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Sustainable Public Transit System for Last Mile Connectivity to Major Work Centres and the Mode Choice of Employees

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BACKGROUND

As stated by Working Group on Urban Transport for the 12th Five Year Plan (FYP)

- Present scene of urban transport across India is categorized by
  - sprawling cities
  - declining share of public transport
  - Less of non-motorised transport
  - focus on supply side yet with low investments
  - sheer neglect of pedestrians
  - Inadequate facilities for cyclists and public transport users
  - increased motorization leading to pollution and high road fatalities/injuries

INTRODUCTION

- Promoting public transport facilities to work centre campuses is a futuristic measure towards sustainable transport

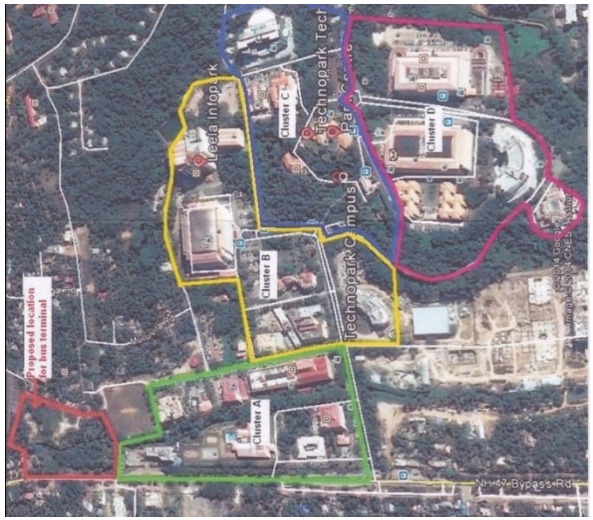
- Last Mile Connectivity (LMC) to the work centres and can create a positive spiral whereby the ridership of public transport increases, its financial viability also improves and the environment goes greener

- Insight in to the travel characteristics of the IT professionals
- Available options for the last mile connectivity influences the mode choice of work trip
- Mode preferences of employees in two major workcentres (IT parks) in Kerala are studied based on user preference surveys
- Mode choice modelling is attempted based on a ranking approach for different mode choices in a scenario where different modes of feeder service co-exist

OBJECTIVES OF THE STUDY

- Assess the factors influencing the mode choice for last mile trip to the work centres under consideration
- Thorough understanding and analysis of travel behavior & mode choice of commuters to workcentre in a particular set of circumstances or transport scenario
- Propose a sustainable scenario for improved last mile connectivity with a fleet design for operation
- Mode choice analysis by stated preference approach in a hypothetical scenario of last mile connectivity options and estimation of modal shift
- Mode choice models for last mile trip based on a ranking approach

STUDY AREA



Zoning inTechnopark

- *300 acres of land*
- *9.33 million square feet built-up area*
- *300 companies*
- *About46,000 professionals*
- *LMC options bus, cabs, IPT,NMT – bicycles*
- *LMC inadequate and costlier*

