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# Transportation System Genetic Algorithm Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System for Millennium Cities of India

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***Abstract:*** In this paper a Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System (TGSO-TDSS) is designed and developed for the strategic optimization of transportation target areas of millennium cities of India. The TGSO-TDSS is comprised of six main subsystems: Transportation Model Base Management Subsystem, Transportation Data Base Access and Management Subsystem, Central Transportation Vision Navigator Board, Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Optimization Vision Technology Base, Transportation Decision Making and User Desk, and Dialog Management Subsystem. The Model uses natural selection and mechanics of natural genetics in the area of mathematical optimization to obtain global optimum in a phase space and provides a comprehensive structured vision communication system framework for the identification and selection of innovative strategic optimal transportation strategic decision indicators with their respective optimized weights for the strategic optimization of transportation target areas of millennium cities of India.

***Keywords****:* Transportation System, Transportation Decision Support System, Genetic Algorithm, Transportation Target Areas, Mathematical Optimization.

## 1. Introduction:

Transportation system is the veins and arteries through whose channels every improvement takes circulation and is an essential requirement for nourishment and rapid progress of a country and its demand is increasing due to increase in population, industrialization, education infrastructure and desire to travel. Due to changes in travel patterns and population growth, inadequate and poor maintenance of roads, frequent accidents, heavy transport taxes, and the rising cost of petrol and diesel, there is an urgent need for the strategic optimization of Transportation Target Areas (TTA) to manage the current Indian transportation system.

Transportation Decision Support System (TDSS) has drawn increased attention as one of the emerging transportation system decision-making tools and transportation decision optimization service delivery vehicles running on the transportation information highway. TDSS is an integrated sets of tangible and intangible transportation information for strategic, tactical and operational planning levels that are designed to supplement a system user's insight and personal rich knowledge base during transportation system decision making and problem-solving activities. Sun et al. [1] demonstrated a Decision Support System for transportation based on dynamic data-driven applications systems to make the system smarter. Glock [2] developed a Decision Support System for the management of returnable transport items which include reusable wrapping materials, like trays, boxes, or pallets with closed-loop supply chains. To minimize all the risks during transportation of hazardous materials, Torretta et al. [3] proposed reported the state of art regarding such decision support systems with their applications. Yazdani et al. [4] proposed a decision support system in sustainable transport evaluation by integrating rough set theory with decision-making trial and evaluation laboratory, and multi-attributive border approximation area comparison approach. Golini et al. [5] proposed an assessment framework using decision support systems for collecting and classifying information relevant to urban freight transport in cities. Glock [6] developed a decision support system based on the literature review for the management of returnable transport items e.g., reusable wrapping materials, like trays, boxes, or pallets with closed-loop supply chains. Mladenovic et al. [7] designed a decision support system having four elements: model, database management, knowledge, and dialogue based on fuzzy analytic hierarchy process to improve the planning of traffic-signal control technology. Using multiple objective genetic algorithms, Papatzikou and Stathopoulos [8] developed a DSS to optimize traffic control of a transportation system. From car driver's angle, a two-phase optimization by genetic algorithm was designed by Petrillo et al. [9] for a DSS.

A Genetic algorithm is a totally robust, powerful, efficient and best algorithm for intelligent searching; has built in best parallel capacities for single and multiple objective, complex or loosely-defined real-life decision problems having large search space, factors and alternatives; fast and efficient approach having quick scan and inductive nature feature with multiple good enough solutions; iterative better solution technique without a little derivative evidence; can optimize discrete as well as continuous functions. Genetic algorithm is the most popular approach in evolutionary algorithms. To obtain the global optimum solution of hazardous pol transportation problem without premature convergence, Zhang, Guo and Yan [10] presented a hybrid genetic algorithm method. Saharkar and Wanjari [11] presented a genetic algorithm for school bus transportation problem to minimize the time. To solve traveling salesman problem, Abbasi et al. [12] developed an innovative solution procedure of a genetic algorithm. To optimize the flow of urban traffic, Dezani et al. [13] presented a new methodology based on a genetic algorithm. Using genetic algorithm, a completely automatic method was proposed by Chiappone et al. [14] for the calibration of a traffic model. Tabir et al. [15] proposed binary chaotic genetic algorithm to improve genetic algorithm. The proposed algorithm enumerates two times better fitness value compared to the normal genetic algorithm. Manzoni, Mariot and Tuba [16] assumed three different balanced crossover operators and compare the efficiency of the operators with the original. Lee [17] reviewed the application of genetic algorithms in the area of operations management and identified potential areas for future research. Sohail [18] discussed the importance of genetic algorithm in the field of computational biology, image reconstruction, time series forecasting and bayesian inference. Alhijawl and Awajan [19] provided a review and summarized the recent contributions related to the genetic algorithm with survey of the real-life applications and roles of GA. In this paper, a Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System (TGSO-TDSS), a comprehensive structured vision communication framework is designed and developed for the strategic optimization of Transportation Target Areas ($TTA_j$) by identifying and selecting innovative strategic optimal Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$ to reduce and manage the traffic and transport related crucial problems of the transportation system of Millennium Cities of India ($MCI_i$).

## 2. Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System

This section presents the design and development of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System (TGSO-TDSS) having a symbiotic approach to achieve the aim of furnishing the process support and content among system users, transportation system decision-makers and transportation system experts for the strategic optimization of Transportation Target Areas ($TTA_j$) of Millennium Cities of India ($MCI_i$). The TGSO-TDSS is comprised of six main Subsystems: Transportation Model Base Management (TMBM) Subsystem, Transportation Data Base Access and Management (TDBAM) Subsystem, Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model based Optimization Vision Technology (OVT) Base, Transportation Decision Making and User (TDMU) Desk, and Dialog Management (DiaM) Subsystem.

