Material change for a better environment

Final Report

Waste Collection - In-cab Technology Trial

A demonstration trial to test the efficiency gains from the use of In-cab technology in waste collection vehicles and to assess the environmental and financial impacts of the trial outcomes.

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Our vision is a world without waste, where resources are used sustainably.

We work with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

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Written by: Entec UK Ltd

Front cover photography: Isys Ikon handheld unit

Executive summary

Key to delivering the WRAP (Waste & Resources Action Programme) objectives of reducing Construction, Demolition and Excavation Waste (CDEW) to landfill (and associated carbon emissions) is the development of efficient logistics systems from the point of collection to delivery for treatment or processing. WRAP's construction programme is aimed at helping industry achieve the objectives set out in the Government's Waste Strategy Review and the Construction Commitments: Halving Waste to Landfill. As a step to meet these commitments WRAP has commissioned Entec UK Ltd to investigate the potential benefits of new and transferred technologies to improve the efficiency of waste collection logistics, delivered a programme of research which included three trials.

This demonstration trial investigated the potential benefits of the use of In-cab technology. In-cab technology is the use of IT hardware and software within the waste collection vehicle which supports the communication of information between the vehicle and remote locations. In-cab technology has been widely used by the courier industry for the past 10 years. The transfer and application of In-cab technology to the waste industry is currently limited. The other demonstration trials in this series include a 'Fuel Efficiency' demonstration trial and a 'Computerised Vehicle Routing System' demonstration trial.

The focus of the trial was to ascertain whether In-cab technology is more efficient than the existing paper based systems (used to communicate information) adopted within the waste industry. The was tested on a single modal (single container collected per trip) skip vehicle and a multi modal (multiple containers collected per trip) wheeled bin waste collection vehicle and was delivered with trial partners Isys and Bakers Waste. The application of this technology to the multi modal services has little or no impact upon the routing efficiency due to the static nature of the rounds. The greater savings are therefore to be found with the single modal services where the workloads change day to day and during each day. Isys can provide a route optimisation tool that can improve route efficiency.

The annual potential savings based upon the trial results extrapolated across the whole of Bakers Waste vehicle fleet is equivalent to:

Annual savings summary

	Single modal (x9 vehicles) savings	Multi modal (x11 vehicles) savings
Mileage	93,600 miles	0 miles
CO_2	124,020 kg CO_2	0 kg CO_2
Fuel	£51,480.00	£0.00
Administration	£13,197.60	£16,130.40

A total of £80,808 of potential annual financial savings (based on fuel and administration) at Bakers Waste have been identified as a result of the trial. The financial return on the investment into In-cab technology breaks even within the second year.

In addition to the above the main benefits to the waste management company (and how the industry) of adopting the In-cab technology is:

- an increased flow of data and information;
- a reduced number of invoice queries;
- improved ability to be proactive with queries – scan and send tickets, photos, etc;
- reduced paperwork;
- reduced stationary spend;
- reduced number of lost documents; and
- the use of website portals for clients to view collection details and obtain reports.

The Environment Agency (EA) has issued a position statement (January 2010) supporting the use of electronic signatures indicating that these can be used for Duty of Care paperwork. This development provides the waste industry with an opportunity to go paperless and realise the efficiencies that this can deliver. Indeed in a press release on the 13 January 2010 the Waste and Recycling Minister Dan Norris indicated that the EA could move to electronic transfer notes by the end of 2011.

In-cab technology therefore is well placed to enable the waste industry to make a stepped change towards a more efficient and sustainable logistics model of operation.

Contents

Acknowledgements

Many thanks to David Cunnington and Paul Baker at Bakers Waste and Richard Bowers at ISYS for their co-operation and assistance to complete this trial.

1.0 Introduction

1.1 Background

Key to delivering the WRAP objectives of reducing Construction, Demolition and Excavation Waste (CDEW) to landfill (and associated carbon emissions) is the development of efficient logistics systems from the point of collection to delivery for treatment or processing. WRAP's construction programme is aimed at helping industry achieve the objectives set out in the Government's Waste Strategy Review and the Construction Commitments: Halving Waste to Landfill by 2012.

Whilst the waste sector has developed new technologies and infrastructure over the past 10 years for recycling and the recovery of waste, the logistics of commercial waste collections has remained largely unchanged. In order to promote and facilitate good practice, WRAP has funded a series of demonstration trials as part of a series of studies to support the development of the waste (and construction) industry towards a more efficient logistics model for waste collection.

The outcomes of this demonstration trial (one of a series of three) are designed to help inform waste management professionals of the various options available to manage more efficiently the collection logistics of the non-inert waste fractions. The focus is on the waste management contractors (WMCs) and how they manage the movement of primarily mixed wastes, considering issues of transport method, vehicle selection and approach to logistics planning. This document is a secondary report of the WRAP MRF 114 project with the main report being the 'Analysis of Collection Logistics for the Transportation of Construction Waste off site for Reprocessing'.

This demonstration trial investigates the potential benefits of the use of In-cab technology. In-cab technology has been widely used by the courier industry for the past 10 years. The transfer and application of In-cab technology to the waste industry is currently limited. The other demonstration trials in this series include a 'Fuel Efficiency' demonstration trial and a 'Computerised Vehicle Routing System' demonstration trial.

1.2 In-cab technology

The term 'In-cab technology' refers to the use of IT hardware and software within the waste collection vehicle which supports the communication of information between the vehicle and remote locations (e.g. depots and reception facilities). This technology typically links with a main IT system used by the WMC to manage and maintain customer data, invoicing and reporting requirements. The hardware includes handheld devices such as Personal Digital Assistants (PDAs) and XDAs (a more robust version of the PDA) and potentially linkages to GPS (Global Positioning System) receivers, in-cab printers and on-board weighing cells fitted to the vehicle. The system avoids double handling of the data and can be significantly quicker and more reliable in the transfer of data than current paper driven systems.

Some In-cab technologies can scan barcodes or radio frequency identification chips. This technology is tried and tested within the courier market and the financial and environmental benefits have been realised. This technology is not widespread within the waste sector and the scale of these benefits is yet to be determined or realised, but is likely to offer significant efficiency improvements.

1.3 Modes of collection

There are two distinctly different modes of CDEW collection that WMCs operate. Due to the logistical differences in the modes of collection it was necessary to test both collection modes. The collection modes are:

- single modal collections using skips and Roll on-Roll off (Ro-Ro) containers and vehicles; and
- multi modal collections using Front End Loader (FEL) and Rear End Loader (REL) containers and vehicles.

