

Application of Instant Crash Injury Risk Data to Assist Medical Treatment and Save Lives

Professor Jeffrey Augenstein
VDI Symposium

8/3/11

US Opportunities for Reduced Casualties

Since January 2009

- 75,000 deaths from crash injuries
- 50% not transported to a medical facility
- Another 300,000 seriously injured

Presentation Overview

- Introduction of the WLIRC
- Current Status of 911 and ACN
- Opportunities for Highway Casualty Reduction using URGENCY
- Concepts for Using URGENCY
- Accuracy requirements for URGENCY
- Recent developments

The Ryder Trauma Center

- Largest Trauma Center in US
- Home of the William Lehman Injury Research Center (WLIRC)



William Lehman Injury Research Center

- William Lehman Injury Research Center (WLIRC)
 - Research team established in 1991
 - Trauma research group housed at the Ryder Trauma Center
 - Part of the Jackson Memorial Hospital in downtown Miami, FL
- Ryder Trauma Center
 - Level 1 Trauma Center
 - Over 3,000 admissions of seriously injured patients
 - Home to the Army Trauma Training Center
 - Extensive Research & Education Facility



WLIRC Research

- Research to date has focused on understanding common mechanisms of injury during motor vehicle crashes
- Identifying opportunities to improve vehicle safety and post crash care
- Pioneered research in Enhanced Automatic Crash Notification (eACN)

Crash Research at WLIRC

- William Lehman Injury Research Center team
 - Research has supported NHTSA R&D, Rulemaking (model center for NHTSA's CIREN Program)
 - Conducted evaluations of advanced safety issues for the automotive industry, tier 1 suppliers and other government entities
 - Ongoing partnership with BMW since 2001 to evaluate and improve ACN technology
- Multidisciplinary Approach to Crash Research
 - Clinical, Engineering, Biomechanics, Epidemiology, Social Work, Crash Investigation, and Computer Science

Study Personnel

- Jeffrey Augenstein, MD, PhD, Chief of Trauma
- Kennerly Digges, PhD, Research Director
- Carl Schulman, MD, Principal Investigator
- George Bahouth, D.Sc., Principal Investigator
- James Stratton, Crash Investigator
- Cindy Delgado, AIS



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The US 911 System

- 6,700 PSAPS in USA, 700 in Canada
- Less than 1% of calls motor vehicle related
- Information gathering procedure
 - check lists that depend on the emergency
- Notification action determined by check list
- Check lists supplied by 2 agencies
 - Newest to revisions to include URGENCY

Issue with 1st Generation ACN

Many more crashes than crashes with injury

Annual US numbers:

- 6,000,000 Crashes that trigger ACN
- 3,000,000 Crashes with any injury (50%)
- 250,000 AIS 2+ Injuries (4%)
- 80,000 AIS 3+ Injuries (1.3%)
- 35,000 Fatalities (0.6%)

Current Status of ACN

- Auto companies with ACN
 - Current- GM, BMW, Daimler, Ford, Rolls Royce
 - New- Toyota, Hyundai
- Most auto companies use built-in cell phones
- Ford uses customer's cell phone to call 911
- For Ford ACN, the customer's voice call goes directly to 911
- Except for Ford, the ACN call goes to a private Call Center
 - The Call Center talks to the customer and to 911
 - May also connect customer directly with 911
 - GM Centers are in Michigan, N Carolina and other locations (OnStar)
 - BMW and Toyota have Centers in Texas, Florida and Canada (ATX)
 - Daimler has a Center based in Atlanta (Hughes)
- eACN vehicles also send crash data to the Call Center

The Call Centers

- Call takers receive on-job training annually
- Call takers sign non-disclosure agreement to protect privacy of persons information
- Language skills include English, Spanish and French (Canada)
- Other languages accommodated through translation service provided by contract services such as AT&T
- Frequency of Calls:
 - 3 to 7 crash calls per year per 1,000 cars
 - Less than 1% of all calls to the Center are crash calls

Current Applicable Regulations

- Federal Rule Part 563 regulates Event Data Recorders (EDR) beginning Sep1, 2010
- EDR installation is voluntary
- If EDR installed, Part 563 sets standards for:
 - Accuracy, storage, survivability, retrievability
 - Minimum data set to be collected
 - Recommendations for additional data
- Follow-up rule to require EDR's is being considered by NHTSA

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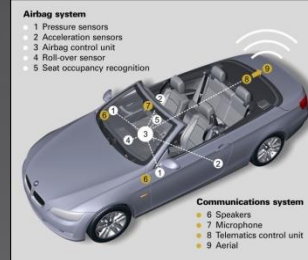
Functions of eACN

- Provide geographic location of crashes with possible injuries
- Provide voice communication with vehicle occupants
- Provide data from vehicle sensors

Result:

