TRACE4EU CONSORTIUM

D4.1 Products & Materials traceability scenarios and requirements

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Executive summary

This Deliverable, titled D4.1, outlines the requirements of four distinct use cases of material or product traceability. These use cases are as follows: tracing Norwegian King Crabs from their catch to export, tracing Hungarian locally farmed potatoes from harvest to the market, tracking lithium contained in electric vehicle batteries to ensure compliance with the EU battery regulation, and tracing Halloumi to increase trust in its Protected Designation of Origin (PDO) label. Although each of these use cases has unique objectives and traceability requirements, all of them can implemented using EBSI's verifiable credential and timestamping services.

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Summary (for dissemination)	This document outlines the requirements and the scenarios for the use cases in WP4 which focus on traceability across various materials and products. Each use case has unique motivations and contexts while promoting transparency, sustainability, and consumer trust across various European markets and supply chains. These use cases include seafood (with a focus on king crab), agrifood (with a focus on potatoes), battery raw materials, and Halloumi cheese. In the subsequent sections, we will provide detailed insights into the specific requirements and objectives of each use case, addressing the diverse challenges and opportunities associated with traceability.
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1 Introduction

This document outlines the requirements for the use cases in WP4 which focus on traceability across various materials and products. Each use case has unique motivations and contexts while promoting transparency, sustainability, and consumer trust across various European markets and supply chains. These use cases include seafood (with a focus on king crab), agrifood (with a focus on potatoes), battery raw materials, and Halloumi cheese. In the subsequent sections, we will provide detailed insights into the specific requirements and objectives of each use case, addressing the diverse challenges and opportunities associated with traceability.

2 Implementation of the Seafood Tracing Application Scenario

2.1 Introduction

The Seafood scenario is designed to facilitate global traceability of seafood products, addressing the challenges posed by data silos and insufficient transparency in the seafood supply chain. The goal of the use case is to leverage EBSI to create and verify traceability data for all stakeholders involved in the seafood supply chain, including catchers, processors, transporters, and traders. These traceability data represent claims related to seafood assets, such as the location and timestamp of the catch. The Seafood scenario aims to optimize traceability and enhance sustainability by improving ecological processes. This use case is highly relevant to EU member states like Spain, the Netherlands, and Sweden (Iceland EAA), which export seafood to other EU countries, ensuring food safety and fair pricing for EU citizens. The Directorate of Fisheries in Norway needs to monitor, control, and surveil (MCS) of the fishery product, the fishers and the landing sites, from the time the fishing operation starts, until the product leaves the country. They also need to identify illegal catching, i.e., seafood (Red King Crab here) that is caught according to the allocated fishing quotas. The detailed challenges to be addressed include the following.

1. Data Silos: One of the biggest challenges is the existence of data silos, where information is stored separately in different IT, IoT, and production systems. This can make it difficult to access and integrate data for comprehensive traceability. It also increases the risk of inconsistencies and errors in the data.
2. Manual Data Entry: Many supply chains still rely on manual data entry for some or all of their traceability information. This can be time-consuming and prone to human error, leading to inaccuracies in the data.
3. Lack of Standardization: Without a standardised format for data collection and reporting, it can be difficult to compare and analyse data across different stages of the supply chain or between different companies.
4. Limited Accessibility: In many cases, traceability data is not easily accessible to all stakeholders in the supply chain. This can limit transparency and make it difficult for consumers, regulators, and other stakeholders to verify the information.
5. Data Security and Privacy: Traditional systems may not provide sufficient security for sensitive data, and there can be privacy concerns when sharing data between different parties.
6. Cost and Complexity: Implementing a comprehensive traceability system can be costly and complex, particularly for smaller businesses or those with limited IT resources.

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7. Tracing: Traditional systems often struggle to trace the source of king crabs, which is important in checking illegal fishing activities.
8. Scalability: As businesses grow and supply chains become more complex, traditional traceability systems can struggle to scale effectively.

2.2 Use case definition

2.2.1 Definition of Scope

Many seafood products can apply the traceability technologies we develop. The use case of this project will focus on the supply chain of live red king crabs, because this supply chain involves a complex and carefully managed process to ensure the delivery of fresh and healthy king crabs. Providing transparency and traceability from the moment the red king crabs are harvested by the fishing companies to their final destination. It begins with fishers/fishing companies who catch the live red king crabs and updates the internal journal system with the catch details. This is followed by the transportation of the crabs to the landing site where the landing is linked to a sales order and each live crab is also marked with a QR code which is attached to the crab's back using a T-bar (A pictorial example is provided in Figure 2.1 below). Each crab's QR code is then linked to a sales order. The crabs are sorted into marked water tanks and checked-in to storage. After checking out the crabs from storage in tanks, they are transported to the airport terminal, where the crabs are then scanned (QR code) and packaged into labelled cartons (labelled with Barcode).The QR code of the crabs in the carton are linked to the carton barcode and the carton barcode is linked to the sales order. Customs clearance is done and issued with the sales order. The carton packed live king crabs are then transported in controlled conditions to the respective destinations. This chain of custody model allows for detailed tracing of each crab's origin, handling, transportation, ensuring that the authorities can check the detect illegal fishing and consumers can enjoy high-quality, sustainably sourced live crabs with confidence.

Figure 2.1: King Crabs with QR codes

2.2.2 Definition of Roles in the Ecosystem

- **The Directorate of Fisheries**: Responsible for monitoring, control and surveillance (MCS) of the fishery product, the fishers and the landing sites, from the time the fishing operation starts, until the product leaves the country. Also responsible for allocating fishing quotas.
- **The Fisher**: Owner of a registered vessel and quota, responsible for catching the crabs and reporting the catch, according to the current regulations, and selling it to a registered landing site.
- **Landing Site**: Procurer of king crabs from the fisher. In collaboration with the fisher, sign a landing/sales note. The note includes detailed information about the catch composition, time, date, vessel, prices, etc. The note is signed by both the landing site and the fisher. The transactions

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between the parties are handled by a fishery sales organisation. In this case Norges Råfisklag. The landing site can transport live crab for live export.

- **Norges Råfisklag**: Responsible for all first-hand transactions for all wild-caught seafood in Norway. They're also responsible for the MCS in collaboration with the Directorate of Fisheries, and for issuing catch certificates for the catches.
- **The Food Safety Authorities**: Responsible for food safety, hygiene, issuing health certificates, etc.
- **Customs**: Responsible for the declaration of goods in and out of Norway.
- **Taxation Authorities**: Responsible for the taxation of the products and goods.
- **Justervesenet**: The metrology service, responsible for ensuring that the weighing equipment used for buying and selling goods is functioning according to the current regulations and standards.
- **Storage Facility**: Can also be at the landing site. Responsible for storing the live crab. A journal of goods going in and out of the facility shall always be kept updated by the internal systems.
- **Transportation**: Transportation can occur between landing sites, storage facilities in Norway, as well as when the products are exported. A bill of lading should always follow.
- Organisations involved in certification, licensing, etc

TABLE 2.1 : ROLES IN THE ECOSYSTEM

Name of the organisation	**Country**	**Organisational Role**	**Functional Role**	**Additional Information**
Official organisation name	*ISO 3166 Alpha-2 code*	*Role an organisation will play in the pilot group.*	*Root TAO, TAO, TI, Wallet Provider, Verifier, IT Provider. Organisation may play one or more roles.*	*e.g., organisation's website, other information*
Directorate of Fisheries	Norway	Accredits Control and Safety Bodies to issue quality attestations	Root TAO	Website
Norges Råfisklag	Norway	Accredits Fishers, Vessels and Boats. Issues sales order VC	TAO/Trusted Issuer	Website
Fisher	Norway	Issues catch VC	Trusted Issuer	
Norwegian Customs	Norway	Issues Customs Clearance VC	Trusted Issuer	Customs Website
Norwegian Tax Authorities	Norway	Issues Tax VC for all taxable participants	Trusted Issuer	Tax Website
Food Safety Authorities	Norway	Issues Safety VC	Trusted Issuer	
Justervesenet	Norway	Issues Measuring Equipment Compliance VC	Trusted Issuer	
Transportation companies	Norway	Issues Transport /Delivery VC	Trusted Issuer	

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Figure 2.2 depicts the flow of the use case . The figure presents a simplified depiction of the flow of data and activities of players in the ecosystem. However, some of these roles participate in all stages, hence why they are not represented in the simplified Figure 2.2. Section 2.2.2 and Table 2.1 above has provided a detailed description of the roles in the ecosystem. We limit the distribution tracing to the customs clearance stage, as the tracing from the catch stage to customs clearance is sufficiently enough for the directorate of fisheries to check the fishing quota and detect illegal fishing.

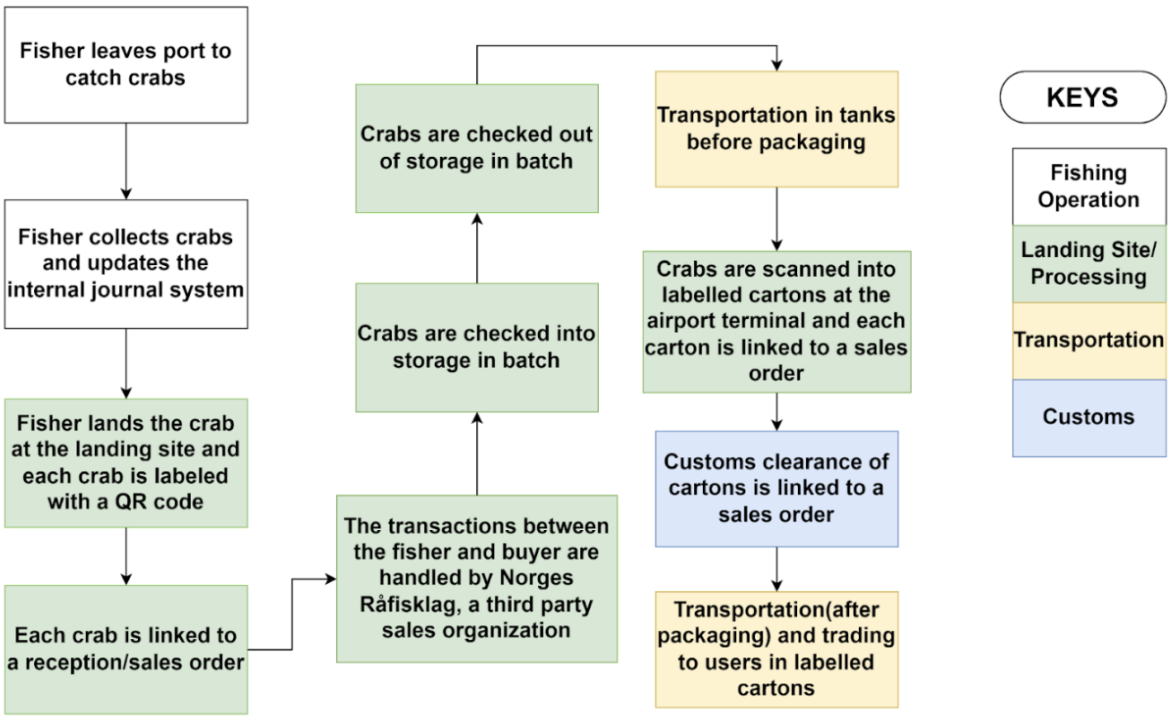

Figure 2.2: Simplified Flow Chart

2.2.3 Current Trust Model Definition

Figure 2.3 below highlights the roles and relationships of the different actors in the trust chain. The Directorate of Fisheries, serving as the root TAO, accredits all trusted issuers, including Norges Råfisklag (which is both a TAO and a trusted issuer). As the umbrella body for all fishers, vessel, and ship owners, Norges Råfisklag maintains a record of all registered members, which explains why it accredits fishers as trusted issuers. The Trust model will be adjusted according to the ongoing further development of EBSI Governance.

