Smart Traffic Routing with Efficient and Effective Traffic System (STREETS)

PROJECT PROPOSAL

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BY
DMATS & City of Dubuque Staff

STREETS PROJECT OBJECTIVES

The goal of this project is to develop a smart, next-generation, traffic management and control system (called here STREETS as an acronym for Smart Traffic Routing with Efficient and Effective Traffic Signals) that will use traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metro area.

The proposed system will reduce wear and tear on major corridors in the Dubuque metro area by distributing traffic more evenly throughout the metro area. It is also expected that the system will reduce congestion, shorten travel times, and improve safety in the metro area. By rerouting traffic on the roads with extra capacities dynamically, it is expected that the proposed system will reduce/eliminate some of the traffic bottlenecks. As an auxiliary outcome of the system operations, the City staff will use the proposed system to identify future projects that will improve safety and reduce congestion in the metro area. Finally, the system will help to measure the effectiveness of safety and congestion projects. This project is one of a kind and will become a replicable model for small urban areas such as Dubuque with populations under 100,000.

PROJECT DETAILS

The Project is broken down into four major tasks.

A. **Systems Engineering Concept** - Develop a Systems Engineering (SE) model that will fully define the project and prepare detailed requirements and scope of services that are suitable for use in the procurement process of the following project tasks. Development of SE model requires that vendors specify all of the components of the V model recommended by Federal Highway. The development of the V model should include constant and regular correspondence and input from project stakeholders including citizen groups, Dubuque County, City of Dubuque, Iowa Department of Transportation, Dubuque MPO, Dubuque School District, EMS groups, Freight groups and others as recommended. The consultant needs to communicate with project team members and stakeholders to ensure that inputs and outputs of the V model are acceptable for the stakeholders and that final results are meeting the project expectations.

B. **Traffic Model** – Develop a microsimulation traffic model of the Dubuque metro area (including all relevant roads and all of the signalized intersections) to represent existing traffic conditions. The model will be capable of replicating signal operations from the field and it will produce truthful outputs of the field traffic conditions (travel times, delays, etc.) so that following traffic assignments/routing can be executed based on verified data. The model will execute traffic assignments (reroute vehicles) based on the estimated/measured traffic impedances of the network links. Prior to integration in the STREETS system, the model will be calibrated and validated to confirm that field data are matched properly. Task B can be further decomposed in the following subtasks:
    - Build a traffic model with necessary spatial (entire network) and temporal (covering operations for entire day) scopes
    - Calibrate and validate model outputs (e.g. travel times between signalized intersections, intersection approach delays, average phase times)
    - Run and test traffic assignments and validate the assignment accuracy based on the field conditions (e.g. propose a method to measure traffic flows during major road work or lane closures; test the same scenario in the model and confirm that the assignment can reflect conditions observed in the field)

C. **Adaptive (Dynamic) Traffic Control System** - Develop a new (or modify an existing) Adaptive Traffic Control System (ATCS) which will change signal timings in real-time after changes in traffic conditions are detected (by the STREETS system). The ATCS is expected to be fed by simulation data, recalibrated on field