More rapid response to injured occupants

Improved diagnosis and triage of injured



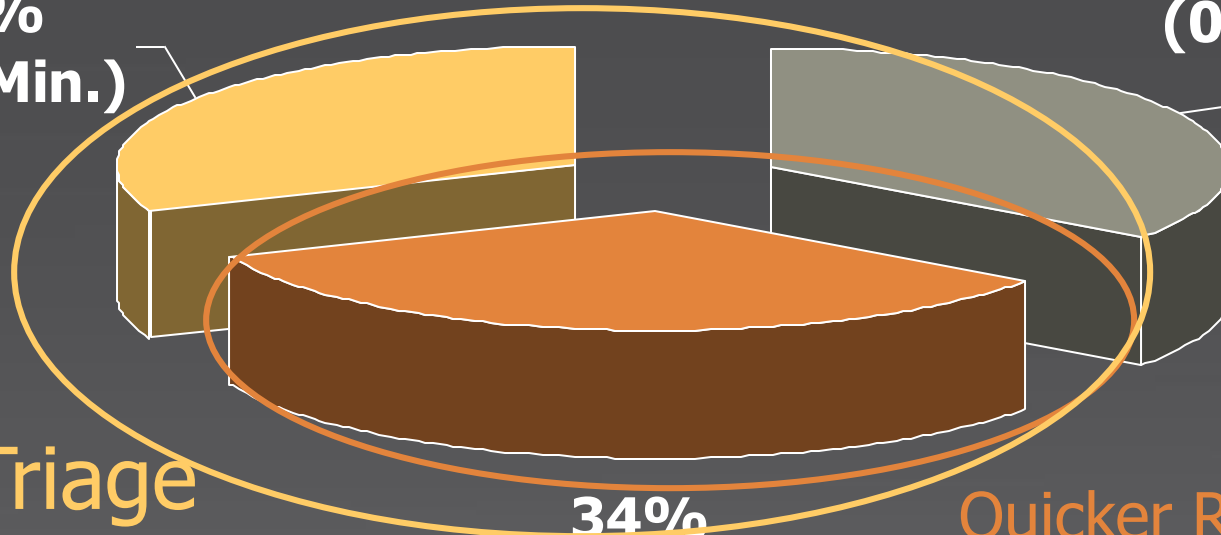
Opportunities for Fatality Reduction

- Risk of Death Reduced by 25% for Accurate Triage and Timely Trauma Center Treatment (Mackenzie, New England Journal of Medicine, 2006)
- NHTSA Studies of Preventable Deaths:
 - 28.5% of all rural (DOT HS 807 973, 1992)
 - 27.6% of all rural (DOT HS 808 341, 1995)
 - 17% of all urban and rural (DOT HS 808 345, 1995)

Fatalities by Time of Death After Crash

OPPORTUNITIES FOR SAVING LIVES 35% (0-9 Min.)

31% (90+ Min.)



Better Triage

34% (10-90 Min.)

Quicker Response

Minutes Post Crash

*Based on FARS 2001 Data

Benefits for Injured Occupants

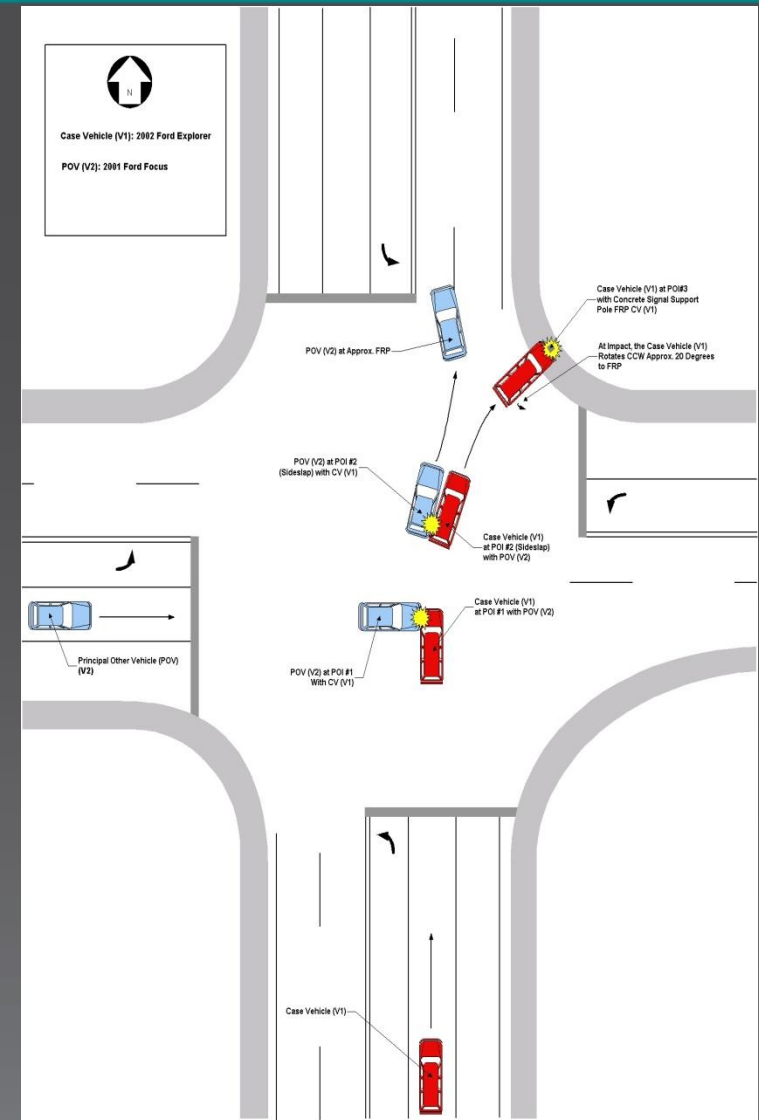
- Rapid and Accurate Location Would Help:
 - people who die on scene who can be saved
 - people with time critical injuries but are treated too late
- Improved Triage Would Reduce the Number of:
 - People who are mis-diagnosed and poorly triaged to the wrong care facility
 - People who are improperly treated in the right hospital due to missed injuries
- Risk of Death Reduced by 25% for Accurate Triage and Timely Trauma Center Treatment (Mackenzie, New England Journal of Medicine, 2006)

Technology for Injured Occupants

- Rapid and Accurate Location :
 - Automatic Crash Notification of Crash Location (ACN)
- Improved Triage:
 - **Enhanced** Automatic Crash Notification using Vehicle Crash Data (eACN)
 - Use of URGENCY Algorithm to Instantly Predict the Probability of Serious Injury Presence

Example Case: Missed Injury

- 42 Year Old Female
- Passenger
- 2002 Ford Explorer XLT
- 12 O' clock PDOF (Primary Impact)
- deltaV 30 mph (48 kph)
- Side Slap Followed By Narrow Object Frontal (Multiple Impact Crash)



Multiple Impact Frontal Crash

Driver Uninjured

Passenger:

- Lap & Shoulder Belt Worn
- Passenger Top Mount Airbag Deployed
- Did Not Meet Any Trauma Criteria On-Scene

