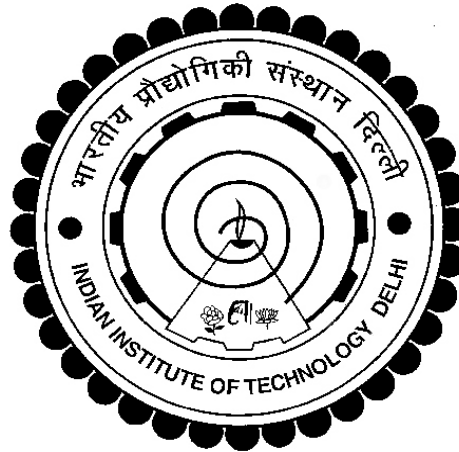


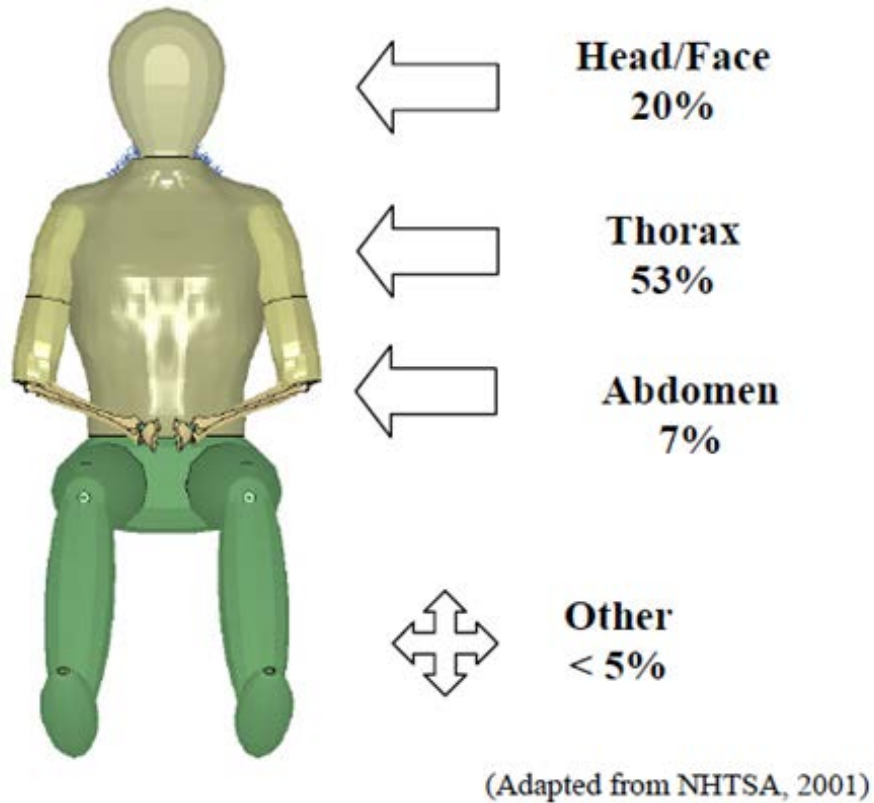
INJURY PREDICTION IN SELECTED OCCUPANT CRASHES ON AN INDIAN HIGHWAY (NH-8) USING HUMAN BODY MODEL

SIMBIO-M 2018



Sanyam Sharma, A. Chawla, S. Mukherjee,
Department of Mechanical Engineering
Indian Institute of Technology, Delhi-110016

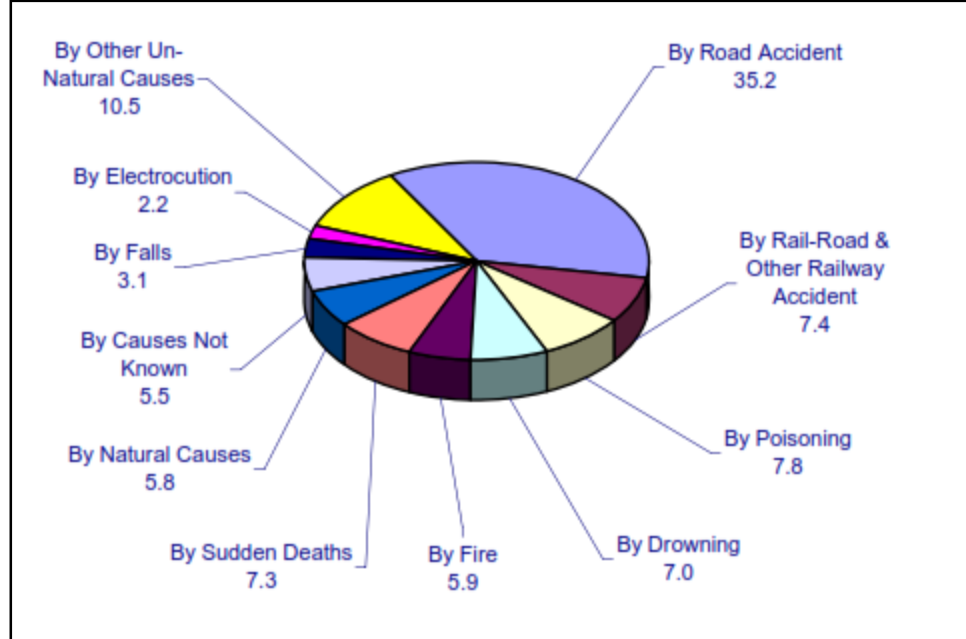
Introduction



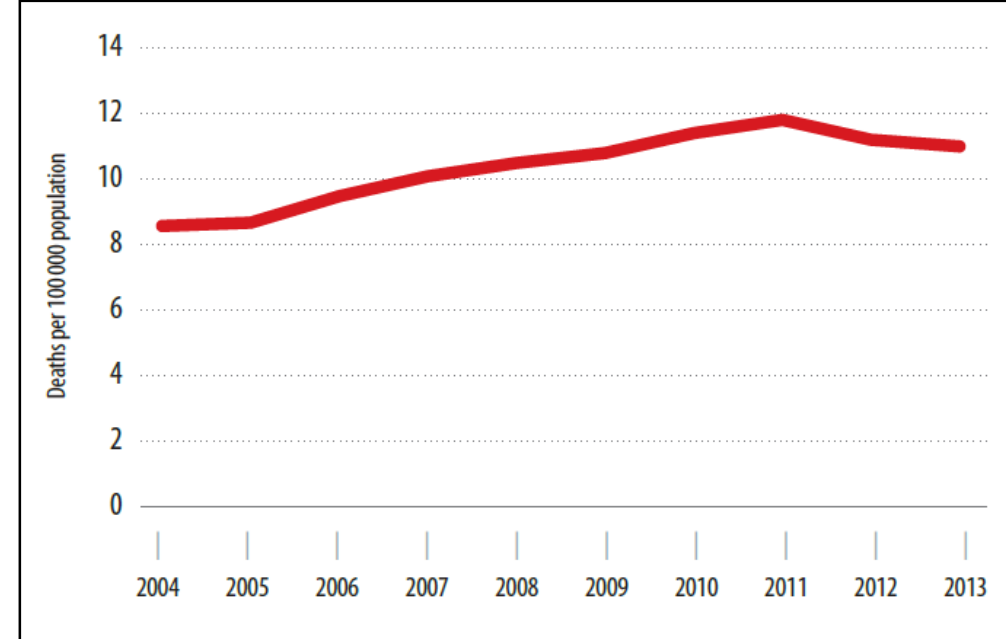
- Road traffic injuries leading cause of death.(WHO 2004, 2009, 2013, 2015)
- Safety devices and features protect the vehicle occupants from major injuries and fatalities (Mukherjee et al. 2007)
- In automotive crashes thoracic region is more susceptible to get injured as compare to other body region.

Fatality injury distribution

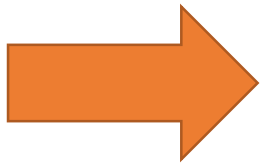
Scenario in India



Various causes of accident deaths during 2012 (National Crime Records Bureau 2014)



Trends in Road traffic deaths (WHO, 2015)

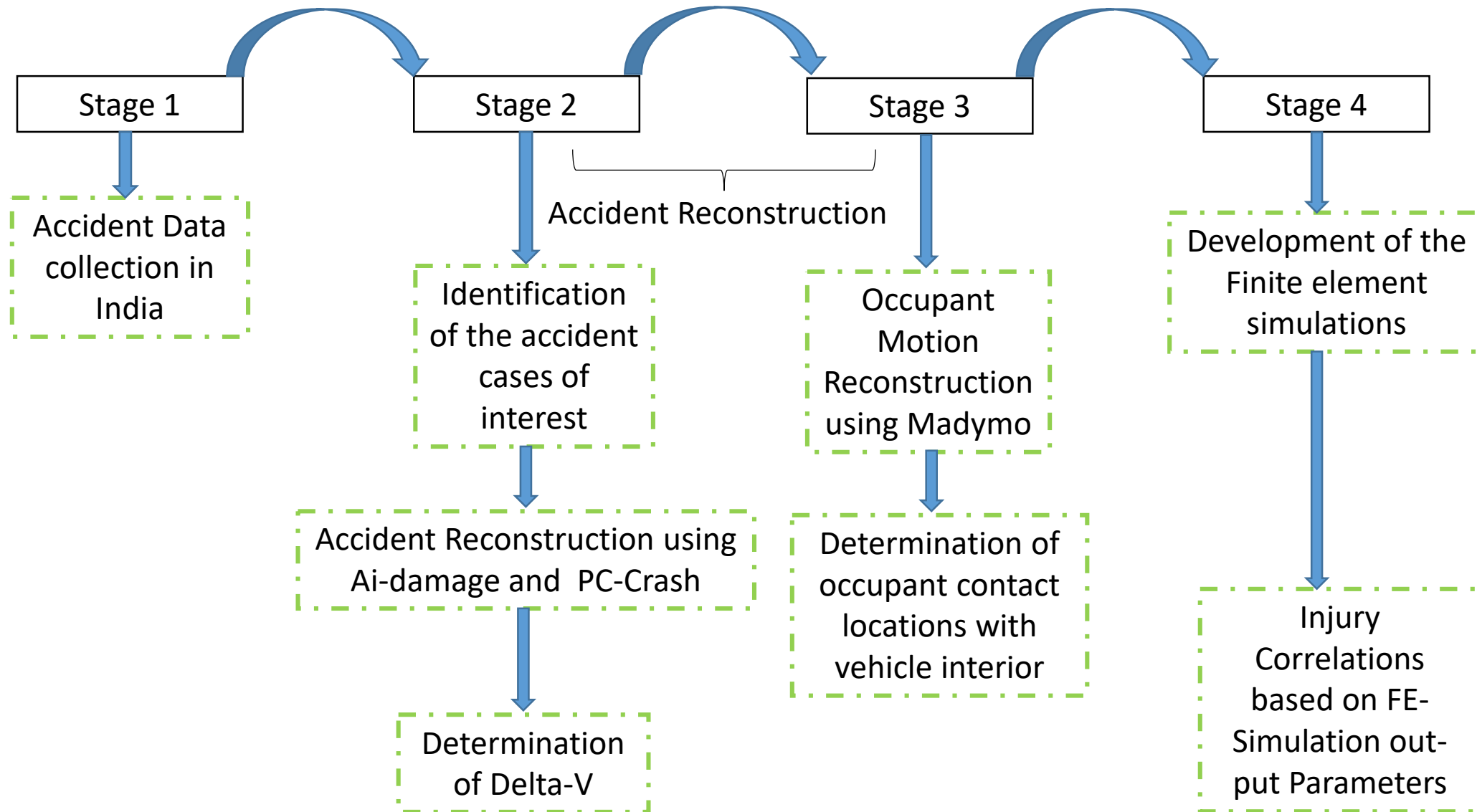


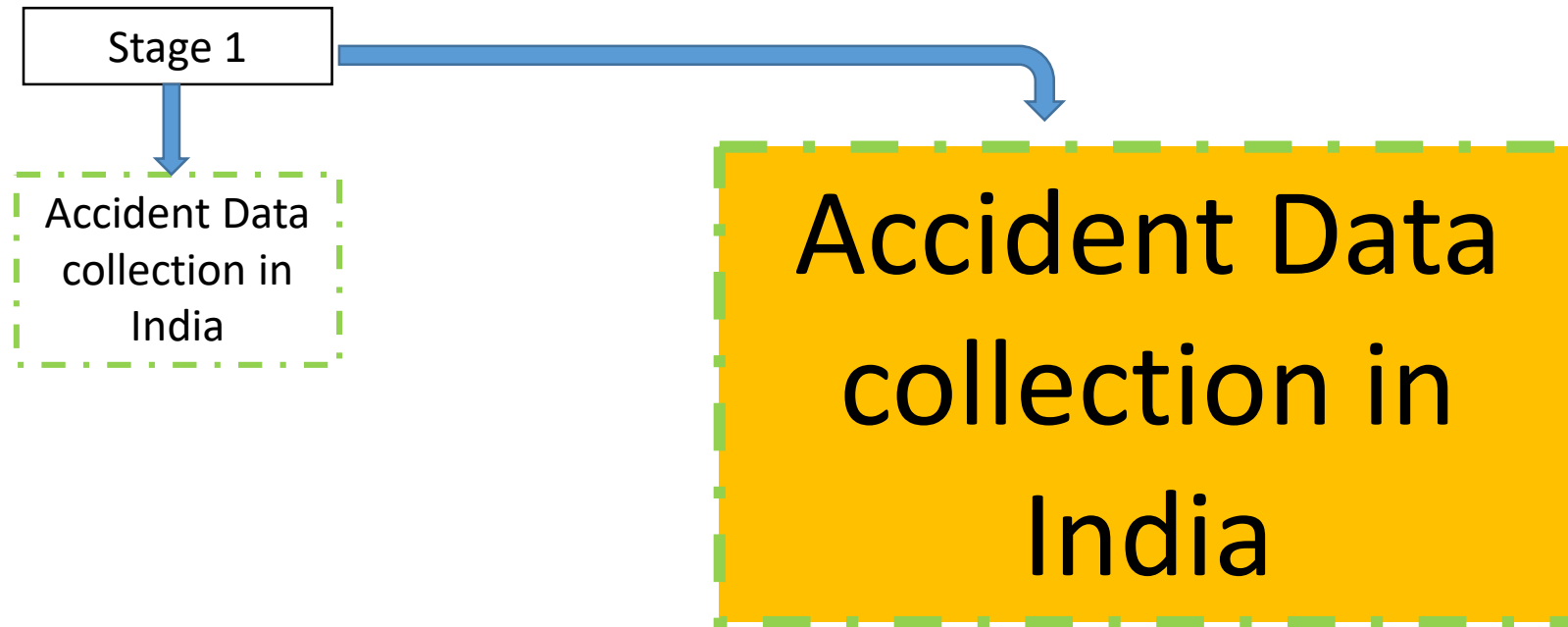
- The frequency of traffic collisions in India is amongst the highest in the world. (Wikipedia page : Traffic collisions in India)
- India did not have its own In-depth crash data collection system.
- Crash data collection is mandatory for the development of the safety regulations.

