Austroads

Research Report
AP-R538-17

Investigating the Potential Benefits of Enhanced End to End Supply Chain Visibility

Investigating the Potential Benefits of Enhanced End to End Supply Chain Visibility

Prepared by

Rose Elphick-Darling, Dr Don Gunasekera, Dr Aida Ghalebeigi

Project Manager

Julian Breheny

Publisher

Austroads Ltd.
Level 9, 287 Elizabeth Street
Sydney NSW 2000 Australia
Phone: +61 2 8265 3300
austroads@austroads.com.au
www.austroads.com.au

Abstract

This report examines the benefits of using end-to-end supply chain visibility technologies and considers issues relating to leadership and practical adoption of the technology.

The project was undertaken with the Australian Logistics Council (ALC) Supply Chain Standards Working Group and GS1 Australia. Pilot studies with TOLL, Arrium OneSteel and Nestlé assessed the impact of adoption of the technology based on GS1 global data standards (GDS).

Adoption of these technologies and common identifiers for goods, transport equipment, places and events, allow activities in the supply chain to be viewed from supplier to customer, including: freight transport assets; pick up storage and delivery locations; and events occurring throughout shipment such as traffic congestion, accidents, or other delays.

The pilots measured benefits of efficiency, integrity, visibility and innovation. Costs were assessed across the variables of preparation, development and implementation.

The pilots show that the benefits are not evenly dispersed across the supply chain network. Costs and added complexity for small transport suppliers countervail benefits in the short term, where bespoke legacy systems are involved. Larger transport suppliers experienced immediate and significant benefits with enhanced business processes and dynamic capabilities, including innovation, already apparent.

The benefits to Australian manufacturers, producers and traders justify an industry-based Supply Chain Visibility Strategy to promulgate adoption. Governments, the standards body and industry peak bodies will need to work together to execute the strategy which is paced to take into consideration the needs of the fragmented freight transport industry.

About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Australian Government Department of Infrastructure and Regional Development
- Australian Local Government Association
- New Zealand Transport Agency.

ISBN 978-1-925451-58-0

Austroads Project No. FS2000

Austroads Publication No. AP-R538-17

Publication date March 2017

Pages 41

Keywords

Supply chain visibility; traceability, GS1, electronic product code information service, transport instruction, transport status, Australian standard transport labelling, transport and logistics, electronic data interchange, global data standards

Key Points

- The Intermodal Visibility pilots implemented the use of global data standards to identify and share information on freight, transport equipment and events along supply chains where the freight has changed mode and custody.
- The pilots confirmed that data standards are a necessary pre-cursor to the creation of visibility in supply chains.
- The pilots demonstrated benefits in terms of efficiency, integrity, visibility and innovation in the supply chain pilots assessed in this report.
- Transport and logistics service providers exhibited a propensity to highly competitive business behaviours with data sharing limited to “one up-one down” parties in the chain and use of highly customised IT systems that militate against integration with other systems and automated messaging formats. In order to contend with customers’ demands for visibility, these companies have developed bespoke customer portals to enable tracking of consignments. The inherent difficulty with this solution is the loss of visibility once the freight changes custody.
- Transport and logistics service suppliers were found to have adopted the standards to deliver visibility for both suppliers/manufacturers and end customers (in this case retailers) to comply with customer requirements rather than perceiving any dynamic capability or value gains for their business. In fact, they generally saw adoption of data standards and subsequent system integration as a cost of doing business.
- However, the pilots indicated that the dynamic capabilities of the logistics service providers were enhanced through improved planning, reduced turnaround times at delivery and pick up points and reduced delivery in full on time failures.
- The Transport and Logistics industry is dominated by small businesses with limited capability to deliver visibility in a cost–effective way. Without an industry-wide change management program, smaller businesses are vulnerable to being excluded from contracts where this capability is specified.
- Participation in digital business will be stymied if smaller logistics service providers are not capable of providing visibility of supply chain events in a cost-effective way. SMEs require a specific demonstration of business value and suitable generic solutions to be available.
- Based on the pilot findings, the productivity “penalty” extrapolated for SMEs in the T&L sector due to inability to integrate incompatible formats is estimated at $1.63 billion; whereas the cost to integrate to a common standard is estimated at one quarter of that figure, or $407.5 million, to deliver tangible benefit to the Australian economy.
- Industry promulgation of adoption of data standards will be best achieved through a focused industry level strategy, a Supply Chain Visibility Strategy, led by customers and major logistics service providers, as opposed to mandatory introduction through government regulation.

Glossary of Terms

Term	Definition
ALC	Australian Logistics Council. A peak national body representing the major and national companies in the Australian freight transport and logistics supply chain. www.austlogistics.com.au
ASN	Advanced Shipping Notice is an electronic document that provides advanced notification with detailed information about a pending delivery. The purpose of an ASN is to notify the customer when shipping occurs and provide physical characteristics about the shipment so the customer can be prepared to accept delivery.
B2B	Electronic commerce using business to business transactions
DC	Distribution Centre. This is a warehouse stocked with products for redistribution to retailers, wholesalers or direct to customers. It may be owned or operated by a retailer or a third party logistics supplier.
DIFOT	Delivery in full on time is a common measure of performance in supply chain
EPCIS	Electronic Product Code Information Services is a standard developed by GS1 to capture and report event based traceability data. EPCIS helps capture visibility event data along the supply chain, including details about physical or digital activity in the supply chain of products and other assets, identified by keys, detailing where the objects are in time, and why; not just within an organisation, but across organisations.
EDI	Electronic Data Interchange is the transfer of data from one computer system to another by standardized message formatting, without the need for human intervention. EDI permits multiple firms -- possibly in different countries -- to exchange documents electronically.
ERP	Enterprise Resource Planning is a category of business-management software—typically a suite of integrated applications—that an organisation can use to collect, store, manage and interpret data from many business activities, including: product planning, cost, manufacturing or service delivery, marketing and sales.
ETA	Estimated time of arrival
FMCG	Fast moving consumer goods
GDP	Gross Domestic Product, representing the economic activity generated by a population.
GDS	Global Data Standards
GLN	Global Location Number is a GS1 identification key to uniquely identify physical locations and entities from supplier sites to customer premises. It can reference master data to a location, for example special instructions, access restrictions etc.
GPS	Global Positioning System
GS1Australia	Global Standards, or GS1, is a neutral, not-for-profit, international organisation that develops and maintains open, global standards for supply and demand chains across multiple sectors. www.gs1au.org
GSIN	Global Shipment Identification Number (GSIN) is a GS1 identification number assigned by a seller and shipper of goods to identify a shipment comprised of one or more logistic units that are intended to be delivered together.
GTIN	Global Trade Item Number is a GS1 identification key used to globally identify tradeable items.
ICT	Information and Communications Technology
LSP	Logistics Service Provider
ONS	GS1's Object Name Service (ONS) is a lookup service which uses the Internet's existing Domain Name System (DNS) to resolve information about a GS1 Identification Key. ONS takes a GS1 Key as input, and returns as output the URL of an EPCIS service (or other service) designated by issuer of the GS1 Key in question.
POD	Proof of Delivery. This document, often contained in a hand-held device, is signed by the consignee/recipient of the goods, confirming delivery of a shipment in good condition. The transport/carrier records the name of the person who signed for the shipment, the time and date of delivery and information pertaining to the goods.

Term	Definition
RFID	Radio Frequency Identification is a means of storing and retrieving data through electromagnetic transmission to an RF compatible integrated circuit. The technology uses small radio transponders, called "tags," that are attached to the objects being tracked. The tags communicate with a reader (or antenna) when a tag is within range of the reader. The reader then passes information about the object to a host computer that processes the information and, in turn, passes the information over internal networks and the internet. Thus, as the tagged objects move in the supply chain, the movements can become visible through a web-interface. The tags can be programmed to hold a substantial amount of information describing the contents of the container, its shipment origin, destination, etc. They can also be used to detect tampering or other security breaches (see Johnson 2007). RFID tags can be passive, requiring an RFID reader; or active, with the tag able to independently transmit.
SAP	SAP SE is a German multinational software corporation that makes enterprise software to manage business operations and customer relations.
SSCC	Serial Shipping Container Code. The Serial Shipping Container Code is the GS1 identification key used by firms to identify a logistic unit, which can be any combination of trade items packaged together for storage and/ or transport purposes; for example a case, pallet or parcel.
SKU	Stock keeping unit. In the field of inventory management, a stock keeping unit or SKU refers to a specific item stored to a specific location. The SKU is intended as the most disaggregated level when dealing with inventory. All units stored in the same SKU are supposed to be indistinguishable.
SME	Small and medium sized enterprise. A small enterprise typically would employ fewer than 20 employees and a medium sized enterprise would employ fewer than 200 employees. Turnovers are typically below $10 million and $50 million respectively.
TMS	Transport Management System
T&L	Transport and Logistics
WMS	Warehouse Management System
3PL	3rd Party Logistics refers to a firm that provides outsourced logistics (and supply chain) services to shippers/suppliers.

Supply chain visibility is generally defined as 'the awareness of, and control over, specific information related to product orders and physical shipments, including transport and logistics activities, and the statuses of events and milestones that occur prior to, and in-transit'[1].

Traceability is defined by the International Standards Organisation (ISO) as 'the ability to identify and trace the history, distribution, location, and application of products, parts, and materials'[2].

GS1 Global Data Standards (GDS) applied in these industry pilots relate to standardisation and automation of identification and messaging between participants through creating the ability to identify, capture and share data.

GS1 Australia, the standards provider and project manager on each pilot, utilised the following standards:

- EPCIS – to enable disparate applications to create and share event based traceability data, both within and across enterprises on the physical movement of goods or objects
- Transport labelling - a "license plate" known as a Serial Shipping Container Code (SSCC) for common identification of the freight unit and transport assets used to handle the goods
- EDI Transport Instruction – used to communicate and share the arrangements (through the agreed conditions) of the movement of the goods (including collection and delivery) between transport service buyers and transport service providers involved and providing the information necessary to perform the handling the movement of the goods
- EDI Transport Status Notification – used to provide update information on the status and movements of a transport related object or activity e.g. "arrived at gate".

1 Aberdeen Group Report, May 2013
2 Praxiom Research Group Limited (2013), ISO Definition Traceability, http://www.praxiom.com/iso-definition.htm#Traceability.

Summary

The lack of supply chain visibility across transport modes continues to generate inefficiencies and costs to freight owners and end users/customers alike. While investments in platforms to enable tracking and real-time visibility are being made available by individual logistics suppliers, changes in product custody or transport modes commonly result in loss of visibility, as interfaces are unable to operate to a common communication standard. Based on the pilot findings, the productivity "penalty" extrapolated for SMEs in the sector due to inability to integrate incompatible formats is estimated at $1.63 billion; whereas the cost to integrate to a common standard is estimated at one quarter of that figure, or $407.5 million, to deliver tangible benefit to the Australian economy.

The purpose of this project was to assess the impact of using end to end supply chain visibility technology in real time industry pilots. In particular, the project aimed to quantify the benefits of improving multi-modal supply chain efficiencies through improved tracking, assess whether such benefits will be achieved through adopting a national end to end supply chain visibility technology standard, recommend how an enhanced end to end supply chain visibility standard could be implemented, determine what issues exist with practical implementation of visibility technology and how they can be addressed and assess who should assume a leadership role, to encourage the widespread adoption of such technology.

The project was undertaken in conjunction with the Australian Logistics Council (ALC) Supply Chain Standards Working Group and GS1 Australia. Case studies involving TOLL, Arrium OneSteel and Nestlé were undertaken to assess the impact of adoption of end to end visibility technology based on GS1 global data standards (GDS).

The approach used in this project involved: collating and analysing qualitative and quantitative information prior to implementation of the pilot, collating and analysing qualitative and quantitative information for the new process (i.e. with the use of GDS) and assessing the benefits across transport modes and transport and logistics providers of applying new standards (i.e. the GDS).

Benefits are evident from the introduction of through-chain visibility. Those benefits include:

- **Efficiency:** reduced delivery failures through errors associated with manual processes, ability to understand costs associated with the transport task, improved time elapsed to investigate delivery in full on time (DIFOT) failures, improved terminal turnaround times, improved planning and scheduling of transport and speedier invoice verification.
- **Integrity:** introduction of event-based data; automation of freight reconciliation at loading/unloading sites; accurate and new reports generated from new data enabling the introduction of decision matrices and diagnostic procedures.
- **Visibility:** significant improvement in visibility of product while in transit or storage, customer visibility now enabled through a unified data capabilities, sharing of data facilitating reduced administrative burden, creation of a common event data pool/s for administrative and supply chain management purposes.
- **Innovation:** new reports driven by availability of new data, new applications being developed to support business processes and compliance.

It is evident from the industry case studies that the transport and logistics suppliers were delivering benefit to shippers through aligning their data formats to be compliant with GDS so they can interface more effectively and automate messages.

The transport operators have reported added complexity and cost to achieve this in the first instance. Customer service and contract retention are the motivators, however firm-level benefits have been realised in the pilots by larger operators. It is anticipated that the cost and complexity of integration will reduce with subsequent implementations and as adoption matures.

The pilots have also found that many transport suppliers are often not geared to reap the benefits as they commonly retain manual or non-compliant bespoke ERP systems and legacy business processes. Therefore, the data that creates the visibility capacity is creating business value for the customer with no immediate business value for the supplier to grasp in order to offset the costs. Without scale and size the transport operator's enterprise systems are generally unable to share in the automated data available.

As the pressure to automate messaging and participate in digital business grows, transport and logistics suppliers will find these bespoke platforms and systems are inadequate. At the transport and logistics industry level, use of the standards has been so limited in uptake that repositories and protocols that would support this sector using the visibility standards, such as global location numbers and data sharing protocols, have not been developed to the level of sectors such as grocery, pharmaceuticals or healthcare in Australia. As the standards body is a member-driven organisation, it reflects low demand for investment from the T&L sector members.

In order to facilitate the adoption of GDS standards in Australian supply chains, government, the standards body and industry peak bodies will need to work together to execute a Supply Chain Visibility Strategy which is paced to take into consideration the needs of the fragmented freight transport industry. The strategy will need to be multi-pronged, consisting of two main streams: the first, focused on customer and major logistics company leadership and the second on inculcating the capacity within SMEs in the sector.

Government can play its role by requiring GDS-compliant data upload for regulatory compliance and policy and budgetary support for the initiatives deployed by peak industry bodies and GS1, the standards provider.

It is not recommended that at this stage the adoption of GDS to create supply chain visibility should be mandated, although this is currently the case in the health care and pharmaceuticals sector. As a minimum, a common identifier for products and assets such as vehicles, pallets or containers, should be introduced, to support adoption of visibility standards.

As applications emerge that demonstrate business value for the transport and storage suppliers, it is likely that these businesses will be more interested in adoption. Government and peak industry bodies could consider supporting adoption through providing smaller businesses with use cases, best practice examples, "how to" guides and by educating business owners to support this.

The adoption of open source standards means that GS1-certified suppliers can support smaller companies and avoid proprietary legacy system interface costs, allowing them to transmit data to and from multiple customers without impacting their own ERP. SMEs without legacy systems have the opportunity to leapfrog capabilities of larger suppliers bound by these systems.

Contents

Tables

Figures

1. Introduction

1.1 Recognising the Importance of Standards

Since the introduction of the motor vehicle in Australia in the first decade of the 20th Century, governments recognised the need to establish standards for vehicle registration and issuance of number plates, to provide a unique identifier for each vehicle. Since the introduction of a standardised vehicle number plate for trucks and passenger vehicles, these standards have evolved towards global harmonisation with UNECE World Forum for Harmonization of Vehicle Regulations (WP.29). Vehicle number plate standards are an essential format for systems that manage vehicle registration, compliance and enforcement activities, and vehicle financing. Without this standard, many transactions in our economy would be compromised.

