TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Veridian Engineering
Buffalo, New York 14225

REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT

NASS CDS CASE NO. 1998-12-229E

RABSS VEHICLES - 1998 CADILLAC DEVILLE
1998 BUICK CENTURY CUSTOM

LOCATION - STATE OF MICHIGAN

CRASH DATE - DECEMBER, 1998

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* 98-12-229E	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Redesigned Air Bag Special Study (RABSS) RABSS Vehicle - 1998 Cadillac Deville 1998 Buick Century Custom Location - State of Michigan		5. *Report Date*: August, 2000 6. *Performing Organization Code*	
7. *Author(s)* Crash Research Section		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Sciences Crash Research Section Veridian Engineering P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0298.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Summary Report Crash Date: December, 1998 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* NASS investigation of a right angle collision that involved a 1998 Cadillac Deville 4-door sedan and a 1998 Buick Century Custom 4-door sedan equipped with redesigned frontal air bags.			
16. *Abstract* This investigation focused on a two vehicle crash involving a 1998 Cadillac Deville 4-door sedan and a 1998 Buick Century Custom 4-door sedan. Each vehicle was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a right angle collision. The Cadillac was initially stationary and faced north in anticipation of turning left (west) at a 4-leg urban intersection. As the Cadillac entered the intersection, the frontal area impacted the left front side surface of the westbound Buick which resulted in moderate damage to both vehicles. The restrained 49 year old male driver of the Cadillac Deville initiated a forward trajectory in response to the 1 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He sustained a contusion to the top of the right foot from contact to the brake pedal with no other injury or treatment reported. The restrained 42 year old male driver of the Buick Century initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint, deployed redesigned driver air bag and knee bolster. Contact to the deployed air bag resulted in unspecified "blunt chest trauma". Loading of the knee bolster resulted in bilateral abrasions and lacerations to the knees. He also sustained a cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The restrained 47 year old male front right passenger of the Buick Century initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the deployed air bag resulted in unspecified "blunt chest/abdominal trauma". He also sustained a cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The Buick occupants were transported by ambulance to the emergency room of a local trauma center for treatment and released.			
17. *Key Words* Redesigned frontal air bag system Collision Deformation Classification (CDC): 81-FDEW-2 Proper use of the manual belt system		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 9	22. *Price*

TABLE OF CONTENTS

REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT
NASS CDS CASE NO. 1998-12-229E
RABSS VEHICLES - 1998 CADILLAC DEVILLE
1998 BUICK CENTURY CUSTOM
CRASH DATE - DECEMBER, 1998

BACKGROUND

This investigation focused on a two vehicle crash involving a 1998 Cadillac Deville 4-door sedan and a 1998 Buick Century Custom 4-door sedan. Each vehicle was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a right angle collision. The Cadillac was initially stationary and faced north in anticipation of turning left (west) at a 4-leg urban intersection. As the Cadillac entered the intersection, the frontal area impacted the left front side surface of the westbound Buick which resulted in moderate damage to both vehicles.

The restrained 49 year old male driver of the Cadillac Deville initiated a forward trajectory in response to the 1 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He sustained a contusion to the top of the right foot from contact to the brake pedal with no other injury or treatment reported. The restrained 42 year old male driver of the Buick Century initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint, deployed redesigned driver air bag and knee bolster. Contact to the deployed air bag resulted in unspecified "blunt chest trauma". Loading of the knee bolster resulted in bilateral abrasions and lacerations to the knees. He also sustained a cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The restrained 47 year old male front right passenger of the Buick Century initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the deployed air bag resulted in unspecified "blunt chest/abdominal trauma". He also sustained a cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The Buick occupants were transported by ambulance to the emergency room of a local trauma center for treatment and released.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 98-12-229E and also included in the Redesigned Air Bag Special Study. The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian the task of case review and final report preparation.

SUMMARY

Crash Site

This two vehicle crash occurred during the morning hours of December, 1998. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in a straight and level 4-leg urban intersection **(see Figure 9 - page 9)** which was controlled by an overhead signal system in green phase for westbound traffic. The northbound roadway consisted of three (one-way)

asphalt travel lanes as the westbound roadway consisted of four (one-way) asphalt travel lanes. The posted speed limit at the crash site was 40 km/h (25 mph) for northbound traffic and 56 km/h (35 mph) for westbound traffic.

