Project 1: Intelligent Industrial Plant Operations Assistant (IIPOA)

1. Project Title

IIPOA – AI-Powered Multi-Disciplinary Industrial Operations Assistant

2. Problem Statement

Large industrial plants require coordination across multiple engineering domains: mechanical, civil, automation, and safety. Challenges include:

- Monitoring and maintaining mechanical equipment (pumps, turbines, motors)
- Tracking structural integrity of facilities and infrastructure
- Ensuring safety compliance in real-time
- Integrating automation systems (PLC/SCADA) with engineering workflows
- Manual, error-prone reporting and coordination

Current issues:

- Fragmented data across domains
- Delayed identification of critical issues
- Risk of accidents due to lack of predictive safety and maintenance insights

3. Proposed Solution

Build an AI-powered **multi-agent operations assistant** that:

- Monitors mechanical equipment for predictive maintenance
- Checks structural health and civil infrastructure stability using IoT sensors and CAD/BIM data
- Oversees PLC and automation system health
- Flags safety violations in real-time

- Automates repetitive reporting and workflow tasks

4. Project Objective

- Centralize multi-domain operational knowledge
- Reduce unplanned downtime
- Enhance workplace safety and compliance
- Automate monitoring and reporting
- Improve engineering decision-making

5. System Architecture

1. **Data Layer**:
    - IoT sensors (vibration, pressure, load, temperature)
    - Structural monitoring sensors (strain gauges, deflection sensors)
    - PLC/Automation logs
    - Safety inspection and incident data
2. **AI Orchestration Layer**:
    - Multi-agent system (LangChain + GPT-4)
    - Agents: Mechanical Health Agent, Structural Integrity Agent, Automation/PLC Agent, Safety Compliance Agent, Report Generator Agent
3. **Knowledge Layer**:
    - RAG system for SOPs, manuals, structural guidelines, and engineering documentation
4. **Frontend Dashboard**:
    - React + Tailwind
    - Real-time alerts

    - Multi-domain KPI visualizations
    - Automated report generation
5. **Backend**:
    - FastAPI, Python, PostgreSQL + FAISS/Chroma for vector-based document retrieval

6. Technology Stack

- **Mechanical**: Sensor analysis, predictive maintenance ML models
- **Automation/PLC**: SCADA/PLC integration, anomaly detection, automated workflow
- **Civil/Structural**: Structural health monitoring, BIM integration, predictive stress analysis
- **Safety**: NLP-based SOP analysis, real-time safety alerts, risk scoring
- **Full Stack**: React, Tailwind, Python, FastAPI, Docker, LangChain + GPT-4

7. Dataset Details

- Mechanical equipment logs and maintenance history
- PLC logs and automation scripts
- Structural sensor readings and CAD/BIM files
- Safety incident reports, inspection logs, regulatory manuals

8. Features

- Predictive maintenance for mechanical systems
- Automated structural integrity assessment
- PLC/automation anomaly detection
- Safety violation detection and recommendations

- Multi-domain KPI dashboard
- Auto-reporting for management

9. Sample Use Cases

User	Use Case
Engineer	Predict turbine bearing failure
Civil Supervisor	Assess structural load risks in a facility
Automation Lead	Detect PLC signal anomalies in real-time
Safety Officer	Receive automated safety compliance alerts
Manager	Review multi-domain operational health report

10. Metrics of Success

- Equipment downtime reduction ≥ 50%
- Safety incident reduction ≥ 40%
- Accuracy of structural risk detection ≥ 90%
- Workflow automation efficiency ≥ 60%

11. Future Enhancements

- Drone-based structural inspections
- AR/VR dashboards for plant visualization
- Autonomous multi-agent maintenance execution
- Integration with ERP (SAP) and construction management software

12. Why This Project is Valuable to John Cockerill

- Directly aligns with multi-disciplinary industrial operations

- Demonstrates AI integration in mechanical, civil, automation, and safety domains
- Reduces operational costs and improves plant safety
- Supports smart, Industry 4.0-enabled execution workflows

13. Author

Prakriti Sharma – AI, Multi-Agent Systems, Industrial Engineering