BYU Civil & Construction Engineering
IRA A. FULTON COLLEGE OF ENGINEERING

MEMORANDUM

TO: TRAVIS JENSEN

FROM: GREGORY S. MACFARLANE, PH.D., PE
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SUBJECT: IMT DEPLOYMENT OPTIMIZATION
IMT PERFORMANCE: PHASE III

MARCH TAC MEETING AGENDA

DATE: 20 MARCH 2023

CC: TECHNICAL ADVISORY COMMITTEE MEMBERS

AGENDA

1. IMT Performance Measures Phase III Project Update (Joel Hyer)
   a. Review the results of the performance measures analysis
   b. Share the results of the statistical analysis conducted on 2018 and 2022 crash data, including those of the user impacts data
   c. Discuss the results with the TAC and decide which items to include in the UDOT report
2. IMT Simulation Project Update (Daniel Jarvis / Brynn Woolley)
   a. IMT Vehicle Deployment
3. Additional discussion
4. Schedule next TAC Meeting: Proposed May 2023.

IMT PERFORMANCE MEASURES PHASE III

PROJECT UPDATE

Figure 1 illustrates the project schedule for the Analysis of Performance Measures of UDOT's Traffic Incident Management Program: Phase III. Tasks 2 and 3 are complete, while Tasks 4 and 5 are underway. These tasks will need to be extended slightly based on the dates that the data were received.

Task	2021			2022												2023		
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1					TAC			TAC			TAC			TAC			TAC	
2																		
3																		
4																		
5																		
6																		
7																		Review
KEY:		Task progress							TAC meeting and updates									

Task	Description
Task 1:	Kickoff Meeting/TAC Meeting/Project Management
Task 2:	Literature Review
Task 3:	Collect Incident Management Performance Data
Task 4:	Analyze Performance Measures Data
Task 5:	Analyze User Cost Data
Task 6:	Compare Performance Measures
Task 7:	Report Results

Figure 1. IMT Performance Measures Phase III project schedule and completion.

Task 3: Collect Incident Management Performance Data

Data were collected for March through August 2022 and have been analyzed.

Task 4/5: Analyze Performance Measures Data/Analyze User Cost Data

The performance measures and user cost data have been evaluated, and the results will be shared in this meeting.

Next Steps

The research team will be compiling results in the UDOT report and finalizing it based on the feedback of TAC members during the meeting to include all content and results to help answer the study questions.

IMT DEPLOYMENT OPTIMIZATION

PROJECT UPDATE

Figure 2 presents the project schedule and completion percentages alongside the original task completion plan. Task 2 (Literature Review) was completed in the spring of 2022, and the research team is currently fully engaged in finalizing the simulation model. The team is currently developing scenarios for IMT response and aims to begin Task 4 by the next Technical Advisory Committee (TAC) meeting in May. While the project is slightly behind our target completion schedule, we anticipate completing it by Quarter 4, 2023.

