Thrive with standard moving towards the Physical Internet

Jaco Voorspuij
1. FixLog Consulting, Veghel, The Netherlands

Corresponding author: jaco.voorspuij@gmail.com

Keywords:
Digital Twin; Supply Chain Visibility; Interoperability;
Global Data Standards; Situational Awareness

Conference Topic(s): *interconnected freight transport; distributed intelligence last mile & city logistics; logistics and supply networks; omni-channel & e-commerce logistics; PI fundamentals and constituents; technologies for interconnected logistics (5G, 3D printing, Artificial Intelligence, IoT, machine learning, augmented reality, blockchain, cloud computing, digital twins, collaborative decision making).*

Physical Internet Roadmap *(Link): Select the most relevant area(s) for your paper:* ☐ *PI Nodes,* ☐ *PI Networks,* ☒ *System of Logistics Networks,* ☒ *Access and Adoption,* ☐ *Governance.*

Abstract

Supply Chain stakeholders have struggled for decades to get even the minimum information from transport and logistics networks that they need to manage their Supply Chains in such a way that these stakeholders can meet the expectations of their Customers. Among other needs, the Supply Chain stakeholders need a reliable answer to two very basic questions:

1. ***Where are my Goods?***
   The SC stakeholders (Sellers and Buyers) think in Goods Sold/Purchased.
   All to often the actors in transport and logistics forget that all transport activity is ultimately to Move Goods from where they are to where they should be.

2. ***Are my Goods still in good condition?***
   Once the Goods are at the right location (hopefully at the right time), the Seller/Buyer of the Goods needs these Goods to be in a condition that they can be used for the intended purpose be it used in manufacturing or consumption by humans or animals.

Knowing the answers to these questions more or less in real-time will create the situational awareness about the Goods and the associated Trade Transactions, which in turn will assist the Supply Chain stakeholders to take the most appropriate actions to address an exceptional situation with the goal to ensure as good an experience for their Customer as possible.

Introduction

Supply Chain stakeholders have struggled for decades to get even the minimum information from transport and logistics networks that they need to manage their Supply Chains in such a way that these stakeholders can meet the expectations of their Customers. Among other needs, the Supply Chain stakeholders need a reliable and timely answer to two very basic questions:

- ***Where are my Goods?***
- ***Are my Goods still in good condition?***

Knowing the answers to these questions more or less in real-time will create the situational awareness about the Goods and the associated Trade Transactions, which in turn will assist the Supply Chain stakeholders to take the most appropriate actions to address an exceptional situation with the goal to ensure as good an experience for their Customer as possible.

It is important to note that these questions are far more about the effectiveness of the Supply Chain (and supporting T&L) than they are about efficiencies (even though the data needed will also enable many efficiency improvements).
The Physical Internet (like the Internet itself) ***must*** help the users of the Physical Internet to be both more efficient **and** more effective (improve Customer experience through more resilience, reliability, predictability, communications).

Key challenges for the actors in T&L to be able to respond to the two questions above included lack of standards, disconnected standards or even conflicting standards. However,

There is now a range of standards from various standardisation bodies that are quite well aligned and may therefore be combined to ensure the flow of data that can respond to the two questions mentioned above.

We will briefly present various standards from UN/CEFACT, GS1 and ISO as well as event and event data standards. We will also cover the work of the International Taskforce Port Call Optimization (ITPCO) and how that is being incorporated in standards and other documents of the IMO, IHO, ISO and other organisations that Maritime Transport relies on.

More importantly, we will indicate how these standards interoperate to solve issues that have plagued Transport and Logistics networks for a very long time. Using the relevant standards in the most appropriate combinations will enable the Supply Chain stakeholders and the operators in Transport and Logistics to collaborate and exchange the information required to be able to respond to the two questions at last.

Most of the standards we will present are targeted mostly at “unitised” cargo (transported in any kind of “packaging” or “container” a.k.a. “transport units”). Therefore, the standards we will present and how they interoperate will be of interest to all supply chain stakeholders (large or small) who manage the transportation of their goods in discrete, identifiable transport units. That said, other standards cover all types of cargo including bulk products (grains, oil&gas, ores, chemicals, etcetera). Bulk transportation (goods that are **not** transported in transport units but rather directly in transport means such as tankers, rail wagons, barges and so on) presents challenges that one generally does not encounter in the context of unitised cargo.

