The Global Language of Business

GS1 Traceability Checklist Assessors Guide

Version 1.0 March 2021

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1. Interoperability, Enabling Technologies, and Supply Chain Technology Trends

1.1. Definitions

1.1.1. Interoperability definitions

- Interoperability is the ability of different information systems, devices and applications ('systems') to access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organisational, regional, national and international boundaries, to provide timely and seamless portability of information, to be accessed and shared appropriately and securely. [*The 4 (four) domains of interoperability are: Send, Receive, Find, and Integrate*.]
- Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged [IEEE Dictionary 1990].

In other words, interoperability is said to exist between two applications (or systems) when one application can accept data (including data in the form of a service request) from the other and perform the task in an appropriate and satisfactory manner (as judged by the user of the receiving system) without the need for extra operator intervention [Brown and Reynolds 2000].

1.1.2. Enabling Technologies definitions

Enabling Technologies are any equipment and/or methodology that alone or in combination with other technologies, provide the means to attain traceability and data exchange [*i.e., Different information systems, applications, equipment, and devices*].

1.2. Introduction

A traceability system is effective when products can be completely traced across the supply chain. The information should be readily accessible in order to know what, how much and from where product(s) need to be recalled.

The tenets of traceability are predicated on the following four principles:

Unique identification of products, logistic units, and locations

Traceability **data capture, verification, and recording**

Links management and traceability **data retrieval**

Traceability **data communication**

Furthermore, effective traceability is achieved through:

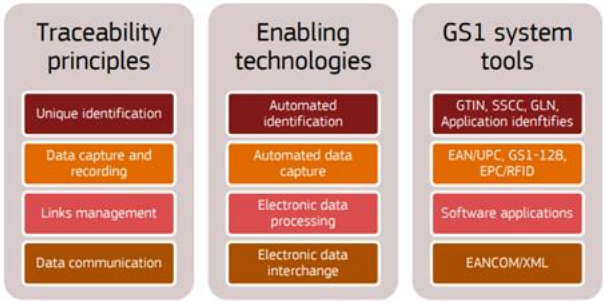
Identification – i.e. how traceable items are identified and coded,

Procedures – i.e. how traceability is acknowledged, performed, and documented,

Operations – i.e. how traceability works and how it is monitored, and how crisis are managed, and

Information – i.e. what information is being used, recorded, and shared.

The following diagram portrays an implementation grid that links the Traceability Principles to Enabling Technologies and GS1 System Tools.



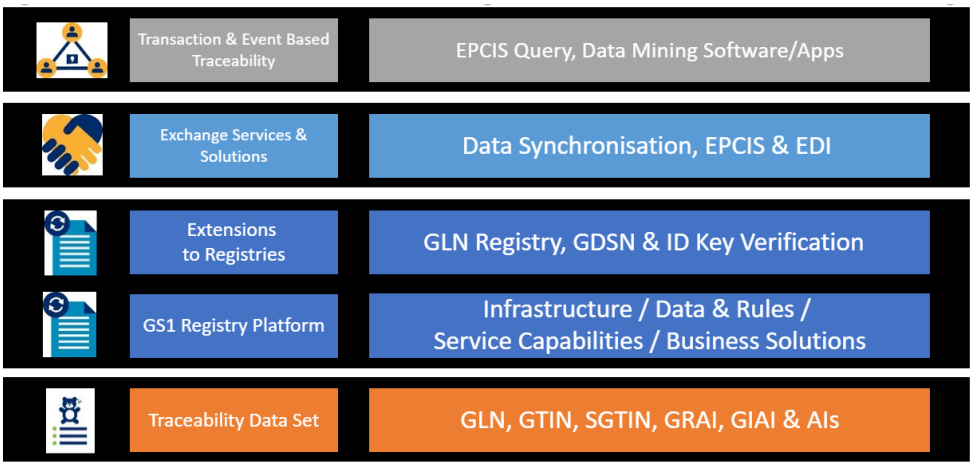
1.3. Interoperability

GS1 standards provide the building blocks needed for interoperable, end-to-end traceability systems.

By building interoperability, based on global open GS1 standards, into traceability systems, trading partners can access, combine, and analyse data from a variety of upstream and downstream sources.

Furthermore, interoperability requires different information systems, applications, and devices (i.e., enabling technologies) to capture, access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organisational, regional, national, and international boundaries, to provide timely and seamless portability of information, to be accessed and shared appropriately and securely.

The following diagram represents the building blocks required for interoperability based on GS1 Standards, GS1 Registries, GS1 Data Services and GS1 Enabling Technologies.



Additionally, AIDC[1] technologies (such as Scanning, RFID[2], POS[3]) have an important role to play too.

Interoperability can be achieved in various ways and one of these ways could be to:

- Identify company internal departments/partners that will share data, include the proper fields in the system, and organise the sharing of data.
- Externally - Identify and understand the interactions and data needs of upstream and downstream partners.
- Link organisation with relevant regulatory databases to enable the capturing and sharing of master, transaction, and event data.
- Detail the requirements for interoperability in data governance and management using available GS1 resources (e.g., EPCIS[4] workbench).

[1] AIDC – Automatic Identification and Data Capture
[2] RFID – Radio Frequency Identification
[3] POS – Point of Sales
[4] EPCIS – Electronic Product Code Information Services

- Designing the traceability data repository functions.
- Designing the traceability data usage functions.
- Establishing traceability links management.

1.3.1. Data Recording requirements

- Master Data, Transaction Data, Visibility Event Data
- Relation Data – internal systems using GS1 identification keys
- Critical Tracking Events (CTEs): Observation, Transformations, Aggregation, etc.

1.3.2. Data Sharing requirements

- Master Data – Trade items, Parties and Locations, Assets, Relation Data
- Transaction Data – Orders, Shipments, Receipts, Invoices, Recalls
- Visibility Event Data – Critical Tracking Events (CTEs) and Key Data Elements (KDEs), EPCIS, CBV[5]

1.3.3. Data Management responsibilities

- The data management aspects of traceability identify and references the necessary requirements for identifying, capturing, and sharing data using a simple model (see Appendix B – Data Management Responsibilities) that works across known and trusted chains of custody or ownership.
- Traceability data is identified, captured, and shared across the "who, what, when, where and why" dimensions, in order to provide applications with sufficient business context to effectively use the data.
- Data management also provides a foundation to enable data sharing across more complex supply chains, where parties need to find and retrieve information from companies that are not their direct trading partners and where trust may need to be established before data can be shared.
- These data management responsibilities follow from rules as defined in the various foundational GS1 standards (GS1 General Specifications, GTIN management rules, GDSN), application standards (Product Recall Management) and those as defined in GTS v2.
- Data management responsibilities include:
    - (IDENTIFICATION) GS1 identification key management – GTIN, GLN, GCN, SSCC, GINC, GSIN, GIAI, GRAI, GSRN, GDTI, CPID
    - (DATA SHARING) Master data – Trade item master data, Party & Location master data, Other master data (related to assets, service relations, etc.)
    - (DATA RECORDING & SHARING) Capturing, recording, and sharing of visibility event data.
    - (DATA SHARING) Transaction data sharing – Despatch Advises, Receiving Advices, etc.
    - (DATA SHARING) Product recall data sharing – Product recall notification, Product removal confirmation; Product recall closeout notification.

