UNIVERSITY OF MICHIGAN

NOCoE Transportation Technology Tournament 2025

Enhancing Multimodal Transportation for Special Events Using Digital Twin and AI: 2026 NFL Draft – Pittsburgh

"The Wolverines"

Sungho Lim
Qingyu Zhou
Livia Gotham
Zhangke Lu
Brynn Woolley
Qingyang Lan
Yafate Desta

Academic Advisor
Dr. Neda Masoud

Industry Advisor
Tony Kratofil, PE | HNTB

In collaboration with
Aecom
City of Detroit
Michigan Department of Transportation
Pittsburgh Downtown Partnership
Pittsburgh Regional Transit
Suburban Mobility Authority for Regional Transportation (SMART)

May 31, 2025

ConOps Summary

For special events like the 2026 NFL Draft to succeed, travel to, from, and within the event area must be easy and predictable. In dense urban environments like Pittsburgh, however, the surge in demand during events often exceeds system capacity, resulting in severe congestion and travel delays. These outcomes increase social costs and reduce the event's economic potential.

Multimodal transportation presents a practical strategy to address these issues by leveraging existing infrastructure to accommodate short-term, concentrated demand. When well executed, multimodal transportation systems distribute concentrated demand across space, time, and modes, and then collect it efficiently. This enables attendees to park, travel, and circulate smoothly, enhancing the overall event experience.

Nonetheless, multimodal transportation can face significant challenges when not deliberately coordinated and instead left to unfold organically through individual decision-making. First, traveler information is often fragmented across multiple platforms, making it difficult for individuals to access real-time updates on parking availability, transit options, or event-related changes. Second, travel decisions are typically made without coordination; individuals act based on personal utility without awareness of others' choices or the broader system dynamics, leading to avoidable congestion. Third, multimodal services such as buses, light rail, and ferries often operate on fixed schedules and are not dynamically adjusted in response to crowd movement or evolving demand patterns.

To address the challenges of current multimodal transportation during special events, this ConOps proposes a multimodal transportation system that integrates three solution components. First, a **Digital Twin** is deployed to monitor real-time system states, forecast future conditions, and provides the information for optimal system-wide decisions on the following two components. Second, a **Dynamic Multimodal Transportation System** is designed to spread concentrated travel demand across space, time, and travel modes while adjusting resource deployment dynamically throughout event phases. Third, **AI-Powered Traveler Guidance and Reservation System** is designed to provide real-time, personalized guidance—from parking reservations to multimodal navigation—to make trips easy, efficient, and predictable. Collectively, the three components address the limitations of the current multimodal transportation system for special events.

The solution is expected to deliver mobility and economic benefits by distributing demand across space, time, and travel modes helping to ease congestion and improve the efficiency of existing parking and transit resources. This will likely result in faster, more predictable travel and increased participation in event activities, boosting local spending. It is also expected to generate operational benefits through a digital twin that enables real-time monitoring, facilitates decision-making through automated decision support, and continuously learns to improve system performance. Additionally, the solution is anticipated to create perception benefits by enhancing the user experience through coordinated multimodal guidance and reservation systems, encouraging long-term public acceptance of multimodal travel and ITS services.

Finally, the ConOps lays out the ITS architecture and complementary measures to support the proposed suit of solutions. The physical and functional components are described based on existing ITS service architecture. Complementary measures are introduced to improve the effectiveness of the proposed solution, which focuses on travel demand management and operational improvements. Demand management strategies help spread travel across space, time, and modes using tools like wayfinding, off peak incentives, and staggered departures. Operational strategies include adaptive signal timing and selective road use to improve operation and system throughput.

Contents

1 Introduction **1**

2 Description of the Problem **1**
2.1 Stakeholders and Interests 2
2.2 Event Characteristics and Study Area 2
2.2.1 Uncertain and Dynamic Demand with Weekday Traveling Public 2
2.2.2 Downtown Riverside Venues with Limited Parking and Access 3
2.3 Challenges in Multimodal Transportation for Events 4
2.4 Available Resources 4

3 Description of the Solution **5**
3.1 Solution Goals 5
3.2 Integrated Solution 5
3.2.1 Digital Twin for Informed Control 5
3.2.2 Dynamic Multimodal Transportation System 6
3.2.3 AI-Powered Traveler Guidance and Reservation 8

4 Solution Architecture **9**

5 Anticipated Impacts **9**

6 Complementary Measures **10**

7 References **11**

A Functional Description **12**

List of Figures

1 NFL Draft venues and surrounding area. 3
2 Pittsburgh multimodal transportation resources. 4
3 Digital twin for multimodal transportation during special events. 7
4 Dynamic multimodal transit operation by event phases. 7
5 **Event app interface for AI-powered guidance. Left**: En-route parking recommendation and reservation. **Center**: Multimodal event travel guidance. **Right**: Event dashboard and alerts. 8
6 Physical architecture of the solution. 9

List of Tables

A.1 Functional description of the solution 12

List of Acronyms

AI Artificial Intelligence

CityTMC City of Pittsburgh Traffic Management Center

ConOps Concept of Operations

DOMI Department of Mobility and Infrastructure

ITS Intelligent Transportation System

LLM Large Language Model

NFL National Football League

PDP Pittsburgh Downtown Partnership

PRT Pittsburgh Regional Transit

TIC Transportation Information Center

TMC Traffic Management Center

TSMO Transportation Systems Management and Operations

1 Introduction

For a special event to be successful, travel to, from, and within the event area must be easy and predictable. This ensures attendees can plan trips effectively and fully participate in event activities. However, when such events occur in dense urban environments, the surge in travel demand often exceeds the city's usual capacity, leading to severe congestion and unpredictable travel times. These issues not only increase social costs, but also reduce the event's potential economic benefits.

Encouraging multimodal travel is a desirable solution to accommodate the spatially concentrated, and short-term surge in demand using existing resources. When implemented effectively, multimodal systems allow attendees to park, commute, and participate seamlessly, despite the limitations of dense urban settings.