1.3.1 Single modal (skip and Ro-Ro container) collections

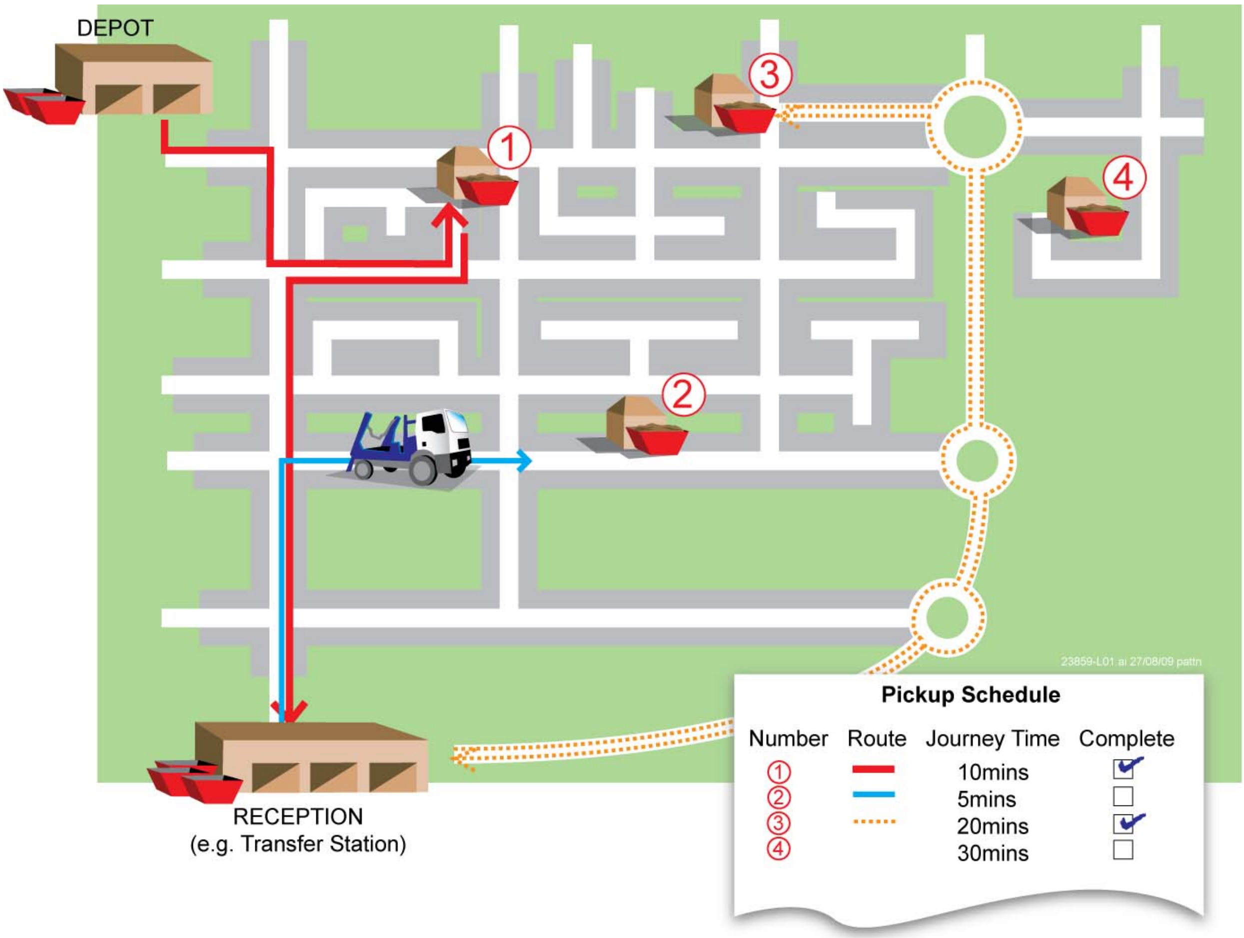
Single modal CDEW collections made by skip or Ro-Ro containers can be characterised as follows:

- for this service mode collections are made on the basis of a single container being picked up from each customer (and an empty container left in its place). Waste is then delivered to a reception facility once loaded on the vehicle[1]. There is therefore a high proportion of driving time and vehicle mileage per load collected which can limit the number of lifts achievable to an average of 6 – 10 per day;

- work is typically allocated the day prior to collections being carried out, with this task being done 'by eye' based on customer proximity and a target number of lifts per day. There are some regular lifts (e.g. every Friday) for larger projects within most daily schedules but these typically represent up to one third of the workload;
- collection routing is typically undertaken by the driver based on local knowledge and the list of jobs assigned for the day;
- for new jobs coming in during the day the driver may have to return to the depot/office to pick up any relevant paperwork or containers required before making the collection;
- it is quite rare for specific collection timeslots to be requested (or offered) – this would only be agreed as an exception to the norm (e.g. where the site is unmanned and requires a key holder to be present at a certain time); and
- collections are typically made over five days, with some Saturday morning collections where necessary (acknowledging increased costs due to overtime payments).

The daily format of this type of collection system is shown in Figure 1.1 below.

Figure 1.1 Schematic presentation of a single-load CDEW collection system



[1] *Some operators use trailers to support the collection of two skips on the same vehicle, albeit this is uncommon.*

As the diagram shows the main logistics considerations are associated with how to route each job between point of collection and drop-off and how to sequence the jobs within the day's work.

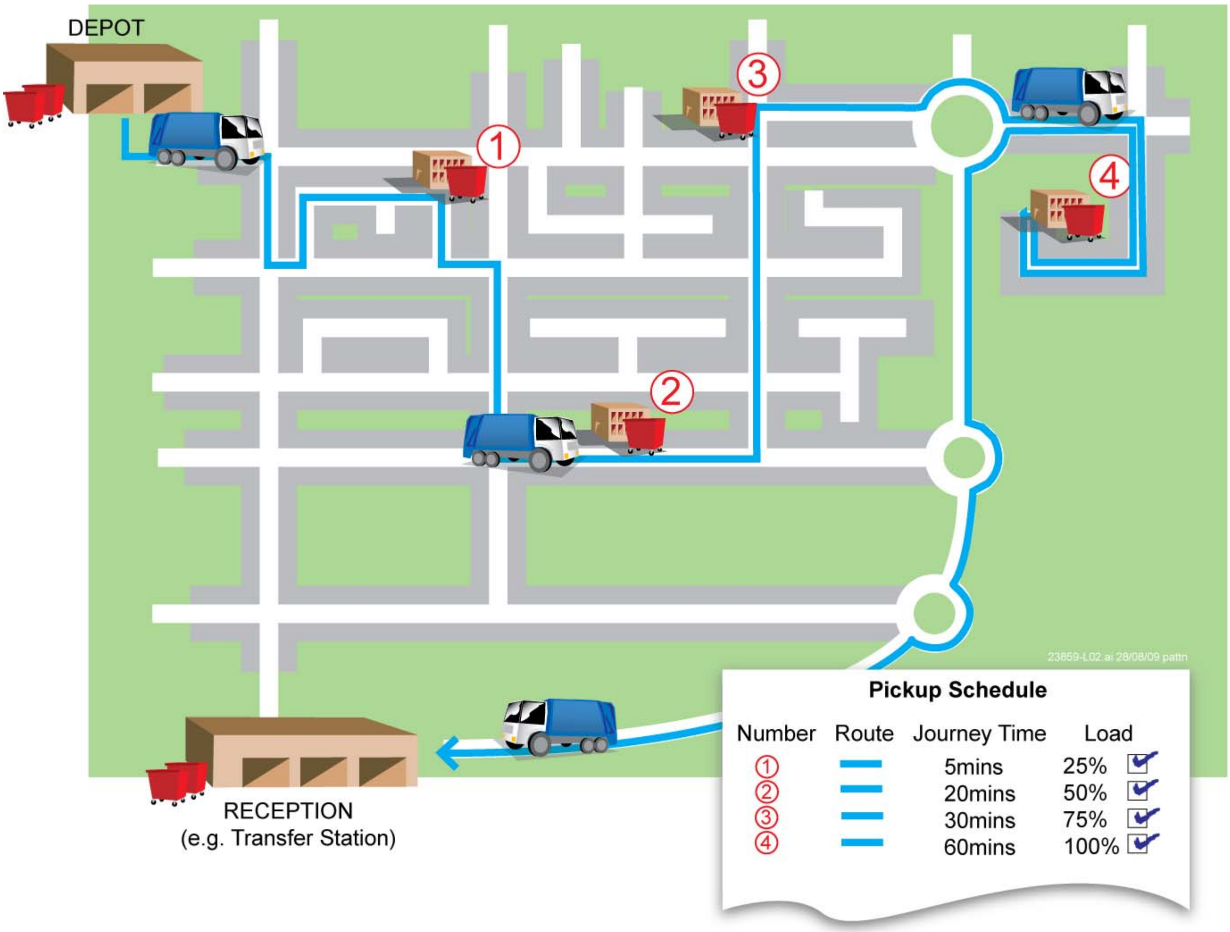
1.3.2 Multi-modal (wheeled bin, FEL and REL) collection rounds

