Collection vehicle research and development

This report describes a collaborative project co-ordinated by WRAP to bring together a wide cross section of waste industry interests to explore improvements to the vehicles used in collecting recyclable materials and food waste.
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Written by: Andy Cunningham, Resource Futures
Foreword

This report describes a collaborative project co-ordinated by WRAP over the last 5 years to bring together a wide cross section of waste industry interests to explore improvements to the vehicles used in collecting recycled materials from our homes.

At the outset of the project the UK was only at the beginning of the major change from a landfill based waste system to one where at least half of our municipal waste would be recycled. Yet the systems available to make this change were still in development and included a fair amount of ingenious adaptation from what had been used for a number of years in small scale recycling operations or the redeployment of large scale refuse vehicles to new uses.

The challenge addressed in this project was to see whether better vehicles could be designed to meet current and anticipated needs and to do so efficiently and safely. WRAP's approach was to convene a broad group of involved parties to debate and share ideas and then to see if those ideas could be captured in a working demonstrator vehicle. The value of this approach was that it provided a conducive environment for collaboration and reduced the risks for all involved in testing new ideas.

Many of the ideas discussed within the project have found expression already in vehicles introduced in the last two years. They are showing their value in recent recycling service procurements and in day-to-day operation. Other ideas will require further development before being adopted commercially.

The purpose of this report is to draw the project to a close and offer the ideas and innovations that have been developed as a source for further innovation to meet the new demands being put on waste services.
1.0 Introduction

As household recycling collections started to take off from around 2005, it became apparent that innovation would be needed in the vehicles used for recycling collections in order to respond to a number of issues emerging from the practical experience of those running services. The method chosen was a piece of action/research in which practitioners worked with WRAP to identify current and anticipated challenges and issues. Efforts were then made to design and implement solutions in the context of working vehicles with ideas and solutions being shared as the programme proceeded.

A steering group was established to work with practitioners in kerbside recycling and the design team Ethical Innovative Solutions (EIS) to identify the strengths and weaknesses of existing designs and to determine the features required for a new generation of collection vehicles. The Steering Group quickly identified a number of issues:

- Restrictions on the range of materials which could be targeted and segregated on vehicles,
- Limited volumetric (rather than weight) capacity restricting the extent to which plastics could be collected
- A range of health and safety concerns about operatives working in traffic, stepping up onto vehicles, loading materials at awkward heights, and noise from loading materials (particularly glass),
- The lack of safe ways to even out loads and make full use of the available capacity.

It was also anticipated that:

- Food waste collections would start to increase under the pressure of LATS and the Landfill Tax and that there was no fully satisfactory vehicle solution available for this waste stream.
- There was a growth in co-mingled collections of recyclate in compacting RCV’s where the inclusion of glass was problematic, reducing the quality of the other materials and producing glass largely useful only for low value aggregates.

The process opened a serious debate in the development of kerbside sort systems. It managed to put the leading exponents of the system together and encouraged a thorough reassessment of the methodology. It got practitioners to approach the issues with positive intent to improve the efficiency and safety and ultimately deliver better value for money.

What has emerged from this project is an improved understanding of operational requirements and a series of practical innovations and improvements which have prompted the development of a new generation of kerbside recycling vehicles. These are now coming into service and are capable of managing multi material separation including the high volume materials, plastics and cardboard. They have given kerbside sort systems the ability to collect many more materials, more safely in a single pass. The project has also presented a complementary solution for collecting glass and food waste alongside co-mingled collections of dry recyclables enabling increased capture and removal of organic waste from landfill and improved value from materials.

"The new generation of kerbside collection vehicles owes a lot to the innovation and debate initiated by this project. It challenged the current operating methods and brought about safer and more efficient systems.”

Paul Jones, Development Director (May Gurney)

EIS – a small design company based in Wales - was appointed, following a competitive tender, to develop two collection vehicle design types, one for the collection of dry recyclables and the other for the collection of food waste and glass. EIS brought to the project fresh ideas from outside the orthodoxy of the waste industry. They were able to make some perceptive observations on the available kerbside collection systems and offer innovative applications in response to the challenges posed by the practitioners. The process did not follow a linear route. Concepts were developed and models tested before committing to production.

