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Analysis, Modeling and Design for Traffic Incident Management Systems

By Pushkin Kachroo, Ph.D., P.E., and Neveen Shlayan
University of Nevada, Las Vegas

Analysis, modeling, and design are three vital, interdependent components that must be present in every Traffic Incident Management (TIM) system for proper assessment and advancement. These components need to be thoroughly studied; however, for proper and coherent modeling, integration of these aspects is vital.

This project's objective is research and development of theories and scientific tools that can be applied in transportation modeling and design based on data, as well as on quantitative, and qualitative, mathematical analysis. Through out the timeline of this project, we (the Transportation Research Center (TRC) at the University of Nevada Las Vegas (UNLV) have met with multiple agencies that are involved in the incident management process in southern Nevada such as Freeway and Arterial Systems of Transportation, Nevada Highway Patrol, and Las Vegas Municipal Police Department and continue to do so.

We have also been attending the TIM steering committee meetings. The aim of attending such meetings is to better understand the existing incident management process and the relationship between the agencies involved. This has allowed us to identify features in the system that can lead to major improvements. The areas that we identified are as follows:

1. Data Acquisition, Automation, and Analysis
2. Structured Modeling of the System using Mathematical and Scientific Theories reflecting existing Conditions
3. Tools Development

Formal language theory has been employed and implemented in incident management modeling. Five reliability measures have been proposed and used for freeway and arterial highways in Las Vegas: variability based on normalized standard deviation, analysis of variance (ANOVA), average time mean estimation, reliability as a measure of non-failures, and information theory based approach. A new model, defining secondary congestion of secondary incidents, has been proposed based on a case study, VISSIM simulations, and collected data. Bayesian safety analyzer is being developed for prediction and estimation. *(Continued on page 2)*

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Formal Methods for Incident Management Modeling

Traffic Incident Management is a multi-jurisdictional process. Complications with communication, compatibility, coordination, institutional responsibilities and legal issues are inherent in a traffic incident management system. Increasing delay in incident clearance due to various conflicts has vital economical, safety, environmental and social impacts. Therefore, a thorough and rigorous modeling of the system is necessary to better understand its properties and systematically solve issues that might arise. This project has developed the use of formal language theory for modeling, analyzing, and implementing the traffic incident management process (Figure1). This theory has been used very effectively for debugging hardware and

software systems. Using formal languages allows us to perform debugging on a traffic incident management system covering all possibilities for inefficiencies and problems for which we can find solutions. This project demonstrates how to use formal language methodology to model the traffic incident management system through a case study in the Las Vegas area.

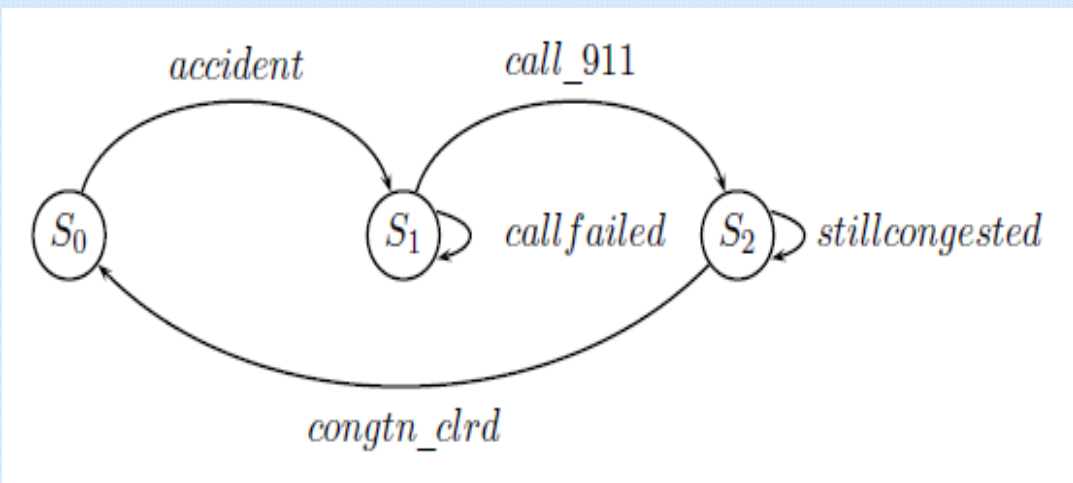


Figure 1. A very simple accident model showing the use of automata theory.