Standardisation of supply chain data is analogous: without a unique number plate for freight moving from supplier through intermediaries to the customer in a standardised format, it is difficult to transmit reliable information between parties. The GS1 organisation was formed as a not-for-profit body to create and manage standards for supply chain data on a global basis. The standards identify what, who, where, when and why of freight.

In industries where error can impact the health and survival of consumers, such as healthcare, pharmaceutical and food products, the need for common standards for product identification and traceability from suppliers to consumers has led to the formation of supply chain data standards. The physical movement of goods takes place in a network of information exchange, commercial and operational transactions enabled by data.

The transport and logistics industry, as a service provider to freight owners, has not been actively engaged in developing or utilising data standards related to its own activities. The impetus in adopting global data standards has come mostly from customers, as a requirement associated with product quality assurance or inventory management.

For many transport and logistics companies, use of proprietary systems and bespoke data formats are the norm. These systems were built to support optimisation of enterprise activities or to integrate with a major customer. They are not always capable of sharing data with additional parties without re-formatting of the data and re-configuration of the data exchange interfaces with new partners, limiting real time data and visibility of the freight as it changes custody.

The transport and logistics sector is now experiencing pressure to enable additional parties to communicate and access data. This trend is expected to grow and transport and logistics suppliers who are unable to deliver this capability may be excluded as service providers. Given the proliferation of small businesses in this industry, this represents a significant challenge to the sector.

Recognising this trend, this study investigates the impact of adopting global data standards for increased visibility, whether there are apparent benefits to the transport and logistics sector and how a sector dominated by small players might best respond.

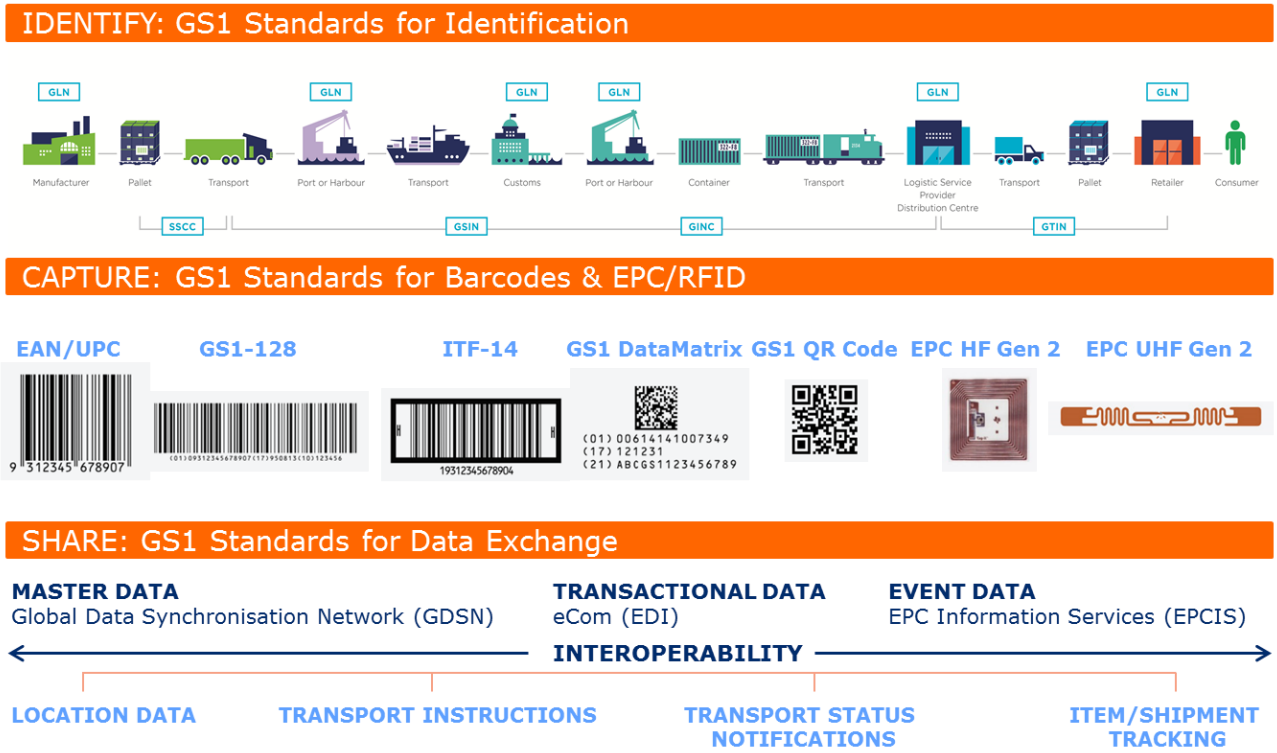
1.2 Achieving Visibility Across Modes in a Supply Chain

It is recognised that GDS enable visibility and traceability of products, parts and materials in supply chain networks in an effective and efficient manner. Increasingly GDS-enabled traceability systems record and follow the trail as products, parts, and materials come from a range of suppliers and are processed and ultimately distributed as end products to various consumers/users. Such traceability systems provide information on the components of products, parts, and materials as well as information on transformations throughout the supply chain. GDS ensures the accuracy of this information, such as product quality, safety and labelling (see United Nations Global Compact and BSR, 2014).

Transport assets such as vehicles, containers or pallets can be tracked and associated with the freight occupying the asset, the location and the current operational status. Multiple attributes such as weight, temperature and inspection data can be associated with the vehicle, container, pallet, as well as to the individual items of freight, providing assurance for customers.

Figure 1.1 details the application of the standards to achieve visibility in supply chains across transport modes and freight custody.

Figure 1.1: GS1 Supply Chain Visibility Model



Source: GS1 Australia 2016

A recent 'proof of concept' study of the application of GS1 Electronic Product Code Information Services (EPCIS) standards in Australia has shown that there are potential benefits of having a common standard for 'event' reporting among supply chain partners.[3] The study highlighted the need for an industry-wide approach to adoption of agreed standards to provide enhanced visibility along supply chains.

3 Good, L., Gahan, P., Butar, I., Dehghan, S. (2015) Leading technological innovation and productivity improvement across the supply chain: An evaluation of the industry pilot or the GS1 EPCIS Standard, Melbourne Centre for Workplace leadership, University of Melbourne.

Use of the standards provides a globally unique identification for all products, business locations, assets and traders, enabling automatic interoperability and exchange of relevant information to create visibility of events in real time in the supply chain. The standards provide a framework of coding and data sharing systems to enable this. Used in conjunction with automated messaging, this improves the ability to track and trace products from source to destination in real time within the supply chain network, providing the participants with a unified "reality" for the shipment.

1.3 What is Driving the Need for Supply Chain Visibility?

According to the Australian Bureau of Infrastructure Transport and Regional Economics, growth in Australia's freight task is projected to continue over the next two decades with total domestic freight projected to grow 80 per cent, between 2010 and 2030.[4] A growing task and tapering productivity across Australian industries indicates a need to accelerate any cost reductions and efficiencies available, in order to remain competitive.

Regulatory compliance motivates not only transport suppliers but also shippers and customers. The manufacturers and retailers involved in this project were acutely aware of their responsibilities and were signatories to the ALC Retail Logistics Code of Conduct (2011) and National Logistics Code of Practice (2011) which cover scheduling and transit times, time slot management, safe loading practices including mass, dimension and load restraint, driver fatigue management including driver health and fitness for duty, speed compliance and vehicle safety. The companies are aware that improvements to visibility and traceability will support assurance systems and compliance in relation to transport regulation.

Key factors influencing demand for increased visibility and traceability in supply chains in Australia include:

- **Productivity:** cost reduction and optimisation of network investment
- **Customer demand:** more intensive control and management
- **Complexity of supply chain networks:** global reach, more suppliers and more collaboration
- **Growth of the task:** doubling of volumes and higher granularity of freight
- **Risk management:** corporate governance and compliance
- **Digital transformation:** Internet of Things, B2B (digital business-to-business trade) capability.

Increasingly numerous entities are participating in the transport of goods between sellers and buyers. Global sourcing and off-shore fabrication further extend this complexity to new time zones and production environments. Supply chains are also deeper, with dependency on a growing number of specialised suppliers inputting to production elements.

Use of IT enables firms to share information across their supply chain by linking electronic applications. However, it has been shown that fragmented and isolated IT applications can result in data inconsistency, and as a consequence weakening the firm's responsiveness and customer satisfaction (Malhotra, Gosain and Sawy 2007; Rai, Patnayakuni and Seth 2006; Wong, CW 2013). The literature supports the idea that supply chain integration can be achieved through electronic linkages to promote accurate, timely and standardised data sharing process across the chain (Bernstein and Haas 2008; Grover and Saeed 2007; Truman 2000).

Supply chain visibility is no longer regarded as an 'option' but rather an all-important necessity and a critical success factor in high performing and globalised supply chains.

SMEs are inevitably adopting web services and IT management systems in order to remain as the large companies' suppliers in the chain (Webb and Schlemmer 2008). These developments have become a necessity to SMEs because "real time collaboration is a key element of agile manufacturing strategies as it can lead to significant strategic and operational benefits for all business partners" (Murtaza and Shah 2004).

4 BITRE, Freightline 1, 2014.

The wider use of GDS is likely to have potential beneficial impacts on the stakeholders including producers and manufacturers, their input and service suppliers (including transport and logistics), wholesalers, retailers and consumers of tradable goods.

1.4 Objectives of the Project

Given this background, the project aimed to investigate the impact of using enhanced end to end supply chain visibility technology in a real time industry setting. More specifically the objectives of the project were to:

- quantify the benefits of improving multi-modal supply chain efficiencies through improved tracking and associated supply chain initiatives
- assess whether such benefits will be achieved through adopting a national end to end supply chain visibility technology standard
- recommend how an enhanced end to end supply chain visibility standard could be implemented
- determine what issues exist with practical implementation of end to end supply chain visibility technology and how they can be addressed, with particular interest in the cost such technology will incur on smaller transport and logistics companies and concerns around data security
- assess who should assume a leadership role, to encourage the widespread adoption of such technology if benefits exist.

This project was undertaken in conjunction with the Australian Logistics Council (ALC), managed through the ALC Technology Committee. The ALC Technology Committee's Supply Chain Standards Working Group (the Working Group) coordinated the work program around the implementation of the industry pilots. The Working Group (comprised of approximately 20 peak transport and logistics industry organisations) is currently supporting industry pilots and implementation of B2B trading; transport labelling; transport instruction and intermodal interoperability. This project complements studies undertaken to date by the Working Group.

The project was funded by Austroads. Austroads is a forum for Australian and New Zealand road agencies to work together to achieve common objectives and promote harmonisation and consistency in their operations. A Project Reference Group was established by Austroads consisting of representatives from all jurisdictions. Project management was undertaken by the Surface Transport Policy Division of the Commonwealth Department of Infrastructure and Regional Development.

2. Methodological Framework

2.1 IT and Business Value

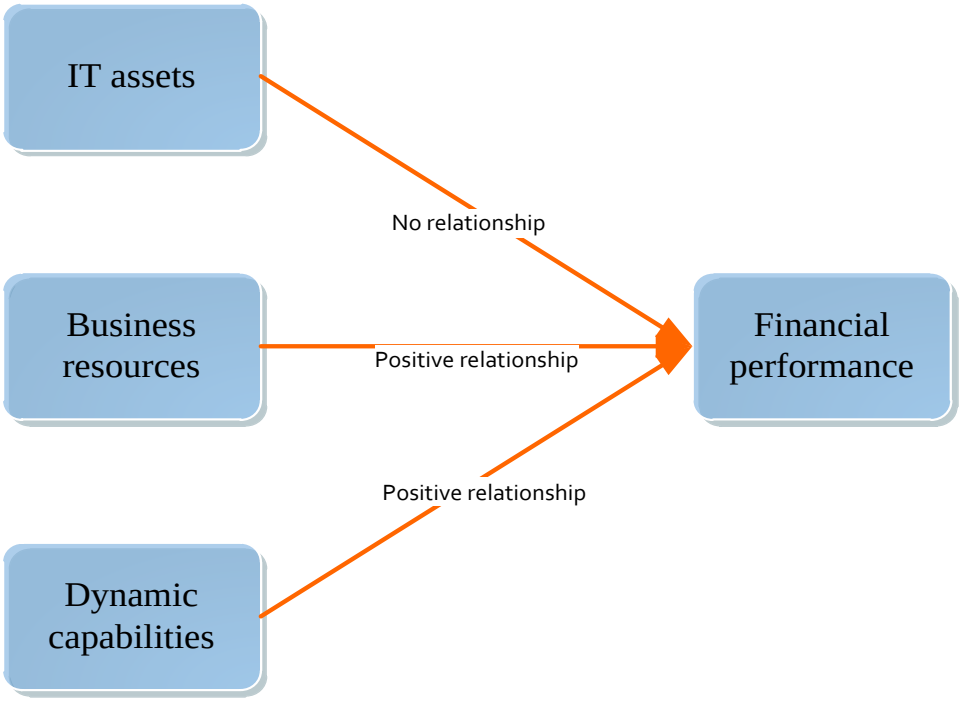
An initial assumption was that, like rail gauge variations generated to create competitive advantage for individual jurisdictions in Australia, inefficiency has been generated by inconsistent messaging formats and lack of interoperability of IT systems within each supply chain network.

The analytical approach in this project relates to the Business Management theories of business value creation from the combination of IT assets[5], business resources[6] and dynamic capabilities[7] in the business (Webb and Schlemmer 2008 see Figure 2.1).

Proving a direct relationship between business performance and information technology is difficult (Bardhan, Krishnan, Lin 2004). Models to measure the impact of data management are limited. IT and data management tends to be viewed as an endogenous factor in firm production, and increasingly generic in nature. Analysis of the impact on firm productivity is largely focused on project-specific models and studies, which are linked with direct deliverables in the business, creating outcomes such as on-time delivery.

Zhu and Kraemer (2002) make the point that the real business value is not in the IT/data/standards themselves; it is in the competitive value created by relevant organisational routines to leverage the IT assets. “IT doesn’t matter – business processes do” (Smith and Finger 2003).

Figure 2.1: Relationship of IT assets to Firm Financial Performance



Source: Webb and Schlemmer 2008

5 IT assets include IT knowledge; IT operations; IT objects
6 Business resources include relationships with customers and suppliers; externally-driven e-business; benchmarking; strategic use of internet and web-based applications; financial resources
7 Dynamic capabilities include product development; alliancing; strategic decision-making

Despite the difficulty in establishing a direct relationship between IT applications and firm performance, several researchers have been able to identify specific business value from IT applications that integrate across businesses in a supply chain network.

Application of IT-enabled transport logistics in trading firms resulted in improvement of cost performance (Wong, CWY, Lai and Teo 2009). Tongzon, Chang and Lee (2009) calculated a reduction of turnaround times for ships after applying data management systems which resulted in lower freight rates for the shipper. The firm was able to invest in IT applications to offer higher quality service to its customers. The IT application either directly or indirectly resulted in more revenues, lower administration costs, better asset utilisation at a lower cost and more customer satisfaction (Tongzon, Chang and Lee 2009).

Tseng and Liao (2015) tested the hypothesis of a correlation between IT and firm performance within SMEs in container shipping agencies. They found that, while IT investment may have short term negative effect on firm performance, over the longer term there was found to be a significant relationship between IT and firm performance.

IT application has also been shown to deliver significant benefits in container flow management and supply chain integration (Lun et al. 2008; Tseng & Liao 2015).

In the research the effectiveness of the IT assets to deliver supply chain visibility was taken into account, as well as the impacts on business resources and dynamic capabilities of the firms.

