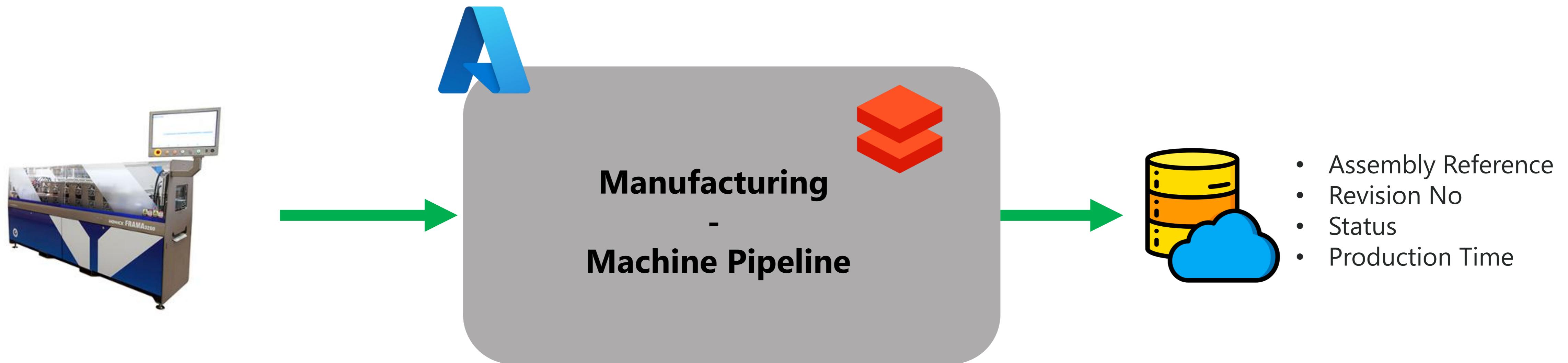
» Select Scheduling Day = Date and Time (optional)

» Select Name of the Howick folder

How to capture production data to evaluate process efficiency?



Digital System – Acquisition Layer



Digital System – Acquisition Layer: MES



Factory Scanning App H J Andrea Sbaragli

Howick Jobs



Assembly Jigs



Logistic



You're now login as Andrea Sbaragli

Digital System – Acquisition Layer: MES

ASSEMBLY REF	REV	COIL	LEN	SCHEDULED DAY	HOWICK FOLDER	HIGH PRIORITY	START TIME	END TIME	OPERATORS	STATUS	ACTION
10581-MRT-ZZ-01-DR-S-6500-DP11	C01	100.0	13.9	07/10/2025	7th-Oct		03/10/2025 08:04		Mark Lui,Cashin Martin	INCOMPLET Trolley: 2	Audit OPEN
10581-MRT-ZZ-01-DR-S-6500-DP12	C01	100.0	14.9	07/10/2025	7th-Oct		03/10/2025 09:15		Andy Ryan	INCOMPLET Trolley: 8	Audit OPEN
10581-MRT-ZZ-01-DR-S-6500-RF04	C01	100.0	28.8	07/10/2025	7th-Oct		03/10/2025 15:37	06/10/2025 11:34	Andrea Sbaragli	COMPLETE Trolley: 10	Audit OPEN
10581-MRT-ZZ-01-DR-S-6500-RF10	C01	100.0	28.7	07/10/2025	7th-Oct		06/10/2025 12:12	06/10/2025 15:33	Andrea Sbaragli,Mark Lui	COMPLETE Trolley: 7 E	Audit OPEN
10581-MRT-ZZ-01-DR-S-6806-LW3	C01	100.0	34.2	07/10/2025	7th-Oct		08/10/2025 14:00		Andrea Sbaragli	PROGRESS Machine 1	Audit OPEN
10581-MRT-ZZ-01-DR-S-6806-LW4	C01	100.0	33	07/10/2025	7th-Oct					NEW	Audit OPEN
10752-MRT-ZZ-GF-DR-S-6508-8FC4	C01	200.0	27.9	07/10/2025	1st-Oct					NEW	Audit OPEN
10752-MRT-ZZ-GF-DR-S-6513-13GW1	C01	150.0	31	07/10/2025	1st-Oct					NEW	Audit OPEN
10300-MRT-Z1-00-DR-S-1150-02	C02			10/10/2025						NEW	Audit OPEN
10300-MRT-Z1-00-DR-S-1001-55	C02						03/07/2025 14:00	03/07/2025 15:00	Andrea Sbaragli	SCRAP	Audit OPEN