In short, we want to present the recently released standards for improved exchange of information among stakeholders in Trade and Transport and Logistics, and *how these standards interoperate and reinforce each other in delivering much improved supply chain visibility, situational awareness and collaborative decision making.*

1 Foundational principles for interoperable standards in Supply Chains and Transport and Logistics

Although it would seem all to obvious, the following principles are all too often overlooked by stakeholders engaged in supply chain and transport and logistics activities:

- **ALL transportation starts with the SALE of GOODS**
  If there were no Sellers and Buyers that agreed that the Seller would (at some agreed pricing) provide the Buyer with an agreed set of products, at an agreed location, at an agreed time and in an agreed condition, then there would also not be any need for transportation of those goods.

- **ALL transportation is ultimately paid for by the Beneficial Cargo Owner (BCO).**
  The Seller or the Buyer. Today, the number of shipments crossing country borders directly related to a Consumer is more then twenty (20) **times** higher than the traditional large shipments between "large" organisations.
  Waste in transport and logistics operations causing higher costs translates into higher product prices for all of us.

- **Cargo does not move unless data moves** [1]
  As the article on the "Insider Thoughts" pages of the ICC explains, there is an ever increasing need for information to be made available to stakeholders involved in the journey of Goods from Seller to Buyer to ensure those goods (shipments) can be transported at all. Regulatory requirements as well as Customer/Consumer demand all require much more data to be available than ever before. So much so, that the traditional ways of paper-based provision of information are no longer able to support all of these requirements.

The most basic conclusion from these foundational principles is that all information to be made available across the supply chain and related transport and logistics **must** be linked to the transaction (SALE of GOODS) that triggered the entire process in the first place.

Because most (nearly all) standardisation efforts have been conducted in various (narrow) silos within the wider area of supply chain and transport and logistics, many standards have been developed without taking into account the need to always be able to link back to the original Sale of Goods transaction. UN/CEFACT called this the Gap/Disconnect between the Trade and Transport domains. In turn that Disconnect makes it difficult for practitioners in the field of supply chain and transport and logistics to "patch together" the often significant number of standards to achieve some level of consistent support for their daily operations.

2 Standardisation efforts moving in the right direction

Fortunately, over the past decade, several standardisation initiatives have realised the need to look at the development of standards in a more holistic fashion and started to fix the Disconnect.

Probably one of the first to do so is the International Taskforce Port Call Optimization (ITPCO)[2] that started its efforts almost ten years ago. It is now one of the most influential groups for development of standards related to the maritime mode of transport. See figures 1 and 2 below.
Because maritime transport takes care of over two thirds of all cargo carried over any distance anywhere in the world we will cover that mode of transport in a bit more detail than others.

1 https://icc.academy/cargo-data-supply-chains/
2 See flyer: https://portcalloptimization.org/images/Flyer%20ITPCO%20221220%20(1).pdf

Figure 1: ITPCO participation

Figure 2: ITPCO Endorsers

Right from the start, ITPCO adopted a roadmap for development of standard. See figure 3 below.

Figure 3: ITPCO Agenda / Roadmap

Note-1: The 8-step approach also includes that the standards developed will find wide-spread adoption and implementation (where applicable).

Note-2: The roadmap shown here is applicable to all standards development efforts. Just replace "port calls" with the name of the process to be improved.

ITPCO also did **not** want to reinvent any wheels. Therefore, the efforts build on standards already available (consolidating and harmonising along the way) and then anchoring that in robust global standardisation organisations (like IHO, ISO and IMO as most appropriate for maritime). Other standardisation organisations like UN/CEFACT, GS1 and may also be included as appropriate.

