CICAS-V RESEARCH ON COMPREHENSIVE COSTS OF INTERSECTION CRASHES

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ABSTRACT

This paper addresses the question: What are the economic and non-economic consequences associated with crashes at intersections in the United States? The paper estimates the magnitude of the safety problem that may be mitigated by reducing violations of traffic signals and stop signs using communication technologies to convey information between the infrastructure and vehicles. The work reported in this paper is part of the U.S. Department of Transportation's (USDOT) Cooperative Intersection Collision Avoidance Systems (CICAS) program.

A methodology for estimating target populations associated with intersection-area crashes is presented and illustrated through its application to CICAS program areas. Using a combination of National Highway Traffic Safety Administration (NHTSA) crash databases, estimated counts were created and valued using established unit comprehensive cost values. The total annual comprehensive cost for police-reported crashes was estimated to be $300 Billion in year 2000 dollars, while comprehensive costs for the crashes in intersection areas was estimated to be $97 Billion annually. Comprehensive costs are broken down further to provide estimates for each of the CICAS programs. A full report containing additional details is forthcoming.

OBJECTIVE

Discussion of USDOT ITS program and CICAS

Through the Cooperative Intersection Collision Avoidance Systems initiative, the USDOT is working in partnership with the automotive manufacturers and State and local departments of transportation to pursue an optimized combination of autonomous-vehicle, autonomous-infrastructure and cooperative communication systems that potentially address the full set of intersection crash problems (USDOT, 2006). CICAS includes three programs that target improving major problem areas in intersection safety. CICAS-V (Violation) attempts to reduce crashes associated with failure to obey traffic signals and stop signs. CICAS-SLTA (Signalized Left Turn Assist) attempts to assist drivers making left turns across oncoming traffic at traffic signals. CICAS-SSA (Stop Sign Assist) attempts to help drivers waiting at stop signs to safely navigate through cross traffic.

Development of Comprehensive Costs for CICAS-V related crashes

In support of CICAS development, there is the need to estimate the size and nature of crash populations potentially targeted by CICAS–V deployment. One of the initial activities associated with this effort is the estimation of the comprehensive costs associated with crashes within the broadest CICAS target population, crashes at intersections.

DISCUSSION OF COMPREHENSIVE COSTS

This paper documents the process and results from applying comprehensive cost estimates from the NHTSA report, Economic Impact of Motor Vehicle Crashes, 2000, "EI", (Blincoe, et al., 2002) in conjunction with crash statistics extracted from several NHTSA crash databases.

Definition of Comprehensive Costs

Two types of costs are presented in the NHTSA EI report – "Economic" costs and "Comprehensive" costs. The total economic cost associated with all motor vehicle crashes was reported as $230 Billion in year 2000 dollars. The analysis presented in this report focuses on the comprehensive costs which are not directly comparable to the NHTSA-reported $230 Billion economic cost value. Comprehensive costs include additional dollar values for other consequences of crashes such as pain and suffering and loss of life.

The EI report provides estimates of annual crash incidence, injury severity distributions, and unit costs associated with motor vehicle crashes in 2000. Information from tables 3 and A-1 from the report was used in this analysis. They show the incidence by crash and injury severity level, and unit costs by crash and injury severity level. Significantly, unreported crashes (i.e. crashes that would not be represented in the NHTSA crash databases) were included. Also, property damage only (PDO) crash frequencies were calculated based on previous insurance-based studies.

These two factors should be noted when making comparisons of crash incidence estimates.

Scope of Application

This paper applies the EI report in conjunction with NHTSA crash statistics extracted from the Fatality Analysis Reporting System (FARS), National Automotive Sampling System (NASS) General Estimates System (GES) and Crashworthiness Data System (CDS), to provide annual comprehensive costs for all police-reported crashes and for the subset of "intersection-area" crashes, consisting of intersection and intersection-related crashes. The intersection-area crash population is then separated by association with applications under each CICAS program. It is important to note that this analysis only considers impacts associated with all police-reported crashes, while the NHTSA EI report also estimates impacts associated with unreported crashes.

Attribution of costs to severity of injury / Required Data

The EI cost methodology estimates comprehensive costs for a given crash population based on counts in four categories:

- Fatalities
- Injured Persons
- Non-Injured Persons in Injury Vehicles
- Property Damage Only (PDO) Vehicles

Costs associated with injured persons are assigned based on the level of injury, as measured by the Maximum Abbreviated Injury Scale (MAIS) injury severity rating. Costs for the other categories are calculated based on a unit cost per person (fatalities, non-injured persons) or per vehicle basis (vehicles sustaining property damage only).

From the EI report, the unit comprehensive costs in Table 1 apply (in year 2000 dollars):

Table 1: Unit Comprehensive Costs from Blincoe et al. (2002), in year 2000 dollars

Category	Per	unit cost
PDO vehicle	Vehicle	$2,532
MAIS-0	person (in injury vehicle)	$1,962
MAIS-1	Person	$15,017
MAIS-2	Person	$157,958
MAIS-3	Person	$314,204
MAIS-4	Person	$731,580
MAIS-5	Person	$2,402,997
Fatality	Person	$3,366,388

PROCESS OF ESTIMATING CRASH FREQUENCY AND INJURY CONSEQUENCES

Availability of U.S. national databases and contents (CDS, GES, FARS)

Since unit comprehensive costs from the EI report vary primarily on the severity of occupant injury on the MAIS scale, application of suitable crash databases was necessary to provide frequency counts that correspond to the units used. Figure 1 illustrates the overlap in coverage between CDS, GES, and FARS, the three databases used in this analysis.

