TRB 2018: WORKSHOP 174

Sunday, January 7, 2018, 1:30pm – 4:30pm *Salon A, Washington D.C. Convention Center*

Workshop 174: Decision Support Subsystem Requirements for the Next Generation Traffic Management Systems and Centers (TMCs)

Sponsoring Committees:

- Freeway Operations [AHB20]
- Regional TSMO Committee [AHB10]
- ITS Committee [AHB15]
- Artificial Intelligence and Advanced Computing Applications Committee [ABJ70]
- Traffic Signal Systems Committee [AHB25]
- ATM Joint Subcommittee [AHB20-5]

Introduction

This document summarizes the feedback attendees provided during the workshop regarding the challenges and potential research needed to advance Decision Support Subsystems required to support for Next Generation Traffic Management Systems and Centers (TMCs).

On Sunday, January 7, 2018 during the National Transportation Research Board's 97th Annual Meeting, several technical committees sponsored a three-hour workshop focused on the decision support subsystems (DSS) for the next generation of traffic management systems (TMSs) and centers (TMCs). The workshop highlighted innovative technologies and successful practices being used to improve the performance of existing legacy TMSs and TMCs. The workshop also discussed and identified research needs to support agencies developing the decision support subsystems with the capabilities necessary to meet the evolving needs, demands and performance expectations of these next generation systems and TMCs, thereby enhancing the ability of these systems to improve the safety and efficiency of the facilities being managed.

The remainder of this document provides brief summaries of each of the three sessions held during the workshop: Session 1, presentations on the state-of-the-practice and opportunities to integrate DSS into TMSs and TMCs; Session 2, a facilitated discussion on what research may be needed to advance using real-time DSS for TMCs and TMCs; Session 3, what topics may be priorities to pursue as potential NCHRP research problem statements; and the action items identified for the co-sponsoring Committee's to consider advancing. This workshop summary and the presentations provided during the workshop are available on the following website: https://sites.google.com/site/trbfreewayops/.

Session 1:

Opportunities to Integrate Decision Support Subsystems into Traffic Management Systems and TMCs

Session Purpose: To detail the need for DSSs in TMSs and TMCs and to highlight current initiatives pushing the state of the practice.
Session Objective: To present a cohesive view of the current opportunities and challenges in support of facilitating a dialogue to address future research needs.
Moderator: Dan Lukasik, Parsons
Session Description: Five presentations were made highlighting innovative approaches being used to integrate DSSs into the design and operation of TMSs and TMCs. These presentations covered a range of issues addressed by agencies in the planning, design, implementation, management, and operation of DSSs into traffic management. The presentations ranged from descriptions of the general need for DSSs, tools available, required elements, and challenges to descriptions of individual implementations throughout the US and in Australia. Below is summary of the presentations and presenters. Copies of each presentations are available at: https://sites.google.com/site/trbfreewayops/.

Decision Support, DS Tools, DS Subsystems, and Applications for Active Traffic Management

Emanuel Robinson, Westat

This presentation describes the general need and major components for decision support subsystems as well as a focus on the Dallas DSS capabilities, challenges, and innovations.

Evolution of Using Decision Support Tools to Actively Manage Traffic

Phil Masters, Parsons

This presentation describes the evolution and history of the tools available for DSSs, the key reasons for implementation, considerations for the development of such systems, and a look forward to future innovations.

The Australian Approach and Architecture for Decision Support Subsystems,

Adam Myers, TRANSMAX, and John Gaffney, VicRoads

This presentation describes the Australian approach to integrating ITS into transportation systems architectures as well as highlights the use and integration of DSS to form a holistic environment for optimizing the traffic network by combining the efforts of government, academia, and technologists.

How Might Decision Support Subsystems Vary from Different Traffic Management Systems?

Matthew Juckes, Kapsch

This presentation outlines different DSSs and their associated roles.

Examples of Decision Support Subsystems Used by Traffic Management Systems and TMCs to Actively Manage Traffic

Doug Gettman, Kimley-Horn

This presentation describes the utilization of adaptive control systems, performance measures for automated traffic signals, and ideas on innovations for the future of the practice.

