TRANSPORTATION TECHNOLOGY TOURNAMENT

USING THIRD-PARTY NAVIGATION APPLICATIONS TO IMPROVE TRANSPORTATION OPERATIONS PLANNING FOR SPECIAL EVENTS: *CONCEPT OF OPERATIONS*

Texas A&M University Team #1:

Farinoush Sharifi

Tahmida Hossain Shimu

Ahmadreza Mahmoudzadeh

Xiaoqiang Kong

Madison Metsker-Galarza

Team Advisor: Dr. Timothy J. Lomax

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Table of Contents

Table of Figures

1. Overview

1.1. Identification

This document is intended to provide guidance to District Department of Transportation (DDOT) officials on the implementation of the historical data and third-party navigation applications in case of an event planning. The material in this document is a collection of Intelligent Transportation System (ITS) knowledge and procedures on the topic presented by Texas A&M University (TAMU) student team.

The first section of this Concept of Operations (ConOps) document includes the system an overview of the document, a summary of the proposed system, and the stakeholders of the proposed system.

1.2. Document Overview

The material in this document is addressing the framework or ConOps for the proposed system. Development of the ConOps is the key step in system engineering plan (SEP) and the first step before any detailed plan developments. The following sections of the current document are:

- Section 2 identifies the references used to develop the current ConOps.
- Section 3 provides information on the current event planning procedure and the events held in DC area.
- Section 4 justifies the changes to propose a new ITS architecture.
- Section 5 introduces the proposed ITS architecture.
- Section 6 defines the performance measures and evaluates the proposed ITS architecture.

1.3. System Overview

Transportation systems management and operations (TSMO) is a set of strategies that aim to create a safe, efficient, reliable, and environmentally-friendly use of the current and proposed transportation infrastructure for all modes. TSMO strategies address the planning for special events (expecting both planned and unplanned events during a special event). Though the current ITS architecture and deployment provide a strong foundation for TSMO, there are still some missing parts to develop a good architecture and incorporate in TSMO studies. This document is using the national ITS standards to provide an architecture for special events planning using the historical data and third-party navigation applications.

There are now some widely used data sources and applications for vehicle navigation on the market. These resources have tremendous potential to improve both DDOT's internal situational awareness and DDOT's ability to provide information to the public during major special events. With this in mind, this ConOps is developed for DDOT to:

1. Use historical, third-party application data from similar events to inform adjustments of road closures, parking restrictions, and traffic control for future events.
2. Systematically push important information on road closures and other roadway restrictions to the public via third-party applications before and during special events.

This document also incorporates any improvisations necessary for the proposed solutions or framework as needed in consultation with officials from DDOT. Some examples can include, but not limited to, recommendations in using particular push notification applications/ platform/ technology, adopting recommended or tested public engagement strategies, and effective public outreach processes.

1.4. Stakeholders

The stakeholders are needed to be primarily identified for any proposed ConOps. The stakeholders for the current ConOps include the users, operators, and maintainer. The following list shows the stakeholders:

1. System users: vehicle drivers, passengers, cyclists and pedestrians
2. System operators: DDOT and City officials
3. Public safety divisions: incident and emergency management including fire, police, and medical supports
4. Information system providers: database management systems (e.g., INRIX) and third-party navigation applications (e.g., Waze)

It is necessary to identify the needs and motivations of each stakeholder and incorporate their specific policies while developing the ITS architecture. Also, each of these stakeholders should be aware of their related concerns to know their responsibilities.

2. References

This ConOps is based on the information obtained from the following sources:

- ITS Professional Capacity Building Program (https://www.pcb.its.dot.gov/)
- Institute of Transportation Engineers (ITE) (http://www.ite.org/)
- Information on National ITS Standards (http://www.standards.its.dot.gov/)
- National ITS Architecture (http://www.iteris.com/itsarch/)
- Transportation Systems Management and Operations in Action (https://ops.fhwa.dot.gov/publications/fhwahop17025/index.htm)
- Washington DC Stadiums Website (National Park and Robert F. Kennedy Memorial Stadium)
- Discussions with DDOT and USDOT-Volpe Center officials (https://www.volpe.dot.gov/home)
- Texas A&M Transportation Institute (TTI) practices for TAMU football event planning (https://events.tti.tamu.edu/)
- Waze Connected Citizen Program (https://www.waze.com/ccp)

