**IMPACT OF GENERAL TRANSIT FEED SPECIFICATION OF HYDERABAD METRO RAIL, INDIA**

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Abstract. The Hyderabad Metro Rail serves as a vital public transportation system in Hyderabad, Telangana, India. As the city's population grows and urban mobility needs increase, it is essential to optimize metro services and analyse commuter behaviour. This research examines General Transit Feed Specification (GTFS) data from Hyderabad Metro Rail Limited (HMRL) for the year 2024 to facilitate Data-Driven Decision Making (DDDM) and enhance the commuter experience. The study concentrates on determining the most frequented metro stations, identifying peak traffic times, and observing commuter behaviours. By employing data visualization methods like histograms and line graphs, the research offers insights that assist stakeholders in optimizing service arrangement, decreasing congestion, and increasing operational efficiency. A quantitative approach is utilized, drawing on data from the “Open Data Telangana” portal to guide metro authorities and urban planners. Results indicate peak travel times, highlighting the necessity for improved crowd management strategies. The research also illustrates how daily and weekly usage patterns can influence policy development. The insights generated from this study are beneficial for public transportation agencies, policymakers, and urban planners looking to enhance transit efficiency and passenger satisfaction. Subsequent research may focus on Phase 2 of the Hyderabad Metro scheduled for 2025, applying Machine Learning (ML) and Artificial Intelligence (AI) to optimize route planning and enhance transport integration.

*Keywords:* General Transit Feed Specification (GTFS); Hyderabad Metro Rail (HMRL); Data-Driven-Decision-Making (DDDM); Commuter behaviour trends; Quantitative.

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1. **Introduction**

India is ushering into a new phase of rail transportation with the long-anticipated launch of bullet trains, monorails, and the enhancement of metro systems in major and secondary cities. It is essential to assess the role of intermodal transport hubs and their influence on future urban development driven by the railways (Mishkat Ahmed; Nitin Srivastava; Gandhali Tipnis; Shigehisa Matsumura, 2020). Traffic congestion results in the loss of countless man-hours, largely due to the uprise in the number of motor vehicles without a parallel growth in road facilities (Yash Kumar Mittal; Virendra Kumar Paul, 2018). Public transit is important in alleviating commuter traffic, and among the options available, rail-based mass rapid transit systems (MRTS) are viewed as the most effective solution.

Metro systems are currently functioning in many major metropolitan areas, including Mumbai, Kolkata, and Delhi, effectively catering to the local commuters (Padmavathi; Dr. B Sunitha, 2019). Hyderabad, a rapidly expanding metropolitan city, has been encountering increasing traffic and transportation issues in recent years. With both buses and trains nearing their capacity, the necessity for a strong MRTS has become clear. To tackle this, the Hyderabad Metro Rail Project (HMRP) was initiated under a Public-Private Partnership (PPP) framework (Paulose N. Kuriakose, 2025).

Despite encountering several challenges, many comprehensive technical evaluations were conducted on the project, (Nagarjuna Pilaka; Ramakrishna Nallathiga, 2015) focusing on factors such as route alignment, structural design, construction methods, and operational strategies. These factors have led to the Hyderabad Metro Rail Project (HMRP) becoming one of the most carefully planned and implemented metro initiatives in India. (Reshma Babu; Jobil Varghese, 2018) To improve urban living conditions, it is crucial to establish a well-operating, safe, and dependable transport network for the public. The Hyderabad Metro Rail intends to provide passengers with a transit experience on par with international standards, prioritizing safety, comfort, and efficiency. (B.V.D.S. Sai Pavan Kumar, 2021) Metro rail systems have consistently proven their advantages in energy efficiency, space optimization, and capacity for passengers, positioning them as a fundamental element of contemporary urban mobility.

