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SCI/NASS COMBINATION CASE REPORT

CASE NUMBER - NASS-2003-09-006C
LOCATION - Maryland
VEHICLE - 2002 GMC ENVOY
CRASH DATE - January 2003

Submitted:

September 9, 2003

Revised:
January 22, 2004

Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be 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 Documentation Page

1. *Report No.* NASS-2003-09-006C	2. *Government Accession No.*	3. *Recipient's Catalog No.*
4. *Title and Subtitle* SCI/NASS Combination Investigation Vehicle - 2002 GMC Envoy Location - Maryland		5. *Report Date:* September 9, 2003 6. *Performing Organization Code*
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-01-C-07002
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NRD-32) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: January 2003 14. *Sponsoring Agency Code*

15. *Supplementary Notes*
SCI/NASS Combination investigation concerning a 2002 GMC Envoy with multiple advanced occupant protection system features and a 1996 Kenworth W900 truck-tractor with one semi-trailer

16. *Abstract*

This combination SCI/NASS investigation covers an air bag deployment crash involving a 2002 GMC Envoy sport utility vehicle (case vehicle) and a 1996 Kenworth W900 truck-tractor with one semi-trailer (other vehicle). This crash is of special interest because the case vehicle was equipped with multiple advanced occupant protection system features and an Event Data Recorder that was successfully downloaded. The case vehicle's driver (39-year-old male) was restrained by the available, manual three-point, lap-and-shoulder safety belt system and sustained minor soft tissue injuries as a result of this crash. There were no other occupants in the case vehicle. The case vehicle was traveling north in the northbound right turn lane a four-lane, northbound roadway that was part of a divided trafficway, approaching a three-leg intersection intending to turn right to travel east. The Kenworth had been traveling south in the southbound roadway and was in the process of making a left turn and was traversing the northbound roadway, intending to complete its left turn and proceed eastbound. The case vehicle driver braked, but could not avoid the collision. The crash occurred in the northbound roadway within the intersection. The front of the case vehicle impacted the right side of the Kenworth, causing the case vehicle's driver and front right passenger air bags to deploy. Both vehicles were towed due to disabling damage. The case vehicle driver was transported to a hospital via ambulance, where he was treated and released. His injuries consisted of a cervical spine strain and bilateral knee contusions.

17. *Key Words* Air Bag Deployment Event Data Recorder Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 8	22. *Price* $3,700

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

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BACKGROUND

This combination SCI/CDS investigation was brought to the NHTSA's attention on February 26, 2003 by NASS/CDS sampling activities. This crash involved a 2002 GMC Envoy SUV (case vehicle) and a 1996 Kenworth W900 truck-tractor pulling one semi-trailer (other vehicle). The crash occurred in January 2003, at 7:32 a.m., in Maryland, and was investigated by the applicable state police. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features and an Event Data Recorder (EDR) that was successfully downloaded. The case vehicle's restrained driver (39-year-old male, white, non-Hispanic) sustained minor soft tissue injuries as a result of this crash. There were no other occupants in the case vehicle. The NASS team investigated the crash in March 2003. The coded NASS case was forwarded to the SCI contractor in July 2003 and updated in August. This report is based on the NASS case documentation and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

The case vehicle was traveling north in the northbound right turn lane a four-lane, northbound roadway that was part of a divided trafficway designated as a U.S. highway (three through lanes and a right-turn lane), approaching a three-leg intersection with a two-lane, undivided county road that joined from the right (east), intending to turn right to travel east. The Kenworth tractor-trailer had been traveling south in the southbound roadway and was in the process of making a left turn onto the county road and was traversing the northbound roadway, intending to complete its left turn and proceed eastward. The case vehicle driver stated that he observed the truck blocking the lane and braked, but could not avoid the collision. The crash occurred in the northbound roadway within the intersection.