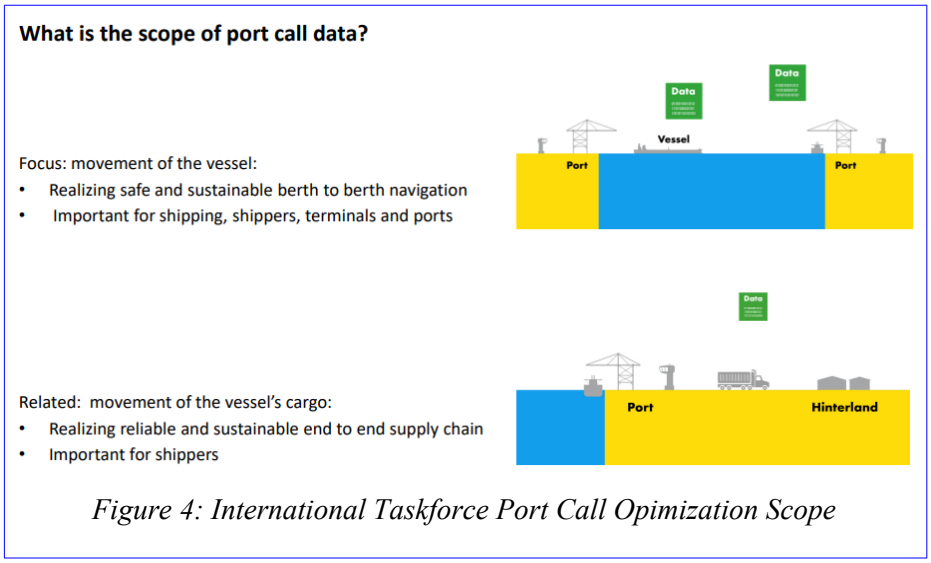

Figure 4: International Taskforce Port Call Opimization Scope

ITPCO also recognised right from the start that although ITPCO was a group that could have operated in a silo, maritime and ports operations have to be an **integral** part of the end-to-end supply chain. The slide in figure 4 is taken from ITPCO Agenda presentation[3].

From this slide, it will be clear that the focus of

3 https://portcalloptimization.org/images/Agenda%20230118.pdf#page=5

ITPCO is on the vessel and operations, events, communications, etc and standards related to the vessel.
These maritime and port standards support two major initiatives in the maritime and ports environment: Port Call Optimization and Just-in-Time Arrival. Both of these are instrumental to improve the performance of Maritime and Ports operations in terms of efficiency, effectiveness and sustainability (see also section 4). The illustration below positions these initiatives.

The ITPCO standardisation results are adopted in several foundational documents of the IHO, IMO and ISO.
E.g., The ISO 28005-series provides the technical specifications to support the maritime community. Work is on-going in ISO TC8 (Ships and Maritime technology) to enhance the ISO 28005-series with the results of global collaboration within the maritime and ports industry to develop standards that are well aligned with the wider supply chain standards.

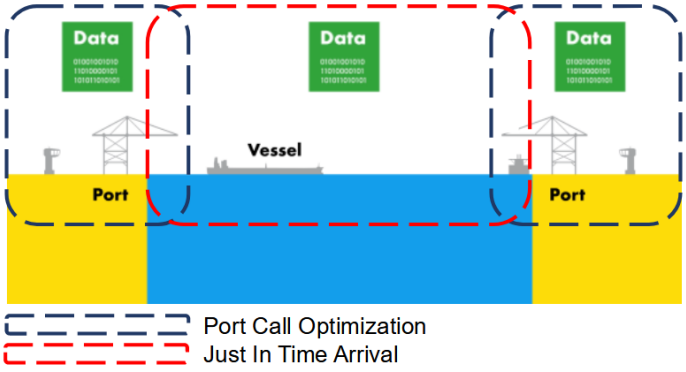

Figure 5: PCO and JIT Arrival in perspective

A key component in these efforts is unambiguous definitions for exactly when an Event is considered to have occurred. E.g., What does "Vessel arrived at berth" mean? Is it when the vessel has started manoeuvring to come alongside, when the first line is ashore, when the last line is secured, when gangway is safely down or yet another trigger point. There may be several hours between the occurrence of these trigger points. Unambiguous definitions have been agreed and documented in ISO 28005; work is ongoing to add more - also related to landside Events up to and including transfer of cargo between port facilities (e.g., terminals) and connecting landside modes of transport.

