

The URGENCY Algorithm A Thermometer for Trauma

VDI Conference Keynote

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Prof. Kennerly Digges

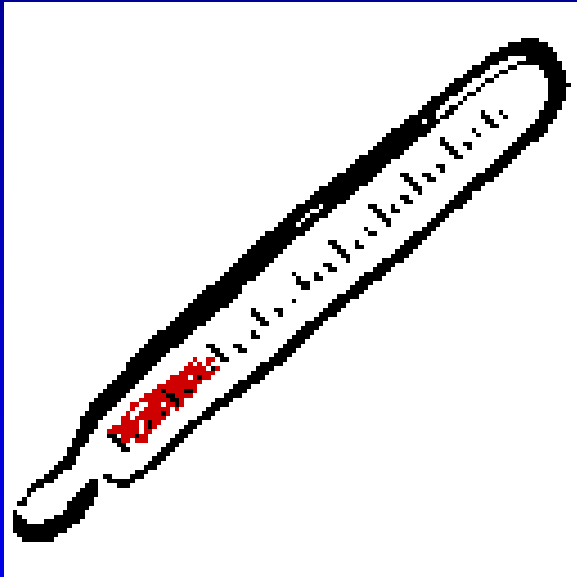
The George Washington University

The Challenge for ACN (Automatic Crash Notification)

Need to Instantly & Automatically:

- Identify vehicles in serious crashes (1/100)
- Locate the vehicle with serious injuries
- Dispatch necessary EMS resources

What is the URGENCY Algorithm?



**URGENCY –
A Thermometer
for Trauma**

- Uses crash scene or crash recorder data
- Estimates the risk of serious injury

Undiscovered Crashes Can Occur on Urban Roads

83 Year Old
Grandmother

Wreck Hidden by
Trees

Undiscovered for
Three DAYS!



Undiscovered Crashes Can Occur on Urban Roads

Application of Automatic Crash Notification

83 Year Old
Grandmother

Wreck Hidden by
Trees

Undiscovered for
Three DAYS!



Need to Identify Crashes with Serious Injuries



Occult Liver Injury!

**Occupant Looks
OK at Scene!**

**Need to Identify
Occult Injuries!**

Identifying Crashes with Serious Injuries is Difficult

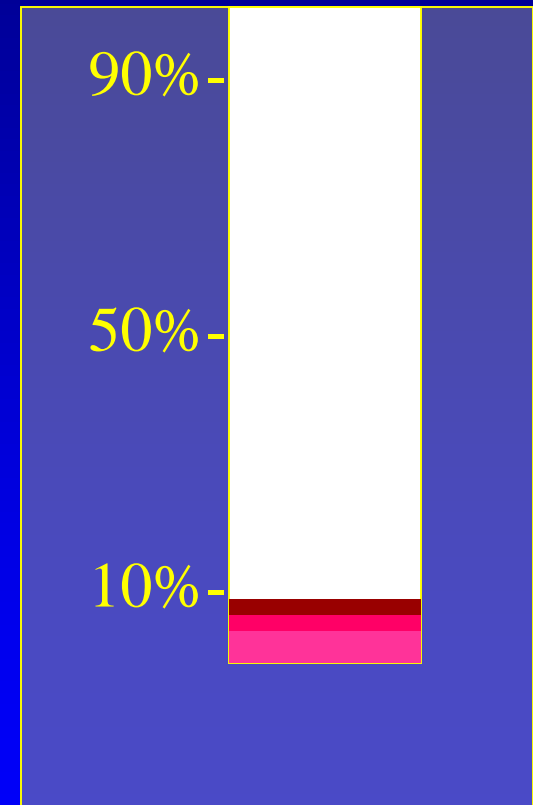


Annual Crashes and Casualties in US

All Crashes	27,000,000	100.0%
Police Crashes	6,300,000	23.0%
MAIS 2+ Crashes	250,000	0.9%
Urgent Crashes	80,000	0.3%
Fatal Crashes	42,000	0.2%

Annual Crashes and Casualties in US

All Crashes	27,000,000
Police Crashes	6,300,000
MAIS 2+ Crashes	250,000
Urgent Crashes	80,000
Fatal Crashes	42,000



Urgent Injury Crashes 1/100

% of Police Crashes

Benefits of Identifying of Serious Injury Crashes (1/100)

- Optimize Application of Rescue Resources
- Prioritize Urgency of Response
- Identify Time Critical Injuries
- Reduce Time to Appropriate Treatment
- Save Lives

