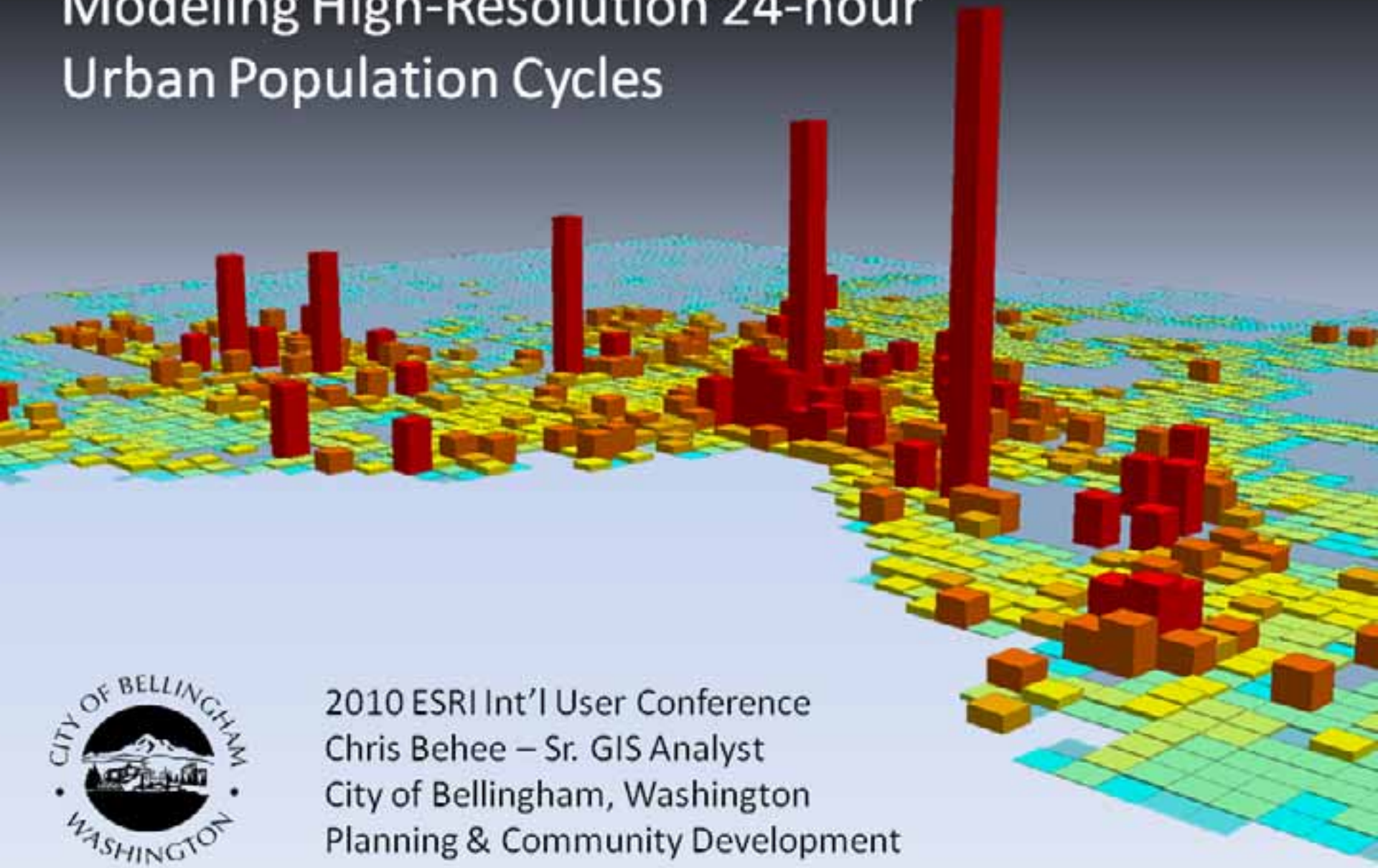
Presentation UC1201

Modeling High-Resolution 24-hour Urban Population Cycles



2010 ESRI Int'l User Conference
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City of Bellingham, Washington
Planning & Community Development

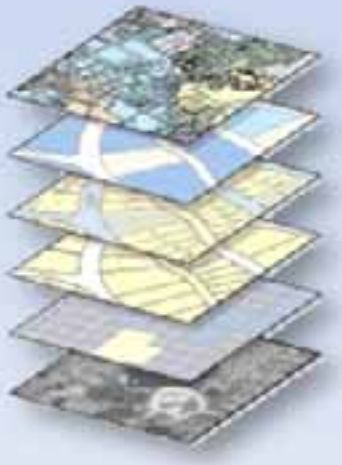
Where is Bellingham?

The Question

How does the population distribution in an urban area like Bellingham fluctuate during a typical 24-hour cycle?

The Applications

- Land Use and Transportation Planning
- Disaster Response / homeland security
- Socio-environmental modeling




The Problem

Typical block-level Census only data depicts nighttime resident population. How do you figure out where people are throughout the day?

