

# Wales National Travel Survey: Diary Evaluation

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**Prepared for:** Transport for Wales



JULY 2023



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# Background

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## **The Wales National Travel Survey**

Transport for Wales (TfW) has commissioned the National Centre for Social Research (NatCen) to work as its delivery partner to design a suitable methodology for the new Wales National Travel Survey (WNTS). Scheduled for a 2024 launch, the WNTS will collect data on travel attitudes and behaviour among the population in Wales.

The primary goals of the WNTS are threefold:

- 1) To monitor changes in travel behaviour and evaluate the degree to which specified targets are being achieved.
- 2) To provide data that will improve the transport evidence base and regional transport models in Wales.
- 3) To develop a robust, repeatable data collection strategy that provides more agency and control over the data generation process.

To fulfill these objectives, the WNTS will incorporate two components:

- 1) A survey that will gather data on household composition, socio-demographic characteristics, attitudes towards travel, and some travel behaviours.
- 2) A travel diary to collect detailed information on travel behaviour over a specific period.

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## The Current Report

This report is one of the outputs from the second stage of a process aimed at identifying and designing the optimal survey modes and tools for delivering the WNTS. A separate report focuses on the modes to collect the survey data has been produced (Cornick, Aizpurua, & Howe, 2023). The review of modes and tools to deliver the WNTS is guided by the National Centre for Social Research's REMoDEL approach, a systematic process for designing or transforming social surveys and for gathering robust evidence around the trade-offs linked with different design options (Cornick, 2021).

### **Key Stages of NatCen's REMoDEL Approach:**

**Review** the research and information needs, including any design parameters - (completed)

**Evaluate** the feasibility of various methodological designs considering different quality dimensions - (in progress)

**Model** a prototype design for further development

**Design** and develop the new methodological approach and questionnaire

**Experiment** by testing the design in a quantitative context

**Launch** the new survey

The review stage of the WNTS was completed in June of 2023, and a separate report was produced outlining the project's key outcomes and indicators of success, in addition to its essential and desirable requirements (Cornick, Aizpurua & Howe, 2023). The current report summarises the evaluation phase of this development, assessing the performance of multiple trip data collection tools to meet the research needs of the project.

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# Evaluation Methodology

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## Aim and Scope

The aim of the evaluate stage is to identify the most suitable designs to answer the research questions and meet the design parameters outlined during the review stage. In the context of the WNTS, this includes two sets of designs for the administration of both the survey and the travel diary. This report focuses on the diary component of the project, with a separate report examining optimal tools to administer the survey (Cornick, Aizpurua, & Howe, 2023).

## Identification of Suitable Designs

The evaluation stage started with members of the Transformation Team at NatCen identifying potential data collection tools for evaluation. This task was completed during a meeting where the key objectives, research needs, and design parameters established during the review stage of the WNTS were thoroughly discussed. All proposed tools were reviewed, with four being shortlisted for further review (see Table 1).

**Table 1.** Potential tools to gather trip data

Data collection tool	Shortlisted	Rationale
Administrative data (e.g., mobile network data)	No	Excluded due to incomplete information (data cannot be associated with individual users), concerns around access to data sources, and consent to data linkage.
Paper travel diary	No	Limits survey design options (requires either interviewer administration or the diary to be posted), relatively high respondent burden, requires considerable post-hoc editing and coding, and high environmental impact and cost due to printing/postage.
Native smartphone app	No	Offers a fully customisable user experience and features to meet most of WNTS' information needs. However, concerns exist about implementation within the current timescale, upfront costs, the need to adapt to different operating systems, and the take-up rate of an option which requires download onto a personal device.
Pre-existing smartphone app	No	Travel apps come in a broad variety, making their global performance evaluation challenging due to their differences. These differences include whether the apps are proprietary academic (e.g., Modalyzer) or commercial (e.g., rMove, NuTripX), their compatibility with different operating systems (Android and iOS) and firmware



Data collection tool	Shortlisted	Rationale
		<p>versions, whether they use open-source code (e.g., MEILI or Itinerum), or the choice of technical solution (hardware or software). They also diverge based on the type of segmentation they use (trip or tripleg), the inferences they make (e.g., travel model, trip purpose, destination), and the sensors they employed (Prelipcen, Susilo &amp; Gidofalvi, 2018).</p> <p>Each application has its own emphasis and functionalities, and to evaluate their performance against the WNTS requirements and information needs, we would need TfW to pre-select an app of interest.</p> <p>Additionally, this solution carries other concerns, including data storage and compliance with GDPR obligations, as well as changes made by app developers which could disrupt the time series.</p>
Modified DfT's Digital Diary** (web-based travel diary)	Yes	<p>Substantial development and investment undertaken by the Department for Transport. Viable product for collecting travel data which has undergone extensive testing.</p> <p>Concerns exist regarding its suitability for a self-completion environment, but it's worthy of further assessment.</p>
Dedicated GPS or Geolocation logger	Yes	<p>Capable of providing highly accurate travel data passively, thereby reducing respondent burden. Some concerns exist regarding onboarding, consent, and data interpretation, and the risk of missing data if individuals forget or decide not to carry the device. However, it leverages current and future technology.</p>
Diary integrated into survey software	Yes	<p>Capable of collecting data in the same software environment as the survey, potentially mitigating issues with attrition or drop-offs.</p> <p>However, some concerns exist about software limitations for user-centric features.</p>
Bespoke progressive web application	Yes	<p>Offers a fully customisable user experience and features that can meet most of WNTS' information needs.</p> <p>However, concerns exist regarding implementation within the current timescale.</p>

DfT: Department for Transport.