Why to conduct this research??

- There is a need of a methodology for prediction of injuries using analytical and numerical models for Indian accident database.
- This methodology may be useful for validation studies of the finite element human body models which is very limited in the literature.
- The development of the experimental studies for organ level and tissue level mechanical characterization depends on the load acting on them in the real world scenarios. These loading conditions can only be determined through either PMHS tests or through the real world accident and injury reconstruction studies.

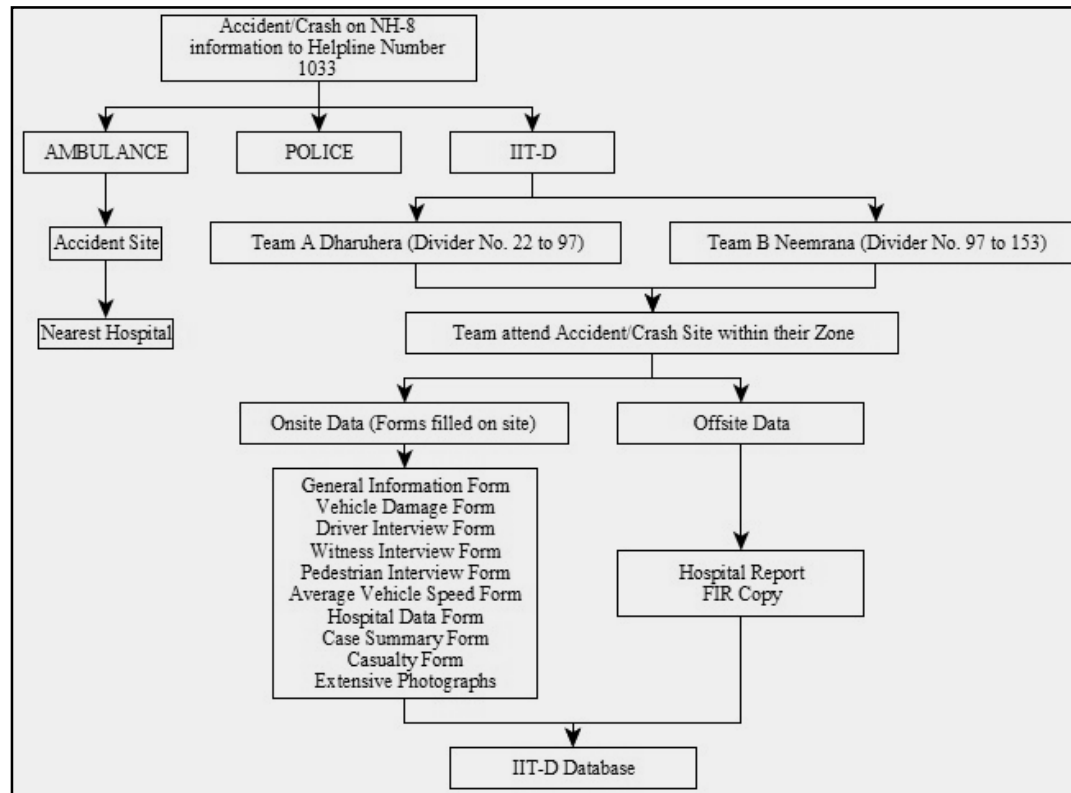
Work Flow



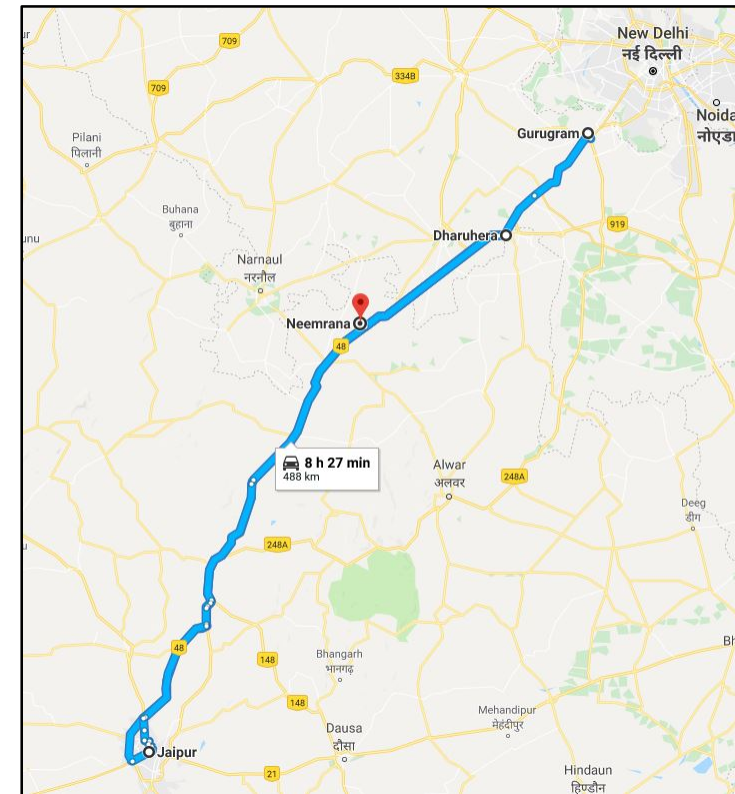


Accident data collection in India

- Actual accident data collected by the data collection team has much useful information for the reconstruction of the crash in terms of its occurrence.
- IIT-Delhi established two teams for accident data collection on NH-8.



Accident Research Methodology



Map Showing the zone covered by the teams

Accident data collection in India

➤ **Inspection and Measurement on the Crash Site**

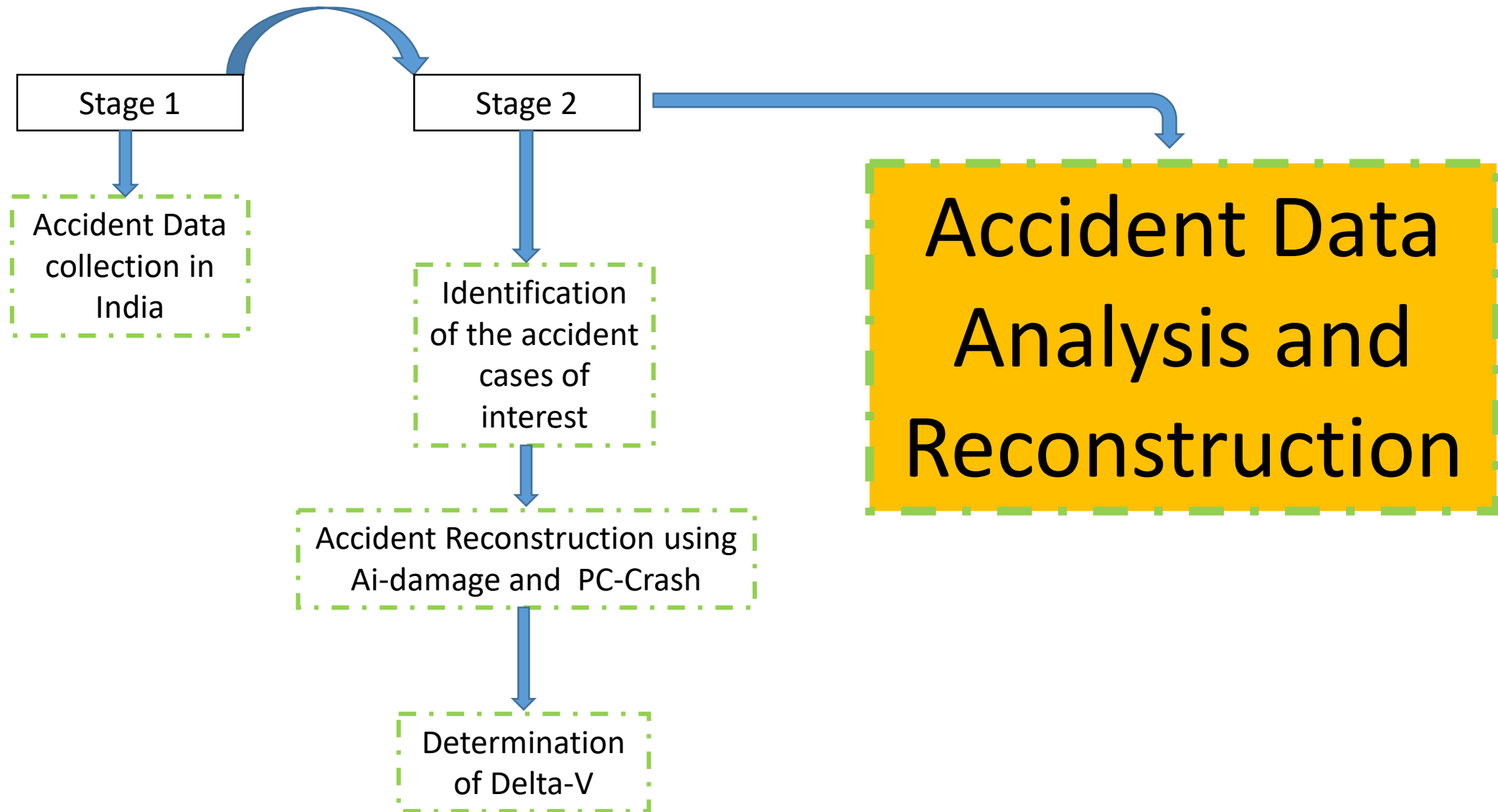
- Skid marks of the colliding vehicles, Point of Impact (POI) of the colliding vehicles, Final resting point of the vehicles, Location of debris found on the site, Location of vehicles parked in the right of way in vicinity of the site, Location of speed breakers around the site, Lane marking on the roads, Location and height of road dividers, Location of poles and traffic lights on and near the crash site, Buildings and walls, Hoardings.

➤ **Collection of Official Data**

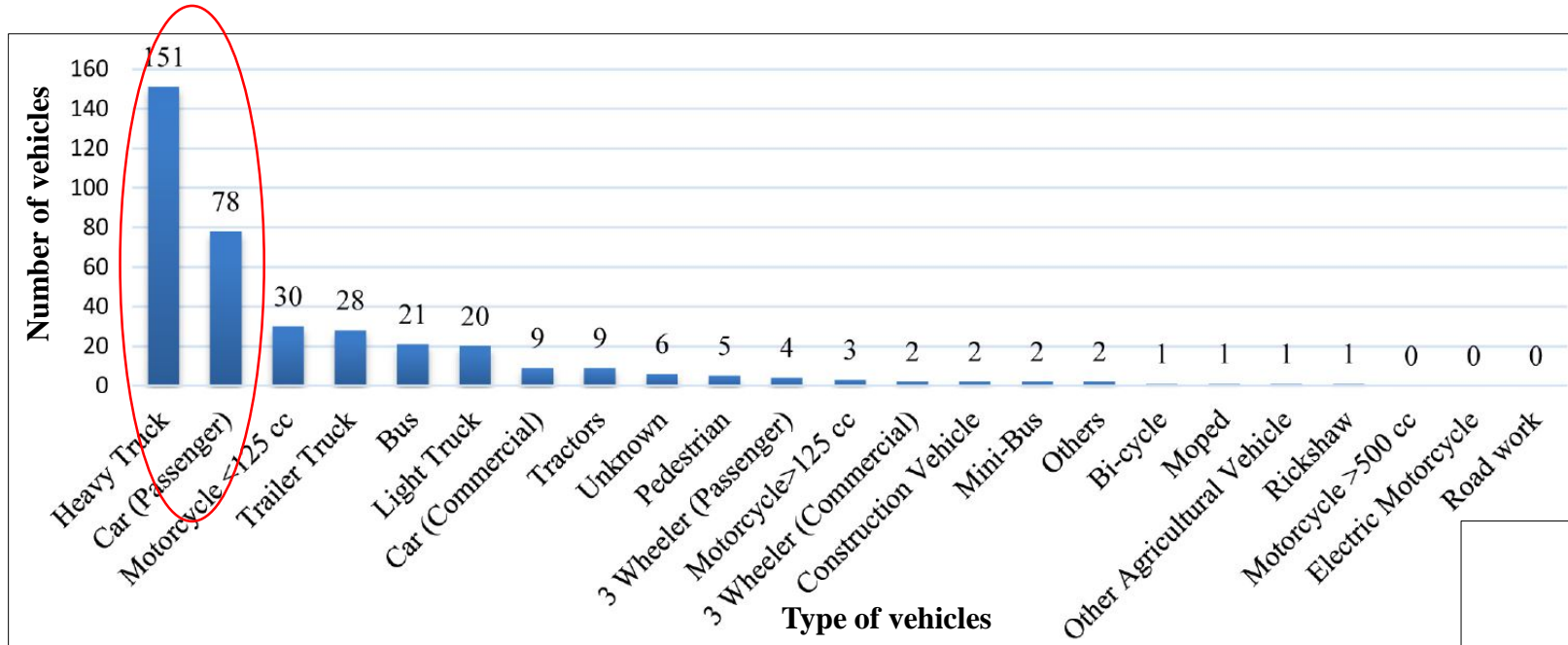
- The police First Information Report (FIR)
- Traffic Inspector (TI) Report,
- The medical report from the hospital.

