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White Paper

Smart Containers
Real-time Smart Container data
for supply chain excellence

Version 1

Note

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Foreword

Technology is entering into every aspect of the supply chain and providing performant and innovative tools. As many are just starting to talk about the dematerialization of certain documents used in trade and transport, others are investigating how devices can communicate information directly to the rest of the supply chain without human intervention.

Smart Containers are taking the digital age of shipping one step further beyond paperless processes by embracing the Internet of Things (IoT) to support enhanced decision-making by the various sectoral stakeholders. This provides greater visibility to the stakeholders within the transaction as well as to regulatory agencies who need detailed information on the consignments before they arrive at the border. This technology can be combined with other innovations such as blockchain, big data or data pipelines to provide even more facilitation to the trading community. In all of these cases, though, we see that creating clear, unambiguous message exchange standards will allow to capitalize the full potential of the enhanced data.

This paper provides a detailed look into the various benefits of using Smart Containers as well as the various potential use cases for this technology. The project team continues its work to provide clear semantic standards for the exchange of this data in order to ensure that all stakeholders understand the same information in the same way.

I hope that this publication will offer a useful aid to all parties interested in the technical applications and implementation of IoT technologies and that this important process will continue to contribute to the enhancement and growth of international trade.

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1 Introduction

This White Paper is part of the UN/CEFACT Transport and Logistics Smart Container Project. The aim of this White Paper is to have a common understanding of Smart Container solutions. The stakeholder(s) of the Smart Container data are identified along with a description of the use cases to explain the potential usage for those data elements of interest. This enables the stakeholders of the logistic chain to reap the maximum benefits from the Smart Container solutions while enabling them to share data and associated costs. This increases their collaboration and resulting efficiency.

The supply chain requirements have changed over the years. Nowadays, supply chain stakeholders place more importance on the need for improved visibility to identify inbound flow of goods to satisfy higher demands and react to the unexpected. Smart devices unlock the potential to provide accurate real-time data as they are permanently fixed to the transport equipment, provide coverage for the whole journey and are not restricted to reaching physical locations to report events.

Recent advances in technology have made possible the usage of lower-cost tracking and monitoring devices that can be permanently attached to marine and inland waterway shipping containers, in essence making them “smart” containers.

Monitoring devices capture various measurements which are then transmitted in near real time for further analysis, alerts or general reporting. These measurements can include one or more type, but are not limited to GPS positioning, temperature, humidity, vibration and shock, radiation, etc. Depending on the type of monitors used, there are a wide array of uses and benefits which can be envisioned for such data. These are described in this paper in a series of use cases.

In addition to data obtained from the environment of the container, positioning data may also be captured and derived from the Internet of Things (IoT). Data could be captured from multiple sources and added to the shipment record. This could be done using Distributed Ledger Technology, such as blockchains.

Although many Smart Containers and devices are already in use, there are no global standards in place to capture and communicate consistently and multimodally the array of data which can be provided by Smart Containers. This paper explains the potential use of Smart Containers, details the benefits for each stakeholder, provides the rationale for further investigation and provides the basis upon which to build a Business Requirements Specifications (BRS) document and to develop internationally standardized messaging to facilitate the usage of this data.

2 Background

2.1 Definition of Smart Containers

During the second half of the twentieth century, the volume of cargo transported in container boxes rose exponentially. Nowadays, about ninety per cent of non-bulk cargo transported by sea worldwide is moved in standardized container boxes from place of stuffing to place of stripping using all modes of transport, sea, inland waterways (barge), rail or road. The concepts of containerization and intermodal transport have had a tremendous impact on supporting global economic growth by transforming and revolutionizing supply chains and logistics.

Containerized cargo transport has been the backbone of international trade development and continues to play a leading role by shaping and defining the relevant dynamics.

Meanwhile, the continuous technological advancements have enabled the container shipping industry to gradually move towards its digital transformation over the years and to start embracing the game-changing benefits of newly-offered opportunities. During the last decade, various large-scale initiatives led by key supply chain stakeholders have been launched to enhance situational awareness, enable end-to-end visibility and performance monitoring and provide for decision-support tools.

