



Contents lists available at ScienceDirect

## Case Studies on Transport Policy

journal homepage: [www.elsevier.com/locate/cstp](http://www.elsevier.com/locate/cstp)



# US-India bilateral collaboration to enhance transportation—A decade of experience

A.M. Shirole<sup>a</sup>, PE, FIE, President, CEO

<sup>a</sup> S & A Shirole<sup>a</sup>, Inc., 4527 Robin Circle N, Robbinsdale, Minneapolis, MN 55422, USA

### ARTICLE INFO

#### Article history:

Received 29 February 2016  
Received in revised form 12 September 2016  
Accepted 24 September 2016  
Available online xxx

#### Keywords:

Atpio  
US-India  
Bilateral collaboration  
Transportation  
Research  
Knowledge and technology transfer

### ABSTRACT

Established in 2004 as a non-profit organization, the Association of Transportation Professionals of Indian Origin (ATPIO) is focused on its strategic objective of facilitating bilateral collaborative activities and partnerships between diverse groups of transportation professionals in US and India. These activities include research, as well as knowledge and technology transfer. Over the past decade ATPIO has organized free webinars, technical presentations at its Annual Meetings, co-sponsored conferences and workshops; as well as collaborated with academics, research organizations and governmental agencies both in US and in India.

This paper summarizes these activities and discusses collaborative research between academics from US and India. The paper also discusses ATPIO's current and proposed future initiatives aimed at bringing public and private sector counterparts from US and India together to facilitate current research based knowledge and technology transfer for betterment of transportation in the 21st Century. The paper concludes with a brief summary of ATPIO's accomplishments and identifies challenges it has encountered in the pursuit of its strategic objective.

© 2016 World Conference on Transport Research Society. Published by Elsevier Ltd. All rights reserved.

## 1. Introduction

The Association of Transportation Professionals of Indian Origin (ATPIO) was established at the 2004 Annual Meeting of the Transportation Research Board in Washington, DC. Dr. Kumares Sinha, Distinguished Professor at Purdue University and Arun Shirole<sup>a</sup>, Executive Director Emeritus of the National Steel Bridge Alliance, then a semi-autonomous division of American Institute of Steel Construction, served as ATPIO's founding President and Vice President, respectively. In subsequent years, Professors Dr. Lalita Sen, Dr. Chandra Bhat, Dr. Ram Pendyala, Dr. Shashi Nambisan, Dr. Vijaya Gopu, Dr. Anuj Sharma, as well as Arun Shirole<sup>a</sup>, Hardik Shah and Salil Gokhale have served as ATPIO President or Vice President. Under their leadership, ATPIO's strategic objective has consistently been focused on facilitating bilateral collaborative activities and partnerships between diverse groups of transportation professionals in US and India. In pursuit of this objective ATPIO has organized its annual meetings that include invited technical presentations, free webinars, workshops and conferences in collaboration with academics, research organizations and governmental agencies both in US and in India. As the ATPIO activities

have increased, so has its membership. Current ATPIO members include well-known academics, senior level public and private sector transportation professionals of Indian origin, as well as students pursuing graduate degrees in transportation related fields in both countries. This paper documents decade long activities of ATPIO and is organized as the followings: (2) ATPIO Annual Meetings; (3) ATPIO Webinars; (4) US-India Transportation Research Collaboration; (5) Selected Examples of Published Bilateral Research; (6) ATPIO's Other Collaborative Activities; (7) Current Initiatives; (8) ATPIO Accomplishments and Challenges; and (8) Conclusion.

## 2. ATPIO annual meetings

Since a large contingent of transportation professionals from India comes to Washington, DC to attend annual meeting of the Transportation Research Board (TRB), ATPIO holds its annual meetings on Sundays before the TRB annual meeting. TRB has been graciously facilitating ATPIO annual meetings at the same venue. ATPIO annual meetings provide a stage for transportation professionals from both US and India to network together, listen to technical presentations, partake in policy level discussions, showcase emerging technologies, brain-storm, garner help for near future ventures and promote transportation themed

E-mail address: [arunshirole@gmail.com](mailto:arunshirole@gmail.com) (A.M. Shirole<sup>a</sup>).

<http://dx.doi.org/10.1016/j.cstp.2016.09.004>

2213-624X/© 2016 World Conference on Transport Research Society. Published by Elsevier Ltd. All rights reserved.

**Table 1**  
Presentations at ATPIO Annual Meetings at Washington D.C. (2011–2013).

Month, Year & # of attendees	Presentations
Jan 2011 70 attended	<ol style="list-style-type: none"> <li>1. "Economic Development in India: Opportunities and Challenges", Mr. V.S. Senthil, IAS, Honorable Minister (Economic), Embassy of India, Washington, D.C.</li> <li>2. 2. "Enhancing Indo-US Partnership in Science and Technology", Michael Cheetham, Executive Director, Indo-US Science and Technology Forum and India Science and Technology Partnership.</li> <li>3. "Elsevier's Interest and Initiatives in Indian Transportation Research", Chris Pringle, Executive Publisher – Geography &amp; Transport, Elsevier, United Kingdom.</li> </ol>
Jan 2012 72 attended	<ol style="list-style-type: none"> <li>1. "Indo-US Collaboration between UNL and IIT-M in the Area of ITS", Dr. Larry Rilett, Professor of Transportation Engineering, and Keith W. Klassmeyer Chair in Engineering and Technology, University of Nebraska Lincoln.</li> <li>2. "Activities of Overseas Transportation Professionals from China and India: Some Observations", Dr. Kumares Sinha, Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering, Purdue University.</li> <li>3. "Role of CTGR in Promoting Transportation Research in India", Dr. S. Velmurugan, Scientist, Central Road Research Institute, India.</li> <li>4. "World Conference on Transport Research in India", Dr. S.L. Dhingra, Institute Chair Professor and Dr. K.V. Krishna Rao; Head of the Civil Engineering Department, Indian Institute of Technology (IIT) Bombay, India.</li> <li>5. "TRANSED 2012 India", Mr. Arvind Singh, Honorable Minister of Transport, Capital Region, Delhi and Ms Abha Negi, Sr. General Manager, Jindal SAW Ltd.</li> </ol>
Jan 2013 68 attended	<ol style="list-style-type: none"> <li>1. "India- ITS Policy Issues", Dr. CSRK Prasad, Professor and Head, Transportation Division, Department of Civil Engineering, National Institute of Technology (NIT) Warangal, India.</li> <li>2. 2. "Updates on Transportation Planning and Implementation Methodologies for Developing Countries (TPMDC) Silver Jubilee", Dr. Gopal Patil, Assistant Professor, Indian Institute of Technology (IIT) Bombay, India.</li> <li>3. "2nd Conference of Transportation Research Group of India", Professor Partha Chakraborty, Indian Institute of Technology (IIT) Kanpur, India.</li> </ol>