Secondary Congestion

Incidents on urban freeways usually have a major impact on the normal operation of traffic causing congestion and delays. With queues propagating rapidly, the probability of secondary incidents occurring increases. Of particular concern is the threat of serious secondary crashes in both directions. However, this secondary impact has been poorly defined by using static time and length thresholds which does not cover the full range of effects,

resulting in erroneous data. In this project, a thorough study of freeway incidents and the progression curve of the associated impacts were evaluated through a case study in the Seattle, Washington, region. Furthermore, simulations were conducted by examining various cases. Moreover, tools are being developed in order to identify secondary incidents based on the theory of shockwave propagation in traffic (Figure 2).

(Continued on page 3)

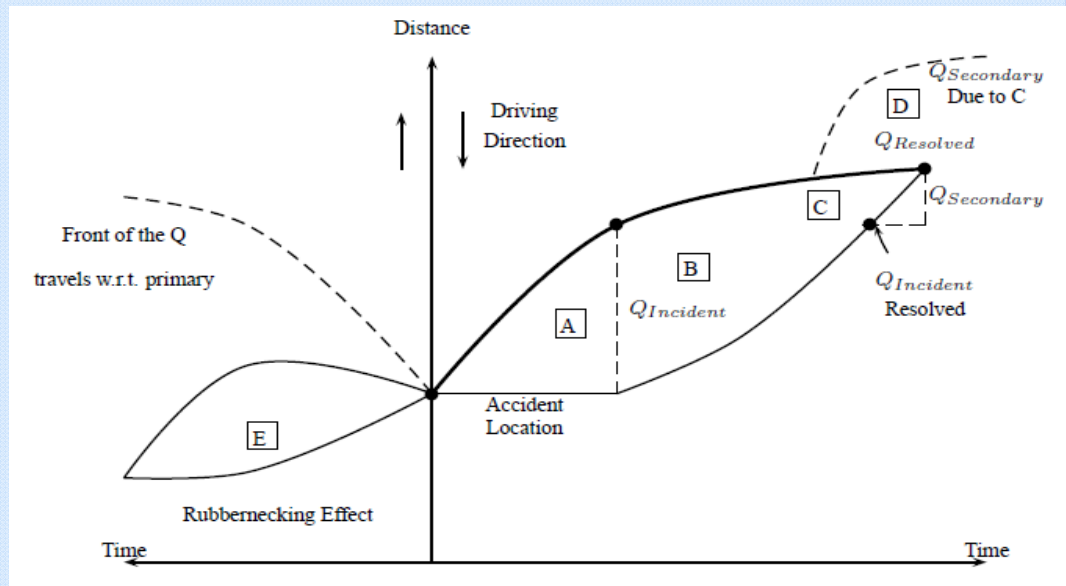


Figure 2. Proposed moving dynamic progression curve for incident related freeway congestion.

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Freeway Reliability Analysis

Travel time is a good indicator of the performance of a street segment or a highway as a whole. However, as a single indicator, it lacks information about the overall performance of the transportation system. Travelers tend to give a higher value to consistency of travel times than the travel time itself in order to better plan their trip. Put in other terms, reliability of the route is of a great importance when assessing the system. Therefore, additional analysis is required on travel times. Various analysis approaches have been developed for this purpose. Most commonly used are the traditional statistical methods demonstrating variability. In this project, travel time data on the I-15 highway in Las Vegas has been analyzed using new techniques developed such as normalized standard deviation, analysis of variance (ANOVA), average time mean estimation, reliability as a measure of non-failures, and information theory based approach. The proposed methods add to the ordinary evaluation criteria of highway systems, thus, introducing new reliability measures.