The front left area of the case vehicle impacted the right front area of the Kenworth truck-tractor, causing the case vehicle's driver and front right passenger air bags to deploy. The vehicles' post-impact movements are not known. The case vehicle and the Kenworth truck-tractor were towed due to disabling damage. The semi-trailer was also towed away from the scene, but it is not known if the trailer sustained any damage.

Figure 1: Case vehicle's northbound approach toward impact within the intersection

CASE VEHICLE

The case vehicle was a 2002 GMC Envoy four-wheel drive, four-door sport utility vehicle (VIN: 1GKDT13S922------), equipped with a V6 4.2 liter gasoline engine and an automatic transmission with a console-mounted selector lever. Four-wheel anti-lock brakes were standard for this model. The odometer reading is not known due to the non-functional electronic instrument panel. The driver indicated that there was somewhat less than 32,000 kilometers [20,000 miles]

on the vehicle, but could not provide a closer estimate. Its wheelbase was 287 centimeters [113.0 inches]. The case vehicle was equipped with dual-stage frontal air bags and seat back-mounted side air bags at the driver and front right passenger seat positions, and an EDR that was successfully downloaded. The case vehicle was towed due to disabling damage.

Figure 2: Case vehicle's front and left side

Figure 3: Case vehicle's left front area

The case vehicle sustained direct contact damage at the front left corner, extending inward across the front and rearward along the left side. The left front wheel assembly was broken, with the wheel and tire pushed rearward and rotated outward approximately -60 degrees (**Figures 2** and **3**). The outer sheet metal of the left fender was torn away, with the inner structures and the left edge of the engine hood crushed inward. There was minor direct damage on the left A-pillar and driver's door. The left headlamp assembly and the entire grille were shattered and broken away, and the front bumper cover was torn off. The front left bumper corner, the left headlamp area and the left edge of the engine hood were crushed rearward. The wheelbase was shortened by 38 centimeters [14.9 inches] on the left and 6 centimeters [2.4 inches] on the right. Direct damage was measured as 49 centimeters [19.3 inches] wide, beginning at the front left bumper corner and extending inward, with induced damage extending across the entire front. Maximum crush was measured as 31 centimeters [12.2 inches] between C2 and C3. There was no glazing damage and all of the doors remained closed and operational. The CDC was determined to be **10-FYEW-2 (310)**. This impact is not eligible for the WinSMASH reconstruction program because the other vehicle is out of scope. The Barrier Equivalent Speed was calculated as 17 km.p.h. [10.6 m.p.h.], but this estimate seems low. The Event Data Recorder (discussed further, below) recorded a maximum longitudinal velocity change of -34.8 km.p.h. [-21.61 m.p.h.]. This was a crash of moderate severity (24 - 40 km.p.h. [15 - 25 m.p.h.]) for the case vehicle.

Inspection of the case vehicle's interior revealed 7 centimeters [2.6 inches] of rearward intrusion by the toe pan in the driver's footwell and no other areas of intrusion. There were numerous points of occupant contact on the interior surfaces, including: scuffing and a cloth transfer on the armrest on the driver's door; scuffing on the lower left instrument panel and on the center console; stretching of the driver's safety belt webbing; and body fluids (mucus/saliva) on the front of the driver's air bag.

The case vehicle was equipped with front impact and seat back-mounted side impact air bags at the driver and front right passenger seat positions, for a total of four air bags. The driver and passenger front impact air bags deployed.

The driver's air bag was mounted in the steering wheel hub with cover flaps in the I-configuration. The center seam measured 12 centimeters [4.7 inches] vertically, with the upper and lower seams measuring 16 centimeters [6.3 inches] horizontally, centered on the vertical seam. The seams opened at the tear points and there was no evidence of damage to the cover flaps or the adjacent structures. The deployed driver's air bag was round with a diameter of 54 centimeters [21.3 inches]. The air bag had two vent ports, each with a diameter of 3 centimeters [1.2 inches], at the 11:00 and 1:00 o'clock positions, and had two tether straps near the center, each 13 centimeters [5.1 inches] wide. There was no evidence of damage to the air bag. There was an area of body fluid (mucus/saliva) in the lower left quadrant (**Figure 4**).

