The 1st Conference of Transportation Research Group of India (CTRG)

The Vivanta by Taj - Yeshwantpur,
Bangalore, India.
7th – 10th Dec, 2011

Organized By:

Transportation Research Group Of India (TRG)

In Association with:

* Transportation Research Board (TRB) of the National Academies, USA
* Transport And Development Institute (T&DI), American Society of Civil Engineers (ASCE)
* Association of Transportation Professionals of Indian Origin (ATPIO)

CONFERENCE REPORT

www.trgindia.org

Preface

We are pleased to present the report of the 1st Conference of Transportation Research Group of India (CTRG), held during 7th to 10th December 2011 at Vivanta by Taj, Yeshwantapur, Bangalore, India. The conference was organized by Transportation Research Group of India (TRG), a registered society under the Karnataka Societies Registration Act, 1960 with Reg. No. DRB/C/SOR/29/2011-12, in association with; Transportation Research Board (TRB), Association of Transportation Professionals of Indian Origin (ATPIO), and Transportation and Development Institute (T&DI) of American Society of Civil Engineers (ASCE).

The objective of the conference is to provide a unique forum in India, for the interchange of ideas among transportation researchers, educators, managers, policymakers from all over the world, with the intention of covering all modes and sectors of transport (road, rail, air, and water; public and private; motorized and non-motorized) as well as all levels (urban, regional, inter-city, and rural transport) and for both passenger as well as freight movement. At the same time, to also address the transportation related issues of; safety, efficiency, economic and social development, local and global environmental impact, energy, land-use, equity and access for the widest range of travelers with special needs etc. CTRG will be held regularly once in every two years and the 2nd CTRG will be organized in Dec. 2013 at a suitable venue (to be announced later) in North India.

The report covers the highlights of the conference as well as the report of each Workshop that was conducted on the last day of conference. The idea of the workshop was to highlight and develop the agenda for transportation research, capacity building, and collaboration for next 2-3 years based on the present situation and needs of the country. **We hope that transportation researchers, educators, managers, and policymakers will be able to utilize the outcomes of these workshops, to develop their activities and action plans in the near future.**

Date: March 8, 2012
Place: Bangalore

Ashish Verma
Animesh Das
(On behalf of Organizing Committee)

Acknowledgement

We wish to acknowledge all the distinguished speakers, authors, and registered delegates for contributing to and supporting 1st CTRG and making it a grand success, especially in terms of quality and standard. We are also grateful to the Chairperson and Rapporteur of each workshop for collating the ideas that emerged in their respective workshop and devoting time and energy in preparing the succinct workshop reports, which are included in this conference report.

Date: March 8, 2012
Place: Bangalore

Ashish Verma
Animesh Das
(On behalf of Organizing Committee)

Contents

Chapter-1

Highlights of 1st CTRG

Transportation Research Group of India (TRG), held its first conference during 7th to 10th Dec. 2011 in the Garden City of Bangalore, which is also well known as the Silicon Valley of the Southeast Asia. The seed for creating such an organization and starting its conference was planted in 2008 during the 1st Indo-United States Symposium on Mass Transit and Travel Behaviour Research (MTTBR-08) held during 12th to 15th Feb. 2008 at the Indian Institute of Technology in Guwahati in the state of Assam, India. This seed germinated in to TRG and its first flower is the 1st conference and close to 300 delegates witnessed this historic moment.

Trigger for the idea to create TRG was the desire of the transportation community in India to assist the government on transportation policies and investments by providing research based inputs. Getting transportation research needs to focus on challenging and highly complex problems and issues in India, a developing country, needed a domestic organization because it requires approaches that are somewhat different from those in the developed countries. For example, when the Highway Advisory Committee (the seed that grew in to the Transportation Research Board) was created under the National Academy of Sciences of the United States of America in the 1920s, the goal was to get the automobiles out of mud. India's current transportation related problems are far different and they include in addition to providing all weather accessible roads throughout the country to how to manage growing mixed traffic on its urban roads, how to improve the safety of the traveling public on all types of roads, and how to instill a sense of discipline regarding safe traffic rules in the minds of the travelers, to name a few. These problems are common among the developing countries and an organization such as TRG could provide service to them including India.

1st CTRG is a very modest beginning and through this regular peer-reviewed conference and various other activities including starting the journal, magazine, and news letter of TRG, the society wishes to promote transport research and capacity building in India and to also create a platform to bridge the gap between researchers on one side and industry and government on the other side, so that results of transportation related research pays off by benefiting the society and nation at large. TRG in the long run would like to assume a role similar to what the esteemed body like Transportation Research Board (TRB) has achieved in the United States and to eventually become advisor to the nation in every aspect and domain of transportation.

The 1st CTRG received 310 abstracts. Based on rigorous double blind peer-reviews 140 papers from more than 13 countries that included India, United States, Germany, United Kingdom, Japan, China, Australia, Philippines, Israel, Greece, Canada, Brazil, and Netherlands, were recommended for presentation and inclusion in proceedings. The quality of the conference program was further enhanced by the distinguished keynote speakers, Kumares Sinha, Lalita Sen, Imad Al-Qadi, Serji Amirkhanian, and Srinivas Peeta from the United States; Rosario Macario from Portugal; Yoshitsugu Hayashi from Japan; and B. B. Pandey, S. Gangopadhyay, and P. K. Sikdar from India, who are well known for their work in their respective areas of expertise. With this, the conference has set the standard of quality very high, probably the best so far in India for a transportation

research conference, and TRG will only strive to make it higher in the future. The conference also received the technical and administrative support of internationally acclaimed organizations like the Transportation Research Board (TRB), Transportation and Development Institute (T&DI) of the American Society of Civil Engineers (ASCE), and Association of Transportation Professionals of Indian Origin (ATPIO).

The conference offered tutorials (on Activity based travel demand modeling, Road Safety Audit, and Intelligent Transport Systems), technical field trips (to Bangalore Metropolitan Transport Corporation, Traffic Management Centre of Traffic Police, Karnataka State Road Transport Corporation, National Aerospace Laboratories), and sessions and workshops related to planning, urban transit, traffic operations and management, safety, sustainability, freight transport and logistics, materials, and pavements.

Transportation Research Board had organized the following three special sessions based on peer-reviewed papers:

1. Properties of Asphalt Mixtures and Binders for Improved Performance
2. Sustainable Materials and Technologies for Pavements, and
3. Mechanistic Concepts for Pavement Design and Evaluation

Also, ATPIO had organized the following two special sessions:

1. Pragmatic Issues in Transportation Engineering in India
2. Solutions/Alternatives for Congestion Relief, Road Infrastructure Financing and Safety

Besides the above, two more special sessions were organized on the theme “Transport Research and Beyond”, with speakers from mainly industries like, IBM, 3M, HCL, TCS, Capita Symonds and from government organizations like, MOUD, NRRDA, to bring there perspective on research, technology development, and capacity building issues.

