

Technical Course

TNC-Paratransit Partnership

Measuring Divertible Trips using ArcGIS

05

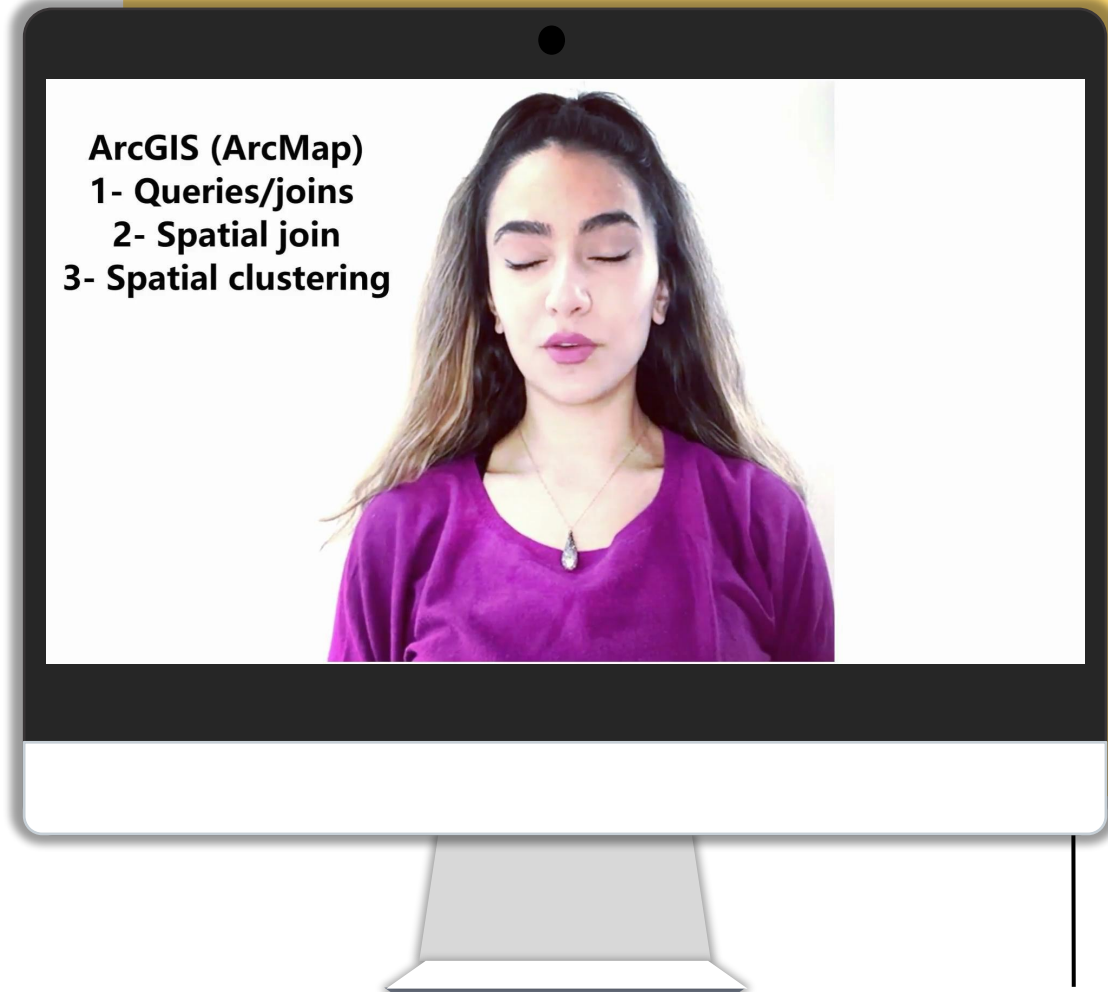
Technical Course

- Methodological Framework
 - Step-by-Step Analysis
 - Pre-recorded Tutorials
 - Summary of findings

Introduction

Welcome to this course!

Watch this short video to learn more about the course purpose, instructor, software, tools and analyses!



Course Overview

For a short introduction about this course content, please click on the video on the right, or the following link:

https://drive.google.com/drive/folders/1n0_iAqRD7aRUrykfyZ_wyvXZBLzriChT



Course Outline

- **Component (1)**
 - Introduction
 - Study objectives
 - **Component (2)**
 - Methodological framework
 - Step-by-step analysis
 - Examples and results
-



Introduction

This analysis includes a multi-step methodological framework.

- We start by analyzing paratransit trips **temporal and geographic distribution**, and **clients' characteristics** to build a robust understanding of the existing service and investigate potential opportunities and challenges for multimodal paratransit services.
- We use the findings from the descriptive and geospatial analyses to develop conceptual frameworks that constitute a criterion to investigate the opportunities and challenges in diverting paratransit trips to TNCs.

Introduction

Because there are very few empirical studies to draw upon for design-specific guidelines, we use these conceptual frameworks along with hypothetical scenarios for trip diversion to explore the implications of multimodal paratransit services through partnerships with TNCs.

Our approach utilizes extensive research about TNCs' operational norms, in addition to the full dataset for 645,668 Access paratransit trips, operated by King County Metro (KCM) in 2019, to build hypothetical scenarios to investigate the potential diversion of trips from Access



Research Objectives

The objective of this analysis is to help King County Metro design its pilot program of using TNCs as an alternative to the regular ADA paratransit service, and provide useful guidelines to other transit agencies.

