

**TRANSPORTATION SCIENCES  
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**REMOTE CHILD SAFETY SEAT CRASH INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT**

**NASS/SCI COMBO CASE NO. 01-13-149K**

**VEHICLE – 1997 PLYMOUTH VOYAGER**

**LOCATION - STATE OF MICHIGAN**

**CRASH DATE – OCTOBER 2001**

Contract No. DTNH22-01-C-17002

Prepared for:

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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 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.

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<i>16. Abstract</i> <p>This remote investigation focused on the performance of a forward-facing child safety seat (CSS) that was installed in the front right position of a 1997 Plymouth Voyager. The Voyager was occupied by a 29-year-old male driver and a 3-year-old male front right passenger who was restrained in a forward-facing Century Breverra Classic booster seat with a five-point harness. The driver's restraint usage was unknown, although injuries and contact evidence suggest he was unrestrained. The driver of the Voyager reportedly fell asleep and relinquished control of the vehicle at an exit ramp on a state highway. The Voyager departed the right roadside in a tracking mode, sideswiped a signpost and continued in a tracking mode along the level roadside. The Voyager impacted a steep dirt embankment adjacent to a bridge support with the front aspect which resulted in frontal air bag deployment and moderate damage to the Voyager. The occupants initiated forward trajectories in response to the frontal impact. The driver loaded the knee bolster and center console and sustained a right intertrochanteric/subtrochanteric femur fracture. He loaded through the deployed driver's air bag and deformed the upper half of the steering wheel rim which resulted in a right upper lung contusion, an abrasion over the right maxilla, a small non-displaced fracture of the right zygoma, and cervical strain. He also sustained a right forehead laceration. The 3-year-old child loaded the harness system of the CSS. He sustained neck abrasions and an anterior chest contusion as a result of loading against the harness system. His left hand was struck by front right passenger's air bag which resulted in a non-displaced linear fracture of the fifth metacarpal. The air bag displaced his left hand rearward into the right aspect of his face which resulted in a contusion to the left hand, a minor right temporal scalp laceration and a right frontal scalp abrasion. Both occupants were transported by ambulance to a local hospital. The driver was admitted for six days and released. The child passenger was treated and released.</p>			
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**REMOTE CHILD SAFETY SEAT CRASH INVESTIGATION  
SCI SUMMARY TECHNICAL REPORT  
NASS/SCI COMBO CASE NO. 01-13-149K  
SUBJECT VEHICLE – 1997 PLYMOUTH VOYAGER  
LOCATION - STATE OF MICHIGAN  
CRASH DATE - OCTOBER 2001**

***BACKGROUND***

This remote investigation focused on the performance of a forward-facing child safety seat (CSS) that was installed in the front right position of a 1997 Plymouth Voyager. The Voyager was occupied by a 29-year-old male driver and a 3-year-old male front right passenger who was restrained in a forward-facing Century Breverra Classic booster seat with a five-point harness. The driver's restraint usage was unknown, although injuries and contact evidence suggest he was unrestrained. The driver of the Voyager reportedly fell asleep and relinquished control of the vehicle at an exit ramp on a state



**Figure 1. Damaged Plymouth Voyager**

highway. The Voyager departed the right roadside in a tracking mode, sideswiped a signpost and continued in a tracking mode along the level roadside. The Voyager impacted a steep dirt embankment adjacent to a bridge support with the front aspect, which resulted in frontal air bag deployment and moderate damage to the Voyager (**Figure 1**). The occupants initiated forward trajectories in response to the frontal impact. The driver loaded the knee bolster and center console and sustained a right intertrochanteric/subtrochanteric femur fracture. He loaded through the deployed driver's air bag and deformed the upper half of the steering wheel rim which resulted in a right upper lung contusion, an abrasion over the right maxilla, a small non-displaced fracture of the right zygoma, and cervical strain. He also sustained a right forehead laceration. The 3-year-old child loaded the harness system of the CSS. He sustained neck abrasions and an anterior chest contusion as a result of loading against the harness system. His left hand was struck by front right passenger's air bag which resulted in a non-displaced linear fracture of the fifth metacarpal. The air bag displaced his left hand rearward into the right aspect of his face which resulted in a contusion to the left hand, a minor right temporal scalp laceration and a right frontal scalp abrasion. Both occupants were transported by ambulance to a local hospital. The driver was admitted for six days and released. The child passenger was treated and released.