For collections made via multi-modal container systems, meaning multiple containers (typically 1,100 litre wheeled bins, FEL and REL containers) or tipped loads can be collected on a single vehicle 'round', the following characteristics apply:

- these collections tend to involve a more static client base than the single modal collections. Where wheeled containers are used to store waste on site collection rounds are set up servicing a range of customer types, so CDEW is likely to be collected (from transient customers) alongside other (C&I) waste material from a relatively fixed client base;
- the common use of compaction vehicles for these collections with sequential pick-ups being made until the vehicle is full means an average of 120 lifts per day might be made on this type of service (covering 70 - 80 customer locations for 1,100 litre containers);
- new customers are typically added to rounds manually by hand – they are rarely formally routed meaning the schedules evolve over time;
- collections tend to be managed on a zonal basis, e.g. Round 1 operates in South Birmingham on a Monday, with drivers having local knowledge of the zones they cover; and
- collections may start as early as 4am, meaning double-shifting of vehicles may be possible.

The daily format of this type of collection system is shown in Figure 1.2 below.

Figure 1.2 Schematic presentation of a multi pickup CDEW collection system



Within this type of system the question of optimum routing is more complex as there are multiple combinations of collection ordering combinations that might be considered. As the WMC builds customer route density the service becomes more cost effective. Due to the temporary and geographically disperse nature of CDE projects most WMCs operate these collections combined with other Commercial and Industrial (C&I) waste lifts using wheeled containers.

1.3.3 Operating restrictions and comparison of single modal and multi modal CDEW collections

Certain material types may not be suited to collection by multi modal vehicles, due to their physical nature meaning they cannot be compacted or may damage the vehicle, or due to their size meaning they need to be stored on site in larger containers. Wood / pallets, soils and rubble, metals and some plastics (e.g. window frames) would generally be regarded as non-compactable or unsuited to a mixed waste multi-modal collection, due to either their form or market value. Similarly, there are materials requiring separate management such as hazardous waste and plasterboard. These would typically be collected via skip, Ro-Ro or curtain-side vehicles.

It is therefore likely that a combination of collection types will be suitable for any given site or project during the demolition, site clearance, preparation and construction/commissioning phases.

1.4 Objectives

As part of the wider MRF 114 project WRAP wished to undertake a series of demonstration trials to highlight logistics related innovation within the waste industry that would help WRAP achieve its key goals of halving waste to Landfill and reducing carbon emissions in the waste industry. The demonstration trials selected showcase where industry innovation and technology transfer can benefit the whole waste industry. Although the main focus of the project is on the logistics benefits of adopting such technology, the wider operational and financial benefits are also considered.

The purpose of the In-cab technology demonstration trial has been to test this innovation in 'the real world'. The objective of the In-cab demonstration trial has been to produce a demonstration trial that can be replicated and adopted industry wide.

2.0 Trial approach

This section of the report details the process used to identify the subject for the trial through to the running of the trial and ultimately to the findings detailed within this report.

2.1 Trial process

The trial process consisted of six discrete tasks. These tasks were:

- the identification of the trial subject;
- the identification of the trial partners / stakeholders;
- defining the trial, including agreement of the trial aims, parameters and timescales;
- delivery of the trial;
- gathering results and analysis; and
- reporting.

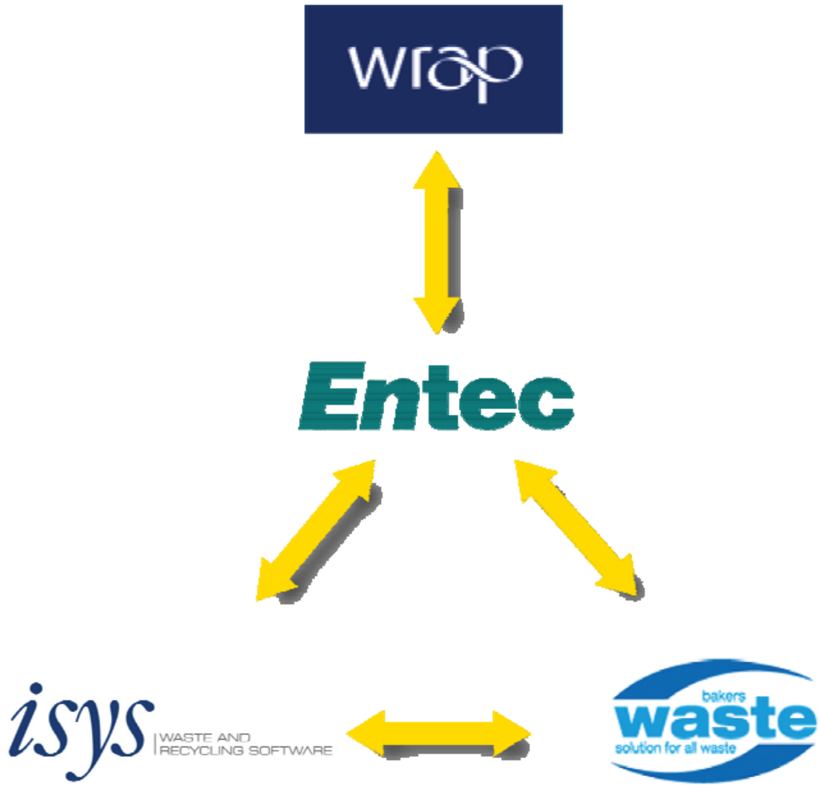
2.2 Trial subject

The trial subject has been developed from the initial desk based research undertaken as part of the MRF 114 project. Through the engagement of WMCs and other stakeholders' valid logistics related trial subjects were identified. The In-cab trial has been selected due to the potential logistics benefits for multi modal and single modal vehicle operations.

2.3 Trial partners / stakeholders

The trial stakeholders include the sponsor (WRAP), the trial manager (Entec), the technology provider (ISYS) and the waste management company (Bakers Waste). The figure below shows the interaction flow between the stakeholders. The trial partners were Isys and Bakers Waste who actually implemented the trial under the guidance of Entec.

Figure 2.1 Stakeholder interactions



2.3.1 WRAP

WRAP works with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way. WRAP provided financial support for the trial.

2.3.2 Entec UK Ltd

Entec is a multidisciplinary engineering and environmental consultancy offering both a breadth and depth of service to provide commercial and technically robust business solutions. Entec has provided consultancy services to WRAP across multiple waste disciplines including best practice guidance and case studies. Entec managed the day to day running of the trial as the project manager.