Session 2

Research Needed to Advance Using Decision Support Subsystems for Traffic Management Systems and TMCs

Session Purpose: To expand upon the successful practices and lessons learned in session one and enable a discussion to identify the high priority topics where research may be needed to support agencies planning, designing, or using DSS for TMSs and TMCs:

- DSS Components (e.g., data [storage, formats], computing, software, analysis [e.g., simulation software, algorithms, software], operator interface, interfaces between components)
- DSS Requirements (e.g., timeliness, monitor performance, action for making decisions, translating data, operators manage and operate, agencies maintain)
- DSS Design (e.g., architecture options, software platform considerations, interface requirements, functions, monitoring performance and thresholds, software platform)
- Use of Innovative Technologies (e.g., artificial intelligences, machine learning, computing, software [e.g., off-the-shelf, open source, applications])

Session Objective: To identify successful practices, technologies utilized, lessons learned, and possible topics appropriate for research, development and technology transfer projects which will address the high-priority needs for the topics noted above.

Moderator: John Corbin, FHWA

Session Description: A facilitated discussion was held in support of identifying the higher-priority topics to support spending more time discussing the current state of the practice, gaps in knowledge, and possible research needs. Materials were developed to support the consideration of 14 topics prior to the workshop to support the discussion. Participants were encouraged to use the document to obtain more information on each topic, which included: current practices, gaps in practice, research and technology transfer needs, and available guidance and research.

Participants were asked to vote for which of these 14 topics concerned them the most. Participants were guided when voting to consider the following: priorities, feasibility, state of the practice, existing research, current deployments and implementations, expertise, ability to act, and the evolution of the concept. Participants were also encouraged to write-in topics of their choosing to address any gaps. The most popular four topics were selected for discussion – see below for the topics and voting results.

Approximately 72 ballots were submitted during the workshop's exercise. Participants engaged in a facilitated discussion with respect to the four most popular topics to identify successful practices, technologies utilized, lessons learned, research and development needs, and additional issues to consideration. The proceeding subsections provide a summary of discussions and takeaways.

Topic 10 - Monitoring and Tracking Performance of DSS	40
Topic 2 - DSS Requirements Unique for TMCs or Different Systems	33
Topic 1 - DSS Requirements Unique for Traffic Signal Systems (tie vote)	32
Topic 7 - Requirements for Adding Prediction Capabilities to DSS (tie vote)	32
Topic 12 - What Technologies Can DSS use (e.g., AI, Data Fusion, Machine Learning)	27
Topic 5 - Storing and Using Archived and Real-Time Data	22
Topic 6 - Analytical Capabilities and Requirements for DSS	19
Topic 9 - Software and Integration Considerations for DSS	14
Topic 13 - What Resources Are Needed to Use, Monitor or Manage DSS	14
Topic 14 - Social Media and Crowdsourcing	10
Topic 15 - Other	9
Topic 4 - Methods, Design & Architecture Options Considerations for DSS	7
Topic 11 - DSS Capabilities that Allow Agencies to Modify DSS	5
Topic 3 - DSS Requirements for Non-Traffic Functions/Services Systems Support	4
Topic 8 - Computing Requirements and Platform Considerations for DSS	0

Figure 1: Session 2 Topic Voting Results

Topic 10: Monitoring and Tracking Performance of DSS (40 votes)

Topic Description: To ensure decision support systems fully meet the needs of TMSs and TMCs and provide the added benefit they are predicted to have, there must be ways to monitor and track their performance. Advancements in how systems monitor, assess, and report on performance provides information needed within a system which could be used by a DSS designed and integrated into a TMS or TMC. Methods that allow systems to monitor and track DSS decisions and the performance with the actions implemented, compare and contrast upgrades, various subsystems, or use of different operational control strategies.

