Scenario Planning and Visualization

Webinar 8 of an 8-part TMIP Webinar series on land use forecasting methods.

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Land Use Forecasting Webinar Series

1. The Evolving State of the Practice
2. Land Use Theory and Data
3. Scenario Planning and Visioning (I-PLACE3S)
4. Spatial Input-Output Frameworks (PECAS)
5. Dynamic Microsimulation (UrbanSim)
6. Modeling Real Estate Demand
7. Modeling Real Estate Supply
8. Scenario Planning and Visualization

2

1. **Urban Visualization**
2. Bridging the Gap Between Urban Simulation, Visualization and Geometric Modeling
3. Application: UrbanVision

URBAN VISUALIZATION

Urban Visualization

- Visualizations of land use forecasting results
  - Used by regional planning agencies to evaluate
    - Alternative transportation investments
    - Land use regulations
    - Environmental protection policies

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Urban Visualization

- Visualizations of land use forecasts
  - Interest several groups of population with different levels of expertise in handling data
    - Policy makers
    - The public
    - Modelers running the simulation

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Urban Visualization

- Traditional urban visualization techniques
  - Focused on handling large urban simulation datasets
  - Making their analysis more intuitive to urban planners
- In the following, we outline a few representative techniques

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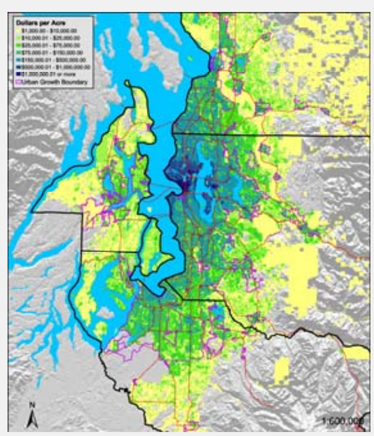
Urban Visualization

- Traditional urban visualization techniques
  - Choropleth maps: Areas **shaded** in proportion to the values of the displayed variables
  - (standard GIS respresentation)



Example simulation output:
Map-based indicator display for Puget Sound
(Total land value per acre, 2000)
From UrbanSim Application in Seattle, WA

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Urban Visualization

- Traditional urban visualization techniques
  - Cartograms: Distort a map by **resizing** its regions according to the values of the displayed variable, but keeping the map recognizable

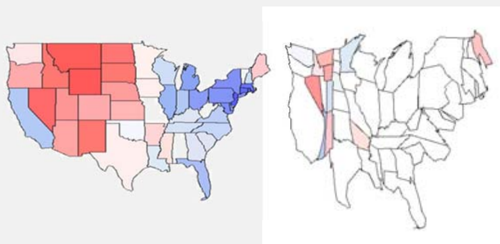

Image from:
Daniel Keim, Stephen North, Christian Panse, “CartoDraw: A Scanline based Cartogram Algorithm”, 2004.

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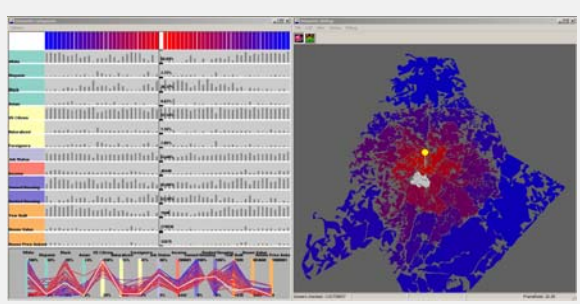
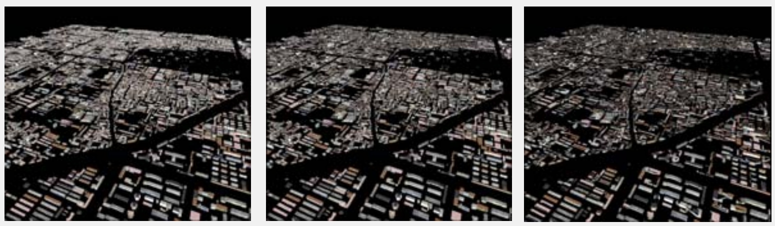
Urban Visualization

- **Legible Cities**
  Chang, Wessel, Kosara, Sauda, Ribarsky
- TVCG 2007



Urban Visualization

- Goal: Visualize an urban model in a focus-dependent, multi-resolution fashion, while retaining the legibility of the city



Original Model 45% polygons 18% polygons

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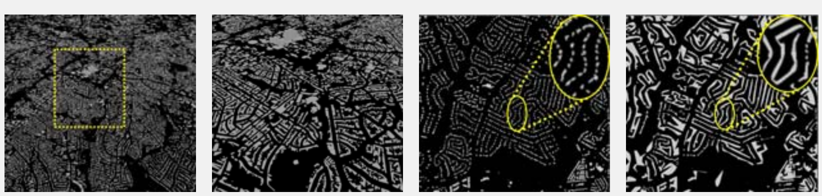
Urban Visualization

- Integrate 3D model view and data view
  - Relationships between the geospatial information of the urban model and the related urban data can be more intuitively identified



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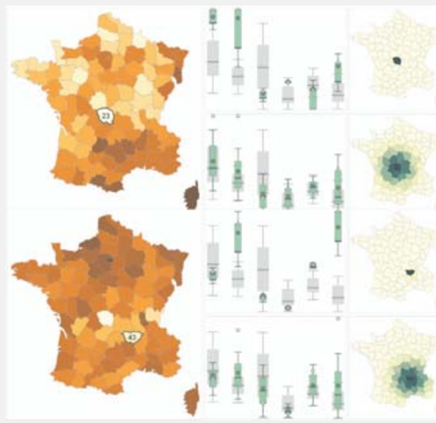
Urban Visualization

- **Geographically Weighted Visualization**
  Dykes, Brunsdon
- TVCG 2007



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Urban Visualization

- Visually encode information about geographic and statistical proximity and variation through
  - geographically weighted (GW)-choropleth maps
  - multivariate GW-boxplots
  - GW-shading and scalograms
- New graphic types reveal information about GW statistics at several scales concurrently

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Visualization of Land Use Model Results

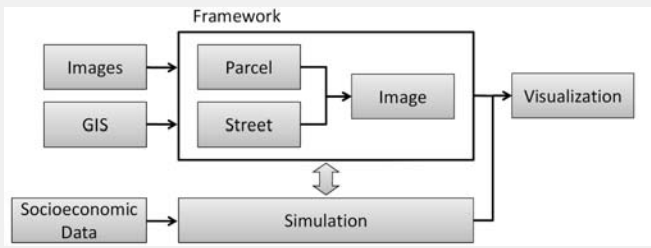
Video

- Vanegas, Aliaga, Benes, Waddell, TVCG 2009

Visualization of Simulated Urban Spaces

- Infer an urban layout
  - Images (aerial view) + Structure (streets, parcels)

  from the values of a set of simulation variables at any given time step



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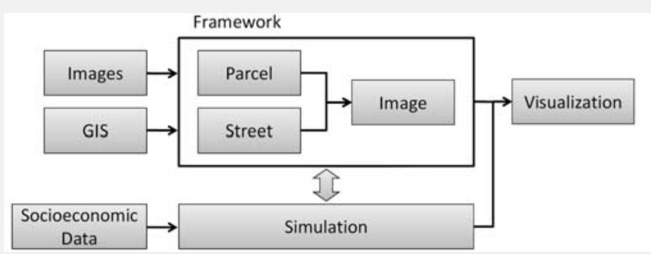
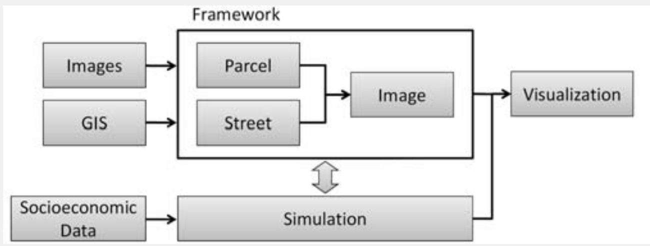
Visualization of Simulated Urban Spaces