**Table 2**  
Presentations at ATPIO Annual Meetings at Washington D.C. (2014–2016).

Month, Year & # of attendees	Presentations
Jan 2014 58 attended	<ol style="list-style-type: none"> <li>1. "Activities and Future Plans of the Transportation Research Group (TRG) of India", Dr. Ashish Verma, Assistant Professor, Indian Institute of Science (IISc), Bengaluru, India.</li> <li>2. "Updates on upcoming 2014 conference on Transportation Planning and Implementation Methodologies for Developing Countries (TPMDC)", Dr. Gopal Patil, Assistant Professor, Indian Institute of Technology (IIT) Bombay, India.</li> <li>3. "Transportation Research at IIT Roorkee", Professor Satish Chandra, Indian Institute of Technology (IIT) Roorkee, India."</li> </ol>
Jan 2015 62 attended	<ol style="list-style-type: none"> <li>1. "Remarks on ATPIO Collaborative Activities", Dr. Kumares Sinha, Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering, Purdue University, USA.</li> <li>2. "Updates on recently completed 2014 conference on Transportation Planning and Implementation Methodologies for Developing Countries (TPMDC)" – Dr. Gopal Patil, Assistant Professor, Indian Institute of Technology (IIT) Bombay, India.</li> <li>3. "Activities and Future Plans of the Transportation Research Group (TRG) of India" – Dr. Ashish Verma, Assistant Professor, Indian Institute of Science (IISc), Bangalore, India.</li> <li>4. "Transportation Engineering Activities at IIT Kharagpur", Dr. Sudeshna Mitra, Indian Institute of Technology (IIT) Kharagpur, India.</li> <li>5. "ATPIO initiated Student Support Program" – Dr. Anuj Sharma, Dr. Sabya Mishra, and Dr. Sushant Sharma, ATPIO Board Officers.</li> </ol>
Jan 2016 65 attended	<ol style="list-style-type: none"> <li>1. 1. "World Conference on Transport Research Society (WCTR) – 2019" – Dr. Vedagiri Perumal, Associate Professor, Indian Institute of Technology (IIT) Bombay, India.</li> <li>2. 2. "TRG and 2015 CTGR Report" – Dr. Tom Mathew, Professor, Indian Institute of Technology (IIT) Bombay, India and Dr. Abdul Pinjari, Associate Professor, University of South Florida.</li> <li>3. "Accessibility and Safety Workshop in India" – Dr. Lalita Sen, Professor Texas Southern University; and Ms. Abha Negi, Chairperson, Global Forum for Empowerment.</li> </ol>

initiatives. Tables 1 and 2 below illustrate the types of technical presentations made at some of the past ATPIO Annual Meetings.

It is worth noting that networking at ATPIO annual meetings has resulted in several joint publications (select few discussed in Section 4 below) involving academics from US and India. One example of the beneficial impact of ATPIO enabled networking is the exchange of research methodology, utilization of available technologies and testing of ideas under both homogenous and heterogeneous settings done in the areas of traffic operations (Anusha et al., 2015; Ramesh et al., 2012; Sharma et al., 2009; Thomas et al., 2013; Vanajakshi et al., 2010). Section 4 also illustrates similar benefits of ATPIO enabled exchanges in more detail. Another not so obvious benefit is that undergraduate and graduate students attending ATPIO annual meeting get a unique opportunity of being exposed to a global view of the field of

transportation. This indeed challenges them to think beyond the artificial constraints levied by national boundaries.

### 3. ATPIO webinars

ATPIO understands that most research in the field of transportation can be considered as applied research. Applied research inherently implies that it needs to include transfer of resulting knowledge and technology for implementation. Therefore, over the past decade ATPIO has held free webinars on topics like Nanotechnology, Transportation Asset Management, Congestion Management, Management of Complex Projects, Performance Specifications, Public Private Partnerships and Smart Cities-Transportation Context. These webinar presentations were based on cutting edge research findings like those of recent Second

**Table 3**  
Recent ATPIO Annual Webinars.

ID	Month, Year	Topic	Presenter	Attendees
1	Nov 2013	Transportation Asset Management: Basic Concepts, Current Practice and Emerging Trends	William Robert, Vice President, Spy Pond Partners, LLC	38
2	Mar 2014	Performance Specifications – Delivering Performance and Harnessing the Innovation	Mr. Sidney Scott, P.E., Senior Vice President Hill International	100
3	Oct 2014	Management of Complex Infrastructure Projects	Dr. Jennifer Shane Associate Professor Iowa State University	50
4	Mar 2015	Public Private Partnership in Virginia	Dusty L Holcombe, Deputy Director, Virginia Office of PPP	58
5	Nov 2015	Smart Cities and the Transportation Context	Naveen Lamba, CH2MHLL, Program Manager	40

Strategic Highway Research Program (SHRP2) and National Cooperative Highway Research Program (NCHRP) projects. [Table 3](#) presents a list of recent webinars conducted by ATPIO.

### 3.1. Typical content of ATPIO webinars – illustrative examples

#### 3.1.1. Management of complex projects

There has been a shift in US infrastructure needs, changing from being primarily building new infrastructure to replacing, expanding, or renewing existing infrastructure. As a result the project management issues involved with infrastructure renewal are markedly different than the issues for new construction, furthering the need for a change in project management approaches for the US infrastructure. This is also true for other forms of construction projects in the US, as well as around the world. The very complicated nature of construction projects has been exacerbated by years of under-funded maintenance and replacement. In other words, what would have been a complex process under ideal circumstances has been made even more challenging because of the need for renewal to avert failures. Adding to the challenge is the fact that complexity can evolve from the interaction of many factors, not all of which will manifest themselves on each project. Construction projects cover a wide spectrum of project types, varying in engineering complexity, size, modality, jurisdictional control, financing approach, contract type, and delivery method. Each project calls for a distinct project management style with teams comprised of different resident skill sets required for successful project completion.

