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The Use of EPC RFID Standards for Livestock and Meat Traceability

The New Zealand RFID Pathfinder Group

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Abstract

Radio Frequency Identification and related Technologies are seen as tools for identification and traceability purposes in the food and food production and distribution sectors. This research focuses on using EPC UHF RFID standards (components of the EPCglobal Network), and especially the EPCIS standard to identify, capture and share information throughout a real-life eleven stage process in the New Zealand venison industry. The researchers used the technologies to investigate the movement of live deer from a farm and a venison processing plant and then exporting of cartons of finished venison cuts by ocean freight to Europe and their delivery to a retail location in Hamburg, Germany. The findings corroborate those of other research indicating that EPC standards and specifically the EPCIS standard are effective tools for enhancing supply chain visibility and traceability.

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1 Executive Summary

The New Zealand RFID Pathfinder (Pathfinder) is an Incorporated Society established in May 2006. Pathfinder envisages superior economic and competitive performance in New Zealand through the adoption of RFID and EPC technologies. Pathfinder's objective is to coordinate and support organisations and individuals involved in the field of Radio Frequency Identification (RFID) and the Electronic Product Code (EPC).

Prompted by their constituents and by their own concerns about safety, governments in Europe and the United States are drafting new laws and regulations requiring various degrees of traceability, especially in the food and food products industries. The new requirements are creating more demand for traceability than ever before. Companies and regulators need systems than can provide robust end-to-end traceability with accurate information and precise identification of the products and services, locations and entities involved.

RFID technologies are seen as tools for identification and traceability within the food and food products sectors.

This research is a continuation of earlier research undertaken in 2010 by the New Zealand Pathfinder Group that investigated and assessed the efficacy of using ultra high frequency (UHF) RFID technology and the EPCglobal Network for livestock traceability. The focus was specifically on cattle as a sample species as outlined by Hartley & Sundermann (2010). That analysis outlined a methodology involving a process that identified, captured and provided data exchange of EPC data involving live animals moving from an on-farm environment through a meat processing facility to delivery of cartons of finished meat cuts to a New Zealand retail facility. The findings of the research confirmed that the EPCglobal Network and specifically the EPCIS standard can *enhance supply chain visibility and establish traceability*.

This research focuses specifically on using EPC UHF RFID standards (components of the EPCglobal Network) to identify, capture and share information throughout an eleven (11) stage process in the New Zealamd venison industry. The researchers used the technologies to investigate the movement of live deer from a farm in Geraldine, New Zealand and through a venison processing plant and then the export of chilled cartons of venison cuts by ocean freight to Europe and their delivery of cartons to retail locations in Hamburg, Germany. The cross-border element of the research provided an additional dimension to earlier research and was purposely included in the research design to examine and assess the EPC standards more rigorously.

The findings corroborate those of earlier research. They confirm that EPC RFID standards and especially EPCIS are efficacous, effective and efficient tools for enhancing supply chain visibility and traceability.

The researchers elected to incorporate an additional dimension into research by using active RFID tags (data loggers) Xsense® to monitor the temperature of individual cartons of venison cuts during the transit from the processing plant in New Zealand to delivery at retail in Hamburg. Further, movement of the shipping container itself was also tracked using Global Positioning System (GPS) technology.

This research was completed under the direction of the New Zealand RFID Pathfinder Group Incorporated with financial support from the Ministry for Primary Industries (Sustainable Farming Fund), industry bodies including GS1 New Zealand, Deer Industry New Zealand Farm IQ and of ANZCO Foods, Downlands Deer and Mountain River Processors. In Hamburg, the researchers worked closely with Prime Meat, a German meat importer and wholesaler that received the consignment and effected delivery to final destination. The researchers wish to thank NAIT (National Animal Identification and Tracing Ltd) and BT9 for their support.

The researchers encourage further research in this field towards greater industry adoption. Pathfinder wish to acknowledge and thank its funders and supporters for their valuable input in this research.

2 Introduction

Prompted by their constituents and by their own concerns about safety, governments in Europe and in the United States in particular have been drafting laws requiring various degrees of traceability, especially in the food industry. In New Zealand, the National Animal Identification and Traceability (NAIT) organisation has recognised *that worldwide lifetime identification and traceability of livestock and domestic animals is becoming increasingly important for a number of reasons, including trade and market access, management of livestock diseases and providing assurance to consumers that their food is safe and of the highest quality* (NAIT 2008 p.1). These new regulatory requirements are creating more demand for traceability than ever before. Companies need systems that can provide end-to-end traceability, with accurate information and precise identification of the products and services, locations and actors involved.

There is general recognition and acceptance in New Zealand that its trading partners will make the existence of credible systems that provide whole-of-life tracing of animal products a major factor in their decisions on which countries or suppliers they purchase from. NAIT has stated that *the driving force behind the NAIT system is the necessity to make individual animal identification and tracing work for the good of all participants and to protect New Zealand farmers in the market place while ensuring New Zealand is positioned well in the event of a biosecurity incursion* (NAIT 2008 p.2).

Radio frequency identification (RFID) has been identified as a technology that will not only speed the process of data collection but will ensure accuracy (NAIT 2008). The use of radio frequency identification technologies as a tool for identification and traceability purposes within the food and food products sectors has been used for many years according to Thakur et al., (2011). Thakur et al., (2011) outline a model for presenting food production processes to provide improved description and integration of traceability information using the EPC core vocabulary and identifiers.

A European consortium dedicated to food safety named SafeFoodEra conducted a collaborative RFID traceability pilot in 2010 with Swedish fisheries to test the efficacy of an EPCIS implementation for fish through the supply chain (Hild 2010). The research was part of eTrace, a project within the European Union food safety programme. The initial project scope was to track fish through the supply chain from vessel, through landing site, processor and wholesaler to final retailer to examine and evaluate traceability systems and product recall solutions (Hild 2010). The pilot outlined a series of process transitions using unique product and location identifiers from catch to retailer over a four day period. The pilot demonstrated the use of chain of custody information of individual boxes of fish throughout the supply chain (Hild 2010). According to the Swedish Fishery Board, the pilot proved positive (Margeirsson and Gunlaugsson 2011) not only as a tool for traceability but because of enhanced levels of information sharing between supply chain stakeholders. The retailer stakeholders attested to significant increases in sales due to traceability assurances (Hild 2010). The report also outlined that RFID and EPCIS worked well in harsh environments as a potential tool to meet the demands of the control regulation, (EG) nr 1224/2009 in EU (Hild 2010). EPCIS systems were shown to improve the speed and efficiency of traceability operations (Hild 2010).

New Zealand mandated the use of RFID technology for cattle in 2012 based on ISO standards, NZ/ISO 11784:2001 & 11785:2001.1 for transponders (low frequency RFID) and a numbering system to identify animals compliant with the International Committee on Animal Recording (ICAR) requirements. The use of RFID technologies will be mandated for other species in the coming years; Deer are scheduled for inclusion in 2013. NAIT may assess and endorse devices containing transponders, which are not NZ/ISO 11784:2001 / NZ/ISO 11785:2001 compliant on a species by species basis.

The EPCglobal Network is a secure means to connect servers containing information related to items identified by using globally unique numbers known as Electronic Product Code (EPC) numbers. The servers, called EPC Information Services (EPCIS) are linked via a set of standards-based network services and the internet. EPC standards and the EPCglobal Network are being used around the world to provide supply chain visibility and traceability.

As with earlier Pathfinder research into the use of RFID technology within the context of livestock identification and traceability outcomes, this research used Ultra High Frequency (UHF) RFID technologies (tags and readers) in conjunction with EPC identification and network standards; part of the broader EPC suite of standards.

This research was conducted over a period of six weeks from late October to early December 2012. Using an eleven (11) stage process design model, stage one (1) saw UHF ear tags encoded with EPC unique identification numbers attached to the ears of a sample population of twenty (20) deer that were being farmed in Geraldine, New Zealand. One animal escaped from the mob while on farm so that the sample population was nineteen (19). The remaining research stages outlined the transport of animals from the farm by road transport to a processing plant in Rakaia, New Zealand where the deer were processed into chilled venison cuts, packaged into cartons and exported by ocean freight in a refrigerated container for delivery to retail locations in Hamburg, Germany.

The researchers elected to incorporate an additional dimension into research by using active RFID tags (data loggers) Xsense® to monitor the temperature of individual cartons during the transit from the processing plant to delivery in Hamburg. In addition to this, the movement of the shipping container was also tracked using Global Positioning System (GPS) technology. Both these elements were managed by Israeli company BT9, an organisation that provides end-to-end cold chain management (CCM) technology and solutions.

3 Objectives

The objective of this research is to:

- Assess the efficacy of using EPC standards and in particular the EPCIS standard as a tool for livestock traceability from a farm in New Zealand to a retail facility based in Hamburg, Germany.

4 Defining Traceability

Schuster and Brock (2007) state that a fundamental requirement for any traceability system is some form of unique identification. While establishing a traceability system for agriculture bears similarities with other industry sectors including the pharmaceutical and medical industries, agriculture has unique attributes in regard to the application of RFID technology. Schuster and Brock (2007) explain that agricultural supply chains have a shared commodity orientation and that these supply chains also have particular complexities due to variations in taste, nutritional content and value across goods of the same type. They note that there are numerous attributes defining quality, safety and identity of food. Other important factors impacting on the agribusiness environment require, in their view, traceability systems to serve several functions for different constituencies including place of origin identification, counterfeit, product falsification, risk mitigation and liability, public safety and mitigating the effects of economic loss (Schuster and Brock 2007).

Myhre outlines that *being able to effectively recall contaminated or harmful product requires that information be available on time and preferably on line* (Myhre et al., 2009 p.1). Myhre et al., (2009 p.1) also report that *traditionally, making links between the input and output of a production process has been made using proprietary, non-standardised and in-house solutions*. As such, they propose a traceability solution for food supply chains based on the EPC Information Services (EPCIS) standard (Myhre et al., 2009) commenting that EPCIS appears to be the de facto standard for exchange of RFID/EPC events. Examining the efficacy of EPCIS as a solution for supply chain traceability, across industries and within enterprises was the focus of their research. The researchers submitted that an EPCIS-based traceability solution for the meat industry should (*1) Uniquely define the ingredients that have been used in each product, (2) be based on predefined queries provided by the EPCIS standards, and (3) provide both upstream and downstream traceability* (Myhre et al., 2009). The Myhre et al., (2009) research methodology combined insight from practice, operations management (OM) theory and information systems (IS) theory to construct a possible solution for tracing meat from farm to fork, based on simple EPCIS queries.

The suggested traceability solution arrived at was based on EPC and EPCIS making use of the EPCIS TransactionEvent in order to construct a logical link between input and output. Furthermore, the researchers suggest utilising three EPCIS fields; bizTransactionList and bizLocation to associate a traceability event with business transactions and business locations, as well as bizStep to describe that event which contains traceability information according to a specified format, enabling different solutions and standards to exist in parallel without (too much) confusion (Myhre et al., 2009). Finally, the researchers outline that in order to retrieve traceability information, the SimpleEventQuery be used to match specific ParentID or EPC's present in the epcList (eg: sGTIN, GLN) (Myhre et al., 2009).

