Australian Progress in GPS Measurement of Urban Travel Behaviour

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Outline

• Introduction and Background
• Recent Projects at ITLS
• Survey Procedures with GPS
• Results of GPS Data Collection
• Variability of Travel Behaviour
• Conclusions
Introduction and Background

• Global Positioning System devices first used in travel behaviour research in 1995
  – Initial devices were vehicle based
  – Portable/wearable devices emerged in late 90s

• GPS devices have become increasingly sophisticated and available as personal tracking devices

• Most recent Australian uses of GPS have been for:
  – TravelSmart evaluations
  – Validation and analysis of traditional household travel surveys
Introduction and Background

• ITLS has been developing GPS for the past 7 years
  – Specifying improved capabilities for GPS devices
  – Refining survey procedures for use with GPS devices
  – Developing software to process the results
  – Exploring potential to replace travel diaries
• A number of projects have been conducted with GPS
Recent Projects

• Validation of the Sydney Continuous Household Travel Survey with GPS (2001-2004)
  – Used mainly in-vehicle devices and some portable devices
  – Households recruited by door knocking
  – Recruited after agreeing to participate in the Sydney HTS
  – Participants asked to carry GPS devices for 3-4 days - 1 day analysed
Recent Projects

• Evaluation of “Households on the Move” TravelSmart intervention in Canberra (2003-2004)
  - Used same mix of GPS devices as previous project
  - Participating households recruited by door knocking
  - Households asked to participate in two waves of a panel (before and after)
  - Both TravelSmart and non-TravelSmart households recruited
  - Participants asked to carry GPS devices for a week in each wave
Recent Projects

- **TravelSmart Evaluation of Households in the West, Adelaide (2005-2008)**
  - Used a newer portable device for all participants (made in South Australia)
  - Established a panel of 200 households
  - Panel recruited by telephone
  - Panel members asked to carry GPS devices for 7 days once each year for three years
  - Subsample carried GPS for 15 days in two waves
  - Project recently completed - results not yet publishable
Recent Projects

  - Pilot survey to research some questions on GPS feasibility
  - Panel of 50 households recruited by telephone
  - Panel members asked to carry GPS devices for 28 days in Waves 1 and 2
  - Six months between waves
  - Panel members asked to carry GPS devices for 15 days in Wave 3
Current and Future Projects

• Pilot GPS Validation of VI STA07 (2007)
  – Households recruited by door knocking
  – Participants asked to carry GPS devices for one week
  – Recruitment of households only after agreement to undertake VI STA07 survey
  – One week included diary day of VI STA07
  – Results provided to the client a month ago
Current and Future Projects

• Long-Term Monitoring of Travel Behaviour Change (2007-2013)
  – Households recruited by telephone
  – Panel of 120 households recruited
  – Participants asked to carry GPS devices for 15 days once per year for six annual waves
  – Panel rotation will be undertaken on a four-year basis
Advantages of GPS

- Passive method requiring very little from the respondent
- Records data very accurately about
  - Routes used
  - Distance travelled
  - Time taken
  - When and where the trip takes place.
- Provides a means to obtain multi-day travel data
- Records distances for all modes of travel
  - Permits the analyst to infer travel mode, estimate VKT and PKT
  - Captures walk and bicycle travel
- Data can potentially serve a number of additional uses, e.g.,
  - Travel speed by time-of-day and route
  - Inputs for fuel consumption and emissions estimates
  - Measures of physical activity and health.
Evolution of Portable GPS Devices
GPS Device Used in South Australia and Long-Term Pilots

May-June 2008  Australian Developments in GPS  13
GPS Device Used in SA Projects

- Similar in size to mobile phone
- Weighs about 110 grams
- Has 8 Mb memory - sufficient for more than a month of data collection
- Powerful antenna/receiver capable of receiving signals in:
  - Trains and buses
  - Inside a handbag or in a pocket
  - In the glove box of a car
  - Inside a house
  - In most shopping centres
- Contains its own battery
GPS Device Used in SA Projects

- Battery life and power management are an issue
- Current battery life is about 8 hours
  - Power management involves the device “sleeping” after no movement for 2 minutes
  - Wakes up every 3 minutes to check for movement
  - Can result in missing start of a trip
Example of Tracking

