Scan4Transport: Connecting the transport unit to its digital twin

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Keywords: *Digital Twin; Transport Unit; Resilience; Supply Chain Visibility; SME inclusion; Linked Data*

Conference Topic(s): *use cases; interconnected freight transport; logistics and supply networks; material handling; omni-channel & e-commerce logistics; PI implementation; technologies for interconnected logistics (digital twins).*

Physical Internet Roadmap *(Link): ☒ System of Logistics Networks, ☒ Access and Adoption*

Abstract

The transport and logistics industry has long struggled with ensuring that operators could always effectively and efficiently handle the transport units at hand. Three challenges especially hampered the industry:

1. *Transport units are often handled by several operators from source to destination. Many operators are SME with low IT capabilities.*
2. *Connectivity to an IT system is often not feasible and thus access to remote data not possible.*
3. *Proprietary approaches by large LSP makes things worse for the SME.*

Scan4Transport[1] (S4T) is a global standard for encoding transport data in a 2D barcode on a Logistics Label attached to Transport Units, supporting organisations across the entire transport chain from seller to buyer.

The 2D barcode:

1. *contains the minimum information available for the (field) operator even in case there is no connection with a remote host system.*
2. *may be read with modern standard mobile phones that all operators (including SME) will have with them.*
3. *is globally standardized independent from any shipper, carrier, receiver, LSP or other stakeholder*

Any operator working with several/many other operators can suffice with a single application to interpret the 2D barcode and be able to handle the transport unit effectively and efficiently

[1] https://www.gs1.org/industries/transport-and-logistics/scan4transport

Introduction

Most of the businesses across the supply chain use different systems, each with their own proprietary standard ("language") for encoding data into barcodes on the labels affixed to Transport Units and sharing information (e.g. transport instructions and status notifications). Subsequently, connecting the different systems ("learning and translating the different languages") and the cost of automating processes to capture data across supply chains is often prohibitive, especially for small and medium sized enterprises (SME). This causes manual processes, duplicated effort, cost and freight visibility delays/gaps for companies across the supply chain as freight is often handled by multiple logistic service providers in the journey from Seller to Buyer.

The transport and logistics industry has long struggled with ensuring that operators out in the field as well as those in logistics centers could always effectively and efficiently handle the transport units at hand. Three challenges especially hampered the industry:

1. The Freight Transport Industry is extremely fragmented with 40,000 Logistic Service Providers in Australia alone and millions around the world to support the delivery of different types of freight (e.g. bulk, satchels, parcels, pallets, ugly freight, etc), to different locations (e.g. metro, regional, interstate, international), via different service levels (e.g. standard, overnight, same day express, etc). The industry has a very high proportion of small and medium sized (SME) operators with little or no information technology capability. Larger Logistic Service Providers (LSP) often rely on large numbers of SME for last mile delivery or first mile collection of transport units.
2. GS1 estimates 50% of the Earths land mass does not support reliable or affordable connectivity with remote host systems. E.g., in Australia over two thirds of the land mass does not have such connectivity. This means that in many cases it is not feasible for the field operator to connect to a remote system to retrieve the relevant information for the transport unit based on some identifier on the transport unit.
3. Large LSP tended to develop their own proprietary approach to alleviate the problems mentioned above. That often makes things worse for the SME working for several large LSP. E.g., when these SME make delivery rounds carrying transport units from several of these LSP, the SME needs to carry specific scanning equipment from each of them and even the recipient of the transport units needs to confirm delivery on multiple LSP devices in case the delivery involves transport units from different large LSP.

However, emerging expectations and even requirements from customers (more specifically consumers in e-commerce context) related to flexibility, last-minute changes and accurate real-time capture of actual events occuring with the transport unit (and its contents) also necessitate a review of the current "traditional" ways of working in transport and logistics.

The figure 1 below indicates the most important issues identified by stakeholders involved in the development of the Scan4Transport standard.

