TRIPP BULLETIN
VOL 14 NO.3 WINTER 2017
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
INDIAN INSTITUTE OF TECHNOLOGY DELHI

Research & Consultancy Projects

Pedestrian safe public transport systems: infrastructure, operations, vehicles, policies and legislation

Sponsor: *Volvo Educational Research Foundations, Sweden*
Project team: *G. Tiwari, S.Mukherjee, and K.R.Rao*
Objective: The main objective of this project is to integrate insights gained from accessibility to informal public transport, as well as accessibility from informal places to formal public (open) space into formal policy documents for improving public transport access and access to public spaces. Since a large number of urban trips are in informal public transport, and access to these systems are by walking, it is important to ensure safe pedestrian access around PT stops (formal bus, as well as informal public transport systems). Often informal public transport stops are not formally planned, therefore, the environment around IPT stop is not mandated to be designed to satisfy pedestrian needs. A liveable city does not only include good functional infrastructure for mobility and access purposes, but will also include quality facilities for 'place making' purposes. In other words, does the city have safe, secure and comfortable areas where people can meet for leisure purposes?

Development and field testing of panic switch based safety device for cars for aiding womens safety

Sponsor: *Ministry of Electronics and Information Technology*
Project team: *Anoop Chawla*
Objective: To develop a safety device for the passengers (especially female passengers) travelling in Cabs and Taxis. The device is expected to be in the form of an SOS / panic button which, when invoked would transmit an SOS signal to a set of predefined locations. The system will be a combination of software and hardware providing an infrastructure for safety of passengers (especially female passengers) commuting in invoked informing concerned agencies, providing them with the relevant vehicle data including location. The data, in full or in part, can be transferred to remote locations which will be handed over in standard format to police authorities.

Improving operational efficiency of bus systems and addressing data gaps in vehicular emissions management

Sponsor: *Shakti Sustainable Energy Foundation, India.*
Project Team: *Geetam Tiwari, K.R. Rao and M. Manoj*
Objective: 1. Develop fleet usage characteristics of all vehicle types;
2) Data analytics support to State Transport Undertakings
3) Web based toolkit for public transport performance evaluation
4) Standardisation of bus specifications
5) State level roadmap for pubolic transport improvement

Indicators of reliability and variability of BRTs/bus systems (INDIRA B)

Sponsors: *CEFIPRA (Indo French Centre for Advanced Scientific Research); Delhi Integrated Multi-Modal Transit System Ltd. (DIMTS)*
Project team: *Geetam Tiwari and K.R. Rao*
Objective: This project includes major interventions at two levels - product and process. The product involves use of Intelligent Transportation Systems (ITS) technology, for developing performance indicators for Bus Rapid Transit (BRT)/ bus systems. At the process level, the aim is to improve the operation of BRT by means of branching modules, dealing with new indicators in an existing management system exploiting an existing real time data acquisition system (AVLS).

The three partners in this work are: COSYS of IFSTTAR (The French Institute of Science and Technology for Transport, Spatial Planning, Development and Network); DIMTS (Delhi Integrated Multi-modal Transit System Ltd.) and TRIPP (Transportation Research and Injury Prevention Programme).

The objective is to assess some of the existing well known quality-of-service indicators, and to develop new ones. Performance indicators should be clear, easily understandable, and useful to the audience. The main outcome of this research is to develop a computer-based research tool consisting of different modules. This could be integrated into an operational platform for analysis and diagnosis of the quality of service of BRTS/bus systems lines in different operational use. The applications will be tested in Delhi, and generic modules will be developed for other cities.

Toward an integrated global transport and health assessment tool (TIGTHAT)

Sponsor: *University of Cambridge, UK*
Project Team: *Geetam Tiwari, M Manoj and Nezamuddin*
Objective: Lay the foundation for a modelling tool that can be readily applied to a wide range of urban settings based on readily available data. Health impacts will be modelled through the pathways of physical activity (PA), air pollution (AP), and road traffic injuries. In this project we will review the availability of data, plan future data mapping, and undertake three case studies to produce new estimates, to develop the model, and to understand which parameters our final result estimates are sensitive to. The longer term version is of a web based tool based on open source code that can be used by policy makers and practitioners to support urban planning. Such a tool should be easy to use, based on the best scientific evidence, and should allow for comparisons between settings

Consulting services to audit the implementation by the states of directions issued by the Supreme Court Committee on road safety