Tracking devices together with interconnected sensors provide international supply chains with smart systems and tools that utilize all this available information to actively monitor service performance. As the productivity gains become more and more apparent, the adoption of such solutions by key stakeholders involved in any step of the logistics process grows. The need to capture inefficiencies, understand delays and look at the big picture by aggregating data is the force that will drive further advancements toward fully transparent supply chains.

As a result of this industry-wide digitalization strategy, in the last few years global programs have been increasingly implemented that aim to equip and upgrade traditional freight containers with onboard tracking and monitoring capabilities, security devices and other multiple-connected sensors.

Most of the container operators compete on the international level on a day-to-day basis and their multiple cross-border operations provide them with direct insights into the complexity of international trade logistics. Simplification, standardization and harmonization of procedures, processes and associated information flows to move goods through the supply chain in a predictable and transparent manner is the way forward. The benefits of getting to that point are not only apparent at the micro level (information sharing and optimization within companies), but the macro level as well (the whole network of partners across the supply chain from different industry segments and lines of business to governmental agencies).

As proven by many studies, efficient trade logistics is the critical link to effective trade facilitation. Boosting the supply chain performance can only be realized by enabling changes in procedures through technology adoption and building smarter solutions to further enhance the level of interconnectivity. Under this perspective, digitalization is a strategic enabler within the industry with innovation-minded approaches being the key variables through which trade can deliver sustainable growth opportunities.

Considering the vital role of container shipping in the connected world of today, the industry initiatives to improve the international supply chain performance have the potential to actively support global trade facilitation efforts and will largely impact economic growth and prosperity on a global level.

The electronic devices incrementally installed on container fleets empower traditional containers to become smarter. Container monitoring devices and sensors encompass three general components that are increasingly combined to enable advanced monitoring:

- Identification;
- Location;
- Physical parameter monitoring such as temperature, humidity, vibration, etc.

Location-aware technologies, real-time reporting, handling and tampering control, environmental condition monitoring, hacking attempts recording, and related alarms and quality management functions are widely available. Such devices collect and monitor a variety

of physical parameters and store and/or transmit related data safely. These connected devices are used to monitor service and equipment performance, and to remotely diagnose problems related to both the container itself and its contents. The Smart Container data may also include the following more detailed data elements:

- ETA Update;
- Actual Executed Transit Time;
- Empty at Gate-In at Depot;
- Depot Reconciliation;
- Trip Tracking;
- Haulage Container Time and all routing points passed; and
- Exception Alerts such as Schedule Deviation Alert, Unexpected Door Opening, Unexpected Temperature or Humidity Change, and Overlanded Container.

With the cost of this technology continually decreasing, improvements in the lifespan and autonomy of the devices together with the streamlining of the maintenance processes, the proliferation of smart sensors is enabling a new age of visibility throughout the supply chain.

Over the last five years, a significant number of containers have already been equipped with tracking and monitoring devices. The relevant accumulated data demonstrate significant gains in transparency, integrity, efficiency, predictability and effectiveness of cargo shipping. The results also show a tremendous improvement in cargo care, service and maintenance with gains that have a positive impact on safety for seagoing personnel and more environment-friendly container operations overall as we move into a predictive state.

2.2 Scope

The focus of this White Paper is on Smart Containers, which are standardized seagoing containers as defined by the International Standards Organization ISO-6346 standard, including refrigerated containers (or “reefers”), dry containers or tank containers used for multimodal (sea, inland waterways, road or rail) cargo transport, fitted with added electronics enabling door-to-door tracking and monitoring. The drive for end-to-end visibility and transparency throughout the entire supply chain can be facilitated by the use of such containers. The equivalent loading equipment for air transportation are referred to as Unit Load Devices (ULDs—see the Smart Assets section below). Added electronics on these assets or embedded within the enclosed shipments likewise enable these containers or pallets to transmit additional information regarding the location, physical status and environmental changes encountered during the transportation process. The data obtained from Smart Containers is the basis for the development of value-added services that can be offered to the relevant stakeholders in the shipping world.

Any container can become a Smart Container. Smart Container electronics can be built in during manufacturing, retrofitted to all types of existing containers, or embedded within the contents of the container. The same electronics can be used to transform gensets, trailers, swap bodies, rail cars, and so on. The equipped assets then become smart assets, enabling fleet management and predictive maintenance including the cleaning/fumigation of containers which may have been loaded with cargoes with noxious properties.