Once the design concepts had firmed up, and following a period of health problems which affected key personnel at EIS, it was decided to transfer the vehicles to CWS Ltd (Colin White Services Ltd) a specialist vehicle fabricator to determine the best way to extract further value from the project and bring it to a conclusion.
In relation to the “dry vehicle” it was decided that the principal ideas had already been identified and incorporated into the new generation vehicles that were starting to enter the market. The added value that would be gained from further expenditure to complete fabrication of the vehicle would not be justified therefore. Instead a report identifying the key innovations and remaining issues would be published as source for vehicle designers and builders generally.

The food waste and glass collection vehicle was different. The ideas from this design had not been taken up by commercial developers or waste collection companies for either household or hospitality sector collections. It was decided to do the relatively small amount of work needed to complete this vehicle as a demonstration model. This would be tested and recorded and as with the other vehicle, the findings would be made available for others to use in the development of new commercial offerings.
2.0 Approach

2.1 The steering group
WRAP having recognised deficiencies in the then available kerbside collection vehicles started a dialogue with kerbside collection operators, vehicle suppliers and others with expertise and experience of developing and trialling and monitoring kerbside systems. The group met to discuss the functions, needs and issues surrounding kerbside collection. It considered safety, efficiency and cost and was conversant with the variety and nuance in current practice. Ideas emerging from the group were shared with a wider audience in workshops and at exhibitions, both to present the thinking and hear the responses of a wider group.

The most pressing concerns were to respond to demand for greater capacity, to provide solutions for food waste collection and to address manual handling issues. These included:

- loading on the off side in traffic,
- the need to climb steps up into the vehicle to load materials,
- operatives reaching, twisting and supporting the weight of materials while loading;
- noise from loading glass.

Food waste collections were then being developed and in particular, it was felt that there was a need for a system which could complement co-mingled collections and recover both food waste and glass - two heavy fractions incompatible with the target materials in the single stream co-mingled collection system.

This analysis led to the decision to develop two different vehicles one focused on kerbside sort and the other to support co-mingled collections.

2.2 The scoping study
A scoping study was produced by Ethical Solutions which investigated collection vehicles past and present. It included archive photographs and commentary and noted how many things have remained constant in refuse and recycling vehicle design. It included for example a kitchen waste collection vehicle from Ohio (1913) a 1950’s battery powered dust cart and went on to examine various stillage, side loading and compaction vehicles in current usage.

It attributed the lack of progress in the field to the availability of suitable chassis cabs and observed the line of descent from the Sentinel steam-lorries to the present day. Now as then, cabs tend to be slab fronted, perched above the front axle, sitting high above the ground and but for the modern comforts, the overall shape and layout of today’s vehicle would be quite familiar to the driver of the 1930’s.

There have been some notable innovations particularly in the USA which have not as yet entered European mainstream usage. The study emphasised the recycling sector’s need for a more appropriate design. An options appraisal was made of current designs in operation and evaluated the strengths and weaknesses of the various dry recycling systems for:

- Fully sorted
- Semi sorted and
- Non sorted

It considered the functionality, efficiency, costs and appearance. It flagged up operator health and safety issues as well as environmental concerns such as noise and littering. Where there were clear advantages such as being user friendly, inexpensive, flexible, these areas were highlighted as essential or desirable attributes to capture in future designs. The table on the following page illustrates the process of determining the priorities.
It was recognised that given the diverse needs of the industry, it would not be possible to create the perfect collection vehicle but nevertheless it was important to build in flexibility and create designs which could be scaled up or modified to a best fit for the operating environment. There would always be inhibiting factors and particularly in the smaller vehicle range for example cabs are not designed for constantly getting in and out wearing all the requisite PPE.

2.3 Concept

Early concept designs for were put forward by EIS to capture the key ideas for improved kerbside operations. The early concept design for the ‘dry vehicle’ presents a clean profile and is designed for ease of operation. It features ergonomic loading heights, utilisation of upper and lower space and could be presented on a range of chassis. The following two illustrations provide the designer’s impression of the vehicle in collection mode and then emptying the chambers. The chambers could in theory have been discharged individually.