Based on our research of paratransit trips and TNC operations, we have developed **a set of criteria for diversion of trips from conventional ADA paratransit to TNCs**, which provides a basis for assisting TNC-KCM partnership.



Trip Diversion Criteria (Benchmarks)

Subsidy-Distance

Trips that can be fully-operated using the specified subsidy:

- Time of the trip
- Distance (miles)
- Subsidy (\$40)

Mobility Assistance

Trips that do not require specialized driver assistance:

- Curb to Curb only

Operational efficiency

Trips that (if diverted) would not impact conventional ADA paratransit efficiency:

- Least efficient service areas

Available data

Different data tables including:

Trips data (2019)

- We used 2019 data as the most recent reference for normal operations.

Clients data (2019)

- We used 2019 registered ADA clients data.

Analysis

A step-by-step guide

Data collection /preparation for ArcMap

Attributes calculation (distance, time intervals, assistantship, passengers)

Applying the different conditions (distance & TNC price/ Agency subsidy, curb to curb, operational efficiency)

Building different scenarios



Clients data

Client ID	Gender	Date Of Birth	Pref Space Type	Preferred Num Spaces	MobAids	Eligible From Date	Eligible To Date	Perm Cond	Curb	Door
XXXX	F	19780401	AM	1	CA	19960812	20210418	0	0	1

Trips data

LDate	Client ID	Activity	Scheduled Time	Estimated Time	Space On	Pass On	MobAids	Latitude	Longitude	Direct Distance
20190101	147236	0	59400	59257	WG1	CLI1	CA,LI	47.608088	-122.320767	21971

Step-by-Step Guide

Defining the conceptual framework

Operational-efficiency: the ability of TNCs to reduce the overall cost of ADA paratransit is essential to sustain the service and improve transportation options overall for persons with disabilities. services. While previous pilots reported some cost savings for using TNCs to supplement paratransit, the same day service SDS might increase paratransit ridership. For this purpose, we analyze Access trips' operational-efficiency by looking at the geographic distribution of trips and trip length.

This step helps transit agencies understand areas with the highest potential of savings to plan TNC service distribution accordingly.

Defining the conceptual framework

Equity of paratransit services: this includes the distribution, availability, and cost of paratransit services and whether that distribution is considered fair and appropriate. Transportation equity analysis is essential and critically important. Multimodal paratransit decisions often have significant equity impacts. Key equity concerns include the user subsidy amount, geographic coverage, and equitable accessibility of the different modes.

For this purpose, we analyze TNCs dynamic pricing in King County, subsidy amount for TNC trips, and the length of paratransit trips.

Defining the conceptual framework

TNCs limitations and compatibility: Since the TNC business model relies critically on drivers acting as independent contractors. Whether any TNCs would be sufficiently interested in creating similar arrangements is unknown. Hence, agencies are using SDS outside of ADA paratransit, and as a separate service serving paratransit riders. In this case, TNCs operational norms limit their delivery of paratransit trips to certain disability types, mobility devices, and assistance offered through drivers.

For this purpose, we look at one type of compatible trips: **curb-to-curb**.

Defining distance thresholds

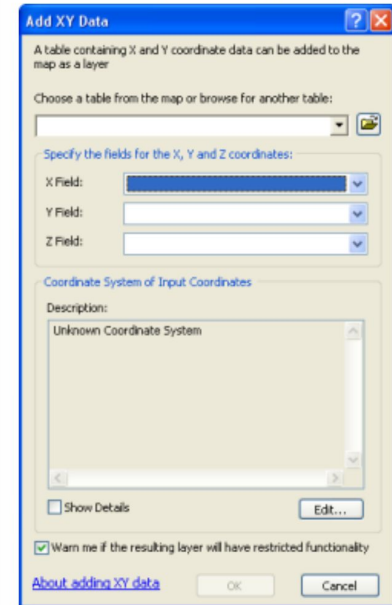
In this step is to estimate trip length that can be covered by determined subsidy amount. Duo to TNC demand surge, we use two different periods and their respective average cost per mile: **regular hours and rush hours.**

King County has two rush hour periods, from 7 am to 9 am, and 5 pm to 6 pm. Using multiple price estimators for different TNCs, we assign an average distance that can be covered using a \$40 subsidy as follows:

	Regular hours	Rush hours
Subsidy	\$40	\$40
Miles	10 miles	5 miles

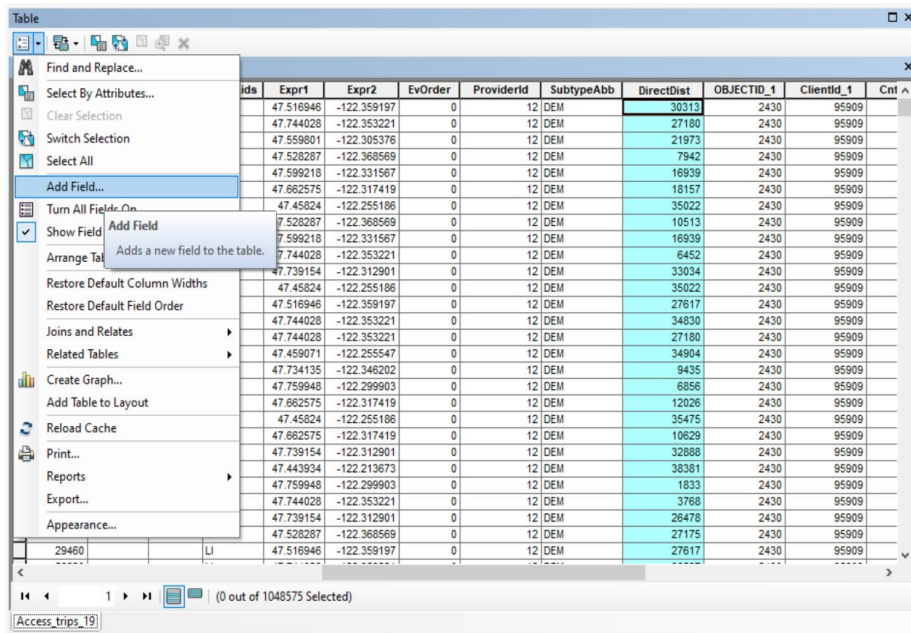
Adding Trips Data to ArcMap

- Click File > Add Data > Add XY Data.
- Select the table that contains x,y coordinate data.
- Identify the columns that hold the x- and y-coordinates (and, optionally, the z-coordinate).
- Specify the coordinate system.



Defining distance thresholds

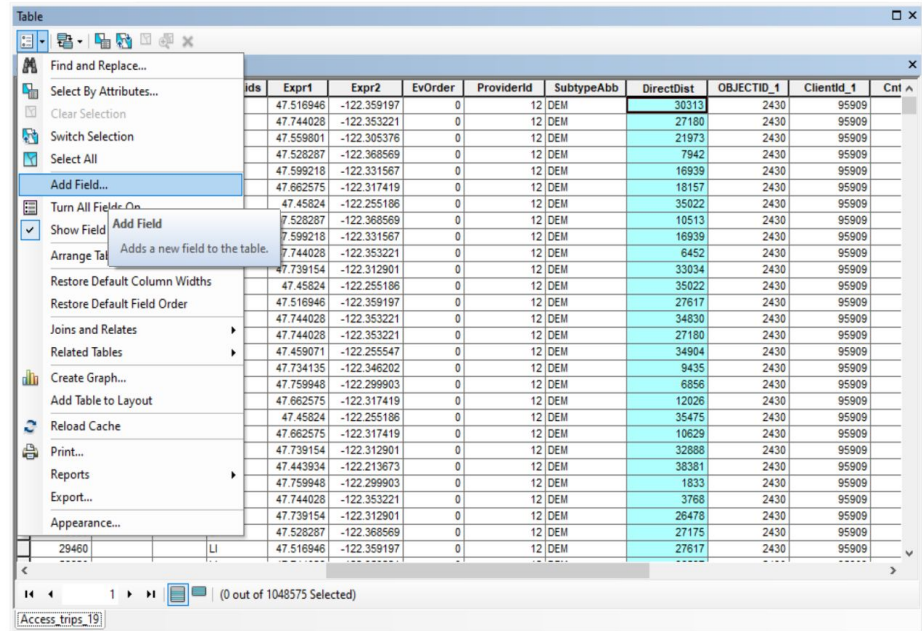
- Open Table of attributes
- Add field (distance_miles)
- Right click > Calculate field > Covert distance to miles
- Add fields (10 miles) and (miles)
- Select by attribute > distance_miles <= 10 miles
- 10 miles > calculate field > 1
- Repeat for 5 miles



Ids	Expr1	Expr2	EvOrder	ProviderId	SubtypeAbb	DirectDist	OBJECTID_1	ClientId_1	Cnt
47.516946	-122.359197	0	12	DEM		30313	2430	95909	
47.744028	-122.353221	0	12	DEM		27180	2430	95909	
47.559801	-122.306376	0	12	DEM		21973	2430	95909	
47.528287	-122.368569	0	12	DEM		7942	2430	95909	
47.599218	-122.331567	0	12	DEM		16939	2430	95909	
47.662575	-122.317419	0	12	DEM		18157	2430	95909	
47.45824	-122.255186	0	12	DEM		35022	2430	95909	
7.528287	-122.368569	0	12	DEM		10513	2430	95909	
7.599218	-122.331567	0	12	DEM		16939	2430	95909	
7.744028	-122.353221	0	12	DEM		6452	2430	95909	
47.739154	-122.312901	0	12	DEM		33034	2430	95909	
47.45824	-122.255186	0	12	DEM		35022	2430	95909	
47.516946	-122.359197	0	12	DEM		27617	2430	95909	
47.744028	-122.353221	0	12	DEM		34830	2430	95909	
47.744028	-122.353221	0	12	DEM		27180	2430	95909	
47.459071	-122.255547	0	12	DEM		34904	2430	95909	
47.734135	-122.346202	0	12	DEM		9435	2430	95909	
47.759948	-122.299903	0	12	DEM		6856	2430	95909	
47.662575	-122.317419	0	12	DEM		12026	2430	95909	
47.45824	-122.255186	0	12	DEM		35475	2430	95909	
47.662575	-122.317419	0	12	DEM		10629	2430	95909	
47.739154	-122.312901	0	12	DEM		32888	2430	95909	
47.443934	-122.213673	0	12	DEM		38381	2430	95909	
47.759948	-122.299903	0	12	DEM		1833	2430	95909	
47.744028	-122.353221	0	12	DEM		3768	2430	95909	
47.739154	-122.312901	0	12	DEM		26478	2430	95909	
47.528287	-122.368569	0	12	DEM		27175	2430	95909	
47.516946	-122.359197	0	12	DEM		27617	2430	95909	