### 2.1 Transportation Model Base Management Subsystem

The TMBM Subsystem accepts the data from Transportation Data Base Access and Management (TDBAM) Subsystem; computes the value using Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model based Optimization Vision Technology (OVT) Base; and displays the final output results through Central Transportation Vision Navigator (CTVN) Board and Transportation Decision Making and User (TDMU) Desk for the strategic optimization of Transportation Target Areas ($TTA_j$) of Millennium Cities of India ($MCI_i$).

### 2.2 Transportation Data Base Access and Management Subsystem

The designed TGSO-TDSS utilizes a relational TDBAM Subsystem for reducing computation time and effort for supportive repetitive interaction processes. The main task of the TDBAM Subsystem is the simplification, preparation, and pre–processing of input data of Transportation Target Areas ($TTA_j$) of Millennium Cities of India ($MCI_i$) and also control and verify the bulk of data required by the Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model. The relational database, which is comprised of daily traffic and transport analysis report as reported by traffic and transportation agencies after pre-processing provides reliable data for necessary policy framework.

### 2.3 Central Transportation Vision Navigator Board

The designed TGSO-TDSS is based on a central black board problem solving architecture where Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model based Optimization Vision Technology (OVT) Base interact through a CTVN Board. In this CTVN-Board common database and specialized TGSO Model based Optimization Vision Technology (OVT) Base sources act upon a central black board problem-solving architecture, according to a strategy aiming at identifying and selecting innovative strategic optimal Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$, both cooperatively and opportunistically.

The CTVN-Board is based on independent and interactive knowledge-based agents such as data completion, data analysis, information visualization, prediction and control functions. It stores a representation of the traffic and transportation problems structure of the Millennium Cities of India ($MCI_i$) and provides a facility for viewing the generation of prioritized course of action chart in real time, as a result of simulation its visual presentation assists cognition and early decision-making. The CTVN-Board is basically communication medium its modular and distributed computing environment allows a kind of parallel processing and reasoning with the integration of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model based OVT-Base and System Users.

### 2.4 Optimization Vision Technology Base

The multicriteria and futurologistic approach of OVT-Base comprising of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model provides an effective dimension to deal with complex traffic and transportation problems structure of the Millennium Cities of India ($MCI_i$). The Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model based OVT-Base provides high levels of mutual affinity and fast decision-making in a virtual meeting environment.

#### 2.4.1 Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model

The Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base provides a comprehensive structured vision communication system framework for the identification and selection of innovative strategic optimal transportation strategic decision indicators ($TSDI_k$) with their respective optimized weights $W_k$ for the strategic optimization of Transportation Target Areas ($TTA_j$) of Millennium Cities of India ($MCI_i$). The main steps of Transportation System-Genetic Algorithm-Strategic

Decision Target Detection and Optimization (TGSO) Model are: generation of set of solutions known as population, evaluation of the chromosomes (fitness function), operations of Genetic algorithm: reproduction operation, crossover operation, and mutation operation. The main purpose of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base is to manage the transportation system; help the commuters by saving travel time; minimizing travel costs; improving the quality, safety, and security of commuters; identifying and selecting innovative strategic optimal transportation strategic decision indicators ($TSDI_k$) with their respective optimized weights $W_k$.

If Decision Targets ($DT_j$), where $j = 1,2, \ldots\ldots, n$ of Indian road transportation system has $n$ different types of Transportation Target Areas ($TTA_j$) for the Data Set ($DS_i$): Millennium Cities of India ($MCI_i$), where $i = 1,2, \ldots\ldots, c$ and the numbers of responsible innovative strategic Decision Variables ($DV_k$): Transportation Strategic Decision Indicators ($TSDI_k$), where $k = 1,2, \ldots\ldots, m$ for each Decision Target ($DT_j$): Transportation Target Areas ($TTA_j$) is $m$, then a Chromosome $(Ch_r)$, where $r = 1,2, \ldots\ldots, t$ can be represented by a matrix having $(m \times n)$ real numbers. The gene $g_{kj} \in [-1, +1]$ of the chromosome represents the $k^{th}$ responsible innovative strategic Transportation Strategic Decision Indicators of the $j^{th}$ Transportation Target Areas for Millennium Cities of India ($MCI_i$) and the positive/negative sign with the value of the gene specify the mutual relationship. The fitness function of chromosome represents the quality performance of different chromosome and also evaluates its closeness with the solution i.e., it represents the number of correct classifications across the entire $MCI_i$.

