Time-Space Convergence and Changing Accessibility Patterns for Cities and Regions

Donald G. Janelle

Center for Spatially Integrated Social Science

University of California, Santa Barbara

UCSB Geography Colloquium

25 October 2001

Question: How do Human Settlement Systems Evolve?

Inspiration:

- Walter Christaller's Central Place Theory
- James Blaut– "Structures of the real world are simply slow processes of long duration" 1961
  - A time-space view of reality
- P.W. Bridgman's *A Sophisticates Primer of Relativity* 1963 Locations, Velocities, Directions

Premises:

- Things are where they are having moved there
- Human geography is, in significant part, a product of the effort required to overcome distance
  - » time-distance
  - » cost-distance

Los Angeles ⟺ Santa Barbara

500 minutes apart in 1901
100 minutes apart in 2001

Time-Space Convergence: 400 minutes
Average Rate of Convergence: 4 minutes per year
"velocity"

Problems of Travel Time as a Metric of Space:

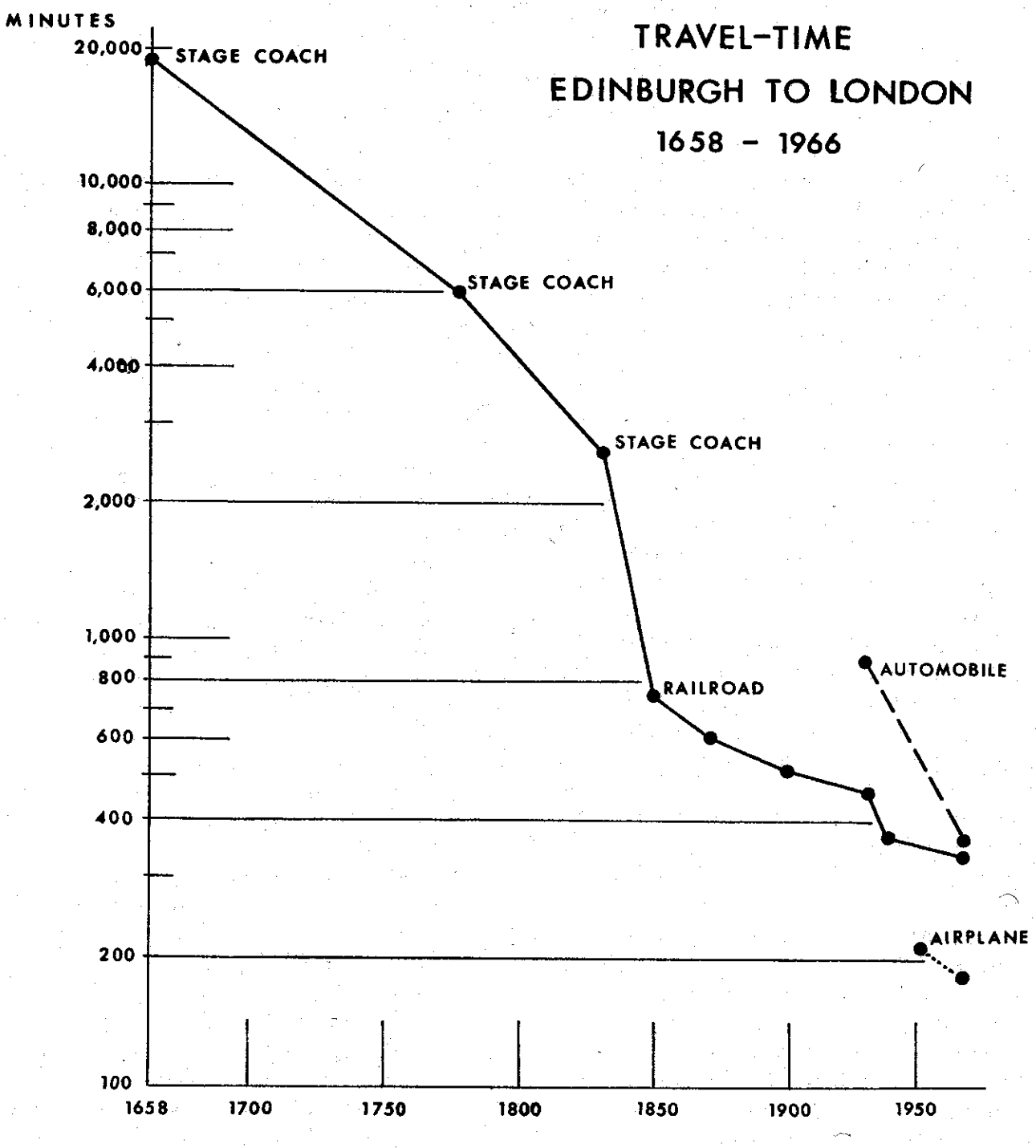
- Variability in convergence and divergence among places
- Time-space inversions
- Asymmetric relationships between places
- Simultaneity of different convergence / divergence levels

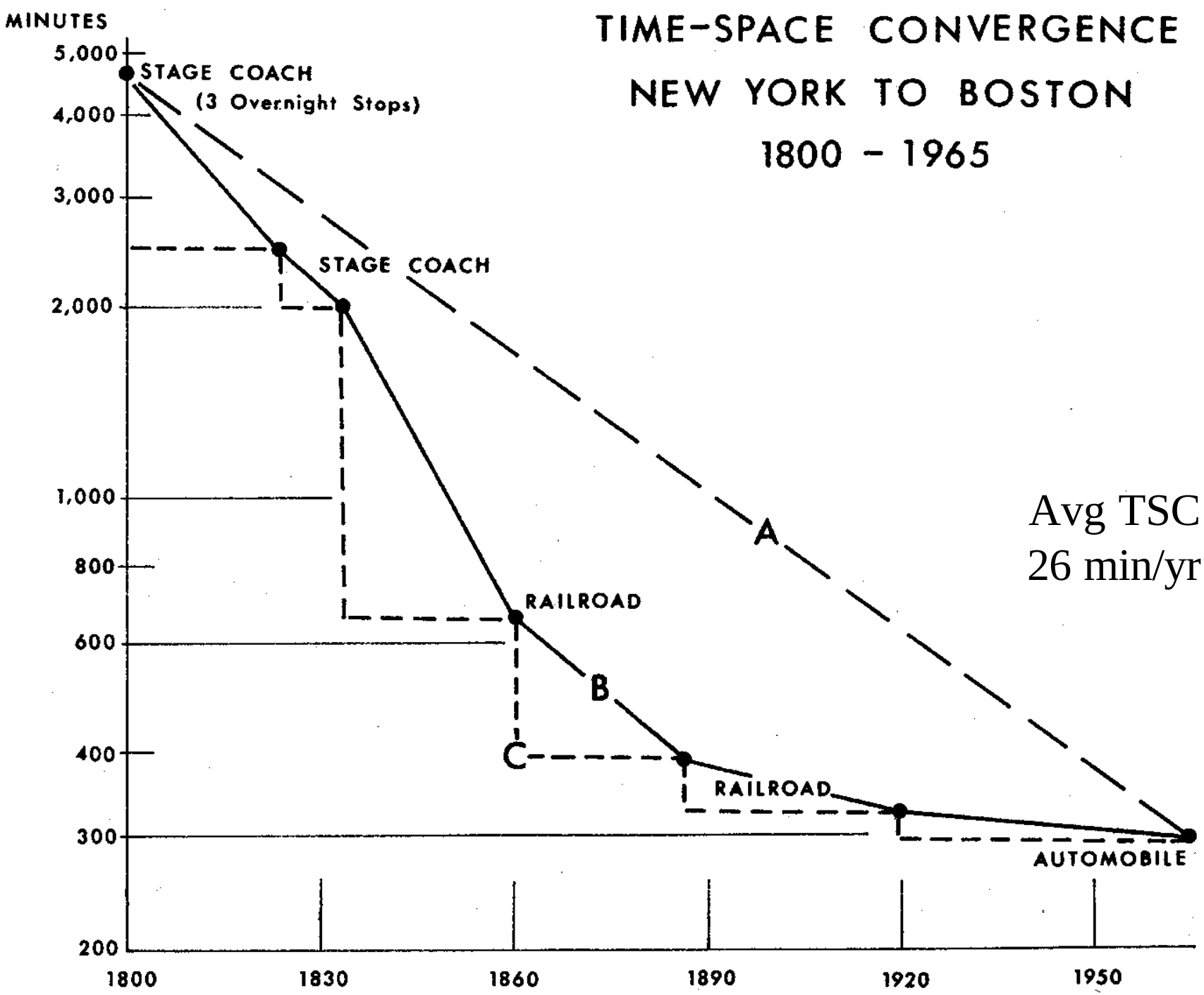
Average Time-Space Convergence

Land
60 min/yr (1658-1966)

Land -Air
29 min/yr (1776-1966)

Railroad
3.4 min/yr (1850-1966)




TIME-SPACE CONVERGENCE
NEW YORK TO BOSTON
1800 - 1965
MINUTES
5,000
4,000
3,000
2,000
1,000
800
600
400
300
200
STAGE COACH
(3 Overnight Stops)
STAGE COACH
RAILROAD
RAILROAD
AUTOMOBILE
A
B
C
1800
1830
1860
1890
1920
1950
Avg TSC
26 min/yr

Presentation Agenda

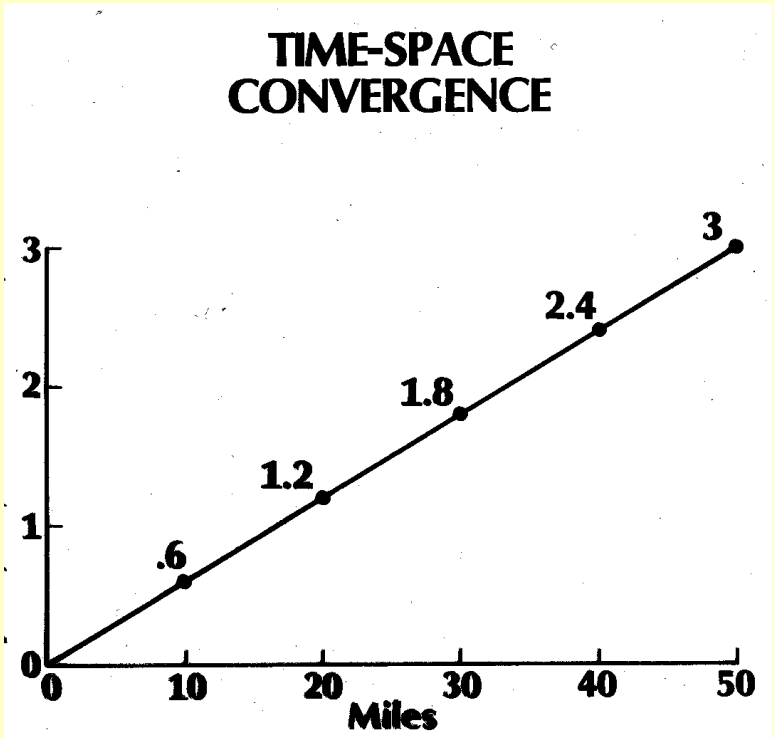
- Experiments in Measuring TSC
- TSC and Settlement System Response
- Stagecoach Networks – Early 1800s
- Highway Development – Mid 1900s
- Speed Limits on Interstate Highways
- Transport Culture and the Economy of Speed