There are many definitions and terms for traceability. The *Codex Alimentarius* is a collection of internationally recognised standards, codes of practice, guidelines and other recommendations relating to foods and food production and food safety administered by The Codex Alimentarius Commission, a body established in 1963 by the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO), (Codex Alimentarius, 2012). Codex Alimentarius is recognized by the World Trade Organisation (WTO) as an international reference point for the resolution of disputes concerning food safety and consumer protection (Codex Alimentarius, 2012). In Codex Alimentarius the term *Traceability/Product Tracing* is used (Codex Alimentarius, 2012). Many others speak of tracking and tracing and in the United States this is simply called record-keeping (CIES 2005). However, in effect all refer to what is basically the same thing. Traceability is also mentioned in ISO 9001:2008 – Quality management systems – Requirements, as one of the aspects that should be considered in a quality management system.

The Food Business Forum – Comite International d'Entreprises a Succursales (CIES), the independent global Food Business Forum define traceability as 'the ability to trace the history, application or location of an entity by means of recorded identifications' (CIES 2005) based on the ISO 9001 Standard: *"Traceability: ability to trace the history, application or location of that which is under consideration."* CIES expand their definition to *Chain Traceability* - the ability to trace the history, application or location of an entity by means of recorded identifications throughout the entire food chain (CIES 2005). To facilitate this CIES notes that describe*, 'in practice, the requirement for traceability is to keep records of suppliers and customers, sometimes called "one step up, one step down". If all food businesses keep these records and the information therein can be communicated and exchanged, chain traceability is achieved'* (CIES 2005).

The CIES guidance document (CIES 2005) contains the following paragraph concerning traceability: *"6.1.17 Traceability - The standard shall require that the supplier develop and maintain appropriate procedures and systems to ensure:*

- *Identification in any case through a code marking on container and product, to identify the source of any out-sourced product, ingredient or service;*
- *record of purchaser and delivery destination for all product supplied.*

From a farmer's perspective, place of origin is recognised as an important input in defining efficacy of traceability systems. Nielsen and Kristensen (2008) emphasise that international competition is seen as a threat to farmer's livelihood.

In the defining the efficacy of the EPCIS standard for livestock traceability, there are various critical considerations: The level of rigor required in a particular context; the product recall/ withdrawal performance requirements and the required levels of traceability robustness and desired outcome(s) dependant on which function in a supply chain a stakeholder participates. For processors and slaughter plants, efficacy may be defined by tracking and tracing the flow of production metrics. Nielsen and Kristensen (2008) state that two primary motives have driven development of traceability for meat and meat products in Denmark: supply chain management and efficiency, and the quest for lean, flexible production with safety and quality control. On analysis, *Chain Traceability* as defined by CIES (2005) establishes a rigorous benchmark of requirements that define traceability and this is the definition this research and analysis referenced as the test for efficacious traceability.

5 Methodology

The research focuses on a sample size of nineteen (19) live deer and cartons of finished venison cuts. The research metholodology outlines an eleven (11) step process model that identifies, captures and provides data exchanges of EPC read event information among authorised supply chain participants covering the movement of live deer from an on-farm location, through a venison processing facility, exporting of cartons of finished venison cuts to Europe and delivery of cartons to two retailer facilies located in Hamburg, Germany.

The following EPC standards were used in the research as outined in a Process Design Model[1].

- **Serialised Global Trade Item Number** (sGTIN) - a unique, serialised identification number used to identify individual deer (UHF ear tags) and cartons of finished venison cuts.
- **Serialised Global Location Number** (sGLN) - a unique, serialised identification number used to identify specific EPC read event locations.
- **Global Returnable Asset Identifier** (GRAI) - a unique serialised identification number that identified the refrigerated shipping container.

EPCglobal defines a *Core Business Vocabulary* (CBV) that specifies various vocabulary elements and their values for use in conjunction with the EPCIS standard. The vocabulary identifiers and definitions ensure that all parties who exchange EPCIS data using the CBV will have a common understanding of the semantic meaning of that data. The CBV used in this research is outlined in the glossary. EPCglobal also define *Business Steps* (*bizstep*) that are standard identifiers for the EPCIS vocbulary. The bizsteps used in this research are outlined in the glossary.

Process Step 1 - Tagging of Animals on farm at Downlands Deer

Figure 5.1 - Animals with UHF RFID ear tags

Figure 5.2 - Reading UHF RFID ear tags

Figure 5.1 and Figure 5.2 illustrate the UHF EPC Generation 2 RFID ear tags positioned in the animals' ears and the tags being read by a handheld UHF RFID reader while the deer are in the holding pen on-farm in Geraldine, New Zealand.

[1] See Appendix

Process Step 2 - Animals leave farm and are loaded onto truck via farm race at Downlands Deer

Figure 5.3 - Recording tag reads in farm race

Figure 5.4 - Truck leaving farm for processor

Figure 5.3 and Figure 5.4 depict process stage 2 where animals are moved from the holding pen on farm in Geraldine where the UHF RFID tags are read and recorded as the animals are herded into the truck in preparation for transport to the processing plant in Rakaia.

Process Step 3 - Animals Arrive at Mountain River Processors' holding pen

Figure 5.5 - View from processors holding pen into truck

Figure 5.6 - Inside the processors holding pen

Figure 5.5 illustrates a view looking from inside the holding pen at the venison processors towards the truck. Figure 5.6 illustrates a view from inside the proceessors holding pen where a UHF RFID antenna is fixed to the holding pen wall.

Process Step 4 - Animals arrive at Mountain River Processors' stun box

Figure 5.7 - Stun Box

Figure 5.8 - RFID reader at Stun Box

Figure 5.7 illustrates animals in the location of the stun box. Note the RFID ear tags in the ears of the animals. Figure 5.8 illustrates the RFID antenna setup at the stun box.

Process Step 5 - Cartons of finished Venison cuts packed into cartons at Mountain River processor and moved from the boning room into chiller room

Figure 5.9 - UHF RFID tags used on cartons

Figure 5.10 - UHF RFID tags positioned on cartons

Figure 5.11 – Tagged cartons moving from boning room to chiller room

Figure 5.9, Figure 5.10 and Figure 5.11 illustrate the affixing of EPC UHF RFID tags on the cartons in the boning room and moving of cartons of finished venison cuts into the chiller room in preparation for loading the shipping container.

Process Step 6 - Cartons of venison cuts loaded into export shipping container at Mountain River Processors' chiller room exit

Figure 5.12 - Loading cartons into container

Figure 5.13 - Cartons of finished venison cuts

Figure 5.12 illustrates cartons of finished venison cuts being loaded into the shipping container where the UHF RFID antenna is positioned either side of the conveyor, reading and recording the identification numbers from the tags affixed to each carton. Figure 5.13 illustrates cartons loaded into the shipping container at the venison processor's facility in preparation for export to Hamburg, Germany (RFID tag highlighted).

Process Step 7 - Container leaving for Port of Lyttleton, Christchurch, New Zealand

Figure 5.14 - Reading container RFID tag on departure fom Mountain River Processors

Figure 5.14 illustrates the truck driver using a handheld UHF RFID reader to scan and read the UHF RFID tag afffixed to the outside of the shipping conatiner on leaving the processsing plant in Rakaia. The unique identificattion number (GRAI) is subsequently recorded in the EPCIS database.

Process Step 8 - Container arriving at Port of Lyttleton, Christchurch, New Zealand

Figure 5.15 - Contaner RFID tag read on arrvial
at Port of Lyttleton, Christchurch

Figure 5.15 illustrates the shipping container arriving at the Port of Lyttleton on a truck where the UHF RFID tag, affixed to the outside of the shipping container is scanned, read and the unique identificattion number (GRAI) recorded for populating the EPCIS database.

Process Step 9 - Cartons of venison cuts receipted on arrival at Prime Meat warehouse, Hamburg

Figure 5.16 - Palletised cartons
after being unloaded

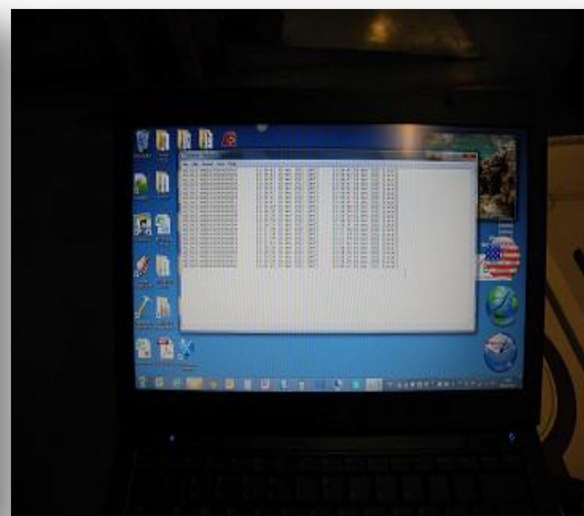


Figure 5.17 - RFID reads as cartons are
unloaded from the shipping container

After the venison was inspected by regulatory authorities, the container was opened at Prime Meat's cold store. Figure 5.16 illustrates the 19 palletised cartons after being unloaded from shipping conatiner in preparation for final delivery. Figure 5.17 illustrates the RFID event reads during the unloading process of the 19 cartons from the shipping container at Prime Meat.

Process Step 10 - Cartons of venison cuts loaded into truck at Prime Meat warehouse, Hamburg

Figure 5.18 - Palletised cartons in preparation or final delivery

Figure 5.19 - Delivery vehicle leaving Prime Meat

After unloading the cartons from the shipping container, they were stored on pallets overnight in Prime Meat's cold store as illustrated in Figure 5.18. Figure 5.19 illustrates the delivery vehicle en route to effect delivery of the cartons to two separate retail locations in Hamburg. Carton RFID tags were scanned at the beginning of the delivery; one pallet containing five (5) cartons and the other pallet containing four (4) cartons, as well as at each delivery location.

Process Step 11 - Cartons of venison cuts delivered to retailers in Hamburg

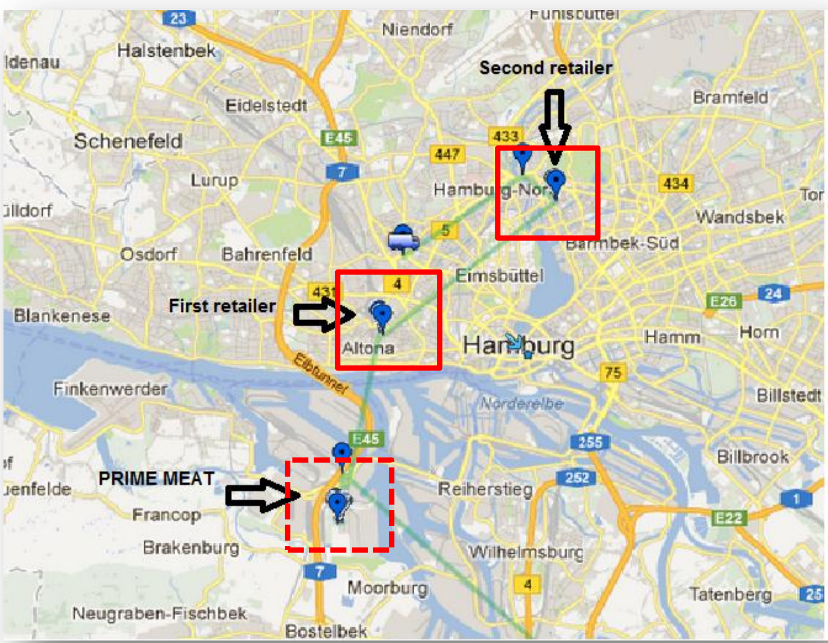


Figure 5.20 - Delivery locations of cartons in Hamburg

Figure 5.20 illustrates the transit route to the two (2) delivery locations in Hamburg as recorded by the GPS unit accompanying the shipment.

