



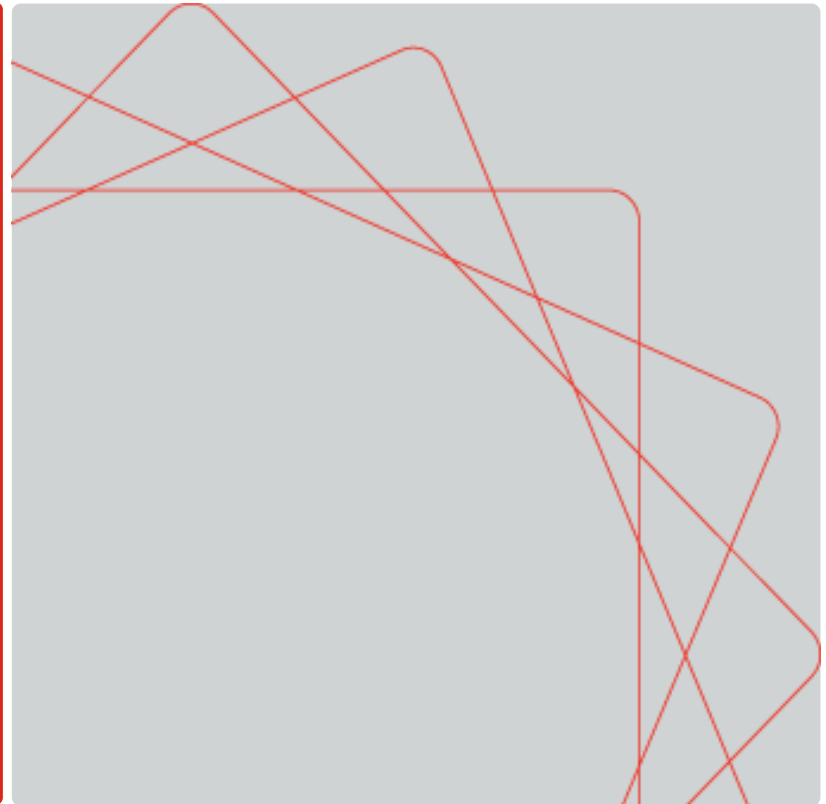
Use of GPS Devices to Enhance Travel Behavior Diaries

**2017 CE Survey Methods
Symposium**

Washington, D.C.

July 18, 2017

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Overview

1. Understanding of Household Travel Surveys (HTS)
2. Limitations of Travel Diaries
3. GPS and Cellular Assisted Enhanced Diaries
4. Logistical, Privacy and Technical Considerations



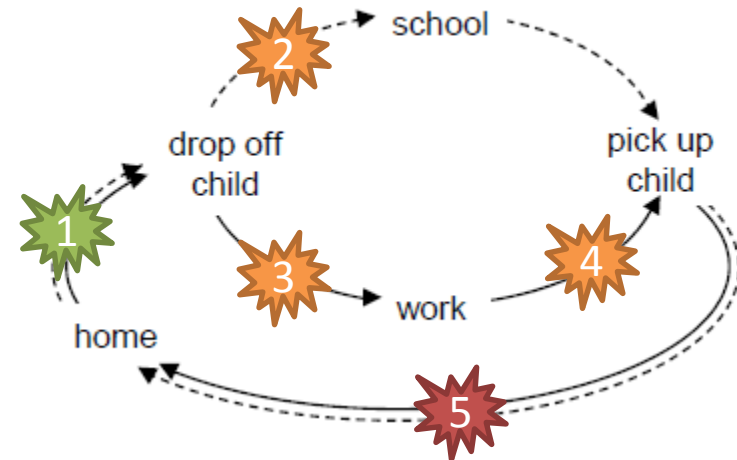
Summary

- A. HTS: capture key data to understand travel behavior
- B. Detailed data = respondent burden
- C. GPS/cellular data to minimize measurement error & item-nonresponse
- D. GPS/smartphone data introduces project management & measurement issues



Understanding Travel Behavior

- Travel Demand Modeling
 - Transportation planning
- High Resolution
 - Spatial
 - Temporal
- Household
 - Number of vehicles
- Person
 - Demographics
- Trip
 - Purpose of trip
 - Mode



National Academies of Sciences, Engineering, and Medicine.
2014. *Activity-Based Travel Demand Models: A Primer*.
Washington, DC: The National Academies Press.
<https://doi.org/10.17226/22357>.



