SOUTH AFRICA ROAD FEDERATION

Non-Motorised Transport Practitioner's Course

Session 12: NMT Data Collection Procedures

NMT Data Collection Procedures

- Part 1: Introduction
- Part 2: Non-Motorised Count Data Applications
- Part 3: Planning the Count Program
- Part 4: Implementing the Count Program
- Part 5: Adjusting Count Data
- Part 6: Sensor Technology Toolbox

Part 1: Introduction

Introduction

- The lack of pedestrian and bicycle volume data is a barrier to road authorities efforts to plan more effective facilities and to improve safety for pedestrians and cyclists.
- Road authorities have well-established procedures for collecting, summarizing, and disseminating motor vehicle traffic volumes, but these procedures do not generally provide pedestrian and bicycle volume data.
- Most pedestrian and bicycle volume data collection is done for specific project locations after preliminary selection of candidate project locations has been made.
- The lack of system wide pedestrian and bicycle volume data limits the ability of road authorities to provide or improve pedestrian and bicycle facilities where the need is greatest and is an impediment to developing better predictive methods for pedestrian and bicycle crashes.

Guidebook on Pedestrian and Bicycle Volume Data Collection - NCHRP Report 797, 2014

- Methods and technologies for counting pedestrians and bicyclists.
- Guidance on developing a non-motorized count program.
- Suggestions on selecting appropriate counting methods and technologies
- Examples of how organizations have used non-motorized count data to better fulfil their missions.
- Correction factors to improve the accuracy of counts produced by automated counters, factors for expanding short-term counts to longer-term volume estimates, and factors for adjusting counts to reflect environmental conditions at the time of the count, such as rain.

Important differences between motorised and non-motorised traffic counting.

- Pedestrian and bicycle volumes are more variable than motor vehicle volumes.
- Pedestrian and bicycle trips tend to be shorter than automobile trips and are often made for different purposes.
- Motor vehicles tend to be easier to detect than pedestrians and bicycles.
- Experience with pedestrian and bicycle counting technology is more limited than for motor vehicles.

Counting System Components (1)

Counting System Components (2)

- **Sensor** (various technologies)
  - The sensor is the portion of the counting device that detects pedestrians or bicyclists. Various sensor technologies are available for non-motorized counting.
- **Counter (Processor)**
  - The counter receives the sensor output and determines whether or not a detection should be recorded.
- **Data Logger**
  - When object detected, information is sent to the device's data logger. Some record every detection, along with the time of detection, others keep a running count of detections and store the totals in 15- or 60-minute
- **Power Supply**
  - A replaceable battery, a permanent electrical connection, solar panel

Counting System Components (3)

- **Communications**
  - Method to transfer count data from the device to the user's database, e.g. Bluetooth or WiFi connections or a cellular modem.
- **Securement**
  - Physical housing (e.g., a box or a utility cabinet) to protect it from the elements and vandalism and a method of fastening it in place to prevent undesired movement or vibration and to discourage theft.
- **Data Management**
  - Some counting products have own data management software; others require end users to manage the count data themselves (e.g. storing it in a spreadsheet).
- **The Counting Device as a Whole**
  - Includes all of the above components (see diagram)

Part 2: Non-motorised count data applications

Non-motorised count data applications

- Measuring the usage of a pedestrian or bicycle facility
- Measuring the change in pedestrian or bicycling activity following the development or improvement of a facility
- Monitoring non-motorized travel patterns
- Using non-motorized count data to evaluate risk or exposure as part of safety analyses
- Applying count data when prioritizing transportation projects
- Using count data in developing and validating multimodal travel demand models

Non-motorised count data applications

Measuring the usage of a pedestrian or bicycle facility

- Pedestrian and bicycle counting can serve as part of a larger transportation system monitoring program. Effort typically entails counting at set locations at regular intervals (e.g. annually) to identify how particular facilities are being used.

Measuring the change in pedestrian or bicycling activity following the development or improvement of a facility

- Collecting bicycle and pedestrian counts before and after a new facility is opened can be valuable for measuring volume changes and making conclusions about success of the facility.
- The data can also be used to forecast the usage of planned facilities and to justify additional system improvements based on past results.

Non-motorised count data applications

Monitoring non-motorised travel patterns

- Continuous pedestrian and bicycle counts can be used to identify usage patterns across the day, week, or year, and to identify factors that influence bicycling and walking levels (e.g. weather, land use patterns, transportation network characteristics, etc.).

