



Survival Factors and Biomechanics
Airbag Safety Study Field Notes
May 18, 2009

Location: Deltona, FL
Aircraft Type: Cirrus SR20
Accident Date: February 17, 2009
Accident Time: 1513
Accident Number: ERA09FA169
Airbag Equipped: yes

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Summary:

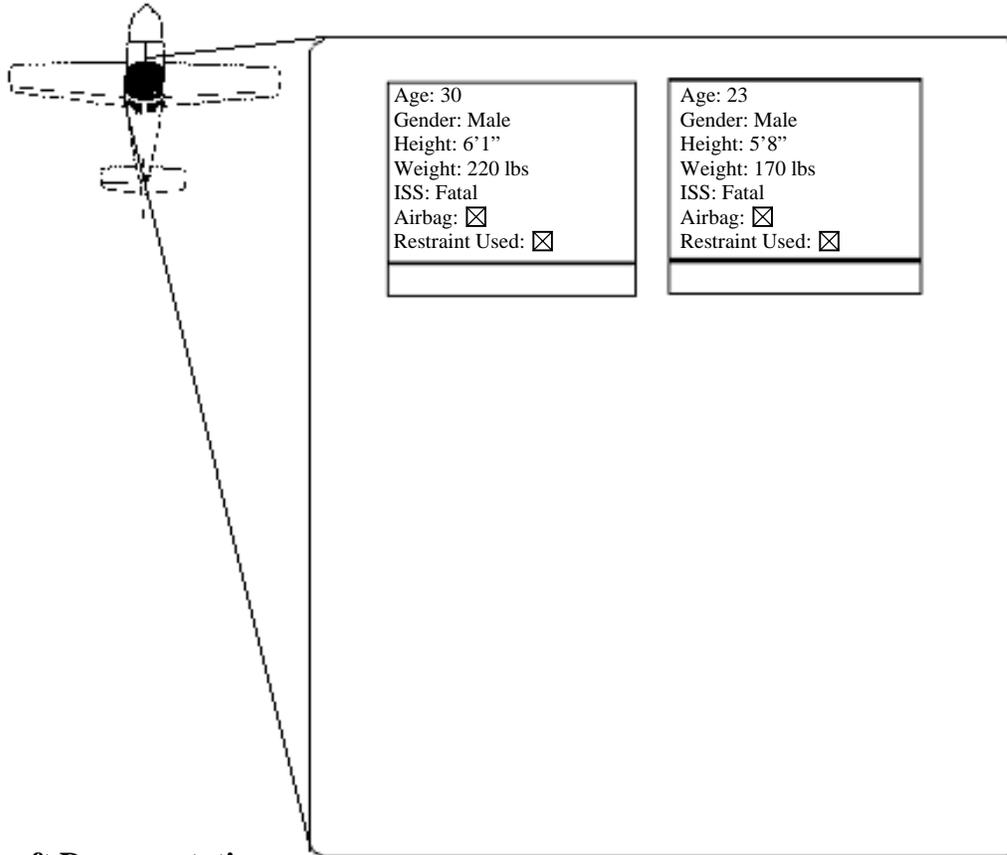
On February 17, 2009, at 1418 eastern standard time, a Cirrus SR20, N493DA, call sign Connection 424, registered to Boston Aviation Leasing II LLC, and operated by Delta Connection Academy (DCA) as a 14 Code of Federal Regulations Part 91 instructional flight, was substantially damaged when it collided with trees and terrain in Deltona, Florida. Visual meteorological conditions prevailed and no flight plan was filed. The commercial pilot flight instructor and commercial pilot receiving instruction were killed. The flight originated from Orlando Sanford International Airport (SFB), Sanford, Florida, at 1408.

Two witnesses in the same neighborhood stated they were checking their mail between 1430 and 1500, when they heard an airplane flying overhead. They observed the airplane flying eastbound between 225 to 250 feet above the trees. Both witnesses stated, "the engine was heard to quit and the airplane made a sharp turn to the right." The nose of the airplane pitched down vertically and the airplane started spinning. Just before the airplane disappeared below the tree line the witnesses observed an orange or red parachute deploy, but the parachute did not inflate. A short time later they heard the sound of an impact. One witness stated he called a local television station and the Volusia County Sheriff Department non-emergency 911 operators and inquired if anyone had reported an aircraft accident. Both the television station and the sheriff department informed the witness that no accidents had been reported.

Delta Connection personnel notified the on duty Delta Academy Manager at 1930 that the airplane was overdue. The Federal Aviation Administration issued an alert aircraft notification at 2153. The airplane was subsequently located on February 18, 2009, at 0315, by the Volusia County Sheriff department.

Abstract:

The survival factors documentation focused on damage to the aircraft fuselage, damage to the cockpit, and the condition of the seats, restraints and the airbags that may have affected the occupants' motion or level of injury. Autopsy reports were reviewed to document the level and extent of occupant injury. The aircraft was equipped with four point restraints at all four seating positions. The outboard shoulder harness of the front two seats was also equipped with an inflatable restraint system (airbag). Aircraft damage and occupant injury patterns indicate that there was extensive intrusion of the instrument panel and the footwell into the survivable space of the first row occupants. Both front seat airbag systems deployed and exhibited squaring of the vent holes but both were also torn on the instrument panel side of the bag. Both front seat restraints showed heavy load marks. The occupants were found with their heads in contact with the instrument panel and their restraint harnessed on their shoulders. The left seat occupant's airbag was found trapped between his head and the radio stack. The right seat occupant's airbag was found off to his right side. Both occupants sustained fatal injuries consisting of extensive blunt force trauma to the face, chest, and lower extremities.

Seating Chart:**Aircraft Documentation:**

Significant damage was noted to the nose of the aircraft (see Figure 1 and Figure 2) with intrusion into the cockpit region at the level of the instrument panel and the foot wells. The windshield was broken. The left and right cabin doors remained attached to the fuselage and neither door window was broken. The right cabin door was found in the opened position. A longitudinal crack was noted on the roof of the aircraft. (See Figure 3.) The cabin roof was fractured at the aft bonded roll cage but the remaining cabin roof was intact. The instrument panel intruded into the passenger compartment by between 10 and 15".¹ Extensive floor crush was also noted in this accident airplane. In addition, the outboard rudder pedal on the left seat side was fractured on the top, outboard corner. (See Figure 4.) The Cirrus Airframe Parachute System (CAPS) had been activated. The enclosure cover was found 40' forward of the right wing tip. The CAPS rocket motor, pick-up collar, rocket lanyards and other associated equipment were found 52' forward of the wreckage.²

¹ This damage was documented by the Cirrus representative before the aircraft was removed from the accident scene. The shape of the instrument panel and foot wells were altered during the recovery and therefore, the survival factors group did not further document the extent of the intrusion.

