New Zealand

The use of EPC Standards and Radio Frequency Identification technologies (RFID) to demonstrate supply chain traceability and product authenticity of Halal meat products exported from New Zealand to Malaysia

Front Cover: Punakaiki (known as pancake rocks) – West Coast, New Zealand.
The rocks are limestone formations that began forming 30 million years ago when lime-rich fragments of dead marine creatures were deposited on the seabed, then overlaid by weaker layers of soft mud and clay.

The use of EPC Standards and Radio Frequency Identification technologies (RFID) to demonstrate supply chain traceability and product authenticity of Halal meat products exported from New Zealand to Malaysia

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Abstract

For Muslims, it is very important that the food consumed must be Halal and free from tainted elements. Given the speed of trade globalisation and the advances in technology, it is now necessary that the Halal concept be fully understood by all industry players and consumers alike. Interest in food safety and quality related assurances have heightened in recent years especially in the Halal food supply chain (Zailani et al., 2010).

Traceability systems 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. Within the context of livestock and meat products, the pillars of a traceability system are founded upon the identification of individual animals or homogenous groups of animals, the ability to track their movements, proper identification of premises and recording of this information in appropriate registers. Product authentication is needed to detect counterfeit and falsified products and to prevent them from entering the distribution channel of genuine products.

At the consumer level, the driving forces are increased sensitivity to food quality, safety, health and nutritional aspects of food products and their interests in the place of origin of food produced, the means of production used including non-food values such as environmental sustainability and animal welfare.

Halal traceability and tracking comprise a very dynamic area in which new techniques and standards are being examined and introduced (Zailani et al., 2010). According to Azah (Azah et al., 2008), Malaysian Muslim consumers are very much concerned about the authenticity of Halal food products claimed by food producers.

Radio Frequency Identification (RFID) and related technologies are seen as tools to enhance product identification, authentication and traceability in the food and food production and distribution sectors. With the power to track and trace items easily, RFID could be the best technology to solve this problem as outlined by Wu (Wu et al., 2006) and Brewer (Brewer et al., 1999).

This research focuses on the use of standards-based EPC Ultra High Frequency (UHF) RFID standards (as components of The EPC Architecture Framework), and especially the EPCIS Standard to identify, capture and share supply chain event information with participating stakeholders. The research outlines an eleven (11) stage process where three types of beef products (discrete cartons containing either lungs, tails or tripe) are packed into cartons at a New Zealand domiciled meat processor and exported to Malaysia.

The findings corroborate those of earlier research outlined by Hartley (Hartley 2013), demonstrating that the use of EPC Standards and specifically the EPCIS Standard are effective tools for enhancing supply chain visibility and traceability outcomes. The findings also support the use of EPC Standards to demonstrate product authenticity outcomes.

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1 Executive Summary

This research was completed under the direction of GS1 New Zealand, GS1 Malaysia, SMTRACK Berhad (formerly known as Smartag Solutions Berhad) and ANZCO Foods Limited, New Zealand.

GS1 New Zealand and GS1 Malaysia are the member organisations in their respective countries of GS1, the international, not-for-profit standards development organisation with member organisations in over 100 countries. GS1 is dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across industry sectors. The GS1 system of Standards is the most widely used supply chain standards system in the world.

SMTRACK Berhad is a track and trace solutions provider based in Malaysia that utilises Radio Frequency Identification (RFID) and innovative technologies to provide online and mobile solutions.

ANZCO Foods Limited is a multinational group of companies, whose core purpose is to procure, process and market New Zealand beef and lamb products globally. ANZCO Foods' Kokiri processing facility is certified as an accredited Halal processing facility in New Zealand for the export of meat products to Malaysia.

Prompted by their constituents and by their own concerns about safety, governments in Europe, the United States and Asia 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.

There is an ever increasing risk that physical products are not what they claim they are. Product authentication is needed to detect counterfeit and falsified products and to prevent them from entering the distribution channel of genuine products. Turcu (Turcu et al., 2013) argue that one of the key issues concerning safety in today's global marketplace is the increasing risk regarding the production of fake branded goods. Turcu (Turcu et al., 2013) outline that the issue is not limited to a few products and certain countries but is a global phenomenon affecting a wide range of industries.

Within the context of Halal meat and meat products, the industry involves farm to table operations. Zailani (Zailani et al., 2010) outline that this has led to the development of new links within the value chain most notably in the area of information technology and given the advancements in science and technology, they contend that it is essential the Halal concept is fully understood by all industry players and customers.

The definitions of Halal, while generally agreed upon by Muslims, display significant gaps when it comes to their application in the industry. Wan-Hansen (Wan-Hansen 2007) outline that due to differing Halal standards not only between countries but also within each country (following the presence of various Halal authorities), confusion and misunderstanding in the certification process have occurred. An effective traceability and tracking system in Malaysia is seen as an essential mitigation strategy to the risks associated with Halal that can disrupt international trade of Halal food and consumer confidence. Traceability and tracking systems function as a tool for communication making information available along the supply chain (Zailani et al., 2010).

To provide an unambiguous definition for product authentication, Lehtonen (Lehtonen et al., 2007) argue the need to distinquish between a product's identity and an identifier; identity being something unique that products have that endures throughout the product's lifecycle. The product's identifier is the name given or a reference to the product's identity and it can be either in product class level, such as the Global Trade Item Number (GTIN) or in serial level such as the Serialised Global Trade Item Number (sGTIN). Based on these definitions, Lehtonen (Lehtonen et al., 2007) posit the following definition for product authentication, namely:

Product Authentication = Identification + Verification of the claimed identity.

Radio Frequency Identification (RFID) technologies are seen as tools for identification and traceability within the food and food products sectors. Turcu (Turcu et al., 2013) outline that RFID technology is seen to provide an efficient and often cost-effective solution to counterfeiting and falsification problems by enabling the unique identification of each container, pallet, case and item manufactured shipped and sold. Thus, assuring the authenticity of a product and retrieving its tracking information can be done by using a production management system with RFID technology and by enabling its use to the trading point.

This research is a continuation of earlier research undertaken in 2010 and 2013 by the New Zealand RFID Pathfinder Group Incorporated and GS1 New Zealand that investigated and assessed the efficacy of using Ultra High Frequency (UHF) RFID technology and The EPCglobal Network (now referred to as The EPCglobal Network Architecture) for livestock and meat traceability.

The 2010 research focused on using cattle as the candidate species (Hartley and Sundermann 2010) whereas the 2013 analysis outlined research with both live deer and packaged venison cuts (Hartley 2013). Hartley's (Hartley 2013) analysis outlined a process of identifying, capturing and providing data exchange of EPC event data involving live animals moving from an on-farm environment through a meat processing facility to delivery of cartons of finished meat cuts to retail facilities located in Hamburg, Germany.

The findings of these antecedents confirmed that The EPCglobal Network Architecture and specifically the EPCIS Standard can enhance supply chain visibility and establish robust traceability outcomes. The research concluded that the results of the examination should provide broad confidence that the EPCglobal suite of RFID standards is efficacious for livestock and meat products traceability as defined in their analysis. Further research was encouraged to corroborate and validate the findings while continuing to extend and expand the investigation and enquiry.

This research was undertaken to build on the antecedents and to continue to focus on the use of EPC UHF RFID standards as components of The EPCglobal Network Architecture as a tool for providing traceability and product authenticity outcomes. This analysis outlines an eleven (11) stage process model that details the movement of beef products (lungs, tails and tripe) packed in cartons from a processing facility located in Kokiri, New Zealand to Kuala Lumpur, Malaysia. The research design model details:

- the identification, capture and recording of information of 109 cartons of beef meat products (discrete cartons containing either lungs, tripe or tails) moving through an eleven (11) node supply chain using a Serialised Global Trade Item Number (sGTIN) encoded into an EPC RFID tag.
- the identification, capture and recording of information regarding the shipping container used for export as it moved through the supply chain. The unique identifier used was a Global Individual Asset Identifier (GIAI) encoded into an EPC RFID tag.
- the identification, capture and recording of discrete read event location (node) information using Global Location Numbers (GLNs).
- the capture of event data encoded into EPC RFID tags using RFID readers and event data at discrete locations in the supply chain.
- the capture of event data using manual input methods where RFID was not possible or practical (i.e. container being loaded onto the vessel in New Zealand).
- the sharing of EPC event data with supply chain participants (the researchers) regarding the movement of cartons of meat products and the shipping container from point of production in New Zealand to delivery in Malaysia.

The findings corroborate those of earlier highlighted research. They confirm that EPC RFID standards and especially the EPCIS are efficacous, effective and efficient tools for enhancing supply chain visibility enabling both robust and reliable traceability and product authenticity outcomes.

The researchers encourage continued research in this field to foster greater worldwide industry adoption. The researchers also acknowledge and thank its sponsors and supporters for their invaluable input into this assignment.

2 Introduction

Prompted by their constituents and by their own concerns about safety, governments in Europe, The United States and increasingly throughout Asia 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 from 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).

Malaysia identifies itself as one of the world's key Halal hubs (Zailani et al., 2010) a status that was significantly compromised following raids by Malaysian authorities in recent years into the unethical practice by some Halal food manufacturers (Zailani et al., 2010). The essence of the raids was to uncover the many occurrences of non-compliance with Halal regulations set by the Malaysian authorities. The resultant commotion pertaining to this was far reaching where Muslim consumers in Malaysia began to question the effectiveness of Halal food traceability and tracking in Malaysia's market. More Halal transparency is likely to increase consumers trust in the Halalness of the food they consume due to the increased amount of information about production processes and food-safety controls. According to Azah (Azah et al., 2008), the Malaysian Muslim consumers are very much concerned about the authenticity of Halal food products claimed by food processors citing that a major problem in Malaysia is the falsification and unreliability of Halal brands, trademarks and logos.

