The UrbanSim Project: Using Urban Simulation to Inform Public Decision-making about Land Use and Transportation Choices

Alan Borning
Dept of Computer Science & Engineering
University of Washington, Seattle

Urban Form and Sustainability

- Most of the world's population lives in cities
- Patterns of urban land use and transportation play a major role in environmental sustainability, e.g.:
  - Resource consumption
  - Greenhouse gas emissions
  - Farmland and open space preservation or loss
- Land use and transportation choices interact. Examples:
  - Automobile use and auto-oriented development mutually reinforcing
  - Transit-oriented development
- If we broaden sustainability to include social and economic sustainability, additional important features include effects on health and community

Role of Modeling and Simulation

- What if we ...?
  - Built a new freeway or light rail line?
  - Established an urban growth boundary and zoned for increased density and mixed-use?
  - Changed the cost of parking, or adopted congestion pricing?
- Integrated land use and transportation models can provide an important tool for exploring policy alternatives and possible urban futures
- To be effective, modeling must be integrated with the political process

The UrbanSim System

- A disaggregate, behaviorally realistic simulation system for modeling the development of urban areas over periods of 20-30 years
- Developed by an interdisciplinary group at the University of Washington over the past decade
  - Paul Waddell, Evans School of Public Affairs
  - Many other students, faculty and staff from Civil Engineering, Information School, Psychology, Statistics, Urban Design and Planning: Sam Clark, Janet Davis, Rob Duisberg, Bjorn Freeman-Benson, Batya Friedman, Dieter Fox, Peter Henry, Peter Kahn, Christoffer Klang, Travis Kriplean, Brian Lee, Peyina Lin, Justin Meyer, Michael Noth, Sebastian Pappert, Adrian Raftery, Hana Sevcikova, Soyoung Shin, Davis Socha Liming Wang, ...
- GNU Public License
- Available for download at www.urbansim.org

UrbanSim Deployment

- Deployment and operational use by regional planning agencies a major project goal
- Operational use:
  - Detroit, Houston, Seattle, Salt Lake City metropolitan areas
- Planned operational use or research and pilot applications:
  - Amsterdam, Brussels, Burlington, Durham, El Paso, Eugene, Honolulu, Lausanne, Melbourne, Paris, Phoenix, San Francisco, Tel Aviv, Zurich
- User community: Users Group meetings in U.S. and Europe, active email list

UrbanSim – System Architecture

- Modeling:
  - Provide interacting component models that represent different agents and processes in the urban environment
  - Component models loosely coupled (for software engineering reasons); communicate via a shared database
  - Dynamically simulate annual time steps
- Example component models:
  - Household Location Choice Model
  - Employment Location Choice Model
  - Real Estate Price Model
  - Building Construction Model
  - Travel (external model)


UrbanSim geographic data:
150 square meter grid cells
& parcel data - Green Lake
neighborhood, Seattle

Example Model - Household Location

- Households that need to be placed in new locations in a given simulated year:
  - Existing household predicted to move by Household Relocation Mode
  - New households from Demographic Transition Model
- Available housing to move into:
  - Units vacated by households that moved out
  - New housing from the Real Estate Developer Model
- Household Location Choice is a probabilistic model – outcome is where household moves to.
- Variables used in computing these probabilities: characteristics both of the household and of the potential housing
- Estimated using observed data for the region being simulated