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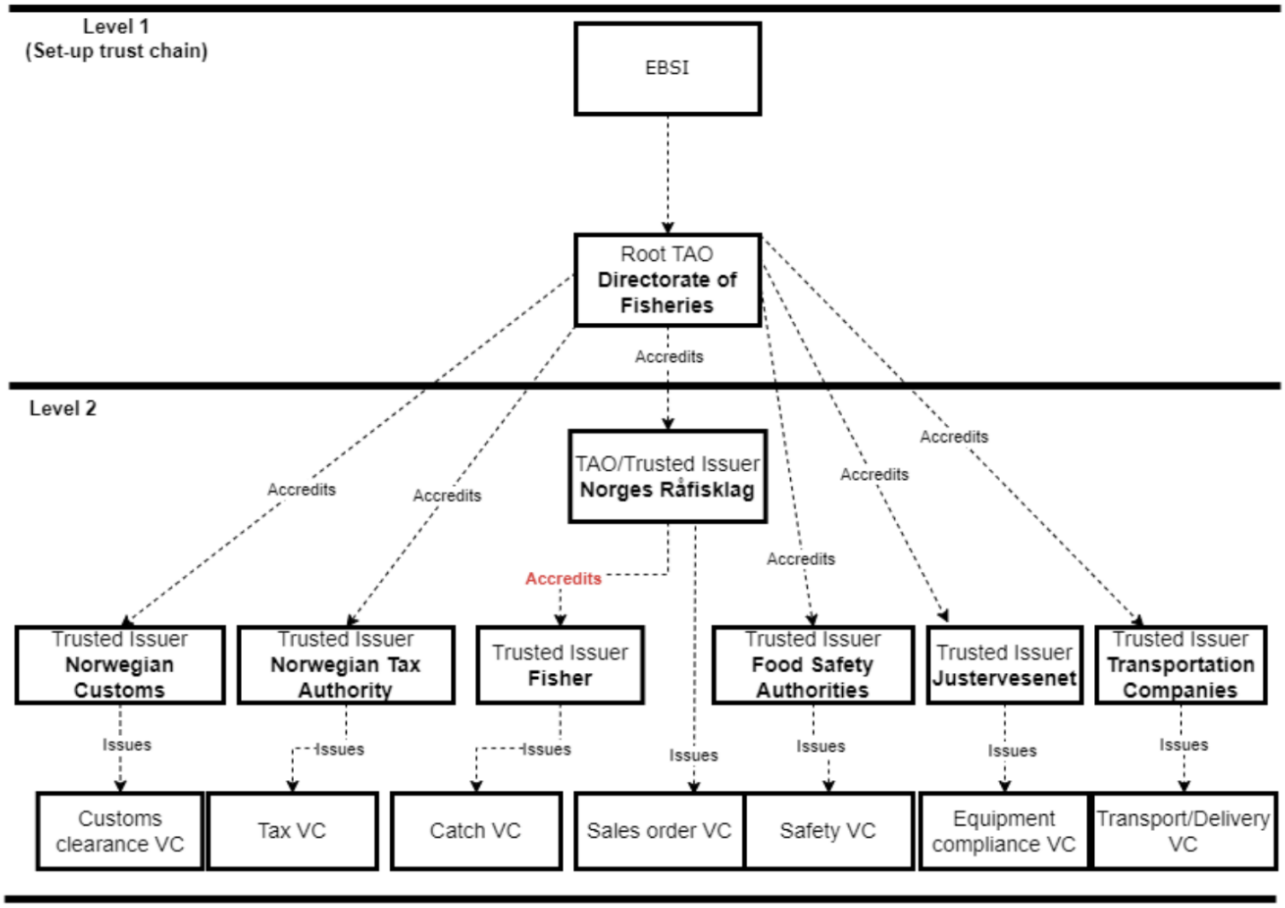

Figure 2.3: Trust Model

2.3 Use case requirements

2.3.1 User Stories

Data Issuance:

- As a TAO (Norges Råfisklag)- I need to accredit reliable issuers to uphold a robust standard of data integrity and trustworthiness within the system.
- As a trusted issuer, I want to be able to issue catch credentials to ensure that catch activities comply with the rules and standard.
- As a trusted issuer, I want to be able to issue a sales order as a verifiable credential that will serve as the contract between the sellers (fishing companies) and buyers.
- As a trusted issuer, I want to be able to issue an ID credential (QR code) to link each crab at arrival to a sales order.
- As a trusted issuer, I want to be able to issue storage credentials (check-in and check-out) to ensure that the crabs are stored under the stipulated conditions.
- As a trusted issuer, I want to be able to issue a waybill as a credential to document the movement of the crabs before packaging and ensure that they are transported under the right conditions.
- As a trusted issuer, I need to issue a carton credential for each package, to ensure that all crabs are linked to a carton and all cartons to a sales order.

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- As a trusted issuer, I need to issue customs clearance as a credential to ensure that goods coming in and exiting Norway are of good quality and satisfies the relevant regulations.
- As a trusted issuer, I need to issue a waybill as a verifiable credential to ensure that crabs packed in cartons are transported to the designated locations under the right conditions.
- As a trusted issuer, I need to issue a tax clearance to ensure that all stakeholders in the supply chain are properly taxed.
- As a trusted issuer, I need to issue an equipment compliance certification to ensure that measuring equipment used at landing conforms with the regulatory standard.

Data Exchange

- As a stakeholder company, I want to be able to create a secure connection to register and exchange data safely with other stakeholders.
- As a system user, I need to be able to verify the identity of other stakeholders to guarantee secure and authorised exchange of data.
- As a trusted issuer/stakeholder, I need to be able to exchange verifiable credentials with other stakeholders via secure connections to maintain data integrity and compliance.

2.3.2 Data model

At landing, the catch credentials submitted by the fisher and the landing credentials issued by Norges Råfisklag are presented in Table 2.2 as landing information. Once landing is completed, Norges Råfisklag issues a sales order credential, which is an agreement between the fisher and the buyer, with the details shown in Table 2.3. After the agreement is signed, the live king crabs are labelled with QR codes (as shown in Table 2.4) and scanned. Each scanned crab is then linked to a sales order. Figure 4 presents the entire landing process as explained here.

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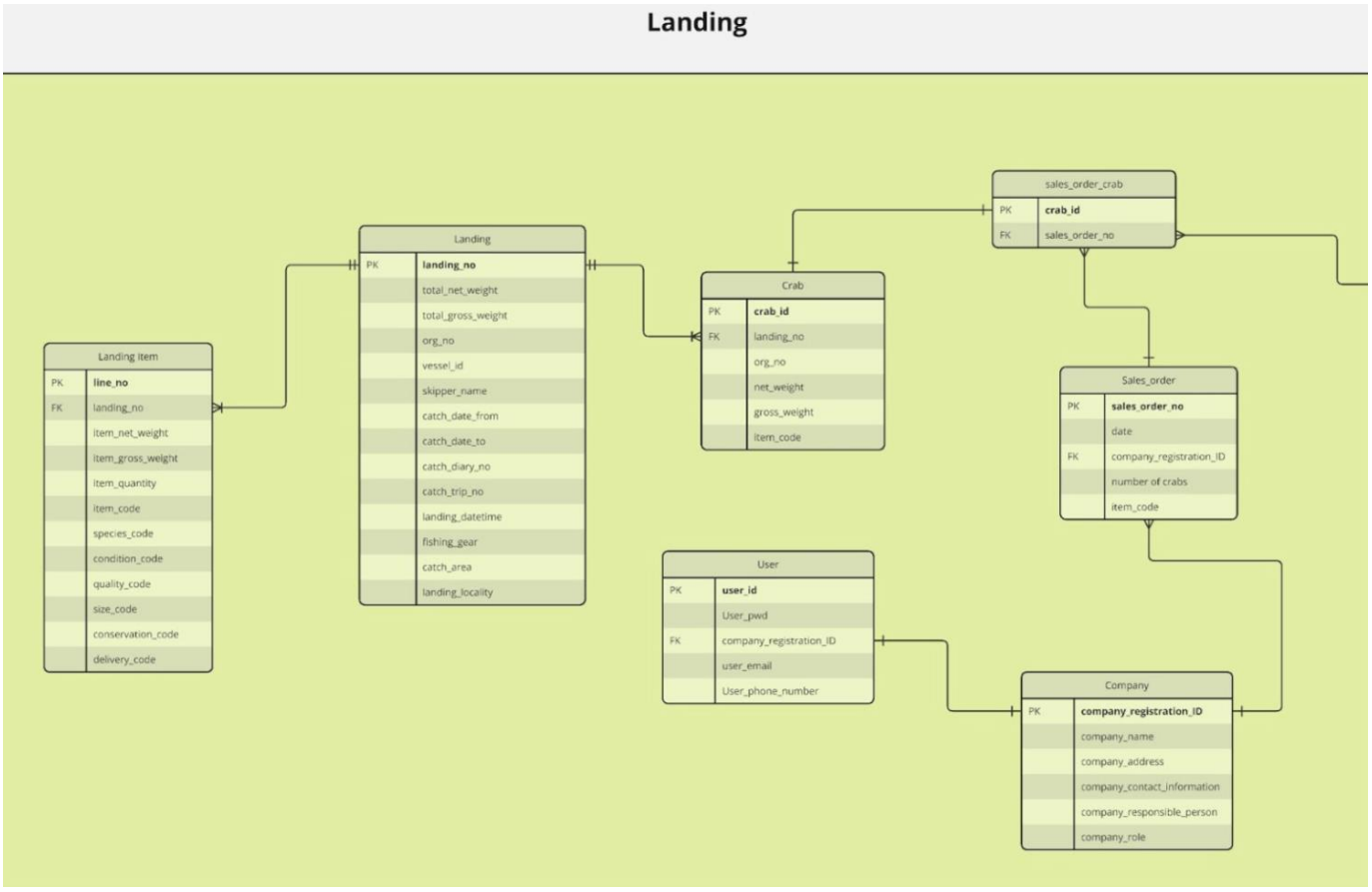

Figure 2.4: Landing

TABLE 2.2: LANDING INFORMATION

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Landing	landing_no total_net_weight total_gross_weight org_number vessel_id skipper_name catch_date_from catch_date_to catch_diary_no catch_trip_no landing_datetime fishing_gear catch_area landing_locality	Landing	Norges Råfisklag	landing_no	Landing Note

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TABLE 2.3 : SALES ORDER GENERATION FOR LANDING

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Sales Order generation	sales _order_no buyer_ID landing_no fishing_vessel_mark vessel_name vessel_calling_signal vessel_flag_state master_of_the_vessel catch_year catch_date fishing_quota number_of_operators_on_board_the_vessel type_of_fishing_gear and_catch_area. catch_composition_divided by_different_criteria (weight group, sex, quality, etc.) price(undisclosed for 12 months)	Sales Order	User A (Norges Råfisklag)	sales _order_no	Sales order

TABLE 2.4 : QR CODE GENERATION

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Crab QR code generation	crab_id sales _order_no landing_no net_weight gross_weight item_code	Single Crab	User A (Norges Råfisklag)	crab_id	QR Code

Figure 2.5 below depicts the storage and transportation processes before packaging. After landing and tagging of each crab, the live crabs are checked into storage in batches and also checked out in batches. Tables 2.5 and 2.6 present the data collected during the storage check-in and check-out, respectively. The checked-out crabs are then transported to the airport terminal for packaging,

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customs clearance, and shipping. Table 2.7 contains the data collected during the transportation of the live crabs before packaging.

Figure 2.5: Storage and Transportation before packaging

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TABLE 2.5 : STORAGE CHECK-IN

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Storage Check In	sales _order_no check in date (Automatic) check in time (Automatic)		Norges Råfisklag	sales _order_no	Sales order

TABLE 2.6 : STORAGE CHECK-OUT

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Storage Check out	sales _order_no check out date (Automatic) Check out time (Automatic)		Norges Råfisklag	sales _order_no	Sales order

TABLE 2.7 : TRANSPORT BEFORE PACKAGING

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Transport before packaging	truck_id sales _order_no pickup_date pickup_time		Transport Company	truck_id	Sales order

At the airport terminal, each crab is scanned into labelled cartons (3-5 crabs per carton), and each carton is linked to a specific sales order. Customs clearance is conducted using the sales order. Thereafter, the cartons packed with live crabs are transported. Figure 2.6 depicts the packaging, customs clearance, and transport processes after packaging. Tables 2.8, 2.9, and 2.10 contain the data collected at these respective stages.