CDS (~5,000 samples) provides a high level of information on injuries sustained by occupants of passenger vehicles which are towed from the crash scene. CDS cases are analyzed by a trained crash investigator and involve significant post-crash follow-up. CDS includes a MAIS rating for each occupant; thus data for an injured occupant captured by CDS corresponds directly to the unit cost methodology. However, while CDS provides a good representation of outcomes for passenger vehicles in tow-away crashes, CDS lacks representation of many other crash victims and crash types and therefore does not have the ability to provide a complete estimate.

GES (~50,000 samples) provides a cross section of police-reported crashes and can yield nationwide estimates of frequency counts of various crash outcomes. GES cases are coded based solely on information present in the police accident report (PAR). Therefore, the more detailed injury information used to code a MAIS rating is absent. Instead, GES uses a KABCO scale based on the assessment in the PAR. This necessitates the use of a translator to relate injury severity as indicated by the KABCO to the MAIS scale.

FARS (non-sampled) consists of a census of all fatal crashes on public roads, and therefore provides the most accurate set of information to count fatalities. Typically, fatal crashes receive a more involved investigation, but the injury coding in FARS is based on the KABCO scale as in GES. For non-fatal injuries in fatal crashes, a translator is needed to relate injury severity to the MAIS scale.

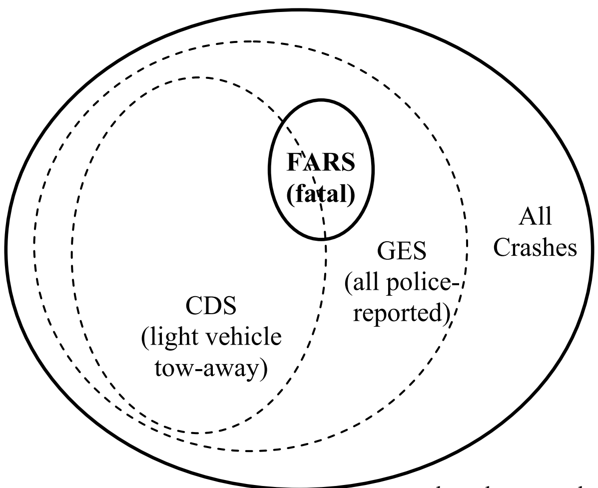


Figure 1: Crash Database Coverage and Overlap

Combining CDS, GES, FARS

Each database is able to provide different detail and has its own limitations. For this analysis, CDS is used for its ability to show distributions of MAIS injury severity levels. FARS is used for its completeness in coverage of fatal crashes. GES is used as an overall representation of the police-reported crash population, but does not attempt to estimate unreported crashes.

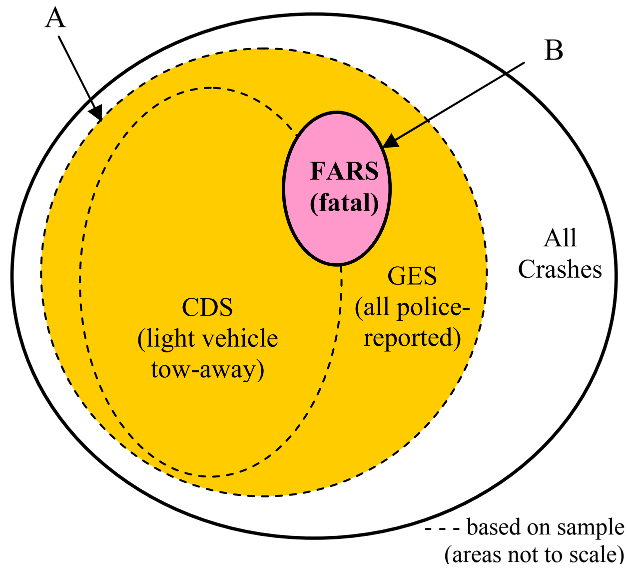
Since GES and FARS use the KABCO scale rather than the MAIS scale, CDS cases were used to estimate the distribution of injuries based on cases that met the CDS inclusion criteria, while the non-CDS-applicable population utilized a KABCO-MAIS translator (Blincoe, 1994), which provides estimates of MAIS distribution based on a KABCO distribution. This categorization allows the application of CDS to focus on a more accurate distribution of injury severities within the injured persons category based on available data, while total counts are derived from GES and FARS. It should be noted that one limitation in using the translator is that the intersection crash distribution being examined for this work may not necessarily match exactly with the original population used for the translator (all crashes); however, the translator is the best currently available means of relating the injury scales.

