ConOps for

Enhancing Network Traffic Flow by Connecting Railroad Preemption with Advanced Traveler Information System

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1 Scope

1.1 Identification

This document is prepared for the student competition of 'Transportation Technology Tournament' hosted by The National Operations Center of Excellence (NOCoE) and the United States Department of Transportation (USDOT) Intelligent Transportation System (ITS) Joint Program Office (JPO) Professional Capacity Building (PCB) program. This will describe the operational concept of the proposed solution by North Dakota State University (NDSU) team for addressing the problem of traffic flow interruption in Moorhead are due to regular train events near Highway-Rail Grade Crossing (HRGC).

Because of a unique set up of two rail tracks going through the downtown area of Moorhead, MN; the traffic flow in that region is periodically disrupted by the train events. City of Moorhead and Minnesota Department of Transportation (MnDOT) has adopted various measures and strategies to alleviate this interruption and NDSU is proposing an advanced traveler information system that will not only work in this scenario but can be applied for any rail crossings all over the country.

1.2 System Overview

The change in traffic flow is more rapid than ever, but the travelers have perpetual requirement of accurate and timely information about the route towards their destination. USDOT Dynamic Mobility Applications (DMA) Program recognizes the impact of mobile communication in providing traveler information on time. Over the years, from numerous Field Operational Tests (FOT) to this day's Connected Vehicle approach, there is the recognition of advanced traveler's information to guide them towards the quickest route as well as avoid any potential hazardous movement. The demand for information escalates when the different mode of transportation intersects. Especially the mode that has to wait due to preemption of another mode may get frustrated and make a wrong judgment of the situation. To avoid this, early information about the upcoming road blockage is proved to be helpful for the travelers. It makes them aware of the condition and assists them to choose other routes.

Figure 1-1 ***Robust Scenario of Proposed System***

Travelers' information is considered in two categories: Pre-trip and En-route. It is more convenient for the road users to access any of that information through their handheld computation device i.e. Smartphone. Today's smartphones are very powerful with different sensors and computational ability. Therefore, it is proved to be an appropriate medium to receive any information. Figure 1.1 shows the robust scenario of how information can be accessed by the user in this system.

1.3 Document Description

This document is composed of six sections. The first section describes this identification of the project with system description. The 'Current systems' section describes existing situation with operational constraints. The 'Justification of Nature of Change' section identifies the stakeholder of the project as well as why this solution is required from the context of the casual user group. The 'Concepts of Proposed System' section describes the physical, functional, and enterprise architecture of the solution. The 'Work estimation' section describes different options of developing this solution and their combined costs. The 'Anticipated Impacts' section describes how this system will influence the current system and why it is recommended over other possible solutions

2 Current System

2.1 Background

The City of Moorhead has had persisting issues with control and management of traffic at a unique context at the intersections of 8th St N (in N-S direction) with 1st, Center, and Main Avenues (in E-W direction) as shown in Figure below. 8th St N (N-S direction) has two consecutive rail tracks within 600 feet and these links also handle incoming traffic from 1st, Center, and Main Avenues (in E-W direction).

Figure 2-1 ***Unique Context with three rail lines affecting traffic movement on three highway intersections 8th St N, Moorhead, MN (Source: Google Earth Pro)***

It becomes particularly challenging during railroad preemption, which disrupts traffic operation not only at these intersections but also over the wider network in the vicinity. In addition, safety is an important consideration. Disruptions are quite perceptible due to multiple train events, up to 100 trains per day have been observed during peak railroad usage periods.

2.2 Operational Policies and Constraints

The problems have been addressed over years through geometric changes and different signal plans, but there are still outstanding concerns, like a queue of traffic becomes so long that it back up to the Main Avenue on the south side. Also, the eastbound left turn traffic experience overspilling from the dedicated left turn lane which impacts the eastbound through traffic.

More recently, adaptive controls have been implemented at the aforementioned intersections which introduce an exclusive left turn phase for the northbound traffic while train dwelling on the adjacent track. Although it managed the northbound left turn traffic flow, there is always a safety concern when a vehicle intended to travel northbound through is trying to take space on the left turn lane.

The problem is compounded when there is a crew change take place. Sometimes the nearby rail yard is scheduled to change crews for long-range trains and that demands for extra stoppage time of the train. Due to the close proximity of the rail yard to the crossings, that affects the traffic movement on the road. The same situation may arise in times of simultaneous train event.