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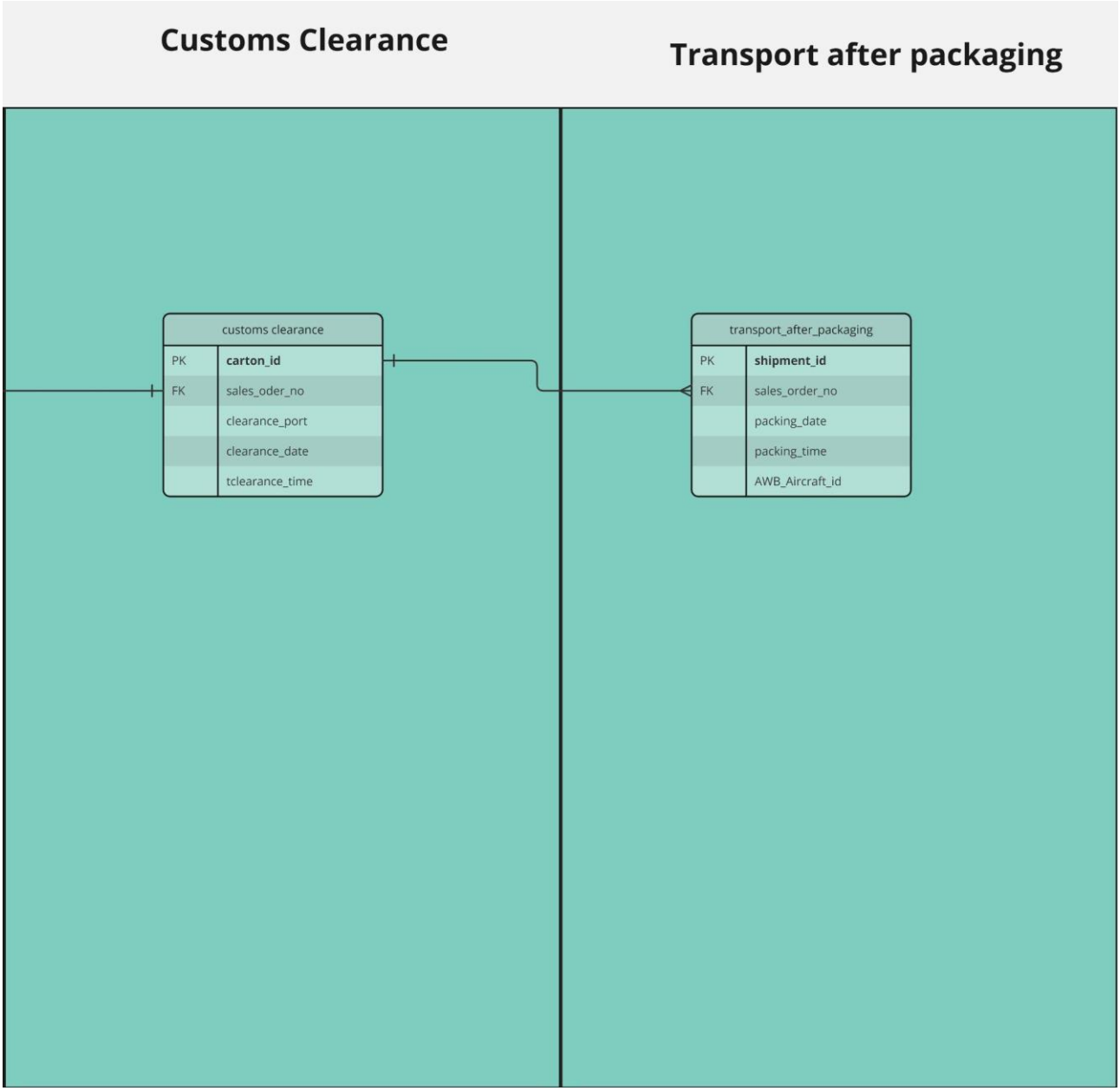

Figure 2.6. Customs clearance and Transportation after packaging

TABLE 2.8 : PACKAGING AT THE TERMINAL

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Airport Terminal	sales _order_no carton_id packing date packing time packing company	Carton	Airport Authority	carton_id	Carton Barcode

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	registration ID AWB (aircraft ID for transportation)				

TABLE 2.9 : CUSTOMS CLEARANCE

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Customs Clearance	carton_id sales _order_no custom_clearance_port custom_clearance_date custom_clearance_time	Carton	Norges Råfisklag	carton_id	Carton Barcode

TABLE 2.10 :TRANSPORT AFTER PACKAGING

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Transportation after packaging	sales _order_no shipment_id transportation_starting_location transportation_starting_date and time transportation_ ending_location transportation_ending_date and time transportation_company_ ID		Transport Company	shipment_id	Carton Barcode

2.4 Capabilities required to implement the use case

1. **Data Collection**: The system should be capable of collecting a wide range of data at each stage of the supply chain. This includes details about the catch as transferred from the boat, landing, storage, packaging, and transportation.

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2. **Data Integration**: The system should be able to integrate data from various sources, including QR codes, journal systems and fishing boats.
3. **Data Confidentiality**: The system should ensure data confidentiality. This will involve the implementation of stringent access controls to thwart any unauthorised data access and the assurance that sensitive information receives appropriate protection.
4. **Data Integrity:** The system should ensure the integrity of the data collected. This refers to the accuracy, consistency, and reliability of data in a system. An assurance that data remains unchanged and uncorrupted throughout its lifecycle.
5. **Data Availability:** Data should be available and ready for use when needed. The system should be easily accessible to all stakeholders in the entire chain, which includes fishermen, buyers, sellers, regulators, and transport companies.
6. **Scalability:** The system should have the ability to accommodate growth and increased complexity in the supply chain. As additional products, stakeholders, and data points are integrated, the system must demonstrate the capability to efficiently manage a growing volume of data. Its design should be oriented towards the effective handling of a substantial number of data points across the entire supply chain.
7. **Tracing**: The system should provide real-time tracing of live king crabs as they move from the catch stage to the customs clearance. This will enable the directorate of fisheries to check fishing quota and detect illegal fishing activities.
8. **Interoperability:** The system should be able to work together seamlessly and effectively with other systems in the supply chain. This is important for effective exchange and usage of data.
9. **Standardisation:** The system should utilise standardised data collection and reporting formats within the system, which is essential to guarantee uniformity and the ability to compare data throughout the entire supply chain.
10. **Compliance**: The system shall be designed to ensure compliance with all relevant laws and regulations. This includes timely reporting/update of catch and landing data to authorities.
11. **Transparency**: The system should offer a significant degree of transparency, enabling all stakeholders to track the product's journey.

3 Implementation of the Agrifood Tracing Scenario

3.1 Introduction

The Agri-food scenario focuses on improving data exchange between food producers and raw food material processors using EBSI. In Hungary, the lack of verifiable information about the quantity, quality, and origin of harvested crops has been a challenge. Additionally, complex planning for kindergarten and school catering demands better supply chain management.

By implementing the Trace4EU traceability solution, this use case seeks to enhance data security, supply chain reliability, and consumer confidence. It aims to provide validated data that can be leveraged by artificial intelligence and machine learning, benefiting not only Hungary but also all European countries with short food supply chains.

3.2 Use case definition

3.2.1 Definition of Scope

The Agrifood use case focuses on tracing potatoes, from the start of farming until the sale of it by retailers and grocery markets. By tracing potatoes, identifying the source of farming (origin, destination) and documenting material specifications becomes more transparent. Potatoes coming from unknown sources (outside of EU countries) become harder to market, hence local/domestic farmers will face less unfair competition. Secondly, as potato is one of the most common grocery products, the proof and verifiability

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of safety and quality standards is fundamental from food safety point of view and possible recall processing.

General overview of the stages and the types of data that could be collected at each step:

1. **Farming**: This is the stage when the potato is harvested. We're collecting data of its type, date of collection, the company/farmer ID, chemicals used. Farming Diary is an Excel table but also available in electronic format since 2013.
2. **Storage**: In this stage, the product is waiting for the shipping company's arrival. The duration of the time spent here is gathered, alongside with the temperatures and humidity by using **IoT devices**
3. **Packaging**: Product is being packed in boxes, receives first QR code
4. **Shipping_1**: The product is being transferred to a warehouse. Travel time, humidity, temperature to be monitored and registered alongside with the fuel consumption. The latter will only serve as information for the company responsible for the transportation, won't be visible for customers.
5. **Warehouse:** Registering movements within the warehouse is cruicial. Store place, temperature is registered. Product becomes a "Parent", smaller portions which are picked for orders are called "child".
6. **Shipping_2**: The product is on its way to the final customer, delivery time, storage temperature and humidity to be registered until product is handed over to the customer.
7. **Audit**: Authorities responsible for the audits (eg. National Food Safety Agency) validate the attestations
8. **Retail/Restaurant/Customer**: The tracking of supply chain stops at this point, the supply chain of the product can be checked by scanning the QR code on the package.

3.2.2 Definition of Roles in the Ecosystem

Name of the organisation	**Country**	**Organisational Role**	**Functional Role**	**Additional Information**
Official organisation name	*ISO 3166 Alpha-2 code*	*Role an organisation will play in the pilot group.*	*Root TAO, TAO, TI, Wallet Provider, Verifier, IT Provider. Organisation may play one or more roles.*	*e.g., organisation's website, other information*
Ministry of Agriculture	HUN	Regulator	Root TAO	Website
National Food Chain Safety Office	HUN	Certifies/Accredits Farmers (TI), Standard Definition, Quality Assurance	Sub-TAO	As the agency of the Ministry of Agriculture, it monitors compliance with food chain safety rules and combats food fraud and the black economy. Website
Farmer	HUN	Producer of Potatoes, issues VC	Issuer	
Packaging	HUN	Adds unique data points to original farmers VC	Issuer	

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Transportation	HUN	Adds unique data points to original farmers VC	Issuer	
Digital Producers Market	HUN	Checks issued VCs and sells products online to customers	Issuer, Verifier	Hungarian online grocery store launched in 2020.
Retailer	HUN	Seller presents VC to consumers	Verifier	

Table 3.1: Roles in the Ecosystem

3.2.3 Trust Model Definition

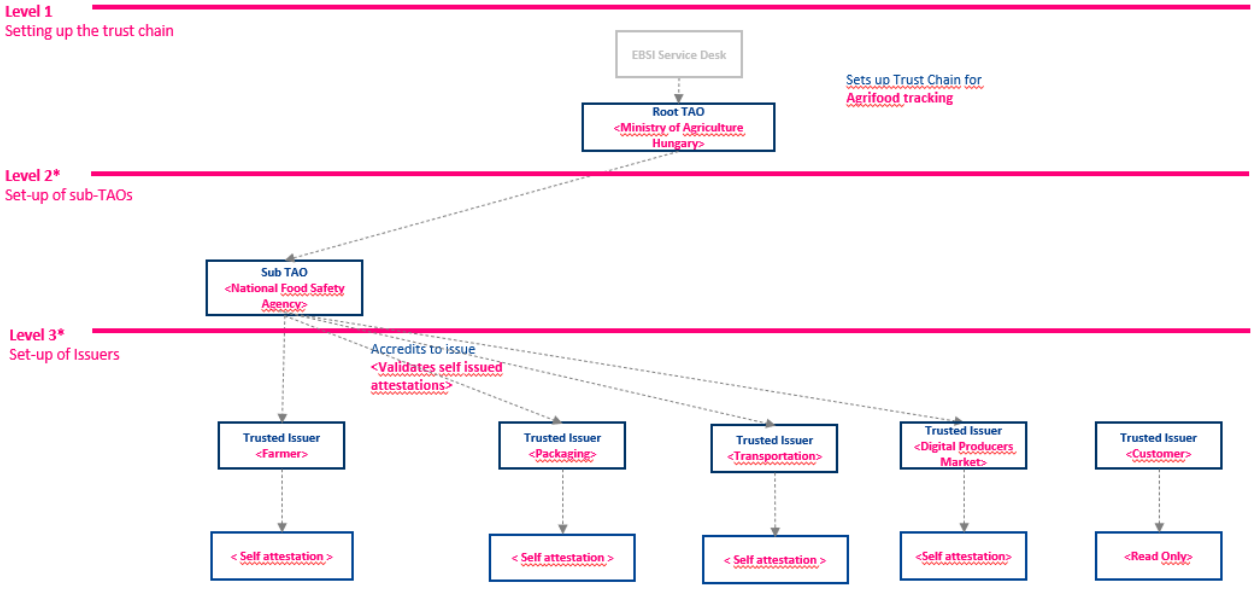

Figure 3.1: Trust Model Agrifood Use Case

3.3 Use case requirements

3.3.1 General Functional Requirements

- Data Collection: The system should be capable of collecting a wide range of data at each stage of the supply chain. This includes details about the crop (potato type, location, sprays/fertilizers used), processing (method, date, location), transportation (route, duration, temperature control), and sale (location, date, price).
- Data Integration: The system should be able to integrate data from various sources, including IoT devices, the currently used systems of producers, logistics company.
- Real-Time Tracking: The system should provide real-time tracking of products as they move through the supply chain. This will enable immediate updates and enhance the accuracy of the traceability data.
- Data Confidentiality: The system should ensure the confidentiality of the data. This includes implementing robust access controls to prevent unauthorized access to the data and ensuring that sensitive information is appropriately protected.
- Data Integrity: The system should ensure the integrity of the data collected. This includes protecting the data from unauthorized access and ensuring it cannot be altered once recorded.

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- Data Availability: The system should be easily accessible to all stakeholders in the supply chain. This includes farmers, processors, distributors, retailers, regulators, and consumers. Each stakeholder should have access to the relevant data they need.
- Scalability: The system should be scalable to accommodate growth and increased complexity in the supply chain. It should be able to handle increasing amounts of data as more products, stakeholders, and data points are added. The system should be designed to manage a massive amount of data points throughout the supply chain efficiently.
- Interoperability: The system should be interoperable with other systems and technologies used in the supply chain. This will allow for seamless data exchange and integration.
- Standardization: The system should use standardized formats for data collection and reporting. This will ensure consistency and comparability of data across the supply chain.
- Compliance: The system should be designed to ensure compliance with all relevant laws and regulations. This includes automatic reporting of catch and landing data to authorities.
- Transparency: The system should provide a high level of transparency, allowing all stakeholders to see the journey of the product
- Data Analysis and Reporting: The system should include tools for analyzing the data and generating reports. This could include sustainability reports, compliance reports, and detailed traceability reports. The system should also incorporate federated learning techniques to improve data analysis and predictive capabilities while maintaining data privacy.
- Consumer Engagement: The system should include features for consumer engagement, such as the ability to scan a QR code on the product to see its origin, validate that it was handled in a proper manner, cooling chain wasn't violated etc.

