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Mobile phone use and seat belt compliance survey 2021

Comparison of survey methods

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1. Introduction

1.1 Project background

The 2021 mobile phone use and seat belt compliance survey carried out for the Department for Transport used a new method to observe vehicle occupants. Instead of requiring observers to stand at the roadside, the 2021 survey used video cameras to capture the traffic and subsequently analysed the video in an office environment.

The goals of the survey remained the same, and it was important to ensure the data captured in 2021 was comparable to that captured in previous surveys. However, there were slight differences in the methods that created advantages and disadvantages.

There are also technological developments underway that may be beneficial for future surveys. AECOM has been working with National Highways for a number of years on the feasibility of automated detection technologies for non-compliant road user behaviours (such as driver distraction, seat belt compliance, and tailgating).

This report provides an evaluation and comparison of three methods that could be used to perform a survey of mobile phone use and seat belt compliance:

- Manual roadside survey
- Video capture and desk-based analysis
- Automated image recognition using infrared cameras

The report provides a recommended survey method as well as recommended changes to the survey design.

2. Survey methods

2.1 Survey methods: Manual roadside survey

The manual roadside survey method requires all of the data capture to be performed by survey operatives at the roadside. This typically involves three individuals recording observations: a mobile phone observer, seatbelt observer, and a traffic enumerator.

Depending on the survey requirements, the observers would either stand still and allow the vehicles to pass them (moving sites) or walk alongside stationary vehicles whilst they are waiting at traffic lights (stationary sites).

The observers would record their observations manually using a paper form, which would typically be customised specifically for the task to ensure consistency.

The selection of sites is limited by the availability of safe places for the observers to stand.

This was the method used for all previous DfT surveys before the 2021 survey.

2.2 Survey methods: Video capture and desk-based analysis

This method uses visible-light video cameras positioned at the survey sites to capture periods of video without operator supervision. The videos are subsequently analysed in an office environment, allowing the observer to pause, rewind, and enhance the image as required to record data about vehicles, occupants, and non-compliance.

This approach is designed to be consistent, auditable, and repeatable. Survey operatives are required to spend less time in the field, therefore exposure to road hazards and members of the public is significantly reduced. Evidence of non-compliance is provided by videos or snapshot images that can be easily checked to provide assurance.

Due to the discrete nature of the survey equipment, there is very little risk that the survey will change the behaviour of road users.

This was the method used for the 2021 DfT survey.

2.3 Survey methods: Automated image recognition using infrared cameras

This method uses an automated road user behaviour detection system installed on a mobile survey vehicle. The system uses a cantilevered gantry attached to a 6 metre tall mast.

The cameras use infrared sensors (with flash) to capture images of vehicles. The images are automatically evaluated by the system to determine whether the occupants are using hand-held devices or not wearing a seat belt. This creates a set of candidate incidents that are subsequently reviewed by a human operator.

The roadside setup is shown in the image to the right. The system can be configured to observe one or multiple lanes of a carriageway, although the performance relies on being able to position the vehicle as close to the highway as is safe.

Such systems have been deployed widely in other countries for the enforcement of non-compliant behaviours, and trialled by National Highways in England.

2.4 Survey methods: Pros and cons of each method

The table below summarises the main pros and cons of each method. A full evaluation of each method is provided in Section 3.

Method	Pros	Cons
Manual survey	- Relatively inexpensive - Consistent with most previous DfT surveys - Mature industry and many suppliers	- Difficult to audit - Operationally unsafe as requires roadside operatives throughout the survey - Inconsistent accuracy - Inconsistent precision - Tends to use inexperienced operatives who require training
Video survey	- Relatively inexpensive - Discrete - Mostly consistent to previous DfT surveys - Mature industry as video traffic surveys are more common - Great flexibility due to very low cost of recording redundant video data - Great auditability as assurance can be completed using the exact imagery as that used by the original analysts - Improved safety as operatives are only required on site for a short period - Easy to increase scale (add more cameras)	- Applying this method is relatively uncommon for vehicle interior observations - Video recording equipment subject to interference whilst operatives are off site - Video image quality is poor in low light - Performing multiple surveys concurrently requires multiple video systems - Video analysis is more time consuming as analysts will utilise pause, rewind, and replay functions - Requires video analyst training and guidance to ensure consistency
Automated image recognition	- High accuracy due to image quality (for instance, the quality is recognised as acceptable for police evidence) - High precision as method is highly repeatable - Excellent operational safety as operatives do not need to leave the vehicle - Great auditability as assurance can be completed using the exact imagery as that used by the original analysts - Image processing is very robust	- Relatively expensive due to higher quality camera systems and dedicated vehicle - Immature market with only a handful of suppliers

3. Survey method evaluation

3.1 Survey method evaluation criteria

The table below describes the criteria used to evaluate the survey methods.

