Quality Vision Technology Based Delhi Bus Transportation Management Decision Support System

A. Kurian and M. Jain

Abstract— **Traffic and transportation problems in Delhi have been aggravating over the years. The present unidirectional flow of traffic during peak hours has resulted in inefficient utilization of network, increase in travel time and longer trip lengths. In this paper quality vision technology based Decision Support System for effective Management of Delhi Bus Transportation System (DBTM-DSS) is designed and developed which when used in an innovative way helps the Delhi Transport Corporation (DTC), Delhi Government and private operators in multi-criteria decision making along with (re)consideration of their ideologies, socio-cultural structures, and quality vision information based decisions. DBTM-DSS aims to support sustainable decision making and implementation by assisting a quality vision technology based communicative action that enhances co-operation by credibility, transparency and legitimacy for strategic planning, management control, operational planning and transaction processing. In particular, attention is focused on the five main components: Model Base Management (MBM) Subsystem comprising of Transportation Informatics Modules [Traffic Congestion (TC) module and Air Pollution Control (APC) module], Data Base Management (DBM) Subsystem, Central Vision Navigator (CVN) Board, Quality Vision Technology (QVT) Base comprising of Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology based Quality Decision Visualization (QDV) Desk and Dialogue Management Generation (DMG) Subsystem.**

Keywords— **Delhi Bus Transportation System, Decision Support System, Quality Vision Technology Base, MCIFDP Methodology, Transportation Informatics Modules.**

I. INTRODUCTION

The Transportation system is a critical component of urban infrastructure and should facilitate the movement of people, services and goods as efficiently as possible from different origins to destinations that are separated in space and time. A well developed and planned transportation system is integral to the development of economic and social activity and accelerates economic growth of a city like Delhi, Mumbai, and Calcutta etc. Bus transportation system provides the principle mode of mass transport in Delhi, not only due to its convenient accessibility, flexibility and cost effectiveness but also due to non-availability of other effective modes of transport and so it serves about half of the entire city's travel demand. The major causes of growing congestion in Delhi is due to vehicular population, rigid road network, heterogeneous mix of traffic, increased per-capita income etc. The type of traffic congestion being witnessed in Delhi is leading to increased costs, longer travel times, constrained economic productivity, and adverse health and environmental externalities.

According to Azeem Uddin [2] the transportation community would accelerate the solution to congestion by being more aggressive in championing the need for transportation systems management and operations. Singh [8] discussed the nature and magnitude of urban transport problems such as congestion, pollution and road accidents. Building on this background, the author also proposed policy measures to improve urban transportation in India. Singh et al. [7] provided an innovative approach as VANETs in solving traffic problems in India that had significantly large amount of public and private vehicles on roads. Talukdari [9] developed a traffic congestion mitigation framework which would be useful for urban planners, transport planners, civil engineers, transport policy makers, congestion management researchers who are directly or indirectly involved or willing to involve in the task of traffic congestion management. Zhang and Batterman [12] used an incremental analysis to estimate pollution impacts and characterize health risks caused by congestion.

Rapid growth, low incomes, and extreme inequality are among the main underlying causes of transport problems in Delhi. Enormous problems faced by Delhi Bus Transportation System (DBTS) are:

- Unplanned, haphazard development at the suburban fringe without adequate infrastructure, transport, and other public services
- Limited network of roads, often narrow, poorly maintained, and unpaved
- Extremely congested roads with an incompatible mix of both motorized and non-motorized vehicles traveling at widely different speeds
- Rapidly increasing ownership and use of private cars and motorcycles
- Inadequate roadway accommodations for buses and non-motorized transport
- Primitive or non-existent traffic control and management, often without even the most basic street signage
- Extremely high and rapidly rising traffic fatalities, especially among pedestrians and motorcyclists
- Overcrowded, uncomfortable, undependable, slow, uncoordinated, inefficient, and dangerous public transport
- Extremely high levels of transport-related pollution, noise and other environmental impacts, especially in large cities

