Active Living Research

Building the Evidence to Prevent Childhood Obesity and Support Active Communities

Collecting and Processing GPS Data for Active Living Research

Format, try to make interactive

Slides & additional info will be on ALR website

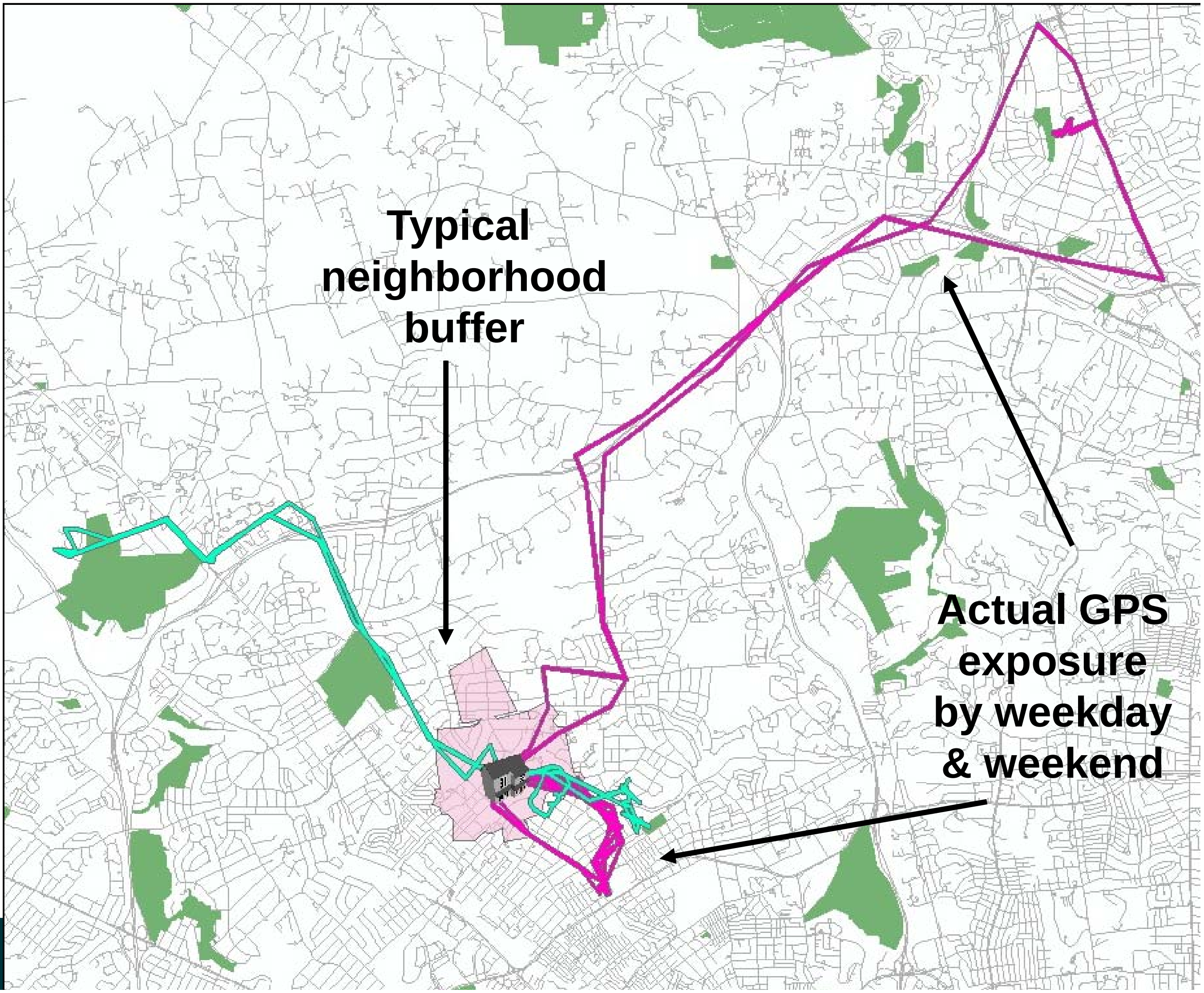
Introductions

- Who we are
- Who's in the audience?
  - Who has used any sort of GPS ever?
  - Who has called their car GPS bad names?
  - Who has thought about using GPS?
  - Who has used GPS in their research?
- What would you like to take away from the workshop?

Learning objectives

- Understand for which research questions the use of GPS is relevant
- Learn best practices of GPS data collecting in free-living studies
- Learn about algorithms for cleaning, processing and categorizing GPS data
- Understand how to validate GPS data
- Learn how to create temporal spatial variables in GIS using GPS data

Impact of GPS on neighborhood research



Research impact

- Better determine strength of relationship
- Better assess true impact of resource access
- Assess place based interventions
- Better understand behavior patterns to change behavior

How does the built environment affect physical activity?

The Built Environment and Location-Based Physical Activity

Philip J. Troped, PhD, MS, Jeffrey S. Wilson, PhD, Charles E. Matthews, PhD, Ellen K. Cromley, PhD, Steven J. Melly, MS

Background: Studies of the built environment and physical activity have implicitly assumed that a substantial amount of activity occurs near home, but in fact the location is unknown.

Purpose: This study aims to examine associations between built environment variables within home and work buffers and moderate-to-vigorous physical activity (MVPA) occurring within these locations.

Methods: Adults (n=148) from Massachusetts wore an accelerometer and GPS unit for up to 4 days. Levels of MVPA were quantified within 50-m and 1-km home and work buffers. Multiple regression models were used to examine associations between five objective built environment variables within 1-km home and work buffers (intersection density, land use mix, population and housing unit density, vegetation index) and MVPA within those areas.

Results: The mean daily minutes of MVPA accumulated in all locations=61.1±32.8, whereas duration within the 1-km home buffers=14.0±16.4 minutes. Intersection density, land use mix, and population and housing unit density within 1-km home buffers were positively associated with MVPA in the buffer, whereas a vegetation index showed an inverse relationship (all $p<0.05$). None of these variables showed associations with total MVPA. Within 1 km of work, only population and housing unit density were significantly associated with MVPA within the buffer.

Conclusions: Findings are consistent with studies showing that certain attributes of the built environment around homes are positively related to physical activity, but in this case only when the outcome was location-based. Simultaneous accelerometer–GPS monitoring shows promise as a method to improve understanding of how the built environment influences physical activity behaviors by allowing activity to be quantified in a range of physical contexts and thereby provide a more explicit link between physical activity outcomes and built environment exposures.

(Am J Prev Med 2010;38(4):429–438) © 2010 American Journal of Preventive Medicine

Where do our children play?