Sponsor: *Delhi Integrated Multi-Modal Transit System Ltd., India*
Project Team: *Geetam Tiwari, K.R. Rao and Dinesh Mohan*
Objective: The Supreme Court Committee on road safety sent directions to the states to implement various policy, institutional and infrastructure related measures in an effort to improve the standards of road safety and reduce accidents and fatalities. The study will cover all categories of important stakeholders/offices of potential road safety related representative bodies within given cities which will be identified in discussion with the client prior to undertaking the field activities. In this connection the consultants proposed to use both quantitative and qualitative techniques during the study to elicit information from potential road related representative bodies. In qualitative techniques, in-depth interviews and focus group discussions will be carried out to cover the identified road related representative bodies.

Simultaneous bus route network design and frequency setting in small and medium sized cities using evolutionary algorithm

Sponor: *Department of Science and Technology*
Project team: *K. R. Rao and Geetam Tiwari*
Objective: Bus Route Network Design (BRND) procedure is applicable for networks of real size in which many parameters need to be determined to reach an optimal solution. As a result, the meta-heuristic approaches, enables us to pursue reasonably global optimal solutions and deal simultaneous with the design of the bus route network. The main objective of this research is to systematically study the procedure of bus route network design in small and medium sized cities, which have different travel behaviours and development characteristics. A multi-objective network design model would be formulated considering passengers (users), operators and the government perspectives.

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.

TRIPP BULLETIN
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Excerpts

STATE-OF-THE-ART OF ROUNDABOUT PERFORMANCE FOR PROMOTING OF URBAN SAFETY

Werner Brilon

Town planning in the 19th century favoured large circular places as elements of agreeable city design. With increasing city traffic at the beginning of the 20th century these locations were the first where roundabouts (which just means one-way direction of traffic on the circle) were established like Columbus Circle in New York (1905) or Place Etoile in Paris (1907). This happened in many countries around the world. In consequence most of the large cities in the 20th century had their monumental large traffic circles.

However, the traffic rules, were quite different in various countries. In Germany circulating traffic had priority; in other European countries the entering traffic had the right-of-way with the consequence that under high traffic demand these intersections became gridlocked. In the US a variety of rules had been tested over the years. However, in 1966 the UK, introduced the "off-site priority rule". This rule means: (a) the circular traffic has priority over the entering vehicles and (b) the vehicles on the inner lanes are privileged in a conflict over vehicles travelling further outside (GOV.UK). This rule is the background of the great success of roundabouts in the UK and it is the reason for exceptionally high capacities at large roundabouts which can only be observed in the UK.

Meanwhile, outside the UK only part (a) of the "off-site priority rule" is valid in most countries; i.e.: traffic on the circular roadway of the roundabout has priority over the approaching traffic. This rule, which has been valid in Germany since ever, has been adopted by the highway code in most countries of the Western Hemisphere during the last three decades.

The acceptance and application of the valid traffic rules are the key for traffic safety of roundabouts. In the Western countries the acceptance of these rules, usually, is quite good. Speaking about safety, thus, organization and acceptance of the traffic rules is a significant basic condition for all conclusions about traffic safety.

Also the styles of roundabout design are specific to different countries. The traditional layout of roundabouts in the early 20th century involved large multi-lane circles. These, however, were not successful regarding safety. Especially two-lane exits emerged as a major source of severe accidents. Thus, in the 1950's and the 1960's the larger circles were no longer favoured in most countries on the European continent or in the US. Later in 1980, the big success of roundabouts in the UK incited planners and researchers in several European countries to study and experiment with roundabouts.

These studies unveiled unexpected gains in traffic performance and safety, however, only for the single-lane roundabouts. These compact intersections were found to be able to carry up to 25000 veh/day combined with rather low delays for road users and with the highest potential to prevent accidents. There are still the most favoured type of roundabouts.

Later on slightly larger - and also smaller - roundabouts were studied in many countries. As a consequence we now have a whole toolbox of different types of roundabouts. Figure 1 tries to illustrate diameters and range of traffic demand for roundabouts for different sizes:

- mini roundabout with a traversable central island and a diameter between 13 m and 23 m
- single-lane roundabouts with a diameter between 26 m (minimum required for European trucks to make a full turn) and 35 m (urban) or 40 m (rural) and only single-lane entries and exits
- Semi-two-lane roundabouts with a diameter of 45 m to 60 m, a lane widths of 8 m to 10 m (no lane marking on the circle) and single lane exits but 1- or 2-lane entries
- larger two-lane roundabouts (which are banned e.g. by German guidelines due to their bad accident experience)
- Turbo-roundabouts with 1- or 2-lane segments on the circle. The entries and exits may have 1 or 2 lanes where the two-lane solution needs a specific design to avoid undesired lane changes.

