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UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

UNITED NATIONS CENTRE FOR TRADE FACILITATION AND ELECTRONIC BUSINESS (UN/CEFACT)

BUSINESS REQUIREMENTS SPECIFICATION

(BRS)

Smart Containers

Approved: UN/CEFACT Bureau on 30 September 2019

Version: 1.0

1. Introduction

The aim of this document is to define the data elements required for a Smart Container Solution. First, we will detail use cases to share a common understanding of the potential of the Smart Container Solutions and then derive the data elements. We will use the existing data elements of the UN/CEFACT Core Components Library (CCL), in particular, the Multi-Modal Transport (MMT) subset, a.k.a. the MMT Reference Data Model. Whenever new data elements are needed, they will be included in the CCL and the MMT subset**.**

Depending on the use case, a different set of data elements may need to be transmitted to satisfy its Smart Container Solution. The use cases are prioritized and organized accordingly. The sum of all data elements for all use cases would provide all data that may be required in any message format used within the context of Smart Container Information Exchanges. The aim of this work is to define only WHAT may be exchanged among stakeholders and not the HOW this information may be exchanged (e.g. EDI, API, EPCIS). The message exchanged will contain only a subset of "the sum of all data elements".

Data governance and roles/credentials-based access to the smart containers' data elements are part of the terms of contracts in place between the smart containers' service providers and the logistic chain stakeholders.

The 'smart container solution' is based on different technical pillars: 1) an active smart device fixed on a container or included in the container, 2) a platform collecting the data, processing it and sharing with the different stakeholders, and 3) various communication protocols including those wireless communications technologies enabling multi-hopping and collaboration between devices. A 'smart device' has an embedded sensor or set of sensors. Extra remote sensors could also be added/paired with the main device to address the specific needs of a given cargo consignment.

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3. Glossary and Business Context

Term / Abbreviation	Description
Ad-hoc additional Sensors	These sensors are added in ad-hoc manner inside of the cargo, . The ad-hoc sensors are not embedded in the tracking devices however they communicate with the cloud via the tracking device.
AIS	Automatic Identification System: Automatic, self-organizing tracking system transmitting vessels' positional and static information via VHF frequencies. Mandatory for commercial vessels under the SOLAS agreement primarily for Safety of Navigation reasons. Signal reception can be achieved by coastal receiving stations or satellites.
ASC MH10	ASC MH10 is an American National Standards Institute (ANSI) Accredited Standards Committee. Among other things, MH10 concerns itself with standards for Unit-Loads & Transport-Packages.
BAPLIE	(BAyPLan Including Empties.) The BAPLIE message is a widely used EDIFACT message in the shipping industry. It is used by and between various parties to advise the exact stowage positions of the cargo on board of an ocean vessel. It is currently chiefly used for container cargo.
BCO	(Beneficial Cargo Owner.) A BCO refers to an importer that takes control of the cargo at the point of entry and does not utilize a third-party source like an NVOCC or Freight Forwarder. Typically, BCOs are large companies that import products regularly, thus, they have an in-house department for import procedures.
BIC	Bureau International des Containers that manages standards for intermodal containers. Also responsible for globally unique owner codes in the context of ISO6346 specifying the Identification Numbering scheme for intermodal containers.
Bill of Lading	A document issued by a carrier, or its agent, to the shipper as a contract of carriage of goods. The BoL is also a receipt for cargo accepted for transportation, and must be presented for taking delivery at the destination. Among other items of information, a bill of lading contains (1) consignor's and consignee's name, (2) names of the ports of departure and destination, (3) name of the vessel, (4) dates of departure and arrival, (5) itemized list of goods being transported with number of packages and kind of packaging, (6) marks and numbers on the packages, (7) weight and/or volume of the cargo, (8) freight rate and amount, and (9) the identification number.
Buyer	The party to whom goods or services are sold as stipulated in a Sales Order Contract.
Bay Plan (a.k.a., Stowage Plan)	The complete configuration (e.g., their IDs, their sizes, their types, port of loading and discharge, etc.) of all containers stowed on the vessel including their positions.
CMR Transport Document	This document, also known as CMR consignment note, constitutes a proof of the contract of carriage by road, determines the scope and responsibility for the operation performed and identifies the parties involved and the goods being transported. Its use implies adherence to the CMR ("Contrat de Transport International de Marchandises par Route") that governs this document. This document includes the instructions that the exporter or the

	importer gives to the carrier, so it necessarily has to accompany the goods in road shipments.
Connectivity technology	Any technology that enables the IoT devices on smart containers to connect and exchange information among them and/or the IT systems on the means of transport or the in physical infrastructure where containers are handled.
Consignee	The party receiving a consignment of goods as stipulated in a Transport Service Contract.
Consignor	The party consigning goods as stipulated in a Transport Service Contract.
Container	In general, in this BRS, the container under discussion is a marine shipping container; which when fitted with a permanently installed monitoring device is considered a 'smart container'. However, for other modes of transport, e.g. air, road, a Unit Load Device (ULD) is also considered a 'container'. Recent developments have been made to ULDs to also convert them into 'smart containers', whereas, when this project was started, they were considered as 'smart assets', where devices were embedded into the interior contents.
Cross-Border Agency	Any governmental agency that has the right to inspect the cargo inside the container, review the transit time of the container, or needs to make sure that cargo has not been exchanged, inserted or removed from the container during the journey, such as Customs, Police, Health or Agriculture Department, among others.
ETCS: the European Train Control System	An automatic train protection system (ATP) to replace the existing national ATP-systems. ERTMS is a system that has been implemented in many countries all over the world and continues to be implemented in even more countries. In ETCS there is an IoT device installed in the railway tracks that can also communicate with any train that passes over it. The IoT device is called a Euro-balise. It transmits information to the train that is relevant for the safe passage of train across the next segment of the railway track (such as speed limits, position references, gradients, etc.).
EPCIS	EPC Information Services (EPCIS) ISO/IEC 19987 and GS1 Core Business Vocabulary (CBV) ISO/IEC 19988 are a set of APIs known as Electronic Product Code Information Services enabling to exchange information of events and sensor data.
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
Fixed additional Sensors	These sensors are fixed inside of the container in given positions, but they are not embedded in the tracking devices. Fixed sensors communicate with the tracking device that will channel their measurements to the cloud.
GS1	GS1 is a non-profit organization dedicated to the design and implementation of global standards and solutions to improve the efficiency & visibility of the supply and demand chains globally and across sectors. GS1 Standards are used to identify, capture, and share information about products, business locations, and more, which enables companies and systems to speak the same language and to connect with each other.
Hot Load	A situation that occurs when the cargo that is loaded into the refrigerated container is above the agreed-upon temperature. This impacts product

	quality, shelf life and could also result in a cargo claim. Hot loads are detectable by smart containers by monitoring the pull down time and comparing against loads where the cargo was loaded at the proper temperature, therefore warning of potential damage, shortened shelf life or cargo loss. (predictive)
Identification Number synonym: ID	Unique reference to an object (physical or virtual). The reference may be represented in many different formats including but not limited to human readable text, barcodes (linear, two-dimensional), RFID tag values. The Reference/ID may be used to locate and access information related to the object it is associated with.
International Freight Forwarder (IFF)	The party undertaking the forwarding of goods by provision of transport, logistics, associated formalities, services, etc.
IMO	(International Maritime Organization.) IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented. It is a specialized agency of the United Nations, In other words, its role is to create a level playing-field to assure that ship operators do not address their financial issues by simply cutting corners that may compromise safety, security and environmental performance. This approach also encourages innovation and efficiency; e.g., the deployment of AIS was driven by mandate of the IMO.
ISO	ISO is the International Organization for Standardization. ISO develop and publish International Standards. It is a global network of the world's leading standardizers. Through it's members (the national standards bodies in 164 different countries) ISO bring together experts from all over the world to develop International Standards.
IoT	The Internet of Things (IoT) is a "proposed development of the internet in which many everyday objects are embedded with microchips giving them network connectivity, allowing them to send and receive data." (Source: Oxford English Dictionnary, www.oed.com as of 30 Sept. 2019).
IoT device	An electronic device that may connect to the Internet to exchange information with an IoT platform
IoT platform	A software application that collects/receives information from IoT devices, stores this information in a database and communicates with users of the application based on business rules agreed with those users.
LCL	(Less than Container Load.) A term used to describe the transportation of small ocean freight shipments not requiring the full capacity of an ocean container. A freight forwarder may create a "consolidation" by putting multiple LCL shipments together in a single container.
Logistics Services Client	The party ordering the logistics services from the logistics service provider and may be either the consignor or the consignee depending on the business scenario
Logistics Services Provider (LSP)	Party providing logistics services such as warehousing, re-packing products, transportation, distribution and assembly.
Mesh technology	Communication technologies that enable the collaboration between IoT devices fixed on smart containers to channel the data of smart containers that have no line of sight (under deck or at the bottom of the pile of containers) and not in position to send their data directly to the cloud.
MH10	See ASC MH10
PDT	(Pull Down Time.) A method for operating a refrigeration system for a container to cool the temperature of cargo from ambient to a predetermined set-point temperature, and a system employing the method.

PLC	(Power Line Communication.) This is a communication technology that enables sending data over existing power cables. This means that, with just power cables running to an electronic device (for example) one can both power it up and at the same time control/retrieve data from it in a half-duplex manner. Sub-categories of Powerline are 4Pin and 7 pin communication that are compliant with ISO standard 10368 for power cable transmission. This is also known as power-line carrier, power-line digital subscriber line (PDSL), mains communication, power-line telecommunications, or power-line networking (PLN).
Roll Off	Rolled Off Container - A shipper's container has not been loaded on the vessel for the following potential reasons: Overbooking, Vessel Omissions (Vessel Skips a Port), Vessel Weight issues, mechanical issues, Customs problems, missed cut off days, Documentation problems, Pending title violation (auto shipments only). This 'roll off' is deliberate as opposed to the use case in this document where the Shipping line made an error and forgot to take a container.
Segment (a.k.a. leg)	Single routing from one point in the trip to the next point e.g. from SGSIN to LKCMB
Seller	The party selling goods or services as stipulated in a Sales Order Contract.
Sensor	An electronic device designed to measure and capture specific physical properties (e.g. temperature, shock, humidity, light, tilt). Sensors may be connected to a very wide range of other devices or application. Within the context of this BRS we will assume the sensor is attached to or embedded in an IoT device.
Smart Container	A container equipped with an IoT device. See also definition for 'Container'.
SMDG	(Ship Message Development Group.) This is a non-profit international Standards development association that develops, maintains and promotes the use of EDI messages for the maritime industry (e.g., BAPLIE message – see above). The SMDG is recognized by the UN/CEFACT to which they submit their deliverables.
Stuffing/stripping	The act of loading/unloading (a.k.a. vanning/devanning) the goods from a shipping container.
Terminal	A location where containers (including 'smart') are transferred from one mode of transport to another mode of transport. There may be temporary storage of the container at a terminal. Terminals are located at airports, ports, railway nodes, and inland waterway locations. Road and rail transportation typically connect with those terminals for multi-modal transport, but for some end-to-end shipments it is not necessary to transport the cargo via road.
Transport Booking	The set of activities describing the transport services agreed between the logistics services client and the logistics services provider.
Transport Unit	An item of any composition established for transport (and/or storage), which needs to be managed through the supply chain. Transport units take many forms, such as a single box containing a limited number of products, a pallet of multiple products, an air cargo ULD or an intermodal container containing multiple pallets.
Trip Plan	End-to-end routing from first pick-up to last drop-off related to the Consignment, e.g., from Shanghai to Gothenburg (via Colombo Sri Lanka). A Trip (voyage, journey) may consist of multiple Segments (a.k.a. legs) or may only be a single Segment.

ULD	(Unit Load Device.) Standardized containers used for transporting cargo in the air mode of transport. ULDs may also be used in the pre-carriage and post-carriage of the cargo, with the main transport being air carriage.
UN/CEFACT	The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) is a subsidiary, intergovernmental body of the United Nations Economic Commission for Europe (UNECE) which serves as a focal point within the United Nations Economic and Social Council for trade facilitation recommendations and electronic business standards. It has global membership and its members are experts from intergovernmental organizations, individual countries' authorities and also from the business community
UN/EDIFACT	UN/EDIFACT (the United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport) comprise a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data, between independent computerized information systems. Recommended within the framework of the United Nations, the rules are approved and published by UNECE in the UNTDID (United Nations Trade Data Interchange Directory) and are maintained under agreed procedures.
UPID	Unique piece ID. Individual transport units created and uniquely identified by the Shipper.
Wireless Communication	A communication technology, which does not use a physical or wired connection between the respective devices to initiate and execute communication. Wireless communication generally works through electromagnetic signals that are broadcast by an enabled device within the air, physical environment or atmosphere. The sending device can be a sender or an intermediate device with the ability to propagate wireless signals. The communication between two devices occurs when the destination or receiving intermediate device captures these signals, creating a wireless communication bridge between the sender and receiver device. Wireless communication has various forms, technology and delivery methods including, for example: • Satellite communication • Mobile communication • Wireless network communication • Infrared communication • Bluetooth communication
ZOI	(Zone of Interest.) A geographical area relevant for tracking a container or other transport equipment/means, along the supply chain.

Figure 1: Glossary of Terms

To ensure a common understanding in this document as to the meaning of consolidation when describing a shipment prepared by a Seller, the following figure is illustrative of the typical multi-segment logistic network involving consolidated shipments processed through the services of a Forwarder: visualization of the concepts of Shipment, Consignment and Trip, as the terms are referred to in this document from multiple Sellers to (an) eventual Buyer(s).

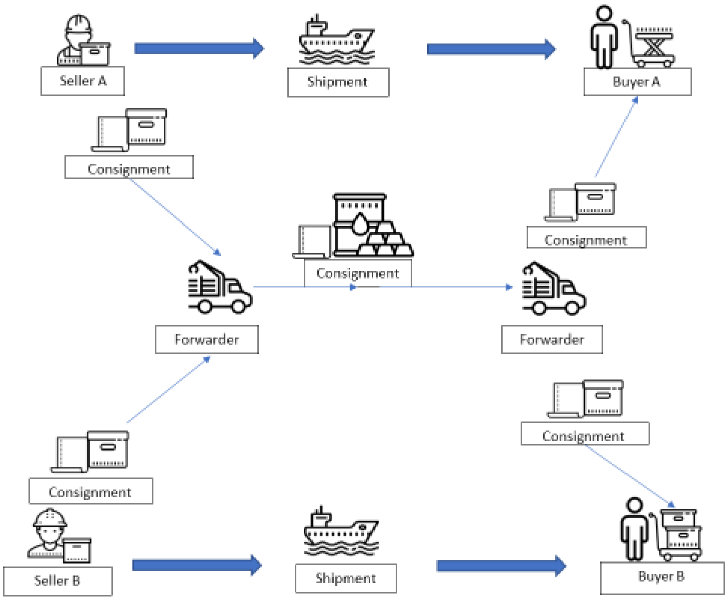


Figure 2: Typical multi-segment logistic network

There are two shipments linked to the TRADE TRANSACTION:
- one from Supplier A to Buyer A (Shipment),
- the other from Supplier B to Buyer B (Shipment).

Each shipment is transported over three legs:

1. Pre-carriage from Supplier to Forwarder,
2. Main carriage from Forwarders,
3. Post-carriage (final mile delivery) from Forwarder to Buyer.

There are various contracts involved that cover the above Trade Transaction. In Figure 2, each of the segments may be executed under a separate Transport Contract. In this case, each of the segments would be considered a separate Consignment. There are five consignments in this figure.

The Consignment transported between Forwarders is the consolidation of Shipments. The contracts associated with the consignments will therefore need to be mapped to the applicable Trade Transaction Unique Cargo Reference Contract (TUCR), the House Consignment Unique Cargo Reference Contract (HUCR) and the Master Consignment Unique Cargo Reference Contract (MUCR). These different contracts can be identified according to the relational figures below:

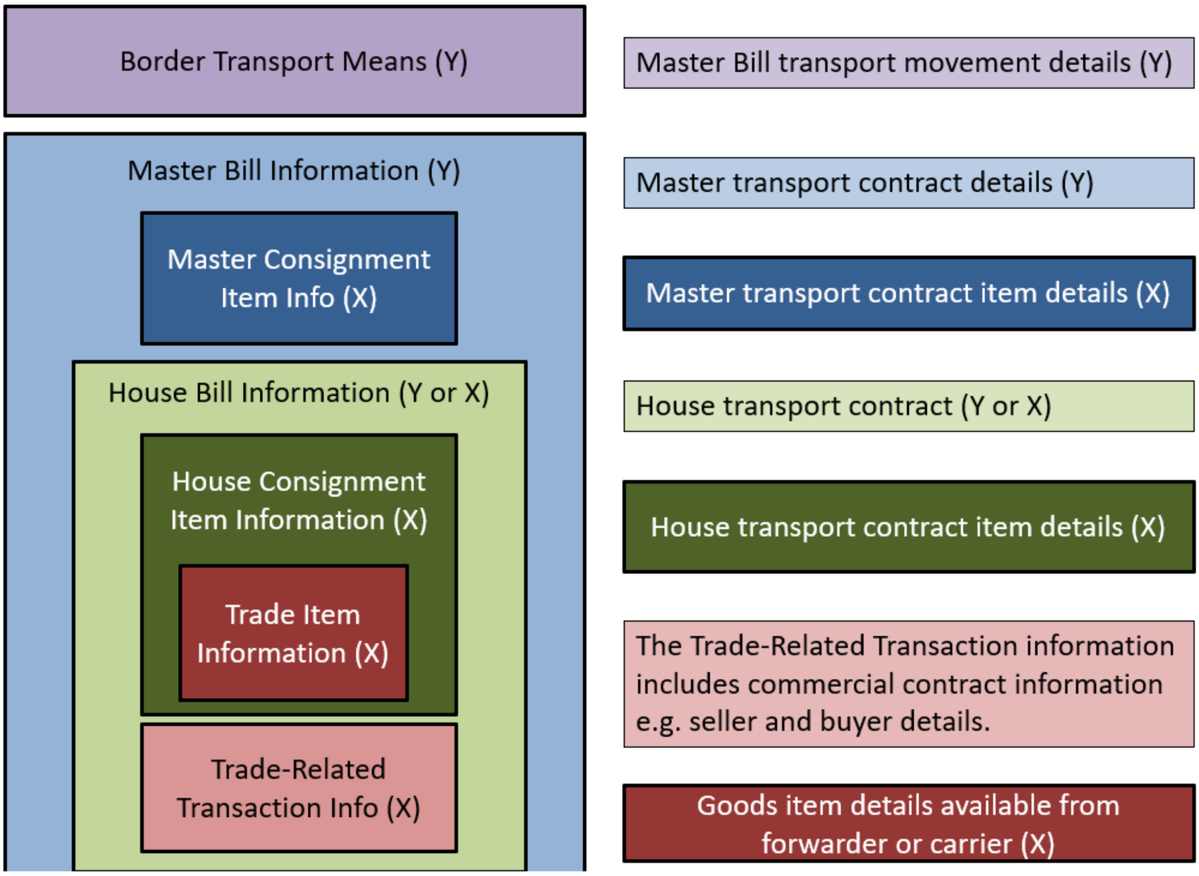


Figure 3: Relationship of the Trade-Related Information and associated Contract to the Transport-Related Data and their associated Transport Contracts