² Based on the Cirrus on-scene documentation.



Figure 1: An on-scene photograph of the accident airplane looking at the right side of the aircraft.



Figure 2: An on-scene photograph of the accident airplane at the nose of the aircraft after the trees were removed from the region.³

³ The tail of the aircraft was resting on some small trees. After removal of the trees, the tail dropped downward toward the ground.



Figure 3: An on-scene photograph showing the longitudinal crack in the roof of the aircraft. (yellow circle)



Figure 4: A photograph showing the fractured outboard rudder pedal on the left seat side.

On-scene photographs detailed many impact marks in the cockpit. The overhead visors were broken on both sides of the aircraft. On the left seat side, impact marks were noted on the left side of the radio stack including the Garmin Pilot adjustment which was bent down and to the left and the knob was missing. The Garmin Push SQ and the Push ID adjustments were also bent down and to the left. The Garmin GPS knob was missing and the adjustment was bent

down and to the left. (See Figure 5.) Damage was also noted to the throttle which was bent toward the left side. (Figure 6) A photograph of the interior of an exemplar aircraft is shown in Figure 7. Blood was noted on the top, left side of the radio stack and on the left side radio stack controls. Blood was also present on the instrument panel adjacent to the left side of the radio stack. The left seat occupant's head came to rest on the left upper corner of the radio stack, with the airbag trapped between the head and radio. The restraint shoulder straps were on the shoulders. The left side stick controller was visible directly adjacent to this occupant's left elbow.

On the right seat side, the temperature gauges were damaged with the knobs missing from the two outboard temperature controls. The instrument panel was found to have a concave depression and buckling in the region indicated by the yellow arrow in Figure 7. Blood was found across the surface of the instrument panel, with the heaviest concentrations found next to the control stick. The right seat occupant's head came to rest at the location of the temperature controls. The restraint shoulder straps were on the shoulders, and the airbag was to the right of the occupant. The right side cabin door also showed damage to the region of the arm rest and under the door handle. (See Figure 8.)



Figure 5: Damage to the radio stack.



Figure 6: Damage to the throttle.



Figure 7: An exemplar view of the Cirrus interior.



Figure 8: Damage to the forward portion of the right cabin door.

Seats

The seats were examined at Quality Aircraft Salvage⁴ yard. The general seat dimensions are shown in Figure 9. The left seat was found in a position that was five pins back from full forward. On the left seat, the carbon fiber seat pan was fractured on both the outboard and inboard front corners. The rear corners were not fractured. The front spreader tube was cracked and deformed downward. (See Figure 10.) The outboard spreader beam was deformed at the support beam 5.5" back from the front spreader tube. The energy absorption module in the seat pan was also deformed. The remaining thickness of the module was documented and is shown in Figure 11.



Figure 9: Dimensions of the seats on an exemplar photograph.

⁴ 12215 Mattioda Road Groveland, FL 34736 1-800-PLANE99



Figure 10: Cracked front spreader tube on the left seat.

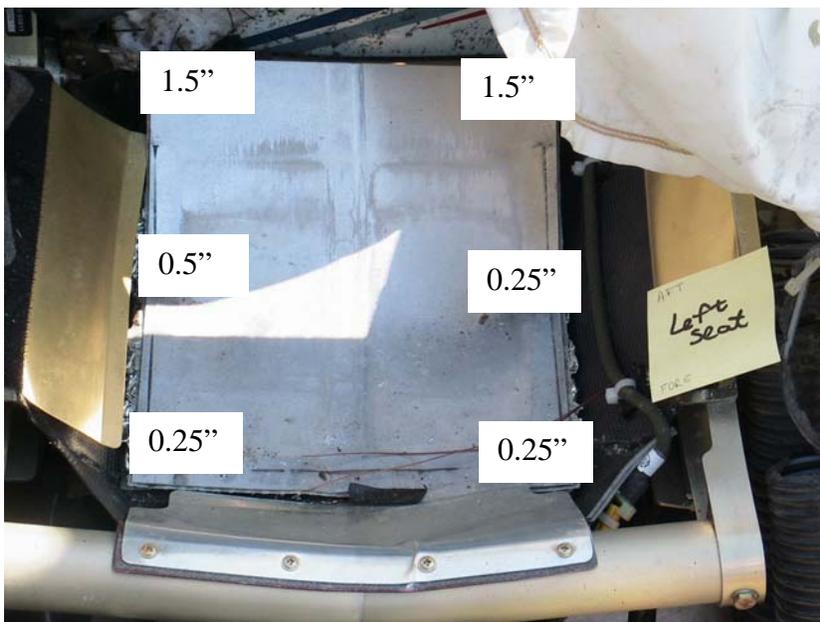


Figure 11: Energy absorption module on the left seat.

The right seat was found in a position that was 1 pin back from full forward. On the right seat, the carbon fiber seat pan was fractured on the inboard front corner extending down to the seat pan and also extending 4" back toward the seat back. The carbon fiber was also cracked on

the outboard front edge with the crack propagating horizontally back 4” toward the seat back. There was no spreader beam damage on this seat but the spreader tube was dented on both the inboard and outboard edges where it impacted the seat adjustment bar. (See Figure 12.) The energy absorption module in the seat pan was also deformed. The remaining thickness of the module was documented and is shown in Figure 13.



Figure 12: Dents on the spreader tube resulting from contact with the seat adjustment bar.

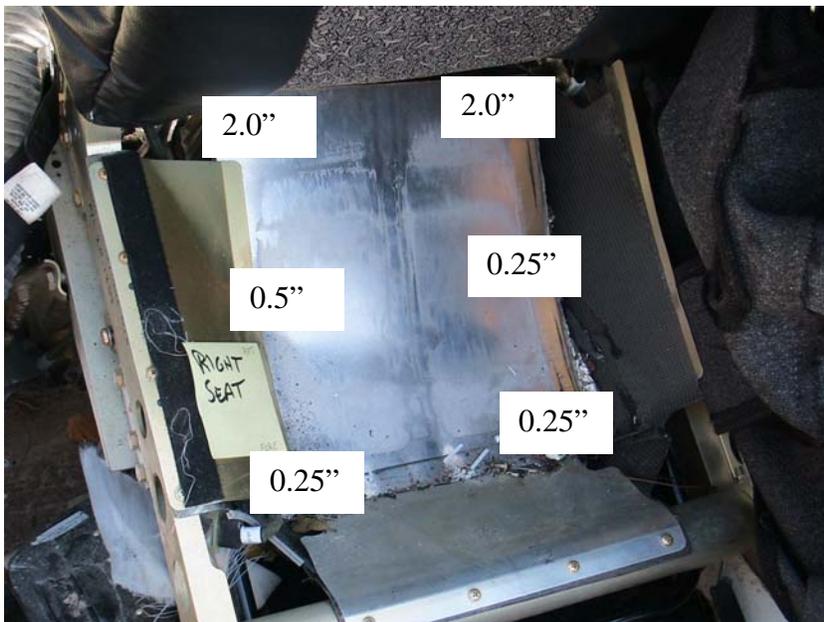


Figure 13: Energy absorption module on the right seat.