Ability of Neve Device
Newest GPS Device
Newest GPS Device
Newest GPS Device

- Has 8 Mb of memory
- Equipped with an Atmel GPS chipset
  - same sensitivity as the Sirf Star III chipset
- Longer battery life (up to 4 days)
- Faster signal acquisition
- Smaller and lighter weight
  - 76mm x 46 mm x 20 mm
  - Weighs 50 grams
Newest GPS Device

• Has a vibration sensor
  – If no vibration is detected for a user-specified period of time, device turns off
  – The moment there is vibration, the device turns on and searches for signal

• Has voice messages:
  – Announces when it is looking for position
  – Announces when it has fixed position
  – Announces when battery power is low

• Also has display lights that indicate status
Costs of Devices

- Earliest wearable devices cost over AU$1,000
- Neve devices cost around AU$1,000
- Atmel devices are currently priced at about AU$200
- Able to be used many times over
  - Hence, capital costs can be spread over multiple uses
- Devices can be used by participants for up to 2 months with current memory
Survey Procedure

- Pre-notification letter
- Telephone or face-to-face recruitment
  - If telephone, devices are couriered to household
  - If face-to-face, devices are handed to household
- Demographic, address, and vehicle data form
- Consent form
- Instructions and FAQs
- Card to indicate no travel days, forgotten device, etc.
- Completed form is returned with the devices
# Vehicle Information

**Adelaide Household Travel Study**

**Vehicle Information**

<table>
<thead>
<tr>
<th>Vehicle 1</th>
<th>Vehicle 2</th>
<th>Vehicle 3</th>
<th>Vehicle 4</th>
<th>Vehicle 5</th>
<th>Vehicle 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make: Car or 4WD</td>
<td>Make: Car or 4WD</td>
<td>Make: Car or 4WD</td>
<td>Make: Car or 4WD</td>
<td>Make: Car or 4WD</td>
<td>Make: Car or 4WD</td>
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<td>Mileage: 50,000</td>
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<td>Mileage: 50,000</td>
<td>Mileage: 50,000</td>
</tr>
<tr>
<td>Owner: John Doe</td>
<td>Owner: Jane Doe</td>
<td>Owner: John Doe</td>
<td>Owner: Jane Doe</td>
<td>Owner: John Doe</td>
<td>Owner: Jane Doe</td>
</tr>
</tbody>
</table>

**Please go back over your forms to make sure that you didn’t forget to report anything.**

If you would like to comment on any aspects of the study or any transport issues, please feel free to do so in the space below:

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# Adelaide Household Travel Study

1. Please answer the questions below on the shops that your household uses.

2. Please open this booklet and answer the questions on the members of your household.

3. Please turn to the back page of this booklet and complete the questions on where the members of your household go to work and study.

4. Please find the vehicle information sheet and complete the questions on the vehicles in your household.

5. The Instruction Sheet is a part of the package sent to you, and contains instructions on how to return the information to us by post or phone.

If you have any questions, queries or problems, do not hesitate to call us on 1800 801 454.

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### Shopping Information

<table>
<thead>
<tr>
<th>Name of the Shop</th>
<th>Shopping centre</th>
<th>Retail outlet</th>
<th>Petrol outlet</th>
<th>Other</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

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Below is the list of shops where your household shops most of the grocery shopping.

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**Household Information**

Please fill in details about the people in your household as you travel with them:

1. If there is more than one job, make sure at least one person at one place.
2. If a person works more than one job, please report where they go most often.
3. Please record what time the person usually arrives at work and on time. Report what time the person usually leaves work.

---

### Address Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Name</th>
<th>Where does the person go to work?</th>
<th>Name of the work</th>
<th>Address (Home)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

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**Australian Developments in GPS**

May-June 2008
# Household Information

1. Indicate yourself, relatives, and any close associates who live in your household. How many people live in your household? [ ] One [ ] Two [ ] Three [ ] Four [ ] Five [ ] Six [ ] Seven [ ] Eight [ ] Nine or more

2. Please answer the questions below about yourself:

<table>
<thead>
<tr>
<th>What is your name and year of birth?</th>
<th>Are you employed?</th>
<th>What sort of work do you do?</th>
<th>Which of the following best describes you?</th>
<th>What type of work do you do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>First name</td>
<td>Last name</td>
<td>Year of birth</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>--------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Phone 1</td>
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</tr>
<tr>
<td>Phone 2</td>
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<td>Phone 3</td>
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<td>Phone 4</td>
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<td>Phone 5</td>
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<td>Phone 7</td>
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<td>Phone 8</td>
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<tr>
<td>Phone 9</td>
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<td></td>
</tr>
</tbody>
</table>

3. Please list all people other than yourself living in your household. Be sure to include related and non-related people, and fill out one row for each person living in your household.