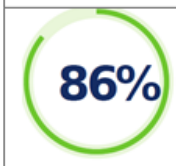
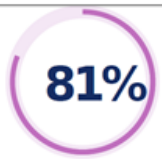
	**Lack of interoperability** – Many parties in the supply chain have different systems with their own proprietary format ("language") for encoding transport data into barcodes on the Transport Label and sharing information (e.g. transport instructions and status notifications).
	**Inefficiency** – Each party in the supply chain needs to develop and maintain the different barcode formats found across the supply chain within their systems. Relabelling and manual processes resulting from the different formats are other consequences impacting the efficiency of these businesses.
	**Poor resilience** – When electronic transport instructions have not been exchanged prior to the freight being handled, the movement of freight is often impacted until the instructions have been sourced or manually processed.
	**Freight visibility challenges** – There are often visibility gaps or delays when Supply Chains rely on information being passed in a daisy-chain style from party to party along the supply chain or not all systems in the supply chain are connected.

Figure 1: Key transport challenges, GS1

One key requirement to be able to implement the Physical Internet (PI) concepts is that transport units are unambiguously identifiable and data about the transport units is always available for the operator physically handling the transport unit at all times.

In "traditional" transport and logistics networks, many transport units do **not** carry a globally unambiguous identifier (let alone that it is available in machine-readable format e.g., in a barcode and/or RFID tag). As already pointed out above, an operator may be able to scan the identifier from the transport unit, but still not be able to do anything useful with it because there is no connection with any host system that contains the data related to the transport unit. We will address that challenge in Chapter 1.

Traditionally, transport and logistics works based on data that is already fixed/static at the moment the sales order between seller and buyer is made. E.g., delivery point is already agreed between seller and buyer then. There is an emerging trend that last mile delivery carriers offer opportunities to the final recipient to interact with the carrier to arrange the "hand-over" between the carrier and the recipient. In general, the seller is not informed about those arrangements. We cover the general topic of dynamic interaction with stakeholder systems in Chapter 2.

Scan4Transport (S4T) is a global standard for encoding transport data in a 2D barcode on a Logistics Label attached to Transport Units of any size and dimensions. The standard supports companies and organisations across the transport process including first mile, line haul, sorting processes and last mile activities and enables them to keep pace with the growing needs of their customers. The S4T standard builds on long-established and well-proven standards from ISO, GS1 and other standardisation bodies.

A large group of stakeholders from diverse backgrounds have contributed to the development of the Scan4Transport standard as well as to the implementation of the standard.

Some of those are LSP like DHL, New Zealand Post, Australia Post, VT Freight Express, Correios Brazil and solution providers Leopard Systems, Avery Dennison, SICK, MixMove as well as cargo owners e.g., CHEP.

The content of the 2D barcode when structured according to the S4T standard may be generated by any stakeholder and any other stakeholder following the S4T standard can then accurately scan and process the contents of the 2D barcode without any confusion about interpretation of any element in the 2D barcode contents.

This achieves the ultimate objective defined in the European Interoperability Framework (EIF) of the European Commission: "Ensure that what is sent is what is understood".

1 Making Structured Data available on the Transport Unit

One of the primary objectives of the Scan4Tranport standard is to make sure that the operator handling the transport unit always has at least the minimum data available to execute the next step in the journey of the transport unit from seller to buyer. Achieving that basic objective enables the first three goals mentioned in figure 1.

The Scan4Transport standard ensures access to minimum required data on the transport unit in the following ways:

1. The 2D barcode contains the minimum information available for the (field) operator even in case there is no connection with a remote host system or if there has been no prior electronic information exchange related to the transport unit.
   This provides much increased resilience, reliability and accuracy for those operations.
2. The 2D barcode may be read with modern standard mobile phones that most/all operators (even the SME) will have with them at all times. This means that even the least sophisticated operators (in terms of IT capability) will be able to be included in the information exchange network.
3. The data structures in the 2D barcode are globally standardized independent from any seller, shipper, carrier, buyer, receiver, logistic service provider or other stakeholder. Therefore, any operator working with several/many other operators can suffice with a single application to interpret the 2D barcode and be able to handle the transport unit effectively and efficiently.

