FTA Report No. 0269

FTA
RESEARCH
FEDERAL TRANSIT ADMINISTRATION

Providing a Dynamic, Data-Driven Micro-Transit Service with Smart Dispatch Using Artificial Intelligence

PREPARED BY
Lisa Johnson
Deputy Director
Prairie Hills Transit

U.S. Department of Transportation
Federal Transit Administration

SEPTEMBER
2024

COVER PHOTO

Chelsea Uphaus, Director of Marketing with ROUSH Cleantech

COVER PHOTO

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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE August 2024	2. REPORT TYPE Final Report	3. DATES COVERED
4. TITLE AND SUBTITLE Providing a Dynamic, Data-Driven Microtransit Service with Smart Dispatch Using Artificial Intelligence		5a. CONTRACT NUMBER 5b. GRANT NUMBER SD-2021-005-00 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Lisa Johnson, Deputy Director – Prairie Hills Transit Dr. Mital Parikh, Ph.D., Director of Microtransit Service – QRyde		5d. PROGRAM NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(ES) West River Transit Authority, Inc dba Prairie Hills Transit 2015 Tumble Weed Trail Spearfish, SD 57783		8. PERFORMING ORGANIZATION REPORT NUMBER FTA Report No. 0269
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Transit Administration Office of Research, Demonstration and Innovation 1200 New Jersey Avenue, SE, Washington, DC 20590		10. SPONSOR/MONITOR'S ACRONYM(S) FTA 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Available from: National Technical Information Service (NTIS), Springfield, VA 22161; (703) 605-6000, Fax (703) 605-6900, email [orders@ntis.gov]; Distribution Code TRI-30

13. SUPPLEMENTARY NOTES
PHT will conduct the project by the FTA Master Agreement https://www.transit.dot.gov/funding/grantee- resources/sample-fta-agreements/fta-master-agreement-fiscal-year-2020 and Circular 6100.1E (https://www.transit.dot.gov/

14. ABSTRACT
This report provides the results of FTA's Accelerating Innovative Mobility (AIM) Initiative Grant goals by implementing innovative technology with an artificial intelligence dispatch to provide a dynamic, data-driven micro-transit service. The advanced technology will optimize the cost of managing transportation operations for its paratransit service by automating its dispatch system. The project is in a rural area, optimally utilizing its resources to manage more rides with the same number of dispatchers currently used to manage its system. The report describes the project's current implementation and future capabilities.

15. SUBJECT TERMS
Rural public transportation with demand response service provided by West River Transit Authority, Inc. dba Prairie Hills Transit, Spearfish, SD 57783.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified	Unlimited	31	19b. TELEPHONE NUMBER

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Acknowledgments

Prairie Hills Transit (PHT) is proud to have supported the U.S. Department of Transportation's (USDOT) Rural Opportunities to Use Transportation for Economic Success (ROUTES) initiative. This initiative, which aims to provide additional employment opportunities and increase opportunities for improved medical access for the population in our rural service area, is a cause we wholeheartedly support. We thank USDOT for funding this project and for their expert guidance through the implementation and completion of the project. We also express our appreciation to the critical partner of this project, HB Software Solutions, and their team of transportation professionals who designed and created the innovative artificial intelligence dispatch system and conducted the independent evaluation of the project.

Abstract

This report comprehensively overviews FTA's Accelerating Innovative Mobility (AIM) Initiative Grant results. The report focuses on successfully implementing an innovative technology with an artificial intelligence dispatch to provide a dynamic, data-driven micro-transit service. The advanced technology optimizes the cost of managing transportation operations for PHT's paratransit service by automating its dispatch system. The report also outlines the project's current implementation and future capabilities, providing a roadmap for the continued success of the project.

Executive Summary

West River Transit Authority, Inc. dba Prairie Hills Transit (PHT) and HB Software Solutions-QRyde, a transportation software technology company, partnered to accomplish the goals of the Federal Transit Administration's (FTA) Accelerating Innovative Mobility (AIM) initiative. The critical achievement was developing and deploying an AI-based dispatch system that optimizes the cost of managing PHT's paratransit operations. This system enables PHT to manage more rides with the same number of dispatchers, significantly improving the efficiency and effectiveness of its operations.

Introducing a revolutionary concept, an artificial intelligence (AI) based dispatch system was developed and deployed to replace the current human-operated dispatch model. This innovative system automates the decisions currently made by human dispatchers, using real-time data from the field (driver apps, consumer apps, text/voice notification systems) to drive most decisions. This reduces the reliance on human dispatchers making decisions based on sticky notes and radio communication. The new system, named **DISPATCH360 by QRYDE, is a game-changer in transportation operations**.

FTA's AIM initiative provides federal research funds to project teams to demonstrate innovative, practical approaches, practices, and technologies that enhance effectiveness, increase efficiency, expand quality, promote safety, and improve public transportation riders' experience.

This project's goal of implementing an AI-based innovative dispatch system that enables patrons to book and manage same-day rides for medical and behavioral treatment appointments has been accomplished through the following tasks:

- Implementation of the software and hardware architecture with communication/network layers.
- Deployment of AI/machine learning technologies to handle new, late, and no-show trips
- Education and service marketing for customers
- Delivery of data expectancy metrics, which is accurate real-time information

Progressive project impacts include:

- Increased access for seniors, students, and individuals with limited personal mobility
- Improved equity and accessibility to public transit

- Improved efficiency
- Use of public-private partnerships for demonstration, data sharing, and knowledge transfer

National significance, since with an increase in ridership, not only will PHT gain environmental benefits such as a reduced carbon footprint, but the project is also expected to improve mobility and increase accessibility to economic opportunities for PHT's customers.

Section 1

Introduction

Since 1989, West River Transit Authority, Inc. dba Prairie Hills Transit (PHT) has been dedicated to providing cost-effective, reliable transportation in rural western South Dakota, encompassing a service area that includes nine counties and 15 communities. PHT serves all ages, including those with varying physical and mental conditions, and provides transportation to school, work, healthcare appointments, veterans, and various personal needs trips. The PHT regional office in Spearfish, SD, hosts an intercity bus service with twice-daily stops. With seven bus facilities, PHT has a fleet size of 55 vehicles that consist of cutaway buses for wheelchairs and five-point child seats, ADA minivans, one trolley, and Ford Transit vans. This vehicle diversity allows PHT to provide the best transportation experience for all riders.