<table>
<thead>
<tr>
<th>What is this person’s name and year of birth?</th>
<th>In what relationship is this person to you?</th>
<th>What sort of work does this person do?</th>
<th>Which of the following best describes this person?</th>
<th>What is the current or highest level of education this person completed?</th>
<th>What type of work do you do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>First name</td>
<td>Last name</td>
<td>Year of birth</td>
<td>Child</td>
<td>Adult</td>
<td>Other</td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>--------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Phone 1</td>
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<tr>
<td>Phone 2</td>
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<td>Phone 3</td>
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<td>Phone 4</td>
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<td>Phone 5</td>
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<td>Phone 6</td>
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<td>Phone 8</td>
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<tr>
<td>Phone 9</td>
<td></td>
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</tr>
</tbody>
</table>
GPS Use Information

NAME: «name»

- Please write in the day of the week for Day 1 (the day that you started using the GPS device).
- Complete Question 1 by ticking the category that best describes what happened each day.
- Complete Question 2 by indicating the approximate time of day the battery ran out, or by indicating this is Not Applicable (N/A).

<table>
<thead>
<tr>
<th>QUESTION 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1</strong></td>
</tr>
<tr>
<td>I didn’t go out at all today</td>
</tr>
<tr>
<td>Oops! I forgot to take my device with me today</td>
</tr>
<tr>
<td>I took the device with me for some of the day</td>
</tr>
<tr>
<td>Yes! I took my device with me all day</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUESTION 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The battery ran out today at approximately...</strong></td>
</tr>
<tr>
<td>AM</td>
</tr>
<tr>
<td>N/A</td>
</tr>
</tbody>
</table>

May
Survey Procedure

- Retrieval of devices and forms:
  - If telephone recruitment, courier picks up
  - If face-to-face, interviewer returns
    - Courier label is left if no one home
- Telephone reminders on day of courier delivery and day before courier pick up
- In subsequent waves, forms are pre-filled
<table>
<thead>
<tr>
<th>Households</th>
<th>Vehicle Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vehicle Information

Adelaide Household Travel Study

Continue Households

If you would like to comment on any aspects of the study or any transport issues, please feel free to do so in the space below:

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University of Sydney
# Household Information - Continuing Households

<table>
<thead>
<tr>
<th>Household Information</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is this person's name and year of birth?</strong></td>
<td><strong>Is this person the household head?</strong></td>
<td><strong>What work or educational level is this person doing?</strong></td>
<td><strong>What is the current or highest level of education that this person has completed?</strong></td>
<td><strong>What type of work does this person do?</strong></td>
<td><strong>What type of work does this person do?</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Andree 1949</strong></td>
<td>No</td>
<td>No School</td>
<td>Filled in</td>
<td>Type of work</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td><strong>Andrew 1949</strong></td>
<td>No</td>
<td>No School</td>
<td>Filled in</td>
<td>Type of work</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peter 1949</strong></td>
<td>No</td>
<td>No School</td>
<td>Filled in</td>
<td>Type of work</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gwendolyn 1949</strong></td>
<td>No</td>
<td>No School</td>
<td>Filled in</td>
<td>Type of work</td>
<td></td>
</tr>
</tbody>
</table>

2. Are there any ADDITIONAL HOUSEHOLD MEMBERS listed above?  
   Yes - please list below all additional household members. Be sure to include all income and expenses, and fill out cards for EACH person living in your household.
Respondent Burden

- Devices require respondents to:
  - Turn them on
  - Recharge them when possible
  - Carry the device with them whenever they leave the home
- In focus groups, respondents indicated this was very easy to do
- Additional household and vehicle forms are easily filled out
- Focus group respondents expressed considerable willingness to take devices for 15 days
Response Rate

