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TITLE PAGE

- **Problem Statement ID –** 25208
- **Problem Statement Title-** AI/ML-based Decision Support System for optimizing rake formation strategies for SAIL.
- **Theme-** Smart Automation
- **PS Category-** Software
- **Team ID-** 117266
- **Team Name (Registered on portal) -** CodeAstra

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RakeMind: AI-Powered Rake Formation Optimization for SAIL Logistics

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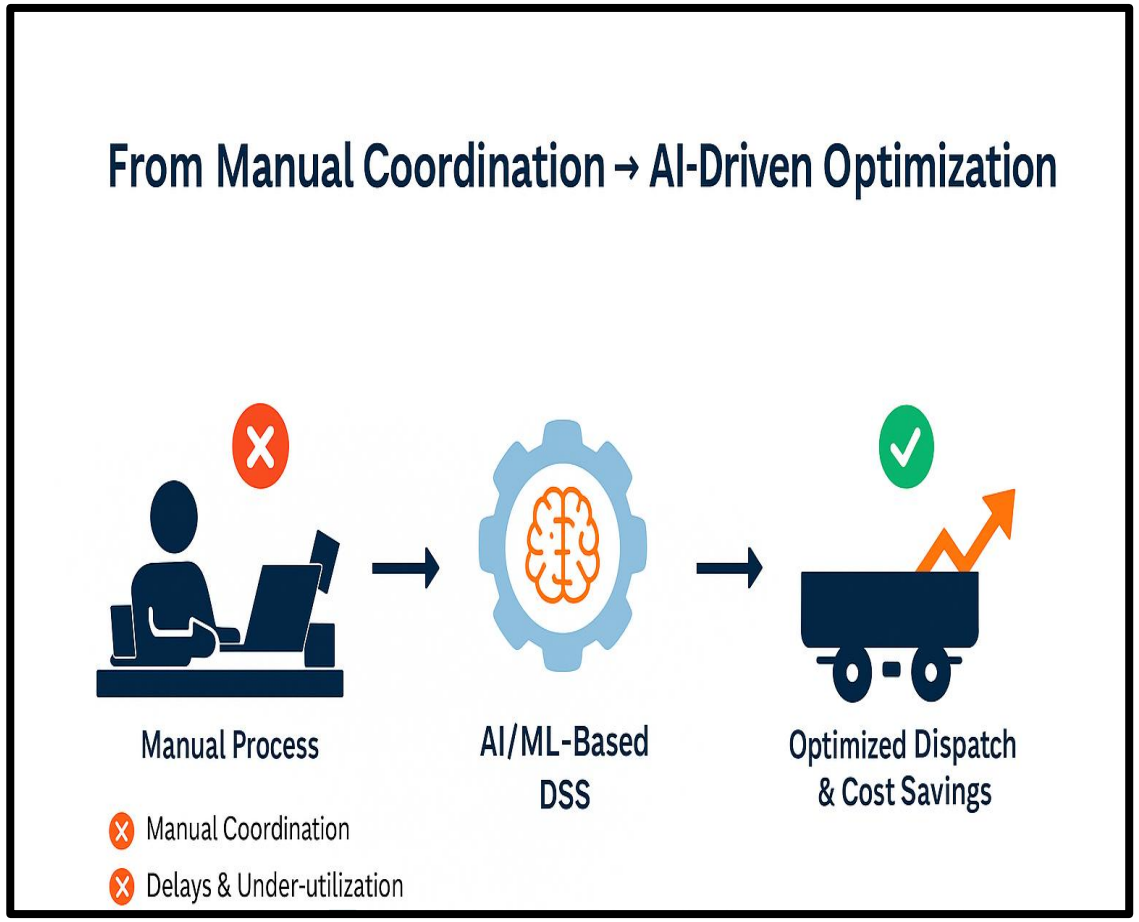
Problem

- **Manual coordination** for rake formation and dispatch planning
- **No dynamic system** for handling sudden changes (e.g., wagon unavailability, loading point issues)
- **Difficulty prioritizing customer orders** based on cost, urgency, or location
- **No unified data-driven platform** for visibility and decision-making of independent factors (Material availability, Wagon/rake availability, Loading point capability etc.) for real-time optimization.