[5] CBV – Core Business Vocabulary

1.3.4. Traceability system capabilities

Identification and labelling	Traceable items are identified and coded and labels identifying trade items.
Record Keeping & Links Management	Comprises the business requirements and business rules that ensure effective record keeping and links management.
Process flows (how traceability is performed and documented)	Recording of process flows of product together with the flow of transactions and information about the product at all stages.
Data standardisation	Structural and semantic data standardisation to the GS1 System and GS1 Traceability Data Standards.
Recording & Verifying Movements	Capabilities for recording and verifying movements both internal, external (One-Up, One-Down), and chain traceability.
Data capture methods	Data capture methods that ensure that data capture devices interpret data contained in a barcode properly and recognises all AI's used and splits information accordingly.
Information Sharing	Send, Receive, Find, Integrate capabilities.
Interoperability and Interconnectivity	Data exchange architectures, application interfaces and standards to enable interoperability and interconnectivity.
Traceability System requirements	The traceability system allows an organisation to document and/or to locate a product through the stages and operations involved in the manufacture, processing, distribution, and handling of traceability objects, including the verification of: • identification of units / batches of all items • registration of information on when and where units / batches are moved or transformed, and • a system linking these data and transferring all relevant traceability information together with the item to the next stage or processing step.

1.3.5. Enabling Traceability

"A traceability solution defines the essential information that must be collected, recorded, and shared to ensure what is known as "one step up, one step down" or "full chain" traceability. Ideally it also has electronic messaging capabilities to exchange essential business information. It should also allow an organisation to document and/or to locate a product through the stages and operations involved in the manufacture, processing, distribution, and handling of traceability objects, including the verification of identification of units / batches of all items, the registration of information on when and where units / batches are moved or transformed, and have the ability to link this data and transferring all relevant traceability information together with the item to the next stage or processing step."

When it comes to traceability data, an organisation should first look at its internal business processes. The organisation should identify which steps in those business processes are important from a traceability perspective. Subsequently, the organisation will need to establish processes to define and capture all the relevant data about these business process steps, which will enable the effective use of the data within and outside of the organisation.

Enabling technologies (i.e. different information systems, applications, equipment, and devices) help and support the internal processes of the business attain traceability and data exchange through its capabilities to perform automated identification, data capture, data verification, electronic data processing and data interchange.

End-to-end supply chain traceability extends the responsibilities of the organisation to include the exchange of data outside of the walls of any one enterprise. Specifically, this refers to the ability to track and trace an object through its entire life cycle and through all parties involved in its production, custody, trade, transformation, and use.

Because of the complexities inherent to most supply chains, each party will need to ensure traceability data can flow in two directions (upstream and downstream). Systems will need to support parties querying for data that may exist upstream or downstream from the organisation.

Standards for identification, capture and sharing, are a key enabler in achieving the required interoperability to establish connections between the systems of the different parties.

It is important for suppliers, retailers, processors, distributors, wholesalers, and operators to understand the value of collecting and maintaining product information that supports, at the very least, "one up/one down" traceability and to meet consumer and regulatory demands for accurate and detailed product information.

The use of the standardised vocabulary is critical to interoperability and critical to provide for querying of data by reducing the variation in how different businesses express common intent.

Interoperability enables trading partners to share information about the physical movement and status of products as they travel throughout the supply chain – from business to business and ultimately to consumers.

The goal of interoperability is to enable disparate applications to create and share visibility event data, both within and across enterprises. This sharing is aimed at enabling users to gain a shared view of physical or digital objects within a relevant business context.

1.4. Enabling Technologies

Enabling technologies are designed to provide, store and extract value from large and varied sources and volumes of data and systems and human interactions, by enabling efficient automated processes and high-velocity data capture, discovery, and/or analysis.

Enabling technologies (i.e. different information systems, applications, equipment, and devices) help and support the internal processes of the business attain traceability and data exchange through its capabilities to perform automated identification, data capture, data verification, and electronic data processing and data interchange.

Enabling Technologies functionality that support interoperability includes:

- **Identification and Capture Data Interphases:** Data Entry, Scan, Read, Image, Sensor, Electronic Messages, Electronic Files
- **Verification:** GLN Registry (Locatenet), GTIN Registry (GCP), GDSN (NPC)
- **Data Storage:** RDBMS, Cloud technologies, Blockchain
- **Data Analysis:** Data Analytics,
- **Data Sharing** (Push/Pull)**:** CSV, XML, XML Schema, SOAP, JSON/JSON-LD, REST
- **Information Security:** Authorisation, Access

1.5. Supply Chain Technology Trends

The goal of traceability across the supply chain, in relation to interoperability and enabling technologies, is to make information accessible to all the relevant supply chain parties.

Almost any useful business-to-business or business-to-consumer application needs data from multiple sources. Integrating all this information is extremely difficult, especially if it is unstructured. The more data can be open, structured, and linked, the stronger impact they will have in enabling greater interoperability.

Supply chains are consistently seeking out new ways to improve customer services. From mass production to just-in-time and one-hour delivery. These have led to unprecedented demands that need to satisfy heightened levels of all of the following:

- automation and "Smart Everything",
- scaling of mass customisation,

- empowered consumers,
- on-demand logistics and services,
- traceability, and
- sustainability.

Additionally, new technologies are constantly emerging and not only allows for information to be more accessible, but they ultimately change supply and retailing in very profound ways, unleashing new potentials for capturing, recording, sharing, and using information.

Supply Chain Technologies comprising of physical tools, information tools, and process automation includes but is not limited to:

- Advanced Analytics (AI – Artificial Intelligence, ML – Machine learning, Big Data)
- Automated Storage and Retrieval Systems (ASRS)
- Autonomous Vehicles & Logistics
- Blockchain
- Computer Vision
- Data Integrations
- Digital Receipts
- Drones
- Internet-Of-Things
- Robotics
- Sensors
- Voice Recognition and Natural Language Processing

No one technology can solve every problem. Therefore, companies must evaluate trends and consider investing in many different technologies. Some of these technologies are described below.

1.5.1. Artificial Intelligence (A.I.)

A.I. describes advanced, smart computing techniques used to analyse complex problems and data. It helps define patterns in data and provides predictive analytics.

A.I. enables the Automation/Smart Everything trend, powering new applications for autonomous robotics, creating new ways of engaging with today's empowered consumers, and solving ever new challenges in real-time.

1.5.2. Autonomous Logistics

In the same way that self-driving cars are disrupting personal transportation, there is a surge of applications that are taking advantage of autonomous systems for logistics.

Robotics and A.I. are other technologies that are contributing to the advancement of autonomous logistics, which is a key enabler for business trends such as on-demand logistics, and Automation/Smart Everything.

1.5.3. Blockchain and Distributed Data

The interest in blockchain has expanded across industry as a way to share data and information across a large number of participants, while offering the possibility of greater data and transactional security.