This webinar presented five-dimensional project management process developed in the SHRP2 Project #10 to aid successful management and delivery of complex projects. It discussed project management strategies that were investigated and presented tools, techniques, and methods that can be used for effective complex-project management.

#### 3.1.2. Asset management framework for the interstate highway system

This webinar discussed Asset Management Framework for Interstate Highway System that was developed in the NCHRP Project #20-74. It provided a brief overview of basic concepts in transportation asset management, with information on available guidance for establishing an asset management program. The presentation also provided a summary of current practices in asset management in US state departments of transportation, as well as the organizational, system and data requirements to support an asset management approach. It then summarized key themes and emerging trends in transportation asset management

based on improvements in technology and asset management-related requirements in the recently adopted US reauthorization legislation Moving Ahead for Progress in the 21st Century (MAP-21).

#### 3.1.3. Performance specifications for rapid renewal

America's highways are facing growing challenges that are exceeding the ability of current contracting practices to address. These challenges will require a new approach to delivering safe, reliable, efficient transportation to America. Performance specifications offer greater flexibility to apply the latest developments in technology and allow innovation and creativity to enhance the safety, speed and quality of construction.

This webinar discussed performance specifications for rapid renewal highway transportation projects developed for implementation in the SHRP 2 Project #R-07. It presented a framework to implement performance specifications and discussed in detail, what performance specifications are, how they change the traditional contracting equation, what are the benefits from DOTs and industry perspectives. The webinar also presented examples of how performance specifications were developed and implemented.

### 4. US-India transportation research collaboration

ATPIO enabled networking between transportation professionals from US and India has resulted in several joint research activities and subsequent publications of research results (some listed in "[Khasnabis et al. \(2009\)](#)"). This bilateral research collaboration has proved to be very rewarding and mutually beneficial for researchers. Some of the activities that have been ignited by ATPIO annual meeting sessions and pursued at different levels are listed below.

- a Exchange of ideas: ATPIO annual meeting provides a platform for likeminded transportation professionals to interact and discuss ideas for possible collaborative opportunities. Several of these ideas have culminated in different deliverables, some of which are described below.
- b Seminars and conference sessions: ATPIO has organized several sessions at Transportation Research Group's (TRG's) biennial conferences (CTRG) held in India. In these conferences the US researchers have presented their research to Indian audience. These conferences are equivalent of Transportation Research Board (TRB) annual meetings in the US and provide a platform to disseminate research to wider Indian audience. This also

- provides an opportunity for Indian faculty and students to interact with US researchers and get their thoughts on their own research activities.
- c Exchange of test beds: Several Institutes and researchers have forged formal relationship, where they share their test beds for data collection. As an example, Sharma, US-based researcher and Vanjakshi, Indian-researcher share their facilities to provide opportunities for the students to verify their research results using real-world data sets.
  - d Data collection technology: The ideas developed in one country for data collection and instrumented roadways are often exchanged. As an example, Bullock, Sharma and Vanjakshi tested three different modes of collecting blue tooth data in both Indian and US conditions. The quality of data collected was compared to ascertain the cheapest and most reliable platform to collect this travel time data.
  - e Student exchange and internship programs: Purdue University, Iowa State University, University of Nebraska Lincoln, IIT Madras and IIT Chennai have been exchanging graduate students for summer internships. These relationships further lead to synergistic research.
  - f Thesis committees: The relationships developed through above exchanges allow the Indian students to appropriately choose the outside committee member for their dissertation. Most of the Indian Universities require an external committee member to advise on the student dissertations. The interaction opportunities presented above make it easier to find the right expert. Inputs by such experts provide a conduit for knowledge transfer.
  - g Joint Workshops/Joint Centers: Leveraging the above described activities and a record of joint research, experts from multiple universities have successfully won financial support for sponsored workshops and joint research centers. This influx of research money further catalyzes joint research in certain thematic areas.

Other examples of collaboration involve development of joint summer classes, semester long on-line courses, and industry collaboration. One of the surrogate measures for describing a healthy exchange of research relationship is the number of joint publications. Following section contains examples of such publications in some thematic areas.

## 5. Select examples published bilateral research

The following select examples represent collaborative research activities in four thematic areas: (5.1) *Transportation challenges, strategies and trends*; (5.2) *Transportation investment decision making*; (5.3) *Highway safety and incident/disaster management*; and (5.4) *Transit and resource allocation*.

### 5.1. Transportation challenges, strategies and trends

#### 5.1.1. "Socio-economic and transport trends in India and the United States: a preliminary comparative study"

While the rate of increase in travel demand may begin to slow in some developed economies of the world, the rapidly developing economies (such as China and India) are just beginning to experience the rapid increases in travel demand that the developed economies experienced several decades ago. In this paper (Pendyala et al., 2009) highlighted some of the socio-economic and transport trends and conditions in India and the United States to shed light on differences and similarities between the two contexts. The paper also highlighted the trajectory of travel demand in the two contexts with a view to identify potential strategies that a rapidly developing nation such as India can deploy to accommodate growth in a sustainable way.

#### 5.1.2. "Indo-US perspectives and advances in mass transit and travel behavior research"

This book (Pendyala and Verma, 2010) contains selected papers presented at the First Indo-US Symposium on "Advances in Mass Transit and Travel Behavior Research", sponsored by the Indo-US Science and Technology Forum. Invited papers contributed by leading scholars of the field in the United States and India provided in-depth coverage of the latest advances and concepts in travel behavior and mass transit research. The book includes several workshop reports that identify directions for a collaborative Indo-US research agenda in transportation systems analysis.