Project Overview

The PHT data management plan (DMP) provides a framework for implementing an AI-based intelligent dispatch to provide a dynamic, data-driven micro-transit service in PHT's service area. Additionally, the developer will submit a compliance statement, including any deviations from the DMP framework outlined in subsequent sections. This plan only applies to federally funded projects. The following section provides an overview of the Accelerated Innovative Mobility (AIM) Challenge Grant.

Accelerating Innovative Mobility (AIM)

FTA's Accelerating Innovative Mobility (AIM) Initiative highlights FTA's commitment to supporting and advancing innovation in the transit industry. AIM will drive innovation by promoting forward-thinking approaches to improving transit financing, planning, system design, and service. The AIM Initiative also supports innovative approaches to advancing strategies that promote accessibility, including equitable and equivalent accessibility for all travelers.

The goals of AIM are to:

- Identify, test, and prove new approaches, technologies, and service models.
- Promote the most promising mobility innovations that can be implemented more broadly through FTA's capital programs.

- Establish a national network of transit stakeholders that are incorporating innovative approaches and business models to improve mobility.

The primary objectives of AIM are to:

- Foster innovative transit technologies, practices, and solutions that advance the state of practice for public transportation in the U.S.
- Leverage private sector investments in mobility for the benefit of transit.
- Ensure innovative technologies and practices permit interoperability across systems and modes.
- Share results of innovative mobility solutions with the transit industry and stakeholders.

Section 2

Project Goals, Objectives, and Benefits

Goal: To solve a complex problem like real-time dispatch by developing a high-performance containerized architecture for bringing together the telemetry data, driver messaging, and performance data from the field almost instantly and with near-zero latency.

Objectives: (1) To develop a user-friendly innovative system for patrons, healthcare centers, and other institutions that will enable them to access information and manage their mobility requests, and (2) to implement a high public transit operational efficiency.

Benefits: To support USDOT's Rural Opportunities to Use Transportation for Economic Success (ROUTES) initiative by providing improved access to employment and healthcare to the population served in the PHT area. In addition, South Dakota DOT can view the demand distribution on a heat map for different times of the day and week. The data will also include the vehicle miles traveled (VMT) in the rural area. The data available from the project will allow the South Dakota DOT to assess the benefits of rural transportation infrastructure projects and provide safety on frequently traveled paths.

Section 3

Independent Evaluation

FTA's Mobility Innovation research portfolio seeks to improve public transportation services by providing technology-enabled mobility options that fill spatial and temporal gaps for travelers and ensure accessibility. FTA fosters emerging and innovative technologies and facilitates public-private partnerships to promote a user-centric approach that improves mobility options for all travelers. FTA conducts mobility innovation research through various research programs. The objectives of FTA's mobility innovation research programs are to:

1. Explore emerging technology solutions and new business approaches
2. Enable the public transportation industry to adopt innovative mobility partnerships and solutions
3. Facilitate widespread deployment of proven mobility solutions and partnerships

An independent evaluation (IE) is required by Federal public transportation law for demonstration projects receiving FTA Public Transportation Innovation funding (49 U.S.C. § 5312(e)(4)). Beyond the statutory requirement, an IE is also a valuable tool for understanding the impact of a project, disseminating key findings and success stories, and identifying project limitations to allow future deployers within the mobility industry to build upon prior work. Effective evaluations may highlight valuable deployments and impactful strategies while illuminating lessons learned to enable continued progress in emerging solutions areas.

Project Scope

PHT plans to implement a new real-time dispatching system for its on-demand public transportation services that reduces data latency so vehicle location updates are conducted in near-zero latency, enabling artificial intelligence (AI) and machine learning techniques to make real-time dispatching decisions automatically. The system should allow up to 85-90% of decisions to be driven by real-time data and should be less reliant on human dispatchers. The planned dispatch system upgrade would allow PHT to monitor its vehicles in near-instant time and expand automated dispatch control to its entire geographical area and services.

The project intends to:

1. Develop a high-performance dispatch system to bring telemetry data, driver messaging, and performance data from the field almost instantly with near-zero latency.
2. Manage more rides with the same number of dispatchers.
3. Achieve a high level of operational efficiency and seamless mobility for PHT customers.

The project's estimated duration, from execution in FTA’s Transit Award Management System (TrAMS) to completion, is 27 months (February 2021 to April 2023).

Evaluation Approach and Process

The Independent Evaluation team will develop an evaluation framework in coordination with the FTA and project team. FTA assigns evaluations to one of three tiers that guide the overall scope of the assessment. Tiers are determined by the project size, budget, concurrent local evaluation efforts, and whether a similar project has been evaluated by the FTA in the past (for example, through the Mobility on Demand Sandbox program). The scope of the evaluations for each tier is as follows:

1. **Tier 1**—Compared to the other tiers, Evaluations at this tier are the most extensive. They consist of a robust quantitative analysis, including surveys, impact assessments, cost-benefit analyses, and data aggregation, to assess the project's successes in alignment with its stated goals. These evaluations will also include a companion qualitative aspect, such as focus groups or expert interviews, to support the overall depth of the review.
2. **Tier 2**—Like Tier 1 evaluations, the evaluations in this tier use a mixed-methods approach to assess the project's qualitative and quantitative aspects. Alternatively, these evaluations may consist exclusively of a robust qualitative analysis. Tier 2 assessments, including quantitatively based hypotheses, have fewer hypotheses to assess than Tier 1 projects.
3. **Special Studies** – Special Studies evaluations are qualitative only but may contain some quantitative summary statistics from the project owner. These evaluations consist of the fewest hypotheses

to assess all the tiers. Special studies projects may be grouped into a final evaluation report according to topic area.

Implementing the AI-based innovative dispatch system demonstration will be evaluated as a Tier 2 project using qualitative and quantitative evaluation. The quantitative aspect will rely on HB Software Solutions' QRyde system data for analyses defined in the logic model outlined in **Error! Reference source not found.**. The logic model contains the f ollowing elements:

1. **Project Goals**—These denote the specific goals that outline each project's aim.
2. **Evaluation Hypothesis**—Each evaluation hypothesis for the specific project is derived from the project-specific goals.
3. **Performance Metric**—Denotes the performance metrics used to measure impact following the evaluation hypotheses for the specific project.
4. **Data Element**—Denotes each attribute for the identified performance metrics.
5. **Data Sources**—Denotes the quantitative and qualitative evaluation methods used.

