Reducing corrugated cardboard weight without compromising performance

A packaging distributor has successfully trialled a lightweight corrugated cardboard carton that could significantly reduce paper waste and carbon emissions.
WRAP works in partnership to encourage and enable businesses and consumers to be more efficient in their use of materials and recycle more things more often. This helps to minimise landfill, reduce carbon emissions and improve our environment.
Packaging distributor Kite Packaging Ltd (Kite) wanted to cut down the amount of space in its warehouses taken up by corrugated cardboard cartons, thereby improving logistical efficiencies, saving money and reducing the amount of card that goes into the household waste stream.

This gave rise to a project, funded by WRAP (Waste & Resources Action programme), in which Kite experimented with changing from double wall flute cartons to a thinner single wall flute alternative.

To ensure the thinner carton was as strong as the old one, independent compression testing was done via consultants The Packaging Industry Research Association (Pira) and packaging manufacturer Svenska Cellulosa Aktiebolaget (SCA). As a result two single wall flute board grades were chosen for the range of stock cartons. These grades weighed less but were of similar strength to the current double wall flute cartons.

Toys R Us, operating through Spark Response as part of their on-line retailing business, acted as one of the customer project partners in the initial trial of the cartons. Their feedback on carton strength validated the compression testing and allowed the project to continue.

ARUP was commissioned to investigate the environmental implications of the project. Its report concluded that if the thinner cartons were adopted, carbon dioxide (CO2) savings of 30% could be made because fewer road trips would be required to transport the same amount of boxes from manufacturer to distributor to end-user.

Kite used an online presentation and bespoke presenter folder to explain the project to existing customers and invite them to take part in a trial of the new cartons. The cartons were offered free, provided the customers filled out an online feedback questionnaire. Overall, customer feedback was very positive.

The calculated savings of the implementation of this project at Kite is 36 tonnes of paper-based packaging material per year, which equates to a reduction of 25 tonnes of corrugated cardboard entering the household waste stream.

If all other manufacturers and distributors of stock corrugated cartons adopted the project, a UK-wide saving of 3,600 tonnes could be achieved.

The testing showed that a further reduction in board grade would be possible in the near future once the marketplace becomes used to the single wall flute cartons.
Contents

1.0 Introduction ............................................................................................................................................. 3

2.0 Methodology / Tasks undertaken ........................................................................................................ 4
  2.1 Overview ............................................................................................................................................... 4
    2.1.1 Types of corrugated cardboard .................................................................................................. 4
  2.2 The benefits of reducing carton weight .............................................................................................. 4
  2.3 Choosing and testing the new board ................................................................................................... 5
    2.3.1 Testing parameters ...................................................................................................................... 5
    2.3.2 Compression values explained .................................................................................................... 6
    2.3.3 Customer trials ............................................................................................................................ 7
    2.3.4 Environmental investigation ........................................................................................................ 7
  2.4 Implementing the trial ......................................................................................................................... 7
    2.4.1 Presentation .................................................................................................................................. 7
    2.4.2 Presenter folder ........................................................................................................................... 8

3.0 Findings / Results .................................................................................................................................... 9
  3.1 Compression test results ................................................................................................................... 9
  3.2 Compression retesting ....................................................................................................................... 11
  3.3 Environmental report ........................................................................................................................ 12
  3.4 Customer partner feedback .............................................................................................................. 12
  3.5 Carton artwork .................................................................................................................................... 12

4.0 Conclusions ............................................................................................................................................ 14

Appendix 1: Customer Questionnaire ........................................................................................................ 15
Appendix 2: Assessment of Customer Questionnaire results .................................................................... 17
1.0 Introduction

The initial idea for this project came during an internal assessment of warehouse space utilisation in which Kite studied the main items stocked at each of its branches. This showed that the most common items were stock cartons.

Using their packaging technology expertise, Kite set out to investigate alternatives to the standard heavier weight fluted corrugated cardboard grades used in these cartons. Reducing the weight of corrugated cardboard at source would not only cut down the amount of packaging being used, but produce other environmental benefits such as reducing the number of trees needed to produce the corrugated cardboard and the pallets for transportation, and fuel savings because greater loads of flatpack cartons could be carried at once.

