

ADVANCED ROUTE RIDERSHIP FORECASTING METHODS

Outline

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2. GIS-Based, Simultaneous-Equations, Route-Level Model
3. Components of Network Modeling Computer Packages
4. Example Modeling Systems
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5. Major Sub-Models
 - (a) Route Assignment
 - (b) Mode Choice

TTC Route Ridership Prediction

- **Combination of rules of thumb (based on experience + survey data) and judgement**
- **Two methods used, depending on type of service change:**
 - additional period(s) of operation; or
 - new route/route extension/major re-routing.

Reference: Toronto Transit Commission, Service Standards Process Technical Background Papers, No. 1, "Ridership Forecasting Methods", January, 1991, pp. 1-11 (see Supplementary Readings)

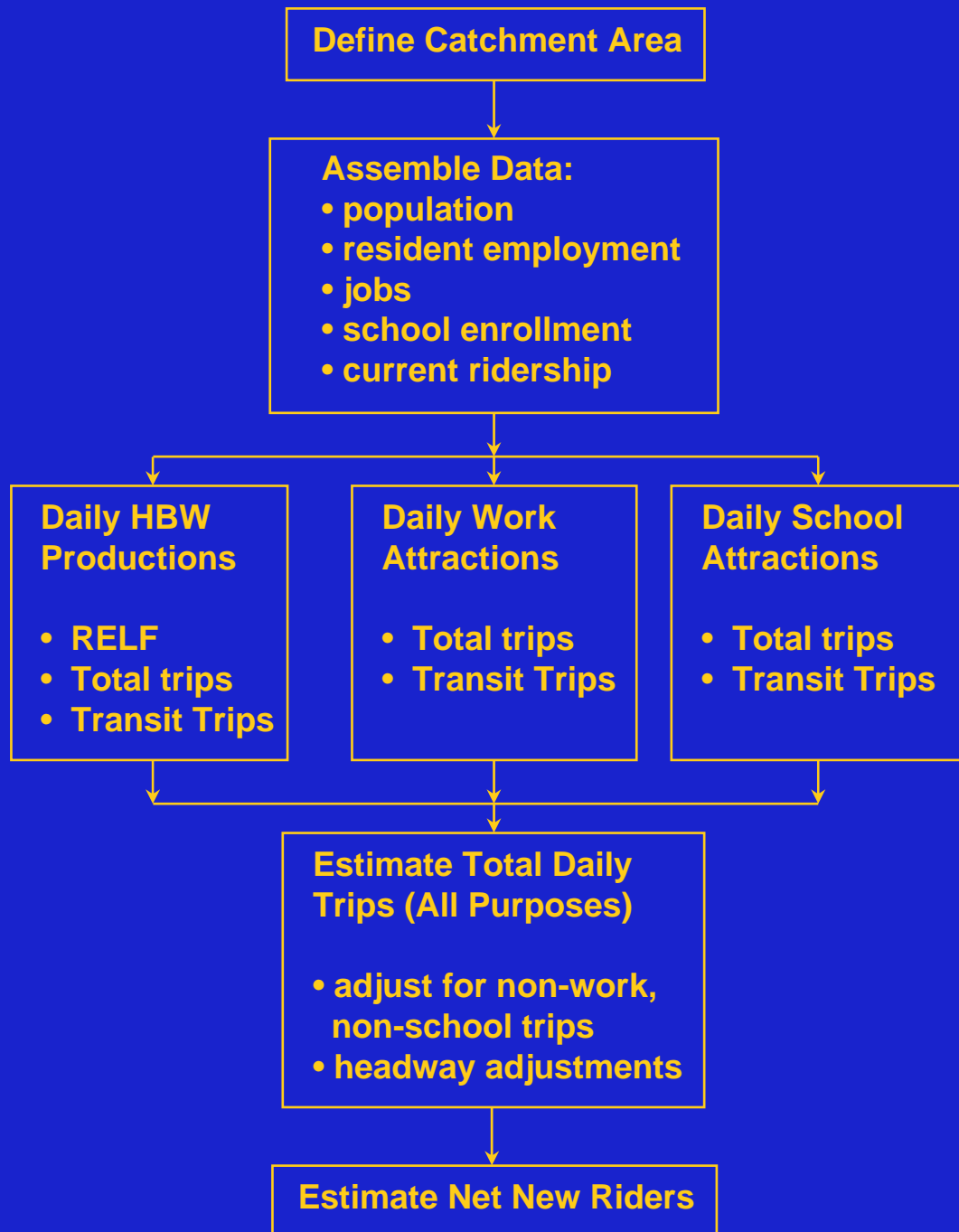
Route Ridership Prediction Method 1

SYSTEM-WIDE AVERAGE OPERATING PERIOD RIDERSHIP PROPORTIONS FOR ADDITIONAL PERIODS OF OPERATION

Added Period/ Base Period	<u>RIDERSHIP IN ADDED PERIOD</u> (% of Base Period)		
	Core Route Section (2)	Suburban Route Section (2)	Industrial Route Section (3)
(a) Day Normal/ AM Peak	75%	63%	66%
(b) Evening/ AM Peak	54%	41%	35%
(c) Total Saturday/ Total Weekday	53%	38%	28%
(d) Total Sunday/ Total Weekday	39%	26%	10%

- (1) Proportions are based on analysis of actual ridership counts on all routes in system. They are used to estimate ridership in proposed additional periods of operation on existing routes.
- (2) Suburban route sections are those which serve non-industrial areas in the cities of Etobicoke, North York, and Scarborough. Core route sections serve non-industrial areas in the Cities of Toronto, York, and East York. Suburban and core categories were separated because of the significant variation in the operating period ridership proportions across the system.
- (3) Industrial route sections are those which serve primarily industrial areas in Metro. These route sections were examined separately because their ridership is characterized by more home-to-work trips which are concentrated in the peak periods, with fewer trips occurring in the off-peak periods, than is the case for route sections serving residential or commercial areas.