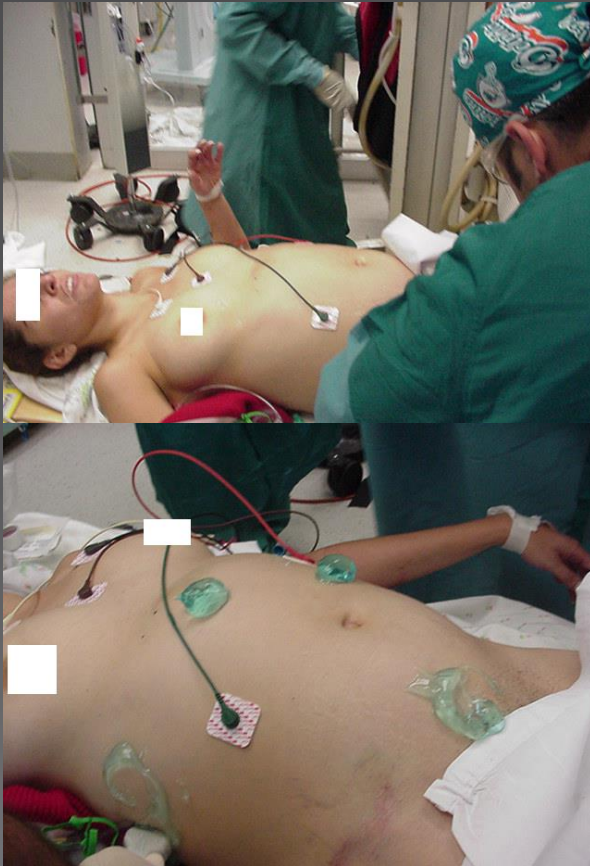


Crash Environment

- Crash occurred 01:39 pm
- Upon Initial Treatment
 - Passenger Taken to local hospital
 - Sent home 5 hours later
 - Following CT Scan



Pre-Trauma Center Care



- 4 Days later, severe stomach cramping persisted
- Returned to local hospital for treatment and was immediately flown to Trauma Center

Occupant Injuries

Injuries:

- AIS 4 Perforation of Sigmoid Colon
- AIS 2 Denuding of Serosa at transverse colon
- AIS 2 Denuding of Serosa at distal jejunum
- Pelvic Abrasions
- Various Facial Contusions/Abrasions

URGENCY Score:

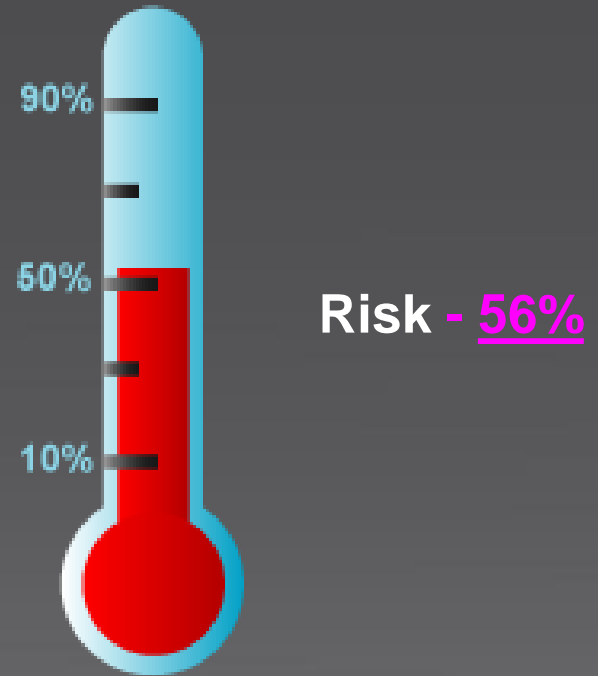
56% Risk of MAIS3+ Serious Injury

Crash Characteristics

- Multiple Impact Event
- Moderate Severity Frontal (30 MPH)
- Narrow Object Collision

Observations

- URGENCY predicted **High Injury Risk**
- If available and used, URGENCY could have prevented the unfavorable outcome



URGENCY Injury
Risk Prediction

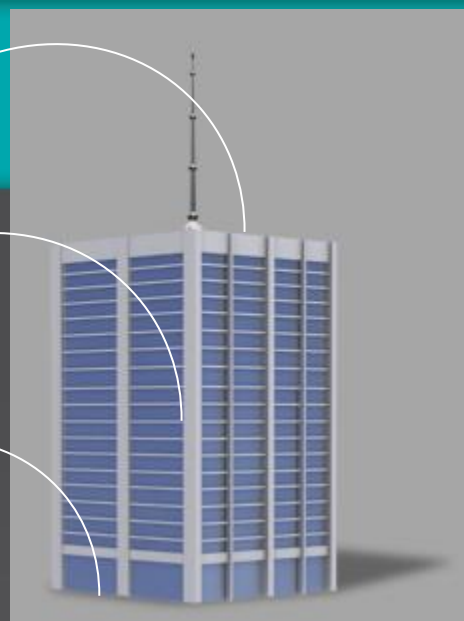
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A Crash Occurs