Discussion Summary: There are a variety of different factors that influence an agency's decision making when it comes to traffic management. Depending on the type of decision to be made and the time required to implement solutions, some of these decisions can be automated and made in real-time using a DSS. While this is a large benefit in the capabilities provided by a DSS, the requirement to monitor and assess the performance any automated or real-time decision will require the system to compile, assess, and report on the actions taken and associated performance. These needs will place additional demands and requirements on the system to compile, analyze, save, and report on these actions and associated performance.

A **challenge with implementing DSS** for TMSs and TMCs is that legacy systems may not have the capabilities necessary to monitor, track, assess the actual performance of the decisions made, and finally, connect that information back to any individual decisions the system may have implemented in association with traffic management actions. Agencies may not have the ability to modify the DSS as the software platform they are using may be proprietary, where any changes may need to be done by the vendor owning the software. The restricted access to the software and not being able to make modifications limits the ability of agencies to use commercial off-the-shelf products to assist with this assessment, tracking and reporting on performance.

The Georgia Department of Transportation (GDOT) has begun to mitigate this challenge by implementing a replicable monitoring and tracking approach with traffic incident management data. In the event of a traffic incident, GDOT tracks when 1) an incident occurs, is reported, and verified; 2) when a response is identified, dispatched, and has arrived; and 3) the response, clearance, and return time to ordinary flow. The monitoring and tracking of actions taken is similar to what is needed to assess DSS decisions made by a DSS.

Topic 2: DSS Requirements Unique for TMCs or Different Systems (33 votes)

Topic Description: Decision support subsystems are used widely throughout different sectors, such as in health care and public safety. Due to an influx in data and Big Data technologies and tools, agencies have the ability to develop and use DSSs with legacy TMCs. It is essential in adapting these systems for transportation, specifically for TMCs, that all requirements are identified to ensure all needs of a TMC are met and they are able to be integrated into the existing software platform and system components (e.g., data bases, computing platform).

Discussion Summary: Next generation TMCs and related systems will have the ability to process and use data from different sources. To use this data to support managing traffic will require these systems to collect, process, verify, use, and share this information in near real-time. It is critical that DSSs cooperatively support these functions and consider the different architecture options, software platform, and interfaces to share and use this data are considered in the design and selection of technologies that may be used.

A **challenge in implementing DSS** is deciding how to parse together using advanced technologies to support agencies making incremental enhancements to the TMSs and TMCs. As each entity's DSS is developed and or evolve, it will be important to ensure the decisions being made and actions carried out are consistent with the policies and procedures of the agency and other stakeholders or partners. Furthermore, every TMS or TMC has its own software platform, requirements, capabilities, and performance expectations.

Agencies are frequently challenged with how to adopt new, make modifications to, or replace existing subsystems to improve their systems operation or capabilities. These legacy systems are challenged with making changes to add a DSS and the required capabilities needed to automate the operation of certain functions given the systems constraints (e.g., architecture, proprietary software platform). The DSS and system capabilities will need to coordinate decisions that may be distributed within the system (e.g., TMC, field hub, roadside equipment). Due of these limited capabilities agencies are challenged with not having proven methods or practices to follow when planning, designing or integrating DSS into these legacy systems.

Topic 1: DSS Requirements Unique for Signal Systems (32 votes, tie vote)

Topic Description: Traffic signal systems provide a unique opportunity to support the development, implementation and testing of the functions and integration of a DSS.
Discussion Summary: The potential to optimize an arterial signal system is currently limited by an individual system's capabilities, functionality, and lack of a DSS. Typical traffic signal systems are relatively disconnected because it is challenging to define an optimal level of service across different facilities that are geographically distributed may not be worth the capital and ongoing operational cost. DSSs may provide TMSs and TMCs with the ability to improve the performance of these systems by incorporating a DSS to automate the management and operation of certain functions. This would allow these functions to be carried out at a RSE (e.g., signal, hub) in a timelier manner and limit the required exchange of information or data with a TMC. New tools and technologies associated with big data may also enhance the capabilities of a DSS or allow the agency to manage and make enhancements (e.g., modular software platform, easy to modify software).