Averages across three years (2001-2003) of CDS data were used in conjunction with GES and FARS data from 2003. Table 2 lists the information and source used to obtain total comprehensive costs for each crash stratification:

Table 2: Values used in calculating comprehensive costs for police-reported crashes

Label in Figure 2	Information (for police-reported crashes)	Source
PDO VEHICLES:		
A	# of PDO vehicles in non-fatal crashes	GES
B	# of PDO vehicles in fatal crashes	FARS
PERSONS NOT IN PDO VEHICLES:		
C	# of fatalities	FARS
D	# of non-injured (KABCO O) in injury vehicles involved in fatal crashes	FARS (fatal crashes)
E	# of injured (KABCO ABC) in injury vehicles involved in fatal crashes	FARS (fatal crashes)
F	# of non-injured (KABCO O) in non-CDS injury vehicles (non-fatal crashes)	GES
G	# of injured (KABCO ABC) in non-CDS injury vehicles (non-fatal crashes)	GES
H	# of occupants of CDS-applicable injury vehicles (non-fatal crashes)	GES
I	% of occupants of CDS-applicable injury vehicles in each MAIS category	CDS

For PDO Vehicles:



For Injuries:

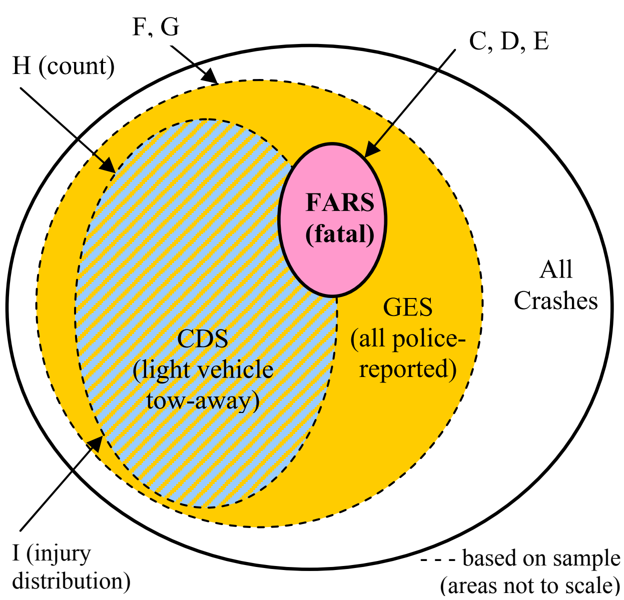


Figure 2: Sources of Data Components

INTERSECTION-AREA RESULTS

This section first reports the results of the various analyses based on FARS, CDS, and GES, and then develops an estimate for annualized totals representing impacts resulting from police reported crashes. All counts and dollar totals represent per-year estimates and are rounded and given to two significant figures; counts less than 100 are indicated as such. Note that totals may not sum exactly due to rounding.

FARS: Distribution of Persons involved in Fatal Crashes

Using FARS, the applicable annual counts were tabulated for crashes involving fatalities. To correspond to the EI methodology, fatalities were counted separately, and occupants of PDO vehicles were excluded from the count since they are counted at the PDO-vehicle level. Table 3 shows the count of persons by injury outcome.

Table 3: Estimated Annual Persons involved in Fatal Crashes (excluding PDO vehicles)

MAIS*	Persons involved in Fatal Crashes, excluding PDO vehicles	
	All Police-Reported Crashes	Intersection-area Crashes
0*[T]	6.5 K	2.0 K
1[T]	25 K	7.4 K
2[T]	6.3 K	1.7 K
3[T]	2.9 K	740
4[T]	460	110
5[T]	260	<100
FATAL	43 K	9.5 K

[T] MAIS values translated from KABCO scale
*Counts <u>exclude</u> occupants of PDO vehicles
Source: 2003 FARS
K - Thousands

CDS: Distribution of MAIS injury levels from CDS analysis

Based on an average of results from 2001-2003 CDS data, Table 4 shows the distribution of injured occupants in CDS-applicable vehicles by MAIS level, for the two crash stratifications. These distributions will be applied to the corresponding occupant count in GES in order to estimate the number of occupants at each MAIS level.

Table 4: MAIS Distributions for Injured in CDS-applicable vehicles

MAIS	Injury Severity Distribution in CDS-applicable Injury Vehicles	
	All Police-Reported Crashes	Intersection-area Crashes
0* (uninj)	19%	20%
1	71%	72%
2	6.5%	5.5%
3	2.5%	1.7%
4	0.55%	0.31%
5	0.29%	0.20%

*MAIS 0 (uninjured) counts <u>exclude</u> occupants of PDO vehicles
Source: 2001-2003 CDS

GES: Distribution of occupants of CDS-applicable injury vehicles involved in non-fatal crashes

GES was used to determine an overall count of occupants of CDS-applicable vehicles in which at least one occupant was injured, for non-fatal crashes. The injury severity distribution from CDS was then applied to the occupant counts to estimate the number of occupants at each MAIS severity level. Table 5 shows the results when the CDS injury severity distribution (from Table 4) is applied to the GES count of CDS-applicable occupants.

Table 5: Occupant Injury Severity for CDS-applicable injury vehicles in non-fatal crashes

MAIS	Occupants of CDS-applicable injury vehicles in non-fatal crashes	
	All Police-Reported Crashes	**Intersection-area Crashes**
GES Count	1.9 M	910 K
	Distributed based on Table 4**:**	
0* (uninj)	370 K	180 K
1	1.3 M	660 K
2	120 K	50 K
3	47 K	15 K
4	11 K	2.9 K
5	5.5 K	1.8 K

*MAIS 0 (uninjured) counts exclude occupants of PDO vehicles
Sources: 2001-3 CDS & 2003 GES
K - Thousands
M - Millions

GES: Distribution of Persons involved in non-fatal crashes, excluding CDS-applicable vehicles

The injury outcomes of all remaining involved persons were estimated based on GES data and involved the use of the KABCO-MAIS translator. Table 6 shows the distribution of involved persons after excluding fatal crashes, occupants of CDS-applicable vehicles, and PDO vehicles.