Arterial and Transit Reliability Analysis

Traffic conditions on arterials tend to be consistent during peak hours; yet, non-recurring events unpredictably affect these conditions. It is vital, for transportation planners, as well as users of the facility to be able to assess traffic conditions. Therefore, a reliability performance measure is essential for evaluation. Reliability can take many measures. Various measures are chosen depending on the evaluation criteria. In this study, average speed, and number of stops data for arterials in Las Vegas was used for evaluating reliability. Reliability assessment was conducted using the five different approaches developed. These techniques were also used for analyzing transit travel time data, where reliability of inter bus operations and user behavior was also studied.

Bayesian Safety Analyzer

A Bayesian network is a probabilistic model which represents relationships between uncertain variables. In traffic studies, it can be used to analyze and predict traffic flow accidents. It has been increasingly used in safety studies in order to analyze the relationships between various contributing factors in crash analyses. In this project, a Bayesian traffic safety analyzer is being developed using crash data and other surrogate information to estimate risks of various locations.

New Research Librarian

Sena Loyd



Sena Loyd recently became NDOT's new Research Librarian. Sena grew up in El Dorado Hills on the outskirts of Sacramento, California. She attended the University of Nevada, Reno's Anthropology program where she completed a Bachelors of Arts (BA) degree with a minor in Holocaust, Genocide, and Peace studies. In May of 2009 she finished her Master of Library and Information Science (MLIS) degree through San Jose State University.

Sena's personal interests are very diverse. At our recent Pi Day, many of us learned that Sena is an excellent cook. Other hobbies include , photography and her new lunch time passion roller hockey. She also loves historical archeology and participated in two digs through the University of Reno, Nevada.

When asked what Sena hopes to accomplish this year with the library, she answered, "My focus will be getting the library catalog on-line, organizing the collection according to the Library of Congress classification scheme and of course, helping people find the information they need!"

Transportation related material reuse in
1930-40s
Rabbithole Springs, Nevada



Railroad tie construction, Double O Mine site. Photo by Sena Loyd.



Exploration, adventure, and mystery greeted those who ventured into the Black Rock. During the Great Depression, many people turned to mining in hopes of generating an income.

Rabbithole Mining District was one such site. In the Rabbithole Mining District, one can see the effects of “making it do” through the “modified reuse” and “reprioritization” (Barna 2008) of many transportation related materials (a result of the hard economic times and the remote location of the site).

Materials that fell under the scope of “making it do” were those materials that were easily accessible and, usually, free or cheap. One of the key materials, as seen in the photo above, was railroad ties. “They were sturdy, durable, of relatively uniform dimensions, capable of being modified with simple hand tools, and did not require special tools to use as construction materials. Whether purchased or scavenged, they were readily available from the two railroads within driving distance of the district.” (Barna 2008, 156)

Other materials that played the role of “making it do” in the Rabbithole Mining District were automobile parts. Charles Miller indicates that a large number of “automobile gold rushes” were a direct result of the economic climate in the 1930s. Automobiles were the primary mode of transportation into the Black Rock during the 1930s and played a large role in dictating the available items for “modified reuse” and “reprioritization” as you can see in the photos below.

Barna, Benjamin T.
2008 *A Material Culture of Making Do: Adapting to the Great Depression in the Rabbithole Mining District*. Master’s Thesis, Department of Anthropology, University of Nevada, Reno. University Microfilms International, Ann Arbor, MI.

Miller, Charles W., Jr.
1998 *The Automobile Gold Rushes and Depression Era Mining*. Moscow, ID. University of Idaho Press.



Automobile door panel reprioritized to repair dugout wall in one of the features, Double O Mine site. Photo by Sean McMurry.



Reprioritized louvered automobile hoods used to short up walls in of the features at the Double O Mine site. Photo by Sean McMurry.

