

STRATEGIC PLANNING

- i. AN ORGANIZATION'S PROCESS OF DEFINING ITS STRATEGY OR DIRECTION AND MAKING SUITABLE DECISIONS IN ALLOCATING IT'S RESOURCES TO PURSUE ITS STRATEGY.
- ii. WHILE IT CAN BE USED TO CHART AN ORGANIZATIONS LONG TERM DIRECTION. IT CAN NOT BE USED TO RELIABLY FORECAST HOW THE FUTURE WILL EVOLVE.
- iii. HENCE INNOVATIONS/ ADAPTATIONS AS PER FORECAST BECOMES A KEY ELEMNET FOR BOTH SURVIVAL AND EXCELLENCE OF ANY EVOLVING ORGANIZATION.

FORECASTING

PRIMARILY AN ATTEMPT TO RECREATE
/GUESS FUTURE FOR EXPLORING
ALTERNATIVES AVAILABLE

- i. IN ANY FUTURISTIC SCENARIO & THEN
- ii. IDENTIFYING THE MOST PROBABLE
ALTERNATIVE
- iii. FORECASTING IS USED FOR MODIFYING
VARIABLES TO INTRODUCE REQUIRED
CHANGE IN A SYSTEM(I.E. OPTIMIZATION)

CLASSIFICATION OF FORECASTING METHODOLOGY

- i. GENIUS FORECASTING
- ii. TRENDS EXPLOITATION
- iii. CONSENSUS METHODS
- iv. SIMULATION METHODS
- v. CROSS IMPACT MATRIX METHOD
- vi. SCENARIO
- vii. DECISION TREES

CONSTRAINTS

- i. LACK OF CERTAINTY
- ii. BLIND SPOTS – TECHNOLOGY : SOCIAL, POLITICAL, ENVIRONMENTAL POLICY FRAMEWORKS
- iii. NORMALLY A VICIOUS CYCLE
FORECAST – NEW SOCIAL POLICY –
CHANGE IN ENVIRONMENT – THUS
AFFECTING ACCURACY OF FORECAST.

CAPACITY ESTIMATION OF A RAIL SYSTEM IS EVALUATED BY FOLLOWING METHODS

- i. ANALYTICAL – PRELIMINARY SOLUTIONS FOR CAPACITY ASSESSMENT.
- ii. OPTIMIZATION – DESIRED SCHEDULES /PATHES IN SATURATED SYSTEMS
- iii. SIMULATION – VALIDATION OF RESULTS/ SCHEDULES / PATHES OBTAINED THROUGH OPTIMIZATION METHOD

AN INTEGRATED APPROACH IS TO BE INITIATED FOR SCIENTIFIC YET PRACTICAL CAPACITY ASSESSMENT AND COST EFFECTIVE SOLUTIONS.

DECISION SUPPORT SYSTEMS

- i. IS A COMPUTER BASED INFORMATION SYSTEM THAT SUPPORTS ORGANISATIONAL DECISION MAKING ACTIVITIES.
- ii. DSS IS AN INTERACTIVE SOFTWARE BASED SYSTEM TO ANALYZE AVAILABLE DATA BASE [COLLECTIVE WISDOM] TO IDENTIFY AND SOLVE PROBLEMS AND MAKE DECISION.

Long Range Decision Support System

- Integrated Approach to Investment Planning**

LRDSS-Historical Perspective

- **Phase I- Aug 94-Jul 96:** World Bank Funded: US \$ 0.75 Million used to develop a prototype
- **Phase II- Apr 97-Jun 2000:** IR funded US \$ 0.55 million to develop basic modules + Rs. 70 lakhs for 2 surveys
- **Phase III- Oct 01- May04:** Jointly funded by IR and USTDA (60:40) US \$1.02 million with focus on Terminals and Intermodal Traffic
- **Phase IV-Oct 06 to June 07:** IR funded US \$52,000 to Refurbish Traffic Assignment Module built in Phase II to support the Eleventh Plan process by identification of investment requirements through scientific analysis

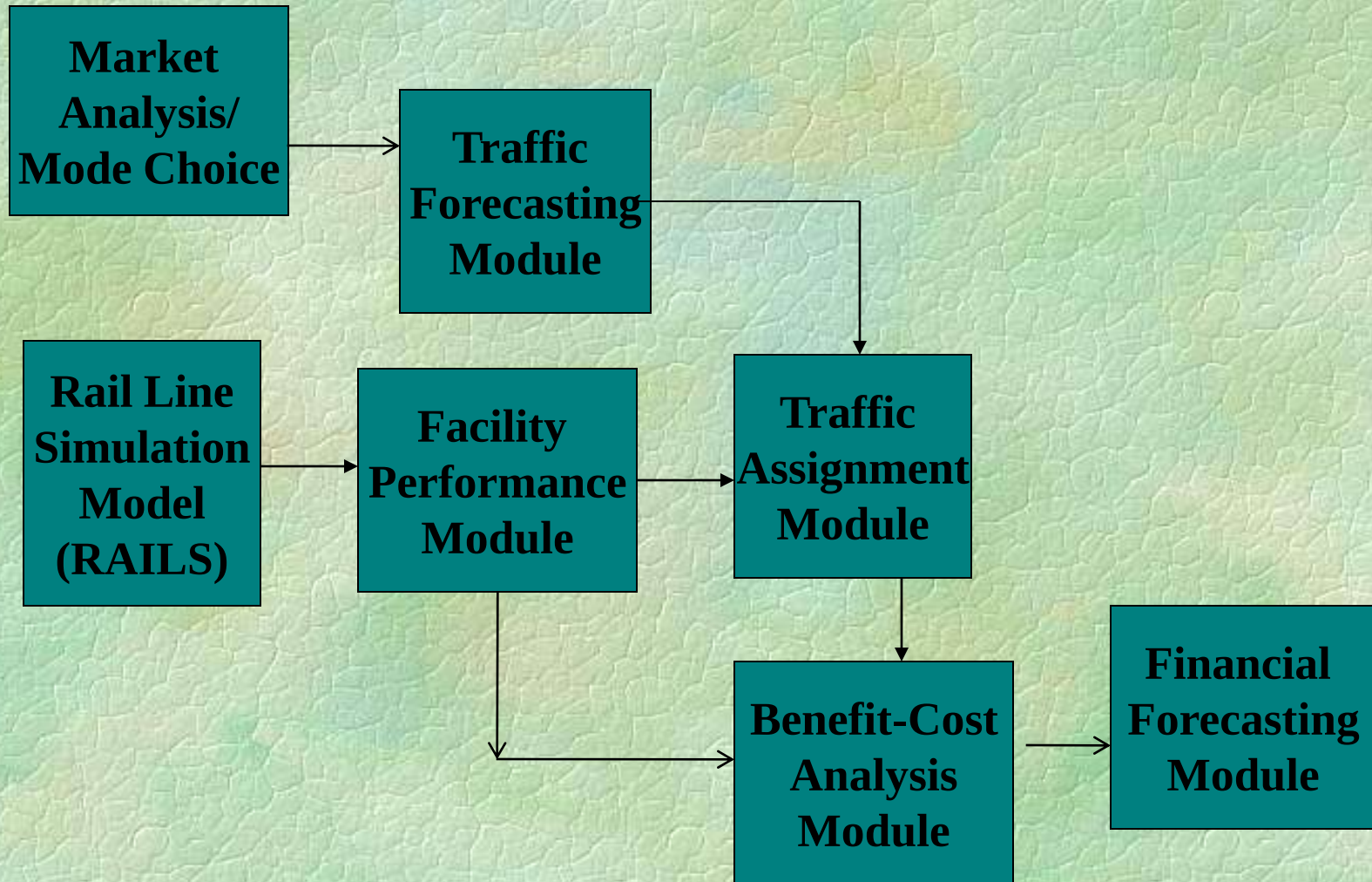
LRDSS - World Class Product

- Designed to provide Decision Support to planners in :
 - Capacity planning - Identification of critical links
 - Evaluation of impact of large investment projects on IR Network
- Present planning process justifies investments on local operational conditions & sub system optimisation , does not take a system wide view
- LRDSS- Integrative Character
 - Interdisciplinary
 - Network Oriented
 - System wide Analysis
 - Simultaneous /Sequential Analysis
 - Customized GIS-based interface -map-based data presentation

Main Objectives

- To **forecast O-D wise traffic flows** in terms of major commodities & empty flows
- To **simulate forecast flows** on various links of network .
- To **identify bottlenecks** to initiate cost-effective measures to improve utilization of track & rolling stock
- To **evolve a strategy for movement of traffic** between pairs of points - selection of a route with least cost.
- To **facilitate selection of new investment schemes** for increasing total system throughput within prevailing budgetary constraints.
- To **conduct Commodity wise, slab wise Lead Analysis**

LRDSS Capacity Planning System- Phase II



Analysis of possible Scenarios :

- Scenarios composed of Proposed future network, Commodity wise O-D Traffic forecast, paths
- IR System simulated at Two Levels:
 - **Selected representative railway links-** where train operations simulated for analysis of impact of line features on costs, delays ,capacities. All links of IR classified (using parametric analysis) in terms of these selected representative links.
RAILS-Micro modelling
 - **System wide basis-** where potential rail traffic flows assigned on optimum and preferred routes across future IR network with proposed set of Line capacity investments - Macro Modelling
- **Identification of Bottlenecks & Evaluation of options for their elimination**

Why Operations Modelling?

- **Strategic Model-** Basis for Traffic Assignment-Traffic flows allocated on various links of IR network based on **optimisation criteria- minimisation of carrier costs**
- **Key Inputs:** Traffic Demand: O-D and commodity wise
 - Network definition- Link/Node characteristics
- Therefore **necessary that costs, time delays, capacity functions of each link form part of base network** for running Strategic Model-TAM.
- Thus **operating level model** necessary
- Not possible to model each individual link of vast IR network. **Essential to categorise network based on a set of common physical characteristics & obtain operating characteristics for these link types.**

Line Simulation -RAILS

- Two Modules- Train Performance Calculator (TPC) and Train Despatch simulator (TDS)
- 37 Representative sections of IR simulated. Track built into the software with all its gradients and curvatures, speed restrictions, type & location of signals. Station details included loop lines and cross over points
- More than 25 Train Types defined (Hauling power & Train load combinations, traction, type & no. of wagons, locos) with associated priority
- Each IR link (combination of Gauge, terrain, traction, number of tracks, signalling) categorised in terms of these representative links by generalisation using parametric analysis.

