Public Roads

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Crash Data Model for the Future
Resource Center: Excellence in Action
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Federal Highway
Administration

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Better Information for

Better Roadway Safety

*Connecticut's journey to modernize
its system for crash data collection,
reporting, and analysis could
serve as a model for other
transportation agencies.*

(Above) In 2015, Connecticut launched a complete overhaul of its crash reporting system to improve the quality, accessibility, and usefulness of its crash data. *Photo: © Kwangmoozaa, iStock.*

As demands to more effectively manage resources for improved driver and road safety increase, having a robust system to capture, store, and analyze crash data is a key need for many State departments of transportation. Gone are the days when crash reports were simply filled out by law enforcement officers, filed away, and sent to State agencies and insurance companies without an afterthought.

With the onset of new automotive technologies, increases in risky driver behaviors such as texting, and improvements in engineering, the need to accurately investigate causation factors of crashes has become more important—and more complex.

In 2010, the Connecticut Department of Transportation (CTDOT) was still laboring under a paper-based crash reporting system from 1995 that was outdated and no longer sustainable. With a backlog of more than a year, the system was limiting the State's ability to analyze its crash data, identify major highway safety problems, and efficiently manage its safety resources to address those problems.

At the request of CTDOT, the Federal Highway Administration performed an assessment of Connecticut's crash data system in 2011. As a result, CTDOT developed a business plan for improvement that focused on creating a new vision for crash data management and building the data collection and reporting tools to support that vision. The plan embraced full implementation of a state-of-the-art electronic reporting system that would provide real-time, accurate, complete, and fully accessible data to the highway safety community.

The resulting system is fully compliant with national crash reporting guidelines published by the National Highway Traffic Safety Administration, known as the Model Minimum Uniform Crash Criteria (MMUCC).

Adopting the latest version of the MMUCC, transitioning to electronic crash reporting, and developing a fully MMUCC-compliant crash database to expand the capabilities of an existing Crash Data Repository all at the same time could be intimidating even for the most progressive States. Most of

these efforts are typically funded independently and developed incrementally. But Connecticut took a different and more aggressive approach, implementing an agile, multifaceted strategy designed to change not only best practices and technologies but also the State's culture surrounding traffic crash investigation and reporting.

In the process, CTDOT developed a roadmap that other States may want to consider following when revamping their own crash reporting systems.

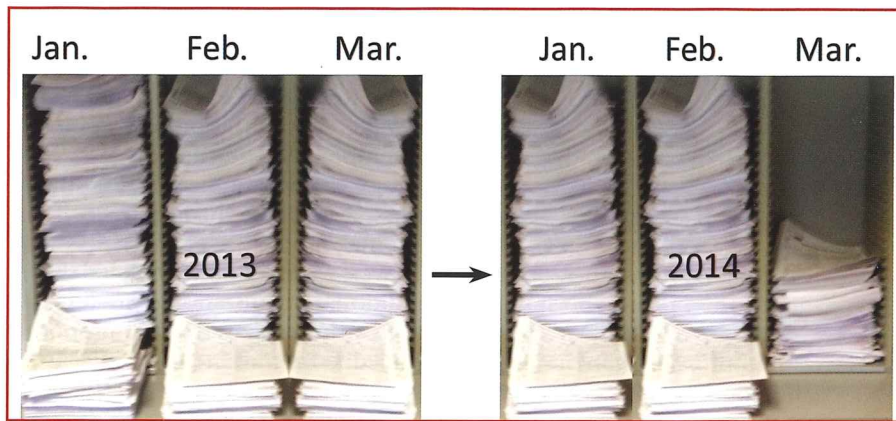## An Antiquated Crash Reporting System

Connecticut is the third smallest State by area but also the fourth most densely populated—resulting in frequently congested roadways and, inevitably, crashes. CTDOT historically did not perceive managing crash data as an important core function, and the crash report form, last revised in 1995, was a simple two-sided document with overlays. Police officers generally

filled the forms out in minutes and sent them off to the State primarily to meet the perceived needs of insurance companies, without any understanding of the data's potential importance to CTDOT.