This is the kind of classification used in Germany. But in most countries on the European continent the view on roundabouts is quite similar. It should be emphasized that all rules in design guidelines of the continental European countries are governed by a maximization of traffic safety as the first target. Capacity is only of secondary importance. Less safe roundabout constructions are not treated as state-of-the-art.

In the UK the situation seems to be different. There the design is not so much oriented in lanes. Instead, if capacity makes it necessary, the lanes are flared out near the roundabout to increase capacity. This is supported by the results of capacity investigations. This leads to a design which can differ considerably from European continental solutions.

An international comparison of traffic safety leads to some complications regarding accident statistics. Already the identification of an accident differs from country to country. Some countries count all accidents (including property damage only) which were reported to the police. Other countries take account of only accidents with personal injuries. Another difference concerns fatalities, e.g. in Germany a fatality is classified as such if the victim dies within 30 days after the accident. Other countries apply completely different definitions.

Also the researchers use different methods of evaluation. E.g. the distance on the approaching arms where accidents are treated as intersection-related varies and is not explained in most of the publications. The most serious way in intersection accident analysis is to define relevant parameters to describe accident risk. The following variables seem to be most characteristic:

$$\textit{accident rate} = \frac{\textit{number of accidents}}{N_T}$$

$$\textit{accident cost rate} = \frac{\textit{number of accidents}}{N_T}$$

Where N_T = no. of vehicles travelled through the intersection,
usually estimated by the average daily traffic (ADT)
damage by accidents: evaluated in currency units

For the calculation of accident cost rates the damage caused by accidents must be evaluated in currency units where the figures used are standardized on a national basis.

These measures of accident occurrence are relative to the exposure to risk as it is represented by the number of vehicles travelling through the intersection. These parameters allow a more meaningful interpretation than absolute figures. Unfortunately all the publications on traffic safety apply different methods of analysis. Therefore, a definitive comparison of the results from different investigations is not easy.

A comparison with other types of intersections or with prior situations was not a topic in this investigation. It was, however, complimented by an observation of road user behaviour at some of the analyzed intersections. Here, among others it was found that at cycle paths the bicyclists up to 50 % use the crossings in the wrong direction which imposes a significant risk.

Mini-roundabouts are small circular junctions with a traversable central island. Small cars have to drive around the central island whereas trucks are forced to cross this island with their rear wheels. These types have first been introduced in the UK under the leadership of Frank Blackmore in 1968. Other countries have imitated this example rather late; e.g. Germany started to experiment with this form in 1997.

The safety of mini roundabouts in Germany has been studied. Report on the pioneering (for Germany) experiment of a conversion of 10 intersections into mini-roundabouts. As a result the accident risk was significantly reduced. The accident cost rate was much lower than a very safe intersection (i.e. ? 10 DM/1000 veh in 1999).

Also the analysis by Baier e.a. of 26 mini roundabouts and 309 conventional intersections confirmed an extraordinary low accident cost rate.

Of course, mini-roundabouts are only allowed in urban areas with a general speed limit of 50 km/h. Details of a reasonable design are described in the guidelines (FGSV 2006). The most important aspect is that the central island should consist of a paved circle which must be elevated by 4 or 5 cm above the asphalted circle.

Effect of the conversion into mini roundabouts

	before (conventional intersection)	after (mini roundabout)
average accident rate [acc./10^6 veh]	0.8	0.4
average accident cost rate [DM/1000 veh]	29.3	3.5

Accident cost rates [E/1000 veh] of mini roundabouts compared to other types of junctions.

	mini roundabouts	unsignalized intersection	signalized intersection
3 arms	2.02	4.68	6.60
4 arms	5.66	13.39	8.40

A turbo-roundabout is a kind of circular intersection where the number of lanes on the circle varies between 1 and 2 and where the traffic through the intersection is strictly channelized by lanes. This type does also allow a safe operation of 2-lane exits. Usually such a roundabout has a diameter of 50 or more meters. Application is useful if one or two of the movements have periods with very large traffic volumes. In Germany traffic guidance is achieved just by lane markings whereas in the Netherlands vertical lane dividers (similar to kerbs in the middle of the roadway) are in use. Even if these circles are quite space-consuming their capacity is limited to around 35000 veh/day.