The lighter carton would only be adopted by customers if it was as robust as the old carton, as confirmed by independent testing.

Kite’s researchers also attempted to assess the likelihood of lighter weight corrugated cardboard stock cartons being adopted generally across the national supply chain as a new industry standard.
2.0 Methodology / Tasks undertaken

2.1 Overview

Data from public-domain household waste reports from councils around the UK reveals that in most areas between 12% and 33% of domestic waste consists of paper and corrugated cardboard. This translates to about 5 million tonnes of paper or card going to landfill or recycling every year.

The boom in internet shopping – especially for household appliances, electronics, books, videos, CDs and computer games – means that more and more products are packaged in corrugated cardboard cartons for delivery to the consumer.

Cartons and corrugated fittings are manufactured in many sizes and styles, some bespoke to the customer’s specific requirements, though many act as a range of ‘stock’ sizes and styles which can accommodate any number of products. These can range from simple brown cartons to high quality die cut printed, point of display products. For this project, however, the focus was on the former type of ‘stock’ carton.

This type of carton is typically used in bulk by fulfilment houses, logistics companies, internet-based companies and retailers to deliver products direct to the home user.

2.1.1 Types of corrugated cardboard

![Diagram of corrugated cardboard types](image)

*Figure 1* Double wall flute corrugated cardboard (above) is substantially thicker than single wall flute (below)

Kite and most other packaging distributors / manufacturers carry a general range of stock cartons, typically in two flute types: single flute and double flute (fluting is the ridged section of paper between two liners that makes up a piece of corrugated board, as shown in the diagram).

Grades may differ from company to company, but the single flute cartons are used mainly for lighter products, whilst the double flute cartons are generally used for heavier products or where the customer over-specifies the carton to ensure successful delivery via single-item transport routes (i.e. couriers).

2.2 The benefits of reducing carton weight

From its stock carton sales data, Kite established that 53% of its customers for double wall stock cartons were businesses that supplied products to the home user.

In terms of paper-based packaging weight, this represented 70% of the total weight of double wall stock cartons supplied by Kite, with the remainder sold to customers supplying business-to-business products.

On average Kite produces about 600 tonnes of double wall stock cartons a year. Of this, 70% or 420 tonnes is likely to enter the household waste stream.

The aim was to develop a lighter weight corrugated cardboard box to reduce this by 63 tonnes, equating to a reduction of 44 tonnes of household waste.

---

1 ‘Cheshire Local Authority household waste composition report, 2005’ and National Office of Statistics, 2005
Kite currently has approximately 0.75% share of this market, so it is estimated that if all other manufacturers and suppliers in the UK adopted the same methodology, the amount of corrugated cardboard carton waste sent to landfill would reduce by 5,867 this 3600 tonnes annually.

There would also be other significant ‘knock-on’ environmental benefits of changing to alternative materials; these include a reduction in pollution because of transport improvements, and a reduction in the number of trees felled to make the timber pallets used to store and transport the cartons, because more flatpack cartons / board can be carried on each pallet.

### 2.3 Choosing and testing the new board

The most crucial aim of the project was to establish a suitable grade of material to achieve the target reduction in weight whilst maintaining an equivalent or greater structural integrity. The principle of using single flute cartons rather than double wall cartons is simply to use fewer grams of paper per metre of board. Kite worked closely with its supplier partner SCA (a corrugated cardboard packaging manufacturer) to select a suitable range of single flute board, which was named 'Enviro-box'. The FEFCO$^2$ style code of all cartons tested is 0201, as shown in Figure 2.

![Figure 2](image-url) The standard FEFCO 0201-style packing box

If customers were to accept the new weight of board, they would have to be satisfied that it was just as strong as the existing product. It was crucial, therefore, to provide independent data to back up claims of weight reduction and strength improvement.

Pira, as a recognised independent test facility for the packaging industry, was asked to carry out initial weight checks and compression testing of the cartons to determine their vertical compression capabilities. These were then compared with the current stock cartons. The expectation of the testing was to improve on the strength of the current carton, or to obtain a result not exceeding a 2% decrease in strength.

