



U.S. Department of Transportation  
Federal Highway Administration

# OPERATIONS AND SAFETY

## Making the Connections





Source of cover photos: Getty Images.

## INTRODUCTION



### OPERATIONS

*“A well-operated system is going to be safer, and a safely operated system is going to operate really well and have fewer crashes. I think there is a great opportunity for us to look at how we can implement operational improvements to save lives and reduce crashes and similarly look at how our safety solutions can be part of an operational strategy as well.”*

Tony Kratofil – former Chief Operations Officer, Michigan Department of Transportation



### SAFETY

The safe and efficient movement of people and goods is one of the most fundamental missions of any transportation agency. Both safety and mobility on the road network are affected by individual users’ behaviors, vehicle designs and features, infrastructure characteristics, and the way the transportation system is managed and operated.

This is one of two Federal Highway Administration (FHWA) brochures that focus on making the connections between operations and safety.<sup>1</sup> This brochure makes the case for linking operations and safety program initiatives, and it highlights opportunities to enhance those connections through examples. It offers organizations ways to overcome challenges with connecting operations and safety and identifies opportunities for greater coordination. It also summarizes the results of an FHWA research project, which involved reviewing examples of State and local plans and conducting interviews with staff from FHWA division offices, State departments of transportation (DOTs), metropolitan planning organizations (MPOs), and local agencies.

### OPERATIONS

Operations is the use of strategies, technologies, mobility services, and programs to move people and goods and optimize the safety, mobility, and reliability of the existing and planned transportation system while minimizing the system’s environmental impact. Operations considers all modes of travel across a whole transportation system and often requires multijurisdictional and interagency collaboration throughout planning, project development, and deployment.

### SAFETY

Safety refers to methods and countermeasures used to prevent road users (e.g., pedestrians, bicyclists, motorists, and transit riders) from being killed or seriously injured. Safety includes the programs and activities falling under the “four E’s” of highway safety: engineering, education, enforcement, and emergency medical services. Examples of programs and activities include: the Strategic Highway Safety Plan, Highway Safety Improvement Program, Vision Zero (or similar initiatives), and Safe System Approach.

<sup>1</sup> The companion brochure is: FHWA. 2023. Transportation Operations Strategies for Safety. Publication No. FHWA-HOP-22-017. Washington, DC: FHWA. Available at: <https://ops.fhwa.dot.gov/publications/fhwahop22017/fhwahop22017.pdf>

## WHY CONNECT OPERATIONS AND SAFETY PROGRAMS?

Operations and safety are inherently linked: operations strategies applied to improve travel efficiency and reliability may affect traffic safety, and, likewise, safety strategies may impact efficient, reliable mobility.

Operations programs, while often focused on enhancing mobility through congestion mitigation, can support safety goals by reducing the risk of roadway crashes, injuries, and fatalities through operations strategies. These strategies include:

- **Traffic management centers** that monitor current conditions and notify travelers of hazards or network disruptions
- **Real-time traffic signal timing** that reduces variability in travel speeds and reduces the stopping frequency
- **Road weather management** that helps keep roadways clear of ice and snow, detect hazardous weather, and warn drivers
- **Variable speed limits** that reduce speed variability among vehicles and are an FHWA Proven Safety Countermeasure<sup>2</sup>

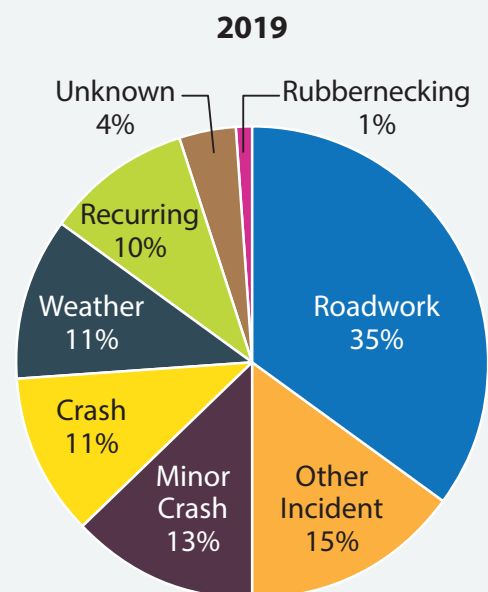
The Kansas and Missouri DOT joint ramp-metering system has shown a 64-percent decrease in the frequency of all crashes and an 81-percent decrease in the frequency of merge-related crashes.