Similar confusion about the exact trigger points for events also exist in all other modes of transport and all over the supply chain.

The ITPCO agenda above, clearly starts with understanding the business process and the slide above indicates that it is also important to understand how this all fits into the "bigger picture". Again, the slide is merely included as an example of positioning the specific standardisation effort within the business process itself and the relationships with adjacent business processes. Similar positioning slides can be created for standardisation efforts anywhere in the supply chain.

UN/CEFACT also started to adopt that more holistic approach to fix the Disconnect between Trade and Transport mentioned above.

One of the first examples of that are the efforts related to the so-called "Smart Containers". The smart containers are any kind of packaging that is equipped with IoT (Internet of Things) devices that can communicate with the world outside the "container". The Smart Containers efforts first delivered a White Paper. This White Paper lists some 20 Use Cases that occur in different places in the life cycle of a smart container as it travels/circulates through the supply chain.[4]
The Business Requirements Specification[5] (the official UN/CEFACT standard) elaborates on these Use Cases and adds a few more. Many of the Use Cases rely on information provided by sensors connected to the IoT devices. These sensors provide the basic information that can help the stakeholders involved to determine whether the goods transported in the smart container are still in "good condition", so they may still be used when those goods arrived at their destination.

4 https://unece.org/DAM/cefact/GuidanceMaterials/WhitePapers/WP-SmartContainers_Eng.pdf#page=9
5 https://unece.org/fileadmin/DAM/cefact/brs/BRS-SmartContainer_v1.0.pdf

More importantly, the BRS clearly places the Use Cases in the business context of Shipments Transported from Seller to Buyer[6]. See figure 6.

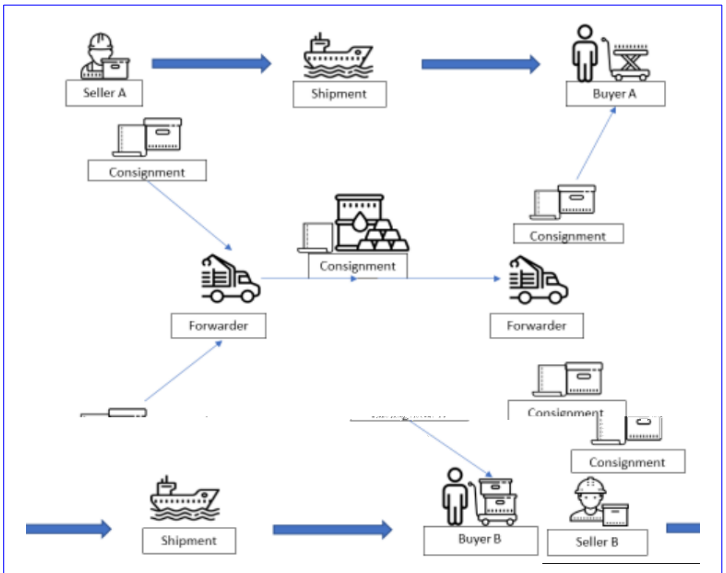

Figure 6: Typical multi-segment logistic network

Even though there is currently only a very small percentage (well below 5%) of all intermodal containers equipped with IoT devices (even less when looking at other kinds of containers), there are initiatives also from major industry actors that will increase that percentage. E.g., Hapag-Lloyd have stated they will equip **all** intermodal containers that they use with IoT devices (enabling tracking in real-time).
That said, this UN/CEFACT standard for developing smart container solutions will assist all stakeholders involved in the transportation of the smart container and the goods transported in it in achieving much better interoperability and as a result better situational awareness related to where there cargo is and also in what condition there cargo may be.

3 Standardisation for end-to-end transportation traceability

In September 2022, UN/CEFACT adopted a new standard that can act as a framework within which many other standards related to visibility and tracking and tracing of products, shipments and consignments can be understood and where feasible aligned and harmonised.