The Inspiration

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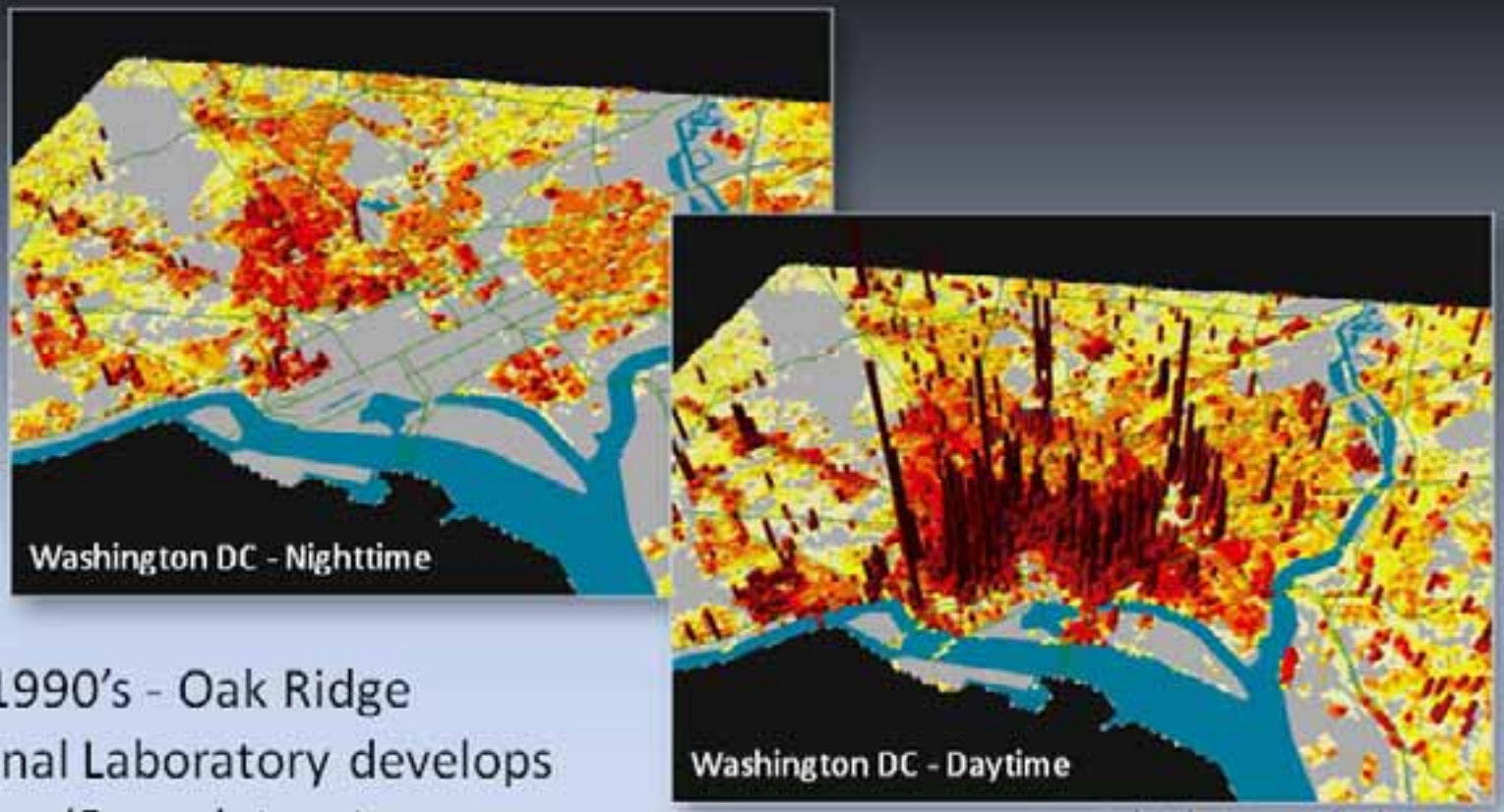

Images courtesy, Oak Ridge National Laboratory

Late 1990's - Oak Ridge National Laboratory develops the *LandScan* dataset.

- USA = 90 meter resolution, global = 1 km resolution
- 2 Population distribution intervals (Daytime, & Nighttime)
- Uses Census Bureau, socio-economic, cultural, and satellite data.

The Goal

Develop a population distribution model similar to *LandScan*, but with higher temporal resolution. Model 12 population distribution intervals per day, rather than 2.

Need to account for:

- Resident population - where people live.
- Employee population - where people work.
- Customer population – where people shop or seek services.
- Student population – where people go to school.
- Large portions of these populations overlap, so what percentage of each population is at what locations, and when?

