FREIGHT DATA EXCHANGE PILOT PROJECT 3

Freight Consignment Data Aggregation

Pilot Project Report

July 2020

Australian Government
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iMOVECRC

GS1 Australia

FOREWORD

In late 2019, the Australian Government, in cooperation with iMOVE and selected industry partners, commenced work on a joint Freight Industry Data Exchange Pilot, aimed at improving the visibility of and access to freight consignment event message information across all parties involved in the handling and transport of several different product supply chains.

The Freight Data Exchange Pilot was designed as three separate but interrelated pilot projects:

- Pilot Project 1: Supply Chain Freight Data Trial;
- Pilot Project 2: Multimodal Supply Chain Trial; and
- Pilot Project 3: Freight Consignment Data Aggregation Pilot Project.

The two Supply Chain Pilot Projects (Pilot Project 1 and 2) were intended to develop and demonstrate the capability for supply chain partners to access freight data in real time, and thereby improve end-to-end supply chain visibility and productivity. The Data Aggregation Pilot Project (Pilot Project 3) was designed to utilise a sample of real-time consignment data to demonstrate the potential of aggregated freight consignment outputs to help inform infrastructure planning and policy.

This report describes and presents the key findings of Pilot Project 3. The results demonstrate the potential uses of aggregated freight supply chain message data and also highlight some of the institutional and technological issues involved in the broader collection and use of such data.

The report was prepared by a joint iMOVE–BITRE project team comprising David Mitchell and Surya Prakash (BITRE), Earl Lappen (iMOVE Australia and GS1) and Emilie Alexandre and Lee-Ann Breger (iMOVE Australia). [1] The report was prepared by David Mitchell, Surya Prakash and Earl Lappen. iMOVE Australia and BITRE would like to thank and acknowledge the assistance of participating industry operators, including Woolworths, Nestlé, Toll Holdings, Infrabuild and GS1 Australia, in providing initial direction to the project. All results and findings are those of BITRE and iMOVE Australia and should not be attributed to the project industry partners.

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AT A GLANCE

Electronic data interchange (EDI) systems are used across businesses to facilitate intercompany communication of business documents, including purchase orders, invoices and transport of freight consignments between supply chain parties, which is the focus of this study.

The primary objective of the Freight Consignment Data Aggregation pilot project was to assess the feasibility and utility of aggregating freight consignment event/message data in producing aggregate outputs that potentially help inform infrastructure planning and policy priorities.

There are multiple EDI systems and standards used across industry. This study used freight consignment information from GS1's Business Message Standard, in particular GS1's Transport Instruction, Transport Status, and to a lesser extent EPCIS, messages standards.

Project-specific methods and systems were developed to:

i. **extract** freight consignment-related data from raw business messages
ii. **store** extracted freight data in a relational database for subsequent aggregation
iii. **aggregate** stored freight consignment data to demonstrate potential outputs.

Due to the impact of the COVID-19 pandemic, however, the project team obtained only a small sample of actual freight consignment messages. This small sample was used as a *seed* in generating a larger (synthetic) sample of freight consignment messages.

The demonstration project outputs highlight the potential of EDI-based freight consignment data, if available at sufficient scale, to augment or potentially replace data collected using traditional survey-based collection methods.

Examples of aggregate outputs that can be produced from such data include:

i. total freight volumes, by origin–destination, commodity and transport mode (where captured)
ii. total and average freight handling times
iii. variability in freight handling times. The data could be used to help identify systematic freight delays or bottlenecks.

The project outcomes suggest several areas for potential further work. These include:

- Developing minimum freight consignment data set standards that would enable the direct sharing of real-time freight consignment data between supply chain partners.
- Developing minimum data transfer technology standards/platform to automate real-time sharing of data between supply chain partners—e.g. via API protocols.
- Developing EDI data transformation standards and tools to facilitate easier exchange of business data, particularly freight supply chain information, across different EDI systems and between different freight supply chain partners.

SUMMARY

HARNESSING FREIGHT DATA TO IMPROVE DECISION-MAKING

NATIONAL FREIGHT DATA HUB

The Australian Government is in the process of developing a business case for the development of a National Freight Data Hub (NFDH). The aim of the NFDH is to provide information about freight movements and infrastructure use across Australia, to help freight industry operators, governments and the broader community better understand the freight system, support day-to-day operations and better plan for the future.

The NFDH is currently consulting with key stakeholders to identify key data priorities. These, in turn, are informed by a set of *enduring* questions regarding the effectiveness, efficiency, resilience and overall performance of Australia's freight transport system. Key foundational data priorities include: network traffic volumes, freight volumes, freight vehicle fleet information, infrastructure location, capacity and condition, and freight transport costs.

FREIGHT DATA EXCHANGE PILOT PROJECTS

Industry cooperation and engagement is essential to the success of the NFDH. Industry holds information about how the freight transport system is used—freight volumes, freight vehicle use, routes used and transport costs. Equally, industry is likely to be the major beneficiary of any productivity improvements that can be achieved through improvements in information availability across supply chains.

Recognising that the increasing use of electronic data exchange across supply chain partners is a potential information source about freight movements, the Australian Government initiated three related Freight Data Exchange (FDE) pilot projects—two 'supply chain' pilots and one 'data aggregation' pilot. The aims of the FDE pilot projects was firstly to investigate how to increase the *visibility* of individual freight consignments, to supply chain parties, as consignments move through the supply chain and secondly investigate how aggregate information, useful to inform planning, could be derived from supply chain messages.

The two 'supply chain' pilot projects:

- Pilot Project 1: Supply Chain Freight Data Trial – involving transport of consumer goods from producer to retailer
- Pilot Project 2: Multimodal Supply Chain Trial – involving transport of steel products from supplier to customers

were intended to identify protocols and standards required to enable the automatic sharing of business information between supply chain partners, so as to establish 'continuous visibility' of each consignment across the supply chain, i.e. from purchase order initiation to sign-off for delivery. At present, freight consignment status is apparently not readily visible when custody passes between supply chain partners. Improved visibility would potentially support, for example, better inventory management and control across retail outlets, distribution centres and in transit—e.g. maintenance of adequate 'shelf stocks' at points of retail sale and minimising while minimising transport costs and inventory-in-transit.

The Freight Consignment Data Aggregation pilot project (Pilot Project 3 – this project) aims were to develop some demonstration outputs, from a sample of data collected through projects 1 and 2. In the event, only a small sample of data was obtained through projects 1 and 2, which the project team leveraged to synthesise a larger sample of (synthetic) freight consignment messages.

ELECTRONIC SUPPLY CHAIN DATA CHARACTERISTICS

Several EDI systems and standards are used across industry. This study used freight consignment information from GS1's Transport Instruction (TI), Transport Status (TS) and EPCIS (Electronic Product Code Information Services)[2] message standards, part of GS1's Business Message Standard.

TI messages are used to convey relevant information about cargo that needs to be moved and include information about the consignor/shipper, consignee/receiver, origin and destination locations, cargo type, cargo volume and weight, request transport service (transport mode), and planned pick-up and delivery dates/times, among other elements.

TS messages are used to query and report relevant information about the current status of a freight consignment. A single freight consignment may have multiple TS notification messages, providing a complete record of the process involved in transporting a consignment between consignor (or shipper) and consignee (or receiver). Information contained in TS messages include actual pick-up and delivery locations and times, and information about each transport leg, including mode of transport and vehicle type.

Each TI message may be combined with one or more related TS messages, linked by either unique consignment/shipment code, to provide a picture of the entire transport supply chain for any single consignment/shipment. Once aggregated, this information can provide insights into freight use of the transport network, providing some of the foundational data to support the NFDH.

GS1's business message system also includes uniquely identifying keys covering business entities and locations, and unique identifiers for consignments, shipments, logistic units and transport assets.

DISTINGUISHING BETWEEN CONSIGNMENTS AND SHIPMENTS

In the GS1 transport messaging system, the terms 'consignment' and 'shipment' have specific and slightly different meanings (Box 2.1, in Section 2, explains the GS1 distinction between the two concepts.) Throughout the report, the term *freight consignment* is used to refer more generally to the movement of a defined freight cargo (consignment or shipment) between supply chain partners.

FREIGHT CONSIGNMENT MESSAGE AGGREGATION SYSTEM

The project team developed a simple system to extract project-relevant freight consignment data from raw TI/TS messages, store multiple messages for later use, and standard query sets to derive aggregate system outputs.

[2] EPCIS is the GS1 [ISO/IEC 19987] standard designed for electronic exchange of physical event based visibility & traceability data.

TI/TS MESSAGE EXTRACTION FUNCTIONS

TI and TS messages conform to an extensible markup language (XML) format. A simple suite of functions was developed for the project to extract relevant data items from each of TI request, TI response, TS request and TS notification functions, to a flat data structure for subsequent uploading to a data store.

Key TI message data items extracted include:

- Consignor (or shipper) location (specified by unique Global Location Number - GLN[3])
- Consignee (or receiver) location (GLN)
- Consignment identifier (if applicable)
- Shipment identifier(s) (if applicable)
- Logistic unit (container/pallet) details
  - Logistic unit identifier(s)
  - Package type
  - Quantity
- Cargo characteristics
  - Cargo type code
  - Cargo type description
  - Gross volume/weight
  - Quantity (number of units)
- Transport instructions (if any)
  - Transport mode
  - Origin (pick-up) location
  - Destination (delivery) location
- Planned departure time
- Planned arrival time

Key TS message data items extracted include:

- Consignor (or shipper) location (GLN)
- Consignee (or receiver) location (GLN)
- Consignment identifier (if applicable)
- Shipment identifier(s) (if applicable)
- Transport movement characteristics
  - Sequence number
  - Transport mode
  - Transport carrier details
  - Transport equipment (e.g. vehicle type) – if available
  - Route identifier
- Actual departure time

[3] GLN (Global Location Number) is the GS1 [ISO/IEC 6523] standard for unique identification of locations, parties or entities.

- Actual arrival time

TI/TS AGGREGATE DATA STORE AND QUERIES

Extracted TI and TS message data were stored in a set of inter-related tables in a standard relational database, which was designed specifically for the current project. The design database table structure and content broadly aligned with the TI/TS message architecture, i.e. broadly there is a separate table for each major *class* within each TI and TS message:

- TS header – Message sender, receiver and document id requests
- TS consignment – TS consignment identifying information
- TS shipment – TS shipment identifying information
- TS transport movement – transport arrangements for each consignment or shipment, including actual transport mode used, planned and actual logistic event locations and datetimes
- TS cargo – one or more cargo units itemised in a consignment or shipment.

Most of the transport movement-related information is stored in the transport movement table.

Aggregate data extraction is then a simple matter of querying across relevant tables and summing results.

CREATING A SYNTHETIC DATA SAMPLE

As already noted, due to the impact of the COVID-19 pandemic on industry priorities, the project obtained only a very small sample of *raw* freight consignment messages from industry. The project team used this small sample to generate a larger *synthetic* data set which it could use to produce reasonable demonstration outputs. (The latter activity was not part of the original project plan.)

Five example freight consignment scenarios were considered, covering a range of typical Australian freight supply chain configurations:

- a single-stage, single-mode freight consignment scenario
- a multi-stage, single-mode freight consignment scenario
- two multi-stage, road and rail freight consignment scenarios
- a multi-stage, road and sea freight consignment scenario.

A larger data sample of synthetic raw messages were then generated for each scenario by applying probability distributions to key message elements—e.g. departure/arrival times, commodity type, freight volume, etc.—and randomly drawing observations.

DEMONSTRATION OUTPUTS AND POTENTIAL USES

The principal objectives of this pilot project were to investigate the feasibility of aggregating raw freight consignment event/message data, and develop prototype methods and systems to produce aggregate outputs that would help inform infrastructure planning and freight policy development.

Key questions that aggregate freight consignment message data could potentially answer include:

- What and how much freight is moved (by commodity, volume, mass)?
- Where does freight move? How much freight is moving between origin–destination pairs?
- What transport mode(s) are used to move freight? What types of freight vehicles are used?

- What routes and corridors are used to transport freight?
- When does freight move? What is the average travel time for freight moving between specific origin-destination pairs?

Freight consignment message data could also potentially provide some freight supply chain-related performance measures, such as:

- Average transit time for freight consignments between specified origin–destination pairs
- Typical variations in transit time for freight consignments between specified origin–destination pairs
- The proportion of freight consignments delayed or late
- Whether there are identifiable systematic (network-related) delays to freight consignments, and if so where?
- Is it possible to estimate, in real time, the ETA for a freight consignment observed at some point in time?
- What proportion of freight consignments are unable to be delivered (failed deliveries)?

The demonstration outputs presented in Section 4 show that it is indeed readily possible to answer almost all of the above-listed questions from either a combination of GS1 TI and TS messages, or separately with GS1 EPCIS data. In particular, it's possible to generate total freight volumes, by mode and broad freight commodity type, and freight volumes between origin–destination pairs. It's also possible to draw reasonable inferences about freight volumes on particular routes or corridors from aggregated message data.

Aggregated freight consignment message data can also provide insights about freight travel times between different freight locations and across key freight corridors, particularly useful for urban operation. Example metrics featured in this report include:

- average travel times and travel time distribution for specified freight origin–destination pairs
- variations in average travel time by time of day
- average travel times for common freight routes and/or freight corridors
- estimated time of arrival (ETA) by time of day, based on historical message information.

In theory, it should also be possible to combine freight consignment message data with freight vehicle GPS information—using either vehicle identifying information or departure/arrival times and locations—and use vehicle GPS trace data to provide real-time tracking of the physical location of freight consignments and/or aggregated data on network infrastructure use. Matching freight consignment messages and vehicle GPS data, however, would pose significant technical challenges and require the cooperation of both supply chain parties and telematics service providers.

INSIGHTS AND FUTURE PRIORITIES

This project's outcomes demonstrate that extracting and aggregating freight-related outputs from freight consignment messages is eminently feasible and relatively straightforward. Moreover, aggregating a sufficiently large and representative sample of freight consignment data could potentially help answer some of the enduring questions and foundational data priorities identified through the NFDH, particularly around freight volumes and freight system performance measures.

Further work is required to address issues identified but not resolved through this study, and the two supply chain pilot projects. These include:

System testing using *real* freight consignment message data

Due to external circumstances, this study was forced to use 'synthetic' data to develop prototype data extraction and storage methods, and demonstration outputs. An obvious next step would be to test the methods and systems developed for this report using a significant sample of *actual* freight consignment messages.

Developing real-time data visibility

This report has illustrated potential *static* freight performance measures that can be derived from freight consignment messages, which are suitable for informing planning and tracking performance, however, these do not address the real-time supply chain visibility needs of industry. Real-time visibility and real-time alerts of supply chain disruptions would arguably deliver greater potential economic benefits, through improved business productivity and reduced economic costs.

Trial of a pilot system that provides real-time visibility of freight consignment messages, including early alerts of disruptions to freight consignments or status updates to freight supply chain partners on the condition of sensitive or perishable freight consignment, remains a potentially high value piece of work.

Improving cross-industry connectivity and interoperability

While this pilot project used data supplied in GS1's business message standard, the project team is aware that there are other business communication standards and systems used across different industries. Even prior to the impact of COVID-19, pilot project industry partners encountered difficulties in linking freight consignment data across their disparate transport management IT systems, often for want of common consignment identifying information across systems. Moreover, anecdotal reports suggest many (smaller) industry operators do not use EDI and that there is significant 're-keying' of information across industry.

A potentially useful action would be to survey the transport and logistics sector, and supply chain partner industries, to better understand current industry EDI capability and use in Australia. Aspects to be considered include the number of different EDI frameworks and systems that are currently in use within the freight and logistics industry, and the extent to which different systems are able to exchange messages digitally, and the extent of information re-entry across the sector.

The European Union has acknowledged the impact of the numerous different business communication standards on freight forwarders and carriers through several recent freight projects. Several of these initiatives have proposed development of de-centralised infrastructure and tools to more easily exchange information between different EDI message frameworks—in effect, an open library of data transformation protocols that would facilitate ready translation of information between different EDI messages formats. Such an initiative may also have benefits for Australian industry.

Identifying minimal freight data exchange requirements

Finally, the outcomes of the project suggest that a common, *minimal* set of data is required in messages exchanged between supply chain parties.

Such a minimal subset of information required to exchange freight might include as little as:

- Consignment/shipment unique identifier
- Pick-up location
- Pick-up date/time (planned and actual)
- Freight type
- Freight volume/mass
- Delivery location
- Delivery date/time (planned and actual)

Enabling exchange and display of a minimal information set, from across multiple disparate systems, via a single software application is another potential means of increasing the visibility of freight consignment information across all supply-chain partners (e.g. ‘Get the App, Close the Gap’). This would require development of the data transformation tools identified above to automatically translate information between different EDI message formats.

INTRODUCTION

The Australian Government is in the process of developing a business case for the development of a National Freight Data Hub (NFDH), in accordance with the National Freight and Supply Chain Strategy (Transport and Infrastructure Council 2019). The aim of the NFDH is to provide information about freight movements in Australia, in order to help freight industry operators, governments and the broader community, better understand the freight system, support day-to-day operators and better plan for the future.[4]

The NFDH is currently developing a strategy and identifying key data priorities, in consultation with key stakeholders. The strategy and key data priorities are informed by a set of *enduring* questions regarding the effectiveness, efficiency, resilience and performance of Australia's freight transport system. Foundational data priorities include: network traffic volumes, freight volumes, freight vehicle stock, infrastructure location, capacity and condition, and freight transport costs.

The broader scope of the NFDH includes projects to:

1. harness existing freight data collections and increase the visibility and accessibility of those collections,
2. funding collection of key freight-related data essential to continued regulatory arrangements, and
3. pilot studies to investigate alternative data sources and develop frameworks for improving data collection and data sharing.

Examples of the latter include a project to include a universal register of freight-related locations for use by industry and a series of Freight Data Exchange (FDE) pilot projects (this project).

FREIGHT DATA EXCHANGE PILOT PROJECTS

The FDE pilot projects were originally intended to investigate and test the real-time exchange of electronic shipment/consignment data between supply chain partners to:

i. improve real-time visibility of supply chain movements,
ii. provide early warning of any problems with particular consignments, and
iii. test the mechanisms by which real-time data exchange could be implemented (e.g. Application Programming Interfaces – APIs).

Some supply chain parties report they have limited visibility of their goods when a shipment leaves their custody and is in the hands of a supply chain partner or transport agent. Part of the issue appears to be that different parties use different logistics tracking systems, often unconnected across adjacent supply chain partners. A range of different industries have developed business information structures and protocols to support seamless supply chain communication (see, for example, Section 2), nonetheless a lack of visibility persists. The inability to link information across supply chain partner systems impedes visibility of freight consignment information across the supply chain.

[4] Development of the NFDH was informed by the 2019 iMOVE Cooperative Research Centre review of Australia's freight data needs (iMOVE Australia 2019).

The potential productivity benefits and cost savings of improved real-time visibility of freight consignments across supply chain parties are likely significant. Benefits include eliminating the need for manually re-entering freight consignment information, reducing the time to accept and proof documents, and facilitating earlier warnings and more timely response to supply chain disruptions or breakdowns.

The second aim of the FDE pilot projects was to assess the feasibility and utility of aggregating freight consignment message/event data to produce outputs that can help inform network operations, infrastructure planning and freight transport policy—which are among the core foundational data priorities of the NFDH. One of the potential immediate uses of aggregated consignment data would be to augment or replace traditional freight survey data (see Box 1.1).

BOX 1.1 – TRADITIONAL VS. NEW FREIGHT DATA SOURCES

Freight data has historically been collected using large scale sample surveys. Such surveys, however, are expensive, infrequent and often there is a significant time lag between collection and availability of survey results. Furthermore, sample surveys, while providing reliable information about trends in total road freight at national and state/territory level, are unable to provide the reliable, detailed information required to inform infrastructure planning and investment decisions at the local level.

Harnessing EDI-based freight consignment data and event messages offers a potential alternative source of data that could augment or ultimately replace traditional survey-based collection methods.

For example, BITRE has been collecting GPS-based telematics data from a small number of participating freight operators for over 18 months. That data provides detailed information about freight vehicle use of the network, places where freight vehicles are significantly affected by road congestion and common places where freight vehicles stop. The data has yielded significant insights into the uses and applications of such data and the development of methods and systems to collect, store and transform such data into policy-relevant information. Freight vehicle telematics data, however, does not provide any information about whether a freight vehicle was laden, nor the volume and type of freight carried.

Freight consignment data collected as a by-product of electronic data exchanged between supply chain partners would, if collected at sufficient scale, potentially provide an alternative means of collecting freight data, more regularly and more frequently, and better inform freight-related network planning, infrastructure investment and freight policy.

FREIGHT DATA EXCHANGE SUPPLY CHAIN PILOT PROJECTS

Two ‘supply chain’ pilot projects, involving cooperating industry partners, were designed to progress the industry-focused outputs of the project. These were:

- Pilot Project 1: Supply Chain Freight Data Trial – involving transport of consumer goods from producer to retailer
- Pilot Project 2: Multimodal Supply Chain Trial – involving transport of steel products from supplier to customers.

Due to the impact of the COVID-19 pandemic on industry partner priorities, as well as difficulties in linking consignment information across supply chain parties, Pilot Projects 1 and 2 delivered only limited tangible results.

It was intended that the Freight Consignment Data Aggregation pilot project would use sample data collected through projects 1 and 2 to develop some demonstration outputs. However, only a small sample of data was obtained through projects 1 and 2, which the project team used to synthesise a larger sample of (synthetic) freight consignment messages.

The remainder of this Section outlines the methodology used for the Freight Consignment Data Aggregation Pilot Project.

FREIGHT CONSIGNMENT DATA AGGREGATION PILOT PROJECT

The main objectives of the Freight Consignment Data Aggregation pilot project were to:

- Investigate the feasibility of aggregating freight consignment event/message data and producing outputs to help inform infrastructure planning and freight policy development.
- Using a sample of 'raw' consignment event/message data, develop prototype methods and systems to process, store and transform the raw data into usable outputs.
- Assess the feasibility and utility of different data collection/sharing methods, including API-based data extraction methods, provided by participating organisations. As already indicated, this was not feasible.
- Identify minimum common data elements, formats and standards to aid data sharing.

Key questions/information identified as potentially answerable by aggregating consignment message information include:

- **What** – What and how much freight is moved?
- **Where** – Where does freight move? How much freight is moving between origin-destination pairs?
- **How** – What transport mode(s) are used to move freight? What types of freight vehicles are used? What routes and corridors are used to transport freight?
- **When** – When does freight move? What is the average travel time for freight moving between specific origin-destination pairs?
- **Freight performance measures**
    - What is the average transit time for freight consignments?
    - What is the typical variation in transit time for freight consignments?
    - What proportion of freight consignments are delayed?
    - Are there identifiable systematic (network-related) delays to freight consignments, and if so where?
    - Is it possible to estimate, in real time, the ETA for a freight consignment observed at some point in time?
    - What proportion of freight consignments are unable to be delivered (failed deliveries)?

These questions shape the outputs presented in Section 4.

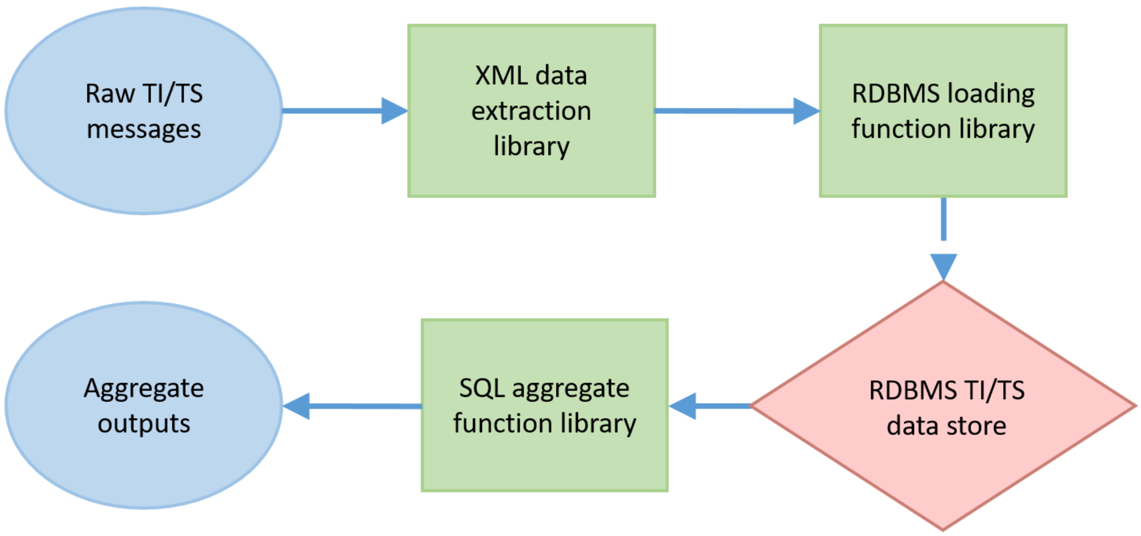
PROJECT METHODOLOGY

The original project plan proposed six stages:

1. TI/TS data exchange protocols and transfer arrangements
2. Development of data extraction methods
3. Design of data storage system
4. Implementation of prototype system build and upload of sample system messages
   - Initial system testing
5. Development of demonstration outputs
6. Reporting

Stage 2 also ended up including development of methods to generate synthetic freight consignment messages.

Figure 1: Project overview – Revise methodology diagram



DATA EXCHANGE PROTOCOLS AND TRANSFER ARRANGEMENTS

Under the original project plan, this phase was to include agreement with industry partners about what data would be provided and the data format. However, industry partners were unable to easily provide a linked/matched sample of consignment data due to system differences and the impact of the COVID-19 pandemic. In lieu of a sample of actual data freight consignment data, the project team developed a synthetic data sample, using a randomly distributed set of records with varying time stamps and shipment characteristics.

