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Retail Product Packaging and Last-mile Delivery
Six Sigma Green Belt ACMA5005

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1 Introduction

This project sets out to follow the Six Sigma methodology within the direct-to-customer e-commerce sector of Bisley to address operational challenges being experienced due to growth. The increasing demand in this sector has exposed limitations in the existing methods, necessitating the establishment of more standardised processes and means of improvement to ensure consistent success.

This project will focus on two primary areas for improvement: the efficiency and flow within the product re-packing process, which currently lacks defined procedures, and the reduction of product damage and associated packaging costs stemming from the re-packaging and delivery stages.

Tools such as process mapping, Pareto analysis and SIPOC analysis will be employed to gain a better understanding of the process so as to visualise the current state and thereby identify key avenues of improvement.

The ultimate goal of this Six Sigma project is to implement improvements that are data-driven and which will enhance process flow, reduce product damage, and thereby increase customer satisfaction within Bisley's e-commerce business area.

2 Define

This six-sigma project will focus on a growing area of the business, which is the direct-to-customer e-commerce region of the company. This business model is comparatively new for Bisley, but has shown remarkable promise in recent years. Dedicated to fulfilling orders for this area of the business, a production area picks products from the warehouse, sorts these 'finished goods' into individual orders, and re-packages these small groups ready to be moved on by courier. As the business has grown, the current mindset and methodologies used in this area have proved increasingly unfit for purpose. With increasing demand in this sector, it's increasingly crucial to establish process flow and operational standards to guarantee regular success.

The focus of this project is two-fold. First, improvements to the flow in the re-packing process. The current operation is ad-hoc and doesn't have a measured procedure or mapped process. Each item is brought to the packing area and is dealt with individually. With increasing volume through this area of the organisation, this mode of operation is increasingly inadequate and consequently unsustainable. By mapping the process and introducing 'flow', it will be possible to find bottlenecks and to target process improvement effectively and cost-efficiently at those congestions (Antony, 2004). Second, the result of the re-packaging process needs improvement. The damages on the product, and the current cost of packaging used have both been too high, and as such, an exercise will be required to analyse in detail the causes of this. Identifying how and why items are damaged through the shipping process through our couriers will help us identify why and how items are being put in a position to receive damage.

2.1 Voice of the Customer (VOC)

Gathering data on the voice of the customer (VoC) is crucial in determining the direction, scope and measures used in any project. To do so, the VoC will be assessed using three objectives. First, to identify customer needs and expectations. In doing so, second, to determine Critical to Quality (CTQ) items. CTQs represent measurable characteristics crucial to customer satisfaction. Finally, to use CTQs to identify focus areas of improvement crucial to success. By understanding customer priorities, this project can prioritise process improvements to address areas that have the greatest impact on customer satisfaction.

Our sources of VoC feedback consists of a mixture of voluntary survey data, both numerical and qualitative, as well as balancing these with on-time in-full deliveries, which will help moderate information which otherwise focused on the negative outcomes and not what the ways in which we do currently meet customer needs.

2.2 Project Charter

To achieve these goals, it's vital to define several indicators to measure the performance of the system. These should aim to track the quality of the system's performance against the needs of the business while controlling for biases caused by crowding out other requirements not being directly tackled by the chosen KPIs'. The KPIs' Crucial to this project are:

- The cycle time, by product, for an item to be packed and moved to the goods-out area.
- The breakage reported by the customer after delivery.
- Count per week of safety incidents of any kind. This shouldn't be anything other than zero for any reason.

Problem Statement - The current process has no defined flow or process. This has been combined with increasing performance requirements due to order volumes. The impact of this on the customer has been to drive up order lead times while risking the quality of the product. Between these growing pressures, consistent complaints about breakage have proven that the current packaging methods haven't been sufficient to deliver the product to the customer through the delivery methods employed. The consequence of not addressing these problems are inevitably customer dissatisfaction.

Objective Statement - The target process improvement of this project is to reduce the time to pack and move the finished product, by type, to the goods out area ready for loading by 10%. Additionally, this project aims to reduce damage rates to 1% or less for *all products* and to achieve this by exploring and implementing methods and design changes throughout the process.

Scope - This project is concerned with anything which can be affected within the production area discussed, which doesn't involve removing equipment or changing the specification of packaging or design of the products. The means of delivery cannot be affected in any way, remaining at least the same size and weight packs being supplied for each product. Additionally, any changes must work for both means of delivery and cannot be altered by said couriers.

Primary Metric - 'Error' in this context is a complaint from the customer regarding any damages or delays caused through the discussed process or downstream of this process. The KPI of this primary metric is the percentage error per production week.

Any stakeholders through any change must be included for a successful change to be adopted and maintained. If not, when the operation settles into a new routine, the processes are sure to slip back into traditional habits. In this project, these people have been identified as the customers, and operators whom any change will affect, and those managers and administrative team members who oversee the processes must be involved in any changes which are proposed, along with any data-gathering exercises.

2.3 High-Level Process Mapping

Figure 1 is a high-level process map exploring the packaging process as initially defined for the packaging process. The process map is bounded by the scope of the project, which can be considered through the DMAIC process. The inputs and outputs of the value stream map feed from other processes within the company to the customer, and the invisibility of the process when using 3rd party couriers.