Table 6: Person Estimates based on GES (non-fatal crash, non-CDS vehicle, non-PDO)

MAIS*	Persons involved in non-fatal crashes, excluding CDS and PDO vehicles	
	All Police-Reported Crashes	**Intersection-area Crashes**
0* [T]	640 K	340 K
1 [T]	950 K	480 K
2 [T]	120 K	57 K
3 [T]	35 K	16 K
4 [T]	3.6 K	1.6 K
5 [T]	1.7 K	720

[T] MAIS values translated from KABCO scale
*Counts exclude occupants of PDO vehicles
Source: 2003 GES
K - Thousands

Summary Counts – Injured and non-injured persons

Table 7 shows the totals reflecting the sum of estimates based on FARS, GES, and GES (with CDS injury distribution) for which unit comprehensive costs apply on a per-person basis. These reflect the annual number of fatalities, non-injured persons in injury vehicles, and injured persons, and represent the combination of counts from Table 3 (fatal crashes), Table 5 (CDS-applicable injury vehicles), and Table 6 (others not already included).

Table 7: Total Combined Person Counts from FARS, GES, and CDS-distributed GES

MAIS*	Total persons involved in all police-reported crashes, excluding occupants of PDO vehicles	
	All Police-Reported Crashes	Intersection-area Crashes
FATAL	**43 K**	**9.5 K**
0*	**1.0 M**	**520 K**
1*	*2.3 M*	*1.1 M*
2*	*250 K*	*110 K*
3*	*85 K*	*33 K*
4*	*15 K*	*4.5 K*
5*	*7.5 K*	*2.6 K*
Total non-fatal Injured persons	**2.7 M**	**1.3 M**

*NOTE: MAIS values derived from GES and FARS are translated from KABCO scale; Counts exclude occupants of PDO vehicles
Sources: 2001-3 CDS, 2003 FARS, 2003 GES
K - Thousands
M - Millions

Summary Counts – PDO Vehicle Count

The count of PDO vehicles is one component used in determining the total comprehensive costs for each stratification. PDO vehicles involved in fatal crashes are counted based on FARS data. The remaining PDO vehicle count is drawn from GES for vehicles in non-fatal crashes. Table 8 summaries the PDO vehicles in each stratification.

Table 8: PDO vehicle counts from FARS and GES

Vehicle Category	Source	PDO Vehicles	
		All Police-Reported Crashes	Intersection-area Crashes
PDO Vehicle involved in fatal crash	**FARS**	*13 K*	*4.2 K*
PDO vehicle in non-fatal crash	**GES**	*8.9 M*	*4.0 M*
Total		**8.9 M**	**4.0 M**

Sources: 2003 FARS, 2003 GES
K - Thousands
M - Millions

Estimates of Comprehensive Cost - Intersection-Area

Using the combined counts from the three databases, the annual comprehensive costs for each stratification were estimated by applying unit comprehensive costs from the EI report. Table 9 shows the tabulations for each crash stratification. Overall, the annual comprehensive costs associated with all police-reported crashes is estimated at $300 Billion, and all intersection-area crashes totaling $97 Billion. These dollar amounts are represented in year 2000 dollars to remain consistent with the EI report.

Table 9: Tabulations of Comprehensive Costs

	All Police-Reported Crashes	Intersection-area Crashes
# of Crashes	6.3 M	2.6 M
# of Fatalities	43 K	9.5 K
× unit cost ($3,366,388)	**$140 B**	**$32 B**
# of Injured persons – MAIS 1	2.3 M	1.1 M
× unit cost ($15,017)	**$35 B**	**$17 B**
# of Injured persons – MAIS 2	250 K	110 K
× unit cost ($157,958)	**$39 B**	**$17 B**
# of Injured persons – MAIS 3	85 K	33 K
× unit cost ($314,204)	**$27 B**	**$10 B**
# of Injured persons – MAIS 4	15 K	4.5 K
× unit cost ($731,580)	**$11 B**	**$3.3 B**
# of Injured persons – MAIS 5	7.5 K	2.6 K
× unit cost ($2,402,997)	**$18 B**	**$6.3 B**
Total Non-fatal Injured persons	**2.7 M**	**1.3 M**
# of PDO Vehicles	8.9 M	4.0 M
× unit cost ($2,532)	**$23 B**	**$10 B**
# of Non-injured persons in Injury Vehicles (MAIS 0)	1.0 M	520 K
× unit cost ($1,962)	**$2.0 B**	**$1.0 B**
Total Comprehensive Cost	**$300 B**	**$97 B**

Sources: 2001-3 CDS, 2003 FARS, 2003 GES
K - Thousands
M - Millions
B - Billions

Overall, totals for intersection-area crashes represent approximately one-third of the total for all crashes. Crashes resulting in injury contribute nearly all of the total comprehensive costs. For all crashes, costs allocated to fatalities are associated with a slightly higher comprehensive cost than costs allocated to non-fatal injuries, with each category comprising nearly half of the total comprehensive cost. For intersection-area crashes, the costs allocated to injuries is more than half the total, while costs allocated to fatalities make up approximately one-third of the total.

