Conventional Transportation Planning Models: Review and Prospects for Alternatives

To be presented at the Session
In Honor of Professor David E. Boyce

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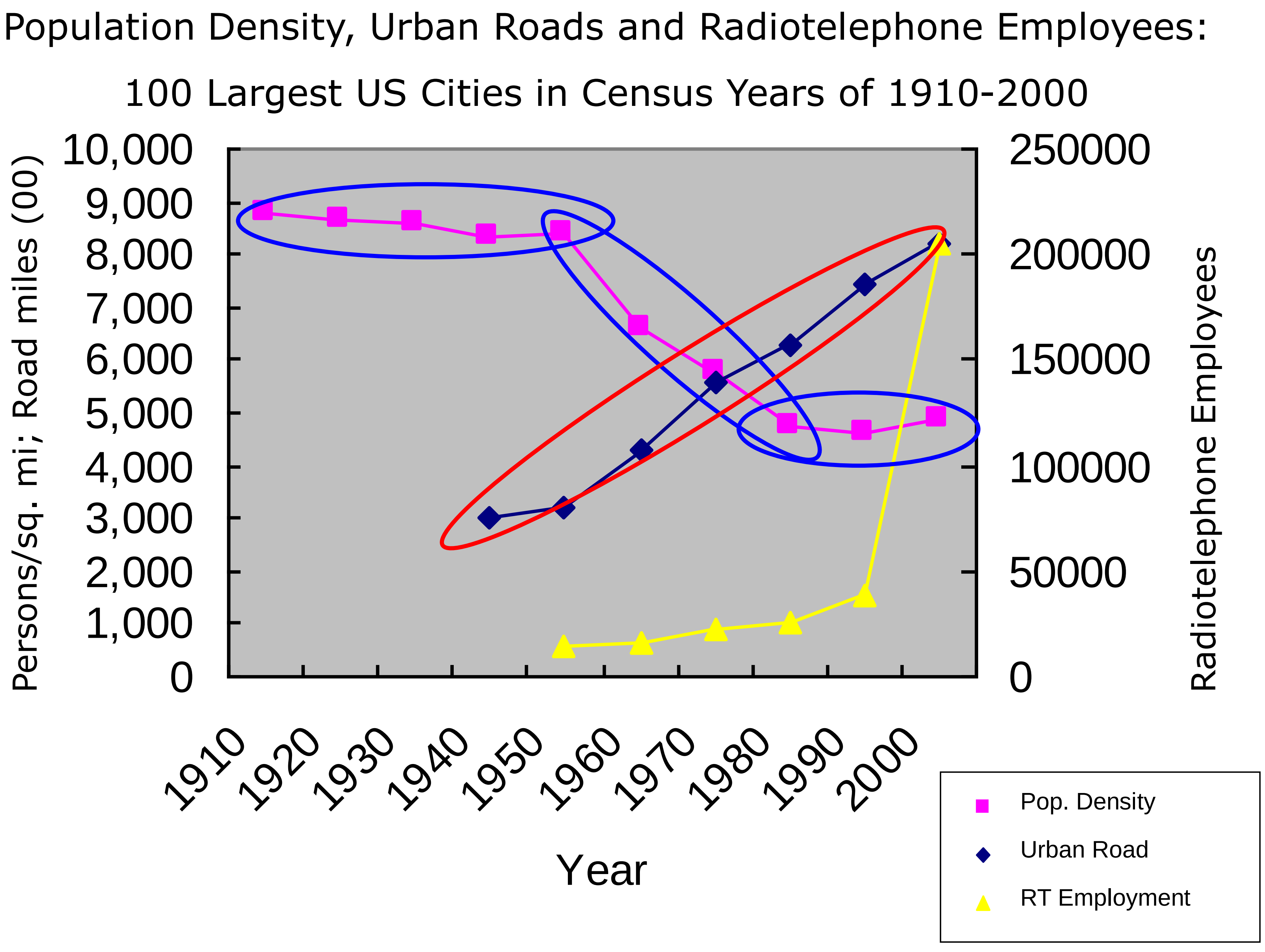
Purpose

- To review the Utility of Conventional Transportation Planning Models
  - Congestion Mitigated?
- To analyze the Implication of the Conventional Transportation Planning Process
  - Automobile Biased Approaches
  - Higher Benefits to Higher Income Travelers
- To shed light on Alternatives.
  - System Optimum Urban Activity Models
    - Bases for Long-Range Plan and Zoning
  - Cost-Effectiveness Analysis toward the System Optimum Plan


Population Density, Urban Roads and Radiotelephone Employees:
100 Largest US Cities in Census Years of 1910-2000
Persons/sq. mi; Road miles (00)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Radiotelephone Employees
250000
200000
150000
100000
50000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
Pop. Density
Urban Road
RT Employment

Granger Causality Test

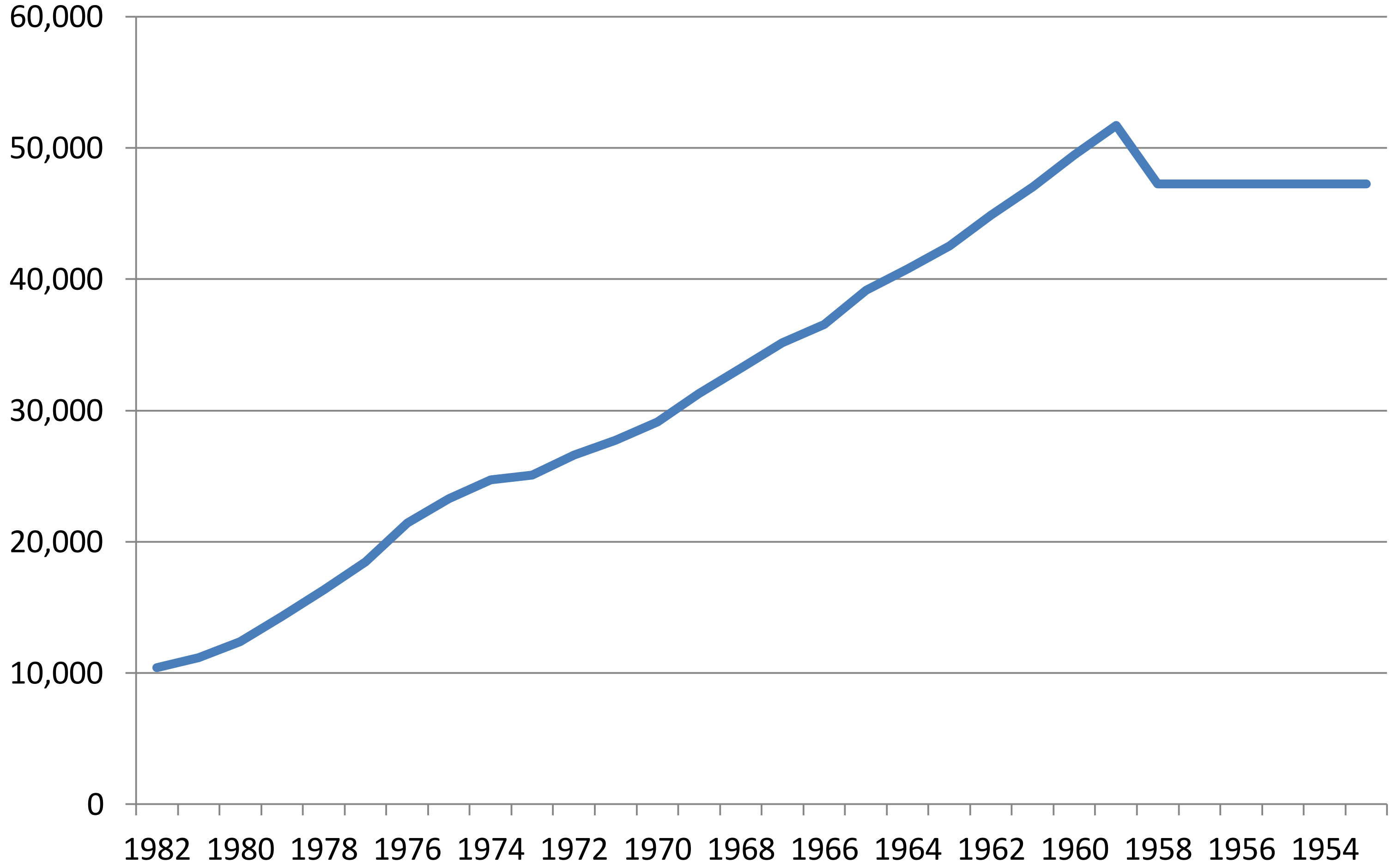
Cause	Effect							
Variables	1910-2000		1910-1950		1950-1980		1980-2000	
	POP	DEN[1]	POP	DEN	POP	DEN	POP	DEN
Urban Land Area	*** (+)	** (-)	*** (+)	*** (-)	* (+)	* (-)	** (+)	*** (-)
Unit Cost ($/sq.foot)	*** (-)	*** (-)	*** (-)	*** (-)	N	N	** (-)	*** (+)
Urban Road (mile)	*** (+)	N	*** (+)	N	*** (+)	*** (-)	N	*** (-)
All Road (mile)	N	* (-)	N	* (-)	N	** (-)	N	*** (-)
Car Registration	*** (+)	* (-)	*** (+)	* (-)	* (+)	* (-)	N	N
Rail (mile)	N	N	* (-)	N	* (-)	* (+)	N	*** (-)
Transit System (mile)	–	–	–	–	–	–	*** (+)	*** (+)