Nevada Technology Transfer (T2) Center, Training for NDOT Employees.

By: Maria Ardila-Coulson

The Nevada Transportation Technology Transfer Center, located at University of Nevada, Reno, provides training and technical assistance for transportation personnel to help them build and maintain better, safer and more cost-effective transportation facilities. Successfully meeting these objectives involves applying proven solutions and innovative approaches.

The main priority of the T2 Center is its training workshops offered throughout the state. Usually one day in length, they provide participants the opportunity to learn from experts and to exchange ideas. Workshop topics range from pavement design and snow removal to roadway drainage and summer survival. Workshops are offered for a nominal cost and include a continental breakfast, lunch and handouts, there is no cost for NDOT employees.

In an effort to save money in these tough economic times, the Nevada T2 Center no longer mails workshop brochures. The workshops are now advertised on the [Center's Web page](http://www.t2.unr.edu), at www.t2.unr.edu where workshop brochures can be downloaded. The Center also compiles electronic addresses and sends information about the upcoming workshops on a regular basis to individuals who have subscribed.

The Center publishes the *Nevada Milepost* and *StreetWise*. The *Milepost* is a quarterly newsletter designed to be an easy read. The articles get right to the point in a clear and concise manner. The *Milepost* also contains information on workshops scheduled for the following quarter. *StreetWise* is a periodical that reports in detail on topics that are too long to run in the newsletter.

The Center offers a Roads Scholars Program for those who attend the workshops on a regular basis. To become a Roads Scholar, a person needs to attend 10 designated one-day workshops during a six-year period. The Center has a library which loans publications, videos and D-CDs; some materials are complementary. In addition, the staff is available to do a computer search on any transportation topic.

New Research Chief

Ken Chambers

We would like to congratulate Ken Chambers as the new Chief of Research. Ken Chambers had been acting Research Chief since February 2009 following the retirement of Dr. Tie He. In February 2010, Alauddin Kahn was appointed as the Chief of Research, and after a brief stint, Khan moved to the Performance Analysis section and Ken Chambers assumed the position as Research Chief.

Ken received a Bachelors of Science (B.S.) Degree in Mechanical Engineering from the University of Nevada, Reno and he brings a variety of experience to the Research Chief position. He has experience in the private sector, and has been at NDOT for 8 years, transitioning to Research from Performance (formerly Operations) Analysis. We believe that Ken has the vision to lead Research into the future.

Ken's personal activities include competitive shooting, catching flicks and raising his 17 year old daughter.



Photo by Julie Duewel

Ken's Favorite Recipe Overnight Cinnamon Rolls

- 1 package 18-24 frozen dinner rolls
- 1 package (3oz) butterscotch pudding
– Not Instant!
- ½ cup butter
- ½ cup brown sugar
- Cinnamon (A lot)

Optional: Chopped pecans and Raisins

Directions:

Put the frozen rolls in a buttered bunt pan, sprinkle with pudding, cinnamon, pecans and raisins.

Melt butter and brown sugar together and pour over the rolls.

Cover with foil and a dish towel, set out overnight. Bake at 350 for 30 minutes.

Turn onto plate immediately.

PRODUCT EVALUATION COMMITTEE MEETING

By Roma Clewell

The Product Evaluation Committee met on Tuesday, March 9th. Two vendor presentations were given: Seth Fischer, NX Infrastructure, presented information about the product and life cycle cost advantages of corrosion resistant, stainless clad rebar and Greg Altringer, Stormwater CM, presented the types of products, features, uses and availability of Portable Roadways. (See details below)

Product Evaluation Committee Decisions:

* A field test of Bridge Preservation's Bridge Deck Membrane (BDM) was requested and authorized with Todd Stefanowicz and Rob Potter as the champions of the project. The bridge deck membrane is a two-component, fast set spray elastomer system, with dielectric properties, that is spray-applied as a waterproofing membrane and serves to protect against water, salts, chemicals, and other corrosive elements on bridge and elevated deck structures. The work plan will be written after the location is determined so that the system can be designed to the location needs. *Photo provided by Joseph Haydu.*



* Silt Fence evaluation performance criteria were established.
* Concrete Stain's evaluation performance criteria modified the solids by weight/mass from 45% minimum to 20% - 35%, and solids by volume from 30% minimum to 22% - 56%.

