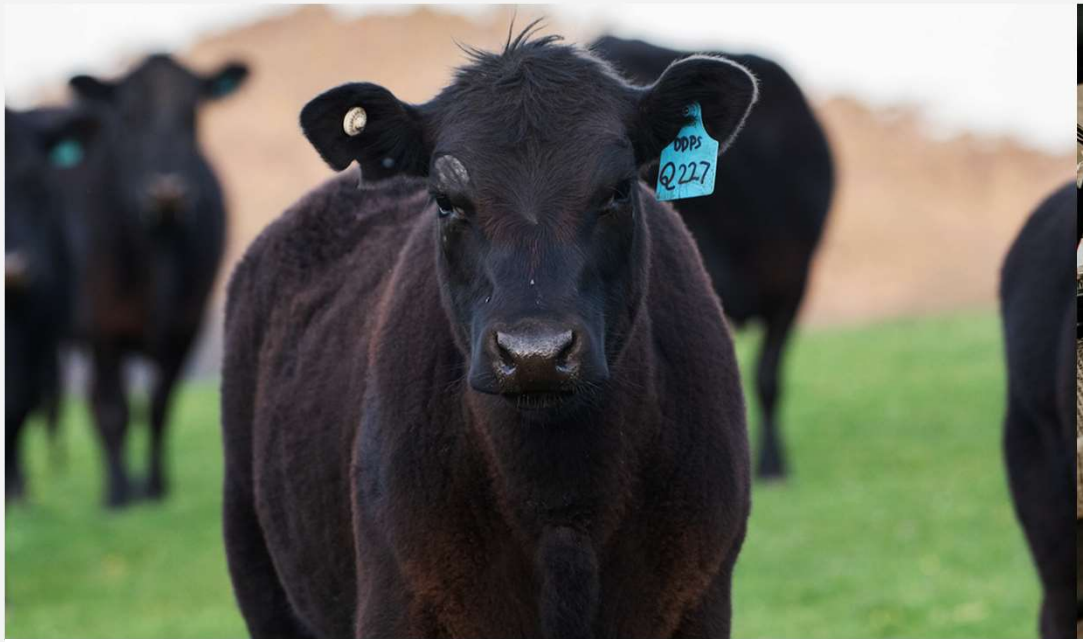


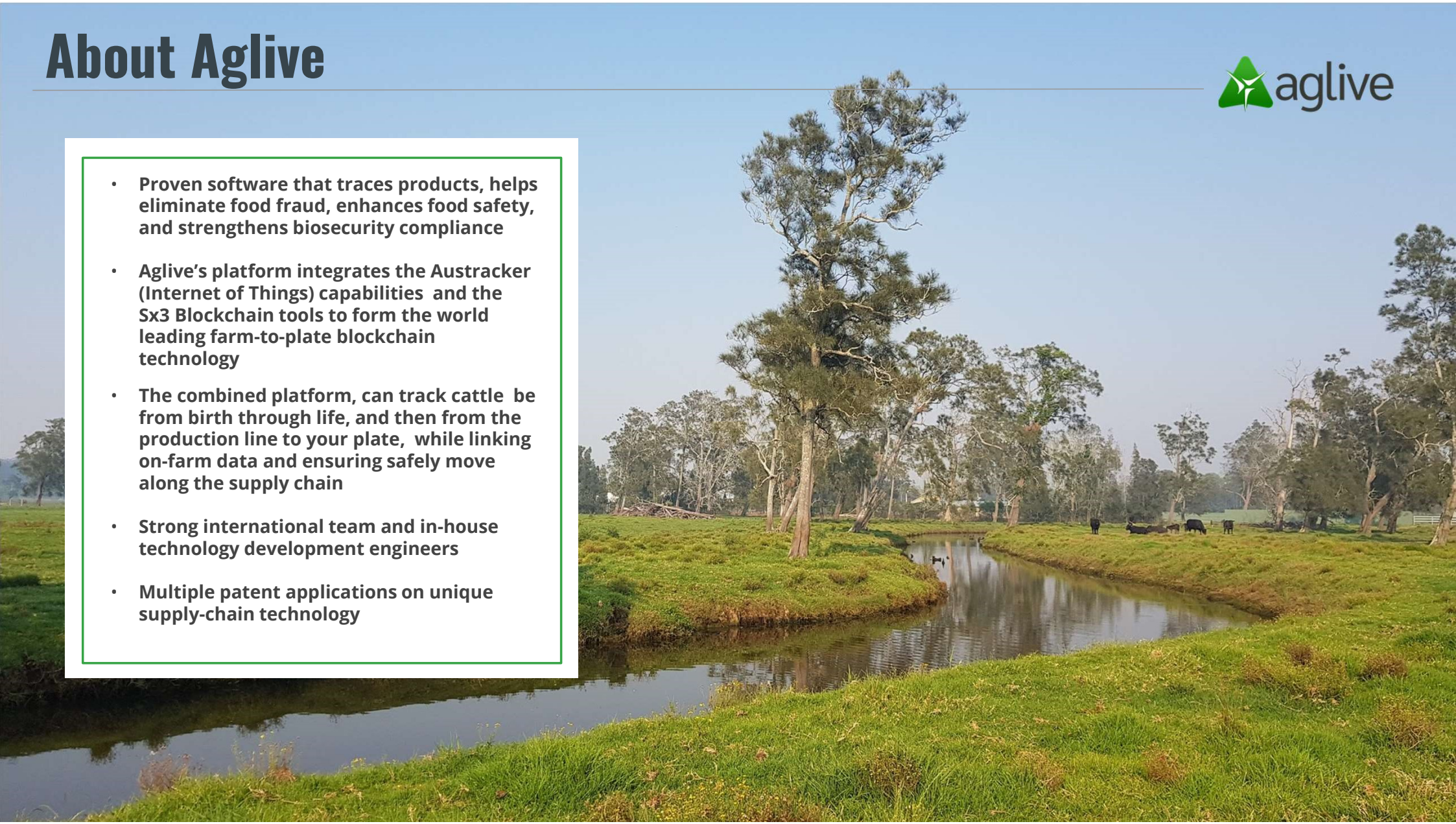
True Farm-to-Plate Platform

(and Supply Chain Traceability Solution)

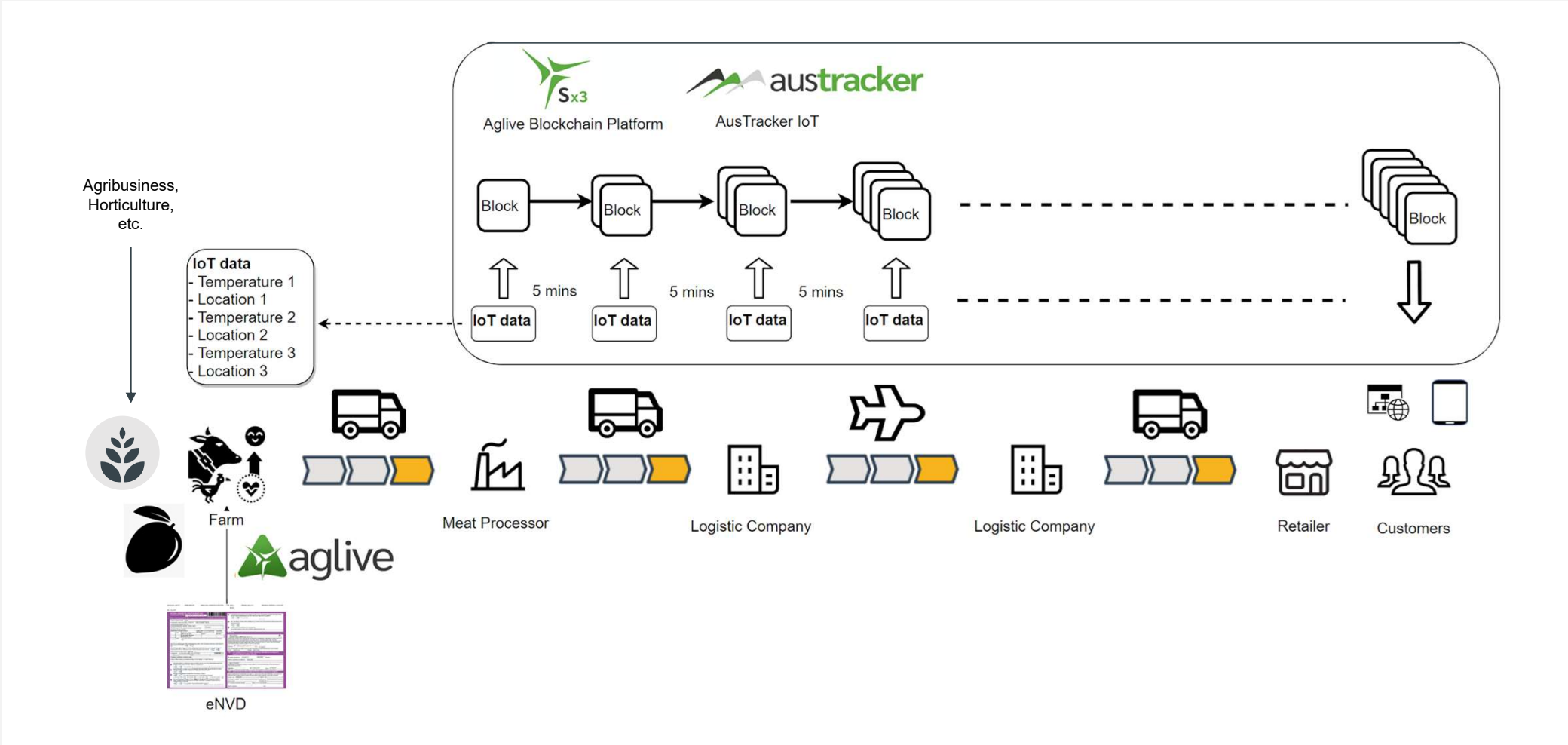
aglive

About Aglive

- Proven software that traces products, helps eliminate food fraud, enhances food safety, and strengthens biosecurity compliance
- Aglive's platform integrates the Austracker (Internet of Things) capabilities and the Sx3 Blockchain tools to form the world leading farm-to-plate blockchain technology
- The combined platform, can track cattle be from birth through life, and then from the production line to your plate, while linking on-farm data and ensuring safely move along the supply chain
- Strong international team and in-house technology development engineers
- Multiple patent applications on unique supply-chain technology



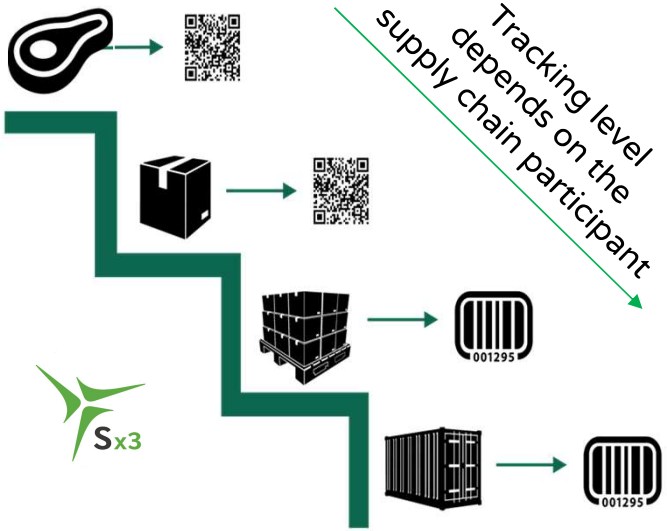
Supply Chain Monitoring



Supply Chain Monitoring – Our Aglive Platform

Our Aglive Platform consists of;

- Aglive IntegriPro captures and digitises all on-farm data
- AusTracker is Aglive's IoT device solution, capturing data from partner solutions, incl. goods movement tracking (allowing accurate delivery times and/ or just-in-time monitoring of stock control), warehouse tracking, cold chain monitoring, humidity verification, shock monitoring, etc.
- Sx3 blockchain solution completes the end-to-end supply chain traceability model through creation of digital twins of serialised trade items and logistic units.



Sx3 Blockchain

- Each physical trade item and logistic unit (pallet and containers) has an unique digital asset (token).
- Supply chain partners can pass control of 'tokens' along the supply chain
- Each participant uses an encrypted key to create a new entry on the ledger and record each token movement
- Tokens can be linked to industry standard data formats, e.g. SSCC label, GS1 code, etc.
- Each participant accesses the blockchain through a node's "full copy of the ledger"
- Nodes analyse and validate the supply chain data before it is appended on the blockchain (Validation is based on a scalable protocols embedded in the blockchain platform)
- Additionally, our solutions integrate (using standard API) with existing supply chain partner's solutions, e.g. scan guns, label printers, etc. to ensure the "our" data collection uses non-intrusive solutions to fit with your process and technologies

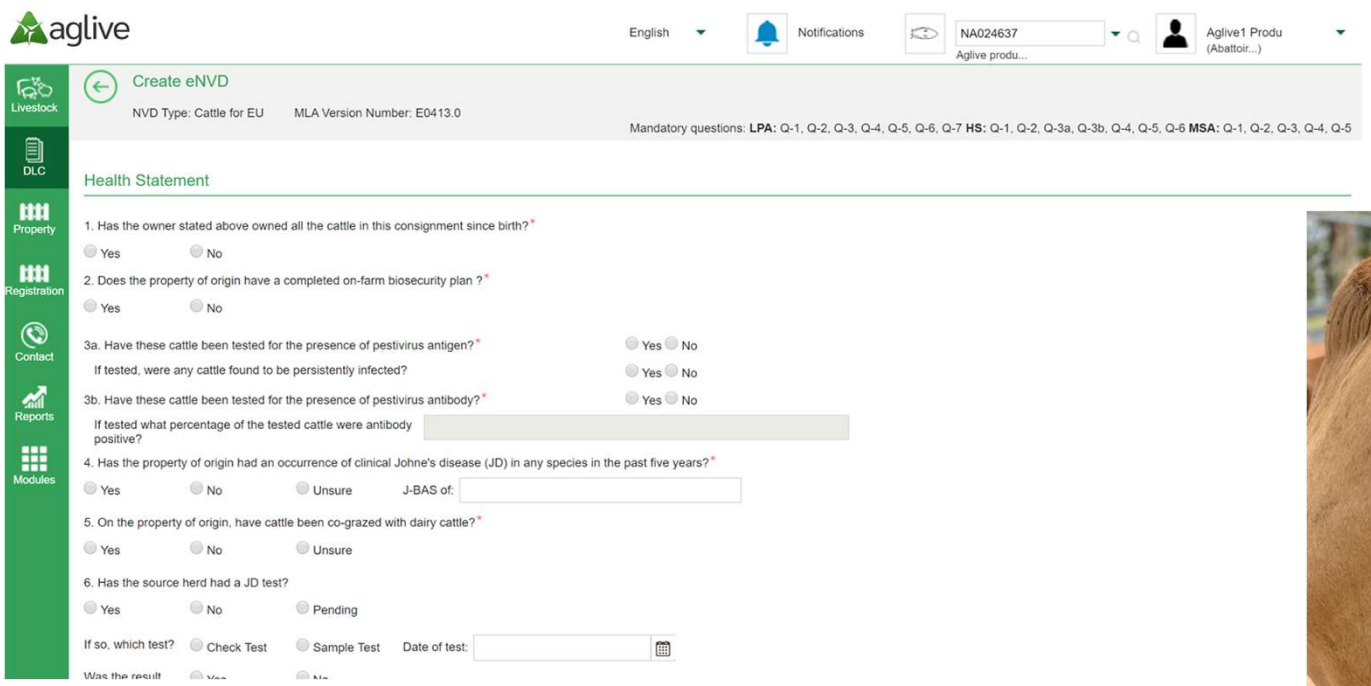
Ecosystem Collaboration

Transformative Concept

We have now built a technology alliance of entities who have agreed to work together to transform agricultural systems by providing an integrated AgTech service platform, extending our Aglive Platform