The qualitative aspect will rely on expert interviews and an institutional group discussion with dispatchers and drivers. All research will be governed by an approved Institutional Review Board (IRB) Human Research Protection Program (HRPP) protocol, and consent will be obtained before engaging with human subjects.

On-site Interview

The IE Team traveled to the Prairie Hills Transit facility and interviewed Barbara Cline, Executive Director, and Lisa Johnson, Deputy Director, about the project. The dispatchers were also given a program presentation, and the IE team could interview them as they were working in real-life situations. The IE Team also interviewed the key partner, HBSS, Owner Himanshu Bhatnagar, via Zoom meeting.

Section 4

Project Description

The project was developed and implemented for dispatchers and drivers as an upgraded technology using an AI-based system. The system will notify passengers by text message when a ride is scheduled and where the bus is located. The system, which syncs with a tablet on the bus, allows dispatchers to contact one driver or message all drivers. The drivers can also communicate with dispatch and passengers via text messages. The developer used AI and machine learning to develop algorithms that break away from static programming, creating business rules that process data stored in large databases. Machine learning devises complex models and algorithms that lend themselves to prediction, for example, identifying passenger no-shows and then implementing higher levels of customer contact to minimize no-shows. Machine learning with extensive use of data uncovered hidden insights through learning from historical relationships and trends in the data. This allowed PHT to offer and place rides on identical vehicles using existing assets to provide rides to its current customer base.

The Accelerated Innovative Mobility (AIM) Challenge’s goal was to establish and prove new approaches with technologies to improve mobility for public transportation. This project was executed in the following three phases.

Phase 1: Concept Development

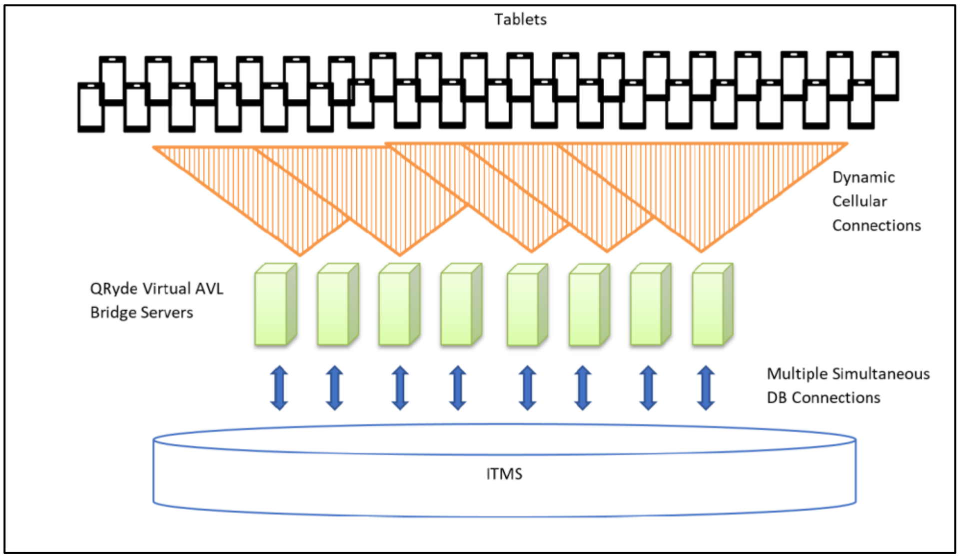
This project aimed to develop an intelligent real-time dispatch that is user-friendly for patrons and efficient for dispatch. Dispatch360, a web-based, real-time scheduling and dispatching portal, achieves this. QRyde's Driver app collects real-time data on vehicle locations, fare collected, time, speed, and direction using QRyde’s Driver app. This app can be installed on the agency-preferred device (Android tablet version).

The real-time GPS vehicle location information from the tablets is shared with the dispatchers and customers. The dispatchers administer the Dispatch360 web portal using the QRyde Global Scheduling Engine (GSE), which maintains real-time knowledge of all its vehicle locations and current and future-day driver assignments.

Dispatch360 is an AI agent technology that monitors the driver’s messages and updates from the field in its real-time caching system. It invokes various rules and algorithms to determine how to resolve the issue. The QRyde feature to find the best route for a trip is called “Ask

SAM," which can operate in auto-mode and fix issues (e.g., assign same-day trips, reassign late trips, and notify consumers when drivers are running late) with minimal human intervention. QRyde has developed an Automated Vehicle Language (AVL) Communication Bridge, a highly scalable NEAR-REALTIME Messaging Architecture supporting 10,000 tablets.

Figure 1 ***Automated Vehicle Locator (AVL) Communication Bridge.***



Phase 2: Design and Testing

At its core, the design involved a Global Scheduling Engine (GSE) to utilize all available resources most efficiently. QRyde already offers an automated schedule in batch mode for any number of future days and all reservations for a designated travel day. Scheduling is based on the actual street network in the service area (e.g., actual x and y coordinates, not zones), parameters associated with network segments as established in the geographic information system (GIS), physical barriers, speed parameters, time of day, and appropriate times for the boarding and alighting of passengers.