#### 5.1.3. "Transport in urban India: challenges and strategies"

India's recent healthy GDP growth brought a challenging problem of increasing traffic chaos. Several factors such as growth in urban population, urban sprawl, heavy investment in motor vehicle centric infrastructure, etc., have led to a congestion nightmare in urban cities of India. This study (Sharma, 2015) discussed India's transportation challenges and strategies as a rapidly growing economy and proposes three broad solutions to break the negative spiral of urban traffic situation, namely, i) data driven urban transport management, ii) transport supply management and iii) transportation demand management. Another collaborative study explored traffic control solutions for cities both in India and the United States. Optimal traffic control can help alleviate congestion without the need for increase in traffic capacity. Sharma, from US, and Vanjakshi, from India, have published in areas of control of signalized intersection and role of information. They studied the role of information provided at a traffic signal intersection on Indian drivers (Sharma et al., 2009, 2012). India is an early adopter of phase count down timers and was an ideal test bed for studying these effects. Trade-off between safety and efficiency by providing appropriate information at signalized intersection were explored. The results of the study were published in the paper "Impact of Signal Timing Information on Safety and Efficiency of Signalized Intersections" (Sharma et al., 2012).

### 5.2. Transportation investment decision making

#### 5.2.1. "Emerging roles of the private sector in transportation asset management in India"

In this paper (Khasnabis et al., 2008) authors examined emerging roles of the private sector in transportation infrastructure programs/asset management strategies in India. Roles identified vary from those of a financier to an operator that may result in successful joint public-private ventures, particularly in developing countries. It presented a case study involving such public private partnership, a joint venture, in India, "Mumbai Pune Expressway/National Highway 4 (MPEW/NH4)". It examined fiscal implications, both from the perspective of the public and the private enterprise and concluded that if properly planned, such joint ventures can be mutually beneficial. However, it also concluded that a careful analysis must be conducted before the project is undertaken to ensure that the project continues to yield benefits, after the private sector fulfills its obligations, and that the project does not become a public burden.

#### 5.2.2. "Mechanisms for transportation infrastructure investment in developing countries"

In this paper (Khasnabis et al., 2010) the authors examine different investment mechanisms for transportation infrastructure projects involving the private enterprise in developing countries. Roles identified vary from those of a financier to an operator for successful public-private ventures. A case study involving such a

joint venture in India, the Mumbai-Pune Expressway/National Highway 4 is presented, and fiscal implications of the program, both from the perspective of the public and the private enterprise, are examined. The study concludes that if properly planned, joint ventures can be mutually beneficial. A joint public-private program may enable the public agency to use the resources saved for other public projects. It also provides the private agency an opportunity to invest funds in a profitable enterprise that yields social benefits, (e.g., improving mobility, promoting economic development, etc.). Careful analysis must be conducted before the project is undertaken to assess the financial and economic implications of the project from each participant's viewpoint, with due regard to risks and uncertainties associated with such long-term investments.

### 5.2.3. "Multi entity perspective transportation infrastructure investment decision making"

Investment in new large transportation infrastructure is capital-intensive and irreversible in nature. Private sector participation in infrastructure investment has gained popularity in recent times because of scarcity of resources at the public sector, and because of the ability of the private sector to build, operate, maintain such facilities, and share future uncertainties. In such cases, there are multiple entities each with different objectives in the project. Traditional techniques used to determine feasibility of such projects and do not consider two critical elements. These are the need (1) to identify major entities involved in these projects and their individual objectives, and (2) the importance of analyzing measures of effectiveness of each entity in a multi-objective context. This paper proposed a framework to address these issues along with a set of relaxation policies to reflect the nature and level of participation by the entities. The framework is examined on the proposed multibillion dollar international river crossing connecting the city of Detroit in the U.S. and the city of Windsor in Canada. This methodology provides a decision making process tool for large-scale transportation infrastructure investment consisting of multiple entities (Mishra et al., 2013a).

### 5.2.4. "Incorporating uncertainty and risk in transportation investment decision making"

This paper (Mishra et al., 2015) presented a framework for addressing uncertainty and risk for large-scale transportation investments involving public-private participation. Demand, fare/toll and demand responsive costs are considered in the uncertainty analysis. Uncertainty analysis provides information on economic feasibility of the project. A set of relaxation policies is proposed to form various Ownership, Tenure and Governance (OTG) strategies reflecting the nature and level of participation by the public and private entity. A Monte Carlo Simulation-based Value at Risk is used to quantify risk. Finally, a methodology is proposed to integrate uncertainty and risk. The framework is tested on the proposed multibillion dollar Detroit River International Crossing connecting the cities of Detroit in the USA with Windsor in Canada. The analysis provides insights to probable outcomes for this transportation infrastructure investment under different OTG scenarios.

## 5.3. Highway safety and Incident/Disaster management

### 5.3.1. "Predicting road accidents and prioritizing road safety improvement measures in developing countries using adapted traffic conflict techniques"

Road accidents in developing countries are increasing at an alarming rate. Thus, there is an urgent need to identify and undertake prioritized road safety improvement actions across

the roadway system. In countries like India, where road accidents are not recorded accurately, data on causes of various types of accidents is not readily available hindering policy making in planning and implementing road safety improvement measures. This research (Buddharaju et al., 2013) presents a mathematical model for predicting road accidents and prioritizing road safety improvement measures for Indian road conditions. An adapted version of the Traffic Conflict Techniques is used to assess the main causes of accidents on Indian roads. Analysis and results of the conflict data are used to develop a mathematical model to identify and prioritize road safety measures. Recommendations made in this study can be used by agencies with limited resources to employ proposed low cost techniques suggested in this research to identify high priority road safety issues and prioritize their respective road safety improvement initiatives.

### 5.3.2. "Disaster management for urban commute in a multimodal transportation context"

An interdependent multimodal transportation system, commonly used for commuting in urban areas, such as Baltimore City and Washington DC, may be comprised of various transportation modes with flexible transfer options, such as automobiles, buses, subways, and other types of rail transit. In disasters there are complexities associated with the dynamic nature of the commuting pattern, formation of choke points, and the ensuing chaos, that may affect people's route choice behavior in the face of urgent evacuation. For road traffic many transportation engineers utilize route guidance system as a tool for managing traffic away from the disaster area. With uncertainty in the commuting pattern during a disaster, system efficiency is crucial to minimizing evacuation time. Within a multimodal framework, this paper (Udenta et al., 2014) offered optimal shortest paths to improve system efficiency of pedestrian and transit modes of transportation in different disaster situations specific to urban commute.