Route Ridership Prediction Method 2



Route Ridership Prediction

Method 2, Mode Split Factors

- **Based on existing average mode splits by:**
 - **zone of origin and destination**
 - **separately for work trip productions and attractions**
- **Example: for extreme Northeast zone:**
 - **transit mode split of 50% for work trip productions leading to CBD**
 - **transit mode split of 19% for all other work trip productions**
 - **transit mode split of 18% for all work trip attractions**

Route Ridership Forecasting & Analysis Requirements

- **Predict Ridership Changes in Response to:**
 - Route extensions, consolidations, realignments, deletions, cutbacks
 - Changes in fares, headways, operating periods, mode of operation
 - Changes in service area population & employment, distributions, patterns of travel demand
- **Analyze socio-economic characteristics of route riders:**
 - Characteristics of people affected by service changes
 - Potential markets for service
 - Distribution of benefits & costs for transit services
- **Problems with single-route ridership forecasting methods:**
 - Network effects ignored (transfers, competing routes)
 - Demand - supply interactions ignored
 - Spatial distribution of travel demand ignored
 - Competing modes (auto, others?) ignored

Alternative Approaches to the Ridership Forecasting Problem

- **GIS-based, simultaneous-equation, route-level models:**
 - capable of including competing/ complementary routes
 - able to address demand-supply interactions
 - "logical next step" beyond Stopher-type model
- **Full network models:**
 - explicitly deal with competing/complementary routes
 - able to include trip distribution and mode split effects
 - "logical next step" beyond TTC-type model

--> Both approaches require a computerized representation of the transit network and the service area.

This is usually achieved through some form of Geographic Information System (GIS).