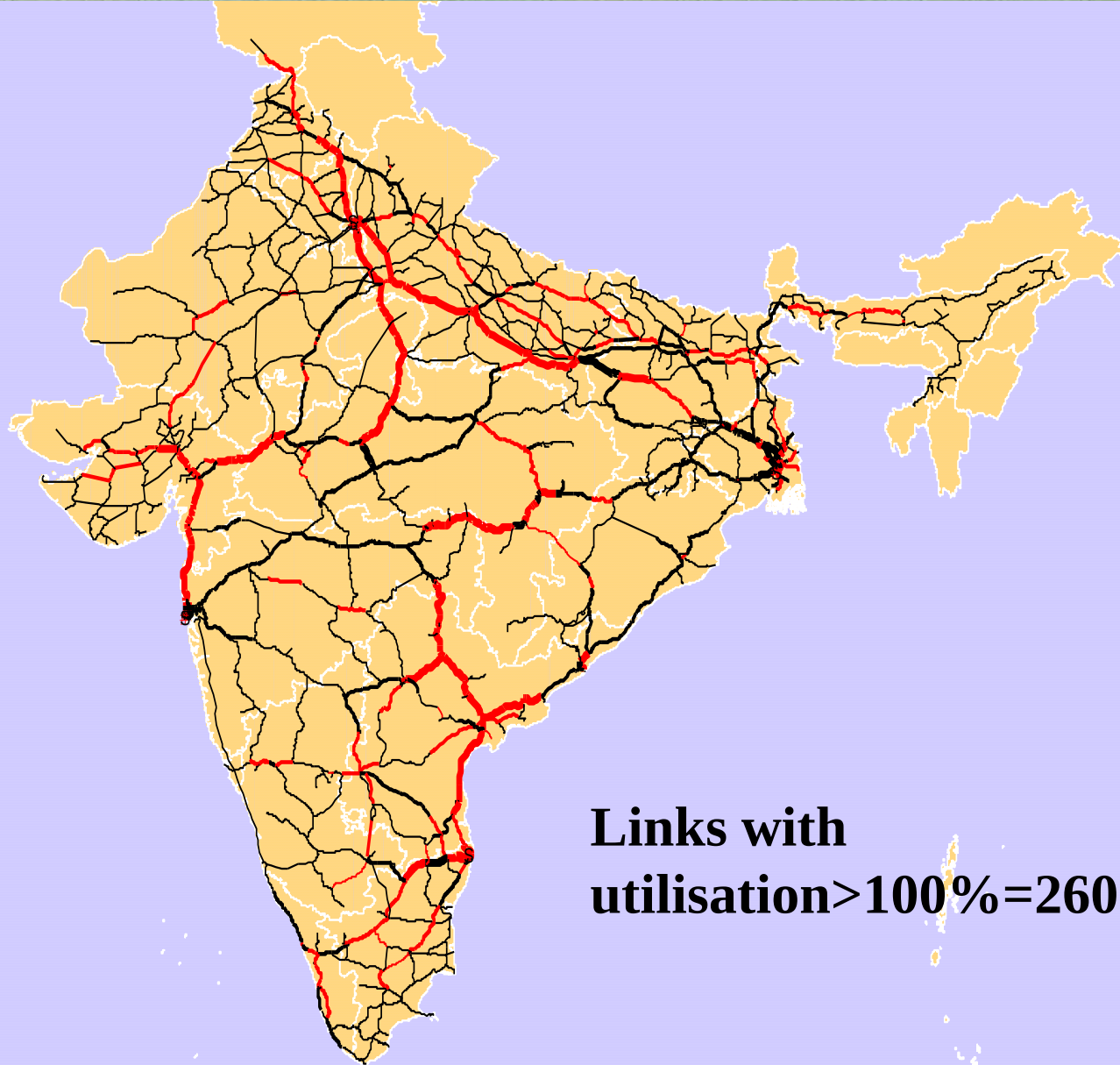
Simulation Runs

- **Calibration:**
 - Within 5% of actual Control Charts .
- **Congestion & Capacity Modeling**
 - Traffic increased incrementally to obtain
 - Congestion curve and congestion function
 - Converted to Speed and cost functions
 - Estimated Line Capacity
- **Scenario Analysis:**
 - Impact of failures
 - Horsepower to Trailing Load ratios
 - Assessment of Line capacity augmentation in different scenarios

Line Capacity Definition

- Existing method based on Master Charting
- Master Chart
 - drawn for a day
 - not adequate to capture complexity of train operations
- For same physical/ operating characteristics, wide variation in capacity over the entire network

Links with 85% or more utilisation



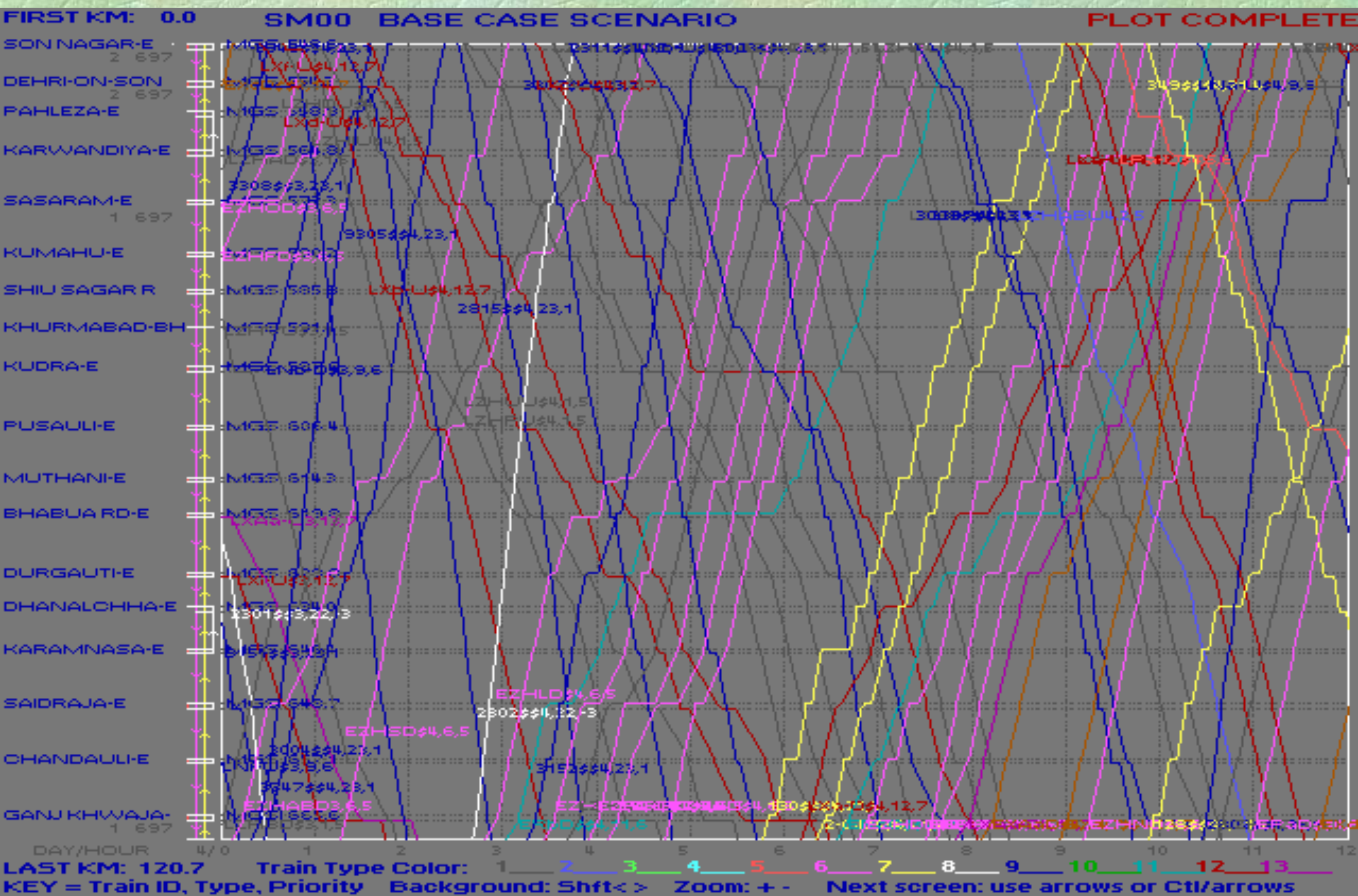
**Links with
utilisation > 100% = 260**

Service Index (Congestion level) based Line Capacity Definition

■ Features

- Performance norm based on transit times
- Takes into account impact of key operating/physical/maintenance factors:
 - traffic mix
 - train characteristics
 - section characteristics
 - maintenance blocks
 - caution/slow orders

Simulated Control Chart of SEB-MGS Section



Transit Time Components

- Average Transit Time per Train (T)
 - Bare Running Time (t_1)
 - Scheduled delays (t_2)
 - Unscheduled delays (t_3)
- $T = t_1 + t_2 + t_3$
- Illustration follows

Bare Running Time (t_1)

- Influencing Factors:
 - Section Characteristics
 - Permanent Speed Restrictions
 - Gradient & Curvature
 - Train Characteristics
 - HP/Trailing Load ratio
 - Tractive Effort /Speed Curves
 - Type of wagons, Rolling Resistance etc.

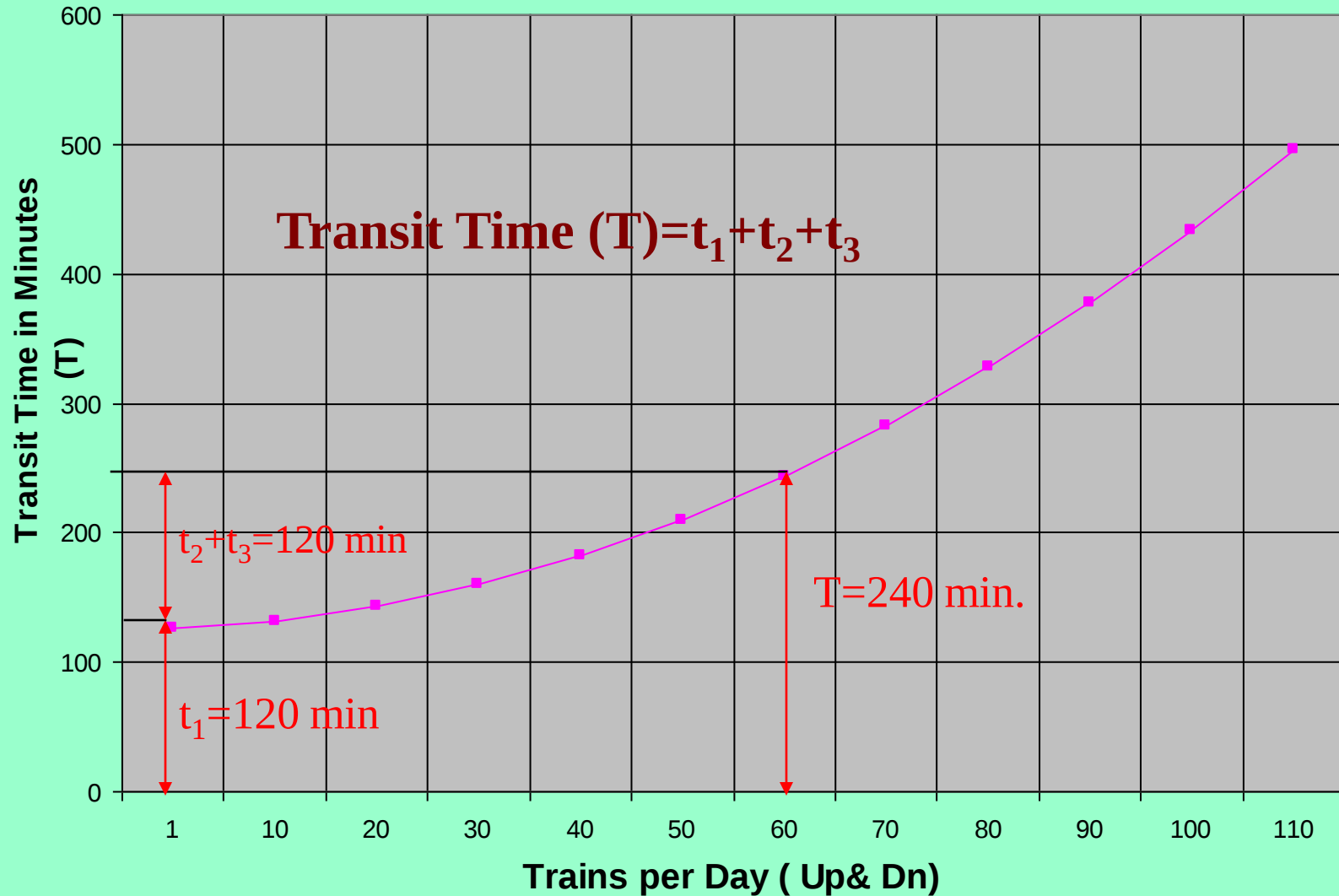
Scheduled Delays (t_2)