3. Current System Situation

Currently, the DDOT develops event planning and traffic control plans using engineering. They may also include their previous experiences based on the engineering judgment. However, to better plan for future games, this study proposes to incorporate the historical data using data sources, like INRIX and NPMRDS for planning, verifying, and adjusting their plans. To request and use these datasets, there are several key points need to be defined such as the event's type, and the location of the event. Also, the navigation applications may access the traffic control plans through basic contact methods, and there are no framework or organized architecture to provide these third-party applications with a consistent access to the information on traffic control plans.

The Washington D.C. is hosting different events regarding the audience counts. Also, the events might be recurring or non-recurring. These events such as a marathon, baseball, block parties, funerals, and presidential inauguration need different types of planning. This ConOps is focusing on the sporting event since it is one of the most critical recurring event in the DC that also attracts the audiences from suburb areas. So, it needs much attention.

The ConOps will focus on the sports venues that attract too many visitors such as baseball games, basketball games, and soccer or football games. They require special event traffic management.

Among all the stadiums, two major baseball venues, one major basketball venue, and four major soccer stadiums, the maximum capacity is 46000 persons. Washington Wizards has its recurring home games from March to October, Washington Redskins has recurring games from early September to end of December, DC United has its recurring game between March and October. The games are happening during the weekends.

4. Justification and Nature of Changes

Before actually developing a conceptual framework for creating an ITS solution for special event management, the project should carefully consider the needs of all stakeholders and the resulting trade-offs between them. Explaining the trade-offs between each of the stakeholders, as well as getting feedback from the involved entities in this matter should be the fundamental approach in dealing with this sort of ITS plan. For this ITS architecture, creating a new application is not a target, as during a special event, half of the spectators arrive from other cities or even states (mostly from Maryland), so downloading a new app for just a day would not reasonably be in the users list of things to do. Rather the focus is more into using the existing applications to communicate traffic management decisions on special events to the user groups. However, the user interface for the targeted traveler information system (Waze, Google Maps, ParkDC, RideDC, social media such as Twitter etc.) should be so modified or redesigned as to provide users maximum information on special events. This modification of application interfaces should be considered, because how we use the user interface can help figure out the outcome or effectiveness of the system itself. Additionally, apart from providing specific guidance to the users in terms of their needs, some additional or optional suggestion for activities should also be communicated to the users based on their choices. This can serve as recommendations to the users as to what else they can do if the specific guidance does not meet their needs or convenience. In those applications, a feedback system should be implemented for asking the users what they actually did and also for rating their experience. This feedback system can be tracked over time to automatically optimize the decisions of special event management and also to help updating the system on its own for future events. This framework for information feeding into different traveler information system is provided in the Figure 1.

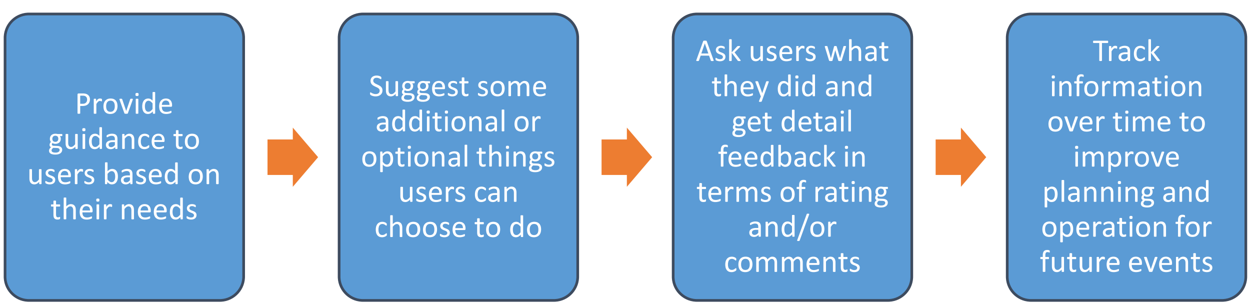

Figure 1. Considerations of information feeding through traveler information system

5. Concepts for the Proposed System

This document is considering two types of events based on the size and occurrence of the event:

1. High occurrence events are the recurring events happening more frequently throughout the year (e.g., baseball games).
2. Low occurrence events are the events happening not more than once a year or even less frequently (e.g., the inauguration of the President of the United States).