Pre-Crash

The 49 year old male driver of the 1998 Cadillac Deville was stationary and faced north in the inboard lane **(Figure 1)** of the one-way roadway in anticipation of turning left (west) at the 4-leg intersection. The 42 year old male driver of the 1998 Buick Century was operating the vehicle westbound in the outboard lane **(Figure 2)** of the one-way roadway at a (driver reported) speed of 56 km/h (35 mph) when he entered the intersection and observed the northbound Cadillac cross his path of travel. Neither driver reported any avoidance maneuvers in anticipation of the impending crash.

Figure 1. Northbound approach for the 1998 Cadillac Deville.

Figure 2. Westbound approach for the 1998 Buick Century Custom.

Crash

An unidentified vehicle traveling northbound (behind the Cadillac) struck the rear area of the stationary Cadillac resulting in minor damage. This initial impact re-directed the Cadillac into the intersection and into the path of the westbound Buick. As the Cadillac entered the urban intersection, the frontal area impacted the left front side surface of the Buick resulting in moderate damage to both vehicles. The damage algorithm of the WinSMASH program computed velocity changes of 20.1 km/h (12.5 mph) for the Cadillac and 22.3 km/h (13.9 mph) for the struck Buick. Respective longitudinal components were -15.4 km/h (-9.6 mph) and -14.3 km/h (-8.9 mph). The impact induced deceleration was sufficient to deploy the redesigned frontal air bag system in both vehicles. At this point, each vehicle began their respective post-impact trajectories into the northwest sector of the intersection as the right front wheel of the Buick struck a barrier curb resulting in moderate rim damage. This curb impact initiated a 2-quarter turn right side "tripover" which resulted in moderate top surface damage. The Buick Century came to rest (on its top) off the north pavement faced southwest as the Cadillac Deville came to rest in the northwest sector of the intersection faced west.

Post-Crash

The driver of the Cadillac Deville exited the vehicle under his own power. The driver of the Buick was removed from the vehicle by rescue personnel in an unconscious state while the exit status of the front right passenger was unknown. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMTs). The Cadillac driver refused treatment as the Buick occupants

were transported by ambulance to the emergency room of a local trauma center for treatment and released. Both subject vehicles were towed from the scene due to disabling damage.

RABSS VEHICLE

1998 Cadillac Deville

The 1998 Cadillac Deville was identified by the Vehicle Identification Number (VIN): 1G6KD54Y9WU (production sequence deleted). The vehicle was a 4-door sedan equipped with front wheel drive and a 4.6 liter, V-8 engine. The vehicle's odometer reading was unknown at the time of the crash. The driver's employer was reported by police as the owner of the vehicle. The seating was configured with front split and rear bench seats. The driver reported no previous crashes or maintenance on the air bag system (original equipment). No cell phone was present or in-use at the time of the collision.

1998 Buick Century Custom

The 1998 Buick Century Custom was identified by the Vehicle Identification Number (VIN): 2G4WS52M3W1 (production sequence deleted). The vehicle was a 4-door sedan equipped with front wheel drive and a 3.1 liter, V-6 engine. The vehicle's odometer reading was unknown at the time of the crash. A local car dealership was reported by police as the owner of the vehicle *(possible employer and/or loaner vehicle)*. The seating was configured with front split and rear bench seats. The driver reported no previous crashes or maintenance on the air bag system (original equipment). A cellular flip phone was present at the time of the collision (usage unknown).

EXTERIOR VEHICLE DAMAGE

Exterior - 1998 Cadillac Deville

The 1998 Cadillac Deville sustained moderate frontal damage as a result of the impact with the Buick Century **(Figure 3)**. The direct contact damage encompassed the full frontal width resulting in a combined direct and induced damage length (Field L) of 100.0 cm (39.4 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 9.0 cm (3.5 in), C2= 28.0 cm (11.0 in), C3= 39.0 cm (15.4 in), C4= 44.0 cm (17.3 in), C5= 37.0 cm (14.6 in), C6= 1.0 cm (0.4 in). The *(SCI revised)* Collision Deformation Classification (CDC) for this impact to the Cadillac was 81-FDEW-2 with a principal direction of force of (+)40 degrees (principal direction of force incremented to reflect shifting of end structure to the left). The grille and headlight assemblies fractured and separated from the vehicle during the collision sequence. The fenders were displaced rearward and to the left which restricted the left front wheel/tire (not deflated). The hood was deformed slightly up and rearward from engagement against the side surface of the Buick. The windshield was fractured by the interior front right passenger air bag module cover flap (only).

Figure 3. Frontal damage to the 1998 Cadillac Deville.