- Approach
  - Spatially match socioeconomic data set with input aerial images and structure of the urban space



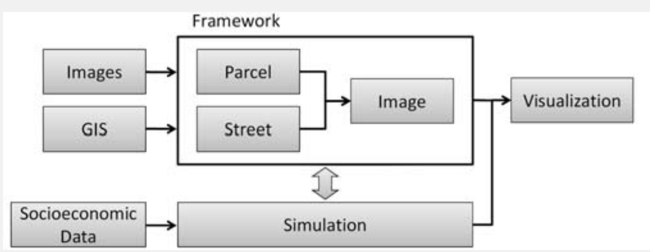
Visualization of Simulated Urban Spaces

- Approach
  - Create new structure that matches a set of attributes inferred from the simulation variables
  - New blank lots are created



Visualization of Simulated Urban Spaces

- Approach
  - Aerial view imagery is “borrowed” from existing lots of the city with similar socioeconomic attributes as the new blank lot



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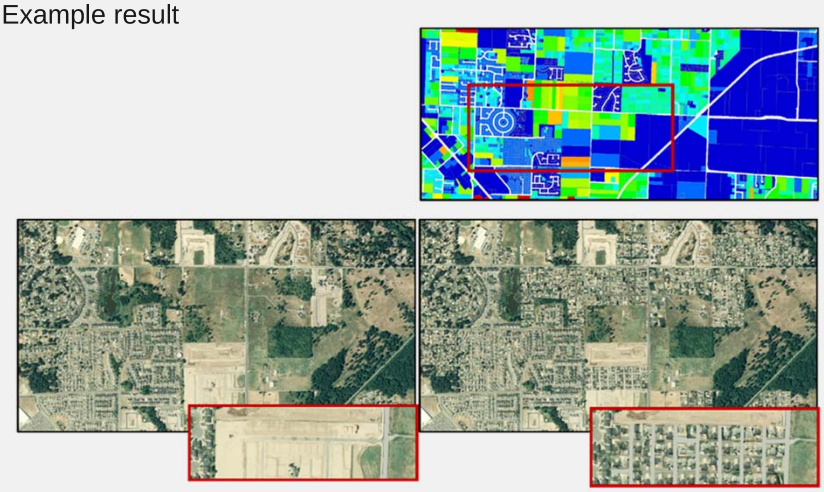
Visualization of Simulated Urban Spaces

- Example result



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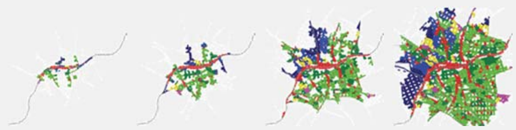
Visualization of Simulated Urban Spaces

- Example result

Bridging the gap between urban simulation, visualization and modeling

- **Interactive Geometric Simulation of 4D Cities**
  Weber, Müller, Wonka, Gross
- Eurographics 2009



Interactive Geometric Simulation of 4D Cities

- Problem:
  - How to model cities that are changing over time?
  - How to use the urban simulation data to infer the geometry of the city (roads, lots, buildings)?

Interactive Geometric Simulation of 4D Cities

- Traffic simulation for street generation

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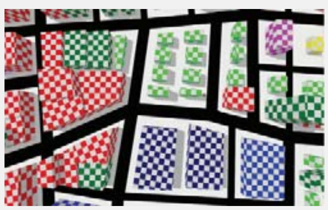
Interactive Geometric Simulation of 4D Cities

- Land use simulation
  - Optimization of a land use value function

$$luv = \lambda_{global} \cdot luv_{global} + \lambda_{local} \frac{\sum_{\forall i} lot[i].area \cdot lot[i].luv}{\sum_{\forall i} lot[i].area}$$

  - Global and Local land use goals



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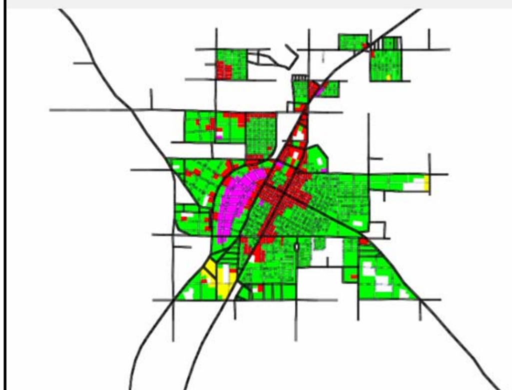
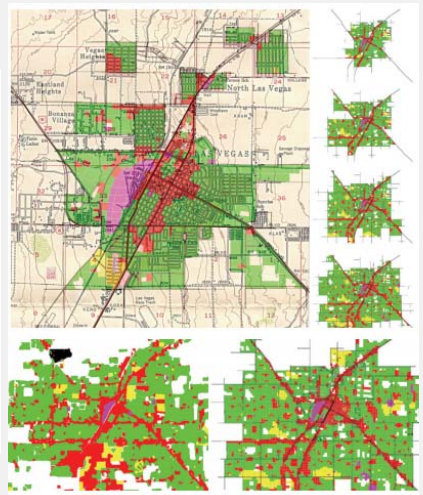
Interactive Geometric Simulation of 4D Cities

- Validation





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Interactive Geometric Simulation of 4D Cities

Video

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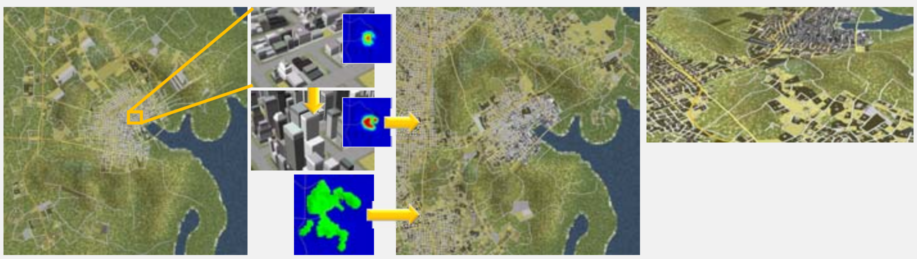
Bridging the gap between urban simulation, visualization and modeling

- **Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling**
  Vanegas, Aliaga, Benes, Waddell
- SIGGRAPH Asia 2009