Medical Benefits of the Urgency Algorithm



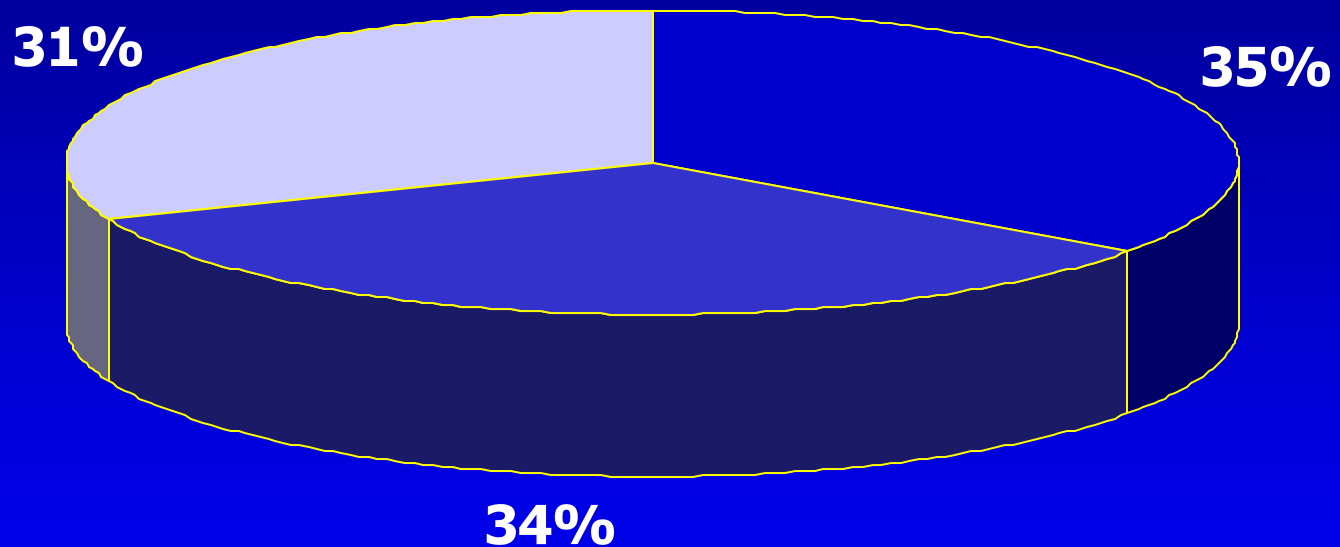
The Golden Hour

- To save lives & reduce disabilities
- To save time in -
 - 911 decisions
 - Field Triage decisions
 - E R Diagnosis
 - Critical Care Treatment
- To aid in detection of
 - Time Critical Injuries
 - Occult Injuries

Which Populations will Benefit?