For the target Data Set ($DS_i$), an occurrence $O_k$ $(1 \leq k \leq U)$ with total $U$ occurrences is represented by $(o_{k1}, o_{k2}, \ldots\ldots, o_{k\,l}, \ldots\ldots, o_{km})$, where $o_{kl}$ $(1 \leq l \leq m)$ denotes the value of the Decision Variables $l$ in occurrence $O_k$. For the occurrence $O_k$, the value of Classification result $(Cr_k)$ of a Chromosome $(Ch_r)$ is denoted by: $Cr_k$= Max $\left\{n_{kl} \mid n_{kl} = \sum_{q=1}^{m} o_{kq}.(Ch_r)_{ql}, 1 \leq l \leq n\right\}$. Now for the occurrence $O_k$, if the value of Ground truth $(Grt_k)$ is matching with the $Cr_k$, then the Indication function $(If_k)$ is represented by one; otherwise by zero. Thus, for Chromosome $(Ch_r)$, its Fitness function $Ff(Ch_r)$ value is obtained as:

$$Ff(Ch_r) = \frac{\sum_{k=1}^{U} If_k}{U}$$

The Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base is basically based on amalgamation of selection operation, crossover operation and mutation operation. The fitness of chromosomes is the main criteria of selection operation. The selection operation should ensure that only fittest chromosomes have more probability to survive. Here, the Population has $M$ Chromosomes and the Selection Probability for each Chromosome $(Ch_r)j$ is derived using:

$$P_S(Ch_r)j = \frac{f(Ch_r)j}{\sum_{l=1}^{M} f(Ch_r)l} \quad .$$

In this Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base, Roulette Wheel Selection (RWS) method is used to select the Chromosome $(Ch_r)j$ using uniformly Random number $R_n \in [0, 1]$ which satisfies the following condition:

$$\sum_{l=0}^{j-1} P_S(Ch_r)j < R_n \leq \sum_{l=0}^{j} P_S(Ch_r)j \text{ , where } P_S = 0 \text{ for } l = 0$$

This RWS method provides better reproductive chances to reproduce for populations having high fitness value. The following special crossover operation is employed in this Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base for identifying and selecting responsible innovative strategic optimal Decision Variable ($DV_k$): Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$:

Let $\alpha$ is a stochastic matrix of the order $(m \times n)$ and the value of every element should lie randomly in the interval [0,1]. $Ch_1$ and $Ch_2$ are two selected parent Chromosomes, and performing crossover operation they generate $Ch_1^{New}$ as first new chromosome and $Ch_2^{New}$ as second new chromosome using Crossover Probability ($P_C$ ):

$$Ch_1^{New} = \alpha . Ch_1 + (1-\alpha). Ch_2 \quad \text{and} \quad Ch_2^{New} = (1-\alpha). Ch_1 + \alpha . Ch_2$$

Random Substitution (RS) technique is used in this TGSO Model of OVT Base for performing mutation operation to identify and determine responsible innovative strategic optimal Decision Variable ($DV_k$): Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$. In RS technique, the Chromosome ($Ch_r$) that participate in mutation is replaced by a new randomly generated Chromosome ($Ch_r$) using Mutation Probability ($P_M$). Chromosomes ($Ch_r$) having high Fitness function $Ff(Ch_r)$ value has always better probability for selection in the next iteration and after numerous iterations the value of best Chromosome ($Ch_r$) will converge to a final value and TGSO Model of OVT Base will ensure an optimum or near to optimum solution.

### 2.5 Transportation Decision Making and User Desk

The TDMU-Desk is primarily intended to be used by system users and transportation system decision members, playing important roles in the strategic planning, management control, operational planning and transaction processing to identify and determine responsible innovative strategic optimal Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$ to strategically optimize Transportation Target Areas ($TTA_j$) to reduce the different traffic and transportation problems of Millennium Cities of India ($MCI_i$). TDMU-Desk not only supports transportation executives, managers, and analysts at strategic, tactical, and operational levels but also supports additional users at lower hierarchical levels and other staff members responsible for lower-level analysis, inputting data, and keeping the transportation database up to date and its major function is to support the three common activities - retrieval, sharing and use of information.

There is a great need for expertise sharing between transportation system decision makers and transportation system experts which is very much essential when a complex decision problem like traffic and transportation problems of Millennium Cities of India ($MCI_i$) is to be divided into $TTA_j$, each of which is then solved by expert groups within the team for effective decision-making. The main factor in an effective and efficient transportation decision making, is the need for healthy interaction between the system users, transportation system decision makers, and transportation system experts during the decision making process to focus on quality based information visualization. TDMU-Desk is thus mainly responsible for detecting traffic and transportation problems of Millennium Cities of India ($MCI_i$), elaborating on the nature of the problem, generating possible decision solutions, evaluating potential decision solutions, and formulating strategies for implementing decision solutions by using the capabilities of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model of OVT Base.

### 2.6 Dialog Management Subsystem

The DiaM Sub-system is designed for the system users, transportation system decision makers and transportation system experts of the Indian transportation system with a variety of decision-making needs related to traffic and transportation problems of Millennium Cities of India ($MCI_i$). The system users are able to select their area of interest $TTA_j$. The DiaM Sub-system captures the system users, transportation system decision makers, and transportation system experts preferences, degree of expertise, and skills and then receives and interprets their input, which is conveyed to CTVN-Board. The DiaM Sub-system capabilities are broadly classified into three categories: Transportation Decision Queries Support (TDQS) Server, Transportation Decision Exchange Support (TDES) Server, and Transportation Decision Execution Management (TDExM) Server due to variety of system users with different decision-making tasks. While TDQS Server allows adhoc retrieval of traffic and transportation problem information of Millennium Cities of India ($MCI_i$), TDES Server supports the $TTA_j$ Decision Questions while TDExM Server supports the decision execution tasks and allows the system users to generate a number of displays from the data available in the system, into the pre-defined format.

The processed data from the TDBAM Subsystem is accepted as the input data for OVT Base which uses Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model having several capabilities, and after the interaction with TGSO Model, the output results are first transmitted in real-time to the CTVN-Board having central vision navigator black board problem solving architecture, and finally to the TDMU Desk, for analysis and decision.