Criterion	Description
Total cost	This represents the total cost of the method to achieve the survey aim, specifically including all equipment and labour. It is a relative comparison to other survey methods. Rating 1 shows the total cost is comparatively high and a rating of 3 would be low cost.
Applicability	Whether the method has a direct application for the survey task (i.e. is it specifically designed to do the activity?). A rating of 1 shows the method will be difficult to apply, whereas a rating of 3 shows the method will naturally be applied to the situation.
Complexity	The complexity of the method. It may be difficult to understand or require high expertise. A rating of 1 shows the method introduces many additional steps or requires specific training to apply, whereas a rating of 3 shows the method is simple and may even reduce the number of steps in a task compared to a traditional approach.
Flexibility	The extent to which the method is constrained by external factors, such as scale limitations, the ability to make dynamic adjustments, environmental conditions, and the accessibility to users of all abilities. A rating of 1 shows the constraints make the method prohibitive, whereas a rating of 3 represents a relatively unconstrained method.
Robustness	This criterion rates the robustness of the method. Specifically, this relates to the chance that the user applies the method accurately and precisely (or consistently). A rating of 1 shows the method is not very robust and a rating of 3 shows the method has strong robustness.
Accuracy	This measures the ability of the method to accurately determine the truth (if applied correctly). A rating of 1 shows the method achieves poor accuracy and a rating of 3 shows the method achieves a high accuracy.
Precision	This reflects the consistency of the method and its ability to allow trends to be measured. Precision is a measure of the closeness of repeat measurements, commonly described by standard deviation from a mean. A rating of 1 shows the method achieves a poor precision and a rating of 3 shows the method achieves a high precision.
Operational safety	This reflects how safe the method is to deploy for operatives. A rating of 1 shows the method is inherently unsafe and requires significant effort to reduce risks, whereas a rating of 3 shows the method creates a very low risk for operatives.
Auditability	This shows the ability of the measure to provide excellent evidence that is easily auditable. A rating of 1 shows the method provides little opportunity for audit or assurance involves significant additional work, and a rating of 3 shows the method is easily auditable in many separate ways.
Industry maturity	This reflects how established the technologies and/or processes are to deliver the method, and the level of competition within the industry. A rating of 1 shows that the control is still in the research or early development phase, and a rating of 3 judges the control is established in a similar domain.

3.2 Survey method evaluation

The criteria introduced in Section 3.1 were used to evaluate each of the three survey methods. A score from 1 to 3 was given against each criteria for each method, where 1 is poor and 3 is good.

The results of this evaluation are shown in the table to the right. A more detailed description of why each criteria score was given for each of the survey methods is provided over the following pages.

The scores evaluated in the context of performing a survey to achieve the following aim:

> *To provide evidence of driver compliance with hand-held mobile phone legislation, and evidence of seat belt wearing rates of drivers and passengers.*

There are differences in how each method would collect data to achieve this aim, therefore the evaluation assumes the most appropriate approach is taken in each case. For instance, the manual survey would require vehicles to be stationary (waiting at traffic lights) for the seat belt observations, whereas the other methods do not have this requirement.

Criterion	Manual survey	Video survey	Automated image recognition
Total cost	2	3	2
Applicability	3	3	2
Complexity	2	2	2
Flexibility	2	3	3
Robustness	1	2	3
Accuracy	2	2	3
Precision	2	2	3
Operational safety	1	2	3
Auditability	1	3	3
Industry maturity	3	2	1

3.2.1 Survey method evaluation: Manual survey

Criterion	Rating	Justification
Total cost	2	The manual survey approach has been used for many years and is considered the benchmark cost. It does not require any expensive equipment and the labour does not need to be highly skilled.
Applicability	3	The requirements of the survey are designed with this method in mind, therefore it is entirely applicable.
Complexity	2	The whole process from organising the survey site visits through to producing the survey data is relatively complex. There are many steps and specific training is required at certain points (for instance, for the survey operatives).
Flexibility	2	The method is primarily limited in scale, due to the availability of survey operatives. It is very likely that an operative will become unavailable at short notice. Other flexibility limitations include site conditions that operatives are exposed to.
Robustness	1	This method is particularly susceptible to poor consistency in its application. Supervision is generally provided, but this is limited to spot checks and operative training sessions. It is possible the operatives do not follow the correct procedure and it is not detected in the assurance processes.
Accuracy	2	The operatives only have one chance to view a vehicle as is passes – this means any distraction or decrease in attention is likely to lead to missed details or inaccurate observations.
Precision	2	Evidence from previous surveys carried out using this method included examples where surveys needed to be repeated (due to concerns about outliers) and often there are large changes in statistics between surveys that are difficult to explain.
Operational safety	1	Requires operatives to stand directly beside the vehicles they are observing. Although mitigations are in place, this still creates a risk to the operatives of road vehicle incidents or confrontation with members of the public. The operatives are also subject to exposure to weather, noise, and air pollution.
Auditability	1	Relies on supervisor spot checks during the fieldwork, and data validation during the compilation of the data. It is not possible to retroactively choose the period of the survey to examine, therefore errors can easily be missed.
Industry maturity	3	This method has been used for many years, and suppliers are familiar with its implementation.