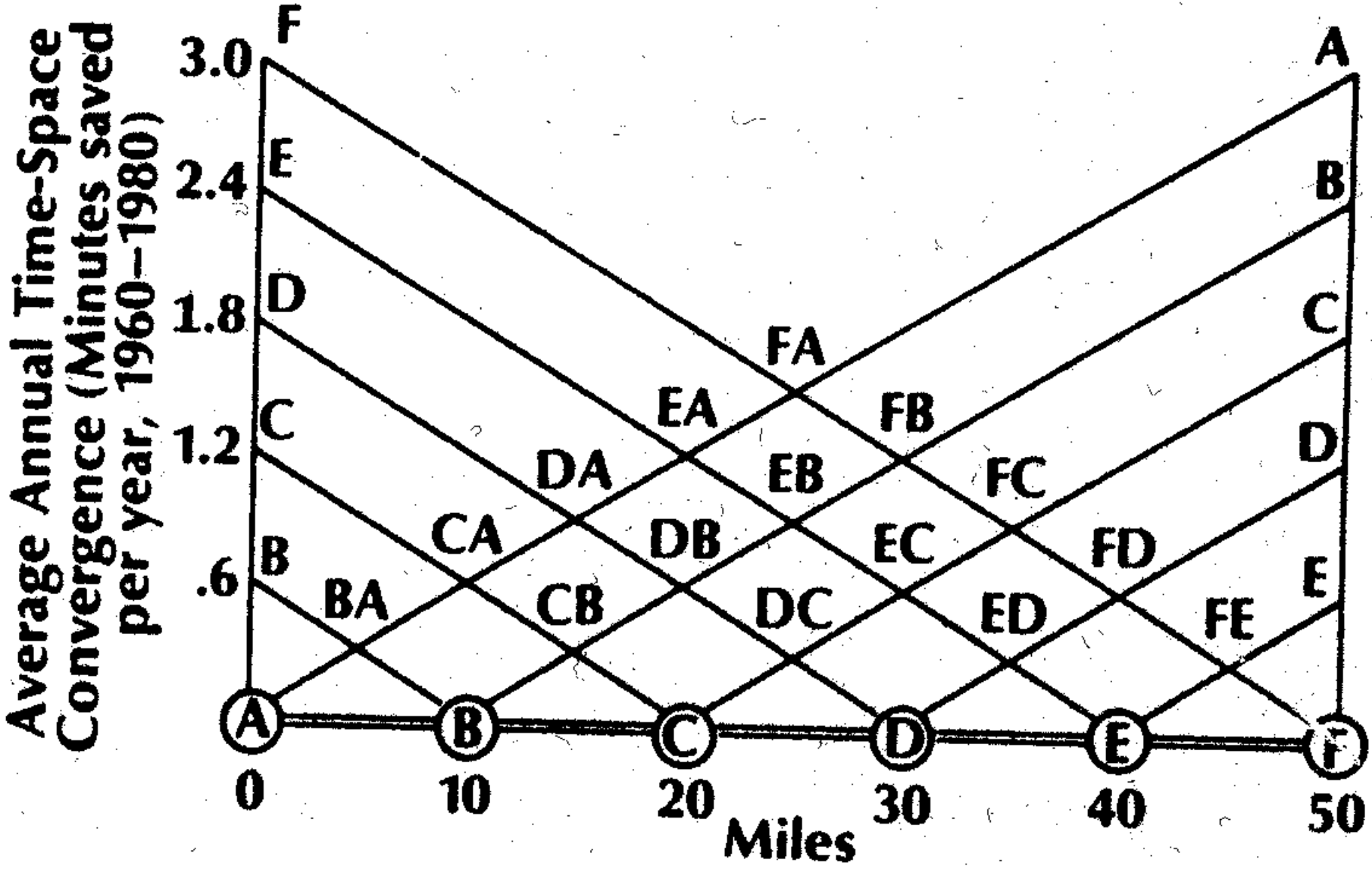
Measuring Time-space Convergence

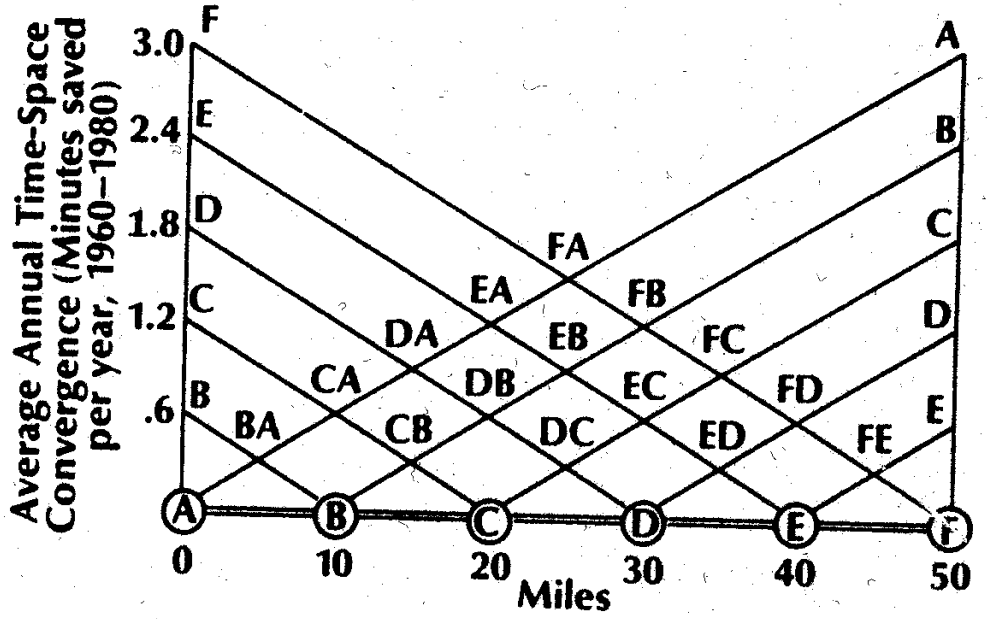
Hypothetical Situation:

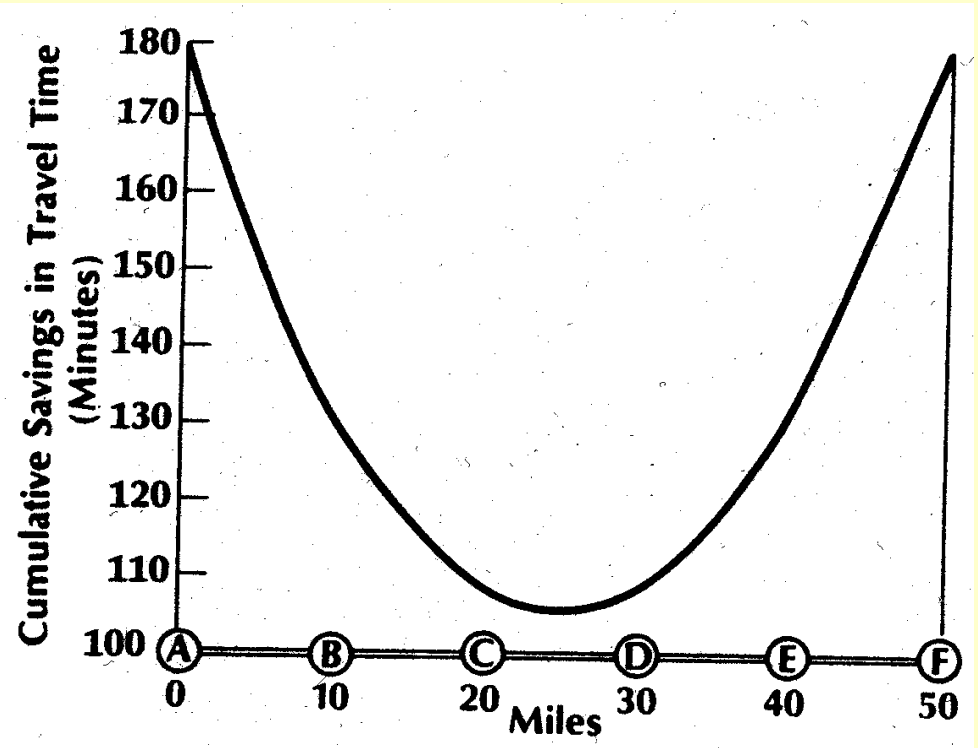
- Line World
- Uniform Travel Speeds
- Uniform Increases in Travel Speeds

	0 (A)	10 (B)	20 (C)	30 (D)	40 (E)	50 (F) Miles
		16	32	48	64	80 Kilometers
Travel-time from A at 25 mph in 1960 (minutes)		24	48	72	96	120
Travel-time from A at 50 mph in 1980		12	24	36	48	60
CONVERGENCE RATES 1960–1980 (minutes per year)		.6	1.2	1.8	2.4	3.0



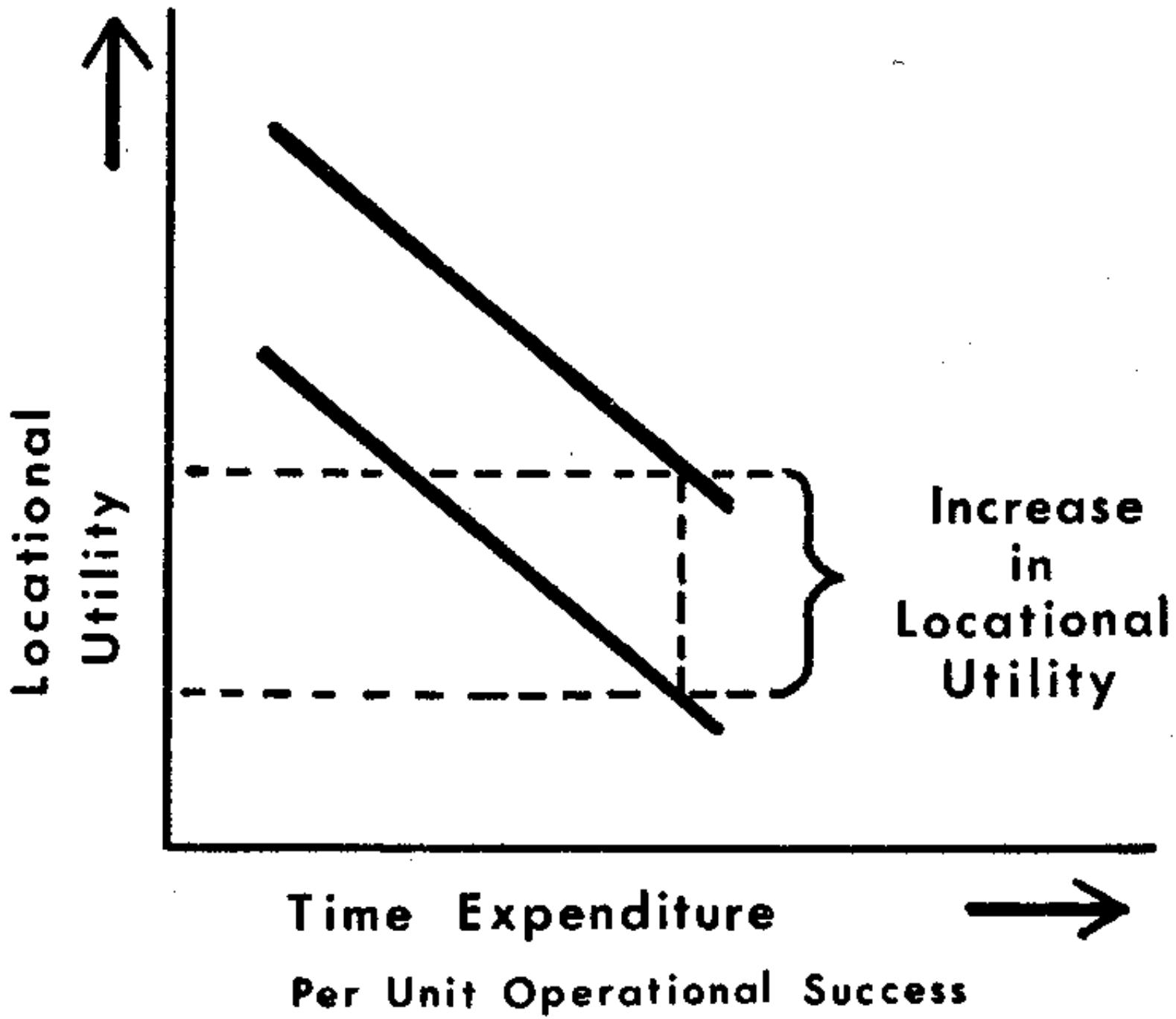

Average Annual Time-Space Convergence (Minutes saved per year, 1960–1980)
3.0
2.4
1.8
1.2
.6
F
E
D
C
B
A
FA
EA
FB
DA
EB
FC
CA
DB
EC
FD
BA
CB
DC
ED
FE
A
B
C
D
E
F
0
10
20
30
40
50
Miles


Average Annual Time-Space Convergence (Minutes saved per year, 1960–1980)
3.0
2.4
1.8
1.2
.6
F
E
D
C
B
A
FA
EA
FB
DA
EB
FC
CA
DB
EC
FD
BA
CB
DC
ED
FE
A
B
C
D
E
F
0
10
20
30
40
50
Miles

