Planning and Analysis Tools of Transportation Demand and Investment

Development of Formal Transportation Planning Process

23 USC Para 134: Metropolitan Planning .

Findings- ISTEA "It is in the national interest to encourage and promote the development of transportation systems embracing various modes of transportation in a manner which will efficiently maximize mobility of people and goods within and through urbanized areas and minimize transportation-related fuel consumption and air pollution. To accomplish this objective, metropolitan planning organizations, in cooperation with the State, shall develop transportation plans and programs for the development of transportation facilities which will function as an intermodal transportation system for the State, the metropolitan areas and the Nation."

Findings- TEA21 (Changes in *italics*) "It is in the national interest to encourage and promote the *safe and efficient management, operations, and* development of *surface* transportation systems that will *serve* the mobility *needs* of people and *freight and foster economic growth and development within and through the urbanized area,* while minimizing transportation-related fuel consumption and air pollution".

Contents (of plans) TEA-21 "The plans and programs for each metropolitan area shall provide for the development and integrated management and operation of transportation systems and facilities (including pedestrian walkways and bicycle transportation facilities) that will function as an intermodal transportation system for the metropolitan area and as an integral part of an intermodal transportation system for the State and the United States."

Process of (Plan) development (TEA21) " The process for developing the plans and programs shall provide for consideration of all modes of transportation and shall be continuing, cooperative, and comprehensive to the degree appropriate, based on the complexity of the transportation problems to be addressed''.

(f) Factors to be considered:

(1) Preservation of existing transportation facilities (i.e. maintenance)
(2) Consistency with energy conservation
(3) Relieve and prevent congestion
(4) Anticipate the likely effect of transportation policy decisions on land use and development
(5) The programming of expenditures on transportation (i.e. how & when $$$ are spent)
(6) The effects of non publicly funded transportation projects
(7) Access to major points/places: ports, historic sites, military installations, etc
(8) The need for connectivity of roads
(9) Needs identified by the transportation management system (i.e. operational efficiency)
(10) Preservation of rights of way
(11) Methods to enhance efficient movement of freight
(12) Use of life-cycle costs in design and engineering of facilities
(13) The overall social, economic, energy and environmental effects of transportation decisions.
(14) Methods to expand and enhance transit service.
(15) Capital investment that would result in increased security for transit systems

Statewide Planning: Basically same as Metropolitan, except state-wide

All of this should lead to a **Continuing**, **Comprehensive**, and **Coordinated** planning process containing:

LPR: Long Range Transportation Plan (20 year forecast period)

(1) Identify transportation facilities that as an integrated metropolitan transportation system
(2) Include a financial plan that demonstrates how the LRP can be implemented using both public and private resources. Include innovative finance techniques such as value capture, tolls, and congestion pricing (value pricing). Aside: ATA Board meeting last year identified as one of the two major lobbying initiatives; fighting tolls on interstates.
(3) Assess capital investments and other measures
(4) Indicate as appropriate proposed transportation enhancement facilities

TIP: Transportation Improvement Plan (3 year period, updated at least every 2 years)

Priority list of projects with finance plan

TMA: Transportation Management Areas (Urbanized areas > 200,000 pop)

Congestion management system: through the use of travel demand reduction and operational management strategies.