Scheduled Jobs flows into the Howick Area of the Manufacturing Execution System (MES)

»»» Jobs have different status and informations

»»» Workers can log in the job by pressing OPEN

Jobs control panel enables to capture several process driven activities

»»» Uptime and downtime events

»»» Record quality checks

»»» Print QR codes and enter Trolley information



Digital System – Acquisition Layer: MES

Factory Scanning App

Assembly Jig overview

PROJECT: -ALL- JIG STATUS: Jig 1 Completed: 0 Available, Jig 2 Completed: 0 Available, Jig 3 Completed: 0 Available, Jig 4 Completed: 0 10752-MRT-ZZ-GF-DR-S-6514-14RC3

ASSEMBLY REF	REV	HIGH PRIORITY	STORAGE TIME	START TIME	END TIME	SCREW NUM	OPERATORS	STATUS	ACTION
10752-MRT-ZZ-01-DR-S-6518-18IW2 QR	C02		1422 hrs	12/08/2025 07:59	12/08/2025 09:52		Paul Mitchell,Brett Thackray,Billy Sweet	ABORT	Audit OPEN
10752-MRT-ZZ-01-DR-S-6519-19FC6 QR	C01		1159 hrs	20/08/2025 12:25	22/08/2025 09:21	280	Carl Chapman,Terry Goodwin,Paul Mitchell,Jonathan Howe	ABORT	Audit OPEN
10752-MRT-ZZ-GF-DR-S-6506-6GW1 QR	C03		893 hrs	02/09/2025 08:28	02/09/2025 11:39	100	Terry Goodwin,Paul Mitchell	ABORT	Audit OPEN
10752-MRT-ZZ-GF-DR-S-6514-14RC3 QR	C01		364 hrs	26/09/2025 12:01		196	Mark Scott,Brett Thackray,Billy Sweet,Kevin Scott	ON HOLD	Audit OPEN
10752-MRT-ZZ-GF-DR-S-6514-14RC4 QR	C01		362 hrs			196		AVAILABLE	Audit
10752-MRT-ZZ-GF-DR-S-6508-8FC1 QR	C02		77 hrs			60		AVAILABLE	Audit
10752-MRT-ZZ-GF-DR-S-6508-8FC2 QR	C01		76 hrs			140		AVAILABLE	Audit
10752-MRT-ZZ-GF-DR-S-6508-8FC3 QR	C01		76 hrs			100		AVAILABLE	Audit
10752-MRT-ZZ-GF-DR-S-6508-8FC4 QR	C01		75 hrs			60		AVAILABLE	Audit
10752-MRT-ZZ-GF-DR-S-6508-8RC1 QR	C01		75 hrs			36		AVAILABLE	Audit

Assembly Ref: SCAN ✓ Verify Assembly Ref



Completed Howick Jobs flows as available into the Jigs area

»»» Jobs have different status and informations

»»» Workers can log in the job by scanning frames QR code

Factory Scanning App

Assembly Ref: 10752-MRT-ZZ-GF-DR-S-6514-14RC3 Reision No: C01 Status: ON HOLD Start Time: 26/09/2025 12:01 End Time: Jig: Jig 4 Operators: Mark Scott, Brett Thackray, Billy Sweet, Kevin Scott

NAME	WORKSTART	END OF SHIFT
Mark Scott	26/Sep 12:01:43 - 26/Sep 13:23:45	26/Sep 13:23:45 -
Brett Thackray	26/Sep 12:17:13 - 26/Sep 13:23:36	26/Sep 13:23:36 -
Billy Sweet	26/Sep 12:17:27 - 26/Sep 13:23:50	26/Sep 13:23:50 -
Kevin Scott	26/Sep 12:17:39 - 26/Sep 13:23:55	26/Sep 13:23:55 -

