

**TECHNO ECONOMIC FEASIBILITY REPORT
FOR DELHI MONORAIL SYSTEM
(September 2007, RITES - NIPPON KOEI - TONICHI - ICRA)
and
DETAILED PROJECT REPORT
(July 2012, RITES)**

September 2013

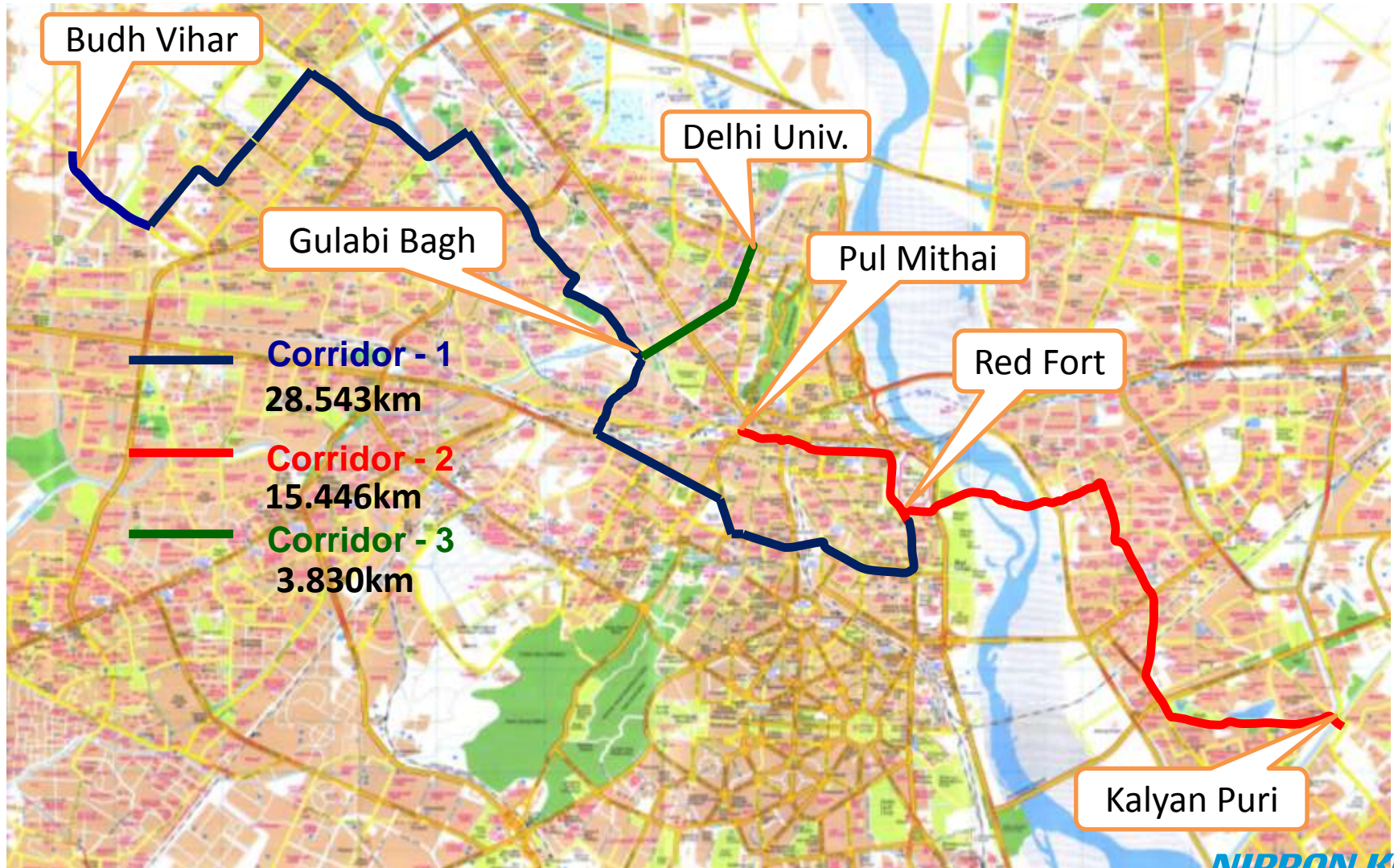
NIPPON KOEI
Challenging mind, Changing dynamics