At the conclusion of the 1st Conference, the TRG Board members decided to hold the 2nd conference in December of 2013 in north India. If anyone is interested in finding more information about the 1st conference or TRG, please visit the following website:
http://www.trgindia.org/trg_conference_2011/index.html

Chapter-2

Workshop Details and Guidelines

Details of Workshops

1. Workshop-A: Transport Modes and Inter-modal issues

Description of theme : Airports and Aviation; Maritime Transport and Ports; Rail Transport; Urban Transport Modes; Inland water transport; Inter-modal Issues; Role of para-transit modes; Infrastructure and Institutional integration; Multi-modal urban transit integration; etc.

2.Workshop-B: Integrated Freight Transport and Logistics Systems

Description of theme : Integrated Supply Chain Management; Integrated Freight and Fleet Management; Inter-modal Freight Transport; Urban Goods Movement; Sustainable Freight Transport and Green Logistics; etc.

3. Workshop-C: Traffic Operations, Management and Control

Description of theme : Traffic Theory and Modelling; Traffic Control and Management; Traffic Network Analysis; Safety Analysis and Policy; Intelligent Transport System; Highway Asset Management; etc.

4. Workshop-D: Pavement Engineering and Management

Description of theme : Recent trends in pavement materials characterization; Analysis and design of highway and airfield pavements; Pavement performance evaluation and prediction; Recent trends in pavement construction, Pavement Maintenance & Rehabilitation; highway Drainage; Recycling technique applications in pavement construction; New materials in highway construction, application of geosynthetics in pavement construction, accelerated pavement testing green highways

5. Workshop-E: Sustainable Transport Planning and Policy

Description of theme : Challenges to sustainable Urban Mobility; Environmentally sustainable transport; NMT role and planning; Inclusion of disabled and poor sections in transport planning; Sustainable highway infrastructure; Integrated Land Use and Transport Planning/ Implementation; Urban and Regional Modelling; Local Environmental Impacts due to Urban Land Use and Transport; Monitoring transport emission and effective measures; Transport and Climate Change; Policy Instruments with focus on Land Use and Environment; Institutional Performance and Strategic Change; Decision-making processes and stakeholder involvement; National and regional policy development; Urban Transport Policy; Social Impacts of Transportation; Transport for Tourism, Mass Events and Special Needs; Emerging Policy Issues: Health, Equity, Aging, Special Needs; Rural Transportation Planning and Policy; etc.

6. Workshop-F: Transport Economics, Finance and Evaluation

Description of theme : Integrated Assessment and macroeconomic Impacts of Transport Policies; Transportation System Performance Measurement; Valuation of Internal and External Benefits and Costs; Transportation Finance; Implementation of Pricing in Transport; Transportation Infrastructure Investment and Economic Development; etc.

7. Workshop-G: Travel Behaviour and Demand Analysis

Description of theme : Travel demand modeling; Activity-based analysis and modeling; Travel behaviour; Data collection methods; GIS/GPS/GSM use in travel demand modeling; Transport and Telecommunications; etc.

Conduct of Workshops

a) All the workshops were of 3 hours duration (1.5 hours before and after the lunch break) and were organized in parallel on last day of the conference i.e. 10th Dec. 2011 (after completion of all technical sessions).

b) All the conference delegates were distributed among the parallel workshops based on their preferences (obtained at the time of registration at conference venue) as well as based on maintaining a good mix of academic, industry, field/government professionals, foreign delegates, and students for each workshop.

c) The parallel workshops were the most important part of the conference, as they will help build the tangible output of the conference in terms of report of each workshop that is being prepared by Chairman and Rapporteur of each workshop. The draft version of these reports was presented in the Valedictory Session of the conference by Chairman/Rapporteur of each workshop.

d) The workshop reports will help build the work agenda for TRG (towards fulfilling its vision, mission and objectives) for the next 2 to 3 years and will also help transportation researchers, educators, managers, and policymakers to develop their activities and action plans in the near future. The idea is that the collective wisdom of many learned delegates attending the conference should set the action plan for transportation research, capacity building, and collaborations in India.

Workshops Guidelines

a) The following deliverables were expected from each workshop pertaining to its theme:-

   a. Research issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

   b. Capacity building/training/education issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

   c. Collaborative opportunities on research/capacity building issues (as identified above) with industry, field/government organizations, and other countries.

   d. Any specific major project(s) that needs special attention and TRG's initiation.

b) The discussion in each workshop was expected to stay absolutely focused on workshop topic and absolutely ON-TIME

   a. Some overlap with other workshop might be inevitable, but expected to be minimized.

   b. Chair/Rapporteur were to guide discussion towards meeting deliverable targets.

   c. The workshop participants should not stray or get caught up discussing a specific localized issue or project.

c) The following was the suggested format for the workshop:-

a. First 1.5 hours: Initial deliberation/presentation by Chairman/Rapporteur to give initial feed for discussion, open discussion and deliberation.

b. Next 1.5 hours: Deliberate and suggest recommendations with respect to the theme of the workshop and under each category of expected deliverables.

c. Recommendations: Bullet-wise points giving specific and crisp recommended actions and strategies pertaining to the topic of the workshop.

d) WORKSHOP REPORT (about 5 PAGES):-

a. Page 1-3: Summarize workshop discussion, workshop description, issues raised, needs identified, etc.

b. Page 4 & 5: Recommendations pertaining to the theme of the workshop.

c. 5-6 slide presentation in Valedictory Session on the draft recommendations of each workshop by either Chairman or Rapporteur.

Chapter-3

Report of Workshop-A: Transport Modes and Inter-modal issues

Chairperson: P. K. Sikdar
Rapporteur: S. Velmurugan

Workshop Discussions

The Workshop – A (Transport Modes and Inter-Modal Issues) addressed the topics of transport modes and inter-modal issues, which are critical aspects for the transport efficiency. The theme of the workshop applies to both urban transport as well as national/regional transport systems. Therefore, the main aspects / areas which have been mentioned in the discussions are listed here as follows.

a) In all major urban areas (where there is airport), the linkage to air transport terminal assumes a significant role. In recent years, all newly developed airports in India as well as other countries are generally planned far away from cities (often 50-100km). In India, the examples are Bangalore and Hyderabad, while Kuala Lumpur Abu Dhabi airports are also very far from the main city. None of these cities have been able to develop mass transit link to the airport, which has given rise to a huge extra road travel. Delhi, though not having airport far away from city, has developed airport link in its metro-rail network. While airports need modernization, this aspect of urban travel needs careful consideration to avoid transport intensive land use development. Airports and aviation generally serve the inter-city travel, and with advent of low-cost airlines, the growth in air travel has been from 18-25% at different times. While with affluence of the population, this market is likely to grow at high rate, legitimate development in infrastructure for air travel at the terminal ends are required to handle the demand. A large number of airports in India are in primitive stage and needs to be developed.

b) The Maritime / Inland Water Transport is generally not considered as the mode for urban travel till date. A conceptual change in the planning process and mindset also is required to exploit these opportunities to ease the urban travel where possibilities of using these modes exist. The cities in Kerala, especially for example Koch, can think of developing water transport based mass rapid transit system. Water transport is one of the most energy efficient modes and serve wonderfully well. The linkage between Guwahati and North Guwahati, Mumbai trans-harbour link between Mumbai and Navi Mimbai, airport link to Kochi airport are some of the examples where these can be developed to next level. While this can be categories as the inland water transport, the maritime options for Mumbai in the western cost as well as along Kochi-Thiruvananthapuram coastline, and similar other parts of the country could have enormous potential for development of maritime transport for regional travel as well. These do not flourish where these exist even now primarily due to poor infrastructure and service planning, which needs to be modernized.

c) Rail transport is another mass mode of transport with significant cost advantages. Railway has been developed in India for last 150 years, but with limited vision. There has been no innovation for fast or high speed railway or even for executive or luxury travel market. As a result this mode has lost its market to low-fare air travel. While railways have unlimited advantages for its extensive network, which no other mode enjoys except road, this has not been exploited for innovating the developments in railways. It has remained with a tag of poor man's transport.

