MERIT

Delivering
Excellence
Together

Newcastle University

UKRI Innovate UK

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

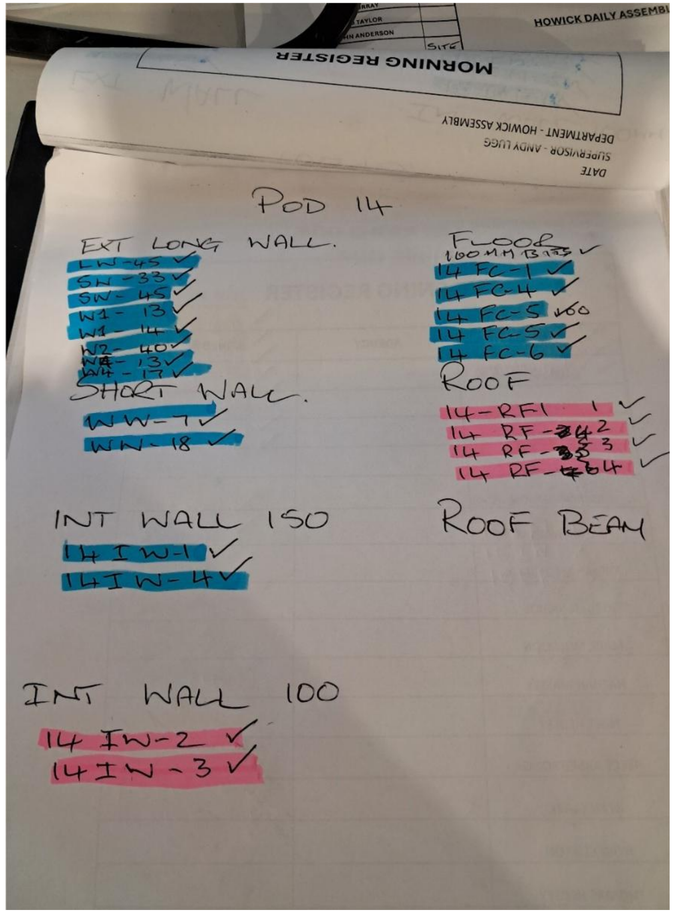
Introduction

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

MERIT

Knowledge based approach

Design

Manufacturing

- Monitoring
- Planning
- Scheduling

Which manufacturing job shop is considered?

Use Case

MERIT

Steel Frame System Coil

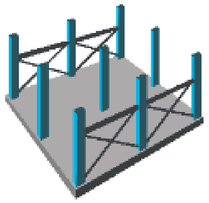
Width x Depth (mm)

75x50 | 100x50 | 150x50 | 200x50 | 250x50

Howick Frama

TROLLEY STORAGE

Assembly Jigs



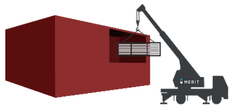
Storage

High Bay

Transition Area

Production Output

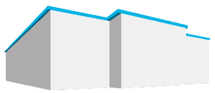
Wall PAM



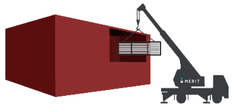
LONG WALL | GABLE END WALL

INTERNAL WALL | ROOF BEAM

ROOF CASSETTE | FLOOR CASSETTE

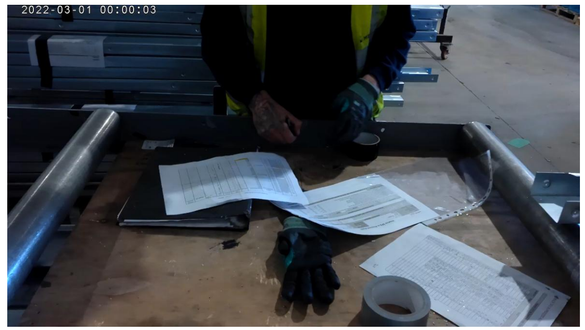


TRANSITION PAM



Use Case

Howick Machine



1 dedicated operator:

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

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

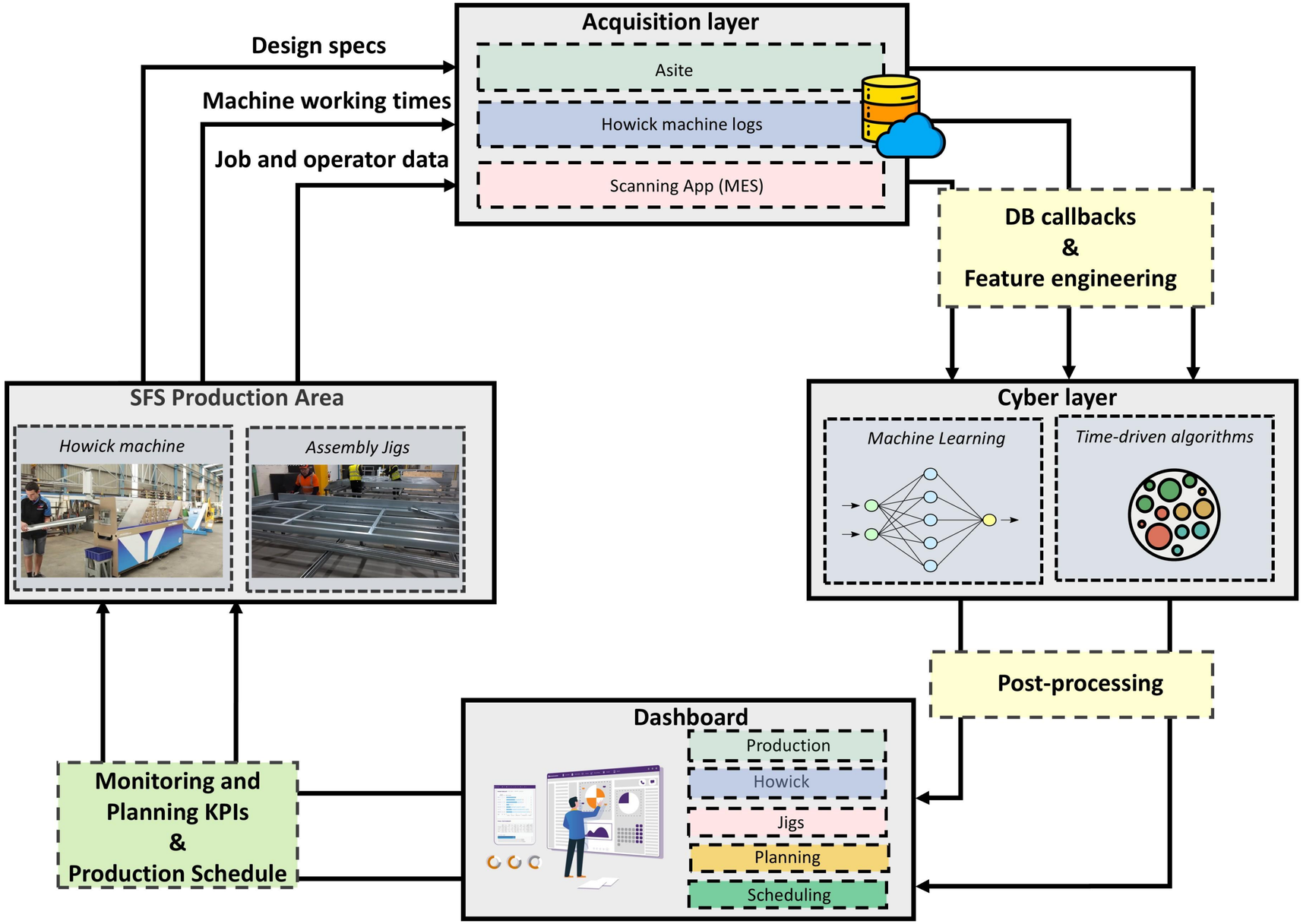
Assembly jigs

- 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

Stillages

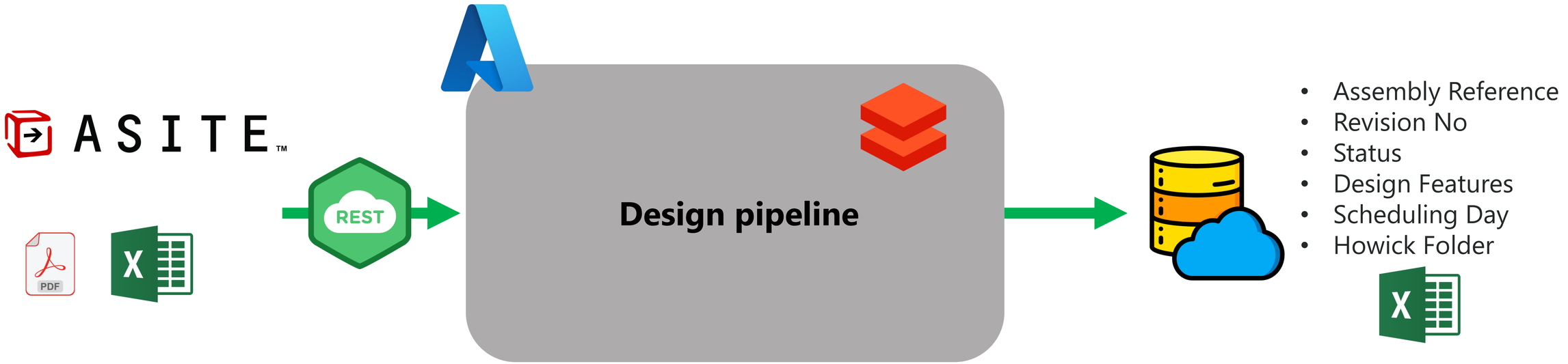
- Store variable number of WallPams
- Used for on-site delivery

