

GPS Data Collection for Regional Travel Surveys

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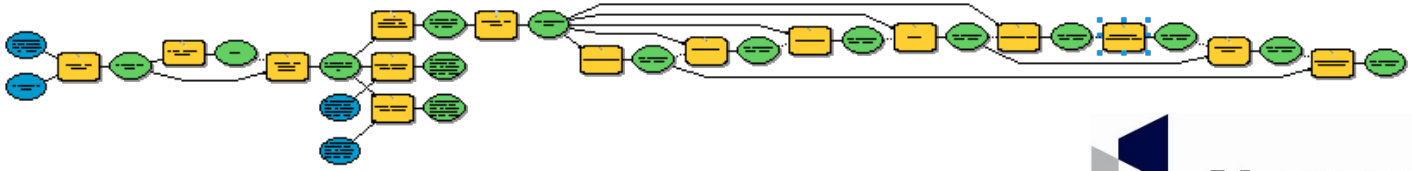


Abt SRBI

Introduction

- **Timothy Michalowski, GIS Director, Abt SRBI**
  - 10+ years GIS experience, focus on GIS for Social Research
  - Previously worked at NYC DOT, Puget Sound Regional Council
  - Master of Urban Planning/GIS from University of Illinois (Chicago)
- **Abt SRBI**
  - National Leading survey research firm, founded in 1981
    17th largest Research firm in USA (*Honomichl List*)
  - Headquarters in NYC, Offices in DC, Chicago, Boston, Arizona, North Carolina, Florida, Ohio
  - Expertise in 16 practice groups, including Transportation, Social Policy, Market Research, Health, Energy, Elections, GIS, etc.

About Abt SRBI GIS

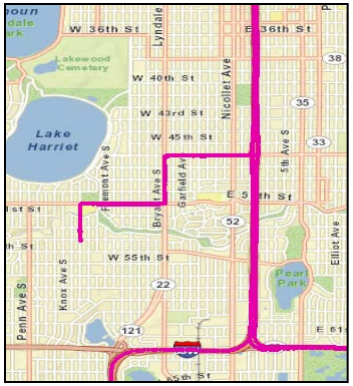
- Clients Include:
  - Amtrak
  - Girl Scouts of America
  - NYC Economic Development Corporation
  - Port Authority of New York and New Jersey
  - USAID
  - Yum! Brands
  - National Oceanic and Atmospheric Administration (NOAA)
  - U.S. Department of Housing & Urban Development (HUD)

Travel Behavior Surveys

- Metropolitan and Regional Transportation Planning Organizations (MPOs and RTPOs)
- Conducted every 5-15 years
- Used for urban/regional planning
  - Travel demand models
  - Regional capacity and level of service planning
- Survey participants
  - **Recruited randomly from general population**
  - **Self report of travel behaviors**
  - **Incentives provided for completion**

Objectives for Travel Surveys

- What are the **origins/destinations** of individual trips?
- What are the **trip segments**?
- What are the trip **distances/times/speeds**?
- What are the travel **modes**?
- Ensuring high **precision** of data



Traditional Survey Methods v. GPS

Travel: How did you get to Location 1?

1. What type(s) of transportation did you use to go to Location 11?

1st			2nd (if needed)			3rd (if needed)	
1	Car, van, truck	4	Public Bus	7	Amtrak	10	Taxi/Shuttle
2	Walk	5	Light Rail (Hiawatha)	8	Bicycle	11	Dial-A-Ride
3	School Bus	6	Commuter Rail (Northstar)	9	Motorcycle/ Moped	12	Other (specify)_____

2. If you used a bus/train for this trip, did you use a pass? ☐ Yes ☐ No --→ How much did you pay?_____

3. If you used car/van/truck or motorcycle/moped for this trip . . .

A. Were you the . . .? ☐ Driver ☐ Passenger

B. Including yourself, how many people were in the vehicle? 1 2 3 4+

Including yourself, how many are household members? 1 2 3 4+

Which household members were with you?

_____, _____, _____, _____

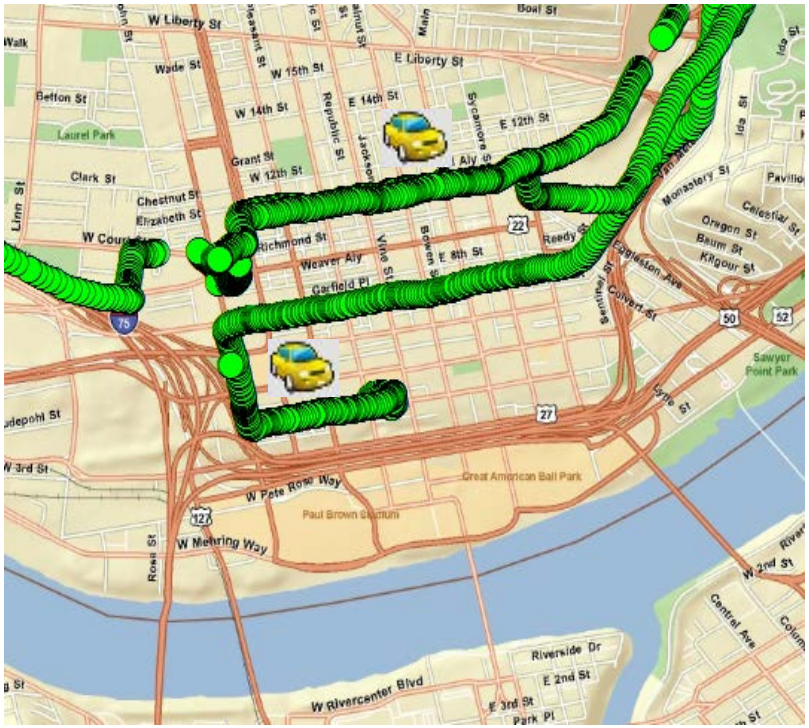
C. Was this vehicle from your household? ☐ Yes ☐ No

D. Did you pay a toll? ☐ Yes ☐ No

E. How much, in total, did you personally pay for parking? ☐ Nothing

$ ___ ___ . ___ ___ Was the rate...? ☐ Hourly ☐ Daily ☐ Monthly ☐ Other

Travel Diary Example



GPS Data Example

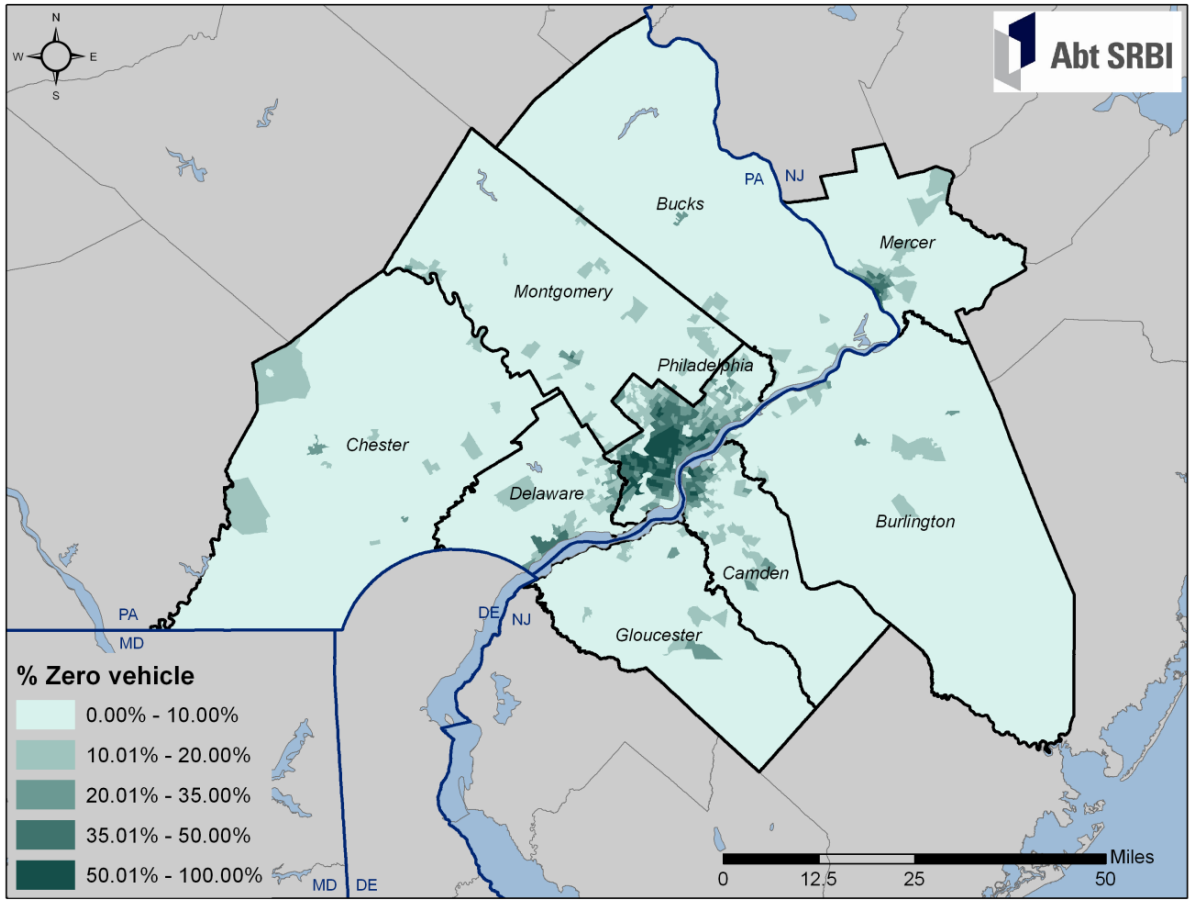
<u>Advantages of GPS</u>: Route information, lower respondent burden, no data entry, increased data quality and data volume