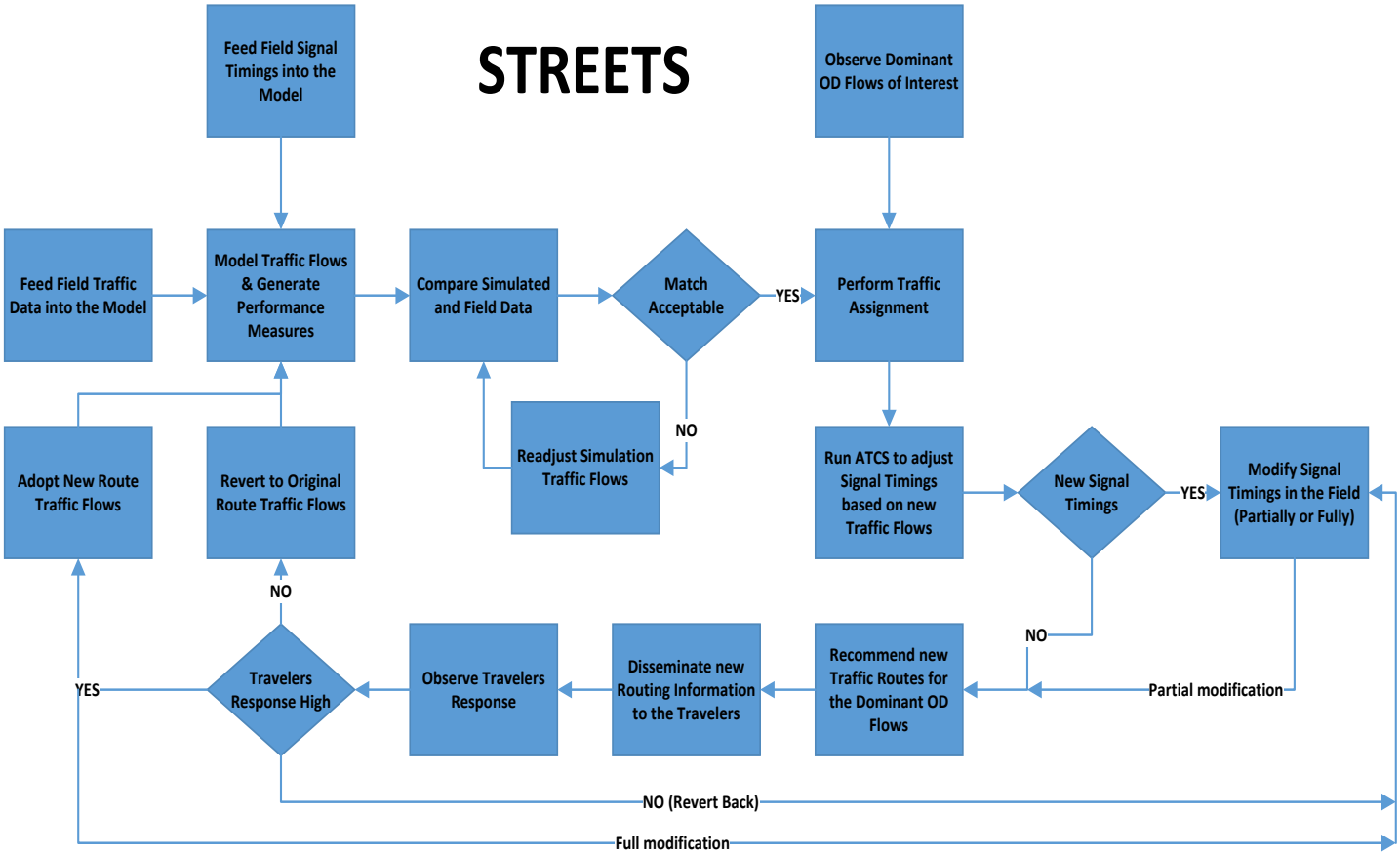
data in near real-time (e.g. 15 minutes), where its adaptive algorithm is triggered only after optimal traffic flows are determined through a traffic assignment procedure. Even then, signal timings must be adjusted in a partial and progressive fashion until it is observed that the proposed routing changes are implemented in the field. Figure II Illustrates the process for ATCS. Task C can be further decomposed in the following subtasks:

- Define an approach which will be used to establish an Adaptive/Dynamic Traffic Control System. If an existing ATCS is used, clearify how will the existing system will be modified to reflect inputs from the simulated/calibrated model
- Prove that the proposed ATCS can be integrated in the model properly to enable signal timing changes to be made in real time without creating disruptions to the field operations
- Ensure that the proposed ATCS has a Software-in-the-Loop (SIL) capability which is compatible with the field traffic controllers. Changes made in the SIL database of the ATCS need to be seamlessly transferrable to the field controllers
- Test responsiveness of the proposed ATCS to ensure that its reactions/signal timing changes do not cause unnecessary transients thus keeping traffic conditions unstable
- Integrate a feedback loop in ATCS operations where suggested signal timing changes, for optimal traffic rerouting, are not fully implemented before there is reassurance from the field that the drivers are adopting/following on the suggested routing options

D. **System Integration** - Develop a framework to utilize existing data sources (and potentially new ones) to feed the above mentioned model and recalibrate/revalidate it in near real-time. Define which data sources (video, detection loops, radar, etc.) should be used (and how) for model inputs and which ones should be used for recalibration of the model and validation of the routes adoption by travelers. Develop protocols and specs to define how those data will be integrated in the STREETS system. Task D can be further decomposed in the following subtasks:

- List all of the potential sources of traffic data to be utilized in the STREETS system
- Define which data will be used for which of the tasks/project components so that the same type of data, from the same sources, are not utilized multiple times. E.g. one set of data should be used for calibration and another set for validation/verification purposes.
- Integrate data from various sources into the system so that the STREETS operations can be executed automatically. E.g. this may require a vendor to develop software to extract video features from the City's CCTV cameras and similar.
- Establish an approach to handle missing data – e.g. use historical and offline values to replace erroneous/ missing data. Integrate a system of warnings/reliability measures to warn operators when the system is working/developing recommendations based on data which are not very reliable/cannot be verified.
- Provide operators with tools and features to monitor STREETS operations (e.g. web interface) with displayed both inputs and outputs and ability to manually intervene as necessary (should not require continuous manual interventions)
- Develop a failsafe mode when the system can detect if the input data are questionable (and output data could be wrong). In such a case enable automatic fallback option to revert to Time-of-Day (TOD) plans and display 'neutral' messages which may impact routing decisions

Overall project process



BACKGROUND INFORMATION ON TRAFFIC CONDITIONS WITHIN THE CITY OF DUBUQUE METRO AREA

The City of Dubuque is the only entity that has a signal system within the Dubuque Metro area. Listed below are facts about the City of Dubuque Traffic Operations and characteristics of the transportation network:

Signal Operations

- The City of Dubuque network has 60 signalized intersections excluding the Central Business District (CBD) of which approximately 80% are connected. Most of these signals are equipped with M50 Siemens controllers with EPAC firmware. The City also uses Siemens' TACTICS central management software, which currently does not meet all of the City's needs for management of traffic signals. The City is equally open to consider STREETS solutions which propose use of the existing or installation of new traffic signal/controller equipment.

- In the Central Business District (CBD) of Dubuque the City operates 45-50 signals with fixed timings where no detection is present. Those signals are usually well coordinated due to a proper combination of cycle lengths, block lengths, and the fact that several streets in CBD are one-way streets etc. Therefore, if the STREETS is implemented through multiple phases, the CBD will likely be the last part of the network where STREETS is deployed.

Detection and Surveillance

- Detection at the signalized intersections within the City is usually implemented through Wavetronix Matrix units which are installed both on the main roads and side streets. There are almost no intersections which operate in semi-actuated mode (no detection on the main street). Some of the Wavetronix detectors are HDS (Wavetronix Advanced Detection) but most of them are Matrix units. Various types of detection

- The second most deployed detection technology within the City is the inductive loop. There are few intersections that are equipped with video detection systems, but the City is not interested in video detection due to its problematic performance in winter conditions. Some of the intersections also have advanced (dilemma-zone) loops and these are usually Wavetronix advanced detectors located about 600 ft. ahead of the intersection.