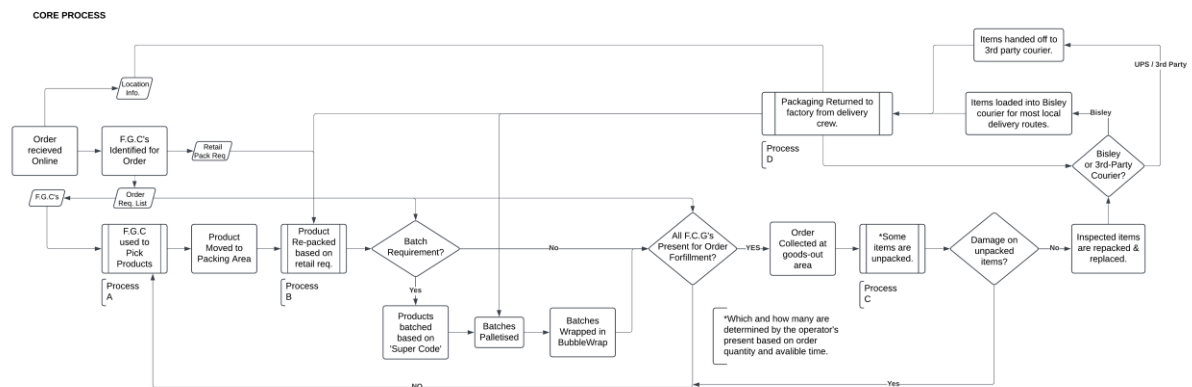


Figure 1 High-Level System Value-Stream Diagram

2.4 Initial FMEA

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detect	RP N
'Finished Goods' Gathered from stores	Item not available	The order is unable to be fulfilled	8	Production delay upstream	4	Scheduling and shortage sheets	1	32
	Incorrect item picked	Process repeated	7	Product label not present	2		2	28
	Item damaged	Process repeated	8	Forklift catches product	1		3	24
Product Re-packing	Bubble wrap runs out	Process Delayed	4		9		1	36
	Insufficient Labour time	Process Delayed	7		3		6	126
	Can't access the finished product	Additional Waste (Motion)	7		8	Front-to-back arrangement	4	224
	Banding snapped	Repeat process	3	Lifting from strapping	7	-	7	147
	Incorrect Structuring	Inconsistent process	5	Undefined packing material	7		5	175
Product Palletised	Pallets not returned	The pallet needs replacing	6		3		2	36
	Pallet worn	Pallet needs replacing	5	General Wear & Tear	8		3	120
Order collected in goods out	Fault / damage found	Process repeated	7		2		1	14
	Wagon / delivery vehicle not arrived	Process Delayed	6		1		1	6

	Product not available in time	Process Delayed	8		7		6	336
Product Delivered to customer	Damage via Bisley Courier	Customer dissatisfaction	8		2		5	80
	Damage via External Courier	Customer dissatisfaction	8		9		7	504
	Delivery not on time	Customer dissatisfaction	5		4		4	80

Table 1 Initial FMEA Failure Modes Definition

3 Measure

Any data collection plan needs to account for all three KPI metrics established in the define phase.

Together, these will provide a rounded measure of the system's state. The primary metric, the percentage of damaged goods reported from transit, will be gathered through measuring the replacement and refund data, along with reported courier breakages. In order to explore the system's capacity, it will be necessary to measure the process directly.

3.1 Cycle Timing

Multi Fixed Height Desk	Time 1	Time 2	Time 3	Time 4	Time 5	Avg. Time	Cumulative Avg. Time (s)	Comments
Product Re-packing	164	202	189	176	211	188	188	Bulky items and complex re-packing requirement, surrounding product with packing peanuts
Product batched	74	92	374	84	98	87	275	Product found to have been packaged wrong, this required stripping off the packaging a repeating previous step
Products Palletised	52	68	65	57	47	58	333	
Stretch & Bubble Wrapped	213	173	283	617	193	216	549	Manual process without any automation. Awkward rolls of pre-inflated bubble wrap. Delay - end of roll
Order moved to goods out	31	49	36	42	31	38	587	Faster process due to utilisation of pallet trucks.
Unpacking	86	41	27	52	39	49	636	random selection, inspecting every 10th item due to high rate of complaints
Inspection	34	10	37	20	25	25	661	
Rowan Midi	Time 1	Time 2	Time 3	Time 4	Time 5	Avg. Time	Cumulative Avg. Time	Comments
Product Re-packing	0	0	0	0	0	0	0	Items doesn't have any additional requirements. Low reported damage rate
Product batched	34	52	23	44	39	38	38	
Products Palletised	35	14	12	17	13	18	57	
Stretch & Bubble Wrapped	163	139	112	142	151	141	198	Manual process without any automation. Awkward rolls of pre-inflated bubble wrap.
Order moved to goods out	41	30	29	33	26	32	230	
Unpacking	94	102	82	117	88	97	326	
Inspection	18	778	25	22	31	175	501	Product was found to have damage, process repeated.
Note Ped	Time 1	Time 2	Time 3	Time 4	Time 5	Avg. Time	Cumulative Avg. Time	Comments
Product Re-packing	123	174	145	131	155	146	146	
Product batched	0	0	0	0	0	0	146	Shipped as single item, requiring no other goods to be shipped with item.
Products Palletised	21	28	35	19	26	26	171	
Stretch & Bubble Wrapped	0	0	0	0	0	0	171	
Order moved to goods out	26	31	68	29	41	39	210	
Unpacking	47	42	24	37	28	36	246	Small, easily handled product is quick to unpack
Inspection	24	17	27	20	22	22	268	

Table 2 Table of Cycle Times Collected

The cycle time per item is an important metric for understanding the efficiency of the process. This data must be recorded and presented by the product. Some products, as mapped out in Figure 2, require additional packaging, checks and palletisation. As such, any recording of cycle time must adjust for these inconsistencies. The cycle time for a given item is defined as the period for the item to pass from the start to the end of the process. However, as this project will focus on the efficiency of processing the items ready for delivery, the cycle time measured as part of the project KPIs will focus on the time after the finished goods have already been picked from storage.

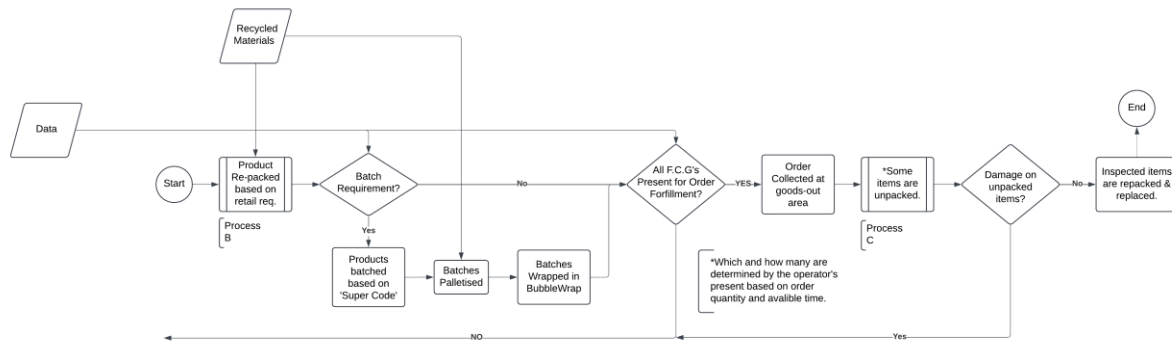


Figure 2 Process Map of Cycle Time Measurements

The 'count' or 'instances' of rework per week is an extension of the primary metric. This measure will include any rework caused by errors discovered in-house before the product has left the site, as well as requirements for replacement products needed due to customer-reported 'errors'. This metric will help track the effectiveness of the quality control systems in place by comparing the difference between total 'errors' or rework with that solely reported by the customer.