Tschangho John Kim, Matthew Claus, Joseph S. Rank and Yu Xiao, 2009 "Technology and Cities: Processes of Technology-Land Substitution in the 20th Century", <u>Journal of Urban Technology,</u> 16,1:63-88.

Congestion Mitigated?

file://localhost/Users/tjohnkim/Documents/conference-travel/2013/13-1113NARSA/Boyce/Amazing Traffic Without Traffic Light.mp4

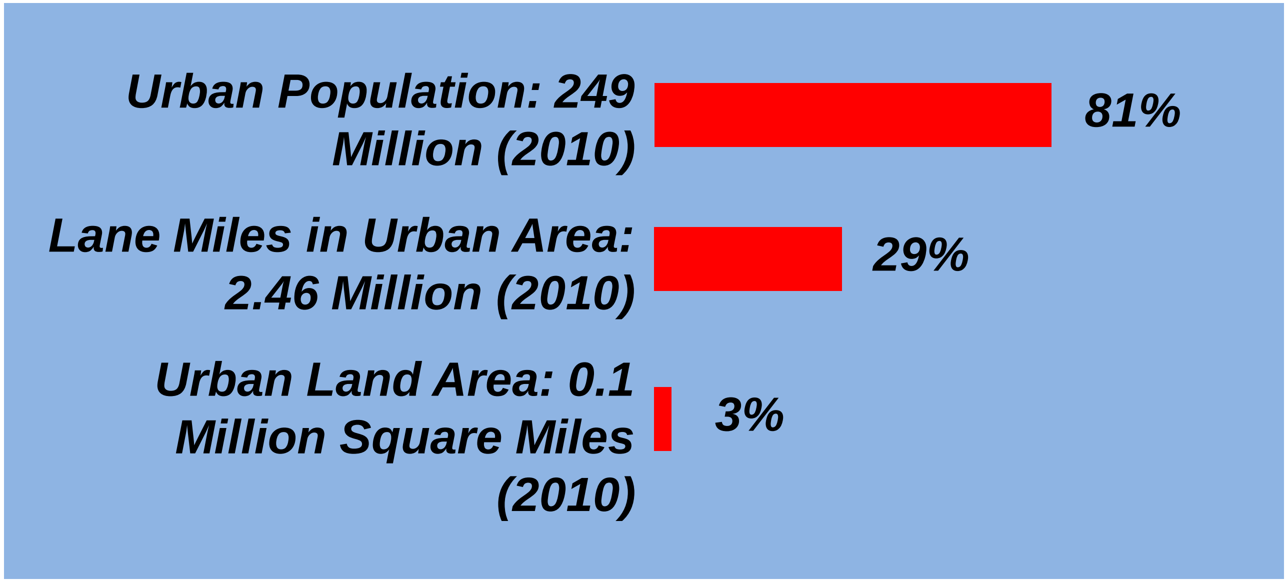
Congestion in 101 Largest Cities in USA: 1982-2011
(Total Delays in 1,000 Person Hours)



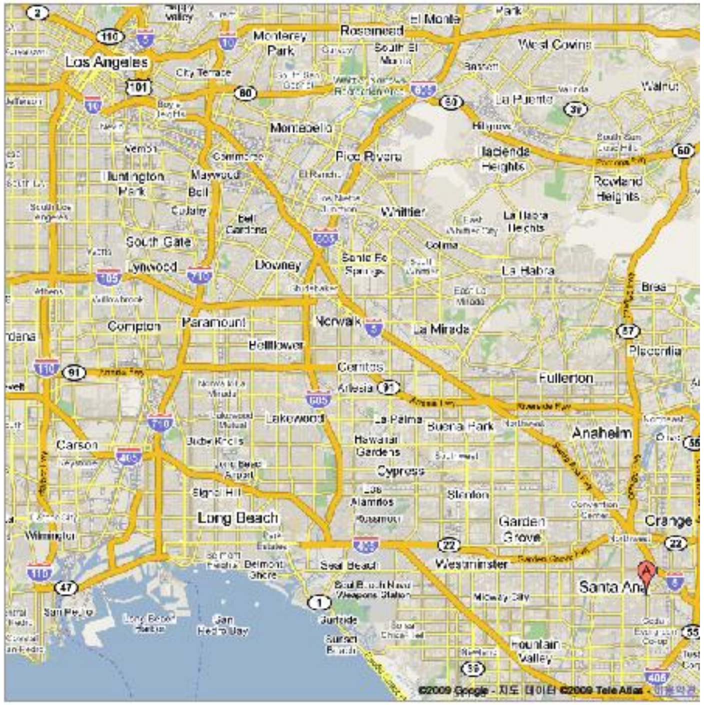
Source: http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/ums/congestion-data/101-combined-avg.pdf

Construct more Roads and Highways?