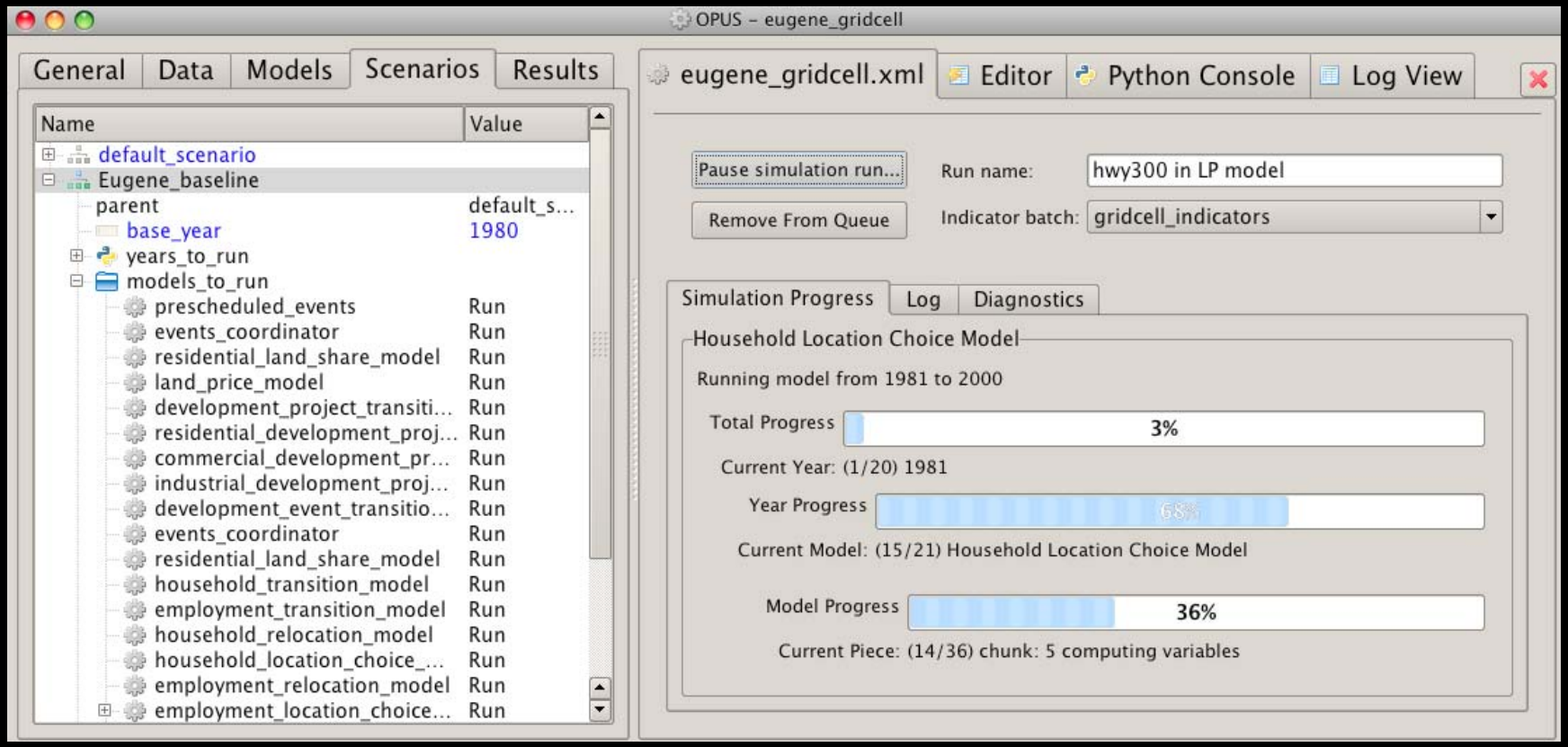
Implementation

- UrbanSim 1, 2, and 3 were written in Java
  - Problems: modelers unwilling to read (let alone write) code; difficult to do quick experiments with alternative modeling approaches
- UrbanSim 4 is now written in Python using Opus (Open Platform for Urban Simulation)
- Much more flexible architecture, comparable performance
- Embedded domain-specific programming language for defining model variables (10x code reduction for these parts of the system)
- Integrated with visualization and statistical libraries (in particular, we have integrated model estimation tools – very important for the modelers)
- A few technically savvy modelers now willing to read code, do interactive experiments using command line tools