Blockchain offers new capabilities and is helping to re-ignite interest in other approaches to managing distributed data, such as edge computing and distributed data warehouses.

This technology is being rapidly evaluated today as a potential enabler for traceability, especially in food safety and other applications.

1.5.4. Computer Vision

While early advances in computer vision focused exclusively on image recognition, the field has expanded. Vision systems can now observe environments and make decisions and conclusions to support a variety of applications, especially to aid product quality control in the warehouse.

This technology is enabling many business trends, most notably Automation/Smart Everything—and is creating efficiency and speed in support of on-demand logistics and services.

1.5.5. Augmented, Virtual (AR/VR) and Mixed Reality

The ability to superimpose digital images and information into the real world using mobile phones, displays and wearable headsets is helping to improve accuracy and efficiency in industrial and commercial settings.

These systems will have a big impact in driving new advances in the Automation/Smart Everything and empowered consumer business trends.

1.5.6. Drones

Organisations are beginning to adopt drones in the first phase of supply chain management: obtaining raw materials.

Drones are also used in mining, prospecting, and land surveying applications. In farming and agriculture. UAVs (unmanned aerial vehicles) are used to inspect plant health, photo-log plant growth, and map crop yields.

Drones are also testing soil to help optimise water content and fertiliser usage, with the intent of improving crop yields.

The last mile to the customer is often the most expensive and inefficient aspect of supply chain management, but drones' potential to speed up deliveries and reduce costs has some believing they will change the way the world delivers goods.

1.5.7. Voice Recognition

Voice recognition and natural language processing have advanced—and are driving the adoption of personal assistant devices.

This new "conversational commerce" is emerging as a hot new trend that is impacting brands, companies, and marketplaces. These players are increasingly connecting with consumers through apps and voice to improve product research, answer questions and simplify purchases.

This technology enabler will have the biggest impact on the trends: empowered consumer and Automation/Smart Everything.

1.5.8. Robotics

Robotic systems take on many forms, whether carrying out actions autonomously or semi-autonomously or acting in concert with other robots or people for more complex tasks.

A new trend in robotics is "collaborative robots" (also referred to as cobots or co-robots) in which robots are interacting with people in warehouses and manufacturing settings.

Robotics is a key enabler in the Automation/Smart Everything trend. It is also assisting in the scaling of mass customisation.

1.5.9. Internet of Things (IoT), Sensors and Biometrics

The IoT has had an enormous impact on every industry, creating a "design platform" that enables the development of a variety of applications.

Key business trends enabled by IoT, sensors and biometrics includes Automation and "Smart Everything", empowered consumers, on-demand logistics and services, traceability, and sustainability.

1.6. Key Takeaways

1.6.1. Interoperability

- Interoperability has to do with the way computer and software systems can connect and communicate with one another.

- Standards established by government and industry help foster better communication between disparate systems.
- GS1 standards provide the building blocks needed for interoperable, and end-to-end traceability systems.
- Interoperability makes it easier for supply chain partners to share information with one another, hence affording more supply chain visibility and transparency.
- Interoperability makes supply chains more efficient.
- Safety and the protection of confidential data is a central part of interoperability standards.
- Lowered costs are a natural result of improved interoperability in supply chains, given improved efficiency in data sharing.

Recognising the importance of interoperability is crucial. Given that so many systems and pieces of equipment are connected with one another over wired and wireless networks, it is important to stay on top of interoperability developments.

1.6.2. Enabling Technologies

- Comprises different information systems, applications, equipment, and devices.
- Includes automatic data identification and capture technologies, data sharing technologies and choreographies (EDI, EPCIS, centralised, networked, blockchain …) and solutions/technologies that are supported by GS1 standards to capture and share standardised data.
- Make up an ecosystem where different "technologies" work together.
- The GS1 System underpins different enabling technologies and their approaches to achieve cost savings, process efficiency, inventory and asset visibility, supply chain transparency and traceability.

Enabling technologies support and help the internal processes of the business attain traceability and data exchange through its capabilities to perform automated identification, data capture, data verification, electronic data processing and data interchange.

1.6.3. Supply Chain Technology Trends

- Supply chain technologies comprises of physical tools, information tools, and process automation.
- New technologies are constantly emerging and unleashing new potentials for capturing, recording, sharing, and using information.
- Trending supply chain technologies satisfy heightened levels of automation, empowered consumers, traceability, and sustainability.
- No one technology can solve every problem. Therefore, companies must evaluate and invest in many different technologies.

The goal of traceability across the supply chain, in relation to interoperability and enabling technologies, is to make information accessible to all relevant supply chain parties.

1.7. Appendix

1.7.1. Summary of interoperability requirements

A Summary of interoperability requirements

The table below provides a summary of the requirements and related GS1 standards, as listed in section 5.

Main topic	Subtopic	GS1 standards
IDENTIFICATION REQUIREMENTS		
Traceable objects	Trade items	GTIN, GTIN + lot ID, GTIN + serial ID
	Assets	GIAI, GRAI
	Logistic units	SSCC, GSIN, GINC
	Coupons	GCN
Parties		GLN, GSRN
Locations		GLN, GLN + GLN extension component
Transactions / documents		GDTI
AIDC REQUIREMENTS		
Barcodes	Trade items (GTIN-only)	(GTIN-only) EAN/UPC, ITF-14, GS1 DataBar non-expanded
	Trade items, assets, logistic units, parties, locations, transactions / documents	(GS1 identification key + attributes) GS1-128, GS1 DataMatrix, GS1 QR Code, GS1 DataBar expanded
RFID	Trade items, assets, logistic units, parties, locations, transactions / documents	EPC/RFID
DATA RECORDING REQUIREMENTS		
Relation data	Suppliers, customers, 3rd parties	Internal, using GS1 identification keys
Critical Tracking Events	Observations	EPCIS: Object Event CBV business steps: commissioning, shipping, receiving, transporting, storing, …
	Transformations	EPCIS: Transformation Event CBV business steps: commissioning
	Aggregations	EPCIS: Aggregation Event CBV business steps: packing, installing, …
DATA SHARING REQUIREMENTS		
Master data	Trade items	GDSN, GS1 SmartSearch, GS1 EDI, EPCIS
	Parties and locations	GLN Service, GS1 EDI, EPCIS
	Assets	EPCIS
	Relation data	Bilateral, no standard
Transaction data	Shipments, receipts	GS1 EDI Despatch Advice (DESADV), Receiving Advice (RECADV), GS1 Transport Status Notification (IFTSTA)
	Recalls	GS1 EDI Product Recall standard
Visibility event data	Critical Tracking Events	ECPIS, CBV

1.7.2. Data Management Responsibilities

B Data management responsibilities

The table below aims to provide a summary of the main data management responsibilities by role.