Direct contact damage was also identified along the rear bumper area attributed to the initial impact. The direct contact damage began 41.0 cm (16.1 in) left of the right rear bumper corner and extended 76.0 cm (29.9 in) inboard. The CDC for this initial impact to the Cadillac was 06-BDEW-1 with a

principal direction of force of 180 degrees. The vehicle was under repair at the time of the NASS inspection, therefore, a crush profile could not be obtained for this impact.

Exterior - 1998 Buick Century Custom

Figure 4. Left front side surface damage to the 1998 Buick Century Custom.

The 1998 Buick Century Custom 4-door sedan sustained moderate left front side surface damage as a result of the impact with the Cadillac Deville **(Figure 4)**. The direct contact damage began 32.0 cm (12.6 in) aft of the front left bumper corner and extended 151.0 cm (59.4 in) rearward. The combined direct and induced damage length (Field L) began at the front left bumper corner and extended 242.0 cm (95.3 in) rearward. Six crush measurements were documented at the level of the mid-door: C1= 5.0 cm (2.0 in), C2= 8.0 cm (3.1 in), C3= 18.0 cm (7.1 in), C4= 7.0 cm (2.8 in), C5= 0 cm, C6= 0 cm. The *(SCI revised)* CDC for this initial impact to the Buick was 10-LYEW-2 with a principal direction of force of (-)50 degrees. The left fender was deformed laterally to the right which restricted the left front wheel/tire (not deflated). Outward bowing of the left front door upper window frame was noted (door jammed).

Direct contact damage was also identified to the right front wheel/tire attributed to the secondary (curb) impact *(rollover tripping mechanism)*. The *(SCI revised)* CDC for this impact was 03-RFWN-2. Rollover damage was documented to the top and right side surfaces with a maximum crush value of 7.0 cm (2.8 in) noted along the left front roof area. The *(SCI revised)* CDC for this final impact to the Buick was 00-TYDO-3 (non-horizontal direction of force). The damage pattern jammed the left front, right front and right rear doors. Extensive post-impact extrication damage was noted as the windshield was removed and the right side pillars were cut.

INTERIOR VEHICLE DAMAGE

Interior - 1998 Cadillac Deville

There was no damage to the interior surfaces of the Cadillac Deville from intrusions or occupant contact.

Interior - 1998 Buick Century Custom

Damage to the interior surfaces of the Buick Century were minimal and attributed to intrusions and occupant contact. Indentations were documented on the left knee bolster (rigid plastic type). The rear view mirror was fractured and separated from the windshield. Intrusions into the driver space included 4.0 cm (1.6 in) of lateral door panel intrusion and 3.0 cm (1.2 in) of vertical roof intrusion.

REDESIGNED AIR BAG SYSTEM

1998 Cadillac Deville

The 1998 Cadillac Deville was equipped with redesigned frontal air bags for the driver and right passenger positions. The air bags had deployed as a result of the impact with the Buick. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The flaps were symmetrical in shape and measured 11.0 cm (4.3 in) square. No contact

evidence was identified on the air bag or exterior surface of the module cover flaps. The NASS researcher measured the diameter of the driver air bag at 64.0 cm (25.2 in) in its deflated state **(Figure 5)**. No internal tether straps were present. The bag was vented by two ports located at the 9 o'clock and 3 o'clock sectors on the rear aspect of the air bag.

The front right passenger air bag deployed from the right mid-instrument panel area with a module design recessed into the instrument panel. This configuration did not utilize a conventional flap as the instrument panel separated to allow the bag to expand. The right mid-windshield area was fractured by the module cover flap. No contact evidence was identified on the air bag or exterior surface of the module cover flap. The NASS researcher measured the passenger air bag at 65.0 cm (25.6 in) in width and 60.0 cm (23.6 in) in height in its deflated state **(Figure 6)**. The bag was tethered by two internal straps and vented by two ports located at the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag. No cutoff switch was found for the front right air bag.

The Cadillac Deville was also equipped with door-mounted side impact air bags for the driver and right front passenger positions. The air bags did not deploy as a result of the crash.

Figure 5. 1998 Cadillac Deville redesigned driver air bag.

Figure 6. 1998 Cadillac Deville redesigned passenger air bag.