1. **Objectives**
2. To pinpoint the busiest times throughout the week for better scheduling and resource distribution.
3. To assess the effectiveness of current metro routes and stops using data visualization techniques.
4. To offer suggestions for enhancing metro operations and boosting service dependability.
5. **Need and Importance of the Study**

This study is essential as it provides a comprehensive analysis of the Hyderabad Metro Rail Project which was developed to tackle the increasing traffic congestion and transportation challenges in Hyderabad a rapidly growing metropolitan city in India It explores the primary objectives of the project which include reducing traffic bottlenecks ensuring a reliable and efficient public transport system and promoting sustainable urban development The study delves into the metro's route alignment and design explaining its integration with existing infrastructure and its coverage of high-traffic and densely populated areas It also examines key design aspects such as horizontal vertical and cross-sectional elements while focusing on the engineering advancements that enhance safety durability and sustainability through innovative construction materials and techniques.

Furthermore the study evaluates the operational strategies implemented to ensure the seamless functioning of the metro system It discusses station design train scheduling passenger flow management and interconnectivity with other modes of transport The research also highlights the project's significant contributions to urban mobility by reducing travel time lowering carbon emissions and fostering environmentally friendly growth Additionally the study reviews the construction methodologies employed and the challenges encountered during execution including planning resource allocation and overcoming technical and logistical obstacles By addressing these aspects this research emphasizes the significance of metro rail systems in transforming urban transportation and improving the overall quality of life in Hyderabad.

1. **Scope of the Study**

The Hyderabad Metro Rail Limited (HMRL) aims to alter the way people travel in Hyderabad by providing a safe, efficient, and eco-friendly public transit option that addresses the city's increasing traffic problems. The project involves extending a thorough network that links residential, commercial, and industrial zones to improve accessibility throughout the city. It works in conjunction with current transportation systems like buses and MMTS trains to facilitate a seamless multimodal commuting experience. The initiative integrates cutting-edge technology and infrastructure, employing contemporary construction methods and environmentally friendly designs to enhance safety and efficiency while prioritizing passenger comfort with thoughtfully designed stations that offer modern amenities, accessibility for individuals with disabilities, and real-time travel updates. Additionally, the metro fosters sustainability by significantly lowering carbon emissions using electric trains, energy-efficient practices, and promoting the use of public transportation to reduce the city’s environmental footprint.

1. **Research Methodology**

Secondary data was collected through various online resources, including articles, research papers, and official websites. This data proved to be highly effective, as it offered both qualitative and quantitative information that was easily accessible, significantly minimizing the time required and effort involved in data gathering. In this research, the secondary data sources comprised annual reports, relevant research journals from various organizations, government documents, and credible websites. This methodology provided a wider perspective, presenting insights from numerous studies and verified statistics to bolster the research results.

To effectively analyse and display the collected data, Tableau software has been employed to create interactive visualizations. By utilizing Tableau, datasets are converted into clear graphical representations, allowing for a more straightforward analysis of trends and patterns related to the research. The software assists in pinpointing crucial insights, comparing various data points, and enhancing data-driven decision-making by providing more accessible and visually engaging insights, thereby improving the understanding of the subject matter.

1. **Limitations of the Study**

The primary limitation of this study is that the secondary data used is restricted to the year 2024. Since the analysis relies solely on previously published reports, government publications, it may not fully capture the long-term trends or recent developments beyond this period. Any changes made in the policies, infrastructure advancements, or new data generated after 2024 are not reflected in this study, which could impact the relevance and accuracy of the findings in the future. Additionally, it is essential to interpret the results with caution as relying on secondary data limits the ability to verify the authenticity of the original data collection methods.

1. **Theoretical Framework**

The visuals in this study have been created based on the dataset in accordance with the outlined objectives. These include identifying peak traffic periods during the week to enhance scheduling and resource allocation, evaluating the efficiency of existing metro routes and stops through data visualization, and providing recommendations to optimize metro operations and improve service reliability. By leveraging data-driven insights, the analysis aims to support informed decision-making for a more efficient and commuter-friendly metro system.

**Chart 1: Line Type Usage by Route ID**

A graph showing different colored rectangles

AI-generated content may be incorrect.

* The chart is titled "Line Type Usage," indicating metro line usage based on stop counts.
* It compares three metro routes – Blue, Green, and Red – displayed with distinct colors.
* Red Line has the highest usage with 29,606 stops.
* Blue Line follows closely with 26,284 stops.
* Green Line has the least usage with only 4,612 stops.