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Science and Medicine in Sport 12 (2009) 583–585

Journal of Science and Medicine in Sport

www.elsevier.com/locate/jsams

Original paper

Combining GPS with heart rate monitoring to measure physical activity in children: A feasibility study

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Centre for Physical Activity and Nutrition Research, Faculty of Health and Environmental Sciences, Auckland University of Technology, New Zealand

Received 2 May 2008; received in revised form 26 August 2008; accepted 11 September 2008

Abstract

The recent development of global positioning system (GPS) receivers with integrated heart rate (HR) monitoring has provided a new method for estimating the energy expenditure associated with children's movement. The purpose of this feasibility study was to trial a combination of GPS surveillance and HR monitoring in 39 primary-aged children from New Zealand. Spatial location and HR data were recorded during a school lunch break using an integrated GPS/HR receiver (1 Hz). Children averaged a total distance of 1.10 ± 0.56 km at speeds ranging from 0 to 18.6 km h^{-1}. Activity patterns were characterised by short bursts of moderate to high speeds followed by longer periods of slow speeds. In addition, boys averaged higher speeds than girls (1.77 ± 0.62 km h^{-1} and 1.36 ± 0.50 km h^{-1}, respectively; $p = 0.003$). The percentage of time spent at 0 km h^{-1} (stationary) ranged from 0.1% to 21.3% with a mean of 6.4 ± 4.6%. These data suggest that while children were relatively active during the lunch period, they spent a substantial portion of time engaged in slow or stationary physical activities. Furthermore, associations between HR, average speed, and stationary time demonstrated that children who moved at faster speeds expended more energy than those who moved at slower speeds. We conclude that the combined approach of GPS and HR monitoring is a promising new method for investigating children's play-related energy expenditure. There is also scope to integrate GPS data with geographic information systems to examine where children play and accumulate physical activity.

Keywords: Activities of daily living; Epidemiology; Global positioning; Heart rate; Methods; Physical fitness

How are our green spaces used?

Preventive Medicine 51 (2010) 148–152

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Greenspace and children's physical activity: A GPS/GIS analysis of the PEACH project

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ARTICLE INFO

Available online 9 June 2010

Keywords:
Exercise
Environment
Child
Geographic information systems

ABSTRACT

Objective. To quantify the volume and intensity of children's physical activity after school in greenspace and elsewhere.

Methods. Data were collected between 2006 and 2008 from 1,307 children aged 10–11 in Bristol, UK. Accelerometers and Global Positioning System receivers measured activity and location every 10 s (epoch) after school for four days. Data were mapped in a Geographic Information System with a greenspace dataset. Activity volume (accelerometer counts per minute), time in moderate-vigorous physical activity (MVPA), and the odds of an epoch being MVPA (using logistic regression) were compared for greenspace, non-greenspace and indoors.

Results. 13% of monitored time was spent outdoors (2% in greenspace), during which time 30% of activity volume and 35% of MVPA was accumulated. 7% of boys' activity volume and 9% of MVPA were in greenspace with girls slightly lower (5% and 6% respectively). The odds of an epoch being MVPA in greenspace relative to outdoor non-greenspace was 1.37 (95% CI 1.22–1.53) for boys and 1.08 (95% CI 0.95–1.22) for girls.

Conclusion. Most activity occurring outdoors is not in greenspace and non-green urban environments are therefore very important for children's activity. However, when boys are in greenspace, activity is more likely to be of higher intensity.

How do our children travel to and from school?

Mapping the Walk to School Using Accelerometry Combined with a Global Positioning System

Ashley R. Cooper, PhD, Angie S. Page, PhD, Benedict W. Wheeler, PhD, Pippa Griew, MSc, Laura Davis, MSc, Melvyn Hillsdon, PhD, Russell Jago, PhD

Background: Walking to school is associated with higher levels of physical activity, but the contribution of the journey itself to physical activity before school is unknown.

Purpose: This study combined accelerometer and GPS data to investigate the level and location of physical activity in children walking to school.

Methods: Participants were 137 children (aged 11.3±0.3 years) from London, England, measured in June–July 2006. Physical activity was measured by accelerometry, and location was determined with a GPS receiver. Travel mode was self-reported. Accelerometer and GPS data were time-matched to provide activity level and location for each 10-second epoch where both were available. Journeys were mapped in a GIS.

Results: Mean accelerometer counts per minute before school (8:00AM to 9:00AM) were 43% higher in those who walked to school than those traveling by car (878.8±387.6 vs 608.7±264.1 counts per minute [cpm], $p<0.001$). Eleven percent (4.5 minutes) of daily moderate to vigorous physical activity (MVPA) occurred in this hour, with walkers recording 2.1 minutes more than car travelers ($p=0.004$). Children followed direct routes between home and the school playground. Total activity during the walk to school was twice that in the playground (2131.3±1170.7 vs 1089.7±938.6 cpm, $p<0.001$), with the journey contributing three times as much MVPA as time in the playground.

Conclusions: Our results provide evidence that the journey to school is purposeful and contributes to higher total physical activity and MVPA in children. Combining accelerometer and GPS data may aid our understanding of the environmental context of physical activity.
(Am J Prev Med 2010;38(2):178–183) © 2010 American Journal of Preventive Medicine

Children's Independent Movement in the Local Environment

Author(s): Roger Mackett | Belinda Brown | Yi Gong | Kay Kitazawa | James Paskins

doi: 10.2148/benv.33.4.454

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Trouble viewing articles as PDF?

Built Environment

Print ISSN: 0263-7960 | **Electronic ISSN:** 0263-7960

Volume: 33 | **Issue:** 4

Cover date: December 2007

Page(s): 454-468

Abstract

This paper presents findings from the project CAPABLE (Children's Activities, Perceptions And Behaviour in the Local Environment) carried out at University College London to explore the concept of independent behaviour by children, by examining variation by age, gender and access to open space to see how independence affects their behaviour, both in terms of how they use their time after school and how they behave when outdoors. A further objective is to look at differences between boys and girls in this type of behaviour. Based on findings from questionnaires completed by children aged 8–11 in Cheshunt, Hertfordshire, it is shown that most of the children are allowed out without an adult, but that but many of these, particularly girls, are only allowed out with other children. It is also shown that children, particularly boys, who are allowed out without an adult go out more after school, and so have more chance to be active and sociable. The paper then uses data from children who have been fitted with physical activity monitors and GPS (global positioning system) monitors and asked to keep diaries, to show how children's travel behaviour differs when they are with adults from when they are not. Conclusions are drawn in terms of the evidence from this research supporting policies that children should be allowed out more without an adult and with increasing children's volume of physical activity.

How far are our children allowed to roam independently?

SPECIAL COMMUNICATIONS

Methodological Advances

Prediction of Activity Mode with Global Positioning System and Accelerometer Data

PHILIP J. TROPED[1], MARCELO S. OLIVEIRA[2], CHARLES E. MATTHEWS[3], ELLEN K. CROMLEY[4], STEVEN J. MELLY[5], and BRUCE A. CRAIG[6]

[1]Department of Health and Kinesiology, Purdue University, West Lafayette, IN; [2]GeoStats LP, Atlanta, GA; [3]Institute for Medicine and Public Health, Vanderbilt University School of Medicine, Nashville, TN; [4]Institute for Community Research, Hartford, CT; [5]Department of Environmental Health, Harvard School of Public Health, Boston, MA; and [6]Department of Statistics, Purdue University, West Lafayette, IN

