APPLICATION OF ITS IN COMPREHENSIVE MOBILITY PLAN

CASE STUDY: GANDHINAGAR

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9th Urban Mobility India Conference & Expo 2016
Planning Mobility for City's Sustainability

Structure of Presentation

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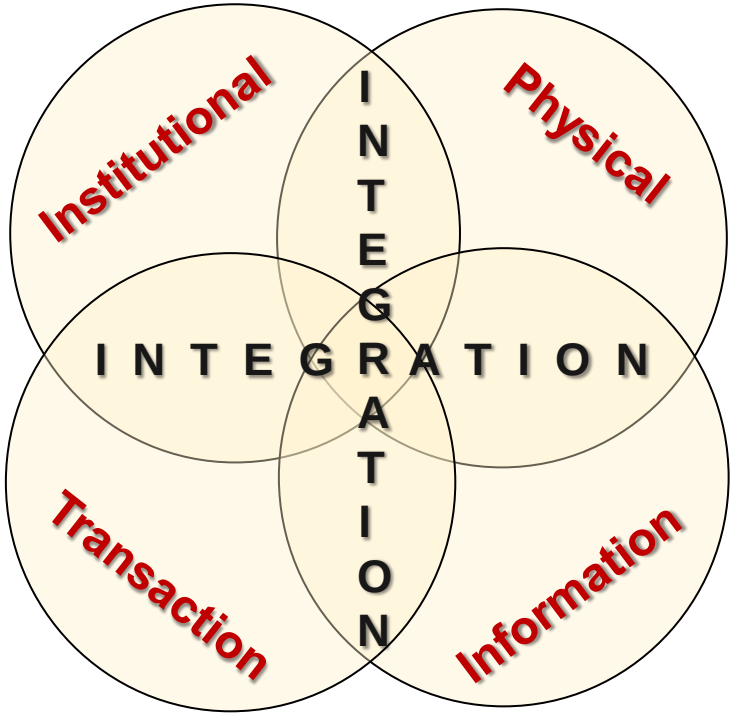
- Objectives & Scope
- Case Study: Gandhinagar
- Travel Demand Assessment & Developing different scenarios
- Smart Transportation Approaches
- Suggested Systems/ITS Tools
- Modal Split for different scenarios
- Financial Feasibility

Introduction

- Intelligent Transport Systems (ITS): Interrelated systems that work together to deliver transportation services.
- Almost every country of the world whether developing or developed, are facing problems in the management of transportation facilities.
- To address these issues, the focus is now shifting from infrastructure development to the optimum use of the existing facilities, where role of ITS proves very useful.

'Smart' & 'Connected' Transport



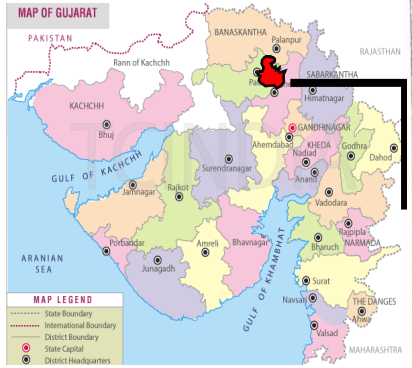
Objectives

- To estimate the base year and horizon year travel demand.
- To formulate and evaluate different alternative public transport based plans with and without ITS facilities.
- To study the financial feasibility of various alternative public transport plans with and without ITS facility.

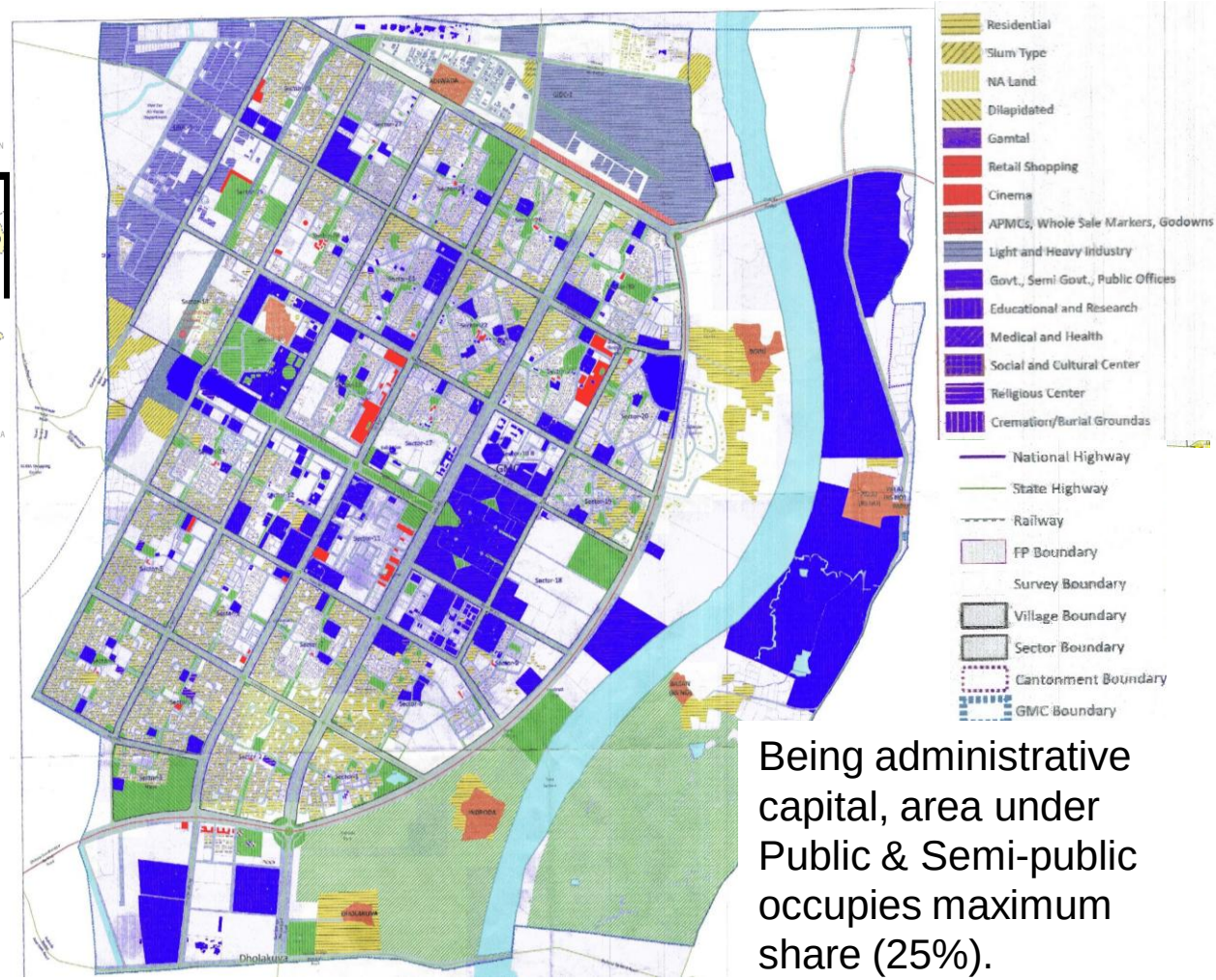
Case Study: Gandhinagar

- Population: 2,06,167*(Census 2011)*
- GUDA area: 387 sq.km.
- GMC area : 57 sq.km.
- Density :36 pph
- WFPR: 34.8%
- Average growth rate: 1.61%