Traffic safety of turbo-roundabouts has recently been investigated, based on a limited sample size. The accident rate on average was 1.0 acc/106 veh and the accident cost rate was 7.7 €/1ooo veh which corresponds to the level of single-lane roundabouts and is better that the risk at conventional intersections.

Therefore, this type of roundabout provides an adequate level of traffic safety and, thus, is a useful instrument of traffic design in urban areas. However, it is not compatible with any kind of bicycle operation which means that for bicycles other kinds of traffic guidance (e.g. bridges) must be applied at the relevant sites.

Accident prediction at roundabouts has first been proposed by Maycock, Hall (1984). Based on the analysis of 84 4-arm at-grade roundabouts they developed a linear model to predict the number of accidents (frequency of all crashes + pedestrian accidents) based on the entry path curvature, the roundabout diameter, entry width, angle of the approach relative to the circle, and traffic volumes. The equations can primarily be used to compare alternative designs according to the British style of roundabout design.

For the US an accident prediction model has been formulated by the NCHRP 572-report which is also mentioned in the US roundabout guide. Here the expected number of crashes per year is estimated by an exponential function of the ADT (annual average daily traffic), e.g.

$$crashes/year = 0.0038.ADT^{0.749}$$ for a 2-lane 4-arm roundabout (see cited literature for other parameters)

Other parts of the model concern accident prediction for each approach. Here the ADTs of the approach, of the circle, and of the exit are of predominant importance. In addition geometric parameters like entry radius, entry width, diameter, and others are used for accident prediction. These models estimate the number of accidents on the approach, entering-circulating, and exiting-circulating separately. These equations have the potential to compare several alternatives for the geometric design regarding safety. It must, however, be mentioned that the equations have a relatively small empirical background and that they are only based on the US background (e.g. definition of crashes, design style).

All investigations underline the fact that cyclists at roundabouts constitute a specific problem. Usually they also get some improvement in safety by a roundabout. However, these improvements are not as significant for them as they are for the other road users like car passengers or pedestrians. As a consequence cyclists at roundabouts face the largest risks.

All the studies come to very similar conclusions. They distinguish between the following kinds of bicycle treatment. Moreover, the reports propose the following actions. These points apply only to single lane roundabouts.

- Bicycles in mixed traffic on the circular roadway together with cars: this is a very safe solution for lower traffic volumes. It should be favoured up to a total traffic volume of 15000 veh/day.
- Bicycling lane on the outer margin of the circular roadway. This is the most dangerous solution. It must be absolutely banned.
- Bicycle paths separated from the roundabout. This is the recommended solution for larger traffic volumes. The crossings of the exits and the entries must be separated from the circle by 4 m, better by 1 car length, i.e. 5 m. The cycle paths should approach the crossings vertical to the direction of the roadway. It is evident that a priority for cyclists at these cross points induces a higher risk than a regulation where cyclist have to yield to motor vehicles.

These recommendations apply for single-lane roundabouts. At multilane roundabouts cyclists cannot be allowed on the same roadway as motor vehicles. Also bicycle crossings at multilane entries - and especially exits - are a significant risk. Thus, multilane roundabouts should only be implemented where the occurrence of cyclists can be completely excluded. Tunnels or bridges for cyclists are a must at these larger roundabouts.

For the mini-roundabouts separate cycle facilities are not recommended. Here, if cyclists cannot be operated on the roundabout itself, then a mini is not a good solution for the relevant situation.

The paper tries to provide an overview about research results on safety at roundabouts with a focus on urban intersections. Even if it is written from a German perspective it includes results from several other countries.

As a conclusion from all studies, there is no doubt that roundabouts are the safest type of intersection. Especially the single-lane roundabouts reveal the highest level of safety. Also Mini-roundabouts have an extraordinary good safety record. Turbo-roundabouts - regarding safety -are on the same level as the single-laned. This high degree of traffic safety depends on the speed-reducing design of the whole intersection.

In comparison to conventional types of intersections like signalized or 2-way-stop intersections, the car occupants and the pedestrians enjoy the highest gains from roundabout safety. On the other hand bicyclists can become a problem for traffic safety at roundabouts. However, also cyclists can be accommodated with a sufficient degree of safety – but only if the requirements for design are strictly obeyed.