ABSTRACT

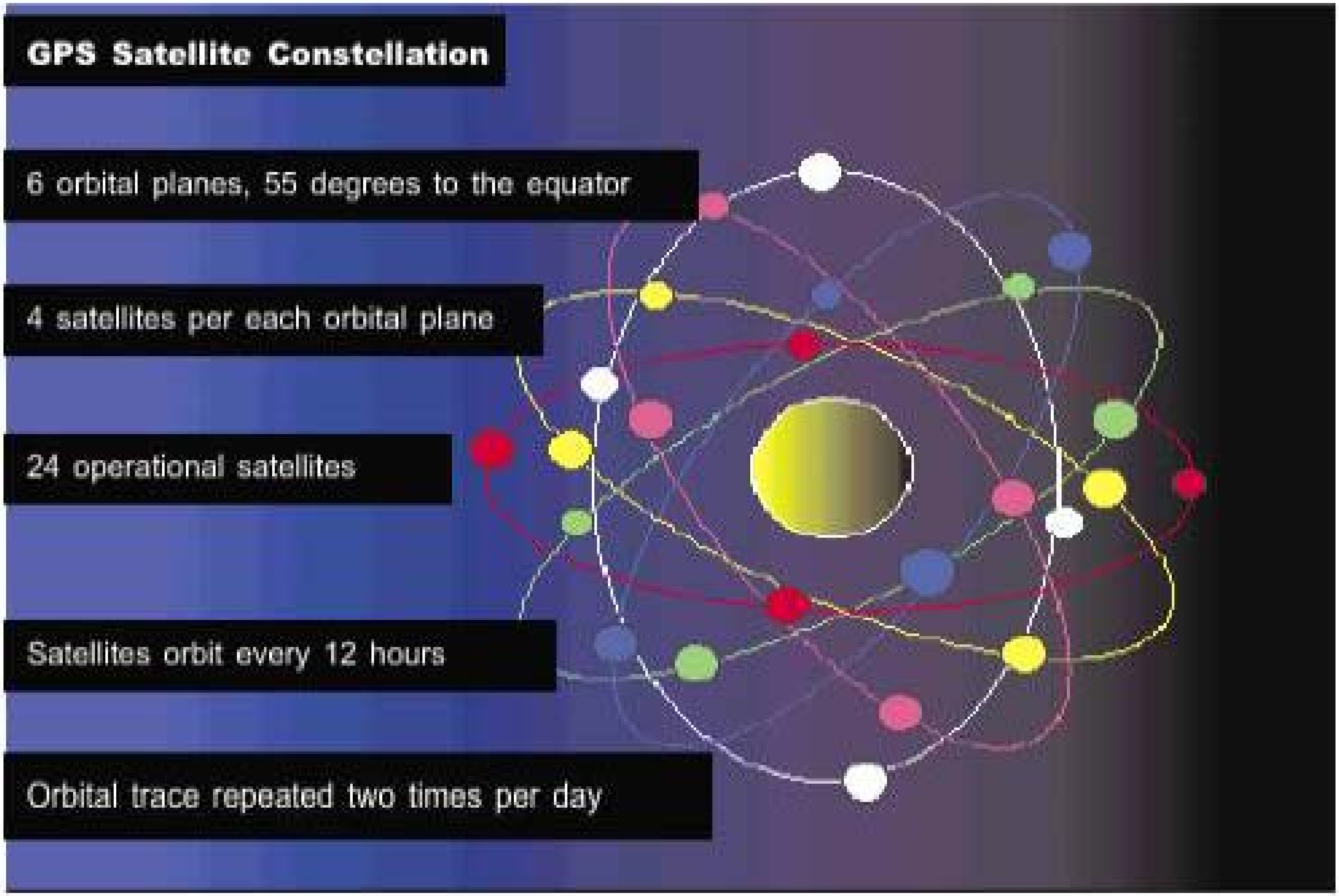
TROPED, P. J., M. S. OLIVEIRA, C. E. MATTHEWS, E. K. CROMLEY, S. J. MELLY, and B. A. CRAIG. Prediction of Activity Mode with Global Positioning System and Accelerometer Data. *Med. Sci. Sports Exerc.*, Vol. 40, No. 5, pp. 972–978, 2008. **Purpose:** The primary aim of this pilot study was to assess how well the combination of global positioning system (GPS) and accelerometer data predicted different activity modes. **Methods:** Ten adults (seven male, three female; 23–51 yr) simultaneously wore a GPS unit and accelerometer during bouts of walking, jogging/running, bicycling, inline skating, or driving an automobile. Discriminant function analysis was used to identify a parsimonious combination of variables derived from accelerometer counts and steps and GPS speed that best classified mode. A total of 29 bouts were used to develop this classification criterion. This criterion was validated using two datasets generated from the complete collection of minute-by-minute values from all bouts. **Results:** Model development with "calibration" data showed that two accelerometer variables alone (median counts and steps) resulted in 26 of 29 bouts (90%) being correctly classified. Prediction of activity mode using counts and steps in a minute-by-minute "validation" dataset (N = 200) was 86.5%. Using three variables from the accelerometer and GPS (median counts, steps and speed) resulted in correct classification in 27 of 29 activity bouts in the "calibration" data (93%). In the "validation" dataset comprising 200 min, the combination of accelerometer counts and steps and GPS speed were able to correctly classify 91% of the observations. Walking and bicycling minutes were correctly classified most frequently (96%). In another "validation" dataset consisting of activity bouts, this combination of variables resulted in correct classification in 42 of 43 bouts (98%). **Conclusion:** This pilot study provides evidence that the addition of GPS to accelerometer monitoring improves physical activity mode classification to a small degree. Larger studies among free-living individuals and with an expanded range of activities are needed to replicate the current findings and further determine the merits of using GPS with accelerometers for mode identification. **Key Words:** PHYSICAL ACTIVITY, EXERCISE, GPS, OBJECTIVE MONITORING, CLASSIFICATION

What types of activities do we undertake?

