A Systematic Design of Multimodal Integrated Transportation Services

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***Abstract*: Over the last decade numerous Mass Rapid Transit Systems have come up in various cities like Metro Rails, Bus Rapid Transit Systems and Monorails. The interlinking of these various public transport modes and various other modes is now the important issue from user point of view and opportunity from planners' point of view, for seamless travel across the various modes and sustainability of the overall public transportation network in the city. This paper is an attempt to understand the Integrated Multi-Modal Urban Transportation for India. With the help of Delhi case study, efforts are made to identify the advantages, disadvantages and challenges of Integrated Multi-Modal Urban Transportation for Indian cities.**

***Keywords*: Bus Rapid Transit Systems and Monorails, of Delhi case study and Multi-Modal Urban Transportation**

1. INTRODUCTION

The Multi Model Transport System (MMTS) includes a combination of one-way modes: vehicle mode (bus, subway, car, tram, etc.) or service mode (private/public), between which commuters have to move. Transfer is an important part of multimodal movement, including mode changes at the transfer node. Thus, seamless movement is an important feature of the system. As it is important to assess the travel needs of multimodal transport services, commuting preferences and preferences, and related relocation needs, should be assessed throughout the travel chain. However, service attributes (time, reliability, etc.) and information about the service can affect the behavior of the trip selection.

Planning for Integration

Integration is important to the need for sustainable development and public transport response. For example, the best way to solve the traffic problem in Delhi is to establish a public transport infrastructure. New public transport, i.e. subways, ports, light rails, etc., need to be properly connected.

Planning and Design of Interchange

Exchange and smooth travel is now an important part of an integrated transport strategy. Exchange is a key element of modern transportation networks and is part of the infrastructure involved in diverse activities. Therefore, one of the starting points for public transport is the key to the first interaction between the user and the available public transport services. The following points should be considered in the exchange plan:

Define the exchange location in the transport network to fulfill the transport function.

- Define interchange the layout for smooth transition.
- The current line interchange location provides efficient access to the current transport network.
- The existing route exchange location provides efficient access to the existing transportation network.

2. MULTIMODAL TRANSPORT

Various transportation (railway, sea, highway etc.). Carriers does not need all the resources of transport and is generally available; Transportation is generally done by sub-actions, which are legally called sub-operations "Real Carriers". "As. Responsible career for full transportation is called multi-mode carrier or MTO.

2.1 Multi Modal Transport System

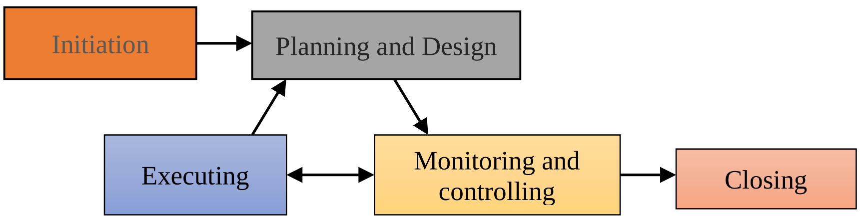

Figure 1. Various Stages in Project Development

The impact models obtain input data from demand models and network models. It integrates different impact models to analyze and evaluate the traffic system. The user's model listened to the movement of movement of public transport passengers and car drivers. Based on the routing and assignment model, calculate traffic and service metrics such as travel time, number of times service frequency was sent, and so on. When the route and assignment process combine different patterns of travel or travel chains, it is called "modal". The operator model determines the operational indicator of public transport services, such as car kilometers, car number, or operating costs. When combined with demand data, you can estimate the profitability of a line. Environmental impact models provide several ways to assess the environmental impact of automobile traffic.

2.2 INTEGRATED MULTI MODAL TRANSPORT SYSTEM

Integrated Multi-Modal Transmission System (IMMT), including two or more modest transport modes, such as buses, subways, cars, tram etc. government or private enterprise, intermediate passenger's transition to other modes is needed. Some vehicles are always dependent on other means of transportation. And the local authorities have defined trucks for them. This multimodal system can support cities with high urbanization and high population density. IMMT's the main objective is to promote public transportation in urban areas. Various modes of integration and integration can reduce the speed of the road and provide passengers with the effect of more convenience, efficiency and cost. In this case, the multimodal transportation system is a single system for all elements of urban transportation to effectively utilize the available transportation resources and infrastructure to achieve more in different modes of commuting. Integrated approach to Good maneuverability.