6 Data Collection and Discussion

Having outlined the eleven step process model, the researchers used the EPCglobal suite of standards to uniquely identify live animals as well as cartons of venison cuts and physical locations through the supply chain. EPC standards were used to capture the information encoded into the RFID tags at related read event points and all data was populated into the EPCIS database for subsequent query and analysis.

The figures and tables provided below outline the EPC read events as recorded in the EPCIS database. A description and analysis of those events is highlighted in the process step model in the Appendix.

The tables that follow are taken from screen shoots of GS1 Hong Kong's EPCIS ezTrack user interface.

DataLink Main

Select View: Search by EPC Only

EPC in urn:epc:id:sgtin:9421900217.003.1073742106

Parent EPC in

Search

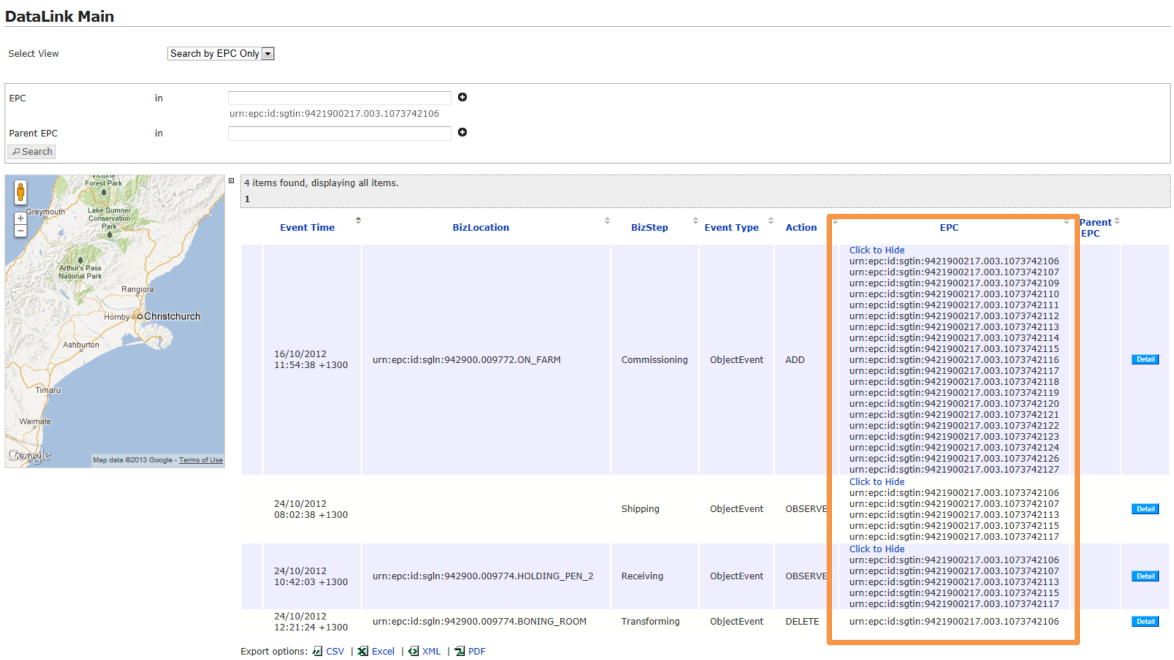
4 items found, displaying all items.
1

Event Time	BizLocation	BizStep	Event Type	Action	EPC	Parent EPC	
16/10/2012 11:54:38 +1300	urn:epc:id:sgln:942900.009772.ON_FARM	Commissioning	ObjectEvent	ADD	Click to Show (20)		Detail
24/10/2012 08:02:38 +1300		Shipping	ObjectEvent	OBSERVE	Click to Show (5)		Detail
24/10/2012 10:42:03 +1300	urn:epc:id:sgln:942900.009774.HOLDING_PEN_2	Receiving	ObjectEvent	OBSERVE	Click to Show (5)		Detail
24/10/2012 12:21:24 +1300	urn:epc:id:sgln:942900.009774.BONING_ROOM	Transforming	ObjectEvent	DELETE	urn:epc:id:sgtin:9421900217.003.1073742106		Detail

Export options: CSV | Excel | XML | PDF

Table 6.1 - Identification of a single animal

Table 6.1 outlines the RFID ear tagging of the original twenty (20) animals. The table identifies the search for data relating to one animal in particular (i.e. the EPC sGTIN urn:epc:id:sgtin:9421900217.003.1073742106). Table 6.1 illustrates four (4) events identified for this animal using the EPCglobal Core Business Vocabulary (CBV) standard namely: *commissioning*, *shipping*, *receiving* and *transforming*. Note that not all events relate to only one (1) animal, the *commissioning* related to twenty (20) animals, the loading and unloading to five (5) animals (i.e. one compartment inside the truck reserved for five (5) animals, and the stun box event relating to processing only one (1) animal at a time.



DataLink Main

Select View: Search by EPC Only

EPC in urn:epc:id:sgtin:9421900217.003.1073742106

Parent EPC in

Search

4 items found, displaying all items.

1

Event Time	BizLocation	BizStep	Event Type	Action	EPC	Parent EPC	
16/10/2012 11:54:38 +1300	urn:epc:id:sgln:942900.009772.ON_FARM	Commissioning	ObjectEvent	ADD	Click to Hide urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742109 urn:epc:id:sgtin:9421900217.003.1073742110 urn:epc:id:sgtin:9421900217.003.1073742111 urn:epc:id:sgtin:9421900217.003.1073742112 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742114 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742116 urn:epc:id:sgtin:9421900217.003.1073742117 urn:epc:id:sgtin:9421900217.003.1073742118 urn:epc:id:sgtin:9421900217.003.1073742119 urn:epc:id:sgtin:9421900217.003.1073742120 urn:epc:id:sgtin:9421900217.003.1073742121 urn:epc:id:sgtin:9421900217.003.1073742122 urn:epc:id:sgtin:9421900217.003.1073742123 urn:epc:id:sgtin:9421900217.003.1073742124 urn:epc:id:sgtin:9421900217.003.1073742126 urn:epc:id:sgtin:9421900217.003.1073742127		Detail
24/10/2012 08:02:38 +1300		Shipping	ObjectEvent	OBSERVE	Click to Hide urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742117		Detail
24/10/2012 10:42:03 +1300	urn:epc:id:sgln:942900.009774.HOLDING_PEN_2	Receiving	ObjectEvent	OBSERVE	Click to Hide urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742117		Detail
24/10/2012 12:21:24 +1300	urn:epc:id:sgln:942900.009774.BONING_ROOM	Transforming	ObjectEvent	DELETE	urn:epc:id:sgtin:9421900217.003.1073742106		Detail

Export options: CSV | Excel | XML | PDF

Table 6.2 - List of EPC identifiers in expanded view

Table 6.2 outlines the same information as Table 6.1 but with the list of EPC numbers expanded. Table 6.2 outlines which other animals / tags were associated with an EPC event. Note, for example, that the five (5) animals that moved from the farm Holding Pen to the truck (into one (1) compartment) came off the truck together.

EPCIS Event Details

Event Time	16/10/2012 11:54:38 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	ADD
EPC	urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742109 urn:epc:id:sgtin:9421900217.003.1073742110 urn:epc:id:sgtin:9421900217.003.1073742111 urn:epc:id:sgtin:9421900217.003.1073742112 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742114 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742116 urn:epc:id:sgtin:9421900217.003.1073742117 urn:epc:id:sgtin:9421900217.003.1073742118 urn:epc:id:sgtin:9421900217.003.1073742119 urn:epc:id:sgtin:9421900217.003.1073742120 urn:epc:id:sgtin:9421900217.003.1073742121 urn:epc:id:sgtin:9421900217.003.1073742122 urn:epc:id:sgtin:9421900217.003.1073742123 urn:epc:id:sgtin:9421900217.003.1073742124 urn:epc:id:sgtin:9421900217.003.1073742126 urn:epc:id:sgtin:9421900217.003.1073742127
BizStep	urn:epcglobal:cbv:bizstep:commissioning
Disposition	urn:epcglobal:cbv:disp:active
BizLocation	urn:epc:id:sgln:942900.009772.ON_FARM
Read Point	urn:epc:id:sgln:942900.009772.DEER_CRUSH

Table 6.3 - Commissioning event - tagging of animals

Table 6.3 outlines a *commissioning event*, i.e. the tagging of the animals. Table 6.3 depicts twenty (20) animals being tagged in one 'go'. The BizStep is *commissioning* where the tags and animals are considered to be *active* from this point on. Note that the values for *business step* and *disposition* are standardised values established by EPCglobal in the Common Business Vocabulary (hence urn:epcglobal:cbv prefix). The GLN *extensions* (DEER_CRUSH and ON_FARM) give more specific location details. The reading event occurred at the DEER_CRUSH location where the animals are considered to be ON_FARM from this point on.

EPCIS Event Details

Event Time	24/10/2012 08:02:38 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	OBSERVE
EPC	urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742117
BizStep	urn:epcglobal:cbv:bizstep:shipping
Disposition	urn:epcglobal:cbv:disp:in_transit
BizLocation	
Read Point	urn:epc:id:sgln:942900.009772.LOADING_RAMP

Table 6.4 - Shipping observation of animals in transit

Table 6.4 depicts five (5) animals being *observed* during a *shipping* process step (i.e. loading animals into a truck). The animals are considered to be *in_transit* from this point on. The animals are identified at the LOADING_RAMP location at the deer farm. Given the shipping event is occurring between two locations (farm to processing plant) on a road, there is little additional information available.

EPCIS Event Details

Event Time	24/10/2012 10:42:03 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	OBSERVE
EPC	urn:epc:id:sgtin:9421900217.003.1073742106 urn:epc:id:sgtin:9421900217.003.1073742107 urn:epc:id:sgtin:9421900217.003.1073742113 urn:epc:id:sgtin:9421900217.003.1073742115 urn:epc:id:sgtin:9421900217.003.1073742117
BizStep	urn:epcglobal:cbv:bizstep:receiving
Disposition	urn:epcglobal:cbv:disp:in_progress
BizLocation	urn:epc:id:sgln:942900.009774.HOLDING_PEN_2
Read Point	urn:epc:id:sgln:942900.009774.UNLOADING_RAMP

Table 6.5 - Animals received at processing plant

Table 6.5 outlines observing the same animals as depicted in Table 6.4 where five (5) animals are being observed together coming off the truck – a *receiving* process step. The business disposition is *in_progress* at the processing plant. Global Location Number urn:epc:id:sgln:942900.009774.xxx uniquely identifies the processing plant. The extensions UNLOADING_RAMP and HOLDING_PEN_2 provide additional, more specific detail. The animals were read at the Unloading Ramp and are considered to be in Holding Pen 2 until further notice.