Currently, gathering data on the whereabouts and condition of “silent” containers (those not fitted with transmitting monitoring devices) is performed manually, which is costly, prone to error, incomplete, and can be fraudulent. Modes of transportation with the longest travel times and less-controlled pathways are more prone to inaccurate data. This lack of information on container tracking affects shipping lines by increasing operational costs as additional resources

are deployed to trace discrepancies between where a consignment should be and where it is. The cost is magnified when incidents result in poor customer service.

The Smart Containers Project provides a solution to these issues:

- Continuous worldwide door-to-door visibility;
- Data capture is automatic and therefore error free and fraud resistant;
- Information that would otherwise be too expensive or even impossible to capture can be easily collected and integrated further; and
- Real-time data means the system-held location and condition of the container reflects reality.

Today's shippers are optimizing their supply chains through digital transformation. Real or near real-time data is the key. Smart Containers means shipping lines and cargo-related stakeholders can have access to container data coming from the source regardless of whether the container is on a ship, in a yard, or at any other point during its pre-haul and post-haul journey.

2.2.1 Smart assets

The non-sea-going counterpart of an ISO Sea Container, used for Air, Rail and/or Road transportation, is referred to as a Unite Load Device (ULD). Such non-transmitting ULDs (or shipments within a ULD) can also be enhanced with added electronics. In this way the ULD becomes a smart device, enabling it to send out real-time information on location, door opening and closing, vibrations, temperature, humidity, and any measured physical parameters of the surrounding environment of the asset to a data collection centre. These tracking and monitoring devices can also be used to equip other types of assets such as wagons and trailers.

3 Current trends: technologies at the service of trade facilitation

3.1 IoT Technologies

Different technologies enable Smart Containers to communicate information captured via a wide range of sensors about their current status (e.g., GPS position, door opening detection, movements vibrations and shocks, atmospheric conditions, etc.) and to remotely change their parameter settings (e.g. temperature setups, remote defrost, etc.) anywhere, anytime. IoT technologies have proven there is huge potential for businesses to leverage their efficiency and mitigate their risks. Smart assets will become a standard in the shipping industry.

3.2 Big Data

Smart Containers transmit a large amount of data which, combined with other data in the primary host system, can be analysed and interpreted to provide even more relevant evaluations. This data is not only useful during the journey of a single container. In the context of multiple trips over an extended time it can provide global visibility of operations. When comparing average turnaround times or damage rates between different ports and yards, one can build and evaluate programmes to bring all stakeholders up to the same level of supply chain excellence.

3.3 Blockchain technology

Blockchains are a Distributed Ledger Technology that can be used to capture data from the original source in real time. Smart Container technology in association with distributed ledger technology, when appropriate, may provide secure solutions for recording the transfer of responsibilities in the supply chain.

3.4 Data pipelines

Data pipelines promote the capture of the right data from the right person at the right time. These concepts provide the key to creating accurate supply chain visibility and more efficient data flows between the consignee and consignor, as well as providing this data to all supply chain actors such as cross-border agencies, which require further information to facilitate a frictionless border crossing.

Snippets of data can be captured and transmitted into the pipeline throughout the journey of the container. These can come from multiple sources, and each source should provide what they know to be true. Smart Containers compliment this approach as they are the only piece of equipment that is used door-to-door and can capture and report factual events such as door closing (loaded), arrival or departure at a geofenced area, or door opening. These snippets of information can be relied upon to be a trustworthy representation of events.

Using this granular information, supply chain stakeholders can work on exception management proactively by reducing the cost of disruption and facilitating the de-risking of legitimate shipments. Additionally, they can finance their supply chain transactions in ways not possible today.

4 List of potential use cases of the Smart Container

Below is a summary of use cases put together by the UN/CEFACT Smart Container Project Team. Each use case will be described in more detail and with the required data elements in a future Business Requirements Specifications (BRS) Document to be developed by this Team.

<i>Case Number/Type</i>	<i>Use Case</i>	<i>Description & Trigger</i>	<i>Receiver</i>	<i>Value Proposition</i>
1 Operational	ETA Update	Message with new ETA at next point or at 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.

