Digital Technologies in Meat Industry

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Food Focus Thailand 2026

Recent Events: China, Malaysia, France (2025–2026)

1 **Jul 2025 · China**

China suspends imports from 17 Thai chicken plants after audits

2 **Mar 2026 · Malaysia**

Malaysia opens its market to Thai pork

News of 8 Mar gives no opening date · expected to add ~THB 1,000 million in exports in 2026

3 **11–12 Oct 2026 · France**

Refrigerated cabinets in 300–500+ French supermarkets hacked to heat up to 50 °C

Breaking news: re-check the figures before the talk

Source: DLD via Prachachat (7 May 2026); Prachachat (reported 8 Mar 2026); CERT-FR CERTFR-2026-ALE-012 (12 Oct 2026, revised 13 Oct)

Big Picture: Why Meat Traceability, Why Now

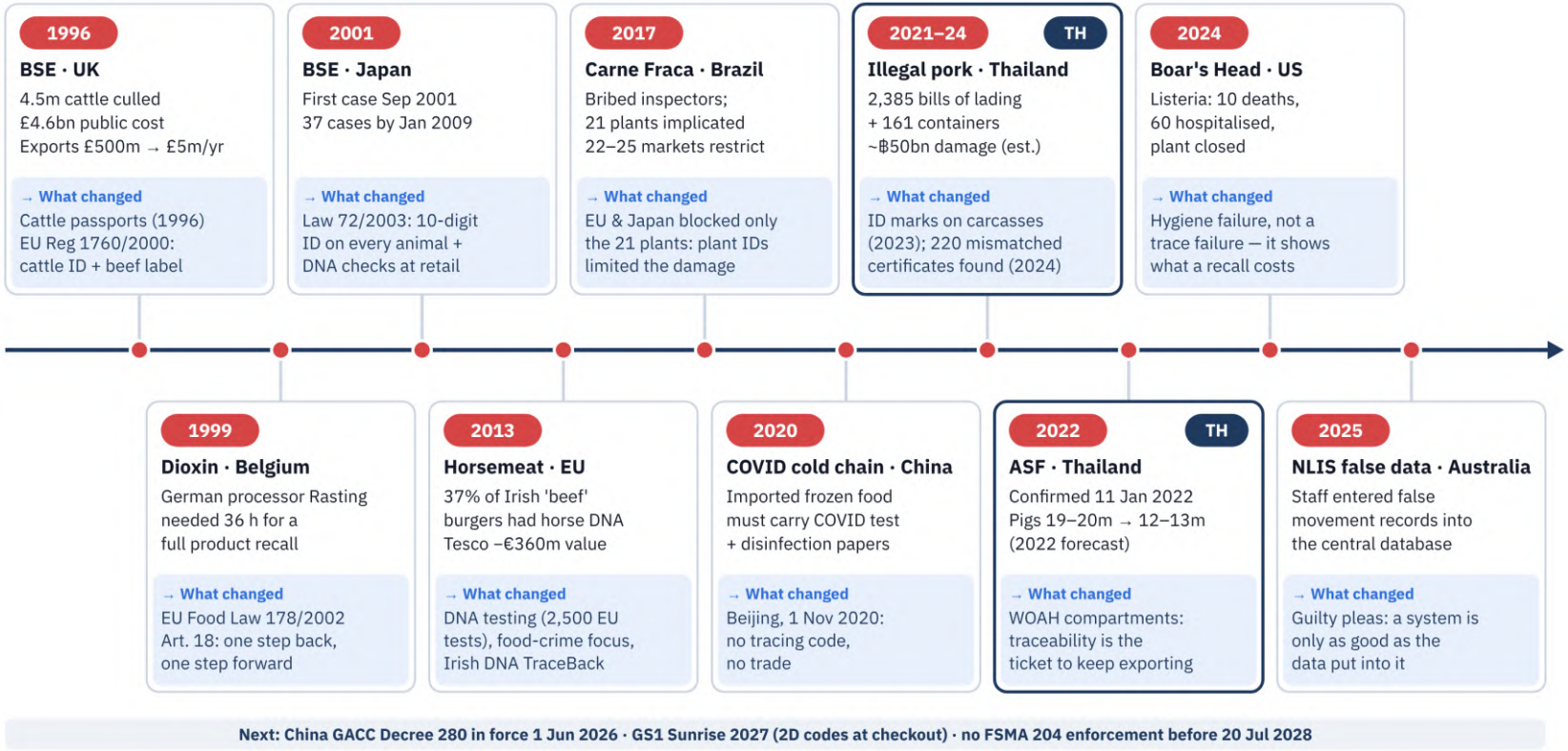
อุตสาหกรรมอาหารไทยกับ **Industry 4.0**



อุตสาหกรรมอาหารไทย: ระดับ **2.0–4.0**

ที่มา: foodfti.com

Meat Crises and Traceability Rules, 1996–2025



Source: NFU/Just Food; FWI; GS1 Rasting case; MAFF; FSAI via Wikipedia; Exame; Beijing Gov; DSI; Pig333/USDA; WOAH; CDC; Agriculture Victoria

Horsemeat Scandal 2013

37%

Irish “beef” burgers with horse DNA
(10 of 27 samples, Jan 2013)

~€360M

Tesco market value lost in one day

Supplier route: complete paperwork at every step



Source: FSAI results via Wikipedia, "2013 horse meat scandal" (historical, 2013)