Potential Determining Factors
Essential & Desirable Design Features & Considerations

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<th>Design Elements &amp; Determining Factors</th>
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<td>Minimal vehicle size (consistent with operation)</td>
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Source: EIS (2007), Collection vehicle research and development- Scoping Study
Early concept design on the road
Early concept design unloading

The unloading mechanism demonstrates an alternative to handling by forklift truck and allows for rapid unloading.
3.0 Design and build food waste and glass vehicle

The steering group identified the need to develop collection solutions for glass and food waste. Both materials are problematic in comingled collections and have potential to contaminate other material streams and to damage machinery. It is more convenient and encourages better participation if food waste is collected weekly. Many recycling collections are made on fortnightly schedules. A separate collection may complement existing systems without necessitating major investment in changing from the current collection and processing infrastructure.

The three most significant design considerations for the food waste collection were:
- ease of loading and emptying
- leachate control
- carrying capacity

For the glass collection key concerns were
- Noise reduction
- Loading height

A concept design was put forward by EIS for which it was agreed that a prototype would be developed. The vehicle is presented on Isuzu NQR 7.5 tonne chassis and designed to be modular with flexibility for range of collection materials and options to use different chassis if required.

**Food waste and glass collection vehicle**
The vehicle is designed to carry glass and food waste. The body is constructed in moulded fibreglass sections or tanks. It is divided into three separate compartments which allow for a two way split of glass bottles: clear glass in one and a mix of green and brown in the other and food waste in the rear section.

Each compartment has a roller shutter door. The doors guard moving parts while in operation and prevent materials spilling out while travelling between pickups and also to provide a sound baffle when tipping glass.

3.1 Glass collection

The glass is loaded at the nearside into stillages and the food waste loaded from the rear either manually or by wheeled bin. In each case, the materials are loaded first into a trough which is approximately one metre from the ground.

The glass stillages extend across the whole width of the truck and have a 1.2 cubic metre volumetric capacity which equates to approximately 320 kg of glass per stillage. The stillages are plastic foam clad to reduce the noise levels associated with loading glass and constructed with locating pockets to allow them to be emptied by a fork lift truck with rotating head.

The trough is fitted with a metal combed rave on which to hang a kerbside box and is designed to receive different sizes and types of box. The system is described in more detail below.

Once the trough is filled, it is emptied into the stillage. This is done mechanically. The trough is conveyed along a track pulled by toothed belt driven by hydraulic motor. The material can be emptied at any place or at pre-programmed variable points in the stillage, thus solving the problem of materials mounding unevenly in the collection chamber.

Trough and rave system

The rave (a) is a shaped metal bar, this bar acts as a holder for a recycling box. The rave is connected to the trough pivot point (b) the shaped semi circular side pieces allow the rave to flip 180degrees (c) without hitting the trough pivot point.

This rave system can be adjusted for height by moving the rest bolt (d) into a different hole, the lower the hole the lower the rave height from the ground.

There is a hinged base to the trough which is connected to an arm (e).There is a free-wheeling wheel attached to the arm (f) this wheel engages with an inclined track on the main tank frame.

As the trough moves along its horizontal track the wheel engages with the separate inclined track. Because the trough continues along its horizontal plain and the wheel in its inclined down plain the contents of the trough are deposited in a spreading fashion.

The gradient of the inclined plain can be adjusted for different materials.
**Trough bogey**

This shaped piece of steel is the means by which the trough is suspended from the steel frame. The bogey has a tube welded (a) to a plate through which a steel rod can be inserted. This rod passes through the tube into the trough and secured. The bronze bushes in the tube allow the pin to rotate freely.

There are two wheels (b) attached to the plate. They allow the bogey to freely run up and down the tracking connected to the main steel frame. Connected to the base of the bogey is a shaped plate with holes in. This plate can be connected to a proprietary toothed belt clamp (c). The shape of the plate (d) stops the belt coming into contact with the bogey.