Crashed Vehicle



TSP

ACN transmits data



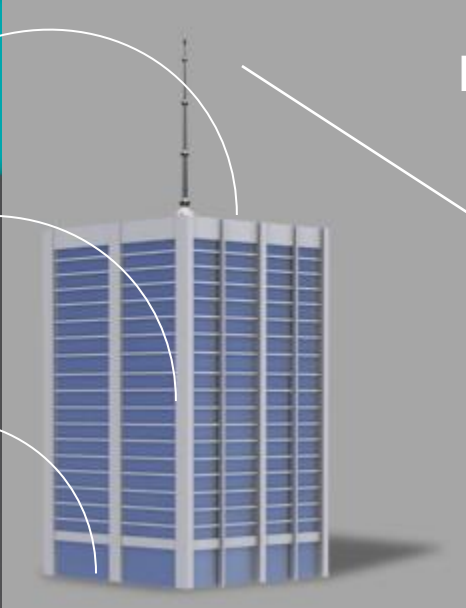
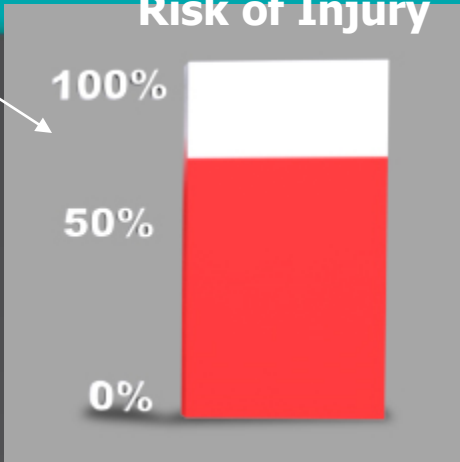
Crash has occurred

- Vehicle location
- Crash data

Crash scene

Estimate of crash severity

Risk of Injury



TSP

URGENCY

ACN transmits data

Crash has occurred

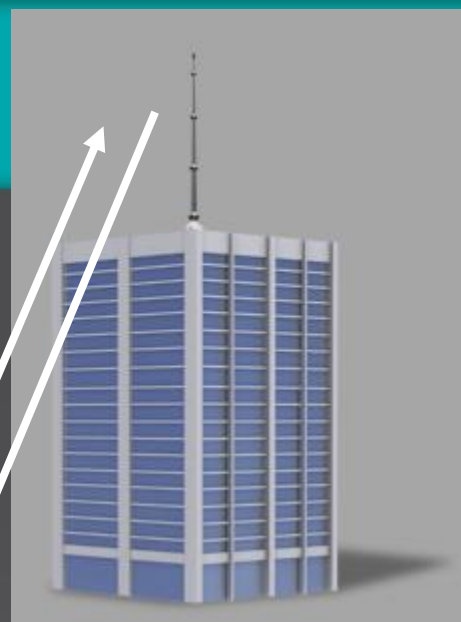
- Vehicle location
- Crash data



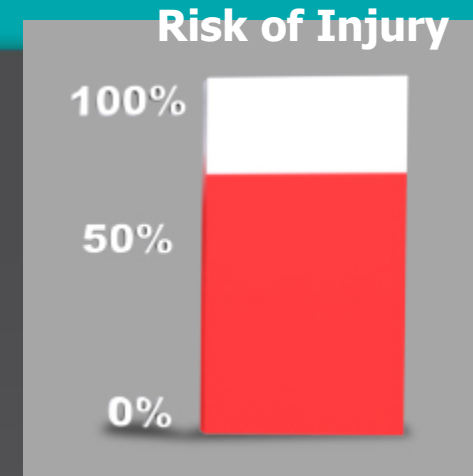
Crash scene

Estimate of crash severity

Voice communication



TSP



URGENCY

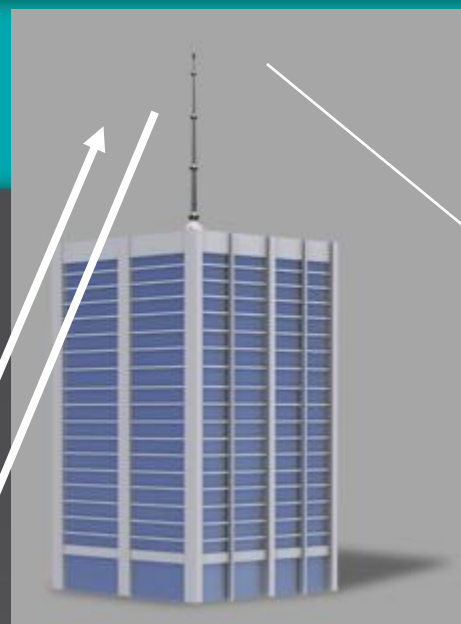


Provide comfort to occupants!
Get additional verbal information

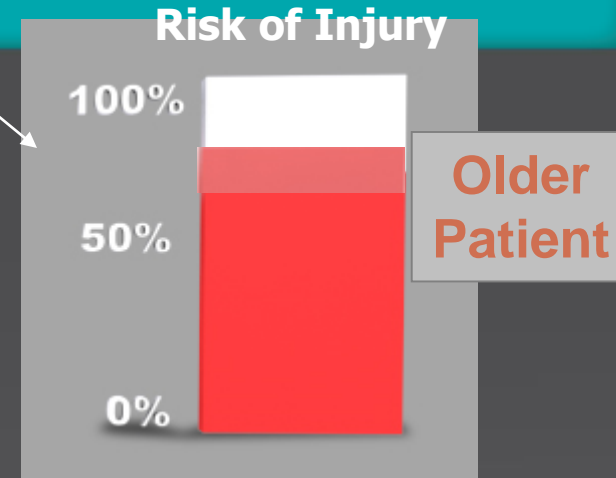
- Number of occupants
- Occupant data (Age, Gender)
- Preliminary Injury Assessment Questions

Crash scene

Estimate of crash severity



TSP



URGENCY

Update URGENCY

Provide comfort to occupants!

