CE-780 Behavioral Travel Modeling

Instructor: Prof. K. V. Krishna Rao

Course Contents

- Introduction to behavioral travel modeling
- Individual choice theory: binary choice models, multinomial and multi-dimensional choice models, issues in model specification, methods and statistics of model estimation with emphasis on maximum-likelihood estimation, aggregation and forecasting with discrete choice models, validation and transferability aspects, ordered multinomial models, nested logit models
- Survey design and analysis: travel surveys and their role in transport planning, survey methods, precision and accuracy in travel surveys, sample design, sampling procedures, survey format, pilot surveys, survey administration, collection of stated and revealed preference data, survey data processing.
- Advanced concepts: accommodating unobserved population heterogeneity in choice behavior, mixed logit models, joint stated preference and revealed preference modeling, and longitudinal choice analysis
- Discrete choice models for integrated land use and transport modeling, review of state-of-the-art and future directions.

Texts/References

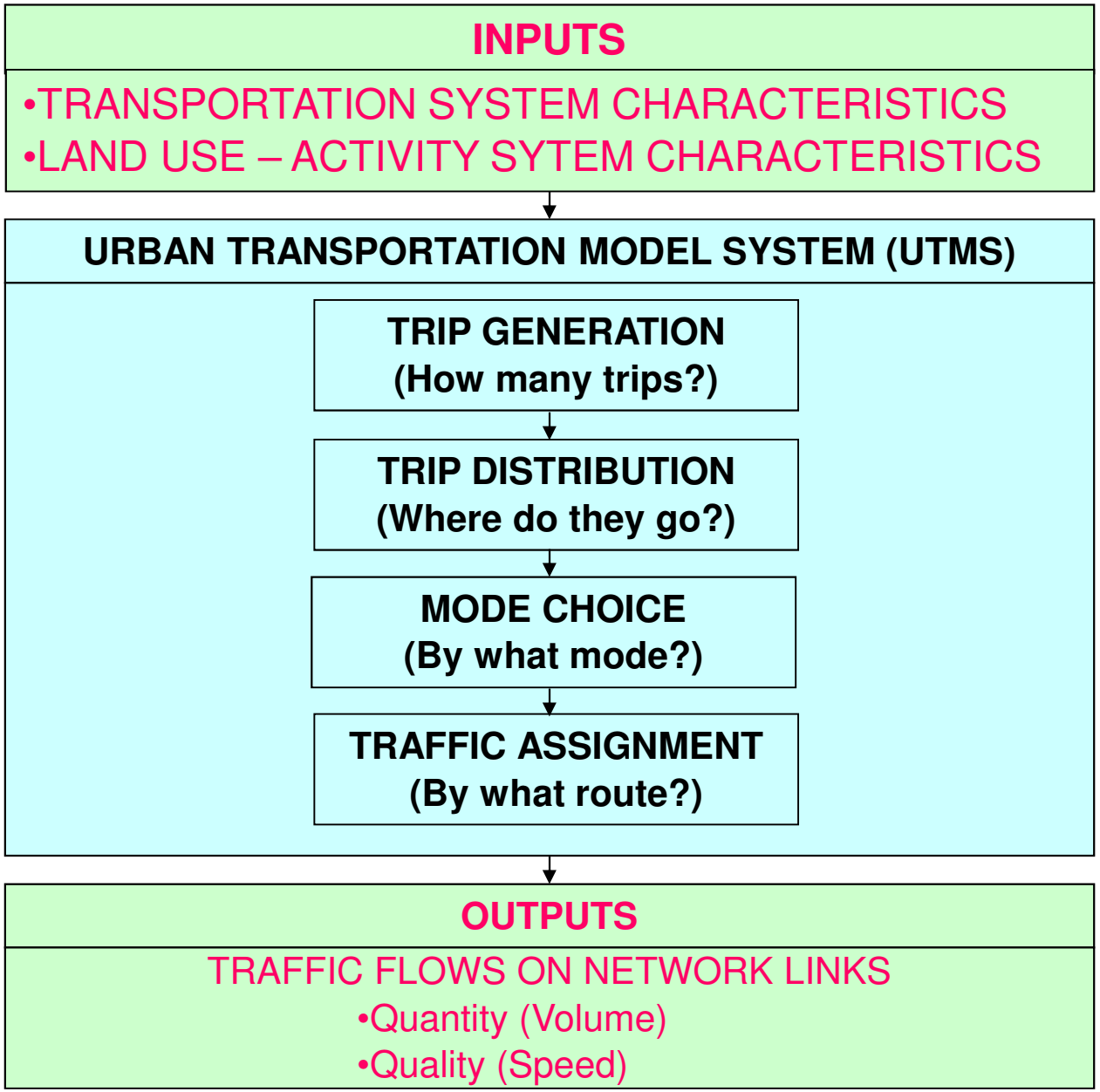
- Ortuzar, J. D. and Willumsen, L.G., Modelling Transport, John Wiley & Sons, New York, 1996.
- Domencich, T.A. and McFadden, D., Urban Travel Demand: A Behavioral Analysis, North-Holland, 1975.
- Ben-Akiva, M. and Lerman, S, Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 1985.
- Oppenheim, N., Urban Travel Demand Modeling: From Individual Choices to General Equilibrium, John Wiley, 1995.
- Borsch Supan Axel , Econometric analysis of discrete choice, Springer-Verlag, Berlin, 1987.
- Richardson, Ampt, and Meyburg, Survey Methods for Transport Planning, Eucalyptus Press, 1995.
- Selected papers from journals such as Transportation Research, Transportation Science, and Transportation Research Record.
- Class Notes

Categories of Demand Models

Sequential Versus Simultaneous Models

- Sequential model
  - The travel demand is modeled in sequential steps of trip generation, trip distribution, modal split and assignment
- Simultaneous model
  - If two or more steps in the sequential approach are combined then it results in a simultaneous model.
  - Simultaneous demand models are also called as direct demand models
  - Examples
    - Combined modal split and distribution model
    - Intercity travel demand model

THE URBAN TRANSPORTATION MODEL SYSTEM



Cross-section model versus Temporal model

- Cross-section model
  - model that uses data on dependent and independent variables collected at one point in time for several spatial units (e.g., TAZs)
  - The traditional four stage urban travel demand model is a cross-sectional model
- Temporal model
  - Model that uses panel data (collected at different points of time) on dependent and independent variables for a single spatial unit (e.g., airport, city, etc)

Trend model versus Econometric Model

- Trend Model
  - Causal variable is only time
  - All growth factor models are trend models
  - e.g., linear, exponential, logistic trend models
- Econometric Models
  - The econometric variables (e.g., GDP, employment, car ownership, etc.,) that cause the changes in demand are used as independent variables
  - Traditional four stage model is an econometric model

Aggregate versus Disaggregate Models

- Aggregate Models
  - The demand model that uses summaries of data is an aggregate model
  - The traditional four stage urban travel demand model is an aggregate travel demand model as it uses zonal summaries or aggregate data
- Disaggregate Model
  - The demand model that uses the data on individual decision making unit as it is and explains the behaviour of the decision making unit when confronted with alternatives is a disaggregate model

Top-down model versus Bottom-up Model

- Top-down model
  - Top down models are also known as market share models. A single modal is developed for a larger spatial unit (state) and the demand for the smaller units (regions, individual airports, etc.) with in the larger unit is worked out by market share methods
- Bottom-up model
  - Separate models are developed for each smaller unit, and when aggregated across all smaller units the demand for the bigger unit comes out