2.3 The Various Characteristics of IMMTS Are As Follows

- Travel relating to several migration methods.
- Accept different transport modes for different possibilities.
- This strategy does not usually focus on a single model.
- Build a smooth network that meets the side transport of railways, railways and waterways.
- Competition between carriers rather than competition between means of transport
- Transport node and smooth exchange process
- Seamless movement is an important feature of the system.

3. DESIGN APPROACH OF MULTIMODAL TRANSPORTATION SYSTEM

The Multimodal Transport System (MMTS) includes a combination of one-way mode, i.e. vehicle mode (bus, subway, car, tram, etc.) or service mode (private/public).

Figure 2. Multimodal Transport Trip (Transfer Point is Denoted by the Bold T)

The various features of the MMTS are travel involving multiple means of transportation. Policy principles build a seamless integrated transport chain network without connecting to a single mode, connect roads, railways, and waterways, and promote competition between transport vehicles rather than transport modes. Smooth exchange flow, an important feature of the seamless travel system.

3.1 Main characteristics

The goal of transport network design is to determine the network with the best performance given the specific design goals. There are a series of decision variables that determine the characteristics of the network, while the goal is to evaluate network performance. Clearly, as the size of the problem grows, the number of possible solutions increases beyond the index, making it an unmanageable issue. It has been shown that the simplest form of network design problem is NP-complete, i.e., algorithms other than small networks cannot solve the network design problem within acceptable computation time.

3.2 Multimodal Transport Network Design

Transport systems with multiple modes can be viewed from two different conceptual are as follows:

Intermodal Transportation Network: Logistics system connecting to two or more modes. Each mode has a service feature that usually allows the cargo (or passenger) to move to another existing mode while traveling from the departure point to the destination.

Multimodal Transportation Network: A set of transmission modes that provide destination-related connections, even if multi-mode transmission is available. A network model describes one side of a transportation system consisting of several supply systems. Each supply system is modeled as "private transport" or "public transport" and uses specific transportation means (cars, heavy goods carriers, bicycles, buses, trains, light rails, etc.).

4. MAIN CHARACTERISTICS

The main literature on transport network design focuses on single mode or transport services and single level networks. Typical examples are city or country road networks, and city or country public transport service networks. However, multimodal transportation systems are configured with several transportation services and different network levels, which may have different operators and agencies. Three dimensions of different operators or authorities are analyzed. The highest level Network Level 3 is characterized by rough networks, limited accessibility and speed, and is ideal for long distance travel. On the other hand, the lowest network level is fine-grained, with high accessibility and low speed, and is suitable for short distance travel and access to higher network levels.

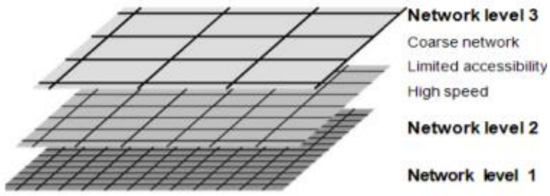

Figure 3. Illustration of multilevel network

There is a horizontal transport service that distinguishes between private mode and public mode. Examples of private modes include private cars (cars), bicycles (human cars) and walks (without cars), but in public mode differentiated line services and demand-oriented services (such as sharing)-boarding concept. On the vertical axis are the various network levels that can be identified, which are closely related to the distance traveled. For each delivery service, the gray area indicates the range of distances it may be suitable for. Many transport services can distinguish between different network levels.

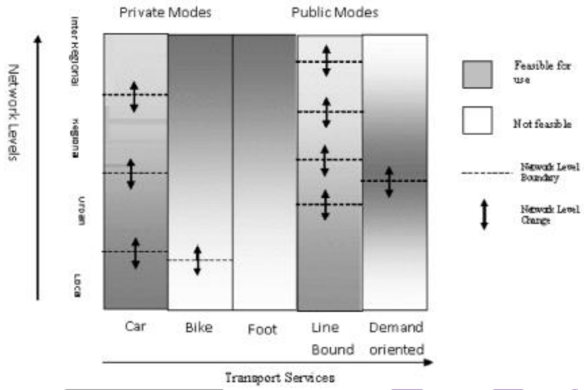

Fig 4: Transport Service

Multilevel transport networks are closely related to multimodal transport networks. The patterns used to access different modes suitable for a particular trip introduce a hierarchical relationship between the two modes, thus introducing a hierarchical relationship between the networks levels used. The concept of a multi-level transport network can also be applied to the description of travel behavior. Bovey's Analysis (1981, 1985) suggests that the private transport network organizational can improve the choice of bicycle drivers and car drivers in the city.