In Malaysia's food industry, food status especially involving Halal status is one of the prime areas that has potential to leverage RFID technology according to Azah (Azah et al., 2008). The definitions of Halal, while generally agreed upon by Muslims, display significant gaps when it comes to their application in the industry. Wan-Hansen (Wan-Hansen 2007) outline that due to differing Halal standards not only between countries but also within each country, confusion and misunderstanding in the certification process have occurred. This may punctuate the value of a detailed supply chain visibility/traceability system instead of relying on a stamp of Halal certification. An effective traceability and tracking system in Malaysia is seen as an essential mitigation strategy.

Azah (Azah et al., 2008) also outlined in their findings that, according to them, current Halal tracking approaches were mainly manual notwithstanding evidence of an increase in the use of web-based information systems. They added that a comprehensive tracking system needed to be employed in Malaysia to assist in depicting trademark and brand fraud on packaging in a real time basis and in a trusted environment. In conclusion, Azah (Azah et al., 2008) summarised that with the power to track and trace items easily and in real time, RFID could be the best solution to solve the pressing problems. They specifically cited a lack of a reliable method to determine whether the food products came from the country which is stated on its packaging or otherwise.

In New Zealand, NAIT outline that RFID is seen 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 (Thakur et al., 2011). Thakur (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 the 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 and deer in 2013 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. 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 EPC Architectural Framework (formerly known as 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 EPC Architectural Framework 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 and meat identification and traceability, this research used Ultra High Frequency (UHF) RFID technologies (tags and readers) based on the EPC suite of Standards.

This research was conducted over a period of four weeks between April and May 2014. Using an eleven (11) stage *Process Design Model*[1], stage one (1) involved the application of EPC Gen 2 UHF label tags encoded with EPC unique identification numbers (sGTIN) to 109 cartons of meat products (35 cartons of tails, 38 cartons of tripe and 36 cartons of lungs). The remaining ten (10) stages outline a process of loading cartons of frozen meat products into a shipping container, the transit of the container from the production facility to the export port (Port of Lyttleton, Christchurch, New Zealand), the transit by ocean freight of the container from the Port of Lyttleton, New Zealand to Port Klang, Malaysia and delivery of the container to a warehouse located in Kuala Lumpur. A ruggedised EPC tag encoded with a Global Individual Asset Identifier (GIAI) was attached to the shipping container on-site at the Kokiri processing plant. The unique identifier was captured and event details recorded at relevant read event nodes outlined in the process design model.

The project research team:

- GS1 New Zealand and GS1 Malaysia – are member organisations in their respective countries of GS1, the international, not-for-profit standards development organisation with member organisations in over 100 countries. GS1 is dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across industry sectors. The GS1 system of standards is the most widely used supply chain standards system in the world.

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[1] Refer: Appendix

- SMTRACK Berhad (SMTRACK) – is a track and trace solutions provider based in Malaysia that utilises Radio Frequency Identification (RFID) and innovative technologies to provide online and mobile solutions.

- ANZCO Foods – is a multinational group of companies, whose core purpose is to procure, process and market New Zealand beef and lamb products globally. The processing facility utilised for this research was ANZCO Kokiri Limited's processing plant, (part of the ANZCO Foods Group) located in the Arnold Valley between the towns of Hokitika and Greymouth on New Zealand's South Island. The facility is certified as an accredited Halal processing facility in New Zealand for exports to Malaysia.

Figure 2.1 – Map of South Island, New Zealand

Figure 2.2 – ANZCO Kokiri

3 Research Objectives

The objectives of this research are to:

- Examine, assess and report on the efficacy of using EPC Standards (and in particular the EPCIS Standard) as a tool for traceability for meat products (meat packed in cartons) and product authenticity from point of production to delivery.
- Examine, assess and report on EPCIS interoperability using event data generated and captured during this research.

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 outline 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 (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 (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.

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 recognised 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*, '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, it can be communicated and exchanged and 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 (Nielsen and Kristensen 2008) emphasise that international competition is seen as a threat to farmer's livelihood.

The World Organisation for Animal Health (OIE) outline that the pillars of a traceability system are founded upon the identification of individual animals or homogenous groups of animals, the ability to track their movements, proper identification of premises and recording of this information in appropriate registers (Vallat 2014). To promote robust traceability, OIE posit that there must be a means of linking the identification and traceability of live animals and the traceability of products of animal origin so as to achieve traceability throughout the animal production and food chain – from farm to fork – taking into account the standards established by the OIE and the Codex Alimentarius Commission (Vallat 2014).

In determining 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 determined by tracking and tracing the flow of production metrics. Nielsen and Kristensen (Neilsen 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.

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 Product Authentication

There is an ever increasing risk that physical products are not what they claim they are. Product authentication is needed to detect counterfeit and falsified products and to prevent them from entering the distribution channel of genuine products. Turcu (Turcu et al., 2013) argue that one of the key issues concerning safety in today's global marketplace is the increasing risk regarding the production of fake branded goods. The issue is not limited to a few products and certain countries but it is a global phenomenon affecting a wider range of industries. Turcu (Turcu et al., 2013) outline that recent studies illustrate that annually, sales of counterfeit products reach tens of billions of dollars and are continuing to escalate.

Counterfeiting impacts legitimate companies, governments, consumers and society at large. The trade of counterfeit products also affects the safety of consumers who are exposed to health and quality risks. Counterfeiting certainly impacts legitimate businesses causing the decrease of sales, lower profits and loss of brand trust and value (Turcu et al., 2013). Lehtonen (Lehtonen et al., 2007) outline that along with legally run business, there is a full-size underground industry that produces and distributes illegal copies of virtually all kinds of products.

Companies can launch countermeasures on a number of fronts including legal actions, consumer education, private investigations and technological countermeasures. Lehtonen (Lehtonen et al., 2007) render the first three measures as inefficient, slow and can only address part of the problem. In additon, Lehtonen (Lehtonen et al., 2007) also describe counterfeiters and falsifiers being both adaptive and creative enough to restart their business if necessary.

Lehtonen (Lehtonen et al., 2007) also describe that *'if this licit supply chain would be secured by giving each item an identify and by implementing reliable ways to prove their identities, distributing counterfeit products through this channel would become substantially harder – and economically unattractive. With the development of mass serialisation and Automatic Identification (Auto-ID) technologies, in particular radio-frequency identification (RFID), the technical countermeasures have enjoyed an increasing importance. RFID has recognised potential in anti-counterfeiting because it allows for many ways to authenticate products.'*

There are different approaches to how RFID tagged products can be authenticated. Based on the authentication factors, Lehtonen (Lehtonen et al., 2007) outline that it is possible to categorise known and secure RFID-based approaches into product authentication based on three primary requirements namely; what the product is (object-specific features based authentication), what the product has (tag authentication), and where the product is (location-based authentication). The essence of their RFID - based authentication techniques can be summarised as follows:

- *Object-Specific (Features-based Authentication)* – the general approach being to make products difficult to clone and within the context of identification, this is achieved by assigning the product a *unique product identifier* issued by the brand owner. Within the context of RFID, the RFID tag stores a signature value that is computed from the unique product identifier, unique tag identifier, signature method and brand owner's validation key.

- *Tag Authentication* – the approach here being to use security features that are difficult to clone. The literature outlines a sufficient number of security methods that provide for this, usually through tag authentication protocols.

- *Location-Based Authentication* – This approach is often referred to as track and trace, the goal being not to prevent cloning of products but to detect the cloned (counterfeit, falsified) products in a defined environment such as a supply chain.

Defining Product Authentication

To provide an unambiguous definition for product authentication, Lehtonen (Lehtonen et al., 2007) posit the need to distinquish between a product's identity and an identifier; identity being something unique that products have that endures throughout the product's lifecycle. The product's identifier is the name given or a reference to the product's identity and it can be either in product class level, such as the Global Trade Item Number (GTIN) or in serial level such as the Serialised Global Trade Item Number (sGTIN).

Based on these definitions, Lehtonen (Lehtonen et al., 2007) derive the following definition for product authentication:

Product Authentication = Identification + Verification of the claimed identity.

This definition aligns with the Kurose and Ross (Kurose and Ross 2003) and Schneider (Schneider 1996) definitions namely; when a product's unique identity is linked to additional information, product authentication as defined can be answered as to whether a product is genuine or counterfeit, diverted from an authorised distribution channel, expired, recalled, stolen, has warranty and so on.

6 Security

Product authentication has to deal with degrees of uncertainty and some authentication methods are stronger than others. Thus, different verifications lead to different levels of confidence and in Lehtonen's view (Lehtonen et al., 2007) because perfect security does not exist, the 100% confidence level is theoretical. In practice however, the 100% confidence level can be associated with the most secure techniques.

Each step in what is essentially a *chain of trust* network is a possible point of attack against a product authentication system. Lehtonen (Lehtonen et al., 2007) cite examples of threats and include tag removal and reapplication, tag cloning, attack against the RF communication, manipulation of equipment and forgery of product history among others and they outline security and functional requirements mitigation strategies to deal with these. While Lehtonen (Lehtonen et al., 2007) conclude their analysis with identifying some deficiencies with The EPC Network (i.e. the still conceptual nature of tag authentication, missing Discovery Services as a component of the network etc), Sandhu (Sandhu 2003) argues that the level of security of a system should always *be good enough* but not more because too high levels of security lead to unnecessary costs, decreased flexibility and reduced usability.