GIS-based, Simultaneous Equations, Route-level Model (Portland Tri-Met Model)

Explicitly addresses demand-supply interactions:

$$R_{iz} = f(S_{iz}, X_{iz}) \quad [1]$$

$$S_{iz} = g(R_{iz}, R_{-1i}, Z_{iz}) \quad [2]$$

where

R_{iz} = ridership on route i in segment z

R_{-1i} = ridership on route i in the
previous time period

S_{iz} = level of service provided on route i
in segment z

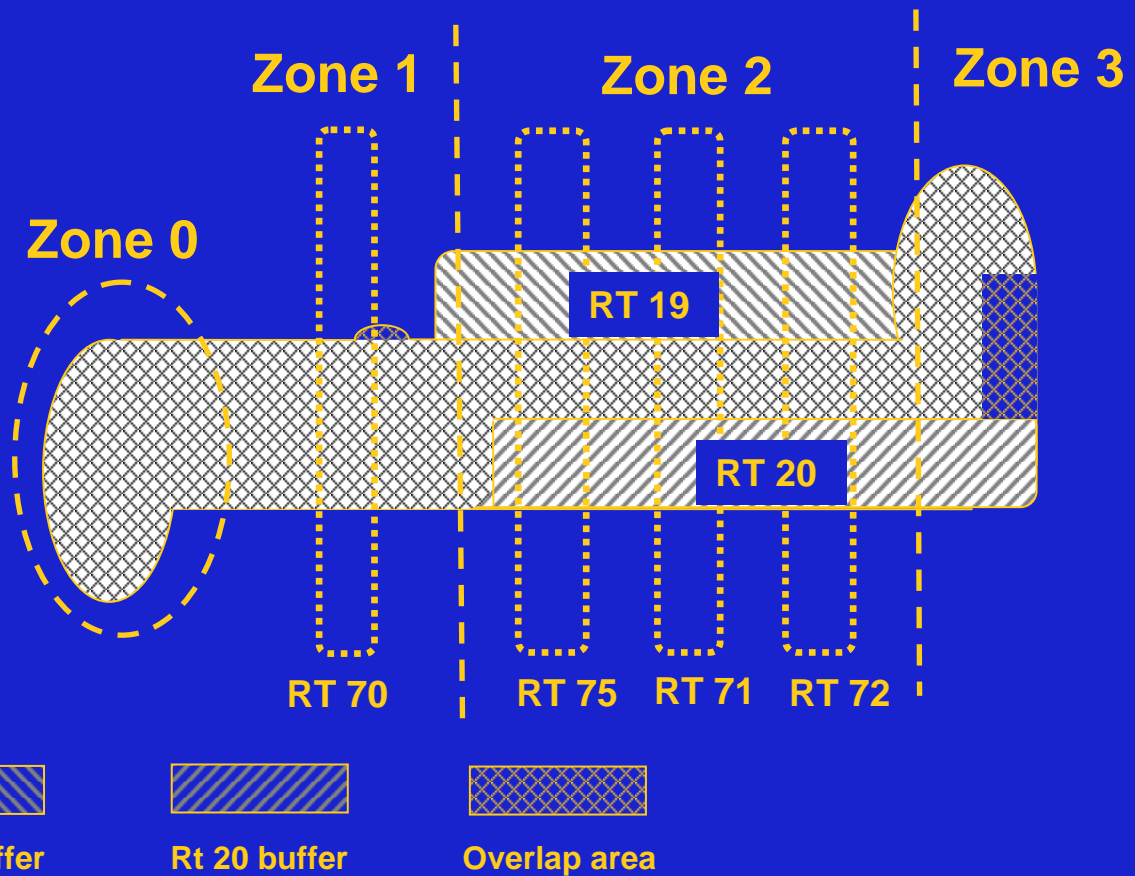
X_{iz} = other explanatory variables affecting
ridership on route i in segment z

Z_{iz} = other explanatory variables affecting
service provided on route i in
segment z

Peng, *et al.* ("A Simultaneous Route-Level Transit Patronage Model: Demand, Supply, and Inter-Route Relationship", *Transportation*, Vol. 24, 1997, pp. 159-181).