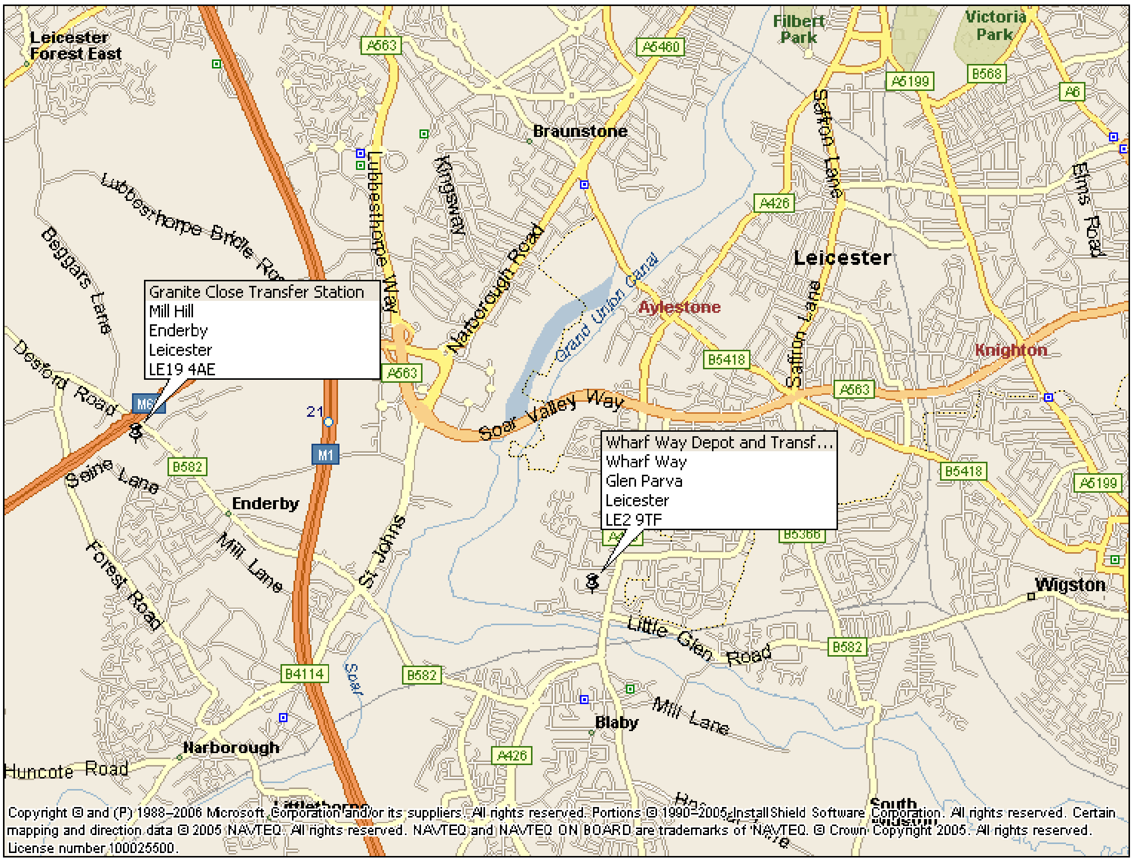
2.3.3 Bakers Waste

Bakers Waste Services was established in 2000 as a sole trader. The company Bakers Waste Services Ltd is now a limited company that employs 13 drivers and various office based staff. Bakers Waste operates out of Leicester and covers the City and wider county of Leicestershire. Bakers Waste provides services to approximately 2,000 clients.

Bakers Waste now proactively promotes environmentally friendly alternatives for the disposal of waste that focus on reduction of waste to landfill, the increase of material reuse and recycling. Since October 2007 Bakers Waste Services have expanded its scope to incorporate an Environmental Division and a Health & Safety Division in order to offer a one stop shop for businesses of all sizes within all industry sectors.

Bakers Waste provided the vehicles and contributed in kind to the testing of the In-cab technology. Bakers Waste operates two transfer stations and one depot since the purchase of another local waste company, Glenfield Waste in 2009. The location of these facilities is shown in Figure 2.2.

Figure 2.2 Location map of the Bakers Waste depot and facilities



Bakers Waste seeks to internalise the waste deposits to maximise the financial benefits of the waste collection and uses the two locations shown above to deposit the waste. Bakers use third party sites also but this is usually for materials outside of the site permit scope. WMCs generally seek to internalise the collection and the disposal process where possible. Deposits of waste are split between the two sites. Spare containers are located at both sites but the availability of specific containers is variable. The Granite Close site has limited capacity for container storage compared with the Wharf Way site. Bakers Waste generally collect from locations within the Leicestershire County boundary.

2.3.4 Isys

Established in 1979, Isys Interactive Systems are market leaders in the supply of waste and recycling software. Isys produce integrated waste management systems that meet both local and national requirements for waste and recycling operations. Based on the latest technology, Isys delivers products using years of industry-related experience and hands-on relationships with Waste Management Companies (WMCs).

Isys software can eliminate much of the time-consuming administrative work; the result is a much more efficient operation, allowing WMCs to spend more time dealing with service-driven issues at the head office or depot. Additional services offered by Isys include hardware and network integration, training, cabling and consultancy. Isys provided the software and the hardware for the In-cab trial.

2.4 Defining the trial

The definition of the trial was based upon the key objectives from WRAP of reducing waste to landfill and reducing CO_2 emissions. The focus of the trial was to ascertain whether In-cab technology is more efficient than the existing paperwork systems widely used within the waste industry. This has been measured in financial terms as well as environmental (CO_2) linked to the mileage travelled and productivity levels.

The trial required In-cab technology to be used to transfer data such as the customer address, contact name and telephone number, container size, waste type, disposal location and any special instructions to and from the driver remotely. To facilitate this transfer of data, In-cab mobile units were used to send and receive the data.

The ability of the In-cab technology to work in 'real time' enables the driver to receive data on changes to the workload e.g. cancelled collections and new collections as soon as possible. The ability to efficiently route and order waste collections is dependant upon the up to date supply of quality data from the office to the driver so that informed decisions can be made. Current paperwork systems require the driver to return to base to collect additional paperwork throughout the day. The use of the In-cab technology can assist in removing the inefficient and unproductive return to base journey time and mileage through the remote transfer of the data.

To evaluate the In-cab trial results it was agreed to monitor:

- the average return to base journey distance;
- the number of avoided return to base trips;
- the number of daily collections; and
- it was also agreed to monitor the fuel efficiency i.e. miles per gallon (mpg) during the trial period.

2.5 Delivering the trial

Bakers waste provided one multi modal and one single modal vehicle for the trial. This was to test the benefits of the technology for the two collection methods discussed previously.

The multi modal vehicle trial started in November 2009 and ran through to the end of January 2010. The single modal vehicle trial operated over 3 weeks during January 2010. Each of the vehicles were fitted with a PSION IKON handheld unit with the Isys mobile software, an in-vehicle charger and base unit chargers for the office. During the trial Bakers Waste also maintained the existing paperwork systems as a back up system only.

The back office IT system used by Bakers is the Isys Skipman and GateHOUSE™ software packages. Skipman is a software package to manage the multitude of tasks required by a waste management company. The main functions of the Skipman software are:

- collection ticket production including drivers tickets, transfer notes and drivers schedules;
- duty of care compliance tracking;
- postcode integration (search facility);
- vehicle scheduling;
- radio Frequency Identification (RFID) and individual container tracking;
- links to GPS tracking;
- full integration with Gatehouse;
- self billing invoicing and manual invoicing;
- summary report writer;
- management & sales reports; and
- full accounts system integration (with Sage).