Zoning in Infopark

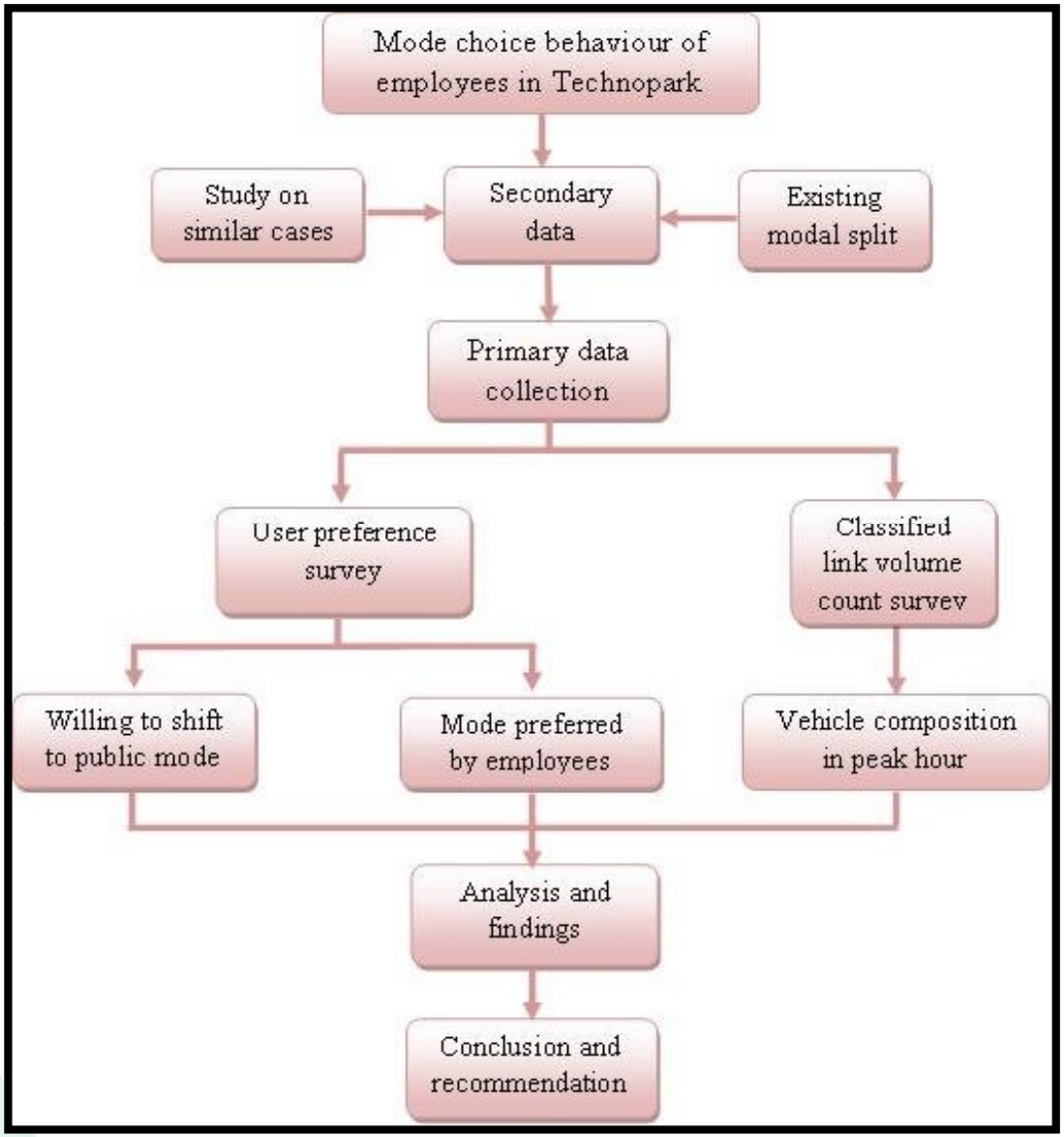
- 80 acres of land
- 4.50 million sqft
- *100 plus companies*
- *About 20,000 professionals*
- *LMC options bus, cabs, IPT,NMT – bicycles*
- *LMC inadequate and costlier*

STUDY AREA

Technopark

Infopark

METHODOLOGY



PRIMARY SURVEYS AND DATA COLLECTION

- The questionnaire comprised of personal information, vehicle information, trip information and mode choices

- The explanatory variables considered to influence the mode choice behavior and available choice of mode were included in the questionnaire

- Ranking type questions were also included for modal serviceability attributes like cost, travel time, walk and wait times

- Data collection on a sample of 3 to 5 % of the total employees on both the IT campuses was done

MODE CHOICE FOR THE LAST MILE CONNECTIVITY AT THE WORKCENTRE

*OPINION SURVEY

Sample No: *Enumerator Name:* *Place & Date:*

PERSONAL INFORMATION

NAME:			GENDER:	M ☐	F ☐
EDUCATION:	Under Graduate ☐	Graduate ☐		Post Graduate ☐	

Age: <18 ☐ 18-30 ☐ 31-45 ☐ 46-60 ☐ >60 ☐

COMPANY NAME		POSITION HELD:
WORKING HOURS		
MONTHLY INCOME*(in Rs 1000)*	<10 ☐ 10-25 ☐ 25-50 ☐ 50-75 ☐ >75 ☐	
DRIVING LICENSE	2W ☐ 4W ☐ NIL ☐	
VEHICLES OWNED	2W ☐ 4W ☐ NIL ☐	

TRAVEL DETAILS

FIRST ORIGIN :