Despite its potential, multimodal transportation- if not deliberately planned- can face practical challenges that reduce its appeal and efficiency. From the attendee's perspective, relevant travel information is often fragmented across modes or difficult to access, making it hard to plan optimal routes. Parking availability poses another hurdle: drivers may circle closer to downtown searching for nonexistent spots or compete for limited parking spaces, contributing to unnecessary congestion. Many attendees are also unfamiliar with the city's layout and local park-and-ride systems, further complicating their journey. At the system level, individual decisions made without coordination can conflict with broader network efficiency goals. Meanwhile, multimodal services, such as buses, light rail, or ferries, may not be dispatched or routed in a way that responds effectively to real time demand and event dynamics. These challenges diminish the attractiveness of multimodal travel and undermine its ability to mitigate congestion and enhance overall access.

The 2026 NFL Draft in Pittsburgh presents an ideal opportunity to implement multimodal transportation solutions. The event occurs on weekdays alongside regular urban traffic, compounding mobility challenges in the city's dense core. Pittsburgh's geography, defined by rivers and bridges, further restricts parking and access capacity. Nonetheless, the region has multiple multimodal transportation assets, such as park-and-ride lots, light rail, buses, and ferries, which could be leveraged to expand access capacity. However, the challenges of multimodal transportation still apply and should be addressed to maximize its full potential.

This ConOps document focuses on enhancing multimodal transportation during special events through leveraging Digital Twin and AI technology. Overall, we propose a multimodal transportation system that integrates the following three components:

- **Digital Twin for Informed Control**: A digital model that monitors system states, forecasts future states, and provides the information for optimal system-wide decisions on the following two components.
- **Dynamic Multimodal Transportation System**: Spread travel demand across space, time, and modes, and adjust multimodal asset deployment dynamically throughout event phases.
- **AI-Powered Traveler Guidance and Reservation**: Provide real-time, personalized guidance from parking reservations to multimodal navigation to make multimodal trip easy, efficient, and predictable.

The remainder of this document is organized as follows: Section 2 provides a description of the problem, including background information on the event and study area, as well as challenges and resources for multimodal transportation for events. Section 3 presents the proposed solutions by outlining the goals and three core components of the integrated solution. Section 4 details the ITS architecture. Section 5 discusses anticipated impacts. Section 6 concludes with a set of complementary measures that can enhance the effectiveness of the proposed solution.

2 Description of the Problem

In this section, we present the backgrounds, key challenges, and available resources. We begin by identifying stakeholders and their interests. Second, the event characteristics and study area are explored to build a richer understanding of the context in which the problem arises. We begin by analyzing event-specific demand, drawing on insights from the 2024 NFL Draft in Detroit as a reference case. We then assess the city of Pittsburgh, particularly the layout of the event venue and its surrounding infrastructure, to evaluate existing transportation options. Then, we identify key challenges in multimodal transportation for the event. Lastly, we lay out existing resources that can be utilized to address the problem. This comprehensive background of the problem helps build a stronger foundation when developing solutions.

2.1 Stakeholders and Interests

Traveling Individuals: Predictable, easy, and short travel

Event attendees and **traveling public** belong in this category of stakeholders. Travelers are the most important stakeholders as they generate economic benefits and could potentially impose more social costs for all stakeholders depending on their travel choices. Travelers desire **predictable, easy, and short travel** so that they can plan their journey easily and engage in activities they want.

There are several things to note about travelers. First, they often do not have access to the best/most up-to-date information on parking and access. Second, their uncoordinated choices to approach the event zone with private transportation may worsen traffic congestion and increase social costs for everyone. Third, event attendees and the traveling public share the same resources for parking and access, and resources such as parking spaces may become available along the day as the traveling public might leave downtown before the main event.

Event-related Stakeholders: Event success, revenue, and easy access

NFL and **local business owners** such as restaurant and hotel owners belong in this category of stakeholders. These stakeholders are interested in an overall smooth event, with easy access to the event and businesses to maximize satisfaction and revenue. Unreliable or congested parking, access, or egress may diminish attendees' ability or willingness to participate in ancillary activities, impacting both the event and local businesses.

Transportation and Parking Companies: Maximize Revenue and Utilization

Transportation and parking companies want maximum revenue overall, often through maximum utilization of their resources. This stakeholder group includes **Pittsburgh Regional Transit**, **ferry companies**, **parking companies**, and **ride-hailing companies**. Private companies compete in the market for profit. Pittsburgh Regional Transit considers profit less and focuses more on serving the public needs and minimizing social costs.

Government Agencies: Maximize Economic Benefit, Minimize Social Cost

Government agencies include Local DOT - **City of Pittsburgh DOMI**, City planning agency - **PDP**, and **PRT**. Government agencies desire to maximize the economic benefit of the special event while minimizing social costs. To achieve these goals, they play a moderating role among stakeholders by setting regulations and making strategic investments. For example, DOMI regulates and issues permits for event operation plans, including roadway closures, traffic control, and public transportation coordination. Regarding transportation, they may provide subsidies to promote transit usage and reduce congestion. For instance, PRT currently incentivizes transit use for Acrisure Stadium events by offering fare-free rides from downtown to the stadium.

2.2 Event Characteristics and Study Area

2.2.1 Uncertain and Dynamic Demand with Weekday Traveling Public

The open and less structured event format creates an unpredictable and dynamic demand profile that is difficult to manage. As a free, multi-day event open to the public, the total number of attendees is hard to predict, and the crowd size may exceed the capacity of the event venues. In such cases, **the full occupancy event venues will be closed for entrance and people will need to be redirected to secondary locations**.

These challenges are further complicated by temporal shifts in crowd movement throughout the event schedule. Ingress tends to occur gradually; however, large numbers of attendees are expected to move between venues during peak activities, such as the main stage announcements. After their primary draft interest concludes, many people will leave the area simultaneously, creating additional surges. These temporal shifts in crowd movements, combined with uncertain demand, make it challenging for supplies to effectively accommodate the crowd.

