Concept of Operations for: ***Updating Safety Service Patrol Routes Using Historical Data to Optimize Response Times***

Approval date: *5/31/2018*

DOCUMENT CONTROL PANEL		
File Name:	Updating Safety Service Patrol Routes Using Historical Data to Optimize the Response Times	
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Version Number:		
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Updating Safety Service Patrol Routes Using Historical Data to Optimize the Response Times

Problem Description

In 2016, 37461 people in the U.S. were killed in traffic crashes. Additionally, 2.35 million people injured or disabled due to traffic crashes. It can be seen that the victim number is huge. However, a large percentage of those killed people did not lose their lives immediately. That means, if they were rescued immediately after traffic accidents happened, they may not lose their lives. Therefore, quick response times are crucial for rescuing the lives. The response times are directly related to the Roadway Operation Patrol (ROP) vehicle locations and their routes to the incident locations. To achieve fewer response times, periodically updating the safety service patrol routes is one of the most effective methods since traffic volume pattern changes every year. It also can save the process time toward an accident since the response time is also a part of process time, which thus saves the time for thousands of other vehicles due to the less blockage time on the road. On the other hand, the quick process of crashes can also save the fuel consumption for other vehicles since less gas will be burned when waiting times decrease. Therefore, with such huge benefits in multiple dimensions, updating ROP routes become an applicable way and is already considered by a lot of engineers.

In Washington D.C, the ROP routes are not updated for several years. As the traffic volumes keep increasing these years, the traffic patterns also vary a lot comparing with previous when the service patrol routes were initially set up. Due to the non-practical of old ROP routes, ROP drivers often need to seek routes by themselves when an incident happens. Therefore, the current status already causes longer response time and delay on other traffics which become one of the serious problems in Washington D.C. Assigned by District Department of Transportation (DDOT), University of Nevada, Reno (UNR) team is pleased to provide an appropriate solution to updating the ROP routes in Washington D.C.

Problem Solutions

DDOT offered UNR team the GPS data of ROP vehicles, event locations (crash locations), and existing ROP routes. The research team will make full use of offered materials with appropriate solution tools. In this research, the basic step is to find the principal components regarding response time. The Principal Components Analysis (PCA) will be conducted by using R software in this research and it is a common method to fulfill data reduction, dimension reduction, and interpretation. In other words, it is an efficient way to find the principal factors which will influence the investigated factor (response times). In this study, the principal components of response time are going to be interpreted and will further be addressed in the updating routes process, which will eventually make the solutions more effective.

As aforementioned, the core of updating ROP routes is to update the response times. To achieve the quick response times, ROP drivers are usually apt to choose the shortest routes. However, the shortest routes may not be the best options for some time period, instead, the fastest routes are the best options. That means, besides the principal components, congestion (volume) conditions is also needed to be considered in this research. Additionally, the accidents frequency of each spot is the major reference to determine the destination of ROP routes.

The software used in the routes selection is the ArcGIS. Incident information and volume information will be joint into one database. Buffer tool will be used to classify these incident data points by clustering these points to a few regions. Center of these regions will be assumed as the destinations of new ROP routes. Additionally, volume conditions is also considered in the routes selection. The traffic volume patterns for AM, MD, and PM may be quite different. Thus, the proposed method is to provide three plans in a day (AM, MD, and PM) to design different ROP routes that can accommodate different traffic patterns in different time periods. Engineering judgments are made to balance the selections between the center of incident regions and traffic volume conditions. Note that although different plans are provided, there still has the limitation of applying dynamic traffic volume in updating traffic routes. However, separate plans are already a compromise method to enable the routes to become more adaptive. Additionally, since Washington D.C is the capital location, there might be a few special events, a backup plan is also going to be provided with non-frequent use routes to satisfy the unusual conditions. In this way, the response strategy will be more complete.