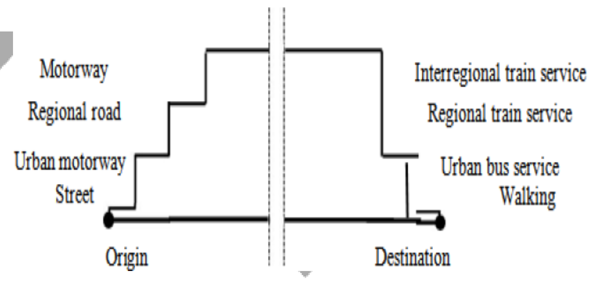

Figure 5 Example of pyramidal route choice for private car (left-hand side) and line bound public transport services (right-hand side)

The notion of explicitly using a hierarchical transmission system for route selection is called pyramid route selection. Figure 5 shows an example of a network level example of a long-distance private car and wired public transport. Of course, in multimodal transport systems, you can use private cars to get into inter-area train service and have similar expressions. The concept of multilevel networks introduces a second relationship between network levels. Low level networks are used to access high level networks.

5. SIMULATION

Multimodal transportation (MMT) plays an important role in international logistics. Multimodal transport is commonly known referred to as a combination of two or more methods of transport of goods, such as road, rail or sea. With multimodal transportation development, Multimodal transportation research also increases. Multimodal Transportation refers to a transport system that is usually running through a carrier and has multiple modes of transport under the control of the operator or under ownership. It involves more than one type of movement, such as trucks, railways, a combination of aero-plane or ships, for example, a container way, a ship and rail system that can run double stack trains. However, the carrier does not need all the resources of transport, which is usually not in this case. Generally transport is usually performed by using actual language substances called as actual carriers.

Responsible for entire transportation or entire transportation is referred Multimodal Transport Operator (MTO). The above mentioned parallel transport is explained: International Multimodal transportation contract from one country to transportation in at least two different ways, which is under multimodal transportation.

6. RESULTS

6.1 DATA SOURCE

Delhi is a biggest metro city in India. This metro city has more people and more traffic problems, so we can reduce traffic by increasing rotary capacity. Collect the necessary hourly traffic data and peak hours in rotary. The choice of a rotary intersection depends on the principle of the target population, which may represent the size and number of roundtables. This allows for capacity analysis by collecting traffic data and monitoring some engineering features. The name of the specified rotor appears in Table 5.1. Data on family travel and transportation were collected. This trip collection is also the distance covered by each trip. According to the population data collected in the past population and employment distribution studies, it is predicted to be 2031 according to traffic analysis zoning of the city.

Table 1: Location of Studied Roundabouts and Dates of Observation

Roundabouts	Date of Observation	Time of day
Rajiv Chauk	27/03/2019	9.15am to 10.15 am
Patel Chauk	28/03/2019	5.00 pm to 6.00 pm
Uttam Nagar Chauk	12/04/2019	9.00 am to 10.00 am
Najafgarh Chauk	13/04/2019	9.00 am to 10.00 am
Dwarka more	14/04/2019	4.30 pm to 5.30 pm

7. DATA COLLECTION

Acceptance/rejection of the gap from video to vertigo collection and follow-up time and free flow rate. Unusual behavior of the driver is observed, such as the act of applying a gap, violating the right of passage and unnecessary temporary drivers. Collect all data manually. The collected traffic data should indicate the current peak traffic conditions. Collect data with the help of a camera to record and exit the vehicle at two roundabouts in Delhi. Enable video information about size, delay, and speed and acceptance gap to choose. This video is used to identify the gap that has been rejected or the delay of the drive approaching the rotor, and finally to identify the acceptable gap or delay that the drive uses to merge into the periodic intersection, and the subsequent time when the queue is present. The vehicles summarized as shown in table above on approach leg and on intersection. The data is collected for 720 minutes duration.