Compounding these issues, the event takes place from Thursday to Saturday, overlapping with two weekday rush periods when downtown Pittsburgh's transportation network is already strained by

regular commuter and business traffic. The added demand from event attendees will strain the existing transportation system and exacerbate traffic and parking issues.

2.2.2 Downtown Riverside Venues with Limited Parking and Access

Pittsburgh features a dense urban core, but access and circulation are constrained by its surrounding rivers. The city lies at the confluence of the Allegheny and Monongahela Rivers, with Downtown and adjacent neighborhoods connected by numerous bridges across these rivers. With a 2020 population of approximately 303,000 (and over 2.4 million in the metropolitan area), its urban density reaches roughly 5,200 people per square mile. Known as the "City of Bridges," Pittsburgh relies on these structures, spanning rivers and valleys, as critical transportation links, especially given its steep and rugged topography. The road network funnels traffic onto key corridors, including Interstates 376 and 279, and across major river crossings. This layout can lead to significant congestion, as bridges could create severe bottlenecks.

The geographic layout of the event venues and parking capacity at walkable distances presents additional challenges. The 2026 NFL Draft will span three days (April 23-25) across two primary locations: the North Shore adjacent to Acrisure Stadium and Point State Park downtown, separated by the Allegheny River as shown in Figure 1. This riverfront configuration naturally restricts access points and parking availability. The limited parking capacity within walking distance of the event is a significant concern. Downtown Pittsburgh offers approximately 16,000 parking spaces—far too few for the 500,000 to 700,000 attendees expected at the 2026 NFL Draft. Even when accounting for nearby lots outside of downtown, the available parking remains insufficient. This shortage, combined with regular weekday demand, calls for a solution that enable attendees to park farther away and access the venue with another mode.

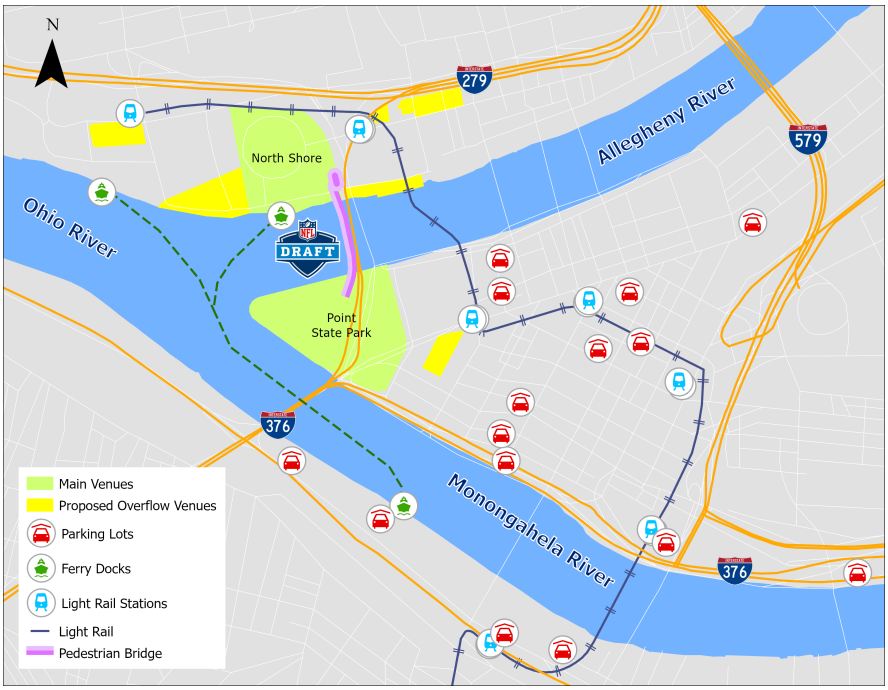

Figure 1: NFL Draft venues and surrounding area.

In addition, due to the separation of the two event venues, attendees will likely travel between the North Shore and Downtown during the event. Currently, there exists a 10-foot-wide pedestrian bridge alongside Interstate 279 connecting the two areas and the North Shore Connector section of the light rail system, a tunnel connecting Downtown and North Shore that opened in 2012. It is unknown at this point which transportation mode the authority will prioritize for mobilizing the large crowd at the event.

Pittsburgh has good multimodal transportation options to move people to the urban core without using private vehicles due to this geographical context. PRT operates light rail, buses, and inclines. To encourage people to use the light rail between the stadium and downtown, rides between those stations are offered free of charge. Private water transport is also a prominent feature of public transit, with examples such as the

Gateway Clipper ferry service that operates on the rivers. Notably, this service has shuttled visitors between Station Square, located on the south bank of the river, and North Shore on event days, such as the 2023 Taylor Swift concert. Large parking spaces with docks can be found along the rivers, and if ferries could expand their operation to those docks, they would be potential park-and-ride locations.

2.3 Challenges in Multimodal Transportation for Events

There are three main challenges to facilitate multimodal transportation for 2026 NFL Draft.

- **Fragmented traveler information:** Travelers lack a centralized source for real-time parking, transit, and event updates. This complicates travel decisions and hinders seamless multimodal navigation.
- **Uncoordinated travel decisions:** Individuals make travel decisions based only on what is best for them, unaware of others' choices or system dynamics. This results in avoidable competition and congestion.
- **Inflexible multimodal operations:** Transit services like buses, light rail, and ferries are not adjusted in real time to respond to changing crowd patterns, reducing their ability to meet peak demand effectively. This issue is compounded when disruptions, such as delays caused by congestion, affect their schedules.

2.4 Available Resources

Parking Facility

Relevant parking resources in Pittsburgh can be categorized into three types: **Downtown parking garages**, **Park-and-ride lots**, and **riverside surface lots**. Downtown garages are equipped with access control and real-time occupancy sensors, this information is accessible through ParkPGH. However, their total capacity falls well short of meeting the anticipated travel demand of the NFL draft. The PRT park-and-ride system includes over 50 lots with a combined total of more than 13,000 spaces. These lots currently do not provide real-time availability information, leaving drivers to rely on vague descriptions or chance. Lastly, if ferry services are integrated to transport users to and from key event areas, riverside surface lots along the Allegheny and Monongahela Rivers can offer additional parking spaces. Figure 2 shows available resources including park-and-ride lots.