เคสหมูเถื่อน 2021–2024

2,385
bills of lading, Jan 2021–Jul 2023
declared import value ฿1.57bn

>76,000 t
smuggled since Jan 2021 (DSI est.)
~42,000 t declared as seafood/polymer

161
containers left at Laem Chabang
~4.5–4.9m kg · ฿460m incl. duties

220
containers, Mar 2024 (pork + beef)
6.0m kg · ฿1.41bn · papers mismatched

~฿50bn
estimated damage to the economy
(as reported by Thai PBS World, 2024)

11 of 12
DSI special cases sent to NACC
by Apr 2025 · no verdict found yet

① Abroad: real meat in branded export boxes
From Brazil, Germany, Canada, China, S. Korea; often near-expiry or offal.
A Jun 2022 seizure held Seara and Westfleisch boxes.

② Customs paperwork: false product data
Declared as frozen seafood (e.g. salmon) or 'polymer' to pay less duty.
Mar 2024 case: 220 health certificates did not match the goods.

③ The gap: documents were never matched
Customs code, DLD import permit, health certificate, origin authority:
each record existed, but nobody cross-checked them.

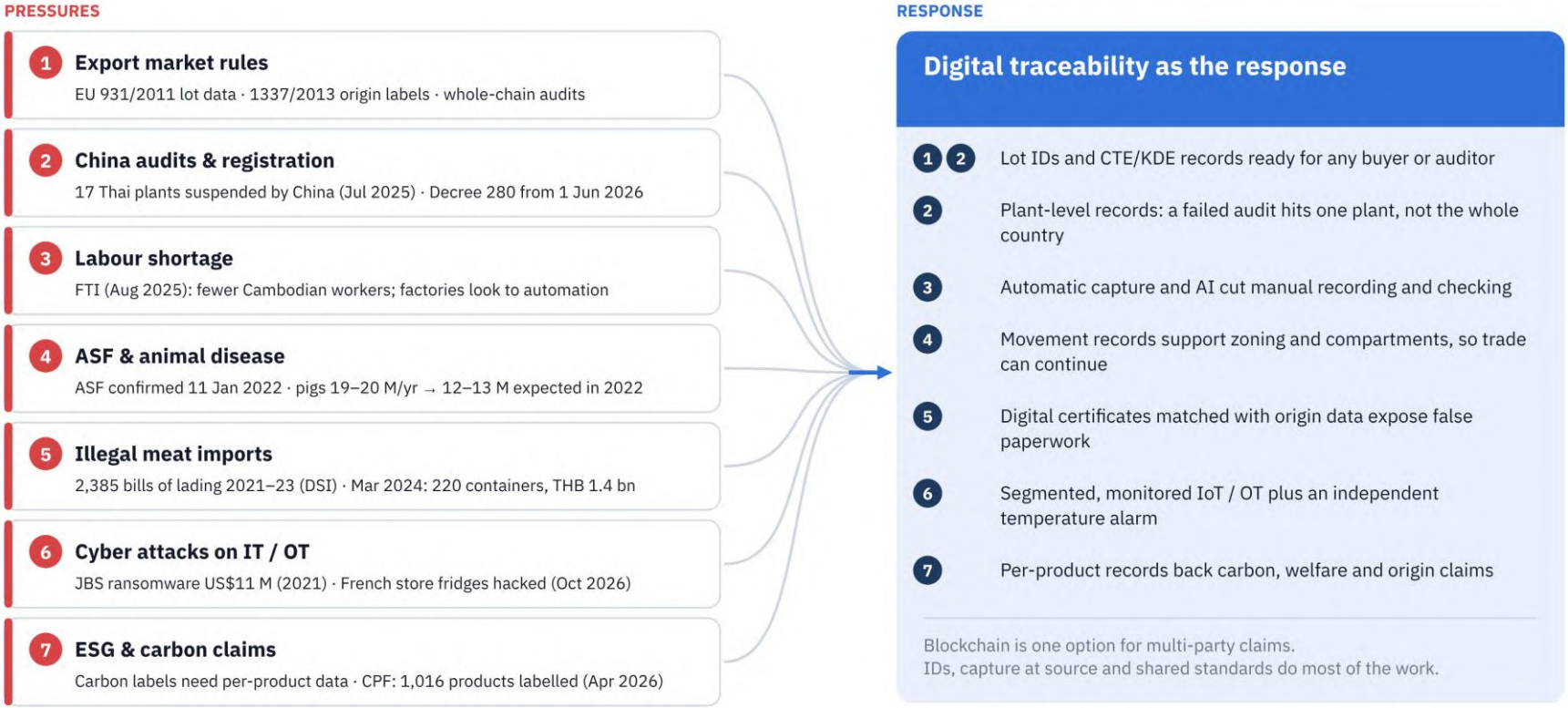
④ Cold stores → Thai market
Sold as ordinary pork. Thai farm-gate price ฿70–76/kg vs cost >฿80/kg
(Jan 2024). Reported risks: ASF virus, β-agonist residues.