Table 2. Summarized vehicle volume on each leg at non-peak 12 hours

Location	Leg No.	Heavy Vehicles	Light Vehicles			Total Number of Vehicles	Total Traffic(PCU)
			Cars & autos	Motor cycles &bicycles	Total		
Rajiv Chauk	E	437	2375	7163	9538	9975	7486
	W	304	1558	7011	8569	8873	6137
	N	665	5396	12407	17803	18468	13927
	S	2698	8569	18867	27436	30134	27455
Patel Chauk	E	551	6403	10583	16986	17537	13623
	W	342	1729	3724	5453	5795	4788
	N	76	893	2565	3458	3534	2451
	S	3021	9823	42161	51984	55005	41477
Uttam Nagar Chauk	E	2128	7562	20444	28006	30134	25232
	W	969	4731	8417	13148	14117	12331
	N	171	3382	4921	8303	8474	6441
	S	931	5548	17746	23294	24225	17689
Najafgarh Chauk	E	836	5092	13034	18126	18962	14535
	W	95	1938	2907	4845	4940	3724
	N	874	3059	5168	8227	9101	8702
	S	1824	8455	16948	25403	27227	23313
Dwarka more	E	2375	10032	17727	27759	30134	27208
	W	418	1976	2907	4883	5301	4902
	N	114	1862	3591	5453	5567	4047
	S	874	10887	29127	40014	40869	28443

The movement of traffic on the approaches or legs and the traffic volume in term of passenger car unit and these data necessary for the analysis. As explained in the table suggest that the passenger car equivalent factors are used to convert the number of vehicles to passenger car equivalent. Figure below clearly shows the maximum and the minimum numbers of vehicle traffic at junction of roundabouts. The reason for this can mostly be attributed to land use. The maximum number of vehicles occurs at Rajiv chowk and minimum number of vehicles occurs at Patel chowk.

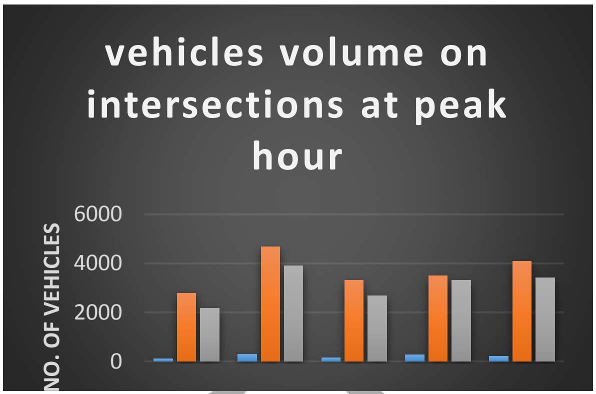

Figure 6: Maximum Peak 12-Hour Vehicles Volume Distribution on Intersections

From table above it is observed that there is unbalanced traffic flow at legs or approaches of roundabouts. However, it is not recommended to build roundabouts as traffic control devices when there is unbalanced traffic on the legs. To analyze the traffic segregation pattern it is necessary to have the patter with direction trends of each vehicles to control situation of jamming and rush occurred at peak hours.

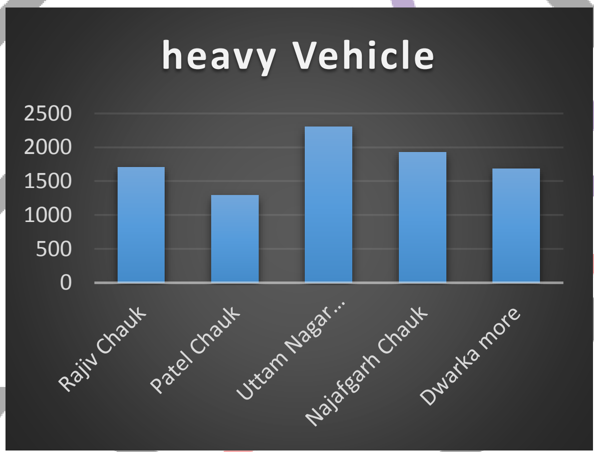

Figure 7: heavy Vehicle

The above exploration gives the basis idea of actual situation of traffic condition. And compare with various destination points of Delhi-India. This thesis explore the scenario on traffic wise categories.

Table3 Route mapping technique through suggestive data analysis

	RC	**PC**	**UN**	**NG**	**DM**
E	1747	2620	3773	5677	8140
W	1395	2182	3187	4668	6764
N	3255	5180	7086	11025	15521
S	4327	8058	10243	16414	22628
Avg.	2681	4510	6072.25	9446	13263.25
Routing (x indicate = Jamming , * indicate = Non jamming)					
E	*	*	*	*	*
W	*	*	*	*	*
N	x	x	x	x	x
S	x	X	x	x	x

8. MODAL CURVE ESTIMATION

Domestic traffic surveys were used to estimate the mode curves of the various transport modes available. The following procedure was used to generate these curves.