**Detail of trough and belt**

**Detail of belt**
Trough travelling on rail

Trough in variable emptying position

Trough emptying into stillage
Main trough frame and track

The main frame (a) is made from steel tube and is welded together. The proprietary tracking (b) is attached to the frame.

The inclined track (c) is also attached to the main frame.

The tracking (b) allows the trough and bogey to run vertically and then horizontally and vice versa.

A toothed belt is attached to one half of the toothed belt clamp on the bogey and runs around a toothed pulley connected to a tensioner at the bottom of the main frame, the belt continues to run around a guide at the top of the frame and then continues around the motor drive toothed pulley and then back to the other half of the bogey toothed belt clamp.

The belt is under tension and as the motor turns the trough is pulled either up or down in whichever direction the motor turns.

As the trough moves along the horizontal plain the wheel on the trough base door arm engages with the inclined track (c); as the trough moves the base is opened progressively. When the trough reaches the end of its horizontal travel the motor, controlled by an electronic program, is returned along its original path.

This system has addressed some of the key challenges of collecting glass at kerbside. The principal advantages of the system include:

- Nearside loading reduces the risk of loading in traffic
- Ergonomic loading height into a trough allows the operative to load in a comfortable position and reduces the risk of muscular skeletal injuries resulting from manual handling.
- Trough system reduces impact of glass on glass while loading and reduces likelihood of injury from glass splinters
- Rave comb allows for the box to be held securely while it is being unloaded
- Sound proofing materials and door closure reduces noise from glass loading
- Loading options allow for even loading across the width of the vehicle and optimises available space.

There are aspects of the prototype which would need to be addressed if put into production.

- Larger capacity troughs of around 60 litres would allow for a pass of around twenty properties before emptying into the stillage (currently around ten).
- Greater carrying capacity with larger glass stillages particularly for green/brown split would increase number of properties served and reduce number of trips required per round (current capacity would meet around 425 properties per trip before first glass stillage was full and about 550 properties before reaching maximum carrying capacity)
- All mechanisms would require protection from forklift damage. Metal deflector plates would guide and locate the stillage when loading and unloading.
• Electrical interlocks would be enabled to ensure that doors had to be closed while the trough mechanism was in operation and system automated to speed up emptying process.

3.2 Food waste collection

Food waste is generally presented for collection in 20-25 litre rigid plastic containers with a lockable lid.

*Food waste containers*

Householders are encouraged to separate food waste into a smaller caddy (5-10 litre capacity) in the kitchen. The caddy is usually lined with a compostable bag or newspaper and when full the contents are transferred to the larger container is stored outside alongside other waste and recycling containers between collections.

*Food waste buckets presented for collection*

The food waste is loaded into the rear tank via a trough or wheeled bin lift. Once the trough is full, the door is closed and similar to the glass unloading, the trough is conveyed on a belt driven rail and emptied at different positions within the tank in order to spread the load and avoid uneven mounding of materials.
Rear loading point

Rail
The trough has a volumetric capacity of 196 litres which equates to approximately 50 kg of wrapped food waste which would be sufficient for approximately 25 household passes.

The system also allows for wheeled bin emptying for collections which make use of slave bins or for commercial food collections. The bin is presented to the bin lift at the rear of the truck and emptied into a chute which directs the material into the body of the collection tank. Before the bin lift can be activated, the chute is opened. The bin is then emptied into the top of the vehicle via the chute. Once the emptying cycle is completed, the chute closes.

The load is then emptied via the side tipping body.
3.3 Trials

The vehicle was tested with materials in situ alongside one of the multi material collections carried out by May Gurney in Bath. In normal circumstances, the standard collection in Bath would incorporate a full range of dry recyclables plus the food waste. For the purpose of this trial, the prototype food waste and glass vehicle went ahead of the regular collection selecting only the glass and food waste from a limited number of properties. The following images record the operation. The vehicle can be loaded in three positions, food waste at the back and two points on the near side for glass.
Vehicle prepared for collection on round

Loading truck

Sorting glass
The glass is separated into the two troughs to be loaded into the stillage. The system would be more efficient if larger troughs were installed to reduce the frequency of emptying into the stillage. With the narrow trough there is potential for the bottles to ‘bridge’ the gap and slow down the emptying.