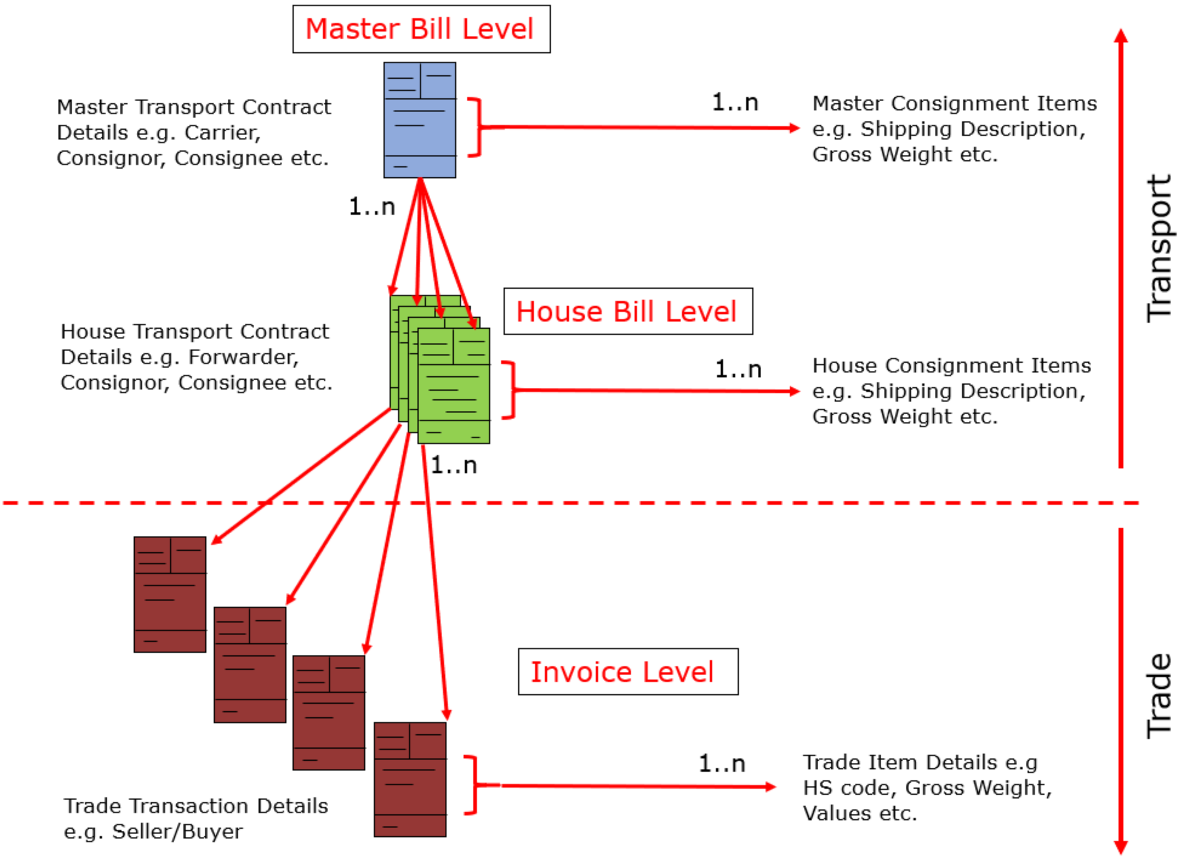


Figure 4: Relationship of the contracts of the Trade Transaction versus the Transport Transactions

Each consignment will follow a specific routing during transport of the cargo. We refer to this routing as the trip plan. The trip may consist of several segments, or it may be just one segment.

4. Business Use Cases Overview Table

Below is a summary of the Use Cases put together by the UN/CEFACT Smart Container work group in the White Paper. Additional Use Cases, #21 and #22 are now added. Each use case is further described in more detail.

Case Number /Type	Use Case	Description & Trigger	Receiver	Value Proposition
1 Operational	ETA Update	Message with new ETA at next point or near final destination can constantly be sent out. ETA calculation is based on comparing planned and actual time and distance.	Supply Chain stakeholder (Carrier, Terminal, Forwarder, Authorities etc.)	Receiver can react proactively and plan container operations or cargo logistics accordingly
2 Operational and Security Awareness	Actual Executed Transit Time	Monitoring the execution of completed transports. For any leg of the trip, compare used time with initial estimation (e.g., the initial trip plan).	Supply Chain stakeholder (Carrier, Terminal, Forwarder, Authorities etc.)	Determine bottlenecks / Delay causes along the trip for operations excellence. Collect historic data as basis for future trip calculation / prediction.
3 Operational and Security Awareness	Schedule Deviation Alert	An alert will be sent out in exceptional case: If container routing deviates from predefined routing, or if actual container arrival or departure is X hours behind predefined trip plan.	Supply Chain responsible operator (Carrier, Terminal, rail/truck operator) and authorities.	Receiver can react proactively, he can determine the root cause and take corrective action in case it is needed: Re-plan the next leg or inform the cargo operator.
4 Operational and Security Awareness	Unexpected Door Opening	An alert will be sent out in case of door opening in an unexpected location, based on pre-defined trip plan. Counter Concept: No alert received means proof that doors were *not* opened during the trip.	Supply Chain responsible operator (Carrier, Terminal, rail/truck operator) and authorities.	Receiver can react proactively at the next point in transport chain: He may check if items were stolen, or unwanted items were placed inside the container. He can inform the cargo operator accordingly.
5 Operational and Security Awareness	Unexpected Temperature Change	An alert will be sent out in case the measured temperature exceeds a predefined threshold, or even earlier when the power source of the reefer container fails.	Supply Chain responsible operator (Carrier, Terminal, rail/truck operator) and authorities.	If the deviation is detected in time, it might not be too late to save the cargo. In any case, the time and place of the exception determines the responsible party.

Case Number /Type	Use Case	Description & Trigger	Receiver	Value Proposition
6 Operational and Security Awareness	Unexpected Humidity Change	An alert will be sent out in case the measured humidity goes above or below a predefined threshold (e.g., the strength of the Cardboard boxes could be compromised due to humidity and cause safety problems and/or denial of acceptance from BCO). The same alert is desired if in a controlled-atmosphere container the amount of O_2, CO_2 and N_2 is outside the acceptable range.	Supply Chain responsible operator (Carrier, Terminal, rail/truck operator)	If the deviation is detected in time, it might not be too late to save the cargo. In any case, the time and place of the exception determines the responsible party.
7 Operational	Missing Container Onboard of Vessel	Mesh technology allows to detect any missing container from onboard of a vessel that was originally specified on the manifest or on the stowage plan without requiring any extra infrastructure (e.g., Gateways).	Shipper, vessel operator, container operator, terminal operator	Vessel operator can take corrective, operational action, and correct the manifest or stowage plan. If a container went overboard, also the Legal and Insurance departments will be informed.
8 Operational	Short-shipped Container	Container is still sending his signal from the port of loading after the vessel (that it should have been loaded on) has sailed.	Vessel operator, container operator, terminal operator	Vessel operator can take corrective, operational action, and correct the manifest or stowage plan.
9 Operational	Overlanded Container	Container discharged in the wrong port. It is sending its signal from a port where it should not be ashore.	Vessel operator, container operator, terminal operator, and authorities.	Vessel operator can take corrective, operational action, and correct the manifest or stowage plan.
10 Operational	Fragile Cargo Shock / Vibration	Unexpected container movement: Shock or Vibration. An alert will be sent out in case the measured shock exceeds a predefined threshold.	Supply Chain responsible operator (Carrier, Terminal, rail/truck operator)	Time and place of the exception determines the responsible party. The container operator obtains new insight about the shock that a container is exposed to.
11 Operational	Dry Container Temperature Monitoring	Constant measuring of temperature in a dry container during a trip.	Vessel operator, container operator	The container operator obtains new insight about the temperature inside a container during a trip on different routes, on deck versus under deck. This is relevant information for shipper and forwarder too.
12 Operational and Security Awareness	Empty Gate-In/Gate-out at Depot	When a Smart Container enters/departs the premises of a depot (geo-fence), this event can be reported. **<u>Note</u>**: it might be duplicate to the CODECO message.	Container and depot Operator, leasing companies and authorities.	This use case will enable the container operator to have better timely control of its fleet management activities. This information is important for authorities when there is regulatory oversight of that zone (free trade zone).

Case Number /Type	Use Case	Description & Trigger	Receiver	Value Proposition
13 Operational and Security Awareness	Depot Reconciliation	Container and depot operator can create a snapshot position of all his containers, sitting in a particular depot (e.g., sea ports, inland, dock and off dock) – based on the last known GPS positions, on demand.	Container and depot Operator, leasing companies and authorities.	Periodic review, or on demand, to reconcile the container inventory with the depot operator. This information is important for authorities when there is regulatory oversight of that zone (free trade zone).
14 Operational	Container Daily Status Message	A shipping line operating a large container fleet globally may receive a heartbeat (Timestamp, Location, Full/Empty, Sitting/Moving, etc.) from each container each day.	Container Operator	Compute usage ratio, show sitting versus moving volumes, determine import or export phase, basis for detention & demurrage calculation etc.
15 Operational and Security Awareness	Trip Tracking for Inland Haulage: the organizer of the trip such as Carrier, International Freight Forwarder, Consignee, or Consignor also known as Beneficial Cargo Owner	While a container is moving inland, various parties to the transport may track the routing and this way find out about the actual routing and for example: Review the ETA for a more efficient planning, Or Check whether the container was crossing a border.	Any contractual party interested and permitted to receive this tracking information such as Consignor, Consignee, Carrier, Logistic service providers, Cross-border agencies, bank or insurance	For safety and security purposes, the origin of goods should be disclosed. But when there are circumstances which are not clarified as to the original shipper, this trip tracking approach may help verify that the shipment is legitimate and does not pose a security risk both from an operational and border security perspectives This can provide for better planning for operations such as stuffing and stripping, vessel planning, depot handling etc…
16 Operational and Security Awareness	Fast Lane for Cross-Border Agency	The Smart Container data might be communicated to the cross-border agencies to enable them to include physical data in their risk assessment even before arrival. The individual authorities define which data they require for their risk assessment. The Smart Container initiative could provide trusted partners new opportunities for increased trusted trader benefits, negotiated with WCO and individual AEO authorities. The Authorized Economical operators have to commit to resolve or justify the reasons behind all the Smart Container raised alerts, if any.	Cross-Border Agency	Speed-up operational clearance, reduce unexpected delays, and increase reliability of time schedule. Benefit also for the cross-border agencies to have more efficient operations.

Case Number /Type	Use Case	Description & Trigger	Receiver	Value Proposition
17 Compliance	Contract Compliance of Container Routing	Actual trip data (time and routing points passed) is provided on demand.	Insurance and bank institutions and Supply Chain stakeholder (Carrier, Terminal, Forwarder, etc.)	Allows bank and insurance institutions check the physical transport execution: Did the container enter political risk areas, excepted countries, pirate areas etc.
18 Green Maintenance	Reefer Pre-trip Inspection (PTI) on demand = predictive maintenance	The Smart Container sends the operations hours of the reefer engine periodically and all the irregularities of performance.	Container Operator	Avoid unnecessary pre-trip inspections and perform them only after predefined operation hours or detected irregularities of performance.
19 Quality	Identifying the shipment	Statement that the product was transported in a monitored Smart Container. The related information is accessible by scanning the QR codes. This is particularly useful for temperature and humidity sensitive commodities (e.g., wine, Tobacco, etc.) being transported in Dry containers.	The Beneficial Cargo Owner (importer and exporter).	The BCO (e.g., consumer, importer) knows that the product was transported in good conditions in a Smart Container. The BCO (e.g., the exporter) will be offering a value-added service. Whenever the conditions were not ideal, the beneficial cargo owner could react and send a new container or adapt its packaging and change the routing.
20 Sovereign	Port Infrastructure usage monitoring by Port Authority –	All actual container movements on roads, bridges and railway within the port boundaries are sent out. Data will be aggregated over time line (e.g. monthly).	Port Authority	Port Authority gains reliable data on the current usage of their infrastructure (roads, bridges, rail tracks, terminals) as basis for future planning.
21 Operational	Intermodal Change	The aim of this use case is to increase the visibility and to monitor (potentially even improve) the timing of the handling of the intermodal changes. Trigger is the detection of unexpected events due to container mishandling during its transfer between different modes of transport	Carriers including Rail Operator and Shipping line, Fleet Manager, Beneficial Cargo Owner, Consignee, Consignor, Insurance and Bank institutions.	Smart container solution gives the visibility to the stakeholders whether or not the container will be able to connect with its next means of transportation enabling them to optimize their processes.
22 Operational	Additional Sensors: Fixed and ad-hoc	The aim of these additional sensors is to enable the measurements of the different physical parameters within specific parts of the container.	Carriers, Fleet Manager, Beneficial Cargo Owner, Consignee, Consignor, Insurance and Bank institutions.	Additional sensors enable us to monitor within different parts of the container and the cargo itself at a more granular level and to be able to add new capabilities to the tracking device (e.g., adding other types of sensors).

4

Figure 5 - Summarized Use Cases

5. Business Use Cases Details

Business Use Case 1: Operational - Estimated Time of Arrival (ETA) Updates

Priority 1

Value proposition:

A message with new Estimated Time of Arrival (ETA) at the next planned point or approaching final destination can be transmitted periodically or upon request. ETA is an estimation of arrival time based on actual time and distance to the next planned point.

Being informed and situationally aware is essential to effectively plan operations. The utilization of smart container tracking solutions provides stakeholders at key delivery points with meaningful data and updates regarding the ETA of the container.

The message receiver can the react proactively and plan container operations or cargo logistics accordingly.

How:

By making use of the GPS positions transmitted by the smart container and having geofenced key Zones Of Interest (ZOI), it is possible to receive notifications when the position of the subject smart container intersects with the geofenced area, together with estimations on ETA based on the distance between the position of the container and the target area.

Example:

For example, a container that arrives in Southampton, UK may be finally destined for Liverpool by road haulage. When the container reaches the geofenced Southampton area a notification could be sent to the delivery point (Liverpool) which combined with additional information (i.e., Google Maps traffic data) would provide with updates on ETA. The warehouse manager may then plan more effectively and make informed decisions accordingly. If the container is expected to arrive after the cut-off time, the manager may choose to send the agency staff home and pre-advise the hauler that cargo would not be unloaded that evening, saving time and resources. Alternatively, if the container is expected soon, the warehouse manager may decide to keep staff a little longer to speed up the handling process.

Conclusion/Benefits:

Based on such principles, optimizing slots according to the expected traffic flow becomes an easier task with obvious productivity gains. Early loads can be replacing those running late without disrupting the operations process.

For this purpose, information sharing about the Estimated Time of Arrival (ETA) could improve planning and accelerate the operations at any container handling terminal **(Priority 1).**

Use Case	ETA Updates
Sender	Smart Container Solution Provider

Receiver	Any contractual party (supply chain stakeholder) interested in receiving the ETA information such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Event driven: the ETA will be calculated whenever the smart container - is crossing in/out of a predefined, geofenced Zone of Interest (ZOI: a predefined geographical zone for geofencing) - is supposed to reach its next ZOI as per its trip plan - per the selected service level - based on x hours/distance before reaching the next ZOI. The triggers will be defined in the contract terms to meet the exact needs of the interested party.
Preconditions	Trip Plan is entered, ZOIs to be geofenced are entered.
Data Transmitted	Asset ID, Next Zone Of Interest (ZOI) as defined in the trip plan by the consignee: it could be the transshipment point or the final place of delivery) → Polygon + GPS position (latitude and longitude), Scheduled ETA at the next ZOI, and Calculated ETA of the next ZOI The place of the event per the UN/LOCODE (if any such Terminal code, Depot code, GS1 Global Location Number (GLN), etc.), GPS position, Timestamp of the trigger event,

Figure 6: ETA Updates

Note. Logistic service providers include the IFF, warehouse planner, 4PL (additional service such as procurement), etc.

Business Use Case 2: Operational and Security Awareness - Actual Executed Transit Time

Priority 2

Value proposition:

The aim of this use case is to monitor the execution of completed transports: for any leg of the trip, compare used time with initial estimation (e.g., the initial trip plan). Monitoring and retrospectively evaluating the execution of completed container transports is a vital step towards optimizing logistics and enabling reliable future estimations so that the supply chain stakeholders can be situationally aware and plan accordingly. The Actual Executed Transit Time is needed to determine bottlenecks and gain insight about delay causes during the trip for operations excellence. In addition, collecting historic data is the basis for future trip calculation and Execution time prediction.

How:

The Smart Container solution can provide precise "door-to-door" timeframes which can then by directly compared to the initial estimated duration. The Actual Executed Transit Duration can be calculated for any leg of the planned trip by making use of the GPS positions of the smart container throughout the voyage. Positional data together with long-lasting stops and geofenced Zones Of Interest (ZOI), enable the acquisition of exact arrival times at any given ZOI. Total trip duration can be broken down for each leg to address the needs of each user who can define key trip waypoints on demand as per personal interest, responsibilities and authorized access.

Example:

Bottlenecks and delays may occur at different stages of the logistics process. The reason for a container arriving late at its destination needs to be examined. If the ocean leg of the trip has been timely executed (based on vessel information obtained by the AIS service), the reason for the delay must be identified in other parts of the supply process – it could be due to ineffective planning of the land journey or due to the operations at port. This would help in arranging the next trip accordingly to avoid the identified bottlenecks by selecting different choices of routes, transport modes and/or alternative service providers.

Conclusion/Benefits:

The identification of trip bottlenecks and delays using the Actual Executed Transit Duration enables comparing, analyzing and reporting to optimize planning and execution of future trips.

Use Case	Actual Executed Transit Time
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving information related to the execution of completed cargo transfers such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Event Driven: Real-time, Upon Arrival at target ZOI User Driven: Retrospective on already executed legs
Preconditions	User-defined trip legs which are underway or have already been executed. User-defined geofenced ZOIs.
Data Transmitted	Container ID, Trip ID, From ($ZOI), To ($ZOI), Leg Start Timestamp, Leg End Timestamp, Actual Executed Transit Time

Figure 7: Actual Executed Transit Time

Business Use Case 3: Operational and Security Awareness - Schedule Deviation Alert (Trip In Progress versus Planned Trip)

Value proposition:

Priority 1

The “Schedule Deviation Alert” determines whether the container is on schedule or not as per planned route and time, and sends alert if any deviation is expected or if a deviation has been identified. Receiver can react proactively. He can determine the root cause and take corrective action if needed, such as re-planning the next leg or informing the cargo operator.