The Data

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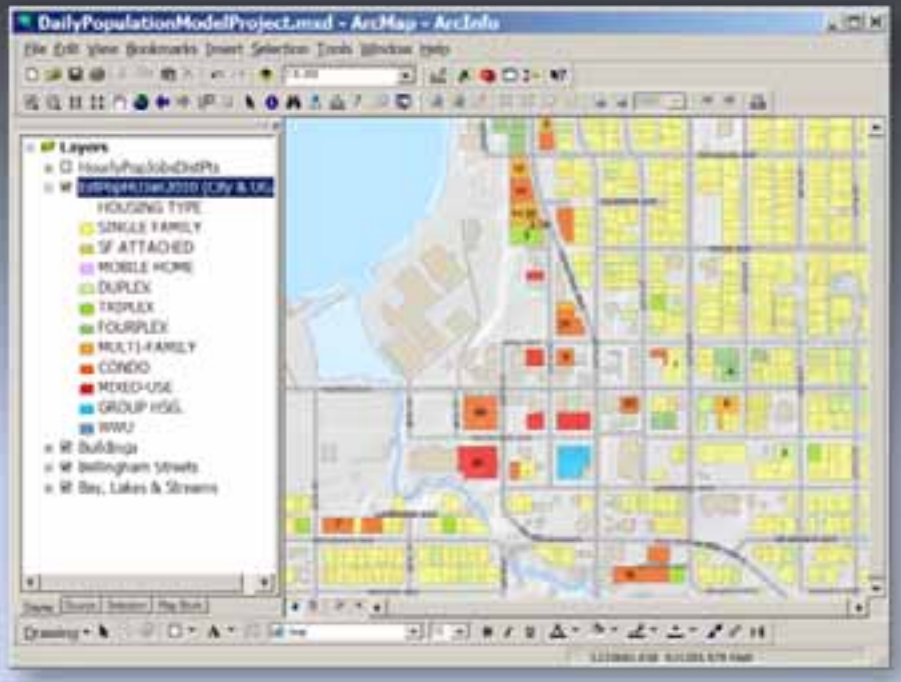
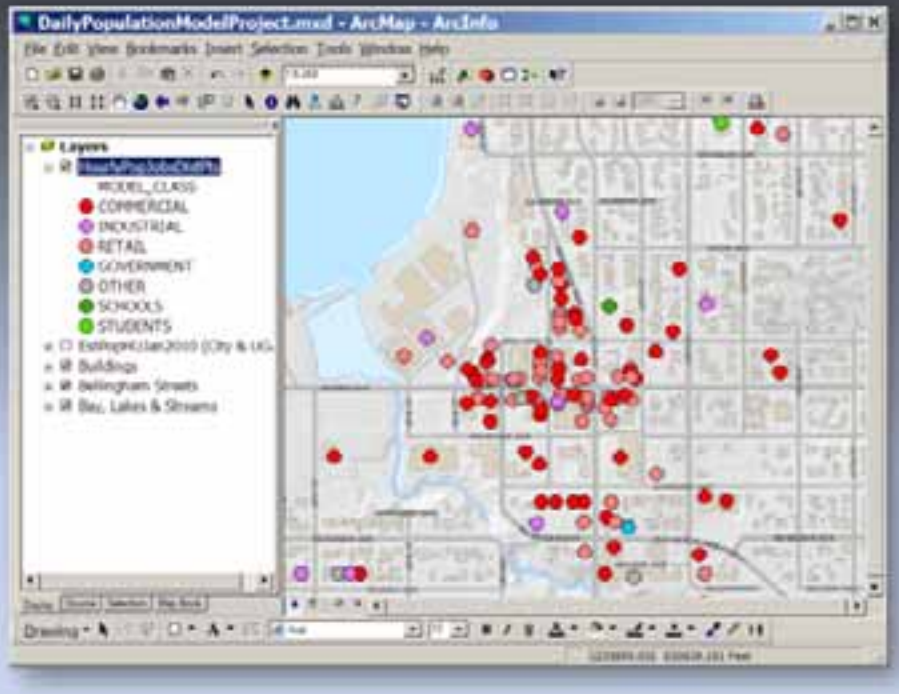


Resident population estimates are made at the parcel-level from County Assessor's tax-use codes. These codes identify housing types and unit counts.

Census 2000 occupancy and vacancy rates are then applied to model the population in these units.

Ancillary data sources are used to identify population in group housing, and student dormitories.



Employee populations are derived from a geo-coded, commercially available, business database (*InfoUSA*). This database is updated annually, and covers private and public employment sectors. Attributes include NAICS (North American Industrial Classification System) codes, total employees, and square footage estimates for each business.

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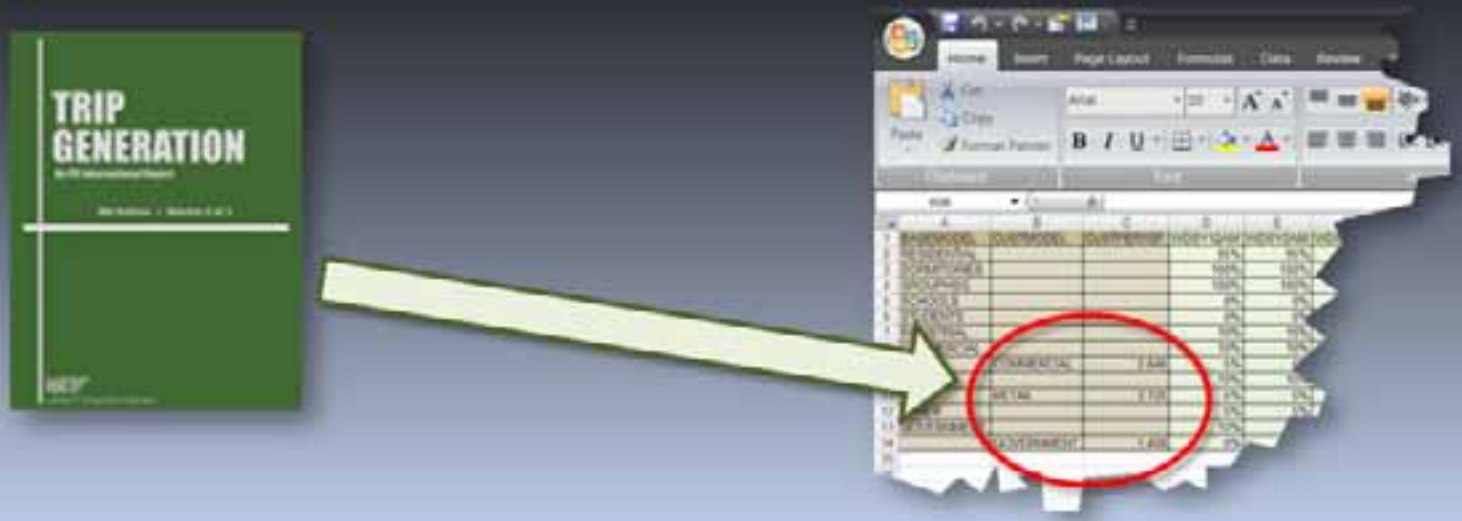

