



## Background

Our company operates five integrated steel plants across eastern India and imports large volumes of coking coal and limestone from international suppliers. After procurement, the raw material is transported by sea in bulk carriers to Indian east coast ports and then further moved to steel plants by rail.

Currently, port-plant logistics planning is carried out using SAP and Excel-based workflows. This planning process includes the scheduling of vessels, selection of discharge ports, and dispatch planning of raw material to plants based on various cost and operational constraints.

### Detailed Description

The logistics team is responsible for minimizing the total cost of transportation while ensuring timely and quality-specific delivery of raw materials to steel plants. Inputs include STEM data (supplier, loadport, parcel size, laydays), vessel schedules, stock availability, and central planning dispatch requirements.

Cost elements considered:

Ocean freight differentials

Port handling and storage costs

Railway freight

Demurrage costs due to vessel delays

Constraints include:

Port and plant-specific stock capacities

Quality and plant wise dispatch requirements

Railway rake availability

Maximum port call limitations per vessel

Sequential discharge constraint (Haldia always second)

Age and arrival time of stock at port (e.g., vessel arrival mid-month)

Expected Solution

The solution should be a System-Driven Logistics Optimization Module with the following capabilities:

a) Optimization Engine:

- Provide least-cost port-plant dispatch plans while satisfying all operational constraints.
- Handle variable, step, and time-dependent costs.
- Incorporate dynamic stock arrivals (linked to vessel ETA) and semi-discrete cargo units.

b) AI Intervention:

- Predict pre-berthing delays at load and discharge ports using AI/ML models.
- Incorporate predictions into vessel scheduling and cost calculations (demurrage).
- c) Data Integration:
  - Extract and utilize data from SAP and Excel-based sources.
- d) Decision Support Features:
  - Sensitivity and what-if analysis to simulate alternative scenarios.
  - User-friendly interface for logistics planners to interact with the model. what to build and give tech stack to use

Based on the comprehensive problem description and research into current logistics optimization and AI technologies, here's what you need to build and the recommended tech stack:

## System Architecture

The solution requires a **System-Driven Logistics Optimization Module** with four core components: an optimization engine, AI/ML prediction system, data integration layer, and decision support interface. <sup>[1] [2] [3]</sup>

## Core Components to Build

### Optimization Engine

- Multi-objective optimization solver for port-plant dispatch planning
- Constraint satisfaction system handling capacity, quality, and sequential discharge requirements
- Cost minimization algorithms incorporating freight differentials, handling costs, and demurrage<sup>[4] [5]</sup>

### AI/ML Prediction System

- Vessel delay prediction models for pre-berthing delays at load/discharge ports
- Dynamic ETA forecasting using historical AIS data and real-time conditions
- Demand forecasting for raw material requirements<sup>[6] [7] [8]</sup>

### Data Integration Layer

- SAP connector for enterprise data extraction
- Excel file processing and validation systems
- Real-time data streaming for vessel tracking and port conditions<sup>[3] [9]</sup>

### Decision Support Interface

- Interactive dashboard for logistics planners
- Scenario simulation and sensitivity analysis tools
- What-if analysis capabilities with visual optimization results<sup>[2] [10]</sup>

## Recommended Tech Stack

### Backend Framework

**Python with Django** - Ideal for enterprise-grade applications with built-in authentication, ORM, and scalability. Django handles complex business logic and integrates well with optimization libraries. [\[11\]](#) [\[12\]](#) [\[13\]](#)

### Optimization Engine

**Google OR-Tools** combined with **Gurobi Optimizer** - OR-Tools provides excellent constraint programming capabilities while Gurobi handles complex mixed-integer programming for cost optimization problems. [\[14\]](#) [\[15\]](#) [\[16\]](#)

### Machine Learning Stack

- **Python scikit-learn** for basic ML algorithms
- **XGBoost** for vessel delay prediction (proven 23% improvement in accuracy over traditional methods)
- **LSTM networks** using **TensorFlow/PyTorch** for time-series forecasting of vessel arrivals [\[7\]](#) [\[8\]](#) [\[17\]](#)

### Frontend Framework

**React.js with TypeScript** - Modern, component-based architecture ideal for complex dashboard interfaces with real-time updates. Pairs excellently with Django REST framework. [\[12\]](#) [\[18\]](#) [\[11\]](#)

### Database and Integration

- **PostgreSQL** for transactional data and optimization results
- **Redis** for caching and real-time data processing
- **Apache Kafka** for streaming vessel tracking data
- **REST APIs** for SAP integration and external data sources [\[9\]](#) [\[3\]](#)

### Deployment and Infrastructure

- **Docker** containers for microservices architecture
- **AWS/Azure** cloud deployment with auto-scaling
- **Kubernetes** for orchestration of optimization and ML workloads [\[19\]](#) [\[20\]](#)

### Additional Tools

- **Pandas/NumPy** for data processing and analysis
- **Plotly/D3.js** for interactive visualizations and sensitivity analysis
- **Celery** for background optimization tasks and batch processing [\[18\]](#) [\[9\]](#)

This tech stack provides the enterprise-grade reliability needed for steel industry operations while incorporating cutting-edge AI capabilities for predictive analytics and optimization. <sup>[1]</sup> <sup>[3]</sup> <sup>[9]</sup>

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