A. Kurian and M. Jain are with Banasthali Vidyapith, Banasthali, Rajasthan, India.

A Decision Support System is an interactive computer-based system which has the objective of enhancing the overall effectiveness of decision makers, especially in their unstructured and semi-structured tasks and utilizes decision models, gives users easy and efficient access to a powerful database and provides various display properties. Kim et al. [5] presented a framework for a geographic information systems–based decision support system designed to provide online routing instructions in response to updated information on traffic and weather conditions for vehicles transporting hazardous materials. Dzemydiene and Dzindzalieta [3] described an approach for development of the architecture of decision support system with integrated embedded components for monitoring and evaluation of transportation processes of dangerous goods. Forsberg et al. [4] developed a new decision support system for transportation planning in Swedish forestry for strategic and tactical decisions. The system used a GIS-based map user-interface. Tan et al. [10] developed a decision support system for urban mass transit service planning, which was designed for several types of users, such as transit operators for service planning, a public agency for regulation of transit services, or transit passengers for route guidance. Arampatzis et al. [1] presented a decision support system integrated in a geographical information system (GIS) for the analysis and evaluation of different transport policies. Tang et al. [11] developed an evaluation support system to integrate a variety of indicators and their related measures method by a framework of input-output outcome of comprehensive transportation to facilitate consultants to monitor current state of operation and management of transport system.

In this paper, a Quality Vision Technology (QVT) based Decision Support System for Delhi Bus Transportation System (DBTM-DSS) is designed and developed for effective management of traffic and transportation problems of Delhi Bus Transportation System which helps in decision making by comparing the effectiveness of various alternate policies which have been devised with the objective of increasing public convenience, operators benefits and environment quality. Delhi bus transportation management is dealt with two somewhat different overlapping Transportation Informatics Modules viz. Traffic Congestion (TC) Module and Air Pollution Control (APC) Module.

II. DELHI BUS TRANSPORTATION DECISION SUPPORT SYSTEM

DBTM-DSS facilitates method that allows Decision Members (DM) to make managerial decision by combining futuristic judgments and personal values in a logical way to solve ill-structured Delhi bus transportation management problems and incorporates the informed futuristic judgment, assumption and intuition of experienced transportation system decision members. DBTM-DSS helps in managerial decision making by comparing the effectiveness of various alternate policies with the objective of reducing traffic and pollution problems, and improving effective coordination among various organizations and providing better commuter facility. The salient features of the DBTM-DSS are: quick and interactive communication, instant content support, group management decision making, anonymity of group member's identity, vast resources of content and system support. DBTM-DSS is comprised of five main components– Model Base Management (MBM) Subsystem, Data Base Management (DBM) Subsystem, Central Vision Navigator (CVN) Board, Quality Vision Technology (QVT) Base and Dialogue Management Generation (DMG) Subsystem.

The proposed DBTM-DSS is based on a central black board problem solving architecture, where Quality Vision Technology (QVT) Base comprising of Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology based Quality Decision Visualization (QDV) Desk associated to different Transportation Informatics Modules interact through a Central Vision Navigator (CVN) Board. Moreover, the quality vision information support of CVN-Board and user friendly approach of Dialogue Management Generation (DMG) Subsystem makes the DBTM-DSS to take strategic, tactical and operational decisions and answer 'what if' queries very effectively.

A. Model Base Management Subsystem

The Model Base Management (MBM) Subsystem accepts the data from Data Base Management (DBM) Subsystem; interacts with the related Transportation Informatics Modules: Traffic Congestion (TC) Module and Air Pollution Control (APC) Module, computes the value using Quality Vision Technology (QVT) Base comprising of Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology based Quality Decision Visualization (QDV) Desk; and displays the results through Central Vision Navigator (CVN) Board and Dialogue Management Generation (DMG) Subsystem for strategic planning, management control, operational planning and transaction processing.