This is the Business Requirements Specification (BRS)
"Integrated Track and Trace for Multi-Modal Transportation"[7]

This standard aims to help stakeholders to always be able to easily answer their main question:
"Where are the Goods at any time?"

The scope is also very clearly defined as
*"Logistic services related to the **transportation of traded goods** between **Seller** and **Buyer**"*
This explicitly includes all modes of transport that may be needed to execute that transportation.
The diagram below depicts that idea in a "basic" fashion. Actual transport and logistics network are often significantly more complex.

Figure 7: Multi-Modal transport from Seller to Buyer

6 https://unece.org/fileadmin/DAM/cefact/brs/BRS-SmartContainer_v1.0.pdf#page=10
7 https://unece.org/sites/default/files/2022-09/BRS-IntegratedTrackandTraceforMulti-ModalTransportationv0.1-Final.pdf

This BRS proposes an approach that will enable tracking and tracing of products and transport assets (transport means and transport equipment) and information sharing about events in a standardised electronic format. Following that approach groups of stakeholders will be able to implement a common well-understood tracking and tracing solution for any and **all traded and identified items**, which includes transport equipment and transport means even when empty.

Within this context it is important we highlight some essential concepts:

1. The standard expects that goods, objects and entities are uniquely identified within the end-to-end process.

2. UN/CEFACT (and other standardisation organisations) recognise that in end-to-end supply chains actors generally operate (mostly) in either the TRADE domain or the TRANSPORT domain. The actors in one domain tend not to know much about how things work in the other domain (and what identifiers they use). This is the Disconnect also mentioned above. To know where goods are it is imperative that the two domains will be linked as part of the daily operational activities that are part of figure 7. That means that the identifiers used in each step of the process must be linked to identifiers used in a previous process step.

3. Terms and definitions used by actors (such as shipment and consignment) have **different** meanings for different actors across the two domains. UN/CEFACT (and other organisations like GS1) provide an unambiguous library of terms and definitions[8] that may be used across the domains. Without a common language across actors, it is next to impossible to achieve good situational awareness to manage the flow of goods well.

Related to bullet 2, the BRS covers events and linking the related identifiers for a range of events (Process steps):

1. Packing
2. Consolidation
3. Combining consignments
4. Loading consignment onto transport means
5. Unloading consignments from transport means
6. De-consolidating consignments
7. Shipment splitting event

In each of these steps, identifiers for shipments, products (trade items), transport units, consignments, transport equipment, transport means etcetera may be established, recorded and shared with parties involved.

Related to bullet 1, figure 8[9], provides an insight into the need for unambiguous global data standard identifiers to enable situational awareness. Each object and entity in the transportation network from Seller (e.g., Manufacturer) to Buyer (e.g., Retailer or Consumer) needs to be identified unambiguously in order to be able to share information related to them among the parties involved in the network. To then be able to use that shared information, it is necessary that the unambiguous identifiers can also be automatically read (captured) 3o tea