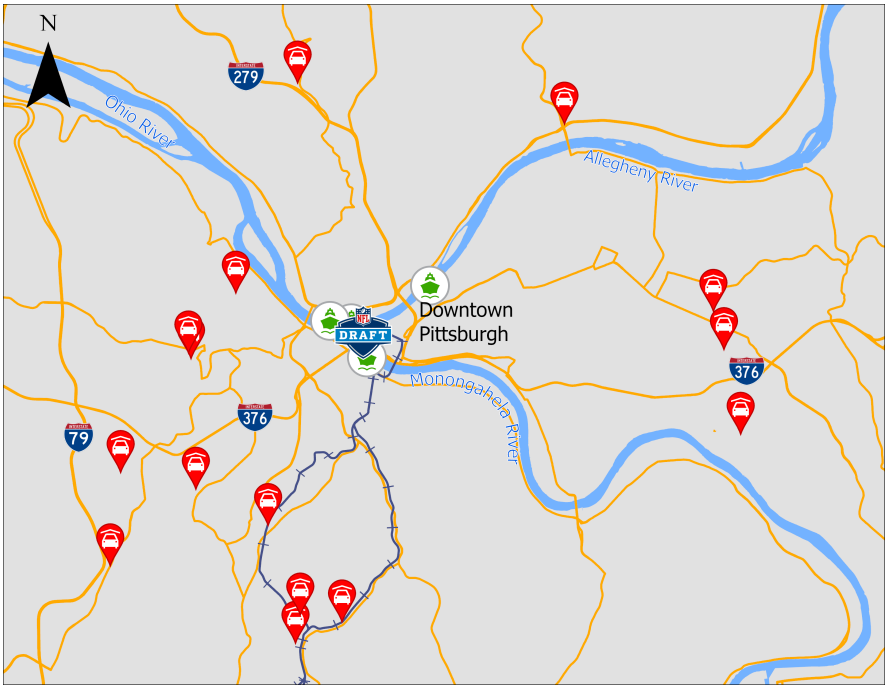

Figure 2: Pittsburgh multimodal transportation resources.

Transit

Pittsburgh offers a range of transit options as described in the study area section. PRT operates **light rail**, **buses**, and a park-and-ride system. Three light rail lines connect the South Side to Downtown and the event area. Bus routes link the Greater Pittsburgh region to Downtown. **Ferry shuttles** operate between Station Square and North Shore on event days. With agreements, service could extend to other riverside parking lots with docks.

Traveler Information Tools

Various traveler information tools can support both travel planning and day-of-event navigation. The **NFL App** is also a key resource for traveler information [1]. The NFL Draft is a non-ticketed event. However, all attendees are required to **RSVP** and scan a registration **QR code upon entry**. As a result, nearly all attendees use the app. The app provides event-specific travel information, including event schedules, parking reservations for partnered facilities, multimodal access options, event alerts, and instructions for alternate entry points if the primary event zone becomes overcrowded. **Google Maps and Apple Maps** allow users to plan routes in advance and navigate in real time with preset destinations. **Parking apps** such as ParkPGH and ParkHero provide real-time availability and reservation options.

While each of these tools is valuable, they operate independently and provide only a subset of the information needed for seamless travel during large, complex events. They are not designed to fully integrate evolving factors such as dynamic parking turnover, crowd density, or multimodal coordination across event zones. Without this level of integration, travelers may make decisions that are suboptimal for both individual convenience and overall system performance.

Traffic Management Center and Sensors

The **CityTMC** serves as the central hub for collecting transportation data from various sources. The city's transportation network is monitored by numerous traffic sensors and cameras that track system performance. Recent projects, such as SmartSpines [2] and Surtrac 2.0 [3], have enhanced traffic sensing and control capabilities on major corridors and downtown intersections. During the 2024 NFL Draft in Detroit, the TMC operated in conjuction with the NFL control center. This arrangement allowed TMC to access RSVP data and parking reservations to help forecast event attendance along with real-time entry data for event zones based on QR code scans at entrances. By integrating both historical and real-time data from these sensors and the NFL App, the CityTMC is equipped to make more informed and optimal operational decisions.

3 Description of the Solution

3.1 Solution Goals

We aim to achieve three goals to facilitate effective movement of travelers during events:

- **Provide multimodal travel guidance with real-time event and traffic context**
- **Reduce inefficiency from uncoordinated travel choices**
- **Dynamically adjust transit operations to match event schedule and demand**

Achieving these goals will improve multimodal transportation through spreading concentrated demand across space and time, supporting smoother traveler experiences, reducing inefficiency from uncoordinated travel choices, and matching service capacity to dynamic condition.

3.2 Integrated Solution

An integrated solution is developed to achieve all three goals. The integrated solution comprises of three components: Digital twin for informed control, dynamic multimodal transportation system, and AI-powered traveler guidance and reservation.

3.2.1 Digital Twin for Informed Control

Effective system management requires accurate and timely information for decision support and automation. To achieve this, we adopt a digital twin—a virtual representation of Pittsburgh's transportation and event

environment. While digital twin is commonly used to model physical infrastructure, here we extend the concept to include data layers and simulations for predictive analytics and control.

The digital twin collects and integrates a rich set of data sources organized into historical and real-time streams:

- **Historical data:**
  - Traffic, transit, and parking data from Pittsburgh
  - Data from past special events in Pittsburgh
  - Data from NFL Draft events in similar cities (e.g., 2024 NFL Draft – Detroit)
- **Real-time data:**
  - Parking occupancy and network traffic status
  - Transit service status
  - Entry data of attendees at event venue entrances
  - Venue occupancy levels and entrance availability
  - RSVP and individual location traces from the NFL app (when permitted)

Real-time data will be sourced through ITS, including sensors, connected infrastructure, and communication technologies that monitor system performance and user behavior in real time. For parking lots or event areas without existing sensors, low-cost removable monitoring solutions can be deployed. For example, overhead cameras with computer vision can track parking lot entries, exits, or available spaces. Drones and mobile phone-based crowd sourcing are also viable options. For instance, the NFL app could detect parking activity using Bluetooth or GPS by identifying when users park and sharing that data. These ITS components are essential for maintaining an up-to-date digital environment and enabling responsive control strategies.

