Park-and-Ride Success: A GIS Analysis

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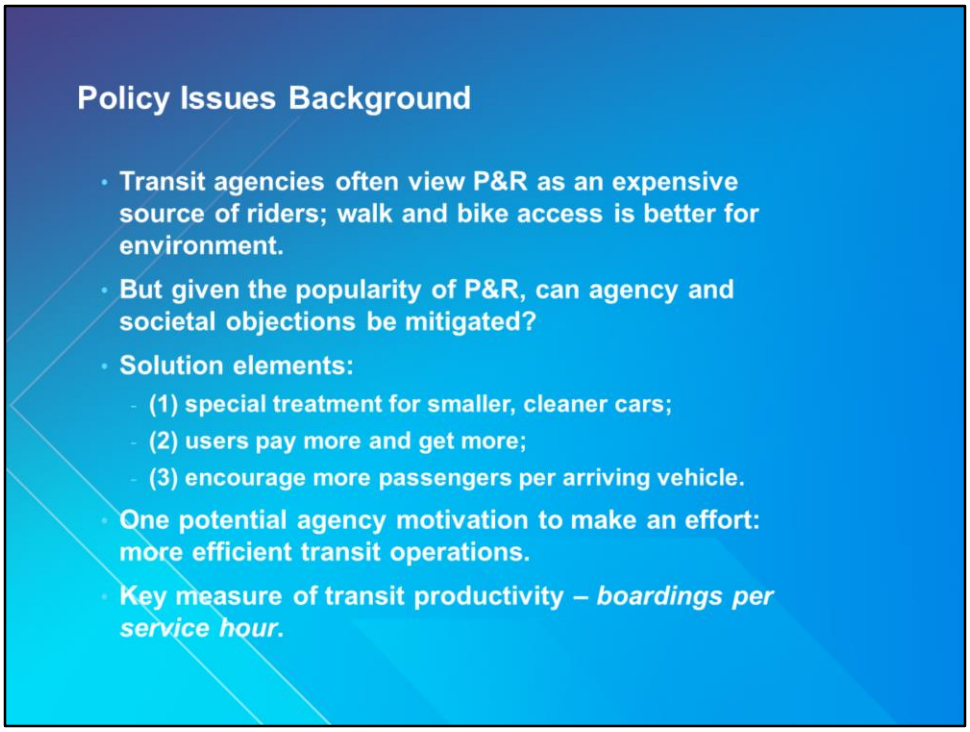
Agenda

- The Objective: Examine the effect of park-and-ride availability on the efficiency of bus transit
- Two basic approaches:
  - Route-level analysis
  - Stop-level analysis
- Two Case Studies:
  - King County Metro (Seattle)
  - Santa Clara Valley Transportation Authority [VTA] (San Jose)
- GIS methods employed:
  - Proximity of bus stops and routes to Park-and-Ride (PnR) lots
  - Spatial Statistics
  - Spatial Regression
- Future Issues and Methods
  - Use Network Analyst
  - Develop Python Implementation

Data source for transit center and parking space count is APTA 2014 Public Transportation Fact Book, Table 16
http://www.apta.com/resources/statistics/Documents/FactBook/2014-APTA-Fact-Book.pdf

According to *APTA Transit Parking 101:*
"Over time, transit agencies have shifted to emphasizing other modes to access transit. In some cases, parking has become only one of the free access modes to be considered. In others, parking is provided but for a fee. Auto access is more often seen as primary at the final stop or station on a transit route or line when in the periphery of the urban area. It competes with, and is sometimes replaced by, other modes in more urban environments. The desire to have TOD as part of the regional portfolio of community types has added pressure to reduce parking. Providing parking, especially free parking, comes at a cost (maintenance, operations, forgone land value), which means having less money for the agency to spend on transit service and forgoing potential development revenue. Some regional planners are raising the question as to whether providing parking for transit, especially in places served by other modes, is compatible with policies for compact and connected development. Some new transit lines have been planned to prioritize putting stations in walkable and bikeable neighborhoods."

Example of Park-and-Ride Facility in Bellevue, WA



Park-and-ride (P&R) transit commuting is a popular multi-modal travel choice for suburban residents in USA, with demand often exceeding supply.

Transit agencies typically consider P&R an expensive way to attract riders ($40,000 to build one parking space), with an additional negative consequence of supporting sprawling suburban development

However, given existing development patterns, revealed consumer preference, and available technology applications, P&R could perhaps be made more economically efficient by developing a better business model for cost allocation and determination of revenue sources, taxes versus fees to consumers.