- Influencing Factors
 - Planned events
 - Caution Orders.
 - Maintenance Blocks.
 - Passenger Train halts.
 - t_2 related to operating policy
- t_1 & t_2 largely fixed over the medium/short term
- time taken by a train to cover a section- sum of t_1 , t_2 and

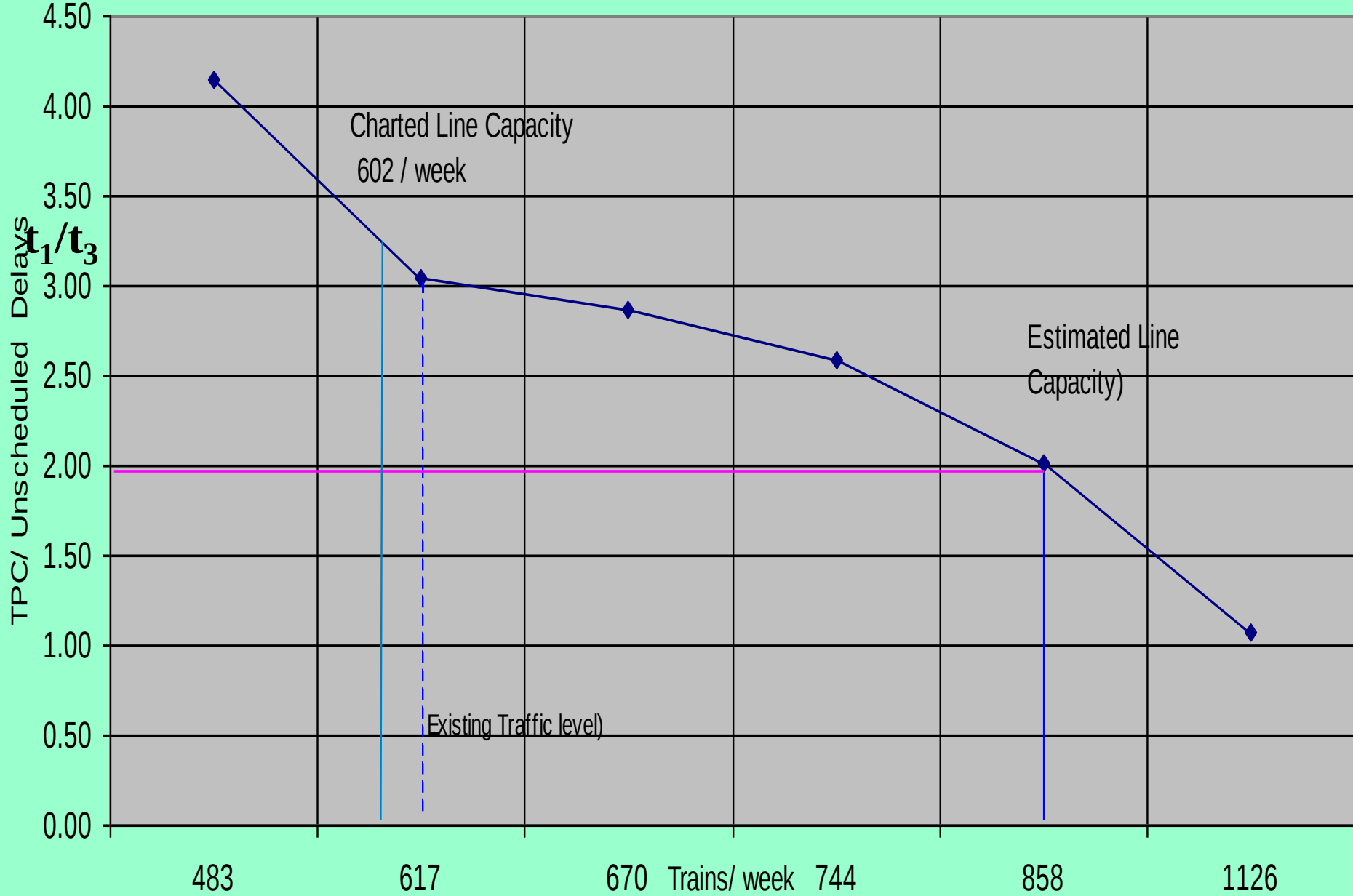
Unscheduled Delays(t_3)

- En-route delays associated with
 - Meets and passes on single line
 - Overtakes on double line
 - traffic mix & speed differentials
 - bunching of trains
 - efficiency of operations
- Unscheduled delays increase as trains on section increases.

**Typical Transit Time/train (min.) Curve
(based on congestion function)**



Capacity Definition : Baroda Surat (Base Case Failures)



Estimated Capacity

- **Definition: (Rule of Thumb)**
 - Level of traffic (Trains per day) at which
Unscheduled delays = $0.5 * \text{TPC Time}$.
- **Below Estimated capacity**
 - Linear increase in transit times/costs.
- **Beyond Estimated capacity**
 - Rate of growth of costs/ deterioration in speeds
very sharp.
- **A Measure of Service Index**

Estimated Capacity

(Generalization using Parametric Analysis)

B2FEB4	BG, Double Line Flat, Electrified, Color Light with IBS/IBH	67
B2FEB2	BG, Double Line Flat, Electrified, Color Light	62
B2HEE2	BG, Double Line Graded Electrified,, Panel Interlocking	54
B1FDA1	BG, Single Line Flat Diesel, Lower Quadrant Signaling	20

RAILS Simulation results

- **HP/TL Ratio of 1.2-1.5 optimum** for freight trains on flat terrain
- Benefit of overpowering beyond 1.5 marginal and below 1.0 substantial line capacity loss
- On Gomoh-Gujhandi section, at headway of 17 min capacity 54 trains / day each way **increased to 79 trains with headway 8 min.**
- **Reduction in failures by 50%** - Increase in line capacity by 9%.
- **Increase of speeds by 10kmph** on SEB-MGS , 15% additional capacity generated
- **High speed turnouts** of 50 kmph on Gomoh-Gujhandi section generate 7% additional capacity
- **BOX N trains run at 100 kmph** on SEB-MGS section
 - 25% 2.13% capacity loss,
 - 50% 0% gain,
 - 100% 10% gain

RAILS-End of Life

- RAILS software stopped working after ten years - seemingly hard coded life for the hard lock key used to run it
- Software in the meantime changed hands from its original developers to another company, which no longer supported this older version.
- Negotiations for an upgrade failed when vendors quoted an unreasonable price.
- Budgetary sanction obtained for new simulation software. CRIS nominated as procuring agency.

Forecasting Methodology-Ph II

- Models used to develop forecast for 01-02,06-07
 - **GAMS** Linear Programming Model
 - Based on production and consumption forecast, assigns traffic by minimizing transportation cost to find OD pairs & corresponding flows. used for forecasting Urea, White POL,
 - **“Furnessing”** Trip Generation Model
 - Requires production level at all originating points and consumption level at destination points. These are then distributed based on the patterns in the base year.
 - Used for forecasting Cement, DAP, Naptha
 - **Factoring:** OD flows projected based on growth rates
 - Used for food grains, NP/NPK, Black POL

Inputs: Planning commission, Ministries forecasts, various studies

Market Analysis-LRDSS Ph II

- Shipper survey conducted by AF Ferguson-Ph II studied stated behaviour & Revealed preferences of shippers to determine significant parameters influencing shipper's choice.
- Sensitivity of consumer demand to various service parameters arrived at.
- RITES conducted study of road freight moving on parallel roads for assessment of rail share of traffic on important links & for enabling analysis of potential traffic that could be attracted to rail
- Rail Share declining (<40%)

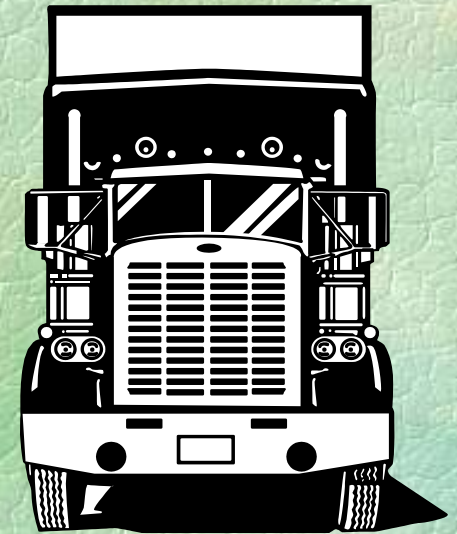
Rail vs Road breakeven point

Lead (km)	Door-to-Door Cost of Movement (per tonne)		Ratio of Rail/Road
	Rail	Road	
50	232	147	1.58
100	232	186	1.25
150	265	235	1.13
200	294	268	1.10
250	327	308	1.06
300	353	345	1.02
350	390	386	1.01
400	419	418	1.00
450	455	455	1.00
500	491	503	0.98
550	526	545	0.97
600	562	587	0.96



Rail vs Road Competition

- **Railways no longer dominant Transport mode-** Fall in market share of I&S, Cement, POL – coastal shipping, pipeline, highways
- Strategic shift in competition range- from 250 km to 750 km
- **With privatisation & de regulation of domestic industry, Railways face tough competition from Road sector due to:**
 - Four laning of national highways along Golden Quadrilateral & construction of six lane express ways.
 - Introduction of Express Freight Services & high axle load volvo trucks
 - Flexibility of Rates of Truck operators



Rate structure of Truck Operators

- Value of Commodity-Higher for high value commodity- Maximum for Motor Vehicles
- O-D: Delhi - Mumbai cheaper than Delhi-Calcutta although about same distance
- Extent of overloading
- Congestion on route, type of roads
- Stringency of enforcement of Motor vehicle act
- Availability of return traffic
- Road prices do not reflect actual road costs as cost of building of roads, traffic Patrol not taken into account