3.3.2 User Stories

- As a potato farmer, I want to issue that my product was harvested in Hungary, and want to be able to prove its origin
- At the packaging state I want to confirm and validate that the product I'm packaging has proof of its origin and add a QR code so that this can be further traced until the final destination of the product
- As a transportation company, I want to prove that the product was handled as required, by capturing the temperature, humidity and gps data during the delivery
- As Digital Producers Market (reseller), i want to ensure the product i've received is local, and was handled as required thorough the whole process.
- As Digital Producers Market, i want to register that the product was stored in the required temperature, humidity etc. during its stay in the warehouse.
- As a kitchen of public catering i want to validate that the product i've purchased is from a short supply chain as required by law.
- As a customer i want to validate the origins of the product and ensure it was handled with proper care, as per the regulations.
- As the National Food Safety Agency, I want to validate the whole journey of the products to make sure it was handled as per the law. I also want to validate the attestations of the farmers, and revoke them in case of offences.

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3.3.3 Data Model

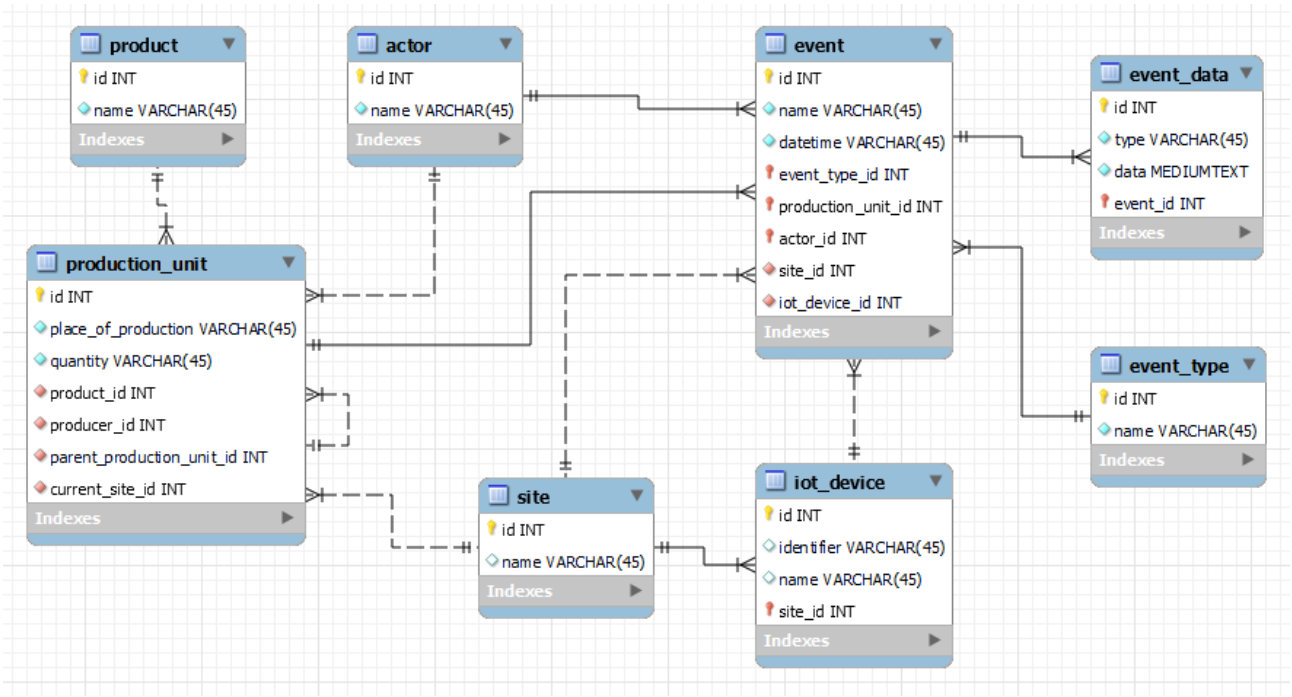

Figure 3.2: Data Model Agrifood Use Case

Every action during te process triggers an event alongside with a timestamp. These events contain information from the

- Actor (farmer, packaging company, transportation company, warehouse worker etc.)
- Event type (packaging, transportation phase, storage)
- IoT device (humidity,temperature)
- Product (producer name, product name, current site, place of production etc.)
- Site (current site, be it the packaging firm, warehouse, or en route)

Example:
actor (producer) creates production units (PU) product (e.g.:potato), current_site], timestamp

The process starts with entering the base data of the product manually in a web based platform.(sensor based data gathering would be preferred, but not too many farmers have the technology required for it), for example:

- Seeding
- Chemicals used when spraying
- Time of the harvest
- Quantity

After the initial data entry, the events get triggered automatically when the QR code is being scanned during the process (eg. When the warehouse receives the goods, they scan them. When they store them at a give location, they scan it again and link it to the designated area in the warehouse by scanning the locations barcode)

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In case the product is purchased in a lot and is received without packaging, the lot can be separated to smaller portions by creating parent-child relations.

The system should collect a wide range of data, including:

1. Details about the seeding (such as species, location, quantity)
2. Details of the stakeholders: farmers, logistics company etc.
3. Information about the farming/gathering
4. Data on transportation (distance, temperature, humidity, fuel consumption)
5. Data about the storage of the product

Every action when handling the product creates an “event” (see above), which contains data about the actor, site, product, and IoT device.

Event	Data Collected	Aggregation	Issuer	Unique Identifier	Data Carrier
Farming	product_id producer_id event_id place_of_production quantity current_site_ID timestamp actor_id event_type_id event_id chemicals used		actor	production_unit	FlexChain application
Storage	parent_production_unit				
Packaging	timestamp production_unit_id event_type_id current_site_id actor_id				QR Code
Shipping	iot_device_id temperature humidity shipping time delivery_note_ID		iot_device		QR Code

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Warehouse	additionally to the previous event informations, the product gets assigned to a specific location within the warehouse invoice_id				QR Code + Logistics software(invoice_ID and delivery_note_ID)
Shipping_2	iot_device_id temperature humidity shipping time delivery_note_ID				QR Code

Table 3.2: Credentials Issued in Agrifood Use Case

4 Implementation of the Battery Materials Tracing Scenario

4.1 Introduction

4.1.1 Regulatory Context: The EU Battery Regulation

The Battery scenario addresses the tracing of critical raw materials in compliance with the EU Battery Regulation (REGULATION (EU) 2023/1542). The Battery Regulation is part of the EU Green Deal and complements the Circular Economy and Strategic Action Plans on Batteries. Article 77 of the Battery Regulation, enacted in August 2023 stipulates that every Electric Vehicle (EV) and industrial battery with a capacity exceeding 2 kWh must be accompanied by a Battery Passport. This passport becomes obligatory from February 2027, and it is required to encompass a comprehensive range of mandatory attributes, including

- General Information
- Labels and Certifications
- Supply Chain Due Diligence
- Product Carbon Footprint (PCF) across various life cycle phases, and components
- Materials Composition
- Circularity & Resource Efficiency
- Performance & Durability

The responsibility for creating the Battery Passport and ensuring the accuracy, completeness, and currency of the information it contains lies with the economic operator, which is the entity placing the battery on the market.

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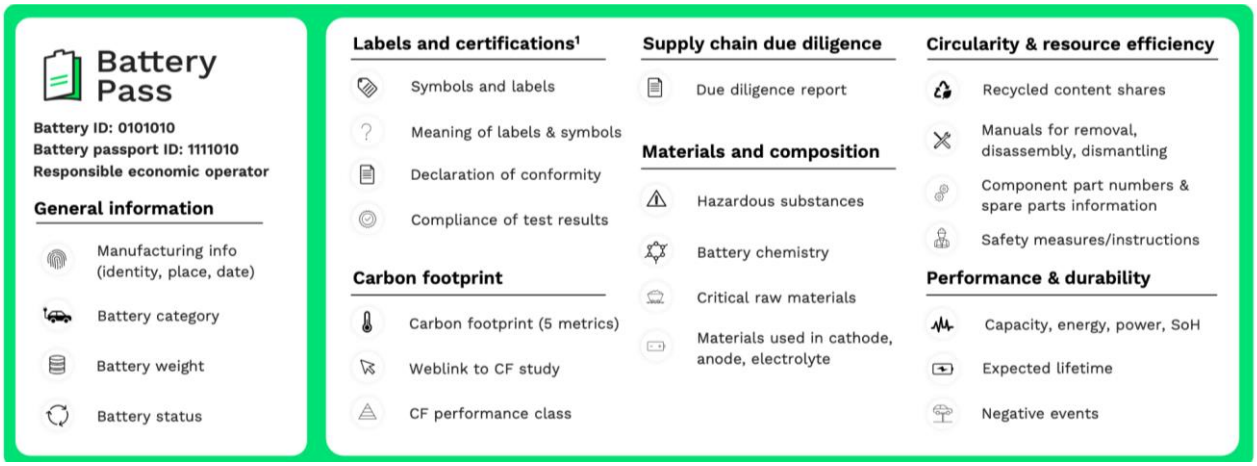

Figure 4.1: Battery Passport Content Categories. Source: Battery Passport Content Guidance

4.1.2 Traceability and the EU Battery Regulation

The data attributes outlined in the regulation, particularly PCF, supply chain due diligence, and materials composition, require extensive data collection and exchange spanning the entire supply chain, extending to the mining stage of the raw materials. The depth of information required implicitly necessitates the existence of some sort of data management system on behalf of the economic operator.

This need is reflected in the Battery Regulation Article 49, which requires economic operators to "establish and operate a system of controls and transparency regarding the supply chain, including a chain of custody or traceability system, identifying upstream actors." Article 49 also specifies the type of information the system should provide, including

- the name and address of the supplier that supplied the raw material present in the batteries
- the country of origin of the raw material and the market transactions from the raw material's extraction to the immediate supplier to the economic operator
- the quantities of the raw material present in the battery
- third-party verification reports concerning the suppliers, which shall be made available by suppliers to their downstream partners

It is important to note, however, that the regulation provides no technical specifications for the sysetm. The focus lies on the data points the system can collect and provide. It is also important to note that the system described in Article 49 is a system the economic operator runs internally. There exists no requirement for a public traceability system for the supply chain. The system described in the regulation is purely is meant to enable the economic operator to carry out the supply chain due diligence.

After reviewing the regulation as a whole, we can conclude that four main data attributes need to be shared along the supply chain (Table 4.1).

Data Attribute	EU Battery Regulation Reference
Product Carbon Footprint	Article 7
Third-party verifications	Article 52 & Article 49
Quantities of raw materials	Article 49
Provenance (country of origin, market transactions)	Article 49

Table 4.1: Supply Chain information requirements as per the battery regulation

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4.1.3 Product Carbon Footprint

Batteries are pivotal in reducing carbon emissions in the transportation sector since the lifetime carbon emissions of an EV are much lower than International Combustion Engine (ICE) cars. However, their manufacturing process, including mining, transportation, and refining, is a significant source of carbon emissions. In fact, the carbon emissions incurred during the production process of an EV are significantly higher than those of a similar ICE vehicle.

The emissions can also vary widely, depending on the processing techniques and the energy sources used. The carbon footprint of a battery, including its components, varies significantly depending on the production location, ranging from 2,400 to 16,000 metric tons.

Further decarbonizing the EV battery supply chain is possible but requires suppliers to provide transparent PCF data at each manufacturing step. Currently, determining the PCF of a specific battery is challenging due to the absence of a standardized calculation method. A uniform methodology is crucial for transparency and informed decisions.

The battery regulation stipulates information requirements for the product carbon footprint in **Article 7** of the regulation. Furthermore, the commission plans to issue a Delegated Act, specifying the methodology for calculating and verifying the PCF in spring 2024. In addition, both the Global Battery Alliance (GBA) and Catena-X are developing PCF Rulebooks aimed at streamlining the calculation methods for EV batteries.

4.1.4 Supply chain due diligence

Regarding battery materials and components, concerns often arise about unethical labor practices, including forced or child labor, and adverse environmental impacts such as excessive water usage and pollution. The opacity of supply chains frequently results in these issues being overlooked or inadequately addressed by downstream suppliers. For this reason, the EU Battery Regulation **mandates in Article 52** comprehensive due diligence for batteries at the product level. This involves identifying, preventing, and mitigating risks associated with the sourcing, processing, and trading of raw and secondary materials.

Companies must develop, implement, and publicly disclose a due diligence policy validated by an accredited body. Economic operators must make their due diligence policy reports publicly accessible, both online and as part of the Battery Passport.

Moreover, companies must maintain a transparent record of their supply chain for a minimum of five years. This record should trace each material's journey from its origin to its final destination with the company distributing the battery within the EU.

4.2 Use case requirements

4.2.1 Focus on the Lithium Supply Chain

Under the EU battery regulation, economic operators must provide comprehensive data for all battery components, including the anode, cathode, electrolyte, separator, and cell casing. This use case will focus on the lithium supply chain and the battery components that contain this raw material.

With more than 90% of batteries used in EVs today containing Lithium, the resource is pivotal in the energy transition of the automotive sector. The increasing demand for EVs has led to a surge in lithium demand, emphasizing the importance of sustainable and responsible sourcing practices. Its supply chain is geographically diverse, with significant reserves in Australia, Chile, and China. Australia leads in lithium production primarily through hard rock mining, while South American countries like Chile extract lithium from brine pools.