This stage was also to have involved agreement on message transmission protocols/arrangements, including testing different data transfer methods, particularly transmission via API. However, due to the above-mentioned issues, development of data exchange protocols and transfer arrangements remains unresolved and informs several recommendations around potential further work.

DATA EXTRACTION METHODS

GS1 TI/TS and EPCIS messages are created and exchanged in XML format. The project team developed a small library of XML/XSLT functions to extract relevant data from the messages for subsequent use. The project team also developed a small suite of functions to create TI/TS messages.

DATA STORAGE SYSTEM DESIGN, IMPLEMENTATION AND TESTING

A prototype relational database system was built to house the sample data set. The database stores freight consignment information present in TI/TS and EPCIS messages. The project team also developed a library of methods for then extracting and aggregating results from the database.

DEMONSTRATION OUTPUTS

Demonstration outputs were developed to answer the key questions identified above. These include:

- total freight volume by freight type and/or transport mode
- total freight volumes by origin and destination
- average freight travel times
- variation in freight travel times
- expected freight arrival times
- proportion of freight consignments arriving 'late'
- proportion of undelivered/undeliverable freight consignments.

TERMINOLOGY

In the GS1 transport messaging system, the terms 'consignment' and 'shipment' have specific and slightly different meanings (see Box 2.1). In general discussion throughout the report, the term *freight consignment* is used to refer more generally to the movement of a defined freight cargo (consignment or shipment) between supply chain partners.

REPORT STRUCTURE

The report is structured as follows.

Section 2 provides a brief overview of business-related electronic data interchange frameworks, with particular reference to GS1's Transport Instruction/Transport Status and EPCIS message architectures and the information content typically captured in those messages.

Section 3 presents elements of the prototype system build that the project team developed for capturing and storing messages. The system build was developed purely for the purpose of demonstrating the feasibility of capturing, storing and aggregating freight consignment data to produce the project outputs. In particular, the prototype system was not designed to operate in real-time—such a system would involve development of automated message transmission and was beyond the scope of this project.

Section 4 presents the type of outputs that can be produced from aggregated freight consignment information. Finally, Section 5 provides some concluding remarks and suggestions for further work.

Several appendices provide additional supporting information, including more detail about GS1's TI/TS and EPCIS message structures and content. The companion report—*Freight Consignment Data Aggregation Pilot–Models, Scenarios, Messages and Data Sets* (Lappen 2020)—provides more extended details of GS1's global communication framework, standards and the scenario design.

ELECTRONIC FREIGHT DATA EXCHANGE FRAMEWORKS

ELECTRONIC BUSINESS DATA EXCHANGE

Electronic data exchange (EDI) systems are used across a range of different industries to facilitate intercompany communication of business documents, including purchase orders, invoices and, of focus to this study, the transport of freight consignments between supply chain parties. Established business EDI frameworks and standards currently in use include:

- GS1 – a not-for-profit organisation that develops and provides global business communication protocols and standards, which originated with the development and application of barcode scanning technology in the retail sector.[5]
- papiNet – a global communication XML standard for the paper and forest products industries.[6]
- RosettaNet – a business communication XML standard for the major computer and consumer electronics, electronic components, semiconductor manufacturing, and telecommunications industries.[7]
- EDIFACT – the XML-based United Nations Electronic Data Interchange (EDI) for Administration, Commerce and Transport. EDIFACT standards are used widely across Europe, due to early adoption.[8]
- Odette – a develops tools and communications standards for business information across automotive manufacturing supply chain.[9]

GS1's protocols and standards are probably are one of the most well-known and well-developed business communication standards.

More recently, the Organisation for the Advancement of Structured Information Standards (OASIS) has developed overarching technical standards for electronic transmission of data between businesses—the Universal Business Language (UBL) (Organization for the Advancement of Structured Information Standards 2018). OASIS' UBL is now an established ISO/IEC standard—ISO/IEC 19845 (International Organisation for Standardisation and International Electrotechnical Commission 2015). The UBL framework also includes freight transport communication elements:

- Transport Service Description (TSD)
- Transport Execution Plan (TEP)
- Goods Item Itinerary (GII)
- Transportation Status (TS)
- Multimodal eWaybill (MWB)
- Transport Progress Status (TPS)
- Common Reporting Schema (CRS).[10]

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5 GS1 standards can be found at: https://www.gs1au.org/resources/standards-and-guidelines/.
6 papiNet standard can be found at: http://www.papinet.org/.
7 RosettaNet standards can be found at: http://www.rosetta.org/. RosettaNet is a subsidiary of GS1 US.
8 The UN EDIFACT standard is available at: https://www.unece.org/cefact/edifact/welcome.html.
9 Odette EDI standards can be found at: https://www.odette.org/.
10 The TSD, TEP, GII, TS, and TPS are part of the ISO/IEC 19845 standard.

EDI MESSAGE FREIGHT CONSIGNMENT DATA ELEMENTS

All of these different standards and frameworks include common freight consignment-related message elements:

- Purchase order/Order response
- Transport service request/Transport service acceptance
- Transport service status request/Transport service status updates.

While the details of the different message standards, field names and content may differ, most of the commonly used standards are implemented in XML, which greatly facilitates ready extraction and exchange of message content.

These messages will typically contain the following information elements of relevant for planning and network monitoring purposes:

- Consignment/shipment unique identifier
- Consignment/shipment origin (pick-up) location
- Consignment/shipment destination (delivery) location
- Cargo characteristics
  - Cargo type
  - Cargo type description
  - Gross volume/weight
  - Quantity (number of units)
- Transport instructions
  - Transport mode
  - Vehicle type
- Planned and actual departure time
- Planned and actual arrival time

These standards are also continually being updated and expanded to cover all transport supply chains. For example, port and maritime industry operators are investigating the development of 'sustainable global standards' to support interoperability between shipping, terminals and ports (see, for example, APMEN 2019, Grangard 2018), incorporating information about port tides, depths and under-keel clearance, berth dimensions and allowable ship size, pilot locations, etc., and real-time data exchange.

EDI CONNECTIVITY AND INTEROPERABILITY – FREIGHT AND LOGISTICS SECTOR

The European Union (EU) has recognised the multiplicity of freight-related EDI protocols and the potential efficiency savings that could results from more standardised freight information transfer, particularly in reducing the costs of interoperability for small and medium-sized enterprises. For example, it established the EU e-Freight Implementation Action (e-IMPACT) project (Fabbri and Urbano 2017), and several preceding related initiatives.[11] The e-IMPACT project recognised that,

[11] Related EU freight data exchange projects include: FREIGHTWISE, e-Freight, INTEGRITY, Smart-CM, SMARTFREIGHT, EURIDICE, RISING, DiSCwise, iCargo and eMAR.

notwithstanding the development of common business communication standards (ISO/IEC 19845), the global transport and logistics industry comprises several million enterprises, that will all have to maintain their capability to connect to existing standards, often multiple standards (Fabbri and Urbano 2017). Their proposed solution was development of a set of open protocols and tools that enable transformation and exchange of information between different communication standards (Fabbri and Urbano 2017).

FOCUS ON GS1'S FREIGHT MESSAGE FRAMEWORK

The remainder of this chapter (and report) focuses on GS1's freight consignment Transport Instruction (TI) and Transport Status (TS) message protocols, which were used to produce this report. Though the implementation details would differ, the broad approach developed here could be applied to extract equivalent freight consignment-related information from other EDI protocols.

GS1 FREIGHT CONSIGNMENT MESSAGE FRAMEWORK

TRANSPORT INSTRUCTION (TI) AND TRANSPORT STATUS (TS) MESSAGES

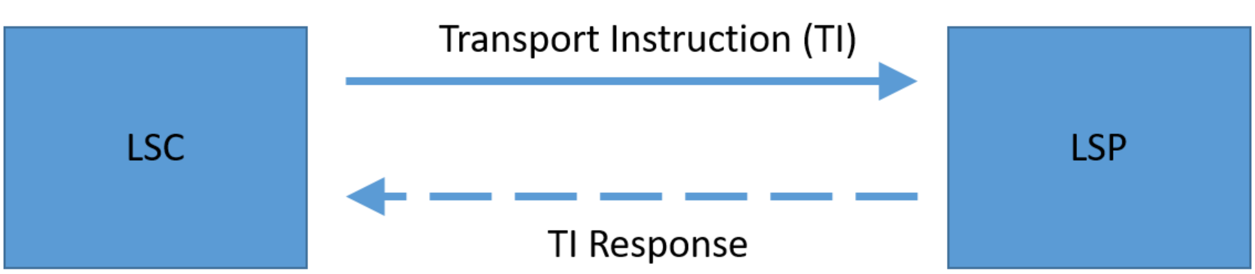
GS1's TI and TS message protocols provides a communication protocol for exchanging transport instructions between supply chain parties (GS1 & ALC 2019). The following sections briefly outline the structure and content of TI and TS messages, particularly highlighting the information contents of direct relevance to this project.

TRANSPORT INSTRUCTION (TI) MESSAGES

The purpose of the TI message is to initiate a request for transport service by a logistics service provider (LSP) or logistics service seller (LSS) and communicate the arrangements (through the agreed conditions) of the movement of the goods (including collection and delivery) between all parties involved and provide the information necessary to enable the handling of the goods.

According to GS1 & ALC (2019), the Transport Instruction is sent by a Logistic Services Buyer (LSB)—either a supplier, retailer, 3rd party warehouse or freight forwarder—to a Logistic Service Provider (LSP)—a freight forwarder or carrier—upon order creation (see Figure 2).

Figure 2: Transport Instruction transaction



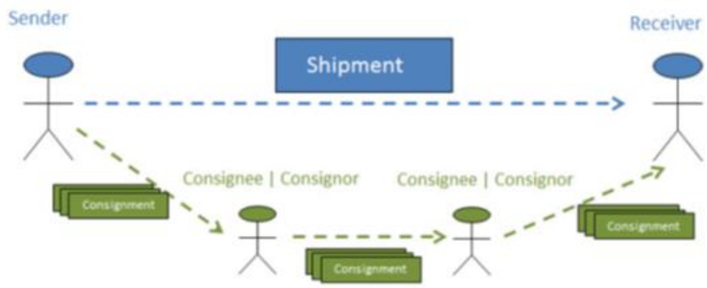
Source: Based on Natvig and Vennesland (2013 Fig. 2, p. 8).

Parties related to supply chain messages, will include:

- Sender – Supplier/manufacturer (origin/source of cargo to be transported)
- Receiver – Customer/retailer (buyer of cargo to be transported)

- Consignor – Logistics/Transport Service Client (cargo provider)
- Consignee – Logistics/Transport Service Provider (cargo carrier – transports and delivers the cargo) (see Figure 3).

Figure 3: Transport Instruction message parties



Source: Reproduced from Lappen (2020).

The TI message can include a request for either executing a *consignment* or executing a *shipment*—consignments typically include more-detailed freight handling/delivery instructions, whereas shipments contain less detail leaving transport arrangements to the shipper. (Box 2.1 provides more details.)

BOX 2.1 – CONSIGNMENTS VS. SHIPMENTS

In GS1 terminology, a *consignment* is a logical grouping of goods (one or more physical entities) that is intended to be transported as a whole from a *consignor* to a *consignee* by a carrier or freight forwarder via one or more modes of transport, under a single-transport contract. Typically, a TI consignment message typically does not contain *trade item*[12] details, but may specify more complex transport details.

By contrast, a *shipment* is an identifiable collection of one or more *trade items* to be transported together from the shipper (original consignor/shipper), to the recipient (final/ultimate consignee). A TI shipment message may contain details about the actual products (*trade items*) contained in the shipment.

Natvig and Vennesland (2013) provide a simple explanation of the difference between *consignment* and *shipment* messages and when to use each. In simple terms:

- a *shipment* message structure is used when the Logistic Service Client (LSC) cannot or does not want to specify the transport execution details, which are left to the LSP to choose.
- in contrast, a *consignment* message structure is used when the LSC specifies the transport execution details, and hence there is no need for provision of the shipment details (Natvig and Vennesland 2013, 28).

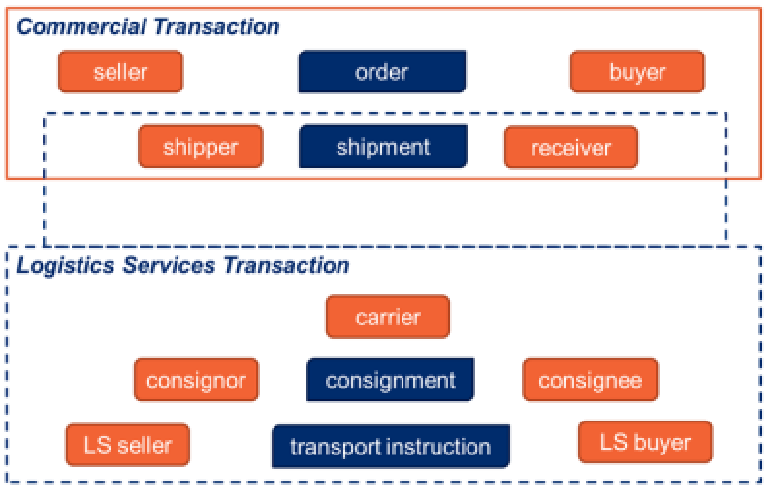
[12] In GS1 terminology, *trade items* are the actual commodities to be carried.

Both the *shipment* and *consignment* structures may be included in a transport instruction if transport activity includes consolidation/de-consolidation, break-bulk and cross-docking activities, or the LSC wishes to specify the shipment details (Natvig and Vennesland 2013, 28).

Figure 4 contrasts the relationships and arrangements embedded in a *shipment* and a *consignment*.

In more complex implementations of the TI message, a consignment may contain details for one of more shipments. This structure would only be used where the initiator of the transport needs to specify complex transport requirements as well as provide specific trade item detail to the LSP. In such cases the structure of the message will have both consignment and shipment details.

Figure 4: GS1 shipments vs. consignments



Source: Reproduced from GS1 Global (2012 Fig. 2, p. 16).

TI MESSAGE STRUCTURE AND CONTENT

The structure of a TI message has two principal parts:

- Standard Business Document Header
- Transport Instruction

The document header contains information about the message sender, including the individual sender contact details, the intended message receiver and the message document itself. The document identification information identifies that the message is a GS1 Transport Instruction and the creation date of the message.

Table 1: TI message structure

Part	Items	Content
Header	Sender details	Name, address, contact details
Header	Receiver details	Name, address, contact details
Header	Document identification	Document type, Creation date/time
Instruction	Transport instruction	Transport service request details

The transport instruction component of a TI message contains information related to the request for provision of a transport service. While the exact content included in TI messages may vary, depending on whether the instructions relate to a consignment or shipment and how much detail the LSC includes, most transport instructions will typically include the following data items:

- TI unique identifier
- TI message creation date/time
- Logistics Service Seller (LSS) identifier
- Logistics Service Buyer (LSB) identifier
- TI consignment/shipment unique (GINC/GSIN) identifier
- Consignor/consignee (consignments) or shipper/receiver (shipments)
- Transport instruction terms
    - Cargo characteristics – cargo type, description, quantity and mass
    - Pick-up location – street address
    - Pick-up date/time
    - Delivery location – street address
    - Delivery date/time
    - Consignment/shipment details (for each separate shipment item included in the consignment)
        - Shipment item number
        - Package type code
        - Number of units
        - Dangerous/hazardous goods details (if applicable)

The TI message format includes a number of *optional* fields that allow the LSC to provide further details about the transport arrangements. These can include:

- *planningStatus* – Planned, Actual or Cancelled
- *vehicleType* – Rigid, Articulated (Prime mover) or LCV
- *vehicleAxles* – Two, Three or Four-plus
- *vehicleCabin* – Standard, Half-size, Central island
- *vehicleEquipment* – whether vehicle is equipped with crane or forklift
- *vehicleLoad* – vehicle loading (trailer) configuration_ – e.g. flat-top, drop deck, skeletal, side-loader, tautliner, etc.
- *vehicleTip* – whether vehicle is equipped with any tipping capability.
- *vehicleID* – vehicle identifier
- *vehicleRego* – vehicle registration number
- *trailerType* – type of trailer, e.g. pig trailer, semi-trailer
- *trailerAxles* – number of trailer axles
- *trailerEquipment* – whether trailer is equipped with crane or forklift
- *trailerLoad* – loading configuration that is applicable to the trailer
- *trailerTip* – whether trailer is equipped with tipping capability
- *trailerLoadArea* – trailer load area
- *trailerMaxLength* – maximum trailer length
- *trailerMaxWeight* – maximum trailer weight.

An example of the structure and content of a typical Transport Instruction message is provided in Appendix B.

The key information elements in TI messages of use to this project (and aggregating consignments/shipments) included:

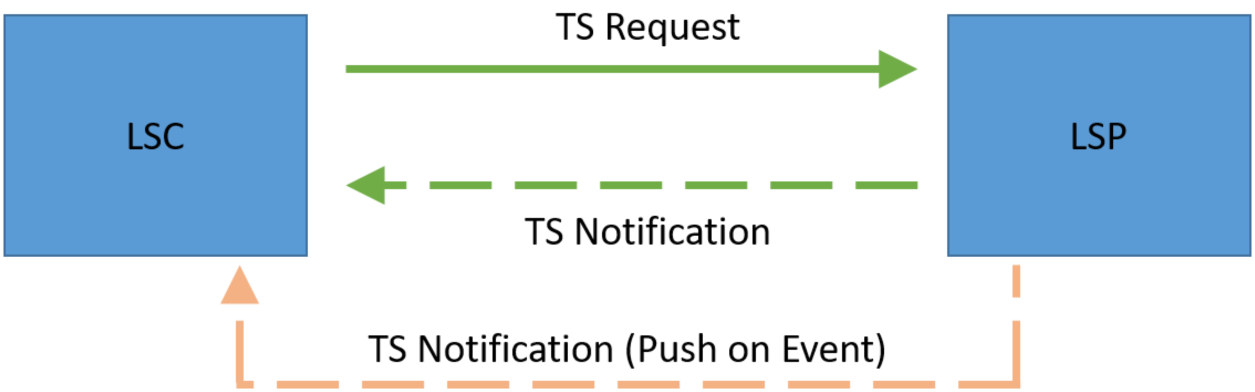
- origin (pick-up) and destination (delivery) locations
- planned and actual departure and arrival times
- cargo characteristics – consignment commodity type(s), volume and weight (if available)
- transport mode
- vehicle (asset) type and configuration (e.g. vehicle and trailer details for road freight), if available.

TRANSPORT STATUS MESSAGES

Transport Status (TS) messages provide a framework for the exchange of information related to the progress of transport consignment/shipment identified in a TI, as the consignment (shipment) progresses along the supply chain. There may be multiple TS message exchanges associated with a single TI, either in response to a TS request by the LSC or at predetermined events in the transport process (Figure 5 illustrates the typical exchange of TS messages between LSC and LSP). At a minimum, a TS message would be sent when execution of the transport instruction has been completed, but delays or changes to the process may trigger additional status notifications.

TS messages may also be sent to multiple different parties (See, for example, GS1 Australia 2016, 8), e.g. to both shipper and receiver, to shipper only, or receiver only.

Figure 5: Transport Instruction transaction



Source: Based on Natvig and Vennesland (2013 Fig. 3, p. 8).

TS MESSAGE STRUCTURE AND CONTENT

Like TI messages, each TS message has two principal parts:

- Standard Business Document Header
- Transport Status request/notification

The document header contains information about the message sender, including the individual sender contact details, the intended message recipient and the message document itself. The document identification information identifies whether the message is a GS1 Transport Status Request or a Transport Status Notification.

Table 2: TS message structure

Part	Items	Content
Header	Sender details	Name, address, contact details
Header	Receiver details	Name, address, contact details
Header	Document identification	Document type, Creation date/time
Status	Transport Status Request	Transport service status request details
	Transport Status Notification	Transport service status notification details

The transport status component of a TS message differs between TS Request and TS Notification messages. Both messages contain the following information:

- TS unique identifier
- TS message creation date/time
- TS requester identifier
- TS provider identifier
- TS code – original or other
- TI consignment/shipment unique (GINC/GSIN) identifier

In addition to the above information, TS Notification messages for consignments also include the following details:

- Actual departure/arrival times
- Actual departure/arrival locations
- Cargo type
- Transport mode
- Status information code – possible values include:
    - **Status only** – status report (pre-defined codes indicate status)
    - **Event log only** – status report with measurements
    - **Status and Movement** – status report with status code and planned or actual time scheduled related to locations
    - **Status movement and event log** – as per Status and movement, with measurements
    - **Information on delivery** – status report with predefined code for final delivery
- Status request – Optional identifier indicating the TS Request to which this message is responding.

TS Notification messages for shipments can include several sections denoting the status of one or more items contained in each shipment, and the transport sequence involved in delivering the shipment. Fields include:

- Transport reference – TI identifier
- Included logistics units – identification of the logistics unites contained in the shipment

- Transport status – a location related to the transport status, containing:
    - Status condition (code)
    - Status date/time
    - Status reason (code)
    - Location
        - GLN
        - Location names
        - Address
        - Longitude/latitude
- Transport Movement – transport movement information, e.g.:
    - Sequence number
    - Transport mode
    - Associated person

TS Request messages will generally be answered by a TS Notification response. TS Notification messages, however, can also be triggered by pre-defined events (e.g. delivery) and so may not have a corresponding TS Request message. Both TS Request and Notification messages may be linked to an original TI request by either the unique consignment identifier (GINC) or unique shipment identifier (GSIN). These fields, along with TS request/notification codes, enable linking of TI and TS messages. (The section below provides a brief outline of the major GS1 identifying codes relevant to this project.)

An example of the structure and content of typical Transport Status Request and Notification messages are provided in Appendix B.

The key information of relevance are in TS Notification messages and include:

- pick-up and drop-off locations – i.e. freight origin and destination
- *actual* departure and arrival times
- cargo characteristics – consignment weight, volume and commodity type (if available)
- transport mode
- vehicle (asset) type and configuration (e.g. vehicle and trailer details for road freight), if available.

EPCIS

GS1's Electronic Product Code Information Services (EPCIS) is a global standard for creating and sharing visibility event data, within and between businesses, to provide information of a relevant across enterprises. Originally conceived as part of broader efforts to enhance collaboration between trading partners through sharing of detailed information about physical or digital objects, EPCIS is open and extensible, with the capacity to be extended by organisations to suit their different business needs (GS1 Global 2014a).

EPCIS messages describe the completion of a single business step within an overall business process. Each step is commonly referred to as an *EPCIS event*, and multiple events may be combined together to provide a detailed picture of a broader business process. Each event typically includes information about:

- Objects that are the subject of the event (**What**)

- Date and time that the event occurred (**When**)
- Location (location identifier) at which the event occurred (**Where**)
- Additional business context information, including the shipping and receiving parties, business event (shipping/receiving), the object status (e.g. active, recalled, damaged), and links to related business transaction documents (**Why/Who**).

EPCIS is defined by an XML schema defined in the EPCIS standard: GS1 Global (2016b).

EPCIS MESSAGE STRUCTURE AND CONTENT

EPCIS (XML-format) messages have a relatively simple structure comprising EPCIS XML-schema and the EPCIS message body, which comprises a list of one or more events. Events can include:

- picking & packing
- loading
- departing
- transporting
- receiving
- unloading.

Each EPCIS message includes:

- Event date/time
- EPC list – an unordered list of one or more EPCs specifying specific objects (e.g. SSCC, GTIN, SGTIN, see below) to which the event relates.
- Action – one of either Observe, Add or Delete
- Business process (business step)
- Activity
- Location
    - Read point
    - Business location
- Source list – an unordered list of source elements that provide context about the originating endpoint
- Destination list – an unordered list of source elements that provide context about the originating endpoint. (GS1 Global 2016b)

EPCIS messages may optionally include *Transformation Event* information, which are used where inputs are consumed or outputs produced. Transformation events were not relevant to this project.

An example of the structure and content of typical EPCIS message is provided in Appendix B.

In order to derive aggregate information from EPCIS messages it is necessary to chain multiple EPCIS messages and create a transport chain. All of the fields in the standard EPCIS message template are used in producing aggregated freight movement outputs.

GS1 FREIGHT IDENTIFYING CODES

GS1's business messaging system, including TI, TS and EPCIS messages, utilise a hierarchy of GS1 freight identifiers that uniquely identify:

- Consignments (GINC)
- Shipments (GSIN)
- Trade items (GTIN and SGTIN)
- Containers (SSCC) and
- Locations (GLN).

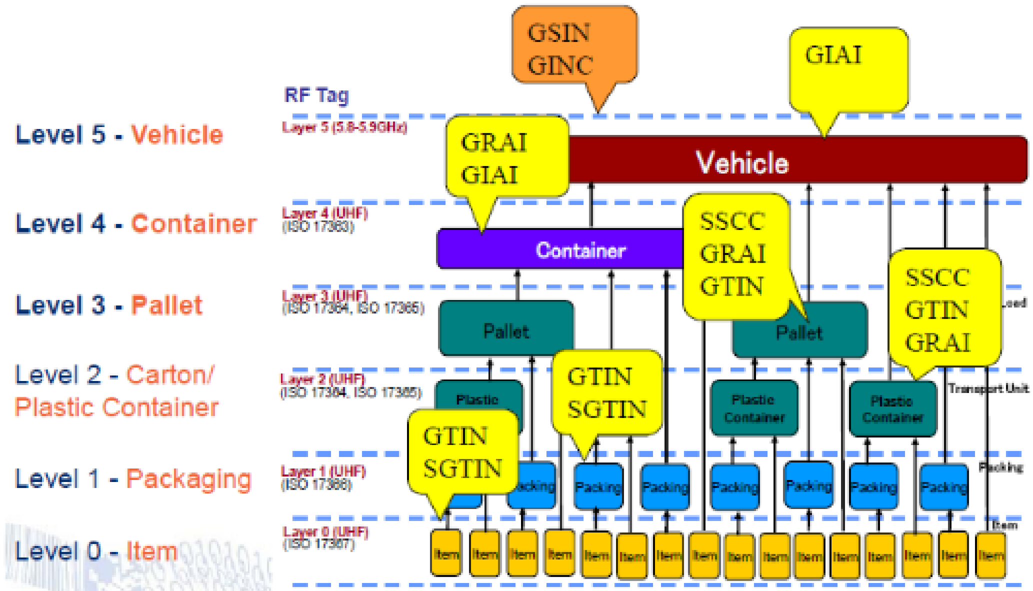
Table 3 lists the principal GS1 freight identifiers pertinent to this project. The first five codes in Table 3—GINC, GSIN, SSCC, GTIN and SGTIN—relate to different levels of aggregation of freight products, from trade items up to shipment/consignment level. Returnable assets, such as vehicles, trailers, pallets, etc., are identified by unique asset numbers (GRAI and GIAI). GS1's Global Location Number (GLN) system, contains a unique identifier for every potential business information and trade location.

