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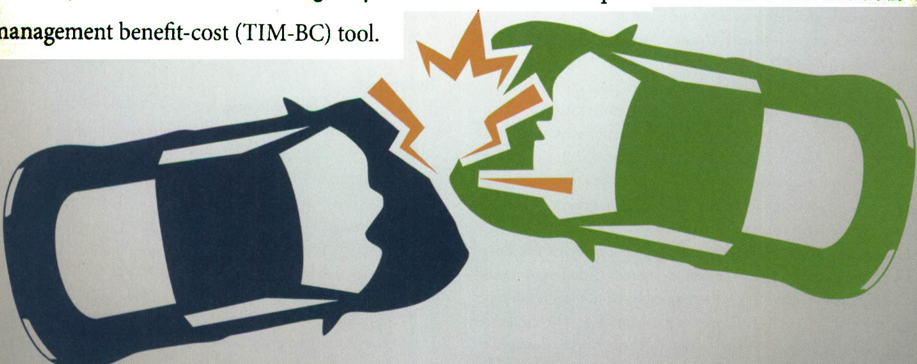
By Jiaqi Ma, Ph.D., Taylor Lochrane, Ph.D., and Paul Jodoin

Traffic incident management (TIM) is a "systematic, planned, coordinated effort to detect, respond to, and remove traffic incidents and restore traffic capacity as safely and quickly as possible."[1] TIM strategies have been introduced to reduce the impact of highway incidents and improve safety and roadway performance. It is critical to understand their benefits and costs and to evaluate associated return on investment for agencies to develop appropriate TIM programs. This article describes a study conducted at the U.S. Federal Highway Administration's (FHWA) Turner Fairbank Highway Research Center to create a simple-to-use, less data-intensive benefit-cost (B/C) analysis tool for TIM. As a result of the study, the Turner-Fairbank Highway Research Center developed a web-based traffic incident management benefit-cost (TIM-BC) tool.



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Background

In 2007, the National TIM Coalition (NTIMC) published the National Unified Goal (NUG) for TIM, which includes three main objectives:

- Responder Safety;
- Safe, Quick Clearance; and
- Prompt, Reliable, Interoperable Communications.[2]

Practitioners may design or select TIM strategies that make up their overall TIM program with these objectives in mind. In addition to these national unified goals, TIM programs typically attempt to reduce overall incident delays, reduce vehicle fuel costs and emissions, reduce probability of secondary incidents, and maintain safety for the driving public. TIM is a relatively low-cost way of reducing congestion and has a very high return on investment. TIM programs and evaluation of them lead to important benefits for the agencies involved, as well as the public, including improved collaboration or coordination among different agencies, improved safety for the driving public and for responders, and reduced environmental and productivity strains from incidents.

Using a traffic simulation program, analysts determined that the Maryland State Highway Agency's Coordinated Highways Action Response Team (CHART) program reduced travel delay on major Maryland corridors by 32.43 million vehicle-hours in 2009, equating to a savings in delay, fuel, and emissions valued at more than $1 billion.[3] The FHWA *Traffic Incident Management Handbook* confirms TIM effectiveness in Maryland by citing a report that the CHART program's reduced average incident duration to 22 minutes resulted in almost 300 fewer secondary crashes in Maryland in 2005.[4] Generally according to previous studies, TIM programs reduce average incident duration by up to 65 percent, reduce the possibility of secondary crashes by 30 to 50 percent, and contribute to savings of up to 2,600 to 7,700 gallons of fuel per incident.[5]

While these successful cases produced favorable return on investment, some TIM programs, if unreasonably planned, could result in more costs than benefits. Due to limited budgets and resources of local highway agencies, program leaders need to be able to prove that program benefits offset (or exceed) the costs of their programs. Also, the B/C ratios in the literature are extremely variable (2 to 36.1) between different programs and different evaluation tools. This wide range indicates a need for a single, consistent, and accurate B/C estimation tool for assessing and comparing TIM strategies.