Security is a process by which an organisation protects its valuable assets. In general, assets are protected to reduce the risk of attack to acceptable levels with the elimination of risk an often unrealisable extreme. Because the level of acceptable risk differs widely from application to application, there is no standard security solution that can apply to all systems. The EPCglobal Architecture Framework cannot be pronounced secure or insecure, nor can any individual standard or service. As 'security' cannot be evaluated without detailed knowledge of the entire system, security, within the context of The EPCglobal Architecture Framework focuses on data protection methods and the mechanisms and specifically data protection when it is stored, shared and published within EPCglobal Standards and their relation to system attributes (Traub et al., 2014).

For operations both inside and outside an organisation's four walls, The EPCglobal Architecture Framework promotes environments with security precautions that appropriately address risks and protect valuable assets and information. Security features are either built into the standards or recommend use of industry best security practices in accordance with the framework.

Traub (Traub et al., 2014) outlines the data protection mechanisms within the Standards and the Standards forming The EPCglobal Architecture Framework including underlying technical principles, network interfaces protocols, application level event interfaces, RFID reader protocols including low level reader protocols, reader management, EPC Information Services (EPCIS) interfaces, Object Naming Service (ONS), number assignment, tag air interfaces, tag data formats and standards, security and EPCglobal Electronic Pedigree standards.

In February 2014, GS1 ratified a new version of the EPC Generation 2 (Gen 2) Ultra High Frequency RFID Standard, which includes features that companies in many industries will find useful including added security features previously available only in active or proprietary passive systems, in an effort to counter counterfeiting.

Until recently, the EPC Gen 2 air interface protocol has been vulnerable to cloning, because a counterfeiter can read the unique Electronic Product Code in a RFID tag and programme it into a different tag that is indistinguishable to the reader. The tag manufacturer's tag identifier (TID) can also be cloned. Traub (Traub 2014) outlines that the new Generation 2, Version 2 (Gen2V2) solves the cloning issue by providing a secret authentication key that is programmed into the tag. Unlike an EPC or TID, this key cannot be read from the tag. Instead, a reader "challenges" the tag by sending it a random number. The tag encrypts that number using the secret key and sends the response back to the reader. The reader uses the secret key to decrypt the response. If the decrypted response matches the challenge, the tag is genuine. A counterfeiter cannot read the secret key or interpret it by listening to the conversation between a tag and a reader. Without the key, it is impossible to clone a tag that a reader will authenticate.

To use this feature, companies must consider three new software requirements when procuring or upgrading their RFID applications or middleware. The application that programmes the tag must choose a secret key - typically, a random number - and programme that along with the EPC and other information.

The application reading the tag must instruct the reader to issue a challenge, check the response and signal an error if there is no match. A new database must manage the keys. The programming application stores the secret key associated with each EPC and the reading application queries the database to get the key for verification. Tag authentication also works in the other direction: the tag can challenge the reader.

7 Research Methodology

This research focuses on identifing and tracking a sample of 109 cartons of frozen meat products and the shipping container in which the cartons were loaded, through a supply chain. The research methodology describes an eleven (11) step *Process Design Model*[2] outlining:

- the identification of cartons, the shipping container and read event locations,
- the Event, Action, BizStep, Disposition, ReadPoint and BizLocation as defined by the EPC Core Business Vocabulary (CBV) of cartons of meat products (and where relevant, the shipping container) from point of production to delivery.

The following EPC standards were used in the research (as outined in a Process Design Model[3]).

- **Serialised Global Trade Item Number** (sGTIN) - a unique, serialised identification number used to identify individual cartons of meat products.
- **Serialised Global Location Number** (sGLN) - a unique, serialised identification number used to identify specific EPC read event locations.
- **Global Individual Asset Identifier** (GIAI) - a unique, serialised identification number used to identify the 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 vocabulary. The bizsteps used in this research are also outlined in the glossary.

Process Step 1 - Tagging of cartons at production at Kokiri (Offal Room)

Figure 7.1 – Labelling station, Kokiri

Figure 7.2 – Tagged carton, Kokiri

Figure 7.1 and Figure 7.2 illustrate the application of shipping labels to the cartons, post production before the cartons are moved into cold storage. At this stage, the carton's unique identification number is captured in preparation for loading the information into the EPCIS.

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[2] See Appendix
[3] See Appendix

Process Step 2 - Loading cartons into shipping container at Kokiri

Figure 7.3 – Loading cartons into shipping container

Figure 7.3 illustrates the cartons of meat products being loaded into a shipping container. The cartons are presented to the RFID antenna thereby ensuring the carton's identification number was captured and recorded. The researchers found that the close proximity of the antenna was not actually required as the tag read perfromance was very good meaning the container could have been loaded 'as usual'.

Process Step 3 - Shipping container leaving Kokiri

Figure 7.4 – RFID tag on shipping container being read at Kokiri prior to despatch

Figure 7.5 – Shipping container leaving Kokiri site

Figure 7.4 illustrates attaching a ruggedised RFID tag to the shipping container and being read by the RFID handheld reader prior to the container being positioned at the Kokiri rail siding in preparation for transit to the Port of Lyttleton in Christchurch, New Zealand. Figure 7.5 illustrates the shipping container loaded onto a rail wagon at Kokiri prior to being transported to the Port of Lyttleton in Christchurch, New Zealand.

Process Step 4 - Shipping container arriving at rail yard, Christchurch, New Zealand

Figure 7.6 – Shipping container in rail marshaling yard in Christchurch

Figure 7.6 illustrates the shipping container positioned in the railway marshalling yards in Christchurch prior to being moved to the Port of Lyttleton in preparation for shipping to Port Klang, Malaysia.

Process Step 5 - Shipping container leaving rail yard in Christchurch, New Zealand

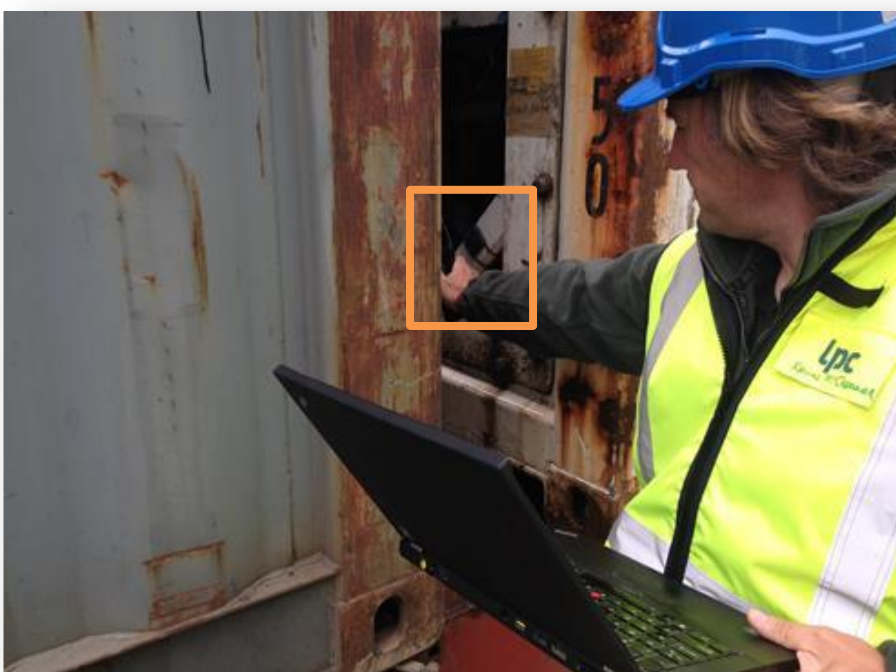

Figure 7.7 – Scaning RFID tag on container in Christchurch rail yard

Figure 7.8 – Container being loaded onto rail wagon
for transport to the Port of Lyttleton

Figure 7.8 illustrates the container being loaded on to a rail wagon in the Christchurch rail marshalling yard for transport to the Port of Lyttleton, Christchurch, New Zealand.

Process Step 6 - Shipping container arriving at Port of Lyttleton, Christchurch, New Zealand

Figure 7.9 – Shipping container arriving at Port of Lyttleton

Figure 7.9 illustrates the shipping container being lifted off the rail wagon after arriving at the Port of Lyttleton in preparation for loading onto the ship for export to Port Klang, Malaysia.

Process Step 7 - Shipping container leaving Port of Lyttleton, Christchurch, New Zealand

Figure 7.10 – Shipping container ready for loading onto ship at Port of Lyttleton

Figure 7.10 illustrates the shipping container positioned at the Port of Lyttleton, Christchurch in preparation for loading on to the ship for export to Port Klang, Malaysia.

Process Step 8 - Shipping container arrives at Port Klang, Malaysia

Figure 7.11 – Container vessel docked at Port Klang, Malaysia

Figure 7.11 depicts a container vessel docked at Port Klang, Malaysia (Illustrative purposes). It was not possible for security and operational reasons to read the RFID tag attached to the shipping container at Kokiri, New Zealand while berthed at Port Klang. The shipping container’s identification (GIAI) and the read event location (GLN) information were entered into the EPCIS manually for this process step.

Process Step 9 - Shipping container departing from Port Klang, Malaysia

Figure 7.12 – Attaching a RFID tag to the shipping container

Figure 7.13 – RFID tag secured to the shipping container

Figures 7.12 and 7.13 illustrate attaching a RFID 'electronic seal' (tag) to the container to both secure and track the container during transit from Port Klang to Agribiz's premises. The RFID electronic seal was an added feature incorporated in the process design model to secure the container from unauthorised opening as well as to enable point-to-point tracking throughout the transit from Port Klang to Agribiz.

