Strategic Station Placement for Sustainable Commuter Rail Development in Texas

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Abstract

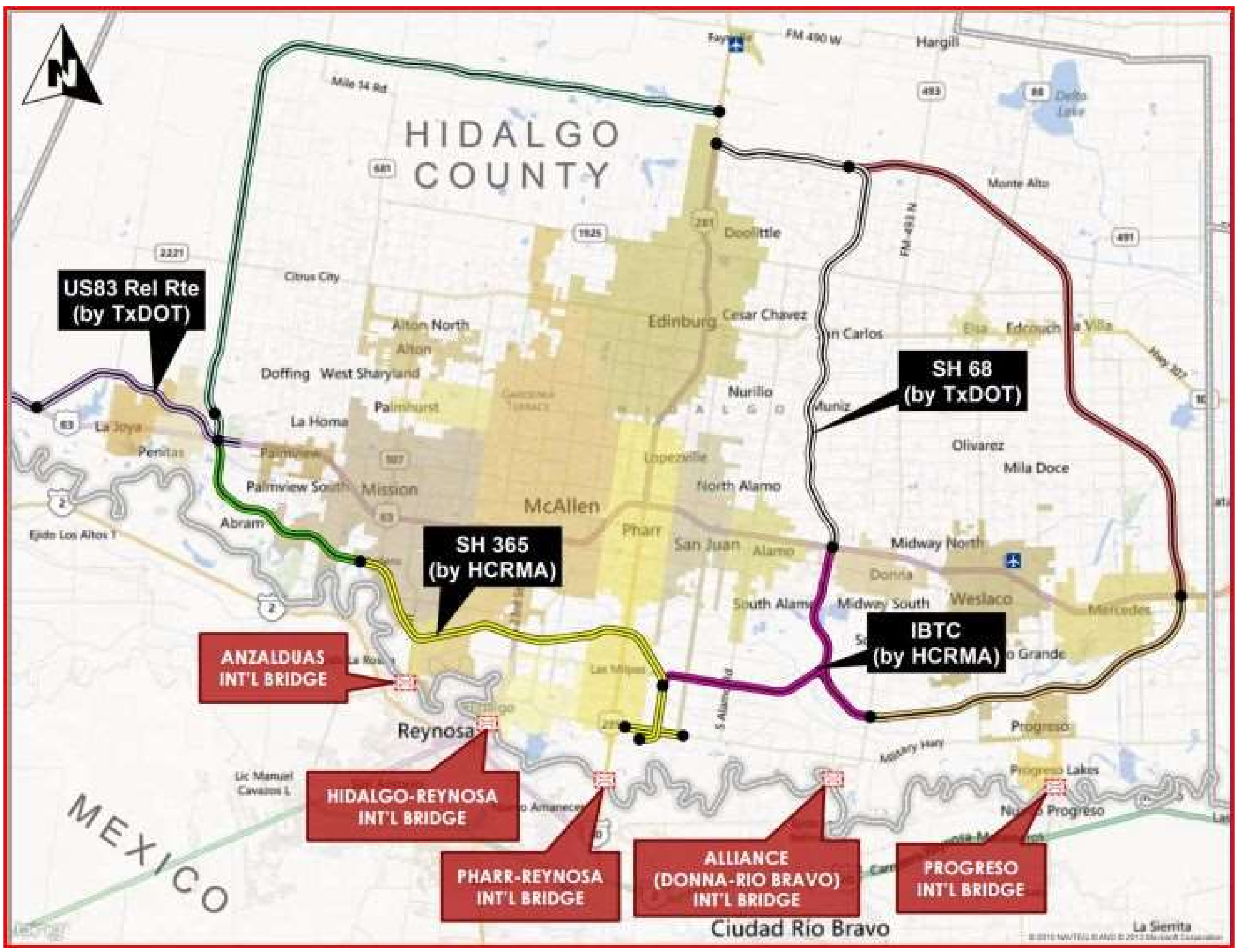
The growing demand for sustainable transportation in the Rio Grande Valley (RGV) region of Texas has sparked interest in developing a commuter rail network connecting Mission, McAllen, and Brownsville. This study leverages regression analysis and Geographic Information Systems (GIS) to strategically determine station placement by integrating key variables including population density, income levels, traffic congestion, transit connectivity, and proximity to public facilities. Through an evidence-based evaluation, three optimal station sites are proposed, supported by environmental, socioeconomic, and spatial data. The findings guide transportation planners, stakeholders, and policymakers in implementing equitable and efficient commuter infrastructure in South Texas.