Restraints:

The accident aircraft was equipped with four-point restraint systems at all four seating positions. For the left, front seat, the position of the load bar was documented in its position as found. The load bar on the buckle side was located 18” from the anchor bolt. On the connector side, the load bar was also located 18” from the anchor bolt. Both inertia reels and the buckle were functional. Scuff marks (Figure 14) were noted to the inboard shoulder harness on the leather cover. In addition, there were two cuts on the leather cover. The first cut was located 5” from the center of the connector and the second cut was 13” up from the center of the connector. On the connector side of the belt, there was a small divot (Figure 15) on the upper pawl⁵ corner. Witness marks (Figure 16) were found under both the inboard and the outboard side of the shoulder harness under the found position of the connector and buckle load bars, respectively. The witness marks were noted to be the result of heavy loading on the restraint systems.



Figure 14: Scuff marks and cuts on the inboard shoulder harness on the left, front seat.

⁵ A pawl is a finger like mechanism that engages the connector side of the belt.

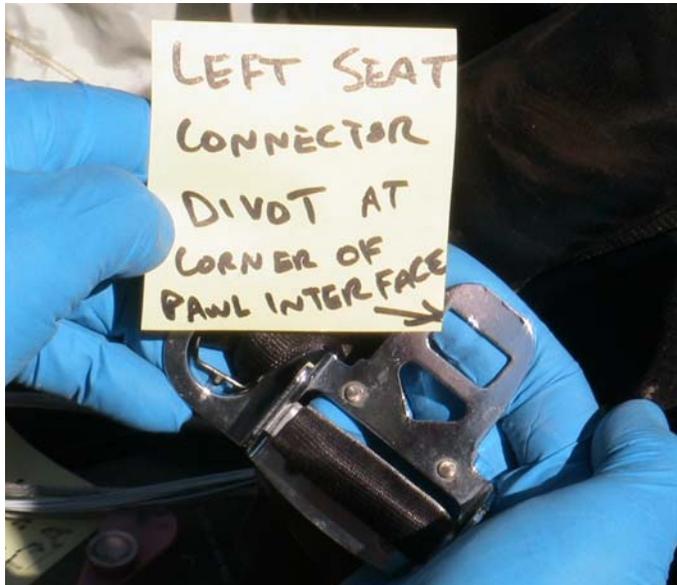


Figure 15: A divot noted on the connector side of the left, front seat's restraint system.



Figure 16: Witness marks on the connector side (left photograph) and the buckle side (right photograph) found under the load bar position for the left, front seat restraint system.

For the right, front seat, the position of the load bar was documented in its position as found. The load bar on the buckle side was located 16.5" from the anchor bolt. On the connector side, the load bar was located 20.5" from the anchor bolt. Both inertia reels and the buckle were functional. On the connector side of the belt, there were two divot marks (Figure 17) on each end of the pawl corner. A small divot (Figure 18) was also noted on the pawl side of the buckle and corresponded to the connector divot on the upper edge. A tear (Figure 19) was documented in the webbing on the connector side of the shoulder restraint, which was located 17.75" from the anchor bolt. Witness marks on this restraint were not as heavy as on the left seat's restraint system. On the connector side, the witness marks began near the tear and extended from 17.75" to 19.75" from the anchor bolt. On the buckle side, the heavy witness marks (Figure 20) were noted under the location of the load bar. Blood was also noted on the inboard shoulder harness on the side facing the occupant. Upon examination, the inboard

shoulder harness was found to be twisted (Figure 21) such that the buckle was facing inboard rather than outboard. After removal of the seat cover, it was discovered that the twist was in the webbing between the inertia reel and the top of the seat back (Figure 22) where the webbing passes through to the front of the seat.

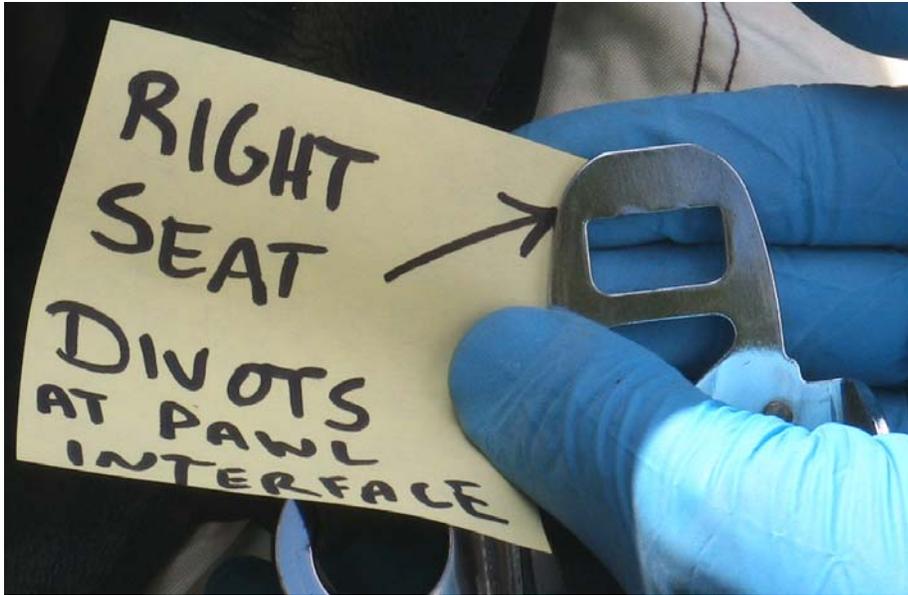


Figure 17: Divot marks on the connector side of the right, front seat's restraint system.



Figure 18: A small divot mark on the pawl side on the buckle, corresponding to the upper edge divot on the connector side.