Key Mode Choice Factors

Core factors comprise: RAPT

Reliability, Availability, Price, Transit Time

(Assured supply, Guaranteed transit)

- Desirable factors include:
Connectivity, Customer information,
Courtesy, Loss and damage,
Claim processing time

Determinants favouring RAIL

- High volumes , Bulk Buyers
- Low Value, Long Lead



Satisfaction Index (scale of 10)

	ROAD	RAIL
■ Reliability	8.34	4.60
■ Availability	8.41	4.61
■ Price	7.57	5.94
■ Transit Time	8.12	4.89
■ Connectivity	8.74	3.72
■ Product Suitability	7.76	5.42
■ Loss/Damage	8.00	4.52
■ Customer Information	7.02	3.55
■ Adaptability	7.78	3.24
■ Customer Friendliness	7.47	3.37
■ Negotiability	7.79	2.78
■ Ease of Payment	8.06	3.97
■ Claim Processing Time	7.71	2.68

RAIL vs. ROAD

Satisfaction Index

WEIGHTED AVERAGE COMPOSITE SATISFACTION INDEX

■	MODE	SCORE <i>(Scale of 10)</i>
■	Road	7.82
■	Rail	3.91

Traffic Assignment Module

- **Core OF LRDSS**
- Refurbished in June 07 with assistance of Peter Cook Consultants for identification of likely Bottle necks in 2011-12 for Eleventh Plan process
- LRDSS Team is presently capable of conducting network wide analysis for identification of potential capacity constraints.
- **System wide impact** of a set of major line capacity proposals can be studied through TAM by defining a scenario where projected traffic flows are assigned on a simulated IR network incorporating these proposed changes.

Traffic Assignment Module

- **Operation Research** based Freight Network Equilibrium Model.
- **Objective function:** Minimize cost of operation of carrying traffic.
- Assign OD flows on paths (series of links & nodes) with least impedance. (Σ congestion cost on links /nodes)
- 3 C/C++ Programs (Logclnet, odd, carrin) , 2 Fortran Programs (Kshort- Batch, Nonlin)

Basic Inputs to TAM :

Demand Side -Existing and Future Traffic Flows by commodity, origin-destination

Supply Side-Existing and Future Network

Sections and their Characteristics- **Rail line Database**

Stations and their Characteristics- **Rail nodes Database**

Project & policy data

Link Types and Link cost databases

Paths between O-D pairs : optimum and preferred

Types of Trains, Payload, stock, commodity carried

Number of Trains per 1000 net tonnes for a commodity

Penalties for not carrying a commodity

Origin Destination Flows 06-07

- **Flows occur between Traffic Analysis Zones (TAZ)-**
Major loading/ unloading points- Ports, Power Houses, Fertiliser, Cement, Steel plants or a cluster of stations for which smaller flows aggregated.
- **Flow pattern of 2006-07 studied. More than 50 new TAZ's added and old ones deleted. Total TAZs=766**
- **Base year 2006-07 O-D Flows:**
 - **Aggregated into 52 and then 10 major commodities using originating traffic data from Zonal EDP centre**
 - **O-D data for empties obtained from FOIS-CRIS**
 - Zonal Rly, Commodity wise totals compared with Revenue Freight Traffic Statistics figures from Stat. Directorate

Network Data

- Network broken up into nodes (stations) and links (sections). 1835 links & 1574 nodes in 2006-07 network. 2011-12 network being updated
- **Link** identified by gauge, number of tracks, traction, terrain and signalling type. Categorised by link type with associated estimated capacity, Charted capacity, cost element.
- **Node** - beginning of a new link. All TAZ's attached to a node. Change of traction, reversal, transshipment points indicated
- **System generates logical network from this data**

Attributes of a Section

LRDSS [Year: 1995-96] [Scenario: Base] [Module: FPM]

File Edit View Theme Graphics Window Help LRDSS

Scale 1: 86,956 73.95 34.22

M_Base

☒ Big City
☒ Rail Node
☒ Rail Line
☐ Node Project
☒ Line Project
☐ Industry Center
☒ Town
0 - 104651
104652 - 5240
524007 - 1664
1664007 - 439
4399820 - 125
☐ Road

Identify Results

1: Rail Line - 97

Rail41_id	284
F_st_name	SONIPAT
T_st_name	DIWANA
Fstncd	SNP
Tstncd	D'WNA
Division1	DLI
Gauge	BG
Division2	DLI
Railway	NR
Numtrack	2
Traction	ELC
Terrain	F
Lntype	B2R2EB4
Lncode	4
Lneq	24
Signalling	D2
Distance	36
Util_nb	71
Util_wb	82
Actssun	24

Clear Clear All

Link Cost database

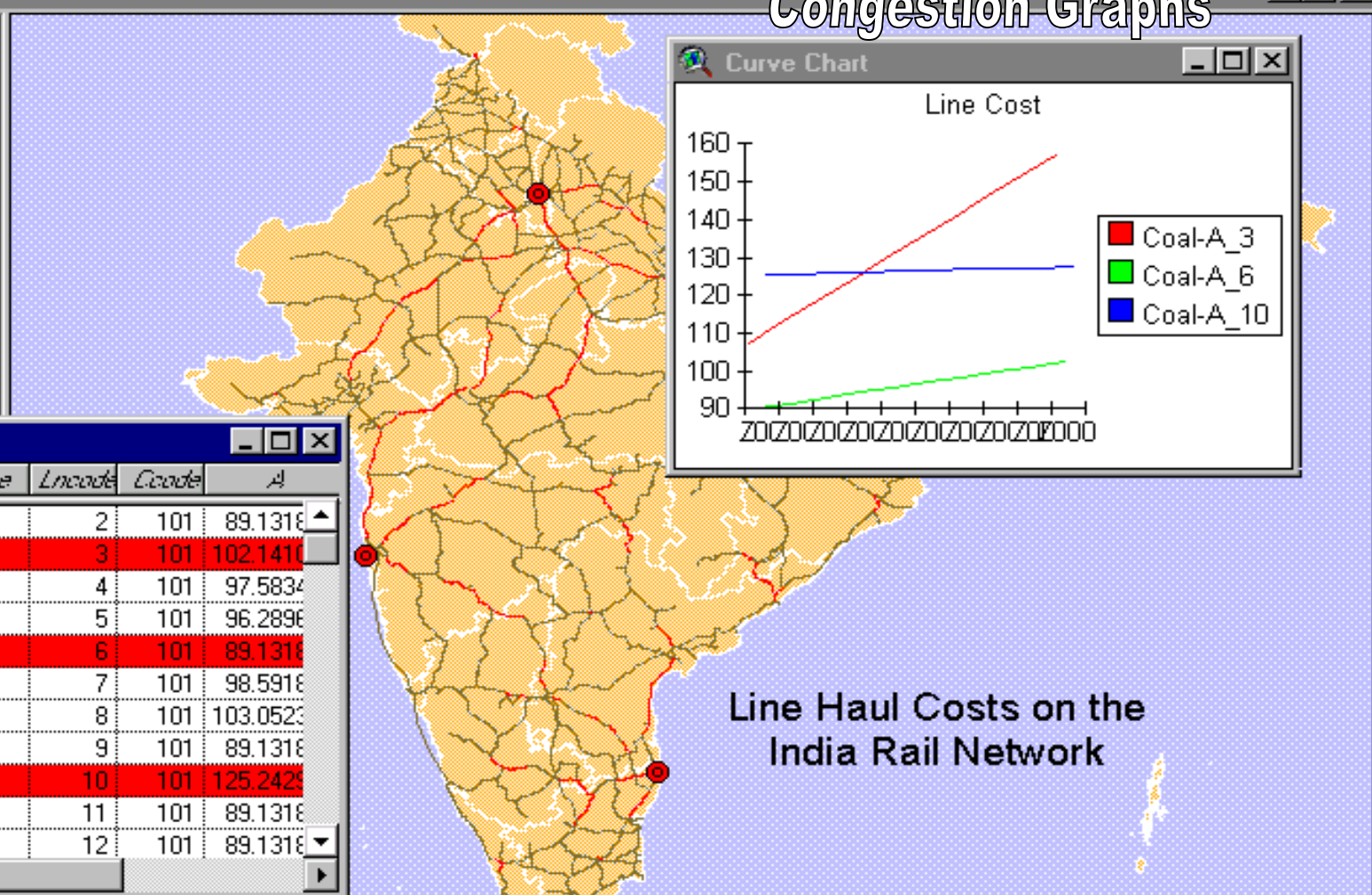
- Operational level simulators – TPC ,TDS of RAILS used for assessing delay and cost functions for the links for different categories of train types, locos etc
- Generated parametric curves describe variation of average train delays and running costs with number of trains operating over a section.
- These curves translated into desired functions through curve fitting routines. Cost per 1000gtkm= $a+bx$ where x is the number of trains on section per week.
- Line Haul Variable Cost function for certain train types on representative links revised by consultant in 2006-07
Closest match done for other train types not covered to generate cost of moving a commodity over a link



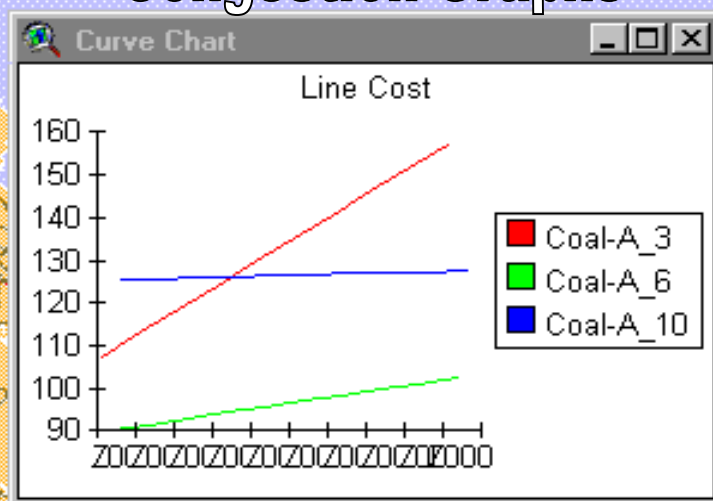
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Scenario Map

- ☒ Big City
- ☐ Node Project
- ☒ Rail Node
- ☐ Line Project
- ☒ Rail Line



Congestion Graphs



Line Cost

Rly	Rly_id	Comm_name	Lncode	Ccode	A
CR	1	Coal-A	2	101	89.1318
CR	1	Coal-A	3	101	102.1411
CR	1	Coal-A	4	101	97.5834
CR	1	Coal-A	5	101	96.2896
CR	1	Coal-A	6	101	89.1318
CR	1	Coal-A	7	101	98.5918
CR	1	Coal-A	8	101	103.0523
CR	1	Coal-A	9	101	89.1318
CR	1	Coal-A	10	101	125.2423
CR	1	Coal-A	11	101	89.1318
CR	1	Coal-A	12	101	89.1318

Line Haul Costs on the India Rail Network

Paths

- Every O-D combination has associated paths
- Shortest path algorithm identifies shortest path in terms of distance. Any change of Traction, gauge, reversal adds assigned penalties in kilometres
- S/w can find paths through given via nodes. Via nodes were picked from FOIS data, Errors removed, data transformed as per input format to get preferred paths on IR network.
- Costs associated with a link in Line Cost table. For each commodity and link associated cost factors include an intercept and a slope term.