HTS Study Design

Household
Survey

Roster
Demographics
Contact information

Person
Level
Travel
Diary

Address - Geocodable to the Census block
Time (HH:MM)
Purpose (e.g. school, shopping, work, etc.)
Mode (vehicle, transit, etc.)



Travel Diary Data Quality

- Item nonresponse
 - Zero trip days
 - Unreported trips
- Measurement error
 - Trip times
 - Trip locations



GPS Data Enhancements

- Subsample given GPS logger or smartphone app
- Location data is collected passively at prescribed intervals
- Purpose inferred by location
- Mode inferred by speed



Typology of Location Data

- Trace files
- Cellular Tower Data
- WiFi
- Bluetooth Beacons
- GPS



GPS Logging

- Devices log location and time
- Data processed ex post facto
- Diary data matched and compared to device data
- Develop underreported trip estimate





Prompted Recall

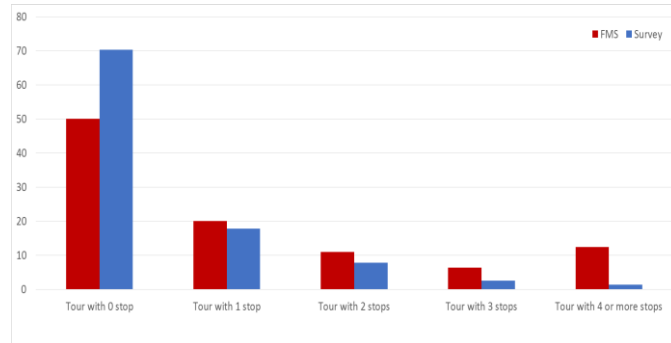
- Location data processed near real time (GSM/Wifi)
- Parsed GPS are transformed to trips (O/D)
- Machine Learning is used to pre-fill diary
- Respondent verifies/edits trips

The screenshot displays a travel diary interface for Monday, 01-04-2013. On the left, a map shows a route with six numbered stops. On the right, a list of activities is shown, all of which have been validated. The activities include Home, Travel Car/Van, Activity Pick Up/Drop Off, Travel Car/Van, Activity Work, Travel Foot, Activity Work, Travel Foot, Activity Change Mode/Transfer, Travel Car/Van, and Activity Home. A green banner at the top of the list states: "All of your travel and activities have been validated."

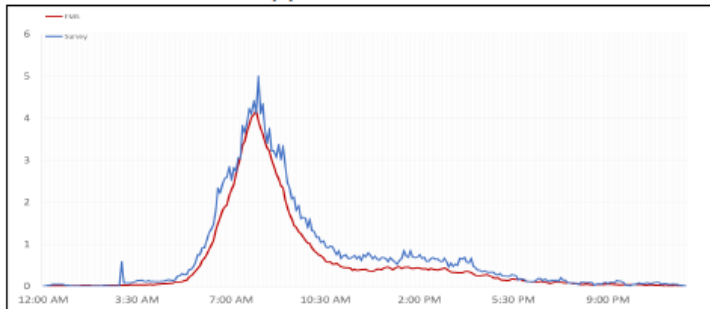
Activity	Start	End	Validation
Home	21:57*	08:15	Validated
Travel Car/Van	08:15	08:18	Validated
Activity Pick Up/Drop Off	08:18	08:25	Validated
Travel Car/Van	08:25	08:47	Validated
Activity Work	08:47	10:35	Validated
Travel Foot	10:35	10:40	Validated
Activity Work	10:40	18:11	Validated
Travel Foot	18:11	18:13	Validated
Activity Change Mode/Transfer	18:13	18:17	Validated
Travel Car/Van	18:17	18:41	Validated
Activity Home	18:41	07:55**	Validated

Zhao, F.; Ghorpade, A.; Pereira, F.C.; Zegras, C.; Ben-Akiva, M. Stop Detection in Smartphone-based Travel Surveys. *Transp. Res. Proc.* 2015, 11, 218–226.