Examine Fatally Injured
Time to Death

Distribution of Fatalities by Time of Death



■ 0-9 ■ 10-90 ■ 91+

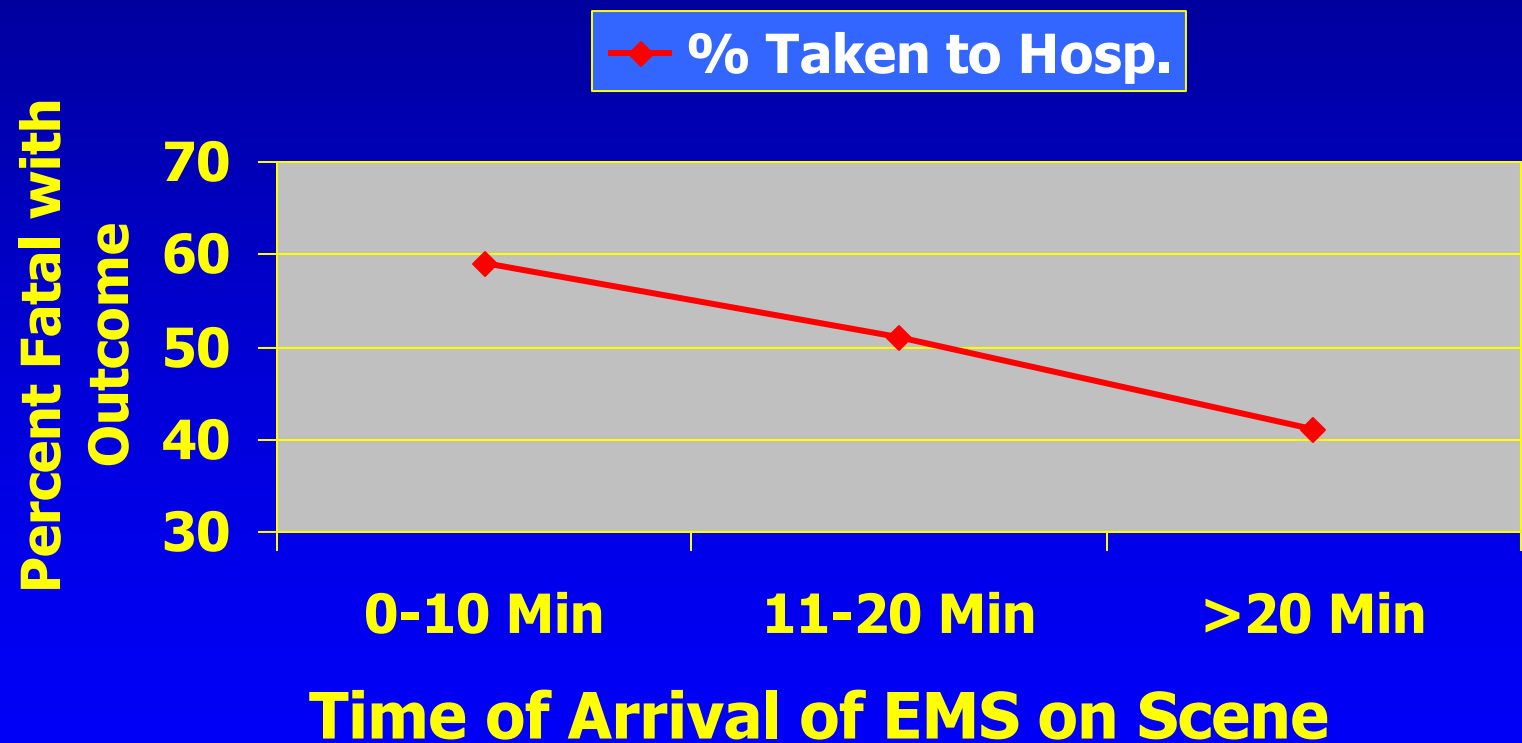
Time of Death in Minutes

Expected Changes in Time to Death

- Time 0-9 sec. (35%) – Expected to decrease with improved vehicle safety
- Time 10-90 sec. (33%) – Expected to increase, and with more occult injuries.
- Time 90+ sec. (32%) -Expected to increase, and with more occult injuries.

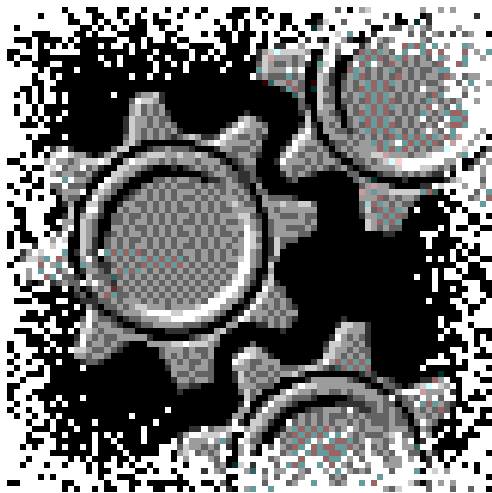
Increased Opportunities for ACN + URGENCY

Effect of EMS Arrival Time on the Ability to Provide Hospital Treatment



20 Minute Delay = Increased Fatalities (20%)

How does URGENCY Work?



- Predicts Probability of Serious Injury
- Based on Logistic Regression Analysis with Weighting Factors
- Applied to NASS Data

Injury Predictor Algorithm

Probability of Injury (P) Using Logistic Regression
Analysis with Weighting Factors