3 Justification of Nature of Change

The current situation is operating somewhat effectively in off-peak hours. But in the peak hours, there is still evidence of long queues of vehicles on the northbound through and eastbound left turn lane. The principal reason is travelers have no clue when the train will be coming on the track. If they get this information before starting their travel or while they are on the road, they can easily change their path before reaching the intersection.

There is approximately 60 seconds interval between the signal controllers learn the existence of the train on the track and the gate closed down on the crossing. It is a very short time span to clear the traffic from the track considering the time requires the termination of current signal phase and transferring the right of way to track clearance. But this time can be very effective for getting a notification and considering a new route for a person. Also, some vehicles take chances of clearing the track although they are standing much behind of the last cleared vehicle just because they have no idea when the gate will come down. The information of when the gate is coming down will lend them a hand for taking a justified decision.

3.1 Identifying Stakeholders

The responsible personnel/authority that is directly affected by the action/policies are called stakeholders. It is very important to recognize the stakeholders as the system should be developed based on their views and the requirements should be documented for future review and understanding of possible stakeholder communities which includes agencies, owners, operators, and benefactors. The foundation of the application must address the need of the user as well as operational goals need to be defined by the system. Therefore everyone in the user group and system environment will be considered as the stakeholder of the project. A list of stakeholders and the transportation system that will be used for this project are provided below:

Table 3-1 Identifying Stakeholders and their possible contribution

List of Stakeholders	Transportation System
City of Moorhead	• City Traffic Management Center • City Vehicle Detectors • Roadside Transportation Field cabinet (TFC)
MetroCOG	• Advanced Traffic Analysis Center • Traffic Analysis Zone (TAZ)
MnDOT	• Freeway Traffic Management Center • Freeway Vehicle Detectors • Controller in TFC
City Transit Department	• City Transit Management Center • City Transit Vehicles
Emergency Vehicle Assistance and Communication (EVAC)	• EVAC vehicles
BNSF	• Rail Track Sensors (underground Circuits/ Shunt) • BNSF Bungalow
Application developers	• Members of Team NDSU • IT department • Third Party web developer
Travelers	• Personal Handheld Computing Devices • Smartphones

4 Concepts for the Proposed System

4.1 Background

On the initial analysis and discussion over the problem statement, there were two different options considered for the solutions: 1) A third party mobile application and 2) Dynamic Message Sign (DMS) boards. Both of these options were considered to provide an approximate time of train arriving on a specific crossing. When considering the pros and cons of each solution, the team found that DMS will be a costly option considering the cost of sign construction and install as well as operation and maintenance cost with power and communication system. Another disadvantage to Dynamic Messaging Signs is that it gives the drivers less time to react and decide on an alternative route. This can lead to frustrated drivers since they might have to drive further to get to their destination. Weather conditions can also limit visibility making it difficult for drivers to read or see the sign. As our communities become more diverse, varying languages can create a barrier. Besides, there are needs for comprehensive data over time to find the exact strategic position of the DMS which was not possible with the time frame provided for this tournament.

To provide an approximate time for the train to reach on the track, it is crucial to have the train information even before it reached in the vicinity of the crossing. The team couldn't get access to this information from BNSF. Therefore, it was decided to use the information from the roadside TFC which is under the jurisdiction of the city.

4.2 Operational Policies and Constraints

According to ITS standards training of PCB, a system should provide several benefits like following:

- Supports interoperability
- Supports 940 compliance
- Minimizes future integration costs
- Facilitates regional integration etc.

While designing this solution, one of the biggest considerations was to make it workable with a different system. Therefore, the application should be workable in the different mobile platform. As well as it should use the existing system for the information so that the future integration will have smooth transition phases. Besides, the solution should be coordinated in a way so that it can experience a smooth transition in a time of regional integration.