Europe, which is like India in size of network, with systematic effort, has changed its rail travel patronage by many innovations like PIS, on-line booking, punctuality, and many more. The best thing which Indian railway system has done in last 60+ years is only the on-line booking. It needs a complete change in the management of the total service including faster travel using high speed railway. Travel between metro cities should be in 5-6 hours and complete upgradation of the system is required. Until about 10 years back Indian Railways were averse to adoption of rail mode in urban transport, except the low standard suburban rail system as in Mumbai, Kolkata and a few others. Except Mumbai, in no other places those were integrated with other modes of travel. Thus, these were not showing any kind of success as in case of Ring Railway in Delhi. A revolutionary zeal is required to develop cities with efficient multi-modal transport systems with rail based mode as mass transport system.

d) Urban transport is a state subject, and federally the responsibility of urban transport has been with Ministry of Urban Development without capacity and fund for it till the JnNURM was launched. JnNURM was launched by the Government after realizing the fact that 60% of the GDP is contributed from urban economy and efficiency of the urban transport is key to all developments of urban India. After the National Urban Transport Policy (NUTP) was adopted by the Government, and with the JnNURM funding made available for urban transport as well, the urban transport scenario has been changing. Ever since the urban transport has been mismanaged and inefficiency has driven the customers to alternative modes in any and every city. JnNURM has mandated reform agenda as well attached to it, and has been trying to inject infrastructure, rolling stock and reform through funding, but with limited success. It has been seen always in urban India that one mode grows at the cost of another, and policies for development has been skewed towards private transport, which needs a drastic change, though NUTP has tried to change the same and JnNURM has adopted this policy. Urban transport all over the world has been promoted now-a-days with 'green objectives', but the scenario in India shows declining trend in use of green modes. The primary reasons for these distortions are the poor planning and management capacity of the ULBs, and therefore, one can find pockets of excellence and that too in an isolated project in a city, but not uniformly across all modes even in one city. Neither ULBs nor the TCPO has ever worked for integrating land use and transport planning, and they have not understood the purpose of the same.

e) Role of para-transit modes cannot be downplayed in any of the Indian cities. Even research studies ignore them as these are not glamorous. A significant amount of travel is catered by these para-transit modes in most cities including the large cities, and these are considered lifeline in case of smaller towns. The TCPO and other planning organizations have failed totally in structuring the planned development of the towns and cities recognizing the roles of various modes including the para-transit. A recent clamor under the programme of JnNURM has drawn in para-transit into focus but without much understanding of their behaviour and the travel pattern and characteristics met by these modes. It is misunderstood to be the domain of NGOs and they have been made responsible for planning and implementation of such developments in urban areas. A much higher level of technicality is involved with management also which need to be investigated and researched for better planning and operation of such para-transits.

f) Institutional arrangement for urban transport has been extremely poor and still it is divided to multiple organizations in cities after cities without any umbrella organization to control the quality and quantity of services. A few states have accepted and adopted to create the urban transport authorities with very and insignificant level of success. Present level of institutional arrangements provide for competition across modes, whereas it should generally be among the providers of services under same mode. The individual institutions of different modes are stronger in existing set ups than the umbrella organization, and it does not meet the objectives. In many cases of para-transit and other unconventional para-transits the service supply and operations are not safe and in violation of every rule, which are not seen and acted by any institution. A massive overhaul of the institutional and management set up with significant innovations in the institutions with defined tasks and targets are required. Qualified land use and transport planners are required to be at the helm of affairs to provide the direction in the institutions, which is grossly lacking at this time.

g) Multi-modal integration is the key for efficiency in urban transport. Complementarities of modes should be adopted as the first principle of planning multi-modal transport for urban India. The seamless travel with highest efficiency will be possible only when all the modes share the same objective and urban transport vision. Of course, there will have to be total transparency in the business model to be collectively adopted for fair division of responsibilities and revenues. In such a system, all effort of marketing, PIS, scheduling, etc must be a coordinated effort so as to maximize the total business for benefit of all partners. For a successful multi-modal integration to be achieved, integrated terminal facilities will have to be developed jointly by all the partner organizations to maximize the integration and the business.

Recommendations from Workshop – A

a) Airports and Aviation

There is need for expansion of airports with proper inter-modal connectivity, which is grossly missing in most of the cities in India. Upgradation of large number of airports will be required to meet the high air travel demand in India. The examples of cities, with newly developed airports (Hyderabad and Bangalore) came to focus in discussion, and were seen with serious lack of transit connectivity, which promotes travel by other inefficient modes. Sustainable urban transport should consider transit connectivity between transport terminals of all major modes like airports, railway stations, etc.

b) Maritime / Inland Water Transport

This mode has been least explored for urban travel, and not developed except for tourism purposes. Example of the city like Kochi was highlighted, where instead of exploring the ways and means of promoting Inland Water Transport and integrating with existing road transport systems, studies are being carried out for “Feasibility of Metro”, which is not environmentally sustainable. Water transport modes should be studied and examined along with the total business model, and it is likely to be highly viable due to its other advantages, if developed with terminal facilities.

c) Rail Transport

Rail based transport systems can be promoted in urban areas without any inhibition, particularly, in those cities which are still the second or third order cities before they become congested. Even some

of the metropolitan cities will be able to accept the rail based transport on ground without much hassles, if tackled at right time. It must be planned as part of the hierarchical set of modes considered for the urban area, so as to develop the integration and complementarity simultaneously. Major innovations are required in inter-city rail services for competing with low-cost air travel, and its extensive network should be exploited to this objective. Method of project based analysis and exploration is required for evaluation of these innovative projects, rather than traditional methods of railway accounting.

d) Urban Transport Modes

Formal public transport of buses to be implemented in most of the second order cities with different sizes of vehicles and service products depending on the demand levels, for which careful studies are to be conducted for assessing the demand levels so as to design the system with a business model. As per the NUTP, the NMT and pedestrian modes are to be promoted in every city of all sizes, and therefore, definite policy framework is to be developed for uniform adoption by all ULBs under JnNURM. Design standards for the city roads (cross section details) with required infrastructures related to NMT and public transport modes as well as pedestrians (actually all VRUs) to be formulated for uniform adoption. Para-transit should be recognized as one of the urban transport modes, which contribute significantly in meeting the demands, while some of these are the green modes. Exploring the possibility of implementing Metro and BRT in big and medium sized cities based on Comprehensive Mobility Studies should be given priority. In the cities where metro is already in operation and/or under expansion, a detailed mechanism for public consultation must be adopted. The development and operation of Janmarg BRT in Ahmedabad is an example where extensive public consultation led to a successful implementation of BRT, which is not the case in any of the other such projects. Urban transport must be seen only as a multi-modal requirement, as no trip O-D can be met by single mode except a few. All modes must get its due share in planning and implementation of transport infrastructure including those for the pedestrians. In this context, the possibility of implementing exclusive two-wheeler lanes in major corridors of the major cities should be explored.