Defining divertible trips (distance - time)

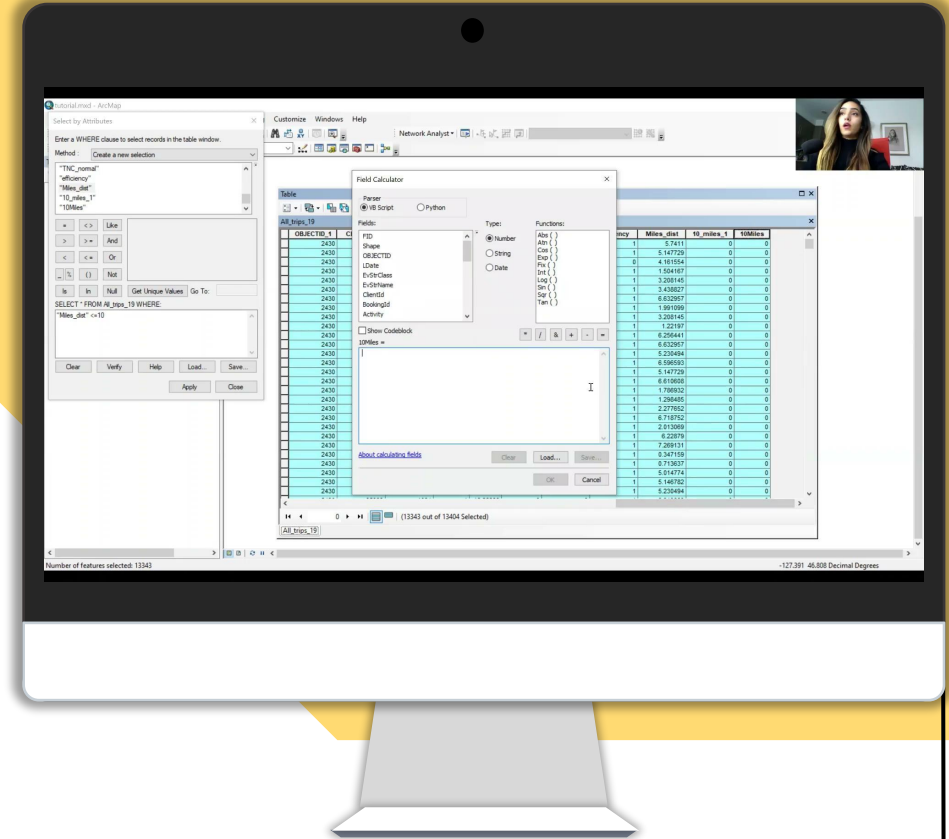
- Select by attribute >
10_miles = 1 AND Time = 'Reg'
- Add field > Divert_reg >
calculate field = 1
- Repeat steps for 5_miles = 1 and Time = 'Rush'



ids	Expr1	Expr2	EvOrder	ProviderId	SubtypeAbb	DirectDist	OBJECTID_1	ClientId_1	Cnt
47.516946	-122.359197	0	12	DEM		30313	2430	95909	
47.744028	-122.353221	0	12	DEM		27180	2430	95909	
47.559801	-122.305376	0	12	DEM		21973	2430	95909	
47.528287	-122.368569	0	12	DEM		7942	2430	95909	
47.599218	-122.331567	0	12	DEM		16939	2430	95909	
47.662575	-122.317419	0	12	DEM		18157	2430	95909	
47.45824	-122.255186	0	12	DEM		35022	2430	95909	
7.528287	-122.368569	0	12	DEM		10513	2430	95909	
7.599218	-122.331567	0	12	DEM		16939	2430	95909	
7.744028	-122.353221	0	12	DEM		6452	2430	95909	
47.739154	-122.312901	0	12	DEM		33034	2430	95909	
47.45824	-122.255186	0	12	DEM		35022	2430	95909	
47.516946	-122.359197	0	12	DEM		27617	2430	95909	
47.744028	-122.353221	0	12	DEM		34830	2430	95909	
47.744028	-122.353221	0	12	DEM		27180	2430	95909	
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47.516946	-122.359197	0	12	DEM		27617	2430	95909	

Select by attribute

Using table options to select records based on their attributes, create and measure new fields.



Defining Mobility Assistance Condition

In this step, we find the number of trips that match the drivers ability to offer assistance to riders. We predefined these trips as **Curb-to-Curb trips**.

This attribute is usually stored in the clients data and not in trips data. if this is the case, you need to **JOIN** the clients data to the trips data, using a key, which is usually a unique **ClientID**



Defining divertible trips (Assistance)

- Table options > Join and relates
- Join trip data to clients data using a key attribute (here: ClientID)
- Keep all records so you do not lose any trip records.