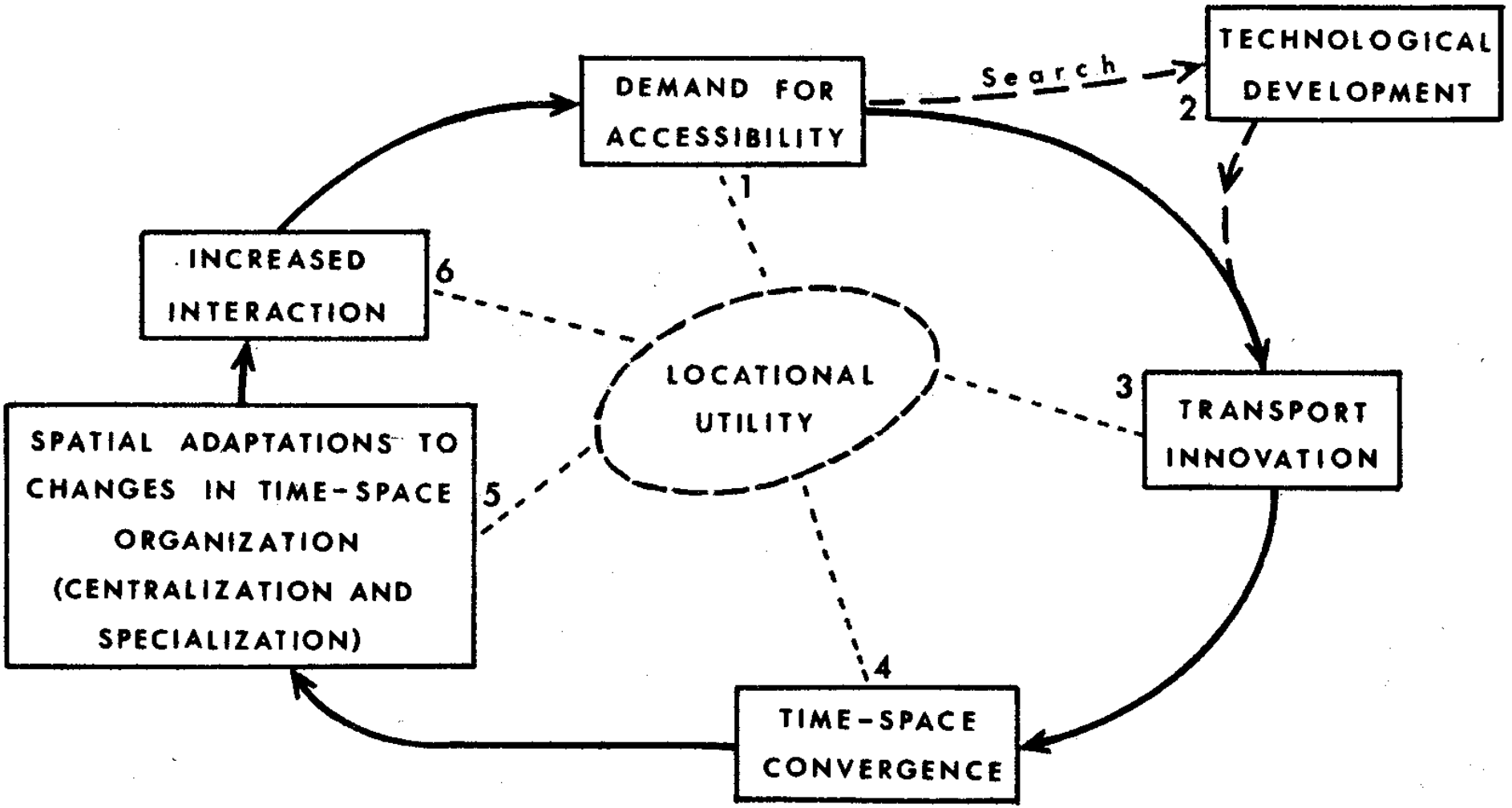

Cumulative Savings in Travel Time (Minutes)
180
170
160
150
140
130
120
110
100
A
B
C
D
E
F
0
10
20
30
40
50
Miles

Time-Space Convergence
Settlement-System Development

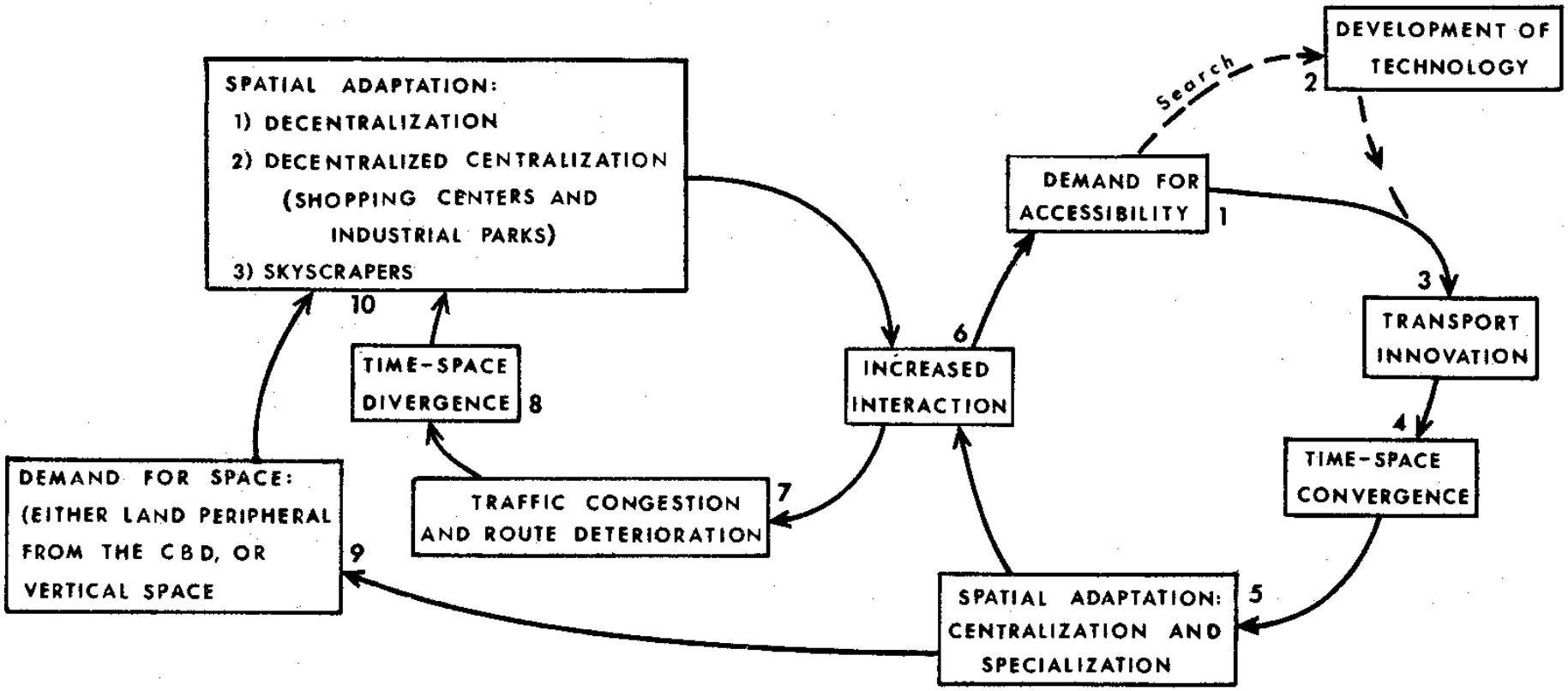
- Demand for Accessibility
- Locational Utility
- Innovation Search and Adoption
- Spatial Adaptation Strategies


Locational Utility
Increase in Locational Utility
Time Expenditure
Per Unit Operational Success

A PROCESS OF SPATIAL REORGANIZATION

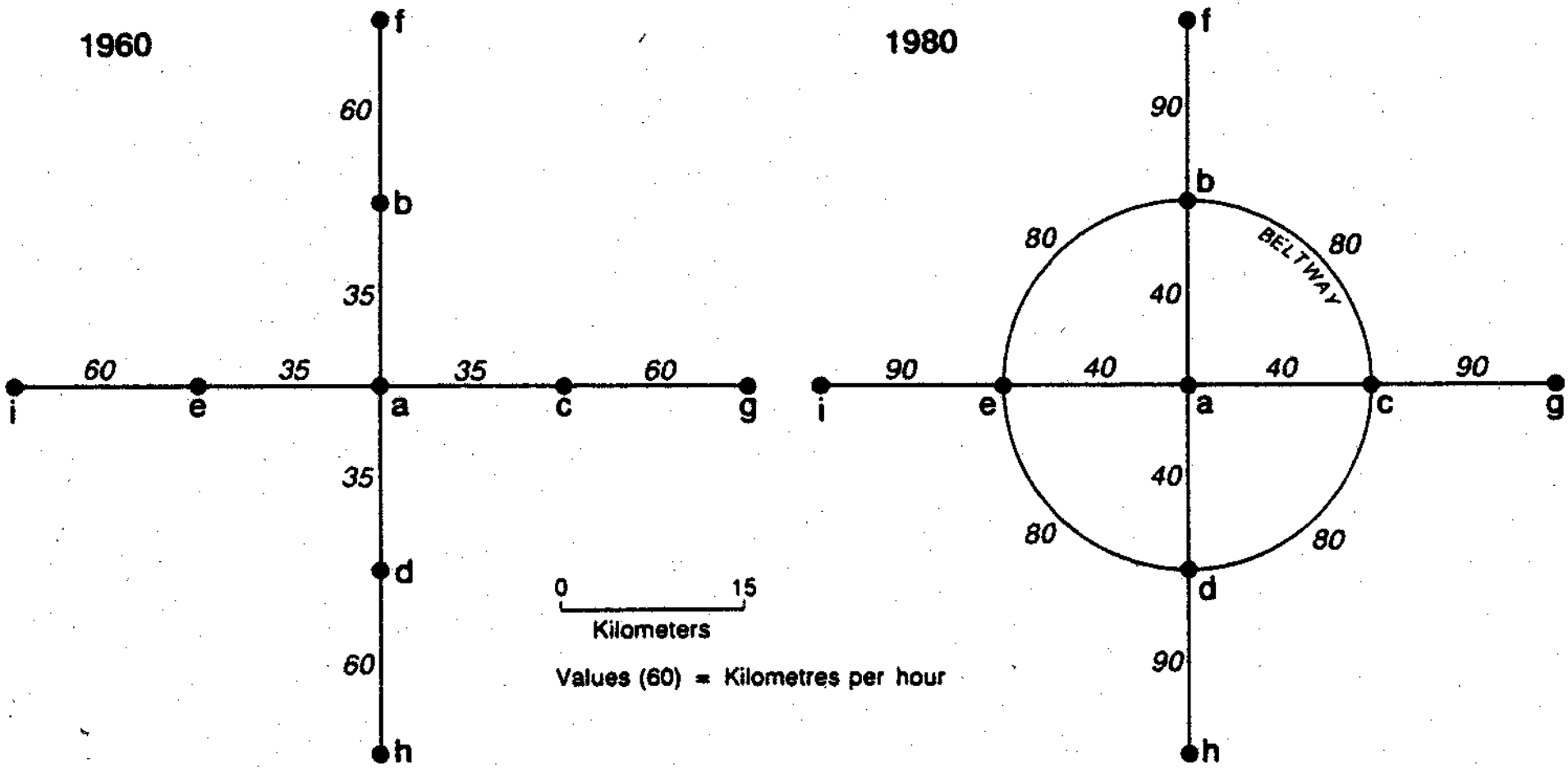


An Expanded Model of the Process of Spatial Reorganization

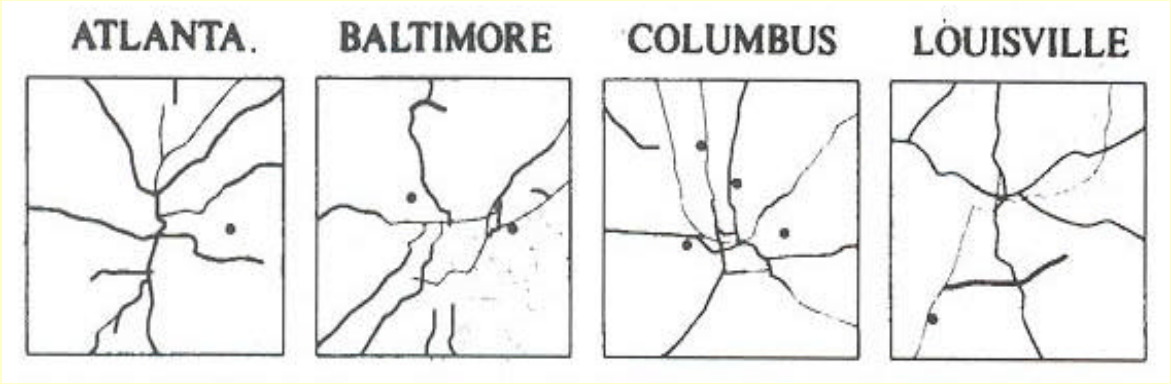


Time-Space Convergence
Metropolitan Expansion

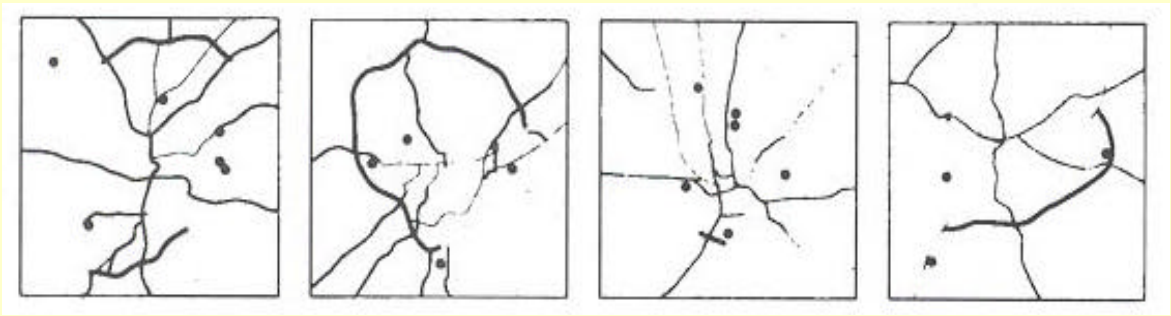
- Morphologies of Cities
- Topologically Equivalent Locations
- TSC and Susceptible Land Supply
- Behavioral Responses to TSC – the Quest for Amenity


1960
f
60
b
35
60
35
35
60
i
e
a
c
g
35
d
60
h
0
15
Kilometers
Values (60) = Kilometres per hour
1980
f
90
b
80
80
BELTWAY
40
90
40
40
90
i
e
a
c
g
40
80
80
d
90
h