For each of these event types, a unique ITS architecture is developed to exactly fit the specifications of that type of event.

5.1. Proposed ITS Architecture for High Occurrence Events: A Feedback-based ITS Architecture

This architecture (Figure 2) is considering the events occurring more frequently throughout the year. Annually, the DDOT will acquire the historical data for the specific event in the previous year. The event planning for the next event will be based on the acquired historical data. The information on traffic control plans and available routes will be pushed to the public through the available traveler information systems. Finally, the feedback from the traveler information systems will be used for the next event happening in the same year. There may be other possible factors to be considered to update the next event planning besides the feedbacks. These factors include the weather condition and possible demand growth (for sold out events). Also, DDOT may annually update the details of each component of this architecture based on the evaluation of the enterprise architecture (EA). The evaluation of the EA may show some changes in the technology, data, application, and business layers, which will improve the planning for future events.

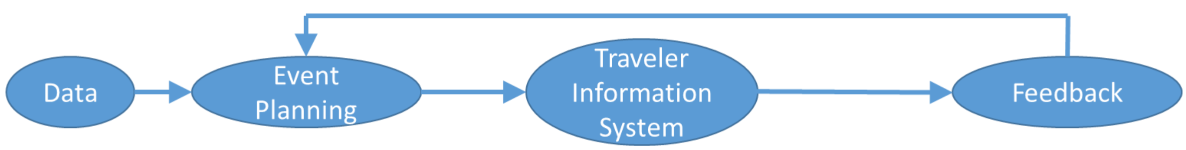

Figure 2. A representation of a feedback-based ITS architecture

5.2. Proposed ITS Architecture for Low Occurrence Events: A Data-based ITS Architecture

This architecture (Figure 3) is focusing on the events occurring once a year or even less frequently. Before each event, the DDOT will acquire the data from the previous event. This data will be updated using the factors including demand growth and weather condition, and be implemented to plan for the next event. Later, the traffic control plans will be pushed to the public through the available traveler information systems. However, each part of this ITS architecture can also be updated based on the evaluation of the EA (the changes in business, technology, data, and application).

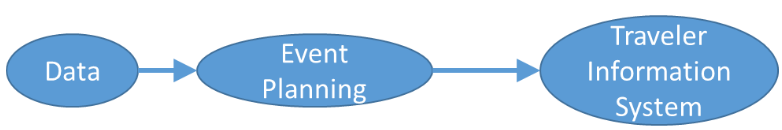

Figure 3. A representation of a data-based ITS architecture

5.3. ITS Architecture Component Details

In this part, the specifications of the ITS architecture and its components are proposed. Clearly, these recommendations are based on the currently available data sources, technologies, and applications. These details may be modified over the years based on the EA. However, the two proposed ITS architectures will stay the same.

5.3.1. Data

5.3.1.1. Probe Vehicle Data

This study proposes to incorporate the historical data for planning and adjusting the future event plans. The vehicle probe data sources are collecting the vehicle position for each time stamp using the sensors and applications (devices integrated with the vehicles' computers or nomadic devices brought into the vehicles). Using these data sources instead of the collected data from infrastructure mounted sensors has become the interest of agencies during the past few years because the agencies do not need to develop any infrastructure. Also, these data sources are accurate and reliable. However, vehicle probe data is a sample of the vehicles on the roads (equipped with sensors), and it cannot provide the volume. Two of the most widely used vehicle probe data sources are INRIX and FHWA's National Performance Management Research Data Set (NPMRDS).