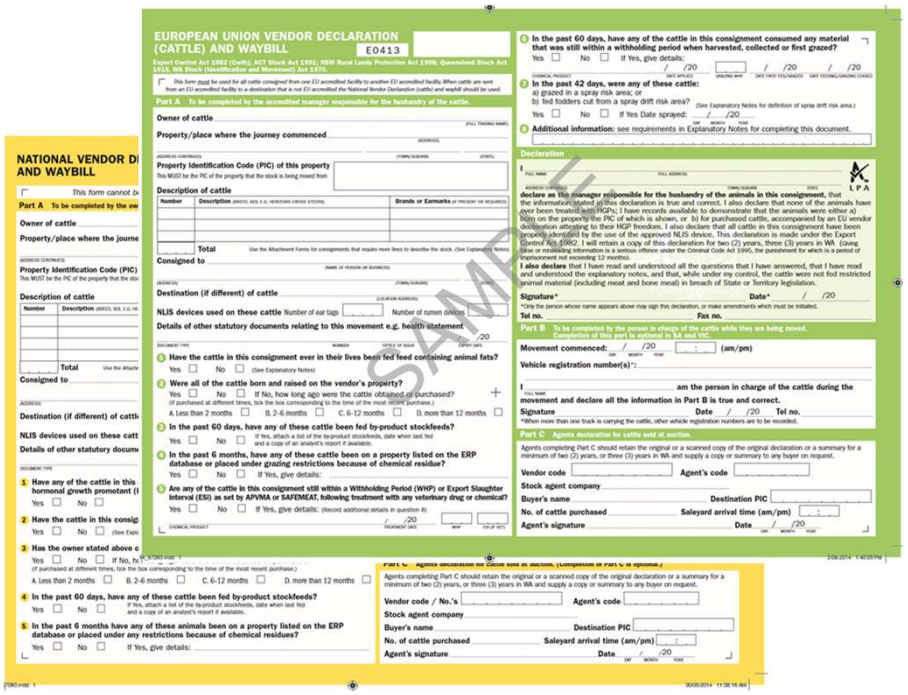
Our IoT Partnerships – Animal Welfare

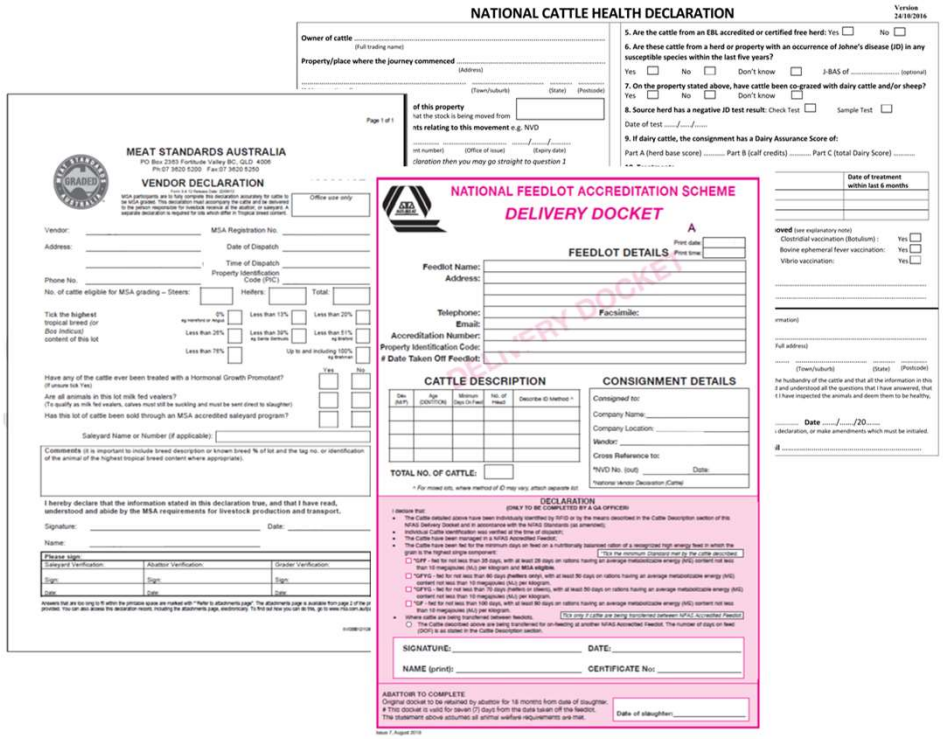
Out IoT partnerships are extending well beyond our own solutions, e.g. our on-farm solution is able to monitor and verify animal welfare data. We are assessing the merits of powerful IoT devices to further reduce manual data capturing, like Ceres Tag, which acts as a 'FitBit for Cows' and captures each animal's individual data



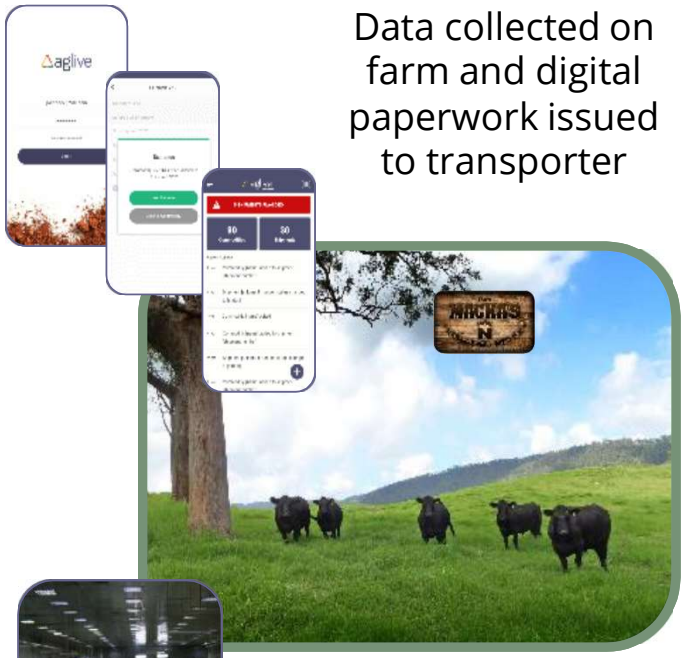
Our Ecosystem – Simpler Compliance Tools

We our continuously growing our ecosystem through collaborating with regulators in various countries to provide easier compliance by replacing paper-based customer declarations with app-based tools





Delivering Food Traceability



Data collected on farm and digital paperwork issued to transporter

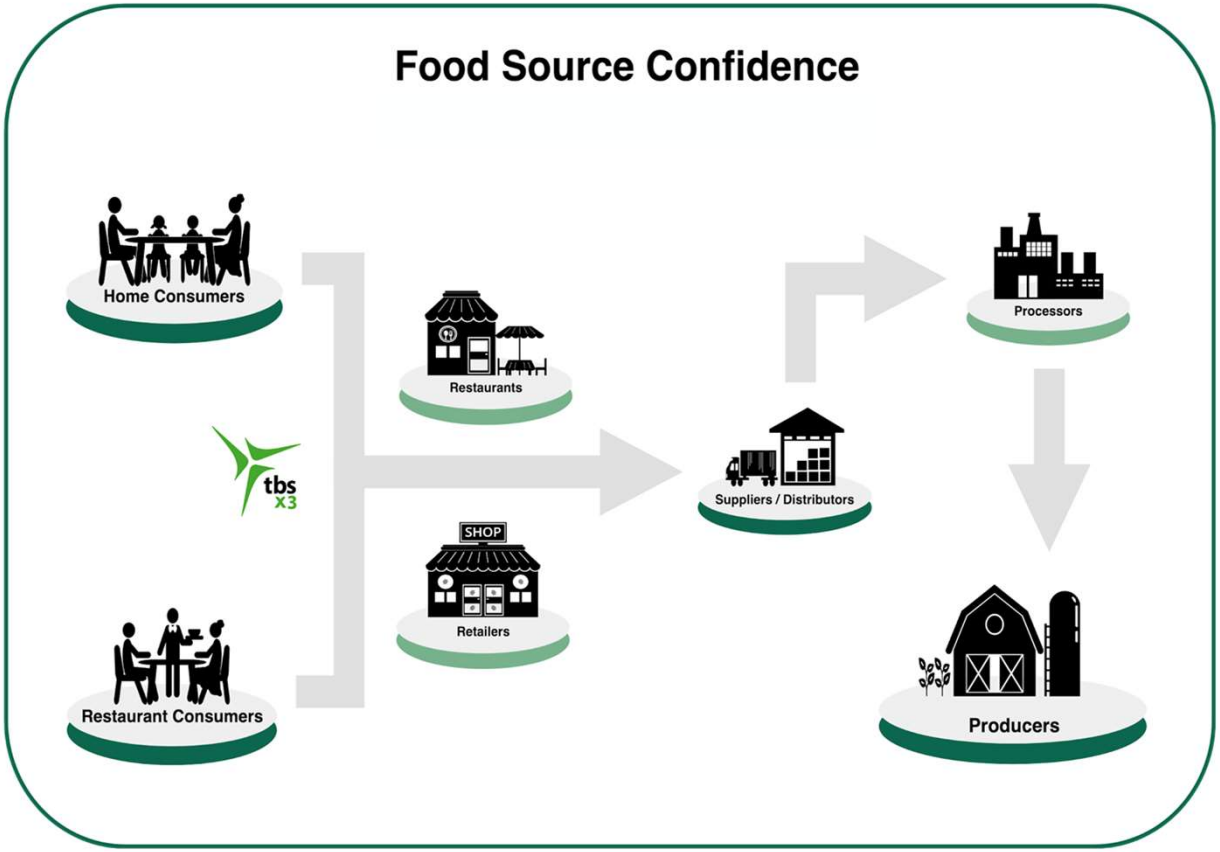
Shipment of beef departs Sydney for Shanghai and is traced along its journey

Beef received in Shanghai and transported to factory for manufacturing

Dumplings made in Crazy Dragon's factory

Dumplings enjoyed in restaurant, and diners scan QR code on menu to receive beef's history

Supporting Food Safety



Proof of Origin:
Provenance, accreditation and certification data for customs, agencies and consumers

Food Recalls:
Promptly identify a contaminated source and contain problems

Easy Food Recalls

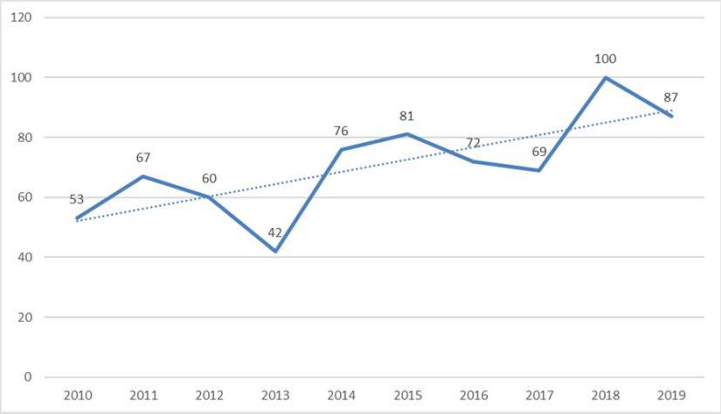
Australian food recalls are rising

Food Recalls Increasing

Between 2010 and 2019 Food Standards Australia has reported 707 recalls

Undeclared allergens and microbiological contamination are the leading causes, with foreign matter and bio-toxins also being significant reasons.

British Retail Consortium (BRC) certificated businesses must achieve traceability within **four hours**



ABC NEWS

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Rockmelon listeria investigation finds outbreak that killed seven largely caused by dust storms

ABC Rural By Clint Jasper

Posted 11 Oct 2018, 6:45pm

An investigation into a series of deaths linked to listeria on rockmelons has concluded the contaminated fruit came from a single farm in New South Wales, and the outbreak was largely caused by the weather.

Between January 16 and April 10, 22 cases of listeriosis occurred across New South Wales, Victoria, Queensland and Tasmania, which led to seven deaths and a miscarriage.

A report released on Thursday by the NSW Department of Primary Industries confirmed those cases were all linked to consumption of rockmelon

PHOTO: Rockmelon sales dropped by 90 per cent after fruit from a single farm was recalled. (ABC Rural: Sarina Locke)

Recall Tools

Our AI tools, incl. reports and recall tools, enable producers (and our customers) to swiftly identify:

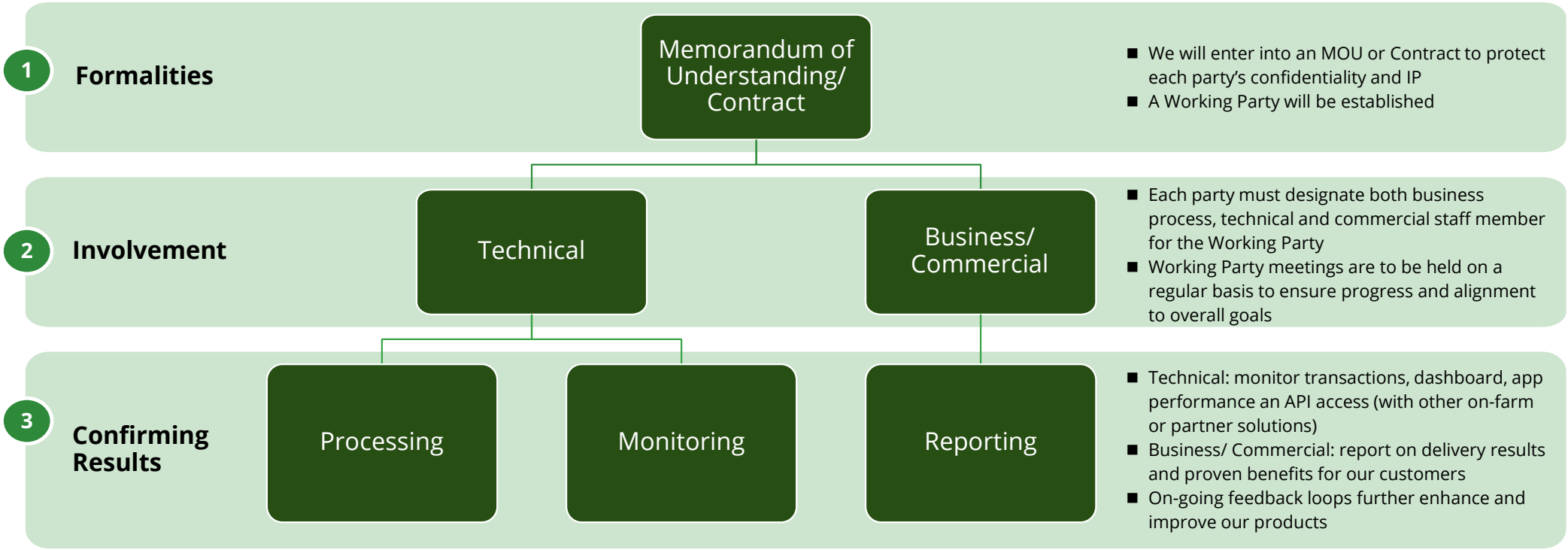
- **Who is affected**
- **How they can be contacted**

Prompt action may prevent additional damage or injury, be important to market perceptions, and limit brand damage, and be a crucial legal defence.

Team Collaboration

aglive

We partner with our customers and solution partners to achieve results



Trail Core Functions

The core functions involved in the Provenance and Traceability solution

1 On-Farm Data (if relevant)

- Livestock Production Assurance 'LPA" electronic National Vendor Declarations 'eNVD's' or Horticulture regulatory requirements
- Meat Standards Australia 'MSA' and National Feedlot Assurance 'NFAS' declarations (if relevant)
- Validated data provides the 'farm' component of the brand story

2 Registry

- Brand owner is issued with an encrypted private key that, in turn, can generate public keys
- An individual public key code is to be generated for each protected item
- The encrypted codes are to be permanently affixed to each protected item

3 Identity

- an individual public key code is to be attached to each protected item in the shipment
- Items are to be bundled into cartons and then cartons are bundled into a pallet and pallet is bundled into a container.

4 Code Activation

- Once the shipment is packed, all bundled codes related to the shipment are activated and tracking commences on the Sx3 Blockchain.
- All activated codes are live on the Sx3 Blockchain and the registry entries are processed by the Sx3 Nodes and entered in the Sx3 Blockchain when consensus is reached

5 Data Capturing/ IoT

- By using multiple data collection devices (e.g. IoT – GPS, Cold Chain, etc.) or data entry points, incl. custodial changes, as the shipment moves along the supply chain is tracked, recorded, and displayed in the Aglive Dashboard
- Each trial participant in granted access to the Aglive Dashboard so the shipment's movements can be monitored in real time.

6 Delivery

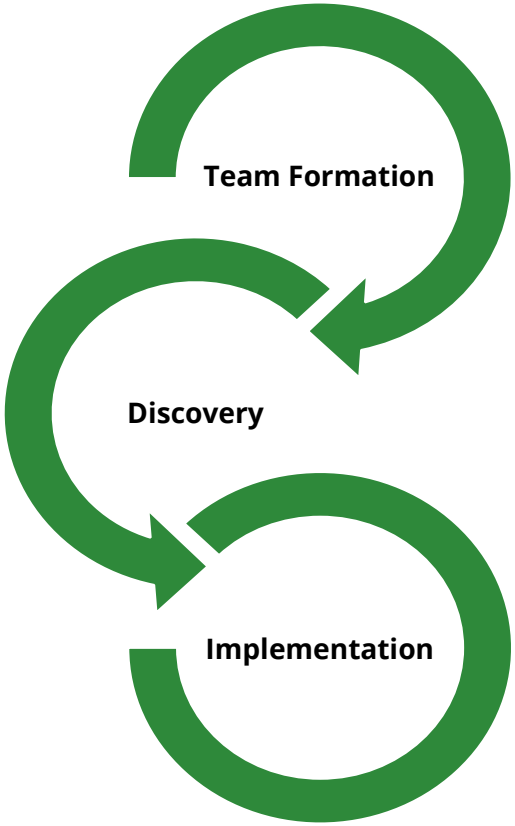
- The shipment is transported and then passed along the supply chain in that location until it is delivered to the end user.
- As the shipment is unbundled that distribution process is to be tracked and recorded on the Sx3 Blockchain by the person taking that action.