Iteratively Developing Data and Models

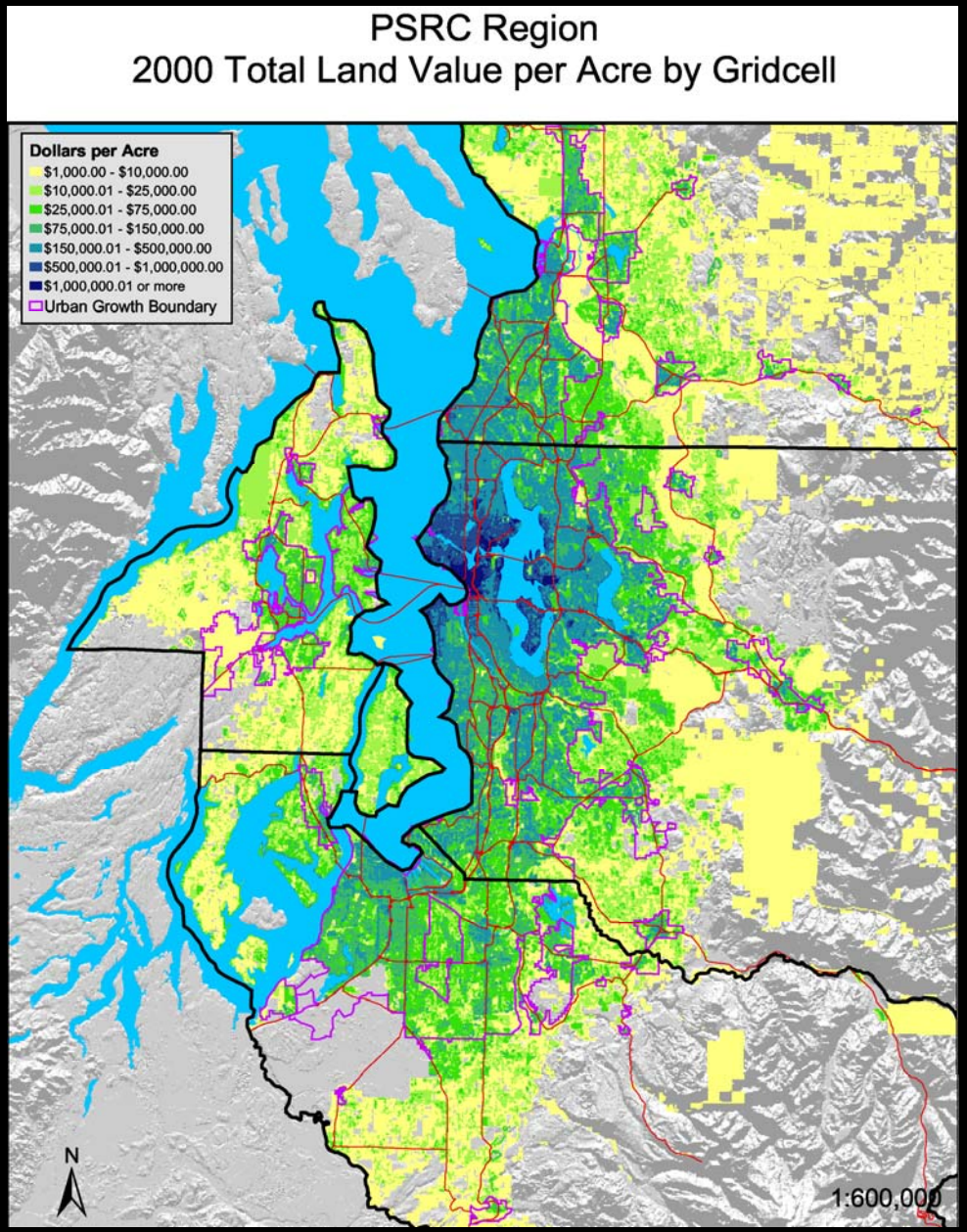
- Estimation
  - Need to fit coefficients for variables in the choice and regression models to observed data
  - For PSRC application, 18 regression models and 17 choice models to be estimated
- Model development
  - Configure the arguments used in constructing the model
  - Selecting the variables to use in the discrete choice or regression equation used in the model
- Both of these are iterative processes that require knowledge of a domain expert, and involve adding or excluding variables, and sometimes defining new ones