How:

By making use of the GPS positions of the smart container, having geofenced key Zones Of Interest (ZOI) and integrating other sources of information such as traffic or weather conditions, the Schedule Deviation Alert process calculates the ETA to reach the next ZOI and compares it with the cut-offs to reach the next ZOI (for each planned trip milestone) and determines if the schedule is running late or the container has deviated from the planned routing. An alert will be sent out if there is an exception case: If the container routing deviates from predefined routing, or if actual container arrival or departure is X hours behind predefined trip plan.

Example:

Knowing that the container will unlikely be on time to get boarded on the train, the stakeholder will be able to reserve a slot on the next scheduled train or organize the next leg using a different mode of transportation in order to reduce the impact of the delays on the supply chain.

In road transportation it is easy to determine a planned routing, but it is also easier to deviate from this pre-determined route, if someone is trying to steal or change the cargo. A deviation alert may be able to inform of potential threat to the original container or its contents.

Conclusion/Benefits:

This information is key since it enables the prediction whether the container will meet the scheduled connection based on the calculation of the Estimated Time of Arrival (ETA) for each leg. Hence, shippers are empowered to take corrective actions to minimize the impact on the transport execution and on the downstream supply chain. In the case of cross-border agencies (e.g. customs) it is important to be informed of unplanned delays or routing deviations, to better evaluate the risk on that particular container.

Use Case	Schedule or Routing Deviation Alert (Trip In Progress versus Planned Trip)
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving the Schedule or Routing deviation information such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Event driven: the Schedule deviation will be calculated whenever the smart container - is crossing in/out of a predefined, geofenced Zone of Interest (ZOI: a predefined geographical zone for geofencing) - is supposed to reach its next ZOI as per its trip plan - per the selected service level - based on x hours/distance before reaching the next ZOI. The triggers will be defined in the contract terms to meet the exact needs of the interested party.
Preconditions	Trip Plan is entered, ZOIs to be geofenced are entered.
Data Transmitted	The place of the event per the UN/LOCODE (if any such Terminal code, Depot code, etc.), GPS position, Timestamp of the trigger event, Container ID, Electronic device ID, Next ZOI (as defined in the trip plan by the consignee, it could be the transshipment point or the final place of delivery), Scheduled ETA at the next ZOI, and Calculated ETA of the next ZOI.

Figure 8: Schedule Deviation Alert

Business Use Case 4: Operational and Security Awareness - Unexpected Door Opening Detection

Priority 1

Value proposition:

The aim is to detect whether the doors are open or closed and to send an alert if the doors were opened unexpectedly based on the trip plan (e.g., when the zone of interest is a depot or a point of delivery, the Door Opening Detection is expected) along with the geolocation and a timestamp. An alert will be sent out in case of door opening in an unexpected location, based on pre-defined trip plan. Receiver can react proactively at the next point in transport chain: he may check if items were stolen, or unwanted items were placed inside the container.

An unauthorized Door Opening Detection alert can inform the cargo operator of the need for inspection accordingly. Counter Concept: No alert received means proof that doors were not opened during the trip.

Note. The door opening detection is different from the custom authorities' seals

How:

A set of sensors are embedded in the tracking device to detect door opening in addition to making use of the GPS positions of the smart container and geofenced key Zones Of Interest (ZOI) and the trip plan (ZOI identified as depot, transshipment zone, or point of delivery, etc.). The tracking solution will detect the door opening and decide whether it is a normal or unexpected event, that latter of which shall be reported as an alert.

Example:

A door opening detection may not be reported as an alert if this detection took a place in a depot where and when a known inspection took place.

Conclusion/Benefits:

The value of this information is to delineate the responsibilities of involved parties of the transport chain and eventually to facilitate cross-border container risk management.

Use Case	Door Opening Detection
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving this alert such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions
Trigger	Event Driven: Door opening detection in unexpected area
Preconditions	Trip Plan is entered
Data Transmitted	Container ID, GPS, timestamp, ZOI if any

Figure 9: Unexpected Door Opening Detection

Business Use Case 5: Operational and Security Awareness- Unexpected Temperature change for Temperature Sensitive Cargo

Priority 1

Value proposition:

A smart container with temperature monitoring combined with GPS capability can determine during the shipment/transshipment process whether the cargo has undergone an unacceptable rise or fall in temperature during the time of transit or while sitting on ground location awaiting transfer to another conveyance. Combined with timestamps, it can be determined when and where the violation of the acceptable temperature range occurred. If the deviation is detected in time, it might not be too late to save the cargo.

In any case, the time and place of the exception determines the responsible party.

How:

Having the trip plan, the acceptable range of temperature and the external power source detection capability, the tracking solution can decide whether there is a gap between the measured values and the excepted ones and communicate an alert if any gap is detected.

Example:

A reefer moved to the shipyard holding area experiences a rapid change of temperature change beyond the expected maximum range, and the device communicates an alert to the system. The terminal operator forgot to connect the reefer to a power supply.

Conclusion/Benefits:

This alert is very useful to identify the liability (i.e., who is responsible for what and where the exception occurred) in case the temperature of the conveyance has affected the shipment, maybe rendering it unusable. If the temperature was not respected due to reefer failure or power failure, and the deviating temperature is detected in time, it might not be too late to save the cargo provided the container can be reached quickly. The stakeholders including the terminal operator, the vessel operator, the ground handler, the shipper and/or the carrier will get an alert and may be able to react proactively to this situation to avoid damage to the cargo.

Use Case	Unexpected Temperature Change for Temperature Sensitive Cargo
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving this alert such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Exception driven: Measured temperature is out of acceptable range.
Preconditions	Acceptable range is entered for controlled temperature
Data Transmitted	Container ID, booking reference, GPS, timestamp, measured parameter, Sensor position within the container, ZOI if any

Figure 10: Unexpected Temperature change

Business Use Case 6: Operational and Security Awareness - Unexpected Humidity Change for Sensitive Cargo

Priority 1

Value proposition:

A smart container with humidity monitoring combined with GPS capability can determine during the shipment/transshipment process whether the cargo has undergone an unacceptable rise or fall in humidity during the time of transit or while sitting on ground location awaiting transfer to another conveyance. Combined with timestamps, it can be determined when, where and to what extent the violation of the humidity range occurred.

Remark: Beyond the humidity, in a controlled-atmosphere reefer container also the amount of O2, CO2 and N2 must be kept within an acceptable range. Violation of these ranges should be reported similar to the humidity. If the deviation is detected in time, it might not be too late to save the cargo. In any case, the time and place of the exception determines the responsible party.

How:

An alert will be sent out in case the measured humidity goes above or below a predefined threshold (e.g., the strength of the Cardboard boxes could be compromised due to humidity and cause safety problems and/or denial of acceptance from the Beneficial Cargo Owner [BCO]).

The same alert is desired if, in a controlled atmosphere container, the amount of oxygen, carbon dioxide and nitrogen are outside the acceptable range.

Precondition is the trip plan with start and end dates, the handover points enroute, and the acceptable range of humidity.

Example:

An air cargo unit load device carrying sensitive archaeological mummified remains at a transiting airport enroute to final destination, experiences a rapid change in humidity while on the ground during a large thunderstorm, beyond the expected maximum range. The ULD unexpectedly had experienced damage during transit that let water into the ULD. The device registers the deviation and communicates an alert to the Smart Container Solution Provider.

Conclusion/Benefits:

This is useful to identify the liability, i.e. who is responsible for the time and place where the exception occurred when the humidity within the container has exceeded acceptable limits. If the humidity was not respected due to container failure or power failure, and the deviating humidity is detected in time, it might not be too late to save the cargo in case the container can be reached quickly. The stakeholders including the terminal operator, airline or vessel operator, the ground handler, or the shipper will get an alert and may be able to react proactively to this situation to avoid damage to the cargo.

Use Case	Unexpected Humidity Change for Sensitive Cargo
Sender	Smart Container Solution Provider

Receiver	Any contractual party (supply chain stakeholder) interested in receiving this alert such as shipper, vessel operator or carrier, terminal operator, the ground handler
Trigger	Exception driven: Measured humidity is out of pre-defined acceptable range.
Preconditions	Acceptable range is entered for controlled humidity along with start and end dates and the handover points enroute of the trip.
Data Transmitted	Container ID + Electronic device ID (must) Booking reference (should) Place of the event UN/LOCODE (if available i.e. if the event occurred within the scope of a UN/LOCODE) Place of event Terminal code or Depot code (if available, as above) Place of event GPS position (must) Timestamp (UTC) of the event when violation detected (must) Next ZOI as defined in the trip plan (must) Scheduled ETA at the next ZOI (must) Measured Humidity (must)

Figure 11: Unexpected Humidity Change

Business Use Case 7: Operational - Missing containers from onboard of vessels

Priority 2

Value proposition:

This use case is to detect any missing container from onboard of vessel that was originally specified on the manifest, particularly if some unusual event has occurred that brings into question if the container is still on-board. Vessel operator can take corrective operational action and correct the manifest or stowage plan.

If a container fell overboard, also the Legal and Insurance departments will be informed. Vessel operator can take corrective operational action and correct the manifest or stowage plan.

How:

Mesh technology allows to detect any missing container from onboard of a vessel that was originally specified on the manifest or on the stowage plan. If containers are reporting in and a reliable signal from any one of those containers is not obtained using mesh technology to send the signal after a certain period of time, it would be known that something might have happened to that container and should be checked to confirm if it is still onboard.

Example:

During a particularly rough storm at sea, there is a shift in some of the containers and several are lost overboard. Containers that can provide a reliable signal are still known to be on-board from the current GPS position of the ship. Those that are not transmitting any signal, may have been lost off ship during the poor weather incident.

Conclusion/Benefits:

Where containers are lost at sea due to weather, collision or other unforeseen circumstances the cargo owner may be unaware until the vessel arrives at the next port of call or port of discharge.

When this data is used with knowledge of an incident or potential loss of containers the shipper can react proactively and make a business decision based on the data, choosing for example to expedite the delivery of stock from another location or utilize Air freight to meet customer demand in time.

Use Case	Missing containers from onboard of vessels
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving this alert such as shipper, vessel operator, terminal operator
Trigger	Exception Driven: disparity between Bay plan (stowage plan) and the mesh network verification of containers actually on board
Preconditions	AIS position is available, stowage plan is available, trip plan is entered and next port known, no signal from the missing container
Data Transmitted	Container ID + Electronic device ID (must) Vessel ID (must) Booking reference (should) Place of event GPS position or AIS position (must) Timestamp (UTC) of the event when missing container detected (must) Timestamp (UTC) of the last event when missing container was still on board (if applicable) Last port of call UN/LOCODE as defined in the trip plan (must) Next port of call UN/LOCODE as defined in the trip plan (must) Scheduled ETA at the port (should)

Figure 12: Missing containers from onboard of vessels

Business Use Case 8: Operational - Short-shipped: Containers left behind on the pier or Rolled off

Priority 2

Value proposition: It sometimes happens that cargo is manifested, and the container is duly on the load list but eventually the container is left behind and is not loaded.

Reasons could be one of the following:

Overbooking

Vessel Omissions (Vessel Skips a Port)

Vessel Weight issues

Mechanical issues

Customs problems

Missed cut off days

Documentation problems

Pending title violation (auto shipments only)

- a cut-and-run scenario where the vessel has to leave before all containers are loaded
- the terminal simply forgot to load.
- during transshipment, the cargo is unloaded from the inbound transport means but not loaded onto the outbound transport means.

Smart containers could detect this short- shipped event before arriving to the next port of call or port of discharge. Without the use of smart container solutions, the detection of this short-shipped container could take many days or even weeks.

How:

The smart container is still sending its location signal from the port of loading after the vessel has sailed where it should have been loaded. In addition, the wireless communications technologies including Mesh, Cellular and other RF technologies used by smart containers could assist all stakeholders in understanding which containers are not associated with the ship during its current voyage. A certain range of location from the current ship's position vis a vis the smart container would identify that it is not on that ship. Or if containers are reporting to vessel infrastructure and a reliable signal is obtained through the use of Power cable communications or cellular, RF or mesh communication from containers not on the manifest, it would be known that a container was loaded on the wrong ship or another scenario is simply that the container signal would be missing from container location system used by the vessel not exclusive to Powerline communications systems, Cargo Load planning systems and BAPLIE file viewer systems.

Example:

A ship left Southampton and proceeds 10 nautical miles enroute to the Mediterranean, but two containers shown on the manifest are not transmitting a signal from the current ship's position, rather they are identified by position as still in Southampton. Also, one reefer is transmitting a signal from the ship, but it is not recognized as a container that was to have been on that ship's manifest.

Conclusion/Benefits:

The stakeholders including the shipper, the Vessel operator can take corrective operational action and correct the manifest or stowage plan.

Use Case	Short-shipped: Forgotten containers on the peer or ramp
Sender	Smart Container Solution Provider
Receiver	Shipping lane (vessel operator), Shipper, terminal operator
Trigger	Exception Driven: distance between the AIS position of the vessel and GPS position of the container (e.g., over one mile)
Preconditions	Trip plan entered, ID and AIS of the vessel
Data Transmitted	Container ID, booking ID, GPS, timestamp, Alert

Figure 13: Containers left behind on the pier or Rolled off

Business Use Case 9: Operational - Overlanded Container: discharged in the wrong port

Priority 2

Value proposition:

In line with "short-shipped Use Case" above, it sometimes happens that the container is discharged in another than the intended and manifested port of discharge. This incorrect discharge can take place before or after the intended port. Smart container solutions could detect this overlanded event potentially even before the vessel crew or the affected terminals do.

How:

Container is discharged in the wrong port; it is sending its signal from a port where it should not be ashore.

Example:

A container coming from Norway is destined to the USA with an intermediate stop of the ship in Le Havre. Upon leaving Le Havre, the smart container is no longer identified to be on that ship, rather it is still in Le Havre. It may be possible to get the container on the next ship out of Le Havre to the USA to avoid any serious delay of the shipment, if the incident is detected early

Conclusion/Benefits:

The stakeholders including the shipper and Vessel operator can take corrective operational action and correct the manifest or stowage plan.
In case of cargo destined to the USA it is very important to inform US Customs immediately to avoid a Custom's fine in case that the manifest and the stowage plan do not match.

Use Case	Overlanded: discharged in the wrong port
Sender	Smart Container Solution Provider
Receiver	Shipping line (vessel operator), Shipper, Terminal operator
Trigger	Exception Driven: discrepancy between the Container GPS and its expected position per its trip plan based on the AIS position of the vessel
Preconditions	Trip plan entered
Data Transmitted	Container ID, Booking ID, GPS, timestamp, ZOI if any

Figure 14: Discharged in the wrong port

Business Use Case 10: Operational - Fragile Cargo / Breakable Artefacts

Priority 2

Value proposition:

Fragile/Breakable valuables often are transported inside container boxes. Although the shipment may be very well cushioned and protected, accidents or unexpected shocks may happen at any step of the journey. The effect of such occurrences can only be verified by examining the cargo once the container door is opened at journey end. What if there was a reliable way to indicate where the critical shock that damaged the cargo took place? An alert will be sent out in case the measured shock exceeds a predefined threshold.

How:

A smart container can keep track and measure shocks and vibrations undergone by the container and the cargo throughout the journey. The magnitude of the shocks combined with spatiotemporal data (GPS & timestamps) can determine where and when such impactful events (potentially causing damage to the cargo) occurred. Relevant sensors inside the container may identify the intensity of shocks & vibrations above accepted thresholds.

Example:

An air cargo unit load device was well supported internally to prevent damage to stone archaeological carvings. However, during transport through an intermediate stopover enroute to final destination, the shipment was removed to add additional cargo. During the process, the container was bumped into another on the ground causing intense vibrations. Sensors were activated immediately and transmitted an alert signal.

Conclusion/Benefits:

Knowing where unexpected events happened adds visibility and facilitates post-inspection. Time and place of the exception determines the responsible party. The container operator obtains new insight about the shock that a container is exposed to. This is particularly useful for insurance purposes while also enabling the shipper and/or carrier to take appropriate measures.

Use Case	Fragile Cargo / Breakable artefacts
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving information related to the safe execution of fragile cargo such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Exception Driven: Measured shock is above a user-defined threshold
Preconditions	Predefined cargo thresholds
Data Transmitted	Container ID, GPS, timestamp, ZOI ID if any, magnitude of the shock

Figure 15: Fragile Cargo / Breakable Artefacts

Business Use Case 11: Operational - Dry Container Temperature Monitoring

Priority 3

Value proposition:

This use case enables constant measuring of temperature in a dry container during a trip. The aim of this functionality is check whether the cargo has been exposed to extreme temperature variation based on a correlation with the ambient temperature (i.e., Temperature sensor embedded in the tracking device).

How:

Where a simple measurement of temperature is provided, rather than having a controlled range, it could lead to recommendations for future shipping, particularly if the extremes identified resulted in some damage to the goods, whether it be high or low temperatures.

Example:

The quality of some goods, such as champagne and beers, could be impacted by the temperature that they have undergone during the trip execution. This monitoring could be useful for beverages and dangerous products (e.g., perfumes, paints, and household products).

Conclusion/Benefits:

This information is valuable for merchandise that does not require a controlled atmosphere but is still sensitive to extreme conditions. The stakeholders such as the container operator, shipper and forwarder obtain new insight about the temperature inside a container during a trip on different routes, on deck versus under deck. They will be able to react accordingly to prevent the worst (explosion of dangerous goods, merchandise spoiling) and/or to rethink the packaging of such merchandise, choose an alternative route, or different container types for future shipments.

Use Case	Container temperature monitoring
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving information related to the cold chain such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions.
Trigger	Exception Driven: Periodic per the service level
Preconditions	Thresholds of the acceptable temperature is entered
Data Transmitted	Container ID, GPS, Timestamp, Temperature

Figure 16: Dry Container Temperature Monitoring

Business Use Case 12: Operational and Security Awareness - Empty gate-in/gate-out at Depot

Priority 2

Value proposition:

When an empty smart container enters/departs the premises of a depot, this event can be reported to the container operator and all interested parties. This event reported by the smart container might be duplicate to the event that the depot operator should send out, typically by EDI message CODECO, for the same container.

How:

Making use of the GPS positions of the smart container and geofenced Zone Of Interest (ZOI) identified as a particular depot, the tracking solution will detect entering/departing this given ZOI and generate the Empty gate-in/gate-out at Depot event

Example:

The container operator will be able to check whether the container is back to the depot or has left the depot and at what time without having to go check the container physically.

Conclusion/Benefits:

This use case will enable the container operator to have better timely control of its fleet management activities. This information is important for authorities when there is regulatory oversight of that zone (free-trade zone).

