

CFS Flow Max Reducing Cutting Truck Idle Time Through Intelligent Planning

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ABSTRACT

The Container Freight Stations (CFS) play a critical role in the smooth flow of import and export cargo, yet they often face significant challenges caused by uncoordinated truck movements and inefficient yard usage. Prolonged truck idle times lead to congestion, wasted fuel, and operational delays, ultimately affecting overall supply chain performance. This project proposes a systematic truck scheduling and yard allocation strategy designed to reduce waiting times and optimize vehicle flow. The approach integrates real-time arrival tracking, predictive slot assignment, and dock usage planning to ensure that incoming trucks are allocated to the right loading or unloading points at the right time. By minimizing unnecessary queuing and maximizing resource utilization, the system can improve throughput, reduce operational costs, and enhance service quality for freight operators. The solution is designed to be adaptable to varying CFS capacities and operational scales, making it a practical and scalable approach for modern logistics hubs seeking efficiency gains without heavy reliance on automation.

Keywords: Logi sync, fleet ease, Tran slink, queue less, path opt.

1. INTRODUCTION

Container Freight Stations (CFS) are critical nodes in port-centric logistics, responsible for consolidation, deconsolidation, customs clearance, and temporary storage of containerized cargo. With the growth of containerized trade, CFS facilities face increasing pressure to handle higher truck volumes within limited space and time. Traditional first-come-first-serve operations lead to uncoordinated truck arrivals, congestion at gates and docks, excessive idle time, fuel wastage, and higher emissions.

The CFS Flow-Max project addresses these challenges through smart planning and low-cost automation. The system introduces structured truck scheduling, automated identification, and intelligent yard and dock allocation to regulate truck movement inside the CFS. By replacing random arrivals with a slot-based approach, the project aims to reduce congestion, improve turnaround time, and enhance overall operational efficiency.

Reducing Idle Time Through Technology

Broadly, "intelligent planning" for idle reduction involves several integrated technologies:

- **Telematics and Geofencing:** Software monitors vehicles in real-time. Geofences around common idling areas (like staging yards) trigger alerts if a vehicle remains stationary for too long.
- **Dynamic Route Optimization:** AI-powered tools calculate the most efficient routes by considering live traffic, weather, and construction, preventing trucks from sitting in stationary traffic where idling is most likely.
- **Driver Coaching:** AI dash cams and sensors provide immediate feedback to drivers, encouraging them to turn off engines for stops longer than 10–15 seconds.

Objectives of the Project

- Reduce truck idle time and congestion at CFS entry gates and yards
- Improve dock and yard utilization through slot-based scheduling
- Minimize human dependency and operational errors
- Demonstrate a scalable, low-cost smart CFS model
- Promote sustainable logistics by reducing fuel consumption and emissions

2. SYSTEM OVERVIEW AND METHODOLOGY

The CFS Flow-Max system follows a structured workflow that controls truck movement from entry to exit. Each truck is assigned a predefined time slot and yard/dock allocation before arrival. Upon reaching the CFS, automated verification and sensor-based monitoring guide the truck through a disciplined internal flow.

Operational Flow

- Truck arrival at entry gate
- RFID-based identification and slot verification
- Gate access control using servo mechanism
- Yard allocation (Normal Yard or Special Yard)
- Dock scheduling and guidance
- Loading/unloading operation
- Exit clearance and system update

This methodology eliminates randomness, ensures predictable movement, and balances workload across available infrastructure.

3. HARDWARE AND SYSTEM COMPONENTS

The prototype integrates simple, reliable electronic components to demonstrate smart CFS operations.

- **RFID Reader and Tags:** RFID technology enables automated truck identification and slot verification. Only authorized trucks with valid bookings are permitted entry, eliminating manual paperwork and reducing entry delays.
- **LED Indicators and LCD Display:** LED indicators provide clear visual guidance on slot availability, dock status, and movement permission. The LCD display shows truck ID, assigned slot, yard type, and dock number, improving driver compliance and reducing confusion.
- **Buzzer and Servo Motor:** The buzzer provides audio alerts during violations or mismatches, while the servo motor simulates an automated boom barrier at the entry gate.
- **ESP8266 Wi-Fi Module:** The Wi-Fi module enables IoT connectivity, supporting future expansion to cloud monitoring, analytics, and remote management.
- **FABRICATION AND IMPLEMENTATION:** The fabrication phase converts the conceptual design into a physical working prototype.
- **Model Design and Layout:** The layout simulates a real CFS environment with clearly defined entry and exit gates, internal lanes, yards, and dock areas. The flow-based design visually demonstrates congestion reduction through planned movement.
- **Material Selection:** Lightweight foam board and plastic sheets were used for durability and ease of fabrication. Labels, arrows, and markings enhance clarity and presentation.
- **Component Assembly and Wiring:** All electronic components were securely mounted and wired according to the system architecture. Protective enclosures were used to ensure safety and reliability during operation.



Testing and Calibration

Each component was tested individually and as part of the integrated system to ensure accurate sensing, reliable control, and smooth operation.

4. RESULTS AND PERFORMANCE ANALYSIS

The prototype was tested through multiple operational cycles to evaluate effectiveness.

Key Observations

- Entry gate congestion was eliminated through RFID-based verification
- Truck idle time inside the yard was significantly reduced
- Dock utilization became more balanced
- Unauthorized or unplanned truck entries were prevented
- Internal traffic flow became smoother and predictable

The results confirm that slot-based scheduling combined with automation improves turnaround time, safety, and operational transparency compared to conventional manual systems.

The project demonstrates that congestion in CFS operations is not solely due to high truck volumes but largely due to poor internal planning. By introducing structured scheduling and automated guidance, the system reduces bottlenecks and improves resource utilization. The use of low-cost components proves that digital transformation is achievable without heavy investment.

From a sustainability perspective, reduced idle time leads to lower fuel consumption and emissions, supporting environmentally responsible logistics practices.

5. LIMITATIONS

- Prototype-level implementation
- Manual simulation of WMS data
- Limited sensor and environmental monitoring

Future Enhancements

- Cloud-based slot booking and analytics
- AI-driven predictive scheduling
- GPS-based real-time truck tracking
- Integration with port and customs systems
- Automated billing based on dwell time

6. CONCLUSION

The CFS Flow-Max project successfully demonstrates that smart planning and basic automation can significantly reduce truck congestion and idle time in Container Freight Stations. By transforming unstructured truck movements into a disciplined, slot-based flow, the system improves efficiency, safety, and sustainability. The project provides a strong foundation for future smart CFS implementations and highlights the importance of digital systems in modern logistics infrastructure.

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