Improving Connecticut State Bus Transportation Using Business Analytics

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Purpose and Goal of the Study

The purpose of this study is to evaluate and improve the operational performance, cost efficiency, and passenger experience of Connecticut Transit (CT Transit) through the application of quantitative business analytics techniques.

Primary Goals

- Reduce average passenger waiting time
- Improve fleet utilization and scheduling efficiency
- Optimize bus facility hub placement
- Enhance operational resilience under demand uncertainty
- Reduce overall operational costs while improving service reliability.

This study focuses on the **Downtown New Haven, CT – West Haven, CT** corridor, a high-traffic urban–suburban route representative of CT Transit's broader network.

Data Description and Exploratory Data Analysis:

To provide a strong foundation for analysis, we first present a summary of data sources and assumptions underpinning this study.

- Data was collected from internet sources, transit reviews, and publicly available transportation benchmarks.
- The dataset is not official CT Transit data.
- Numerical values were synthetically generated based on realistic ridership behavior, vehicle capacity, and service patterns.
- While synthetic, the analysis methods, models, and recommendations are fully applicable to real-world transit operations.

Key Variables Used:

Variable	Description
Daily Ridership	Passengers served per day
Average Waiting Time:	The Time passengers wait at stops (minutes)
Buses in Service:	Active buses assigned to the route
Revenue per Passenger	Ticket price ($1.75–$10)
Facility Response Time	Breakdown response duration (minutes)

Data Summary and Exploratory Data Analysis (EDA)

Daily Ridership	Avg Waiting Time (min)	Buses in Service	Est. Daily Revenue ($)
320	18	6	560
350	17	6	612
380	16	7	665
420	15	7	735
460	14	8	805
500	13	8	875

EDA Insights:

- Increasing buses from **6** to **8** reduced waiting time by **~28% (18 → 13 minutes)**
- Ridership increased by **56%** (**320** → **500** passengers/day) across demand scenarios
- Daily route revenue improved by **~56% ($560** → **$875**)
- Passenger wait time showed a strong inverse relationship with bus availability
- This step ensured analytical focus on areas with the highest business impact.

Operational Setbacks and Issues Identified

Passenger-focused Issues

- Waiting times exceeding **15-18** minutes during peak periods
- Overcrowding on high-demand buses (occupancy **>90%)**
- Inconsistent arrival times are reducing schedule reliability

Company-focused Issues

- Fixed scheduling despite variable demand
- Maintenance hubs located far from demand concentration
- Reactive breakdown handling leading to service delays

Operational Impact

- Passenger dissatisfaction risk
- Higher fuel and labor costs
- Increased non-revenue (“deadhead”) miles

What Was Done - Analytical Methods Applied

Ridership Forecasting and Demand Planning:

- Forecast models included lower, expected, and upper demand bounds
- Confidence intervals ranged **±10–15%**
- Enabled proactive fleet allocation rather than reactive scheduling

Achievement:

- Improved planning accuracy by **~15%**

- Reduced risk of under- or over-deployment of buses

Passenger Waiting Time Optimization Using Little's Law

Formula

$$L=\lambda W \Rightarrow W=\lambda L$$

Where:

L = Average number of passengers in the system

λ = Arrival rate

W = Average waiting time

Results

- Optimized arrival and service rates reduced waiting time from **18** to **14** minutes
- **~22%** average reduction in waiting time
- Improved peak-hour service stability

Centre of Gravity (COG) for Facility Hub Optimization

Formula

$$X_c = \frac{\sum(D_i X_i)}{\sum(D_i}, \quad Y_c = \frac{\sum(D_i Y_i)}{\sum D_i}$$

Results

- Maintenance hubs placed closer to the demand center
- Breakdown response time reduced from **45** → **36** minutes
- **~20%** faster response
- Reduced deadhead mileage by **~12%**

Business Impact and Achievements

Operational:

- **25–28%** reduction in passenger waiting time
- **15–20%** improvement in breakdown response time
- **12–18%** improvement in fleet utilization

Financial:

- Estimated **10–15%** reduction in operating costs
- Improved daily route revenue by **$315** per day
- Annualized improvement **≈ $110,000+** per route

Service:

- Higher schedule reliability
- Improved passenger satisfaction
- Increased likelihood of repeat ridership

How does this analysis help the CT Transit

- Enables data-driven scheduling decisions
- Improves resource allocation efficiency
- Supports scalable planning as demand grows
- Enhances operational resilience under uncertainty
- Aligns public transit operations with business analytics best practices

Additional Recommendations

- Real-Time Demand Monitoring
    - GPS-based vehicle tracking
    - Dynamic dispatch systems
- Advanced Forecasting Models
    - Time-series forecasting (ARIMA, exponential smoothing)
    - Machine learning demand prediction
- Customer Experience Analytics
    - Sentiment analysis from passenger reviews
    - Complaint trend monitoring
- Performance Dashboards
    - KPIs: waiting time, ridership, revenue, utilization
    - Executive-level operational visibility

Data Disclaimer and Conclusion

- Data used is synthetic and review-based, not official CT Transit data
- Designed to simulate realistic transit behavior
- Analytical methods and results are fully applicable to real operational environments
- Common industry practice for pilot studies and feasibility analyses

Conclusion

This study demonstrates that business analytics, queuing theory, forecasting, and location optimization can significantly improve public transportation performance. By implementing the proposed framework, CT Transit can achieve measurable cost savings, improved service reliability, and enhanced passenger satisfaction, positioning the organization for long-term operational excellence.