One input to a better system is understanding the implications of P&R for the cost of transit operations as influenced by the efficiency of obtaining riders.

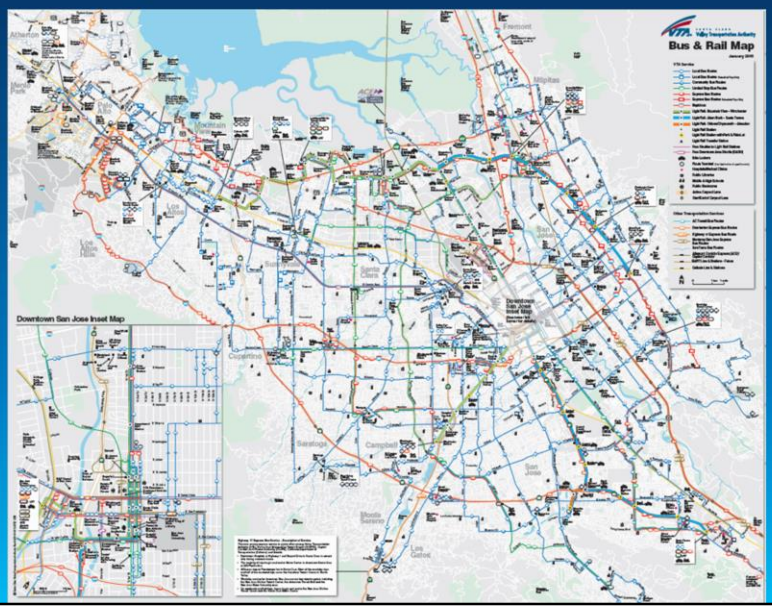
GIS is critical

- Visualizing transit networks and operations
- Turning numerically coded lists of bus stops and boardings into physical understanding
- Facilitating communication between transit planners and outside analysts
- Visualizing and communicating solutions
- Generating data for statistical analyses
- Tolls like Network Analyst promise to provide great insights

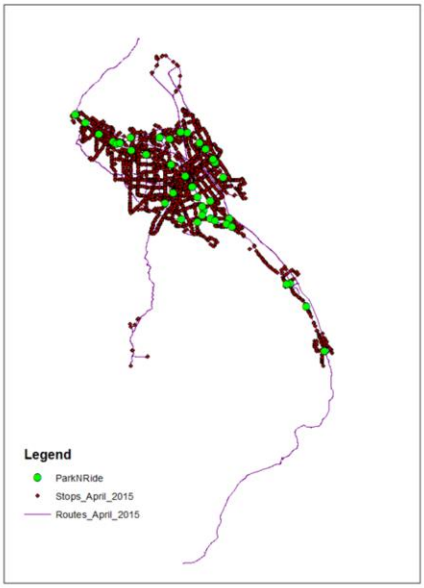
Overview of VTA

- Serves Santa Clara County (and parts of Alameda and San Mateo Counties)
- Includes bus and light rail
- 440 buses in peak service
- 34th largest transit agency in USA by ridership
- 40 Park & Ride lots operated by VTA