Ken Nishino

Existing Transport System and Mobility Plan in New Delhi



Planned Monorail Corridors in the Feasibility Study (2007)



Planned 3 Monorail Corridors

- Corridor 1 : Budh Vihar to Red Fort
(28.543km)
- Corridor 2 : Kalyanpuri to Pul Mithai
(15.446km)
- Corridor 3 : Delhi University to Gulabi Bagh
(3.830km)

Demand Forecast

Corridor		2021		2031		2041	
No.	Section	Daily	PHPDT	Daily	PHPDT	Daily	PHPDT
1	Budh Vihar – Red Fort	365,588	20,780	445,652	25,331	517,402	29,409
2	Kalyanpuri – Pul Mithal	168,600	9,583	205,523	11,682	238,613	13,563
3	Delhi Univ. – Gulabi Bagh	90,618	5,151	110,463	6,279	128,248	7,290

Source: FS Report 2007

Note: Above data are taken from the following sections

Corridor 1 : between Shalimar Bagh and Wazirpur Industrial Area

Corridor 2 : between Taj Enclave and Gandhi Nagar

Corridor 3 : between Kamia Nagar and Gulabi Bagh

Maximum Station Loads at each Corridor

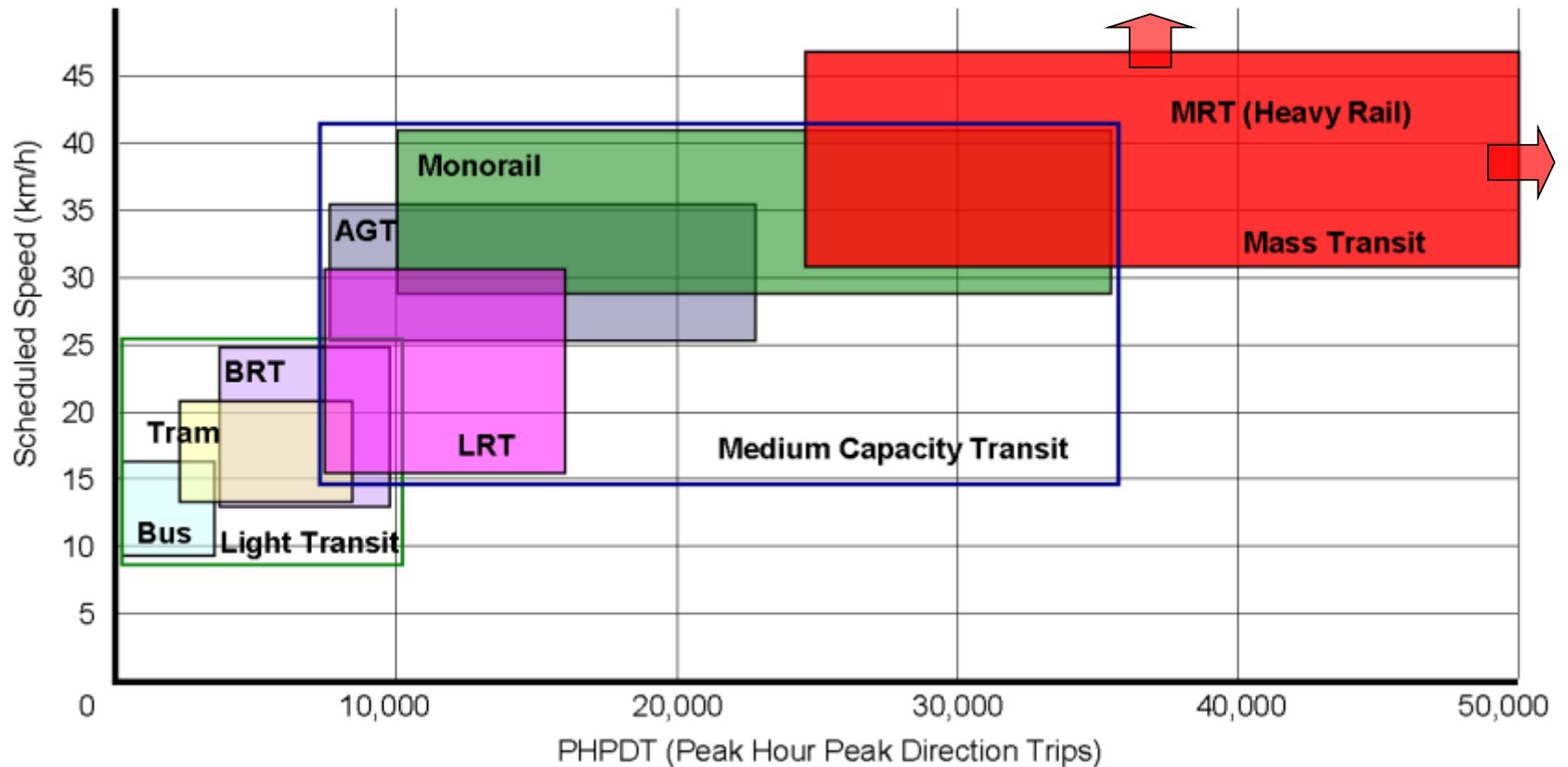
Corridor		2021		2031		2041	
No.	Station	Daily Boarding /Alighting	Peak Hour	Daily Boarding /Alighting	Peak Hour	Daily Boarding /Alighting	Peak Hour
1	Budh Bihar	48,200	4,820	58,800	5,880	68,300	6,830
2	Geeta Colony	29,300	2,930	35,700	3,570	41,400	4,140
3	Kamla Nagar	29,700	2,970	36,200	3,620	42,000	4,200