Digital System - Overview



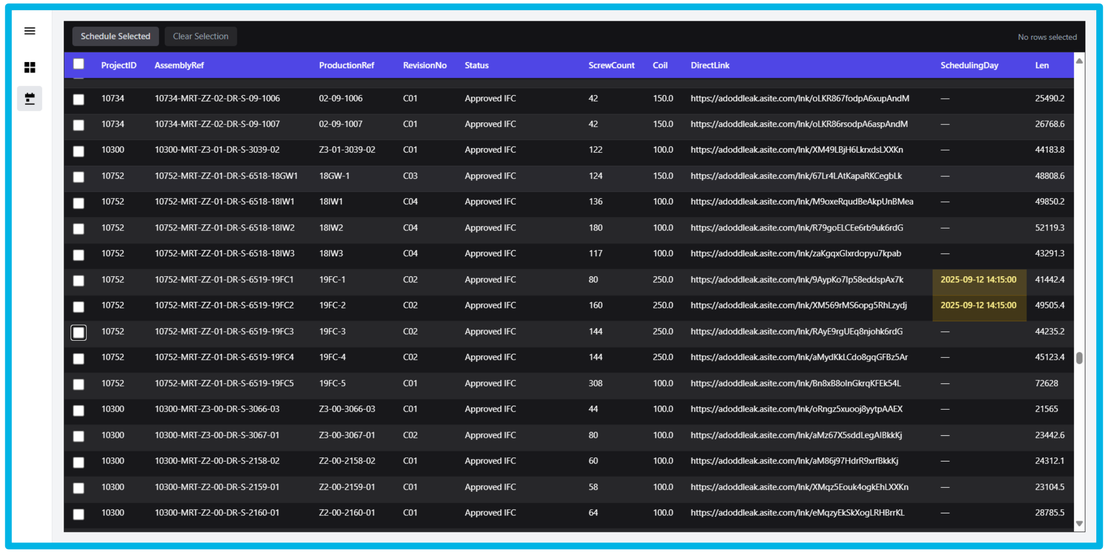
Digital System – Acquisition Layer

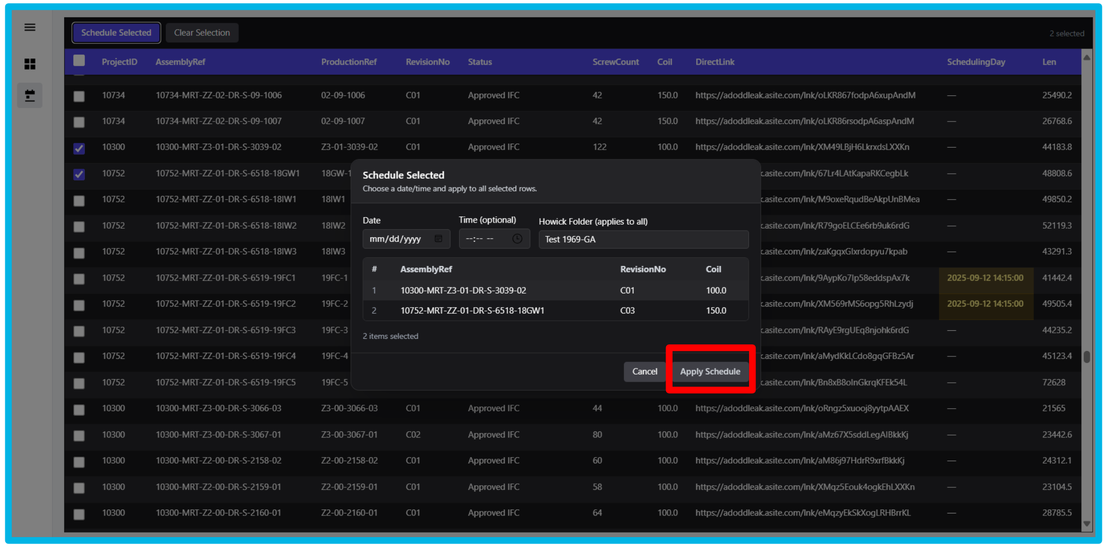
MERIT



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

Digital System – Dashboard: Scheduling





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

Manufacturing