I. Introduction

The Rio Grande Valley, encompassing Hidalgo, Cameron, and Starr counties, faces significant transportation challenges due to rapid urbanization, economic disparity, and insufficient regional transit infrastructure. With over 1.3 million residents, the region's growth demands a transition from automobile-dependent travel to efficient public transportation alternatives.
Historically, Texas has concentrated rail infrastructure around metropolitan hubs like Dallas-Fort Worth and Houston. In contrast, South Texas communities have had limited access to intercity rail services. The proposed commuter rail system aims to bridge this gap, providing cost-effective, environmentally friendly transit options and spurring regional economic development.
This report focuses on three primary commuter rail alignments:

1. **Upper 365 Loop Route**
2. **Lower 365 Loop Route**
3. **Elevated Route along Highway 83**

The study incorporates regression-based modelling, spatial analytics, and empirical transportation data to identify optimal station sites along these corridors.



II. Literature Review

Multiple studies affirm the correlation between population density, socioeconomic characteristics, and transit station success. In urban rail planning, factors like traffic congestion and facility accessibility (hospitals, schools, airports) significantly influence ridership potential (Zhao et al., 2019). Moreover, GIS-enabled transportation models (Esri, 2021) have demonstrated utility in optimizing transit corridors through data visualization and multi-criteria evaluation.
Research on commuter rail systems in California, Florida, and Illinois highlights the importance of integrating local bus services with regional rail to ensure last-mile connectivity (TRB, 2020). Texas-specific insights from the "Texas Rail Plan" emphasize environmental compliance, stakeholder involvement, and phased implementation for long-term success (TxDOT, 2023).

III. Methodology

A. Data Sources

The study incorporates primary and secondary data:

- **Demographics**: U.S. Census Bureau, LandScan USA
- **Traffic Volume**: TxDOT STARS II, StreetLight Data
- **Transit Networks**: Valley Metro, Metro McAllen, Brownsville Metro
- **Key Infrastructure**: GIS-mapped locations of hospitals, airports, schools, malls
- **Environmental Data**: VIIRS Nighttime Lights, FEMA flood zones, NEPA datasets