Data management responsibility	Primary party (data source, initiator)	Secondary parties (data recipients, others)	Responsibilities defined in
(IDENTIFICATION) GS1 identification key management			
GTIN	Brand owner (*)	n/a	[GENSPES] [GTIN-MAN]
GLN	Location owner, location primary user (**)	n/a	[GENSPECS] [GLN-ALL]
GCN	Coupon offer issuer	n/a	[GENSPECS] [DCM]
SSCC	Physical builder or brand owner	n/a	[GENSPECS] [LOG_LAB]
GINC	Carrier or freight forwarder	n/a	
GSIN	Shipper, consignor	n/a	
GIAI, GRAI	Asset owner or manager	n/a	[GENSPECS]
GSRN	Organisation offering the service	n/a	
GDTI	Document issuer	n/a	
CPID	Buyer (OEM)	n/a	
(DATA SHARING) Master data			
Trade item master data	Data source (brand owner (*), see GTIN)	Any party that fulfils the conditions under which these data are to be shared.	[GDSN], [GENSPECS]
Party & location master data	Data source (location owner or manager, see GLN)		[GLN-SER], [GENSPECS]
Other master data (related to assets, service relations, ...)	Party that assigned the identification key, see above.		[GENSPECS]
(DATA RECORDING & SHARING) Capturing, recording and sharing of visibility event data			
Object events	Any party that is engaged in any of the following business steps: commissioning, shipping, receiving, transporting ...	Any party that fulfils the conditions under which these data are to be shared, for example based on chain of custody or chain of ownership relations.	[GTS2]
Transformation events	Any party that is engaged in any of the following business steps: commissioning, processing, ...		
Aggregation events	Any party that is engaged in any of the following business steps: packing, loading, unloading ...		
(DATA SHARING) Transaction data sharing			
Despatch advice	Shipper, consignor, seller	Receiver, consignee, buyer	[GS1-EDI] [LIM]
Receiving advice	Receiver, consignee, buyer	Shipper, consignor, seller	[GS1-EDI] [LIM]
Transport status notification	Logistics service provider, carrier	Receiver, consignee, buyer	[GS1-EDI] [LIM]
(DATA SHARING) Product recall			
Product recall notification	Product recall initiator	Product recall recipient	[GS1-EDI] [RECALL]
Product removal confirmation	Product recall recipient	Product recall initiator	
Product recall closeout notif.	Product recall initiator	Product recall recipient	
Notes: (*) see [GENSPECS] section 4 for non-branded items and exceptions. (**) See [GENSPECS] section 4 for exceptions.			

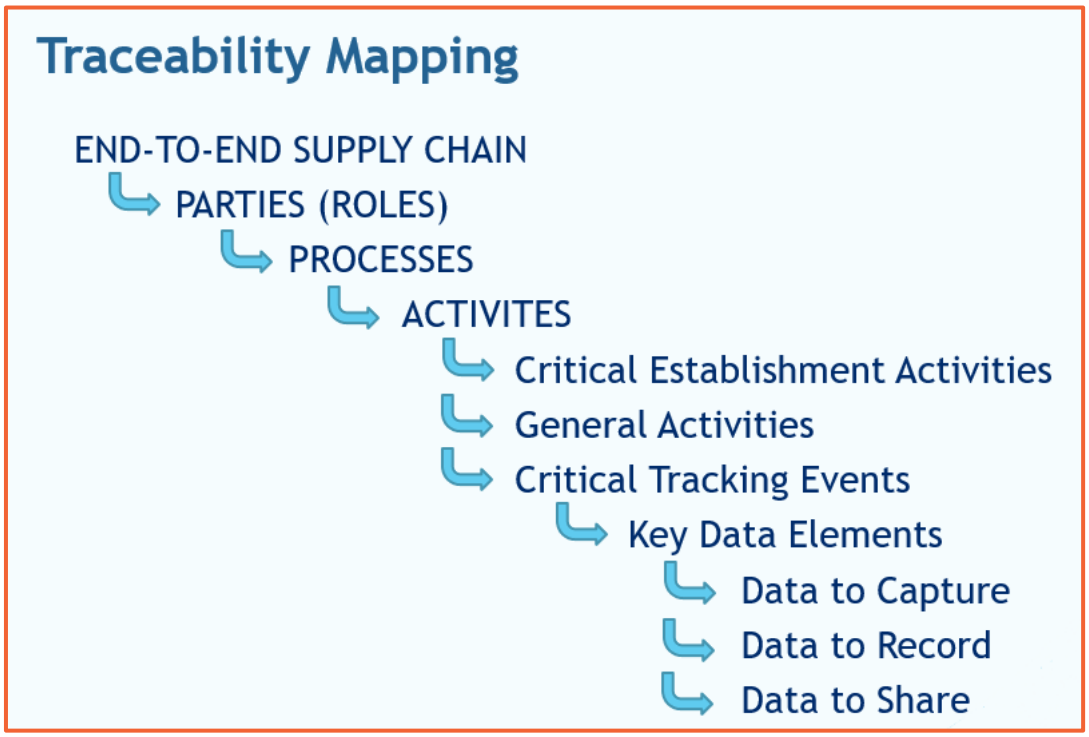
2. Data Reflecting the Full Supply Chain (CTEs & KDEs)

2.1. Introduction

GS1 standards provide the building blocks needed for interoperable, end-to-end traceability systems. By building traceability systems based on global, open GS1 standards, trading partners can access, combine and analyse data from a variety of upstream and downstream sources.

Furthermore, interoperability is the ability of different information systems, devices and applications ('systems') to access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organisational, regional and national boundaries, to provide timely and seamless portability of information.

When it comes to traceability data, an organisation should first look at its internal business processes. The organisation should identify which steps in those business processes are important from a traceability perspective. Subsequently, the organisation will need to establish processes to define and capture all of the relevant data about these business process steps, which will enable the effective use of the data within and outside of the organisation. The traceability mapping diagram below illustrates a view of the depth and one-to-many relationships of traceability data, cascading from the top (the full end-to-end supply chain), across parties, processes and activities and all the way to the bottom (to the data that is captured recorded and shared).



End-to-end supply chain traceability extends the responsibilities of the organisation to include the exchange of data outside of the walls of any one enterprise. Specifically, this refers to the ability to track and trace an object through its entire life cycle and through all parties involved in its production, custody, trade, transformation, and use.

Because of the complexities inherent to most supply chains, each party will need to ensure traceability data can flow in two directions (upstream and downstream). Systems will need to support parties querying for data that may exist upstream or downstream from the organisation. Standards for identification, capture and sharing, are a key enabler in achieving the required interoperability to establish connections between the systems of the different parties.

GTSv2 introduced the key concepts for achieving interoperable traceability, which includes:

- **Critical Tracking Events (CTEs)**: These are the actual events (e.g. receiving, packing, shipping, transporting) that occur to the traceable object during its lifecycle. These include: Creation, Transformation, Transportation and Depletion events.