Overview of UTMS

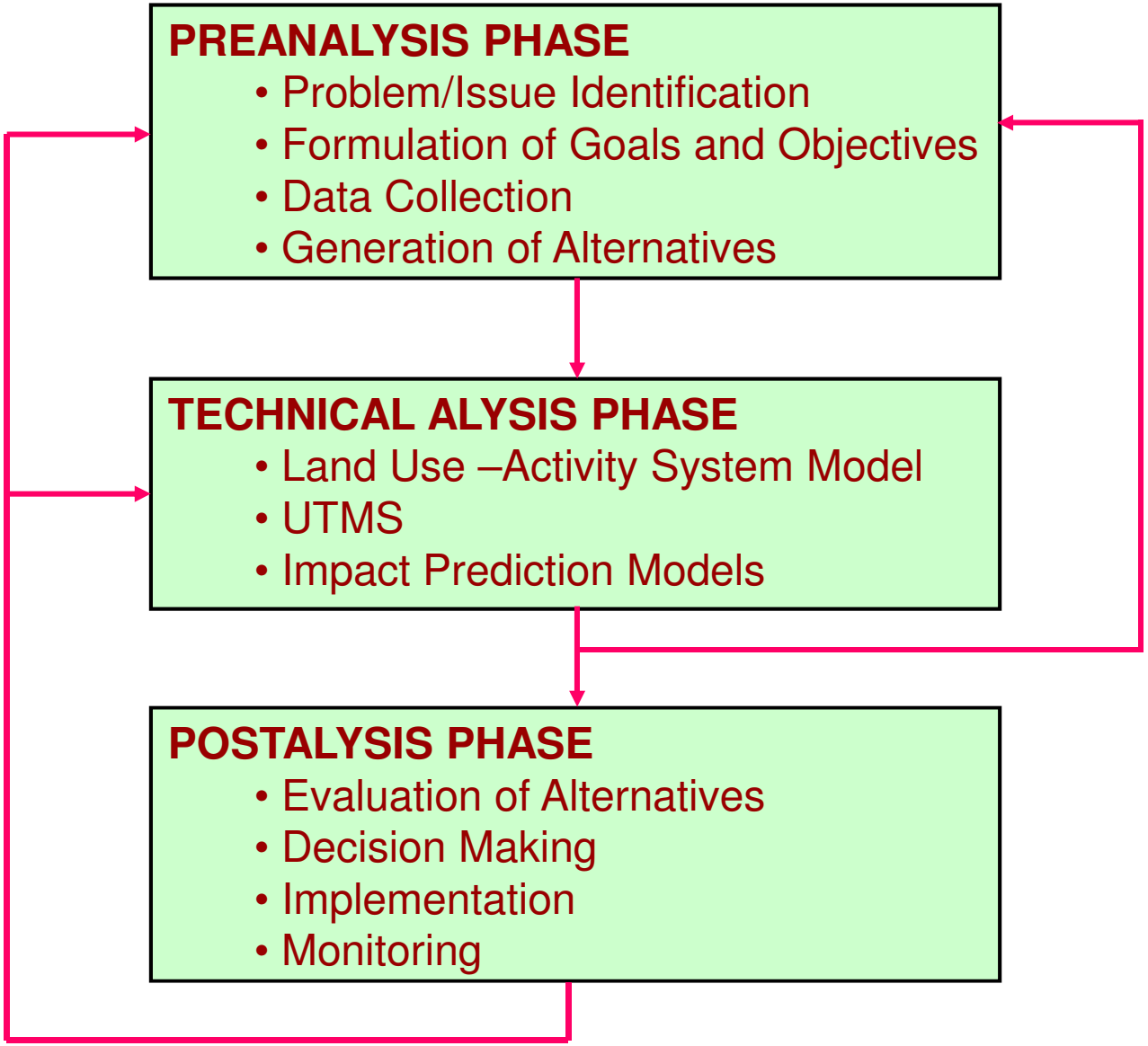
UTMS

- Metropolitan Planning Organisation (MPO) divides the urban region into 100 - 2000 Traffic Analysis zones (TAZs)
- MPO develops networks that represent all major roads and public transport lines, generally termed as strategic network
- Performs household travel survey, cordon line and screen line surveys, speed surveys, etc.
- Collects data relating to demography, land use and activity system
- Establishes travel pattern in terms of trips made by purpose, time, mode, route and destination.
- This data is then used to estimate several submodels, viz., *trip generation*, *distribution*, *modal split* and *assignment* representing the travel pattern.

UTMS

- The models would include explanatory variables relevant to all major policy issues, such as transit fares, road tolls, land use policies, etc.
- The model set is then validated by comparing the base year volumes obtained by the calibrated model with actual traffic volume counts in certain parts of the region
- This validation is done also for public transport ridership, regional modal shares and number of trips
- After the model is validated, it is run for those future years of interest, based on the amount and location of projected population and employment
- Generally, models are run on a 20-year horizon for facility planning and are also run on intermediate years for the requirement of transit ridership estimation or emission deadlines, etc.

URBAN TRANSPORTATION PLANNING PROCESS



Pre-analysis Phase

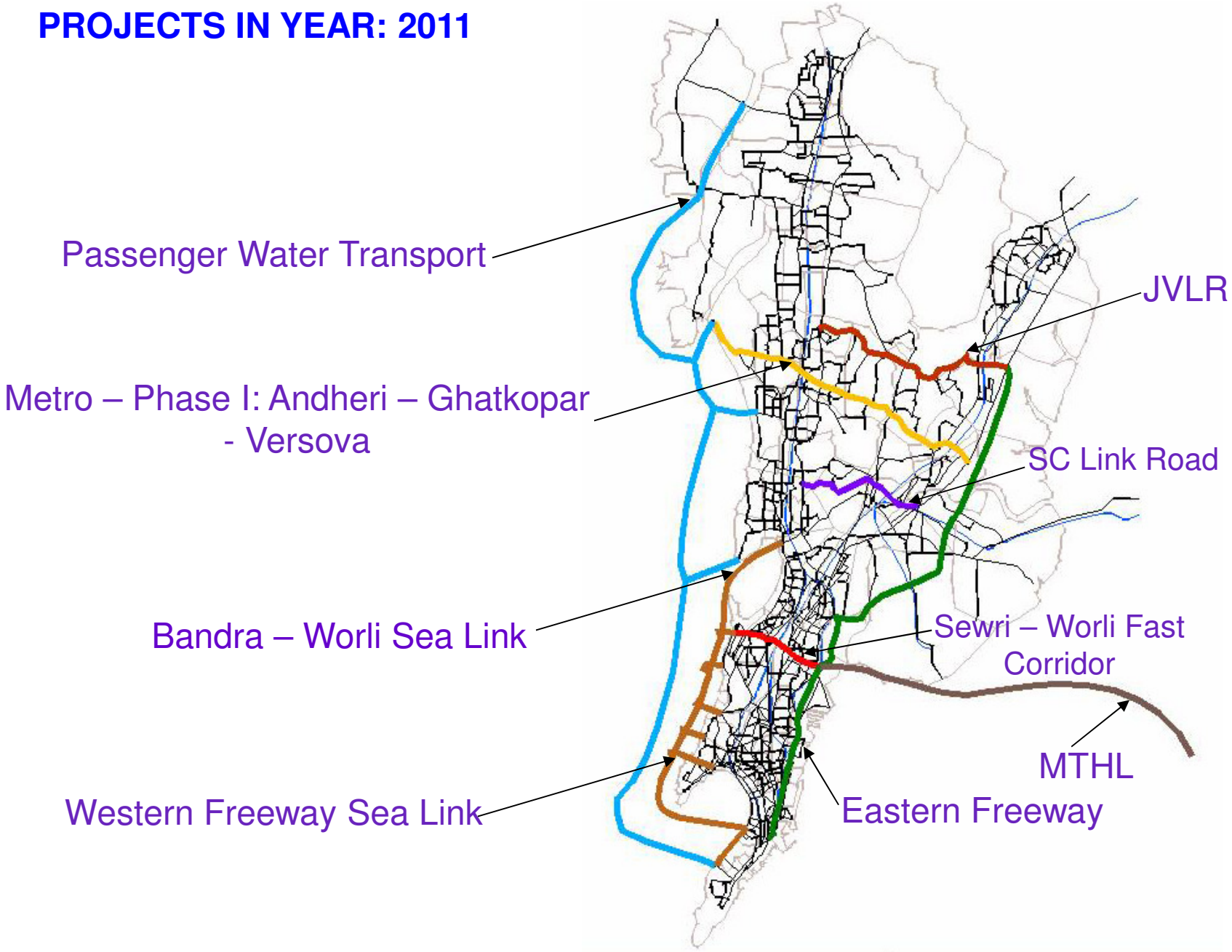
- Define problem broadly
  - Examples
    - Maximise public transport accessibility
    - Achieve reasonable level of service on roads
- Identify broad objectives
  - Examples
    - Public transport area coverage >95%
    - Congestion inside transit vehicles < 5 standees/m^2
    - LoS of Arterial Road network ≥ D