Audit Sheet Fit QR codes to Frame Location Stillage loc. missing

Jobs control panel enables to capture several process driven activities

»»» Uptime and downtime events

»»» Record quality checks

»»» Enter Storage Location

Digital System – Acquisition Layer: MES

The screenshot shows a digital interface for managing stillages. At the top, there's a header with icons for home, history, jobs, and more, and a user name 'Andrea Sbaragli'. Below the header is a section titled 'Logistic overview' with a 'SharePoint: Stillage Delivery Note' button. A search bar labeled 'STILLAGE NAME' with a 'Filter' button is present. The main area is a table with columns: STILLAGE NAME, LOCATION, STATUS, FRAME COUNT, FACTORY TIME, and SHIPPING TIME. The table lists eight stillages:

STILLAGE NAME	LOCATION	STATUS	FRAME COUNT	FACTORY TIME	SHIPPING TIME
Wall Pam Stillage 1	Factory	AVAILABLE	2	06/10/2025 12:27	<button>OPEN</button>
Wall Pam Stillage 2	Factory	AVAILABLE	0	06/10/2025 08:59	<button>OPEN</button>
Wall Pam Stillage 3	Factory	AVAILABLE	0	06/10/2025 11:32	<button>OPEN</button>
Wall Pam Stillage 4	Shipped to Site	FULL	1	01/10/2025 11:34	06/10/2025 10:08 <button>OPEN</button>
Wall Pam Stillage 5	Factory	AVAILABLE	0	06/10/2025 13:47	<button>OPEN</button>
Wall Pam Stillage 6	Factory	AVAILABLE	0	06/10/2025 15:54	<button>OPEN</button>
Wall Pam Stillage 7	Factory	FULL	1	03/10/2025 10:40	03/10/2025 10:34 <button>OPEN</button>
Wall Pam Stillage 8	Factory	FULL	0	07/10/2025 09:31	<button>OPEN</button>

At the bottom right of the table area, it says '8 stillages'.



The Logistic Area digitize Stillages delivery to site

- »»» Stillages have several features
- »»» Admin staff logs into Stillages by pressin OPEN

This screenshot shows a detailed view of a specific stillage. On the left is a sidebar with filters for Stillage Name (Wall Pam Stillage 4), Status (FULL), Location (Shipped to Site), Frame Count (1), Shipping Time (06/10/2025 10:08), and Factory Time (01/10/2025 11:34). The main panel has a title 'Frames in Wall Pam Stillage 4 (shipped)' with '1 frames' and 'Project: 10300'. It lists one frame: '10300-test8 [C01]'. To the right is a list titled 'Frames NOT in Wall Pam Stillage 4' with '7 frames': '10300-test12 [C22]', '10300-test15 [C22]', '10300-test7 [C12]', '10711-MRT-ZZ-GF-DR-S-6501-1IW1 [C06]' (with a note 'Stillage is FULL or Shipped to Site. Cannot transfer frame to it'), '10300-test20 [C03]', '10752-MRT-ZZ-01-DR-S-6518-19GW3 [C02]', and '10300-test22 [C01]'. At the bottom are buttons for 'Return to Factory' and 'Confirm Stillage Return'.

Stillages control panel list stored frames and has several features

- »»» Possibility to modify Status, Location and Stored Frames
- »»» Automatic generation of Delivery Notes

How to leverage these data for a data-driven decision making?