Pre 1957



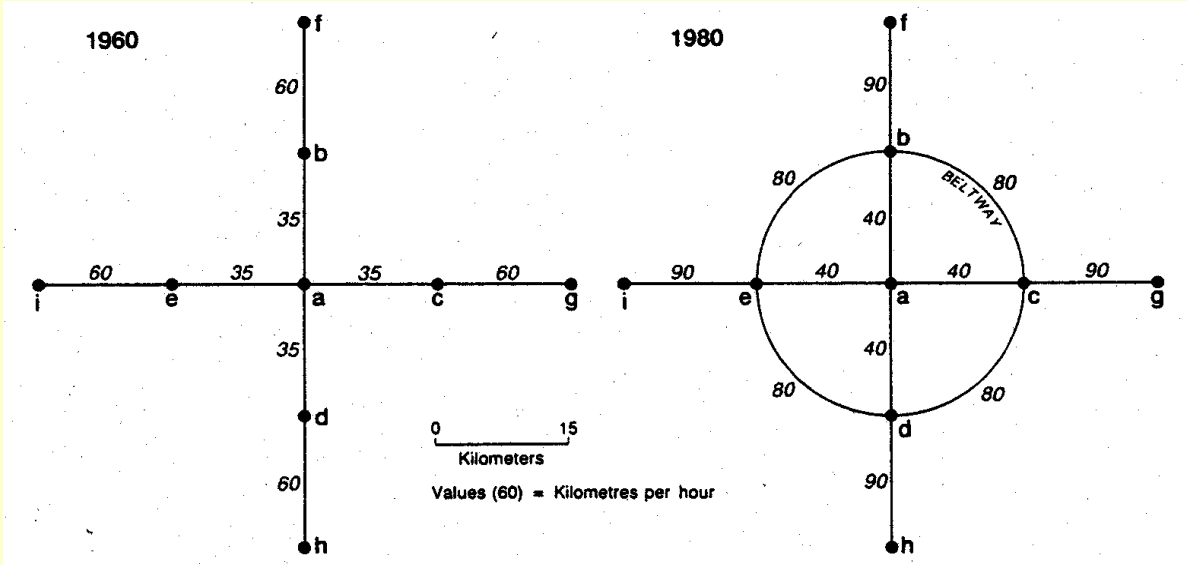
1961-1965



1976-1980

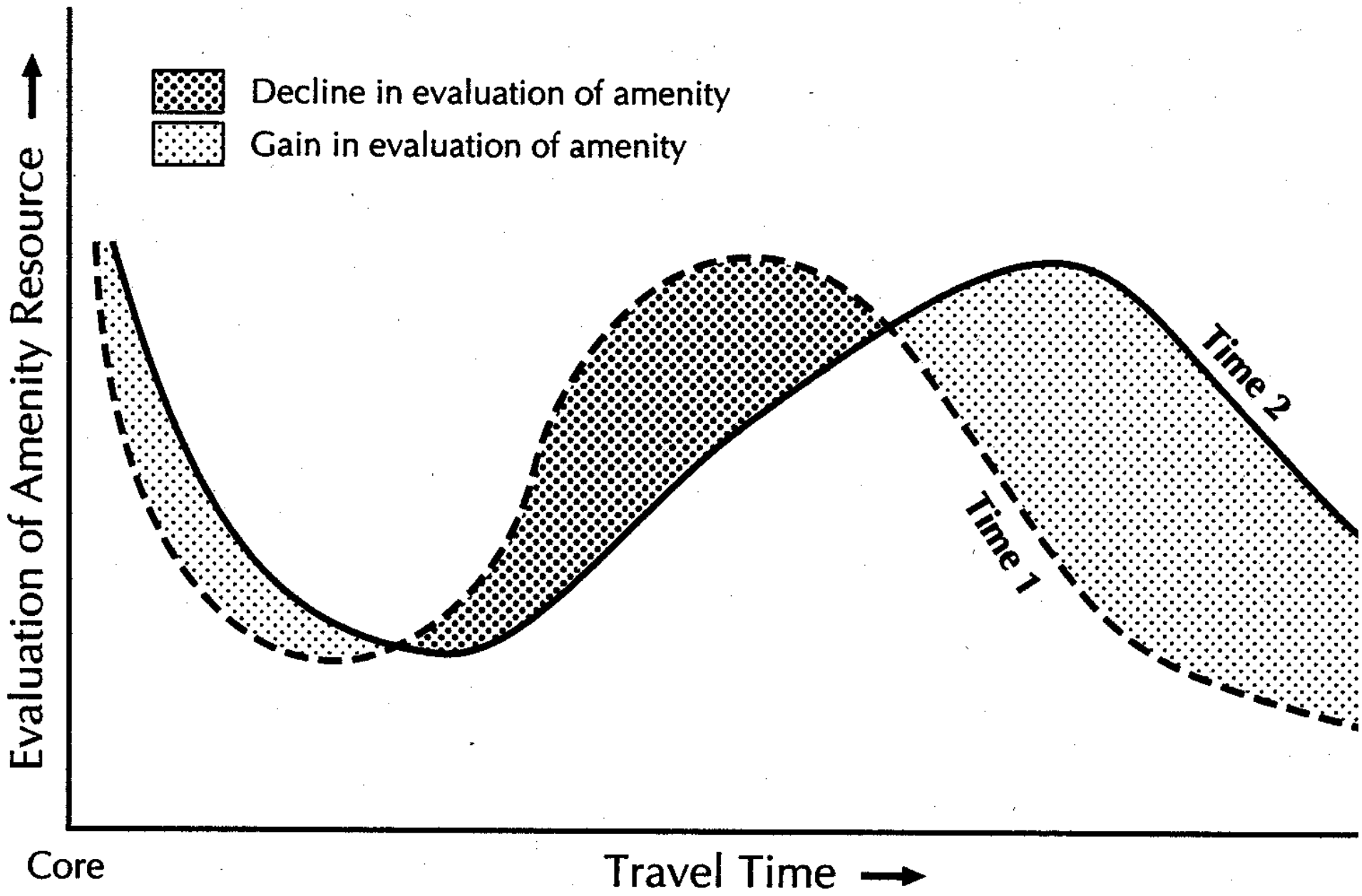
Convergence Rates for Metropolitan Settings

Topologically Equivalent Locations	**Average Travel Time (minutes)** each place to all 8 other places		**Convergence Rates 1960-1980** Average minutes per year, each place to all 8 other places using shortest time paths
	1960	**1980**	
City Center **- a**	33.2	27.5	**0.29**
b,c,d,e - Beltway	49.3	25.5	**1.19**
f,g,h,i - Ends	62.4	34.3	**1.4**

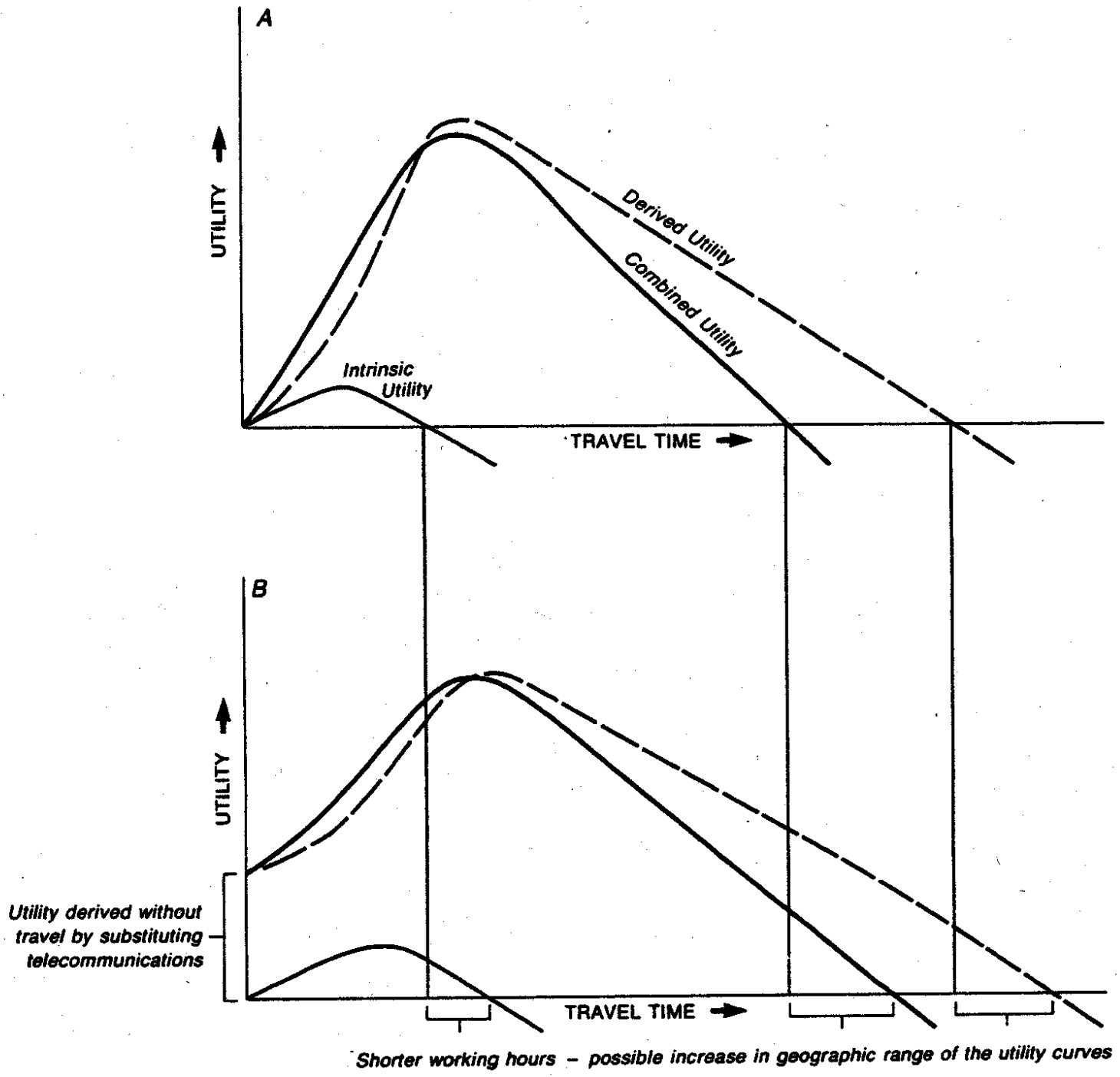


Travel Speeds and Accessible Land Resources from Urban Center

Average Travel Speed (Km/hr)	Average Daily Commuter Trip (1-way minutes)	Potential Distance from City Center (km)	Land Resource (Sq Km)
60	30	30	2827
70	30	35	3848
80	30	40	5027
80	50	67	14103

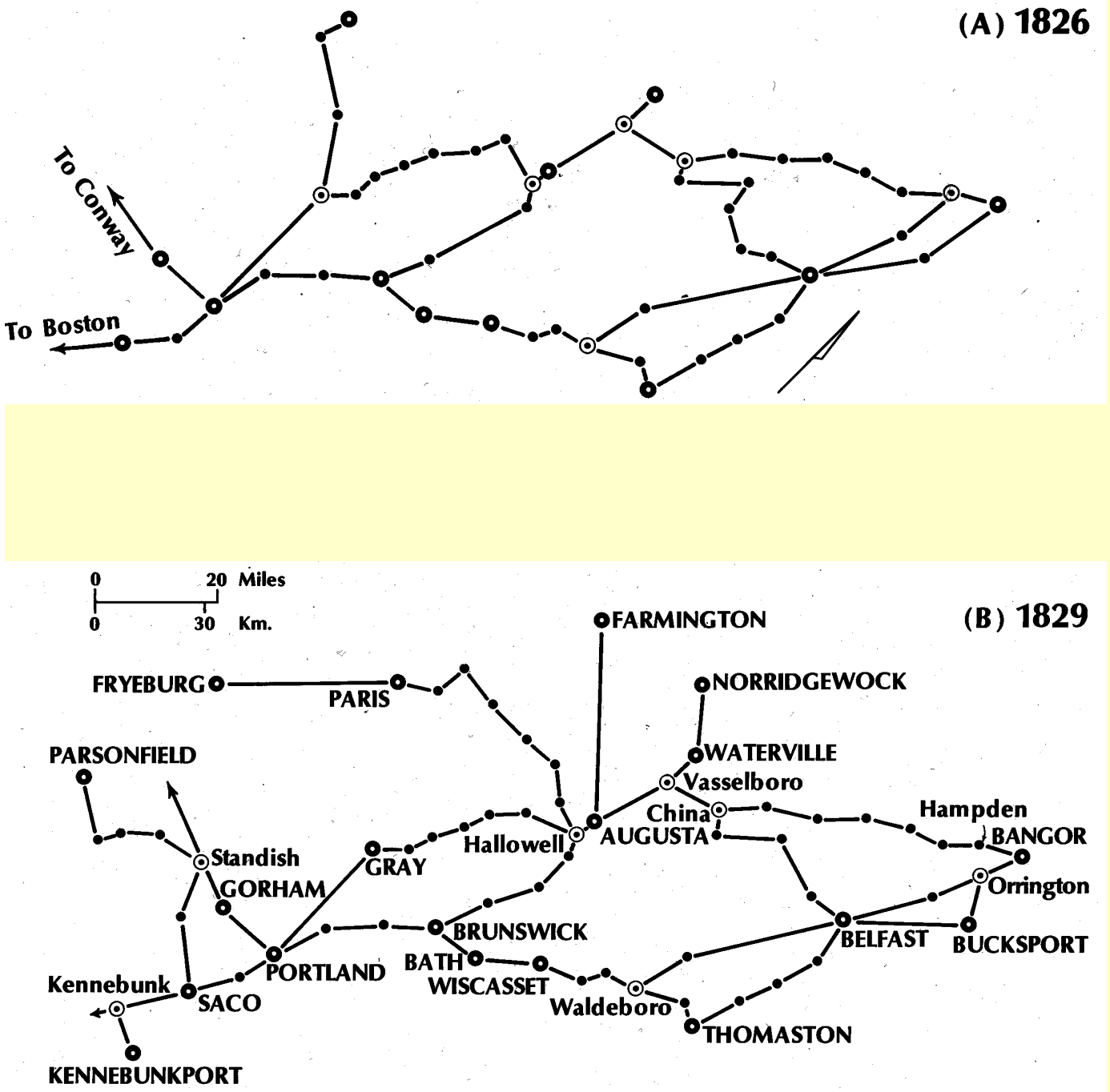

Decline in evaluation of amenity
Gain in evaluation of amenity
Evaluation of Amenity Resource
Time 2
Time 1
Core
Travel Time