**Mixed green and brown glass in one stillage**  
**Clear glass in other stillage**

The food waste containers are tipped into the trough which will hold approximately 50 kg of food waste before requiring emptying.
Once full the trough is emptied into the main tank and returned to its loading position. Having smooth facing on the inner trough would ease material flow from the trough to the tank.

**Food waste trough**  
![Food waste trough](image)

**Trough emptying into tank**  
![Trough emptying into tank](image)

The glass is unloaded by forklift truck with 360 rotating head. The trough is raised and sent to the back of the chamber so the fork lift can get clear access. The stillage is lifted to the edge of the vehicle before the forks are fully engaged and the material emptied into a bulk bay.

**Glass stillage unloaded with fork lift**  
![Glass stillage unloaded with fork lift](image)

**Stillage rotated to empty in bulk bay**  
![Stillage rotated to empty in bulk bay](image)

The food waste would normally be tipped directly but in this case to comply with licensing conditions was emptied into a bucket loader.
The practical trial proved useful and has prompted thought for minor modifications to speed up the loading process and to ensure a smooth and safe operation.

3.4 Summary

There was an identified need to develop a vehicle to complement co-mingled collections of recyclables and to collect glass and food separately at kerbside to avoid the potential for cross contamination of materials and damage to sorting belts and baling machines and injury to personnel. It will help increase the recycling service offered to the public and take glass out of systems where it is proving problematic. The vehicle is built with modern materials and of distinctive design.

It is as yet only suitable for demonstration and sensitive motors and mechanisms would need more robust protection from fork lift damage. Safety lock mechanisms would need to be enabled post demonstration to protect operatives from moving parts. It has been observed that some of the virtues of utilising lightweight materials have been lost in the heavy supporting infrastructure. It is likely that if this model is to be developed further for production there would be modifications to the bin lift and tipping mechanisms and would most likely be presented on a heavier chassis.

In summary:

- The food waste and glass vehicle is presented as a demonstration model.
- When used beyond demonstration safety interlocks will need to be mobilised
- More protection (e.g. deflector plates) to avoid fork lift and stillage damage to lifting mechanisms and motors will be needed.
- Some of the virtues of the lightweight materials are lost through ‘belt and bracers’ reinforced structures in heavy materials (steel and plywood)
4.0  Dry recycling collection vehicle

There has been a pressing need to develop suitable multi material collection vehicles that can manage the high volumes of material outputs from householders in a safe and efficient way. The creative process of developing and commissioning this vehicle design led to some of the innovation being explored and developed in parallel by others in the industry, taken up and put out in the field before the completion of the project.

The design presented a number of improvements

- Ergonomic loading
- High volume capacity for plastics
- Options for single or two sided loading
- Noise control for emptying glass

The vehicle manages loading of all materials at ground level, overcoming the necessity to climb steps to load upper compartments. All materials can be loaded at trunk height either directly into low profile stillages or into troughs which empty into upper compartments.

Viewing the vehicle from the side, there are five loading positions beginning left to right with paper in the large compartment at the front and then four other material options on the lower level. The upper compartment is for plastics and to be loaded from a rear trough.

*Multi material kerbside sort vehicle – design prototype*

The upper chamber and lower level containers are constructed in fibre glass.
Two of the more successful kerbside vehicle designs following the start of this project are featured on the following page. Both have been developed to production standard and are fully operational on collections in different parts of the UK.

As with the design prototype, both vehicles are loaded at ground level. The heavy materials such as glass, paper and food waste are stored in the lower chambers. The light weight but high volume materials such as plastics are loaded at ground level and then conveyed to the upper chamber. The bottom chambers comprise a series of stillages which are emptied by fork lift truck and the upper chamber is discharged mechanically onto the floor of a holding bay similar to the prototype developed by this project.
Multi material kerbside sort vehicle subsequently developed by May Gurney

Multi material kerbside sort vehicle subsequently developed by Bryson Recycling
4.1 Features of the multi material kerbside sort vehicle

There is a sliding door in the main door to access a trough. Paper would be loaded into the trough which when full would be emptied into a large stillage within the first chamber. As with the other trough mechanisms, it can be directed to unload in any position above the stillage thus spreading the load evenly and maximising capacity.