Use Case	Empty gate-in/gate-out at Depot
Sender	Smart Container Solution Provider
Receiver	Container Operator
Trigger	Event Driven: Container has entered the geofence of the depot
Data Transmitted	Container ID, size and type, Depot ID, timestamp, GPS

Figure 17: Empty gate-in/gate-out at Depot

Business Use Case 13: Operational and Security Awareness - Depot reconciliation

Priority 2

Value proposition:

A container operator, such as a shipping line or a leasing company, strives for clear visibility on the number of empty containers sitting in a particular depot at any time. During daily operations, the empty container inventory is monitored by capturing the gate-in and gate-out events as per "Empty gate-in at Depot UC" above. The large number of movement reports may lead to discrepancies in some cases. Therefore, on a periodic review, or on demand, the container operator may wish to reconcile the container inventory with the depot operator.

The stakeholders can create a snapshot position of all their containers sitting in a particular depot (e.g. sea ports, inland, dock and off dock) based on the last known GPS positions, on demand.

How:

For this purpose, the container operator will be able to create a snapshot position of all his smart containers, sitting in a particular depot – based on the last known GPS positions. Precondition is again that the depot premises (area) are defined by a geofence and that geofence is somehow identifiable as a particular depot.

Example:

Periodically, the terminal operator will generate a snapshot of all the available containers and check this against the 'gate in-gate out' report.

Conclusion/Benefits:

Enabling periodic review, or on demand, to reconcile the container inventory with the depot operator. This information is important for authorities when there is regulatory oversight of that zone (free-trade zone). Depot reconciliation will enhance the fleet management and optimize the resources usage.

Use Case	Depot reconciliation
Sender	Smart Container Solution Provider
Receiver	Container Operator
Trigger	Event Driven: On demand, for a given ZOI (e.g., depot)
Preconditions	Depot is identified as a ZOI

Data Transmitted	For all containers in a given ZOI (e.g., depot) at a given date Container ID, size and type, gate in date

Figure 18: Depot reconciliation

Business Use Case 14: Operational - Container Daily Status Message for fleet management & Usage KPIs

Priority 1

Value proposition:

A shipping line operating a large container fleet globally may receive a heartbeat (Timestamp, Location, Full/Empty, Sitting/Moving, etc.) from each container each day. The aim is to compute the usage ratio of the containers and to compile a snapshot of all empty containers and their locations in order to maximize their quick reuse (relocation plan) which result in productivity increase and reduction of their global environmental impact. In addition, recommendations for empty containers repositioning (e.g., containers match back and containers import/export balancing, etc.) to reduce congestion and pollution could be done based on the container's status data. The container repositioning will identify the potential containers match back between an import mission and an export mission without going through the transporter depot. To be able to compute the carbon footprint, the distance traveled by container per different means of transportation (trains, trailers, vessels, barges, etc.) could be compiled based on this container status message.

How:

The usage of the data recorded from tracking of routings, timestamps, and actual movements and events can be compiled in an historical database of the shipping line, perhaps analyzed real-time in conjunction with artificial intelligence, to help maximize use and reuse of the containers, and create continually improving efficiencies in the operations.

Example:

The data could be used as well for Automation of Detention and Demurrage (D&D) fee collection. An inefficient system means loss of potential D&D revenue. Calculating and billing D&D fees requires labor intensive data collection, a process that is subject to error, fraud and lost opportunities. Reliable tracking provided by Smart Containers means your billing system automatically knows the time of entry and exit of the container in the yard.

Conclusion/Benefits:

The container data status enables cost effective fleet management. Container usage incurs a daily cost (e.g., storage and leasing cost). Idle full, unused, slow, abandoned, or moving empty containers are costly.

Use Case	Container daily status for Fleet Management & Usage KPIs
Sender	Smart Container Solution Provider
Receivers	Shipping line/fleet manager
Trigger	Periodic
Preconditions	Trip plan communicated, actual routings and associated events captured

Data Transmitted	- Container ID, - The current location of the container: GPS position and the current Zone of interest (ZOI) (if known), (e.g., depot, terminal) - Timestamps - The next planned location/ZOI (if known), - Movement status: Idle (sitting) or On move, - Load Status: Full or Empty - Consignment Status: in mission (e.g., Booked by a consignee) or Not

Figure 19: Container Daily Status Message for fleet management & Usage KPIs

Business Use Case 15: Operational and Security Awareness - Trip Tracking for merchant haulage container

Priority 2

Value proposition:

With a smart container, the shipping line could track the routing of the container and this way find out about the identity of the customer. Data governance, however, will respect the competitive advantages of all the stakeholders (e.g., mechanisms shall be in place to shield this kind of information).

How: Location and timing information obtained through internet of things reporting to the shipping line may identify the route and whereabouts of the smart container while it was out of the possession of the shipping line. Such information could be used to identify the location of loading of the container.

Example:

To protect the competitive advantage of each stakeholder, all involved parties will have access to the information that matters to them, as authorized through any given regulation and/or contractual term. For example, in a Merchant Haulage scenario, a forwarder would pick-up an empty container from a depot and return the loaded container to the terminal. In the meantime, the container was loaded at the customer's premises and not loaded by the forwarder themselves. The forwarder may choose the parties who will receive the location and the identity of his customer. Customs agencies and the shipping line, however, will have access to the original shipper information. If for some reason the container is suspect of carrying illegal merchandise or dangerous goods or firearms which have not been declared, it could lead to identification of the source.

Conclusion/Benefits: For safety and security purposes, the origin of goods should be disclosed. But when there are circumstances which are not clarified as to the original shipper, this trip tracking approach may help verify that the shipment is legitimate and does not pose a security risk.

Use Case	Trip Tracking for merchant haulage container
Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested and permitted through law or within the contract to receive this tracking information such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-borders agencies, broker, bank and insurance institutions

Trigger	Event driven: the routing of the container may be calculated whenever the smart container - is crossing in/out of a known security monitoring area, or predefined, geofenced Zone of Interest (ZOI: a predefined geographical zone for geofencing) - time stamps are provided that can identify stopping points for times exceeding simple movement past a monitor. The triggers will be defined in the contract terms to meet the exact needs of the interested party.
Preconditions	Data governance rules are entered, identified ZOI
Data Transmitted	Time/date stamps, identified ZOI, door opened, door closed event

Figure 20: Trip Tracking for merchant haulage container

Business Use Case 16: Operational and Security Awareness - Fast lanes for cross-border agencies

Priority 1

Value proposition: The Smart Container data might be communicated to the cross-border agencies to enable them to include physical data in their risk assessment even before arrival. The individual authorities define which data they require for their risk assessment. The Smart Container initiative could provide trusted partners new opportunities for increased trusted trader benefits, negotiated with Customs Authorities and individual Authorized Economic Operators (AEO) authorities.

AEOs must commit to resolve or justify the reasons behind all the Smart-Container-raised alerts, if any.

This use case enables to speed-up operational clearance, reduce unexpected delays, improve data quality/visibility and increase reliability of time schedule.

There is benefit also for the cross-border agencies to have more efficient operations.

How: Before a container arrives at a border, the transport organizer or the shipper declares to customs the intended routing of the container from the place of stuffing (origin) to the place of stripping (final destination) along with the appropriate transport references (such as the bill of lading, the air waybill, the CMR, the booking ID, …), the operator code and the container number for identification. When the smart container passes through a ZOI (before the ZOI at the border), this information goes to the cross-border customs to start the risk analysis. The arrival of a smart container at the border will trigger sharing with the agency the required digital documents and send various smart container information such as all known geofences that it has been through since the point of origin (where it has been) and possibly the GPS positions of the unexpected door opening detections during the whole trip. As a result, the smart container may already be cleared when it arrives at the border.

Example: Imported perishable goods have to be inspected and cleared by different cross border agencies quickly otherwise they will lose their commercial value. Making a stock of High Value Goods is very costly, hence it is far more economical to reduce the stock if you can reduce the total transit times including the clearance process.

Conclusion/Benefits: Based on this physical real data, the agency can perform their risk assessment in an efficient manner and decide whether to control or release the container quickly. This will result in shortening the actual transit time and reducing the associated risks.

The automatic declaration triggered by the arrival of the smart container will be done according to the World Trade Organization (WTO) Trade Facilitation Agreement TFA set of 7.8 of references that covers expedited shipments.

In addition, the smart container will offer visibility on a new set of real trip data. This new data could be included in the Authorized Economic Operator requirements as defined by the WCO.

Use Case	Fast lanes for cross-border agencies
Sender	Smart Container Solution Provider
Receiver	Cross-border agencies
Trigger	Event Driven: Geofencing or planned trip
Preconditions	Trip plan communicated
Data Transmitted	Container ID, Shipper, Shipping lane, Point of Origin, Point of Delivery, History of container usage, Door opening detection Alerts, Long last stops, ETA, the Actual Executed Transit Time, the Schedule Deviation Alert, Unexpected temperature or Humidity Change, Overlanded Container, all routing points passed.

Figure 21: Fast lanes for cross-border agencies

Business Use Case 17: Compliance-
Contract Compliance of Container Routing

Priority 1

Value proposition: Bank and insurance institutions check the physical transport execution before approving the financial transaction. Because of risk in areas of geopolitical conflict, the contract will specify if containers shall not enter specific regions or countries. Otherwise, the bank institutions may be required to pay significant penalties for non-compliance and the insurance institutions may not be held responsible for any loss in these specific regions. In addition, cross-border agencies have to make sure that the physical flow is aligned with the declarations that have been made in order to clear the cargo.

How: Information gleaned from periodic smart container positioning notifications will verify that the physical flow is aligned with the documentation flow and in compliance with the contract.

Example: GPS positioning recorded by the smart device or smart container, or geofencing coordinates transmitted for arrival in a foreign port would indicate if the container has been moved into or through a non-permitted region or country, as identified in the contract. For example, for cross-border agencies, the point of origin or the route shall not be different from the ones specified in the declarations otherwise it may indicate non-compliance.

Conclusion/Benefits: This use case would substantiate compliance with the geopolitical terms or restrictions thereof in the contract and accelerate the verification of the declaration with the actual trip execution for a better risk management analysis and accelerated release of funds.

Use Case	Geopolitical Contract Compliance

Sender	Smart Container Solution Provider
Receiver	Any contractual party (supply chain stakeholder) interested in receiving the actual route information such as Consignor, Consignee, Terminal Operator, Carrier, Logistic service providers, Cross-border agencies, broker, bank and insurance institutions.
Trigger	Event driven: points along the actual route will be identified whenever the smart container - is crossing in/out of a predefined, geofenced Zone of Interest (ZOI: a predefined geographical zone for geofencing) - reaches its next ZOI as per its trip plan The triggers will be defined in the contract terms to meet the exact needs of the interested party.
Preconditions	Trip Plan is entered, ZOIs to be geofenced are entered.
Data Transmitted	Container ID, GPS, AIS, Timestamp, ETA, Electronic device ID (must), Booking reference (should), Place of the event UN/LOCODE (if available i.e. if the event occurred within the scope of a UN/LOCODE) Place of event Terminal code or Depot code (if available, as above) Place of event GPS position (must) Timestamp (UTC) of the event when violation detected (must) Next ZOI as defined in the trip plan (must) Scheduled ETA at the next ZOI (must) Shipper, Shipping lane, Point of Origin, Point of Delivery, History of container usage, Long last stops, the Actual Executed Transit Time, the Schedule Deviation Alert, Overlanded Container, all routing points passed.

Figure 22: Contract Compliance of Container Routing

Business Use Case 18: Green Maintenance - Reefer Pre-trip Inspection (PTI) on demand = predictive maintenance

Priority 1

Value proposition: The Smart Container sends the operations hours of the reefer engine periodically and all the irregularities of performance.

How: Maintenance information regarding the smart container and its operational performance could be captured and transmitted without human intervention, either unsolicited or upon request.

Example:-Date/Time since installation and last maintenance of the engine of the smart container could be programmed into the transmissions.

Conclusion/Benefits: Maintenance history information might avoid unnecessary pre-trip inspections and perform them only after predefined operation hours or detected irregularities of performance.

Use Case	Green Maintenance: Reefer Pre-trip Inspection (PTI) on demand = predictive maintenance
Sender	Service Provider
Receiver	Container Operator

Trigger	The Smart Container sends the operations hours of the reefer engine periodically and all the irregularities of performance.
Preconditions	last maintenance report, records of abnormal functioning during previous trip, reaching a given period or number of functioning hours, ...
Data Transmitted	Container ID, GPS, AIS, Timestamp, ETA Container ID + Electronic device ID (must) Booking reference (should) Place of the event UN/LOCODE (if available i.e. if the event occurred within the scope of a UN/LOCODE) Place of event Terminal code or Depot code (if available, as above) Place of event GPS position (must) Timestamp (UTC) of the event when violation detected (must) Next ZOI as defined in the trip plan (must) Scheduled ETA at the next ZOI (must)

Figure 23: Reefer Pre-trip Inspection (PTI) on demand

Business Use Case 19: Quality-Identifying the shipment

Priority 1

Value proposition: A statement or information in a barcode can be made on a product label, outer carton or in accompanying material that the product was transported in a monitored Smart Container.
The related pertinent information on this shipment as provided by the smart container can be retrieved by scanning the "Quick-Reference Codes." This is particularly useful for temperature and humidity sensitive commodities (e.g. wine, tobacco, etc.) being transported in dry containers.

How: Identification that a product has been shipped in a Smart Container would be a good marketing tool, providing confidence for the consumer that the goods were transported and received in good condition.

Example:-The consumer at a grocery store could see that the product has been shipped in a Smart Container based on the information provided on the packaging.

Conclusion/Benefits: From this additional information, the BCO (e.g. consumer, importer) knows that the product was transported in good condition in a Smart Container.

The BCO (e.g. the exporter) will be offering a value-added service.

Whenever the conditions were not ideal, the beneficial cargo owner could react and send a new container or adapt its packaging and change the routing.

Use Case	Quality: Identifying the shipment
Sender	Service Provider
Receiver	The Beneficial Cargo Owner (importer and exporter).
Trigger	Statement that the product was transported in a monitored Smart Container. The related information is accessible by scanning the "Quick-Reference Codes." This is particularly useful for temperature

	and humidity sensitive commodities (e.g. wine, tobacco, etc.) being transported in dry containers.
Preconditions	records of environmental transport conditions using appropriate cargo sensors (e.g. Temperature, Humidity, etc.)
Data Transmitted	Container ID, GPS, AIS, Timestamp, ETA Container ID + Electronic device ID (must) Booking reference (should) Place of the event UN/LOCODE (if available i.e. if the event occurred within the scope of a UN/LOCODE) Place of event Terminal code or Depot code (if available, as above) Place of event GPS position (must) Timestamp (UTC) of the event when violation detected (must) Next ZOI as defined in the trip plan (must) Scheduled ETA at the next ZOI (must)

Figure 24: Identifying the shipment

Business Use Case 20: Sovereign- Port Infrastructure usage monitoring by Port Authority

Priority 1

Value proposition: All actual container movements on roads, bridges and railways within the port boundaries are transmitted. Data will be aggregated over time line (e.g. monthly).

How: Using standard APIs, the Smart Container service providers could share aggregated, anonymized data with the Port authorities that will merge all the inputs and include this new set of data in their infrastructure planning according to their needs.

Example:-Whenever the port authorities decide whether they need to expand their infrastructure, the visibility of the usage of their current infrastructure and how this usage increased over time, will help to make more economically sound decisions.

Conclusion/Benefits: Port Authority gains reliable data on the current usage of their infrastructure (roads, bridges, rail tracks, terminals) as the basis for future planning.

Use Case	Sovereign: Port Infrastructure usage monitoring by Port Authority
Sender	Service Provider
Receiver	Port Authority
Trigger	All actual container movements on roads, bridges and railways within the port boundaries are sent out. Data will be aggregated over time line (e.g. monthly).
Preconditions	significant monitored assets movements in the considered area, massive historic to be able to predict needs evolution
Data Transmitted	Container ID, GPS, AIS, Timestamp, ETA Container ID + Electronic device ID (must) Booking reference (should) Place of the event UN/LOCODE (if available i.e. if the event occurred within the scope of a UN/LOCODE) Place of event Terminal code or Depot code (if available, as above) Place of event GPS position (must)

	Timestamp (UTC) of the event when violation detected (must) Next ZOI as defined in the trip plan (must) Scheduled ETA at the next ZOI (must)

Figure 25: Port Infrastructure usage monitoring by Port Authority

Business Use Case 21: Operational – Intermodal Change

Priority 1

Value proposition: The aim of this use case is to increase the visibility and to monitor (potentially even improve) the timing of the handling of the intermodal changes. The scope is proper handling of the container before loading it at port of origin and/or handling after arrival at destination port. Any delays and/or potential mishandling (e.g., involving shocks, unusual orientation, any damage) need to be captured to guarantee the safety of the cargo goods and the efficiency of the operations.

From the carrier side, the smart container service will enhance the intermodal change. Having the ETA of the container at the terminal will give visibility to the carrier whether or not the container will be able to connect with its next means of transportation (e.g., vessel, truck, or train). In the transshipment scenario, the next carrier will have more visibility of the exact location of the container and its estimated arrival time, enabling him to optimize its process. On the import side, the consignee, will also have a better estimation of the arrival time of his cargo.

The carriers, including the railway operators, could have access to the smart container information for efficient composition or load planning for the next means of transport (e.g., whether it has dangerous goods or not, based on the next destination etc.).

Especially for railway operators, if the wagons are equipped with IoT devices, it is possible to capture the container IDs on board of the train. The smart container could also interact with the rail infrastructure giving you additional information about the location of the container within the train (e.g., based on mesh technology).

In general, in the vicinity of other smart assets, the smart container could interact to offer other services.

How: Data on the physical transport execution of a given smart container, including the multi-modal legs, can be captured and analyzed to provide current location, ETA at destination, and any out-of-normal range events recorded along with their time stamps and geolocation. This data can be beneficial to many stakeholders, depending on their role in a particular shipment. For the intermodal changes, the captured data is especially valuable due to the transfer of responsibilities between different carriers and the increased risks associated with their handling operations.

Based on multiple journeys' historical data and data science analysis, the estimation of the different parameters and the impact of given values such as ETA, the duration of the handling operations, KPIs for different terminals and port could be enhanced to continually improve efficiencies in the operations.

Examples: The data could be used to detect improper handling, unusual container shock and/or wrong orientation. Reliable tracking provided by Smart Containers can identify various types of damage caused by improper intermodal change and could potentially indicate incorrect positioning angle that could cause a roll-over event. Damage incurred could be used in conjunction with physical inspection data as evidence of improper securing of the container on its platform, such as a rail wagon or truck bed, or dropping the container from a height.

Additionally, analyzing data across many containers may better determine actual average time taken for specific intermodal changes (e.g., at specific locations). Results like these can then be used to improve the planning and the execution processes involving these intermodal change points.

Conclusion/Benefits: The container data captured, analyzed and reported enables cost effective operations and provide evidence for intermodal change damage claims. Knowing where and when mishandling occurred, helps in determining the responsible party. The receiver obtains new insight about the shock or unusual orientation to which a container may have been exposed. This is particularly useful for insurance and financial purposes while also enabling the shipper and/or carrier to take appropriate and timely mitigation measures, if necessary.