➤ **Vehicle Damage Profile data**

- CDC (Collision Deformation Classification): 8 digit alpha-numeric code used to classify crash impact damage (created and maintained by SAE and used globally by all automotive safety industries).
- Damage profile specifies the type of collision and damage sustained to the vehicle which will be input to simulation software's.
- Photographs of exterior and interiors of the damaged vehicles.

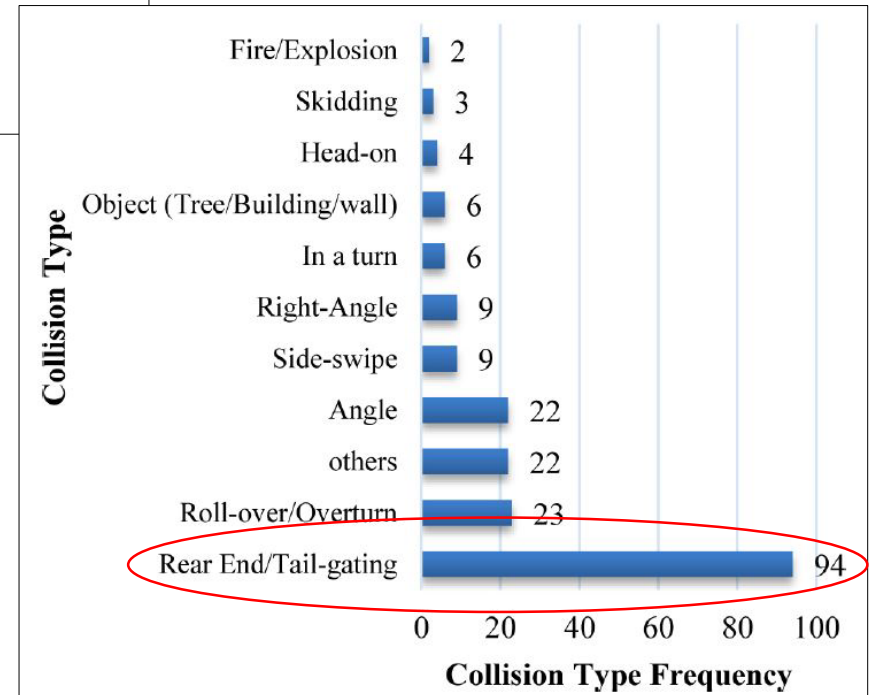


Accident Data Analysis



Frequency of vehicle types involved in crash

Frequency in database according to collision type



Selected Accident cases from NH-8

Cases are selected on the basis of following criteria:

1. Bases on frequency of vehicle types involved in crash: Accident cases involving heavy trucks and passenger cars.
2. Based on frequency in database according to collision type: Rear end and tail gating cases.

Following are the cases selected based on the above two criteria:

Case Details	Vehicle Involved		Orientation of impact
	Vehicle 1	Vehicle 2	
Case DT-30	Maruti Suzuki Alto Lxi	Eicher Truck 20.16	Frontal Impact (Offset Frontal)
Case DT-97	Toyota Innova	Tata truck	Full Frontal Impact
Case DT-58	Toyota corolla 1.8e	Tata 25.15c-Ex truck	Frontal Impact (With Under-ride)
Case NT-58	Tata 2518c Truck	Truck (Unknown Model)	Frontal Impact (Offset Frontal)

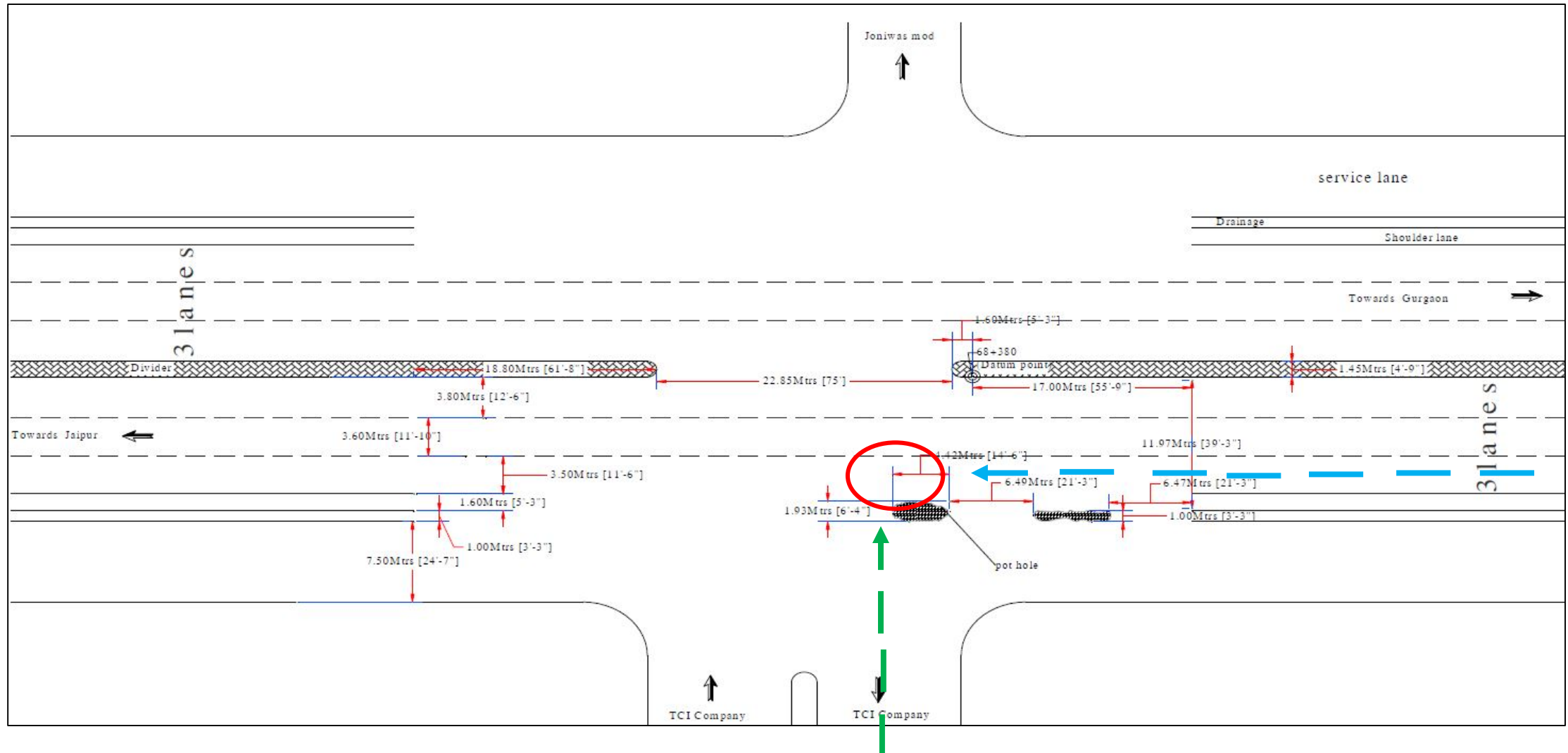
Case 1: Dharuhera Team (DT) Case No. 30

❖ Location: On NH-8, divider number 68.

- Maruti Alto Car (Vehicle 1) going from Delhi to Jaipur, in Lane 3 with 4 passenger.
- (Eicher 20.16) Truck moving from left side of the highway and trying to cross towards Delhi side.
- Suddenly truck driver noticed an Alto car and applied brakes with it's front in the lane 3.
- Accident took place at night around 1 a.m. and the street lights were not working.
- Damage : Alto car's bonnet is damaged and the car got stuck under the truck.
- Injury:
Alto car: 4 passenger, 2 passenger injured (1 G.I., 1 M.I.)



Plan of accident site with dimensions



Steps

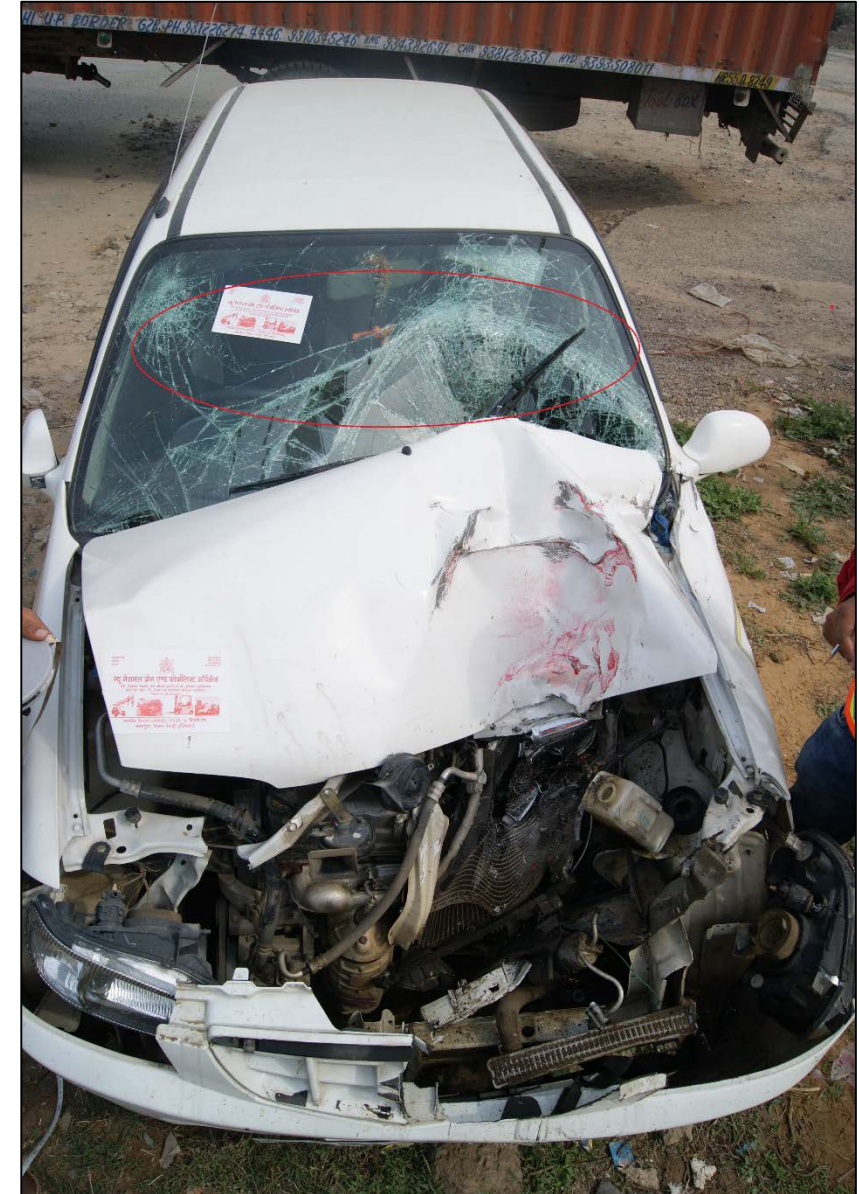
Deformation

Vheicle	C1	C2	C3	C4	C5	C6
V1	35	60	75	41	33	35
v2	5	5	10	15	10	5

		Vehicle 1	Vehicle 2
	Calculation variables	Ai-damage calculations	Ai-damage calculations
1	Energy Abbsobtion (J)	124637	495830
2	Impact Angle (PDOF)	0	90
3	Total Delta-V	55.73	3.51
4	Longitudinal Delta-V	-55.73	-3.51
5	Lateral Delta-v	0	-3.51
6	Delta V at centroid	57.08	19.07
7	Delta Omega (ded / s)	-127.28	-121.08
8	Equivalent test speed (ETS)	53.97	3.82
9	Equivalent energy speed (EES)	54.62	8.91
10	Closing velocity	76.15	