Adapted from
Guert Hupkes
1982



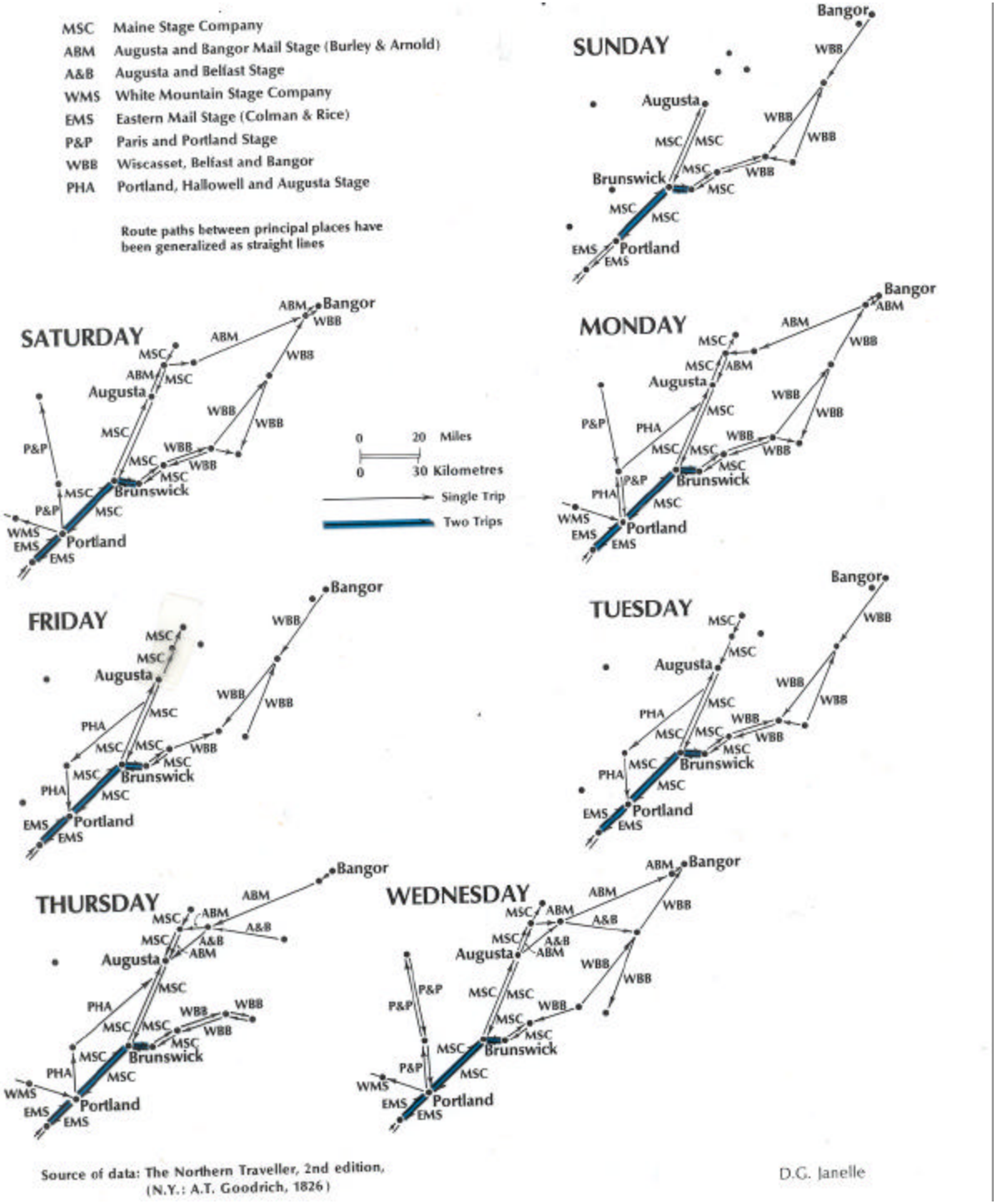
Temporal Discontinuity of Networks

- Stagecoach Networks and Travel in Early 19th Century Maine
- Frontier Situation
- Rapid Change
- Time Distance Matrices and Multi-Dimensional Scaling

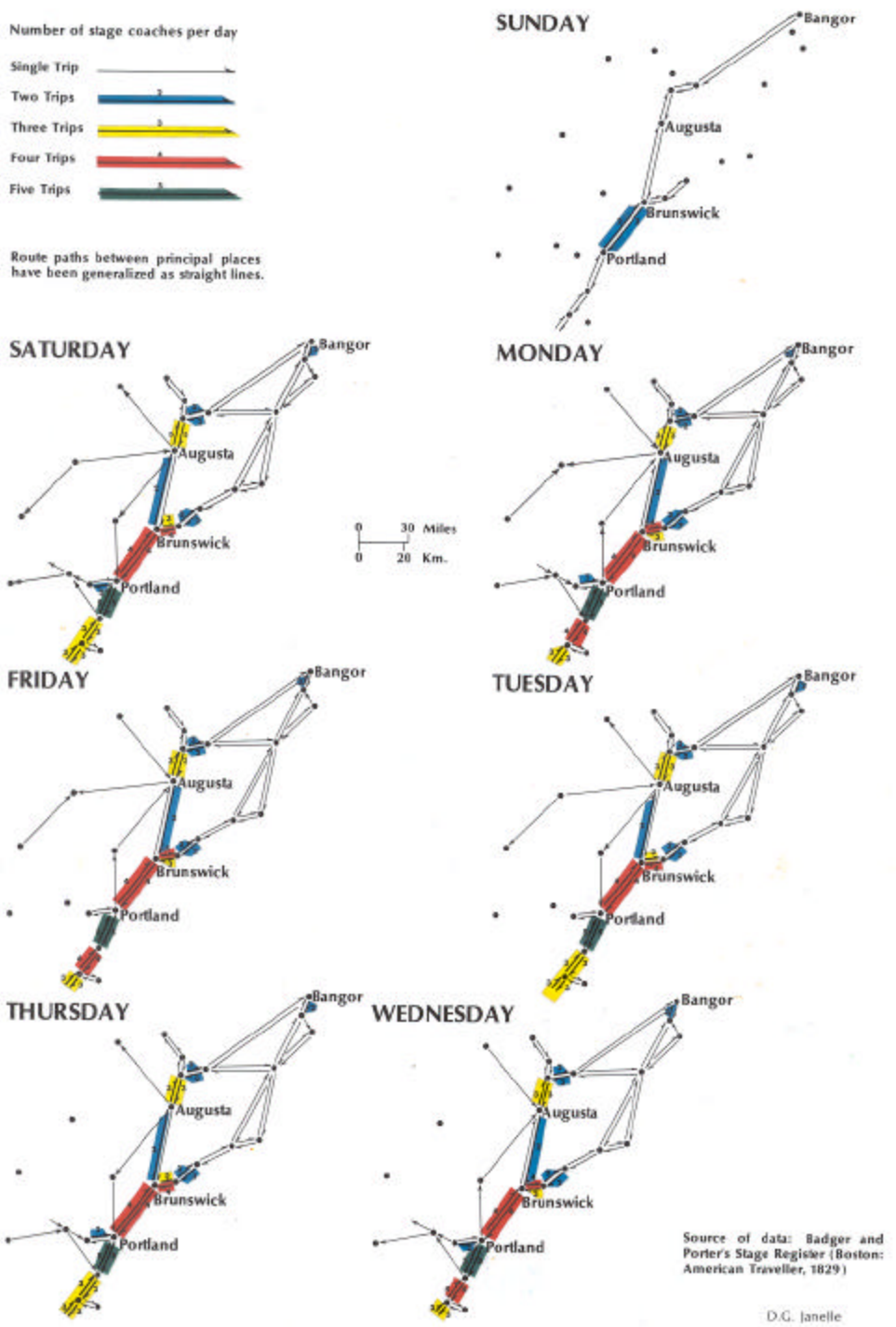


Stage Coach Network - Maine

Stage Coach Networks Maine 1826

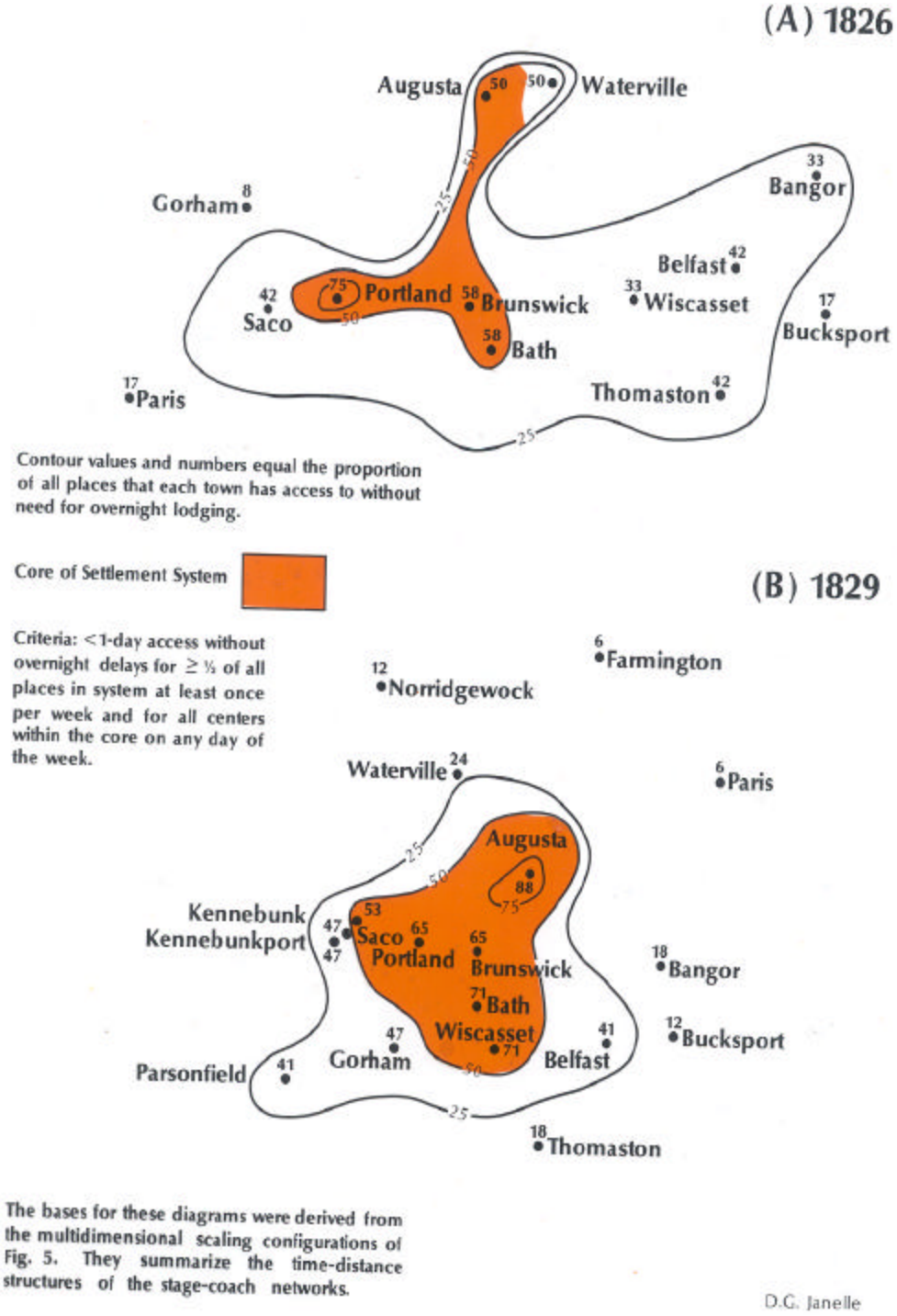


Stage Coach Networks Maine 1829



Multi-Dimensional Scaling of Trip-Time Matrices for Travel in Early 19th Century Maine