NOTE: In an e-commerce context, many of the transport units will be handled/delivered by so-called designated operators (in plain language: National Post organisations). Postal operators deliver more transport units than any other transport service provider. They also deliver to less populated areas that other logistic service providers choose not to service. Therefore, it would a lot of sense from the Physical Internet perspective if the transport and logistics networks operated by the Designated Operators and other Supply Chain and T&L stakeholders would be much better integrated than they are today. Interoperability may be improved by making the minimum data available in a well described and structured format on the transport unit such that even when the transport unit changes hands between carriers (be they designated operators or non-postal service providers) the next operator is able to handle the transport unit (even if there is no electronic interface between them). The UPU (Universal Postal Union) is currently going through a process to decide if (and if so, how) the UPU will facilitate better integration of the postal networks with the wider Supply

Chain T&L networks. It is foreseen that the UPU will make their decision on their Extraordinary Congress in October 2023.

The sample list of participants in the development of the S4T standard includes organisations that are designated operators as well as other LSP. The S4T standard enables them to exchange transport units if they so desire. Currently not all participants listed exchange transport units with all other participants listed.

1.1 What kinds of information can the 2D barcode provide?

1. The globally unique identifier for the transport unit.
   This is a mandatory data-element. Without it the S4T standard cannot deliver its full potential.
2. Basic data about the transport unit
   Weight, dimensions, volume, returnable asset identifier (e.g., for roll-cage, pallet or container) as appropriate.
3. Trade and Transport Reference identifiers
   Identifier for the Trade Transaction (shipment) and Transport Contract (consignment) as appropriate.
4. Ship-to / Return-to information
   Structured address data, geo-coordinates, identifier for the ship-to location, contact details as appropriate.
5. Handling instructions
   Dangerous Goods flag, delivery window, Signature required as apprporpiate.
6. A Digital Link (URL / URI)
   This enable the operator to access remote information in case Internet connectivity is available. We will cover this in more detail in Chapter 2.

The list of data-elements is not exhaustive. It merely indicates the information that is most commonly used in daily operations in freight transport. Here is an example of what the content of the 2D barcode could look like.

"https://example.com/00/395211001001300012 1?4300=GS1+AISBL&4302=Avenue+Louise+326&4305=Bruxelles&4307=BE&420=1050&403=123%2B1021JK%2B0320%2B12%0B&s4t"

This example contains (in sequence) Digital Link, Transport Unit Identifier, structured delivery address, and handling instructions. (&s4t indicates the barcode content follows the Scan4Transport standard).

The data-elements in the 2D barcode are individually identifiable based on their Application Identifier (or AI). Application Identifiers (or Data Identifiers) have been used for half a century in barcodes to ensure consistent interpretation of data-elements in barcodes.

E.g., the transport unit identifier highlighted in green consists of the AI "00" followed by the value of the identifier "395211001001300012 1" (a so-called SSCC or Serial Shipping Container Code compliant with ISO/IEC 15459-1).

Similarly, application identifier "4300" indicates the value that follows is the name of the Ship-to / Deliver-to organisation, whereas AI "420" precedes the postal code of the Ship-to location. GS1 provides a very comprehensive list of Application Identifiers on their website.

The most popular 2D barcode types today that may also be used for the Scan4Transport approach are:

Figure 2: Sample 2D barcode types for Scan4Transport

The standard also supports "special" characters like é, è, ö, ü, ã, ç, Σ, Ω as well as other Latin and non-Latin characters. This means the S4T standard can be used in countries all over the world.

NOTE: According to "Addressing the Unaddressed" there are approcimately one **billion** people in the world who do not have a "functional" postal address, mainly living in developing countries. In addition there are also developed countries where the addressing systems do not provide a very precise way to find a physical location. In rural areas buildings may be many miles apart. In Japan, house/block-numbers on the same street are not (always) in sequential order (e.g., number 26 may be in between number 4 and 8). Making efficient and effective deliveries to locations that do not provide precise positioning information requires the use of geographical coordinates. The Scan4Transport standard supports including geocoordinates in the 2D barcode. Modern satellite navigation systems (as available on pretty much all mobile phones) are able to use those geocoordinates to direct the (SME) operator to the right location without fail.

1.2 Improving Interoperability

While shippers commonly use 5 or more Logistic Service Providers, larger shippers rely on 50-100 Logistic Service Providers to meet their transport needs. The number of Logistic Service Providers explodes when the subcontractors involved in the movement of freight are included. These subcontractors are very often SME.