What Thailand added (2022–2024)
- ✓ Identification marks on imported carcasses so they can be traced back (2023)
- ✓ Cold-store inspections; licence revocation threatened for registrants (2022–23)
- ✓ Certificates checked with the origin country: 220 mismatches found (Mar 2024)

Customs, DLD and health-certificate records were never cross-checked against each other

ที่มา: DSI (24 Apr 2025); Thai PBS World (Sep 2024; … (full list in notes)

Pressures on Thai Meat Processors



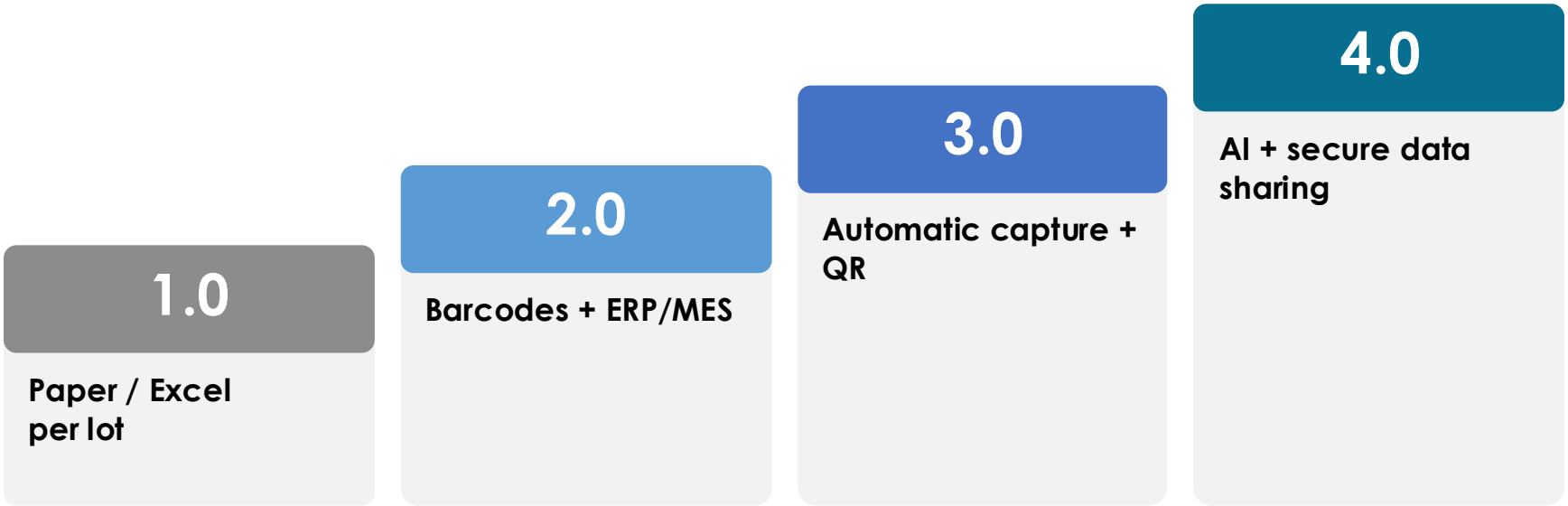
Source: EUR-Lex; DLD/Prachachat (2026); GACC/SFA (2026); The Thaiger via ASEAN Now (Aug 2025); DSI (2025); CERT-FR (Oct 2026); CPF (Apr 2026)

Common Failure: False or Unlinked Records

A database holds only what people type into it. Traceability works when records start at the source, are linked by the same code and are checked against the real product.

1. Record at the source
2. One shared ID
3. Check against the product

Digital Traceability Maturity: 1.0 to 4.0



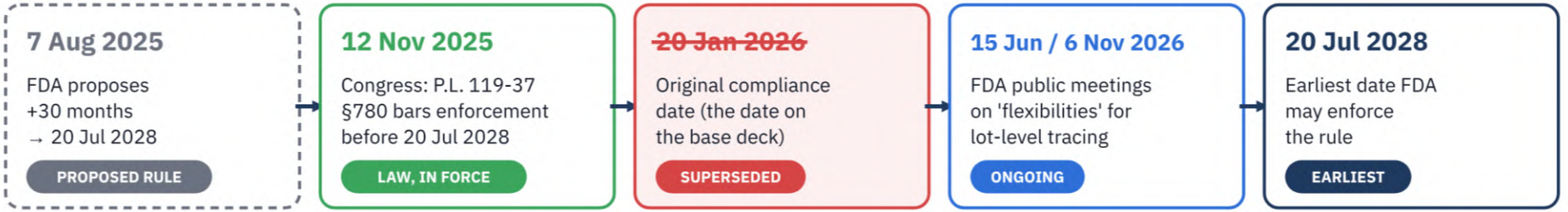
Regulation: Global → Asia-Pacific → ASEAN → Thailand

Meat Traceability Regulation Timeline, 2000–2028



Source: EUR-Lex; FDA; CRS R48925 (Apr 2026); MAFF; FAOLEX; ISC; SFA; VnEconomy; Tạp chí Công Thương; RRI; WOAH Asia; Avinews

FSMA 204 Food Traceability Rule



Milestones in date order, not to scale

ON the Food Traceability List

FDA rule applies (enforcement ≥ Jul 2028)

- Finfish, crustaceans, shellfish
- Shell eggs (domesticated chicken)
- Cheeses, nut butters, fresh produce
- Ready-to-eat deli salads

~485,000 US establishments in scope; exemptions cover ~98% of shell-egg producers

Thai seafood & egg exporters: covered directly

NOT on the list: meat & poultry

Mostly USDA-FSIS jurisdiction, not FDA

- 21 CFR §1.1305(g): food under USDA's exclusive jurisdiction is exempt
- FSIS 'Product of USA' rule since 1 Jan 2026: origin records required