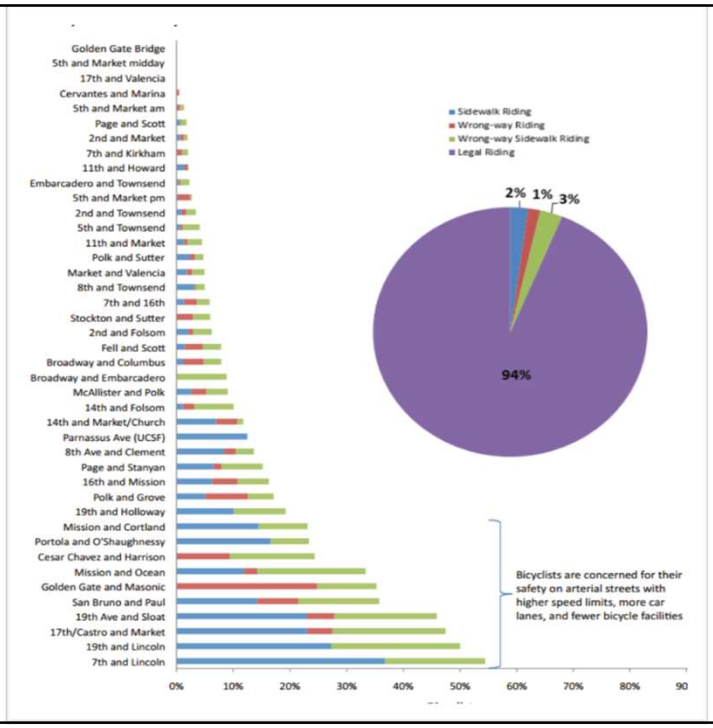
Using non-motorized count data to evaluate risk or exposure as part of safety analyses

- Non-motorised counts can be used to inform a safety analysis of a facility or area and better evaluate crash data.
- Pedestrian and bicycle volumes may be used to quantify exposure and develop crash rates and to identify the before-and-after safety effects of upgrading a facility.
- Volumes may also be used to estimate pedestrian or bicycle miles travelled for use as a regional exposure metric.

Non-motorised count data applications

Applying count data when prioritizing transportation projects

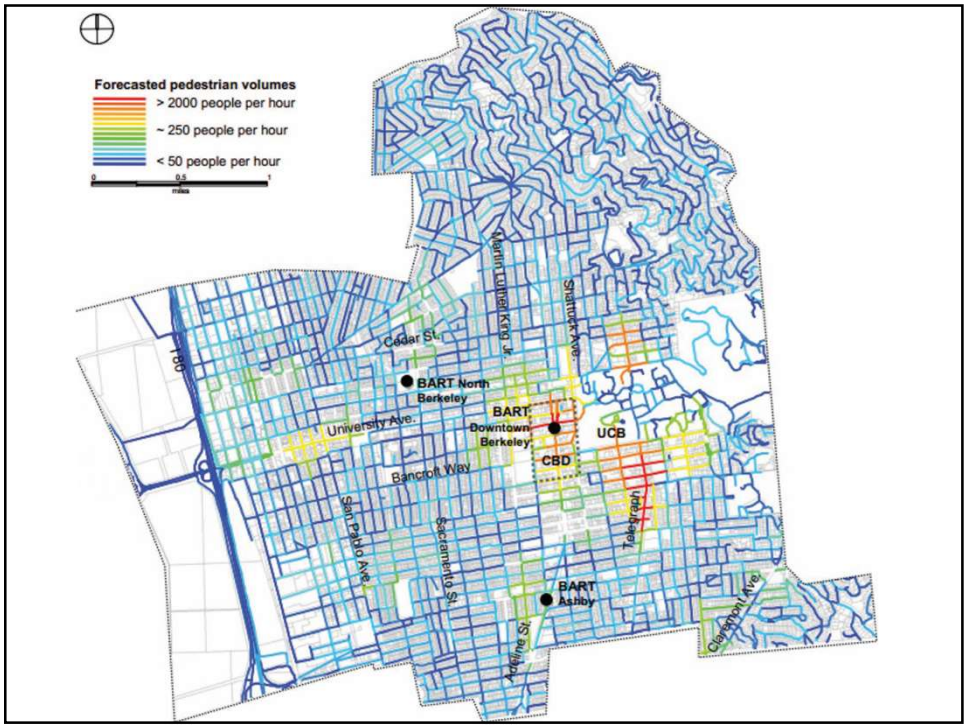
- Road authorities may use multimodal counts to help identify high-priority locations for improvements. Existing pedestrian and bicycle counts may help define essential multimodal networks where projects should be a priority.
- In addition, an authority may use historic counts to identify which factors most influence rates of walking and bicycling and prioritize projects accordingly.
- Counts that measure improper user behaviours (i.e., wrong-way bike riding) can help indicate areas with deficiencies where improvements may be needed.



