

Digitally signed meat labels

Traceability - Primal to Steak / Steak to Primal Track 2 -
Digitally signed labels using Countermark

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1.0 Executive summary

The Australian Meat Processor Corporation (AMPC) put out a call on LinkedIn for companies that could meet the challenge of implementing 'Primal to Steak / Steak to Primal' traceability. Wessex Technology (Wessex) had already developed Countermark and offered it as a potential solution. Initial discussions between AMPC and Wessex indicated two possible solutions, Track 1 explored directly printing traceability data on to the primal while still in the abattoir and Track 2 is based on secure labels and delivery paperwork used through the supply chain. The project investigated both solutions and this report describes Track 2 – secure labels and delivery paperwork. A separate report covers Track 1 - labelling the primal.

The project shows that standard label printers and scales can be used to implement full Primal to Steak / Steak to Primal traceability. The Countermark server can generate alerts for suspicious activity and the integrity of all transactions is ensured by Ethereum blockchain.

With further enhancements, such as linking batch numbers to the Animal Identity, Countermark can provide tools for customs agencies to check content of packing cartons and assist public health officials with lists of supermarkets where meat from identified animals has been sold. Incorporating the Animal Identity also creates full 'Farm to Plate / Plate to Farm' traceability providing Consumer-friendly access and useful marketing information for the farmer.

2.0 Introduction

The purpose of the project is to evaluate if Countermark can facilitate Primal to Steak / Steak to Primal traceability of red meat in the form of primals distributed within the existing AMPC customer base including domestic and export markets.

This project will seek to address this challenge in two linked methods:

- ◆ Track 1 – By digitally signing the steaks in the Australian abattoir before they are cut from a primal elsewhere.
- ◆ Track 2 – By digitally signing every label used to control the shipment from the abattoir to the consumer and providing a web-based interface for local meat processors to use when cutting steaks from primals.

Countermark is currently used to digitally sign ISO9000 certificates, it is this inherent ability of Countermark to produce trustworthy documents, or in this case labels, that underpins the Track 2 project.

The existing Countermark system has been extended to interface to a suitable label printer and scales. Also, customised web pages were created that are used by operators implementing each of the separate primal to steak processes. The revised version of the Countermark system described in this document is called Countermark.Track2.

Information about Countermark can be found in section 9.1 and at www.countermark.com

2.1 Countermark traceability overview

Figure 1 shows elements of the Countermark.Track2 and how the different operators interact with it.

The structure of the Countermark system makes it relatively straight forward to add functionality for the farmer, customs and public health – these roles are not included in the scope of the project and can be added in the future. Abattoirs and local meat processors can vary in size and are likely to have their own existing traceability software.

The Countermark system has interfaces and reporting tools that allow data to be exported back into third party software.

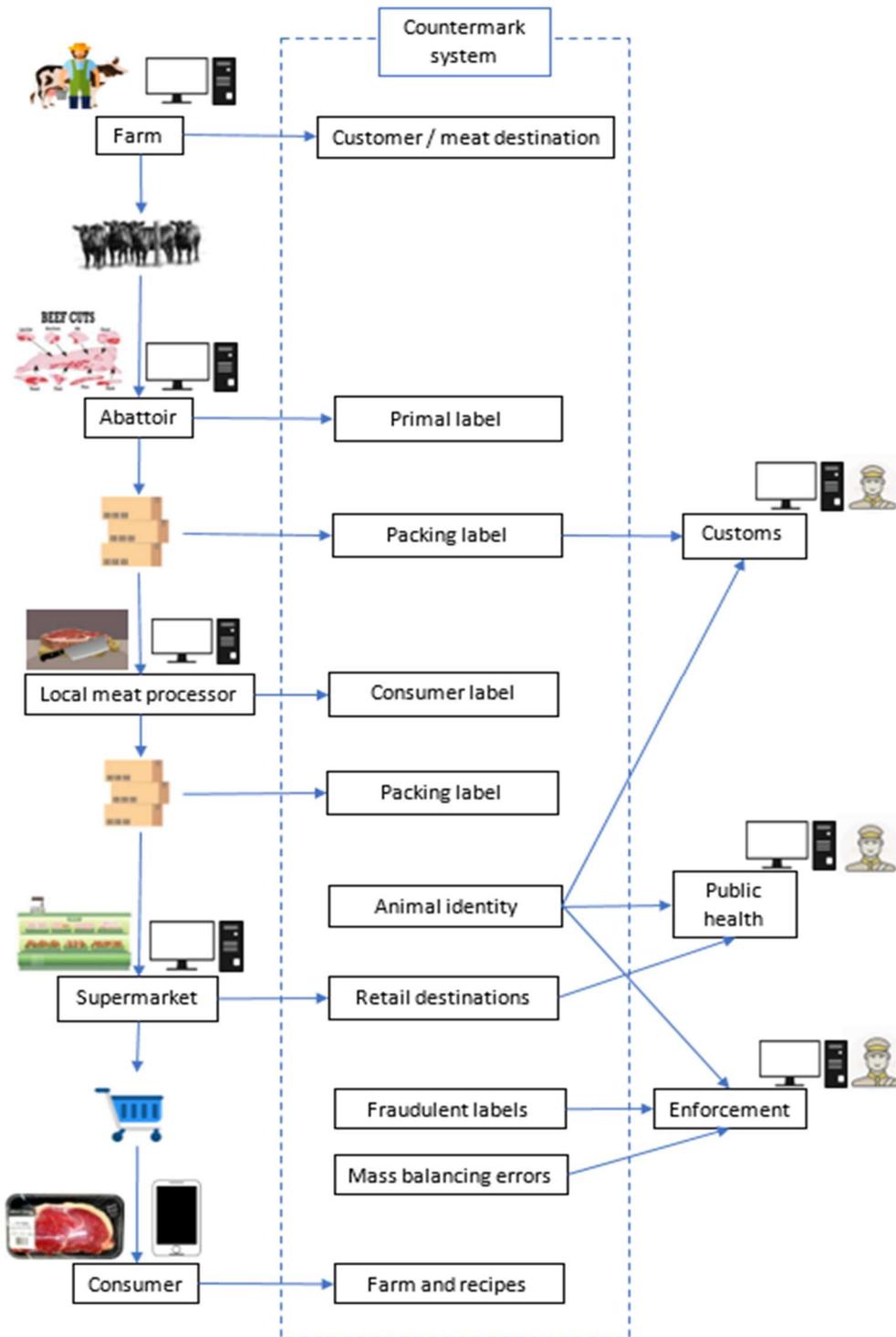


Figure 1 - Countermark Primal to Steak / Steak to Primal user roles, system elements and boundary

2.2 Track 1 – Track 2 interaction

Track 1 of this project is described in a separate report. Two items relevant to Track 2 were completed as part of Track 1 in the test kitchens at Reading University.

2.2.1 Track 2 - system test

The process of weighing, packing and receiving primals at a local meat processor and then slicing into steaks with Consumer labels was completed to confirm operation of Countermark.Track2 on real primals and steaks.

2.2.2 Track 2 – exudate measurement

The primal slicing software uses mass balancing to verify that the amount of meat cut from the primal is reasonable and never more than is possible. The total mass of the primal will include exudate and four of the primals were evaluated for the amount of exudate present - this data will inform future mass balancing controls.

2.3 The Countermark server

The Countermark system is a collection of servers and databases hosted on the Microsoft Cloud (Azure). In this document it is referred to as the Countermark server, it undertakes all Countermark activity including Countermark creation and reading, data manipulation, management and storage, archiving, backup and access control. This cloud hosted design allows the Countermark functionality to be accessed anywhere there is an internet connection.

The Countermark app is available for Android and iOS. The Countermark app needs an internet connection to the Countermark server in order to operate - all phone related data activity is done on the Countermark server.

In this application the key roles shown in Figure 1 only need internet access to the Countermark server to review data, create labels and weigh primals and slice meat. The only locally installed software is a printer and scales driver software called PrintNode (PrintNode.com, n.d.).

2.4 Acknowledgements

Countermark is proprietary technology of Wessex and is protected by patents (USA Patent No. 9010654, 2015) (Japan Patent No. 6006315, 2014), (USA Patent No. 9104936, 2015). Countermark (and the Countermark logo) is a Wessex trademark. All other trademarks used in this report are acknowledged.

The authors would like to thank (in chronological order):

- ◆ Sean Starling and Stuart Shaw at AMPC
- ◆ Declan McDonnell of ABP Foods and his team at the Ellesmere (UK) plant for the primals and the use of their test kitchen
- ◆ The teams at XACT Marking and Matthews for doing the printing and providing their printers and supplying the inkjet ink
- ◆ Dr. Sameer Kalil Ghawi, PhD, MSc, PgD, BSc, MIFST, Department of Food and Nutritional Sciences University of Reading for the use of their development kitchens and the guidance on food handling and processing
- ◆ PrintNode (PrintNode.com, n.d.) – supplier of the printer and scales interface

3.0 Project objectives

To develop and demonstrate to AMPC staff (and probably one Australian supply chain) the provider's approach to offering a cost-effective and robust Primal to Steak / Steak to Primal traceability system, within a demonstration facility (i.e. not within an active supply chain).

4.0 Methodology for Track 2

The methodology used was selected to minimise risk, cost and software development effort.

4.1 Design methods

4.1.1 Software design methodology

The software was designed using Wessex's existing design methodology which has been certified to comply with ISO9001 by LRQA with the scope "The design, supply and support of document and product authentication systems".

4.1.2 Code reuse

The extension to the existing Countermark application was based on adding new webpages and otherwise extending the Countermark system with as much reuse of existing code as possible.

4.1.3 Multilingual interfaces

Countermark system has multilingual support, with the ability to add translations of pages to create multiple language versions of the Countermark website and Countermark app; the current second language is Chinese. It was decided that the new elements needed for Countermark.Track2 would be in English but maintain the option to add further languages as needed.

It was decided that the labels would support up to two languages (the seller and the buyer). The primary language is English, the optional languages currently supported are French and Chinese.

4.1.4 Browser support

The Countermark website is regularly tested for compatibility with Chrome, Edge, Firefox and Safari. The extensions for this project should operate in these browsers and have currently been tested with Chrome.

4.1.5 Software design methodology

An Agile approach was used to develop the Countermark.Track2.

4.1.6 Software test

Software test was completed using a fully documented software test procedure at the end of each sprint in the development cycle. This formal testing allowed issues to be resolved quickly and greatly reduced the amount of software rework. The software test on real primals at Reading University (section 2.2.1) was also useful to confirm correct operation of the Countermark.Track2 software.

4.2 Actions for Track 2

The key development steps to implement Countermark.Track2 were:

- ◆ Determine system architecture
- ◆ Design Countermark protected labels
- ◆ Create database with Countermark.Track2 dependent data
- ◆ Identify suitable scales and printer
- ◆ Interface scales and printer with Countermark.Track2
- ◆ Set up a test line in an office / non-food environment possibly using wood blocks to represent primal and packed steaks
- ◆ Create new web pages for the key process stages
- ◆ Implement mass balance rules – no more steaks produced and packed than possible from a primal
- ◆ Investigate the risks of third parties intercepting the Countermarks on the Consumer packaging and reusing them.

4.3 System architecture for Countermark.Track2

Countermark.Track2 uses as much of the existing Countermark infrastructure as possible (Figure 2). The main additions are an additional database for the meat specific data, and the scales and printer connected to the internet via the PrintNode driver PC.

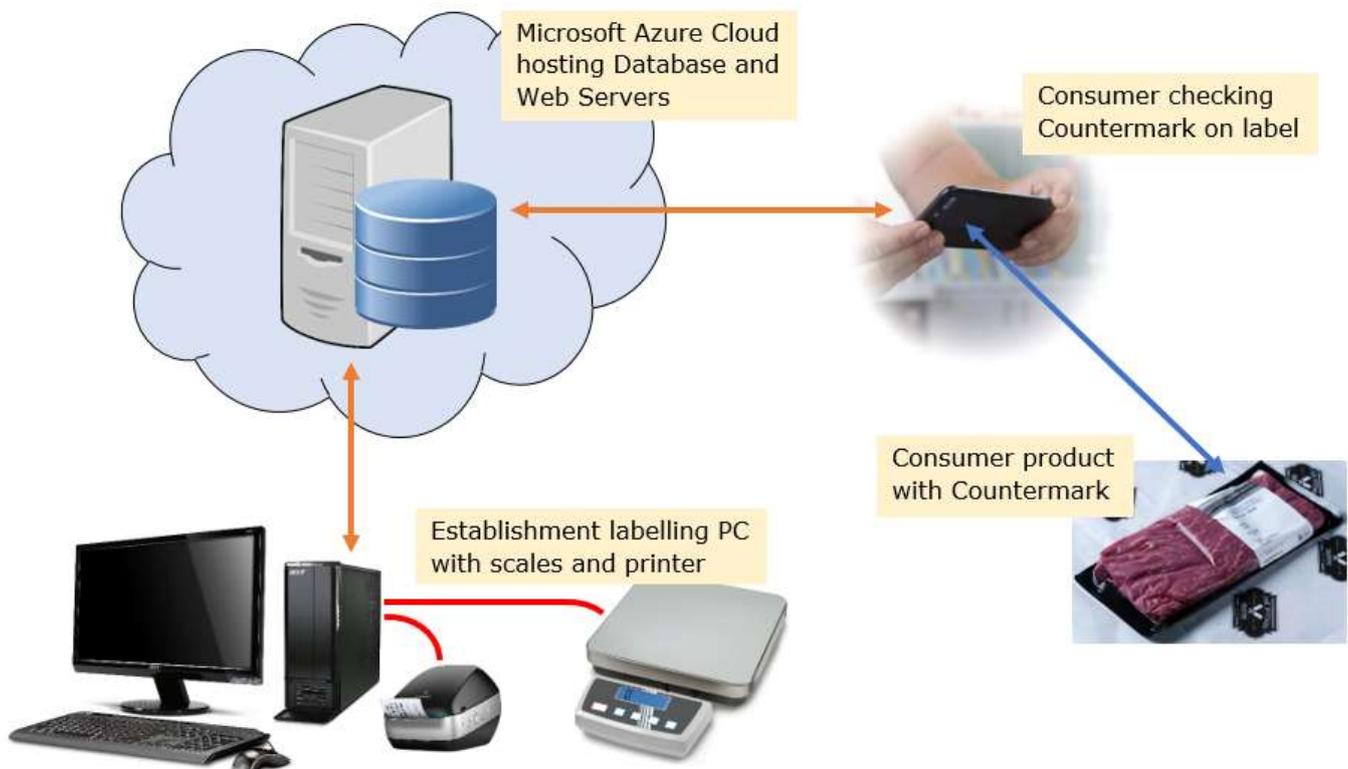


Figure 2 - System architecture

4.4 Make all labels Countermark protected documents

Countermark protects documents by storing a PDF copy of the document (or label for this project) in the Countermark server, together with other product related data such as GTIN reference (GTIN.info, n.d.), weight, use by date etc. When the Countermark on a label is scanned by the Countermark app, the Countermark app will retrieve the original copy of the label and present it with the related data to the phone user. The phone user can then compare the physical label with the copy displayed on their browser. This process is simple and easy for the Consumer to understand. This process uses existing label materials and does not require traditional security features such as secure inks, holograms or other secure document features.

The labels produced by Countermark.Track2 are stored as high-resolution PDF files. They are scaled to the appropriate size by the Windows 10 printer driver.

4.4.1 Primal label

The Primal label (Figure 3) is produced by the Countermark.Track2 system - Create a Primal page, it is based on samples provided by AMPC (section 9.2). The label shows information in two languages, Chinese and English. The

Countermark contains the data shown on the label and the Animal Identity, farm details, expiry data and the GTIN number.



Figure 3 - Primal label

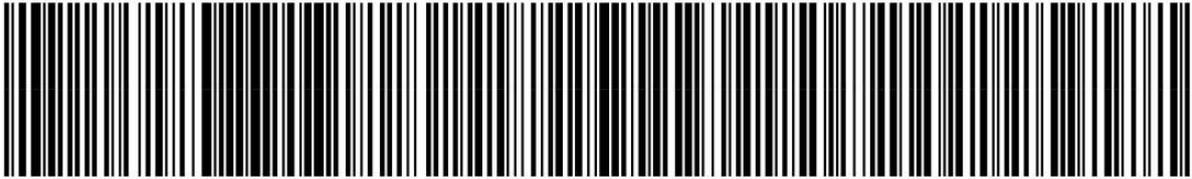
4.4.2 Packing label

The Packing label (Figure 4) is produced using the Countermark.Track2 – Create a Packing Label page and is based on the existing shipping labels provided by AMPC (section 9.2). The Countermark is present in two forms, the Countermark itself and the Countermark top row which is included in the SSCC barcode as a serial number. This means the Countermark can be accessed directly or via the existing barcode reading technology present in the

supply chain. A separate API is yet to be created to allow third parties to read the data from a Countermark using the Countermark top row extracted from this barcode.

The Packing label Countermark produces a list of all of Countermark labelled items inside the package, this can include other packing label Countermarks.