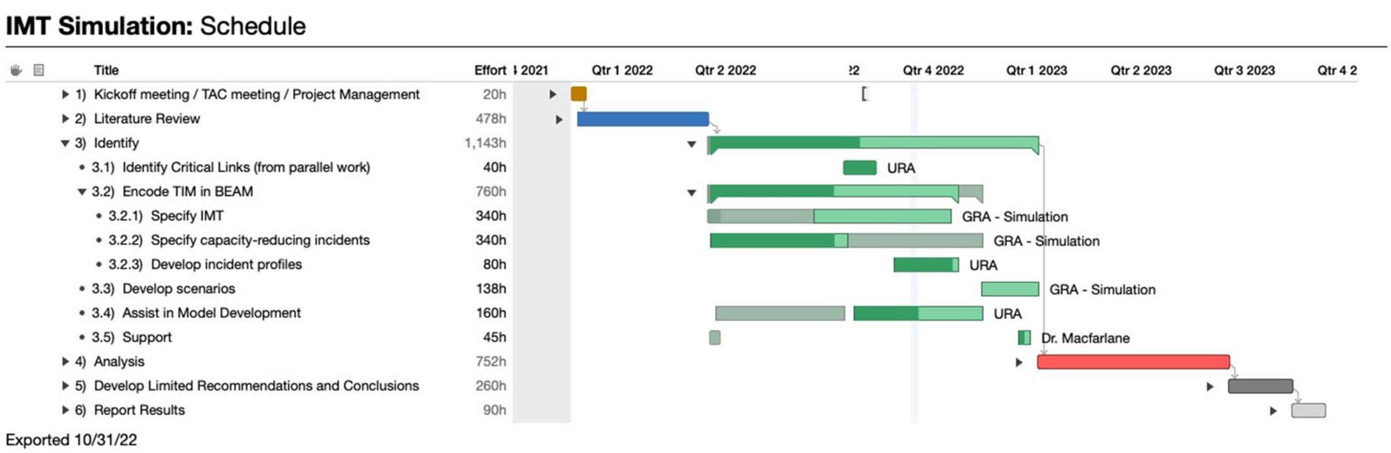

Figure 2. Project schedule and completion. Shaded bars represent task completion, and shadows represent the original schedule. The blue line represents today (March 2023).

METHODOLOGY

We are using MATSim, an open-source framework for mesoscopic modeling, to represent and analyze the IMT system. MATSim is an activity-based model implemented in Java that models transport users as individual agents. It is an iterative model that allows users to adjust travel plans during a single iteration, from iteration to iteration, or both. Details on the operations of MATSim and its background are found in Horni et al. (2016). We will primarily use two features of MATSim:

1. Network change events: These allow the capacity or speed of a highway link to change at a particular point in the day.
2. On-demand vehicle services: These enable agents to adapt to changing conditions, such as a capacity-reducing highway incident.

We have developed the Network Change Events feature based on input data from parallel work. Currently, we are completing the development of the on-demand vehicle services, which will enable the deployment of incident management teams. We aim to discuss our assumptions regarding the modeling of vehicle dispatch and the effectiveness of IMT upon arrival in this portion of the agenda.

IMT Assignment

When an incident occurs, one or more IMT vehicles are requested to manage the situation. A dispatch algorithm is employed to assign the best vehicle for the task. Currently, the model selects the vehicle based on the least-cost path that considers congestion and link speed, but alternatively, the shortest path between the two points could be used. Figure 3 presents the two assignment methods, where the blue line represents the shortest path, and the green line illustrates the least cost path. Our research aims to investigate how UDOT currently manages its IMT vehicle dispatch.

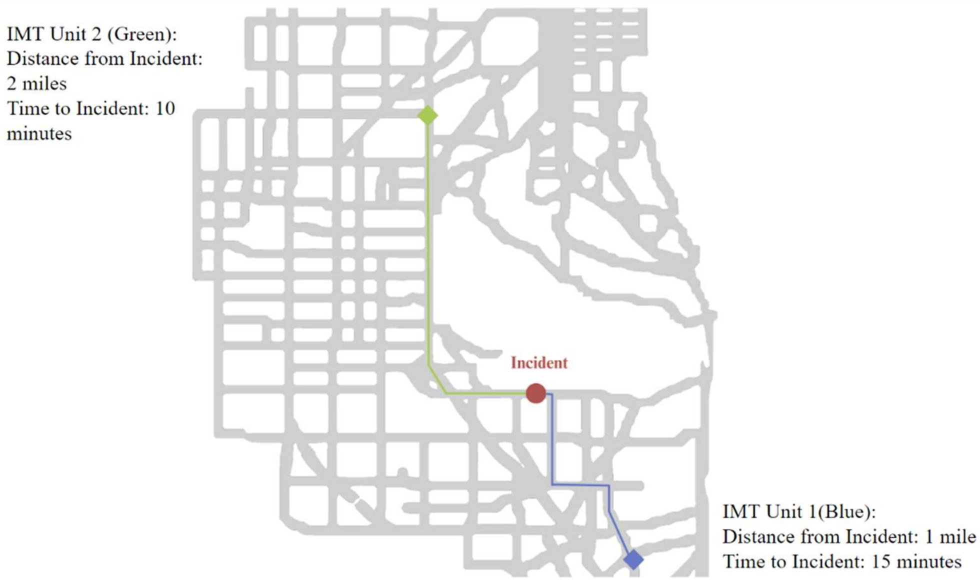

Figure 3: The different IMT assignment methods that could be used.

During an incident, the link's capacity is reduced, causing congestion, but we do not understand how this affects IMT vehicles' travel behavior. We need to determine how quickly IMT units can move through traffic, for example, when driving on the shoulder of I-15. Alternatively, the vehicles can be modeled to follow a straight-line distance from their location to the incident, ignoring congestion. However, using that method, we must decide on a constant value for vehicle speeds, such as 35 mph.

