Side Impact Car Crash

External Airbag To Reduce Injury Severity Through B-Pillar Intrusion Reduction

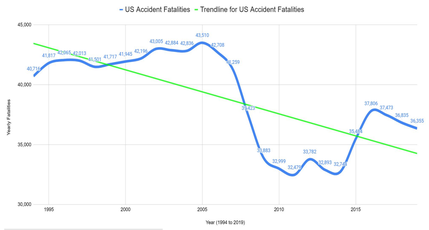
Problem / Question

Car safety has increased in the last four decades. A significant challenge remains - Side and Angle Collisions. Colloquially called T-Bone car crash, it accounts for 45% of fatalities across 35% of multiple car accidents.

1. What is the best way of reducing fatalities & serious injuries in a T-bone car crash?
2. Can we apply airbag technology progress in creating External Airbag that reduces the risk of fatality & serious injury?
3. Can we prove that viability of external airbags using multiple simulations?

Background Research

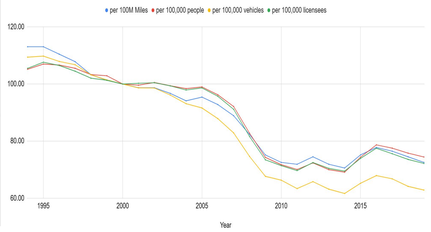
Chart 1: US Automotive Fatalities



- Automotive accident deaths (Chart 1) has decreased in the last 25 years.
- Fatalities is down across factors - miles driven, population, car population and licensed drivers (Chart 2).

- **T-bone car crash**, known as side or angle collision, is one of the most dangerous kind 45% (~8,000) of all fatalities involving multiple cars across 35% of the accidents.
- 1 fatality for every 363 side collision accidents, average is 1 fatality for every 470 accidents

Chart 2: Improved Safety of US Automotive Industry



- Autoliv researchers found that front-seat protection has contributed to safety more than rear-seat occupant protection in the last twenty years.
- B pillar is the zone next to the driver and the far side passenger. **A 2022 IIHS study found a 10 cm reduction in the intrusion of the B-pillar resulted in a 30% increase in the survival of the car occupants**.
- Lifetime economic cost to society for each fatality is $1.4 million. In 2020, the economic cost to society from side collision fatalities is $11.2 billion.

Engineering Goal

- Design a safety mechanism that can be added to cars to increase the safety of car occupants in side-impact collisions.
- Project goal will be achieved by measuring the intrusion of the B-pillar.
- Build car-height-level side airbags into side roof rails that can be attached to cars.
- Cameras on the edges of the rails will monitor for potential side and angle car crashes.
- When crash is imminent, the airbags will be deployed to aabsorb 30%+ kinetic energy.
- Image 1 shows deployment scenario while Image 2 shows airbag coverage

Figure 1: Airbag deploy mechanism prior to collision

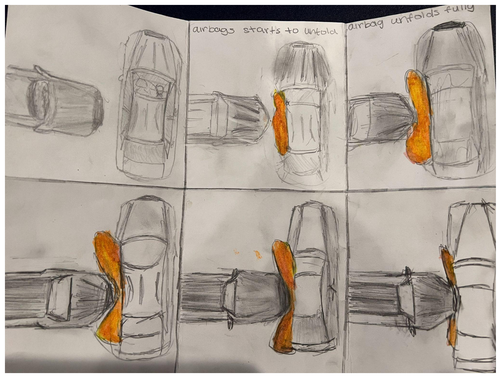
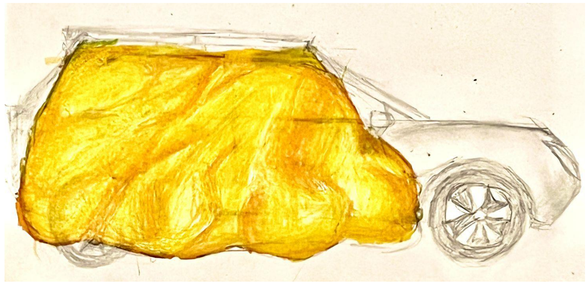


Figure 2: Airbag upon deployment – covers A to C pillars



Variables

Controlled Variables	Independent Variables	Dependent Variable

• Angle of collision - 270^0 (driver side crash)
• Surface - Asphalt drag strip track
• Car information
  ○ Pickup Truck: Gavril Pickup - 4398 lbs
  ○ Sedan: Bruckell Sedan - Bastion Luxe 3.5 AWD - 4343 lbs
  ○ SUV: Gavril SUV - 4652 lbs
	• Speed of collision: 20, 40, 60, 80 mph
	• Presence or absence of external airbag (king size mattress)
	• Target cars options were either of sedan or SUV
	• Collision car options were either pickup truck, sedan or SUV.
		• Distance of incursion of B-pillar

Materials

- Software for Simulation: BeamNG V0.27 & Blender
- Blender is the free and open source 3D creation suite.
- I recreated the accidents in the gaming software platform - BeamNG.
  - I chose Freeform and selected Drag race in Gridmap v2 as the environment.
  - I selected three cars amongst the various options - one each for the the SUV, Sedan and Pickup Truck.