Process Step 10 - Cartons of meat receipted on arrival at Agribiz, Subang Jaya, Malaysia

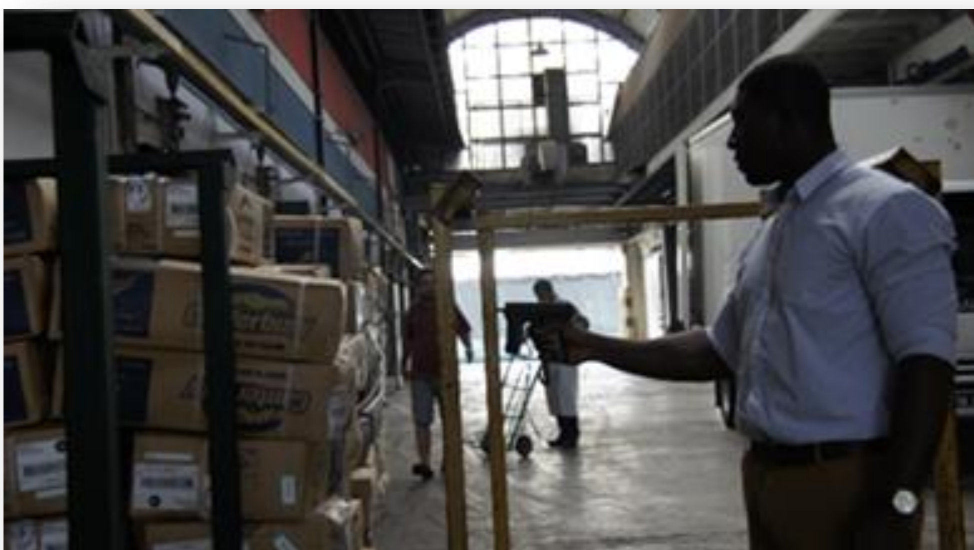

Figure 7.14 - Reading RFID labels on the cartons using a handheld RFID reader

Figure 7.14 illustrates the cartons of meat products being received and scanned into Agribiz's warehouse. A RFID handheld reader is used to read the RFID tag's encoded data. The data is verified against that which was captured and recorded in the EPCIS during the container loading process in Kokiri, New Zealand.

Process Step 11 - Cartons of meat stored in Agribiz Cold Storage, Subang Jaya, Malaysia

Figure 7.15 – Cartons being moved into cold storage

Figure 7.16 – RFID tags on the cartons being read in the cold storage facility

Figure 7.15 illustrates the cartons being moved into cold storage at Agribiz. Figure 7.16 illustrates the RFID tags on each carton being read by a RFID handheld reader. The data is transmitted to the EPCIS over a WiFi connection.

8 Data Collection and Discussion

In collecting event data, the researchers used the EPCglobal suite of identifiers and standards to uniquely identify cartons of meat products and the physical locations in each of the eleven (11) read event nodes outlined in the *Process Design Model.* The shipping container was also tracked throughout its transit from New Zealand to Malaysia using its unique Global Individual Asset Identifier (GIAI).

Data collection was undertaken using a combination of RFID readers (fixed and handheld devices) to read RFID tags as well as manual data collection and input methods. Manual data collection (i.e. using direct computer input) was necessary in situations where access to the shipping container was either not possible or operationally impractical; when the container was being loaded onto or off the vessel, for example.

To examine and assess EPCIS interoperability as a research objective, event data was populated into two discrete EPCIS repositories; (a) 'ezTrack', operated by GS1 Hong Hong, and (b) SMTRACK, operated by SMTRACK Berhad, Malaysia. EPCIS queries to both repositories were undertaken using an independent, third party EPCIS query tool[4].

Outlined on the following pages, the researchers illustrate a series of screenshots captured using the EPCIS query tool. Highlighted are the *what, why, where and when* dimensions that the EPCIS suite of standards capture and report on.

[4] http://www.vizworkbench.com/ui/home - a service of Ken Traub Consulting LLC (www.kentraub.com)

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Halal Step 1 (3 items) results

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Document type EPCIS Query Results (inside SOAP Envelope)

– 3 EPCIS Events

		Event 1	Event 2	Event 3
Type	**Event Type**	**Object Event** ADD	**Object Event** ADD	**Object Event** ADD
When	**Event Time**	2014-04-04 08:50:00.000 GMT+12:00	2014-04-04 10:01:00.000 GMT+12:00	2014-04-07 09:45:00.000 GMT+12:00
	Record Time	2014-05-05 02:53:03.544 UTC	2014-05-05 02:53:04.066 UTC	2014-05-05 02:53:03.806 UTC
What	**"What" Dimension**	*GTIN* 99419781032089 *Serial* 68	*GTIN* 99419781034007 *Serial* 108	*GTIN* 99419781032102 *Serial* 92
Where	**Read Point**	*GLN* 9429000049184 *Ext* OFFAL_ROOM	*GLN* 9429000049184 *Ext* OFFAL_ROOM	*GLN* 9429000049184 *Ext* OFFAL_ROOM
	Biz Location	*GLN* 9429000049184 *Ext* FREEZER	*GLN* 9429000049184 *Ext* FREEZER	*GLN* 9429000049184 *Ext* FREEZER
Why	**Biz Step**	**Commissioning** (CBV)	**Commissioning** (CBV)	**Commissioning** (CBV)
	Disposition	**Active** (CBV)	**Active** (CBV)	**Active** (CBV)

Table 8.1 – EPCIS screenshot of RFID tagged cartons being read at Kokiri

Table 8.1 illustrates read events outlined in **step 1** of the *Process Design Model* (refer: Appendix). Illustrated is a sample of three cartons labelled with RFID tags at Kokiri identified by **sGTINs** 994419781032089.68 (tails), 994419781034007.108 (lungs) and 994419781032102.92 (tripe) and then read with a RFID reader. The **read point** is identified by a sGLN (9429000049184.OFFAL_ROOM) and the **Biz Location** is identified by **sGLN** (GLN 94390000184_FREEZER). **Event Type**, **BizStep** and **Disposition** for each event are also identified, as are event time and record time.

EPCIS repository queried for event data: ezTrack, Hong Kong

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New Query results
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Document type EPCIS Query Results (inside SOAP Envelope)

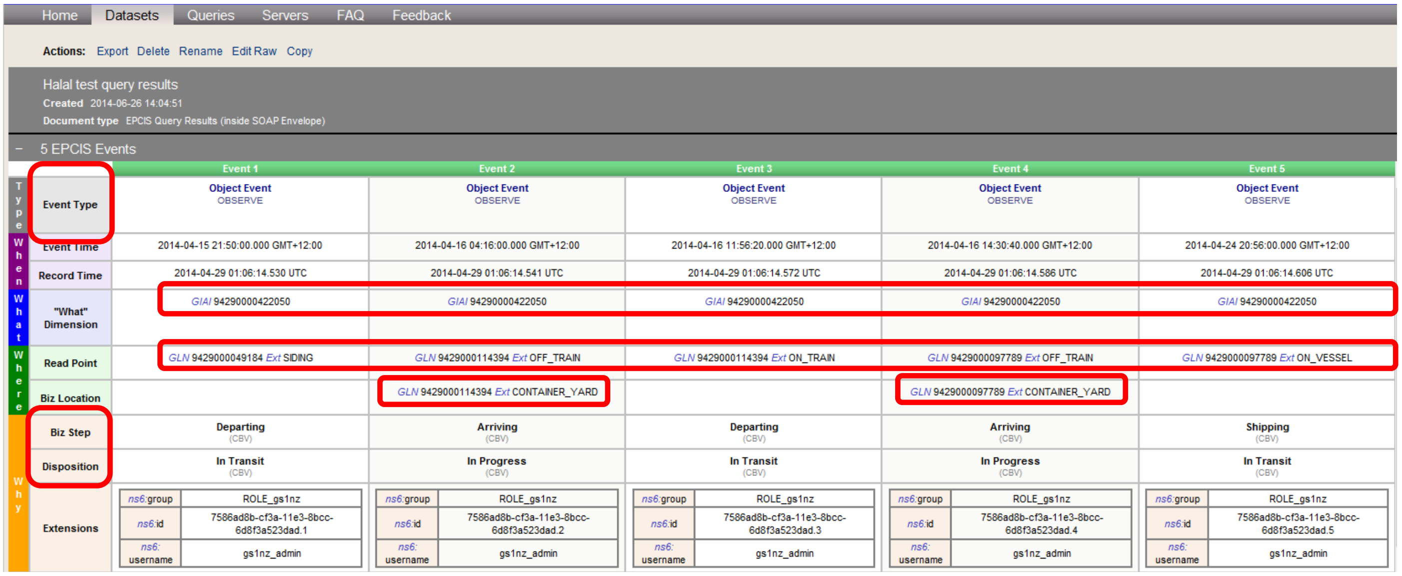
− 3 EPCIS Events

		Event 1	Event 2	Event 3
Type	Event Type	**Aggregation Event** ADD	**Aggregation Event** ADD	**Aggregation Event** ADD
When	Event Time	2014-04-15 12:02:11.000 GMT+12:00	2014-04-15 12:02:11.000 GMT+12:00	2014-04-15 12:02:12.000 GMT+12:00
When	Record Time	2014-04-29 00:56:48.440 UTC	2014-04-29 00:56:48.445 UTC	2014-04-29 00:56:48.450 UTC
What	"What" Dimension	*Parent* *GIAI* 94290000422050 *GTIN* 99419781032089 *Serial* 98	*Parent* *GIAI* 94290000422050 *GTIN* 99419781032102 *Serial* 244	*Parent* *GIAI* 94290000422050 *GTIN* 99419781032102 *Serial* 44
Where	Read Point	*GLN* 9429000049184 *Ext* LOADING_DOCK	*GLN* 9429000049184 *Ext* LOADING_DOCK	*GLN* 9429000049184 *Ext* LOADING_DOCK
Where	Biz Location	*GLN* 9429000049184 *Ext* CONTAINER_ON_SITE	*GLN* 9429000049184 *Ext* CONTAINER_ON_SITE	*GLN* 9429000049184 *Ext* CONTAINER_ON_SITE
Why	Biz Step	**Loading** (CBV)	**Loading** (CBV)	**Loading** (CBV)
Why	Disposition	**In Progress** (CBV)	**In Progress** (CBV)	**In Progress** (CBV)
Why	Extensions	*ns6*:username gs1nz_admin *ns6*:id 230bfad8-cf39-11e3-8bcc-6d8f3a523dad.3 *ns6*:group ROLE_gs1nz	*ns6*:group ROLE_gs1nz *ns6*:username gs1nz_admin *ns6*:id 230bfad8-cf39-11e3-8bcc-6d8f3a523dad.4	*ns6*:group ROLE_gs1nz *ns6*:id 230bfad8-cf39-11e3-8bcc-6d8f3a523dad.5 *ns6*:username gs1nz_admin