Table 3: GS1 freight identifiers

Key	Description	Identifies	Key length (characters)
GINC	Global Identification Number for Consignment	A grouping of logistics units that are assembled to be transported together under one transport message (should not be confused with shipment which identifies a grouping for trade purposes)	17
GSIN	Global Shipment Identification Number	A grouping of logistics units that comprise a shipment	4-30
SSCC	Serial Shipping Container Code	Any item of any composition established for transport and/or storage which needs to be managed through the supply chain. Assigned for the lifetime of the item.	14-30
GTIN	Global Trade Item Number	Any item (product or service) that may be priced, or ordered, or invoiced at any point in any supply chain	4-30
SGTIN	Serial Global Trade Item Number	Same as GTIN, but a sequence number is added for unique identification.	14
GRAI	Global Returnable Asset Number	Reusable package or transport equipment that is considered an asset. Assigned for the lifetime of the asset.	> 15
GIAI	Global Individual Asset Number	A diverse range of business applications, for example recording the life cycle history of an asset.	18
GLN	Global Location Number	Physical locations and legal entities.	13

Figure 6 shows the relationship between GS1 GINC, GSIN, SSCC and GTIN codes and elements, and shipment/consignment components—items, carton, pallet, container and vehicle.

Figure 6: GS1 TI/TS message code elements



Source: Reproduced from Natvig and Vennesland (2013 Fig. 10, p. 29)

COMBINING TI AND TS MESSAGES TO IDENTIFY FREIGHT TRANSPORT TASK

Every TI message may be joined with one or more related TS messages, linked by either GINC/GSIN codes, to provide a picture of the entire transport supply chain for any single consignment/shipment. When aggregated, this information can be used to provide insights into total freight volumes and freight use of the transport network, among other things. For example, it should theoretically be possible to estimate the volume of freight moving between identified origin and destination pairs, the average freight transit time, and even the proportion of late or failed deliveries.

Section 3 provides an outline the data extraction methods and prototype database system developed for this project to store and manage a sample of TI and TS messages and subsequently produce aggregate outputs.

PROJECT DATASET AND DATA MANAGEMENT PROCESSES

INTRODUCTION

This section provides a brief description of the sample freight consignment message set and the key message attributes of interest to this project (discussed in Section 2), and also the data extraction procedures and database system developed to store the extracted message data for subsequent aggregation.

SAMPLE FREIGHT CONSIGNMENT MESSAGE DATA

Under the original Freight Data Exchange pilot project plan it was intended that the Freight Consignment Data Aggregation pilot project (this project) would utilise data collected through the Freight Supply Chain pilot projects (Projects 1 and 2), to aggregate freight consignment event/message data and develop some demonstration outputs. However, due to issues outlined in Section 1, only a very small sample of freight consignment message data was obtained.

In lieu of a sufficient sample of *actual* data set being available, the project team developed a *synthetic* data sample based on five separate freight supply chain transport scenarios, involving multiple freight consignments for each supply chain. The five freight supply chain scenarios were designed to cover a reasonably representative range of typical Australian freight supply chains:

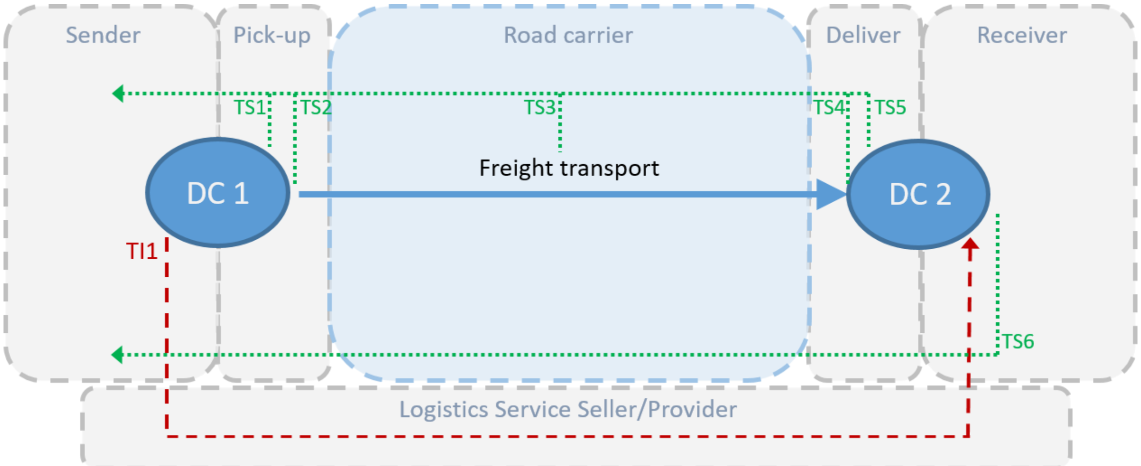
1. a short-distance single-stage single-mode urban freight consignment scenario
2. a short-distance multi-stage single-mode urban freight consignment scenario
3. a multi-stage multi-modal (road and rail) long-distance (North–South) freight consignment scenario
4. a multi-stage multi-modal (road and rail) long-distance (East–West) freight consignment scenario
5. a multi-stage multi-modal (road and sea) freight consignment scenario.

Trip characteristics, such as departure time, travel time, loading/unloading time, etc., were varied so that the results generated from aggregating the sample trip information provided some degree of variation.[13]

For each scenario one synthetic Transport Instruction (TI) and multiple related Transport Status (TS) messages were generated—the number of TS messages varied with the number of supply chain stages involved between origin and destination. Figure 7 illustrates the freight supply chain assumed in Scenario 1 and the TI and TS message exchanges involved—one TI message and six TS messages for each consignment. More details about the assumptions underpinning Scenario 1 and each of the other four scenarios are provided in Appendix A.

[13] The message contents were varied by randomly selecting value from separate probability distributions for key message elements—e.g. departure/arrival times, commodity type, freight volume, etc.

Figure 7: Scenario 1 TI–TS messages



Across all five scenarios, the synthetic data set comprised 485 TI messages—97 shipments for each scenario—and 6790 separate TS messages. While this sample size was suitable for the purpose of this project, it would represent only a tiny fraction of the total potential number of freight supply chain movements and corresponding freight consignment messages being exchanged daily by supply chain partners.

PROJECT-RELEVANT TI AND TS MESSAGE DATA ELEMENTS

The TI and TS message elements required to produce aggregate freight-related measures are principally those elements specifying the type and volume of the cargo, the location of the consignment origin and destination, and any intermediate waypoints, planned and actual departure and arrival times, and messages identifying cargo condition. Tables 4 and 5 show the key TI message elements and Table 6 shows the key TS message elements relevant to this project.[14]

Commodity and freight volume information, where available, are specified in the TI message **transportCargoCharacteristics** element, which can include:

- **cargoTypeCode** – Code specifying the classification of a type of cargo
- **cargoTypeDescription** – Free text field specifying the classification of the type of cargo
- **totalGrossVolume** – Measure of the cargo volume, typically length x width x height
- **totalGrossWeight** – Measure of the mass of the goods including the weight of transport packaging
- **totalPackageQuantity** – Total number of logistic units (e.g. pallets) in the cargo.

Planned freight consignment origin and destinations are specified in TI and TS location message elements. In TI Consignment messages these elements are named: **plannedPickUp** and **plannedDropOff**, and in TI Shipment messages these elements are named: **shipFrom** and **shipTo**. In TS Consignment and TS Shipment messages, location information includes both planned and actual locations—

[14] A full list of all possible TI and TS XML message elements is provided in the companion report—*Freight Consignment Data Aggregation Pilot–Models, Scenarios, Messages and Data Sets* (Lappen 2020).

e.g. plannedDeparture, actualDeparture, plannedArrival and actualArrival. Within each of these items is provision to include:

- gln – GS1 Global Location Number
- city – Name of the logistic event location city
- postalCode – Post code for the logistic event location
- streetAddress – Street address for the logistic event location
- addtionalLocationIdentification – Other means of identifying the logistic location.

TI Consignment and Shipment messages allow for specification of planned pick-up (despatch) and drop-off (delivery) dates and times, and TS messages generally include both planned and actual logistic event dates and times.

Transport mode related information is found in the TI message transportInstructionTransportMovement and transportInstructionTerms elements provide for specification of the preferred transport mode or service type. Actual transport mode use is capture for each transport movement in TS message relatedTransportMeans sub-elements.

FREIGHT DATA EXTRACTION METHODS

A small range of functions was developed for this project to extract relevant information from raw TI, TS and EPCIS (XML-format) messages. These functions essentially descend the XML node tree of each message and extract relevant data item names and attributes in key–value pair format for subsequent use or direct upload to a flat data store.

Separate functions were required to extract data from TI and TS messages, which differ in slightly structure and content. Additionally, separate TI and TS function variants were created to handle consignments and shipments, as the data elements contained in TI and TS messages differ according to whether the messages relate to a consignment or shipment (refer to Box 2.1).

GS1's message suite also includes TI response messages—i.e. a response to a TI request message—and TS request messages, which initiate a TS notification message. TI response and TS request messages were not essential to this project and not considered further.

The full set of TI/TS data extraction methods developed for the project comprised:

- TI consignment data extract – extract relevant data elements from a valid TI consignment XML object
- TI shipment data extract – extract relevant data elements from a valid TI shipment XML object
- TS consignment notification – extract relevant data items from a valid TS consignment XML object.
- TS shipment notification – extract relevant data items from a valid TS shipment notification XML object.[15]

[15] All data extraction functions were developed in R—a software environment for statistical computing—which enabled both extraction of raw message data and output generation in one development environment. However, the data extraction procedures could equally have been implemented in any programming language that can read and parse XML.

FREIGHT CONSIGNMENT MESSAGE DATA STORE

A small relational database was constructed to store the extracted TI and TS sample message information. The relational database greatly facilitated subsequent querying and aggregation of freight consignment records.

DATABASE STRUCTURE

The database structure developed to store the freight consignment message data comprises a linked set of TI message tables and a linked set of TS messages tables, each linked by the unique consignment or shipment identifier. The choice of this structure reflects, as much as practicable, the hierarchical structure and content of the original TI and TS message formats.

Table 4: Transport Instruction Consignment Key Message elements

Question		Message elements	Data type	No.	Description
		transportInstructionConsignment			
What		**transportCargoCharacteristics**	GS1 TransportCargoCharacteristicsType	1	Aggregate information on the goods contained in this consignment
		cargoTypeCode	GS1 cargoTypeCode	1	Code specifying the classification of a type of cargo, for example hazardous cargo.
		cargoTypeDescription	GS1 cargoTypeDescription	0..1	Free text field specifing the classification of the type of cargo
	How much	totalGrossVolume	Numeric	0..1	Measure of the cargo volume, typically length x width x height
		totalGrossWeight	Numeric	0..1	Measure of the mass of the goods including the weight of transport packaging.
		totalPackageQuantity	Integer	0..1	Total number of logistic units (e.g. pallets) in the cargo.
Where		**plannedPickUp**	GS1 LogisticEventType	0..1	Details on the planned collection of the consignment
		logisticLocation	GS1 LogisticLocationType	0..1	The location where the logistic event occurs
		unLocationCode	UNLocationCodeType	0..1	UN/ECE geographic coding scheme used in trade and transport to identify seaports, airports, road and rail terminals, etc.
		gln	GS1 GLNType	0..1	GS1 global location number (GLN) of the logistic location
		additionalLocationIdentification	GS1 IdentifierType	0..n	Identification of a location by use of a code other than the GLN
		sublocationIdentification	String	0..1	Further text specifying the exact logistic location, e.g. dock
		locationName	String	0..1	The name of this logistic location
		address	GS1 AddressType	0..1	Address of the party involved in the business transaction
		city	String	0..1	Name of the city
		postalCode	String	0..1	Postal code for the address
		streetAddressOne	String	0..1	The first free form line of an address
	When	**logisticEventPeriod**	GS1 DateTimeRangeType	0..1	Timeframe during which the logistic event occurs
		beginDate	Date	0..1	Date specifying the first day for the date time range
		beginTime	Time	0..1	Time specifying the start time for the date time range
		endDate	Date	0..1	Date specifying the last day for the date time range
		endTime	Time	0..1	Time specifying the end time for the date time range
		logisticEventDateTime	GS1 DateOptionalTimeType	0..1	The date and time on which the logistic event occurs
		date	Date	1	The specification of a day as a calendar date
		time	Time	0..1	The specification of a point in time during the day
		plannedDropOff	GS1 LogisticEventType		
		As per plannedPickUp (above)			
How		**transportInstructionTransportMovement**	GS1 TransportInstructionTransportMovementType	1..n	The transport movement details for this consignment
		sequenceNumber	Integer	1	Unique number specifying the sequency of ths transport movement
		transportModeTypeCode	GS1 TransportModeTypeCode	1	Code specifying the transport mode used for this transport movement.

Table 5: Transport Instruction Shipment Key Message elements

Question	Message elements	Data type	No.	Description
	transportInstructionShipment			
What	**transportCargoCharacteristics**		1	
	cargoTypeCode	GS1 cargoTypeCode	1	Code specifying the classification of a type of cargo, for example hazardous cargo.
	cargoTypeDescription	GS1 cargoTypeDescription	0..1	Free text field specifing the classification of the type of cargo
How much	totalGrossVolume	Numeric	0..1	Measure of the cargo volume, typically length x width x height
	totalGrossWeight	Numeric	0..1	Measure of the mass of the goods including the weight of transport packaging.
	totalPackageQuantity	Integer	0..1	Total number of logistic units (e.g. pallets) in the cargo.
Where	**shipFrom**	GS1 TransactionalPartyType	0..1	The physical location from where goods will be or have been shipped
	address	GS1 AddressType	0..1	Address of the party involved in the business transaction
	city	String	0..1	Name of the city
	postalCode	String	0..1	Postal code for the address
	streetAddressOne	String	0..1	The first free form line of an address
	shipTo	GS1 TransactionalPartyType	0..1	The physical location to where goods will be or have been shipped
	address	GS1 AddressType	0..1	Address of the party involved in the business transaction
	city	String	0..1	Name of the city
	postalCode	String	0..1	Postal code for the address
	streetAddressOne	String	0..1	The first free form line of an address
When	**plannedDelivery**	GS1 LogisticEventType	1	Details on the planned delivery of the shipment.
	logisticEventDateTime	GS1 DateOptionalTimeType	0..1	The date and time on which the logistic event occurs
	date	Date	1	The specification of a day as a calendar date
	time	Time	0..1	The specification of a point in time during the day
	plannedDespatch	GS1 LogisticEventType	1	Details on the planned despatch of the shipment.
	logisticEventDateTime	GS1 DateOptionalTimeType	0..1	The date and time on which the logistic event occurs
	date	Date	1	The specification of a day as a calendar date
	time	Time	0..1	The specification of a point in time during the day
How	**transportInstructionTerms**	GS1 TransactionalPartyType	1	Code specifying the service level requested for the transport service, e.g. Express Service
	transportServiceCategoryType	GS1 TransportServiceCategoryCodeType	1	Code specifying the service level requested for the transport service, e.g. Road Transport

Table 6: Transport Status Notification Key Message elements

Question	Message elements	Data type	No.	Description
	transportStatusNotificationShipment			
Condition	**transportStatus**	GS1 TransportStatusType	1..n	Transport status details for this consignment
	transportStatusConditionCode	GS1 TransportStatusConditionTypeCode	1..n	Code specifying the transport status condition.
How	**transportStatusNotificationTransportMovement**	GS1 TransportInstructionTransportMovementType	1..n	The transport movement details for this consignment
	sequenceNumber	Integer	1	Unique number specifying the sequency of ths transport movement
	transportModeTypeCode	GS1 TransportModeTypeCode	1	Code specifying the transport mode used for this transport movement
	routeIdentifier	IdentifierType	0..1	Unique identifier of the standard route used for this transport movement
Where	**plannedDeparture**	GS1 LogisticEventType	0..1	The expected time of departure from the designated departure location
When	**logisticLocation**	GS1 LogisticLocationType	0..1	The location where the logistic event occurs
	unLocationCode	UNLocationCodeType	0..1	UN/ECE geographic coding scheme used in trade and transport to identify seaports, airports, road and rail terminals, etc.
	gln	GS1 GLNType	0..1	GS1 global location number (GLN) of the logistic location
	additionalLocationIdentification	GS1 IdentifierType	0..n	Identification of a location by use of a code other than the GLN
	sublocationIdentification	String	0..1	Further text specifying the exact logistic location, e.g. dock
	locationName	String	0..1	The name of this logistic location
	address	GS1 AddressType	0..1	Address of the party involved in the business transaction
	city	String	0..1	Name of the city
	postalCode	String	0..1	Postal code for the address
	streetAddressOne	String	0..1	The first free form line of an address
	logisticEventPeriod	GS1 DateTimeRangeType	0..1	Timeframe during which the logistic event occurs
	beginDate	Date	0..1	Date specifying the first day for the date time range
	beginTime	Time	0..1	Time specifying the start time for the date time range
	endDate	Date	0..1	Date specifying the last day for the date time range
	endTime	Time	0..1	Time specifying the end time for the date time range
	logisticEventDateTime	GS1 DateOptionalTimeType	0..1	The date and time on which the logistic event occurs
	date	Date	1	The specification of a day as a calendar date
	time	Time	0..1	The specification of a point in time during the day
	plannedArrival	*GS1 LogisticEventType - See plannedDeparture*	0..1	The expected time of arrival at the designated arrival location
	actualDeparture	*GS1 LogisticEventType - See plannedDeparture*	0..1	The actual time of departure from the designated departure location
	actualArrival	*GS1 LogisticEventType - See plannedDeparture*	0..1	The actual time of arrival at the designated arrival location
	actualLoading	*GS1 LogisticEventType - See plannedDeparture*	0..1	The actual time and location of loading
	actualUnloading	*GS1 LogisticEventType - See plannedDeparture*	0..1	The actual time and location of unloading
	recipientSignOff	*GS1 LogisticEventType - See plannedDeparture*	0..1	The expected time of departure from the designated departure location
	plannedWayPoint	*GS1 LogisticEventType - See plannedDeparture*	0..n	Planned adminstrative procedure taking place at designated location
	actualWayPoint	*GS1 LogisticEventType - See plannedDeparture*	0..n	Actual adminstrative procedure taking place at designated location
How	**relatedTransportMeans**	GS1 TransportMeansType	0..1	The type of vehicle, aircraft, etc used for the transport of goods
	transportMeansType	GS1 TransportMeansTypeCodeType	1	Code specifying the type of vehicle, aircraft, etc. used for the transport of goods
	transportMeansName	GS1 IdentifierType	0..1	The unique identifier of a particular means of transport, e.g. licence no.
	transportMeansID	String	0..1	The name of a particular transport means, e.g. vessel name

TI TABLE SET

TI messages can vary depending on whether the message relates to a consignment or a shipment, and the number of shipments identified within a consignment (if any), the number of trade items identified within each shipment (if any), and the number of transport movements involved in the freight task. In the relational database, this information was stored in the following five related TI tables:

- **ti_header** – TI message sender, receiver and document information
- **ti_consignment** – TI consignment identifying information
- **ti_shipment** – TI shipment identifying information
- **ti_transport** – transport information for each consignment or shipment, including freight volume, planned logistic locations and event times
- **ti_cargo** – one or more cargo items listed in a consignment or shipment.

TS TABLE SET

TS messages also contains a nested nodal structure the contents of which vary according to whether the TS message relates to a consignment or shipment. Further, TS messages can contain separate information for each shipment included within a consignment (if any), trade items separately enumerated within each shipment (if any), and each transport movement. Accordingly, the project database includes five linked TS tables:

- **ts_header** – TS message sender, receiver and document id requests
- **ts_consignment** – TS consignment identifying information
- **ts_shipment** – TS shipment identifying information
- **ts_transport** – transport arrangements for each consignment or shipment, including actual transport mode used, planned and actual logistic event locations and datetimes
- **ts_cargo** – one or more cargo units itemised in a consignment or shipment.

Each of these tables is linked by one or more unique identifiers.

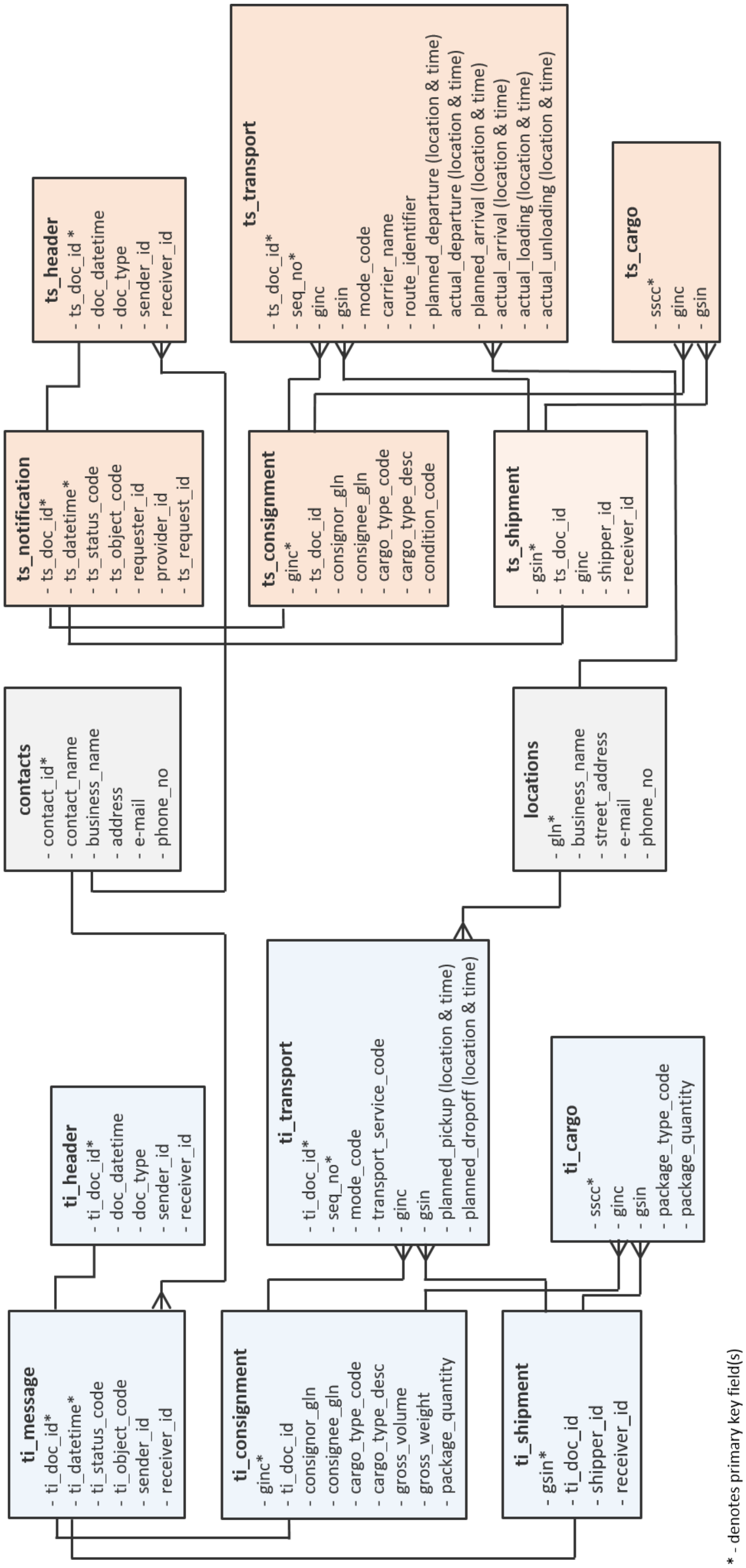
LOCATION AND BUSINESS CONTACT TABLES

Two additional tables are used to uniquely store common business location and business contact information, which link to TI and TS message elements by unique identifiers:

- **location** – set of unique business location information
- **contacts** – set of unique contact information.

Figure 8 outlines the relational database system table structure used to store the sample TI/TS data set. (Appendix C provides more detail on the content of the database tables.)

Figure 8: Pilot project – TI–TS message relational database table structure



DATABASE UPLOAD FUNCTIONS

Another set of functions were developed to insert data from TI and TS messages into the project database. Separate sets of functions were developed to: i) facilitate bulk upload of data extracted from one or more TI or TS messages, and ii) combined extraction and database upload of single TI or TS message.

The bulk upload functions were used in the project to upload the message content extracted from the synthetic messages. The combined extraction and upload versions of those functions were designed for the case where TI and TS messages were to be ingested via an API. In the event the latter functions were not used in the project.

AGGREGATING MULTIPLE FREIGHT CONSIGNMENT MESSAGES

Lastly, a set of simple database queries were developed to aggregate freight consignment message data to answer the questions posed in Section 1. The following section presents aggregate freight outputs that demonstrate the types of aggregate outputs that could be produced using a sufficient sample of actual TI and TS messages.