Case Number/Type	Use Case	Description & Trigger	Receiver	Value Proposition
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, they can determine the root cause and take corrective action if 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. <u>Counter Concept:</u> No alert received means proof that doors were <i>not</i> 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: they may check if items were stolen, or unwanted items were placed inside the container. They 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 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.
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 the Beneficial Cargo Owner [BCO]). The same alert is desired if, in a controlled atmosphere container, the amount of oxygen, carbon dioxide and nitrate 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.

<i>Case Number/Type</i>	<i>Use Case</i>	<i>Description & Trigger</i>	<i>Receiver</i>	<i>Value Proposition</i>
7 Operational	Missing Container Onboard of Vessel	Meshing technology allows to detect any missing container from onboard of a vessel that was originally specified on the manifest or on the stowage plan.	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 its signal from the port of loading after the vessel has sailed where it should have been loaded.	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 at Depot	When a Smart Container enters into the premises of a depot (geo-fence), this event can be reported. Note: it might be duplicate to the UN/EDIFACT CODECO message for gate-in/gate-out.	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).

<i>Case Number/Type</i>	<i>Use Case</i>	<i>Description & Trigger</i>	<i>Receiver</i>	<i>Value Proposition</i>
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 BCO)	While a container is moving inland, various parties to the transport may track the routing and find out about the actual routing and, for example, review the ETA for more efficient planning or Check whether the container is 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 consignment is legitimate and does not pose a security risk both from the operational and border security perspectives. This can provide for better planning for operations such as stuffing and stripping, vessel planning, depot handling, etc.

<i>Case Number/Type</i>	<i>Use Case</i>	<i>Description & Trigger</i>	<i>Receiver</i>	<i>Value Proposition</i>
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 Authorized Economic Operators (AEO) authorities. AEOs must 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, improve data quality/visibility and increase reliability of time schedule. Benefit also for the cross-border agencies to have more efficient operations.
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 to 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.

<i>Case Number/Type</i>	<i>Use Case</i>	<i>Description & Trigger</i>	<i>Receiver</i>	<i>Value Proposition</i>
19 Quality	Identifying the Consignment	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.	The BCO (importer and exporter).	<p>The BCO (e.g. consumer, importer) knows that the product was transported in good conditions in a Smart Container.</p> <p>The BCO (e.g. the exporter) will be offering a value-added service.</p> <p>Whenever the conditions were not ideal, the BCO could react and send a new container or adapt its packaging and change the routing.</p>
20 Sovereign	Port Infrastructure Usage Monitoring by Port Authority	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).	Port Authority	Port Authority gains reliable data on the current usage of their infrastructure (roads, bridges, rail tracks, terminals) as the basis for future planning.

5 The benefits of Smart Container solutions

Digitalization fosters an environment of transparency to support competitiveness on equal terms and enables companies to focus on containing and cutting down logistics and supply chain management costs. Given that this is a common goal for all involved actors—be it carriers, shippers, forwarders, IT and service providers or governmental bodies—a collaborative approach becomes the norm for enhanced supply chain visibility and analytics.

Smart Container solutions are the missing link in the full digitalization of the supply chain. Supply chains will become more transparent, reliable, agile, secure, resilient, connected and sustainable. The Smart Container offers door-to-door visibility, which enables logistics-chain excellence and sustainability.

Thanks to Smart Containers, the computer representation of the supply chain will become synchronized with the physical world, enabling:

- Speed and accuracy of decision-making;
- Automation as part of transport and logistics execution;
- Seamless collaboration between stakeholders; and
- Better predictability of the supply chain.

All supply chains are different but having trustworthy data and efficient data exchange will illuminate weaknesses in the current supply chain processes. Smart containers can compare the

planned versus executed trip and generate real-time alerts in case of any gap—avoiding potential problems and eliminating the costs incurred while compensating for the lack of data.