Finally, a crucial metric to keep track of regardless of project type, scope, goals or complexity is safety incidents. This should always be zero, no matter what changes are proposed/implemented and the state of the other KPIs. If there are any instances of this KPI, it is a priority to investigate the causes and effects, integrating improvements into the conclusions drawn from any other data.

3.2 Courier Data Collection

COURIER	Count		PRODUCT TYPE	Count
BISLEY VAN	6		DESK	228
BJS	29		Filing Cabinet	397
DPD	10		MultiDrawer	346
FURDECO	1348		Multiple	615
UPS	232		Accessories	119
UNKNOWN	288		Other Storage	168
			Pedestal	40
			Total Count	1913

Figure 3 Courier Raw Recorded Data

Figure 3 is the collated data on couriers for the period between August 2021 and March 2025. The reported count of failures falls within a total of 27,600 orders. This data therefore records that 6.9% of orders had some form of failure to deliver on time and in full associated with them. The figures listed are a summary of the quantifiable aspects of the recorded for data recorded relevant to the project for each incident of failure. Other information recorded included product codes, the conclusion of the incident and the cause of the incident as reported by the customer.

Incidents with causes including "item no longer wanted" and "website error" have been excluded from this dataset; the reasoning is that these types of problems are not the fault of the process and are outside the scope of this project, respectively.