Video



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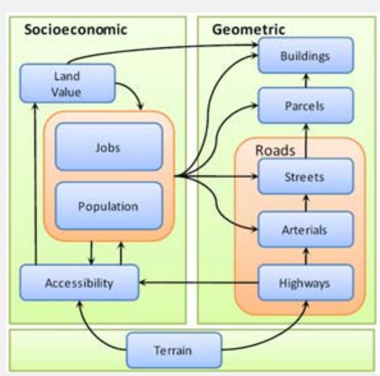
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling



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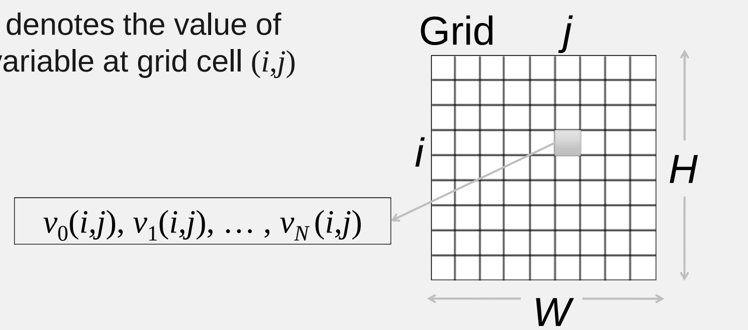
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- System
  - Consists of N variables defined over a spatial domain
  - Each variable sampled over a 2D spatial grid $\boldsymbol{G}$ of size W x H
  - $v_k(i,j)$ denotes the value of k-th variable at grid cell (i,j)



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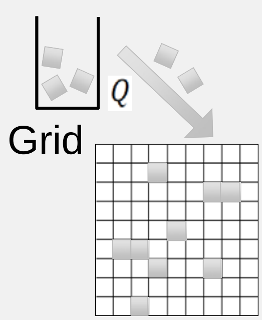
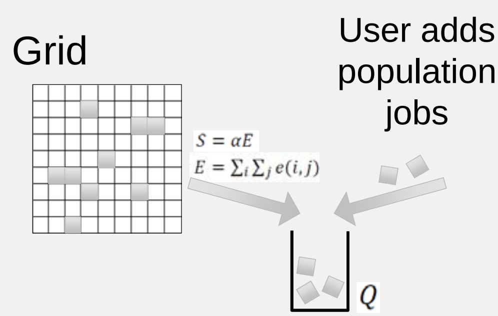
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Operations
  - Location and de-location of behavioral variables using location choice and mobility algorithms





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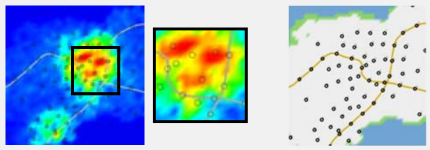
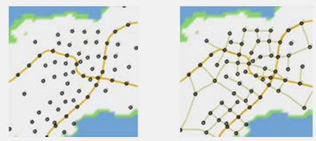
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Arterials and Streets
  - Seeds



  - Expansion of Arterials



  - Expansion of Streets

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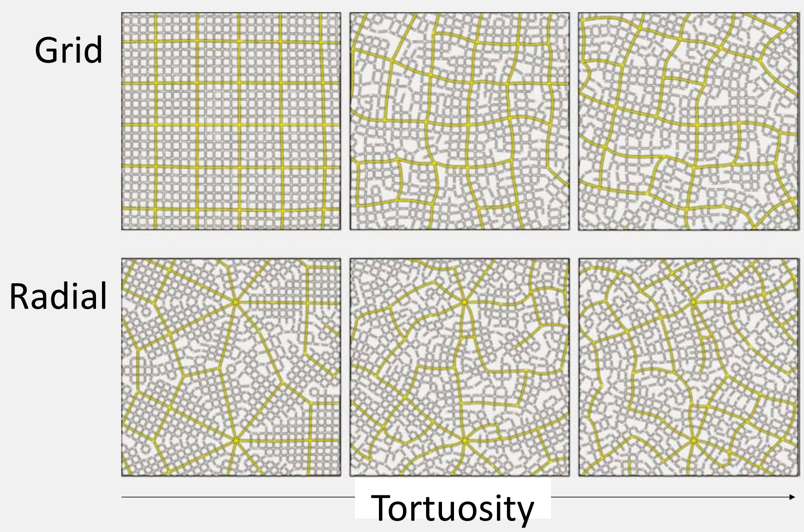
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling



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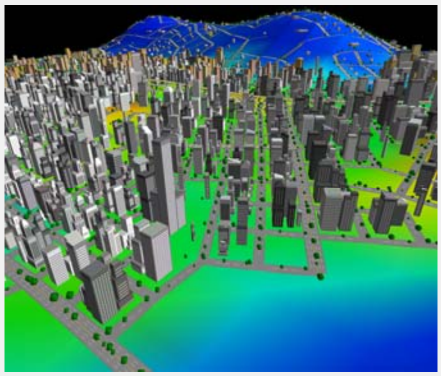
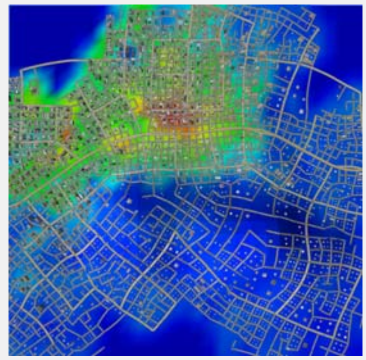
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling





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Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Validation of urban behavioral+geometric simulation model

Procedural Buildings, Parcels and Cities

Buildings Video

Parcels Video

Cities Video

Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

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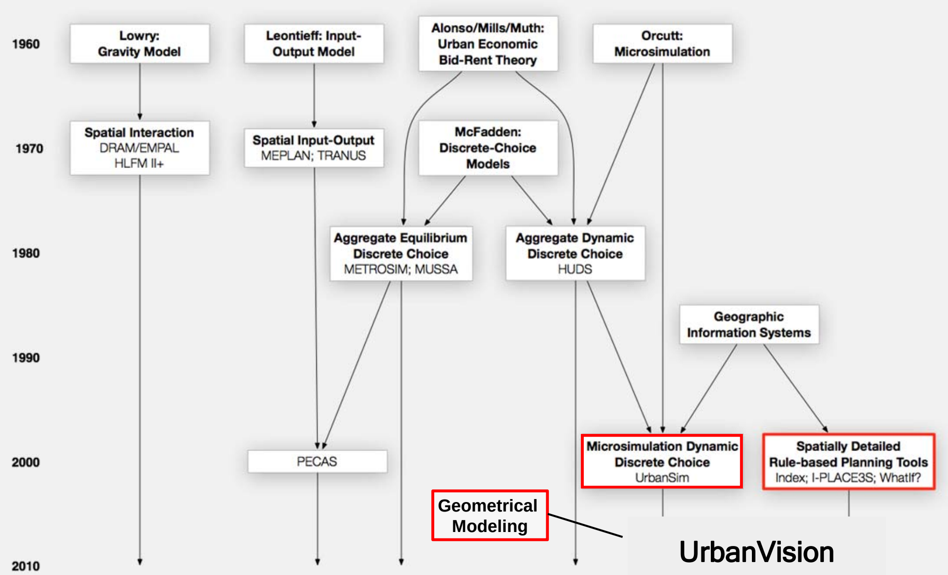
Geneology: Land Use Models & Scenario Planning Tools