Source: FHWA. 2021. *Variable Speed Limits*. FHWA-SA-21-054. Washington, DC: FHWA. <https://highways.dot.gov/safety/proven-safety-countermeasures/variable-speed-limits>, last accessed December 5, 2022.

2 FHWA. 2021. *Variable Speed Limits*. FHWA-SA-21-054. Washington, DC: FHWA. <https://highways.dot.gov/safety/proven-safety-countermeasures/variable-speed-limits>, last accessed December 5, 2022.

### *Crashes: A Major Source of Congestion in Pennsylvania*

At least 24 percent of congestion on Pennsylvania’s core roadway network was attributed to crashes. By reducing crashes, mobility can be significantly improved.



**Figure 1. Chart. Pennsylvania Department of Transportation Causes of Congestion for 2019.**

Note: “Other incident” indicates noncrash traffic hazards affecting traffic flow (e.g., disabled vehicle, debris on roadway).

Source: Pennsylvania Department of Transportation. 2021. *Transportation Systems Management and Operations Performance Report*. 5th ed. [https://www.penndot.pa.gov/ProjectAndPrograms/operations/Documents/2021-April\\_TSMO-Performance-Report.pdf](https://www.penndot.pa.gov/ProjectAndPrograms/operations/Documents/2021-April_TSMO-Performance-Report.pdf), last accessed December 2, 2022.



- **Dynamic lane use control** that allows for the dynamic closing or opening of lanes as circumstances warrant and provides warning of lane closures
- **Localized bottleneck reduction approaches** that mitigate or reduce crashes within weaving or merging areas
- **Ramp metering** that improves traffic flow by breaking up vehicle platoons entering the freeway from an entrance ramp and keeping the freeway operating under capacity
- **Traffic incident management** that decreases the amount of time needed to respond to and clear traffic incidents, improving the safety of crash victims, incident responders, and the traveling public. The probability of a secondary crash increases by an estimated 2.8 percent for every additional minute of primary incident duration.<sup>3</sup>

Safety programs, while typically focused on reducing serious injuries and fatalities, support mobility goals by reducing crash-induced lane closures and related traffic disruptions (figure 1). Safety program activities that promote safety and mobility goals include:

- Data-driven safety analysis that identifies locations, roadway features, driver behaviors, and vehicle characteristics associated with crashes
- Road safety audits that identify safety countermeasures with the potential to reduce crashes or crash severity
- Spot measures and systemic treatments that can reduce conflict points, crashes, or crash severity, such as roundabouts, Road Diets, reduced left-turn conflict intersections, and advanced safety technology in work zones

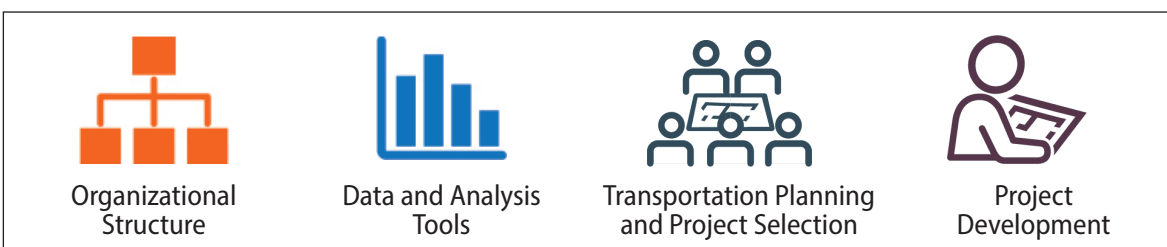
Safety and mobility are both improved by strategies that promote uniform and appropriate vehicle speeds, sufficient separation between road users, reduced conflict points, traveler awareness of unusual conditions, and avoidance or reduction of system disruptions (e.g., work zones and incidents). Because of these connections, transportation organizations are better positioned to get more value from their investments in safety and operations when they are considered holistically during planning, policy, program, and system management decisions.