### 5.3.3. "Optimization based prioritization model for highway safety countermeasure implementation strategy"

This paper (Maji et al., 2010) presented, an optimization model encompassing multiple time periods based on benefit-cost and cost effectiveness analysis methods. The model optimally allocates countermeasures to candidate location to maximize safety benefits subjected budget, and other policy constraints. The proposed model can suggest implementation plans of safety improvement countermeasures to be implemented at candidate locations in a multi-year analysis period. The paper also reviews the budget sensitivity analysis over a multi-year horizon to assess the optimum future funding needs. A real world case study is used to showcase applicability and efficiency of the proposed optimization model. The proposed optimization model extends the cost-benefit and cost effectiveness analysis methods are in line with the economic appraisal and project prioritization process suggested in the Highway Safety Manual 2010.

## 5.4. Transit and resource allocation

### 5.4.1. "Single stage integer programming model for long term transit fleet resource allocation"

The authors presented a procedure for resource allocation among transit agencies for transit fleet management, specifically focusing on the purchase of new buses and rebuilding of existing buses (Mishra et al., 2010). The model is formulated as a nonlinear optimization problem of maximizing the total weighted average remaining life of the fleet subject to budgetary, policy, and other constraints. The problem is solved using integer programming and its application is demonstrated through a case study using actual

transit fleet data from the Michigan DOT. This proposed model is an extension of earlier research on a two-stage sequential optimization method, solved by linear programming. The proposed model has a single-stage structure designed to attain a better solution by allocating resources among different improvement options and different agencies in a single step. A comparison of the results by the two methods shows that while both approaches are viable, the single-stage approach produces better results. The proposed model, as demonstrated in the case study is considered more robust, compact, efficient and suitable for both short-term and long range planning.

#### 5.4.2. "Optimal resource allocation among transit agencies for fleet management"

Most transit agencies require government support for the replacement of their aging fleet. A procedure for equitable resource allocation among competing transit agencies for the purpose of transit fleet management is presented in this study (Mathew et al., 2010). The proposed procedure is a 3-dimensional model that includes the choice of a fleet improvement program, agencies that may receive them, and the timing of investments.

#### 5.4.3. "Preserving an aging transit fleet: an optimal resource allocation perspective based on service life and constrained budget"

In this study (Mishra et al., 2013b), authors develop an optimization model for allocation of funds among different fleet improvement programs within budget constraints over the planning period. This is achieved by minimizing the net present cost (NPC) of the investment within the constraint of a minimum level of fleet quality expressed as a surrogate of the remaining life of the fleet. Integer programming is used to solve the formulated optimization problem using branch and bound algorithm. The model formulation and application are demonstrated with a real world case study of transit agencies. It is observed that minimizing NPC provides a realistic way to allocate resources between different program options among different transit agencies while maintaining a desired quality level. The proposed model is generalized and can be used as a resource allocation tool for transit fleet management by any transit agency.

#### 5.4.4. "A multi-objective optimization model for transit fleet resource allocation"

State and local transit agencies require government support to preserve their aging transit fleets. With the passage of time, transit fleets get older and require maintenance costs to keep them operational. To provide services at a desired level, transit agencies must maintain a minimum fleet size. Two imperative considerations from the transit planning viewpoint are (a) the remaining life of the total fleet and (b) the cost required to maintain the fleet size. While the former is a quality measure indicating the health of the fleet, the latter is an economic measure requiring minimum expenditure levels. Ideally, agencies would like to maximize the total remaining life of the fleet and minimize the total cost required to maintain the fleet size. In this paper (Mishra et al., 2013c), a multi-objective optimization (MO) model is proposed to incorporate simultaneously the two objectives when subjected to budget and various operational constraints. The MO problem is solved with a classical weight sum approach by using the branch and bound algorithm, which has proved to be better than other solution methodologies. The model is applied to a large-scale transit fleet system in the state of Michigan. The case study results demonstrated that the proposed model is compact, efficient, robust, and suitable for long-range planning with multiple solutions to choose from a Pareto-optimal frontier.

## 6. ATPIO's other collaborative activities

### 6.1. Co-sponsored international symposium and conferences

ATPIO actively facilitates collaboration between academia in US and India. ATPIO members regularly participate in organizing conferences held in US and India. One such activity was "First International Symposium on Advances in Transport Sustainability" at Arizona State University in 2011 that ATPIO organized, in collaboration with TRB and International Road Federation (IRF).

ATPIO has been co-sponsoring biennial international conferences on "Transportation Planning and Implementation Management in Developing Countries (TPMDC)" organized by the Indian Institute of Technology, Mumbai (IIT-B). ATPIO members have actively participated in the review of submitted papers and have organized ATPIO sessions in each of the 2008, 2010, 2012 and 2014 TPMDC Conferences. Historically many developing countries are represented in these conferences. IIT-B will host the 2019 World Conference on Transport Research (WCTR) and ATPIO will be assisting IIT-B in organizing this WCTR. Another example is ATPIO's co-sponsorship of Transportation Research Group's (TRG's) biennial conferences (CTRG) in held India. Members of ATPIO have actively participated in the review of submitted Conference papers and have organized ATPIO sessions in 2011, 2013 and 2015 TRG Conferences. Also, one senior member of ATPIO serves on Editorial Board of TRG's Journal. Table 4 shows various sessions sponsored by ATPIO in the international conferences.

### 6.2. Co-sponsored international workshop

ATPIO co-sponsored and actively participated in organizing the International Workshop on Urban Development in Varanasi, India from April 1, to 9 April, 2015. The objective of this workshop was to:

- Foster professional learning through cooperation, collaboration, and communication;
- Advance the profession through teaching, research, and outreach activities including publications, professional trainings, classroom courses, and workshops;
- Nurture students, professionals, civic leaders, businesses, and citizens to play a meaningful role in creating communities that enrich people's lives.

The workshop's main session known as the "Smart City Initiatives for Varanasi" was held at Banaras Hindu University (BHU). Varanasi is believed to be the oldest living city on earth and is known for its history, culture, archeological sites, educational institutes, music, rituals, and the holy river Ganga. 91 masters and Ph.D. students of BHU, La Salle University-Columbia, A.P. Institute of Environmental Design of Sardar Patel University, College of Engineering-Thiruvantapuram and 20 faculty members, professionals, as well as officials from City of Varanasi participated in this workshop. Over the duration of nine days, workshop participants brainstormed various urban development issues of Varanasi spread over six planning areas:

- Heritage Conservation and Tourism Management;
- Urban Mobility and Infrastructure Planning;
- Land Use Planning and Built Environment;
- Economic Development Projects;
- Environmental Planning and Management; and
- Livable Communities.