Customer populations are estimated based on the Institute of Transportation Engineers "Trip Generation Manual, 7th Edition." This model estimates average daily customers per 1,000 square feet of use by industry sector (industrial, commercial, retail, government, etc.). The average daily customers are converted to peak load values for each NAICS sector and multiplied by the square footage estimates from the business database.

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Table CF.4. Bellingham School District #501
Inventory of School Facilities

	Site Acres	Facility Sq Ft	Student Capacity	2008-2009 Enrollment	Capacity Used
Elementary					
Alderwood	10.7	30,947	300	269	90%
Birchwood	4.6	33,510	350	350	100%
Carl Cozier	4.2	45,350	500	405	
Columbia	3.0	35,041	500	20	
Geneva	8.8	52,013	500		
Happy Valley	7.5	29,697	450		
Larrabee	13		20		

Student populations are based on City of Bellingham Comprehensive Plan totals for K-12 public school enrollment by school site, and current FTE enrollment statistics for Western Washington University, Whatcom Community College, and Bellingham Technical College.

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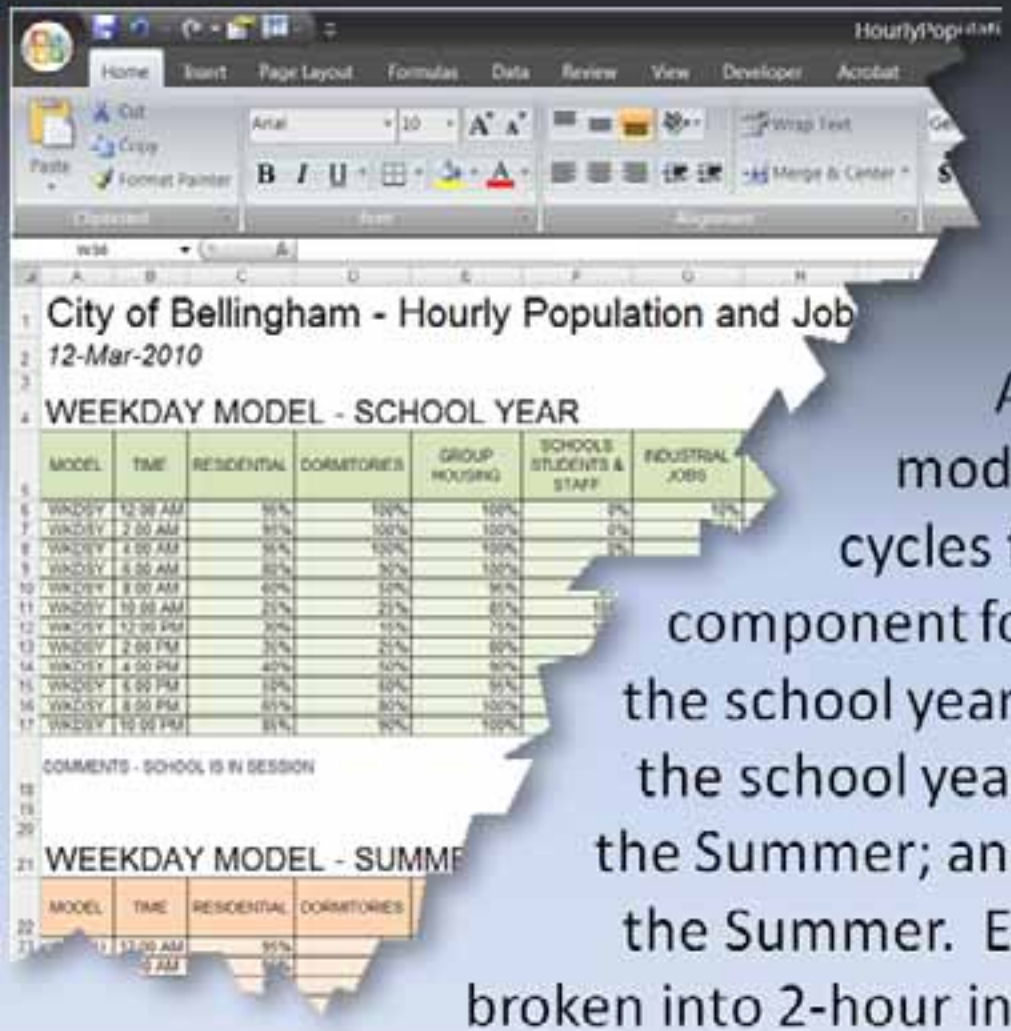

An Excel worksheet models typical 24-hour cycles for each population component for a weekday during the school year; a weekend during the school year; a weekday during the Summer; and a weekend during the Summer. Each 24-hour cycle is broken into 2-hour intervals beginning at 12:00am and progressing through 2:00am, 4:00am etc.