- **Key Data Elements (KDEs)**: These are the pieces of data that describe the actual instances of the CTEs.
- **Links Management and traceability data retrieval**
- **EPCIS & CBV** (Electronic Product Code Information Services & Core Business Vocabulary)

2.2. The CTE/KDE Framework

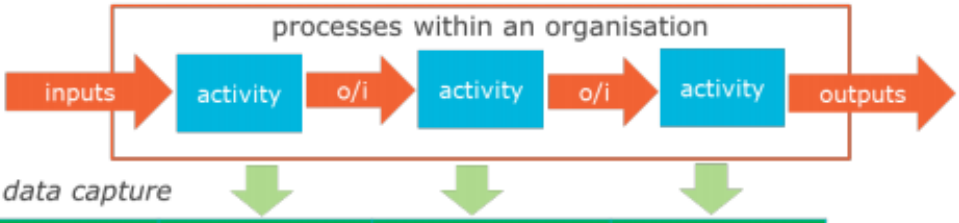
Traceability processes are only as good as the weakest link and there are various links or points in a supply chain at which data capture is necessary to follow product movement. The CTE/KDE Framework provides the ability to clearly identify which data elements need to be provided in order to effectively trace products throughout the supply chain.

It is important to establish the CTEs and KDEs for each of the role (player) in the value chain to ensure that the link from origin to final product is not broken.

Key data Elements		**Critical Tracking Events**			
		Creation	Transportation	Transformation	Depletion
		Harvest, hatch, grow, catch	Load, fill, order, ship, return, transport, receive, unload, store, warehouse	Process, Production, package, batch input or output, separate, sort, combine, mix, repack, comingle, rework	Sell to consumer, consumption, discard, dispose, lose
Who	Event owner: - Supplier	X	X	X	X
	Event owner: - Trading Partner	X	X	X	X
	Event owner: - Transporter		X	X	
	Event owner: - Customer		X	X	X
What	Item, Good, Product, Trailer, Vehicle, Commodity, Variety, Packaging type, Packaging materials, Packaging style, Batch, Lot Code, Sell-by or Use-by Date, Quantity, Unit of measure	X	X	X	X
When	Date, Time	X	X	X	X
Where	Origin, Event Location, Product Source, Product Destination	X	X	X	X
Why	Business process of Critical Tracking Event (CTE)	X	X	X	X
Links	Activity, Bill of Lading, Invoice,	X	X	X	

	Packing Slip, Load information, Farm Ticket, Purchase order, Work order				

Figure 3-1 Critical Tracking Events (CTE) and Key Data Elements (KDE) - example



KDE:	CTE 1	CTE 2	CTE 3
Who	gln	gln	gln
What	gtin+lot	gtin+lot	sscc
Where	gln	gln	gln
When	date+time	date+time	date+time
Why	business process	business process	business process

2.2.1. What are Critical Tracking Events (CTEs)

Critical Tracking Events (CTE) are various points in a supply chain at which data capture is necessary to follow product movements and link supply chain partners.

- It is important for suppliers, retailers, processors, distributors, wholesalers, and foodservice operators to understand the value of collecting and maintaining product information that supports, at the very least, "one up/one down" traceability.
- Critical tracking events identify those core business processes where traceability data capture is vital to a successful traceability process. These include:
    - **Creation Events** - Harvest, Hatch, Grow, Catch, etc.
        - ***Creation CTEs***
    - **Transportation Events (transfer/exchange/movement of goods)**
        - ***Transfer CTEs; Shipping CTEs; Receiving CTEs***
    - **Transformation Events (aggregation/disaggregation/manipulation of products/ commingling)**
        - ***Transformation Input CTEs; Transformation Processing CTEs, Transformation Output CTEs; Aggregation CTEs; Disaggregation CTEs; Commingling CTEs***
    - **Terminal Events (these events exist at the terminals of a supply chain, for example cooling, washing, and sorting)**
        - ***Terminal CTEs***
    - **Depletion Events (when the traceable object exits from the system)**
        - ***Consumption CTEs; Disposal CTEs***

2.2.2. What are Key Data Elements (KDEs)?

Key Data Elements (KDEs) ensure that captured and recorded data can be interpreted by all supply chain partners. KDEs are the "currently required" and "linking" key data elements for capture and record-keeping at critical tracking events. Key Data Elements define: Who, What, Where, When, Why, for each Critical Tracking Event identified above. Additionally, Links (or Linking KDEs) identify transaction references, business document types and business activities to be captured, recorded and kept.

Since many KDEs are expressed as identification keys, master data (MD) related to these keys will be required. For a trade item class, for example, master data might include the trade item's dimensions, descriptive text, nutritional information (in the case of a food product) etc. Although master data is static, it can change over time. It is important to refer to the master data in effect at the time of the Critical Tracking Event.

Key Data Elements define:

- **Who** or which parties are involved?
- **What** is the primary product or item being traced?
- **Where** did a movement or event that included the product take place?
- **When** did a movement or event that included the product occur?
- **Why** was the product at that location at that time? What business process was happening? What business transactions were taking place?

Identifiers (i.e. GS1 Identification Keys) - are used to determine, who or which parties are involved, what are the specific trade items and logistic units, and the locations where movements or events occurred, as follows:

- Parties
- People
- Trade Items
- Batch/Serial/Expiry
- Logistic Units
- Physical Locations

Activity / Document Types & Attributes - Identify the activity, the data to be captured and the traceability data and documentation to be kept, and includes, but is not limited to:

- Master Data
- Purchase Order
- Purchase Order Response
- Goods Receipt
- Receiving Advice
- Payment
- Goods Putaway / Storage
- Stock Movements
- Sensor Data Recording
- Consumption Data for Reimbursement

GS1 Key Association – is the linkage between the various identifiers at the time of the Critical Tracking Event. Examples include:

- Party GLN + Drop Point Location GLN + GSIN/GINC/SSCC
- Party GLN + Storage Location GLN + SGTIN

2.2.3. What is EPCIS & CBV?

Electronic Product Code Information Services (EPCIS) is a GS1 standard that enables trading partners to share information about the physical movement and status of products as they travel throughout the supply chain – from business to business and ultimately to consumers. It helps answer the "who, what, where, when and why" questions to meet consumer and regulatory demands for accurate and detailed product information.

The goal of EPCIS is to enable disparate applications to create and share visibility event data, both within and across enterprises. This sharing is aimed at enabling users to gain a shared view of physical or digital objects within a relevant business context.

EPCIS is intended to be used in conjunction with the GS1 Core Business Vocabulary (CBV) standard. The CBV provides definitions of data values that may be used to populate the data structures defined in the EPCIS standard. The use of the standardised vocabulary provided by the CBV standard is critical to interoperability and critical to provide for querying of data by reducing the variation in how different businesses express common intent.

Strawberry KDEs for the Harvesting CTE. Example:

WHO	
GLN of party	Used to identify the strawberry company that grows the strawberries
WHAT	
GTIN	Global Trade Item Number that identifies the type of trade item. In this case, the strawberry farmer would assign a unique GTIN to the strawberry varieties that he grows
Batch/lot number	The batch/lot number associates a trade item with information the manufacturer considers relevant for traceability of the trade item. The data may refer to the trade item itself or to items contained in it. In combination with the GTIN the batch/lot number identifies a group of trade item instances.
Serial number	A numeric or alphanumeric code assigned to an individual instance of an entity for its lifetime. In combination with the GTIN the Serial number identifies exactly one trade item instance.
Quantity	The quantity of the respective trade item.
Net weight	Used to identify the net weight of the trade item. Net weight excludes any packaging materials. Has to be associated with a valid unit of measurement.
SSCC	Serial Shipping Container Code that identifies an individual logistic unit.
WHERE	
GLN of physical location	Used to identify the farm or specific location of the Harvest Used to identify production and inventory locations.
WHEN	
Date and time of Critical Tracking Event (CTE)	E.g. production, shipping, receiving, harvesting date
WHY	
Business process of Critical Tracking Event (CTE)	Used to record the process context of the critical tracking event. Example: shipping, harvesting, picking
Disposition	Status of the traceable object subsequent to the CTE. Example: available for sale, quarantined.
Transaction reference	Example: sales note, PO reference.