- Predominantly used the following method:
  - Random sample of addresses
  - Phone match and include only those households that can be matched
  - Post out pre-notification letter
  - Telephone recruitment
  - Courier devices and survey forms to the recruited respondents
  - Courier pick up of devices and completed survey forms
Response Rates

- With this method, response has been similar to conventional surveys using this method - about 30 percent
  - This is for a panel survey and one week GPS use
- For a one-time survey, response would be expected to be higher
Response Bias

• Despite low response rate, no evidence of significant bias

• Results of a small 50 household sample in South Australia and of a larger 200 household sample show good correspondence to Census statistics from 2001

• Sydney HTS validation showed some biases – very different study
## GPS Demographics

<table>
<thead>
<tr>
<th>Demographic</th>
<th>2001 Census</th>
<th>Adelaide HTS</th>
<th>Main Wave 1</th>
<th>Add-On Wave 1</th>
<th>Add-On Wave 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>N/A</td>
<td>~3,000</td>
<td>202</td>
<td>47</td>
<td>46</td>
</tr>
<tr>
<td>Average HH Size</td>
<td>2.37</td>
<td>2.46</td>
<td>2.65</td>
<td>3.00</td>
<td>2.88</td>
</tr>
<tr>
<td>Average Number of Vehicles</td>
<td>1.36</td>
<td>1.56</td>
<td>1.88</td>
<td>1.86</td>
<td>1.61</td>
</tr>
<tr>
<td>Average Number of Adults</td>
<td>1.90</td>
<td>1.82</td>
<td>2.06</td>
<td>2.11</td>
<td>2.00</td>
</tr>
<tr>
<td>Proportion of Population Adults</td>
<td>80.3%</td>
<td>74.0%</td>
<td>77.7%</td>
<td>71.3%</td>
<td>74.1%</td>
</tr>
<tr>
<td>Average Number of Children</td>
<td>0.47</td>
<td>0.59</td>
<td>0.49</td>
<td>0.85</td>
<td>0.7</td>
</tr>
<tr>
<td>Proportion of Population Children</td>
<td>19.7%</td>
<td>26.0%</td>
<td>22.3%</td>
<td>28.7%</td>
<td>25.9%</td>
</tr>
<tr>
<td>Average Number of Males</td>
<td>1.15</td>
<td>1.16</td>
<td>1.28</td>
<td>1.46</td>
<td>1.35</td>
</tr>
<tr>
<td>Average Number of Females</td>
<td>1.22</td>
<td>1.25</td>
<td>1.38</td>
<td>1.54</td>
<td>1.53</td>
</tr>
<tr>
<td>Average Number of Full-Time Workers</td>
<td>0.62</td>
<td>0.70</td>
<td>0.96</td>
<td>0.89</td>
<td>0.76</td>
</tr>
<tr>
<td>Average Number of Full-Time Students</td>
<td>0.40</td>
<td>0.47</td>
<td>0.56</td>
<td>1.00</td>
<td>0.74</td>
</tr>
</tbody>
</table>
Disadvantages of GPS Surveys

- Signal loss and degradation may occur
- Devices may take time to acquire position
  - cold start problem
- Devices can easily be left at home or the respondent can forget to charge them
- Processing requirements can be extensive
- There is no established method to determine who is a passenger and who is a driver in a private vehicle
Data Processing

• Processing permits correction of some of the errors in GPS and also makes the data more useful

• Multiple procedures are included in our software:
  – Identification of trips
  – Repair of cold start and canyon/tunnel problems
  – Identifying mode of travel
  – Identifying purpose of travel
Canyon Problems

NEVE - old and new antenna

Old antenna struggles to pickup position near CBD
Visual Checking

• Before mode and purpose identification are undertaken, all trips are given a visual check
  – May identify a missed trip, due to a gap between trip ends
  – May identify a spurious stop
  – May identify a spurious trip from stationary wandering of position

• As a result of many visual checks, the software is now very efficient at identifying most problems
Example Output