Non-motorised count data applications

Using count data in developing and validating multimodal travel demand models

- Many authorities have developed vehicle travel demand models to forecast future motorized vehicle volumes, relatively few areas have undertaken comparable efforts to assess pedestrian and bicycle demand.
- Multimodal travel demand modelling is an emerging field which has the potential to estimate pedestrian and bicycle demand over a large transportation network.
- Non-motorized counts are a key element in calibrating a multimodal model. Once developed and calibrated, models could be used to:
  - Estimate multimodal demand over a large network with limited new data collection.
  - Estimate the influence of infrastructure changes (i.e. the addition of a new bike facility) on travel behaviour.
  - Project future multimodal demand.



Part 3: Planning the counting program

Planning the counting program

Step 1: Specify the data collection purpose

Step 2: Identify data collection resources

Step 3: Select general count locations and determine the count timeframe

Step 4: Consider available counting methods and technologies

Planning the counting program

Step 1: Specify the data collection purpose

- Measuring changes in pedestrian and bicycle activity relative to baseline levels.
- Documenting changes in activity levels after projects are implemented.
- Informing the general public about pedestrian and bicycle activity and trends.
- Monitoring variations in pedestrian and bicycle activity levels by time of day, day of week, or season of the year, and under different weather conditions.
- Identifying variations in activity in different types of locations (e.g., considering land uses and/or facility types) and calculating context-specific expansion factors.

Planning the counting program

Step 1 (cont.): Specify the data collection purpose

- Assessing local and system wide activity to prioritize locations for new pedestrian and bicycle facilities.
- Quantifying exposure, as part of an analysis of pedestrian or bicycle crash risk at specific locations.
- Developing models to predict future pedestrian or bicycle volumes at different locations throughout a community.
- Identify data collection resources.
- Select general count locations and determine the count timeframe.
- Consider available counting methods and technologies.

Planning the counting program

Step 2: Identify data collection resources

- Lack of staff time and volunteer interest, and
- Funding limitations or cutbacks.

Step 3: Select general count locations and determine the count timeframe

- Pedestrian and bicycle data collection programs can benefit from combining two approaches:
  - Gathering short-duration counts (typically less than 1 day to several days, but potentially up to several months) at many locations; and
  - Gathering continuous counts over multiple years at a small sample of locations.

Planning the counting program

Step 4: Consider available counting methods and technologies

- Various methods available to count pedestrians and bicyclists, including manual counts, passive infrared, active infrared, pneumatic tubes, inductive loops, piezoelectric sensor, radio beam, and automated video.
- Pedestrian and bicycle data collection programs often use more than one method. For example, certain counting technologies only count bicycles, while others count people regardless of mode
- Identifying Sites Appropriate for the Counting Method
  - One of the most important considerations for a site is the desired detection zone. This is the screen line or area where pedestrians or bicyclists will be counted. Each technology has its own type of detection zone.

Planning the counting program

Step 4 (cont.): Consider available counting methods and technologies

Site characteristics affecting particular counting technologies:

- Peak-hour user volume.
- Mix of users (e.g., pedestrians, bicyclists, automobiles).
- Facility width (detection zone width).
- Facility surface.
- Vehicular traffic flows or presence of vehicular traffic.
- Trees and other vegetation that could block a sensor or create background interference.
- Locations of debris storage that could block a sensor.

Planning the counting program

Step 4 (cont.): Consider available counting methods and technologies

Site characteristics affecting particular counting technologies (cont.)

- Windows that could deflect or distort a sensor beam.
- Metal or synthetic surfaces that may experience variation in radiant temperature when exposed to sunlight.
- Poles, walls, and other potential objects for mounting devices.
- General security (potential for theft or vandalism of devices).
- Built or social environment characteristics that create non-standard walking or bicycling movements.
- Adjacent land use characteristics that may influence bicycling and walking travel paths.

