GPS in Household Travel Surveys: A Range of Options

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Household Travel Surveys (HTS)

- Conducted at regional and statewide level on stratified sample of population to collect basic travel and socio-demographic information
- Resulting dataset is used as input to travel demand model
- Early surveys were conducted using mail-out / mail-back surveys with travel information recorded on travel diaries
- Next generation of HTS were conducted by telephone interviews
- Within past decade, new technologies added to survey toolkit:
  - Web surveys (taken via desktop or laptop PC)
  - GPS logging devices (to passively capture travel details)
  - Smartphone apps (for survey entry or for GPS data logging)

- This presentation will focus on uses of GPS in household travel surveys

Since the Beginning…

- GPS subsample dual method (diary and GPS)
  - 2000-2005, diaries for persons, GPS for vehicles (California Statewide, St Louis, and Kansas City – 1 day, Washington DC and Baltimore – 2 or 4 days)
  - Starting with Chicago HTS in 2006, person-based GPS added for multi-modal travel (7 day vehicle and 7 day wearable)
  - 2007 - 2011 person-based GPS (Indianapolis - 1 day and Massachusetts Statewide – 2 or 4 days)

- Primary purpose – trip rate correction factors

More Recently…

- GPS subsample dual method (diary and GPS)
  - 2010-2012 both options, vehicle and person, used for different purposes / reasons / populations (Denver, Atlanta, California Statewide – 7 day vehicle, 3 or 4 day wearable)
  - 100% GPS and diary sample (Oakland/San Francisco Bay Area – 3100 households, 3 days wearable)

- Secondary uses of GPS datasets include analyses of mode choice, route choice, congestion and travel times, active transport