## 3. Strategic Optimization of Transportation Target Areas of Millennium Cities of India using TGSO Model:

In this research study for strategic optimization of Decision Target ($DT_j$): Transportation Target Areas ($TTA_j$) by identifying and determining responsible innovative strategic optimal Decision Variable ($DV_k$) : Transportation Strategic Decision Indicators ($TSDI_k$) with their respective optimized weights $W_k$, using Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization (TGSO) Model, a total 41 target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$) [ https://worldpopulationreview.com/countries/cities/india ] were selected to reduce and manage their traffic and transport related crucial problems. Majority of these selected cities are continuously facing one or another type of severe, crucial and complex traffic and transport related problems due to lot of technical or nontechnical factors. The selected Millennium Cities of India ($MCI_i$) were then ranked as a priority from 0 not important to 10 very important by using Modified Delphi Technique [20]. After three rounds of Modified Delphi Technique, total 35 target Millennium Cities of India ($MCI_i$) (Figure 1) were then prioritized for immediate attention.

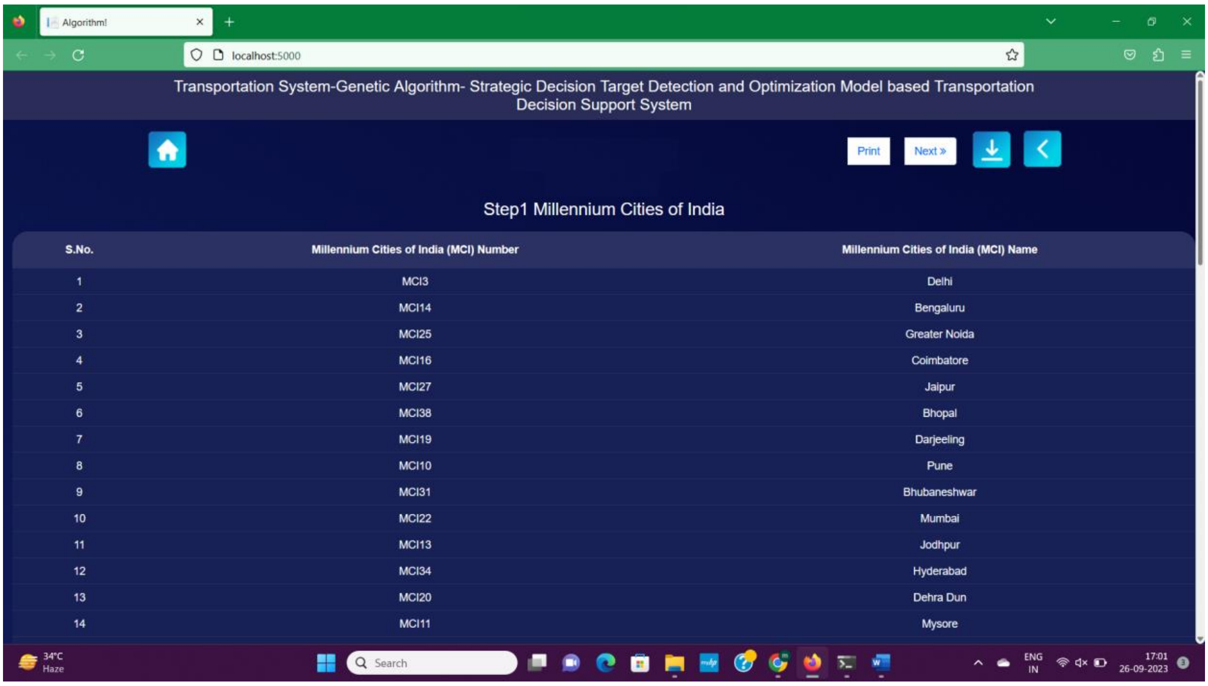


**Fig.1: Prioritized Millennium Cities of India ($MCI_i$)**

Three multi-functional core groups consisting of Group-A: target millennium cities transportation expert group having total 174 eminent researchers, experts, futurologists and professors from IITs, IIMs, IIITs, NITs, Central Institute of Road Transport (CIRT), Ministry of Road Transport and Highways, Ministry of Housing and Urban Affairs, CSIR-Central Road Research Institute New Delhi and Institute of Urban Transport (India); Group-B: target millennium cities knowledgeable residents group having total 86 residents and Group-C: target millennium cities road users group having total 2798 road users namely pedestrians, cyclists, motorcyclists, scooterists, bus commuters, licensed auto-cars-jeeps-bus drivers, private cars-jeeps owners, and straphangers helped in observing, judging and screening different types of severe, crucial, and complex traffic and transport related problems faced by majority of prioritized target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$) and then strategically detecting and categorizing the various crucial and important Decision Target ($DT_j$) i.e. Transportation Target Areas ($TTA_j$) of Indian road transportation system which signifies the different traffic and transport related crucial and severe problems of prioritized target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$).