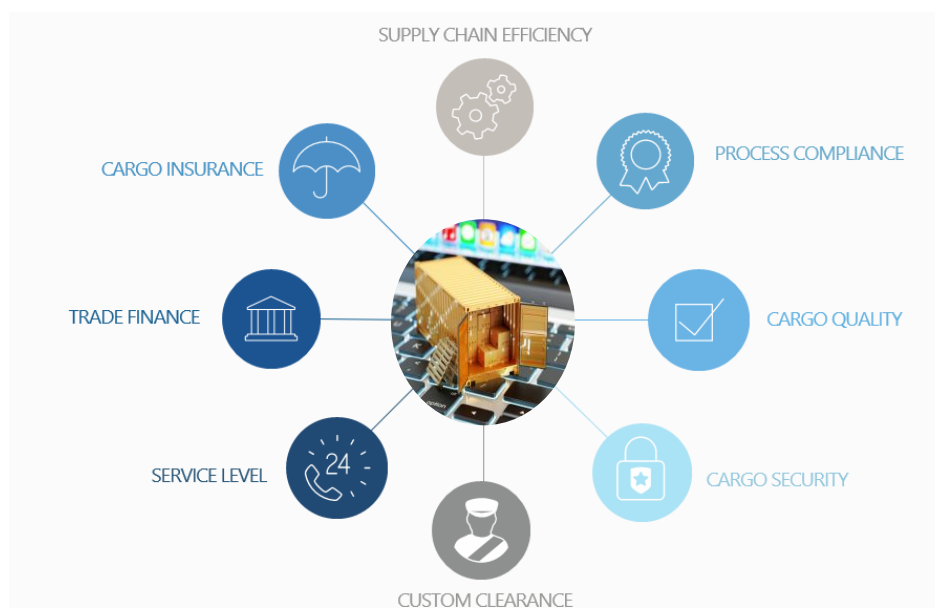


Figure 1: Benefits of Smart Container solutions

The use of Smart Containers within the supply chain provides benefits in many ways to the varied stakeholders, as seen in Figure 1 (above). The realization of efficiency of time and expenses, the transparency of operational movements and events, and the near real-time reporting of such events allows the operator to be responsive to hazards that cost time and money, and to be able to react quickly to mitigate such issues. The safety and security of consignment and transport equipment is enhanced, and movement across country borders is facilitated. In addition to productivity gains, more efficient transportation will lead to better resource usage, facilitating the shift to cleaner modes of transportation, and an eco-friendlier environment.

As identified in the multiple use-case examples above, Smart Container monitoring can be used for numerous purposes by supply chain stakeholders.

5.1 Transport operators

During any given trip many transport operators are involved, and no single one has total door-to-door visibility. Hence, as a common asset, a container—once equipped with smart technologies—will enable stakeholders to have better visibility, collaboration, and coordination. In addition, Smart Containers allow for the delineation of the responsibilities of each actor and help to identify bottlenecks which may be opportunities for improvement and savings. Total visibility enables actors to enhance their processes, resulting in the reduction of transport lead time and costs.

Regardless of the mode of transportation, using the Smart Container data will enable the transport operators to have better control of their operations and resources. Smart Container solutions facilitate efficient fleet management and enables operators to offer a value-added service while ensuring better service quality. Having reliable information to act on and enhance processes mitigates risks and results in the mastering of operational costs.

5.2 Logistic service providers

Logistic service providers (e.g. handling operators, international freight forwarders, brokers, fleet managers) benefit by obtaining timelier and more accurate information from the data transmitted by the Smart Containers as a result of compilation, analysis and reporting from the host systems on the status of the consignments. Faster knowledge of hazards or unanticipated events allows for better risk mitigation to ensure the consignments are secure and in safe condition.

5.3 Consignors and consignees

The consignment process involves sending goods from a consignor to a consignee. The consignor is the shipper and the consignee is the recipient. One can refer to either as the Beneficial Cargo Owner (BCO).

The BCO is the stakeholder that requires more complete and timely information about the consignment. Today, the BCO has little information about the consignment during the end-to-end transportation process, resulting in a passive role. Therefore, the BCO is not able to take any action in case of occurrence of any incident negatively impacting the consignment.

In fact, Smart Container information may allow the BCO to take an active role in mitigating negative circumstances in a timely manner. In general, even when no negative incident occurs, having Smart Container data will allow them to make decisions to optimize their supply chain and monitor the quality of their products.

Smart Containers enable better inventory management which may avoid out-of-stock scenarios while reducing the quantity of stock in general. Having better door-to-door visibility may also result in reduction of lead time, including in the customs clearance process.