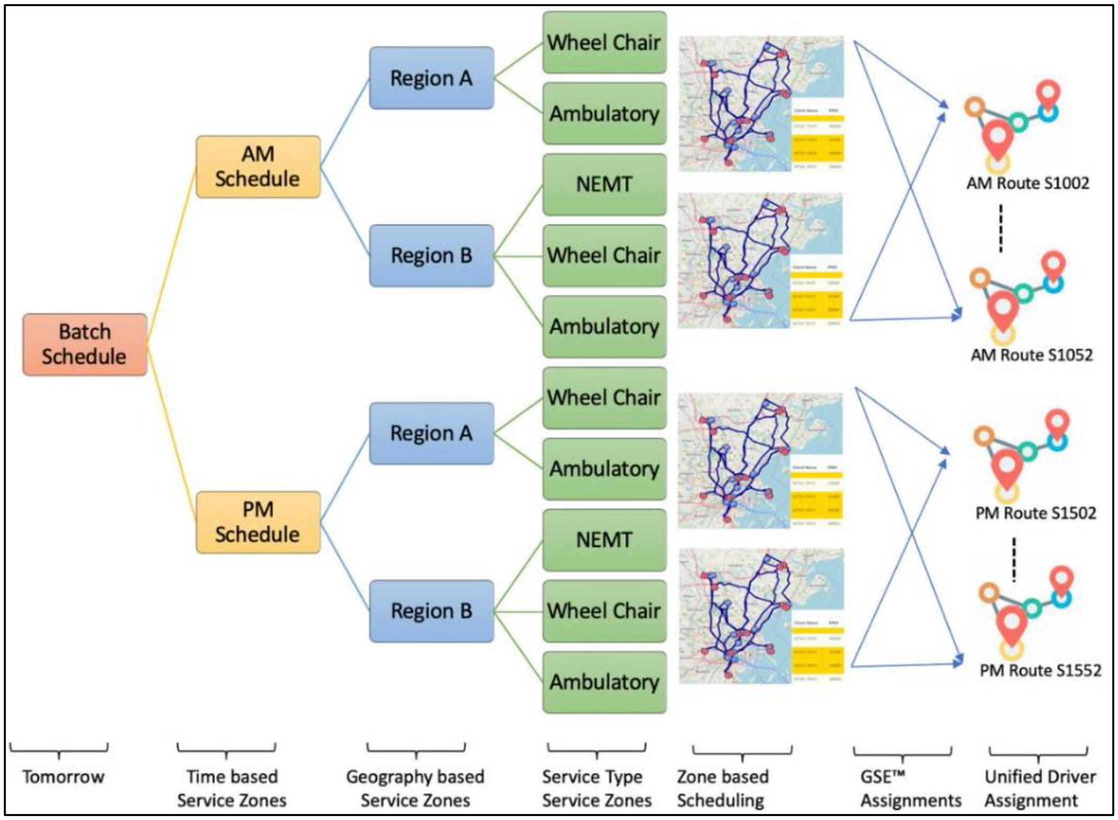
***Figure 2** Samsung Tablet showing a manifest with the QRYDE app.*

GSE uses a **divide and conquer approach**, where a more significant problem (e.g., scheduling rides in a large urban or rural geographic area) is broken into more minor issues, which are solved individually using an integrated Self-Organizing Map (SOM) and Simulated Annealing (SA) methods. GSE's methodology yields the most efficient and equitable algorithm in the industry. Additional elements of GSE's methodology include:

Subscription Rides: Schedule subscription rides, build weekday templates and overlay other trips.

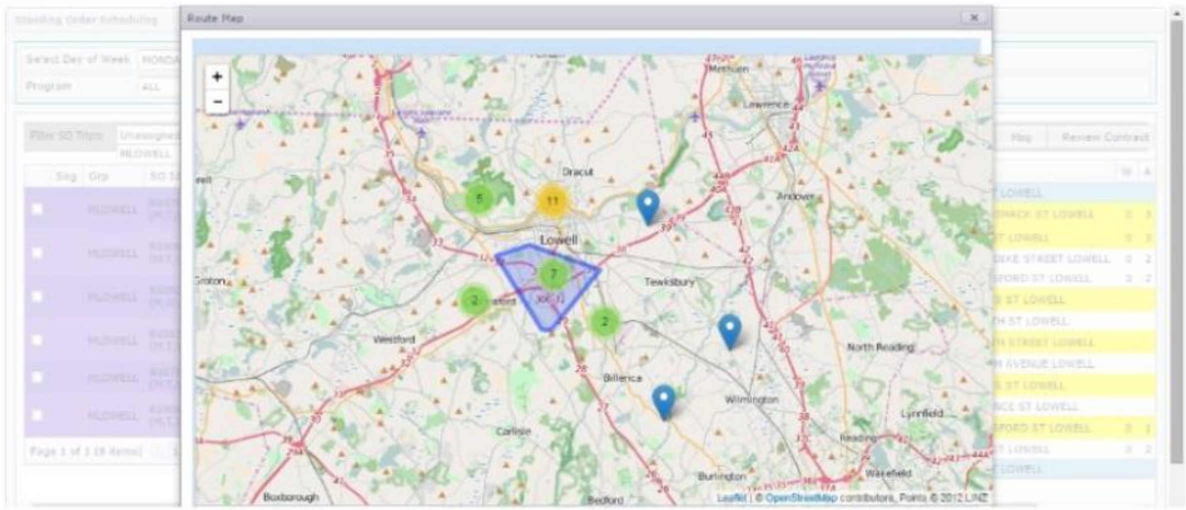
Three-dimensional Division: Each region is treated separately, and rides are re-scheduled if needed on dedicated vehicles, with some rides crossing the region boundaries.

Figure 3 *Batch Scheduling through GSE.*



Creating Shared Ride Groups: Before starting the scheduling process, GSE builds shared rides from the data for standing orders and daily trips. QRyde can automatically scan the standing orders and determine which standing orders can be grouped based on the **Neighborhood Proximity Clustering (NPC)** method. It enables users to view rides that can be picked up or dropped off together within an area and within a known time. The user can then issue commands to combine them in a group and create a shared group.

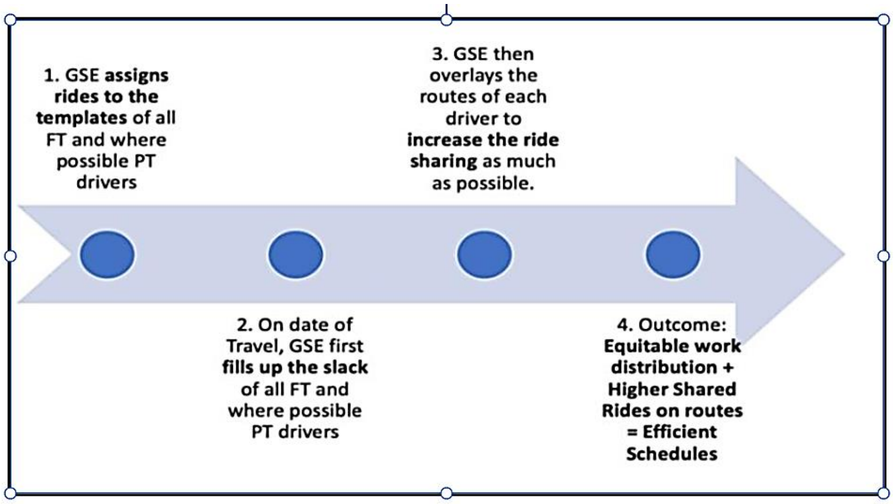
Figure 4 ***Neighborhood Proximity Clustering (NPC) method.***