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<sup>3</sup> Karlaftis, M. G., S.P. Latoski, N. J. Richards, and K. C. Sinha. 1998. "ITS Impacts on Safety and Traffic Management: An Investigation of Secondary Crash Causes." *ITS Journal - Intelligent Transportation Systems Journal* 5, no. 1:39–52. <https://doi.org/10.1080/10248079908903756>, last accessed January 30, 2023.

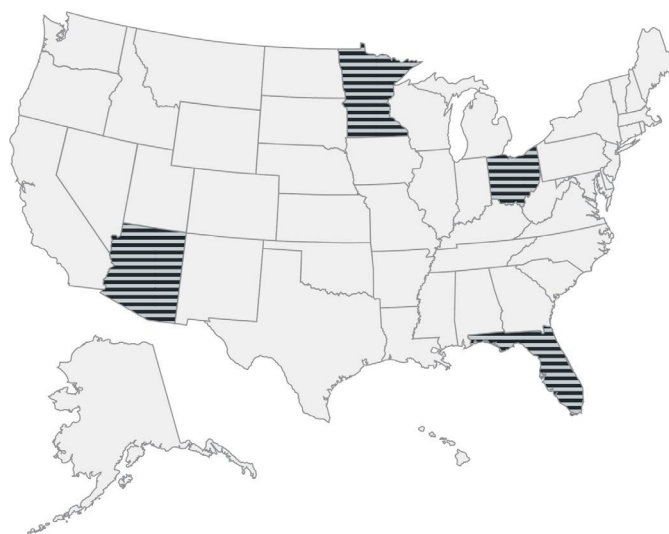
## HOW CAN TRANSPORTATION AGENCIES STRENGTHEN THE RELATIONSHIP BETWEEN OPERATIONS AND SAFETY?

While there are many opportunities for transportation agencies to consider safety and operations more holistically, a few areas are highlighted in the following section (figure 2). Examples from Arizona, Florida, Ohio, and Minnesota illustrate how transportation agencies are strengthening the relationship between operations and safety (figure 3).



Source: Federal Highway Administration.

**Figure 2. Diagram. Opportunity areas for transportation agencies to strengthen the connection between safety and operations.**



Source: Federal Highway Administration.