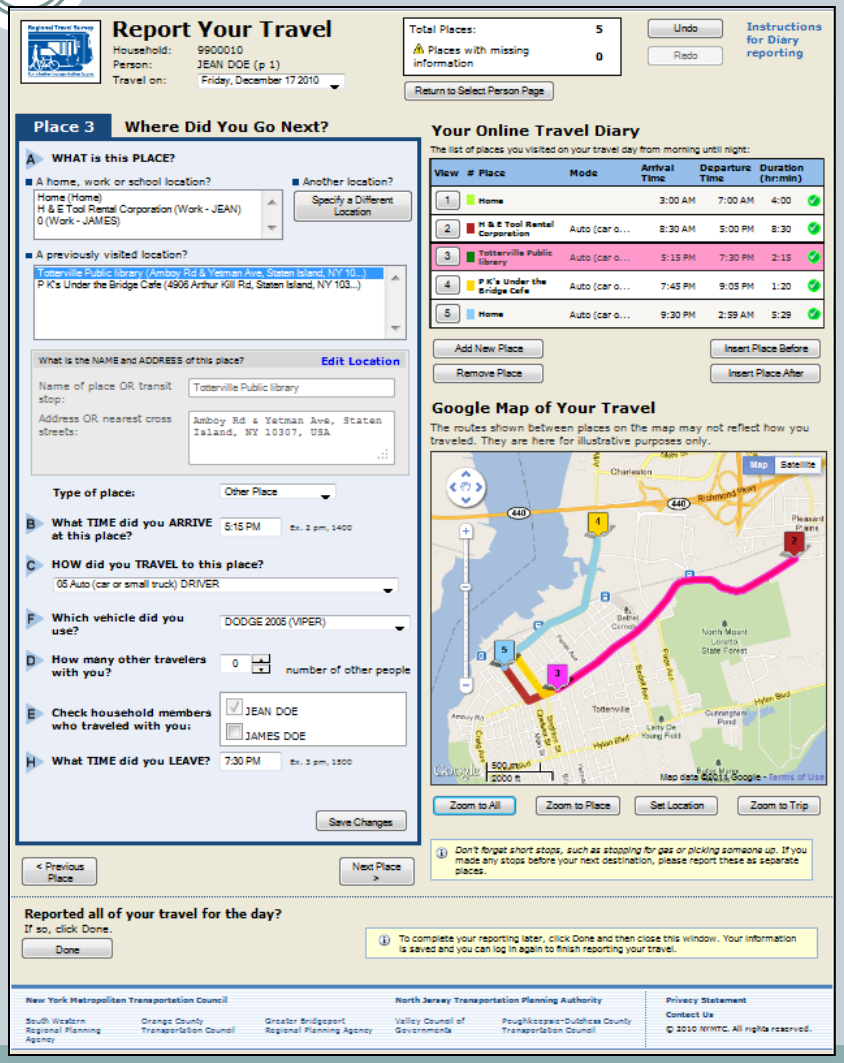
Along the Way…

- GPS-based prompted recall subset in diary survey for trip rate correction factors (10% sample NYC metro – 1880 GPS households – 2 or 4 days GPS, followed by CATI or CASI 1 day PR, 2010-2011)
- GPS-based prompted recall used for 100% GPS survey (Jerusalem, 8800 households – 1 day CAPI, 2010-2011)
- 100% GPS survey with 30% GPS prompted recall subset for imputation algorithm validation/calibration (Cleveland, 4250 households – 3 or 4 days GPS, followed by CATI or CASI 1 day PR, 2012-2013)

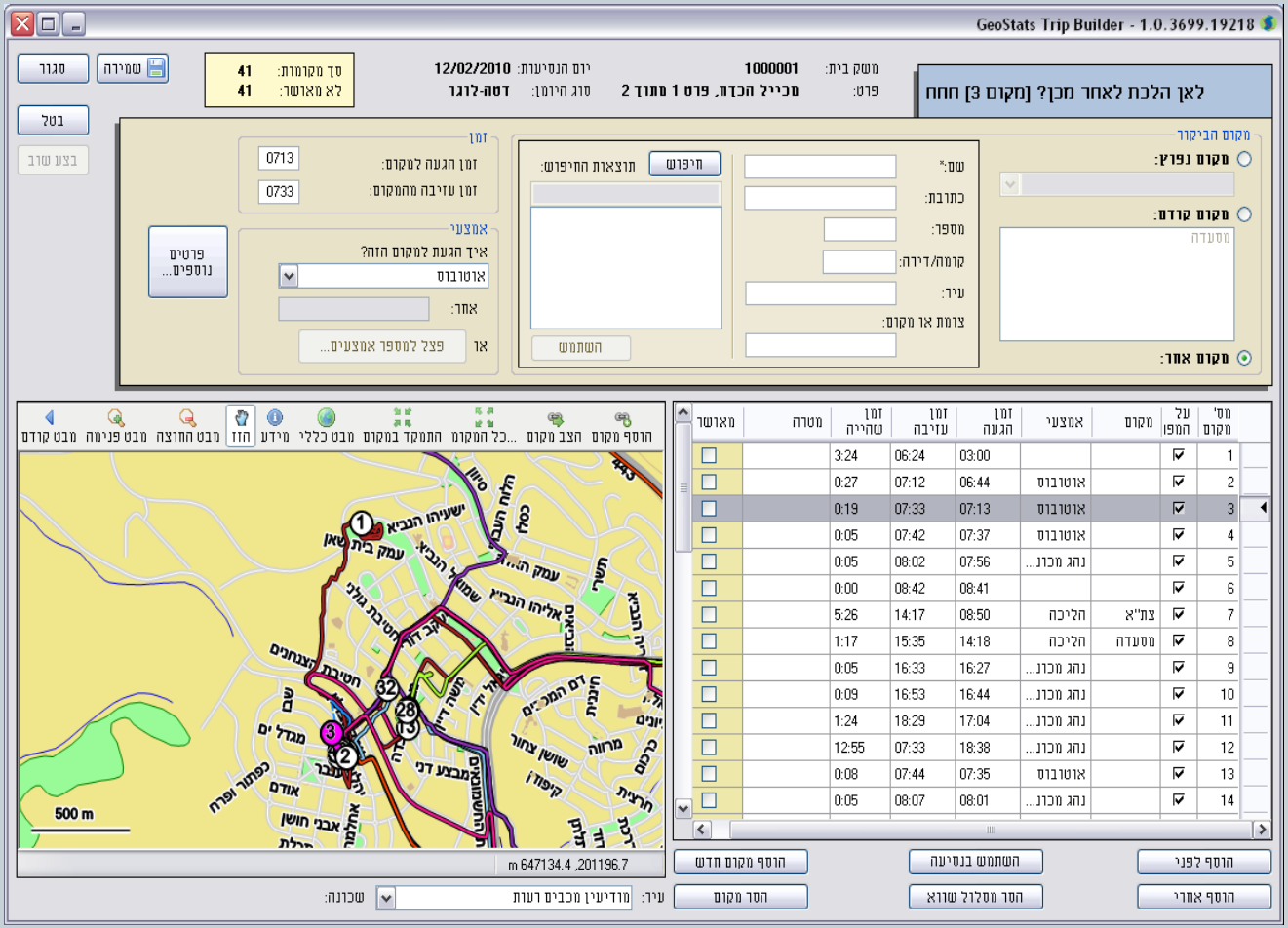
NYC Regional Travel Survey (NY-NJ-CT)