Use Case	Intermodal Change. Container Loaded on Multi-modal Conveyance - Inland Waterway, Rail or Truck
Sender	Smart Container Solution Provider
Receivers	Carriers including Rail Operator and Shipping line, Fleet Manager, Beneficial Cargo Owner, Consignee, Consignor, Insurance and Bank institutions.
Trigger	Detection of unexpected events due to container mishandling during its transfer between different modes of transport
Preconditions	Trip plan communicated, actual intermodal changes and associated events captured
Data Transmitted	- The container ID, current GPS position, current and next Zone Of Interest (ZOI) if any (e.g., port terminal, rail terminal, inland waterway terminal, shunting yard) - Timestamps - Shock magnitude - Door opening and/or breaching detection - Light detection - Wrong orientation (e.g., the doors should be oriented to the back of the train)

Figure 26: Intermodal Change

Business Use Case 22 – Additional Sensors: Fixed or Ad-hoc

Priority 2

Value proposition

The focus of this use case is the use of multiple fixed or ad-hoc sensors within the container in addition to the ones embedded in the tracking devices. The aim of these additional sensors is to capture the measurements of the different physical parameters at specific parts within the container. Sensors can be fixed in various positions inside of the container. Another type of additional sensors is ad-hoc, which can be attached to the pallets or added inside the bags of cargo. Fixed and ad-hoc sensors can be paired with the tracking device that is responsible to channel their data to the cloud.

How

There is a difference between the physical parameters measured within different parts of the container (e.g., temperature inside individual boxes). The additional sensors can take the measurements and make use of the communication capability (and its firmware intelligence) of the tracking device by being paired with it and establishing a wireless communication. The use of standards will determine where the additional sensors should be added in the container and whether they should be fixed or ad-hoc.

Examples

Ensuring temperature controls across the supply chain is critical to an unbroken cold chain. Air flow can be restricted inside a container due to many factors. Stacking cartons too high, for example, can cause a lack of air to properly flow through the container. Hot loaded cargo can also affect the cartons and pallets nearby in the container causing temperatures to stay warmer longer. Therefore, internal sensors placed strategically in the smart container at various points in the container and in various cartons or pallets, can more accurately draw a picture of current temperatures inside the reefer.

Conclusions/Benefits

Additional sensors enable us to monitor the container and the cargo at a more granular level and provide more insight of what the container and cargo has been through in terms of shocks /vibration, temperature or humidity. Moreover, we cannot embed all type of sensors inside of the tracking devices. Hence, additional sensors allow us to add specific sensors to address the specific needs of a particular cargo (e.g., humidity measurements for coffee, wheat and shocks for fragile cargo). Temperature measurements, for example, reinforce the good practices of an unbroken cold chain and will lead to better quality goods, reduced claims and longer shelf life.

Use Case	Additional sensors: Fixed or ad-hoc
Sender	Smart Container Solution Provider
Receivers	Carriers including Rail Operator and Shipping line, Fleet Manager, Beneficial Cargo Owner, Consignee, Consignor, Insurance and Bank institutions.
Trigger	Detection by additional sensors measuring unexpected values with to regards to the predefined values.
Preconditions	Trip plan and defined values are communicated, and pairing process is done correctly
Data Transmitted	- The container ID, the additional sensors IDs and positions, the actual measurements (e.g., temperature, shock magnitude, etc.) current GPS position, current and next Zone Of Interest (ZOI) if any (e.g., port terminal, rail terminal, inland waterway terminal, shunting yard) - Timestamp

Figure 27: Additional Sensors: Fixed or Ad-hoc

6. Business Process Diagrams

Methodology to explain **what, where, when and why**

The diagrams below are intended to provide the flow of information and relative timing of data transmission that is required to enable the various Use Cases above to be realized. More than one of the Use Cases may be achieved through the same basic information flow.

Installing an IoT device on a container is a prerequisite for any of the use cases detailed above.

The installation of the device requires an installer/ who will physically attach the device to the container. Tests will be performed to make sure that the device is working correctly (e.g., GPS measurements, Door opening Detection, Connectivity, etc.)

A message will be sent to communicate the following data elements: the IoTDevice ID, the Container ID, the who/installer ID, where/Location, when/Timestamp. These data elements are needed to verify whether the pairing process was successful and to check whether the installer has followed the installation process, as per the manual provided by the IoT solution provider.

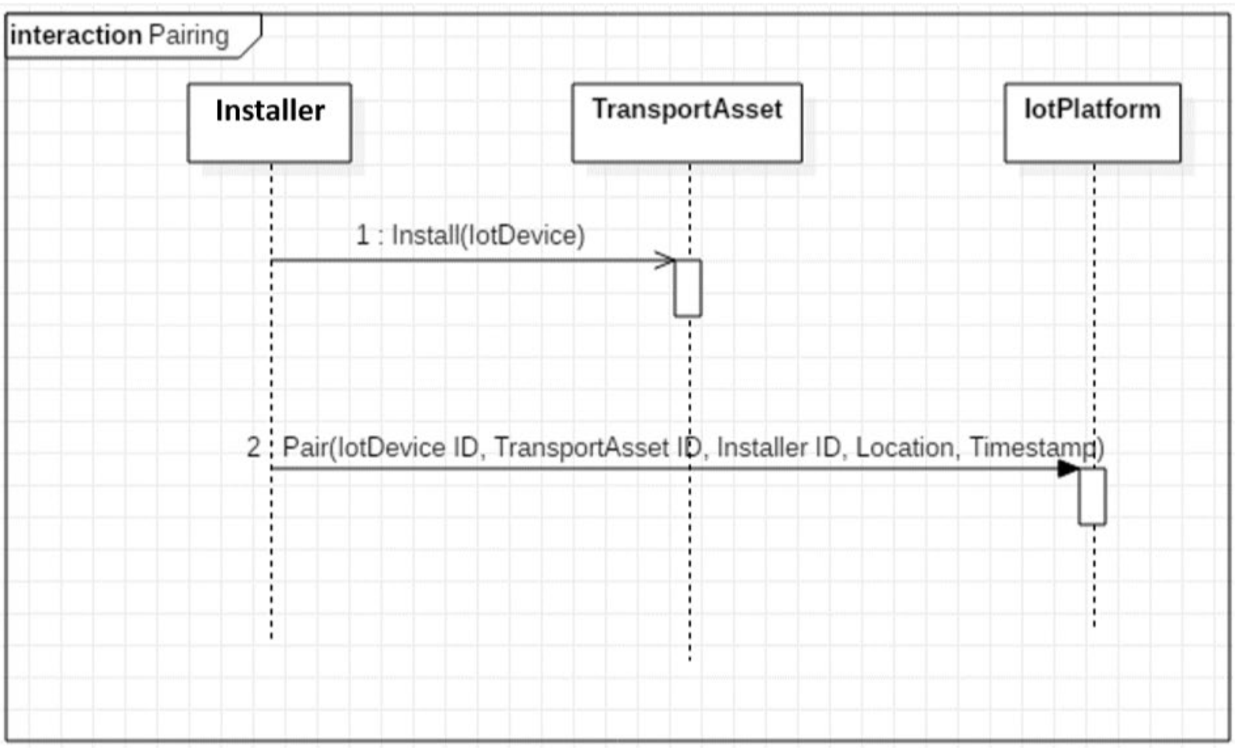


Figure 28: Pairing Process

The basic Smart Container Solution will periodically provide physical measurements on the conditions of the physical transport execution. If the BCO provides information about the planned trip (e.g., via the booking reference), a Smart Container Solution can be configured to provide smart contextualized information.

One should keep in mind that the configuration of a Smart Container Solution is variable and can be accomplished by pairing a booking with a given Transport Asset.

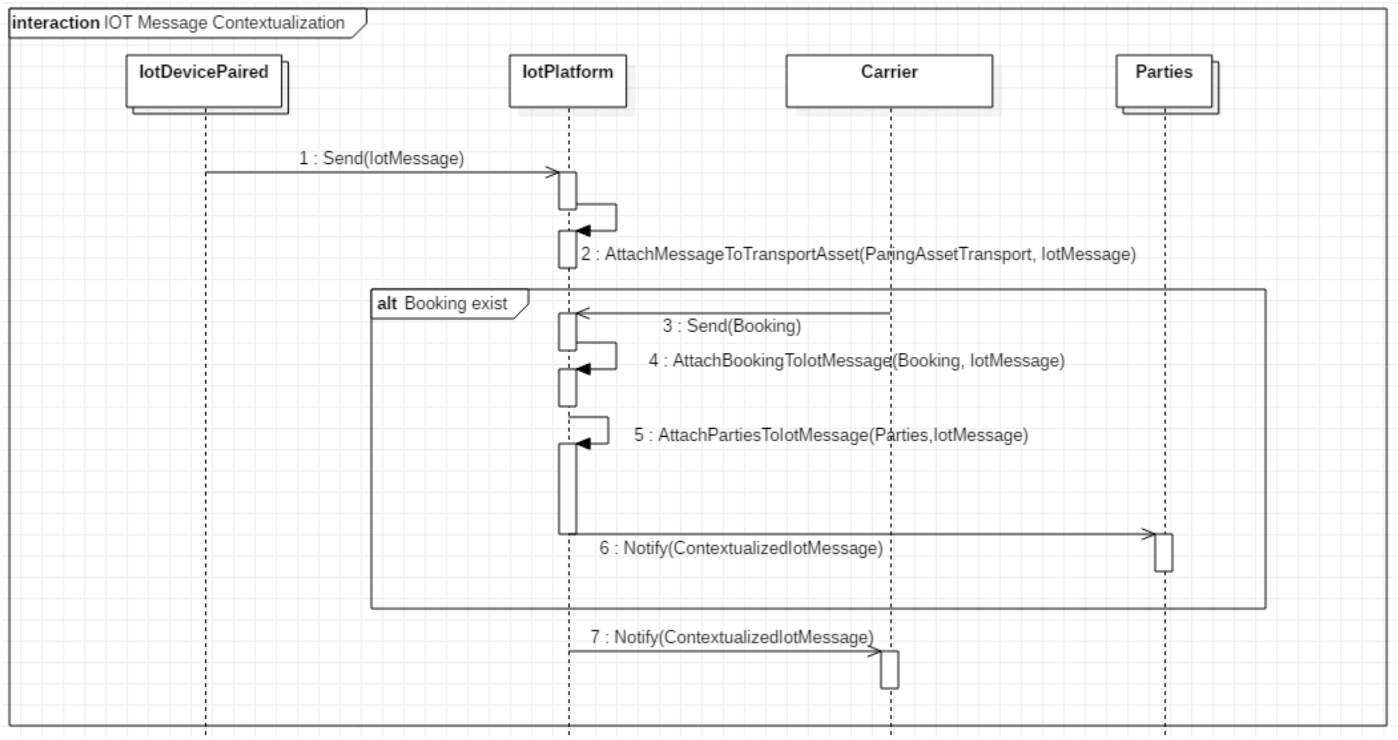


Figure 29: Message Notification Diagram

Figure 29 should be read in conjunction with Figure 30 <Transport Asset Physical Measurement> below. Ultimately, the objective is to ensure that the various Actors receive the measurement information they need as and when they need it. Although beyond the scope of the current BRS, stakeholders should have access *only* to the data that they are entitled to access. IoT smart container service providers would need to implement mechanisms to ensure proper access control.

To achieve that objective and to understand how we may do that, it is necessary to run through the above sequence diagram in some detail.
The first step is to “pair” a container (be it an intermodal container, an Air Cargo container/ULD or any other container) with an IoT device that will perform the measuring tasks on this container and for the specific contents of the container. An IoT device may be paired with a container for extended periods across many different journeys or it may be attached for a single journey of the container.
The process IotDevicePaired takes care of linking the IoT device Identification and the Container Identification. That link is then also stored within the IoT platform.

The next step (Step 1 in Figure 29) is that the IoT device starts sharing data/messages with the IoT platform. The IoT Message in figure 29 will include the Identification for the IoT device.

Based on the prior pairing of IoT device ID and Container Identification, the IoT platform can link the IoT message to a specific Container (Transport Asset). (Step 2)

The IoT messages may be sent for Container(s) that are currently being managed under an active Transport Booking or they may be managed independently from such a Transport Booking (e.g. empty containers may sit around on yards awaiting assignment to a new Transport Booking).

In case there is no active Transport Booking (in Figure 29 we jump from step 2 to Step 7) the IoT platform will inform the owner/manager of the Container (Transport Asset) status/location, which in this diagram is the Carrier.

Let us assume that there is an active Transport Booking. In that case (Step 3 in Figure 29), one actor (in this figure, a carrier) will provide (or has already provided) details regarding the Transport Booking to the IoT platform Solution Provider. At the very least, the IoT platform provider must receive information linking the Transport Booking Identifier (usually a Consignment Note, Waybill, Bill of Lading or similar) to all containers grouped together under the Transport Booking Identifier. For instance, a single Ocean Bill of Lading may cover multiple, sometimes many dozens of containers (one-to-many association between Transport Booking ID and Container Identifiers). Some of those containers may be paired with their own IoT device (one-to-one link between container and IoT device) and under the same Transport Booking; other containers may not be paired with an IoT device.

Based on this Transport Booking information the IoT platform can link the IoT message (which it linked to a Container ID in the previous step) with the appropriate Transport Booking. (Step 4)

The Transport Booking information should also identify parties involved in the Transport Booking including any Parties (stakeholders) who should be notified regarding IoT messages sent from the IoT device (Step 5). The IoT platform must also know the criteria that decide which Party receives Notifications, based on the IoT message content.

Alternatively, the IoT platform may only send the info to the Transport Booking owner (in this figure, the Carrier) and that owner should then determine the parties to be notified.
Both are likely to be common models in the industry.

Assuming the IoT platform does know the Notify Parties on the Transport Booking (as well as the appropriate criteria to send them messages), the IoT Platform will be able to transmit to those Notify Parties the appropriate Contextualized IoT messages. Again, bear in mind that those Parties may be interested only in specific exceptions or deviations from normal. The rules as identified in the Transport Booking for sending information to Notify Parties may become quite complex. (Step 6.)

Figure 29 depicts the most common scenarios (in today's practices).

More and more, however, Shippers are taking control over their end-to-end Logistics in detail. These Shippers may become the direct Customers of the IoT platforms, meaning that the Shipper may generate and share the Transport Booking and may use the primary Identifiers for that booking that are different from those that the Carrier would use. For example, the Shipper may use a Shipment/Sales Order number related to a set of linked consignments booked with a set of multiple different carriers. A single Shipment number could conceivably cover a pre-carriage segment (via Road), the main carriage segment (via ocean) and finally the post-carriage segment (via rail). Each of the segments booked with the individual carriers would be handled under separate transport contracts with each of these carriers (Road > CMR; Ocean > BoL; Rail >Rail-BoL).

It may be necessary to also share details regarding those individual Transport Bookings with the IoT Platform in case the IoT platform would be responsible to send messages to the involved parties on those separate individual Transport Bookings.

Even in those more complex scenarios the IoT platform still would follow the three basic steps of:

1. Linking the IoT message to the Container;
2. Linking the IoT message to the applicable Transport Booking(s);
3. Sending the appropriate information, to the appropriate Notify Parties in the appropriate formats.

The sea/intermodal Container IDs are the same over the lifetime of the physical container. Under a particular Transport Booking they carry specific contents. In ISO terms, the combination of the container and its contents is called a Transport Unit (ISO 15459-1).

This ISO standard for Transport Unit Identification Number (also known as the ISO License Plate Number <LPN>) covers two different implementation approaches: GS1 Serial Shipping Container Code and ASC (American Standards Commission) MH10. DHL Express uses the ASC MH10 LPN as default identifier for parcels.

GS1 Serial Shipping Container Code (SSCC) is widely used by stakeholders in dozens of industry sectors to identify Transport Units. Several global Logistic Service Providers (LSP) use the GS1 SSCC as their default Identification Number for Transport Units in some of their business units.

The owners of Transport Bookings (especially BCO) may well start to use these ISO 15459-1 compliant Transport Unit IDs to be able to easily track the combination of Cargo Content and physical Container ***by a single unambiguous Tracking Number*** across all modes of transport and all logistic service providers.

Note. Some industries like the air cargo industry have their own standards for this identification. For example, IATA has defined the ULD identification and use of an Air Waybill number (AWB#) as the primary key for identification of a consignment that may be containerized in a ULD.

Bear in mind that the BCO may be interested in particular in Goods Items that they know they packed into a specific Container for this Transport Booking.

The only *Unique and Unambiguous* Identification that remains unchanged along the logistic network is the Transport Unit ID. The Container ID remains constant but it must be used in combination with the Transport Booking to find the right Event records (and the Transport Booking ID changes/may change when the container is handed over to another service provider). Clearly, this Tracking Number would/may NOT be visible on the physical container (but rather embedded in a technical device available on or in the container). The Transport Booking Owner (and/or other involved parties) may well want to indicate their preferences, regarding the information they want the IoT platform to provide to them, based on those ISO 15459-1 compliant Transport Unit IDs.

The 22 Use Cases listed above have each been identified as a ‘Type’ of Use Case, based on the input of the BCO with respect to the planned trip plan and the new services that the smart container solution will be in position to offer. More than one Use Case may be identified for a specific Type, (e.g. Operational).

Use cases: Daily operations based on the BCO (Booking owner) input to parametrize the Smart Container Solution

1- **Basic Regular Measurements:** see Figure 30 below
IoT device performs physical measurements (e.g., temperature, humidity, shock) and shares information via messages/APIs (periodically, based on SLA). Information may be shared at a regular interval (e.g. a Container Daily Status Message) or to ensure the consumer/customer a certain level of quality by sharing an Identification of the consignment (a label as proof that the cargo was shipped in smart container).

2- **Physical Measurements Alerts versus Events:** see Figure 31 below
If the Smart Container Services Client provides the *Expected Physical Measurements Value(s)* or accepts the default values in the system, if any, the Smart Container will generate an alert whenever a measurement is out of range. In this case, the IoT device may be capable of adapting its behavior to become context-aware since it has increasingly more information about the expected behavior for that particular trip/booking.

Note. The shock’s magnitude in particular should be specified based on tests/pilots performed by the tracking service providers and the stakeholders[1] .

[1] Beneficial Cargo Owners (BCO) Smart Container Services Clients and Smart Container Service Providers may enter into a joint program to gather initial measurements, then eventually determine the limits/thresholds that will trigger alerts.