GateHOUSE™ manages and maintains weights data on materials coming into and leaving a site. GateHOUSE™ is integrated with Microsoft Office and Industry Standard Microsoft SQL Server Database engines. The main functions of the GateHOUSE™ software are:

- the production of weighbridge tickets and invoices;
- GateHOUSE™ can be configured to suit any weighing operation;
- a summary report writer;
- invoicing based on weights and parameters in a pricing matrix;
- production of management and sales reports; and
- accounts system integration.

Skipman combined with GateHOUSE™ provides a comprehensive software package for all the WMCs' requirements.

The function of the In-cab technology using the Isys mobile software (designed to be compatible with other Isys software) is to further enhance the flow and availability of data to these systems through automating the process.

The trial tested a 7.5 tonne Mercedes skip vehicle (single modal) and a 26 tonne MAN FEL (multi modal) vehicle. The 7.5 tonne skip vehicle (Figure 2.3) is used for collections which are difficult to access and as a mop up vehicle.

Figure 2.3 7.5 tonne single modal (skip) vehicle

Figure 2.4 26 tonne multi modal (FEL) vehicle

2.6 Findings and analysis

2.6.1 Data

The data gathered as listed in Section 2.4 forms the basis of the results and the analysis of this trial.

In support of the data the Entec project manager spent a half day on one of the test vehicles to see the system in operation and to gather operational insights on the technology from the driver of the single modal vehicle. Interviews were also conducted with the driver of the multi modal vehicle and the operations manager at Bakers Waste.

2.6.2 CO_2 calculation

The CO_2 emission calculation has been undertaken using the 2009 Guidelines to Defra / DECC's Green House Gas (GHG) Conversion Factors for Company Reporting. The calculation has been undertaken using the Annex 7 data for freight transport and uses the conversion factor for litres of diesel into total Kg of CO_2.

2.6.3 Financial calculation

Fuel savings have been calculated using a standard pump price for Diesel of £1.10 per litre (correct 31st January 2010).

Other financial calculations are based upon data provided from Bakers waste and are identified in further sections of this report.

2.7 The In-cab trial system

The following section details the operation of the In-cab technology tested.

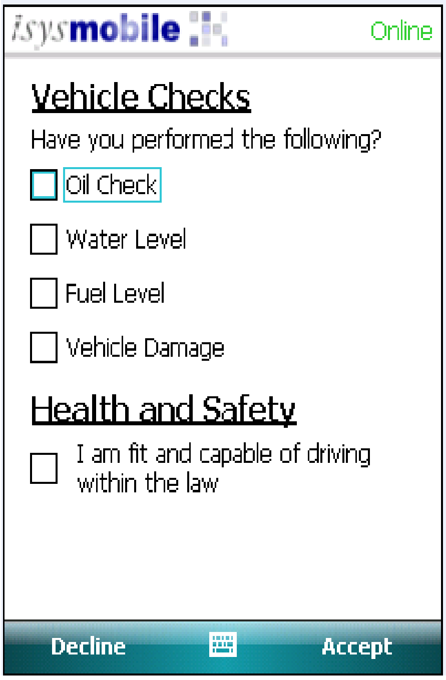
The In-cab technology trial (Isys and Bakers) uses the Psion Ikon rugged handheld unit (Figure 2.5). The unit can come with scanner, camera, phone and GPS if required. For the purposes of the trial the unit was only activated to transfer data and to take photographs using the built in camera. Navigation through the screens is via the use of a stylus onto the touch screen.

Figure 2.5 The Ikon In-cab unit

The Ikon In-cab unit has been operated by Bakers Waste on an FEL Bin round and skip round for the purposes of the trial. The round data is held in the ISYS waste management system and the movements are sent to the Ikon handheld which is situated in the drivers cab.

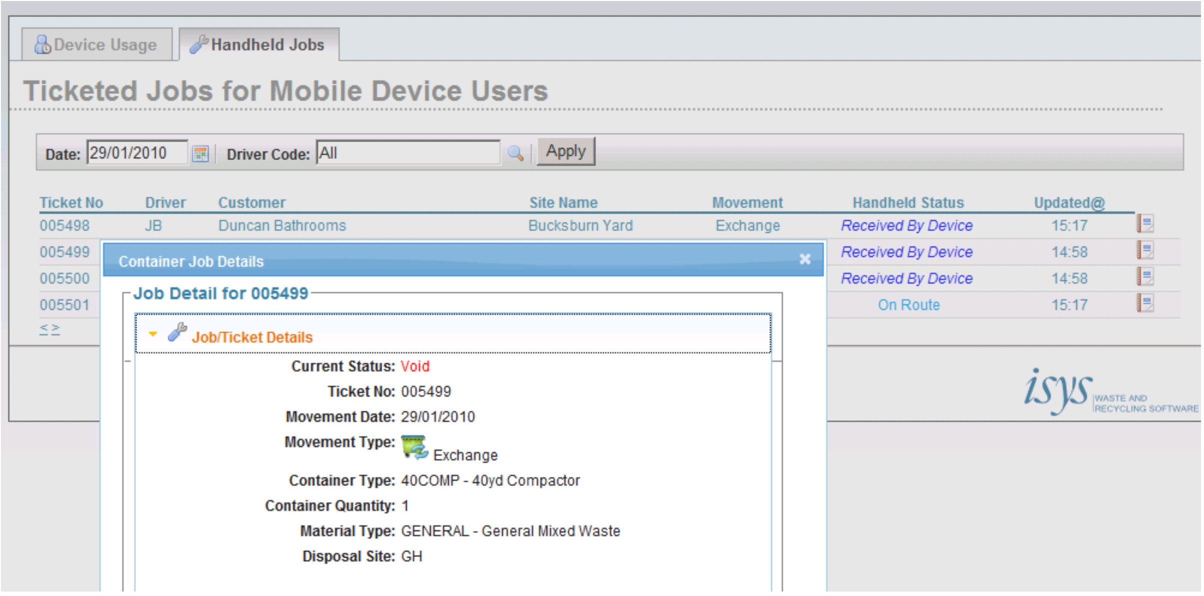
When the driver begins the shift they sign into the mobile system. To sign in a check list of safety items have to be completed before the system will allow the operator to log in and start the days work (Figure 2.6).

Figure 2.6 Ikon unit start up screen



This log in is registered in the Isys system in the office (Figure 2.7).

Figure 2.7 Registration screen (office system)

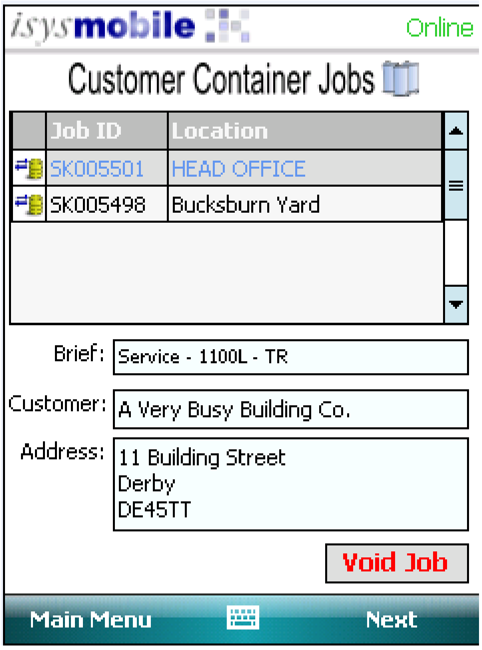


The main set up screen allows the driver to select movements as well as a disposal section for tipping at third party sites (Figure 2.8).