Figure 4: Front of driver's air bag

The front right passenger's air bag was mounted in the mid-instrument panel, with a single cover flap hinged at the top. The cover flap measured 33 centimeters [13.0 inches] horizontally and 14 centimeters [5.5 inches] vertically. The cover flap opened at the tear points and there was no evidence of damage to the cover flaps or the adjacent structures. The deployed passenger air bag was rectangular, measuring 76 centimeters [29.9 inches] horizontally and 55 centimeters [21.7 inches] vertically. The air bag had two vent ports, each with a diameter of 4 centimeters [1.6 inches] at the 9:30 and 2:30 o'clock positions. There were two horizontal tethers, each 40 centimeters [15.7 inches] wide. There was no evidence of damage or occupant contact on the passenger's air bag (**Figure 5**).

Figure 5: Front of passenger's air bag

EVENT DATA RECORDER

The Event Data Recorder (EDR) was successfully downloaded in the field. The Sensing and Diagnostic Module (SDM) report is attached as **Figures 7 - 9**. The System Status at Deployment report (**Figure 7**) indicates that a deployment event was recorded on ignition cycle 1,939, with

the EDR download occurring on ignition cycle 1,941. The Supplemental Inflatable Restraint (SIR) warning lamp was off, indicating no faults in the air bag system, and the driver's safety belt was buckled.

The Pre-Crash Data (**Figures 7** and **8**) indicate that the case vehicle was traveling 88.5 km.p.h. [55.0 m.p.h.] at five seconds prior to algorithm enable, and accelerated to 98.2 km.p.h. [61 m.p.h.] at two seconds prior. The driver braked during the last one second interval and the case vehicle's speed decreased to 78.8 km.p.h. [49 m.p.h.] at one second prior to algorithm enable.

The command for first stage deployment was issued to the driver's and front right passenger's air bags at 15 milliseconds [0.015 seconds] after algorithm enable, and the command for second stage deployment was not issued. The EDR recorded a maximum longitudinal velocity change of -34.8 km.p.h. [-21.61 m.p.h.] at 170 milliseconds [0.17 seconds] after algorithm enable (**Figure 7**). The Deployment Data and Graph (**Figures 7** and **9**) show a gradual slope (i.e., not a steep spike) that reached -31.4 km.p.h. [-19.53 m.p.h.] at 110 milliseconds, and then recording stopped.

CASE VEHICLE DRIVER KINEMATICS

The case vehicle driver (39-year-old male; white, non-Hispanic; 173 centimeters and 73 kilograms [68 inches, 161 pounds]) was restrained by the available manual, three-point, lap-and-shoulder safety belt system. He was seated in a normal driving posture with the seat back slightly reclined and the seat track adjusted at the middle position (**Figure 6**).

Figure 6: Driver's seat area

According to the EDR, the driver had been accelerating and then braked at between one and two seconds prior to the impact. He probably moved forward in response to the braking deceleration, loading the safety belt system and causing the retractor to lock. At impact, he moved further forward and leftward, toward the 10:00 o'clock direction of force, but was held in place by the safety belt system. He encountered the deployed air bag, depositing a fluid transfer (mucous/saliva) on the air bag, but because he was restrained, he did not impact the air bag with the full force of his inertia and did not sustain any air bag injuries. Because he was cushioned by the air bag, he did not load heavily into the safety belt and did not sustain any safety belt injuries. His knees impacted the knee bolster, causing bilateral knee contusions, and the motion of his head relative to his restrained torso caused him to sustain a muscle strain in the cervical spine region.