Blue Inc 蓝色公司	Destination: People's Republic of China 目的地 中华人民共和国	16970
Product of Brisbane, Australia 产品 澳大利亚布里斯班	Shelf Life 120 Days 保质期 120 天	



(01) 3165140379533 (3103) 006602 (13) 220413 (21) 4MPC-64XD-WTJ2-H7AY

<p>*A* SHORT RUMP DEN 2 RUMP 臀部 BONELESS BEEF KEEP REFRIGERATED 无骨牛肉 需要冷藏</p>	<p>IW/VAC 0°C 2PC 包装上 年-月-日 PACKED ON 2022-04-13</p>		<p>批号 BATCH NO. 79130422 TIME:13:54 工厂注册号 EST. 237 6.60kg 14.55lb NET WEIGHT 净重</p>	
--	--	--	---	--

<p>4MPC-64XD-WTJ2-H7AY 6SUL-X320-YKA1-F9D9</p>	<p>如果冷冻自生产之日起 24 个月到期 If Frozen Expiry 24 month from Date of Production</p>	<p>WL0004A</p>
--	---	----------------

Figure 4 - Packing label

4.4.3 Consumer label

The Consumer label (Figure 5) is produced using the Countermark.Track2 – Create a Consumer Label page and is based on a sample of consumer labels found in the UK (section 9.2). The Primal Label Countermark is used to access relevant data for all consumer labels for steaks cut from that primal. This web page also checks the weight of the primal and prevents operators at the local meat processor producing more steaks than is reasonable for the weight of the primal.

A Consumer checking the Consumer label Countermark will get a link showing the farm data, and a link to the primal information.



Figure 5 - Consumer label

4.5 Create an additional database

It is anticipated that in later iterations of the Countermark.Track2 software some of the data for labels and traceability will originate from third party systems. A small database was created to hold this information for this stage of development. External interfaces to other data systems are not included in this project.

The data tables needed for Countermark.Track2 are shown in Figure 1Figure 6.

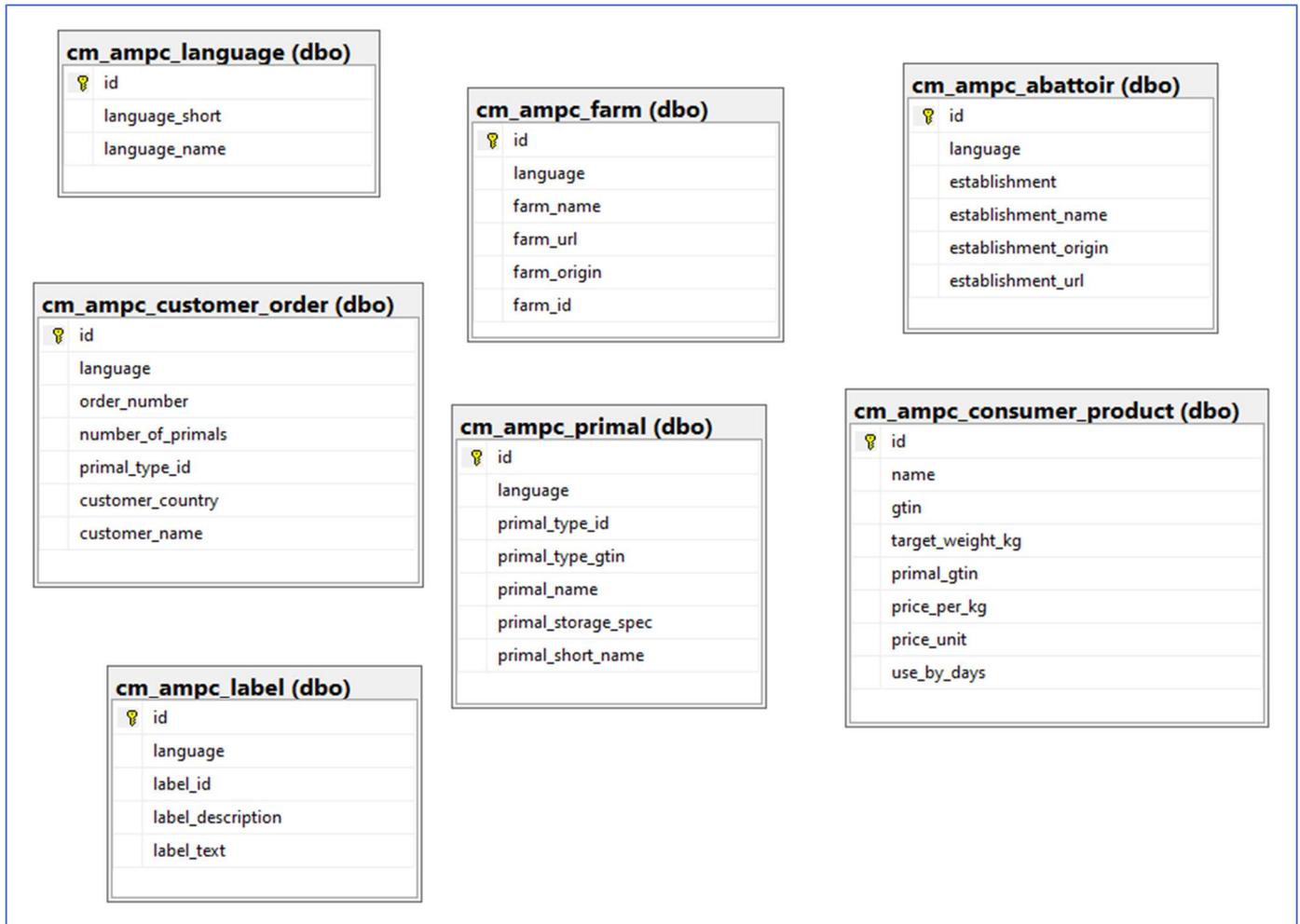


Figure 6 – Countermark.Track2 database tables

4.6 Select scales and labelling equipment

4.6.1 Scales

Industrial scales were investigated to determine the types of computer interfaces that were available. The most common types are RS232, USB and Ethernet. The majority were RS232 interfaces, presumably for ruggedness and ease of interfacing with older industrial equipment.

Model DE12K1A (Figure 7) from Kern (kern-sohn.com, n.d.) was chosen for the development and demonstration part of the project. It was connected via the RS232 port to the host PC (an HP desktop). It was also connected to an HP laptop using an RS232 to USB adaptor.



Figure 7 - Kern scales DE12K1A

4.6.2 Printer

A simple label printer with a wide choice of labels was needed to allow generation of the different size labels required (small Consumer labels up to the larger Packing labels). A Dymo (Dymo.co.uk, n.d.) LabelWriter printer (model 400 (Figure 8)) was used as it is considered suitable for this demonstration.

The printer considerations are:

- ◆ Resolution – minimum of 300dpi
- ◆ Label size – appropriate for task (packing label 160mm by 100mm has been used for this study)
- ◆ Windows driver – required
- ◆ Suited to a meat processing environment



Figure 8 - Dymo LabelWriter 400

4.7 Interface scales and printer with Countermark.Track2

For the selected architecture, the system needs to be able to read scales via the internet. A third-party package from PrintNode (PrintNode.com, n.d.) was used as it provides a well-supported programmatic interface to a wide variety of scales, making it easy in future to select a different set of scales. See Appendix 5 - for details.

The PrintNode software is also able to implement remote (internet connected) printing.

The PrintNode driver is itself internet connected, in this application it is sufficient that the printer and / or scales are connected to an internet connected PC with the PrintNode driver installed. It does not need to be the same PC as is used for interacting with the Countermark.Track2 web application.

4.8 Non-food test line

To provide an easy development environment, wooden blocks were used to represent steaks cut from a primal, these were all typically 200g, each representing one steak. A number of wooden blocks were put on the scales to represent a primal when testing the software (Figure 9).

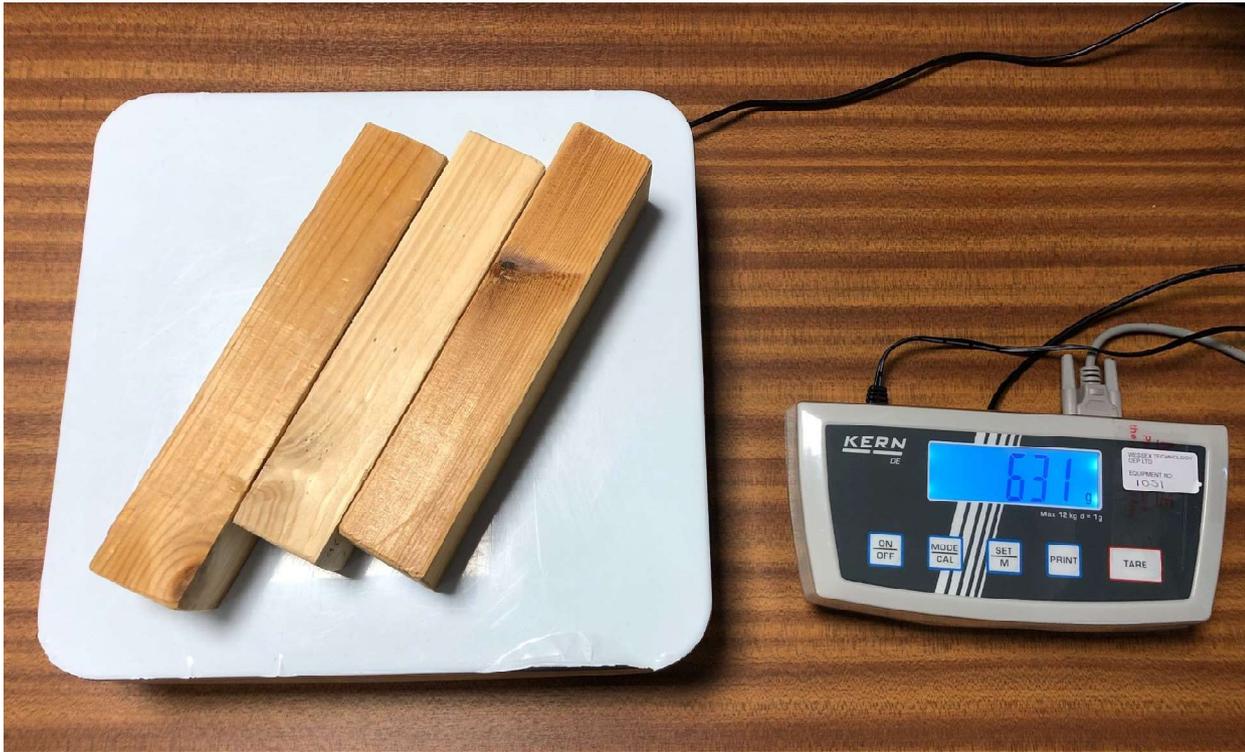


Figure 9 - Wooden blocks representing steaks

4.9 New web pages

Seven new webpages were added to the Countermark website, these are described in section 9.4:

- ◆ Create a Primal Label
- ◆ Create a Packing Label
- ◆ Create a Consumer Label
- ◆ View Consumer Label
- ◆ View Primal Label
- ◆ View Packing Label
- ◆ Packing Label Log

4.10 Implement mass balance rules and integrity checks

The following mass balance rules protect the integrity of meat using the Countermark.Track2 system.

4.10.1 Primal label check

The stated weight on the Primal label can be checked against the weight shown when checking the Countermark. Someone producing fraudulent primals attempting to reuse a Countermark primal label will have to ensure the weight of the substituted primal is the same as the original primal.

Two 'goods-in' receiving scans of a Countermark at different local meat processors would trigger an alarm as it indicates one of the two primals is suspicious and both would require verification.

4.10.2 Consumer label check

The stated weight on the Consumer label can be checked against the weight shown when checking the Countermark. Someone producing fraudulent Consumer packs attempting to reuse a Countermark Consumer label will have to ensure the weight of the substituted Consumer pack is the same as the original.

The same check will show the original use by date, increasing the risk of the substituted steak not being accepted by the customer due to the reduced or lapsed shelf life. The shelf life of the consumer pack will be much less than that of a primal, so this deterrent is significantly higher for a Consumer label than a Primal label.

The Consumer label is less likely than a primal label to be scanned twice. Two scans of a Consumer Countermark in different locations would trigger an alarm as it indicates one of the two Consumer packs is suspicious and both would require verification. A secondary check could be Consumer scans from a different geographic area to the supermarket where the original consumer pack was sent.

4.10.3 Mass balance when steaks are cut from a primal

The Countermark.Track2 software checks that only a feasible weight of steaks has been cut from the known weight of the primal. Once the weight is reached, no further consumer Countermarks are produced - this stops a local meat producer introducing other meat into the Countermark controlled system.

5.0 Project outcomes

The project has been completed and has demonstrated Primal to Steak / Steak to Primal traceability using Countermark.Track2. The software has been tested at each step of its development and we had the opportunity to test the full process on three primals at the University of Reading test kitchen.

5.1 Scales and printer interfacing

The PrintNode software (PrintNode.com, n.d.) has an extensive list of scales and printer types that are supported and thus can be attached to the Countermark.Track2 system. The devices do not need to be attached to the same PC as used by the operator for interacting with the Countermark applications.

It should be straightforward to do further trials with PrintNode. See section 6.1 for more discussion about PrintNode.

5.2 Traceability – Steak to Primal using the Countermark app

Accessing the traceability data using the Countermark App is shown in Figure 10.

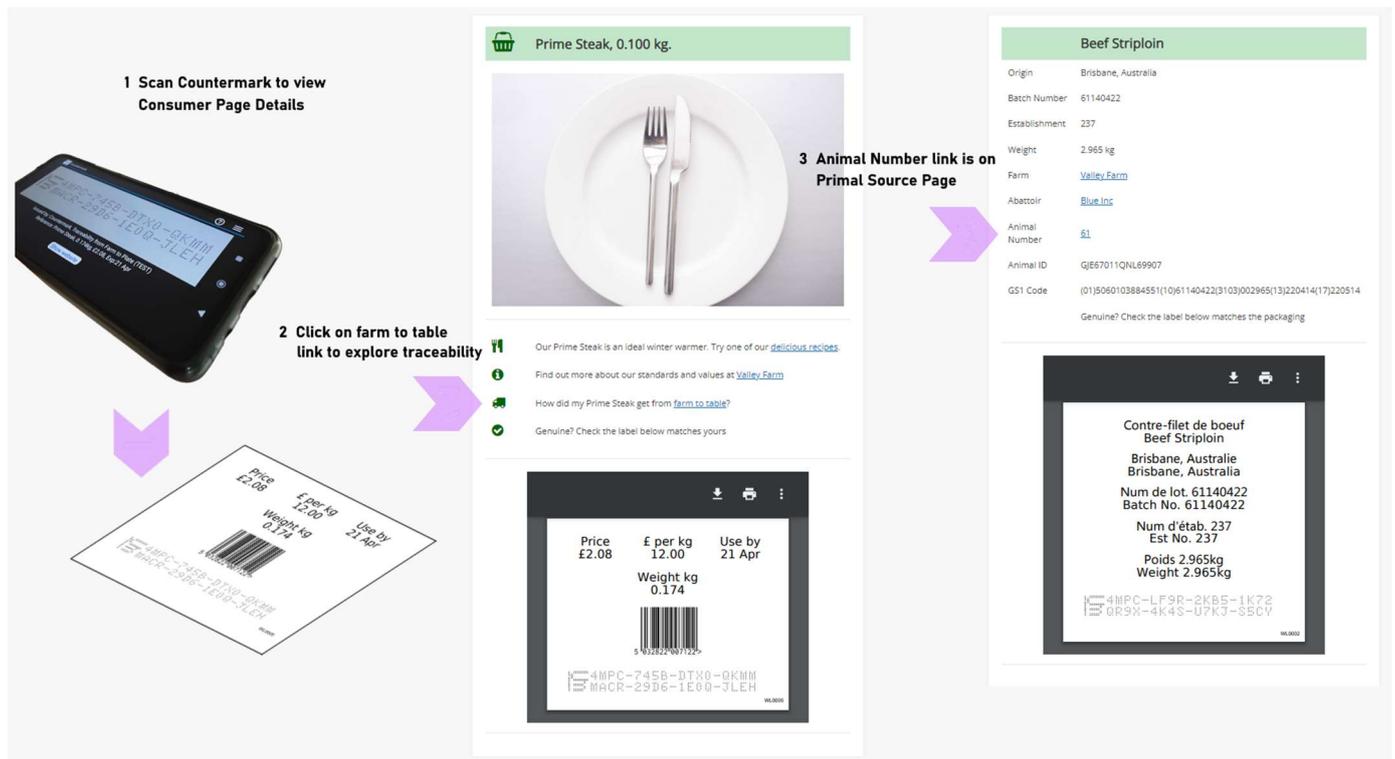


Figure 10 - Checking a Consumer label

When the Consumer uses the Countermark app to check the Consumer label on their steak, they are directed to the web pages as shown in the central panel of Figure 10. The options are:

- ◆ Delicious recipes link - this shows some recipes that can be edited by the farm, perhaps reflecting seasonal or cultural preferences.
- ◆ Click on the link to the farm's web page
- ◆ Farm to Table link - select a link to see the primal information including origin, batch number, establishment number for the abattoir, Animal Identity etc. The Consumer will also see the original Primal label.

The last item is the electronic copy of the label that should be on their steak. This allows the Consumer to check that the label is not fraudulent.

An example of what happens when a Consumer checks a fraudulent Countermark is shown in Figure 11 and Figure 12. The fraudulent label, in this case, has been put on a chicken product. The Countermark app reads the Countermark and reports the relevant data, in this case the Countermark belongs to a portion of Tesco Stewing Steak, weighing 0.526 kg, price at £1.47 which expires on the 14 April. If the Consumer selects 'Show website' button, they will see the original label for that Countermark and all of the relevant details for the original product.