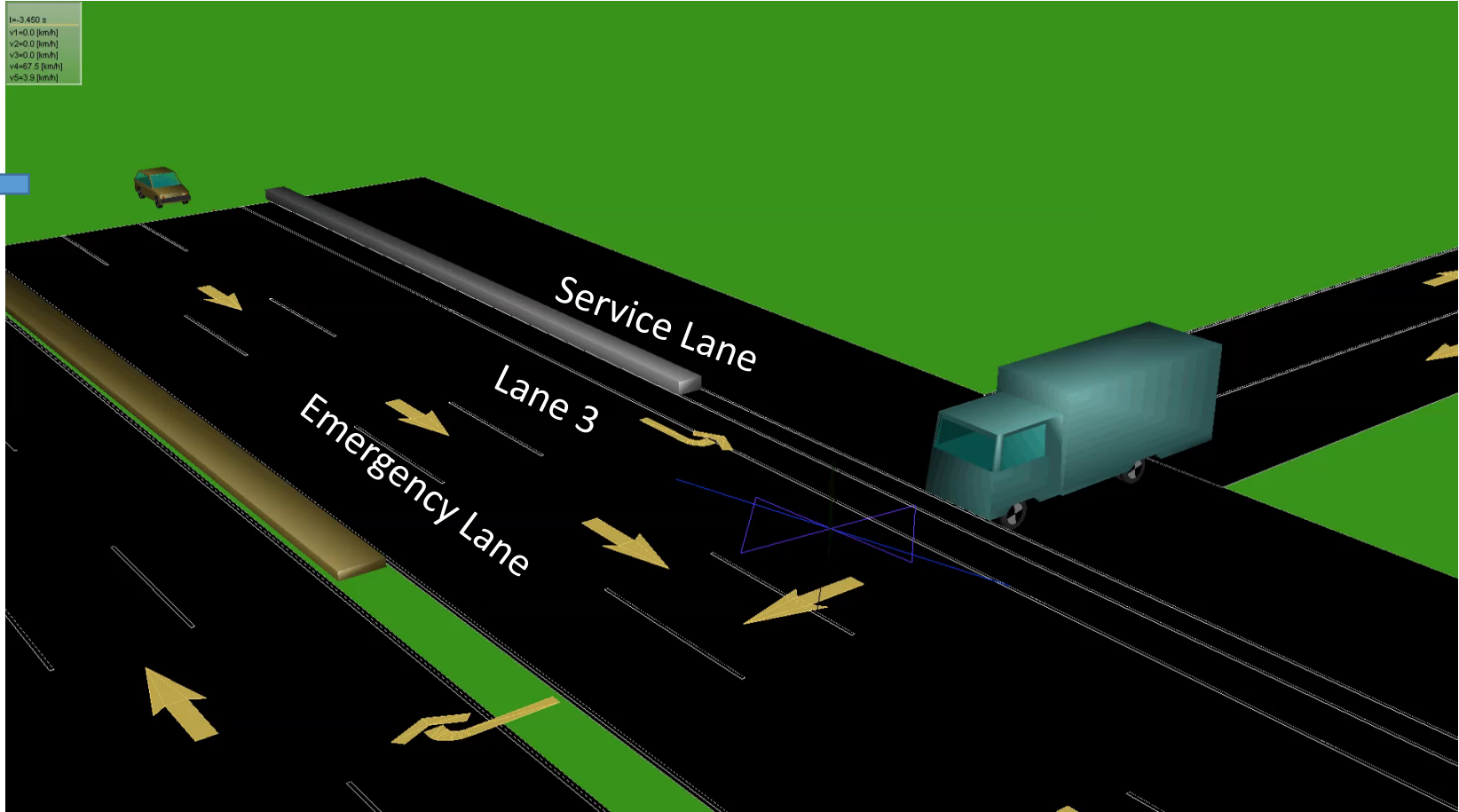
Initial estimate of Delta-V for the vehicles

$\Delta V (\text{Car}) < 57.08$ & $\Delta V (\text{Truck}) < 19.07$



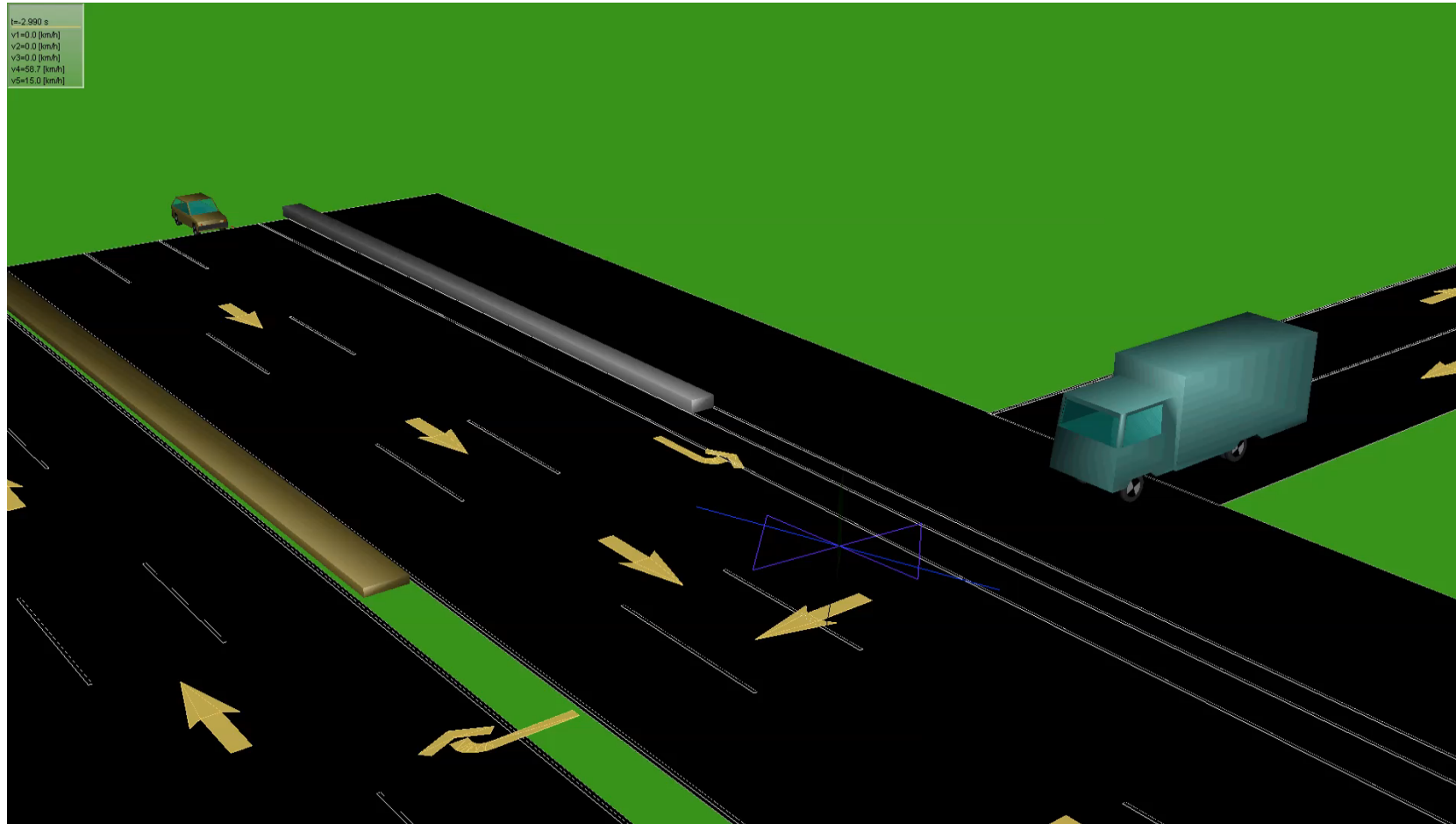
$\Delta V (Car) < 57.08 \text{ \& } \Delta V (Truck) < 19.07$

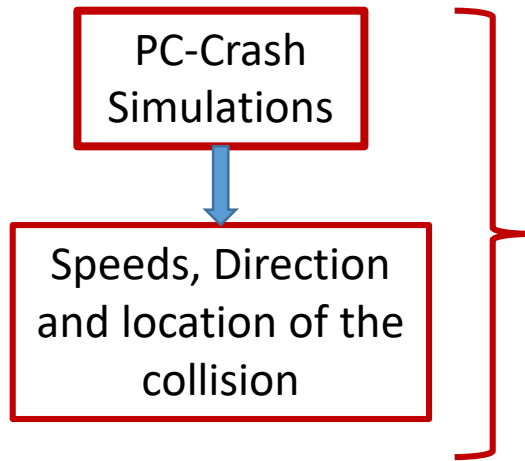
PC-Crash
Simulations



$\Delta V (Car) < 57.08$ & $\Delta V (Truck) < 19.07$

PC-Crash
Simulations





Condition	Truck Velocity (Kmph)	Car Velocity (Kmph)
As per Witness	30-40	70
As per Laser Gun Measurement	45	75.5
As per Truck Driver	10-20	70-80
As per Car Driver	40	60-70

Case 2: Dharuhera Team (DT) Case No. 97

❖ Location: On NH-8, divider number 53+540.

- Time: 10:35 PM
- Toyota Innova collided with Tata 3516 Ex Truck (with trailer).
- Collision Type: Rear End.
- Speed Restriction: 40 kph
- Junction Type: No junction, straight road
- Injury:

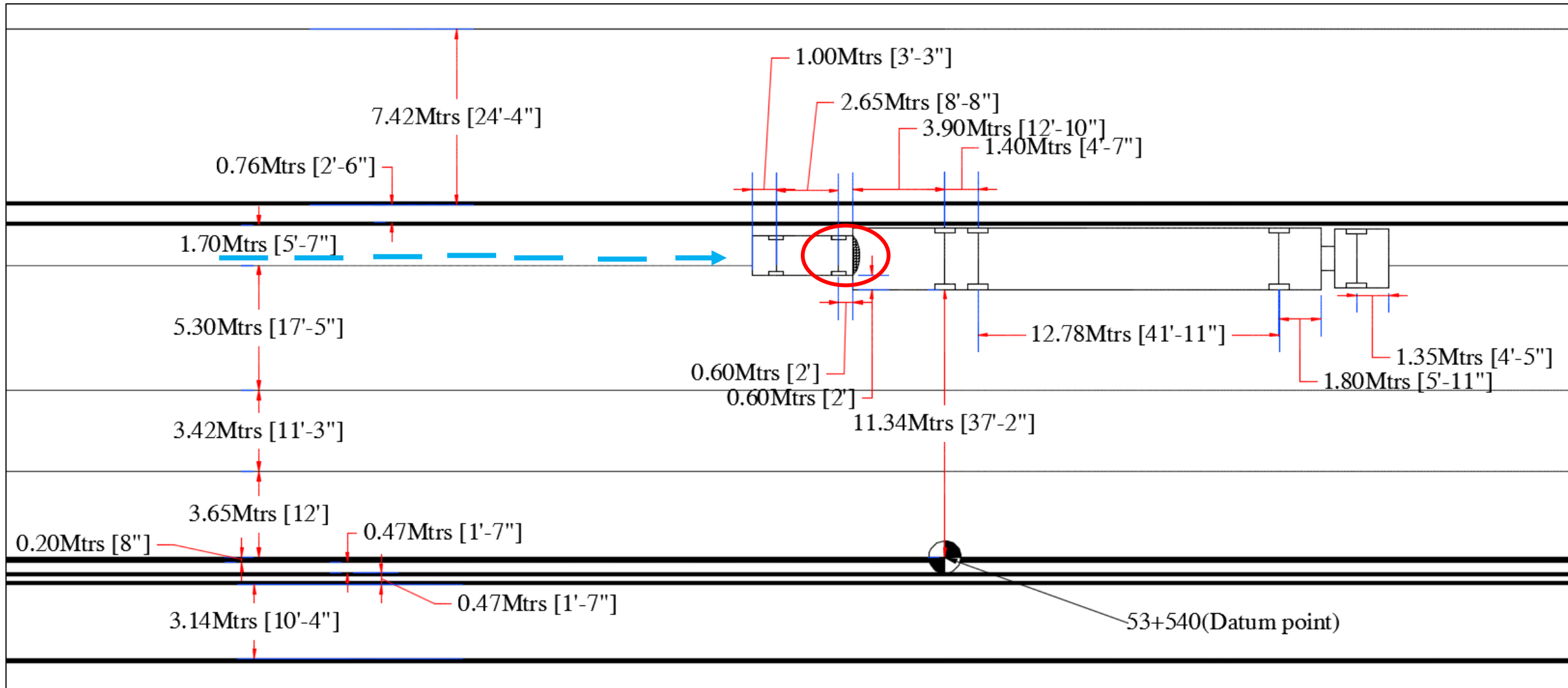
Toyota Innova : 3 occupants;
2 male with grievous injuries
and 1 male with minor injury.

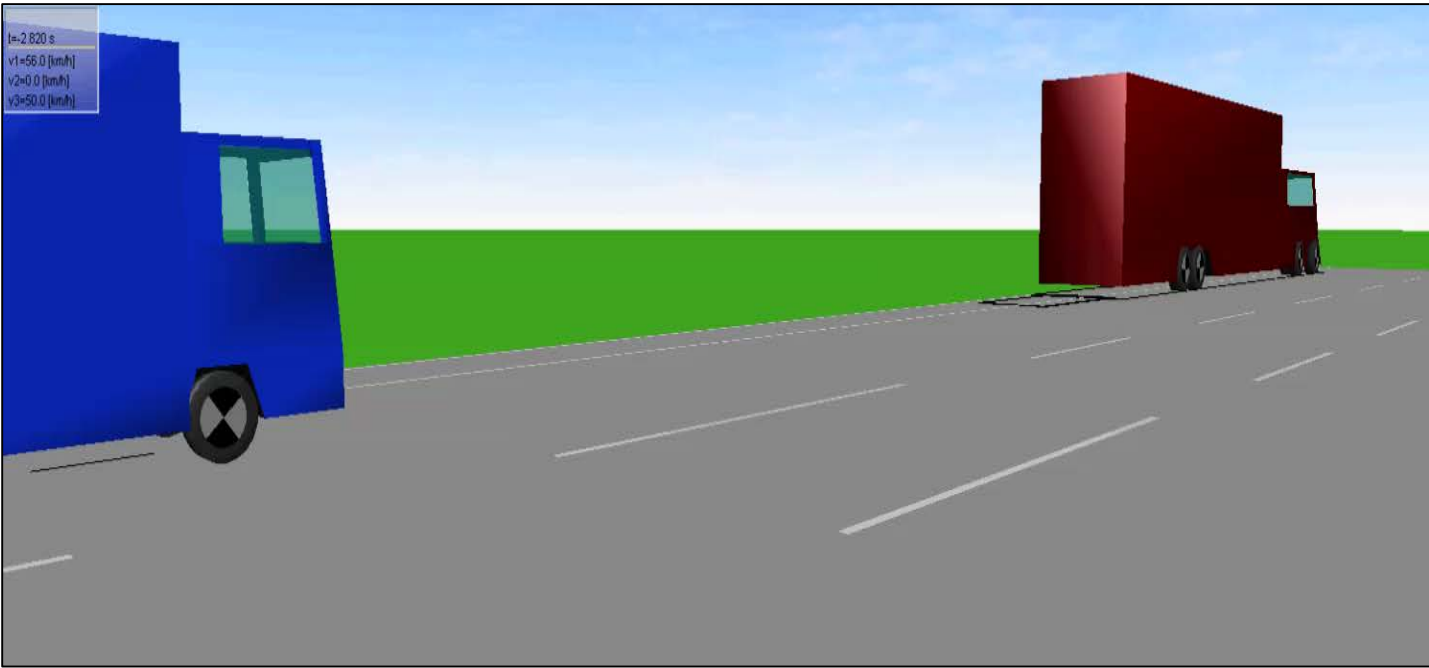


Crash Description

- Vehicle 1 (Tata truck) was parked in the shoulder lane.
- Vehicle 2 (Toyota Innova) was moving towards Jaipur.
- An unknown vehicle tried to overtake the Innova and due to this Innova car driver took a left turn and lost his control and collided with parked truck.
- Innova driver could not notice the parked truck may be because it would be in the blind spot. When he noticed it, it was too late to avoid the accident.