DETAILS OF TRIP :														
ORIGIN	TIME OF START	DESTINATION	TIME OF REACH	MODE*			TRAVEL TIME			TRAVEL COST			DISTANCE (km)	IS IT A SHARED RIDE (Y/N)
				M1	M2	M3	M1	M2	M3	M1	M2	M3		
MAIN TRIP														
LAST MILE TRIP														

If currently by personalized mode,	
Is it a shared ride Yes ☐ No ☐	Willingness to shift to public mode if a reliable last mile connectivity comes at Infopark: Yes ☐ No ☐

Preferred modes for last mile connectivity ***(rank from 1 to 7)***:

i. Solar/Electric/Hybrid Vehicle: ☐
ii. Personalised Rapid Transit : ☐
iii. Feeder Service - KSRTC Bus: ☐
iv. Auto rickshaw : ☐
v. Walk : ☐
vi. Cycle : ☐
vii. Motor cycle : ☐

PRT

**Conducted byNational Transportation Planning and Research Centre*

Stated Preference Survey for the Last Mile Trip

Rank (1- 4)

Existing Trip

Walk time	Wait Time	Journey Time	Travel Cost

PROPOSED SCENARIO

CHOICE

Solar/ Electric vehicle

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant ☐
4-Mit.not ☐
5-Def. not ☐

Personal Rapid Transit (PRT)

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chang ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

Feeder Bus Service (From Kakkanad)

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

Cycle

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

Auto

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

Walk

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

Alternate Option

Walk time	Wait Time	Journey Time	Travel Cost

1-Def. ☐
2Mit.chan ☐
3-Cant sav ☐
4-Mit.not ☐
5-Def. not ☐

**NOTE:-*

MODE*	WALK (W)	TWO WHEELER (TW)	AUTO RICKSHAW (AR)	BUS (B)	CAR (C)	CYCLE (CY)

**Conducted byNational Transportation Planning and Research Centre*

SOCIO-ECONOMIC CHARACTERISTICS

- Study revealed factors like gender composition, age distribution, education level, monthly income, vehicle ownership etc effects the trip making characteristics and mode choice

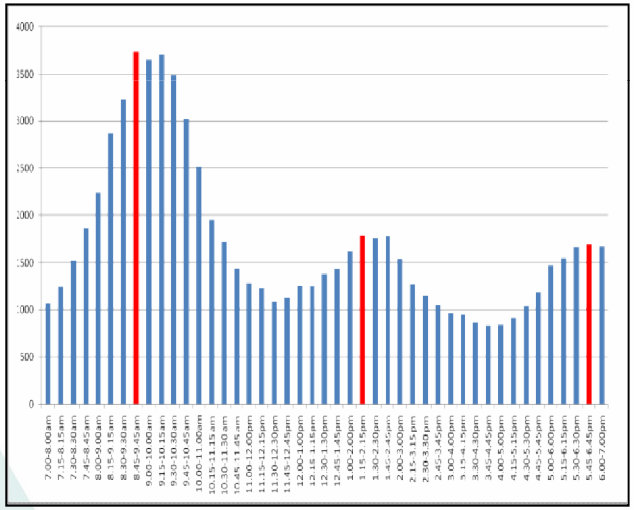
Socio Economic Characteristics	Male (%)	Female (%)
Gender composition	56	44
Personal mode users	63	37

- Most of the employees belong to the age group of 18-30 (72.94%)
- 60% of employees have monthly income below Rs 25,000/-
- 75% of males own a vehicle either car or 2-wheeler or even 33% owns both
- 45% of females own a vehicle either car or 2-wheeler or even 16% owns both
- 76% of males own driving license and rest of the 15% has either 2-wheeler or car license
- 40% of males own driving license and rest of the 20% has either 2-wheeler or car license

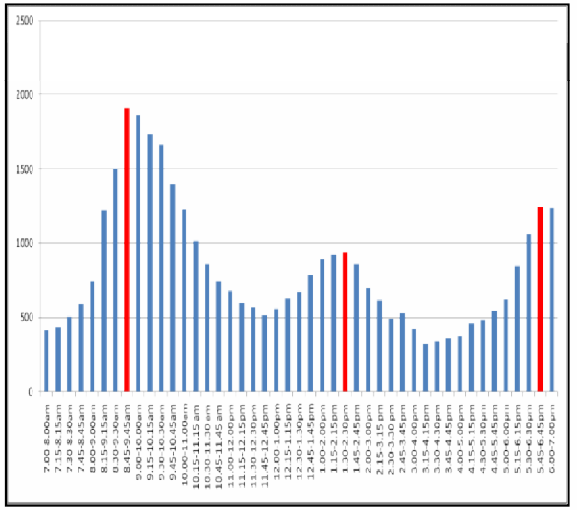
TRAFFIC AND TRAVEL CHARACTERISTICS

- Similar traffic and travel characteristics were observed for the employees of both the IT campuses of Technopark and Infopark