Trips 1-3, Sunday 9th Dec, 2001

1 start / 3 end: Home

2 end / 3 start: Shop

1 end / 2 start: Visit Friend
Example Output

Map Layers:
- Local Streets
- Drainage Region
- Parks
- Bridges

Day - 3 Route System:
- Trip 1
- Trip 2
- Trip 3
- Trip 4
- Trip 5

<table>
<thead>
<tr>
<th>Trip Purpose Mode</th>
<th>Departure Time</th>
<th>Trip Time (Min)</th>
<th>Trip Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip 1</td>
<td>7:51:01</td>
<td>12</td>
<td>10.5</td>
</tr>
<tr>
<td>Trip 2</td>
<td>17:06:14</td>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>Trip 3</td>
<td>17:13:02</td>
<td>14</td>
<td>119</td>
</tr>
<tr>
<td>Trip 4</td>
<td>17:36:59</td>
<td>7</td>
<td>3.4</td>
</tr>
<tr>
<td>Trip 5</td>
<td>18:50:32</td>
<td>7</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Canberra, Map 1A
Friday, 7 May 2004
Variability of Day to Day Travel

• Three waves of data collected from same households
  • 2 waves of 28-day data
  • 1 wave of 15-day data

• Better compliance with the task in waves 2 and 3
The Data

- Panel set up in September-December 2005 – 50 households
  - Household members over 14 asked to use GPS devices for all travel for 28 days
- Second wave in March-April 2006
  - Same request as for wave 1
- Third wave in September-December 2006 – 44 continuing households
  - Requested to use GPS for 15 days
- Start days varied through the week
## Sample Dispositions

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Sample</td>
<td>288</td>
<td>90</td>
<td>--</td>
</tr>
<tr>
<td>Known Ineligible Households</td>
<td>81 (28%)</td>
<td>27 (30%)</td>
<td>--</td>
</tr>
<tr>
<td>Unknown Disposition</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>--</td>
</tr>
<tr>
<td>Estimated Eligible Households</td>
<td>207</td>
<td>63</td>
<td>46</td>
</tr>
<tr>
<td>Refusals</td>
<td>150 (72%)</td>
<td>46 (73%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Recruited (New Recruits)</td>
<td>57 (27%)</td>
<td>17 (27%)</td>
<td>--</td>
</tr>
<tr>
<td>Completed (New Recruits)</td>
<td>50 (24%)</td>
<td>14 (22%)</td>
<td>--</td>
</tr>
<tr>
<td>Continuing Households Recruited</td>
<td>--</td>
<td>35 (70%)</td>
<td>44 (96%)</td>
</tr>
<tr>
<td>Continuing Households Completed</td>
<td>--</td>
<td>32 (64%)</td>
<td>36 (78%)</td>
</tr>
<tr>
<td>TOTAL Complete Households</td>
<td>50 (24%)</td>
<td>46 (41%)</td>
<td>36 (78%)</td>
</tr>
<tr>
<td>Households Failing to Comply</td>
<td>7 (3%)</td>
<td>6 (5%)</td>
<td>8 (17%)</td>
</tr>
</tbody>
</table>
### Days of GPS Data

<table>
<thead>
<tr>
<th>Number of Days</th>
<th>Wave 1 (50 HH)</th>
<th>Wave 2 (46 HH)</th>
<th>Wave 3 (36 HH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Days</td>
<td>1 (1%)</td>
<td>39 (44%)</td>
<td>22 (31%)</td>
</tr>
<tr>
<td>6 to less than 7 days per week</td>
<td>13 (12%)</td>
<td>21 (24%)</td>
<td>20 (28%)</td>
</tr>
<tr>
<td>5 to less than 6 days per week</td>
<td>10 (10%)</td>
<td>7 (8%)</td>
<td>12 (17%)</td>
</tr>
<tr>
<td>3 to less than 5 days per week</td>
<td>27 (25%)</td>
<td>8 (9%)</td>
<td>10 (14%)</td>
</tr>
<tr>
<td>1 to less than 3 days per week</td>
<td>32 (30%)</td>
<td>9 (10%)</td>
<td>6 (8%)</td>
</tr>
<tr>
<td>More than 0 and less than 1 per week</td>
<td>24 (22%)</td>
<td>5 (6%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>107 (100%)</strong></td>
<td><strong>89 (100%)</strong></td>
<td><strong>71 (100%)</strong></td>
</tr>
<tr>
<td><strong>Persons retained</strong></td>
<td><strong>75 (70%)</strong></td>
<td><strong>79 (89%)</strong></td>
<td><strong>53 (75%)</strong></td>
</tr>
</tbody>
</table>
The Data