7 Verifiable Data

- The end user/ consumer can use the free Aglive App to check that: (1) the item has a valid ID; (2) no anomalies are detected in the logistics movements; and (3) the ID is valid and has not been previously used.
- Consumer validates the "plate" component of the journey

Our Approach

Building sustainable future partnerships with our technology partners and customers



- Once the MOU/ Contract is signed to establish confidentiality, the Working Party will be established, and we work together to determine the best commercial and operational outcomes
- Detailed workshops and/ or scenario map (with data requirements) will be initiated to determine the various implementation stages, goals, roles, data requirements and commercial and operational requirements
- Discovery process to determine the process/ technical requirements will be identified, managed and resolved – reducing double entry or rework through relevant fit-for-purpose add-ons
- Working Party will "meet" regularly to assess and monitor trial progress
- Aglive will guide the relevant users to operate and monitor the Aglive IntegriPro on-farm solution and or AusTracker and/ or the Sx3 Blockchain
- The Aglive Dashboard enhancements will be defined and delivered to meet your operational and reporting requirements
- Marketing issues and the requirement to inform and educate end-users will be considered and actioned
- Consider an effective trading alliance between the parties to gain long-term benefits from the partnership

Aim

Design and implement an effective solution that can be easily and consistently implemented at scale across your business and beyond

A Selection of Our Customers

IUS WINES

Est. 1884
MACKA'S
AUSTRALIAN BLACK ANGUS BEEF

Aurora
DAIRIES
MANAGED BY WARAKIRRI

Wine Tracked to China

Aglive completed the world's first wine export blockchain traceability trials tracking a wine shipment from Coonawarra to Qingdao China

aglive

Successful Wine Trial

The Aglive/ TBSx3 wine trial was successfully completed and a series of further live trials are underway

Initial Shipping Trial Participants

Lead Partner

- Lead partner for TBSx3's initial shipping trial
- Globally, DP World Group have 77 terminals on 6 continents
- By 2020, the group intends to handle ~100 million containers per year

International Companies

- Hamburg Sud and DB Schenker joined with Aglive to conduct the trial
- DP World Group introduced DB Schenker, a major trucking business that serves the DB World Group internationally
- Hamburg Sud shipped the container to China
- DB Schenker carried containers from DB World's port in China to the distribution warehouse

Industry Support

- Ius Wines, a Coonawarra-based global wine company, was also a participant in the trial
- The trial involved the shipment of Ius wine in a container from Coonawarra through the entire trade logistics system and in the distribution system in China

Meat Traceability Trials (Underway)

Developing a digital biosecurity platform for Australian beef industry

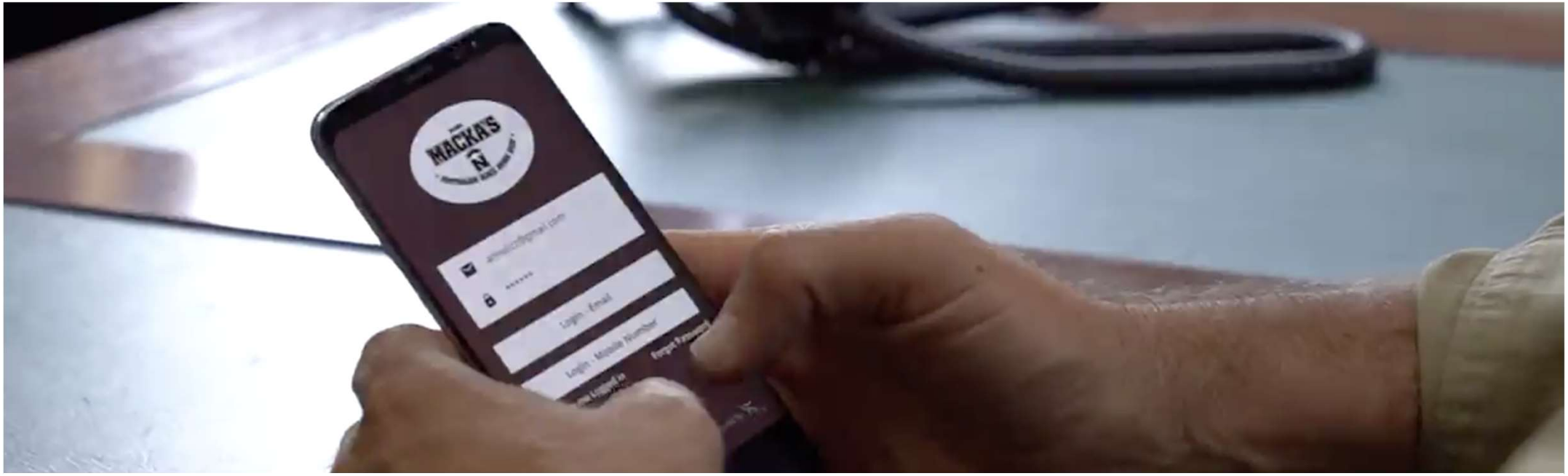
MEAT & LIVESTOCK AUSTRALIA

Est. 1884 MACKA'S AUSTRALIAN BLACK ANGUS BEEF

DB SCHENKER

CATHAY PACIFIC

aglive

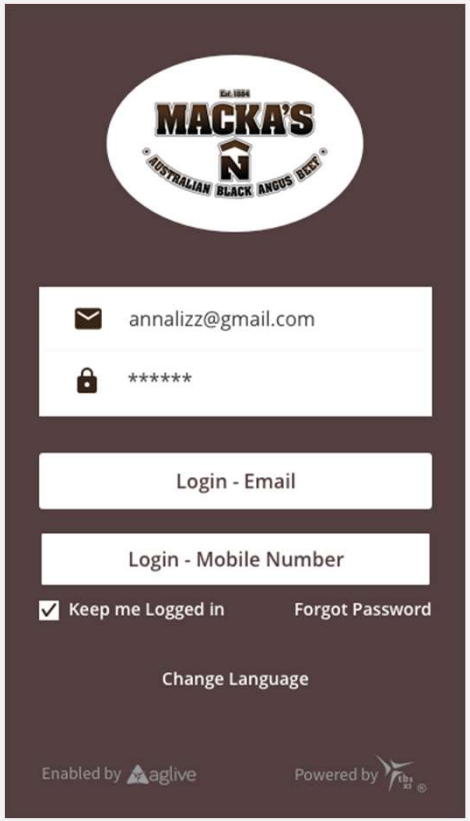


Powerful Tools

Our consumer and supply chain apps can be integrated with Artificial Intelligence (AI) to analyze the data we capture and store unleashing deeper insights and boosting productivity

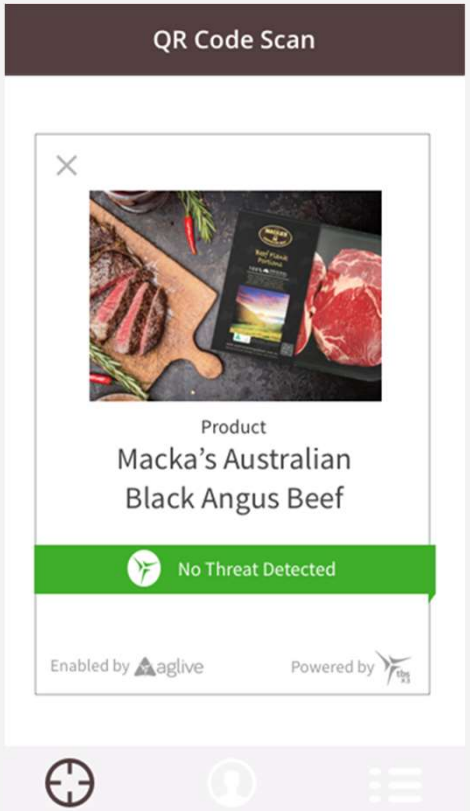
aglive

Free Consumer App

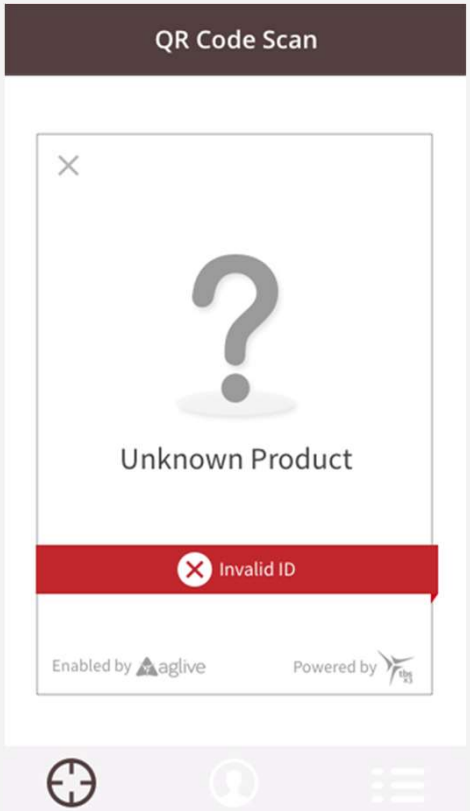


Login

Scan

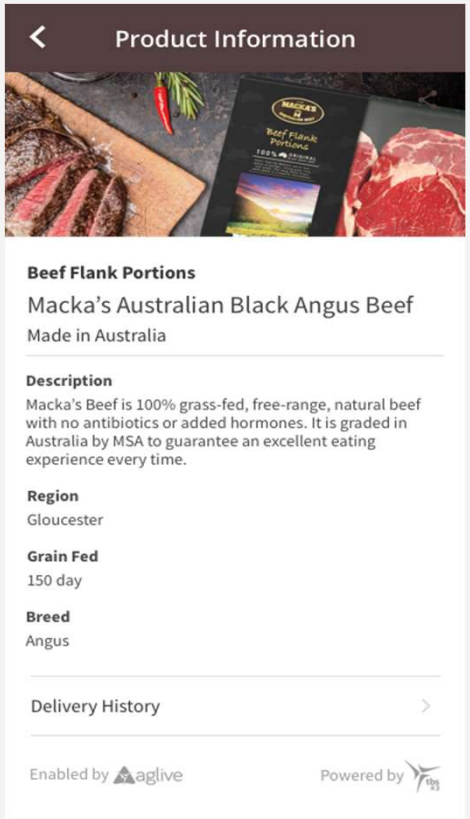


Positive Result

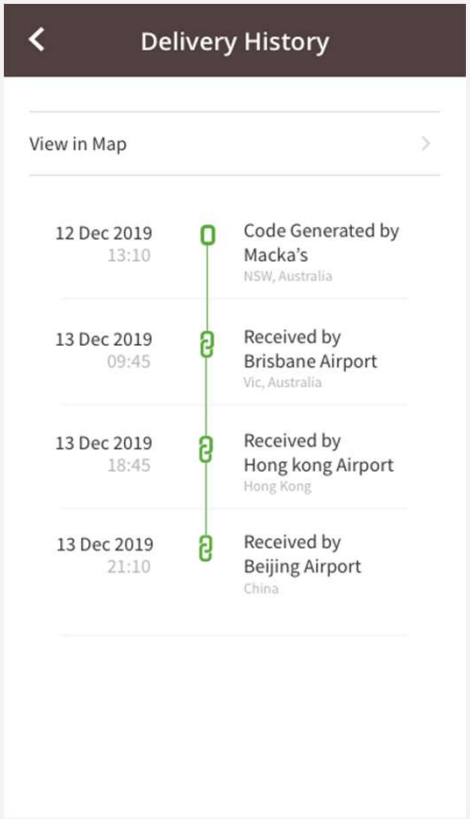


Negative Result

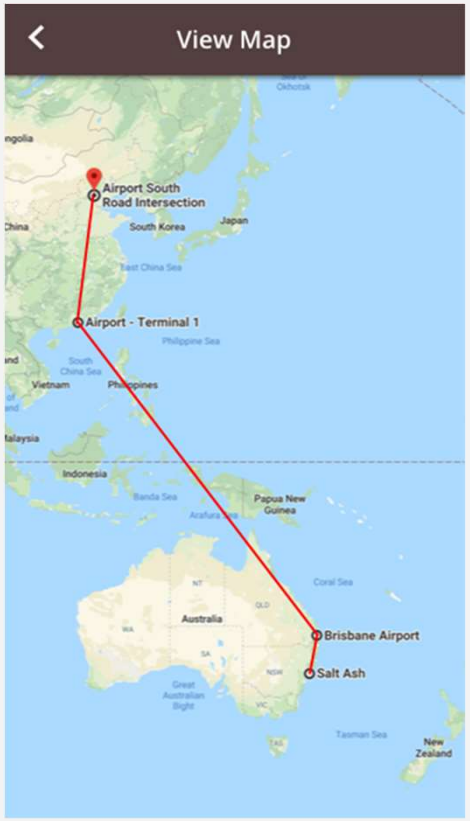
Deep Consumer Info



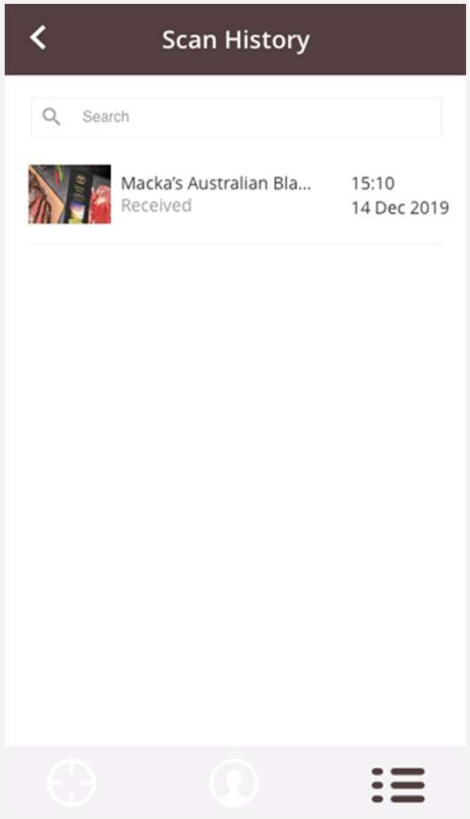
Product Info



Delivery History



Map



Scan History

Medicinal Cannabis Project (Underway)

Membership of a CRC-P along with an ASX-listed medicinal cannabis company, NSW and Commonwealth Governments, and two leading universities

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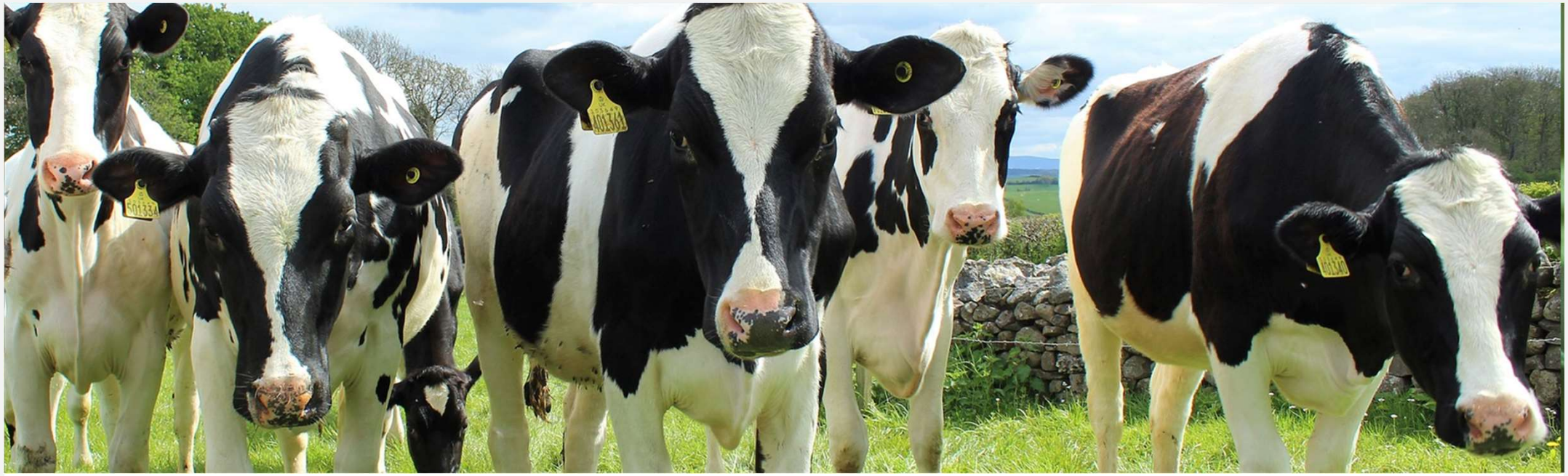

‘Clean Green’ Milk Trials (Underway)

Tracking shipments of Tasmanian milk into Vietnam
Enhancing our links to biosecurity in Tasmania - a state keen to market its environmental benefits

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Our Plan and Vision

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We are committed to restoring integrity and credibility to global supply chains

- Counterfeit products are a global problem with significant impact on consumers' wellbeing
- Counterfeit medications have been found to contain no active ingredients, or have even been found to contain toxic substances such as rat poison, antifreeze, boric acid, and more
- Similar issues have been encountered in several other categories including food, dairy, and wine

Food

- "In every single country where food is produced or grown, food fraud is occurring" – Inscatech (2013)
- China is hungry for Australian beef, but every second kilo shoppers buy could be fake – PwC (2019)
- Economic adulteration and counterfeiting of global food and consumer products is expected to cost $10 - $15 billion per year – IFIS (2016)

Dairy

- The Chinese baby formula contamination scandal highlights the need for supply chain security in the dairy sector (2008)
  - Milk powder was adulterated with melamine, leading to six fatalities
  - Over 300,000 babies became ill from contaminated products
  - Following the scandal, China has unveiled some of the strictest food safety laws in history

Wine

- It has been estimated that for some popular French wines, one fake bottle may be sold for every genuine bottle (2020)
- Distrust of counterfeit wines has led to a deterioration in the levels of French wines and spirits imported into China (2015)

Australia New Zealand Food Standards Code

To: **Fresh Produce Safety Centre Australia & New Zealand**

From: **Aglive Pty Ltd**

Delivering evidence-based digital Traceability and Visibility across the end-to-end Supply Chain from Farm-to-Table

Project Application Form

Version changes *(Update whenever proposal is changed)*

Date last updated	Person	Comment
19-03-2020	Micha Veen	Initial Application Proposal
25-03-2020	Paul Ryan	Review and Approval of the Application Proposal

1. Project code *(if relevant)*

FSANZ to provide

2. Project title *(One line only)*

Evidence-based digital supply chain traceability and visibility from Tree-to-Table

3. Project summary

Brief summary of project.