The broad categories of benefits associated with the use of the data standards in terms of efficiency, integrity, visibility and innovation are as follows:

- **Efficiency:** The benefits associated with efficiency of supply chains are generated by eliminating unnecessary transactions, and enabling better informed and more accurate risk assessments. Efficiency is broadly defined around standard Delivery in Full on Time (DIFOT) measures and focused on time and cost savings.
- **Integrity:** This relates to the integrity of data being used to drive business decisions as well as the use of GDS in verifying the integrity of a product throughout the supply chain. Integrity is defined around protection of product authenticity, management of defined risks and product quality, and data integrity.
- **Visibility:** GDS can increase the visibility and transparency of supply chain processes. Here, visibility is defined around improved planning and management of variables within the supply chain.
- **Innovation:** GDS can provide a platform for innovation by enabling new ways to utilise information through ‘smart’ supply chain processes. Innovation here reflects the ability to create new value from the use of data analytics and to utilise supply chain visibility to lift customer service.

The categories of costs associated with the use of GDS relate to:

- **Preparation:** Collating and cleaning up master data eg. Pick up and delivery locations; Understanding the standards and new data formats.
- **Development:** Developing messages for EPCIS/EDI transport instruction and transport status and stored procedures, writing queries, populating existing customer portals or pilot portal/repository.
- **Implementation:** Staff training; creating interfaces between proprietary systems such as supplier ERP, transport firm transport management system (TMS), 3PL distribution manager Warehouse Management System (WMS), shipping line portal, port community system, freight forwarder’s system and customer’s ERP.

Estimates of costs were based on an average of AU$100 per hour expended on each activity, which represents a median cost between outsourced consultants used by some companies and internal staff resources used by others. Costs did not include hardware purchases, as it is assumed that companies adopting global data standards have data which is being stored on existing computers and in data warehousing. Additional investment in RFID equipment in the form of sensors, barcode readers or hand held devices may be made at receival and dispatch points.

Base assumptions in adopting this analytical framework were:

- the majority of companies involved in the pilots had pre-existing technological competence
- the companies were of sufficient size to apply resources to the task
- the companies had a strong interest in addressing competitive pressure through gaining advantage via adoption of GDS
- there was existing digitisation in the value chain, indicating partner readiness
- there was existing intermittent and latent visibility in each supply chain.

2.2 Methodology Applied

Three streams of activity were undertaken during the project. Firstly, the business activities of adoption and application of the standards in the enterprise system were planned and executed with each company working in collaboration with GS1 Australia. Secondly, the evaluation of the impacts detailed in this report was conducted through baseline and in-operation comparison of metrics agreed with each firm, based on a series of KPIs supplied by Victoria University Institute for Supply Chain and Logistics. Thirdly, the policy implications for government and industry in relation to an industry-wide approach to adoption of GDS in Australia's supply chains was conducted through review of the experience in overseas jurisdictions and consultation with key stakeholders in the ALC Supply Chain Standards Working Group and documented in this report.

The methodological framework in capturing data related to costs and benefits in each supply chain comprised of three specific activities:

1. a baseline survey to determine the use of GDS in each supply chain prior to the pilots
2. establishing key performance indicators (KPIs) and associated metrics relating to efficiency, integrity, visibility and innovation in supply chains
3. identifying impacts experienced or anticipated in each supply chain in implementing the GDS through the pilots.

The data collection process included:

- Formal engagement with the key stakeholders to understand the scope of the activity and in some cases, to map the pilot supply chain events. Face to face consultation meetings and teleconference team meetings were conducted regularly over this period.
- Determining the baseline data available for measuring efficiency, integrity, visibility and innovation pre-pilot/implementation. It is notable that for some KPIs, no baseline data was available.
- Identifying benefits and costs to be measured. A GDS metrics spreadsheet was developed mapping metrics to KPIs for efficiency, integrity, visibility and innovation, based on common supply chain metrics and the purported benefits of increased supply chain visibility, identified during initial literature search. The spreadsheet established a starting point for participants to select and quantify costs and benefits. Additional benefits were also identified for measurement by the companies, relating to their internal KPIs, their recurrent issues experienced and their anticipated benefits. Data was then collated, analysed and presented as qualitative and quantitative assessment of likely costs and benefits of using GDS.
- Policy considerations and insights into potential industry-wide approach to GDS. The ALC Supply Chain Standards Working Group members were consulted regarding their views on industry rollout of GDS and the respective roles of government and industry. The experience of international jurisdictions was also researched in relation to broader industry adoption and whether the standards were promulgated through voluntary programs or legislated as a mandatory requirement.

The pilots were focused on supply chains with a mix of current capabilities in electronic messaging, trialling or rolling out the implementation of GDS in existing electronic interfaces and introducing the GS1 standards to associate a cargo item with a transport asset (e.g. pallet, container, ship, truck) in a supply chain event (e.g. truck/train arrival, truck loading) in real time across these supply chains.

The project was designed over a period of 18 months during 2015 and 2016, to enable sufficient time for the GDS to be embedded in the supply chain and for the impacts to become evident.

2.3 Key Participants

The project relates to several use case models and pilots that the ALC Supply Chain Standards Working Group has been engaged in between 2014 and 2016. The specific case supply chains that are analysed in this project are:

- **Toll Customised:** import and distribution of a retail product, piloting the use of GS1 EPCIS event visibility protocol and standard with international freight forwarder, shipping line, 3PL, Toll IPEC and Toll Express
- **Arrium OneSteel:** implementation of GS1 Australian Transport Label Standard for labelling bundled steel product (break bulk) implementation of GS1 Transport Instruction standard with K&S Corporation, Kings Transport and MMM Logistics for deliveries of bundled steel from East Coast manufacturing sites; and pilot of GS1 Transport Status standard with K&S Corporation
- **Nestlé:** implementation of GS1 Transport Instruction messaging standards with SCT Logistics.

The project followed multimodal movements from despatch facilities on the East Coast across to the West utilising road and rail transportation means and imported product using seafreight shipment, rail and road. Linehaul road movement as well as distribution tasks utilising smaller delivery equipment on last kilometre to retail was included.

The industry pilots were supported by GS1 Australia's Trade and Transport Industry Engagement team, which assisted companies in each supply chain to understand the standard, adapt current databases and enterprise systems to receive and transmit data in a compliant format and to supply a platform (GS1 Hong Kong's EzTrack) for capturing and sharing data during the pilot as required.

The Australian Logistics Council (ALC) and GS1 Australia convened regular meetings to facilitate collaboration and project coordination.

3. Case Studies

3.1 International Case Studies

A survey by IBM (2012) of 664 supply chain management executives in 29 countries globally has indicated that visibility is among the top organisational challenges they will face in coming years.

Analysis of supply chain visibility using GDS in three case studies (i.e. Axfood (local food retailing), IKEA (global furniture relating) and Clas Ohlson (regional hardware retailing)) in Sweden by Semianiaka and Silina (2012) has indicated that: global data identification standards implementation is an important enabler of supply chain visibility; implementation of global data identification standards should differ in different supply chain designs; and benefits from global data identification standards implementation are different within different supply chain designs.

The Axfood case study has demonstrated that adoption of GS1 global data standards enabled the company to trace and recall the goods, and added visibility to ordering and the invoicing processes. In the case of the IKEA case study, legal demands for traceability (supply visibility) were fulfilled with the help of GS1 standards at the pallet level with the use of SSCC, which was further used in combination with proprietary standards on the item and carton levels. To increase the level of supply chain visibility, exclusive supply chains need to develop more proper standards or more sophisticated ICT systems, which require major investments (Semianiaka and Silina, 2012).

Semianiaka and Silina (2012) point out that the benefits which a firm enjoys from adopting a global data identification standard depends on the levels at which these standards were implemented. The most basic benefits such as the automation of point of sales (POS) processes and basic warehouse management are reached when the standards are used on the item and carton levels. This is similar to the Clas Ohlson case study in combination with a proper ICT system, where the use of item and carton labelling can help create an automated ordering system to better manage stock levels. Greater benefits can be achieved when using the pallet identification standard as in IKEA case study, where the ability to trace goods and manage space in the DCs and warehouses was improved. The deployment of data identification standards at all levels integrated into an ICT system allows the firm to increase the efficiency of transactions, decrease the time of decision-making in emergency situations, and conduct space shelf management with the help of master data and merchant flow.

Several case studies of the use of GDS have also been undertaken in a number of Asia Pacific Economic Cooperation (APEC) economies recently. In particular, two recent APEC case studies have focussed on wine exports from Australia to Hong Kong, China and boxed beef exported from Australia to the USA. These two case studies have shown several key benefits.

For the wine case study, quantifiable benefits achieved through utilising GDS for traceability were associated with eliminating the five percent of DIFOT failures relative to a baseline situation (i.e. without GDS). These failures cost 0.54 percent of the value of this supply chain.

In the case of the boxed beef case study, the estimated benefits were associated with savings in manual data entry; container demurrage and detention; and amelioration of the impact of missing or damaged port shipping marks. The benefits derived from adopting GDS account for 0.67 percent of the value of this supply chain in the boxed beef case study (see APEC, forthcoming).

There are several other current/planned GDS initiatives operating in the APEC region. Malaysia has initiated a process using GDS in their frozen durian export trade. This initiative is aimed at ensuring traceability (and potential recall) of the products to address common interest issues such as uplifting product branding and maintaining consumer trust in relation to authenticating product brand. Further pilots demonstrating the use of GDS in product supply chains from Malaysia, Mexico and Peru are underway through the auspices of the APEC Policy Support Unit.

McKinsey & Company (2012) analysis of over 80 healthcare industry leaders around the world has estimated the potential value of adopting a single global standard in healthcare. Adopting global product identification to match patients with drugs, for example, could help hospitals reduce the number and severity of adverse drug events, which, according to McKinsey & Company (2012), occur more than 25 million times a year and lead to over 100,000 deaths annually. Product recalls, now occurring about 15 times per week in medical devices and 20 times per week in pharmaceuticals in the United States alone, could be managed more efficiently and more comprehensively using global standards in healthcare, according to McKinsey & Company (2012). Global standards could help reduce the growth of counterfeit drugs, supplement electronic medical records and support the development of personalised medicine and customised medical devices.

The global healthcare industry has half a trillion dollars tied up in inventory. Global standards could enable inventory reduction of US$60-94 billion and reduce the costs of managing and storing inventory by US$10-14 billion (McKinsey & Company, 2012).

Information and communication technology (ICT) plays a key role in providing real-time visibility, efficient data exchange, and better flexibility to react to unexpected changes during shipment along supply chains. Despite these benefits and strong government promotion, the uptake of recent technological advances in transport and logistics industries has been low in many parts of the world. By reviewing 33 European Union multimodal projects, Harris et al (2015) have identified three sets of factors hindering the adoption of ICT, namely, user-related, technology-related, and policy-related barriers.

The user-related barriers comprise of economic, operational and managerial barriers and relate to a firm's operating environment. Traditionally, the size of the firm plays a crucial role in the level of ICT implementation where SMEs are more likely to have constraints on financial, human resources and ICT expertise leading to a higher probability of being less able to "afford" appropriate solutions compared to larger firms. The economic and financial factors are another barrier, including large investment requirements, the implementation costs, managing and maintenance costs, as well as the unfavourable financial conditions of relevant firms.

Operation-related constraints include human capital issues such as difficulty in employing qualified personnel, lack of ICT specialists and personnel skill shortage to operate new applications, as well as insufficient ICT- oriented training and educational activities. SMEs may suffer disproportionately from these types of barriers.

Managerial constraints may relate to the uncertainty of commercial success with regard to ICT applications, including a lack of knowledge on payback period and unclear returns on investment, unfamiliarity with the commercially available ICT applications and difficulty in quantifying the potential benefits of ICT applications.

The technology-related constraints relate to the technological barriers that prevent firms making full use of ICT applications, including issues such as interoperability of systems, ICT integration, standardisation, security and data protection.

The policy-related constraints relate to the coordination and harmonisation of different policy levels which could prove to be an effective enabler for facilitating some new technologies or methods implemented through specific regulation (see Harris et al, 2015).

3.2 Australian Case Studies

In this section the case studies involve piloting adoption of GDS to improve the visibility of the supply chain across transport mode and freight custody.

Benefits assessment was a process highly dependent on the business tools at the disposal of firms to generate meaningful actions to enhance efficiency. While the standards enable whole-of-supply-chain, real time data capture and exchange, it is up to the participants in each supply chain to utilise the data to effect decisions and activities that benefit the traders, regulators and each business in the chain. In this report, we document examples of how participants are creating benefits by using the standards.

3.3 Arrium OneSteel

Arrium Limited is an international diversified mining and materials company listed on the Australian Securities Exchange, with three key business segments: Arrium Mining Consumables, Arrium Mining, and Arrium Steel. www.arrium.com

Arrium's Steel business, known as OneSteel, is Australia's only manufacturer of steel long products with steel-making capacity of approximately 2.5 million tonnes per annum supplied from its OneSteel Rod, Bar & Wire and OneSteel Whyalla business units. It is also Australia's leading steel distributor (Metalcentre) and reinforcing steel supplier (ARC and OneSteel Reinforcing - OSR). (Source: http://www.arrium.com/about-us/about-arrium)

OneSteel manufactures and distributes long steel products in Australia, with around 200 sites across the country. OneSteel services more than 30,000 customers, offers more than 40,000 products and employs around 4,500 people. OneSteel is also a significant supplier of scrap metal to foundries, smelters and steel mills in Australia and internationally through its OneSteel Recycling business.

The OneSteel transport task involves collection and delivery to and from steel manufacturing plants, through processing and distribution, ultimately resulting in deliveries to end customers, often on construction sites.

Noting that involvement in the ALC GDS pilots is part of the B2B digital business strategy of the Company, the freight task for the case study covered two elements: the delivery of bundled steel rod and bar products from its OneSteel Rod, Bar and Wire business, and the delivery of processed steel from its downstream businesses (Metalcentre/ARC/OSR).

3.3.1 Delivery of Bundled Steel from OneSteel Rod, Bar and Wire plants

The precursor project for OneSteel was to adopt product labelling consistent and compliant with GS1 identification protocols.

Steel is produced and supplied in bundles of a typical 2000kg mass. Each bundle is labelled and identified with the global trade item number (GTIN) related to the size, grade and length of product. It is also allocated a unique bundle, or serial number. The combination of the GTIN and Serial Number provided a unique and powerful identification of the load. The GS1 DataMatrix barcode applied to the label also includes other attributes such as batch number, mass, and piece count.

This identification provided unique linkage to the history and test certificate data associated to the supplied material which was able to be accessed via the GTIN / Serial Number combination that is on the product label. This combination, also known as a SGTIN, is a crucial key for both efficiency and traceability as it allowed all parties in the supply chain to uniquely identify each logistic unit and its content. Scanning the SGTIN barcoded on each logistic unit allowed the physical movement of units to be matched with the electronic business messages that refer to them. Previously this was a manual task.