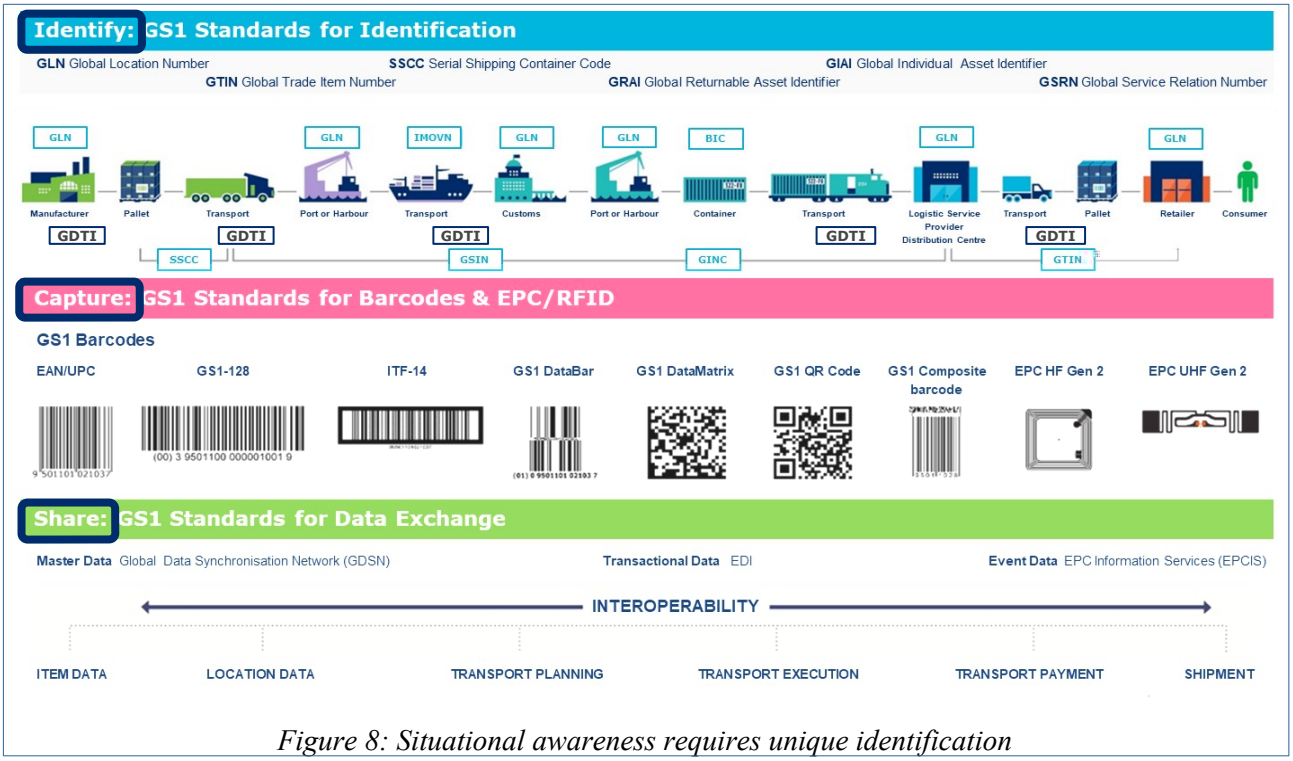

Figure 8: Situational awareness requires unique identification

Figure 9[10] "maps" various standardisation initiatives within the TRANSPORT domain that we briefly covered above.