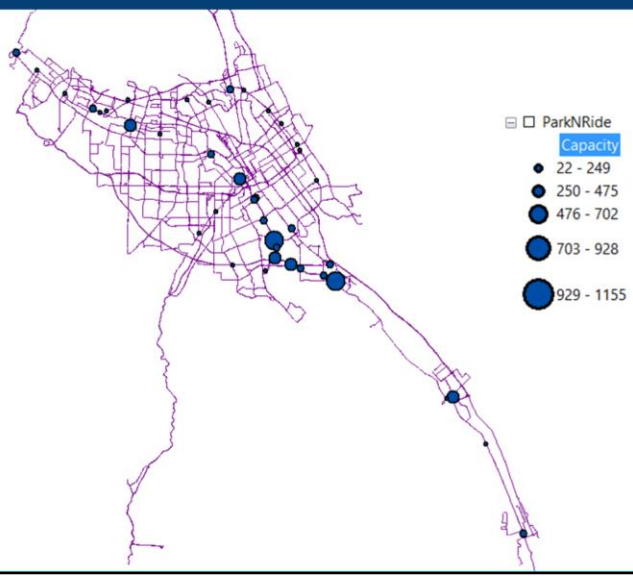
The VTA System

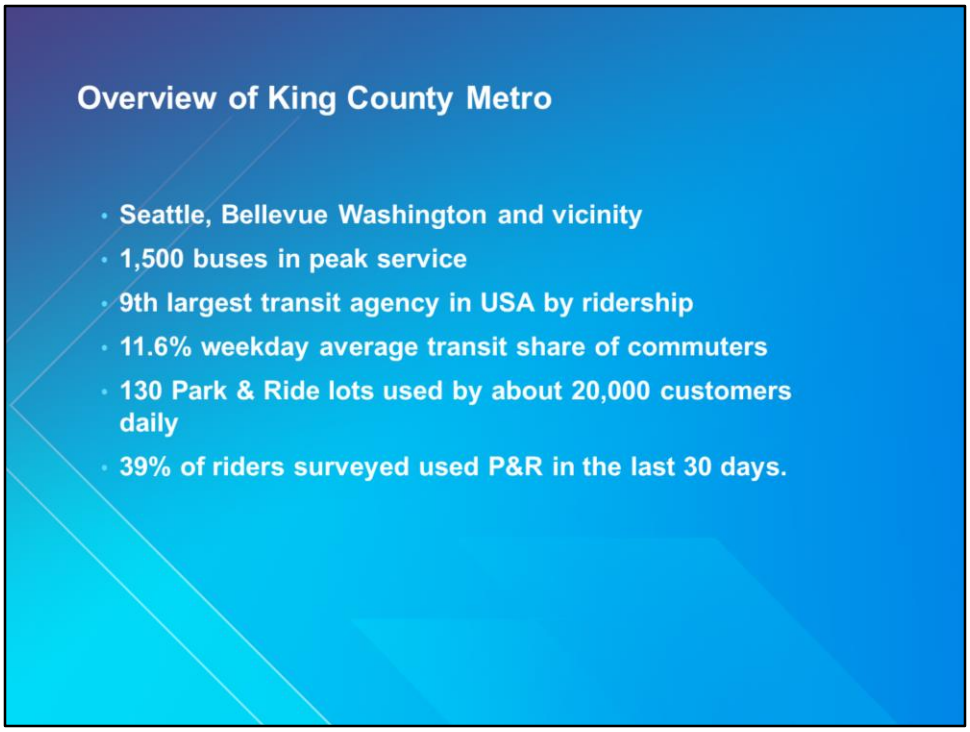


VTA Routes, Stops, and PnR Lots



VTA Routes and P&R Lots by Capacity





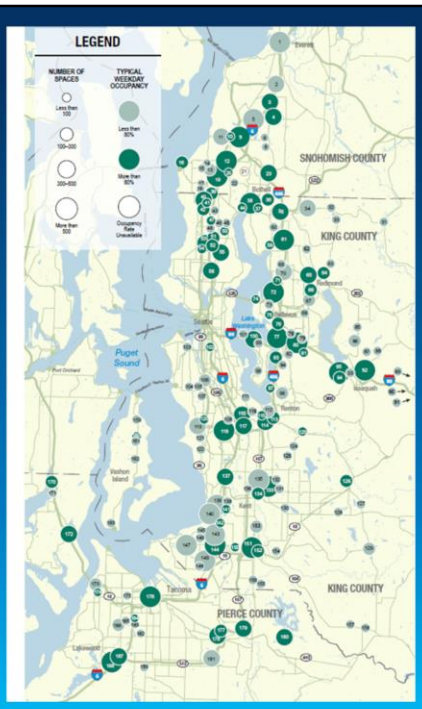
National Transit Data Base for buses in peak service