#### 2.3.1 Testing parameters

The compression test machine model was a lab validator. All tested cartons were pre-conditioned for 24 hours prior to testing to standard environmental test conditions: 73.4 +/- 2°F (23 +/- 1°C) and 50 +/- 2% relative humidity.

---

$^2$ FEFCO International Fibreboard Casecodes. This code which is prepared in collaboration with ESBO (The European Solid Board Organisation), contains a methodical presentation of all existing box design styles, a code number being assigned to each design. As a reference document, the code is used world-wide and it has been adopted by the United Nations.
All cartons were U-sealed using standard 50mm width polypropylene adhesive tape and then compressed to first failure point.

### 2.3.2 Compression values explained

The compression values are measured in kgf or kilograms force. The machine applies compression evenly across the top and base of the carton. The result obtained is at the first failure (signified by the drop on the graph). This point is where the displacement (the amount of compression in millimetres) and force applied in kilograms change as the carton collapses.

Using this result, the carton compression capabilities can be obtained.

For example, a stock carton achieving 221kgf, with a packed weight of 6kg, could theoretically be stacked 38 high without collapsing. This is calculated by 221/6 + 1, with 221 the compression result, 6kg pack weight and 1 because the total stack weight of 221kg is applied to the base layer or carton.

In reality it is very unlikely that the carton will remain stationary or be stacked perfectly in line with the other cartons, and the forces applied through handling and distribution vary within different environments; therefore a safety factor is normally applied to the equation.

A safety factor of 3 would result in an equivalent 73kgf (221 + 3). This equates to a more realistic stack height of 13 cartons.
2.3.3 Customer trials

Toys R Us, operating through Spark Response, were one of a number of customers who helped Kite carry out initial packing and transit trials of the carton. Initial customer samples were produced and supplied to Toys R Us, to gain their feedback for the project.

Further trials were conducted with other customers. An online presentation and bespoke presenter folder were used to explain the project and the Enviro-box credentials. Customers were invited to take part in trials of the new cartons. The cartons were offered free provided the customers filled out an online feedback questionnaire within a month of trial carton delivery. If no questionnaire was completed, Kite could invoice for the trial stock.

Each customer was assessed individually to ensure that the amount of trial cartons issued were representative to their normal ordering pattern to ensure a fair system of distribution.

2.3.4 Environmental investigation

ARUP were commissioned to calculate the environmental benefits of the reduction in space and weight in relation to the emissions due to transportation. The data to calculate carbon reductions is based upon the following scenarios:

Current scenario
- A fully laden 44ft articulated lorry delivering an average pallet weight of 198kg (product) + 15 kg (wooden pallet) x 46 pallets per delivery over a total 7,437.55 miles in one year.
- A returning empty 44ft articulated lorry over 7,437.55 miles per year
- A 7.5 tonne lorry delivering an average pallet weight of 198kg (product) + 15kg (wooden pallet) x 20 pallets per delivery over a total 5306.46 miles in one year.
- A returning empty 7.5 tonne lorry over 5,306.46 miles per year

New scenario
- A fully laden 44ft articulated lorry delivering an average pallet weight of 198kg (product) + 15kg (wooden pallet) x 46 pallets per delivery over a total 5,218.62 miles in one year.
- A returning empty 44ft articulated lorry over 5,318.62 miles per year
- A 7.5 tonne lorry delivering an average pallet weight of 198kg (product) + 15kg (wooden pallet) x 20 pallets per delivery over a total 3,794.67 miles in one year.
- A returning empty 7.5 tonne lorry over 3,794.67 miles per year

The results of the environmental investigation are given in Section 3.3.

2.4 Implementing the trial

The project was announced internally at Kite’s annual sales conference, where a presentation pack was distributed to regional sales representatives for them to use with their customers.

This consisted of a digital presentation, a presenter folder and carton samples.