At the end of workshop, 28 most crucial urban issues were identified and the solutions of these issues were offered, e.g. for the Urban Mobility and Infrastructure area, the participants worked

**Table 4**  
ATPIO Sessions at Various Conferences.

Conference Name/ Date	Session Chair and Papers Presented
CTRG-2011 (Dec. 8, 2011)	Chair: Dr. Murthy Bondada <ul style="list-style-type: none"> <li>• Capacity Enhancement of Urban Roads with Segregation of Non-Motorised Traffic, K. Krishnamurthy, V. Thamizharasan</li> <li>• Level of Service Parameters for Bus Transit in the Indian context, Shreya Das, Debapratim Pandit</li> <li>• Methodology To Develop Pedestrian Walkability Index And Level Of Service Of Walkways, Prof. M. N. Sreehari, Rohith B.E</li> <li>• Sustainable Urban Transport Policy – The Case For India's Auto-rickshaw Sector, Akshay Mani, Madhav Pai, Rishi Aggarwal</li> <li>• If you build it, will they come? A comparative study of cycle tracks in Delhi and Ahmedabad, Christopher Kost, Santhosh Kodukula</li> </ul>
TPMDC 2012 (Dec. 13, 2012)	Chair: Dr. Chandra Bhat (Session-5A; 11:00–13:00) <ul style="list-style-type: none"> <li>• Critical Evaluation of Bus Rapid Transit System (BRT) Corridor Performance in Delhi, S Velmurugan</li> <li>• Modeling Pedestrian Travel Behavior for Shaping Sustainable Transport Research and Policies for Indian Cities, Vaishali Patankar, K V Krishna Rao</li> <li>• Combined Model of Destination and Mode Choices in Leisure travel, Praveen S, Rajat Rastogi</li> <li>• Planning and Design strategies under semi urban conditions for high speed intercity corridors in India Sandeep Shanbhag, Sevaram,</li> <li>• Understanding Urban Human Activity and Mobility Patterns Using Large-scale Location-based Data from Online Social Media Hasan Samiul, Zhan Xianyuan, Satish V Ukkusuri</li> <li>• Traffic Characteristics and Problems of Fast growing Cities: A Case Study of Ghaziabad City Nataraju Jakkula, S Velmurugan</li> </ul>
TPMDC 2014 (Dec. 10, 2014)	Chair: Mr. Arun Shirole <ul style="list-style-type: none"> <li>• (Invited) Asset management of transportation infrastructure, Arun Shirole,</li> <li>• Entropy Weighted UE Model for Determination of Unique Path Flow for SUE Traffic Assignment Problem, Amit Kumara, and S. Peeta;</li> <li>• Risk Measure Consideration in Transportation Infrastructure., S. Mishra, and S. Sharma;</li> <li>• Investigation of use of Bluetooth Sensors for Travel Time... Jijo K. M., Lelitha V., D. Bullock, A. Sharma;</li> <li>• Effectiveness of Restricting Unauthorized Shared Tempo System: User Perspective, Shobhit Jain, Vinod Vasudevan.</li> </ul>
CTRG 2015 (Dec 8, 2015)	Chair: Dr. Anuj Sharma <ul style="list-style-type: none"> <li>• Spatial distribution of urban trips in recently expanded Surat city through Fuzzy Logic and Artificial Neural Network: A comparative study Salini P S<sup>*</sup>, Ashu Kedia, Sowjanya Dhulipala &amp; Bhimaji Krishnaji Katti Devesh Tiwari, Shahbaz Khan<sup>*</sup> &amp; Deepak John Peter</li> <li>• Impact of Model Specification on the Estimation of Value of Time, Neeraj Saxena<sup>*</sup>, Taha Hossein Rashidi &amp; Vinayak V. Dixit</li> <li>• An approach for improvement of transfer facilities at metro stations, Shubhajit Sadhukhan<sup>*</sup>, Uttam K. Banerjee &amp; Bhargab Maitra</li> <li>• Assessment of Driving Behaviour and Skills of Heavy Vehicle Drivers in India; Neelima Chakrabarty<sup>*</sup>, S. Velmurugan, Kamini Gupta &amp; Reetesh Rikku</li> <li>• Transportation Investment Decision Making for Medium to Large Transportation Networks; Sabyasachee Mishra, Amit Kumar<sup>*</sup>, Mihalis M. Golias, Timothy F Welch, Hossein Taghizad &amp; Khademul Haque</li> </ul>

on: (1) Water Transportation: Boat and Dock Development; (2) Parking Issues along the Ghats; (3) Bi-cycle and tri-cycle plan of the city; (4) City Connectivity with Major Transportation Hubs; and (5) School Transportation projects and offered various solutions to the local government.

### 6.3. AASHTO India tour

In 2009, ATPIO assisted the Association of State Highway and Transportation Officials (AASHTO) in planning and organizing itinerary for its high level AASHTO delegation of transportation leaders to India. Three ATPIO representatives were part of this delegation. This AASHTO tour helped set the stage for future collaborative efforts between AASHTO and Indian Roads Congress (IRC). Transportation leaders from India and United States reaffirmed strong interest in collaboration in order to advance the mutual goals of enhancement of transportation in both nations. The delegation took important steps to facilitate future cooperation. These included:

- Signing of an MOU setting up a cooperative relationship between AASHTO and IRC which established collaboration for information exchange in the areas of: system operations and management; pavement and bridge technologies; Intelligent Transportation Systems (ITS) and tolling; financing and Public Private Partnerships (PPP); industry best practices; and

capacity analysis of mixed-traffic conditions appropriate for developing countries.

- Familiarization with India's policies, plans and practices with respect to intercity national highways and the rural road system.
- Establishment of contacts with the highest level Indian Central Government decision makers, planners and administrators, as well as with state highway administrators, members of highway research and academic communities and private highway consulting practitioners.

The discussions suggested that future collaborative efforts might start with: technical exchange programs; training programs; joint research and development initiatives; and joint programs to address the key concerns and needs expressed by the elected officials and top administrators including centralized codes and standards development.