FID	Shape	LDate	EvStrClass	EvStrName	ClientId	BookingId	Activity
0	Point	20190101	Para	8004R	147236	24510619	0
1	Point	20190101	Para	8004R	147236	24510619	1
2	Point	20190101	Para	9526	152431	24510886	0
3	Point	20190101	Para	9526	152431	24510886	1
4	Point	20190101	Para	PEB1	148610	24511035	0
5	Point	20190101	Para	PEB1	148610	24511035	1
6	Point	20190101	Para	8717	137081	24510402	0
7	Point	20190101	Para	8717	137081	24510402	1
8	Point	20190101	Para	8720	125922	24510670	0
9	Point	20190101	Para	8720	125922	24510670	1
10	Point	20190101	Para	8716	136360	24510168	0
11	Point	20190101	Para	8716	136360	24510168	1
12	Point	20190101	Para	9526	151383	24510552	0
13	Point	20190101	Para	9526	151383	24510552	1
14	Point	20190101	Para	PEB1	143224	24510553	0
15	Point	20190101	Para	PEB1	143224	24510553	1
16	Point	20190101	Para	8720	125970	24510818	0
17	Point	20190101	Para	8720	125970	24510818	1
18	Point	20190101	Para	8710	107630	24510184	0
19	Point	20190101	Para	8710	107630	24510184	1
20	Point	20190101	Para	PEB1	152833	24510969	0
21	Point	20190101	Para	PEB1	152833	24510969	1
22	Point	20190101	Para	9526	145675	24510470	0
23	Point	20190101	Para	9526	145675	24510470	1
24	Point	20190101	Para	9504	151062	24510985	0
25	Point	20190101	Para	9504	151062	24510985	1
26	Point	20190101	Para	9526	144881	24510988	0
27	Point	20190101	Para	9526	144881	24510988	1
28	Point	20190101	Para	9504	147236	24510618	0
29	Point	20190101	Para	9504	147236	24510618	1
30	Point	20190101	Para	8717	30773	24523138	0
31	Point	20190101	Para	8717	30773	24523138	1
32	Point	20190101	Para	9520	128397	24515801	0
33	Point	20190101	Para	9527	71078	24516202	0
34	Point	20190101	Para	8717	30773	24523138	1
35	Point	20190101	Para	9527	71078	24516202	1
36	Point	20190101	Para	8717	133920	24524040	0
37	Point	20190101	Para	8717	133920	24524040	1
38	Point	20190101	Para	PEB1	112461	24526294	1
39	Point	20190101	Para	9506	41255	24525892	1
40	Point	20190101	Para	8744	151451	24524840	0
41	Point	20190101	Para	PEB1	112461	24526294	1
42	Point	20190101	Para	8717	90320	24525729	0
43	Point	20190101	Para	8744	151451	24524840	0
44	Point	20190101	Para	8717	90320	24525729	1

Join Data

Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.

What do you want to join to this layer?

Join attributes from a table

1. Choose the field in this layer that the join will be based on:
ClientId
2. Choose the table to join to this layer, or load the table from disk:
Client_home_19
 Show the attribute tables of layers in this list
3. Choose the field in the table to base the join on:
clientid

Join Options

Keep all records
All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.

Keep only matching records
If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.

Validate Join

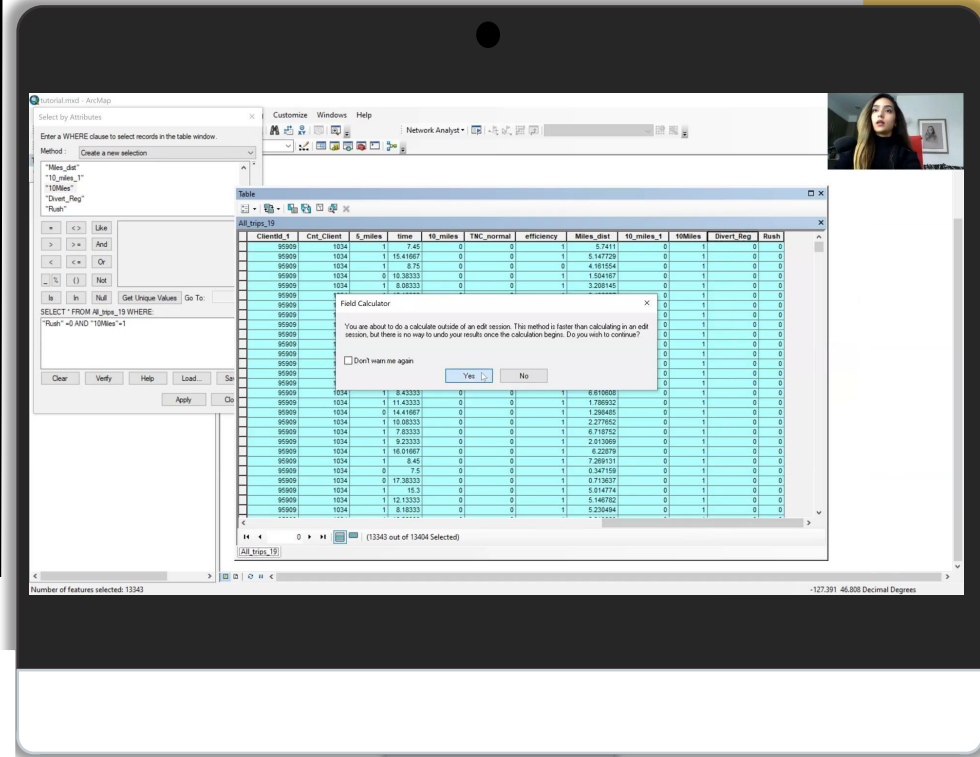
About joining data

OK Cancel

Defining divertible trips (Assistance)

- Select by attribute > Curb = 1
- In case curb to curb attribute is not available, you can estimate the required assistance based on Age, Disability level or Mobility device.