Get additional verbal information

- Number of occupants
- Occupant data (Age, Gender)
- Preliminary Injury Assessment Questions

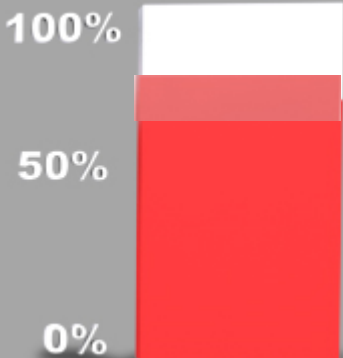
Voice communication



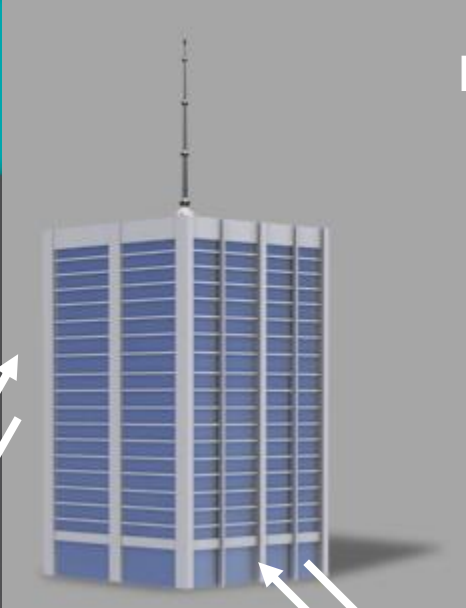
Crash scene

Estimate of crash severity

Risk of Injury



URGENCY



TSP 911

Voice communication



TSP Contacts
Appropriate Rescue
or Public Services
Voice Link between
TSP and Rescue

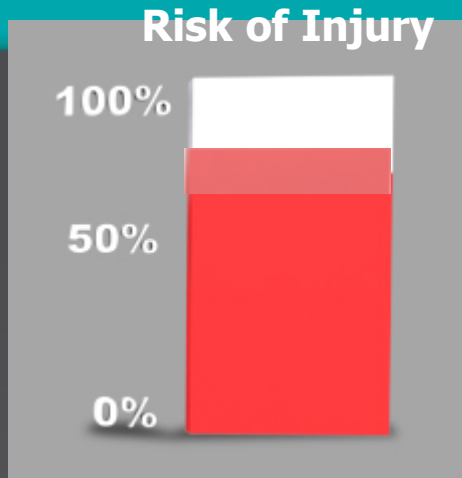
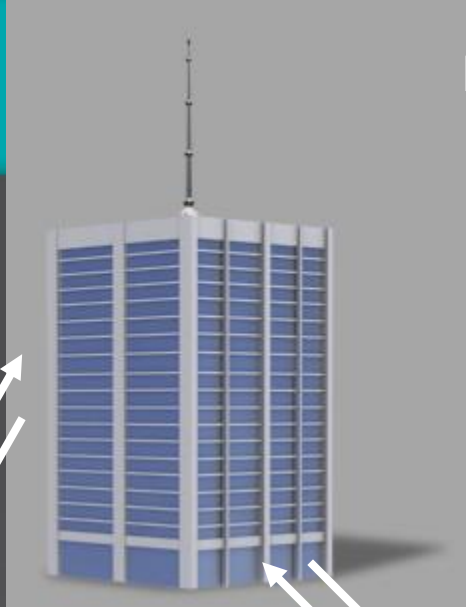
Voice Link between occupant
and rescue services



Crash scene

**Knowledge:
What to expect**

Estimate of crash severity



Voice communication

TSP 911

URGENCY

TSP Contacts
Appropriate Rescue
or Public Services

Voice Link between
TSP and Rescue

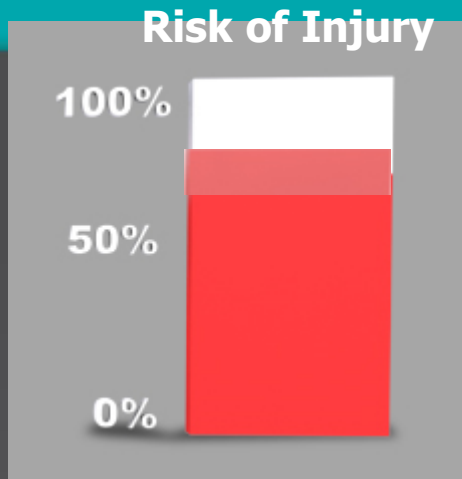
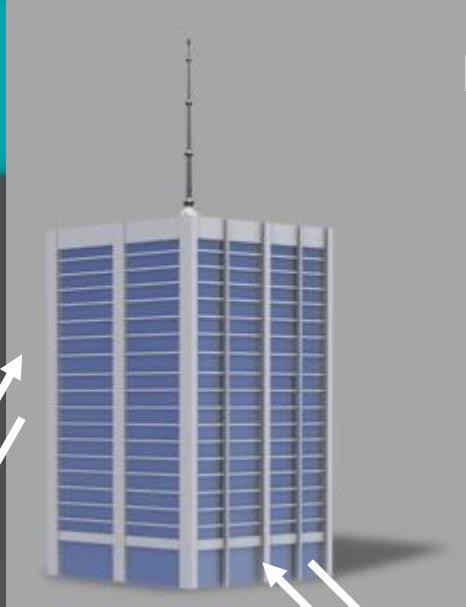
Voice Link between occupant
and rescue services



Crash scene

**Decision:
What to send**

Estimate of crash severity



Voice communication

TSP 911

URGENCY

TSP Contacts
Appropriate Rescue
or Public Services
Voice Link between
TSP and Rescue

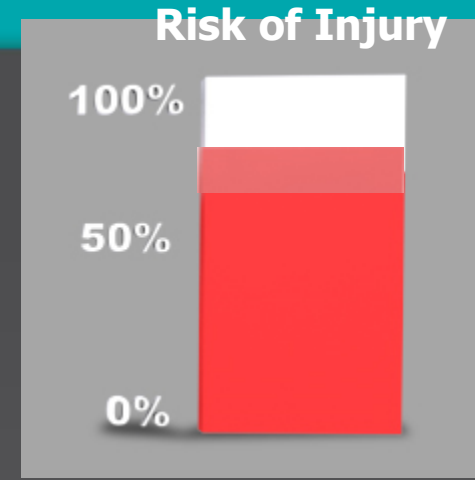
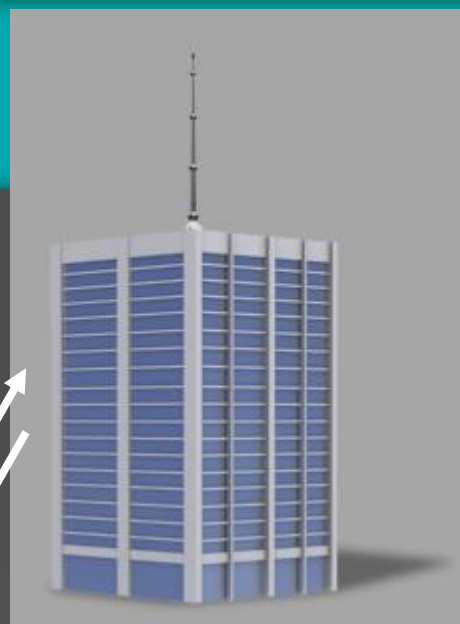
Voice Link between occupant
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Crash scene

