Accomplishments of the FHWA/NHTSA National Crash Analysis Center (NCAC) 1993-2008

NCAC History
Since 1992, the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) have partnered to support the FHWA/NHTSA National Crash Analysis Center (NCAC). The George Washington University (GWU) School of Engineering and Applied Science has operated the NCAC under various contracts from its inception. Over the years, the research activities at the NCAC were expanded through additional support from other governmental agencies (e.g., State Department and Federal Reserve Board) and private organizations (e.g., Ford Motor Company, Hyundai Motor Corporation, and American Automobile Manufacturers Association). The NCAC is believed to have made significant contributions that have advanced safety and security research on many fronts. As the NCAC program is brought to a close it is useful to review its accomplishments.

The NCAC was originally established to conduct advanced research for resolving transportation safety issues and to consolidate crash test films, data, and related documentation into a national repository. NCAC research has involved statistical analysis of crash data, injury investigations, vehicle dynamics analyses, biomechanics studies, crashworthiness evaluations, modeling and crash simulation for vehicle-to-vehicle and vehicle-to-barrier impacts, and development of simulation protocols/software and parallel computing technologies. The NCAC has also been effective in capturing the benefits of resource sharing to meet specific research needs of different Federal agencies.

The NCAC has become a globally unique storehouse of safety expertise and information that focused on advancing new technologies and tools for crash analysis. While the NCAC was primarily intended to support the USDOT's strategic goal to reduce fatalities and injuries on the Nation's roadways, it has also served to enhance efforts to improve safety worldwide. Efforts have addressed safety issues from both the vehicle and road perspectives. Since 2000, NCAC research activities have expanded to include simulation analysis and design optimization for infrastructure security. These research activities have helped the US Department of State and others to design better devices for the physical protection of federal government facilities domestically and overseas.

NCAC resources have helped many researchers understand and quantify the crash performance of vehicles, the effects of a vehicle’s performance on drivers and passengers, and the compatibility of vehicles with each other and with roadside hardware during crashes. Using the data and information collected by the NCAC, researchers have been able to optimize the safety of vehicle and hardware designs, formulate guidelines for more effective deployment of safety features, and develop innovative safety treatments to avoid crashes, or minimize the impact of crashes.

The NCAC library has provided a national resource for crash test reports and films, as well as current computer models used by the national and international transportation community. The NCAC has provided an environment for visiting scholars to interact with the research team and to conduct research using the wealth of data and facilities available. The NCAC has also provided a very rich educational environment for hundreds of graduate students in the unique GWU Transportation Safety Engineering Program.

Goals and Objectives
The overriding mission of the NCAC was to advance the knowledge and technologies for crash analyses for transportation safety and to provide a forum for collaboration between the government, industry, and academia. The original objectives of the NCAC program included:

- Conduct advanced research to assist researchers and engineers in resolving transportation safety issues.
• Improve safety by expanding knowledge about crashes.
• Develop and share detailed finite element vehicle and hardware models.
• Lead efforts to apply computer simulation tools to enable the study the complex interactions associated with crashes.
• Advance the state-of-the-art in crash analysis methods and technologies.
• Combine and maintain FHWA and NHTSA crash test films and documentation collected over the past two decades into a single national library.
• Conduct crash testing to validate computer models and produce relevant data for crash analysis to improve highway and vehicle safety.

A key facet of the NCAC mission was the sharing of resources, findings, data, models, and technologies with others to expedite the ability to address complex safety problems.

Accomplishments
Over the life of the NCAC Program many things were accomplished. A summary of the major accomplishments is provided in Table 1.

There were also indirect benefits of the efforts of the NCAC. These included:
- Provided rich educational opportunities for many graduate students pursuing the unique Transportation Safety Engineering degree at GWU.
- Provided an environment for visiting scholars to interact with the NCAC research team and to conduct research using the wealth of data and facilities available.
- Established a solid working relationship with industry in pursuit of improved highway safety.

Products
The NCAC produces a variety of products through its research efforts, including:
- Reports, Technical Summaries, & Papers that have documented the research efforts and findings.
- Presentations – Materials that provide an overview of efforts and include crash videos & animations.
- FE Models – The data files for each of the finite elements models developed have been posted. These data define each element in the models and serve as direct input to simulation software. Users can combine or modify the data as appropriate for comparative analysis.
- Library Materials – Crash films, test, and related documents are accessible through the NCAC Library. Efforts to convert these materials to digital formats continue.

Information for accessing these products is available through the NCAC website.