RESULTS BEYOND INTERSECTION-AREA – DETAILS FOR POTENTIAL CICAS CRASHES

In order to better understand the potential target populations associated with CICAS countermeasures, it is necessary to examine the crash and cost statistics beyond the intersection-area level. These estimates were generated based on the previously discussed methodology; however, since CDS does not report within-intersection crashes separately from intersection-related crashes, the same injury severity distribution is applied for CDS-applicable vehicles in all intersection-area crashes.

Within-Intersection vs. Intersection-Related

Figure 3 reports comprehensive costs and fatalities associated with within-intersection and intersection-related crashes. Estimates in the following figures are reported to two significant figures, as before. Categories in which fatality counts are below 100 are reported as “<100”.

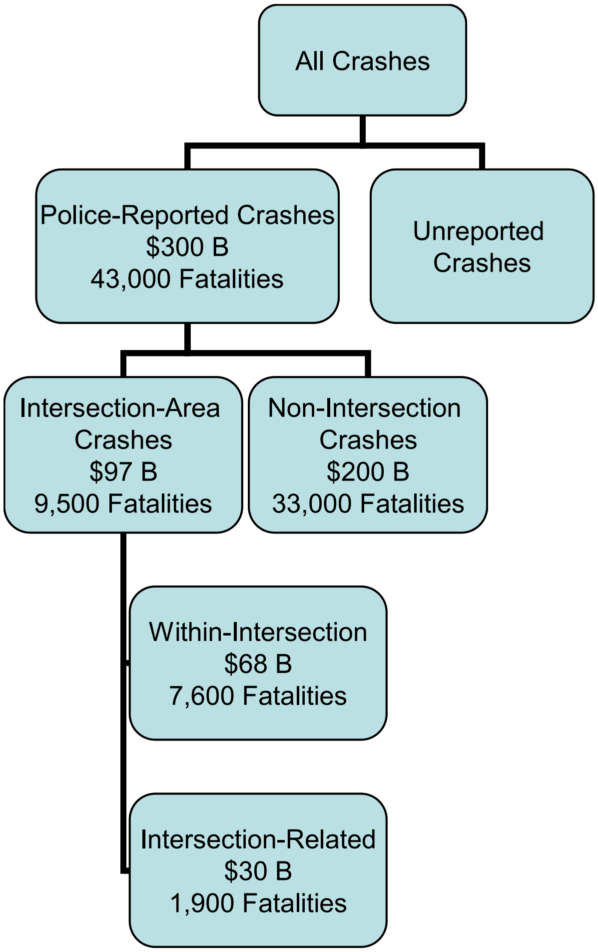


Figure 3: Within and Intersection-Related Costs & Fatalities

Detailed Classification by Governing Traffic Control

For both within-intersection and intersection-related crashes, the comprehensive cost and fatality estimates are reported by applicable traffic control device (traffic signal, stop sign, no applicable control, and other controls). Within the traffic signal and stop sign categories, consequences of crashes that are potentially associated with CICAS are separately identified, based on currently available information. These subcategories are described in Table 10; these categories are based in part on five common crossing path crash scenario classifications involving two or more vehicles (from Najm, et al., 2001, depicted graphically in Figure 4):

LTAP/OD: Left Turn Across Path / Opposite Direction (longitudinal)
LTAP/LD: Left Turn Across Path / Lateral Direction
LTIP: Left Turn Into Path
RTIP: Right Turn Into Path
SCP: Straight Crossing Path

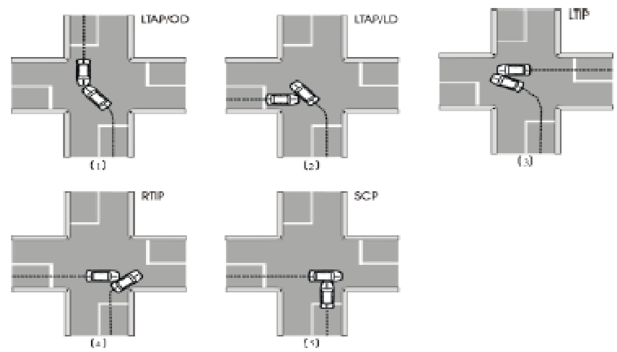


Figure 4: Common Crossing Path Crash Scenarios (from Najm et al., 2001)

Table 10: Description of Crashes potentially associated with CICAS Program Areas

Category Label in Figures	Traffic Control	Description of crashes*
V (Crossing Path Only)	Traffic Signal or Stop Sign Violation	Violation-related crossing path crashes
V (Non-Crossing Path)	Traffic Signal or Stop Sign Violation	Violation-related non-crossing path crashes
SLTA (LTAP/OD)	Traffic Signal / Longitudinal Gap	Non-violation-related LTAP/OD crashes
SLTA (Left Turn & Ped)	Traffic Signal / Longitudinal Gap	Non-violation-related single vehicle crashes involving a left-turning vehicle and a pedestrian/cyclist
SSA (4 Crossing Path Types)	Stop Sign / Lateral Gap	Non-violation-related SCP, LTAP/LD, LTIP, and RTIP (lateral) crossing path crashes

* Intersection-Area crashes may also be addressed through the Vehicle Safety Communications Application (VSCA) initiative.