The case vehicle driver was transported via ambulance to a hospital, where he was treated and released.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1.	Cervical spine strain	640278.1 minor	non-contact, inertial force	Probable	Emergency Room
2.	Bruises, bilateral knees	890402.1 minor	Knee bolster	Probable	Interviewee

OTHER VEHICLE

The other vehicle was a 1996 Kenworth W900 6x4 conventional truck-tractor (VIN: 1XKWDB9XXTJ------) towing an unknown make semi-trailer (VIN: 1R9D24304T0------). Based on the damage distribution on the case vehicle, the Kenworth was probably impacted at the right front corner area, probably including the right front wheel and tire, but the exact location not known. The police crash report does not mention any contact or damage to the semi-trailer. The Kenworth was towed due to disabling damage and the trailer was also towed away.

1GKDT13S922[redacted] System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	1939
Ignition Cycles At Investigation	1941
Maximum SDM Recorded Velocity Change (MPH)	-21.61
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	170
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	15
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	15
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.93	-3.10	-4.34	-5.58	-6.82	-8.99	-12.09	-15.50	-18.29	-18.29	-19.53	N/A	N/A	N/A	N/A

PRE-CRASH DATA				
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	55	3008	65	OFF
-4	58	3072	65	OFF
-3	60	3072	29	OFF
-2	61	2240	23	OFF
-1	49	1728	0	ON