- Three peak hours observed-due to working shifts existing in the campus

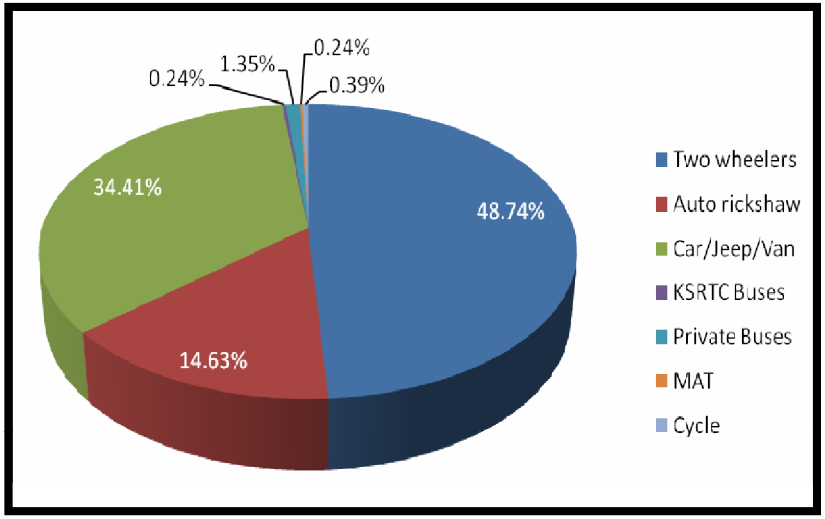


Hourly Traffic volume at Main Gate



Hourly Traffic volume at Rear Gate

TRAFFIC AND TRAVEL CHARACTERISTICS

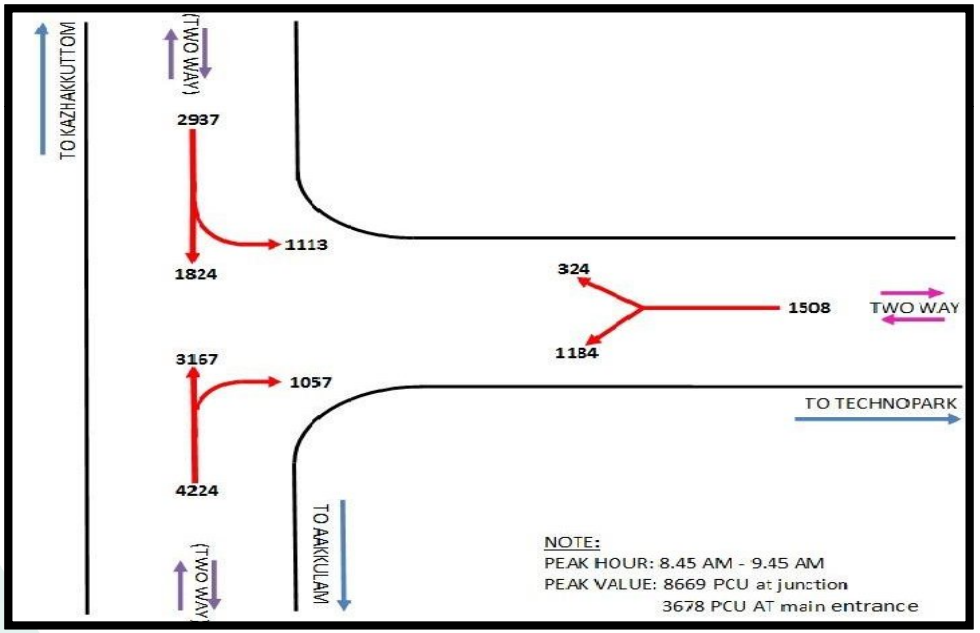


Traffic Inflow Composition at Main Gate during morning peak hour

- study revealed that 62% of employees adhere to personalised modes while 26% use the public transport and 12% on to non-motorised transport