The screenshot displays a data analysis window titled 'Table' with a sub-window 'Catalog'. The main window shows a table with the following columns: PrefNumSpa, AdaCode, AdaCode_X, AdaCode_Y, MobAids_12, EligFromDa, EligToDate, PermCond, Curb, and Door. The 'Curb' column is highlighted in cyan. The 'Select by Attributes' dialog box is open, showing a WHERE clause: 'Curb' = 1. The dialog box also includes a list of attributes: 'EligFromDa', 'EligToDate', 'PermCond', 'Curb', and 'Door'. The 'Curb' attribute is selected. The dialog box has buttons for 'Clear', 'Verify', 'Help', 'Load...', 'Save...', 'Apply', and 'Close'. The table has 18 rows of data, with the first row being 1 2_3 3 3 0 0 0 0 1 0. The table is titled 'TNC_NE_Curb_111'.



Boolean algebra

Using Boolean algebra to select records that meet more than one criterion

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Join Options

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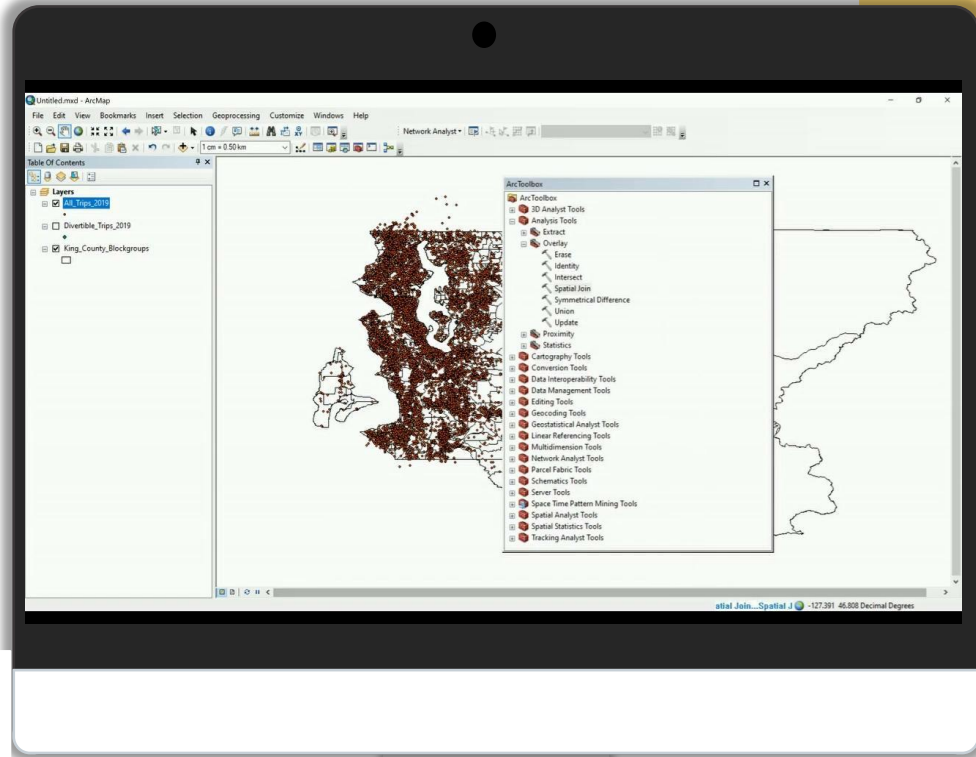
Keep only matching records
If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.

[About joining data](#)

Defining divertible trips (Efficiency)

- Use previous illustrations to create a new field for operational efficiency
- Use field calculator to measure the new field as (Efficiency = Pax_count / Trip_Distance)

The screenshot illustrates the process of creating a new field in a GIS application. On the left, a data table with columns 'DirectID_1', 'OBJECTID_1', 'ClientID_2', 'Cnt_Client', '5_miles_1', 'time_1', '10_miles_1', 'TNC_norm_1', and 'clientid_3' is shown. A context menu is open over the table, with 'Field Calculator...' selected. On the right, the 'Field Calculator' dialog box is open, showing the 'Expression' field containing the formula $\text{Pax_count/Trip_Distance}$. The dialog box also shows the 'Parser' set to 'VB Script', the 'Type' set to 'Number', and a list of functions including 'Abs()', 'Atn()', 'Cos()', 'Exp()', 'Fix()', 'Int()', 'Log()', 'Sin()', 'Sqr()', and 'Tan()'. A dashed line with an arrow points from the 'Field Calculator...' menu item to the 'Field Calculator' dialog box.