Figure 3 illustrates the digital twin framework. By fusing these inputs, the digital twin enables predictive modeling of demand patterns and forecasting future system states under varying conditions. It can simulate various intervention scenarios, from no intervention to multiple combinations of operational strategies, helping inform both automated control and human-in-the-loop decision-making. This simulations are used to optimize the operation of multimodal transportation. The digital twin can also help identify gaps in the ITS infrastructure, informing decisions about installing or maintaining ITS devices to support more effective interventions. For example, it can flag when a GPS unit on a transit vehicle is malfunctioning or when parking occupancy data is missing. In addition to supporting system-level decision-making, the digital twin can help identify travel options for individuals that are more aligned with overall system performance goals. In summary, the digital twin is a central tool for proactive, data-informed control throughout the event.

3.2.2 Dynamic Multimodal Transportation System

The Dynamic Multimodal Transportation System enables responsive **supply-side** management of transit resources during the event. By distributing travel demand across space and modes and using higher-capacity transit for passenger collection, this approach improves both overall traffic conditions and access near the event area. It also supports travel to secondary event locations as needed.

For these functions to work effectively, transit must operate in response to the dynamic demand patterns generated by the event. Using sensing and forecasting from the digital twin, we optimize the flexible operation of multimodal transit services. While the digital twin was introduced previously, here it is used specifically to support real-time operations based on live and forecast conditions. Key capabilities include:

- **Adaptive transit operation**: Modify frequency, dispatch, or headways of PRT buses and light rail in response to demand forecasts.
- **Parking-to-shuttle coordination**: Actively adjust transit and ferry departures from parking lots in real time, based on crowding and app reservations.
- **In-transit event alert**: Provide event travel information and alerts for onboard passengers.

However, fully dynamic operations must be grounded in the operational realities of transit agencies. Limited fleets, fixed staffing levels, and institutional constraints mean that agencies cannot always adjust services on short notice. To make dynamic responsiveness feasible, we propose a proactive planning framework that aligns with agency capabilities. Digital twin simulations are used ahead of time to test various demand scenarios and establish clear service adjustment plans—including frequency, dispatch, and headway modifications—for PRT and light rail systems. These pre-planned responses can then be activated as needed during the event, enabling responsive operations without requiring improvisation. Tabletop

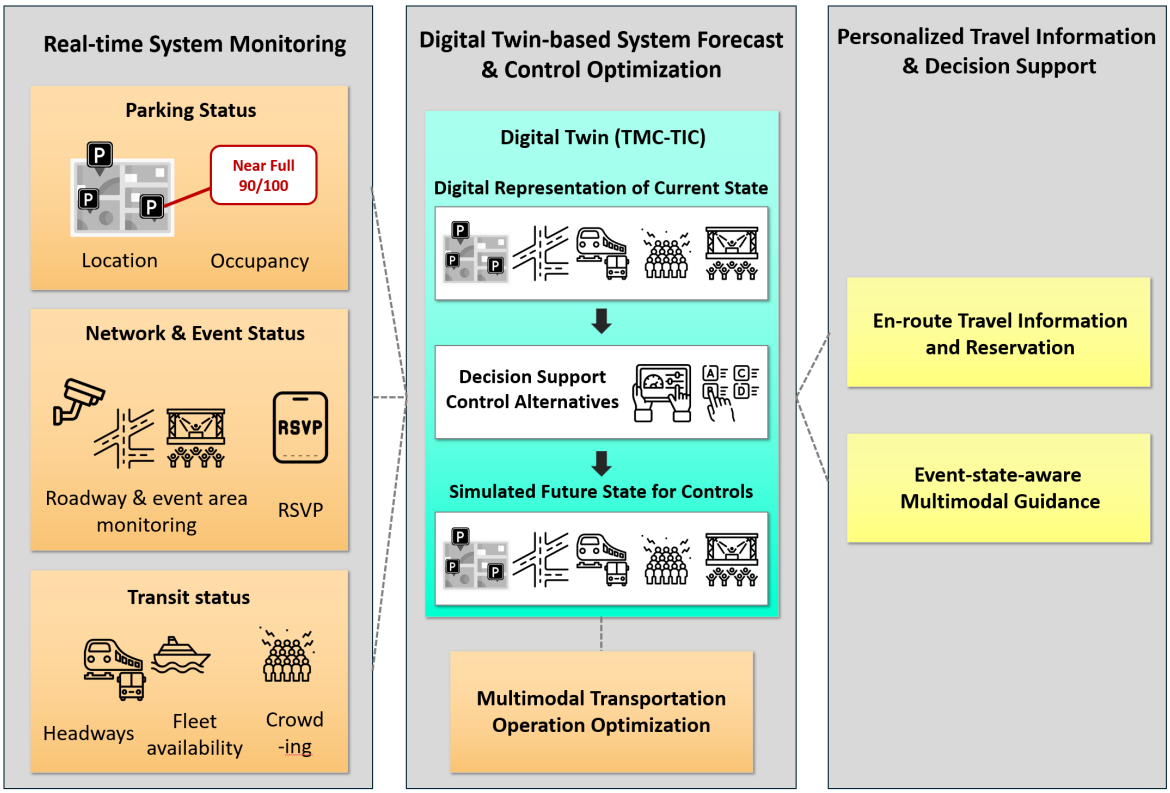

Figure 3: Digital twin for multimodal transportation during special events.

exercises conducted with agency staff further ensure familiarity, coordination, and trust in the system's recommendations during live operations.