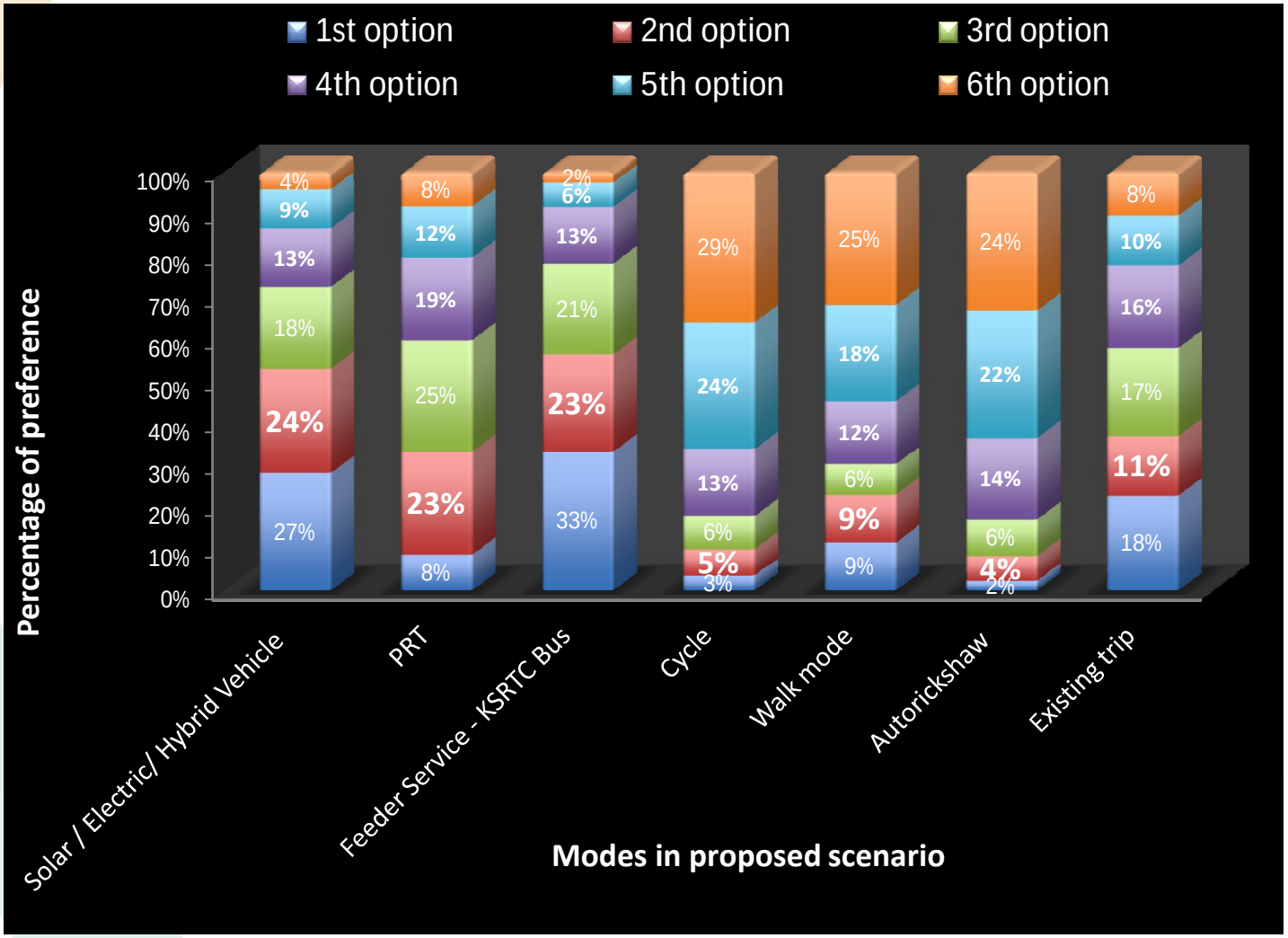
TRAFFIC AND TRAVEL CHARACTERISTICS

- peak hour →8.45am to 9.45am → 3678 PCU
- exceeds the design service volume of 3600PCU
- volume capacity ratio is 1.022
- study revealed 62% of employees adhere to personalised modes while 26% use the public transport and 12% on to non-motorised transport