Procedure

1. Following scenarios were simulated for 4 speeds: 20 mph, 40 mph, 60 mph and 80 mph
   a. Standing sedan being hit by SUV
   b. Standing sedan being hit by pickup truck
   c. Standing SUV being hit by sedan
   d. Standing SUV being hit by pickup truck
2. The simulations were run with and without an external airbag.
3. In beamNG, a 170 lb king size mattress was used as a stand-in for the external airbag.

I was able to measure the B-pillar collapse in all these scenarios, and mapped the outcome.

Simulation Results

Simulation Results

Images Credit: All images created by Pranavi Chatrathi and are screenshots from BeamNG

Chart: B-Pillar Intrusion Measurement

Target: SUV	Moving Car: Sedan - B Pillar Intrusion (in cms)		
	EXTERNAL AIRBAG	NO AIRBAG	Difference
20 MPH	1	2	100%
40 MPH	4	5	25%
60 MPH	6	12	100%
80 MPH	11	17	55%

Target: SUV	Moving Car: SUV - B Pillar Intrusion (in cms)		
20 MPH	2	3	50%
40 MPH	3	5	67%
60 MPH	7	14	100%
80 MPH	13	19	46%

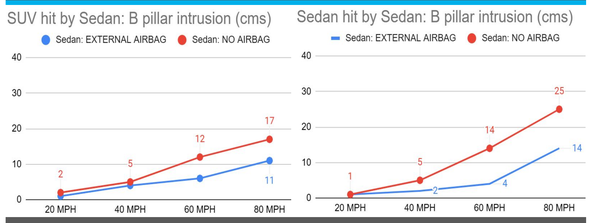
Target: SUV	Moving Car: Pickup - B Pillar Intrusion (in cms)		
20 MPH	1	4	300%
40 MPH	4	7	75%
60 MPH	9	16	78%
80 MPH	21	24	14%

Target: Sedan	Moving Car: Sedan - B Pillar Intrusion (in cms)		
	EXTERNAL AIRBAG	NO AIRBAG	Difference
20 MPH	1	1	0%
40 MPH	2	5	150%
60 MPH	4	14	250%
80 MPH	14	25	79%

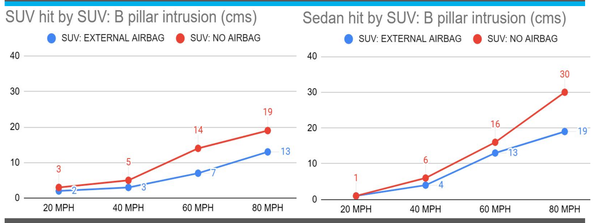
Target: Sedan	Moving Car: SUV - B Pillar Intrusion (in cms)		
20 MPH	1	1	0%
40 MPH	4	6	50%
60 MPH	13	16	23%
80 MPH	19	30	58%

Target: Sedan	Moving Car: Pickup - B Pillar Intrusion (in cms)		
20 MPH	2	2	0%
40 MPH	4	4	0%
60 MPH	No Data	12	
80 MPH	16	35	119%

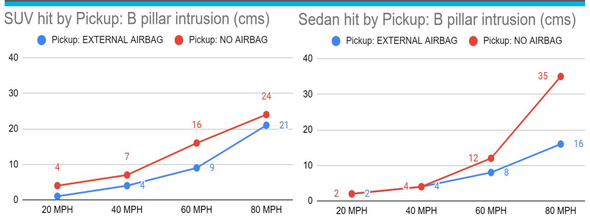
Charts: Hit by Sedan



Charts: Hit by SUV



Charts: Hit by Pickup



Results

The data from BeamNG shows clear trends.

1. The external airbag is ineffective across both sedan and SUV at 20 mph and 40 mph
2. At 60 mph, the external airbag shows effectiveness across all vehicles
3. At 80 mph, the speed at which serious injury and higher is forecasted, there is a large reduction in B pillar intrusion.

The visual evidence from simulation shows massive improvement in the protection of the driver at 40 mph, 60 mph and 80 mph. There was no analysis done for moving vehicles and other secondary collisions.

SUV performance, both with and without external airbags, is better than Sedan performance at speeds higher than 20 mph. At speeds higher than 60 mph, the sedan door gets slammed well into the steering wheel.

Conclusion

- Sidecar crashes have physics going against them. External Airbags can reduce severity of severe accidents and increase the chances of car occupant's survival.
- Putting the airbag in upper side rail aids develop after market solution for existing cars.
- Project validates safety concept. Future expansion is model development, simulation in LS-DYNA and simulating for simultaneous travelling vehicles.

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