It should be emphasized that the high degree of safety is coherent to road user discipline and to the acceptance of the existing traffic rules. This acceptance should be strengthened by an adequate intersection design. Therefore, the favourable safety effects of roundabouts can only be achieved if the rules for modern roundabout design, as they are documented in many national design guidelines, are strictly applied.

It must also be ascertained that roundabouts are not the optimal solution in each situation. Following the continental European guidelines there are limits in capacity which in detail have to be figured out for each single case by adequate capacity models. Beyond these limits signalized intersections remain useful solutions to manage traffic at urban intersections with a very large traffic demand.

Overall, it can clearly be stated that the adequate use of roundabouts may be a real boon for traffic safety - especially in urban areas.

Excerpts from a TRIPP Annual Lecture which is a chapter in our forthcoming publication: "The Safe Way: State of the Art Lectures on Road Safety".

TRIPP BULLETIN
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
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News

Pedestrian road safety in relation to urban road type and traffic flow

Athanasios Galanisa, George Botzorisb, Nikolaos Eliou
Transportation Research Procedia, Volume 24, 2017, Pages 220-227

Abstract: The paper presents an analysis of the relationship between pedestrian road safety, urban road type and motorists' traffic flow. A suitable index for the evaluation of the walkability level of an urban street is the pedestrian traffic flow and the walking behavior. The researchers examined six urban streets of various types in the city of Volos (a medium-sized Greek city, 130,000 inhabitants). They collected data of the pedestrian traffic flow and their legal or illegal walking behavior for each road segment of the examined streets. Furthermore, they collected data of motorists' traffic flow in the same road segments of the streets in the study area. The combination of those data with the administrative ranking of each road can indicate a walkability level of an examined street or a specific route and reveal pedestrians' mobility and safety issues. This study supports that walking behavior differs for various road types. Pedestrians with the highest rate of legal behavior were presented in main arterials (91.8%) and the lowest one in local streets (53.7%). Low level of motorized traffic flow in combination with maintenance and mobility problems in pedestrian infrastructure incites pedestrians to walk in the street thus underestimating their safety issues. Promotion of pedestrian mobility emphasizing in safety issues can change the modal split in favor of vulnerable road users, increase the sustainability index of an urban area and improve the citizens' quality of life.

Media reporting of traffic legislation changes in British Columbia

Jeffrey R. Brubachera,Ediweera Desapriya, Herbert Chan, Yamesha Ranatunga, Rahana Harjee, Shannon Erdelyi, Mark Asbridge, Roy Purssell, Ian Pike
Accident Analysis and Prevention 82 (2015) 227–233.

Abstract: Introduction: In 2010, British Columbia (BC) introduced new traffic laws designed to deter impaired driving, speeding, and distracted driving. These laws generated significant media attention and were associated with reductions in fatal crashes and in ambulance calls and hospital admissions for road trauma.
Objective: To understand the extent and type of media coverage of the new traffic laws and to identify how the laws were framed by the media.
Methods: We reviewed a database of injury related news coverage (May 2010–December 2012) and extracted reports that mentioned distracted driving, impaired driving, or speeding. Articles were classified according to: (i) Type, (ii) Issue discussed, (iii) 'Reference to new laws', and (iv) 'Pro/anti traffic law'. Articles mentioning the new laws were reread and common themes in how the laws were framed were identified and discussed.
Results: Over the course of the study, 1848 articles mentioned distraction, impairment, or speeding and 597 reports mentioned the new laws: 65 against, 227 neutral, and 305 supportive. Reports against the new laws framed them as unfair or as causing economic damage to the entertainment industry. Reports in favor of the new laws framed them in terms of preventing impaired driving and related trauma or of bringing justice to drinking drivers. Growing evidence of the effectiveness of the new laws generated media support.
Conclusions: BC's new traffic laws generated considerable media attention both pro and con. We believe that this media attention helped inform the public of the new laws and enhanced their deterrent effect.