1998 Buick Century Custom

The 1998 Buick Century Custom was equipped with redesigned frontal air bags for the driver and right passenger positions. The air bags had deployed as a result of the impact with the Cadillac. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The flaps were symmetrical in shape and measured 10.0 cm (3.9 in) in width and 9.0 cm (3.5 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, skin oil and dirt was documented on the upper center portion of the air bag face along with blood spattering to the left portion on the rear aspect of the air bag. The NASS researcher measured the diameter of the driver air bag at 65.0 cm (25.6 in) in its deflated state **(Figure 7)**. The bag was tethered by two internal straps and vented by two ports located at the 9 o'clock and 3 o'clock sectors on the rear aspect of the air bag.

The front right passenger air bag deployed from the right top instrument panel area with a single cover flap design hinged at the forward aspect. The cover flap was rectangular in shape and measured 38.0

cm (15.0 in) in width and 21.0 cm (8.3 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flap, blood spattering was noted at the upper right quadrant of the air bag face. The NASS researcher measured the passenger air bag at 63.0 cm (24.8 in) in width and 70.0 cm (27.6 in) in height in its deflated state **(Figure 8)**. No vent ports were present. The bag was tethered by two internal straps. No cutoff switch was found for the front right air bag.

Figure 7. 1998 Buick Century Custom redesigned driver air bag.

Figure 8. 1998 Buick Century Custom redesigned passenger air bag.

DRIVER DEMOGRAPHICS

1998 Cadillac Deville

Age/Sex:	49 year old male
Height:	173 cm (68 in)
Weight:	113 kg (250 lb)
Seat Track Position:	Middle position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	None
Type of Medical Treatment:	Refused

Driver Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Contusion top of right foot	Minor (890402.1,1)	Brake pedal

Driver Kinematics

The 49 year old male driver of the 1998 Cadillac Deville was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the middle position. His hands were placed at the 7 o'clock and 1 o'clock positions on the steering wheel rim. Belt usage was confirmed by the lack of significant interior contacts and injury. At impact with the Buick, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He sustained a contusion to the top of the right foot from contact to the brake pedal with no other injury or treatment reported. The combination of restraint options provided protection against further contact to the steering wheel hub/rim and potential serious injury.

DRIVER DEMOGRAPHICS

1998 Buick Century Custom

Age/Sex:	42 year old male
Height:	178 cm (70 in)
Weight:	104 kg (230 lb)
Seat Track Position:	Middle position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to the emergency room of a local trauma center and released

Driver Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Loss of consciousness (length unk.)	Moderate (160406.2,0)	Left front window frame
Cervical spine strain	Minor (640278.1,6)	Non-contact injury (flexion)
Blunt chest injury (NFS)	Minor (415099.7,0)	Front left air bag
Posterior left hand laceration	Minor (790600.1,2)	Left front door interior surface
Right knee abrasion	Minor (890202.1,1)	Left knee bolster
Bilateral knee lacerations	Minor (890600.1,3)	Left knee bolster

Driver Kinematics

The 42 year old male driver of the 1998 Buick Century Custom was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the middle position. The NASS interview stated he was belted, further evidenced by the police report data. At impact with the Cadillac, he initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint, deployed redesigned driver air bag and knee bolster. Contact to the deployed driver air bag was confirmed by the transfers documented to the upper portion of the air bag face. Although the unspecified "blunt chest trauma" was sourced to the driver air bag in the NASS case file, it is the SCI investigator's opinion that this injury was probably caused by the manual restraint, however, this could not be confirmed without injury specifics regarding the type of injury and aspect. Loading of the knee bolster resulted in bilateral abrasions and lacerations to the knees, evidenced by the deformation documented to this component. He also sustained a cervical spine strain *(sourced to the driver air bag in the NASS case file)* which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The driver reported a short loss of

consciousness which was sourced to the window frame in the NASS case file, however, this could not be confirmed without an associated soft tissue injury to the head. The combination of restraint options provided protection against further contact to the steering wheel hub/rim and potential serious injury. No injuries were attributed to the curb or subsequent rollover impact.

FRONT RIGHT PASSENGER DEMOGRAPHICS

1998 Buick Century Custom

Age/Sex:	47 year old male
Height:	178 cm (70 in)
Weight:	79 kg (175 lb)
Seat Track Position:	Middle position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	None
Type of Medical Treatment:	Transported to the emergency room of a local trauma center and released

Front Right Passenger Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Cervical spine strain	Minor (640278.1,6)	Non-contact injury (flexion)
Blunt chest injury (NFS)	Minor (415099.7,0)	Front right air bag
Blunt abdominal injury (NFS)	Minor (515099.7,0)	Front right air bag

Front Right Passenger Kinematics

The 47 year old male front right passenger of the 1998 Buick Century Custom was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the middle position. The NASS interview stated he was belted, further evidenced by the police report data. At impact with the Cadillac, he initiated a forward and lateral trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the deployed passenger air bag resulted in unspecified "blunt chest/abdominal trauma". Although this injury was sourced to the passenger air bag in the NASS case file, it is the SCI investigator's opinion that this injury was probably caused by the manual restraint, however, this could not be confirmed without injury specifics regarding the type of injury and aspect. He also sustained a cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The combination of restraint options provided protection against further contact to the instrument panel and potential serious injury. No injuries were attributed to the curb or subsequent rollover impact.