DEMONSTRATION OUTPUTS

INTRODUCTION

This section demonstrates the possible aggregate outputs that can be generated from freight consignment message data. The demonstration outputs are based on the *synthetic* data sample described in Section 3, so are illustrative only. The key outputs that can be generated from aggregated message data include:

- freight volumes, by origin–destination pair, route, transport mode and broad commodity type (where available)
- freight transit times—mean and variance, etc.
- freight transport delays.

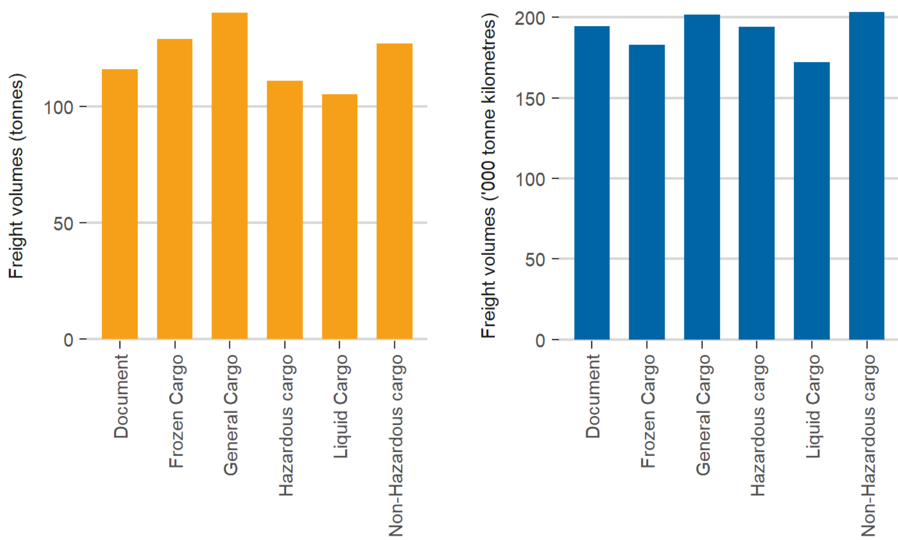
Availability of a sufficiently larger and more representative sample of freight consignment messages could facilitate identification of systematic (network-related) delays and help operators better predict freight transit times on particular routes.

Some example total (all-scenario) aggregate outputs are presented first followed by presentation of supply chain-specific aggregate outputs. Importantly, all outputs presented in this section are based on the *synthetic* data samples generated for the five supply chain scenarios, and do not represent actual freight volumes of transit times.

TOTAL FREIGHT VOLUME OUTPUTS

The TI and TS messages can be aggregated to provide estimates of total freight volumes by commodity type, transport mode and time period—e.g. year, month, day (of week) or hour (of day)—or a combination of these dimensions. Figure 9 provides demonstration output of total freight volumes by commodity type, from across all five scenarios—the left-hand panel reports total freight movements, measured in tonnes, and the right-hand panel provides estimates of the total freight tonne kilometres.

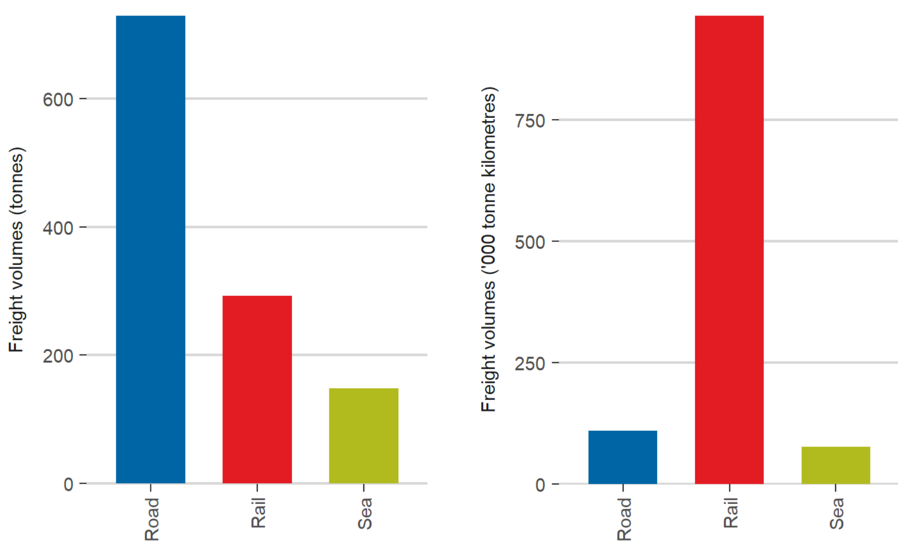
Figure 9: Total synthesised freight volumes, by commodity type, all scenarios



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

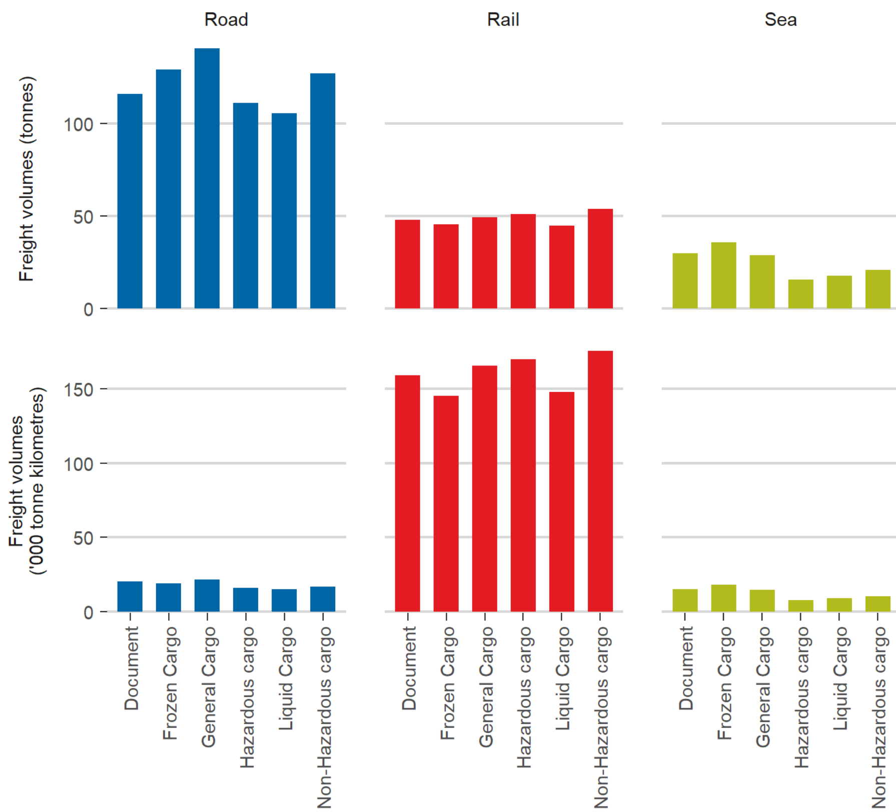
Figure 10 provides an example of total freight movements by transport mode. Again, the left-hand panel provides estimates of freight tonnes and the right-hand panel provides an example of the total freight tonne kilometres. Differences in average road, rail and sea haulage distances account for the difference in the relative size of the freight task when measured in tonnes and tonne kilometres.

Figure 10: Total synthesised freight volumes, by commodity type, all scenarios



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 11: Total synthesised freight volumes, by transport mode and commodity, all scenarios

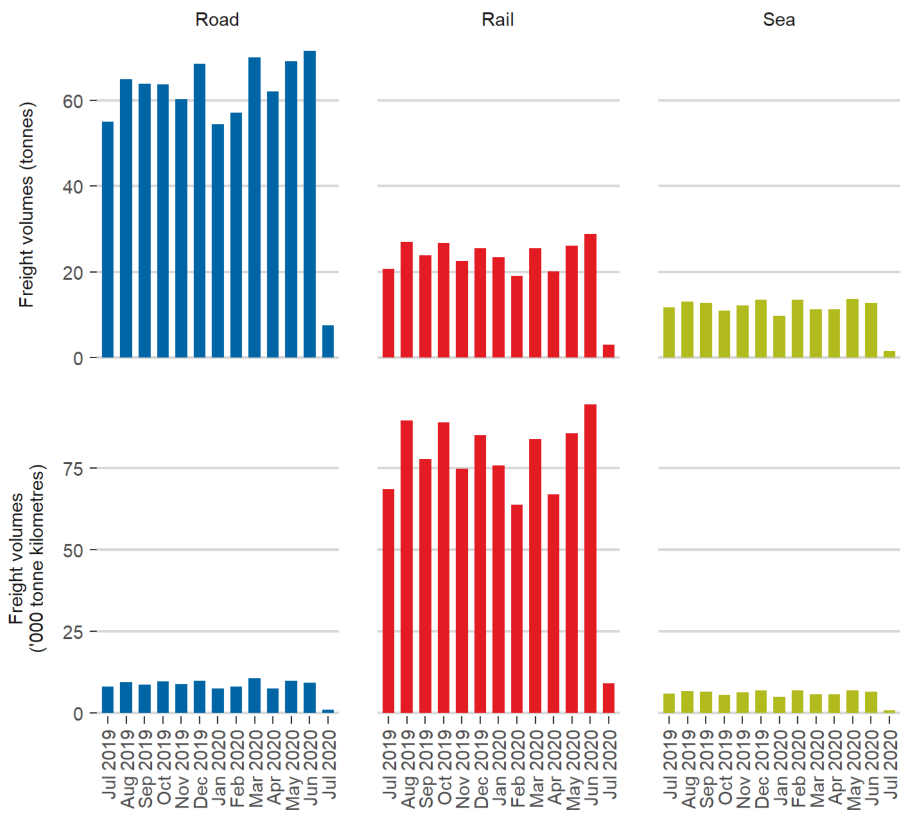


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 11 provides an example breakdown of aggregate freight volumes by commodity and transport mode in both tonnes (top row) and tonne kilometres (bottom row). Again, differences in average road, rail and sea haulage distances involved in the five supply chain scenarios account for the difference in the relative size of the different freight task measures (tonnes or tonne kilometres) across the different modes—i.e. rail haulage distances across the five scenario are much longer than for either road or rail, hence the greater significance of rail when measured in tonne kilometres.

Finally, Figure 12 illustrates how freight consignment message data could be aggregated to provide monthly estimates of total freight volumes by transport mode, again in both tonnes (top row) and tonne kilometres (bottom row).

Figure 12: Total synthesised freight volumes, by month-year and transport mode, all scenarios



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

The rest of this section presents examples of supply chain-specific aggregate outputs that could be produced from freight consignment message data.

SCENARIO 1 OUTPUTS – INTRASTATE ROAD FREIGHT MOVEMENT

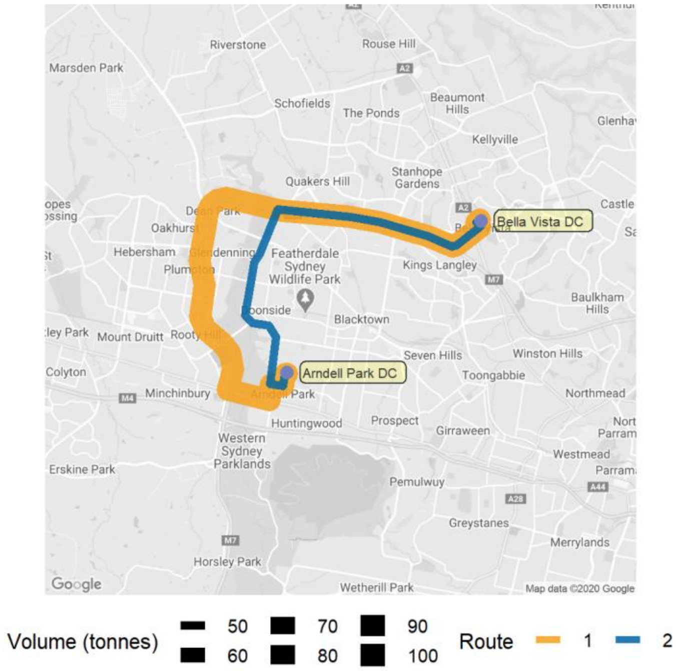
ORIGIN–DESTINATION FREIGHT VOLUMES

Scenario 1 involves single-stage, single-mode transport of freight consignments from Arndell Park to Bella Vista (New South Wales). Figure 15 shows Scenario 1 synthetic freight volumes assigned to the transport network. For the purposes of exposition, two alternative 'standard' road freight routes[16] were defined for this scenario—one via the Great Western Highway and Westlink M7 and the second via Doonside Road, Knox Road and joining the M7 at Quakers Hill.[17] About 25 per cent of freight as assumed to move via the second route.

[16] Freight routes can be identified in TI/TS messages in the *route identifier* element (ref:GS1:2016:TS-Standard).

[17] The Greater Western Hwy/M7 route is generally the quicker of the two routes, but is approximately 5 kilometres longer than via Knox Road.

Figure 13: Origin–destination volumes – Scenario 1



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

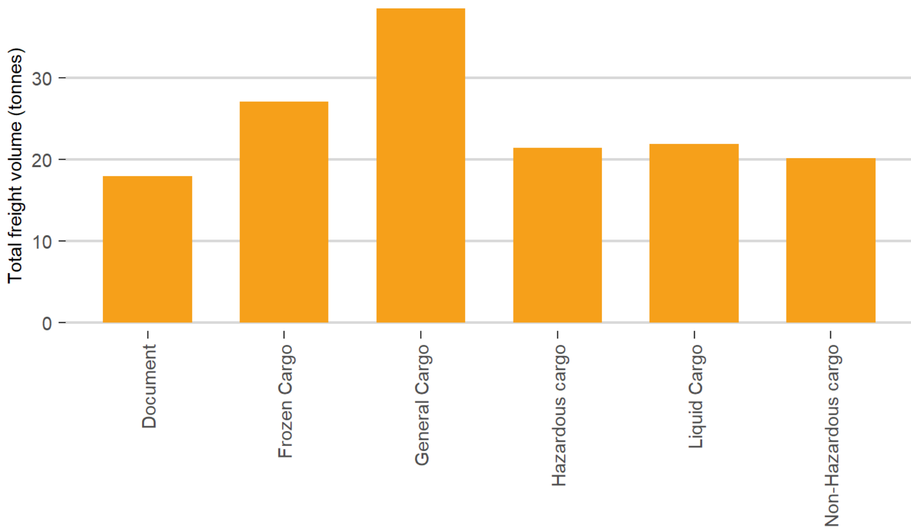
Aggregate outputs of freight volumes by commodity type, transport mode, month, day or hour (departure or arrival time) can be derived for each Scenario origin–destination pair. Figure 14, for example, illustrates total synthetic freight volumes by commodity type for Scenario 1.

FREIGHT TRAVEL TIME MEASURES

The availability of *planned* and *actual* freight consignment departure, arrival, loading and unloading dates and time in TI/TS messages permit derivation of supply chain freight travel times for individual supply chains. Such information could provide not only freight transit times, but also insights about the efficiency of other stages of freight supply chains, such as typical freight consignment dwell times and loading/unloading time at distribution centres, intermodal terminals and other points of the supply chain.

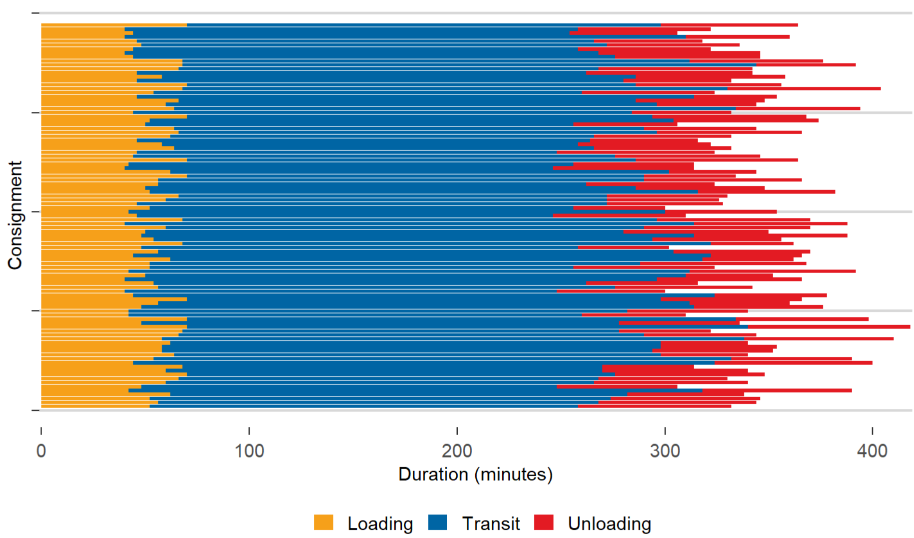
Figure 15 provides an example of total consignment/shipment transit times for a sample of the synthetic Scenario 1 freight consignments, split into loading time, unloading time and freight transit time—measured as the difference between transport movement departure and arrival times. Under the Scenario 1 assumptions, freight transit time, on average comprise around 66 per cent of total supply chain time, between loading start and unloading end.

Figure 14: Scenario 1 freight volumes by commodity type



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

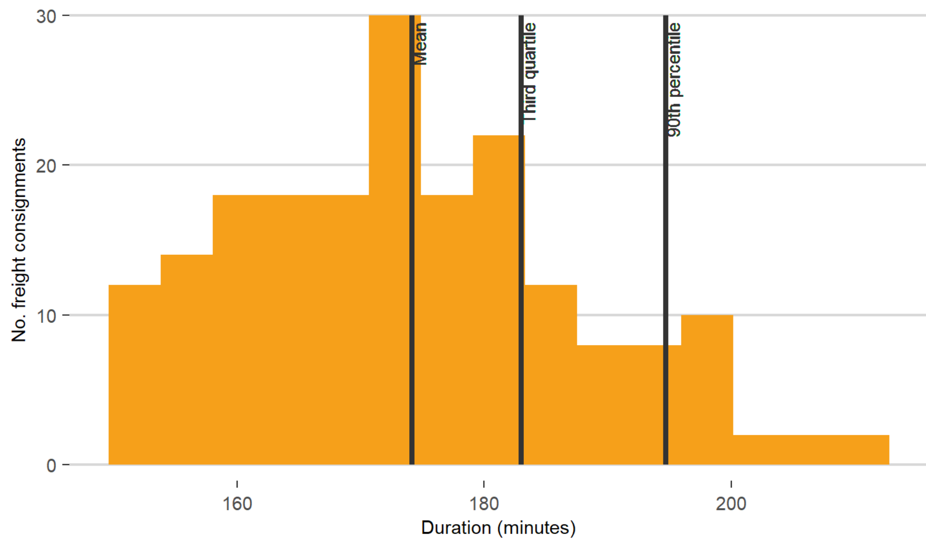
Figure 15: Scenario 1 - sample shipment supply chain duration, by supply chain stage



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 16 shows the travel time distribution for the Scenario 1 synthetic consignments, as well as the average (mean) travel time and the 75th and 90th percentile travel times. Under the scenario data generating assumptions, the average travel time from shipment loading to delivery of the shipment at final destination—around 174 minutes, and around 25 per cent of trips take longer than 183 minutes, and 10 per cent of trips take more than 195 minutes.

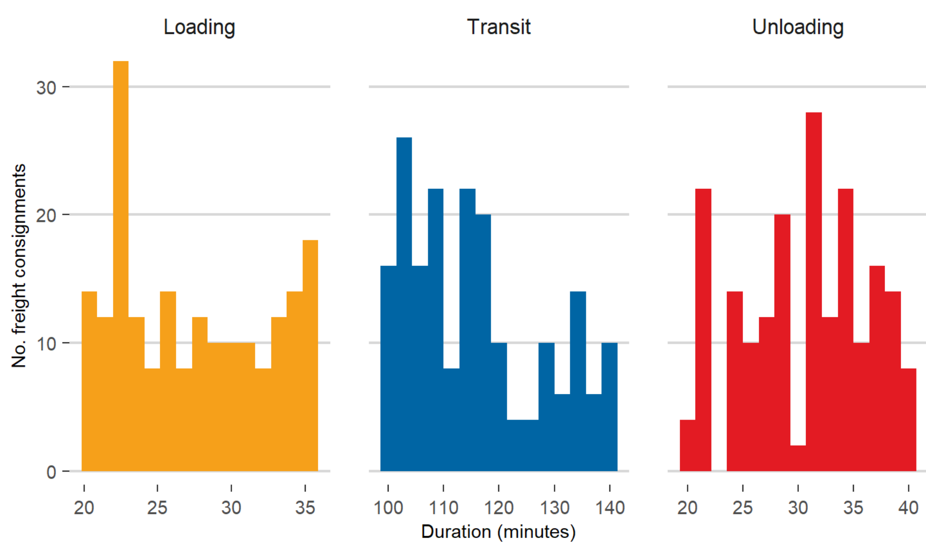
Figure 16: Scenario 1 freight volumes by commodity type



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 17 shows the distribution of time across the different stages under the Scenario 1 supply chain—loading, travel and unloading. The median loading time is 27 minutes, the median unloading time is 32 minutes, and the median freight travel time 114 minutes. Freight transit time comprises approximately 66 per cent of the total supply chain time between loading of the consignment/shipment at the consignor's premises to availability at the consignee's facility.

Figure 17: Scenario 1 histogram of supply chain durations by supply chain stage

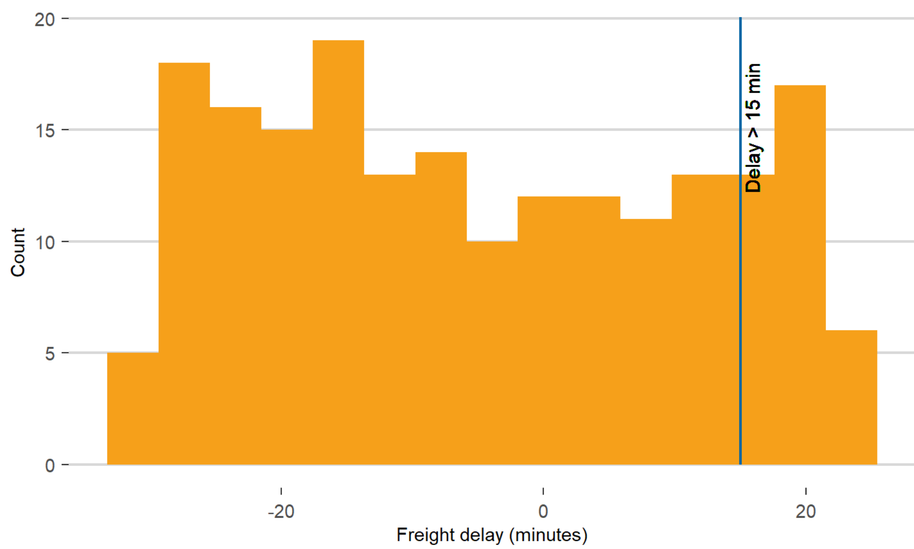


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 18 illustrates how aggregated TI and TS message data might be used to provide measures of freight delay and derive estimates of expected transit/arrival times. The figure shows the distribution of the difference between actual and planned arrival times—positive values are consignments/shipments arriving after the 'planned' arrival time, while negative values indicate early arrivals. The results of the synthetic data imply 41 per cent of consignments arrive after the planned arrival time, and 16 per cent of consignments are more than 15 minutes late compared with the nominated arrival time. With a larger data sample, estimates could be provided by time of day, day of the week and/or month.

Aggregated information about typical travel times and the distribution of travel times could also be used to predict freight arrival times. For example, under the Scenario 1 synthetic estimates, the average simulated travel time is around 114 minutes and around 90 per cent of consignments arrive within 135 minutes of departure. Knowing the average travel time and variation in travel times would facilitate updated estimates of expected arrival times based on time of departure.

Figure 18: Scenario 1 - sample shipment supply chain late delivery distribution



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

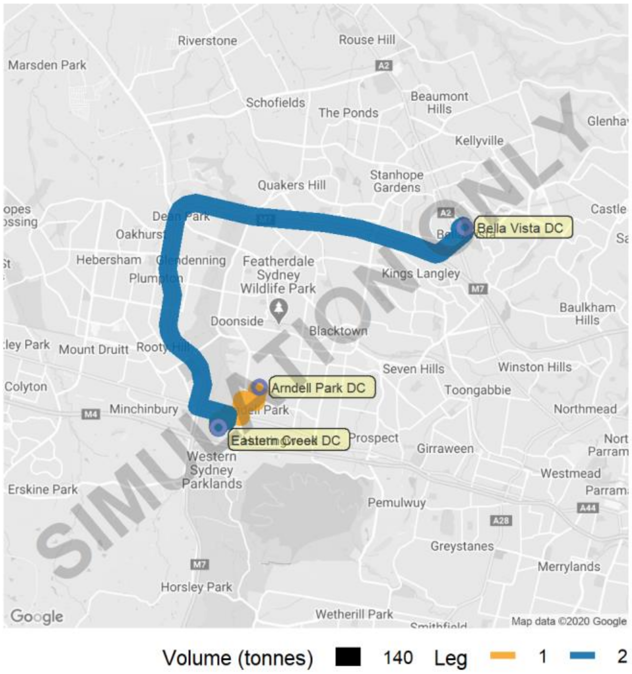
SCENARIO 2 OUTPUTS – ARNDELL PARK – BELLA VISTA, VIA EASTERN CREEK

Scenario 2 was designed as a multi-stage freight movement from Arndell Park to Bella Vista via a distribution centre—i.e. three nodes and two transport legs—with road transport used for both transport legs (one approximately 2.7 kilometres and the second around 20 kilometres). Separate measures of freight volumes, handling/transit times, etc. can be derived for each supply chain leg.