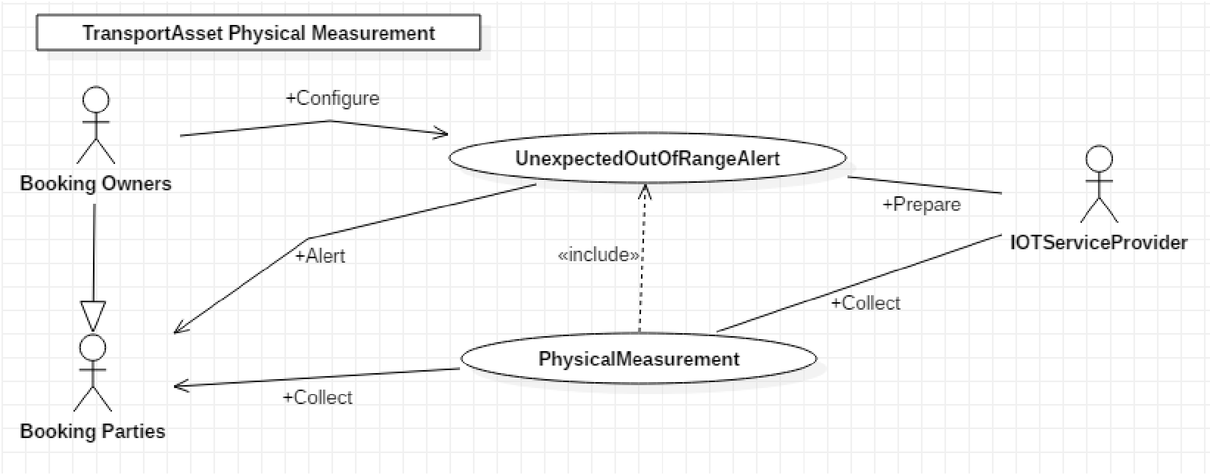


Figure 30: Expected Values to differentiate Events versus Alerts

Figure 30 covers many use cases (those that measure temperature, humidity, GPS/geofencing, shock, light, etc.) and then share that information as well as use cases that trigger exception alerts.

Different parties could be interested in "Periodic update", otherwise could be interested in alerts only. Some parties are able to change the setting via the Booking References; others are able only to see the measurements/alerts. Push or/and pull mechanisms could be covered by this figure.

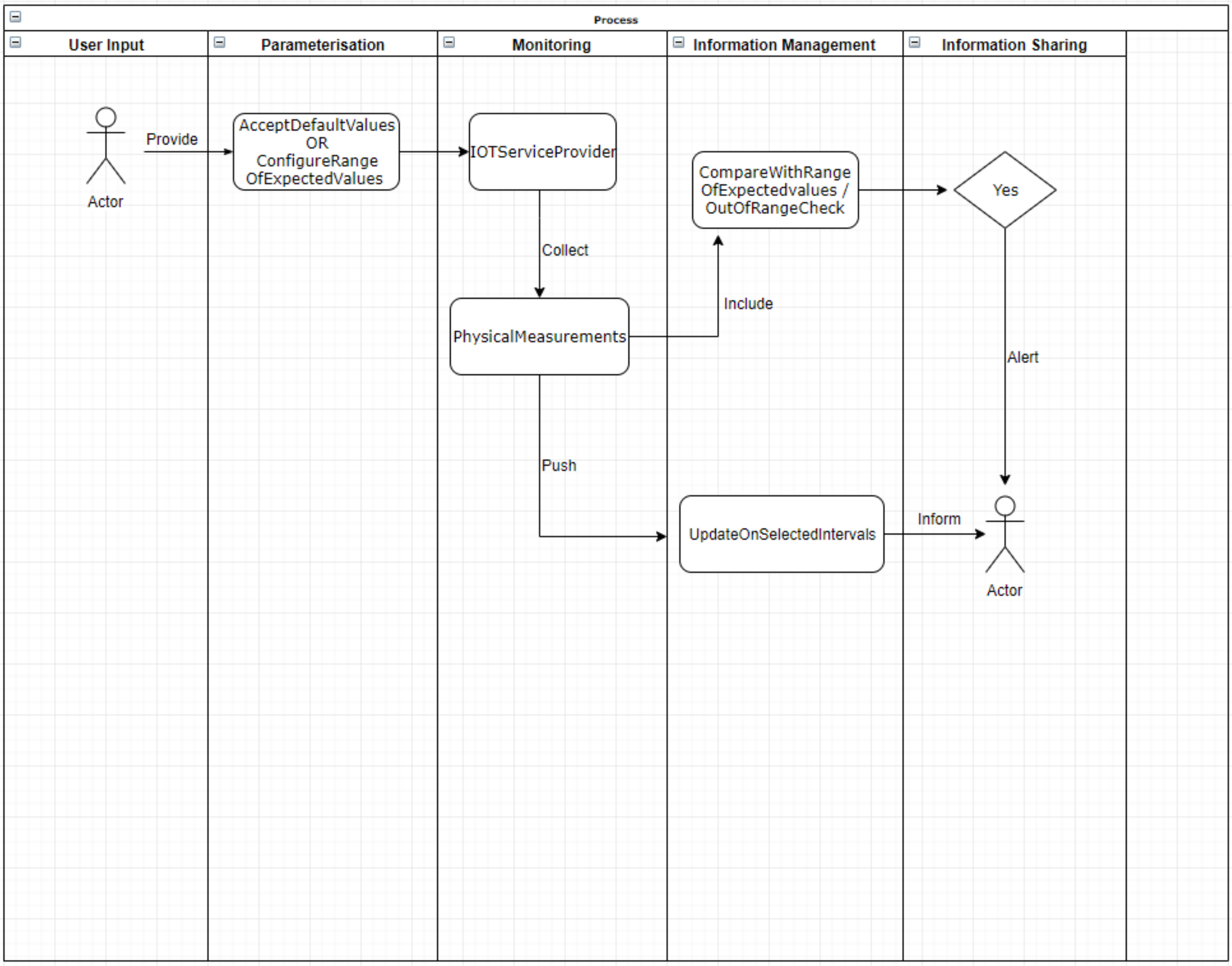


Figure 31: Detailed flow for the Events versus Alerts differentiation

3- **Trip Plan and Spatiotemporal data:** see Figure 32 below
If *the trip plan* is communicated (location where the container should be along with the time dimension), the smart container solution may generate alerts related to geospatial information. These communications may be used in the Use Cases Schedule or Routing deviation alert, the Overlanded container, Contract Compliance for container routing, Actual Executed Transit Time, Empty gate-in at depot and Depot reconciliation. The smart container service provider could provide predictive services such ETA calculation based on these alerts.

4- **ZOI attributes and policies:** see Figure 32 below
If information linking the ZOI/geofenced area (ZOI) and the qualifier (Private depot, final place of Delivery, etc.) is provided, then the smart container solution will be able to differentiate the allowed/disallowed events based on the reported geoposition and will generate alerts. Communications regarding those events may be used in the Use Cases unexpected door opening detection, trip tracking for inland haulage, shielding of the door opening at the borders per the fast lane use case (all data governance aspects).

5- **Means of Transportation:** see Figure 32 below
If the *means of transportation* are communicated for each segment, (or there is a

gateway, or the IoT Device is capable to analyze the signature movement / accelerometer), the smart container will be in position to inform about any Missing Container onboard of vessel and any Short shipped container.

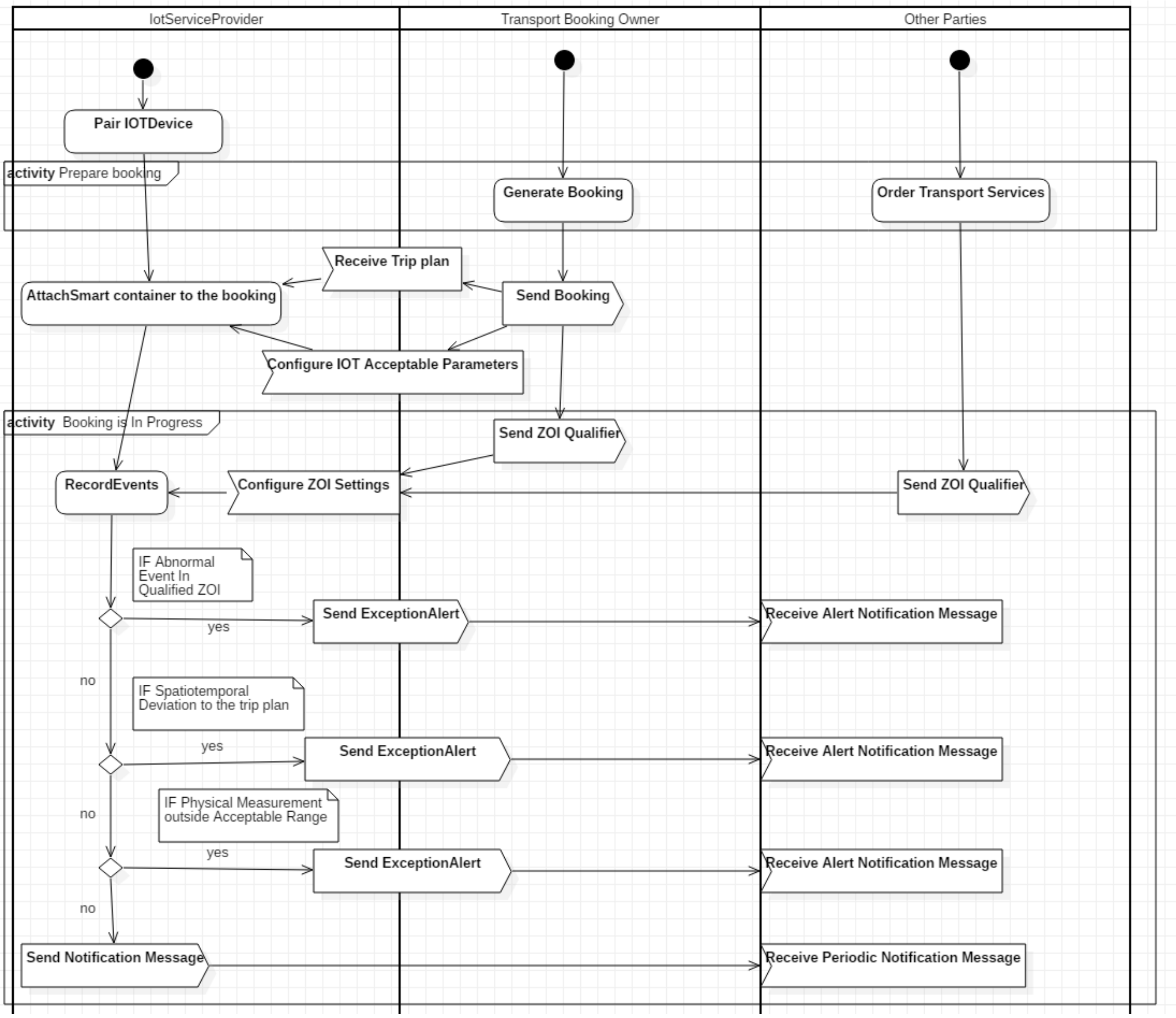


Figure 32: Summary Process Diagram enabling spatial temporal value-added services

Note. The activity Booking in progress means that the physical transportation is in progress (Transport in progress)

Figure 32 above combines the above Figures (28, 29 and 31) and adds the concept of Zones of Interest (ZOI)) enabling the IoT Solution provider to offer value-added services as indicated above in bullet 3 “Trip Plan and Spatiotemporal data”, and in bullet 4 “ZOI attributes and policies” related use cases.

The pairing process (first step in Figure 32) has been described in more detail in Figure 28.

Figure 29 “Message Notification diagram” and associated text describes the general concepts for capturing data through the IoT device and then sharing that data to involved parties.
The structure of Figure 29 served as the basis for Figure 32. In Figure 32, however, we add more

elements to the criteria/parameters that may trigger the sharing of data collected in the IoT Solution. More specifically, Figure 29 illustrates how spatial temporal data (provided by the Transport Booking Owner, as well as other parties) may be used to enable even more targeted management of transportation of smart containers and their content throughout logistic networks.

The Transport Booking Owner provides both the 'basic' transport contract information (e.g. ship-from, ship-to, Bill of Lading, Handling Units such as containers) as well as much more detailed planning information regarding the trip including all the waypoints and timings for each waypoint along the planned trajectory of the trip.

The Transport Booking Owner also provides the parameters (e.g. trigger thresholds on specific types of sensors) to the IoTServiceProvider. This has been described in Figure 31 (process parameterization).

Ideally, all the above steps would be completed before the smart container starts to move under the Transport Booking involved.

Both the Transport Booking Owner and other Parties may wish to further fine tune (beyond the basics described in Figure 31) what information they would like to receive from the IoT Solution, so they can make better use of the information they will receive. In Figure 32, the parameters enabling this further fine tuning are called "Send ZOI qualifiers".

Each party may decide independently which and when to send these ZOI qualifiers. In other words, some of the ZOI qualifiers may be sent to the IoTServiceProvider before the smart container starts moving or when the execution of the transport booking has already started.

Each party involved in a movement of a smart container may have different views on what events are of interest. The carrier may be interested each time the container passes one of several waypoints along the trajectory of the movement. Hence, the carrier would configure a ZOI for each of those waypoints. The Consignee may be interested only when the container is nearing the port of discharge, so the consignee would configure a ZOI only for that port. It is conceivable that, even when both the Carrier and the Consignee are interested in Events for that port, they may have a different view on the geographical dimensions for their individual ZOI. However, we consider this complexity out of the scope of this BRS.

We need to highlight that the most relevant data elements for the Cargo being transported may vary between the Transport Booking Owner (middle swim lane) and other parties (right swim lane). For example, a Carrier acting as the Transport Booking Owner in association with the IoTServiceProvider may focus on Handling Units (like Containers) and Consignment (Bill of Lading) and may not be interested in knowing detail regarding the cargo inside the Handling Units. The Seller and the Buyer may be interested primarily in the Cargo/Goods, Tracking Numbers for their Goods and Commercial Transaction between Buyer and Seller. As a result, the IoTServiceProvider may receive different References from the various parties when configuring their ZOI.

In all of the *above* use cases, there is interaction among multiple stakeholders. Therefore, we included process diagrams (figures above) to illustrate those interactions.

In the *below* use cases, each Party receiving its own information from the IoT Solution may process that information independently from any other Party. In effect, it is not necessary to interact with other parties to implement the below Use Cases and reap the benefits of them.

Based on the flows already explained in previous figures, the following Use Cases could be easily implemented by information owners, who would be willing to dive deeper and utilize modern analytics, data science concepts and technology advancements.

Use cases: Going beyond a given IoT Device/trip

6- **Analytics going beyond a particular trip:**
If we follow a smart container during its lifespan, we could schedule all the necessary IoT device maintenance based on its past performance having undergone shocks, extreme heat/cold, etc. based on the health check parameters as defined by the BCO. This enables more targeted Reefer Pre-Trip Inspection (PTI) instead of requiring it systematically before each trip.
Note. The service provider will monitor the lifespan of its IoT device; but also, could monitor and keep the history of its smart container measurements. In fact, the smart container may have been paired with more than a single IoT device (from even different smart container service providers) during its life time.

Use cases: Data Science going beyond a particular IoT Device

7- **Anonymized data, once collected and aggregated from multiple smart containers** across many trips/routes (independent from individual trips or a particular BCO), could be analyzed to get a better understanding of the transportation landscape. Some possibilities include analyzing the lead time between two ports, identifying the bottlenecks for given routes, port infrastructure usage monitoring by port Authority KPIs, or calculating average duration of stationary period of containers in a specific ZOI (e.g., specific terminal)). This could be valuable information to be shared with the various smart container solution stakeholders to give them insights on how to improve their processes and operations.

Use case: Specific IoT related information

8- **IoT devices information:** The smart container service provider has to provide all relevant information about the IoT device and Platform. For the IoT device this includes the hardware version, the firmware version, the remaining battery level, the communication capabilities (2G, 3G, 4G, 5G, Satellite, Mesh technology etc.), all the available functionalities, and any available version of the firmware update, etc.

7. Inputs for Smart Container Data Modeling

This Chapter provides a brief overview of the contents of Annex 2, which provides a starting point for the detailed Data Modeling that will be based on the content of this BRS document. It identifies a series of primary categories of data considered necessary for communications related to smart container data reporting. Identification of the underlying data components under these categories provides the data elements to be included in future messaging.

Below we will merely indicate a number of main entities and standards that are already used to some extent to cover elements of the overall business requirements for smart containers.

This chapter provides this overview only as a way of summarizing concepts and entities identified above and therefore, to be included in the Data Modeling exercise. The Data Modeling must also take into account how the necessary logical "links" indicated in this BRS may be implemented technically.

Assets:

- (Smart) Transport Equipment (e.g. intermodal Containers)
- IoT devices
- Sensors
- Vessels
- Transport Means
- Others

IoT devices may be paired with Transport Equipment (turning the equipment into smart equipment). The IoT device (and the equipment) may also exist stand-alone.
Within the context of this BRS, the data modeling will need to include different attributes for each of the above assets.

Involved Parties:

- Smart Container Services Provider
- Smart Container Services Clients
  Such as Carriers, Beneficial Cargo Owners, Freight Forwarders
- Asset owner
- Asset operator
- Border Agencies (e.g. Customs)
- Port Authorities
- Carriers (e.g. Shipping Lines, inland waterways, short-sea shipping, rail, road)
- Insurance companies
- Banks
- Agents
- Others

Locations:

- Ports
- Terminals e.g. in ports, inland waterways, rail airports

- Berths, Quay
- Gates
- Yard locations, Parking positions
- Port Traffic area
- Pilot boarding area
- Zones of Interest
- Asset / Container Depots
- Warehouse
- Manufacturing site
- Others

Each location may be identified using a different global Identification standard (e.g. UN/LOCODE or GS1 GLN = Global Location Number). Locations may be indicated with a single geo position (longitude & latitude) or with a polygon (a sequence of corner points connected by straight lines).

Determination of geo-position may occur in different ways; it may be necessary to include information regarding the determination of the geo-position alongside the geo-position itself. Various, differing attributes may be applicable for different kinds of locations. Since Zones of Interest play a special role in the context of smart containers, the data modeling will have to pay extra attention to correctly modeling ZOI.

Many of the locations above may play a different role depending on the Transport and/or Trade context; e.g., a port may be place of un/loading, a manufacturing site may be a point of pick-up or a warehouse may be a point of discharge.

Transport & Trade references:

- Transport Booking
  such as Bill of Lading, Air Waybill, Rail-Bill of Lading, Consignment Note
- Trip Plan
- Bay Plan
- Trade Transactions
  such as Sales Order, Shipment
- Transport Units (e.g. boxes, pallets, crates) with Product/Cargo inside.
- Product related references
  such as Product code (e.g. GTIN = Global Trade Item Number), Customs references (e.g. HS-code), Cargo Type (e.g. Hazardous, Chilled/Frozen/Ambient)

Events and Alerts:

- What – Identification of object that the event/alert relates to e.g. Vessel, Container
- Where – Location identification
- When – Timestamp (ISO 8601 compliant)
- Why – business context
  (e.g. UN/CEFACT code lists and EPCIS Core Business Vocabulary)
  and/or Event type (e.g. measure, alert)
- Event/Alert ID

- Others

Since smart container services rely highly on the use of sensors, it is necessary to describe the concept of the sensor in more detail in the Data Modeling. As indicated in the chapters above, it will be particularly important to model the below sensor concepts:

Characteristics Range of Values [X, Y]

Expected Values Setting Configuration range [A, B]

Note: The "Expected Values Setting Configuration range [A, B]" will be communicated by the buyer of the IoT service (e.g., carrier including shipping line, rail operators, etc.) as part of the booking information, which will include the detailed trip plan.