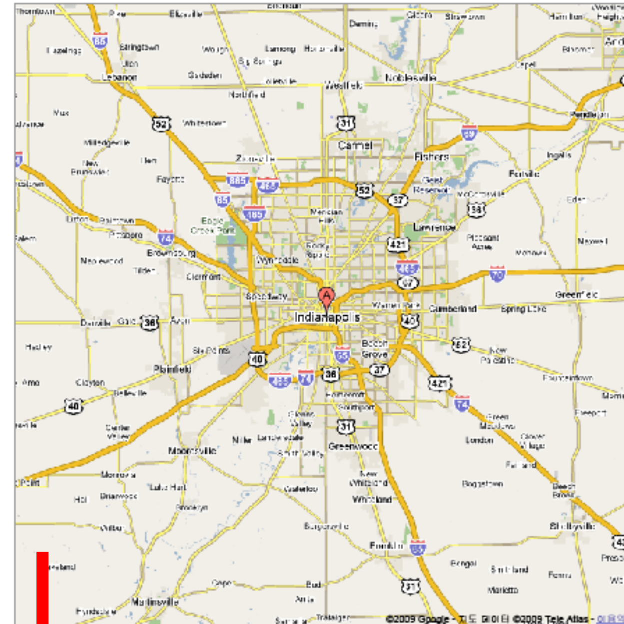
About 80% of total population in US live in urbanized areas occupying only about 3% of total land where almost 30% of total lane miles of roads exist.

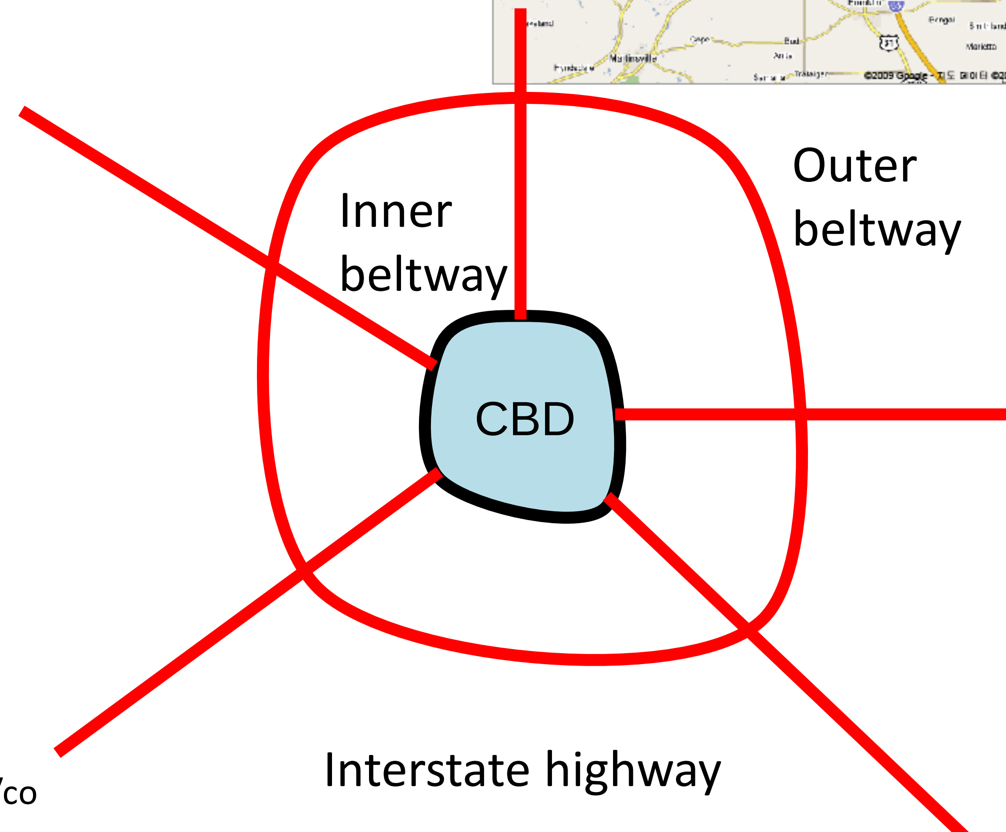


Source: http://www.census.gov/geo/reference/ua/urban-rural-2010.html , http://www.bts.gov/publications/national_transportation_statistics/, and http://www.newgeography.com/content/002747-new-us-urban-area-data-released



Are Building More Highways Solutions to overcome Congestion in Megacities?





Roads and parking facilities are usually the single largest category of impervious surface, occupying between 30 to 60% of the total surface*.

*http://people.hofstra.edu/geotrans/eng/ch6en/conc6en/ch6c1en.html

Evolution of Transportation Policy: USA

Period	Main Issues	Federal Policy Focus
1950s	National Defense	Defense Highways (Federal-Aid Highway Act of 1956)
1960s	Fiscal Crisis, Urban Exodus Suburbanization	Urban Mass Transportation Act of 1964 ($ 375 m) Highway Oriented
1970s	Oil Crisis, Back to the City	Transit Oriented (Urban Mass Transportation Act of 1970, added $ 12 b)
1980s	Environmental Concerns, Fiscal Conservatism	TSM, Public-Private Partnership
1990s	Global Warming	CAAA 1990, ISTEA 1991, TEA21 1998
2000s	Alternative Energy Sources Terrorism	Railroad Revitalized, SAFETEA-LU 2005, ARRA 2009
2010s	**Livability** **Sustainability** **Economic Recovery**	Moving Ahead for Progress in the 21st Century Act (MAP-21) **?**

Performance of Typical Transportation Planning Models

Boyce, D., 2002, Is the sequential travel forecasting procedure counterproductive? *ASCE Journal of Urban Planning and Development* 128, 169-183.

- The sequential travel forecasting procedure is widely accepted with- out question by transportation planners, yet its origins are obscure, its effects on practice and research may well be negative, and by focusing attention on indi- vidual steps, it tends to impede overall progress in improving forecasting methods.