EPCIS Event Details

Event Time	24/10/2012 12:21:24 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	DELETE
EPC	urn:epc:id:sgtin:9421900217.003.1073742106
BizStep	urn:epcglobal:cbv:bizstep:transforming
Disposition	urn:epcglobal:cbv:disp:in_progress
BizLocation	urn:epc:id:sgln:942900.009774.BONING_ROOM
Read Point	urn:epc:id:sgln:942900.009774.STUN_BOX
Extensions	http://www.gs1nz.org/cbv/ext: batch=deer_epcis_pilot

Table 6.6 - Animals are deleted for processing

Table 6.6 outlines a RFID tag (and therefore an animal) being *deleted* at the processor's stun box. This event is captured one (1) animal at a time (i.e. a unique date/timestamp for each animal). The process step is *transforming* and still *in_progress* from this point on. The read event taken at the Stun Box assumes the animal moves into the boning room from this point on. For more granular levels of traceability additional read points could be defined.

Additional and important data is the *batch* entry in the *Extensions* . Batch establishes an association between a single animal (sGTIN urn:epc:id:sgtin:9421900217.003.1073742106) and a batch of twenty (20) animals called *deer_epcis_pilot.* The same batch ID will be referred to in the EPCIS records for the cartons of venison allowing a linkage between the animals and the cartons; not as 1-to-1 relationship, but as a many to-many relationship.

EPCIS Event Details

Event Time	25/10/2012 11:25:53 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	ADD
EPC	urn:epc:id:sgtin:94130000.01420.1 urn:epc:id:sgtin:94130000.01420.2 urn:epc:id:sgtin:94130000.01420.3 urn:epc:id:sgtin:94130000.01420.4 urn:epc:id:sgtin:94130000.01420.5 urn:epc:id:sgtin:94130000.01420.6 urn:epc:id:sgtin:94130000.01420.7 urn:epc:id:sgtin:94130000.01420.8 urn:epc:id:sgtin:94130000.01420.9
BizStep	urn:epcglobal:cbv:bizstep:commissioning
Disposition	urn:epcglobal:cbv:disp:active
BizLocation	urn:epc:id:sgln:942900.009774.CHILLER_ROOM
Read Point	urn:epc:id:sgln:942900.009774.BONING_ROOM_EXIT
Extensions	http://www.gs1nz.org/cbv/ext: batch=deer_epcis_pilot

Table 6.7 - Cartons moving from boning room to chiller

Table 6.7 illustrates the movement of nine (9) of the nineteen (19) cartons of finished venison cuts moving from the boning room into the chiller room as cartons where the B*izStep* is *commissioning* and the read event occurred at the exit point in the boning room (BONING_ROOM_EXIT). Highlighted in the extensions section is batch extension *deer_epcis_pilot* signifying the relationship between the nine (9) cartons and the total batch of nineteen (19) animals.

EPCIS Event Details

Event Time	26/10/2012 07:31:09 +1300
Timezone Offset	+13:00
Event Type	AggregationEvent
Action	ADD
EPC	urn:epc:id:sgtin:94130000.01420.1 urn:epc:id:sgtin:94130000.01420.10 urn:epc:id:sgtin:94130000.01420.11 urn:epc:id:sgtin:94130000.01420.12 urn:epc:id:sgtin:94130000.01420.16 urn:epc:id:sgtin:94130000.01420.17 urn:epc:id:sgtin:94130000.01420.18 urn:epc:id:sgtin:94130000.01420.2 urn:epc:id:sgtin:94130000.01420.20 urn:epc:id:sgtin:94130000.01420.21 urn:epc:id:sgtin:94130000.01420.22 urn:epc:id:sgtin:94130000.01420.23 urn:epc:id:sgtin:94130000.01420.3 urn:epc:id:sgtin:94130000.01420.4 urn:epc:id:sgtin:94130000.01420.5 urn:epc:id:sgtin:94130000.01420.6 urn:epc:id:sgtin:94130000.01420.7 urn:epc:id:sgtin:94130000.01420.8 urn:epc:id:sgtin:94130000.01420.9
Parent EPC	urn:epc:id:grai:942900000.135.24680
BizStep	urn:epcglobal:cbv:bizstep:staging_outbound
Disposition	urn:epcglobal:cbv:disp:container_closed
BizLocation	urn:epc:id:sgln:942900.009774.CONTAINER_ON_SITE
Read Point	urn:epc:id:sgln:942900.009774.CHILLER_ROOM_EXIT

Table 6.8 - Cartons being loaded into shipping container

Table 6.8 illustrates that the 19 cartons of finished venison cuts have been loaded into the shipping container (*BizStep*: staging_outbound and *Event Type* - *AggregationEvent*) from the chiller (ie: urn.epc:id:sgln:942900.009774.CHILLER_ROOM_EXIT). The container is identified by the Parent EPC 942900000.135.24680 where the EPC unique identifier is a global returnable asset identifier - GRAI.

EPCIS Event Details

Event Time	26/10/2012 07:53:00 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	OBSERVE
EPC	urn:epc:id:grai:942900000.135.24680
BizStep	urn:epcglobal:cbv:bizstep:shipping
Disposition	urn:epcglobal:cbv:disp:in_transit
BizLocation	
Read Point	urn:epc:id:sgln:942900.009774.EXIT_GATE

Table 6.9 - Container leaves processors site

Table 6.9 illustrates the shipping container, identified by the unique EPC identifier (urn:epc:id:grai:942900000.135.24680) leaving the processing plant where the read point is identified by the unique location number (urn:epc:id:sgln:942900.009774.EXIT_GATE). The BizStep is a *shipping* event and the container is considered to be in transit from the processors plant in Rakaia to the Port of Lyttleton, Christchurch (*in_transit)*.

EPCIS Event Details

Event Time	26/10/2012 09:13:00 +1300
Timezone Offset	+13:00
Event Type	ObjectEvent
Action	OBSERVE
EPC	urn:epc:id:grai:942900000.135.24680
BizStep	urn:epcglobal:cbv:bizstep:shipping
Disposition	urn:epcglobal:cbv:disp:in_transit
BizLocation	
Read Point	urn:epc:id:sgln:942900.009778.ENTRY_GATE

Table: 6.10 - Container arrives at Port of Lyttleton, Christchurch

Table 6.10 illustrates a read event where the container (urn:epc:id:grai:942900000.135.24680) is arriving at the Port of Lyttleton, Christchurch where the read point is urn:epc:id:sgln:942900.009778.ENTRY_GATE to the Port of Lyttleton. Note the transit time from Mountain River Processors in Table 6.9 (26/10/2012 07:53:00 +1300) to the Port of Lyttleton in Table 6.10 (26/10/2012 09:13:00 +1300). The BizStep is *shipping*.

EPCIS Event Details

Event Time	11/12/2012 01:09:46 +1300
Timezone Offset	+01:00
Event Type	AggregationEvent
Action	DELETE
EPC	urn:epc:id:sgtin:94130000.01420.1 urn:epc:id:sgtin:94130000.01420.10 urn:epc:id:sgtin:94130000.01420.11 urn:epc:id:sgtin:94130000.01420.12 urn:epc:id:sgtin:94130000.01420.16 urn:epc:id:sgtin:94130000.01420.17 urn:epc:id:sgtin:94130000.01420.18 urn:epc:id:sgtin:94130000.01420.2 urn:epc:id:sgtin:94130000.01420.20 urn:epc:id:sgtin:94130000.01420.21 urn:epc:id:sgtin:94130000.01420.22 urn:epc:id:sgtin:94130000.01420.23 urn:epc:id:sgtin:94130000.01420.3 urn:epc:id:sgtin:94130000.01420.4 urn:epc:id:sgtin:94130000.01420.5 urn:epc:id:sgtin:94130000.01420.6 urn:epc:id:sgtin:94130000.01420.7 urn:epc:id:sgtin:94130000.01420.8 urn:epc:id:sgtin:94130000.01420.9
Parent EPC	urn:epc:id:grai:942900000.135.24680
BizStep	urn:epcglobal:cbv:bizstep:receiving
Disposition	urn:epcglobal:cbv:disp:sellable_not_accessible
BizLocation	urn:epc:id:sgln:4006468.00000.CHILLER
Read Point	urn:epc:id:sgln:4006468.00000.DOCK_DOOR

Table 6.11 - Receipt of cartons at Prime Meat, Hamburg

Table 6.11 identifies receipt of the nineteen (19) cartons of finished venison cuts into Prime Meat's cold storage facility in Hamburg identified by their global location identifiers urn:epc:id:sgln:4006468.00000.CHILLER and urn:epc:id:sgln:4006468.00000.DOCK_DOOR. The *BizStep* is a *receiving* event. Note the date range from Table 6.10 (26/10/2012 09:13:00 +1300) to Table 6.11 (11/12/2012 01:09:46 +1300) which is the transit time taken from arrival at The Port of Lyttleton to Prime Meat, Hamburg. This is an AggregationEvent/ DELETE where the association between the nineteen (19) cartons and the container is deleted. The container is identified by Parent EPC urn:epc:id:grai:942900000.135.24680.

EPCIS Event Details

Event Time	11/12/2012 22:40:28 +1300
Timezone Offset	+01:00
Event Type	ObjectEvent
Action	OBSERVE
EPC	urn:epc:id:sgtin:94130000.01420.11 urn:epc:id:sgtin:94130000.01420.18 urn:epc:id:sgtin:94130000.01420.2 urn:epc:id:sgtin:94130000.01420.22 urn:epc:id:sgtin:94130000.01420.23
BizStep	urn:epcglobal:cbv:bizstep:shipping
Disposition	urn:epcglobal:cbv:disp:in_transit
BizLocation	
Read Point	urn:epc:id:sgln:4006468.00000.DOCK_DOOR

Table 6.12 - Cartons loaded into delivery truck

Table 6.12 illustrates one of the two deliveries being undertaken in Hamburg. Five (5) cartons of finished venison cuts being loaded in the delivery truck in Hamburg from Prime Meat's cold store facility identified by their global location identifier urn:epc:id:sgln:4006468.00000.DOCK_DOOR. The BizStep is a *shipping* event and the *BizLocation* is purposely blank as the location is actually the delivery transit roads within the Hamburg metropolitan area.