A **challenge with implementing DSS** for TMSs and TMCs for adaptive traffic signal control systems is they often rely on extensive and reliable detection methods to obtain the information needed to support their operation. These systems provide benefits by allowing for increased efficiency and real-time by making adjustments in their operation. The communication system and on-street RSE capabilities may not be in place to allow DSS to be integrated into legacy systems without also making changes to these other components.

Topic 7 – Requirements for Adding Prediction Capabilities to DSS (32 votes, tie vote)

Topic Description: The ability to incorporate analytics in decision support subsystems can allow TMCs to automate functions or decisions, streamline various processes, mitigate, or resolve decisions involving related functions faster, and ensuring more consistent and reliable operation. However, integrating analytics with TMCs requires additional resources, such as personnel considerations, computing, compatibility of algorithms and analytical methods currently being used, and a modular and flexible software platform to accommodate changes and different evolving needs.

Discussion Summary: Predictive capabilities is an expected core capability of a DSS for the next generation of traffic management systems and TMCs. These predictive capabilities and functions of the DSS need to be integrated into the concept of operations and design of systems to ensure all of the requirements and needs (e.g., data, processing, computing) are considered. If an agency begins developing a DSS outside of a design or redesign of the system, the requirements of a next generation DSS need to be considered.

A **challenge in implementing DSS** for TMSs and TMCs using prediction capabilities is that this tool requires complexity in the algorithms and data needed and the increased level of agency coordination and subsystem organization. While some research has been done to test the feasibility of predictive capabilities in DSS, more work must be done to fully realize how this tool can be used and how they could be integrated into the software platform of the system. Due to the timing of the workshop, this discussion was abbreviated but noted as something to discuss in the future.

Additional Insights from the Facilitated Discussion

There were a number of write-in topics. These topics may or may not have been at the forefront of research topic discussions in previous annual workshops. Regardless, they emerged as significant concerns for research during this year's workshop. The image below shows the write-it topics.

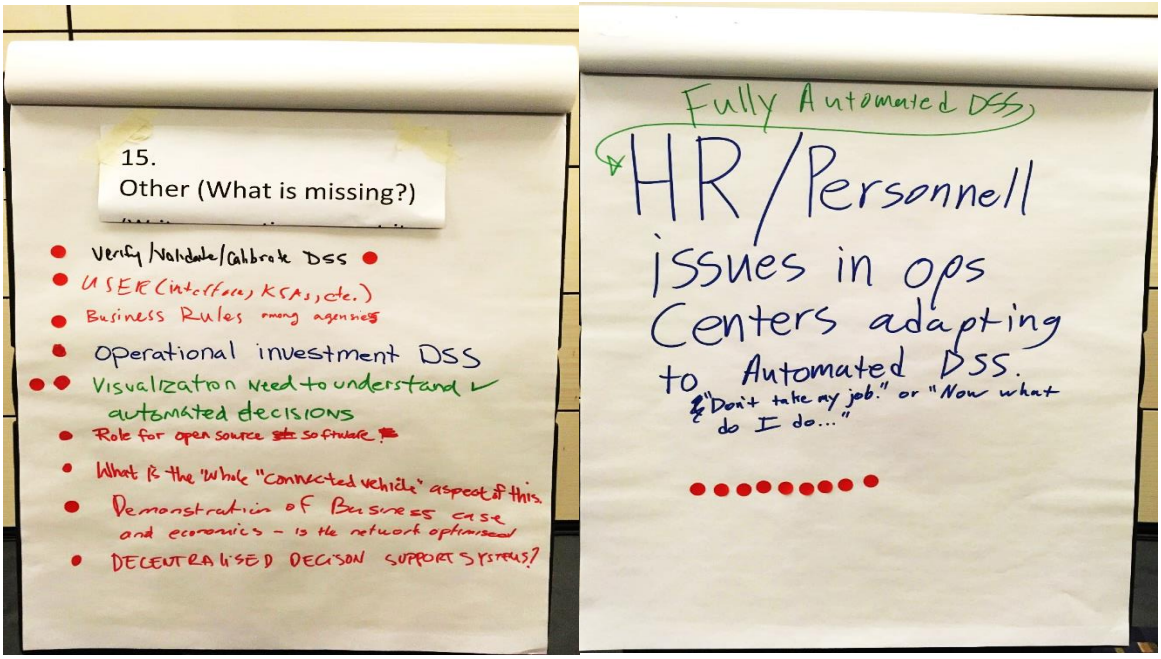

Figure 2: Write-in Voting Results

Session 3:

Action Planning – Identify Topics to Pursue Possible NCHRP Research Problem Statements

Session Purpose: To evolve the conversation from potential opportunities and industry-wide research needs and challenges to a select few actionable research problem statements to support proposed projects or action items the co-sponsoring TRB Committees could consider in the support of advancing the consideration and integration of DSS into the next generation traffic management systems and traffic management centers.

Session Objective: To develop a list of three or four topics, each with a description of the research problem possible statement or synthesis topic, the co-sponsoring TRB Committees could begin to develop research problem statements could consider advancing to the NCHRP Program.

Session Description: During this discussion, which was moderated by Michael Pack, participants identified and agreed to the following list of topics (not in priority order) as the priorities to consider developing research problem statements:

1. Develop guidance and resources to assist agencies planning, designing, deploying, and integrating DSS appropriately scaled for different types and maturity of legacy systems.

2. Develop guidance to support agencies developing the capabilities and methods to assess and report on the performance of decisions made by a DSS and the associated actions implemented by the system. The guidance also needs to assist agencies in the planning, design, development, selection of technologies, evaluation, and assessment of the performance of the DSS used to support the active management and operation of TMSs and TMCs. Where this guidance needs to support agencies assessing DSS for a range of different types of systems, for a range of operational strategies, and for different conditions within which the DSS would identify and implement the actions most appropriate based on the current and projected conditions detected by or reported to the system.

3. Investigate how different traffic management functions and decisions could be automated by developing and implementing a DSS as a part of a range of different types of legacy traffic management system. Agencies also need guidance to consider how the DSS could automate the implementation and operation of several functions that may need to be coordinated and used at the same time under a range of different conditions.

The following topics were identified as needing investigation and guidance developed for agencies:

- Guidance is needed to support agencies considering the original role of the operator in any decisions involving the selection or implementation of actions that a DSS may automate. This research and guidance should consider the assessment of what an operator was performing, what may be needed when a new DSS is developed and integrated into the operation of a legacy system where it may replace or change the tasks an operator may have previously conducted or performed.
- Guidance is needed to support the evaluation of what tasks or functions may no longer be needed by an operator and how the operator's time could be reallocated to other tasks or services in the TMC.

Conclusion

Review Action Plan & Next Steps for Committees

The final session of the workshop identified the next steps to be addressed by the various co-sponsoring TRB Committees. During this session, this document was identified as the deliverable to be produced which will compile and provide a high-level summary of the presentations, discussions, participant feedback, and needs to consider for future research.

This document will assist the co-sponsoring TRB Committees and their volunteers in their collaboration and development of possible research proposals to consider advancing to the NCHRP Program or other groups which may support these efforts (e.g., V2I Pooled Fund Study, TMC Pooled Fund Study). It is encouraged that any TRB Committee and volunteers looking to develop and advance any proposals to reach out to the other co-sponsoring TRB Committees to gather volunteers to support the development and ultimate advancement of research problem statements.

The need was also identified for the co-sponsoring TRB Committees to host a workshop during the 2019 TRB Annual Meeting focusing on the Next Generation Traffic Management Systems and TMCs. In addition to addressing the key concepts and requirements of these next generation systems, the workshop would also serve to continue the dialog and collaboration associated with these systems developing the capabilities necessary to implement and use decision support subsystems. The 2019 workshop may be best suited as an environment to focus conversations on the values, expectations, characteristics, and framework around which industry and agencies may begin planning for and developing the next generation traffic management systems and centers. The TRB Freeway Operations Committee was identified and volunteered to take the lead in drafting and facilitating the development of the proposal and details for this workshop for other TRB Committees to consider.