\*\* At a minimum, the diary would need to be updated to support data collection in two languages and update some features to facilitate self-administration.

## Review of Potential Tools

Each shortlisted tool underwent an evaluation to identify its strengths, limitations, and to assess the potential trade-offs of each approach. To ensure a systematic approach, the NatCen Centre for Social Survey Transformation created a standardised form featuring a series of dimensions related to the quality and usability of the data which would be generated. These dimensions were drawn from a modified version of the Total Survey Quality framework (Biemer, 2010), and included project-specific parameters for the trip data (e.g., captures in-frequent trips, such as long-distance journeys or minimises underreporting).

Table 2 outlines these dimensions and their corresponding parameters.

**Table 2.** WNTS data quality evaluative dimensions

Dimension	Description	Parameters for the diary
Accuracy	Measurement and representation error are minimised	<p>Maximises compliance with the selection of travel days</p> <p>Obtains enough trip data to accurately represent travel behaviours of adults (16 and over) in Wales, accounting for seasonality and variability in travel across days and times</p> <p>Could produce a sample that is representative of school-aged children (5-15 years), if this was required</p> <p>Captures in-frequent trips, such as long-distance journeys</p> <p>Produces a smooth representation of days of the week</p> <p>Underreporting of trips is minimised</p>
Credibility	The data will be sufficiently robust and reliable to support its intended uses	<p>Data collection is robust to achieve National Statistics status</p> <p>Data can continue to be collected in unexpected events (e.g., pandemic)</p> <p>Ensure minimal reliance on third parties for critical processes, such as recruitment or data collection (e.g., postal system)</p>
Comparability	The data will allow any comparisons required by the analysis objectives	<p>Produce a large-enough effective sample size to facilitate analysis by region (North Wales, Mid-Wales, South-West Wales, and South East Wales) as well as by urban/rural location</p> <p>Produces a large enough sample to confidently compare estimates for remote and non-remote workers</p> <p>Generates a large enough sample for disaggregated analysis based on language and protected characteristics (e.g., gender, sexual orientation, pregnancy status, race/ethnicity, religion, physical ability)</p>
Coherence	Data gathered from different tools and sources can be reliably combined	Transition from the core survey to the travel diary is smooth, minimising dropouts between the two components
Completeness	The data gathered answers the research questions while minimising the burden on respondents	<p>Minimises the risk of attrition</p> <p>Allows for collection of longer diaries (over 2 days)</p> <p>The diary supports proxy data collection, supporting a household design and collection of information from children if required</p>

In addition to these five data quality dimensions (accuracy, credibility, comparability, coherence, and completeness), four data user dimensions were considered, as displayed in Table 3.

**Table 3.** WNTS user quality evaluative dimensions

Dimension	Description	Parameters for the diary
Relevance	Data satisfy users' needs	The tool is expected to remain relevant in 5 to 10 years Optimise technology use to meet social expectations
Timeliness	The data is available in sufficient time to meet information needs	Diary is launched by no later than December 2024 Data is collected rapidly, allowing to distribute the processing work throughout the duration of the fieldwork Can be internally developed, avoiding the need for additional procurement and time associated with outsourcing Weighted data sets are provided within three months of the end of the survey year
Cost-effectiveness	Approach offers value for money	Data is collected in a cost-effective way Data is collected in a way that is environmentally sustainable Data collection minimises burden by automating respondent tasks
Usability	Ease of use and efficiency with which respondents can complete the tasks when interacting with the tool (i.e., user friendly and accessible design)	Maximises inclusivity Proves unique travel features to minimise respondent burden (pre-populated information, journey sharing features, view and editing options...) Onboarding is streamlined for self-administration Allows data collection in both Welsh and English languages

These standardised forms were used to assess each of the shortlisted tools. The goal was to evaluate how likely each proposed tool would be to fulfill the requirements for trip data. The review process began with a qualitative assessment of the design's likelihood of satisfying each specific parameter. Following this, we assigned a score based on the following rating scale:

#### Rating scale for each design parameter

- 1) Very likely
- 2) Fairly likely
- 3) Fairly unlikely
- 4) Very unlikely
- 5) Unknown/More information required

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# Evaluation outcomes: Diary tools

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In this section, we evaluate the four shortlisted tools (see Table 1) against the design parameters. As described in the previous section, two of these tools – the modified DfT’s digital diary and the diary integrated into the survey software - rely on respondents’ memory, requiring participants to self-report their travel behaviour based on their own recollection or with the assistance of proxies. The other two tools – a GPS device and a progressive web application - function primarily or entirely through automation. They collect GPS trajectories and employ classification methods to extract trip-related information (e.g., transport mode). Additionally, respondents using the progressive web application receive follow-up questions (‘prompted recall’) to supplement the GPS data (e.g., they might be asked to specify the purpose of their trip or provide information about their co-travellers) or to replace passively collected data. On smartphones, progressive web apps take advantage of built-in sensors, such as GPS and accelerometers, for passive data collection, automatically gathering travel data. On devices like desktops, which typically lack mobility and have limited sensor capabilities, progressive web apps may not have access to the same level of passive data collection. In such cases, users might need to manually input data through an easy-to-use interface

## **Accuracy**

The accuracy of data collection tools is crucial in ensuring the validity and representativeness of the collected data. Memory-based tools, such as self-reported diaries, carry the risk of underreporting, especially when it comes to unusual and shorter trips. Studies have estimated that self-reported diaries may miss up to 30% of trips (Sammer et al., 2018). They are also prone to recall errors, especially when completing diaries retrospectively, which leads to inaccuracies in reported distances and travel times due to rounding. Social desirability can also lead to misreporting if participants consider certain places or purposes as sensitive or disclosive.