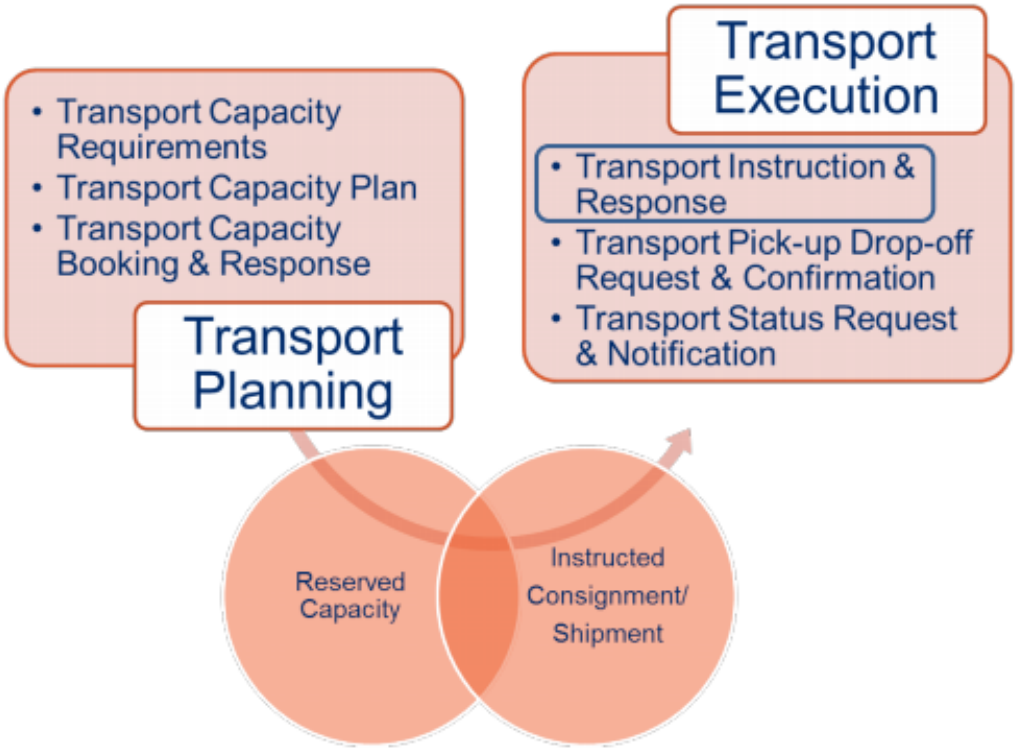
Using the SGTIN to identify individual units opened up the opportunity to implement a wide range of applications such as cross docking, shipment routing, and automated receiving. (https://www.youtube.com/watch?v=xqIVPXjGeBQ)

3.3.2 Delivery of Processed Steel from OneSteel Metalcentre/ARC/OSR

The Company had 500-600 transport-related messages daily from the participating sites. Errors from legacy systems and manual processes were regular. OneSteel commenced the introduction of transport instruction messages compliant with the GS1 Australian Transport Instruction Standard by sending and receiving "planned" and "actual" transport messages to its transport suppliers.

> *The transport instruction is a comprehensive message used to convey relevant information regarding cargo that needs to be transported using one or more modes of transport. The main objective of the Transport Instruction is to communicate the arrangements of the movement of the goods (including collection and delivery) and providing the information necessary to perform the handling of the goods between all parties involved. The Transport Instruction can include a request for either executing a consignment or executing a shipment. The Transport Instruction will be sent by the Logistic Services Buyer (supplier, retailer, 3rd party warehouse or freight forwarder) to a Logistic Services Seller (freight forwarder or carrier).* [8]

Figure 3.1: Transport planning and execution schema



Source: GS1 Australia

8 GS1 Australia, GS1 XML Transport Instruction and Response Implementation Guide, Issue 1.0, September 2012

The pilot and subsequent implementation of transport instruction involved:

1. Gaining an understanding of the GS1 "language" and protocols related to transport instruction messages, including how these are structured and how they relate to this particular product.
2. Mapping existing messages between the company's production sites and transport suppliers to the GS1 standard.
3. Piloting the Transport Instruction message with two transport suppliers through using a test server to mediate messages to and from the transport suppliers' systems and OneSteel's multiple ERP systems. The initial trial was for one pickup and delivery task from the Sunshine Victoria plant using K&S Freighters, involving 60 to 100 transport instructions per day.
4. Cleaning up the location master data held by the company. This involved a program of correcting data to ensure location codes were compliant. In this case, the company discovered that sites were detailed with a variety of descriptors from street address, GPS coordinates, delivery contacts and specific instructions or extended attributes for each customer, e.g. bay/door/dock for delivery or pick up.
5. Moving to production mode post-pilot. This involves large and smaller transport suppliers.
6. Subsequent development of apps to utilise the new data.

OneSteel is currently piloting the Transport Status message with transport suppliers.

For the transport suppliers, the information for the Transport Status message could be provided via on-board telematics including global positioning system (GPS) devices in the vehicle transmitting status messages to the transport supplier's legacy system(s), which in turn communicates status to the OneSteel system, using the GS1 Transport Status message standard.

Alternatively, transport status could be generated via driver input utilising in-cab tablet devices. Supply of such devices helps smaller companies and subcontractors to use the GS1-compliant system without significant infrastructure investment.

The Company envisaged incorporating reference to the GS1 standards in contract documentation and was keen to ensure SME suppliers are not "shut out" if they have limited in-house IT capacity. The Company was aware of system integration suppliers who are GS1 compliant who can support the smaller companies in a cost-effective way.

Adoption of the SAP Transport Management capability compliant with GS1 standards enabled the company to gain visibility in real time across transport operations. This transport management product is relatively new to the Australian market and is under implementation with three Australian companies, one a logistics supplier.

Development of the capacity to trace all events as they happen was dependent on working relationships between the Company, its transport suppliers and their GPS system providers.

3.3.3 Benefits

Efficiency

Pre-introduction of the standards, a baseline transport cost per tonne for the trial sites undertaking metropolitan delivery was recorded. Post-implementation, the benchmark cost per tonne metric had reduced in all of the locations. The data shown in Table 3.1 indicates further cost reduction continued over time since the implementation phase.

Table 3.1: Cost variance by period of implementation of GDS

Location	Months Since Implementation	Variance to Baseline cost
State 1	12	-11.5%
State 2	4	- 5.2%
State 3	2	-5.0%

Source: Arrium OneSteel, 2016.

In the case of bundled steel product supplied from the OneSteel Rod, Bar and Wire business unit, OneSteel found that by scanning the label when loading the vehicles, turnaround time was reduced by around one quarter (28 percent) at the sites where the GDS has been applied to the product transport labels and bundles. Depending on whether the transport contract was on the basis of tonnage or time, the transport operator would also benefit by the reduced time.

Three transport suppliers were trialling the GS1 Transport Status Notification and Response standard with OneSteel. This not only provided event-based messages but was linked to OneSteel's financial system, now able to automatically validate invoices from the transport suppliers. Automation of this process reduced the administrative time for handling vendor invoices. Fully implemented, this would represent a tangible benefit. The cost savings through elimination of manual errors and avoidance of supplier queries related to invoices which are assessed as requiring on average 1.5 hours of administrative resource per resolution.

Integrity

Prior to the introduction of GDS, cost per tonne was a relatively crude measurement of efficiency. Using the standards applied in the Transport Management System (TMS) data was available to the Company to support better decisions in planning transport.

Transport costs and decisions were largely separate to the plant operations and there was a lack of detailed information about the cost of transport.

The new transport management system was able to take the data from supplier messages and calculate the cost to serve effectively, enabling account managers to determine the most cost-effective options for delivery with customers. Account managers have had access to this data for only a limited period, but reported that they were already able to improve their decision-making capacity.

Visibility

Data on truck utilisation was now available and development of reports was based on time in and time out and duration on site at customer premises. Turnaround times at customer sites and truck demurrage were now able to be monitored. It is too early to assess a trend in respect of this metric.

As event data is shared with transport suppliers it could be used to deal with liquidated damages claims related to DIFOT by providing a "common truth" of the shipment, underpinned by data recording delivery times linked to the product, location and transport identity.

Innovation

Having more accurate data on the location of the vehicle enabled development and implementation of improved services, e.g. the customer to be notified in a timely manner prior to delivery so that on-site preparations could be made that will result in faster turnaround of the delivery on-site through clearing driveways and loading areas and ensuring on-site equipment and labour is prepared.

In a related development, the SteelDrive smart phone application has been developed by BlueScope, K&S Freighters and Toll (http://www.steeldrive.org/). This application captures photos of load restraint for compliance purposes and can be made available for smaller operators and subcontracting transport companies.

Other opportunities for improvements in safety and efficiency such as site inspection data, were being considered, including working with GS1 to utilise (and enhance) the GS1 Locatenet repository/directory to support the identification of locations with Global Location Numbers and to better record and share delivery site information.

3.3.4 Impact on Businesses

A significant impact which can be overlooked in the process of business process change is the ability and willingness of staff to adapt to change. It was pointed out that individuals who are highly attuned to process are valued in the transport and logistics sector, given the nature of the task. These individuals may not adapt as readily to change or the need to introduce problem-solving and analytical skill sets, which are now increasingly valued.

Cultural change within the business units and partner businesses has been a factor in the pace and success of change related to new systems and processes, with long term employees and smaller transport suppliers requiring support to transition to the changes.

Alignment with transport suppliers with variable IT technical capacity and legacy systems has also had an impact on relationships with suppliers. Smaller transport suppliers view the integration with OneSteel's Transport Management System and the new GS1-compliant formats as creating additional complexity and cost to their work. It was noted that transport companies can utilise their coding and business process with other customers, with the effort and cost reducing with progressive implementations.

3.4 Nestlé

The initial scope of the Nestlé pilot was to implement the GS1 EPCIS capability with its transport and logistics supplier for delivery of perishable product to grocery retailer distribution centres, involving road and rail modes transporting product from the East to West Coast of Australia.

Internal technology priorities have resulted in the Company being in a position to proceed with one element of the visibility suite, which is the GS1 Transport Instruction message. It is notable that during the planning for implementation, a major FMCG customer notified Nestlé that use of GS1-compliant transport messages will be required. This decision by the customer's customer will now drive the use of the data standards for communications between the transport companies working with Nestlé.

An average of 100-120 truckloads per week departed the factory in this specific supply chain. At baseline, the transmission of data related to transport was predominantly manual. There were 25 messages representing key milestones on a scheduled shipment around DIFOT. The schematic of this supply chain with its players, events and messages, is represented in Figure 3.2.

Using the EPCIS standard and GS1 messages such as the Transport Instruction, the company's expectation was to progressively move to a dashboard system to manage an automated messaging process.

Five key event-related messages were most relevant to the transport task:

1. Truck departed
2. SSCC label arrived at SCT DC/hub
3. SSCC label departed SCT DC/hub
4. SSCC arrive at customer
5. Receipted at customer.

Vulnerable stages were where a load goes through an interim hub and was unloaded to change transport mode, or when a load is split (Nestlé try to avoid this) for shipment.

The FMCG retailer uses a B2B e-commerce portal to interact with Nestlé's customer-facing team. This team was embedded in the FMCG customer and consisted of Replenishment Planners. These planners were notified if a shipment was late and it was their role to investigate issues with shipments. No messages were automated until after the event.

Interaction with the FMCG B2B e-commerce portal to book delivery windows is via an EDI message. When the customer order is entered in the system, a delivery window is allocated for the goods. The retailer manages inbound capacity constraints through a national capacity team, which assesses pallets in and out and may push an order out to the next day. The EDI messages from the retailer's B2B portal makes it easier to follow up, as the system interfaces with Nestlé ERP.

In relation to the transit from the Nestlé production facility/distribution centre, the Company attempts to group the product into full shipments of palletised product. Once a shipment is prepared, an invoice is issued to the retailer just prior to shipment. The invoice is electronic and a hard copy goes with the transport driver. Custody of the product is with the transport company once the pallets leave the factory.

When goods have been loaded out on transport, the first message is a notification that the goods have arrived at the DC (SCT or retailer DC). This message was manual and in the form of a telephone call or email.

Anticipating the requirements of customers, SCT Logistics, the transport and logistics supplier to Nestlé for this pilot, invested in a proprietary customer reporting portal that allows any customer to track their freight.

3.4.1 Anticipated Benefits

Nestlé established a baseline and metrics to determine the anticipated benefits of this implementation, which will commence with the implementation of the GS1 Transport Instruction Message.

Efficiency

At baseline, an average 30 minutes is required for a Nestlé Business Unit to chase up a request from a Replenishment Planner located in the FMCG retailer, reporting on DIFOT misses the day after delivery took place. It can then take a further 24 hours or more to receive the Proof of Delivery (POD) from the transport company, so that an order problem can be identified. The re-work involved in handling queries and re-issuing documents is substantial. Once the Customer Service Team has investigated an issue with a shipment, the Accounts team must access all the transport documents and ultimately issue a credit to the FMCG retailer customer.

With the EPCIS and Transport Instruction messaging in place, this information will be available instantly. The POD can be scanned and forwarded immediately to the Customer Service team.

Integrity

Introduction of pallet SSCC level tracking and real-time visibility enables the retailer to associate individual pallets with an ASN from Nestlé and to be able to subsequently associate those pallets to a vehicle registration at the retailer DC. At baseline, multiple ASNs or partial consignments linked to the one ASN can be loaded on a vehicle and this made reconciliation problematic and prone to error based on manual paperwork carried by the driver.

Visibility

From the retailer perspective, visibility of the product is expected to drive greater certainty into the receival process. Invoices from the supplier would be automatically reconciled with the actual proof of delivery when cartons of product are associated with the pallet SSCC. Likewise, reconciliation of transport invoices from the transport supplier can in turn be accomplished using automated processing, based on the proof of delivery supplied by the retailer to Nestlé.

Innovation

Nestlé anticipates being an early responder to customer demand by being able to comply with transport messaging that is GS1-compliant.

The Company also expects to derive analytics that will lead to a much better understanding of their transport task, allowing them greater responsiveness.

The extension of data standards to transport activities is part of the retailer's supply chain transformation program aimed at taking advantage of B2B capacity investment to generate efficiencies both in Australian and Asian operations.

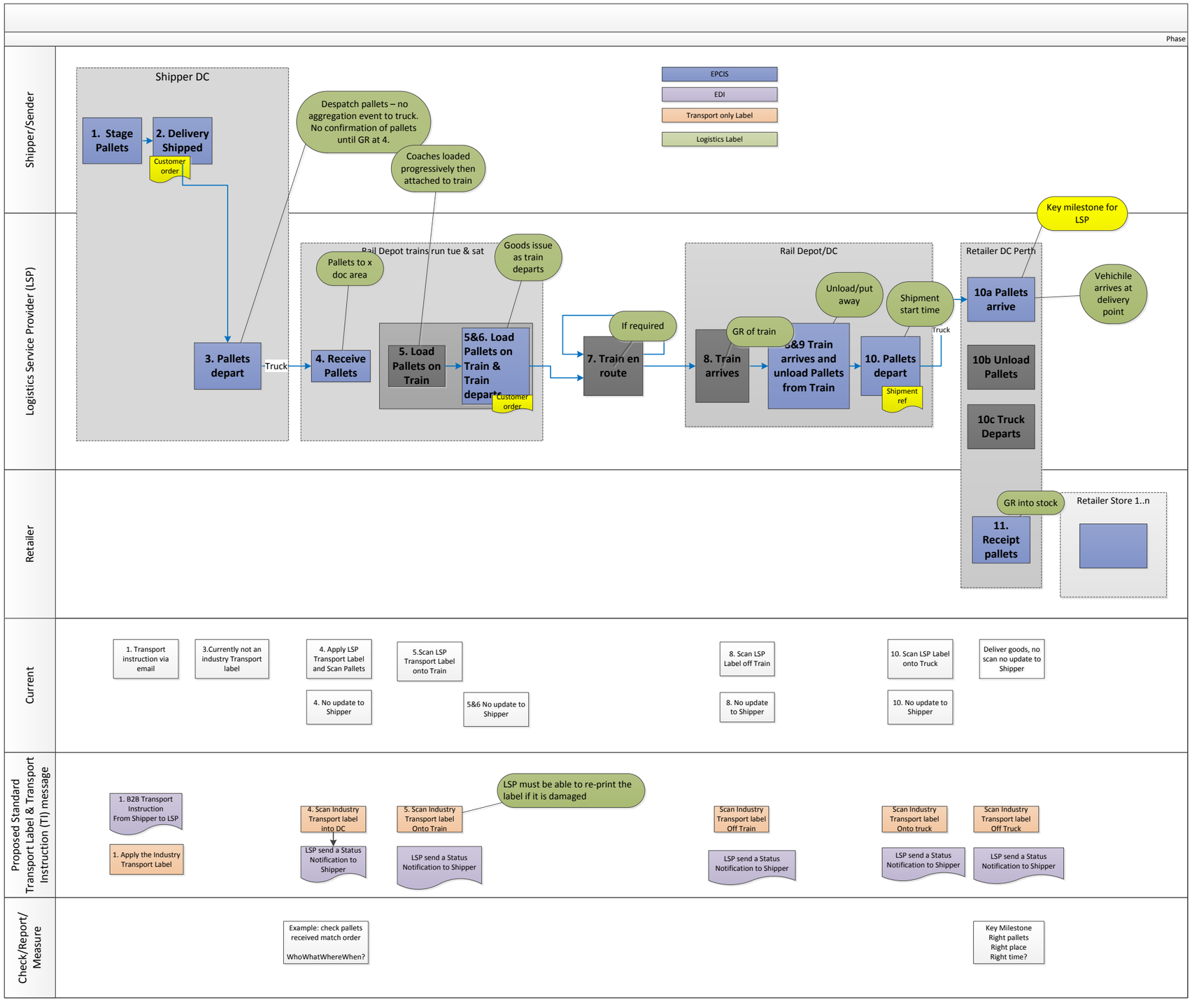
3.4.2 Impact on the Businesses

The transport and logistics supplier has investigated the impact of system integration to supply event-based, real time visibility from factory pickup of palletised product in Sydney, transported to the SCT facility in Parkes NSW, for transfer to rail wagons for East-West rail transit and subsequent road delivery to the retailer distribution centre in metropolitan Perth, Western Australia.