(Expected to increase in future years with influence of upcoming developments)



Gujarat State



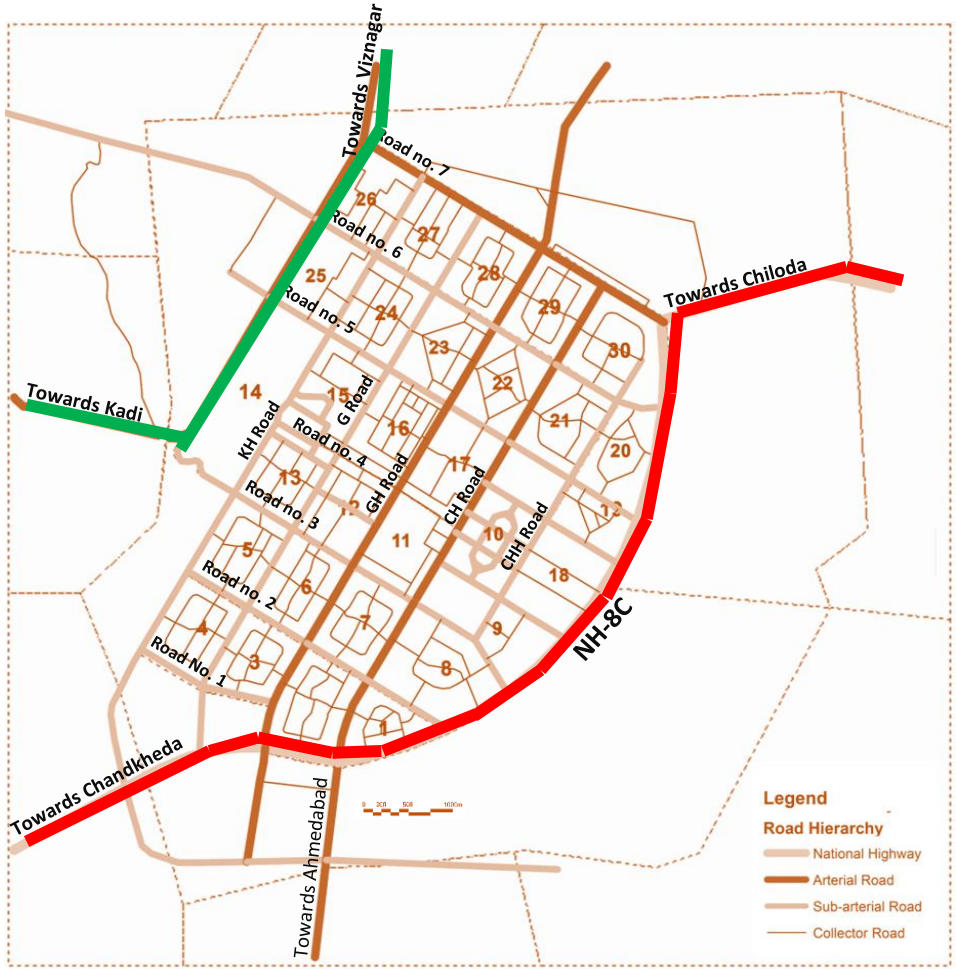
Land use:

Land use	%Breakup	Area (Ha)
Residential	22	1254
Public Semi-public	25	1425
Industrial	7	399
Commercial	2	114
Open spaces/recreational	10	570
Traffic and Transportation	17	969
Cantonment Land	3	171
Vacant Land	14	798
Total	**100**	**5700**

Being administrative capital, area under Public & Semi-public occupies maximum share (25%).

Network Characteristics

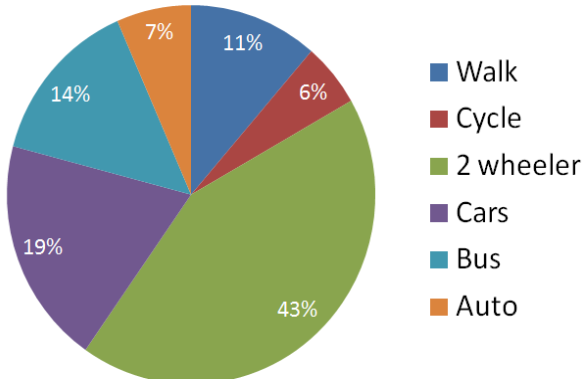
- **Grid Iron Pattern** with 30 sectors
- **NH 8C and SH-71** passes through the city linking with Ahmedabad and other parts of country
- **Total Road Network** =441 km *(excluding local roads153.46km)*
- Major road network have journey speeds > than 30kmph.
- **Average Journey Speed** observed is **44.34 kmph**
- Delays observed are **operational delays** *(Max: 31 sec; Min: 7sec)*
- 88% of the study network has footpaths, while 12% is deprived of it, but faces a major issue of **discontinuity** despite its availability.
- Pedestrian facilities like zebra crossings are present but **no FoB/Subway** is present, even on stretches where average speeds observed are > 55kmph.



Travel Characteristics

Household Travel Characteristics:

Modal Split



ATL(INCL. WALK)	3.19 km
ATL(EX. WALK)	3.53 km
PCTR(EX. WALK)	0.95
PCTR (INCL.WALK)	1.14

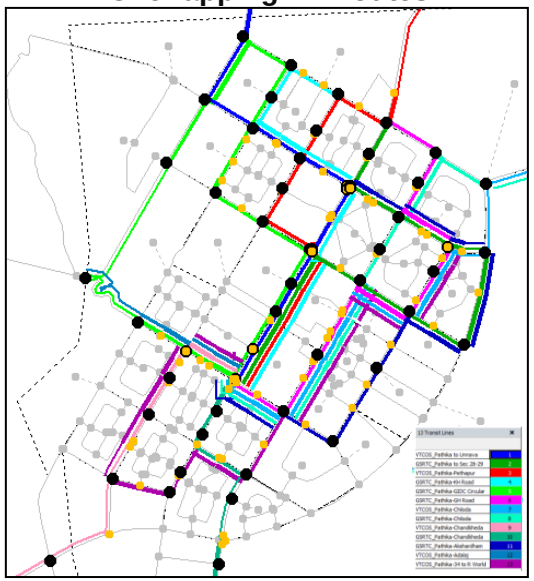
Mode/ Purpose	Overall % Without NMT	Work %	Education%	Business%	Shopping%	Recreation%	Medical%
Walk		7	12	31	21	15	20
Cycle		4	10	0	2	0	0
2W	52	48	36	31	47	19	40
Car	23	29	8	25	14	40	40
Bus	17	8	27	13	4	19	0
Auto	8	5	7	0	12	8	0

Source: Primary Survey conducted by SPA , 2016

Public Transportation:

- Total route length: 151.6km
- Average Trip Length: 4.1km
- Overlapping routes high within core areas, hence disparity in coverage
- Density of bus networks is: 1.92Km/Km^2.
- Service coverage indicate that 66% of population are within 500m walking distance.
- City has good transport system that offers a good level of service but, the key attribute like waiting time and service coverage lags behind(>10min).