GPS devices are helpful in addressing misreporting issues due to their precision in recording time and positional characteristics of travel. They can help rectify inaccuracies in trip data stemming from self-reported data, although they are not immune to measurement errors such as missing trips or false detection of trips. While response rates for self-reported surveys and diaries have been declining, studies using GPS devices have encountered similar non-response challenges, although they tend to increase uptake among younger participants, which are often under-represented in social surveys (McCool, Mussmann, & Schouten, 2021).

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In terms of overall accuracy, the progressive web application and DfT's digital diary scored best. Both tools performed best in obtaining sufficient trip data, capturing infrequent journeys, such as long-distance trips, and producing a smooth representation of travel patterns across days of the week. This is attributed to their ability to collect travel data over longer periods and, in the case of the progressive web application, passively gather part of the information (location data), which reduces respondent burden and mitigates the risk of attrition.

Despite the automated data collection capabilities of GPS devices, this tool scored worst in terms of accuracy. This is due to compliance concerns such as users not wearing the devices consistently or properly. If a GPS logger is not carried, there is no provision to manually add data. In addition, there are limitations in the passively collected data, which will not provide comprehensive answers to all questions about trips (e.g., public transport costs, zero-emission car miles travelled per person, etc.).

Compared to DfT's digital diary and the progressive web app, collecting trip information using survey software scored lower on accuracy due to the limitation of supporting only diaries covering 1 to 3 days. This is due to the lack of travel-specific features, such as the ability to share and repeat journeys, or add return journeys. As discussed in the section comparing single- and multi-day travel diaries (see page 24), this reduces the volume of data that could be collected per person. Although a diary covering fewer days may yield a higher response rate and lower attrition due to reduced burden, a larger sample would be required to gather sufficient trip data to conduct the required analyses.

Compliance with selected travel days is an important factor to accurately depict travel patterns across days of the week. All designs except the progressive web application scored a 3 in this parameter, indicating that they are "fairly unlikely" to achieve this. The progressive web app was considered more likely to be successful due to its ability to send reminders to respondents on their smartphones and the semi-automated nature of data collection.

In terms of producing a representative sample of school-aged children, all designs except the GPS logger were considered "fairly" capable as they allow for proxy-reporting. However, it is important to note that proxy reporting tends to underreport certain trips and is less accurate than self-reporting (Badoe & Steuart, 2010).

Previous research suggests that underreporting of trips is less common with passively collected data compared to self-reported data (Thomas, Geurs, Koolwaaij, & Bijlsma, 2018). This underreporting is expected to be more prevalent for longer self-reported diaries, which cause more fatigue. The GPS device was considered "fairly unlikely" to minimise underreporting of trips due to concerns with user compliance and signal loss in certain areas (e.g., rural areas, urban canyons, tube stations, and adverse weather conditions), rather than inaccuracy issues. Additionally, there are concerns about the risk of conditioning and the potential for respondents to increase their activity or alter their travel behaviour if they know that their activity is being tracked. This should be investigated further as it could lead to overestimation of certain trips or modes of transport (see Toepoel, Luiten, & Zandvliet, 2021).

In the case of the progressive web app, which employs a semi-automated approach to data collection (passive data supplemented by survey answers), the performance of the self-reported component remained uncertain, and would depend on diary length. This is an area that would benefit from further research.

**Table 4.** Accuracy scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Accuracy	Maximises compliance with the selection of travel days	3	3	3	1
	Obtains enough trip data to accurately represent travel behaviours of adults (16 and over) in Wales, accounting for seasonality and variability in travel across days and times	1	3	2	1
	Could produce a sample that is representative of school-aged children (5-15 years), if this was required	2	3	2	2
	Captures in-frequent trips, such as long-distance journeys	1	1	3	1
	Produces a smooth representation of days of the week	1	3	2	1
	Underreporting of trips is minimised	3	3	2	5

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

### Credibility

Credibility refers to the robustness of the data and the degree of confidence it inspires for its intended use. In this regard, the DfT’s digital diary and the progressive web application outperformed the other tools.

A key aspect of credibility is the potential for achieving National Statistics status, which was identified as a design requirement in the WNTS Review Report (Cornick, Aizpurua, & Howe, 2023). Both the digital diary and the progressive web app were considered “very likely” to meet this requirement due to the high volume of trip data they would produce. Similarly, the diary integrated into the survey software was also deemed “very likely” to fulfill this requirement, drawing from successful precedent in other nations. However, the suitability of a GPS device for achieving National Statistics status remained uncertain. While GPS devices provide precise location data, the resultant information does not fully meet the information needs of WNTS. The nature of this data is substantially different to that produced by other established tools, raising doubts about whether it would meet the criteria for trustworthiness, quality, and public value required to attain National Statistics status.