Figure 19: Witness marks and a tear in the webbing on the connector side of the right, front seats restraint system.

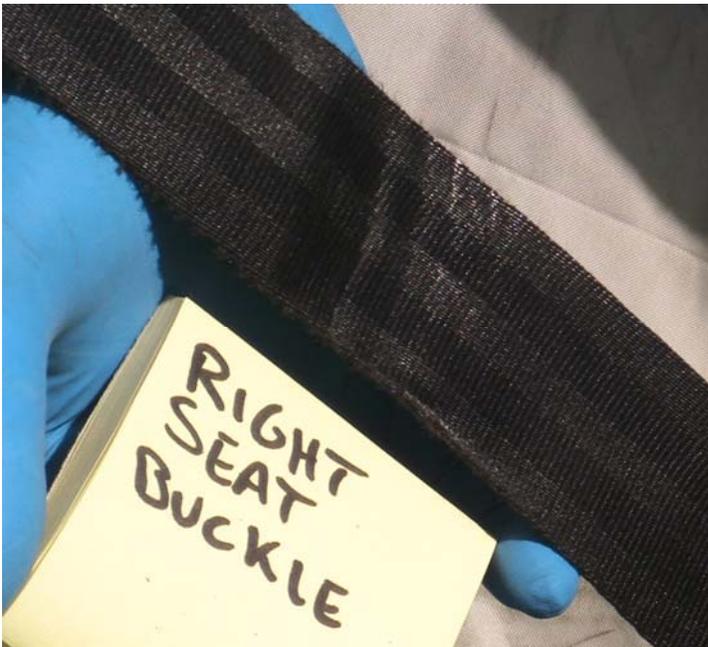


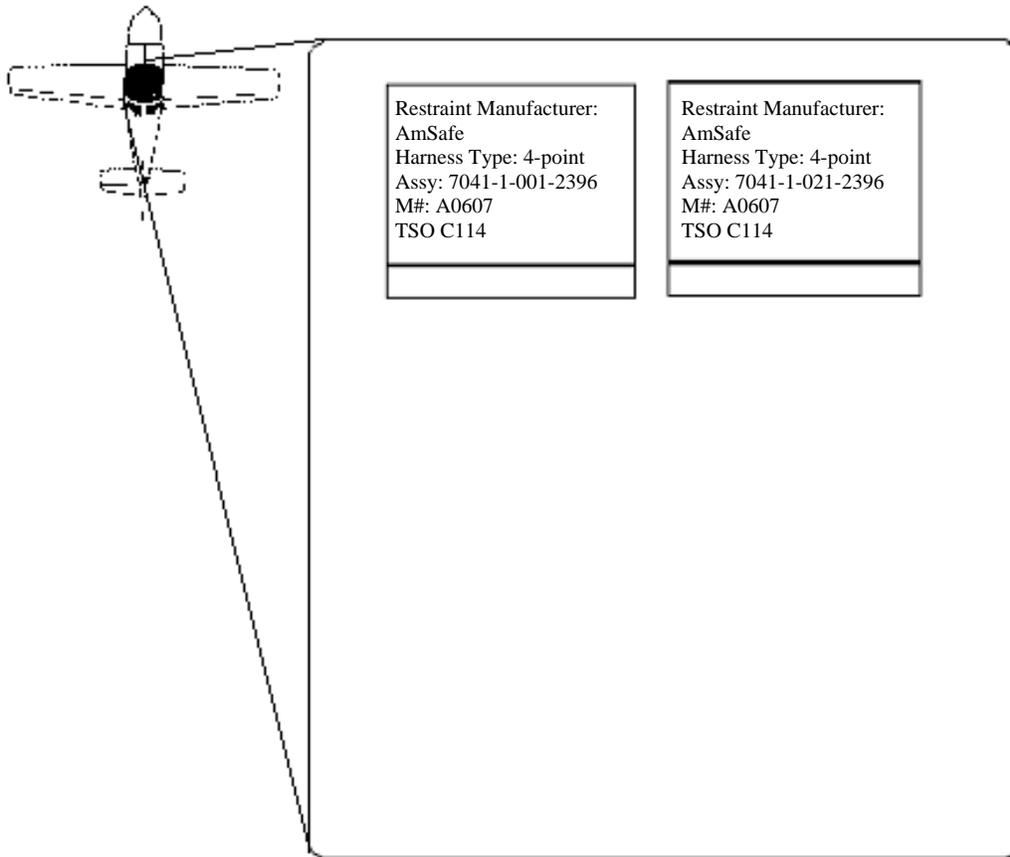
Figure 20: Witness marks on the buckle side found under the load bar position for the right, front seat restraint system.



Figure 21: Photographs showing the inverted inboard shoulder harness on the right, front seat.



Figure 22: The twist in the webbing, marked with a yellow arrow, of the inboard shoulder harness on the right, front seat originated between the inertial reel and the top of the seat back.

Restraint Numbers:**Airbags:**

The two front seats were equipped with restraint mounted airbag systems that deployed from the outboard shoulder harness. The airbags are in the shape of an inverted L. The airbags measured 19" wide at the top and 10" wide at the bottom. The airbag necked down at approximately 10.5" from the bottom. The total height of the airbag was approximately 25". Based on the photographs from the accident site, the left front airbag was found between the occupant's head and the instrument panel. For the right front occupant, the airbag was found off to the outboard side of the occupant, between the occupant and the boarding door. Labels on the airbag system are shown below. General photographs of both the instrument panel side and the occupant side of both the front left and right airbags are shown in Figure 23 through Figure 26.

Airbag Labels:

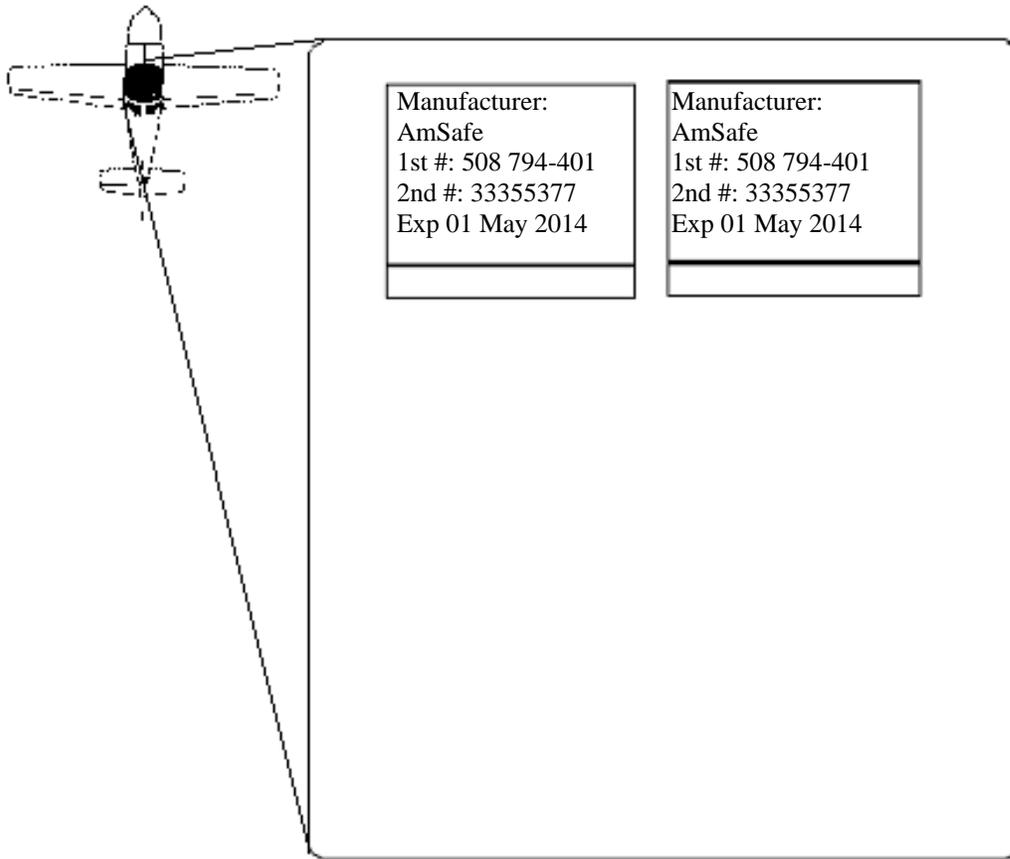




Figure 23: The instrument panel side of the left, front seat airbag.



Figure 24: The occupant side of the left, front seat airbag.



Figure 25: The instrument panel side of the right, front seat airbag.



Figure 26: The occupant side of the right, front seat airbag.

Each airbag is equipped with two vent holes on the instrument panel side of the airbag. One vent hole is in the upper lobe and the other is in the lower lobe of the airbag. These vent holes allow the compressed gas to pass out of the airbag during loading to the bag. Squaring of these originally round vent holes is an indication that loads were placed on the airbag.

For the left, front seat airbag, the top vent hole (Figure 27) was squared extending to 15 threads. The squaring was also noted to be asymmetric. The bottom vent hole (Figure 28) was squared extending 11 threads with a more classic V-shaped pattern. The doubler panel⁶ vent hole was also squared extending approximately 10-11 threads.

The perimeter seams did not show seam combing (or stretching of the airbag seams). The perimeter seam was fractured (Figure 29) on the lower inboard side, below the curve at two stitch points. The doubler seams were intact. The mounting seams, those seams that attach the airbag to the belt, were intact and the hose attachment⁷ seams were intact. Upon examination of the seat back, after the seat cover was removed, it was noted that the inflator brackets, mounted on the seatback, were loose. The inflator hose was intact. A half-moon shaped tear was present on the instrument panel side of the airbag. The threads on the torn edges were heavily frayed. The tear (Figure 30) was located 9" from the top of the bag on the inboard edge of the bag and terminated 9" from the top of the bag in the center of the airbag. The total length of the tear was approximately 9". Scraping marks were noted along the tear pattern on the lower side of the tear. In addition, black scuff marks were found extending from the bottom of the tear toward the bottom of the airbag. A thread scrape extending 3.5" from the inboard edge of the tear down toward the middle of the tear was documented and was noted to be in line with the black scuff marks and also inline with a partial puncture/divot (0.5" below the tear, 0.5" in diameter) in the airbag (Figure 31).



Figure 27: The top vent hole on the instrument panel side of the left, front airbag.

⁶ The doubler panel is a panel inside the airbag that is only present on the lower lobe of the bag.

⁷ The hose attachment is essentially a sock for the inflator.



Figure 28: The bottom vent hole on the instrument panel side of the left, front airbag.

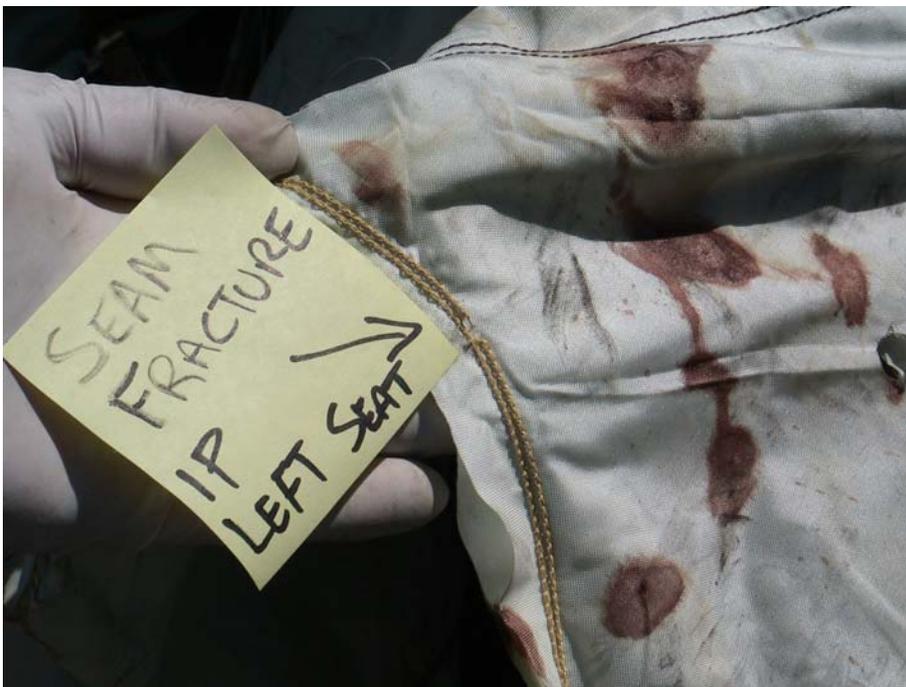


Figure 29: The perimeter seam was fractured on the lower inboard side, below the curve at two stitch points on the left, front airbag.



Figure 30: A tear was documented on the instrument panel side of the left, front airbag.