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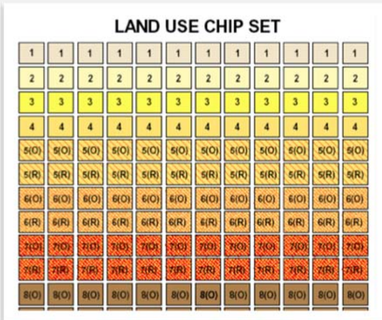
Stakeholders Create Scenarios Using Place Types



Stakeholders assign place types to map: must match target population and employment

Source: SACOG

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Fusion: Visioning, Modeling, Visualization

- Take the best elements of modeling and scenario planning and **hybridize**
- Use scenario planning to engage community in creating a preferred **Vision**
- Use disaggregate land use models to **Analyze** scenarios
- Use 3D visualization and indicators to **Visualize** scenarios
- This is the aim of the **UrbanVision** platform

The UrbanVision Project

- Funded by Metropolitan Transportation Commission, NSF, and the University of California (MRPI)
  - MTC Plan Bay Area, a Sustainable Communities Strategies Planning Process
  - Involves visioning, modeling, and visualization for community engagement
- Collaborative Project between UC Berkeley and Purdue University
- Summary:
  - Develop an extension to UrbanSim
  - Add 3D geometric modeling and rendering
  - Add flexible indicator and accessibility framework
  - Add scenario editing/creation interface

UrbanVision Design Elements and Use Cases

- **Use Case 1**: Visualize completed scenarios
  - Generate 3D buildings and streetscapes consistent with scenario
  - Support interactive exploration of 3D rendering, including comparison of scenarios
  - Generate animated visualization of traffic and pedestrians consistent with scenario
  - Generate indicators consistent with scenario
- **Use Case 2**: Generate detail for a zone-level scenario
  - Given initial vision-based scenario at a zone level, fill-in details
  - Use zoning editor to set zoning and overlays for scenario at a parcel level
  - Generate buildings within building envelopes, up to zone-level targets
  - Allocate target population and employment
- **Use Case 3**: Create, Model, and Visualize scenarios, generate preferred scenario
  - Use UrbanSim and new developer model + zoning editor + 3D Visualization

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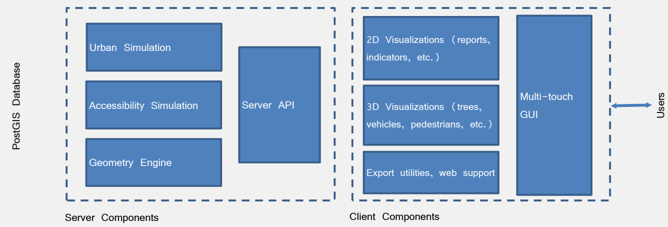
UrbanVision System Design



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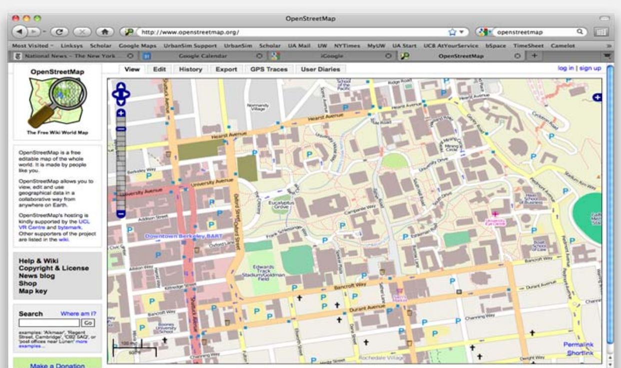
Data Sources

- Digital terrain models
- Digital orthophotos
- Street Network
    - openstreetmap.org
- Parcels
- Building attributes
- Google buildings where available and of good quality
- Zoning
- General Plans
- Planned Developments
- Business establishments
- Synthesized population
- Planning boundaries



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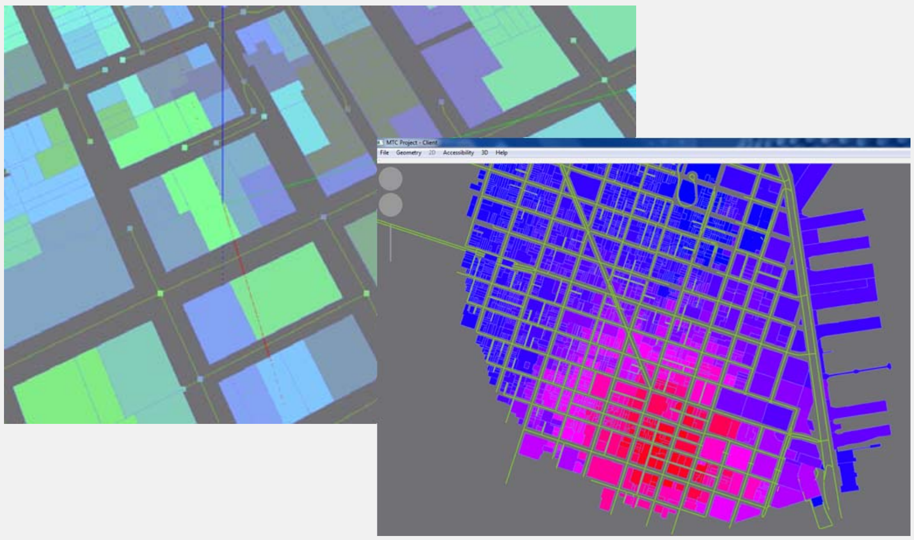
Connecting Urban Geometry, Computing Accessibilities



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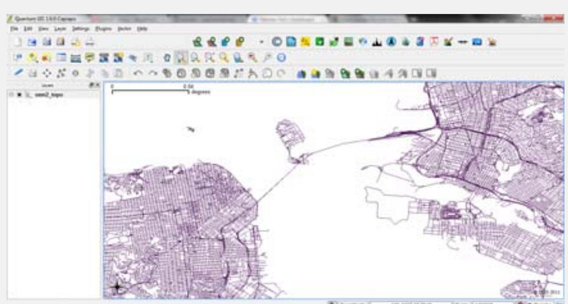
San Francisco Bay Area Case Study

- Full street network - 463K street edges
- Full parcel set - 2.1M parcels
- Data stored as households, businesses, buildings



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The “buffer query”

- Variables in location choice models
- Variables in travel model generators/attractors
- Real estate comparables
- Micro-accessibility measures for walkability