Weekday, School Year Model

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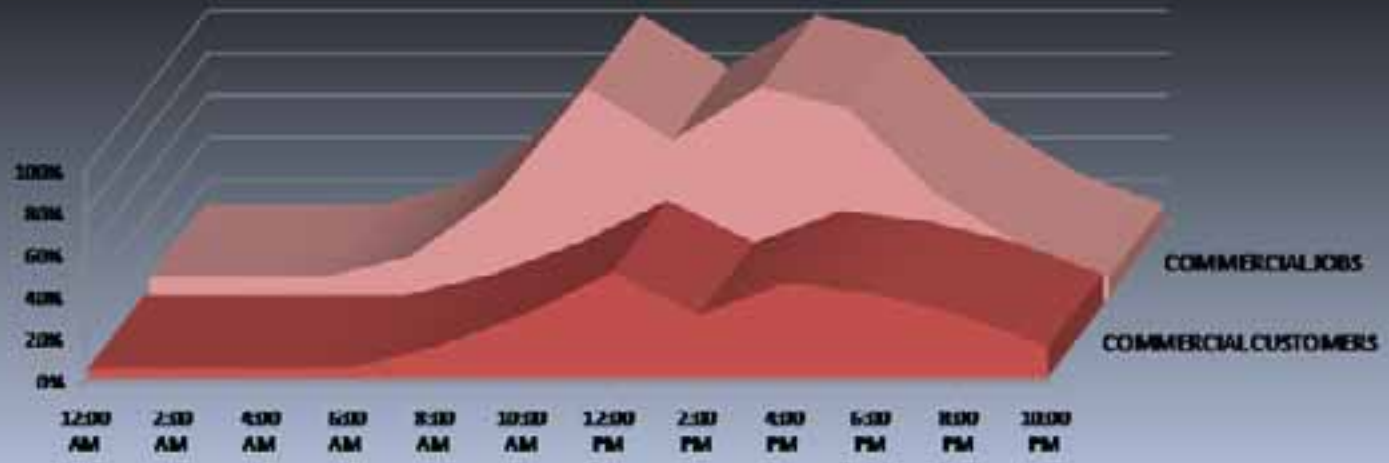

Commercial employment sites stay at 10% through the night hours and load rapidly from 6:00am to peak at 100% at 10:00am and 2:00pm on either side of the lunch hour. Commercial customers stay at 5% through the night hours and load slowly to a 50% peak at noon. They then taper slightly and decrease steadily throughout the evening hours.

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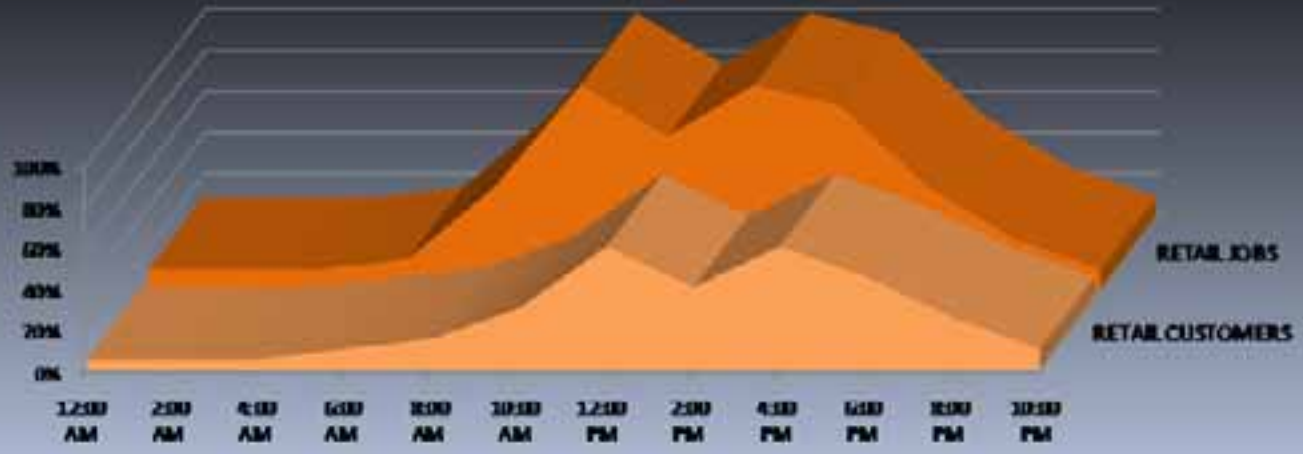

Retail employment sites stay at 10% through the night hours and load rapidly from 6:00am to peak at 100% at 10:00am and 2:00pm on either side of the lunch hour. Retail customers drop to 5% at night and load steadily from 6:00am to a 60% peak at noon. They then taper slowly throughout the evening hours. Note: Retail customers reach a 100% peak at noon on weekends.

