📌 Overview

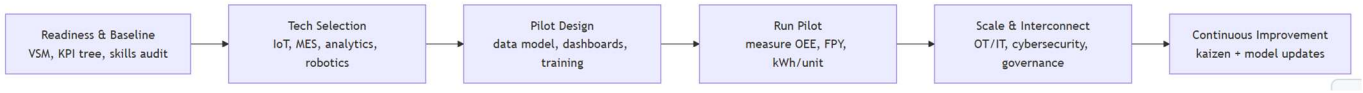
This project develops a practical **Smart Lean Manufacturing** framework that integrates **Lean** principles with **Industry 4.0** technologies for the **UK automotive sector**. It consolidates literature, case insights, and a phased implementation roadmap toward **data-driven, connected, and adaptive** operations.

Goal: Build and validate a phased framework that improves **productivity, quality, flexibility, and sustainability** while addressing **people, process, technology, and cybersecurity**.

🎯 Objectives

1. Assess Lean adoption, challenges, and opportunities in UK automotive.
2. Map relevant Industry 4.0 technologies to Lean value streams.
3. Design a phased implementation roadmap (assessment → pilots → scale).
4. Define KPIs for validation (productivity, quality, cost, **OEE**, energy, lead time).
5. Address human factors, training, and cybersecurity for safe adoption.

Roadmap at a glance



🧩 Framework (Lean × I4.0)

- **Lean core:** Waste elimination, flow, JIT, **Jidoka**, **Kaizen**, **VSM**, **TPM**, **SMED**.
- **I4.0 enablers:** IoT sensors, CPS, robotics/AGVs, analytics/**AI-ML**, digital twins, AR, MES.
- **Phases: Readiness** → **Tech selection** → **Pilot** → **Scale** → **Interconnect** → **Data-driven optimisation** → **Training** → **Continuous improvement**.

📈 KPIs (examples used in validation plan)

- **Productivity:** Throughput, cycle time, flow efficiency, **OEE**
- **Quality:** First-pass yield, defects per million (DPMO), rework rate
- **Cost/Energy:** Conversion cost per unit, **kWh/unit**, maintenance cost
- **Flexibility:** Changeover time (**SMED**), mix responsiveness
- **Sustainability:** Energy intensity, scrap rate, **CO_2e per unit**
- **People:** Training hours, ergonomics incidents, idea implementation rate