Figure 11 - Example of a fraudulent Countermark

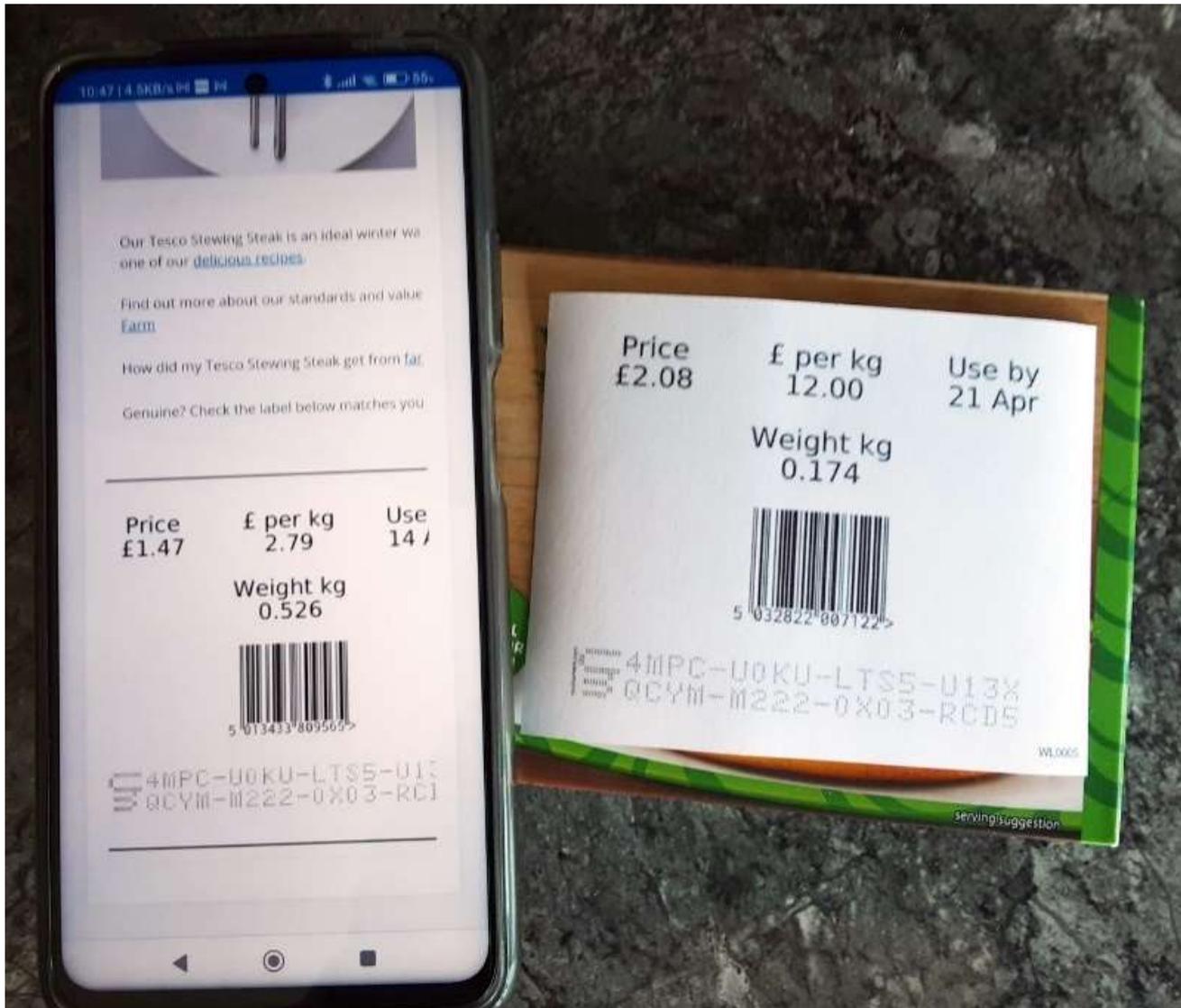


Figure 12 - Countermark re-use label comparison

5.3 Checking traceability data using the Countermark.Track2 website

The top row of the Countermark from a Packing label can be entered as shown in Figure 13. This page is available to people logged into Countermark.Track2 which does the search and reports the data, listing all the primals shipped under that Packing label. The list can be scrolled to a particular primal and the data for that primal will be displayed.

The Countermark is an alphanumeric string and the top row has special properties that allow the look up described above. Adding the Countermark top row to invoices or delivery notes allows the search detailed in Figure 13 to be done at any time in the future, allowing traceability exercises to be completed by the buyer or seller long after the meat has been consumed.

1 Enter Countermark
Top Row
 Packing Date: From 01/04/2022 To To
 Packing Details: Top Row 4MPC-P3AT GS1 Code GS1 Code

2 Press Search Packing Labels
 Search For Label Direction Newest First Results Per Page 10
 Search Packing Labels

3 List of Labels Found
 (1 Packing label item found in 0.02s)
 Packing Label Search Results
 Download Countermarks

Type	Top Row	Date Packed	GTIN	Weight	No Items	State
Label 829	4MPC-P3AT-TTDS-TPUX	19 Apr 2022 14:11 (UTC +01:00)	-	2.123 kg	3	Closed

4 Click to view Label contents
 (1 Packing label item found in 0.02s)
 Packing Label Search Results
 Download Countermarks

Type	Top Row	Date Packed	GTIN	Weight	No Items	State
Label 829	4MPC-P3AT-TTDS-TPUX	19 Apr 2022 14:11 (UTC +01:00)	-	2.123 kg	3	Closed

5 Click on Label for Packing Details
 Packing Label for 4MPC-P3AT-TTDS-TPUX
 Download Label Data

Type	Top Row	Date Scanned	GTIN	Weight
Label 829	4MPC-P3AT-TTDS-TPUX	19 Apr 2022 14:13 (UTC +01:00)	-	2.123 kg
Item 20392	4MPC-2E47-BTYJ-KPC8	19 Apr 2022 14:14 (UTC +01:00)	3165140379533	0.658 kg
Item 20393	4MPC-YHX8-5KBG-27C	19 Apr 2022 14:14 (UTC +01:00)	3165140379533	0.647 kg
Item 20395	4MPC-EXGD-9TPY-CGY6	19 Apr 2022 14:15 (UTC +01:00)	3165140379533	0.818 kg

6 Click on Item for Primal Details

Ox Rump
 Establishment: 236
 Abattoir: ABP Surminster
 Date Packed: 19 Apr 2022 14:11 (UTC +01:00)
 No Items: 3
 Weight: 2.123 kg
 GS1 Code: (01)3165140379533(3103002123)(13)220419(21)4MPC-P3AT-TTDS-TPUX

Packing Details Page

Ox Rump
 Origin: Queensland, Australia
 Batch Number: 75190422
 Establishment: 236
 Weight: 0.658 kg
 Farm: Hilsop Farm
 Abattoir: JBS Australia Pty Limited
 Animal Number: ZS
 Animal ID: 00J7645
 GS1 Code: (01)3165140379533(1075190422)(3103000658)(13)220419(17)220519
 Genuine? Check the label below matches the packaging

Primal Details Page

Croupe de boeuf
 Ox Rump
 Queensland, Australia
 Queensland, Australia
 Num de lot, 75190422
 Batch No. 75190422
 Num d'etab. 235
 Est No. 235
 Poids 0.658kg
 Weight 0.658kg
 4MPC-2E47-BTYJ-KPC8
 U7XC-UXDD-14NR-X3U9

Figure 13 - Traceability flow using website

5.4 Fraud detection

Countermark.Track2 offers different ways to identify fraudulent activity. Some of these are already present, others are not yet implemented.

5.4.1 Adding different product label to the consumer packing

This activity can be seen by checking the Countermark and doing a visual comparison between the suspicious label and the screen on the Countermark app (section 5.2).

5.4.2 Moving Countermarks between products

This activity can be seen by checking the Countermark and doing a visual comparison between the suspicious label and the screen on the Countermark app.

5.4.3 Duplicating Primal labels

This activity can be seen when different companies scan the same Countermark within their operations. Also, the fraudster must match the weight of the fraudulent primal with the original primal. This fraud is likely to be picked up by goods-in scanning. The software to detect this activity is not currently implemented.

5.4.4 Duplicating Packing labels

This activity can be seen when different companies scan the same Countermark as part of their goods in process. The software to detect this activity is not currently implemented.

5.4.5 Duplicating Consumer labels

Customers are less likely to scan their Countermarks than manufacturing operations, however the short shelf life of products means that a product with a duplicated label will have a shorter shelf life than the original. The fraudster must match the weight of the fraudulent pack with the original.

5.4.6 Duplicating Animal Identities

This is not yet implemented, however if the abattoirs do upload Animal Identities to the Countermark system it will be possible to report duplicated Animal Identities. The software to detect this activity is not currently implemented.

5.4.7 Mass balancing

Countermark.Track2 will prevent fraud on a packing line (cutting primals into steaks and packaging into Consumer packs), the mass balancing will detect that an improbable weight of steaks has been cut from a primal. This will prevent the Consumer label from being printed.

6.0 Discussion

6.1 Scales and printer interfacing

Printer integration was achieved by the use of PrintNode (PrintNode.com, n.d.), a third-party utility designed for easy programmatic printer use. Using this saved development time (with printing available from Javascript and PHP) and provides an easy route to using different printers in future. The company has proved responsive to requests for assistance. Other options are available (e.g. QZ Tray (qz.io, n.d.)), but these were not evaluated in this study.

Scales can be difficult to interface as there is no universal interface - different makes/models use different commands to control/read them. As with the printer, PrintNode provides a simple interface that will support other scales in the future without extensive code rewrite. The Kern printer selected has a partial PrintNode integration, which although not perfect, is good enough for initial proof of concept. PrintNode are willing to resolve the interface, but this was not progressed further.

The PrintNode software has a long list of scales and printer types that are supported and thus can be attached to the Countermark.Track2 system. The devices do not need to be attached to the same PC as used by the operator for interacting with the Countermark applications.

This flexibility means that workstation design can be optimised for the operator and process, and the scales and printers already in use are likely to be compatible with the Countermark.Track2 application.

There were some limitations with the PrintNode software, for example it will advise if a printer or scales are offline, but at present the PrintNode software does not advise that the printer is out of paper.

Having all of the printers and scales connected to the same system has some advantages:

- ◆ Operators doing out of shift processing can be monitored remotely
- ◆ It should be easy to have spare units on standby

and disadvantages:

- ◆ A server failure at PrintNode will bring all printing and weighing to a stop
- ◆ A separate console will need to be developed so that every printer and scale will need to be individually allocated to workstations in different abattoirs and local meat processors
- ◆ The licensing model used by PrintNode will need to be reviewed.

6.2 Data interfacing

For development and demonstration purposes, the system uses a small set of representative data stored in tables of an interface database. This is used to simulate either a full database portal to actual data (for customer orders, products, required weights etc) or an API that can accept the required data, as provided by abattoirs and local meat processors. This has not been explored during this study.

Data is entered into the site in several places, mainly for the generation of labels. Some of this data will need to be typed in each time, but many other fields may be able to be pre-filled. Pre-filled data may be obtained directly or indirectly from user login details. Establishment Identity would be expected to be directly related to the user login and would seldom change, whereas Consumer products would alter from time to time and Animal Identity would be continually changing.

Predominantly static data would be held in a Countermark database, with more dynamic data held in national or customer databases.

6.3 Mass balance rules

Mass balance is the process used to ensure, for instance, that the amount of meat cut from a primal is no more than the original weight of the validated primal e.g. it should not be possible to cut 25 steaks of 200g from a 4.9 kg primal. Experiments conducted in the Track 1 study showed that mass balancing can be applied, assuming that the measurements are performed at appropriate times in the meat lifecycle (freezing / thawing / wrapping) and with suitable tolerances. Even using the wooden blocks, as done for this study, there was a degree of weight variance as the (originally damp) blocks dried out – this was a useful effect in proving tolerance acceptance of weights. The required tolerance would need further evaluation in a production environment.

A check has been implemented as each steak was cut from each primal which would ensure that steaks from other sources are not being introduced at the Consumer packing stage.

6.4 Product recall

As each steak retains traceability back to the primal, and possibly to the Animal Identity and farm, any recall of a product can be fully realised. When the local meat processor uses the Countermark packing process, the three important attributes required for a recall would be in place:

- ◆ The public health authorities can look at consumer packs and identify farms and abattoirs that may be the source of the problem
- ◆ Once the source of the problem is known, any supermarkets stocking product from the same source can be notified with a list of suspect Consumer packs
- ◆ The provenance of the problematic product can be checked – was the problem due to fraudulent activity?

6.5 Industrial scanning

Consumer scanning is done using the Countermark app (Android/iOS). When items are required to be scanned in a processing environment, it is not appropriate for the operator to use a mobile phone, so the Countermark Scanner is used. This consists of an industrial camera (Figure 14), connected to a small PC, which allows an image of the Countermark to be captured and sent to the Countermark server for analysis and storage.



Figure 14 - A typical food-environment grade camera

7.0 Conclusions / Recommendations – Track 2

7.1 Conclusions

Wessex have successfully demonstrated:

1. Primal to Steak / Steak to Primal traceability
2. Framework for fraud detection
3. Scanning labels with the Countermark app to obtain original details of the primal and the steak
4. The ability to generate digitally-signed, secure labels (Primal, Packing, Consumer) using Countermarks to reference securely held information
5. Interfacing to standard printers and scales from the Countermark.Track2 system
6. Manual data entry for checking Countermarks
7. Farmers' pages
8. A method of implementing a recall system

7.2 Recommendations

We strongly recommend moving the system to a meat processing environment – includes camera, printer, scales, data interfaces

Future steps would be:

1. Source data integration – work with a chosen processing facility to understand how the Countermark system would receive data for orders, suppliers etc. These might be APIs, database connections, local files.
2. Investigate operator interfaces such as touchscreens and any automation interfaces
3. Establish a qualification process for existing printers and labels
4. Evaluate the scanner (industrial enclosed camera) in a meat processing environment to replace the phone app used for this study
5. Implement the reuse detection triggers – location/time checks when Countermarks are scanned. Consider the best notification options
6. Investigate licencing options to understand if PrintNode (printer and scales interface) is a suitable technology partner and ensure a robust scales and printer interface.

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9.0 Appendices

9.1 Appendix 1 – Countermark overview

9.1.1 Key Countermark characteristics

Countermark is a new type of data-carrier - it is similar to a QR code except Countermark uses two rows of human readable characters instead of black and white squares - giving important advantages:

- ◆ If the automated code reading fails the Countermark can be entered manually
- ◆ Countermark can be printed by inkjet printers which are already widely used in food processing
- ◆ Countermark is encrypted and has a proprietary format so is very hard to falsify
- ◆ Each Countermark has data assigned after creation, so data from product processing, such as weight or end customer can be added after the Countermark has been printed
- ◆ The top row of a Countermark can be printed on delivery paperwork, linking the historical Consumer records directly to a product and facilitating audits long after the food has been consumed
- ◆ The FBI have advised against using QR codes for secure applications (FBI, 2022).

9.1.2 Countermark as a digital signature

Countermark acts as a digital signature for the product it is printed on. Each Countermark:

- ◆ is unique and features randomised characters (eliminating sequential, predictable codes)
- ◆ acts like an encrypted hyperlink
- ◆ requires the Countermark app in order to access the data protected by the Countermark
- ◆ is backed by blockchain to provide evidence of tampering.

9.1.3 Countermark fonts and manual data entry

Countermarks can currently be printed and read in four separate fonts, Latin, Katakana (Japan), Cyrillic (Eastern Europe), and Chinese (Figure 15). This allows human readability in most major economies. In all fonts the numbers 0-9 are used, with 22 alphabetic characters. This means that each block of 4 characters has 1,048,576 possible combinations. The encryption used in Countermark means individual symbols appear randomised.

The randomisation of the symbols means manual data entry of Countermarks is easy – the manual Countermark search software checks the internal Countermark record after each new symbol is entered. Entering just 4 symbols would find a unique Countermark within over a million possible combinations. This characteristic makes entering numbers manually much less onerous than conventional serial numbers.



Figure 15 - Countermark is available in Latin, Katakana, Cyrillic and Chinese fonts

9.1.4 Countermark spoof protection

The first four characters in the top row of a Countermark are known as “Top Left Text” and can be used for branding. For Australian Meat Processor Corporation, the following branding has been allocated for this project:

- ◆ “AMPC” in the Top Left Text on the live Countermark system
- ◆ “4MPC” in the Top Left Text on the development Countermark system.

Fraud control systems operate in the Countermark software that detect if characters within the Top Left Text have been amended. If another Countermark user were to try to produce spoof Countermarks with AMPC in this position it would be detected the first time the Countermark was read and Wessex would know which account had created the fraudulent Countermark. This anti-spoof technology is simply not possible with public domain codes such as QR, Data Matrix or conventional barcodes.

9.1.5 Countermark uses dots

Countermark uses dots to form the basic element of a Countermark compared to black and white square cells of other codes. The use of dots gives two strong advantages to Countermark - dots are the basic element of ink jet print and laser marking which gives faster printing and better print results compared with trying to print solid blocks of ink with discrete dots as happens with other types of code. A second advantage is that the software algorithms used

by Countermark do not need solid white backgrounds and solid black print to work. This allows Countermarks to be printed on and read from non-uniform surfaces.

9.1.6 Countermark top row as a public key

The top row of a Countermark can be used in a similar way to a public key in cryptography. The top row can be copied, shared and used to access the Countermark data system. However, the Countermark top row cannot be used to generate an entire Countermark as would be present on a Countermark protected product. Adding Countermark to invoices, delivery notes etc. allows audits to be completed long after the product with the Countermark has been sold, or in the case of meat, eaten.