The transport and logistics company has raised the following issues:

- Orders are currently received at a consolidated level and no pallet level SSCC identification is provided to the transport supplier from Nestlé. At baseline, the SSCC labels on the cartons and pallets were used by the customer for receival purposes at the retailer. This information was not known until the last minute in the packing process and was not provided to the transport and logistics supplier. The SSCC would associate a pallet with product in cartons and in turn, could be associated with the transport asset (truck or train).
- A transport label was generated by the transport supplier and attached to each pallet. This label purely contains information on where it is going and the number of the pallet in relation to the consolidated number that was received from the customer. This is a transport and logistics supplier number count and does not reflect any individual pallets from the customer. There is potential to link transport instruction with the pallet and in turn, with the Nestlé Advanced Shipping Notice (ASN).
- The transport and logistics supplier was concerned at the cost associated with building unique interface formats based on the standards of each customer. The requirement to "customise" individual interfaces for each customer is a cost to the transport and logistics supplier. This is the downside of having no common supply chain data standard in use.
- The transport and logistics supplier expressed concern that tracking freight at the SSCC pallet level through their warehouse management system may create a financial impost. While this is not the experience of companies tracking at the pallet SSCC level, it did indicate the need for greater awareness across the T&L industry and wide dissemination of advice from IT system suppliers.
- There is no co-investment in collaborative development with customers and there is a sense that the benefits of supplying greater visibility accrue strongly in favour of the Customer.

Figure 3.2: Nestlé Pilot supply chain events, players and messages



Source: GS1 Australia, 2016

3.5 TOLL

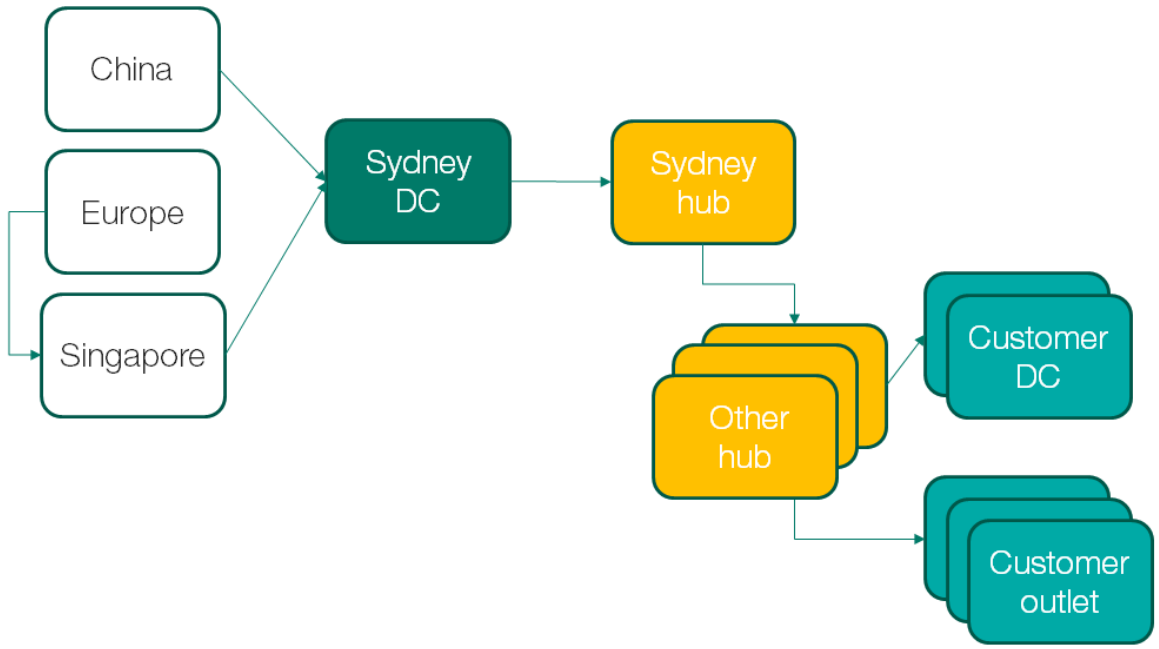
Toll Group is the Asia Pacific region's leading provider of logistics services, operating globally across over 50 countries.

Toll is interested in innovative products that promote the seamless integration of logistics services. The GS1 EPCIS pilot provided an opportunity to learn about an emerging supply chain event visibility standard that could benefit Toll's customers and the supply chain industry.

The pilot involved applying GS1 EPCIS standards to a global multi-leg, multi-modal supply chain and trialling some of the features of the standard. The inbound characteristics of the supply chain involved the import of freight from China and Europe and its subsequent storage in a distribution centre (DC) in Sydney. Outbound from the DC, the freight moved through several distribution hubs before being delivered to end customers.

The supply chain parties in the pilot involved an international freight forwarding entity, a 3PL warehousing entity and two 3PL transport entities. The domestic entities were autonomous Toll business units.

Figure 3.3: Toll EPCIS pilot supply chain



Source: Toll Group, 2016

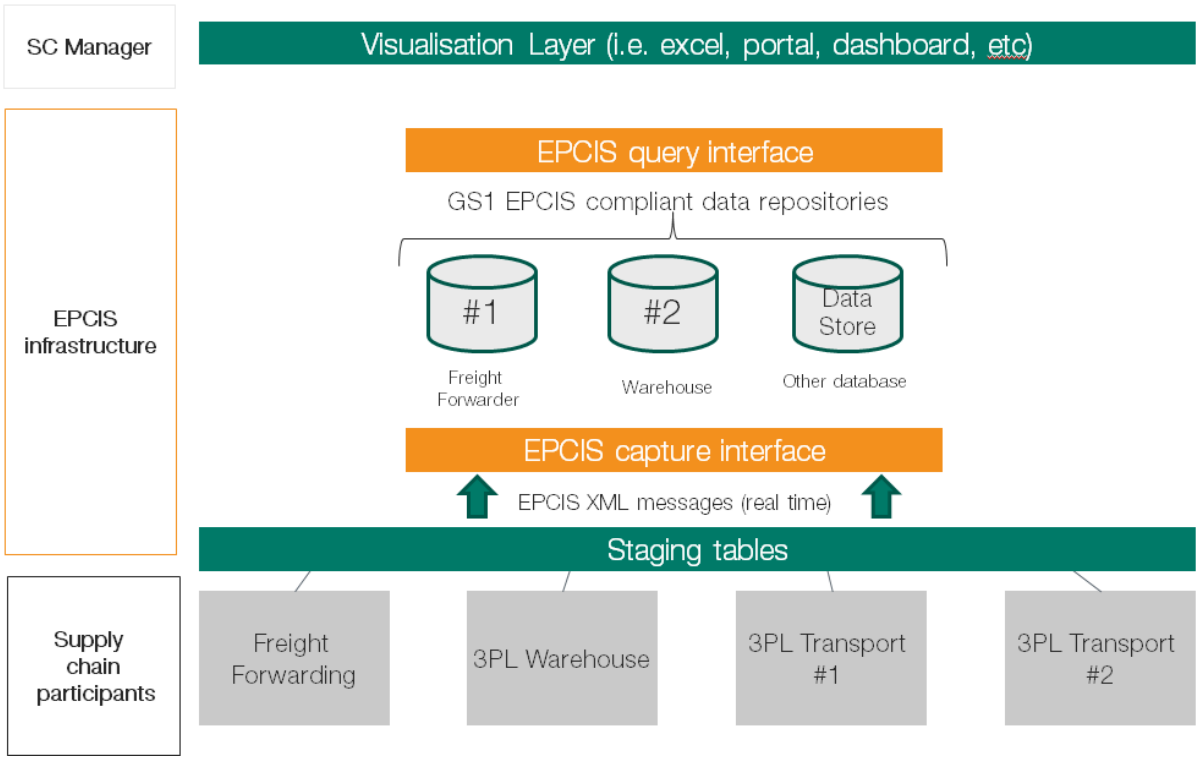
3.5.1 Set up for the pilot

A summary of the tasks undertaken included:

- setup of GS1 foundational keys and master data
- research of the GS1 EPCIS standards
- testing of EPCIS technology open-source frameworks (Fosstrack, Oliot)
- infrastructure commissioning and setup (EPCIS data repositories)
- business process and system process analysis
- mapping of events to the GS1 EPCIS standard events types
- code development for message creation and posting based on GS1 EPCIS standard
- setup of source systems for event subscription and polling from three sources into the repository
- development of internal queries and testing of internal customer service portal to enable querying on consignment number, customer, delivery reference, or SSCC.

The system design is illustrated in Figure 3.4.

Figure 3.4: System design using GS1 EPCIS standard



Source: Toll Group, 2016

For the deployment, only one of the virtual machines was used to capture all EPCIS event messages.

3.5.2 GS1 foundational keys and master data

Table 3.2 below shows the requirements from GS1 system and Toll implementation.

Table 3.2: Foundational keys deployed

GS1 system	Toll implementation
GS1 Global Company Prefix	Toll has established multiple company prefixes with GS1 Australia
GTIN (Global Trade Item Number)	Product master data such as GTIN is interfaced from customers ERP into Toll WMS
sGTIN Serialised GTIN	A serialised GTIN was constructed by combining the product GTIN and ASN (Advanced Shipping Notice) number and ASN Line number
Serialised carton identification using SSCC	All dispatched (outbound) cartons have SSCC labels
Serialised pallet identification using SSCC	Pallets of cartons are “aggregations” in EPCIS. These also are assigned an SSCC.
GLNs (Global location Number)	GLNs were created for the pilot. Approximately 700 locations were created to uniquely identify customer delivery points.
GIAI Global Individual Asset Identifier	Inbound container IDs have been assigned GIAI based on shipping container ID and Toll company prefix

3.5.3 Messages in the pilot

Table 3.3 shows the requirements from messages and events implemented.

Table 3.3: Messages and event types used in Toll EPCIS pilot

Actions	Event types	Disposition	Business step
Add	Object	In Progress	Packing
Observe	Aggregate		Staging Outbound
Delete			Receiving
			Shipping
			Transporting

Source: Toll Group, 2016.

3.5.4 Reporting systems

Two reporting systems were built on EPCIS data and foundational data tables. A web-based system, which has multi-attribute search capabilities, and a supply chain health reporting system which displayed supply chain events (ship depart, ship arrived, into DC, despatched from DC, scanned at hub, out for delivery, POD) against customer-provided dates.

The pilot of the EPCIS standard was in operation for over six months. In this time, over 2 million messages were written, providing a useful database to run queries from.

3.5.5 Benefits

Reporting supply chain events using the GS1 EPCIS standard was found to be robust to change. During the pilot, as the supply chain parties were operationally changed, the collection of data was unperturbed as new party's event data was received and written to the GS1 EPCIS standard. Queries and reports were able to be completed whilst the underlying parties changed.

Some efficiencies were achieved based on queries and reports developed from the GS1 EPCIS data repository and related systems.

Customer Service Efficiency

For the customer's supply chain, Toll provides a customer service team for warehouse order fulfilment and customer delivery. One of the functions of the team is to manage customer enquiries.

Using EPCIS event related data and new reporting systems, the customer service team was able to improve the speed of responses. The number of enquiries able to be resolved on the same day had risen by 20% compared to pre-trial numbers.

The abovementioned customer service efficiency gains are attributed to order and event information being cross-referenced and searchable across several supply chain parties' event data.

Planning Efficiency

Inbound planning for container receipt and de-stuffing had improved with the ability to consolidate and report shipment status and container detail through the journey. The customer benefits from inbound planning, which Toll was able to do at product and SKU (stock keeping unit) level, were due to access to shipping event data, such as the estimated time of arrival (ETA) from another logistics provider in the chain.

To create an effective planning capability, Toll consolidated data from a third party logistics provider, the customer's ASN data and Toll's warehouse management system master data.

In the absence of cross-referenced data, which was held in EPCIS data repositories and other systems, this planning capability was slow and convoluted.

It should be noted that systematically cross-referencing data of itself would have provided this efficiency. The effect of GS1 EPCIS was to stimulate this activity in long supply chain management. The Company view was that ultimately the effect of GS1 EPCIS usage will be to provide a means to access data from a range of other providers that can be used for long supply chain management.

The planning efficiency experienced was a reduction of 30% of a planner's work hours.

Visibility

The visibility in this supply chain increased to now cover the end-to-end supply chain, across road, sea-shipping, trans-shipment, intermediate storage and distribution to DCs and direct to customer.

In addition to the efficiencies identified above, the availability of structured data provided the ability to undertake supply chain diagnostics. This capability enabled advanced notice when a service failure might occur and action could be taken to avert this outcome. For example, the late arrival of shipments to Australia could be compensated by prioritising cartage of containers with certain SKUs from the port to warehouse to expedite critical shipments. This was not benchmarked and quantified in the pilot.

3.5.6 Test of the EPCIS Standard in An Industry Setting

The EPCIS standard adequately covered the long supply chain in this pilot.

Some requirements for GS1 EPCIS that Toll identified as not satisfactorily in place at present are:

- unique and universal location identifiers (centralised GLN repository)
- GTINs (centralised product GTIN repository)
- ONS (Object Name Service) and security protocols.

Though the standard and data repositories exist for some of the above, in practice they are not available and were developed by Toll for this pilot. The ONS and security protocols were not explored.

The dependence on others to implement the standard is obviously a critical matter. Whilst Toll has implemented it in this pilot, the Company indicated it would have been a better test if the freight forwarding (non-Toll) party had supported the standard. For the pilot the Company received data in csv format and generated EPCIS event messages from that. This was satisfactory for the pilot, but would have been more powerful had a direct B2B link been established.

The pilot did not test complex queries within EPCIS – i.e. the ability to recursively search aggregations across multiple GS1 EPCIS data repositories. To work in a practical sense, this capability is dependent on a functioning ONS and some industry adoption of GS1 EPCIS. This will be an area for future investigation for Toll.

The Company expects the likely direction of adoption for GS1 EPCIS is along industry lines. There will be those industries that are more likely than others to adopt this standard, such as the healthcare industry. This may be in response to regulation, but also reflective of need – the healthcare industry suffers losses from counterfeiting. GS1 EPCIS can help mitigate this through supporting traceability. Where an industry is adopting GS1, it is likely some of the shortcomings noted – i.e. centralised repositories – may be established. For logistics service providers seeking to service these industries, Toll confirmed that existing knowledge of GS1 EPCIS would be valuable.