Abt SRBI GPS Travel Survey
Los Angeles Region

- Southern California Association of Governments (SCAG)
- April 2012 to October 2012
- ~900 households participated
- **~1,800 total GPS units sent out**

Abt SRBI GPS Travel Survey Philadelphia Region

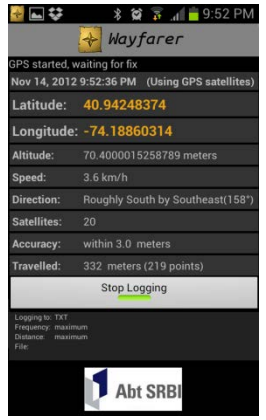
- Delaware Valley Regional Planning Commission (DVRPC)
- August 2012 to April 2013
- ~750 households participated
- **~1,500 GPS units sent out**



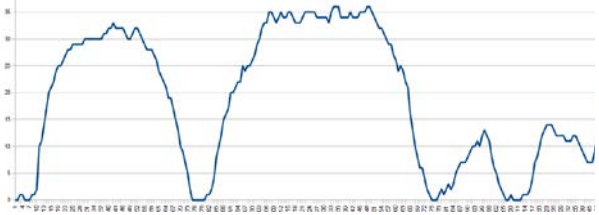
GPS Loggers vs GPS Smartphones

GPS Data Loggers

GPS Smartphone Application



GPS data collection devices result in same core GPS data



- Passive GPS Data Collection
- Usable by all members of general population (~55% of cell phones users have smartphones)
- Collects GPS data every 1 second, batteries last multiple days

- Utilization of participants' current smartphones
- No need to purchase, mail, manage GPS devices
- Customized prompting for additional survey questions

Abt SRBI GPS Device

- Lightweight: 2.5 oz
- Records every **1 second** of travel activity
- Passive device – Powers on automatically with movement
- Carried <u>everywhere</u>

GPS Deployment

SEND = FedEx

RETURN = USPS

Table

MASTER

QHHID	PERSONID	HHPERSONID	AGE	SEND	RETURN	GPSID_SEND	GPSID_RETURN	CHARGERSENT	CHARGERRETURN	GPS STATUS
207451	4	20745104	13	10/03/2011 2:03:12 PM	10/21/2011 3:38:13 PM	05057091	05057091	0	0	1
209089	1	20908901	61	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057097	05057097	1	1	1
209089	2	20908902	64	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057034	05057034	0	0	1
168351	1	16835101	99	09/28/2011 3:25:23 PM	10/14/2011 1:43:20 PM	05057203	05057203	1	1	1
201991	1	20199101	69	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	812342	812342	1	1	2
201991	2	20199102	72	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	01104337	01104337	0	0	1
130800	1	13080001	63	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	01104285	01104285	1	1	1
164653	1	16465301	89	09/28/2011 3:25:23 PM	10/06/2011 5:06:30 PM	05057060	05057060	1	1	2
120547	1	12054701	70	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057055	05057055	1	1	1
214073	1	21407301	66	09/28/2011 3:25:23 PM	10/14/2011 1:43:20 PM	908810	908810	1	1	1
214073	2	21407302	63	09/28/2011 3:25:23 PM	10/14/2011 1:43:20 PM	811251	811251	0	0	1
100970	1	10097001	71	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057227	05057227	1	1	1
100970	2	10097002	65	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057089	05057089	0	0	1
	4	20351701	66	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057103	05057103	1	0	1
		318501	68	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057056	05057056	1	1	1
		318502	70	09/28/2011 3:25:23 PM	10/20/2011 10:25:05 AM	05057139	05057139	0	0	1
		517901	50	10/03/2011 2:03:12 PM	10/27/2011 9:35:32 AM	05057014	05057014	1	1	2
		517902	53	10/03/2011 2:03:12 PM	10/27/2011 9:35:32 AM	05057122	05057122	0	0	2
		517903	26	10/03/2011 2:03:12 PM	10/27/2011 9:35:32 AM	05057218	05057218	0	0	1
		514601	86	10/03/2011 2:03:12 PM	10/20/2011 10:25:05 AM	05057130	05057130	1	1	2
		624501	56	09/28/2011 3:25:23 PM	10/13/2011 4:07:32 PM	812404	812404	1	2	1
		624502	55	09/28/2011 3:25:23 PM	10/13/2011 4:07:32 PM	01104329	01104329	0	0	1

(0 out of 1453 Selected)

GPS Mail Database

Statistical Tests for GPS Compliance

One-way ANOVA

Variable	F statistic	P value
Age	1.487	0.004
Household size	7.450	0.000

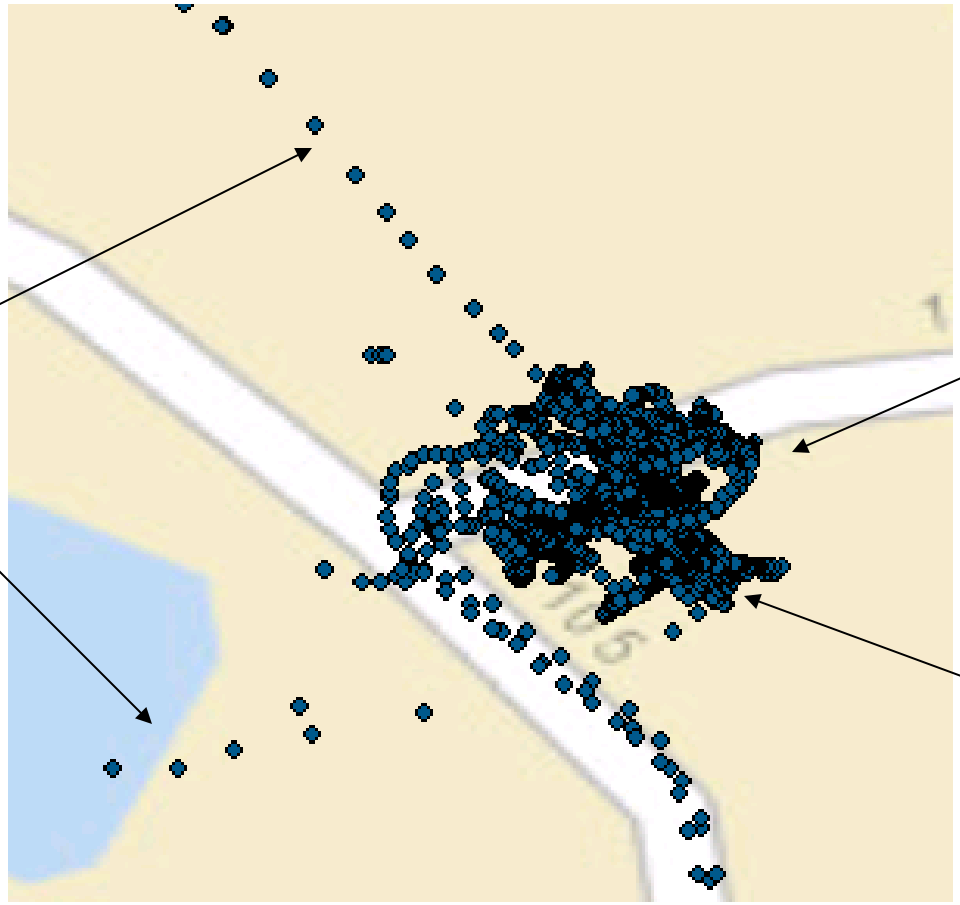
- Age and household size are positively correlated with non-compliance in GPS study
- Gender and regional location not correlated with GPS compliance
- Larger households size = more GPS units = greater overall burden
  Incentive of $25 per GPS unit, not per household
  Limiting to 4 persons per household > 16 and < 85 years old