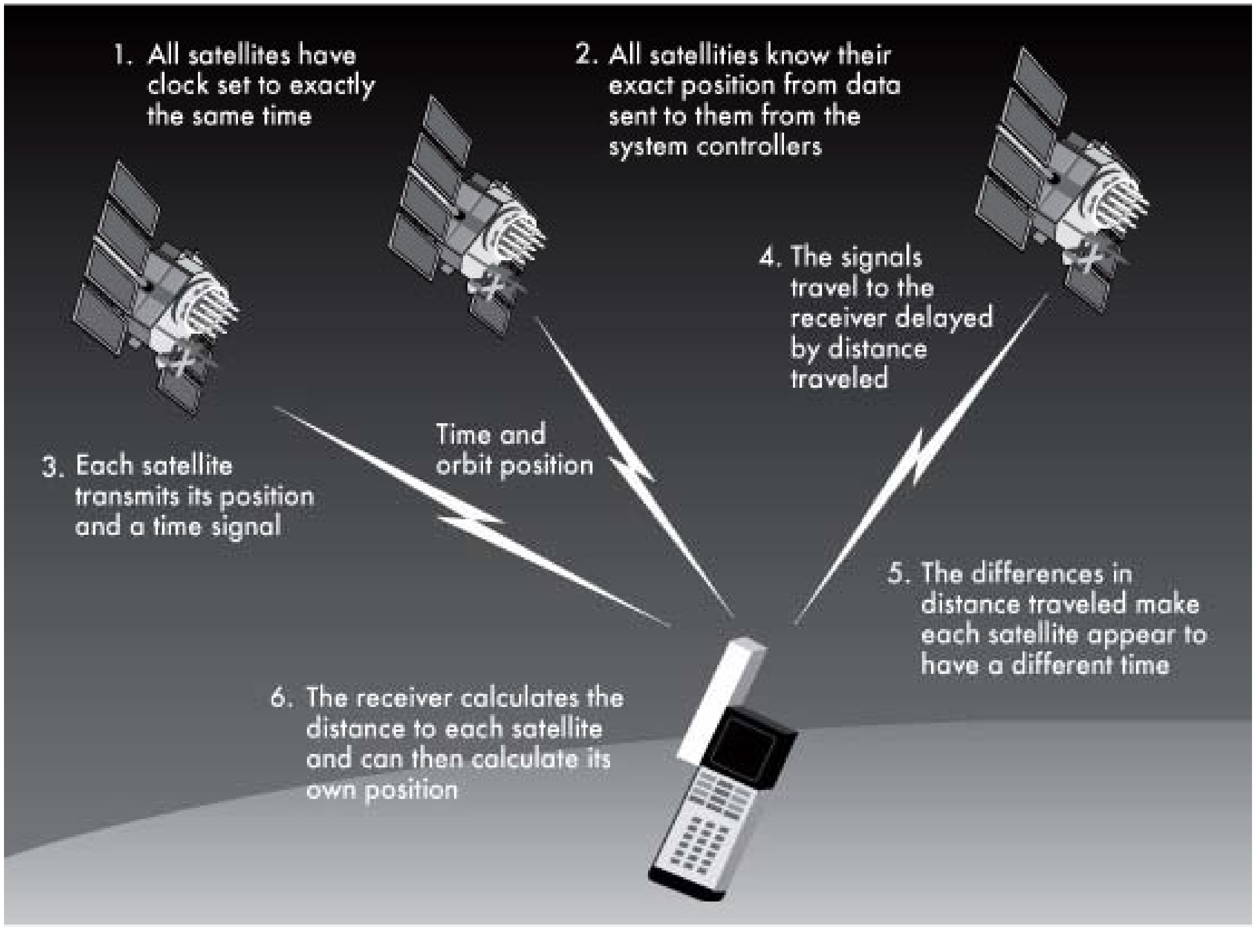
Questions

- What research questions do you hope to answer with GPS data?
- When is GPS data appropriate?

How GPS Works



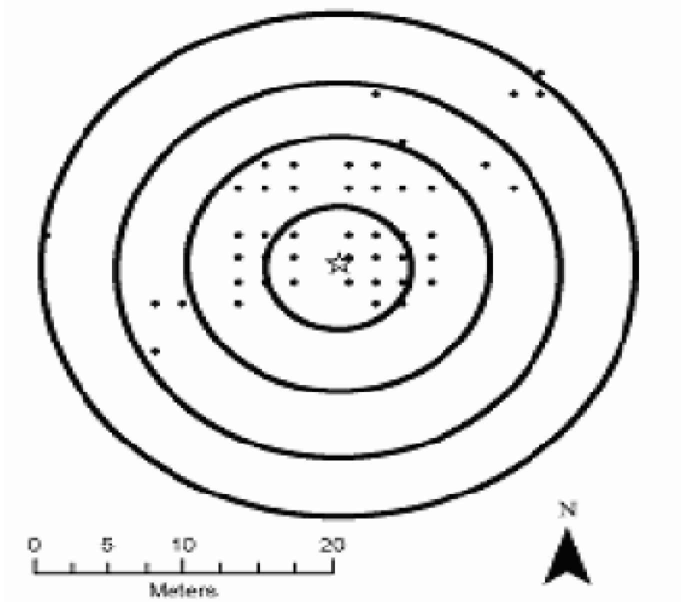
How GPS Works



www.aero.org

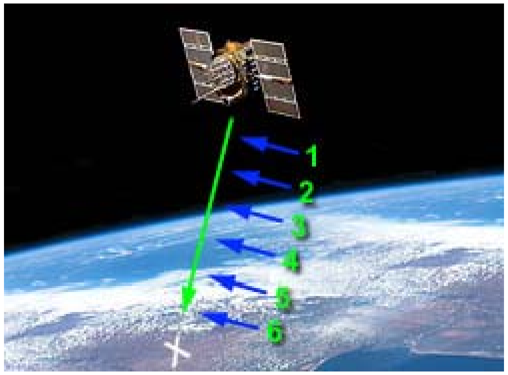
GPS Accuracy

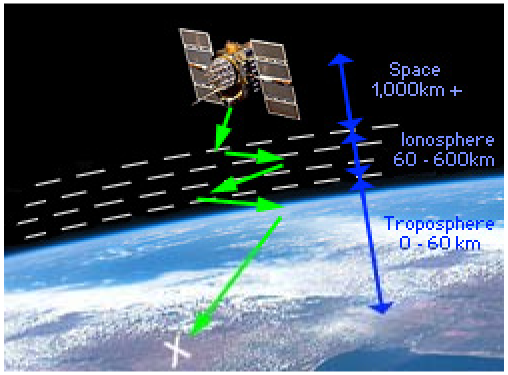
- 3 meters is best case accuracy from several studies
- Scott will be presenting more on this, later in the day



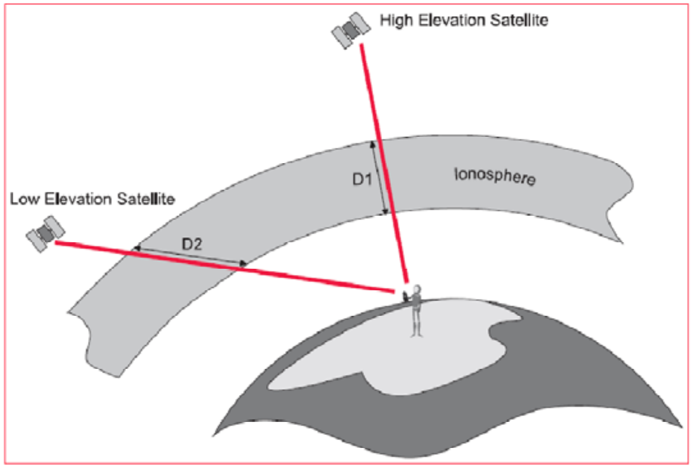
Daniel Rodriguez & Elizabeth Shay, 2008 ALR Conference Presentation
http://www.activelivingresearch.org/files/GPS-Accelerometers_Workshop.pdf

