Post-Crash Injury Control
The Public Safety Component of the Information Superhighway

Briefing for Dr. Ricardo Martinez, Administrator,
National Highway Traffic Safety Administration

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by Multidisciplinary Multi-Institutional Research Team

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Introduction

- Prehospital deaths are an increasing problem requiring urgent national attention.

- Until recently the overall number of deaths from automobile crashes in the United States has declined for nearly a decade, only increasing again since 1992.

- The number of deaths from automobile crashes occurring prior to emergency care has nearly doubled since 1977. Between 1992 and 1996, there was over a 20% increase in prehospital pretreatment deaths in automobile crash occupants.

- Prehospital interventions may have reduced the rate of increase, but have not resulted in any absolute reduction in prehospital deaths.

- From a global perspective, it is predicted by the World Health Organization, Harvard School of Public Health and the World Bank, that road traffic crashes will be the second leading global public health problem by the year 2020, accounting for over 1.4 million deaths per year, up from the current figure of 999,000, and 9th in global impact.

Current Research Findings--Medical and Engineering Analysis of Crash Data

This project was motivated not only by the very alarming statistics as noted above, but also by an increasing intolerance in the managed care environment for overtriage of patients to trauma centers following automobile crashes. Using the NASS and MTOS databases, the researchers performed over 500 analyses to relate the crash information to the severity and outcome of injured automobile crash occupants. "Compelling Injuries" were defined as the new gold standard dependant variable for triage studies. Methods are being developed to assess marginal outcome and economic gain (or loss).

The researchers have found, that within the limits of the current applications of technology, only marginal improvement on positive accuracy, sensitivity and specificity is likely to be achieved from improved triage algorithms. **However, substantial improvement in triage and prehospital emergency care may be achieved by rapidly integrating emerging technologies and informatics to the problems related to crash notification, identification response and selection of emergency care needs.**

Comment

Private industry and consumer-based applications of technologies, if focused and resourced, can rapidly provide automobiles with a "black box" technology to collect and store the crash imprint, together with vehicle identification, seat belt use, air bag deployment, occupant size and weight and instantly transmit the information, together with GPS location, to local emergency services. Crash imprint (including the direction, force and velocity of the crash and forces applied to the human body) can be used to predict injury probability, location and severity of injuries, and thus summon emergency medical and other resources that might be needed. Ultimately, human factors such as eye movement (to detect when the driver is falling asleep, etc.) can also be incorporated. Accurate triage and treatment could result in substantial reduction in prehospital and inhospital mortality from automobile crashes. It could also reduce the cost of emergency care by virtue of accurate matching of resources with needs and focused care delivery.

Current prehospital response times in urban areas are 35 minutes between estimated time of crash and arrival in hospital. In rural areas, this figure is approximately 55 minutes. Mortalities are significantly higher in rural areas where identification that a crash has occurred, location of crash, alerting of the emergency medical services, accurate triage, early treatment and effective matching of patient need and available health care resources, are all challenged. It has been estimated that a 9 minute reduction in the prehospital time could result in saving approximately 3,000 lives per year. Other researchers feel that implementation of emerging technologies to a program of post-crash injury control as part of the Intelligent Transport System, could save up to 10,000 lives a year, and begin to impact on the alarming increases in prehospital deaths from automobile crashes.

- Technologies and treatments are at hand to influence prehospital deaths from automobile crashes and to systematically study and improve prevention, treatment and rehabilitation for these patients.

- Changes in the Federal Informed Consent Rules together with focus on improved resuscitation (both fluids and pharmacologic) will result in substantial testing of new and early treatments for injured patients.

- An absolute prerequisite for evaluation of emerging technologies and treatments is a firm and knowledgeable foundation of existing practices and causes of death and disability so that case mix differences can be controlled for and valid scientific evidence marshaled behind potential products.

- The temporal cycle of issues such as air bags can be substantially shortened by quality data and quality data management in combination with firm scientific methodologies and metrics for measuring change. By providing these foundations, the Department of Transportation is in a timely and unique position to profoundly affect public safety into the next century.

- Multidisciplinary teams, such as the one involved in this project, are fundamental to such progress. The identification of compelling injuries, i.e. those that need trauma center care, as a part of this project, is an example of such science.

- Multidisciplinary crash investigation is the foundation for the way forward. The crash must be studied in terms of its medical consequences and potential for intervention. Multidisciplinary teams, such as the four in existence and the three being established, need to be vigorously resourced and widely available, by incremental implementation State by State.

- This "new" multidisciplinary scientific discipline will have lasting benefits not only for automobile crash trauma patients but also for many other types of emergency illnesses and personal safety and security.

Recommendation

The researchers propose that:

1. A major program in post-crash injury control be initiated as a matter of urgency, as part of the Intelligent Transport System and as the Public Safety Component of the Information Superhighway, funded from the Highway Trust Fund and in response to widespread request for greater emphasis on safety.

2. Funding immediately be made available to provide metrics and analysis of existing data so that the magnitude and characteristics of the problem of early death and resource-need mismatch can be fully characterized.

Research Questions/Needs

A. The development of methodologies and metrics and completion of tasks that:

1. Establish a comprehensive baseline understanding of post-crash prehospitalization events. This requires:
   1) continuation of the multidisciplinary research team to provide leadership,
   2) detailed analysis of existing data, and
   3) augmentation of existing data resources.

2. Enable scientifically robust studies which will allow estimation of the impacts of technologies, triage and treatment improvements in post-crash prehospital emergency care, as well as impacts of policy change, e.g., air bags deployment.

3. Establish the causes of death in the timelines between crash and demise.

4. Establish the threshold of severity, complexity and urgency that require trauma center care and/or more intense prehospital treatment.

5. Analyze at risk subsets, e.g. the elderly, children, rural area casualties, casualties other than car accidents, such as pickup-truck occupants, pedestrians, cyclists and motorcycles.

6. Profile and evaluate casualty patterns and the development of geographic, demographic and exposure (travel, travel conditions) profiles and their temporal relationship to crash severity and emergency response process and outcome.

B. Establish an incremental approach to crash investigation, based on:

1. Expanded role of existing crash investigation sites,

2. Leadership, uniformed methodologies and compatibility within the existing CIREN group,

3. A rapid advancement into other states.

Post-Crash Injury Control
Briefing for Dr. Martinez, Administrator, NHTSA

Drs. Champion, Cushing, Digges, Hunt (ACEP), Larkin (ACEP), Malliaris, Sacco, and

NHTSA's Lou Lombardo

3/27/97

Today's Situation:
Vehicle Crashes (1995 data)

- Preventable Death & Disability from:
- 19,769 Deaths/yr at Scene
- 21,740 Deaths/yr After Pre + Hospital Care
- ~2,000,000 Disabling Injuries/yr

Growing Global Problem

World wide Automotive Crashes

1 million deaths per year

Global Health Problem No. 2 by 2020

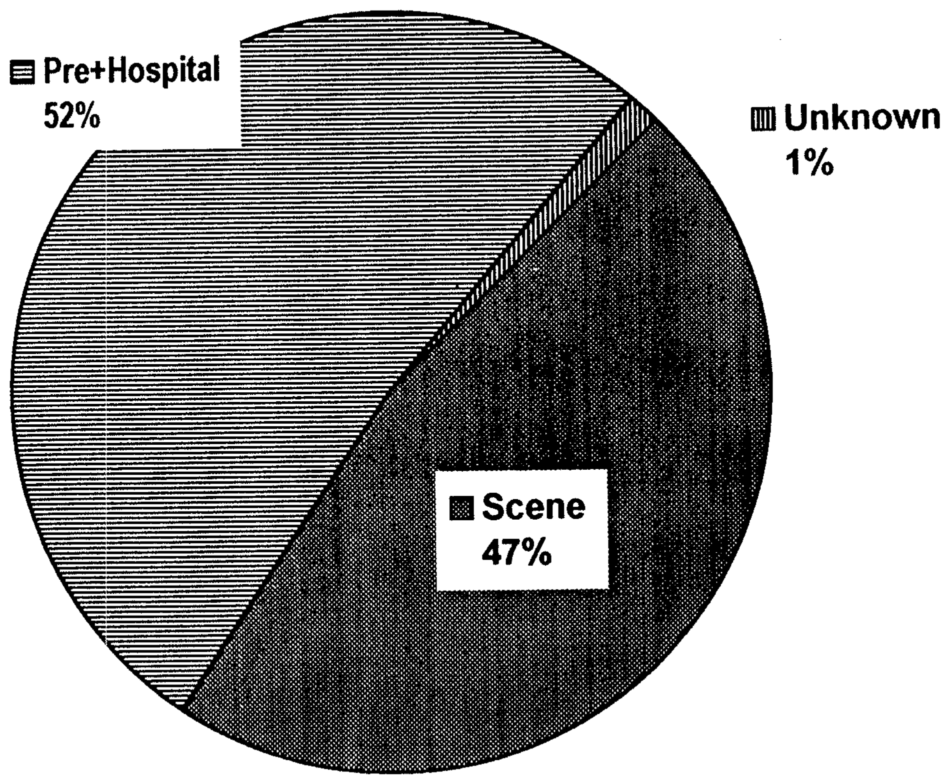
Where Are We Today?