Part 4: Implementing the counting programme

Implementing the counting programme

- Step 1: Obtaining permission
- Step 2: Procuring counting devices
- Step 3: Making an inventory and preparing devices
- Step 4: Training staff
- Step 5: Installing and validating devices
- Step 6: Calibrating devices
- Step 7: Maintaining devices
- Step 8: Managing count data
- Step 9: Cleaning count data
- Step 10: Applying count data.

Implementing the counting programme

Step 1: Obtaining permission

- Before installing counting devices at a site, check with local agencies, utilities, and other organizations responsible for managing poles, signs, pavement, walls, or other features at the site.

Step 2: Procuring counting devices

- Choosing good equipment and a good vendor is important when using automated technology as part of a count program. The sensor technology itself is supported by other equipment, such as mounting devices and data loggers, that is also essential for the success of a counting product, and the vendor's customer service record is important to consider.

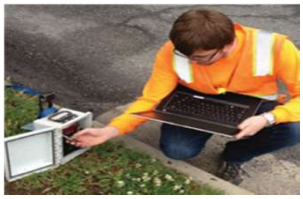
Implementing the counting programme

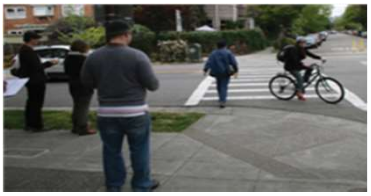
Step 3: Inventorying and preparing devices

Equipment should be inventoried soon after it is received from a vendor. An inventory will document whether or not all of the expected equipment has been delivered. An inventory is useful for identifying any additional tools or supporting equipment that may be necessary to obtain in advance of field installation (e.g., wrenches, screws, fastening devices, and batteries).

Step 4: Training staff

Staff training is important for both automated and manual counting, although the kind of training is different.





Implementing the counting programme

Step 5: Installing and validating equipment.

- Equipment installation can be one of the most challenging steps in the data collection process. Count managers should budget significant time for installation to ensure that it is done correctly.

Step 6: Calibrating devices

- The sensors used in some counting technologies, such as inductive loops and pneumatic tubes, can be adjusted to make the sensor more or less sensitive and thereby less prone to non-detections (undercounting) or false-positive detections (over-counting). The initial test period during installation can suggest whether or not a sensitivity adjustment is needed

Implementing the counting programme

Step 7: Maintaining devices

- Counting equipment must be regularly maintained to ensure accurate consistent counts. In particular, staff should visit permanent count sites regularly (at least every 3 months) to check that devices are still present (not stolen or vandalized), pointed in the correct direction, and in working condition (see the follow-up activities checklist provided earlier). Staff should check for the accumulation of dirt, mud, water, or other materials that could affect the sensor or other equipment components. In addition, staff should download and review the count data to make sure that the equipment is working properly.

Step 8: Managing count data

- Various systems are available for managing data after they have been downloaded from the counter, including agency-developed spreadsheets, vendor-supplied software, software developed in-house, and cloud-based repositories.

Implementing the counting programme

Step 9: Cleaning and correcting count data

- Once counts are in a database format, they should be reviewed for unusual data. Some unusual counts are incorrect measurements by the technology itself (i.e., missing counts or counts of movements not intended to be counted). Potential reasons for incorrect counts include:
  - Blocked sensor
  - Multiple counts of the same person
  - Equipment malfunction
  - Incorrect initial installation

Step 10: Applying count data

At this point, the count data have been collected, adjusted, cleaned, and stored and are ready to be used.

Part 5: Adjusting Count data

Adjusting Count data

- Sources of automated counter errors
- Measured accuracy and precision of automated sensor technologies
- Correction factors for automated counters, used to adjust raw counts to more closely represent the ground truth
- Expansion factors, applied to short-duration counts to estimate volumes over longer periods of time

Adjusting Count data

Sources of automated counter errors

- **Occlusion:** Some counter technologies count users who cross an invisible screen line. When two or more people cross the line simultaneously, an undercount occurs because the device only detects the person nearest the sensor.
- **Environmental Conditions:** cold or hot weather and lighting, may cause counting inaccuracies in different counting technologies, because of particular characteristics of those technologies.
- **Counter Bypassing:** Even though a counter may accurately count the pedestrians or bicyclists that pass through its detection zone, it may still not count all of the users if it is possible for users to bypass the detection zone.