Source: FS Report 2007

Selection of Suitable Urban Transit System

System Item	(a) Bus (surface)	(b) Bus (elevated)	(c) LRT (at grade)	(d) AGT (elevated)	(e) Monorail (suspension type)	(f) Monorail (straddle type)	(g) Heavy Rail (elevated)	(h) Heavy Rail (underground)
System Appearance								
Capacity	Small	Small	Small – Medium	Medium	Medium	Medium – Large	Large	Large
Speed	Low	Low – Medium	Low – Medium	Medium	Medium	Medium – Large	Large	Large
Cost for Construction	Lowest	Low – Medium	Low – Medium	Medium	Medium – High	Medium – High	Medium – High	Highest
Cost for O&M	Low – Medium	Medium	Low – Medium	Medium	Medium	Medium	Medium – High	Medium – High
Required Space	Large	Medium	Large	Small – Medium	Small – Medium	Small – Medium	Medium – Large	Small
Environmental Impact (air / noise / landscape)	Large / Large / Small	Large / Medium / Large	Medium / Medium / Small	Small / Medium / Large	Small / Medium / Medium	Small / Medium / Small	Medium / Medium / Large	Small / Small / Small
Past Experiences	Many	A few	Many	Many	A few	Many	Many	Many
Features	<ul style="list-style-type: none"> – Small capacity – Lowest cost – Limited effect 	<ul style="list-style-type: none"> – Small capacity – Less E&M facilities – Few experiences 	<ul style="list-style-type: none"> – Small to medium capacity – Passenger friendly system – Disturbing road traffic 	<ul style="list-style-type: none"> – Medium capacity – Unmanned operation is possible 	<ul style="list-style-type: none"> – Medium capacity – Heavier structure than straddle type 	<ul style="list-style-type: none"> – Medium to large capacity – Simple track structure – Less environmental impacts 	<ul style="list-style-type: none"> – Large capacity – Higher speed – Large space for depot and workshop 	<ul style="list-style-type: none"> – Large capacity – Higher speed – Highest construction cost – Less environmental impacts

System Selection Chart



Characteristics of Monorail

- Medium capacity transit system between BRT and MRT
- Suitable for narrow corridor
- Applicable for steep slope and small curve alignments
- Lower construction cost than MRT