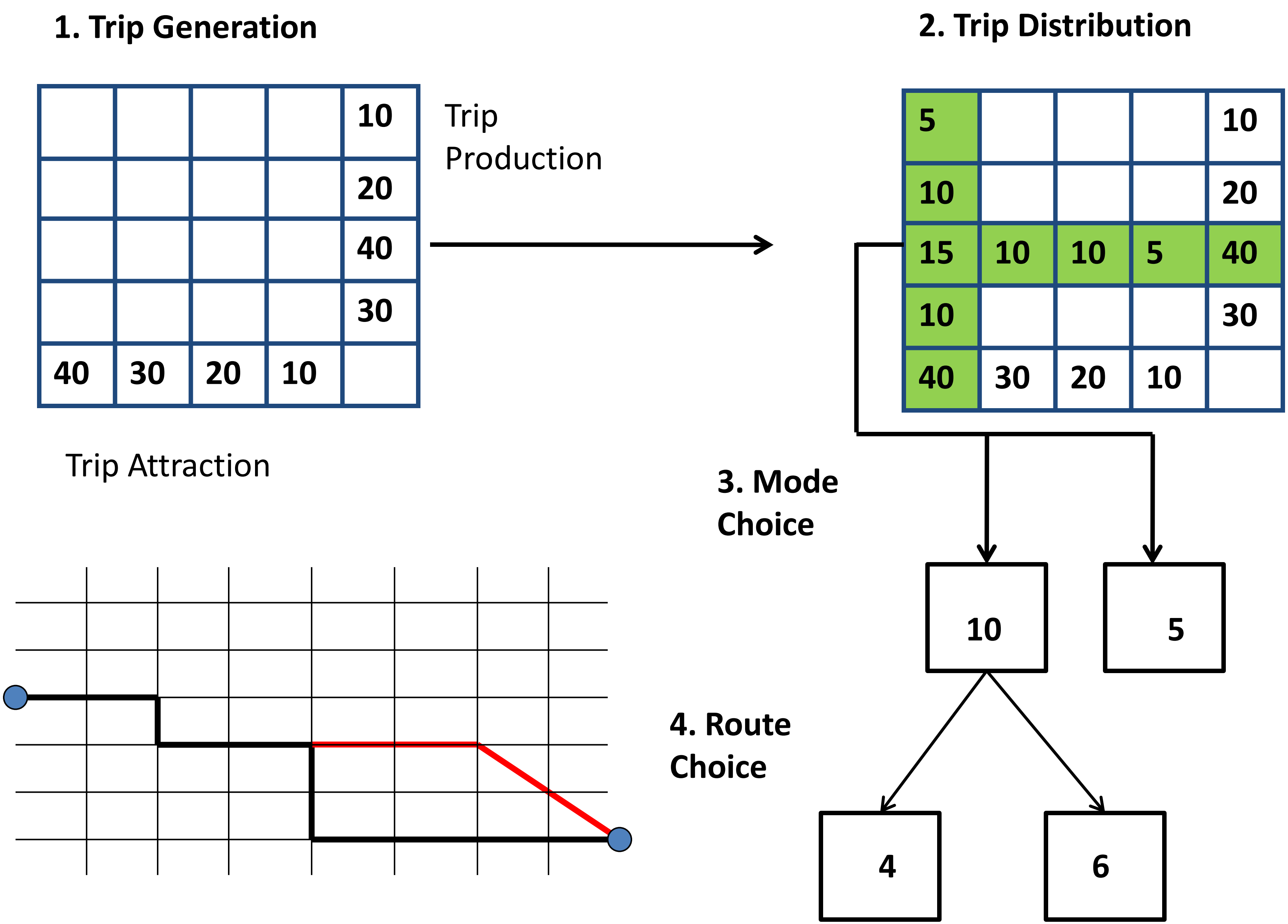
- The experience of the 50-year history of urban travel forecasting strongly indicates that meaningful advances over the sequential procedure require a *revo- lutionary* approach, not the evolutionary, piecemeal improvements to individual steps introduced in the past.

Typical four-step Transportation Planning Models

- Assume that travelers choose the alternative that gives them the highest utility, measured by generalized costs.
- Generalized cost is a linear sum of monetary and time elements (walking, waiting, transfer and parking charges).

$$G = p + g(t)$$

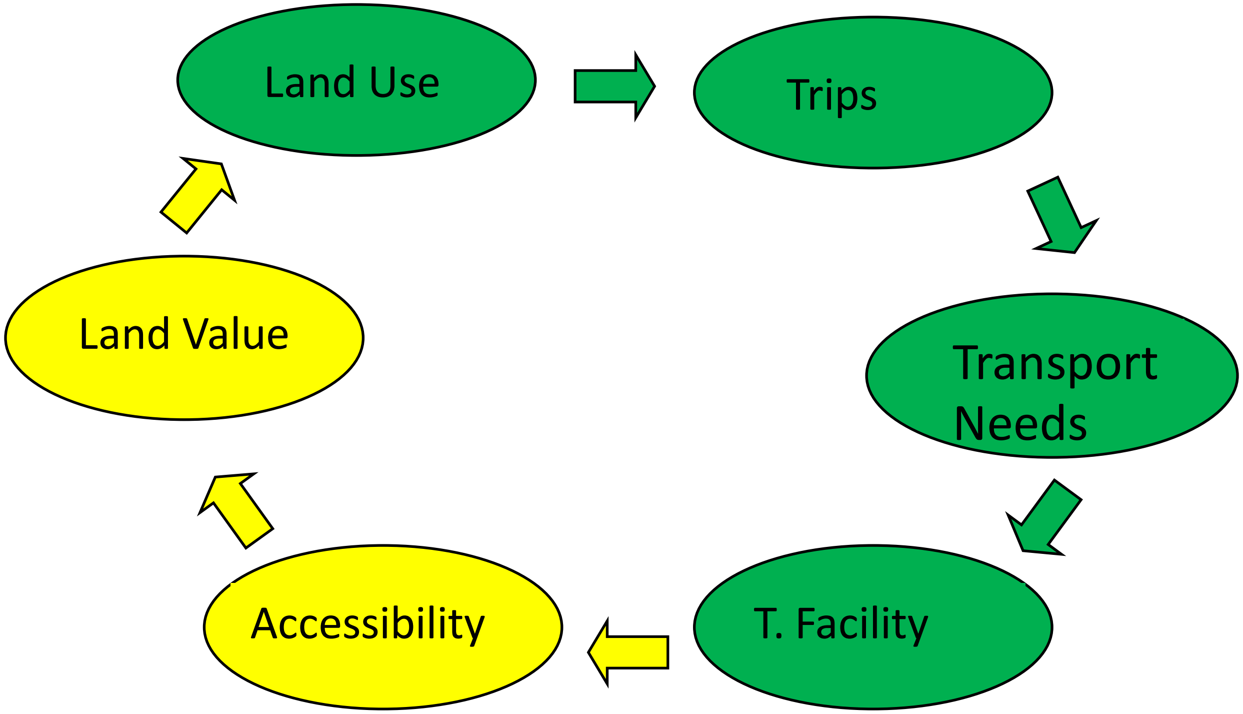
  - *p* refers to the monetary (out-of-pocket) costs of the journey.
  - *g(t)* refers to the non-monetary (time) costs of an uncongested journey.
- Since travel time savings tend to be the largest element of benefits, the alternative that gives the largest travel time saving is probably going to give the largest benefit.



Typical Modeling Processes for Transportation Planning

Conventional Transportation Planning Models: Missing Links

Recommend transportation facilities that meet demand originating from areas wherever and whenever developers choose to build, frequently neglecting feedback impacts on Land Use.



Transportation investment decision by the cost-benefit analysis

- The costs: land acquisition, construction, and maintenance cost.
  - Travel time and only the out-of-pocket cost (gasoline, toll, parking fee)
  - Total social costs including congestion and cleaning the polluted air not considered.
  - For Transit: The fare plus the door-to-door travel time includes transfer, walking, and waiting time.
- The benefits: savings in travel time and maintenance costs, accident reductions, and environmental benefits.

Inelasticity of Travel Cost over Distance

- People usually do not take the reduction in travel time as an opportunity to spend the time saved in other activities
  - The inelasticity of travel cost with respect to the commuting distance.
- They tend to travel further, sometimes as part of a long term decision about where to live.
  - This has led to much greater benefits to those with high incomes than those with low incomes and has contributed to the decentralization of urban areas which makes it difficult to encourage people to switch from the car to alternative modes (Mackett, 2010).