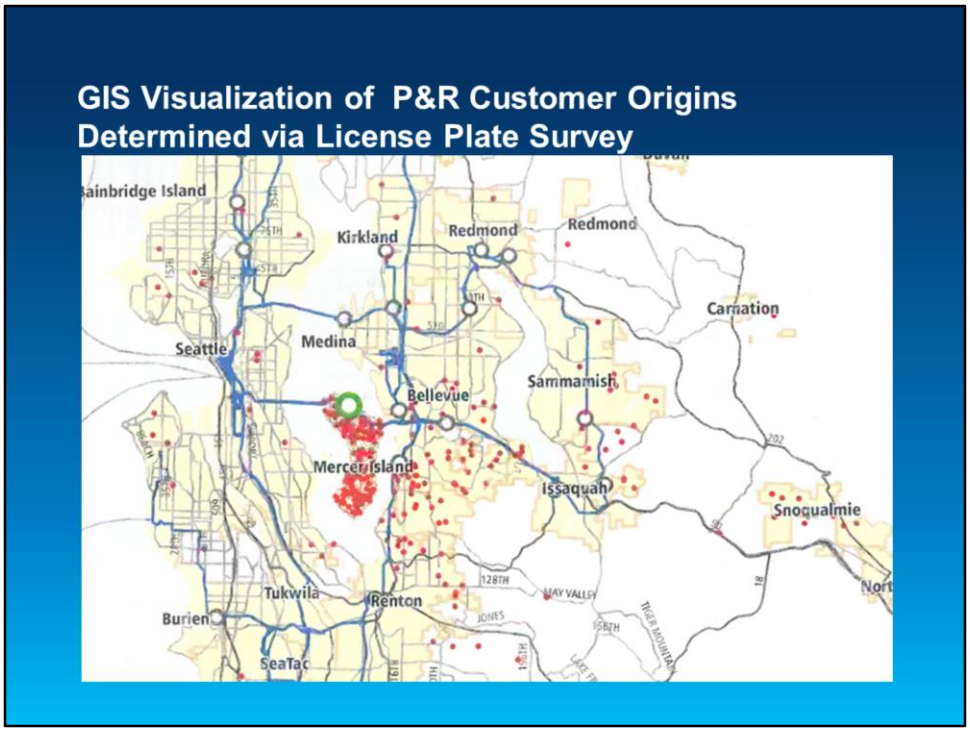
121 million boardings in 2014 according to Metro web site. National rank from same source.

2013 American Community Survey for commute market share

Metro web site for Park & Ride data. 400,000 daily riders.

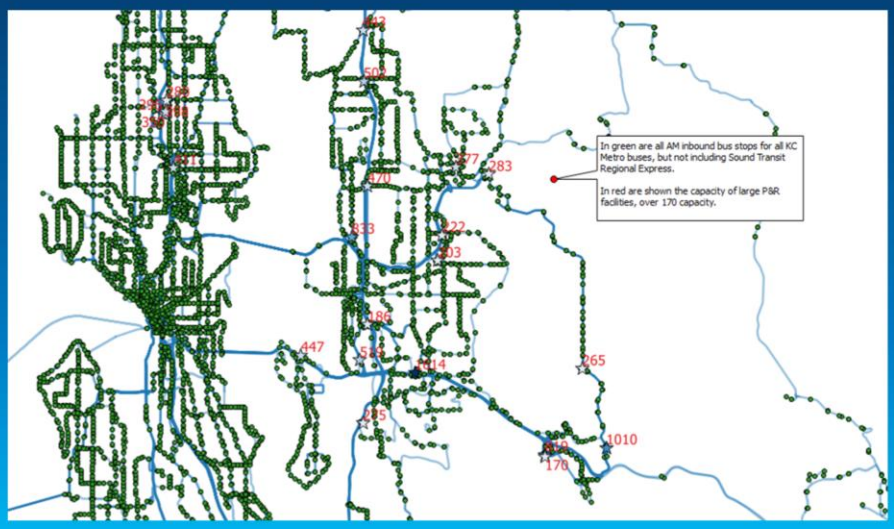
Seattle Region's P & R Lots



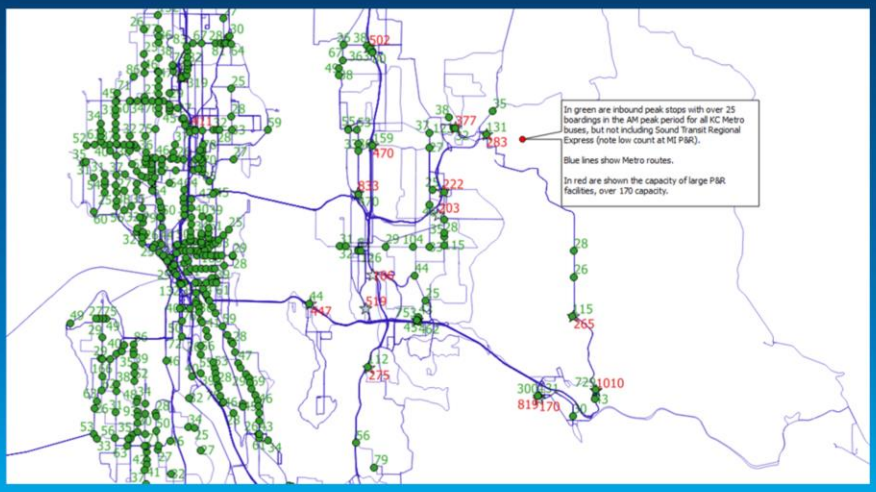


Easy to see that collecting customers for a bus ride would likely be more efficient for the transit agency by letting them come to the central collection point of the P&R identified by the green dot.