This crash was selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 01-13-149K. The crash occurred in October 2001. Initial notification of this crash was made following a NASS CDS case review. The NASS PSU performed the vehicle inspection and scene inspection. Due to the presence of the CSS, NHTSA assigned the tasks of case review and report preparation to the Veridian Special Crash Investigation (SCI) team.

## SUMMARY

### Crash Site

This single vehicle crash occurred at an interchange on the southbound lanes of a four-lane divided highway during nighttime hours of October 2001. At the time of the crash, there were no adverse conditions and the asphalt road surface was dry. The north/south divided highway consisted of two travel lanes in each direction separated by a concrete median (Jersey) barrier. The travel lanes were straight and level. An exit ramp with a right curve was present at the crash site, and a level grassy gore area separated the right side exit ramp from the southbound travel lanes. A sign marked "Exit" was present on the north aspect of the gore. The gore measured 130 m (427') in length and ended at a steep embankment with a positive slope adjacent to a roadway and bridge which crossed the highway. There were no traffic controls present at the scene. The posted speed limit for the divided highway was 113 km/h (70 mph). The NASS scene schematic is included as **Figure 13** at the end of this report.

### Pre-Crash

The 29-year-old male driver of the 1997 Plymouth Voyager was operating the vehicle in a southbound direction (**Figure 2**) on the divided highway during nighttime hours. The driver reportedly fell asleep and relinquished control of the vehicle at an interchange with a right side exit ramp. It was unknown if the driver's intent was to exit the highway at the interchange. The vehicle departed the roadway onto the grassy gore area between the southbound travel lanes and the exit ramp in a tracking mode.

### Crash

The 1997 Plymouth Voyager struck a non-breakaway sign post (**Figure 3**) with the left side aspect as it departed the roadway. The direction of force was in the 12 o'clock sector. The sideswipe impact resulted in minor damage to the Voyager and did not significantly alter its forward trajectory. The Voyager continued an additional 50 m (164') in a forward tracking mode along the level gore and impacted the sloped grassy embankment with the front aspect (**Figure 4**). The principal direction of force was in the 12 o'clock sector. The frontal impact was sufficient to deploy the frontal air bag system in the vehicle. The damage algorithm of the WinSMASH program computed a total delta-V of 31.0 km/h (19.3 mph) based on the frontal crush profile.



**Figure 2. Southbound approach for the Plymouth Voyager**



**Figure 3. View of sign post from the sideswipe impact**



**Figure 4. View of embankment**

The longitudinal and lateral components were -31.0 km/h (-19.3 mph) and 0.0 km/h, respectively. The barrier equivalent speed was 31.4 km/h (19.5 mph). The Plymouth Voyager came to rest adjacent to the embankment.

### **Post-Crash**

The driver and front right child passenger were removed from the vehicle by rescue personnel. The interview reported that the driver was not alert at the time he was removed from the vehicle. He sustained incapacitating injuries and was transported by ambulance to a local hospital for treatment and admitted for six days. The child was transported by ambulance to a local hospital and treated and released. It was not known if the front right child passenger was removed from the CSS at the scene or if he was transported to the hospital in the CSS.