9.1.7 Countermark interfaces for printing and reading

Countermark has a range of print interfaces including Microsoft Windows, Comma Separated Value (CSV) files etc. Integrating Countermark with new printing devices is normally relatively straight forward.

Countermarks can be read using the dedicated Countermark app for iPhone and Android. There are also API's available to partner companies.

9.1.8 Further information

More information about Countermark can be found at www.countermark.com, links to the Countermark app can be found at this location or via the App Store (iOS) and Play Store (Android).

9.2 Appendix 2 – Example labels

Example labels provided by AMPC



Figure 16 - Example label from AMPC - Packing label



Figure 17 - Example label from AMPC - Primal label



Figure 18 - Example label from AMPC - Consumer label

9.3 Appendix 3 - Website workflow

This section shows the work flow of the system as the user performs various activities.

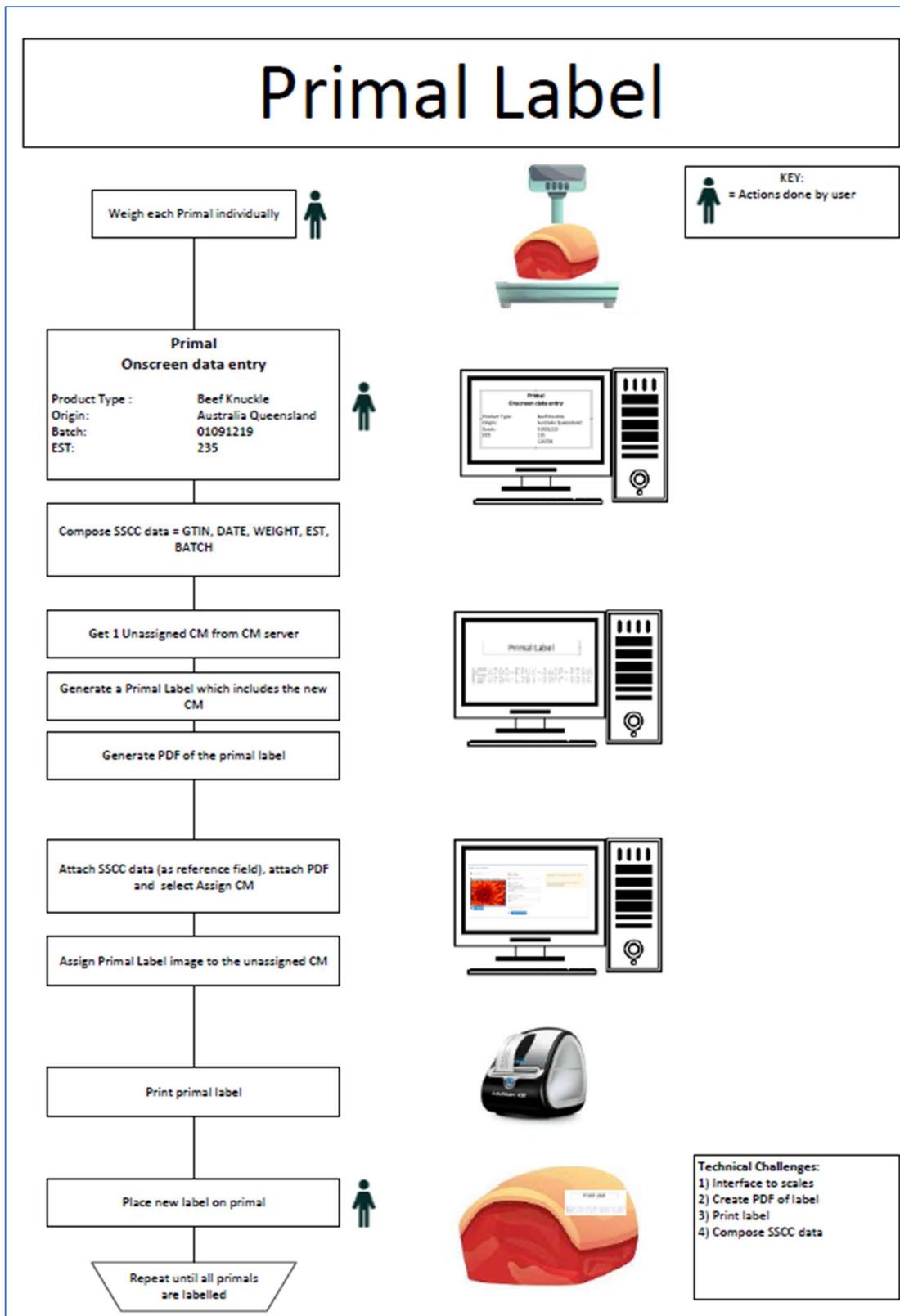


Figure 19 - User workflow - Primal label

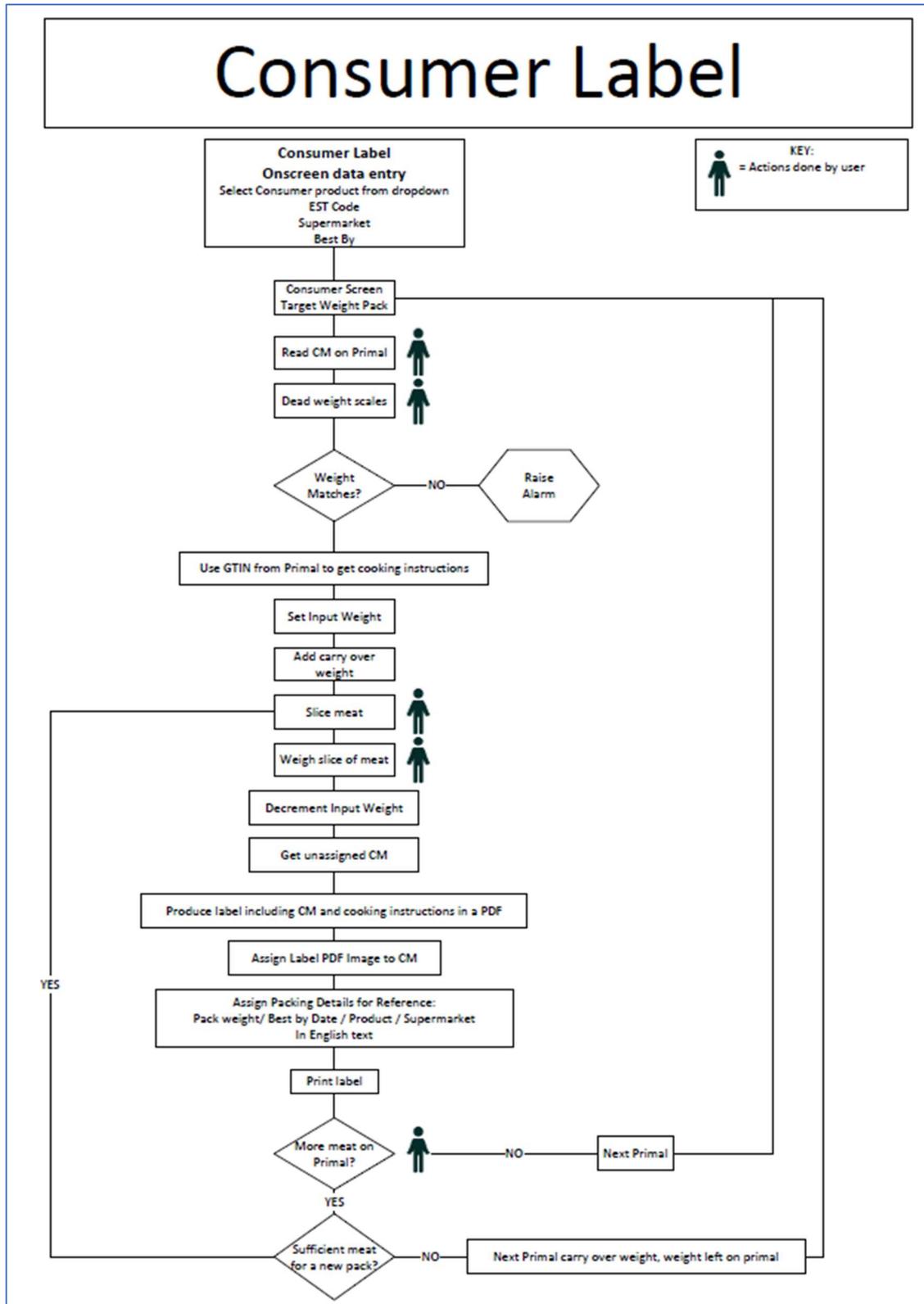


Figure 20 - User workflow - Consumer label

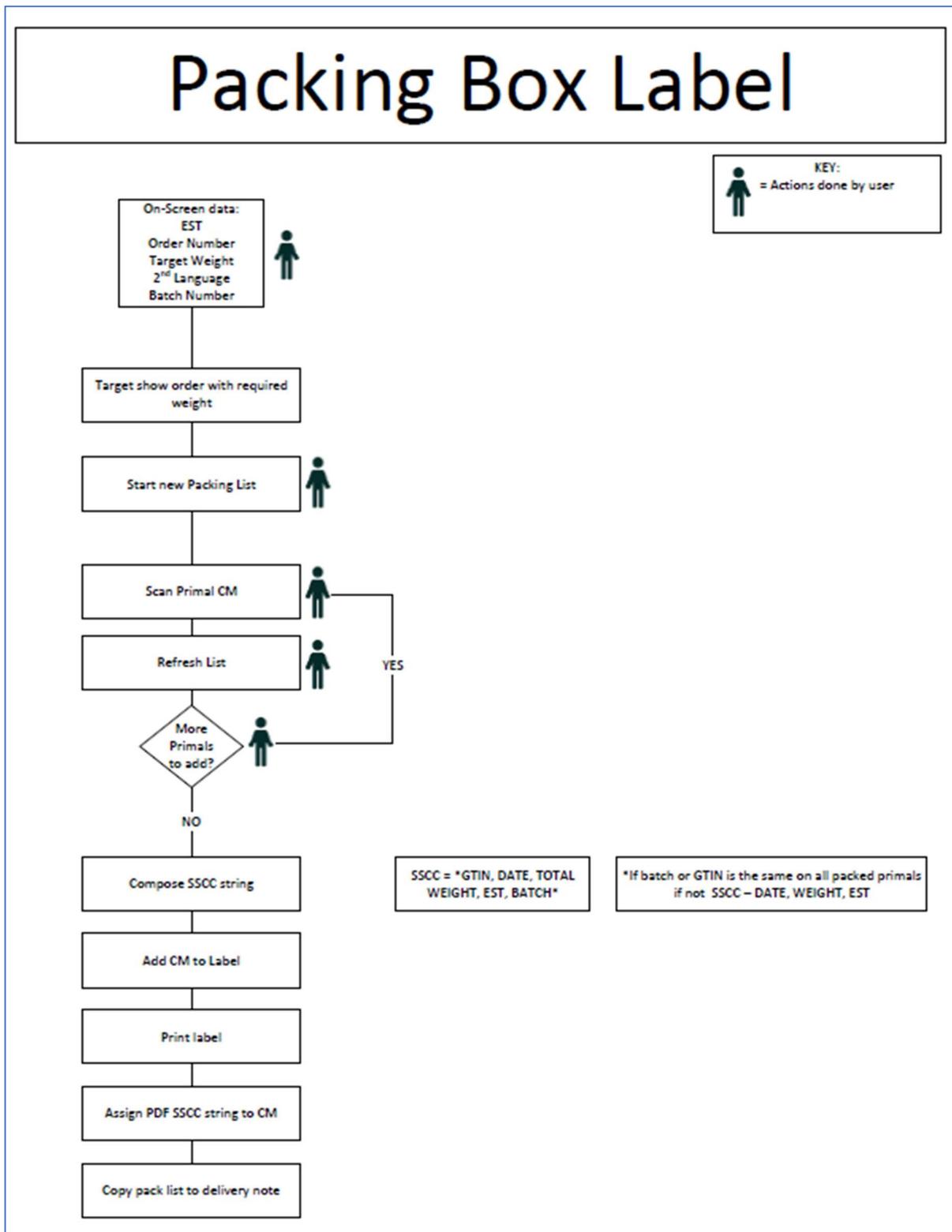


Figure 21 - User workflow - Packing label

9.4 Appendix 4 - User flow with web pages

9.4.1 Logging on

Open a web browser and enter the Countermark URL.

From the Welcome page, click on the Login link (Figure 22) towards the top right-hand side.



Figure 22 – Countermark welcome page login link

In the login box (Figure 23), enter the Account Number provided by Wessex Technology, followed by the Email Address and Password, then press the Login To Countermark button.

Figure 23 - Login box

The Countermark home page menu is now shown (Figure 24). Click on the AMPC Label Home box.

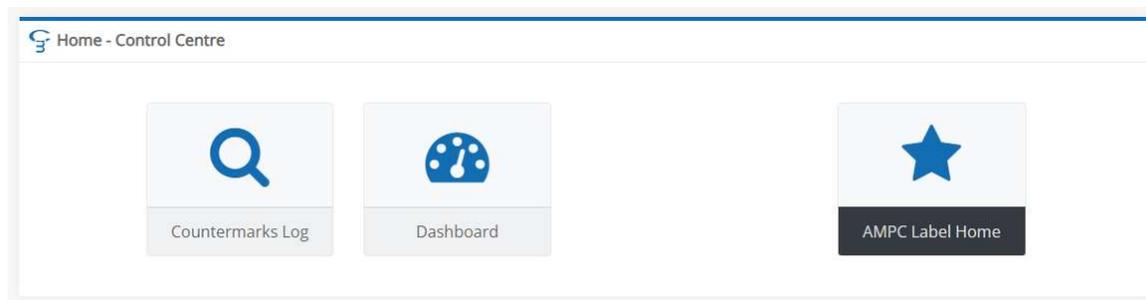


Figure 24 - Countermark home page menu

A Label Home page appears (Figure 25) showing Countermark labels that can be produced for typical processing activities. Each of the label pages are detailed in section 9.4.2 to 9.4.8.

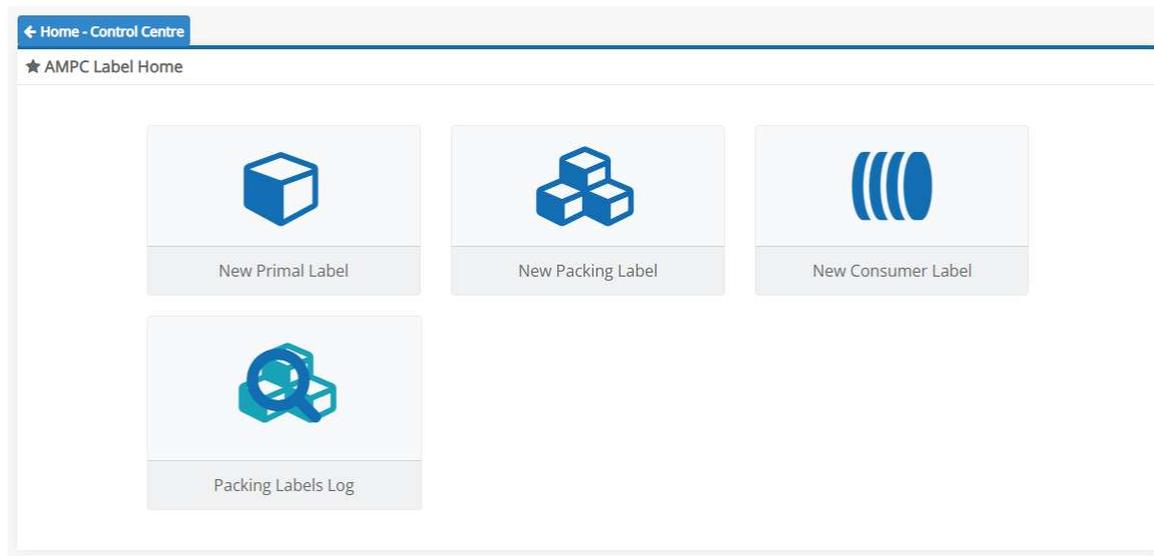


Figure 25 - Label home page

9.4.2 Create a Primal label

The primal processing involves weighing, protective wrapping and labelling. Existing labels (Figure 17) contain information such as Establishment ID, Primal Type and Batch Number.

The Create a Primal Label entry screen (Figure 26) adds Farm Name, Expiry Date and Animal Identity to support future traceability endeavours. The weight is obtained from an electronic scale that has a serial or USB communications port.

Figure 26 - Create a Primal Label - entry screen

When the Create Label button is pressed the entered details are used to generate a label along with an initially empty Countermark.

A blank Countermark has the same general outward appearance as any other Countermark but it does not yet hold any data. The data is written to it at a later stage as a one-time-only process. This is known as assigning the Countermark.

The completed label is rendered as a PDF (Figure 27) which is stored in the Countermark database with its unique webpage link. This information is then assigned to the Countermark.