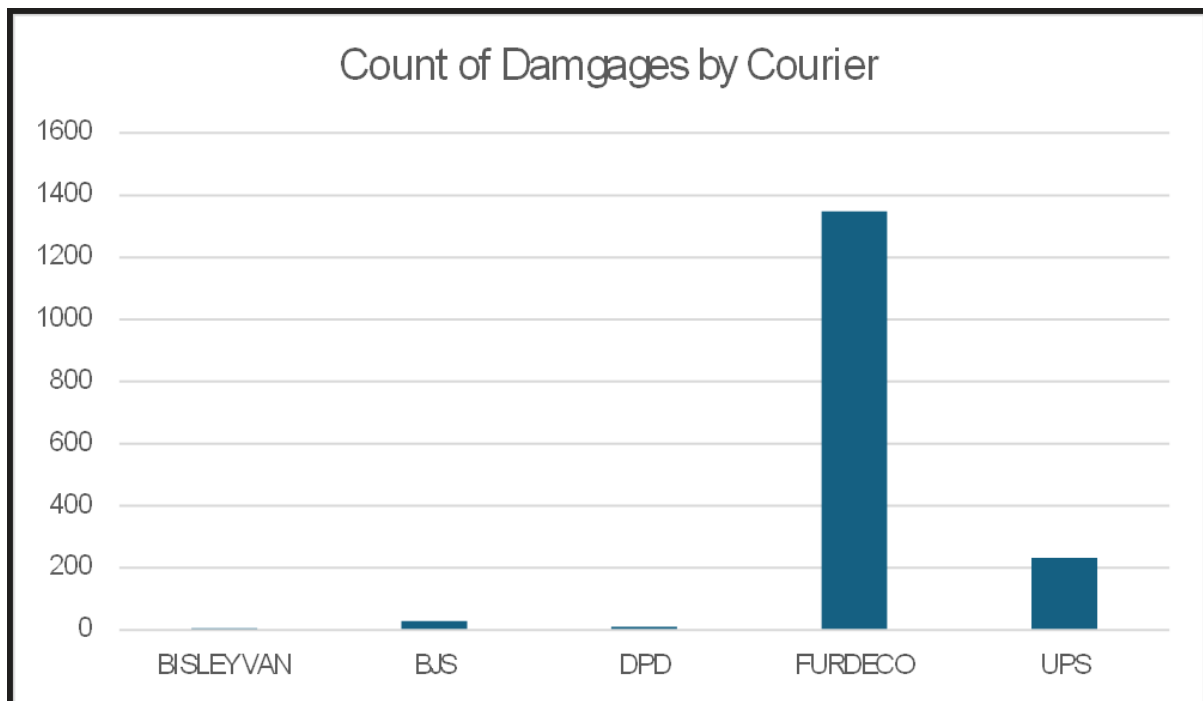


Figure 4 Bar-Graph of Damages count by Courier

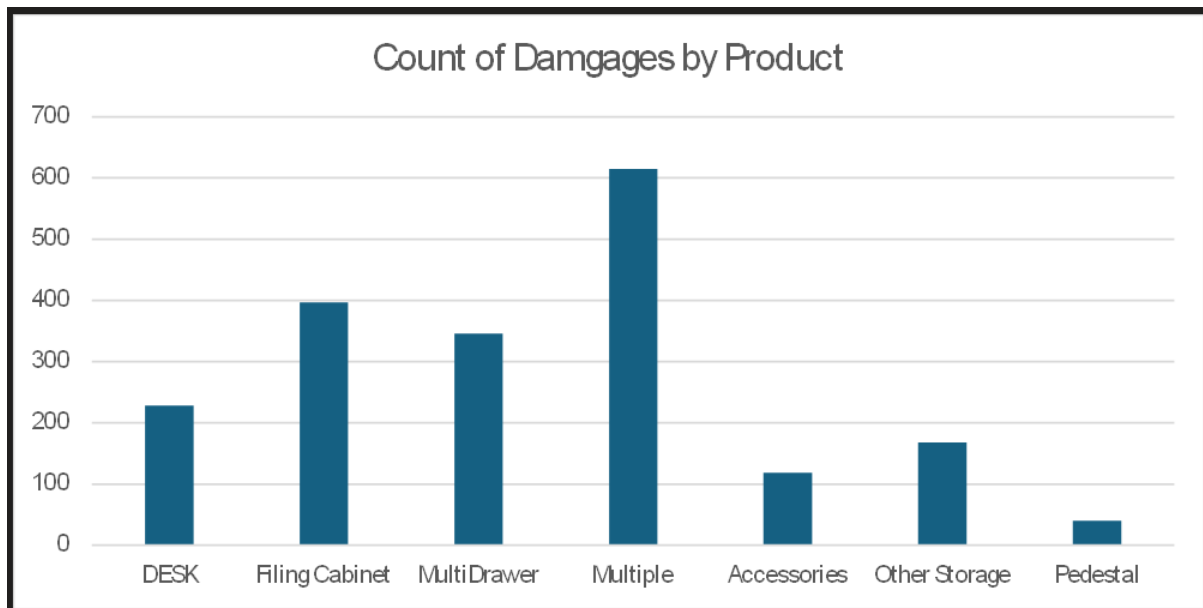


Figure 5 Bar-Graph of Damage Count per Product

As shown in Figure 4, the count of damages by DPD, BJS and by internal couriers. The main faults lie with Furdeco and, to a lesser extent, UPS. Between these two couriers, 97.2% of all confirmed, courier-only damages and delays are caused. Of the total damages over the period, 1611 (84%) were some form of damage. The remaining errors were incidents of late delivery, incorrect delivery or incorrect items being delivered. These damages required rework to be undertaken to replace the items damaged. These damages were broken down as follows:

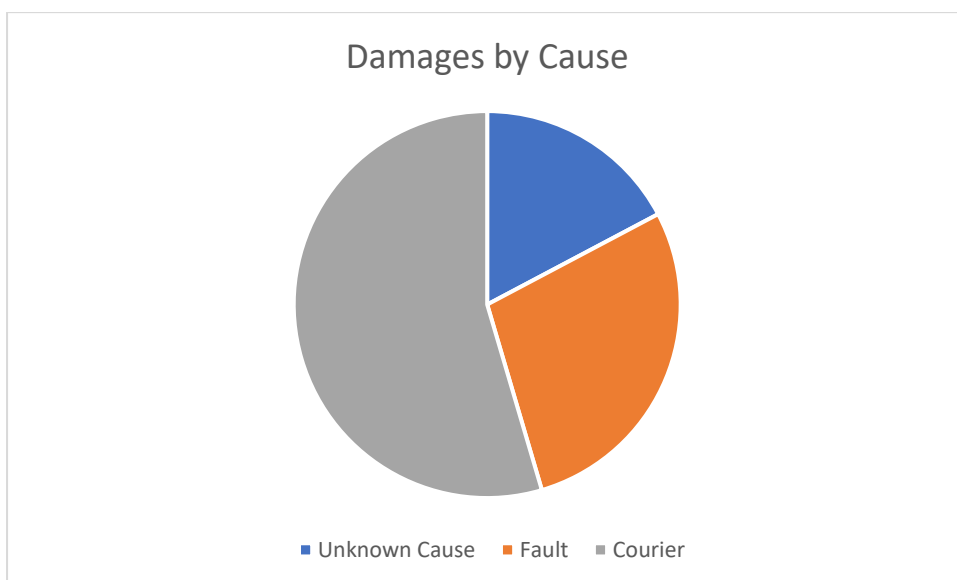


Figure 6 Damages by Cause

3.3 Voice of the Customer Qualitative Data

In addition to these quantitative measures, it is also key to include some measure of qualitative feedback from the customer. These will help fine-tune any conclusions made throughout the project by comparing individual customer experiences with those concluded through analysis of numerical measures.

Date	Feedback type	Comments
06/12/2025	Email	I do know that the delivery driver parked in the wrong street, was on his own so carried it with no assistance when it's clearly not a one man job, and had to separate the packages in order to make the long journey from the van - he did not want to move the van closer to the delivery address. So the packaging was fairly sketchy at this point. The whole thing took such a long time that I signed for it as by this time had been standing around for 20 minutes waiting for this to unfold and I was in a work meeting at the same time.
23/01/2025	Email	Images provided of disintegrated boxes and damaged desktops.
20/01/2025	Email	I've attached images (all in one document due to uploading restrictions) of the damage to two separate corners of the Rowan Maxi wardrobe, the packaging has clearly been extremely wet during transport causing it to disintegrate & the product's protection has been removed, leading to both corners being damaged. This wasn't noticed during delivery, but when inspecting the items we not only noticed this, but also realised that the same corners have gouged the flooring since the product has been dragged across it when the delivery company brought it into the selected delivery room (images also attached).
07/01/2025	Email	Thanks for you help just now on the phone. Please find attached pictures of the delivery and the scratches. As I said both units have 1 long scratch across the top of the unit which I assume has been made when opening the packaging by the delivery people - they did note there was a lot of packaging, so thank you.
24/10/2024	Email	1. Firstly, I am pleased to confirm that the replacement filing cabinet arrived in good condition and that the delivery service provided by MPS Services was very satisfactory. I inspected and took photographs of the packaging before the contents were removed and there was nothing untoward to report. 2. However, as we were unpacking the largest and heaviest box we saw that it contained an oak veneer back panel in addition to the two wardrobe doors. We were not expecting the back panel, but I assume that it was intended to provide protection/support for the new doors. We had to flip the carton by 180 degrees to remove the doors as, when we initially laid it on the floor, we realised that the oak panel was on top. While doing so one of the doors slipped against the other. Unfortunately, one of them was badly scraped by a sharp corner on the other in the process. I think that this would not have occurred had each door been separately wrapped either in light cardboard or other protective wrapping. Instead, they were laid side by side on top of the

		oak panel with two large thin cardboard sheets separating the doors from the panel. The upshot is that we cannot use even the undamaged door as the paintwork is a different shade to that on the original wardrobe doors and drawer. I attach some photographs by way of evidence. There was no point in opening the carton containing the replacement drawer.
19/08/2024	Email	Unfortunately I am contacting due to serious issues with our products we received last week. Firstly, 2 panels arrived extremely damaged. We didn't notice this until we constructed the wardrobes over the weekend. Please see attached photos. The packaging of one of the boxes was completely ripped open in the van, so presumably this happened during transit.
08/10/2024	Email	I have photos of the damaged packaging, but this form only allows me to upload one photo.
26/08/2024	Feefo	Although my Bisley 29/39 'chalk' multi-drawer had been well wrapped for transit to me, while unpacking it I discovered a small but significant dent on one side of the unit which would have been there when despatched. While this fault didn't prevent the normal use of the unit [By standing the offending part alongside another unit - bought some years earlier - I've been able to make the dent less noticeable] I firmly believe the unit should not have left the factory in that condition and should have been picked up by diligent quality control
15/08/2024	Feefo	Very well packed but company let down by delivery company. Great product, delivery service very poor.