### **VEHICLE DATA – 1997 Plymouth Voyager**

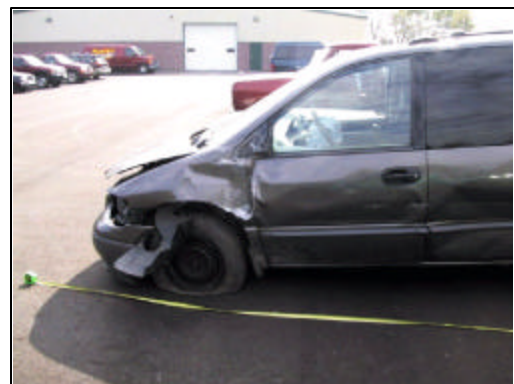
The 1997 Plymouth Voyager was identified by the Vehicle Identification Number (VIN): 2P4FP2539VR (production sequence omitted). At the time of the NASS vehicle inspection, the odometer read 180,247 km (112,003 miles). The Plymouth Voyager was a three-door mini-van configured with a right side sliding door and a rear hatch. The vehicle was equipped with a 3.0 liter, 6 cylinder engine, front-wheel drive, automatic transmission, power brakes, power steering, and a tilt steering wheel. It was not known if the vehicle was equipped with an optional four-wheel anti-lock braking system. The specific tire data was not reported.

The front seating positions in the Plymouth Voyager were configured with box-mounted bucket seats with pivoting arm rests on the inboard aspects and integral head restraints. The position of the arm rests at the time of the crash was not known. The pre-crash orientation of both front seat backs was slightly reclined, and both retained their pre-impact orientation. The second row was configured with a two-person bench seat with adjustable head restraints. The third row was configured with a three-person bench seat with adjustable head restraints for the outboard positions. At the time of the vehicle inspection, the adjustable head restraints were removed from the second and third row seat backs.

### **VEHICLE DAMAGE**

#### **Exterior Damage – 1997 Plymouth Voyager**

The 1997 Plymouth Voyager sustained minor damage as a result of the sideswipe impact with the sign post (**Figure 5**). The direct damage began 296.0 cm (116.5”) forward of the left rear axle and extended 264.0 cm (103.9”) rearward along the left side plane. The left side mirror was separated from the vehicle. The left front rim exhibited deformation and abrasions and the left front tire was deflated. Longitudinal abrasions began approximately 53.0 cm (20.9”) forward of the leading edge of the left front door and extended vertically from the top of the left front fender to the center trim strip. The abrasions continued in a rearward direction along the left front door and along the left side plane and terminated at the left rear wheel. Lateral crush was present on the left front



**Figure 5. Left front side view of sideswipe damage**



fender and left side panel aft of the left front door. The maximum lateral crush was located at the rear aspect of the left front fender and measured 10.0 cm (3.9"). The Collision Deformation Classification (CDC) for the sideswipe event was 12-LDAS-2.

The Plymouth Voyager sustained moderate damage as a result of the frontal impact with the embankment. The direct contact damage involved the entire frontal width of the Voyager. The combined direct and induced damage involved the entire bumper beam and measured 134.0 cm (52.8"). The center and right lower aspect of the front bumper fascia were abraded with dirt deposits. The entire bumper fascia was displaced left and partially separated from the vehicle. The bumper beam was displaced rearward and the bottom right aspect of the beam was deformed upward (**Figure 6**). The left aspect of the Styrofoam filler was separated. The grille was displaced and the left head lamp assembly was separated. The left front fender was displaced slightly left from induced damage. The right head lamp assembly was displaced and the front aspect of the right front fender was displaced to the left. The right front tire was deflated. The hood was displaced upward. Six crush measurements were taken along the bumper beam and were as follows: C1 = 19.0 cm (7.5"), C2 = 17.0 cm (6.7"), C3 = 21.0 cm (8.3"), C4 = 26.0 cm (10.2"), C5 = 28.0 cm (11.0"), C6 = 28.0 cm (11.0"). The CDC for the frontal impact with the embankment was 12-FDEW-2.