Biased Results Favoring Status-Quo Trip Patterns

Method for forecasting travel demand to replicate the observed reality by using:

- Entropy maximization as a constraint or as a part of objective function (Wilson and Senior, 1974) for finding the minimum total generalized costs for all links and routes in the system favor status-quo trip patterns.

$$C = \sum_{ij} T_{ij}\, c_{ij}$$

As a constraint

$$S = -\sum_{ij} T_{ij} \log T_{ij}$$

As a part of an objective function

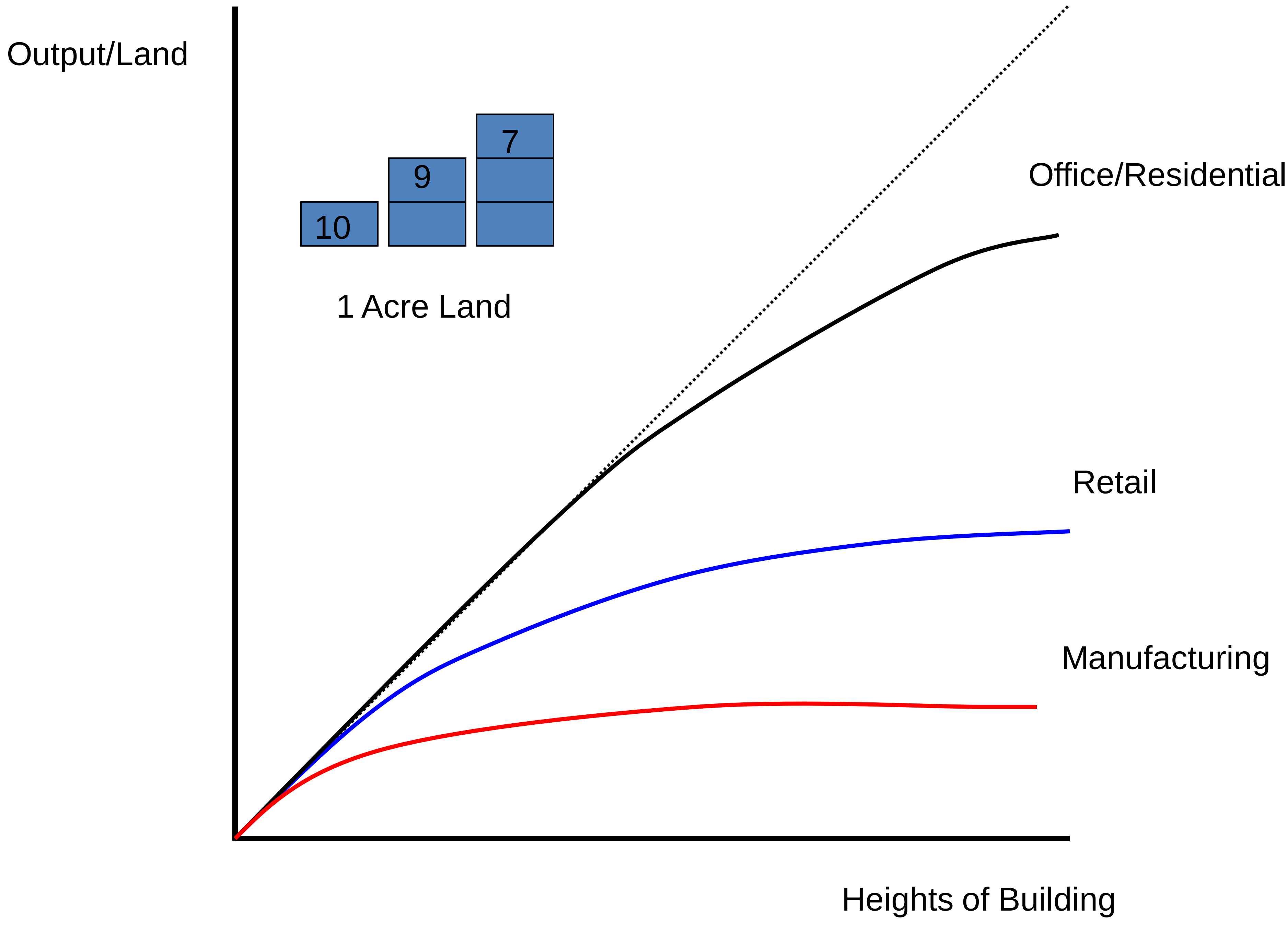
Typical Process for Investment Decision in Transport Infrastructure

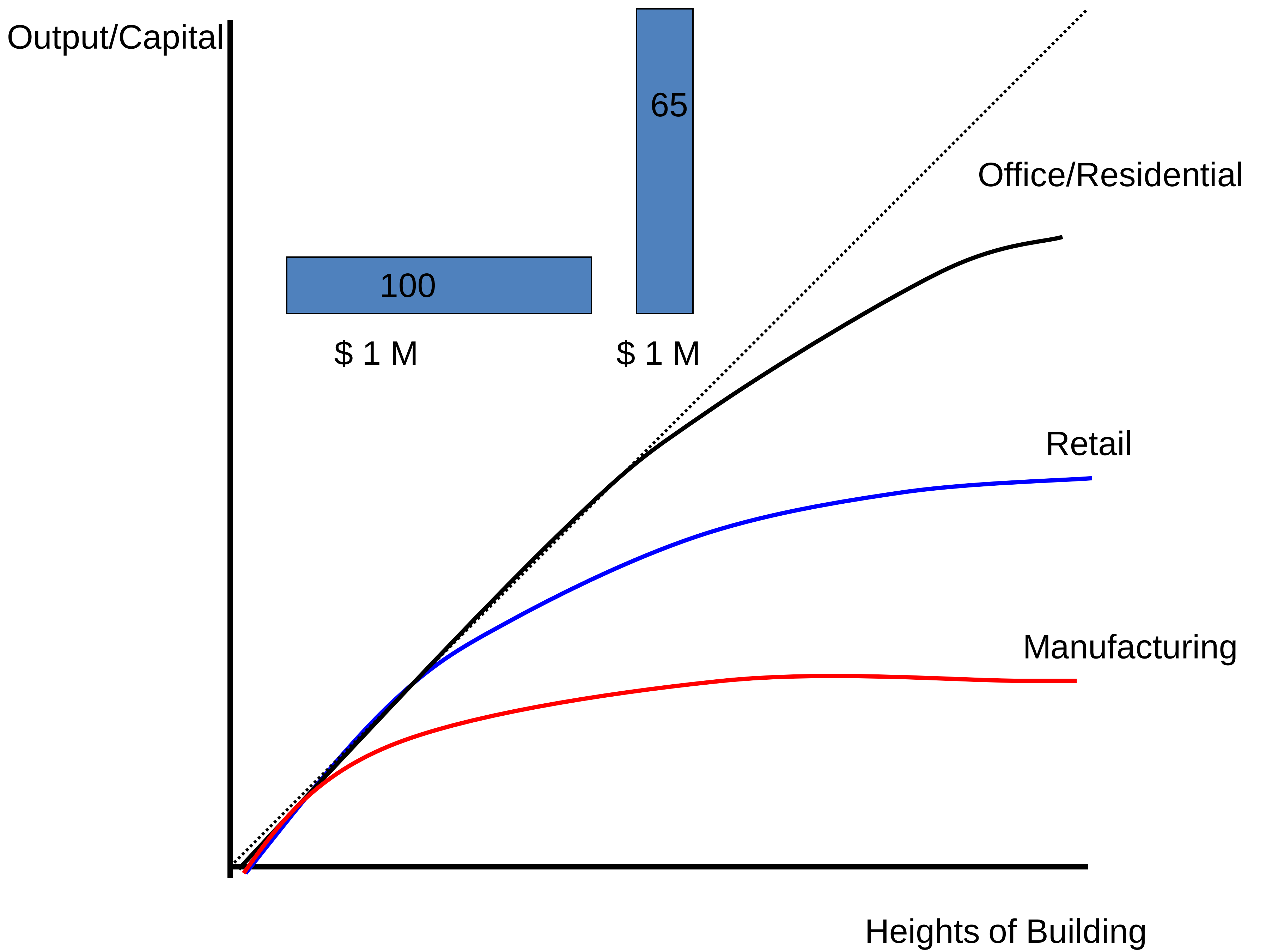
- Higher benefits for projects resulting in enhancing speed and reducing travel time, particularly that of high income travelers.
- Automobiles are usually perceived cheaper and preferable due to the door-to-door travel time is usually faster than transit.
- The conventional transportation planning model typically results in recommending increase of highway capacities to connect the origin and destination, further affecting the use of automobiles.
- No policy variable affecting the shape of urban form and structure in it nor there is any feed-back how the four-step process results would affect land use decisions.