On the basis of input received from different members of Group-A, Group-B and Group-C through e-mails and mobile numbers, total 177 crucial and important Transportation Target Areas ($TTA_j$) of prioritized target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$) were classified and tabulated. The total 177 strategically detected and categorized $TTA_j$ were then ranked by using three rounds of Modified Delphi Technique and total 12 highest prioritized $TTA_j$ (Figure 2) for prioritized target $MCI_i$ were then selected. These selected highest prioritized $TTA_j$ supported the creation of top-level strategic decision target thrusts that should be addressed for traffic and transport related crucial and severe complex problems of prioritized target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$) and then using TGSO Model these highest prioritized $TTA_j$ were finally strategically optimized.


| S.No. | Transportation Target Areas (TTA) Number | Transportation Target Areas (TTA) Name |
|---|---|---|
| 1 | TTA2 | Traffic Congestion |
| 2 | TTA19 | Road Accidents |
| 3 | TTA1 | Environmental Pollution |
| 4 | TTA4 | Traffic Management |
| 5 | TTA11 | Road Maintenance |
| 6 | TTA3 | Road Safety |
| 7 | TTA12 | Public Awareness |
| 8 | TTA13 | Public Transport |
| 9 | TTA20 | Increase in Fuel Prices |
| 10 | TTA21 | Traveler Information System |
| 11 | TTA8 | Parking Space Issue |
| 12 | TTA18 | Difficulties for Pedestrians |

**Fig.2: Highest Prioritized Transportation Target Areas ($TTA_j$)**

Group-A and Group-B also helped in identifying and determining the total 589 innovative strategic optimal Decision Variables ($DV_k$): Transportation Strategic Decision Indicators ($TSDI_k$), which are mainly responsible finally for the strategic optimization of the detected and categorized $TTA_j$, for the prioritized target Data Set ($DS_i$). Normally, there are lot of $TSDI_k$ which are mainly responsible to increase/decrease or maximize/minimize the specific $TTA_j$ but it is more significant for different users with various roles (system users, transportation planners, transportation engineers, traffic administrators, transportation system decision makers and transportation system experts) to select only the significant, relevant, innovative and strategic optimal $TSDI_k$ and discarding the redundant and irrelevant ones to minimize the execution cost and time.

The total 589 identified and determined $TSDI_k$ were also ranked by using Modified Delphi Technique and after three rounds, total 66 highest prioritized significant, relevant, innovative and strategic optimal $TSDI_k$ were then selected for the strategic optimization of the 12 highest prioritized $TTA_j$. The 66 highest prioritized strategic optimal $TSDI_k$ were encoded by using the three-value ordinal scale: 1(for largest presence, affecting seriously), 0 (for absence, the lowest level), 0.5 (medium or normal range) for each prioritized target $MCI_i$ and the values of Ground truth ($Grt_k$) were also mentioned for each prioritized target $MCI_i$. A total of 10 Chromosomes ($Ch_r$) were generated while Crossover Probability ($P_C$ ) and Mutation Probability ($P_M$) was 0.8 and 0.2 respectively. Total four cross validation runs of the TGSO Model converges to the best Chromosomes ($Ch_r$) ensuring an optimum or near to optimum solution and then the results were evaluated. The Visual Studio 2010 Platform was used as a front-end application for the development of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System (TGSO-TDSS). The SQL Server 2008 was used as a back-end application for preparing the database. The TGSO Model was developed with PHP programming language using Apache server.

## 4. Results

The best result obtained from the fourth run of the TGSO Model is presented here. The optimality reached after 13th iteration and generated best Chromosome ($Ch_8$) (Figure 3) for 12 highest prioritized strategically optimized Transportation Target Areas ($TTA_j$) with only 15 most responsible and crucial strategic optimal $TSDI_k$ having highest optimized weights $W_k$ out of total 66 $TSDI_k$ in a set of competing futuristic alternatives of the prioritized target Data Set ($DS_i$): Millennium Cities of India ($MCI_i$), as main output results which were first sent in real-time to the Central Transportation Vision Navigator (CTVN) Board having central vision navigator black board problem solving architecture and then these main output results with action plans were finally sent to Transportation Decision Making-User Desk (TDMU-Desk) of Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System (TGSO-TDSS) for critical analysis, strategic decision and final action.

The generated main output results were evaluated to measure the performance of the designed and developed TGSO Model and it is very encouraging that the range of specificity and sensitivity calculated for all the 12 highest prioritized strategically optimized Transportation Target Areas ($TTA_j$), is between 93-98 % and 84-92% respectively and the mean accuracy of developed Model is 96%, which clearly matched with the opinion of the eminent Indian transportation experts and researchers.