This project intends to conduct a pilot trial for a fully integrated supply-chain traceability and visibility solution that connects ANZ farmers (across the horticulture sectors) with food processing facilities, distribution, logistics and exporters to retailers and end-consumers ("Project").

Our Aglive end-to-end platform will prove the authenticity of the five high risk horticulture sector products and link those goods with evidence of the journey, brand story, and compliance collected and shared as the produce moves along the physical supply chain. The objective of this project is to fully integrate the physical and digital supply chain to ensure full end-to-end traceability, visibility and authentication to eliminate Food Fraud. The platform can be extended to capture supporting information regarding genetics, nutritional information and the marketing appeal of 'ANZ clean green'. In short, any information that will persuade discerning consumers to buy safe and authentic ANZ Food.

The platform also includes both Android and iOS supplier and consumer apps, allowing the supply chain participants and the end-consumer to have direct visibility in the produce/ product(s) that flow through the physical supply chain. We are also looking to integrate our consumer app with existing consumer app solutions, e.g. WeChat, which will further enhance the adoptability of the platform with the end-consumer in the various regions, incl. China. These apps can not only validate authenticity, but also gather consumer feedback.

The Project will be led by a Supply Chain Innovation Specialist, with the support of a well-established technology team, who will collaborative closely with the various supply chain participants to focus on:

- Capturing relevant data from different supply chain solution sources, through our public API solution, allowing the Aglive end-to-end solution to seamlessly capture data from existing supply chain processes
- Use Internet of Things (IoT) devices, where relevant, to further reduce the manual data capturing and introduce automated/ effective and more consistent data capturing to reduce the human intervention and increase the compliance effectiveness of the end-to-end traceability solution

Each supply chain participant will provide specific services and expertise that creates and verifies the complete solution underpinning and enhancing the claim of 'clean, green and safe' ANZ Food.

The Project will leverage the existing Aglive technology capabilities across the single platform, being:

- **Aglive IntegriPro**, the Meat & Livestock Australia-licensed (mobile) eNVD system, captures and digitises all on-farm data for the verification of the journey and integrity including geo-location validation for the farm, and associated transport journey, for maintaining the animal welfare. This solution captures nutritional data and is extended into the horticulture environment
- **AusTracker** is Aglive's IoT device solution, which also allows tracking functionalities, e.g. goods movement tracking (allowing accurate delivery times and/ or just-in-time monitoring of stock control), warehouse tracking, cold chain monitoring, humidity verification, shock monitoring, etc. AustTracker allows further post-meat processor monitoring to verify the condition of the perishable produce through temperature and shock sensors integrated with in-vehicle GPS devices in the transporter via our AusTracker IoT product (integrated into the Aglive TBSx3 traceability platform). Where transporters/ containers already have these IoT devices fitted, we will integrate with these third-party systems to capture the required data through the use of standard API's (refer attachment: Cold Chain Monitoring).
- **SX3** is the blockchain solution, using digital twins of serialised trade items and logistic units, which underpins this comprehensive platform through verification of the various data elements that is either collected through our in-house applications, or external IoT and integrated data services. Our Sx3 blockchain system uses three layers of protection to ensure:
  - Is the item's code genuine?
  - Does the tracked logistics information add up?
  - Has this code ever been sold before?

  Over time additional features and functions can be built to extend the platform e.g. dashboard/ business intelligence tools, integration solutions, etc. which will further enhance the end-to-end supply chain verification solution.

The Project will validate three core data group elements during the supply chain model, which are critical to providing end consumers and supply chain participants with evidence:

1. Identity (Sx3) – RFID, ABN, mobile device EIMI, MSM
2. Location, performance, status (AusTracker) – GPS/ Geo-location, shock/ movement, humidity, temperature (cold-chain monitoring), etc.
3. On-farm produce/ animal (Aglive IntegriPro) – eNVD & MSA digital declarations, RFID status checks pre-despatch, brand claims (organic, etc) and relevant IoT information

All three solutions are in operation and currently commercially deployed (individually), and Aglive has conducted the first trials to deliver this fully integrated solution. This project intends to further integrate and optimise these solutions to create the full end-to-end supply chain visibility and traceability, ensuring that the consumer can be fully confident that he/ she is purchasing the genuine product.

Our goal is to help:

- consumers 'get what they paid for';
- Horticulture producers earn a premium for providing quality produce.

Additional insights in our current, operational **Sx3** Blockchain solution:

- Each physical trade item and logistic unit (pallet and containers) has an unique digital asset (token).
- Supply chain partners/ participants can pass control of 'tokens' along the supply chain
- Each supply chain participant uses an encrypted key to create a new entry on the ledger and record each token movement
- Tokens can be linked to industry standard data formats, e.g. SSCC label, GS1 code, etc.
- Each supply chain participant accesses the blockchain through a node's "full copy of the ledger"
- Nodes analyse and validate the supply chain data before it is appended on the blockchain (Validation is based on a scalable protocol embedded in the blockchain platform)
- Our solutions integrate (using standard Public API) with existing supply chain partner's solutions, e.g. scan guns, label printers, etc. to ensure the "our" data collection uses non-intrusive solutions to fit with our supply chain partner's processes and technologies

4. Applicant organisation details

Organisation name:	Aglive Pty Ltd		
ABN:	32 111 343 670		
Street address:	Suite 1A, 45 Riversdale Road Newtown Vic 3220	**Postal address:**	PO Box 196 Geelong Vic 3220
Project leader		***Admin contact***	
Name:	Micha Veen	**Name:**	Barb Bolger
Phone:		**Phone:**	03 9008 6103
Fax:		**Fax:**	03 5221 6251
Mobile:	0432 037 938	**Mobile:**	03 9008 6103
Email:	Micha@aglive.com	**Email:**	admin@aglive.com

5. Background/previous research & development

Define the problem or opportunity that this project is aiming to address. Following are samples of questions to address:

- *How has the project 'come about'?*
- *What currently happens and why does it need changing?*
- *What alternatives have been investigated or are available? What happens in other industries?*
- *Experimentation/investigation work to date*

Aglive has been a long-term supporter of, and software partner in, the research, trial and implementation of a solid compliance and traceability system. Aglive has previously been involved in multiple red-meat traceability projects from proof of concept trials to final commercial ready and 'MLA Licensed' (mobile) solution that utilises MLA's V3 API's and allows Aglive connectivity to the NLIS / MLA central databases to certify and validate industry compliance data.

The regulatory LPA electronic National Vendor Declaration (incorporating NFAS, MSA, EU and animal health declarations) has been integrated into the Aglive IntegriPro red meat industry platform, which includes livestock management and downstream data sharing with processors including NLIS and central database interface. Currently the project team is closely collaborating with multiple farmers, brand owners, logistics partners and distribution/ retail centres to ensure alignment between the on-farm integrity data to the QR codes on packaged products. This project will further build on the investment Aglive has already made in the red-meat industry. It will expand the ability to market safe and healthy produce to discerning consumers. It will help meet the growing demand for provenance information.

The Aglive supplier app and web platform further enables downstream supply nodes such as horticulture transporters, wholesalers, government agencies. processors, shipping lines, certification and audit companies. air cargo, land-based transporters, value added processors and retailers to have a secure and permission-based node access login to view, receive and add data pertinent to their role in the supply chain. Thus, eventually eliminating the current data-siloed system of supply chain data. Where supply stakeholders already have third-party cloud-based system, we share data via public API to create an eco-system of software service provide.

The Australian red-meat industry already has a head start compared to some other agricultural sectors. The earlier investment in establishing a mandated national traceability and integrity system across the red-meat industry was a positive step. Digitising the eNVD and NLIS systems was also a wise move. We would be keen to use our knowledge, experience to extend this same solution across the horticulture industry. We would like to help with transforming the way supply chain data is collected, stored, shared, and provided to end users to support the FSANZ. Additionally, we have close existing partnerships with both Cathay Pacific Cargo and DB Schenker, which have a strong presence in (US) horticulture and grain sectors

6. Project outputs/outcomes

List the outputs/outcomes of this project, distinguishing these from the outcomes from any further research and development after this project.

Key Objectives of the Project

The project's objective is to undertake a series of Tree-to-Table product to end consumer traceability and visibility trials to deliver the following objectives to meet Fresh Produce Safety Centre Australia & New Zealand requirements:

1. Provide an effective packaging 'marker' that contains evidence-based compliance and origin data to underpin the branded offering with a whole of supply chain traceability guarantee of genuine produce
2. Extend the supplier app to the horticulture supply chain participants, enabling the connection of their production story data to be conveyed on the packaging label market downstream to retailers and their end consumers.
3. A branded consumer app enabling end consumers to verify origin and provenance and leave critical end consumer feedback of eating experience and to deliver recipes and other relevant information from the producer
4. Prove that the technology can accurately verify location, identity and condition of the product as it moves from farm to end retail point.
5. Determine through analysis of the data, and costs, the development and scalability of a platform. Identify, through stakeholder feedback, a cost versus benefits assessment, if the technology is fit for purpose. It will also include the avoidance costs of produce recalls.

Expected outcomes from Aglive Tree-to-Table trials

- Stage 1: Initial business/ technical requirements gathered into requirements/ specifications and delivery plan, incl.
    - Business Requirements/ Priority Requirements List (PRL)
    - A Timebox plan including the requirements, acceptance criteria and other specifications for product re-configuration (data field requirements) and integration based on supply chain partner requirements
    - A scenario, test and data requirements map
    - A business process, solution and technical solution architecture document
    - Risks, Assumptions, Issues and Dependencies Log for identification and resolution
- Stage 2: Design/ Develop technical requirements for Trial 1 from Tree-to-Distributor/ Retailer (with box and retail product label)
- Stage 3: Optimise the Design/ Develop technical requirements for Trial 2 from Farm-to-End-consumer (Tree-to-Table)
- Stage 4: (Optional) – Introduce end-to-end Trial from Tree-to-Table to including;
    - IoT device: Identity, Location, Condition (temperature, humidity, shock)
    - Integration with one supply chain partner (minimum)
- Stage 5: Final report on trial outcomes recorded and reported plus project material providing the outcomes of the project, incl.:
    - Visibility of the traceability and marker/ token technologies used and their respective strengths & weaknesses
    - Supply Chain participant's feedback report on the useability of the solution, perceived benefits and impact on the 'speed of commerce'
    - Information captured, stored, secured, and shared along the value chain including how captured, secured (data/ security) and shared.
    - Objective report on the accuracy and verification of data collected along the supply chain.
    - Report on supply chain efficiencies, net gains, and losses
    - End-consumer feedback analysis
    - Net cost verses benefit analysis including an analysis of the value proposition for various stakeholders? and how the system could be improved and commercialised in the industry

Note: The above project outputs/outcomes may vary depending on the level of supply chain control and integration and the availability of support which cannot be verified until the various supply chain stakeholders are known, and specific customer requirements are subsequently gathered.

7. Value proposition and benefits to the Fresh Produce Safety Centre Australia & New Zealand

Describe the value proposition and benefits to the Fresh Produce Safety Centre Australia & New Zealand assuming a successful outcome of this project. Indicate how these were or will be calculated.

A successful project will have significant benefits for the ANZ Horticulture Industry:

- The captured supply chain data is providing bio security data which allows real time visibility and traceability, but more importantly enables safe trade and removes artificial trade barriers
- ANZ's horticulture industry has long enjoyed a domestic and international reputation as a sustainable producer of premium safe food—primarily due to its high standards across all stages of the supply chain, from Tree to Table, however due to the increased competition from imported fresh and processed produce, market price pressures and the increase of "fake" produce, a shift is required to protect the ANZ reputation. Through the introduction of an independent, verifiable solution which integrates the physical with the digital supply chain, the consumer, and all supply chain participants, are able to verify where their produce is coming from, where it has travelled through and how the produce is free from any bio security issues
- Delivering an end-to-end food supply chain traceability and visibility technology is intended to drive food security, which incl.;
    - Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or used for export markets.
    - Food access: Access to adequate food sources to support a nutritious diet
    - Utilisation: Utilisation of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of these type of supply chain traceability solution inputs to deliver appropriate food security.
    - Stability: To be food secure, a population (within and outside ANZ – e.g. countries which depend on ANZ food supply), household or individual must always have access to adequate food. They should not risk losing access to food because of sudden shocks (e.g. an economic, climatic or health crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

8. Further research, adoption and/or commercialisation strategy

How the project outcomes might be disseminated or commercialised for benefit of the Fresh Produce Safety Centre Australia & New Zealand and/or adoption by other companies. Where next after this project?

Project outcomes will be documented in a final report, with an abridged version (that does not contain any commercially sensitive details) made available to Fresh Produce Safety Centre Australia & New Zealand for public viewing.

Throughout the project the trial activities will be documented, and marketing collateral incl. pictures, video's and user testimonials will be prepared for use by Fresh Produce Safety Centre Australia & New Zealand in informing our industry and encouraging commercial adoption. Our open source architecture enables other third-party label businesses and farm app systems to collaborate. Interoperability is core to our platform and will help fast-track industry change that is in line with industry goals and strategies.

9. Project and Background Intellectual Property (IP)

List Intellectual Property anticipated to arise from the project and expected ownership of this project IP.
List any relevant Background IP and its ownership that will be required for the project.

The Aglive platform and applications is using a label IDs and 'digital twin' tokens. This ID process was developed using various application platforms and tools under licence or under contract with third party system and software firms. Aglive retains all rights (including intellectual property rights) in the Aglive system and our existing web, mobile, and blockchain applications. These rights are retained whether it is used in relation to the Project or it is customised and designed to provide traceability for the horticulture industry.

Aglive has recently merged with industrial blockchain provider TBSx3 Pty Ltd which has developed the technology that can protect items from counterfeit or substitution as they move along the supply chain. TBSx3 has existing patents pending.

The Aglive IntegriPro Paddock to Processor platform includes integration with other apps provided by both TBSx3 and Austracker. This suite of integrated apps enables GPS logistics, IoT and temperature monitoring. Together, these integrated technologies form a complete end-to-solution which is existing IP owned by the Aglive Pty Ltd.

The Aglive system has the capability to meet the compliance needs of integrity programs, commercial brands, and regulators in other vertical markets locally and internationally. All technologies being trialled in this Project are the intellectual property of their respective owners. Because these technologies have already been used commercially, we do not expect any new intellectual property to arise from the trials. However, if any new IP does arise from the trials, the ownership of that enhancement will be owned by the trial participant to which the new IP relates.

10. Service providers *(May include the funding partner)*

Organisation name	ABN	Contracted by	Main contact	Phone
Aglive Pty Ltd	32 111 343 670	MLA/MDC	Paul Ryan	M: 0433 128 244
Unique Excellence Pty Ltd	72 609 621 927	Aglive	Micha Veen	M: 0432 037 938

11. Milestones and budget

No	Milestones	Service Provider	Days/ Weeks	Operating Expenses	Capital Assets	Total AUD
1	Business Requirements/ Timebox (and other documentation)	Aglive	3 – 5 days	$10,000	-	$10,000
2	Configuration and user setup/training	Aglive	3 – 4 weeks	$45,000	-	$45,000
3	Live field trials and testing ○ Trail 1: xx-xx to xx-xx * ○ Trail 2: xx-xx to xx-xx ○ Trail 3: xx-xx to xx-xx	Aglive	$12,500 per Trial	$37,500	-	$37,500
4	Final Reporting & marketing materials	Aglive	2 – 3 days	$5,000		$5,000
				Total		**$97,500**

** The timings of these activities will need to be determined as part of the initial engagement.*

Thanks in advance for considering our application and we look forward to answering any questions, concerns or clarifications.

Cheers,

Micha Veen

Supply Chain Innovation Specialist

Aglive Pty Ltd

+61 (0) 432 037 938

www.aglive.com

aglive

Helping build a sustainable future

Enhancing credibility, integrity and transparency in biological product supply chains.

Aglive Group Limited

White Paper September 2018

Enhancing credibility, integrity and transparency in biological product supply chains: Ending disasters and meeting consumer needs.

Aglive Group Limited, September 2018.

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1. Summary

Tools that allow tracking of supplies and sales are routinely used in businesses to enhance profitability and to inform marketing strategies. New digital and communication technologies are allowing greater visibility of trade event details in supply and distribution chains. These information technologies are increasingly important in a globalised trade system. Intelligence about supply chains is also important in the preparation for rare but

potentially catastrophic contamination or infection events that can disrupt large-scale biological systems. Health emergencies affecting the food supply system and biosecurity emergencies in animals can both be economically costly and cause large scale harm and death. Preparation and planning for such emergencies can protect businesses and mitigate harm to humans and animals.

Technology for identifying items of trade and domestic animals and tracking their distribution and locations is providing new tools to reduce the liabilities and harmful consequences of such emergencies. In this report techniques for ensuring supply chain traceability and transparency are reviewed and the key principles and methods for their use are summarized. Some best practices for using centralised data management systems for traceability implementation in the food chain, and the impact of modern information technology on these systems are described.