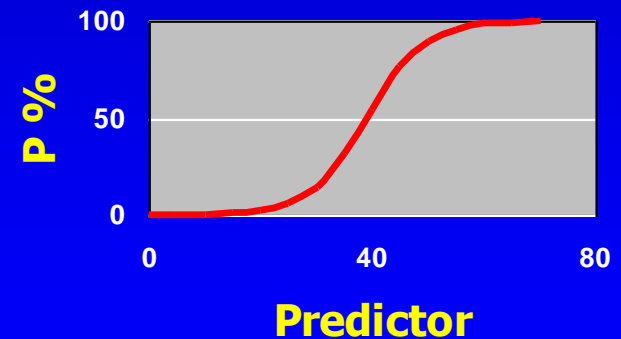
$$P = 1/[1+\exp(-w)]$$

$$w = A_0 + A_1 * \text{Pred } 1 + A_2 * \text{Pred } 2 + \dots$$

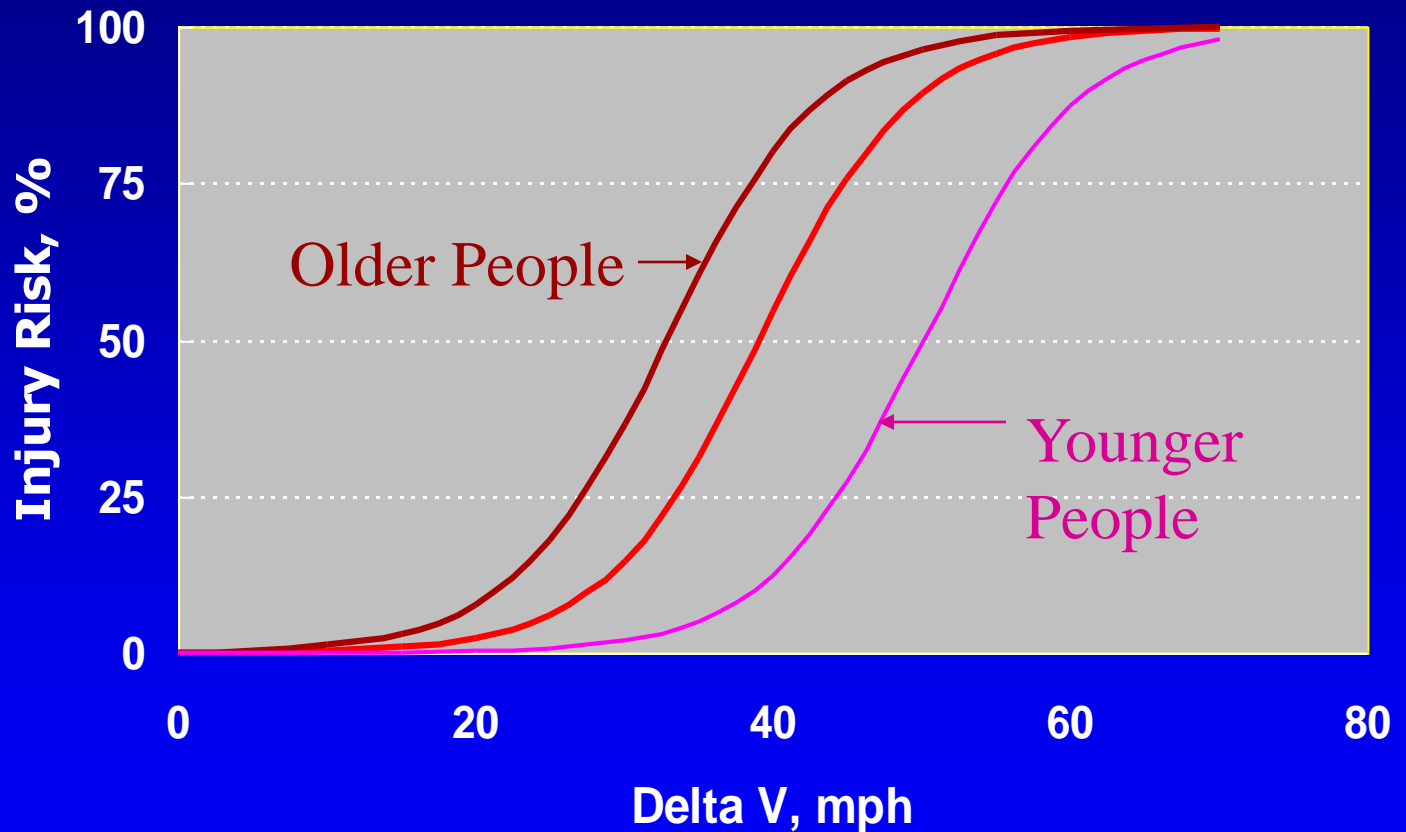
A_0 = Intercept

A_n = Coefficient

Pred n = Value of Predictor



Probability of AIS 3+ Injury vs. Delta-V - Frontal Crash



2 Predictors
(Delta V, Age)

URGENCY Predictors of Injury

- Delta V & Damage Location
- Rollover
- Belt Use
- Single Vs. Multi-vehicle Crash
- Extent of Damage
- Ejection & Partial Ejection
- Entrapment
- Age & Gender
- Vehicle Weight

Illustrated Application to Field Cases

- **Frontal Crash**
- **Restrained Occupant with Air Bag**
- **21 mph vehicle-to-vehicle crash**
- **2500 lb. Car**
- **30 Year Old**
- **Male**
- **6 Predictors**