Plan of accident site with dimensions





Condition	Truck Velocity (Kmph)	Car Velocity (Kmph)
As per Witness	Not Known	Not Known
As per Laser Gun Measurement	0.0	77.96
As per Truck Driver	0	70-80
As per Car-Driver	Not Known	Not Known
As per Ai-Damage s/w	0.0	68.5

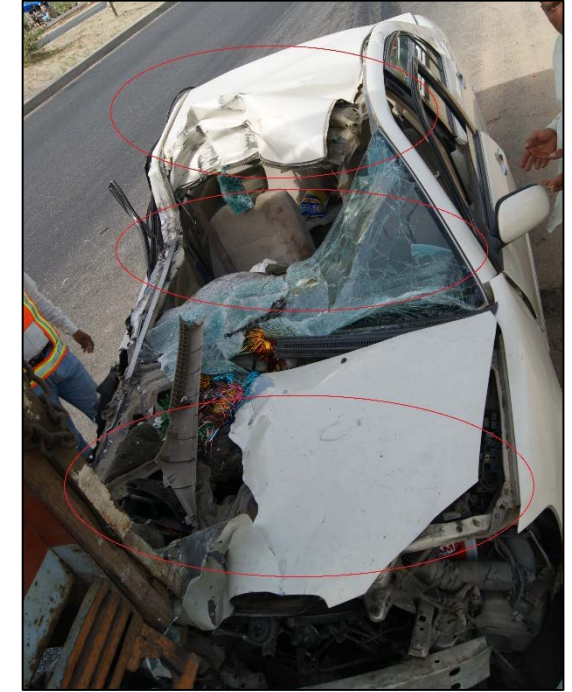
Result obtained through simulations
= 58 kmph before hitting the truck

=0 kmph after impact

Case 3: Dharuhera Team (DT) Case No. 58



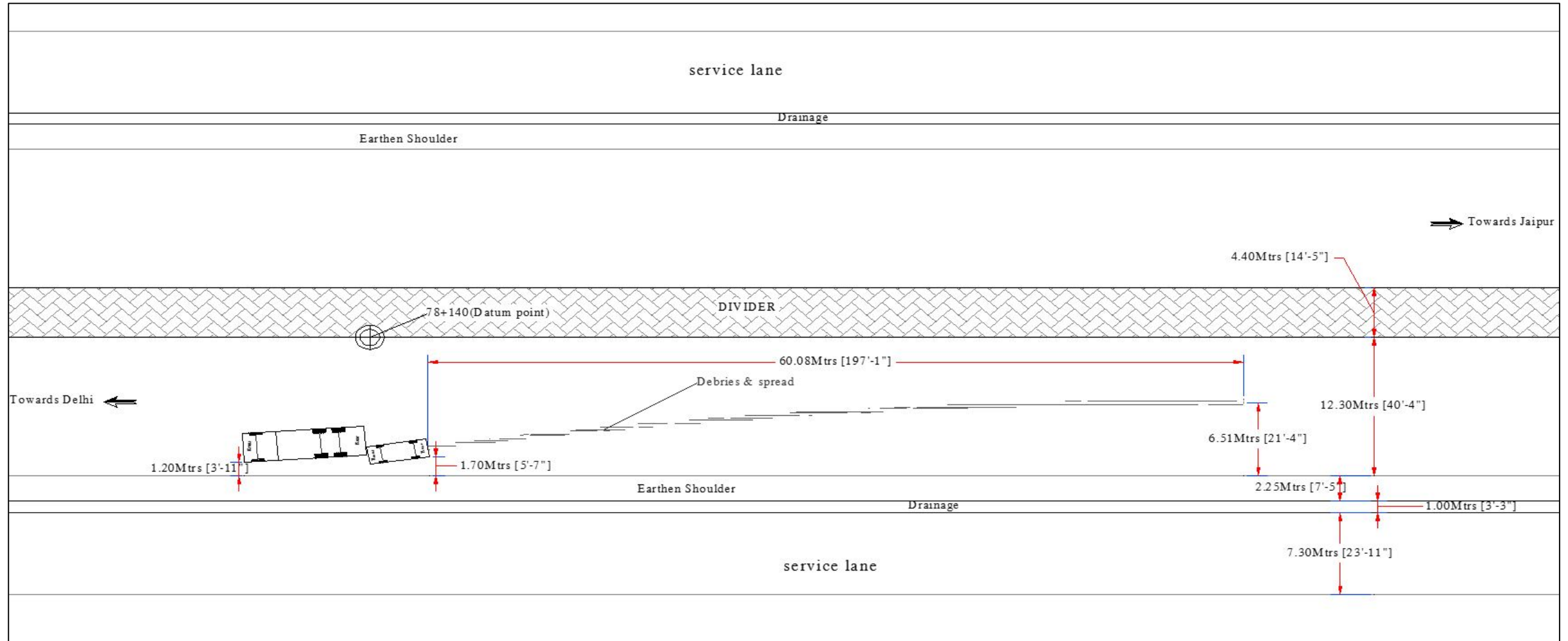
- ❖ Location: On NH-8, divider number 78+140.
- Time: 6:47 AM.
- Toyota corolla 1.8e (V1) collided with Tata 25.15c-Ex truck 9 (V2).
- Collision Type: Rear end (Under run)
- Speed Restriction: 40 kmph
- Junction Type: Y-Junction
- Injury:
Ford Fusion: 5 occupants;
1 male (Driver)-Grievous injury,
2 male and 1 female-Minor injury.



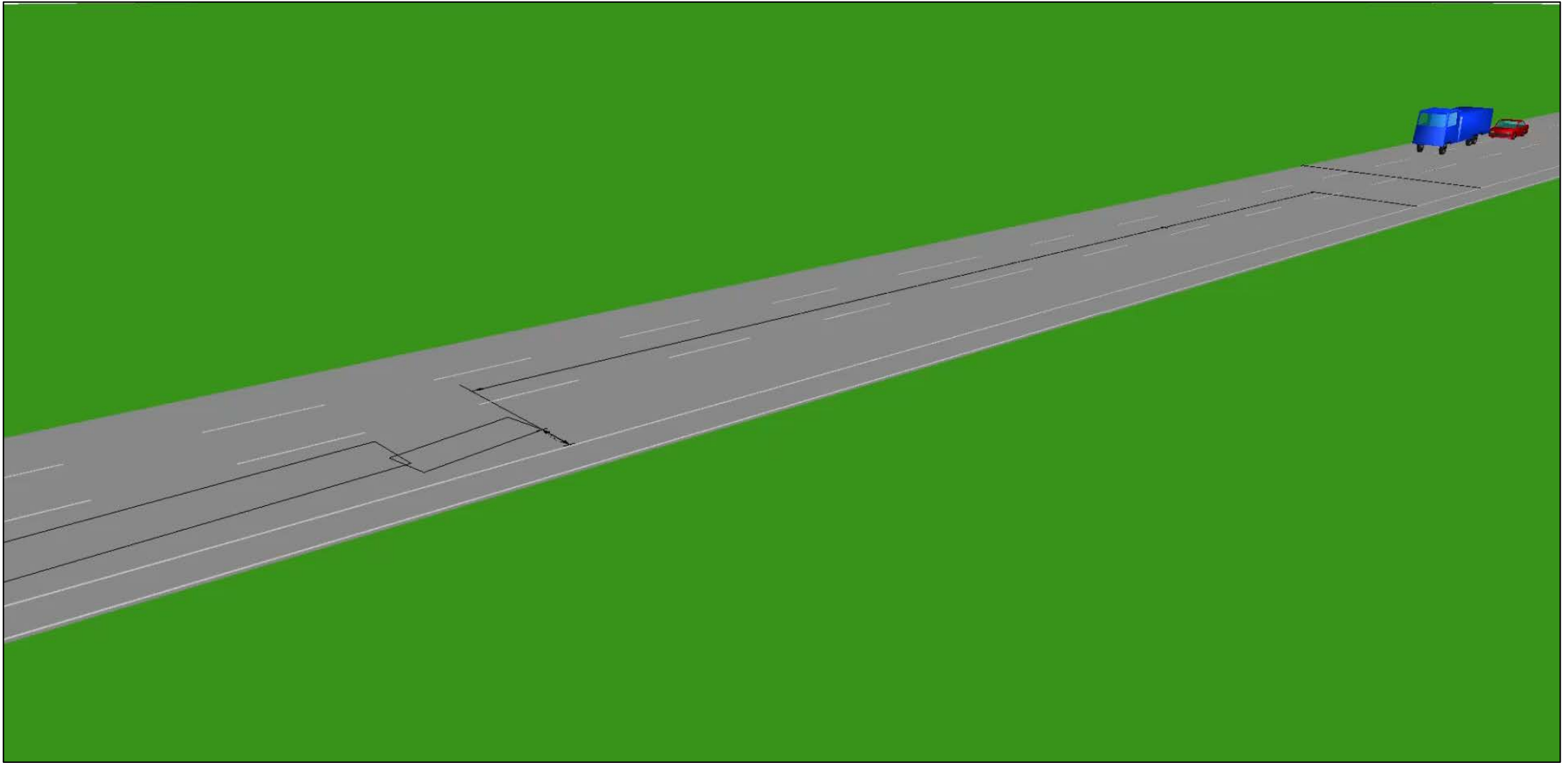
Crash Description

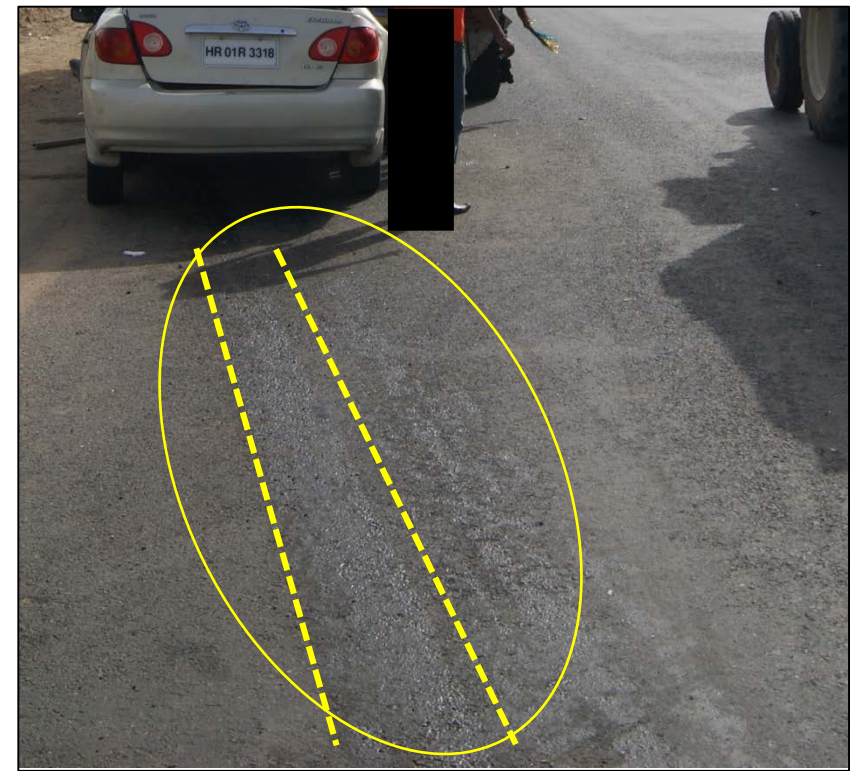
- Toyota corolla (Vehicle 1) with five occupants was moving towards Delhi side.
- Tata truck (Vehicle 2) was also moving towards Delhi ahead of Toyota corolla.
- Toyota came from behind the truck, collided with it and stuck under rear part of the truck and moved with it for 60 m distance.
- 2m of the front right end of the Toyota was drove under the left back side of the truck.

Plan of accident site with dimensions



PC-Crash Simulation Video of collision







Condition	Truck Velocity (Kmph)	Car Velocity (Kmph)
As per Witness	Not Known	Not Known
As per Laser Gun Measurement	55.96	86.00
As per Truck Driver	Not Known	Not Known
As per Car-Driver	Not Known	Not Known
As per Ai-Damage s/w	N/A	N/A

- Result obtained through simulation for car =96 kmph before hitting the truck
=80 kmph after breaking/at Impact
- Speed of truck before impact = 40 Kmph
- Speed of truck before impact = 40 Kmph

Case 3: Neemrana Team (NT) Case No. 58

- ❖ Location: On NH-8, divider number 68+420
- Time: 1:00 A.M.
- Vehicles Involved: Tata 11.09ex Truck (V1), Tata Bus (Rajasthan roadways bus) (V2),
- Speed Restriction: 40 kph
- Junction Type: Median cut, 6 lane
- Injury: 03 Male (Grievous injuries), 10 Male Minor injury

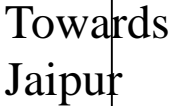


Figure:
Accident scene
and Vehicle 1

Crash Description

- Vehicle 1 (Tata truck) was moving towards Delhi.
- In between near a place called Bewal, there a truck was parked on the left side of the road.
- The model and other specifications is unknown for the vehicle 2 as it was fled away from the scene after accident.
- There was no street lights on the road and it was the time of 2 AM in the night when the accident happened.
- The fast moving truck (V1) was collided with the canter truck even if the driver applied the break. The skid marks of V1 is shown in the figure 2.