Raw GPS Data Output

Longitude	Latitude	Speed	Course	Sat	HDOP	Altitude	date	time	distance
-93.2671	45.09099	0	0	8	0	238	19/8/2011	22:45:01	0
-93.2671	45.09098	0	0	8	0	237	19/8/2011	22:45:02	0
-93.2671	45.09098	0	0	8	0	237	19/8/2011	22:45:03	0
-93.2671	45.09098	0	0	8	0	237	19/8/2011	22:45:04	0
-93.2671	45.09097	0	0	8	0	237	19/8/2011	22:45:05	0
-93.2671	45.09097	0	0	8	0	237	19/8/2011	22:45:06	0
-93.2671	45.09095	2	0	8	0	237	19/8/2011	22:45:07	1
-93.2671	45.09095	0	0	8	0	237	19/8/2011	22:45:08	0
-93.2671	45.09094	0	0	8	0	237	19/8/2011	22:45:09	0
-93.2671	45.09094	0	0	8	0	236	19/8/2011	22:45:10	0
-93.2671	45.09094	2	0	8	0	236	19/8/2011	22:45:11	0
-93.2671	45.0909	4	0	8	0	237	19/8/2011	22:45:12	3
-93.2671	45.09089	4	0	8	0	237	19/8/2011	22:45:13	1
-93.2671	45.09087	2	0	8	0	237	19/8/2011	22:45:14	1
-93.2671	45.09086	2	0	8	0	237	19/8/2011	22:45:15	1
-93.2671	45.09086	2	0	8	0	237	19/8/2011	22:45:16	0
-93.2671	45.09083	2	0	8	0	237	19/8/2011	22:45:17	2
-93.2671	45.09082	2	0	8	0	237	19/8/2011	22:45:18	1
-93.2671	45.09081	2	0	8	0	238	19/8/2011	22:45:19	1
-93.2671	45.0908	2	0	8	0	238	19/8/2011	22:45:20	0
-93.2671	45.09078	2	0	8	0	238	19/8/2011	22:45:21	1
-93.2671	45.09077	2	0	8	0	238	19/8/2011	22:45:22	0
-93.2671	45.09076	2	0	8	0	238	19/8/2011	22:45:23	1
-93.2671	45.09075	2	0	8	0	238	19/8/2011	22:45:24	1
-93.2671	45.09075	2	0	8	0	239	19/8/2011	22:45:25	0
-93.2671	45.09075	0	0	8	0	239	19/8/2011	22:45:26	0
-93.2671	45.09075	0	0	8	0	239	19/8/2011	22:45:27	0
-93.2671	45.09075	0	0	8	0	240	19/8/2011	22:45:28	0

- Longitude
- Latitude
- Speed
- Course
- Number of Satellites
- HDOP
- Altitude
- Date
- Time
- Distance travelled

GPS Data Before Processing



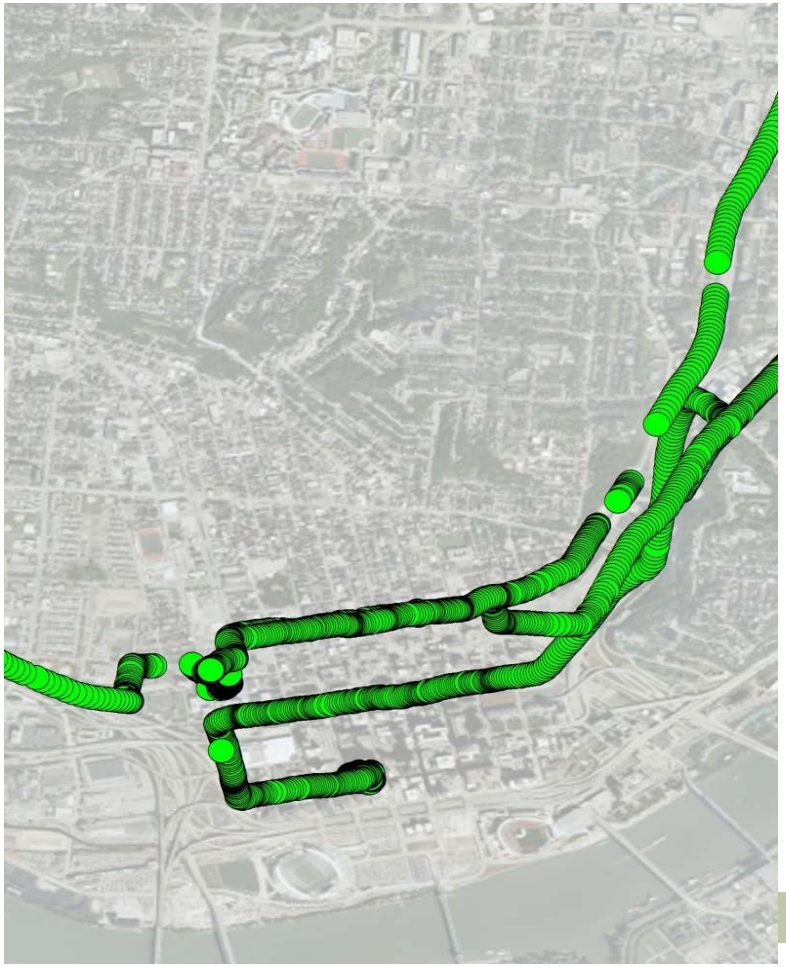
Distorted waypoints resulting from indoor use