3.5.7 Impact on the Businesses

The pilot has enabled identification, capture, and query from four supply chain parties.

Standardisation achieved through this pilot has provided insights into business processes and supported communications both internally and with external partners on supply chain management matters. Standardisation has also led to improved efficiency of existing processes.

Importantly, standardisation has enabled inter-operability between supply chain partners, and the ability to change transport providers during the pilot without interruption to reporting, which the Company found useful.

4. Findings

4.1 Benefits of GDS Application

The firms involved in the case studies have identified benefits across the four parameters of efficiency, integrity, visibility, and innovation.

Benefits are evident from the introduction of through-chain visibility. Those benefits include:

- **Efficiency:** reduced DIFOT failures through errors associated with manual processes, ability to understand costs associated with the transport task, improved time elapsed to investigate DIFOT failures, improved terminal turnaround times, improved planning and scheduling of transport and speedier invoice verification
- **Integrity:** introduction of event-based data, automation of freight reconciliation at loading/unloading sites, accurate and new reports generated from new data enabling the introduction of decision matrices and diagnostic procedures
- **Visibility:** significant improvement in visibility of product while in transit or storage, customer visibility now enabled through a unified portal, sharing of data facilitating reduced administrative burden, creation of a common event data pool for administrative and supply chain management purposes
- **Innovation:** new reports driven by availability of new data, new applications being developed to support business processes and compliance.

It is evident from the industry case studies that the transport and logistics suppliers were delivering benefit to shippers through aligning their data formats to be compliant with GDS so they could interface more effectively and automate messages.

They have incrementally lifted capability within their supply chain network through adopting global standards to enable greater visibility and have achieved productivity gains shared across their value chains.

The implementation of new and revised business processes and new applications to generate further benefit is now being realised in several of the companies.

However, small businesses, usually transport companies servicing the pilot companies, found increased complexity and cost as they have been forced to invest to integrate with their customers' now GS1-compliant EDI formats.

4.2 Costs of Adoption of GDS

Cost variables include preparation, development and implementation of global data standards. Estimates of costs are based on an average of AUD100 per hour expended on each activity, representing a mix of in-house and outsourced resourcing. Costs do not include hardware purchases, as it is assumed that companies adopting global data standards have data which is being stored on existing computers. Additional investment in RFID equipment in the form of sensors, barcode readers or hand held devices may be made at receival and dispatch points.

4.2.1 Preparation

Prior to embarking on system integration, a key task in making GDS useful is the need for clean data, which can then be shared by supply chain stakeholders. There may be anomalies related to coding errors. For example, one firm found that it had coded multiple location data for the one site, so that GDS-compliant transport instructions required cleaning up the existing coded data to be consistent with global location numbers.

- **Collating and cleaning up master data e.g. locations – 20 hours**

A cost in preparing for adoption of the standards is for the business to understand the global data standards system and the associated new data formats. Data fields on business forms will require review in anticipation of these new formats.

- **Understanding the standards and new data formats – 40 hours**

4.2.2 Development

Development involves programming of messages in a format e.g. Javascript, so that the message can be transmitted and received in a portal repository shared by supply chain participants, or transmitted direct to relevant parties through EDI.

- **Developing messages for EPCIS and stored procedures – 80 hours**

Programming queries so that each participant can retrieve required data from the portal or another party using the global data standard is then required.

- **Writing queries for EPCIS – 20 hours**

4.2.3 Implementation

System integration for full automation of messages and to implement visibility requires construction of interfaces between the supply chain partner systems, including:

- supplier ERP
- transport firm transport management system (TMS)
- 3PL Distribution Manager Warehouse Management System (WMS)
- Shipping Line portal
- port community system
- freight forwarder's system
- customer's ERP.

This task requires time, resource commitment and ICT development work. Those more advanced in implementation of supply chain event visibility generally spend around two months on the task, combining internal staff and ICT consultants.

Work practices can strongly rely on individual knowledge and "workabouts" developed in the workplace to overcome recurring dilemmas. While automated interfaces eliminate manual processes, change requires the support of staff to utilise the technology correctly to record and collate correct data. This requires leadership and cooperation of management and staff. Adequate training and awareness is a cost the business will bear to reap the benefits of process automation and data harvesting.

- **Training staff in new processes – 40 hours**

For a small business to implement a basic EDI and EPCIS messaging capability there are two options:

- **Option 1: Basic, non-integrated, using web forms.** This may be a fixed cost deal available with no set up, similar to a mobile phone plan. The basic service fee is estimated at AU$50 per month, based on volume, unlimited messaging or customer plus increments of AU$20 per month for each new customer on-boarded.
- **Option 2: Integrated set up.** This may be a hosted service or built in-house which may cost between AU$1,500 and AU$15,000 to build. Charges are based on message types (data used) and there may also be a charge per customer/trading partner.

To operate this automated messaging capability, the ongoing cost is around AU$150 per month, again depending on the number of messages and trading partners messaged. For firms with EDI messaging capability, EPCIS messages will cost a similar amount to EDI XML messages.

4.2.4 Membership of Standards Body

The cost of membership of GS1 (global data standard body) which issues unique identifiers for goods, transport equipment is outlined in Table 4.1.

Table 4.1: GS1 membership costs (2016-17)

	Less than $1 million turnover	$1-5 million turnover	$5-10 million turnover	$10-25 million turnover
Year 1	AU$1,119	AU$1,269	AU$1,383	AU$1,494
Per year thereafter	AU$624	AU$774	AU$888	AU$999

(See https://www.gs1au.org/resources/application-forms-and-fees/)

The costs to a small business to implement global data standards and to utilise them in creating supply chain visibility are likely to involve a cost of AU$15,000 to AU$45,000 to achieve GDS compliant interfaces with their supply chain partners.[9]

For a larger business, standardisation of messaging is likely to complement existing enterprise level systems, such as transport management, warehouse management, or ERP and the scale of integration and customer/supplier engagement will be larger. Full integration with EDI XML messaging to enhance visibility is most likely to be undertaken by enterprise level businesses with existing EDI messaging capability.

Each business will need to prepare a specific business case to assess the business value.

4.3 Development of the Standards in the T&L Industry

A comprehensive GLN repository with accurate location master data for the T&L industry is a gap identified during the pilot. GS1 operates a service called LocateNet developed for the health care industry to undertake this task. **Mass adoption of data standards in the T&L industry will require a member mandate from GS1 members to develop a similar service for the T&L industry. This is likely to require senior leadership from the industry**.

In response to strong global interest in the EPCIS standard as a visibility enabler for “distributed event-based traceability”, GS1 has launched a Global Innovation Network Incubator to review interoperability standards to enable discovery, trust and confidentiality to protect security of data across multiple repositories.

These two instances of the need for further development of the standards point to the need for the T&L industry to engage with the standards provider to advance the efficacy of the standards.

9 This figure is based on survey of the actual costs experienced by companies having implemented GDS capability.

4.4 Learnings from the Pilots

Several key learnings are apparent from the case studies, as follows:

- An **incremental approach is most effective**. Companies commenced what has become a journey to inculcate GDS in their value chains by taking one step at a time and fitting in this work with other initiatives within their organisation. The change process requires alteration to data formats, means of capturing data and reporting, all of which require staff training and sometimes a cultural change in the workforce at a particular site. It also requires cooperation beyond the one organisation, so pacing the change to ensure all participants can make steady progress is essential.
- **Partner readiness is a critical factor** in adoption of GDS in a supply chain network. There have been variable timings for partner adoption. A fundamental pre-requisite for adoption of supply chain visibility is the readiness of the partners to undertake the process concurrently. This is not always easy as IT teams have shifting priorities, depending on the strategic imperatives of the company. Gaining alignment is a major step prior to initiating change.
- Most of the firms involved in the case studies were **dealing with legacy systems** and the need to exchange data with these systems. This can mean multiple coding tasks to match the formats and capacity of legacy systems. This can increase the cost of adoption of the GDS where direct interfaces are built. GS1 has found that on average the transport partner must send and receive a minimum of five messages in order to execute a shipment and on average relate to five to eight customers. To minimise this cost, system integrators are available which incorporate it as a Software-as-a Service offering. These integrations do become progressively cheaper as the coding from one can be utilised on a further integration. Message formats can be effectively “translated” through a service plan, similar to a telephony account. We have found that SMEs tend to create bespoke and highly customised ERP systems which make it harder to integrate to a generic model.
- Transport suppliers are at a disadvantage in relation to convincing customers to adopt GDS, despite the cost associated with adapting formats that are customised for each customer. Data interchange may come from the customer’s 3PL supplier’s warehouse management system rather than the customer’s own system. Having **use cases that demonstrate the benefits of GDS** are an important tool for transport suppliers working with a number of customers. The solution is to **use a system integrator service**. The benefit of widespread adoption of GDS is that it would influence customers to standardise messages and remove the perception by suppliers that customisation of messages creates a competitive advantage, as opposed to the service delivery offerings derived from visibility being the strategic advantage.
- The **power of major customers** to influence transport suppliers to adopt standard messaging protocols will be the determining factor in the promulgation of GDS in Australian supply chain networks. The major FMCG retailers have e-commerce B2B platforms to interact with suppliers and it is anticipated that the norm will become compliance with GS1 messaging standards for B2B data interchange. Messages that relate to booking delivery windows at retailer distribution centres, aspects related to transport safety and Chain of Responsibility compliance, are likely to require GS1-compliant data interchange. During the pilot, Nestlé was notified of the requirement for all B2B transport messages with a major FMCG company to be GS1-compliant.
- **Concerns regarding security of shared data were not front of mind** for pilot participants. Each seemed confident that their existing arrangements were sufficiently robust. This may be attributed to the use of an intermediary platform to send and receive data from external systems during the pilots. The issue may be more evident in a fully integrated production environment or an international trade setting where institutional protections vary between countries.

4.5 Application of the GDS to Regulatory Activity

Linking transport assets to locations can enable improved fleet management and discharge of regulatory requirements, such as fatigue management, chain of responsibility and potentially, management of mass of containers and vehicles.

It also enables transport instructions to be issued from the shipper which establish the appropriate vehicle for the freight to be carried, avoiding freight being left at warehouses and depots or trucks being overloaded.

By transmitting the vehicle registration and driver identification to the customer receival site, the retailer or manufacturer is able to check that this vehicle is associated with not only the customer order and manifest data, but that this driver has completed a site Chain of Responsibility orientation and complies with the ALC Retail Logistics Code of Conduct (2011) and the National Logistics Code of Practice (2011), which cover scheduling and transit times, time slot management, safe loading practices including mass, dimension and load restraint, driver fatigue management including driver health and fitness for duty, speed compliance and vehicle safety.

In-cab telematics in the road freight sector is used to improve safety, efficiency and business processes. Data from such technologies is routinely shared between supply chains and their participants, driving efficiencies in scale and productivity and is being used to proactively manage compliance risks (National Transport Commission, 2013). Australian governments have already recognised that interoperability standards and platforms must be public, transparent and performance based, especially in the context of telematics.

According to the National Transport Commission (2013), governments should provide standards and policy directions to help facilitate supply chain interoperability. The regulatory framework being used for technologies such as telematics may provide useful insights into facilitating enhanced use of other technologies like GDS to further improve efficiency and productivity in the transport sector.

Ensuring that any relevant Commonwealth and State government related regulatory portals are GDS-compliant in transport and logistics grids at major airports and ports and they are consistently applied to the freight industry would be a major advance in ‘leading by example’ in relation to facilitating the adoption of GDS widely. This could extend to air and sea ports and intermodal terminals and their community systems as key points of interaction with the freight transport industry.

Adoption of GDS and the resulting data and information gathering/sharing capability can potentially help to better collect/share commodity/goods, tonnages and origin-destination data. Such data can be useful in strategic planning; monitoring of changing demand trends; trip distribution modelling; and corridor performance analysis.

Other potential benefits associated with the use of GDS include capacity optimisation and scheduling (terminals, network infrastructure), planning for investment (demand, network utilisation by freight, private sector data), linking real time compliance monitoring (container weights, transport security) and emergency management (real time response data).

4.5.1 Benefits of Improved Supply Chain Visibility to Road Transport Agencies

Road transport authorities in Australia and elsewhere collect a range of traffic data for managing day-to-day network operations, responding to accidents and incidents, providing information to road users and for longer-term network planning. In general, the sources of this data are stationary, fixed point measurement devices distributed across the road network (see BITRE, 2014).

Potentially, given the increasingly mobile nature of supply chain visibility devices (such as RFID sensors and readers), with appropriate enhancements, modifications and placements, they could have the ability to help collect information about travel patterns, travel routes etc. of the vehicles carrying products between different locations across the road network. For example, in a recent study, Bahga et al. (2013) have illustrated a novel cloud based IT framework, (described as ‘CloudTrack’), for data driven intelligent transportation systems. CloudTrack provides information of an entire fleet of food supply vehicles that can be used to track and monitor in real-time. This study demonstrates the feasibility of ‘CloudTrack’ as a scalable platform for data driven intelligent transportation systems, based on new cloud-based programming models and data structures.

There are several potential benefits if supply chain visibility technologies such as RFID can be appropriately used to collect road usage related data in the future. These benefits include reducing the cost of collecting transport-related data, expanding the range and increasing the accuracy of available transport-related data, providing better real-time information for network managers and users and better informing long-term planning of future infrastructure needs (See BITRE, 2014).

5. Promulgation of GDS in the Transport and Logistics Industry

It has been estimated that Australia's transport, postal and warehousing industry accounts for 10% of GDP and employs 618,900 workers (Department of Employment 2016). There were over 165,000 businesses with an estimated worth of at least $131.6 billion in 2013. In 2015, there were 196 Transport, Postal and Warehousing businesses with workforces larger than 100 employees, representing just over one percent of businesses in the sector. These businesses however employ 208,998 workers in 2015.[10] This figure represents more than one third of employment in the sector.

The structural characteristics of the industry, with a small number of firms doing the "heavy lifting" and a long tail of SMEs, are most relevant to delivering change in this industry and in framing strategies to bring about greater productivity. Membership of GS1 Australia, indicating the adoption of GDS, is 92 companies from this sector; that is 0.056 percent of the sector's businesses.

The adoption of GDS has to date largely been driven by major commercial partners perceiving the ability to gain business value, particularly in relation to visibility in global procurement and extended supply chains. It has also been driven by regulatory requirements for product traceability in pharmaceuticals, dangerous and prohibited goods and food products. Customer requirements for integration with major retailers' GS1-compliant systems and B2B portals (e.g. WOWLink; Coles Supplier Portal) strongly influence suppliers and in turn, transport and logistics service providers.[11]

In Australia, generally there has been a slow rate of uptake of GDS by the freight logistics sector. Figure 5.1 demonstrates the low uptake of GDS in the sector in comparison with other sectors in the Australian economy, indicated by their membership of the standards body, GS1 Australia. It is notable that one quarter of these member businesses are microbusinesses and around 16,000 have less than $50 million in revenue. There are 92 businesses in T&L with current membership of GS1, indicating a misalignment in adoption of data standards with their customers in other sectors such as retail and FMCG.