Given that all tools are self-administered and three of them rely on respondents using their own devices, they are likely to ensure continuous data collection even during unforeseen events, such as a pandemic. However, the GPS device performed slightly worse in this aspect, as it requires physical interaction to distribute the devices, which could be limited during isolation periods.

Regarding reliance on third parties, DfT’s digital diary, the diary integrated into the survey software, and the progressive web application were considered “fairly likely” to minimise dependance on third parties for critical processes such as recruitment and data collection. This is primarily because respondents use their own devices, and contact information for most respondents would have been collected during the initial survey. For those who choose not to share their contact information, recruitment for the second phase would rely on the postal service. However, it is expected that contact information would be available for the majority of survey respondents.

**Table 5.** Credibility scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Credibility	Data collection is sufficiently robust to achieve National Statistics status	1	5	1	1
	Data can continue to be collected in unexpected events (e.g., pandemic)	1	2	1	1
	Ensure minimal reliance on third parties for critical processes, such as recruitment or data collection (e.g., postal system, public transportation)	2	4	2	2

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

### Comparability

The comparability dimension evaluates the ability to obtain a sufficiently large sample that enables meaningful comparisons between different groups of interest. In the case of WNTS, this involves analysing trip data by regions, comparing trip behaviour in rural and urban areas, examining potential differences between remote and non-remote workers, and exploring variations based on protected characteristics.

DfT's digital diary and the progressive web app emerged as the top-performing tools in this regard. They facilitate the collection of longer diaries, which results in a higher volume of data. In contrast, the GPS device performed worse in this dimension due to the higher costs associated with acquiring and distributing the loggers, as well as the risk of non-returned devices or chargers. These increased distribution cost would impact the sample size achievable within a given budget. Similarly, if the sample were to be increased over time, it would be limited by the availability of devices, restricting the pace at which the sample could be scaled up.

**Table 6.** Comparability scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Comparability	Produce a large-enough effective sample size to facilitate analysis by region (North Wales, Mid-Wales, South-West Wales and South East Wales) as well as by urban/rural location	1	2	2	1
	Produce a large enough sample to confidently compare estimates for remote and non-remote workers	1	2	2	1
	Generate a large enough sample for disaggregated analysis based on language and protected characteristics (e.g., gender, sexual orientation, pregnancy status, race/ethnicity, religion, physical ability)	2	5	2	2

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

### Coherence

Coherence refers to the ability to effectively combine data collected from different tools and sources. In the context of trip data collection, where no tools will be combined, the focus is on the coherence between the survey mode and the diary tool.

If a web survey is used, the smoothest transition would occur with Tool 3, as the diary would be integrated within the same software platform where respondents completed the survey. This would be followed by DfT's digital diary and the progressive web app, as both tools rely on online data collection, allowing respondents to use their preferred devices to complete the survey and diary components. While there would be a separate interface for the diary, it remains within the online environment, providing a consistent and familiar user experience. In

contrast, the GPS device presents the least smooth transition. Participants would need to familiarise themselves with a different tool and be willing to wear it throughout the designated time.

**Table 7.** Coherence scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Coherence	Transition from the core survey to the travel diary is smooth, minimising dropouts between the two components	2	3	1	2

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

### Completeness

Completeness refers to the extent to which all necessary information required to answer the research questions is gathered. This includes the ability to collect and link survey and trip data, obtain sufficient trip data for meaningful analyses, and support proxy data collection for gathering information from children. In this domain, both the diary integrated within the survey software and the progressive web application performed better than the other tools.

DfT's Digital Diary scored the worst in terms of minimising the risk of attrition. This is attributed to its longer recording period (7 days) and reliance on respondents' memory. In multi-day diary surveys, participants make daily decisions about their participation. Some remain committed throughout, while others drop out after the initial days or towards the end of the diary, leading to item nonresponse that can introduce nonresponse error and reduce statistical power (Hu, Melipillan, West, Kirlin, & Paniagua, 2020). For a detailed discussion of the trade-offs between single- and multi-day travel diaries refer to page 24.

The progressive web app, despite collecting data over longer periods, is expected to have lower attrition rates due to its passive data collection approach. By reducing the input needed from participants and prompting them to provide additional information, it mitigates the reliance on memory alone. On the other hand, attrition with the GPS device was seen as a risk due to the burden of carrying an external device at all times.

The use of multi-day travel surveys lasting between 3 and 7 days was considered "very likely" with the progressive app, and "fairly likely" with the GPS device, given the passive nature of data collection. The GPS device scored worse due to concerns about battery drainage and the need for participants to charge the devices, which could potentially lead to disengagement.

While the digital diary is designed as a 7-day diary, its performance in a self-completion environment is unknown. Previous research has shown that supervision in the context of travel diaries can improve completeness, despite not reducing respondent fatigue (Kagerbauer & Stark, 2018), which suggests that completeness and engagement could be reduced if the digital diary was self-administered.

