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Special Crash Investigations Remote Child Restraint System Investigation Vehicle: 2004 GMC Yukon Location: Montana Crash Date: July 2018

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15. Supplementary Notes This report documents the remote investigation of a child restraint system (CRS) used by the juvenile occupant of a 2004 GMC Yukon involved in a rollover crash and the disparate injuries sustained by the occupants of the vehicle. Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team.			
16. Abstract This single-vehicle crash occurred in July 2018 in the afternoon on a two-lane, undivided U.S. highway in Montana. The GMC was traveling westbound in the first lane and was being driven by an improperly belted 30-year-old female. The 16-month-old child was seated in a Graco ComfortSport Model 1747504 convertible CRS that was in the second row right seat position. The CRS was being used in the forward facing orientation. The 6-year-old child was seated on a Graco Nautilus 3-in-1 booster safety seat that was in the second row left position and was unbelted. The vehicle drifted off the north side of the roadway. The driver overcorrected to the left and then back to the right. The vehicle departed the roadway to the north, rolled multiple times, and came to rest on its roof. The driver sustained fatal injuries. During the rollover the 6-year-old was ejected from the vehicle. He sustained moderate leg injuries and was transported to a local hospital by ambulance and then by helicopter to an area trauma center located approximately 370 km (230 miles) from the crash scene. The 16-month-old remained in the CRS. He sustained multiple moderate injuries and was transported to the same hospital and trauma center as his sibling. The GMC was towed from the scene due to damage.			
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Special Crash Investigations
Remote Child Restraint System Investigation
Case Number: DS18019
Vehicle: 2004 GMC Yukon
Location: Montana
Crash Date: July 2018

BACKGROUND

This report documents the remote investigation of a child restraint system (CRS) used by the juvenile occupant of a 2004 GMC Yukon involved in a rollover crash and the disparate injuries sustained by the occupants of the vehicle (**Figure 1**). A 16-month-old male occupant restrained in a CRS and an unbelted 6-year-old male occupant were transported to a trauma center 230 miles away. The driver of the GMC was fatally injured. The investigation looked at what role manual restraint usage played in the occupants' kinematics and injury mitigation, with a focus on the CRS-



Figure 1. 2004 GMC Yukon

restrained occupant. This investigation was initiated in response to a notification by a local Crash Investigation Sampling System (CISS) investigator. The Special Crash Investigations (SCI) group of the National Highway Traffic Safety Administration assigned the case to Dynamic Science, Inc., in August 2018.

This single-vehicle crash occurred in July 2018 in the afternoon on a two-lane, undivided U.S. highway in Montana. The GMC was traveling westbound in the first lane and was being driven by an improperly belted 30-year-old female. The 16-month-old child was seated in a Graco ComfortSport Model 1747504 convertible CRS that was in the second row right seat position. The CRS was being used in the forward facing orientation. The 6-year-old child was seated on a Graco Nautilus 3-in-1 booster safety seat that was in the second row left position and was unbelted. The vehicle drifted off the north side of the roadway. The driver overcorrected to the left and then back to the right. The vehicle departed the roadway to the north, rolled multiple times, and came to rest on its roof. The driver sustained fatal injuries. During the rollover the 6-year-old was ejected from the vehicle. He sustained moderate leg injuries and was transported to a local hospital by ambulance and then by helicopter to an area trauma center located approximately 370 km (230 miles) from the crash scene. The 16-month-old remained in the CRS. He sustained multiple moderate injuries and was transported to the same hospital and trauma center as his sibling. The GMC was towed from the scene due to damage.

SUMMARY

Crash Site

The crash site was a U.S. highway. The two-lane, undivided roadway was straight, level, and constructed of asphalt. There were no reported defects to the roadway and visibility was unobstructed. The posted speed limit was 112 km/h (70 mph). Pavement markings on the road include solid white fog lines on both roadway edges, and a continuous dashed yellow centerline. There was a rumble strip on the center line, but not on the road edges. The overall roadway width was 9.1 m (30 ft) with 0.8 m (2.5 ft) shoulders. The weather at the nearest reporting station was 26 degrees C (79 degrees F), 40 percent humidity, fair skies, and the winds were out of the southeast at 25 km/h (16 mph) with gusts up to 38 km/h (24 mph). A crash diagram is attached at the end of this technical report.