2. Key messages.

- The scope of transparency provisions in modern food-related supply chains exceeds that required for legal compliance and is driven by industry leadership.
- Traceability management systems that go beyond traditional "one step up – one step down" paper-based recordkeeping system and centralizing storage of supply chain data offer more agile responses to food chain and biosecurity emergencies. They offer enhancement and protection of brand reputation.
- Widespread availability of portable electronic information technologies such as intelligent phones with internet and GPS functions is enriching the technical options for supply chain communications at both ends of the supply chain -- primary suppliers and final consumers. Use of these systems can directly connect farmers and consumers.
- The wide scope and complexity of information requirements for food supply management require extensive consultation between supply chain stakeholders, consideration of the wide range of relevant standards, guidelines, and interests and careful design and implementation of centralised systems for ensuring transparency.
- Digital data records (tokens) that include geographical location (GPS) tagging to provide highly informative digital fingerprints to uniquely identify supply chain events and map boundaries around geographical compartments of animals. These provide a trail of digital fingerprints as a powerful tool for detecting violations of the chain of custody and more targeted management of biosecurity emergencies such as outbreaks of foot-and-mouth disease.

3. Information management is crucial for business profitability and crisis management.

Management of information about the performance of the supply chain is a standard business activity for improving cost efficiency and service performance. Leading companies exploit information exchange with logistics and trade partners to enhance business agility

and explore new market opportunities (Heany B 2013). Supplier related information is used for marketing purposes (Fearne 1998).

Crises affecting public health or animal welfare should not occur, but they need to be planned for and visibility of relevant information on location and distribution of animals and food commodities is crucial for mitigating disasters when they do happen. Transmissible disease disasters and food contamination incidents can cost billions of dollars, involve slaughter of hundreds of thousands of animals, cause thousands of human illnesses, and kill many people. Efforts to prevent them involve government agencies like the US FDA in the United States, the EU Rapid Alert System for Food and Feed, and border control agencies charged with responsibility for biosecurity. Besides legal and moral obligations, businesses need to recognise these risks because they can be enormously costly to the business if unmanaged and can destroy the business.

In the food industry especially, with far-reaching distribution channels, in addition to routine use of information technology to obtain operational intelligence about supply logistics and sales, businesses need to take proactive steps to ensure supply chain information transparency, so they mitigate the effects of rare and often catastrophic food chain emergencies caused by contamination (Table 1).

This report is about data management tools for enhancing supply chain transparency in the food and food related industries. It recognises both opportunities to improve competitiveness and profitability from transparent information management and the importance of supply chain data visibility to mitigate disasters. The choreography of information flow in modern food chains is described, biosecurity principles are outlined, and examples of best practices for supply chain transparency and traceability are presented.

Table 1. Illustrative examples of recent food chain health emergencies having major health and political consequences.

Date	Event	Nature and extent of consequences
2011	Massive outbreak of infectious bloody diarrhoea in Germany, and France, with many patients suffering kidney damage. The cause was pathogenic bacterial contamination of vegetable produce detected by genetic fingerprinting. This was eventually identified as being caused by contaminated fenugreek seeds imported into Europe via the United Kingdom from Egypt. The implicated bacterium was a pathogenic Shiga toxin producing strain of *E. coli* associated with human faeces. (European Food Safety Authority 2011, Federal Institute for Risk Assessment 2012, Pennington 2011)	Some 4000 hospitalisations and more than 50 deaths with massive costs to German healthcare system. Widespread economic damage to many components of produce delivery chains unrelated to the causative agent. E.g. lost sales to Spanish produce exporters amounted to about $200 million in economic losses a week
2013	"Horsegate". Major food crime scandal detected by DNA testing in the UK and Ireland and continental Europe involving widespread fraudulent substitution of beef by horsemeat (UK Government 2014, Brookes et al 2017, Hobbs 2016)	Europe wide disruption of processed food delivery chain and loss of confidence of consumers in product integrity. Widespread moral outrage in the UK and Ireland where horsemeat is not an acceptable food.
2008-2010	Fraudulent melamine adulteration of milk products in China intended to artificially boost apparent protein content of diluted milk. In 2008 health authorities discovered melamine had been added to raw milk at many milk collection stations. A second 2009 event involved milk powder and milk containing foods and beverages. The third event in 2010 involved left over melamine tainted milk powder produced in 2008; more than 100 tons of tainted powder were discovered (Chen 2009, Conference talk by Jun-Shi Chen at 2011 Australian Food Safety Conference).	In 2008 290,000 children are diagnosed with urinary tract abnormalities. In the second event 25,000 tons of tainted milk powder were found and destroyed. In the third event the source of contaminated milk products was tainted milk powder left over from the 2008 event. Incomplete recall of contaminated products after the initial event resulted in follow-on contamination in subsequent years.
2014-2017	Hepatitis A virus contaminated frozen uncooked berries imported into Australia from China. In February 2015 the recall of two associated brands of frozen mixed berries was announced by the national food standards agency, and in June 2017 a further similar recall of frozen berries was needed. Genetic fingerprinting of virus nucleic acid was reported as confirming a common source to contamination associated with the 2015 and 2017 product recalls (OzFoodNet Working Group 2017, Han 2017).	Removal of frozen berry products from retail supermarkets, brand devaluation and divestment of commercial assets; loss of consumer confidence and political action to strengthen country of origin labelling on food packaging

Table 2. Different categories of system used to assure supply chain transparency.

Example of sector coverage	**Example of sector coverage**	**Example of sector coverage**
Product traceability and identification systems and services used at the individual firm	Documented within-the firm-traceability provisions often certified by specialist third-parties	FSSC 22000 2018, International Standards Organization 2005a
	Third-party systems for information management used for supply chain traceability transparency	GS1 2017, GS1 2018, 2018a, (see also Denso Wave 2018), Heany 2013 Aglive Group Ltd 2018
	Premium branded beef with guaranteed traceability	Fearne 1998.
Industry sector-wide traceability collaborations	The meat supply chain in Australia	National Livestock Identification System 2016, 2018
	Fresh produce supply chains in United States and Canada	Produce Traceability Initiative 2011, National Institute for Animal Agriculture 2018. World Perspectives Incorporated 2018.
	Cattle sector in the United States	National Institute for Animal Agriculture 2018. World Perspectives Incorporated 2018
Public standards and laws enforced across entire food sectors by government agencies	The European Union food and feed industry. Regulatory response network in European Union using Rapid Alert system for Food and Feed (RASFF)	European Communities 2002, Commission of European Communities 2000, Hobbs 2016, Borit 2016
	Exporters of egg products from Australia	Australian Quarantine and Inspection Service 2007.
	High risk foods in the United States subject to mandatory recall	United States of America Congress 2011, Zach 2016
International standards and agreements	Government agencies involved in food certification and inspection world-wide	Codex Alimentarius Commission 2006.
	Governments that are party to WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)	GATT 1994.
	Any organization involved in the food or feed chain world-wide	International Standards Organization 2007
International industry collaborations involved in benchmarking standards and recognising certification programmes	The commercial food industry especially the major retail supply chains in developed countries	Global Food Safety Initiative 2018

4. Management systems at different levels govern food supply chain transparency.

Provision for traceability in food chains has evolved over many years and are numerous management systems provide supply chain transparency. Table 2 lists the main categories involved.

Within the firm management systems provide directly for traceability, and an example given is the standard food safety management system FSSC 22,000. Third-party service businesses have important roles: one of the most important of these is the almost universally used identification services provided by the non-profit organization GS1. GS1 offer barcode products and other standardised numerical identifiers for traded items (such as packets, cases, and containers), businesses, and locations. These are widely used for identification and communication in logistics, transport and retail point-of-sale spanning the complete supply chain (Table 2). More specialised traceability services are used in marketing. During the Mad Cow disease crisis of the 1990s an enterprising UK company marketed premium specialty branded beef supported by guaranteed traceability of the original cattle farm to final consumers (Table 2).

Collaborations can be formed between the multiple partners in industry sectors to ensure traceability, protect brand reputation, and to mitigate the consequences of any food chain emergencies. Two examples are given in Table 2 where there is comprehensive implementation of barcode enabled electronic traceability from farm to point-of-sale. These are the meat supply chain in Australia and the fresh produce supply chain in North America. There are also ongoing discussions about comprehensive traceability in the US cattle industry (Table 2).

Statutory legal obligations enforced by government agencies are another management system driving supply chain transparency. Traditional export and import regulations subject goods to traceability requirements. In the European Union the General Food Law of 2002 enshrined traceability as a key requirement and enabled a rapid response communication network used by public agencies to react to food emergencies. In United States *US Food Safety Modernization Act (Public Law 111 2011)* contains many preventative safety provisions and includes traceability and associated information technology under “Building Domestic Capacity”. It provided for mandatory recall for high risk foods and was complemented by pilot studies to improve traceability systems (Table 2).

Government agencies such as the US Food and Drug Administration (US FDA), and the European Community’s Rapid Alert System for Food and Feed (RASFF) play an important well documented role in coordinating and implementing recalls of potentially hazardous food relying heavily on traceability data provided by food companies.

The general context for implementation of traceability in international trade is governed by the commercial and governmental agreements that harmonise standards and the key provisions are listed in table.

5. Traceability systems can support diverse objectives.

To understand better the operation of multiple management systems and complex food supply chains is useful to identify some of the main types of objective sought by businesses when using traceability tools.

The main types of benefits that are offered by better business systems for product traceability and supply chain transparency are:

- Credible and effective assurance can be given consumers that product provenance and attributes meet their expectations. This is especially important with long supply chains between initial growers and final retail point-of-sale make it difficult for when final consumers cannot directly verify for themselves many important marketing attributes of the purchased product, such as credentials and standards of the primary suppliers of materials and ingredients (for example the practices of an organic beef producer or free range egg producer in a distant location, or labour standards associated with fair trade certified coffee).
- Precisely targeted recall of manufactured items from the market if they are discovered to be unfit for intended use can be carried out more rapidly, efficiently, and cost effectively. Product recalls enable manufacturers and retailers to limit the harm that food emergencies cause to consumers, protect the image of their brand, and minimize their own legal liabilities.
- Traceability is much more than just crisis resolution. Traceability systems provide access to data which can be analysed and used in day-to-day business decision-making. This can be data about inventory, data about logistics outcomes in the distribution network, and data about sales provided by point-of-sale technology (GS1 2017).
- Improvements to supply chain traceability management provide new opportunities for businesses. These opportunities include wider access to export markets, more detailed information about consumer preferences, and new avenues for tailoring of products to specialized market sectors.

To be more specific, traceability related business objectives include:

- the support of food safety and quality objectives
- meeting of customer specifications
- improvement of effectiveness, productivity and profitability of an organization
- strengthening of consumer trust in product integrity
- compliance with trading partner specifications
- determination of the history or origin of a product and status of product delivery
- facilitating the withdrawal or recall of products in the marketplace and the minimisation of associated costs
- identification of responsible organizations in the food or feed chain
- verification of specific information about the product
- verification of the integrity of the chain of responsibility for a product during its movement through the distribution chain
- communication of information to relevant stakeholders, consumers and trading partners

Credibility, integrity and transparency of supply chains.

- fulfilment of national, regional, or international regulations and policies
- reduction of business risks beyond that required by legal compliance
- increasing the opportunities for stakeholder compensation from other participants in the delivery chain for costs they incur from damage caused by adverse events such as product recalls
- ensuring accountability of stakeholders for non-compliance with specified standards
- enhancement of control and prevention actions relating to disease and pest outbreaks (biosecurity)
- protection of brand reputation and increase of transparency in the supply chain.

These considerations fit with different types of management strategy using the tools of traceability and transparency. These include compliance orientated strategy, process and supply chain orientated strategy and marketing or branding orientated strategies (Luning and Marcelis 2009).

6. Major failures to control food risk drive ongoing change in safety management systems.

Although crisis management is not the only objective of traceability systems it is a prominent driver of system change because of the large consumer market served by many food supply chains and amplification of public attention on them by news media and political reaction.

The historical record of food crises provides many examples.

The European bovine spongiform encephalitis (Mad Cow Disease) emergency of 1990 and other food crises entrenched a precautionary policy stance in the European Union towards a range of food risk issues (Borit 2016, Dabbene et al. 2014, Hobbs 2016, Meuwissen et al. 2003,).

In North America early 2000s saw food borne disease crises causing numerous illnesses and deaths gain considerable publicity, with economic damage more than $1 billion.

These included a 2006 outbreak in which pathogenic *Escherichia coli* that was sourced to raw spinach grown in California with 205 confirmed illnesses and three deaths. A 2008 Salmonella outbreak caused by capsicum contamination through irrigation water in Mexico infected 1442 people and was implicated in two deaths. In 2009 Peanut Corporation of America was responsible for the most expensive food recall in US history with economic losses of the order of US$1 billion. The Salmonella contamination disaster involved at least 361 companies and 3913 different products using Peanut Corporation of America sourced ingredients. Peanut Corporation of America was declared bankrupt and criminal charges wer filed against company executives (Zach 2016).

These events triggered industry and government responses.

Credibility, integrity and transparency of supply chains.

The US Food Safety Modernization Act (Public Law 111 2011) was enacted. The US FDA commissioned a report from the Institute of Food Technologists (2012) on pilot projects for improving product tracing and that report provides detailed documentation of the challenges and benefits of improved supply-chain traceability. The fresh produce industry sector initiated the *Produce Traceability Initiative* (National Institute for Animal Agriculture 2018, Produce Traceability Initiative 2011).

The scope and range of traceability provisions and need for transparency in supply chains seems likely to increase, as major food contamination crises continue to be reported (Table 1). Four recent crises affecting food supply chains from three different continents are shown in Table 1. They show that in the EU nearly 10 years after introduction of legal requirements for food chain traceability, actual traceability of products entering the sector still needs improvement. Traceability can stop at national borders, so initial suppliers are not unaccountable for poor practices. In some developing countries there is very little transparency and supply chains are hugely complicated. The repeated occurrence of disasters show that industry and consumers need to be more aware of public health research reports.

A key factor allowing these major health emergencies to be identified and stopped were ability of public health investigators to identify defective items and locate sources of harm through biological and chemical fingerprinting. This illustrate the importance of transparent access to product identification and traceability records of businesses to stop outbreaks continuing and the continued vulnerability of extended food supply chains to accidental contamination and criminal adulteration.

The first example in the table is perhaps the largest food safety emergency in recent memory, occurring early 2011 in Germany and France. The root cause of this incident turned out to be contamination of imported gourmet specialty seeds (fenugreek) with a toxin-producing gut bacterium which most likely originated from misuse of human sewage on an unidentified farm in Egypt. Traceability was blocked at the Egyptian border. The disaster was made possible by (i) inadequate border biosecurity controls on the importation of specialty seeds from Egypt to Europe, and by (ii) inadequate processing methods used for production of sprouted seed salad components from those seeds. DNA fingerprinting of the pathogen provided a natural label of unsafe food and was used to trace dispersed cases of disease to a common source. Figure 1 taken from the Federal Institute for Risk Assessment 2012 report provides an illustration of the complex nature of food supply chains (see Figure 1) and the crucial role of traceability of supply chain transactions in investigation of these emergencies (see Federal Institute for Risk Assessment 2012 for detailed discussion). Long time-scale survival of the bacterial pathogen in traded seed commodities highlights the important role of supply chain records retention. Visibility to emergency investigators of supply-chain transaction records across the whole supply chain is necessary for speedy and complete recovery from these emergencies.

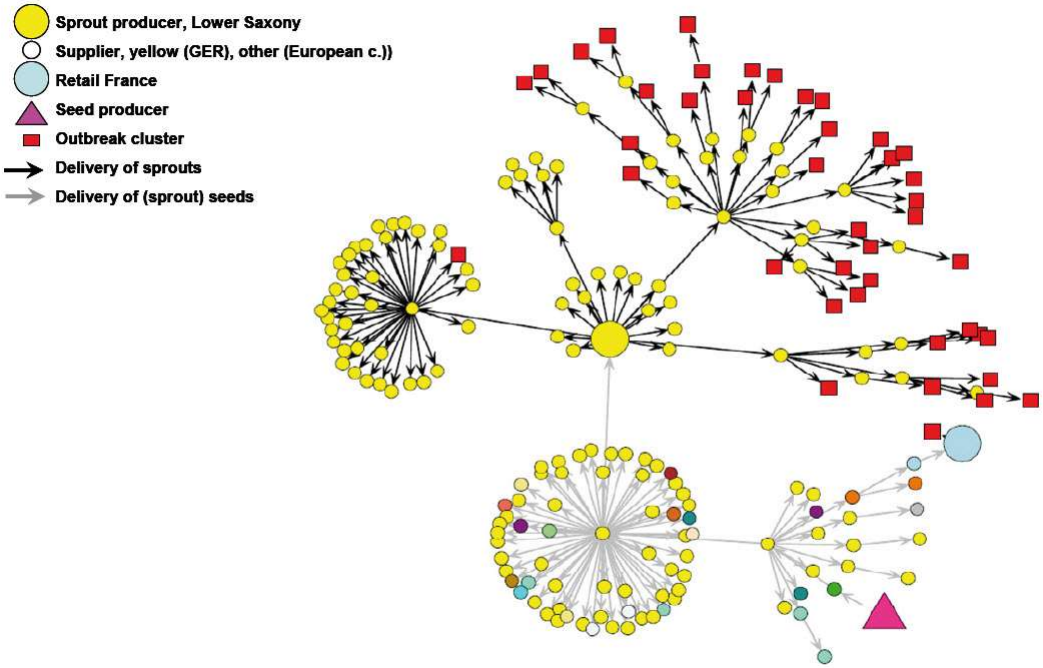

Figure 1. Diagram of the supply chain for fenugreek seeds implicated in European Shiga toxic E. coli outbreak of 2011. It shows the role of tracing and tracking of items identified as causing disease through the complex transnational supply networks starting with a seed producer in Egypt and proceeding through importers and intermediate seed suppliers and processers. All businesses that came in contact with the suspect batch via seeds or sprouted seeds are shown. From Federal Institute for Risk Assessment 2012.