Proxy data collection is fully supported by DfT's digital diary, which is designed as a household-level survey. It has specific features that allow household members to fill in diaries for others from their own account, with a banner indicating who they are reporting on behalf of to mitigate errors (e.g., reporting own trips on someone else's diary). Proxy data collection is also possible with the self-reported diary integrated into the survey software (Tool 3), although with limited functionality. The progressive web app would enable manual proxy reporting, but it does not fully leverage the passive data collection capabilities of the tool and would create a difference in the



type of data collected between proxies and non-proxies. Finally, the GPS device does not allow for proxy data collection.

**Table 8.** Completeness scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Completeness	Minimises the risk of attrition	4	3	2	1
	Allows for collection of longer diaries (over 2 days)	5	2	3	1
	The diary supports proxy data collection, supporting a household design and collection of information from children if required	1	4	2	3

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

## Relevance

Relevance is an important consideration when developing sustainable data collection approaches that minimise disruptions to the time series in the long-term. In this regard, the progressive web app outperformed the other tools. It leverages existing technology by gathering GPS data to reduce respondent burden and supplements this information with self-reports for completeness. By sending notifications to participants, and being used on respondents' own devices, it reduces the risk of nonresponse and mitigates adoption barriers among smartphone users. Considering the increasing use of smartphones in the UK (Statista, 2023), the progressive web app is expected to remain relevant in the coming years.

In contrast, memory-based travel diaries are considered "fairly unlikely" to remain relevant, as there is a shift toward semi-automated data collection tools in travel surveys. DfT's digital diary itself was initially designed as a Minimum Viable Product, while an enhanced version with additional features such as GPS to record journeys was developed (Evans, Sykes, Whiye, & Evans, 2020). The poor performance of memory-based travel diaries in this domain is also attributed to the consistent decline in response rates that surveys have experienced in the last few decades.

While GPS devices were seen as relevant, they provide limited information on their own. GPS devices can accurately collect information on travel location, routes, and speed of travel, but they do not capture other information such as trip purpose, which limits their value within the context of WNTS.

**Table 9.** Relevance scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Relevance	The mode(s) of administration are expected to remain relevant in 5 to 10 years	3	2	3	1
	Optimise technology use to meet social expectations	2	3	2	1

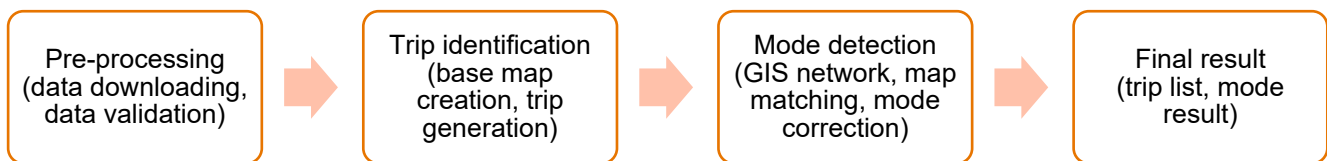
Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

## Timeliness

Timeliness refers to the ability to deliver data on time to meet project requirements. There are great differences across the tools in this aspect, with the progressive web app, which performed best across all other dimensions, being highly unlikely to meet the deadlines. Since it is an externally developed tool, it would need to go through a tendering process, software development, iterative testing designs, and the establishment of data extraction and processing procedures.

Similarly, the GPS device is unlikely to meet the timeliness requirements. It would require outsourcing and the development of data transfer and trip identification processes (see Figure 1). Although GPS devices allow for rapid data collection once the processes are in place, the setup is expected to take time.

**Figure 1.** General sequence to analyse GPS data



Source: Adapted from Shen & Stopher (2014).

On the other hand, DfT’s digital diary shows better potential for timeliness. While some adjustments would be necessary, such as making the diary available in Welsh, and introducing cues for self-administration, it is considered “fairly likely” to be launched by the end of 2024. In memory-based diaries, information is not recorded as rapidly as with GPS, but the data would be available by the end of the travel week for each participant.

The diary integrated within the survey software is the tool that is most likely to meet the time requirements, as it does not require outsourcing, and data processing relies on self-reports.

**Table 10.** Timeliness scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Timeliness	Diary is launched by no later than December 2024	2	3	1	4
	Weighted data sets are provided within three months of the end of the survey year	1	4	1	4
	Can be internally developed, avoiding the need for additional procurement and time associated with outsourcing	4	4	1	4
	Data is collected rapidly, allowing to distribute the processing work throughout the duration of the fieldwork	2	1	2	5

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

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## Cost-effectiveness

Cost-effectiveness aims to optimise value for money by considering both the economic and environmental costs of data collection.

The diary integrated within the survey software and the progressive web app emerged as the most cost-effective options in the medium to long term. Collecting data with GPS devices incurs high distribution costs but low development costs, as the devices typically offer basic features and there are off-the-shelf options available (although the availability of dedicated GPS loggers has decreased with the increased capabilities of smartphones). On the other hand, a progressive web app entails high development costs initially, but eliminates distribution costs (Prelipcean & Yamamoto, 2018). In the longer term, a progressive web app is more scalable and cheaper to implement, since participants use their own devices.

DfT's digital diary, in its current state, is not considered cost-effective. This is mainly due to the substantial processing work required, such as coding trip purposes (captured in open fields), mapping physical locations described in the diaries, cross-referencing diaries within household members, and resolving inconsistencies, among other tasks. All of this processing work is done manually, in addition to a number of automated tasks aimed at data validation (e.g., checking for inconsistent or impossible responses). The current version of the diary lacks logic checks, as it intended to mimic the paper diary, which does not allow for any verification.