Having Smart Container data may also decrease cargo loss, packaging costs, non-quality costs, the levy of fines, legal costs, insurance fees and investigation processes, damage to goods, the number of back orders, cancelled orders and the number of defective products delivered.

At the same time, door-to-door visibility may result in increased cargo security; better service level, on-time deliveries; and decreased the lead time since the processes flow better.

In summary, Smart Container data will increase the profitability of the consignment through stabilization of the unit price from unexpected costs.

5.4 Vessel crew

Vessel crew are responsible to ensure that the internal temperatures of refrigerated containers (or reefers) are correctly maintained during the sea passage and while in port. In addition, they must be able to tell the exact number of all types of containers—full and empty—loaded on the vessel at any time. Today, the crew must walk all over the vessel to check manually whether each reefer is working correctly.

Smart Containers may play a role in enhancing the operations on board vessels by enabling the crew to remotely monitor the temperature of the reefers and to ensure that the engines of the reefers are running correctly. Early alerts will enable the vessel crew to take mitigating actions to attempt to save the cargo instead of discovering damaged cargo after the fact (e.g. upon delivery to the BCO).

In addition, thanks to Smart Container solutions, the vessel crew will be able to compare remotely, in a timely manner, and at any time during the voyage, the total number of full and

empty containers aboard the vessel to substantiate the numbers originally loaded according to the stowage plan.

5.5 Container owners

Container owners and leasing companies want to have valid confirmation of their containers located in a depot and to efficiently control their container inventory in general.

Smart Containers may enable container owners and leasing companies to generate periodic (e.g. monthly) or on-demand reviews to reconcile their container inventory with the depot operators. This would result in more efficient fleet management.

5.6 Depot operators

The depot operator is responsible to report daily the exact number of containers available at their location. As of today, this task is prone to error since it is performed manually in a time-consuming manner. Smart Container solutions may enable efficient daily or on-demand determination of the container inventory.

5.7 Inland and sea terminal operators

Terminals play an instrumental role in the movement of containerized cargo from consignor to consignee. Containers are intermodal by definition, and the terminals are the place where they change transportation modes. Smart Container solutions will enable terminal operators to verify the exact location of each container in their yard efficiently, and in real time.

Smart Container solutions could provide the ETA at the terminal. This ETA may apply to trucks, rail wagons or barges and could help improve operations at the terminal or port.

Smart containers are able to monitor the temperature of reefers and alert in case of a negative occurrence, enabling the terminal operators to take mitigating actions to save the cargo, instead of later finding that a violation of the required temperature range had occurred (e.g., discovered at delivery at the BCO premises). The Smart Container could enable the sharing of data regarding proper container handling—information which is currently not always available.

The terminal operator has the responsibility to locate dangerous goods at its own terminal in accordance with the dangerous goods rules of segregation, as defined by the International Maritime Organization (IMO). Today, the positions and the contents of the containers with dangerous goods are recorded manually and provided by different stakeholders to be fed into the terminal's operating system, which checks whether the segregation rules are respected. Alerts are raised if any incompatibility is detected. Smart Container solutions will feed the terminal operating system with reliable data on the physical position of the container, the declarative information about its contents and transmit alerts if the monitored physical parameters violate acceptable limits. Hence, Smart Container solutions ensure the correctness and completeness of the dangerous goods information. In addition, Smart Containers can monitor specific physical data related to the transported dangerous goods, which enables better risk management, enhanced safety of agents handling these containers and reduced negative environmental impact.

5.8 Cross-border Regulatory Authorities (Customs, Sanitary, etc.)

Depending on the information gathered, Smart Container solutions can provide accurate data about the physical trip of the container prior to its arrival. This data could help customs officers perform a risk assessment by enabling them to compare the declared trip versus the executed

one, thereby accelerating the clearance process—even allowing pre-arrival clearance. Customs Authorities could create a “fast lane” for Smart Container processing.

Whenever Smart Containers generate alerts regarding measured physical parameters violating the acceptable thresholds (e.g. perishables or pharmaceuticals), the cross-border authorities, including Sanitary Authorities, may flag that container for inspection. In fact, improvement in data quality will allow for better inspection predictability. This may reduce the number of inspections requested by authorities and reduce the delay whenever an inspection is requested. Thus, Smart Container solutions bring more efficiency and improved security in container movements for cross-border authorities. In addition, alerts resulting from some physical parameter monitoring (e.g. fumigation of fresh food, dangerous goods) may enhance the safety of the agents who must inspect that container.