3.2.2 Survey method evaluation: Video survey

Criterion	Rating	Justification
Total cost	3	Significantly reduces the cost of fieldwork. Survey operatives are required to attend site and set up video cameras, but they do not need to remain throughout the survey. The same operative crew is also able to visit many local sites in the same day to install equipment, which can be programmed to capture video at some future time. There are additional costs related to office-based staff to analyse the video, and although the video analysis takes longer to complete compared to site-based observations, an analyst is able to simultaneously capture data for all three sub-survey types (mobile phone use, seat belt use, traffic survey).
Applicability	3	Like the manual survey method, it is designed to record all observations of every vehicle. The method can be aligned with the survey design of the manual survey method and observations can be made at the same sites. Observation of rear seat passengers is possible by careful positioning of the camera systems, although the increased prevalence of tinted rear windows is likely to reduce the number of observations (as with the manual survey method).
Complexity	2	Set up on site requires expertise, as the positioning and configuration of the cameras is crucial to the success of the method. However, the process makes site work relatively quick, and many sites can be attended by the same operative crew in the same day. The video analysis makes the capture of the observations immediately digital (unlike the manual survey method), and uses software that many analysts will be familiar with.
Flexibility	3	The method is easily scaled by using more camera systems. The site requires street furniture to support the cameras (such as lamp columns), but otherwise it is relatively site agnostic. Environmental conditions can affect the quality of the video, but periods of poor lighting or weather can be avoided by selecting an alternative period of video for the analysis. The video analysis is relatively accessible to most analysts, and guidance can be produced to ensure consistency.
Robustness	2	The method is very process driven, and steps are well defined. However, it still requires human interpretation of images, which introduces subjectivity and can lead to inconsistency.
Accuracy	2	There remains a level of interpretation of images that can lead to inconsistency in analysis (e.g. the driver’s age). Rear passengers are also difficult to observe as camera systems tend to be configured to observe the driver. There are cases where an observation cannot be confirmed (such as the vehicle interior is dark or the driver’s hands are not visible). However, the video can be reviewed and re-analysed as desired.
Precision	2	The method provides good repeatability – there are cases where two analysts may disagree on aspects such as driver age or sex, but not typically on the crucial metrics of phone use and seat belt wearing. It is relatively easy to test this as the video can be re-analysed.
Operational safety	2	Exposure of staff to site risks is reduced as the site time is low, although there are new risks associated with equipment installation. The method uses experienced staff familiar with the tasks.
Auditability	3	The method is highly auditable, as the video used to create the survey data can be reviewed.
Industry maturity	2	Traffic surveys are very commonly carried out using this technique, therefore many companies are familiar with the method. However, analysis of the videos for vehicle interior behaviour is relatively uncommon and new.

3.2.3 Survey method evaluation: Automated image recognition

Criterion	Rating	Justification
Total cost	2	This method requires equipment and a dedicated platform (such as a vehicle with mast to allow the system to be moved easily to new locations). The upfront cost of this can be large, but careful planning and high utilisation of the equipment reduces the cost per site. The operational cost is marginally higher than the video survey method as it requires survey personnel to remain on site, although they can perform other tasks such as analysis in parallel.
Applicability	2	This method is based on an approach designed to detect non-compliant behaviour for the purposes of enforcement or intervention. Therefore, it has typically prioritised the reduction of false positives at the detriment of false negatives. However, it is possible to tweak the system calibration in order to lower the threshold, although this is subject to further research and development.
Complexity	2	Although the underlying software utilises complex machine learning algorithms to determine whether non-compliant activity is taking place, this does not require input from the survey operatives. There are some additional tasks related to camera set up and calibration, although the equipment suppliers are able to connect remotely to the devices to assist.
Flexibility	3	The system provides excellent flexibility regarding environmental conditions – all survey operatives are safely housed inside a survey vehicle with suitable facilities, and the system uses infrared cameras that are less susceptible to weather interference or changing lighting conditions. The automated nature of the system and process-driven approach makes the method very accessible.
Robustness	3	The system is designed for enforcement, therefore there are calibration and data security processes built in. Multiple images are captured that are admissible as evidence to allow prosecution of an offence. This provides a fundamentally robust system.
Accuracy	3	The infrared imagery provides a very clear view of the vehicle interior (as illumination does not rely on ambient lighting conditions). This significantly reduces the ambiguity experienced in the other methods.
Precision	3	Due to the consistent and high quality of the images, it is possible to achieve high precision with this method. The consistency is ensured by following a thorough calibration exercise during system initialisation.
Operational safety	3	The survey operatives are able to remain inside the survey vehicle at all times, even during equipment deployment. The vehicle is also equipped with welfare facilities.
Auditability	3	As with the video survey method, the same images are available for validation and verification. The robust process from initial deployment to assurance creates a complete digital paper trail.
Industry maturity	1	These systems have been developed for the purposes of enforcement and targeted intervention, and are not yet widely deployed. Although the underlying hardware is well established, the software is subject to ongoing development and the level of operational experience is still low.