Overcrowding in Suburban Trains

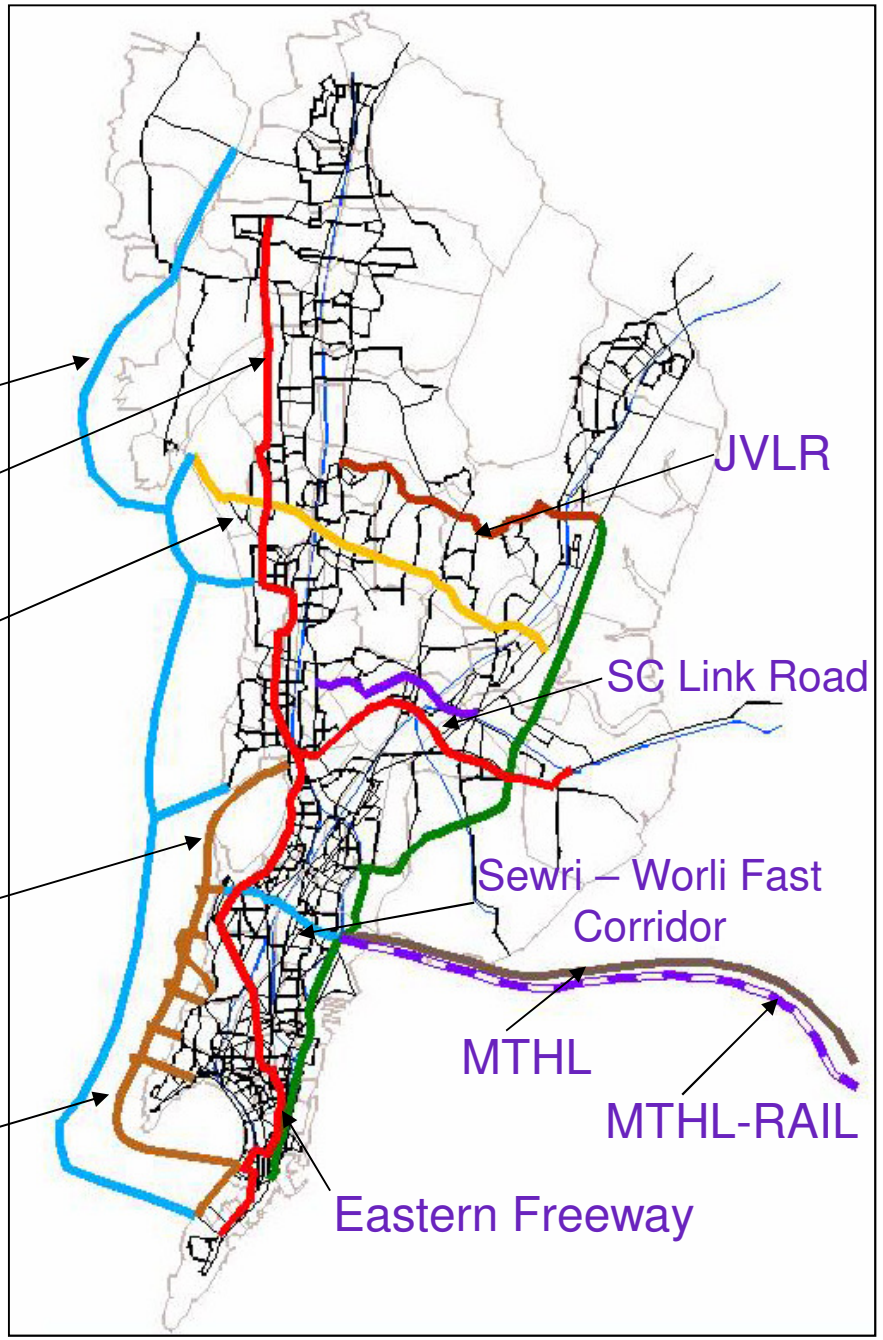
Generation of Alternatives

- Generate alternatives by judgment
- Narrow them down to manageable number by DELPHI technique
- “No Action Alternative” needs to be considered for comparative evaluation
- Generate enough number of
  - transit investment schemes
  - road network investment schemes
  - land use options