Given the strategic importance of lithium in the global transition to greener transportation, the lithium supply chain becomes a key focus area for economic operators' due diligence efforts. This includes ensuring responsible mining practices, addressing environmental impacts throughout the supply chain, and managing geopolitical risks associated with lithium sourcing.

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The extraction and processing of lithium present unique environmental and social challenges. Lithium processing, whether from hard rock or brine, involves several steps, each with its environmental footprint. In brine extraction, for instance, there are concerns about water usage and its impact on local ecosystems and communities. After extraction and processing, lithium is refined and converted into various compounds, like lithium carbonate or hydroxide, critical for battery production.

The process of the lithium supply chain involves several stages, beginning with mining either from hard rock or brine pools, followed by extracting lithium compounds, refining them, and finally supplying them to battery manufacturers for use in cathodes.

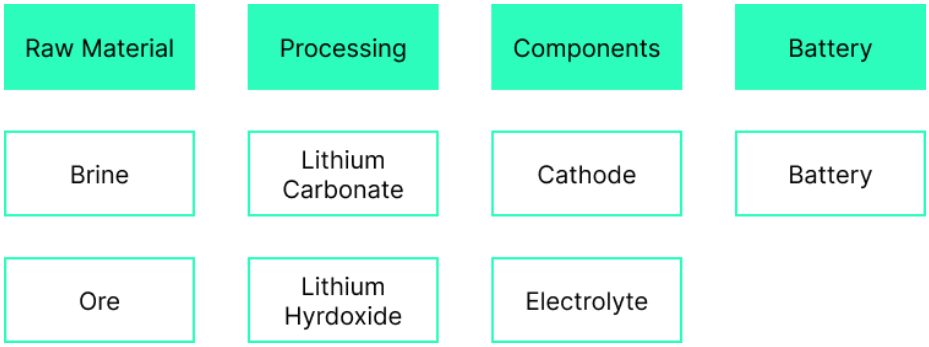

Figure 4.2: Lithium processing stages. Source: S&PGlobal

4.2.2 Basic Design of the Traceability System

The goal of this use case is to develop and implement a data sharing and data verification system based on EBSI, allowing economic operators to securely connect with upstream suppliers and exchange relevant supply chain data. Regardless of the specific information flow pathways, it's essential that the data underpinning key attributes in the Battery Passport, such as greenhouse gas emissions, is highly reliable. This is of particular interest to the economic operator, who is ultimately accountable for the accuracy of the information.

This project will demonstrate a solution for ensuring data integrity by associating supply chain data with trusted, decentralized identifiers assigned to organizations within the supply chain. These identifiers are backed by a trust framework that authenticates their connection to actual organizational entities.

Figure 4.3 below illustrates how the system fits into the overall data-sharing model of the battery supply chain. The system will support Tier-1 (stakeholders only connect to their direct supplier) data exchange and Tier-n (a stakeholder can connect with all of their upstream suppliers). In both cases, the data exchange occurs peer-to-peer, that is, without the intervention of an intermediary.

The system will be closely aligned with the Catena-X standards. Catena-X is a data ecosystem for the global automotive sector that is emerging as a standard for the whole industry. The standards integrate SSI concepts for trading partner authentication and access management using credentials managed in each stakeholder's identity wallet. The present system will adopt this concept, allowing stakeholders to create EBSI DIDs and receive and store membership credentials and legal identity credentials in their cloud wallet.

In addition, the present system will also use verifiable credentials for the types of product-related data listed above. All the information a supplier shares with a downstream partner will be shared as a verifiable credential. Moreover, the suppliers will receive verifiable credentials, such as the responsible mining certification from third-party verifications, which can also be shared with downstream partners. This is not part of the Catena-X standard but can significantly increase the data Level of Assurance (LoA).

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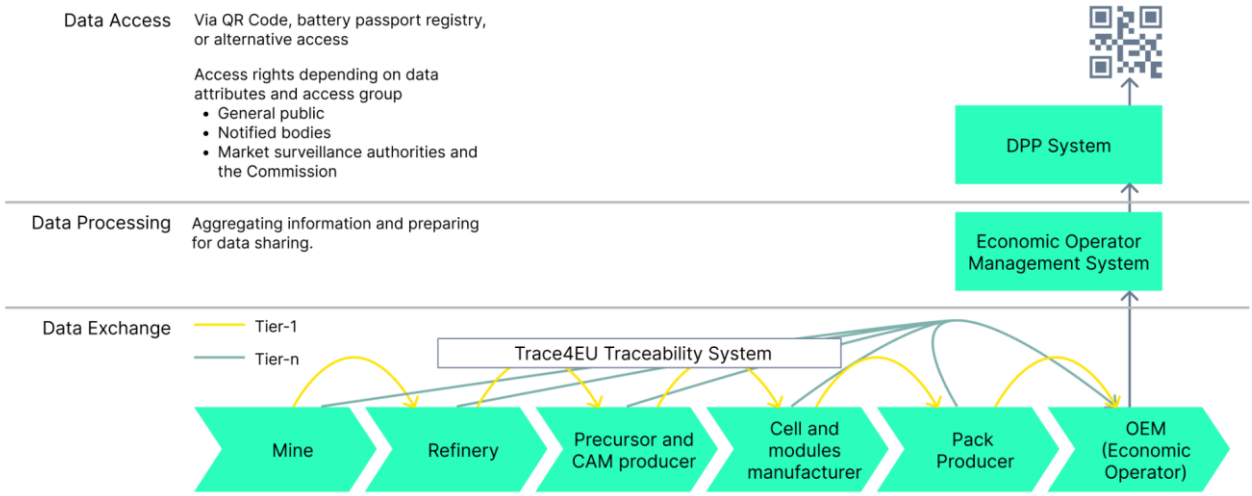

Figure 4.3: Data flow in the battery supply chain

Note, that this system aims to provide the material traceability data required to comply with the EU battery regulation. It does not aim at creating a system for the exact traceability of material flows. Such traceability, or chain-of-custody system might be adopted in the future in light of the data requirements of the battery supply chain.

It is also possible that manufacturers of intermediate components will adopt the concept of a Digital Product Passport (DPP). Provided these DPPs contain all the relevant information, it will significantly ease the data collection burden on the economic operator and enhance the business confidentiality of the manufacturers upstream supply chain.

4.2.3 Definition of Roles in the Ecosystem

In our initial trust model, we have chosen Catena-X as the Root TAO because it is an organization that has many major players from the automotive sector as its members, making it an ideal choice. Moreover, the current operating model of Catena-X already includes Catena-X as the issuer of the membership credential that will be used by trading partners to authenticate each other. In the future, more Sub-TAOs will be accredited as Catena-X embraces decentralization with the help of SSI technology.

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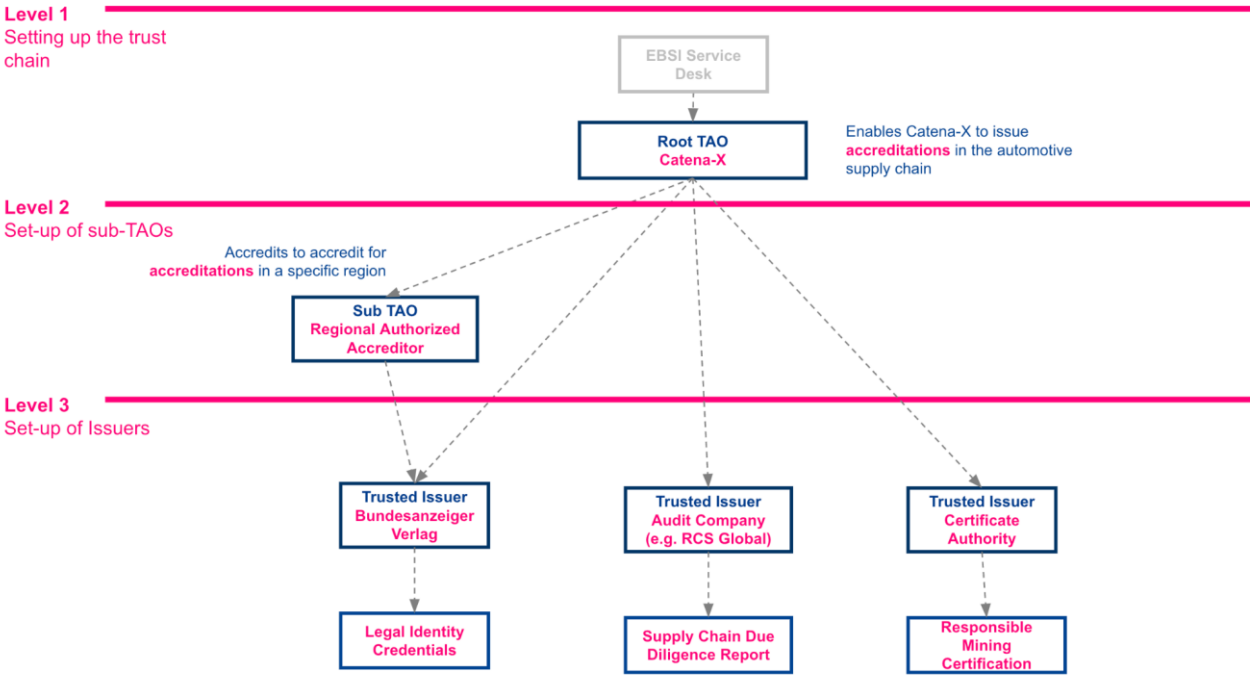

Figure 4.4: Trust model for the battery use case

On the trusted issuer level, there are number of issuers of relevant third-party verifications which are specified in the table below.

Name of the organisation	**Country**	**Organisational Role**	**Functional Role**	**Accredited to Issue**
Official organisation name	*ISO 3166 Alpha-2 code*	*Role an organisation will play in the pilot group.*	*Root TAO, TAO, TI, Wallet Provider, Verifier, IT Provider. Organisations may play one or more roles.*	*Accreditation or credential type*
Catena-X		Accreditation of issuers	Root TAO	Accreditation to Trusted Issuers Accreditation of Accreditors
Bundesanzeiger Verlag		Issuer of verifiable Legal Entity Identifier (vLEI)	Trusted Issuer	vLEI
Certificate Authority		Providing Certifications to Supply Chain Actors	Trusted Issuer	Responsible Mining Certification
RCS Global		Supply Chain Due Diligence Report issuer	Trusted Issuer, Verifier	Supply Chain Due Diligence Report
Mining Corporation		Supply Chain Entity	Trusted Issuer	Mining PCF Due Diligence Data
Refinery		Supply Chain Entity	Trusted Issuer	Refinery PCF Due Diligence Data
Battery manufacturer		Supply Chain Entity	Trusted Issuer	Refinery PCF Due Diligence Data

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Economic Operator		Supply Chain Entity	Verifier	
Regulator		Verifier of the DPP	Verifier	
Spherity GmbH		Wallet Provider	Wallet Provider, IT Provider	

Table 4.2: Roles in the Ecosystem

4.2.4 General Functional Requirements

Data Issuance:

- vLEI Issuance Capability: The system must enable authorized entities to issue verifiable Legal Entity Identifiers (vLEI) to relevant stakeholders.
- Certification Issuance Functionality: The system should allow trusted issuers to grant third-party certifications, such as responsible mining certifications, to mining operators and others, covering environmental, social, and governance (ESG) standards.
- PCF Credential Issuance: Supply chain participants must be able to issue their Product Carbon Footprint (PCF) as a verifiable credential within the system.
- DPP Credential Generation: The system should enable economic operators to issue Digital Product Passports (DPP) as verifiable credentials.
- Due Diligence Report Generation: The system must allow third-party auditors to issue supply chain due diligence reports.
- Accreditation Management: A root Trusted Accreditation Organisation (TAO) should be able to accredit and manage trusted issuers within the system.
- Schema Registration Capability: The system must enable the Trusted Accreditation Organisation (TAO) to register and manage trusted schemas for verifiable credentials. These schemas define the structure, attributes, and validation rules for the credentials that trusted issuers can issue.

Data Exchange:

- Secure P2P Connection Establishment: The system must facilitate stakeholders in establishing secure peer-to-peer (P2P) data exchange connections.
- Authentication Protocols: Stakeholders should be able to authenticate each other within the system to ensure secure and reliable interactions.
- Credential Exchange Mechanism: The system must provide a secure and efficient mechanism for stakeholders to exchange verifiable credentials through the established P2P connections.

4.2.5 User Stories

Data Issuance:

- As a trusted issuer, I want to issue vLEI to stakeholders so that their legal identities can be verified within the network.
- As a certification authority, I need to issue ESG certifications to mining operators to ensure compliance with environmental and social standards.
- As a supply chain participant, I want to issue a verifiable PCF credential to demonstrate my product's carbon footprint transparently.
- As an economic operator, I need to issue a DPP as a verifiable credential to comply with EU regulations.

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- As a third-party auditor, I want to generate and issue supply chain due diligence reports to provide transparency and accountability in the supply chain.
- As a TAO, I need to accredit trusted issuers to maintain a high standard of data integrity and trustworthiness in the system.