*Paper loading point*

*Full door opens to remove paper stillage*

Under the trough, there is a position on which to hang the kerbside box while unloading. To empty the trough the sliding door needs to be closed thus guarding the mechanisms while in motion.

To unload, the trough is located at the back of the chamber, the side door opened and the stillage removed via fork lift truck.

Within the chamber there are metal runners to locate the stillage without damaging the mechanisms. The stillage was not constructed at time of recording but depending on handling systems used would either be rotated to empty or have a drop door underneath.

The four lower compartments provide ergonomic loading positions for the operative where materials are fed through the apertures. The materials used in their construction were selected to deflect and deaden the noise emitted while loading glass. The main tank is constructed of fibreglass and the hood of rubber.
The stillages are designed to be unloaded by fork lift truck. Each stillage has the potential for loading one or two sided. It is also possible to split materials into two streams and empty separately if desired.

There is a separate compartment within the stillage, nicknamed the Babushka after the Russian doll within a doll etc. This compartment is located on a rail and can be located on or transferred to either side of the vehicle.

This Babushka tank can be loaded with a separate material, say brown glass or textiles alongside a mainstream material or more likely be filled with one material and then moved over to create space for loading more material.
This unfortunately is still work in progress but provides an exciting design concept to be developed to practical fruition.

The idea is that there would be two doors on the stillage enabling one material to be retained while the other was being tipped.

**Transverse tank cassette and pusher “Babushka”**

The rectangular shaped cassette is made from thin mild steel with a steel box section frame around the inside set flush to the top.

Attached to the inside top edge of the outer fibreglass tank is a proprietary channel (a)

Attached to the outside of the cassette is a steel bar with wheels attached (b). These wheels locate in the channel of the fibre glass tank and allow the cassette to move horizontally across the length of the fibreglass tank (c)

Sandwiched between the wheels and the outer wall of the cassette is a shaped bar (d)

This is shaped so a round steel bar can locate in the recessed shape. (e)

The round steel bar is connected to a long round tube (f) that protrudes through a slot in the outer end wall of the fibreglass tank.

To push the cassette from one end of the fibreglass tank to the other, push the tube down and pull away from the tank.

This action lifts the round steel bar outer of its recess. Once free from the recess, the tube can be pulled away from the tank. By lifting the tube and pushing towards the tank at the same time the round steel pin will locate in its recess and the cassette can be pushed towards the other end of the outer tank. This process can be repeated as many times as required.

The action if reversed will move the tank in the opposite direction.

Once the cassette is in the desired position the tube can be pushed home to its rest position. The tube will locate in the slot and stop the tank moving (g).
Plastics can be loaded at the rear of the truck into a trough which is then conveyed to the upper chamber and unloaded evenly. The picture below depicts the closed position and as with the paper compartment, a trough is accessed via a sliding door, boxes are rested on the metal combs.

**Rear view closed while travelling**  **Rear view open for loading**

The trough is approximately 196 litres and would contain around 3 – 4 kg of plastic bottles

**Plastics trough**
Rear doors open for unloading

To unload the plastics, the bulkhead would push the material from the front to the back of the truck and off the edge of the sloping bottom door. The intention was to have a fluted skirting on the sides of the lower door to direct the flow of the plastics while emptying.

Bulkhead travelling forward on the same tracking as the loading trough
**Emptying Pusher**

The emptying pusher is made from light weight steel box section covered in thin plywood and two layers of fibreglass and one gel coat.

The pusher runs in the main tracking (a) (the same one as the trough) by the means of a three wheeled bogey (b). The bogey is connected to the pusher by bolts. The bogey is connected to simplex chain (c), this chain is controlled forwards and backwards by an electric motor. The chain is also connected to the bottom of the pusher.