The Medical Community, Operating
With More Time and Information
Could Save ~10,000 Lives/yr

Fatalities in Crashes by Location (1995 FARS)

- 23,899 “Rural” Roads (57%)
- 16,907 “Urban” Roads (40%)
- 992 Unknown (3%)

Location of Crash Deaths



Average EMS Response Times, Urban & Rural (1995)

Time of Crash to Hospital Arrival:

- 15,608 Urban Fatal Crashes:

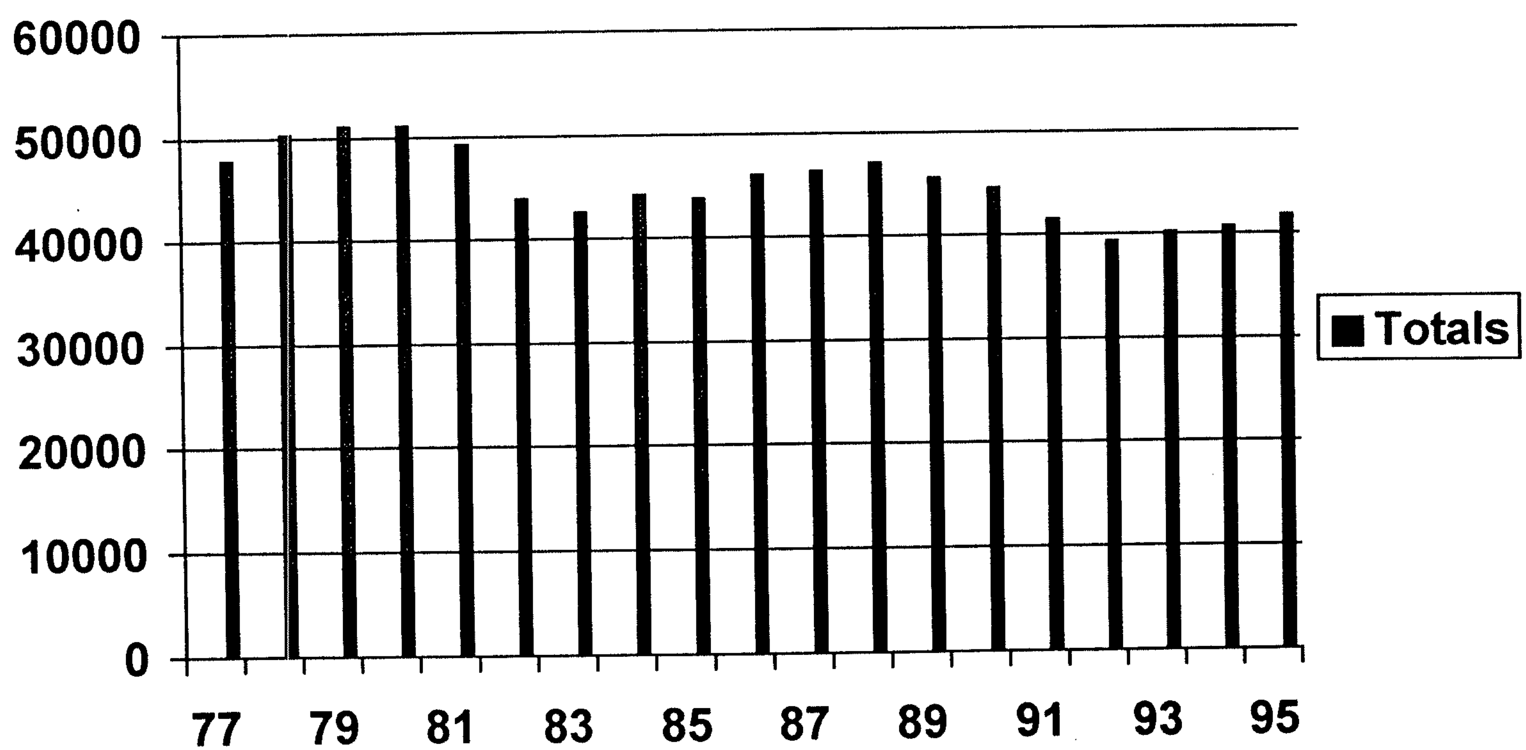
  35.21 minutes (73.2% Unknown)

- 20,712 Rural Fatal Crashes:

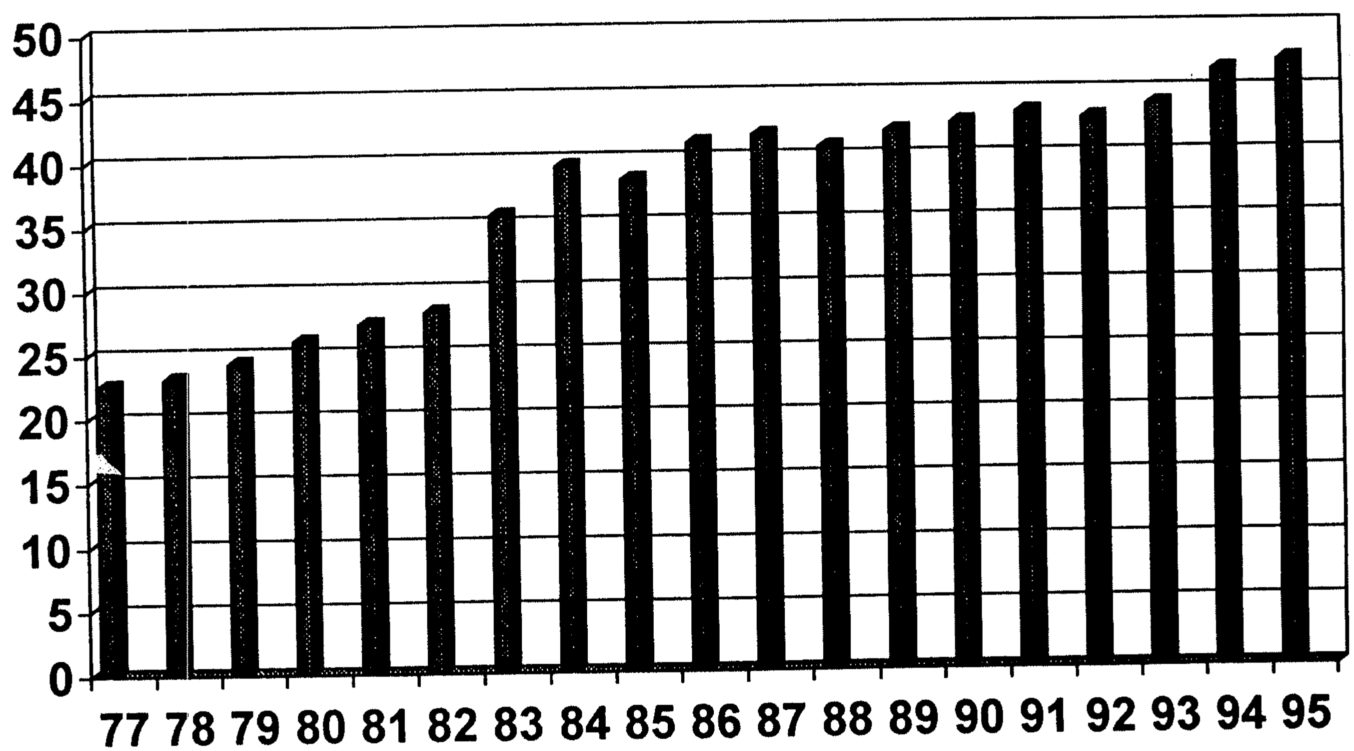
  52.95 minutes (70.3% Unknown)