**Figure 6. View of crushed bumper beam**



**Figure 7. View of deformed steering wheel rim**

#### **Interior Damage – 1997 Plymouth Voyager**

Interior damage to the 1997 Plymouth Voyager was minor and attributed to occupant contact. There was no glazing damage, integrity loss, or intrusion. The rearview mirror was displaced forward on the left side, most likely a result of the driver's air bag expansion. The top half of the steering wheel rim was deformed forward 4.0 cm (1.6") from occupant loading (**Figure 7**). The knee bolster was scuffed from contact with the driver's left knee, and the center console area was



**Figure 8. View of fractured center console**

fractured from contact with the driver's right knee and lower leg (**Figure 8**). A scuff was located on the upper aspect of the center console from possible contact with the driver's right hand or arm. Body fluid (blood) was present on the upper and middle aspects of the center console. The NASS researcher identified a possible contact point to the right A-pillar from the driver, however, it was not likely based on the driver's probable trajectory, injuries, and accompanying contact evidence.



### ***MANUAL RESTRAINT SYSTEMS – 1997 Plymouth Voyager***

The 1997 Plymouth Voyager was equipped with manual 3-point lap and shoulder belts with Emergency Locking Retractors (ELR's) for both front seat positions. The front right manual restraint was configured with a cinching latch plate. The adjustable D-rings were located in the full-down positions at the time of the NASS vehicle inspection. The NASS researcher documented that the restraints exhibited historical use. The second row seating positions were configured with manual 3-point lap and shoulder belts with ELR's and cinching latch plates. The left adjustable D-ring was located in the full-down position and the right adjustable D-ring was located in the full-up position at the time of the vehicle inspection. The third row was configured with manual 3-point lap and shoulder belts with cinching latch plates and ELR's for both outboard positions. The center position was configured with a lap belt. There were no photographs taken of the manual restraint system and no documentation of any loading evidence to the seat belts.

### ***CHILD SAFETY SEAT***

A Century Breverra Classic forward-facing booster seat was installed on the front right bucket seat of the Plymouth Voyager (**Figure 9**). The model number was 4865MAL01 and the manufacture date was February 16, 2000. There were no recalls associated with this CSS. The history of the CSS was not known. The CSS was configured with a five-point harness system for use with children who weighed between 13.6–18.0 kg (30-40 lb) and were between 89-127 cm (35-50") in height. The CSS could also be used as a belt-positioning-booster without the harness system for children who weighed between 13.6-36.3 kg (30-80 lb) and were between 89-127 cm (35-50") in height. The CSS was configured with a tether. The CSS was occupied by a 3-year-old male child who weighed 17 kg (37 lb) and measured 91 cm (36") in height. The child was within the manufacturer's recommended height and weight limits that were specified for this CSS.

The Century Breverra Classic CSS was installed with the vehicle's manual 3-point lap and shoulder belt. The seat belt was routed through the rear aspect of the seat per the manufacturer's instructions. The NASS researcher noted that the tether was used to install the CSS, although the tether anchor point was not specified. The 1997 Plymouth Voyager was not specifically equipped with a tether anchor for the front right seat position. Information regarding the steps taken to install the CSS was not reported. It was not known how tightly the child was secured within the harness system of the CSS.

As shown in **Figure 10**, at the time of the CSS inspection, both harness straps were routed through the bottom set of harness slots. The webbing of both harness straps exhibited longitudinal creases. The CSS was



**Figure 9. Century Breverra Classic Booster Seat**



**Figure 10. Frontal view of the Century CSS showing the harness system**

configured with a split harness retainer clip and both harness straps were gathered in the outboard aspects of the respective retainer clip aspects. The pre-crash position of the harness retainer clip was not reported, and the retainer clip was located approximately 25 cm (10”) below the bottom harness slots at the time of the inspection. Loading evidence to the harness straps could not be determined from the available photographs.

