



PROJECTS

► Traffic Flow at IGI Airport

TRIPP, IIT Delhi has undertaken an in-depth study of the traffic flow at the IGI airport. The suggested changes involve redesigning of both the Arrival and Departure wings of the terminal to ensure a smooth, conflict-free, flow of traffic and pedestrians. These changes have been made to accommodate the likely increase in air-traffic in the future. The suggested innovations would include modifications to already existing structures where possible.

The approaches to and departures from the airport would be designed to ensure a snarl-free traffic flow with dedicated lanes, pull-in bays and parking(long and short term) lots for cars, taxis, buses, and three-wheelers. Segregation will prevent conflict between moving and parked vehicles and pedestrians. Lighting, drainage and other such services have been suitably incorporated in the total layout. Clear signages and information systems will make for well-informed mobility.

Clearly defined spaces will be available for different activities. The convenience of the end-users have been kept in mind in deciding the specific locations of dormitories, toilets, canteens, kiosks, left-luggage rooms, etc. The meet-and-greet points, the placement of the lounges and its entrances and exits will prevent any bottleneck from forming between the waiting visitors and the incoming and outgoing pedestrian crossings with convenient access to trolleys and wheelchairs. All pedestrian paths and ramps will have trolley and wheelchair friendly gradients.

Electronic sensors will monitor the waiting time of parked vehicles in the drop-off area of the departure wing. There will be separate long and short term parking lots for cars, buses, taxis, etc. Luggage trolleys will be available at convenient locations for passengers and their stacking and retrieval made easy. The access and speeds of all vehicular traffic will be regulated to ensure a safe, conflict-free, flow.

► High Capacity Bus Systems

TRIPP, IIT Delhi and RITES (Rail India Technical and Economic Services) have made a feasibility study for modifying seven traffic corridors in New Delhi to accommodate High Capacity Bus Systems with dedicated lanes:

1. Nangloi – Shivaji Terminal
2. Azadpur – Nehru Place
3. Jahangirpuri – Old Delhi Railway Station
4. Dr. Ambedkar Nagar – ISBT
5. Anand Vihar – Shivaji Terminal
6. Hari Nagar Clock Tower – Central Secretariat
7. Badarpur – Pragati Maidan.

The design work on two of these seven traffic corridors is now complete. Bus systems represent the most widely used mode for public transport. Upgraded bus services, primarily those which have partially or fully separated right of way, represent a very cost effective method to improve the balance between automobiles and mass transit transport; they are flexible to deploy and route; they offer high passenger throughputs at a fraction of the cost of other mass rapid transit systems like metros and sky buses. The HCBS is not just the redesigning of a road but a complete urban planning solution; the main components are separate busways, special bus shelters, feeder services like three wheelers and rickshaws, safe spaces for pedestrians and the roadside providers of commercial services.

Central bus lanes have been preferred to curbside bus lanes because of the large number of side entries and two wheelers; the closely placed traffic lights for vehicles may be combined with bus shelters; the road has a heavy volume of two and three wheeler traffic; and these arterials pass through heavy commercial landuse areas (like Vikas Marg).

Initially, road users on the corridors of the HCBS, will have to be guided by the design elements used in its construction, law enforcement and appropriate signage and information systems. The participation and sense of ownership on the part of the public will contribute to the safety and success of the transportation system as a whole.



The proposed traffic circulation at the Indira Gandhi International Airport



Artist's visualisation of the Ambedkar Nagar Bus Stop

► The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology Delhi, is an interdisciplinary programme focussing on the reduction of adverse health effects of road transport. TRIPP attempts to integrate all issues concerned with transportation in order to promote safety, cleaner air, and energy conservation. Faculty members are involved in planning safer urban and inter-city transportation systems, and developing designs for vehicles, safety equipment and infrastructure for the future. Activities include applied research projects, special courses and workshops, and supervision of student projects at postgraduate and undergraduate levels. Projects are done in collaboration with associated departments and centres at IIT Delhi, government departments, industry and international agencies.





Safer Vehicle Design

Sudipto Mukherjee and Anoop Chawla

Experimental setup



Split Hopkinson Pressure Bar: for dynamic properties at varying strain rates



Mechanical testing of hard and soft tissue



The safety of motorcycle occupants is enhanced by examining the crash worthiness of vehicles. This depends upon the study of impulses and energy components, such as kinetic energy, energy absorption, and energy dissipation; the analyses requires both the principle of work and energy and that of impulse and momentum in solving problems involving impact and excitation.