ORIGIN–DESTINATION FREIGHT VOLUMES

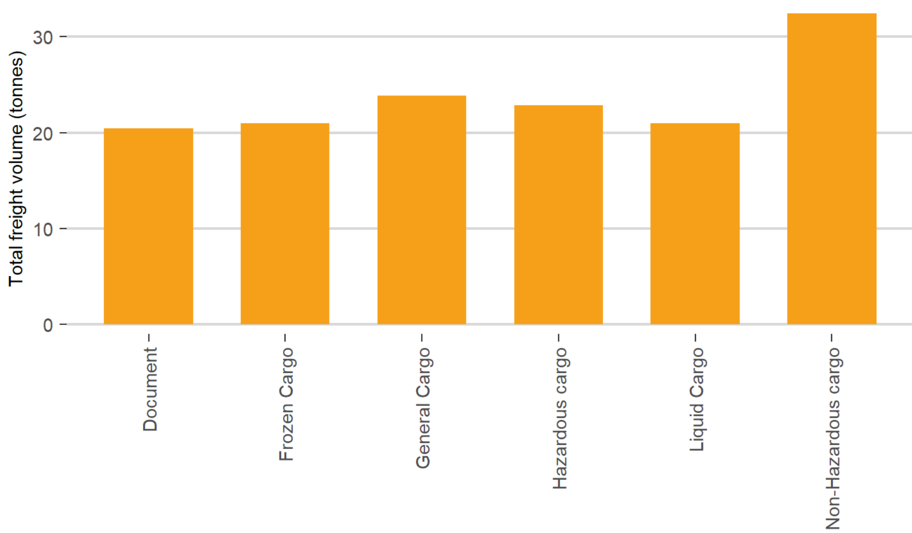
Figure 19 shows Scenario 2 synthetic sample origin–destination freight volumes assigned to the transport network. For simplicity, it was assumed the same route is used for all supply chain movements. (The transport legs are differentiated by colour in Figure 19). Figure 20 illustrates total synthetic freight volumes by commodity type for Scenario 2.

Figure 19: Origin–destination volumes – Scenario 2



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 20: Scenario 2 freight volumes by commodity type

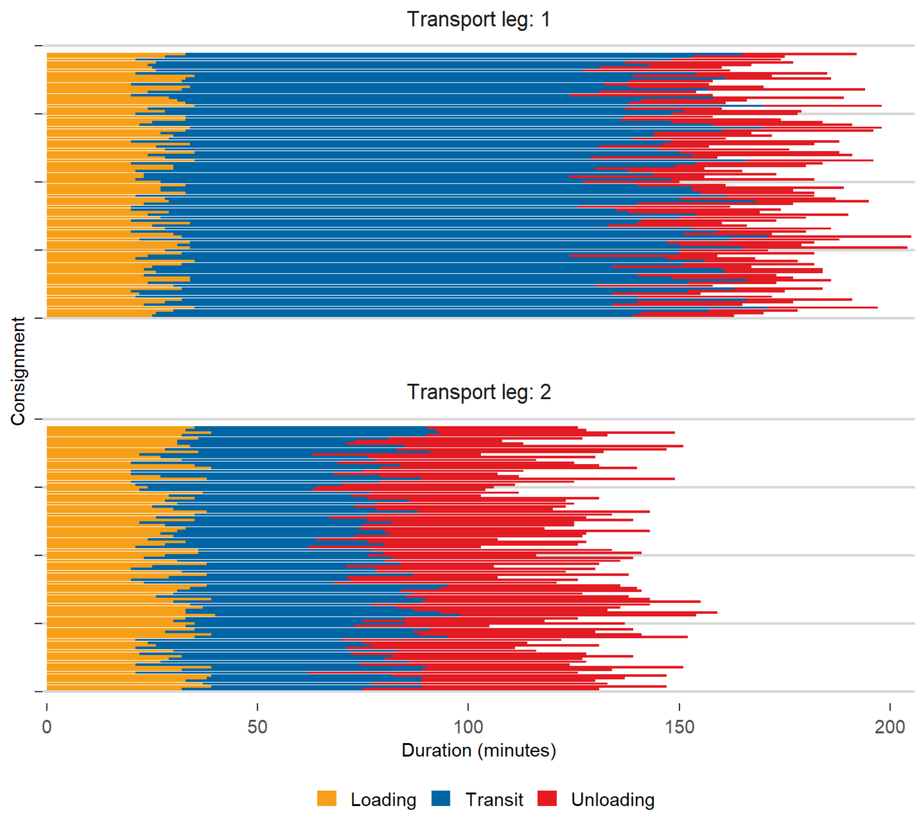


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

FREIGHT TRAVEL TIME MEASURES

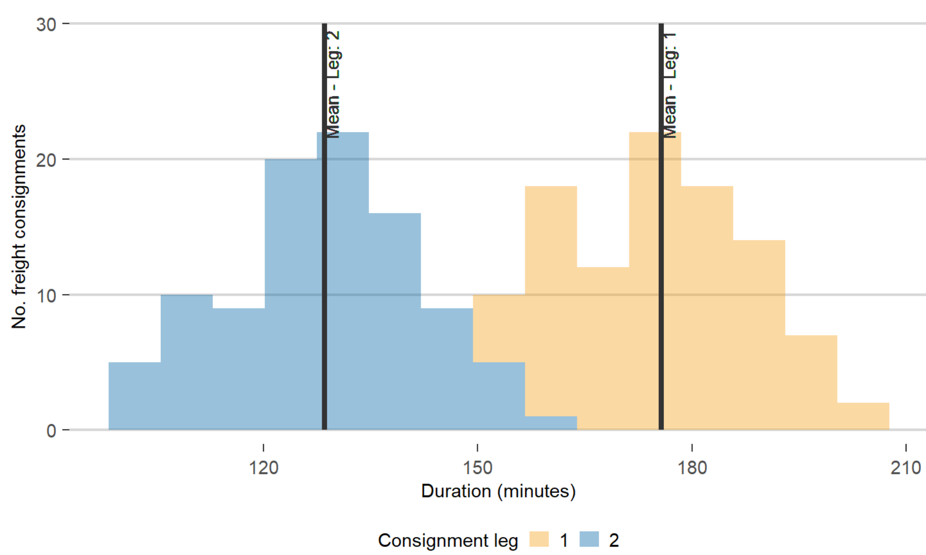
Separate travel time measures are derived for each transport leg and for the entire supply chain. Figure 21 provides an overview of freight consignment loading, transit and unloading times for a sample of Scenario 2 synthetic shipments.

Figure 21: Scenario 2 - sample shipment supply chain duration, by supply chain stage and transport leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 22: Scenario 2 supply chain freight transit time distribution, by supply chain leg

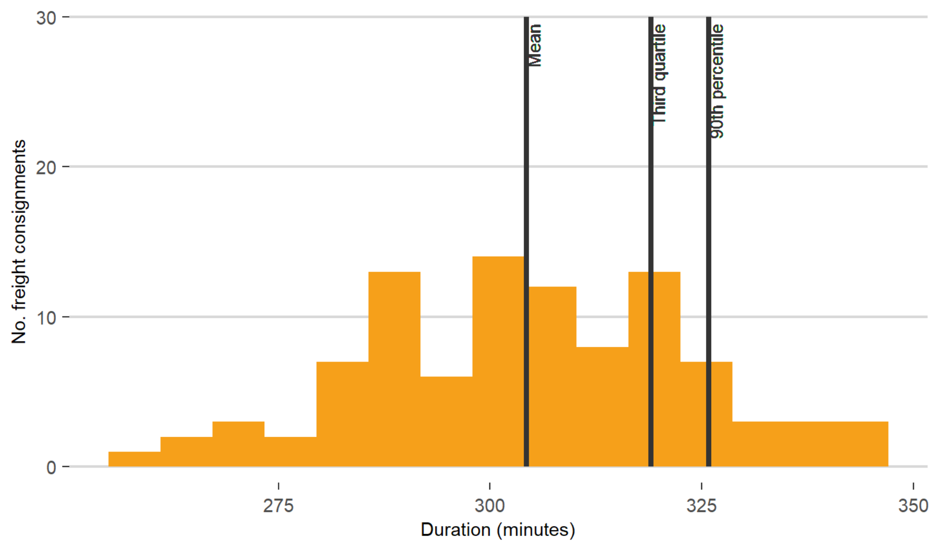


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 22, for example, shows the distribution of total freight consignment handling time—between time of vehicle loading to time of consignment delivery—for each leg of the supply chain for Scenario

2 synthetic shipments. The average travel time from shipment loading to delivery for leg 1 is around 176 minutes, and the average travel time for leg 2 is around 129 minutes. The total average time across the entire supply chain is 304 minutes. And Figure 23 shows the distribution of total travel time for all Scenario 2 freight consignments, as well as the mean, 75th percentile (third quartile) and 90th percentile travel time.

Figure 23: Scenario 2 total supply chain freight transit time distribution

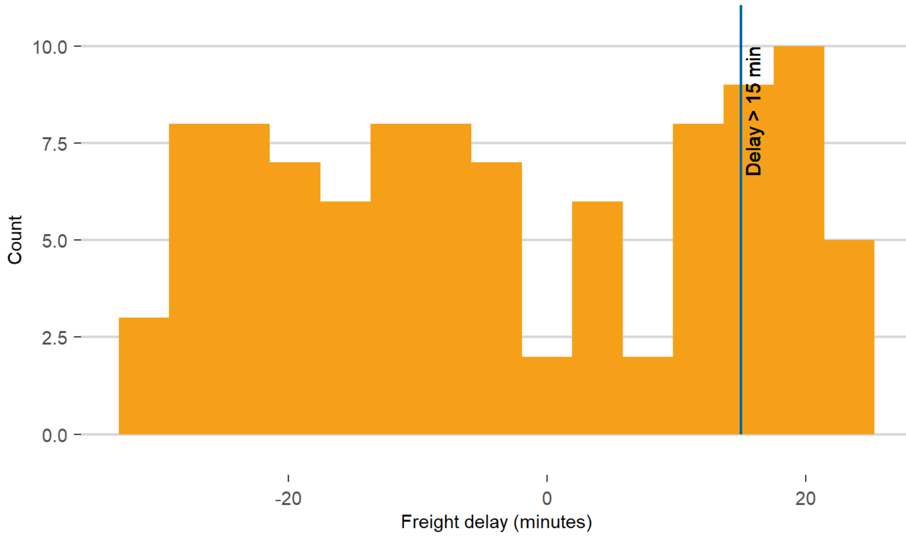


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

FREIGHT CONSIGNMENT DELAY MEASURES

Another potential use of the freight consignment message data would be identifying the proportion of freight arriving late. Figure 24 shows the distribution of freight delay—i.e. the difference between actual and planned delivery time—for Scenario 2 freight consignments. Positive values are consignments/shipments arriving after the 'planned' arrival time, while negative values are consignments arriving ahead of the planned arrival time. In this example, the synthetic Scenario 2 data imply 41 per cent of consignments arrive after the planned arrival time, and approximately 21 per cent of consignments arrive more than 15 minutes after the planned arrival time.

Figure 24: Scenario 2 - sample shipment supply chain late delivery distribution



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

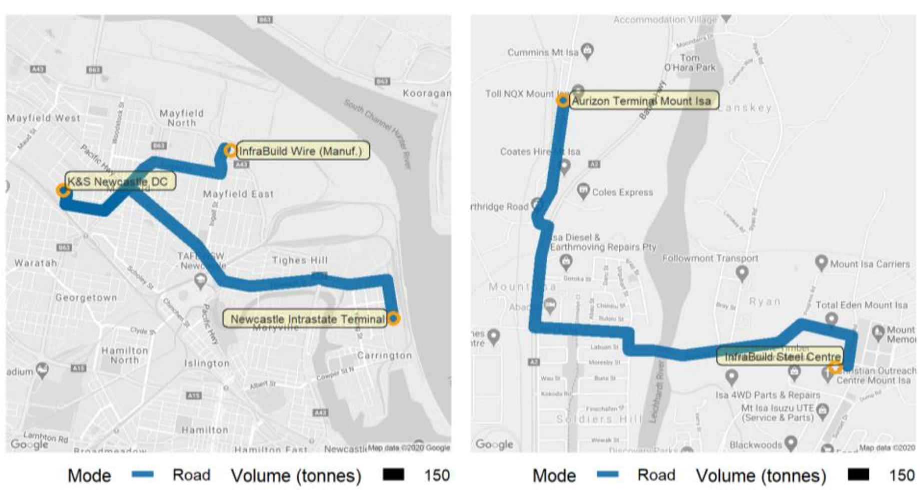
SCENARIO 3 OUTPUTS – NORTH-SOUTH INTERMODAL INTERSTATE FREIGHT SCENARIO

Scenario 3 also features multiple transport legs—from Mayfield (NSW) to Mount Isa (Queensland), via two DCs and an intermodal freight terminal. Scenario 3 involves five handling points and four transport legs—three shorter-distance road transport legs and one long interstate rail transport haul.

ORIGIN–DESTINATION FREIGHT VOLUMES

Figures 25 and 26 illustrate the Scenario 3 supply chain movements that can be extracted from freight consignment data—Figure 25 shows the road legs, to and from the rail terminal.

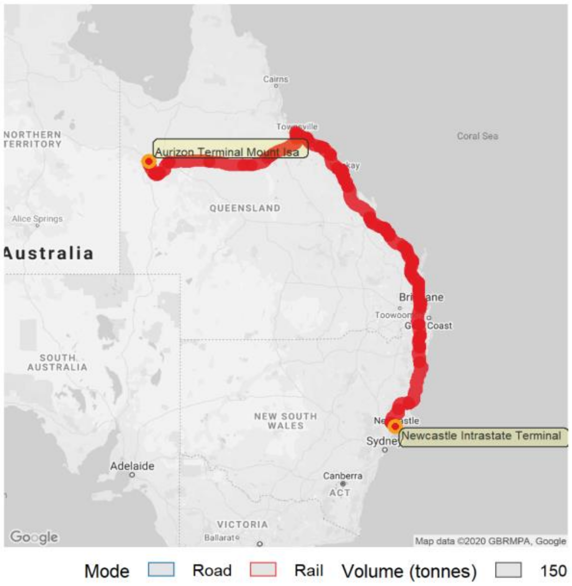
Figure 25: Origin–destination volumes – Scenario 3 (Legs 1 and 2)



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

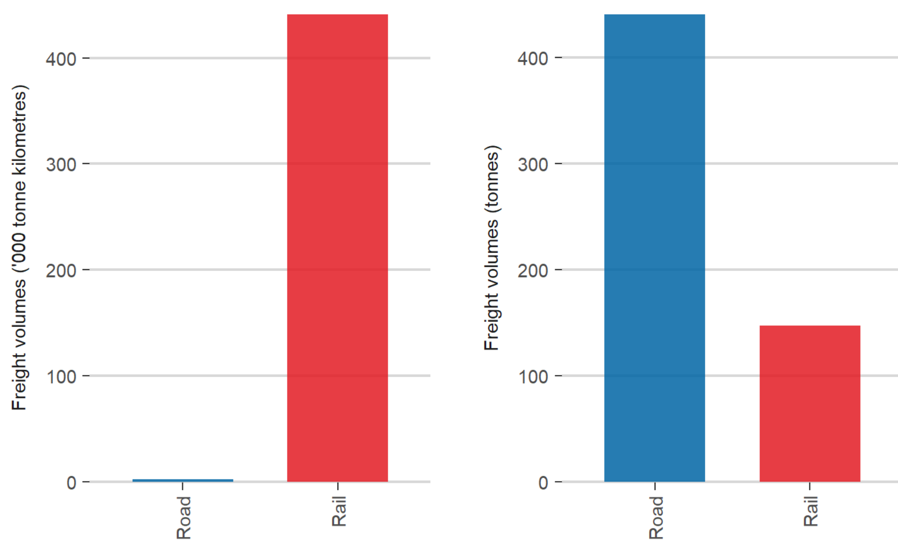
Figure 26 shows the rail leg, between Newcastle Intrastate (rail) Terminal and Mount Isa (rail) Terminal.[18]

Figure 26: Origin–destination volumes – Scenario 3 (Leg 4)



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 27: Scenario 3 freight volumes by transport mode



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

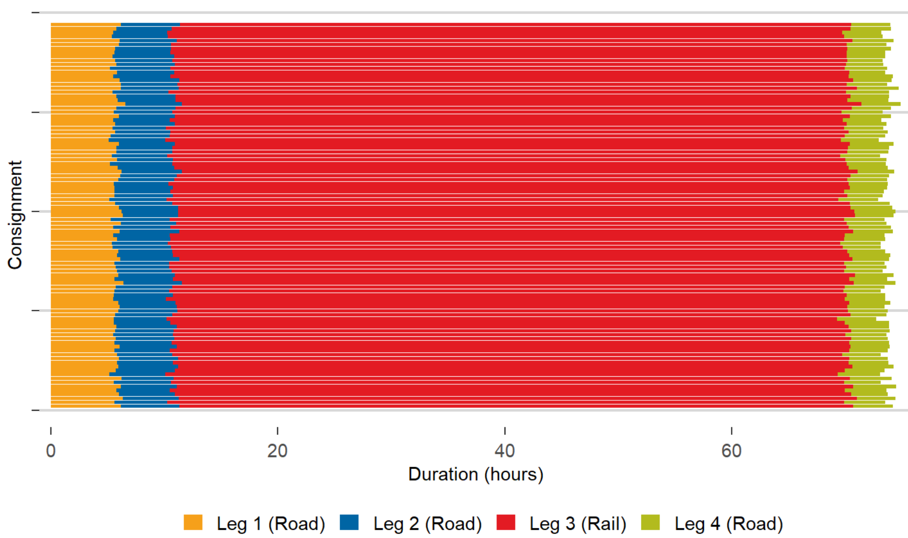
[18] Interstate rail travel between New South Wales and Northern Queensland presumably includes transfer from standard gauge to narrow gauge rollingstock north of Brisbane, and travels to Mount Isa via Townsville.

Estimates of the implied freight volumes derived from the sample of Scenario 3 freight consignment messages are shown in Figure 27, measured in both total tonnages and tonne kilometres. The tonnage estimates represent the number of tonnes 'uplifted'—i.e. total tonnes times the number of separate transport legs—hence the road freight (3 legs) estimate appears three times the size of the rail freight (1 leg) estimate. The tonne kilometre (mass distance) estimates show the total tonnes times the distance travelled by each mode.[19] Measured in tonne kilometres, the rail freight task dwarfs the road freight task, reflecting the nature of this supply chain scenario—one very long rail line-haul component and two short-distance road segments.

FREIGHT TRAVEL TIME MEASURES

Figure 28 shows the consignment/shipment transit times for a sample of the Scenario 3 shipments, by transport leg. The long rail transport leg in this scenario dominates the overall travel time—the rail freight leg accounts for around 76 per cent of the typical total transit time in this scenario.

Figure 28 Scenario 3 - sample shipment supply chain duration, by supply chain stage and leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 29 shows the distribution of total freight handling time—between time of vehicle loading to time of consignment delivery—for each leg of the Scenario 3 supply chain, and Table 7 reports the average travel time (minutes), for each stage and each leg.

---

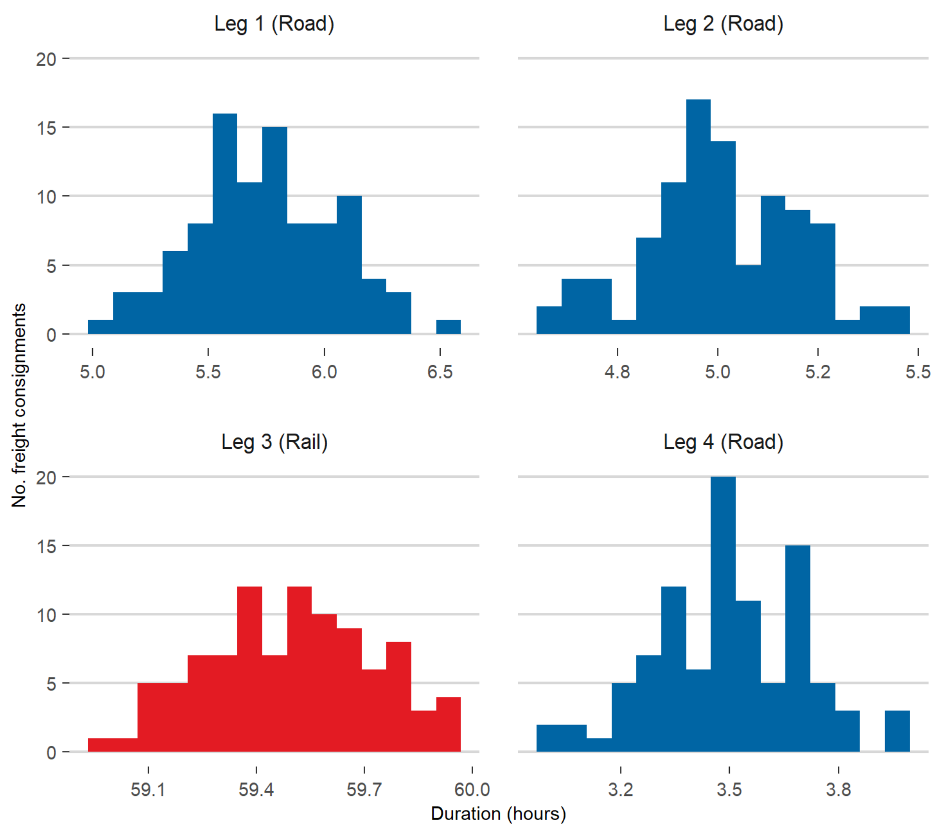
[19] Mass distance freight measures are invariant to the transport arrangements, and hence generally preferred as a measure of freight transport activity.

Table 7: Scenario 3 – Median stage durations

Stage	Transport leg 1	Transport leg 2	Transport leg 3	Transport leg 4	Total
	(hours)				
Loading	0.9	0.5	0.8	0.5	2.6
Transit	1.0	1.0	28.0	0.8	30.8
Unloading	1.0	1.0	1.0	0.5	3.5
Total	2.9	2.5	29.8	1.8	36.9

Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 29: Scenario 3 supply chain transit time distribution, by supply chain leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Other supply chain related metrics that could be derived from freight consignment messages for Scenario 3 include divergences between planned and actual freight arrivals, the 90th percentile arrival time and estimated delivery times.

SCENARIO 4 OUTPUTS – EAST-WEST INTERMODAL INTERSTATE FREIGHT SCENARIO

Scenario 4 involves the multimodal transport movement of consumer goods between eastern Australia and Perth. It involves four handling points and three transport legs—one medium-length haul between Sydney and Parkes, a long-haul rail movement from Parkes Intermodal Rail Terminal to the Perth Intermodal rail terminal, and a final short-haul road movement to the Perth International

Airport DC (WA). As Scenario 4 is very similar in profile to Scenario 3, the derived sample outputs presented here are also very similar.

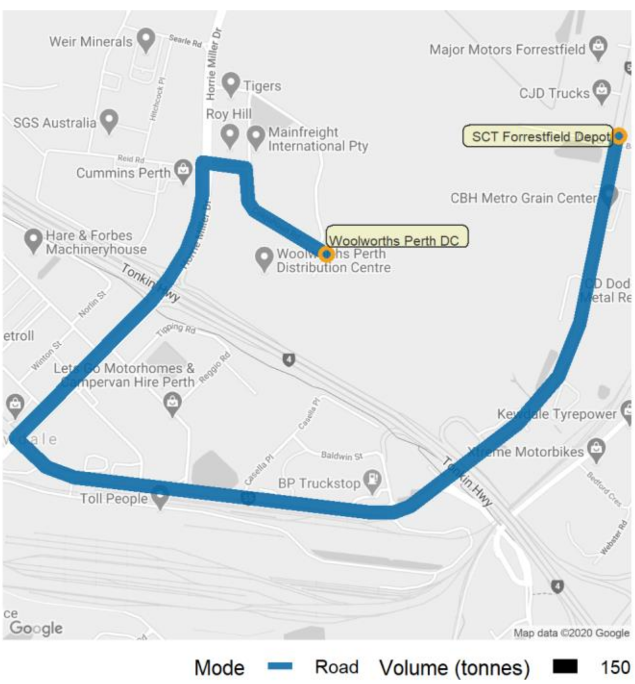
ORIGIN–DESTINATION FREIGHT VOLUMES

Figures 30 and 31 illustrate the Scenario 4 supply chain movements that can be extracted from freight consignment data—Figure 30 shows all transport legs, and Figure 31 provides more magnified views of the road transport legs. Again, like Scenarios 2 and 3, the project team modelled only one road transport route for each leg in Scenario 4.

Figure 30: Origin–destination volumes – Scenario 4

Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

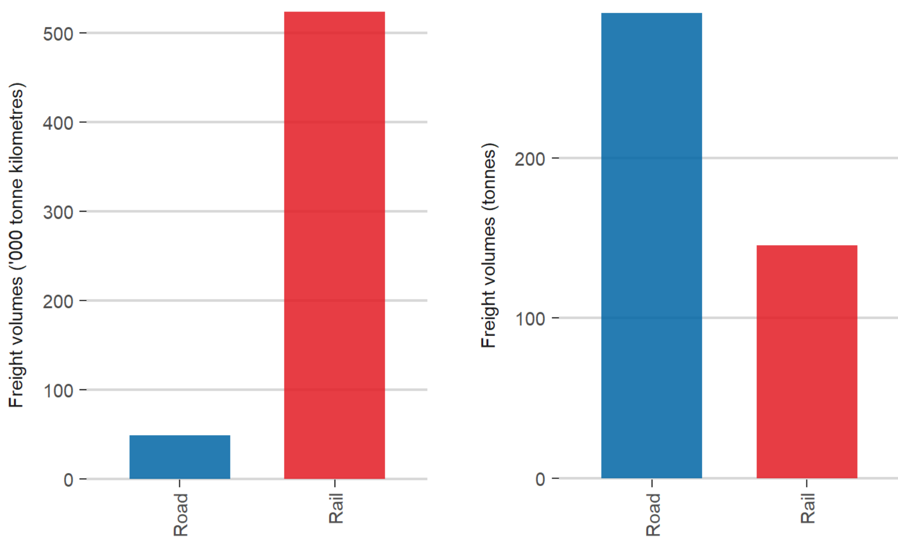
Figure 31: Origin–destination volumes – Scenario 4 (Leg 3)



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 32 shows estimates of the implied freight volumes, measured in both total tonnages and tonne kilometres, for Scenario 4 freight consignment synthetic messages. Like the case of Scenario 3, the road freight (2 legs) tonnage estimate is twice that of rail freight (1 leg), which the tonne kilometre (mass distance) estimate shows that total rail freight tonne kilometres in this scenario is are approximately ten times the size of the road freight tonne kilometre task.