The CTE/KDE model is still the clearest way to design meat traceability (see file 03)

Thai chicken & pork: indirect via US buyers' data asks

24 h

Records on request: in an outbreak or recall, as a sortable spreadsheet

24 h sortable spreadsheet in an outbreak / recall

Source: P.L. 119-37 §780 via QA Magazine (Nov 2025); CRS R48925 (Apr 2026); FDA FSMA 204 page (Oct 2026); 21 CFR 1.1305(g)

EU Requirements for Meat Exporters

Reg 931/2011

8 data items per consignment, updated daily

Reg 1337/2013

“Reared in / Slaughtered in” label + lot code (pork, poultry)

Reg 853/2004

Meat ≤7 °C · offal ≤3 °C · poultry meat ≤4 °C

Digital Product Passport (ESPR): food, feed and live animals are excluded

Source: EUR-Lex: Reg 931/2011, 1337/2013, 853/2004, 2024/1781 Art. 1(2), 2021/2117

China: GACC Decree 280 and Plant Registration

17

Thai plants suspended after the Jul 2025 audit

- **GACC Decree 280** in force 1 Jun 2026: meat plants need an audit and a DLD recommendation; no automatic renewal
- **Overseas cold stores** must also register
- **Plant registration number** works as the export passport: track renewal dates

Source: SFA trade circular (Jul 2026); REACH24H; DLD via Prachachat (7 May 2026); GFPT MD&A FY2025

Vietnam: Law 78/2025 and VeriGoods



VIDEO · EMBEDDED MP4 (from base deck)

New digital rules improve food traceability (Vietnam Today news report)

Vietnam Today · 2025–26 (per deck context)

Link: available in base deck (embedded mp4, 8.5 MB); source and permission unknown; check its claims

- Law 78/2025 (in force 1 Jan 2026) + VeriGoods system (23 Dec 2025)
- Circular 31/2026: full rollout 1 Jan 2027 · records kept 12/60 months
- Meat not yet on the Ministry of Industry and Trade list

Source: Tạp chí Công Thương (MoIT journal, Jun 2026); LuatVietnam (Jun 2026); Viet Nam News (Dec 2025); VnEconomy (Dec 2025)

ตัวอย่างระบบตรวจสอบย้อนกลับของไทย

! บังคับ

- e-Movement (ใบเคลื่อนย้าย):
  ใบอนุญาต ร.3/ร.4/ร.5 ทั้งสัตว์และซาก
- ใบอนุญาตโรงฆ่าสัตว์

? สมัครใจ

- ปศุสัตว์ OK: 6,776 ร้าน 76 จังหวัด (ก.ค. 2026)
- QR Trace on Cloud (มกอช.)
- i-Trace (CP Axtra × กรมปศุสัตว์ เนื้อโค)
- TraceThai: ระบบต้นแบบ สินค้าอินทรีย์ ไม่ครอบคลุมเนื้อสัตว์

ระบบเหล่านี้ยังไม่เชื่อมกันทางกฎหมาย

ที่มา: WOAH Asia/DLD case study (Apr 2024); Avinews (Jul 2026);

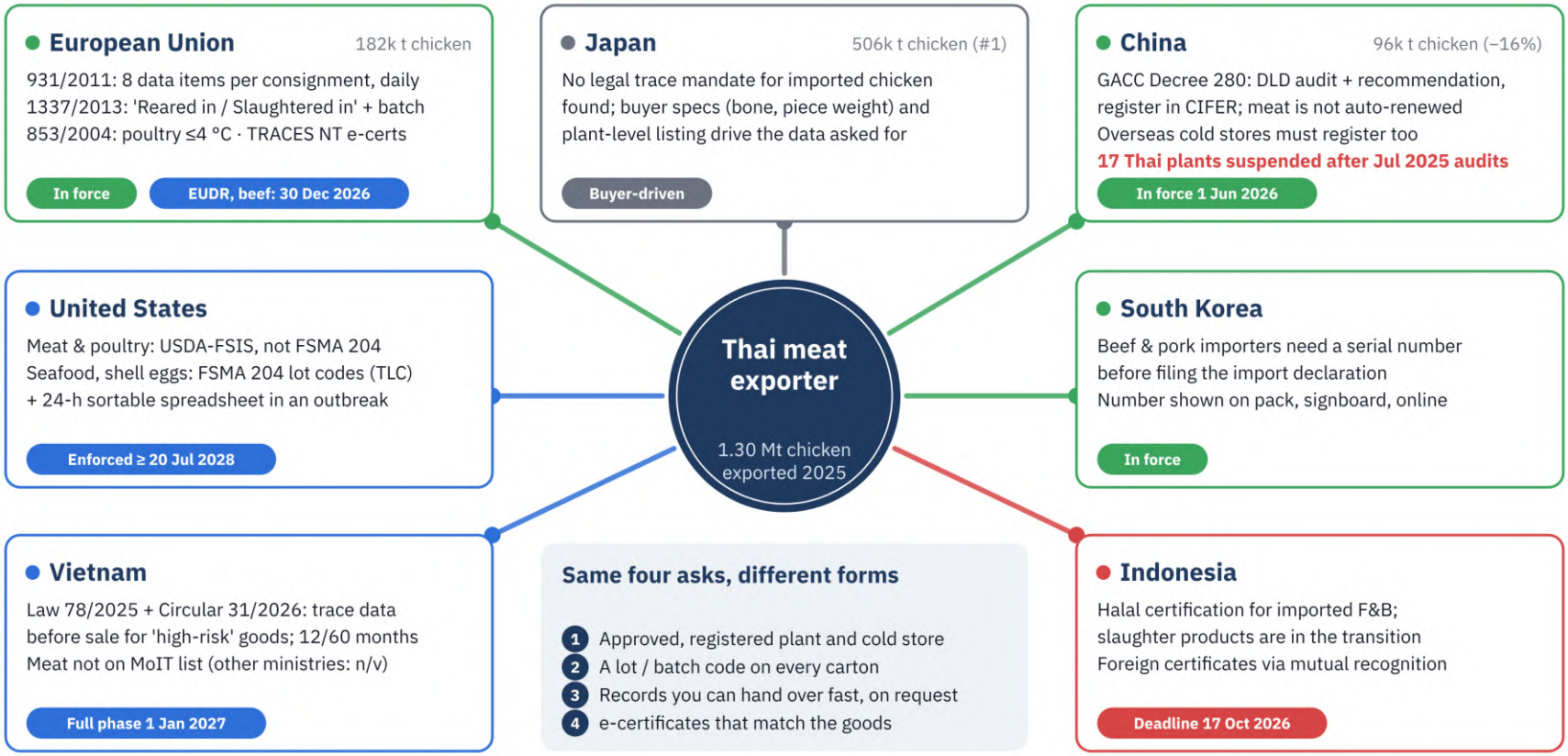
National Meat Traceability Systems Compared