Toward Developing Alternative Transportation Planning Models

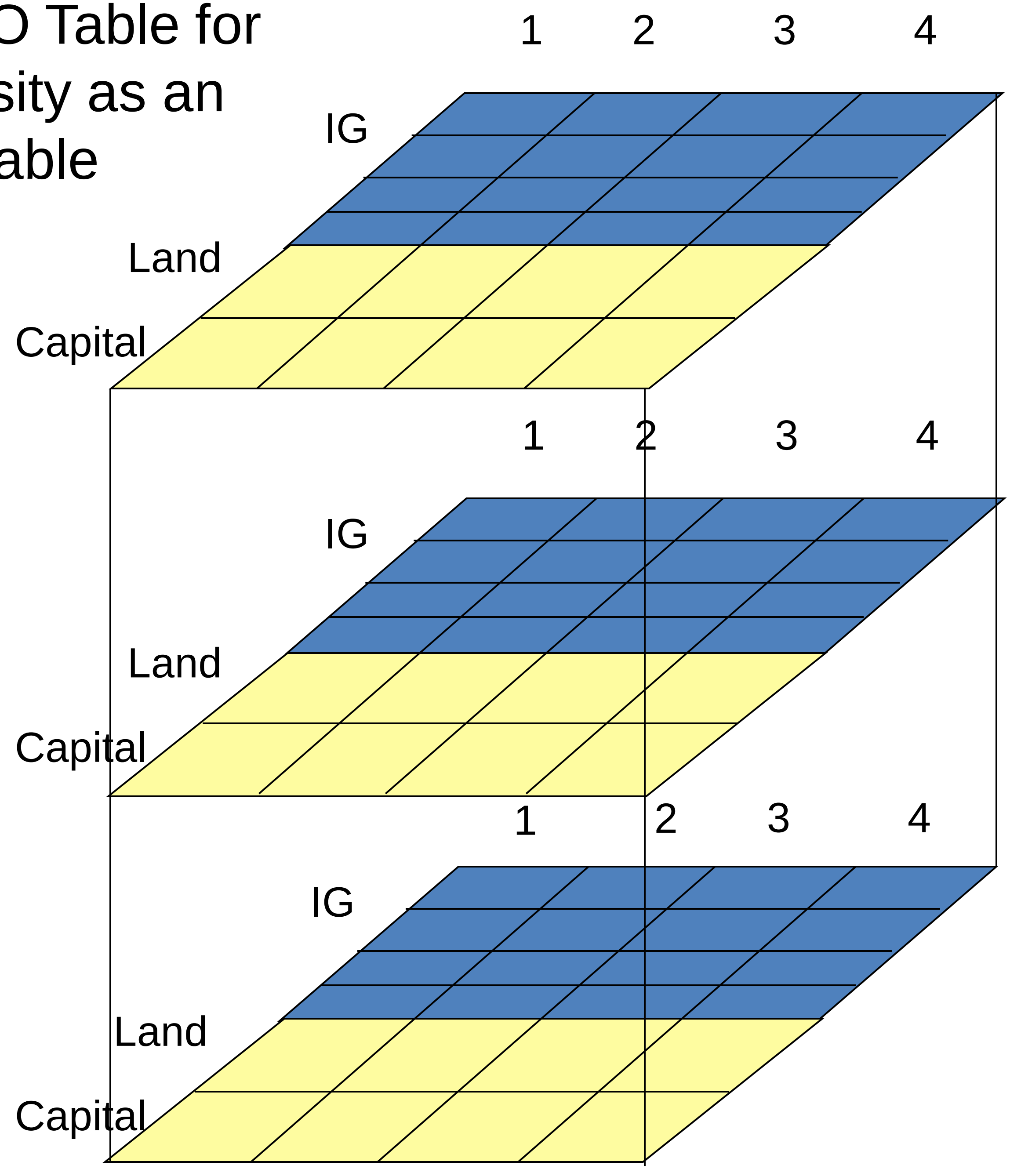
Early Contributors

- Robert B. Mitchell and Chester Rapkin:
  - *Urban Traffic-A Function of Land Use*, 1954, New York 27, Columbia University Press, 1954. xviii, 226 pp.
- Edwin Mills
  - "An Aggregative Model of Resource Allocation in a Metropolitan Area." American Economic Review, Vol. LVII, No. 2, May 1967, pp. 197-210. Reprinted in Urban Analysis (Alfred Page and Warren Seyfried, Editors). Glenview: Scott, Foresman and Company, 1970.
  - "Planning and Market Processes in Urban Models," Public and Urban Economics: Essays in Honor of William S. Vickrey (Ronald Grieson, Editor). Lexington: D.C. Heath and Company, 1976, pp. 313-330.
  - "Markets and Efficient Resource Allocation in Urban Areas," Swedish Journal of Economics, Vol. 74, No. 1, March 1972, pp. 100-113. Reprinted in The Automobile. (Lars Lundquist, Kenneth Button and Peter Nijkamp, Editors). Northhampton. MA: Edward Elgar, 2003.