After the aforementioned procedures, a new system of ROP routes will be generated with traffic volume concerns. The ROP vehicles will be benefited by volumes update to avoid the peak hour platoons without having delays due to rerouting. Meanwhile, updated clustering incident regions will try to benefit the ROP drivers to make routes selection become easier. With this regard, drivers can easily do destination regions selections now rather than destination spots selections in previous, which means the clustering incident regions will benefit a lot in saving the decision times. It will direct the ROP drivers to arrive at a nearby place of the crashes in the shortest time.

Team Qualifications and Availability

UNR has assembled a strong team of transportation researchers to the diverse and challenging aspects of this research. Each research team member has his own advantages. Two members of electronic engineering are very knowledgeable of software usage and programming. Three members of transportation engineering are responsible for the methodology and result examination.

The research team brings local resources, experience, and skills in all of the research disciplines, including but not limited to the GIS toolbox usage, algorithm selection, engineering justification. Additionally, the team is also proficient in data classification and surrogate data collection. Three team members have taken the UNR advanced GIS class, which provided strong support to this research.

Scope of Work

Task 1: Project Management and Progress Meetings

Team weekly meetings have been conducted for one month since the research initiated. Besides the monthly deliveries, each team member has been assigned to his dedicated field in this research. In previous meetings, the team already discussed the general approaches to updating the ROP routes on the basis of the provided materials.

In the next a few weeks, the team will dedicate to conducting data analysis and routes selection. Weekly meetings will continue to be held every Friday to discuss the newly progress achieved by each team member. By the end of the project, the team should be able to deliver an integrated procedure memorandum for updating ROP routes, an integrated database that tied the response time data and the event locations, the newly updated ROP routes, and a summary report for the project. The quarterly progress flow chart was indicated in the following Figure 1.