The chains all drive in the same direction and act like a winch pulling the pusher in either direction.

The pusher is shaped to act like a snow plough; the shape is also there to allow for clearance for other items in the tank.
5.0 Conclusions and recommendations

The key areas addressed by the project have been tackling the operational practicalities for managing:
- Volume
- Safety
- One pass multi material separation
- Collection system for food waste and glass to complement co-mingled dry recycling collections

It has taken place before a backdrop of:
- Developing markets for mixed plastics (greater volumes arising)
- Legislative drivers to reduce landfill (escalating disposal costs)
- Need to divert organic material from landfill (carbon reduction)
- Manual handling issues (need to revise and reform methodologies)

It brought together a broad range of interests to share and develop contemporary best practice and to identify the issues that operators were struggling to overcome and anticipate future challenges. Participating in the process benefited the industry by testing ideas with peers in a cooperative and positive forum.

"This research and development project helped give us confidence to provide practical solutions for dealing with the increasingly high volumes of plastics and cardboard arising in the domestic waste stream. Ideas were shared that helped us to focus on mechanizing our recycling vehicles to enable a wider range of materials to be collected through kerbside sort recycling, more safely and more efficiently than ever before. We believe that over the coming years this shared process will revolutionise the face of kerbside recycling in the UK"

Eric Randall, Bryson Recycling

5.1 Food waste and glass vehicle – key observations

The decision to complete the food waste and glass vehicle for demonstration has provided further ideas and recommendations for improved revisions such as:
- When used beyond demonstration safety interlocks will need to be mobilised
- More protection (e.g. deflector plates) may be needed to avoid forklift and stillage damage to lifting mechanisms and motors.
- Some of the virtues of the lightweight materials are lost through ‘belt and bracers’ reinforced structures in heavy materials (steel and plywood)
- Building on a larger chassis to achieve heavier payloads
- Presenting the bin lift on the near side of the vehicle
- Having stabilizing legs on off side to secure while tipping

5.2 Dry recycling vehicle – key observations

While there has been significant development during the lifetime of this project in the design of multi-material sort vehicles some questions are, as yet, to be fully answered in the current crop of production vehicles and some of the emerging concepts derived from this project will serve as a launch point for the development of future improvements such as:
- Improved loading heights for boxes/stillages
- Ability to load either side with inner sliding container “Babushka”
- Innovative materials to reduce noise
Further developments pre-production of a dry recycling vehicle incorporating these concepts have been offered by CWS Ltd:

**Paper section**
- Need deflector plate to protect paper lift mechanism from forklift/stillage damage

Lower stillages: transverse tanks require:
- Springs on lids to prevent over centring
- Spacers on both stillages
- Bolts on side – counter sunk or dome headed to prevent catching
- Locking mechanisms both sides for sliding (Babushka) cassettes
- Leaver linkage or pole to move cassette – (will need docking point to prevent slip) could pull with hook
- Brush strips on travelling cassettes

Stillage locating flange needs to be strengthened and made more pointed to receive stillage.

**Plastics tank**
- Travelling bulkhead needs to be extended to just clear floor
- Deflector required on bulkhead in front of wheel
- Mechanism – shaft, sprocket and chain – tube or box section fixed back to side pads
- Lining upper sides with wood panel
- Gap between floor and folding rear door needs attention to ensure smooth material flow
- Sides between folding door and plastics tank need material to stop product falling off (suggested aluminium sheet and material used together to stop material bunching).
- Possible to create access from paper to plastics tank for maintenance purposes
- Pusher shaft – keyway shaft so sprockets are aligned and stay in constant position

**Rear door**
- Requires support stay to prevent wind blowing door shut.
- Offside under run could be utilised for tool boxes, storage etc.

**Electrics**
- Fit upper deck view camera* – twin camera reversing system, one for upstairs one for reversing
- Fit inverter for motor drive and electronic rotational counter – recommend small pc to drive
- Interlock switches on all doors and e stops on both sides of vehicle
- All buttons and levers need to be fully labelled
- Possible to use same motor to do two jobs: paper lift and plastics pusher.