Annual Motor Vehicle Fatalities

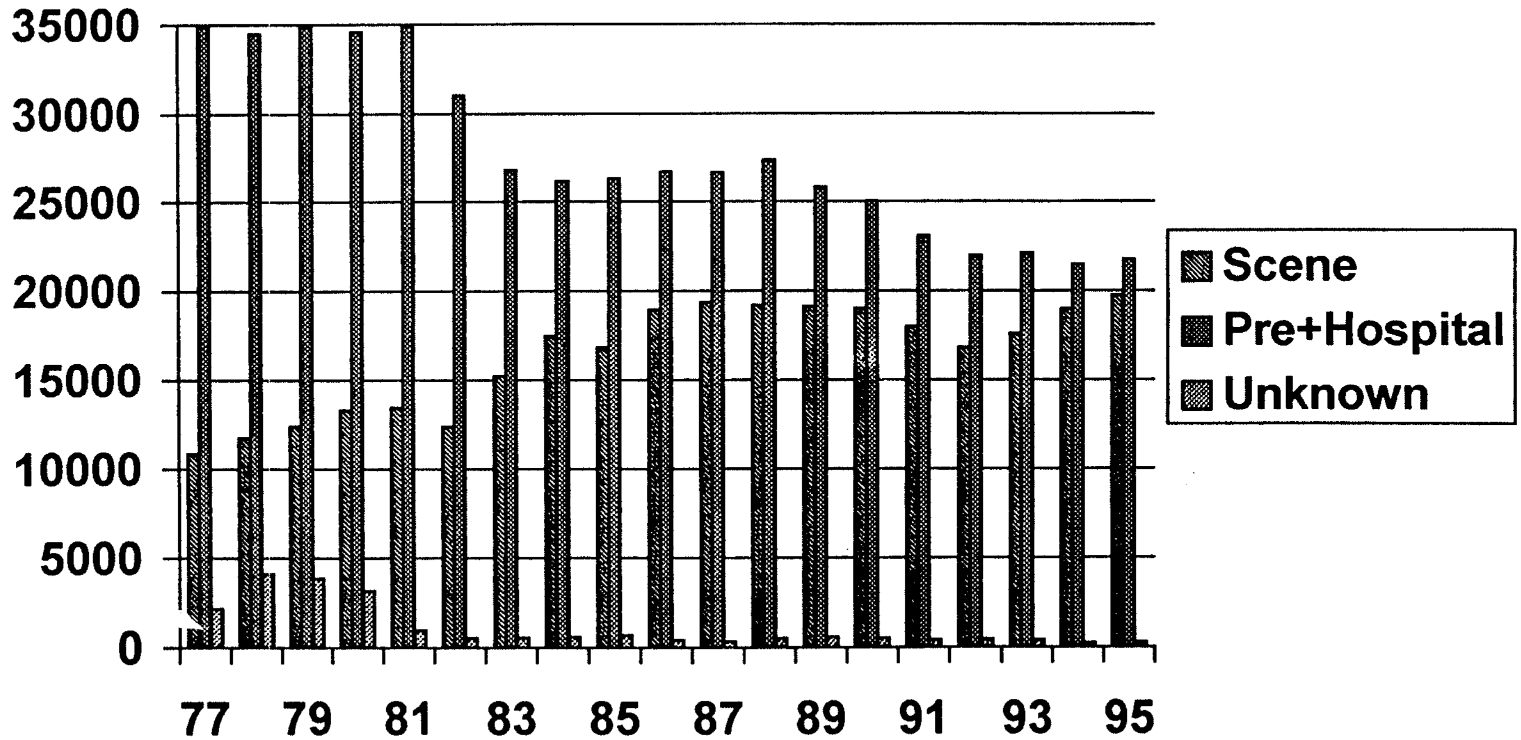
(FARS)



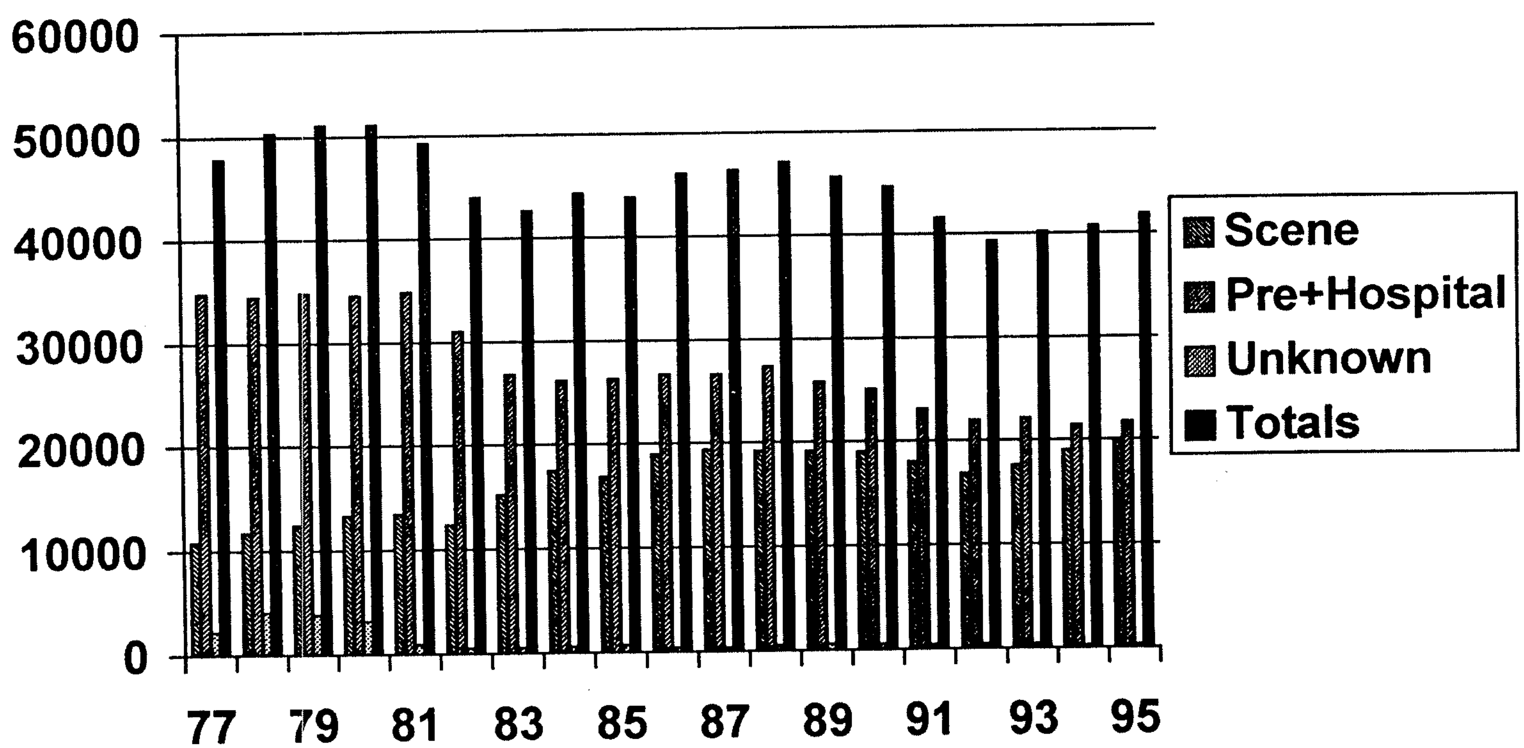
Percent Deaths at Scene Before Pre + Hospital Care (FARS)



Deaths at Scene vs. Deaths of Taken to Hospital (FARS)



Deaths at Scene vs. Deaths of Taken to Hospital (FARS)



20 Year Trends in Post-Crash Deaths

- Total Deaths Declined by ~10,000/year
- Deaths Pre-, In, & Post-Hospital:

  Decreased by >10,000/year
- Scene Deaths:

  Doubled to ~20,000/year

Injuries More Occult

- More People Protected by Belts & Bags
- Fewer “Tell Tale” Signs of Crash Violence
- External Injury Mitigation
- New Injury Complexes
- Higher Speed Crashes, More Occult Injuries
- Mistriage

Emergency Health Care

- External Environment:

  Managed Care

- Internal Environment:

  Resource-Need Mismatch

New Injury Patterns

- Belts & Bags > Appearance of No Injury
- Increased Potential of Fatal Misjudgements
  - Patients & Other Motorists
  - Police
  - EMS
  - Nurses
  - Physicians