Overall, this approach enables effective capacity management under dynamic demand conditions by maximizing the use of existing transit resources. Adaptive transit operations are pre-planned with realistic agency constraints in mind, ensuring that service adjustments are both feasible and responsive. As a result, multimodal transportation can more effectively reduce congestion, enhance reliability, and maintain well-coordinated, attractive travel options throughout all phases of the event.

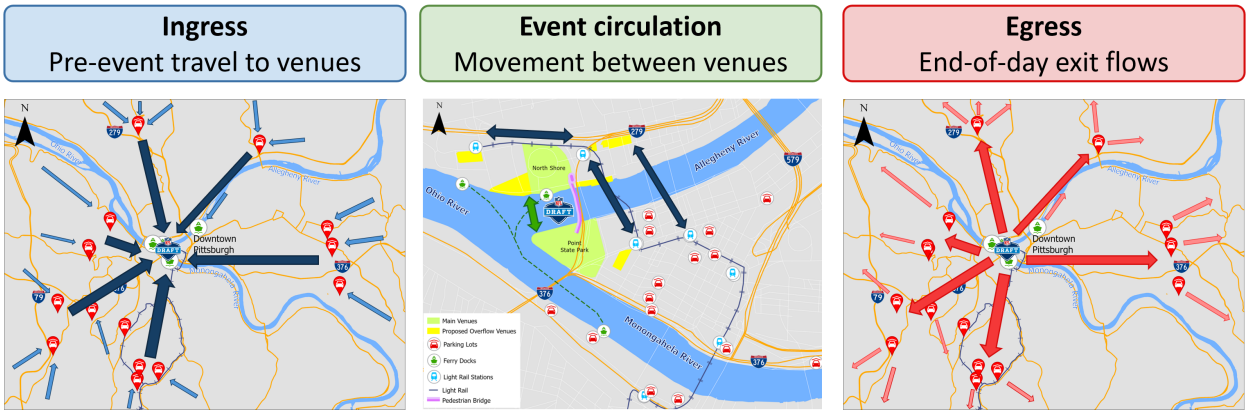

Figure 4: Dynamic multimodal transit operation by event phases.

3.2.3 AI-Powered Traveler Guidance and Reservation

The AI-powered event app is the user-targeted, **demand-side** control tool in our solution. We adopt an AI-powered event app to address uncoordinated travel decisions and fragmented traveler information. The app provides personalized multimodal travel guidance to ensure a smoother multimodal travel experience, and parking recommendation and reservation system that nudge user decisions toward improved system efficiency.

To maximize accessibility, the service is deployed directly within the NFL app, which all attendees are expected to have. By integrating information from the digital twin and leveraging large language models (LLMs), the app offers intelligent, real-time recommendations tailored to each traveler's context. Figure 5 illustrates these key features.

- **En-route parking recommendation and reservation:** Suggests and reserves parking spots based on estimated time of arrival, preventing competition for parking and unnecessary vehicle circulation.
- **Multimodal event travel guidance:** Provides dynamic routing options that combine multiple travel modes and return-trip information.
- **Event dashboard and alerts:** Notifies users when venue areas or access points (e.g., pedestrian bridges) are projected to exceed safe capacity, and redirects them accordingly.

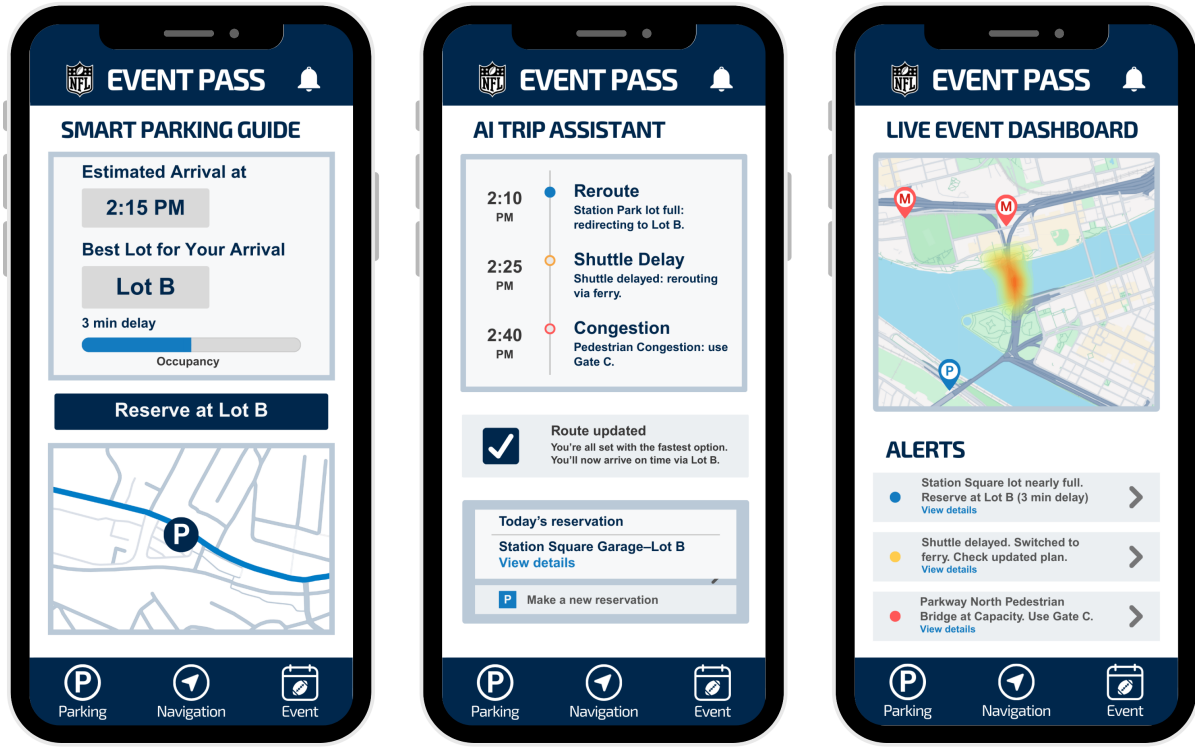

Figure 5: Event app interface for AI-powered guidance. Left: En-route parking recommendation and reservation. **Center**: Multimodal event travel guidance. **Right**: Event dashboard and alerts.