Figure 27 - Create a Primal Label – PDF label creation

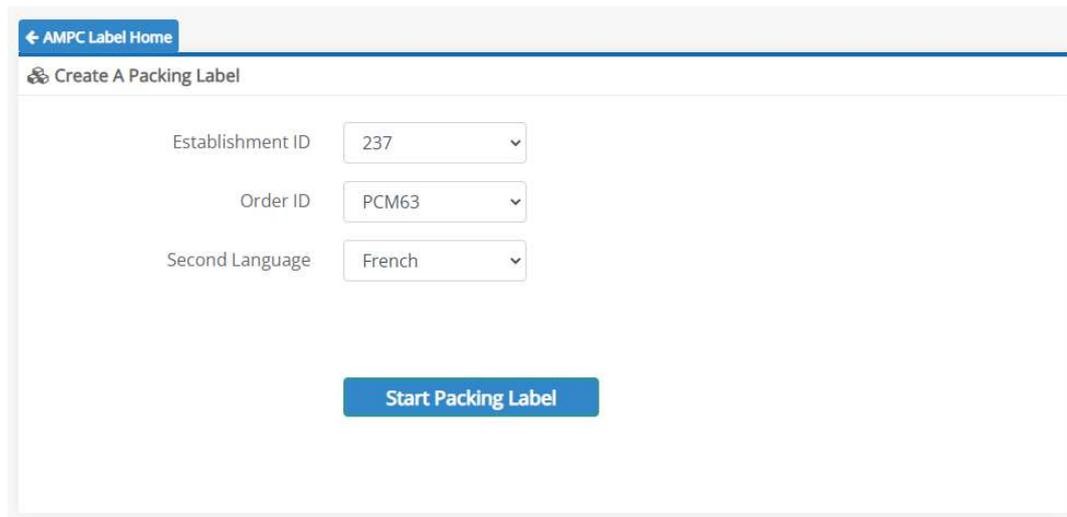
Once created, the label may then be printed and attached to the primal protective wrapping in the normal manner.

The information held inside the Countermark is safely stored and can be retrieved at any point using the Android / iOS smartphone app, or by entering the Countermark top-row into the website search facility.

9.4.3 Create a Packing Label

Packing labels can also be produced by the Countermark system. Several primals or Consumer packs of the same type can be shipped in one box.

After preliminary information is entered (Figure 28), a Countermark is generated (Figure 29) which acts as a virtual container.



← AMPC Label Home

Create A Packing Label

Establishment ID 237

Order ID PCM63

Second Language French

Start Packing Label

Figure 28 - Create a Packing Label - entry screen



← AMPC Label Home

Create A Packing Label

4MPC-D70A-GB2D-D6RG
3ML3-4CU3-XC2K-RYER

Refresh Close List Remove Last Item

Figure 29 - Create a Packing Label - Countermark generation

This Countermark is scanned using the Android / iOS app to start the Packing label creation process. Each Countermarked Primal or Consumer pack is scanned as it is packed into the box and at the same time it is consigned to the virtual container. When the box is full the virtual container will show a list of the contents and the total net weight (Figure 30).

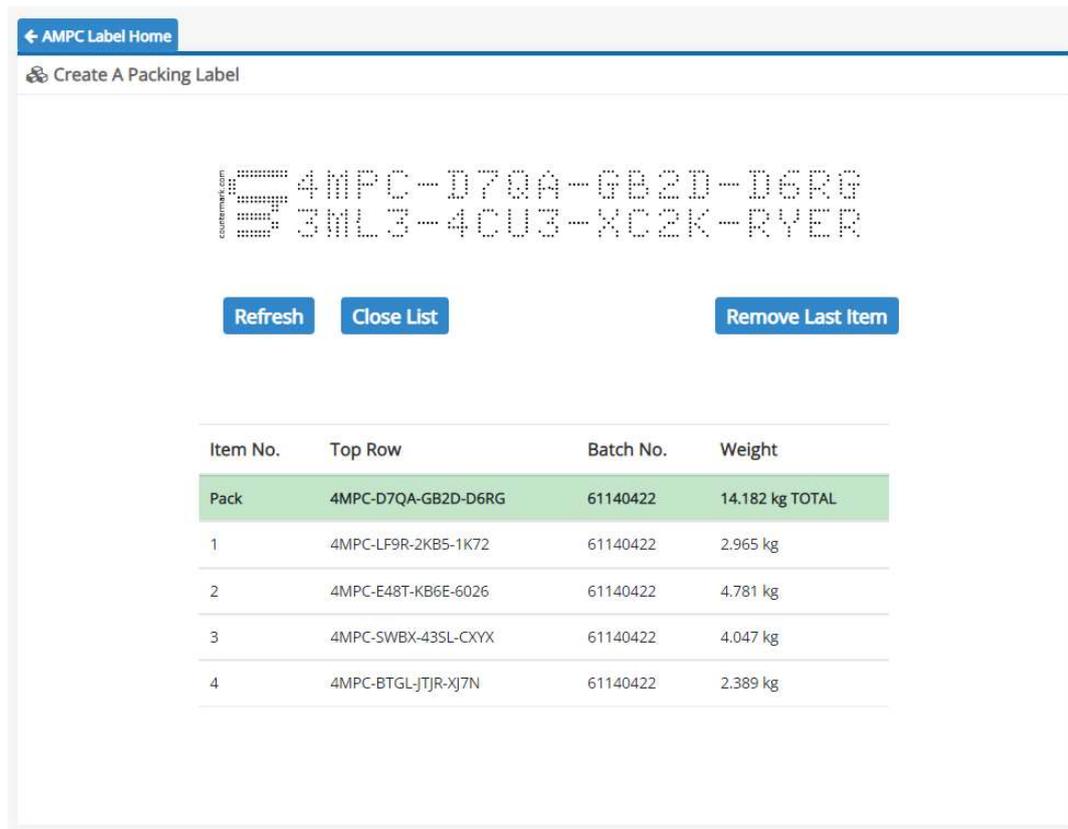


Figure 30 - Create a Packing Label – assigned contents list

The Close List button produces the Packing label from these details (Figure 31).



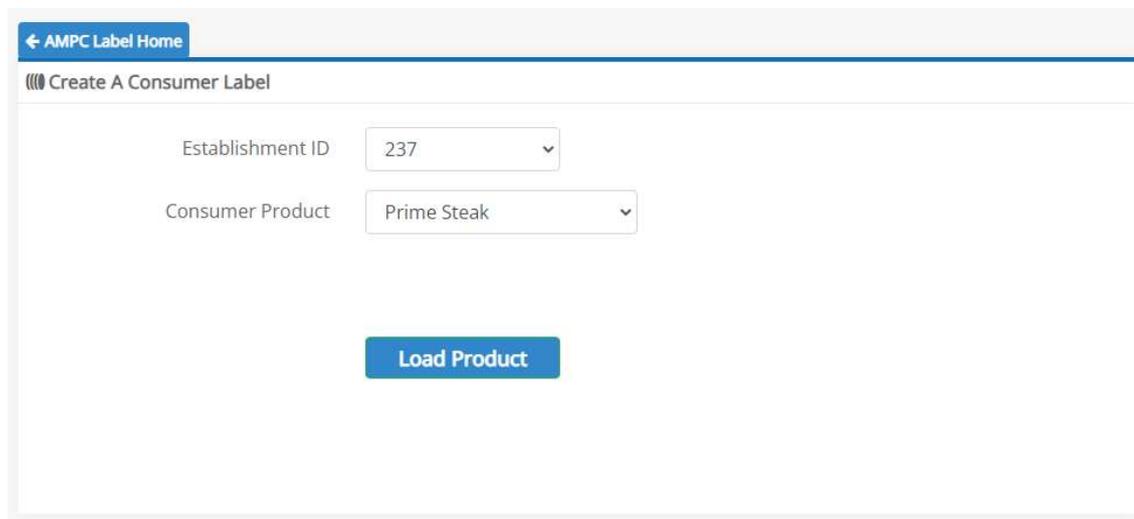
Figure 31 - Create a Packing Label – PDF label creation

Information inherited from the Primal / Consumer pack Countermarks are used to complete the packing Countermark and to create a GS1 barcode (GS1.org, 2022). The packing Countermark is visible in the bottom left-hand corner and the Countermark top-row is appended to the GS1 barcode. This allows existing conventional barcode scanning equipment to access the Countermark top-row.

9.4.4 Create a Consumer label

Primals received at a local processing centre can continue to be tracked by the Countermark system during subsequent slicing operations.

After selecting the consumer product from a list (Figure 32), the GTIN of the required primal is shown to the operator to prevent the wrong one being selected (Figure 33).



← AMPC Label Home

☰ Create A Consumer Label

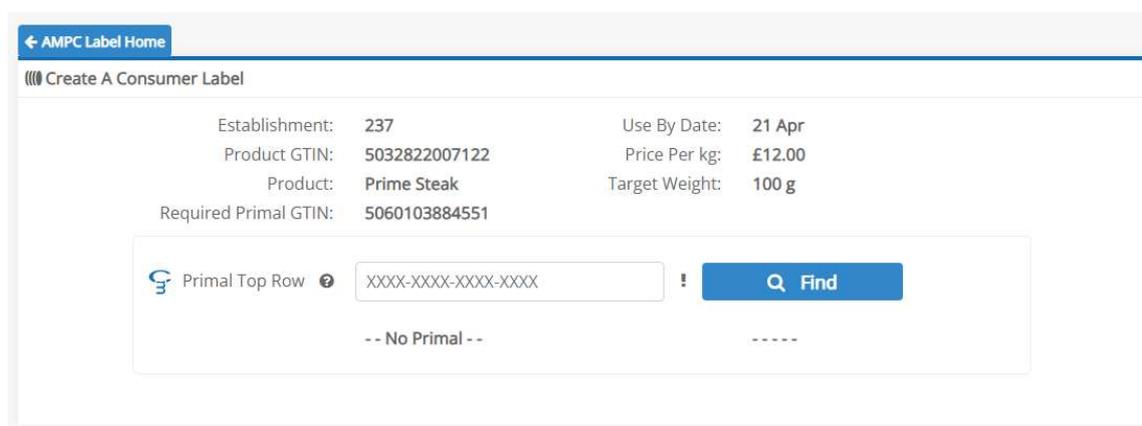
Establishment ID: 237

Consumer Product: Prime Steak

Load Product

Figure 32 - Create a Consumer Label - entry screen

Product name, Target Weight and Use By Date are also shown (Figure 33) for reference to ensure that the correct product is being processed.



← AMPC Label Home

☰ Create A Consumer Label

Establishment:	237	Use By Date:	21 Apr
Product GTIN:	5032822007122	Price Per kg:	£12.00
Product:	Prime Steak	Target Weight:	100 g
Required Primal GTIN:	5060103884551		

Primal Top Row: XXXX-XXXX-XXXX-XXXX

Find

-- No Primal --

Figure 33 – Create a Consumer Label – reference screen

The Countermark top-row from the specific primal is entered, and its basic details are shown. The actual weight is verified against the previously stored weight before proceeding (Figure 34).

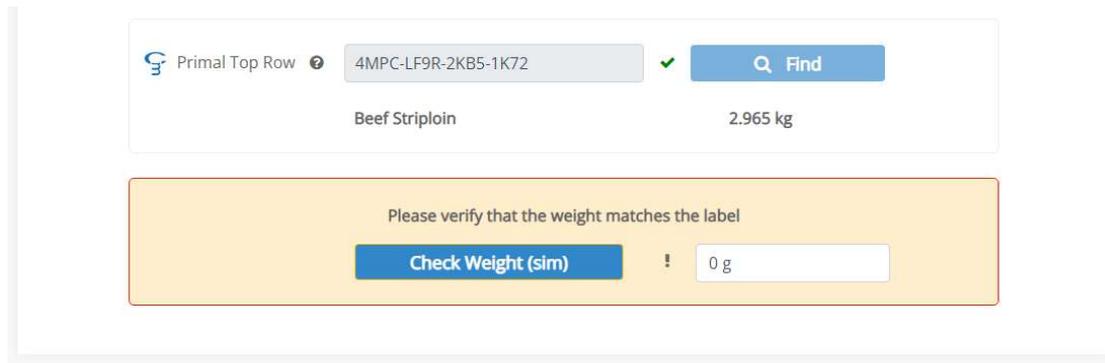


Figure 34 – Create a Consumer Label – verification screen

The slicing operation is now started until the target weight is reached. The "Add More (nnn g)" helper text shows how much more weight is required to be added (Figure 35).

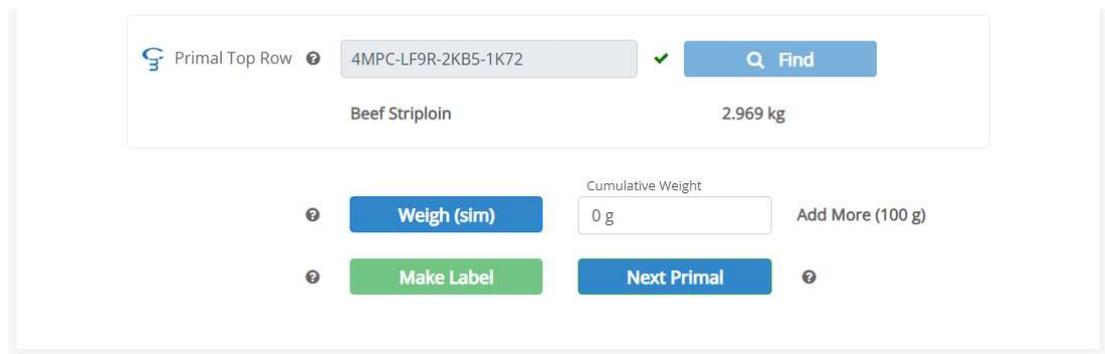


Figure 35 – Create a Consumer Label – slicing operation

Once the target weight has been achieved (Figure 36), the Make Label button is pressed. The label is sent to the printer and an image of the label shown to the operator underneath the buttons.

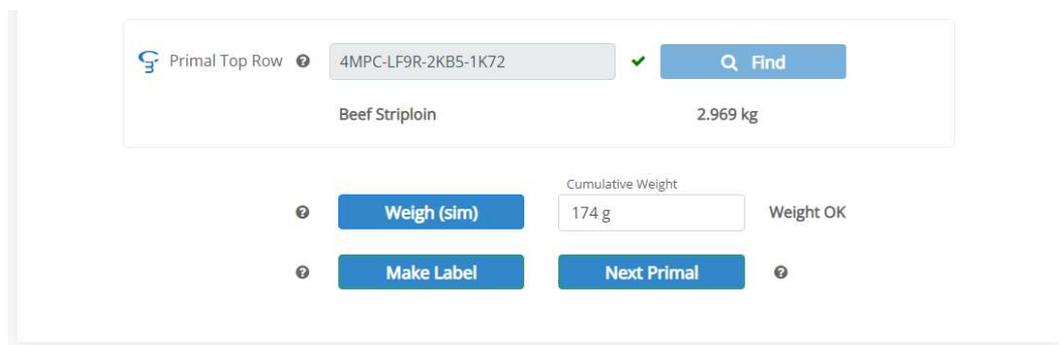


Figure 36 – Create a Consumer Label – target weight achieved

The label contains important consumer information such as price, weight and use-by date as well as a retail point-of-sale EAN-13 barcode. The label PDF is again stored (Figure 37) in the Countermark with its traceability URL. Scanning this Countermark is the starting point for consumers wishing to find out more about their purchase.

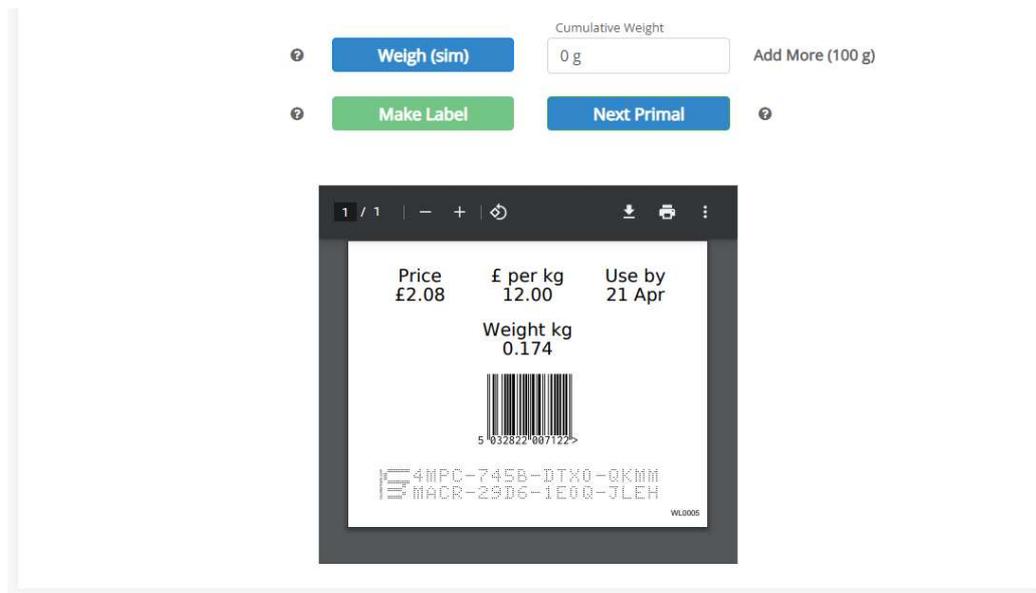


Figure 37 – Create a Consumer Label – PDF label creation

The label image is removed automatically when any button is pressed. Slicing continues until the primal is exhausted, at which point pressing the Next Primal button allows a new primal to be loaded.

9.4.5 View Consumer Details

Scanning the consumer Countermark using the Android / iOS smartphone app allows access to the consumer view URL (Figure 38). This is expected to be viewed mainly on smartphone or tablet devices with reassuring pictures and links of interest such as recipes.

The consumer label containing the Countermark is shown at the bottom of this page so that the consumer can verify the label details match with the actual packaging in front of them. A more detailed view of the central section shows various links including the "How did my consumer product get from farm to table". Following this link takes the consumer to the same page as if they had scanned the primal Countermark.