INRIX collects real-time anonymous traffic data from mobile phones, connected cars, trucks, delivery vans, and other fleet vehicles equipped with GPS locator devices. These data collectors send INRIX billions of data points per month, and INRIX provides the speed and travel time over the specific time and distance. NPMRDS is used by states to monitor system performance across the National Highway System (NHS). Data is mainly collected through probe data vendors: Bluetooth/wifi (trafficCast, Acyclica, Iteris, TrafficNow, Traffax and others) and GPS (HERE, TomTom, Google, etc). This dataset includes the travel times measured every five minutes. Although NPMRDS has the advantage of covering the complete NHS and very precise scale of traffic condition, this dataset only covers the NHS. So, it may not be an appropriate data source while the study goes to a smaller scale (for a special event planning). Therefore, INRIX trip database will be the applicable data source for the proposed ITS architecture.

5.3.1.2. Acquiring Historical Data

To request any historical datasets (including INRIX), there are several key points to be characterized:

1. Location of the event (e.g., Nationals Park) and the region of the desired traffic control plan
2. Duration of the desired dataset: It is proposed to acquire the historical data during the special event besides before and after the event. It will help to identify the pattern of travel time and average speed over the time and the recovery of the network after the event. This will lead to locate the potential bottlenecks and congested areas and improve the future traffic control plan.
3. The number of historical datasets: DDOT should decide on the number of previous events for acquiring the data. Clearly, this number may vary considering the data quality and reliability procedure (explained in the following part).
4. Selection of the desired past events for acquiring data: The DDOT officials need to identify the similar past events based on the factors including type and location of the events, competing teams, and weather conditions. They may also neglect some events. For instance, if the Wi-Fi connection or internet bandwidth faced some problems during an event, the event data should not be used for this evaluation. Therefore, the DDOT officials will select the events from the

previous years to acquire the historical data at the beginning of the ITS architecture (based on the event similarities).

5. Also, a historical data for a similar day with no special event may help to find out the normal traffic condition and use this dataset as a control dataset for other changing factors.

5.3.1.3. Challenges of Using Third-party Data Sources

There are always some associative trade-offs regarding data while using third party data sources:

1. Data completeness: The first and most pressing challenge of this sort of datasets is the completeness, which can be perceived as the missing information on all user groups, all types of events, covering all variables needed to generate a comprehensive ITS solution for special event traffic management. This issue is specifically of concern while dealing with low occurrence events, and historical data on those events possess a large technological and information gaps over time. INRIX is primarily probe vehicle data, which is not complete and does not represent the whole vehicle group scenario. It cannot be used on its own to estimate the demand, and it needs to be supplemented by other software data (depending on the research question), like traffic count cameras. Other than that, INRIX database has a huge gap in coverage of other user groups.
2. Data quality: INRIX trip database may have some noises in travel time. Therefore, this dataset should be quality assured and filtered before use.

The data completeness may not be a crucial part while developing the traffic control plans for vehicles. The agencies will use the travel time and average speed to plan for future events. However, DDOT needs to integrate multiple data sources to estimate the total vehicle demand or other user groups' demand. These integrated data sources may include but not limited to the traffic control camera data, loop detectors 'data, number of parking spots, number of bike spots, and the number of the sold ticket.

To overcome the data quality challenge, it is necessary to compute a reliability index and select multiple previous events over a period. The significant difference between only replying on engineering judgment and actually performing an evaluation based on some reliability indices is using the historical data. For instance, using multiple datasets allow the agency to compare an index such as "congestion duration" for a recurring event. It helps them to learn the effect of different policies on this index. So, they can choose the most beneficial policy which reduces the congestion duration. Another form of simple and fast reliability index is specifying a slice of travel time to incorporate in the planning (95-percentile of the travel time).

A practical example is provided here to elaborate the data part:

The DDOT is considering the planning for a baseball event, which is held multiple times during one season of the year. DDOT may follow the feedback-based ITS architecture to improve the process. Before the beginning of the games, the DDOT selects similar events of the previous year to acquire the INRIX data for and may neglect some events. These datasets are over a specified region and time. DDOT may incorporate a data quality assurance using a reliability index (congestion reduction or percentile) to improve the quality of the INRIX trip data source.

5.3.2. Event Planning

This component is a combination of engineering, civil design, and communication. Using the historical data, the traffic control plans will be developed based on the operational and civil design standards. This part includes a broad knowledge of siting to traffic devices guidelines. Also, planning for an event needs a very well developed architecture for the communication between the different entities before and during the event. Though this part is not the main focus of the current ConOps, there are some recommendations proposed on the communication part to improve the whole ITS architecture.