Overlapping PT routes



Base Year Modelling

- 27 internal traffic analysis zones(TAZ) & 8 external TAZ have been considered for carrying out travel demand modelling.

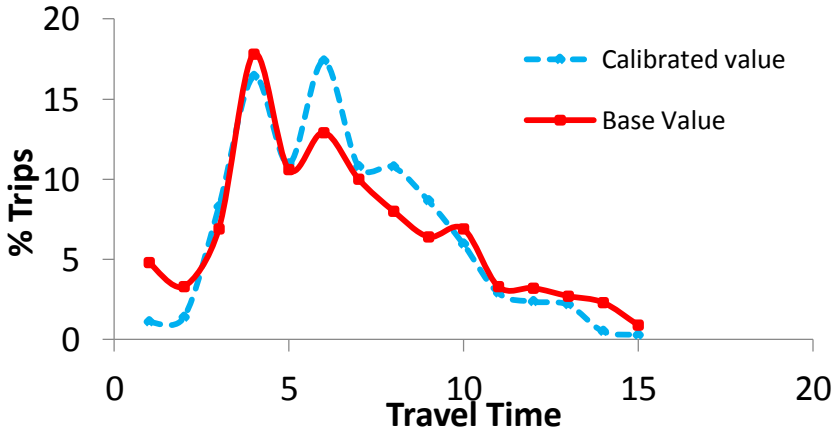
Travel Demand Model:

- Trips Generated = Function (Socio-Economic, location, population... etc., as variables).
- Trips Produced=1.14*Population+157.3
- Trip attractions=0.38* Employment, E(PSP)+4.35*E(Commercial)+15.95*E(Recreational) +50.37*E(Terminals) +328.5

Estimated Base year trip ends : 2,79,223

Calibration of Travel Demand Models:

Observed average travel time & distance were 7.4minutes & 3.53km, while from calibrated model was7.53minutes & 3.94km



Modal Split

- **Technique :** **Abstract Logit Model**
- **Input Parameters** : **Travel Time, Travel Cost , Income, Frequency** *(supply of PT system)*

Abstract Logit Model Output

Variable	Coefficient	Std.Error	b/St.Er.	P[|Z|>z]
Income (X1)	-0.233	0.104	-2.251	0.003
Travel Cost (X2)	0.547	0.093	-5.894	0
Travel Time (X3)	-0.14	0.064	2.205	0.006
Frequency (X4)	-0.125	-0.077	1.632	0.005
ASC_Car	0.688	.....(Fixed Parameter).....		
ASC_TW	1.148	.....(Fixed Parameter).....		
ASC_Auto	-0.811	.....(Fixed Parameter).....		
ASC_Bus	-1.026	.....(Fixed Parameter).....		
Statistical Tests:				
Log Likelihood	Parameter	Chi-Squared	R-Squared	Adjusted R-square
-321.38	8	621.47	0.595	0.581

Utility Equations:

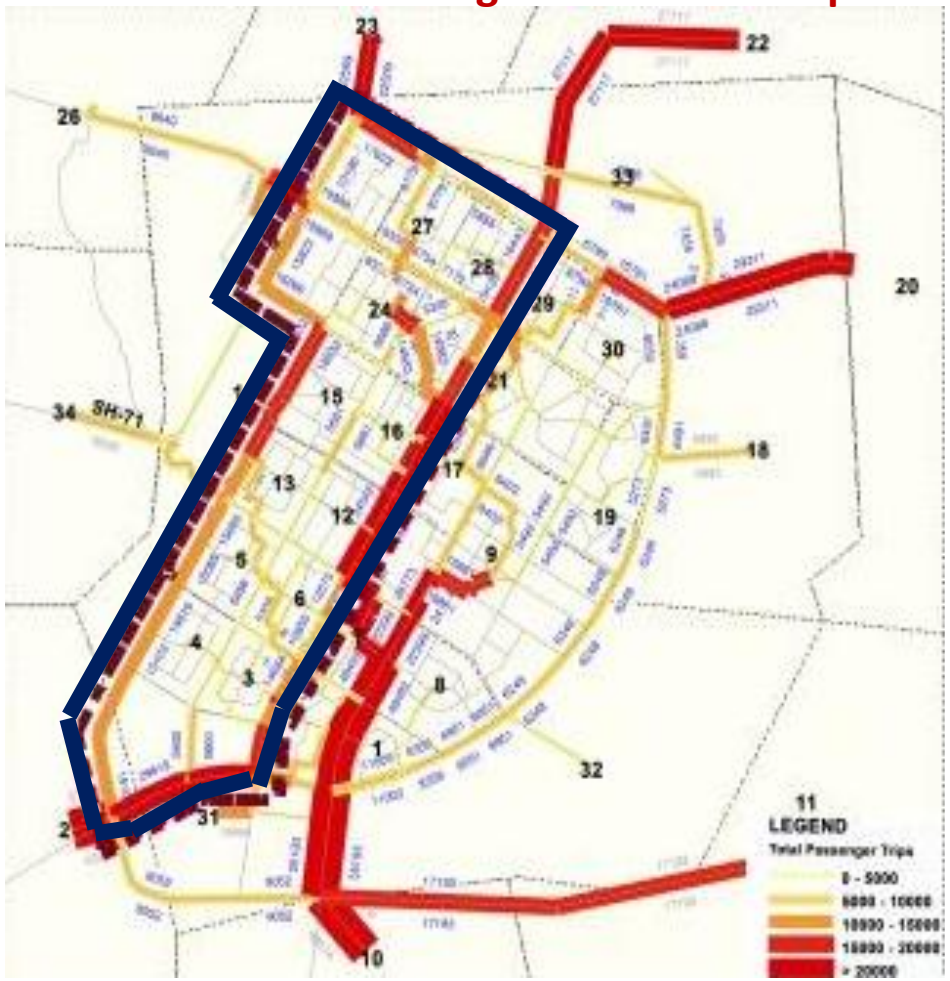
- U(Car) = 0.68-0.23*X1-0.14*X2 +0.55*X3-0.12*X4
- U(2W) = 1.14-0.23*X1-0.14*X2 +0.55*X3-0.12*X4
- U(Auto) = -0.81-0.23*X1-0.14*X2 +0.55*X3-0.12*X4
- U(Bus) = -1.02-0.23*X1-0.14*X2 +0.55*X3-0.12*X4

Observed & Predicted Modal Split:

Mode	Observed (Primary Survey,2016)	Estimated (Logit Model)
Car	23	21.3
Two Wheeler	52	46.8
Auto rickshaws	8	11.3
Public Transport	17	20.6