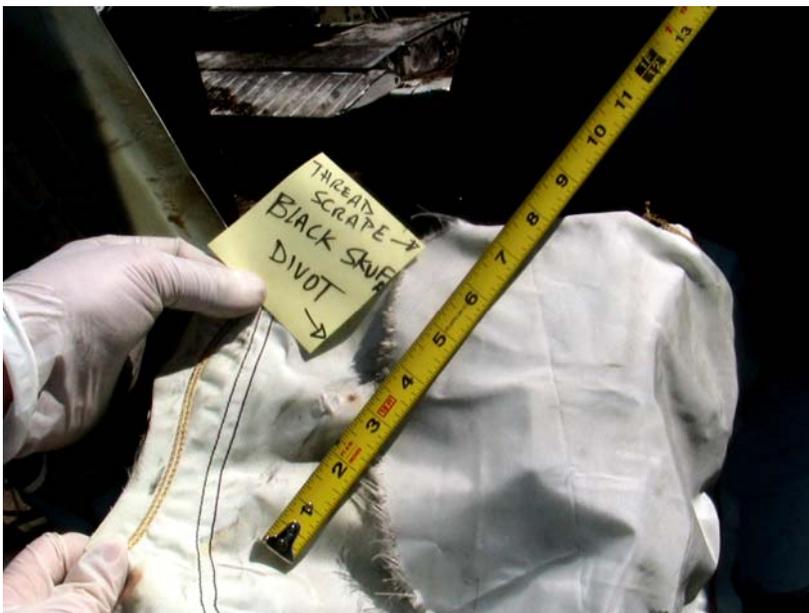


Figure 31: A thread scrape extending 3.5 “ from the inboard edge of the tear down toward the middle of the tear was documented and was noted to be in line with the black scuff marks as well as a partial puncture/divot (0.5” below the tear, 0.5” in diameter) in the left, front airbag.

On the instrument panel side of the left, front airbag, blood marks were noted mainly in the lower portion of the airbag (Table 1). Marks 2-6 were noted to be in a hand-like shape. On the occupant side of the left, front airbag, blood marks were again

mainly in the lower portion of the airbag (Table 2). Also, on the occupant side of this airbag, black scrape marks were noted along the center of the airbag.

Table 1: Locations and dimensions of the blood marks on the instrument panel side of the left, front airbag.

| Mark | Measurement from top of Airbag | Measurement from Outboard Edge of Airbag | Size |
|------|--------------------------------|--|----------------|
| 1 | 9" | 5" | 2" x 1" |
| 2 | 15" | 6.5" | 1.5" diameter |
| 3 | 16.5" | 5" - 7.5" | 2.5" |
| 4 | 19" | 7" | 1" diameter |
| 5 | 19.5" | 8" | 0.75" diameter |
| 6 | 19.5" | 9" (at inboard edge of bag) | 0.75" |
| 7 | 24" | 3" | 0.5" x 1.5" |

Table 2: Locations and dimensions of the blood marks on the occupant side of the left, front airbag.

| Mark | Measurement from top of Airbag | Measurement from Outboard Edge of Airbag | Size |
|------|--------------------------------|--|--|
| 1 | 12.5" | 10" | 1.75" x 0.75" (more diffuse blood spot) |
| 2 | 17.5" | 8.5" | 1" x 0.5" |
| 3 | 19.5" | 10.5" (at inboard edge of bag) | 1.5" x 0.5" |

For the right, front seat airbag, the top vent hole (Figure 32) was squared extending 15 threads. The bottom vent hole (Figure 33) was squared also extending 15 threads. The doubler panel vent hole was also squared extending approximately 8-9 threads. The perimeter seam was fractured (Figure 34) on the curve on the lower inboard side two to three stitch points. The doubler seams were intact. The mounting seams were intact and the hose attachment seams were intact.

An L-shaped tear was present on the upper corner on the instrument panel side of the airbag. The tear (Figure 35) started at the top seam and 15" from the outboard edge. The tear progressed 5" straight toward the center of the airbag and then tore out 6.5" toward the inboard edge of the airbag. The tear terminated on the inboard edge of the airbag, 9" down from the top and 19" from the outboard edge. In the center of the airbag on the instrument panel side, there were half-moon shaped scrape marks that extended from the inboard top edge across the entire upper lobe and were approximately 16" in length. A black mark was noted near the tear (Figure 36) corresponding to the notch in the tear where the tear appeared to slightly change direction. In addition, black scrape marks were noted on the bottom lobe of the airbag.



Figure 32: The top vent hole on the instrument panel side of the right, front airbag.

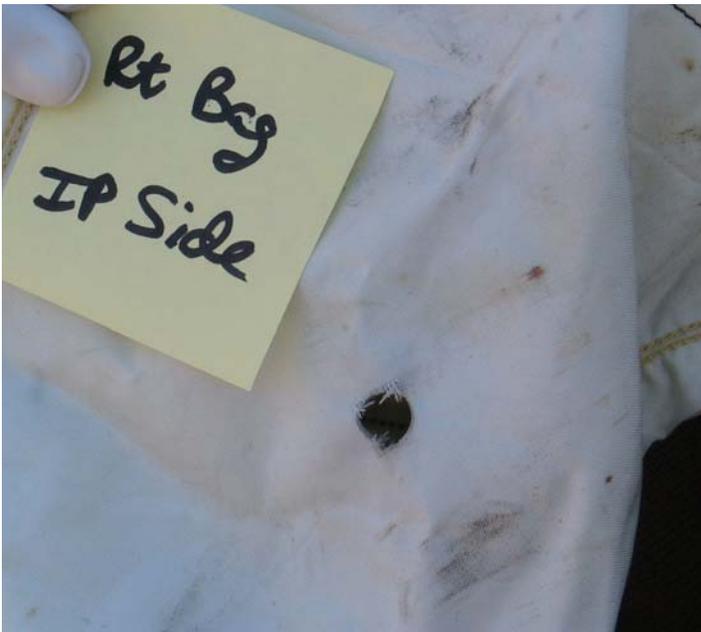


Figure 33: The bottom vent hole on the instrument panel side of the right, front airbag.