To develop this system the involvement of the following agencies and people are required:

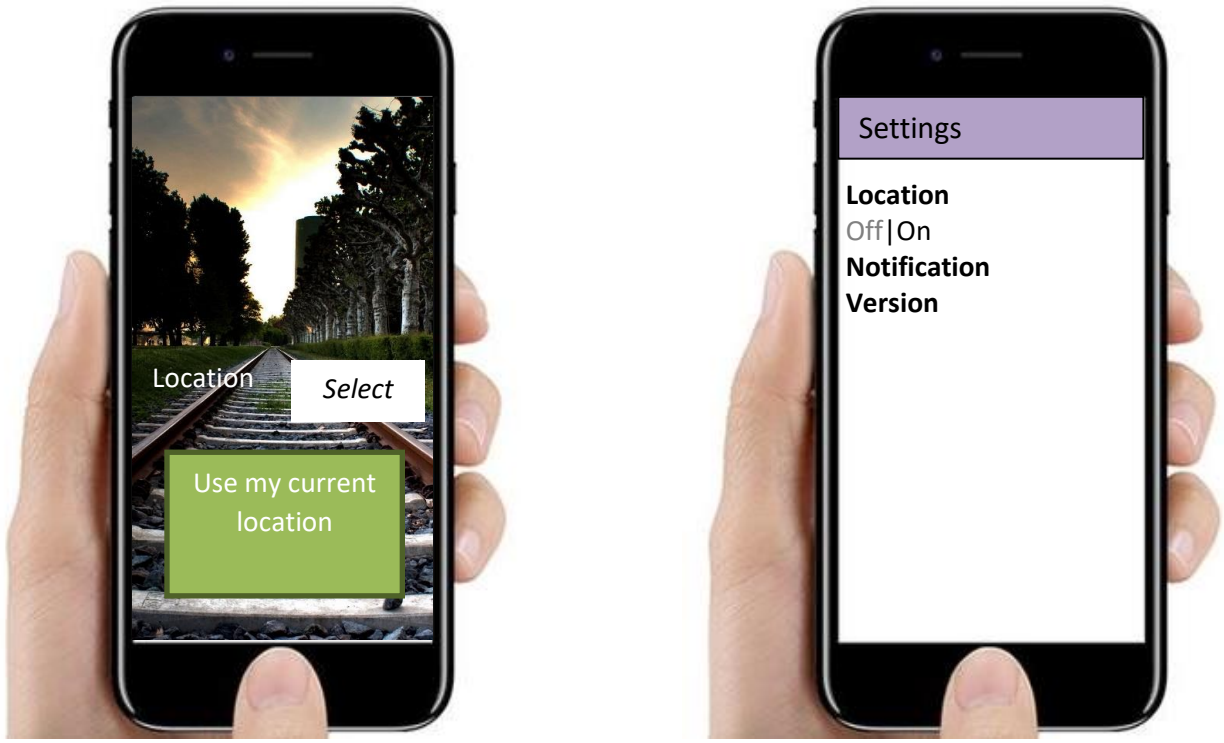
- City of Moorhead
- MnDOT
- BNSF
- Team NDSU
- Wireless Carrier

4.3 Description of the Proposed System

4.3.1 Physical Architecture

This will be a free app for everyone. Once people install the app in a Smartphone, it will ask for the permission to get access to the location. (Figure 4-1-a) If the user refuses to provide the GPS information, the app will ask to set a base location and depending on that information it will show the appropriate map. Our application would be scalable so that it can be utilized in different region of the country with same problem statement. The app will have a map indicating all the avenues across the streets an extra layer of indication or markings for the railroad crossings. It will also show the nearby underpasses as an escape route. At this point, to demonstrate the boundary of a map, two scape points will be determined which will make sure all the crossings are shown on the map. Based on those points (fixing them by latitude and longitude) a region will be mapped on the user's device. If the user agrees to share the location of the device, then it will show the map of its current position.

On the map, all the crossings will be marked as a green button to show that the track is now open for crossing. Once there is a train on the track, all the crossings will turn into red except for the underpasses which will remain green as an escape route. There will be a setting option (Figure 4-1-b) on the app to manually activate the location as well as to determine the notification sound for informing about an existing train on the nearby track. It will also contain the version information of the application.



(a) (b)

Figure 4-1 Physical Architecture of the application

4.3.2 Functional Architecture

Since the app would resemble Google Maps it would be easy for the user to get used to the interface. Once the user can see the map on the screen, it will also show the rail crossings (marked by round button)

Figure 4-2 Map view of the application while Train occupies KO track

and underpass (marked by square button). For trains on a track from any direction, the crossings on that track will turn into red and the underpass/escape route will keep blinking green. In Figure 4-2, there is an eastbound train on the KO track, therefore all the crossings are marked red, except for the underpass on 2nd Avenue on Fargo side which will show blinking green. Since there is no train on BNSF track, the crossings are kept green. In this case, the first indication of the train will be received by the crossing signal on the furthest west side, it is assumed to be safe in considering all upcoming tracks closed. Also, it gives an extra time to the road user in deciding new route based on the provided information.