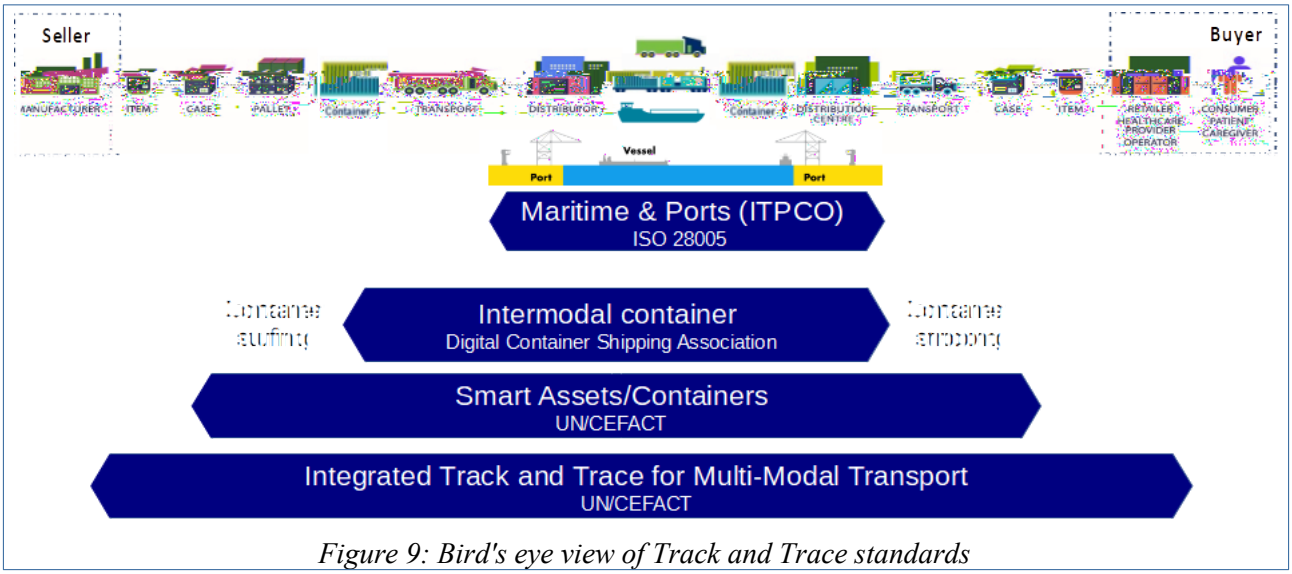

Figure 9: Bird's eye view of Track and Trace standards

Across the top, we see the transport network between Seller and Buyer. The navy-blue arrows indicate how far across the standards "extend" across the transport network between Seller and Buyer. Although the DCSA efforts have not been covered above, they are included in the diagram because the DCSA efforts are being followed closely by many organisations. In this context it is important to note that the DCSA efforts look at all intermodal container related processes but only between the cut-off points of stuffing the container and stripping it. These two activities may occur at various locations/stages in the transport network. It will often happen in a facility within the port[11] (the stripping in the figure). However, they may also happen in locations (far) away from the

10 Courtesy of FixLog Consulting; https://fixlog.consulting

11 Using the port as example only; similar activities may occur related to rail, inland waterways etc.

port (the stuffing in the figure occurs in one of those locations). In principle, the Seller may already stuff the container.

The two UN/CEFACT arrows at the bottom of the figure, indicate that they extend over (much) more of the transport network. There is an important distinction between the "Integrated Track and Trace" standard and the others in the figure. The other standards (currently) do **not** concern themselves with the Goods/Cargo being transported; instead they focus on tracking and tracing of the various assets. Assuming you also know what Goods are in/on which assets, you may also know "*Where are the Goods?"*. The UN/CEFACT Track and Trace standard on the other hand, aims to enable that the links between the Goods and Assets are always created such that stakeholders involved in the supply chain may always know their goods are, in effect "fixing the Disconnect".

It should be noted here that these standardisation initiatives have laid a solid foundation, but there is still significant further effort required. However, with this framework all further efforts may position themselves in their "proper" place. As a result, they may align their efforts with the work that has already been done ensuring interoperability among the results of all those efforts. The positioning will also (significantly) help to explain to the stakeholders what sets of standards will be relevant to the challenges they are addressing and why.

4 Standardisation for end-to-end Product Transparency

All transportation is driven by stakeholders acting in a Value Chain that may be very complex, spanning the world, involving many different stages and processes and many transformations of materials and goods before the final product is sold to the ultimate buyer. The figure below[12] gives an impression of the Value Chain for products (textiles) created from cotton.