Table 8.2 – EPCIS screenshot of read events for individual cartons at Kokiri

Table 8.2 illustrates read events corresponding to **step 2** of the *Process Design Model* (refer: Appendix). Three (3) cartons of meat products identified by **sGTINs** (two cartons of tails and one carton of tripe) are being loaded into the shipping container at Kokiri identified at **Read Point** GLN 9429000049184_LOADING_DOCK where the **Biz Location** is identified by **sGLN** (GLN 9429000049184_CONTAINER_ON_SITE). **Event Type**, **BizStep** and **Disposition** for each event are identified, as are event time and record time.

EPCIS repository queried for event data: ezTrack, Hong Kong



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Halal test query results

Created 2014-06-26 14:04:51

Document type EPCIS Query Results (inside SOAP Envelope)

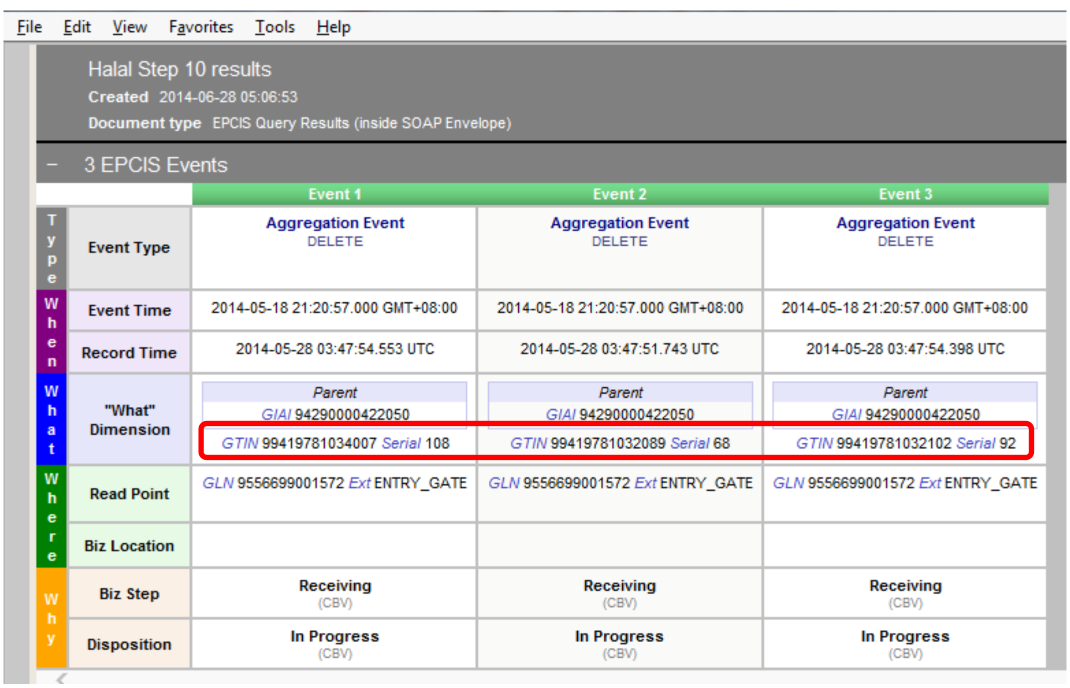
− 5 EPCIS Events

	Event 1	Event 2	Event 3	Event 4	Event 5
Event Type	Object Event OBSERVE	Object Event OBSERVE	Object Event OBSERVE	Object Event OBSERVE	Object Event OBSERVE
Event Time	2014-04-15 21:50:00.000 GMT+12:00	2014-04-16 04:16:00.000 GMT+12:00	2014-04-16 11:56:20.000 GMT+12:00	2014-04-16 14:30:40.000 GMT+12:00	2014-04-24 20:56:00.000 GMT+12:00
Record Time	2014-04-29 01:06:14.530 UTC	2014-04-29 01:06:14.541 UTC	2014-04-29 01:06:14.572 UTC	2014-04-29 01:06:14.586 UTC	2014-04-29 01:06:14.606 UTC
"What" Dimension	GIAI 94290000422050	GIAI 94290000422050	GIAI 94290000422050	GIAI 94290000422050	GIAI 94290000422050
Read Point	GLN 9429000049184 Ext SIDING	GLN 9429000114394 Ext OFF_TRAIN	GLN 9429000114394 Ext ON_TRAIN	GLN 9429000097789 Ext OFF_TRAIN	GLN 9429000097789 Ext ON_VESSEL
Biz Location		GLN 9429000114394 Ext CONTAINER_YARD		GLN 9429000097789 Ext CONTAINER_YARD	
Biz Step	Departing (CBV)	Arriving (CBV)	Departing (CBV)	Arriving (CBV)	Shipping (CBV)
Disposition	In Transit (CBV)	In Progress (CBV)	In Transit (CBV)	In Progress (CBV)	In Transit (CBV)
Extensions	ns6:group ROLE_gs1nz; ns6:id 7586ad8b-cf3a-11e3-8bcc-6d8f3a523dad.1; ns6:username gs1nz_admin	ns6:group ROLE_gs1nz; ns6:id 7586ad8b-cf3a-11e3-8bcc-6d8f3a523dad.2; ns6:username gs1nz_admin	ns6:group ROLE_gs1nz; ns6:id 7586ad8b-cf3a-11e3-8bcc-6d8f3a523dad.3; ns6:username gs1nz_admin	ns6:group ROLE_gs1nz; ns6:id 7586ad8b-cf3a-11e3-8bcc-6d8f3a523dad.4; ns6:username gs1nz_admin	ns6:group ROLE_gs1nz; ns6:id 7586ad8b-cf3a-11e3-8bcc-6d8f3a523dad.5; ns6:username gs1nz_admin

Table 8.3 – EPCIS screenshot of New Zealand based read events relating to the shipping container

Table 8.3 illustrates read events relating to ***steps* 3 - 7** inclusive, of the *Process Design Model* (refer: Appendix). EPCIS query results are identified for five (5) New Zealand based read events for the shipping container (GIAI 94290000422050). The results outline read events starting from **Read Point** Kokiri rail siding (GLN 9429000049184_SIDING) and finishing at **Read Point,** Port of Lyttleton (GLN 9429000097780_ON_VESSEL). **Event Type**, **BizStep** and **Disposition** for each event are identified, as are event time and record time.

EPCIS repository queried for event data: ezTrack, Hong Kong



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Halal Step 10 results

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Document type EPCIS Query Results (inside SOAP Envelope)

− 3 EPCIS Events

	Event 1	Event 2	Event 3
Event Type	Aggregation Event DELETE	Aggregation Event DELETE	Aggregation Event DELETE
Event Time	2014-05-18 21:20:57.000 GMT+08:00	2014-05-18 21:20:57.000 GMT+08:00	2014-05-18 21:20:57.000 GMT+08:00
Record Time	2014-05-28 03:47:54.553 UTC	2014-05-28 03:47:51.743 UTC	2014-05-28 03:47:54.398 UTC
"What" Dimension	Parent GIAI 94290000422050; GTIN 99419781034007 Serial 108	Parent GIAI 94290000422050; GTIN 99419781032089 Serial 68	Parent GIAI 94290000422050; GTIN 99419781032102 Serial 92
Read Point	GLN 9556699001572 Ext ENTRY_GATE	GLN 9556699001572 Ext ENTRY_GATE	GLN 9556699001572 Ext ENTRY_GATE
Biz Location			
Biz Step	Receiving (CBV)	Receiving (CBV)	Receiving (CBV)
Disposition	In Progress (CBV)	In Progress (CBV)	In Progress (CBV)

Table 8.4 – Receipt of cartons into Agribiz, Malaysia

Table 8.4 illustrates the receipt of three (3) cartons of meat products at **Read Point** Agribiz, Malaysia (GLN 9556699001572_ENTRY_GATE) representing **step 10** of the *Process Design Model* (refer: Appendix). The cartons identified are the same as those identified in Table 8.1 for **step 1** in the *Process Design Model.* The **Parent** EPC identifier is the shipping container (GIAI 94240000422050) and illustrates that the cartons of meat products were unloaded from it. **Event Type**, **BizStep** and **Disposition** for each event are identified, as are event time and record time.