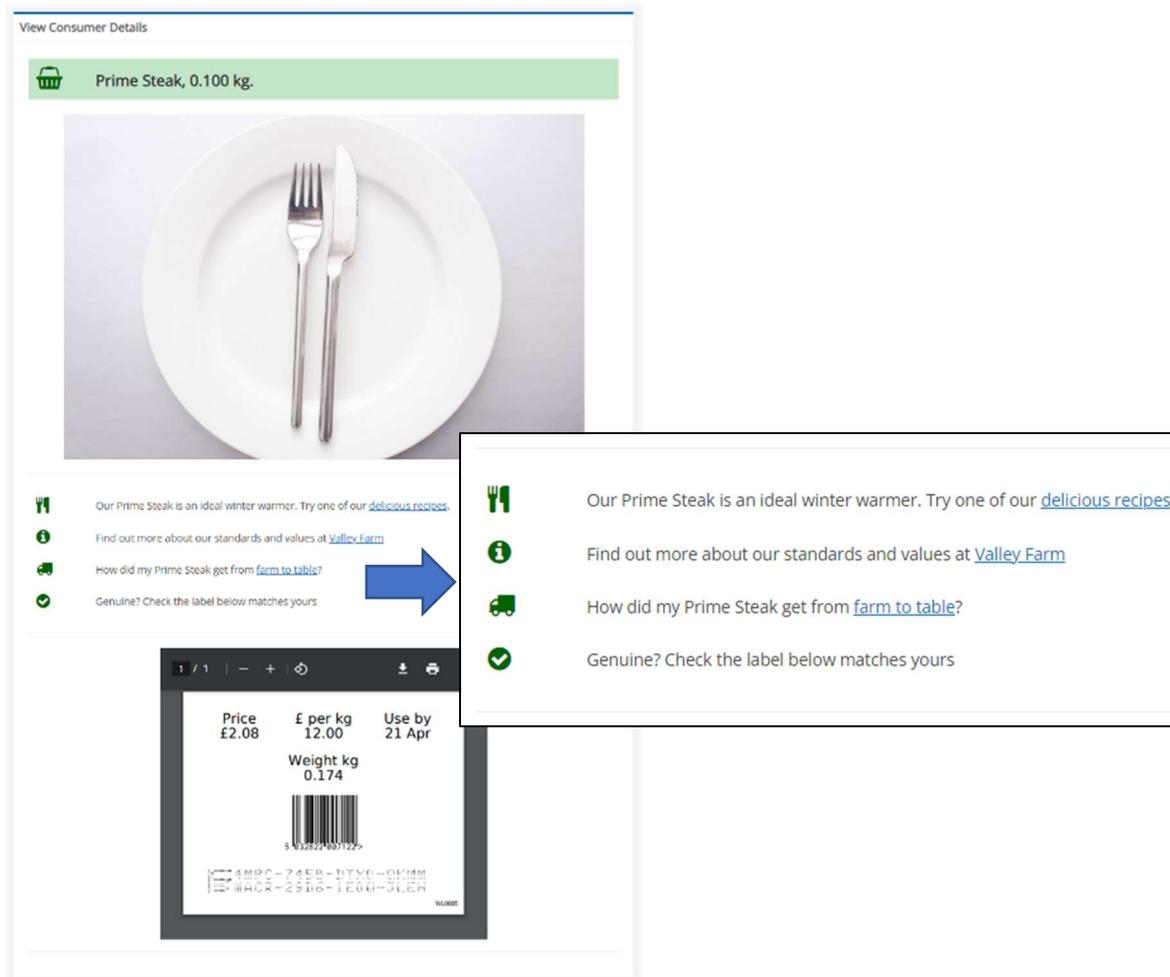


Figure 38 – View Consumer Details screen

9.4.6 View Primal Details

The primal label can also be scanned with the Android / iOS smartphone app to provide access to the primal view URL (Figure 39). The farm-to-table link from relevant consumer pages as shown above will also result in the primal view page being displayed.

This page contains more details than the consumer view page. Traceability links to the Farm, Abattoir and Abattoir Animal Number are provided. Animal Identity and GS1 barcode encoded information (GTIN, batch, weight, dates) are also shown. The label PDF is still shown at the bottom for verification against the actual label.

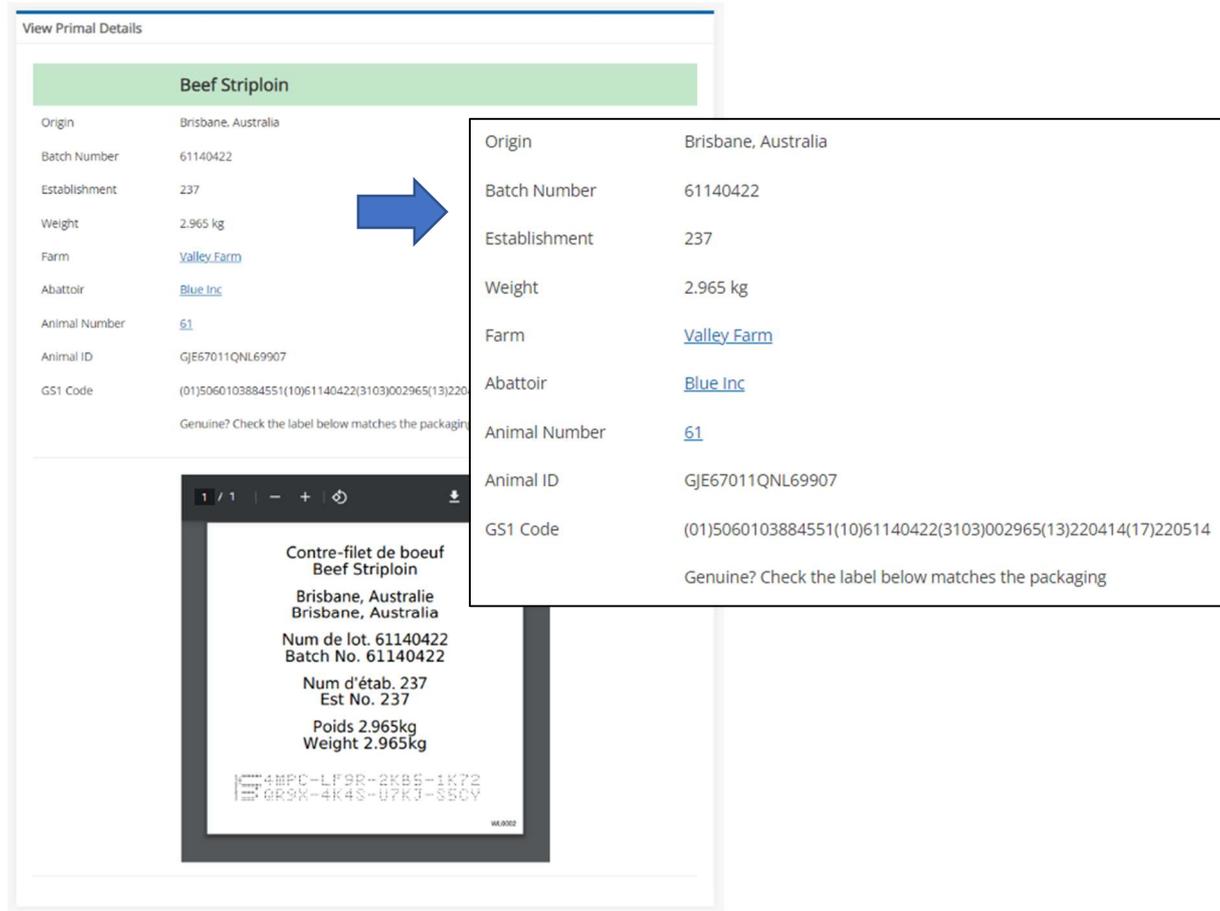


Figure 39 – View Primal Details screen

9.4.7 Packing Labels Log

A search facility is available to assist with managing Packing labels (Figure 40). Labels and/or items can be searched for specifically by Countermark top-row or within a date range to limit the quantity of results returned.

The screenshot shows the 'AMPC Label Home' interface for the 'Packing Labels Log Page'. It features two main filter sections: 'Packing Date' and 'Packing Details'. The 'Packing Date' section includes 'From' (14/04/2022) and 'To' (To) input fields. The 'Packing Details' section includes 'Top Row' (Label Top Row) and 'GS1 Code' (GS1 Code) input fields. Below these are three dropdown menus: 'Search For' (Label or Item), 'Direction' (Newest First), and 'Results Per Page' (10). A prominent blue 'Search Packing Labels' button is centered at the bottom of the form area.

Figure 40 - Packing Labels Log – data selection screen

The Search Packing Labels button is pressed to initiate a search.

Typical results show a list of Items (Primals) and Labels (Packing labels) that match the search criteria (Figure 41). This list can be downloaded as a CSV file for easy transfer of results to other systems. Any of these rows can be clicked for further details on a specific Packing label.

(9 Packing label items found in 0.08s)

Packing Label Search Results

? [Download Countermarks](#)

Type	Top Row	Date Packed	GTIN	Weight	No Items	State
Item 20390	4MPC-BTGL-JTJR-XJ7N	14 Apr 2022 13:54 (UTC +01:00)	5060103884551	2.389 kg	-	-
Item 20389	4MPC-SWBX-43SL-CXYX	14 Apr 2022 13:54 (UTC +01:00)	5060103884551	4.047 kg	-	-
Item 20388	4MPC-E48T-KB6E-6026	14 Apr 2022 13:53 (UTC +01:00)	5060103884551	4.781 kg	-	-
Item 20387	4MPC-LF9R-2KB5-1K72	14 Apr 2022 13:53 (UTC +01:00)	5060103884551	2.965 kg	-	-
Label 828	4MPC-D7QA-GB2D-D6RG	14 Apr 2022 13:52 (UTC +01:00)	-	14,182 kg	4	Closed
Item 20385	4MPC-LLEA-M3QC-K819	14 Apr 2022 11:34 (UTC +01:00)	3165140379533	0.747 kg	-	-
Item 20383	4MPC-2991-E3FR-9B7T	14 Apr 2022 11:32 (UTC +01:00)	3165140379533	0.662 kg	-	-
Item 20382	4MPC-LSE9-T3KH-BG50	14 Apr 2022 11:32 (UTC +01:00)	3165140379533	0.608 kg	-	-
Label 827	4MPC-KU9F-E3R5-7Q57	14 Apr 2022 11:27 (UTC +01:00)	-	2.017 kg	3	Closed

Figure 41 – Packing Labels Log – typical search results

The highlighted row shows the line that was clicked in this Packing label. A single Packing label and its associated primal items are shown in this result table (Figure 42). Again, these results can be downloaded as a CSV file.

Any of these rows can be clicked to either open the specific primal item viewing page (as shown above in View Primal Label Details page) or will open a similar page to View Packing Label Details page.

Packing Label for 4MPC-D7QA-GB2D-D6RG

? [Download Label Data](#)

Type	Top Row	Date Scanned	GTIN	Weight
Label 828	4MPC-D7QA-GB2D-D6RG	14 Apr 2022 13:53 (UTC +01:00)	-	14,182 kg
Item 20387	4MPC-LF9R-2KB5-1K72	14 Apr 2022 13:53 (UTC +01:00)	5060103884551	2.965 kg
Item 20388	4MPC-E48T-KB6E-6026	14 Apr 2022 13:53 (UTC +01:00)	5060103884551	4.781 kg
Item 20389	4MPC-SWBX-43SL-CXYX	14 Apr 2022 13:54 (UTC +01:00)	5060103884551	4.047 kg
Item 20390	4MPC-BTGL-JTJR-XJ7N	14 Apr 2022 13:54 (UTC +01:00)	5060103884551	2.389 kg

Figure 42 – Packing Labels Log – selected entry results

9.4.8 View Packing Label Details

For completeness the Packing label can also be scanned with the Android / iOS smartphone app, or linked directly from the Packing Labels log above. This gives access to the Packing label through its URL (Figure 43). The page is not intended to be for customer traceability, but may be useful internally for tracking any primals that have shared history.

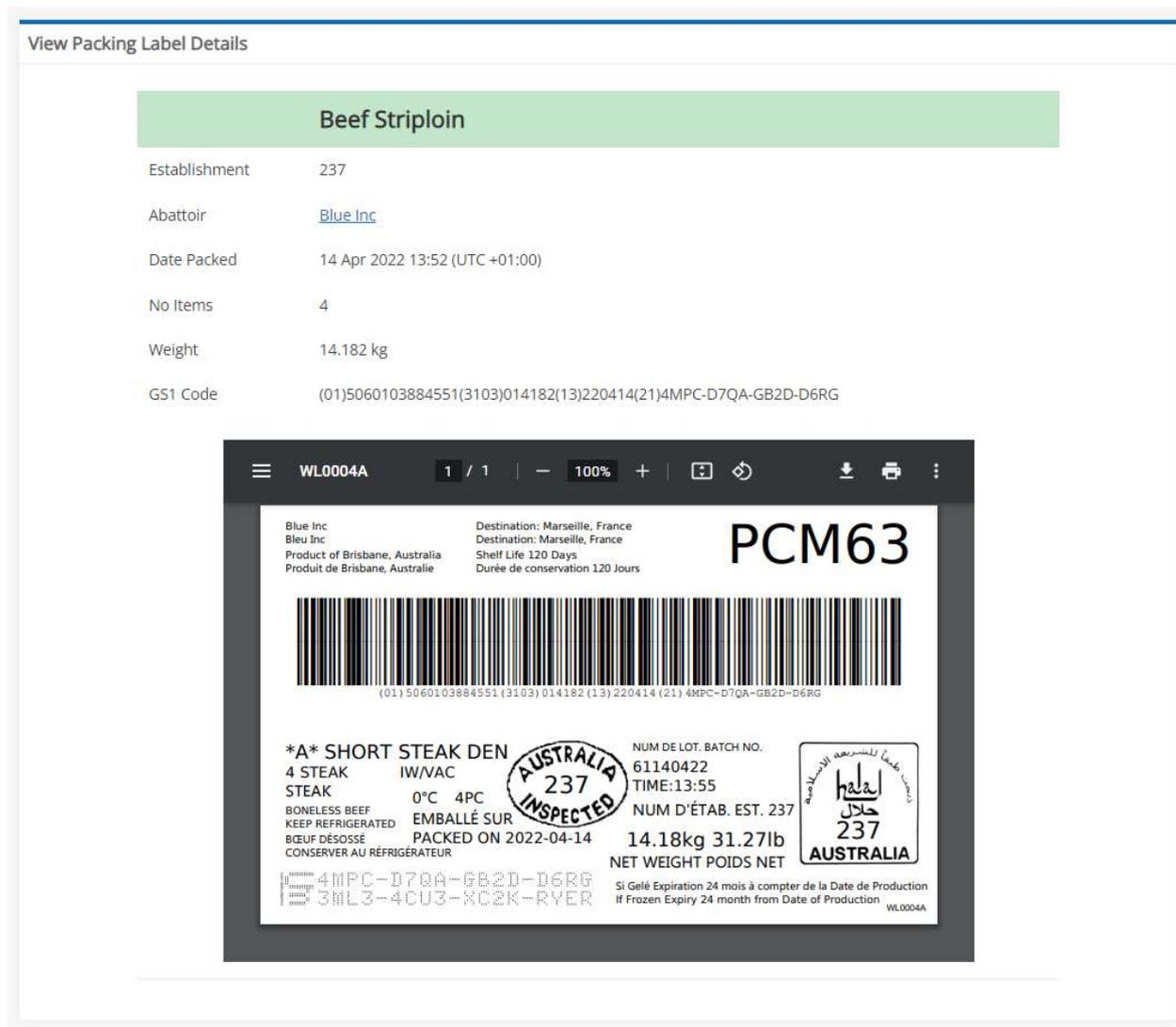


Figure 43 – View Packing Label Details screen

9.5 Appendix 5 - PrintNode

PrintNode (PrintNode.com, n.d.) is third party software used to interface to scales and printers (Figure 44). They provide comprehensive support for a wide range of scale and printing devices, which is continually being extended.

In particular, it provides a programmatic interface that allows control of the device from Javascript or PHP.

Secure access is provided on a per-user basis so that the facility's own combination of printers and scales can be utilised.



Figure 44 – PrintNode home page

9.6 Appendix 6 – Data flow

The data flows around the system as shown in this simplified diagram (Figure 45).