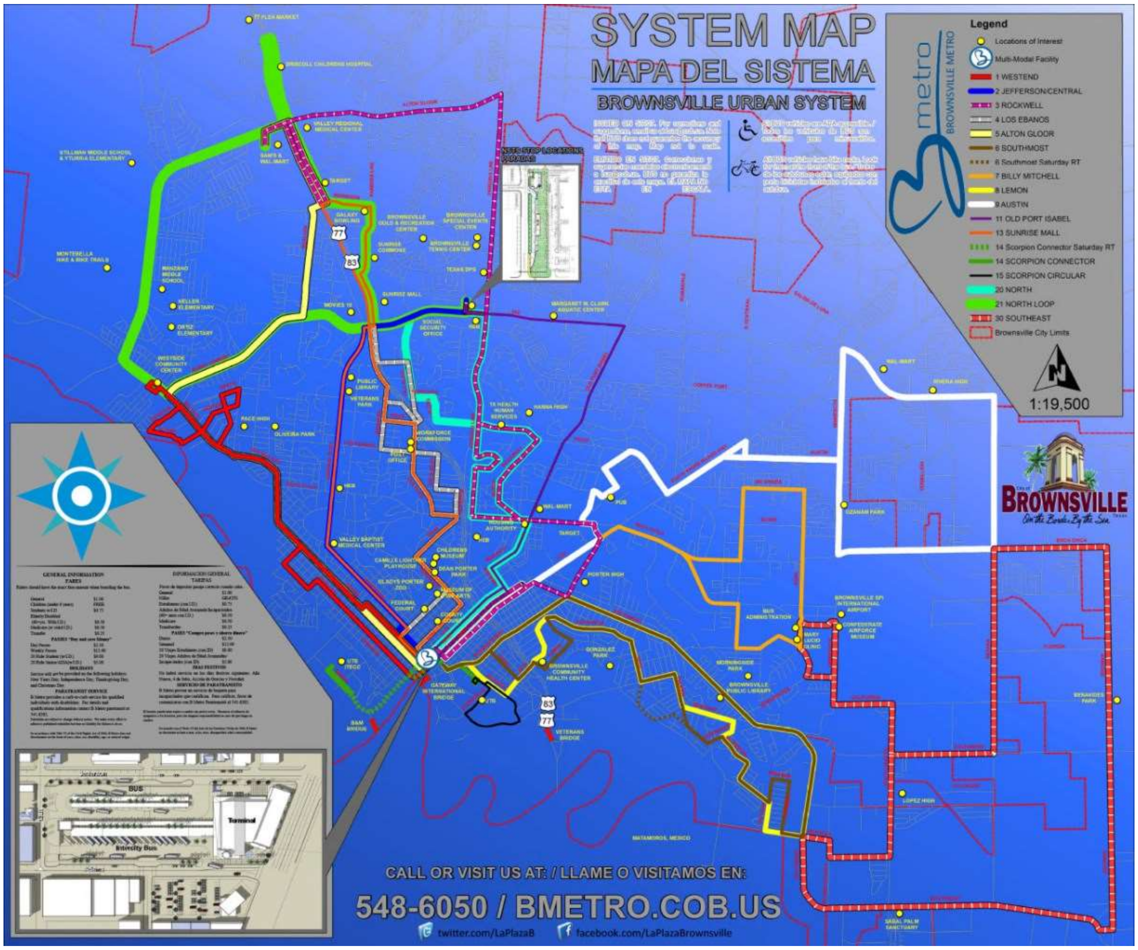
B. Regression Variables

Eight key variables were selected for regression analysis:

1. Population Density
2. Median Household Income
3. Average Daily Vehicle Traffic
4. Number of Bus Routes and Frequency
5. Proximity to Medical Facilities
6. Proximity to Shopping Centers
7. Proximity to Educational Institutions
8. Proximity to Airports and Entertainment Centers

C. GIS and Statistical Modeling

GIS heatmaps were generated using ArcGIS Pro to visualize population clusters, infrastructure overlays, and ecological constraints. A multivariate regression model was applied to score and rank potential station sites. Raster-based SDSS (Spatial Decision Support Systems) were also employed to calculate suitability indexes for land use compatibility.



SYSTEM MAP
MAPA DEL SISTEMA
BROWNSVILLE URBAN SYSTEM
metro
BROWNSVILLE METRO
Legend
Locations of Interest
Multi-Modal Facility
1 WESTEND
2 JEFFERSON/CENTRAL
3 ROCKWELL
4 LOS EBANOS
5 ALTON GLOOR
6 SOUTHMOST
6 Southmost Saturday RT
7 BILLY MITCHELL
8 LEMON
9 AUSTIN
11 OLD PORT ISABEL
13 SUNRISE MALL
14 Scorpion Connector Saturday RT
14 SCORPION CONNECTOR
15 SCORPION CIRCULAR
20 NORTH
21 NORTH LOOP
30 SOUTHEAST
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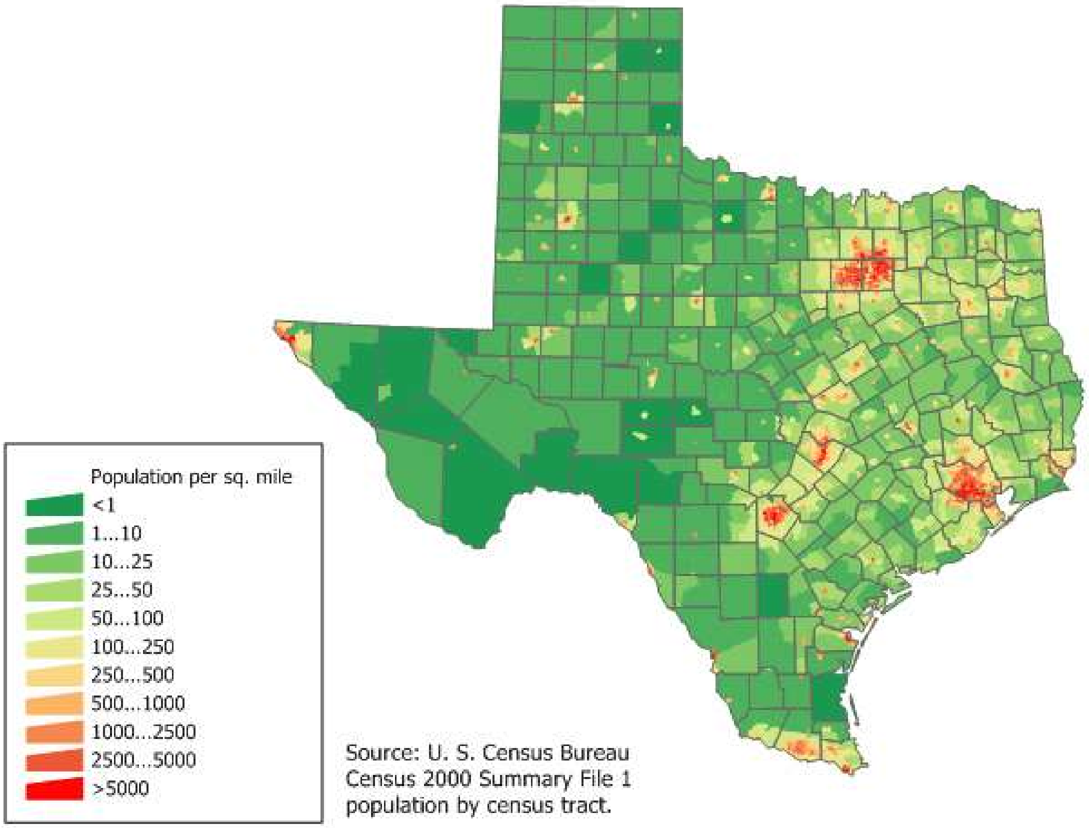
IV. Results