Crash reports were manually coded, processed, and entered into a mainframe database with limited ability to access information. In an attempt to defray costs, CTDOT entered only one-third of the data from each report into the system.

CTDOT received the majority of its 110,000 crash report forms filed annually on paper. A small pilot project with the Connecticut State Police initiated in 2010 included limited electronic submissions. However, the State lacked standards for accepting data electronically, and the reports had to be manually reentered into the CTDOT system.

Over the years, trying to maintain an adequate crash database became increasingly more difficult. By 2012, CTDOT faced a 14-month backlog of crashes needing to be entered into its database. In an attempt

What Are Model Minimum Uniform Crash Criteria?

In 1998, NHTSA and the Governors Highway Safety Association cooperatively developed a voluntary data collection guideline. The MMUCC guideline identifies a minimum set of motor vehicle crash data elements and their attributes that States should consider collecting and including in their State crash data systems. For more information, see www.nhtsa.gov/mmucc.

Before the system overhaul, Connecticut faced a 14-month backlog in entering crash data from paper reporting forms. *Photo: CTDOT and CTSRC.*

to reduce the backlog, the agency decided to stop entering property damage crashes on local roads for several years. The resultant truncated database barely provided enough information to meet the needs of CTDOT engineers, with little or no regard for potential users outside of CTDOT.

As a result, CTDOT collected very little valuable, relevant, or timely data to support a data-driven highway safety program. The outdated, paper-based system was crumbling under its own weight from years of neglect.

A Business Plan That Makes a Difference

In October 2011, at its own request, CTDOT participated in a Crash Data Improvement Program (CDIP) assessment sponsored by FHWA. A team of subject matter experts assessed all aspects of the State's crash data system and developed a report detailing current practices and making actionable recommendations for improvement.

Connecticut's CDIP report identified a number of challenges, including the aforementioned backlog, outdated crash data collection content, paper-based submissions, and processes that limited data capture. The CDIP also noted the culture of law enforcement officers who lacked an appreciation of the use and importance of the crash data they were providing. The report

April 18, 2012

Prepared for the Connecticut Department of Transportation

STATE OF CONNECTICUT — CRASH DATA IMPROVEMENT BUSINESS PLAN

DATA NEXUS, INC.

Data Nexus, Inc. | FINAL

Cover of the *State of Connecticut Crash Data Improvement Business Plan*. Photo: CTDOT.

emphasized the absence of capabilities to facilitate expanded electronic reporting, including a default tool to help low-technology agencies.

Recommendations included establishing a crash database that was MMUCC compliant and capable of capturing all fields from the report form to support safety analyses, and creating a business plan for collection and management of crash data. The report also provided suggestions for improving the timeliness and quality of the data, such as accurate location reporting. The May 2012 final report is available from CTDOT's Crash Initiatives page at www.ct.gov/dot/crashinitiative.

CTDOT recognized the importance of the CDIP's findings and adopted all CDIP strategies for improving its crash data system into its Strategic Highway Safety Plan. CTDOT then independently contracted to develop a business plan to improve its crash data system. The plan identified two major goals: 1) achieving full MMUCC compliance and 2) converting to a completely electronic reporting system by January 1, 2015.

The business plan defined the tasks, milestones, timeframes, and resources needed to fully deploy a new crash reporting system. To implement it, CTDOT established a dedicated multidisciplinary project team that met weekly, led by a project director and facilitated by a "crash data champion" who functioned as a day-to-day project manager. This team consisted of individuals from CTDOT's Offices of Information Systems; Coordination, Modeling, and Crash Data; and Highway Safety; and representatives from the University of Connecticut's Transportation Safety Research Center (CTSRC).

Mike Gracer, the project's chief developer and information technology consultant, says, "I was impressed with the quality, dedication, and makeup of the team, which was allowed to function outside of the traditional organizational processes to give the project the full attention it needed on a day-to-day basis."