Figure 2.8 Mobile unit main screen

When the system has logged in, the driver views a list of jobs in the order that the main scheduling system at base has them recorded (Figure 2.9).

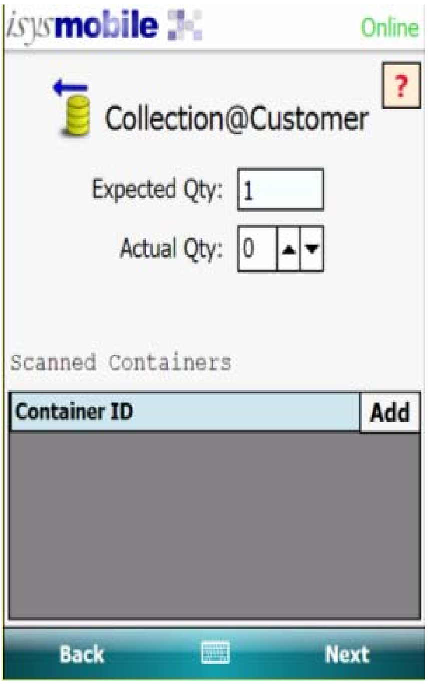
Figure 2.9 Job screen



On arrival at the depot the driver has the full address details, and access to any Driver instructions, either ad hoc instructions or data permanently held against the customers assigned to the days work. This is notified to the driver by a flashing “Driver Instructions” lettering.

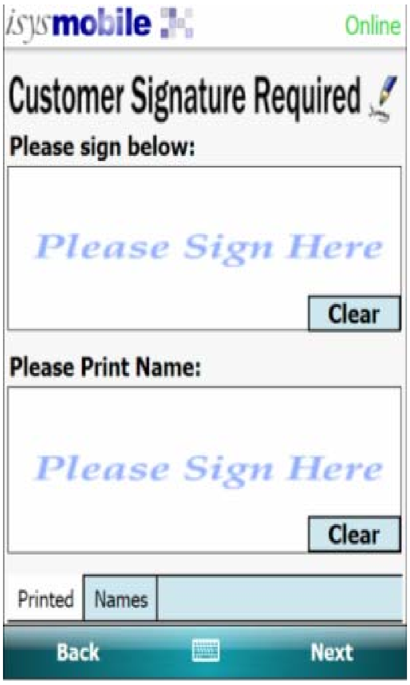
When the driver arrives on site they know exactly what is being collected, exchanged or delivered. If the number of items changes the driver simply selects this from the drop down list (Figure 2.10).

Figure 2.10 Collection/delivery/exchange confirmation screen



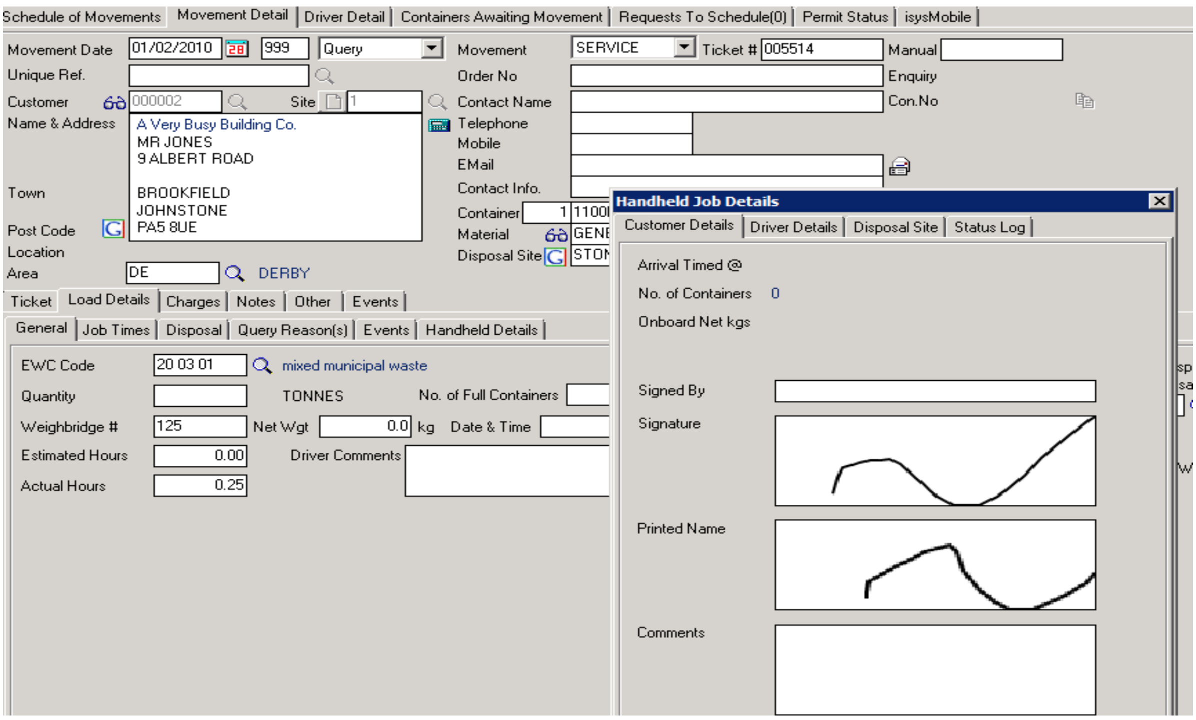
The customer can then sign and print on the mobile unit screen (Figure 2.11). A ticket can be issued on site if required via an optional in-cab printer (not tested in the trial). The system also has the facility to take photographs and transmit them back to base within 10 – 20 seconds.

Figure 2.11 Customer signature screen



At the end of the round (multi modal collections) or ad hoc work (individual delivery, collection or an exchange – single modal collections), the driver will sign-off the movements and all the transactions will flow back to the ISYS system with job times, weights, signatures and photographs where applicable (Figure 2.12). The mobile unit updates to receive data and transmits recent data every 7-10 seconds. The EWC codes have now been replaced by the List of Wastes (LOW) codes.

Figure 2.12 Data flow screen in the office from the mobile unit



The system also has the benefit of progressing the signed-off jobs through the system for invoicing, as long as no remarks or cancellations for failed jobs are recorded. Non signed-off jobs are put into query for review by an approriate person to resolve the issue.

3.0 Trial findings and analysis

3.1 Trial results

This section of the report details the data obtained from the trial, site visit and the user interviews.

3.1.1 The single modal (skip) vehicle trial

The skip vehicle undertakes between seven and fifteen jobs per day, with the actual number completed being largely dependent on the type of job. An average day of work is between eight and ten jobs.

There are three types of job undertaken:

- the delivery of a container;
- the collection of a container; and
- the exchange of a container.

The container delivery job is the easiest and quickest job to undertake whilst the exchange is the most time consuming.

Data (for additional deliveries, collections and exchanges of containers) was sent to the handheld unit from the office between three and five times per day during the trial period.

The live update (every seven seconds) provides greater flexibility, increasing the number of jobs that can be completed without a 'return to base' journey. The trial period identified that between two and three return to base journeys were avoided each day that would have been required with the paperwork system. The average round trip distance of each of these journeys is 20 miles.