	Japan	S. Korea	Australia	EU	USA	Vietnam	Thailand
ID unit	Individual cattle 10-digit ID, tags in both ears	Cattle: individual Pigs/poultry: lot 12-digit number	Individual animal RFID eID (cattle, sheep, goats)	Individual bovine; lot/batch for pork & poultry	Lot code (TLC) for listed foods; EID tag for some cattle	Product / batch code (VeriGoods)	Farm premises + movement permit; no retail ID unit
Mandatory?	**Yes** cattle & beef only	Yes: cattle, pigs, chickens, ducks, eggs	**Yes** under state law	**Yes** all food + meat-specific rules	Cattle EID: yes FSMA 204: not enforced before 20 Jul 2028	Yes for 'high-risk' goods; meat not on MoIT list yet	Permits: yes Product trace to consumer: voluntary
Who runs the database	NLBC (gov't-entrusted), public lookup	MAFRA database, operated by KAPE	ISC (industry body) under state law	Member-State cattle DBs + TRACES NT (EC)	Firms hold records; FDA system not built yet (GAO, Jan 2026)	MoIT VeriGoods + national portal	Split: DLD e-Movement, ACFS QR Trace, private systems
Code the consumer sees	ID or lot no. on pack and in beef restaurants	12-digit no. on pack, signboard, online listing	**None** (B2B / regulator)	Beef ref. code; 'Reared in / Slaughtered in' + batch code	No trace code; 'Product of USA' claim rules (2026)	QR verification; voluntary 'green tick'	Voluntary: มศุสัตว์ OK logo, QR (ACFS, retail)
Blockchain in the law?	**Not required**	**Not required**	**Not required**	**Not required**	**Not required**	**Not required**	**Not required;** used in some voluntary systems

Mandatory, national system | Partial / phased / limited scope | Voluntary or none | No legal mandate found requires blockchain

Source: MAFF; FAOLEX & mtrace.go.kr; ISC; EUR-Lex; FDA; CRS R48925; Tạp chí Công Thương; WOAH Asia (DLD); Avinews

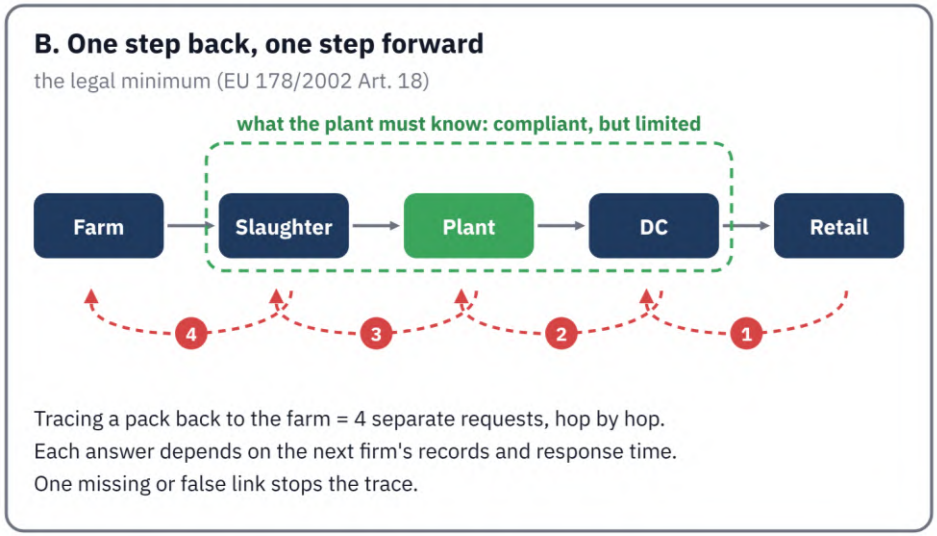
Export Market Requirements for Thai Meat