EPCIS Event Details

Event Time	12/12/2012 01:58:34 +1300
Timezone Offset	+01:00
Event Type	ObjectEvent
Action	DELETE
EPC	urn:epc:id:sgtin:94130000.01420.11 urn:epc:id:sgtin:94130000.01420.18 urn:epc:id:sgtin:94130000.01420.2 urn:epc:id:sgtin:94130000.01420.22 urn:epc:id:sgtin:94130000.01420.23
BizStep	urn:epcglobal:cbv:bizstep:receiving
Disposition	urn:epcglobal:sellable_accessible
BizLocation	urn:epc:id:sgln:4023339.00000.IN_STORE
Read Point	urn:epc:id:sgln:4023339.00000.RECEIVING_BAY

Table 6.13 - Delivery of consignment to Hamburg retailer

Table 6.13 illustrates delivery of five (5) cartons to a retailer in Hamburg identified by their global location identifier urn:epc:id:sgln:4023339.00000.RECEIVING_BAY. The BizStep is a *receiving* event). This stage in the process is considered a DELETE event as the shipment has now been delivered and the items are in the custody of the retailer. (Note: The sGLN for the retailer was provided by GS1 Germany for purposes of this pilot).

Conclusion

In this research, all tag data (live animals, cartons of venison cuts and physical locations) was successfully read, identified and captured from all designated read points and successfully transmitted and populated into the EPCIS. Because each EPC identifier used in the research (ie: sGTIN for animals and cartons of venison cuts, sGLN for read locations) was able to be identified, recorded and reported on in the EPCIS, chain traceability demonstrating history, application, location and record throughout the entire supply chain was demonstrated; *one step up, one step down* – thereby achieving the stated traceability performance objectives. The EPCIS provides robust query and analysis capability based on EPC identifiers.

The researchers include an important caveat to the conclusion. In the live animal to venison cuts conversion process, it is difficult to determine the exact association or relationship between individual venison pieces (or constituent pieces in the case of an aggregation process) and the entire animal (a live animal or carcass) without recording and tracking the boning process in detail at every each step. This should not be considered a technological shortcoming but a fundamental aspect of all meat related processing; most cartons will usually always contain cuts from multiple animals and tracking the contents of one particular carton upstream will nearly always point to multiple animals. It is only for specific (larger) cuts of venison that a 1-to-1 link could (theoretically) be established. It is not technically impossible however but will be determined by a supportive business case. Within the context of chain traceability as defined, the research demonstrates chain traceability at batch level. As there is a demonstrable and reliable association between the finished cartons (venison cuts) and a batch of animals as recorded in the EPCIS, the researchers consider the result compliant with the chain traceability as defined.

7 Temperature Monitoring and GPS Tracking

As outlined in the introduction, the researchers elected to incorporate an additional dimension into the research by using active RFID temperature tags (data loggers) to monitor the temperature of individual cartons during the transit from the Rakaia processing plant to delivery at the retailer in Hamburg, Germany. Further, movement of the shipping container was also tracked using a Global Positioning System (GPS). Both these elements were organised and monitored by an Israel based end-to-end cold chain management (CCM) and technology company named BT9.

Figure 7.1 - Active RFID tag

Figure 7.1 illustrates the ruggedised 'active' RFID tags that were inserted into each of the nineteen (19) cartons of finished venison cuts. The tags operate at 433MHz and were programmed to broadcast temperature and humidity information every thirty (30) or sixty (60) minutes (dependent on when a Global System for Mobile communication Network (GSM) was in range) throughout the duration of the export consignment stages (stages 7 to 10) of the research project from the processing plant located in Rakaia, New Zealand to final delivery in Hamburg, Germany.

Figure 7.2 - Cartons loaded into container with communication unit installed

Figure 7.2 illustrates cartons were loaded into a refrigerated shipping container and the Communication Unit (CU) 'activated' to enable broadcasting and transmission of temperature information from each carton as well as the location of the shipping container. Broadcasting of any information is dependent on a communication 'handshake' between the CU and a GSM network. In the absence of a network, the CU is programme to go into sleep mode to conserve battery.

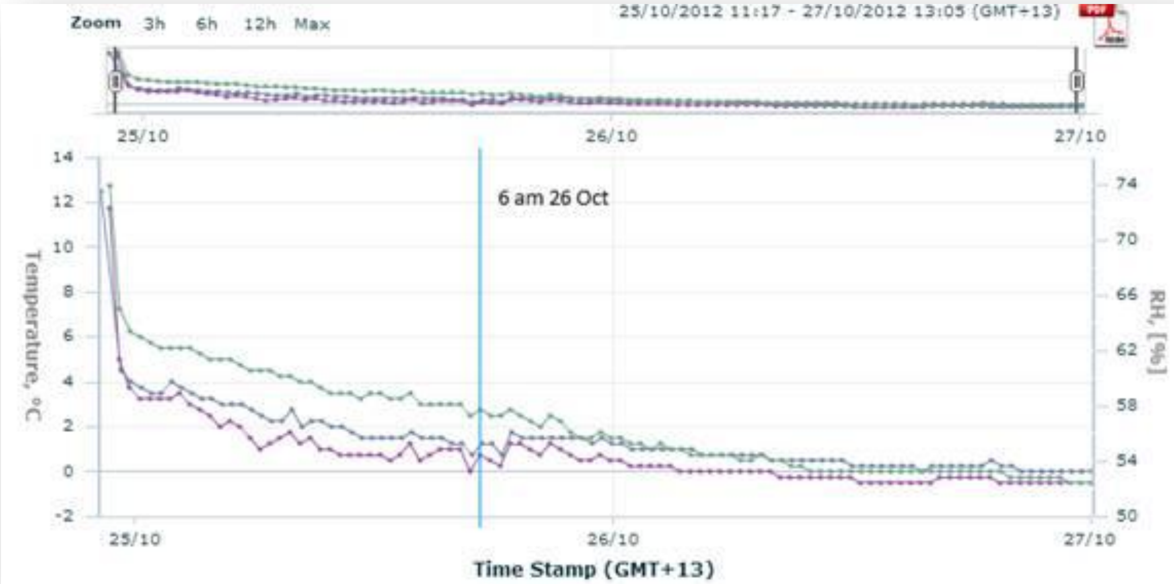


Table 7.1 - Temperature profile of cartons

Table 7.1 illustrates information on a selection of three (3) cartons of finished venison cuts during the period 25.10.12 (when the container was being loaded on-site at the processing plant) to closing of the container doors in preparation for exporting. The temperature threshold was established at -1c to +1c -> -1C to + 1C (27.10.12).

Figure 7.3 - Transit map of shipping container from Rakaia to Port of Lyttleton

Figure 7.4 - Satellite view of Port of Lyttleton where container is exported from

Figure 7.3 illustrates a map which tracks the shipping container from the processing plant in Rakaia to the Port of Lyttleton. Figure 7.4 is a satellite image of the location where the container will be exported from; Port of Lyttleton, Christchurch, New Zealand.

Figure 7.5 - Map of the transit from New Zealand to Hamburg, Germany

Figure 7.5 illustrates the trade route of the shipment. The route is from Port Lyttleton, New Zealand transhipping in Singapore and delivery to Hamburg, Germany. Clearly, the map was compiled using information from the CU inside the container once connection had been established with a GSM Network.

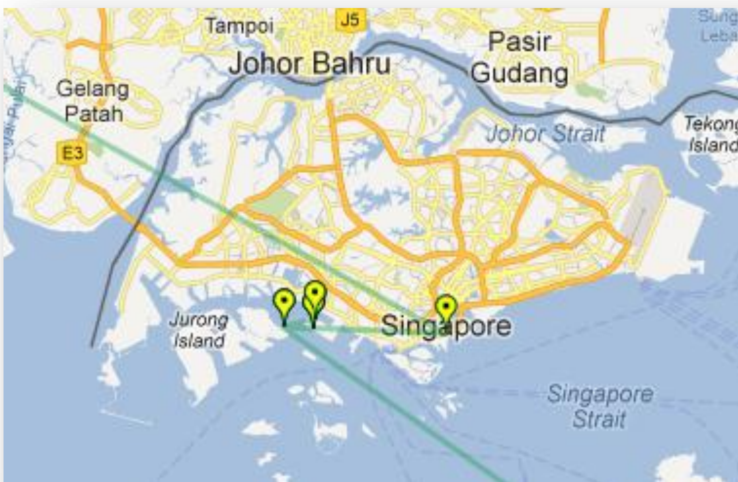


Figure 7.6 - Container movement at Port of Singapore

Figure 7.6 illustrates the positioning of the shipping container at the Port of Singapore and the internal transhipment between port terminals in Singapore. This is useful information for any necessary intervention for out of specification (spoiled) product.

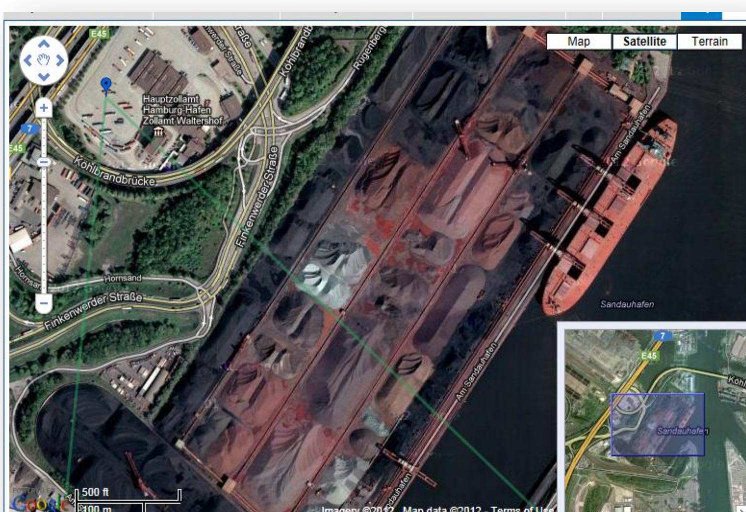


Figure 7.7 - Satellite view of Port of Hamburg and container location after arrival

Figure 7.7 illustrates the positioning of the shipping container on wharf in Hamburg, Germany prior to delivery to Prime Meat.

Figure 7.8 - Satellite view of container position in Port of Hamburg

Figure 7.8 illustrates a more granular image the shipping container position on wharf in Hamburg prior to delivery to Prime Meat.

Shipment Report >> GS1 MAERSK JUBAIL V255N

Shipment General Info | Consolidated Data | Pallet Specific Data | Location & Thresholds | QC | Alerts | Map

Pallet ID -- Select -- Legend - Over - Below Export to

No.	Select	Company Name	Pallet ID	Comments	Sensor ID	Produce Item	Variety	Last Temp	Last Reading	Grouping	Pallet History
1		GS1	GS1-14201		392969	Meat	Chilled Meat	-0.25	11/12/2012 9:57 p.m.		Click
2		GS1	GS1-142010		393076	Meat	Chilled Meat	-0.50	11/12/2012 9:06 p.m.		Click
3		GS1	GS1-142011		393075	Meat	Chilled Meat	-0.25	12/12/2012 1:05 a.m.		Click
4		GS1	GS1-142012		393085	Meat	Chilled Meat	-0.25	12/12/2012 12:08 a.m.		Click
5		GS1	GS1-142016		392986	Meat	Chilled Meat	-0.50	11/12/2012 9:30 p.m.		Click
6		GS1	GS1-142017		393109	Meat	Chilled Meat	-0.25	11/12/2012 10:37 p.m.		Click
7		GS1	GS1-142018		393092	Meat	Chilled Meat	0.00	12/12/2012 12:37 a.m.		Click
8		GS1	GS1-14202		393074	Meat	Chilled Meat	0.25	12/12/2012 12:57 a.m.		Click
9		GS1	GS1-142020		393099	Meat	Chilled Meat	-0.25	11/12/2012 11:56 p.m.		Click
10		GS1	GS1-142021		393079	Meat	Chilled Meat	0.50	11/12/2012 11:57 p.m.		Click
11		GS1	GS1-142022		393069	Meat	Chilled Meat	0.00	12/12/2012 12:48 a.m.		Click
12		GS1	GS1-142023		393102	Meat	Chilled Meat	-0.25	12/12/2012 1:05 a.m.		Click
13		GS1	GS1-14203		393107	Meat	Chilled Meat	-0.50	11/12/2012 9:39 p.m.		Click
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	Chilled	[illegible]	11/12/2012		[illegible]

Table 7.2 - Temperature profile of cartons on arrival in Hamburg

Table 7.2 illustrates the temperature readings of thirteen (13) cartons taken from the period 11.12.12 – 12.12.12 at the reading times identified under the heading ‘last reading’. At this time, the cartons were in the custody of Prime Meat after having been unloaded from the shipping container and were being prepared for delivery.