Sources of GPS Error: Atmospheric Delays





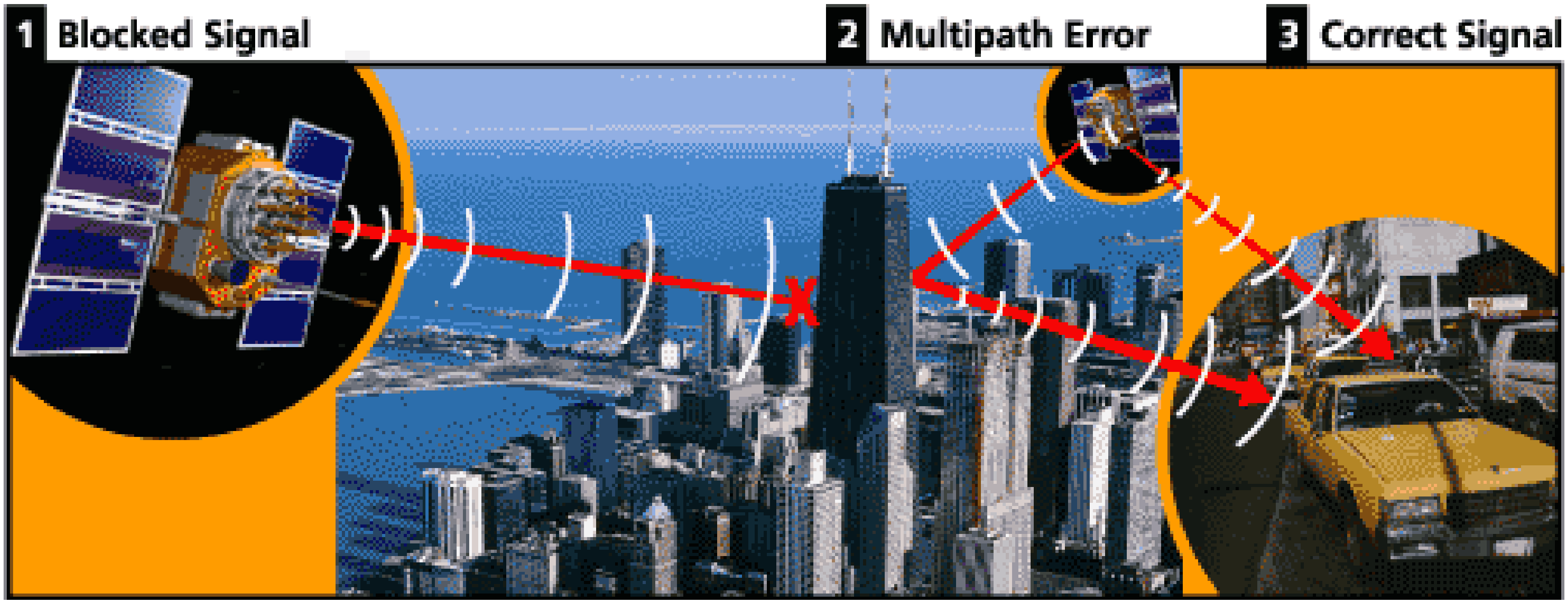
www.geoplane.com



Position of the satellite in the sky effects accuracy; the higher the better.

Other sources of inference include sunspots and water vapor.

Sources of GPS Error: Terrestrial



Also:

- Tree coverage when outdoors
- Electronic interference

www.garmin.com

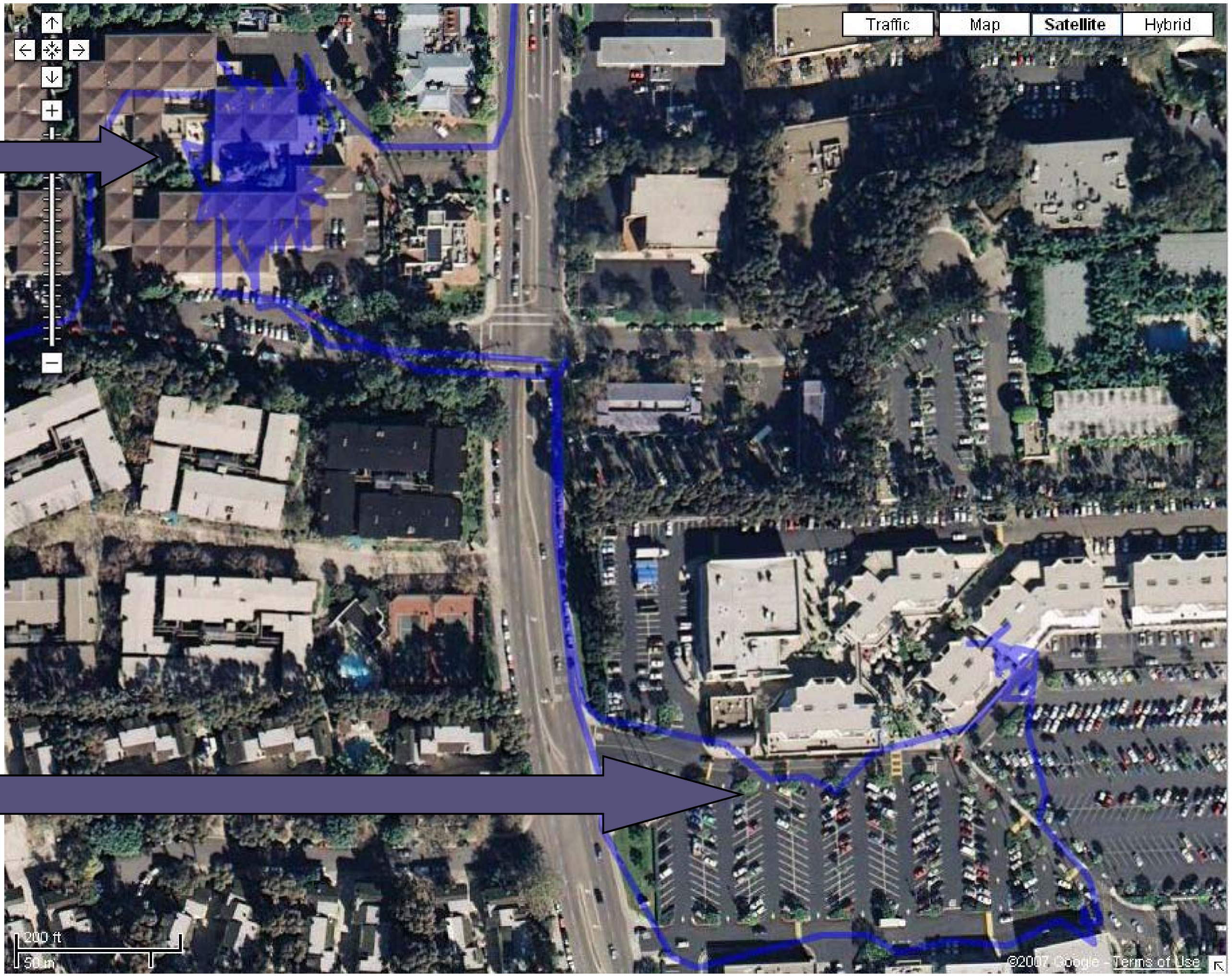
Other Problems with GPS

- Doesn't work well indoors
  - Poor view of satellites
  - Error due to multipath reflections
- Delay in determining initial position (first fix)
  - Caused by GPS need to find satellites, demodulate the navigation message and acquire the GPS constellation data
  - When moving from indoors (no signal) to outdoors, initial position is often reported some distance from indoor location.
  - Difficult to obtain first fix when moving > 50 km/hr