- The City has also deployed a number of travel-time measurement systems. Currently the City has 8 Acyclica devices installed on Hwy 20 (5 devices) and NW Arterial (3 devices). There are also 5 City owned and two state owned Wavetronix HD units located through City. It is expected that the number of these or similar devices will grow in the near future and the potential proposers can integrate in their proposal a modes number of additional devices whose installation will be covered by the City, outside of the potential contract. The City budget for ITS equipment allows a full upgrade of 2-3 signalized intersections per year. Also, some of the funding from recently increases gas tax may improve future funding of ITS equipment and solutions.

- The City has an extensive network of CCTV and the video detection cameras which are both used for traffic surveillance and post-event investigation of the events that affect safety and security of the travelers. These cameras are backed up with a powerful recording, archiving and reviewing software (Milestone) which gives the City staff opportunity to quickly and conveniently review the cameras' video footage. Once videos are recorded (24/7) they are stored on the City's database for 30 days before being discarded. Recordings of some very important events can be archived permanently. The City staff feels that these video capabilities are not leveraged enough for traffic management purposes. Therefore, the City encourages proposed STREETS solutions which will leverage the City's video capabilities. Currently, the City does not have an automatic procedure to extract any traffic-related metrics from the video footage recorded by its cameras.

Institutional Requirements

- The magnitude of traffic and video operations in the City significantly exceeds capacities of the City's traffic operations staff and the STREETS system should be developed with this notion in mind. The system is intended to be an automatic system that gives the City staff the ability to monitor traffic operations and intervene as necessary but without the need for constant or significant manual operations. **Ideally, if no significant traffic disturbance events occur, STREETS is supposed to run 24/7 without requiring operators to interfere manually with traffic operations.** The City understands that potentially there will be the need to maintain (operationally) the system remotely (for a fee) but that option should be avoided if possible and it will be reviewed as potential alternative only if the benefit/cost ratio of such a solution outperforms some of the other options.
- City and DMATS staff training should be included in the scope.

Traffic behavior with in the metro

- Some of the characteristics of traffic behavior in the network:
    - Drivers are sometimes very slow to pull off from the standing queue at signalized intersections. Therefore, headways between vehicles are longer and saturation flow rates might be lower. This can impact efficiency of the green times.
    - Drivers tend to be very aware of the necessary lane changes well ahead of the merging/diverging times and this sometimes creates an issue because uneven utilization of the lanes on some of the roads.
    - There is a lot of truck traffic throughout the network which has a hilly topology. Very often signals that are timed to provide good coordination for truck traffic may not fit for light vehicles (they get to the next signal too soon in some cases). Future development of the STREETS system should take this problem in consideration and propose how existing (e.g. video surveillance) or new technologies can be integrated in STREETS to avoid these very inefficient and sometimes unsafe traffic occurrences.
- Design changes are planned for the following facilities design changes in near future:
    - University Ave & Asbury Rd, University Ave & Loras Blvd, and University Ave and Pennsylvania Ave will be converted to roundabouts
    - University Ave & Grandview Ave will be converted from a 4-way stop intersection into a 8-phase signalized intersection
    - Loras Blvd & Grandview Ave will be converted to a 8-phase actuated signal this summer
- The major corridors and intersections that face congestion issues:
    - Hwy 20 is the most problematic and has a lot of congestion. One of the main goals of this project is to remove such congestion and distribute it more evenly across the other roads in the network.
    - Locust Street & the Mississippi River Bridge on Hwy 20 are heavily congested.
    - Intersection of NW Arterial and Hwy 20
    - Pennsylvania Ave & NW Arterial has a nearby high school that generates high traffic demand in the mornings and early afternoons. Similar traffic problems are observed at NW Arterial and Asbury Rd.
    - Hwy 61/151 and US 52 can be problematic
    - Asbury is also a problematic corridor and the most problematic intersections are Asbury and JFK Road and NW Arterial and JFK Rd
    - Chavenelle Rd & NW Arterial can be a problem intersection – operating problematically in peak periods
    - There are many residential and retail areas along NW Arterial which create congestion problems.