e) Lack of integrated land use and transport planning

Urban India has seen total lack of integration in land use and transport development. Flourishing Ring Railway of Delhi was blamed for not having land use along the system, which is a perverted theory. Land use may not go to transport, but transport has to come to land use, and there are ways and means for that. Current transport demands are to be met through specific projects, but there should not be attempt to shape the structure of the city and influence its future growth. The western concept of TOD is to be seen with caution, and there are better theories here to implement. A complete about turn from western land use planning, and adoption of mixed land use in India as the norm, has created the whole city as the market place. With absence of development control, and extremely poor enforcement in this regard, the cities have become totally unmanaged with congestion and chaos everywhere. It is not easy to regulate the mixed land use in its true sense and a strict enforcement system needs to be created for cleaning the mess. All track based systems must be thought as part of the transport system early in city's development so that the land for their future developments can be frozen to keep the cost of future developments low. Impact of industrial development along the regional corridors on demand for various transport modes should be considered.

f) **Intermediate Public Transport (IPT) or Para Transit**

No institutional framework is in place for the organised development of IPT in any of the cities, which must be explored by studies. Studies to be conducted for understanding level of adequacy of IPT in such cities where the IPT is serving as the principal mode. The para-transit must be recognized as one of the modes of urban transport and should be developed in integration with other mass transit systems as the feeder system. In every urban transport study and research the IPT must be recognized, and should duly consider the characteristics of travel by IPT. The economics of IPT and formal public transport should be explored in relation to system efficiency and cost to customers.

g) **Multi-modal Integration**

Integration of road, rail and other modes of transport in urban areas will bring transport efficiency in the city and their complementarities will be best utilized. In all major cities development of LRT, BRT, monorail etc and MRTS is to be explored based on travel demands at opportune time before the city gets congested. Development of integrated ropeway system for the movement of passengers and goods in hilly areas can also be considered. The elements of integration and the implementation methodology are required to be developed based on different groups of modes required to be integrated according to the city sizes. The technologies and systems required for integration are to be identified and coordinated effort will be required for successful implementation.

h) **Infrastructure and Institutional Integration**

Integrated operations require commensurate infrastructure for the operations, and therefore, the cost benefit of such integration through these infrastructures are to be examined by systematic studies. There is serious lacking in integrated city development strategies – there is need for Unified Metropolitan Transport Authority (UMTA) with power and funding capability. Institutional integration to be developed by acceptance from all involved agencies, and the apex body to be given power and authority for funding and enforcing the performance parameters for all involved. The data on success or failure of the systems shall be maintained by the apex body and there has to be appropriate system for monitoring the performance. UMTA with strong enforcing arm is required to be implemented in every state as part of NUTP. Transparent governance is to be designed and implemented so as to achieve both institutional goals as well as integration. All inefficiencies and unsustainable infrastructure and services developments by ULBs must be curbed by logical set up of institutions with qualifies technical staff.

Chapter-4

Report of Workshop-B: Integrated Freight Transport and Logistics Systems

Chairperson: Srinivas Peeta
Rapporteur: K. A. Raju

Description:

The topics related to Integrated Freight Transport Logistic Systems that were presented in the conference were mentioned briefly, and the participants in the workshop were invited to speak on these items, specifically with respect to the following three areas:

a. Research issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

b. Capacity building/training/education issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

c. Collaborative opportunities on research/capacity building issues (as identified above) with industry, field/government organizations, and other countries.

Chair persons have narrated the role of various modes of Transport in logistics and the challenges being faced by the sector

The issues discussed were

- Infrastructure Issues and Challenges
  - ✓ Congestion
  - ✓Operational inefficiencies
  - ✓Non standard equipment (such as trucks, cranes, etc).
  - ✓Under utilization of infrastructure available.
  - ✓Supply demand mismatch

- Institutional Issues
  - ✓ Highly Fragmented industry
  - ✓ Manual, non-uniform or discrete processes across the industry
  - ✓ Non-presence of renowned logistics companies
  - ✓ Non-availability of Quality manpower

- Technological Issues
  - ✓ Old technology
  - ✓ Adoption of new technologies is expensive
  - ✓ No clear Return on Investments for New Technologies
  - ✓ Manual processes leading to operational inefficiencies

The items that were brought up during the following discussions are listed in the following paragraphs.

a. Research issues/topics that needs to be addressed in immediate future i.e. next 2-3 years: Research Topics that were suggested are

- Development of goods traffic demand models. These models should address
  - ✓ International, National, regional and local goods traffic
  - ✓ Identify exclusive goods corridors

✓Infrastructure requirements at intermodal transfer points such as ports, rail yards, consolidation/deconsolidation hubs etc.
✓Impact on the economy of the country.

• Applied research on mobile technology applications in logistics industry to
✓Improve operational efficiency of logistics industry
✓Provide real time visibility of the events that happen in the field and required information
✓Reduce the usage of paper

b. Capacity building/training/education issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

• Considering the lack of skilled manpower for Logistics Industry it was suggested to build robust institutional framework for creating logistics manpower in India
✓ TRG to act as an enabler in networking/ creating platform for logistics professionals who will provide recommendations and draw the road map for development of skilled man power for Logistics Industry in India
✓ More number of driving schools for truck driving
✓ Certificate courses in ITI/Polytechnic colleges and vocational courses for Logistics Operations such as Warehouse management and Terminal Operations for filed level and supervisory roles
✓Logistics should be a part of curriculum in Masters Program of Transportation Planning/Engineering
✓ Recruit faculty with logistics background in reputed institutes to develop skilled man power for managerial and strategic roles

c. Collaborative opportunities on research/capacity building issues (as identified above) with industry, field/government organizations, and other countries.

Though Logistics Industry is primarily dominated by private enterprises, it consists of several players such as Govt to create infrastructure, policies etc. Therefore,

• Any initiative will necessarily require a collaborative approach by various industry stakeholders. TRG may play a major role
✓ In pulling together the market leaders to push their resources to establish institutionalized training and research infrastructure for Logistics Industry
✓ Convince Government to support industry players by providing more conducive environment while mandating certification levels for recruiting.

Chapter-5

Report of Workshop-C: Traffic Operations, Management and Control

Chairperson: V. Thamizh Arasan
Rapporteur: Ravi Shekar and Ashish Bhaskar

Preamble: This Workshop on the theme, 'Traffic operations, management and control' is one of the seven workshops organized as a part of the First Conference of the Transportation Research Group of India held during 7-10, December, 2011 at Bangalore. The Workshop was intended to deliberate on the following three issues and come out with specific recommendations as deliverables of the workshop:

1. Research issues / topics that needs to be addressed in the immediate future.
2. Capacity building / training / education issues that needs to be addressed in the immediate future.
3. Collaborative opportunities on research / capacity building with industry, govt. organizations / educational and research institutions in India and in other countries.