Turning traffic volume at Techno park Main entrance gate junction

USER PREFERENCE FOR LAST MILE CONNECTIVITY



MODEL DEVELOPMENT

Model Calibration for Modal Shift

- using NLOGIT software

The general expression for the probability of choosing an alternative 'i' (i=1, 2, 3...., j) from a set of j alternatives

$$\mathbf{Prob(y_i=j)=exp(\beta' x_{ij})/(\Sigma^{j}_{m=1}\, exp(\beta' x_{im})}$$

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
TT	-.05915**	.02666	-2.22	.0265	-.11140	-.00690
TC	-.00790	.03664	-.22	.8292	-.07972	.06392
A_PERSON	-2.37110**	1.05432	-2.25	.0245	-4.43752	-.30468
PER_INC1	.55461**	.27269	2.03	.0420	.02014	1.08908
PER_DIS1	.07712*	.04400	1.75	.0797	-.00912	.16336

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

U (Personal mode) = -2.37110 -0.05915* TT -0.00790* TC+0.55461* PER_INC1+.07712* PER_DIS1

U (Public mode) = -0.05915* TT -0.00790* TC

- **Estimated 48% shift from personal modes to public modes in a stated transport scenario with reliable LMC options**

MODEL DEVELOPMENT

Ranking Preference of Last Mile Connectivity Modes

```
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function     -7589.14973
Estimation based on N =   1110, K =   9
Inf.Cr.AIC  =  15196.3 AIC/N =   13.690
Model estimated: Apr 21, 2016, 15:25:24
Model estimated using RANK data for LHS.
Constants only model must be computed directly
To compute pseudo RSQ, use NLOGIT ;...;RHS=ONE$
Number of obs.=  1110, skipped    0 obs
```