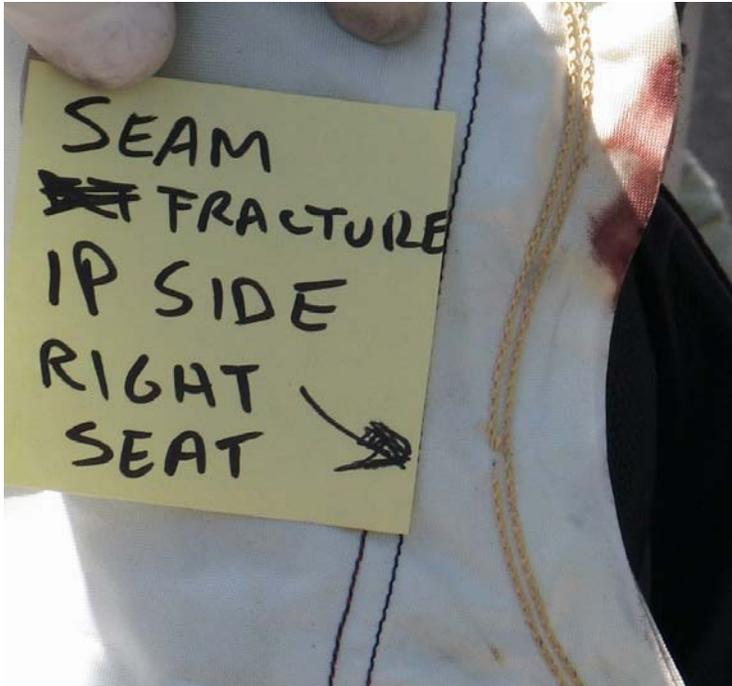


Figure 34: The perimeter seam was fractured on the lower inboard side, along the curve at two to three stitch points on the right, front airbag.



Figure 35: An L-shaped tear was found on the instrument panel side of the right, front airbag.

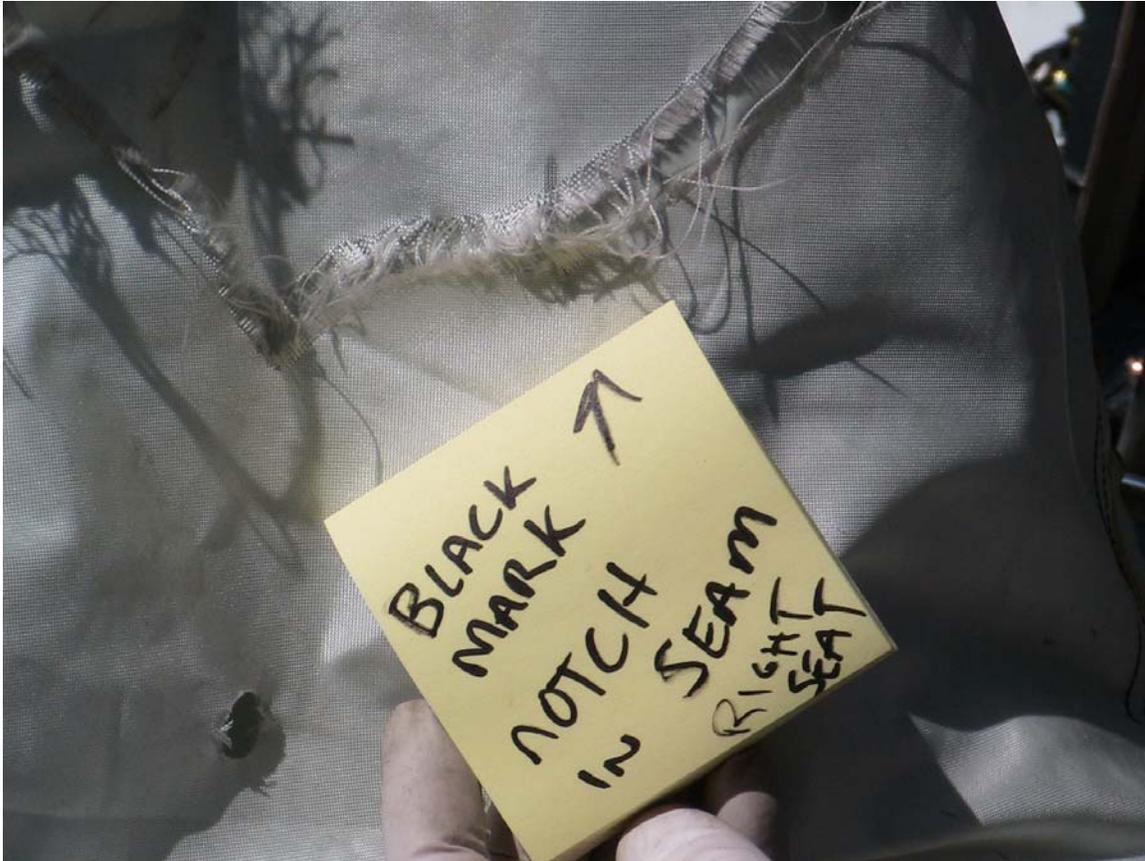


Figure 36: A black mark was noted near the tear on the instrument panel side of the right, front airbag. The mark was near the notch in the tear.

Two blood marks were noted on the instrument panel side of the airbag (Table 3) predominately on the lower edges of the airbag. Blood marks were not found on the occupant side of the airbag. Black scuff marks were noted of the occupant side of the airbag at the top of the airbag on the upper lobe. Black scuff marks were also present on the bottom, outboard edge of the airbag. A small hole on the occupant side of the airbag was found 12" down from the top and 11" from the outboard edge of the airbag. The hole was approximately 0.25" in diameter or approximately 4-5 threads in diameter (Figure 37).

Table 3: Locations and dimensions of the blood marks on the instrument panel side of the right, front airbag.

| Mark | Measurement from top of Airbag | Measurement from Outboard Edge of Airbag | Size |
|------------|--|---|---------------|
| 1 | 15" | 13.5" (on lower edge of airbag curve) | 1.75" x 0.5" |
| 2 (streak) | 22.5" to the bottom edge of the airbag | From 7.5" to the bottom, outboard edge of bag | 1.5" diameter |



Figure 37: A small hole was found on the occupant side of the right, front seat airbag.

Medical/Autopsy Information:

The District Seven Medical Examiner at Daytona Beach, Florida conducted a postmortem examination of the commercial pilot flight instructor and the commercial pilot receiving instruction on February 18, 2009. The injuries are summarized in Table 4 and are graphically displayed in Figure 38 and Figure 39.