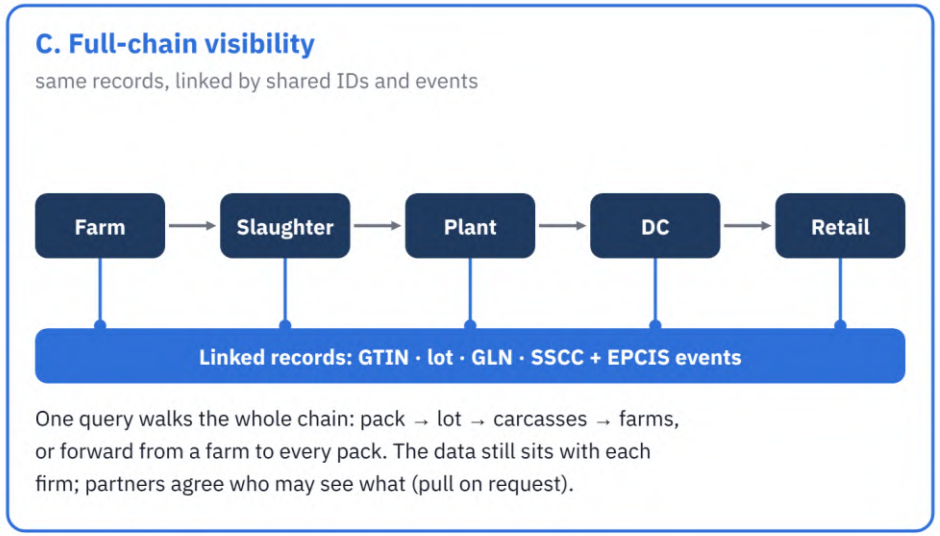


Source: EUR-Lex; Arendt; SFA & REACH24H; Prachachat (May 2026); FDA; CRS; FAOLEX; Tạp chí Công Thương; USDA FAS; RRI; GFPT MD&A 2025

Traceability Fundamentals

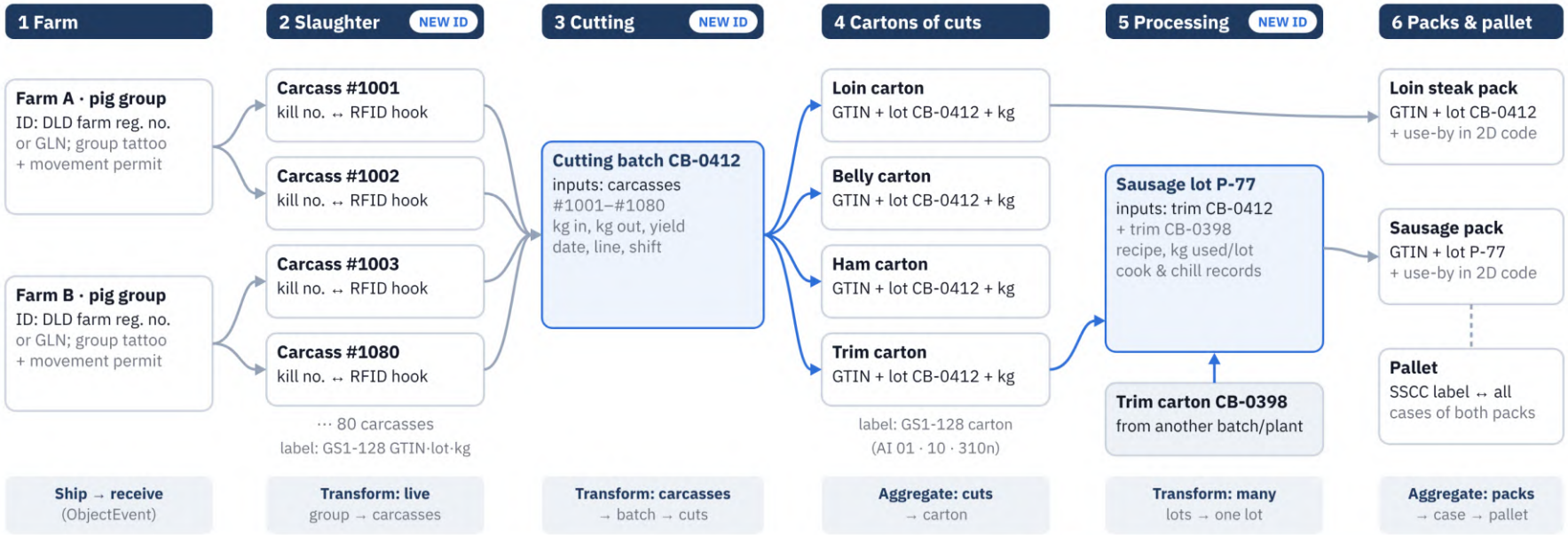
One Step Back, One Step Forward





Source: EU Reg 178/2002 Art. 18; EU Reg 931/2011; GS1 Rasting/Westfleisch case (2006); GDST

Lot Transformation: Split, Merge, Mass Balance



Split: one → many

One carcass ends up in many cartons and packs. A recall walks forward: carcass → every pack it reached.

Merge: many → one

50–80 carcasses → 1 cutting batch (German beef plant). Japan's beef ID law stops here: minced meat and trimmings are excluded.