Each stakeholder involved in the event planning process has different responsibilities. The fire stations and emergency medical services (EMS) are responsible for the possible unforeseen events which may happen during and after the event. The police officers should interact in operating the required streets and highways to evacuate the population after the game. The taxi drivers should have access to the population who are leaving the scene. It should be noticed that the location for park and ride of such drivers should be defined beforehand to have smooth traffic. So, they are not allowed to pick or drop off people anywhere close to the event's location. Public transportation authorities are responsible for transporting the population to or from the event's location. So, the DDOT officials need to have access to the representatives of different stakeholders to synchronize their actions. For instance, if a disaster such as a fire incident happens during/after the game, close communication is needed between the principal coordinator, fire stations, and the police departments to communicate about their responsibilities regarding the road closure. In other words, all staff including fire, police, transportation, EMS should be in one room to better react to events that occur unexpectedly.

5.3.3. Traveler Information Systems

This part of the ConOps focuses on pushing those planning decisions for road closures, rerouting, traffic lights, and parking to the specific user groups based on their needs. Now, for information sharing, the team considered two major technical approaches that will cover the needs of all users in all situations. For attaining the objectives of the most effective traveler information system on the receiving ends of users, the team came up with following two ways to send out decisions before and during special events:

1. Planning decisions for parking adjustments, route changes, lane/road closures, etc. will be communicated to the appropriate users using third-party applications.
2. Information on real-time adjustments or change of plans will be communicated using a more widely reachable medium such as the social media and texts. This approach will be more suitable for service alerts, crash/collision notification, congestion and increased travel time and other emergency incident alerts. This kind of initiatives has already been adopted by some of the DOTs. For example, Delaware DOT uses the social media Tweeter to send out information of service alerts, crash occurrence, and road closures due to incidents.

5.3.3.1. Third-party Navigation Application

There are multiple navigation applications widely used around the US and DC area. These applications are Waze, Google maps, Here Wego, Transit, and other local applications including ParkDC (for real-time parking availability and rate information for the Penn Quarter and Chinatown neighborhoods in Washington, DC), RideDC portal (for near real-time information about multi-modal transportation options and locations on the map), DC Rider (for Metro users).

The reason for not developing any new applications that the population nearly doubles in DC area during the day. Mostly, they come from Maryland. So, it is more preferable to push information to the public through the already well-known and widely used applications.

Although the DDOT can share the information with all available applications, there is a cost associated with this process. Therefore, it is more efficient for the DDOT to recognize the more widely used applications and push the information to the public through them. Also, the EA of the targeted navigation applications has a key role in selecting them. So, the main application of interest in this project is Waze because of the Waze Connected Citizens Program (CCP), which is a free data exchange program to improve the mobility on a local and global scale. In this program, Waze partners with government agencies and private road operators. DDOT may share the planned road closure or incident data with Waze to be displayed on the Waze map. Therefore, the route data and average travel time can be accessed by drivers, which leads to a considerable reduction in congestion.

To request partnering with Waze through the CCP, DDOT may decide on:

1. The region of coverage
2. Data sharing format (spreadsheet, email,...)
3. Type of traffic information (special event)
4. Period of the traffic information
5. The deadline to provide the Waze with data before the event

It should be noted that interactive maps may be useful to show the real-time data. However, there is always a need for an offline version of the map in case of the weak network.

Other than Waze, DDOT may include other user groups' application to cover all modes of transportation. Other user groups' transit may not be the priority of the DDOT at this stage. However, the concept can be more developed in future steps.

5.3.3.2. Using Social Media for Service Alerts

Using social media for sending out service alerts can be of greater significance regarding executing an efficient ITS planning for special events, as it can be used effectively not just before the special event day, but also on or during the day of the event. There are factors that can cause significant changes in planning on the event day that ultimately can cause system failure. By adopting a social media platform, any change of plans due to these unforeseeable incidents can be tackled, and user satisfaction can be achieved. For a better implementation of an efficient service alert system, it is suggested that implementing a two-way service alert system. This two-way service alert system would consider a dissatisfaction or notification of a service requests from users (can be sent out through a call, text, email or a hashtag tweet) and any possible change or modification of existing facilities, services, systems or traffic plans will be communicated via social media, texts or emails to all user groups.