International Course

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology, Delhi organized its International Course on Transportation Planning and Safety from 30 Nov. - 07 Dec. 2017 and one day research workshop on 8th December 2017 at the Indian Institute of Technology Delhi. The Course was supported by Ministry of Housing and Urban Affairst, Govt. of India, World Health Organisation (SEARO), India, Volvo Research and Educational Research Foundations (Sweden), TATA Trusts, Independent Council of Road Safety International (ICoRSI) India, Shakti Sustainable Energy Foundation, India. The programme was attended by 53 participants out of which 13 participants represented 5 countries other than India. This seven day Course was designed to bring together professionals working in the area of transportation planning, safety promotion, biomechanics of impact and vehicle crashworthiness to acquaint them with the state-of-the-art information in the field. The Course has been designed for n interdisciplinary audience of traffic and road engineers, behavioral scientists, mechanical & automotive engineers, law enforcers, police officers and doctors. The course was organised in two parallel modules. First three days were common for all participants to give a global perspective to the road safety problem followed by two parallel modules on Traffic Safety and Biomechanics and Crashworthiness. Faculty members were from Prof. Anoop Chawla, Prof. Dinesh Mohan, Prof. Geetam Tiwari, Prof. Sudipto Mukherjee, Prof. Puneet Mahajan, Dr. K.R. Rao, Dr. K.N. Jha; Prof. K.R. Rao, Prof. S. Sanghi, Prof. S. Mukherjee, Prof. P. Mahajan , Prof.. Girish Agarwal, Shiv Nadar University, India, Dr. Mathew Varghese, St. Stephens Hospital, Delhi, India, Prof. Hermann Knoflacher, University of Technology, Vienna, Austria, Dr. Sylvain Lassarre, IFSTTAR, France; Dr. Jacobo Antona Makoshi, JARI, Japan, Prof. Francisco J Lopez-Valdes, Comillas University, Spain, Dr. Maria Segui-Gomez, International Federation of Automotive, S ain, Dr. Karin Brolin, Chalmers University, Sweden; Prof. Shrikant I BangdiwalaUniversity of North Carolina, USA and Prof. Kavi Bhalla, Bloomberg School of Public Health, USA

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Ministry of Urban Development India: MoUD Chair for Urban Transport & Traffic Planning
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TRIPP BULLETIN
VOL 14 NO. 3 WINTER 2017
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
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A TRIPP Bulletin Insert

***Excerpts from** a work in progress: "Improving operational efficiency of bus systems and addressing data gaps in vehicular management*"

Status Report on City Bus Systems in India

The sustainable development of cities depends on developing safe and low-carbon transport systems which provide access to the required goods, services and activities for all citizens. An efficient public transport system helps meet the mobility needs of a city, using fewer ¬financial and energy resources, compared to private vehicle-oriented mobil¬ity. It also helps in improving the public health and well-being of inhabitants by reducing pollution and improving safety on roads. To address the challenges of urban growth various national-level policy initiatives particularly National Urban Transport Policy, 2016, National Transport Development Policy, Twelfth Five Year Plan, 2014, National Mission on Sustainable Habitats, 2011, and the High Powered Expert Committee report on Indian urban ¬infrastructure and services, 2011 have also emphasized the need to provide good quality public transport systems in cities.

According to urban transport planners, buses are future of urban transport. Buses are the most important mode of Public Transportation for a majority of people particularly in low to middle income countries. Buses take up over 90% of public transport in Indian cities, and serve as an economical and convenient mode of transport for all classes of society. Many small- and medium-sized Indian cities are still low on per capita incomes and vehicle ownership rates compared to many developed and developing economies. As a result, usage of personal cars and two-wheelers is still prohibitively expensive for large sections of the society, who still rely on public transport. City bus systems will continue to be the backbone of urban mobility in India and serve as an economical and convenient mode of transport for all classes of society.

Between 1991 and 2011 urban population increased by more than 70%, from 217 million to 377 million live in 8000 urban centres. The 53 million plus cities including mega cities holds 13.3% of total country population in 2011 (or 40% of total urban population) in only 0.2% of land area; contributing to 32% of GDP. While by 2030 smaller cities are estimated to grow much faster as compared to larger cities.

To get a better understanding about the importance of bus based public transport in India, it is important to discuss this in the background of typical urban fabric of Indian cities. Indian cities have mix land use structure with substantial informal settlements (15-60% population living in slums). Indian cities are already dense with 30,000 – 40,000 people per square kilometre within the city administrative boundary.

However in India, the inherent dense, mixed land use urban fabric with narrow lanes and compact structures have kept the average travel lengths to be small. Also the urban areas are uniformly dotted with low income settlements or regularized unauthorized slums or informal settlements, thus presenting the income group mix and large service workforce catering to nearby middle and high income groups, at walking or cycling distances. A large proportion of low income households have remained dependent upon walk, cycle or bus for their commute.