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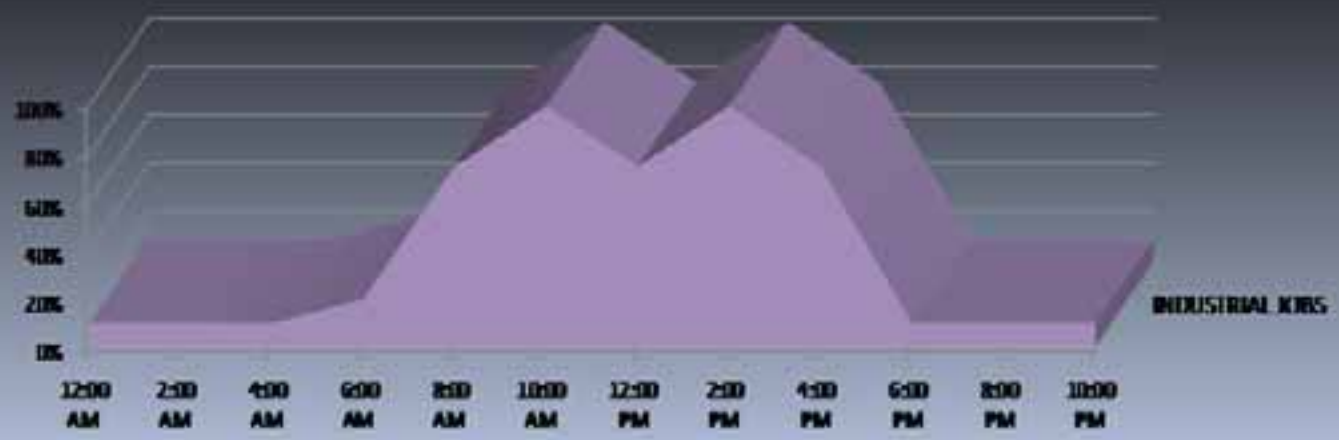

Industrial employment sites stay at 10% through the night hours and load very rapidly from 6:00am to peak at 100% at 10:00am and 2:00pm on either side of the lunch hour. They then decline rapidly after 4:00pm.

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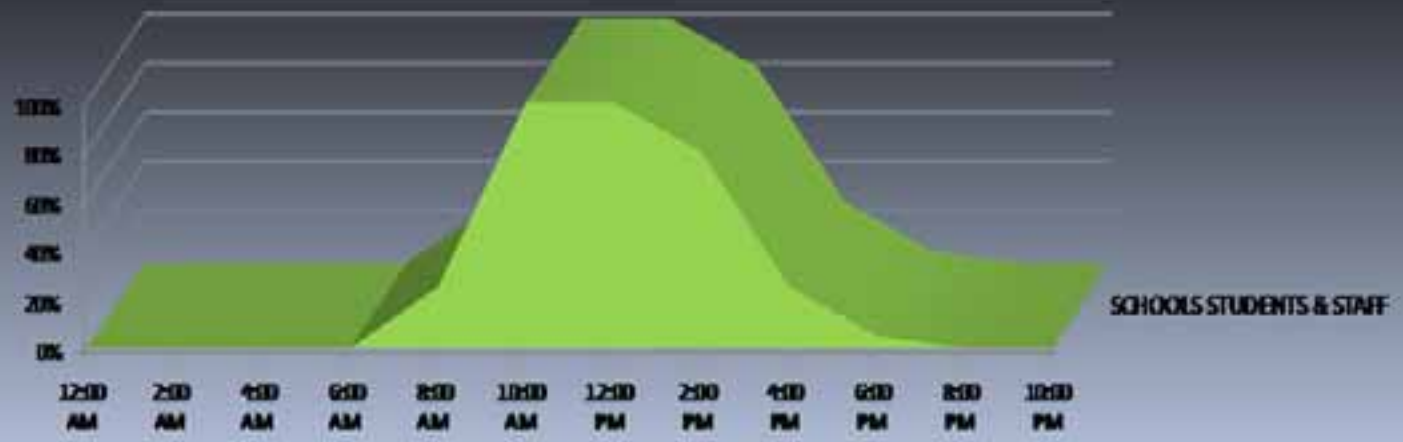

School employment sites drop to 0% at night and load rapidly from 6:00am. Students begin arriving at 8:00am and 100% school occupancy is reached by 10:00am and persists until Noon. Occupancy drops rapidly in the afternoon but does not fall to 0% until after 6:00pm to account for extracurricular sports and activities.

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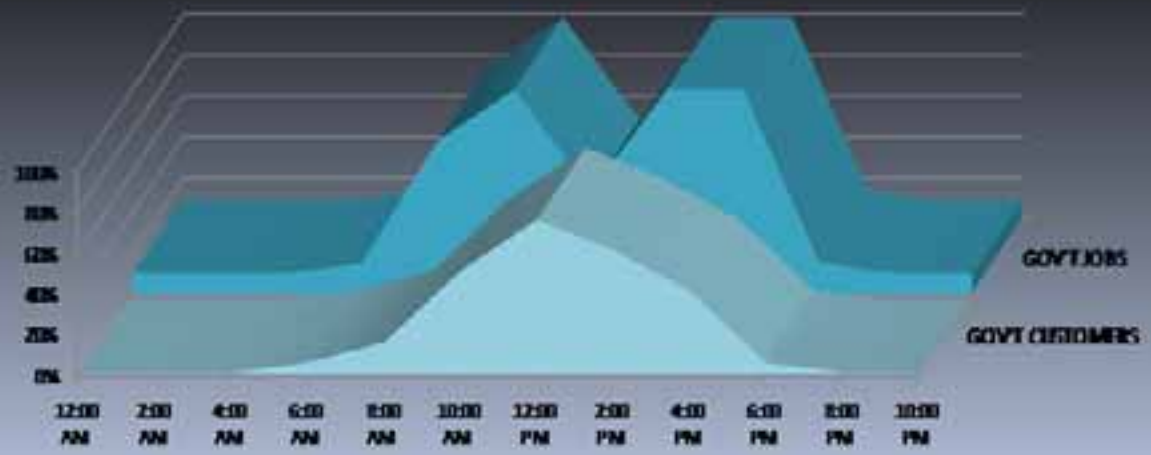

Government employment sites stay at 10% through the night hours (fire and police), and load rapidly from 6:00am to peak at 100% at 10:00am then drop to 50% at noon. The afternoon peak persists at 100% from 2:00pm to 4:00pm and declines very rapidly to 15% by 6:00pm. Government customers drop to 0% at night and load steadily from 6:00am to a 75% peak at noon; then decline steadily until 6:00pm.