Portland Tri-Met Model (cont'd)

- Uses GIS to identify interactions between routes. Routes can be:
 - independent
 - complementary
 - competing



$$OVPOPPC_{ijz} = OVPOP_{ijz} / (POP_{iz} + POP_{jz})$$

where i, j denotes competing routes

POP_{kz} = population in catchment area for route k ($k=i, j$) in zone z

$OVPOP_{ijz}$ = population in overlap area in zone z for routes i and j

Portland Tri-Met Model (cont'd)

- To capture inter-route effects, modify equation [1] and add equation [3]:

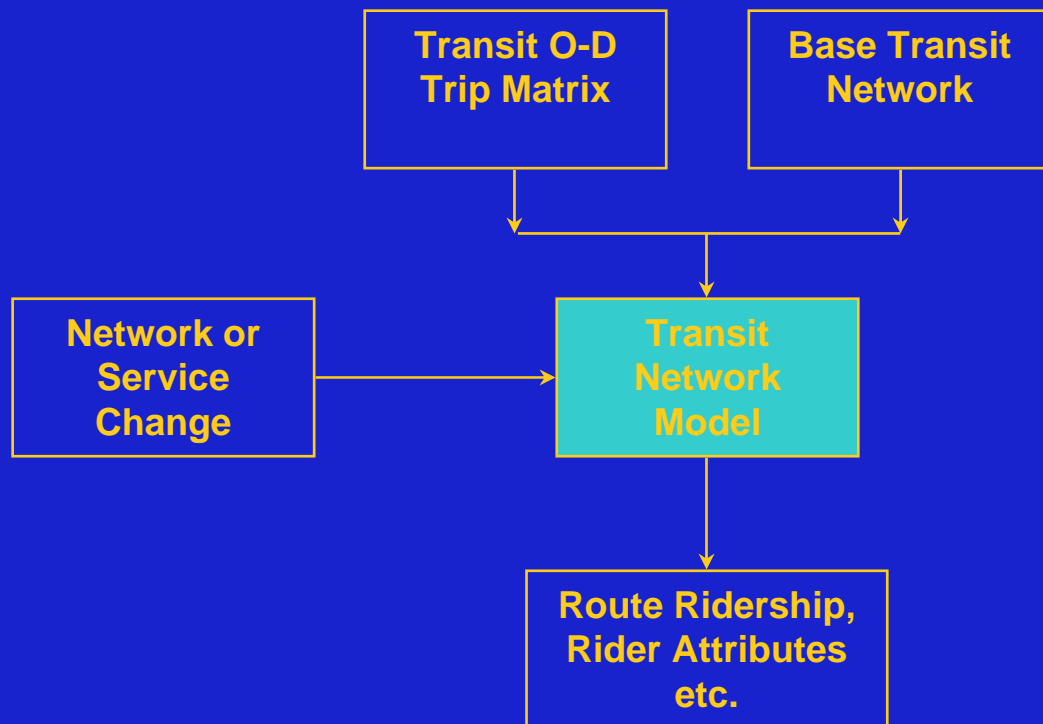
$$R_{iz} = f(S_{iz}, \sum_j R_{jz}, \sum_k R_{kz}, \sum_j OVPOPPC_{ijz}, X_{iz}) \quad [1a]$$

where

$$\sum_j R_{jz} = h(S_{iz}, \sum_j OVPOP_{ijz}, POP_{jz}, Z_{jz}) \quad [3]$$

R_{kz} = alightings from complementary route k in zone z

Generalized Network-Based Modeling/Analysis Approach



Transit Network Model Capabilities

- **Interactive computer graphics for network editing & display**
- **Network database management system**
- **Network assignment procedure**
- **Flexible display & output of results & base data**
 - **plots & reports**
 - **screen displays, printer & plotter hard copies**

Transit Network Database

- **Geocoded transit links & nodes**
- **"Mapping" of transit lines onto network links & nodes**
- **Transit line attributes**
 - headways (by service period)
 - travel times (by service period)
 - "mode" of service (bus, subway, etc.)
- **System attributes**
 - operating cost data
 - energy consumption data
 - fares

Transit Origin-Destination Flow Matrix

- **Three Levels of Analysis:**

- 1. Fixed Transit Flows**

- use observed current transit o-d flows obtained from area-wide survey (e.g., Telephone survey)
- assumes demand for transit will not change as service changes (at least in the short run)
- typical approach currently adopted

- 2. Variable Modal Split, Fixed Total Demand**

- use observed current total (all modes) o-d flows
- apply a modal split model to determine transit flows
- preferred approach for significant service changes
- not, however, generally operational

- 3. Variable Total Demand & Modal Split**

- requires full demand modeling capability (i.e., Generation, distribution, modal split)
- not generally necessary for transit service planning, since total o-d flows are unlikely to change significantly during service planning period

Typical Package Outputs

- **Link and line volumes**
- **Boardings by link, line, node**
- **O-D travel times**
 - in-vehicle
 - out-of-vehicle (walk, wait, transfer, etc.)
- **Revenues, operating costs, energy consumption by link or line**
- **Revenues, operating costs, rider characteristics by origin or destination zone**

Outputs may be displayed in tables, reports, plots (network or zone based).