RANK	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
WTT	-.02897***	.01032	-2.81	.0050	-.04921	-.00874
JT	-.00305**	.00142	-2.16	.0310	-.00583	-.00028
TC	-.00317**	.00147	-2.16	.0309	-.00604	-.00029
A_1	1.10133***	.08584	12.83	.0000	.93309	1.26957
A_2	1.79746***	.07099	25.32	.0000	1.65833	1.93659
A_3	1.76161***	.07330	24.03	.0000	1.61795	1.90527
A_4	2.01502***	.08093	24.90	.0000	1.85640	2.17365
A_5	-.18926*	.10138	-1.87	.0619	-.38796	.00944
A_6	-.78549***	.11587	-6.78	.0000	-1.01258	-.55839

```
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

MODEL DEVELOPMENT

Ranking Preference of Last Mile Connectivity Modes

The utility function for each of the LMC options of solar/electric vehicle, PRT, feeder bus service, bicycle, autorickshaw and walk mode getting the ranks as 1, 2, 3, 4, 5, 6,7 are:

U (1) =1.10133-WTT*.02897-JT*.00305-TC*0.00317

U (2) =1.79746-WTT*.02897-JT*.00305-TC*0.00317

U (3) =1.76161-WTT*.02897-JT*.00305-TC*0.00317

U (4) = 2.01502-WTT*.02897-JT*.00305-TC*0.00317

U (5) =-0.18926-WTT*.02897-JT*.00305-TC*0.00317

U (6) =-0.78549-WTT*.02897-JT*.00305-TC*0.00317

U (7) = -WTT*.02897-JT*.00305-TC*0.00317

- The variables are found to be significant and their sign is logical
- Wald –statistic for all variables greater than 1.96 showing the significance of variables
- The models are found to be statistically significant with satisfactory pseudo rho-square values of 0.2

AVERAGE TRIP LENGTH AND TRAVEL COST

Comparison of average trip length and travel cost

Trip Particulars	Average Trip Cost (Rs)	Average Trip Length (Km)	Average Cost Per Km (Rs)
Technopark			
Last Mile Trip	2.3	25.43	11.06
Main Trip	12	15.68	1.31
Infopark			
Last Mile Trip	3	19.90	6.63
Main Trip	13.04	31.40	2.40

- Employees spend about 8.5 times the cost of main trip for their last mile trip →inadequacy of last mile connectivity and the related issues
- Provide reliable service of last mile connectivity by means of sustainable modes with due regard to the user preferences

DEMAND ESTIMATION AND FLEET DESIGN OF LMC

Route Selection and Fleet Design for Technopark

- Route 1 connects buildings in the Technopark campus phase 1 with the proposed bus terminal near the campus. This route could be utilized by the modes like solar vehicles, PRT and bus

- Route 2 connects Kazhakuttam railway station, Kazhakuttam junction and proposed bus terminal with Technopark campus

- Route 3 connects Kazhakuttam railway station to the Technopark campus

Route 1 -solar vehicle service for LMC in Technopark

Route 3- solar vehicle service for LMC in Technopark

DEMAND ESTIMATION AND FLEET DESIGN OF LMC

- A modal shift of 20% from personalized mode to public transport is considered while estimating the demand

Mode	Average speed (kmph)
PRT	30
solar vehicle	35
feeder buses	40

Fleet Design for Last Mile Connectivity in Technopark Campus

Route	Vehicle type	Length (km)	Stops	Time to complete one trip (min)	Frequency (min)	Number of sets	Demand in an hour	Demand / frequency	No. of vehicles required in one set	Total no. of vehicles required
R1	Solar	4.3	8	9.4	5	2	448	37	2 (14seater+23seater)	4
	Bus	6.7	9	12.3	7	2	858	100	3 (41 seater)	6
	PRT	5	5	11.3	3	4	268	13	3 (5 seater)	12
R2	Bus	12	9	20.3	7	3	376	44	1 ((41 seater)	3
R3	Solar	5.2	8	10.9	5	2	210	18	2 (7seater+ 14seater)	4
							2160			

- Number of PRT vehicles required - 12 five seater
- Number of solar vehicles required - 2 seven seaters, 4 fourteen seaters, 2 twenty three seater
- Number of feeder buses required - 9 forty two seaters

DEMAND ESTIMATION AND FLEET DESIGN OF LMC

Route Selection and Fleet Design for Infopark

- The route selected connects buildings in the Infopark campus phase 1 with the three points- Kakkanad bus stop, Infopark main gate and Seaport-Airport road. This route could be utilized by the modes like solar vehicles and buses.

- Solar cars start from the Kakkanad Bus stop, connect each building inside the Infopark campus and extend upto Seaport-Airport road. Then it can return by the same path and reach Kakkanad bus stop.

- Buses may start from Kakkanad bus stop, connects all buildings in the campus and reaches near the Seaport Airport Road. Then it can return by the same path and reach bus terminal

Route 1 -solar vehicle service for LMC in Infopark

Route 3- solar vehicle service for LMC in Infopark

Fleet Design for Last Mile Connectivity in Infopark

Vehicle type	Length (km)	Stops	Time to complete one trip (min)	Frequency (min)	Number of sets	Demand in an hour	Demand/ frequency	No. of vehicles required in one set	Total no. of vehicles required
Solar	10.32	9	22	5	5	442	37	2	10
Bus	10.32	9	20	7	3	1033	121	3	9
						1475			

Number of solar vehicles required =

Five sets of 2 seven seaters/ one fourteen seater and 1 twenty three seater

Number of feeder buses required = 9 forty one seaters

Fleet Design for Last Mile Connectivity in Infopark

Vehicle type	Length (km)	Stops	Time to complete one trip (min)	Frequency (min)	Number of sets	Demand in an hour	Demand/ frequency	No. of vehicles required in one set	Total no. of vehicles required
Solar	10.32	9	22	5	5	442	37	2	10
Bus	10.32	9	20	7	3	1033	121	3	9
						1475			

Number of solar vehicles required =

Five sets of 2 seven seaters/ one fourteen seater and

1 twenty three seater

Number of feeder buses required = 9 forty one seaters

CONCLUSION

•Paper gives an overview of the integration of last mile connectivity options with the existing and imminent public transport system in the workcentres of IT campuses

•Potential demands of the passenger traffic and mobility requirements of employees and visitors within the campus for their last mile connectivity to the work centre are assessed based on the data collected by primary and secondary surveys

•Mode choice analysis of users is done in detail after conducting user preference surveys on a stated preference approach. The possible modal shift is ascetained for a stated transport scenario with reliable last mile options based on the utility function calibrated by NLOGIT software

CONCLUSION

•Feasibility of deploying various feeder services for the work centre campuses is ascertained and the fleet requirement is estimated

•Fleet design of sustainable modes for last mile connectivity in the work centre campuses is done with due care to the demand and user preferences

•Possible road map is brought for initial implementation of greener transport in campuses and ipso facto leading to large scale use of greener transport modes in the state or nationwide

THANK YOU