Figure 7: Sensing and Diagnostic Module System Status Report

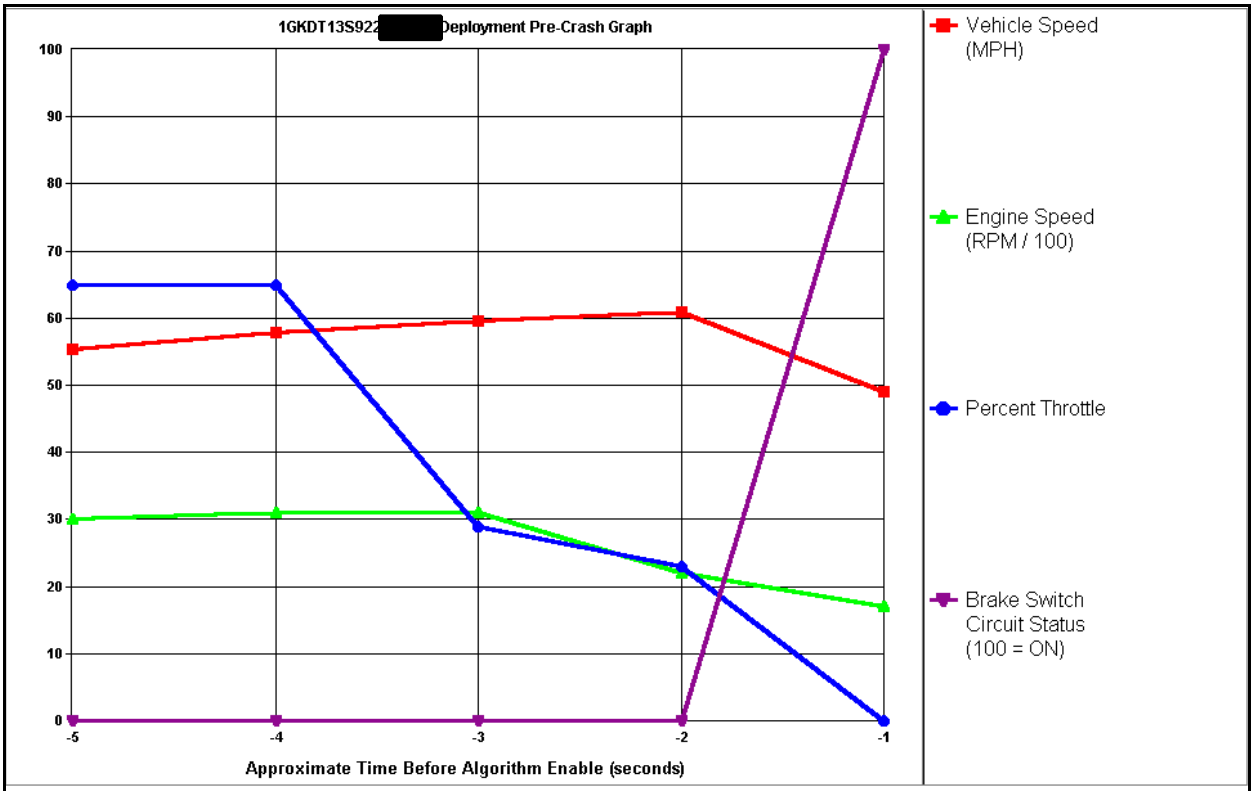


Figure 8: Sensing and Diagnostic Module Pre-Crash Graph

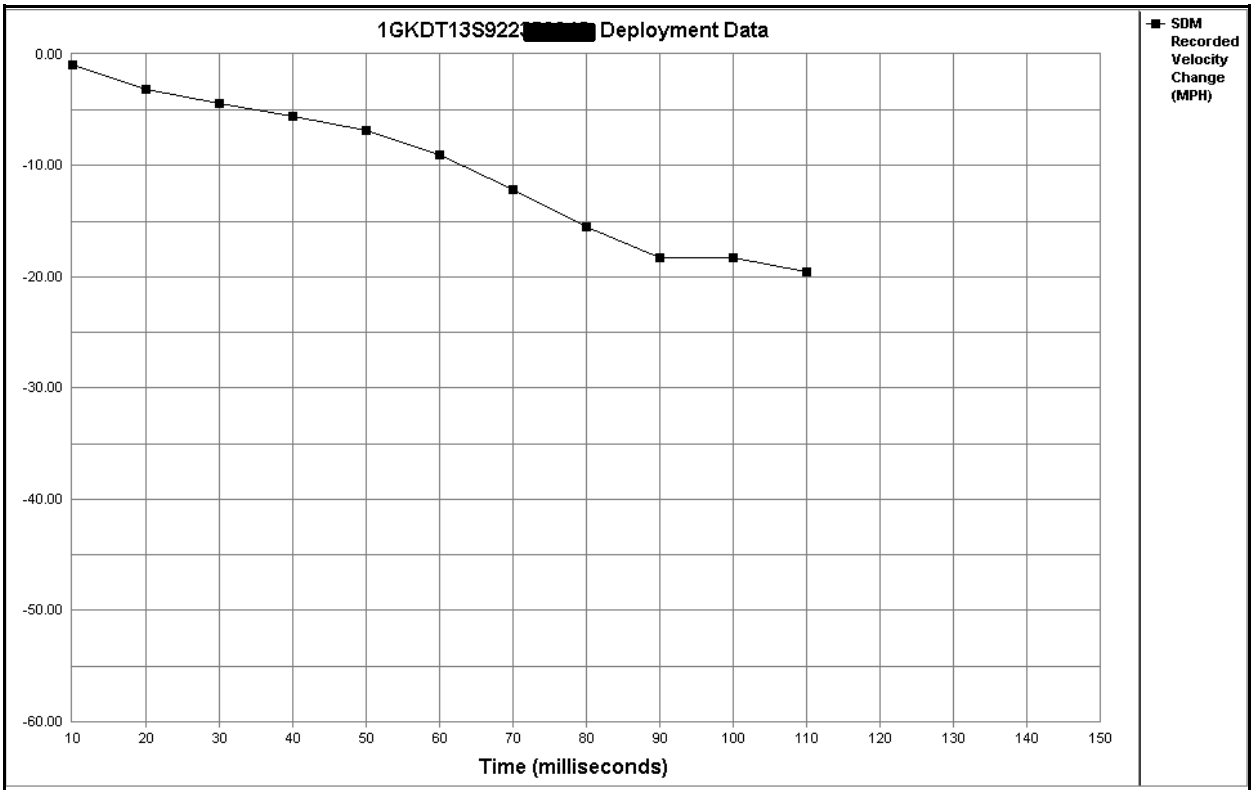
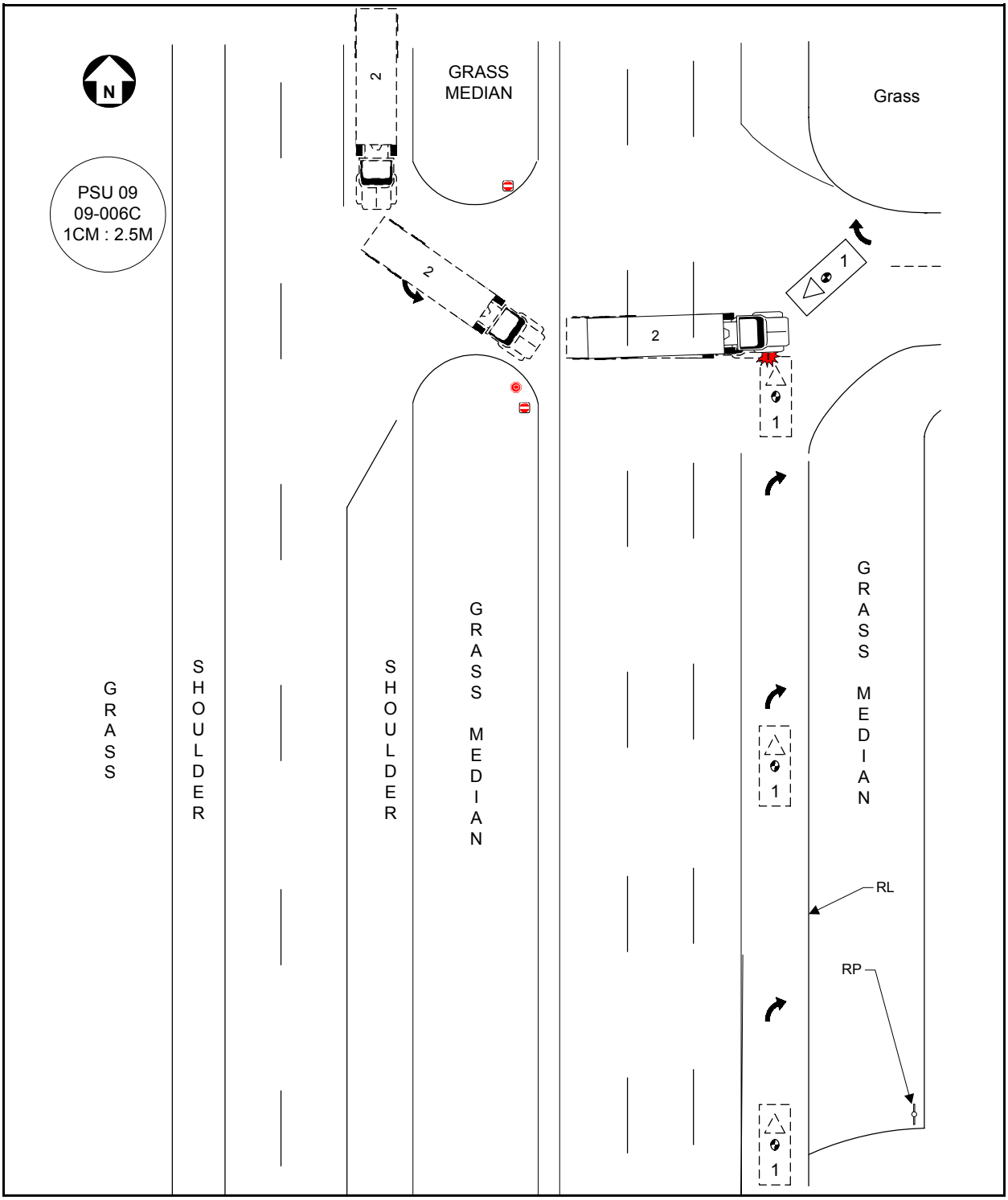


Figure 9: Sensing and Diagnostic Module Deployment Data Graph


N
PSU 09
09-006C
1CM : 2.5M
GRASS
SHOULDER
SHOULDER
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GRASS MEDIAN
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1
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1
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RL
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