Adjusting Count data

Measured accuracy and precision of automated sensor technologies

- Accuracy refers to how close, on average, the automated count is to reality. Consistency refers to the counter's ability to reproduce consistent levels of accuracy across multiple observation periods. Three metrics are provided:
  - Average Percentage Deviation (APD)
  - Average of the Absolute Percent Difference (AAPD)
  - Pearson's Correlation Coefficient (r)

Correction factors for automated counters, used to adjust raw counts to more closely represent the ground truth

- Correction factors correct for systematic counting errors associated with a particular technology, such as those associated with occlusion. Applying a correction factor produces a better estimate of the "true" count of pedestrians or bicyclists who passed through the counter's detection zone

Adjusting Count data

Expansion factors, applied to short-duration counts to estimate volumes over longer periods of time

- Expansion factors are used to estimate pedestrian or bicycle volumes under conditions different than actually counted. Similar to the well established procedures for estimating long-term motorized traffic volumes, permanent counters are used to develop these factors.
- Expansion factors include the following types of adjustments:
  - Temporal adjustments are used to estimate volumes at a different time, or for a longer time period, than was counted
  - Environmental adjustments. Environmental adjustments are used to estimate what the counted volume would have been under different conditions than occurred during the count.

Part 6: Sensor Technology Toolbox

Sensor Technology Toolbox

- Manual in-field counting
- Manual counts from video
- Automated counts from video
- Pneumatic tubes
- Inductive loop detectors
- Passive infrared
- Active infrared
- Piezoelectric strips
- Radio beams
- Laser scanners
- Thermal
- Pressure acoustic pads
- Magnetometers
- Fiberoptic sensors

Sensor Technology Toolbox

Sensor technologies

- Description of how the counting technology or method detects pedestrians or bicyclists
- Typical applications for the technology
- General installation considerations for the technology
- Relative level of effort and cost
- Strengths and limitations
- Accuracy

Sensor Technology Toolbox

Manual in-field counting

- Manual counts can capture both pedestrian and bicycle volumes and can capture other information as well (e.g., gender, helmet use, or risky behaviours). They can capture both screen line volumes and intersection turning movement and crossing volumes.

Sensor Technology Toolbox

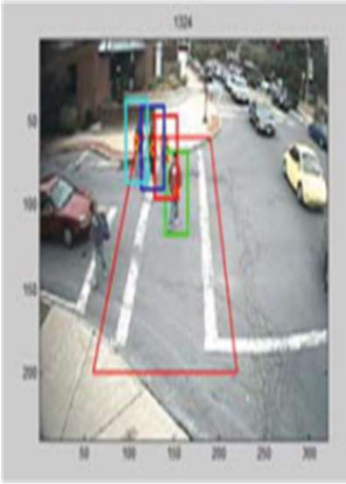
Manual counts from video

- Manual counts on video can be used to capture pedestrian and bicycle volumes, including crossing counts and turning movement counts at intersections.
- Useful for observing individual characteristics (e.g., gender and helmet usage), although these details can be hard to discern in lower resolution video images or in images taken from a distance.
- Specific behaviours that would be missed by most automated technologies can be observed (e.g., wrong-way riding, traffic control device compliance, and sidewalk riding).

Sensor Technology Toolbox

Automated counts from video

- Can capture pedestrian or bicycle volumes.
- Can capture both screen line volumes and intersection turning movement volumes, although it may take multiple cameras to collect data from an entire intersection.



Sensor Technology Toolbox

Pneumatic tubes

- Pneumatic tubes can be very effective when bicycle data need to be collected for several days up to several weeks.
- Tubes are most appropriate for paved surfaces with minimal pedestrian use.

Sensor Technology Toolbox

Inductive loop detectors

- Loop detectors are generally intended for permanent count locations (embedded loops), but can be used for shorter duration counts with temporary surface loops designed for bicycle counting.
- Loop detectors are used to collect screen line counts and are typically used on paved facilities.

Sensor Technology Toolbox

Passive infrared

- Passive IR devices are appropriate for collecting counts for several weeks or as permanent installations.
- Cannot differentiate between pedestrians and bicyclists, so are best for facilities with one user type or in conjunction with a bicycle-only counting technology to differentiate users.