| Transportation Target Areas (TTA)> Transportation Strategic Decision Indicators(TSDI) below | TTA2 | TTA19 | TTA1 | TTA4 | TTA11 | TTA3 | TTA12 | TTA13 | TTA20 | TTA21 | TTA8 | TTA18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TSDI5 | -0.067152077 | -0.024377557 | 0.182280738 | -0.37862379 | -0.502070726 | 0.306571956 | 0.195000462 | 0.472785288 | 0.240477094 | 0.181696437 | -0.37724112 | 0.544450378 |
| TSDI8 | -0.166203543 | 0.152630553 | 0.143186315 | 0.23561869 | 0.687437101 | -0.039552281 | 0.961363765 | -0.665399248 | 0.396248965 | 0.031653489 | -0.240026822 | 0.333368327 |
| TSDI9 | 0.115745289 | 0.449807539 | 0.209249979 | 0.653555968 | 0.238971583 | -0.098015474 | 0.570092607 | 0.636608203 | 0.430955786 | 0.868561256 | -0.053985041 | -0.501807488 |
| TSDI13 | 0.331132723 | -0.215248766 | 0.990824249 | 0.231222871 | 0.199640044 | -0.099101512 | -0.297682965 | 0.473385095 | -0.147411392 | 0.277458251 | 0.038282228 | -0.571057498 |
| TSDI22 | 0.384169751 | 0.20180084 | 0.372156343 | 0.331425643 | 0.383072481 | 0.367554621 | 0.48876247 | 0.462102945 | 0.072635977 | 0.155137892 | 0.297062565 | 0.065662373 |
| TSDI60 | 0.601914143 | -0.707682001 | 0.020754304 | -0.178672454 | -0.315131339 | -0.520407632 | -0.432302413 | 0.309215808 | 0.793371141 | 0.363018885 | 0.038550127 | 0.154370747 |
| TSDI65 | 0.090461982 | -0.037019975 | 0.340523595 | -0.241011593 | 0.079627935 | 0.45805578 | 0.015823879 | 0.55335221 | -0.786168159 | 0.313093755 | 0.30276344 | -0.942753201 |
| TSDI68 | 0.207387569 | 0.696744988 | 0.712059963 | 0.529840425 | 0.814681797 | 0.456196921 | 0.502651922 | 0.320921385 | 0.110200423 | 0.484134504 | 0.453129155 | 0.198569704 |
| TSDI69 | 0.631624753 | 0.553796797 | 0.4178562 | -0.594317769 | -0.323369229 | 0.271638481 | 0.420778542 | 0.731928045 | 0.420598632 | 0.358186195 | -0.347537243 | 0.540557731 |
| TSDI75 | 0.640852078 | 0.095648514 | 0.1438501 | 0.128942401 | 0.155893991 | 0.47662244 | 0.231390468 | 0.857416584 | 0.328320369 | 0.162474621 | -0.950198224 | 0.133811204 |
| TSDI89 | -0.126485815 | -0.599123793 | 0.151123899 | -0.988745213 | 0.376812216 | 0.44671021 | 0.127831931 | 0.089126687 | 0.071090437 | -0.292979937 | -0.061835694 | -0.56763366 |
| TSDI105 | -0.042173086 | -0.851265108 | -0.453218531 | 0.358819507 | 0.236417167 | 0.447655696 | -0.044936184 | -0.16483185 | 0.174344107 | 0.779967249 | 0.530993901 | 0.411756695 |
| TSDI122 | 0.734541207 | -0.243488373 | -0.137488938 | 0.823174992 | 0.521681078 | -0.330234754 | -0.142239539 | 0.405071599 | -0.027754557 | 0.02344599 | 0.546261429 | -0.0100111 |
| TSDI123 | 0.156156458 | 0.886264901 | -0.110063269 | -0.267286211 | 0.247684443 | 0.295197151 | 0.258052486 | 0.596144214 | 0.269154896 | -0.271522207 | 0.219827745 | -0.353476918 |

**Fig.3: Best Chromosome ($Ch_8$) for $TTA_j$ with $TSDI_k$ and Optimized Weights $W_k$**

## 5. Action Plan

The movement of residents, commuters and floating population in Millennium Cities of India ($MCI_i$) is mainly dependent on cycle, motorcycle, scooter, private and government bus, licensed auto-cars-jeeps-tempo and private cars-jeeps. The limited space, poor road condition and heavy growth in traffic has resulted into severe traffic congestion, reduced travel speed, excessive travel time, fatal accidents and poor level of service. Today, Indian traffic and transportation system in majority of $MCI_i$ is operating at its seams with residents and commuters travelling in unbearable, indeed inhuman conditions, with couple of residents, children and commuters either dying or getting injured in road accidents every day. This pathetic traffic and transport situation cannot continue far too long. There is always a danger that the situation might worsen to an explosive stage. So, there is an urgent need to make a serious and urgent attempt for an effective and efficient action plan to improve the overall quality of Indian traffic and transportation system in such $MCI_i$.

To reduce the Decision Target ($DT_2$) i.e., Transportation Target Area ($TTA_2$): Traffic Congestion (TrC) which is one of the major traffic and transport related crucial and severe problems of the Indian road transportation system of the majority of Millennium Cities of India ($MCI_i$), immediate efforts on $TSDI_{367}$: Revolutionize Traffic Light Management ($W_{367}$ = 0.862922455) is the most prioritized strategic optimal $TSDI_k$ and proper policies to check $TSDI_{170}$: Increase in the Number of Vehicles ($W_{170}$ = 0.821744743) on roads is the second most prioritized strategic optimal $TSDI_k$ while $TSDI_{122}$: Encourage the Use of Alternative Routes ($W_{122}$ = 0.734541207) is the third most prioritized strategically optimal $TSDI_k$. To minimize the Decision Target ($DT_{19}$) i.e., Transportation Target Area ($TTA_{19}$): Road Accidents which is becoming an explosive traffic and transport related problems of the Indian road transportation system of the majority of $MCI_i$, immediate efforts on reduction of $TSDI_{447}$: Traffic Volume ($W_{447}$ = 0.973643671) is the most prioritized strategic optimal $TSDI_k$ while strict Enforcement of Rules and Regulations ($TSDI_{123}$, $W_{123}$ = 0.886264901) and Reckless Driving due to Mobile Phones, Food, or other Activities ($TSDI_{346}$, $W_{346}$ = 0.663545609) are the second and third most prioritized strategic optimal $TSDI_k$ respectively.