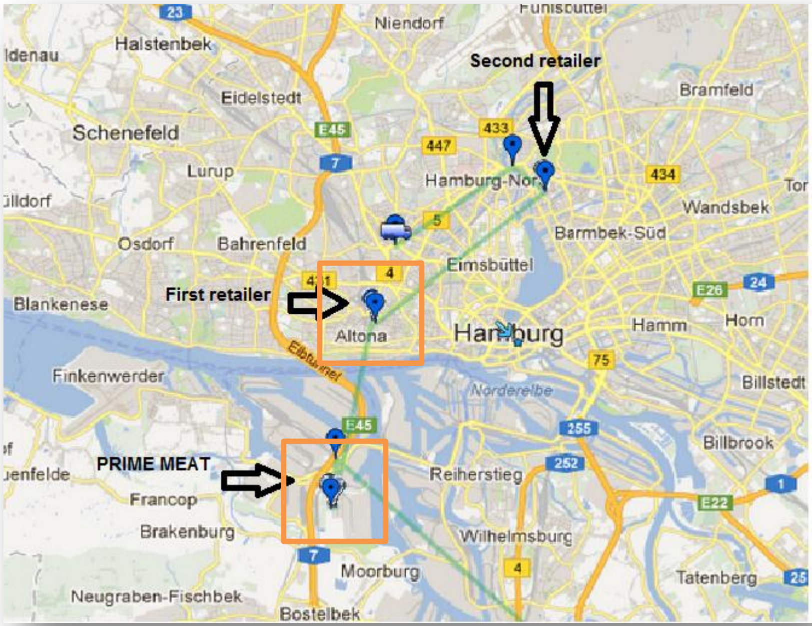


Figure 7.9 - Map of delivery transit to end customers in Hamburg

Figure 7.9 illustrates the transit from Prime Meat to the two final delivery destinations in Hamburg identified by the truck arrows positioned in the map. The position locaters (blue icons on the green transit line) indicate stopping points during the transit.

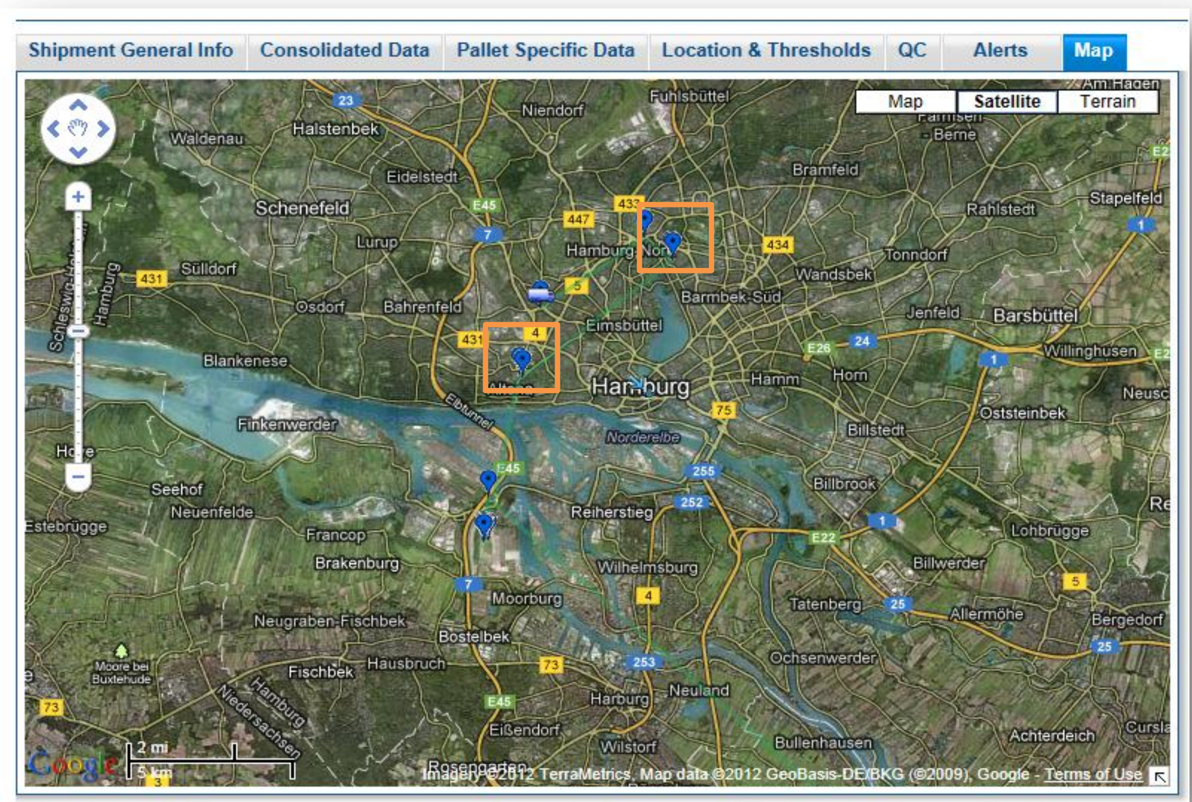


Figure 7.10 - Delivery route and address locations in Hamburg

Figure 7.10 illustrates an alternative satellite view of the transit route from Prime Meat to delivery at the two final delivery destinations represented by the orange squares.

8 Advantages and Disadvantages of Methodology Selection

The advantage in selecting the research methodology to demonstrate utility and efficacy using a 'real world' scenario is just that – it emulates closely the real world. There are disadvantages and risks involved in selecting the methodology as outlined:

- Live animals are unpredictable as is weather.
- Utilising 'working' facilities such as a venison processing plant for research purposes can be disruptive for the workforce as it often causes disruption and interruption to carefully planned production schedules. There are also concerns in compromising health, safety and quality procedures.
- Invariably there is a significant amount of 'good-will' involved with on-location research which needs to be accounted for both in research design and the on-site research itself – as good-will has limits.
- Equipment failure during research is disruptive and can cause lengthy, unplanned delays.
- Performance of RFID equipment can be compromised by electromagnetic fields caused by motors and working machinery. UHF RFID has known performance degradation issues in environments containing moisture and metal. Setting up readers and tags in these types of environments often requires on-site pre-configuration and setup to ensure optimal performance and to mitigate potential disruptive delays.
- Secure, reliable access to computer networks (especially for wireless requirements) for event data transmission may be difficult and can compromise data transfer performance.
- When undertaking research in on-site locations, a limited opportunity exists for repetitive testing given the testing environment is a working production environment where production lines generally will not/ cannot postpone or stop for research purposes and where animals are easily stressed. Having outlined the disadvantages and risks associated with on-location research, the rigor and authenticity of the results gained in the research justifies the methodology selection. Indeed, understanding the requirements of a discerning regulatory and user community, results secured in any other way may be viewed as contrived or theoretical.

9 Conclusion and Further Research

Chain traceability, as outlined by the Food Business Forum (CIES 2005 p.7) was adopted by the researchers as a benchmark reference against which the stated objective was measured and assessed, namely: *Chain Traceability* – the ability to trace the history, application or location of an entity by means of recorded identifications throughout the entire supply chain. To facilitate this CIES describe, 'in practise, the requirement for traceability is to keep records of suppliers and customers, sometimes called 'on step up, one step down'. The basis for adopting this definition was to support and align with the goal of extended and interoperable supply chain traceability as the most desirous outcome for traceability especially for food and food products. 'If all food business keep these records and the information therein, can be communicated and exchanged, chain traceability is achieved (CIES 2005 p.7).

In this research, all tag data (item and location) was successfully read, identified and captured from all designated read points and successfully transmitted and populated into the EPCIS thereby achieving the stated traceability performance objectives. The researchers include an important caveat to the conclusion however. In the live animal to venison cuts conversion process, it is difficult to determine the exact association or relationship between individual venison pieces (or constituent pieces in the case of an aggregation process) and the entire animal (a live animal or carcass) without recording and tracking the boning process in detail at every step. This is considered an intrinsic issue and establishing 1-to-1 traceability is difficult to achieve for most cuts. It is not technically impossible however but will be determined by a supportive business case. Within the context of chain traceability as defined, the research demonstrates chain traceability at batch level. As there is a demonstrable and reliable association between the finished cartons (venison cuts) and a batch of animals as recorded in the EPCIS, the researchers consider the result compliant with the chain traceability as defined.

Innovation in RFID technology, especially tag technology has witnessed the emergence of sensor based tags able to monitor movement, temperature, humidity and other environmental sensitivity measurements. Currently, the EPCglobal suite of standards do not provide for this and the researchers consider the incorporation of this technology through an external agency in this analysis as an added benefit generating meaningful additional value. Despite EPC standards not currently existing for reading sensor-data, there is nothing preventing the incorporation of additional information into EPCIS events through the use of extensions.

The results of this research should provide broad confidence that the EPCglobal suite of RFID standards is efficacious for livestock traceability as defined. Notwithstanding, further research is encouraged to corroborate and validate the findings while continuing to extend and expand the investigation and enquiry. Investigation into the use of EPC standards on alternative species (sheep for example) is recommended.

The researchers outline a summary of recommendations to assist future research:

Measuring and reporting on RFID reader and RFID tag performance fell outside the scope of this analysis. However, some brief commentary will prove beneficial for future research and investigation. A critical element of the research design was utilising UHF RFID hardware components (tags, readers) that complied with EPCglobal standards. High performing tags are a necessary infrastructure component and any failure in performance at any of the supply chain read event locations would compromise traceability outcomes. Malfunctioning and/or poor performing tags should be expected. To mitigate the risk of malfunctioning tags or tags with suboptimal performance, it is recommended that tags be tested for both sensitivity and overall operating performance (preferably using an accredited anechoic chamber) before applying to animals. Further, prior to applying tags on animals, packaging or fixtures (eg: walls, for location identification) it is recommended that tags be tested in the intended operational environment (or similar) using both hand held and fixed RFID readers preferably from multiple hardware vendors. This will confirm if performance and compliance with EPC standards is achievable.