The live updating of the handheld system also avoids wasted journeys such as when a client cancels a collection. This information can be downloaded to the driver within minutes of receiving the cancellation in the office. In the trial period (3 weeks) this occurred twice saving approximately 40 miles of unproductive journey distance (and time).

The use of the camera can be of particular benefit where failed collections occur. Should a driver arrive at a site and find the access to a container blocked by vehicles or other obstructions a timed photograph can be taken to prove the access issue. If it is not possible to obtain access to the container this will be recorded as a failed service. When charging for a failed collection or when receiving a query from a client the photograph can be sent via e-mail to assist in the resolution of the dispute, streamlining this process considerably.

A non logistical beneficial finding of the trial was the reduced time to put the drivers work on to the main office IT system for invoicing. This update is completed automatically by the handheld downloading data to the main system during the day or overnight (dependant upon the system settings). Through discussions with operational and administrative staff this saves in the region of 30 minutes per vehicle per day.

It was noted during the visit that the order in which the collection, delivery and exchange jobs were assigned could affect the efficiency of the days work. The correct ordering of these jobs can reduce the need to return to base to pick up skips or drop-off unused skips. Providing the driver with all of the up to date information is therefore essential to these efficiencies being achieved.

The system provides the operational staff back at the office with an opportunity to monitor the time spent on site to collect the container. Where longer than would be expected is spent on site this can then be investigated to resolve any issues that may be delaying the swift turnaround of the vehicle to move into the next collection.

The 7.5 tonne skip vehicle is fitted with an Ad Blue[2] tank (located next to the diesel tank) which improves the vehicle emissions. This vehicle achieves and average of 9 mpg. The 26 tonne FEL vehicle achieves and average of 5 mpg.

Some initial minor glitches with the screen ordering and level of detail provided on the confirmation screen were quickly resolved.

[2] Ad Blue is a fuel additive that improves the fuel efficiency of a vehicle. http://www.adblueonline.co.uk/pages.php?pageid=2

3.1.2 Multi modal (FEL) vehicle trial

The FEL vehicle normally empties the waste from thirty to fifty containers per day with an average day being forty. The delivery and collection of the FEL containers from site is undertaken by another vehicle.

The use of the In-cab technology has added to the workload of the driver on this mode of operation due to each collection being logged with the customer on site. This has added about one hour to each day. A minor adjustment to the software can resolve this via setting a default of no signature being required unless requested by the client. The sites that request signatures require these as proof of collection and are often national companies or brokers who require signed paperwork as proof of the service delivery for invoicing purposes. It was assumed under the old paperwork system that all collections within the day were collected unless the drivers' notes / paperwork indicated otherwise.

The more stable client base of the FEL collection rounds means that the units are rarely used to send data to the driver in the vehicle. Additions to and removal of collections for this mode of collection is normally completed in the office in advance of the vehicle leaving for its day of work.

Again the time to put the drivers work onto the office IT system has been reduced due to the real time update from the handheld unit to the office system. The automation of this process requires checking but on average saves 30 minutes per vehicle per day.

3.2 Trial analysis

During the trial the skip vehicle saved on average two 'return to base' journeys per day of operation (Monday to Friday inclusive). The average journey distance saved was 20 miles per journey. This equates to a mileage saving of 40 miles per day per vehicle. This is equivalent to 93,600 miles (40 miles x 5 days x 9 vehicles x 52 weeks) per annum.

The fuel saved equates to the 9 mpg over the 40 miles saved per day. This is equivalent to 4.44 gallons or 20 litres (4.44 gallons x 4.5 litres per gallon) per day per vehicle. This is equivalent to 46,800 litres of fuel (20 litres x 5 days x 9 vehicles x 52 weeks) per annum.

The carbon savings have been calculated using the Defra GHG tool [3] and the litres of diesel conversion factor of 2.6391. This equates to 53 kg of CO_2 saved per day per vehicle based upon 20 litres of fuel. This equates to 124,020 kg of CO_2 (53 kg CO_2 x 5 days x 9 vehicles x 52 weeks) per annum.

At a pump price of £1.10 per litre the financial saving based upon 20 litres of fuel saved for the skip vehicle equates to £22 per day per vehicle. This is £51,480 (£22 x 5 days x 9 vehicles x 52 weeks) per annum.

On larger single modal vehicles which have a lower mpg, the savings in terms of CO_2 and cost will be greater than indicated above. Thus the savings predicted are at the lower end of what may actually be achieved.

The trial of the In-cab technology on the FEL vehicle identified no potential logistics savings. The additional time spent confirming each collection can be resolved long term through minor changes to the confirmation of collections on a daily basis. This will still maintain the capability to log failed collections, etc and assign photographs to the file. There is some potential for administrative efficiencies for the FEL vehicle collections if the In-cab systems are integrated with bar coding or tagged containers; this was not evaluated within this trial.

The In-cab trial has indicated that the technology can save a substantial amount of time undertaking data input into the main IT system for invoicing. This equates to a saving of approximately 30 minutes per vehicle. At an average cost to a company for an administrator of £22,000 per annum (37.5 hour week) the 30 minute saving equates to £5.64 per week per vehicle. This is a saving of £29,328 (£5.64 x 5 days x 20 vehicles x 52 weeks) per annum.

[3] 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting using annex 7 – Freight transport, table 7a.

Bakers Waste has an existing fleet of twenty one vehicles. The fleet consists of:

- Multi modal vehicles;
  - two front end loaders;
  - nine rear end loaders;
- Single modal vehicles;
  - three Roll on-Roll off vehicles;
  - six skip vehicles; and
- Miscellaneous;
  - one van.

The annual savings (excluding the van) based upon the trial results and the Bakers Waste vehicle fleet is equivalent to:

Table 3.1 Annual savings summary

	Single modal (x9 vehicles) savings	Multi modal (x11 vehicles) savings
Mileage	93,600 miles	0 miles
CO_2	124,020 kg CO_2	0 kg CO_2
Fuel	£51,480.00	£0.00
Administration	£13,197.60	£16,130.40

Note: Annual savings are based upon a 5 day operational week for 52 weeks per annum (260 days of operation).

A total of £80,808 of potential annual financial savings (based on fuel and administration) at Bakers Waste have been identified as a result of the trial. The time saved by the reduced return to base journeys has not been calculated but has the potential to increase productivity of the single modal vehicles by 10%. The time saved is based upon the reduced return to base requirement being upto 1 hour per day (from an average working day of 9 to 10 hours) based upon an average vehicle travel speed of 40mph. In addition to this Bakers estimate that going paperless will save upto £10,000 in stationary orders (paper documents based upon historical purchases) per annum.

3.2.1 Breakeven analysis

The cost of the hardware and the software is approximately £2,500 (this excludes the main system) per In-cab unit. This is typical of costs quoted by two companies using similar systems. The cost of configuration, training and project management (unit commissioning) is approximately £2,250 per unit although this is likely to be more efficient (£1,250) per unit with larger numbers of units purchased.

To fit the twenty front line vehicles at Bakers Waste would costs an estimated £76,000 (20 units x £2,500 + 1 vehicle x £2,250 for unit commissioning + 19 vehicles x £1,250 unit commissioning). These costs have been determined through discussions with technology suppliers. This data has been derived through discussions with Isys and also via discussions with Ethos Recycling (a waste management company based in the South of England) that have also trialled similar technology. The use of In-cab printers was found to be costly and infrequently used and was replaced by the use of blank collection notes written as required by hand.