The determination of a violation-related crash (discussed further below) is based on a combination of variables including police citations, contributing factors, and crossing path pre-crash scenarios. It should be noted that the different databases used have varying levels of information to support violation classification; the estimation based on the available information from each database has been presented here. In addition, violation-related crashes may also be addressed by more than one potential countermeasure. However, in these estimates, violation-related crashes are reported under CICAS-V so as to avoid counting crashes more than once. At intersections with multiple CICAS countermeasures, CICAS-V is expected to activate earlier in the vehicle's approach so that the driver has time to stop. CICAS-SLTA and CICAS-SSA are expected to assist drivers with safe gap acceptance when the vehicle is near the intersection.

The combination of within-intersection and intersection-related, intersection-area crashes, are shown in Figure 5. In the figures, the term "No Applicable Controls" refers to the FARS and GES code "No Controls". The term "No Applicable Controls" is used to clarify that the intersection is not necessarily an uncontrolled intersection, but that even if there were controls present they did not govern any of the vehicles involved in the crash. These crashes may potentially be addressed through the Vehicle Safety Communications Application (VSCA) initiative.

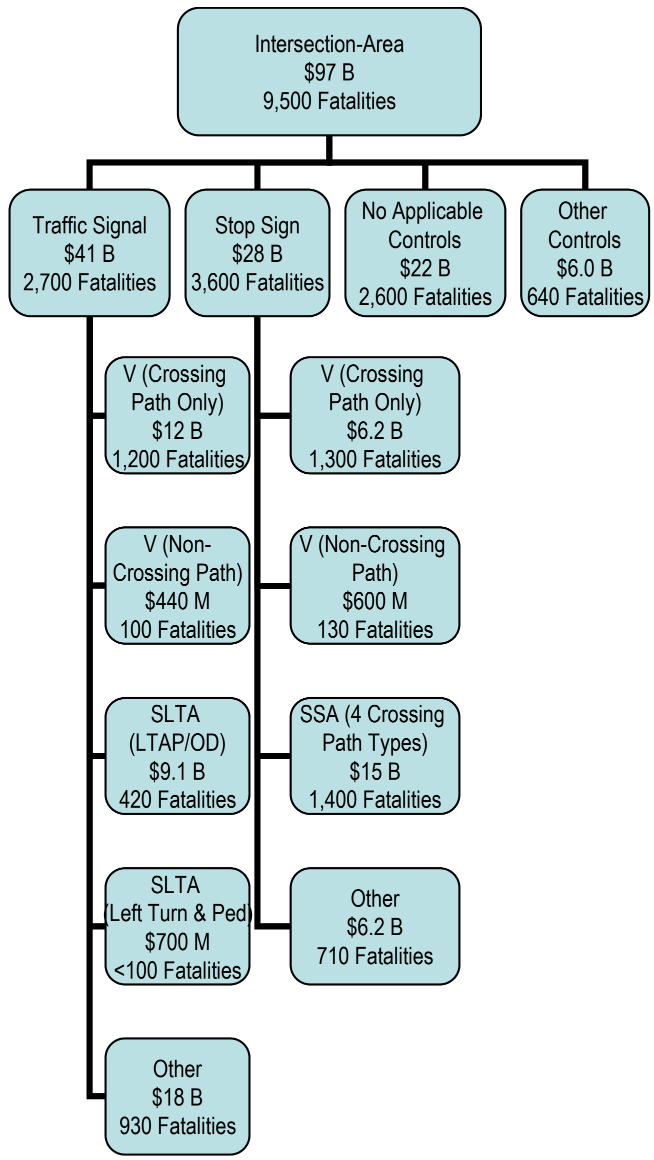


Figure 5: Comprehensive Costs & Fatalities for Intersection-Area Crashes

The figure also serves to illustrate the differences in crash consequences associated with crashes occurring with differing traffic controls. Table 11 summarizes intersection-area results by traffic control device. For example, crashes at stop signs have a higher number of fatalities but a lower total comprehensive cost as compared to traffic signal crashes. This occurs in large part due to a substantially higher number of non-fatal injuries occurring at traffic signals compared to stop signs.

Table 11: Intersection-Area Summary by Traffic Control

Traffic Control	Comprehensive Costs	Fatalities	Injuries
Traffic Signal	$41 B	2,700	640 K
Stop Sign	$28 B	3,600	330 K
No Applicable Controls	$22 B	2,600	260 K
Other Controls	$6.0 B	640	72 K
Total	**$97 B**	**9,500**	**1.3 M**

CICAS Program Area Estimates

Violation-Related Definition Based on a review and discussion of various approaches, the definition of a violation-related crash at a traffic signal or stop sign for use in this crash data analysis is as follows:

a. Single vehicle crashes:

For FARS, police citation for failure to obey traffic control device, and/or contributing factor for failure to obey traffic control device.

For GES, police citation for running a traffic signal or stop sign.

b. Multiple vehicle crashes:

For FARS, police citation for failure to obey traffic control device, and/or contributing factor for failure to obey traffic control device, and/or a crossing path crash scenario of SCP, LTIP, or LTAP/LD at a traffic signal.

For GES, police citation for running a traffic signal or stop sign, and/or a crossing path crash scenario of SCP, LTIP, or LTAP/LD at a traffic signal.