2.4.1 Presentation

The digital presentation took the form of a cover page (as shown in Figure 5). Due to the diversity of customers and varying levels of staff contacts within those companies, this format offered the presenter the option to elaborate on the aspects of the project that were most pertinent to the individual customers. For example, if a customer is most interested in the integrity of the stock cartons, they would click on this arm of the diagram in Figure 5 and further pages would become available to better inform the customer.
2.4.2 Presenter folder

The presenter folder, in the form of a 6-page gate folder, provided a brief introduction to Kite and WRAP, the project aim, and the credentials of the Enviro-box.

With a customer target list compiled, contact was made to present the Enviro-box to Kite's clients. Free trial cartons were offered to customers that were prepared to take part in the trial, in exchange for a completed questionnaire within a month of trial carton delivery.

Feedback via the online questionnaire was enforced as a pre-requisite to the agreement, so that if no questionnaire was completed then Kite could invoice for the trial stock. The questionnaire is reproduced in Appendix 1.

Using a web-based form enabled easy access for all and centralised the collation of data.
### 3.0 Findings / Results

#### 3.1 Compression test results

<table>
<thead>
<tr>
<th>Carton type</th>
<th>Difference in weight</th>
<th>Difference in strength</th>
<th>Comments</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x9x9</td>
<td>-67g</td>
<td>-24.48kgf</td>
<td>A 67g weight saving on the current carton; however it was 12.41% down in strength.</td>
<td>Retest in the next material grade up in strength</td>
</tr>
<tr>
<td>12x12x12</td>
<td>-40g</td>
<td>-84.9kgf</td>
<td>A 40g weight saving on the current carton; however it was 47.5% down in strength. Observations showed hand holes created a weak point for the compression.</td>
<td>Retest in the common material chosen for the 12x9x9 cartons. Remove the hand holes for this model.</td>
</tr>
<tr>
<td>14x14x14</td>
<td></td>
<td></td>
<td>The current carton was tested; however, alternative carton samples were not provided.</td>
<td>Provide a sample in made in the chosen material for the above cartons and test. Do not include hand holes in the design.</td>
</tr>
<tr>
<td>16x16x16</td>
<td>-213g</td>
<td>-29.41kgf</td>
<td>A 213g weight saving on the current carton; however it was 13.1% down in strength.</td>
<td>Provide a sample in the chosen material for the above cartons and test. Do not include hand holes in the design.</td>
</tr>
<tr>
<td>18x12x12</td>
<td>-39g</td>
<td>-46.78kgf</td>
<td>A 39g weight saving on the current carton; however, it was 25.2% down in strength. Observations showed hand holes created a weak point for the compression.</td>
<td>Provide a sample in the chosen material for the above cartons and test. Do not include hand holes in the design.</td>
</tr>
<tr>
<td>18x18x12</td>
<td></td>
<td></td>
<td>Three materials trialled. Optimum weight saving shows a 104g reduction; however, the strength of this is down by 2%. The optimum board grade shows a 69g saving with a 5.4% increase in strength.</td>
<td>Approved</td>
</tr>
<tr>
<td>a) -89g</td>
<td>-16.98kgf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) -69g</td>
<td>+13.51kgf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) -104g</td>
<td>-4.70kgf</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reducing corrugated cardboard weight without compromising performance

Multi depth creases

The current carton was tested; however, alternative carton samples were not provided.

Table 1 Compression test results

<table>
<thead>
<tr>
<th>Carton Size</th>
<th>Weight Change</th>
<th>Strength Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>18x18x18</td>
<td>-98g</td>
<td>-121.82kgf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retest in an alternative material.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test with and without hand holes located within multi depth crease area.</td>
</tr>
<tr>
<td>24x18x18</td>
<td>+350g</td>
<td>+18.50kgf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approved in current grade for strength.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material grade increase in weight, not acceptable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retest again with repositioned hand holes with the multi depth creases.</td>
</tr>
<tr>
<td>24x24x24</td>
<td></td>
<td>The current carton was tested; however, alternative carton samples were not provided.</td>
</tr>
<tr>
<td>30x18x18</td>
<td>+404g</td>
<td>-22.73kgf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approved in current grade for strength.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material grade increase in weight, not acceptable. Retest again with repositioned hand holes with the multi depth creases.</td>
</tr>
</tbody>
</table>

The testing highlighted the following weak points in the carton design, as illustrated in Figure 6:

- the multi depth creases of the carton, required to provide the customer with a variable height box, are a natural weak point and compressed by approximately 5mm; and
- the hand holes also create a stress raiser in the carton, allowing a crease fracture to propagate from the aperture. However, observations showed that the positioning of these hand holes in relation to the multi depth creases of the cartons is crucial to maintain a minimum strength performance loss.