Examples Of Transit Network Modeling & Analysis Packages

1. MADITUC

Modele d'Analyse Desagregée des Itinéraires en Transport Urban Collectif

or

Model for the Disaggregate Analysis of Itineraries on a Transit Network

- Developed at the Ecole Polytechnique, University of Montreal (Robert Chapleau)
- Requires "Montreal-style" O-D survey data, including transit route choice information
 - does not have general demand modeling capabilities
- Designed specifically for transit service planning
- Is "line-oriented" rather than "link/node-oriented" in design
- Uses "all-or-nothing" assignment combined with detailed determination of network access/egress points
- Runs on mainframe/minicomputer & PC's
- Requires SAS for data analysis & graphics
- Used in 4 Canadian cities
 - Montreal, Quebec, Toronto, Winnipeg

Examples of Transit Network Modeling & Analysis Packages, cont'd

2. EMME/2

Equilibre Multi-Modal, Multi-Modal Equilibrium/2

- Developed at the Centre for Transportation Research, University of Montreal (Michael Florian)
- Developed as a general regional transportation modeling package
 - can be used to generate transit O-D flows from a travel demand model
 - or, can input observed transit O-D matrix
 - link/node oriented in its design
- Two types of transit assignment available
 1. "Aggregate" zone-to-zone flow multipath assignment procedure
 - generally not precise enough for transit route planning applications
 2. "Disaggregate" point-to-point trip assignment procedure
 - intended to be comparable to MADITUC
 - probabilistic (multipath) assignment
- Commercially available package
- Runs on mainframes, minicomputers, microcomputers
- "Stand-alone" package

Transit Route Assignment Procedures

- Assignment procedures "assign" origin-destination trips to specific paths through the transit network, thereby "loading" the specific transit routes with riders.

Two major approaches to transit assignment exist:

1. All-or-nothing assignment, in which all flow for a given origin-destination pair is assigned to a single path, with this path being the least "cost" (travel time, etc.) path between the origin and the destination.
 2. Multi-path assignment, in which several attractive paths between an origin and a destination are identified, and the flow is split probabilistically over these paths.
- > If access/egress points are well defined, then all-or-nothing usually works very well (e.g., most radial systems). If several access and/or egress points are potentially attractive (e.g., in a fine grid network), multi-path assignment may perform better.

Transit Route Assignment Procedures

- Assignment procedures can also be either:
 1. Aggregate, in that they assign total zone-to-zone flows on a centroid-to-centroid basis.
 2. Disaggregate, in that they can assign individual trips from "actual" geocoded origin points to "actual" geocoded destination points.
- > Disaggregate assignment methods clearly preferable for service planning purposes, providing sufficiently disaggregated transit trip data are available.

Logit Mode Choice Model

$$P_{it} = \frac{e^{V_{it}}}{\sum_{j=1}^n e^{V_{jt}}}$$

P_{it} = Probability That Individual t Will Choose Alternative i

V_{it} = "Systematic Utility" of Alternative i for Individual t

$$= \beta_1 X_{it,1} + \beta_2 X_{it,2} + \dots + \beta_m X_{it,m}$$

$X_{it,k}$ = k^{th} Explanatory Variable (Travel Time, etc.)

β_k = Model Coefficient for Variable No. k

n = No. of Alternatives Available

m = No. of Explanatory Variables

Typical Variables In A Work Trip Mode Choice Model

- **Modal characteristics:**
 - In-vehicle travel time
 - Out-of-vehicle travel time
 - Out-of-pocket travel cost

- **Traveller characteristics:**
 - Income
 - Gender
 - Auto availability
 - Occupation