To minimize the Decision Target ($DT_1$) i.e., Transportation Target Area ($TTA_1$): Environmental Pollution (EP) which is another major burning traffic and transport related problems of the Indian road transportation system of the majority of $MCI_i$, immediate efforts on reduction of $TSDI_{13}$: Air Pollution Level ($W_{13}$ = 0.990824249) is the most prioritized strategic optimal $TSDI_k$ while proper policies to check $TSDI_{170}$: Increase in the Number of Vehicles ($W_{170}$ = 0.806246895) on roads is the second most prioritized strategic optimal $TSDI_k$. The encouragement for $TSDI_{214}$: Long-Term Car Parking ($W_{214}$ = 0.759216424) is the third most prioritized strategic optimal $TSDI_k$. To improve the Decision Target ($DT_4$): Transportation Target Area ($TTA_4$): Traffic Management (TM), which is one of the critical traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, immediate efforts on $TSDI_{367}$: Revolutionize Traffic Light Management ($W_{367}$ = 0.944492264) is the most prioritized strategic optimal $TSDI_k$ while $TSDI_{122}$: Encourage the Use of Alternative Routes ($W_{122}$ = 0.823174992) and Reckless Driving due to Mobile Phones, Food, or other Activities ($TSDI_{346}$, $W_{346}$ = 0.630246523) are the second and third most prioritized strategic optimal $TSDI_k$ respectively.

To improve the Decision Target ($DT_{11}$): Transportation Target Area ($TTA_{11}$): Road Maintenance (RM), which is another very critical traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, Regular Inspections of Potholes, Cracks, and other Damage ($TSDI_{348}$, $W_{348}$ = 0.937440103), Communication between Road Maintenance Crews and the Public ($TSDI_{68}$, $W_{68}$ = **0.814681797**) and Sustainable Funding ($TSDI_{416}$, $W_{416}$ = 0.742619077) are the first, second and third most prioritized strategic optimal $TSDI_k$ respectively. To enhance the Decision Target ($DT_3$) i.e., Transportation Target Area ($TTA_3$): Road Safety (RS) which is one of the major traffic death related crucial traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, proper strict implementation of $TSDI_{357}$: Speed Limit ($W_{357}$ = 0.960701421) is the most prioritized strategic optimal $TSDI_k$. Road Damages ($TSDI_{373}$, $W_{373}$ = 0.522481695) and Reckless Driving due to Mobile Phones, Food, or other Activities ($TSDI_{346}$, $W_{346}$ = 0.419465131) are the second and third most prioritized strategic optimal $TSDI_k$ respectively.

To improve the Decision Target ($DT_{12}$) i.e., Transportation Target Area ($TTA_{12}$): Public Awareness (PA) which is one of the weakest public related traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, immediate implementation of $TSDI_8$: Public Awareness Programs and Strategies ($W_8$ = 0.961363765) is the most prioritized strategic optimal $TSDI_k$. Extensive use of Social Media Platforms ($TSDI_{403}$, $W_{403}$ = 0.527483223) and Organizing Public Events ($TSDI_{278}$, $W_{278}$ = 0.459256829) are the second and third most prioritized strategic optimal $TSDI_k$ respectively. To improve the Decision Targets ($DT_{13}$): Transportation Target Area ($TTA_{13}$): Public Transport (PT), which is one of the most critical traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, increase in the Frequency of Bus ($TSDI_{146}$, $W_{146}$ = 0.963295173), excellent Connectivity and convenience ($TSDI_{75}$, $W_{75}$ =0.857416584) and admirable Commuters Satisfaction and Safety ($TSDI_{69}$, $W_{69}$ = 0.731928045) are the first, second and third most prioritized strategic optimal $TSDI_k$ respectively.

To improve the Decision Targets ($DT_{20}$): Transportation Target Area ($TTA_{20}$): Increase in Fuel Prices (IIFP) which is one of the major burning traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, Use of Viable Alternatives ($TSDI_{558}$, $W_{558}$ = 0.854772314), Use of Electric Vehicles ($TSDI_{549}$, $W_{549}$ = 0.809455896) and use of CNG Vehicles ($TSDI_{60}$, $W_{60}$ = 0.793371141) are the first, second and third most prioritized strategic optimal $TSDI_k$ respectively. To improve the Decision Targets ($DT_{21}$): Transportation Target Area ($TTA_{21}$): Traveler Information System (TInfo) which is one of the critical traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, immediate introduction of Real-time Traffic Information ($TSDI_{342}$, $W_{342}$ = 0.886264901), proper Accuracy and Timeliness ($TSDI_9$, $W_9$ = 0.868561256 ) of information and Ease of Use ($TSDI_{105}$, $W_{105}$ = 0.779967249 ) are the first, second and third most prioritized strategic optimal $TSDI_k$ respectively.

To improve the Decision Targets ($DT_8$): Transportation Target Area ($TTA_8$): Parking Space Issue (PSI) which is also one of the most crucial and severe traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, Off Street Parking Facilities ($TSDI_{266}$, $W_{266}$ = 0.990824249), On-street Parking ($TSDI_{270}$, $W_{270}$ = 0.779967249) and Parking Duration ($TSDI_{290}$, $W_{290}$ = 0.734541207) are the most, second most and third most prioritized strategic optimal $TSDI_k$ respectively. To improve the Decision Targets ($DT_{18}$): Transportation Target Area ($TTA_{18}$): Difficulties for Pedestrians (DfP) which is also one of the most critical traffic and transport problems of the Indian road transportation system of the majority of $MCI_i$, Traffic Volume ($TSDI_{447}$, $W_{447}$ = 0.740743793), Use Footbridges and Underpasses ($TSDI_{535}$, $W_{535}$ = 0.579927069) and Obstruction by Parked Cars ($TSDI_{265}$, $W_{265}$ = 0.501476207) are the most, second most and third most prioritized strategic optimal $TSDI_k$ respectively.