Output/Land
7
9
10
1 Acre Land
Office/Residential
Retail
Manufacturing
Heights of Building


Output/Capital
100
65
$ 1 M
$ 1 M
Office/Residential
Retail
Manufacturing
Heights of Building

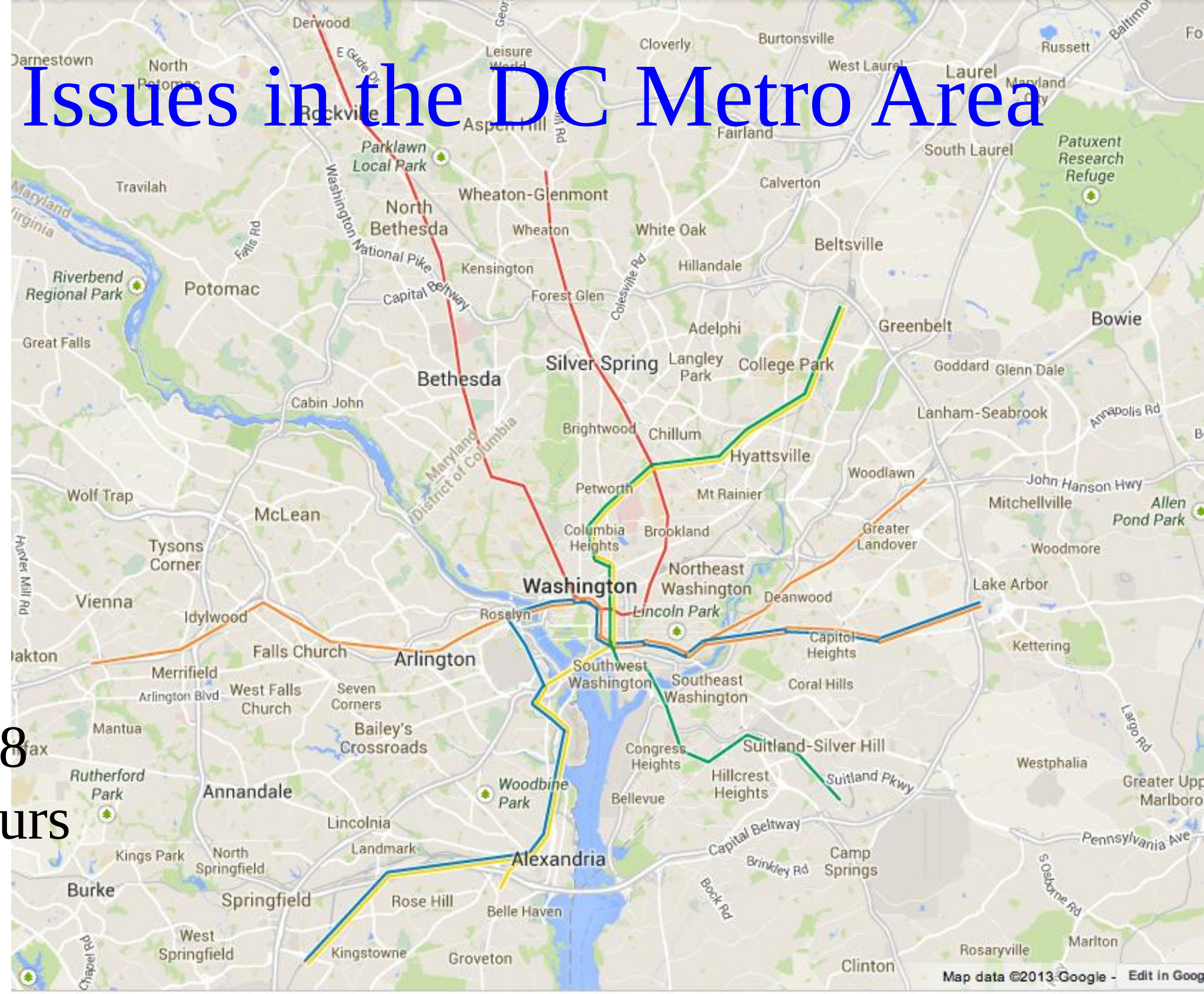
Conceptual 3D I-O Table for Determining Density as an Endogenous Variable



Transportation Issues in the DC Metro Area

TTI' 2012 report: the Washington, D.C. Metropolitan Area is the most congested urban area in the nation.

Yearly Delay per Auto Commuter increased 18 hours in 1982 to 67 hours in 2011.



In 2000, only 9.3 % MD and only 7.6 %VA commuters use transit to get to work in DC.

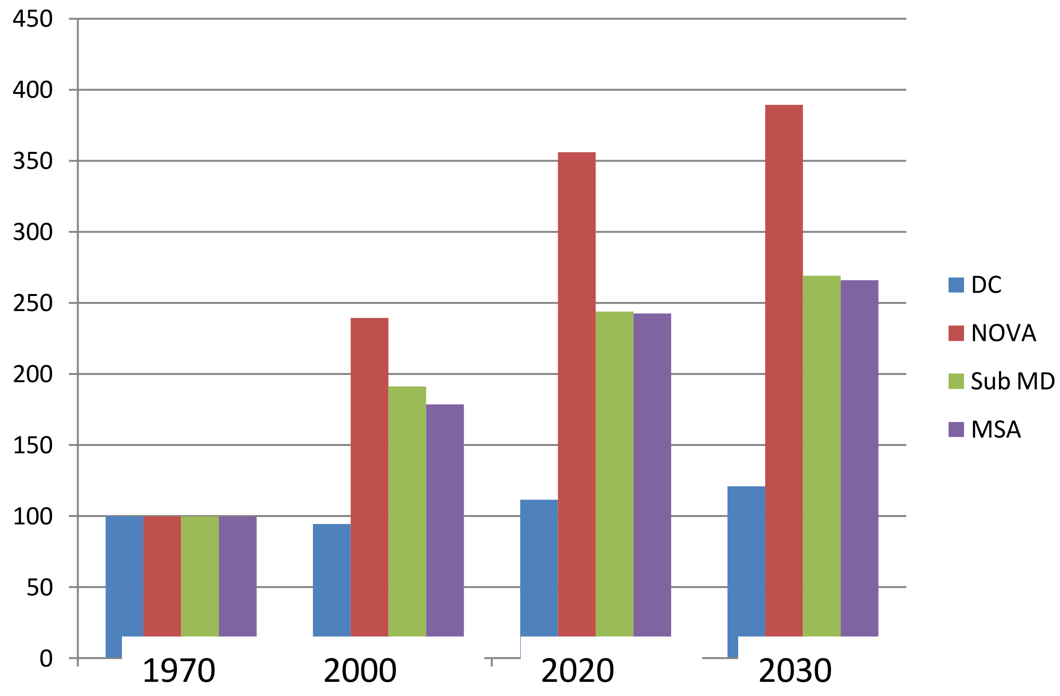
http://mobility.tamu.edu/ums/congestion_data/national_congestion_tables.stm

NOVA's Socio-Economic Setting

Households (Thousands)

	1970	2000	2020	2030
District of Columbia	262.5 (100)	248.3 (94.6)	292.9 (111.6)	317.7 (121.0)
NOVA	297.3 (100)	711.6 (239.4)	1,057.7 (355.8)	1,157.9 (389.5)
Suburban Maryland	392.2 (100)	750.4 (191.3)	956.9 (244.0)	1,055.7 (269.2)
MSA Regional Total	952.0 (100)	1,701.3 (178.7)	2,307.5 (242.4)	2,531.3 (265.9)