Appendix

<table>
<tr><th>Read Event Number</th><th>Process Step, EPC Identifier and RFID Hardware Used</th><th>Process Step Image</th></tr>
<tr><td>1</td><td>

Tagging of Animals on Farm at Downlands Deer

EPC Item Identifier (Deer) - sGTIN per individual animal range
EPC Location Identifier: (Downlands Deer) – urn:epc:id:sgln:942900.009772.xxx
Item (Deer) sGTIN Range: urn:epc:id:sgtin:9421900217.003.1073742106 - 1073742127
RFID Reader Utilised – Motorola MC3190Z

EPCIS:

<table>
<tr><td>Event</td><td>ObjectEvent</td></tr>
<tr><td>Action</td><td>ADD</td></tr>
<tr><td>BizStep</td><td>urn:epcglobal:cbv:bizstep:commissioning</td></tr>
<tr><td>Disposition</td><td>urn:epcglobal:cbv:disp:active</td></tr>
<tr><td>ReadPoint</td><td>urn:epc:id:sgln:942900.009772.DEER_CRUSH</td></tr>
<tr><td>BizLocation</td><td>urn:epc:id:sgln:942900.009772.ON_FARM</td></tr>
</table>

</td><td></td></tr>
<tr><td>2</td><td>

Animals Leave Farm and are Loaded onto Truck via Farm Race at Downlands Deer

EPC Item Identifier (Deer) - sGTIN per individual animal range in Read Event # 1
EPC Location Identifier: (Downlands Deer) – urn:epc:id:sgln:942900.009772.xxx
RFID Reader Utilised – Impinj Speedway R420

EPCIS:

<table>
<tr><td>Event</td><td>ObjectEvent</td></tr>
<tr><td>Action</td><td>OBSERVE</td></tr>
<tr><td>BizStep</td><td>urn:epcglobal:cbv:bizstep:shipping</td></tr>
<tr><td>Disposition</td><td>urn:epcglobal:cbv:disp:in_transit</td></tr>
<tr><td>ReadPoint</td><td>urn:epc:id:sgln:942900.009772.LOADING_RAMP</td></tr>
<tr><td>BizLocation</td><td>Not applicable</td></tr>
</table>

</td><td>
</td></tr>
</table>

3

Animals Arrive at Mountain River Processor Holding Yard

EPC Item Identifier (Deer) - sGTIN per individual animal range in Read Event # 1
EPC Location Identifier (Mountain River) - urn:epc:id:sgln:942900.009774.xxx
RFID Reader Utilised – Impinj Speedway R420

EPCIS:

Event	ObjectEvent
Action	OBSERVE
BizStep	urn:epcglobal:cbv:bizstep:receiving
Disposition	urn:epcglobal:cbv:disp:active
ReadPoint	urn:epc:id:sgln:942900.009774.UNLOADING_RAMP
BizLocation	urn:epc:id:sgln:942900.009774.HOLDING_PEN_2

4

Animals Arrive at Mountain River Processor Stun Box

EPC Item Identifier (Deer) - sGTIN per individual animal range in Read Event # 1
EPC Location Identifier (Mountain River) - urn:epc:id:sgln:942900.009774.xxx
RFID Reader Utilised – Impinj Speedway R420

EPCIS:

Event	ObjectEvent
Action	DELETE
BizStep	urn:epcglobal:cbv:bizstep:transforming
Disposition	urn:epcglobal:cbv:disp:in_progress
ReadPoint	urn:epc:id:sgln:942900.009774.STUN_BOX
BizLocation	urn:epc:id:sgln:942900.009774.BONING_ROOM
Batch	EPCIS Pilot

5

Cartons of Finished Venison Cuts Moved into Chiller Room

EPC Item Identifier (Cartons) - sGTIN per carton label range urn:epc:id:sgtin:94130000.01420.1 - 99
EPC Location Identifier (Mountain River) - urn:epc:id:sgln:942900.009774.xxx
RFID Reader Utilised - Impinj Speedway R420

EPCIS:

Event	ObjectEvent
Action	ADD
BizStep	urn:epcglobal:cbv:bizstep:commissioning
Disposition	urn:epcglobal:cbv:active
ReadPoint	urn:epc:id:sgln:942900.009774.BONING_ROOM_EXIT
BizLocation	urn:epc:id:sgln:942900.009774.CHILLER_ROOM
Batch	EPCIS Pilot

:

6

Cartons of Venison Cuts Loaded Into Export Shipping Container at Mountain River Processor

EPC Item Identifier (Cartons) - sGTIN per carton label range urn:epc:id:sgtin:94130000.01420.1 - 99
EPC Item Identifier (Shipping Container) - urn:epc:id:grai:942900000.135.24680
EPC Location Identifier (Mountain River) - urn:epc:id:sgln:942900.009774.xxx
RFID Reader Utilised - Motorola MC3190Z

EPCIS:

Event	AggregationEvent
Action	ADD
BizStep	urn:epcglobal:cbv:bizstep:staging outbound
Disposition	urn:epcglobal: container_closed
ReadPoint	urn:epc:id:sgln:942900.009774.CHILLER_ROOM_EXIT
BizLocation	urn:epc:id:sgln:942900.009774.CONTAINER_ON_SITE

7	**Container Leaving Mountain River Processor** EPC Item Identifier (Shipping Container) - urn:epc:id:grai:942900000.135.24680 EPC Location Identifier (Mountain River) - urn:epc:id:sgln:942900.009774.xxx RFID Reader Utilised – Motorola MC3190Z		
	EPCIS:		

	Event	ObjectEvent
EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:shipping
	Disposition	urn:epcglobal:in_transit
	ReadPoint	urn:epc:id:sgln:942900.009774.EXIT_GATE
	BizLocation	Not Applicable

8	**Container Arriving at The Port of Lyttleton, Christchurch, New Zealand** EPC Item Identifier (Shipping Container) - urn:epc:id:grai:942900000.135.24680 EPC Location Identifier (Lyttleton Port) - urn:epc:id:sgln:942900.009778.xxx RFID Reader Utilised – Motorola MC3190Z	

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:shipping
	Disposition	urn:epcglobal:in_transit
	ReadPoint	urn:epc:id:sgln:942900.009778.ENTRY_GATE
	BizLocation	Not Applicable

9

Cartons of Venison Cuts Receipted on arrival at Prime Meat's Warehouse, Hamburg, Germany

EPC Item Identifier (Cartons) - sGTIN per carton label range urn:epc:id:sgtin:94130000.01420.1 - 99
EPC Location Identifier (Prime Meat) - urn:epc:id:sgln:4006468.00000.xxx:
RFID Reader Utilised - Tracient Padl Reader

EPCIS:

Event	AggregationEvent
Action	DELETE
BizStep	urn:epcglobal:cbv.bizstep:receiving
Disposition	urn:epcglobal:sellable_not_accessable
ReadPoint	urn:epc:id:sgln:4006468.00000.DOCK_DOOR
BizLocation	urn:epc:id:sgln:4006468.00000.CHILLER

10

Cartons of Venison Cuts loaded onto truck Prime Meat's Warehouse, Hamburg, Germany

EPC Item Identifier (Cartons) – sGTIN per carton label range urn:epc:id:sgtin:94130000.01420.1 - 99
EPC Location Identifier (Prime Meat) - urn:epc:id:sgln:4006468.00000.xxx
RFID Reader Utilised - Tracient Padl Reader

EPCIS:

Event	ObjectEvent
Action	OBSERVE
BizStep	urn:epcglobal:cbv.bizstep:shipping
Disposition	urn:epcglobal:in_transit
ReadPoint	urn:epc:id:sgln:4006468.00000.DOCK_DOOR
BizLocation	Not applicable

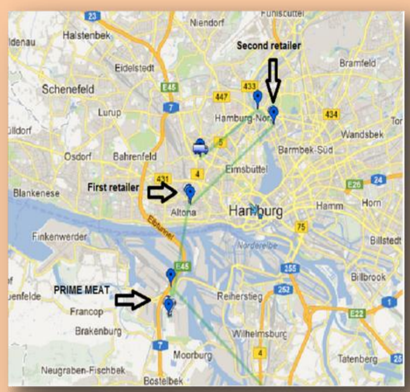
11

Cartons of Venison Cuts arrive at Retailer in Hamburg, Germany

EPC Item Identifier (Cartons) - sGTIN carton label range urn:epc:id:sgtin:94130000.01420.1 - 99
EPC Location Identifier (Retailer # 1) - urn:epc:id:sgln:4023339.00000.xxx
RFID Reader Utilised – Tracient Padl Reader

EPCIS:

Event	ObjectEvent
Action	DELETE
BizStep	urn:epcglobal:cbv.bizstep:receiving
Disposition	urn:epcglobal:sellable_accessible
ReadPoint	urn:epc:id:sgln:4023339.00000.IN_STORE
BizLocation	urn:epc:id:sgln:4023339.00000.RECEIVING_BAY



Glossary and Definitions

- **Business Step** *(bizstep)* **-** denotes a specific activity within a business process. The business step field of an event specifies what business step was taking place that caused the event to be captured. These identifiers populate the *bizstep* field in an EPCIS event.

  - **commissioning –** is the process of associating an EPC with a particular object (product, shipment, asset or container). A tag may have been encoded and applied in this step or may have been previously encoded.
  - **receiving -** denotes a specific activity within a business process that indicates that an object (ie: product, shipment or asset) is being received at a location and is added to the receiver's inventory.
  - **shipping** - indicates the overall process of picking, staging, loading and departing. It may be used when more granular process step information is unknown or inaccessible. It may indicate a final event from a shipping point. The use of *shipping* is mutually exclusive from the use of *departing, staging, loading*.
  - **transforming -** denotes a specific activity within a business process where one or more objects are an input into a process that irreversibly changes that object/ those objects into a new object or objects; the output has a new identity and characteristics.

- **Core Business Vocabulary Standard** (CBV) specifies various vocabulary elements and their values for use in conjunction with the EPCIS standard, which defines mechanisms to exchange information both within and across company boundaries. The Standard Vocabularies specified in the CBV are business steps, disposition and business transaction types. The elements and definitions are agreed to by parties prior to exchanging data and there is general agreement on their meaning. The vocabulary identifiers and definitions in this standard will ensure that all parties who exchange EPCIS data using the Core Business Vocabulary will have a common understanding of the semantic meaning of that data. This standard is intended to provide a basic capability that meets the above goal. In particular, this standard is designed to define vocabularies that are core to the EPCIS abstract data model and are applicable to a broad set of business scenarios common to many industries that have a desire or requirement to share data. This standard intends to provide a useful set of values and definitions that can be consistently understood by each party in the supply chain.

- **Disposition -** denotes the business state of the object. The disposition field of an event specifies the business condition of the subject of the event (the things specified in the 'what' dimension), subsequent to the event. The disposition is assumed to hold true until another event indicates a change of disposition. Identifiers for dispositions are outlined in the Core Business Vocabulary (CBV).