Plan of accident site with dimensions



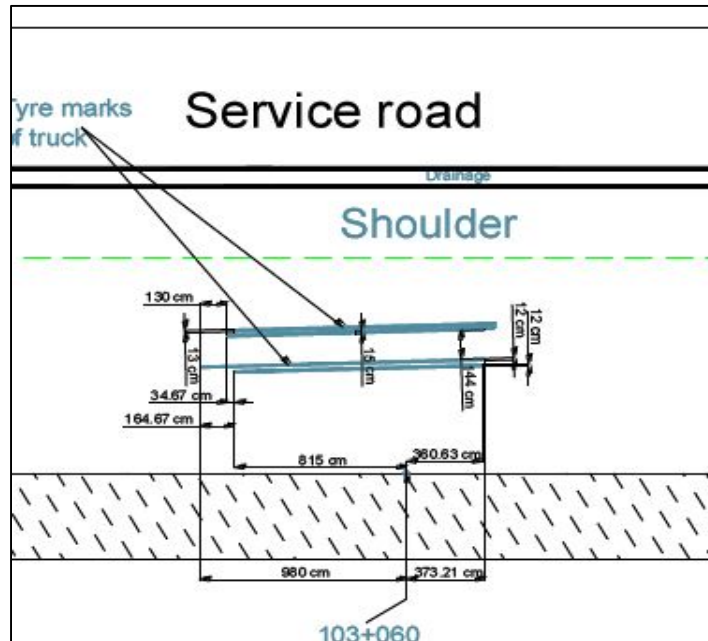
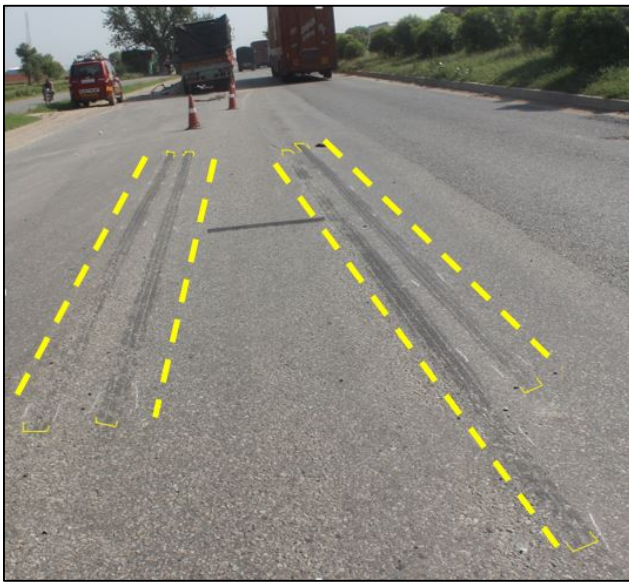
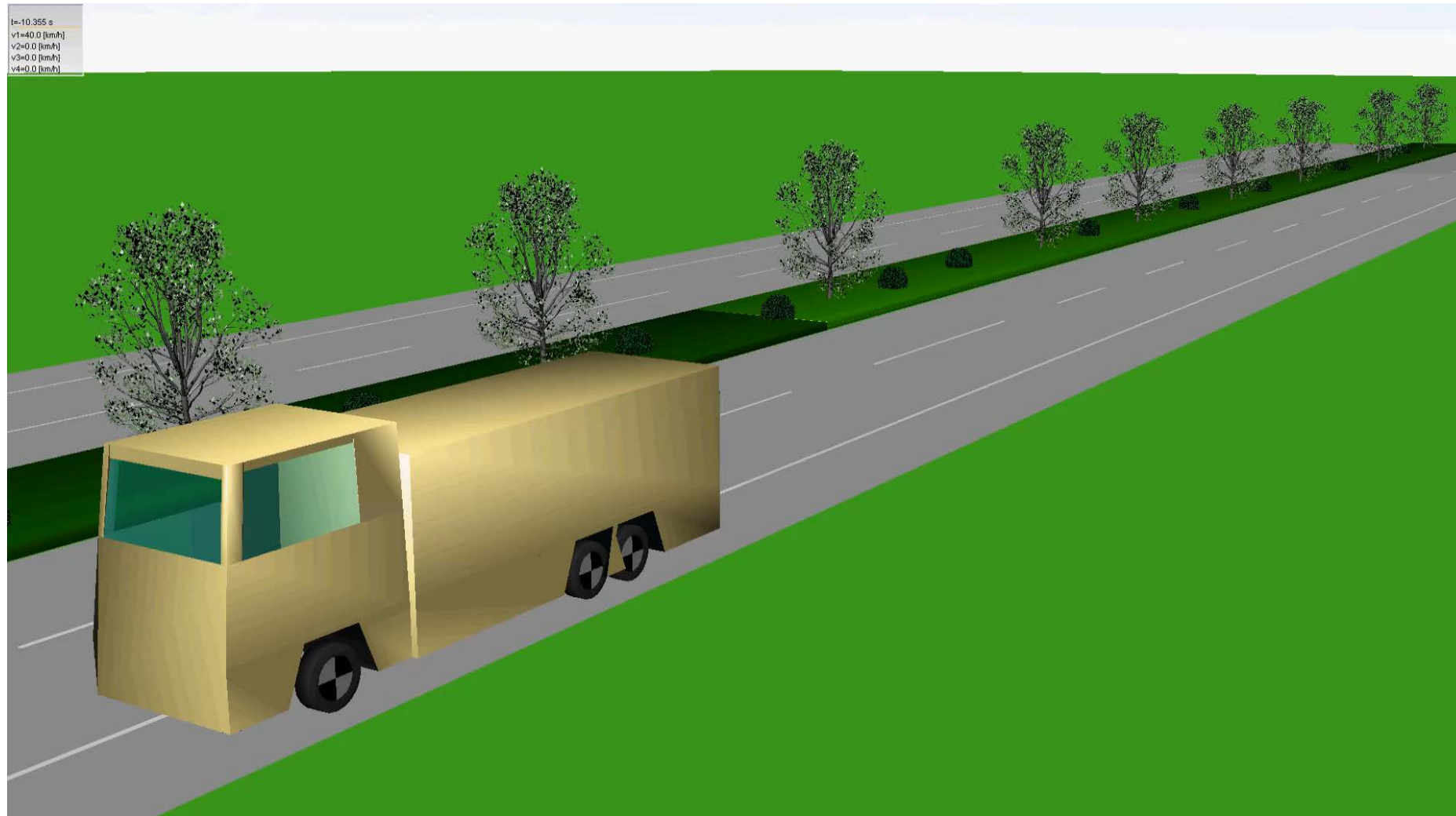


Figure : Layout plan of the skid marks and actual skid marks on road

PC-Crash simulation



Speed Estimation/Analysis

- The length of the skid marks is 13.53 cm. $V_{\min} = \sqrt{2\mu gS} = 4.2 \text{ m/sec}$ or 15.12 kmph
Where, μ = drag coefficient = 0.7
 g = acceleration due to gravity = 9.8 m/sec^2
 S = Skid length
- From the skid marks its clear that the vehicle velocity was at least 15.12 kmph
- PC-crash simulation suggest that the speed of the V1 should be 28.5 kmph just before impact and after impact it becomes 5 kmph.
- No other information like vehicle deformation measurement, witness interview, driver interview and other relevant details are available.



Case DT-30



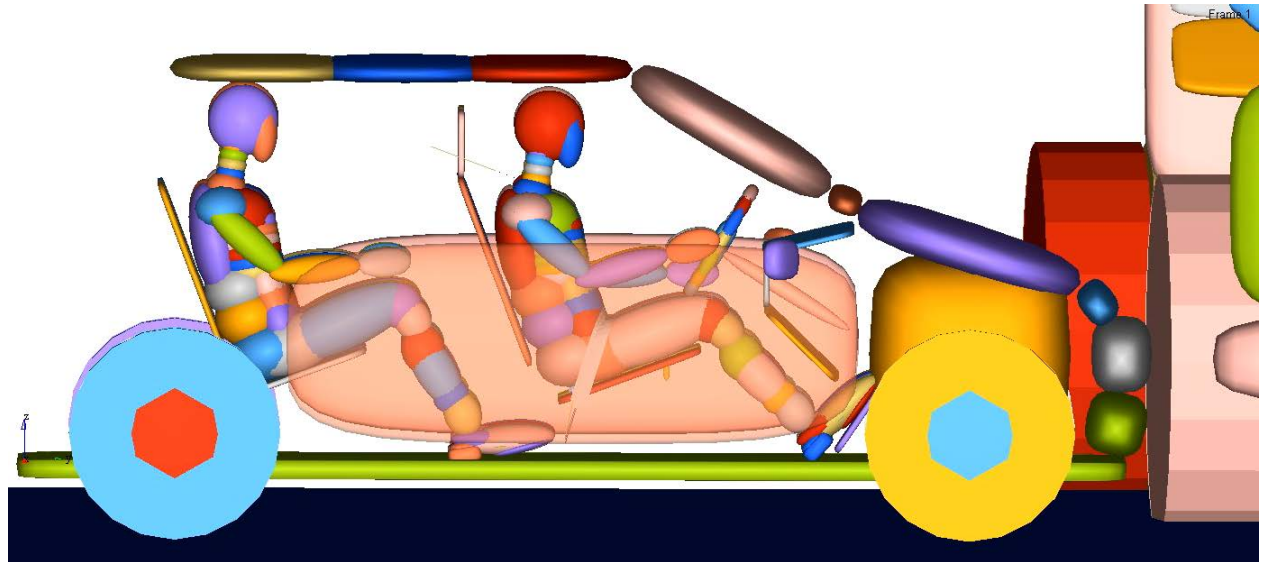
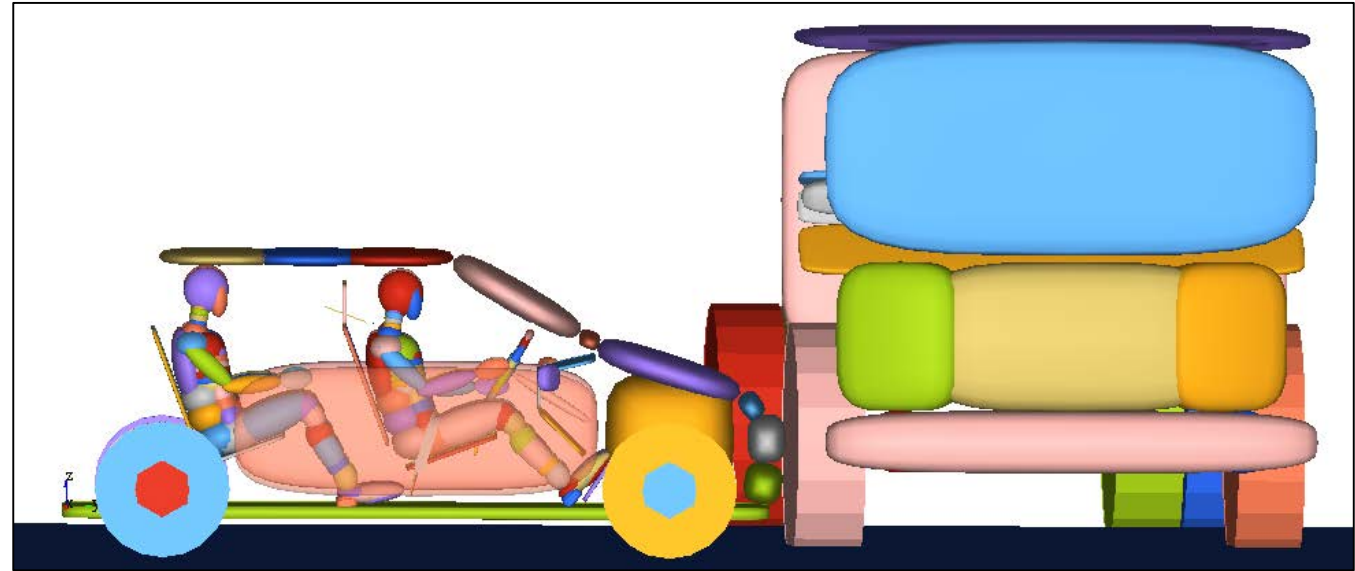
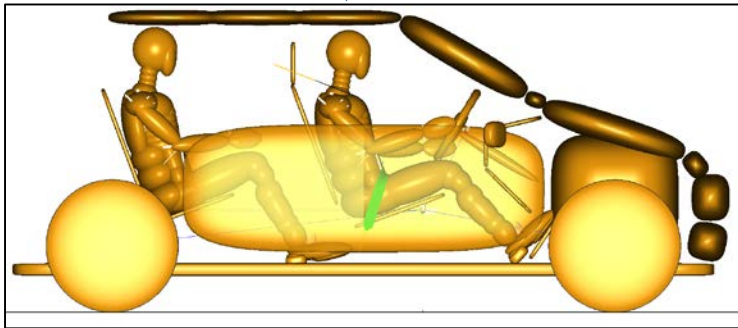
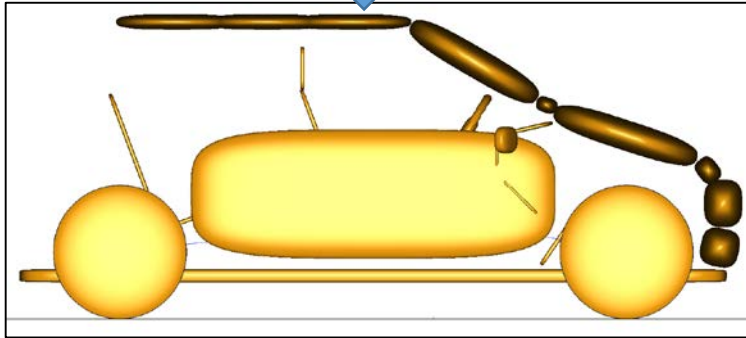
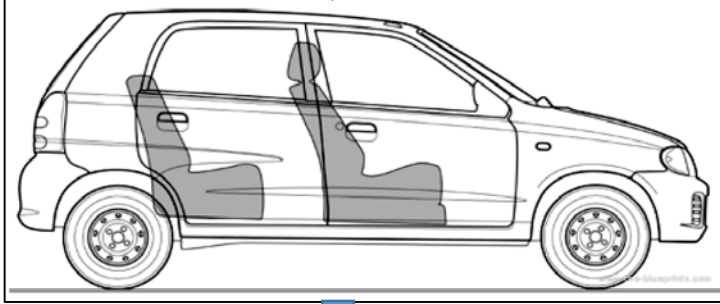
PC-Crash
Simulations