3.3 Survey design requirements

The table opposite shows the requirements of the 2021 DfT survey for seat belt wearing and mobile phone use. Each of the requirements is assessed for each of the survey methods, where:

● shows the requirement can be met

◎ shows the requirement can be met, but another method is notably better

○ shows the requirement cannot be met

Most notably, the manual survey is the only method that can perform a stationary survey, but this survey design was intentionally added as observers cannot note down all the observations of vehicle occupants quickly enough if the vehicles are moving past. The other methods do not have this challenge.

The image-based methods may struggle more to observe rear seat passengers, although alternative or additional camera setups can be used. They also allow more detailed observations to be made, such as specific mobile phone use behaviours.

Data		Manual survey	Video survey	Automated image recognition
Survey types				
Moving sites		●	●	●
Stationary sites		●	○	○
Traffic count		●	●	●
Survey meta data				
Date & time		◎	●	●
Vehicle details				
Vehicle	Type	●	●	●
	Colour	●	●	●
	Vehicle speed	◎	◎	●
Occupant information				
Driver only	Hand-held mobile phone use	◎	●	●
All occupants	Seating position (inc. on lap)	●	◎	◎
	Sex, age group	◎	●	◎
	Seat belt use	●	●	●
	Other notable behaviours (eating, smoking, etc)	◎	●	◎

4. Proposed future survey method

4.1 Recommended survey method

The evaluation provided in Section 3 shows the equipment used in the automated image recognition method provides the most accurate, precise, robust, and auditable data. However, the method is expensive and the automated algorithms are primarily configured for the purpose of enforcement rather than survey.

The video survey method has proved to offer improvements over the manual survey method in terms of operational safety and auditability. It is also slightly more cost-effective. Therefore,

> ***the recommended survey method is to combine the video survey method with the infrared image capture equipment used in the automated image recognition method.***

The automated image recognition should not be used as it will lead to a high number of false negatives. This aspect of the survey should remain human-driven. This recommendation mitigates the main limitation of the video survey method – the relatively poor image quality – but retains all of the benefits.

The recommended method also requires small changes to how the cameras are positioned at the roadside, and how the survey design is configured to best suit the approach (i.e. no requirement for separate moving and stationary sites). Consideration also needs to be given to supplementary activities to capture data where the method is not suitable, such as observing rear passengers in vehicles with tinted rear windows.

This hybrid method has the additional benefit that it will create a set of curated images that can be used for training automated systems (machine learning). Over time this may allow the automated image recognition systems to improve their accuracy and consistency, allowing the desired comparisons, and assessment of trends.

4.2 Recommended changes to the survey design

The recommended survey method would require small adjustments to the survey design:

- There is no need for stationary surveys (where the vehicles are stopped) although it can continue to use stationary sites.
- It is important to record the state of vehicles during observation (stationary, moving off, moving, etc).
- Additional cameras can be positioned to observe rear seat passengers, or a supplementary sample of manual roadside surveys could be performed.

The following changes to the survey specification would improve the robustness of the survey or add value:

- Counterbalancing of time of day and day of week (to reduce related biases and add insight).
- Additional categories for phone use (interaction in phone cradle, phone on lap but not in hand, etc).
- Record additional details on phone position when in use (holding, looking, interacting, height, charging, etc).
- Record additional details on restraint use (plugged in but behind back, chest strap under arm, passenger belt plugged in to driver buckle, lap belt in old vehicle, etc).
- Perform additional surveys between 6pm and 7am (to capture night-time behaviour) – this is feasible with infrared equipment.
- Perform shorter and more frequent surveys throughout the year (to capture any seasonal variation).
- Perform surveys at sites on the strategic road network.

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