The next meeting is **Tuesday, June 1, at 1:30 p.m. in the 3rd Floor Conference Room of Headquarters.** Everyone is welcome!

Portable Roadways

By Roma Clewell.

Ingress and egress from work areas can leave debris strung across the roadway. Access to remote locations, across wetlands, and over turf or vegetation that should be preserved is difficult when maintaining transportation facilities. Stormwater CM, according to Greg Altringer, offers temporary, portable roadways that can carry heavy transportation equipment across almost any terrain for a low cost. Once purchased these portable roadways can be moved to another site and some have lifetime guarantees.

Photos provided by Greg Altringer.



Stainless Clad Rebar

By Roma Clewell



NDOT has been tasked with building bridges that have a 75 to 100 year design life by the Federal Highway Administration. One of the failures that contributes to lower design life of bridges is oxidation (rust) of rebar. Seth Fischer, NX Infrastructures, presented a solution: stainless clad rebar.

Rebar is used to reinforce concrete and masonry structures such as bridges. There are several types of rebar, common rebar (black rebar) is made of unfinished tempered steel, making it susceptible to rusting. Another type of rebar is epoxy coated rebar that provides additional protection of the rebar, but is still susceptible to rusting if the unguarded area is compromised. The stainless clad rebar offers corrosion resistance equivalent to solid stainless steel as confirmed through FHWA research.

Rust on the rebar increases other problems with the bridge deck such as the volume of the steel on which it was formed, it causes severe internal pressure on the surrounding concrete, leading to cracking, spalling, and ultimately, structural failure.

NX Infrastructure introduced a corrosion-resistant, stainless clad rebar with a carbon steel core. Their rebar is produced with a metallurgically bonded outer layer of stainless steel resulting in a durable and corrosion resistant cladding. If any part of the rebar is compromised, through chipping, or scratches, the surrounding area will remain corrosion resistant.



The product was fatigue tested to 2 million cycles (150-275 Mpa) with no impairment to the metallurgical bond. A high bond shear strength test has been demonstrated between the core and cladding of 300 Mpa when tested according to ASTM standards.

The steel rebar can be bent up to 180 degrees using standard equipment and can be saw cut on site to fulfill unexpected design changes.

Lastly, stainless clad rebar offers the lowest lifecycle cost in the industry (11%-15%). It is environmentally friendly expending 30-40% less energy during production relative to a conventional rebar manufacturing process, with negligible emissions of hazardous slag and dust, and corresponding limited disposal of these materials. The rebar also has the lowest carbon footprint among steel derived rebar manufacturers.



Photos provided by Seth Fischer.



Pi Day 2010

Photos by Julie Duewel

Library Corner:

The NDOT library is here to help! It holds a large selection of magazines, journals, study materials, and publications from FHWA, TRB, TRR, AASHTO, and US DOT. If the library doesn't have what you want, the librarian can get it! The library is located in room 115 of the NDOT Headquarters building. The librarian can send requested material anywhere in Nevada!

Also, look at our webpage on the NDOT Homepage for our research publications, under, "Reports and Publications-Research Division Publications"..... www.nevadadot.com

About NDOT's R&T Review

The NDOT Research Division administers the Department's research, development and technology transfer program and serves as the "clearing-house" for product evaluations.

Research and Technology Review is published quarterly by the NDOT Research Division. Its purpose is to provide the latest information on the NDOT research activities including product information and other pertinent research topics.

If you have comments or need additional information regarding any of the topics discussed in this issue, please contact the Research Division.

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