Data Exchange:

- As a stakeholder, I want to create secure P2P connections with other stakeholders to exchange data safely.
- As a system user, I need to authenticate other stakeholders to ensure secure and authorized data exchange.
- As a participant in the supply chain, I want to exchange verifiable credentials with other stakeholders through secure connections to maintain data integrity and compliance.

4.2.6 Data model

Based on the Functional Requirements and User Stories listed above, the data model contains the following credentials.

Legal Entity Identifier (LEI) credential

Establishing the legal identity of a stakeholder participating in traceability is paramount. It allows parties to authenticate each other during data exchange and links the organization's EBSI DID with a real-world legal identity. The figure below shows the data attributes of the verifiable LEI credential issues by Bundesanzeiger Verlag. Bundesanzeiger can issue this credential in 80 countries worldwide.

```
{
  "entityId": "did:ebsi:WRfXPg8dantKVubE3HX8pw", //DID of the credential subject
  "entityPrimaryName": "Spherity Gmbh", //Entity Name
  "entityAddress": "Emil-Figge Str. 80", //Entity Address
  "entityZipCode": "44227", //Entity Zipcode
  "entityCity": "Dortmund", //Entity City
  "entityCountry": "DE", //Country where the Entity is registered
  "registerEntityNumber": "8945009FTKJ5UNQHLA94", //Legal Entity Identifier
  "issuerName": "legalentityidentifier.org", //Name of the issuer
  "registerType": "LEI", //Type of Registry (in this case LEI)
  "issuanceDate": "2024-02-11T10:47:17Z"
  "issuanceValidUntil": "2029-02-11T10:47:17Z",
  "issuanceValidFrom": "2024-02-11T10:47:17Z",
  "issuerPolicy": "Legal Entity Identifier Credential Policy",
}
```

Third-party verification: Responsible Mining Certification Credential

The Responsible Mining Certification is a certification that verifies responsible mining practices. The certification contains multiple attributes that might be adjusted in the future as data schemas are being published in standard registries like Catena-X. A responsible mining certification, in this case the IRMA Certification, serves as an example of a third-party verification of the kind that is mentioned in the Battery Regulation.

```
{
   "entityId": "did:ebsi:WRfXPg8dantKVubE3HX8pw", //DID of the credential subject
   "certificationID": "sDiD4CMuEJ", //Unique identifier for the certification
   "entityName": "SQM Lithium", //Name of the mining entity being certified
   "mineSiteName": "SQM Nueva Victoria", //Name of the mine site being certified
```


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```
    "certificationStandard": "IRMA-STD-001", //Name of the standard used (e.g., IRMA, Fairmined)
    "certificationLevel": "IRMA 75", //Level or grade of certification achieved
    "auditEntity": "SCS Global Services", //Name of auditing entity
    "issuingBody": "IRMA", //Organization that issued the Certification
    "certificationDate": "2024-02-11T10:47:17Z", //Date of issuance
    "expirationDate": "2029-02-11T10:47:17Z", //Date of expiry of the certification
    "certificationScope": "Business Integrity, Social Responsbility, Environmental Resonsibility", //Scope or aspects covered by the certification
    "documentUrl": "https://example.com/IRMA/sDiD4CMuEJ", // URL to access the full due certification report
}
```

Product Carbon Footprint (PCF)

It's worth noting that both the GBA and Catena-X have developed comprehensive rulebooks and data schemas for calculating PCF. The code presented below highlights the data model for the Catena-X PCF credential. Furthermore, the Commission is anticipated to release a delegated act that will outline the PCF declaration format in early 2024. As a result, we expect the conversion to a final data format to be completed this year.

```
{
  "documentId": "3893bb5d-da16-4dc1-9185-11d97476c254", // Unique identifier of the PCF document
  "specVersion": "2.0.1-20230314", // Version of the specification or standard used
  "partialFullPcf": "Cradle-to-gate", // Scope of the PCF (from raw material extraction to the factory gate)
  "precedingPfIds": {
    "id": "3893bb5d-da16-4dc1-9185-11d97476c254" // ID of any preceding product footprint documents
  },
  "version": 0, // Version number of the PCF document
  "created": "2022-05-22T21:47:32Z", // Creation date of the document
  "extWBCSD_pfStatus": "Active", // Status of the PCF document (e.g., Active, Expired)
  "validityPeriodStart": "2022-01-01T00:00:01Z", // Start date of the validity period of the PCF data
  "validityPeriodEnd": "2022-12-31T23:59:59Z", // End date of the validity period of the PCF data
  "comment": "Comment for version 42.", // Additional comments or notes
  "pcfLegalStatement": "This PCF (Product Carbon Footprint) is for information purposes only.", // Legal disclaimer or statement
  "companyName": "EnergyTech Batteries Inc.", // Name of the company responsible for the product
  "companyIds": {
    "companyId": "urn:uuid:51131FB5-42A2-4267-A402-0ECFEFAD1619" // Unique identifier of the company
    "entityId": "did:ebsi:WRfXPg8dantKVubE3HX8pw" //DID of the company
  },
  "productDescription": "Lithium-ion battery for electric vehicles", // Description of the product
  "productIds": {
    "productId": "urn:gtin:4712345060507" // Unique identifier of the product
  },
  "extWBCSD_productCodeCpc": "011-99000", // Product code according to a specific classification system
  "productName": "EnergyTech EV PowerCell", // Name of the product
  "pcf": {
    "declaredUnit": "kilogram", // Unit of measurement for the product quantity
    "unitaryProductAmount": 500, // Amount of product per declared unit
    "productMassPerDeclaredUnit": 10, // Mass of the product per declared unit
    "exemptedEmissionsPercent": 0, // Percentage of emissions exempted from the calculation
    "exemptedEmissionsDescription": "No exemption", // Description of any exempted emissions
    "extWBCSD_packagingEmissionsIncluded": true, // Indicates if packaging emissions are included
    "boundaryProcessesDescription": "Includes mining, processing, and assembly stages", // Description of processes included in the PCF
    "geographyCountrySubdivision": "EU-DE", // Geographic subdivision of the country for the product
    "geographyCountry": "DE", // Country code for the product
    "geographyRegionOrSubregion": "Europe", // Geographic region or product
```


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```
  "referencePeriodStart": "2022-01-01T00:00:01Z",
  "referencePeriodEnd": "2022-12-31T23:59:59Z",
// List of cross sectoral standards used
  "crossSectoralStandardsUsed": [
   {
    "crossSectoralStandard": "GHG Protocol Product standard"
   }
  ],
// List of the product or sector-specific rule
  "productOrSectorSpecificRules": [
   {
    "extWBCSD_operator": "PEF", // Operator or organization defining specific rules
    "productOrSectorSpecificRules": {
     "ruleName": "urn:ev-batteries:PCF:2024:v1"
    },
    "extWBCSD_otherOperatorName": "ISO" // Name of another operator involved in defining rules
   }
  ],
  "extWBCSD_characterizationFactors": "IPCC AR6", // Characterization factors used (e.g., IPCC Assessment Report 5)
  "extWBCSD_allocationRulesDescription": "Allocated based on energy usage per production stage", // Description of allocation rules used
  "extTFS_allocationWasteIncineration": "system expansion", // Allocation method for waste incineration emissions
  "primaryDataShare": 80.5, // Percentage of primary data used in the PCF calculation
  "secondaryEmissionFactorSources": [
  // Sources of secondary emission factors
   {
    "secondaryEmissionFactorSource": "ecoinvent 3.8" // Specific secondary emission factor source used
   }
  ],
  "dataQualityRating": { // Data quality rating of the PCF
    "coveragePercent": 95, // Coverage percentage of the data
    "technologicalDQR": 1, // Technological data quality rating
    "temporalDQR": 1, // Temporal data quality rating
    "geographicalDQR": 2, // Geographical data quality rating
    "completenessDQR": 2, // Completeness data quality rating
    "reliabilityDQR": 2 // Reliability data quality rating
  },
  "pcfExcludingBiogenic": 2, // PCF value excluding biogenic carbon emissions
  "pcfIncludingBiogenic": 1, // PCF value including biogenic carbon emissions
  "fossilGhgEmissions": 0.5, // Fossil greenhouse gas emissions
  "biogenicCarbonEmissionsOtherThanCO2": 1, // Biogenic carbon emissions other than CO2
  "biogenicCarbonWithdrawal": 0, // Biogenic carbon withdrawal
  "dlucGhgEmissions": 0.4, // Direct land-use change greenhouse gas emissions
  "extTFS_luGhgEmissions": 0.3, // Land use greenhouse gas emissions
  "aircraftGhgEmissions": 0, // Greenhouse gas emissions from aircraft
  "extWBCSD_packagingGhgEmissions": 0, // Greenhouse gas emissions from packaging
  "distributionStagePcfExcludingBiogenic": 1.5, // Distribution stage PCF excluding biogenic emissions
  "distributionStagePcfIncludingBiogenic": 0, // Distribution stage PCF including biogenic emissions
  "distributionStageFossilGhgEmissions": 0.5, // Distribution stage fossil greenhouse gas emissions
  "distributionStageBiogenicCarbonEmissionsOtherThanCO2": 1, // Distribution stage biogenic carbon emissions other than CO2
  "distributionStageBiogenicCarbonWithdrawal": 0.5, // Distribution stage biogenic carbon withdrawal
  "extTFS_distributionStageDlucGhgEmissions": 1, // Distribution stage direct land-use change greenhouse gas emissions
  "extTFS_distributionStageLuGhgEmissions": 1.1, // Distribution stage land use greenhouse gas emissions
  "carbonContentTotal": 2.5, // Total carbon content
  "extWBCSD_fossilCarbonContent": 0.1, // Fossil carbon content
```


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```
  "carbonContentBiogenic": 0 // Biogenic carbon content
}
```

Supply Chain Due Diligence Report

The Supply Chain Due Diligence Report is a mandatory part of the Battery Pass. The full report will be published as a pdf document and linked in the Battery Passport. However, the Battery Pass consortium recommends the extract certain key attributes and include them as data fields in the Battery Pass for easier access and verification. This is reflected in the data schema below. This schema will be defined with the pilot partner RCS Global as we prepare for the pilot.