PROJECTS IN YEAR: 2011



PROJECTS IN YEAR: 2021



PROJECTS IN YEAR: 2031

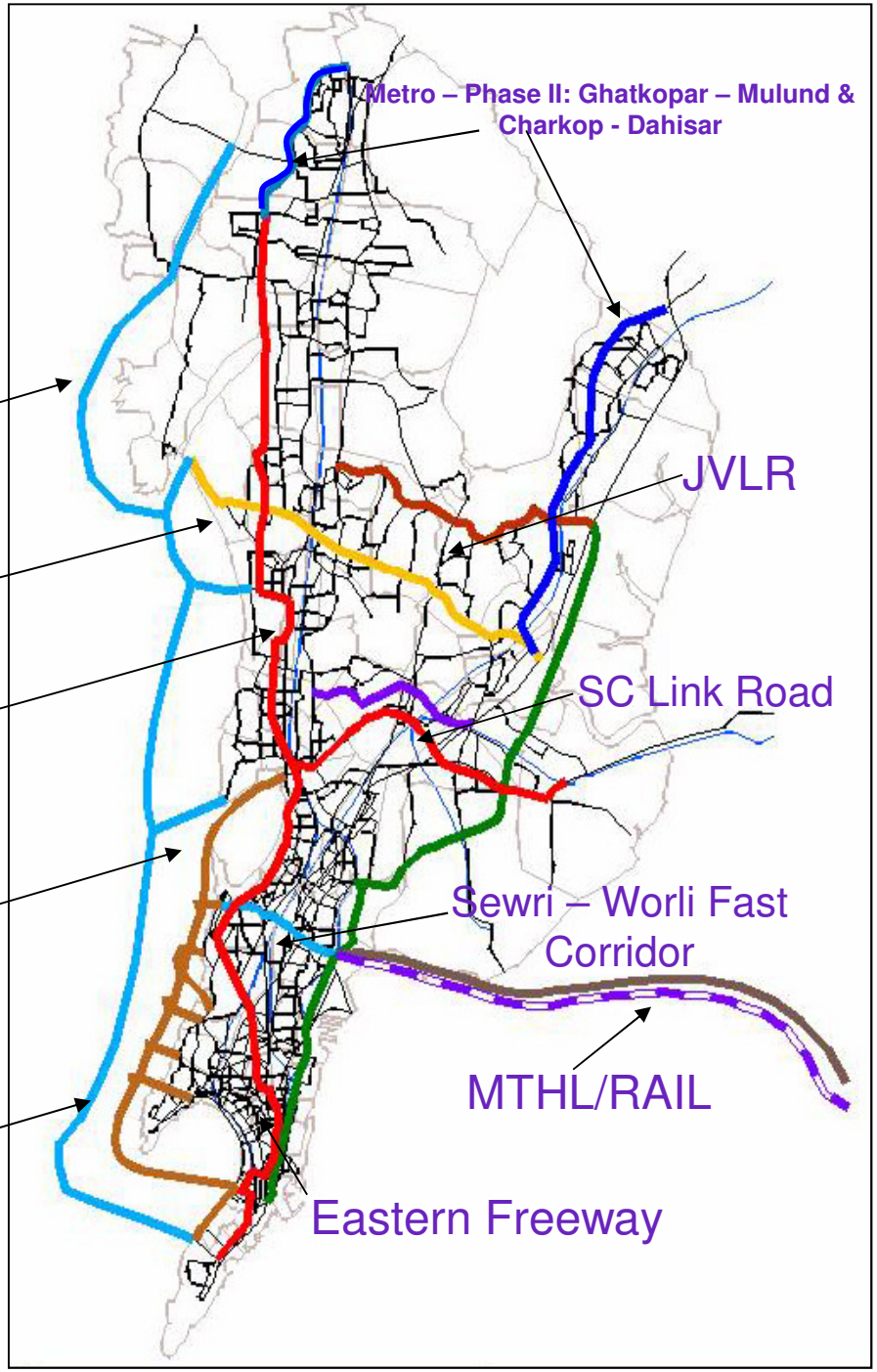
Passenger Water Transport

Metro – Phase I: Andheri – Ghatkopar - Versova

Metro Phase II:**Colaba – Mahim - Charkop / Mankhurd**

Bandra – Worli Sea Link

Western Freeway Sea Link



PROJECTS IN YEAR: 2041

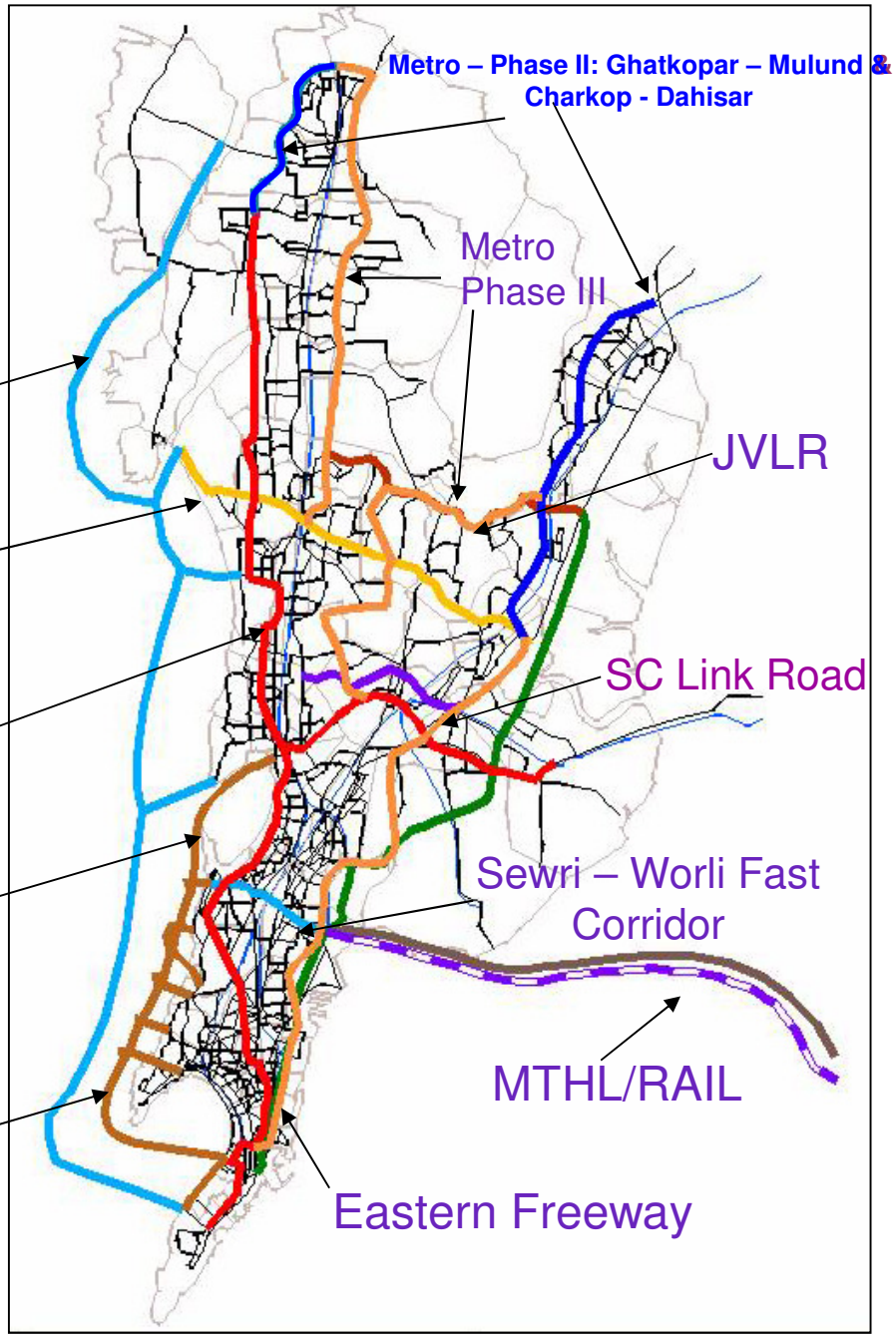
Passenger Water Transport

Metro – Phase I: Andheri – Ghatkopar - Versova

Metro Phase II:**Colaba – Mahim - Charkop** / **Mankhurd**

Bandra – Worli Sea Link

Western Freeway Sea Link



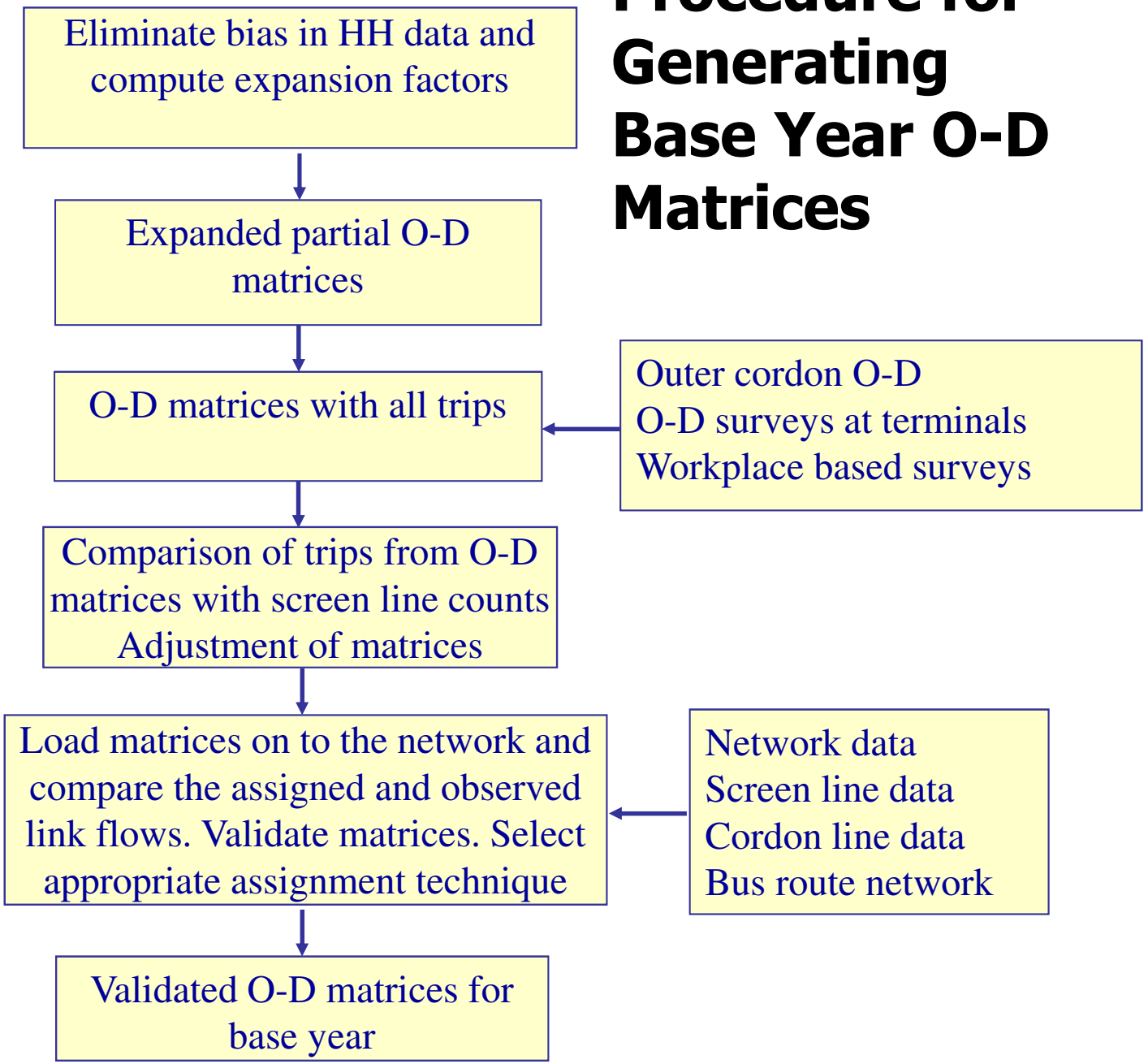
Plan Evaluation Criteria

- Measures of congestion
  - LoS (A-F) on each network link
- Travel Delay
  - Person hours
- Measures of pollution
  - Number of tons of each pollutant produced per day
- Economic welfare (equity measure)
  - Net benefit to travelers in terms of reduction in generalised cost of travel
  - Net benefits to travelers by income class