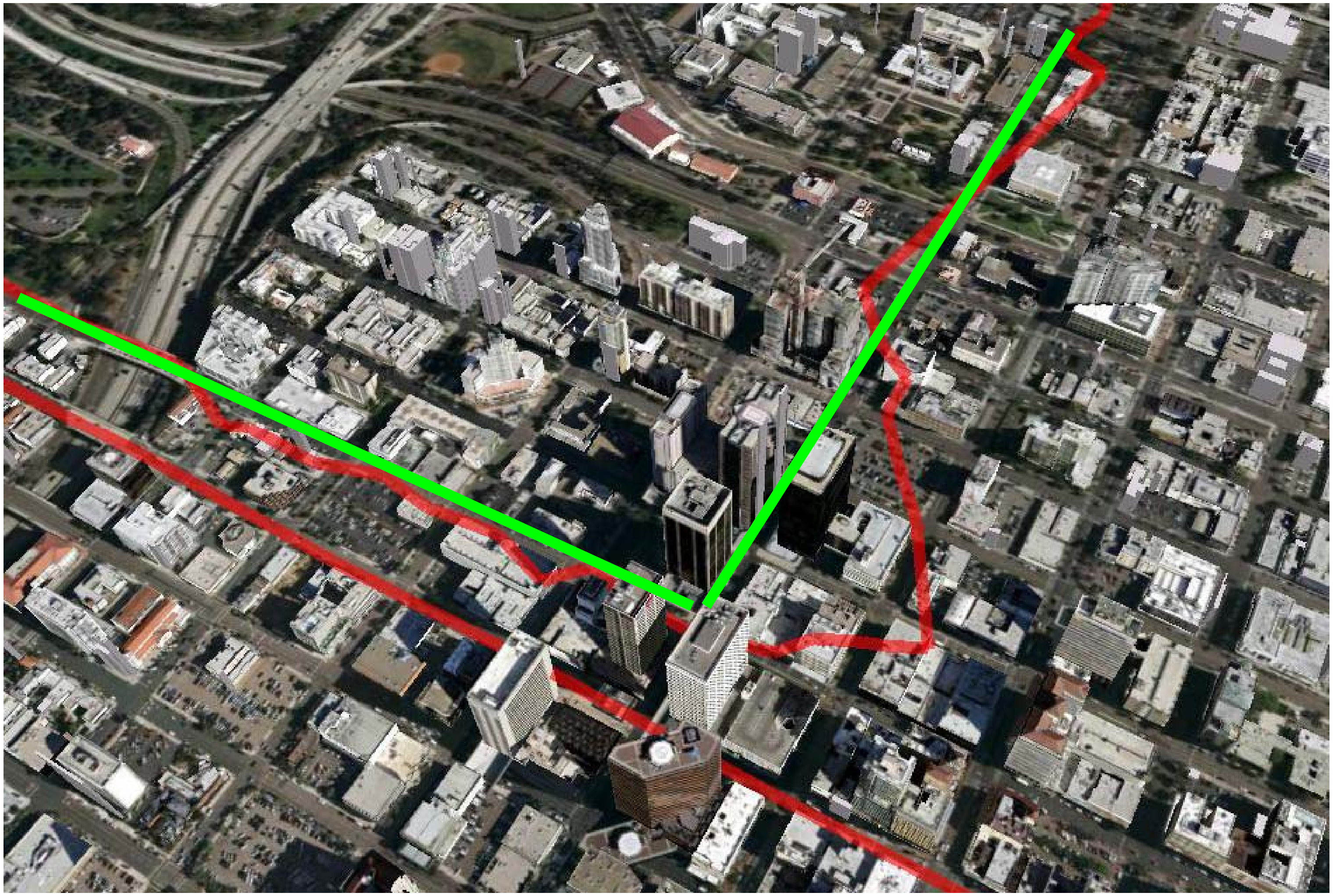
GPS Jitter and Building Interference

Jitter while in building

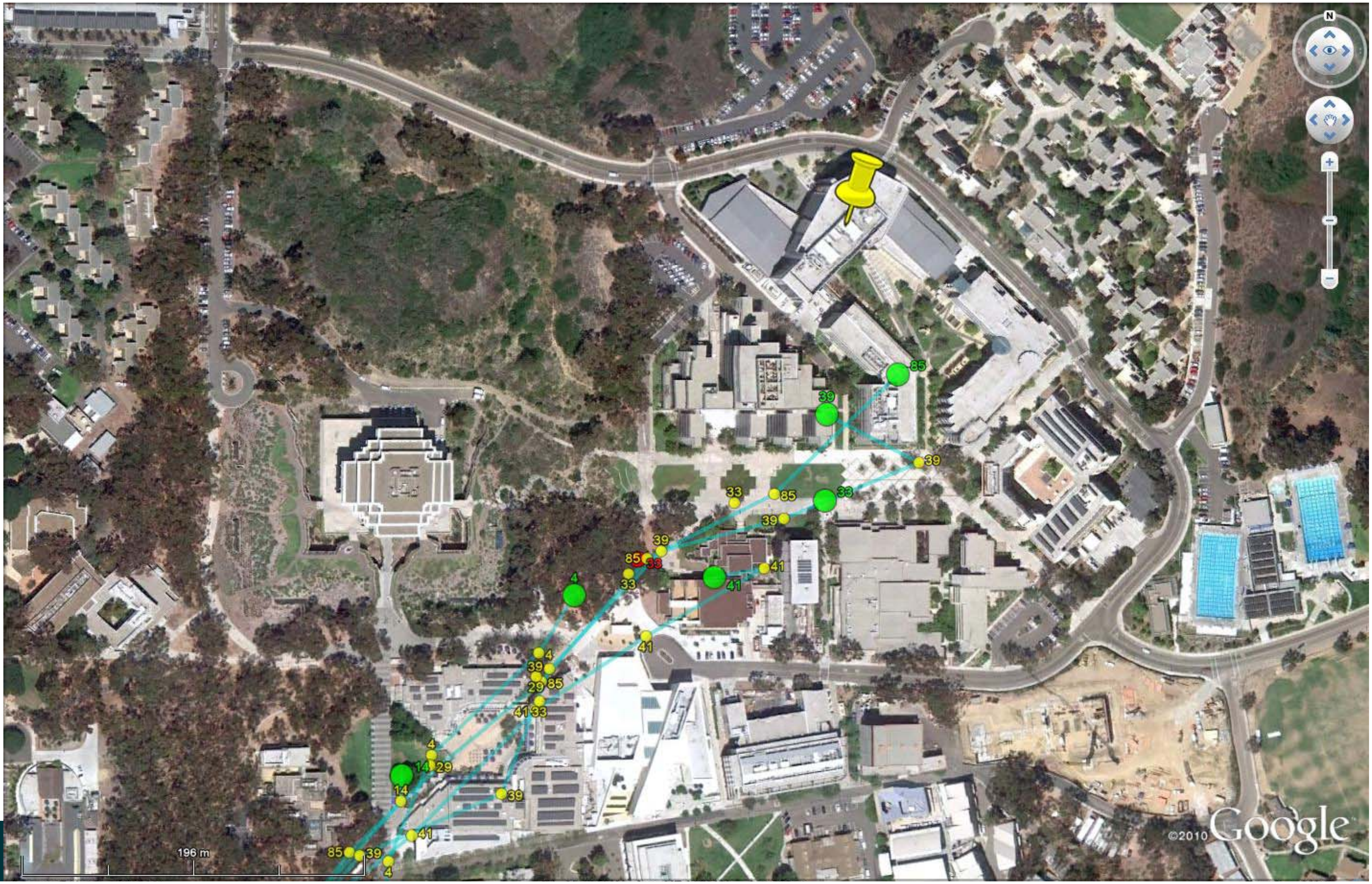
Building interference while outside



GPS Issues: Urban Canyons



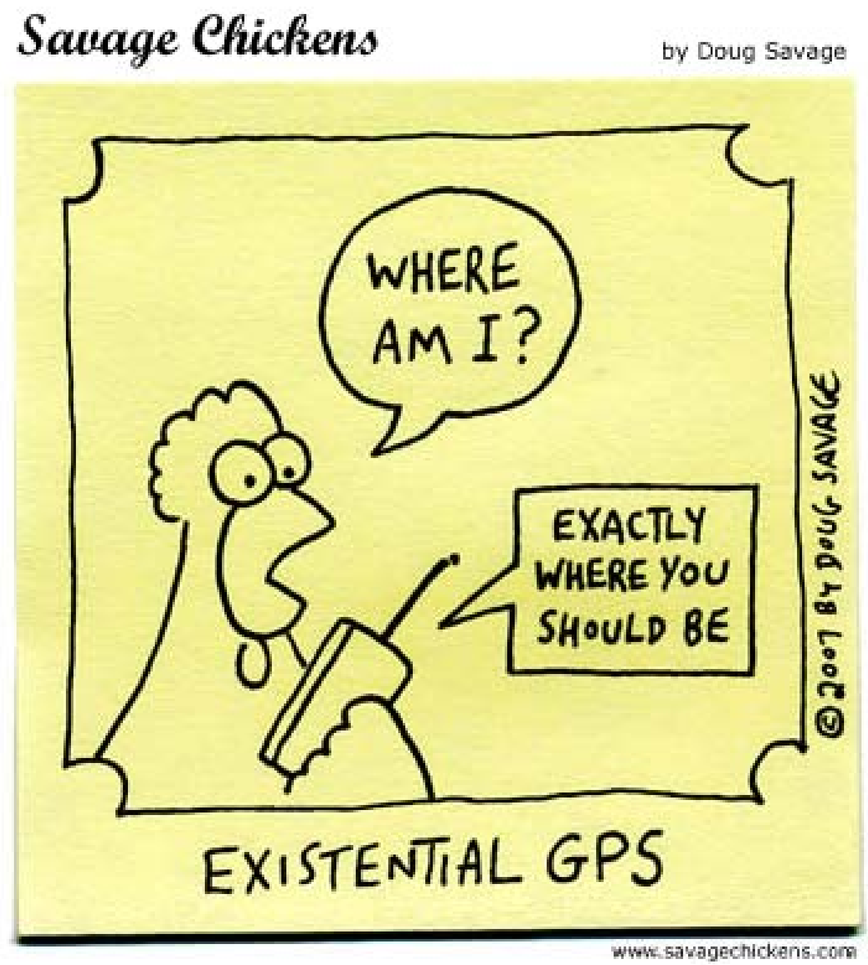
GPS Issues: Time to Acquire Fix



So why would you bother???

- Research benefits are great
- Solutions to problems being created