The Opus/UrbanSim GUI



Indicators

- Indicators provide the principal mechanism for summarizing results from the simulation. Examples:
  - Population density
  - Average household income
  - Acres of buildable land
  - Greenhouse gas emissions from transportation
- Several interrelated indicator projects
  - Results Manager section of GUI
  - Technical documentation for indicators
  - Indicator Perspectives
  - Household Indicators
- Interested both in supporting the technical modeling work, and in supporting public participation in the planning process
- The work on laying the groundwork for public participation strongly informed by Value Sensitive Design theory and methods

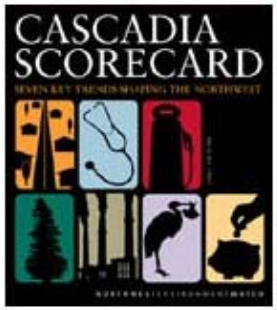


Example simulation output: Map-based indicator display for Puget Sound region

Indicator Perspectives (1)

NORTHWEST ENVIRONMENT WATCH

Cascadia Scorecard perspective on UrbanSim indicators



The Cascadia Scorecard is Northwest Environment Watch's new gauge of regional progress. The Scorecard puts a spotlight on the long view and the questions that most matter over time: Are we living longer, healthier lives? Are we building strong human communities? Are we handing down to our children a place whose ecosystems are regenerating?

In modeling sprawl, one of the seven key trends monitored by the Cascadia Scorecard, UrbanSim helps us to evaluate possible futures for our cities in comparison to historical trends and where we stand today. By better understanding the impact of public policy on sprawl, we can make better choices for a sustainable future.

Why Is Sprawl an Issue?

Sprawl—dispersed, automobile-oriented urban development—figures into the Scorecard because it contributes to a distressing array of ills. Sprawl locks northwesterners into an auto-dependent

Indicator Perspectives (2)

King County

King County Benchmarks

Perspective on UrbanSim Indicators

Since 1996, the King County Benchmark Program has published annual reports on progress in meeting the goals outlined in the Countywide Planning Policies (CPPs). As a complement to these progress reports, we provide links to indicators produced by UrbanSim, a tool for modeling the future impacts regional land use and transportation decisions. UrbanSim helps us to evaluate possible futures for our cities in comparison to historical trends and where we stand today.

Follow this link to learn more about Benchmark Indicators produced by UrbanSim in key areas of King County's growth management policy.

- Land Use

The King County Benchmark Program also includes indicators in the following additional categories. We plan to add information about these as well, as new indicators are implemented in UrbanSim.

- Economics
- Affordable Housing
- Transportation
- Environment

Benchmarking as a Strategy for Change

As one of the first and most durable efforts at monitoring outcomes in the public sector, the King County Benchmark Program demonstrates how measurement of broad quality-of-life outcomes can help determine if public policy and programs are making a difference. The purpose of King County's Benchmark Program is to provide the King County Growth Management Council and other users with a method for:

- Evaluating the progress of the County and its jurisdiction in managing growth, and
- Encouraging and measuring the implemention of the goals outlined in the Countywide Planning Policies

Public outcome monitoring is a strategy for a change: it alerts us to what we are doing well, and to where we need to do better. It is closely connected to both the policy goals that it monitors, and to the strategic planning, programs, and services

Indicator Perspectives (3)

Washington REALTORS®

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REALTORS® recognize the need to sustain and enhance the quality of life enjoyed by Washington's citizens. We believe we can build better communities by supporting quality growth and seeking sustainable economies and housing opportunities that embrace the environmental qualities we cherish, while protecting a property owner's ability to own, use, buy, and sell property.

The Washington REALTORS®' Quality of Life Program is based on the principles that Washington residents have told us are important for building better communities. REALTORS®, like other residents who live and work in the community, want a strong economy, plenty of housing opportunities, good schools and parks, safe neighborhoods and great transportation choices.

The Quality of Life Project is about creating communities where everyone thrives. Quality of life starts with a good job. It means having a roof over your head – and a range of choices in housing design, style, and price. It means the opportunity to live in communities with clean, safe neighborhoods, good schools, and efficient transportation. Our Quality of Life Project is designed to impact public policy in order to ensure economic vitality, provide housing opportunities, and preserve the environment that we cherish here.