Evolution of the Toolbox Strategy

Despite the guidance provided by the new business plan, it was initially not clear to CTDOT how extensive

and complex revamping the crash reporting system would become. Early activity focused on continuing to build out a geospatial rendition of the State's road network to support more accurate reporting of crash locations; reducing the paper backlog to manageable levels; designing a user-friendly, MMUCC-compliant crash report; and enhancing the existing Crash Data Repository hosted by the CTSRC by developing a new, MMUCC-compliant database.

While the framework of the business plan was helpful, it became clear that the team needed more flexible and creative methods—what the technology industry calls "agile system development." CTDOT's new approach enabled the evolution of the following strategic elements designed to optimize transparency, communication, customer engagement, and flexibility in technical services and products:

- Weekly guidance provided to the project team by executive leadership.
- A commitment to include law enforcement as partners in all aspects of planning, developing, and implementing the new crash reporting system.
- A strategy to engage the software vendors of police departments' records management systems (RMS) as part of a multiple-solution approach.
- An outreach and marketing plan that provided the tools, training, and technical support necessary to make the transition as easy as possible for law enforcement agencies and their vendors.
- Creation of a full-time position for a crash data liaison to provide day-to-day technical support to individual law enforcement agencies.
- Configuration of the Crash Data Repository to make it a valuable resource for law enforcement and traffic safety planning.

By May 2013, the project team decided on a solution for electronic report submission involving multiple RMS vendors, complemented by a default electronic, PDF-based crash report form that participating law enforcement agencies could access free of charge. In addition, CTDOT began developing a system to import and validate crash reports, creating a formal training program
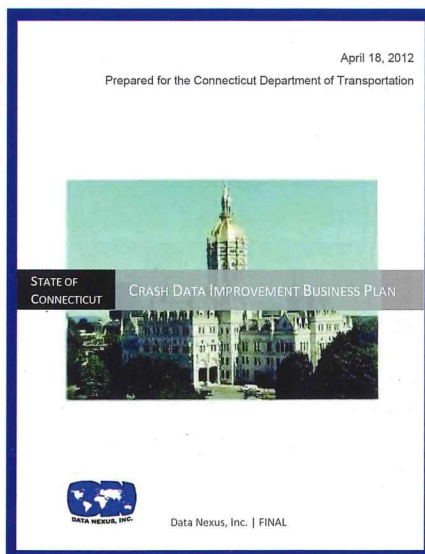
Connecticut's MMUCC Best Practice Toolbox
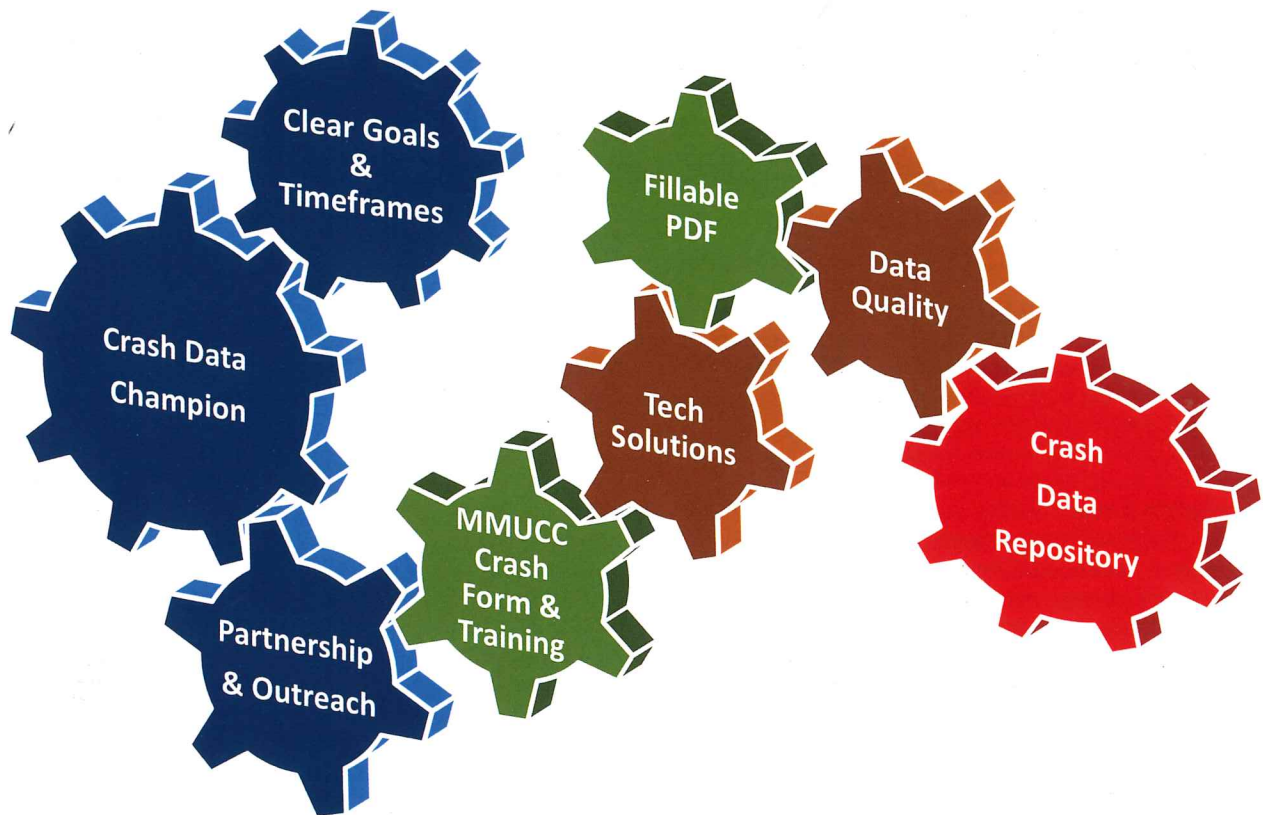
The toolbox consisted of eight key components, which helped the State to successfully overhaul its reporting system.
Photo: CTDOT.