5.3.4. Feedback

The last step of the ITS architecture is performing a feedback analysis. The feedback is used to make sure that the current direction of architecture will ultimately reach the desired direction of the project. Such policies will run a loop to force the architecture to be in the desired direction so that the project goals and system mechanisms are aligned. To do so, the user's feedback collected using the third-party navigation tools will be used on top of an operation performance measure (OPM) of the system. The OPM evaluation will be described in the evaluation part of the report. The user's feedback will be used again in event planning step. The feedbacks can be collected regarding user's experience of the app, or their experience of using the suggested paths. The experience can be automatically measured regarding the travel times, or their rating of using the proposed routes.

5.3.5. ITS Architecture Components Integration

A large part of the proposed ITS architecture deals with collaboration with privately owned agencies and government entities (DDOT) in terms of sharing datasets and information. Now, these entities, whether private companies or, government bodies, have their own EA based on which projects are run and works are executed. Depending on the limited understanding and information that we could gather under the scope of this project, there are times when the data available to address all sorts of ITS solutions that can be provided for the special events, there might not be technologies available for implementing it. On the other hand, the technologies might be there. However, the data is not found (in case of the minority groups like travel information on pedestrians and bicyclists). These all come down to how the EAs of that particular entity work, and how different these are from each other.

The data management system that we are dealing with, INRIX, also has its own set of algorithms for data collection, sorting, storing, and managing. Each digital database contains a certain level of information bias that may not be consistent with one another and makes it difficult to compare INRIX trip data and other data sources. On the other hand, the target is to feed decision information to another user program (e.g., Waze) which again contains separate algorithms for information sharing. These mutually independent systems may or may not be consistent with one another in terms of objectives and mechanisms, which should be taken into consideration while working with these third-party applications.

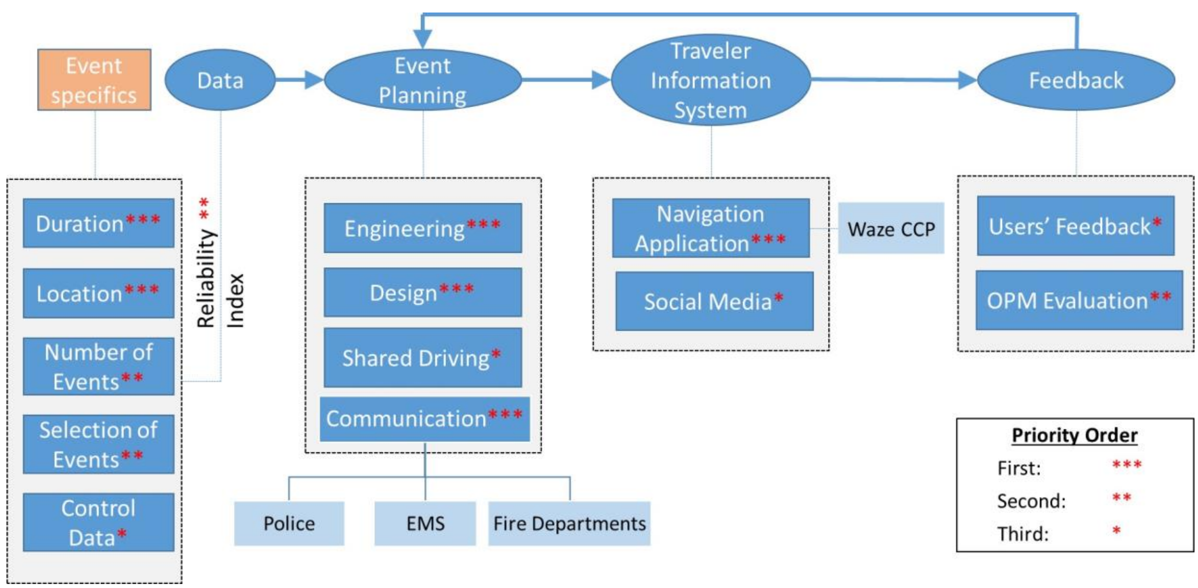

Figure 4. A detailed ITS architecture including the feedback step. The priorities show the level of importance and focus of the ITS architecture. The first level priorities must be implemented to apply the proposed ITS architecture. The second and third level priorities may be optional based on the agency policies, costs, and timeline.