Estimate of crash severity

Voice communication



URGENCY

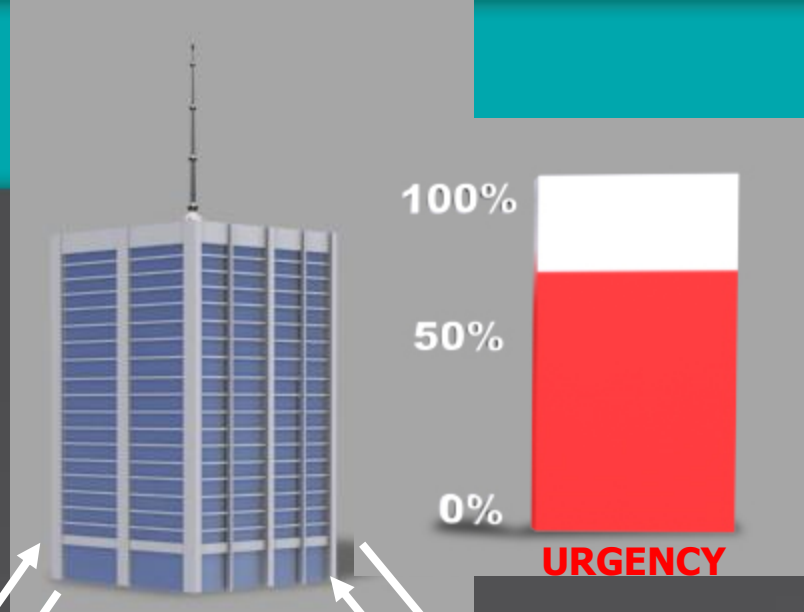
Scene Information

On-scene Evaluations
Reduce False Positives



**Confirm
URGENCY
risk**

Additional Scene
Data for URGENCY

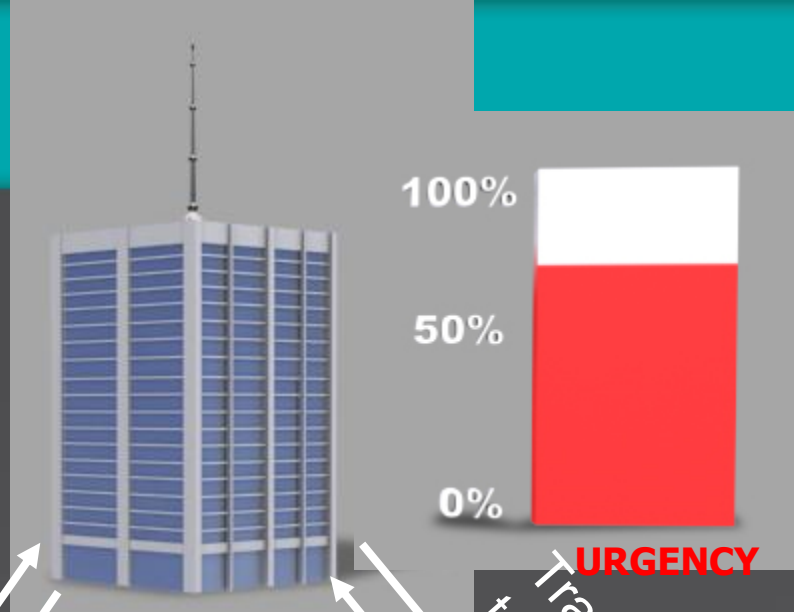


Updated URGENCY
Expected Injuries

Early communication
with Trauma Center

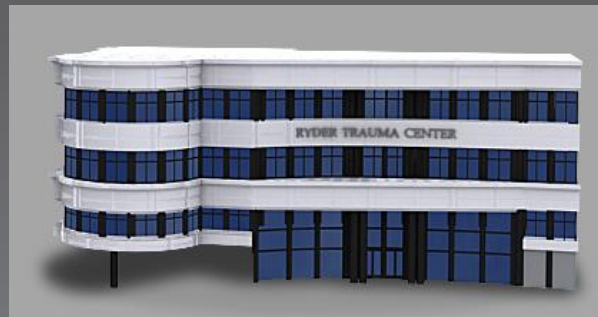


As more crash data is collected, better rescue decisions can be made!