Epilogue
The FHWA HNTSA NCAC program was formally closed in January 2009 to implement an updated research and outreach agenda as well as a new contracting mechanism. The Advanced Crash Analysis Program (ACAP) started in December 2008 to carry on and expand research efforts in this area.

Under the 1992 FHWA contract the FHWA/NHTSA National Crash Analysis Center (NCAC) was created at George Washington University (GWU). As part of the GWU support for these research endeavors, they have institutionalized a National Crash Analysis Center some year ago and have undertook research under the subsequent FHWA/NHTSA Cooperative Agreements as well as for other government and private sector organizations under the NCAC name.

For More Information
See the NCAC Website (www.ncac.gwu.edu) for more information on the program and its accomplishments.

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Table 1 – Summary of Accomplishments

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<th>Topic Area</th>
<th>Accomplishments</th>
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| **Vehicle Modeling**        | - Developed & validated 16 finite element (FE) vehicle models in collaboration with NHTSA, including 1994 Chevy C2500 pick-up, 1998 GeoMetro, 1996 Dodge Neon, 2006 Ford F250, 2003 Ford Explorer, 1997 Toyota Rav 4, & 2001 Ford Taurus. These can be used for simulation of frontal crashes and many can be used for side-impact, roof crush, and other impact modes.  
- Posted the validated FE vehicle models developed for free download & use by others and provided technical advice to users as needed.  
- Provided leadership in the evolution of vehicle modeling particularly related to element size, modeling suspension & steering systems, & material properties.  
- Adapted new technologies to enhance the reverse engineering process including laser scanning and meshing procedures.  
- Developed a detailed FE model of a 2007 Chevy Silverado & conducted extensive validations of the model which included comparisons to New Car Assessment Program (NCAP) frontal impact tests, inertial properties, & non-destructive suspension response tests.  
- Developed finite element models for single-unit trucks and a tractor-trailer combination.  
- Collaborated to develop & enhance an FE model of a tractor-trailer vehicle.  
- Developed new validation tests and worked to apply proposed verification & validation protocols to recently developed models.  
- Established protocols for the testing of materials samples and the documentation of the FE models.  
- Undertook continual updating & maintenance of the developed models to support continued use. |
| **Roadside Safety Analyses** | - Developed finite element models for guardrails, concrete safety shapes, transitions, end treatments, sign supports, breakaway devices, cable barriers, mailboxes, and other roadside hardware.  
- Established a website for convenient dissemination of these models to other researchers. Much of the crash simulation work around the world uses NCAC-developed models.  
- Demonstrated the viability and potentials for using crash simulation in the analyses of the safety performance of roadside hardware.  
- Models were made available free of charge to promote use of crash simulation in analyses undertaken by state, academia, & industry.  
- Analyzed the effects of guardrail height on safety performance through parametric analyses of varying rail heights.  
- Investigated the interface effectiveness implications of lateral placement of cable median barriers through pioneering applications of vehicle dynamics analysis tools.  
- Analyzed effective combinations of elements and optimal designs for portable concrete barrier (PCB) shape.  
- Evaluated the impacts of proposed new roadside hardware crashworthiness criteria by comparisons of similar impacts with the previous and proposed vehicles (i.e., by adding mass).  
- Developed new end treatment designs for steel-backed timber guardrails using simulation.  
- Analyzed the implications of various raised median designs for arterial highways.  
- Investigated the effects of varying edge drop conditions using vehicle... |
| **Vehicle Safety** | • Analyzed vehicle-to-vehicle compatibility using crash simulation for front-to-front and front-to-side impacts.  
• Conducted vehicle compatibility studies for NHTSA to evaluate structural interaction between passenger cars varying classes of light truck vehicles (LTV).  
• Developed a barrier design to accurately measure “height of force” for NCAP tests.  
• Evaluated override barrier design to detect Safety Energy Absorbing Structures (SEAS) in LTVs.  
• Analyzed performance of child safety seats in various positions for varying sized children.  
• Investigated rollover crash forces.  
• Conducted tests to analyze fluid movements in plastic fuel tanks to analyze implications for failure.  
• Modeling and evaluation of vehicle roof crush performance.  
• Research to reduce the vulnerability of fuel tanks in crashes from all directions. |
| **Biomechanics** | • Developed FE models of various crash test dummies.  
• Used modeling to analyze high-severity low delta v crashes based upon Crash Outcome Data Evaluation System (CODES) data.  
• Side impact injury risk for far side belted passenger vehicle occupants.  
• Prepared finite element modeling of the rupture of the three-layer human thoracic aorta under crash impact loadings.  
• Analyzed risk to various age groups of occupants in child restraint devices in different positions in the vehicle. |
| **Crash Data Analyses** | • Conducted a comprehensive analysis of motorcycle crashes using Fatality Analysis Reporting System (FARS) & General Estimates System (GES) data.  
• Linked NCAP test data with FARS crashes to assess the effects of stiffness measures on crash severity.  
• Investigated characteristics of multiple impact crashes that produce serious injuries.  
• Used Crash Injury Research Engineering Network (CIREN) data to assess the performance of second generation airbags. |
| **Infrastructure Security** | • Analyzed the effectiveness of pile and shallow foundations for physical protection barriers.  
• Developed designs for surface planter barriers for DOS used alone or in combinations.  
• Analyzed design requirements for pile and shallow foundation barrier designs.  
• Analyzed and tested knee wall, cable fence, removable bollard, shallow and pile foundation barriers, and surface planters for DOS.  
• Evaluated the performance of baseline anti-ram barriers including chain link fences, water filled barriers, portable concrete barriers, and masonry walls for DOS. |
| **Computing & Simulation Technology** | • Pursued enhancement of computer technology to speed up crash simulation processing. |
- Tested new software elements for the developers of LSDyna and established computer performance benchmarks.
- Maintained expertise in LSDyna & associated pre- and post- processors, Madymo, HVE, CarSim, and other software.
- Provided benchmark models for the evaluation of computational accuracy, reliability, and consistency in LSDyna and high performance computer hardware.
- Investigated the use of meshless methods to represent soils in modeling and simulation of post behavior.
- Improved the techniques and internal material models for crash simulations using LSDyna.
- Developed material failure models for dynamic impact application and implemented them in LSDyna.
- Developed material constitutive model for metals based upon experimental data.
- Investigated improved means to model & analyze material fracture and tire failure in crash simulations.
- Established protocols for model validation using full scale crash tests.
- Operated the FHW FOIL to capture crash performance measures to enhance models or validate them.
- Addressed security needs by using models to develop various anti-ram barriers.
- Conducted numerous workshops and seminars to exchange ideas and develop consensus on crash analysis methods.