Table 3 Customer Feed-back Random Selection Table

4 Analyse

A variety of data visualisation techniques are crucial in understanding the information collected during the measurement phase. The different areas in which data has been collected will be measured individually and finally compared through the lens of a root cause analysis in order to achieve a clear picture from the measure phase.

4.1 System Timings

Here, each product will be considered individually since each product has independent factors affecting the timing, and they cannot be cross-compared directly.

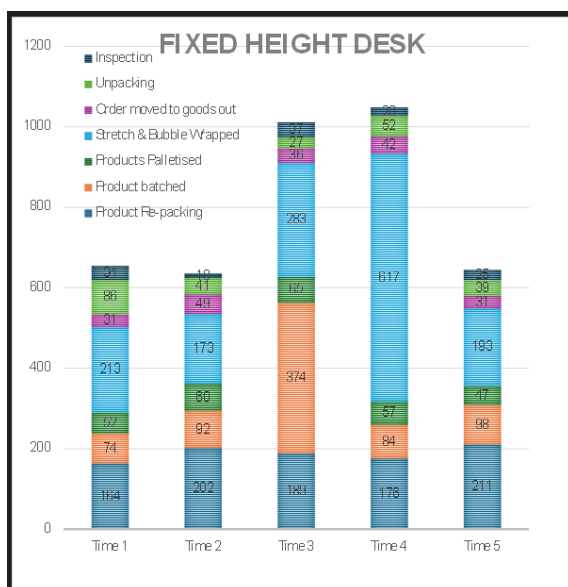


Figure 7 Graphs 7a, 7b and 7c showing process timings

Above in figures 7a, 7b and 7c, several charts display the timings collected in the measure phase, broken down to each stage in the process, where the overall time in the process is the combination of each stage.

For the fixed-height desking product, the 3rd and 4th items had significant variations due to two different issues encountered during the process. Both were due to issues encountered with the application of packaging. The first issue during the third run was due to the finished goods packaging, or 'house detail' packaging, being reapplied incorrectly. The second error was due to the roll of packing material running out and the operator having to retrieve another. These rolls of bubble wrap are inflated through a machine on the other side of the packing area, which greatly increases the delay. During the observation of the fixed height desking going through the system, this product has the greatest variation and number of delays. The Timings for this product are the most volatile. These volatilities can be attributed to the number of stages this particular product has and the method by which it is packed, having to be palletised and bubble-wrapped. The complexity has left the process vulnerable to stoppages.

Second is the Rowan midi product. The general variation in the process for this process is much better than the fixed height desking, however, damage was found on one item, and it needed to be packed twice. This particular problem isn't product-specific, however, and happens across all the product ranges occasionally. Similarly, the 'note pedestal' has very limited variation. The largest time cost for the Rowan Midi and the Note Pedestal is the palletising and wrapping portion of the process.

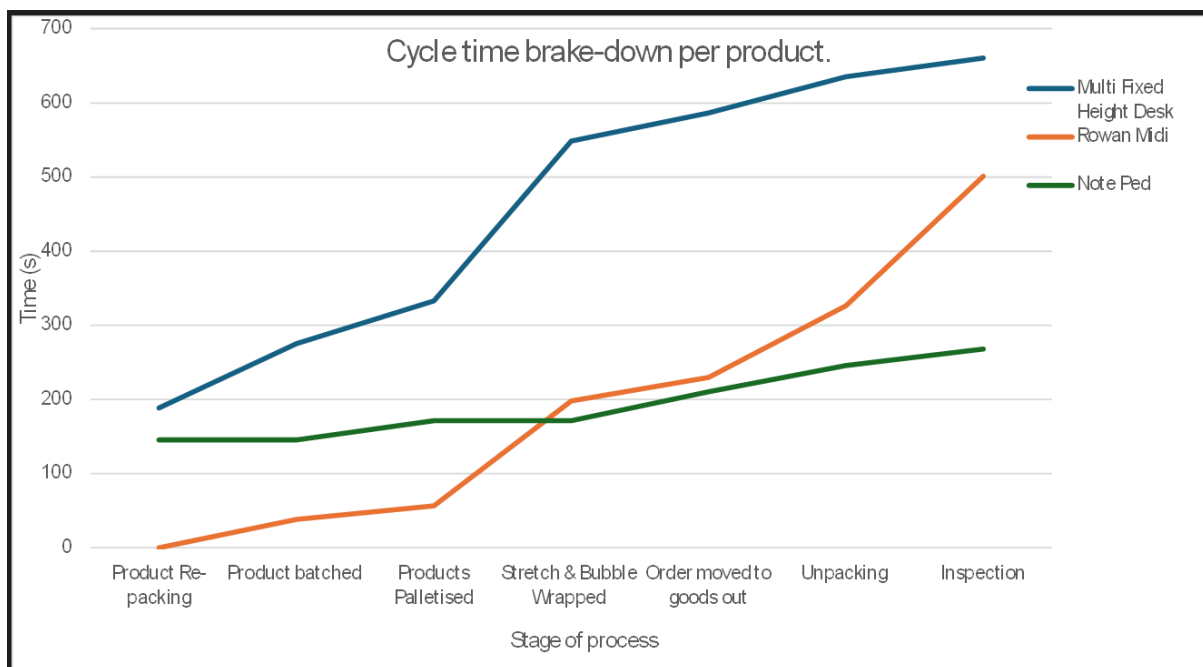


Figure 8 Cycle Cumulative Time Graph

4.2 Capability & Cost-benefit Analysis

Further to the data collected on the courier system, we can use a capability analysis to better understand the recorded failures in the process.