for law enforcement, implementing a field coordinator team to oversee the training, and developing a more rigorous process for existing CTDOT coders to assess data quality.

The cumulative framework of all of these strategies came to be known as the MMUCC Best Practice Toolbox. The toolbox consists of the eight core essential activities and strategies that had evolved over time to achieve a successful outcome: setting clear goals and timeframes, designating a crash data champion, establishing partnerships and outreach, creating a fillable PDF, developing the MMUCC Crash Form and training, identifying information technology solutions, improving data quality, and developing a Crash Data Repository.

"The toolbox was as much a commitment to a coherent and systematic way of doing business as it was a composite mix of strategies

that evolved based on experience," says Chuck Grasso, a retired sergeant with the Enfield, CT, police department and a crash data liaison for CTSRC. "All of these strategies, as well as the data collection, validation, and documentation, are easily transferable for replication in other States."

Early Toolbox Strategies

The toolbox's early strategies laid the groundwork for success by creating a robust environment that can support collaborative and coordinated planning.

Setting clear goals and timeframes. Based on the results of the CDIP, the team focused on two overarching goals: achieving total compliance with national MMUCC guidelines and implementing fully electronic crash reporting by all law enforcement agencies. These

two goals served as the major drivers for all planning tasks related to improving the quality, timeliness, and completeness of crash data.

Early in 2013, CTDOT decided that any change in the crash form needed to take effect on January 1, 2015. This would ensure all required annual reporting would be conducted on data elements and definitions that did not change during that reporting period. A 2-year timeline for an overhaul of the crash system did not seem overly ambitious at the time, but the team soon realized how difficult this could be to achieve. However, CTDOT remained committed to the deadline and employed creative and innovative solutions as necessary. Setting and adhering to clear goals provided the necessary targets, timeframes, and motivation to sustain the project and achieve success regardless of any setbacks.

CTDOT developed a fillable PDF of the revised crash reporting form, part of which is shown here, to enable law enforcement agencies without access to a fully electronic system to easily submit reports electronically. *Photo: CTDOT.*

Designating a crash data champion. The CDIP assessment introduced the concept of recruiting a crash data champion. CTDOT tasked this individual with bringing together the many disparate groups and elements and facilitating the development and monitoring of a cohesive strategy. A champion whose primary focus and responsibility was system planning and implementation was essential to the process. For Connecticut's effort, a staff member of the CTSRC served as the champion and worked onsite at CTDOT as an integral part of the team.