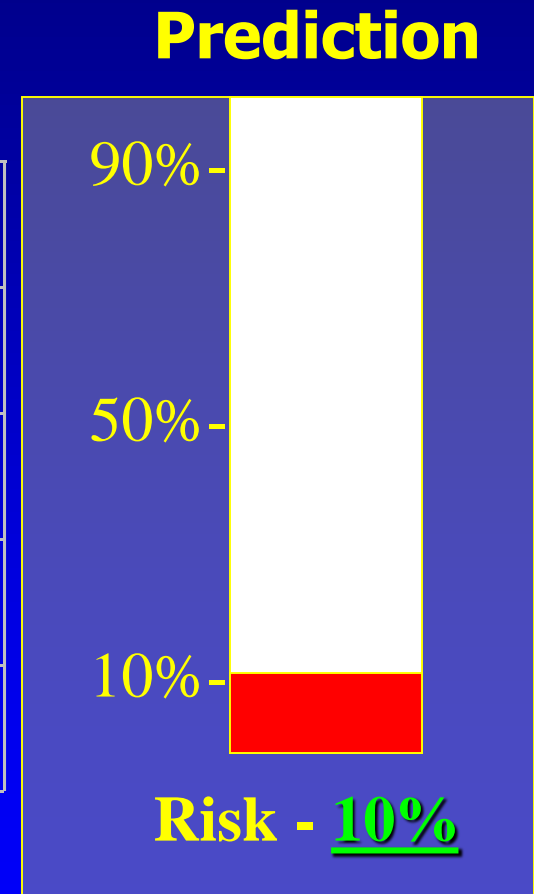
**What is the probability of an MAIS 3
Injury?**

Urgency Variables (Partial) Frontal Crash + 5 Predictors

Delta V, Mph	21
Air Bag + Belt	Yes
Vehicle Weight, lb.	2500
Occupant Age	30
Occupant Gender	Male

Urgency Presentation

Delta V, Mph	21
Air Bag + Belt	Yes
Vehicle Weight, lb.	2500
Occupant Age	25
Occupant Gender	Male



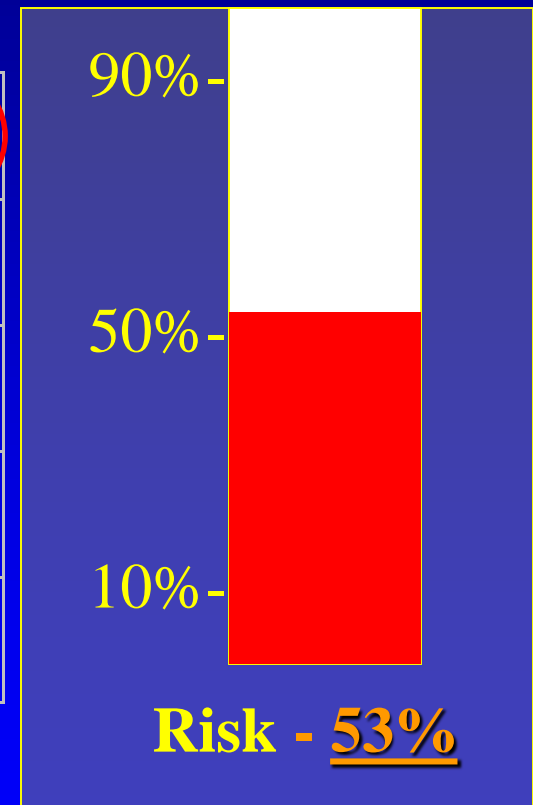
Examine Higher Speed – 35 mph

Urgency Presentation

Higher Delta-V

Delta V, Mph	35
Air Bag + Belt	Yes
Vehicle Weight, lb.	2500
Occupant Age	25
Occupant Gender	Male

Prediction



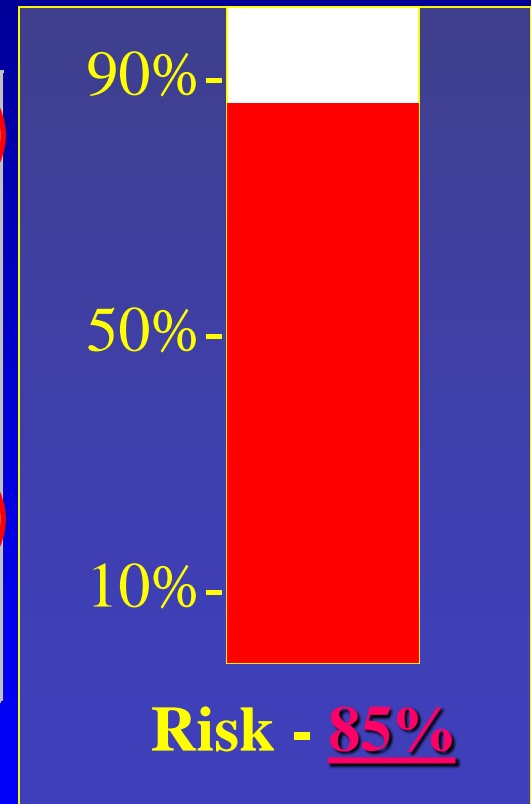
Examine Older Occupant – 70 YO

Urgency Presentation

Older Occupant

Delta V, Mph	35
Air Bag + Belt	Yes
Vehicle Weight, lb.	2500
Occupant Age	70
Occupant Gender	Male