A lathe machine has a five horsepower motor and stores a kinetic energy of about 1 KiloJoules. The operators of these machines wear helmets, wear eyeglasses and undergo three years of fulltime training and their skills are constantly upgraded by retraining programs. In contrast, a modern vehicle is a 100 to 600 horsepower machine weighing 800 to 4000 kg without load. When travelling at 40 k.m. per hour it stores kinetic energy of the order of 100 KiloJoules. The operators of these machines come from the general population and can never be perfect. Acceptance of these facts, and engineering for safety is therefore, the first step towards a safer vehicle design. There are two distinct segments at risk. There are people in the vehicle and people outside the vehicle. Research over the last 40 years have led to the evolution of seat belts, air bags and crush zones which are able to protect the users of four wheel vehicles fairly effectively. In our environment, there is a large proportion of road users outside the vehicle who are exposed catastrophically to 100 KJ of energy over a duration as short as 10 milliseconds. Here the aim is to elucidate some basic principles used in the design for safer vehicles.

One of the questions often asked is if safety has to be engineered or if it can be done actively by the operators or passengers. Let us start by computing the time we have on hand. If the dashboard is 1m away (any more and you will not be able to open the glove compartment) and the car comes to a dead halt, if unobstructed, you will cover the distance in 1/11 sec. This is about the time taken for the flick of an eyelash. It is known that the time taken for one human synapse is about 1/30 sec. Three synapse cycles is too little a time for the human brain to take any cognitive action. So any preventive measure has to be based on reflex action. Clearly safety has to be engineered and cannot be left to conscious or reflex evasive actions.

The simple understanding of the nature of impact is to derive an equivalence of impact when travelling in a vehicle at 40 km/h. or approximately 11 m/s. Recounting our high school physics, we realize that this is the velocity attained by a body under free fall through a height of roughly two floors, very close to the vaulting record of Sergei Bubka. As a kid, I (some of you as well) have jumped down from one floor height and am still healthy, but not two floors. Mr. Bubka however vaults this height and survives because of the cushioning. So the obvious solution that comes to mind is to provide cushioning. For Mr. Bubka, the International Olympic Committee recommends a cushioning of 1 m depth! This is one of the best possible safety devices. The problem is that most car users would not like to strap a cushion on the moment they sit inside the vehicle. It is however used in the expensive cars: the cushion appears only when there is an impact; it is an air cushion and is called an airbag! The requirement of rapid deployment and providing cushioning requires a sophisticated system involving accelerometers, ignitors, jets and intricately folded membrane structure.

What are the other options? Bungee jumping for one allows people to drop from the height of a few stories and still survive. The bungee rope is specially designed to limit the load to tolerable levels. This is the most popular measure for car safety, and is called a 'seat belt'. It is important to understand that just as one cannot buy rope off the street and go bungee jumping, the same is true of seat belts. Any belt used to strap the rider cannot provide safety. A device called a centrifugal clutch is used to allow the belt to extend when the motion is slow. This allows the user to adjust the belt. For rapid movement, of the type of 1 m in 1/11 of a second, the clutch locks up, and restrains the user. That is not all. If the belt were rigid, there would be no bungee jumping, but a hanging. It would be as good as hitting the dashboard. The belt is a result of precision engineering that would bring the occupant to rest not with zero travel, but only after a travel of maybe half a meter. This ensures that we do not have lacerated necks and completely crushed ribs. Needless to say, for the seat belt to save lives, it has to be a precision-engineered system.

Slowing down is a good safety principle. For example if the vehicle speed is 20 km/h, the energy, which varies as a square of the velocity becomes a fourth. So the survival height becomes 1.5 m in place of 6 m, a drop that many of us expect to survive. Present day society does not want to countenance a slowdown. An engineered crushing mechanism can provide an equivalent slowdown. The bonnet of a car typically has a length of over a metre. If the design of the vehicle allows the front of the vehicle to compress on impact, then the dashboard of the vehicle does not stop instantaneously but travels forward. This gives additional space to the designer of the airbag and seatbelt to bring the rider to rest with less damage. It does not however help the rider who is not strapped on or in the absence of an airbag. It is not sufficient to have a crush zone. The crushing must be supported by appropriate seat belt design to save lives. There are many more people outside the vehicle than inside the vehicle in less motorised countries. The riders of vehicles are reasonably safe due to the effort of engineers in the US, Europe and Japan. The principles used in protecting the occupants are applicable in protecting the road user as well. Bonnets that fold on impact, rounding of the front profile, sinking the hard pivots of the windscreen wiper below the bonnet are some of the measures that have been taken.

Very sophisticated experimental and simulation tools are used to achieve the goals mentioned above. However the present-day bumper and bonnets with small clearance to the engine are not VRU friendly designs. Similarly, bus and truck front designs can be improved to make them more pedestrian and two-wheeler friendly.