-
Machine Pipeline

- Assembly Reference
- Revision No
- Status
- Production Time

Digital System – Acquisition Layer: MES

MERIT

Factory Scanning App

Andrea Sbaragli

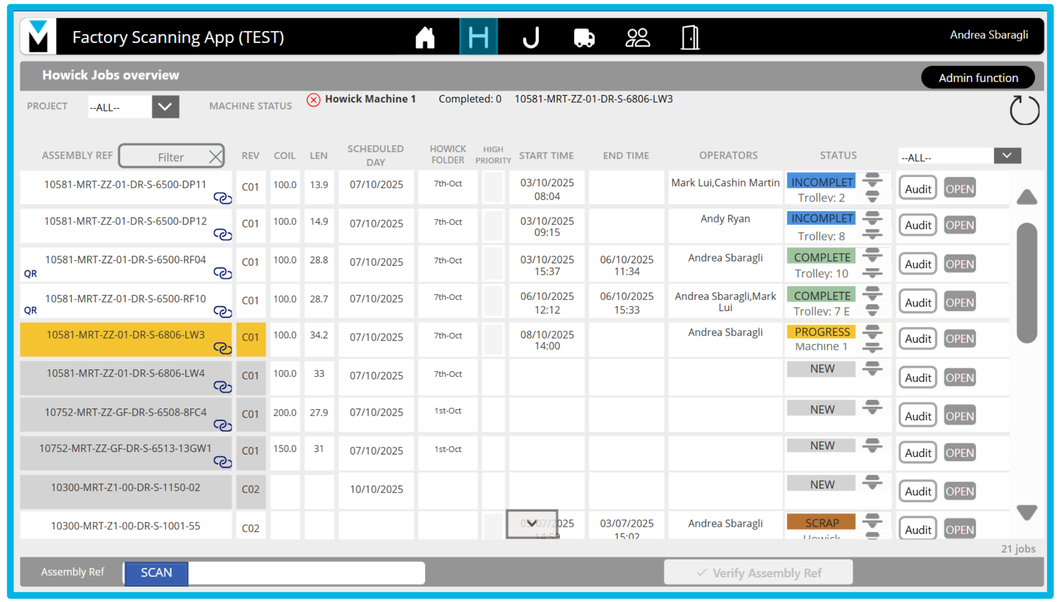
Howick Jobs

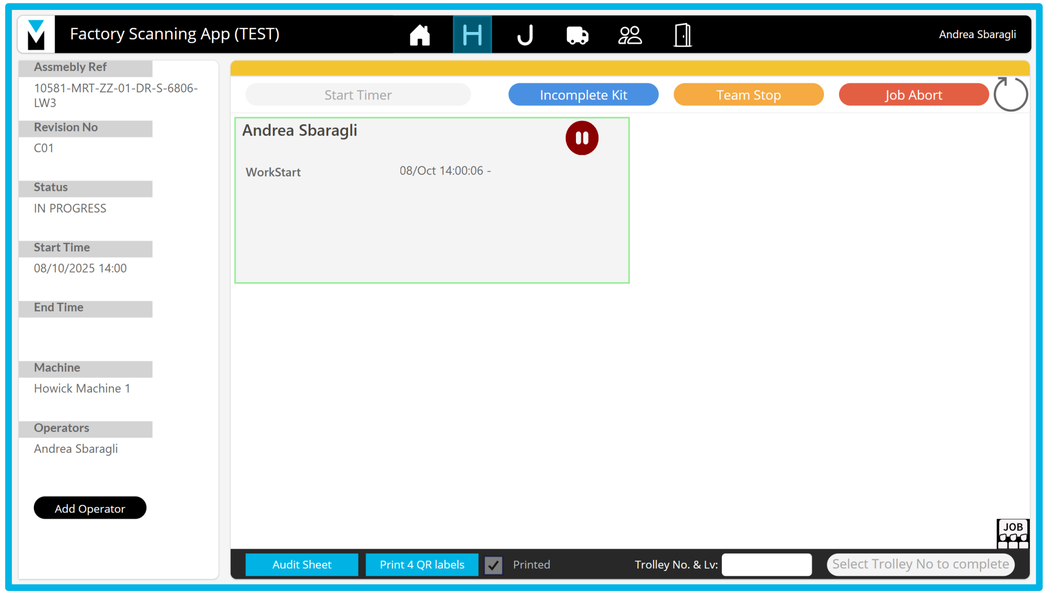
Assembly Jigs

Logistic

You're now login as Andrea Sbaragli