Capacity of Large Size Monorail

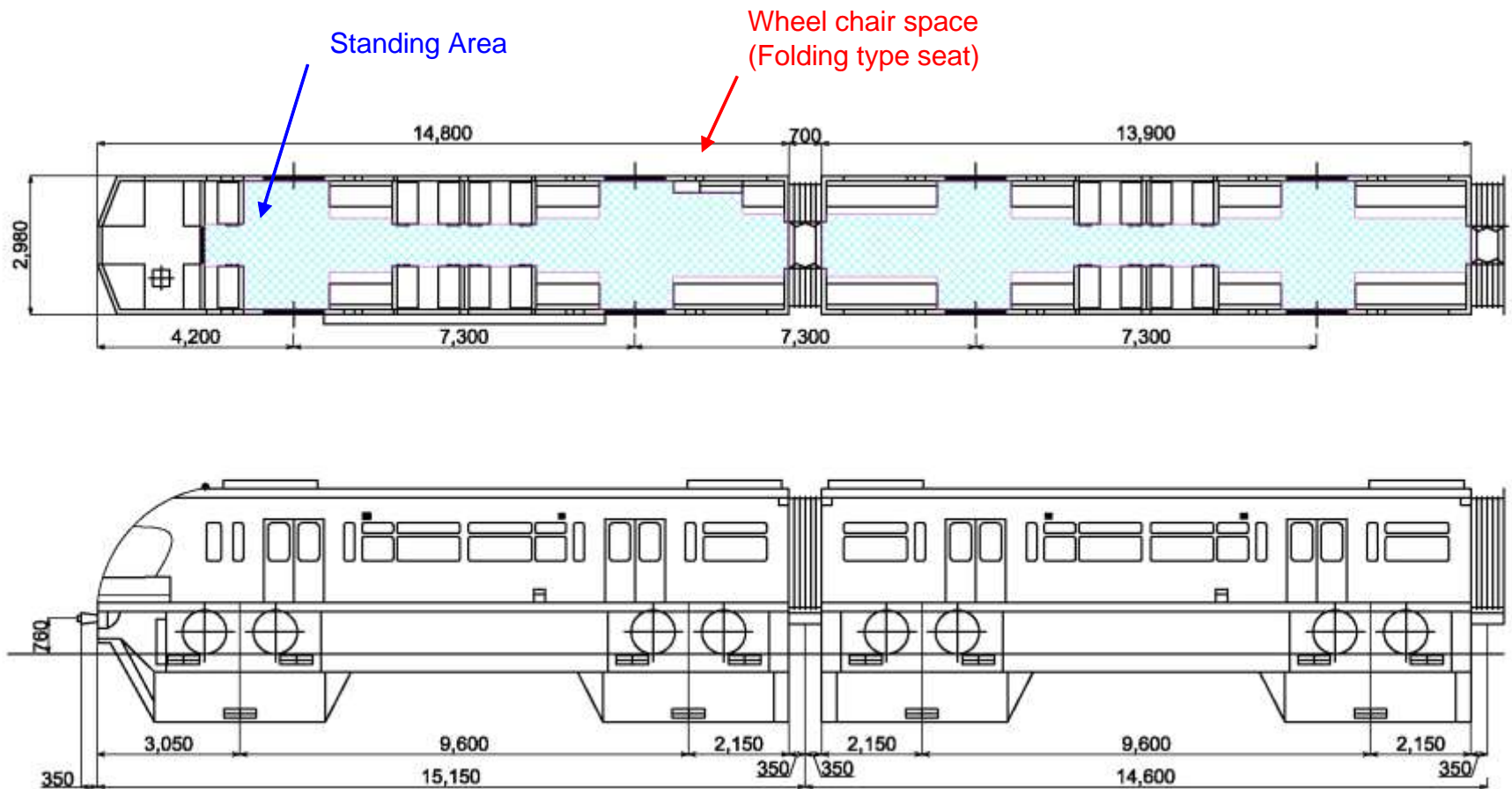
Headway		No. of Train (per hour)	2-car train	4-car train	6-car train	7-car train	8-car train
90 sec	(1.5 min)	40	8,000	16,400	24,800	29,200	33,600
			14,000	29,200	44,000	52,000	60,000
120 sec	(2 min)	30	6,000	12,300	18,600	21,900	25,200
			10,500	21,900	33,000	39,000	45,000
150 sec	(2.5 min)	24	4,800	9,840	14,880	17,520	20,160
			8,400	17,520	26,400	31,200	36,000
180 sec	(3 min)	20	4,000	8,200	12,400	14,600	16,800
			7,000	14,600	22,000	26,000	30,000
240 sec	(4 min)	15	3,000	6,150	9,300	10,950	12,600
			5,250	10,950	16,500	19,500	22,500
300 sec	(5 min)	12	2,400	4,920	7,440	8,760	10,080
			4,200	8,760	13,200	15,600	18,000
360 sec	(6 min)	10	2,000	4,100	6,200	7,300	8,400
			3,500	7,300	11,000	13,000	15,000
600 sec	(10 min)	6	1,200	2,460	3,720	4,380	5,040
			2,100	4,380	6,600	7,800	9,000
720 sec	(12 min)	5	1,000	2,050	3,100	3,650	4,200
			1,750	3,650	5,500	6,500	7,500
900 sec	(15 min)	4	800	1,640	2,480	2,920	3,360
			1,400	2,920	4,400	5,200	6,000