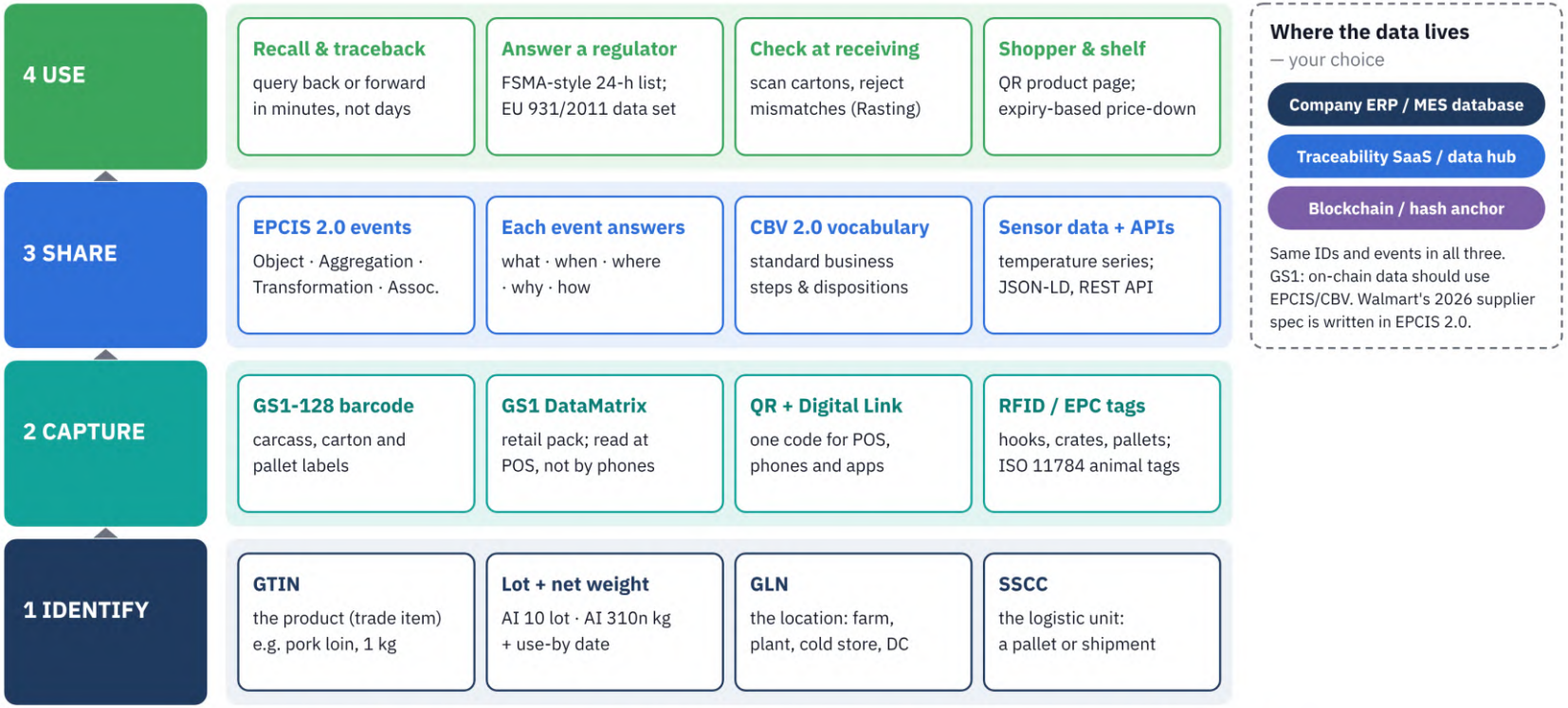
Mass balance check

kg in = kg out + trim + bone + loss. A gap means missing inputs or substitution — the fraud signal.

The ID changes at every transformation. The record linking input lots to the output lot keeps it traceable.

Source: GS1 Rasting/Westfleisch case (2006, historical); MAFF Law 72/2003; 21 CFR 1.1350; Walmart EPCIS 2.0 supplier docs (Aug 2026)

GS1 Standards for Traceability



Storage is a choice. Whether the data is true depends on layers 1–2 and on independent checks (audits, DNA).

Source: GS1 EPCIS, Digital Link and blockchain pages; GS1 Rasting case; Walmart EPCIS 2.0 docs (Aug 2026); Advanced Automation & NACS (2026); IFPA

Summary: Fundamentals

5 Cybersecurity protects the data

4 AI, IoT and digital labels add value

3 Records linked at every hand-over

2 Data captured where the event happens

1 An ID on every lot and carcass

So far

Market pull · IDs · linked records

Next

What AI, IoT and labels add on top of the ID

One test for every technology: is the result linked to the lot or carcass ID?