The second example in the table is the discovery of criminally fraudulent substitution of horsemeat for beef in many processed food products by European authorities in 2013. This food fraud was detected and traced using genetic fingerprinting methods. Suitably chosen DNA methods yield a natural label for horsemeat adulterated food and provided investigators with knowledge of the huge scope of this food chain fraud. Findings of the official enquiries by the United Kingdom government into this incident emphasise the role that product identification and traceability management can play in deterring food crime (UK Government 2014). The incident illustrates that food businesses need measures to protect against fraud and counterfeiting.

A shocking dairy product supply chain scandal was discovered in China by public health and crime prevention authorities when extensive adulteration of milk products with melamine was established to have caused kidney stone damage to 290,000 children (Table 1). Melamine is an artificial chemical that leaves a distinctive detectable chemical fingerprint when added to food. The scale of this crisis and the evident failure of food safety managers to remove all contaminated milk products from the food system *two years after the first melamine incident* show the daunting practical challenges of managing a massive supply chain in a large developing country. Absence of supply chain transparency prolonged

unacceptable damage to public health in China and added to public distrust of food suppliers and government.

The fourth table example illustrates the consequences of poor hygienic practices by growers producing frozen ready-to-eat berries for international export. Genetic fingerprinting of hepatitis A virus from a cluster of cases of hepatitis disease in Australia led to detection of a common source of virus infection. This contamination was linked with Chinese frozen berry produce being sold in Australian retail outlets. A long time-interval between the two different but causally linked frozen berry product recalls demonstrates the extended survival period of infectious hepatitis A virus in frozen products. It also indicates the importance of record keeping systems for delivery chain events extending over several years. The take-home business message is that these food emergencies can destroy brand reputations.

Taken with the 2011 European outbreak caused by bacterial contamination of imported Egyptian fenugreek seeds, and other food-borne hepatitis A outbreaks (Collier et al. 2014, Fitzgerald et al. 2014), it seems likely that improved supply chain traceability has a valuable biosecurity role to focus efforts on better management of contaminants distribution in fresh produce across national borders.

7. Methods and concepts used in implementing product identification and traceability.

The methods used to implement effective product identification and traceability provisions, as illustrated in Table 2, vary greatly because of diverse products, supply chain configurations, local circumstances, and needs of the stakeholders (e.g. Institute of Food Technologists 2012). Product identification and traceability specialist GS1 (2017) provides a good overview of different arrangements.

Four different functions or fundamental needs can be identified as the foundation for a standardised and widely usable traceability system

- internationally unique identification of products, locations, and participating parties
- labelling of all products and packages with identification codes
- efficient data capture and recording during transition of tradable objects through supply chains
- provision of access to information (data visibility) to stakeholders.

Identification of products locations and participating parties

An important first step in achieving supply chain transparency is unique and accessible identification of trade items, participating parties to transactions, locations and other details. A widely used approach to identification is pre-assignment of university recognised identifying numbers such as Global Location Number (GLN), Global Trade Item Numbers (GTIN), Serial Shipping Container Load Container IDs, Property Identification Codes (PIC),

Vessel numbers and the like. A not-for-profit third-party organization GS1 has a role of establishing standards for digital identification used worldwide (GS1 2018).

Although locations and events during unit movement down the chain can be identified by preassigned identifiers as mentioned above, more flexible options for uniquely identifying locations and events are now realistic because of technology improvements. These are possible because of the widely available use of intelligent handheld devices such as phones and tablets equipped with GPS capability. With appropriate software these can record date, time and geographical location tokens (geo-tokens). Location specific records play a role at most stages of the supply chain and in some contexts are especially valuable. They can be used to identify the location of fishery catches to promote environmental sustainability. Alternatively they can enable mapping of domestic animal locations for more tightly defined geographical compartments (Scott et al. 2005) which provides better implementation of biosecurity arrangements without needing pre-registration of locations prior to a traceability system implementation.

Labelling of products and packages.

Permanent labelling packages and other tradable units is ubiquitous. Identification is achieved by including a globally unique identification code usually via a barcode or similar symbol (GS1 2017, Denso Wave 2018, Kemeny and Ilie-Zudore 2016).

Physical labelling should be permanent and not harmful to the traceable unit. Animals labelling for the life of the animal can be achieved by placing an RFID device as a permanent bolus within the rumen. Labelling of animals can also be achieved by tags added to ears. Not all record details have to be physically attached to the traceable unit if a unique permanent identifier on the unit is linked to records preserved in an internet accessible data warehouse. Through this approach extensive, easily accessible and verifiable information is preserved independently of the physical unit.

Capture and recording of critical tracking events during passage through the supply chain.

A further important traceability function is the capture and recording of information about critical tracking events in the supply chain.

As a tradable unit passes through the supply chain, an event history can be recorded by capturing at each node in the chain the unique label identifier code together with additional information such as lot numbers assigned during product transformations, time and date records, geographical location tags (geo-tags) created with GPS enabled devices, and custodian ID and dispatch destination.

Key events include a variety of transformations such as merging of different input streams, or fragmentation of an input unit such as when different meat cuts are created in a meat butchery operation.

An illustration of the range and type of information needed to characterise a critical tracking event is given in Table 3.

Table 3. Characteristics of key tracking events involved in landing a fish catch at the dock requiring recording to provide traceability (based on draft discussions at the Global Dialogue on Seafood Traceability 2018)

	Category	Key Data Element
Why	Event ID Event Type and Business Step, Disposition	Globally Unique Event ID landing of seafood at dock
Who	Vessel Information	Vessel ID Source Destination
What	Traceable Objects Business Transaction List	FAO 3 Alpha Species Code Species Scientific Name Production Method Defined by a List Gross Weight Drained Weight Product Form Defined by a List GS1 Container IDs Alternative Non-GS1 IDs Catch Certificate ID
When	Date/Time	Landing Date/Time Landing Time Zone Offset dates of capture
Where	Locations	Event Capture Location Vessel GLN (if assigned) Landing Location

The table shows that a wide variety of identification codes need to be specified and that event time and location records are widely useful data elements for traceability.

Recording of these key data elements is a labour intensive process, and automated data capture technology is widely used to improve efficiency and reduce errors and costs. Dedicated barcode readers, QR scanners, intelligent phones with appropriate image processing software, or RFID scanners are used to do this.

Credibility, integrity and transparency of supply chains.

Shared access to information through information networks.

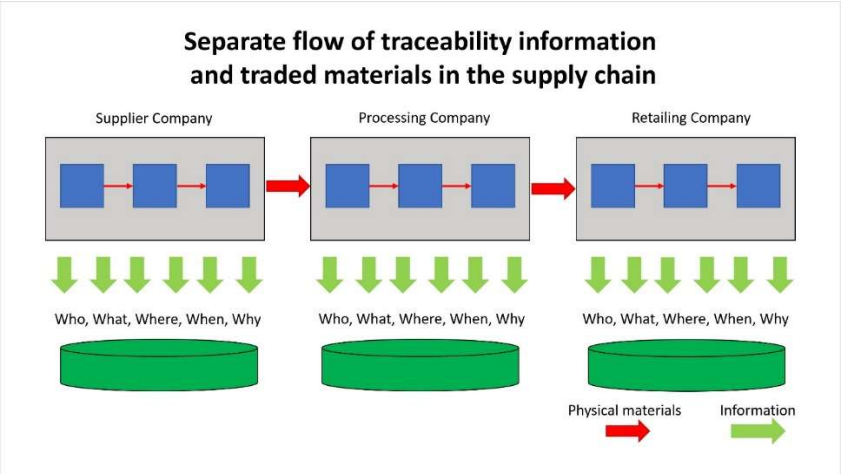

Figure 2. Simplified schematic of main features of traceability information flow and traded goods flow in a supply chain to emphasise retention of critical to traceability data *within organisations. (This is a modified version of a figure in GS1 2017).*

Sharing of information is essential to provide visibility and transparency across a supply chain, and there is considerable evolution of methods and approaches for information sharing and exchange. These processes will be illustrated with a simple version of the initial events information sharing, followed by some discussion of more complicated patterns of data sharing.

The flow of information and goods in supply chains are distinct processes. Figure 1 illustrates this distinction in a schematic supply chain.

It represents operations within individual businesses as a series of internal process steps, and goods transfers between businesses as a series of supply chain events. It highlights that answers to the questions *who, what, where, when* and *why* are generally necessary to provide information for traceability. *Critical tracking events* can be identified in a supply chain where answers to these questions provide information which enables traceability. Critical tracking events occur at the process input stage and at the completion event for each transformation along the chain.

The diagram indicates that the initial stage of traceability information management is storage within-the-business of key data elements in an organised information management system such as the company database. Provision of complete supply chain data transparency requires sharing of this information with other stakeholders, and this can be done in several different ways.

One step up – one step down sharing model.

One route of sharing this information is through immediate trading partners and this is often a legal requirement. Such sharing is done through lot numbers and codes on product

package labels and in accompanying trade transaction documents. This is the traditional form of information networking, commonly referred to as *one step up – one step* down data exchange. This is the simplest and lowest cost choreography for providing transparency in a supply chain.

A typical example of one step up – one step down sharing are the legal requirements imposed on exporters of egg exports listed in Table 2. These requirements make it a legal obligation for export businesses to keep paper records *within-the-business* of product identity, supplier identity, and destination of outputs. They involve specifying:

- identification of units/batches of all inputs (which are needed to enable product traceability)
- lot identification of processed product (requiring manufacturing production records and lot or batch number labelling)
- information on when and where traceability units are moved and/or transformed and moved to (e.g by paper documents such as Transfer Certificates and Declarations of Compliance)

In principle, one step up – one step down sharing and recording of traceability information should allow investigators of a food contamination emergency to locate the source of a contamination problem and implement effective corrective measures.

In practice, modern food supply chains have many characteristics which make it difficult to achieve timely and effective corrective action. Supply chains can lack transparency of relevant information when because of reliance on one step up – one step down the key records are kept in a distributed form at the nodes of the chain. As investigators progressively creep up and down supply chains with their inquiries (Figure 1) to obtain required information on product distribution, health emergencies affecting the food chain can sometimes unnecessarily continue for weeks or months before resolution, at great human and sometimes huge economic costs (see Table 1).

Features of the supply chain that impede transparency are complex but well documented. see Dabbene et al. GS1 2017, 2014, Scholten et al. 2016, Trienekens et a. 2012, Storøy et al. 2013, Federal Institute for Risk Assessment 2012.

Centralised data sharing model.

Alternatives to one step up – one step down sharing of traceability information have been developed.

These are comprehensively presented, and aptly named as *traceability choreographies* in **3.3.5 Sharing of traceability** data in the GS1 Global Traceability Standard (2017).

One of these choreographies is a *centralised model* for information sharing. In this model all participants in the supply chain send traceability data to a central information repository (which acts as a specialised third-party database) and if necessary request they request key traceability data from it (Illustrated in Figure 3).

A key capability of such centralised third-party systems is their ability to efficiently deliver transparency across the entire supply chain. Improvements in modern information technology open many opportunities for effective use of third-party traceability systems. GS1 note in their report that centralised repositories may have different data access control policies for different parties, and place controls on the scope of queries to the database by different stakeholders.

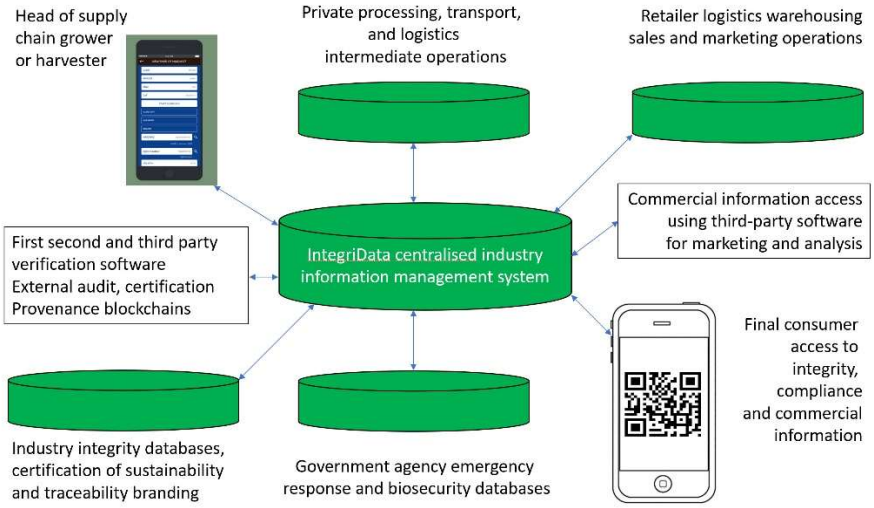

Figure 3. Diagram of parties interacting with a centralised supply chain information management system for verification and analysis of data.

Centralised traceability communication can overcome some of the problems of other types of traceability system provided that extra costs can be controlled. Since there is a dedicated third-party organisation carrying out traceability functions, the risks of inadequate resources or inadequate program maintenance are minimized. Conflicts of interest and privacy concerns can be managed by appropriate collaborations and agreements between participating partners in the third-party organizations.

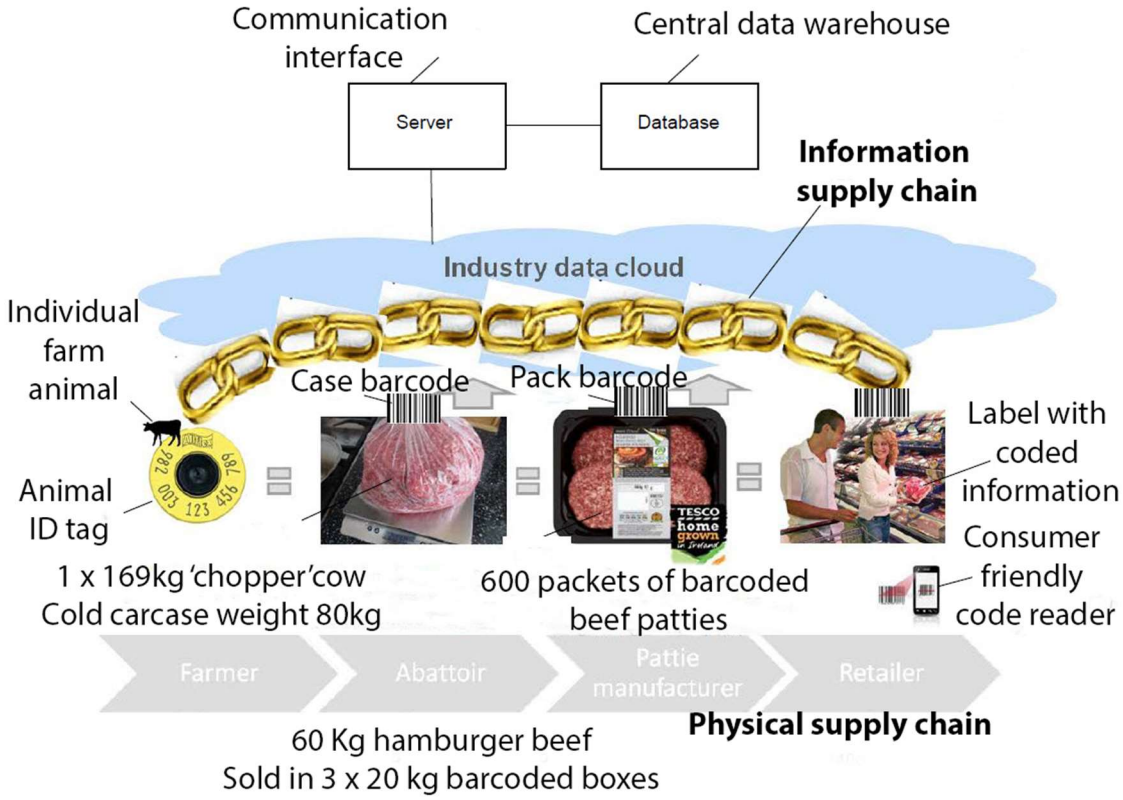

Figure 4. Schematic outline of a communication channel between farmers and consumers.

One application of sharing of information by centralised third-party systems is providing visibility to final consumers of information primary providers of product at the start of the supply chain. Figure 3 provides an illustration of how this can work in practice using the capabilities of the Australian National Livestock Identification System communication network.

The golden chain in the figure represents communication between farmer and consumer going through an internet cloud based centralised database. An intending purchaser of beef patties may wish to verify the credentials of a certified organic beef producer at a distant geographical location before making a purchase decision. To raise a query to the database for information the consumer uses a specialised phone app and scans the product label with the phone camera, and the app then uses the unique label code to call down information from the central database. A package of information downloaded to the consumers phone may provide verification of date and location of animal harvesting, and details and images about farm credentials, location and farming methods.