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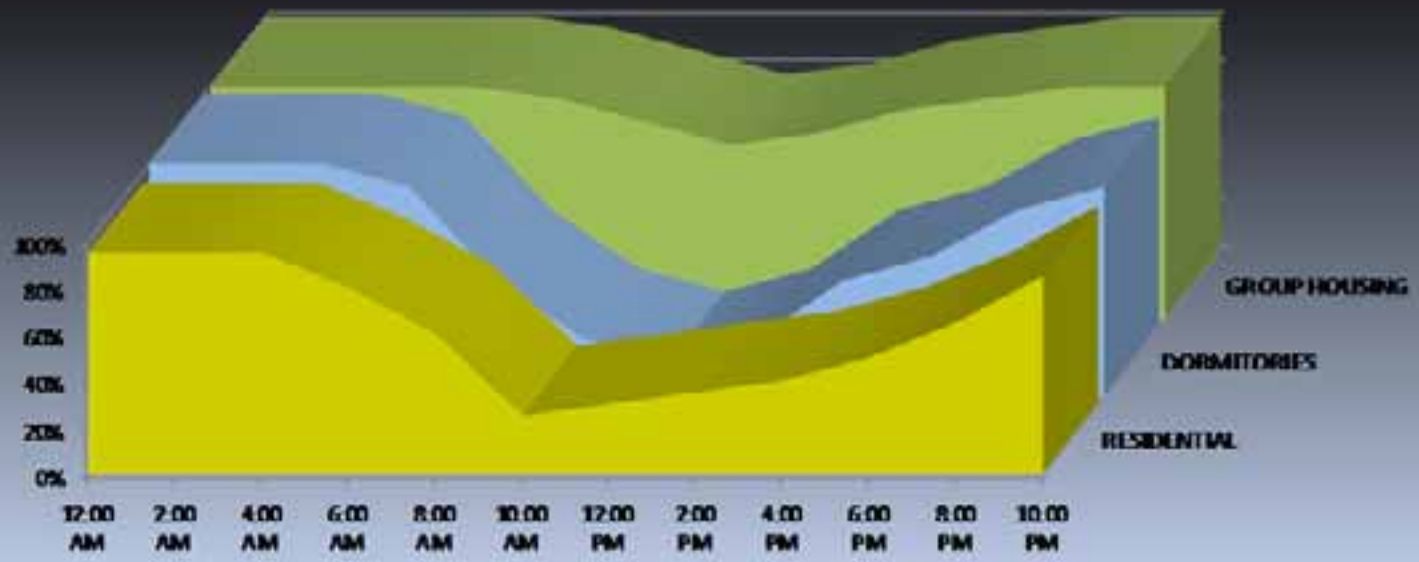


Residential housing stays at 95% occupancy through the night and declines rapidly from 6:00am to 10:00am to a low of 25%. It then slowly increases to 50% at 6:00pm and then increases more rapidly until 10:00pm.

Dormitories follow a similar pattern but are 100% occupied at night.

Group housing (primarily nursing homes, assisted living, and convalescent care) stays at 100% throughout the night and decreases only slightly to 80% at mid-afternoon.

The Calculation

For time interval "N" (12 intervals)

- Max. Residents per location x load factor = residents
- Max. Employees per location x load factor = employees
- Max. Customers per location x load factor = customers
- Max. Students per location x load factor = students
- Residents + Employees + Customers + Students = Population
- Generate distribution for Population "N"