B Route



Commodity train type data

- Based on FOIS data for June07 to Nov 07 reg:
 - stock types in which a commodity is carried, average payloads,
 - % of the time commodity carried in a given rake type is hauled by multiple units,
 - % of loading in a given type of stock for a particular rake type and commodity
- Requisite files for commodity and associated train types changed – relating % of time it is carried in that train type, frequency of full load running, seasonality factor etc. to get more realistic conversion for number of trains per 1000 net tons & gross to net ton ratio.
- Depending on O-D, a commodity can be carried in various train types- BOBR, BOXN, BRN. Thus a commodity can be sub classified (coal-A, coal-B) depending on Train Type carrying it.

Penalty for noncarriage

- This database indicates the penalty for not carrying a commodity on the system
- Higher the penalty, less likely is the system to drop the commodity
- Penalty is a function of revenue foregone for not carrying that commodity

TAM- Minos Software

- Run Program **without** unsatisfied demand
 - All traffic assigned to the links even if it exceeds Physical line capacity constraints
 - Assignment problem will assign as much as possible to each of the paths and then assign remainder to least cost path.
 - Good indicator of bottlenecks when sufficient o-d paths provided
 - What would be the constraints if all demand satisfied?
- Run Program **with** unsatisfied demand:
 - Additional option of assigning flow to shortage variable.
 - Higher penalty sub commodities loaded first on network
 - Analyst gets an idea of how much traffic can easily be carried on the network

Base Case calibration-steps

- **Calibration** - A procedure whereby results of model brought closer to actual outcomes for base year.
- Residual capacity on a link for each direction arrived at by deducting from charted capacity- actual number of passenger, suburban, departmental trains as obtained from line capacity charts
- Assignment of Base Year Traffic without unsatisfied demand done on preferred paths.
- Links where model assigned more trains than residual capacity designated as infeasible links.
- Stations in a TAZ, nodal point of a TAZ changed, paths realigned , directionality altered (to correctly reflect up & down direction) to simulate actual traffic pattern & remove infeasibilities

Forecast 2011-12 – Growth Factor

Commodity	Million Tonnes		Growth Factor
	2005-06	2011-12	
Containers	20.09	50.02	2.49
Food Grains	36.14	79.88	2.21
Other Goods	42.57	149.88	3.52
POL	33.47	33.14	0.99
Iron and Steel	17.29	25.94	1.5
Cement	60.56	112.04	1.85

Coal: Growth rates selectively applied on specific ODs based on expansion plans of powerhouses. New Ods added based on new power plants proposed

Iron Ore to Steel Plants: projections based on proposed new steel plants, expansion plans of existing plants

Fertiliser: Imports would increase by about 6 million tons. Traffic distributed across ports assuming a similar share of the total and then to destinations based on their existing shares.

Iron Ore for export- Projections

- **Completion of Daitari – Banspani line:**
Additional about 5 MT of iron ore traffic to Paradeep which is currently moving by road to Paradeep & Haldia
- **Closure of mining in Kudremukh** expected to lead to movement of about 6 MT of iron ore from Bellary & Hospet to Mangalore by rail.
- **Another 2 MT of iron ore from Bellary-Hospet area to Goa Port** expected to shift from road to rail with increase in capacity in that area.

Forecast Flows 2011-12

Commodity	2005-06 mtons	2011-12 mtons
Cement	60	112
Coal	283	386
Container	20	50
Fertiliser	31	37
Food Grain	36	80
Iron Ore For Exports	41	50
Iron & Steel	17	26
Other Goods	42	150
POL	33	33
Raw M,aterial For Steel Plants	76	116
Total	642	1041

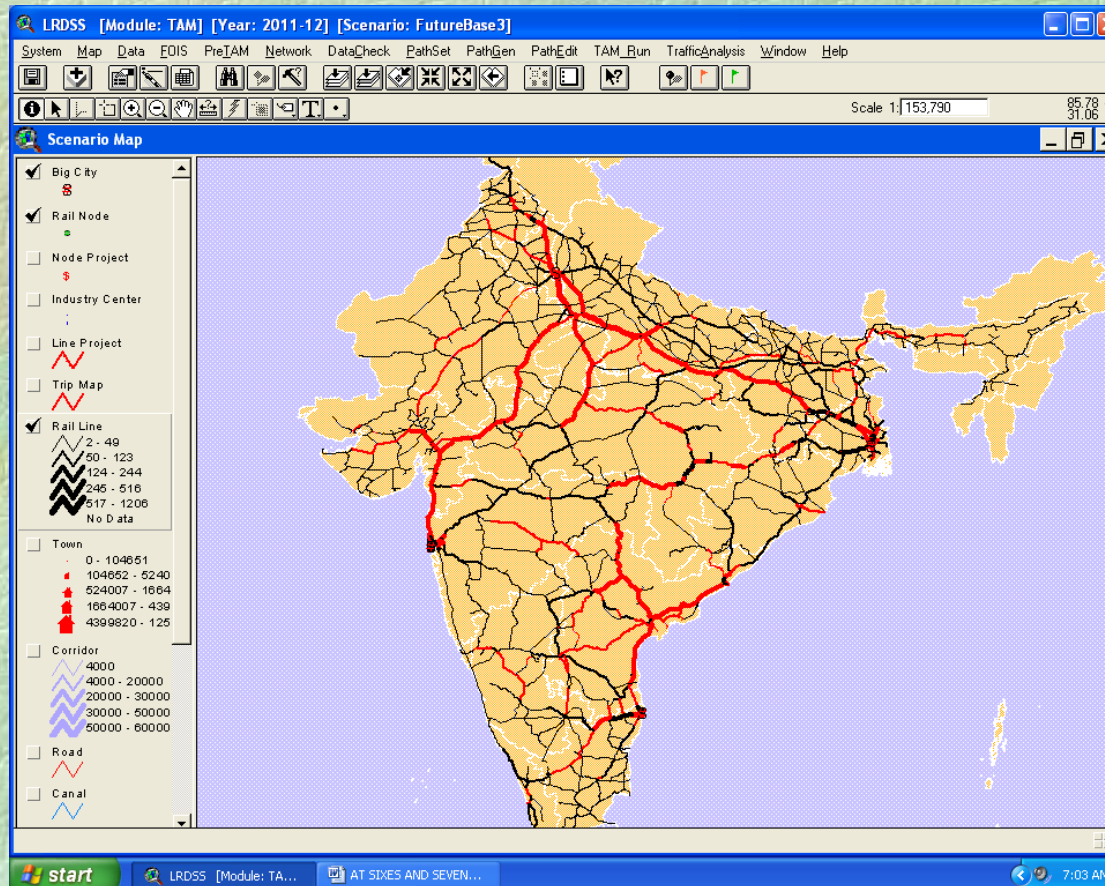
Corresponding increase over base year in number of empties

Assignment of Future Traffic

- Terminal year of XI Five-year plan 2011-12 taken as key year for analysis of future scenario.
- Assignment on both Preferred & Shortest Paths on likely Network of 2011-12 assuming certain ongoing projects (without DFC) completed by that time. This alters Linktype and thus capacity of link.
- Flows of base year 05-06 used to forecast future yr O-D's
- Assignment of passenger trains likely to be introduced in future done outside TAM on basis of master plan for introduction of passenger trains prepared by Chg Dte
- Passenger Trains likely to be introduced on each link added to base case figures to get future passenger trains

Identification of Bottlenecks

- Set of links identified where traffic >100% of capacity in either direction for 2011-12 demand on 2005-06 network.
- List of constrained sections on the network used by Planning Directorate for identification of critical high density routes.



Analysis of Critical Links

- Bottleneck links grouped according to priority in three classes:
- **Operational Improvements** (within 10% of chartered capacity)
- **Low Cost Improvements** (over 10% of chartered capacity but less than estimated capacity)-Minor investment in traffic Facilities
- **Major Action** (Links with capacity greater than estimated capacity)- Significant improvements in infrastructure-New Line, Doubling, electrification, major signalling upgrade

Capability of TAM- Outputs

- **Identification of likely Bottlenecks**
- **Origin-Destination Analysis**
 - Major Loading unloading points, Major Flows
- Commodity wise traffic on each link. (inTonnes & Trains)
- ODs that use a particular link.
- Route paths between pairs of points.
- Results displayed on a GIS based User Interface-
 - Understanding traffic patterns over entire network
 - visually evaluating alternative routes
- Commodity Lead Analysis-slab wise
- Comparative Evaluation among alternative scenarios.

Best Use of LRDSS

- Level of data detail used in system is intended for system wide analysis as project screening tool
- Useful primarily for rapid identification of key locations of bottlenecks and screening capacity improvement options.
- Evaluating groups of projects at Pre Feasibility stage, eliminating clearly unfeasible options and pointing the way to those specific locations and projects that are candidates for more detailed design and study.

Dissemination of Results

- Set of critical bottlenecks, O-D's using a particular link can be further analysed by Planning Directorate and disseminated to Zonal Rlys for conducting Engg & Traffic surveys to review, correlate simulation results with field conditions and thereby assist in planning for Works Programmes
- Should be an Ongoing Exercise
- Other specific Scenarios as defined by Planning / TT/ Infra dtes can also be evaluated

Analysis of O-D Flows 2006-07

- Total Ods = 19272 (L) + 22835 (E)
- Total tons originating basis EDP data: 729 mtons
- Total tonnage to be assigned: 722.9 mtons
- **Top 100 O-D Pairs : 31% of total flows**
- **First 300 O-D Pairs : 46% of total flows**
- **First 1000 O-D Pairs: 66% of total flows**
- **First 2000 O-D Pairs: 77% of total flows**
- **Focuses attention on major loading/ unloading points to evaluate facilities, rolling stock to keep pace**