- **Sample statistics compared to 2001 Census data**

- **Main differences:**
  - Too few 1-person households
  - Too many 4-person and 5+-person households
  - Too few non-car-owning households
  - Too many 2 car households

- **Some differences could be attributed to differences between 2001 and 2005-7**
Multi-Day Analysis

- **Five principal variables chosen for analysis:**
  - Travel time per trip
  - Travel distance per trip
  - Travel time per person per day
  - Travel distance per person per day (PKT)
  - Trips per person per day

- **Initial analysis of means by recording day**
Mean Trips per Person per Day

![Graph showing mean trips per person per day across different days and waves.](image)
Travel Time per Person by Day

Days

Travel Time per Person

Wave 1 Wave 2 Wave 3
Multi-Day Analysis

- Subsequent analysis accumulated the data by day
  - Day 1 would be the mean for all persons for the first recording day
  - “Day 2” would be the mean of the first and second days for all persons
  - “Day 15” would be the mean of the first fifteen days for all persons
- Recall that waves 1 and 3 are in approximately the same season and wave 2 is 6 months different
- Following graphs show 21 days of data (but wave 3 is only for 15 days)
Multi-Day Analysis - Means

![Graphs showing mean travel time per trip, mean trips per day, and mean PKT per day across different waves.](image_url)
Multi-Day Analysis - Variances

- Variance of Travel Time per Trip
- Variance in Trips per Day
- Variance in PKT per Day

Days: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

- Wave 1
- Wave 2
- Wave 3
Multi-Day Analysis

- Means all begin with some substantial changes and then stabilise to similar values.

- Variances show less stability, especially for PKT per day:
  - Wave 2 was affected by Easter Holidays – increasing variance towards the end.
  - Wave 2 stabilises in parallel to wave 1.
  - Appears as though wave 3 might have replicated a similar pattern if more days were collected.
Weekdays Only Versus All Days

- Preceding analyses mixed weekdays and weekend days by cumulating through the data
- Next analysis separated out weekdays only to compare with all days
- Results show marked similarity as shown next
Halo Effects

• Issue is whether people’s travel behaviour is affected by carrying GPS devices
• Most probable would be that behaviour would be different in first two or three days
• This could account for the instability in means and variances for the first few days
• Examined by comparing days 1-12 with days 4-15
Test for Halo Effects: Average PKT per day
Halo Effects

• Ignoring the first three days made a change, but increased rather than decreased the difference
• Stability still occurs at the same point in time
• Early variability is not a function of the halo effects of carrying the devices
Intrapersonal Variability

• In one-day surveys, nothing is revealed about intrapersonal variability

• It could be a significant contributor to variance in multi-day data

• If it is large, then the apparent decreases in variance shown with multi-day data will be in even larger for interpersonal variability

• Analysed the proportion of total variance that is intrapersonal variance
Importance of Intrapersonal Variability in Total Variability

<table>
<thead>
<tr>
<th>Percentage to TSS</th>
<th>No. of trips per day</th>
<th>Travel time per day</th>
<th>Travel distance per day</th>
<th>Percentage to TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>20%</td>
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<tr>
<td>80%</td>
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<td>80%</td>
</tr>
</tbody>
</table>

- No. of trips per day
- Travel time per day
- Travel distance per day

<table>
<thead>
<tr>
<th>Percentage to TSS</th>
<th>No. of trips per day</th>
<th>Person travel time per day</th>
<th>Person travel distance per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>20%</td>
<td>20%</td>
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<td>30%</td>
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<tr>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
</tbody>
</table>

- No. of trips per day
- Person travel time per day
- Person travel distance per day

- all Mondays
- all Tuesdays
- all Wednesdays
- all Thursdays
- all Fridays
- all Saturdays
- all Sundays

May-June 2008

Australian Developments in GPS
Intrapersonal Variability

- Accounts for 76 percent of variability for the entire data set
  - For weekdays only, this drops to 64-71 percent
  - For weekdays of week 1 only, it drops to about 40-60 percent, depending on the measure
- Increases with more weeks of observation
- Lower on weekdays than weekend days, except for number of trips per day
  - Trips per day is highest on Monday and low on the weekend
Summary of Multi-Day Variability