Pre-Crash

The GMC was traveling westbound in the first lane at a minimum speed of 111 km/h (69 mph).¹ The driver had a history of seizures and was using multiple anticonvulsants. The coroner indicated that the driver probably had a seizure prior to the crash. The vehicle initially drifted off the right side of the roadway (**Figure 2**). The driver corrected to the left and the vehicle re-entered the roadway. The driver then over-corrected to the right and the vehicle departed the roadway a second time while beginning clockwise rotation (**Figure 3**).

Crash

The vehicle traveled off the roadway a short distance before tripping and beginning a left side leading rollover (Event 1). The second row left passenger was ejected during the rollover. While rolling, the vehicle struck a barbed wire fence (Event 2). The vehicle rolled 10 quarter turns, while traveling approximately 44 m (147 ft) before coming to rest on its roof facing east (**Figure 4**).



Figure 2. Right side roadway departure, looking northwest (police photo)



Figure 3. Second roadway departure, looking northwest (police photo)

¹ Calculated combined speed based on asphalt ($f=0.7$) skid distance, grass ($f=0.6$) skid distance, and rollover ($f=0.48$) distance.

Post-Crash

The driver of the GMC had been using the lap belt only prior to the crash. She was removed by a passerby who cut the lap belt and placed her on the ground. A passerby who was a respiratory therapist went to the driver and began CPR. The driver did not survive and was declared deceased on scene. The 6-year-old was located on his back on the ground approximately 9.7 m (32 ft) southeast of the vehicle. He was awake and crying. The 16-month-old had been extricated by passersby and was being held by them upon police arrival. Both children sustained police reported “suspected serious” injuries and were transported from the scene by ground ambulance to a local hospital. The 6-year-old arrived with a Glasgow Coma Scale (GCS) score of 13. He was treated and then transferred by helicopter to a trauma center. The 16-month-old arrived with a GCS score of 14. He was treated and then transferred by helicopter to a trauma center.



Figure 4. Final rest position, looking north (police photo)

2004 GMC YUKON XL 1500

Description

The GMC was a 2004 GMC Yukon XL 1500, a 5-door sport utility vehicle (SUV) identified by the Vehicle Identification Number 1GKFK16Z74Rxxxxxx. The vehicle was equipped with a 5.3-liter, 8-cylinder, flex fuel engine, automatic transmission, and 4-wheel drive. The vehicle manufacturer’s recommended tire size was P265/70R17 with a cold tire pressure of 220 kPa (32 psi). The vehicle was equipped with Yokohoma Geolander tires of the recommended size. The specific tire information was as follows.

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire Flat	7 mm (9/32 in)	No	Debeaded
LR	358 kPa (52 psi)	7 mm (9/32 in)	No	None
RR	358 kPa (52 psi)	7 mm (9/32 in)	No	None
RF	358 kPa (52 psi)	8 mm (11/32 in)	No	None

The GMC was configured with seating for seven occupants. The front and second row were equipped with bucket seats with adjustable head restraints. The third row was equipped with a bench seat with folding back.

Exterior Damage

The GMC sustained moderate top plane damage as a result of the rollover (**Figure 5**). The damage extended from roof side rail to roof side rail. The maximum crush was located at the right A-pillar with an estimated measurement of 22 cm (8.6 in). The Collision Deformation Classification (CDC) was 00TDDO3. The damage from the impact with the barb wire fence could not be separated from the rollover damage.



Figure 5. Rollover damage, 2004 GMC Yukon

Child Restraint Systems

Graco ComfortSport Convertible Safety Seat The 16-month-old male was seated in a Graco ComfortSport CRS (**Figure 6**) identified by the model number 1747504 and manufacture date of January 12, 2009. This CRS was being used in a forward-facing orientation. The child weighed 13 kg (30 lbs) and met the CRS weight range of 9 to 18 kg (20 to 40 lbs). It was configured with an adjustable 5-point harness system, adjustable harness slots, and Lower Anchors and Tethers for Children (LATCH). The CRS was intended to be using either LATCH or the vehicle's seat belt. In this case the seat was installed using LATCH on the second row right seat cushion. The LATCH strap connectors were attached to the left and right LATCH anchors. It is not known if the seat was anchored correctly. The tether was not used. The harness shoulder straps were positioned through the top set of harness slots.



Figure 6. Graco ComfortSport CRS

Graco Nautilus 3-in-1 Booster Safety Seat

The 6-year-old was seated in a Graco Nautilus 3-in-1 CRS booster seat (**Figure 7**). The child was not using the lap and shoulder seat belt.



Figure 7. Graco Nautilus 3-in-1 CRS (police image)

Interior Damage

The GMC sustained moderate interior damage as a result of intrusion and integrity loss (**Figure 8**).