Multi depth creases
3.2 Compression retesting

The initial testing at Pira showed that many of the alternative cartons did not achieve the required reduction in weight. Further research was done and more testing carried out at SCA’s Pira-approved testing facilities.

These tests showed that the strength required in the larger cartons was still not being achieved using the board grades tested. It was therefore decided to use the same grade as approved on the medium-sized cartons and to suffer a small loss in the material weight saving.

This resulted in two board types being chosen for the range of cartons.

The test results for these board types are given in Table 2.

<table>
<thead>
<tr>
<th>Carton Size (cm inches for carton size kgf is correct for compression)</th>
<th>Current box compression test results (kgf)</th>
<th>New Enviro-box compression test results (kgf)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x9x9</td>
<td>222</td>
<td>294</td>
<td>32.4</td>
</tr>
<tr>
<td>12x12x12</td>
<td>263</td>
<td>324</td>
<td>23.2</td>
</tr>
<tr>
<td>14x14x14</td>
<td>261</td>
<td>302</td>
<td>15.7</td>
</tr>
<tr>
<td>16x16x16</td>
<td>254</td>
<td>372</td>
<td>46.5</td>
</tr>
<tr>
<td>18x12x12</td>
<td>232</td>
<td>328</td>
<td>41.4</td>
</tr>
<tr>
<td>18x18x12</td>
<td>237</td>
<td>307</td>
<td>29.5</td>
</tr>
<tr>
<td>18x18x18</td>
<td>297</td>
<td>302</td>
<td>1.7</td>
</tr>
<tr>
<td>24x18x18</td>
<td>229</td>
<td>272</td>
<td>18.8</td>
</tr>
<tr>
<td>24x24x24</td>
<td>282</td>
<td>310</td>
<td>9.9</td>
</tr>
<tr>
<td>30x18x18</td>
<td>351</td>
<td>340</td>
<td>-3.1</td>
</tr>
</tbody>
</table>

Table 2 Compression retest results

The weights of the cartons in the current and alternative board grades are shown in Table 3.

<table>
<thead>
<tr>
<th>Size (cm)</th>
<th>Current box weight (g)</th>
<th>New Enviro-box weight (g)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x9x9</td>
<td>318</td>
<td>301</td>
<td>-5.3</td>
</tr>
<tr>
<td>12x12x12</td>
<td>492</td>
<td>454</td>
<td>-7.7</td>
</tr>
<tr>
<td>14x14x14</td>
<td>670</td>
<td>659</td>
<td>-1.6</td>
</tr>
<tr>
<td>16x16x16</td>
<td>877</td>
<td>851</td>
<td>-3.0</td>
</tr>
<tr>
<td>18x12x12</td>
<td>611</td>
<td>605</td>
<td>-1.0</td>
</tr>
<tr>
<td>18x18x12</td>
<td>921</td>
<td>899</td>
<td>-2.4</td>
</tr>
<tr>
<td>18x18x18</td>
<td>1,139</td>
<td>1,075</td>
<td>-5.6</td>
</tr>
</tbody>
</table>
Table 3 Weight difference between Enviro-box and conventional carton

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight Enviro-box</th>
<th>Weight Conventional</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>24x18x18</td>
<td>1,294</td>
<td>1,250</td>
<td>-3.4</td>
</tr>
<tr>
<td>24x24x24</td>
<td>1,989</td>
<td>1,894</td>
<td>-4.8</td>
</tr>
<tr>
<td>30x18x18</td>
<td>1,512</td>
<td>1,424</td>
<td>-5.8</td>
</tr>
</tbody>
</table>

3.3 Environmental report

ARUP provided an analysis report based upon the reduction of transportation logistics of the new cartons. This report does not, however, investigate the savings made during the manufacture of the material.