Data Collection

- Data gathering and data cleaning is part of an ongoing process
- This exercise is fundamental to accurate travel modeling
- Household travel survey need to be performed every decade, coordinated with the national census
- Usual traffic surveys such as cordon line and screen line counts and O-D surveys need to be performed more frequently (three times in a decade)
- Panel surveys on the same household can be used to model household and firm location behaviour
- Survey of employment is needed to supplement national economic census
- Demographic data need to be collected from census.
- Land use data need to be collected from development plan sheets supplemented with satellite imagery
- Survey firms to determine goods movement by commodity type

Procedure for Generating Base Year O-D Matrices



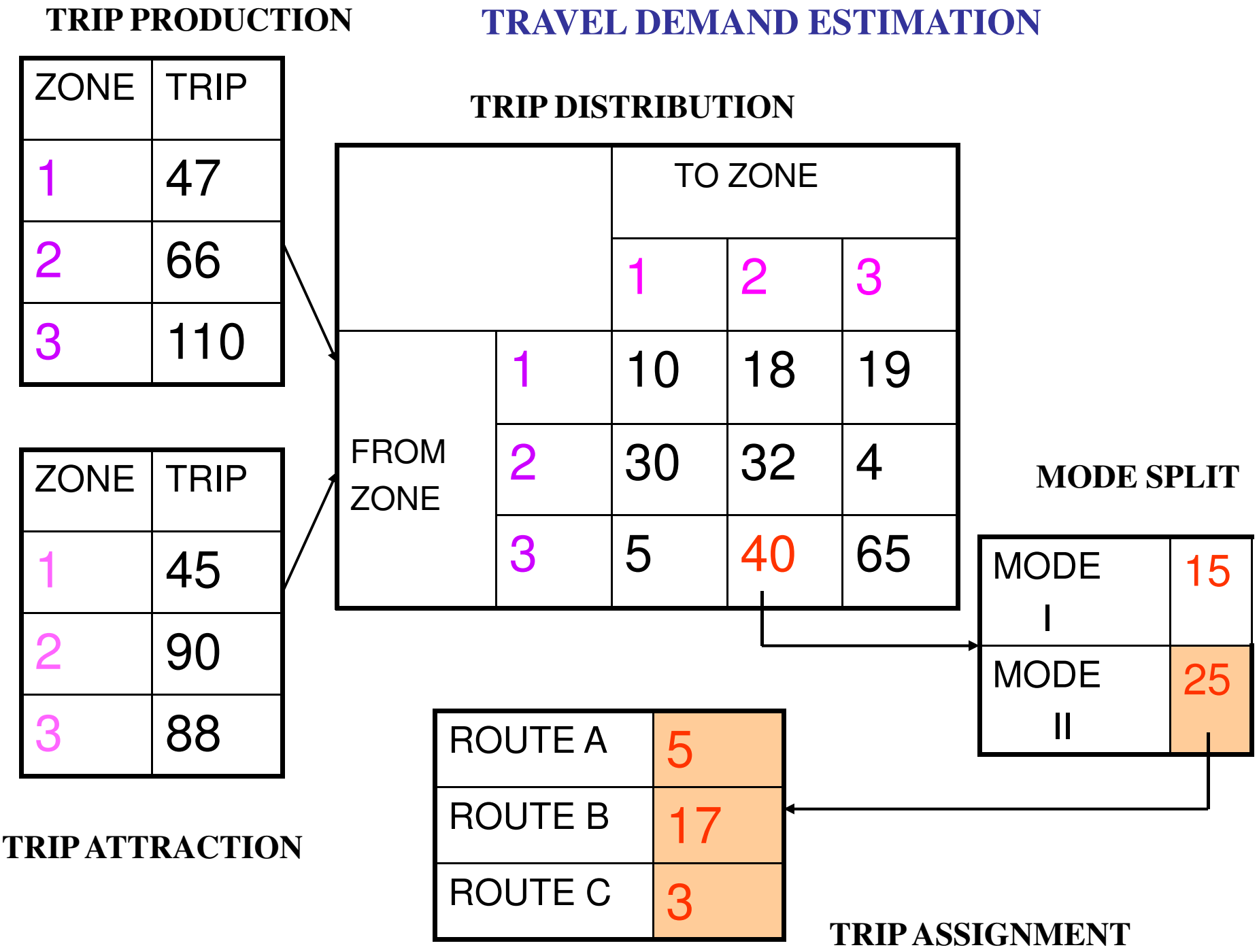
Technical Analysis Phase

- Activity Forecasts
  - Population and employment forecasts are taken from the planning body (for example MMRDA projects population using ratio method)
  - Other important variables in travel models like household income and size need to be forecast
  - Allocate the households and employment to the traffic analysis zones
  - A land use model would be more appropriate in allocating the future activities to zones

Technical Analysis Phase

- Car ownership model
- UTMS
  - Trip generation
  - Trip distribution
  - Modal split
  - Assignment/ route choice
- Impact Prediction Models
  - Travel impacts
  - Air pollution impacts
  - Noise pollution impacts
  - Ecological impacts
  - Social impacts

TRAVEL DEMAND ESTIMATION



Post-analysis Phase

- Plan Evaluation
  - Done using economic, equity and environmental measures
  - Reduction in generalized cost categorized by at least three income groups represents social equity
  - Environmental measures consider pollution impacts, noise impacts, ecological impacts, social impacts

Good Modeling Practice

- Time Representation
  - Peak and off-peak periods
- Data Gathering
  - Household travel survey every decade with tours
  - Vehicle speed surveys
  - Data for urban model
- Activity Forecasts
  - GIS land use model or economic urban model