The discussions on various aspects related to the identified issues on traffic operations, management and control were elaborate and effective with the active participation of the delegates present in the Workshop. The summary of the deliberations made on each of the three issues and the identified topics of research are as follows.

1. Research Issues

The discussions on research issues were, in general, concerned with identification of research topics in the areas of Traffic Operations Management and Control. To facilitate focused discussion, the research issues were classified into (i) Fundamental Research and (ii) Applied Research. The gist of the discussions and the recommendations on each of the research areas are as follows.

(i) Fundamental Research:

The measures of road traffic flow characteristics, as adopted under homogeneous traffic conditions prevailing in developed countries cannot be applied for the highly heterogeneous traffic conditions, involving vehicles of wide ranging static and dynamic characteristics, prevailing on Indian roads. Hence, there is urgent need to develop appropriate methodologies to measure the flow characteristics of Indian road traffic and quantify the same as accurately as possible. To fulfill this need, the following research topics have been identified:

- ✓ Modeling heterogeneous traffic flow to enhance accuracy of qualification of flow characteristics.
- ✓ Modeling pedestrian traffic flow
- ✓ Enhancing the accuracy of quantification of heterogeneous traffic flow
- ✓ Development of appropriate measure to quantify heterogeneous traffic density
- ✓ Development of guidelines for level of service of different types of Indian roads
- ✓ Quantifying level of service of traffic signals
- ✓ Quantifying the influence of road-side friction on traffic flow
- ✓ PCU value of vehicles under highly heterogeneous traffic conditions
- ✓ Capacity guidelines for different types of Indian roads
- ✓ Effect of variation in road geometry on traffic flow
- ✓ Development of appropriate sensors for traffic data collection

(ii) Applied Research

The inadequacy in terms of both quantity and quality of the major components of the road-transport infrastructure, namely, the way, the vehicle, the terminal and the control, in India has created chaotic conditions in road transport. This situation, obviously, provides enormous opportunities for doing applied research in the areas of Traffic Operations Management and Control. Finding methodologies and techniques to facilitate safe, fast and economic movement of people and goods under the suboptimal conditions prevailing on Indian roads is a great challenge and an opportunity to the researchers interested on the subject matter. In the light of the said points, the following research topics have been identified for applied research to meet the immediate needs:

- ✓ Traffic segregation on urban roads to enhance quality of traffic flow
- ✓ Development of bus priority systems
- ✓ Enhancing access to public transit modes
- ✓ Pedestrian malls in CBD areas as traffic regulation measure
- ✓ Modal coordination for patronizing public transport
- ✓ Traffic management with the objective of reducing air pollution
- ✓ Congestion pricing
- ✓ Travel demand management as a tool to reduce congestion
- ✓ Introducing 'Stop Control' at uncontrolled intersections
- ✓ Enhancing the use of Foot and Bicycle modes
- ✓ Effect of intersection geometry on capacity of signalized intersections
- ✓ Introducing hierarchy system in urban roads
- ✓ Parking management (on-street and off-street)
- ✓ Safety of vulnerable road users
- ✓ Development of methodology to enhance the level of accuracy of accident data
- ✓ Traffic calming at vulnerable locations

2. Capacity building, Training and Education

In India, there is shortage of qualified human resource to operate, manage and control the road traffic on scientific basis and this is one of the reasons for the difficult traffic situation on Indian roads. Also, the road accident rate is increasing at an alarming rate resulting in enormous loss (due to property damage, injuries and fatalities) to the economy of the country despite sustained efforts through engineering, enforcement and education measures to reduce the accident rate. Hence there is an urgent need to analyze the situation in a systematic way and propose effective implementable solutions to mitigate the adverse effects. In the light of the aforementioned points, the following measures have been proposed to facilitate capacity building, training and education. It is recommended that TRG may play a major role in implementing the measures.

- ✓ Creating of Traffic Engineering Cells formed by employing qualified professionals in all the major cities (say population more than a million) of the country as well as at the state levels to facilitate analysis of traffic engineering problems on scientific basis and provide appropriate solutions
- ✓ Passing of a certificate course on basic road traffic rules and regulations (the curriculum and syllabus for the course being formulated involving experts) to be made as a prerequisite to appear for driving-skill test forgetting driving licenses. Since such a measure involves enormous resources, the course may be offered on distance education mode and reputed schools and other educational institutions may conduct the examinations on a regular basis at frequent intervals.

.

- ✓ Augmenting and enhancing the efficiency of driver licensing and vehicle licensing systems under Public-Private Partnership (PPP) mode. Since the task is huge involving a large number of skilled persons and other infrastructural facilities, private participation with due accountability may be encouraged in the project.
- ✓ TRG may offer well structured short courses on 'Traffic operations and control' on a regular basis as a continuing education programme.

3. Collaborative Projects:

The Transportation Research Group of India (TRG), as a professional body, cannot exist in isolation and sustain itself. Hence, there is a need to collaborate with other similar professional bodies within the country as well as in other countries, government departments, educational institutions, industry, etc. Since TRG is very young, it is proposed, at this stage, that TRG should strive to enlarge its membership spectrum covering individuals and institutions within the country and in other parts of the world, which will pave the way for collaborative projects subsequently.

Chapter-6

Report of Workshop-D: Pavement Engineering and Management

Chairperson: Rajib Basu Mallick
Rapporteur: Animesh Das

Description:

The items (related to pavement engineering and management) that were presented in the conference were mentioned briefly, and the participants in the workshop were invited to speak on these items, specifically with respect to the following three areas:

a. Research issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.
b. Capacity building/training/education issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.
c. Collaborative opportunities on research/capacity building issues (as identified above) with industry, field/government organizations, and other countries.

Initially, there was some confusion regarding the objective and goal of the workshop. The general consensus was that the objective of the workshop should be mentioned well in advance such that the participants can be well-prepared. Also, many of the participants (most of them from foreign countries) were unaware of the research-funding policies that exist in India and some time was spent in explaining to them how things work here.

One important question that came up was: what is it that the researchers want to achieve in the area of pavement engineering? Overall, the answer was to move towards performance related specifications for constructing good performing and long lasting pavements. To develop such specifications, the need for research, particularly with Indian conditions/Indian road/test sections, was acknowledged by all.

Next, the issue of availability of data related to climatic and traffic conditions were discussed. Dr. Das and Dr. Devesh Tiwari gave good overviews on this topic and identified the gaps that exist.The lack of funding from state highway agencies was discussed. Unlike the US, state PWDs do not fund any research in India. However, Dr. D. T. Thube, Director, National Rural Roads Development Agency, assured the researchers that there is funding available for relevant projects.

The items that were brought up during the following discussions are listed in the following paragraphs.

a. Research issues/topics that need to be addressed in immediate future i.e. next 2-3 years: Several issues were raised, as follows.

- ✓ Design of un-surfaced granular pavements for low volume traffic.
- ✓ Recycled materials in pavement construction and soil stabilization.
- ✓ Development of bituminous mix design protocol for Indian conditions.
- ✓ Development of a pavement maintenance management tool which can be readily adopted by engineers and planners.
- ✓ Development of alternative rehabilitation approaches for pavements under Indian conditions.

b. Capacity building/training/education issues/topics that needs to be addressed in immediate future i.e. next 2-3 years.