Currently, there are various software tools available to practitioners, such as the Tool for Operations Benefit Cost Analysis (TOPS-BC), ITS Deployment Analysis System (IDAS), and Florida Intelligent Transportation Systems Evaluation Tool (FITSEval), each with a unique way of defining benefits and costs.[5] These tools only focus on general operational strategies (e.g., advanced traveler information, congestion pricing). TIM is only considered as a single operational strategy without recognizing detailed characteristics of different TIM strategies. Therefore, current tools provide inconsistent evaluation results and can only generate rough estimates of B/C ratios of various TIM programs.

The study conducted at the FHWA Turner Fairbank Highway Research Center aims to create an easy-to-use, less data intensive benefit-cost analysis tool for TIM (TIM-BC) that can consistently evaluate a wide range of TIM strategies with standardized methodology that can be universally and equitably employed in such B/C ratio estimation. This tool can not only help practitioners estimate B/C ratios of their TIM programs, but also enable stakeholders to think critically about ways to trim program operational costs or increase the efficiency of their programs.

TIM Overview: Strategies, Benefits, and Costs

TIM Strategies

Public agencies have been using various TIM strategies. Table 1 identifies TIM strategies by distinct TIM categories that agencies can employ as a component of their overall TIM programs. All time periods during an incident are covered by the strategies, which include planning activities prior to the occurrence of incidents, response to actual incidents, and activities following the occurrence of incidents. The strategies can be strategic, tactical, and/or supportive. Based on the suggestion of FHWA's *Best Practices in Traffic Incident Management* document from 2010, strategies are arranged into five categories, as seen in Table 1. Some TIM strategies fall under multiple categories; these strategies are only listed once in the category that best describes the activity in the table below.[6] A sixth category titled "Other" was created for activities that do not fit into any of the existing TIM categories. Figure 1 exemplifies field operations of the Safety Service Patrol (SSP) program of the Virginia Department of Transportation.

It is important to note the variety of potential stakeholders in TIM programming, because in most cases they come from many different agencies. With the variety of TIM strategies available to local agencies, there is an extensive set of potential stakeholders or operators that can be involved in running TIM programs. For a TIM program to be truly effective, it requires active coordination and cooperation among the various agencies to time responses, maximize the flow of information, and avoid duplication of efforts during an incident. The following list identifies a number of the major players in the implementation of TIM strategies, as well as the actual roadway users and drivers involved in incidents:

- Law enforcement;
- Fire, rescue, and emergency medical services;
- Towing and recovery teams;
- Hazardous materials response teams/contractors (in some areas, these teams can be found in the towing and recovery community);

Table 1. TIM strategies listed by category.

TIM Category [6]	TIM Strategy/Activity
Detection and verification	• Incident detection through video monitoring, speed or queue monitoring, mobile phone applications, or 511
Traveler information	• Incident/event notification provided via dynamic message signs (DMS), 511 (website, mobile, etc.), or highway advisory radio (HAR) • Providing real-time incident information/video to media outlets
Response	• Safety Service Patrols (SSP) [can be used for incident detection and response] • Automated vehicle location computer aided dispatch (CAD) systems • Pre-planned diversion routes shared between agencies • Prepositioning assets, vehicles, signs, lighting, tow trucks, etc. • Prequalified list of towing services (including capabilities and equipment) for use during incident response and clearance • Prequalified list of HazMat contractors (including capabilities and equipment) for use during incident response • Pre-established procedure for fatal incidents that defines responsibilities for the coroner/medical examiner
Scene management and traffic control	• Traffic diversion/detour (and preplanning of detours) – Modifying traffic signal timing on detour routes/arterials – Opening/closing HOV and HOT lanes during incident • Temporary traffic control devices (portable DMS and lane control signs) and procedures around incident or at the end of the incident queue • Move Over Laws (require drivers to reduce speed and move to adjacent lane when approaching incident scene) • Application of certain design treatments with TIM impacts • Incident command system (ICS) used on-scene (consistent with National Incident Management System/ICS standards)
Quick clearance and recovery	• Safe, Quick Clearance Laws – Authority Removal Laws (allowing pre-designated responders to remove disabled or wrecked vehicles and spilled cargo) – Driver Removal Laws (require drivers involved in minor crashes (not involving injuries) to move vehicles out of the travel lanes) • Policy for removal of abandoned vehicles
Other (mostly cross-agency coordination, communication, and training)	• Agency coordination and communication – Agreements for information and data collection/integration/sharing across agencies – Interoperable, interagency communications on-site between incident responders – Use of transportation management centers (TMCs) and traffic operations centers (TOCs) to coordinate detection, notification, and response – Agreements for shared use of equipment/signing and shared quick clearance goals and detour setup times • Training incident responders on NIMS/ICS • Agency support for post-incident debriefings, special event planning, and TIM planning for maintenance/construction projects