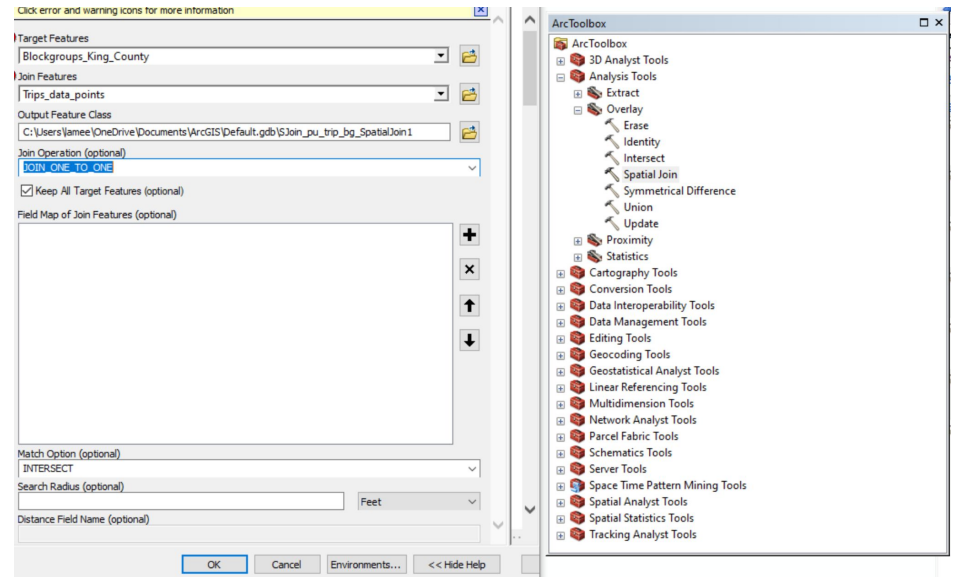


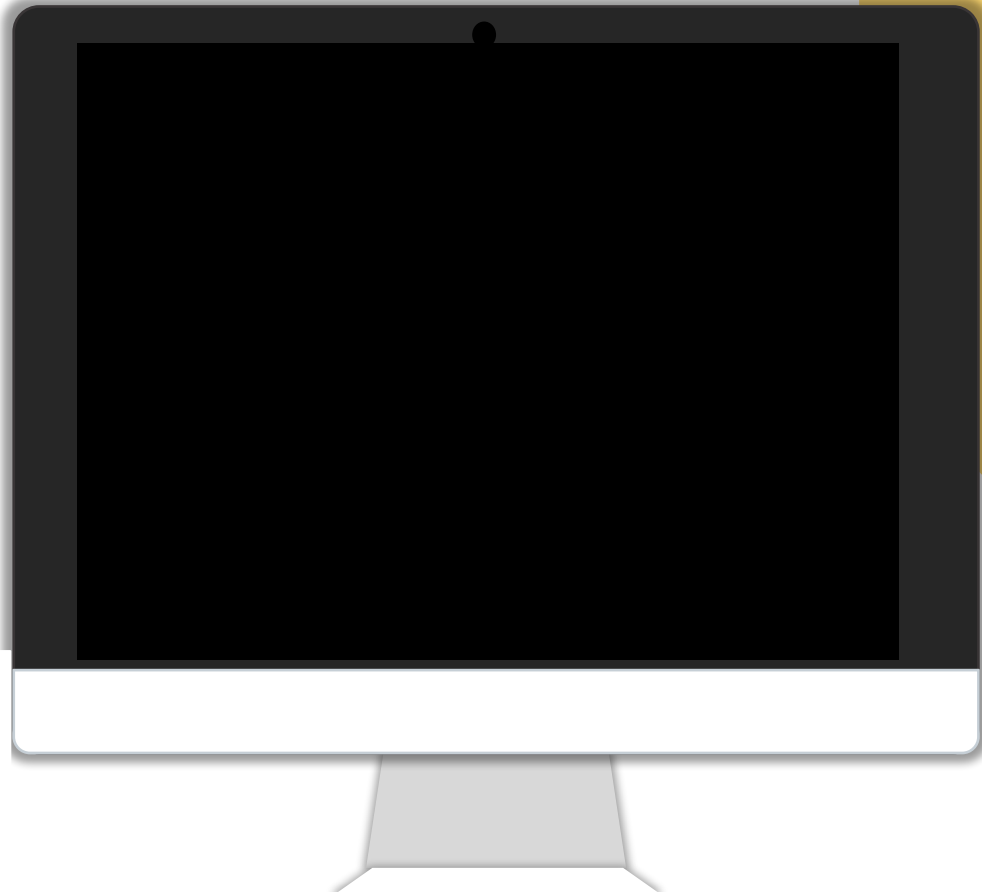
Spatial Join

Spatial join between trips data (points) and census block groups (polygons)

Spatial Join (trips data to service areas)

- ArcToolBox > Analysis tools > Overlay > Spatial Join
- Target feature = polygons for the service area depending on the desired resolution (here: block groups)
- input feature = Trips data that have the efficiency values