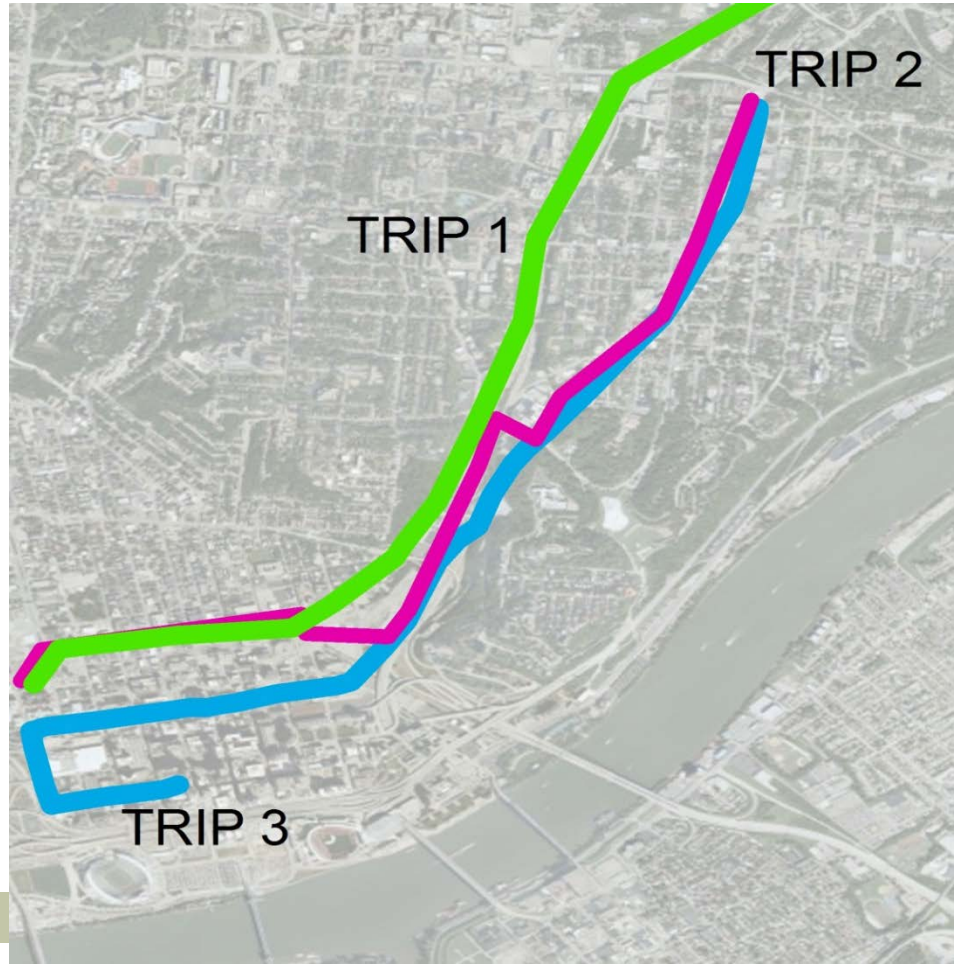
Participant carries GPS units indoors

Extraneous stationary data

Determining Trips from GPS Data

150,000,000+ GPS Points → ***70,000+ Trips***





Abt SRBI GPS Processing Model

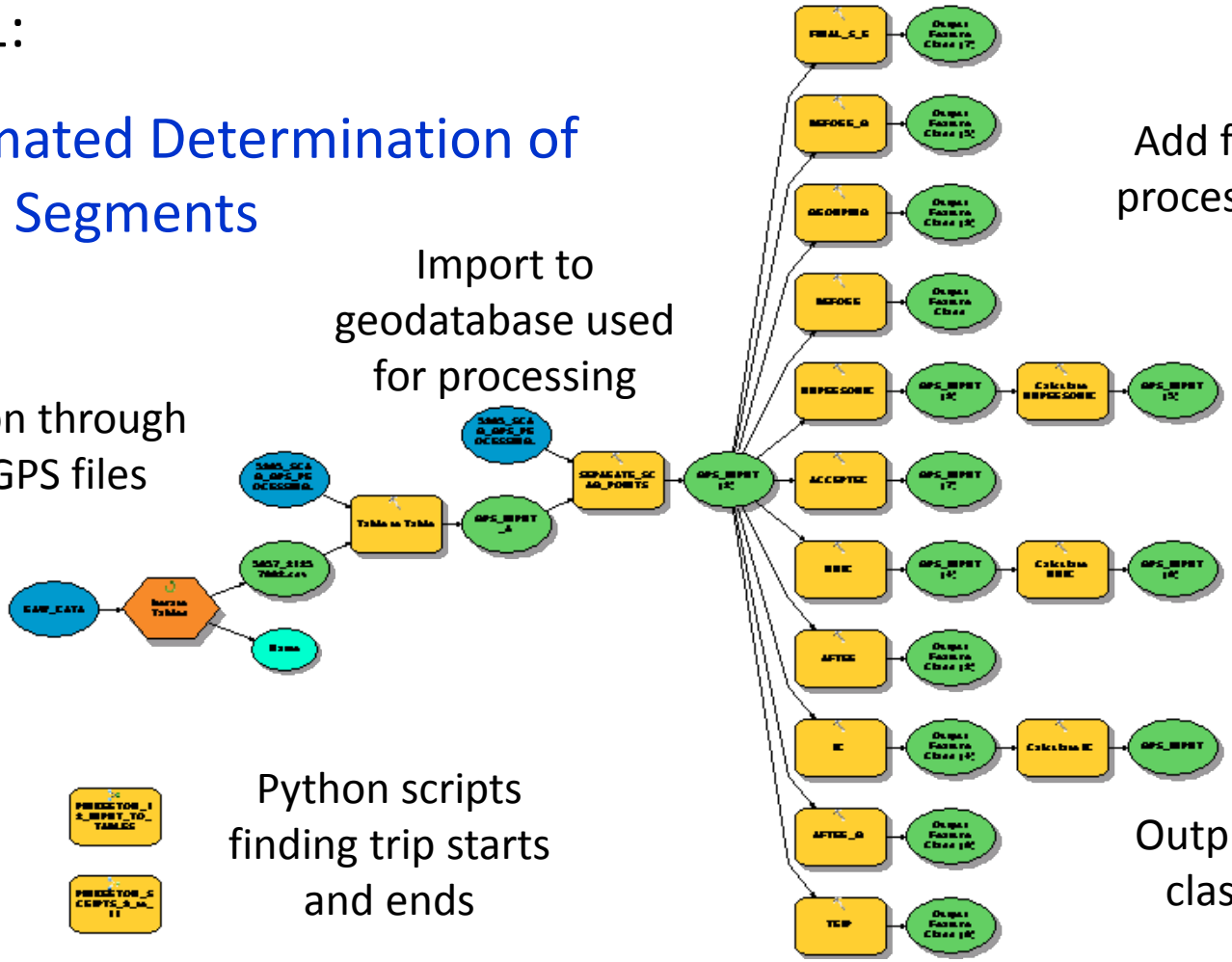
Step 1:

Automated Determination of Travel Segments

Iteration through raw GPS files

Import to geodatabase used for processing

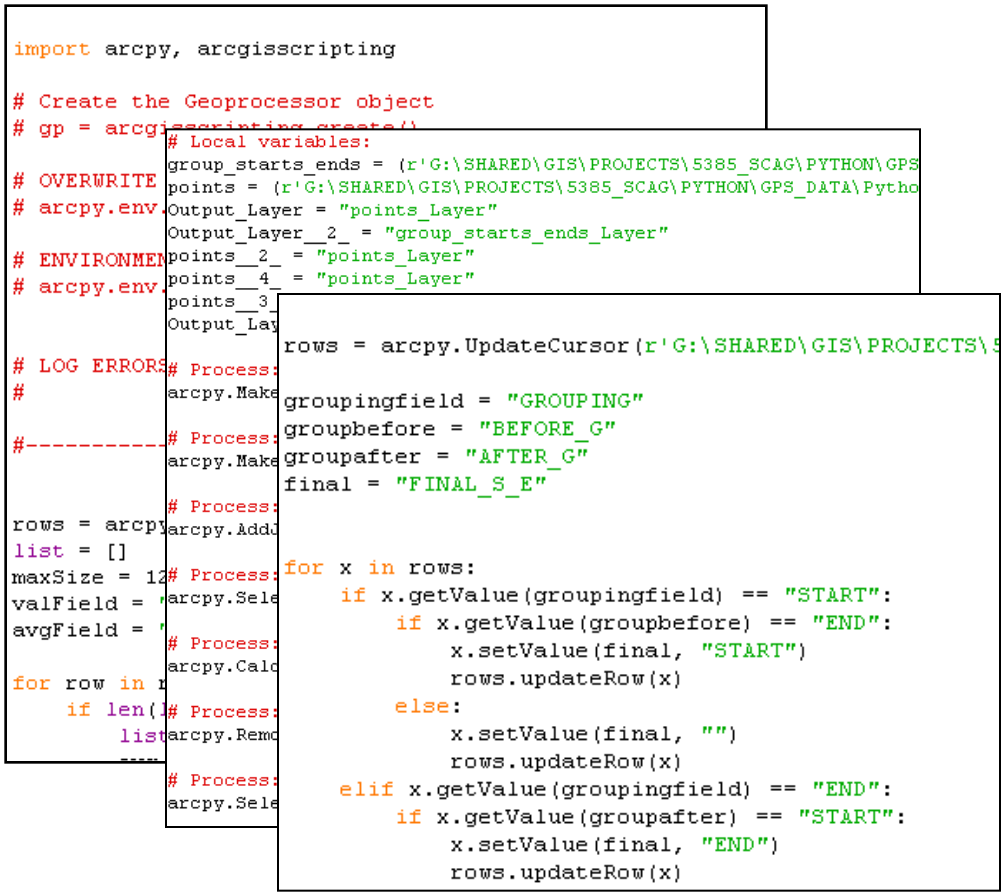
Add fields to a processing table



Python scripts finding trip starts and ends

Output: cleaned feature class of GPS trips per participant

Python Scripting for Trip Segments



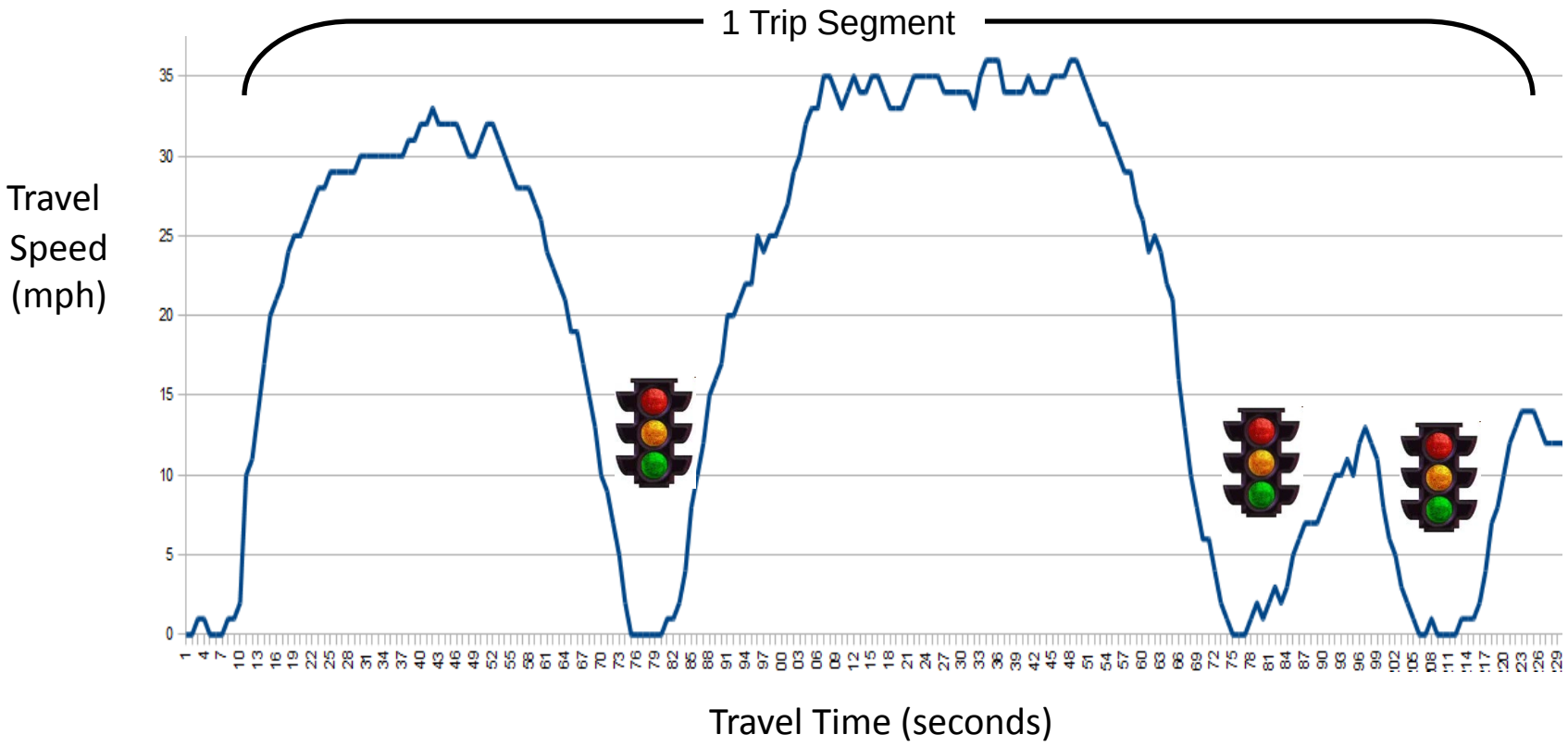
```
import arcpy, arcgisscripting

# Create the Geoprocessor object
# gp = arcg

# OVERWRITE
# arcpy.env.

# ENVIRONMEN
# arcpy.env.

# LOG ERRORS
#

#----------

rows = arcpy
list = []
maxSize = 12
valField = '
avgField = '

for row in r
    if len(l
        list
        ----
```

```
# Local variables:
group_starts_ends = (r'G:\SHARED\GIS\PROJECTS\5385_SCAG\PYTHON\GPS
points = (r'G:\SHARED\GIS\PROJECTS\5385_SCAG\PYTHON\GPS_DATA\Pytho
Output_Layer = "points_Layer"
Output_Layer__2_ = "group_starts_ends_Layer"
points__2_ = "points_Layer"
points__4_ = "points_Layer"
points__3
Output_Lay

# Process:
arcpy.Make

# Process:
arcpy.Make

# Process:
arcpy.Addd

# Process:
arcpy.Sele

# Process:
arcpy.Calc

# Process:
arcpy.Remo

# Process:
arcpy.Sele
```

```
rows = arcpy.UpdateCursor(r'G:\SHARED\GIS\PROJECTS\5

groupingfield = "GROUPING"
groupbefore = "BEFORE_G"
groupafter = "AFTER_G"
final = "FINAL_S_E"


for x in rows:
    if x.getValue(groupingfield) == "START":
        if x.getValue(groupbefore) == "END":
            x.setValue(final, "START")
            rows.updateRow(x)
        else:
            x.setValue(final, "")
            rows.updateRow(x)
    elif x.getValue(groupingfield) == "END":
        if x.getValue(groupafter) == "START":
            x.setValue(final, "END")
            rows.updateRow(x)
```

- Algorithm calculates a single start point and end point for each trip/trip segment
- Based on accelerating and decelerating speeds in the raw data
- Identifies clouds of “starts” and “ends” in the data and selects a final start and final end point and time

Trip Segment Intervals



< 120 second gaps = Same trip segment (stop light)

> 120 second gap = New trip segment

The Abt SRBI Automated GPS Model

Step 2:

Manual Review of Trip Segments

- Zooms the map sequentially to each flagged trip
- User accepts or rejects trip segments
- Layer symbology updated to show approval status of trips

```
import arcpy

MXD = arcpy.mapping.MapDocument("Current")
lstLayers=arcpy.mapping.ListLayers(MXD)

dataframe = arcpy.mapping.ListDataFrames(MXD, "Layers")[0]

pointslayer=arcpy.mapping.ListLayers(MXD,'GPS_POINTS')

allFrames=arcpy.mapping.ListDataFrames(MXD)

for dataFrame in allFrames:
     MXD.activeView=dataFrame
     for points in pointslayer:
         arcpy.ApplySymbologyFromLayer_management(points, r"C:\GIS\GIS_5385_SCAG

arcpy.RefreshActiveView()
```