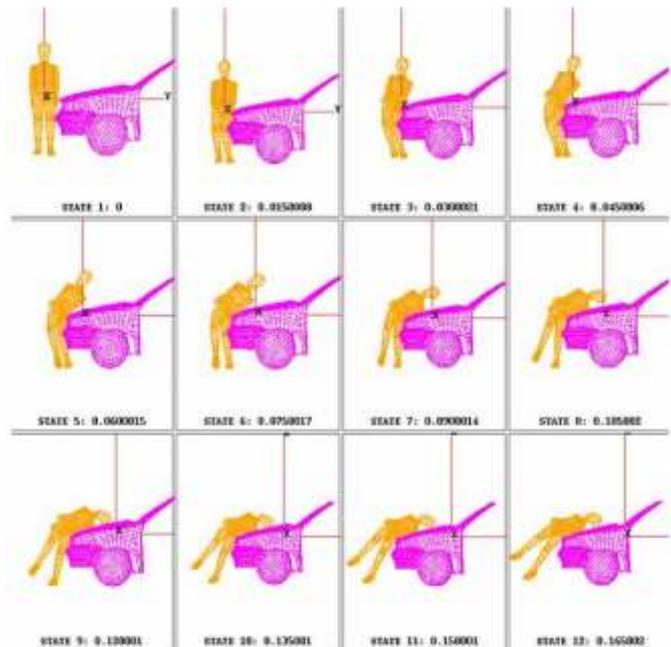
Over the last few years, we have been doing extensive work in the area of safety analysis with emphasis on computer simulations of vehicle crashes. Simulating crash situations helps to estimate the injury caused to occupants as well as pedestrians. The team at TRIPP has developed extensive simulations for car crashes, motor cycle crashes as well as three wheelers. The team includes consultants to the Japan Automobile Research Institute (JARI), for whom we have been doing extensive simulation work for the last 5 years. This work is interdisciplinary and needs inputs from disciplines like Mechanical Engineering, Biomechanics, Computer Science, etc. At TRIPP expertise in all these areas is available, enabling us to carry out this inter-disciplinary research. Development of human dummy as well as human body finite element (FE) models is closely related to this activity. We have been using available human body/dummy models and have worked on extending the available models. One objective of our work is to generate data about the dynamic properties of the human body tissue. This data would include mechanical properties under impact conditions and their variations with strain rate and the energy of the impact.

Facilities are in place for static and dynamic testing on soft tissues, both tensile and compressive; three-point/four point bending (static and dynamic) on bones; oblique/angular impact tests and the Split Hopkinson pressure bar are in place. In order to examine tissue characterization within four hours of post mortem, it is desirable that the testing machines be taken to the hospital; these compact and cost effective machines are designed in-house.

Airbags deployment has to meet stringent requirements, as it has to be fully deployed within 5 ms to avoid 'slapping' the rider. The airbag mass is about 200 gm. and moves at a peak speed of around $0.5m/0.005s = 100m/s$! Energy content is about 1000 Joules ! The slap can be strong enough to break the riders jaw; following which it has to deflate as the rider impacts the surface to minimize the injury to the rider; so the design of an airbag is a tricky issue. Needless to say, the driver side and passenger side airbags are of completely different designs because of the space availability. We are conducting simulations to evolve airbags for two wheeled vehicles.

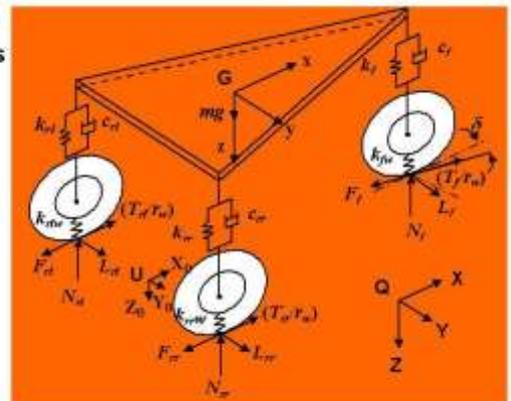
Over the next few years we will be embarking on a coordinated effort to study safer designs for the vulnerable road users using simulation, experiments recording crash data and crash reconstruction techniques. Our work is also aimed at evolving standards relevant to India and transportation patterns relevant to 75% of the world's population!

Vulnerable Road User (VRU) Simulation



Three wheeled vehicle (TWW) rollover analysis

- A 6-degree of freedom model is used in our analysis to reduce computation time.
- Validation of the model against accelerations measured over speed breakers.
- Dynamic maneuver simulation
Slowly Increasing Steer, NHTSA J-Turn, Road Edge Recovery maneuvers.



Human Body Models

- Dummies are used to study automobile safety.
- Pedestrians can be in many more orientations in crash situations.
- To investigate methods to make the roads safer for pedestrians, must develop FE human body models,
- Could be more accurate and less expensive way of knowledge generation at least in the university environment.