8. Door-to-door Common Reference

Before going into the details of how to achieve true door-to-door visibility to all stakeholders for a specific smart container, it is important that we bear in mind the contents of Chapter 6 and more specifically the figures 29 and 32.

The IoT device attached (paired) to the smart container will generally capture information related to the entire container only. In that case, the IoT device can only transmit container-level information to the IoT platform.

Note: It is conceivable that in future the cargo/transport units held within the container may communicate with the IoT device on the container. The current scope of this document however, will not include this scenario.

Figure 29 in Chapter 6 explains that within the IoT platform much more information may be linked to the smart container such as information provided in the Transport Booking and authorized Parties / Stakeholders to the smart container. This already provides various powerful ways to exchange information regarding the progress and condition of the smart containers on their Trip from Seller to Buyer.

Figure 32 takes this a step further by adding geospatial information (zones of interest) to enable even more sophisticated options for providing all stakeholders with the information that is relevant to them at the time that it is most needed.

The challenge in supporting these sophisticated, powerful tools is that the various stakeholder almost invariably will use a wide range of different reference numbers related to the cargo transported in the smart container. These different references need to be "linked" somehow in order for the IoT Solution to be able to send the right Event Information at the right time to the relevant parties.

Also consider that often the journey from Seller to Buyer will be made up of multiple segments (e.g. road pre-carriage, main carriage, post-carriage) each of which may use a different transport mode by a different logistic service provider. There will be a separate Transport Booking Reference for each of these legs. The Buyer may not know the Transport Booking References for all of the segments.

Without common references end-to-end, it would be difficult (perhaps not feasible) to link the requirements from the various involved parties together in the IoT Solution.

The challenge becomes especially acute in LCL (Less than Container Load) scenarios.
These scenarios are often also described as "consolidation and break-bulk". The following is a common example:

Consider a freight forwarder who receives transport units (e.g. pallets) from three different Shippers (Sellers). Each of these transport units may be identified uniquely by an ISO-15459-1 compliant ID. The Buyer and the Seller may have exchanged information regarding the commercial/trade transaction reference (e.g. Purchase/Sales order).

The freight forwarder will stuff these pallets into a number of smart containers. Ideally, he records exactly which pallets he stuffed into which smart container.

Now, also assume that the Shipper has left the entire management (decisions on routing, carriers etc.) to the freight forwarder (the most common scenario in LCL). That means that the freight forwarder will issue the Transport Bookings to the various carriers he selects for each segment in the end-to-end Trip. In general, the freight forwarder will not communicate the individual transport booking references to the Shipper (and definitely not to the Buyer/Receiver).

Also assume that the freight forwarder is the Client for the IoT Service Provider. The freight forwarder would provide the IoT Service Provider with all the detail captured above: involved parties, Trip Plan, Segments, Container ID, contained transport unit IDs, etc.

In figure 32, we clearly indicate that parties other than the freight forwarder need to be able to independently communicate with the IoT Service Provider e.g. to configure the ZOI Settings for them. That would include the Buyer/Receiver of the cargo. It is also clear from the description above that most likely the Buyer/Receiver will not have the Transport Booking References for each segment in the Trip. They would most likely however, have the transport unit IDs issued by the Seller/Shipper. Assuming the freight forwarder has shared these Shipper-assigned transport unit IDs with the IoT Service Provider, the IoT Service Provider can link the communications from the Buyer (requesting progress and condition information) to the original information provided by the freight forwarder. It would also allow the IoT Service Provider to validate that any requestor of information is actually authorized to receive the requested information.

Another trend in Logistics that we need to be aware of is the concept of Piece Level Tracking.

Note. We should stress that in Air Cargo (like in maritime) there is a lot of consolidation and break-bulk traffic. In those scenarios the approach in Air Cargo would be pretty much the same as in the maritime scenario described above using Unit IDs, except that each of the individual transport units created and uniquely identified by the Shipper would have its own UPID (Unique Piece ID), versus a UPID assigned to a container. The individual transport units from different Shippers may be consolidated into a smart ULD (Unit Load Device). Air Cargo can manage transportation at the ULD (consolidated) level, but reporting to Customs, however, is by number of pieces of specific commodity type at the house bill level. (In future, Shipper-assigned UPIDs may be reported, but they are not presently required.)

IATA released a Recommended Practice (RP 1689) for Piece Level Tracking (approved at CSC/40 in March 2018). The principle is summarized by IATA as:
"*The piece level tracking capability is the process that enables the end-to-end tracking and monitoring of cargo* ***shipments*** *(time and location) at* ***piece*** *level.*"

There is a clear distinction here between the **Piece** (any type of transport unit) and the **Shipment** (a grouping of one or multiple transport units). RP 1689 further clearly states that the Unique Piece ID (UPID) should be assigned as early as possible in the life of the piece and shall be ISO 15459-1 compliant (preferably by the shipper/seller). It goes on to say that the UPID should be used by all parties handling the Piece for tracking & tracing purposes. The IATA Recommended Practice also applies when the Shipper has stuffed the smart container/s himself. In that scenario the Seller/Shipper can assign a container ID tracking number to each smart container.

If all the pieces in the shipment are of a single commodity for one receiver, this could be a UPID number. This UPID can be assigned to the shipment at source – the Seller can then also link the trade transaction information related to the Goods inside the container (e.g. Product Numbers, Quantities, Values, HS-code) to that UPID. The Seller may share the UPID with any involved party (e.g. the Buyer). That UPID could then be used to enable tracking the smart container end-to-end (through all legs of the journey towards the Buyer). It would then also be a good candidate to enable all parties involved in the movement of the smart container to send their ZOI qualifiers to the IoT Service Provider linked to this common reference.

Clearly this Piece Level Tracking process would add a level of granularity to the currently most common practice of tracking and tracing at the level of the Shipment. We clearly need to consider piece level tracking for future shipping operations involving smart containers.
In fact Piece Level Tracking has been practiced by Postal and Parcel Carriers already for several decades. They assign a unique piece ID to their transport units (they call them parcels or postal items) and track and manage those pieces using the UPID assigned to the transport unit.

Some operators using Air and Maritime modes of transport have also adopted Piece Level Tracking approaches in parts of their logistic networks. Those operators would benefit from support for piece level ID numbers in the IOT Solutions already today.

We should keep in mind that smart containers may come in very different shapes and sizes (even small packages) going forward. Clearly in the current BRS we have focused on larger size containers like the intermodal container and the Air Cargo ULD (Unit Load Devices). The general concepts for smart containers described in this BRS would also apply to the smaller smart containers that may be used in eCommerce environments in both B2B and B2C in future.

9. Conclusion

The basis of this BRS document was initially developed in the UN/CEFACT approved white paper: Smart Containers Real-time Smart Container data for supply chain excellence http://www.unece.org/fileadmin/DAM/cefact/GuidanceMaterials/WhitePaperSmartContainers.pdf. The white paper content has been expanded upon to provide the detail in this Business Requirements Specification Document.

Now that we have shared a common understanding of the Smart container solution potential, detailed many use cases and derived smart container data elements to be transmitted for each use case, the next steps will be to fully identify and update existing data elements, introduce new data elements into the UN/CEFACT Core Component Library (CCL), in particular the Multi-Modal Transport (MMT) subset, a.k.a. the MMT Reference Data Model. and to implement the message(s) notification structures.

The ultimate goal is to define the structure of the APIs to facilitate the integration of the smart container data in the different platforms and systems of the stakeholders.

Annex 1 – Standards relevant to Smart Containers

Intermodal containers (including those equipped with IoT devices, which are the focus of this Business Requirements Specification) are transported on many different modes and locations of many kinds all over the world. There are many standards already in use in these different modes and on these locations for a very wide range of purposes. Some of those purposes overlap with the areas that we describe in this BRS document.

In this Annex we provide an overview of standards that may be relevant to the next step of Data Modeling based on this BRS. The overview is merely indicative and further analysis of the below standards as well as standards not yet identified here will be required in the next step/s based on this BRS.

ISO Standards relevant to this work:
Mainly codes lists:

- *ISO 6346: Freight containers -*
  Coding, identification and marking, which uniquely identifies a freight container.
- *ISO 9897, Freight Containers* -
  Container Equipment Data Interchange (CEDEX). This standard defines the exact positions of the constituent elements of a freight container. It is also used to identify the location of a damage. For Smart Container Solution, this standard could be used to locate the position of cargo container tracking and monitoring systems and the various additional fixed sensors in the container. This standard covers the dimensions codes, parts (component) of a freight container.

Different standards of data exchange (Container Equipment Data EXchange (CEDEX) - General communication codes) including:

- 18185 part 1 to 5, Freight containers - Electronic seals
- 10368, Freight Thermal Container - Remote condition monitoring
- ISO 10374, Freight containers - Automatic identification

EPCIS (ISO/IEC 19987) combined with the Core Business Vocabulary (ISO/IEC 19988): Provide structure for information exchange of Event Information among business partners that do NOT need to have a prior data sharing agreement in place.

Exchanges typically run via EPCIS repositories where organizations record Event Information in a standardized format (via the so-called capture interface). There may be several (even many) EPCIS repositories that organizations may record their Events in.

Other organizations can find the Event Information that is relevant to them using the Query interface.

The EPCIS environment covers the following four questions in each Event stored within the EPCIS environment: What, Where, When, Why.

- What object does the Event relate to?
- Where did the Event occur?
- When did it occur?

- Why did it occur? Providing the business context of the Event.

More information may be found using the below link.

https://www.gs1.org/standards/epcis

The EPCIS and CBV standards are maintained by GS1. EPCIS may refer to (and thus include Vocabularies that are maintained by non-GS1 standardization bodies).

GS1 is currently in the process of adding support for the exchange of Sensor Data into the EPCIS framework.

The data-elements used in EPCIS to answer the four questions above often rely on other ISO standards for unambiguous interpretation of the use of those data-elements.

Annex 2 – Inputs for Smart Container Data Modeling

This Annex provides a starting point for the detailed Data Modeling that will be based on the content of this BRS document. It elaborates on the contents of Chapter 7 (with the same name).

Annex 2 identifies a series of primary categories of data considered necessary for communications related to smart container data reporting. Identification of the underlying data components under these categories provides the data elements to be included in future messaging.

The tables and text below are in no way intended to be comprehensive. They merely represent initial ideas and concepts that the group working on the BRS developed from a business perspective. Furthermore, the task of the BRS work group is limited to providing a solid description/specification of the business requirements related to smart containers (as provided in the above segments in this document), not to identify all elements required. That will be accomplished through the detailed Data Modeling exercise to follow. Future refinement on the full set of data elements will also be an on-going future endeavor as business models may change.

Below are a number of Data Categories and associated Data elements identified in the initial approach to the data modeling input:

Event
IoT Service Provider ID Event ID Event Code (UN/CEFACT Code List) REC24 ; EPCIS and Core Business Vocabulary (CBV) code lists. Asset ID **TimeStamp** **GPS Position** Location Name (optional) **Location ID** Responsible Container Party ID (optional) Transport Equipment Operator Party ID **Sensor** (optional) **Transport Booking Reference** (optional) Event type {e.g. Alert, Measure} **Smart Transport Equipment ID**
Bold elements described in more detail below.

Timestamp formatting to be compliant with UNECE Recommendation 7 and ISO 8601	**TimeStamp** Universal UTC Date Hour Minutes Seconds

GPS Position
GPS Source Enum: {AIS, From Tracking Device, From mobile Gateway, From Stationary mobile} (optional, by default from the tracking device) GPS Acquisition source Enum{Galileo, GPS, GLONASS, BeiDou} (optional) Acquisition precision GPS (optional) Acquisition satellite number (optional) Actual Latitude

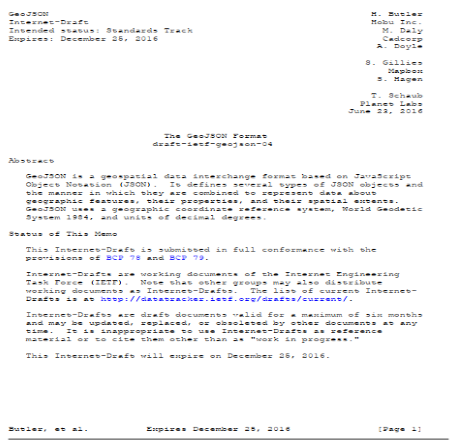
Actual Longitude

Figure 33: Intial approach to the data modeling input

<u>Note</u>: GPS - Format Degree/Decimal. To simplify, the calculation shall be decimal. Anyway, this has to be aligned with the UN/CEFACT core format.

There is a difference between how the information is communicated versus how it is displayed.

Standards for mapping polygons (and exchanging information) around them exist already.
GeoJSON.
See PDF document to the right



GeoJSON
Internet-Draft
Intended status: Standards Track
Expires: December 25, 2016

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June 23, 2016

The GeoJSON Format
draft-ietf-geojson-04

Abstract

GeoJSON is a geospatial data interchange format based on JavaScript Object Notation (JSON). It defines several types of JSON objects and the manner in which they are combined to represent data about geographic features, their properties, and their spatial extents. GeoJSON uses a geographic coordinate reference system, World Geodetic System 1984, and units of decimal degrees.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on December 25, 2016.

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Location ID / Place Code
UN/LOCODE (**Recommendation 16)**
Facility Agency Code (optional)
Code list agencies Enum{SMDG, IMO , BIC, GS1}
Polygon Center GPS coordinates
Place type geometry Enum {Circle, Polygon}
Set of GPS Positions [1..n]

Figure 34: Communicated data versus displayed data

<u>Note</u>. Agency code: Child code (subset of UN/LOCODE) for registered facilities
The SMDG Terminal code list as used in the EDIFACT communications,
The IMO GISIS list used for reporting to authorities including terminal and berths
The BIC global facilities list for inland depots and repair shop
The GS1 global location numbers

<u>Note</u>. Recommendation 16 has to enable the geofencing for the zones that are covered by the UN/LOCODE.

Some locations of interest:

- Depot pick-up and Depot return: Empty container
- Master Contract Consignor Place Of Acceptance (was defined Point Of Origin POO)
- POL: Places Of Loading
- POT: Places of Transshipment
- POD: Places Of Discharge
- FDD: Final Place OF Delivery at ultimate consignee

Locations are closely linked to the concept of Zones of Interest that are a central concept in this smart container BRS.

ZOI (Zone Of Interest are the places in "trip plan" for geofencing/facility)
Place Type Enum {Depot pick-up, Master Contract Consignor Place Of Acceptance, POL, POT, POD, FDD, Depot return} (optional) Indicator Public information OR Private information (optional) Place Code (optional) Place Name (optional)

Figure 35: Locations and Zones of Interest

Note. A location may take on a specific role for a specific consignment being handled at a specific time.

Sensor
Sensor ID Sensor Owner ID (optional) Sensor Manufacturer ID (optional) Sensor Position (optional) Sensor type Enum {} Sensor Unit Enum Characteristics Range of Values [X, Y] Expected Values Setting Configuration range [A, B] (optional) **Note**: The "Expected Values Setting Configuration range [A, B]" will be communicated by the buyer of the IoT service (e.g., carrier including shipping line, rail operators etc.) as part of the booking information which will include the detailed Trip Plan.

Figure 36: Sensor information

Note. to be checked whether there is an ISO code list for sensor types and for values

As part of the development for EPCIS 2.0, GS1 have published the below on GITHUB regarding Units of Measure.

- **Units of measure** for sensor observations (published GitHub)
- List: https://github.com/mgh128/UnitConverterUNECERec20/blob/master/js/UnitConverterUNECERec20.js
- Demo tool: https://mgh128.github.io/UnitConverterUNECERec20/

Below is an example of what that looks like in EPCIS data-elements.

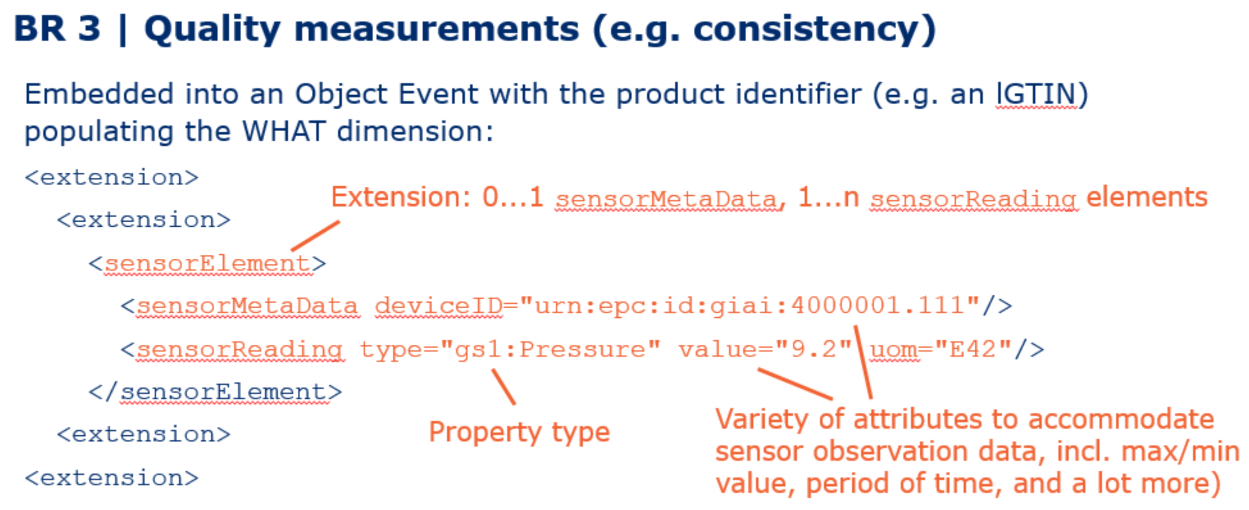

Figure 37: EPCIS Data element example

<u>**Note**</u>: here, consistency is measured in ‘E42’ (kilogram-force per square centimeter)

From the figure above it may not be necessary to identify the sensor-type because the sensor Reading identifies exactly what has been measured.
This makes sense because the IoT device (be it fixed to the container or placed inside) may be able to make many different kinds of readings.
In any case alignment with this EPCIS update will likely prove beneficial for both the Smart Container developments and the further development of EPCIS.

Regarding Sensor ID (deviceID in figure above) it may be relevant that in the Rail Industry there is the ERTMS (European Rail Traffic Management System). One of its main components is ETCS (see Glossary).