REALTORS® are taking the lead in developing policy proposals that reflect our Quality of Life Principles.

In the Puget Sound region, UrbanSim is being used to simulate the long term effects of different transportation and land use plans in order to provide useful information for the discussion of the proposals. Below we explain how UrbanSim can help evaluate such alternatives with respect to one of the Quality of Life principles: *Providing Housing Opportunities*.

Providing Housing Opportunities

REALTORS® understand that home ownership is the cornerstone of the American Dream and deserves consideration as a top priority when it comes to quality of life. Home ownership contributes to community responsibility; civic, economic, business and employment stability; family security and well being.

Every citizen should have the opportunity to purchase an affordable, safe, and decent home near where they work, shop and play. Choice in style, price and location is critical to increasing home ownership. These objectives should be met through market-driven approaches that foster a wide-range of urban, suburban and rural housing choices at all prices.

When there is sufficient housing to accommodate growth in a community, it relieves pressures on housing prices and provides the opportunities of home ownership for all.

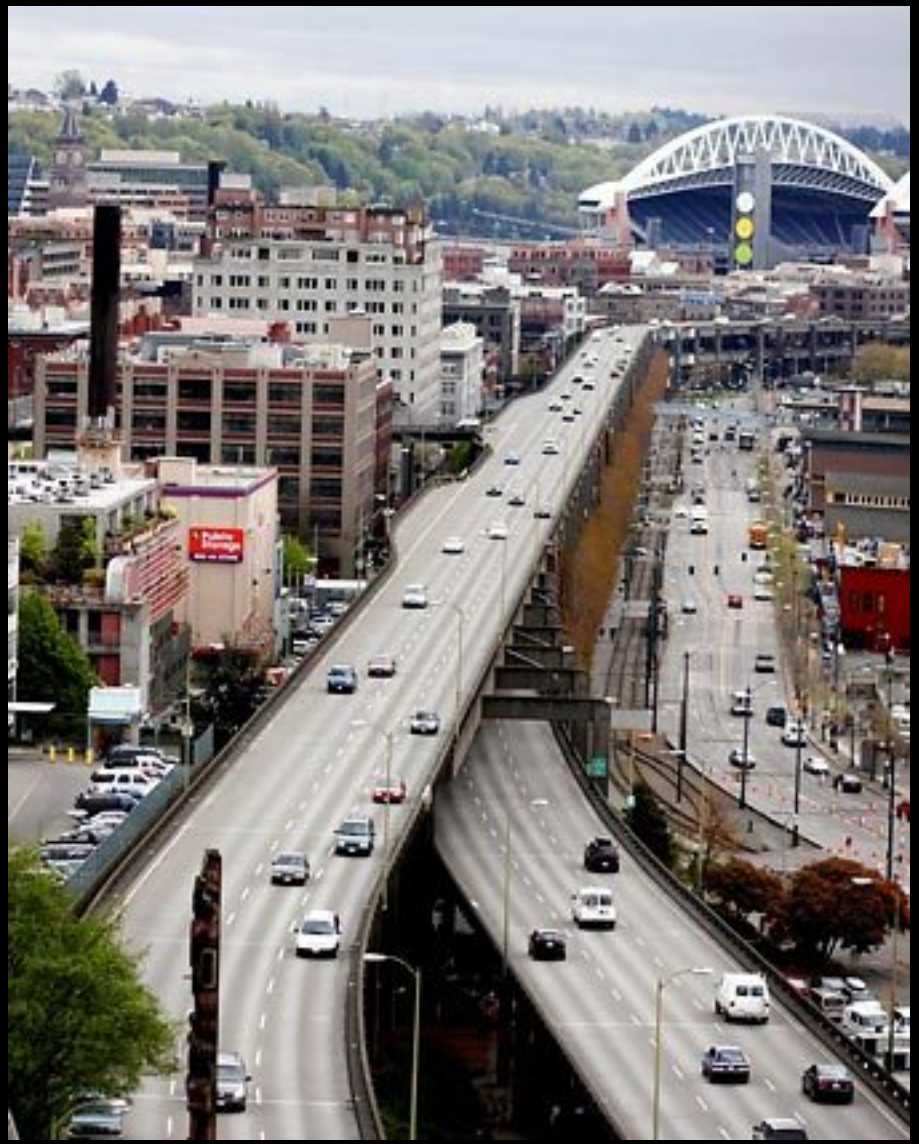
Home prices skyrocket when housing is not available where jobs are located – that causes people to buy homes further away from where they work, exacerbating traffic problems. Providing affordable housing choices close to where people work, live and play prevents long commutes and increased traffic on our roads. A community should