**Chart 2: Number of Trips Per Day**

A graph with blue and orange bars

AI-generated content may be incorrect.

* The chart displays the number of trips occurring daily for different metro routes.
* The Miyapur - L.B. Nagar (C1) and Nagole - Raidurg (C3) routes show the highest daily trip counts.
* Onward trips are in blue, and return trips are in orange, maintaining consistency with the first chart.
* Nagole, Raidurg, Miyapur, and L.B. Nagar have the highest number of daily trips at 565, 575, 562, and 550 respectively.
* Stations like HITEC City, Ameerpet, and Secunderabad East have very few daily trips with less than 10 trips.

**Chart 3: Hourly Train Arrivals**

A graph of progress bar

AI-generated content may be incorrect.

* The chart is titled "Hourly Train Arrivals," indicating the focus is on train frequency at different times of the day.
* Routes are categorized into three groups: JBS Parade Ground - MG Bus Station - JBS Parade Ground (C2), Miyapur - LB Nagar - Miyapur (C1), Nagole - Raidurg - Nagole (C3)
* Each route is further divided into six time-of-day slots.
* The chart is divided into two major sections: Onward Trips: Train arrivals for the forward direction. Return Trips: Train arrivals in the opposite direction.
* The “Late Evening (6 PM - 9 PM)” slot generally has the highest number of arrivals.
* The “Late Night (after 9 PM)” slot has the least number of arrivals.
* The “Onward” and “Return” directions exhibit similar patterns, though there are slight variations in trip counts.

**Chart 4: Line Usage According to Time of The Day- Heat Map**

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* The heatmap shows train line usage across different time slots for three routes: BLUE, GREEN, and RED.
* Heatmap: Darker shades indicate higher usage, while lighter shades represent lower usage.
* RED Line has the highest usage overall, peaking at 6,066 during Late Evening.
* BLUE Line follows, with a peak usage of 5,394 in the Late Evening.
* GREEN Line has the lowest overall usage, remaining below 1,000 in all time slots.

**Chart 5: Line Usage According to Time of Day-Line Chart**

A graph with a line

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* Line chart: Displays trends in train usage throughout the day.
* “Late Evening (6 PM - 9 PM)” sees the highest train usage across all lines.
* “Late Night (after 9 PM)” has the lowest train usage
* The busiest time for train usage is “Late Evening”, while the “Late Night” has the least demand.

1. **Findings**

The analysis indicates that train usage is highest during the Late Evening (6 PM - 9 PM) across all metro lines, whereas Late Night (after 9 PM) shows the least demand. The Red Line sees the most passenger activity, reaching a peak of 6,066 stops, followed by the Blue Line at 5,394 stops, while the Green Line remains below 1,000 stops throughout all time periods. Throughout the day, train ridership varies, with a notable increase evident during the evening hours, as demonstrated by the heatmap and line chart visualizations.

Operational data points to opportunities for resource optimization and the implementation of dynamic pricing models to manage ridership levels. Elevated fares could deter passengers during off-peak times, while offers such as discounts on underutilized routes like the Green Line might motivate people for increased usage. Enhancing accessibility and overall metro ridership could further be achieved by providing targeted incentives for students, residents, and regular commuters.

1. **Conclusion**

The Hyderabad Metro Rail is important for urban transit, providing an effective and eco-friendly transportation option. An examination of ridership patterns reveals trends in peak and off-peak traffic, with the busiest time occurring in the Late Evening (6 PM – 9 PM) and the Late Night (after 9 PM) showing the least demand. The Red Line consistently experiences the highest number of passengers, while the Green Line is found underutilized. These findings undermine the necessity for improved resource distribution, scheduling, and infrastructure modifications to boost the metro's efficiency.

A harmonious balance between ridership and revenue can be attained through enhanced operational practices, focused incentives, and adjustments for specific routes. Implementing discounts and adaptable pricing strategies could stimulate greater usage of the Green Line. Moreover, increasing train frequency during peak periods and refining schedules based on demand patterns will notably improve service dependability. By utilizing data-driven insights into the Hyderabad Metro, a more sustainable urban transit system can be developed, leading to an improved commuter experience and increased ridership.

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