Equitable Distribution of Work to Drivers: Transportation daily scheduling has two problems: peak travel time (7:00 -10:00 a.m. and 3:00 – 5:00 p.m.) and all other times. This leads to the clustering of operators during peak hours while relaxing the use of operators during non-peak hours. For equitable distribution of work to the drivers, the availability of the drivers for the travel date and the demand distribution for the day must be determined. Therefore, creating a manifest for each driver at least 24 hours before is almost necessary. If additional help is needed, it can be requested ahead of time and not keep drivers waiting for work. If the demand is low, the part-time drivers can be informed the day before. Global Scheduling Engine (GSE) offers help by following a five-step process for filling up the work shifts of the drivers:

1. GSE builds the templates with standing orders and odd-ball trips.
2. GSE downloads the template routes for that travel date.
3. GSE fills up the slack, which minimizes the deadheading, gives the drivers a continuous route for the day, and gives them work for their shifts.
4. GSE runs minimum deviation to find the best route that fits in trips for each driver along the way, maximizing the shared rides.
5. GSE offers any rides left to a third-party contractor, if available.

Figure 5 ***Neighborhood Proximity Clustering (NPC) method.***



Algorithm Optimization Parameters: To determine the best trip assignment, batch scheduling uses a complex function that uses criteria such as shared ride factor, vehicle miles, deadheading, customer service, seniority, and driver wait. The algorithm builds routes by starting with self-organized random trips into groups, placing them on segments, and adding more trips using minimum distortion.

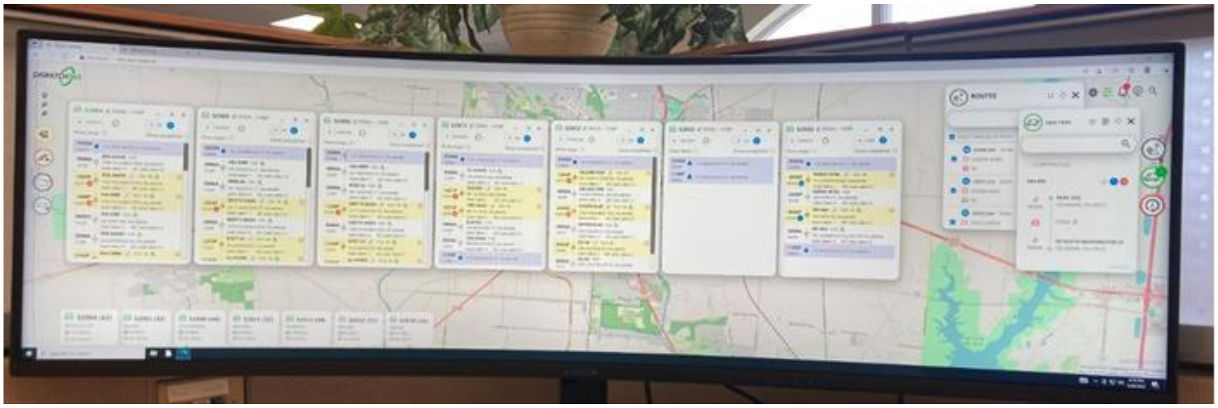
The algorithm assigns trips to the best-fit segments, reducing the system's total energy. This model is run for all scheduling zones one by one in the background until the entire batch process is completed. The output is a very efficient schedule for all drivers implementing all rules and contracts.

Phase 3: Operations and Evaluation

The program went live on April 25, 2022, for the dispatchers to evaluate in real-life scenarios.

The initial evaluation of the program allowed dispatchers to view real-time locations from driver tablets. The Dispatch360 program will enable dispatchers to search for routes, view single or multiple routes simultaneously, edit routes, and track vehicle locations for the routes. The interface to evaluate and view various routes simultaneously allows dispatchers to navigate between routes with ease without closing individual routes, as seen below.

Figure 6 ***Dispatch360 Software View on PC Monitor.***



Dispatch360 allows dispatchers to view new trips booked via the call center or a mobile app in real-time and choose the best route placements using the "Ask SAM" (find the best route) or the Continuous option available. The system allows dispatchers to manage both new and late trips with artificial intelligence-based automation, which saves dispatchers time and creates less chaos in managing the services.

Dispatch360 has streamlined communication between dispatchers and drivers. Drivers can receive instant notifications (less than a few milliseconds) for the messages sent to them. The system allows dispatchers to communicate with passengers via text message or innovative voice recording directly from the system and send them notifications on late or on-time arrivals. This reduces the dwell times drivers spend waiting when they arrive to pick up riders and reduces rider anxiety.

To complete the project, the evaluation phase was accomplished in short-, mid-, and long-term timelines. The short-term objective was to implement a high-performance hardware architecture with an appropriate communication/networking layer, upgrade the existing dispatching software, test the high-performance system, and set up measurement metrics within the system to generate metrics on demand.

The mid-term objective was to implement artificial intelligence/machine learning technologies to help with basic decision support activities such as handling no-shows, evaluating late trips, making recommendations for will calls and new trip requests, deploying data analytics across all stakeholder systems, and adding additional metrics.

The long-term objective is a fully developed intelligent dispatch technology, including all metrics to be monitored and reported, all features to be matured/adapted for all stakeholders, a new system to be thoroughly tested and used for six months, and stakeholder feedback for future improvements.

Section 5

Performance Measurement Results

Reaction Time for Trip Data Transfer

The project is an advanced technology for the PHT dispatch team, with 21 comprehensive training modules provided by the developers. The reaction time of transferring a trip into a segment and being visualized by the driver has been reduced from 45 seconds to less than 10 seconds. This includes a message of a no-show and additions to the manifest.

Bus Tracking

The program was designed to track single or multiple vehicles and uses color coding to display the vehicle status (whether off-route, off-schedule, in a no-stop zone, or in other areas where they may not be allowed). When the dispatcher clicks on the vehicle, the manifest shows the schedule. The dispatcher can add, cancel, and designate a trip as a no-show for the driver.