- Medical examiners/coroners;
- Emergency dispatchers; and
- Departments of transportation/traffic management center staff. [7]

Benefits of TIM Strategies

Applying the TIM strategies shown in Table 1 can have major benefits. Some of these benefits are translated into slightly different measures of effectiveness (MOEs), or "indirect benefits" of the TIM strategies, that are directly quantifiable for the estimation of benefits and costs:

- Reduced congestion
  - Reduces fuel consumption
  - Reduces emissions
  - Reduces time delays
  - Improves travel time reliability
  - Reduces vehicle operating costs
- Efficiency and productivity increases for local agencies (law enforcement, responders, highway agencies, etc.)
  - Improves customer satisfaction for these agencies
- Improved safety of those involved in incidents and other road users
  - Reduces injury/mortality rates
  - Reduces opportunity for secondary incidents
- Reduces number of required law enforcement at the scene
- Widened understanding by responders of how their actions affect greater community
- Increased confidence by drivers and customers.

Virginia Department of Transportation

Figure 1. Safety Service Patrol.

Ultimately, benefits from TIM programs are generally viewed by society in the forms of improved health, productivity, and security. A survey conducted in 1997 by the City of San Antonio, Texas Department of Transportation (TxDOT) and VIA indicated that improved traveler information dissemination resulted in increased driver confidence, a direct benefit to roadway users.[8] The benefits listed above apply most directly to system users (i.e., drivers and passengers on the roadway) and responding agencies, but they additionally apply to the whole population and many local businesses or industries due to reduced medical costs to society, reduced burden on the environment, and reduced burdens to productivity.

The Intelligent Transportation Systems (ITS) Knowledge Resources Database website is a valuable resource for identifying and understanding benefits of various operations and ITS implementations.[9] The benefits shown in the database are categorized into one of the six goals identified by the U.S. Department of Transportation (USDOT): safety, mobility, efficiency, productivity, energy and environmental impacts, and customer satisfaction. Users can view benefits aligned with specific applications, goals, or locations.

Costs of TIM Strategies

There are a number of predominant cost elements that can result from the application of TIM strategies previously listed in Table 1:

- Staffing costs;
- Planning and operations costs, including training;
- Implementation costs, especially for strategies involving infrastructure modifications;
- Equipment procurement, maintenance/upkeep, and depreciation (vehicles, signs, temporary traffic control devices, lighting, video monitoring, etc.)
    - A major element of equipment upkeep is fuel costs for patrol or response vehicles; and
- IT systems and support (for communication with other agencies or the public).

Mostly, TIM program costs are born by the roadway users through taxes and the local responding agencies.[10] The ITS Knowledge Resources Database website is also a valuable resource for estimating costs of various operations and ITS implementations.[9] It is most useful for users who intend to develop cost estimates in the planning or design stages of a project in addition to conducting cost-benefit analyses. The database, where possible, provides estimates for both capital costs and operations and maintenance (O&M) costs that a project may require. Users can view costs aligned with specific applications or locations.