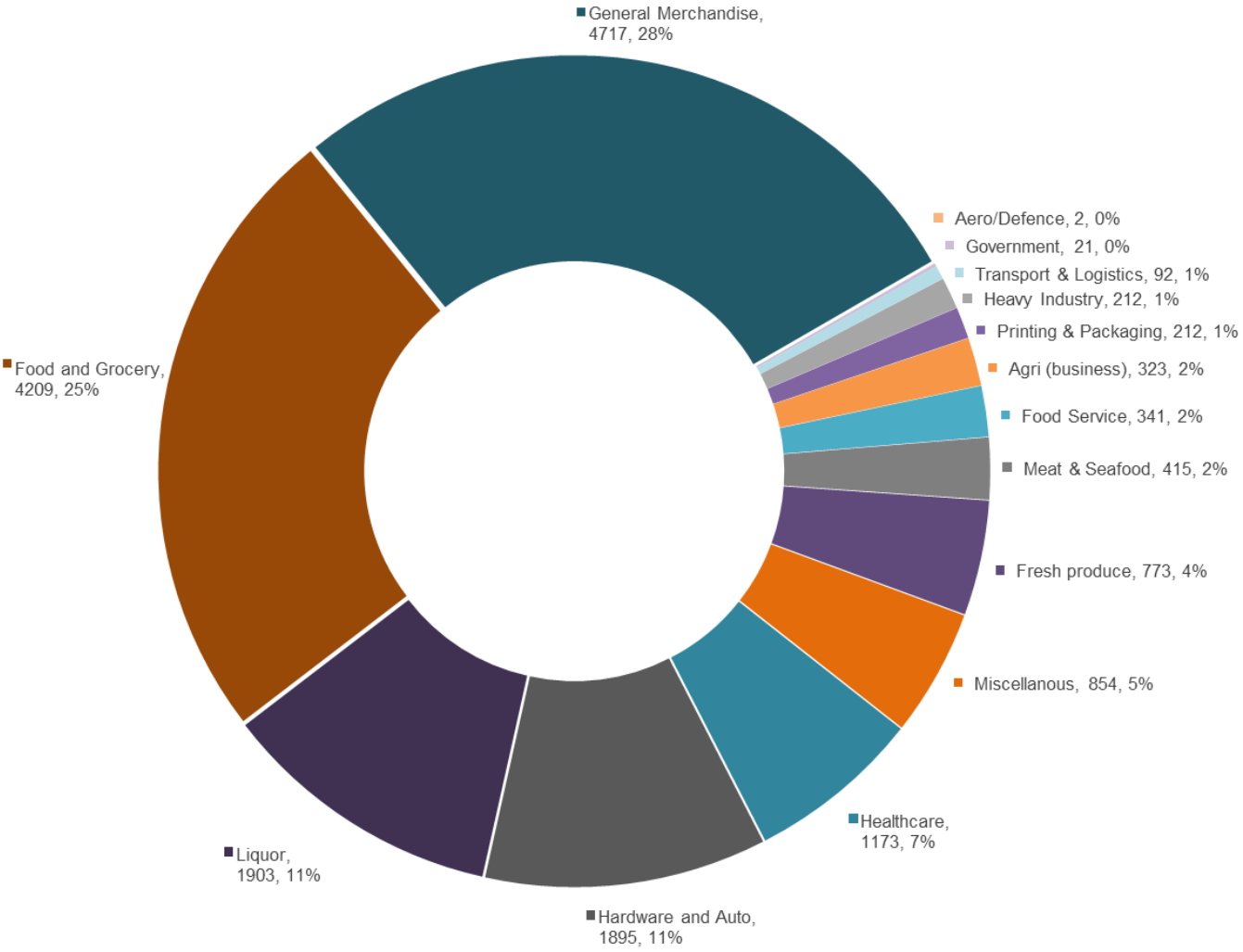
As a service provider to retailers or manufacturers, smaller transport companies often have limited opportunity to influence decisions on data standards for messaging. As the capability may not be embedded as a standard condition in contracts, the pilots found that the transport supplier is frequently entering multiple agreements to comply with different data formats. This lack of uniformity creates inefficiencies and costs for the service provider, much of which is internalised at the expense of productivity in the sector.

In order for GDS to progress as a tool for enhanced end to end supply chain visibility in Australia, a multi-pronged approach will be needed to support adoption. It is apparent that a Supply Chain Visibility Strategy that encourages leadership by larger companies, combined with support for small businesses, is required, given the structure of the industry. Customers and regulators also have a pivotal role to play in enacting the strategy by incorporating GS1 standards compliance in contractual and compliance requirements.

10 Workplace Gender Equality Agency, 2015.

11 Coles Supply Standards August 2016, https://www.supplierportal.coles.com.au/csp/wps/wcm/connect/b3a293804efaae1f8c6cdea6eb652d39/Coles+Supply+Standards_August+2016_iOS+Optimised+v10.pdf?MOD=AJPERES&CACHEID=b3a293804efaae1f8c6cdea6eb652d39
Woolworths Supply Chain https://www.wowlink.com.au/wps/portal/!ut/p/c1/04_SB8K8xLLM9MSSzPy8xBz9CP0os3izQB8jJydDRwMDA2djA6Mg_zDHsNBgYwN3U6B8pFm8n79RqJuJp6GhhZmroYGRmYeJk0-Yp

Figure 5.1: Current GS1 Australia membership by Industry Verticals



Source: GS1 Australia, 2016

Interoperability between systems and visibility across modes cannot be achieved without first identifying the freight, then capturing the events in the supply chain and then being able to share with partners to a common dashboard or through inter-partner messaging.

Each firm involved in the case studies took a sustained period of time to apply the standards to their business processes and then to share data to achieve interoperability. A firm does not simply “adopt” standards without activating a process that is essentially a business process improvement project. This also needs to be done in collaboration with partners who are aligned and concurrently participating in this process. Adopting new data standards to achieve visibility is inherently a shared activity, where partners agree the return on investment from their individual business cases will create value in their supply chain network.

This is not always the case for smaller partners who need to outsource capability, operate on very thin margins and have to juggle resources and priorities in their business. Adoption of standards may mean investment in business IT systems or new equipment capable of automating messaging, such as barcode or RFID sensors and readers. While equipment is not a major cost, retraining staff and changing business processes require resources and commitment.

5.1 Is There a T&L SME Solution?

The indicative benefit of a "vanilla" versus proprietary solution to messaging in the sector, which extends beyond visibility to immediate productivity bonus can be summarised in the following scenario, which is achievable with current technology.

The current reality for the owner-driver or small transport business is that the driver will carry multiple devices in order to send or receive data from customers. S/he is likely to carry POD devices that are capable of sending messages configured for the ERP system of the consignor; freight forwarder; customer's warehouse management system; the port community system; in addition to the fleet control system or home ERP system (scheduling, accounts, customer database). Often these devices simply convert information to an emailed PDF, requiring manual re-entry into an ERP.

The operator will then spend many hours associating the data with the company billing system and ensuring the hours and tasks are correlated with invoicing.

Using GDS, many hours can be saved and one generic device utilised, which would identify the driver, the vehicle, the aggregated freight on a pallet or in a container, and the items of freight transported.

If the data is based on the SSCC "number plate", which was scanned and automatically uploaded to the relevant systems, an automatic proof of delivery would be triggered along with payment to the transport supplier, saving numerous hours of administrative work.

The costs for the transport supplier would be incorporated in a telecoms bundle, with monthly plans including email, phone, data storage, global location numbers and transport applications. For companies with less than $20 million turnover, this would represent a sizeable benefit and significant lift in the productivity of the sector.

It is well recognised that the technology required for end to end supply chain visibility is already widely available. The case studies undertaken in this project have demonstrated this.

Furthermore, efforts have already been made to encourage the use of transport and freight labelling standards to embrace the rise of automated messaging in Australian supply chain networks. The ALC and GS1 Australia have recently launched the new Australian Transport Standards for Freight Labelling and EDI developed with the ALC Supply Chain Standards Work Group for the Australian Transport & Logistics Industry.[12]

An estimated 163,000 SMEs operate in the T&L Sector. GS1 has identified an average of five automated messages from T&L operators in a supply chain. The cost to fully integrate for each message in the non-GDS format required by each supply chain partner is a fixed cost of $100,000, based on the experience of the case study companies.

Using GDS to standardise these messages reduces this cost to $25,000, a reduction in the fixed cost of 75 percent.

Extrapolated across the SME base of the industry, this represents a significant productivity benefit.

5.2 Voluntary Introduction with Self-Regulation or Mandatory Approaches

A fundamental mismatch is evident between the Transport and Logistics sector and other sectors of the economy that depend on the services of T&L, in terms of capability to track and monitor tradable goods. This mismatch formed the impetus for convening the ALC Supply Chain Standards Working Group.

12 GS1 Australia, 2015, Australian Freight Labelling Guideline https://www.gs1au.org/resources/forms/request-to-access-australian-freight-labelling-guideline/

The Australian Transport Standards include the ALC-endorsed Australian Freight Labelling Guideline and Australian Transport EDI User Guides to provide one common label format to identify freight and one common file format to exchange data throughout the freight transportation process. The full transport data standards solution is detailed in Appendix A. These measures are expected to give an opportunity to improve freight efficiency and better connect all modes of transport in the Australian transport and logistics sector.

Any visibility/traceability related systems being used by SMEs at present may have limited recognition for GDS compliance-related applications. Also, the initial cost to install and use GDS and operational tools could be relatively high for some SMEs. These barriers need to be resolved for the SMEs (as they are a majority stakeholders in the transport and logistics industry) to consider adopting and using GDS for efficient operational and any compliance purposes in the future.

It is important to recognise that industry-wide large scale adoption of GDS in many sectors of the Australian economy to enhance end to end supply chain visibility standard will require a reasonably modest lead time (around five years at least). This will enable gradual phasing of the roll out of the visibility technologies and system integration tools. This may need to be supported by an industry facilitation program which will have budgetary implications. This will likely be the case in relation to many SMEs who may face potential relative cost burdens as barriers to adoption of GDS.

There are examples of mandatory introduction of data standards currently impacting the T&L industry. For example, mandating the GS1 global data standards to enable supply chain visibility is currently under implementation through government regulation for sensitive products in the health care and pharmaceutical sectors, where traceability and recall are matters of life and death.[13]

The implementation of the use of telematics can provide useful insights here. Some larger transport operators have recognised the valuable safety and commercial benefits of all vehicles in the supply chain operating with telematics. According to the National Transport Commission (2013), a mandatory requirement to install and use telematics is one of the few mechanisms through which smaller operators in the chain, notably in subcontracting operations, can be integrated into telematics-based systems. Other examples are the mandating of Customs EDI lodgement of import/export clearance documentation in the 1990s. It is unlikely that this change would have been industry-driven.

The case has not yet been proven in the T&L industry for the need to mandate the GS1 global data standards to enable supply chain visibility. The case studies have indicated a tangible benefit accrues to supply chains that have visibility activated through adoption of GDS. However, the case studies have not demonstrated short term benefit streams are evenly shared between supply chain network partners. In particular, small transport suppliers are struggling to capture the benefits in their own businesses. Mandatory introduction of the standards may create a burden on SMEs with limited capacity. Until further analysis is conducted on how SMEs can adopt an effective and affordable application of the standards, it may be pre-emptive to consider a mandatory response. Therefore, it is recommended that further studies of the benefit capture, costs and solutions for small transport operators be undertaken to shed more light on the impacts over time from adoption of GDS.

At a broader policy level, preparation of a Regulatory Impact Statement is warranted in relation to mandating visibility standards within the Sector, given the findings of this project.

It is apparent that Australia's manufacturers and retailers are in the early stages of implementing supply chain visibility. The nascent nature of this application of the standards reinforces the need to allow more time to assess the speed of industry adoption and the subsequent commercial requirements on logistics service providers to comply.

13 Health Purchasing Victoria (HPV) includes clauses for Contract Template and Tender Documents - https://www.hpv.org.au/assets/14-October-2015/2016-08-30-Guide-to-National-Product-Catalogue-Clause.pdf and Supporting Checklist and Fact Sheet for Suppliers & Distributors:
NPC Data Publishing Checklist - https://www.hpv.org.au/assets/VPCS/NPC-Data-Publishing-Checklist-for-Suppliers-and-Distributors-Fact-Sheet.pdf
Supplier Fact Sheet - https://www.hpv.org.au/assets/VPCS/Victorian-Product-Catalogue-System-Information-for-Suppliers-Fact-Sheet.pdf

Based on the calibre of benefits identified in the case studies from standardising event-based messages and creating supply chain visibility, benefits are likely to be of an order to justify an industry-based strategy to promulgate adoption, as opposed to mandatory adoption.

An example of an industry-driven standard was the adoption of the EAN-13 barcoding standard by major retailers in all global jurisdictions including Australia, having the scale and reach to influence this change. A proliferation of proprietary standards may have occurred without the leadership of major customers. With FMCG retailers requiring visibility, it is likely that standards will extend beyond product identification to supply chain events, including transport and storage.

5.3 Role of Governments

As businesses progress in the digital economy, new interactions between businesses and regulatory agencies which take advantage of the automated event data should be considered in the armoury of tools at each level of Australian government's disposal to address issues such as counterfeiting and guaranteed place-of-origin, authenticity and pedigree of products.

In the context of the recently announced National Freight and Supply Chain Strategy,[14] supply chain visibility and government agency access to this data for strategic transport network planning, is a consideration relevant to how governments might improve infrastructure planning.

It emerges that Commonwealth and State Governments (under the COAG framework) could consider two streams of activity in relation to the adoption of GDS to facilitate enhanced productivity in the transport and logistics industries:

- supporting industry understanding and uptake of GDS by working with transport and logistics peak bodies and the standards-providers
- conducting analysis on how GDS might be utilised in gathering data related to relevant regulatory and strategic transport infrastructure planning activities.

All levels of Australian governments have a strategic leadership role to play in encouraging the large scale use of GDS-compliant technologies.

Interoperability technologies (by harmonising the interpretation of the business processes, as well as standardising the structure and content of the data interchanges) can support multimodal transport options, enabling goods to remain visible regardless of the transportation mode. For governments seeking to **encourage modal choice**, this is a benefit.[15]

Governments can play an important role in **facilitating the uptake of digital business** by: providing incentives for e-business technology and systems uptake; promoting dissemination of information to increase awareness of e-business models; benchmarking and establishing performance indicators; encouraging private-public partnerships; and providing for common standards and linkages across all tiers of government.

Open standards and non-proprietary information exchanges enable seamless data transfer among entities along supply chains and in intermodal transport operations (Ferreira and Bunker, 2003). For example, the US Government is supporting the development of an open standards port information platform to enable open exchange of information between port users, in a bid to improve traffic congestion around major ports.[16]

14 http://minister.infrastructure.gov.au/chester/releases/2016/November/dc199_2016.aspx
15 Ferreira, L. and Bunker, J. 2003, The Role of Governments in Improving Freight Logistics in Queensland, Working Paper 1: A Review of Evidence. Queensland University of Technology (QUT) and Queensland Government (see http://eprints.qut.edu.au/2768/1/2768.pdf)
16 US Federal Maritime Commission (December 2016 http://www.fmc.gov/news/supply_chain_interim_status_report.aspx

Governments need to **support reliable telecommunications infrastructure** (for example, the National Broadband Network (NBN)) to enable the use of well-functioning ICT solutions in the transport and logistics industry to help harvest potential benefits of using GDS along supply chains by transport and logistics providers more widely.

Smaller companies which are often unaware of the benefits of ICT solutions in freight labelling and EDI, may not have the skills or knowledge for the implementation of the required technology. In regard to this, Governments may have a role in working closely with the industry to give **guidance/assistance on the adoption of required technologies in supply chain visibility and traceability to SMEs.**

Adoption of GDS and the resulting data and information gathering/sharing capability can potentially help to better **collect and share data on commodities and goods movement**, including tonnages and origin-destination data. Such data can be useful in strategic planning; monitoring changing trends; trip distribution modelling; and analysing transport corridor performance.

Other potential public benefits associated with the use of GDS include: capacity optimisation and scheduling (terminals; network infrastructure); planning for investment (demand; network utilisation by freight; private sector data); linking real time compliance monitoring (container weights; transport security) and emergency management (real time response data).