Figure 7 ***Multiple Vehicles in Tracking View.***

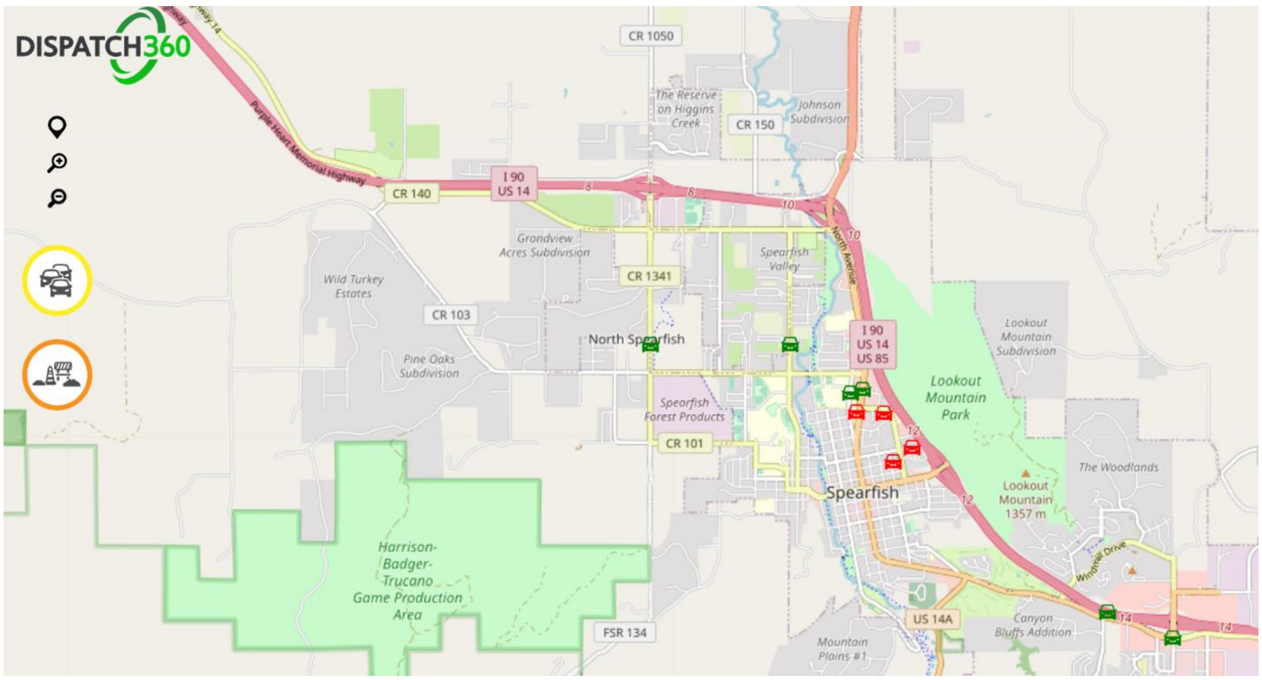
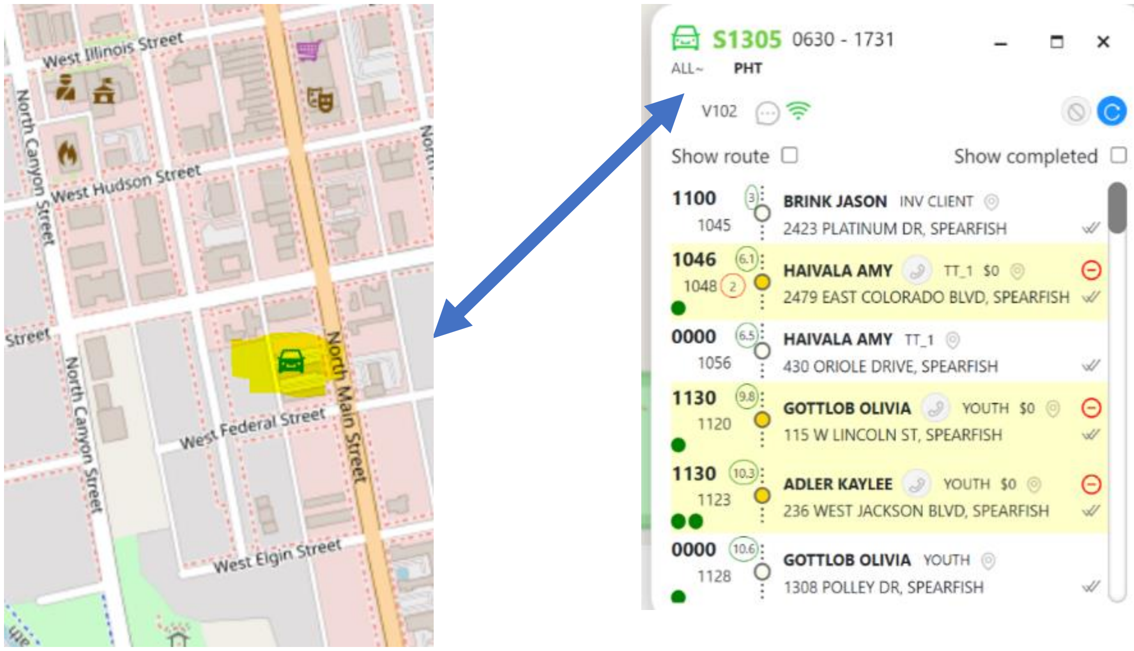


Figure 8 *Click on Single Vehicle to View Manifest on the Right.*



Quality of Service Metrics

On-time performance improvement with the new AI/machine learning program will help with basic decision-support activities. Evaluating and resolving late trips can be done daily within the program. The trip can either be reassigned to a different driver, run through Ask SAM to find the best placement, or run continuously to allow the system to resolve late trips without dispatch intervention. Solving late trips promptly is essential for efficient customer service and improving on-time performance.