Proposed Solution

- **AI-powered Decision Support System that:**
  a. Analyzes **material availability, order priority, rake/wagon capacity,** and **loading point capability.**
  b. Dynamically **forms, sequences, and dispatches rakes** for minimum cost and maximum utilization.
  c. Suggests **real-time adjustments** to handle changes in resource availability or order status.
- **How It Addresses the Problem**
  a. Automates decision-making using **AI/ML algorithms.**
  b. Ensures **full rake loading** from most cost-effective stockyards.
  c. Reduces **demurrage, idle freight, and delays.**

Innovation and Uniqueness

- AI-based platform for **multi-constraint rake optimization**
- Adaptive ML models learn from **historical dispatch and cost data.**

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TECHNICAL APPROACH

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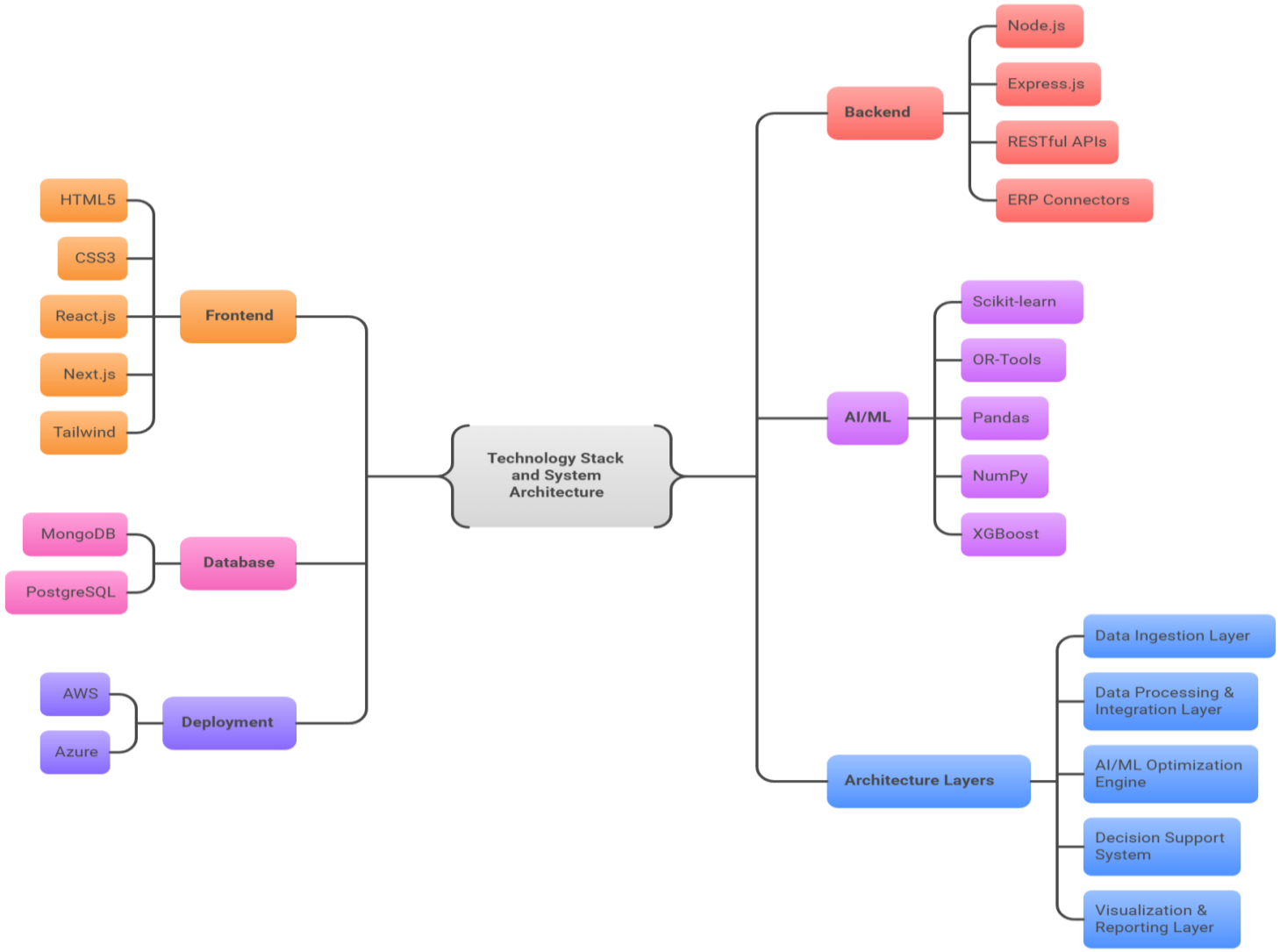
Technologies to be used