Estimated Travel Demand

Peak Hr Passenger Directional Trips

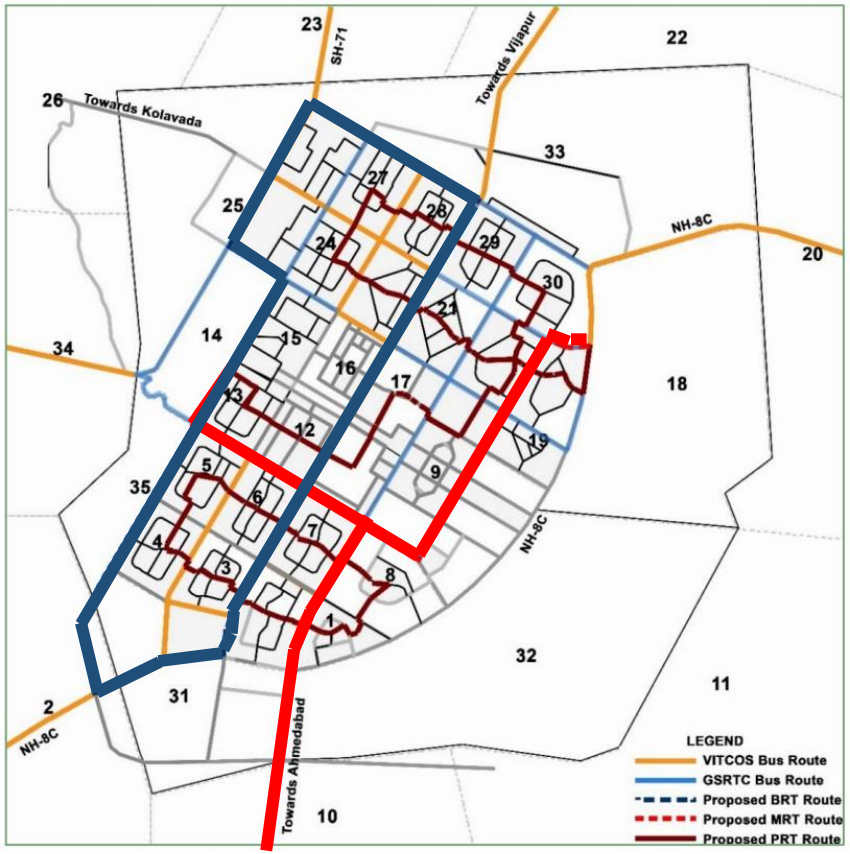


- Distributed passenger matrix when assigned on network indicate that optimization of existing system alone; at more acceptable passenger loading standards will not satisfy demand expected.
- Proposed Modes: **BRTS** since the PHPDT is more than 4000 for a certain corridor.
- Need for alternate like **Personalized Rapid Transit (PRT)** is also identified either as transitional or feeder mode to serve stations along BRTS & higher density development nodes that generate travel demand which exceeds capacity of buses in mixed traffic apart from M**etro** already proposed providing connectivity to Ahmedabad.
- Further, change in modal split has been estimated after incorporating few of the **ITS technologies** discussed below to achieve smart transportation in Gandhinagar.

Different Scenarios

- **Scenario-1:** Business as Usual(Base year network & modal split)
- **Scenario-2:** Base network+ Proposed MRTS + BRTS(20km) + Organized Bus System & Feeder connectivity
- **Scenario-3:** Base network+ Proposed MRTS + BRTS + PRT + Organized Bus System & Feeder connectivity
- **Scenario-4:** Base network+ Proposed MRTS + BRTS + PRT + Organized Bus System & Feeder connectivity+ ITS Components (Real time Information, Common Ticketing, Control Centre)

Network Map of Proposed Systems



Utility Equations of Proposed Modes:

- U(Metro) = -0.916-0.23*X1-0.14*X2 +0.55*X3-0.12*X4 *(ASC value of Metro is in between bus & IPT assuming bus & IPT users are more likely to shift to metro)*
- U(PRT) = -0.979-0.23*X1-0.14*X2 +0.55*X3-0.12*X4 *(ASC value in between that of 2W & IPT)*

Estimated Modal Split in Different Scenarios

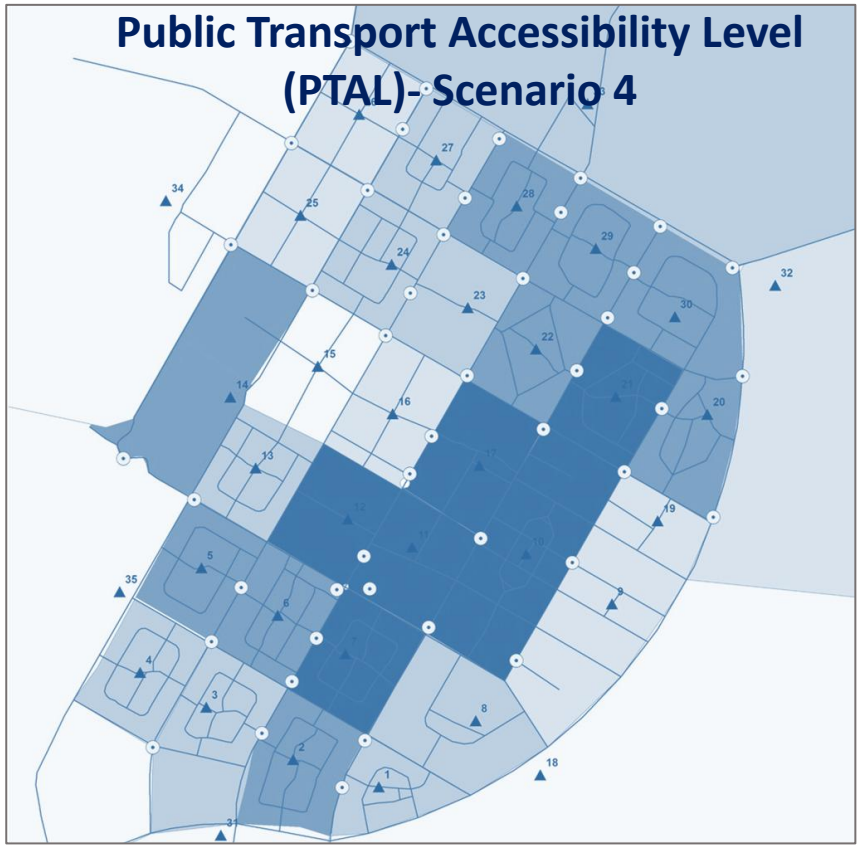
Mode	Scenario 1	Scenario 2	Scenario 3		Scenario 4	
	BAU	Base year network +MRTS + BRTS + Organized bus service + Feeder connectivity	Base year network + MRTS + BRTS + PRT + Organized bus service + Feeder connectivity		Base year network + MRTS + BRTS + PRT + Organized bus service + Feeder connectivity + **ITS Components**	
Car	21.3	7.2	7.6		6.6	
TW	46.8	30.1	29.7		25.4	
Auto	11.3	4	4.9		4.5	
Bus	20.8	48.5	33.3		35.6	
Metro	-	10.2	7.1	**57.8**	7.6	**63.5**
PRT	-	-	17.4		20.3	

For Scenario 4 it is assumed that there would be reduction of 10% travel cost for all public transport users and the reduced travel time (savings in transaction time and waiting time) for different modes as discussed above.

Conclusion:

Incorporating savings in travel time due to ITS as in Scenario-4 & assuming cost reduction by 10% for card user's ridership of public transport additionally gets enhanced by 5.7%.