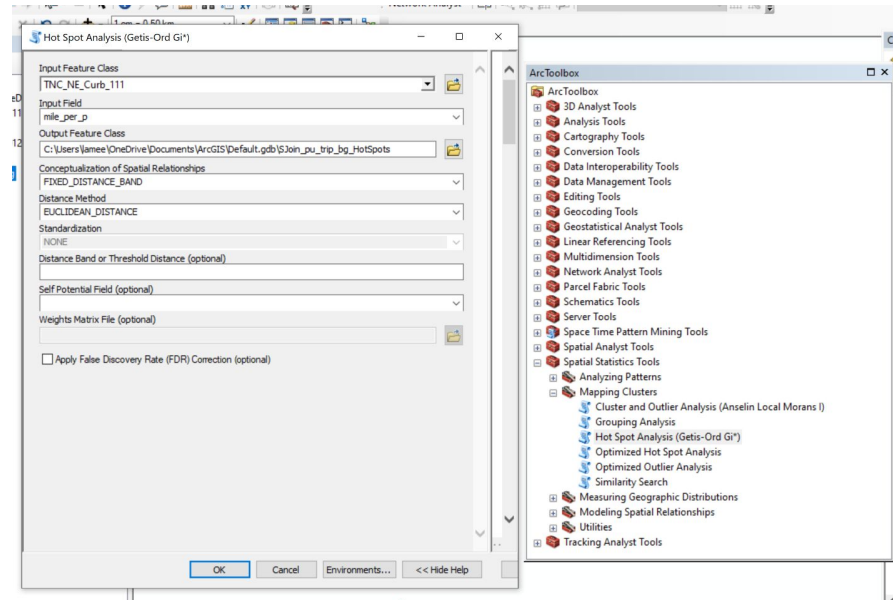


GI hotspot analysis

Spatial join between trips data
(points) and census block groups
(polygons)

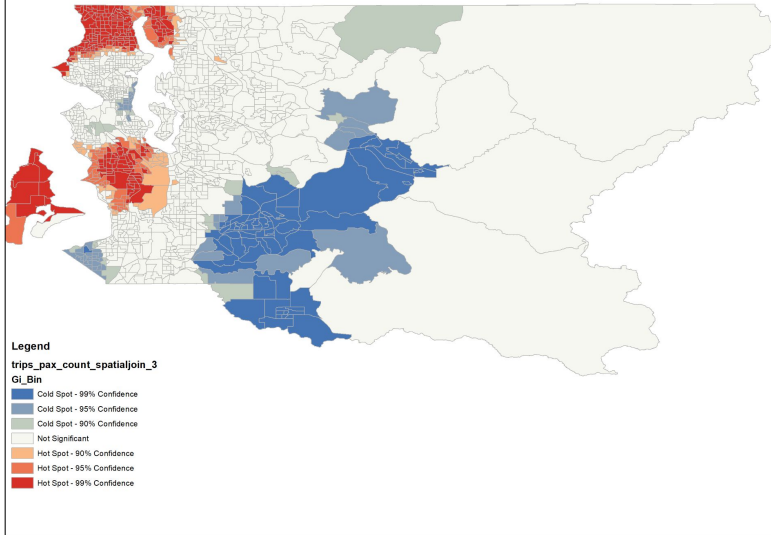
Operational Efficiency Hotspots

- ArcToolBox > Spatial Statistics tools > Hot Spot Analysis (Getis-Ord GI*)
- Input_feature = Trips data that have the efficiency values
- Output_feature = polygons for the service area depending on the desired resolution (here: block groups)

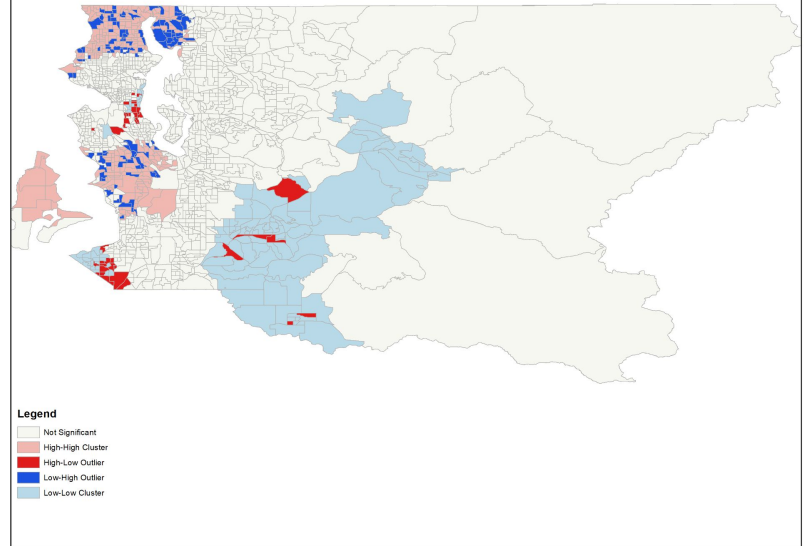


Operational Efficiency Hotspots

Statistically significant cold and hot spots efficiency (passenger/mile) for Access 2019 trips



Optimized Outlier Analysis for efficiency per census blockgroup (passenger/mile) for Access 2019 trips





Thank you!

Do you have any questions or
any suggestions?