Digital System – Dashboard



Production

» To track overall project status

Howick

» Machine and workforce efficiency

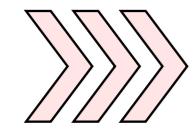
Jigs

» Jigs and workforce efficiency

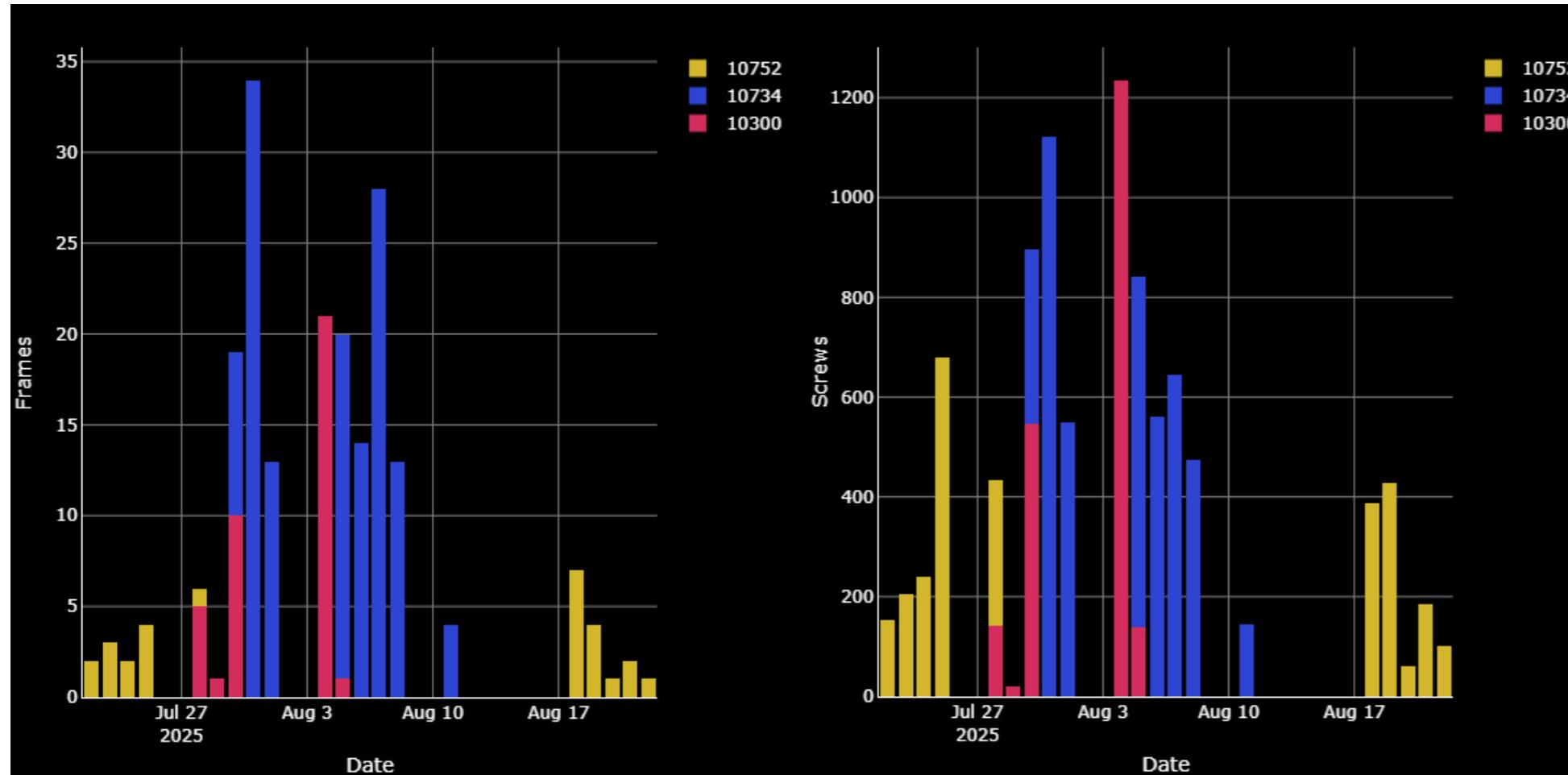
Planning

» Forecast cycle times before scheduling

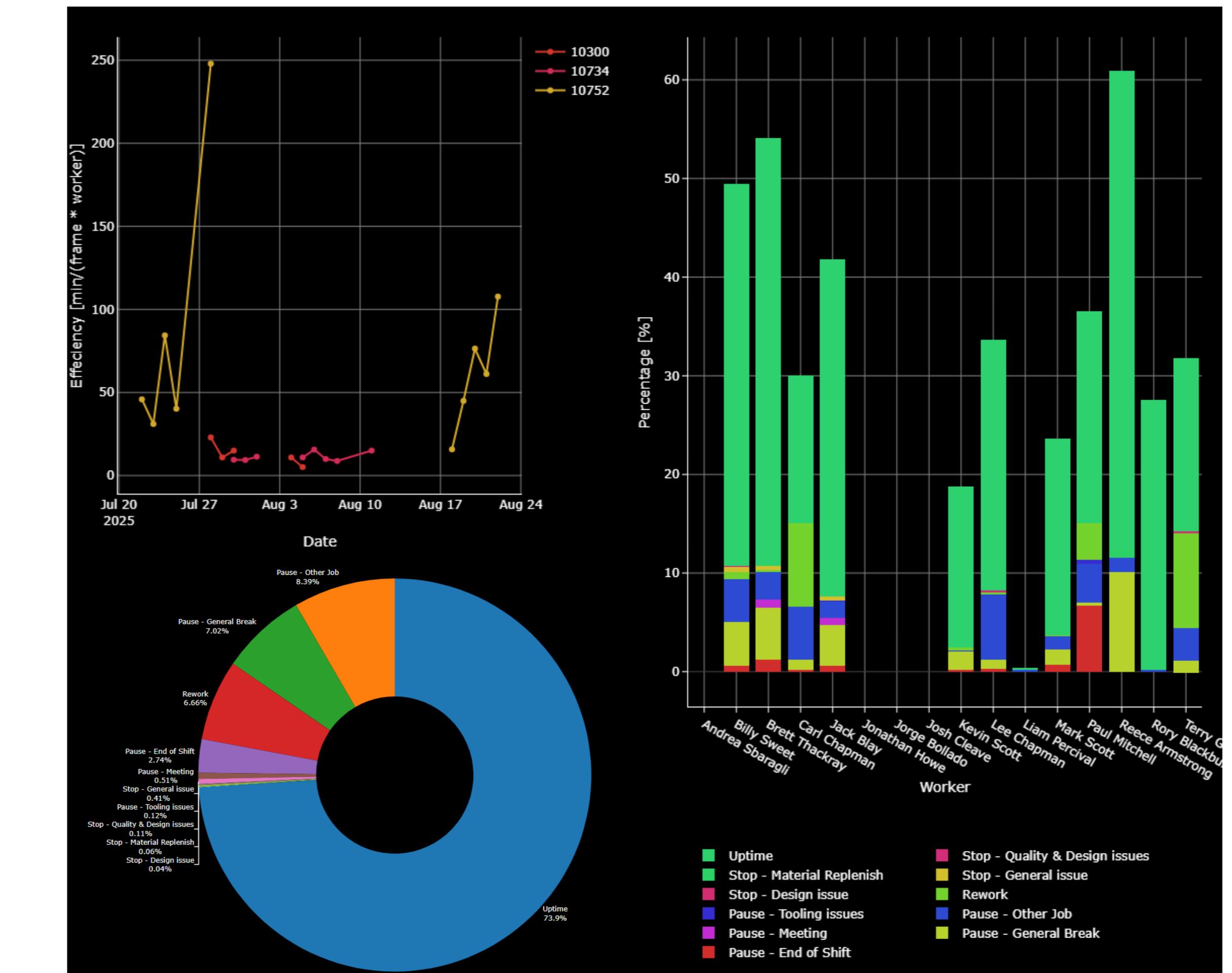
Digital System – Dashboard: Jigs



Jigs area efficiency



Workforce efficiency



Digital System – Dashboard: Planning



Manufacturing engineers interact with this table to forecast the Assembly Reference (ARef) Work Time (WT) for production cycles

ProjectID	ARef	Coil	Len	WT [min]
P1	AR-01	C1	50.2	7.4
P1	AR-02	C1	32.7	5.5
P2	AR-03	C3	15.0	3.7
...
P4	AR-50	C3	77.5	13.1



Enhanced visibility for **coil consumption** and **cost allocation**



Detailed **shipping due dates** to site

What is the methodology to forecast working times?

Digital System – Dashboard: Planning



This approach has been validated with 8 months of productions involving 2099 frames having working times between 0.2 to 26.4 minutes