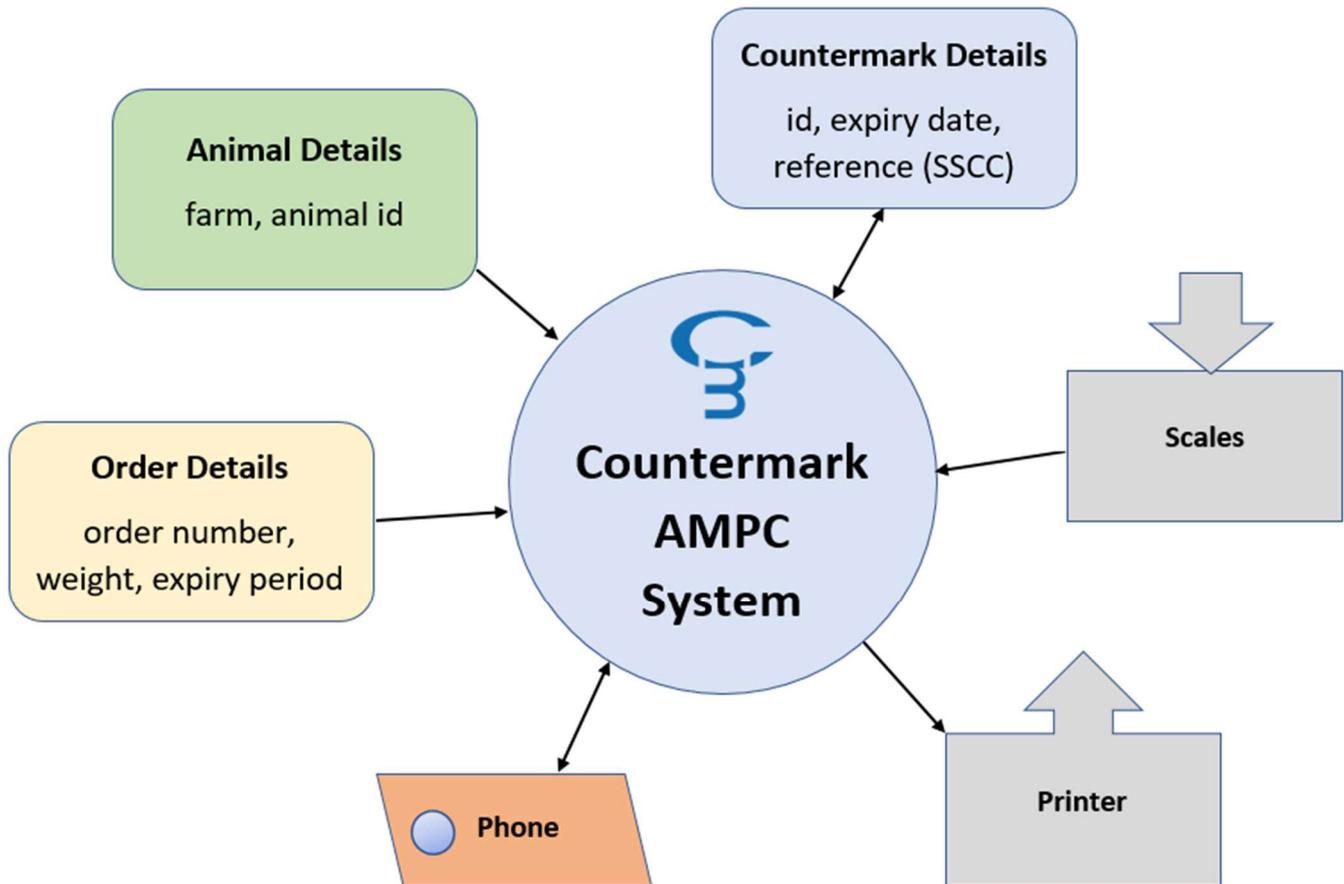


Figure 45 - Top-level data flow diagram

In detail, the following data items are used in the system:

9.6.1 Primal label entry

Input fields

Establishment ID, Second Language, Primal Type, Farm Name, Expiry Date, Animal Kill number, Animal Identity, Weight

Label content

Primal Type, Farm Origin, Batch Number, Establishment ID, Weight, Countermark and label type number

Countermark content

Label PDF, Label URL, Farm ID, Establishment ID, Animal Identity, Primal State, GTIN, GS1 Code (containing GTIN, Batch Number, Weight) and Creation Date/Time

9.6.2 Packing label entry

Input fields

Establishment ID, Order ID, Second Language

Label content

Establishment Name, Destination, Establishment Origin, Shelf Life, Order ID, GS1 Code (containing GTIN of first item in list, Net Weight, Packing Date, Countermark Top-row) Primal Type, class and related short versions, packaging details, Storage details, Inspection stamp, Batch Number, Packing Time, Establishment ID, Net Weight, Halal Stamp, Countermark, Refrigeration instructions and label type number.

Countermark content

Label PDF, Label URL, Farm ID, Establishment ID, Primal State, GTIN, GS1 Code (containing GTIN of first item in list, Net Weight, Packing Date, Countermark Top-row), Creation Date/Time, Packing List ID, Packing List Item ID(s), Number of Items

9.6.3 Consumer label entry

Input fields

Establishment ID, Consumer Product, Primal Countermark top-row(s), Primal Weight(s), Consumer Steak Weight(s)

Label content

Price, Unit of Currency, Price per kg, Use by Date Weight, EAN-13 point of sale barcode, Countermark and label type number.

Countermark content

Label PDF, Label URL, Farm ID, Establishment ID, Animal Identity, Primal State, GTIN, GS1 Code (containing GTIN, Batch Number, Weight) and Creation Date/Time

The data flows are represented in the following diagrams (Figure 46 / Figure 47 / Figure 48 / Figure 49 / Figure 50 / Figure 51 / Figure 52 / Figure 53):