**Testing**
- Executed successful full scale crash tests using single unit trucks to evaluate removable bollards, surface planters, and knee walls.
- Evaluated full-scale cable fence security barrier and various pendulum tests of component parts.
- Executed more than 70 component tests conducted for cable connections, guardrail posts, secure mailboxes, engine mounts, and sand barrels.
- Upgraded regularly the FOIL cameras and data collection devices to maintain a state-of-art status.
- Updated annually the facilities operation & maintenance manual.
- Conducted vehicle drop tests to analyze dynamic roof crush strengths for pick-up trucks.
- Conducted bogie tests of sign support performance.
- Hosted more than 20 facility tours annually.

**Library & Information Resources**
- Compiled a crash library with more than 20,000 films and videos as well as reports and data related to crash testing.
- Cataloged and added hundreds of new items to the library collection.
- Provided retrieval services to more than 200 customers annually.
- Undertaking long-term efforts to create an all-digital library.
- Completed major website update that added better access to models and options to post reports.
- Served as the repository for the Roadside Design Guide background reference documents.
- Digitized & cataloged the FHWA materials for roadside hardware “accepted” for use on the National Highway System.

**Outreach**
- Supported FHWAs Centers of Excellence for Crash Simulation since its inception.
- Provided numerous opportunities for local Fire & Rescue teams to practice using their specialized tools on crashed vehicles at the FOIL.
- Made regular presentations and participated in the technical and research activities of the Transportation Research Board, Society of Automotive Engineers, and other professional groups.
- Presented at iCrash, LS Dyna Users Conference, and other fora to share research experiences & findings from simulation analyses.
- Authored or co-authored numerous technical papers to refereed technical conferences and journals.
- Gained insights on the growing problem of motorcycle crashes through efforts of the visiting scholar from Honda (Japan).
- Completed major website update that added better access to models and options to post reports.
- Worked with student interns to conduct experiments that provided them a deep understanding of testing methods & outputs.
- Involved in support agreements with several universities worldwide, including the University of Stuttgart, Univerite’dé Valenciennes et Hainaut-Cambresis, and Monash University.
- Provided support & research opportunities for up to 15 graduate students annually.
- Provided meaningful crash analysis educational experiences to over 150 students in the Transportation Safety Engineering program pursuing Doctor of Science and Master of Science degrees.