Some Current Projects

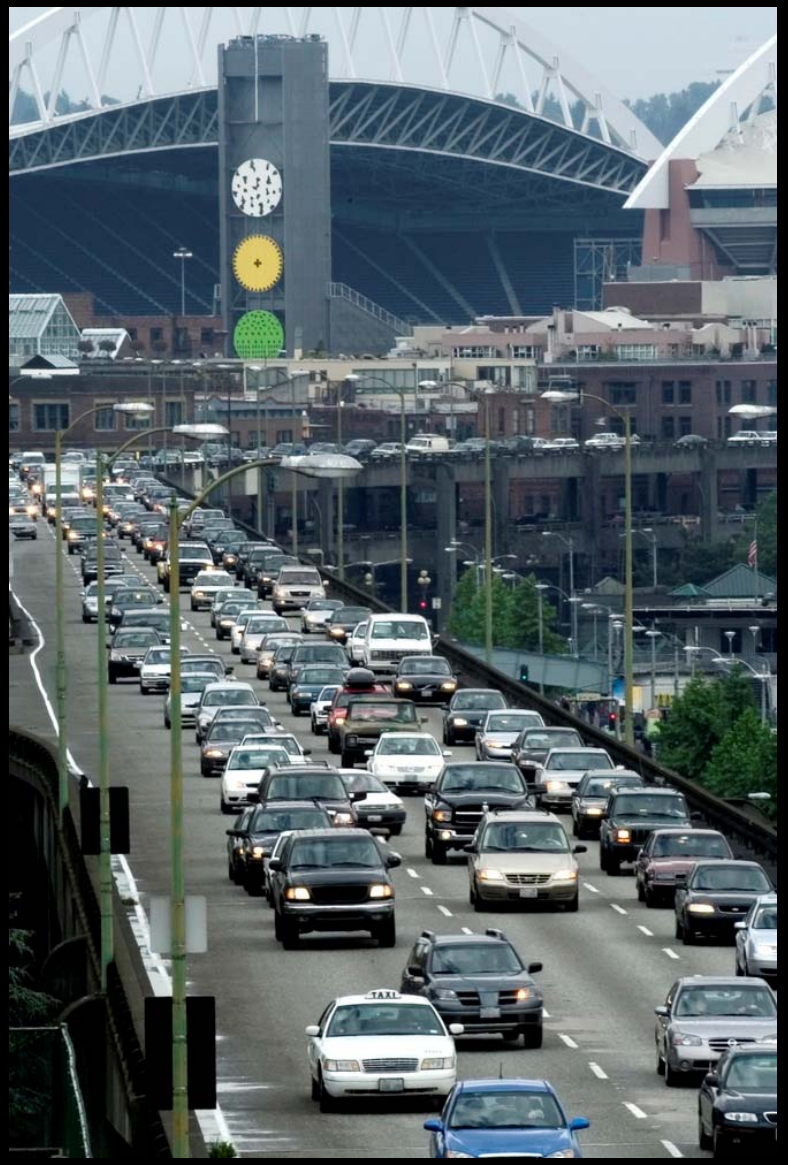
- Studying how the new UrbanSim GUI and interaction techniques change modeler practice at planning organizations
  - Importance of experimentation in appropriating UrbanSim to a new region
  - Iterative development of models — better to get a working but primitive system up soon, rather than spending lots of time up front getting the data in great shape
- Modeling and presenting uncertainty in simulation results using Bayesian Melding
- Using data from a Seattle area congestion pricing study to build better travel models
- OneBusAway project & activity recognition to inform travel models