This transmission of information between initial supplier and final customer through a complicated delivery chain is often referred to as identity preservation. Traditionally this visibility is achieved by permanent package labels that identify product sources and their locations (for example wine bottle labels identifying vineyards). More technically advanced identity preservation is now possible using scannable codes such as QR codes to provide

consumers with a much richer and more graphic display of information about the product they are considering purchasing.

Tracing-backwards and tracing-forwards along the supply chain

During responses to health emergencies, centralised data sharing provides much greater visibility than one step up – one step down data sharing. An early steps in response to a food emergency is identification of sources of supply for food items found to have caused ill-health in consumers. The emergency response investigators have to move up the supply chain to identify the initial source of the food item, called tracing-backwards, and then trace forwards from that supplier to all recipients of supplies from the same or similar lots of food (as illustrated in Figure 1). With centralised data sharing all of this information can be obtained efficiently with one query to a database instead of by a time consuming process of enquiry by creeping progressively up the supply chain (*tracing-back*) to initial suppliers and then tracking all distribution down the chain (*tracking* or *tracing-forward*) to comprehensively locate all potential recipients for suspect product.

(The Federal Institute of Risk Assessment 2012 report describes how trace-backwards and trace-forward in the supply chain are important activities in the resolution of food emergencies (see Figure 1 and Table 1). Thus *trace-back* and *trace-forward* activities complement each other in enabling a full and effective response to food supply chain emergency)

Other data sharing models.

GS1 2017 also define a *networked traceability* model where parties keep traceability information in their own local data management system and provide access in a way that enables all supply chain partners, and not only the immediate chain trading partners to query the local database

A *cumulative information transfer scenario* is also described by GS1. This is a traceability choreography where information is systematically enhanced and pushed forward to the next party in the chain in parallel to product flow. It enables sharing of upstream data with parties further downstream, but not the opposite. Characteristically there is highly asymmetric information visibility with this arrangement. Downstream parties receive a complete copy of all relevant upstream data while upstream parties have limited visibility downstream. This arrangement makes it challenging and costly for downstream parties to process and verify large volumes of traceability information.

Lastly GS1 describe a fully *decentralised and replicated traceability* scenario which is a mix of the cumulative and network scenarios. This scenario includes blockchain (distributed ledger) technologies that are currently being explored because of their potential to supply tamperproof records that are shared freely by all participants in the information network.

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Requirements for network sharing of traceability information through centralised databases.

Centralised supply chain information management systems have a broad range of uses and multiple parties will make use of the information (Figure 3). This provides for data visibility and efficient communication but also places requirements on precise definitions for key data elements, recognition of variation standards across different stakeholders and final uses of data. Standardised communication protocols and integrated communication system design are essential for effective supply chain transparency. The different requirements of primary growers, private transport and logistics operations, processors and manufacturers, retail sales management, consumer needs, government food safety management and biosecurity arrangements all need to be accommodated.

This can be facilitated by collaborative partnerships between the different industry stakeholders to provide joint oversight of the centralised information system (Produce Traceability Initiative 2011, National Livestock Identification System 2018). Interfacing between the centralised system and specialised peripheral users relies on specialised information management systems such as the Integridata® management system available from Aglive Group Limited. One of the concerns stakeholders may have is whether they are exposed to any new liabilities by sharing commercially sensitive data with a third-party. Stakeholder consultation with and involvement with database management cooperative ventures can overcome such concerns (see for example discussions in World Perspectives Incorporated 2018 and best practice examples in section 8).

There are other important requirements of stakeholders. Large food retailers with comprehensive systems for management of supply chain intelligence connected with logistics and marketing is essential to their day-to-day operations need to ensure that centralised database operations are consistent with their requirements.

Elaborate communication networks represented by Figure 3 have their own technological requirements. Specialised communication tools, data formats and markup language conventions (such as XML extensible markup language) are used to facilitate rapid and accurate digital communication (e.g. see GS1 2018). International harmonisation of terminology, data management conventions, and open systems architecture for databases is crucial for achieving efficient communication and sharing of traceability data across international trade. The examples given in Table 2 illustrate the importance of traceability across international borders.

An additional requirement on an accessible information system is that it should be transparently verifiable and resistant to fraudulent misrepresentation or alteration. Modern distributed ledger systems (blockchain ledgers, a *decentralised and replicated traceability* system) are discussed in section 9 below) show considerable potential for fraud proofing these systems.

A wide range of technologies such as barcode scanners, intelligent phones and tablets, GPS geo-token recording, wireless and cable communication systems, database and cloud storage facilities are used in such systems and new options continually become available.

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Provision for flexible acceptance of new technologies (termed interoperability) needs to be recognized to allow for ongoing system improvement with new technology.

Geo-fencing using a centralised database.

The widespread distribution of new technical options opens up new applications for using the transparency of centralised data repositories for sharing of unique records to verify animal identity and location. Biosecurity measures needed for animal disease outbreak containment provide a further example of importance of animal identification, location, movement event and disposal record visibility.

Foot-and-mouth disease is a contagious disease of cloven-hoofed animals such as cattle, swine, goats and sheep that is highly contagious and present on all continents except Australasia, North America and Antarctica. The control measures include widespread slaughter of infected animals which provokes public outrage and entail huge economic costs. A 2001 outbreak of foot and mouth disease in the United Kingdom is estimated to have cost as much as US$13.8 billion, with about 36% of these losses from lost tourism. In this outbreak the UK government paid out the equivalent of US$4.2 billion in compensation to the agriculture and food chain industry (Grubman and Baxt 2004). Precise and rapid definition of the geographical scope of outbreaks using geo-tagging records and centralized databases has considerable potential for mitigating the damage caused by responses to an outbreak. The veterinary scientists working on biosecurity measures have proposed the concept of geographical compartmentalisation for management of animal disease outbreaks (Scott et al 2005). Centralised databases of domestic animal identity and location established using GPS geo-tokens and sharing via an information management network are potentially able to mitigate some of the damage from of foot-and-mouth disease outbreak.

Aglive Group Limited have developed new software and database tools that take full advantage of the capabilities of widely used intelligent phone and tablet computers , automated data collection technology, and internet access to centralized data storage systems to offer increased effectiveness and efficiency to businesses and government agencies who need to track food and animals though commercial channels of distribution and establish boundaries to their geographical location (section 9 of this report gives more detail).

8. Traceability has a key role in response to biosecurity emergencies.

Biosecurity risk management provides an excellent example of the extensively developed management concepts put in place by professional risk managers that rely on heavily on supply chain transparency and product traceability. International trade in biological products such as animals, seeds, and foods pose a broad range of risks that go beyond food-borne illness. These risks include pests such as snails, exotic bees and ants, crop diseases, and animal diseases such as the agents of Mad-cow disease and Foot-and-mouth disease and any newly emerging diseases.

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National agencies (biosecurity agencies) monitoring imports of biological materials have a responsibility to control product provenance and traceability. The discussion below is based on biosecurity management in Australia. Other countries may have slight differences, but the overall principles will be similar. Current further specific details of these biosecurity arrangements are provided at the Australian government departmental website (Department of Agriculture and Water Resources 2018, see also Australian Quarantine and Inspection Service 2007).

Some major trading partners will only allow imports of plant and animal products from jurisdictions which can show proof of freedom from pests and diseases or which apply extensive measures to manage the risks of infection. Some countries may also ask for proof of other quality assurances such as animal welfare practices used in production or food safety, including chemical use, to satisfy their import requirements. In all cases, accurate and timely data that can be verified and trusted is required.

Regulators within the biosecurity sphere need to be able to verify the validity of the data accompanying plant or animal products whether they be from other areas of Australia or from overseas.

There are also many agencies along the supply chain who also require information including the retailer and consumer. Accreditation bodies also need the ability to verify that the standards they set are being met.

Verification of data currently relies heavily on auditing at every point of the supply chain. This is very labour intensive and time consuming.

Aglive's Integridata centralized information sharing software can be used to collect and check data at any point on the supply chain. It is based on Geo-Chain technology. Geo-Chain technology is a novel extension of GPS satellite web tracking that uses blockchain technology. Geo-Chain captures, validates and stores product integrity and farm management data in real time at critical tracking events such as crop or animal treatments or consignments. As the physical product moves along the supply chain, 'at-call' traceability can be accessed from the paperless and transparent database.

This provides the advantage of being able to provide accurate, detailed and timely information that can be trusted to those who use the system. It is hoped that by using Integridata, field audits could be reduced in number or in many cases replaced by efficient and robust desktop audits.

The Biosecurity System

A biosecurity system consists of a set of activities that are designed to:

- anticipate biosecurity risk;
- prevent the entry of exotic pests and diseases;
- screen goods, conveyances and people at the border to detect non‑compliance;
- prepare for an outbreak or incursion of exotic pests and diseases;

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- detect any pest and disease outbreaks or incursions;
- trace any pest and disease outbreaks or incursions
- respond to an incursion of an exotic or established pest or disease; and
- recover from an incursion and adapt to the new circumstances created by an incursion.

Associated with each of these activities is a range of risk management interventions undertaken by various participants in the biosecurity system. These are outlined below.

Anticipate biosecurity risk

Understanding the context in which a biosecurity system helps identify the potential biosecurity risks facing a jurisdiction increasing capacity to prepare for and manage those risks in a timely and cost-effective manner.

Key activities contributing to this element of the biosecurity system are environmental scanning, information sharing between jursdictions and active surveillance for pests and diseases risks.

These activities generate considerable volumes of data and information. Ensuring that this translates to robust intelligence that can be used to manage risk effectively requires the capacity to analyse, report and provide timely access to the outputs of these activities to all relevant participants in the biosecurity system.

Using this information, risk analyses are generally undertaken in response to a new import proposal where risk management measures have not been established or where biosecurity risks could differ significantly from those associated with the import of similar goods. These are designed to assist the jurisdiction to consider the level of biosecurity risk associated with the importation of goods and measures which may be required of importers to reduce the risk associated with the commodity.

Prevent entry of risk material

Preventing pests and diseases from entering a jurisdiction on goods or conveyances is generally considered to be the most cost-effective approach to managing biosecurity risk. Prevention activities occur both pre-border and at the border of a jurisdiction.

Pre-border activities include certification arrangements requiring verification of activities required of importers to minimize biosecurity risks. Science based standards, guidelines and codes of practice for the safe trade of animal, plant and food products guide these requirements.

A further approach to preventing biosecurity risks is the development of import protocols that define the conditions under which biosecurity risk material can be imported to Australia. These conditions are generally based on the import risk analyses.

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Audit and verification activities to provide assurance that import conditions are met and that risks are mitigated prior to arriving at the border are conducted. .

Screen risk material at the border

The screening of passengers, cargo, plants, animals and mail at ports and airports and through mail centres to ensure that they meet import conditions is an important risk management intervention.

Many imported goods are not of biosecurity concern. For those that are, clearance without inspection, using declarations and information provided by the importer, is common. Goods may be released from biosecurity control or directed for further assessment. This could include inspection, diagnostic testing, and, where a biosecurity concern is identified, management such as treatment, export or destruction.

Some jurisdictions operate an 'approved arrangements' system that permits authorized entities to perform certain activities with goods under biosecurity control without the supervision of biosecurity officers. This involves using their own premises, facilities, equipment and people and is subject to periodic compliance monitoring and auditing. Verification of these arrangements is necessary to ensure the system is robust and has integrity.

Collectively, the activities undertaken to anticipate biosecurity risk, prevent risk material arriving at the Australian border and to screen passengers, cargo, plants, animals and mail at the border to ensure they comply with import conditions contribute to reducing the likelihood of exotic pests and diseases, which have the potential to cause harm to the economy, the environment and the community (including people, animal and plants), from entering, becoming established and spreading.

Prepare for an incursion

It is not expected that pre-border and border activities will successfully intercept all threats to plant and animal health from exotic pests and diseases – some biosecurity risk material will inevitably cross the border.

A major set of activities that helps participants in the biosecurity system prepare for an incursion of a potentially harmful exotic pest or disease is the development and maintenance of emergency response arrangements and contingency plans. These define the approach that will be taken in an incursion response so that participants are able to respond quickly and effectively when one occurs.

As well as formal arrangements and contingency plans, training activities are used to help participants in the biosecurity system maintain their readiness for a response to an incursion of an emergency pest or disease. Accreditations of individuals and organizations are maintained to ensure readiness to respond to biosecurity incursions.

Good on-farm biosecurity practices can be a powerful means of reducing the risk that an

exotic pest or disease can establish and spread. Quality Assurance programs recognizing on-farm biosecurity activities hold potential to reduce impacts on individual enterprises of incursions while reducing more general risk. Accreditation of these schemes and participants requires audit and verification processes.

Detect an incursion post border

Early detection of an exotic pest or disease incursion can significantly improve the outcomes of response activities. Targeted, or active, and general surveillance programs to ensure timely detection of pests and diseases are important components of the biosecurity system.

Surveillance activities are undertaken by jurisdictional veterinary authorities, private practitioners, industries and non-government organizations under a range of arrangements.

Early detection of exotic incursions also relies on having sound diagnostic capability and capacity available to support identification of pests and diseases. Diagnostic services (i) underpin the identification of exotic, emerging and nationally significant endemic pests and diseases; (ii) assist in assessing the magnitude of an incursion, which helps determine whether a pest or disease is eradicable; and (iii) provide evidence to support any claim that a pest or disease has been eradicated. They provide the necessary information to support pest and disease control programs and reporting requirements.

Trace an incursion

Not all exotic pest and disease incursions are initially identified at source. A diseased animal, for example, might have been moved from its property before identification occurs at a sale yard or abattoir, or an infected plant might have been sold from an importer to a retail chain before detection occurs. The capacity to rapidly and accurately trace the source of an incursion is an important part of the detection element of the biosecurity system.

Respond to an incursion

Following the detection of an exotic pest or disease, response actions are implemented. The sequential phases of response activities are:

i) The incident definition phase where an initial investigation is undertaken by the relevant government authority.
ii) The emergency response phase during which the Emergency Response Plan (ERP) is implemented. The control measures used may evolve as new information about the outbreak becomes available. This phase continues until it is determined that the incursion has been contained or eradicated, or cannot be contained or eradicated.
iii) The proof of freedom phase following a declaration that an outbreak has been contained or eradicated. This period may include research and/or surveillance activities and will end when the it has been determined that the ERP has been successful.
iv) Where containment or eradication is not feasible, a transition to management phase may be implemented to adjustment to the ongoing presence of the pest or disease.

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As an interim measure to allow time for adjustment, containment activities may be undertaken.

Recover and/or Adapt to an incursion

A number of activities undertaken as part of the biosecurity system are designed to reduce the ongoing impacts of introduced pests or diseases on the environment, the economy and the community. These can be short term actions that occur immediately after an incursion as part of the recovery strategy or they may become long term activities that help the system adapt to changed circumstances.

Area freedom claims are based on surveillance activities and surveys that may be undertaken for a specific time or may become ongoing activities. Re‐opening of international markets is a particularly important recovery strategy for trade dependent industries and requires certification. Verification that goods for export meet importing country requirements will be required.

Not all pests and diseases that enter Australia will be successfully eradicated. This might occur because the pest or disease was not detected sufficiently early or because it is technically infeasible to eradicate. Containment of pests and diseases to specific areas or regions can be used to minimise their negative impacts.

Quarantine and movement restrictions on high risk material that are implemented are used to limit the spread of pests and diseases. Certification systems exist to govern the movement of plant products under the quarantine regulations.
In some cases, long-term management strategies will be implemented that seek to reduce the adverse impacts of the pest or disease. These plans might include changes in regional or local biosecurity practices to reduce the chance of a pest or disease spreading.

The biosecurity system also comprises a range of long term activities that are designed to ensure that those pests and diseases that have established and spread following incursions that occurred sometime in the past are managed effectively. These include community led programmes that coordinate action targeting established pests and diseases where collective action has a social benefit (for example, weeds or rabbits).

A substantial proportion of the activity that occurs at the jurisdictional level is directed at ensuring that relevant participants in the biosecurity system comply with biosecurity regulations. More and more Assurance Arrangements which require auditing and verification systems are being used as efficient ways of ensuring this compliance.

Part of recovering from and adapting to pest or disease incursions is evaluating outcomes of emergency response activities, including eradication and containment actions. Evaluation processes are used to update response tools, plans and procedures and to encourage the application of best practice across biosecurity sectors nationally.

9. Best and emerging practices for centralized provision of supply chain transparency.

The North American vegetable produce supply chain sector is implementing full electronic product traceability from grower to point-of-sale.

Started in 2006, the fresh produce supply chain in the US and Canada has achieved whole chain traceability of products as an industry driven voluntary initiative. At that stage many companies in the produce industry had very good traceability programs within their organizations, but the relevant traceability information was not transferred as the product moved through the supply chain. Major concerns about foodborne illness and food fraud risks, and the inadequacy of fresh produce sector provisions for consumer information about food were the motivational drivers for change in this supply-chain sector.

The Produce Traceability Initiative (PTI) was established in 2008 bringing together major stakeholder partners CPMA (Canadian Produce Marketing Association), the barcode organization GS1 US, PMA (Produce Marketing Association), and the United Fresh Produce Association. The PTI is arguably the most wide-reaching voluntary (US) industry initiative working towards case-level product tracing and improved food safety (Institute of Food Technologists 2012).