Strawberry KDEs for the Receiving CTE. Example:

	
who	GLN of supplier GLN of customer
what	SSCC GTIN + batch/lot ID + quantity OR GTIN + serial ID
when	date time of receipt
where	GLN of receiving location
why	[cbv] receiving

2.3. An Effective Traceability Framework that reflects full supply chain data

2.3.1. End-to-End Supply Chain Visibility, Efficiency & Interoperability (Mind-map) Diagram

2.3.2. Supply Chain Diagram – Stakeholders in a supply chain:

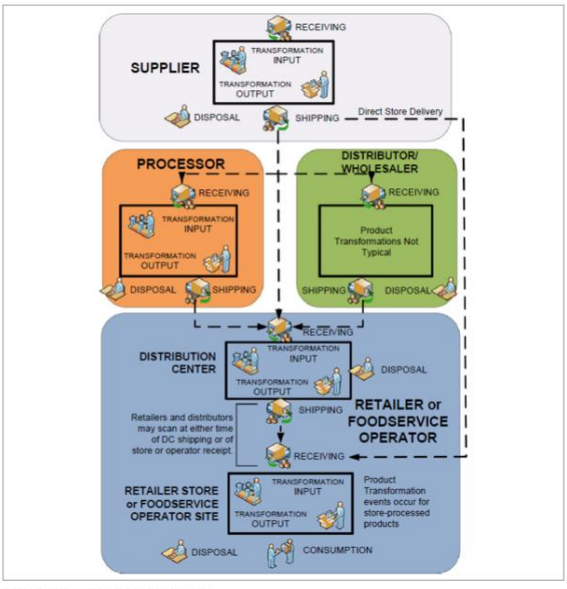


Figure 6–Critical tracking events for meat and poultry.

2.3.3. Process Flow Diagram:

2.3.4. Role of different entities in the Processed Food distribution channel:

Role	Activities	Examples
Primary roles		
Raw Material Suppliers	Produce and ship	
Warehouse Operators	Receives, stores, despatch	
Manufactures	Receive, produce, stores, sell, ship	
Transporters	Load, Transport, Unload	
Distributors		
Retail Warehouses		
Retailers	Receive, stores, sell, ship	
Food Service Operators	Storage, prepare, cook, sell to consumer	
Restaurants		
Schools		
Secondary roles		
Feed Suppliers	Produce and ship	
Packaging Material Suppliers	Produce and ship	
Ingredient Suppliers	Produce and ship	
Third-Party Logistics Service Providers	Transport (plans, markets and executes transport services) and store	
Regulatory Organisations	Compliance oversight	
Service Providers	Maintenance, Checking, Chemical treatments, Measurement of environmental data	

2.3.5. CTE/KDE Framework

NOTE: Although multiple CTEs are clustered together below, it should be noted that each and every critical tracking event will have a unique relationship with each of its KDEs. The KDEs required will vary depending on the CTE that is being performed. Every CTE must be mapped separately.

ROLE	Represents a unique set of functions or responsibilities. Primary or Secondary
CTEs	Critical tracking events identify those core business processes where traceability data capture is vital to a successful traceability process. These include: • Creation Events - Harvest, Hatch, Grow, Catch, etc.: Creation CTEs • Transportation Events (transfer/exchange/movement of goods): Transfer CTEs; Shipping CTEs; Receiving CTEs

	• Transformation Events (aggregation/disaggregation/manipulation of products/ commingling): Transformation Input CTEs; Transformation Output CTEs; Aggregation CTEs; Disaggregation CTEs; Commingling CTEs • Terminal Events (these events exist at the terminals of a supply chain, for example cooling, washing, and sorting): Terminal CTEs • Depletion Events (when the traceable object exits from the system): Consumption CTEs; Disposal CTEs
KDEs	
WHO	Who or which parties are involved? • Immediate Supplier; Even Owner; Subsequent Customer; Transporter, Carrier, Trailer
WHERE	Where did a movement or event that included the product take place? • Origin, Location, Destination
WHEN	When did a movement or event that included the product occur? • Date; Time
WHAT	What is the primary product or item being traced? What business process was happening? What business transactions were taking place? • Product; Commodity • Packaging Type; Materials; Style • Variety; Species • Batch/Lot code; Sell-by Date, Use-by Date • Serial number • Quantity; Amount
WHY	Why was the product at that location at that time? • Business process of Critical Tracking Event (CTE) • Disposition • Transaction reference
LINKING KDEs	
Identifiers	Identifiers (i.e. GS1 Identification Keys) - are used to determine, who or which parties are involved.
Activity / Document Types & Attributes	Identify the activity, the data to be captured and the traceability data and documentation to be kept.
DATA AND DOCUMENT REQUIREMENTS for specific events	
DATA TO COLLECT (Identify)	
<Insert>	
<Insert>	
DATA TO RECORD (Capture)	
<Insert>	
<Insert>	
DATA TO SHARE (Share)	
<Insert>	
<Insert>	
DOCUMENT TYPES	

<Insert>	
<Insert>	
NOTES:	

2.4. CTE/KDE Framework with EPCIS & CBV

As mentioned earlier, EPCIS is a GS1 standard that enables trading partners to share information about the physical movement and status of products as they travel throughout the supply chain. The EPCIS and CBV standards, where applicable, can be used in conjunction with the CTE/KDE framework.

The following table places the EPCIS &CBV standard data values and CTE/KDE Framework information elements side by side in an attempt to correspond and contrast these elements to provide a clearer understanding of the relationship between the EPCIS & CBV standards and the CTE/KDE Framework.