```
{
  "documentId": "DD2024-00123", // Unique identifier for the due diligence report
  "economicOperatorId": "did:ebsi:WRfXPg8dantKVubE3HX8pw", // Identifier of the economic operator
  "complianceStatus": "Compliant", // Compliance status regarding supply chain due diligence
  "auditDate": "2024-01-15T00:00:00Z", // Date when the audit or assessment was conducted
  "auditingBody": "Global Audit Services Ltd.", // Name of the third-party organization conducting the audit
  "keyFindings": "No major compliance issues; minor improvements needed in labor practices", // Summary of key findings from the audit
  "recommendations": "Enhance worker safety training, improve working conditions in certain departments", // Recommendations for improvement or corrective actions, if any
  "verificationStatus": "Verified", // Status of third-party verification
  "documentUrl": "https://example.com/due_diligence_reports/DD2024-00123", // URL to access the full due diligence report
  "complianceAreas": {
    "environmentalImpact": "Compliant", // Compliance status regarding environmental impact
    "laborRights": "Partially Compliant", // Compliance status regarding labor rights
    "humanRights": "Compliant", // Compliance status regarding human rights
    "communityImpact": "Compliant", // Compliance status regarding community impact
    "supplyChainTransparency": "Compliant" // Compliance status regarding supply chain transparency
  },
  "riskManagementMeasures": "Regular audits, employee training programs, supplier assessments", // Description of risk management measures implemented
  "additionalComments": "Plans to re-audit in 12 months due to partial compliance in labor rights" // Any additional comments or notes relevant to the due diligence process
}
```

Verifiable Credential Issuance

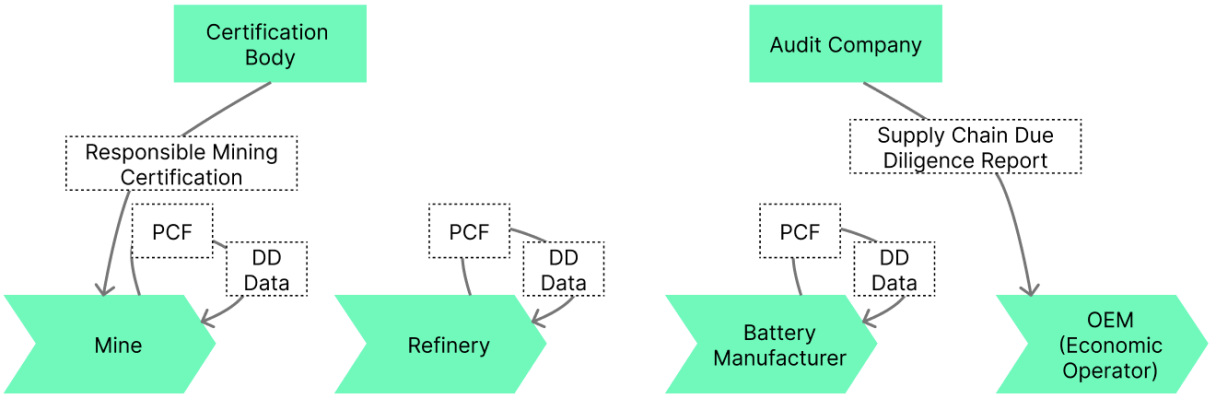

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Figure 4.4: Verifiable Credential issuance along the supply chain. PCF and Due Diligence (DD) Data are self-issued credentials

Verifiable Presentation Sharing

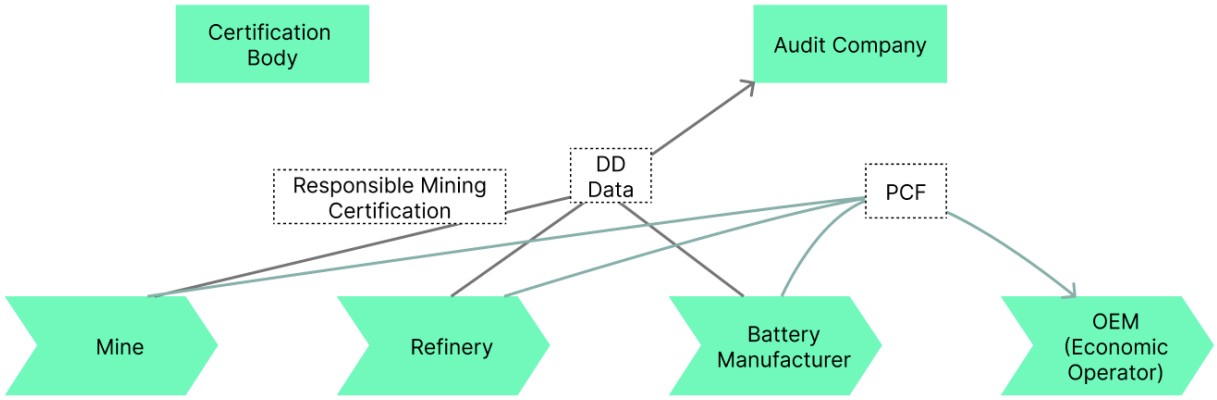

Figure 4.5: Verifiable Presentation sharing along the supply chain. The PCF is shared directly with the Economic Operator

5 Implementation of the Halloumi PDO tracing scenario

5.1 Introduction

The Halloumi scenario demonstrates the effectiveness of the European Blockchain Services Infrastructure (EBSI) in safeguarding PDO and PGI* registered EU products, with a focus on Halloumi cheese. This use case aims to protect the authenticity of Halloumi produced in Cyprus according to specific product specifications. It utilises EBSI capabilities and APIs to provide trusted, digitalized, and automated services for both professionals involved in the Halloumi production and consumers. By ensuring that consumers receive genuine PDO Halloumi cheese, this scenario protects the producer's investment and consumers' rights across the EU. With significant market potential due to Halloumi's popularity, this application scenario can serve as a model for other EU PDO/PGI products seeking to adopt blockchain technology for authenticity tracing, benefiting European PDO products more broadly.

*EU Quality schemes (Geographical Indications)
PDO – Protected Designation of Origin (food, agricultural products and wines.) - certification currently possessed by Halloumi
PGI – Protected Geographical Indication (food, agricultural products and wines.)

5.1.1 Supply chain stages & Processing steps

Registration and Certification of farmers and Halloumi cheese producers based on the Halloumi PDO production qualifying criteria.

- Production
- Storage
- Distribution
- Retailing - consumption
- Monitoring
- Auditing

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5.1.2 Description of the main Formal Procedures executed by the Control Body (Bureau Veritas)

Bureau Veritas Hellas MAE (BV) is the authorised body entrusted by the Ministry of Agriculture, Rural Development and Environment (MADRE) of the Republic of Cyprus (the Competent Authority) carrying out the control and certification procedures which relate to the evaluation of the compliance level of the use of the protected designation of origin (PDO) "Halloumi"/"Hellim", in accordance with its requirements specification. The audit and certification process is carried out on the basis of a Control Plan which was developed according to (a) the provisions of the Contract/Agreement between the Competent Authority and the Control Body (BV), (b) the Regulation (EU) 2021/591, of the executive decision of the European Commission (EU) 2021/586, (c) of the Single Document, as published in the Official Journal of the European Union (EU C 246 of 28.7.2015, p. 9), (d) of the Product Specification, (e) of the decision of the Minister of Agriculture Κ.Δ.Π. 326/2014, and (e) of the Decree of the Minister of Energy, Trade and Industry Κ.Δ.Π 10/2021. This Control Plan includes:

1. Procedures for inclusion in the control and certification system of businesses that produce, process, package, store, and market the product " Χαλλούμι" (Halloumi)/'Hellim' PDO.
2. The control, surveillance, and certification procedures of producers of the raw materials used to produce "Halloumi", as well as feed producers.
3. Rights and obligations of the companies to be certified, of the certified businesses, of the businesses that wish to secure an accreditation and those that have already secured one, as well as of the

5.2 Use case definition

5.2.1 Definition of Scope

Supply of raw Materials for the Halloumi production, its manufacturing process, and the supply-distribution journey.

Identification of products

	ID	**Data Carrier**
Χαλλούμι/ Halloumi / Hellim	PDO-CY-01243	REGISTER OF PROTECTED DESIGNATION O ORIGIN AND PROTECTED GEOGRAPHICAL INDICATIONS ESTABLISHED BY ARTICLE 11 OF REGULATION (EU) NO 1151/2012

Table 5.1: Identification of the product

Every PDO product is recorded in the PDO registry and receives a unique ID.

For the "Χαλλούμι" /"Halloumi" /"Helim" specifications and technical information, please check the following link : CY/PDO/005/01243

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5.2.2 Product Description

- "Fresh Halloumi" is a product produced from curds derived from the coagulation of milk with pus. It is baked and given its characteristic shape. "Pus" is the preparation containing the enzyme chymosin (rennin), obtained from the fourth stomach of calves and has the property of curdling milk. Includes and other similar enzymes but does not include rennet derived from pigs.
- "Mature Halloumi" is the product produced from cheese curd that comes from coagulation of milk with pus. It is baked, given its characteristic shape, *and left to mature in brine.* "Pus" is the preparation containing the enzyme chymosin (rennin) taken from the fourth stomach of calves and has the property of curdling milk. Includes and other similar enzymes but does not include rennet derived from pigs.

5.2.3 Why blockchain/EBSI?

While other technology options exist to help manage supply chains, blockchain provides an alternative way, one that can bring together different parties that have not directly established trusted relationships with one another through the transparency it provides and its tamper-evident nature. Blockchain stores every transaction or exchange of data that occurs in the network, potentially reducing the need for third parties and/or intermediaries by providing a means by which all parties (actors) in the network may share access to the same data, including what is added to the data, by whom, chronologically. Data cannot be removed. By enabling each party to see the same data, in near real time, and assure that 'you see what I see' from a data perspective, blockchain can help eliminate complex and costly data reconciliation required by most commercially available systems today.

EBSI is the blockchain platform developed and funded by EC in order to facilitate the application of administrative services (use cases) through a trusted and secure framework of capabilities supporting transactions (exchange of data) between citizens, civil administration, and companies (legal entities).

5.2.4 Challenges

Blockchain is not a silver bullet, and EBSI is currently under development, and evolving based on the value-impact to the public of the proposed services (UCs). Some supply chains may be better served through other existing technologies and solutions. Furthermore, different stages of the supply chain might be more suitable and feasible for leveraging blockchain than others. A few key challenges include:

- Value for each actor
- Availability of supporting infrastructure, i.e., tools, and enabling technology
- Level of digital maturity of various actors (e.g., farmers)
- Level of connectivity
- Level of data quality and standardisation
- Incentive(s) for different actors
- Level of collaboration/mistrust between partners
- Integration with existing individual MIS/ERP platforms (databases, back-end systems, etc.)
- Required Investment (cost to set up, digital transformation, and technology operations)

5.2.5 Main goals of the traceability solution

1. Significantly improve the traceability of Halloumi cheese (being one of the most significant Cypriot local and traditional PDO products) and its certification process.
2. Protect the product's integrity, the producers' investment, and the consumers.

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a. Decisively reduce the possibility of fraud (counterfeiting, or, not fulfilling the PDO certification standards).
b. Increase productivity (control - minimise effort/costs) and promote healthy competition.

3. Provide immediate, reliable, transparent, and immutable product certification.
4. Ensure the integrity of the traceability process.
5. Provide fast, trustworthy, and secure forensic (audit trailing) means. This should include the identification of products that may have been altered by environmental factors throughout the production and distribution chain (e.g., transportation, storage conditions, production environment conditions etc.).
6. Facilitate the effective and secure administration/management of the entire production and supply chain.
7. Monitor the physical movement (transportation, distribution, retailing), as well as the status of products by collecting and exchanging information at various points throughout the supply process chain.

5.2.6 Definition of Roles in the Ecosystem

Name of the organisation	**Country**	**Organisational Role**	**Functional Role**	**Additional Information**
Official organisation name	*ISO 3166 Alpha-2 code*	*Role an organisation will play in the pilot group.*	*Root TAO, TAO, TI, Wallet Provider, Verifier, IT Provider. Organisation may play one or more roles.*	*e.g., organisation's website, other information*
GOLDMAN		Specify, Design and Develop the EBSI Application (Halloumi UC)	IT Provider, Wallet Provider	
Ministry of Energy, Commerce and Industry - MECI/CYSAB		Accredits Laboratories and Control Bodies to to issue quality attestations	Root TAO	CY Standards Accreditation Body CYSAB (under MECI), defines quality standards and accredits Bodies to run quality processes.
Ministry of Agriculture, Rural Development, and the Environment – MADRE		Accredits TIs (farmers) to issue raw material /products' attestations (VCs). Accredits Control Body to accredit Halloumi Producers	TAO	
Control Body Bureau Veritas - BV		Accredits certified Producers to issue Halloumi product VC	sub-TAO	