It should be noted that GES does not contain the driver contributing factor variable present in FARS, and thus differences exist in the GES vs. FARS estimation process. Additional detail in the police report narrative may provide evidence of a violation even when no citation was issued. In FARS, the driver factors variable would capture this information, while in GES only violations actually charged are captured. Despite the differences, the classification presented here provides the best ability to identify violation-related crashes based on the information available.

For each CICAS program, comprehensive costs and fatalities associated with each variant subcategory were tabulated to illustrate the potential focus areas. Figure 6 shows the CICAS-V results, Figure 7 shows the CICAS-SLTA results, and Figure 8 shows the CICAS-SSA results. These summary figures allow the relative contribution of potential impacts for each program to be readily identified.

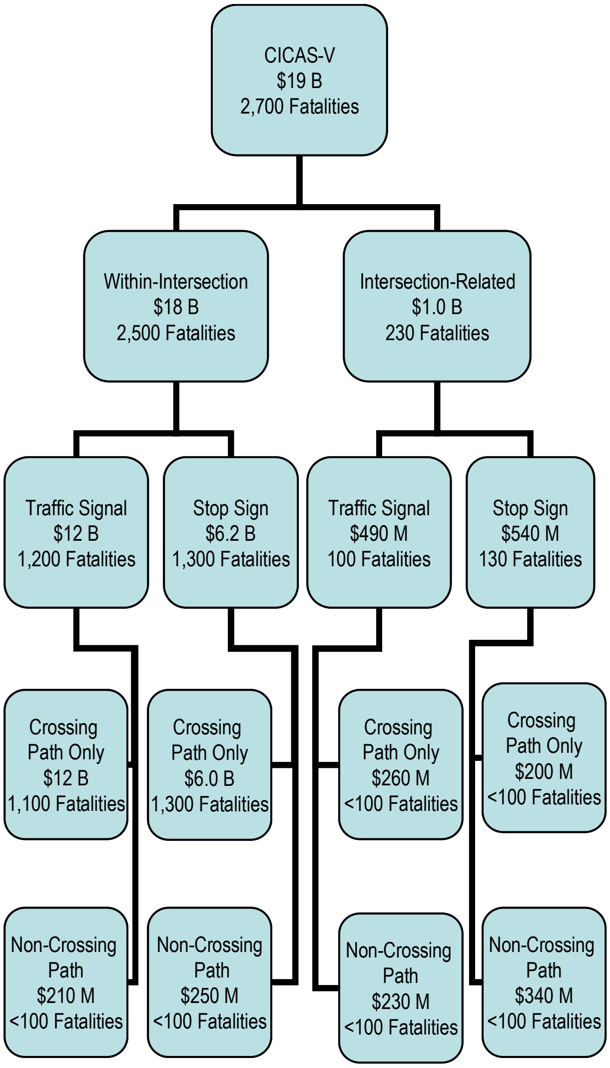


Figure 6: CICAS-V / Comprehensive Costs & Fatalities

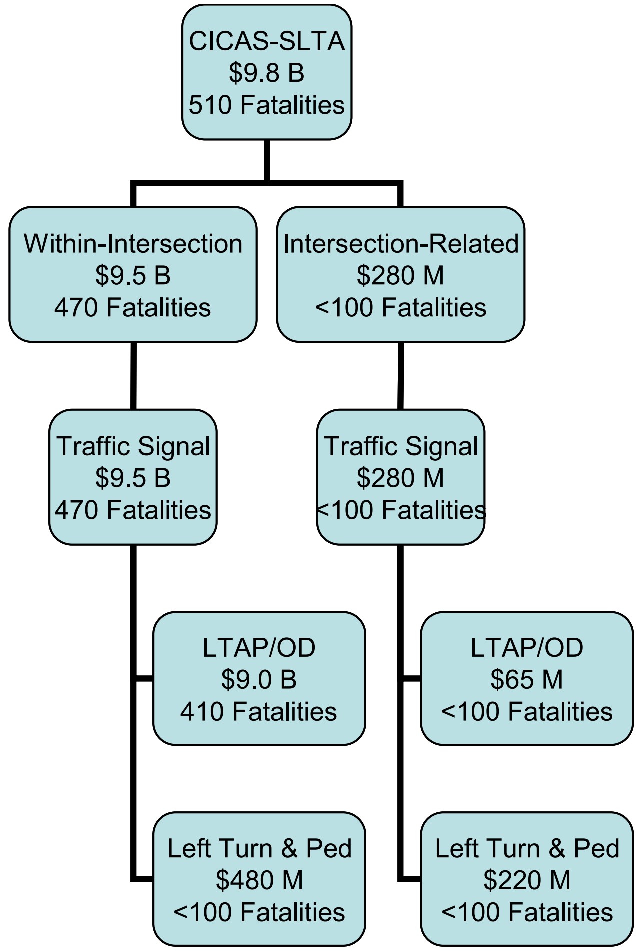


Figure 7: CICAS-SLTA / Comprehensive Costs & Fatalities

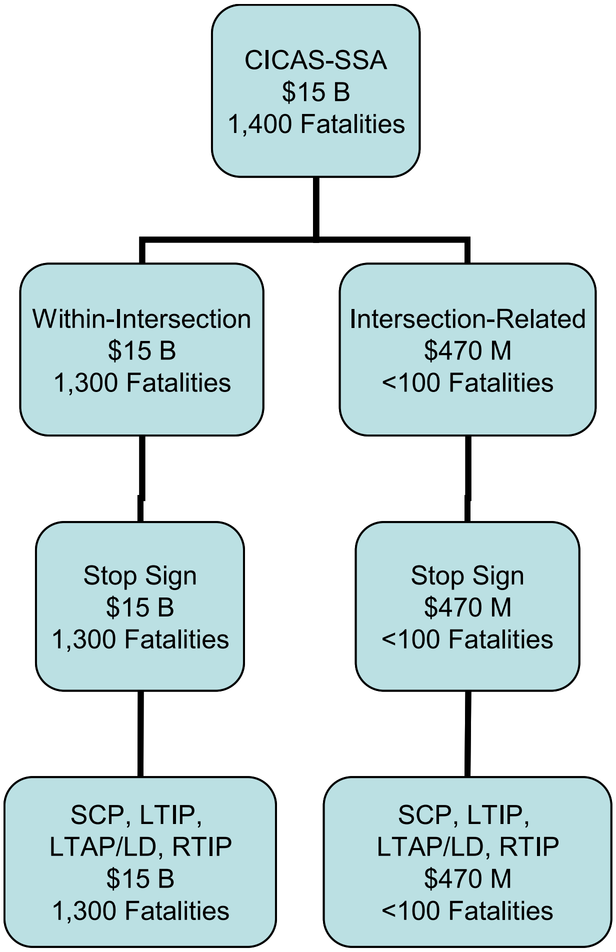


Figure 8: CICAS-SSA / Comprehensive Costs & Fatalities

SUMMARY / RECOMMENDATIONS FOR FUTURE

Using the unit comprehensive costs from the EI report, this analysis estimates the **comprehensive cost of intersection-area crashes at $97 Billion** in year 2000 dollars, **representing 33% of the total comprehensive cost** for all police-reported crashes (see Figure 9).

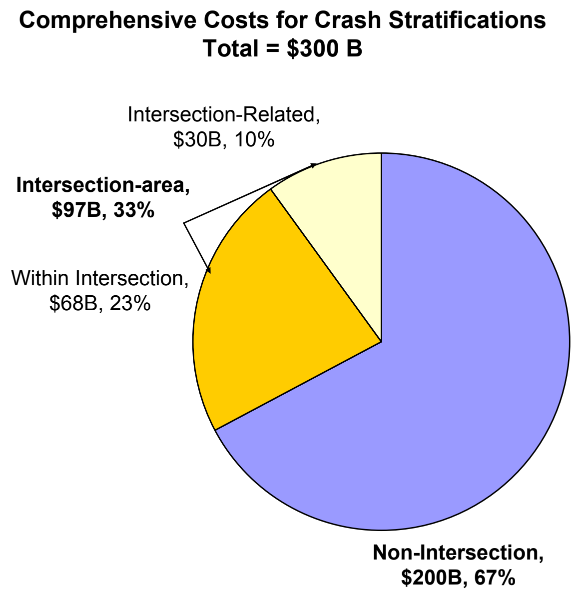


Figure 9: Comprehensive Costs for Crash Stratifications

Table 12 shows the potential target population for each CICAS program, representing the estimates corresponding to totals for intersection-area crashes reported in the previous section. Depending on the crash scenarios included, CICAS-V may potentially target crashes responsible for up to $19 Billion in comprehensive costs and 2,700 fatalities annually. Combined with the other CICAS programs, this represents a target of up to $45 Billion in comprehensive costs and 4,600 fatalities.