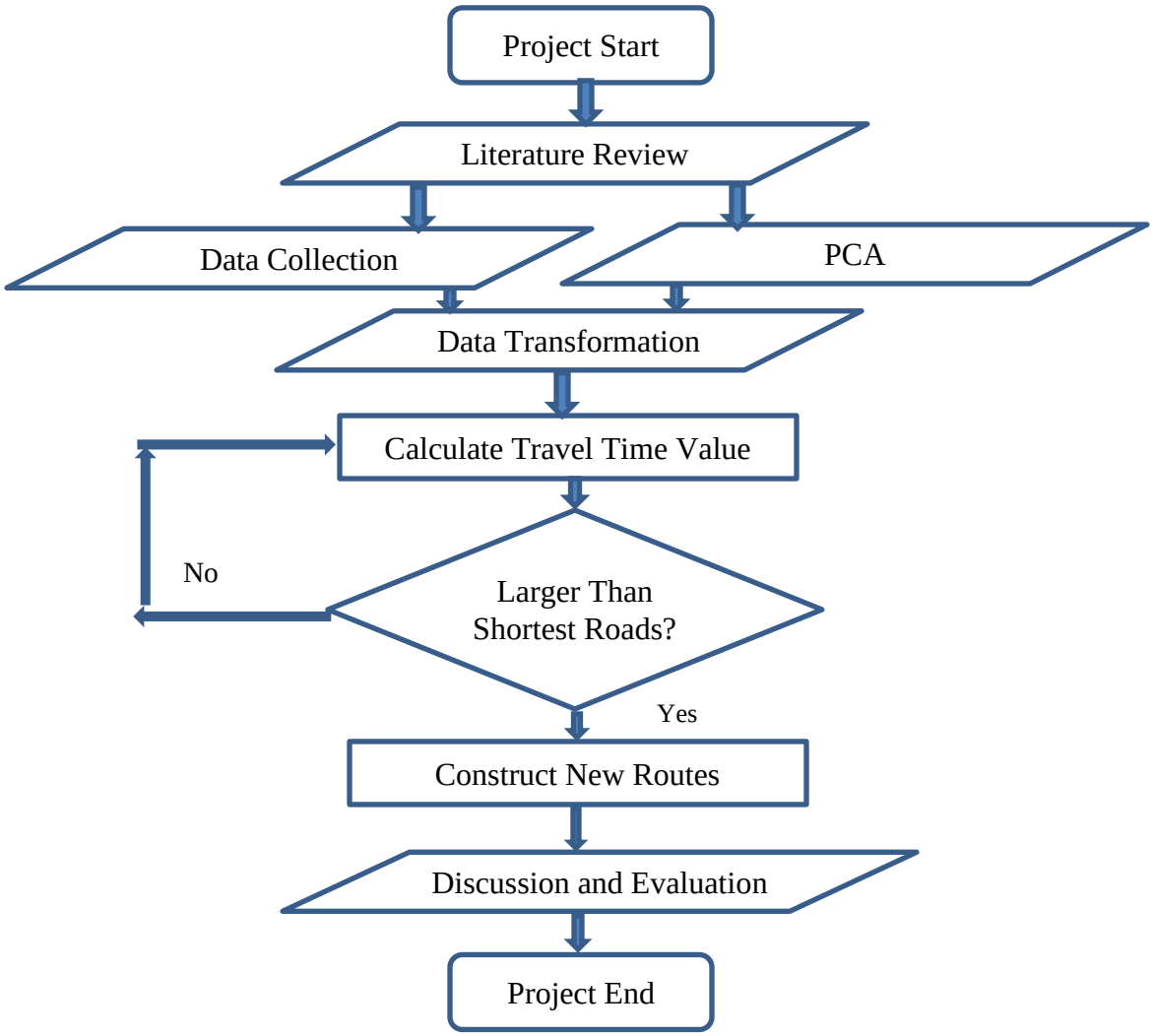

Figure 1 Quarterly Progress Flow Chart

Task 2. Literature Review on ROP Development

UNR team will also review the related fields to ROP which may have guidance to update the current ROP routes. The review files include but not limited to papers published in the transportation journals, geographic journals, and reports from both DDOT and other states. Those valuable materials will help the team to justify every step as well as understand the data and methods.

Task 3 Data Collection

Currently, three sorts of data have already been acquired from DDOT: ROP vehicle GPS data, event locations response times, and ROP routes with maps. Those data already includes most information needed for this research. However, to develop more adaptive plans, volume data is also important to be obtained. History traffic condition and travel times of google maps can support the choices of ROP routes, one of our team member will work on extract the history traffic conditions and travel times from Google map. Besides that, UNR already acquired the INRIX account, which is easier for the team to acquire raw volume data if necessary in this research. The data to be collected and possible data source follows:

- Roadway shapefile for Washington D.C. region
- Crash data shapefile
- ROP vehicle GPS data
- Event locations and response times data
- Existing ROP routes

Task 4 Data Transformation

To best utilize these raw data, data transformation is of significant importance to be applied in both PCA and GIS analysis. For PCA, the generalized variance matrix for the response time will be calculated and the variance for each principal component will be collected. For ArcGIS, to enable the GIS tools to do further operations, it is needed to transform these raw data into the files can be recognized in the software. The detail tasks are listed as follows:

- Transform the raw incident data file to a shapefile
- Transform the raw ROP vehicle GPS data to a shapefile
- Mark existing ROP routes on the roadway shapefile
- Create a toolbox contained the potential function to be used
- Create an ArcMap file and its unique directory to collect all the data in one file
- Reference the ArcMap file to a common coordinate plane
- Join response times to the incident data layer
- Assign different volume conditions to each roadway with different field name in the attribute table (AM, MD, and PM)

Task 5 New routes designing

In this task, engineering justification will be made at some crucial steps. It aims to classify these transformed data and build the simplest and effective way to make routes selection. The details are listed as follows:

- Generate Cluster sections by using the crash data points (Clustering sections may overlap)
- Mark arterial segments using 1, 2, and 3 in the attribute table to indicate no congestion, medium congestion, and congestion for three fields (AM, MD, and PM)
- Connect the cluster sections with their nearest ROP vehicles
- The shortest routes will be collected as the basis of new ROP routes
- Create two fields to represent the weights by first two principal components