► Enrique Penalosa in Delhi

An accomplished public official, economist and administrator, Enrique Penalosa completed his three-year term as Mayor of Bogota, Colombia on December 31, 2000. During his tenure as mayor of Bogota (1998-2001), Penalosa led massive efforts related to transportation, land use and housing for the poor, pollution abatement, and the critical need for public spaces. Penalosa is credited with turning Bogota into a vibrant city with innovative urban reforms and introducing a very efficient and modern Bus Rapid Transport Systems (BRTS). These reforms and changes have earned international recognition and become models for dozens of cities worldwide. Penalosa was in Delhi on 3rd December 2004 when he interacted with senior policy makers and politicians including Ms. Shiela Dixit (Chief Minister of Delhi) and Montek Singh Ahluwalia (Vice-Chairman of the Planning Commission). In making his presentation, Penalosa said that: To talk about transport is to talk about urban structure: A city for cars is different from a city for pedestrians and bicycles. A compact, more pedestrian and bicycle friendly city, whose population uses public transport, can have a better quality of life than a spread-out city even with lower income. Urban transport unlike health or education, does not improve with economic development. One truth about urban transport: It does not matter what is done, traffic jams will become worse, unless a radically new model is adopted. Speaking against elevated highways he remarked that, European cities are probably the world's best because not one of them has an elevated highway running through it.

Rail mass transit is wonderful; but it is too expensive. Rail systems can only serve a very limited area of a city. Not one developing country subway system serves more than 10% of the population. Rail systems demand enormous resources, which are taken from other valuable uses. BRT's can achieve very high coverage at low investment costs. If public transport is to reach all points of Delhi during the next 100 years, the ONLY public transport we can talk about is buses. High quality public pedestrian space around the BRT systems is as important as the buses themselves. BRT projects must be urban improvement projects which are so attractive that citizens would want them in their neighborhoods.



► TRIPP Review

TRIPP organised a one day Workshop on Future Directions in Transportation Research at the Indian Institute of Technology Delhi on the 19th of October 2004. Special invitees to this workshop included Professor Yashpal (former Director, Space Applications Centre, Secretary Department of Science and Technology and Chairman of the University Grants Commission), Professor Roddam Narasimha (Chairman of the Engineering Mechanic Unit, Jawaharlal Nehru Centre for Advanced Scientific Research and Director, National Institute of Advanced Studies, Bangalore) and Dr. V. Sumantran (Executive Director of the Passenger Car Business and the Engineering Research Centre of Tata Engineering). Professor Sachin C. Maheshwari chaired the

At this workshop all faculty members and professionals associated with TRIPP made presentations of their ongoing work and shared their vision for the future with the experts:

- | | |
|---|--------------------------------------|
| Injury Prevention and Transportation Research | - Dinesh Mohan |
| Transportation Research | - Geetam Tiwari |
| Image Recognition Systems | - Subhashis Banerjee |
| Geographical Information Systems | - A.K. Gosain |
| Hazard Centre | - Dunu Roy |
| Institute for Democracy and Sustainability | - Rajendra Ravi |
| Biomechanics and Crashworthiness | - Anoop Chawla and Sudipto Mukherjee |
| Helmet Research | - Puneet Mahajan |
| Emissions | - Sanjeev Sanghi |
| Bus Ventilation Systems | - Sunil Kale |

Based on this interaction and inputs from the invited experts TRIPP will develop guidelines for future directions and thrust areas



► International Course

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology, Delhi the French National Institute for Transport and Safety Research (INRETS) France, and the International Research Council on the Biomechanics of Impacts (IRCBI) organized a seven day International Course on Transportation Planning and Safety from 09-15 December 2004 at the Indian Institute of Technology Delhi. The course was co-sponsored by the Volvo Research and Education Foundations, World Health Organisation, Ford India Ltd. and the Ministry of Road Transport and Highways. The course (an annual feature for the last 14 years), was attended by 49 participants from 17 countries. The faculty members included Anoop Chawla (IIT Delhi), Dinesh Mohan (IIT Delhi), Elaine Wodzin (USA), Geetam Tiwari (IIT Delhi), Harald Zellmer (Autoliv, Germany), Hermann Knoflacher (Technical University of Vienna), Marie-Chantal Jayet (INRETS, France), Mathew Varghese (St. Stephen's Hospital, Delhi), Murray Mackay (University of Birmingham, UK), Nicole Muhlrad (INRETS, France), Shrikant Bangdiwala (University of North Carolina, USA), Sudipto Mukherjee (IIT Delhi) and Sylvain Lassarre (INRETS, France).



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