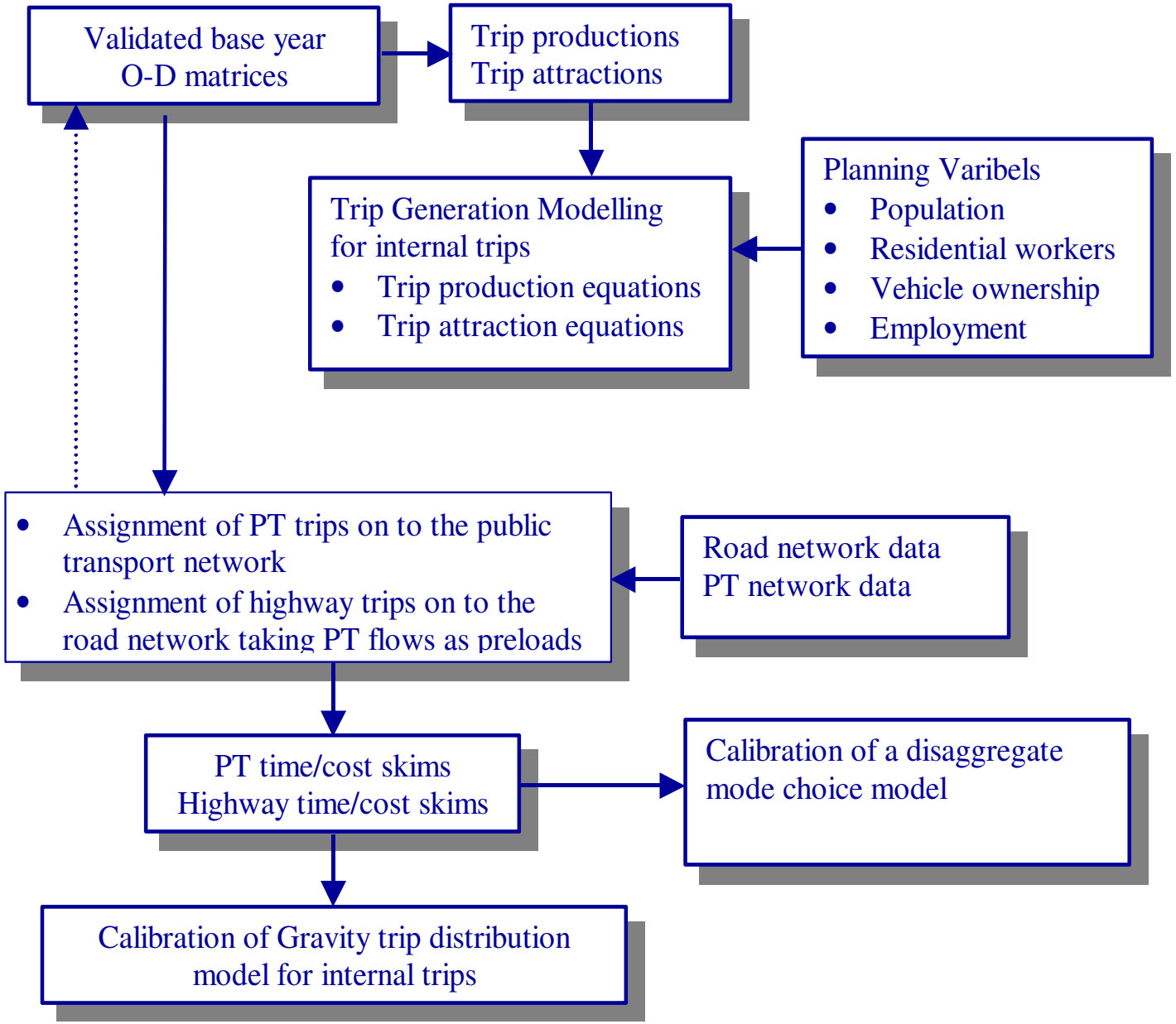
Good Modeling Practice

- Car Ownership
  - Discrete choice model, dependent on land use, parking costs, and accessibility by mode
- Trip Generation
  - Walk and bicycle modes
  - More trip purposes
  - Dependent on car ownership
  - Three or more time periods
- Trip Distribution
  - Full Model Equilibration
  - Composite costs used (all modes, all costs)
  - All-day trip tours represented

Good Modeling Practice

- Mode Choice
  - Discrete choice models used
  - Land use variables in transit, walk, and bike models
- Goods Movement
  - Fixed trip tables
- Assignment
  - Capacity-restrained
  - Cleaned-up link capacities
  - Speeds calibrated
  - Three or more time periods