Digital System – Acquisition Layer: MES





MERIT

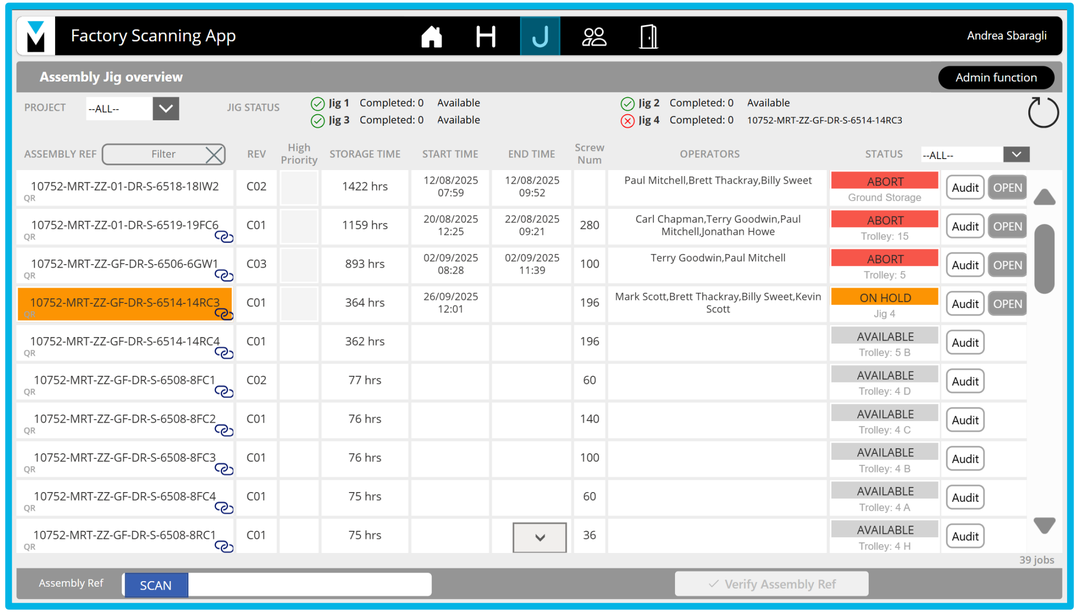
Scheduled Jobs flows into the Howick Area of the Manufacturing Excution System (MES)

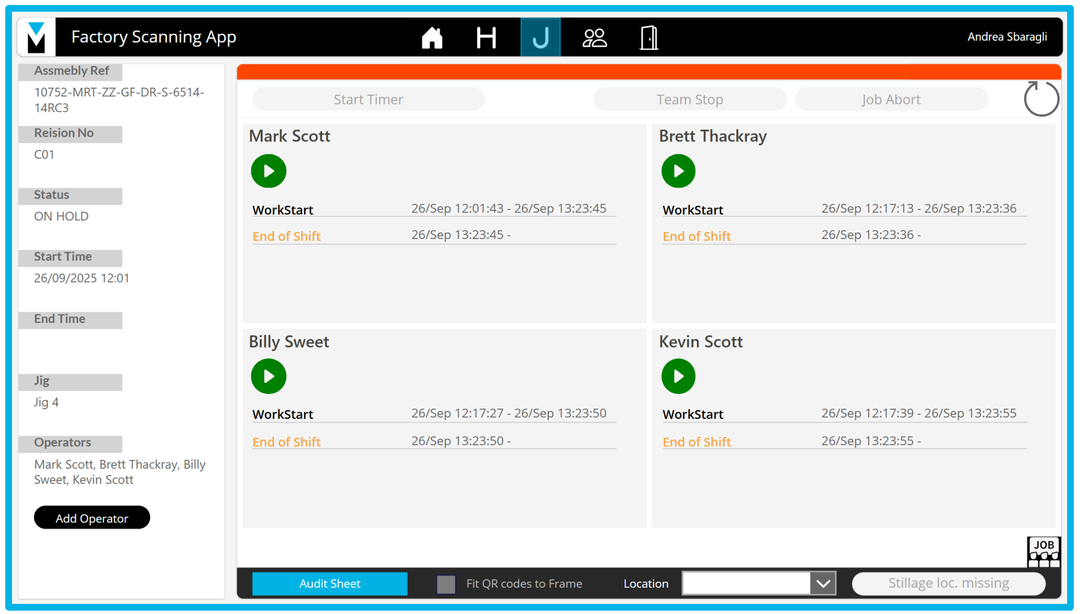
- Jobs have different status and informations
- Workers can log in the job by pressing OPEN