To encourage attendees to use the app and ensure a smooth user experience, several complementary strategies can be implemented. First, focus group testing of the traveler information features within the NFL app can help evaluate ease of use and inform interface improvements. Second, a coordinated promotional campaign with the NFL, local government, and groups like the Pittsburgh Downtown Partnership can increase awareness and adoption of the app when traveling. Third, incentive programs—such as food or beverage discounts with local businesses can provide a strong motivation for users to actively engage with the app.

4 Solution Architecture

The physical architecture of the proposed solutions is shown in Figure 6. The functional description of the proposed solutions is shown in Table A.1 in Appendix A.

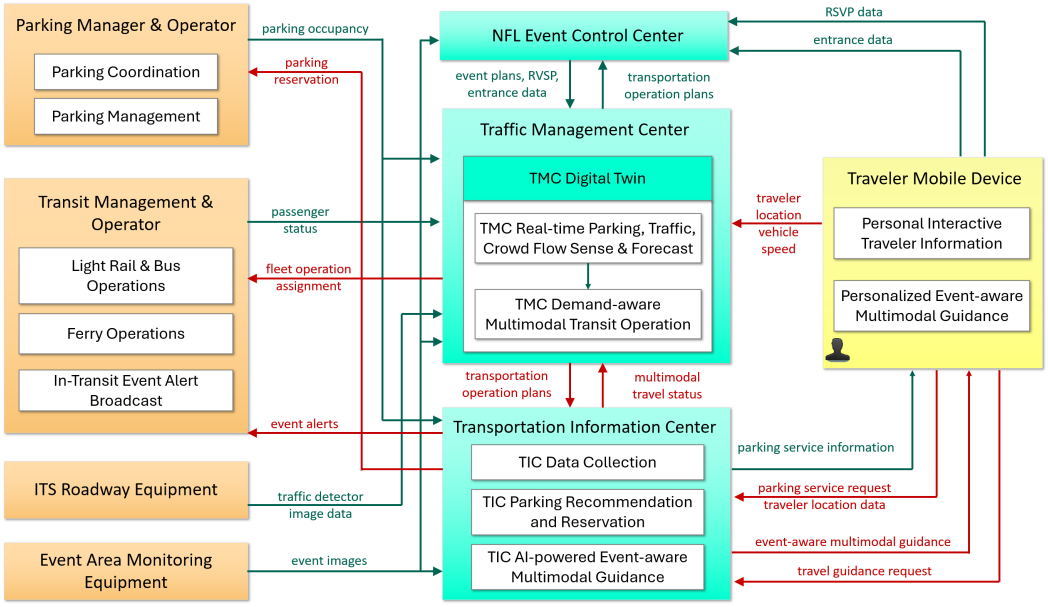

Figure 6: Physical architecture of the solution.

5 Anticipated Impacts

Mobility and Economic Benefit

Our solution delivers mobility and economic benefits by improving travel efficiency and maximizing the use of existing resources. By distributing excess demand across time, space and travel modes, our approach reduces pressure on any single system. Existing parking and multimodal transportation resources are allocated more efficiently, and the real-time traveler information and reservation system enables travelers to navigate more smoothly. These improvements reduce overall congestion and lead to faster, more predictable travel times for all travelers.

A recent example illustrates this potential mobility benefit. During the 2024 NFL Draft in Detroit, multimodal transportation information was shared through the NFL app. As a result, many public transportation modes saw record-high ridership, with some reaching full capacity despite the added services [4]. This evidence from a comparable case supports our solution: providing appropriate information can encourage multimodal travel and distribute travel demands across space and modes during large events.

Enhanced mobility translates into economic benefits. Congestion and unpredictable travel times often deter people from fully participating in event-related activities. With more reliable and efficient travel, attendees are more likely to engage in additional activities, increasing their overall satisfaction and time spent at the event. This benefits vendors through increased foot traffic and boosts local spending. Additionally, by optimizing the use of existing resources, our solution enhances the return on prior infrastructure investments, further contributing to the long-term economic value of the host community. Lastly, the digital twin developed for this solution can be expanded with additional functions to support a wider range of ITS services.

Operational Benefit

Our solution enhances operations by automatically assisting decision-making and automating service delivery. At its core, the digital twin continuously and autonomously collects data from a wide range of sources

using various sensors, including GPS units on vehicles, parking detection systems, cameras, and loop detectors deployed throughout the city, among others, to monitor resource utilization and overall system performance. This information enables the system to learn diverse demand patterns and how they evolve over time. With this accumulated knowledge, informed operational decisions, such as multimodal transportation management, traveler information services, and parking reservations, can be automated and optimized.

The system continuously improves by learning from newly collected data and refining its decisions based on observed outcomes. It repeatedly monitors performance and resource utilization to understand how people respond to various controls, using these insights to make better future decisions. Over time, this forms a self-reinforcing learning loop that continuously improves system understanding and performance. In addition, the digital twin and AI model enable the simulation of diverse scenarios and testing of different strategies, supporting the design of future transportation TSMO plans for special events.

Perception Benefit: Public Acceptance of Multimodal ITS

The implementation of our solution is expected to enhance public awareness and acceptance of multimodal travel and ITS services. By improving the multimodal travel experience through better traveler information and a convenient reservation system, travelers will experience smoother and more convenient multimodal trips. This positive experience will help build favorable perceptions of multimodal travel and ITS, ultimately fostering long-term acceptance and broader adoption for both future events and everyday travel.

6 Complementary Measures

A more holistic approach can be applied to maximize the effectiveness and impact of our proposed solution. In this section, we introduce such complementary measures, organized into two categories: travel demand management and operational improvements. A key feature of our solution, the digital twin, can be expanded to support and optimize these measures by simulating the event under diverse scenarios, assessing the effectiveness of each strategy, and improving the overall performance of the holistic approach.