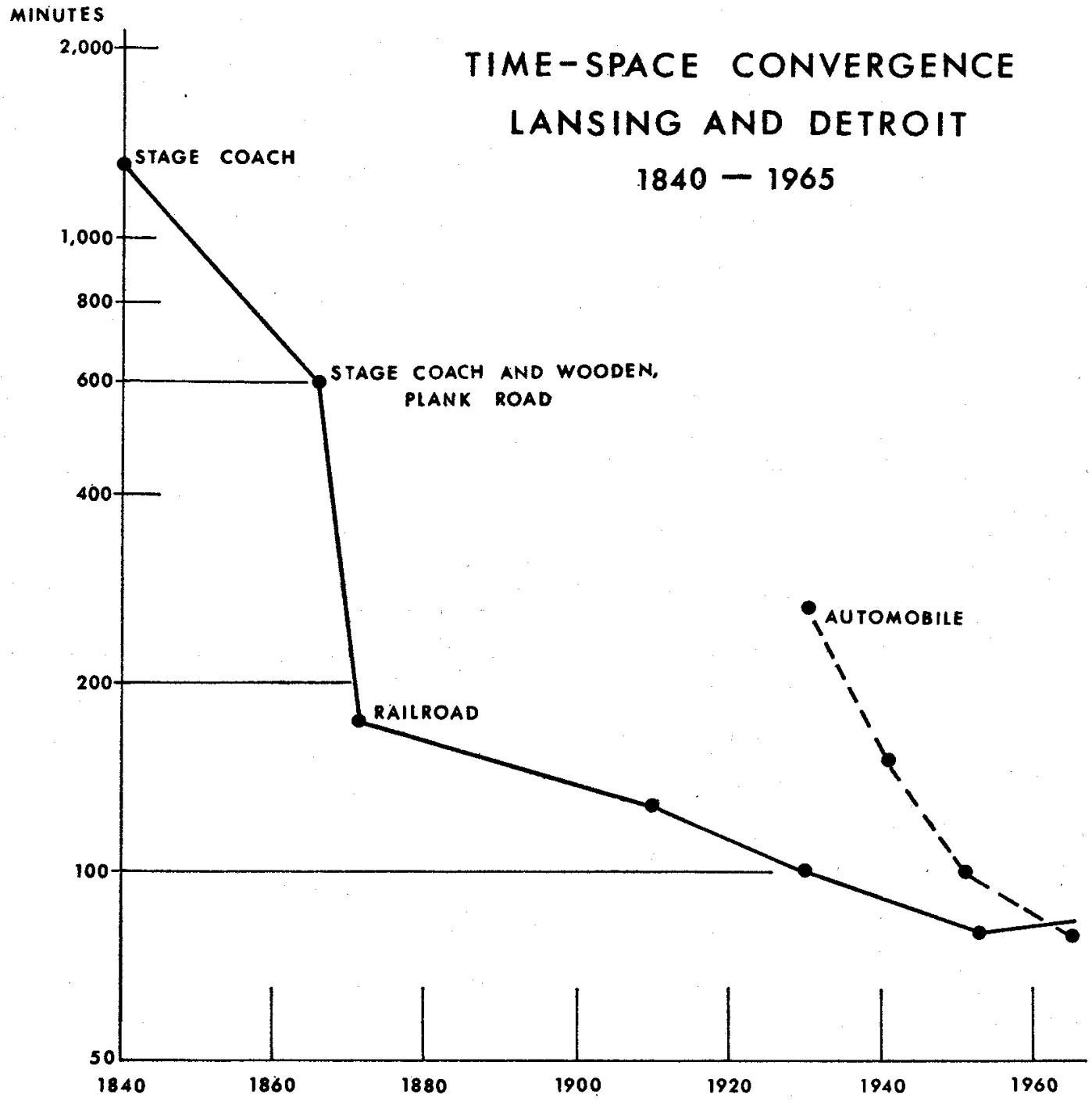
Contour values = % of all places a town has access to without overnight stays

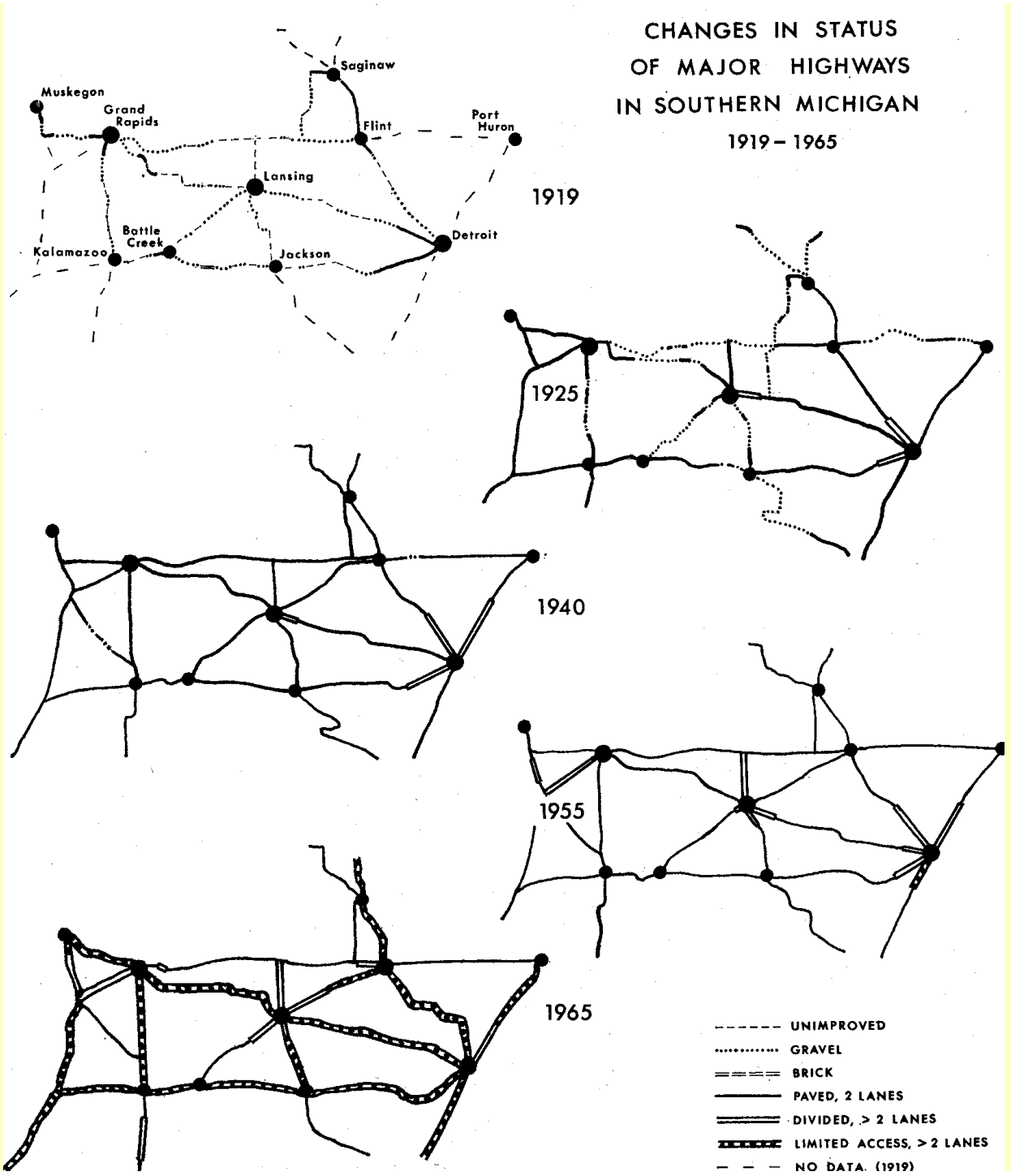


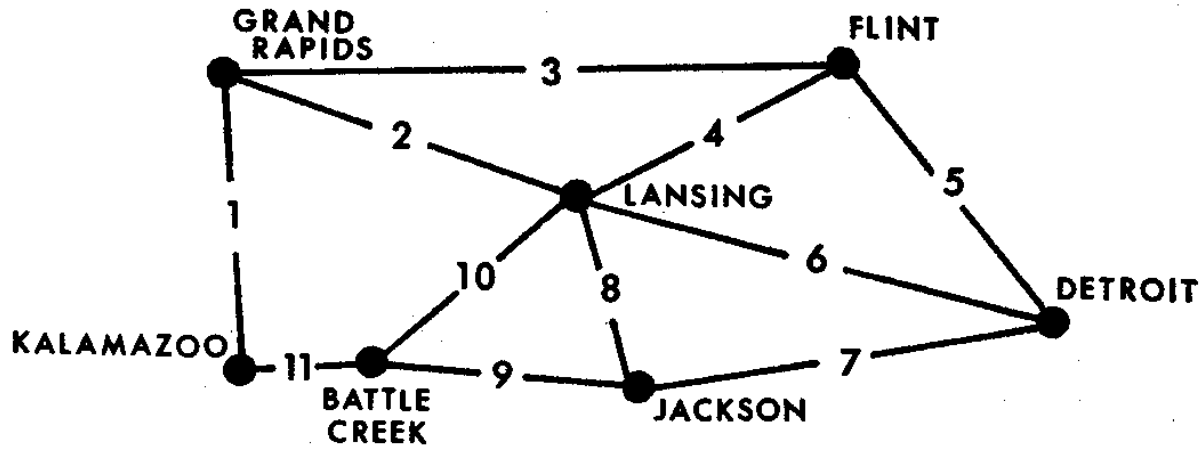
Road Investments in Michigan

- TSC as Surrogate of Network Investment
- Relative Advantage for Linkage Investment
- Declines in Travel Time per Unit Mile

Average TSC
9.5 min/yr

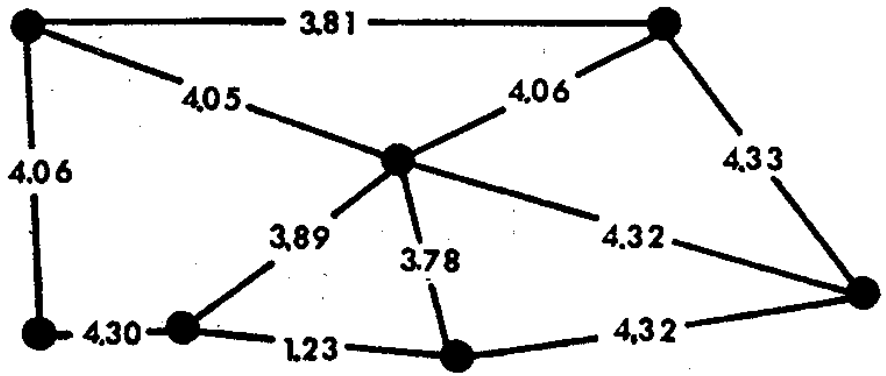



CHANGES IN STATUS
OF MAJOR HIGHWAYS
IN SOUTHERN MICHIGAN
1919 – 1965
Saginaw
Muskegon
Grand Rapids
Flint
Port Huron
Lansing
Detroit
Battle Creek
Kalamazoo
Jackson
1919
1925
1940
1955
1965
UNIMPROVED
GRAVEL
BRICK
PAVED, 2 LANES
DIVIDED, > 2 LANES
LIMITED ACCESS, > 2 LANES
NO DATA. (1919)

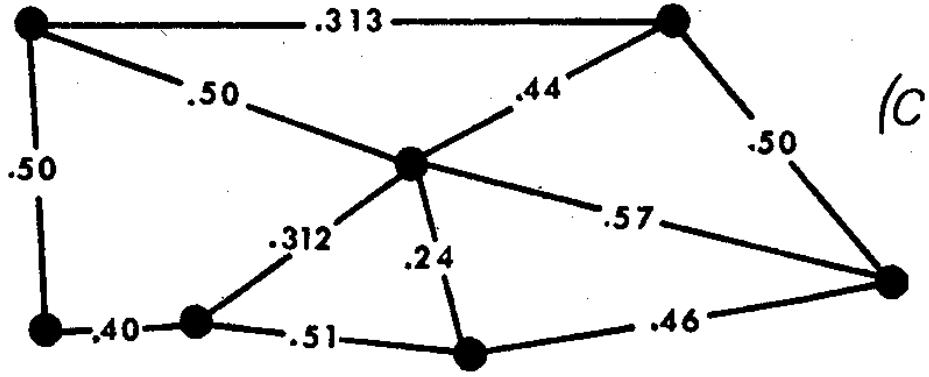


Minutes Saved Per Route Mile (Convergence Measure of Route Improvement)