All the King County Bus Stops



Large P&R Facilities are Prominent Among the Most Highly Used King County Suburban Bus Stops



Route-level Analysis vs. Stop-level Analysis

Route-level Analysis examines the ridership on a route or busline over the course of a specific period. It may measure the additional ridership on the route associated with stops close to P&R lots.

- Pros: Fiscal impact is often thought of by public transit agencies at the route level
- Cons: There are fewer routes than stops, so some stop-level detail is sacrificed, and the number of observations is smaller that with stop-level data; harder to incorporate demographic and economic data related to the neighborhood of a stop

Stop-level Analysis examines the ridership at a particular stop (that may be served by several routes. Stops close to P&R lots can be identified.

- Pros: More observations and more easily associated with economic and demographic characteristics of the neighborhood
- Cons: Not the natural units in which to discuss fiscal impacts in transit, and traditional fiscal impacts may be difficult to analyze

Stop-level regression coefficient estimates for King County Metro (based on inbound stops)

$$Boardings = \beta_0 + \beta_1(Dummy\ variable: Located\ with\ Quarter\ Mile\ of\ PnR\ Lot) + \epsilon$$

$$\beta_0 = 15.949857$$
$$\beta_1 = 49.982603$$

Stop-level Analysis of VTA

$$Boardings = \beta_0 + \beta_1(Dummy\ variable: Located\ with\ Quarter\ Mile\ of\ PnR\ Lot) + \epsilon$$

$$\beta_0 = .7948004$$

$$\beta_1 = 1.271221$$

Model Developed to Quantify Park & Ride Influence For King County Metro Transit

$$\begin{aligned} &Boardings\ per\ hour \\ &= \beta_0 + \beta_1(AM\ Park\ \&\ Ride\ influence\ fraction) \\ &+ \beta_2(All - day\ boardings\ per\ route\ mile) \\ &+ \beta_3(Stops\ per\ mile\ over\ entire\ route) + \epsilon \end{aligned}$$

where the estimated values are:

$$\beta_0 = 7.9$$
$$\beta_1 = 16.6$$
$$\beta_2 = 15.5$$
$$\beta_3 = -2.4$$

- **The constant measures other undetermined influences**
- **All coefficients are highly statistically significant**
- **The signs on the variable coefficients make physical sense**

20

Using ordinary least squares regression, we developed a three variable linear equation that computes an accurate estimate for the annualized peak period boardings per hour for each of the 53 separate bus routes.
Adjusted R-squared is 0.90
The coefficients of the linear equation are statistically significant.
One of the variables describes the P&R influence on the bus route, ranging from zero to 97 percent.
Two other influences on number of riders per service hour:

Boardings per route mile
Stops per mile over entire route

15% Financial Benefit from Park & Ride Across 53 Bus Routes in the King County suburbs of Seattle

- The regression coefficient on the P&R influence factor lets us estimate the number of service hours saved by picking up passengers at P&R locations.
- Instead of suburban buses having to pick up these riders at bus stops widely scattered over dispersed locations, 50,000 service hours are saved annually by the 41 routes out of 53 stopping at P&R facilities. These hours are worth $17 million.
- In other words, if the beneficial impact of the P&R facilities were not present, instead of $95 million actually spent, $112 million in service hours would be spent on the 53 routes.

21

Summary: Across 53 Eastside routes, 50 thousand transit service hours saved annually, worth $17 million. In detail:

For the 41 routes coded >0 for P&R influence, the coefficient multiplied by the influence variable provides a calculation of the marginal P&R contribution to higher boardings per service hour, which for these routes can be translated to 49,562 service hours saved in reaching the ridership achieved.