High densities in Indian cities' have resulted in short trip lengths irrespective of city size. Even in big cities like Mumbai and Hyderabad 70% of the trips are less than 5 km. In cities like Pune 80% of the trips are shorter than 5 km. The average trip length (including walk) in medium and small size cities is less than 5 km.

While the proactive efforts of central government resulted in transformation of the city bus transport scene in India, still the progress on various reforms in urban transport sector, which are essential to make it sustainable in long run, are not very satisfactory. In order to create a sustainable mass of city buses in each city and to run them successfully, treating public transport as an essential public service, it is important to set up a dedicated urban transport fund at central, state and urban local body level. The funding from the central government may be tied to the actual performance and operations of the buses on per km operated basis and quality of service rather than upfront funding the capital cost of buses. In order to enable such kind of monitoring by central government it is essential to set up a Control Centre at national level, collect and assess fine grained data, directly from the buses and analyse them for scientific decision making.

The metropolitan cities need steering towards technological advancements in bus operations covering the user, operator, planner and regulator due to sheer size of their operations, whereby a certain degree of resilience has been built over the years as far as core operational and management issues are concerned.

Small -medium size cities need comprehensive planning strategy, technical support in handling new technology fleet and locally controlled fare revision mechanism towards achieving good operating ratios.

Ergonomically designed buses – The concept of ergonomics in bus design got introduced with implementation of UBS. Besides the functionality, the look and feel as well as the comfort for the passengers guided the design of the buses.

Introduction of modern low floor, semi low floor buses with ITS features for urban transport, which made it possible to replicate metro experience on the city buses.

Complete image makeover of urban buses in India- Earlier the CBS was presumed to be service for the poor and the have-nots and accordingly was seen as a mode with contempt. With implementation of UBS, the CBS compared with a service for haves also just like metro. These buses not only transformed the image of public transport by bus but also improved the image of the city also with modern means of public transport.

Introduction of ITS on public transport system- Audio/Visual Passenger Information System (PIS) got introduced in a big way for the first time on city buses there by making the CBS a very convenient and passenger friendly experience.

Hence, it is strongly recommended to research the typical urban bus prototypes for varied Indian cities and develop Indian urban bus specifications keeping in mind the anthropometrics, pedestrian and NMV safe vehicle front, appropriate interior design keeping universal accessibility, inclusiveness and enhanced safety and security perceptions for vulnerable groups. Additionally the engine, chassis, ITS and other aspects shall adhere to robust fuel economy and efficiency standards at par with international norms.

Continued overleaf

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VOL 14 NO. 3 WINTER 2017
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Continued from overleaf:

Excerpts from *a work in progress: "Improving operational efficiency of bus systems and addressing data gaps in vehicular management*"

Status Report on Freight Vehicles Mobility in India

According to Census 2011, the level of urbanisation has increased from 27.81% in 2001 to 31.16% in 2011. The urban sector contributes 62% of the country's economy. And it is expected that the urban sector will play a major role in realisation of the stipulated growth in Indian economy. Given the vital role of urbanisation in Indian economy, the steady growth in urbanisation will lead to increase in consumption of goods and services and thus increased demand for freight transport in India. Figure 1 shows the compound annual growth of "goods vehicles" 1951 to 2011 in India. The figure gives us the impression that after 1991 there has been a steady increase in the number of freight vehicles in India.

Road and rail transport carried approximately 87 per cent of the total freight in the year 2007-2008 out of the six modes of freight transport, i.e., rail, road, coastal shipping, airways, inland waterway, pipelines. Railways began losing its share from early 1990s and its share has dropped down to 37 per cent in 2011. As a result, road accounts to approximately 50% of the total freight transport in India 2011.

The Ministry of Railways highlights the lack of the investment, issues related to cleanliness, punctuality of services, safety, quality of service, increased congestion and low speed of movement as the major challenges to cope with increased freight and passenger demand. The change in the nature of goods, increase in share of manufactured goods like white goods and tough competition offered by the road transport in terms of flexibility, time sensitivity, cost savings and user adaptability has further added up the difficulties of railways.