- Still more accurate than self report
- More impactful on policy makers

Any questions, all questions are good!



Existing GPS devices on market

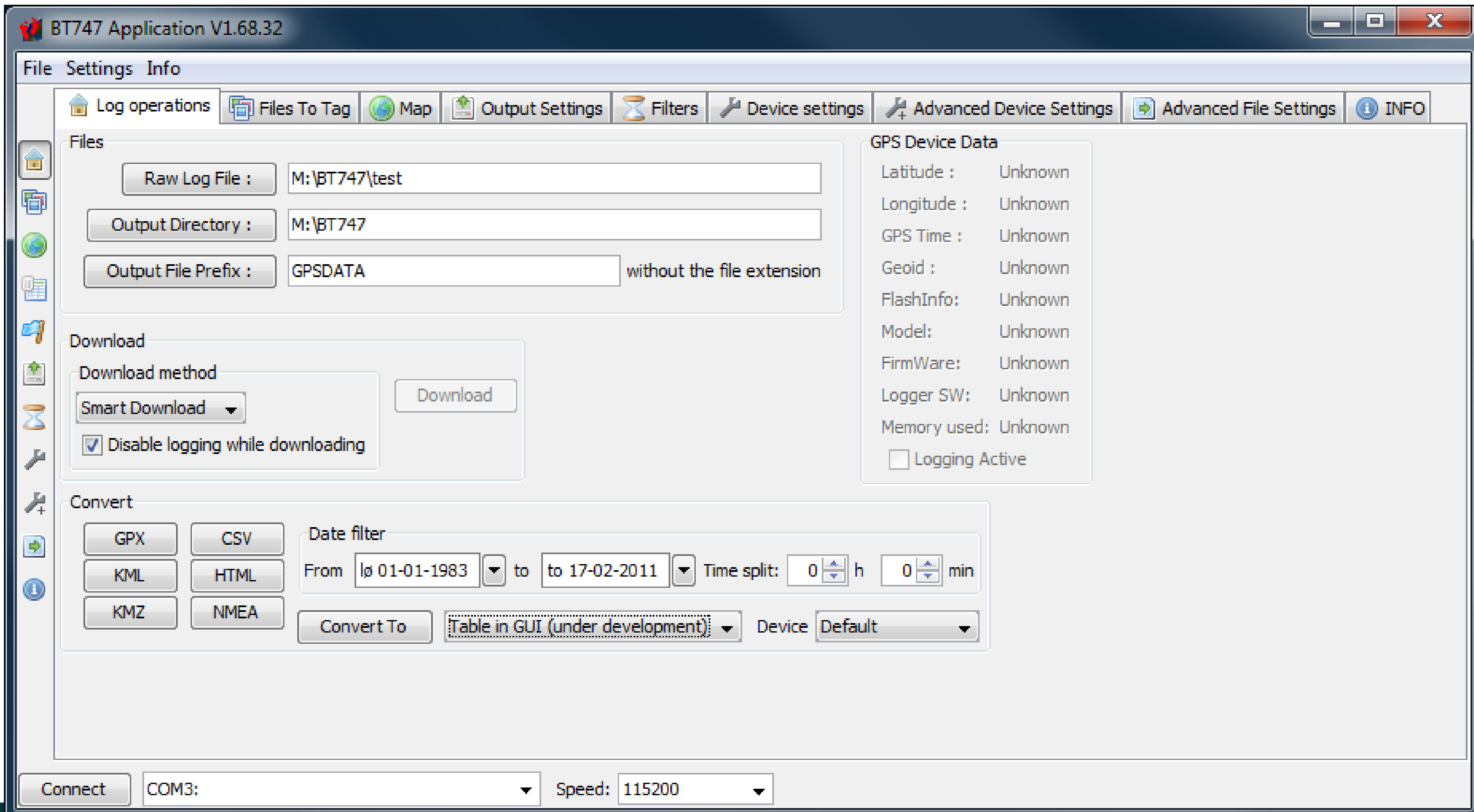
- Constantly changing
  - Garmin watchesl
  - GlobalSat DG-100
  - GlobalSat BT-335
  - GlobalSat TR-203
  - QStarz BT-Q1000X
  - Telespial Trackstic
  - FRWD B100

- Anyone else used something else? Or had different experiences?