Speeds, Direction
and location of the
collision

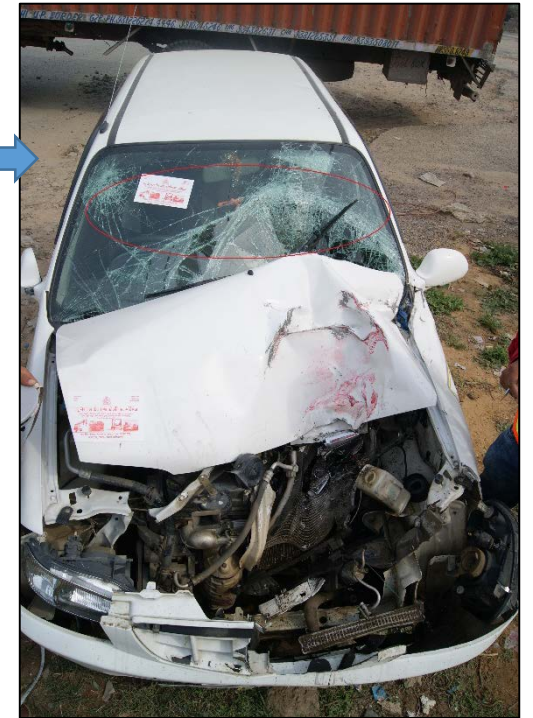
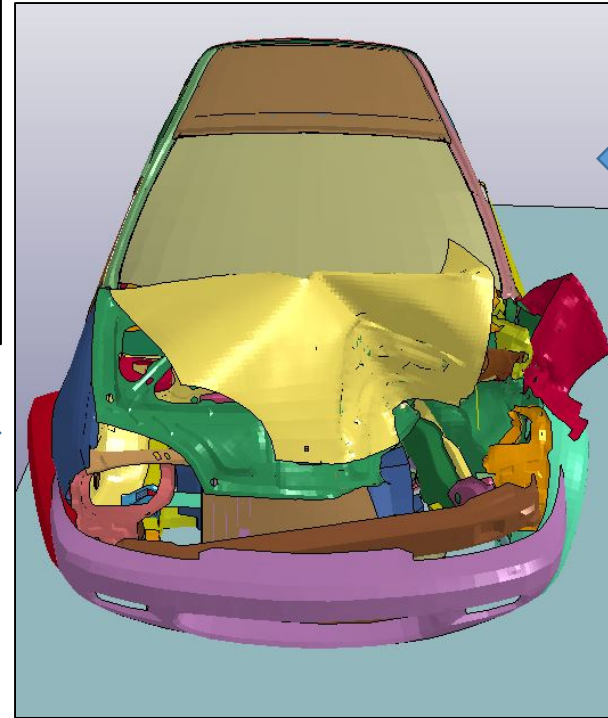
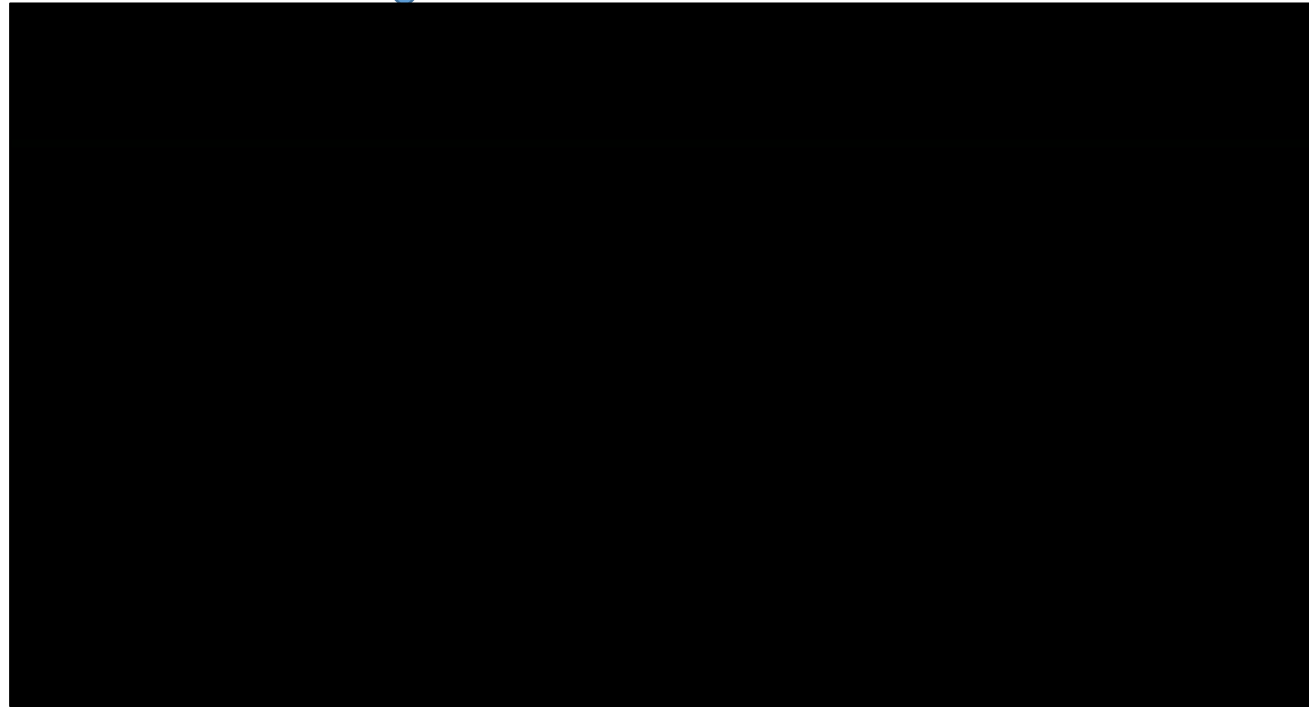
Condition	Truck Velocity (Kmph)	Car Velocity (Kmph)
As per Witness	30-40	70
As per Laser Gun Measurement	45	75.5
As per Truck Driver	10-20	70-80
As per Car Driver	40	60-70

Occupant Motion Simulations ?