Talcher- Paradeep (PPT sdg) Coal 9.98 mtons

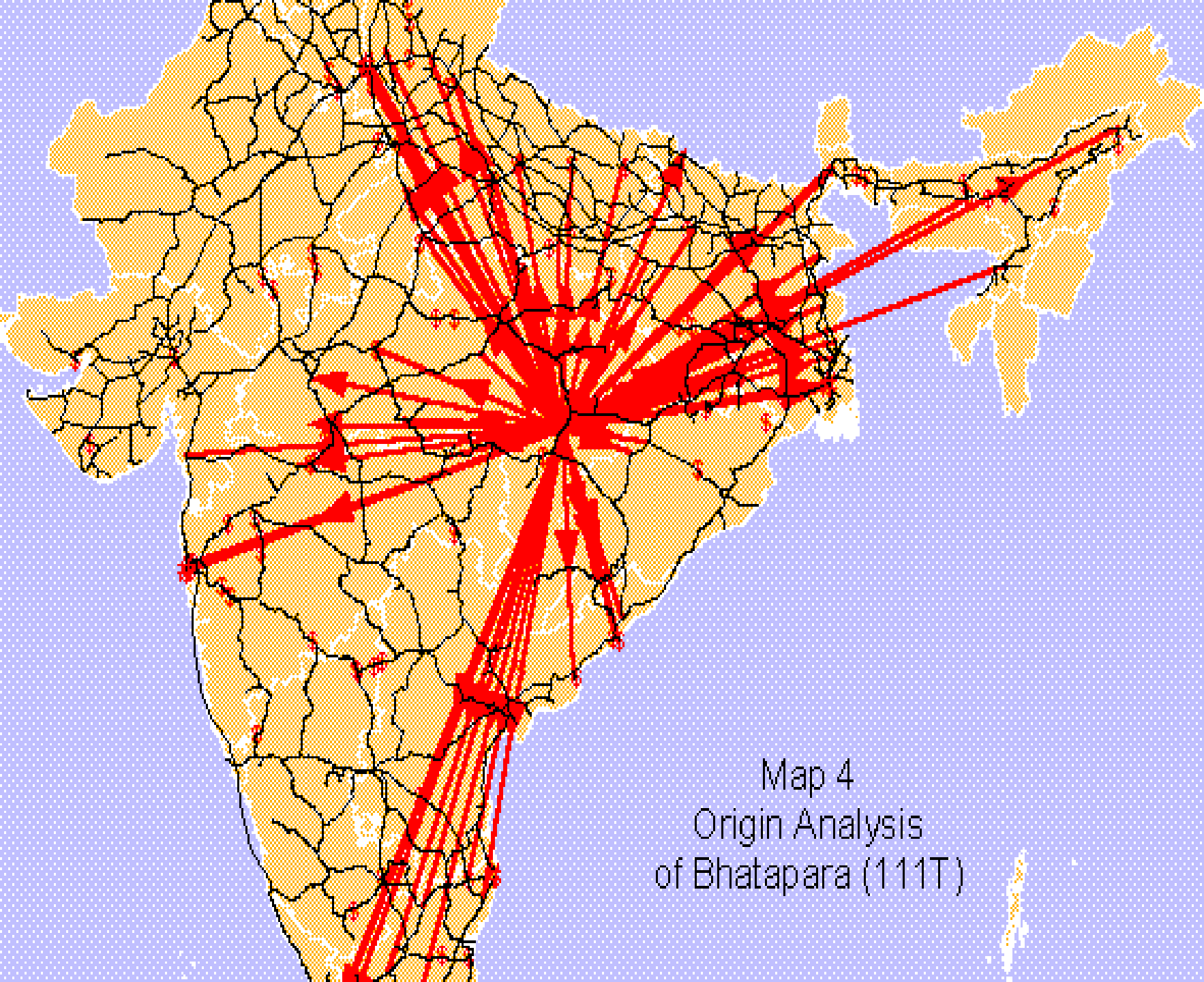
Dalli Rajhara- Marauda Rmsp 8.34 mtons

Commodity Lead Analysis 2006-07 flows

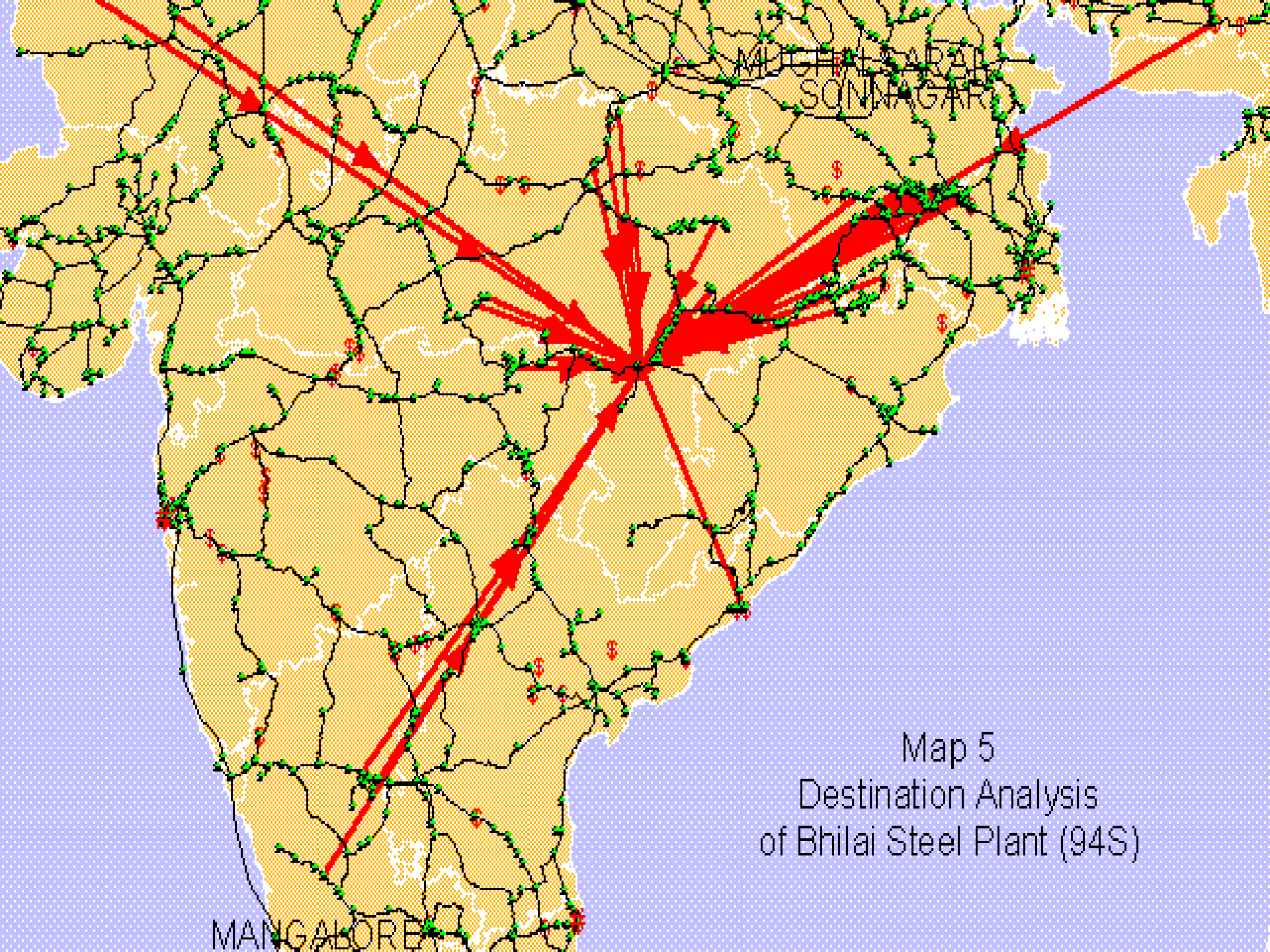
■ **Lead analysis:**

- 21 % Coal loaded for 1-100 km lead.
- 59 % wheat, 54% Rice loaded for leads > 1000 km.
- 42 % RMSP loaded for 100 - 150 km. Lead
- 63% Containers loaded for leads > 1000 km
- 50% Iron-Steel loaded for leads > 1000 km
- 58% cement loaded for 300-750 km leads

■ Commodity wise Percentage of Traffic flows, NTKM in various distance slabs available



Map 4
Origin Analysis
of Bhatapara (111T)



Map 5
Destination Analysis
of Bhilai Steel Plant (94S)



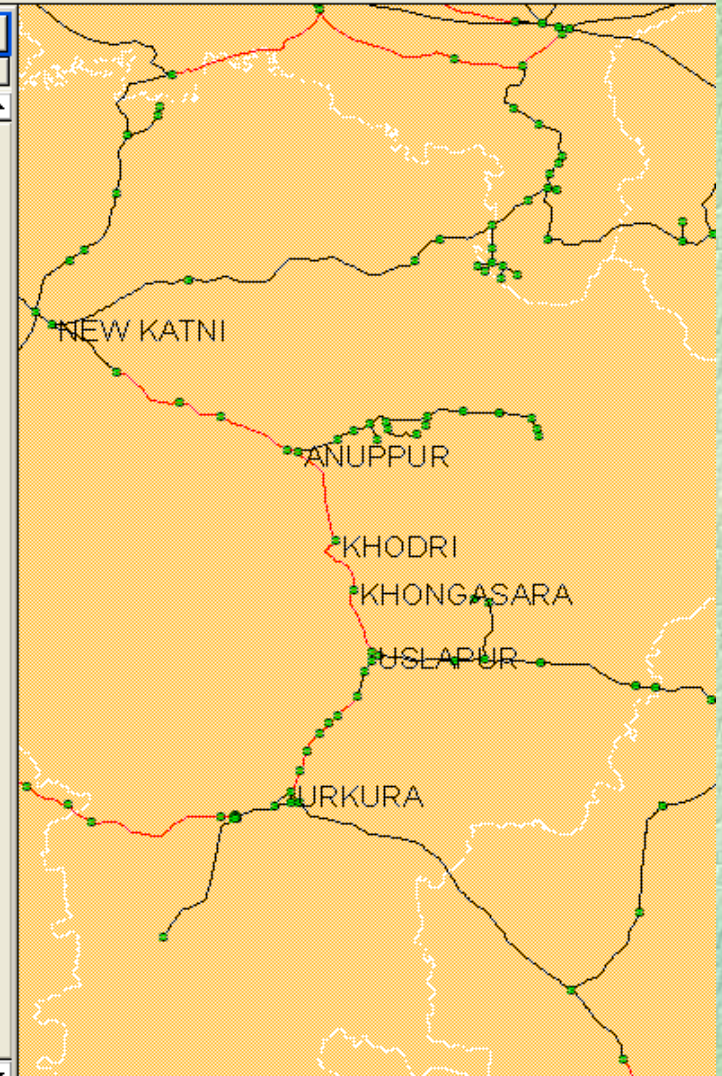
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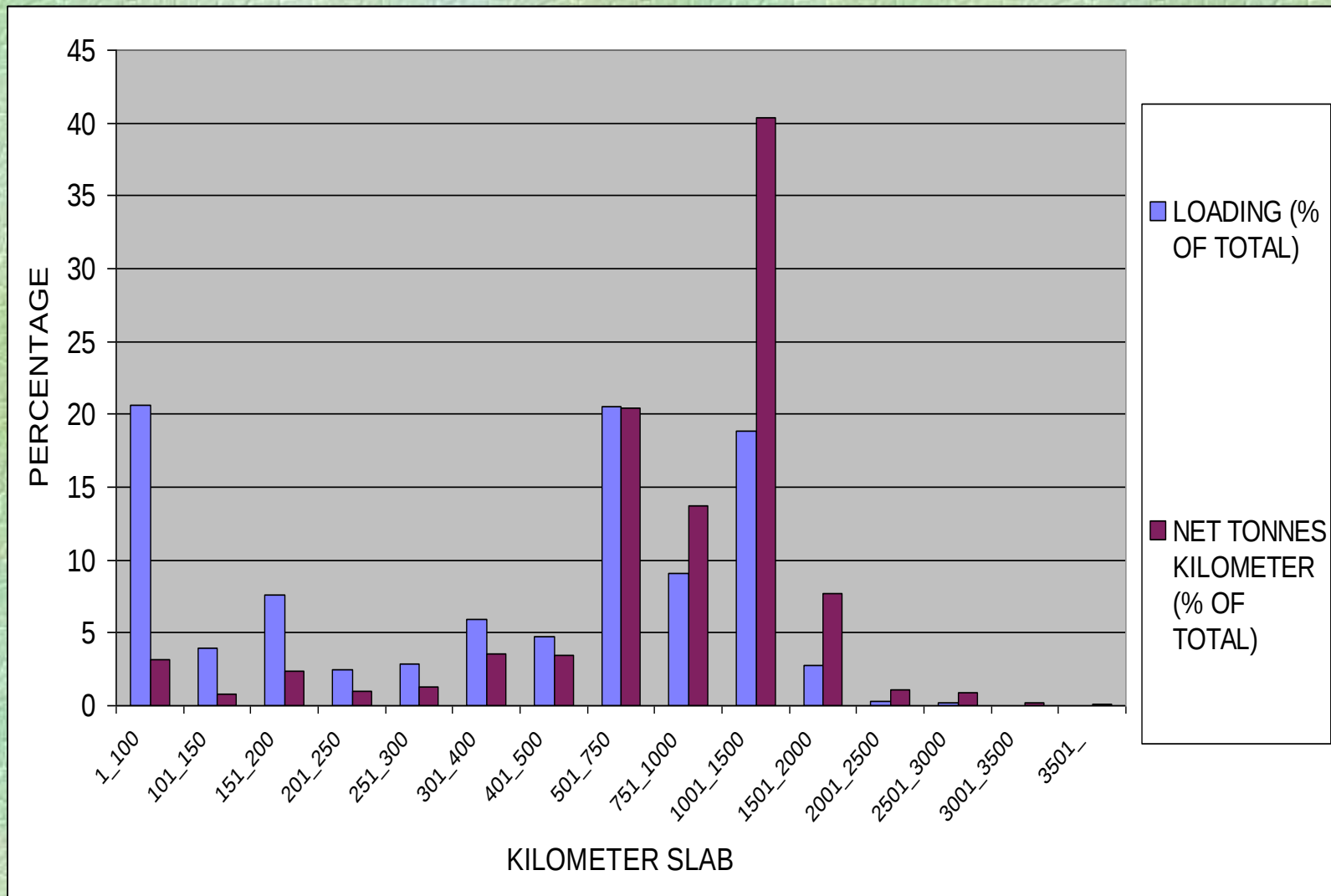
Scenario Map