1900 – 1925



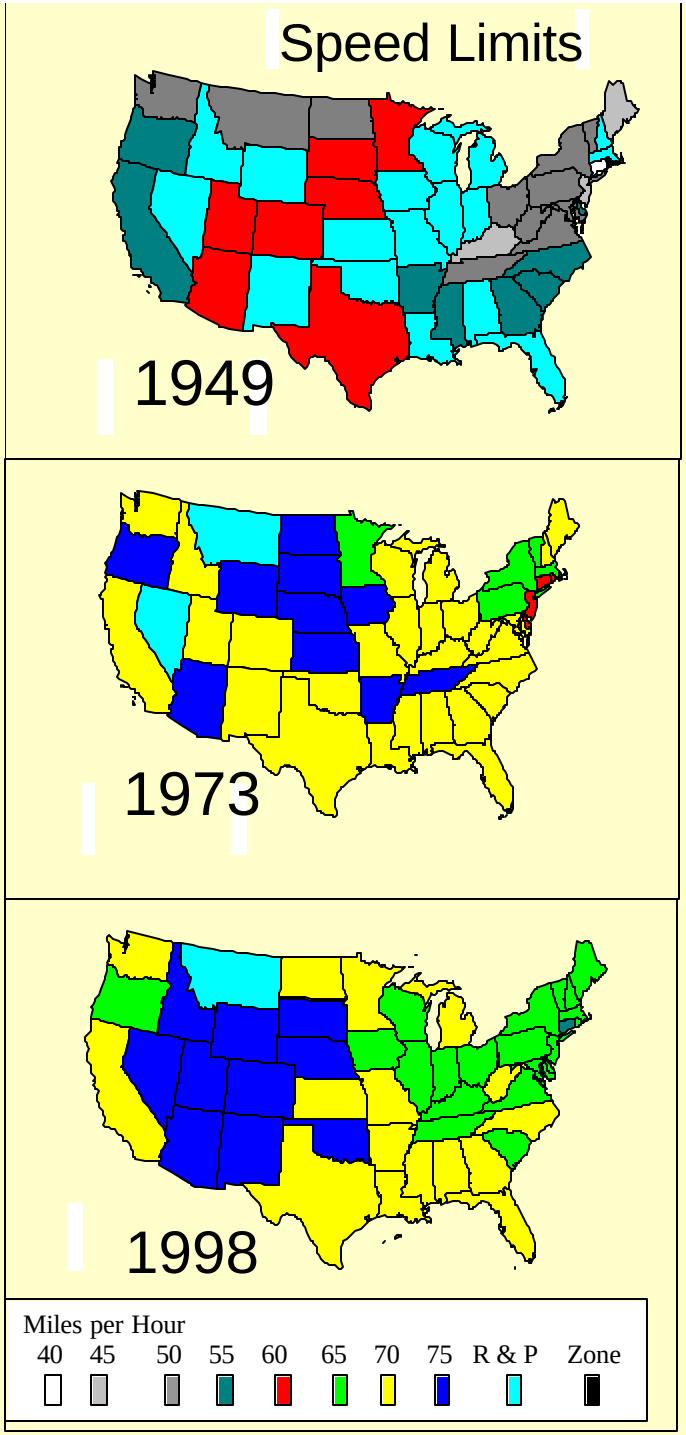
1940 – 1965



Speed Limits on America's Interstates

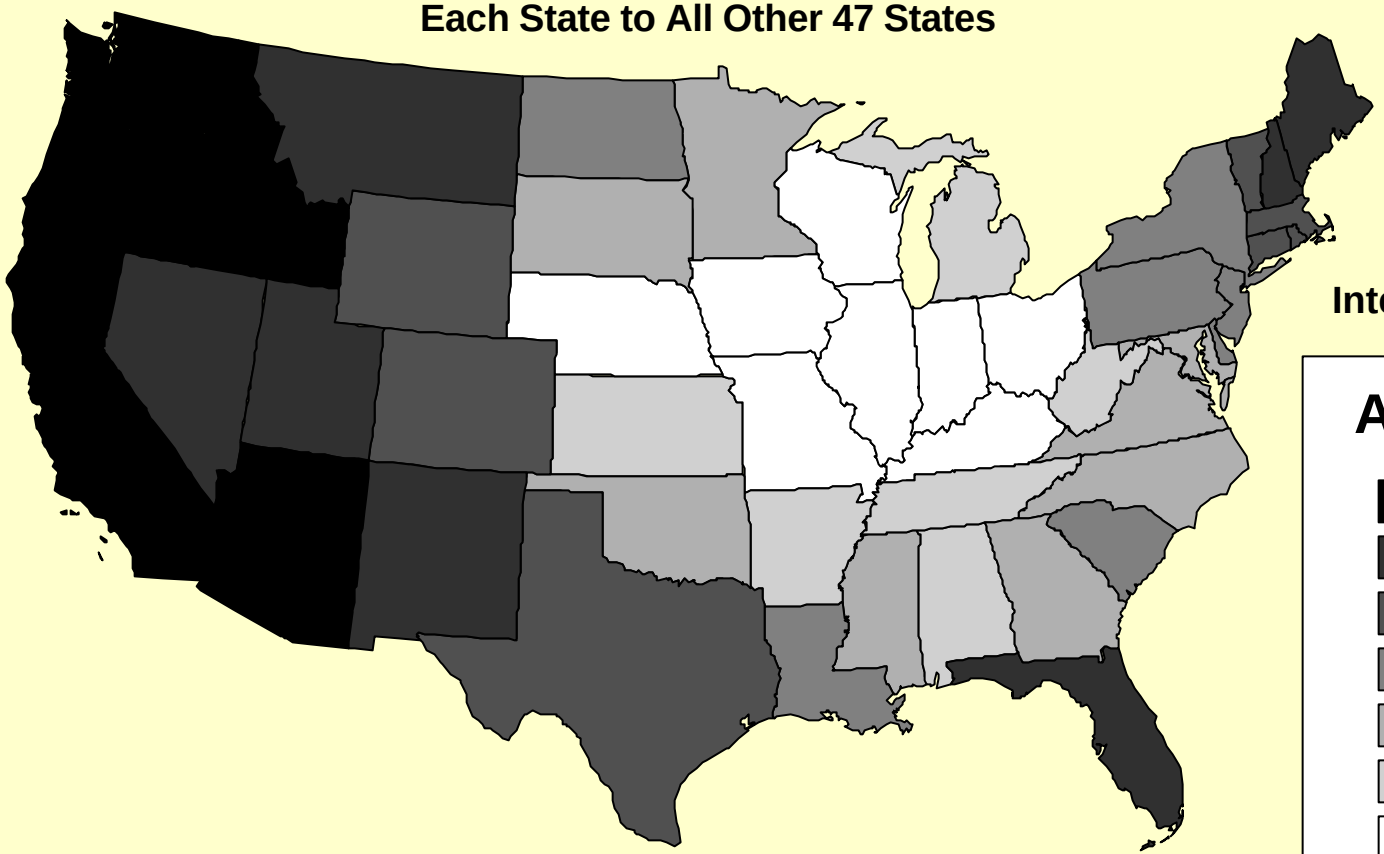
Historical Benchmarks

- **1901**– CT – 12 mph Open Roads / 8 mph Cities
- **1942** – Office of Defense Transportation – 35 mph
- **1956** – The Federal Aid Highway Act / The Highway Revenue Act -- creating the Dwight D. Eisenhower System of Interstate and Defense Highways
- **1973 – 74** OPEC Oil Embargo
- **1974** – 55 mph
- **1987** – 65 mph on Rural Interstates
- **1995** – Restoring State Control over Speed Limits


Speed Limits
1949
1973
1998
Miles per Hour
40
45
50
55
60
65
70
75
R & P
Zone

Average Travel Time (Hours)