The position of crash data champion was dynamic, and the responsibilities evolved over time. The champion wore multiple hats, serving as project manager, meeting facilitator, internal advocate, and broker in negotiating both internal consensus and agreements with law enforcement and vendor partners. Most importantly, the champion functioned as the bridge between technology providers, law enforcement, crash program managers, and RMS vendors.

Team member Maribeth Wojenski, the chief supervisor of crash management operations at CTDOT at the time of the project, says, "Without this dedicated position, the probability of delivering the project on time and within resource limitations would have been significantly diminished."

*Establishing partnerships and outreach.* The project's partnership efforts went through several developmental phases. Early activities focused on building general awareness of the project and creating credibility with the law enforcement community. These activities included monthly briefings to CTDOT's Traffic Records Coordinating Committee and a vendor summit sponsored by the University of Connecticut to showcase software applications and respond to questions regarding the project. The project team then began direct engagement by writing an open letter to local officials and police chiefs, distributing brochures and posters to the law enforcement community, and posting a program video on the CTSRC website that explained the project.

The project team further strengthened its partnerships by hosting law enforcement workshops designed to solicit input on a new crash report as well as functionality for the electronic PDF. "Law enforcement was brought in early in the process to assure buy-in by the 'boots on the ground' who would ultimately determine the success or failure of the project," says Sergeant Andy Gallagher with the Stamford, CT, police department. "Early train-the-trainer sessions where the electronic report was demonstrated were vital in ensuring the project's success."

This phase included outreach to law enforcement agencies' RMS vendors. CTDOT also offered seed funding to interested RMS vendors to modify their systems to enable electronic capture and reporting of crash data.

The intensive final phase of partnering included a classroom-based MMUCC training course followed by technical support in the field on a daily basis. Crucial to the improvement effort was the collaborative and trusting relationship built and sustained with law enforcement and the vendor community.

Setting goals and timelines, designating a champion, and having strong partnerships proved critical for the expedited overhaul of the crash reporting system. Connecticut's model relied on a firm commitment to the project launch date, incentives, technical assistance, continuous and constant communication and feedback to partners, and a sense of inclusiveness that left no agency behind. This collaborative model enabled CTDOT and its partners to achieve their goals without the need for further regulatory authority.
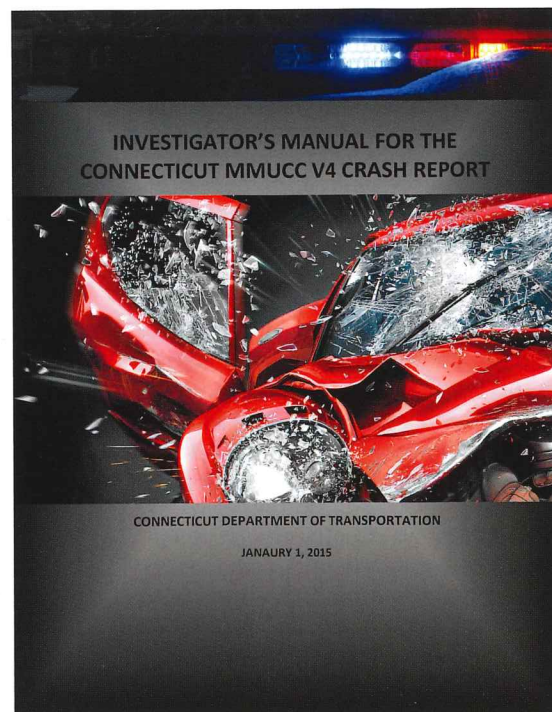
CTDOT developed a comprehensive manual for crash investigators on how to use the new report. *Photo: CTDOT.*

CTDOT partnered closely with law enforcement agencies, including holding workshops for officers to provide input on the development of the new crash reporting form. *Photo: Chris LaRosa, University of Connecticut.*

Toolbox Strategies for Law Enforcement

The CTDOT project team decided early on to actively engage its law enforcement partners in the process to update its 20-year-old crash reporting form. The University of Connecticut hosted three sequential workshops for law enforcement to provide input on the new crash report form. Each workshop resulted in significant edits to the crash report. At the end of the workshop series, CTDOT finalized the form in July 2014 and then began developing the data collection system and tools with which to implement the new form.