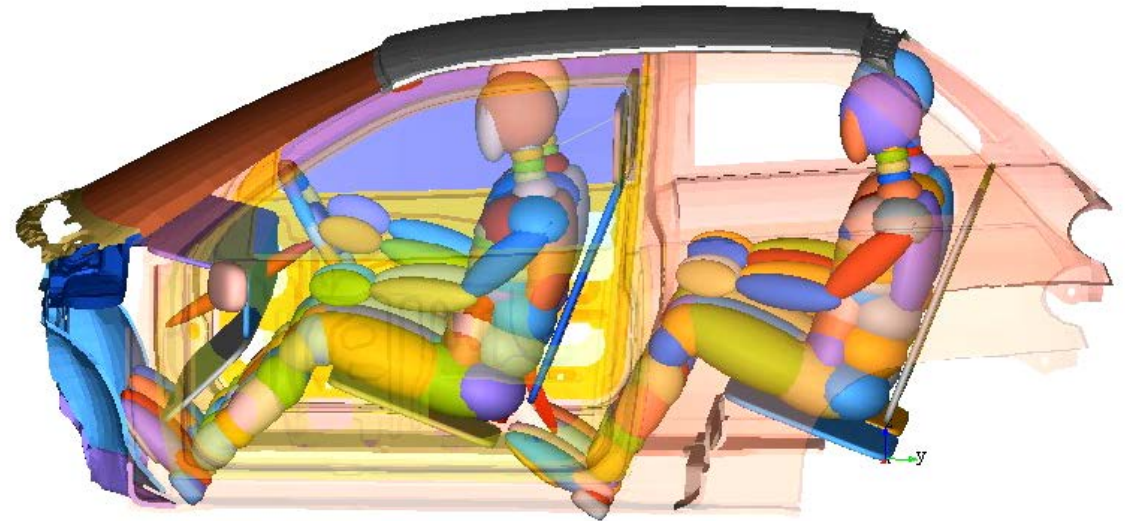
Occupant Motion Simulations

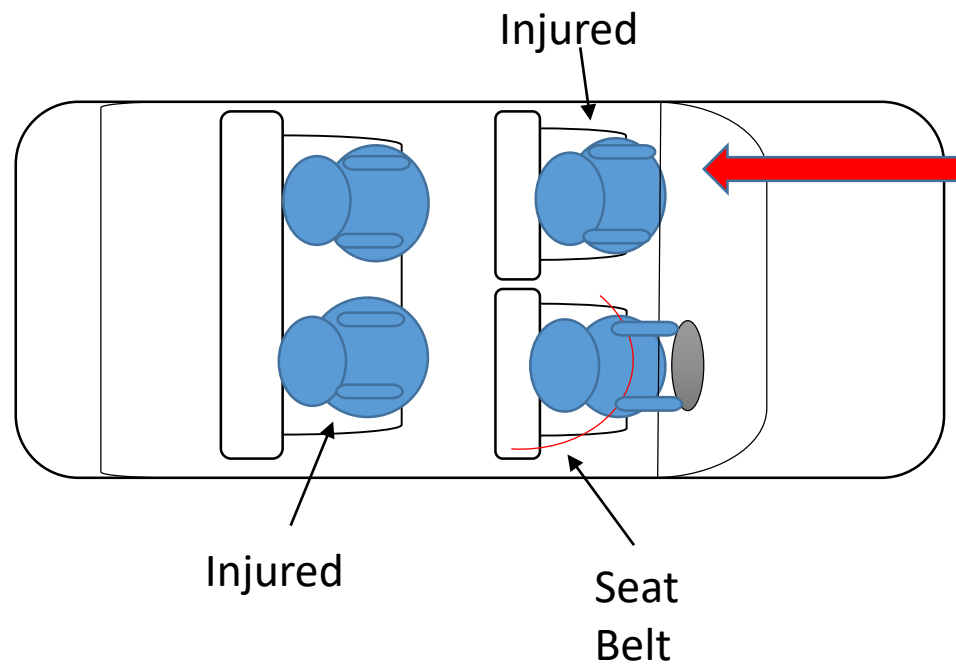


Occupant Motion Simulations

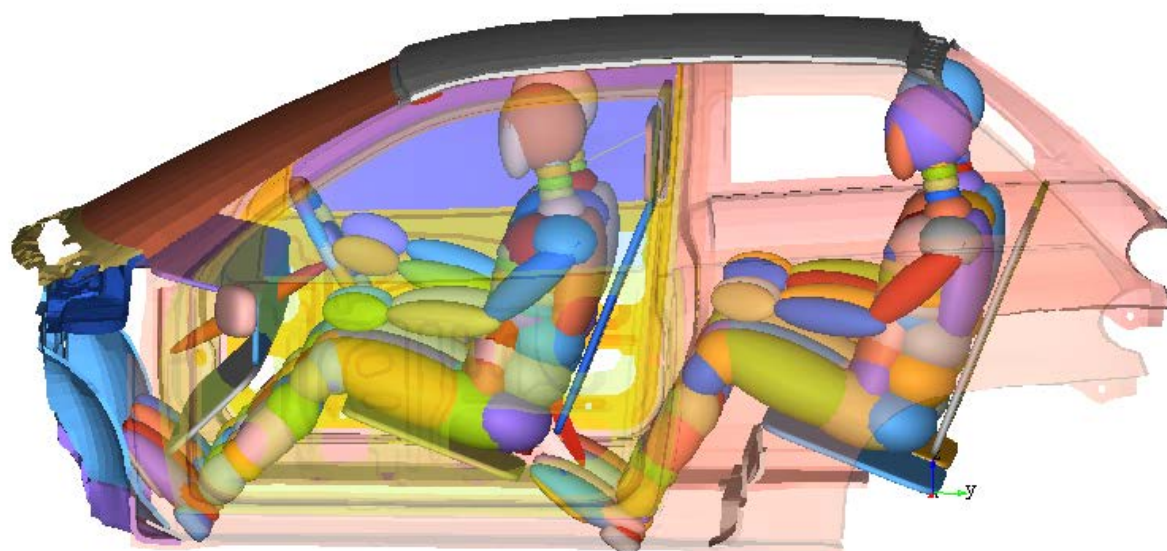


Occupant Motion Simulations

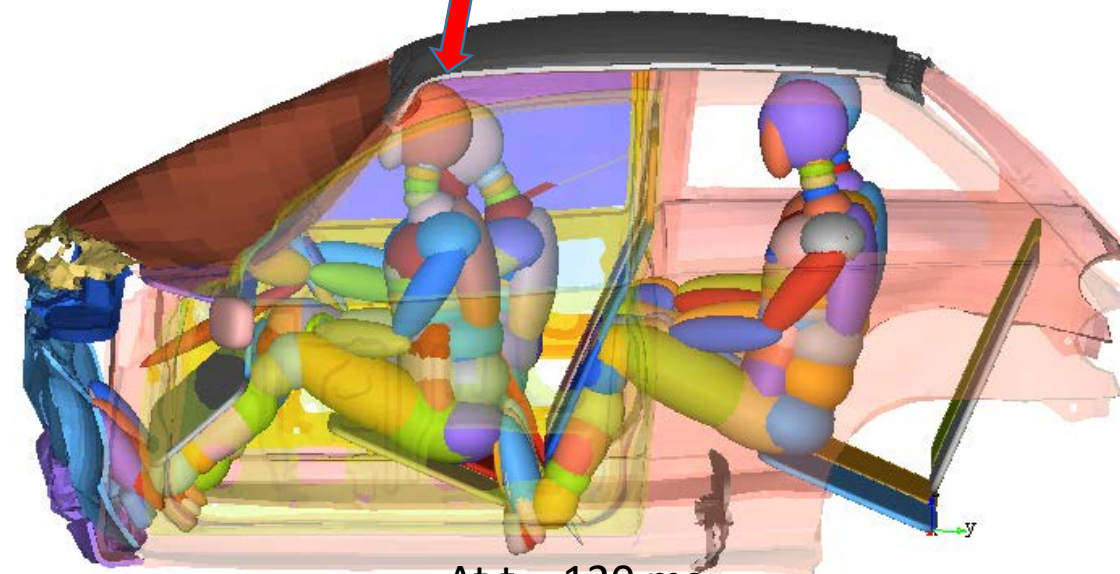




Injury Description	AIS CODE	Body Region	AIS
Parieto-temporal blunt contusion 3*4 cm	140606.3	Head	3
Occipital region contusion 3*3cm	140606.3	Head	3
Frontal region contusion 8*4 cm	140608.4	Head	4
Left supraorbital region blunt contusion 3*1cm	210402.1	Face	1
right eyebrow contusion 2*2 cm	210402.1	Face	1
Nose ext blunt contusion	210402.1	Face	1
Right cheek contusion 4*6 cm	210402.1	Face	1
Left cheek contusion 4*3 cm	210402.1	Face	1
Lacerated wound 8*3 cm submandibular right	210602.1	Face	1
Chest blunt contusion 8*8 cm	410402.1	Thorax	1
Right knee blunt contusion 3*3 cm	850802.1	L/E	1
Right lower 1/2 tibia fibular contusion 6* cm	810402.1	L/E	1
Left wrist Lacerated wound 2*1 cm	751440.2	U/E	2
Loss of consciousness	160202.2	Head	2
Nasal bleeding	251090.1	Face	1



At t = 0 ms

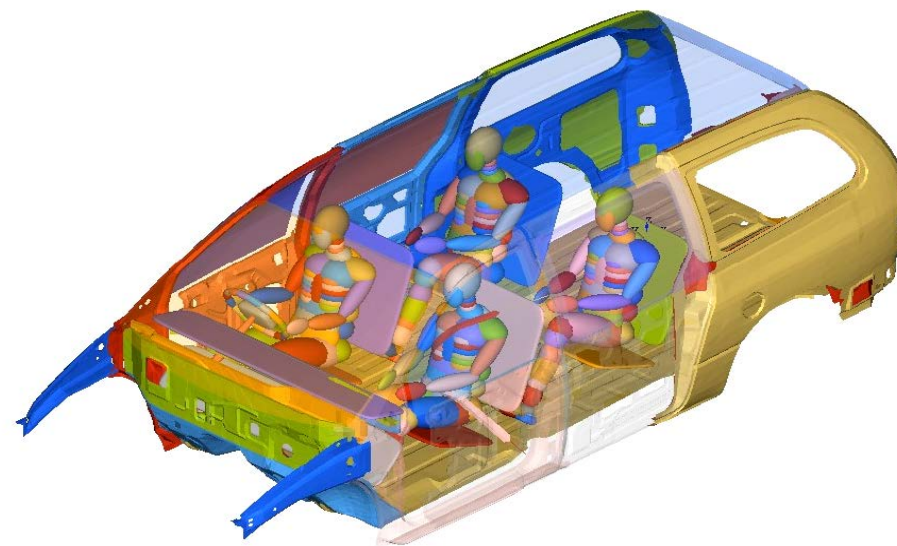
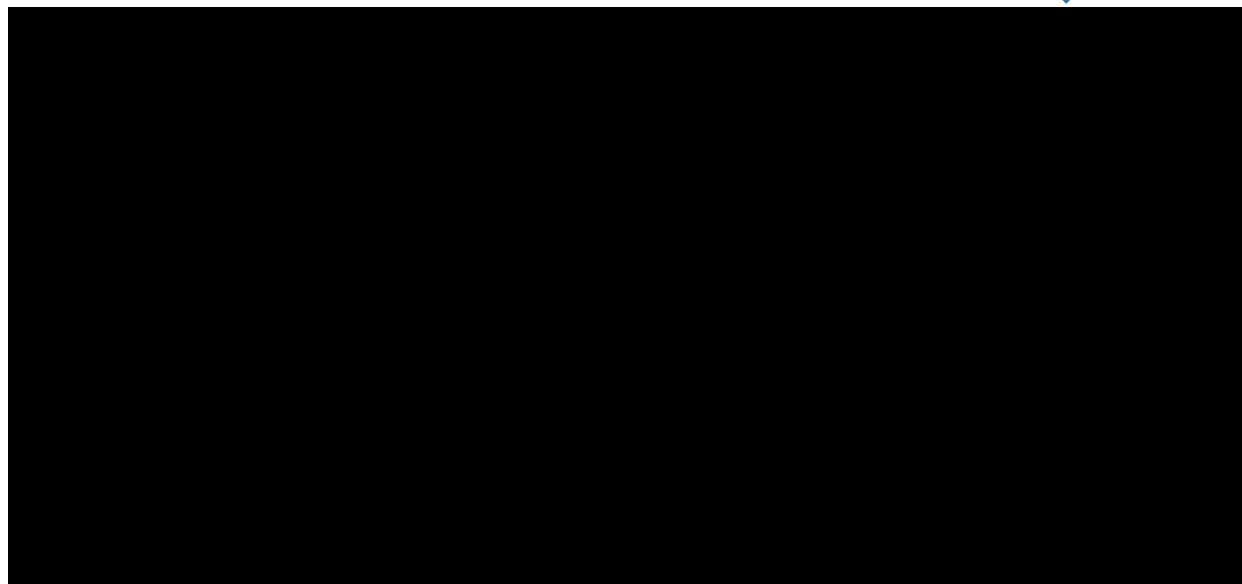


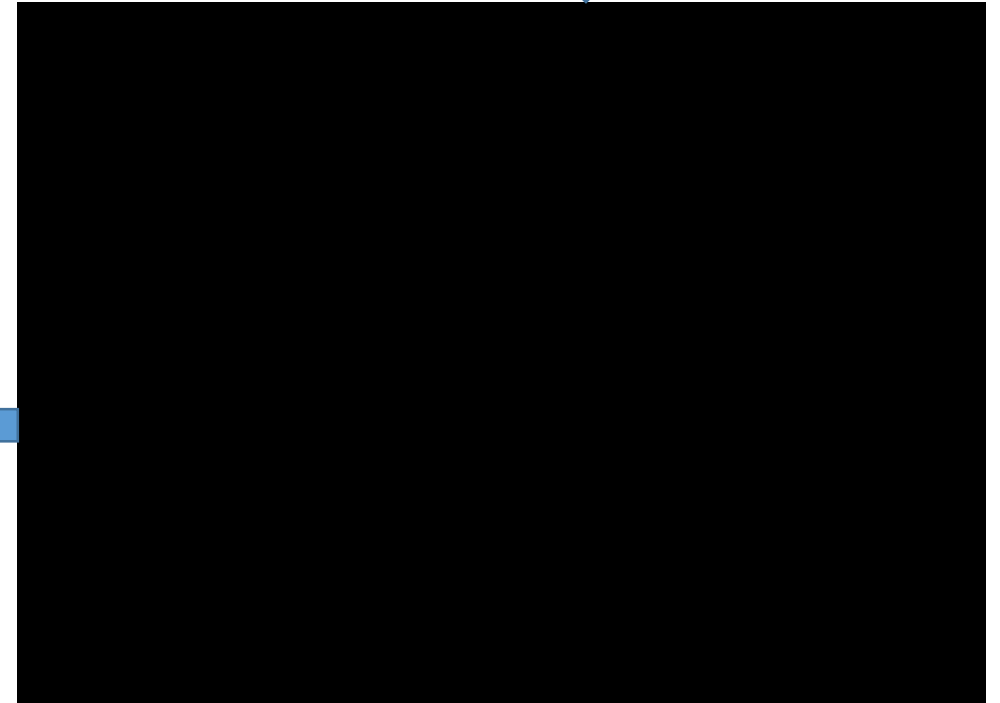
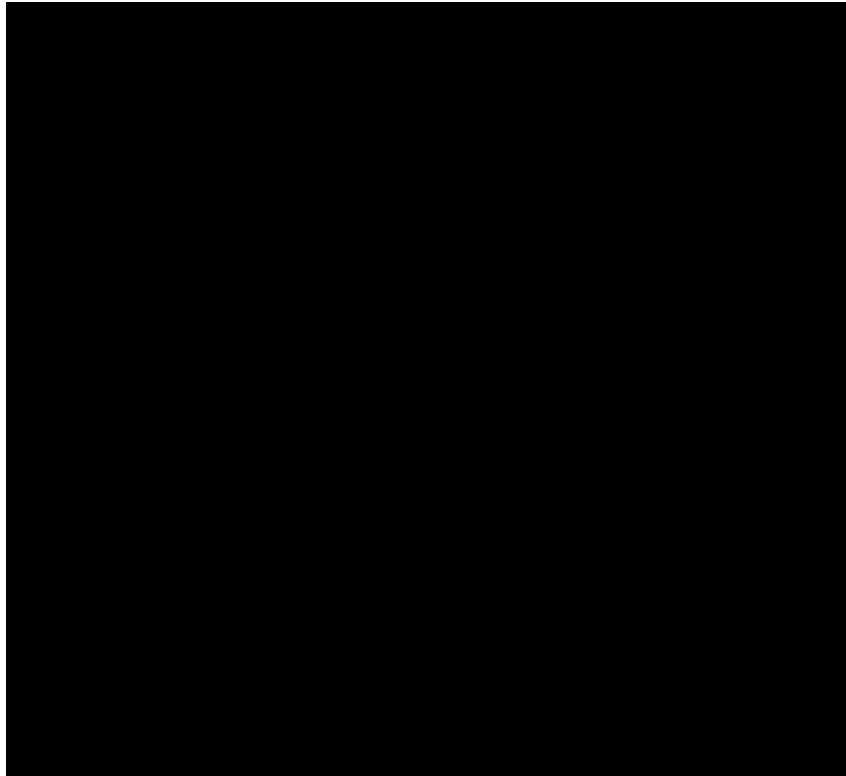
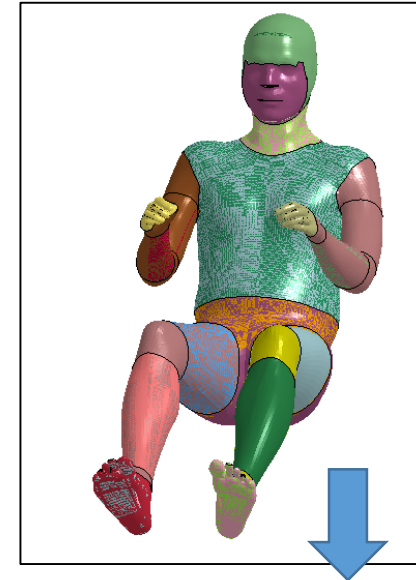
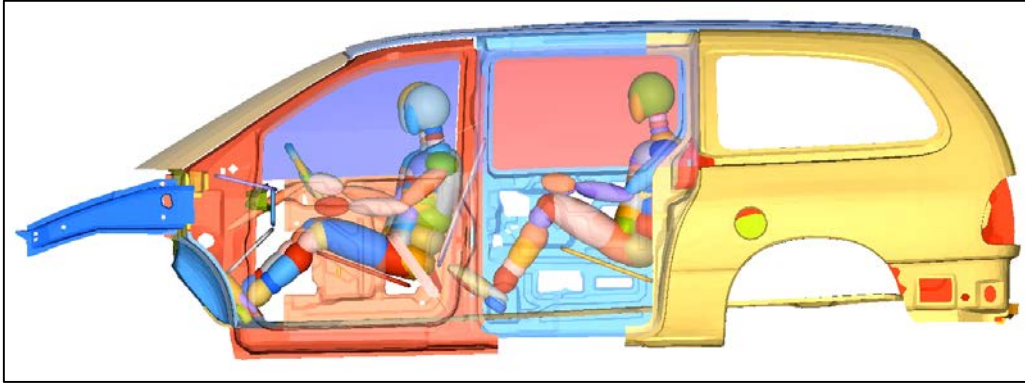
At t = 120 ms



Similarly for
Case DT-97

Result obtained through PC Crash
simulations
= 58 kmph before hitting the truck
=0 kmph after impact





Conclusions

- There is a methodology established for occupant injury prediction for Indian accident database.
- The accident reconstruction method is not only based on the data collection from the site but and also on the injury reports that was collected as one of the datasets.

Limitations and Future Scope

- The Madymo occupant collisions will depend on the structural stiffness characteristics of both the vehicles structures coming in contact. This will affect the contact characteristics in the collision simulations. This was not taken into account as we neither have the Indian vehicle FE models nor such type of data from the industry.
- The FE model of vehicle for vehicle motion reconstruction were chosen based on the type, dimensions and weights of the case vehicles. Structurally, the case vehicle might behave differently than the actual case vehicle.

THANK YOU