Evaluation of Scenario

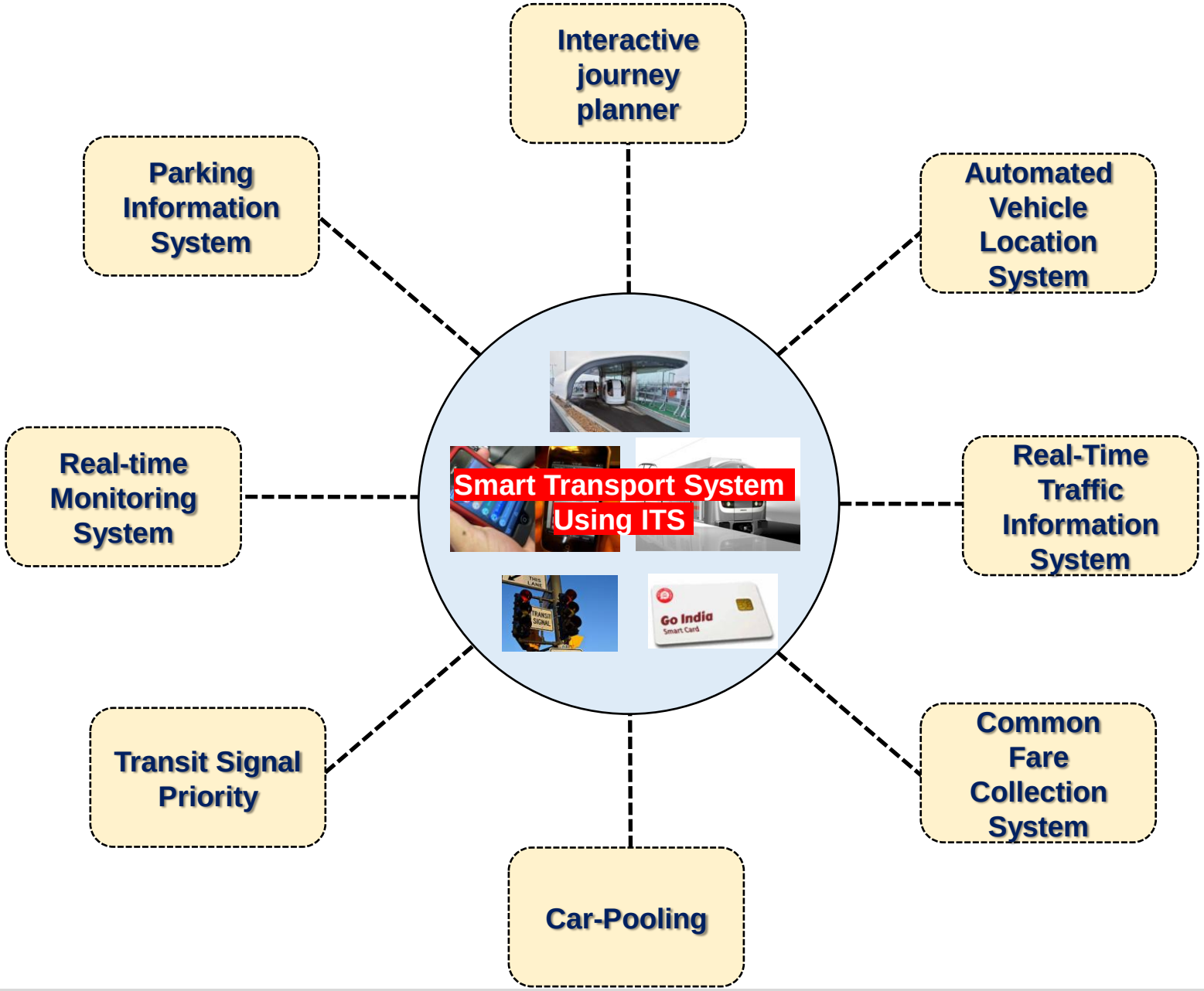


PTAL	Range of Index	Description
1a (Low)	.01-2.50	Very poor
1b	2.51-5.00	Very poor
2	5.01-10.00	Poor
3	10.01-15.00	Moderate
4	15.01-20.00	Good
5	20.01-25.00	Very good
6a	25.01-40.00	excellent
6b	40.01+	excellent

Parameters for Evaluation	Scenario-1	Scenario-4
Passenger-Km	7,33,505	11,28,469
Vehicle-Km	10,21,517	5,81,486
Vehicle-Hr	27,609	16,412
Savings with respect to Scenario 1:		
Health Savings/day (Rs)	-	111036
Time Savings/day (Rs)	-	17,62,458
VOC Savings/day (Rs)	-	1,32,155

- 97% of area falls under category of 1a &1b which shows poor PTAL in scenario-1which touches 4th level by providing BRTS+MRTS+PRT+ITS in Scenario-4.
- Planning strategic transport system as in scenario-4 has lead to a reduction in 41% vehicle-hrs & 44% vehicle-km compared to scenario-1.

SMART TRANSPORTATION APPROACHES



BENEFITS:

- Seamless travel;
- Improve in transit delivery;
- Reliability on public transport;
- Savings in transaction & journey time;
- Distributed demand rather peak hr demand (Diffusing Demand);
- Managing assets more efficiently;

Suggested system/ ITS tools

- *Real Time Passenger Information System*
- *Smart Card*
- *Speed Cameras*
- *Control centre*

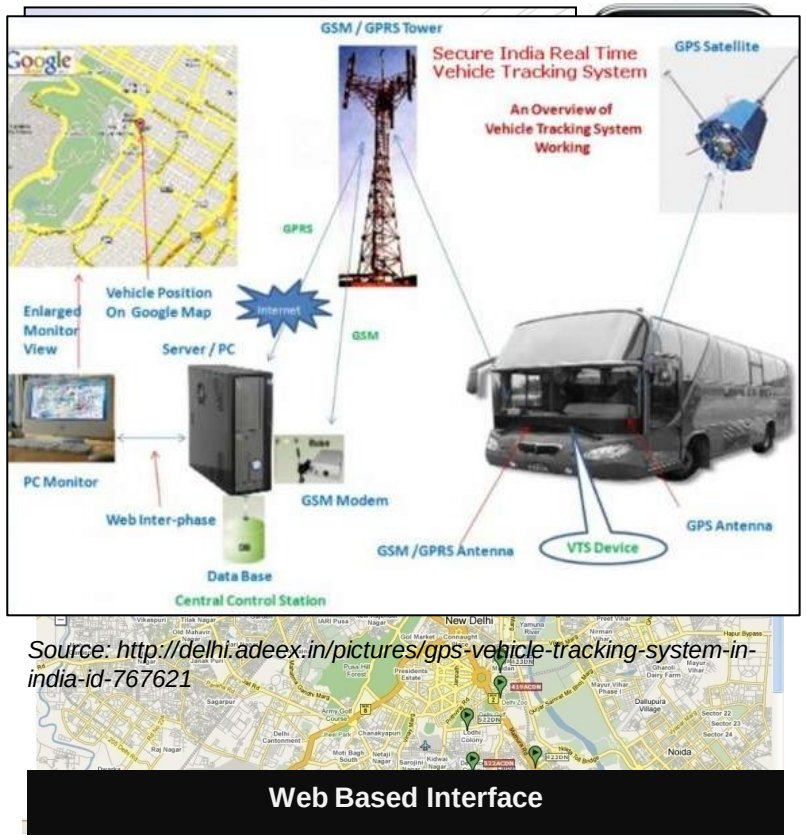
Real-time Passenger Information System

- Aim at bridging information gap by providing pre-trip and/or en-route information to travelers about various travel options, helping in informed travel decisions.
- The system uses GPS technology to determine location and time of the bus, thus predicting expected arrival time at stops en-route.
- RTPIS system may be:
    1. Display on bus stops
    2. Web based interface for monitoring through control room.
    3. Mobile app for users to find out bus schedules