There were vertical and lateral intrusions to the right pillars (A, B, and C), the right roof, and the right roof side rail. The intrusions extended into both the front and second rows. The tempered

glazing was disintegrated on both sides and on the roof. The laminated glazing to the windshield was cracked and displaced. Both right side doors were jammed shut.

Manual Restraint Systems

The front row was equipped with integral driver and front right passenger lap and shoulder seat belts. The driver's belt was equipped with continuous loop belt webbing, a sliding latch plate, and an emergency locking retractor (ELR). The driver of the GMC had been using the lap belt only prior to the crash. The lap portion of the driver's seat belt was cut during her extrication (**Figure 9**). The second row seats were equipped with lap and shoulder seat belts.



Figure 8. Right side intrusion, 2004 GMC Yukon



Figure 9. Driver seat belt, 2004 GMC Yukon

SUPPLEMENTAL RESTRAINT SYSTEMS

The Yukon was equipped with multiple-stage frontal air bags for the driver and front right passenger positions. There were no air bag deployments.

Rollover Mitigation

NHTSA has given this vehicle model a 3-star rating on a 5-star scale with a risk of rollover of 26.3 percent for the 4-wheel drive model. For unknown reasons, the driver allowed the vehicle to drift off the right side of the roadway. The driver corrected to the left and the vehicle re-entered the roadway. The driver over-corrected to the right and vehicle departed the roadway a second time while beginning a clockwise rotation. The vehicle traveled off the roadway a short distance before tripping and beginning a left side leading rollover. The second row left passenger was ejected during the rollover. While rolling, the vehicle struck a barbed wire fence. The vehicle rolled 10 quarter turns, while traveling approximately 44 m (147 ft) before coming to rest on its roof facing east.

NHTSA Recalls and Investigations

There were no open recalls for this vehicle.

2004 GMC YUKON OCCUPANTS

Driver Demographics

Age/Sex: 30 years/female
 Height: 163 cm (64 in)
 Weight: 69 kg (152 lbs)
 Eyewear: Unknown
 Seat type: Bucket
 Seat track position: Unknown
 Manual restraint usage: Lap and shoulder belt available, lap belt only used
 Usage source: Police report
 Air bags: Frontal air bag available, no deployment
 Alcohol/drug data: No alcohol detected. The following drugs were detected: acetaminophen, ethosuximide, flouxetine, lamotrigine, and valproic acid.²

Egress from vehicle: Removed by passersby
 Transport from scene: None
 Type of medical treatment: CPR by passerby

Driver Injuries

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Traumatic aorta rupture	420210.5	Left door panel	Probable
2	Right rib fractures 1-11, left rib fractures 1-4	450203.3	Left door panel	Probable
3	Right lung contusion	441406.2	Center console first row	Probable
4	Thoracic cavity injury Hemothorax, Right No Further Specificity	442200.3	Center console first row	Probable
5	Left comminuted forearm fracture	751900.2	Ground	Probable
6	Thoracic spine fracture at T-11	650416.2	This occupants seat cushion	Possible
7	Facial abrasions	210202.1	Ground	Possible
8	Facial contusions	210402.1	Ground	Possible

² The drugs were generally related to the control of epileptic seizures.

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
9	Torso abrasions	410202.1	Injured, unknown source	Unknown
10	Torso contusions	410402.1	Injured, unknown source	Unknown
11	Extremity abrasions	910200.1	Injured, unknown source	Unknown
12	Extremity contusions	910400.1	Injured, unknown source	Unknown

Source: Autopsy report

Driver Kinematics

The 30-year-old female driver was seated in an unknown posture and was using the lap belt only. She was actively steering the vehicle first to the left and then to the right prior to the vehicle tripping. During the rollover she was displaced in multiple directions but remained in her seat with the lap belt in place. Her left arm and head likely contacted the ground during the rollover sequence. She was removed by a passerby and died at the scene.