- ✓ Collection of road performance data using modern equipment and storage in GIS form.
- ✓ Development synthesis documents on various topics and using these for development of codes/ guidelines.
- ✓ Training programs (may even be webinar) for field engineers by TRG, at least once a year. Three instant topics can be identified as, safety, maintenance and recycling.
- ✓ The PWD/ CPWD should approach local Universities to do research to solve the immediate field problems faced by them. To initiate such a process, one day brain storming session can be arranged between the field engineers, industry, government officials and academicians. The research problems thus identified can be put up on the TRG website, inviting various Universities to take up as student's thesis problem.
- ✓ TRG should form some sub committees with persons having expertise in relevant areas.

c. Collaborative opportunities on research/capacity building issues (as identified above) with industry, field/government organizations, and other countries.

- ✓ Systematic preservation of road performance data and open access to all (like LTPP data). Researchers can use this data for their research to develop better understanding on pavement performance.
- ✓ By becoming individual member to TRB committees. ASCE student membership is free. NNCHRP research projects are open to all.

Chapter-7

Report of Workshop-E: Sustainable Transport Planning and Policy

Chairperson: M.V.L.R. Anjaneyulu
Rapporteur: E. Madhu

The workshop started with a brief introduction to Transport Planning and its role in achieving sustainable urban mobility by the chairman. Chairman presented the workshop guidelines before the participants and requested the participants to give their fair view on each of the topics including the problems faced by them in participating in related projects.

Participants expressed their opinion and deliberated on various related issues.

Dr. Murthy expressed that sustainable urban development, such as providing walkways, bicycle paths, should be encouraged; bus transport system, the only mode affordable to everyone, should be made accessible to every part of the urban areas; sustainable urban development is only possible with sustainable urban mobility plans.

Dr. Beena C Balakrishan, Consultant is of the opinion that master plan has to be critically evaluated from the sustainable development point of view; urban development policies should encourage or result in short distance trips so that dependence on automobiles can be reduced; and bus transportation system made more popular and user friendly by providing bus rapid transit, increasing the frequency of services, operating low floor buses, providing different types of services to cater to the needs of all categories of people.

Dr. Gangopadhyay expressed that the past transport planning policies were biased to car traffic and these resulted in the presented problems of unmanageable size; planning policies should be oriented towards public transport, pedestrians and nonmotorised transport; integration of different public transport modes; transport should be not only green but also economically viable and socially acceptable; all modes have their role to play and hence all modes should be considered while preparing transport plans; facilities for physically challenged should be provided.

Ms. Shreya opined that mixed land use will result in short distance travel and hence dependence on automobiles.

Transportation plays a substantial role in the modern world; it provides tremendous benefits to society, but it also imposes significant economic, social and environmental costs. Sustainable transport planning requires integrating environmental, social, and economic factors in order to develop optimal solutions to our many pressing issues, especially carbon emissions and climate change.

Sustainable transportation aims at promoting better and healthier ways of meeting individual and community needs while reducing the social and environmental impacts of current mobility practices. It attempts to achieve these through reducing resource inputs, waste outputs and minimizing transportation's often deleterious effects on the public realm. It is about adapting the techniques and technologies most appropriate to the type of service needed. It is about making important everyday destinations, such as shopping, employment, basic services and recreation, closer and more accessible,

rather than increasing mobility in order to overcome inaccessibility. It is about healthier ways of getting around communities -ways that improve the individual's health through more activity; the few minutes' walk to the transit stop or station or the pleasant bicycle trip to the store. It attempts to find ways of improving the health of communities through lowering traffic and its accompanying pollution and safety hazards.

Technical and technological factors, such as improved fuel efficiency, reduced motor emissions or systems that control traffic flow on major highways, are important; but they are not the essence of sustainable transportation. Sustainable transportation involves taking many dimensions of transportation and land-use planning into account simultaneously, as well as public visioning processes aimed at describing the future we desire, and then taking the steps necessary to attain that vision. Sustainable transportation is essentially a societal, rather than strictly technical, process that depends upon planning, policy, economics and citizen involvement.

Sustainable transportation aims at lowering financial costs to society and to the individual through lessening dependence upon automobiles as the main mode of individual mobility. At present, it appears that we are at the early stages of a significant change, or 'paradigm shift", in the ways in which transportation is conceived, planned, financed and implemented. The shift is away from automobile-oriented planning that emphasizes system growth - or 'bigger is better' - towards emphasizing appropriate modes, infrastructure and technologies that may tend towards "smaller is beautiful' or 'closer is beautiful", and slowing our increasingly hyper-mobile societies.

- ✓ Sustainable transportation
- ✓ Emphasizes accessibility and quality (closer, better)
- ✓ Emphasizes plurality (multi-modality)
- ✓ Emphasizes interconnections (inter-modality)
- ✓ Seeks to interrupt and reverse harmful trends
- ✓ Works backwards from a preferred vision to planning and provision (deliberate and decide)
- ✓ Manages transportation or mobility demand
- ✓ Incorporates full costs within planning and provision
- ✓ Emphasizes integrated planning combining transportation with other relevant areas.

The following are the actions to be taken up for making our transport system sustainable:

1. Identify the principles for sustainable transportation planning. Some of the principles are given below:

- ✓ Integrated transportation & land use planning
- ✓ Protect environmental health
- ✓ Incorporate social objectives
- ✓ Support economic development
- ✓ Take a strategic approach
- ✓ Consider all modes
- ✓ Manage transportation demand
- ✓ Manage transportation supply
- ✓ Provide implementation guidance
- ✓ Provide financial guidance
- ✓ Measure performance
- ✓ Create a living plan with public involvement

2. Formulate and suggest strategies for each principle, to help develop more sustainable plans. Not every strategy is appropriate for every plan or community, and each offers distinct benefits and challenges.

For example the strategies for integrated transportation & land use planning can be:

- ✓ Conduct transportation planning and land use planning concurrently, to accommodate the effects of land use on transportation demand and supply, as well as the effects of transportation systems on the demand for, and patterns of, land development.
- ✓ Use transportation plan policies to encourage supportive land use form and design (e.g. compact, mixed-use, pedestrian-friendly).
- ✓ Highlight the importance of supportive land use policies to the achievement of transportation objectives
- ✓ Similarly, the strategies for the principle - Consider all modes can be as follows:
- ✓ Identify strategies to increase walking, cycling, transit, ridesharing and teleworking.
- ✓ Recognize synergies and tensions among different modes (e.g. seasonal shifts between cycling and transit, competition between transit and ridesharing), and their implications for transportation objectives.
- ✓ Identify strategies to make transit operations more sustainable.
- ✓ Identify strategies to make motor vehicle use more sustainable (e.g. incident management, signal optimization, traveller information).
- ✓ Identify strategies to achieve transportation goals through parking management.
- ✓ Identify strategies to make the intersection points between urban and intercity transportation systems more effective and efficient (e.g. transit service to airports, rail-road grade separations).
- ✓ Identify strategies to make freight activity more sustainable (e.g. modal shift from road to rail, efficient routing practices).