Figure 32: Scenario 4 freight volumes by transport mode

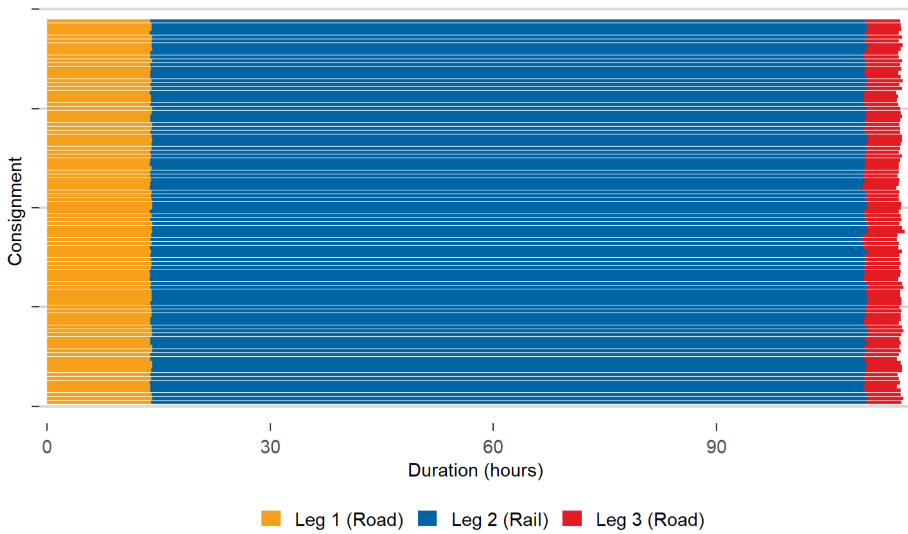


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

FREIGHT TRAVEL TIME MEASURES

Figure 33 shows the consignment/shipment transit times for a sample of the synthetic Scenario 4 shipments, by transport leg. Like Scenario 3, the long rail transport leg in this scenario dominates the overall travel time—the rail freight leg accounts for around 70 per cent of the typical total transit time in this scenario.

Figure 33: Scenario 4 - sample shipment supply chain duration, by supply chain stage and leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

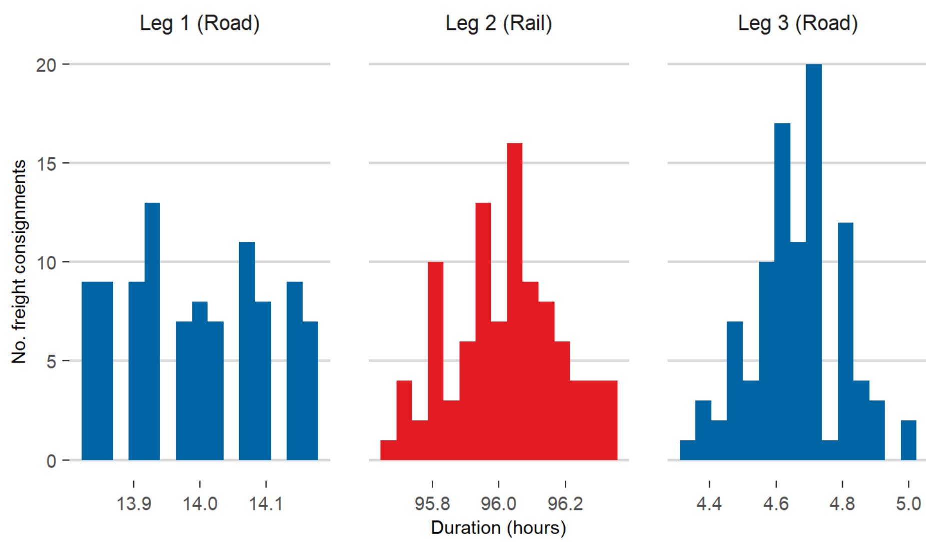
Figure 34 shows the distribution of total freight handling time—between time of vehicle loading to time of consignment delivery—for each leg of the Scenario 4 supply chain, and Table 8 reports the average travel time (minutes), for each stage and each leg. (Note that though the distributional spread shown in Figure 34 appear broadly similar for each transport leg, they are distributed over significantly different time intervals.)

Table 8: Scenario 4 – Median stage durations

Stage	Transport leg 1	Transport leg 2	Transport leg 3	Transport leg 4	Total
	(hours)				
Loading	0.2	1	0.5	1.8	0.2
Transit	7.0	48	2.3	57.4	7.0
Unloading	5.7	40	0.6	46.3	5.7
Total	1.0	7	1.2	9.2	1.0

Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

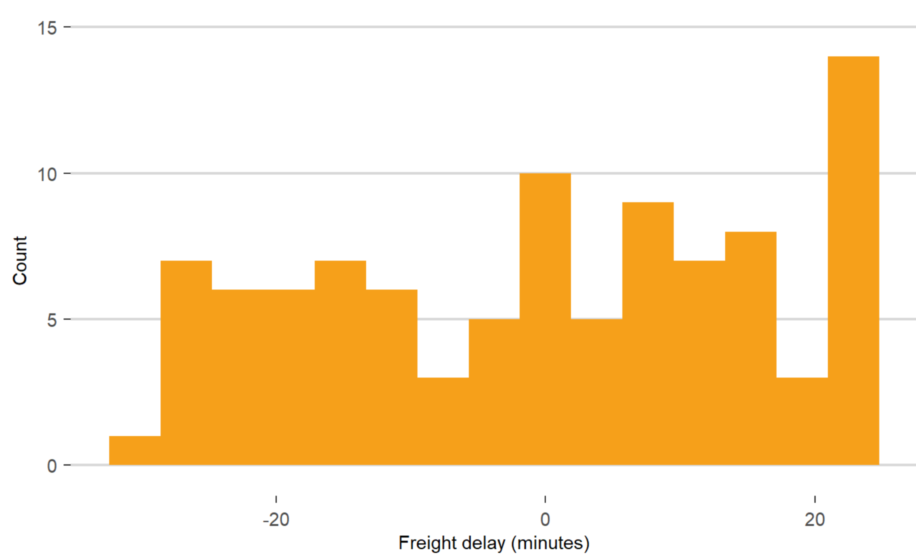
Figure 34: Scenario 4 supply chain freight transit times, by supply chain leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Other supply chain related metrics that could be derived from freight consignment messages for Scenario 4, such as divergences between planned and actual freight arrivals, the 90th percentile arrival time and estimated delivery times. Figure 35 shows the distribution of the difference between actual and planned delivery time at the consignee—positive values are consignments/shipments arriving after the 'planned' arrival time, while negative values indicate early arrivals. The results of the synthetic data imply 53 per cent of consignments arrive after the planned arrival time, and 23 per cent of consignments are more than 15 minutes late compared with the nominated arrival time.

Figure 35: Scenario 4 – sample shipment supply chain late delivery distribution



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

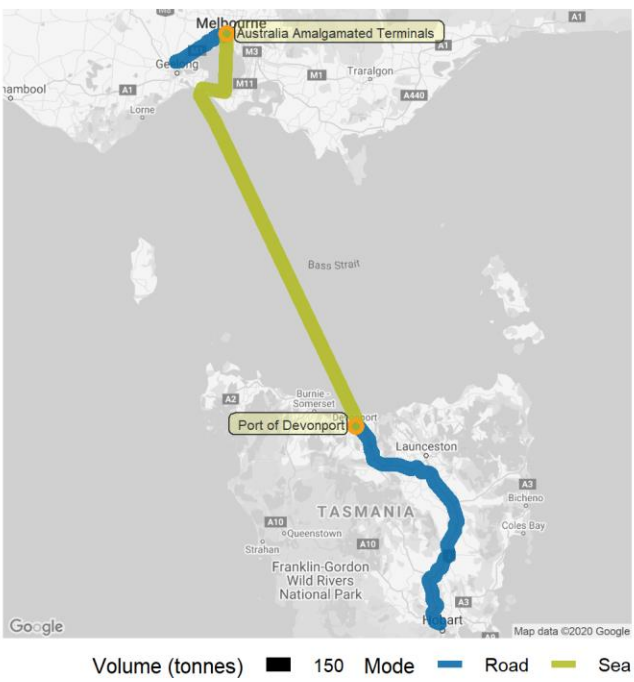
SCENARIO 5 OUTPUTS – INTERSTATE (BASS STRAIT) INTERMODAL FREIGHT SCENARIO

Finally, Scenario 5 is a multimodal supply chain involving movement of construction products between Geelong (Vic.) and Hobart (Tas.), and includes a sea freight component (via the Bass Strait). The scenario involves four handling points and three transport legs—one local road transport haul, one longer intrastate road leg and maritime movement between the Ports of Geelong and Devonport. Again, TI and TS messages could be used to provide freight volumes measures, freight transit times, potentially freight ETAs and measure of lateness.

ORIGIN–DESTINATION FREIGHT VOLUMES

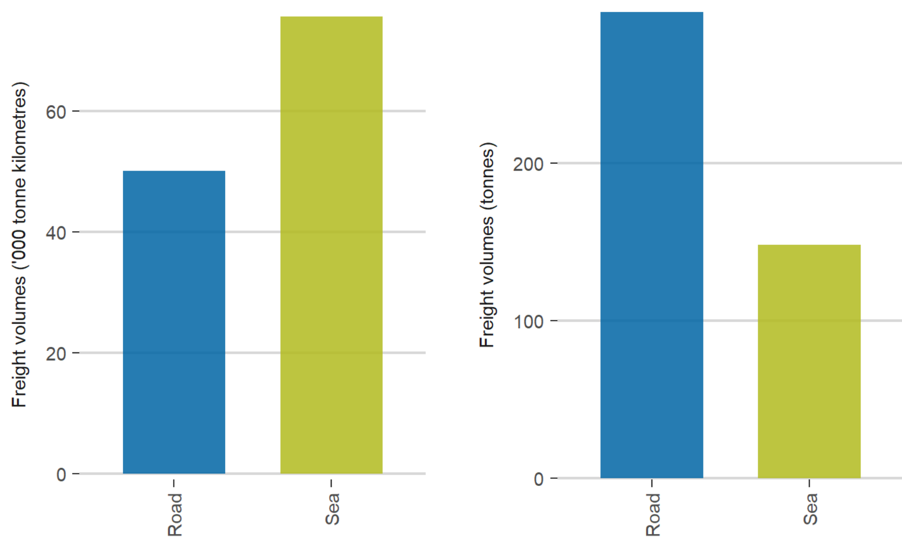
Like the other multi-stage scenarios, Figure 36 illustrates the Scenario 5 supply chain movement and route information that could potentially be extracted from freight consignment message data. (Only one route was considered for each transport leg—in this scenario, there is generally only one feasible route for each transport leg.) Again, aggregate outputs of freight volumes by commodity type, transport mode and/or time of departure/arrival can be derived for each Scenario origin–destination pair. Figure 37 shows estimates of the implied freight volumes under Scenario 5, measured in both total tonnages and tonne kilometres, split by transport mode.

Figure 36: Origin–destination volumes – Scenario 5 (Leg 1)



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 37: Scenario 5 freight volumes by transport mode

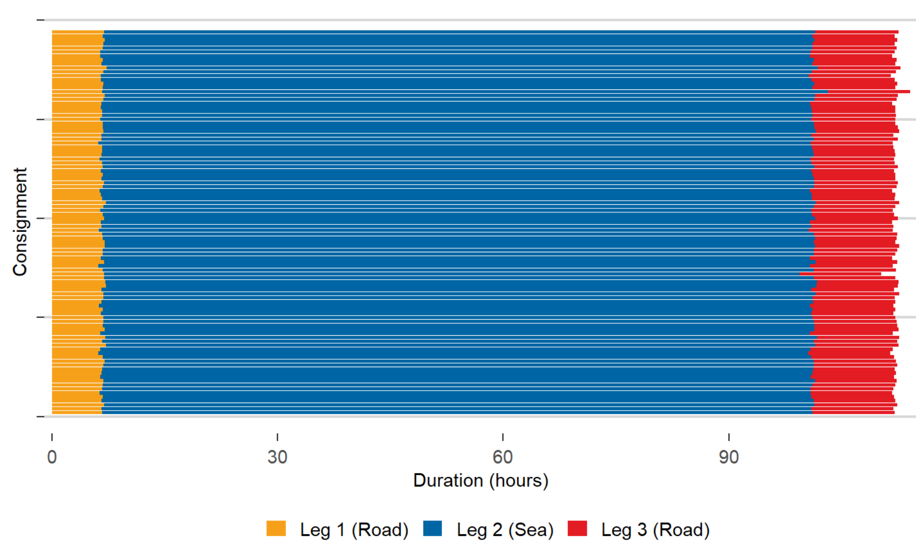


Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

FREIGHT TRAVEL TIME MEASURES

Separate travel time measures can be derived for each transport leg and for the entire supply chain. Figure 38 shows the consignment/shipment transit time, for a sample of the synthetic Scenario 5 freight consignments by transport leg. The sea freight transport leg in this scenario dominates the overall travel time, accounting for around 84 per cent of the typical total transit time in this scenario.

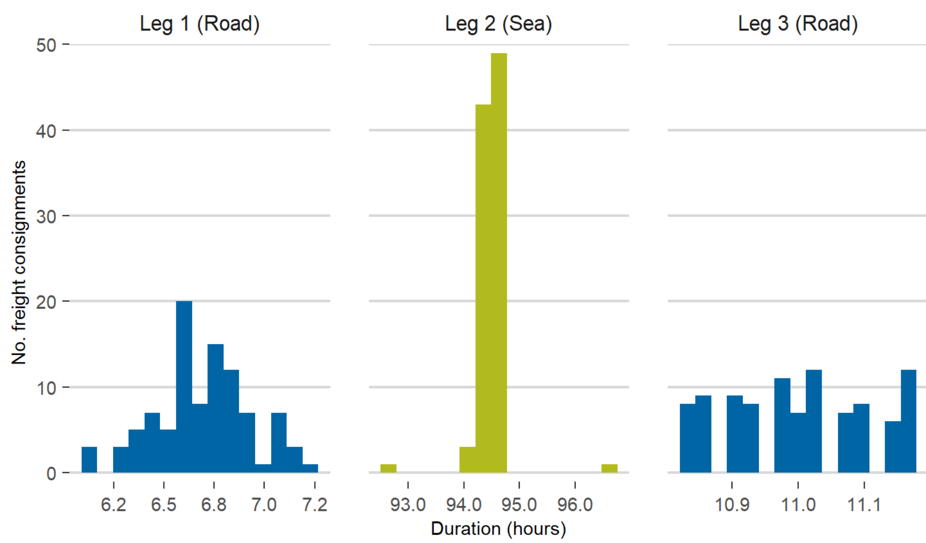
Figure 38: Scenario 5 - sample shipment supply chain duration, by supply chain stage



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Figure 39, for example, shows the distribution of total freight handling time—between time of vehicle loading to time of consignment delivery—for each leg of the supply chain for the Scenario 5 synthetic shipments sample. (Again, as for Scenarios 3 and 4, note that the distributional spread of transit times are distributed over significantly different time intervals in Figure 39.)

Figure 39: Scenario 5 supply chain freight transit times, by supply chain leg



Note: Estimates based on synthetic freight consignment data and do not necessarily reflect actual supply chain data.

Again, other supply chain related metrics that could be derived from freight consignment messages for Scenario 5, such as divergences between planned and actual freight arrivals, the 90th percentile arrival time, estimated delivery times or average travel times.

OTHER POTENTIAL OUTPUTS AND USES

Other potential outputs that it was not possible to explore using the synthetic data set, but that may be feasible with a sufficiently large sample of actual consignment message data could include:

BENCHMARKING TRAVEL TIMES AND MEASURING FREIGHT DELAY

Incorporating realistic freight delays in the synthetic supply chain scenario data was beyond the scope of the analysis. Actual consignment message data may provide more scope to explore measures of freight delay. Were more realistic consignment message data made available, it could be used to develop benchmarking measure of interest to supply chain participants (e.g. average loading/unloading times), and other insights into other aspects of individual supply chains, say about where delays are most significant and where process improvements may provide the greatest potential savings.

PREDICTIVE SUPPLY CHAIN ETAS

Related to freight delay metrics would be predictive estimates of the time of consignment arrival. With a sufficiently large sample of actual consignment message data it would, in theory, be possible to use statistical methods to develop predictive measure of arrival times.

LINKING TO VEHICLE LOCATION

Linking asset information contained in TI and TS messages to freight vehicle identities could, in theory, facilitate real-time tracking of freight consignments—by tracking in real time the vehicle in which an individual consignment or shipment is being carried. This would require access to real-time vehicle GPS information, and the cooperation of vehicle telematics service providers. Linking freight consignment and vehicle GPS information on any significant scale would also be technically challenging—there are a large number of vehicle telematics service providers offering a range of different types and levels of service, at varying levels of cost.

RECOMMENDATIONS AND CONCLUDING REMARKS

INTRODUCTION

This project has investigated the feasibility of using raw freight consignment messages, transmitted between supply chain partners, to provide aggregate freight volume measures and freight supply chain information, developed methods to extract relevant information from freight consignment messages and produced some sample outputs from a synthetic sample of raw freight consignment messages.

The work demonstrates that extracting and aggregating freight-related information from freight consignment messages is feasible and readily implementable.

KEY FINDINGS

The key findings from the study are that the raw consignment message data contains the sort of detailed data about freight movements that, when aggregated, could provide valuable insights for infrastructure planning, network operations planning, corridor planning and freight policy. In particular, such data can provide valuable insights into the volume and pattern of urban freight movements, which is a major gap in transport data collection and hampers the ability of policy makers to make well-informed decisions.

Raw freight consignment message data can also provide insights about freight travel times between different freight locations and across key freight corridors, particularly in urban areas. Example metrics featured in this report include:

- average travel times and travel time distribution between high-volume freight locations
- variations in average travel time by time of day
- average travel times for common freight routes and/or freight corridors
- estimated time of arrival (ETA) by time of day, based on historical message information.

Freight consignment/shipment messages also identify the transport mode for each transport leg and include scope to identify vehicle type, vehicle configuration and differentiate between multiple routes. The inclusion of mode and vehicle type information in messages, would facilitate aggregation of modally-based volume and travel time measures. Vehicle type information is optional, so provision of vehicle type-based outputs would be dependent on a sufficient proportion of messages containing this information.

The transport route information in freight consignment messages appears limited to a short text description, sufficient to provide a general idea of the route chosen, but not unambiguously identify all network segments traversed. In theory, at least, it would potentially be possible to link each freight consignment message with freight vehicle GPS information—using departure/arrival times and locations—and then use vehicle GPS trace data to determine the actual route used to transport each consignment. While possible in theory, the feasibility and resources required to link consignment and GPS-trace information would need to tested.

RECOMMENDATIONS AND FURTHER WORK

The key findings and unexplored elements of the three pilot projects suggest a range of potential further work that would help improve the visibility and availability of freight data in Australia. These are framed as a series of recommended potential follow-up projects.

SYSTEM TESTING USING ACTUAL FREIGHT CONSIGNMENT MESSAGE DATA

Difficulties in matching consignment message data across supply chain partner systems and impact of the COVID-19 pandemic on industry priorities meant that only a very small sample of actual freight consignment data was made available for this (the data aggregation) project. This forced the project team into

generating a synthetic data set to develop and test methods to process freight consignment messages. This report has presented some *demonstration* sample outputs using that synthetic data sample. The natural next step would be to fully test the feasibility of the framework and utility of the outputs using an effective sample of actual data for a small number of different origin–destination pairs, and feeding the data through the raw data extraction, data store and output generation processes.

Recommendation 1

> Test the methods and systems established in this report using a sufficient sample of *actual* freight consignment messages.

DEVELOPING REAL-TIME SUPPLY CHAIN DATA VISIBILITY

This report has illustrated a range of potential *static* freight performance measures that can be derived from GS1 TI and TS (and EPCIS) messages exchanged between supply chain partners. While static measures can provide information suitable for informing planning and measuring system performance, they do not provide the type of *real-time* alert type information required from time-to-time by individual supply chain partners, nor a real-time view about where any particular shipment/consignment may be (physically) at any point in time.

Linking TI and TS asset information details to freight vehicle identities could, in theory, facilitate real-time tracking of freight shipments/consignments—by enabling real-time tracking of the vehicle in which the shipment/consignment is being carried. This would require access to real-time vehicle GPS information, which would require the cooperation of vehicle telematics service providers. This is not a trivial issue, as there are a large number of vehicle telematics service providers providing a range of different levels of service (at varying cost).

Recommendation 2

> Test the implementation of real-time freight consignment message transfer and early identification of consignment delays or condition warning messages.

IMPROVING CROSS-INDUSTRY CONNECTIVITY AND INTEROPERABILITY

Prior to the impact of COVID-19, industry also encountered difficulties in linking data across different client IT systems. In particular, identifying a unique key linking consignment information across supply chain parties was a particular difficulty encountered by industry partners—while each party has visibility of a consignment/shipment when within their span of control, they may lose visibility when custody transfers to other supply chain parties. Part of the issue is that freight transport information systems in Australia are not sufficiently developed to handle automated transfer of information across the supply chain. This meant the project team were unable to implement methods to access data via API---one of the the original objectives of this project was to develop methods and assess the broader feasibility of automated transfer of consignment messages via API (or similar type interfaces).

Limited industry feedback suggests that much of the Australian freight transport and logistics sector is currently not sufficiently developed to handle automated data transfer nor provide API access. As a consequence, it presently appears difficult to follow freight consignments when custody is transferred between shipper and logistics service provider (LSP) and again from LSP to receiver—and provide real-time view of freight data across supply chains.

Developing a better understanding of the current state of Australian industry supply chain related EDI capability and use, including the range of different communication frameworks/standards in use would appear to be a useful piece of research. Other related issues that could be explored include the number of different EDI frameworks and systems that are currently in use within the freight and logistics industry, and the extent to which different systems are able to exchange messages digitally or not.

Recommendation 3

> Undertake a survey of Australian freight transport and logistics sector, and related industry partners, to gauge Australian industry preparedness/readiness for more widespread adoption of electronic business data interchange.

Recommendation 4

> Subject on the outcome of the industry survey (Recommendation 3), consideration be given to developing a scope of works to assess the feasibility of fostering development of protocols and standards to improve the exchange of electronic freight supply chain information between Australian businesses.

IDENTIFYING A MINIMAL FREIGHT DATA EXCHANGE DATASET

The outcomes of the project suggest that a common, minimal set of data is required in messages exchanged between supply chain parties. This includes:

- Pick-up date/time
- Pick-up location
- Consignment type
- Volume/mass
- Delivery date/time
- Delivery location

These constitute the minimal subset of information required to exchange freight data. Another way of addressing the issues targeted by Recommendation 4 might be a separate application that enabled more widespread visibility of freight consignment information across all supply-chain partners, by exchanging a minimal set of information via a common platform/delivery application that would improve real-time visibility.

Recommendation 5 – ‘Get the App, Close the Gap’

Identify a minimal set of data that could be exchanged between supply chain partners, and develop a message framework, backend data exchange protocols, and a front-end application to enable more widespread real-time data availability and visibility.

APPENDICES

A. SCENARIO DESIGN

In lieu of a large sample of data from the project's industry partners, the project team constructed five sample freight supply chain transport scenarios, and generated multiple synthetic trips for each of the five supply chains. Trip characteristics, such as departure time, travel time, loading/unloading time, etc., were varied so that the results generated from aggregating the sample trip information provided some degree of variation.

This appendix outlines the five sample supply chain scenarios, and presents a broad overview of the *process flow* for each scenario.

SCENARIO 1 – INTRASTATE ROAD FREIGHT MOVEMENT

Scenario 1 is intended to be reflective of single-direction intrastate origin–destination road freight movement. The example scenario is a direct delivery from Nestlé's Arndell Park DC to Woolworths' Bella Vista (NSW):

- Nestlé – Arndell Park DC (12/15 Contaplas St, Arndell Park NSW 2148)
- Woolworths – Bella Vista DC (1 Woolworths Way, Bella Vista NSW 2153)

The process flow is illustrated in Figure A.1 involves one TI message, sent from shipper to transporter, and up to six (6) separate event (TS) messages covering:

- Loading
- Departing
- In-transit activity
- Arrival
- Unloading
- Delivery

Figure A.1 Scenario 1 process flow

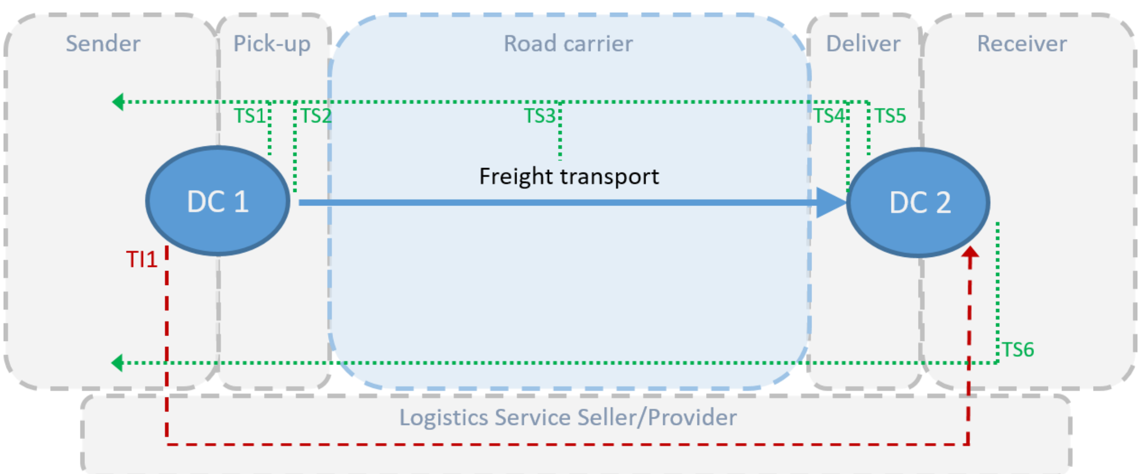


Table A.1 Scenario 1 supply chain legs and assumed event durations

Event	1st Leg
Origin	Arndell Park
Destination	Bella Vista
Mode	Road
Distance	13.8 km
Loading	15–60 min
Departing	10–30 min
In-Transit	25–60 min
Arrival	10–30 min
Unloading	15–60 min
Staging	–
Delivered	10–30 min

Notes: Event durations assumed by project team.