EMS Job Is Increasingly Difficult

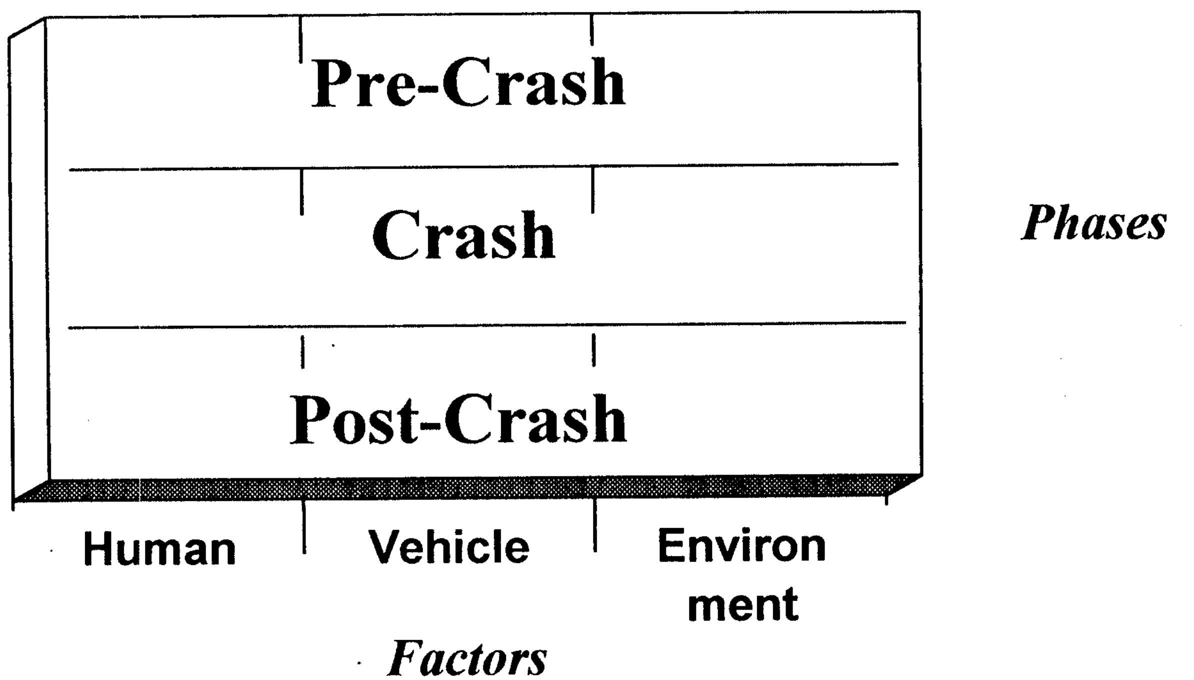
- Problem: Which Patients Require Special Care for "High Suspicion of Internal Injuries"?
- As more and more people are protected by air bags and/or safety belts, internal injuries will be more difficult to detect (less frequently accompanied by external injuries).
- Triage, transport, and treatment decision-making will be subject to more uncertainties and, therefore, result in more errors.

Where Do We Want To Go?

Smarter, Faster, More Cost/Effective
Emergency Care

Post-Crash Injury Control

Haddon Matrix



Post-Crash Injury Control

Injury Control

- Crash Avoidance
- Crashworthiness &
- ***Post-Crash Injury Control***

Focus:

- Growing Problem of Pre-Hospital Deaths
- Disabilities

Post-Crash Injury Control

Goals:

- Major Reductions in Deaths & Disabilities
- Use Emerging Informatics & Therapies
- Deliver Definitive Care Faster
- Improve Pre-Hospital Care

Post-Crash Injury Control

RDT&E Program

- Analyses to Define Current Baseline
- Research, Development , Testing & Evaluation of Technologies e.g. ACN
- Measure Effectiveness in Hospital Studies
- Develop Continuous Improvements in Care

Opportunities

- Earlier Notification & Alert
- Precision Response:
  - Location
  - Level of Care
- EMS Research:
  - Precision Triage
  - New Therapies

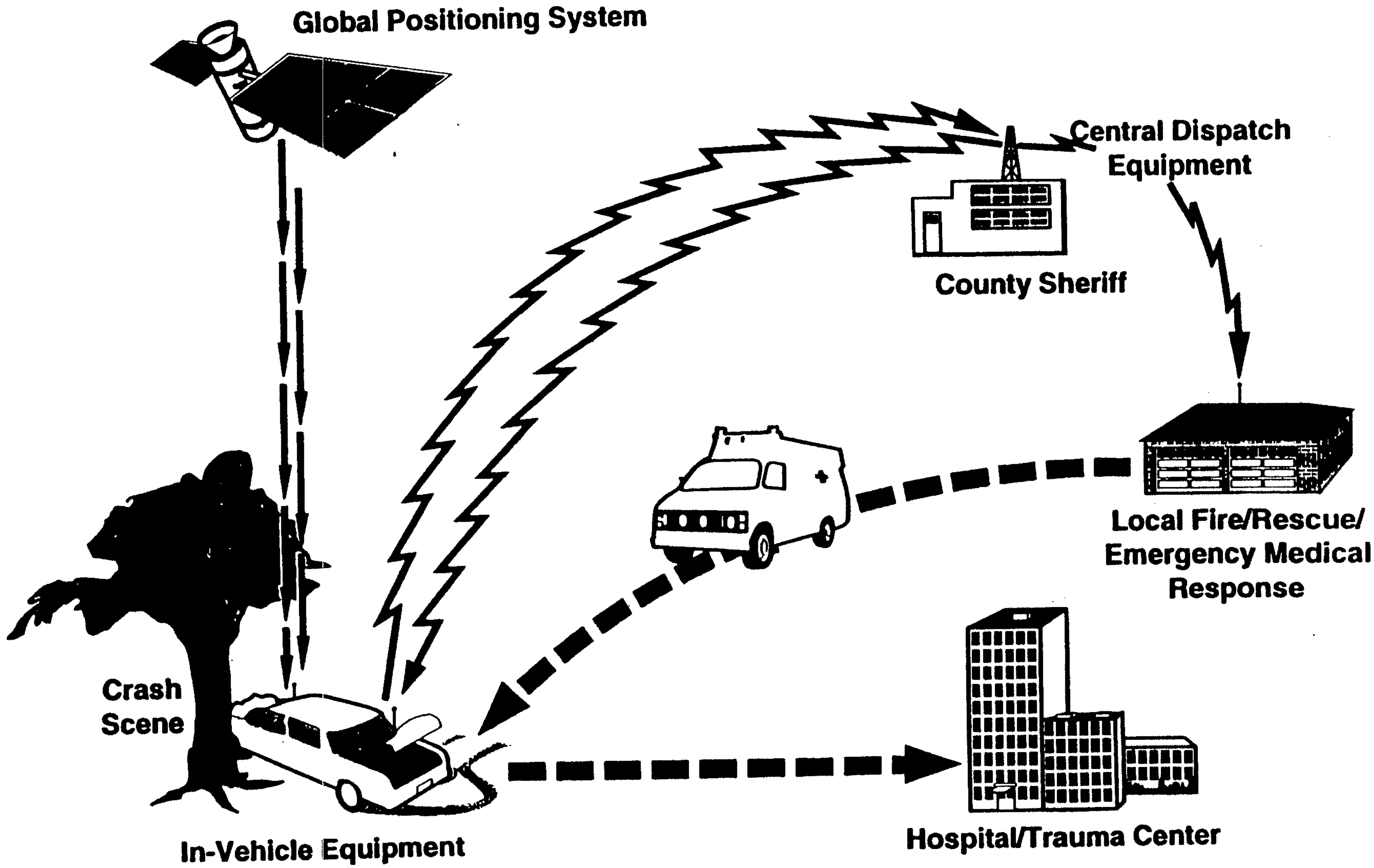
Advanced Emergency Care System

Intelligent Transport Systems Deliver Safety:

- Whenever & Wherever Americans Are In Danger,
- In Time to Save Lives, Prevent Mistriage & Treat Injuries.
- Set International Gold Standard

How Do We Get There?

Apply Automatic Life-Saving Technologies, Information, & People in RDT& E programs and Educate for Continuous Improvements in Crash Patient Care


Global Positioning System
Central Dispatch Equipment
County Sheriff
Local Fire/Rescue/ Emergency Medical Response
Crash Scene
In-Vehicle Equipment
Hospital/Trauma Center

When Every Second is a Matter of Life or Death

1. Automatically Communicate Information:

- Location of Crash
- Crash Severity
- Injury Probability/Severity

2. Computer Software for Faster & Smarter

- Triage, Transport & Treatment Decisions

Finding Golden People in the Golden Hour

Low Urgency Crashes:

- ~26 million crashes/year (~20 mil PDO)
- ~5 mil injury crashes/year (4.5 mil MAIS 1)

High Urgency Crashes :

- ~500,000 people hospitalized each year
- ~ 200,000 Seriously Injured each year
- ~42,000 Fatalities/year (5 Deaths/hour)

Scanning for Golden People With Information

Where are they at anytime 24 hours/day?:

- Anyplace ~4 million miles of roads

Who will get them?:

- 50,000 ambulances, ~500 helicopters

Will they get to the right care, in time?:

- ~5,000 hospitals, 350 Trauma Centers

Automatic Collision Notification

Several New Systems With Differing Features

- NHTSA/Calspan Demonstration

  (Only 1,000 cars for only one year, begins 1997)

- GM Onstar in some 1997 Cadillacs

  (Air Bag Deployment Only)

- Ford RESCU on some 1997 Lincolns

  (Not ACN, Push Button)

- Mercedes etc.