Device selection

- Test them for yourself!!
- Battery life
- Memory
- Device features: Size, cost
- Interface
- Fix time
- Chipset
- Software for downloading

Open source free GPS software - BT747.org

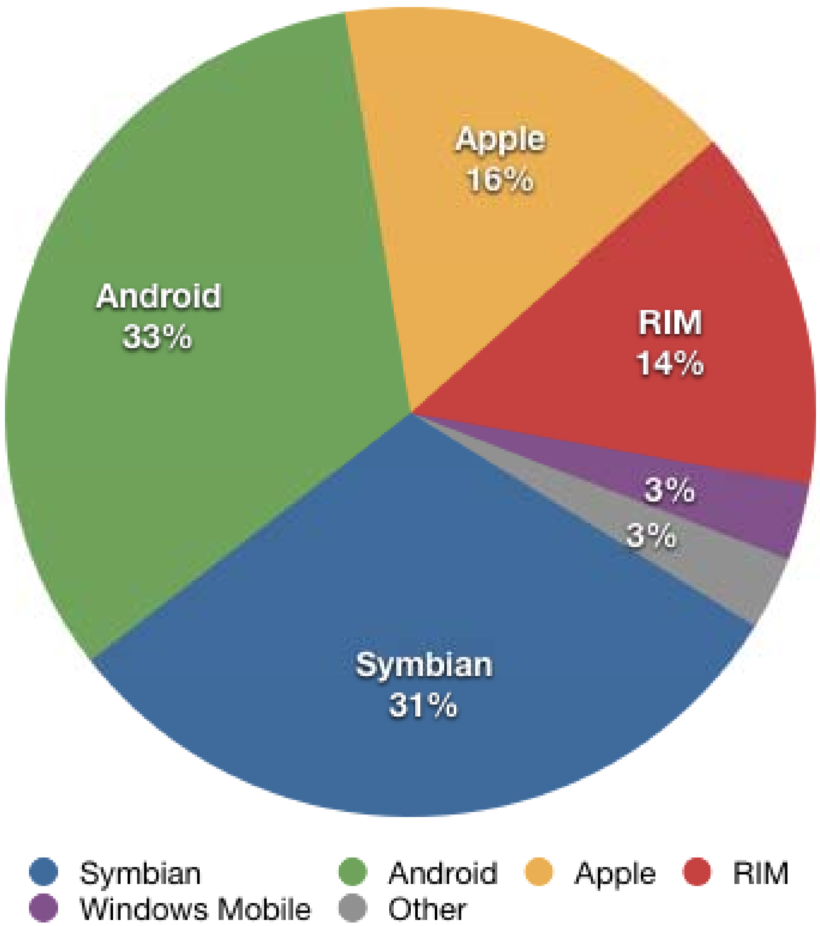


GPS in Smartphones

- Capabilities
  - Assisted GPS
  - Wifi and cellular positioning
  - Integrated accelerometers
  - High resolution cameras

- Limitations
  - Battery life and data restrictions
  - Positioning inconsistency
  - User interference?

Smartphone distribution



- 63M US smartphone owners in Q4 2010, up 60% from previous year
- Smartphone penetration higher in ethnic minorities
- Can this existing network of smartphones be harnessed?

Current applications of GPS in mobile technologies

International Journal of Health Geographics

BioMed Central

Methodology

Open Access

Using GPS-enabled cell phones to track the travel patterns of adolescents

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Published: 21 May 2008

International Journal of Health Geographics 2008, **7**:22 doi:10.1186/1476-072X-7-22

Received: 21 February 2008
Accepted: 21 May 2008

This article is available from: http://www.ij-healthgeographics.com/content/7/1/22

Abstract

Background: Few tools exist to directly measure the microsocial and physical environments of adolescents in circumstances where participatory observation is not practical or ethical. Yet measuring these environments is important as they are significantly associated with adolescent health-risk. For example, health-related behaviors such as cigarette smoking often occur in specific places where smoking may be relatively surreptitious.

Results: We assessed the feasibility of using GPS-enabled cell phones to track adolescent travel patterns and gather daily diary data. We enrolled 15 adolescent women from a clinic-based setting and asked them to carry the phones for 1 week. We found that these phones can accurately and reliably track participant locations, as well as record diary information on adolescent behaviors. Participants had variable paths extending beyond their immediate neighborhoods, and denied that GPS-tracking influenced their activity.

Conclusion: GPS-enabled cell phones offer a feasible and, in many ways, ideal modality of monitoring the location and travel patterns of adolescents. In addition, cell phones allow space- and time-specific interaction, probing, and intervention which significantly extends both research and health promotion beyond a clinical setting. Future studies can employ GPS-enabled cell phones to better understand adolescent environments, how they are associated with health-risk behaviors, and perhaps intervene to change health behavior.

- Patient monitoring – diabetes, cardiac rehab
- Lab-based activity recognition or validation studies
- Pilot studies in free-living populations

GPS in other devices used by researchers

The v2.3 SenseCam shown close up and as typically worn by a user. The model pictured here has a clear plastic case that reveals some of the internal components.

Example images captured by SenseCam.

Any questions, all questions are good!

GPS Device Testing

- When you have made your choice and bought your devices you need to test all units
- Device Malfunctioning Tests
  - Signal Acquisition
    - Cold/Warm
  - Static Validity
  - Dynamic Validity

Signal Acquisition

- Test to determine the amount of time needed to acquire a signal in cold and warm start conditions
- Ensure that the signal acquisition times are within the manufacturer's specifications
- Procedure:
  - Configure GPS and turn it off for the appropriate amount of time (cold: over night; warm: 10-30 minutes indoors)
  - Go to an open area and turn on the device and record the time at which it was turned on
  - Check the GPS data file to determine the time for the first data capture and calculate the difference in time from when you turned on the device and when it first captured data.

Static Validity

- Test the accuracy and precision of location data capture when the GPS device is not moving
- Use manufacturer's specification as a guideline for error rate
- Procedure:
  - Locate geodetic point (point with a known latitude and longitude coordinates, usually based on a land survey)
  - Collect data at geodetic location
  - Determine the accuracy and precision of estimated coordinates (usually using GIS)

Dynamic Validity

- Test of the accuracy and precision of location data capture when the GPS device is moving
- Look for variation between devices
- Procedure
  - Travel along a known path during a specific time period
  - Compare the GPS trace from devices collecting data at the same time to determine if any one device has a trace substantially different from the others

Preparing devices for deployment

- Deciding on # days
- Deciding on epoch
  - Sensitivity
  - Data management
  - Memory
- Deciding on settings (e.g. elevation, indoor/outdoor)
- Matching times to other devices e.g. accelerometers
- Fully charge battery
- Double check settings
- Checklist for staff
- Keep devices off till shortly before giving to participants

Participant compliance issues

- Wear time expectations
  - Locations/activities of interest
- Initialization requirements
  - Cold, warm, and hot starts
  - User input
- Battery charging requirements
- Additional instrumentation
- Logging of wear time
- Reminders for increasing compliance
- Incentives

SMS reminders

- Successful use of SMS reminders, morning and evening, to 11-15 years olds to wear and charge device
- Compliance rates can vary over time, on weekends, & in different populations
- Be prepared for data loss and drop out in your sample size calculations
- Other tips from researchers in the audience to improve compliance?