Prediction



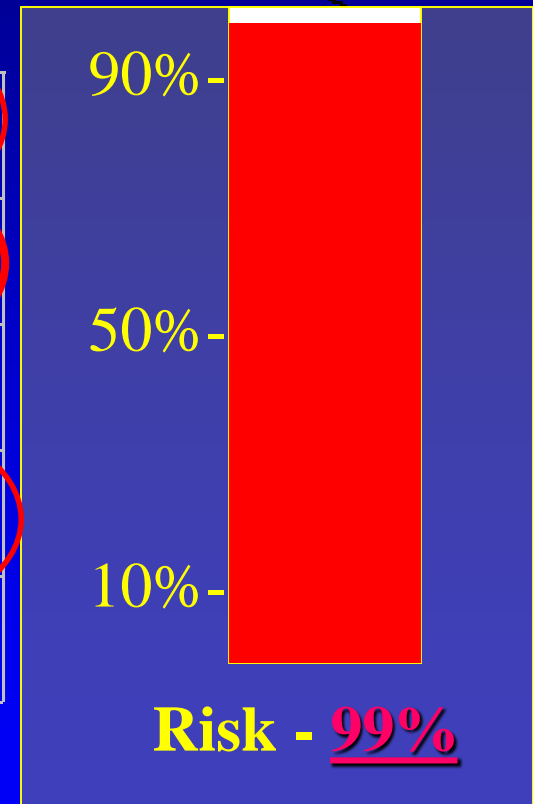
Examine Unrestrained Occupant

Urgency Presentation

No Restraint

Delta V, Mph	35
Air Bag + Belt	No
Vehicle Weight, lb.	2500
Occupant Age	70
Occupant Gender	Male

Prediction



Validation of Urgency Algorithm

- Validation for Frontal Crashes with Air Bags
- Reported at 19th ESV Conference
- Paper by Augenstein, and Digges
- Accuracy using 4, 5, 6 and 7 Predictors

Baseline Predictors –

o Frontal Crashes

o Air Bag + Safety Belt

+ 4 Predictors

- Delta-V
- Vehicle Weight
- Occupant Age
- Occupant Gender

Urgency Algorithm Accuracy

4 Predictors

<u>Predictors</u>	<u>No Injury</u>	<u>AIS 3+ Injury</u>
Baseline (4 Predictors)	52%	61%

Percent Correct Predictions

Urgency Algorithm Accuracy 5 Predictors

<u>Predictors</u>	<u>No Injury</u>	<u>AIS 3+ Injury</u>
Baseline	52%	61%
Pole Crashes	59%	71%

Percent Correct Predictions

Added Factor for Pole Crashes

Urgency Algorithm Accuracy 6 Predictors

<u>Predictors</u>	<u>No Injury</u>	<u>AIS 3+ Injury</u>
Baseline	52%	61%
Pole Crashes	59%	71%
Multiple Impacts	73%	83%

Percent Correct Predictions

Added Factor for Multiple Impact Crashes

Urgency Algorithm Accuracy 7 Predictors

<u>Predictors</u>	<u>No Injury</u>	<u>AIS 3+ Injury</u>
Baseline	52%	61%
Pole Crashes	59%	71%
Multiple Impacts	73%	83%
Close-in Occupants	94%	95%

Percent Correct Predictions

Added Factor for Close-in Occupants

Summary

Test Condition

% of MAIS 3+ Injuries Predicted

- 4 Predictor URGENCY 61%
- 5 Predictor URGENCY 71%
- 6 Predictor URGENCY 83%
- 7 Predictor URGENCY 95%

Applications of ACN + URGENCY

NHTSA Field Operational Test

850 Vehicles

Erie County, New York State

Crash Locator Map from NHTSA ACN Field Operational Test

NHTSA/Calspan Automated Collision Notification System

File View Agencies Locate Incident Help

504

Crash Information

Time of Crash:
 Crash Date: 11/19/98
 Crash Time: 1:56:00 PM
 Elapsed Time: 0 days 00:01:52