**FRONTAL AIR BAG SYSTEM – 1997 Plymouth Voyager**

The 1997 Plymouth Voyager was equipped with frontal air bags for the driver and front right passenger positions that deployed as a result of the frontal impact with the embankment. The driver’s air bag was housed in the center of the steering wheel hub with asymmetrical H-configuration cover flaps. The top flap measured 2.5 cm (1.0”) in height and 17.5 cm (6.9”) in width at the tear seam. The bottom flap measured 8.0 cm (3.1”) in height and 17.5 cm (6.9”) in width at the tear seam. The driver’s air bag measured 50.0 cm



**Figure 11. Driver's air bag**

(19.7”) in diameter in its deflated state (**Figure 11**), was tethered by two internal straps, and was vented internally through the instrument panel. The NASS researcher documented minor striations on the left aspect of the air bag adjacent to the seam, but the source was not specified. There was no occupant contact evidence documented on the surface of the air bag.



**Figure 12. Front right passenger's air bag**

The front right passenger’s air bag deployed from a mid-mount module with symmetrical H-configuration module cover flaps. Each cover flap measured 7.0 cm (2.8”) in height and 29.0 cm (11.4”) in width. The upper flap exhibited a lateral fracture on the right aspect, but the cause was unknown. The front right passenger’s air bag measured 70.0 cm (27.6”) in height and 50.0 cm (19.7”) in width in its deflated state (**Figure 12**). The air bag was not tethered and was vented internally through the instrument panel. There was no occupant contact evidence documented on the surface of the bag.

**OCCUPANT DEMOGRAPHICS – 1997 Plymouth Voyager**

**Driver**

Age/Sex: 29-year-old male  
 Height: 170 cm (67")  
 Weight: 77 kg (170 lb)  
 Seat Track Position: Between mid-track and full-rear positions  
 Manual Restraint Use: Unrestrained (SCI revised)  
 Usage Source: Injuries, vehicle inspection  
 Eyewear: None (wire-framed sunglasses were found in the vehicle but undamaged)  
 Type of Medical Treatment: Transported by ambulance to a local hospital and admitted for six days

**Driver Injuries**

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanism</b>
Pulmonary contusion in the right upper anterior lobe	Serious (441406.3,1)	Steering wheel rim/column as a result of loading through the driver's air bag
Right intertrochanteric/subtrochanteric femur fracture which was severely comminuted	Serious (851810.3,1)	Knee impact to center console transferred through femur
Closed head injury (driver had no recollection of crash days after the event)	Moderate (160410.2,0)	Steering wheel rim
Small non-displaced fracture of the right zygoma	Moderate (251800.2,1)	Driver's air bag
Abrasions over the right maxilla	Minor (290202.1,1)	Driver's air bag
Laceration over the right eyebrow	Minor (290600.1,7)	Unknown
Cervical spine strain	Minor (640278.1,6)	Indirect – steering wheel rim

Injury source: Post-ER Medical Record

**Driver Kinematics**

The 29-year-old male driver was operating the Plymouth Voyager on the two-lane highway during nighttime hours. The driver's seat track was adjusted between the mid-track and full-rear positions and slightly reclined. Although the NASS researcher identified proper restraint usage, based on the injuries and contact evidence, it was likely that the driver was unrestrained. The NASS researcher also identified the driver as wearing eyeglasses/sunglasses, however, the interview stated that the driver did not wear glasses. The sunglasses found in the vehicle were undamaged, and due to the nighttime nature of the crash, it was unlikely that the driver was wearing sunglasses. The driver reportedly fell asleep, but his exact pre-crash posture was unknown. The sideswipe impact with the sign post probably did not significantly alter the

driver's posture, and based on the distance that the Voyager traveled after the pole impact, it was unlikely that the driver woke up prior to the second impact.