Traceability Information	EPCIS & CBV data values	CTE/KDE information elements
Critical Tracking Events (CTEs)		
Event Type	Object Event Aggregation Event Transaction Event Transformation Event	• Creation Events: Creation CTEs • Transportation Events: Transfer CTEs; Shipping CTEs; Receiving CTEs • Transformation Events: Transformation Input CTEs; Transformation Output CTEs; Aggregation CTEs; Disaggregation CTEs; Commingling CTEs • Terminal Events: Terminal CTEs • Depletion Events: Consumption CTEs; Disposal CTEs
Event Action	Add Observe Delete	
Event Definition	Definition of the event	
Key Data Elements (KDEs)		
WHO	Traceability Party: a) Carrier / 3PL b) Processor / Manufacturer / Primary Producer c) Retailer / Point of Sale / Service Operator d) Warehouse / DC e) Authorities	Who or which parties are involved? Roles include: a) Transporter b) Traceable Item Creator / Traceable Item Source c) Traceable Item Creator / Traceable Item Recipient d) Traceable Item Creator / Traceable Item Recipient / Traceable Item Creator / Traceable Item Source e) Authorities
WHAT	The traceability object(s)	What is the primary product or item being traced? What business process was happening? What

		business transactions were taking place?
Traceability (EPCIS) Object	- digital object (document) - physical object a) Class-level b) Batch/Lot-level c) Instance-level	RAW - Raw Material PM - Packaging Material SFG - Semi-Finished Goods FG - Finished Goods Note: These may be identified as either Fix Measure (FM) or Variable Measure (VM)
Input	One or several instances of traceable items, as inputs, that are subjected to internal processes. Inputs may be data, physical entities or a mixture of both.	Base Case Crate Truck Load Keg/Barrel Pallet Container Shipment Vessel etc.
Output	One or several instances of traceable items, as outputs, that result from internal processes. Outputs may be data, physical entities or a mixture of both.	Base Case Crate Truck Load Keg/Barrel Pallet Container Shipment Vessel etc.
Parent traceable object	Higher Order (Larger) level of packaging or aggregation of child traceable objects	
Child traceable object	The traceability object(s) that make up the Parent Traceable object	
WHEN	When the event occurred	When did a movement or event that included the product occur?
	Event Time	• Date/Time
	Event Time Zone Offset	
WHERE	Where the event took place	Where did a movement or event that included the product take place? • Origin, Location, Destination
Location	Specific place and/or business location at which the traceability object was last seen.	Location GLN

Read Point	Can be a barcode scanner or RFID reader at a door or area within a location	
WHY	Why the event occurred	Why was the product at that location at that time?
Business Step(s)	May refer to one of the CBV business steps or a user defined business step	• Business process of Critical Tracking Event (CTE)
Disposition	An objects current state. CBV defines various dispositions and where they should be used.	• Disposition
Business Transaction	Link to transaction information that provides insight into why the EPCIS event was generated	• Transaction reference Examples include: Purchase Order Number, Delivery Note Number, Dispatch Note Number, Routing / Carrier Instructions, Material Safety Data Sheet, Ship Notice / Manifest, Shipment and Billing Notice, Delivery Acknowledgement, Receiving / Acceptance Advice, Invoice, Remittance Advice, Export Documentation, Import Documentation, Customs Clearance
Source Type	Depicts transfer of ownership (From) (Traceable Item source)	
Source Id	Unique Source Identifier	
Destination Type	Depicts transfer of ownership (To)	
Destination Id	Unique Destination Identifier	
EXTENSIONS	EPCIS CTE Extensions	• Container BIC Code, Bill of Lading Number, Export Customs Status, Vessel IMO Code, Voyage No. (Route Identifier), Estimated Time of Arrival, Time Zone at Destination, Import Customs Status
INFORMATION		
Item Master Data	GDSN	
Location Master Data	GLN Registry	

Transactional Data	Country of Origin Level of Lot control (Supplier vs. Company's own lot numbers) ETC. Product Code Lot Number Work Order Number Total Quantity Container / Shipment Information Other Transactional Information	
Physical (Visibility) Event Data – event based traceability data	SSCC AI(00) GTIN AI(01) GTIN Contained AI(02) Batch / Lot Number AI(10) Production date AI(11) Packaging date AI(13) Best Before date AI(15) Expiration date AI(17) Serial number AI(21) Variable Count AI(30) Count of TIs in a LU AI(37) Trade measure of a VM Trade item AI(31nn) Date and Time of Production AI(8008) ETC.	
Traceability Record-Keeping System/Forms (for data recording)		
Traceability information to be recorded		
Tags/Labels and Data Attributes		

A Summary of interoperability requirements

The table below provides a summary of the requirements and related GS1 standards, as listed in section 5.

Main topic	Subtopic	GS1 standards
IDENTIFICATION REQUIREMENTS		
Traceable objects	Trade items	GTIN, GTIN + lot ID, GTIN + serial ID
	Assets	GIAI, GRAI
	Logistic units	SSCC, GSIN, GINC
	Coupons	GCN
Parties		GLN, GSRN
Locations		GLN, GLN + GLN extension component
Transactions / documents		GDTI
AIDC REQUIREMENTS		
Barcodes	Trade items (GTIN-only)	(GTIN-only) EAN/UPC, ITF-14, GS1 DataBar non-expanded
	Trade items, assets, logistic units, parties, locations, transactions / documents	(GS1 identification key + attributes) GS1-128, GS1 DataMatrix, GS1 QR Code, GS1 DataBar expanded
RFID	Trade items, assets, logistic units, parties, locations, transactions / documents	EPC/RFID
DATA RECORDING REQUIREMENTS		
Relation data	Suppliers, customers, 3rd parties	Internal, using GS1 identification keys
Critical Tracking Events	Observations	EPCIS: Object Event CBV business steps: commissioning, shipping, receiving, transporting, storing, …
	Transformations	EPCIS: Transformation Event CBV business steps: commissioning
	Aggregations	EPCIS: Aggregation Event CBV business steps: packing, installing, …
DATA SHARING REQUIREMENTS		
Master data	Trade items	GDSN, GS1 SmartSearch, GS1 EDI, EPCIS
	Parties and locations	GLN Service, GS1 EDI, EPCIS
	Assets	EPCIS
	Relation data	Bilateral, no standard
Transaction data	Shipments, receipts	GS1 EDI Despatch Advice (DESADV), Receiving Advice (RECADV), GS1 Transport Status Notification (IFTSTA)
	Recalls	GS1 EDI Product Recall standard
Visibility event data	Critical Tracking Events	ECPIS, CBV

B Data management responsibilities

The table below aims to provide a summary of the main data management responsibilities by role.