Basic Data of passenger loading capacity

Unit: person

Condition	2-car train	4-car train	6-car train	7-car train	8-car train
Nominal	200	410	620	730	840
Full loaded	350	730	1,100	1,300	1,500

Dimension of Large Size Monorail



Advantages of Monorail System

- Proven and Safe Technology

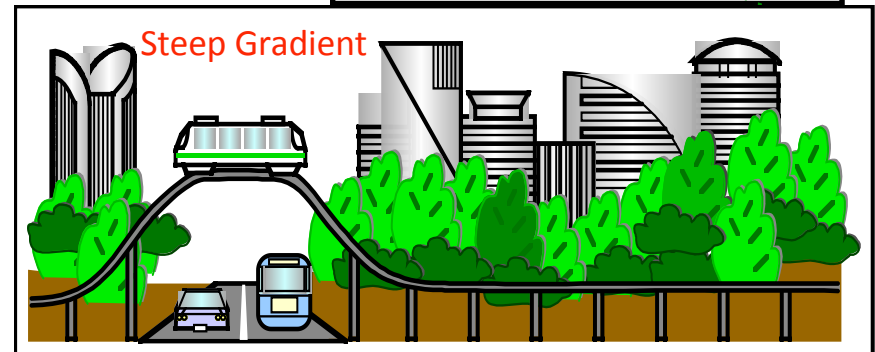
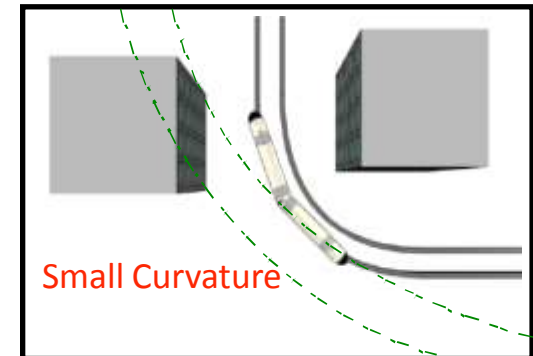
Proven in Japan and all over the world.

- Flexibility in Design, Slim Structure

Min. Curve Radius 60m

Max. Gradient 6.0%

Slim structure



- Environmental Friendly Features

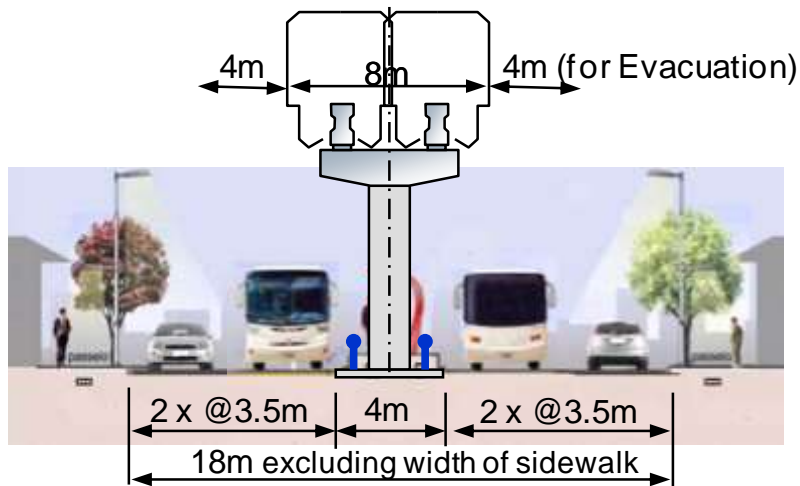
- Quiet (Using electric power, rubber tyre)
- No emission gas (GHG, NOx, SOx).
- Saving fuel consumption
- Less land acquisition
- Keep access to the sky