- Create travel time field for each segment (denoted by weighted value, not exact travel time) which will be indicated by the different weight combinations (engineering justification) of congestion conditions and principal components
- The adjacent segments to the shortest routes will be considered to replace the segment of shortest routes by comparing the travel time field values
- The new routes finally can be determined by the segment combinations with less value in travel time field

Task 6 Group discussion and justification to the results

Although the engineering justification has been made in the previous tasks, it still needs to figure out whether the new routes have any irrational aspects. Group discussion is a good way to eliminate the fluctuation of judgments. After that, the ROP routes can be finalized and ready to use.

Task 7 Evaluation of existing ROP routes and updated ROP routes

To ensure the quality of updated ROP routes, the evaluation between the old routes and new routes is needed. The evaluation will be conducted by using online Google maps with the travel time as Measure of Effectiveness (MOE). The travel times of both old and new ROP routes will be collected at the same time of AM, MD, and PM individually. A figure will be provided to indicate the saved time after the routes updated.

Task 8 Final Report

A final report will be well written by the team to introduce the complete process for this research project. Section 1 will describe the problem in this research. Section 2 will address the proposed solutions to the problem. Section 3 will document the details of methodology in use. Section 4 will list the updated routes and an evaluation of the existing routes and updated routes regarding the estimated travel times. Section 5 will demonstrate how to make the engineering justification. Section 6 will reiterate the benefits of the updating ROP routes. Section 7 will be a summary of the research works and potential future works.

Task 9 Presentation Slides

Presentation slides with good quality will be prepared by the end of the research works. The slides will clearly state the background of updating ROP routes, introduce the importance of fewer response times, list the principal components to the response times and the critical factors for the routes update, provide an example to show how the methodology applied, and show the updated new ROP routes and their advantages.

Estimated Budget and Timeline

Project task budget

This is a contest project, the software that will be used has already been installed in the school's computers. The data has been offered by DDOT. Therefore, the budget will be zero.

Timeline

The timeline will include before works and after works into a table, it is shown as follows:

TABLE 1 Timeline

Project Name Updating Safety Service Patrol Routes Using Historical Data to Optimize Response Times 4/30/2018 - 6/28/2018		2018 April to June								
Tasks	Duration	1	2	3	4	5	6	7	8	9
Task 1: Project Management	9 W									
Task 2: Literature Review	2 W									
Task 3: Data Collection & PCA	3 W									
Task 4-5: Data Transformation and Routes Design	2 W									
Task 6-7: Discussion & Evaluation	2 W									
Task 8-9: Final Report and Slides	4 W									

Estimated Effectiveness of this project

After the new ROP routes are applied to the field, the effectiveness will be gradually shown. The multi-plans strategy is advantageous than one-plan strategy in the volume consideration. Compared to the existing routes, the new routes may guide the vehicles to escape from platoons and congestions and thus contributed to a decrease in the response times. Fewer response times will also decrease the total operation times to accidents, which indirectly saves the lives and also saves the travel time for thousands of vehicle that blocked by the crashes. At the same time, the fuel consumptions will also be saved and consequently result in the protection of air quality. What's more, ROP routes for cluster regions will guide drivers more effectively due to less consideration is needed for drivers when crashes happen. The better driving condition will also enhance the ROP driver's safety when they are on duty. Therefore, although this is a small achievement, it has the potential to benefit a lot of dimensions.

DOCUMENT REVISION HISTORY			
Version Number	**Approved Date**	**Description of Change(s)**	**Created/ Modified By**
1	5/20	Initial Version	Rui Yue
2	5/24	Structure Revision	Rui Yue
3	5/29	Ideas Revision	Jianqing Wu
4	5/31	Final Version and Grammar Revision	Rui Yue and Jianqing WU