A. High-Priority Corridors

Traffic volume and demographic overlays identify Highway 83 as the most congested corridor (50,000+ vehicles/day). Urban centers like McAllen and Brownsville exhibit high transit demand due to dense residential patterns and existing infrastructure.



B. Regression Analysis Outputs

Population density and proximity to facilities showed the strongest correlation to potential ridership. Income levels inversely correlated with dependency on public transit, reaffirming the importance of affordability in fare structuring.

C. Optimal Station Locations

- **McAllen Station**:
  - High population density (3,500+ persons/sq. mile)
  - Existing Metro McAllen integration
  - Near McAllen Medical Center, shopping centers
- **Brownsville Station**:
  - Access to Port of Brownsville and airport
  - Brownsville Metro connectivity
  - Dense commercial/residential zones
- **Mission Station**:
  - Near educational and medical hubs
  - Gateway for Starr County rural commuters
  - Main terminal proposed near southwest 365 Loop

V. Environmental and Regulatory Compliance

Commuter rail construction mandates Environmental Impact Assessments (EIA) under NEPA guidelines. Environmental risks identified include:

- **Air Quality**: Diesel emissions during construction
- **Noise Pollution**: Residential noise buffers required
- **Wetlands**: Several alignment segments cross protected zones

Mitigation strategies:

- Adoption of electric or hybrid rail systems
- Green roofing and solar energy in station design
- Wildlife corridors near Lower 365 Loop

Permitting needs include Section 404 Clean Water Act, floodplain development permits, and endangered species clearance.

VI. Integration with Existing Transit

To ensure first-mile/last-mile connectivity, the proposed rail system must integrate with Valley Metro's intercity bus routes and local services like Metro McAllen. Key enhancements include:

- Realigning bus stops to rail stations
- Increasing off-peak frequency
- Launching park-and-ride facilities

Valleywide aerial spraying for mosquitoes Graphics courtesy Cari Lambrecht

VII. Discussion

The study validates that strategic station placement can alleviate congestion, promote economic growth, and serve transit-dependent populations. Station siting must consider not just current demand, but also forecasted urban expansion, especially in outer suburbs of Mission and Harlingen. Public engagement remains vital for environmental justice, particularly in minority and low-income neighbourhoods. Equitable access and affordable pricing models can elevate public trust and long-term adoption.

VIII. Conclusion

This research demonstrates that strategic, data-driven station placement is central to sustainable commuter rail development. With integration into local transit networks and adherence to environmental regulations, the system can significantly enhance regional mobility. The proposed sites—McAllen, Brownsville, and Mission—offer the best blend of access, ridership potential, and infrastructure readiness.

Further research should explore dynamic travel behavior modeling and incorporate community feedback through interactive GIS dashboards.

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