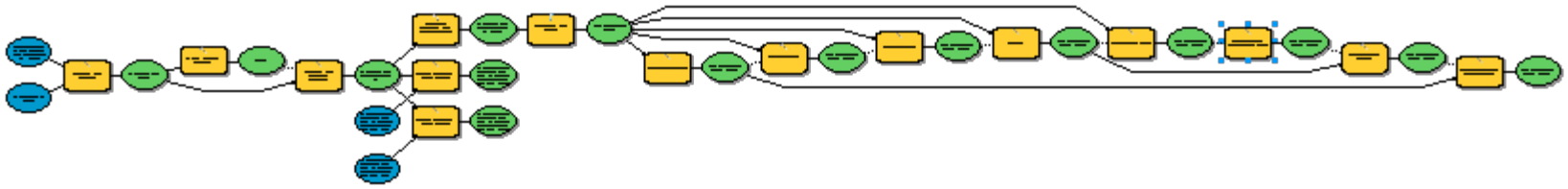
The Abt SRBI Automated GPS Model

Step 3:

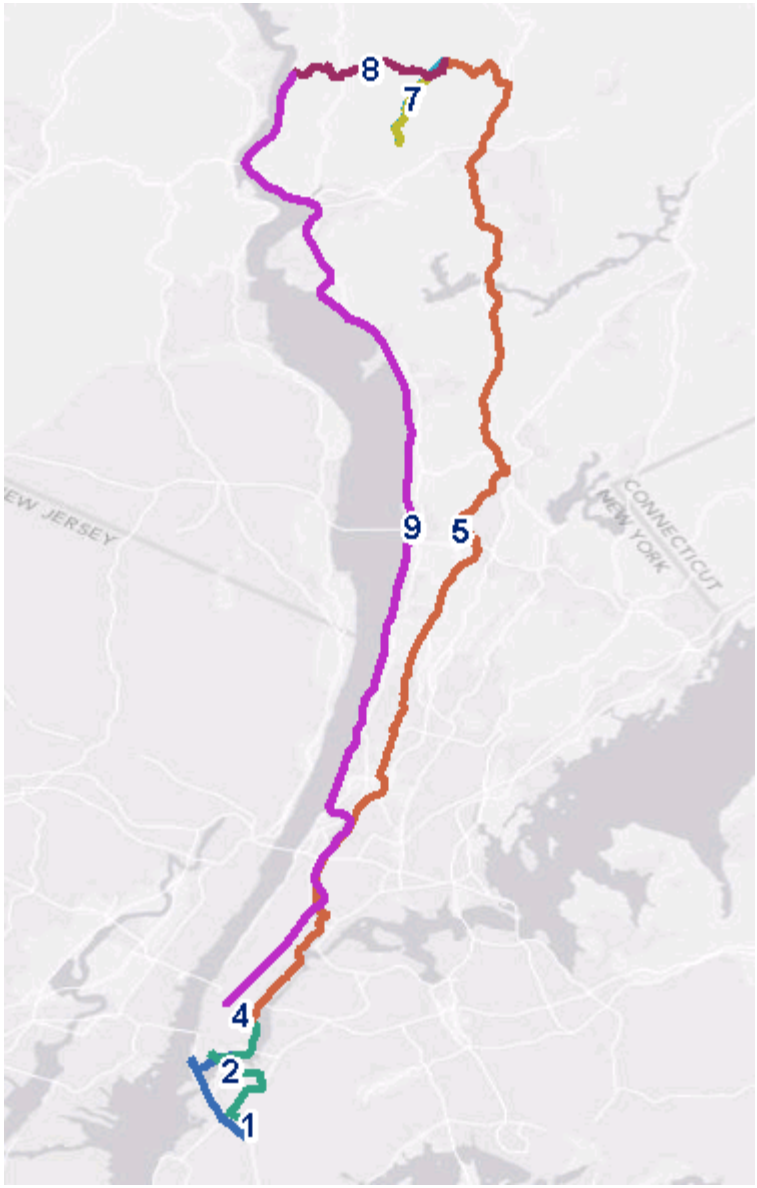
Trip Speed Calculations & Final Products

- Uses the datetime module in python to calculate total trip time
- Calculates length of trip line to determine trip distance
- Divides distance by time to generate trip speed

```
for x in rows:
    if x.getValue(final) == "START" and x.getValue(accepted) == 1:
        startlist.append(x.getValue(date))
        startlist.append(x.getValue(time))
    elif x.getValue(final) == "END":
        endlist.append(x.getValue(date))
        endlist.append(x.getValue(time))

del x, rows

startlist2 = []
endlist2 = []

while len(startlist) > 0 and len(endlist) > 0:
    ds = startlist[0]
    ts = startlist[1]
    tst = ts.time()

    de = endlist [0]
    te = endlist [1]
    tet = te.time()

    startlist2.append(datetime.datetime.combine(ds, tst))
    endlist2.append(datetime.datetime.combine(de, tet))
    startlist.pop(0)
    startlist.pop(0)
    endlist.pop(0)
    endlist.pop(0)
```