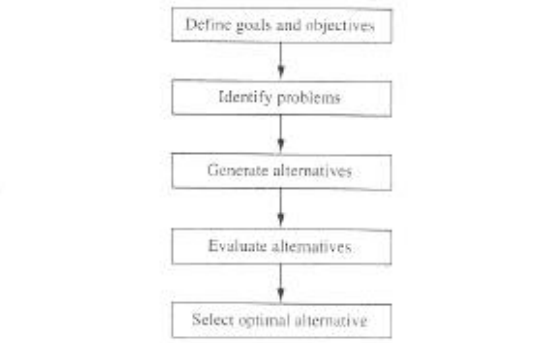

Figure 2.5 The rational approach toward transportation planning

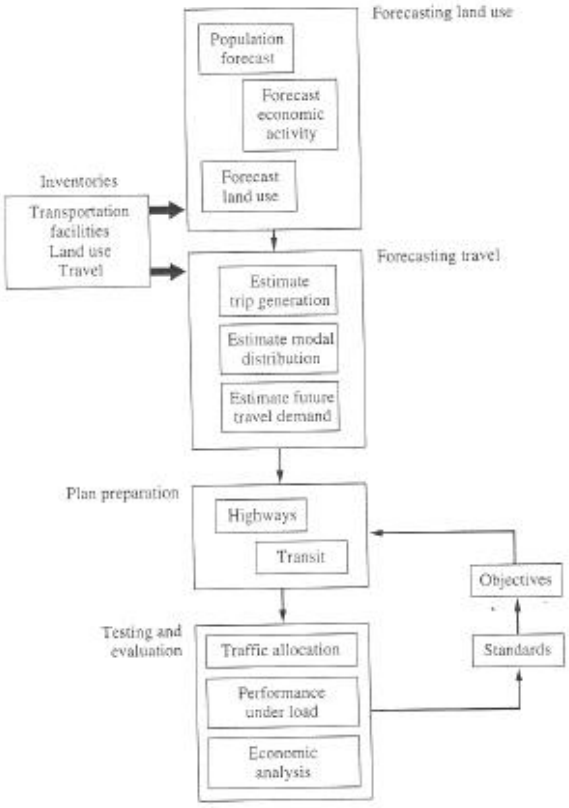

Figure 2.6 The planning process !

HOW?
Basic relationship between: **land use** and **transportation demand**
Begins with an Inventory of

(1) Land use
(2) Transportation facilities
(3) Transportation demand
Trip demand

Concepts of urban form and structure:

- **Urban Form.** The spatial pattern or "arrangement" of individual elements – such as buildings, streets, parks, and other land uses =(collectively called the *built environment*), as well as the social groups, economic activities and public institutions. These form the elements of a zoning plan.
- **Urban Interaction.** The collective set of interrelationships, linkages, and flows that integrate and bind the pattern and behavior of individual land uses, groups, and activities into the functioning entities, or subsystem. These include transportation systems, communication systems, energy systems, sewer systems.
- **Urban Spatial Structure.** Results from the combination of the urban form and the urban interaction with a set of organizational rules to create a city system.

Criteria for measuring and comparing urban structure

Level	Criteria	Description & Examples
Context	Timing	Time & stage of development
	Functional character	Dominant mode & type of production (service center, mining town)
	External environment	Socio-economic & cultural environment
	Relative location	Position within larger metropolitan area (bedroom community)
Macro-form	Scale	Size: in area, population, income, etc.
	Shape	Geo. shape; multi-nucleated centers, coastal
	Site & Topo. base	Physical landscape
	Transport network	Type & config. Of transport networks (rail, bus, highway)
Internal form & function	Density	Shape of density gradient
	Homogeneity	Degree of mixing of uses
	Concentricity	Degree to which uses & activities are organized zonally
	Sectorality	Degree to which uses & activities are organized in sectors
	Connectivity	Degree to which sub-areas are connected by transportation networks, social interactions
	Conformity	Correspondence between function and form
	Substitutability	Degree to which urban form can evolve from one use to another
Organization & Behavior	Organizational principles	Underlying mechanism of spatial sorting and integration
	Cybernetic properties	Sensitivity of form to change
	Regulatory mechanisms	Strength of zoning, building controls, financial constraints
	Goal orientation	Degree to which urban structure evolves toward a priori objectives

Concepts of:

Accessibility: the basic concept underlying the relationship between land use and transportation is accessibility.

- Accessibility increases when movement becomes less costly.
- Personal accessibility is usually measured by a weighted sum of the available opportunities (activity sites), where the weight is some inverse function of the cost of getting to each opportunity (and may also be a product of the value of each opportunity, if one is bundling opportunities of different types).

$$A_{k,i} = \Sigma\ O_{k,j}\ D^{-b}{}_{j,i}$$

Where:

$A_{k,i}$ = accessibility of attraction *k* at location *i*
$O_{k,j}$ = # of opportunities *k* at location *j*
$D_{j,i}$ = cost of travel between *i* and *j*
b = some constant (usually > 1, often 2)

Location Theory: drawing on agricultural land economics: assume there is one market located at the center of a featureless field. The equilibrium value of the land (bid rent, the most that one would pay for it), L:

0 = net revenue from crop production - cost of getting crop to market – Bid Rent

Thus Bid Rent and Transportation Costs share the net revenue, so

$$0 = E\,(p - a) - E\,f\,D - L$$

Solving for Bid rent L,

$$L = E\,(p - a) - E\,f\,D$$

Where:

E = yield per unit land
p = market price per unit of commodity at site
a = production $$ per unit of commodity at site
f = transportation $$ per unit yield, per unit distance to market from site
D = distance to market

If we now consider different uses (crops) having different separation costs then you can see how different land uses naturally evolved around a center market.