Additional Scene Data for URGENCY

Transmit data to Trauma Center



Vehicle

Rescue on Scene

Early communication with Trauma Center



Knowledge of What to Expect



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Definition of Terms

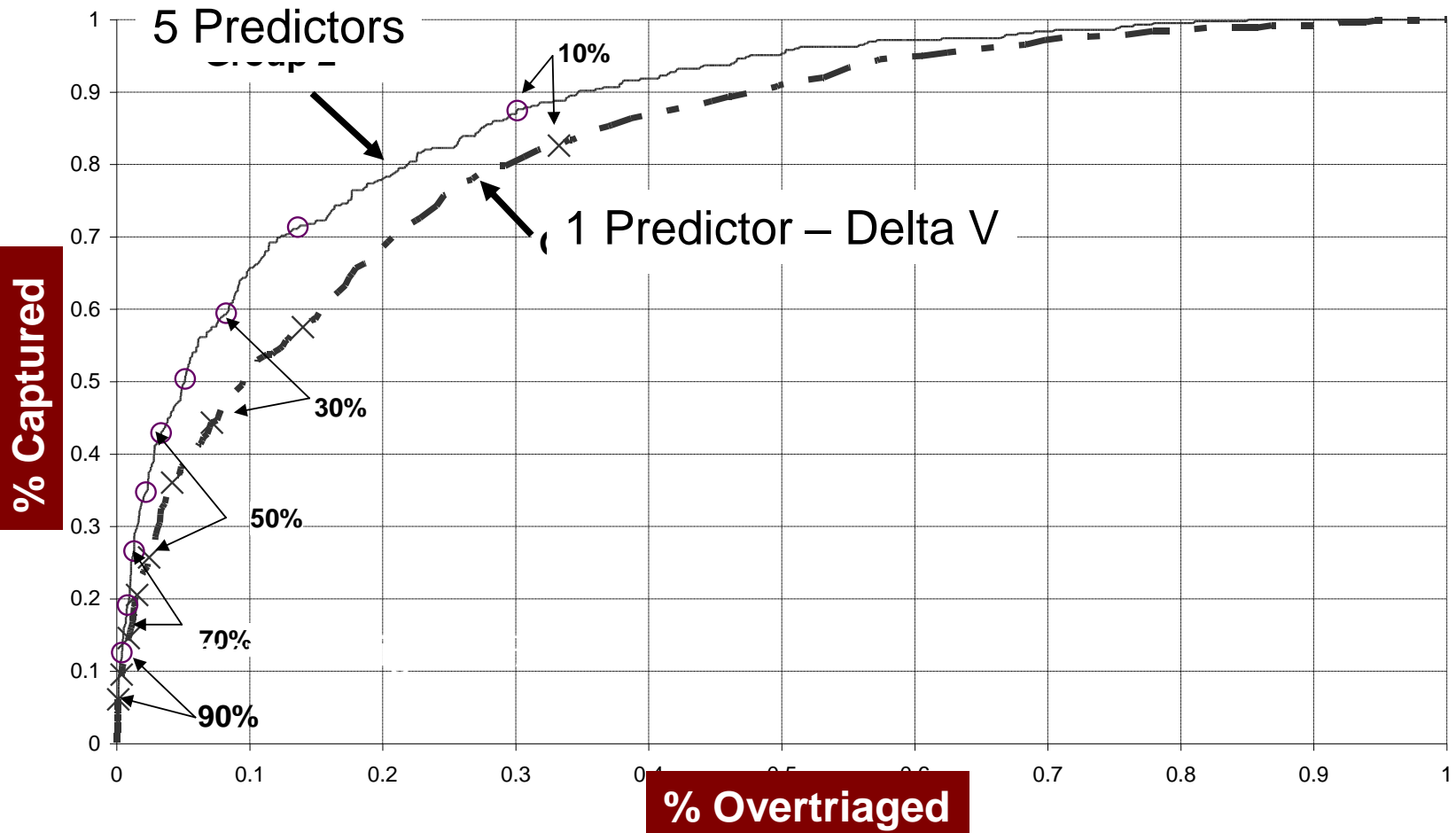
- False negative – Sensitivity - The model fails to identify a case with a serious injury – **Under Triage**
- False positive – Specificity - The model identifies an uninjured case as having a serious injury- **Over Triage**
- Positive predictive value (**PPV**) – Percent of positive values that are correctly identified
- Objective of the model – minimize the false negatives without increasing the false positives
Hold the PPV to less than .20 (1 in 5 correct)

URGENCY Predictive Performance

Crash (cut point)	Sensitivity	Specificity	PPV
Frontal (0.1)	0.5937	0.8824	0.2685
Nearside (0.05)	0.8394	0.7409	0.1920
Farside (0.05)	0.7383	0.9052	0.2079
Rear (0.05)	0.5206	0.9721	0.2353
Rollover (0.1)	0.4377	0.8967	0.2792

ROC Curve Showing Risk Thresholds

Frontal Model Performance



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Issues

- Privacy of crash and other personal data
- Implementation of eACN
 - Leadership of US Center for Disease Control (CDC)
- Benefits assessment

Privacy Issues

- Many current vehicles record crash event data on-board the vehicle (EDR)
 - Data belongs to the vehicle owner (NHTSA)
 - State laws may govern data access
 - Data can be accessed by legal action
- eACN is currently a service to the owner
 - Service agreement permits the transmission of data to the Call Center
- Government mandate of eACN would need to address privacy

CDC Leadership - Expert Panel

Participants in the CDC Panel Included:

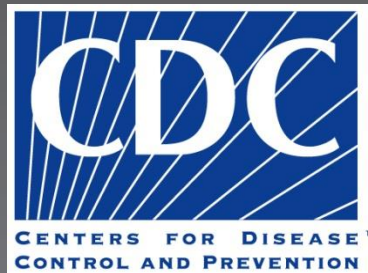
Peter Baur – BMW

Jeff Augenstein – WLIRC

George Bahouth – WLIRC

Ken Digges – WLIRC

Report published - 2009



RECOMMENDATIONS FROM THE EXPERT PANEL:
**ADVANCED AUTOMATIC
COLLISION NOTIFICATION AND
TRIAGE OF THE INJURED PATIENT**



— PREPARED BY THE —
CENTERS FOR DISEASE CONTROL AND PREVENTION,
NATIONAL CENTER FOR INJURY PREVENTION AND CONTROL, DIVISION OF INJURY RESPONSE

— WITH SUPPORT FROM —
ONSTAR, THE GENERAL MOTORS FOUNDATION, AND THE CDC FOUNDATION

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention



Recommendations of CDC Expert Panel

- Current eACN data can improve accuracy of triage.
- Use eACN data prediction to inform PSAP of high injury risk crashes