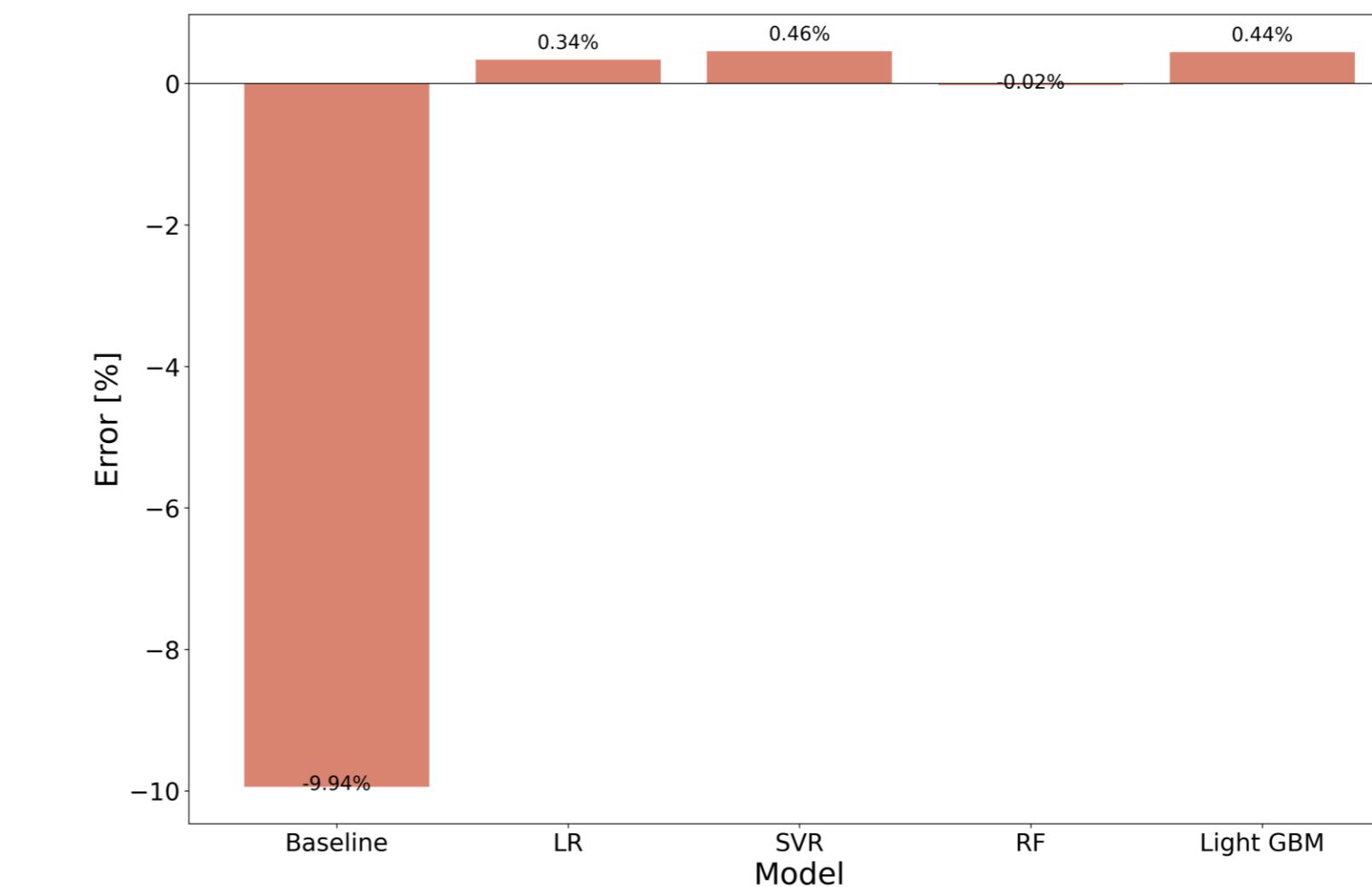
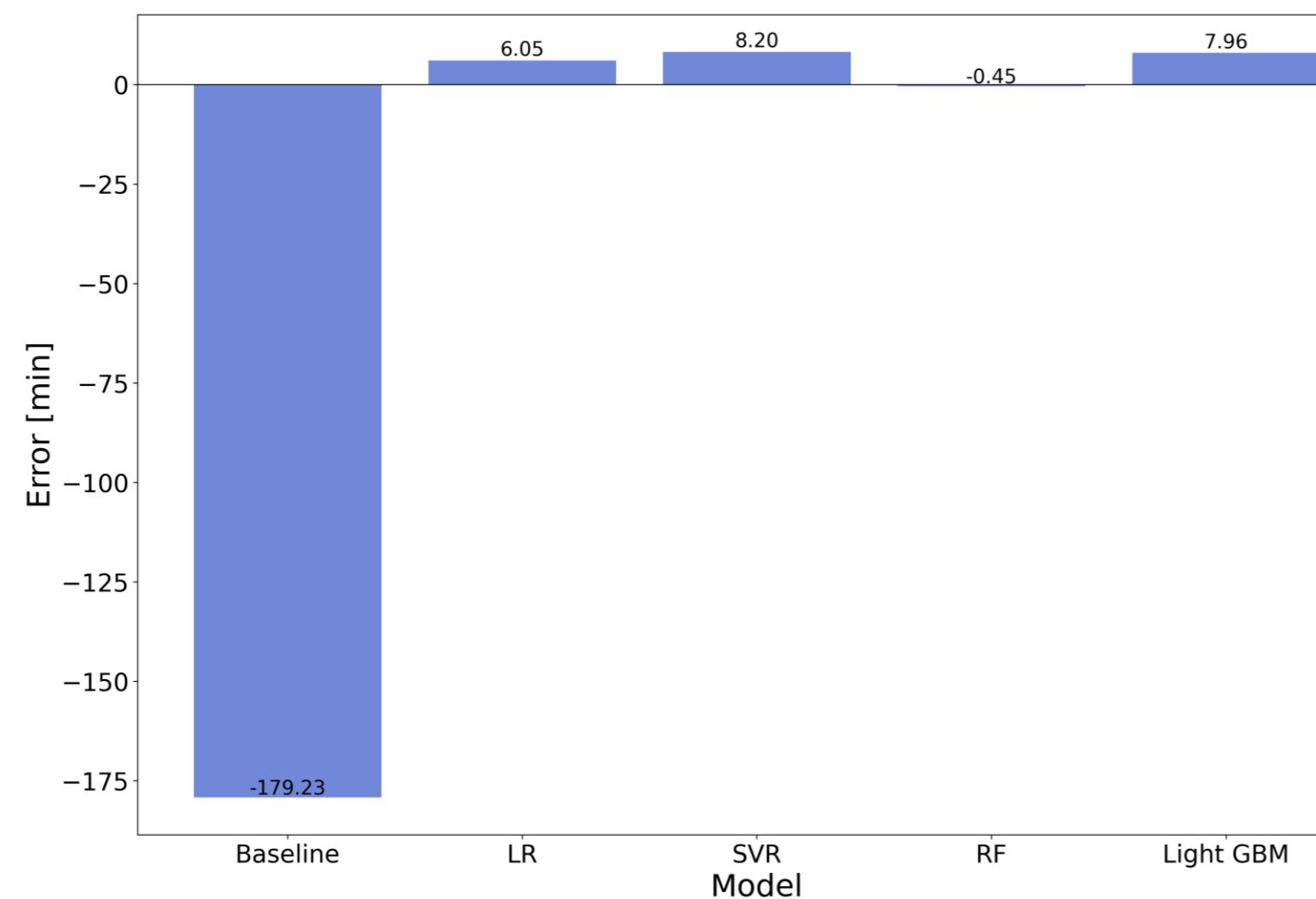
Feature extraction of design features