The diary integrated within the survey software is expected to be the cheapest option, although it would require a larger sample size to compensate for the lower volume of data that a diary covering fewer days would provide.

In terms of environmental impact, all tools are expected to be sustainable, given their online administration. The GPS loggers ranked slightly worse in this regard, as this approach would require distributing the devices, resulting in additional postage costs.

**Table 11.** Cost-effectiveness scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Cost-effectiveness	Data is collected and processed in a cost-effective way	4	5	2	2
	Data is collected in a way that is environmentally sustainable	1	2	1	1

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

## Usability

Usability refers to how easily and effectively participants can interact with and navigate the tools to record their travel behaviour. It encompasses various factors such as the collection of self-reported data in English and Welsh, burden reduction through task automation, availability of travel-specific features for user-friendliness, clarity of onboarding processes, and inclusivity.

The progressive web app emerged as the best-performing tool, with a high likelihood of meeting all usability parameters. Except for the GPS logger (not applicable), all tools would support data collection in multiple languages. The progressive web app and the GPS logger minimise respondent burden by automating the collection of location data (latitude and longitude coordinates). A major advantage of smartphone-based data collection is that participants do not have to carry separate devices while travelling. However, the effect of the progressive web app on the smartphone battery should be investigated, as it could affect usability. Furthermore,

the specific features and capabilities of the app can vary depending on the browser and operating system used. This should be investigated further if this data collection tool was chosen.

The two recall-based tools were considered “fairly unlikely” to reduce burden due to their reliance on respondent’s memory. While the NTS digital diary was considered burdensome due to its 7-day duration, it offers advantageous features to help participants report their trips compared to the alternative diary (Tool 3). These travel-specific features that DfT’s diary offers are particularly useful for frequent trips, such as daily commutes, where details can be repeated across different days of the week. Additional features include the ability to add return journeys, automatically filling in the information from one-way trips, and share journeys with household members who were co-travelers. The usefulness of these features would depend on diary length (longer duration enhances their utility), survey design (individual- versus household-level), and whether proxies are allowed.

Onboarding in a self-completion environment was considered challenging for both DfT’s digital diary and the GPS logger. The digital diary has been developed in the context of an interviewer-administered survey, where interviewers play a crucial role in onboarding household members, explaining how the diary works, supervising data collection, and validating diaries before submission. Therefore, onboarding new users to the digital diary without interviewer assistance was considered “very unlikely” to be streamlined. This assessment also takes into account the specificity of the diary measures (data collected at the stage and journey level, which might not be intuitive for respondents).

Onboarding for the GPS logger was also seen as challenging due to multiple steps where individuals could potentially drop out. Onboarding involves receiving the devices through the postal system, opening the envelopes, potentially charging the devices, and consistently using them for the designated duration.

The GPS logger approach was considered the most inclusive since devices are sent to everyone, while other tools rely on respondents having an internet connection and their own device.

**Table 12.** Usability scores by data collection tool

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Usability	Allows data collection in both Welsh and English languages	1	NA	1	1
	Data collection minimises burden by automating respondent tasks	3	1	3	1
	Proves unique travel features to minimise respondent burden (pre-populated information, journey sharing features, view and editing options...)	2	1	3	1
	Onboarding is streamlined for self-administration	4	4	1	2
	Maximises inclusivity	2	1	2	2

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.

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## Summary

Overall, the progressive web application emerged as the top-performing tool across data quality and user dimensions. It ranked first in seven out of nine evaluated areas (i.e., accuracy, comparability, completeness, cost-effectiveness, credibility, relevance, and usability). However, it ranked poorly in timeliness, due to the need for development and testing, making a 2024 launch highly unlikely. Nonetheless, the progressive web app is a highly promising tool and, if not selected for implementation now, should be considered for future improvements of the WNTS considering the growing adoption of smartphones, reduced burden, and improved accuracy from passive data collection against self-reported diaries, and ability to accommodate longer diaries. Experimentation on when and how to best gather consent to tracking would be helpful to optimise uptake.

The diary integrated within the survey software environment ranked second overall. It performed well in terms of coherence (given the continuation in user experience from the survey environment to the diary environment), cost-effectiveness, credibility, and timeliness (due to no third-party involvement). However, it scored comparatively poorly in accuracy and usability. This is primarily due to its reliance on memory, which has been shown to underreport tips when compared to passive data collection, limited travel-specific features, and limitations in the number of travel days that could realistically be collected per person.

DfT's digital diary ranked third, scoring strongly in comparability and credibility. This is due to the use of a 7-day travel diary, which captures both intra- and interpersonal variation in travel behaviour, resulting in a higher volume of trip data. However, it scored worse in cost-effectiveness due to high processing costs and usability limitations. While the diary incorporates travel-specific features aimed at reducing burden, it is reliant on memory, requiring participants to input all their trips (and those of other people if proxying is allowed) for 7 days. In addition, the diary is currently not fully optimised for smartphone completion, despite the growing proportion of respondents who choose this device for survey participation (Gummer et al., 2023). Onboarding challenges in a self-completion environment were also noted since this tool was designed under an interviewer-administered frame.