Table 4: A table of the occupant injury description and classification along with the age, height and weight for each occupant.

| Occupant Location | Gender | Age | Height | Weight | Description Of Injuries | Injury Classification |
|---------------------------|---------------|------------------|---------------------|---------------|--|------------------------------|
| 1 st Row, Left | Male | 30 (12/21/78) | 6' 1'' ⁸ | 220 lbs | Inwardly displaced fractures of the nasal bones, medial zygomatic arches, mandible, maxilla, and central inferior frontal bone, subarachnoid and intraparenchymal hemorrhages, 2 nd cervical vertebra body fracture, fracture separation of the right clavicle from shoulder, fracture of left clavicle, fracture of the left 3 rd -6 th and lateral right 2 nd -6 th ribs, fracture of the right sternoclavicular joint, left hemothorax, lacerated 10 th intercostal muscles and pleural lining, multiple subpleural contusions of right lung, subadventitial/epicardial hemorrhage of posterior right ventricle, multiple lacerations of right liver lobe, hilar lacerations of spleen, fracture of the distal right radius and ulna, fracture of the right metacarpal bones, fracture of proximal left tibia which is separated from distal left femur, open | Fatal |

⁸ Height was obtained from this occupant's driver's license found on-scene. The only source of weight information was the autopsy report. The autopsy report listed his weight at 220 lbs and his length as 67".

| | | | | | | |
|----------------------------|------|----------------|------|-------------------------|--|-------|
| | | | | | fracture of distal shaft of right tibia and fibula, fracture of right tarsal bones, open fracture of distal shaft of left tibia and fibula, fracture of left tibia from talus, multiple abrasion, contusions and lacerations of the face, chest, abdomen, upper and lower extremities with extremity laceration overlying fractures | |
| 1 st Row, Right | Male | 23 (5/4/85) | 5'8" | 170 lbs ⁹ | Fracture of the maxilla, nasal bones and the nasal-zygomatic junctions, anterolateral fracture of the right 2 nd -5 th , 8 th and 9 th ribs, fracture of the left 6 th -8 th ribs at the junction of the sternum, fracture of the lateral left 8 th -10 th ribs, right lung hemothorax, lacerations of the right lobe of the liver, separation of the 5 th lumbar vertebra and the sacrum with a corresponding distal abdominal aortic laceration, fracture of the mid-shaft of the left humerus, fracture of the distal 1/3 rd of the left femur shaft, bilateral distal tibial and fibular open fractures, multiple abrasions and lacerations of the forehead, lips, chin, chest, abdomen, upper ¹⁰ and lower extremities | Fatal |

⁹ Height and weight were based on this occupant's employee identification badge found on-scene. The autopsy report listed his weight at 157 lbs and his length as 64".

¹⁰ A plastic knob component from the aircraft was recovered during the autopsy from a 2cm deep puncture of the medial left anterior elbow region. The doctor who performed the autopsy described the knob as a black plastic knob of about a 1 cm diameter and similar depth. Its sides had multiple raised vertical ribs

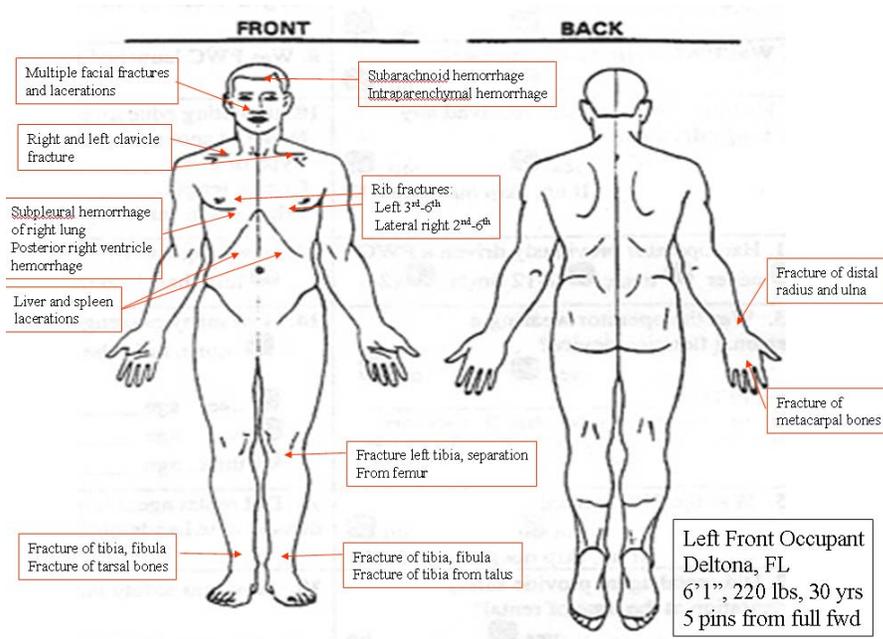


Figure 38: A diagram highlighting the major injuries listed above for the left, front occupant.

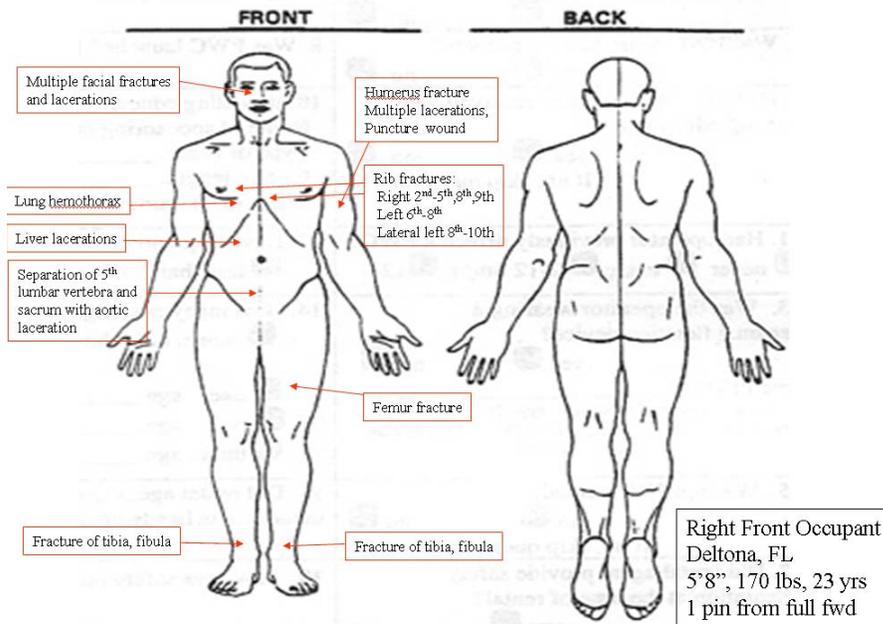


Figure 39: A diagram highlighting the major injuries listed above for the right, front occupant.

that were spaced about 1 mm or less apart from another. The ribs on the sides of the knob gave it an overall appearance that it was a stationary but rotary (clockwise/counterclockwise) type of control knob.