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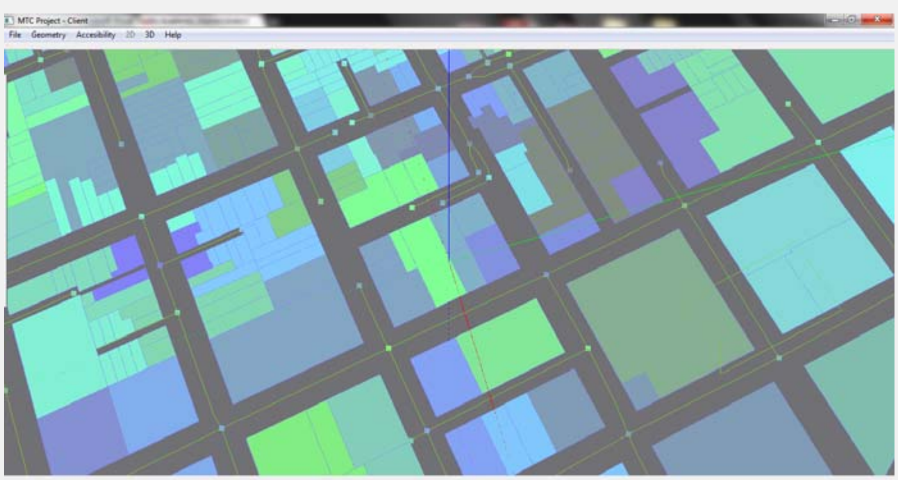
Parcel - Street Network Linkage

- Given a variable associated with a parcel, connect it to the street network and aggregate



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Types of Data

Parcels	Buildings	Households	Persons	Jobs
Parcel id	Building id	Household id	Person id	Job id
Zones, cities, zip code, etc.	Parcel id	Building id	Household id / Job id (if worker)	Building id
1.18 million parcels	1.0 million buildings	1.28 million households	3.2 million people	1.85 million jobs

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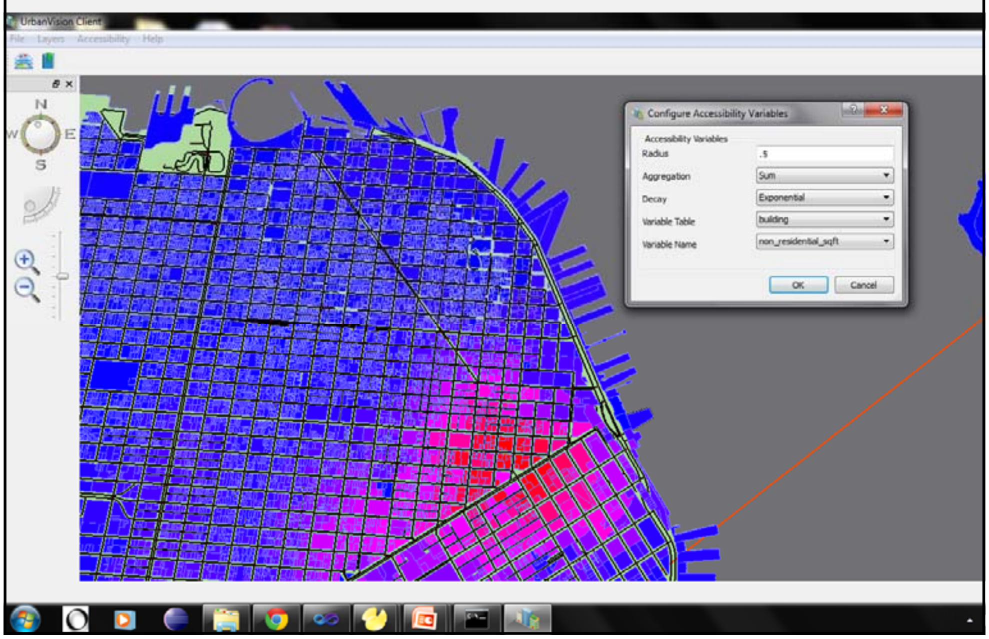
Heatmap #1: Non-residential Sqft



Heatmap #2: Residential Sqft

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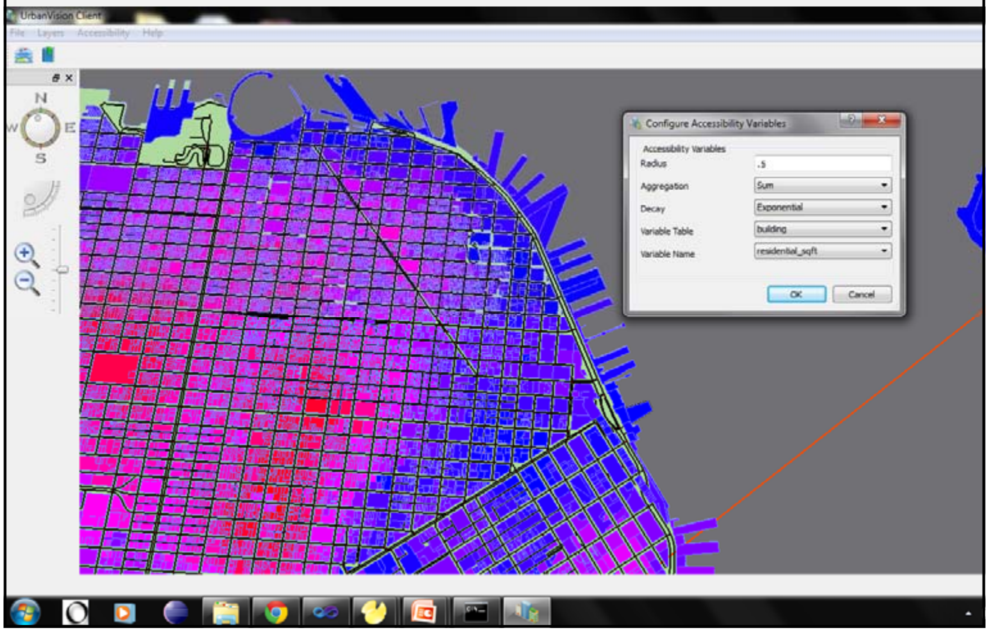

Heatmap #3: Entropy Res/Nonres Sqft (areas of diversity)

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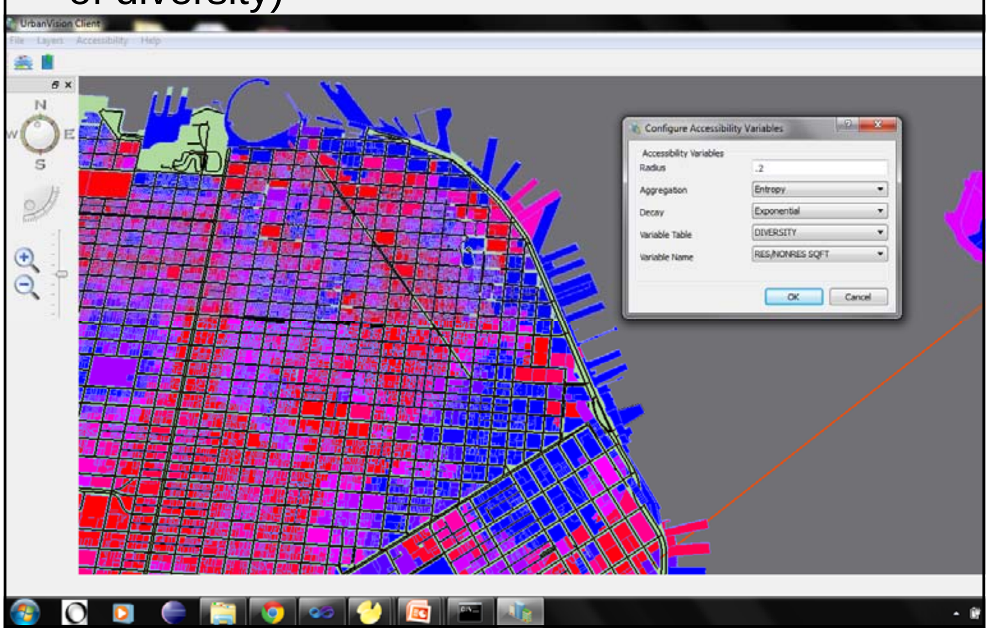