Defects Per Million Opportunities (DPMO) is a metric within this analysis, representing the number of defects expected in one million opportunities for defects to occur during production. Aiming for a Six Sigma level, processes strive to achieve a DPMO of 3.4. This value is agreed to denote a very high standard of quality with very few defects (Bueno et al., 2020; Kakaei-Lafdani et al., 2021). Within this process, the goal was to achieve 1 % failures within the model, which would translate to 623 DPMO as shown in equation 2.

$$DPMO = \frac{D}{N \cdot O} \cdot 10^6$$

Equation 1 Defects per Million Opportunities Formulae

$$\left(\frac{76}{7627 \cdot 16} \right) \cdot 10^6 = 622.7874656$$

Equation 2 1% DPMO Target Calculation

1913 faults / 3.6 year period = 528 faults per year

27647 deliveries / 3.6 year period = 7627 yearly deliveries

We can define the 'unit' (N) as the number of deliveries and the 'defects' (D) as the occurrence of faults. Therefore N = 7627 and D = 528. The 'opportunities' (O) in the capability analysis are defined as the number of chances/opportunities for the process to fail in each cycle. To measure this, we can consider each operation in the process map to have a possibility for failure, and so our opportunities per unit are 16. The value shown in equation 3 will be used as a metric to track the improvements to the system over time and through the course of the control phase, should stabilise below the stated KPI goal (623 DPMO).

$$\left(\frac{528}{7627 \cdot 16} \right) \cdot 10^6 = 4326.733971$$

Equation 3 Current State DPMO Calculation

Over the period between August 2021 and March 2025 the total orders were valued at an estimated total of £8,260,000, which averages out at £2,280,000 per annum. Over the same period, the total value of the orders that had verified complaints against them was £600,000, with a total complaint value of £182,277. Of this value, some of these faults were refunded, and some were replaced. These values are slightly higher than the 6.9% fault rate, which has been measured for the number of orders alone. This suggests a bias towards failing on larger value orders over single or low-value items, something supported by the damages breakdown by product, where the biggest group was orders with multiple items shown in Figure 5 previously.

Within the cost-benefit analysis, in Table 4, the assumption has also been made that any changes to the work area would take a week, generating a loss of a week's worth of revenue.

ITEM	COST	BENEFITS	TOTAL SAVINGS (FIRST YEAR)
MAN-HOURS INVESTED IN PROJECT	-£ 2,800.00		-£ 2,800.00
REFUND COSTS ONE YEAR AVERAGE		£ 58,200.00	£ 55,400.00
EST RE-WORK COST		£ 62,000.00	£ 117,400.00
EST SHUTDOWN COST TO RE-MODIFY WORK AREA	-£ 43,500.00		£ 73,900.00
			£ 73,900.00

Table 4 Cost-Benefit Analysis Calculation

Pareto analysis shown in figure X highlights the most significant factors contributing to potential failures in the process; it also shows the 'significant many' lies to the right of the 80% line, the most notable of which include damages by internal couriers and the product not being available when the courier arrives. The most notable issues identified by the Pareto analysis are:

- Damages caused by external couriers. This appears to be a major contributor to failures.
- Product not available when the courier arrives.
- Compliance improvements are suggested as a potential area for investigation, specifically concerning snapped banding, which is reported as a common cause of stoppages and rework.
- Poor layout is also highlighted as a major contributor, leading to work being batched in the area.

The Pareto analysis suggests that these issues will need to be the primary focus of future improvements in the next phase of this project.

Drawing on the information from the measure and analysis phases, root causes can be ascertained and key factors contributing to the operational challenges in this part of the business can be laid out ready for the next step in the DMAIC process.