Because the data required to effectively handle the transport unit is in the 2D barcode on the unit, an operator can get that data from the unit with a SINGLE scan using a SINGLE application completely independent from the stakeholder that created the 2D barcode in the first place. In effect, all stakeholders capable of generating and/or scanning/working with the Scan4Transport 2D barcode have become interoperable in line with the main objective of the European Interoperability Framework.

Looking at the SME operator delivering transport units from several large LSP, he can now use his own mobile phone (instead of several LSP devices) **and** the recipient of the transport units also needs to sign off on a SINGLE device only (the SME operators mobile phone). Therefore, this also has a significant impact on Customer/Consumer Experience.

We need to reiterate here that the vast majority of LSP are SME who have (very) low IT capability. They will however generally have mobile phones that are capable of scanning 2D barcodes (at least a QR-code). They may install a SINGLE application (from any solution provider) that will interpret the Scan4Transport 2D barcode and present the information to the operator so the operator can effectively and correctly execute the next step in the journey of the transport unit from Seller to Buyer.

1.3 Improving Efficiency

Having the data available on the transport unit in a standardised and fully structured format, eliminates the need for manual data capture in those cases where information is not available for the operator. Elimination of that manual work (being able to capture all required data in a single scan) ensures that the operator can execute his/her transport task much more quickly. It also ensures that the data captured is 100% accurate and the operator (and clients and partners) no longer need to waste time on correcting errors due to manual data capture. The efficiency manifests both in speed of execution and reduction of time spent on non-value-added activities.

The improved interoperability mentioned above also has a significant impact on efficiency (or rather utilisation of T&L resources). Because more stakeholders LSP, Shippers etcetera can work well with more LSP (even the very small ones) it becomes feasible to consolidate more freight flows with a single (SME) LSP, especially in sparsely populated areas but also in very densely and regulated/constricted areas (such as inner cities). This increases the utilisation of the transport execution resources in those cases and provides a significant boost to the efficiency of those operations. In addition, that increased efficiency may reduce undiserable effects of transport execution and increase quality of living.

Utilisation and efficiency are also increased because the (SME) operator may use the geocoordinates (if available in the 2D barcode) to navigate to the desired location in the quickest way and avoiding going to the wrong place/s before going to the right one (thus freeing up more time for other transportation acitivities).

1.4 Improving Resilience

From a Physical Internet perspective the improvement in resileince (combined with the improvement in interoperability) may be the most interesting aspect of Scan4Transport. We already indicated that having the minimum data available on the transport unit means that it is not technically necessary to have electronic information exchanges in advance of the physical hand-over of the transport unit to a next service provider.

That means that in case of disruptions in transport and logistics networks, a service provider may decide then and there to engage with a service provier (other than the one originally planned) to make sure the transport unit can continue on its journey to the Buyer despite the disruption in the network.

In fact, the combination of resilience and interoperability enables supply chain stakeholders to delay making firm decisions on how exactly a transport unit may be transported on the next leg right up to “the last minute before” the transport unit really needs to start on that next leg. At that point in time, the stakeholder may have much more information available regarding the actual freight and transport mix and where the individual transport units need to go than will be available in the currently customary up-front planning processes. Based on that last minute information, the stakeholder may make better decisions on how to route the individual transport units over the various next legs and service providers even when there are no disruptions in the T&L networks. Note that this is also exactly the way that routers in the Electronic Internet route packets through the network.

2 Enabling dynamic interaction with stakeholder systems

The above chapter deals with the use cases where the operator may **not** have access to remote systems. In this chapter we will cover use cases where the operator **does** have connectivity with the Internet and may access one, several or in principle **any** remote IT system.

There are three logical groups of IT systems that the operator may connect with

1. their own;
2. those operated by the Seller of the goods contained in the transport unit
3. third party system/s, which includes other LSP systems

NOTE: They may access any combination of these three groups of systems. E.g., the SME operator may **not** have its own IT systems, but they may want/need to access IT systems of the Seller and/or the LSP they may be handling the transport unit for.