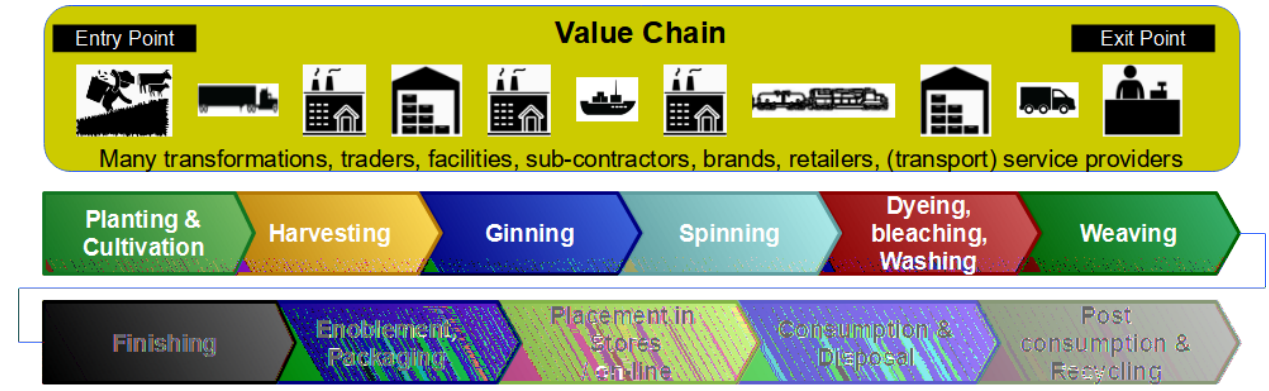

Figure 10: Sample Complex Value Chain - Cotton - Textiles

Figure 10 shows several facilities for processing materials and goods as well as facilities for storing them. In between those, there is always also some kind of transportation (also indicated). We need to stress here that this figure is still a (considerable) simplification of the actual Value Chain.

Next to ten main steps up to Consumption & Disposal, you will also see a stage for what should happen with the product after that. In many countries around the world, regulators are getting more serious about the United Nations Sustainable Development Goals (UNSDG); see also[13]. An ever increasing number of regulations has been put in place or will (likely) be put in place in the next few years to ensure products coming out of complex value chains help to achieve some of those UNSDG or at least do not hamper achieving those goals.

12 Image courtesy of FixLog Consulting; https://fixlog.consulting

13 https://unctad.org/news/transport-newsletter-article-no-101-un-cefact-track-and-trace-publication

Another term/abbreviation often used in this context is ESG (Environmental, Social and Governance). The European Union especially has high ambitions. The *"Ecodesign for Sustainable Products Regulation"* is the cornerstone of the Commission's approach to more environmentally sustainable and circular products. An important element of these ambitions is the creation of so-called *"Digital Product Passports"* (DPP). These DPP will include data that will need to come from all over the Value Chain for the particular product (batch).

Various UN/CEFACT deliverables aim to provide visibility of the ESG conditions under which products (especially raw materials) were made, and where they were made e.g., working conditions, use of chemicals. Among the UN/CEFACT products is the *"Sustainable textile and leather traceability and transparency project"*.

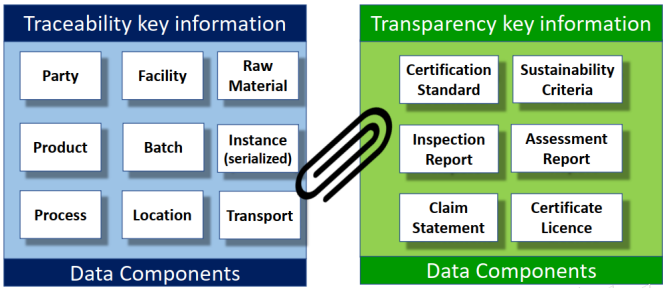

Figure 11: Traceability versus Transparency

The figure above illustrates that next to the data associated with "traditional" traceability, it will be necessary to also have evidence "Transparency Key Information" linked to the traceability data regarding the validity of the traceability data. This is not entirely new and UN/CEFACT has recently published a White Paper *"Digital Product Conformity Certificate Exchange"* that describes how the links between the Traceability and Transparency information may be established and used across the Value Chain.

Figure 12: Standards for Product Transparency

5 In Conclusion

There are many standards that can support track and trace. In fact there are so many that many actors in the supply chain get confused about which ones may be useful for them. Furthermore, many standards have been developed with a siloed view on a particular area of the transport networks between Seller and Buyer.

Fortunately, over the past decade, more and more standards are being developed with a more holistic view of the supply chain and the transport networks between Seller and Buyer. This has now resulted in a

set of standards that can be deployed in unison in interoperable ways and serve as the basis for even further (in-depth) coverage of various process in supply chains.

We also have a framework within which further standardisation efforts may be positioned to ensure early alignment and interoperability as well as clear messaging towards users of standards developed. There is also the emerging area of standards related to Product Transparency, which is needed to support achievement of UNSDG and ESG goals and regulations.
Here too, a framework for the development of interoperable standards is beginning to appear that will help stakeholders in (complex) Value Chains to meet the future needs related to capturing and reporting on Product Transparency Information.