Impact Details:
 Lat/Long: N 42 56' 12.88" W 78 42' 19.44"
 Position Error: 1.08 m

Final Resting Position:
 Left Side
 Rollover

Change in Velocity = 38 mph

504: 4905 Genesee St., Erie FIRE DISTRICT: Hy-View

Communications

Vehicle	Fax	Voice	Call status	Hold	Prerec
Cheektowaga Police	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
Cheektowaga Fire	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
ECMC	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
Manual Dial:	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
Manual Dial:	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>

Vehicle Information - 7164802923

Vehicle	Owner	Likely Occupants
Make: Ford		
Model: Taurus		
Color: Blue		
Year: 1994		
Plate: 123456		

Incident:504 Thursday November 19 1998, 1:56:52 PM

URGENCY Display from NHTSA ACN Field Operational Test

NHTSA/Calspan Automated Collision Notification System

File View Agencies Locate Incident Help

504

Crash Information

504: 4905 Genesee St., Erie FIRE DISTRICT: Hy-View

Time of Crash

Crash Date: 11/19/98
Crash Time: 1:55:00 PM
Elapsed Time: 0 days 00:06:03

Impact Details:

Lat/Long: N 42 56' 12.88" W 78 42' 19.4"
Position Error: 1.08 m

Final Resting Position:
Left Side
Rollover

Change in Velocity = 38

Post Crash Algorithm: Injury Probability

File Data Help

Vehicle / Crash Data

Clear Data RollOver: Yes
Crash Delta V (mph): 38
Side Damage, Passenger Compartment: No
Rear Damage: No
Curb Weight (lbs): 3200

Occupant Data

Clear Data Seat Belt Used: No
Age: 30
Gender: Female
Entrapment: No
Complete Ejection: No