In the paragraphs below we will dive a little deeper into how the S4T standards enable these connections.

2.1 Operator accessing own IT system.

For accessing your own systems you do **not** need to have any URL or URI present in the 2D barcode (you know where to access your own system). In general, in this case, the device used by the operator will run its own app(lication).

That app will have interpreted the content of the 2D barcode and used that information within the context of that app. The app will then connect and communicate with the operators own remote IT systems using their own proprietary protocols, formats etcetera.

This internal communications topic is outside the scope of this paper.

2.2 Operator accessing the Seller's IT system.

The operator may also need to access the Seller's system. Here are a few use cases where that makes sense:

- The Buyer has contacted the Seller (e.g., on the Sellers webshop) that the delivery needs to be *rescheduled* to another (later/earlier) date and time but still at the same delivery location.
- The Buyer may also *change the location* of the delivery.
- The operator needs to *confirm delivery directly to the Sellers* IT systems. This will often be the case where an SME is doing the ultimate delivery to the Buyer.

To support all of these use cases, the seller may create a 2D barcode with this sample content:
https://TransportUnit.Seller.com/00/3952110010013000121?
4300=GS1+AISBL&4302=Avenue+Louise+326&4305=Bruxelles&4307=BE&420=1050&403=123%2B1021JK%2B0320%2B12%0B&s4t

The value <TransportUnit.Seller.com> is merely an illustration of the purpose of the URL. The Seller will have to provide an application on that URL that is able to interact with the transport operator. That application will then need to interpret the 00/3952110010013000121 part of the URL and "connect" the front-end application with the relevant records in the Sellers back-end IT systems. Once that has been done, the front-end application may offer a menu of options via the front-end to the transport service provider. It could offer to provide the latest delivery information known to the Seller (e.g., changed dates and/or locations,

contact details and so on). The Sellers application could also offer an option for the transport operator to confirm delivery of the specific transport unit. This feature to be able to easily connect any transport or logistic service provider to the Sellers IT system is potentially the most powerful aspect of the Scan4Transport to realise the ideas and concepts of the Physical Internet and to put the Seller (owner of the goods in the transport units) more in control of what happens with those goods on their journey from Seller to Buyer.

2.3 Operator accessing third party IT system.

There are also several use cases where the operator may want or need to access a system from a third party. Here are some examples:

- The operator needs to *confirm delivery to the larger LSP* IT systems. This will often be the case where an SME is doing the ultimate delivery to the Buyer on behalf of a larger LSP who operates (advanced) IT systems. This is a common use case in the Scan4Transport pilots.
- The operator wants to look up opening hours, contact details, geo coordinates or other details related to the location e.g., based on the Global Location Number (GLN) for the Ship-to location).

In case the SME transport operator needs to confirm delivery directly to the large LSP system, the scenario runs very much the same as described above for the Sellers IT systems. However, the URL in the 2D barcode would have to point to the application operated by the large LSP. That LSP application would then offer the approiate functionality to the SME operator (including the option to confirm delivery and/or exceptions for the delivery e.g., failed delivery).

We highlighted that a GLN for the location may be included in the 2D barcode. The application running on the transport operators device (or the Web applications operated by the Seller or the larger LSP) may use that GLN to access Data Linked to the GLN anywhere on the Web. This concept is often referred to as “Linked Data”.

Let’s assume a delivery has to be made to GS1 New Zealand Auckland office (which is identified with GLN = 9429300016329). The New Zealand government operates a free Web-service that will provide information about New Zealand business and locations based on the GLN. In this example you may directly acces the location information using the below URL https://www.nzbn.govt.nz/mynzbn/opndetails/9429000000000/9429300016329/
(9429000000000 identifies GS1 New Zealand as the organisation associated with this location).

Alternatively (and even more powerful), the GLN may be used to access Webservices (e.g., operated by GS1 or other parties) that may be accessed to find out basic data about the location and may also provide **multiple** different links to more information (Linked Data) for the location. In the below demonstration Web-application screenshot you see a map of where the GS1 NZ offices in Auckland are (https://www.portmasterdata.com/id/9429300016329).