Trip counts Prompted Recall vs Diary



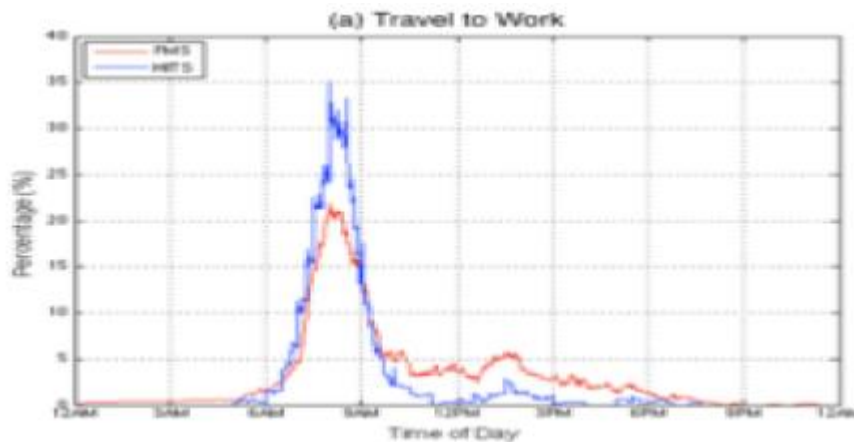
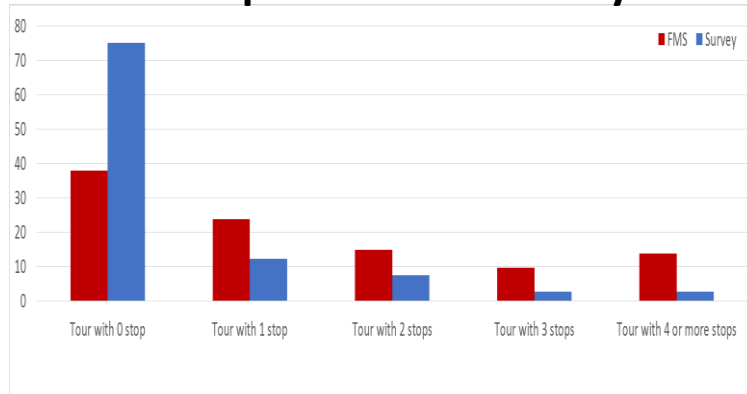
(a) Travel to Work



Nahmias-Biran B., Han Y., Taepan K., Zhao F., Bekhor S., Zegras C., Ben-Akiva M. "Enriching Activity Based Models Using Smartphone-Based Travel Surveys." SMART Future Urban Mobility Symposium 2017. 11 July 2017, Singapore.

Top Three Purposes of Home-Based Tours: Tel Aviv		
Status	THS	FMS
Full time worker	Work	Work
	Accompany	Accompany
	Shopping	Personal
Part time worker	Work	Work
	Accompany	Personal
	Shopping	Accompany
Unemployed (looking for a job)	Shopping	Personal
	Personal	Education
	Accompany	Accompany
Unemployed (not looking for a job)	Shopping	Education
	Social visit	Personal
	Personal	Accompany
Retired	Shopping	Personal
	Personal	Shopping
	Social visit	Social visit
Professional soldiers	Work	Work
	Shopping	Entertainment
	Education	Social visit
Enlisted Soldiers	Work	Work
	Other	Social visit
	Social visit	Personal

Trip counts Prompted Recall vs Diary



Top Three Purposes of Home-Based Tours: Singapore		
Status	HITS	FMS
Employed Full-time	Work	Work
	Pick-up/Drop-off	Eating
	Work-related	Personal
Employed Part-time	Work	Work
	Pick-up/Drop-off	Eating
	Shopping	Personal
Self-employed	Work-related	Work
	Work	Personal
	Pick-up/Drop-off	Shopping
Homemaker	Pick-up/Drop-off	Eating
	Shopping	Shopping
	Eating	Personal
Full-time student	Education	Education
	Shopping	Work
	Work	Eating
Retired	Others	Eating
	Pick-up/Drop-off	Personal
	Social visit	Recreation