EPCIS repository queried for event data: SMTRACK, Malaysia

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Halal Step 11 (OBJECT/EVENT DELETE) results
Created 2014-07-03 12:14:21
Document type EPCIS Query Results (inside SOAP Envelope)

– 3 EPCIS Events

		Event 1	Event 2	Event 3
Type	Event Type	Object Event DELETE	Object Event DELETE	Object Event DELETE
When	Event Time	2014-05-19 16:31:24.000 GMT+08:00	2014-05-19 16:31:24.000 GMT+08:00	2014-05-19 16:31:24.000 GMT+08:00
	Record Time	2014-05-22 11:42:50.482 UTC	2014-05-22 11:42:52.619 UTC	2014-05-22 11:42:52.747 UTC
What	"What" Dimension	*GTIN* 99419781032089 *Serial* 68	*GTIN* 99419781032102 *Serial* 92	*GTIN* 99419781034007 *Serial* 108
Where	Read Point	*GLN* 9556699001572 *Ext* IN_STORE	*GLN* 9556699001572 *Ext* IN_STORE	*GLN* 9556699001572 *Ext* IN_STORE
	Biz Location	*GLN* 9556699001572 *Ext* RECEIVING_BAY	*GLN* 9556699001572 *Ext* RECEIVING_BAY	*GLN* 9556699001572 *Ext* RECEIVING_BAY
Why	Biz Step	Receiving (CBV)	Receiving (CBV)	Receiving (CBV)
	Disposition	Sellable Accessible (CBV)	Sellable Accessible (CBV)	Sellable Accessible (CBV)

Table 8.5 – Final read event of cartons at Agribiz, Malaysia

Table 8.5 illustrates the DELETE[5] event type for the three (3) cartons of meat products that were outlined in Table 8.1. This event occurred at **Read Point** Agribiz, Malaysia (GLN 9556699001572_IN_STORE) representing **step 11** of the *Process Design Model* (refer: Appendix). **Event Type**, **BizStep** and **Disposition** for each event are identified where Disposition *Sellable Accessible* indicates that the product can be sold as is and the customer can access product for purchase. Event time and record time are also indicated.

EPCIS repository queried for event data: SMTRACK, Malaysia

Conclusion

For practical reasons, the EPCIS screenshots outlined illustrate event reporting for a limited number of cartons of meat products. The large number of cartons involved in the total sample consignment is too large to illustrate graphically in this report. Despite this, all cartons shipped were receipted into the Agribiz storage facility in Malaysia.

[5] Within the context of the data elements in the EPCIS Standard, DELETE indicates the last event in a product's lifecycle for an Object Event or indicates removing child EPCs from a parent EPC in an Aggregation Event.

Because each EPC identifier used in the research (i.e. sGTIN for cartons, GIAI for the shipping container, GLN and sGLN for read locations) was able to be identified, captured, recorded and made available for query 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. Further, within the context of the purpose and functionality of the EPCIS, the dimensions of 'what, where, when and why' were demonstrated thereby establishing the required traceability and product authenticity outcomes.

The Process Design Model[6] used in this research outlines the EPCIS Event Structure; a list of data elements and an indication where the core business vocabulary provides identifiers that may be used for the data elements including:

- *Business Step* - The specific activity within a business process i.e. an event that specifies what business process step was taking place that caused the event to be captured.
- *Disposition* - The business state or business condition of an object in the 'what' dimension subsequent to the event.
- *Read Point* - The location where the EPCIS event took place.
- *Business Location* - The location where the subject of the event is assumed to be, following an EPCIS event until a new event takes place that indicates otherwise.

The researchers conclude that the EPCIS provides a robust standards-based tool for traceability and product authenticity query and analysis.

As outlined, the researchers adopted the definition for product authenticity as defined by Lehtonen (Lehtonen et al., 2007) namely; *Product Authentication = Identification + Verification of the claimed identity*. For the same reasons outlined above for traceability objectives and outcomes, the researchers are confident that the objectives set to demonstrate product authenticity have been met. The researcher's conclusion is also supported in applying the definition established by Kurose and Ross (Kurose and Ross 2003) and Schneider (Schneider 1996) namely; when a product's unique identity is linked to additional information, product authentication can be answered.

The researchers include an important caveat to the conclusion, however. This analysis did not provide for the total 'Halalness' concept as outlined in Zailani (Zailani et al., 2010), specifically the halal nature of live animals either in their farming environment or during the processing stages, apart from the point of production of cartons of finished product. Typically, the consolidation of production units (cartons of meat products) occurs in a processing facility over the duration of several weeks. The exact origin of the animals was unknown for this pilot and therefore could not be included in the scope of the research. Therefore, the objective of product authentication set by the researchers is considered effective and efficacious from the point of production of cartons of meat products to the point of delivery of cartons to the assigned Malaysian deconsolidation point.

As outlined in previous research by Hartley (Hartley 2013), it is important to reiterate that in the live animal to meat products conversion process, it is difficult to determine the exact association or relationship between individual 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 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 meat that a 1-to-1 link could (theoretically) be established. It is not technically impossible however but will usually be determined by a supportive business case.

Within the context of chain traceability as defined, this analysis demonstrates chain traceability at batch level. Batch traceability should not be considered as less secure, rather less specific. If one animal is later identified as being at risk, it can be traced forward to all cartons that *could contain* meat from that animal. However, it may result in the recall of cartons that don't actually contain meat from that animal. Product authentication is achieved at carton level from the point of production to delivery in Malaysia.

[6] See Appendix

Traub (Traub 2012) outlines that with the development of upgraded EPCIS Standards, an anticipated enhancement is the ability to handle *transformations*. Traub (Traub 2012) describes that in the food-processing industry, many companies grind together different cuts of meat to make hamburgers for example. The transformation of one thing into another occurs in many manufacturing industries as well. The new EPCIS structure would allow both a list of inputs consumed and a list of outputs produced to be carried in the same event (Traub 2012). EPCIS Version 1.1 has recently been ratified and published.

9 EPCIS Interoperability

The Electronic Product Code Information Services (EPCIS) is a set of interfaces that support sharing of visibility data. The Standard defines capture and query interfaces to obtain and share business event information. The EPCIS Standard can be used for sharing EPC related information within and across enterprises and is the bridge between the physical world and information systems. The EPCIS is designed as a distributed network architecture providing the *what, where, when, and why* of events occurring in any supply chain. Important business information is exchanged including time, location, disposition and business step of each event that occurs during the life of an item in the supply chain. The standard may be implemented by applications, but the applications themselves are developed by end users and solution providers.

Antecedents by Hartley and Sundermann (Hartley and Sundermann 2010) and Hartley (Hartley 2013) investigating the efficacy of using the EPCIS Standard for supply chain traceability outcomes focused on the use of a single EPCIS implementation (i.e. server). For the purposes of that research, this was justifiable within the defined scope. The business value offered by the EPCIS standards however, is realised through the query and reporting capability that delivers rich event information to trading partners made available through a distributed network of EPCIS servers, analogous to the World Wide Web.

As outlined, this research included as an objective, the examination and assessment of EPCIS interoperability. To demonstrate this, EPC Query messages were sent to both SMTRACK's EPCIS repository based in Malaysia[7] and GS1 Hong Kong's ezTrack EPCIS repository based in Hong Kong[8] using an independent, third party EPCIS query tool[9].

Defining Interoperability

A literature review reveals many definitions for interoperability, all describing the same themes, namely; the ability of making systems work together efficiently and effectively in the exchange of data between the systems (inter-operate). Open standards like those on which the suite of EPCIS standards are built on, imply interoperability.

According to ISO/IEC 2382-01, Information Technology Vocabulary, Fundamental Terms, interoperability is defined as follows: "The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units".

In alignment with this definition, Rezaei (Rezaei et al., 2014) outline *syntactic interoperability,* the definition the researchers use to determine efficacy against the research objective.

> **Syntactic interoperability -** *where two or more systems are capable of communicating and exchanging data, they are exhibiting syntactic interoperability. Specified data formats, communication protocols and the like are fundamental. XML or SQL standards are among the tools of syntactic interoperability. Syntactical interoperability is a necessary condition for further interoperability.*

[7] Operated by SMTRACK Berhad, Malaysia
[8] Operated by GS1 Hong Kong
[9] http://www.vizworkbench.com/ - a service of Ken Traub Consulting LLC (www.kentraub.com)

For one party to query an EPCIS repository for event data relating to a third party, it may be necessary for both parties to register their unique company/entity identifier (Company Prefix) with EPCglobal Inc; in the Object Naming Service (ONS). The Object Name Service (ONS) is a service that enables the discovery of object information on the basis of an EPC[10]. For the purposes of this research, to enable EPCIS queries for items registered with ANZCO Foods Limited, their unique GS1 Company Prefix (9419781[11]) was registered in the ONS. This allowed for EPC search, discovery and reporting of items and location facilities assigned to them using the EPCIS query tool as outlined.

Conclusion

The EPCIS screenshots illustrated in Section 8 - *Data Collection and Discussion*, are the results of query requests made on the two EPCIS repositories using the independent, third party EPCIS query tool. The reports accurately outline the EPCIS event information outlined in the *Process Design Model* (refer: Appendix). Consequently, the researchers are confident that EPCIS interoperability has been demonstrated and confirmed as defined.

10 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 and all this provides.

Notwithstanding, there are notable disadvantages and risks involved in selecting the methodology as outlined:

- Utilising fully operational facilities such as a beef processing plant (e.g. Kokiri) for research purposes can be disruptive both for the operational workforce and the researchers as it can easily disrupt and interrupt carefully planned, often time-sensitive production schedules. Concerns around compromising health and safety procedures and protocols are important to understand and adherence to health and safety regulations and protocols is essential. Good communication with all stakeholders involved in the research prior to any on-site activity is highly recommended to both understand and establish expectations and boundaries.

- When working in fully operational production environments, scheduled timelines (e.g. transport operators, port authorities) often change with little or no warning. Delays of this nature need to be considered when developing the research design.