**Figure 3. Diagram. Map showing the States that are highlighted as examples below.**

### Organizational Structure



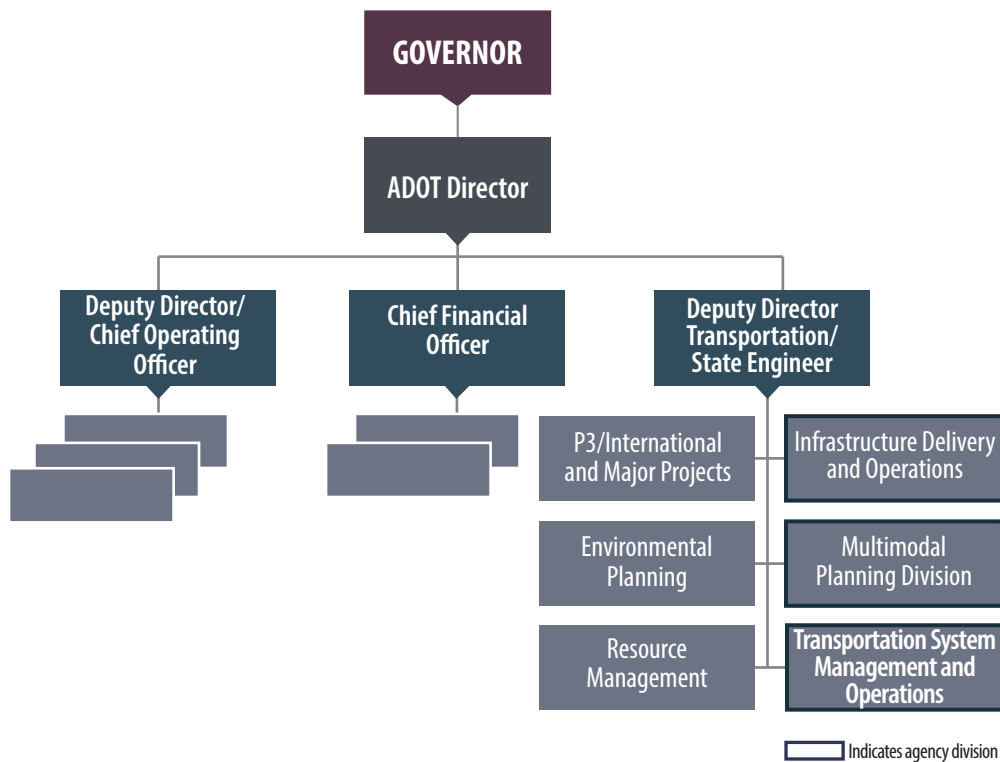
State and local transportation agencies have organized in a variety of ways to create connections between safety and operations. This can be accomplished by modifying organizational structures (e.g., colocating operations and safety programs within an operating unit), issuing executive directives or other leadership actions, building connections across geographic units, and establishing committees that bring together operations and safety issues and interests.

**Example in Practice: Arizona**

In 2015, Arizona DOT (ADOT) reorganized and formed a new high-level Transportation System Management and Operations (TSMO) Division, which contains both operations and safety functions (figure 4). The integrated organizational structure and the Arizona Management System—a formal, continuous improvement process—encourage mutual problem-solving within the safety and operations functions.

ADOT has a regional traffic engineer position for the northern, southern, and central Arizona traffic engineering regions. The three regional traffic engineers are focused on operations and safety in the TSMO Division and help connect headquarters to ADOT districts. ADOT staff members report that having regional traffic engineers has resulted in better safety and mobility, a more efficient use of resources, and more timely identification of and responsiveness to needs.

ADOT’s organizational structure helps to advance key projects more easily because of routine coordination and better access to operations and safety funding programs. The result is that all ADOT’s TSMO projects are designed with safety as a top priority.



Source: Arizona Department of Transportation, adapted by Federal Highway Administration.

**Figure 4. Graphic. Partial organizational chart for the Arizona Department of Transportation, illustrating that the Transportation System Management and Operations Division (lower right) is an upper-tier division within the organization.**

## Data and Analysis Tools



The availability of operations and safety data, as well as analysis tools, has greatly expanded in recent years. Transportation agencies are investing in the integration of data resources across platforms and analytical tools. They recognize the benefits of combining safety and operations datasets to better understand network safety and mobility performance, identify issues, and develop solutions. This allows transportation agencies to identify strategies that improve both safety and mobility, and to prioritize investments and actions that deliver both.

### Example in Practice: Florida

Florida DOT (FDOT) is data-driven in its decisionmaking and is developing a robust infrastructure for collecting, maintaining, and analyzing safety and operations datasets. FDOT uses a geographic information system for an array of purposes, from pinpointing the locations of pedestrian hybrid beacons and school zones to identifying sites where congestion and crash issues are overlapping. Operations data are also used to assist first responders with safety efforts. FDOT's TSMO unit has used crash data to address wrong-way driving for more than 5 years. The agency has worked with the University of Central Florida to develop analytical tools that leverage just-in-time data, traditional datasets, and predictive analysis to screen the road network for safety improvements.<sup>4</sup>

## Transportation Planning and Project Selection



Developing formal processes for integrating operations and safety objectives into an agency's planning, funding, and programming efforts can advance the level of coordination between the two disciplines and identify shared objectives. Such integration starts with developing prioritization processes and tools that can be brought into existing planning practices. This approach can leverage limited funding to maximize mobility and safety.