Unusually long stops or deviation from the declared route could result in the flagging of a container for inspection. This location tracking could be of significant help in identifying suspicious consignments.

Unexpected-door-opening detection could result in cross-border agencies requesting inspection of a container. Any indication that the consignment has been tampered with during the journey is very likely to preclude advance clearance of a container. Timely notification would allow cross-border authorities to plan an inspection that may not further delay clearance of the consignment.

Smart Container solutions are particularly important for cross-border agencies performing the clearance processes inland (e.g. dry port, transfer to bonded warehouse, etc.) as they must verify whether the cargo really crossed the border. In addition, Smart Container solutions are important for authorities when there is regulatory oversight of a free-trade zone since they can prove that the containers were imported and exported without tampering.

Coordinated Border Management between countries, which strives for seamless border crossing without physically checking each vehicle, can also be facilitated by Smart Container devices and sensors at the border as they can detect when a consignment enters or leaves a territory, thus triggering an automatic customs declaration and any associated duty or relief reclamations.

Speeding up the clearance process is of importance to all stakeholders and early reporting of consignment and transportation details will help facilitate this important factor for trade.

5.9 Port Authorities

The Port Authority is responsible for providing adequate infrastructure within a port such as roads, bridges, rail tracks, depots or terminals. They must plan infrastructure maintenance and possible improvements well in advance. For that purpose, they need reliable data on the actual usage of the infrastructure (for example, the number of containers carried on a certain road per month). They need that data broken down by road section, or for a bridge, for a particular rail track, etc.

Smart Containers can provide decision support when optimizing the future investment in the port infrastructure. In addition, the real-time Smart Container data could be used to reduce the congestion on the roads and to manage the traffic flow. A more efficient flow of traffic could lead to a reduction of carbon emissions and contribute to making the port environment eco-friendlier.

The Port Authority also needs high-level statistics on the volume of containers moving through their port as basis for communications with the federal government or for comparison with other ports. Currently it is difficult for them to obtain this data from a single source. They can only make assumptions based on the import and export volumes.

5.10 Banks and insurance institutions

Institutions related to banking and insurance are heavily involved in the logistics process. From planning and monitoring of contract compliance to post-evaluation of completed routes of transport and transactions, they play an important role in supporting the seamless execution of relevant supply chains.

Having additional reliable data sources to support decision-making enables smoother operations and more informed risk analyses. From this perspective, data from Smart Containers can provide added transparency and visibility through every step of the cargo voyage process, which is fundamental both for real-time, situational awareness and for future planning based on historical data.

Certain modes of travel, such as air, can be easily monitored utilizing international standard messaging during take-offs and landings and such events must be reported to customs authorities in the subject country. However, monitoring and reporting for other modes of transport (sea and land) can be much more challenging. With the addition of real-time tracking devices that transmit geospatial information, awareness is much higher and any route deviation can be detected in a timely manner.

From an insurance institution's point of view, the ability to monitor the execution of any journey at cargo level enables direct compliance and risk evaluation together with fast resolution in the case of a claims request or any type of contract breach. Examples include time-stamped events related to the potential impact to the cargo transported due to environmental factors (i.e. temperature, humidity, etc.), and shocks and vibrations together with the actual physical location of any subject occurrence. In this way, any cargo damage can be evaluated based on actual data from the source to facilitate claims resolution and optimize risk mitigation.

Similarly, the value of having Smart Container data available is realized when banks are able to issue documents much faster, auditors can verify compliance of the actual trip compared to the plan, timely or faster processing of payments is achieved and, control is gained over operational costs through the acceleration of all relevant procedures. As international trade grows, higher volumes of goods are imported from developing countries. For the involved banks to finance the cargo, they must wait for the invoice approval by the client, which usually happens very late in transit or once cargo has arrived at the destination. By knowing the physical position of a Smart Container at any time, involved stakeholders would have information about border-crossings, transfer of responsibility and possession. This would help to accelerate payment releases to the appropriate parties and, thus, speed up the whole supply chain.