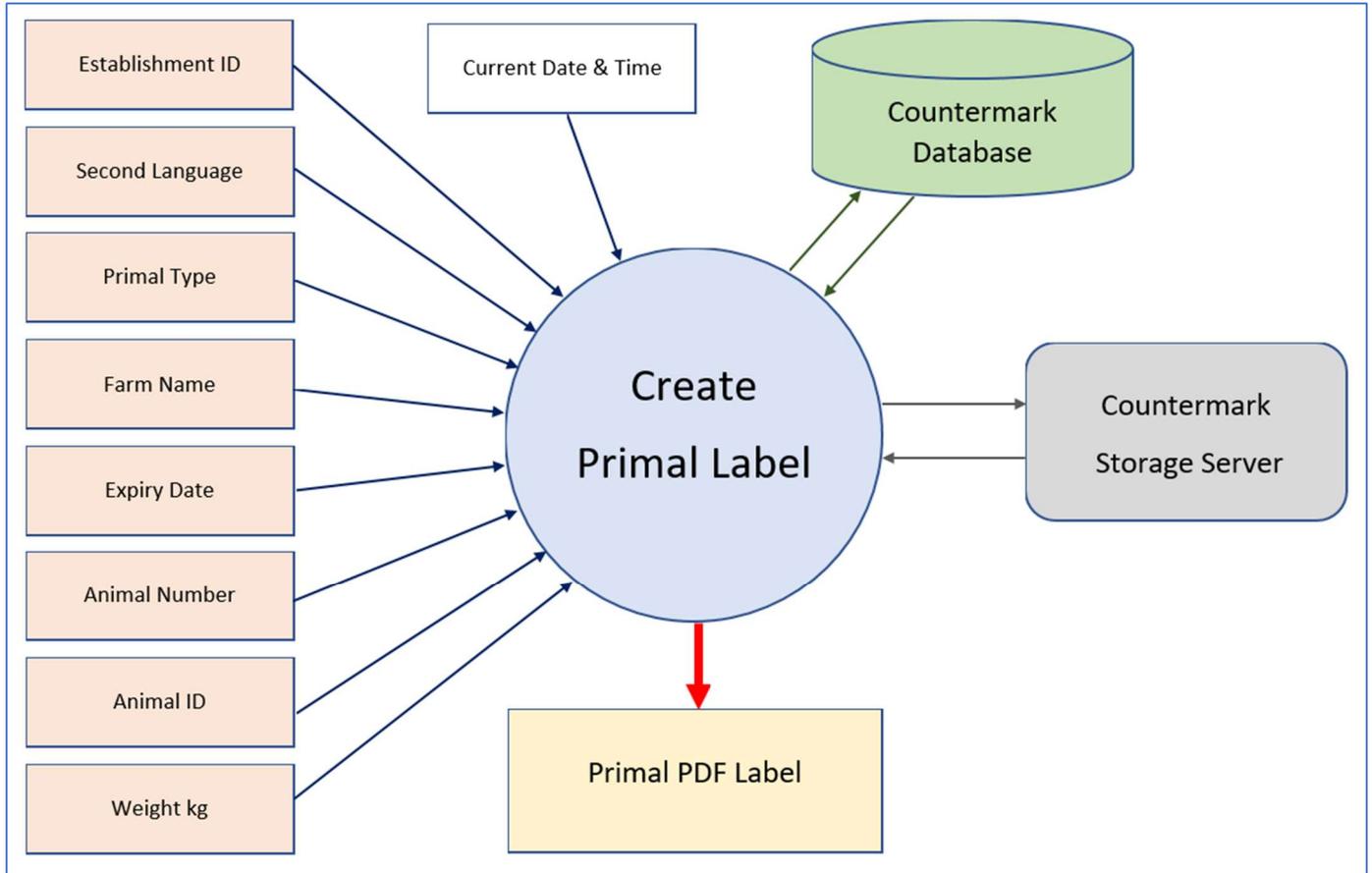


Figure 46 - Data flow - create Primal label

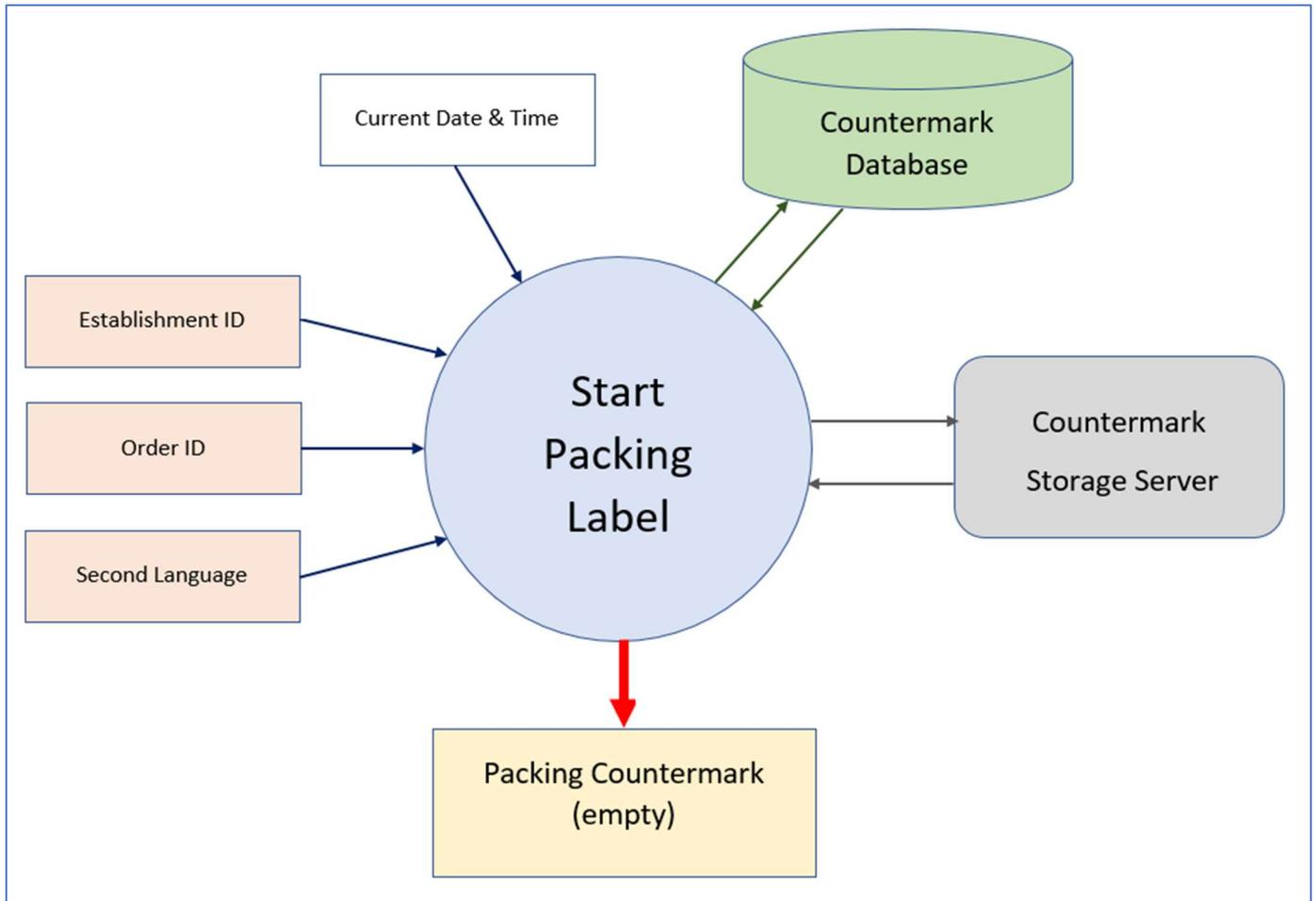


Figure 47 - Data flow - start Packing label

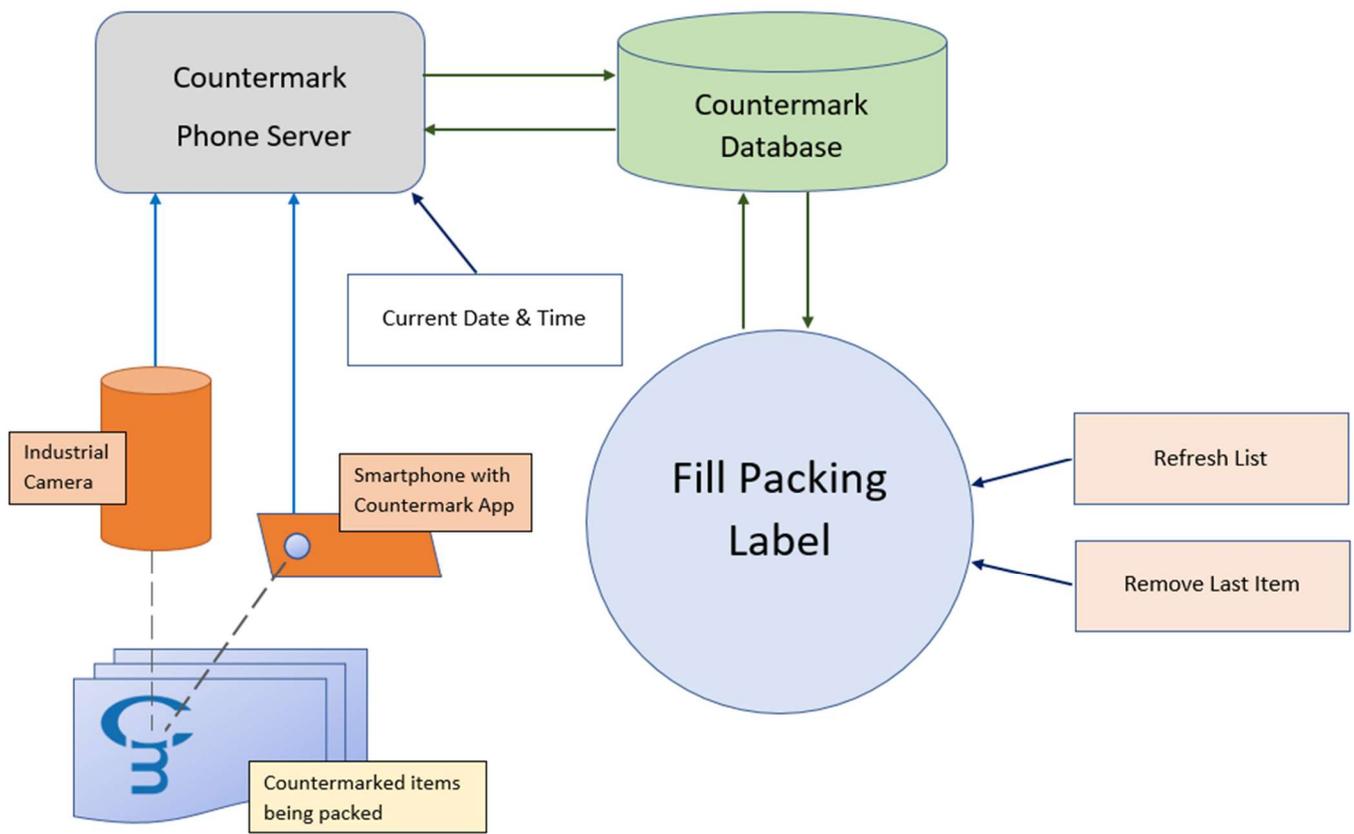


Figure 48 - Data flow - fill Packing label

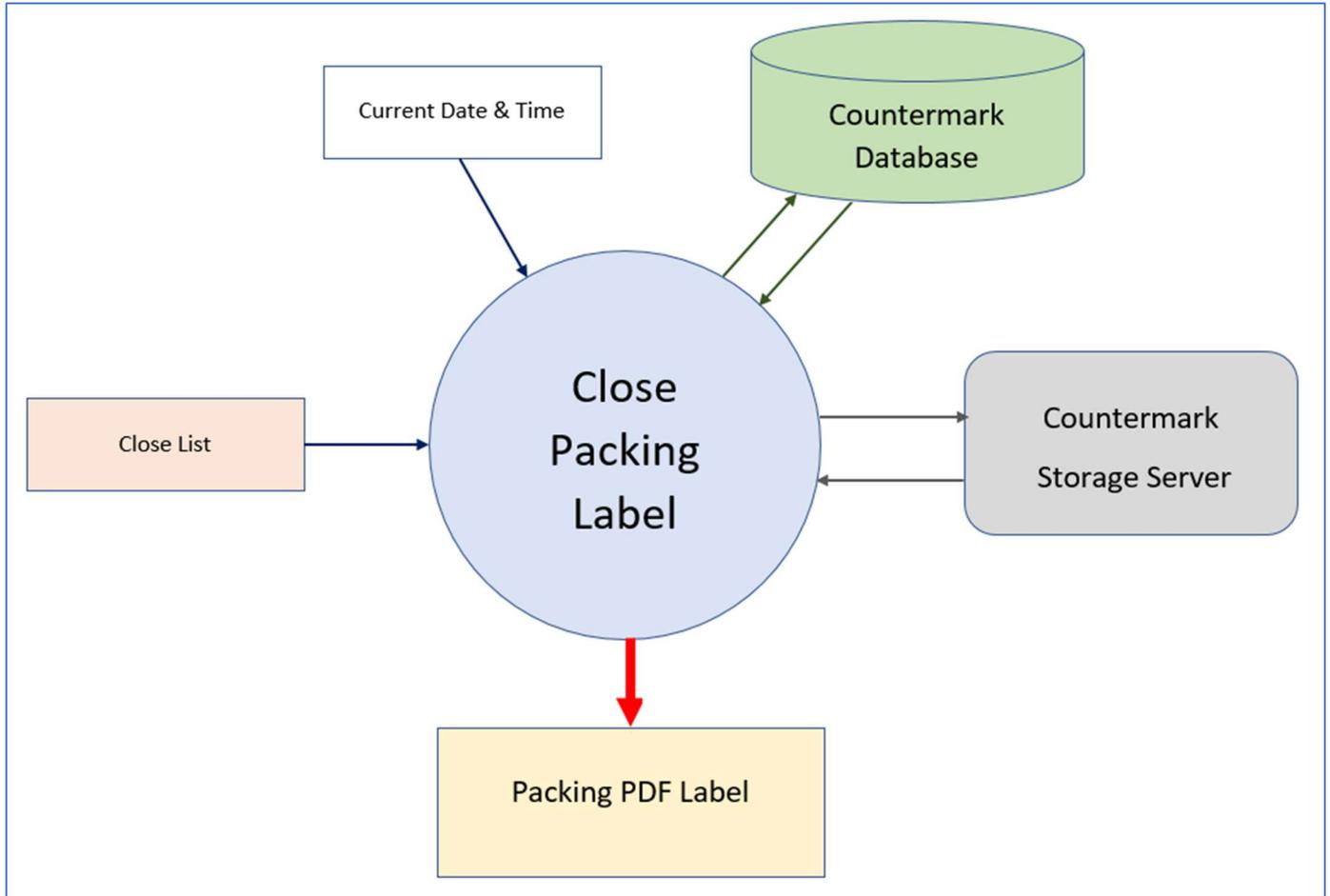


Figure 49 – Data flow - close Packing label

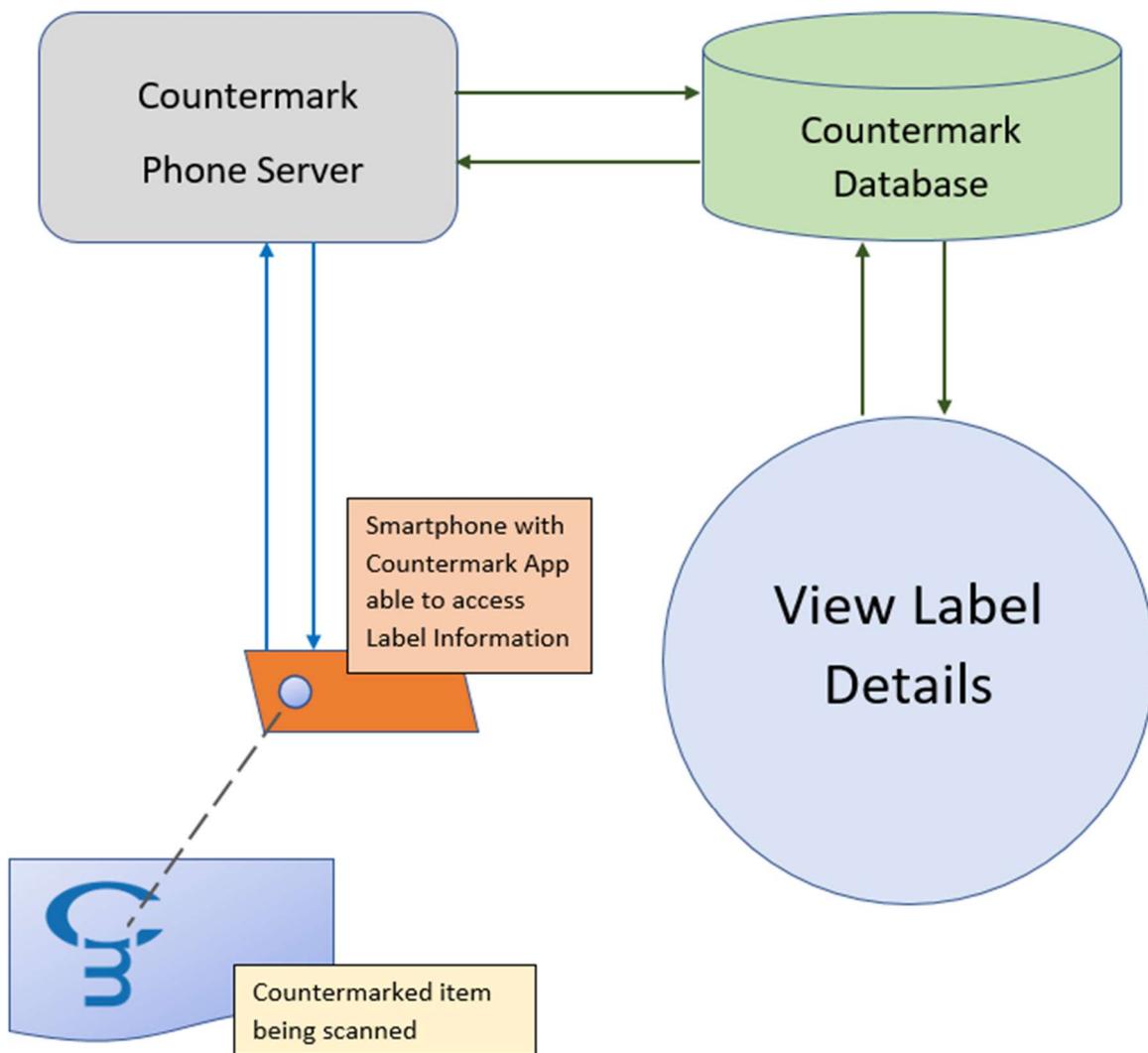


Figure 50 - Data flow - view label details

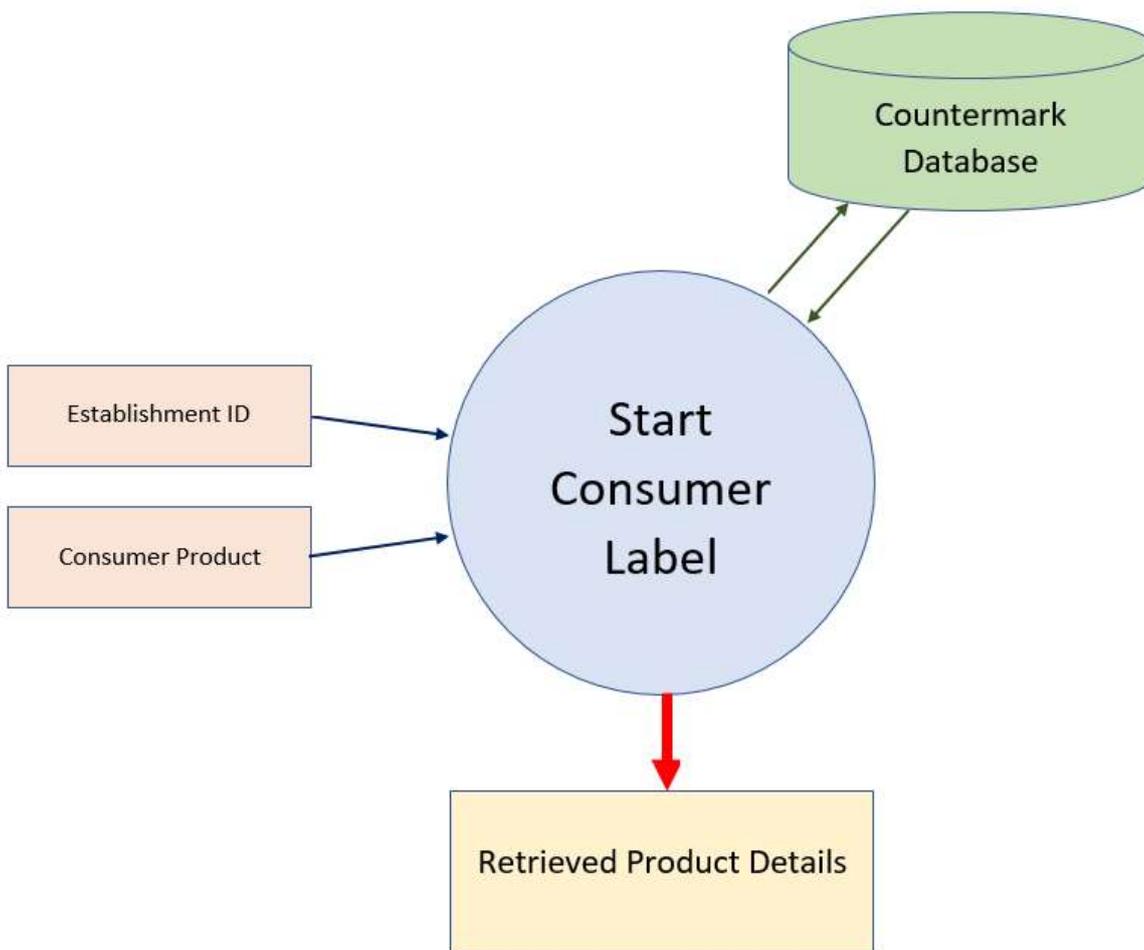


Figure 51 - Data flow - start Consumer label

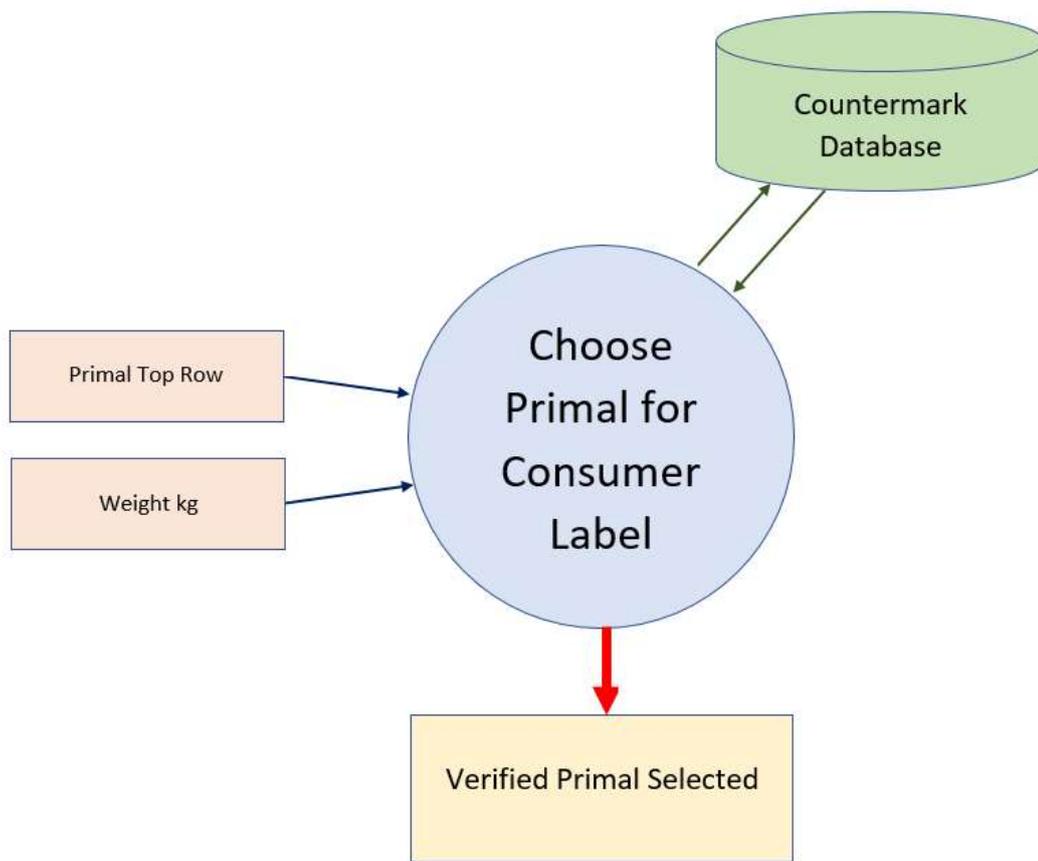


Figure 52 - Data flow - choose primal for Consumer label

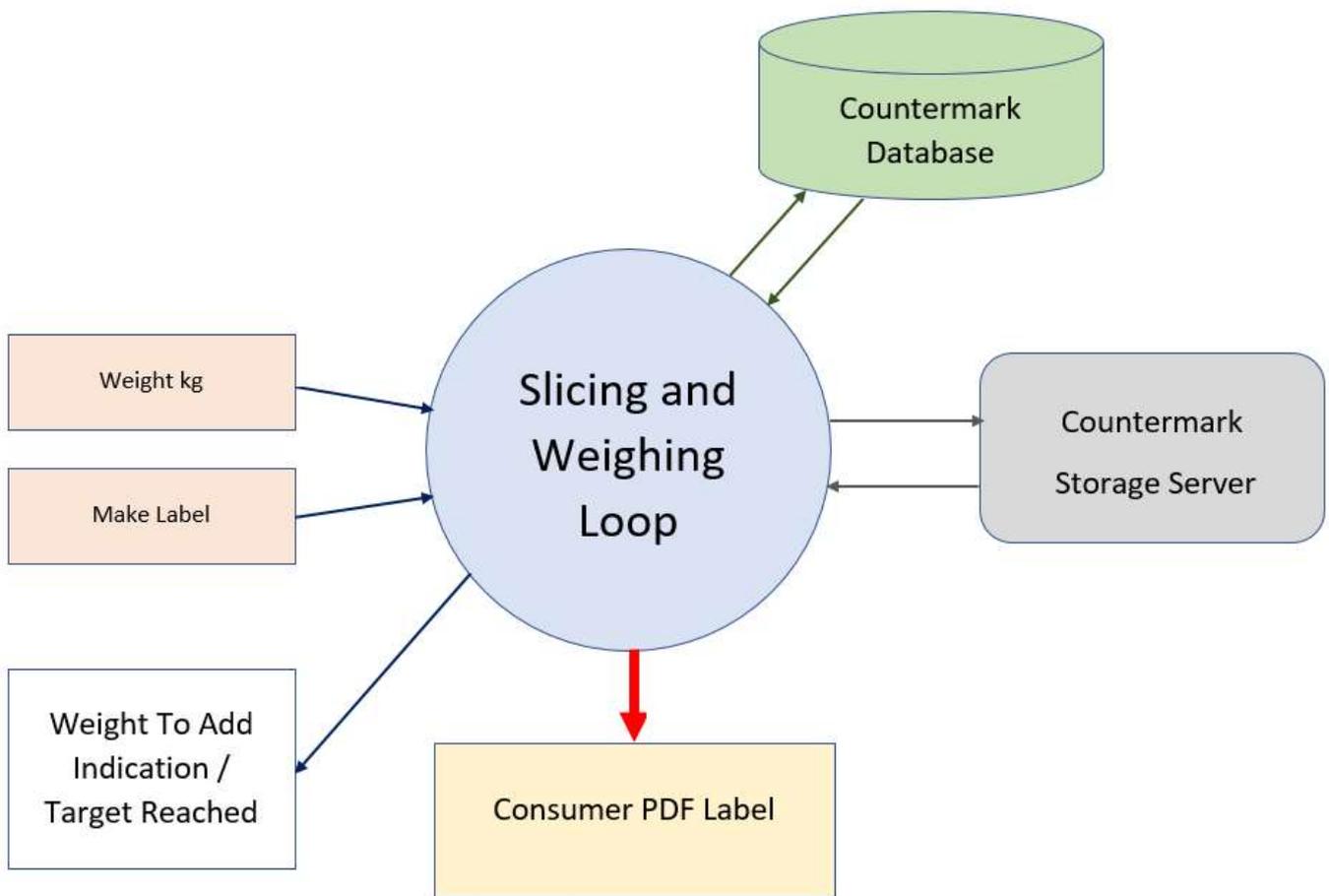


Figure 53 - Data flow - slicing and weighing loop

9.7 Appendix 5 – Glossary

Term (From both reports)	Meaning
AMPC	Australian Meat Processor Corporation
Animal Identity	Nationally controlled system for identifying farm animals
Consumer	The member of the public buying their steak
Consumer label	Label produced by the Countermark system that is attached to consumer packaging, typically has retail barcode, price, weight and other Consumer data
Consumer package	The package that the Consumer has their steaks packed in
Countermark	A proprietary printable data carrier developed by Wessex Technology OEP Ltd.
Countermark.Track2	A variant of the Countermark system developed for this project
CSV	Comma Separated Values – a file format used for data interchange between different software packages
GS1	International standards organisation
GTIN	Global Trade Item Number (GTIN) is a unique and internationally recognised identifier for a product
Inkjet Print, Inkjet Printing	Older style of industrial printing where individual droplets of ink are ejected from a printing nozzle at high speed, characters are formed from these individual dots, normally in a matrix of 7 dots high and 5 dots wide typically appearing as 1 2 3 A B C
Mass balancing	A method of controlling loss in production processes, where mass or weight is measured at different stages of a process
Microsoft Cloud	Cloud hosting system, operated by Microsoft, sometimes referred to as Azure
n.d. (in bibliography)	No date
Packing label	Label that can be used on the outside of a consignment, will be associated with (can be used to list) the Countermarks of the items in the consignment
Primal label	Label attached to each individual primal
SSCC	Serial Shipping Container Code (SSCC) is an 18-digit number used to identify logistics units
Track 1, Track 2	Sub-projects
Wessex	Wessex Technology OEP Ltd.