At impact with the embankment, the frontal air bag system deployed and the driver initiated a forward trajectory toward the 12 o'clock direction of force. His left knee struck the knee bolster which resulted in an angular scuff on the bolster under the steering column. His right knee and right lower leg impacted the left aspect of the center console/instrument panel. The right leg contact caused the forces to be transmitted along the right femur, which resulted in a right intertrochanteric/subtrochanteric femur fracture which was severely comminuted. The driver's torso continued in a forward direction and he loaded the deployed driver's air bag. He loaded through the air bag and engaged the steering wheel and compressed the steering wheel rim, evidenced by the 4.0 cm (1.6") forward displacement of the upper half of the rim. His face most likely contacted the steering wheel rim as he loaded through the air bag. The loading to the steering wheel assembly resulted in a pulmonary contusion in the right upper anterior lobe, a closed head injury, a small non-displaced fracture of the right zygoma, abrasions over the right maxilla, and an indirect cervical spine strain. The driver sustained a laceration over the right eyebrow, however, the source of the injury was unknown. The driver rebounded rearward, although his final rest position in the vehicle was not known. He was removed from the vehicle by rescue personnel and transported by ambulance to a local hospital and admitted for treatment. He was released six days following the crash.

**Front Right Child Passenger**

Age/Sex: 3-year-old male  
 Height: 91 cm (36")  
 Weight: 17 kg (37 lb)  
 Seat Track Position: Full-rear  
 Manual Restraint Use: Forward-facing CSS  
 Usage Source: Injuries, vehicle inspection  
 Eyewear: None  
 Type of Medical Treatment: Transported by ambulance to a local hospital and treated and released

**Front Right Child Passenger Injuries**

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanism</b>
Non-displaced linear fracture along the shaft of the fifth left metacarpal	Moderate (752002.2.2)	Front right passenger's air bag
0.3 cm (0.1") right temporal scalp laceration	Minor (190602.1,1)	Air bag-related, fling of left hand into right forehead
Abrasion on the right forehead	Minor (290202.1,1)	Air bag-related, fling of left hand into right forehead
Abrasions on the anterior neck	Minor (390202.1,5)	CSS harness straps

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanism</b>
Abrasions on the lateral neck	Minor (390202.1,9)	CSS harness straps
Anterior chest contusion	Minor (490402.1,9)	CSS harness straps
Contusion on the anterior left hand	Minor (790402.1,2)	Air bag-related, fling of left hand into right forehead

Injury source: Emergency room records

### **Front Right Child Passenger Kinematics**

The 3-year-old male child was restrained in the forward-facing Century Breverra Classic booster seat. The CSS was installed in the front right position of the 1997 Plymouth Voyager with the manual 3-point lap and shoulder belt and cinching latch plate. The front right bucket seat was adjusted to the full-rear track position. The child was restrained in an upright posture in the CSS by the five-point harness system. The tightness of the harness system and placement of the harness retainer clip were not known.

The child's position was most likely unaltered as a result of the sideswipe impact. At impact with the embankment, the frontal air bag system deployed and the CSS and child initiated forward trajectories toward the 12 o'clock impact force. The exact positions of the child's arms were not known, but it was likely that the left arm was extended forward, based on the injuries sustained. The deploying front right passenger's air bag struck the child's left hand, which caused a non-displaced linear fracture along the shaft of the fifth left metacarpal. The air bag displaced his left hand rearward into his right forehead area which resulted in a 0.3 cm (0.1") right temporal scalp laceration, a contusion on the anterior left hand, and an abrasion on the right forehead. The CSS loaded the vehicle's manual restraint and the child loaded the harness system of the CSS. The child's loading of the harness system resulted in abrasions on the anterior neck, abrasions on the lateral neck and an anterior chest contusion. It was not known if the front right child passenger was removed from the CSS at the scene or if he was transported to the hospital in the CSS. He was transported by ambulance to a local hospital and treated and released.