TRANSPORTATION INFORMATICS MODULES

(I) TRAFFIC CONGESTION (TC) MODULE

Traffic congestion is probably the most visible, most pervasive, and most immediate transport problem plaguing Delhi on a daily basis. It affects all modes of transportation and all socioeconomic groups. The Traffic Congestion (TC) Module helps the transportation system decision makers in following types of decision issues:

→ How much it is helpful to charge peak-hour tolls in reducing traffic congestion in Delhi?

→ What proportion of congestion is in Delhi at different hours?

→ How we can overcome the congestion by the Principle of Triple Convergence?

→ Can anything be done to slow future increases in traffic congestion?

→ Are the high occupancy toll lanes an alternative to reduce congestion?

(II) AIR POLLUTION CONTROL (APC) MODULE

The transport sector is a major consumer of fossil fuels and thus a major contributor towards Environmental Pollution. The

major cause of controlling air pollutants such as Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM) and Sulphur Dioxide (SO$_2$) is their adverse health effects. According to the World Health Organization (WHO), 4–8% of deaths occurring annually in the world are related to air pollution. The APC module helps the transportation system decision makers in following types of decision issues:

➔ What will be the benefit in terms of reduction in pollution load and fuel saving in switching to alternative?
➔ What are the various causes of environmental pollution (black smoke and greenhouse gases) in vehicles? What factors are to be dealt with within the vehicle to reduce smoke?
➔ What is the relation of smoke emission with fuel consumption and traffic scenario and how it should be measured (optical measurement / smoke meters)?
➔ How much is the potential for the introduction of incentives to improve black smoke emissions in terms of possible fuel savings?
➔ What is the percentage of casualties reported in the local hospitals due to smoke emission and how it can be reduced?
➔ What technological changes are required to curve the menace of environmental pollution?

B. Data Base Management Subsystem

The main task of the DBM Subsystem is the simplification, preparation, and pre–processing of input data of Delhi bus transportation management and also control and verification of the bulk of data required by the informatics modules. The relational database, which is comprised of daily transport analysis report as reported by Delhi Transport Corporation (DTC) after pre-processing provides reliable data for necessary policy framework. The pre-processing of this data involves separation of transport analysis data, data of traffic jams, pollution and gridlock, bad roads and traffic engineering policy and further does the job of cleansing, structuring and formatting of data to maintain data integrity in DBM Subsystem. The subsystem facilitates post processing of records returned by the database, which is extensively and intensively queried through SQL.

C. Central Vision Navigator Board

The designed DBTM-DSS is based on a central black board problem solving architecture where Quality Decision Visualization (QDV) Desk based Quality Vision Technology (QVT) Base connected to various Delhi bus transportation management components interact through a Central Vision Navigator (CVN) Board. In this CVN Board common globally shared database, local knowledge base and specialized Quality Vision Technology (QVT) Base sources act upon a central black board problem solving architecture, according to a strategy aiming at building a problem solution, both cooperatively and opportunistically. The CVN Board for Delhi bus transportation management is based on independent and interactive knowledge based agents as data completion, data analysis, information visualization, and prediction and control functions. CVN Board supports new data types and provides

synchronization of multiple data streams and real life applications via real time scheduling and fast interrupt processing. The merger of the discrete media like tables and text, with the continuous media such as audio and images make the Delhi bus transportation management information visualization and interaction process more direct and straight for Decision Members (DM), improves retention, and this plays a pivotal role in the positive contribution to the support system.

D. Quality Vision Technology Base

The Multi-criteria and futurologistic approach of Quality Vision Technology (QVT) Base comprising of Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology based Quality Decision Visualization (QDV) Desk (Figure 1) provides an effective dimension to deal with complex decision problems of Delhi bus transportation system.