Creating a fillable PDF. During the workshops, it became apparent that not all local law enforcement agencies would be able to participate immediately in the electronic submission process. To provide a "safety net" for agencies without participating records management vendors, or whose vendors would not be ready at launch, the project team developed a universal, low-cost tool: a fillable PDF version of the crash report that could be used in the field.

CTDOT received feedback on the functionality of this tool from workshop participants. The resulting "smart" form includes extensive use of dropdown menus and clickable elements to streamline data entry, compliance with the overall requirements for electronic submission to ensure consistent and valid data, and a table of contents for quick navigation through the form. The developers included built-in support for 123 edit rules, context-sensitive help, and error-checking functionality.

The project team's efforts were so successful that the schema, or organizational blueprint, developed by Connecticut for MMUCC 4th Edition (current at the time) served as the basis for the MMUCC 5th Edition schema recently released by NHTSA.

Creating and delivering a training curriculum. The team then began the process of training law enforcement officers on MMUCC terms and concepts. Prior to this, most officers in Connecticut received only minimal instruction in completing the actual crash report as new recruits in the academy. Limited emphasis was placed on the value of the crash report to the highway safety community. To aid in the development of the course, the project team incorporated Connecticut-specific MMUCC guidelines, case study scenarios, and an appreciation of the value of new data elements.

With that foundation, CTDOT developed a comprehensive, 6-hour classroom course that covers all MMUCC data elements and attributes and includes training videos, visual examples, workgroup exercises, and a period of open discussion. The CTSRC used animation and humor in the production of its videos to keep officers engaged. Incentives to participate in the training course include offering law enforcement credits for inservice training. Material from the MMUCC course is now used for all recruit training, and the course is available on request for refresher training. Training content and videos also are available on the CTSRC website at https://ctsrc.uconn.edu.

Almost every police agency in the State received an onsite visit as the project moved closer to the launch date. To assist with delivering the training, the CTSRC relied on a cadre of trained law enforcement instructors and crash investigation experts to facilitate effective communication with active-duty officers and law enforcement agencies. Three part-time law enforcement officers with significant crash investigation expertise conducted followup training.

After the project launched, the CTSRC hired two full-time law enforcement field coordinators to provide technical advice, troubleshoot submission issues, and produce weekly newsletters and podcasts addressing common MMUCC issues.

Toolbox Strategies for Electronic Reporting

By partnering with law enforcement agencies and their RMS vendors, CTDOT's team realized it needed to develop tools to enable the seamless transmission of electronic crash data from a variety of users to the comprehensive database. In addition, having all reports submitted electronically for the first time necessitated a change in protocols at CTDOT for validating and editing the data.

Identifying technology solutions. The team first developed a schema

Year by Year: Crash Severity Comparisons

- A, injury of any type (serious, minor, possible)