Sensor Technology Toolbox

Active infrared

- Active IR devices are most commonly used to collect bicycle or pedestrian screen line counts on multi-use paths. They can be installed temporarily or permanently.
- They cannot differentiate between pedestrians and bicyclists, so are best used on facilities with a single user type or in conjunction with a bicycle-only counting technology.

Sensor Technology Toolbox

Piezoelectric strips

- Piezoelectric materials emit an electric signal when they are physically deformed. Counters using this technology consist of two strips embedded in pavement across the travelled way. The electric signal is detected by the data logger. Piezoelectric materials emit an electric signal when they are physically deformed.
- Piezoelectric strips are used for collecting bicycle counts at permanent count sites. They can be used on paved multi-use paths or cycle tracks.

Sensor Technology Toolbox

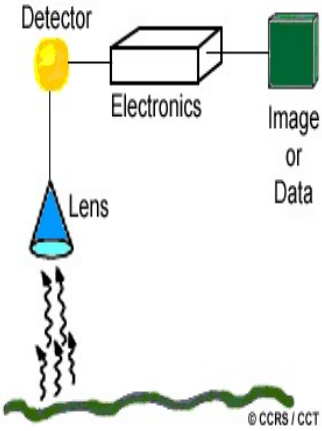
Radio beams

- Radio beam counters are used for screen line counts on sidewalks, pathways, and cycle tracks and can be used in both short-term and permanent counting applications.
- As with other beam type technologies, they are subject to occlusion errors.

Sensor Technology Toolbox

Thermal

- Thermal devices generate infrared images by detecting body heat. They work similarly to passive infrared counters, but are mounted above the detection area. This positioning allows thermal devices to monitor the movement of persons and not just count the number of persons to pass the device. Thermal sensors are not affected by changes in ambient light.
- Thermal sensors are primarily used for presence-detection applications (e.g., traffic signal detectors and monitoring intrusions into restricted areas).



Sensor Technology Toolbox

Laser scanners

- Laser scanners emit laser pulses in a range of directions and analyse the reflections of the pulses to determine characteristics of the device's surroundings, including the presence of pedestrians or bicyclists.
- Non-motorized applications of laser scanners have primarily been indoors.

Sensor Technology Toolbox

Pressure and acoustic pads

- Pressure and acoustic pads are installed in ground, either flush with or under the surface.
- Pressure and acoustic pads are primarily used to count pedestrians on unpaved trails.
- Pressure pads can also count bicyclists, while acoustic pads can only count pedestrians.

Sensor Technology Toolbox

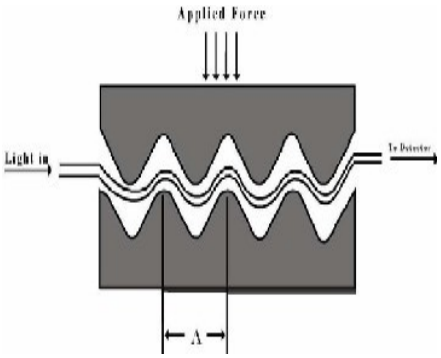
Magnetometers

- Magnetometers detect bicycle activity through changes in the normal magnetic field as a bicycle's metal parts pass by.
- Magnetometers are best suited to rural locations because the device is highly sensitive to ferrous objects. Due to the magnetometer's limited detection range, they are preferably installed where bicyclists will travel single file. Therefore, they are typically used to count bicyclists on rural bike paths or mountain bike trails.

Sensor Technology Toolbox

Fiberoptic pressure sensors

- Fiberoptic pressure sensors detect changes in the amount of light transmitted through an embedded fiber optic cable, based on the amount of pressure (weight) applied to the cable.
- Fiberoptic pressure sensors can be used for permanent count stations. The technology could be applied to exclusive bicycle facilities, pathways, mixed-traffic roadways, and sidewalks.



Drones

- A UAV's primary role is not for flying, it's for collecting data, or information. In terms of traffic management, the key thing is that the highways agency, or local traffic planners, want data. A UAV is a lot less expensive than a helicopter or an aircraft.
- Satellites are also expensive pieces of kit; probably £100,000 a day. A UAV would be between £1,000 and £2,000 a day. That's the main benefit of drones.

ITS International Journal, January/ February 2013