Second Row Left Occupant Demographics

Age/Sex: 6 years/male
 Height: Unknown
 Weight: Unknown
 Eyewear: Unknown
 Seat type: Bucket
 Seat track position: Non-adjustable
 Manual restraint usage: Lap and shoulder belt available, not used
 Usage source: Police report
 Egress from vehicle: Fully ejected during rollover
 Transport from scene: Ambulance
 Type of medical treatment: Transported, stabilized, then transferred to a trauma center

Second Row Left Occupant Injuries

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Tibia fracture Proximal tibia fracture NFS, Right	854111.2	Ground	Possible
2	Fibula [malleoli] fracture NFS, Right	854441.2	Ground	Probable
3	Left thigh laceration	810600.1	Barb wire fence	Probable

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
4	Forehead contusion	210202.1	Ground	Possible
5	Left lateral flank laceration	510600.1	Barb wire fence	Probable
6	Laceration, right buttock	810600.1	Barb wire fence	Probable
7	Contusion, right leg	810402.1	Ground	Possible
8	Contusion, left leg	810402.1	Ground	Possible

Source: ER records, nurses notes, radiology report

Second Row Left Occupant Kinematics

The 6-year-old male second row left passenger was seated in an unknown posture and was not belted. It has been reported that he was seated unrestrained on a booster seat. During the initial trip, he was likely displaced to the left. During the rollover sequence he was fully ejected. The ejection medium was the second row left side window. He came to rest approximately 9.7 m (32 ft) southeast of the vehicle's final rest position.

Second Row Right Occupant Demographics

Age/Sex: 16 months/male
Height: 64 cm (25 in)
Weight: 14 kg (30 lbs)
Eyewear: None
Seat type: Bucket
Seat track position: Non-adjustable
Manual restraint usage: Lap and shoulder belt available, not used. Seated in CRS anchored to seat with LATCH.
Usage source: Police report
Egress from vehicle: Removed by passerby
Transport from scene: Ambulance
Type of medical treatment: Transported, treatment unknown, then transferred

Second Row Right Occupant Injuries

Injury No.	Injury	AIS 2015	Involved Physical Components (IPC)	IPC Confidence
1	Slight anterior subluxation C2 on C3	650204.2	Roof right side rail	Probable
2	Posterior scalp contusion	110402.1	Roof right side rail	Probable
3	Contusion, right need	310402.1	Child safety seat harness system,	Certain
4	Abrasion, upper lip	210202.1	Injured, unknown source	Unknown
5	Toe abrasion	810202.1	Right door panel	Possible

Source: ER records, nursing notes, radiology reports

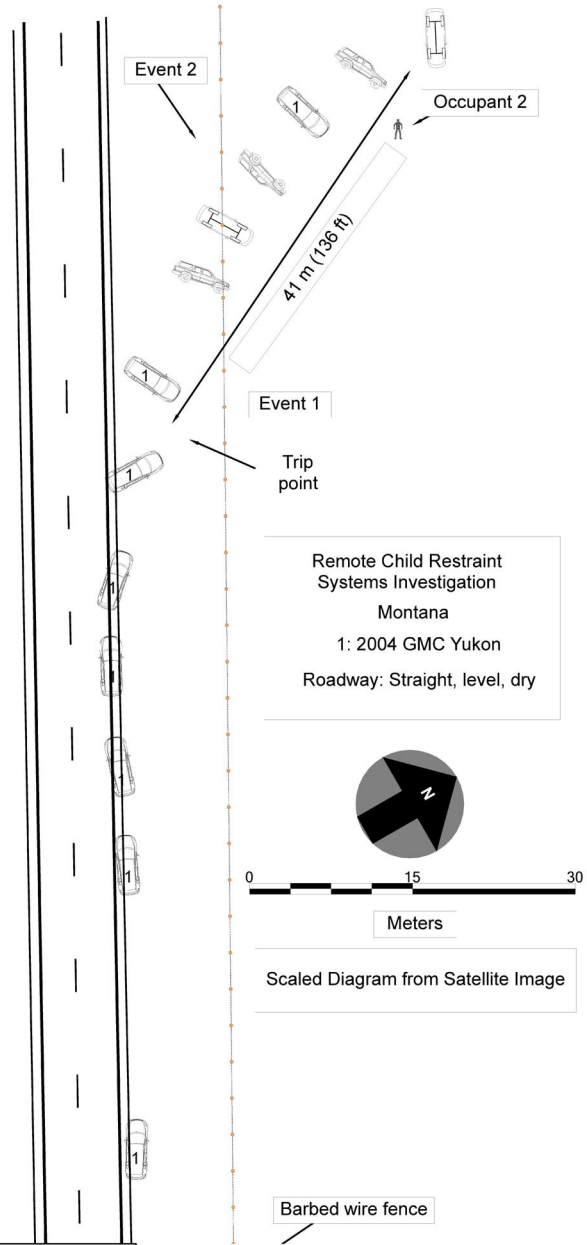
Second Row Right Occupant Kinematics

The 16-month-old male child was seated in a Graco ComfortSport CRS that was anchored to the bucket seat. The seat was installed using LATCH on the second row right seat cushion. The LATCH strap connectors were attached to the left and right LATCH anchors. It is not known if the seat was anchored correctly. The child was restrained by the CRS’s internal harness. The harness shoulder straps were positioned through the top set of harness slots. During the rollover sequence he remained in the CRS. There was intrusion damage in this seating area and he likely contacted the right roof rail with his head, causing the neck injury.