Table 12: CICAS Potential Target Population Categories

	Comprehensive Costs	Fatalities
CICAS-V (Traffic Signals & Stop Signs)	**$19 B**	**2,700**
CICAS-V (Traffic Signals Only)	*$13 B*	*1,300*
CICAS-V (Stop Signs Only)	*$6.8 B*	*1,500*
CICAS-SLTA (Traffic Signals)	**$9.8 B**	**510**
CICAS-SSA (Stop Signs)	**$15 B**	**1,400**

These potential target population estimates have established a starting point for further refinement. Individual CICAS programs can examine the corresponding target population and determine scenarios, environmental and driver factors, and other conditions that offer promise for specific countermeasures. Upon development of these countermeasures, estimates of their effectiveness could then be used to assess potential program benefits associated with varying deployment strategies.

REFERENCES

Blincoe, L., A. Seay, E. Zaloshnja, T. Miller, E. Romano, S. Luchter, and R. Spicer. 2002. *The Economic Impact of Motor Vehicle Crashes, 2000*, National Highway Traffic Safety Administration, Washington D.C., Report No. DOT HS 809 446, May 2002. Available from http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/Communication%20&%20Consumer%20Information/Articles/Associated%20Files/EconomicImpact2000.pdf.

Blincoe, L.J. 1994. *Estimating the Benefits from Increased Safety Belt Use*, National Highway Traffic Safety Administration Technical Report, Washington, D.C., June, 1994.

Najm, W.G., J.D. Smith, and D.L. Smith. 2001. *Analysis of Crossing Path Crashes*, National Highway Traffic Safety Administration, Washington, D.C., Report No. DOT HS 809 423, July 2001. Available from http://www-nrd.nhtsa.dot.gov/pdf/nrd-12/DOTHS809423.pdf.

USDOT Web Site. 2006. Cooperative Intersection Collision Avoidance Systems – ITS. Available from http://www.its.dot.gov/cicas/index.htm, accessed October, 2006.