(Our interpretation – *This technology will save lives - Use it NOW!*)



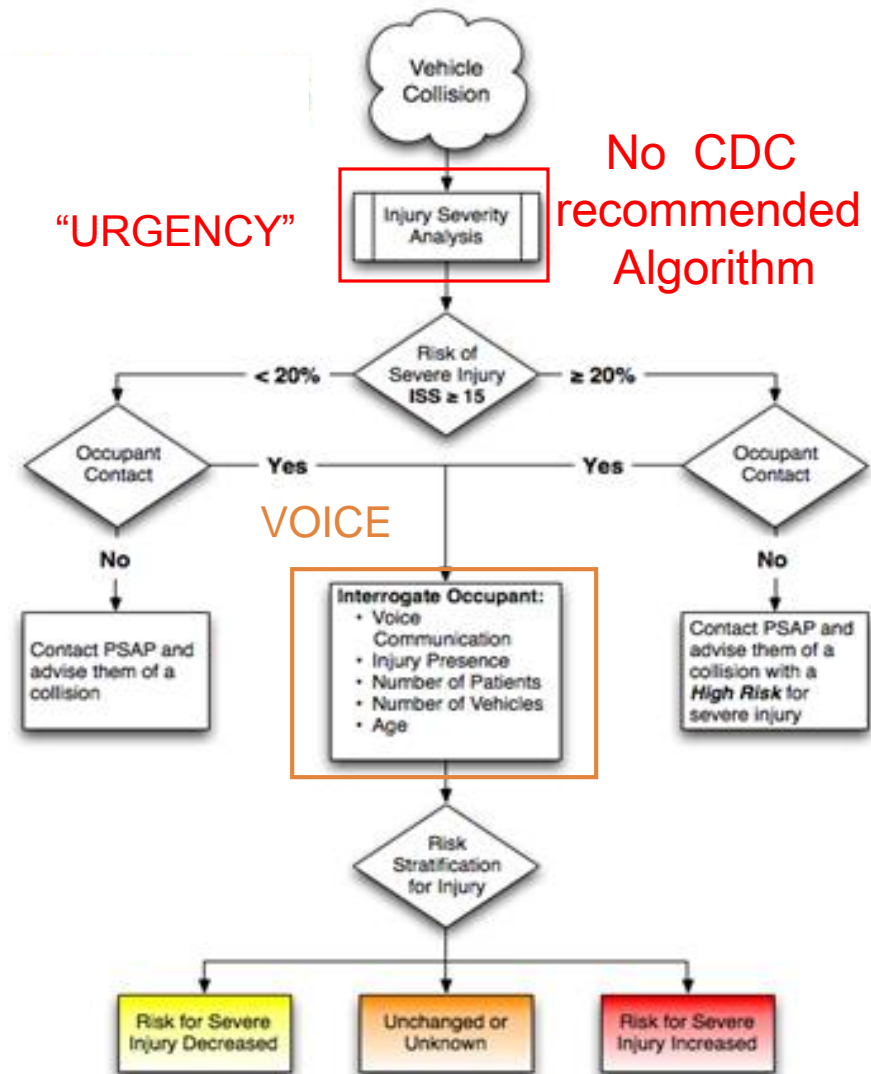
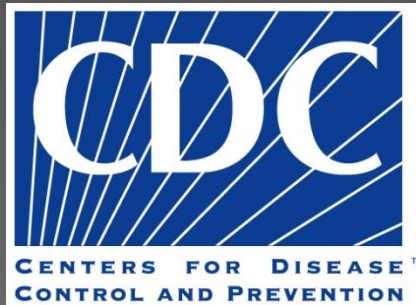
Recommendations of CDC Expert Panel

- Data to be transmitted
 - As recommended by BMW URGENCY Algorithm
- Voice communication data:
 - Age > 54, Nr. of patients, Nr. of vehicles, Are there injuries?
- High Risk Criteria: Risk > 20% for [ISS] > 15



Recommendations of CDC Expert Panel

eACN Protocol
Recommended by
CDC Committee



CDC Recommended Changes in Triage Criteria -



Falls

- Adults: > 20 ft. (one story is equal to 10 ft.)
- Children: > 10 ft. or 2-3 times the height of the child

High-Risk Auto Crash

- Intrusion: > 12 in. occupant site; > 18 in. any site
- Ejection (partial or complete) from automobile
- Death in same passenger compartment
- Vehicle telemetry data consistent with high risk of injury

Auto v. Pedestrian/Bicyclist Thrown, Run Over, or with Significant (>20 MPH) Impact
Motorcycle Crash > 20 MPH

YES

Transport to closest appropriate trauma center which, depending on the trauma system, need not be the highest level trauma center.

NO

Assess special patient or system considerations

Step 3: Mechanism of Injury Criteria
(Slide from CDC Presentation)

CDC Step 3: Triage Changes

Added

- Vehicle telemetry data consistent with high risk of injury



OnStar Announcement May 20, 2009

- “OnStar Creates Injury Severity Prediction to Improve Automatic Crash Response”
 - “Based on findings of CDC expert panel which used OnStar data”



Impediments to the Use of eACN Technology

- A defined risk threshold for a “Severe Crash”
 - Acceptable over-triage and under-triage

Solution: CDC Recommendations

- Lack of procedures for implementing eACN triage with 911
Solution: “Severe Crash” identification by voice call to 911

- A suitable demonstration of the efficacy of eACN
Solution: Initial research at WLIRC to evaluate accuracy
Follow-on research to assess benefits

- Lack of knowledge and advocacy of users
 - 911 (PSAP) and medical services

Solutions: Revised check-lists for PSAP’s

Educational programs for medical services

The Next Steps

- Educational programs for medical services
- Implement CDC triage protocols for eACN
 - Universal application of crash data in rescue/triage decisions
 - Incorporate in check lists at PSAP's
- Continued improvement and benefits assessment of URGENCY.

Questions???

and Discussion