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





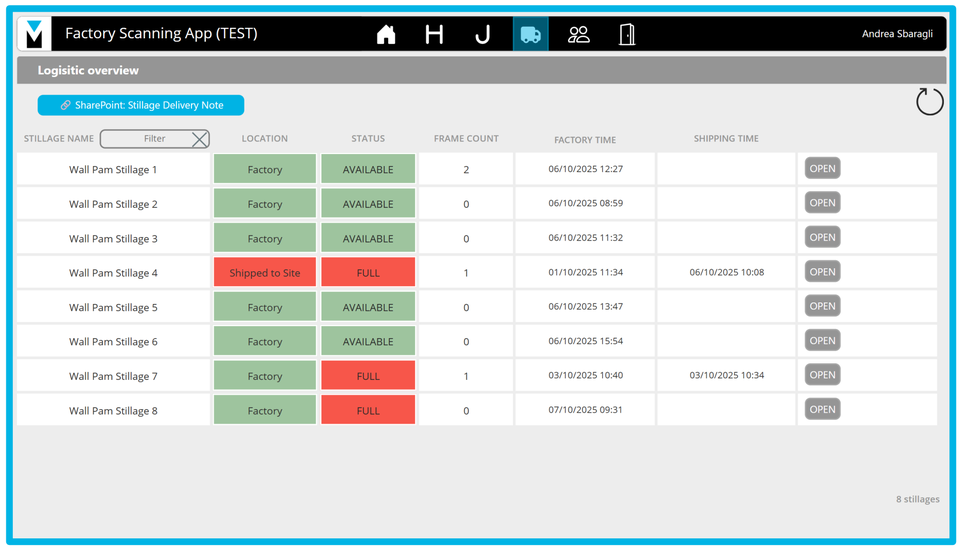
Completed Howick Jobs flows as available into the Jigs area

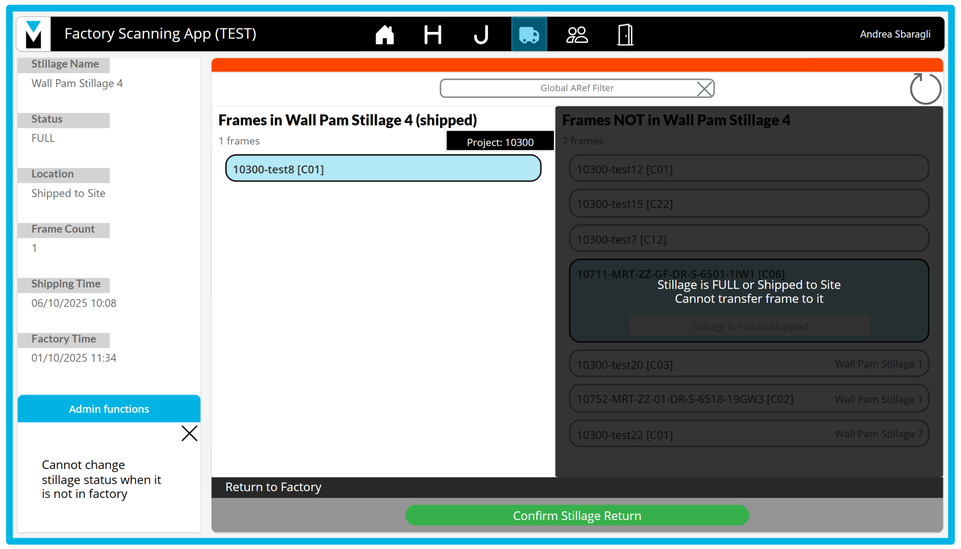
- Jobs have different status and informations
- Workers can log in the job by scanning frames QR code

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





MERIT

The Logistic Area digitize Stillages delivery to site

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

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?