Incident ID: 504

Estimate of Injury Probability

100%
50%
0%

89%

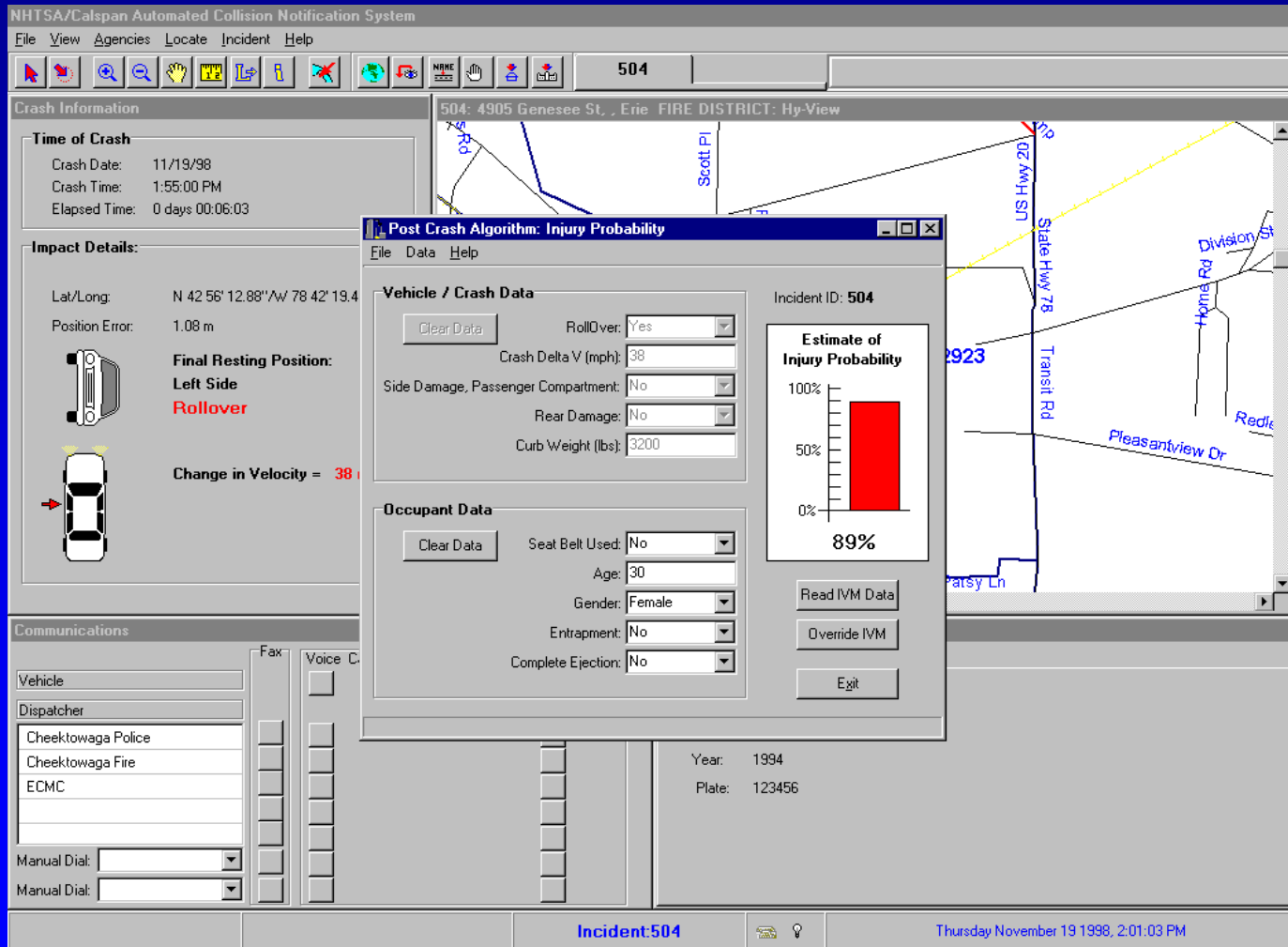
Read IVM Data
Override IVM
Exit

Year: 1994
Plate: 123456

Vehicle
Dispatcher
Cheektowaga Police
Cheektowaga Fire
ECMC

Manual Dial:
Manual Dial:
Fax:
Voice C:

Incident:504 Thursday November 19 1998, 2:01:03 PM

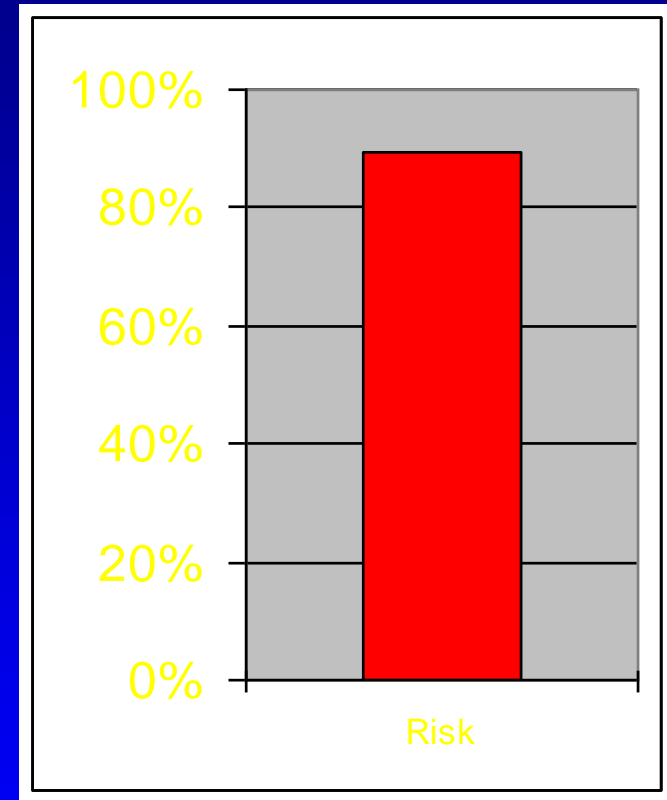
The screenshot displays the NHTSA/Calspan Automated Collision Notification System interface. The main window shows crash information for incident 504, including the date and time of the crash (11/19/98 at 1:55:00 PM) and the location (4905 Genesee St., Erie). A map in the background shows the crash site at the intersection of State Hwy 78 and Transit Rd. A pop-up window titled 'Post Crash Algorithm: Injury Probability' is open, displaying vehicle and occupant data. The vehicle data includes a roll-over status of 'Yes', a crash delta V of 38 mph, and a curb weight of 3200 lbs. The occupant data shows a 30-year-old female with no seat belt use. The algorithm estimates an 89% injury probability, shown as a red bar in a graph. The interface also includes a communications section with a list of agencies (Cheektowaga Police, Cheektowaga Fire, ECMC) and a status bar at the bottom showing the incident number and date/time.

Results of NHTSA ACN + URGENCY Field Operational Test

- The URGENCY Algorithm detected all but one minor AIS 1 (minor) Injury.
- The Crash Detection time averaged less than 1 minute, with none more than 2 min.
- Numerous deficiencies in the infrastructure were reported.

Conclusions

- URGENCY algorithm can be used to augment conventional Triage methods.
- Reduced time, and more accurate triage = lives saved.
- Extensions to alert EMS of specific occult injuries are possible.



SUSPECT LIVER INJURY

Risk

89%

Many thanks to BMW
for sponsoring this
paper!!



The End

Questions?