Bottom right you will aso see a table with different Linked Data targets. The bottom one connects directly to the records for GS1 NZ Auckland in the New Zealand Location Registry.

These Links To Other Sources Of Data can already be posted to a global service operated by GS1. They may then be retrieved by any application that can then present them to its users (very much like the demonstration application does in the screenshot below).

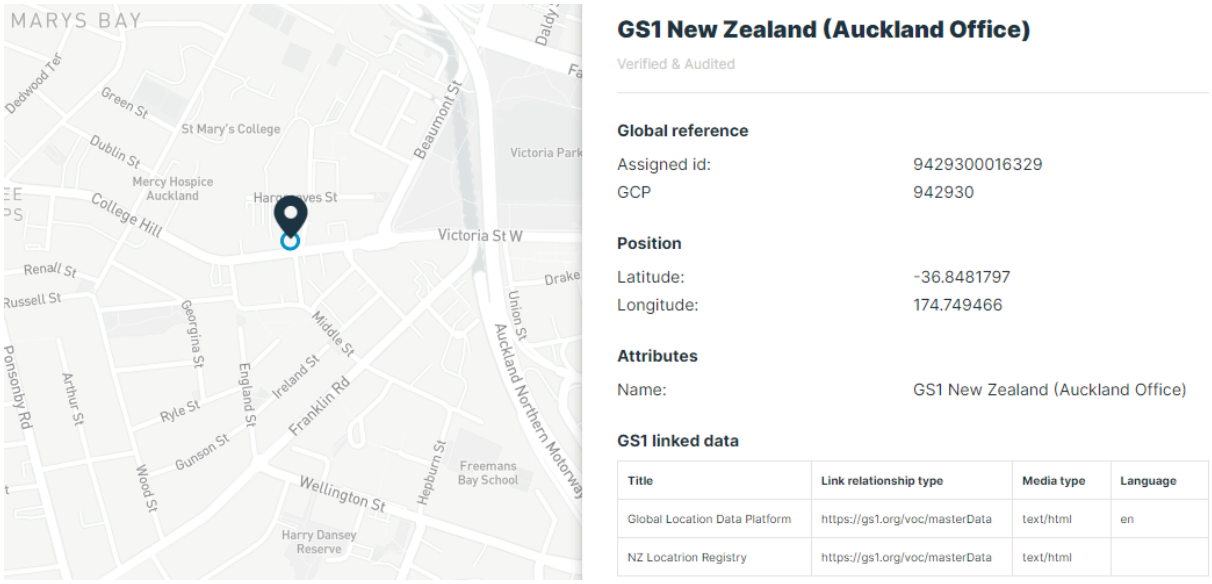


Figure 3: Linking to Other Sources of Data for locations

Using this Links To Other Sources Of Data (L2SD) approach, any application that supports the GLN as location (or organisation) identifier may make its presence known to the world by posting its L2SD links to the global service. Any other application may then retrieve those L2SD records to connect to applications that can provide more information about the GLN.

3 In Conclusion

The Scan4Transport standard delivers many benefits for the Transport & Logistics industry and the realization of the Physical Internet:

- Improves first and last mile processes through the capture of essential information relating to the transport task from the barcode on the transport label (e.g., when the freight is handled and scanned before the electronic instructions have been received).
- Improved efficiency and interoperability across industry through a standard label across the entire supply chain. The same 2D barcode may be used at any stage in the journey of the transport unit.
- Enhances delivery accuracy by encoding Ship-to GEO locations (e.g., Construction sites, rural address, gates to terminals / ports / airports, which do not have a clear/granular street address).
- Where connections to the Internet are available Links To Other Sources Of Data enable access to the latest information for the transport unit e.g., delivery location or delivery date and time may have changed since the transport unit and label have been created. It also enables that stakeholders handling the transport units may provide feedback into the primary source application e.g., confirmation of delivery.

These lead to smoother processes and greater customer satisfaction.

The results of the pilot implementations of Scan4Transport standards have been documented in a report[2] and a video[3] that are available on the Web.

[2] https://www.gs1.org/sites/gs1/files/s4t-pilot-report-v1-1.pdf
[3] https://youtu.be/MIscdZQP0xA