5.4. Cost and Timeline

After defining different factors involved in the system, an estimate for the work is needed to develop and implement the solution. It includes the budget and the timeline. For estimating the cost of the project, the project team recommends to first look into the size of dataset that needs to be acquired from INRIX. Next, costs of different tasks should be considered, such as having a reserved bus, providing EMS services, and costs of implementing technology need to be estimated for data acquisition and storage, and budget needs to be allocated based on the estimated cost. The timeline means defining the start time and end time for different tasks. For instance:

1. When does mass communication begin (considering the communication between stakeholders and their groups, the website content, the app content, and the social media content)?
2. What time do streets need to be shut down to increase pedestrian safety?
3. What time does traffic control need to be set-up?
4. What time do routes begin (traffic signal giving priority to certain routes)?
5. What time does transit service start and end?

Based on these critical components, the project team recommends developing a schedule for data acquiring, analyzing the data, planning for the event, contacting Waze CCP for information sharing and other event planning.

5.5. Additional Recommendations for Implementing the Proposed ITS Architecture

1. With the continuous emerging of autonomous and connected vehicle technologies, the framework for this ITS solution architecture needs to be redefined or modified in a greater extent, as the capabilities of these technologies will change the overall scenarios of identified needs and objectives. With more connected vehicles market penetration, stakeholders, system components, agreements between different components, everything will change.
2. For sending out information or updates on the sudden change of plan during an event, apart from the social media service alerts approach, third-party applications, such as Waze can also be used; however, information sharing between those apps and DDOT needs to be improved.
3. Some type of contingency plans for handling incidental issues can be taken into consideration, even though such indication may not be attained from the historical data. For example, some DOTs provide stand-by trucks for emergency situations near events. These stand-by trucks can also ensure proper implementation of the event planning.
4. During special events, multiple users gather at the same spot, all of whom access their networks for using those third-party apps. If somehow, the network connectivity is lost, the entire system will be at a higher risk of failure. Hence, cell-phone network connection providers need to increase the band-width for the event day to ensure uninterrupted network availability for all users.
5. Uber and Lyft are also third-party application, which can be of greater consideration for the traffic planning on special events. One of the major considerations for planning for these apps can be deciding how to manage their pickup and drop off locations on special events. These passenger services pick up and drop off passengers anywhere and everywhere, which can increase travel time, delay and can cause inconvenience for other road users. The concept of geofencing can be utilized for these apps, where the drivers can only receive alerts, as well as the passengers, can only set up pickup locations if they are within the specified boundary.
6. Some alternative sources of data can be identified, such as the ticket sales for a game day to anticipate the expected number of the attendees. This type of data sources can help figure out the most effective ITS solution.

6. Evaluation of the Proposed System

This part will focus on the pros and cons of having an integrated system. The proposed architecture needs to be evaluated to quantify (or qualify) how well the proposed goals and targets are being achieved. In other words, developing an operation performance measurement program will justify the stakeholders' directions, the responsibilities of different parts, and the relation between the decisions and their impacts on the public. Also, part of an evaluation plan is the evaluation of outcomes. Outcomes of a performance measure are based on the user's overview, the system's impact on the user. So, the user's behavior is the primary assessment that can be quantified/qualified after performing the architecture. In other words, to have an effective performance measurement system, the conditions should be monitored successively. To monitor the conditions, different directions should be considered. In other words, this ITS architecture has multiple goals, so, the goals should be measured by having different viewpoints. To do so, the operational benefit, safety benefit, mobility benefit, and environmental benefit will be considered. Each of them will be explained in the following paragraphs.