Automatic Collision Notification 1997 Market Demand Poll

- 48% of car buyers said Auto 911 Dialing safety equipment is “important” or “very important” in their buy decisions.
- 57% want Front Air Bags

Source: Dohring Co., Automotive News, 2/10/97, p. 56

Post-Crash Injury Control Project

- Improve Emergency Decision-making on:
  * Triage
  * Transport: Where to? & How to?
  * Treatment
- By Using Crash Information
- Instantly Transmitted, &
- Computerized Decision Support

Post-Crash Injury Control Project Tasks

- Create Medical Panel
- Develop Multi-Disciplinary* Review Process
- Conduct Data Analyses
- Perform Reviews by Medical, EMS, & NHTSA
- Achieve Algorithm Consensus
- Facilitate National Acceptance

* EMT's, Nurses, Emergency Physicians, Trauma Surgeons, Engineers

Medical & Engineering Analyses

Crash Data Sources:

National Accident Sampling System (NASS)

- Database of > 100,000 crash investigations '79 -'95
- Nationally Representative Sample (~5,000 cases/yr)

Fatal Accident Reporting System (FARS)

- Census of Crash Fatalities on Public Roads since 1977

Analyses, Briefings & Reviews:

- Several Hundred Statistical Analyses
- 16 Briefings & Reviews

Current Triage Guidelines

Reviewed Mechanism of Injury:

- Ejection
- Crush >20 inches
- Intrusion > 12 inches

Finding:

- For Major Improvements We Need Automatic Collision Notification & Communication of Crash Information

Improve Decisionmaking with Information

Information Automatically Communicated:

- ACN > Better Dispatch Decisions
- ACN + Scene Data >

  Better Triage, Transport Decisions &
  Better Pre-Hospital Treatment
- Data @ Hospital > Better Treatment

Makes Possible A Data System For Continuous Improvements In Prevention, Treatment & Rehabilitation of Crash Injuries

Crash Signal Information

NHTSA/Calspan ACN System Data:

- Delta V
- Principal Direction of Force (PDOF)
- Rollover Indicator/Counter
- Travel Speed
- Vehicle Data (VIN Related)
- *2-Way Voice Communications*

Crash Signal Information

Future ACN Systems Potentially Additional Data:

- Belt Use & Type by Position
- Occupant Presence & Position
- Driver Age, & Health (Smart Card)
- Air Bag Deployment

Progress To Date

Quantified Probabilities of Injuries by:

- Delta V & PDOF
- Rollover
- Age
- Belt Use
- Compelling Injuries
- Cummulative Effects of Multiple Injuries
- Many Scene & Other Variables

Compelling Injuries

AIS 3+'s that Need Trauma Center Care:

- 35,000/yr Surviving, Towaway Car Occ's
- 20,000/yr Fatalities, Towaway Car Occ's
- 140,000/yr Compelling Injuries (Car Occ's)

Multiple Injuries

Quantified Multiple Injuries & Risk of Death:

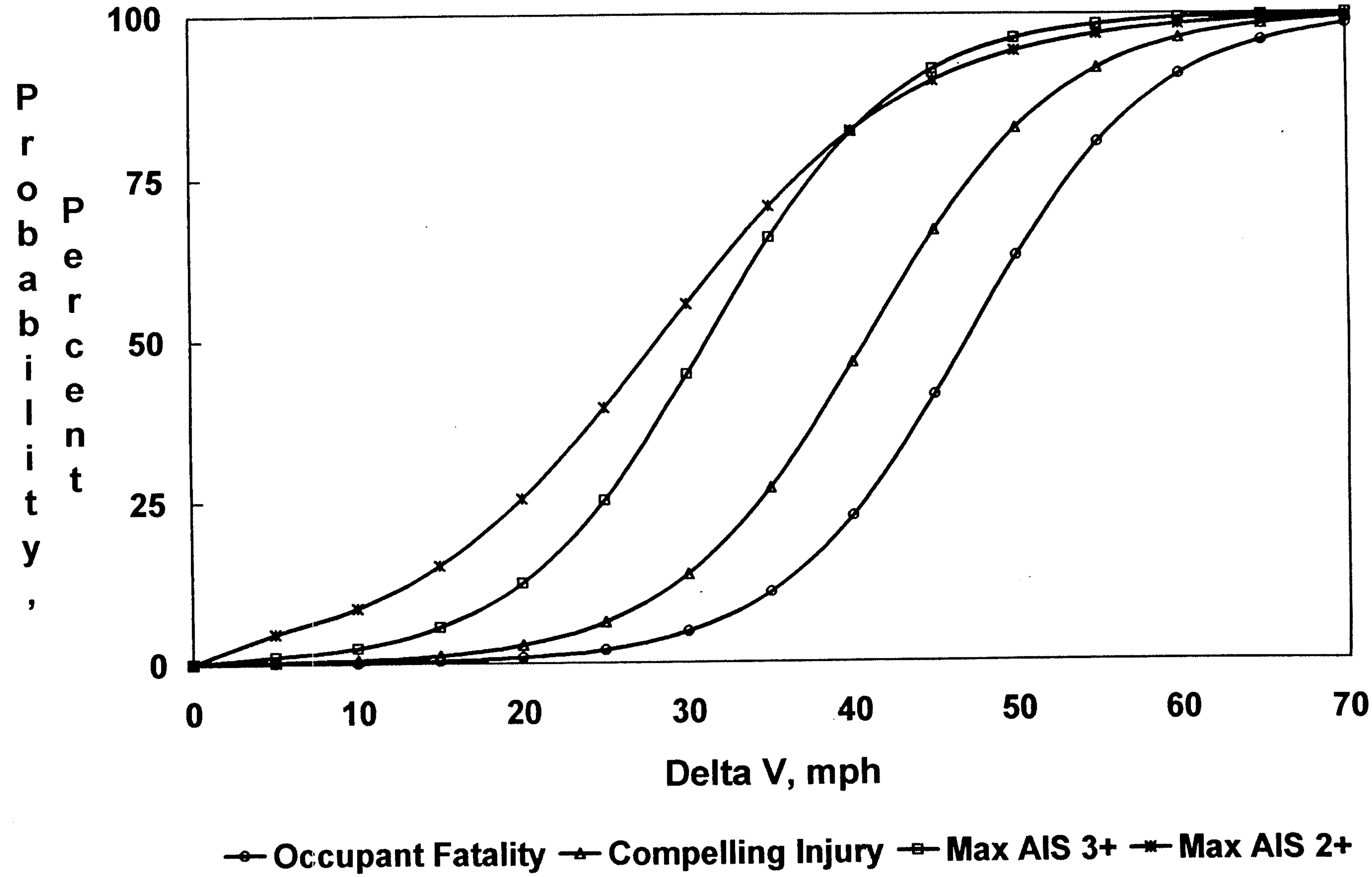
- >50% of fatalities have > 8 injuries
- 3 MAIS 3's worse than 1 MAIS 4

ACN Decision Progress To Date

Results:

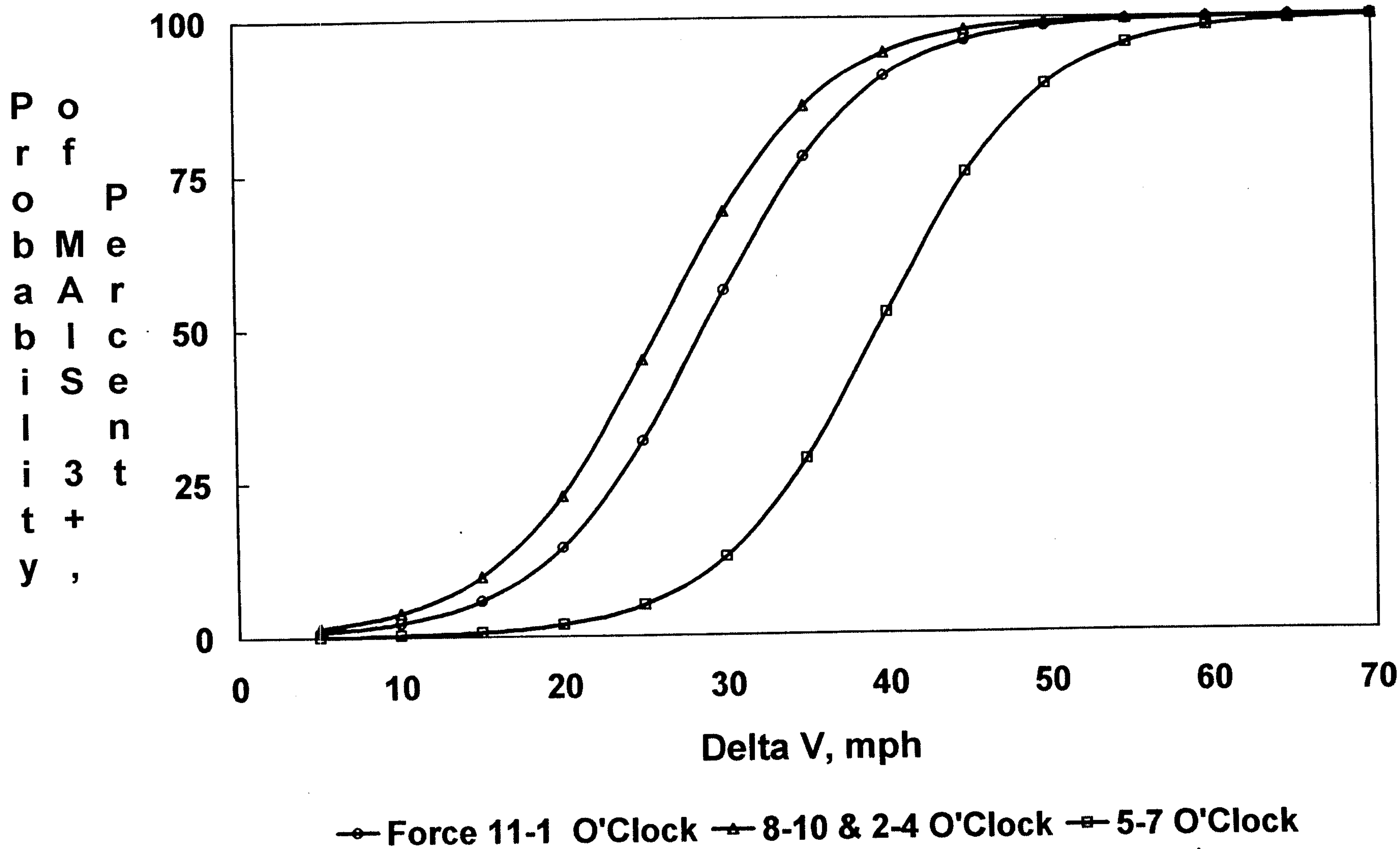
- Created the basis for Triage Software 1.0
- Triage Software 1.0 can be incorporated on a vehicle based chip and on computers at Hospitals and Emergency Dispatchers

Fig. 1 Probability of Shown Outcome, as a Function of Car Crash Severity



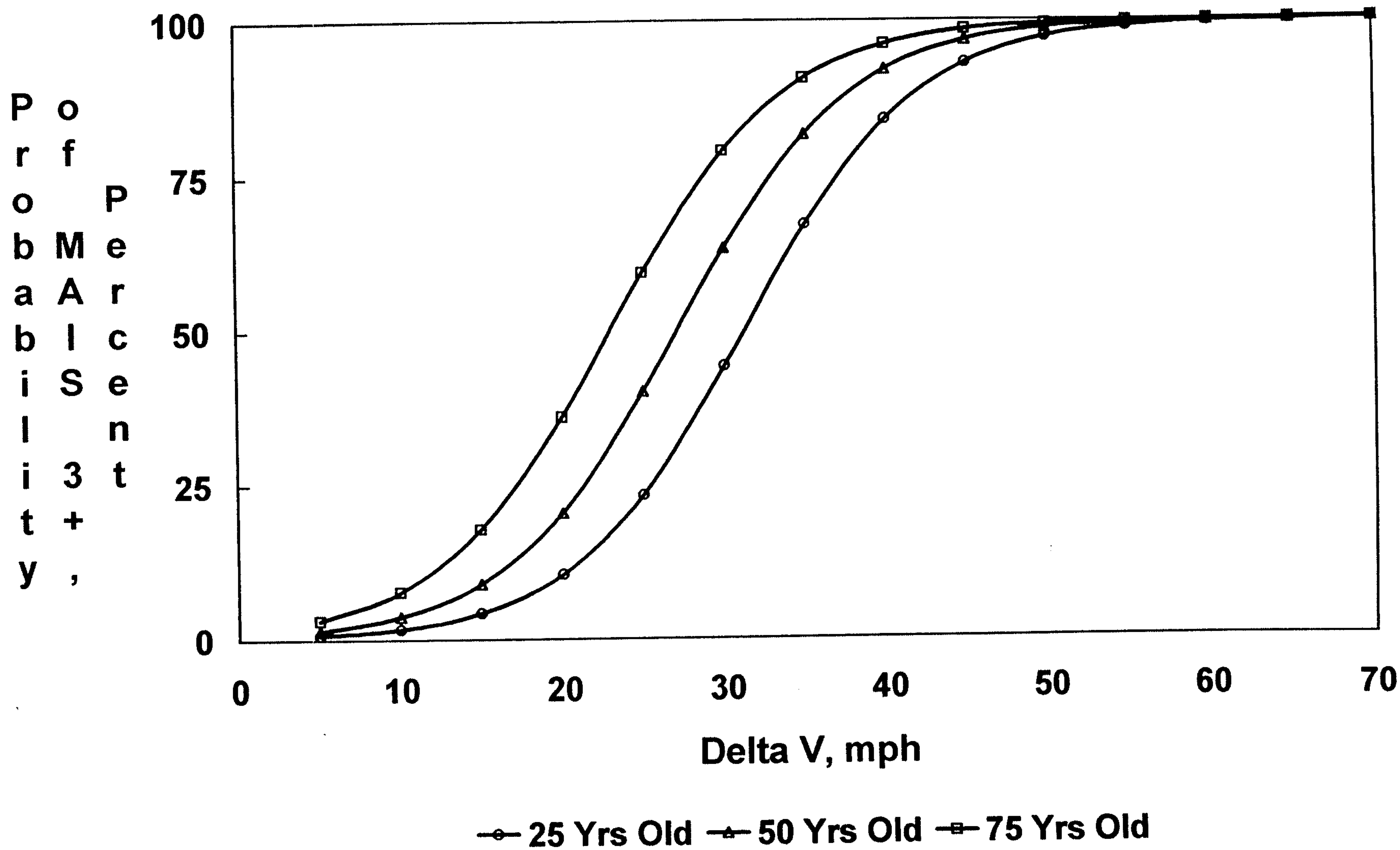
The NASS/CDS 1988-1995

Fig. 2 Sensitivity of Compelling/Max AIS 3+ to the Direction of Force, as a Function of Car Crash Severity



The NASS/CDS 1988-1995

Fig. 3 Sensitivity of Compelling/Max AIS 3+ to an Occupant's Age, as a Function of Car Crash Severity



The NASS/CDS 1988-1995

Fig. 4 Increase of Compelling/ MAIS 3+ Probability over Shown Base, Due to Shown Influences