Example of one route: For Metro route 210, without P&R, this line in the AM achieved 44.5 boardings per service hour across 2,288 service hours. The marginal influence of P&R from the regression estimation is 10.2 boardings per service hour, which is equivalent to saving 678 service hours. This is demonstrated by noting that 2,288 X 44.5 is equal to (2,288 + 678) X (44.5 – 10.2) with some rounding.

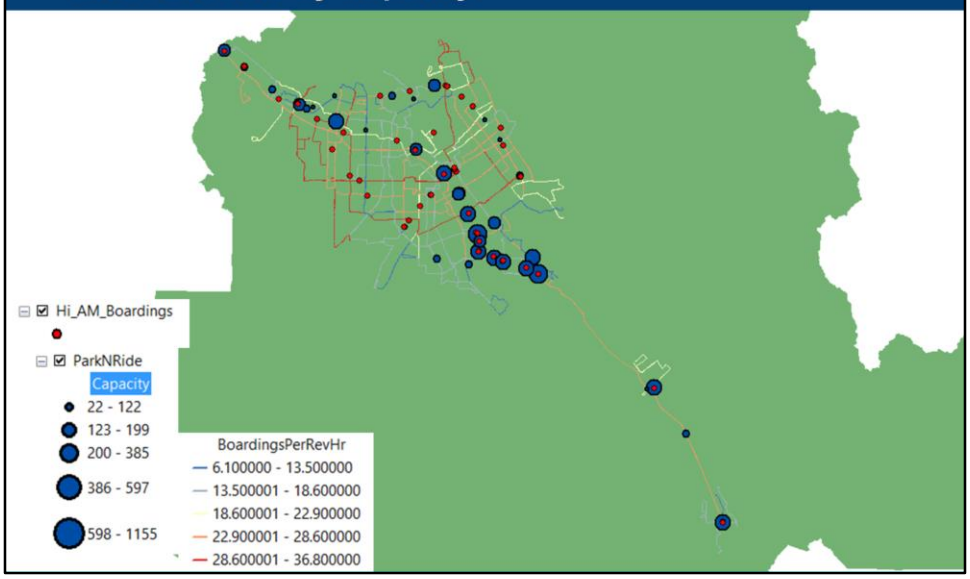
When 678 hours of saving is multiplied by the $262 per service hour operating cost of route 210, an annual dollar savings for this one route from P&R influenced operations comes into view, in this case, $178 thousand.

Differences in network structure and data availability between the two agencies requires a different methodology for determining park & ride influence on bus productivity in the VTA System

	King County Metro	Santa Clara VTA
Service area size	2000 square miles	346 square miles
Service area population	2 million	1.8 million
Annual bus fare revenue	$123 million	$29 million
Annual bus operations cost	$440 million	$226 million
Bus cost per service hour	$159	$184
Boardings per service hour	36	27
Many long commuter bus routes from park & ride lots	Yes	No
Many bus routes to rail stations	No	Yes

Source: 2013 National Transit Database of Federal Transit Administration and examination of maps

VTA High Productivity Routes, High Boardings Stops, and P&R Lots by Capacity



Data and Data Sources

- The data about King County Metro:
  - Stop-level data and route level data provided by KC staff
    - Boardings by route and by bus stop for the AM peak period
    - Annual hours of service for each route
    - Length and number of stops on each of 53 bus routes.
  - GIS Data obtained from public files on the King County web site.
    - Which stops are at P&R facilities and are in the peak direction from maps.
- The data about VTA
  - Stop-level data and route level data provided by VTA
    - Boardings by route and by bus stop for AM peak periods determine from boardings and alightings data
    - Annual hours of service for each route
    - Length and number of stops on each of 97 routes
  - GIS Data about stops, routes, and P&R lots obtained from VTA

SUMMARY AND CONCLUSIONS

IMPACT OF PARK AND RIDE ON EFFICIENCY OF TRANSIT

- Route-level analysis: Park and ride variables are positive and statistically significant for King County, indicating park-and-ride contributes to greater boardings per revenue hour
- Stop-level analysis: Both park and ride dummy variables are positive and statistically significant for King County and VTA, indicating quarter mile proximity to park-and-ride expands the number of boardings at those stops

GIS IS ESSENTIAL IN THE ANALYSIS OF PARK AND RIDE IMPACT ON TRANSIT EFFICIENCY

- ✓ Geographic view necessary to understand context
- ✓ Proximity vital as a measurement of influence
- ✓ Spatial statistical & related methods yield essential estimates

Questions or Comments?

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