- Low Construction Cost



Typical Monorail Structure

4 Lanes



Kita-Kyusyu Monorail, Fukuoka, Japan

Operation in Tokyo, Japan

Time	Weekdays																														
4	H 58																														
5	R	R	Δ	H	R	Δ	11	18	24	32	38	42	49	55																	
6	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	00	05	11	16	20	24	30	34	38	42	48	52	56					
7	00 04 07 11 15 19 23 26 30 33 36 40 43 46 50 53 56																														
8	00 03 06 10 13 16 20 23 26 30 33 36 40 43 46 50 53 56																														
9	00 03 06 10 13 16 20 23 28 32 36 40 44 48 52 56																														
10	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
11	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
12	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
13	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
14	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
15	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
16	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	H	R	Δ	00	04	08	12	16	20	24	28	32	36	40	44	48	52	56	
17	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	00	03	07	11	15	20	23	27	31	35	38	43	46	50	54	58
18	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	H	Δ	02	07	10	14	18	22	26	30	34	37	41	45	48	53	57	
19	R 01 05 09 15 20 24 30 34 40 45 50 55																														
20	R 00 05 10 14 20 24 30 35 40 45 50 55																														
21	R 00 05 09 15 20 25 31 35 41 46 51 55																														
22	R 01 06 10 15 20 26 31 35 41 46 53 58																														
23	S 03 08 15 21 26 30 37 51																														
0	H 01																														

Frequent Operation
18 trains/hour → It will be increased up to 24 Trains/hour by improvement of Terminal Station

Flexible Alignment
Passing through without demolishing existing structures.



H: Haneda Express R: Rapid train S: For Showajima Δ: Waits for Haneda Express to pass at Showajima Station

Features of Monorail



Construction Features of Monorail



Comparison of Construction Features



Result of Financial/Economic Analysis in the FS Report (2007)

a) FIRR

No.	Corridor	with Land Cost	without Land Cost
1	Budh Vihar to Red Fort	4.25%	6.10%
2	Kalyanpuri to Pul Mithai	2.01%	2.86%
3	Delhi University to Gulabi Bagh	6.21%	7.02%
All Corridor		3.80%	5.28%