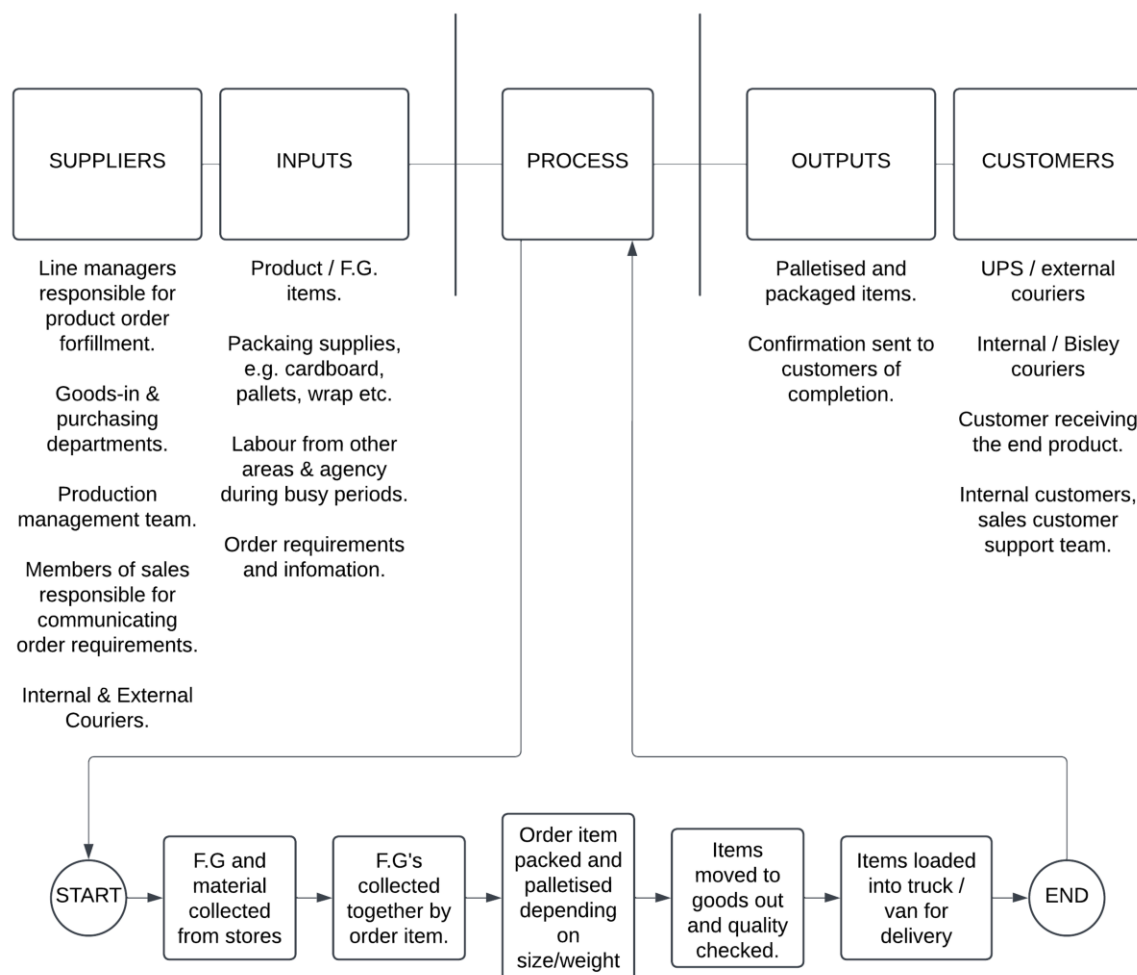


Figure 9 SIPOC Analysis of Internal Process

A significant root cause is inefficiencies and inconsistencies within the product re-packing process. The project charter identifies that the current process lacks defined flow and measured procedures, leading to an ad-hoc operation where each item is dealt with individually. This lack of standardisation is evidenced in the system timings analysis, where the fixed-height desking product experienced significant variations and delays due to issues such as incorrect application of 'house detail' packaging and running out of materials around the operators. The operator having to retrieve more bubble wrap

from another area highlights the sub-optimal layout and potential for unnecessary motion, which will be a key lean waste to tackle in the improvement phase.

Furthermore, the analysis of courier data points to **external couriers, specifically Furdeco and UPS, as a major source of product damage and delivery delays**. This suggests that while Bisley might be improving its internal processes, the handling and transportation by these external parties remain a critical area needing attention. Qualitative customer feedback corroborates this, with reports of disintegrated boxes and damage occurring during transit, sometimes compounded by the delivery drivers' handling methods. The Pareto analysis reinforces these findings by identifying damages caused by external couriers and the product not being available when the courier arrives as significant contributors to failures.

Snapped banding during palletising is also highlighted as a cause for repeated processes; this particular issue represents an area in which process optimisation and the application of standard work sheets might be applied to address shortcomings. Customer feedback, alongside the primary metric data, strongly suggests that the current packaging is inadequate for the handling and conditions encountered during external courier delivery. The cost-benefit analysis further underscores the impact of these root causes by highlighting substantial costs associated with refunds and rework. In summary of the above analysis, the root causes as discovered by this project can be laid out as:

1. Damages caused by External Couriers:
 - Insufficient Packaging for External Transit
 - Handling by External Couriers
2. Product not being available when the courier arrives:
 - Inefficient Internal Processes Leading to Delays
 - Potential Issues with Scheduling or Shortage Sheets
3. Compliance Improvements (Design Structures and Snapped Banding):
 - Weaknesses in Design Structures
 - Issues with Banding Materials or Application
4. Poor Layout Leading to Work Batching:
 - Inefficient Arrangement of Workspace

5 Improve and Control

5.1 Process Improvement

The layout of the workspace was identified as a key area to improve flow and remove bottlenecks from the process. In order to decide on a new floor plan, it's important to design the workflow to remove paths where the work doubles back on itself during movement.

Currently, the work moves through the system by manual lifting and a pallet truck. Placing items on rollers, at floor level, could remove the issues with bottlenecked work areas in two ways:

- Work placed directly onto rollers once complete reduces product waiting.
- Work moved by rollers reduces manual time and, therefore, the cost associated with having to transport the items across the production area.

This change would aim to tackle waiting, motion and inventory, which are elements of 'waste' according to lean methodology. (Kianian & Larsson, 2015). In order to prove this, a trial should be run to find the time-saving benefit associated with such a change in order to fully examine the cost-benefits of this change.

In this new process, cameras positioned around the de-packing area during the packaging change-over phase can record the product's condition as it moves past the quality check, providing proof it left the factory in a good condition for every individual item and removing the need to unpack the products before they leave.

Improvements around damages by external couriers could be mitigated by changing couriers or specific routes. The majority of damages happened during transit with Furdeco, and so steps could be taken in the immediate future to address these problems in the short-term. Additional protection could be added to packages being sent via this courier. Packages with less chance of being broken, i.e. packages with the lowest damage rates, should be prioritised for being sent through Furdeco unless absolutely necessary.

Additionally, there is a major cross-over between deliveries of multiple items, and damage. However, this may simply be due to the fact that more items are on each individual delivery, and so there happens to be a bigger baseline chance of damage being discovered on one of the items. As such, a trial of splitting some deliveries up should be considered to explore if this is correlation or causality. As a long-term control, it should be explored whether continuing to use Furdeco as a courier is the best choice.

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	O c c u r	Current Process Controls	D e t e c	R P N	Recommended Action(s)	New Potential Failures	Expected RPN			
											S e v	O c c	D e t	R P N
'Finished Goods' Gathered from stores	Item not available	Order unable to be fulfilled	8	Production delay	4	Scheduling and shortage sheets	1	32	-	-	8	4	1	32
	Incorrect item picked	Process repeated	7	Product label not present	2	-	2	28	-	-	7	2	2	28
	Item damaged	Process repeated	8	Forklift catches product	1	-	3	24	-	-	8	1	3	24
Product Re-packing	Bubble-wrap runs out	Process Paused	4	Insufficient material on hand	9	-	1	36	-	-	4	9	1	36
	Insufficient Labour time	Process Paused	7	Insufficient labour on hand	3	-	6	126	-	-	7	3	6	126
	Can't access finished product	Poor arrangement	7	Current layout of production area	8	Front-to-back arrangement	4	224	New layout, moving product through the process in one direction	-	7	3	4	84
	Banding snapped	Repeat process	3	Lifting from strapping	7	-	7	147	Loading exclusively using pallet jack	Product can fall from height	4	2	7	56
	Incorrect Structuring	Inconsistent process	5	Un-defined packing material	7	Material picked based on requirements	5	175	Quality requirement to match specified materials	Quality failure due to additional requirements	5	7	1	35
Product Palletised	Pallets not returned	Pallet needs replacing	6	Couriers not returning material	3	-	2	36	-	-	6	3	2	36
	Pallet worn	Pallet needs replacing	5	General Wear&Tear	8	-	3	120	-	-	5	8	3	120
Order collected in goods out	Fault / damage found	Process repeated & product scrapped	7	Product Dropped or Product Faulty	2	Product checked before packing	1	14	-	-	7	2	1	14
	Wagon / delivery vehicle not arrived	Product cannot be sent on time	6	External factors	1	-	1	6	-	-	6	1	1	6
	Product not available in time	Product cannot be sent on time	8	Accumulated above delays	7	-	6	336	Cumulative improvements snapped banding, pallet jack etc	-				0
Product Delivered to customers	Damage via Bisley Courier	Customer dissatisfaction	8	Damage in transit	2	-	5	80	-	-	8	2	5	80
	Damage via External Courier	Customer dissatisfaction	8	Damage in transit	9	-	7	504	Replace Furdeco with other couriers	Worse courier coverage	8	3	7	168
	Delivery not on time	Customer dissatisfaction	5	Accumulated above delays	4	-	4	80	-	-	5	4	4	80
TOTAL						1968				TOTAL 925				