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Accessibility Engine:
High-performance Accessibility Queries

- On a Bay Area all-streets network has 456K links, 355K Nodes, computing a Walk Score (our implementation), accumulating approximately 15 different Points of Interest for each node, takes less than 3 seconds.
- On a national all-streets network with approximately 12 million nodes, queries such as the number of intersections within 1/3 kilometer runs in 15 seconds (total, for all nodes in the national network)
- Point-to-Point Accessibilities (minimum path) queries are extremely fast:
  - Bay Area sized network: ~ 20-40 microseconds per query
  - Continental sized network: ~ 100 microseconds per query
- This Accessibility Engine is being developed into an API for use in models and other ad-hoc queries

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Building Types in UrbanVision
Used for Proforma Real Estate Modeling and for Procedural Modeling of 3D Buildings

Single-Family Detached	Includes Manufactured/Prefab/Mobile Homes
Single-Family Attached	Townhouses
Multi-Family	Includes Affordable/Senior Housing
Office	Includes Civic, Institutional, Infrastructure...
Hotel	
Light Industrial	
Warehouse Industrial	
Heavy Industrial	
Strip Mall	
Big-Box Retail	
Residential Focus Mixed	
Retail Focus Mixed	Includes Traditional Main Street Type
Employment Focus Mixed	Urban Village, Downtown

14 base types, total of 64 sub-types, used for both real estate modeling (pro-formas), and procedural modeling and rendering

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Procedurally-Generated Buildings

Video

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Developer Model
Uses Geometry & Accessibility Engines

Spec Development Model

Identify Sites — Determine Feasibility — Generate Outputs

- Optimize proforma NPVs of auto-generated, physically feasible, and entitled development proposals
- Provide information to parcel and building databases

Fee Development Model

User Specified Events

- Accepts inputs from cities, counties, and others regarding redevelopment projects and other projects made possible by public subsidy rather than market demand

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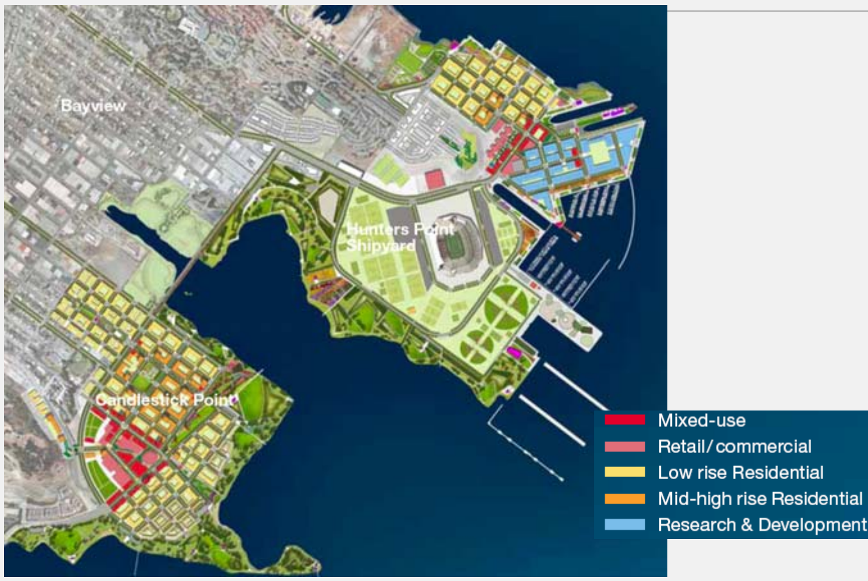
Layout of Planned Developments



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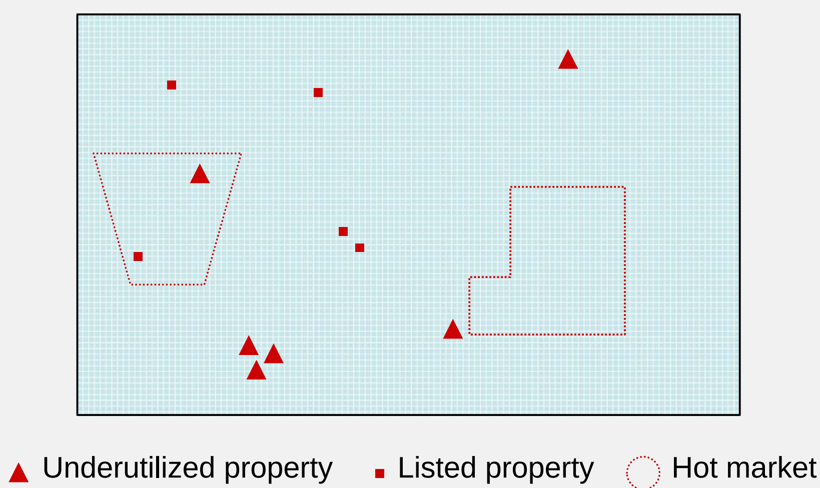
Simulating Developer Site Selection Process Filtering on Spatial Criteria (what is adjacent and nearby)



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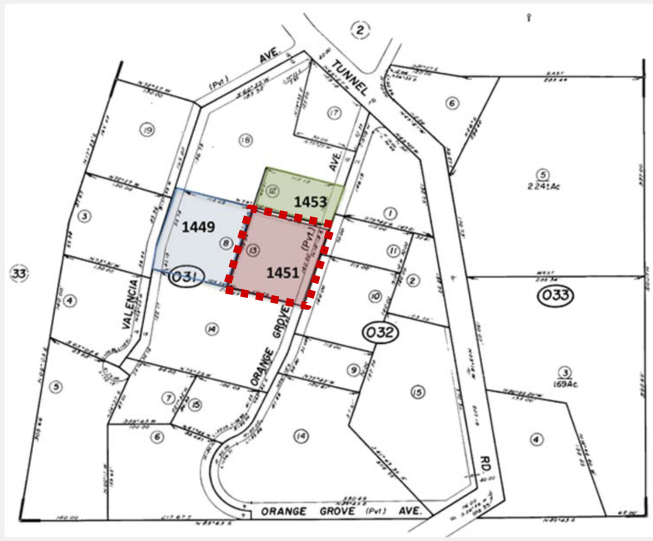
Considering Alternative Development Configurations for Redevelopment and Subdivision