Data management responsibility	Primary party (data source, initiator)	Secondary parties (data recipients, others)	Responsibilities defined in
(IDENTIFICATION) GS1 identification key management			
GTIN	Brand owner (*)	n/a	[GENSPES] [GTIN-MAN]
GLN	Location owner, location primary user (**)	n/a	[GENSPECS] [GLN-ALL]
GCN	Coupon offer issuer	n/a	[GENSPECS] [DCM]
SSCC	Physical builder or brand owner	n/a	[GENSPECS] [LOG_LAB]
GINC	Carrier or freight forwarder	n/a	
GSIN	Shipper, consignor	n/a	
GIAI, GRAI	Asset owner or manager	n/a	[GENSPECS]
GSRN	Organisation offering the service	n/a	
GDTI	Document issuer	n/a	
CPID	Buyer (OEM)	n/a	
(DATA SHARING) Master data			
Trade item master data	Data source (brand owner (*), see GTIN)	Any party that fulfils the conditions under which these data are to be shared.	[GDSN], [GENSPECS]
Party & location master data	Data source (location owner or manager, see GLN)		[GLN-SER], [GENSPECS]
Other master data (related to assets, service relations, ...)	Party that assigned the identification key, see above.		[GENSPECS]
(DATA RECORDING & SHARING) Capturing, recording and sharing of visibility event data			
Object events	Any party that is engaged in any of the following business steps: commissioning, shipping, receiving, transporting ...	Any party that fulfils the conditions under which these data are to be shared, for example based on chain of custody or chain of ownership relations.	[GTS2]
Transformation events	Any party that is engaged in any of the following business steps: commissioning, processing, ...		
Aggregation events	Any party that is engaged in any of the following business steps: packing, loading, unloading ...		
(DATA SHARING) Transaction data sharing			
Despatch advice	Shipper, consignor, seller	Receiver, consignee, buyer	[GS1-EDI] [LIM]
Receiving advice	Receiver, consignee, buyer	Shipper, consignor, seller	[GS1-EDI] [LIM]
Transport status notification	Logistics service provider, carrier	Receiver, consignee, buyer	[GS1-EDI] [LIM]
(DATA SHARING) Product recall			
Product recall notification	Product recall initiator	Product recall recipient	[GS1-EDI] [RECALL]
Product removal confirmation	Product recall recipient	Product recall initiator	
Product recall closeout notif.	Product recall initiator	Product recall recipient	
Notes: (*) see [GENSPECS] section 4 for non-branded items and exceptions. (**) See [GENSPECS] section 4 for exceptions.			

3. Serialisation

In archieving product serialisation to the individual retail unit packaging adds complexity to manufacturing, packaging and distribution. However, by using GS1 standards to establish a common language for identification, data capture and data sharing, this complexity can be reduced and risk can be removed from the supply chain. The following section covers at a general level some of the important concepts and best practices used by companies across sectors.

3.1. Serial Number Repositories

Stakeholders producing finished goods packaging that is serialised require a Serial number issuing and record keeping repository. Additionally, supply chain participants may also require repositories if they are re-packaging or kitting products to create a new finished good that also must be serialised. This is typically a component of the firm's ERP system. It is also sometimes a primary component of the firm's Serialisation Solution. The process of assigning Serial numbers from an ERP or above-packaging line control system is called provisioning. Best practices for repositories and Serial number provisioning:

- Measures and controls should be in place to ensure provisioning of duplicate Serial numbers for the same product (single GTIN) is not possible.
- In some cases a brand owner will produce the same product (GTIN) at multiple locations. In this case the Serial number repository and provisioning process should have controls in place to ensure unique numbers are issued to the different locations to eliminate the chance of duplication.
- Serial number repositories based on the GS1 standard AI(21) should take into account overall necessary capacities to support randomisation and ensure duplication does not occur within a certain timeframe. Different industries, like Healthcare, have established guidelines on how often a Serial number may be reused based on a timeframe, should overall capacity be a challenge.
- Firms should avoid using a single range of AI(21) across multiple products (GTINs) as this can sometimes drastically reduce the available capacity of Serial numbers, specifically if randomisation is utilised.
- Conversely assigning individual ranges of AI(21) to each product (GTIN) can greatly extend the overall capacity of products which can be serialised before requiring reuse at some time in the distant future.
- Controls and business process should be in place to correctly capture the final disposition of Serial numbers provisioned to a packaging site or line. Serial numbers that are not used on product or are marked on product packaging that was rejected or removed for quality inspections should be recorded with the correct disposition.

3.2.Serial Number Randomisation

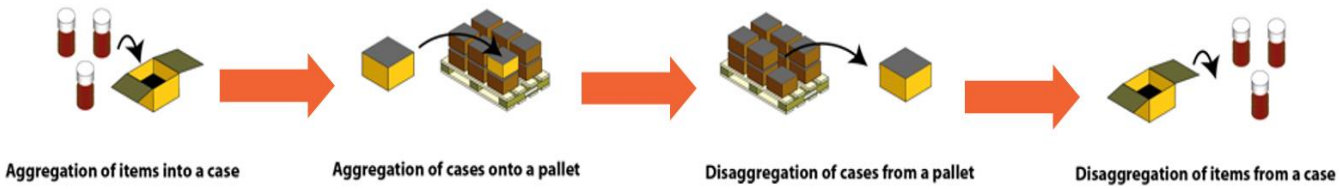
Randomisation is sometimes a desirable approach to add a level of security to the identified product. If a range of Serial numbers on a given product line are un-guessable due to randomisation this can deter and disrupt counterfeiters. In some industries, like Healthcare, randomization is mandated by regulations. Randomisation best practices:

- Randomisation methodologies have been established by industries to serve their specific supply chains or meet regulations or both – firms should look to align to what has been established for a given industry regarding randomisation methods.
- Randomisation can impact overall capacity of GS1's AI(21) product attribute. This is sometimes the case if alpha-numeric Serial numbers are prohibited, as this reduces the available total combination of AI(21) Serial numbers for a given product (GTIN).

3.3. Aggregation and Inference

It is common to utilise aggregation of individual serialised products in a parent-child arrangement. Aggregation is sometimes essential to enable supply chain efficiency, e.g., opening case and pallet level packages to scan every individually serialised product in a shipment is impractical. Stakeholders typically aggregate all of the individually serialised products within a case (children SGTINs) to a unique serialised product identifier at the case level (parent SGTIN). This can be scaled to work with cases (children) to pallets or containers (parents). Aggregation is used to support supply chain efficiency and speed through Inference.

Aggregation consists of electronically associating individual serial numbers to a serial number that represents the grouping. In this example, there is an aggregation for bundles (consisting of individual bottles), and of cases (consisting of bundles). Not shown is the final aggregation, pallets (consisting of cases). Each "parent" receives its own serial number that is electronically associated with the serial numbers of the "children." That's the basis of the electronic pedigree.



Inference is the concept of assuming that the individually serialised products claimed to be within a serialised shipping case or container are accurate. Inference is used by trading partners to fulfill supply chain speed and efficiency requirements and is often established between trusted trading partners. As a downstream partner I merely need to scan, perhaps on receipt, the SGTIN at the case level and correlate to the claim of the seller on what individually serialised items are contained within. For inference to work aggregation must be accurate and reliable and requires additional diligence, training and business process on the part of those handling serialised product. Aggregation best practices:

- Packaging operations should have in place inspections and processes to ensure rejected serialised product is not incorrectly assigned to higher levels of packaging through aggregation.
- Packaging line level controls must have safety measures in place to ensure that the individual serialised products placed in a serialised shipper case or container are accurate. This can involve vision inspection systems checking every single SGTIN of products within their entire higher levels of packaging.
- Where higher level packaging is opened for quality inspection or has been damaged and sent to rework, controls should be in place to ensure that if an aggregated shipping case or container have had their contents changed, this is accounted for and corrected.
- There are specific rules regarding shipper case identification for aggregation in the instance of a partial case. A GS1 MO should be consulted on those methodologies if partial cases are a regular characteristic of a packaging.

*Some product categories are serialised without the need for aggregation or inference. In these instances, the individual identities of products (SGTINs) are not shared with downstream trading partners. Instead, the serialised identifiers on products are used for product authentication by the brand owner to inspect product within the supply chain or to address post-retailer customer complaints or inquiries.