### 6.4. USTDA's smart city project

In February 2016, the U.S. Trade and Development Agency (USTDA), concluded a grant agreement in the presence of Chief Minister N. Chandrababu Naidu of the State Government of Andhra Pradesh to continue USTDA's support of India's ambitious goal of developing smart cities across the country. The agreement will advance the City of Visakhapatnam's (Vizag) efforts to make it more efficient and sustainable through the development of

interconnected infrastructure, communications and data systems. ATPIO representatives Dr. Mohan Venigalla of George Mason University and Mr. Siva Narla of the Institute of Transportation Engineers represented ATPIO and facilitated a discussion on cooperation between ATPIO and the Vishakhapatnam smart city project.

## 7. Current initiatives

### 7.1. ATPIO professional development programs

ATPIO expects to continue to organize webinars on contemporary transportation related topics that will be free and open to members and friends of ATPIO. ATPIO also considers mentoring as an important and effective adult learning strategy that can have a profound influence on an individual's development, whether it is in research or in professional practice. Therefore ATPIO has initiated the following two distinct Mentor-Protégé programs:

#### 7.1.1. Mentor-Protégé program for professionals

This program is intended to provide guidance to professionals of Indian origin in early years of their career. ATPIO will identify and arrange for Mentor suitable for each selected Protégé and monitor mentoring process to assure its success. Typical duration for mentor-protégé interaction will be one year.

#### 7.1.2. Mentor-Protégé program for students

This program is intended to provide guidance to students of Indian origin entering in the final year of their transportation related undergraduate study at an accredited academic institution in India or in US. ATPIO will identify and arrange for Mentor appropriate for each selected Protégé and monitor mentoring process to assure its success. Duration for mentor-protégé interaction will be one year.

### 7.2. ATPIO outreach

ATPIO's current and proposed future initiatives are underway to facilitate an active dialog between agencies and organizations in US and India. Dialogs have been on-going with the Government of India, US Trade Development Agency (USTDA), Indian Roads Congress (IRC), universities with active research in transportation and the Association of Multi-modal Transport Operators of India (AMTOI). These initiatives aim at bringing public and private sector counterparts from US and India together to facilitate collaborative research, as well as knowledge and technology transfer for betterment of transportation in the 21st Century.

A number of ATPIO members are actively involved in, and interact with, various committees of TRB, AASHTO, American Society of Civil Engineers, Institute of Transportation Engineers, International Road Federation, Indian Road Congress, Institution of Engineers (India) and World Road Association (PIARC). Therefore, ATPIO members are in a rather unique position to be knowledgeable about cutting edge technologies and innovation taking place around the world. As ATPIO enters into its second decade of existence, it can expect to benefit from its outreach.

## 8. ATPIO accomplishments and challenges

Transportation networks and systems are critically important to advancing economic development and enhancing societal prosperity. The age and degree of maturity of the transportation systems vary within and across the US and India. For example, in the US the interstate road network has been developed over the past 50+ years, whereas India has been significantly enhancing its national highway network over the past two decades. India's

rapidly growing economy and societal changes pose many transportation challenges that require strategic research aimed at effectively resolving them in a timely manner. Some examples of these challenges are problem of increasing traffic chaos; growth in urban population; urban sprawl' heavy investment in vehicle-centric infrastructure, etc. that have led to a congestion nightmare in urban cities of India. At the same time, rapidly changing vehicle technologies such as autonomous vehicles, connected vehicles and advanced collision warning not only present opportunities but also pose new challenges. Furthermore, rideshare services such as Uber and Lyft have been transforming the demand side of the equation. Such trends demand well-researched and readily implementable solutions that can be arrived at through US-India bilateral collaboration.

ATPIO's US-India bilateral activities have successfully provided a stage for policy level discussions, showcase for emerging technologies, forum for brain-storming and garnering help for near future ventures and promoting transportation themed initiatives. The networking at ATPIO annual meetings has resulted in several joint publications involving academics from US and India. Bilateral research collaboration has proved to be mutually beneficial for researchers. In addition such collaboration has provided researchers an opportunity to study and replicate successful strategies being implemented on the other side. These exchanges have also provided undergraduate and graduate students an opportunity to have a broader view of the field of transportation. They are challenged to think beyond the artificial constraints levied by nations and implementable research irrespective of the national boundaries.

There have been challenges and hurdles for ATPIO's efforts in facilitating and organizing bilateral research, as well as knowledge and technology transfer activities. Significant geographic distance-divide and time difference between US and India, poses ATPIO some limitations on its ability to provide opportunities for researchers to have consistent on-going interactions between them. In order to address these limitations, ATPIO has initiated some actions. As a simple practical solution, ATPIO makes recordings of its webinars accessible via internet ([www.atpio.org](http://www.atpio.org)). Further, ATPIO web site has started routinely posting announcements and information on upcoming transportation related seminars, workshops and conferences in US and India for the benefit of its members and friends. As a proactive step, it initiated development and implementation of bilateral memorandum of understanding (MOUs) with organizations and institutions in India that facilitate on-going discussions to identify and jointly pursue research areas of mutual interest. Another initiative currently underway is ATPIO's collaborative assistance to US Trade Development Agency (USTDA) and Indian state, Andhra Pradesh, delegation on "Smart City". Also being pursued is the establishment of collaborative working relationships with governmental agencies in US and India. Both of these initiatives have the promise for even more successful next decade of ATPIO's collaborative research, knowledge and technology transfer activities.

## 9. Conclusion

Since it was established in 2004 the Association of Transportation Professionals of Indian Origin (ATPIO) has successfully facilitated bilateral collaborative activities and partnerships between diverse groups of transportation professionals in US and India. These activities have included research, as well as knowledge and technology transfer.

Over the past decade ATPIO has organized free webinars, technical presentations at its Annual Meetings, co-sponsored conferences and workshops in US and India; as well as collaborated with academics, research organizations and governmental



agencies both in US and in India. These decade long activities and discussions resulted joint publications involving collaborative research between academics from US and India. ATPIO's current and proposed future initiatives are expected to bring public and private sector counterparts from US and India together to facilitate state of the art research based knowledge and technology transfer for betterment of transportation in the 21st Century.