  - **active -** Commissioned objects (product, shipment, asset or container) introduced into the supply chain. **Business Step:** c*ommissioning.*
  - **in_transit -** Object (product, shipment, asset or container) being shipped between two trading partners. **Business Step:** r*eceiving, picking, loading, accepting, staging_outbound, arriving.*
  - **in_progress -** Default disposition for object (product, shipment, asset or container) proceeding through points in the supply chain. **Business Step:** *shipping, departing.*
  - **sellable_not_accessible** - Product can be sold as is but customer cannot access product for purchase. **Business Step:** *receiving, storing, loading, holding, inspecting*.

- **Electronic Product Code** (EPC) is a family of coding schemes created as an eventual successor to the barcode. The EPC was created as a low-cost method of tracking goods using radio-frequency identification technology. It is designed to meet the needs of various industries, while guaranteeing uniqueness for all EPC-compliant tags. EPC tags were designed to identify each item manufactured, as opposed to just the manufacturer and class of products, as bar codes do today. The EPC accommodates existing coding schemes and defines new schemes where necessary.

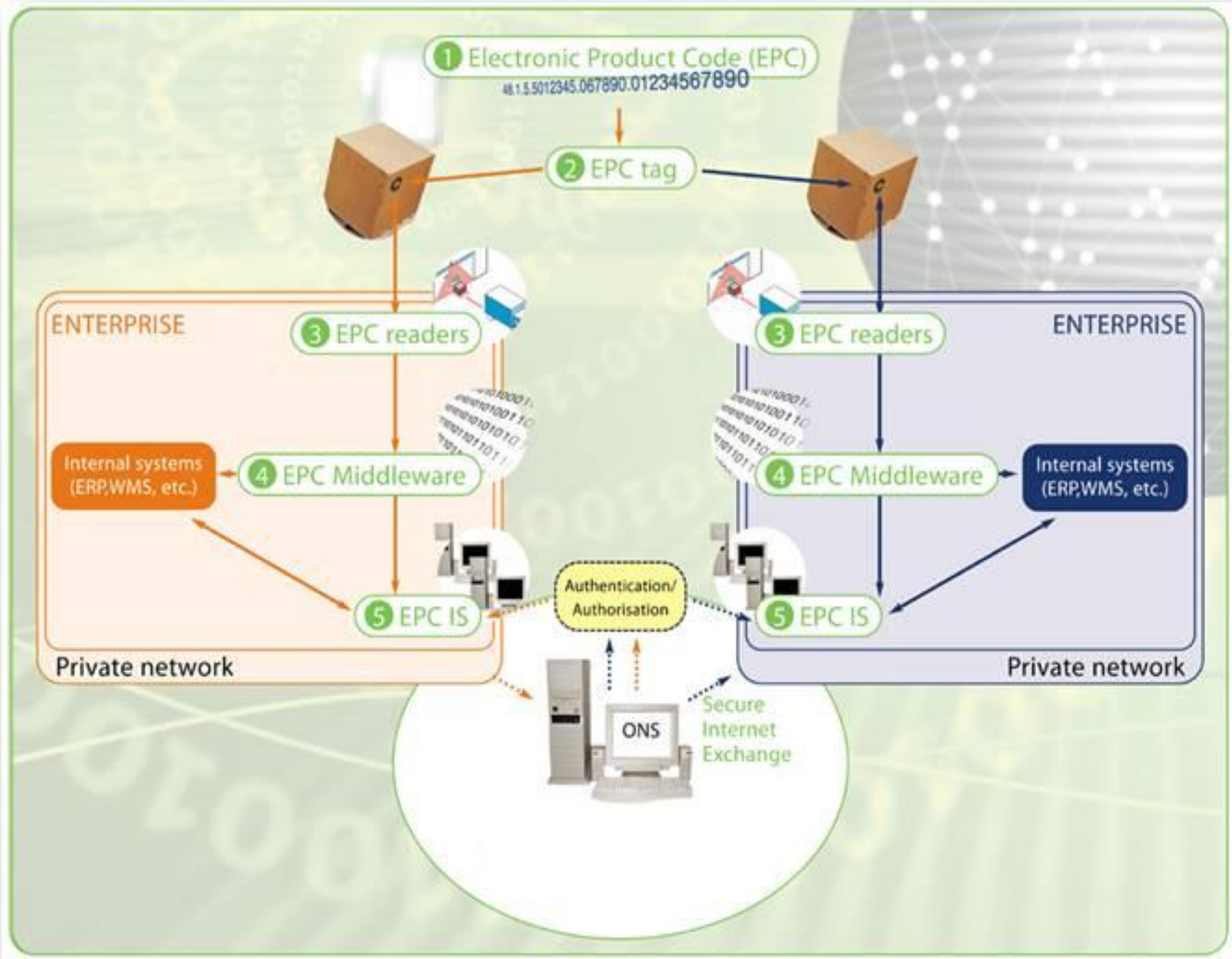
- **EPCglobal Network** is a global standard system that combines radio frequency identification (RFID) technology, existing communications network infrastructure and the Electronic Product Code (a number for uniquely identifying an item). The network manages dynamic information that is specific to variable for individual products. This includes data regarding the movement of an object throughout the product life cycle. The EPCglobal Network is a computer network used to share product data between trading partners. It was created by EPCglobal. The basis for the information flow in the network is the Electronic Product Code (EPC) of each product which is stored on an RFID tag. The network manages dynamic information that is specific to variable for individual products. This includes data regarding the movement of an object throughout the product life cycle.

- **The Object Name Service** (ONS) is a service that enables the discovery of object information on the basis of an EPC. With the Electronic Product Code a matched URL or IP-address is searched within a data base and sent back to the requester when found. Under the URL further information about the object which is associated with the EPC can be found. The ONS is comparable to the Domain Name System which is used in the internet to translate names into IP addresses.

- The **EPC Information Service** (EPCIS) is a standard designed to enable EPC-related data sharing within and across enterprises. This data sharing is aimed to enable all network participants a common view of object information. At the EPCIS each company designated who has access to its dynamic information.

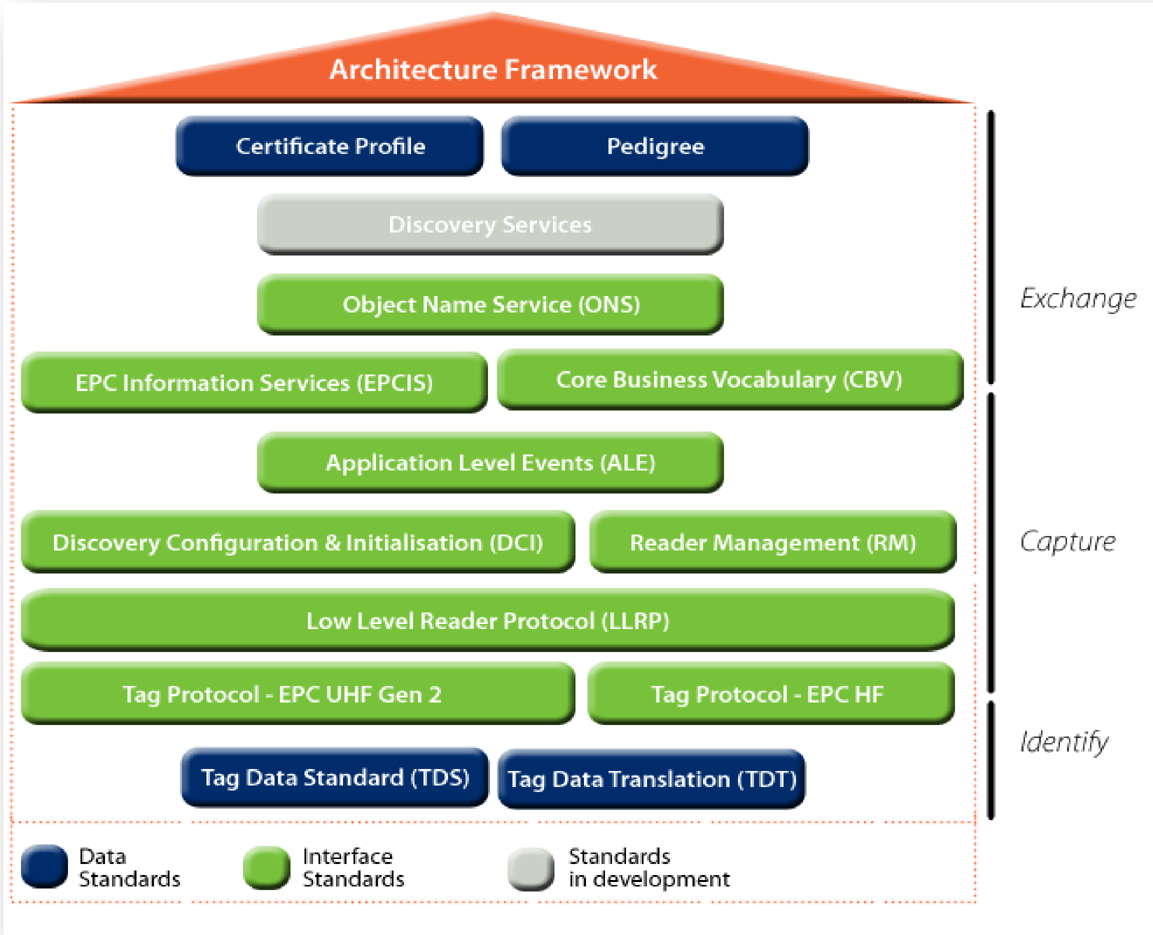
- **Serialised Global Location Number (sGLN)** is part of the GS1 systems of standards. It is a simple tool used to identify a location and can identify locations uniquely where required. The GS1 Identification Key is used to identify physical locations or legal entities. The key comprises a GS1 Company Prefix, Location Reference, and Check Digit. Location identified with GLN could be a physical location such as a warehouse or a legal entity such as a company or customer or a function that takes place within a legal entity. It can also be used to identify something as specific as a particular shelf in a store. GLN is also used within companies to identify specific locations both electronically in a database and physically where the GLN can be produced in a bar code or GS1 EPC tag. To ensure that a GLN always uniquely identifies an individual location or entity, in the case of a GLN, the GLN is constructed as a Serialised Global Location Number (*SGLN*) by combining a GLN identifier with a unique serial number.

- **Serialised Global Trade Item Number (sGTIN)** is designed as a universal identifier that provides a unique identity for every physical object anywhere in the world, for all time. Its structure is defined in the EPCglobal Tag Data Standard. However, the Global Trade Item Number (*GTIN*) only identifies the product type or stock-keeping unit (*SKU*) rather than an individual instance of a particular product type. To ensure that an EPC always uniquely identifies an individual physical object, in the case of a GTIN, the EPC is constructed as a Serialized Global Trade Item Number (*SGTIN*) by combining a GTIN product identifier with a unique serial number.



EPCglobal Standards Overview (Source: EPCglobal Inc;)

The EPCglobal Network is a suite of standards and tools utilising RFID technology for automatic identification of items moving through the supply chain. It uses the principle of the Internet to easily locate and exchange information.



The EPCglobal Network Architecture (Source: EPCglobal Inc;)

The EPCglobal Architecture Framework is a collection of interrelated standards for hardware, software, and data interfaces, together with core services that are operated by EPCglobal and its delegates, all in service of a common goal of enhancing the supply chain through the use of Electronic Product Codes (EPCs).

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