• GPS measurement captures much more information than one-day or two-day diaries
• The importance of the information captured may have large impacts on modelling
• The modelling implications of multi-day data need to be researched but may be far-reaching on model quality
• Possibility that significant amounts of unexplained variance are actually a result of the methodology of measurement
### Modelling Implications

- **Panel consisted of 50 and fewer households** – care must be taken in drawing conclusions
- **Analysis suggests that one-day and even two-day data are quite unstable**

<table>
<thead>
<tr>
<th>Measure – Mean (standard deviation)</th>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First Day</td>
<td>15&lt;sup&gt;th&lt;/sup&gt; Day</td>
<td>21&lt;sup&gt;st&lt;/sup&gt; Day</td>
</tr>
<tr>
<td>Travel Time per Trip</td>
<td>13.44 (11.0)</td>
<td>13.44 (11.0)</td>
<td>13.35 (11.2)</td>
</tr>
<tr>
<td>Travel Distance per Trip</td>
<td>8.00 (19.8)</td>
<td>6.54 (9.9)</td>
<td>6.49 (9.7)</td>
</tr>
<tr>
<td>Trips per Person per Day</td>
<td>4.15 (4.4)</td>
<td>4.10 (3.6)</td>
<td>3.98 (3.6)</td>
</tr>
<tr>
<td>Travel Time per Person per Day</td>
<td>56.53 (60.0)</td>
<td>57.45 (53.8)</td>
<td>55.77 (53.2)</td>
</tr>
<tr>
<td>Travel Distance per Person per Day</td>
<td>33.17 (60.9)</td>
<td>28.13 (36.8)</td>
<td>27.24 (35.8)</td>
</tr>
</tbody>
</table>
Conclusions

- Use of GPS is now more feasible
- Sampling issues are similar to those for conventional surveys
  - However, large households are not underrepresented
- Ideal appears to be about 15 days of data
- Multi-day data appear to be important for modelling and description
Travel Time and Speed

![Map showing travel times and speeds between locations.]

<table>
<thead>
<tr>
<th>Average Speed (Km/h)</th>
<th>Trip Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.3</td>
<td>13.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start (Time)</th>
<th>End (Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:55:57</td>
<td>8:34:48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Street/Suburb</th>
<th>Street/Suburb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wonora Rd Kogarah</td>
<td>Burren St Newtown</td>
</tr>
</tbody>
</table>

SPEED ON CAR TRIPS

Thursday, 7 October 2004

South Sydney (C)
Drive Cycle Analysis

- Top driver is a conservative driver
- Bottom one is a more aggressive driver
- Both drove the identical route at the same time
Multi-mode Travel

NEVE - New antenna
Train, Ferry and Walk

Ferry
Walk
Tunnel
Train

Map Layers
- HW OC
- HWwayA
- HWwayB
- HWwayC
- HWwayD
- HWwayE
- HWwayF

Scale: 200 500 1.000 2.000

May-June 2008
Australian Developments in GPS
**Sample Size**

- Conventional wisdom suggests we need about 1500 to 3500 households for modelling
  - Produces from 3750 to 9000 person days of travel

- Assuming this is the requirement in person days of travel, then GPS can produce this from:
  - 240 households for 15 days = 9000 person days
  - 100 households for 15 days = 3750 person days

- These sample sizes are too small politically and for segmentation
Sample Sizes

- Sample sizes for modelling will be smaller, because we remove irrelevant and extraneous variance
- Also, we remove reporting error
- However, sample sizes may need to increase for political and other reasons
- Suppose we need 600 to 750 households with 15 days of travel
  - This will produce from 22,500 to 28,000 person days of travel
New Method of Recruitment

- Based on our focus group experiences, the following would be ideal:
  - Recruit by door knocking
  - Provide in-home instructions on device use
  - Collect odometer readings and household/vehicle data at the time of instruction
  - Have devices picked up by interviewer or courier, together with a final odometer reading
Survey Costs

- Need to pilot test the above method
- Cost per person day of data is much smaller than conventional surveys
- Data quality is much higher
- Also need to test a method to determine use of car passenger by non-family members
Conclusions

• GPS is not a foolproof or 100 percent accurate method of collecting travel data
• GPS offers huge advantages over conventional surveys
• Quality and nature of the data obtainable is far higher than self-report methods can attain