Travel Demand Management

Given the limited capacity of the transportation network, concentrated peak travel demand is difficult to serve. To address this, travel demands can be strategically distributed across space and time through the following complementary measures.

- **Incentivizing Off-Peak Travel**: Encourage travelers to use non-peak times and less crowded modes
- **Event Schedule-Transportation Coordination**: Event timing can be planned with transportation impacts in mind to help smooth travel flows.
- **Staggered Egress**: Phase crowd departures to break up surges into more manageable waves.
- **Physical Wayfinding and Traveler Information at Key Hubs**: Install physical signage and real-time updates at key travel hubs to support efficient crowd movement. When large groups are exiting venues or approaching decision points—such as intersections or transit connections—clear, visible guidance helps travelers choose less congested routes or modes without needing to stop and check an app.

In addition to distributing demand, unnecessary travel can be reduced. For example, during weekday events like the NFL Draft, nearby workers can be encouraged or incentivized to work remotely, easing the background travel load in the downtown area.

Operational Improvements

Traffic management strategies can be implemented alongside our proposed solutions to improve operations and increase system throughput.

- **Zoning and Road Management**: Implement selective road closures, lane reallocation, and reversible lanes to prioritize flow in high-demand directions and support safe pedestrian access.
- **Dynamic Traffic Control**: Use adaptive signal timing and traffic light reprogramming to respond to real-time congestion and prioritize major movement patterns.

References

[1] National Football League. 2025 nfl draft info, 2025. URL https://www.nfl.com/draft/event-info/. Accessed: 2025-05-25.

[2] City of Pittsburgh. Smartspines project overview, 2021. URL https://engage.pittsburghpa.gov/smartspines. Accessed: 2025-05-23.

[3] Metro21: Smart Cities Institute. Surtrac 2.0: Next-gen adaptive traffic signal control, 2020. URL https://www.cmu.edu/metro21/projects/safe-mobility/surtrac_2.0.html. Accessed: 2025-05-23.

[4] Al Prysiazniuk and Joshua Fink. Its and special events in detroit. In *ITS Michigan Annual Meeting*. City of Detroit and AECOM, 2023. PE and RSP1 designations included.

[5] U.S. Department of Transportation, ITS Joint Program Office. Arc-it service packages - area sorted, 2025. URL https://www.arc-it.net/html/servicepackages/servicepackages-areaspsort.html. Accessed: 2025-05-25.

A Functional Description

Functional description, a description of physical objects in physical architecture [5], is described in this appendix.

Physical Object	Class	Description
Event Area Monitoring Equipment	Field	The 'Event Area Monitoring Equipment' represents cameras and sensors installed to monitor event status and overcrowding at event zones.
ITS Roadway Equipment	Field	The 'ITS Roadway Equipment' represents the ITS equipment that is distributed on and along the roadway that monitors and controls traffic and monitors and manages the roadway. This physical object includes traffic detectors, environmental sensors, traffic signals, highway advisory radios, dynamic message signs, CCTV cameras and video image processing systems, grade crossing warning systems, and ramp metering systems.
NFL Event Control Center	Center	The 'NFL Event Control Center' works with the local TMC to ensure the event adheres to the schedule and flows smoothly. It collects RSVP data, entrance data, and camera feeds to make event-related decisions. They are often temporarily installed at local TMC to collaboratively control overall operations during events.
Parking Manager & Operator	Center & Field	The 'Parking Manager and Operator' manages one or more parking lots by providing configuration and control of field infrastructure, user account management and interfaces with financial systems to manage payment. It also covers monitoring and management of parking facilities.
Traffic Management Center	Center	The 'Traffic Management Center' monitors and controls traffic and the road network. It represents centers that manage a broad range of transportation facilities including freeway systems, rural and suburban highway systems, and urban and suburban traffic control systems. It communicates with ITS Roadway Equipment and Connected Vehicle Roadside Equipment (RSE) to monitor and manage traffic flow and monitor the condition of the roadway, surrounding environmental conditions, and field equipment status. It manages traffic and transportation resources to support allied agencies in responding to, and recovering from, incidents ranging from minor traffic incidents through major disasters. The digital twin is incorporated into the original function. In the TMC digital twin, data on parking, transit passenger status, event related data are collected to monitor and forecast how parking and transportation network status will evolve in near-time.
Transit Management & Operator	Center & Field	The 'Transit Management Center' manages transit vehicle fleets and coordinates with other modes and transportation services. It provides operations, maintenance, customer information, planning and management functions for the transit property. It spans distinct central dispatch and garage management systems and supports the spectrum of fixed route, flexible route, paratransit services, transit rail, and bus rapid transit (BRT) service. The physical object's interfaces support communication between transit departments and with other operating entities such as emergency response services and traffic management systems.
Transportation Information Center	Center	The 'Transportation Information Center' collects, processes, stores, and disseminates transportation information to system operators and the traveling public. The physical object can play several different roles in an integrated ITS. In one role, the TIC provides a data collection, fusing, and repackaging function, collecting information from transportation system operators and redistributing this information to other system operators in the region and other TICs. The second role of a TIC is focused on delivery of traveler information to subscribers and the public at large. Information provided includes basic advisories, traffic and road conditions, transit schedule information, yellow pages information, ride matching information, and parking information. The TIC is commonly implemented as a website or a web-based application service, but it represents any traveler information distribution service. TIC receives information from TMC to provide real-time traveler information, parking recommendations and reservations, and event-aware travel guidance.
Traveler Mobile Device	Personal	The 'Personal Information Device' provides the capability for travelers to receive formatted traveler information wherever they are. Capabilities include traveler information, trip planning, and route guidance. Frequently a smart phone, the Personal Information Device provides travelers with the capability to receive route planning and other personally focused transportation services from the infrastructure in the field, at home, at work, or while en-route. This subsystem also supports safety related services with the capability to broadcast safety messages and initiate a distress signal or request for help. For the 2026 NFL draft, NFL app is used to receive, interact, reserve with TIC.

Table A.1: Functional description of the solution