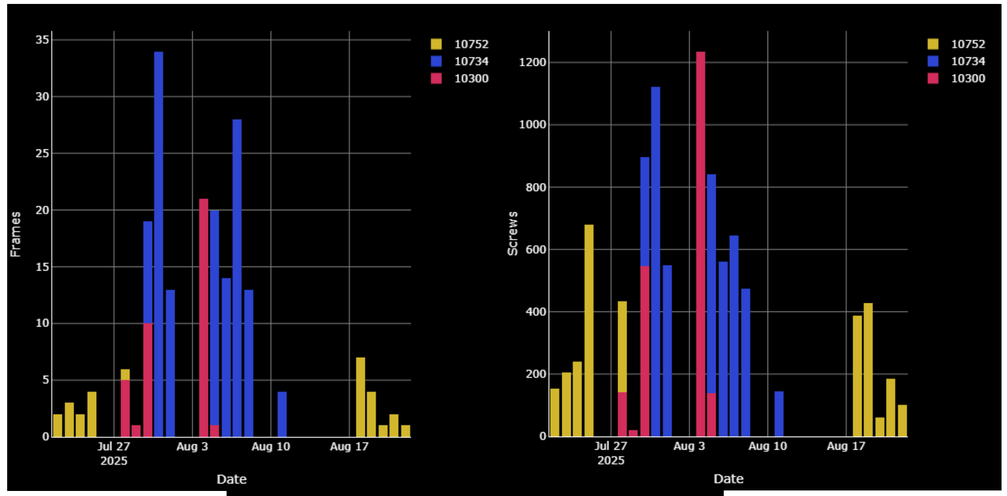
Digital System – Dashboard

- **Production** — To track overall project status
- **Howick** — Machine and workforce efficiency
- **Jigs** — Jigs and workforce efficiency
- **Planning** — Forecast cycle times before scheduling

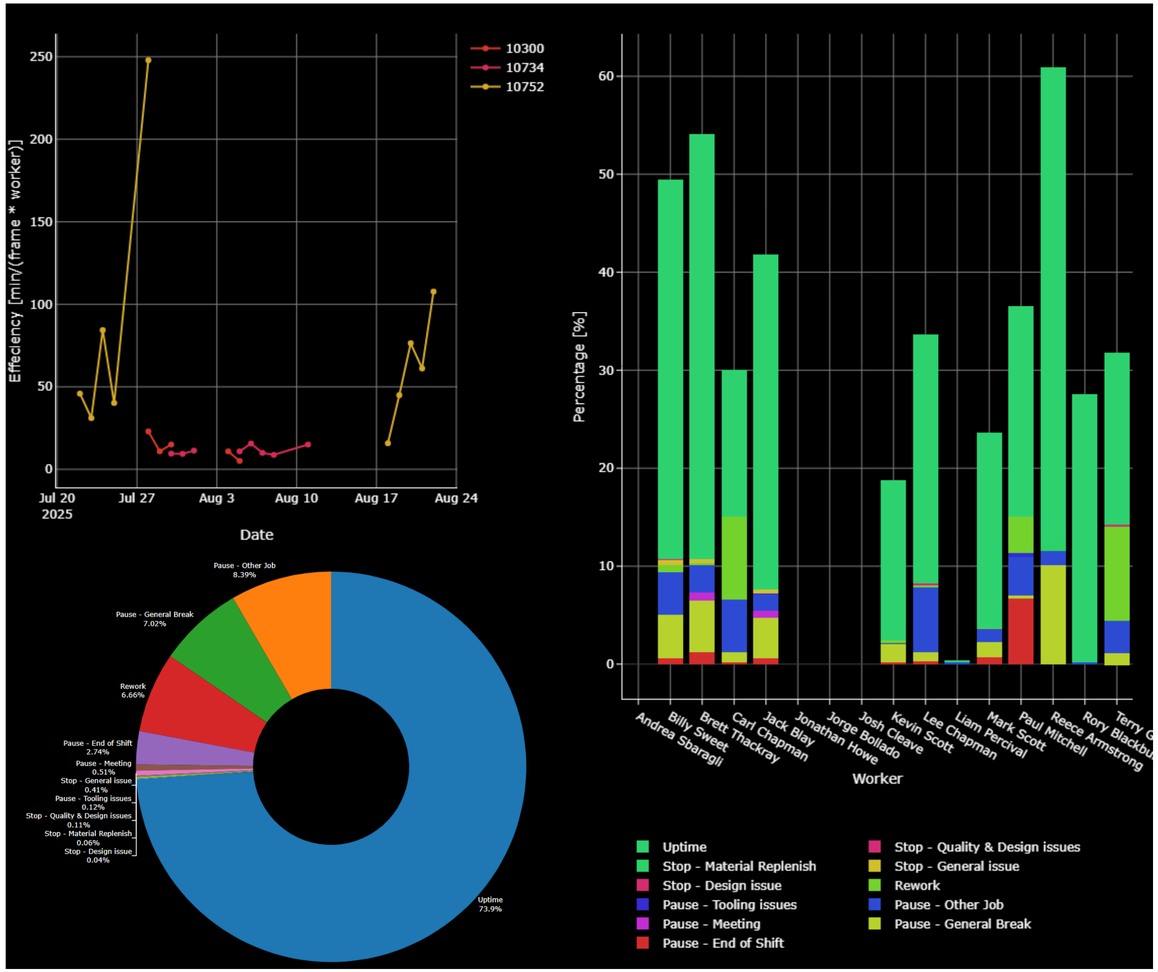
Digital System – Dashboard: Jigs

MERIT

Jigs area efficiency



Workforce efficiency



Digital System – Dashboard: Planning

Manufacturing engineers interacts 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