Benefits:

- Improving system control
- Improving bus safety in an emergency condition
- Improving quality of service
- Providing better bus scheduling

Real Time Passenger Information(RTPI) system

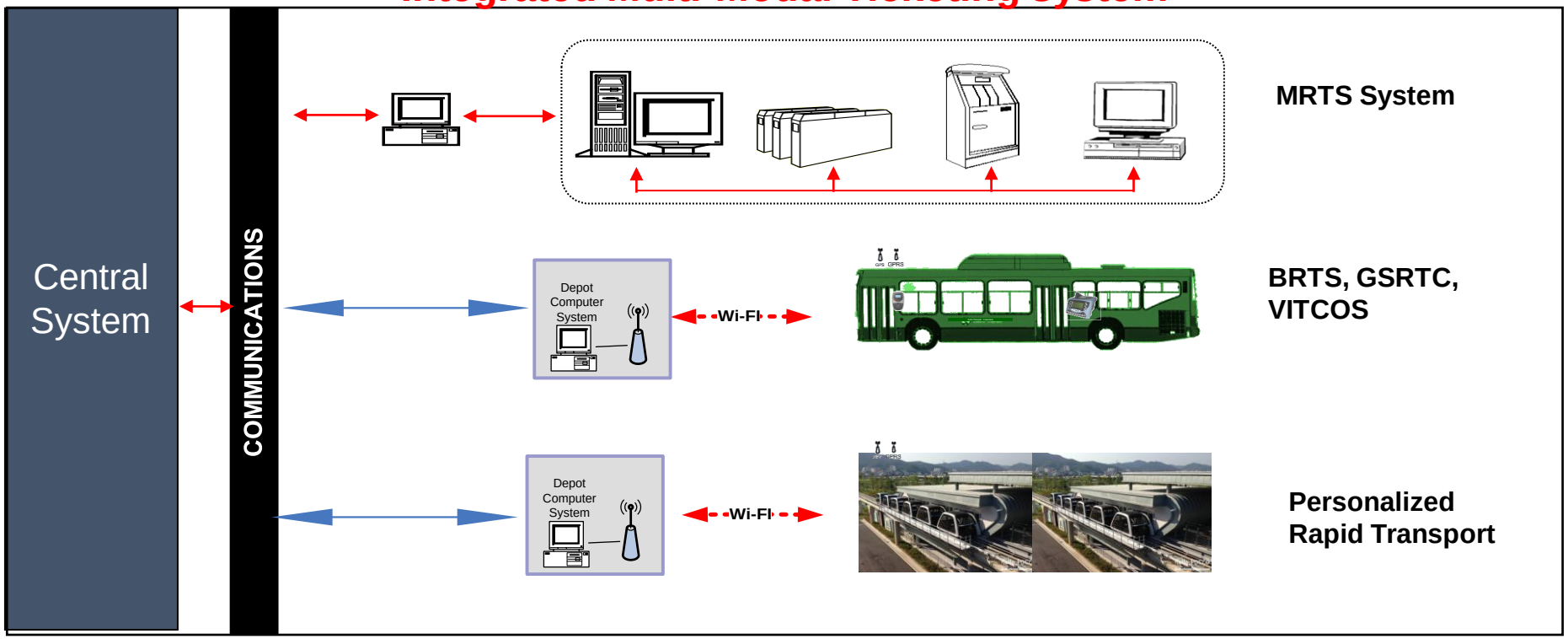


Source: http://delhi.adeex.in/pictures/gps-vehicle-tracking-system-in-india-id-767621

Web Based Interface

Smart Card (Common Ticketing)

Integrated Multi-Modal Ticketing system



Advantages:

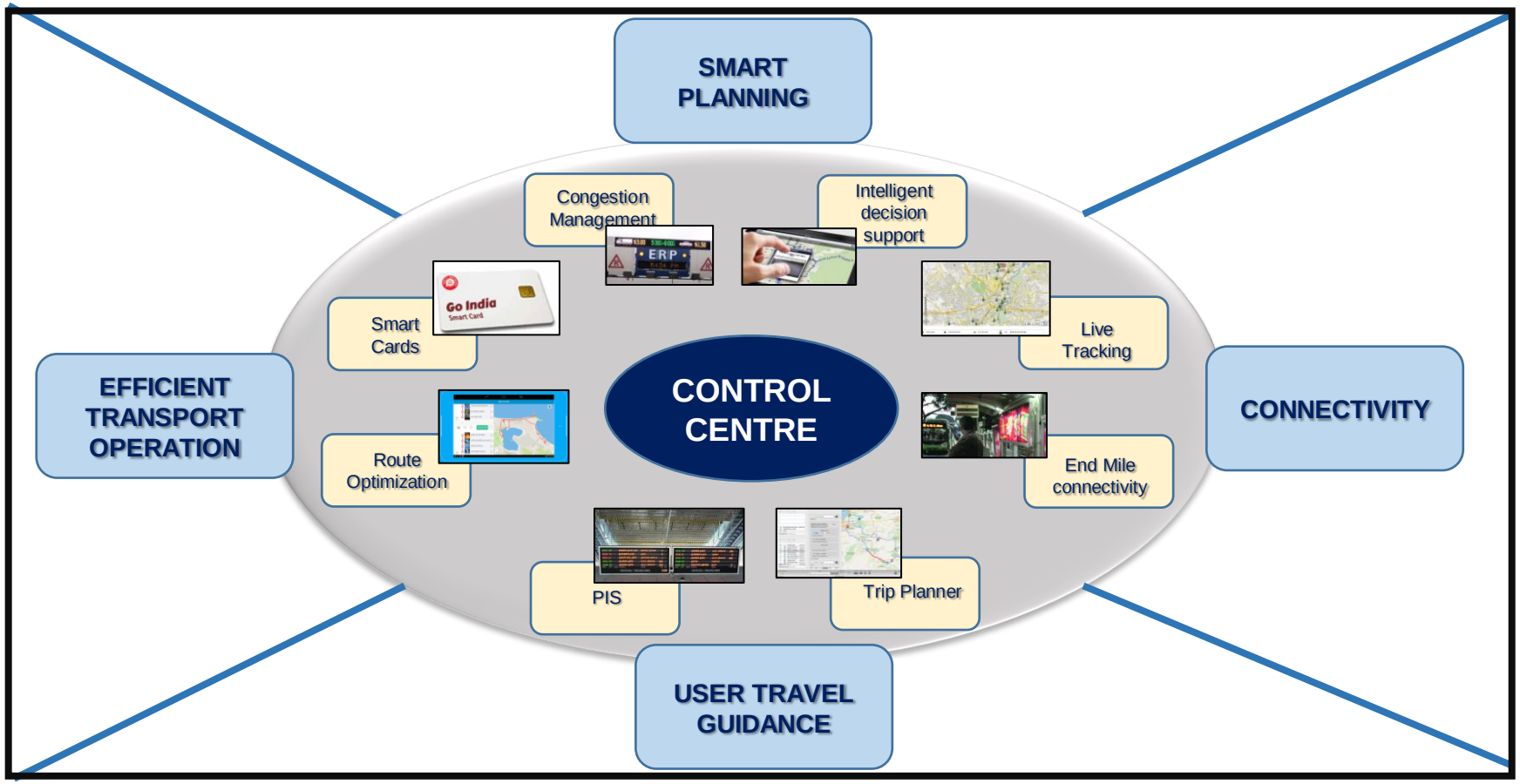
For Authorities	For Operators	For Passengers
Creation of seamless journeys in PT networks	Reduce use of cash	No need to carry cash
Unification of ticketing	Reduction in revenue pilferage	Convenience & speed
Better control of revenues & subsidies	Reduce maintenance costs	Easier ways to reload value or renew passes
Integration with other transport services like parking, tolls and taxis	Improved cash flow	Seamless journeys in multimodal
Source of planning data for PT management	Allows faster boarding and helps in reducing overall journey time	Additional appreciated services when available
Reduce cost of selling tickets	Reduced cost of selling tickets	