A user can get access to this information in both Pre-trip and En-route condition. If they use this app before starting a trip, it will show them the most updated situation and store that location for that time. In this case, the user can see whether there is any railroad crossing on his route towards the destination and if there is any train occupying the track. If this situation changes after the user starts the trip, there will be distinctive notification sound and the map will automatically show up on the screen to alert the user about an upcoming train event and display other possible routes. This application will mostly help the daily commuters to use this information for avoiding unnecessary delay on the road.

4.3.3 Enterprise Architecture

To find the information of the oncoming train, the system will rely on the TFC information. The first indication is received by the BNSF underground circuitry (shunt) and send it to the BNSF Bungalow. Then a signal from Bungalow picks up the Advanced preemption relay in the cabinet. This is when the white flashlight starts beaconing and this information is sent to the MnDOT server through the Controller.

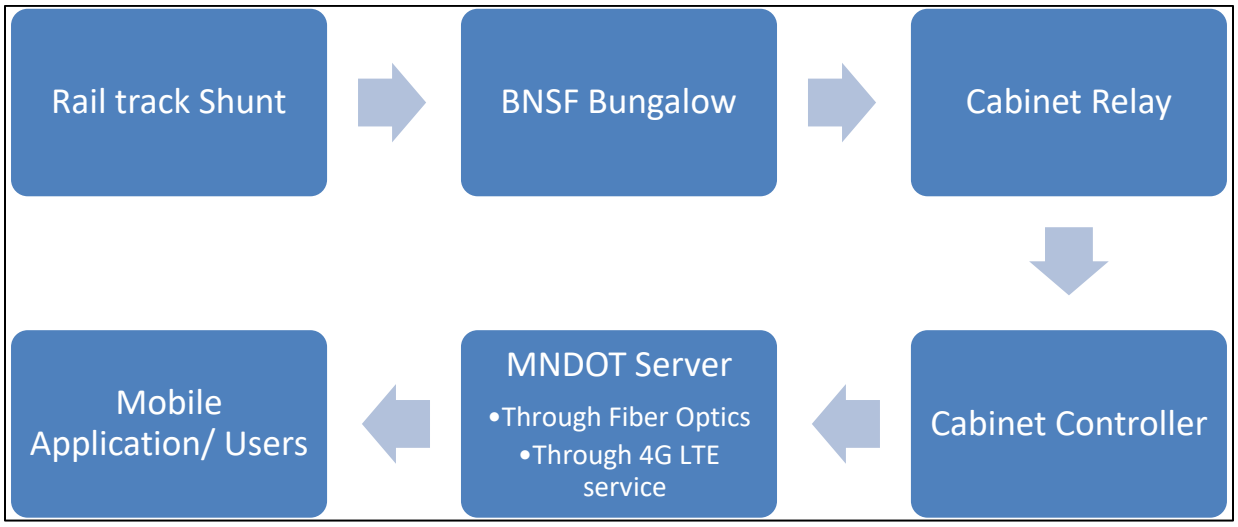


Figure 4-3 Data collection and transmission towards application

As our solution is a cross-platform application, serving as mobile and web application, and the available data is in MnDOT server, we need to connect them to get the data to our application from that server. We will be using a RESTful web service, also referred as RESTful API, to establish a connection between two applications. A RESTful API is based on representational state transfer (REST) technology, an architectural style, and approach to communications often used in web services development. this technology is generally preferred to the more robust Simple Object Access Protocol (SOAP) technology

because REST leverages less bandwidth, making it more suitable for internet usage. An API for a website is code that allows two software programs to communicate with each another. The API spells out the proper way for a developer to write a program requesting services from an operating system or other application.