M.C.I.F.D.P. Methodology

Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology (Madhuri [6]) is a cross-disciplinary, multi-dimensional, multi-person, multi-objective, multi-level, multi-period methodology and it implicates iterative multi criteria approach for futurologistic decision problems and consolidates information about tangible and intangible criteria and alternatives in futuristic decision making process. MCIFDP Methodology is a non-linear framework for analyzing both deductive and inductive iterative futuristic thinking that allows the consideration of several Multi Futuristic Decision Indicators (MFDI) at a time, along with an iterative feedback control mechanism and numerical trade-off without the use of the syllogism.

The synthesis picture for Bus Transportation System of Delhi (DBTS), resulting from the prognosis picture by Outside-In Approach (OIA) and the optative picture by Inside–Out Approach (IOA) will help in clustering by DBTS Decision Making (DBTS-DM) Team into a reasonable set of mutually exclusive and encompassing Multi Futuristic Decision Indicators (MFDI) for the Goal. The synthesis picture created by DBTS Expert (DBTS-ET) Team, for DBTS generated total 356 MFDI for different levels **L**. Delphi Questionnaire was formed from generated MFDI for DBTS. MFDI of the Goal were rated and ranked by DBTS Future Scan (DBTS-FS) Team. Feedback of DBTS-FS Team was analyzed to compute Futuristic Decision Priority (FDP) Weights w_j^{fL} for the Goal.

Quality Decision Visualization Desk

The Quality Decision Visualization (QDV) Desk (Madhuri [6]) receives its data input Overall Futuristic Decision Priority (OFDP) Weights (W_j^{fL}) from prioritized MFDI based on Futuristic Decision Priority (FDP) Weights (w_j^{fL}). The job of understanding the variability in the process is probabilistic and based on the experiences and suggestions of the QDV-Desk which aims to preserve the best practice but eliminate the necessity of physical co-location thus enabling the team to collaborate rapidly and continuously with experts worldwide, irrespective of the geographical constraints. This provides a

totally new level of cognitive–style thinking in multi criteria decision making. The MCIFDP methodology and QDV-Desk are supported by Windows based software ITERATIVE PRIORITY 1.3, written in 'V-Basic'.

Application of QDV-Desk

The QDV-Desk selects Prioritized Multi Futuristic Decision Indicators (MFDI) and Prioritized Target Population 'p' for the Goal and forms Target Population Evaluation (TPE) Chart. The three matrices Futuristic Cluster (FC) Matrix W_2^{fL} , Futuristic Cluster (FC) Matrix W_3^{fL+1} and Futuristic Level Relationship (FLR) Matrix $W_4^{fL, fL+1}$ are designed and then superimposed to formulate Futuristic Quality Super (FQS) Matrix M. The Final Limit Futuristic Decision Priority (FLFDP) Weights W_j^{SP*} for the goal are obtained in Final Limit Futuristic Quality Super (FLFQS) Matrix. The Optimal Super Prioritized Final Limit Futuristic Decision Indicators (FLFDI) are then selected based on Optimal Super Prioritized Final Limit Futuristic Decision Priority Weights W_j^{SP**} to formulate futuristic decision prioritized scenario and action plan for the goal.

E. Dialog Management Generation Subsystem

The Dialogue Management Generation (DMG) Subsystem is designed for Decision Members (DM) with a variety of Delhi bus transportation management decision-making needs. The DM are able to select their area of interest transportation informatics module. The DMG Subsystem captures the DM preferences, degree of expertise, skills and then receives and interprets their input, which is conveyed to Central Vision Navigator (CVN) Board and finally presents the output in the form of charts, text, graphs and tables along with suitable form and visual displays. The DMG Subsystem capabilities of DBT-DSS are broadly classified into two categories: Queries Support Display (QSD) Desk and Decision Support Display (DSD) Desk due to variety of users with different decision making tasks. While QSD-Desk allows adhoc retrieval of Delhi bus transportation management information, DSD-Desk supports the DBTS decision-making tasks and allows the user to generate a number of displays from the data available in the system, into pre-defined format.