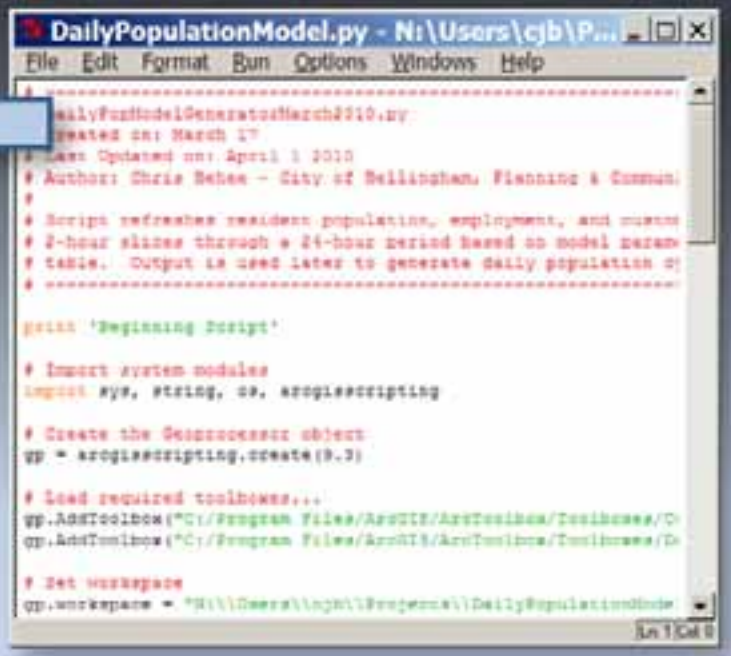
Repeat for next time interval

Running The Model

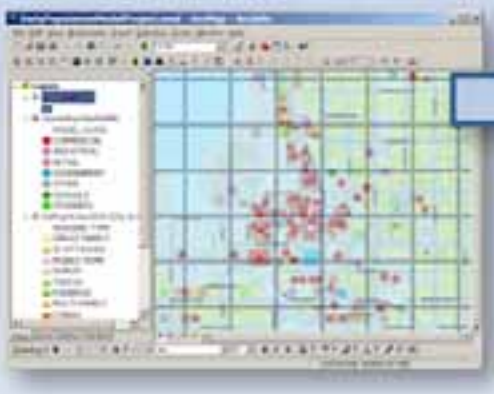
Modeling High-Resolution 24-hour Urban Population Cycles

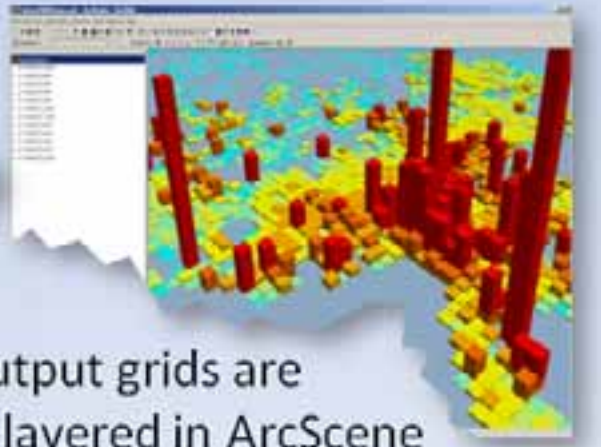
Loops through
12 time intervals

Python Script



Runs summary statistics on each
distribution for 500 foot grid cells

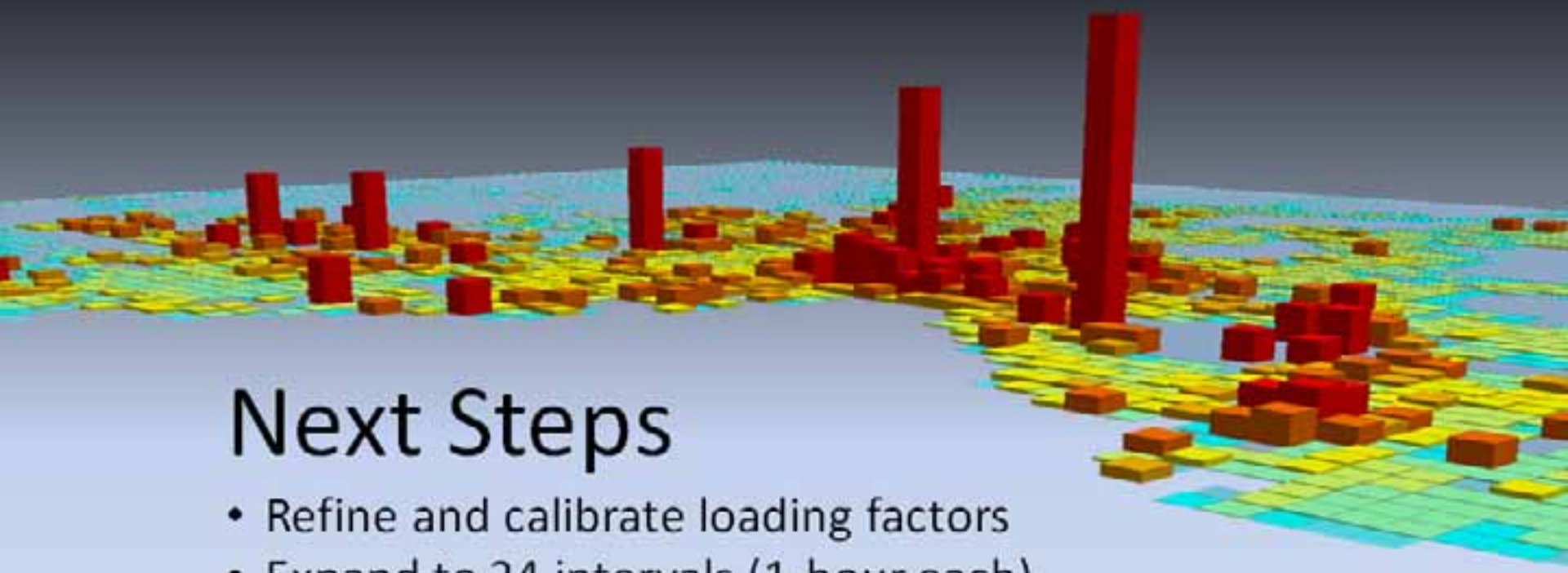




Time interval output grids are
sequenced and layered in ArcScene

The Results

(Time-series animation)



Next Steps

- Refine and calibrate loading factors
- Expand to 24 intervals (1-hour each)
- Expand spatial extent to entire County or beyond.
- Allow address-based user input for scenario-based modeling. For example, sporting events at local stadium, festivals or parades downtown, etc.

Thank You

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