- *Study carried out at New Delhi and Chandni Chowk Metro stations, Delhi in 2015 shows that the average transaction time taken by cash users is 18sec (if including waiting time is 414sec) as opposed to smart card users which is 4sec.*
- *Similarly, for bus users the average transaction time taken by cash users is 15sec (if including waiting time is 138sec). From literatures, a value of 4.5sec for card users.*

Reference: Development of Integrated Smart Card for Public Transport System, Unpublished thesis work: Narendra Verma,2015

Control Centre

- Key hub for all transportation activities
- Operating & managing overall traffic by collecting traffic information from the BMS, Transport Card System, unmanned surveillance system & traffic-related authorities and institutions such as Traffic Broadcasting, Traffic signal controller, Police Agency.



Speed Management

- **Installation of speed camera :**
  - Reduce traffic speeds and road crashes, and help to reduce injury severity
  - Crash rate reduction by 25% on enforced network
  - Speed reductions of 5-10km/hr

Installation

- Designing System
- Installation & Project Management
- Commissioning
- Ongoing Maintenance

Detection

- Fixed Speed Cameras
- Red Light / Speed Cameras
- Mobile Speed Cameras
- Point to Point

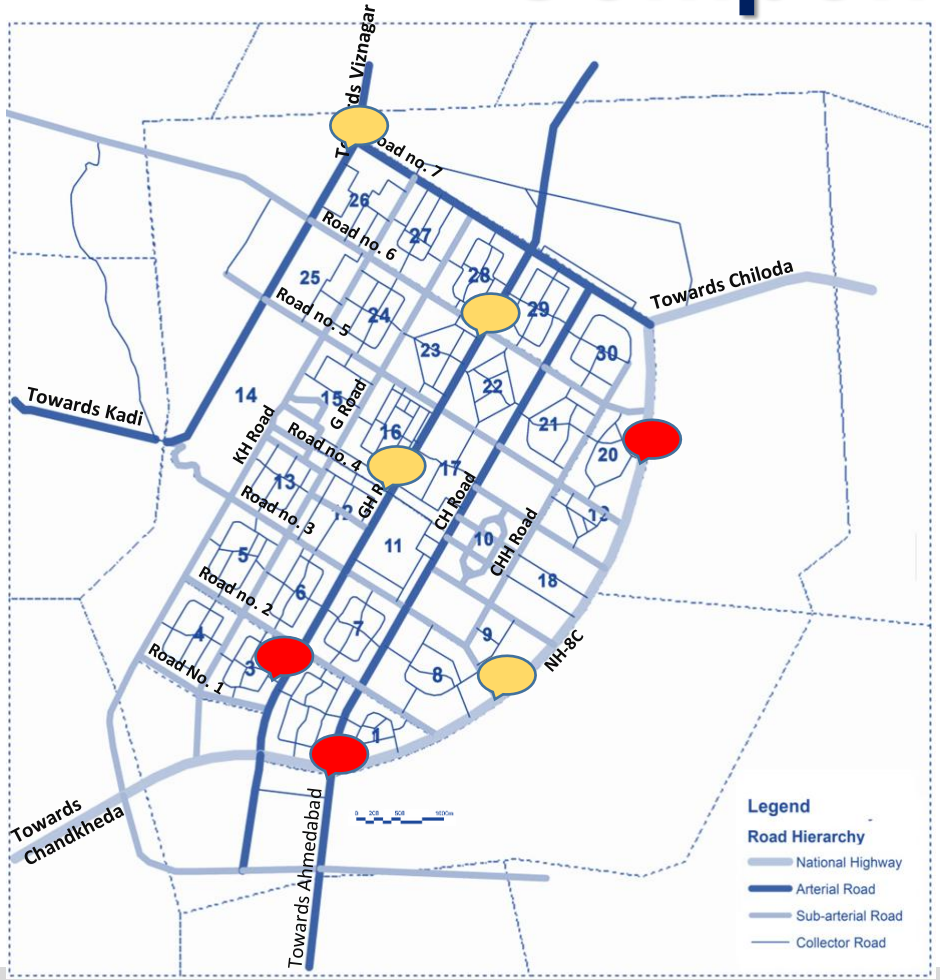
Prosecution

- Image Scan & Transfer
- Camera Image Download
- Image verification
- Vehicle data verification
- Police Authorization
- Traffic Infringement Notification

Collection

- Payments Processing
- Payments Tracking
- Letters & Phone Calls
- Nominations
- Fine Avoidance Tracking Activities

Proposed Location of Speed Enforcement Component -Gandhinagar



Speed reduction by empty camera boxes:*

- 8-10 km/h near camera box sites
- 5 km/h between boxes

Speed Camera

Psychological treatment (Empty Boxes)

*Source: Thesis Work, "Enhancing Safety Of Road Users Through ITS", Sharad Yadav,2015

Breakdown of Cost Components

Capital Cost		
Personalized Rapid Transit(PRT)		
Proposed Route Length	*24*	*km*
Track(24km)+Stations(56)+Pods(252)	1005.20	Cr
Maintenance Yard+ Power Station & Distribution + Backup	17.30	Cr
Assets: Corporate Office	1.40	Cr
Contingency+Fund Syndication+ Training + Approvals	43.80	Cr
Total (PRT)	**1067.60**	**Cr**
Bus Rapid Transit(BRT)		
Proposed Route Length	*20.08*	*km*
Roadway development (20.08 Km)	177.9	Cr
Bus Stop (22)	10.1	Cr
Foot Over Bridge	5.4	Cr
Fleet(40)	31.9	Cr
Total (BRT)	**245.40**	**Cr**
Common Ticketing		
System Hardware	50.4	Cr
SystemSoftware	6.8	Cr
Contingencies@3%	1.7	Cr
Total (Smart Card)	**58.90**	**Cr**
ITS Components		
ITS application and External Tracking (LS)	5.8	Cr
Control Center (1 no.)	12.3	Cr
Speed Camera (3 locations)*	1.5	Cr
Red light cameras (3 locations)*	0.5	Cr
Total (ITS)	**20.10**	**Cr**
Overall Capital Cost	**1392.00**	**Cr**
Landed Project Cost (LPC)	**1440.70**	**Cr**
LPC+ Interest During Construction(IDC)	**1493.34**	**Cr**