SCENARIO 2 – INTRASTATE ROAD FREIGHT MOVEMENT WITH INDIRECT DELIVERY VIA DC

Scenario 2 is intended to reflect a two-stage delivery process between origin and destination, with a freight consignment transiting via a transport provider's distribution centre (DC). Again, the example involves delivery from Nestlé's Arndell Park DC to Woolworths' Bella Vista (NSW), transiting via Toll's Eastern Creek DC. The supply chain locations involved are:

- Nestlé – Arndell Park DC (12/15 Contaplas St, Arndell Park NSW 2148)
- Toll – Eastern Creek DC (7 William Dean St, Eastern Creek NSW 2766)
- Woolworths – Bella Vista DC (1 Woolworths Way, Bella Vista NSW 2153)

The process flow is illustrated in Figure A.2 and involves one TI message, sent from shipper to transporter, and up to eleven (11) separate event (TS) messages covering, for each leg:

- Loading
- Departing
- In-transit activity
- Arrival
- Unloading

and a further TS message upon delivery.

Figure A.2 Scenario 2 process flow

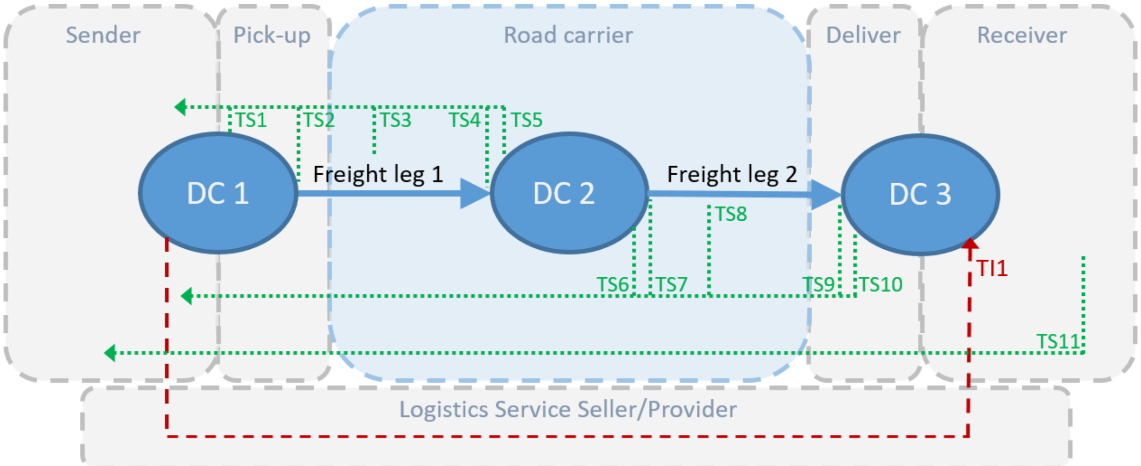


Table A.2 Scenario 2 supply chain legs and assumed event durations

Event	1st Leg	2nd Leg
Origin	Arndell Park	Eastern Creek
Destination	Eastern Creek	Bella Vista
Mode	Road	Road
Distance	2.7 km	18.9 km
Loading	15–60 min	15–60 min
Departing	10–30 min	–
In-Transit	10–20 min	25–60 min
Arrival	10–30 min	10–30 min
Unloading	15–60 min	15–60 min
Staging	15–60 min	–
Delivered	–	10–30 min

Notes: Event durations assumed by project team

SCENARIO 3 – INTERSTATE INTERMODAL FREIGHT MOVEMENT VIA DC

Scenario 3 is intended to be reflective of an interstate multi-modal, multi-stage freight movement process between an origin and destination. The scenario involves an interstate movement from Mayfield (NSW) to Mount Isa (Queensland) via a combination of road and rail, with the freight consignment transiting via several DCs and a intermodal terminal—a freight haul length of around 3180 kilometres. The supply chain locations involved are:

- InfraBuild Wire (Manufacturing) Mayfield (Ingall St, Mayfield North NSW 2304)
- K&S Freighters Newcastle DC (1 Leonard St, Mayfield NSW 2304)
- Pacific National Newcastle Intrastate Terminal (Corner Darling and Robertson Streets, Carrington NSW 2294)
- Aurizon Terminal Mount Isa (North Ridge Road, Mount Isa QLD 4825)

- InfraBuild Steel Centre - Mount Isa (45 Commercial Rd, Ryan QLD 4825)

The process flow is illustrated in Figure A.3 and involves one TI message, sent from shipper to transporter, and up to 21 separate event (TS) messages covering: loading, departure, arrival and unloading messages at each point in the supply chain and in-transit status updates.

Figure A.3 Scenario 3 process flow

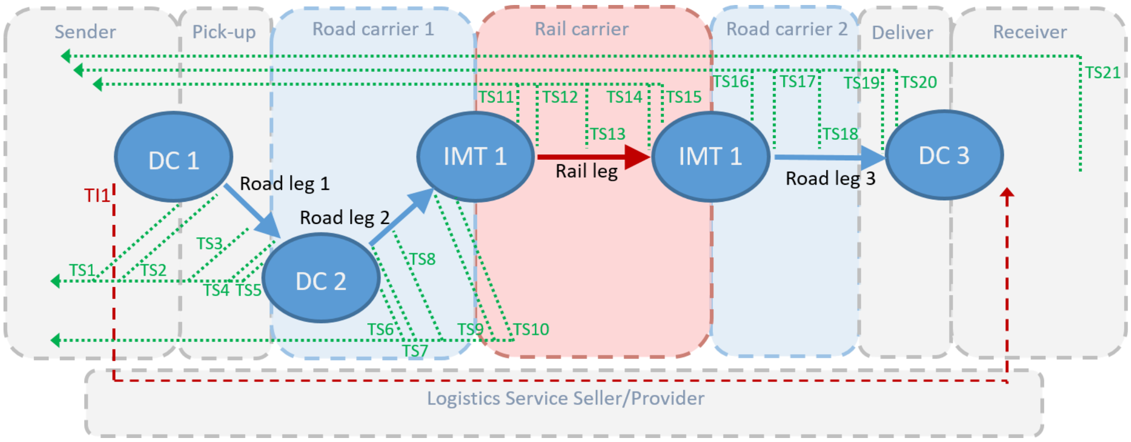


Table A.3 Scenario 3 supply chain legs and assumed event duration ranges

	1st Leg	2nd Leg	3rd leg	4th Leg
Origin	Mayfield North	Mayfield to Pacific National (PN)	PN Newcastle Intrastate Terminal	Aurizon Terminal Mt Isa
Destination	Mayfield	Newcastle Intrastate Terminal	Aurizon Terminal Mount Isa	InfraBuild Steel Centre Mt Isa
Mode	Road	Road	Rail	Road
Distance	3 km	7 km	3159 km	4.5 km
Loading	15–60 min	15–60 min	15–60 min	15–60 min
Departing	10–30 min	10–30 min	10–30 min	10–30 min
In-Transit Time	10–30 min	10–15 min	50 hrs (2 days)	15–30 min
Arrival	10–30 min	10–30 min	10–30 min	10–30 min
Unloading	15–60 min	15–60 min	15–60 min	15–60 min
Staging	15–60 min	15 min–2 days	15 min–1day	
Delivered				10–30 min

Notes: Event durations assumed by project team

SCENARIO 4 – INTERSTATE INTERMODAL FREIGHT MOVEMENT VIA DC

Scenario 4 also simulates an interstate multi-modal, multi-stage freight movement process between an origin and destination. The scenario involves an interstate movement from Nestlé (Arndell Park, NSW) to the Woolworths DC in Perth, via a combination of road and rail (and freight haul length over 4000 kilometres). The supply chain locations involved are:

- Nestlé Arndell Park DC (12/15 Contaplas St, Arndell Park NSW 2148)

- SCT Parkes Rail Depot (249 Brolgan Road Parkes NSW 2870)
- SCT Forrestfield Depot (800 – 820 Abernethy Road Forrestfield WA 6058)
- Woolworths Perth DC (20-60 Colquhoun Road, Perth International Airport, WA 6105)

The process flow is illustrated in Figure A.4 and involves one TI message, sent from shipper to transporter, and up to 16 separate event (TS) messages covering: loading, departure, arrival and unloading messages at each point in the supply chain and in-transit status updates.

Figure A.4 Scenario 4 process flow

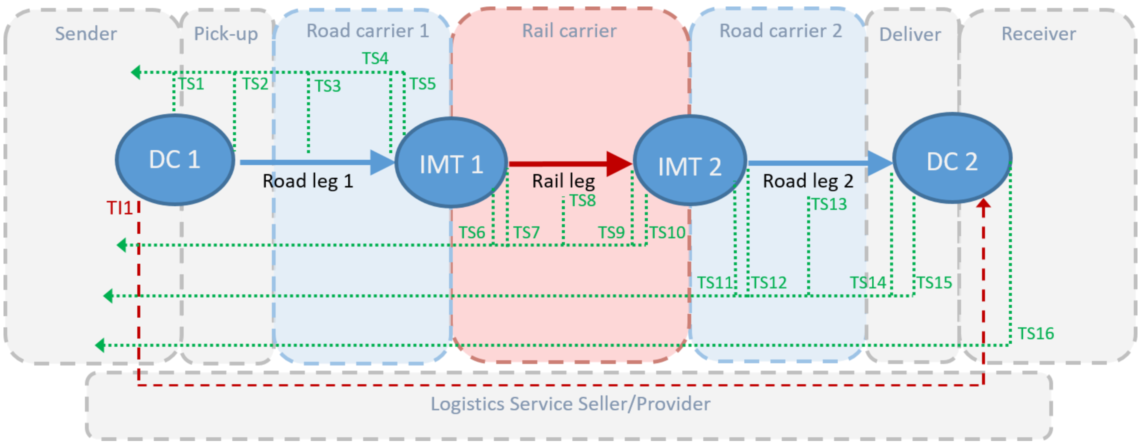


Table A.4 Scenario 4 supply chain legs and assumed event duration ranges

Event	1st Leg	2nd Leg	3rd leg
Origin	Arndell Park	Parkes Rail Depot	Forrestfield Rail Depot
Destination	Parkes Rail Depot	Forrestfield Rail Depot	Perth DC
Mode	Road	Rail	Road
Distance	328–507 km	2600–3600 km	8–10 km
Loading	15–60 min	15–60 min	15–60 min
Departing	10–30 min	10–30 min	10–30 min
In-transit	4–6 hrs	38-40 hrs	10–30 min
Arrival	10–30 min	10–30 min	10–30 min
Unloading	15–60 min	15–60 min	15–60 min
Staging	15 min – 3 days	15–60 min	
Delivered			10–30 min

Notes: Event durations assumed by project team

SCENARIO 5 – INTERSTATE (BASS STRAIT) INTERMODAL FREIGHT MOVEMENT

Scenario 5 also simulates an interstate multi-modal, multi-stage freight movement process between an origin and destination, this time via a combination of road and sea freight. The scenario involves an interstate movement of construction materials from Geelong to Hobart, with road transport from the origin to the Port of Melbourne and from the Port of Devonport to Hobart, and sea freight transport between Melbourne and Devonport. The supply chain locations involved are:

- InfraBuild Construction Solutions - Geelong (65-85 O'Briens Rd, Corio VIC 3214)
- Swire Shipping Melbourne - Australia Amalgamated Terminals (Appleton Dock Road, West Melbourne, Vic)
- Tasmanian Ports Corporation (48 Formby Rd, Devonport TAS 7310)
- InfraBuild Construction Solutions - Hobart (9 Sunmont St, Derwent Park TAS 7009)

The process flow is illustrated in Figure A.5 and involves one TI message, sent from shipper to transporter, and up to 16 separate event (TS) messages covering: loading, departure, arrival and unloading messages at each point in the supply chain and in-transit status updates.

Figure A.5 Scenario 5 process flow

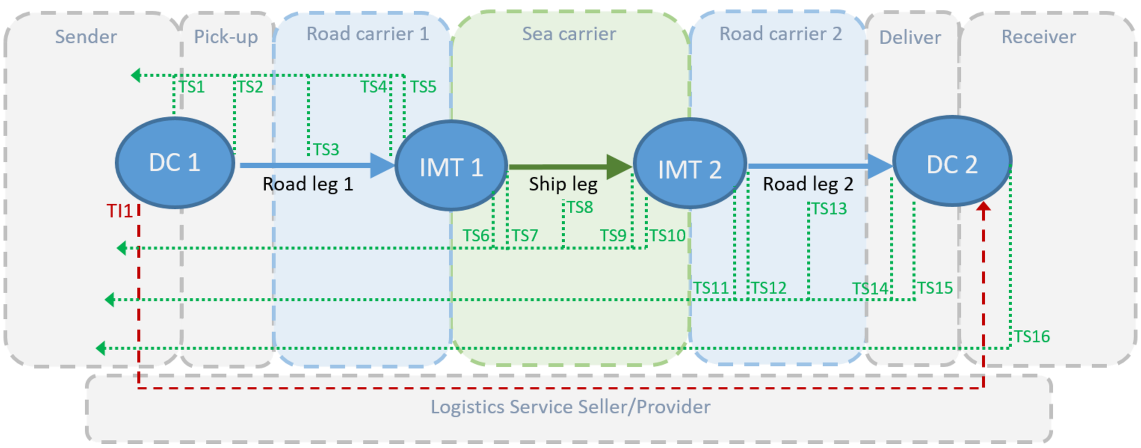


Table A.5 Scenario 5 supply chain legs and assumed event duration ranges

Event	1st Leg	2nd Leg	3rd leg
Origin	Geelong	West Melbourne Shipping Terminal	Port of Devonport
Destination	West Melbourne Shipping Terminal	Port of Devonport	Derwent Park Hobart
Mode	Road	Sea	Road
Distance	75 km	491 km	250–280 km
Loading	15–60 min	15–60 min	15–60 min
Departing	10–30 min	10–30 min	10–30 min
In-transit	60–90 min	11–15 hrs	3.0–3.5 hrs
Arrival	10–30 min	10–30 min	10–30 min
Unloading	15–60 min	15–60 min	15–60 min
Staging	15–60 min	15–60 min	
Delivered			10–30 min

Notes: Event durations assumed by project team

B. TRANSPORT INSTRUCTION/STATUS MESSAGE EXAMPLES

Listing B.1 provides an example of a TI consignment message and Listing B.2 provides a TI shipment message example. Listing B.3 provides an example of a TS Notification message.

Listing B.1 Example Transport Instruction Consignment message


```xml
<?xml version="1.0" encoding="UTF-8"?><transport_instruction:transportInstructionMessage xmlns:transport_instruction="urn:gs1:ecom:transport_instruction:xsd:3" xmlns:sh="http://www.unece.org/cefact/namespaces/StandardBusinessDocumentHeader" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="urn:gs1:ecom:transport_instruction:xsd:3 ../Schemas/gs1/ecom/TransportInstruction.xsd">
	<sh:StandardBusinessDocumentHeader>
		<sh:HeaderVersion>1.0</sh:HeaderVersion>
		<sh:Sender>
			<sh:Identifier Authority="GS1">7365566156190</sh:Identifier>
			<sh:ContactInformation>
				<sh:Contact>John Doe</sh:Contact>
				<sh:EmailAddress>John_Doe@purchasing.XYZretailer.com</sh:EmailAddress>
				<sh:FaxNumber>+1-212-555-1213</sh:FaxNumber>
				<sh:TelephoneNumber>+1-212-555-2122</sh:TelephoneNumber>
				<sh:ContactTypeIdentifier>Buyer</sh:ContactTypeIdentifier>
			</sh:ContactInformation>
		</sh:Sender>
		<sh:Receiver>
			<sh:Identifier Authority="GS1">4048623000003</sh:Identifier>
			<sh:ContactInformation>
				<sh:Contact>Mary Smith</sh:Contact>
				<sh:EmailAddress>Mary_Smith@widgets.com</sh:EmailAddress>
				<sh:FaxNumber>+1-312-555-1214</sh:FaxNumber>
				<sh:TelephoneNumber>+1-312-555-2125</sh:TelephoneNumber>
				<sh:ContactTypeIdentifier>Seller</sh:ContactTypeIdentifier>
			</sh:ContactInformation>
		</sh:Receiver>
		<sh:DocumentIdentification>
			<sh:Standard>GS1</sh:Standard>
			<sh:TypeVersion>3.2</sh:TypeVersion>
			<sh:InstanceIdentifier>TRINS00001</sh:InstanceIdentifier>
			<sh:Type>Transport Instruction</sh:Type>
			<sh:MultipleType>false</sh:MultipleType>
			<sh:CreationDateAndTime>2011-01-12T12:00:00.000-05:00</sh:CreationDateAndTime>
		</sh:DocumentIdentification>
	</sh:StandardBusinessDocumentHeader>
    <transportInstruction>
        <creationDateTime>2011-01-12T12:00:00.000-05:00</creationDateTime>
        <documentStatusCode>ORIGINAL</documentStatusCode>
        <transportInstructionIdentification>
            <entityIdentification>TRINS00001</entityIdentification>
        </transportInstructionIdentification>
        <transportInstructionFunction>CONSIGNMENT</transportInstructionFunction>
        <logisticServicesSeller>
            <gln>4048623000003</gln>
        </logisticServicesSeller>
        <logisticServicesBuyer>
            <gln>7365566156190</gln>
        </logisticServicesBuyer>
        <transportInstructionConsignment>
            <ginc>7365566156191234567</ginc>
            <consignor>
```

```xml
            <gln>7365566156190</gln>
        </consignor>
        <consignee>
            <gln>7300011234566</gln>
        </consignee>
        <transportInstructionTerms>
            <transportServiceCategoryType>30</transportServiceCategoryType>
        </transportInstructionTerms>
        <transportCargoCharacteristics>
            <cargoTypeCode>21</cargoTypeCode>
            <cargoTypeDescription languageCode="en">General cargo</cargoTypeDescription>
            <totalGrossVolume measurementUnitCode="CBM">3.5</totalGrossVolume>
            <totalGrossWeight measurementUnitCode="KGM">1500</totalGrossWeight>
            <totalPackageQuantity>5</totalPackageQuantity>
        </transportCargoCharacteristics>
        <transportInstructionTransportMovement>
            <sequenceNumber>1</sequenceNumber>
            <transportModeTypeCode>30</transportModeTypeCode>
            <plannedDeparture>
                <logisticLocation>
                    <address>
                        <city>Stockholm</city>
                    </address>
                </logisticLocation>
                <logisticEventDateTime>
                    <date>2011-01-14</date>
                </logisticEventDateTime>
            </plannedDeparture>
            <plannedArrival>
                <logisticLocation>
                    <address>
                        <city>Lund</city>
                    </address>
                </logisticLocation>
            </plannedArrival>
        </transportInstructionTransportMovement>
        <packageTotal>
            <packageTypeCode>201</packageTypeCode>
            <totalPackageQuantity>3</totalPackageQuantity>
        </packageTotal>
        <packageTotal>
            <packageTypeCode>211</packageTypeCode>
            <totalPackageQuantity>2</totalPackageQuantity>
        </packageTotal>
        <transportInstructionConsignmentItem>
            <lineItemNumber>1</lineItemNumber>
            <transportCargoCharacteristics>
                <cargoTypeCode>21</cargoTypeCode>
                <cargoTypeDescription languageCode="en">Furniture</cargoTypeDescription>
            </transportCargoCharacteristics>
            <logisticUnit>
                <sscc>373655661561900018</sscc>
                <packageTypeCode>201</packageTypeCode>
            </logisticUnit>
            <logisticUnit>
                <sscc>373655661561900025</sscc>
                <packageTypeCode>201</packageTypeCode>
            </logisticUnit>
            <logisticUnit>
```

```
                    <sscc>373655661561900032</sscc>
                    <packageTypeCode>201</packageTypeCode>
                </logisticUnit>
                <logisticUnit>
                    <sscc>373655661561900049</sscc>
                    <packageTypeCode>211</packageTypeCode>
                </logisticUnit>
                <logisticUnit>
                    <sscc>373655661561900056</sscc>
                    <packageTypeCode>211</packageTypeCode>
                </logisticUnit>
            </transportInstructionConsignmentItem>
        </transportInstructionConsignment>
    </transportInstruction>
</transport_instruction:transportInstructionMessage>
```


Listing B.2 Example Transport Instruction Shipment message


```
<?xml version="1.0" encoding="UTF-8"?><transport_instruction:transportInstructionMessage xmlns:transport
_instruction="urn:gs1:ecom:transport_instruction:xsd:3" xmlns:sh="http://www.unece.org/cefact/namespaces
/StandardBusinessDocumentHeader" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocatio
n="urn:gs1:ecom:transport_instruction:xsd:3 ../Schemas/gs1/ecom/TransportInstruction.xsd">
      <sh:StandardBusinessDocumentHeader>
              <sh:HeaderVersion>1.0</sh:HeaderVersion>
              <sh:Sender>
                      <sh:Identifier Authority="GS1">4048623000003</sh:Identifier>
                      <sh:ContactInformation>
                              <sh:Contact>John Doe</sh:Contact>
                              <sh:EmailAddress>John_Doe@purchasing.XYZretailer.com</sh:EmailAddress>
                              <sh:FaxNumber>+1-212-555-1213</sh:FaxNumber>
                              <sh:TelephoneNumber>+1-212-555-2122</sh:TelephoneNumber>
                              <sh:ContactTypeIdentifier>Buyer</sh:ContactTypeIdentifier>
                      </sh:ContactInformation>
              </sh:Sender>
              <sh:Receiver>
                      <sh:Identifier Authority="GS1">7365566156190</sh:Identifier>
                      <sh:ContactInformation>
                              <sh:Contact>Mary Smith</sh:Contact>
                              <sh:EmailAddress>Mary_Smith@widgets.com</sh:EmailAddress>
                              <sh:FaxNumber>+1-312-555-1214</sh:FaxNumber>
                              <sh:TelephoneNumber>+1-312-555-2125</sh:TelephoneNumber>
                              <sh:ContactTypeIdentifier>Seller</sh:ContactTypeIdentifier>
                      </sh:ContactInformation>
              </sh:Receiver>
              <sh:DocumentIdentification>
                      <sh:Standard>GS1</sh:Standard>
                      <sh:TypeVersion>3.2</sh:TypeVersion>
                      <sh:InstanceIdentifier>TRINR00001</sh:InstanceIdentifier>
                      <sh:Type>Transport Instruction</sh:Type>
                      <sh:MultipleType>false</sh:MultipleType>
                      <sh:CreationDateAndTime>2011-01-12T12:00:00.000-05:00</sh:CreationDateAndTime>
              </sh:DocumentIdentification>
      </sh:StandardBusinessDocumentHeader>
    <transportInstruction>
        <creationDateTime>2011-01-12T12:00:00.000-05:00</creationDateTime>
        <documentStatusCode>ORIGINAL</documentStatusCode>
        <transportInstructionIdentification>
            <entityIdentification>TRINS00002</entityIdentification>
```

```xml
        </transportInstructionIdentification>
        <transportInstructionFunction>SHIPMENT</transportInstructionFunction>
        <logisticServicesSeller>
            <gln>4048623000003</gln>
        </logisticServicesSeller>
        <logisticServicesBuyer>
            <gln>7365566156190</gln>
        </logisticServicesBuyer>
        <transportInstructionShipment>
            <gsin>73655661561900123</gsin>
            <receiver>
                <gln>7300011234566</gln>
            </receiver>
            <shipper>
                <gln>7365566156190</gln>
            </shipper>
            <shipTo>
                <address>
                    <city>Lund</city>
                    <postalCode>22478</postalCode>
                    <streetAddressOne>Glimmervägen 125</streetAddressOne>
                </address>
            </shipTo>
            <transportInstructionTerms>
                <transportServiceCategoryType>30</transportServiceCategoryType>
            </transportInstructionTerms>
            <transportCargoCharacteristics>
                <cargoTypeCode>21</cargoTypeCode>
                <cargoTypeDescription languageCode="en">General cargo</cargoTypeDescription>
                <totalGrossVolume measurementUnitCode="CBM">3.5</totalGrossVolume>
                <totalGrossWeight measurementUnitCode="KGM">1500</totalGrossWeight>
                <totalPackageQuantity>5</totalPackageQuantity>
            </transportCargoCharacteristics>
            <plannedDelivery>
                <logisticEventDateTime>
                    <date>2011-01-18</date>
                </logisticEventDateTime>
            </plannedDelivery>
            <packageTotal>
                <packageTypeCode>201</packageTypeCode>
                <totalPackageQuantity>3</totalPackageQuantity>
            </packageTotal>
            <packageTotal>
                <packageTypeCode>211</packageTypeCode>
                <totalPackageQuantity>2</totalPackageQuantity>
            </packageTotal>
            <transportInstructionShipmentItem>
                <lineItemNumber>1</lineItemNumber>
                <logisticUnit>
                    <sscc>373655661561900018</sscc>
                    <packageTypeCode>201</packageTypeCode>
                </logisticUnit>
                <logisticUnit>
                    <sscc>373655661561900025</sscc>
                    <packageTypeCode>201</packageTypeCode>
                </logisticUnit>
                <logisticUnit>
                    <sscc>373655661561900032</sscc>
                    <packageTypeCode>201</packageTypeCode>
```

```
                </logisticUnit>
                <transactionalTradeItem>
                    <gtin>03736556615609</gtin>
                    <tradeItemQuantity>3</tradeItemQuantity>
                </transactionalTradeItem>
            </transportInstructionShipmentItem>
            <transportInstructionShipmentItem>
                <lineItemNumber>2</lineItemNumber>
                <logisticUnit>
                    <sscc>373655661561900049</sscc>
                    <packageTypeCode>211</packageTypeCode>
                    <tradeItemQuantity>10</tradeItemQuantity>
                </logisticUnit>
                <logisticUnit>
                    <sscc>373655661561900056</sscc>
                    <packageTypeCode>211</packageTypeCode>
                    <tradeItemQuantity>10</tradeItemQuantity>
                </logisticUnit>
                <transactionalTradeItem>
                    <gtin>03736556615616</gtin>
                    <tradeItemQuantity>20</tradeItemQuantity>
                </transactionalTradeItem>
            </transportInstructionShipmentItem>
        </transportInstructionShipment>
    </transportInstruction>
</transport_instruction:transportInstructionMessage>
```