Table 5 Second FMEA with Stated Improvements

ITEM	COST	BENEFITS	NET SAVINGS (4 YR)
ROLLERS @ £241.6 PER MTR	-£ 4,831.46		-£ 4,831.46
LINK			
25% PACKAING COST ADDITION FURDECO	-£ 4,600.00		-£ 9,431.46
TP-LINK CAMERA x3 + 3 DAY SETUP	-£ 588.00		-£ 10,019.46
ROWAN MIDI ELIMINATED CHECKS (TIME)	£ 1,092.50		-£ 8,926.96
PRODUCT MOVE TO GOODS OUT ELIMATED (TIME)	£ 4,370.00		-£ 4,556.96
FURDECO REDUCTION TO 2% DAMAGES (SHORT-TERM)	£ 8,005.00		£ 3,448.04

Table 6 Second Cost-Benefit for Considered Improvements

In order to better control the process in the future, new standard work must be implemented using improved factory layouts and the application of technology to remove work content. Using this system of rollers to move product through the process also has the added benefit of significantly reducing the amount of manual-handling going on with the product from the dressing area to the goods-out area. This has the dual improvement of the health and safety of the operators, and effectively eliminating the risk of snapping the banding through lifting the product during its movement.

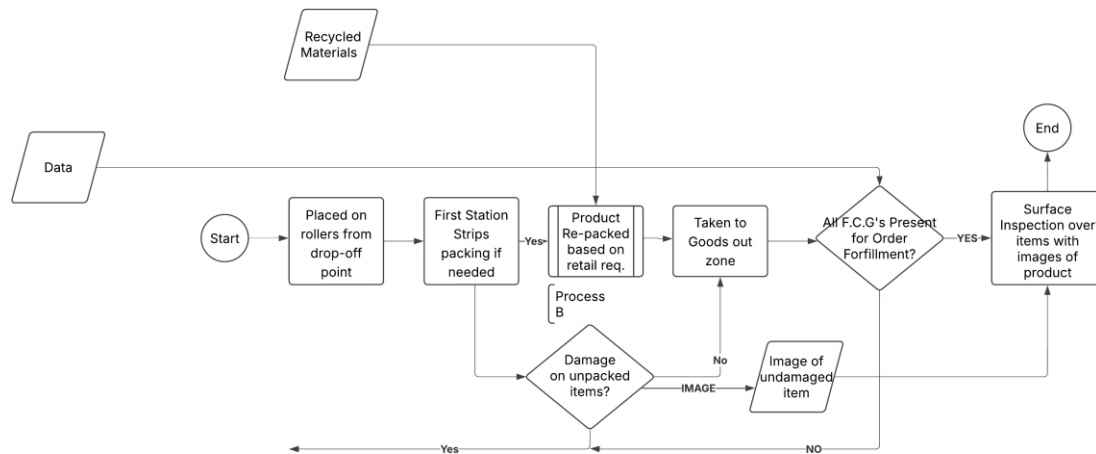


Figure 10 Process Map of Proposed Improved Process

As shown in Figure 10, the products that need to be re-packed or have packing added pass through a separate de-packing area, which records the product state. Products not requiring this step can skip being subject to a possible quality check, as they haven't had any process applied to them from leaving the final-assembly areas they originated from, and in doing so, this process has been duplicating work on items that do not need additional packaging or palletising.

5.2 Pilot Plan and Action/Response Plan

A pilot implementation would primarily be focused on an improved workspace layout by applying rollers and the proposed process map. Testing camera usage for documenting product condition would also need to be trialled, but this would need to be implemented once the process has achieved stability. New standard work procedures need to accompany layout changes (targeting <623 DPMO) and methods of continuous improvement to achieve lasting improvement. Short-term strategies for high-damage couriers, such as enhanced packaging or splitting multi-item deliveries, should be piloted, which can be done parallel to modifying the work layout.

Three major, and common, challenges to the implementation of this project need to be addressed.

First, overcoming resistance to change. The response plan to deal with this involves:

- Identify and involve the key stakeholders throughout the project. These include customers, operators, and management / administrative team.
- Communicate the benefits of the proposed improvements to all the stakeholders, such as the reduction in manual-handling due to the introduction of rollers. For management, highlight the findings from the cost-benefit analysis.

Second, any issues which could foreseeably arise from implementing physical changes (e.g., New Layout, Equipment):

- Use the cost-benefit analysis (Table 4 and Table 6) to clearly present the financial justification for the proposed physical changes, mainly the potential savings against the investment.
- Plan for the estimated shutdown cost to re-modify the work area, which was factored into the initial cost-benefit analysis.
- Conduct a trial for specific proposed changes, such as placing items on rollers, to gather data and definitively prove the time-saving benefit associated with the change before implementation.
- Design the new workflow and layout specifically to remove bottlenecks and eliminate unnecessary work paths.

Finally, the damages caused by external couriers will need to be considered as the main action point for any implemented improvement:

- Implement short-term mitigation strategies while acknowledging the constraint on directly altering courier operations. This will include adding additional protection to packages being sent via couriers.
- Conduct a trial of splitting deliveries that contain multiple items, as the data implied a bias towards failures on larger value orders.
- Continuously monitor the primary metric of percentage error per production week, gathered through tracking replacement/refund data and reported courier breakages, as well as the damage count specifically by courier, to assess the effectiveness of mitigation strategies.

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