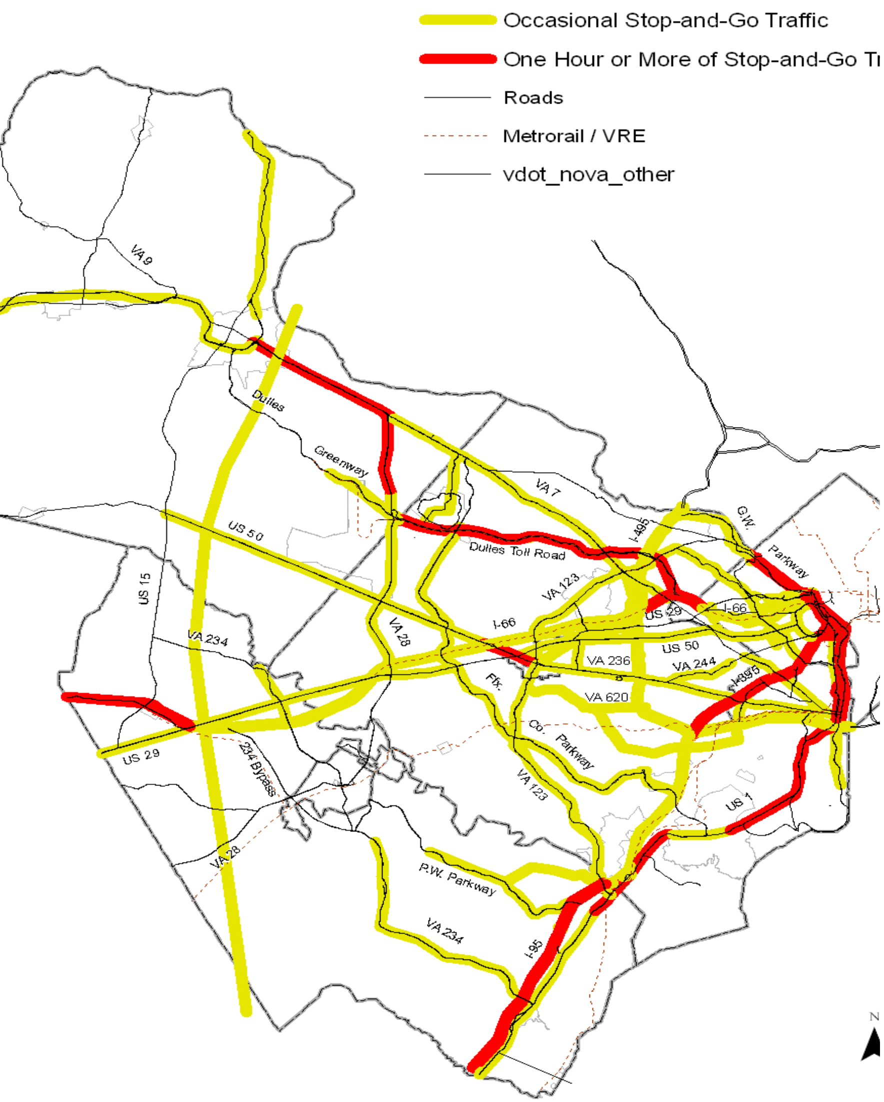
Households Projection (%)



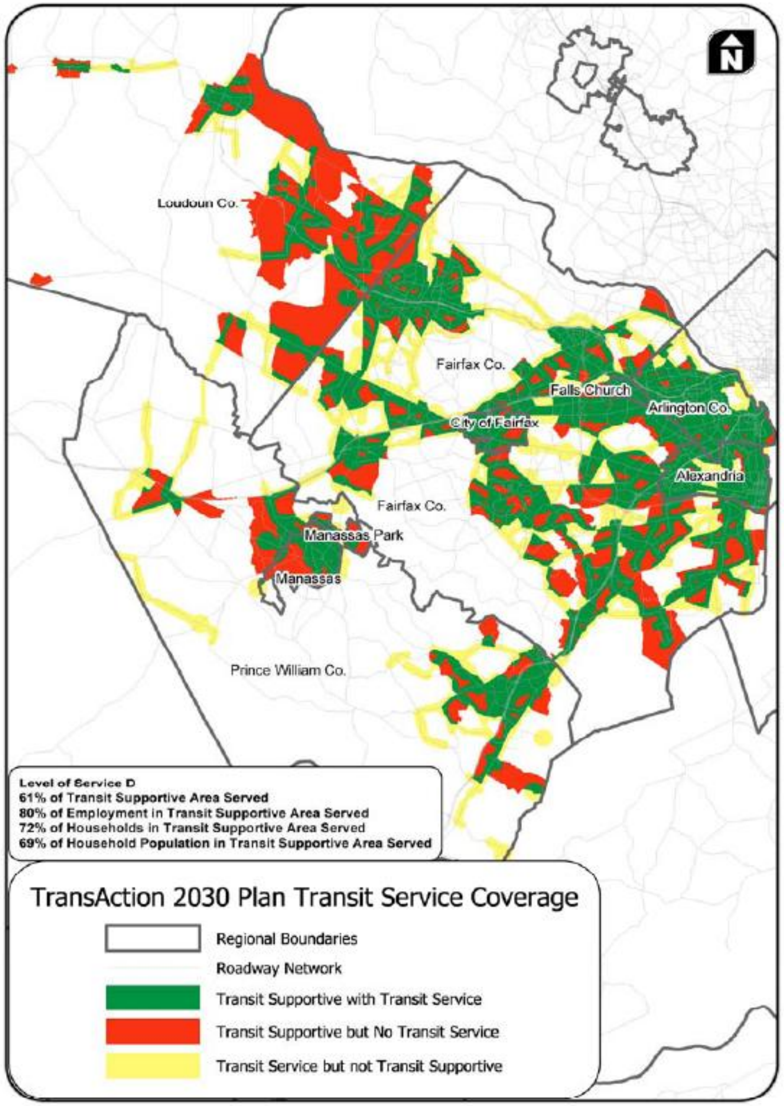
http://www.nvta.org/content.asp?contentid=1369

TransAction 2030

Highway System 2030



Land Use 2030



An Alternative Urban Systems Model: Integrated 3D Land Use-Transportation Model

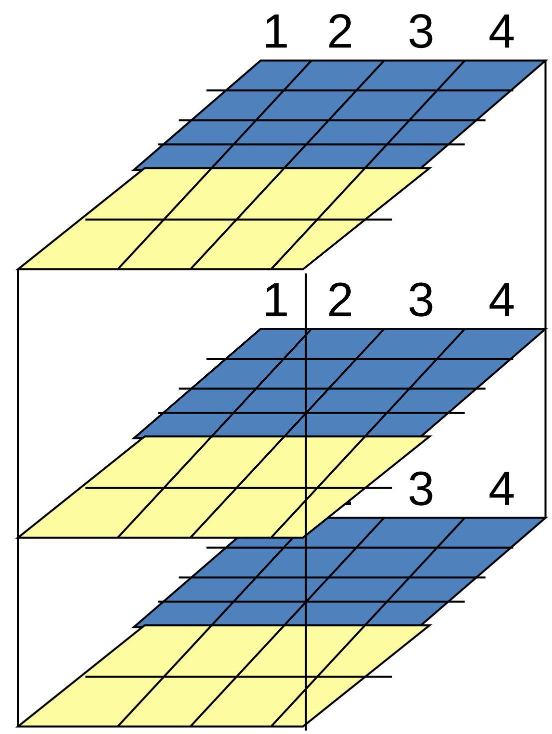
$$A = \lfloor a_{rqs} \rfloor$$

$$U : \min_{x} \quad Z(x) = \sum_{a} \int_{0}^{f_a} d_a(x)dx + \partial E$$

$$s.t. \quad X = AX + E$$

$$E_c + E_s \geq E$$

$$X \geq 0$$



Kim, T.J. 1986, "Modeling the Density Variations of Urban Land Uses with Transportation Network Congestion," Journal of Urban Economics, 1986, 19:264-276.

Normative Model for Optimum Urban System