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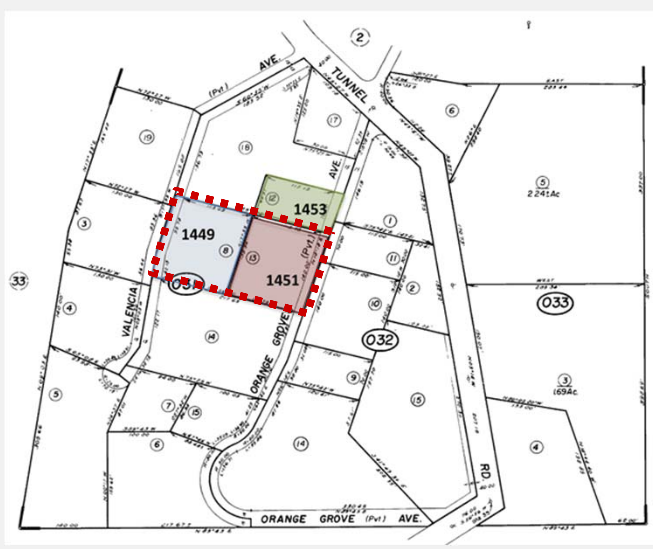

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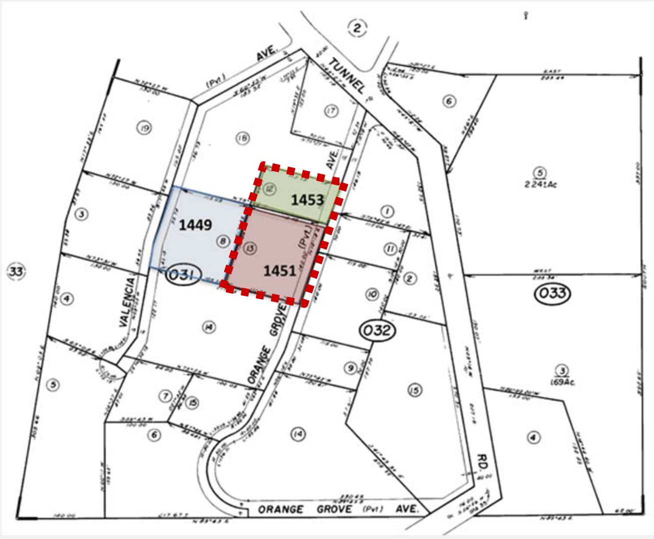

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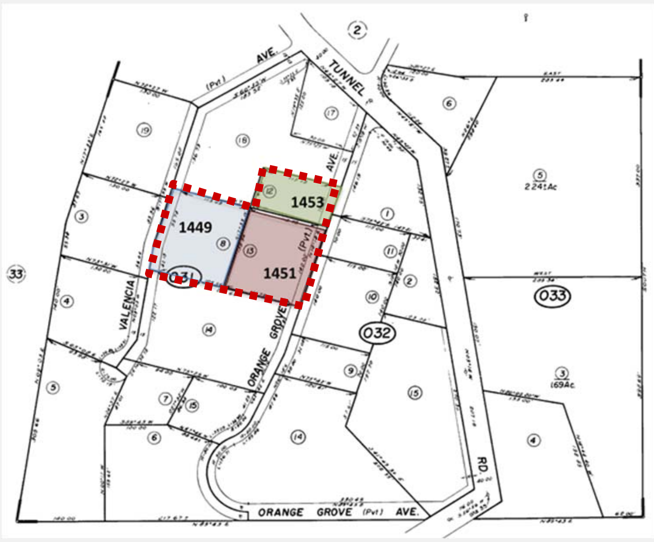
Considering Alternative Development Configurations for Redevelopment and Subdivision



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Doing Market Analysis

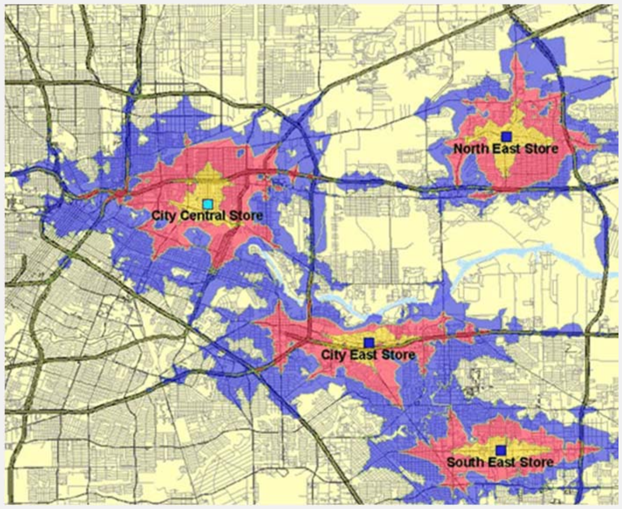

Image source: MappingAnalytics.com

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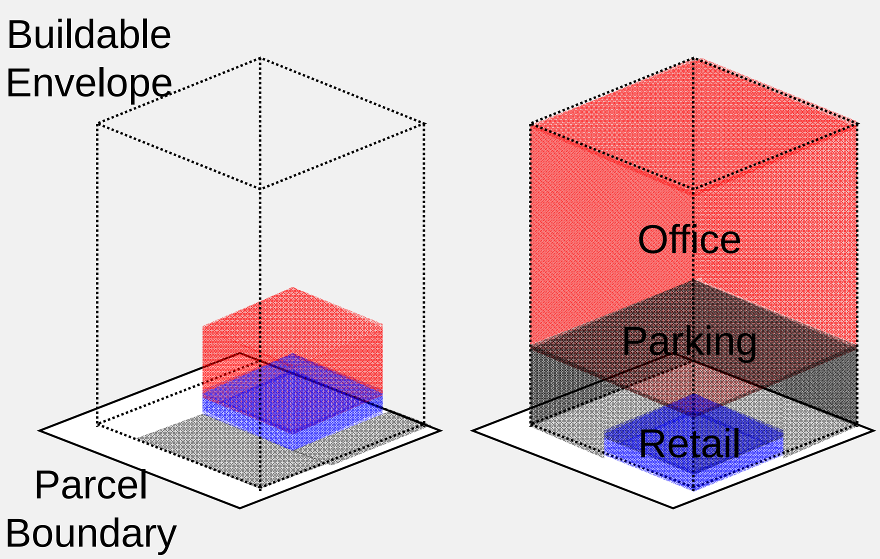
Assessing Building Envelope from General Plan and Zoning



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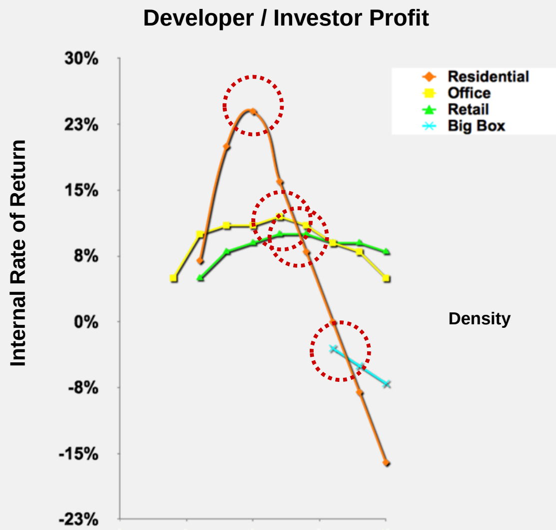
And Simulating the Proforma Analysis to Maximize Profit based on Alternative Densities and Uses