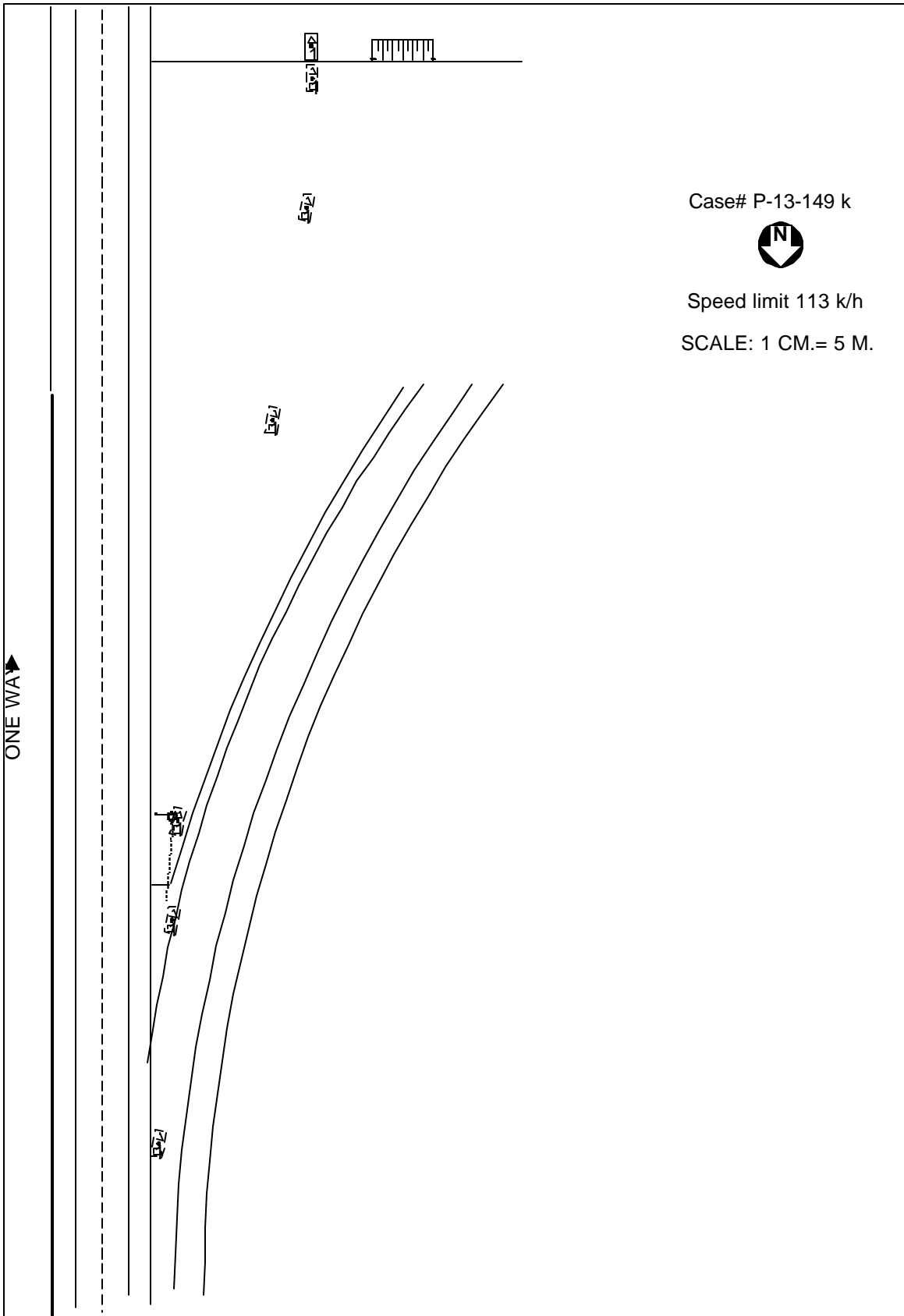


Figure 13. NASS scene schematic