To calculate the carbon savings data including link length, annual average daily traffic flows (AADT), annual average speed, road type and percentage of light duty vehicles and heavy duty vehicles were taken into account.

The carbon emissions predicted for the current situation and new situations, as outlined in Section 2.3.4 of this report, are presented in Table 4.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Present scenario (tonnes carbon/year)</th>
<th>New scenario (tonnes carbon/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outbound 44ft lorry (full)</td>
<td>1,273</td>
<td>893</td>
</tr>
<tr>
<td>Inbound 44ft lorry (empty)</td>
<td>1,273</td>
<td>893</td>
</tr>
<tr>
<td>Outbound 7.5t lorry (full)</td>
<td>499</td>
<td>357</td>
</tr>
<tr>
<td>Inbound 7.5t lorry (empty)</td>
<td>499</td>
<td>357</td>
</tr>
<tr>
<td>Total</td>
<td>3,544</td>
<td>2,500</td>
</tr>
</tbody>
</table>

Table 4 Annual carbon emissions for current and new transport scenarios

Table 4 shows that there is a considerable reduction in carbon emissions as a result of the proposed operations: from an estimated 3,544 tonnes of carbon/year from one 44ft articulated lorry and one 7.5t under present operating conditions to a predicted 2,500 tonnes of carbon/year under the new operating conditions. This means that the new methods of operation are likely to bring about a reduction of nearly 30% in carbon emissions.

3.4 Customer partner feedback

The main customer partner for the project, Toys R Us, uses Spark Response for their fulfilment packaging for direct supply products to on-line end-users. Alan Sawyers (Commercial and Operations Development), provided the following to express their opinion of the trial.

‘On behalf of our client, Toys "R" Us, we moved to this type of carton at the suggestion of Kite, having previously used double wall cartons.

Spark/Toys "R" Us have seen a benefit in switching box types in terms of reduced costs through storage space (which in effect adds to the cost saving realised by the client).

Following a recent review of our packaging usage and guidelines, we determined that the heavy-duty single wall cartons provide equal security and protection from damage in transit to our client's products than the double wall cartons.

This review of our carton usage for Toys "R" Us has had a positive effect on other areas of our business in that it has given us knowledge and experience, enabling us to review packaging used for our other clients.’

3.5 Carton artwork

The final carton artwork for this project included an environmental statement as shown below, which is printed on the base flap of the carton.
This box has been independently tested and has been proven to out perform a standard double wall equivalent whilst significantly reducing the environmental impact.

Kite Packaging in partnership with wrap
4.0 Conclusions

The aim of this project was to reduce household corrugated paper waste by replacing current double wall stock cartons with a single wall alternative. The original target reduction of 44 tonnes was not quite achieved due to the specific board grade required to meet the comparative strength tests.

However, the change has saved Kite an estimated 36 tonnes of paper based on 2005 figures, 25 tonnes of which would ultimately have entered the household waste stream. This achievement, if adopted by all other manufacturers and distributors, could result in a UK saving of 3,600 tonnes a year going into the household waste stream.

The project’s success was due to careful planning, anticipation of customer perception and thorough testing to ensure the new product was as good as the old. Whilst the tonnage savings remain relatively small in comparison to the total corrugated waste tonnage, this concept can be applied to many other carton types, opening up the opportunity to decrease corrugated cardboard waste even further in the future.

Other companies will now need to decide whether to take up the concept and there is the opportunity for it to become a new industry standard for selected ranges of stock cartons. The main initial drivers will of course be the environmental benefits and ‘soft’ savings relating to storage and transport. As the concept becomes commonplace the use of stronger single wall board material will increase and drive the cost down, making the project more attractive to those companies looking for cost benefits as well as environmental improvements.