## 6. Conclusions

In this research paper, a Transportation System-Genetic Algorithm-Strategic Decision Target Detection and Optimization Model based Transportation Decision Support System is designed and developed for the strategic optimization of highest prioritized Transportation Target Areas by identifying and selecting most responsible and crucial strategic optimal Transportation Strategic Decision Indicators with their respective optimized weights to reduce and manage the traffic and transport related crucial problems of the transportation system of Millennium Cities of India. Total four cross validation runs of the model converges to the best Chromosomes ($Ch_r$) and then the results were evaluated. The range of specificity and sensitivity was calculated for all the highest prioritized strategically optimized Transportation Target Areas and it lies between 93-98 % and 84-92% respectively. The mean accuracy of developed model was 96%, and the output results clearly matched with the opinion of the eminent Indian transportation experts and researchers. The designed and developed Transportation Decision Support System is very robust and bound to draw great attention in near future as one of the most emerging strategic optimization decision making complex tool for reducing the transport and traffic related crucial problems and will definitely improve the quality, efficiency, safety and security of present poor Indian transportation system of Millennium Cities of India.

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**Refrences**

[1] F. Sun, A. Dubey, J. White and A. Gokhale (2019) “Transit-hub: A smart public transportation decision support system with multi-timescale analytical services” Cluster Computing, 22, 2239-2254.

[2] C. H. Glock (2017) “Decision support models for managing returnable transport items in supply chains: A systematic literature review” International Journal of Production Economics, 183, 561-569.
[3] V. Torretta, E.C. Rada, M. Schiavon and P. Viotti (2017) “Decision support systems for assessing risks involved in transporting hazardous materials: A review” Safety science, 92, 1-9.
[4] M. Yazdani, D. Pamucar, P. Chatterjee and S. Chakraborty (2020) “Development of a decision support framework for sustainable freight transport system evaluation using rough numbers” International Journal of Production Research, 58(14), 4325-4351.
[5] R. Golini, C. Guerlain, A. Lagorio and R. Pinto (2018) “An assessment framework to support collective decision making on urban freight transport” Transport, 33(4), 890-901.
[6] C. H. Glock (2017) “Decision support models for managing returnable transport items in supply chains: A systematic literature review” International Journal of Production Economics, 183, 561-569.
[7] M. N. Mladenovic, K. Mangaroska and M. M. Abbas (2017) “Decision support system for planning traffic operations assets” Journal of Infrastructure Systems, 23(3), 05017001. http://dx.doi.org/10.1061/(ASCE)IS.1943-555X.0000358
[8] E. Papatzikou and A. Stathopoulos (2018) “Decision support system for network traffic control risk management” Int J Sci Eng Res, 9(10), 1848-1857.
[9] A. Petrillo, P. Carotenuto, I. Baffo and F. De Felice (2018) “A web-based multiple criteria decision support system for evaluation analysis of carpooling” Environment, Development and Sustainability, 20, 2321-2341.
[10] T. Zhang, J. Guo, and Q. Yan (2018) “Optimization of hazardous pol transportation problem based on simulated annealing genetic algorithm” Chemical Engineering Transactions, 66, 1471-1476.
[11] N. Saharkar, M. Wanjari (2018) “A Genetic algorithm based approach to solve transport problems for school buses” Journal of Engineering and Applied Sciences, 13(4), 848-851.
[12] M. Abbasi, M. Rafiee, M. R. Khosravi, A. Jolfaei, V. G. Menon and J. M. Koushyar (2020) “An efficient parallel genetic algorithm solution for vehicle routing problem in cloud implementation of the intelligent transportation systems” Journal of cloud Computing, 9, 1-14.
[13] H. Dezani, R. D. Bassi, N. Marranghello, L. Gomes, F. Damiani and I. N. Da Silva (2014) “Optimizing urban traffic flow using Genetic Algorithm with Petri net analysis as fitness function” Neurocomputing, 124, 162-167.
[14] S. Chiappone, O. Giuffrè, A. Granà, R. Mauro A. Sferlazza (2016) “Traffic simulation models calibration using speed–density relationship: An automated procedure based on genetic algorithm” Expert Systems with Applications, 44, 147-155.
[15] M. Tahir, A. Tubaishat, F. Al-Obeidat, B. Shah, Z. Halim and M. Waqas (2022) “A novel binary chaotic genetic algorithm for feature selection and its utility in affective computing and healthcare” Neural Computing and Applications, 1-22.
[16] L. Manzoni, L. Mariotand E. Tuba (2020) “Balanced crossover operators in genetic algorithms” Swarm and Evolutionary Computation, 54, 100646.
[17] C. K. H. Lee (2018) “A review of applications of genetic algorithms in operations management” Engineering Applications of Artificial Intelligence, 76, 1-12.
[18] A. Sohail (2023) “Genetic algorithms in the fields of artificial intelligence and data sciences” Annals of Data Science, 10(4), 1007-1018.
[19] B. Alhijawi and A. Awajan (2023) “Genetic algorithms: Theory, genetic operators, solutions, and applications” Evolutionary Intelligence, 1-12.
[20] R. Bryar, S. Anto-Awuakye, J. Christie, C. Davisand K. Plumb (2013) “Using the Delphi approach to identify priority areas for health visiting practice in an area of deprivation” Nursing research and practice, 2013.