

Requirement Analysis Document (RAD)

Project Title:

AI-Based Logistics Optimization Platform for Cost-Optimal Vessel Scheduling and Port-Plant Linkages

Project Description:

This project aims to develop an **AI-powered logistics decision-support system** for SAIL to optimize vessel scheduling, port-plant linkage, and dispatch planning for imported coal and limestone. The system will integrate seamlessly with SAIL's SAP ecosystem to replace manual planning with intelligent, predictive, and cost-optimized logistics decisioning.

By leveraging **Machine Learning (ML)**, **operations research models**, and **real-time data visibility**, the platform will help drive cost savings, ensure uninterrupted production, and enhance logistics agility across all five integrated steel plants.

Module-wise Requirements with Time & ML Models

1. Import & Vessel Forecasting Module

Estimated Time: 4 weeks

Description:

Forecasts vessel arrivals using supplier STEMs, historical sailing time, weather patterns, and port performance.

Key Features:

- STEM data ingestion and vessel ETA forecasting
- Quality and port-wise vessel forecasting

- SAP integration for vessel tracking

ML Models:

- Time Series Forecasting: **ARIMA, Prophet**
 - Delay Prediction: **Gradient Boosting, Random Forest**
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2. Port-Plant Linkage Optimization Module

Estimated Time: 6 weeks

Description:

Automates optimal port-plant dispatch mapping based on real-time port stocks, vessel arrivals, rake availability, and demand.

Key Features:

- Daily and monthly dispatch planning
- Constraint-based optimization
- Cost-efficient route allocation

ML/OR Techniques:

- Integer/Mixed Integer Linear Programming (ILP/MILP)
 - Constraint Satisfaction Programming (CSP)
 - ML-assisted heuristics
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3. Logistics Cost Optimization Engine

Estimated Time: 6 weeks

Description:

Minimizes total logistics cost considering freight (ocean + rail), port handling charges, delays, and penalties.

Key Features:

- Total cost simulation per dispatch strategy
- Optimization across multiple cost factors
- Route and stock optimization

ML Models:

- Cost Prediction: **XGBoost, CatBoost**
 - Optimization: **Bayesian Optimization**
 - Strategy Learning: **Reinforcement Learning (RL)**
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4. AI-Based Recommendation Engine

Estimated Time: 6 weeks

Description:

Recommends optimal planning actions (vessel-port mapping, dispatch strategies) based on historical data and business rules.

Key Features:

- Historical pattern analysis
- SOP recommendations
- Next-best action engine

ML Models:

- Collaborative Filtering for dispatch patterns
 - Explainable Models: **Decision Trees, RuleFit, EBM**
 - Sequence Models: **Transformers (if high volume)**
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5. Visibility & Simulation Dashboard

Estimated Time: 5 weeks

Description:

Interactive real-time dashboard to monitor vessel movement, port stock, plant demand, and simulate alternate scenarios.

Key Features:

- Live supply chain map
- “What-if” simulation capability
- Alerts and visual analytics

ML Models:

- Anomaly Detection: **Isolation Forest, Autoencoders**
 - ML-based simulation surrogates
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6. Governance, KPI & Deviation Reporting Module

Estimated Time: 4 weeks

Description:

Tracks logistics KPIs, reports deviations from optimized plans, and highlights cost impact.

Key Features:

- SLA and deviation tracking
- Predictive performance monitoring
- Root cause analytics

ML Models:

- Clustering: **K-Means, DBSCAN**
- Model Drift Detection

7. Integration Layer with SAP & External Systems

Estimated Time: 4 weeks

Description:

Handles seamless integration between SAP, port systems, customs data, and rake data for planning and updates.

Key Features:

- REST/ODATA APIs
- Real-time data sync
- Adapter layer for legacy SAP

No ML required (data engineering focus).

8. Training, UAT & Change Management

Estimated Time: 4 weeks

Description:

UAT, deployment, user training, feedback loop, and change enablement.

Key Features:

- User acceptance testing
- Documentation & SOPs
- Master user training

Optional: Light ML tracking for user behavior/adoption.

Time & Delivery Estimation

Module	Time
1. Vessel Forecasting	4 weeks
2. Port-Plant Optimizer	6 weeks
3. Cost Optimizer	6 weeks
4. AI Recommendation Engine	6 weeks
5. Visibility Dashboard	5 weeks
6. Governance & Reporting	4 weeks
7. SAP Integration	4 weeks
8. UAT & Training	4 weeks
Total (sequential)	39 weeks

Recommended Tech Stack

1. Modeling (AI/ML Modules)

- Python (core language)
- Scikit-learn (classical ML)
- XGBoost, LightGBM, CatBoost (advanced regressors)
- Prophet / ARIMA (time series forecasting)
- OR-Tools / PuLP / Pyomo (optimization)
- TensorFlow / PyTorch (if deep learning is required)

2. API Development

- FastAPI (lightweight, high-performance API framework)
- Pydantic (schema validation)
- Uvicorn (ASGI server)
- MySQL or MongoDB (data storage)

3. Web App (Dashboard/UI)

- Angular 17 (frontend framework)
- Tailwind CSS / Bootstrap (styling)
- Chart.js / D3.js (visualization)
- Nginx (web server)