Listing B.3 Example Transport Status Notification message


```
<?xml version="1.0" encoding="UTF-8"?><transport_status_notification:transportStatusNotificationMessage
xmlns:transport_status_notification="urn:gs1:ecom:transport_status_notification:xsd:3" xmlns:sh="http://
www.unece.org/cefact/namespaces/StandardBusinessDocumentHeader" xmlns:xsi="http://www.w3.org/2001/XMLSch
ema-instance" xsi:schemaLocation="urn:gs1:ecom:transport_status_notification:xsd:3 ../Schemas/gs1/ecom/T
ransportStatusNotification.xsd">
	<sh:StandardBusinessDocumentHeader>
		<sh:HeaderVersion>1.0</sh:HeaderVersion>
		<sh:Sender>
			<sh:Identifier Authority="GS1">4048623000003</sh:Identifier>
			<sh:ContactInformation>
				<sh:Contact>John Doe</sh:Contact>
				<sh:EmailAddress>John_Doe@purchasing.XYZretailer.com</sh:EmailAddress>
				<sh:FaxNumber>+1-212-555-1213</sh:FaxNumber>
				<sh:TelephoneNumber>+1-212-555-2122</sh:TelephoneNumber>
				<sh:ContactTypeIdentifier>Buyer</sh:ContactTypeIdentifier>
			</sh:ContactInformation>
		</sh:Sender>
		<sh:Receiver>
			<sh:Identifier Authority="GS1">7365566156190</sh:Identifier>
			<sh:ContactInformation>
				<sh:Contact>Mary Smith</sh:Contact>
				<sh:EmailAddress>Mary_Smith@widgets.com</sh:EmailAddress>
				<sh:FaxNumber>+1-312-555-1214</sh:FaxNumber>
				<sh:TelephoneNumber>+1-312-555-2125</sh:TelephoneNumber>
				<sh:ContactTypeIdentifier>Seller</sh:ContactTypeIdentifier>
			</sh:ContactInformation>
		</sh:Receiver>
		<sh:DocumentIdentification>
			<sh:Standard>GS1</sh:Standard>
```

```xml
                    <sh:TypeVersion>3.2</sh:TypeVersion>
                    <sh:InstanceIdentifier>TRSN00001</sh:InstanceIdentifier>
                    <sh:Type>Transport Status Notification</sh:Type>
                    <sh:MultipleType>false</sh:MultipleType>
                    <sh:CreationDateAndTime>2011-01-12T12:10:00.000-05:00</sh:CreationDateAndTime>
            </sh:DocumentIdentification>
    </sh:StandardBusinessDocumentHeader>
    <transportStatusNotification>
        <creationDateTime>2011-01-12T12:10:00.000-05:00</creationDateTime>
        <documentStatusCode>ORIGINAL</documentStatusCode>
        <transportStatusNotificationIdentification>
            <entityIdentification>TRSN00001</entityIdentification>
        </transportStatusNotificationIdentification>
        <transportStatusInformationCode>STATUS_AND_MOVEMENT</transportStatusInformationCode>
        <transportStatusObjectCode>CONSIGNMENT</transportStatusObjectCode>
        <transportStatusRequestor>
            <gln>7365566156190</gln>
        </transportStatusRequestor>
        <transportStatusProvider>
            <gln>4048623000003</gln>
        </transportStatusProvider>
        <transportStatusRequest>
            <entityIdentification>TRSR00001</entityIdentification>
        </transportStatusRequest>
        <transportStatusNotificationConsignment>
            <ginc>7365566156191234567</ginc>
            <cargoTypeCode>21</cargoTypeCode>
            <consignor>
                <gln>7365566156190</gln>
            </consignor>
            <consignee>
                <gln>7300011234566</gln>
            </consignee>
            <transportStatus>
                <transportStatusConditionCode>29</transportStatusConditionCode>
            </transportStatus>
            <transportStatusNotificationTransportMovement>
                <sequenceNumber>1</sequenceNumber>
                <transportModeTypeCode>30</transportModeTypeCode>
                <actualDeparture>
                    <logisticLocation>
                        <address>
                            <city>Stockholm</city>
                        </address>
                    </logisticLocation>
                    <logisticEventDateTime>
                        <date>2011-01-14</date>
                        <time>11:08:00</time>
                    </logisticEventDateTime>
                </actualDeparture>
                <actualArrival>
                    <logisticLocation>
                        <address>
                            <city>Lund</city>
                        </address>
                    </logisticLocation>
                    <logisticEventDateTime>
                        <date>2011-01-14</date>
                        <time>18:08:00</time>
```

```
                    </logisticEventDateTime>
                </actualArrival>
            </transportStatusNotificationTransportMovement>
        </transportStatusNotificationConsignment>
    </transportStatusNotification>
</transport_status_notification:transportStatusNotificationMessage>
```

C. RELATIONAL DATABASE STRUCTURE

This appendix outlines the structure and elements of the relational database developed to store the sample freight consignment message data. Figure 47 illustrates the relational database system table structure used for storing information contained in TI messages.

TI MESSAGE TABLES

As outlined in Section 3, the database developed for this project comprises the following five TI message tables:

- **ti_header** – TI message sender, receiver and document information
- **ti_consignment** – TI consignment identifying information
- **ti_shipment** – TI shipment identifying information
- **ti_transport** – transport information for each consignment or shipment, including freight volume, planned logistic locations and event times
- **ti_cargo** – one or more cargo items listed in a consignment or shipment.

The structure of each table is listed below.

Table C.1 TI header table structure

Column name	Type	Description
ti_doc_id	text	Transport Instruction document unique identifier (*Primary key*)
ti_datetime	timestamp	Transport Instruction document creation datetime
sender_id	text	Transport Instruction sender identifier
receiver_id	text	Transport Instruction receiver identifier
doc_standard	text	Transport Instruction document standard
doc_version	text	Transport Instruction document version
doc_type	text	Transport Instruction document type
doc_multiple	boolean	Transport Instruction single or multiple document identifier

Table C.2 TI consignment table structure

Column name	Type	Description
ginc	text	GS1 Global Identification Number for Consignment (*Primary key*)
ti_doc_id	text	TI document unique identifier
consignor_gln	text	Consignor Global Location Number (GLN)
consignee_gln	text	Consignee Global Location Number (GLN)
ti_service_code	integer	TI Transport Service Category Type code
ti_cargo_type_code	integer	TI Cargo type code
ti_cargo_type_desc	text	TI Cargo type description
ti_gross_volume	real	TI gross volume (cubic volume)
ti_gross_weight	real	TI gross weight
ti_package_quantity	real	TI package quantity (no. units)

Figure C.1 Pilot project – TI message relational database table structure

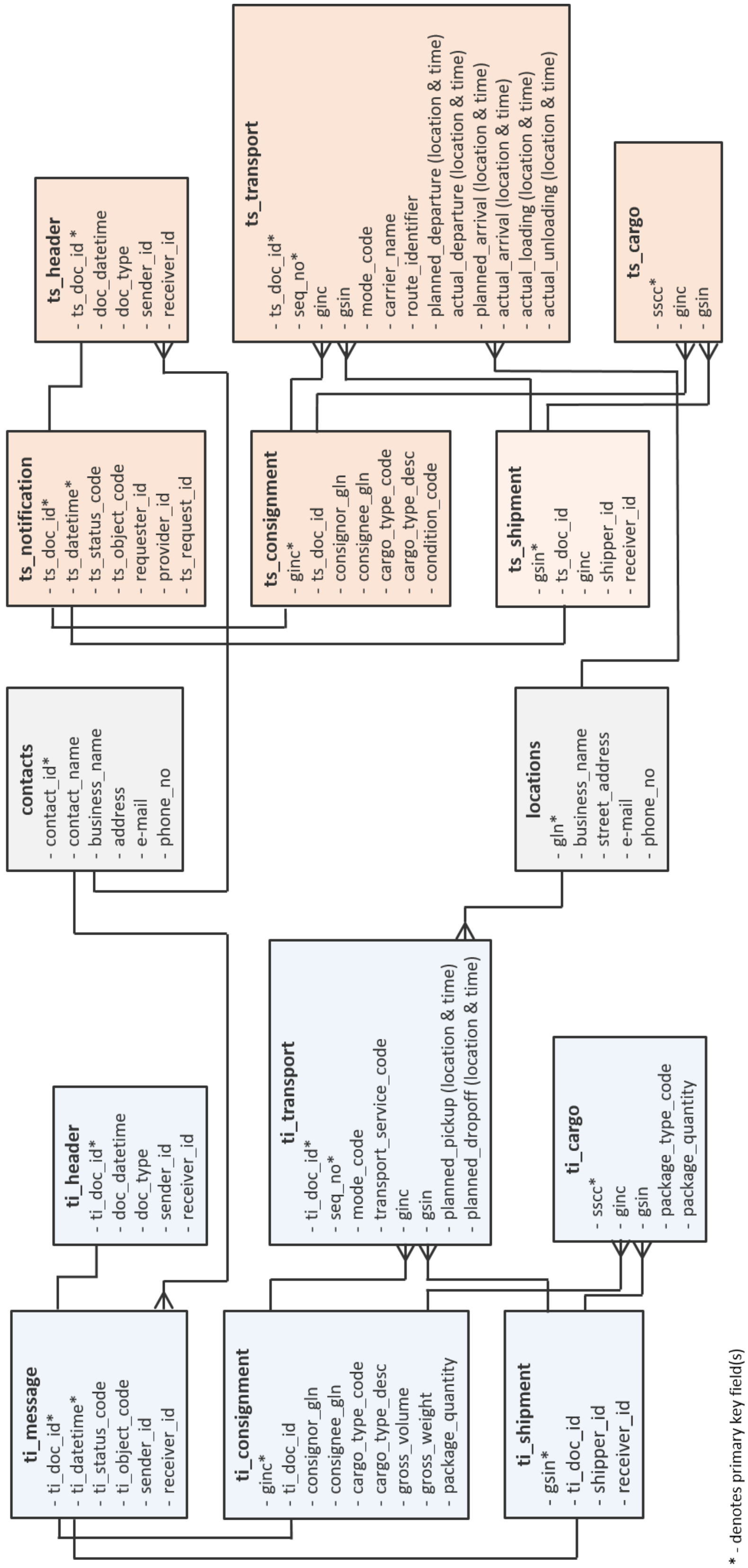


Table C.3 TI shipment table structure

Column name	Type	Description
gsin	text	GS1 Global Shipment Identification Number (*Primary key*)
ti_doc_id	text	TI document unique identifier
shipper_gln	text	Shipper Global Location Number (GLN)
receiver_gln	text	Receiver Global Location Number (GLN)

Table C4 TI transport movement table structure

Column name	Type	Description
ti_doc_id	text	TI document unique identifier (*Primary key*)
seq_no	text	Transport sequence number (*Primary key*)
ginc	text	GS1 Global Identification Number for Consignment
gsin	text	GS1 Global Shipment Identification Number
planned_delivery_dt	timestamp	Planned delivery datetime
ship_from_city	text	Address of pick-up location: City
ship_from_postcode	text	Address of pick-up location: Postcode
ship_from_address	text	Address of pick-up location: Street address
ship_to_city	text	Address of drop-off location: City
ship_to_postcode	text	Address of drop-off location: City
ship_to_address	text	Address of drop-off location: City

Table C5 TI cargo table structure

Column name	Type	Description
line_item_no	integer	Line item number (*Primary key*)
sscc	text	Serial Shipping Container Code (GS1) (*Primary key*)
gsin	text	GS1 Global Shipment Identification Number
package_type_code	integer	GS1 Package Type code

TS MESSAGE TABLES

The database comprises the following five TS message tables:

- **ts_header** – TS message sender, receiver and document id requests
- **ts_consignment** – TS consignment identifying information
- **ts_shipment** – TS shipment identifying information
- **ts_transport** – transport arrangements for each consignment or shipment, including actual transport mode used, planned and actual logistic event locations and datetimes
- **ts_cargo** – one or more cargo units itemised in a consignment or shipment.

The structure of each table is listed below.

Table C.6 TS header table structure

Column name	Type	Description
ts_doc_id	text	Transport Status Notification document unique identifier (*Primary key*)
ts_datetime	timestamp	Transport Status Notification document creation datetime
sender_id	text	Transport Status sender identifier
receiver_id	text	Transport Status receiver identifier
doc_standard	text	Transport Status document standard
doc_version	text	Transport Status document version
doc_type	text	Transport Status document type
doc_multiple	boolean	Transport Status single or multiple document identifier

Table C.7 TS consignment table structur

Column name	Type	Description
ginc	text	GS1 Global Identification Number for Consignment (*Primary key*)
ts_doc_id	text	TS document unique identifier
ts_cargo_type_code	text	TS cargo type classification code (e.g. hazardous cargo)
ts_cargo_type_desc	text	TS cargo type classification free text description
ts_avp_list	text	TS optional attribute pair list (comma-separated free-text field)
ts_condition_code	text	Code specifying the transport status condition
consignor_gln	text	Consignor Global Location Number (GLN)
consignee_gln	text	Consignee Global Location Number (GLN)

Table C.8 TS shipment table structure

Column name	Type	Description
gsin	text	GS1 Global Shipment Identification Number (*Primary key*)
ts_doc_id	text	TS document unique identifier
ginc	text	GS1 Global Identification Number for Consignment
ts_avp_list	text	TS optional attribute pair list (comma-separated free-text field)
shipper_gln	text	Shipper Global Location Number (GLN)
receiver_gln	text	Receiver Global Location Number (GLN)

Table C.9 TS transport movement table structure

Column name	Type	Description
ginc	text	GS1 Global Identification Number for Consignment
gsin	text	GS1 Global Shipment Identification Number
sscc	text	Serial Shipping Container Code (GS1) (*Primary key*)
mode_code	text	Transport mode code
carrier_name	text	Transport carrier name
route_identifier	text	Transport route identifier
planned_departure	timestamp	Planned departure datetime
actual_departure	timestamp	Actual departure datetime
planned_arrival	timestamp	Planned arrival datetime
actual_arrival	timestamp	Actual arrival datetime
actual_loading	timestamp	Actual loading datetime
actual_unloading	timestamp	Actual unloading time
recipient_signoff	text	Expected time of departure from the designated departure location
planned_waypoint	text	Planned administrative procedure taking place at designated location
actual_waypoint	text	Actual administrative procedure taking place at designated location
tran_means_type	text	Code specifying the type of vehicle, aircraft, etc. used for the transport of goods
tran_means_id	text	Name of a particular transport means, e.g. vessel name
tran_equip_type	text	Transport equipment type code
tran_equip_grai	text	Transport equipment Global Returnable Asset Identifier (GS1)
tran_equip_agrai	text	Transport equipment Additional Global Returnable Asset Identifier (GS1)

Table C.10 TS cargo table structure

Column name	Type	Description
ts_doc_id	integer	Transport Status Notification document unique identifier
sscc	text	Serial Shipping Container Code (GS1) (*Primary key*)
gsin	text	GS1 Global Shipment Identification Number

LOCATION AND BUSINESS CONTACT TABLES

The two additional tables: **location** and **contacts** store common business location and business contact information, respectively. The structure of those tables are listed below:

Table C.11 GS1 location table structure

Column name	Type	Description
gs1_gln	text	GS1 Global Location Number (*Primary key*)
business_name	text	Business name
street_address	text	Street address

Table C.12 GS1 contact table structure

Column name	Type	Description
contact_id	text	GS1 Contact identifier (*Primary key*)
contact_name	text	Contact name
street_address	text	Contact street address
email_address	text	Contact e-mail address
phone_no	text	Contact telephone number
fax_no	text	Contact fax number

GLOSSARY

This glossary largely covers terms used by GS1 to describe business processes and agents involved in the transport of freight, and used throughout this report. GS1's full glossary of terms is available online at: www.gs1au.org/resources/glossary.

TRANSPORT MANAGEMENT ROLES

The following transport management roles are defined in terms of the adoption and applicability to the Australian logistics sector.

Logistic Service Client (LSC)

The purchaser of logistics services from another entity. Can be a retailer, manufacturer, material supplier, freight forwarder, distribution centre, usually purchasing a single service at a time.

Logistic Service Provider (LSP)

An umbrella term for entities that provide logistics services for another entity. Can be a carrier, freight forwarder or distribution centre.

Logistic Service Buyer (LSB)

An entity, which purchases a combination of many different logistics services from another entity.

Logistic Service Seller (LSS)

An entity, which provides a combination of many different logistics services for another entity.

Carrier

The party that physically transports goods from one place to another.

Consignee

In a consignment view / scenario, the entity who will receive the physical shipment.

Consignor

In a consignment view / scenario, the entity who will ship the physical shipment.

Shipper

In a shipment scenario, a party who engages in shipping goods, typically the seller of the goods.

Receiver

In a Shipment scenario, a party who engages in receiving goods. The Receiver is also the Final/Ultimate Consignee.

TRANSPORT MANAGEMENT TERMS

The following transport management terms are defined in terms of the adoption and applicability to the Australian logistics sector.

Consignment

A consignment is a logical grouping of goods (one or more physical entities) that is intended to be transported as a whole from a consignor to a consignee by a carrier or freight forwarder via one or more modes of transport, subject to one single transport contract. Typically, a Transport Instruction Consignment message does not contain Trade Item detail, but may have more complex transport details included, the Items within a consignment are not Trade Items but logistic Items. There is usually no requirement other than general Dangerous goods details to specify specific Trade Item detail.

- A consignment can contain several consignment items, which can be contained in several pieces of transport equipment.
- During transport a consignment can make several transport movements.

Transport Movement

The transport movement information specifies details of the movement of goods such as mode and means of transport, locations, departure, and arrival date(s) and time(s).

- A transport movement may have one associated transport means.

Consignment Item

A consignment item is a (collection of) Load Units that can be identified (uniquely) within the consignment and may be treated/handled in the same way during transportation (and associated administrative processes).

- A consignment item may relate to several logistic units.
- Also multiple different consignment items may relate to the same logistic unit.

Shipment

A shipment is an identifiable collection of one or more Trade Items available to be transported together from the shipper (Original Consignor/Shipper), to the receiver (Final/Ultimate Consignee). Typically, the shipment is the entity communicated between trading partners in the Despatch and Receiving Advice. A transport Instruction Shipment message may contain details about the actual products (trade items); the level of detail is typically governed by the commercial arrangements between the Shipper and the initial Logistics Service Provider, for carriage of the goods and status notification and tracking requirements. The Transport Instruction Shipment message contains minimal transport details typically notification of the basic transport (Road, Rail, Air) with the more specific transport requirements to be identified and evoked by the Logistic Service Provider not the Shipper.

- A shipment may contain several shipment items.
- A shipment may have one defined transport movement. Transport movement is used here to bring in the carrier and mode of transport for the shipment.

Shipment Item

A shipment item is a (collection of) Trade Items and/or Logistic Units that can each be identified (uniquely) within a shipment.

- A shipment item must relate to one trade item,
- A shipment item may relate to several logistic units containing the trade item.

Logistic Unit

A logistic unit is an item of any composition established for transport and/or storage which needs to be managed through the supply chain. Logistic units take many forms, a single box containing a limited number of products, a pallet of multiple products, or an intermodal container containing multiple pallets Ideally each Logistic Unit has been identified with a SSCC and marked with an agreed label format

Trade Item

A trade item is any item (product or service) upon which there is a need to retrieve pre-defined information and that may be priced, or ordered, or invoiced at any point in any supply chain. Typically identified by a GTIN.

Individual Item

An individual item is an individual trade product or batch of similar trade products produced by human or mechanical effort or by a natural process.

Transport Means

A transport means is a particular device (with its own engine/power) used to convey goods or other objects from place to place during logistics cargo movements. For example, a b double, or Rail locomotion.

Transport Equipment

Transport equipment is a piece of equipment used to hold, protect or secure cargo for logistics purposes. Transport Equipment is to be moved using Transport Means. For example, containers, rail trucks, etc.

Consignment

A logical composition of items related to logistics services. Focus is on how logistics units are packaged and transported.

Consignee

The receiver of the cargo from the leg addressed by the consignment.

Consignor

The provider of the cargo to the leg addressed by the consignment. For a door-to-door transport the first consignor will be the sender.

LSC

Logistics Service Client. The role responsible for gathering information about a transport service as well as purchasing and following up a logistics service

LSP

Logistics Service Provider. The role responsible for announcing, selling and executing logistics services.

OASIS

Organization for the Advancement of Structured Information Standards

Shipment

Trade items related to a commercial transaction which will be transported.

Transaction

The message exchange that takes place between two collaborating parties. May involve one or more messages in order to complete the transaction.

Transport Instruction (TI)

A Transport Instruction is a comprehensive message used to convey relevant information about cargo that needs to be transported using one or more modes of transport. The Transport Instruction is sent from the Logistics Services Buyer (LSB) to a Logistics Services Seller (LSS) (GS1 Global 2012).

Transport Status (TS)

A Transport Status request or notification is a comprehensive message used to convey relevant information with regard to the transport status and progress for a transport event (GS1 Global 2014b).

TI

Transport Instruction

TS

Transport Status

TSD

Transport Service Description

UBL

Universal Business Language. A library of standard electronic XML business messages.

urn

Uniform resource name. Intended to serve as persistent, location-independent identifiers for resources, allowing the simple mapping of namespaces into a single URN namespace. Defined in RFC 2141.

XML

eXtensible Markup Language. A markup language that defines a set of rules for encoding messages in a format that is both human-readable and machine-readable. Often used in web services to communicate messages between collaborating parties. Relies on XML Schemas (XSD).

XSD

XML Schema Definition. A schema describing the structure of an XML message.

XSLT

eXtensible Stylesheet Language Transformation

Logistic Service Client (LSC)

The purchaser of logistics services from another entity. Can be a retailer, manufacturer, material supplier, freight forwarder, distribution centre, usually purchasing a single service at a time.

Logistic Service Provider (LSP)

An umbrella term for entities that provide logistics services for another entity. Can be a carrier, freight forwarder or distribution centre, usually providing a single service at a time.

Logistic Service Buyer (LSB)

An entity, which purchases a combination of many different logistics services from another entity.

Logistic Service Seller (LSS)

An entity, which provides a combination of many different logistics services for another entity.

EPCIS

Electronic Product Code Information Services

Electronic Product Code Information Services (EPCIS)

A business information standard originally conceived as part of broader efforts to enhance collaboration between trading partners through sharing of detailed information about physical or digital objects. EPCIS originated using the EPC, but is not limited to EPC. EPCIS is open and extensible, with the capacity to be extended by organisations to suit their different business needs.

OTHER TERMS

EDIFACT

United Nations/Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) is the international EDI standard developed under the United Nations.

EPCIS

Electronic Product Code Information Service is a Global GS1 Standard for creating and sharing visibility event data, both within and across enterprises.

ACRONYMS AND ABBREVIATIONS

ELECTRONIC DATA INTERCHANGE-RELATED ACRONYMS AND ABBREVIATIONS

API – Application Programming Interface

EDIFACT – United Nations/Electronic Data Interchange for Administration, Commerce and Transport

EPCIS – Electronic Product Code Information Services

GIAI – GS1 Global Individual Asset Identifier

GINC – GS1 Global Identification Number for Consignment

GLN – Global Location Number (GS1)

GRAI – GS1 Global Returnable Asset Identifier

GS1 – Global Standards One

GSIN – GS1 Global Shipment Identification Number

GTIN – Global Trade Item Number

ID – Identifier

LSB – Logistics Service Buyer

LSC – Logistics Service Client

LSP – Logistics Service Provider

LSS – Logistics Service Seller

OASIS – Organization for the Advancement of Structured Information Standards

SGTIN – Serial Global Trade Item Number

SSCC – Serial Shipping Container Code (GS1)

TI – Transport Instruction

TS – Transport Status

TSD – Transport Service Description

UBL – Universal Business Language

URN – Uniform resource name

XML – eXtensible Markup Language

XSD – XML Schema Definition

XSLT – eXtensible Stylesheet Language Transformation

NON-EDI ACRONYMS AND ABBREVIATIONS

FDE – Freight Data Exchange

NFDH – National Freight Data Hub

OD – origin–destination

TIC – Transport and Infrastructure Council

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