Link Flow

Item	Content	Activity_U	Flow_Up	Train_Up	Activity_D	Flow_Dn	Train_Dn
Link ID	887						
Direction	DN						
From Station	USLAPUR						
To Station	KHONGASARA						
Railway	SER						
Distance	57						
Traction	ELC						
Gauge	BG						
Total Capacity	31						
Commodity		Act_Up	Flow_Up	Train_Up	Act_Dn	Flow_Dn	Train_Dn
	Coal	17712295	48527	14.96	12974181	35546	10.98
	RawMatStl	231786	634	0.20	780902	2141	0.65
	Container	527358	1444	1.24	160349	439	0.38
	ImDreExp	7143	20	0.01	213377	584	0.17
	FoodGrain	181967	498	0.25	389949	1070	0.59
	OtherGood	461544	1261	0.61	1653380	4533	2.13
	POL	91632	250	0.10	208812	572	0.22
	IronSteel	2080268	5698	1.74	0	0	0.00
	Cement	910333	2494	1.14	59033	161	0.07
	Fertiliser	197076	541	0.27	408386	1120	0.52
	E-BLC	2	0	0.00	22	0	0.04
	E-BOBS	3	0	0.00	25	0	0.05
	E-BOX	38	0	0.11	275	0	0.71
	E-BOXN	2942	5	8.03	2928	3	7.91
	E-BRN	3	0	0.00	418	0	1.05
	E-BTPN	9	0	0.02	27	0	0.05
	E-TNK	38	0	0.11	36	0	0.08
	E-MIXD	41	0	0.10	46	0	0.09
	E-BCN	89	0	0.16	201	0	0.49
	E-BCM	0	0	0.00	0	0	0.00
	Total (Freight)	22401402	61367	20.52	16848369	46166	15.71
	Total (Empty)	3165	5	8.53	3978	3	10.47



COAL LEAD ANALYSIS



“Mission Areas”

Apply concept of simulation-based link capacity

Apply improved management-oriented solutions to selected bottlenecks, low cost improvements to others and major investments to selected bottlenecks

- Strategies for cost reduction:

- Reduction in failures
- Removal of Slack in Passenger Train Schedules
- Reduction in Headway
- High Speed Turnouts
- Signaling Improvements
- Reduce Speed Differentials

“Mission Areas”

- Strategies for Revenue Enhancement:
 - Improve quality of Service
 - Improved reliability.
 - Making wagons available on demand.
 - Faster transit for high value goods.
 - Long term arrangement with bulk users.
 - Meet Physical Distribution Needs to Customers
 - “Join Them (truckers), if you can’t beat them.”
 - Integrated transport solution for high value goods shipper. (TTS Approach)

LRDSS- Immediate Tasks ahead

- ✓ Collection, verification & collation of data from CRIS-FOIS & Zonal EDP centres for preparing O-D flows for 2006-07. Modification of programs to get TAM input data
- ✓ Updation of Network files taking into account sanctioned projects completed by 2006-07, Commodity-train type data, Generation of path data and other input files reg commodity-train types, link costs, tons to trains
- Endeavour to calibrate Base case scenario for 2006-07 by Jan 2008.
- Refine future scenario for 2011-12 taking into account traffic pattern in 2006-07, feedback received from Plg & PP dtes on bottlenecks already furnished, assumptions made

LRDSS- Immediate Tasks ahead

- **Analyse Scenario I-** Assign 2011-12 forecast demand on 2006-07 network to identify present bottlenecks.
- **Analyse Scenario II-** Assignment of 2011-12 demand on anticipated IR Network of 2011-12 (incorporating sanctioned projects likely to be completed) to assess links likely to become critical in future
- **Analyse Scenario III-** Upgrade 2011-12 network incorporating major newly sanctioned line capacity works on HDN routes & assigning 2011-12 forecast flows to get a list of critical bottlenecks for assistance in planning for next Works Programme
- Endeavour to complete the exercise by end of March 08

LRDSS- Institutionalisation

- LRDSS- a tool with IR that provides analytical support for investment decision making - **Need to create a Permanent set up for functions of LRDSS unit in the Railway Board**
 - Scenario Analysis
 - Constant maintenance and updation of databases
 - Development and upgradation of software
 - Development of Team Expertise
- **LRDSS unit needs to be strengthened by**
- a) positioning one Director against vacant post
- b) Consultants, Programmers to co-ordinate with team to analyse software, data updation requirements

THANK YOU

A thick, solid orange horizontal bar with a slight upward curve at both ends, positioned below the 'THANK YOU' text.

Phase III additions to the DSS

- Further link simulations to improve performance measures
- A Multimodal Traffic Corridor Analysis module to understand modal choice and cater to an increasing demand for inter-modal traffic
- A Terminal Analysis Model to focus on bottlenecks arising from congested terminals impacting sectional capacities and therefore traffic flows

Terminal Analysis

- Study work processes at 20 terminals- loading /unloading ,enroute terminals to ascertain reasons for detention to rolling stock
- Define terminal efficiency parameters
- Evolve benchmarks
- Identify customer needs wrt terminal operation & transit time.
- Review& recommend changes in rating/commercial policy
- Estimate system wide investments required for reducing terminal detention

Terminal Analysis Module Objectives

- Develop a better understanding of the detention to rolling stock
- Identify international benchmarks for terminal performance
- Define terminal efficiency parameters, evolve benchmarks and identify bottlenecks
- Modeling of 20 terminals, representing range of IR terminals
- Identify means to eliminate or reduce bottlenecks and reduce wagon detention and increase capacity
- Carry out cost-benefit analysis of proposed investments

Model Outputs

- Train delays
 - Including trains held outside of terminal
- Assignment of delay to
 - facility
 - e.g., heavily used intersection
 - resource
 - e.g., lack of shunting engines
 - e.g., lack of examination crews
- Activity summary
 - Utilization of all of the facilities and resources, including
 - time spent in examination, loading/unloading
 - track usage
- Feeds investment analysis

Resource Requirements

- Terminal
 - Cranes and/or packers
 - Load and support tracks
 - Examination crews
 - Land area
 - Gate-hours
- Train operations
 - By market/product/year
 - By origination/termination
 - Starts, hours, fuel usage
- Rolling stock
 - Hours, number
- Line infrastructure
 - Physical facilities
 - Train usage

Intermodal Traffic

- Inter modal only 5% of total freight of IR as compared to 20% in developed countries
- Develop a model for estimation of service parameters and costs for one selected corridor.
- Examine IR potential to improve market share & investments required in selected corridor-service requirements

Multimodal Corridor Analysis Module Objectives

- Develop a better understanding of the multi-modal transport market and related modal choice by shippers
- Better understand international intermodal practices and service levels
- Analyze a pilot corridor (Delhi-Mumbai, with Ahmedabad as satellite and Kota and Vadodra) to forecast traffic, modal split, container service requirements, investments, costs and revenues
- Carry out cost-benefit analysis of proposed investments

Multimodal Corridor Analysis Model

- A tool to calculate
 - Highway versus Rail split of containerizable goods
 - Operational statistics
 - Train starts
 - Wagon hours, wagon kilometers
 - Lifts, etc.
 - Resource estimates
 - Terminal (land, cranes, etc.)
 - Line
 - Rolling stock and locomotive
 - Cost/benefit analysis

Modal Split Model

- Models the choice between Highway and Rail
- Determinants include for rail and highway:
 - Price
 - Transit time
 - Quality of service such as reliability and frequency of service
- Customer survey will assist in developing modal-split model
- Estimates total rail traffic, based on estimates of total demand
 - By terminal-terminal market, product, and year

Financial Analysis

- Activity-based costing
- Sample activities:
 - Container loading/mode transfer
 - Train operations/maintenance
- Revenue estimation
- Expenses include
 - Operational costs
 - Capital costs
- By market/product/year

Benchmarking of Operations

- Setting up performance standards - Average Transit speeds for different sections & train types
- Simulate speed curves of different types of trains on various link types at varying traffic levels under different scenarios -Zero failures, minimal speed restrictions
- Undertake variance analysis for differences and identify the factors that influence speed
- Essential to define performance norms as they impact on cost of operations

Types of Decisions Supported - 1

1. Identification of operating policies to improve rail operations for similar types of rail lines (Link Simulation Analysis)
2. Estimation of future traffic demand by major commodity, origin-destination and route/link (Traffic Forecasting)
3. Identification of the location and timing of bottlenecks for future rail operations (Traffic Assignment)
4. Prioritization of actions to get more out of existing rail line capacity (Link Simulation and Traffic Assignment)

Types of Decisions Supported - 2

5. Economic and financial return of packages of improvements to the IR network (BCAM)
6. Screening of potential projects for viability (BCAM)
7. Prioritization of actions (investments and/or operating policies) for capacity expansion for a given rail line or for the IR system as a whole (TAM/BCAM)
8. Identification of markets for potential rail traffic (MAM)
9. Identification of the major influences on the financial viability of IR by service type (EFAM)

Capacity Analysis

- Ability to increase frequency of trains by train type
- Analyze delays as traffic increases
- Estimate capacity based on maximum tolerable delay (determined by IR)

Line Capacity Estimation

- Trains simulated to run-s/w determines crossings & precedences based on assigned priorities.
- Starting from base level, calibrated traffic, trains increased
 - keeping constant traffic mix
 - extrapolating base case failures
- Maximum number of trains that can be dispatched in a 7- day period
- Analysis of Output - a string chart similar to control charts- yields estimated capacity.