This initiative is directed at ensuring traceability of packaged containers of produce (cases). The PTI objective is to create a whole chain traceability by incorporating modern information technology and product identification standards supported by GS1 (GS1 2017, 2018, 2018s). An industry steering team guided an ongoing program focused on providing produce traceability through the entire chain from grower to point-of-sale.

The PTI uses a Global Trade Item Number (GTIN) to uniquely identify trade items, and these includes products/or services that are sold, delivered and invoiced at any point on the supply chain. The GTIN allows organizations to identify trade items at all levels of packaging as well as providing accurate machine reading of those trade items when placed within GS1 barcodes.

The GS1-128 barcode is a packaging case level barcode that allows companies to encode additional information with the GTIN, such as lot number and best-before dates. It illustrates how informative digital fingerprints can be created by structured aggregation of component data elements and become a vehicle for effective product communication throughout the information chain. In 2016 major foodservice operators made GS1-128 case labelling mandatory for all products shipped. As part of the ongoing PTI initiative in a pilot study of blockchain distributed ledger technology was announced by Walmart, Kroger, Wegmans, Doll, Driscoll's and IBM, and Walmart confirmed that PTI labelling will be a basic requirement for blockchain platform (GS1 2018, Institute of Food Technologists 2012, Produce Traceability Initiative 2011, National Institute for Animal Agriculture 2018).

The Australian National Livestock Identification System underpins beef industry access to export markets.

Australia exports two-thirds of its beef and veal production. The country is disease-free from most agricultural and aquatic pests and diseases (including Foot-and-mouth disease and Bovine spongiform encephalitis) and its strong "clean and green" reputation provides a trading advantage. The implementation of a comprehensive red-meat supply chain traceability program provides protection against damage the industry and collapse of export markets from an animal disease epidemic or chemical contamination incident.

The *National Livestock Identification System* (NLIS) is Australia's system for the identification and traceability of cattle, sheep and goats. The system was introduced in 1999 with the objective of enhancing Australia's ability to trace cattle during food borne disease outbreaks. The scheme was expanded in 2009 to include sheep and goats. Comprehensive supply chain coverage of this program is a competitive advantage in global markets. The collaborating partners in NLIS are MLA (Meat and Livestock Australia), Animal Health Australia, The Australian Government Department of Agriculture, Safe Meat, Cattle Council of Australia, Sheepmeat Council of Australia, GICA (Goat Industry Council of Australia), AMIC (Australian Meat Industry Council), ALFA (Australian Lot Feeders Association), ALPA (Australian Livestock and Property Agents Association), ALMA (Australian livestock markets Association).

Collaboration of Australian federal and state and territory governments has resulted in a comprehensive policy agreement, namely the *National Traceability Performance Standards*, under which NLIS operates. A major biosecurity risk highlighted in policy documents is the potential introduction of Foot-and-mouth disease. NLIS has published standards for traceability of cattle (National Livestock Identification System 2016) that define the comprehensive scope of the system. The standards apply to all cattle and cattle movements in Australia. They also apply to the personnel responsible for the care and management and movement of cattle to or from farms, feedlots, sale-yards, transit centres, artificial breeding centres, veterinarians, export depots, Agents' Property Identification Codes (PICs), transport vehicles, travelling stock routes, knackeries, processing establishments, agricultural show societies and similar events or any other movement between locations with a different PIC.

The NLIS nominates the use of permanent cattle identification with electronic IDs (EID). These include RFID devices attached to an animal's ear and electronically tagged boluses in the animal's rumen which provide for efficient electronic interrogation of individual cattle on properties, and are crucial for traceability when they move on and off properties. The critical data elements required to be recorded during movement of cattle are defined by the NLIS standard. These include the Property Identification Code from which the cattle were dispatched, date of dispatch, numbers and description of cattle being dispatched, serial number of the movement document and accompanies the cattle, name and signature of the person making the declaration and data it was made, and the intended destination of the cattle.

An electronic livestock transfer document system, termed the electronic National Vendor Declaration System (eNVD), has been developed for use in the National Livestock Identification System by Meat and Livestock Australia subsidiary Integrity Systems Company

(ISC). The objective is to replace all paper-based livestock identity and integrity data with more efficient and cost-effective digital information systems.

Accessible centralised cloud-based data repository.

The NLIS has a central database the collect individual supply chain transactions. This records the movement of all cattle, and links individual cattle involved in the movement between different properties with the accompanying movement records. It is through queries made to this database that individual cattle movements can be quickly and reliably traced throughout animal life. The software integration company Aglive Group Limited has been contracted extend the capabilities of this system.

Figure 5. is a diagram that illustrates the scope of ongoing development of these communication tools by Aglive Group Limited.

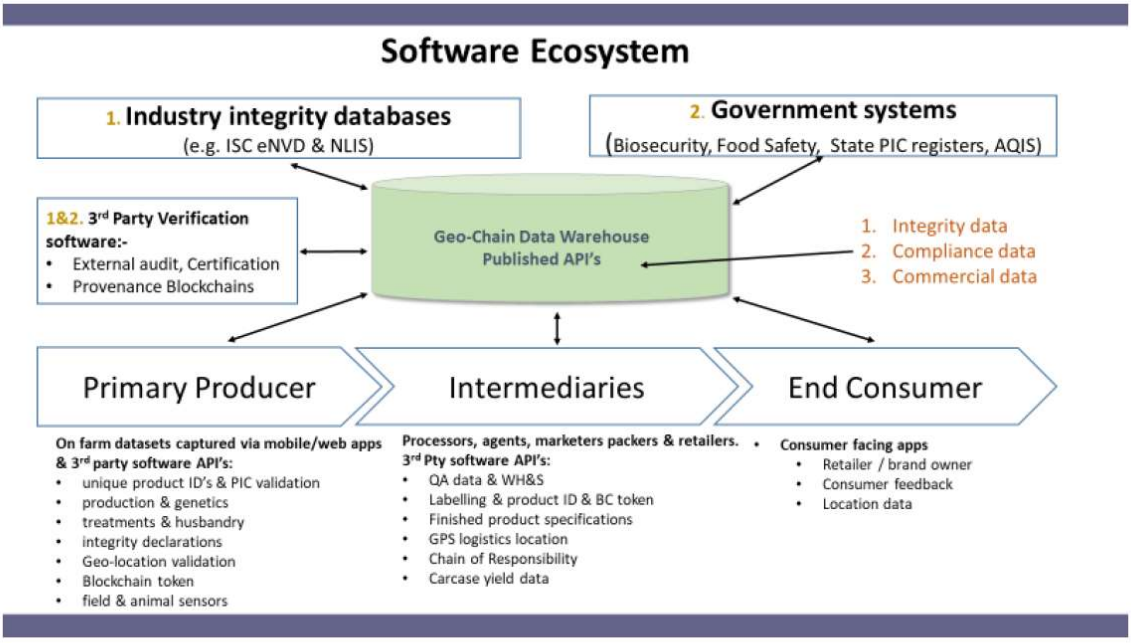

Figure 5. A software ecosystem around an enriched central database provides transparency and information for a wide variety of stakeholders.

Industry integrity databases can accept data from primary producers through electronic National Vendor Declarations (eNVDs) acceptable to the National Livestock Identification system.

Labour costs for date recording are saved by use of devices like intelligent phones and scanners to automatically digitise key data elements. Unique location data elements (geo-tokens generated by GPS linked devices) provide strong verification of the integrity of data elements. The software system can also exploit blockchain distributed ledger tokens for strong protection against fraudulent records and transparent verification by third parties.

Credibility, integrity and transparency of supply chains.

An organised set of digital data elements such as a combination of animal electronic ID number, Property Identification Code and a geo-token provides a distinctive and unique digital fingerprint characterising events involving an animal as it passes through the supply chain. This feature is valuable for ensuring rapid traceability with the aid of digital databases.

Integridata® is a central data warehousing system that provides integrated traceability and product integrity communication and management. It is marketed by Aglive Group Limited and is integrated with the NLIS system. The implementation of a central data warehouse with standardised protocols for data exchange (APIs) makes possible the efficient provision of key information to a variety of important stakeholders. These include government agencies involved in biosecurity or food safety, intermediaries in the supply chain and end consumers who could verify product provenance with intelligent phone QR code scanner software at retail outlets before purchase.

Systematic use of geo-tokens enhances system reliability and management capability.

A key element of the systems developed by Aglive is integration of GPS based geographical location tracking to produce geo-tokens (digital data elements) associated with physical movement of product along the supply chain. These can be integrated with other data elements such as Property Identification Codes to provide a unique and informative fingerprint of events occurring during movement of materials along the supply chain. Users of databases in which these digital fingerprints are collected obtain complete visibility of the chain and can detect whether there is a potential compliance incident by locating breaks in the digital supply chain. Stakeholders and regulators can use this information technology to monitor and rapidly quarantine any specific farm or region if there is a disease outbreak. The relevant traceability fingerprint can be efficiently delivered to final retailed products as a product label code such as a QR or other barcode via the data warehouse.

This system avoids the problems of data silos, slow and untargeted costly responses to emergencies, and vulnerability to loss of traceability that are characteristic of traditional one step up – one step down paper-based records.

Blockchain enhancement of traceability system transparency and credibility.

Several different food chain sectors are showing active interest in the potential blockchain distributed ledger systems as an adjunct to traceability and product integrity. The discussion of the Produce Traceability Initiative (PTI) is one example already mentioned. Business advantages of block chain for these applications have been reviewed by McKinsey management consultants (Carson et al. 2018), and the Institute of Food Technologists have summarised its potential application to the food industry (Institute of Food Technologists 2018). Fishcoin have published a white paper on blockchain's application to traceability management in the global seafood industry (Fishcoin 2018). This Fishcoin white paper outlines the potential direction of distributed ledgers in the seafood sector and illustrates the driving force of environmental activism and consumer concerns in shaping traceability provisions. It also illustrates the challenges of providing credible transparency in a complex

supply chain and the demanding data management preparations needed for digital traceability communication systems.

A meat industry trade magazine recently provided a primer on how blockchain technology fits into the industry (Bricher 2018), noting that the system is too new to see exactly how it will work across the manufacturing plant just yet. It provides the example of the US company Cargill rolling out the first ever US Food pilot using blockchain technology to create a transparent farm-to-store digital trail for provenance of branded turkeys, starting from a farm in Texas. These reports are representative of wide ranging current industry discussions of advanced traceability technology.

10. Glossary

Aglive. Alive Group Limited is a public company based in Geelong Victoria. Aglive has experience in agricultural and food supply chains, farming, logistics, marine technology, processing and packaging, GPS tracking and GIS mapping software development and technological device integration within information management systems.

AI. Application Identifier. Numerical prefix used in barcodes and RFID tags to define the meaning and format of encoded data elements in GS1 one traceability systems. Used in the following barcodes GS!-128, GS1 DataBar, GS1 QR code. For example in a GS1 dataBar AI (3103) indicates net weight with three decimal positions.

AIDC. Automated Identification and Data Collection/Capture.

APIs. A set of functions and procedures that allow the creation of software applications which access the features or data of an operating system, application, or other service.

Blockchain. A decentralized, distributed and public digital ledger that is used to record transactions across many computers so that the record cannot be altered retroactively without the alteration of all subsequent blocks and the consensus of the network. The distributed feature of the ledger provide security against fraudulent alteration or misrepresentation of recordings made to the ledger by participants in the blockchain.

Chain of custody. A time-ordered sequence of parties who take physical custody of an object or collection of objects as they move through a supply chain network (after GS1 2017)

Certification. Voluntary assessment and approval by an accredited party and compliance to articular standard. The purpose of certification is to reach a define performance and make this known to stakeholders, who include customers, consumers of food, governments, and financing institutions such as banks (after Meussen et. al. 2003). Process by which accredited certification bodies, based on an audit, provide written assurance that food safety/quality management systems and their implementation conform to scheme requirements (after FSSC 22000).

CTEs. Critical tracking events are events in the supply chain where a change of product custody (transmission) or transformation of product implies the need for retention and communication of key data elements defining both the upstream and downstream participants of the event. This record retention prevents breaks in the chain of traceability of final product. Examples of key tracking events include harvesting of produce by a grower, manufacturing of processed products, and shipping of products to downstream organisations in the supply chain

EAN/UPC Barcodes. Longest established and widely used barcode in the GS1 system

EID. Digitally encoded electronic identification message or token.

Geo-Chain technology. A comprehensive mobile device and internet-based traceability platform pioneered in the Australian red meat sector by Aglive Group Limited.

Geo-location. Ability of technology such as a GPS enabled smart phone to enable the geographical location of the user to be encoded as a digital message (token or geo-token).

Geo-tag. Digital record made by a GPS enabled device such as intelligent phone provides a record of the geographical location.

GS1. An international product barcode standards and supply chain service company. See GS1 Standards webpage. https://www.gs1.org/standards

GS1-128 barcode. An informative one-dimensional barcode symbol used in general distribution and logistics but not at retail point-of-sale.

GS1 DataBar. Compact one-dimensional barcodes they can hold additional product attributes such as the weight of fresh foods.

GLN. Global location number. A coded identifier or key for physical locations, internal physical locations and parties involved in supply chain transactions (GS1 2018a) .

GTIN. A Global Trade Item Number is an identifier or key used for uniquely identifying trade items, which includes products/or services that are sold, delivered and invoiced at any point on the supply chain (GS1 2018a) Can be used for the batch or lot number for more fine-grained identification, or with our serial number for instance level identification.

Identification of items. Addition of unambiguous label on a traceable unit that provides information forward determining its source. This includes use of lot numbers, barcodes, QR-codes and RFID devices.

Identity preservation (after Meuwissen et al. 2003). This is a set of measures taken to preserve and communicate the exact identity and source of food and food ingredients to the end user. They include systematic retention of records about sources of inputs and linkage of these records to items of final product. The purpose of identity preservation is to add economic value to the product and it is typically associated with credence attributes which are difficult to perceive or verify by the final consumer. They include country of

origin, organic, kosher, halal, free-range, and fair trade claims (discussed by Dabbene et. 2014).

Integridata® A central data warehousing system that provides an integrated traceability and product integrity communication and management system, is marketed by Aglive Group Limited.

Identifier. A label code or symbol attached to a traceable unit to provide discriminating and informative information about the source and history of the item. Can consist of a barcode, QR code, lot number or similar accessible information. Used as an aid to identity preservation and traceability.

Interoperability. Suitability of information systems to accept addition of new technical devices or components while continuing to provide expected outcomes

KDE Key data elements. Data required to be recorded and made available in a critical tracking event to accurately represent what occurred at that step in the business process in order to ensure traceability (after GS1 2017). Items such as geo-tokens, ID codes, lot or batch numbers, pallet or case IDs corresponding to key events that need to be defined and captured to be used in a digital information management system.

Logistic unit. An identifiable traceable unit undergoing movement or exchange between different locations or businesses. This could be a container load, truckload or shipload. This can also be a case or package of fresh produce or a a pallet being relocated within a warehouse

Lot and lot identification. A lot which is a set of units of a product which have been produced and/or processed or packaged under similar circumstances. Lot identification is a process of assigning a unique code to a lot and documenting that assignment in a record system. Similar concepts apply to batch identification.

PIC. Property Identification Codes, as used to identify locations and establishments in a traceability management system.

PRPs. A term used in ISO 22000 for prerequisite programs for safety management.

QR-code. Quick response code. A type of barcode that is two-dimensional and capable of encoding more bits of information than the one-dimensional barcode. It can be scanned by the camera uncommonly available intelligent phones and produce a string of numerals or letters as output, available from GS1 and Denso Wave.

SSCC. Serial shipping container code. An identifier for logistics units such as pallets, parcels for trade items packaged together for storage and transport (GS1 2018a).

Token. Digitally encoded identifier consisting of a string of digits managed by an information system and transmitted as a packet to characterise an event in the distribution chain, for example a geo-token or EID.

Tracing and tracking (after Hobbs 2016). In a technical context tracing implies the ability to trace the source of a product (or ingredients) backward or upstream in the supply chain, while tracking implies the ability to follow a product forward downstream in the supply chain. Some authors use the terms trace (tracing)) backward and trace forward.

Transparency of a supply chain. Ability of third parties to the supply chain and final consumers to obtain information about material sources and treatments across the complete supply chain. This may involve (i) targeted communication of information to consumers to allow verification of label and advertising claims and (ii) enabling timely access by government agencies to information they need to track and trace distribution of materials in responses to health emergencies.

Traceability (After Hoyle 2017). Traceability is a process characteristic. It consists of the ability to trace history, application, use and location of individual items or the characteristics through recorded identification codes. Traceability can relate to (i) the origin of materials and parts;(ii) the processing history;(iii) the distribution and location of the product or service after delivery (after GS1 2017).

Traceable object. This is a physical or digital object for which there is a need to retrieve information about its history, application, or location (after GS1 2017)

Traceability system. The set of methods, procedures and routines used by an individual party to manage traceability in its supply chains (after GS1 2017

TRU. Traceable resource unit, such as an animal, mob of animals, batch or lot of a manufactured or processed item, pallet case or bulk package of a product that are produced or packaged under the same conditions.

Standard (after International Standard Organization). Documented specifications, guidelines or characteristics that can be consistently applied to ensure that materials, products, processes and services are fit for that purpose.

RFID. Small devices that encode a unique digital identity code by (token) means of a radio-frequency sensitive circuit.

Verification. Confirmation, supervision of objective evidence, as specified requirements have been fulfilled

Validation. Obtaining evidence that control measures are capable of being effective

XML. Extensible markup language used for electronic data communication.

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