5 Work Estimation

One of the big advantages of using REST is it is not constrained to XML, but instead can return XML, JSON, YAML or any other format depending on what the client requests. And users aren't required to know procedure names or specific parameters in a specific order. Therefore, this system will have interoperability with any other platform. Besides for data collection, it is depending on the existing system, therefore there are no additional costs incurred for facility installation. The only cost for this project will be in communication. There are two options considered for sending the data from the controller to the MnDOT server. Those areas under an Advanced Traffic management system (ATMS) are interconnected with most of their signal controllers through fiber optic. They can easily send this information to their server. If there is no fiber connection, a wireless ISP (3G/4G LTE) device can be set up with a cabinet strip heater. This will surely limit the impact on the operations budget to be carried by the city for setting up ATMS.

5.1 Cost Estimation

For this project, a Transportation Management Center (TMC) with basic facilities and communication in a small area has been considered. On the other hand, the wired ISP with strip heater is considered with a bandwidth capability of 3 megabits per second. The comparative cost for both types of devices is provided in the following list:

Table 5-1 Cost Estimation of ITS Device

ITS Device Type	Installation Cost ($K)	Operation and Maintenance Cost ($K per year)
Transportation Management Center	2471	371
Wireless ISP (for each)	**2.5**	**0.2**
Strip heater	**0.2**	**0.5**

Costs are based on ITS Cost database (https://www.itscosts.its.dot.gov/its/benecost.nsf/CostHome)

6 Anticipated Impacts

There are several operational benefits for the app. The app can be used at any train crossing where there is a communication box from BNSF that sends signals to close the crossing. Using the existing infrastructure of the communication box will require fewer materials and labor to install the device that will send the signal to a spot where the message can be sent to the app. Other operational benefits include being cost-effective and allowing easy access for anyone with a Smartphone. The only controller needed is for some individuals to run the app so it minimizes staff need for minimum maintenance. Using one-way communication from the signal to the app will reduce the chance of hacking. The app will also be easier to update compared to updating a DMS. There is also the potential in the future to integrate with Google Maps or other similar routing apps to give drivers an alternative route.

There are also safety benefits for using the app. The main objective of this system is to create a way to reduce the congestion from vehicles being backed up onto the street adjacent streets while the railroad crossing is active with a training event occurring. Using the app will allow drivers to be able to choose an alternative route knowing that there is a train coming soon. This will create less congestion since most drivers will have decided to use a different route. This will also prevent potential preempt trap situation when people trying to speed up to get through the train crossing because they see the lights starting to flash and with wrong judgment get themselves stuck on the crossing with more cars in front of it. With less congestion and aggressive drivers, there will be a reduction in crashes.

Not only are there operational and safety benefits, but there are also environmental benefits to using an app to notify drivers about incoming trains. There will be fewer emissions from vehicles waiting at train crossings because they will have chosen a different route making it more likely that they will make it their destination faster. The app will also not require additional construction reducing potential risks of water pollution and CO_2 emissions.

The primary benefit of using an application for addressing a challenge is its mobility. The app is essentially a downloaded program on user's smartphone. They have the liberty to check it as per their demand. The app will be regularly updating and any change on the TFC controller will be notified to the user irrespective of their position.

While there are many benefits to using an app, there is a potential risk. The major risk is distractive driving. Distractive driving is one of the leading causes of motor vehicle crashes. There are different alternatives to reduce the risk of distractive driving while using the app. The app will have a setting that allows a distinctive ringtone to go off to notify the driver that a train is coming. This will allow the driver to never have a look at the phone while driving and allow them to decide faster on a different route.

Moreover, this system will be safe from the security point of view while transmitting data over the internet. This will only accept one-way data from the server which ensures no backward data accessibility and therefore zero chances of cyber leaking.

7 Abbreviation

API	Application Program Interface
ATMS	Advanced Traffic management system
BNSF	Burlington Northern Santa Fe
CO_2	Carbon-Di-Oxide
ConOps	Concepts of Operation
DMA	Dynamic Mobility Applications
DMS	Dynamic Message Sign
EVAC	Emergency Vehicle Assistance and Communication
FOT	Field Operational Tests
HGRC	Highway-Rail Grade Crossing
ISP	Internet Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
JSON	JavaScript Object Notation
MnDOT	Minnesota Department of Transportation
NDSU	North Dakota State University
NOCoE	National Operations Center of Excellence
PCB	Professional Capacity Building
REST	Representational State Transfer
SOAP	Simple Object Access Protocol
TAZ	Traffic Analysis Zone
TFC	Transportation Field cabinet
TMC	Transportation Management Center
USDOT	United States Department of Transportation
XML	Extensible Markup Language
YAML	Yet Another Markup Language