8.1 Aggregation of trips

General travel surveys gather information about the distance traveled by an individual and the transportation used for each trip. Data are grouped based on the distance traveled by individuals within the group, which is an increase of one kilometer. The number of moves for each mode of transport in each group is expressed as a percentage of the total number of moves per category in table below. This is done to get a modal share of each transport mode over the specified distance. Then put it into Microsoft Excel for curve fitting.

Table 4: Model Count – Rajiv Chauk to Uttam Nagar

Distance	Walk	Cycle	Cycle rickshaw	Scooter and motor	Car, van or jeep	Auto rickshaw	Taxi	DTTC bus	Total
0 - < 2	354	350	356	340	10	9	10	9	1438
2 - < 4	1	50	200	200	5	21	40	4	520
4- < 6	1	25	100	150	50	70	30	5	430
6 - < 8	0	8	20	200	76	79	60	60	503
8 - < 10	0	4	5	270	109	168	100	22	678
10- < 12	0	2	2	265	300	299	109	14	991
12 -< 14	0	8	1	200	340	125	160	33	867
14 -< 16	0	2	0	240	390	99	290	2	1023
16-< 18	0	0	0	208	399	129	298	61	1095
18- < 20	0	0	0	150	387	25	297	13	872
20-<22	0	0	0	151	365	24	299	18	857
22-< 24	0	0	0	140	332	26	290	14	802
24-<26	0	0	0	150	234	49	293	14	740

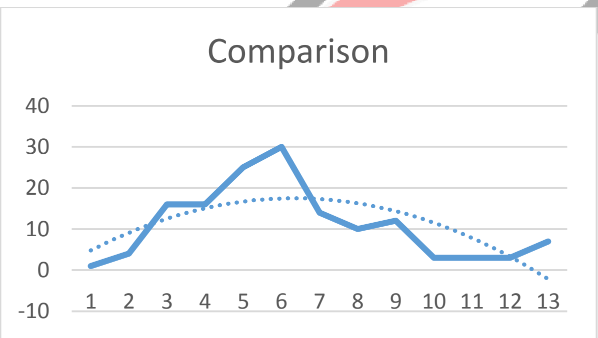

Fig 8: Comparison

$y = -0.4446x^2 + 5.6414x - 0.4056$

$R^2 = 0.4692$

Table 5: Modal Functions

Mode of Transport %	Modal Function	R2
Walk	y = 0.2747x2 - 4.6703x + 17.308	R^2 = 0.4762
Cycle	y = 0.3077x2 - 5.5495x + 22.846	R^2 = 0.8262
Scooter & Motorcycle	y = -0.0839x2 - 0.5395x + 35.294	R^2 = 0.5777
Car Jeep	y = -0.473x2 + 10.166x - 14.594	R^2 = 0.9229
Auto Riksha	y = -0.4446x2 + 5.6414x - 0.4056	R^2 = 0.4692
Taxi	y = 0.0305x2 + 2.8317x - 0.8182	R^2 = 0.9542
Dtdc Bus	y = -0.0594x2 + 0.7607x + 1.1888	R^2 = 0.0654

9. CONCLUSIONS &SUGGESTIONS

This paper proposes a new method for assessing the level of resilience of road segments associated with the surrounding network using traffic homogeneity. In this way, we consider that the elastic part is based on the inherent variability or considerable instability in the traffic flow, which is highly correlated and has not previously been implemented in this way. The focus of this method is on elasticity and is therefore more robust than robustness, as the road segment also takes into account the ability to recover from faults and the classic robustness itself. In this regard, as part of the holistic approach, a distinction is made between resistance and recovery. Contrary to many other studies, the rationale for this approach is not a general description of the entire network or network and its specific measures. Traffic segregation is a situation that occurs through transmission networks by increasing usage rates, slower speeds, longer travel times, and higher vehicle queues. This can lead to some traffic congestion when the traffic is large enough that the interaction between the vehicles can increase traffic flow. Although congestion is a possible mode of transportation, this thesis will focus on traffic congestion on public roads.

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