3. Develop guidelines for preparation of sustainable transportation plans at urban, regional and national level
4. Identify the data requirements for preparation of sustainable transport plan and develop the formats for collection of data needed.
5. Develop a repository of data, other than local data, required for preparation of sustainable transport plans or provide information about the where the data will be available.
6. Develop manuals on trip generation, trip distribution, mode choice, route choice and land use transport planning
7. Identify the economic, social and environmental impacts of transportation, indicators to express these impacts, methods and data needs to estimate the impacts.
8. Develop operational models for integrated land use transport planning. The models can be excel or any other software based and should provide easy to follow graphical interface. The model should enable user agency to feed the data collected from field and analyse.
9. Promote alternate modes of transport such inland water transport wherever possible.
10. Capacity building at local level so that transportation plans can be prepared locally or plans prepared can be critically evaluated before implementation.
11. Develop tools for educating local policy makers
12. Develop tools and methodologies for system wide evaluation of major infrastructure projects.
13. Academic and research organizations should take the works, the outputs of which will be useful to the society, but not for purpose of publications alone. Research should be oriented to solve the local problems.
14. Organise workshops/seminars/conferences for knowledge and expertise sharing.
15. Create a pool of knowledge, expertise and experience for solving the transport problems and achieving sustainable transport.

16. Transportation planning requires a wide variety of data, some of which are collected on a regular basis by various agencies. By allowing sharing of data, data collection efforts for transportation planning can be minimized, better models can be developed. This calls for development of standards for interoperability of data.

Chapter-8

Report of Workshop-F: Transport Economics, Finance and Evaluation

Chairperson: M. Parida
Rapporteur: A. K. Maurya

Discussion took place for different modes of transportation such as aviation, rail based transport, and road transport etc. Salient features of discussion on each aspect are given as follows:

1. Airport

- ✓ Codes and specifications for secondary airport development not available.
- ✓ Lower geometric norms without compromising air safety can bring in economy in aviation sector.
- ✓ Economic feasibility of non-metro airport need to be given attention.
- ✓ Karnataka Govt. intends to provide air service for all district headquarters. Traffic feasibility need to ascertained for these corridors.
- ✓ Following topics were suggested for further study:
  - Economic evaluation of smaller airports development.
  - Low cost geometrics
  - Traffic feasibility analysis for new sectors for air services
  - Formulation of codes for non-metro airports with respect to airside/landside
  - Integration of aviation sector within a multimodal transport framework.

2. Railways

Dr. Julian is currently involved in a High Speed Rail Corridor Development Project in India. He presented an overview of High Speed Rail (HSR) development in Spain. He discussed about different financial models of HSR development. Members discussed various aspects of HSR development and converged on the following topics:

- ✓ There is a need to compare different financial models of HSR development.
- ✓ Post implementation study need to be carried out to compare Estimated Cost and Demand vs. Real Cost and Demand.
- ✓ Financing models for creation of basic infrastructure/operational arrangement.

3. Transport Economics

- ✓ There is a need to estimate all External Costs and Benefits accurately including accident costs.
- ✓ There is a need to compare PPP/ROT projects of transportation development.
- ✓ Econometric method of traffic projection need to be fine tuned and make available for professionals.
- ✓ Feasibility of Area Licencing System/Congestion Pricing in Indian need to be explored. However, members were sceptical about viability of these schemes.
- ✓ Differential parking charges.
- ✓ Annual taxation to dissuade use of personalized vehicles.
- ✓ Development of Zonal Fares for megacities.
- ✓ City level funds for funding urban transport activities better.

4. RECOMMENDATIONS OF WORKSHOP

F1. Research Issues/Topics that need to be addressed in immediate future (i.e. next 2-3 years).

- ✓ Air traffic demand estimation

- ✓ Economic feasibility of airport development for medium sized cities
- ✓ Formulation of codes of practice for non metro airports w.r.t. air sides/land sides
- ✓ Multi-modal transportation strategy at regional level
- ✓ Risk sharing for transportation project
- ✓ Pricing of high speed rail facility
- ✓ Reliable estimation of external cost and benefits
- ✓ Peak hour pricing for toll facility
- ✓ Differential pricing for parking
- ✓ Econometric method of traffic projection
- ✓ Pricing for public transportation system in metro cities

F2. Capacity Building/Training/Education that needs to be addressed in immediate future (i.e. next 2-3 years)

Training course on

- ✓ Financing models of Rail facility
- ✓ High Speed regional rail system
- ✓ E course development on transportation economics

Elective courses:

- ✓ Transportation economics
- ✓ Transportation infrastructure

F3. Collaborative Opportunities on Research/Capacity Building

- ✓ Collaboration with Foundation Caminos De Hierro
  - Development of high speed regional railways
  - Comparison between estimated demand and cost Vs actual demand and cost
  - Financing models for high speed rail transportation
  - Regional impact assessment of high speed rail development

- ✓ Julian Sastre Gonzalez (julians@funacioncdh.com)

Chapter-9

Report of Workshop-G: Travel Behaviour and Demand Analysis

Chairperson: T. V. Ramanayya
Rapporteur: Mohan Rao

The panel members deliberated on various aspects Travel Demand Modelling and the need for Travel Demand Management. The main focus is the consumer behaviour approach is more appropriate in demand estimation. Accordingly a brief note is presented below on various components of this approach. The panel members also deliberated on Research Areas, Training needs and Collaborative Activities that need to be pursued by TRG for the general benefit of Field Engineers and Academic and Research Personal in this area.

One of the major problems in the development of transportation planning programmes is the accurate estimation of travel demand. Travel demand constitutes the total number of trips undertaken for various purposes to different destinations together with the choice of mode, choice of time of the day and the choice of the route etc. Several efforts have been made to develop mathematical models in order to predict the travel demand to help making process. The problem is considered from the consumer's point of view and the various methods are discussed.

The theory of travel demand can best be approached by studying the consumer choice behaviour in relation to level of utility is usually associated with the purchase of $Q_1, Q_2 \ldots Q_n$ quantity of goods priced $P_1, P_2 \ldots P_n$.

However, every consumer would like to maximise the utility thus delivered by procuring such a combination and quantity of goods subject of course to his budgetary constraint. That is he would like to maximise $U (Q_1, Q_2 \ldots Q_n)$ subject to $\Sigma^n_{i=1} P_i Q_i \leq Y$; where P i is the price of the ith good and Y the total budget or income of the consumer. Thus the demand function for travel emerges as $Q_n = D_n(P,S,A)$. Where P = Pricing; S = Socio Economic; A = Activity System; Q_n = Demand for travel for the purpose n. In the terminology that is commonly employed in traffic demand formulation could be rewritten as follows:

$T^n_{ijkr} = D^n_{ijkr} (L, S, A)$; Where L = Level of Service; S= Socio Economic; A= Activity System
T^n_{ijkr} = The total number of trips for the purpose 'n' between origin 'i'to destination 'j' by mode 'k' route 'r';
$D^n_{ijkr}(.)$= Demand function.

Two important questions need to be answered here before the demand function is defined.

Firstly it is desirable to know what forms of the function $D^n_{ijkr}(.)$ are appropriate for appropriate for various types of travel demand forecasting. Secondly it is necessary to define the variables in each of the sets of independent variables in the equation, generating numerous travel demand estimation procedures including the traditional UTP system.