Table 1 *Two-year Data of Trips Performed.*

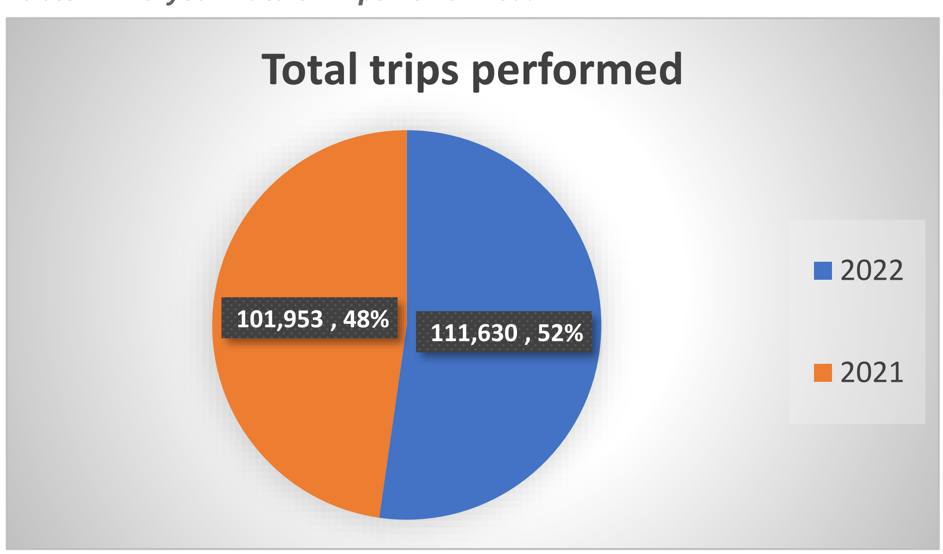
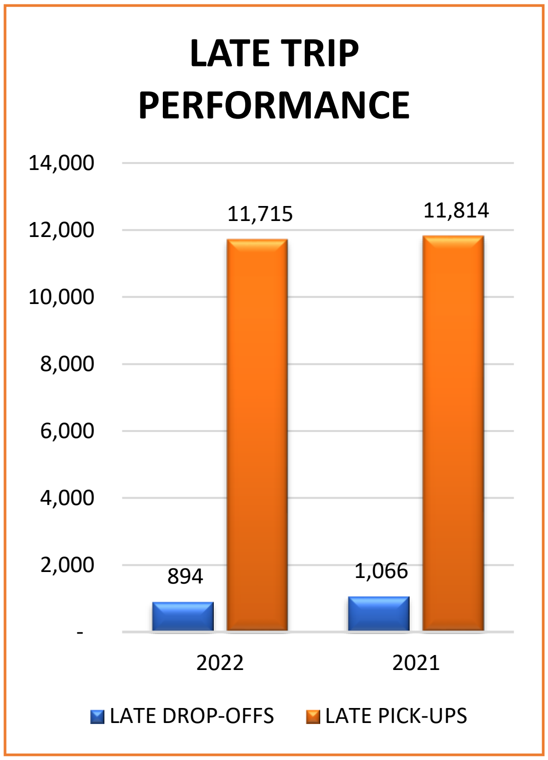


Table 2 ***Late and On-Time Performance.***



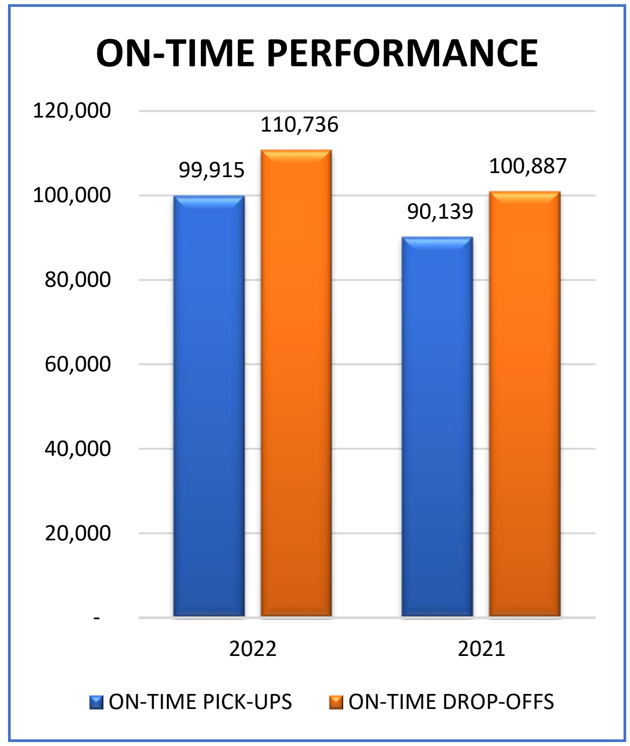
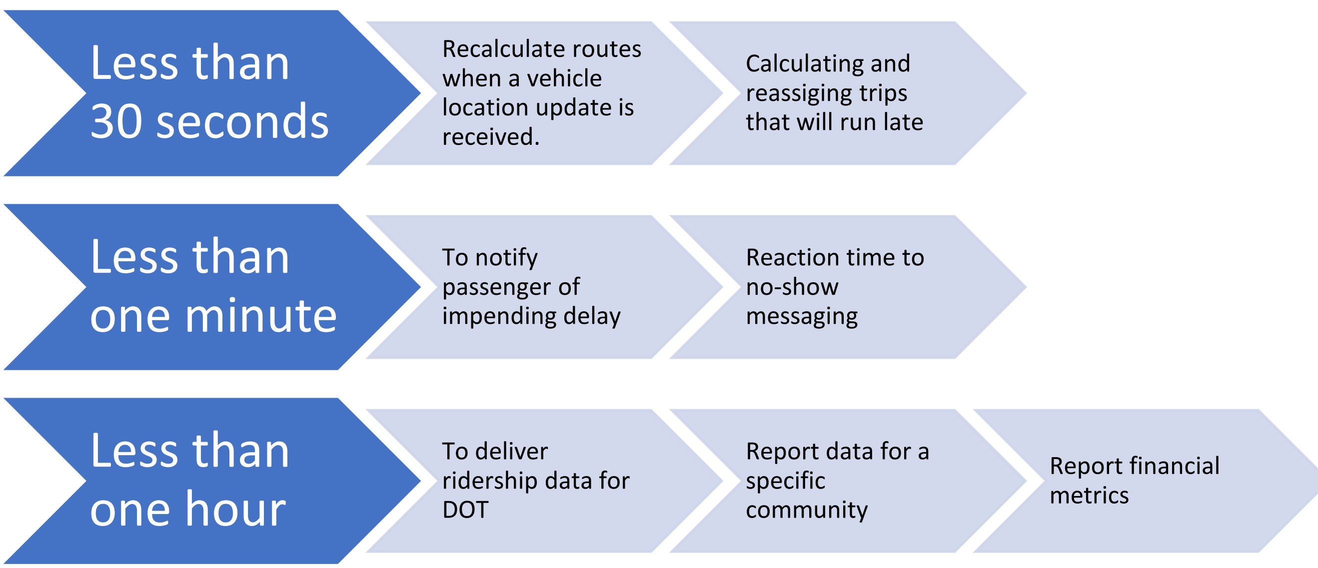