Land Values: the above suggests a linear function if all bidders have the same net revenue (value):

$LV_i = \boldsymbol{a} - \boldsymbol{b}\ D_i$

Where: LV_i is the land value at location *i (say "zone i")*

a and ***b*** are constants and D_i is distance from CBD to the centroid of *zone i*

However, there are finite number of different users having different "net revenue" (value) potential. The high valued ones will bid up the rents where transportation is the cheapest, leaving the higher transportation cost areas to the lower valued uses. Thus, land values don't become negative, but decay to zero at large distance in an inverse power relationship where the empirical value of the inverse power, d, may have a value around 2 (inverse square)

$$LV_i = \boldsymbol{a}\, D_i^{-\boldsymbol{d}}$$

Or include more terms:

$$LV_i = \boldsymbol{a} + \boldsymbol{b}_1 C_i^{-\boldsymbol{c}} + \boldsymbol{b}_2 M_i^{-\boldsymbol{m}} + \boldsymbol{b}_3 E_i^{-\boldsymbol{e}} + \boldsymbol{b}_4 S_i^{-\boldsymbol{s}}$$

Where: C_i is distance to employment center, M_i is distance to recreation center, etc.

Instead of using distance, we can consider "accessibility" to various attractions as the measure for attractiveness of land (Hansen's Accessibility Model) . Thus, if H_i is the amount of vacant land (unused development rights) at location *i* , then the development potential could be expressed as:

$$D_i = A_i H_i$$

Then the population growth would be distributed to zones based on the relative development potential $A_iH_i / \Sigma_i(A_iH_i)$. If the total growth in population for a future year is G_t , the population to zone i could be expected to be

$$G_i = G_t\ D_i / \Sigma_i (D_i) = G_t\ A_iH_i / \Sigma_i(A_iH_i)$$

Travel Demand Forecasting (Aggregate Approach):

Quantifies the amount of travel on the transportation system

"Traditional 4-Step Process in the formal transportation planning process

-1. Formulate goals and objectives, collect data

0. Urban Activity:
   - Establish land-use & socio-economic data for target year.

1. **Trip Generation**
2. **Trip Distribution**
3. **Modal Split**
4. **Network Assignment**

5. Transportation Supply (Network Description)

Travel Demand Forecasting (Disaggregate Approach):

1. Focus on individual travelers
2. Generate individuals with individual characteristics
   a. Age, gender, prominent daily activity (work, school, stay home), daily secondary activity and daily travel tour behavior
      i. Rely either on census plus incremental forecasts of changes
   b. Gather data on individual trip attractions (work, school, shop, dine, recreate, other) plus incremental forecasts of changes.
   c. Assign specific attractions to each stop of each daily tour to each individual.
   d. Assign specific departure time to each trip segment.

Urban Activity:

1. Disaggregate area into Traffic Assignment Zones (TAZ); assign geographic tags to each zone.
2. For each TAZ provide:
   - Total land area, then broken down to area devoted to each land-use/zoning classification:
     - Residential
     - Commercial
     - Retail
     - Educational
     - Recreational
     - Open space
3. Each classification can then be broken down into it's trip generation characteristics. For example: Type of dwelling units and density (see table 11-3), income, floor space, type

Trip Generation:

- Two parts
  - Trip Production (Home-based trips, HB, Non-home-based)
  - Trip Attractions (Home-based work, Home-based shop, Home-based school, Home-based other, Non-home-based)
- Two tools: Multiple regression (trip productions); cross classification (trip attraction)
  - Try to find relationships used in your reference city. For example LincolnTravelDemandModel SCAG_Modelling TCRP B-15 Characteristics of Urban Travel see especially: Overall Trip Rates