■ K, fatal (kill)
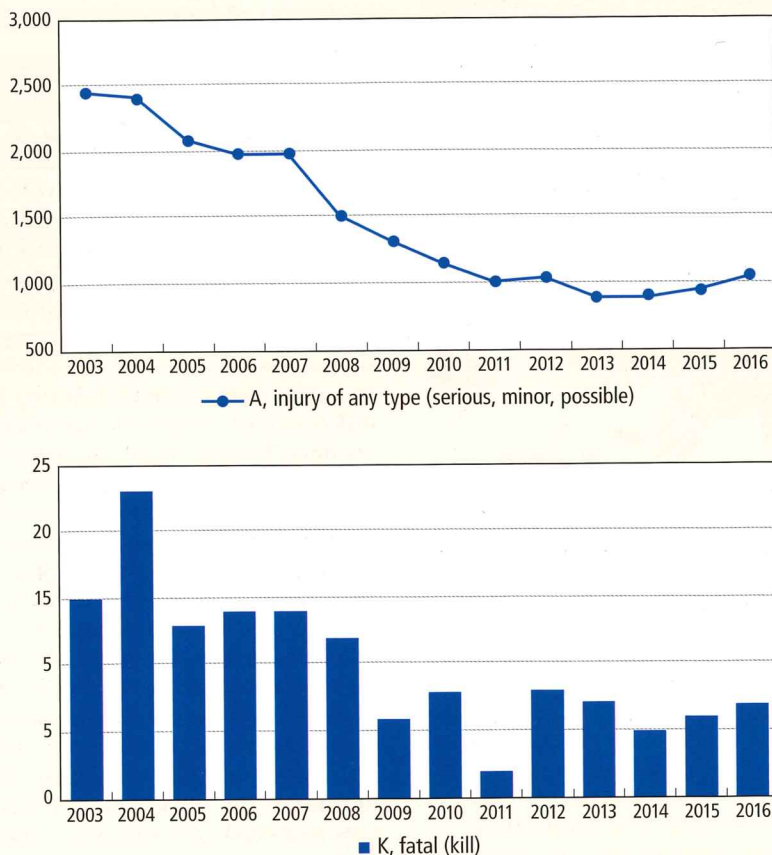
These graphs generated from the Crash Data Repository show the trend of injury (line graph) and fatal (bar graph) crashes in Connecticut for 16- and 17-year-old drivers since 2003. In 2008, the State implemented a legislative change to its graduated drivers licensing law, reflected in the drop in crashes for the following years. *Source: CTDOT.*

to establish the formatting requirements for data transmission. This was captured in the *State of Connecticut's Crash Data Guidelines,* a major element of the toolkit, which defined data elements and attributes, their values, and edit and validation rules to ensure data quality. CTDOT added the rules to the State's file transfer website to validate crashes at the time of submission from law enforcement agencies.

The team also incorporated data validation and edit rules into the fillable PDF to ensure compatibility and required software vendors to incorporate them into their software. To help, CTDOT created the

Testing and Certification Guide. This guide provided crash scenarios that vendors had to enter into their systems before submitting their software to CTDOT for certification.

CTDOT also developed a Crash Uploader tool for easy transmission of the fillable PDF. By providing the tool at no cost to local agencies, the team prevented barriers to submitting crash reports electronically. CTDOT also purchased licenses for crash diagramming software and provided them for free to all law enforcement agencies in the State.

Improving crash data quality. One byproduct of the new crash reporting system was the change in validation and editing protocols

at CTDOT. Under the old paper reporting system, technicians needed to enter data for every field, review the crash diagram, and locate the crash based on the best information available. The new system provides built-in validations and edits within the fillable PDF or the local agency's electronic system. To make it even more robust, the team implemented those same validations and edit checks within the CTDOT system that receives crash reports.

Technicians can now spend the majority of their time reviewing advisory edits, checking for inconsistencies, and easily locating the crash based on required GPS data in the crash report. As a result of the new protocols, high-quality crash data are now available within 30 days of receipt of the crash report.

Toolbox Strategies for Data Accessibility and Analysis

Key to gaining support for the project from law enforcement agencies—without a mandate—was making timely crash data easily accessible to the agencies by using innovative data visualizations. These types of tools were not previously available from CTDOT. Law enforcement agencies relied on their own software and staff for crash data analysis.

Developing a Crash Data Repository. The collection of accurate, timely, and complete data led to the expansion and enhancement of the Connecticut Crash Data Repository hosted at the University of Connecticut. This public-facing website at www.ctcrash.uconn.edu enables users to query, display, and analyze more than 20 years of crash data from across the State. Registration for the site is free and open to the public. Users may view summaries, run and save queries, view data from individual reports and diagrams, map crashes, generate summary tables, and download raw crash data for further analysis. All personal and private information has been removed from the crash data to protect the privacy of those involved in the crashes.

A key enhancement to the repository is a series of dashboards, which provide the ability to explore data summaries. The team designed the dashboards to enable users to quickly filter the data and then generate a PDF report of facts and

figures. Users can save queries and export the resulting crash data to conduct analysis in a statistics package of their choosing.