Ministry of Health (State General Lab – SGL)		Issues Isotopic attestations (VC)	TI and Verifier	

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Major Retailer/Storage/Exporter/Distributor		Issues Product Journey VC	TI and Verifier	
Milk Producer - Supplier		Issues raw material VC	TI	
Fresh Mint Producer - Supplier		Issues raw material VC	TI	
Enzymes Producer - Supplier		Issues raw material VC	TI	
Halloumi Producer		Issues product VC	TI and Verifier	
Retailer			Verifier	
Consumer			Verifier	

Table 5.2: Roles in the Ecosystem

5.2.7 Trust Model Definition

Actors, roles and relationships.

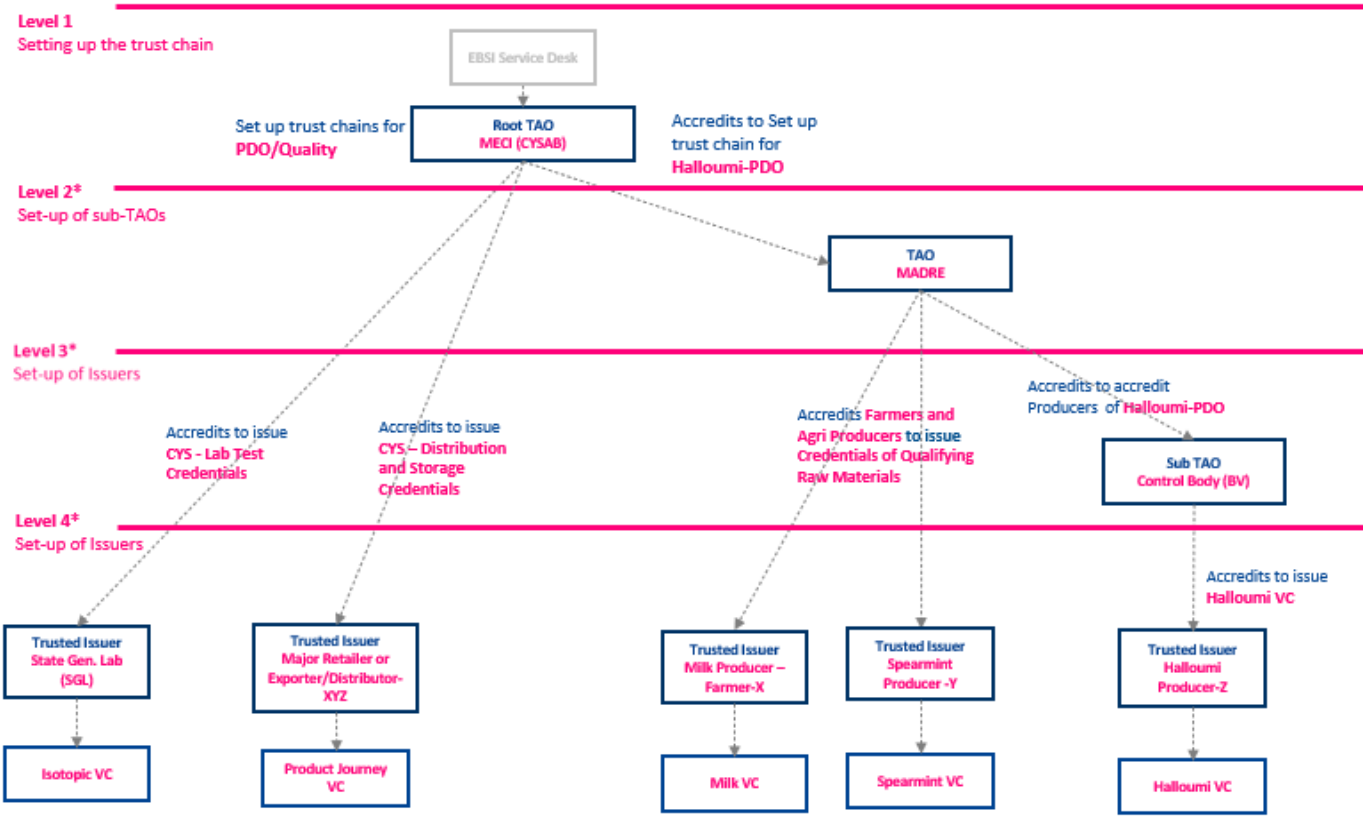

Figure 5.1: Trust model for Halloumi use case

5.3 Use case requirements

5.3.1 General Functional Requirements

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Requirements description

- The various stages of the production and/or supply chain should be marked with smart tags (eg, QR). Data to be captured related to each stage of the process will be compliant with the track-and-trace auditing requirements specified in the formal certification and auditing manual for the PDO product (Halloumi cheese).
- The solution should be supporting the creation of QR codes (and/or NFTs?).
- Tracking-tracing functionality accurately reveals the origin, real-time location, and status of the product/lot in question at any time.
- Traceability data will be related to the existing isotopic database of the State General Chemistry which will be enriched, for the certification of the product's origin as well as its production process [option *to be discussed/confirmed - SGL RFP*].
- The platform will allow interested parties to use the data in preparation for filing new applications to certify their entry in the Halloumi (PDO) industry, a process executed via a Competent Authority [option *to be discussed/confirmed - SGL RFP*]. There should be a facility function for the applicant to request certification and once awarded, to be able to enter the Halloumi product supply chain. Interoperability must be enabled with essential data sources or systems [*to be identified*] with which interaction is required throughout the process.
- The employment of a digital wallet will be necessary for users to interact exchanging EBSI VCs. The User/Holder wallet must be EBSI compliant (WCT v.3).
- The solution will be utilising EBSI's current capabilities (existing APIs) as well as new API's that will be developed by the EBSI core team, which are necessary to support Traceability Use Cases, as these will be specified by the Trace4EU project.
- System interoperability functions should be provided as services via APIs (interface keys, e.g., jwt tokens).
- Data Interface and API Integrations, used to verify or retrieve information/data/certificates/accreditations where appropriate:
  - SGL's Isotopic Database
  - CYLogin system for user identification and access management
  - EBSI APIs (eg, DID Registry, and other relevant EBSI VCs)
  - Existing/operational 3rd party ERP system(s) [*to be discussed/confirmed - SGL RFP*]
  - Provision for interconnection with other relevant authorities/services/departments in case the need arises through the analysis of the system specifications [to be discussed/confirmed - SGL RFP].
- Webhook notification interface to create and send notifications for asynchronous tasks in progress. Integrating notifications will ensure a common view of physical and digital product status. [option *to be discussed/confirmed - SGL RFP*]
- Certification /accreditation process based on EBSI's Verifiable Credentials capabilities. This will require the development of new VC schemas relevant to the characteristics of the products, product test results (authenticity, and quality/nutritional values), and any other product data that may be deemed necessary for the implementation of the Use Case.
- Audit support in full alignment with the formal Auditing process (externally contracted to Bureau Veritas – ref. BV paper)
- Ability to onboard Actors and integrate corresponding entities based on a custom-designed EBSI Trust model (TAO, TIs, Verifiers, Holders)

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Non-EBSI related requirements (options aligned with SGL RFP, to be discussed/confirmed)

- The solution platform must be accessible through a web application (Web responsive app), also accessible via mobile devices. Through the online application the user will be able to collect data, or request for the digital registration of products.
- The platform will provide user profile management (role-based) for controlled access to data/functions as determined by the Competent Authority's security policy. Access management must be compatible and interoperable with the Gov.cy/CYLogin system.
- Webhook notification interface to create and send notifications for asynchronous tasks in progress. Integrating notifications will ensure a common view of physical and digital product status.

Main issues to be addressed

More can be done to equip competent Authorities, producers, retailers, and consumers with real-time traceability of products within the current global food supply chain.

Blockchain, a type of distributed ledger technology (DLT), has been increasingly gaining market traction in supply chains, for example, in proving product provenance and implementing track-and-trace of products through the supply chain. While blockchain alone does not solve traceability, it can be a game-changer. When implemented effectively, it can connect and enable efficiency, transparency, and accountability among participating actors. Better and more reliable data can help optimise business decisions and reach higher standards for production, efficiency, and sustainability.

Companies are increasingly looking towards adopting Supply Chain Management (SCM) systems that enable inter-enterprise cooperation and collaboration with suppliers, competent Authorities, business partners and customers. Although there are potential benefits for achieving competitive advantage, companies also face significant challenges in digitising their supply chains such as:

- Coordinating process and digital transformation across multiple, disbursed, and often disconnected supply chain actors.
- Lack of connectivity, particularly with upstream suppliers.
- Heavy and costly data reconciliation processes.
- Ineffective solutions for handling large amounts of disparate and potentially inconsistent data.
- Making relevant parts of the SCM system and the data it captures available to be shared between different actors to foster cooperation and collaboration across the entire value chain in a secure and trusted way.

It is therefore important that the development of such solutions is appropriately governed, driven, and coordinated by competent Authorities, rather than individual companies themselves, to secure legislative compliance, interoperability, standardisation, re-use, and cost effectiveness.

5.3.2 Data Model

Subject	**Issuer**	**Data Collected**
Material - Milk	Farmer	Raw material Type/ID, Prod date, quantity

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Material - SpearMint	Farmer	Raw material Type/ID, Prod date, quantity
Product - Halloumi cheese	Producer	Product Type/ID, Prod date, quantity
Transportation	Farmer, Producer, Distributor-Supplier	Product Type/ID, Prod date, quantity
Storage	Farmer, Producer, Distributor-Supplier	Product Type/ID, Prod date, quantity
Retail	Major Retailer / exporter-distributor-Supplier	Product Type/ID, Prod date, quantity

NOTES on issuing and exchanging VCs (scenarios-based)

1. Each actor in the supply chain (Milk producer, mint producer, halloumi producer, distributor, retailer, etc) creates his EBSI business wallet (did:ebsi:xxx)
2. The Root-TAO, TAO, and sub-TAO accredit each one of the actors accordingly as a trusted issuer (TI) of a specific VC schema having first been certified (CYSAB/BV current process). The schemas to be used should be enhanced to support the "proof" property. This will be a VC type that the issuer is required to provide in order to be able to issue a VC to someone else in the chain.
3. Each actor in the supply chain may use his business wallet to issue a verifiable credential for a specific batch of halloumi ingredients that he has produced. This VC will be issued to the next in-chain actor. That is, the actor that will receive this batch of ingredients for further processing. But in order to be able to do this, the current actor must prove that he has in his possession (issued to him) the required VC specific to the batch from the previous in-chain actor. This is something that we can not enforce at the moment with the existing EBSI processes/capabilities, and we should ask for it. So, the issued VC for the next in-chain actor will include the next actor's DID (that is, the owner of the VC) and, amongst other data, the actual VC issued to the current actor from the previous actor and for the specific batch. The current actor could initiate the issuance of the VC from the previous in-chain actor by scanning a QRcode on the previous actor's mobile, or through the previous actor's website.
4. When the batch reaches the retailer (shop) the retailer will have a VC issued to him from the previous in-chain actor and which will include all the info needed (VCs) to trace back the production of this specific batch. The VC in possession of the retailer will actually be a chain of VCs, each one embedded within the next one (see schematic at the end).
5. All packages belonging to the batch will have a QRcode printed on them which the user can scan with his mobile. The QRcode will fetch the VC issued to the retailer from an off-chain database, verify the validity of the VC using EBSI's TIR and display to the user information from all the VCs that have been used to produce this batch.

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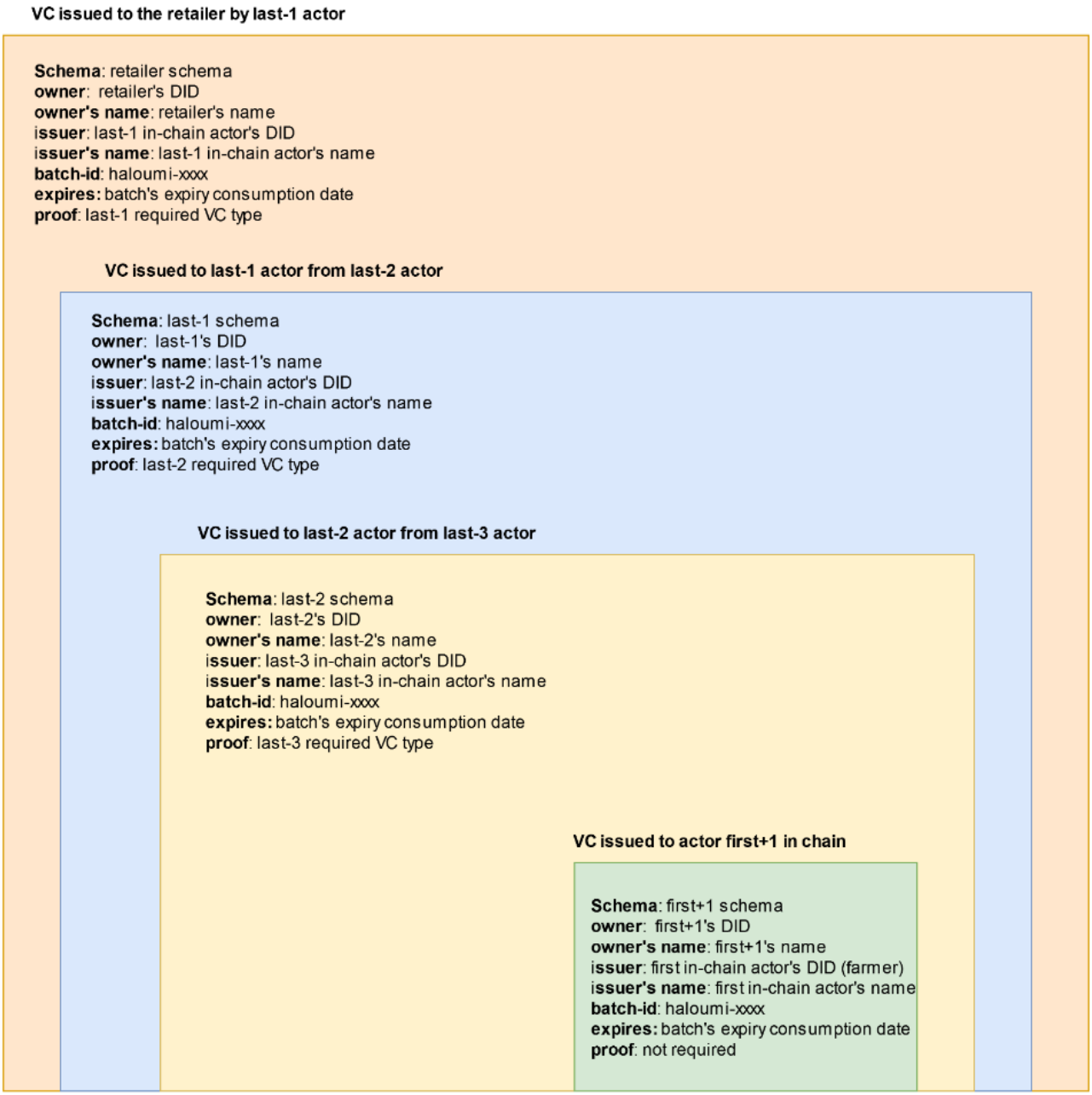

Further Notes on VCs:

1. The possession of a VC in this solution is proof that the owner of the VC is certified in all respects to take part in the supply chain.
2. The inspection agent assigned by the government will perform periodic inspections in all actor's premises and he will be able to revoke an actor's accreditation to issue VCs in case the actor is found not to be compliant with health or other regulations.
3. An actor should NOT be able to issue a VC for the next in-chain actor if the next in-chain actor's status is revoked. This is something that can not be enforced at the moment. Need to ask EBSI. Maybe there should be a registry like TIR but with a list of DIDs of organizations/companies who are eligible to get issued VCs (instead of eligible to issue VCs).

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4. The last actor in-chain (retailer) is a special case since he is not an issuer. Need to decide how to enforce rules 1 and 2 above in case the retailer is forbidden to sell the product.
5. An actor should only be able to issue a VC for the next in-chain actor if he can prove that he has in his possession the required VC that is needed for issuing the specific VC. See steps 2 and 3 in the flow above.
6. The first actor in-chain (farmer) is also a special case since he is not required to provide any proof in order to issue a VC for the next (first+1) in-chain actor.
7. The described solution is not limited to Halloumi use case but can be used by any other traceability use case.

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