Retrieval Mode	Persons			
	GPS		Diary	
	Mean	N	Mean	N
CATI	5.3	2,461	3.9	14,117
CASI	5.6	1,658	4.3	12,042
Mail	0	0	4.3	5,361
Total	5.4	4,119	4.1	31,520

Retrieval Mode	Households			
	GPS		Diary	
	Mean	N	Mean	N
CATI	11.6	1,117	8.2	6,648
CASI	12.1	773	10.6	4,879
Mail	0	0	10.1	2,258
Total	11.8	1,890	9.4	13,785



Jerusalem 100% GPS Travel Habits Survey



Jerusalem Trip and Tour Rate Results

Sector	Person Type	Cars	No. of Participants				Trip Rate			Tour Rate		
			GPS	Non-GPS	Non-Mobile	% GPS exclude Non-Mobile	GPS	Non-GPS	Ratio	GPS	Non-GPS	Ratio
1=Secular	1=Worker	0	295	42	44	87.5%	4.02	3.14	1.28	1.34	1.12	1.19
		1+	1,629	145	110	91.8%	5.38	3.56	1.51	1.62	1.21	1.33
	2=Non-worker	0	238	39	140	85.9%	4.16	2.95	1.41	1.44	1.18	1.22
		1+	472	49	137	90.6%	4.92	3.00	1.64	1.70	1.24	1.37
	3=School	0	37	3	12	92.5%	3.84	3.33	1.15	1.30	1.67	0.78
		1+	190	18	42	91.3%	3.58	2.72	1.31	1.31	1.22	1.07
2=Orthodox	1=Worker	0	247	67	24	78.7%	4.32	3.46	1.25	1.53	1.39	1.11
		1+	165	23	10	87.8%	6.47	3.17	2.04	1.95	1.26	1.54
	2=Non-worker	0	443	148	130	75.0%	5.33	3.87	1.38	1.88	1.74	1.08
		1+	125	23	26	84.5%	5.94	4.74	1.25	2.01	2.09	0.96
	3=School	0	94	54	12	63.5%	3.62	2.26	1.60	1.33	1.07	1.24
		1+	48	15	8	76.2%	4.04	2.20	1.84	1.56	0.93	1.67
3=Arab	1=Worker	0	116	19	32	85.9%	3.70	2.11	1.76	1.19	0.95	1.26
		1+	366	33	50	91.7%	4.97	2.42	2.05	1.34	1.06	1.26
	2=Non-worker	0	130	9	167	93.5%	3.11	2.44	1.27	1.08	1.00	1.08
		1+	203	19	242	91.4%	3.88	2.79	1.39	1.31	1.11	1.18
	3=School	0	73	8	32	90.1%	2.74	2.00	1.37	1.08	1.00	1.08
		1+	124	14	52	89.9%	2.75	2.14	1.28	1.10	1.00	1.10

Cleveland GPS Household Travel Survey: Pretest and Pilot Study Design

Pretest (September 2011)

- 5 task force or staff participant households in PR subsample to test materials, methods, questionnaires

Pilot (October – November 2011)

- 150 hh recruited (original goals: 50 PR, 100 GPS only)
- All persons of age 13 – 75 provided with wearable GPS data logger for three days (four days if first day is Friday)
- 75+ only hh created new category: Log only
- Incentives offered, tailored to level of burden

Cleveland Pilot Study Results

Phase	% CATI	% WEB	Total Recruits	Total Retrieved / Completed	% CM
Recruitment (all)	57%	43%	150	102	68%
Retrieval (PR Only)	53%	47%	41	30	73%
Retrieval (GPS Only)	NA	NA	94	67	71%
Retrieval (Log Only)	NA	NA	15	5	33%