A. SEQUENTIAL AGGREGATE MODELS

The traditional UTP system is the main example of this class. The basic philosophy is to develop the total travel demand in a series of independent steps as follows:

1. Trip Generation :

$T^n_i = \Sigma I \; a^n I \; s^i I + k^n I$

$T^n j = \Sigma I \; b^n 1 \; A^j 1 + k^n 2$

Here T_i^n = Number of trips generated from origin 'i'.
T^n_j = Number of trips attracted to zone 'j', n = Trip purpose, a I, b I , k I = Empirical parameters; S and A are Socio-economic and activity system variables.

2. Trip Distribution:

$T^n_{ij} = D_n(T^n I \; , T^n j \; , \; L_{ij})$ Where T^n_{ij}=Trips made between zone 'i' and zone 'j' for the purpose 'n'

3. Model Split:

The trip interchanges between any two zones is further split mode wise by the following sub model $T^n_{ijk} = D_{nm}(T^n_{ijm}, L_{ijm}, R_{ij})$ Where T^n_{ijk}= Trips for purpose 'n' from zone 'i' to zone 'j' by mode 'k' ; T^n_{ijm}=Results of the trip distribution stage. L_{ijm}=Level of service variables for all modes 'm' between 'i' and 'j' Common forms for $D_n(.)$ are the regression equations or table look ups.

4. Route Assignment:

$T^n_{ijkr} = D_{nmr}(T^n_{ijm}, L_{ijm}, R_{ij})$ where T^n_{ijkr}=Number of trips made between zone 'i' to zone 'j' by mode 'k' via route 'r'; T^n_{ijm}=Results of the mode split stage. L_{ijm}= Level of service variables; R_{ij}= Route factors. Thus it is clear that total travel demand T^n_{ijkr} is established though a series of stage $T^n i$, $T^n j$ T^n_{ij}, T^n_{ijk}, T^n_{ijkr}, the results of one stage being the input to the next stage, but not vice – versa .

FACTORS AFFECTING TRIP GENERATION

TRIP PRODUCTIONS: A large number of explanatory variables have been employed in previous studies to relate trip productions in urban area: The most important among them are:

1.	Land use factors	Intensity of residential activity Total population Persons per acre. Number of dwelling units etc.
2.	Household factors	Vehicle ownership. Income. Family size. Family structure.
3.	Socio economic factors	Rateable value of property. Age structure of population Occupational structure of workers.
4.	Urbanisation factors	Degree of urbanisation. Distance from CBD
5.	Accessibility factors	The quality of transportation. Accessibility of the zone etc.

TRIP ATTRACTIONS:

The factors employed in trip attractions models:

1.	Land use factors	Commercial land use Industrial land use Employment centres Manufacturing Retail and wholesale trade Recreational centres etc.
2.	Activity factors	Intensity of each of the activity as above.
3.	Accessibility and location factors	Intensity of each of the activity as above.

A. CATEGORY ANALYSIS:

Category analysis is a technique based on the household and its characteristics without entering into the statistical problems of linear least squares.

Wootten and Pick have proposed a scheme for developing the category matrix based on their studies in England. The household characteristics are isolated into three groups, which are of real importance in affecting the amount of travel.

I. Household income; II Car ownership; III Composition of the household

B. PERSON TRIP MODELS:

Chari has proposed a trip production model based on person trips and characteristics rather than household or zonal variables. Models based on individual properties are observed to be capable of removing most of the draw backs of zonal models.

$T^{n}_{i}(k) = a0 \Sigma^{p}_{i} a_1 nx_1 \Sigma^{s}_{q=1} \Sigma^{c}_{j=1} aj^{n}_{q} z_{jq}$

Where $T^{n}_{i}(k)$= Estimation of number of trips per person 'i' per day belonging to group 'k' and for purpose 'n'

a_0, a_1 , aj_q = Regression coefficnts; x_1,z_{jq}=Continuous and dummy independent variables, S,C= Number of continuous variables , number of dummy variables , and number of classes within a dummy set respectively.

Application of GIS in Travel Demand Estimation:

Geographical Information System (GIS) is a latest tool with many applications in the transportation planning and management. This tool facilitates the spatial data (study area maps) and attribute data (characteristics of traffic, demographic details etc.) in integrated manner. Global Positing System (GPS) is a hardware which can be used for data collection about location of the facility, to trace the traveller behaviour and demand analysis. The data collected by GPS and integrated in GIS environment, facilitates the adaptation of Intelligent Transportation System (ITS) in any city/area. The application of GIS/GPS in the travel behaviour and demand analysis is accomplished through

- ✓ collection of travel information data such as travel time, speed, delay of the vehicles
- ✓ advanced traveller information system about the bus schedule at the bus stops and to monitor the behaviour of the travellers

- ✓ to validate the home interviews' responses by tracing the Origin, destination details in GIS map, then analyse the choices of modes which are available on the routes selected by the users.
- ✓ for finding shortest path to various facilities/services as well as relative accessibility of different locations in a city.
- ✓ Thus the primary role substantial role of GIS in facilitating the integration of territory data, road and transit network data (vector and grid) with several transport modelling analysis techniques (trip chain analysis, path calculation and trip assignment) may lead to a better understanding of the complex equilibrium of urban transport and may suggest new means of managing congestion in urban areas.

A. RESEARCH ISSUES:

Most of the field engineers are not equipped to develop demand models and calibrate them. If a readymade Trip Rates are developed for different city sizes it will be very useful to them to estimate the demand and field verification with some field data. As such TRG could act as clearing house in trying to obtain the data bases from various sources and allow others to use it.

Database development on:

- ➢ Trip generation characteristics of different land uses, intensity of land uses across different categories (city sizes) in India.
- ➢ Trip rates purpose wise for different sizes of cities
- ➢ Trip rates for income group wise of households across different sizes of city.
- ➢ Three way trip rates as illustrated below

Income Group I						**Income Group II**						**Income Group III**					
P1		**P2**		**...**		**P1**		**P2**		**...**		**P1**		**P2**		**...**	
M1	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**	**M1**	**M2..**
P1,P2 … are Purpose 1,2,…																	
M1,M2 are modes 1,2 ..																	

B. CAPACITY BUILDING:

Transport demand estimation and demand management is not fully utilised by field engineers. To help them TRG should involve capacity building through Training Programs and workshops. The major areas identified are:

- ✓ Use of Demand modelling software for field engineers.
- ✓ Period training at different levels of field personal in the use of packages.
- ✓ Proper training to understand what if scenarios of alternate plans of infrastructure development.
- ✓ Use of GIS, IT and other advance tools in demand modelling and demand management

C. COLLABORATIVE OPPURTUNITIES ON RESEARCH:

TRG may develop contacts with leading Research and Academic institutions across the world in the field of Travel Demand Estimation and Demand Management.

- ✓ Developing collaboration in innovation strategies of urban demand management with Institutional/Research Organisation through joint projects
- ✓ Organising a yearly meet to exchange recent developments in the areas of demand modelling mobility management, organisation appropriate for different sizes of cities.

Transportation Research Group of India
101, First Floor, Infantry Court
130, Infantry Road, Bangalore - 560001
Tel: +91 80 40745800
Fax: +91 80 40745899
E-mail: secretariat@trgindia.org
Web: www.trgindia.org