The repository can assist law enforcement agencies in identifying problem areas in their jurisdictions, applying for CTDOT grants for enforcement activities, and planning high-visibility enforcement in high-crash locations to help prevent crashes from occurring in the future. Advanced tools enable users to query crash data on almost every data element on the crash report form and produce maps and graphics to visually represent the data. Users can then align policy changes with changes in crash frequencies.

For example, the repository can produce maps with color-coded pushpins representing the severity of each crash, which can easily be converted to heat maps indicating where crash densities are the heaviest. Law enforcement can use these maps to help determine where to target education or enforcement activities. Users also may choose to display aerial maps or Google Street View maps. These can help engineers identify problems with the roadway environment or design.

Connecticut's Crash Data Repository is constantly evolving as CTDOT identifies and adds new features. It has become the primary resource for analyzing crash data for a range of users—from law enforcement to the media—and serves to support highway safety grants, the State's annual Highway Safety Plan and its Strategic Highway Safety Plan, new legislation, educational and public awareness programs, and roadway and engineering improvements.

A Roadmap to Project Success

CTDOT implemented its new crash reporting system on January 1, 2015, as planned. The project's success was made possible because of the full commitment of CTDOT management to move forward aggressively, manage interim challenges creatively, offer startup tools and resources, and maintain open communications and accountability.

Despite a lack of authority to mandate that local agencies participate, the project team achieved full voluntary participation of all agencies by creating a culture of

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Program Accomplishments

- Attained 99.3 percent MMUCC compliance for data collected at crash scenes.
- Achieved full voluntary participation of all local agencies.
- Changed Connecticut's crash reporting culture.
- Produced state-of-the-art training materials that can be adapted by any State.
- Developed cutting-edge tools to facilitate crash reporting.
- Demonstrated a successful DOT/university partnership model for a multidisciplinary project.

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inclusiveness and collaboration. The resources and partnership opportunities offered by the project, including financial incentives, technical assistance, training, and tools, won over law enforcement and vendors alike. The toolbox formula combined with a philosophy of agile system development effectively achieved full participation and commitment in a way that a regulatory approach would not have accomplished.

Connecticut's path can serve as a roadmap for other States, which can adapt CTDOT's state-of-the-art tools and training materials to their own needs. All of the tools and materials developed in the project, including software, are available to other States upon request.

Thanks to its success, the project received national recognition. The Association of Transportation Safety Information Professionals gave the project its Best Practices in Traffic Records award in 2015 and the Governors Highway Safety Association recognized it with a Special Achievement Award in 2016. In addition, Harvard University's Kennedy School of Government recognized the CTSRC with its prestigious Innovations in American Government Award for the data sharing capabilities of the repository.

Connecticut now enjoys the distinction of having one of the Nation's most comprehensive and timely crash reporting systems. "By embracing a proactive, partnership-driven, and innovative approach to modernizing our system, we were able to effect serious systemic change in record time," says Wojenski. "I am truly grateful to the multidisciplinary team of professionals that guided the way as well

as the law enforcement community and others that stayed with the effort to make it happen. It was truly a collective win for all of us."

Robbin Cabelus is the director of Transportation Planning and Highway Safety for CTDOT. She holds a B.S. in civil engineering from the University of Connecticut.

Mario Damiata served over 40 years as a highway safety specialist with NHTSA with specialties in driver behavior and traffic records management programs. He is currently serving as the roadway safety consultant and "data champion" to CTDOT. He has a B.A. in English from Georgetown University and has done graduate work in Public Policy and Public Administration at American University.

Eric Jackson, Ph.D., is an associate research professor at the University of Connecticut and is the director of the CTSRC. Dr. Jackson earned his B.S. degree in civil engineering from the University of Kentucky and his master's degree and Ph.D. in transportation systems from the University of Connecticut.

Robert Pollack is a transportation specialist with the FHWA's Office of Safety, where he leads a roadway data technical assistance program. He has both bachelor's and master's degrees in psychology from Illinois State University.

For more information, see www .ct.gov/dot/crashinitiative or contact Eric Jackson at 860-486-8426 or eric.d.jackson@uconn.edu.