- High use of web recruitment and of web retrieval (PR households)
- The retrieval rate for GPS only and GPS+PR households exceeded expected rates by a few percentage points
- Log only households did not mail back completed logs as expected

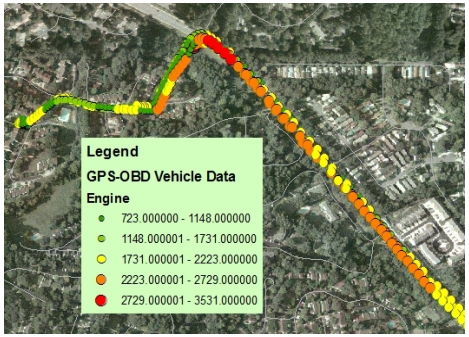
Cleveland Main Survey Overview

- 4,250 Complete Households
  - 2,575 Households GPS-only (no travel retrieval)
  - 1,250 Households GPS-based Prompted Recall (PR)
  - 425 Households Log only (75+ households)
- 12-month data collection period starting on Feb 15, 2012
- Travel details for GPS-only sample to be derived /imputed

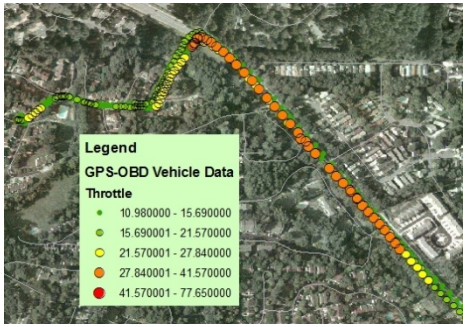
Extensions for Vehicle Activity

- Vehicle GPS and Onboard Diagnostic (OBD) sensors (California Statewide Travel Survey – 1300 households, 2012-2013)
  - GPS device measures all vehicle trips (second-by-second traces with instantaneous speed and heading)
  - OBD device measures engine activity (mass air flow, engine speed, engine load, throttle position – 5 second frequencies)
  - Combined metrics can be used for fuel consumption and emissions modeling
  - 500 households from alternative fuel vehicle sample