Together with the Rail Industry, GS1 have over the past few years developed several standards (see also https://www.gs1.org/industries/technical-industries/rail/rail-standards)
One of those standards is the “Application Standard: Identification of components and parts in the rail industry”. That standard also covers the globally unambiguous identification of the Euro-balise in a way that is manufacturer and rail operator / infrastructure manager independent.
We may adopt the same approach outlined in this application standard also for the IoT devices affixed to the smart containers.

Examples of events:

- Tracking Device Status: Device paired, Device unpaired, Device tearing, Device tampering
- New sensor paired, sensor unpaired, sensor undetected, sensor configured, bad sensor
- Device Life time Indicator
- Door Opening,
- Roof Opening,
- Hatch Opening
- “Physical parameter measurement” ex: temperature, humidity, gas (CO_2, O_2), pressure, shock, smoke, etc.
- Alert out of range Physical parameters measurement,
- Reefer Only: Reefer unplugged Alert, Loss of Interface, Reefer ON, Reefer OFF, Reefer Powered, Reefer Unpowered

- Container overlanded, deviation alert, compliance alert,
- On time, in advance, Late,
- Manutention signature {Loaded, unloaded, trans-boarded}
- Long-lasting Idle Time, Long-lasting Idle movement,
- Geo-fencing: entering the ZOI, Leaving the ZOI,
- Full, Empty, Overloaded,
- Smart asset proximity detection

Transport Booking Reference
Transport Booking Reference ID (optional, example empty container) Transport Equipment Operator (optional)
Smart Transport Equipment ID
Trip plan {ordered set of segments (start ZOI + end ZOI) + mode of transport + Party+ ETD/ETA}
Consignment Information (e.g. House Transport Contract Reference(s))
Indicator Smart Booking Requested/Expected measurements for the different sensors (e.g., humidity, temperature settings)
Stakeholders / Involved Parties

Figure 38: Transport Booking Reference Data

Note. The Transport Booking Reference represents an order booking for a smart container service.

Note. "The Master consignment shipping instructions" (a.k.a. Transport Booking) should be reviewed to ensure that they may provide the IoT device settings, which need monitoring! Such as controlled atmosphere containers

Note. This list of Trip Plan to be reviewed /completed. Waypoints of data-pipeline project defines already this list.

Consignment information - See Chapter #3 for Business Context
Master Contract (MUCR - information shared with the carriers – less information) optional House Contract (HUCR - information shared with the forwarder – a bit more) optional Trade Related Contract (TUCR - between buyer and seller most information) optional

Figure 39: Consignment information

Container ID + 3 IDs (trade transaction ID, house consignment ID, master level – bill number)

Smart Transport Equipment ID
Transport Equipment standard ID (e.g Container number: Ex: 4 letters + 7 digits written on the container- defined by BIC) Transport Equipment Owner ID (Optional – 3 letters code defined by SMDG) Manufacturer (Optional) **Pairing Information** Electronic Device ID Manufacturer Electronic Device ID (Optional) Transport Equipment **Type** {DRY, REEFER, GENSET, Chassis, Wagon, Pallet…} Transport Equipment **Size** (Optional) Transport Equipment tare weight (Optional)

Figure 40: Smart Transport Equipment ID

Note. The BIC manages the global database for container Owner Code (part of the container ID). There might be similar reference databases for other assets (e.g. ULD) available.
We need to agree on the electronic asset ID because the electronic ID may be different from the Physical/visible ID on the asset.

Note: **ISO codes exist for Asset Size and types (**Size type code is defined by ISO6346)

Pairing Information
Pairing Date Pairing ZOI Pairing Installer Status Enum{First installation, replacement, maintenance}

Figure 41: Pairing information

Pairing event as definition of the process from whom to whom

Stakeholders / Involved Parties
Master Consignor Master Consignee House Consignor House Consignee Carrier ID Terminal Handler ID Customs Port authority Insurance Bank Vessel Crew

Figure 42: Stakeholders

Note: list of stakeholders: This list should include all the stakeholders/actors that either manipulate the container or are interested to get the information/events related to a given asset / container.

Code lists may exist to indicate the role a specific party/stakeholder plays. Attributes to be captured may differ for each role (stakeholder type).

Below is a further elaboration of relevant attributes, related to an Involved Party responsible for handling containers.

Responsible Container Party
Responsible Container Party ID Contact Email (optional) Phone number (optional) Indicator ZOI or Segment Linked to the segment / ZOI of trip plan

Figure 43: Responsible Container Party

<u>Note</u>: For a given segment or place / ZOI, the Responsible Container Party information is needed so we can contact the involved party whenever an immediate reaction is needed (e.g., Reefer temperature is out of expected range, fire risk is detected, etc.). Whenever, the exact information of the responsible is not available, the default value the contact of the asset owner may be used.

Responsibility
Sends Information Receives Information Handles Operation

Figure 44: Responsibility

Handling Operation
Operation list enum {loading, unloading, stacking, cargo type specific DG} From Container Support To Container Support

Figure 45: Handling Operation

<u>Note</u>. Loading/unloading on a trailer/wagon/ vessel/barge

<u>Note</u>. Known on which transport mode you are or you will be + movement signature detected thanks to the accelerometer.

Container Support
Type enum {Mobile,_Vehicle, Parked}

Figure 46: Container Support

Mobile_Vehicle
Vehicle Enum {Wagon, Trailer, Vessel, Barge}

Figure 47: Mobile Vehicle

Parked (Stationary Support)
Enum {Parking, Terminal, Quay} (**<u>Note</u>**. non moveable objects) Location ID/Place Code (optional) Sub Place Code (optional) GPS position

Figure 48: Parked

Example:
Place Code: Port
Sub Place code: Terminal
GPS: exact position within the sub Place code or Place code

Below are a number of other relevant concepts linked to the concepts of Trip Plan and Zones of Interest (ZOI) to help trigger appropriate communications from the IoT platform to Involved Parties. This needs elaboration during the Data Modeling exercise.

Geo-fencing
Location ID/Place Code Next Place Code ETA to next Place Code: Timestamp Actual Execution Time Duration

Figure 49: Geo-fencing

Computed information
ETA updates Actual Executed time updates Deviation

Figure 50: Computed information

Duration
Days Hours Minutes Seconds

Figure 51: Duration

For many of the data elements for the entities / concepts indicated above it will be beneficial to use standard codes lists as that will enable accurate processing by Information Systems. Below we included a number of areas where such codes lists would be useful. The list of areas below is by no means comprehensive. During Data Modeling, several more areas may be identified.

Codes list to be defined as part of the content of the code: types the codes or link to an external list:
Codes to be defined for the service level
Codes to be defined for different IoT devices
Codes for categories and types
Codes for the communication capabilities

In the pages below you will find more detailed information on specific data elements and what they may look like as a result of the Data Modeling exercise. Here to the information provided is just indicative. The Data Modeling exercise will determine the final technical details for each data element.

The tables below identify some of the data elements identified so far, that need to be modeled to cover the use cases as identified by the Smart Container Workgroup. The lists below are groups of data elements from a business perspective, as discussed in Chapter 7 and the pages above. The next step is to compare if there are currently equivalent entries for these data elements in the MMT, or to add missing data elements into the MMT for future messaging usage.

Device

Data elements related to the device that is permanently attached to a container. Typically there would be one device in the container.

Data Element	Description	Format	Example
Device ID	Unique ID of a device. Remark : A device represents a collection of multiple sensors	Char(35)	AB345678
Device Types		Codes	
Device Manufacturer	Manufacturer X	Char(35)	Device Manufacturer Manufacturer X
Device Owner	Device Owner	Char(35)	Device Owner X
Device position	Physical position where the device is located in the container: ISO9897 Location coding system Defines exact location within the container, also used for damage location identification	Char(4)	Connected to reefer engine or at Top Corner "2N"
Device life time indicator	The remaining life calculated based on the battery's usage	Percentage	

Figure 52: Proposed Device Data Model

Sensor

Data elements related to the single sensor that is permanently attached to a container. Typically there would be several sensors in a container.

Data Element	Description	Format	Example
Sensor ID	Unique ID of a sensor. Remark: A sensor represents a collection of multiple sensors	Char(35)	AB345678
Sensor Types		Codes	
Sensor Manufacturer	Sensor Manufacturer	Char(35)	Sensor Manufacturer X
Sensor Owner	Sensor Owner	Char(35)	Sensor Owner X
Sensor position	Physical position where the sensor is located in the container: ISO9897 Location coding system 4-char code Defines exact location within the container, also used for damage location identification	Char(4)	Connected to reefer engine or at Top Corner “2N”
Sensor life time indicator	Percentage of the remaining battery or ask Manufacturer		

Figure 53: Proposed Sensor Data Model

Container

Master data elements in table below are related to a shipping container.
Note: For master data of a ULD Unit Load Device used in air traffic, a separate entity will be needed.

Data Element	Description	Format	Example
Container ID	Unique ID of a container. The ID as per ISO6346 consists of 4 letters followed by 7 digits	Char(11)	ZIMU1234567
Container Size/Type	Size/Type code as per ISO6346	Char(4)	43R1
Container Owner	Container owner e.g. a Shipping Line or a Leasing Company. Code List: e.g. SMDG Master Liner Codes	Char(3)	CMA

Figure 54: Proposed Container Data Model

Event

Data elements related to one particular event reported by a smart container.
What / Where / When / Why the event happened.

Data Element	Description	Format	Example
Time of reporting UTC	When the event was reported from the smart container (UTC)	Timestamp YYYYMMDD HHMMSS	20190129164000
Event timestamp UTC	When the event occurred (UTC)	Timestamp YYYYMMDD HHMMSS	20190129163200
Event code Transport related	Code to explain what happened with container and cargo. Possible reference to "Transport_Event" in the CCL Examples: > heartbeat > reefer temperature out of range > reefer engine connected > reefer engine disconnected > door opening > door closing > roof opening > entering a zone > leaving a zone > …		
Event code Device related	Code to explain what happened with the device. Examples: > New sensor paired > sensor unpaired > sensor undetected > sensor configured > bad sensor > loss of interface > …		

Data Element	Description	Format	Example
Measurement value taken	> Actual temperature > amount of shock > humidity > gas … measured by the device (unit of measurement in separate element below)	Numeric	-14
Unit of Measurement	Related to measurement value above. Example "Degree C" Use ISO Standard	Numeric	degree C
Event Position Lat/Lon	Where the event occurred expressed in geo coordinates. This will be available for every event	Lat / Lon numeric	53.2100 N 12.3400 E
GPS Source	Terrestrial AIS, From Tracking Device, From Gateway, from GSM	Code	
GPS Acquisition Source	Galileo, GPS, GLONASS, BeiDou	Code	
GPS Precision	Distance in meters		
GPS Satellite number			
User defined Position Location	Only available if the event occurred within the boundaries defined by a user Precondition is a geo-fence (polygon)	Char (35)	ABCDE
Event Position Location	Where the event occurred expressed in UN/LOCODE. Only available if the event occurred within the defined boundaries of a UN/LOCODE. Precondition is a geo-fence (polygon)	Char (5)	DEHAM

Data Element	Description	Format	Example
Event Position Depot/terminal	Where the event occurred expressed in terminal or depot code, within a UN/LOCODE. Only available if the event occurred within the defined boundaries (geofence) of a depot or terminal. Code list by **SMDG** (for terminal) or by **BIC** (for inland depot) Precondition is a geo-fence (polygon)	Char (10)	CTB *(SMDG Terminal Code)* DEHAMHHLA *(BIC Facility Code)*
Depot/Terminal code list agency	SMDG or BIC or … Use codes from EDIFACT data element 3055	Char (3)	306 (for SMDG)

Figure 55: Proposed Event Data Model

Transport Booking

Data elements related to the shipment context (synonyms: booking, conveyance) that the container belongs to at the time of event reporting.

Data Element	Description	Format	Example
Booking number	Booking reference issued by the container operator, typically the shipping line. Synonym: Trip-ID. ⇨ Leave empty if container not in mission at time of event reporting	Char(15)	12345678
Container Operator	The party that issued the booking reference and that operates the container at time of event reporting. In case of a shipping line, use SMDG Master Liner code list	Char(3)	HLC
Current Location Role in Shipment	Pick-up depot, original consignor, inland rail ramp export, first POL, last POD, inland rail ramp import, final consignee, Drop-off depot etcetera	Code	
Next Location UN/LOCODE	Next location as per transport plan, expressed in	Char(5)	DEHAM

Data Element	Description	Format	Example
	UN/LOCODE. If container is at sea then it is the Next port of call.		
Next Location Terminal / Depot	Next location Terminal or Depot as per transport plan, if any. Code list by SMDG (for terminal) or by BIC (for inland depot)	Char(10)	CTB DEHAMHHLA
Scheduled ETA at next location	ETA at next location as per transport plan (as per schedule)	Timestamp YYYYMMDD HHMM	2019-01-29-1632
Calculated ETA at next location	ETA at next location as calculated based on current position	Timestamp YYYYMMDD HHMM	2019-01-29-1632
ATD at last location	Actual time of departure at previous location, based on previous reporting	Timestamp YYYYMMDD HHMM	2019-01-29-1632
Trip Start Time	Actual time of departure at the first location in current trip. This can be used to calculate the actual executed transit time.	Timestamp YYYYMMDD HHMM	2019-01-29-1632
Previous Location UN/LOCODE	Previous location as per transport plan, expressed in UN/LOCODE. If container is at sea then it is the Last port of call.	Char(5)	DEHAM
Container Full or Empty	Full or empty at time of event reporting	Char(1)	E, F
Container sitting or moving	Container sitting or moving at time of event	Char(1)	S, M
Party: Shipper	Synonym: Ship From. The party from whom goods will be or have been originally shipped.		
Party: Consignee	The party consigning goods as stipulated in a Transport Service Contract.		

Data Element	Description	Format	Example
Party: Notify	The party to be notified of events related to the consignment.		

Figure 56: Proposed Transport Booking Data Model

Means of Transport

Data elements related to the current means of transport at the time of event reporting.

Data Element	Description	Format	Example
Vessel ID IMO	IMO Number of the vessel on which the container is loaded at time of event reporting	Num(7)	1234567
Vessel ID Call Sign	Call Sign of the vessel on which the container is loaded at time of event reporting	Char(7)	DGSH3
Vessel Name	Name of the vessel on which the container is loaded at time of event reporting	Char(70)	MSC ZOE
Railcar ID	Unique ID of the railcar on which the container is loaded at time of event reporting		

Figure 57: Proposed Means of Transport Data Model

Annex 3 - Mapping Data Elements to Use Cases

This indicative, while doing the data modeling some of them will change.

The Use Cases reuse many of the same data elements.

Use Case # Data Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Device	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Device ID	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Device Type	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Device Manufacturer	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Device Owner	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Device position	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Device life time indicator	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	M	O	O	O	O
Sensor	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Sensor ID	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Sensor Manufacturer	M	O	O	O	M	M	M	O	O	M	M	O	O	O	O	M	O	M	M	O	O	O
Sensor Owner	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Sensor position	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Sensor life time indicator	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	M	O	O	O	O
Sensor Type	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
GPS	M	M	M									M	M			M	M	M	M	M	M	
Temperature					M						M					M			O			M
Humidity						M										M			O			
Shock										M						M			O		M	
Gases																M			O			
Door Latch				M											O	M						
Active power							M	O	O					O				M				
Switch to backup power					O	O		O	O		O			O								
Container (Asset)	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Container ID	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Container Manufacturer	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	M	O	O	O	O
Container Owner	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Container Type	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Container Size	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Length	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Width	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Height	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Volume	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Event	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Time of reporting UTC	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Event timestamp UTC	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Event code Transport related	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
heartbeat	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	O	M	M	M

Use Case # Data Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
reefer temperature					M														M			M
out of range																						
reefer engine connected					O	O		O	O									M				M
reefer engine disconnected					O	O	O	O	O									M				M
door opening				M	O	O					O				O	M						
door closing				M	O	O					O				O	M						
roof opening				O	O	O					O					M						
entering a zone	O	O	O									M			M		M			M		
leaving a zone	O	O	O												M		M			M		
Event code Device related	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
New sensor paired																		O				
sensor unpaired																		O				
sensor undetected							M											O				
sensor configured					O	O					O							O				
bad sensor					O	O					O							O				
loss of interface							M															
Time Threshold					O	O					O					M			O			
Temperature					M	O					M								O			M
Temperature threshold					M	O				O						M			O			M
Humidity threshold					O	M				O						M			O			
Shock event					O	O				M						M			O		M	
Light event				M	O	O				O						M			O			
Position angle threshold										O						M			O		M	
Measurement value taken		M		M	M	M				M	O					M		M	O		M	M
Unit of Measurement		M		M	M	M				M	O					M		M	O		M	M
Event Position Lat/Long	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M		M	M	M	M	M	M
GPS Source	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M		M	M	M	M	M	M
GPS Acquisition Source	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
GPS Precision	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
GPS Satellite number	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
Event Position UN/LOCODE	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
Event Position Depot/terminal	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
Depot/Terminal code list agency	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		
Shipment/Booking	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Booking number	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O		O	O	O	O
Air Waybill number	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O		O	O	O	O
Container Operator	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Current Location Role in Shipment	O	O	M	M	M	M	M	M	M	M	M	O	M	O	M	M	M	M	M	M	M	M

Use Case # Data Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Next Location UN/LOCODE	O	O	O	O	O	O	O	M	M	O	O				M	M	M	O	O	O	O	O
Next Location Terminal / Depot	M	O	M	O	O	O	O	M	M	O	O				M	M	M	O	O	O	O	O
Scheduled ETA at next location	M	O	M	O	O	O	O	M	M	O	O				M	M	M		O	O	O	O
Calculated ETA at next location	M	O	M	O	O	O	O	M	M	O	O					M	M		O	O	O	O
ATD at last location	M	M	M	M	M	M	M	M	M	M	O	O	O		M		M		O	O	O	O
Trip Start Time	O	O	O	O	O	O	O	O	O	O	O						O		O	O	O	O
Previous Location UN/LOCODE	O	O	O	O	O	O	O	O	O	O	O	O					O			O	O	O
Container Full or Empty	O	O	O	O	O	O	O	M	M	O	M	M	M	M	M		M	O	O	O	O	O
Container sitting or moving	O	O	O	O	O	O	O	M	M	O	M	M	M	M	M	M	M	O	O	O	O	O
Party: Shipper	O	O	O	M	M	M	M	M	M	M	M						M		O	O	O	O
Party: Consignee	O	O	O	M	M	M	M	M	M	M	M						M		O	O	O	O
Party: Notify	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Means of Transport	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Vessel ID IMO	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Vessel ID Call Sign	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Vessel Name	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Rail Operator	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Railcar ID	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Rail (Train) Number	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Truck Operator	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Truck Number	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Airline Operator	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O
Flight Number	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O

Figure 58: Mapping Proposed Data Elements to Use Cases

M = Mandatory

O = Optional