- Invariably, there is a significant amount of 'goodwill' involved with on-location research that needs to be accounted for both in terms of research design and the on-site research activities. Goodwill has limitations.

- Equipment failure during research can cause disruptive, often timely delays. Mitigation strategies need to be determined before any activities begin.

- Performance of RFID equipment can sometimes be compromised by electromagnetic fields caused by electric motors and working machinery. Although UHF RFID is largely unperturbed by such electromagnetic fields, it has well known and understood 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. This needs to be accounted for in the research design.

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[10] 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.

[11] The research design model in the Appendix section identifies the ANZCO Global Company Prefix 9419781.

- Secure, reliable access to computer networks (especially for wireless requirements) for event data transmission may be difficult to achieve and failure in this area can compromise real time data transfer and/or performance. If real time data transfer or access to networks (i.e. the internet) is required in the research design, network accessibility and functional requirements need to be well understood and provided for in the research design.

- When undertaking research involving on-site locations, often limited opportunity exists for repetitive testing and analysis. The testing environment is also an operational production environment where processes generally will not/ cannot be postponed or stopped for research purposes, an issue often complicated in situations involving live animals. The research design needs to provide for this.

- Research assignments can be conducted in remote geographical locations where regular and reliable transport services may not always be available (e.g. infrequent airline services). This can be further complicated if the research is undertaken in locations where weather conditions are a known dependency (i.e. small regional airports frequently affected by inclement weather conditions). Contingencies should be provided for in the research design. Additionally, travel and accommodation costs can be expensive when research is undertaken in remote locations and should be budgeted for appropriately.

Having identified and outlined the disadvantages and potential risks associated with on-location research, the researchers consider the degree of rigor and authenticity of the results gained in the research justifies the methodology selection. Understanding the requirements of discerning regulatory environments and what can be extensive user community requirements, the results secured using alternative methodologies (i.e. desk modelling, simulated laboratory trials etc) may be viewed as constructed, contrived or theoretical.

11 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 traceability 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 'one 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, it can be communicated and exchanged and chain traceability is achieved' (CIES 2005 p.7).

In this research, all tag, location and event data was successfully read, captured and recorded in the EPCIS as a necessary requirement to demonstrate efficacious traceability and product authenticity (from the point of production) outcomes. Clearly, illustrating compliance in meeting the requirements of the: 'what, where, when and why', throughout the eleven (11) nodes of the research supply chain, coupled with the inclusion of EPCIS Event Structure data elements and identifiers as necessary supplementary information confirms both research objectives namely; the efficacy of using EPC standards for traceability and product authenticity outcomes as well as EPCIS interoperability.

The researchers used *syntactic interoperability* on which to examine EPCIS interoperability and efficacy. Interoperability as outlined and defined in **ISO/IEC 2382-01**, *Information Technology Vocabulary, Fundamental Terms* was used as a basis for assessment. Based on the findings as outlined, the researchers are confident that EPCIS interoperability has been clearly demonstrated.

The results of this research should provide broad confidence that the EPCglobal suite of standards is efficacious as a robust tool for livestock and meat 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 (pigs, 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 may 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 before applying to animals, cartons and containers etc.

- Further, prior to applying tags on animals, packaging or fixtures (e.g. 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.

- A literature review outlines a still limited number of trials and research projects where EPCIS implementations have been utilised to demonstrate traceability objectives and outcomes similar to this research. This research highlights both a desire and an opportunity to extend the research model to provide for the use of data capture technologies beyond RFID to include linear and two-dimensional barcodes and manual data input methods such as the use of a simple computer keyboard. Given the EPCIS Standard is agnostic to data entry inputs, research using data capture methods other than RFID or in combination with RFID is encouraged as this may promote increased and faster user adoption.

Appendix

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

Tagging of cartons at production at Kokiri (Offal Room)

EPC Item Identifier (Cartons) - sGTIN per carton label range:
urn:epc:id:sgtin:9419781.903208.xxx (tails)
urn:epc:id:sgtin:9419781.903210.xxx (tripe)
urn:epc:id:sgtin:9419781.903400.xxx (lungs)
EPC Location Identifier (ANZCO, Kokiri) - urn:epc:id:sgln:942900.004918.xxx
RFID Reader Utilised - Tracient Padl (handheld)

<table>
<tr><td>EPCIS:</td><td>Event</td><td>ObjectEvent</td></tr>
<tr><td></td><td>Action</td><td>ADD</td></tr>
<tr><td></td><td>BizStep</td><td>urn:epcglobal:cbv:bizstep: commissioning</td></tr>
<tr><td></td><td>Disposition</td><td>urn:epcglobal:cbv:active</td></tr>
<tr><td></td><td>ReadPoint</td><td>urn:epc:id:sgln:942900.004918.OFFAL_ROOM</td></tr>
<tr><td></td><td>BizLocation</td><td>urn:epc:id:sgln:942900.004918.FREEZER</td></tr>
</table>

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

Loading cartons into shipping container at Kokiri

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Item Identifier (Cartons) - sGTIN per carton label range:
urn:epc:id:sgtin:9419781.903208.xxx (tails)
urn:epc:id:sgtin:9419781.903210.xxx (tripe)
urn:epc:id:sgtin:9419781.903400.xxx (lungs)
EPC Location Identifier (ANZCO, Kokiri) - urn:epc:id:sgln:942900.004918.xxx
RFID Reader Utilised - Impinj Speedway R420 (fixed)

<table>
<tr><td>EPCIS:</td><td>Event</td><td>AggregationEvent</td></tr>
<tr><td></td><td>Action</td><td>ADD</td></tr>
<tr><td></td><td>BizStep</td><td>urn:epcglobal:cbv:bizstep:loading</td></tr>
<tr><td></td><td>Disposition</td><td>urn:epcglobal:cbv:disp:in_progress</td></tr>
<tr><td></td><td>ReadPoint</td><td>urn:epc:id:sgln:942900.004918.LOADING_DOCK</td></tr>
<tr><td></td><td>BizLocation</td><td>urn:epc:id:sgln:942900.004918.CONTAINER_ON_SITE</td></tr>
</table>

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

3

Shipping container leaving Kokiri

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (ANZCO, Kokiri) - urn:epc:id:sgln:942900.004918.xxx
RFID Reader Utilised - None

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:departing
	Disposition	urn:epcglobal:cbv:disp:in_transit
	ReadPoint	urn:epc:id:sgln:942900.004918.SIDING
	BizLocation	N/A

4

Shipping container arriving at rail yard, Christchurch, New Zealand

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Christchurch Rail Yard) - urn:epc:id:sgln:942900.011439.xxx
RFID Reader Utilised - None

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:arriving
	Disposition	urn:epcglobal:in_progress
	ReadPoint	urn:epc:id:sgln:942900.011439.OFF_TRAIN
	BizLocation	urn:epc:id:sgln:942900.011439.CONTAINER_YARD

5

Shipping container leaving rail yard, Christchurch, New Zealand

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Christchurch Rail Yard) - urn:epc:id:sgln:942900.011439.xxx
RFID Reader Utilised - Tracient Padl (handheld)

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:departing
	Disposition	urn:epcglobal:cbv:disp:in_transit
	ReadPoint	urn:epc:id:sgln:942900.011439.ON_TRAIN
	BizLocation	N/A

6

Shipping container arriving at Port of Lyttleton, Christchurch, New Zealand

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Lyttleton Port) - urn:epc:id:sgln:942900.009778.xxx
RFID Reader Utilised - Tracient Padl (handheld)

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:arriving
	Disposition	urn:epcglobal:in_progress
	ReadPoint	urn:epc:id:sgln:942900.009778.OFF_TRAIN
	BizLocation	urn:epc:id:sgln:942900.009778.CONTAINER_YARD

7

Shipping container leaving Port of Lyttleton, Christchurch, New Zealand

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Lyttleton Port) - urn:epc:id:sgln:942900.009778.xxx
RFID Reader Utilised - None

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:shipping
	Disposition	urn:epcglobal:cbv:disp:in_transit
	ReadPoint	urn:epc:id:sgln:942900.009778.ON_VESSEL
	BizLocation	N/A

8

Shipping container arrives at Port Klang, Malaysia

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Malaysian Port) - urn:epc:id:sgln:955669.900233.xxxx
RFID Reader Utilised – None

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:arriving
	Disposition	urn:epcglobal:cbv:disp:in_progress
	ReadPoint	urn:epc:id:sgln:955669. 900233.ON_DOCK
	BizLocation	urn:epc:id:sgln:955669.900233.NORTH_PORT

9

Shipping container departing from Port Klang, Malaysia

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Location Identifier (Malaysian Port) - urn:epc:id:sgln:955669.900233.xxxx
RFID Reader Utilised - AIAI

EPCIS:	Event	ObjectEvent
	Action	OBSERVE
	BizStep	urn:epcglobal:cbv:bizstep:departing
	Disposition	urn:epcglobal:cbv:disp:in_transit
	ReadPoint	urn:epc:id:sgln:955669.900233.DOCK_DOOR
	BizLocation	N/A

10

Cartons of meat receipted on arrival at Agribiz, Subang Jaya, Malaysia

EPC Item Identifier (Shipping Container) - urn:epc:id:giai:94290000.422050
EPC Item Identifier (Cartons) - sGTIN per carton label range
urn:epc:id:sgtin:9419781.903208.xxx (tails)
urn:epc:id:sgtin:9419781.903210.xxx (tripe)
urn:epc:id:sgtin:9419781.903400.xxx (lungs)
EPC Location Identifier (Agribiz) - urn:epc:id:sgln:955669.900157.xxxx
RFID Reader Utilised - AIAI

EPCIS:	Event	AggregationEvent
	Action	DELETE
	BizStep	urn:epcglobal:cbv:bizstep:receiving
	Disposition	urn:epcglobal:cbv:disp:in_progress
	ReadPoint	urn:epc:id:sgln:955669.900157.ENTRY_GATE
	BizLocation	N/A

11

Cartons of meat stored in Agribiz Cold Storage Facility, Subang Jaya, Malaysia

EPC Item Identifier (Cartons) - sGTIN per carton label range
urn:epc:id:sgtin:9419781.903208.xxx (tails)
urn:epc:id:sgtin:9419781.903210.xxx (tripe)
urn:epc:id:sgtin:9419781.903400.xxx (lungs)
EPC Location Identifier (Agribiz Receiving Dock) - urn:epc:id:sgln:955669.900157.xxxx
RFID Reader Utilised – AIAI

EPCIS:	Event	ObjectEvent
	Action	DELETE
	BizStep	urn:epcglobal:cbv:bizstep:storing
	Disposition	urn:epcglobal:cbv:disp:sellable_accessible
	ReadPoint	urn:epc:id:sgln:955669.900157.IN_STORE
	BizLocation	urn:epc:id:sgln:955669.900157.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 (i.e. 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.