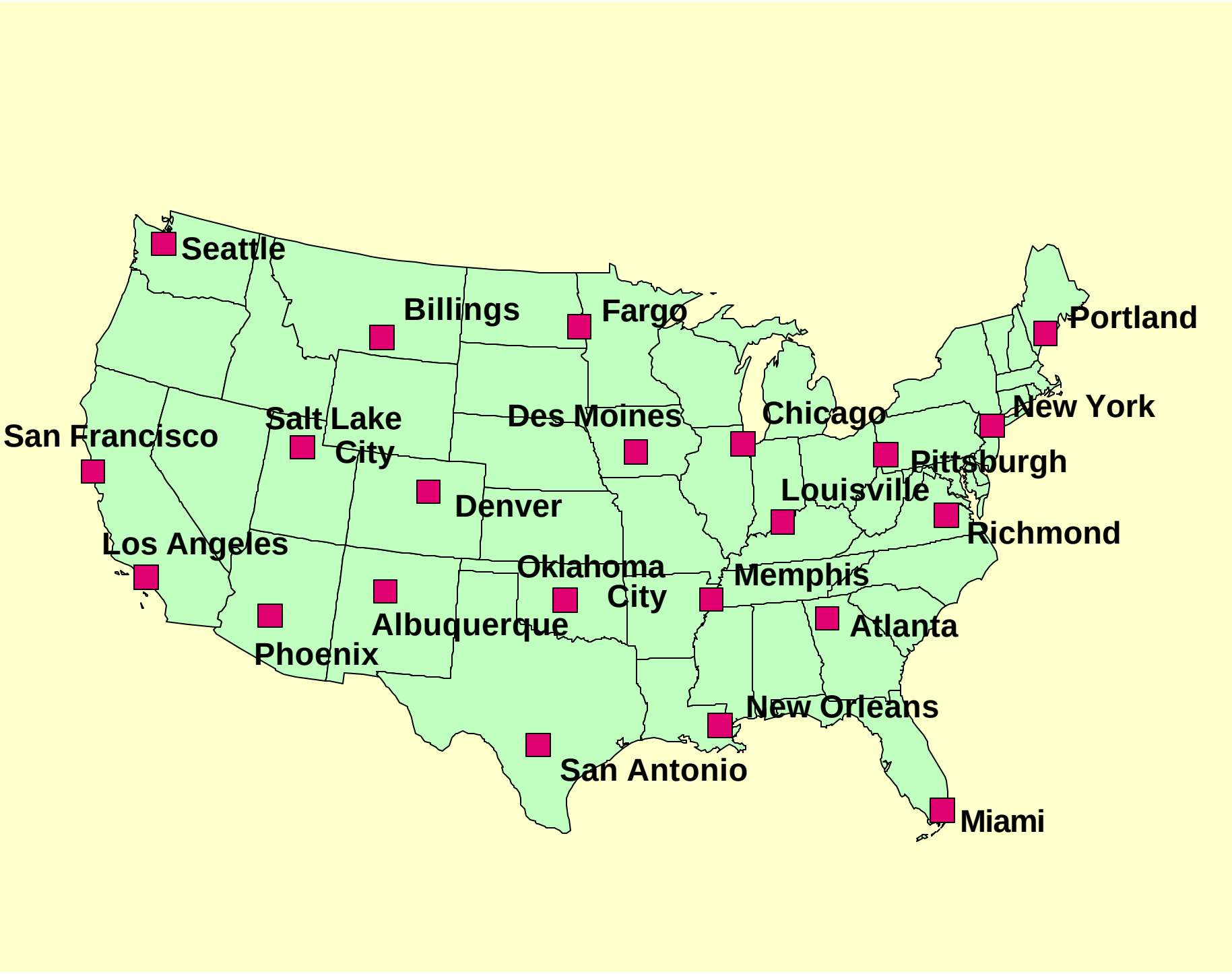
Each State to All Other 47 States

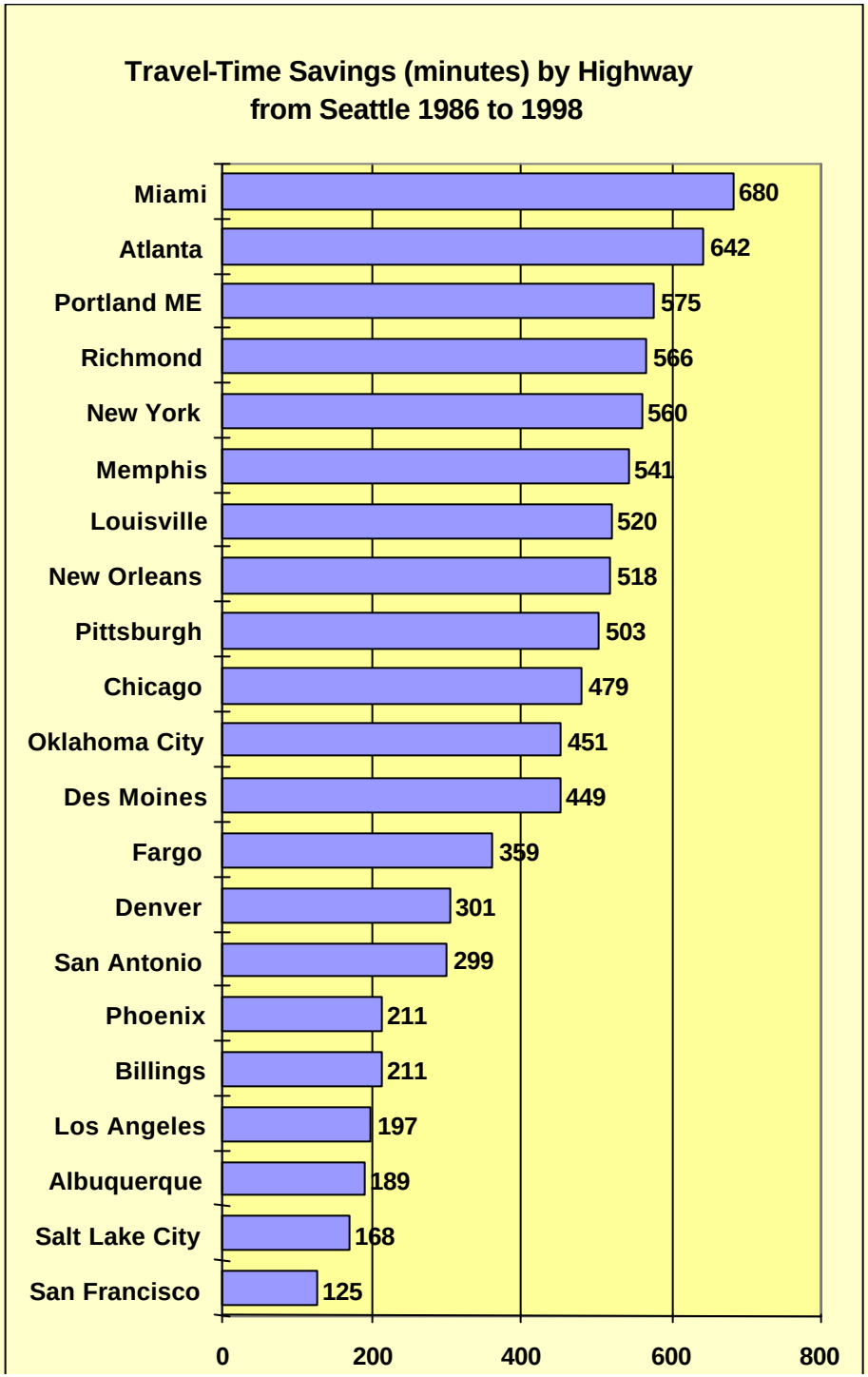


Interstate Highways @ 55 MPH

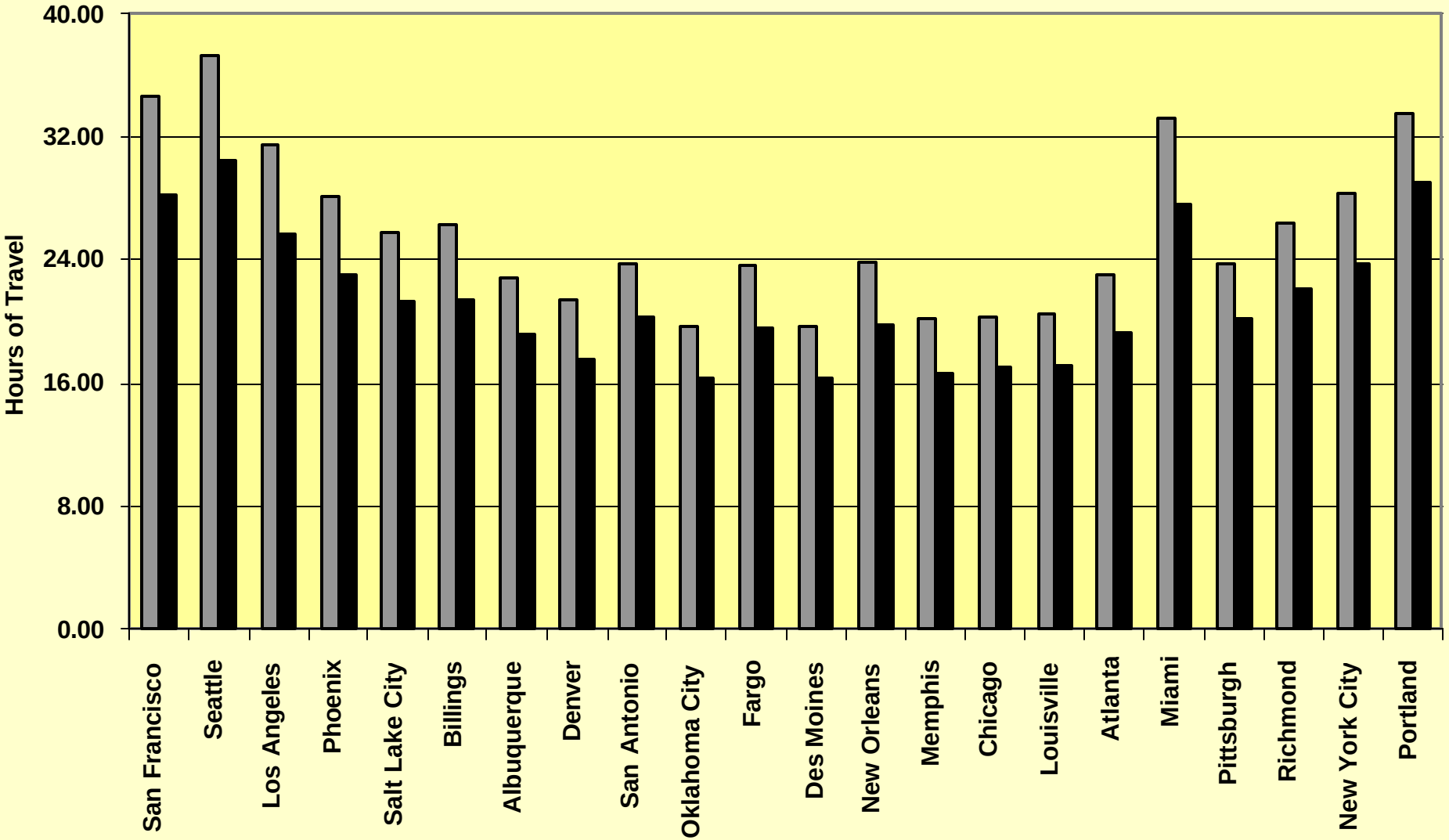
AVERAGE HOURS

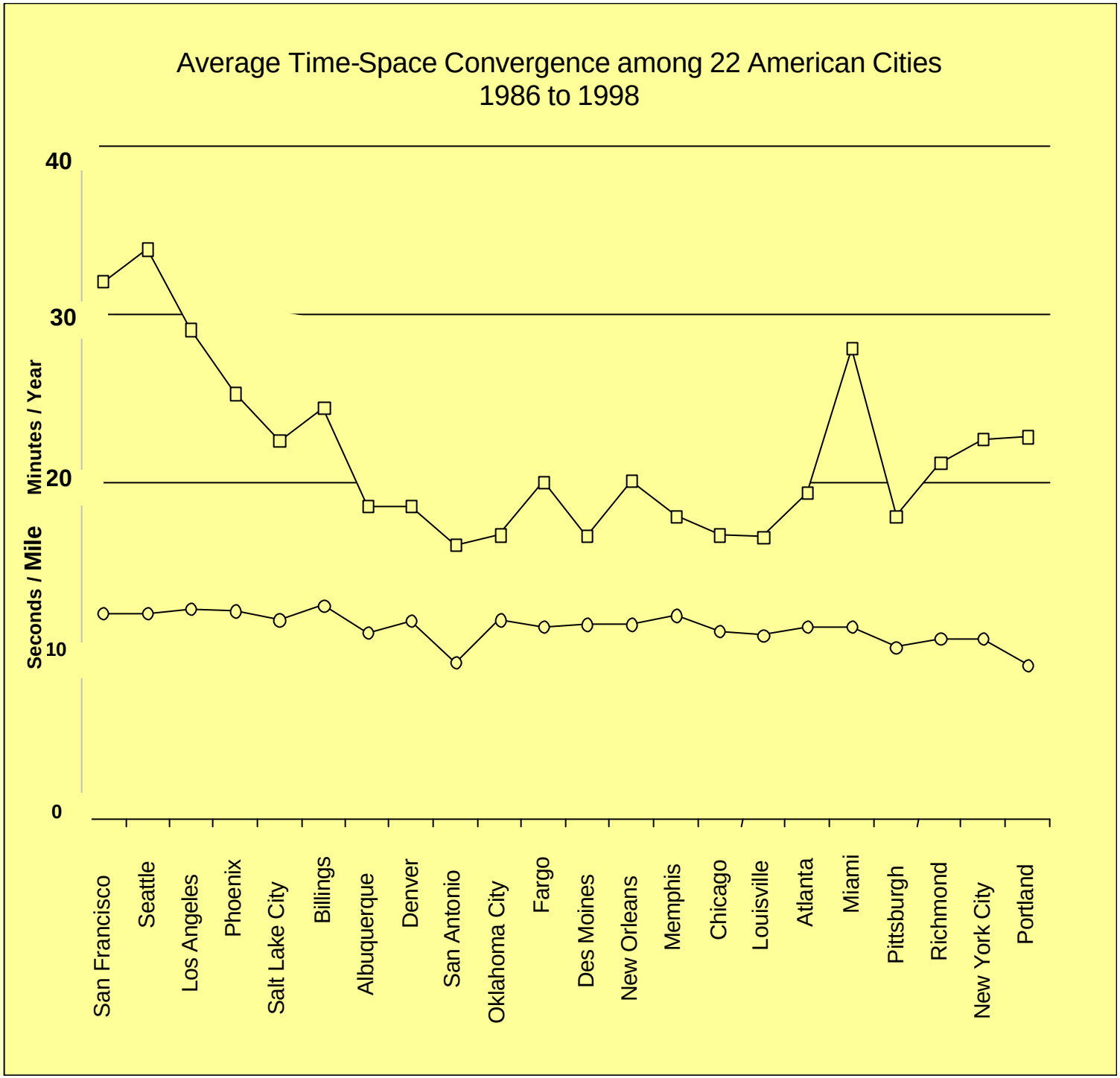
31.5 to 39.4	(5)
24.1 to 31.5	(7)
22 to 24.1	(7)
20.1 to 22	(7)
19.1 to 20.1	(8)
17.6 to 19.1	(6)
16.1 to 17.6	(8)


Seattle
Billings
Fargo
Portland
New York
Salt Lake City
Des Moines
Chicago
San Francisco
Pittsburgh
Louisville
Denver
Richmond
Los Angeles
Oklahoma City
Memphis
Albuquerque
Atlanta
Phoenix
New Orleans
San Antonio
Miami


Travel-Time Savings (minutes) by Highway
from Seattle 1986 to 1998
Miami
680
Atlanta
642
Portland ME
575
Richmond
566
New York
560
Memphis
541
Louisville
520
New Orleans
518
Pittsburgh
503
Chicago
479
Oklahoma City
451
Des Moines
449
Fargo
359
Denver
301
San Antonio
299
Phoenix
211
Billings
211
Los Angeles
197
Albuquerque
189
Salt Lake City
168
San Francisco
125
0
200
400
600
800

Changes in Average Highway Travel Times by City for Trips among 22 American Cities 1986 to 1998




Average Time-Space Convergence among 22 American Cities
1986 to 1998
Seconds / Mile
Minutes / Year
40
30
20
10
0
San Francisco
Seattle
Los Angeles
Phoenix
Salt Lake City
Billings
Albuquerque
Denver
San Antonio
Oklahoma City
Fargo
Des Moines
New Orleans
Memphis
Chicago
Louisville
Atlanta
Miami
Pittsburgh
Richmond
New York City
Portland

Transport Culture and the Economy of Speed

Distance as Contested Social Construct

- The politics of speed-limit legislation and enforcement
- Technological warfare -- fuzz busters

Safety and Environmental Concerns

- "**time pollution**" (the complete social costing of travel speed, John Whitelegg)

Cost of Doing Business

- **Transport Culture –** an attribute of modernism that reinforces prevailing value systems for maintenance of an **Economic System Dependent on Speed** for capital accumulation
- Toffler's Axiom: **"Survival of the Fastest" –** quick response, just-in-time

Conclusions

- There is need to understand how things move through time-space
- Representation of space in non-Euclidean and fluid frameworks can yield useful insights about social processes
- Understanding settlement system development benefits from both experimental and empirical assessment of time-space convergence processes
- Recognition and analysis of the political and economic motivations that underlie time-space convergence processes offer research challenges that are related to issues of equity, prosperity, and environmental quality

References

- DG Janelle and M Beuthe, Globalization and Research Issues in Transportation, *Journal of Transport Geography* 5(Sept 1997) 199-206.
- DG Janelle, Sustainable Transportation and Information Technology: Suggested Research Issues, *Journal of Transport Geography* 5, (March 1997) 39-40.
- DG Janelle, Metropolitan Expansion, Telecommuting, and Transportation, in S Hanson, ed, *The Geography of Urban Transportation*, second edition (New York: Guilford Press, 1995) 407-34.
- DG Janelle, Stage Coach Operations in Maine, 1826-1829. *Proceedings of the New England St. Lawrence Valley Geographical Society* 6 (July 1977) 15-18.
- DG Janelle, Time Space Convergence and Urban Transportation Issues, in *Systems Thinking and the Quality of Life*. CK Blong, ed (Washington, DC: The Society for General Systems Research, 1975) 594-600.
- DG Janelle, Transportation Innovation and the Reinforcement of Urban Hierarchies, *High Speed Ground Transportation Journal* 8 (Fall 1974) 261-69.
- DG Janelle, Spatial Reorganization: A Model and Concept, *Annals of the Association of American Geographers* 59 (June 1969) 348-64.
- DG Janelle, Central Place Development in a Time-Space Framework, *The Professional Geographer* 20 (Jan 1968) 5-10.