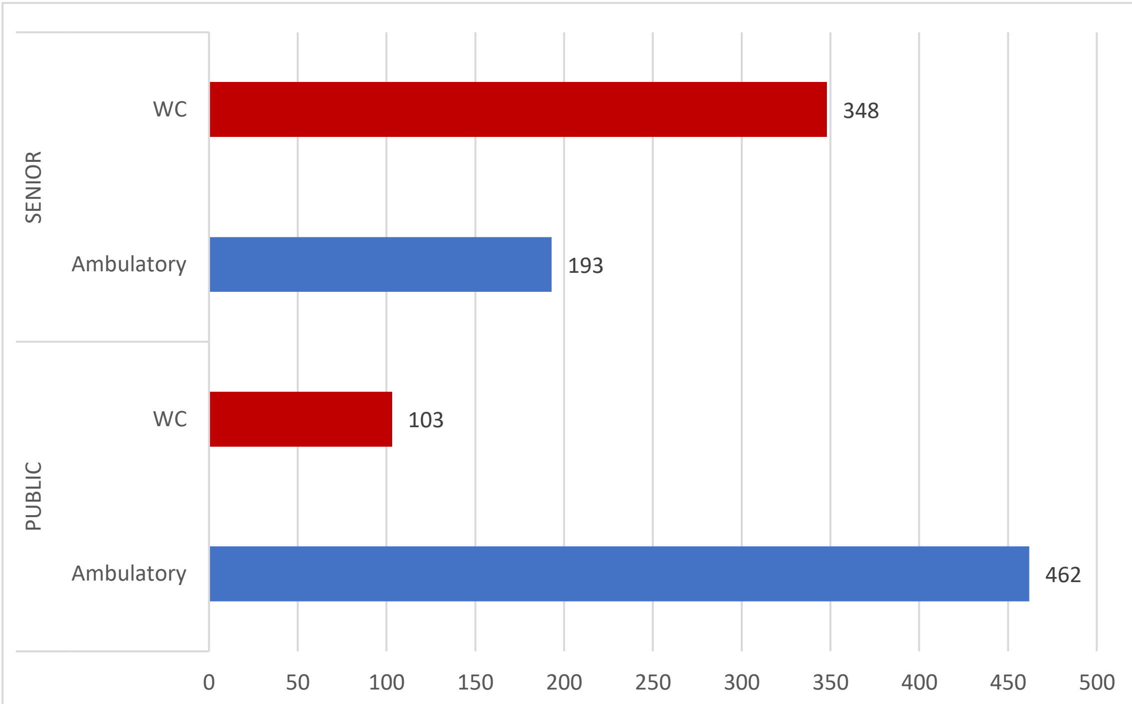
Figure 9 ***Decision Optimization Metrics.***



Unduplicated Passenger Metrics

Since the program's implementation, the data show a consistent number of new riders, averaging 25 per month. Over the past 12 months, the data was broken down by Public (under age 60), Senior (over age 60), and wheelchair utilization (WC).

Table 3 ***2022 Unduplicated Passengers***



PUBLIC	SENIOR	TOTAL
565	541	1106

Section 6

Grant Success Stories

During the period of the project implementation, the following successes were achieved:

1. As a 5311 rural public transportation agency in South Dakota, our grants were always managed by South Dakota DOT. We applied for this grant through the federal website www.grants.gov, and when PHT was selected to receive the grant, South Dakota DOT declined to manage it. With the guidance of FTA and the many hours of PHT staff and board members, PHT can now manage grants through the Transit Award Management System (TrAMS) with FTA. Additionally, PHT can submit and receive grant funds through the FTA e-invoicing system.

2. Lisa Johnson, Deputy Director of PHT, supports this project and cooperates in describing and supporting the efforts of QRyde by responding to reference requests by other transportation entities.

3. Prairie Hills Transit has demonstrated the project to other rural transit agencies in South Dakota and is proposing an artificial intelligent dispatch system. The success is in paying it forward for other rural agencies to promote a dynamic dispatch program.

Section 7

Financial

Description of Grant Activity Funding

The total activity budget is **$386,140.** FTA funded 80 percent of the project, which was $308,912. The remaining 20 percent of funding was subsidized by an in-kind match of $46,336 from key partner HB Software Solutions, and PHT's cost was $30,892.

The budget consisted of the following seven tasks.

Table 4 ***Budget Seven Tasks Outlined***

1	PROJECT MANAGEMENT	Project management, business process requirements
2	COMMUNITY OUTREACH	Marketing and outreach
3	DATA MANAGEMENT PLAN	Performance management and dashboards
4	DEPLOYMENT	AIM incubator and support: education and conference activities to disseminate knowledge
5	SOFTWARE DEVELOPMENT	Software licenses; notification engine licenses; system level performance tuning; hardware and containerized system software
6	FIELD DEMONSTRATION	Hosting and support (two years)
7	PROJECT REPORT	Documentation

Table 5 ***Financial Activity***

Salaries for management, engineer team, implementation team	$76,970
Software licenses, development, hosting	$230,584
Support, marketing, outreach, documentation	$32,250
Hardware (in-kind match)	$46,336
TOTAL	**$386,140**

Section 8

Future Use and Sustainability

This project shows how this innovative transit technology in a rural service area incentivizes people to choose public transportation, promotes economic development in communities, and enhances public/private partnerships to improve personal mobility. The program can be implemented at the state level to provide a real-time update and visibility of assets and to allow for greater ride coordination between multiple agencies.

The system will be enhanced to allow dispatchers to live-stream and communicate with drivers using video streaming. This will also enable the dispatchers to view incidents on the vehicle in real-time. Another enhancement will allow communication between dispatchers and drivers using holograms.

The program's sustainability will depend on maintaining the current versions and the technology equipment for the dispatchers and drivers by working closely with the partner, HB Software Solutions.

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