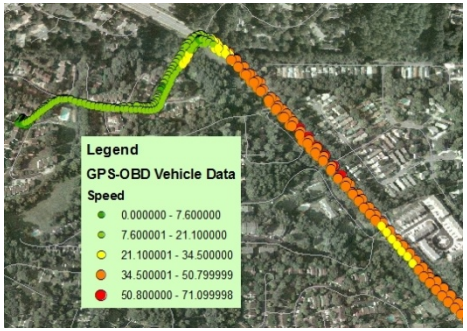
Sample GPS and OBD Data



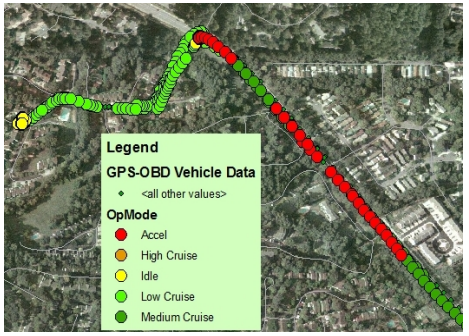
Engine Speed



Throttle Position



Vehicle Speed

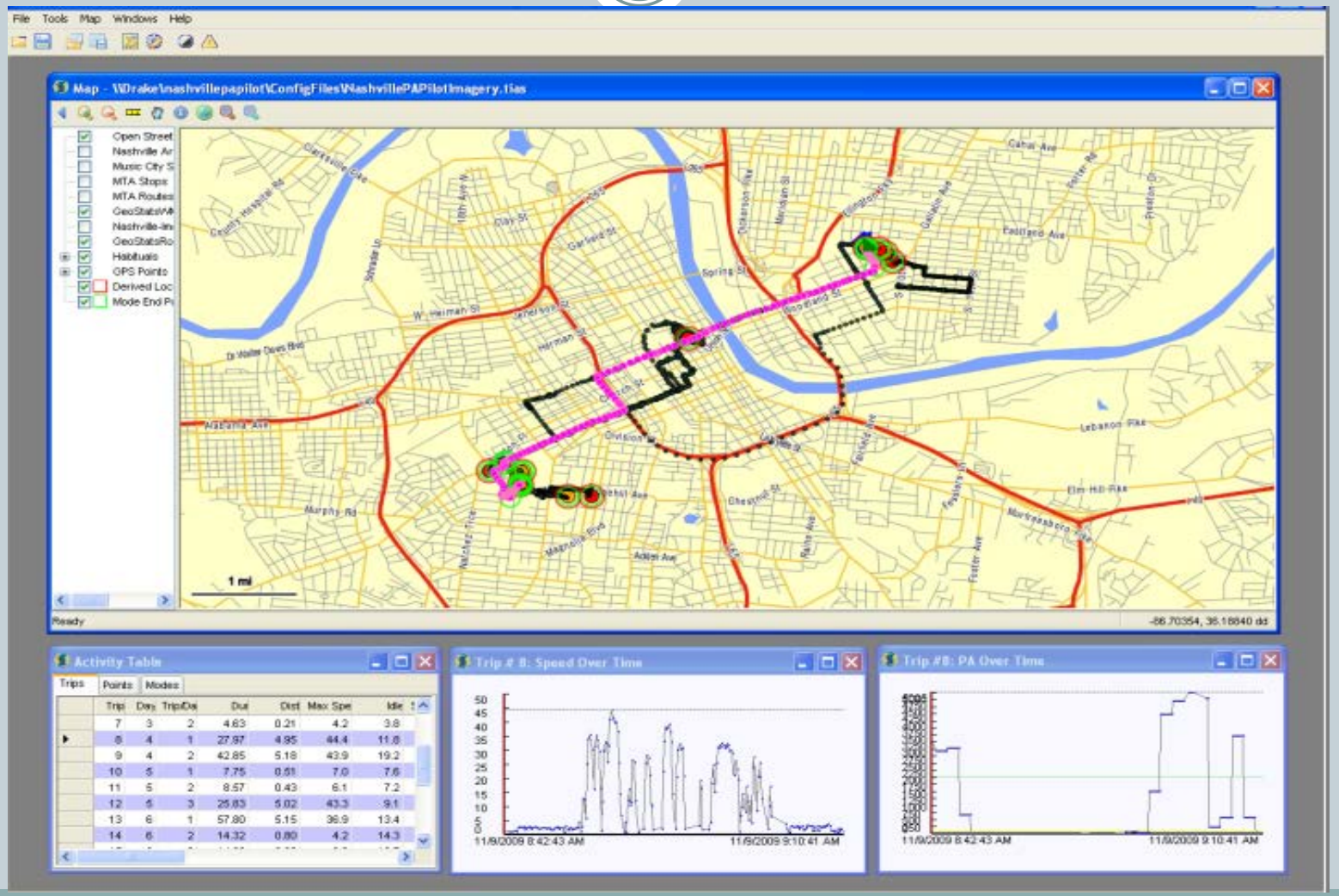


Operating Mode

Extensions for Physical Activity

- Wearable GPS and / or accelerometers (activity monitors) for measuring travel and physical activity (Atlanta – 500 households 2001-2002, Nashville – 600 households, 2012)
  - GPS devices measure all modes of travel (second-by-second)
  - Accelerometers measure physical activity intensity
  - Both devices in tandem identify where / how physical activity occurs

Nashville Walk-Bus-Walk Trip



Trends over the Past Decade

- Increasing size of GPS subsamples
  - Primary purpose: trip rate correction factors for diary participants
- Longer deployment durations and longer study durations
- Expansion from dual method to GPS only method
  - There is still value in dual methods for some agencies
- Although wearable devices are commonplace, doesn't necessarily mean that they are only solution
  - Vehicle approach appropriate for certain goals and has lower burden
- Agencies see value of GPS data beyond correction factors
- GPS loggers used in tandem with other sensors to meet additional data needs

The Future

- Multi-modal surveys (web, phone, mail, GPS)
  - "Different strokes for different folks"
- GPS only surveys (with or without prompted recall)
  - Standalone GPS data loggers
  - Smartphone data logging apps
- Data mining of large-scale consumer datasets
  - GPS data from personal navigation devices, smartphones
  - Other transactional data (e.g., credit cards, farecards)

Acknowledgements

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Thanks!

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