The processed data from Data Base Management (DBM) Subsystem is accepted as the input data for Quality Vision Technology (QVT) Base which uses Quality Decision Visualization (QDV) Desk having several capabilities, and after the interaction of related transportation informatics modules, the output results are transmitted in real-time through Central Vision Navigator (CVN) Board having central vision navigator black board problem solving architecture, to the DMG Subsystem, for display, analysis and decision. Development phases of DBT-DSS are shown in Figure 2.

III. CONCLUSION

In this paper a Decision Support System DBTM-DSS is designed and developed for effective management and to support complex traffic and transportation decision problems of Delhi Bus Transportation System (DBTS). In particular

emphasis is focused on the Quality Vision Technology (QVT) Base comprising of Multi Criteria Iterative Futuristic Decision Process (MCIFDP) Methodology based Quality Decision Visualization (QDV) Desk. The multi-criteria and futrologistic approach of Quality Vision Technology (QVT) Base provides a comprehensive structured quality vision communication system framework for decision making of multi-criteria complex traffic and transportation decision problems decision problems of Delhi Bus Transportation System by choosing the best one in a set of competing futuristic alternatives. The Support System will help in operating at strategic, tactical and operational level, through the best use of the existing facilities.
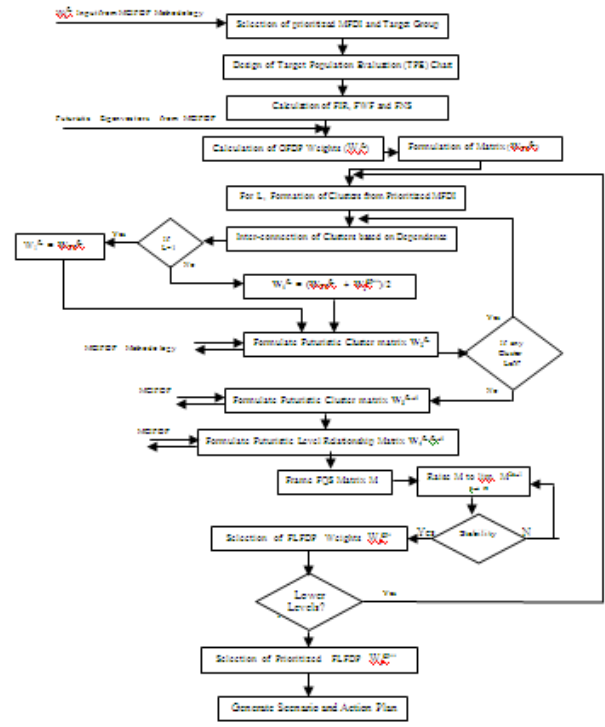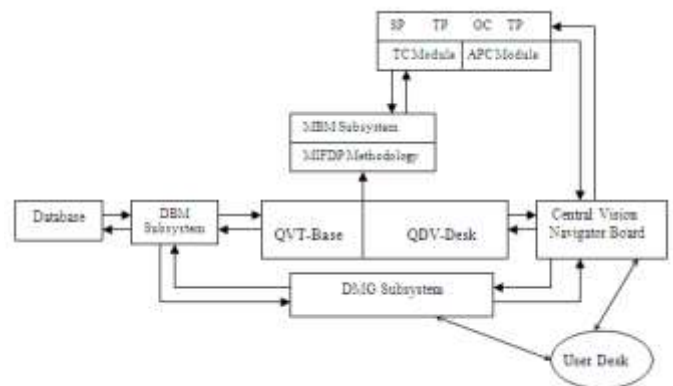

Figure 1: Flow Chart for QDV-Desk

Figure 2: DBTM-DSS

REFERENCES

[1] Arampatzis G, C.T. Kiranoudis, P. Scaloubacas and D. Assimacopoulos, "A GIS-based Decision Support System for Planning Urban Transportation

Policies", *European Journal of Operational Research,* vol. 152, pp. 465-475, 2004.
https://doi.org/10.1016/S0377-2217(03)00037-7

[2] Azeem Uddin, "Traffic congestion in Indian cities: Challenges of a rising power", *Kyoto of the Cities, Naples*, vol. 26-28, pp. 1-7, 2009.