Stakeholder Survey

Different TIM strategies shown in Table 1 function differently from each other, and the evaluation methods vary accordingly. Due to the limited project budget, interviews with a focus group were conducted as a part of the project to determine what specific TIM strategies they would like to be included in the new tool. Seven state DOT traffic incident management leaders from agencies around the United States were included in the focus group. The focus group was asked which TIM strategies they use at their agencies. The strategies were then ranked from highest to lowest based on the percentage of respondents' agencies that utilize that strategy. The results are shown in Table 2. Based on these results, the eight most cost-effective and commonly used TIM strategies are identified. They include safety service patrols, driver removal laws, authority removal laws, shared quick-clearance goals, pre-established towing service agreements, dispatch collocation, TIM task forces, and TIM training. It is essential for the TIM tool to satisfy the requirements and needs of the anticipated users and to consider the TIM strategies that are either used most frequently or are desired specifically by these users.

Web-based TIM-BC Tool

A web-based Traffic Incident Management Benefit-Cost (TIM-BC) tool was developed at Turner-Fairbank Highway Research Center. The tool adopts standardized methodology that can be universally employed in benefit-cost ratio estimation for selected eight TIM programs. The evaluations benefit from the standardized methodology by creating consistency, thereby instilling greater confidence in the validity of the results. Cost-effective evaluations benefit TIM programs and taxpayers alike due to the user-friendly, less data-intensive nature of the tool. The tool and its accompanying user manual can be downloaded from the FHWA website, www.fhwa.dot.gov/software/research/operations/timbc/.[11]

The evaluation method adopted by the tool is duration-based with the assumption that the benefits of TIM strategies—including decreased travel delay and fuel consumption, reduced emissions and increased safety—originate from the duration reduction of all or a proportion of incidents due to the TIM program. Regression models

Table 2. Summary of survey responses regarding TIM strategy usage.

Reported Use by Respondents' Agencies (%)	TIM Strategies
100% *(All respondents' agencies report using this TIM strategy)*	• Safety Service Patrols (SSP) (includes other roadside assistance programs) for incident detection • Safety Service Patrols (SSP) (includes other roadside assistance programs) for emergency response and incident management – SSP with automated vehicle location • Prepositioned assets, vehicles, signs, lighting, tow truck, etc. • Pre-established procedures for equipment and emergency lighting at the site of an incident to maximize traffic flow *(i.e. vehicle and equipment staging procedures, light-shedding procedures, PPE used by responders, pre-established signed accident investigation sites)* • Use of an interdisciplinary TIM taskforce/committee that supports on-scene activities • Provide incident/event information via 511 • Provide real-time information/video to media outlets • Incident Command System used on-scene (consistent with NIMS/ICS standards) • Temporary Traffic Control (portable digital message signs (DMS) and lane control signs) available • Prequalified list of towing services (including capabilities and equipment) for use during incident response and clearance • Policy for removal of abandoned vehicles • Agency support and execution of training incident responders on NIMS/ICS – Agency support for post-incident debriefing – Agency support for special event planning – Agency support for maintenance/construction project TIM planning • Use of transportation management centers (TMCs) and traffic operations centers (TOCs) to coordinate incident detection, notification, and response
75% to 99%	• Pre-planned diversion routes shared between agencies • Provide incident/event information via: – Integrated Voice Response (IVR) – Mobile application – 511 website – Personalization services (i.e. text, email messages) • Traffic control procedures for the end of the incident traffic queue • Prequalified list of HazMat contractors (including capabilities and equipment) for use during incident response • Authority Removal Laws (allowing pre-designated responders to remove disabled or wrecked vehicles and spilled cargo) • Multi-agency data/video sharing agreements • Pre-established agreements or memoranda of understanding between various agencies that includes shared quick-clearance goals (e.g., 75% of all incidents within 90 minutes) • Interoperable, interagency communications on-site between incident responders
50% to 75%	• Implementation of changes to HOV/HOT restrictions around incident • Highway advisory radio • Policies for pre-planned detours and alternate routes identified and shared between agencies • Policies in place for expedited accident reconstruction/investigation • Driver Removal laws (require drivers involved in minor crashes (not involving injuries) to move vehicles out of the travel lanes)
Under 50%	• Automated SSP data integration with TMC (i.e., event response data automatically entered into advanced Transportation Management System) • Real-time arterial signal timing changes • Multi-jurisdictional policies for modifying traffic signal timing on main or detour routes • Policies for towing utilizing public–private partnerships that use both incentive payments and disincentive liquidated damages to ensure shortened clearance times • Agreements for shared use of equipment/signing

and loop-up tables are embedded in the tool to predict benefits based on incident duration reduction. Large amounts of microscopic simulation data, supplemented with real-world data, are used to develop these models and tables. Readers can refer to the project final report for details of evaluation methods and model development.[12]