Owing to India's economic growth and increase in road transport it is expected that the freight demand will increase from 1,604 billion tonne kilometres in 2011-2012 to 16,653 billion tonne kilometres in 2046-47. Rapid growth in freight transport has consequently contributed to increase in heavy duty vehicles. ICRA highlights that Medium & Heavy Commercial Vehicle (M&HCV) Truck segment experienced a growth of 19.0% in 10 months of Financial Year 2015. It is anticipated that Medium & Heavy Commercial Vehicle (M&HCV) truck is likely to post a growth of 12-14% in financial year 2016. Heavy duty vehicles are a major source of PM, SO2, NOx and CO and it is expected that steady growth of heavy duty vehicles will lead to an increase in oil imports from 76% of 141 million tonnes (MT) to 93% by 2031. With the present policy scenarios, it will not be possible to meet recommended air quality standards by 2030. It has been observed from that Heavy/Light commercial vehicles and buses constitute the highest per cent consumption of diesel in each zone of the country. The estimates shows that "despite relatively low truck numbers (5 per cent of total vehicles), the impact from road freight in India is significantly higher than that of other vehicles, including accidents (26 per cent), PM emissions (59 per cent) CO2 emissions (63 per cent) and in total diesel consumption (74 per cent)". Petroleum Conservation Research Association also highlights that "Of the total diesel consumed by road transport, trucks and buses accounted for about 77 per cent with buses consuming around 7.08 million tonnes per annum and trucks consuming 24.25 million tonnes per annum."

Burgeoning freight demand, lack of logistic plans accompanied with rising freight externalities will consequently worsen the situation. Thus, this calls for the need to strict policy implementation, technology advancement and cleaner fuel usage to meet the aim. Improvement in fuel economy standards and implementation of the fuel efficiency policy for heavy duty vehicle will help to cut down the energy demand, reduce fuel consumption and encourage the use efficient vehicles. However, there is very little information available about their fuel efficiency performance, annual mileage, vehicle age, emission standard, etc. This is limiting the implementation of key policy initiatives aimed to regulate their emissions through vehicle scrappage, inspection and maintenance programs. Taking into account the above facts the aim of the position paper is to analyse the secondary data presently available for heavy duty vehicles at national level in India. The analysis will help to identify the gaps and will act as an initial step for the future work to be carried out. Further, the results will help government and decision makers to prioritize the high potential freight policies with respect to environment, fuel standards and emissions.

Growing urbanisation, industrialisation, motorisation have raised questions on the energy security and level of environmental pollution in the country over last few decades. However, systematic planning and sustainable approaches can help India to address the rising demands. Currently, there is significant scope to improve the intra-city and intercity freight operations which can result in large scale emission reduction by the way of higher operating performance due to adoption of upgraded technology.

For the efficient implementation of the policies it is therefore essential to investigate factors like projected growth, cost of operation, knowledge of vehicle characteristics, in terms of vehicle size, fuel type used and age distribution, fuel quality, etc. Extensive surveys were conducted at 14 major entry points of Delhi to understand the freight vehicle characteristics in terms of vintage, mileage by fuel type, kilometres travelled, fuel used for various types of HDV and LDV vehicles, and emission standards for the present fleet. IISD (2013) have description regarding the variation of the mileage for the trucks. It is found that "new trucks with a carrying capacity between 15 and 21 tonnes give a mileage of 3.5 to 4 km/litre and small trucks with a 2.5 tonne capacity give a mileage of 8 km/litre. After five to eight years, the mileage for large trucks reduces to 2 to 2.5 km/litre." Similarly, CSIR (2014), from the observations of secondary sources, found 5.05 km/litre for buses, 8.58 km/litre for LCVs, 4.46 km/litre for HCVs and 3.59 km/litre for multi axle vehicles.

Taking into account the above facts we collected data at national level of the existing fleet characteristics, age, vehicle emission standards, mileage, etc. for freight vehicles used for inter-city and inter-state mobility. Based on the analysis of state wise freight vehicles registration data we conducted surveys on NH-8, NH-6 and NH-2 covering states of Haryana, Rajasthan, Gujarat, Maharashtra, Chhattisgarh, Orissa, Jharkhand, West Bengal, Bihar, Uttar Pradesh, and Delhi. Approximately, the survey covers 4940 kilometre of length. The survey included classified vehicle count and origin and destination survey of freight vehicles which primarily included information on registration number, fuel type used, Year of make/model, ownership, odometer reading, fuel mileage (km/l), commodity type carried etc.