Failure Analysis

- Traffic levels 788 trains/week
- train hours lost/week 105 hours
 - Wagons-50, Coaches-4, Locos- 14,
 - Rails-10, Signals-5, Others -22
- Reduction in train hours lost due to failures reduced from 105 to Zero
- Gain in train hours = 395 hrs.
- Cascade factor = 3.75
- Additional Trains each way = 10
- Gain in Line Capacity = 18 %

Impact of Longer Trains

- 116 wagon train length on 20.32 T axle load on Talcher-Paradeep Section.
- Extension of loop length at alternative stations from 786 m to 1500 m
- Financial IRR 17 per cent
- Economic IRR 14 per cent
 - Network of 2001-02 (Double Line, Electrified section)

Impact of Longer / Heavier trains

- Longer trains are beneficial for lines carrying over 20 million tons of traffic per year
- Heavy axle load is beneficial for routes carrying over 40 Million Tons of Traffic.

- To overcome challenges to sustainability of LRDSS, following steps suggested :
- Creation of permanent structure for functions of LRDSS unit in the Railway Board
- For further refinements, LRDSS unit needs to be strengthened by positioning one officer against vacant post of a Director
- Creation of close linkage between CRIS and LRDSS to provide expertise in Information Systems Management- detailed modeling, programming & database management to maintain and update system.
- Formalise data exchange between FOIS & LRDSS

Cost/Benefit Analysis

- Comparision between financial scenarios
 - Base case
 - Alternative scenarios include
 - High growth, low growth
 - ???
- NPV, IRR, cash flows estimated over study period (nominally 20 years)

Investment Analysis

- Model outputs structured for existing cost/benefit analysis models
- Can be used to examine various types of improvements
 - Low, medium and high cost investments, and associated benefits

Line Simulation/Benchmarking Objectives

- Develop a better understanding of relationships between train type, speed and traffic conditions in IR for more situations using current parameters for benchmarking
- Calibrate RAILS simulation model for 25 new links
- Develop a more representative database for line capacity (phase II had 17 simulations)
- Help identify links where more capacity can be realized under current conditions

Bottleneck Analysis

- Traffic Assignment was done w.r.t
 - Charted Capacity
 - Estimated capacity
- Bottlenecks in 2006-'07
 - w.r.t Charted Capacity=437
 - w.r.t Estimated Capacity=188

Impact of heavier axle load(23T axle)

- Talcher - Paradeep section
- . Investment in strengthening of formation, bridges and accelerated track renewal costs
- Financial IRR: 9%
- Economic IRR: 6%
 - Network assumed is of 2001-02

Impact of Longer and heavier trains

- Longer trains are beneficial for lines carrying over 20 million tons of traffic per year
- Heavy axle load is beneficial for routes carrying 40 Million Tons of Traffic.

LRDSS - Investment Planning System for:

- Identifying & forecasting potential rail transport demand- Commodity wise, Origin-Destination wise
- Simulating base case, future traffic flows
- Identifying location & timing of future bottlenecks
- Criticality of bottlenecks
- Evaluating different investment options by simulation modelling to improve future performance

Multiple levels of Analysis

- Level 0 Analysis

- Global level- Tonkm, Train km, Leads

- Level 1 Analysis

- Existing and future commodity wise traffic flows on each section for the key years

- Level 2 Analysis

- List of O-D pairs likely to use that section

- Level 3 Analysis

- Micro Level analysis (RAILS) to study impact of investment alternatives on sectional line capacity.

Phase III Components

1. Terminal Analysis Model Development and Analysis (20 selected terminals)
2. Multi-modal Corridor Analysis Model and Pilot Analysis (Delhi-Mumbai Corridor)
3. Simulation/benchmarking of Rail Line sections (25)
4. Integration with Phase II software
5. Training of LRDSS team in Phase III use

Share of Rail & Road Traffic

- **Medium and Long Distance Segments**

■ Year	Rail	Rail	Road	Road
	mtons		mtons	
■ 1978-79	185	65.8%	96.0	34.2%
■ 1986-87	255	51.5%	240.7	48.5%
■ 1997-98	386	48.2%	415.6	51.8%
■ 2007-08	769	30.1%	1558.9	61.0%

- In 1997-98 these segments are > 250 Km.
- In earlier years distances > 100 km. were treated as medium and long distance segments

Comparison of Commodity wise LRDSS Forecast with 2001-02 BE

Commodity	2001-02 LRDSS	2001-02 BE		
Cement	45.4	44.5		
Coal	235	234.5		
Container	13			
Fertilizer	29.6	27.5		
Reduction in subsidy in urea and other fertilisers				
Foodgrain	29.6	24		
Less takeoff by APL as Public Price linked with economic price				
Iron & Steel	14.1	11		
Less demand -recession, product priced high wrt road for some leads				
Iron-ore Export	12.4	16		
POL	43.4	37.5		
Increased use of CNG & decrease in pol demand due to recession				
Raw mat steel plants	43.4	40		
Others	32.3	65		
Total	498.2	500		
Excludes O-D Flows< 1000 tonnes				

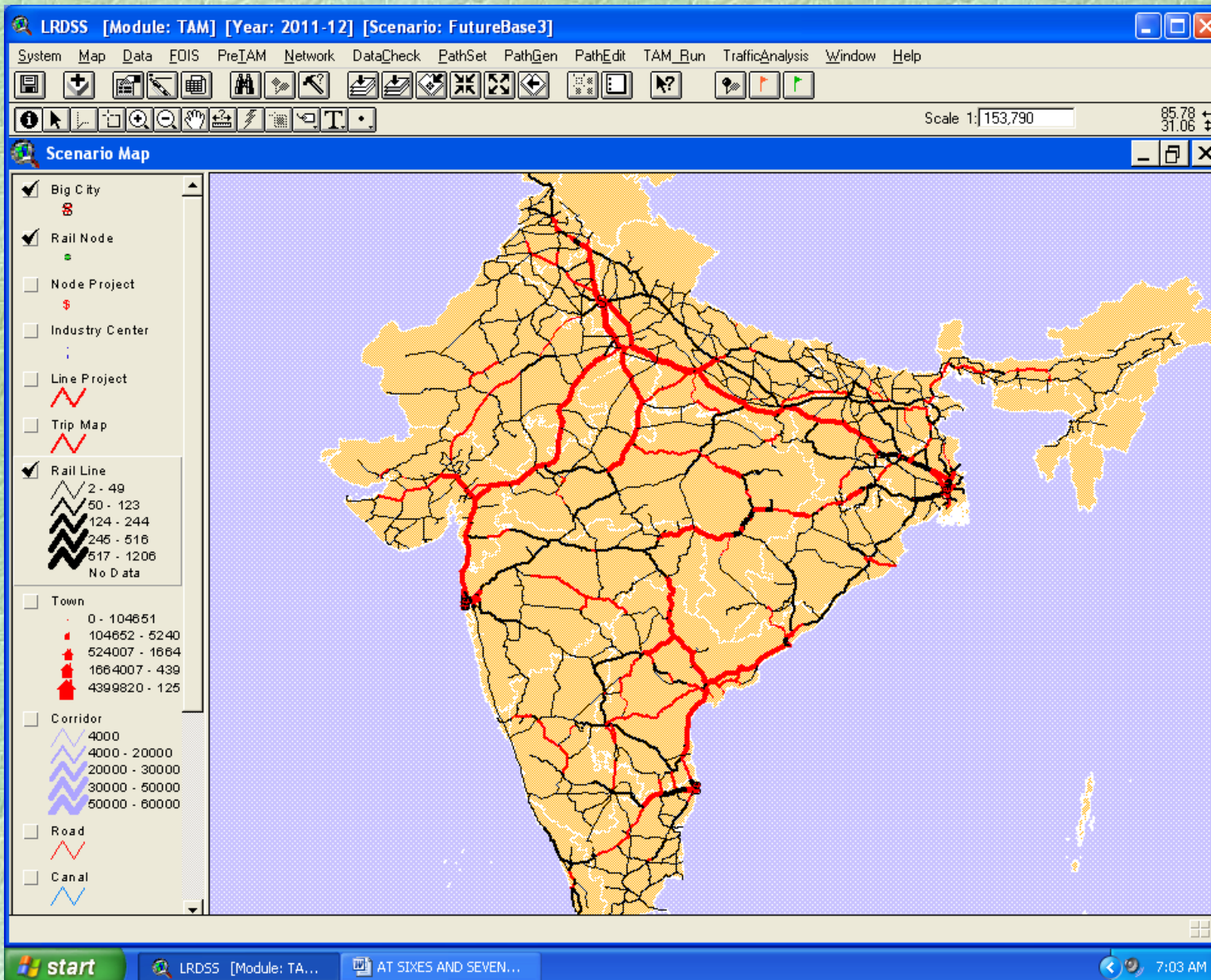
Base year rail o-d flows

- Base Year Flows aggregated into ten major commodities using Rly EDP data - coal, pol, iron ore export, cement, iron & steel, fertiliser, containers, food grn, raw material for steel plants, others
- Total ODs in Base Case= 15076
- only flows > 1000 tons per annum assigned on network

Network Databases

- Two distinct databases representing IR network:
 - Railline Database
 - Railnode database
- There are 1796 links and 1531 nodes for the base case
- Nodes Database contains information like TAZ centroids, Transshipment point, Rail terminal/yard, Traction change point, Reversal etc.

Bottlenecks in 2011-12



Network databases

- Rail Line Database :Physical characteristics of the Links eg Gauge, Number of Lines, Signaling system, traction, charted capacity, estimated capacity etc.
- System creates Logical Network
- A set of paths between o-d pairs made incorporating penalties for traction change, reversal, transshipment
- Paths via certain specified stations also made

Link type databases

- The generated parametric curves describe variation of average train delays and running costs with number of trains operating over a section.
- These curves translated into desired functions through curve fitting routines.
- Cost per 1000gtkm= $a+bx$ where x is the number of trains on section per week

■