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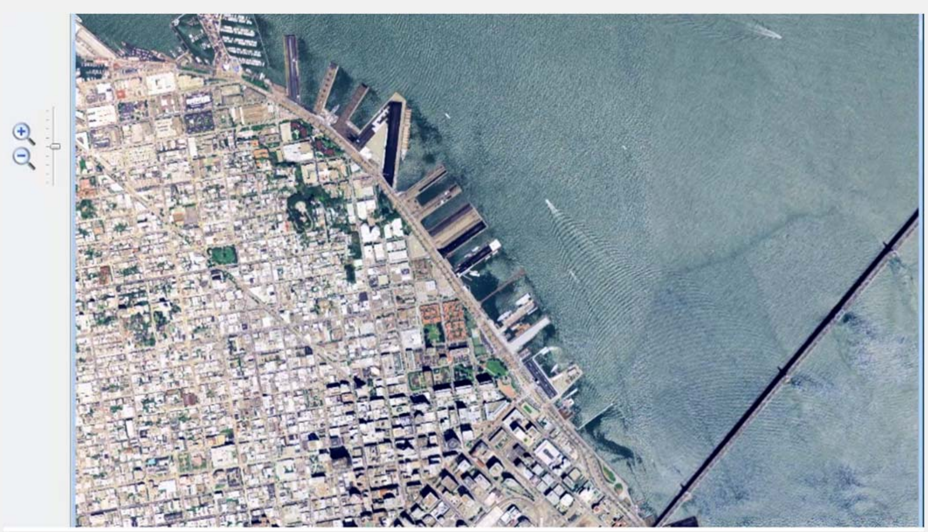
UrbanVision: Visualization Interface

Video



Paul Waddell, 2011

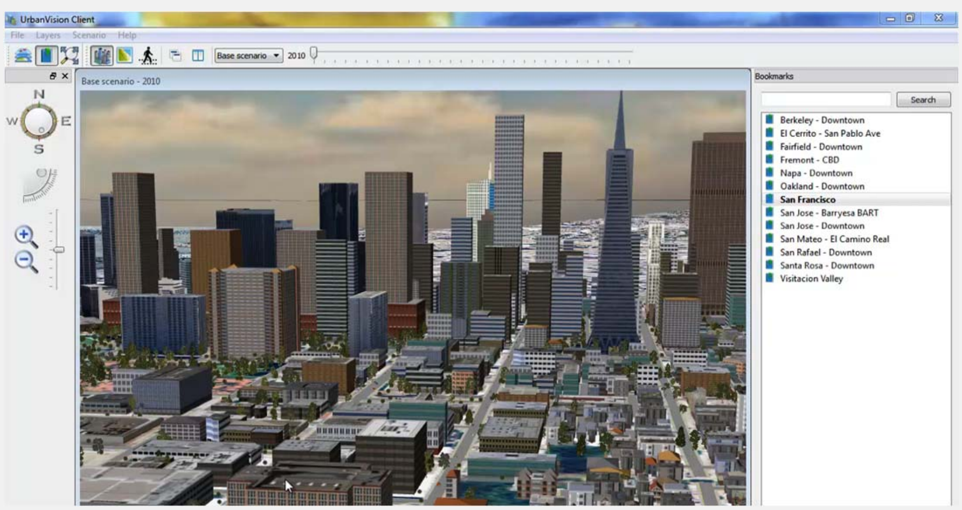
UrbanVision: Visualization Interface - Street View

[Video]

Paul Waddell, 2011

UrbanVision: Indicator Workspace

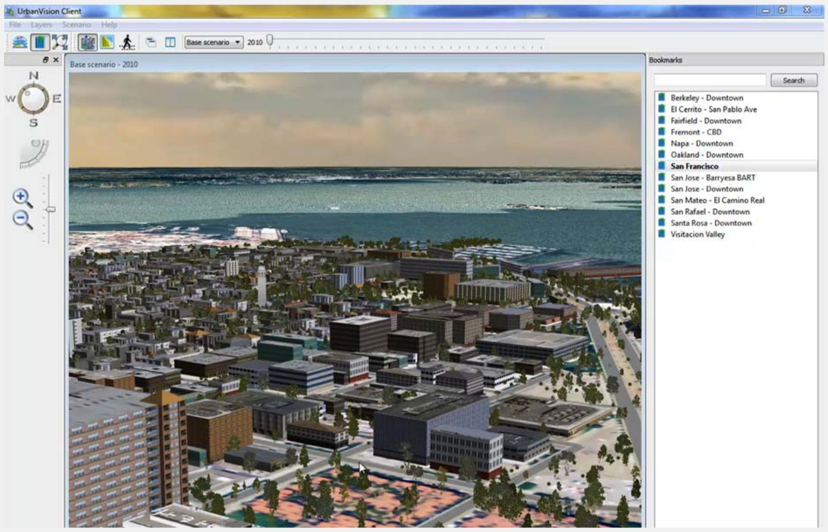
[Video]



Paul Waddell, 2011

UrbanVision: Zoning Editor Interface

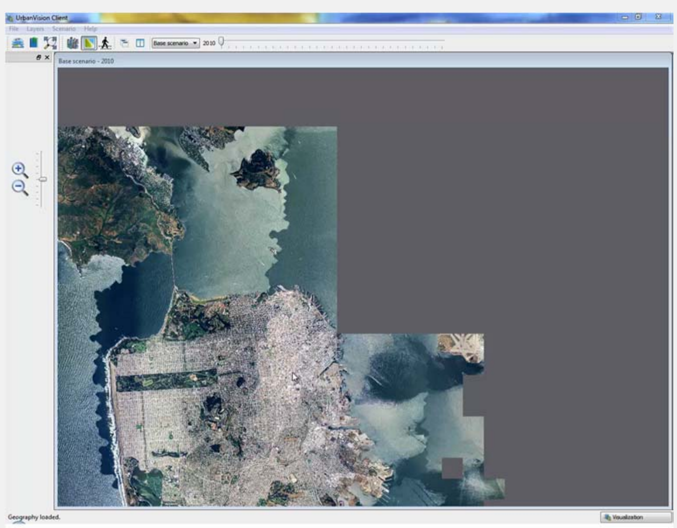
Video



Paul Waddell, 2011

UrbanVision: Travel Model Network Matching

Video



Summary and Next Steps

- Developed an integrated UrbanVision platform for
  - **Visioning**: engaging communities in designing their future
  - **Modeling**: analyzing alternative land use and transportation policy/design scenarios
  - **Visualizing:** 3D representation of alternative scenarios, with indicators
- Developed efficient pedestrian-scale accessibility and urban design calculator
- Implementing a realistic real estate development simulator
- Tightly coupling: UrbanSim+Activity-Based Travel Model+UrbanVision
- Will launch in public workshops in the Bay Area in January 2012
- **Immersive Cities Lab** at UC Berkeley

Questions and Discussion

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