Machine learning models to forecast work times

Regressor	TrTime [sec]	RMSE	MAE	MAPE	MdAE	MdAPE	R ²
Baseline	NA	1.19	0.78	19.09%	0.50	17.81%	0.84
LR	NA	0.72	0.51	14.51%	0.37	11.36%	0.94
SVR	8.2	0.88	0.55	17.26%	0.39	12.39%	0.92
RF	44.0	0.85	0.52	13.79%	0.33	10.84%	0.92
Light GBM	14.8	0.85	0.55	16.02%	0.37	11.92%	0.92

Error Propagation on the test set (420 frames)



Conclusions



Use Case

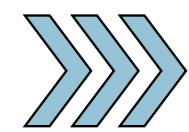
- How manufacturing operations are structured?
- Which digital solution is required to improve the operations?

Digital
Solution

- Acquisition Layer: which data has to be captured for a data-driven decision making?
- Cyber Layer: What are algorithms to be leveraged to derive KPIs?
- Dashboard: How to structure the data analytics?

Conclusions

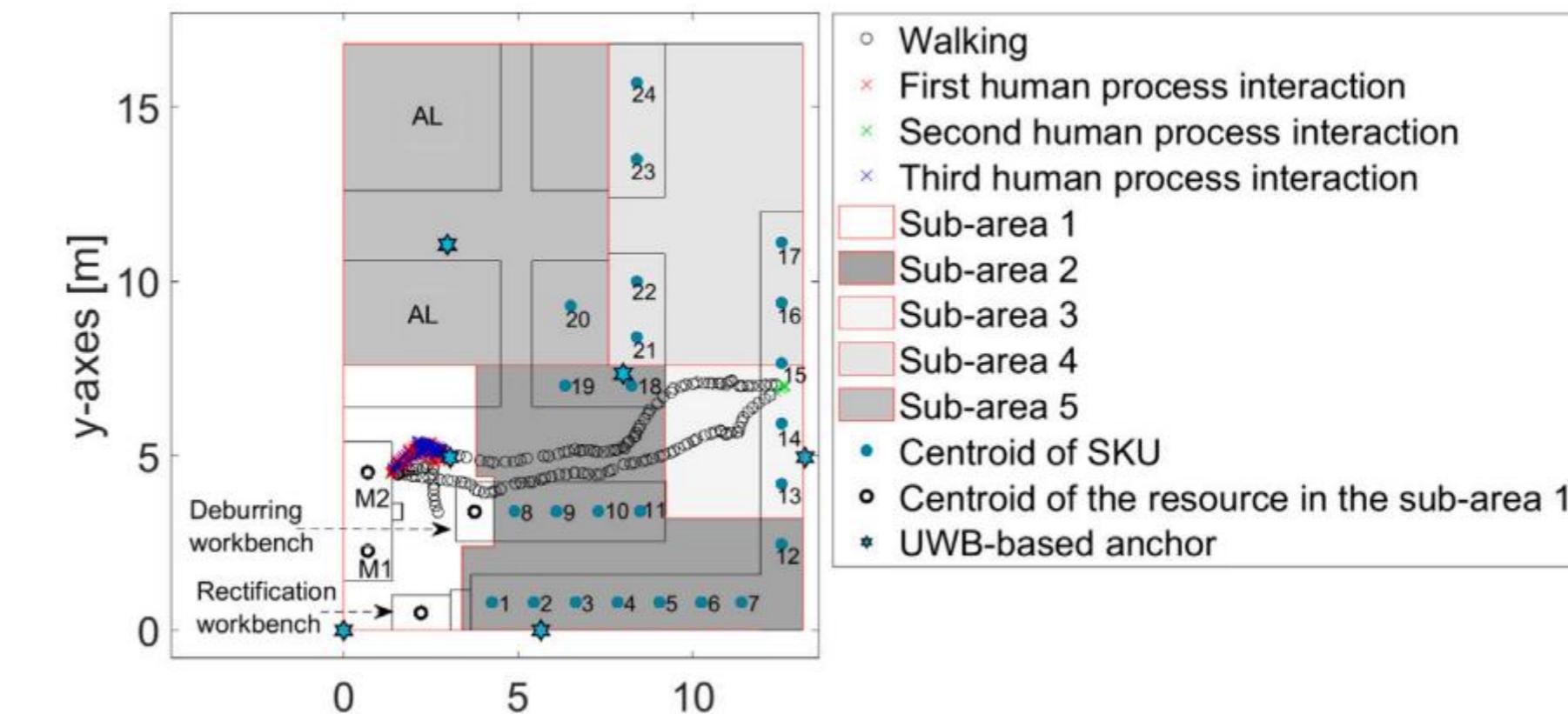
What is coming next?



Finalise the data analytics dashboard



Use of Internet of Things sensors to improve assets visibility



Delivery Team



Automation Team



Namra Mahak
Automation Developer



Mark Lui
Power Platform
Engineer



Shambhavee Pandey
Dev Project Lead



Cashin Martin
Data Engineer

Production Team



Robert Wade
Director of Production



Gary Armstrong
Manufacturing Engineer



Daniel Stanbury
Programme and Performance
Reporting Specialist



MERIT



Innovate
UK

*Thank you very much
for your attention*

*Andrea Sbaragli, PhD
15th October 2025*