5.4 Leadership to Encourage the Use of End to End Supply Chain Visibility

As indicated earlier, industry sectors are likely to be motivated to adopt GDS for commercial gain, as customers or end customers demand visibility of events in their supply chains. Industry and government can support the leadership of major retailers through working together to promote the benefits of using GDS in collaboration with domestic industry peak bodies (such as freight forwarders; logistics associations; transport peak bodies, chambers of commerce etc.). The ALC Technology Committee and Supply Chain Standards Working Group in collaboration with the Australian Government should take a lead role in this regard.

6. Conclusions and Recommendations

The project achieved its objective of investigating the benefits of using end to end supply chain visibility technology using global data standards in real time industry pilots.

In relation to whether benefits will be achieved through adopting a national end to end supply chain visibility technology standard, the pilots have indicated that the benefits to Australian manufacturers, producers and traders from standardising event-based messages and creating supply chain visibility are apparent and of an order to justify adoption.

It is recommended that one common label format to identify freight and one common file format to exchange data throughout the freight transportation process should be encouraged to be used widely in the transport and logistics industry.

On the question of whether a standard should be mandated, the findings suggest that an industry-led adoption program be implemented in the first instance. As adoption of GS1 compliant product identification is currently being mandated in high-risk supply chains, this process will provide a model should industry-led adoption fail to reach critical mass within a period of five years.

It is recommended that peak bodies in T&L, retail and manufacturing work together in promoting the benefits of using enhanced visibility technologies through development of a Supply Chain Visibility Strategy with the support of relevant government agencies. It is further recommended that this Strategy be aligned with the National Freight and Supply Chain Strategy recently announced by the Australian Government.

It is evident that the majority stakeholders in the T&L industry are small enterprises. The research and pilots found that further study of the most cost-effective models for SME adoption require further research, given the majority of firms in the pilots were of medium to large size.

It is recommended that building on the evidence from this report, further case studies be conducted with SMEs to demonstrate best practice adoption and benefits for small logistics service providers.

Some smaller and medium sized companies which are often unaware of the benefits of ICT solutions in freight labelling and EDI, may not have the skills or knowledge for the implementation of the required technology. Practical examples of support for SMEs may include:

- peak industry bodies and GS1working with solution providers to provide SME solutions that are GDS compliant and promoting these solutions to small businesses in the transport industry
- encouraging transport companies and solution providers to utilise available incentives such as the innovation incentives (see https://www.ato.gov.au/business/large-business/in-detail/business-bulletins/articles/new-innovation-incentives-for-investors/) as a means to accelerate uptake within industry
- pilots/proof of concepts within federal/state departments (with a reasonable logistics component) in trialling/utilising the industry standard
- preparation and dissemination of a standard contract clause wording for freight and logistics tenders that articulate the data standard.

In relation to the issues that exist with practical implementation of visibility technology and how they can be addressed, the finding is that SMEs will require support to resolve barriers associated with a lack of compatible data formats and inter-operable IT system capabilities.

It is recommended that consideration be given to resolving barriers experienced by logistics service providers, particularly SMEs as visibility/traceability related systems being used by some SMEs at present may have limited recognition for standards-compliant applications.

Network capacity to support data automation and messaging can be enhanced by improved telecommunications networks.

It is recommended that governments continue to support reliable telecommunications infrastructure (for example, the National Broadband Network (NBN)) to enable the end to end use of enhanced visibility technologies in the transport and logistics industry.

Privacy issues concerning data security being shared by multiple firms can be a potential challenge that is likely to confront the wide spread adoption of visibility and traceability related technologies. Such issues require guidance from relevant regulatory authorities as part of the broader digital business developments.

It is recommended that data security protocols related to collaborative arrangements required for supply chain visibility be reviewed and included in guidance for GS1-certified suppliers and participants.

In relation to who should assume a leadership role, to encourage the widespread adoption of such technology, it is apparent that T&L customers will play a leading role, in collaboration with major logistics service providers, in incorporating visibility requirements including data standards, into commercial transactions. Through the development of a Supply Chain Visibility Strategy, industry leaders will be supported by a pathway to achieve visibility at an industry level. This will provide the “pull” for implementation, while an SME facilitation program will provide the “push”. Adoption of global data standards will be best achieved through an industry-led Supply Chain Visibility Strategy, as opposed to mandatory introduction through government regulation.

It is recommended that T&L customers, along with major logistics service providers, provide the leadership for a Supply Chain Visibility Strategy. As part of that Strategy, T&L peak bodies and governments work together to provide facilitation of SME capability to adopt visibility standards.

References

ACIL Allen Consulting, 2014, *The Economic Significance of the Australian Logistics Industry*, Australian Logistics Council, www.austlogistics.com.au.

APEC (Asia Pacific Economic Cooperation) forthcoming, *Final Report Study on the Application of Global Data Standards for APEC Supply Chain Connectivity*, APEC Policy Support Unit, Prepared by the Institute for Supply Chain and Logistics, Victoria University.

Australian Logistics Council, 2011, *Retail Logistics Supply Chain Code of Conduct V1* https://www.nhvr.gov.au/files/201412cop-rlsc-code-of-practice.pdf

Australian Government, 2014, *Freightline 1*, Department of Infrastructure and Regional Development, BITRE https://bitre.gov.au/publications/2014/files/Freightline_01.pdf

Bahga, A. and Madisetti, V. K., 2013, 'Cloud-Based Information Technology Framework for Data Driven Intelligent Transportation Systems', *Journal of Transportation Technologies*, 3, pp. 131-141.

Bernstein, PA & Haas, LM, 2008, 'Information Integration in the Enterprise', *Communications of the ACM*, vol. 51, no. 9, pp. 72-9.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2014), *New traffic data sources – An overview*, Paper prepared in support of proposed BITRE/IPA joint workshop: 'Exploring New Sources of Traffic Data', 26 May 2014, Sydney (see https://bitre.gov.au/events/2014/files/NewDataSources-BackgroundPaper-April%202014.pdf)

Ebel, T *et al*, 2012, *Strength in unity: The promise of global standards in health care*, October, McKinsey & Company, (see http://www.gs1.org/docs/healthcare/McKinsey_Healthcare_Report_Strength_in_Unity.pdf)

Federal Maritime Commission US, 2016, *FMC Supply Chain Innovation Teams Interim Status Report*, Executive Summary, 6 December 2016, (see http://www.fmc.gov/news/supply_chain_interim_status_report.aspx)

Ferreira, L. and Bunker, J., 2003, *The Role of Governments in Improving Freight Logistics in Queensland: Working Paper 1: A Review of Evidence*, Queensland University of Technology (QUT) and Queensland Government. (see http://eprints.qut.edu.au/2768/1/2768.pdf)

Good, L., Gahan, P. and Dehghan, S. 2015, Leading technological innovation and productivity improvement across the supply chain, An evaluation of the Industry Pilot of the GS1 Electronic Product Code Information Service (EPCIS) Standard. Melbourne: Centre for Workplace Leadership, University of Melbourne. http://www.workplaceleadership.com.au/publications/leading-technological-innovation-productivity-improvement-across-supply-chain/

Grover, V & Saeed, KA 2007, 'The Impact of Product, Market, and Relationship Characteristics on Interorganizational System Integration in Manufacturer-Supplier Dyads', *Journal of Management Information Systems*, vol. 23, no. 4, pp. 185-216.

GS1 Australia, 2015, *Australian Freight Labelling Guideline*, https://www.gs1au.org/resources/forms/request-to-access-australian-freight-labelling-guideline/

Harris, I, Wang, Y. and Wang, H. 2015, 'ICT in multimodal transport and technological trends: Unleashing potential for the future', *International Journal of Production Economics*, 159, pp 88-103.

IBM, 2012, White Paper: How enabling supply chain visibility can improve the bottom line, January, IBM Corporation USA.

Kilgariff, M. and Brown, K. 2012, 'ALC Supply Chain Standards Working Group', Presentation to the Supply Chian Week 2012 (http://www.austlogistics.com.au/wpcontent/pdf/presentations/SCW_TL_Session5_ALC_DRAFT_MKilgariff_KenBrown_Sep2012.pdf)

Lun, YHV, Wong, CWY, Lai, KH & Cheng, TCE 2008, 'Institutional Perspective on the Adoption of Technology for the Security Enhancement of Container Transport', *Transport Reviews*, vol. 28, no. 1, pp. 21-33.

Malhotra, A, Gosain, S & Sawy, OAE 2007, 'Leveraging Standard Electronic Business Interfaces to Enable Adaptive Supply Chain Partnerships'*, Info. Sys. Research*, vol. 18, no. 3, pp. 260-79.

Murtaza, M & Shah, JR 2004, 'Managing Information for Effective Business Partner Relationships', *Information Systems Management*, vol. 21, no. 2, pp. 43-52.

Nettsträter, A, Geißen, T, Witthaut, M, Ebel, D & Schoneboom, J 2015, 'Logistics Software Systems and Functions: An Overview of Erp, Wms, Tms and Scm Systems', in M ten Hompel, J Rehof & O Wolf (eds), *Cloud Computing for Logistics*, Springer International Publishing, Cham, pp. 1-11, DOI 10.1007/978-3-319-13404-8_1, <http://dx.doi.org/10.1007/978-3-319-13404-8_1>.

Rai, A, Patnayakuni, R & Seth, N 2006, 'Firm Performance Impacts of Digitally Enabled Supply Chain Integration Capabilities', *MIS quarterly*, pp. 225-46.

Semianiaka, N. and Silina, E. 2012 *'The role of global data identification standards for supply chain visibility: the case of GS1'*, Master of Science Thesis ME200X 2012:148, KTH Industrial Engineering and Management Industrial Management SE-100 44, Stockholm. (see http://www.diva-portal.org/smash/get/diva2:578565/FULLTEXT01.pdf%E2%80%8E)

Tongzon, J, Chang, Y-T & Lee, S-Y 2009, 'How Supply Chain Oriented Is the Port Sector?', *International Journal of Production Economics*, vol. 122, no. 1, pp. 21-34.

Truman, GE 2000, 'Integration in Electronic Exchange Environments', *Journal of Management Information Systems*, vol. 17, no. 1, pp. 209-44.

Tseng, P-H & Liao, C-H 2015, 'Supply Chain Integration, Information Technology, Market Orientation and Firm Performance in Container Shipping Firms', *The International Journal of Logistics Management*, vol. 26, no. 1, pp. 82-106.

United Nations Global Compact and BSR 2014, *A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains*, UN, New York.

Webb, BR & Schlemmer, F. 2008, 'Predicting Web Services Performance from Internet Performance: An Empirical Study of Resources and Capabilities in E‐Business Smes', *Journal of Knowledge Management*, vol. 12, no. 6, pp. 137-55.

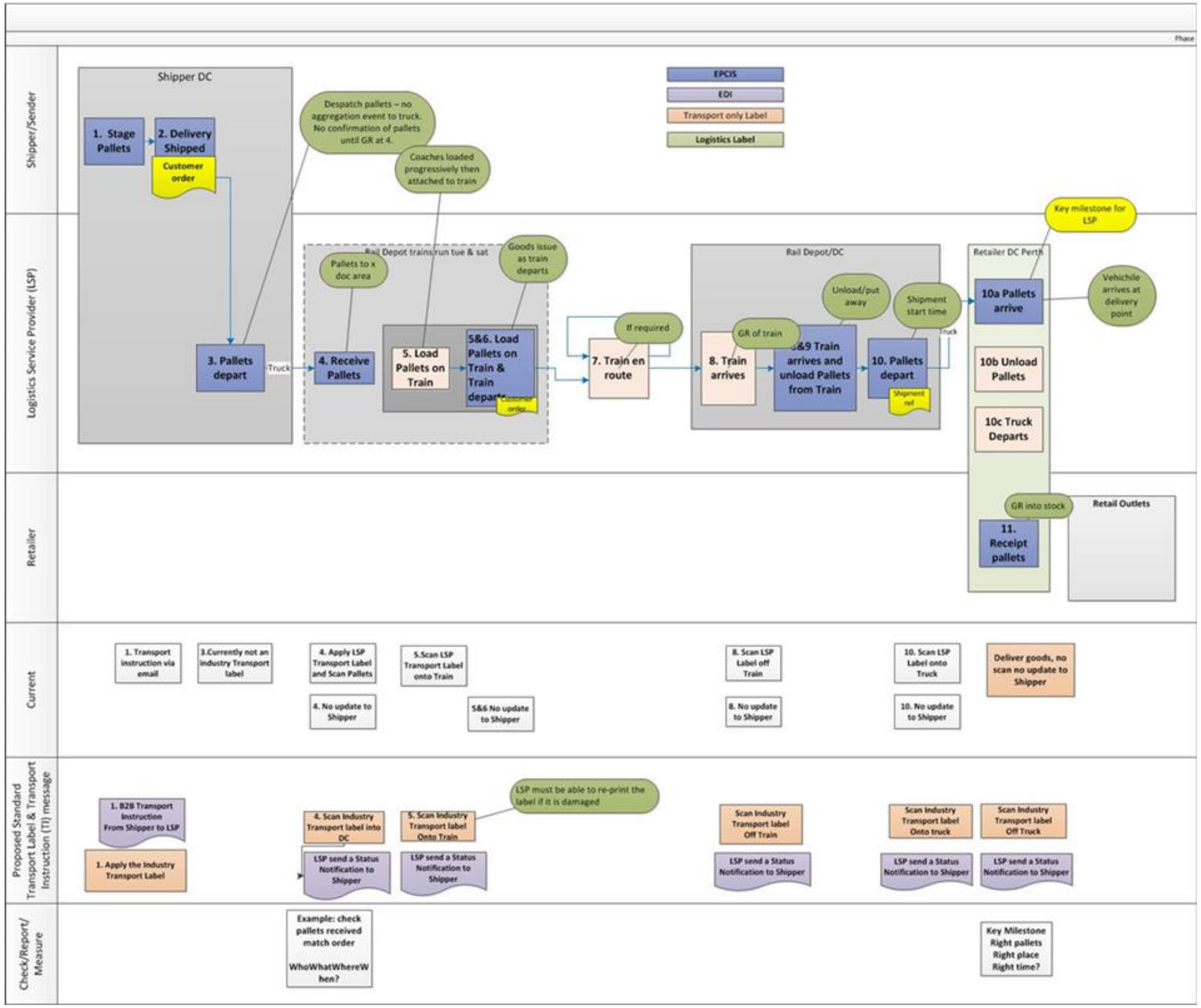
Williams J. 2013, *Developing a Compliance Framework for Heavy Vehicle Telematics – Discussion paper*, December, National Transport Commission, Australia. (see https://www.ntc.gov.au/Media/Reports/(5973CD25-4A5D-6EF8-F057-6DEA0233B901).pdf).

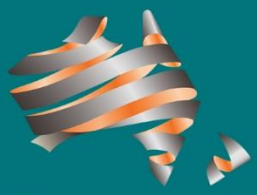
Wong, CW 2013, 'Leveraging Environmental Information Integration to Enable Environmental Management Capability and Performance', *Journal of Supply Chain Management*, vol. 49, no. 2, pp. 114-36.

Wong, CWY, Lai, K-h & Teo, TSH 2009, 'Institutional Pressures and Mindful It Management: The Case of a Container Terminal in China', *Information & Management*, vol. 46, no. 8, pp. 434-41.

Zhu, K., and K.L. Kraemer 2002, ‘e-Commerce metrics for net-enhanced organizations: Assessing the value of e-Commerce to firm performance in the manufacturing Sector,’ *Information Systems Research* 13(3), 275-295.

Appendix A GS1 Supply Chain Visibility System





Austroads

Level 9, 287 Elizabeth Street
Sydney NSW 2000 Australia

Phone: +61 2 8265 3300

austroads@austroads.com.au
www.austroads.com.au