The GPS logger performed worse than other tools across most dimensions. Challenges with logistics, such as device distribution and return and compliance using the devices, contributed to its lower ranking. While smartphones are devices that most people in the UK own and carry on a daily basis, GPS loggers would be used specifically for the project, providing no apparent features or benefits for users. While GPS loggers provide highly accurate location data, they lack detailed information required by WNTS (e.g., ticket cost). Similarly, while GPS loggers have low burden for respondents given the passive nature of data collection, there is some burden associated with device charging and continuous wearing. For further details on how the shortlisted designs performed across dimensions, see Table 13.

**Table 13.** Average score by quality dimension and design

<b>Dimension</b>	<b>Tool 1</b>	<b>Tool 2</b>	<b>Tool 3</b>	<b>Tool 4</b>
Accuracy	1.83	2.67	2.33	1.20
Coherence	2.00	3.00	1.00	2.00
Comparability	1.33	2.00	2.00	1.33
Completeness	2.50	3.00	2.33	1.67
Cost-effectiveness	2.50	2.00	1.50	1.50
Credibility	1.33	3.00	1.33	1.33
Relevance	2.50	2.50	2.50	1.00
Timeliness	2.25	3.00	1.25	4.00
Usability	2.40	1.75	2.00	1.40
<b>Overall</b>	<b>2.04</b>	<b>2.56</b>	<b>1.90</b>	<b>1.67</b>

Note: Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown. Average scores are computed based on the original scale (1 'Very likely' – 4 'Very unlikely'), excluding 5 ('Unknown'). Therefore, lower scores represent better performance.

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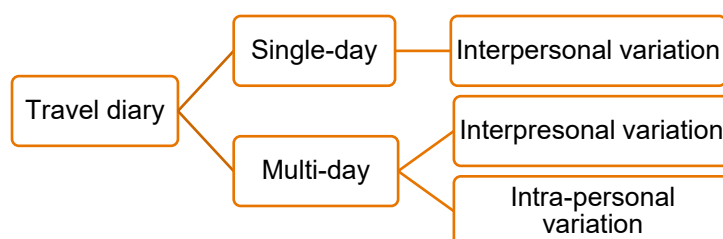
# Length of travel diaries

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## Single- and multi-day travel diaries

This section of the report discusses the advantages and disadvantages of diary length for recording travel activities. The chosen travel duration has important implications for the accuracy of trip estimates.

**Figure 2.** Single- and multi-day travel diaries



Single-day travel surveys are commonly used in national travel surveys (e.g., Denmark, Finland) where each respondent reports their travel activity for a single day. The choice of a one-day survey is influenced by logistical factors, including challenges persuading people to participate in a multi-day diary, attrition rates, survey costs, and data quality concerns arising from respondent fatigue (e.g., underreporting or misreporting).

These single-day surveys operate under the assumption that travel activities follow repetitive patterns and that, if travel data is collected for a randomly chosen day of some longer period, an unbiased sample of behaviour for that entire period can be achieved. However, studies have shown that both intra-personal variation in travel (variation in an individual's travel behaviour over different days), is as relevant as interpersonal variation (differences between individuals) (Li, Houston, Boarnet, & Park, 2018; Raux, Ma, & Cornelis, 2016). Regular trips tend to stabilize after a week, while the average elapsed time for irregular activities, such as recreation, increases as the observation period extends (Senbil, M. & Kitamura, R., 2009).

Although single-day diaries allow to study trends on travel behaviour at the aggregate level (provided that sample sizes are sufficiently large), they are unsuitable for studying individual day-to-day variation in travel

behaviour. In addition, they may not be the most cost-effective method for data collection due to substantial variability in travel, which requires larger sample sizes.

On the other hand, multi-day travel diaries offer some benefits, but come at the cost of increased respondent burden. These diaries, which can vary in duration (e.g., 3 days in the Netherlands, 7 days in Germany), improve the precision of trip estimates by capturing both interpersonal and intra-personal variability in travel behaviour. They also allow to document infrequent travel activities- by collecting a larger volume of data.

The two major arguments against multi-day diaries are respondent burden and the potential for less accurate reporting as the duration of the survey increases. This includes underreporting of trips and increased attrition. While passive data collection can mitigate these concerns by reducing respondent burden, if survey questions are still asked to gather trip details (e.g., purpose, ticket cost, number of people traveling, etc.) the longer the data collection, the higher is the expected burden. Reduced accuracy in long travel diaries is expected to be more pronounced in self-completion environments where interviewers cannot supervise the quality of the data, and less complete diaries are expected (Kagerbauer & Stark, 2018).

Another consideration when collecting multi-day diaries is that independence of observations is violated, which requires special modeling techniques to avoid underestimating the variance of the population. Table 14 provides a summary of the advantages and disadvantages of single-day and multi-day travel diaries.