Based upon the findings of this project, changing from corrugated double wall cartons to a single wall alternative, could result in the following approximate annual cost savings:

<table>
<thead>
<tr>
<th></th>
<th>Annual cost savings per tonne</th>
<th>Annual cost savings per 1000 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper material saving</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Pallet saving</td>
<td>£55</td>
<td>£55,000</td>
</tr>
<tr>
<td>Transport saving</td>
<td>£60</td>
<td>£60,000</td>
</tr>
<tr>
<td>Storage saving</td>
<td>£55</td>
<td>£55,000</td>
</tr>
<tr>
<td>Overall saving</td>
<td>£170</td>
<td>£170,000</td>
</tr>
</tbody>
</table>

Additionally, the changes will result in PRN savings as well as a carbon saving of approximately 30% (depending on vehicle types and route networks used).
Appendix 1: Customer Questionnaire

1. Carton Use

Please select which cartons you are evaluating. Select all that apply:
- 12x9x9
- 18x18x12
- 12x12x12
- 18x18x18
- 14x14x14
- 24x18x18
- 16x16x16
- 24x24x24
- 18x12x12
- 30x18x18

2. Method of Use

Which best describes your company in relation to the use of the stock cartons?
- Distributors,
- Printing,
- Healthcare products supply,
- Engineering,
- Manufacturing IT equipment,
- Tool & Equipment Supply,
- Manufacturing Lighting products,
- Construction.
If ‘other’, please specify:

3. Environmental

The introduction of these cartons reduces the transportation CO₂ emissions by 30% in comparison to double wall stock cartons. In terms of priority, how does this achievement rank with your company’s environmental policies?

5. High priority
4.
3.
2.
1. Low priority

An estimated 850 pallets have been reduced annually with this change. How does this improvement in palletisation affect your business’s storage and distribution?

5. Highly
4.
3.
2.
1. No effect

4. Carton Specification

Testing has proven that these cartons are as strong as the previous grade of stock cartons; to what level has this had an effect upon how you use these cartons?

5. Positive
4.
3. No change
2.
1. Negative

The larger cartons have included hand holes for ease of use by you and your customers; do you consider this inclusion an advantage to your company?

Yes
No
Not applicable

5. Comments

Please add any comments that you feel may be relevant:
Appendix 2: Assessment of Customer Questionnaire results

A total of 39,548 cartons were supplied to 53 customers over the main five-month trial period. The results were collated from the web feedback, and upon analysis the following data was established:

**Stock cartons regularly purchased:**

The percentages of customers that trialled each carton are given below. (The percentages do not total 100% as some customers purchase more than one carton.)

<table>
<thead>
<tr>
<th>Carton type</th>
<th>% of customers trialled</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x9x9</td>
<td>41</td>
</tr>
<tr>
<td>18x18x12</td>
<td>9</td>
</tr>
<tr>
<td>12x12x12</td>
<td>15</td>
</tr>
<tr>
<td>18x18x18</td>
<td>6</td>
</tr>
<tr>
<td>14x14x14</td>
<td>6</td>
</tr>
<tr>
<td>24x18x18</td>
<td>47</td>
</tr>
<tr>
<td>16x16x16</td>
<td>21</td>
</tr>
<tr>
<td>24x24x24</td>
<td>3</td>
</tr>
<tr>
<td>18x12x12</td>
<td>47</td>
</tr>
<tr>
<td>30x18x18</td>
<td>6</td>
</tr>
</tbody>
</table>

**Company type:**

30% Distributors  
17% Manufacturing – other  
17% ‘Other’  
9% Engineering  
6% Printing  
6% Healthcare products supply  
6% Tool & equipment supply  
3% Manufacturing IT equipment  
3% Manufacturing lighting products  
3% Construction

**Ranking with customers’ company environmental policies:**

47% of customers scored this as a 5, rating highly against their company’s own environmental policies  
30% scored it as a 4  
20% scored it as a 3 (average)  
3% scored it as a 2

**Improvement in palletisation effect of customers business’s storage and distribution:**

(score from 1 to 5)

20% of customers scored 5 (high)  
34% 4  
7% 3 (average)  
3% 2  
23% 1, little or no effect
Strength of the cartons and the level of effect upon how they are used: (score from 1 to 5)

21% of customers scored this as a 5 (high)
24%  4
55%  3 (no change)

The inclusion of hand holes for the larger cartons for ease of use by the customer and their customers, considering this inclusion an advantage or not:

51% of customers stated "yes", they did consider this as an advantage.
11% stated "no"
34% stated not applicable.