BASE YEAR TRAVEL DEMAND PROCESS

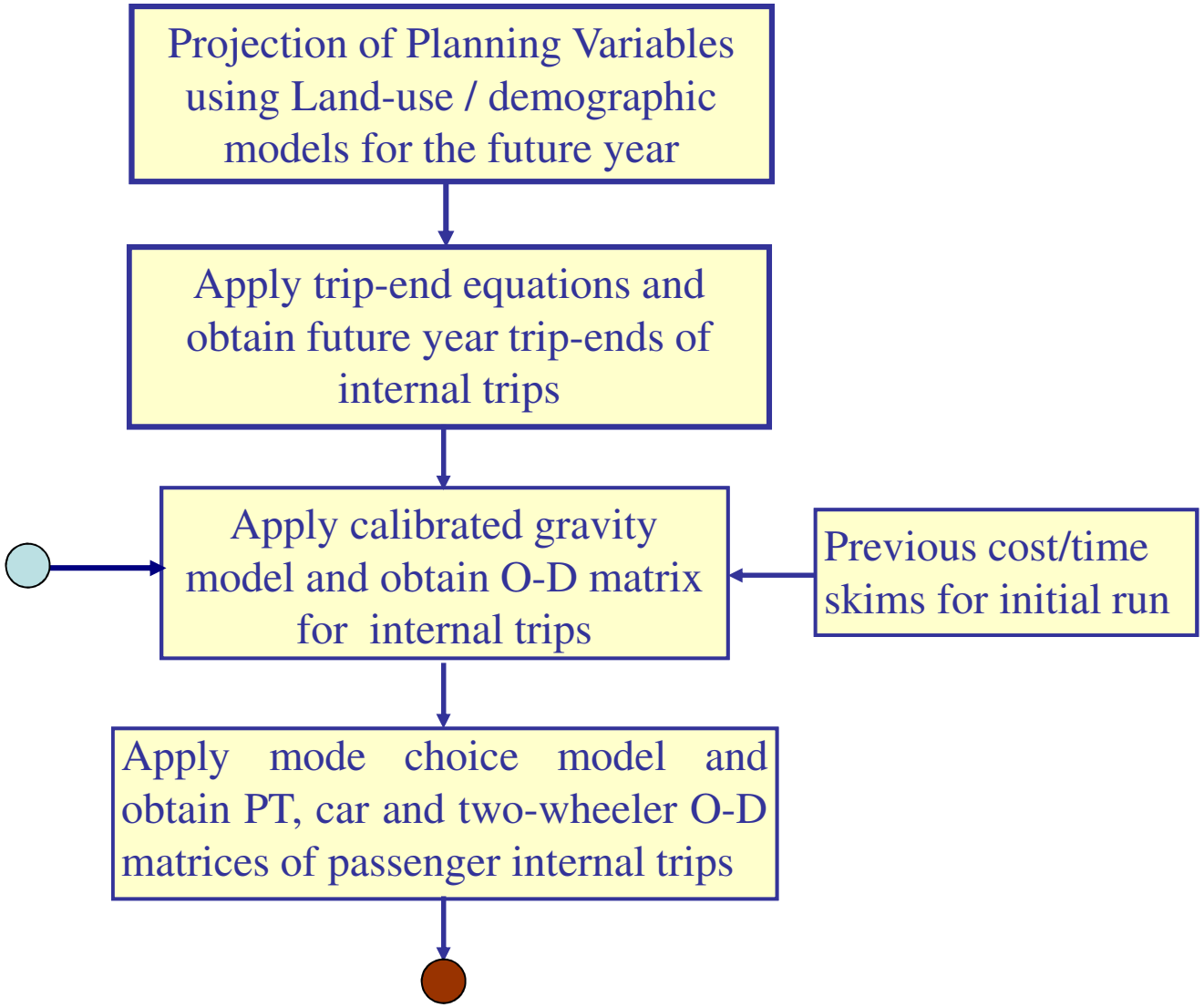


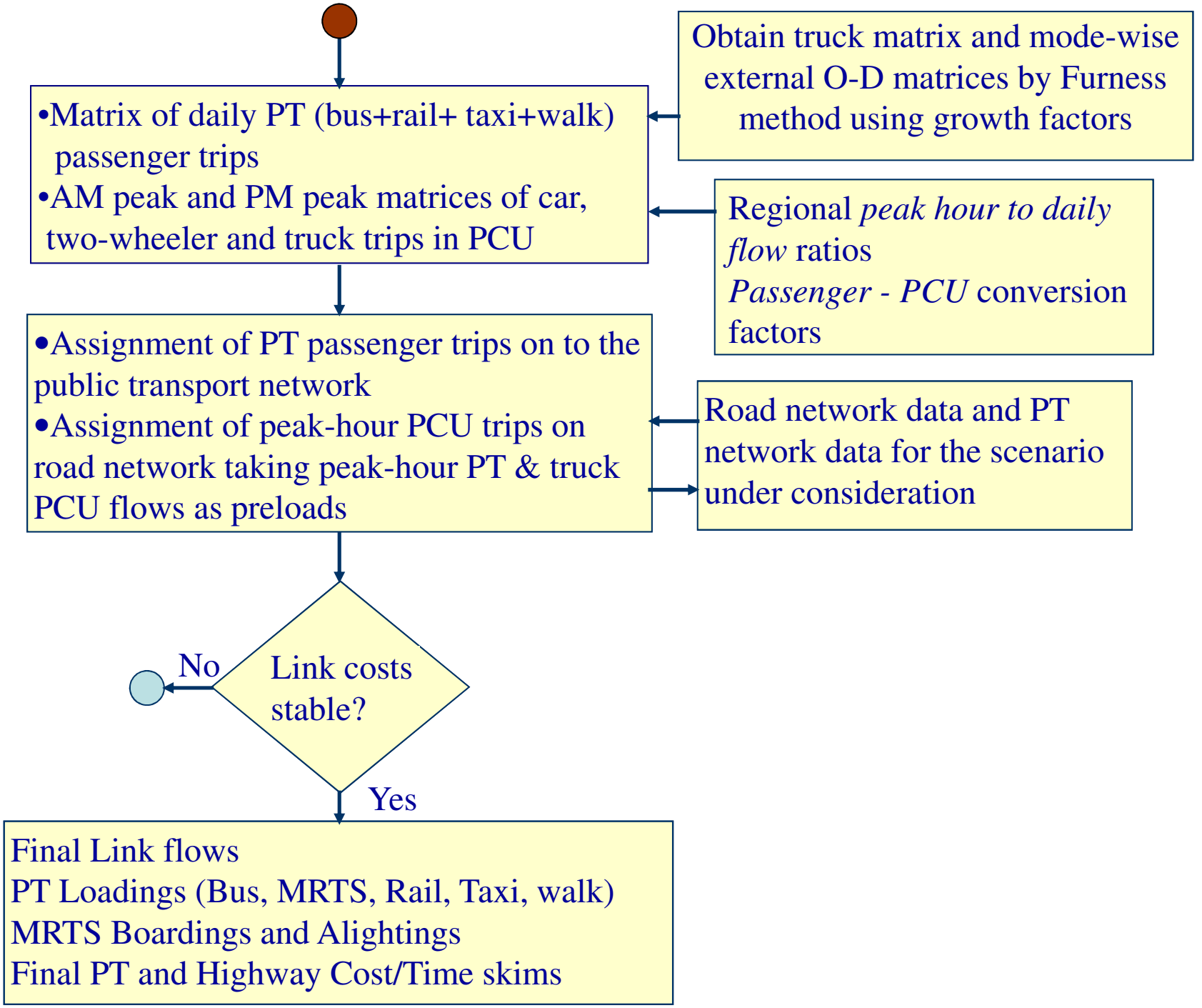
ASSIGNMENT OF PUBLIC TRANSPORT TRIPS

- **Assignment based on Generalized Time**
  - ✉ **In-vehicle travel time**
  - ✉ **Waiting time**
  - ✉ **Transfer time**
  - ✉ **Walk time**
  - ✉ **Fare**
  - ✉ **Discomfort**

- **GT = IVTT + WTFAC * WT + TRFAC * TR + WKFAC * WKT + FARE / VOT + DCFAC * DC**
- **Path building based on GT**
- **Assignment by Logistic choice function based on GT**

FORECASTING

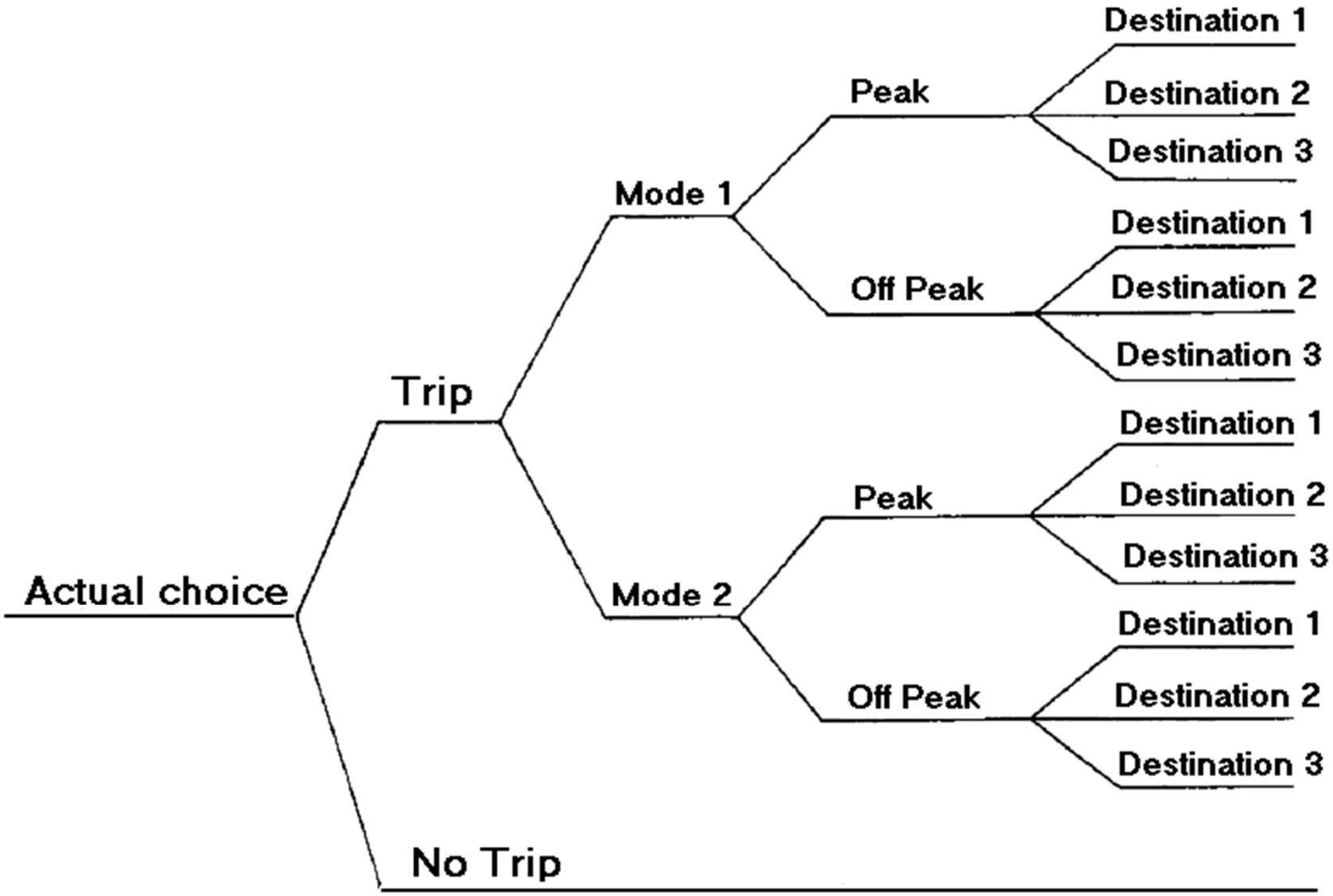



•Matrix of daily PT (bus+rail+ taxi+walk) passenger trips
•AM peak and PM peak matrices of car, two-wheeler and truck trips in PCU
Obtain truck matrix and mode-wise external O-D matrices by Furness method using growth factors
Regional *peak hour to daily flow* ratios
Passenger - PCU conversion factors
•Assignment of PT passenger trips on to the public transport network
•Assignment of peak-hour PCU trips on road network taking peak-hour PT & truck PCU flows as preloads
Road network data and PT network data for the scenario under consideration
Link costs stable?
No
Yes
Final Link flows
PT Loadings (Bus, MRTS, Rail, Taxi, walk)
MRTS Boardings and Alightings
Final PT and Highway Cost/Time skims