6.1. Operational Benefits

Based on the proposed ITS architecture, user benefit should be assessed. The proposed architecture is using some valid source of the dataset (sometimes after performing data processing or removing the outliers), which help people to decide better. The dataset can show the real-time traffic condition closer to the reality, which helps the traveler information software to visualize the data more accurately and suggest better directions to the traveler groups whose destination is the event location. By having such decisions by people, the traffic will become dispersed in the network, which reduces the traffic congestion through the network. This can be quantified by measuring the overall level of services among the network. Also, comparing indices measured by using travel time, and speed (which are two major sources of collected data) such as the congestion duration for a recurring event help to evaluate the proposed architecture.

6.2. Safety Benefit

The proposed architecture mainly uses historical data, instead of changing the current situation based on the engineering judgments. Using historical data let the authorities know the bottlenecks' location and its impact on traffic flow. So, they can quickly take care of these bottlenecks such as crashes, and collisions. It reduces the congestion through the network, which is a factor for having a safer, and quicker travel way for the goers. To measure this performance measure factor, the number of collisions should be counted.

6.3. Mobility Benefits

Mobility factor plays an important role in here. Some big events are happening in DC annually, which need special event traffic management protocols. The factors considered in the architecture such as providing the buses (public transit agencies), providing the travel way for commuters, and the familiarity of people with the local apps (who are mainly using the private vehicles), let the network to become more mobile, and the traffic becomes smoother. In such a system that gain benefit by using different modes of transportations, the travel time reliability plays a significant role. The reliability can be found by historical data. From a different perspective, by having such architecture, the system will gain a communication benefit through close communication between different agencies. The benefit of such communication can be measured by defining factors related to travel time, such as the required time to have an EMS/Firemen to the needed location. Also, it should be noticed that providing reliable transit services for spectators attract the audience to use such system more often, which leads to more revenue for the authorities. This factor could also be considered as a measuring tool.

6.4. Environmental Benefit

Up to this point, it was discussed that by using such architecture, the network would become more reliable, the people will feel more satisfied by being suggested of using less crowded routes, and the travel way will become safer. Considering all of these factors together has a positive effect on air quality. In other words, by having a less congested network, and well-organized facilities, such as the public transit, and taxi providers at special locations, the people can drive better throughout the network. For instance, the drivers can try to keep the speed constant throughout their path instead of pressing the brake successively at a congested network, and the taxi drivers could not change the traffic flow (changing the following vehicles' speed) by stopping at illegal places. The driving condition and the traffic flow (and the level of services) have a direct effect on the air quality. Since the exhausting systems of such vehicles will discharge less amount of polluted gas in a fixed time. So, by measuring the amount of polluted gas in the air with the appropriate application, the amount of benefit that is gained by having such architecture can be qualified.

6.5. Costs and Risks

Every ITS architecture has some drawbacks which should be considered. These abnormalities could happen during an unplanned situation, but it is necessary to have sagacious steps in solving them. Some of the risks will be explained in the following paragraphs.

6.5.1. Data and Navigation Tools

Using navigation applications are one of the foundations of proposing this architecture. The navigation tools are working in the presence of internet connection on mobile devices, which enable them to monitor real-time traffic. In other words, if the bandwidth fails to provide the internet connection, the navigation faces problems. Also, since such software will not store the information in the absence of internet connection, the traffic alerts and hazards will not be posted on the map, so the data will not be reliable enough.

The data obtaining, storage, and processing are expensive, so they should be implemented wisely. Also, the architecture is proposing to post the data in the preferable navigation tool in the region. Posting the information on all the navigation tools is costly, so choosing the navigation tools is playing an important role.

6.5.2. Communication

The assumption which is made based on the communication between the stakeholders should be analogous to each other. In other words, the decision by one party should not be based on the wrong guess of what other parties will do. However, this ConOps did not focus on the communication and the risks of communication in detail.

6.5.3. Companies

Also, the companies might not be willing to cooperate with some plans. The small company will cooperate, however, the companies that have the dominant market position such as shared driving company might be reluctant to cooperate with all plans. One of the plans might be to park at the specified location or such regulation.

To wrap it up, the architecture should become a standard to make the risks as insignificant as possible. Also, it should be noticed that the automation will decrease the human error, but it needs supervision. So, the supervision of the automated tasks by having an engineering judgment is suggested.