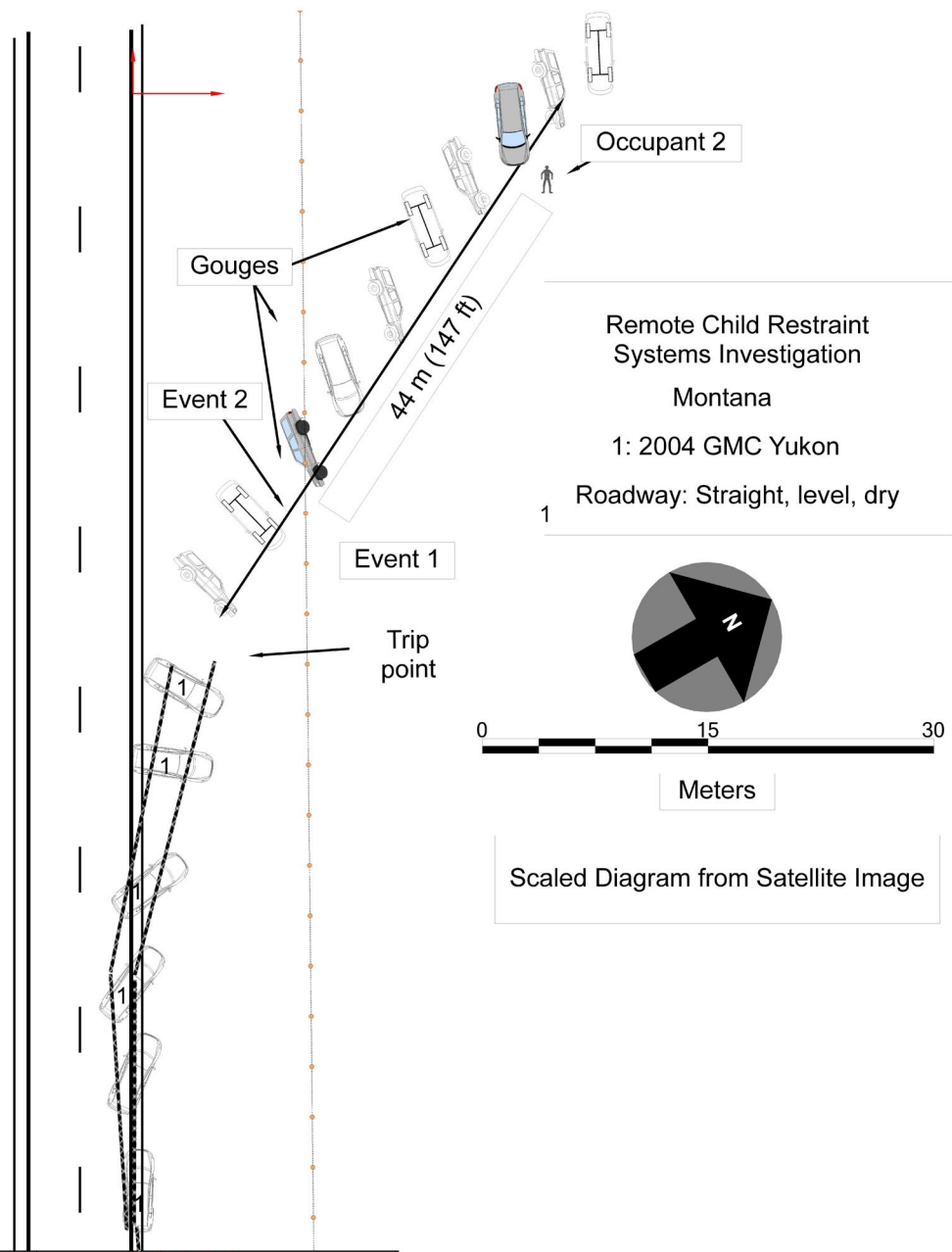


Figure 10. ComfortSport CRS (police photo)

CRASH DIAGRAM



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