Definition of a Behavioural Model

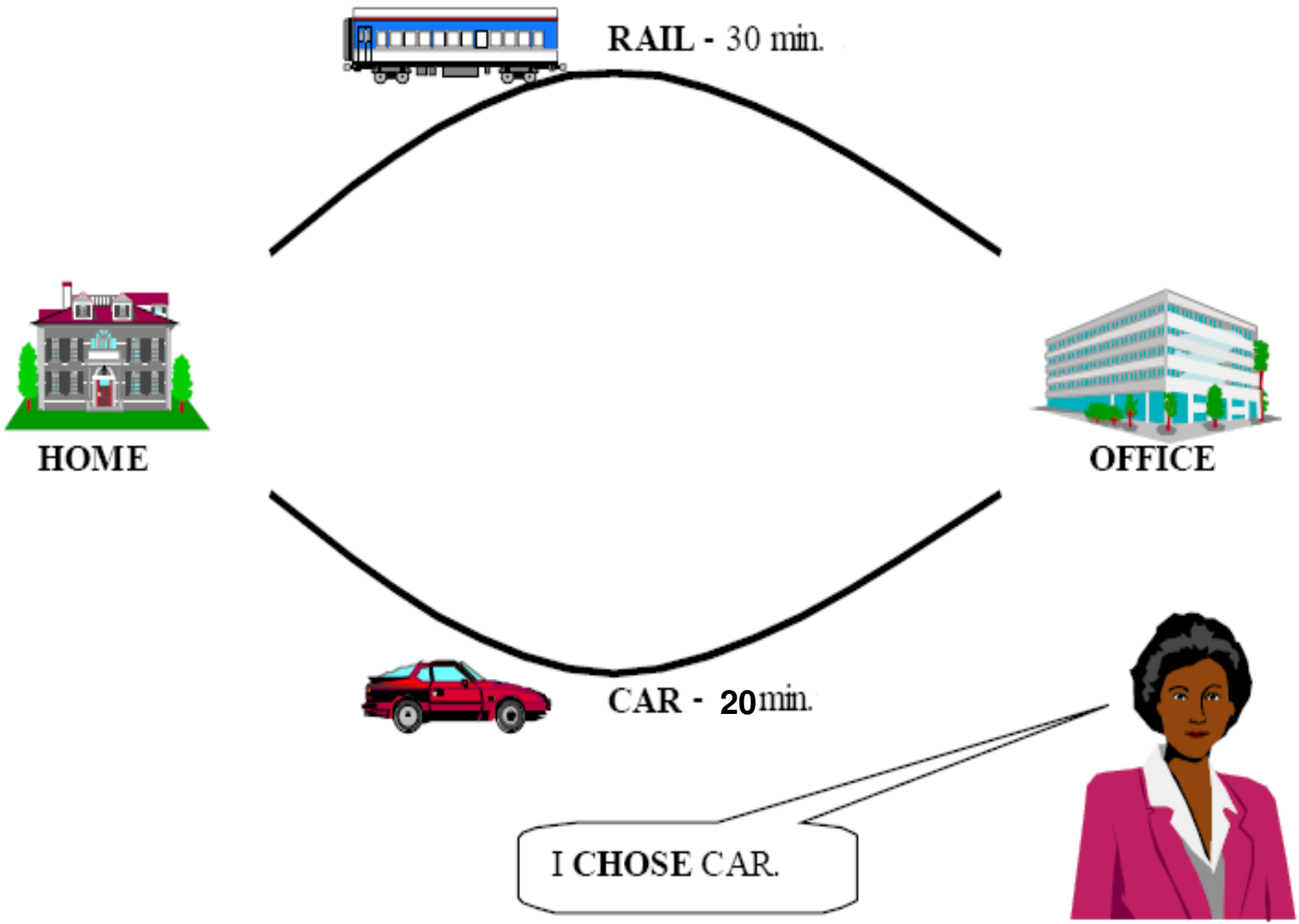
A behavioural model is one that explains the decisions of an individual when confronted with several alternatives.

Travel as a Choice Process

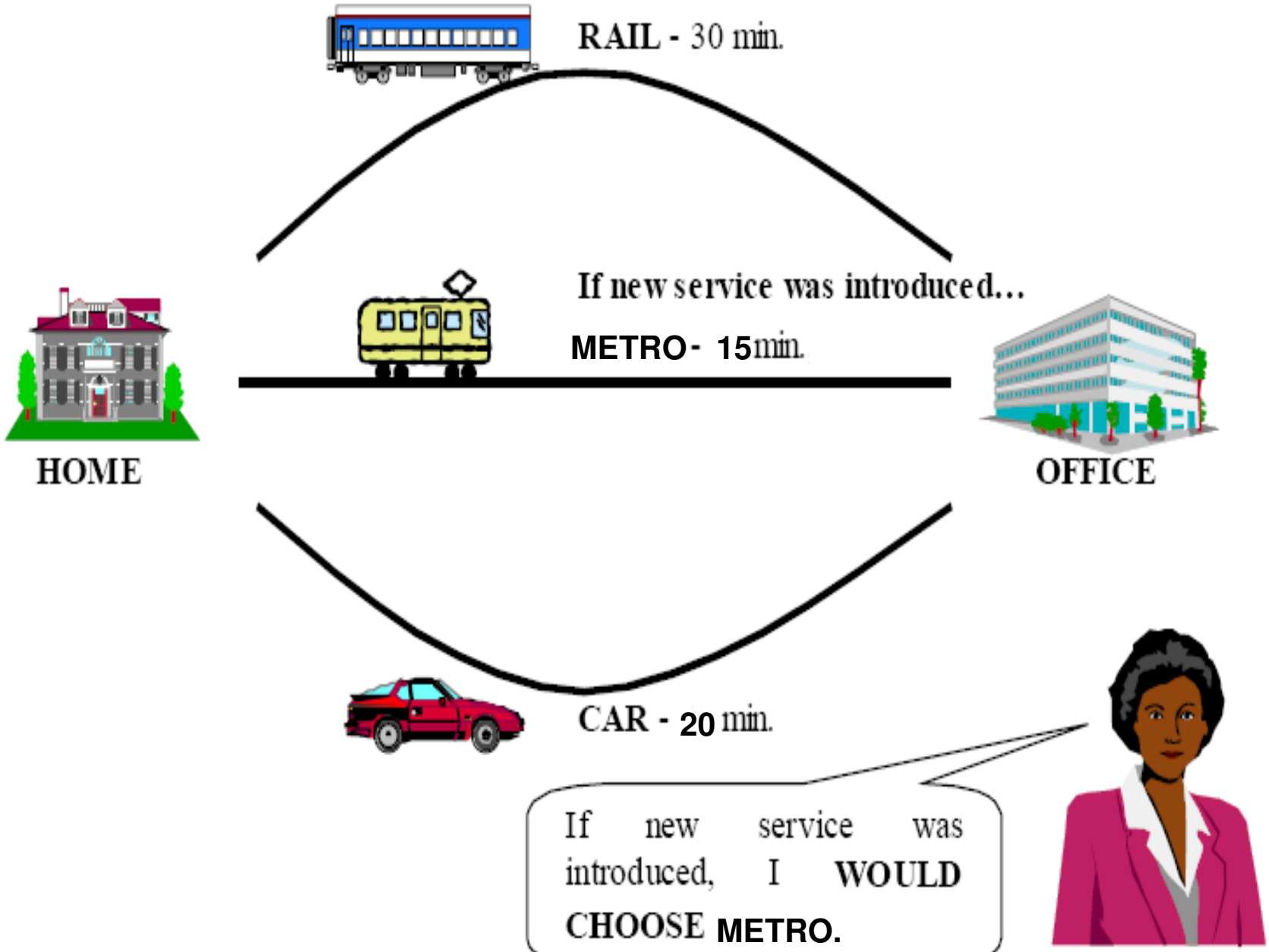


Factors Influencing the Choice of Mode

- Socioeconomic Characteristics of Trip Maker
  - Car Availability and/or ownership
  - Possession of driving license
  - Household Structure
  - Income
  - Residential Density
- Characteristics of Journey
  - Trip purpose
  - Time of day of travel
- Characteristics of Transport System
  - Travel time
  - Waiting Time
  - Travel cost
  - Comfort & Convenience
  - Reliability & regularity
  - Protection & Security



Revealed Preference (RP) Data



HYPOTHETICAL BEHAVIOUR

Stated Preference (SP) Data