Over time, institutions related to banking, finance, and insurance could benefit from having access to data sources with consequent productivity gains resulting in more efficient supply chains. Based on actual data and by post-evaluating completed journeys, banks could grant lower rates to finance supply chains. Insurance companies could tailor their services to facilitate building new products and support efficient, end-to-end risk management. As a result, enhanced cargo security could be realized in the whole transportation process resulting in fewer governmental fines and lower legal costs.

6 Credentials based access to the Smart Container data

This project team foresees that the Smart Container data would be generated, monitored and managed by neutral Smart Container service providers who commercialize the devices and their related data transmission technologies.

These service providers would have control of the data and the platform to store them.

The Smart Container data would be managed in a safe way that respects the competitiveness of all stakeholders. The rules of data sharing should be specified in the contractual data governance agreement between the service provider and his customer, should it be the carrier, the BCO, authorities, or any other party.

Based on the transport contract for a given consignment, the stakeholders would have access to their specific data, as agreed in the contract between the service provider and involved parties.

7 Standardization

Standards are the keystone of any technology for the following reasons:

- Standards are recognized nationwide and/or worldwide;
- Standards are the result of a collective effort—the participants of standardization working groups are tech companies and end users representing all fields of the industry;
- Standards guarantee interoperability which allows technologies to work anywhere; and
- Standards may be revised to meet the needs of the industry allowing for the continuity of their relevance over time.

Without the appropriate standards, the deployment and the use of technologies would be completely different. The risks of not having standards include

- Proprietary technologies with limitations in deployment;
- Lack of interoperability between technologies;
- Less neutrality in decision-making—the most technologically advanced participants are in the strongest position to influence the process; and
- No international validation of technologies deployment.

With the ramp-up of new and emerging technologies, standards are more necessary than ever to ensure interoperability, to ensure that all parties can participate in the process, to guarantee some neutrality in the decision-making process and to ensure the international recognition of technologies used in deployment.

Through wider adoption of standards between various transportation modes, more seamless transport can also be facilitated. This will result in supply chain efficiency by improving collaboration between the stakeholders.

8 Smart Container standards: data elements and message structures

This White Paper is one of the deliverables of the UN/CEFACT Transport & Logistics Domain Smart Container Project. Further deliverables of this Smart Container Project will define the

data elements generated by Smart Containers and Smart Container standard message structures. These deliverables will be defined in the Business Requirements Specification (BRS) and associated schema based on the UN/CEFACT Multi-Modal Transport Reference Data Model subset of the Core Components Library.

The Smart Container data message structures will be technology agnostic. These Smart Container standards will accelerate the integration of Smart Container data on different platforms, simplifying the utilization of the data as an additional source for decision-making and operations enhancement. In addition, utilizing the Smart Container standard data will ensure that communications between the supply chain actors are maintained, and participants are not locked out by using proprietary data or message formats.

9 Conclusion

In this White Paper, we have defined the concept of a Smart Container, identified twenty use cases of the Smart Container data utilization and explained the benefits of Smart Container solutions to ten potential stakeholders of the supply chain. A common understanding of Smart Container capabilities enables the comparison of different Smart Container solutions.

This White Paper is the initial step toward identifying all Smart Container solution data elements and defining message structures. The next deliverable will be a Business Requirements Specification (BRS) document that includes standardized data elements and message structures to accelerate the full integration of Smart Container data within the stakeholders' platforms via shared Application Programming Interfaces. The messaging standards for the Smart Container data will reduce the development efforts required by stakeholders to integrate new Smart Container data or new service providers into supply chain excellence.

Standards will enable the whole ecosystem to maximize the benefits of Smart Container solutions and ensure that no stakeholder will be locked into a single service provider. Standards will also ensure interoperability and increase collaboration between stakeholders. Sharing standardized Smart Container data among stakeholders will facilitate massive deployment and wide adoption of Smart Container solutions and pave the way towards cost optimization.

Smart Containers are taking the digital age of shipping one step beyond paperless processes by embracing the Internet of Things (IoT) to support enhanced decision-making by the various sectoral stakeholders. In a fast-evolving digitalized world, where interoperability and collaboration are fundamental, the availability of standardized Smart Container data offers end-to-end visibility, thus enabling more efficient, eco-friendly, safer, and better integrated international trade.