Operation and Maintenance Cost		
Personalized Rapid Transit(PRT)		
Manpower Cost:	**39.87**	**Cr/yr**
No. of Employees @each station	*48*	
No. of Employees at Control Centre	*29*	
No. of Employees at Maintenance Yard	*46*	
Salary @each station Employee	*10172*	*Rs/month*
Salary @each control centre Employee	*28828*	*Rs/month*
Salary @each Yard Employee	*19674*	*Rs/month*
Staff Welfare Cost @ each Employee	*1500*	*Rs/month*
Total Employees	*2763*	
Total Guide Way Maintenance Cost @0.08 Cr/km/Yr	**1.92**	**Cr/yr**
Total Vehicle Maintenance Cost @0.01 Cr/nos/Yr	**22.52**	**Cr/yr**
Total Station Maintenance Cost @0.14 Cr/nos/yr	**7.84**	**Cr/yr**
Total O& M Cost (PRT)	**72.15**	**Cr/ yr**
Bus Rapid Transit(BRT)		
Bus Stops Maintenance	0.92	Cr/yr
Tyres & Tubes	0.61	Cr/yr
Spare Parts	0.60	Cr/yr
Fuel Consumption	22.93	Cr/yr
Staff Cost	0.04	Cr/yr
Repair and Maintenance	2.31	Cr/yr
Total O& M Cost (BRT)	**27.41**	**Cr/yr**
Common Ticketing		
Total O & M Cost (Smart Card)	**0.28**	**Cr/Yr**
ITS Components		
Total O & M Cost (ITS Components) @3%	**0.60**	**Cr/Yr**
Overall O& M Cost	**100.44**	**Cr/Yr**

**Reference: (IRAP toolkit, 2013) (Austroads, Reviewing ITS Technologies and opportunities, 2010) (JICA, 2013)*

Parameters considered for Financial Feasibility

Following assumptions were made in order to carry out financial feasibility study:

- Concession Period: 30 years (2018 - 2027)
- Construction period: 2 years (2018-2019)
- Operation starts: 2020
- Inflation rate: 7% per annum
- Government Contribution: 40% of Total Cost
- Debt equity ratio: 2:1 (66.67% : 33.33%)
- Interest Rate: 16%
- Tax Rate: 30%
- Tax benefit: tax free profit for first 5 years
- The financial feasibility of the project is carried out for two conditions:

  -Without viability gap funding(VGF)

  -With 40% VGF

Year	Total Cost(Cr)		Total Revenue (Cr)				Net Operating Income	Loan Repayment		Net Profit Before Taxes	Taxes	Net Profit After Taxes
	Capital Cost	O&M	Fare Revenue	Advertisent Revenue	Commercial Revenue	Total Revenue		Repaid Amount	Interest @16%			
2018	417.6											
2019	451.5											
LPC @2020	**869.1**						-869.1	573.6		-869.1		-869.1
2020		100.4	231.4	11.6	11.6	254.5	154.1	75.0	79.8	-0.7	0.0	-0.7
2021		107.5	240.7	12.0	12.0	264.8	157.3	75.0	67.8	14.5	0.0	14.5
2022		115.0	250.5	12.5	12.5	275.5	160.5	75.0	55.8	29.7	0.0	29.7
2023		123.0	260.6	13.0	13.0	286.7	163.6	75.0	43.8	44.9	0.0	44.9
2024		131.7	271.2	13.6	13.6	298.3	166.7	75.0	31.8	59.9	18.0	41.9
2025		140.9	334.0	16.7	16.7	367.4	226.5	75.0	19.8	131.7	39.5	92.2
2026		150.7	347.1	17.4	17.4	381.8	231.0	75.0	7.8	148.3	44.5	103.8
2027		161.3	360.7	18.0	18.0	396.8	235.5	56.4		179.1	53.7	125.4
2028		172.6	374.9	18.7	18.7	412.4	239.8			239.8	71.9	167.9
2029		184.7	389.7	19.5	19.5	428.6	244.0			244.0	73.2	170.8
2030		197.6	489.0	24.5	24.5	537.9	340.3			340.3	102.1	238.2
2031		211.4	507.6	25.4	25.4	558.4	346.9			346.9	104.1	242.9
2032		226.2	526.7	26.3	26.3	579.3	353.1			353.1	105.9	247.2
2033		242.0	546.8	27.3	27.3	601.4	359.4			359.4	107.8	251.6
2034		259.0	567.7	28.4	28.4	624.5	365.5			365.5	109.6	255.8
2035		277.1	725.6	36.3	36.3	798.2	521.0			521.0	156.3	364.7
2036		296.5	752.3	37.6	37.6	827.6	531.1			531.1	159.3	371.7
2037		317.3	780.2	39.0	39.0	858.2	540.9			540.9	162.3	378.6
2038		339.5	809.0	40.5	40.5	890.0	550.5			550.5	165.1	385.3
2039		363.2	839.1	42.0	42.0	923.0	559.8			559.8	167.9	391.8
2040		388.7	1091.9	54.6	54.6	1201.1	812.5			812.5	243.7	568.7
2041		415.9	1131.0	56.6	56.6	1244.2	828.3			828.3	248.5	579.8
2042		445.0	1171.7	58.6	58.6	1288.8	843.8			843.8	253.1	590.7
2043		476.1	1213.8	60.7	60.7	1335.2	859.1			859.1	257.7	601.3
2044		509.5	1257.6	62.9	62.9	1383.4	873.9			873.9	262.2	611.7
2045		545.1	1661.2	83.1	83.1	1827.3	1282.2			1282.2	384.6	897.5
2046		583.3	1719.1	86.0	86.0	1891.0	1307.7			1307.7	392.3	915.4
2047		624.1	1779.2	89.0	89.0	1957.1	1333.0			1333.0	399.9	933.1
2048		667.8	1841.5	92.1	92.1	2025.7	1357.9			1357.9	407.4	950.5
2049		714.6	1906.2	95.3	95.3	2096.8	1382.2			1382.2	414.7	967.6
IRR										**17.60%**		**14.90%**
NPV @12%										**954.73**		**425.77**

Conclusions:

- Financial Internal Rate of Return (FIRR) is observed to be 8.64% without VGF.
- FIRR of 17.6% including ITS components with 40% VGF.
- FIRR without including ITS components is 16.9% with 40% VGF).

Conclusion

- It is concluded that system comprising combination of smart, low capacity & eco-friendly system like PRT, integrated with high capacity MRTS and BRTS along with ITS turns out to be most sustainable to meet future demand.
- Planning strategic transport system as in scenario-4 has lead to a reduction in 41% vehicle-hrs & 44% vehicle-km compared to scenario-1.
- Incorporating savings in travel time and travel cost due to smart card & other ITS components overall ridership of public transport gets enhanced by 5.7%.
- The proposed public transport system yields FIRR of 17.6% with ITS components included and FIRR of 16.9% excluding ITS components (with 40% VGF).
- Implementation of such Smart People Mover projects across the cities would definitely have a positive effect on behavioural changes of residents and also support development and attraction of the cities.

THANK YOU !!!