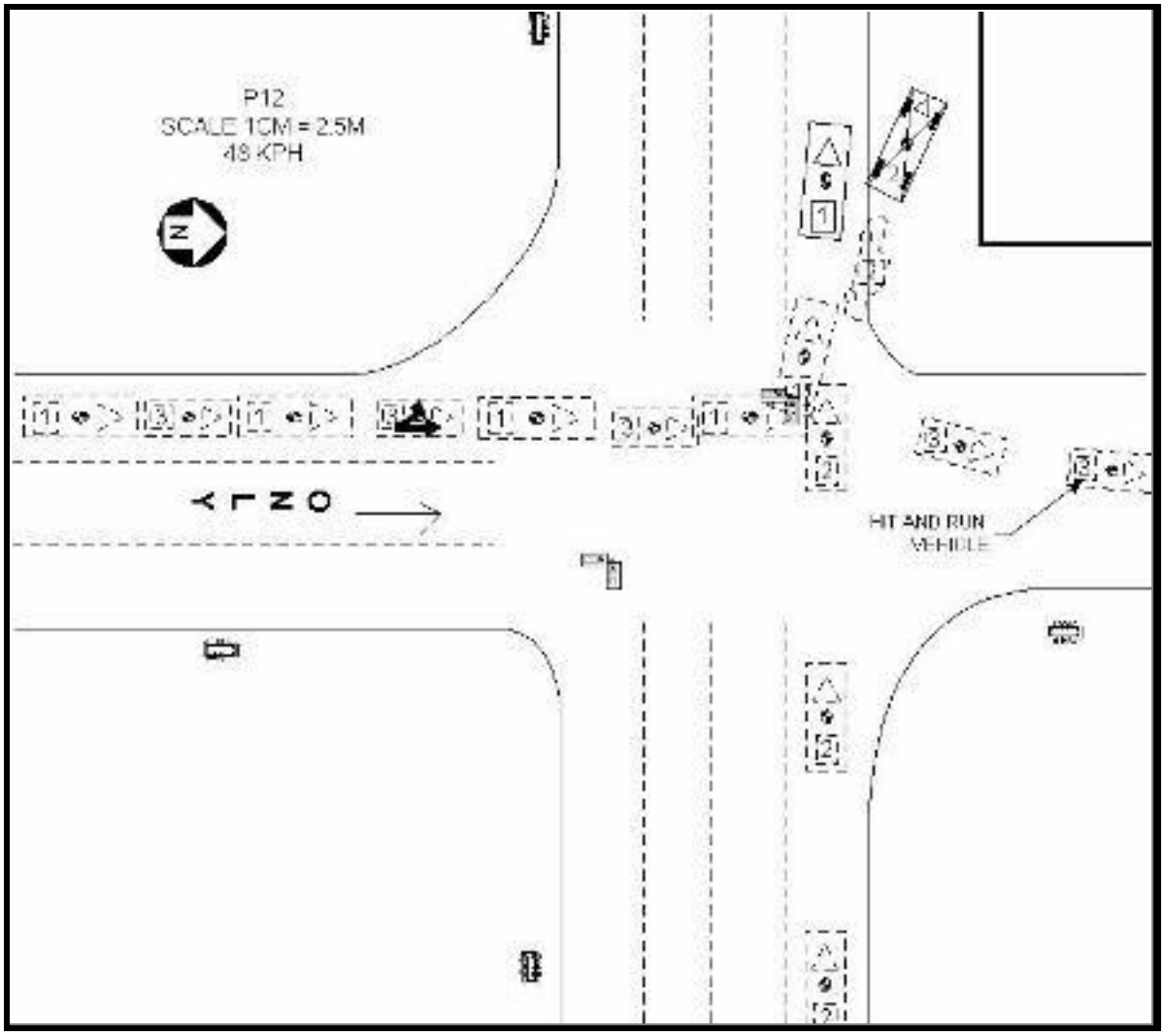

Figure 9. NASS Scene Diagram.