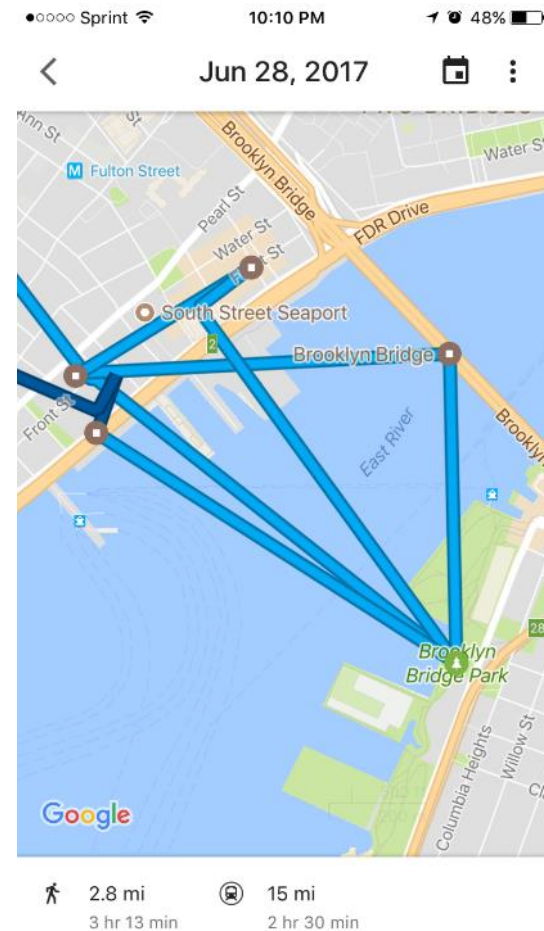
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Location Quality Issues

- Location data vulnerable to measurement error
 - User error
 - Device error
 - Processing error
 - GPS signal quality

http://bit.ly/AAPOR17_GPS





Logistical and Privacy Issues

- Data privacy
- Recruitment Bias?

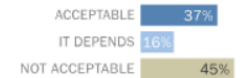
Auto insurance



Auto insurance

Your insurance company is offering a discount to you if you agree to place a device in your car that allows monitoring of your driving speed and location. After the company collects data about your driving habits, it may offer you further discounts to reward you for safe driving.

Would this be acceptable or not?



Source: Survey conducted Jan. 28 - Feb. 16, 2015.

Note: Refused responses not shown.

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Logistical and Privacy Issues (2)

- Smartphone ownership
- Cost
 - Device/shipping cost
 - GSM cost
 - App cost

% of U.S. adults who own the following devices

	Any cellphone	Smartphone	Cellphone, but not smartphone
Total	95%	77%	18%
Men	96%	78%	18%
Women	94%	75%	19%
White	94%	77%	17%
Black	94%	72%	23%
Hispanic	98%	75%	23%
Ages 18-29	100%	92%	8%
30-49	99%	88%	11%
50-64	97%	74%	23%
65+	80%	42%	38%
Less than high school graduate	92%	54%	39%
High school graduate	92%	69%	23%
Some college	96%	80%	16%
College graduate	97%	89%	8%
Less than \$30,000	92%	64%	29%
\$30,000-\$49,999	95%	74%	21%
\$50,000-\$74,999	96%	83%	13%
\$75,000+	99%	93%	6%
Urban	95%	77%	17%
Suburban	96%	79%	16%
Rural	94%	67%	27%

Source: Survey conducted Sept. 29-Nov. 6, 2016.

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Conclusion

- Travel diaries have a high level of respondent burden
- GPS and cellular data can improve the quality of travel diary data
- Passive location data add complexity and cost
- Location data is subject to error
- Diaries still need to capture attitudes and opinions



Questions?

Use of GPS Devices to Enhance Travel Behavior Diaries

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