Discussions with Ethos Recycling who have been using In-cab technology now for a year indicates that in addition to the above costs there are ongoing sim card costs and maintenance costs of approximately £440 per unit per annum. This cost is for the sim card required to transmit data and the replacement of broken screens, replacement batteries, keys and general wear and tear. Therefore in addition to the above implementation cost is an ongoing running and maintenance cost for Bakers of £8,800 (£440 x 20 vehicles) per annum for the front line fleet.

Table 3.2 Breakeven analysis summary

	Year One	Year two
Costs	£76,000 + £8,800 = £84,800	£76,000 + £8,800 + £8,800 = £93,600
Savings	£80,808	£80,808 + £80,808 = £161,616

In year one of implementing the In-cab system the costs will be £84,800 and the savings will be £80,808. At the end of year two the cumulative implementation and maintenance cost of the In-cab system will be approximately £93,600 and the savings should be £161,616. The financial return on the investment alone breaks even within the second year. Given the reduced annual maintenance charges the extent of the financial benefit therefore increases year on year beyond the breakeven point.

The vehicles in the trial have been registered in 2009 and as such are relatively new vehicles using new fuel efficient engines and an Ad Blue tank to improve fuel efficiency and emissions. Older vehicles are likely to be less efficient than these vehicles and hence the savings indicated above are likely to be less than is potentially achievable, especially where operators are using ageing vehicles.

3.3 Practical considerations for implementation

The trial has highlighted the importance of system compatibility for the implementation of In-cab technologies. The requirement for patches to harmonise different software packages and suppliers introduces additional cost and the time delays can be considerable (several weeks to months). This also increases the number of stakeholders involved which then requires improved communication and planning with strong leadership to avoid delays and or additional costs.

Potential solutions to the compatibility issues identified above are to source In-cab technology via:

- an existing software supplier (if available); or
- to source a new integrated hardware and software package linking the back office and the front line In-cab technologies.

The use of an existing supplier may overcome the compatibility issues but may not offer the best value In-cab solution for the WMC.

The wholesale replacement of the back office and front line In-cab hardware and software will also overcome the compatibility issue. This option may not be financially or politically viable for WMCs who have invested in back office systems recently. This may also affect the breakeven point for the implementation of In-cab technologies.

3.4 Trial partner interactions

It has been essential during the commencement, carrying out and completion of the trial to consider and manage the interactions of the trial partners. It is critical to develop relationships at a senior level within the organisations to ensure that the support required is willingly given. The senior commitment also needs to be supported by staff that will be required to give their time to the trial whilst also undertaking their day to day job. Senior staff need to free up a suitable amount of other staff time to be able to efficiently and effectively carry out a trial. Senior management commitment and support is therefore key.

4.0 Summary and discussion

The In-cab technology trial identified potential savings of £80,808 per annum based upon the current mix of vehicles within the Bakers Waste fleet. The implementation costs of £76,000 per annum and the running costs of £8,800 indicate that the payback period for the In-cab technology is more than one year and less than two years.

The waste industry has little altruistic intent and is only likely to adopt this technology if there is a clear financial benefit to do so. The trial indicates that the In-cab technology will pay back the investment within two years which as a return on investment is a short period of time for capital expenditure projects. The In-cab technology therefore represents a potential quick win for the waste industry as a whole.

The saving in time through reduced return to base journeys could improve the productivity of single modal vehicles by 10%. The ability to send updated information on cancelled and new tasks further empowers the operational staff to achieve this greater productivity. The reduction in lost paperwork through the use of this system cannot be measured but will reduce previously lost revenue to the WMC. Waste industry operators have however indicated that this could be between £1,000 and £2,000 per week for a medium sized company operating 10 to 20 vehicles.

Bakers Waste is typical of many local medium sized waste management businesses across the UK. Prior to implementing the new Isys IT software Bakers had invested only a minimum amount of resource into developing its IT infrastructure. The success of the In-cab technology and the ease of implementation will be dependent upon the compatibility of the back office and the In-cab systems and software. There is thus an advantage to sourcing both the office and the In-cab systems from the same supplier.

The replication of the implementation of the In-cab technology at Bakers Waste (and the findings) to other WMCs is considered practical and achievable. Indeed the adoption of similar technology by Ethos supports this. Whilst carrying out the trial is understood that both Biffa and SITA are testing similar systems. Even larger companies such as Biffa who operate over 800 refuse collection vehicles nationally operate depots with similar numbers of vehicles to Bakers and Ethos, indicating that the implementation of In-cab technology could be replicated at a depot level.

An additional benefit of the In-cab system is the ability to increase the scale of the business in terms of turnover whilst not needing to proportionally increase the support and administrative resources. This is due to the automation of the In-cab technology and the invoicing systems. Ethos have not increased the administrative staff since implementing In-cab technology, despite turnover increasing by 50%.

The acceptance of the In-cab system by clients will be critical to its success. Although Bakers identified some isolated examples of resistance, over 99% of the clients showed no objections. Indeed this may be due to this technology being widespread within the courier sector and utility sector. The acceptance of the system by operational staff at the waste companies will also be key to its success. The driver of the trial skip vehicle at Bakers indicated that he would be happy to never use paperwork again and was more than happy to solely rely on the In-cab handheld unit after trialling the technology for three weeks. Human factors therefore should not be a significant barrier to the widespread implementation of this technology.

By having all of the information to hand in real time the operations staff can plan the day's work more effectively.

The operational staff at Bakers Waste indicated that the storage of electronic data is cheap and reliable. This reduces the costs of archiving paperwork, which could be replaced with terabyte servers taking up no more space than a large filing cabinet. Additionally the Bakers Waste staff indicated that the main benefits of the In-cab technology to the business would be:

- an increased flow of data and information;
- a reduced number of invoice queries;
- improved ability to be proactive with queries – scan and send tickets, photos, etc;
- reduced paperwork;
- reduced stationary spend (£10K spend per annum on tickets);
- reduced number of lost documents; and
- the use of website portals for clients to view the collection details and obtain reports.

The Environment Agency (EA) has issued a position statement[4] (January 2010) on the use of electronic signatures[5] indicating that these can be used for Duty of Care paperwork. The same rules with storage of Duty of Care date apply but electronic storage is acceptable. This is as a result of an EA project launched in May 2009

[4] *http://www.environment-agency.gov.uk/static/documents/Business/position_statement_e_signatures_WTN_v1.pdfc*

[5] *http://www.environment-agency.gov.uk/business/topics/waste/34867.aspx*

using technology supplied by Codegate Ltd[6]. This recent development provides the waste industry with an opportunity to go paperless and realise the efficiencies that this can deliver. Indeed in a press release on the 13 January 2010 by the waste and recycling minister Dan Norris indicated that the EA could move to electronic transfer notes by the end of 2011[7].

In-cab technology therefore is well placed to enable the waste industry to make a stepped change towards a more efficient and sustainable logistics model of operation.

[6] *http://www.environment-agency.gov.uk/news/108056.aspx?month=6&year=2009&coverage=National&sector=Agriculture%2cClimatechange%2cConstruction%2cConsultations%2cDrought%2cEnergy%2cFishingandaquaculture%2cFlood%2cPollution%2cRegulation%2cReports%2cWaste%2cWater%2cWildlifeandconservation&persona=Business%2cEvent%2cHome%2cProsecution%2cScience*

[7] *http://www.letsrecycle.com/do/ecco.py/view_item?listid=37&listcatid=5453&listitemid=54364&section=waste_management*

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