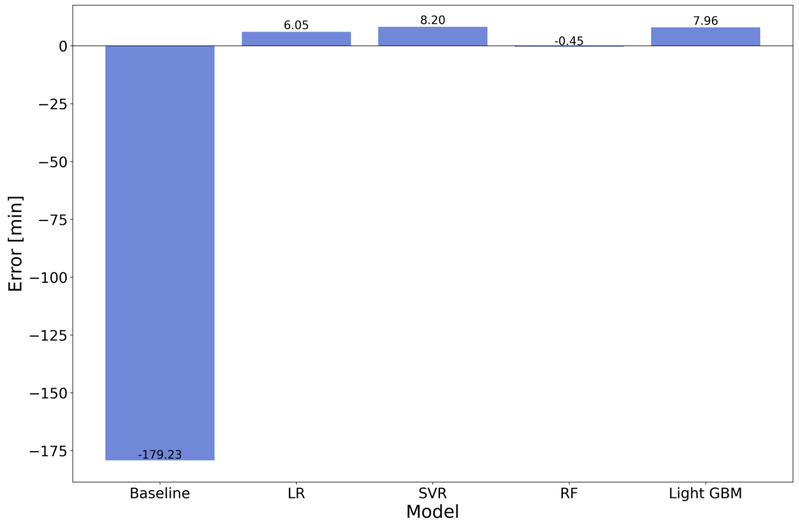
This approach has been validated with 8 months of productions involving 2099 frames having working times between 0.2 to 26.4 minutes

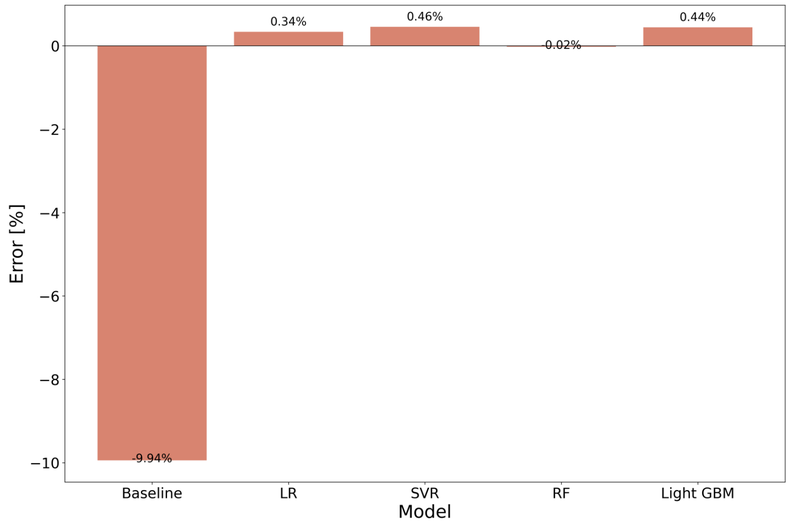
Feature extraction of design features

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

MERIT

Use Case

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

Digital Solution

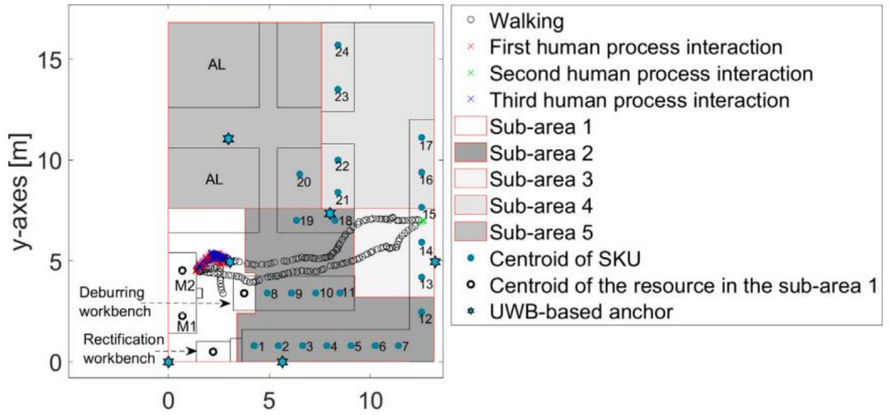
- Acquisition Layer: which data has to be captured for a data-driven decision making?
- Cyber Layer: What are algorithms to be leveraged to derive KPIs?
- Dashboard: How to structured the data analytics?

Conclusions

What is coming next?

- Finalise the data analytics dashboard

- Use of Internet of Things sensors to improve assets visibility



Delivery Team

MERIT

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

Newcastle University

UKRI Innovate UK

Thank you very much for your attention

Andrea Sbaragli, PhD
15th October 2025