Customer comments
A customer feedback section gave the option to leave a personal opinion of the project / trial. Below are the comments left by customers. Company names have been omitted to protect customer confidentiality:

"Seems to be ok at the moment, only sent out 6 with comebacks from any of the customers."

"We find the boxes to be just as good if not better than the normal double walled boxes. Very pleased with them."

"Would be more useful if they were multi crease."

"We would be happy to change to this new board grade."

"Would be nice if the boxes were scored for folding"

"Great step forward for our nature of the business. The boxes are stronger so they should not fall apart during shipments to customers by courier."

"This item is still being assessed and appears to be coping with our requirements."

"Overall quality was good – exactly equal to stock cartons, but any future orders will need to have the cartons scored."

"Multi depth cartons would be more suitable to our needs. We were surprised by the cartons’ rigidity and have had good feedback from packing room staff."

"Full trial yet to be realised from customer feedback. Puncture testing is extremely important to ********** as its metallic products are expensive aircraft parts with a two year material lead time and are sent worldwide, handled by a number of systems and must arrive free from damage. This box looks as though it fulfils ********** expectations in an economical manner."

"The carton 24x24x18 would be more flexible if it had folds in it."

"I feel that this particular size should be multi-score to allow packaging single or multiple items."

"Yes they are good because they are enviro friendly but other than that they do not make a huge difference to us. Hand holes in the larger boxes are of no use as the consignments are too heavy for anyone to carry."

"Was very impressed with the quality of these cartons and hope to start purchasing soon!"

"These new cartons are very strong and take up less space than the previous cartons. Ideal for smaller companies like ourselves."

"We would be happy to use these boxes, there were no problems with the quality and performance of the boxes, and ***** is always happy to be more environmentally friendly."
“This carton/material is easily as good if not better than our current specification. I have been using them to send samples between our Bournemouth site and Egham sites – using just normal postage and the cartons have stood up well to three trips – far better than our current cartons. I think they are excellent and will be investigating how we can transfer to this specification.”

Overall, there was a very good response by those who wrote comments. Some customers requested multi-scored creases; however, Kite has decided to look at these as individual cases rather than introducing this design across the stock carton range. The reasons for this are:

- only a few customers request multi-scored cartons;
- multi-scored cartons need to be cut with a knife, and since most companies have banned the use of non safety knives, it would be difficult for operators to use the cartons effectively; and
- the use of multi-scores was proven to reduce the overall vertical compression strength of the carton, which means that a higher board grade is required to match the current compression values. This results in a heavier board and defeats the main aim of this project: to reduce tonnage of household waste.
Figure and Table Index

**FIGURE 1** DOUBLE WALL FLUTE CORRUGATED CARDBOARD (ABOVE) IS SUBSTANTIALLY THICKER THAN SINGLE WALL FLUTE (BELOW)  
4
**FIGURE 2** THE STANDARD FEFCO 0201-STYLE PACKING BOX  
5
**FIGURE 3** THE LAB VALIDATOR USED TO CARRY OUT THE COMPRESSION TESTS ON THE CARTONS  
6
**FIGURE 4** COMPRESSION CAPABILITIES  
6
**FIGURE 5** THE MAIN PAGE OF THE CUSTOMER PRESENTATION INTRODUCING THE ENVIRO-BOX  
8
**FIGURE 6** THE HAND HOLE WAS REPOSITIONED AFTER INITIAL TESTING  
11

**TABLE 1** COMPRESSION TEST RESULTS ........................................................................................................... 10
**TABLE 2** COMPRESSION RETEST RESULTS ..................................................................................................... 11
**TABLE 3** WEIGHT DIFFERENCE BETWEEN ENVIRO-BOX AND CONVENTIONAL CARTON  .......................... 12
**TABLE 4** ANNUAL CO₂ EMISSIONS FOR CURRENT AND NEW TRANSPORT SCENARIOS  ......................... 12