- **Frontend (Web):** HTML5, CSS3, React.js, Next.js, Tailwind.
- **Backend:** Node.js, Express.js, RESTful APIs, ERP Connectors
- **Database:** MongoDB / PostgreSQL
- **AI/ML:** Scikit-learn, OR-Tools, Pandas, NumPy, XGBoost multi-constraint rake optimization.
- **Deployment:** AWS / Azure Cloud for scalability & real-time access

Architecture/Implementation Layers

- **Data Ingestion Layer:** Collects real-time data from ERP, warehouse systems, and railway APIs.
- **Data Processing & Integration Layer:** Cleans, filters, and merges data (inventory, rakes, customer orders, loading points).
- **AI/ML Optimization Engine :** Applies algorithms for cost minimization, rake allocation, route optimization, and order prioritization
- **Decision Support System (DSS):** Generates daily **rake formation schedules** and **dispatch recommendations**.
- **Visualization & Reporting Layer :** Web-based dashboard showing cost efficiency, wagon utilization, and daily movement plan.



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FEASIBILITY AND VIABILITY

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Technical Feasibility

- Uses an **AI Optimization Engine** to automatically create the smartest, cost-effective rake plans.
- Employs **Machine Learning** to forecast demand and predict travel times, cutting down on delays.
- Plugs directly into existing systems (like **ERP**) for live data on **orders**, **inventory**, and **wagons**.
- **Cloud-based infrastructure** ensures the system is powerful, reliable, and can scale up as needed.

Market Viability

- Heavy industries like steel and cement face **huge logistics costs**, creating a clear need.
- This tool directly **cuts major expenses from freight penalties** and **shipping delays**.
- The solution can easily be adapted for other **big sectors like mining, ports, and manufacturing**.
- Helps make **Indian logistics smarter**, supporting the national goal of industrial efficiency.

Potential Challenges and Risks

- **Bad data from existing systems** can lead to flawed AI suggestions.
- **Managers may resist change** and not trust the AI's decisions.
- **Real-world disruptions** like breakdowns can instantly derail the AI's perfect plan.
- **Integrating with SAIL's legacy IT systems** could be technically difficult and slow.

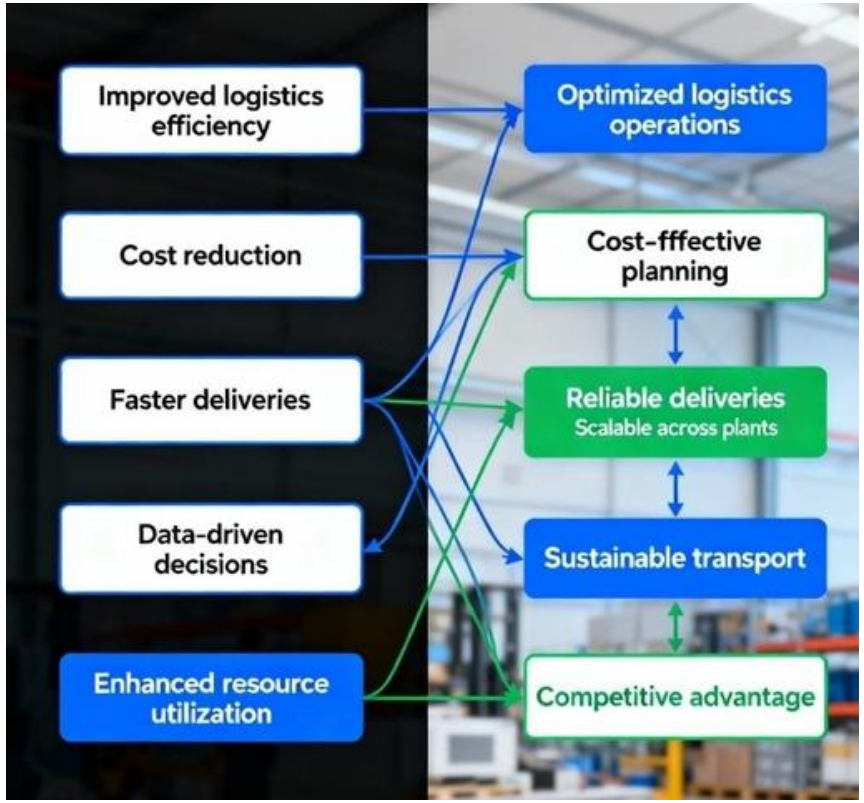
Strategies for Overcoming These Challenges