The Alaskan Way Viaduct - Downtown Seattle

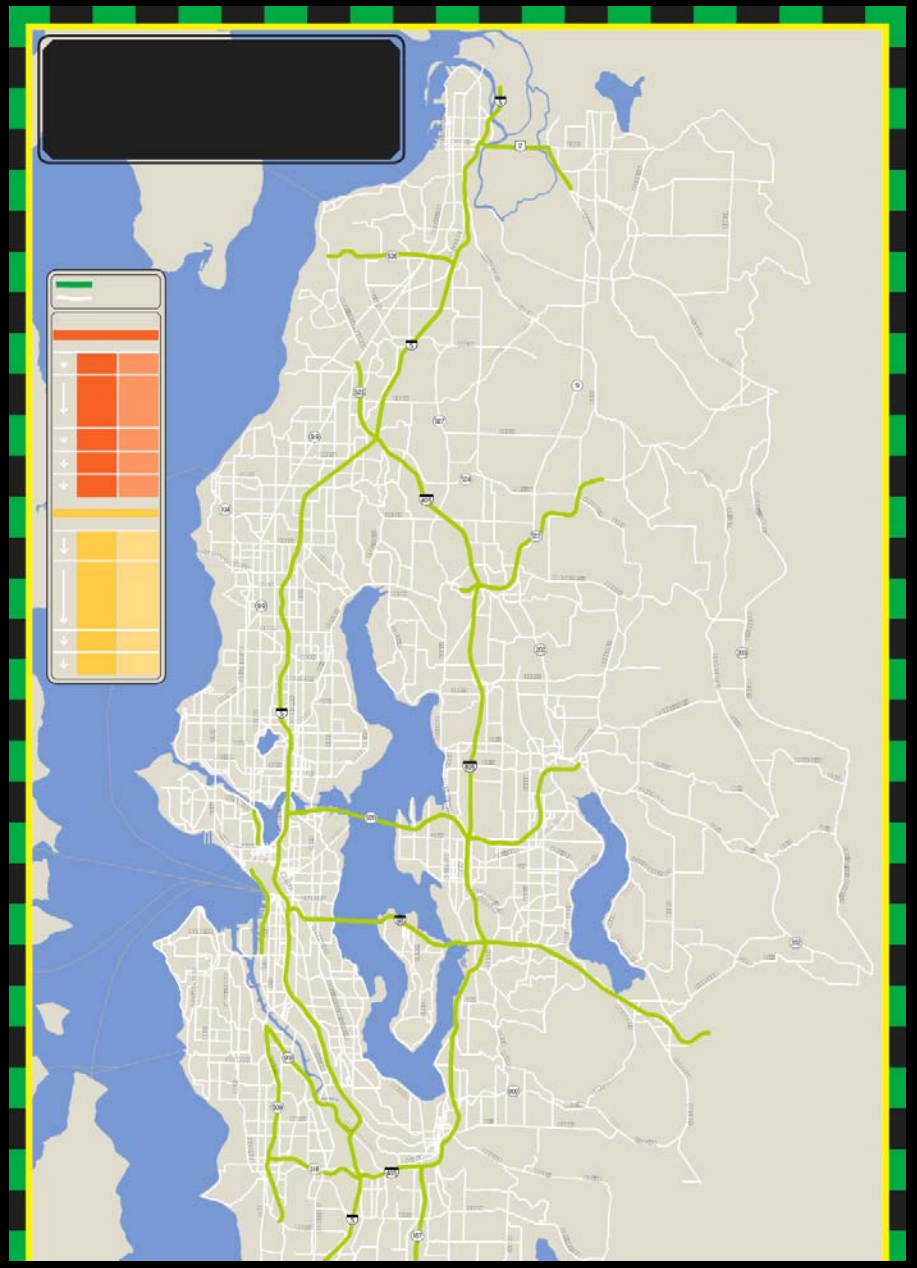
- completed 1953
- near a fault line
- damaged in 2001 earthquake



What would happen if it weren't replaced??



Tolling Scheme



Analyzing GPS Traces from Congestion Pricing Study