### Acknowledgements

The author acknowledges and thanks Drs. Anuj Sharma, Sabyasachee Mishra, Ram Pendyala, Mohan Venigalla and Mr. Jaydeep Chaudhari for their valuable input provided during the preparation of this paper.

### References

- Anusha, S.P., Vanajakshi, L., Subramanian, S.C., Sharma, A., 2015. Performance comparison of two model based schemes for estimation of queue and delay at signalized intersections. 2015 IEEE Intelligent Vehicles Symposium (IV). Presented at the 2015 IEEE Intelligent Vehicles Symposium (IV) 988–993. doi: <http://dx.doi.org/10.1109/IVS.2015.7225813>.
- Buddharaju, R., Jha, M.K., Kang, M.-W., Mishra, S., Ponnada, M.R., 2013. Predicting road accidents and prioritizing road safety improvement measures in developing countries using adapted traffic conflict techniques. Presented at the Transportation Research Board 92nd Annual Meeting .
- Khasnabis, S., Dhingra, S.L., Mishra, S., Safi, C., 2008. Emerging private-sector roles for transportation asset management in India. Presented at the Transportation Research Board 87th Annual Meeting .
- Khasnabis, S., Mishra, S., Swain, S., Manori, A., 2009. A framework for assessing incident management strategies using micro-simulation techniques. Presented at the Compendium of Papers in International Symposium in Freeway and Tollway Operations, Hawaii, Hawaii.
- Khasnabis, S., Dhingra, S.L., Mishra, S., Safi, C., 2010. Mechanisms for transportation infrastructure investment in developing countries. *J. Urban Plan. Dev.* 136, 94–103. doi: [http://dx.doi.org/10.1061/\(ASCE\)0733-9488\(2010\)136:1\(94\)](http://dx.doi.org/10.1061/(ASCE)0733-9488(2010)136:1(94)).
- Maji, A., Mishra, S., Chittor, R., Tiwari, A., 2010. Optimization based prioritization model for highway safety countermeasure implementation strategy. Presented at the Compendium of Papers in 94th Annual Board Meeting of Transportation Research Board, National Research Council, Washington D.C.
- Mathew, T.V., Khasnabis, S., Mishra, S., 2010. Optimal resource allocation among transit agencies for fleet management. *Transp. Res. Part Policy Pract.* 44, 418–432. doi: <http://dx.doi.org/10.1016/j.tra.2010.03.016>.
- Mishra, S., Mathew, T., Khasnabis, S., 2010. Single-stage integer programming model for long-term transit fleet resource allocation. *J. Transp. Eng.* 136, 281–290. doi: [http://dx.doi.org/10.1061/\(ASCE\)0733-947X\(2010\)136:4\(281\)](http://dx.doi.org/10.1061/(ASCE)0733-947X(2010)136:4(281)).
- Mishra, S., Khasnabis, S., Swain, S., 2013a. Multi-entity perspective transportation infrastructure investment decision making. *Transp. Policy* 30, 1–12. doi: <http://dx.doi.org/10.1016/j.tranpol.2013.07.004>.
- Mishra, S., Sharma, S., Mathew, T., Khasnabis, S., 2013b. Multiobjective optimization model for transit fleet resource allocation. *Transp. Res. Rec. J. Transp. Res. Board* 2351, 1–13. doi: <http://dx.doi.org/10.3141/2351-01>.
- Mishra, S., Sharma, S., Khasnabis, S., Mathew, T.V., 2013c. Preserving an aging transit fleet: an optimal resource allocation perspective based on service life and constrained budget. *Transp. Res. Part Policy Pract.* 47, 111–123. doi: <http://dx.doi.org/10.1016/j.tra.2012.10.029>.
- Mishra, S., Khasnabis, S., Swain, S., 2015. Incorporating uncertainty and risk in transportation investment decision-making. *Transp. Plan. Technol.* 38, 738–760. doi: <http://dx.doi.org/10.1080/03081060.2015.1059121>.
- Pendyala, R., Verma, A., 2010. Challenges and opportunities in the transportation sector for Indo-US partnerships in research and technology transfer. Presented at the Indo-US Perspective and Advances in Mass Transit and Travel Behavior Research 200, USA, pp. 3–16 Lulu.com.
- Pendyala, R., Verma, A., Konduri, K., Sana, B., 2009. Socio-economic and transport trends in India and the United States: a preliminary comparative study. *Transp. Lett.* 1, 121–146. doi: <http://dx.doi.org/10.3328/TL;1;2009.01.02.121-146>.
- Ramesh, V., Raj, J., Vajanakshi, L., Wang, S., Sharma, A., Rilett, L., 2012. Performance comparison of a radar based traffic sensor – smartsensor HD for indian and american traffic conditions. Presented at the 5th Urban Mobility Indian Conference and Expo 2012, New Delhi, India.
- Sharma, A., Vanajakshi, L., Rao, N., 2009. Effect of phase countdown timers on queue discharge characteristics under heterogeneous traffic conditions. *Transp. Res. Rec. J. Transp. Res. Board* 2130, 93–100. doi: <http://dx.doi.org/10.3141/2130-12>.
- Sharma, A., Vanajakshi, L., Girish, H., 2012. Impact of signal timing information on safety and efficiency of signalized intersections. *J. Transp. Eng.* 138, 467–478. doi: [http://dx.doi.org/10.1061/\(ASCE\)TE.1943-5436.0000343](http://dx.doi.org/10.1061/(ASCE)TE.1943-5436.0000343).
- Sharma, A., 2015. Transport in urban India: challenges and strategies. *Adm. J. Lal Bahadur Shastri Natl. Acad. Adm.* 56.
- Thomas, H., Anusha, S.P., Vanajakshi, L., Sharma, A., 2013. Queue length and delay estimation at signalized intersections using detector data. Presented at the 6th Urban Mobility India Conference and Expo 2012, New-Delhi, India.
- Udenta, F.C., Jha, M.K., Mishra, S., Maji, A., 2014. Disaster management for urban commute in a multimodal transportation context. Presented at the Transportation Research Board 93rd Annual Meeting .
- Vanajakshi, L.D., Sharma, A., Lakshmi, R., 2010. Red light violation characteristics under heterogeneous traffic conditions: with and without countdown timers. Presented at the Transportation Research Board 89th Annual Meeting .