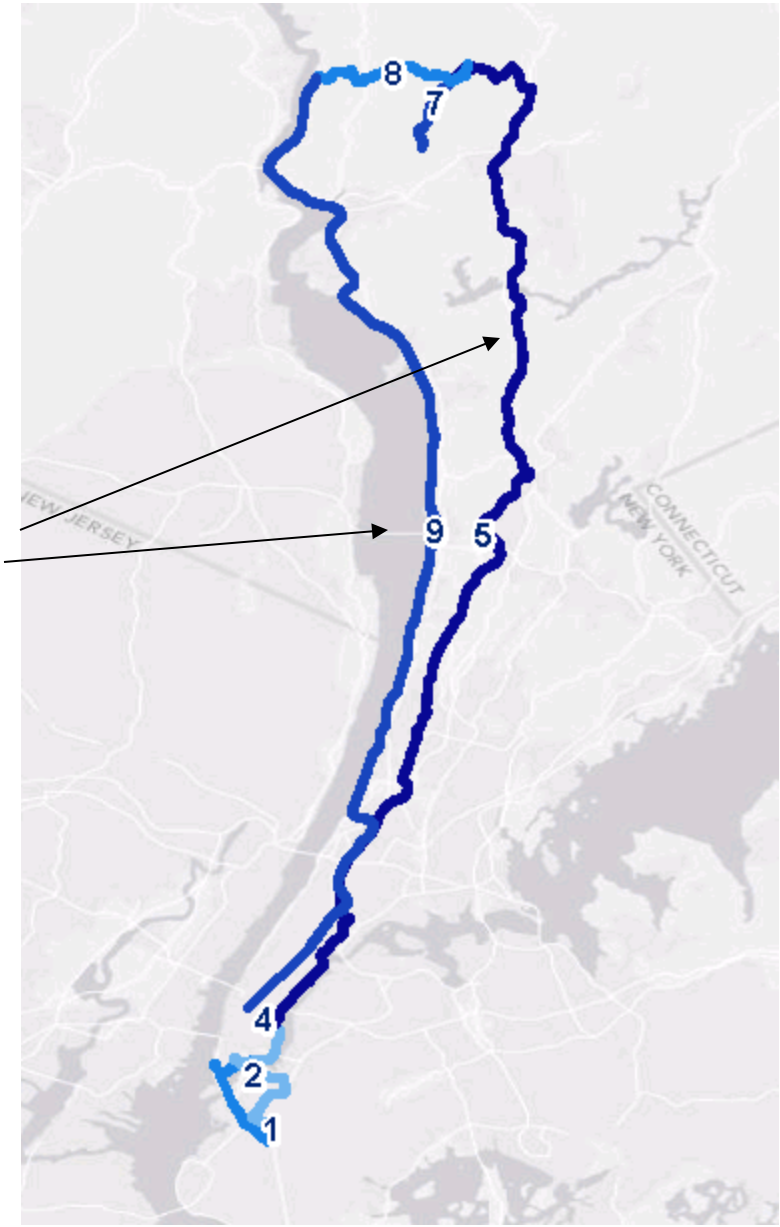


Numbered Trip Segments, Categorical Symbology by Trip Number



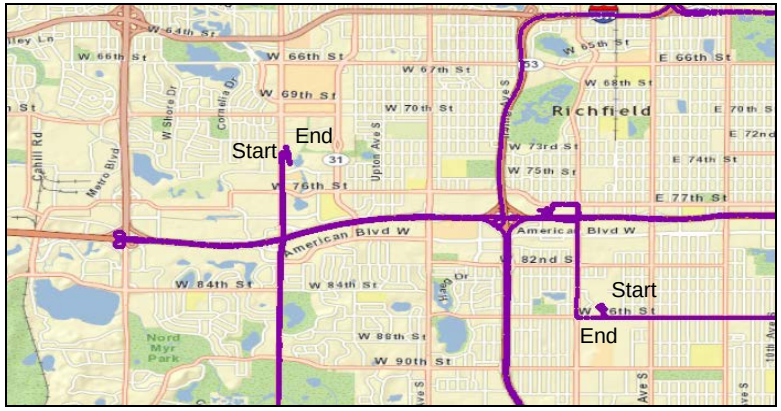
Higher average speed

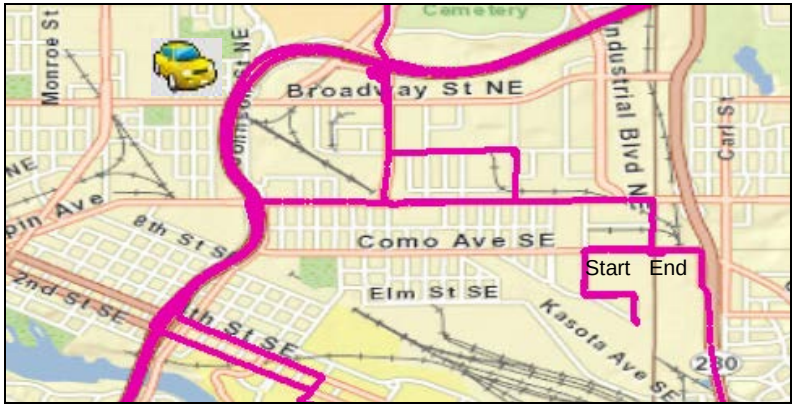
Trip Segments Symbolized by Speed



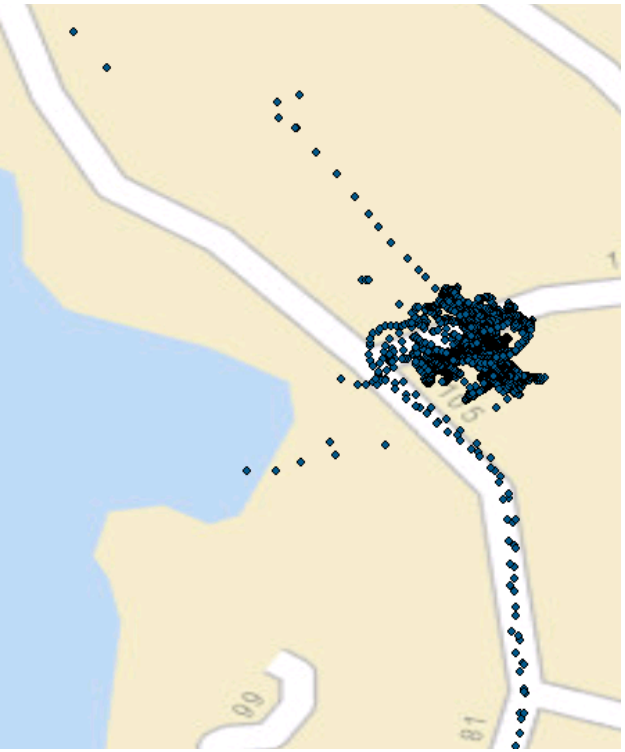
Final Products

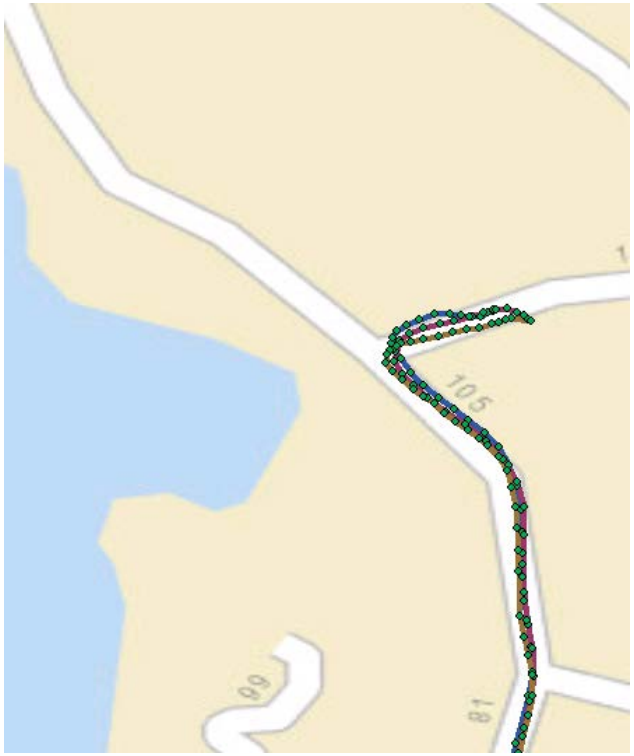
- Route information in line and point format
- Origin and destination points for each trip
- Removal of stationary non-trip data
- Improved accuracy of trip distance, time, and speed calculations compared to diaries