### Example in Practice: Ohio

Ohio DOT's (ODOT's) TSMO program developed and uses the Traffic Operation Assessment Systems Tool (TOAST), an investment prioritization tool that incorporates mobility and safety factors. TOAST is a spreadsheet-based tool that helps ODOT prioritize road segments for TSMO investments based on both operational and safety performance measures. TOAST was developed to enable data-driven decisions by identifying corridors that may benefit the most from operational improvements throughout the State. TOAST performance measures include travel time performance, bottlenecks, incident clearance, secondary crashes, traffic volume per lane, freight corridors, and TSMO safety. ODOT's Highway Safety program uses a similar process to prioritize safety investments. The resulting lists of TSMO and safety priorities are vetted through safety and operations staff, and the programs coordinate to ensure at least one of the programs funds the top priorities.<sup>5</sup>

4 M. Abdel-Aty. 2019. "Real-Time Crash Risk Visualization Tool for Traffic Safety Management" (presentation, Safety Data Forum 2.0, April 9, 2019). <https://www.transportation.gov/office-policy/transportation-policy/real-time-crash-risk-visualization-tool-traffic-safety>, last accessed December 5, 2022.

5 ODOT. n.d. "Traffic Operation Assessment Systems Tool (TOAST)" (website). <https://www.transportation.ohio.gov/programs/tsmo/resources/toast>, last accessed December 5, 2022.



ODOT's TSMO program also created a TSMO Countermeasures Benefit-Cost Tool to inform ODOT studies in support of prioritizing TSMO strategies.<sup>6</sup> The tool includes estimates for safety or crash-reduction benefits for operations strategies such as ramp metering, queue-warning systems, and variable speed limits.

## Project Development



Coordination between safety and operations during project development (planning, alternatives analysis, design, construction) is typically strong because priorities and goals often have to be balanced as projects are being formed. Performance-based practical design provides opportunities for collaboration among the design, operations, and safety disciplines, all of which support and contribute to successful solutions. For both project prioritization and projects under design, employing visualization techniques using safety and operations data can facilitate strategic decisionmaking and inform public stakeholders. This balance removes any sense of competition and enhances safety and mobility in the final project.

### Example in Practice: Minnesota

Minnesota DOT (MnDOT) wanted to convert a major section of Highway 10 between Minneapolis/St. Paul and suburban areas in Minnesota from a four-lane divided highway into a freeway. However, due to budget constraints and the impact on adjacent land uses, the project was not feasible. MnDOT used performance-based practical design to improve safety and capacity within the project budget. The multidisciplinary team developed and reviewed a range of low-cost alternative potential improvement projects and selected 20 of them for further quantitative evaluation. The *Highway Safety Manual*<sup>7</sup> safety performance functions and crash modification factors were used to quantify the predicted safety impacts, and traffic operations analyses were performed for the alternatives to determine rush-hour delays. MnDOT determined that the 20 proposed projects would provide 96 percent of the safety benefits and 90 percent of the operational benefits of the freeway alternative at less than 50 percent of the cost of the freeway.<sup>8</sup>

6 ODOT. 2019. *ODOT TSMO Countermeasure Benefit Cost Tool*. [https://www.dot.state.oh.us/Documents/TSMO/ODOT%20TSMO\\_Countermeasure\\_Benefit\\_Cost\\_Tool.xlsx](https://www.dot.state.oh.us/Documents/TSMO/ODOT%20TSMO_Countermeasure_Benefit_Cost_Tool.xlsx), last accessed December 2, 2022.

7 For more information, see: FHWA. 2022. "Highway Safety Manual" (website). <https://highways.dot.gov/safety/data-analysis-tools/highway-safety-manual>, last accessed March 7, 2023.

8 FHWA. 2016. *Case Study: Demonstrating Performance-Based Practical Design – Minnesota Highway 10 Access Planning Study*. Publication No. FHWA-HIF-16-030. Washington, DC: FHWA. <https://www.fhwa.dot.gov/design/pbpd/documents/hif16030.pdf>, last accessed December 5, 2022.