[3] Dzemydiene Dale and Ramunas Dzindzalieta, "Development of Architecture of Embedded Decision Support Systems for Risk Evaluation of Transportation of Dangerous Goods Technological and Economic Development of Economy", vol 16 (4), 654–671, 2010.

[4] Forsberg M, M. Frisk and M. Ronnqvisty, "FlowOpt – A Decision Support Tool for Strategic and Tactical Transportation Planning in Forestry", *International Journal of Forest Engineering*, vol. 16(2), 101-114, 2005.

[5] Kim Minseok, Elise Miller-Hooks and Rahul Nair, "A Geographic Information System-Based Real-Time Decision Support Framework for Routing Vehicles Carrying Hazardous Materials", *Journal of Intelligent Transportation Systems*, vol. 15(1), 28–41, 2011.
https://doi.org/10.1080/15472450.2011.544584

[6] Madhuri, "Vision of Delhi Bus Transportation System using Multi Criteria Iterative Futuristic Decision Process Methodology based Quality Decision Visualization (QDV) Desk" *Working Paper AIM & ACT/BV/2016-12, Banasthali Vidyapith, Banasthali, Rajasthan*, pp.1-13, 2016.

[7] Singh Geetanjali, Neelima Chakrabarty and Kamini Gupta, "Traffic Congestion Detection and Management Using Vehicular Ad-Hoc Networks (VANETs) In India", *International Journal of Advanced Computer Technology*, vol. 3, pp. 19-26, 2014.

[8] Singh, Sanjay Kumar, "Urban Transport in India: Issues, Challenges, and the Way Forward", *European Transport \ Trasporti Europei*, vol. 52, pp. 1-26, 2012.

[9] Talukdari, Mahmud Hassan, "Framework for Traffic Congestion Management", *Economia. Seria Management*, vol. 16, pp. 54-64, 2013.

[10] Tan Man-Chun, Cong-On Tong, Jian-Min Xu, "Study and Implementation of a Decision Support System for Urban Mass Transit Service Planning", *Journal of Information Technology Management*, vol. XV, pp. 14-32, 2004.

[11] Tang Xi-Jin, Nie K. and Liu Y., "Meta-Synthesis Approach to Exploring Constructing Comprehensive Transportation System in China", *Journal of Systems Science and Systems Engineering*, vol. 14, pp. 476-494, 2005.
https://doi.org/10.1007/s11518-006-0206-7

[12] Zhang Kai, and Stuart Batterman, "Air Pollution and health risks due to vehicle traffic", *Science of the Total Environment*, vol. 450-451, pp. 307-316, 2013.
https://doi.org/10.1016/j.scitotenv.2013.01.074

Mr. A. Kurian had did his Master's Degree in Applied Mathematics from Faculty of Engineering & Technology of M. S. University of Baroda, India in the year 1991. He did his Bachelor's degree in Education. He was invested 12 years in teaching Mathematics, Statistics and Engineering mathematicsin UAE. He was teaching mathematics, statistics at Emirates College of technology, Abu Dhabi UAE. Currently he is working in Manipal University of Dubai Campus. He also taught mathematics, business statistics at American college of Dubai . He is a person with rich experience of teaching mathematics in UAE using modern technology available also expert in curriculum development for the course required. His area of interest are Engineering mathematics, statistics, business mathematics/Advanced operations research. Now he is doing Ph.D. in operations research from banasthali vidyapith, Rajasthan, India.

Dr. Madhuri Jain is working as a Assistant Professor in Department of Mathematics & Statistics, Banasthali Vidyapith, Rajasthan, India. She has more than six years of teaching experience. Her area of research is transportation system, bio-medical engineering, decision support system, intelligent transportation system. She has more than twenty publications in International/National refereed journals. She has attended near about six international conferences and presented a paper. She also chaired a session in an international conference.