IMT Effects on Network

After dispatching IMT vehicles, the next question is how effective they are in restoring the network to its original capacity and what impact additional vehicles would have on their effectiveness. For Joel's data, we calculated a time-weighted average of capacity reduction for each incident. For instance, an incident on I-15 SB caused an 80% capacity reduction for one and a half hours, requiring two IMTs' assistance. We can model three different scenarios for such an incident:

1. No IMT responds, and the link is eventually restored to its full capacity on its own (3 hours)
2. One IMT responds, improves capacity upon arrival, and moves up the time needed for the link to be restored to its full capacity (2 hours)
3. A second IMT responds, improves capacity further, and aids in restoring the link to its full capacity more quickly (1.5 hours)

Figure 4 shows the hypothetical incident scenarios outlined above:

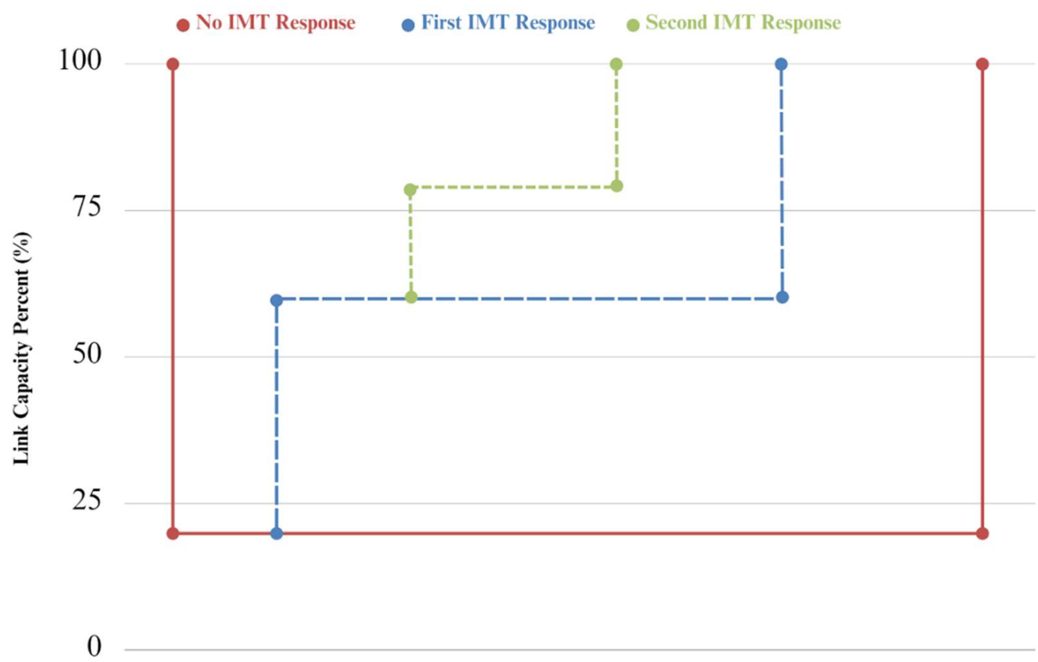

Figure 4: Impact of IMTs on link capacity reduction.

Upon arrival, an IMT can either move up the time it takes for capacity to return to normal or improve capacity by some percentage 'X.' Our literature review has identified sources discussing the relationship between the number of vehicles at an incident and their effectiveness. For instance, a group of researchers in Maryland (Kim and Chang) calculated a marginal cost-to-benefit ratio to determine the optimal fleet size. We will use their findings to estimate the impact of each additional vehicle on restoring a link to capacity. Still, we would appreciate the TAC members' opinions on adjusting the 'nobs' of IMT effectiveness. Specifically, we have two questions: Do we know how much an IMT improves capacity upon arrival? On average, what impact would each additional IMT have on an incident's roadway clearance time?

In summary, our research aims to simulate the IMT vehicles' responses to incidents, determine the best vehicle assignment approach, and evaluate the impact of each vehicle on the duration of an incident. Once these decisions are made, and the 'nobs' are set, we can proceed with the analysis portion of our research, which will be discussed in the May TAC meeting.

REFERENCES

Horni, A., Nagel, K. and Axhausen, K.W. (eds.) 2016 *The Multi-Agent Transport Simulation MATSim*. London: Ubiquity Press. DOI: http://dx.doi.org/10.5334/baw. License: CC-BY 4.0

Kim, W., Franz, M., & Chang, G.-L. (2012). Enhancement of freeway incident traffic management and resulting benefits [Tech Report]. https://rosap.ntl.bts.gov/view/dot/24229