**Table 14.** Advantages and disadvantages of multi-day vs. single-day travel diaries

	<b>Advantages</b>	<b>Disadvantages</b>
<b>Single-day</b>	<ul style="list-style-type: none"> <li>○ Lower respondent burden</li> <li>○ Lower risk of recall errors and underreporting</li> <li>○ Lower risk of drop out between the survey and the diary</li> </ul>	<ul style="list-style-type: none"> <li>○ Reduced accuracy at the aggregate level due to lower volume of data</li> <li>○ Does not allow to capture intra-personal variation in travel behaviour</li> <li>○ Less ability to capture infrequent travel activities and modes</li> <li>○ Less volume of trip data, which would require a larger sample to meet the objectives of the analysis</li> </ul>
<b>Multi-day</b>	<ul style="list-style-type: none"> <li>○ Higher level of precision due to higher volume of data</li> <li>○ Captures infrequent travel behaviour and modes</li> <li>○ Captures intra-personal travel variability, allowing users to study differences in individual travel behaviour</li> <li>○ Requires a smaller sample size at the person level (number of diaries)</li> </ul>	<ul style="list-style-type: none"> <li>○ Higher costs</li> <li>○ Increased respondent burden (mitigated with passive data collection)</li> <li>○ Increased attrition (mitigated with passive data collection)</li> <li>○ Higher risk of underreporting (mitigated with passive data collection)</li> <li>○ Lower response rates</li> <li>○ Complex data management and analysis (independence of observations assumption is violated)</li> </ul>



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# Discussion topics

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This report summarises the findings from the Evaluation stage as they pertain to the tool used to collect trip data. After a thorough review of WNTS' research needs, four designs were shortlisted for further assessment: a progressive web app, a GPS logger, a modified version of DfT's digital diary, and a diary integrated within the survey software.

Overall, the progressive web app performed best across both data and user quality dimensions, followed by the diary integrated within the survey software, and DfT's digital diary.

In addition to addressing any questions or comments that Transport for Wales and the Welsh Government may have, we recommend discussing in greater detail several points before proceeding to the Model stage:

- Choosing the tool(s) to carry forward into the modeling stage.
- The ability of the preferred tool to facilitate individual- and household-level data collection.
- The advantages and disadvantages of different diary lengths, and what type of length the preferred tool would allow.
- Discussing dropout rates between the survey and the diary in a self-completion web environment, and potential experiments to understand and address this issue.
- Trade-offs between timeliness and other data quality and user dimensions (e.g., completeness, accuracy, usability).
  - o Consider developing multiple tools on varying timelines.

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# Appendices

## Appendix A. Complete Proforma by design

Dimension	Design parameter	Tool 1	Tool 2	Tool 3	Tool 4
Accuracy	Maximises compliance with the selection of travel days	3	3	3	1
	Obtains enough trip data to accurately represent travel behaviours of adults (16 and over) in Wales, accounting for seasonality and variability in travel across days and times	1	3	2	1
	Could produce a sample that is representative of school-aged children (5-15 years), if this was required	2	3	2	2
	Captures in-frequent trips, such as long-distance journeys	1	1	3	1
	Produces a smooth representation of days of the week	1	3	2	1
	Underreporting of trips is minimised	3	3	2	5
Credibility	Data collection is sufficiently robust to achieve National Statistics status	1	5	1	1
	Data can continue to be collected in unexpected events (e.g., pandemic)	1	2	1	1
	Ensure minimal reliance on third parties for critical processes, such as recruitment or data collection (e.g., postal system, public transportation)	2	4	2	2
Comparability	Produce a large-enough effective sample size to facilitate analysis by region (North Wales, Mid-Wales, South-West Wales and South East Wales) as well as by urban/rural location	1	2	2	1
	Produce a large enough sample to confidently compare estimates for remote and non-remote workers	1	2	2	1
	Generate a large enough sample for disaggregated analysis based on language and protected characteristics (e.g., gender, sexual orientation, pregnancy status, race/ethnicity, religion, physical ability)	2	5	2	2
Coherence	Transition from the core survey to the travel diary is smooth, minimising dropouts between the two components	2	3	1	2
Completeness	Minimises the risk of attrition	4	3	2	1
	Allows for collection of longer diaries (over 2 days)	5	2	3	1
	The diary supports proxy data collection, supporting a household design and collection of information from children if required	1	4	2	3
Relevance	The mode(s) of administration are expected to remain relevant in 5 to 10 years	3	2	3	1
	Optimise technology use to meet social expectations	2	3	2	1
Timeliness	Diary is launched by no later than December 2024	2	3	1	4
	Weighted data sets are provided within three months of the end of the survey year	1	4	1	4
	Can be internally developed, avoiding the need for additional procurement and time associated with outsourcing	4	4	1	4
	Data is collected rapidly, allowing to distribute the processing work throughout the duration of the fieldwork	2	1	2	5
Cost-effectiveness	Data is collected and processed in a cost-effective way	4	5	2	2
	Data is collected in a way that is environmentally sustainable	1	2	1	1
Usability	Allows data collection in both Welsh and English languages	1	NA	1	1
	Data collection minimises burden by automating respondent tasks	3	1	3	1
	Proves unique travel features to minimise respondent burden (pre-populated information, journey sharing features, view and editing options...)	2	1	3	1
	Onboarding is streamlined for self-administration	4	4	1	2
	Maximises inclusivity	2	1	2	2

Tool 1: 7-day Digital Diary (web-based travel diary); Tool 2: Dedicated GPS or Geolocation logger; Tool 3: Travel collection within survey software (2-3-day diary); Tool 4: Bespoke progressive web application. Rating: 1 = Very likely; 2 = Fairly likely; 3 = Fairly unlikely; 4 = Very unlikely; 5 = Unknown.