GPS Final Products



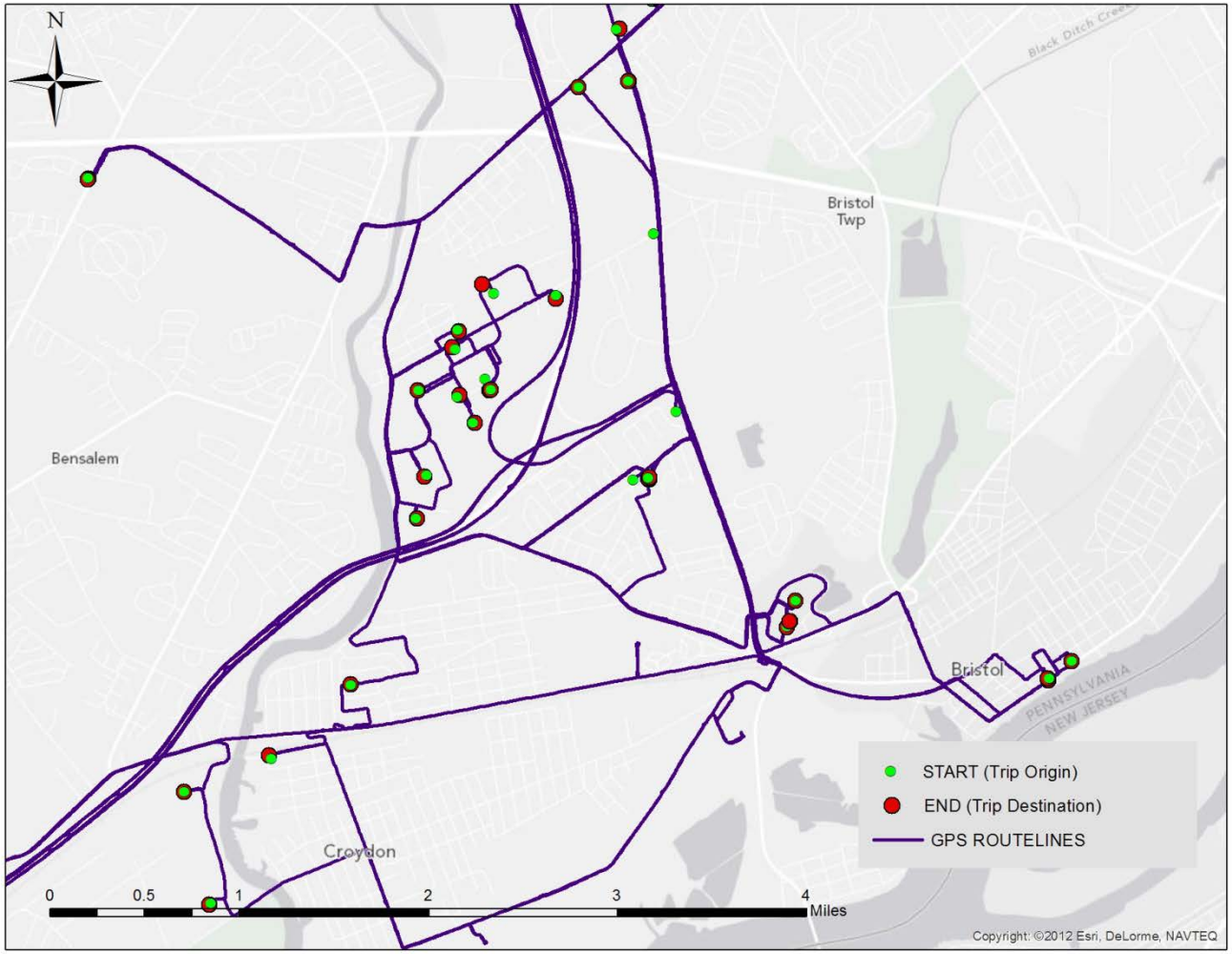


Raw GPS Data

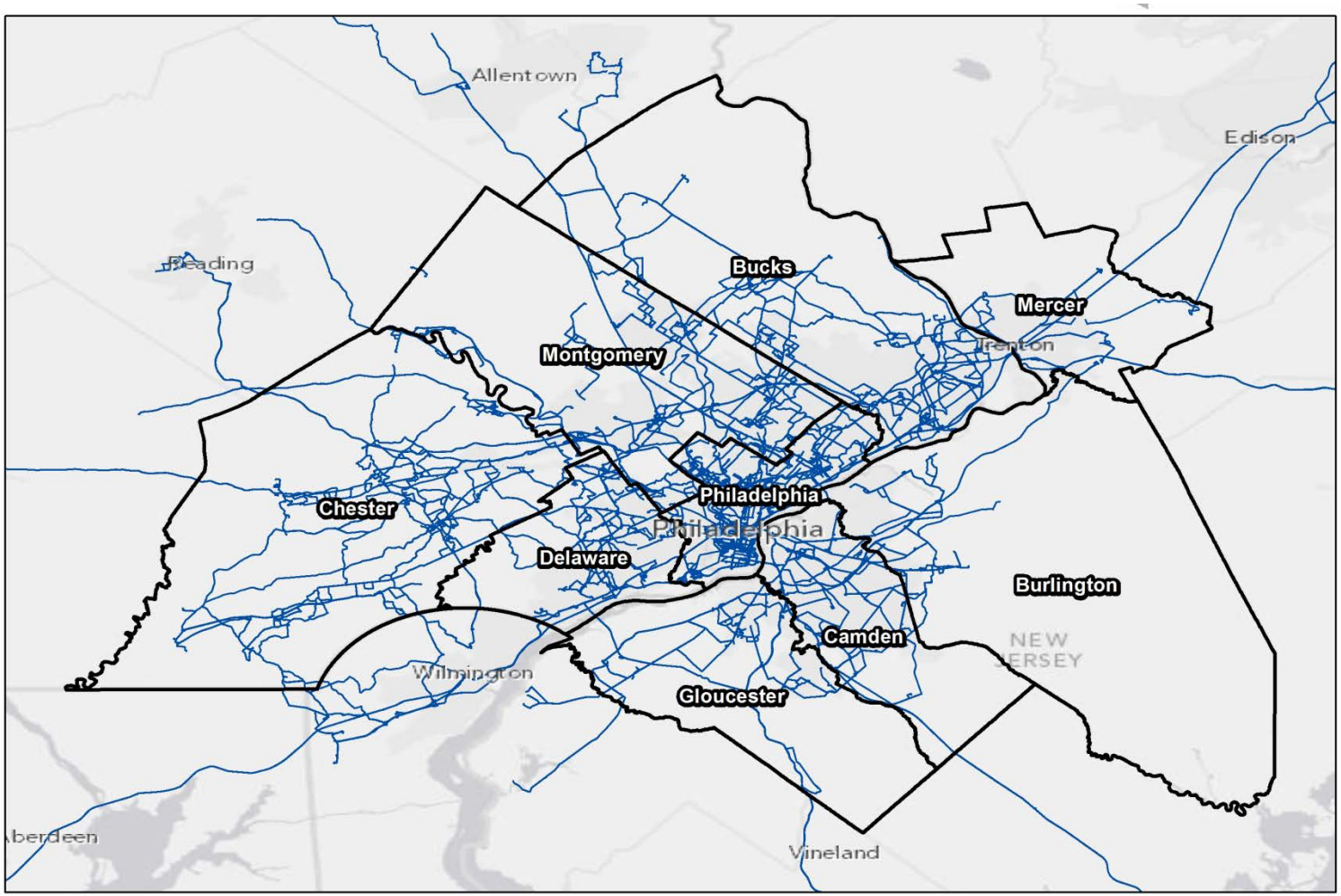
Cleaned Points

Output Trip Lines

GPS Final Products



GPS Final Products



GPS Trave Survey Challenges

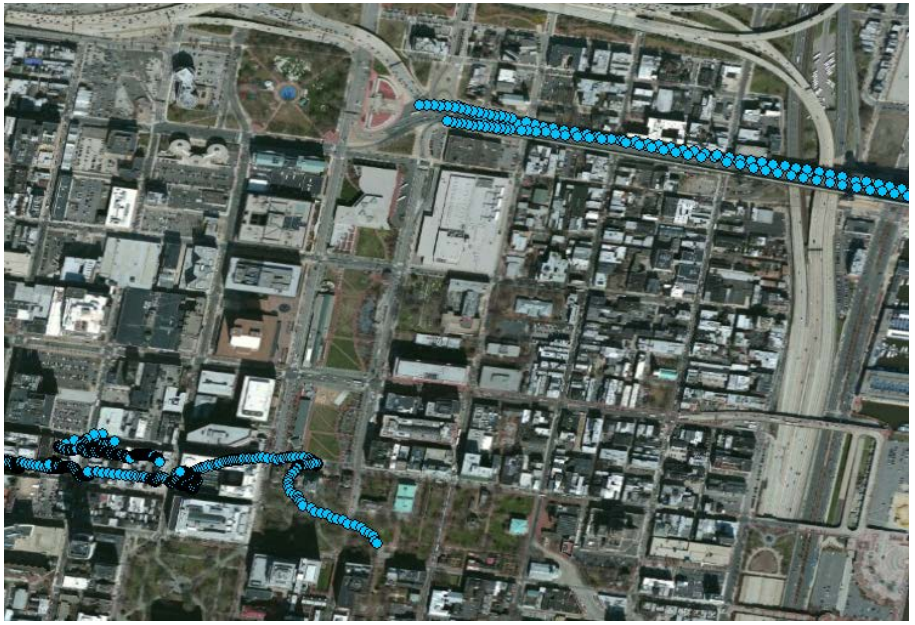
- Determining **mode** of travel
  - Combination of speed, routes
  - Bicycling can mimic vehicles in traffic
  - Studying collected travel speed patterns
- Ensuring new trips are new trips
  - LA traffic > 2 minutes
  - Goal: limiting manual verification
- Capturing tunnel travel (subway)

GPS Trave Survey Challenges

- Capturing tunnel travel (subway)

A. Line Dataset

B. Final Point Deliverables



GPS Travel Survey Conclusions

- **Successful data collection method**
  - 200+ million GPS points collected
  - 30,000+ days of travel information collected
- **Lowers respondent burden**
  - Higher response rates with GPS compared to travel diaries
  - No filling out of lengthy forms
- **GPS Loggers work for now, smartphones are next step**
  - GPS loggers and Smartphones used in collaboration to reach all populations
- **More robust, accurate data for planning**
  - Route information
  - Eliminates data entry errors
  - Output integrates with travel demand models
- **ESRI products provide the necessary tools**
  - SQL Server 64 bit for all data storage
  - ModelBuilder, Python
  - ArcMap for Review (developing a mapping API)

Contact Information

Thank you

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