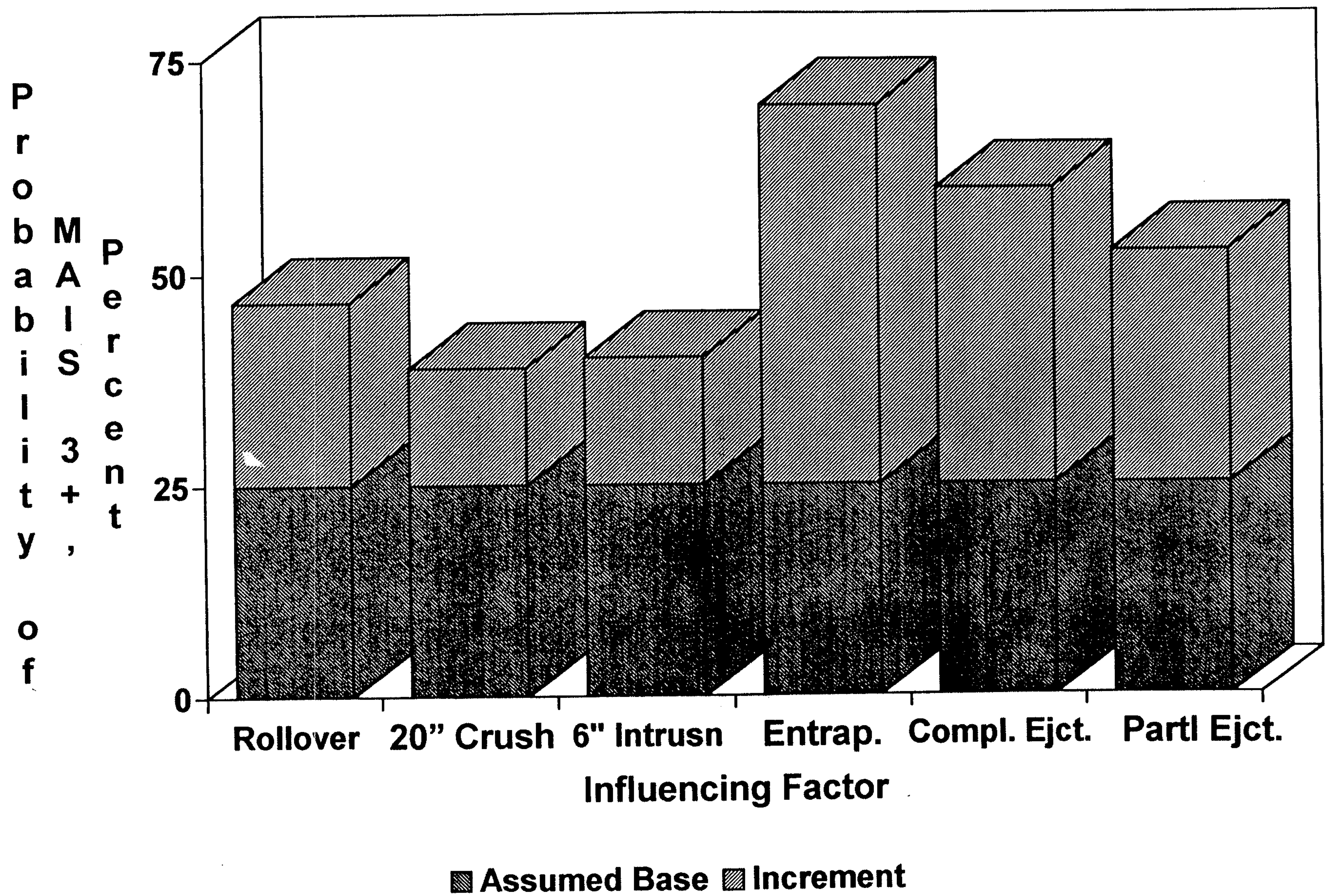


Table I(E), & Relation (11)

NHTSA/Calspan ACN
"~5 mph Delta V" Crashes

Initial Indicator: "Low" Urgency

Out of the 26 million vehicles in crashes/year, automatically identifies 5 mph DV crashes:

- 20 million crashes/yr, 0.01% of which have 2,000 MAIS 3+ injured people
- Voice, Police, or EMS if Necessary

NHTSA/Calspan ACN
"~10 mph Delta V" Crashes

Initial Indicator: "Moderate" Urgency

Out of the 26 million vehicles in crashes/year, automatically identifies 7-12 mph crashes:

- 3 million crashes/yr, 0.3% of which have 10,000 MAIS 3+ injured people
- Voice, Police, or EMS if Necessary

NHTSA/Calspan ACN
"~15-25 mph Delta V" Crashes

Initial Indicator: "Serious" Urgency

Out of the 26 million vehicles in crashes/yr, automatically identifies 15-25 mph crashes:

- 3 mil. crashes/yr, 2% of which have 58,000 MAIS 3+ injured people
- Voice, Police, EMS or Helicopter

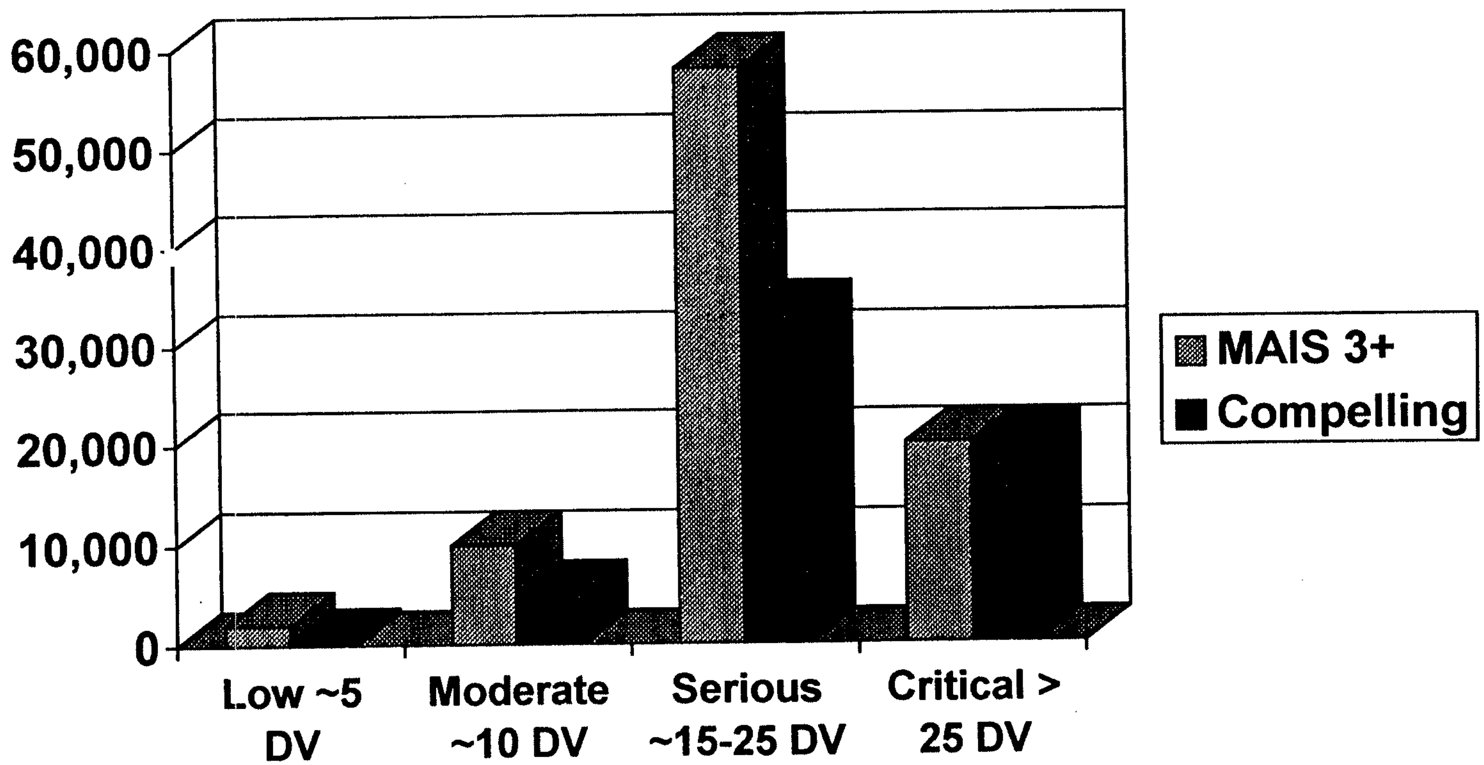
NHTSA/Calspan ACN ">25 mph Delta V" Crashes