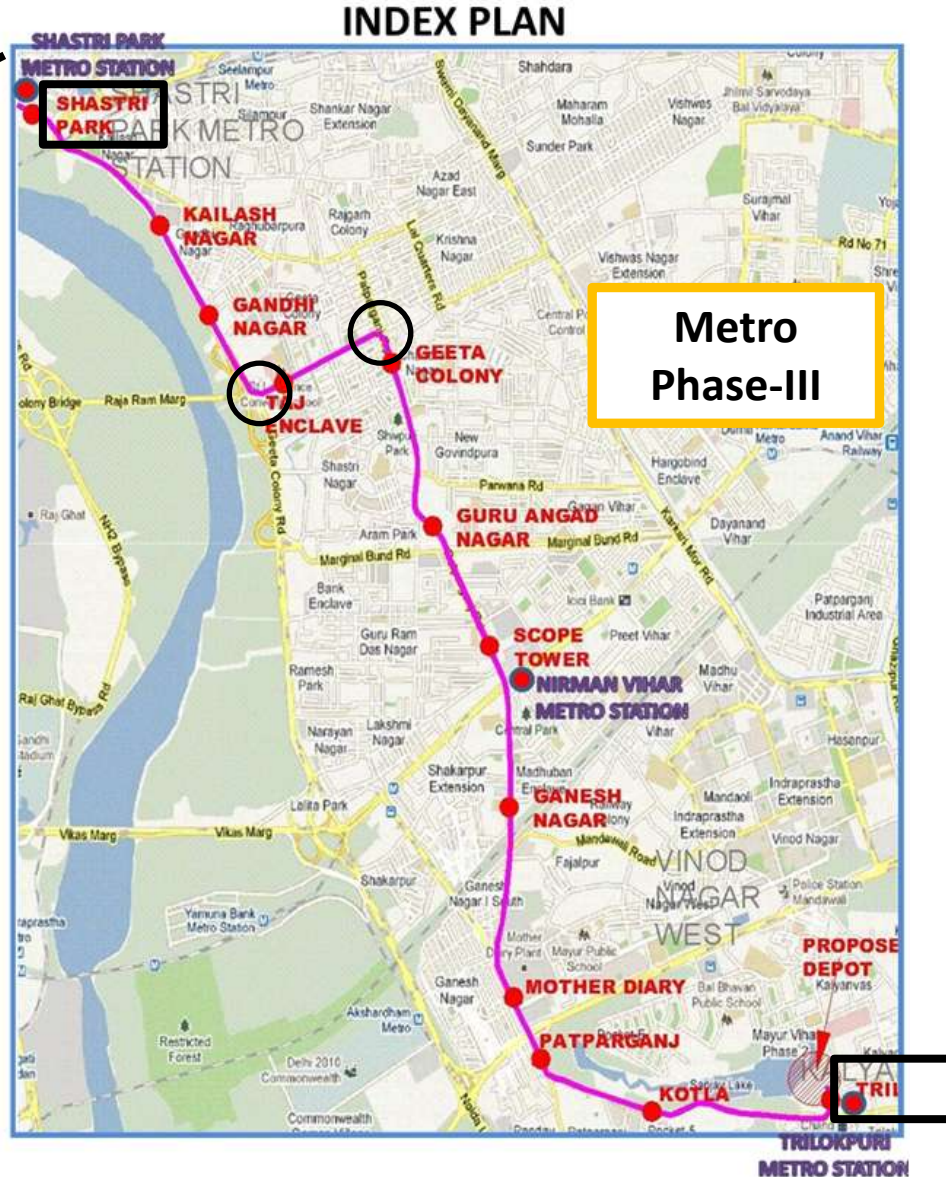
Source: FS Report 2007

b) EIRR (All Corridor) : 23.55%

Source: FS Report 2007

Planned Monorail Route in the DPR (2012)

Sonia Vihar



Demand Forecast and Train Operation Plan

Transport Demand

Year	Maximum PHPDT	Daily Passengers (Lakh)	Daily PKM (in Lakh)	Daily PKM / KM (in Kakh)
2016	7615	1.32	8.54	0.77
2021	9339	1.61	10.47	0.95
2031	12551	2.20	14.07	1.28
2041	15229	2.70	17.15	1.56

Train Operation Plan

Year	No. of Cars/Train	Train/Hour	Peak Hour Head way (minutes)	Capacity Per Hour
2016	4	14	4.3	7952
2021	4	16	3.8	9088
2031	6	16	3.8	13632
2041	6	18	3.3	15336

Civil Design

Curvature

S. No.	Radius (m)	No. of Occurrences	Length (m)
1	< 100	10	1100.18
2	> 100 to 200	2	211.28
3	> 200 to 500	13	1735.71
4	> 500 to 1000	9	897.34
5	> 1000	10	705.12
		44	4649.62

Gradients

S. No.	Description	No. of Occurrences	Length (m)	Length (%)
1	Level (0%)	25	5990.54	54.09
2	> 0% to 1 %	4	728.00	6.57
3	> 1% to 2%	9	2032.11	18.35
4	> 2% to 3%	8	1200.85	10.84
5	> 3%	6	1123.50	10.14
		52	11075.00	100.00

Result of Financial/Economic Analysis in the DPR (2012)

a) FIRR

Option	Corridor	Length	FIRR
1	Shastri Park – Trilokpuri	11.00km	2.31%
2	Shastri Park – Trilokpuri – Mayur Vihar	15.18km	1.27%

Source: DPR 2012

b) EIRR: Corridor Shastri Park to Trilokpuri

Base case :	19.47%
20% increase Capital Cost Case	16.38%

Source: DPR 2012

Thank You Very Much for Your Kind Attention!



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