## CHALLENGES IN CONNECTING OPERATIONS AND SAFETY

As illustrated above, integrating operations and safety planning and project activities, business processes, and data is beneficial to transportation agencies and the traveling public. However, some of the challenges to integrating operations and safety include:

- Difficulty quantifying the safety performance impacts of some operations strategies
- Lack of understanding of how safety strategies benefit operations. Some causes of top safety concerns (e.g., impaired driving) may not be best addressed through operations strategies.
- Being able to access staff and funding sources from safety to support operations initiatives and vice versa
- Ensuring the safety of the most vulnerable transportation system users (e.g., pedestrians, bicyclists) while improving system operations for all users
- Interpreting, compiling, and using a variety of data with different time, space, and units/types

Agencies can learn more about quantifying safety performance impacts of operations strategies in the FHWA report *Safety Analysis Needs Assessment for Transportation Systems Management and Operations*. FHWA identifies safety performance analysis gaps, limitations, and needs for operations in the report. It also summarizes safety performance knowledge related to specific operations strategies and discusses the relationship between traffic operational performance and safety performance.

Source: FHWA. *Safety Analysis Needs Assessment for Transportation Systems Management and Operations*. Publication No. FHWA-SA-19-041. Washington, DC: FHWA. <https://safety.fhwa.dot.gov/rsdp/downloads/fhwssa19041.pdf>, last accessed December 2, 2022.

## IMPROVING CONNECTIONS AND NEXT STEPS

Coordination among safety and operations groups and regular cross-pollination of knowledge throughout the agency can strengthen staff knowledge, improve project outcomes, and contribute to a safer, more efficient transportation system. Based on the reviews and interviews conducted as part of this project, the following are 10 actions agencies can consider to unlock the synergistic benefits from coordinating operations and safety:

1. Conduct a self-assessment of your agency to determine your strengths and weaknesses in connecting operations and safety, and then identify solutions for moving forward
2. Invite safety staff to operations events, committees, meetings, planning efforts, and training, and vice versa
3. Look for ways to include operations strategies in the Strategic Highway Safety Plan
4. Learn about the Safe System approach and how operations and safety professionals can join efforts on the approach

5. Conduct safety evaluation studies for operations-related strategies that your agency has implemented, and investigate other States' research activities for this area
6. Leverage technology and data to account for both safety and operations in key decisions
7. Connect operations and safety in data governance plans
8. Investigate and use tools that can help quantify and assess safety and operations benefits to determine priority projects and select optimum solutions
9. Involve both operations and safety staff during planning and project development activities
10. Seek opportunities for collaboration and explore innovative solutions that integrate safety and operations

## LEARN MORE

FHWA has developed several resources that can be helpful in better understanding how to connect operations and safety:

- FHWA, "Communicating with Other Programs" (website), *Enhancing Transportation: Connecting Operations and Safety* (fact sheet and presentation), [https://ops.fhwa.dot.gov/plan4ops/focus\\_areas/integrating/tsmo\\_factsheets.htm](https://ops.fhwa.dot.gov/plan4ops/focus_areas/integrating/tsmo_factsheets.htm)
- FHWA, "Organizing and Planning for Operations" (web page), <https://ops.fhwa.dot.gov/plan4ops>
- FHWA, Office of Safety (web page), <https://safety.fhwa.dot.gov/>
- FHWA, "Communicating TSMO" (web page and case studies), [https://ops.fhwa.dot.gov/plan4ops/focus\\_areas/communicating\\_tsmo.htm](https://ops.fhwa.dot.gov/plan4ops/focus_areas/communicating_tsmo.htm)
- FHWA, "Zero Deaths and Safe System" (web page), [https://safety.fhwa.dot.gov/zerodeaths/zero\\_deaths\\_vision.cfm](https://safety.fhwa.dot.gov/zerodeaths/zero_deaths_vision.cfm)

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