Initial Indicator: "Critical" Urgency

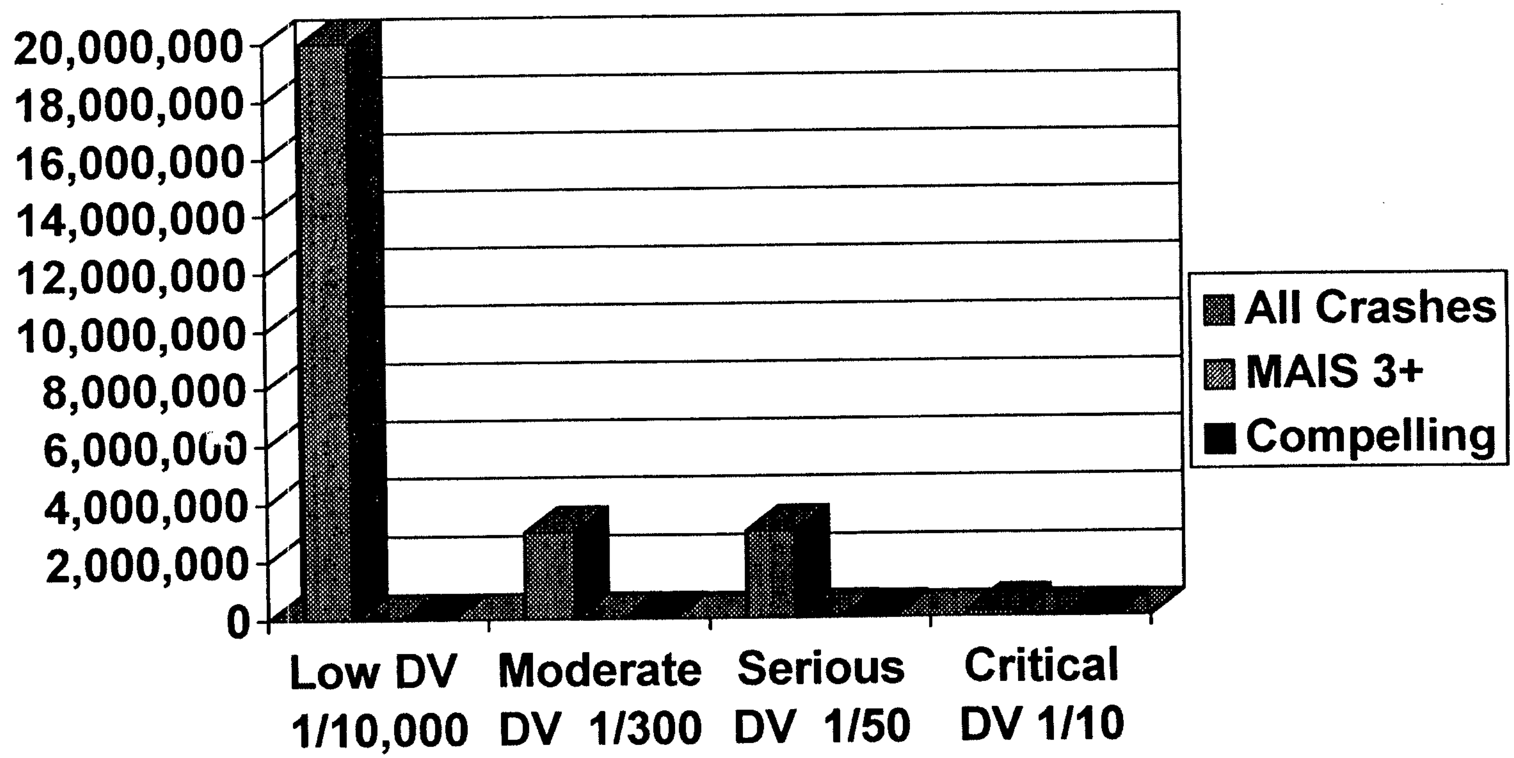
Out of the 26 million vehicles in crashes/year, automatically identifies >25 mph crashes:

- 200,000 crashes/yr, 10% of which have 20,000 MAIS 3+ injured people
- Voice, Police, EMS or Helicopter

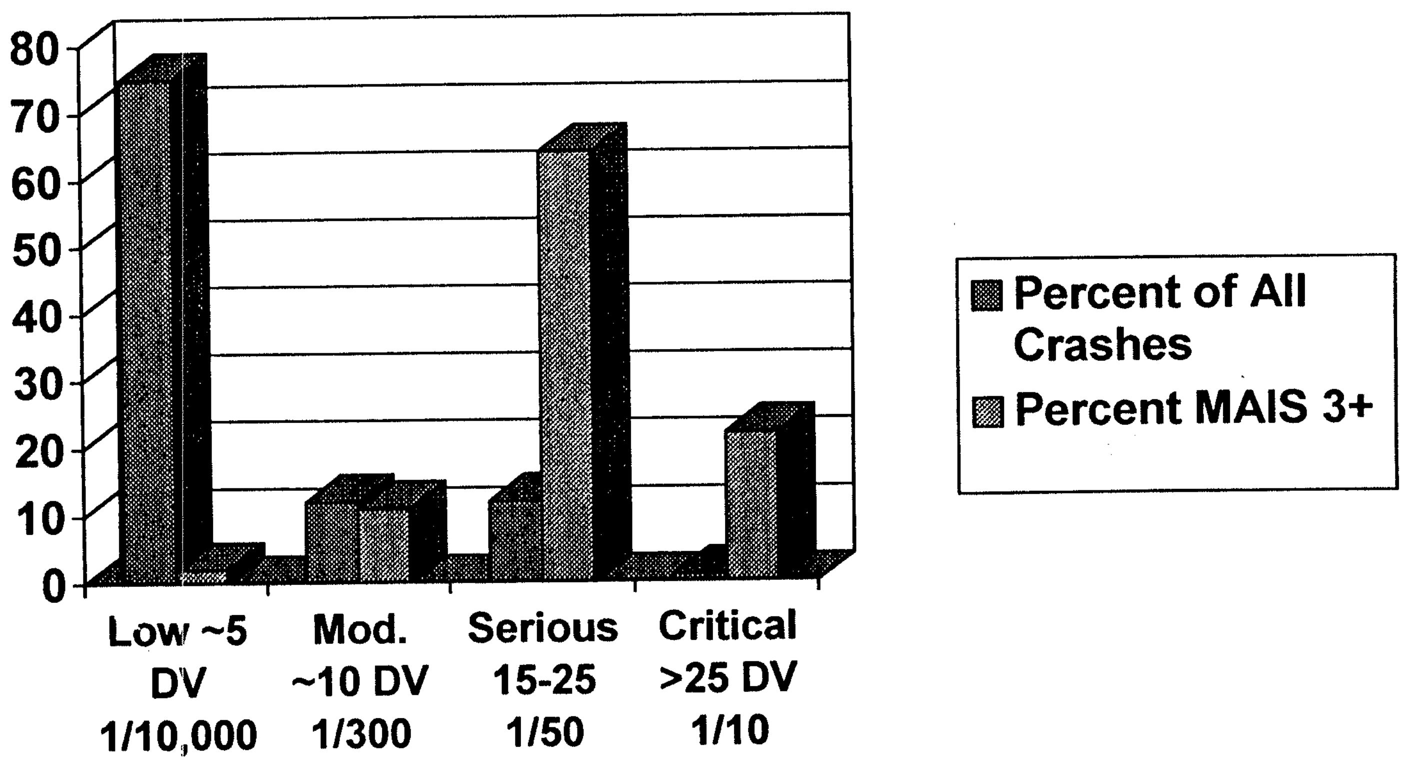
Initial Classification of Crash Urgency: Seriously Injured People



Initial Classification of Crash Urgency: Crashes vs. Seriously Injured People



Initial Classification of Car Crash Urgency: Crashes vs. Seriously Injured People



NHTSA/Calspan ACN
Finds & Classifies Crashes Fast

Automatic Decision Aids:

- Delta V >>> Initial Classification by Probabilities
- PDOF >>> Instantly Refines Injury Probabilities
- Rollover >>> Further Refines Probabilities
- Travel Speed > Additional Risk Indicator
- Vehicle Data (VIN Related) > May Adjust Risk

Interactive Decision Aid:

- 2-Way Voice Communications

Estimated ACN Benefits
Without Triage Algorithm

Fatality Reduction Estimates for ACN:

- 5 min. reduction ~= 1727 Lives Saved/Year
- 7 min. reduction ~= 2394 Lives Saved/Year
- 9 min. reduction ~= 3069 Lives Saved/Year

Source: Evanco, W.M., Reducing Accident Fatalities With Rural Mayday Systems, April 1996, Mitretek, McLean, VA, Sponsor: FHWA

Preventable Deaths

- ~10,000 Deaths per Year
- ~ 27 Deaths per Day

* Estimate with Automatic Lifesaving Technologies fully deployed.

* Benefits from ***Informed*** ACN Technologies:
Reductions in Occult Injury Deaths,
Fewer Rural Fatalities, &
Fewer Preventable Mortality Deaths

Post-Crash Injury Control Benefits

- Automatic Life-Saving Technologies for ***Instantaneous & Informed*** Triage, Transport, & Treatment Decisions
- Data for Continuous Improvements in Prevention, Treatment and Rehabilitation
- Major Reductions in Mortality & Morbidity
- Major Savings in Emergency Costs

Savings

- Reduced Deaths
- Reduced Disabilities
- Economic & Human Cost Savings:

  ~$50 Billion/yr

“L” Chip - “L” for Life Saver

The “L” Chip will enable American motorists to reduce the devastating human and economic consequences that violent crashes on US roads cause to themselves, their families, their friends, and society.

Next Steps

- Triage Algorithm Development
- NHTSA Reviews
- Triage Software Programming
- Software Demonstration & Deployment
- Medical Review & Acceptance

Action Plan

Public Safety Component of the Information Superhighway

- Develop a Post-Crash Injury Control Program
- Establish a New Discipline for Crash Care Development
- Develop Methodologies and Metrics for Evaluation of New Technologies & Treatments
- Analytically Define Current Baseline of Care
- Proceed with R&D in Post-Crash Care