- **The EPCglobal Architecture Framework** 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 Architecture Framework 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 (framework) is the Electronic Product Code (EPC) of each product which is stored on an RFID tag. The framework provide for the management of dynamic information that is specific to variable for individual products. This includes data regarding the movement of an object throughout the product life cycle.

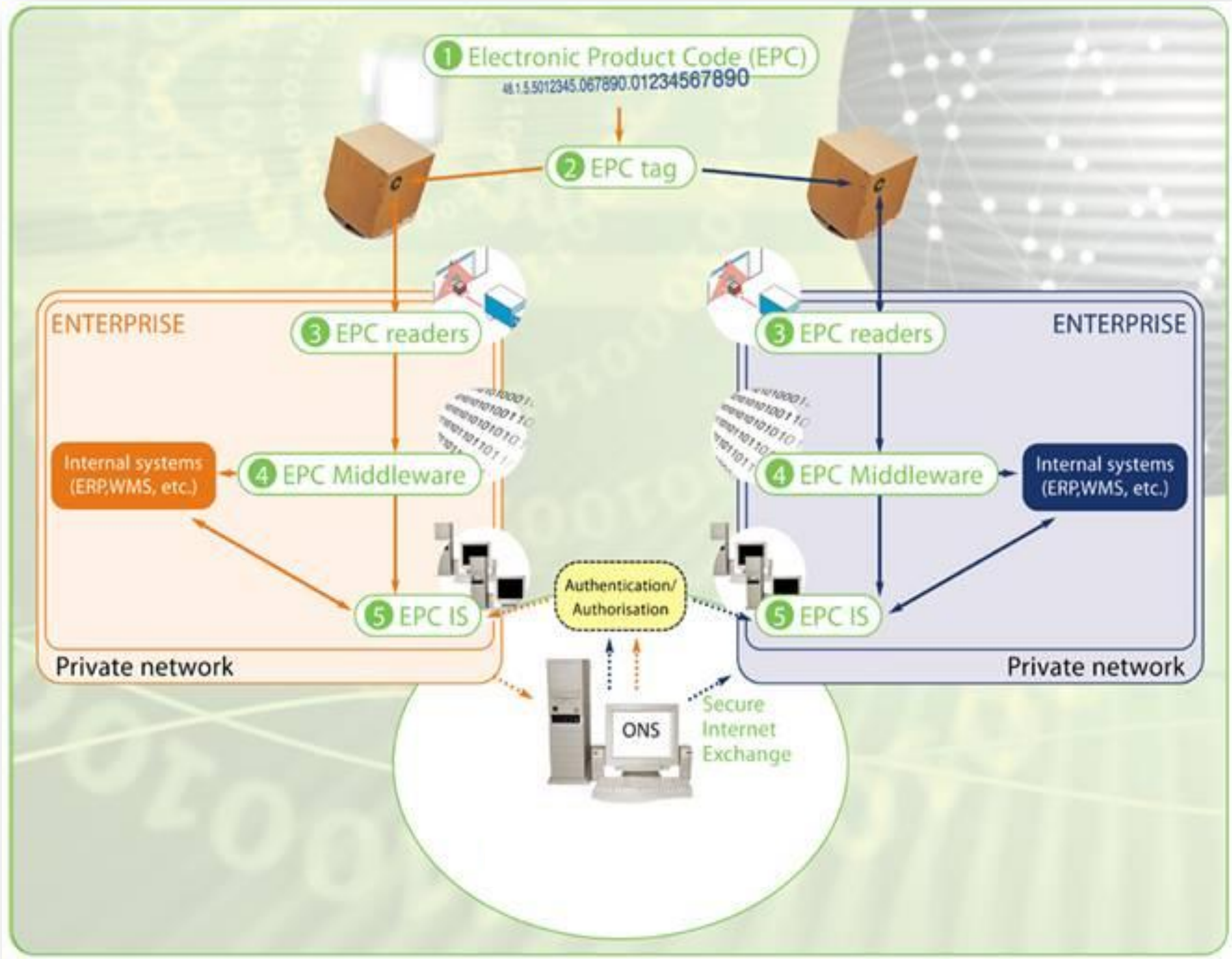
- **The Object Name Service** (ONS) is a service that enables the discovery of object information on the basis of an EPC. With the Electronic Product Code a matched URL or IP-address is searched within a data base and sent back to the requester when found. Under the URL further information about the 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.

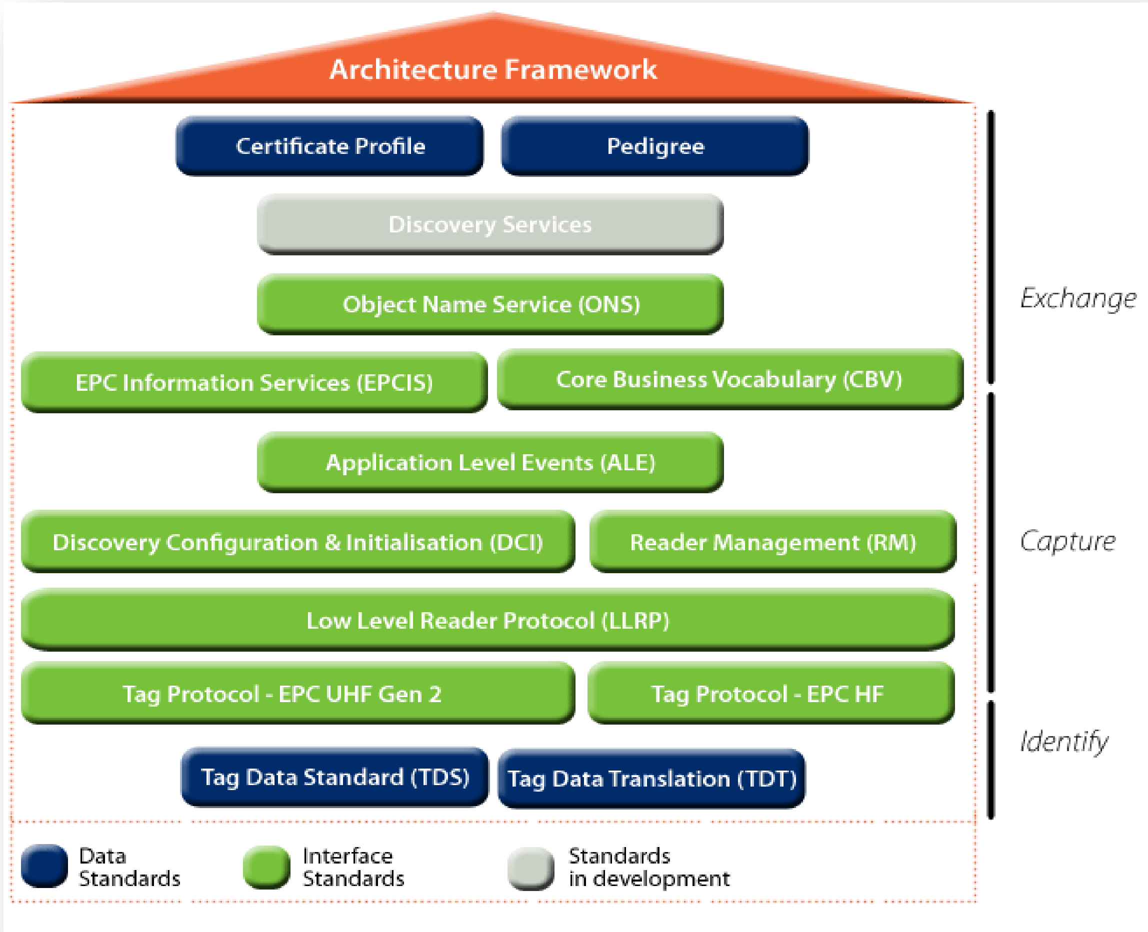
- **Serialised Global Trade Item Number (sGTIN)** is designed as a universal identifier that provides a unique identity for every physical object anywhere in the world, for all time. Its structure is defined in the EPCglobal Tag Data Standard. However, the Global Trade Item Number (*GTIN*) only identifies 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.

- **Global Returnable Asset Identifier** (GRAI) is one of two GS1 Keys for asset identification. This GS1 Key is especially suitable for the management of reusable transport items, transport equipment, and tools and can identify these returnable assets by type and if needed also individually for tracking and sorting purposes. The GRAI can be encoded in a bar code or EPC/RFID tag that can be scanned to automatically register the returnable asset’s movements, for example, when used to ship goods or when returned empty.



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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