The eight different TIM strategies identified above feature different sub-tools, which users can use to input their own parameters depending on their local experiences and engineering judgment. The tool also provides default values for these parameters to facilitate quick TIM-BC evaluation, particularly for areas where targeted TIM strategies have not been implemented and no relevant data are available. Figure 2 shows the system flow process and architecture of the TIM-BC tool. A screenshot of the main navigation page is shown in Figure 3. Each sub-tool is a module in the main page.

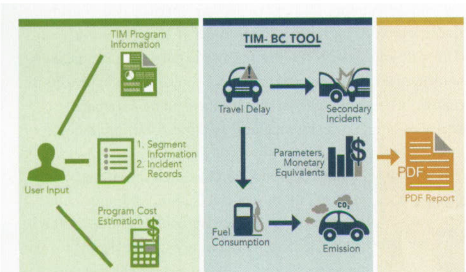

Figure 2. System flow process and architecture of TIM-BC tool.

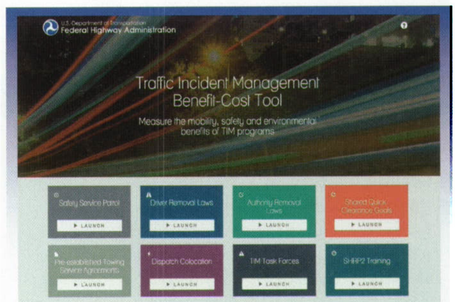

Figure 3. TIM-BC tool navigation page with panels linking to all eight sub-tools.

A key user interface Safety Service Patrol-Benefit-Cost (SSP-BC), a sub-tool used for evaluating SSP programs, is presented in Figure 4. Aside from basic SSP program information, which includes location, number of vehicles, and staff for backend program cost calculation, the user has the flexibility to input information on roadway geometry, the SSP program, traffic, weather, and incidents. The tool can also automatically generate an evaluation report that is professionally designed for an effective presentation of evaluation results.

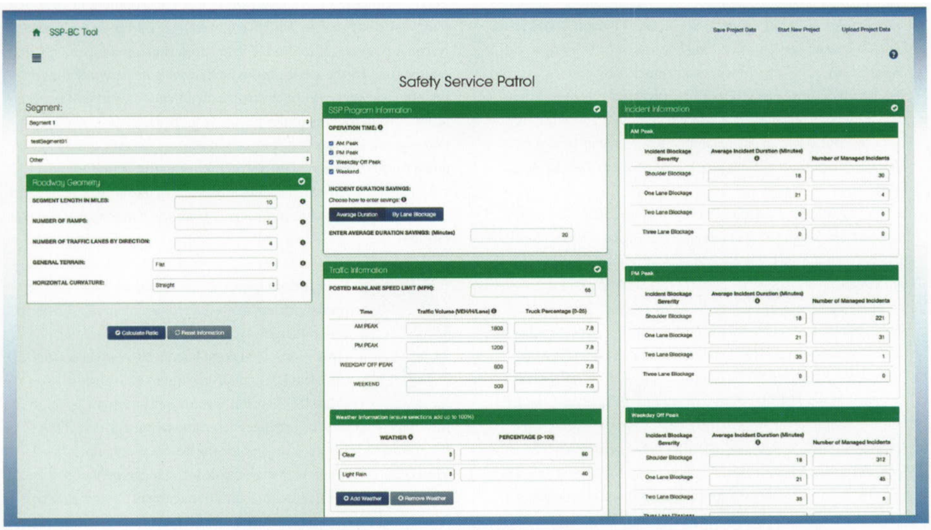

Figure 4. User interface of SSP-BC sub-tool for data input on roadway geometry, SSP program information, traffic information, and incident information.

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