- **Implement a robust data validation** layer to automatically clean and verify information before the AI uses it.
- **Run a pilot program at the Bokaro** plant to demonstrate real-world cost savings and build trust with plant managers.
- **Design the AI to be dynamic**, allowing it to quickly re-calculate the best plan when unexpected disruptions happen.
- **Use modern APIs as a bridge** to connect with SAIL's legacy systems, avoiding a complex and costly overhaul.

IMPACT AND BENEFITS

Impacts

- **Improves logistics efficiency:** AI ensures timely rake dispatch and full load use.
- **Reduces costs:** Minimizes freight, demurrage, and delay penalties.
- **Enables data-driven planning:** Uses real-time insights for better decisions.
- **Optimizes resource use:** Maximizes wagon and siding capacity.
- **Enhances delivery reliability:** Meets SLAs through smart scheduling.
- **Supports sustainability:** Cuts fuel waste via optimized routes.
- **Strengthens competitiveness:** Streamlines operations for faster order fulfillment.



Benefits

- **Optimized logistics:** AI-driven rake planning ensures efficient material movement.
- **Cost-effective operations:** Reduces freight, demurrage, and idle rake costs.
- **Faster deliveries:** Automates scheduling to meet customer deadlines.
- **Data-backed decisions:** Uses real-time insights for strategic planning.
- **Improved asset utilization:** Maximizes wagon and siding productivity.
- **Scalable solution:** Adaptable across multiple plants and routes.
- **Sustainable transport:** Lowers resource waste through efficient route optimization.

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RESEARCH AND REFERENCES

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- **Academic Research**
- Rail Freight Operations Optimization Studies (2023): AI-driven logistics planning has demonstrated 18–25% improvement in rake utilization and shipment time reduction.(SOURCE)
- Operations Research Journal (2022): ML-based scheduling systems outperform rule-based systems in dynamic supply chain environments by up to 30% in cost efficiency.(SOURCE)
- **Market Analysis**
- Existing Solutions: SAP Transportation Management, Oracle SCM Cloud, and niche logistics AI startups — limited integration with Indian rail freight data.
- McKinsey Logistics Report (2025): Predictive AI in transportation can reduce idle freight costs by 15–20% annually.(SOURCE.)
- **Government / Policy Alignment**
- PM Gati Shakti National Master Plan (2021): Focus on integrated and intelligent multimodal logistics infrastructure.(SOURCE)
- National Steel Policy (2017): Emphasis on adopting digital and smart automation for logistics efficiency.(SOURCE)
- **Technology Validation**
- AI Model: Reinforcement Learning (RL) and Constraint Optimization techniques suitable for multi-variable decision environments (material, rake type, route, timing).
- System Architecture: Cloud-based decision suppoprt dashboard with analytics visualization for planners.
- **Impact Evidence**
- Pilot Studies: Predictive load planning in steel and cement logistics (2023–2024) achieved 12% increase in on-time deliveries and 8% cost savings.(SOURCE)
- Productivity Surveys: Automation of sequencing and load allocation reduced demurrage penalties across PSUs.(SOURCE)

Prototype: https://rail-rake.base44.app/

Demo: https://drive.google.com/file/d/11o693RzkdiZjmK5Q-lTkOggakigS3tx4/view?usp=drivesdk