Sub-topic 1

AI for Quality Assessment, Carcass Grading and Yield Prediction

Carcass Value Beyond Weight

A$80

Value gap between two beef carcasses of the same weight and fat

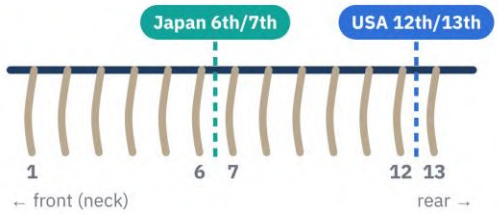
- **Grading** turns a carcass into a price
- **Weight** is easy to measure but does not show value
- **A grade adds value** only when a price grid or a decision uses it

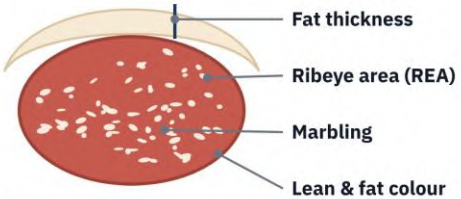
Source: MLA's Dr Alex Ball via Beef Central (Jul 2017; historical, 2015 quote)

Carcass Grading Systems and Measurement Sites

Beef

Graded on a cut ribeye surface at a fixed rib



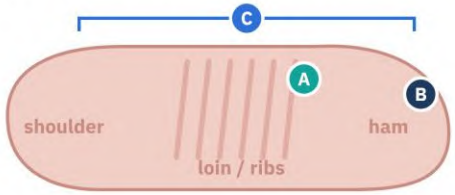


USDA Quality: marbling + maturity → Prime / Choice / Select … Yield: fat, KPH %, hot weight, REA → Yield Grade 1–5

JMGA Yield %: REA, rib thickness, fat, weight → A / B / C. Quality: BMS 1–12, colour, fat, firmness → 1–5 ⇒ "A5"

Pork

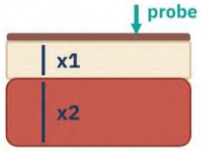
EU grades estimated lean-meat % (LMP)



A Handheld ultrasound, 2nd–3rd last rib, 7 cm off midline: backfat x1, loin x2

B Ham split line: fat over gluteus medius (ZP ruler or CSB Image-Meater camera)

C AutoFom III: 16-transducer ultrasound array scans the back before opening



LMP = 60.99
– 0.858 × backfat x1
+ 0.164 × loin depth x2

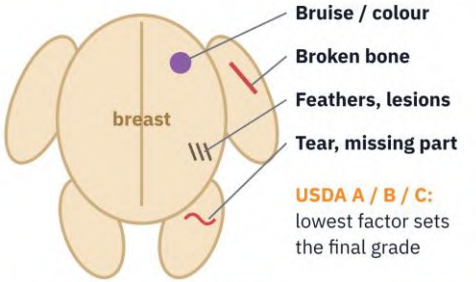
German handheld-ultrasound formula, EU Dec. 2011/258

EU class by LMP %

S	E	U	R	O	P
≥60	55–60	50–55	45–50	40–45	<40

Poultry

Whole bird and parts; grade = weakest factor



USDA A / B / C: lowest factor sets the final grade

after defeathering	after evisceration	at distribution

Vision cameras grade 7 parts separately, so one defect does not downgrade the bird

Breast fillet: woody breast

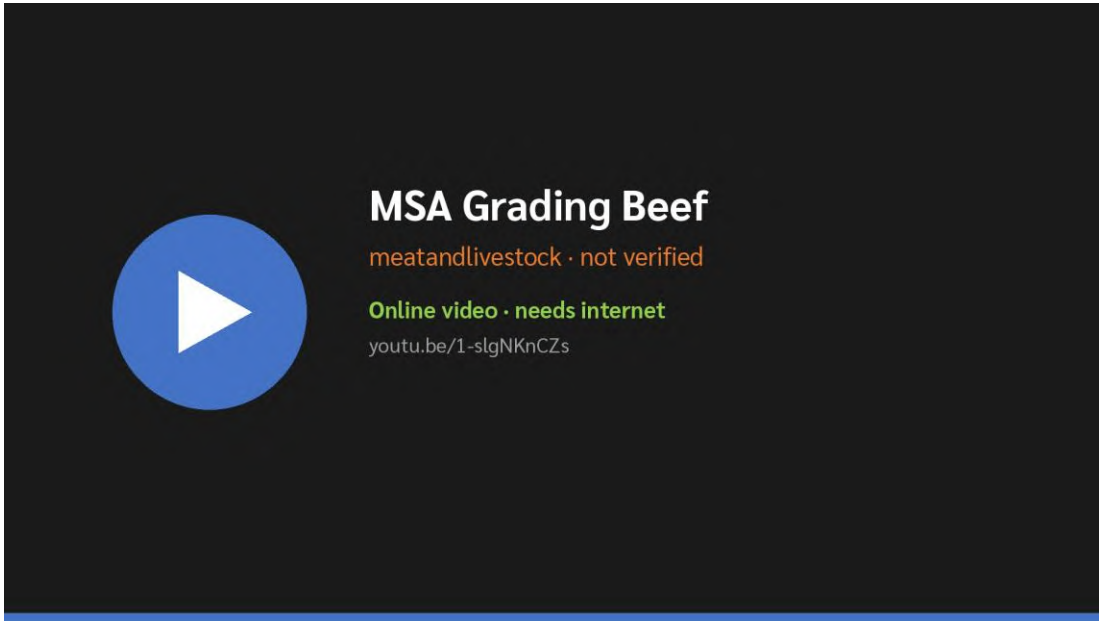


none	mild	severe

Thumb check → multispectral / HSI + AI

Source: USDA AMS beef standard (2017); JMGA; EU Reg 1308/2013; Decision 2011/258/EU; USDA Poultry Grading Manual; Meatingplace (2017)

MSA Beef Grading



► **Watch on YouTube** youtube.com/watch?v=1-slgNKnCZs

VIDEO · ONLINE (needs internet)

MSA Grading Beef

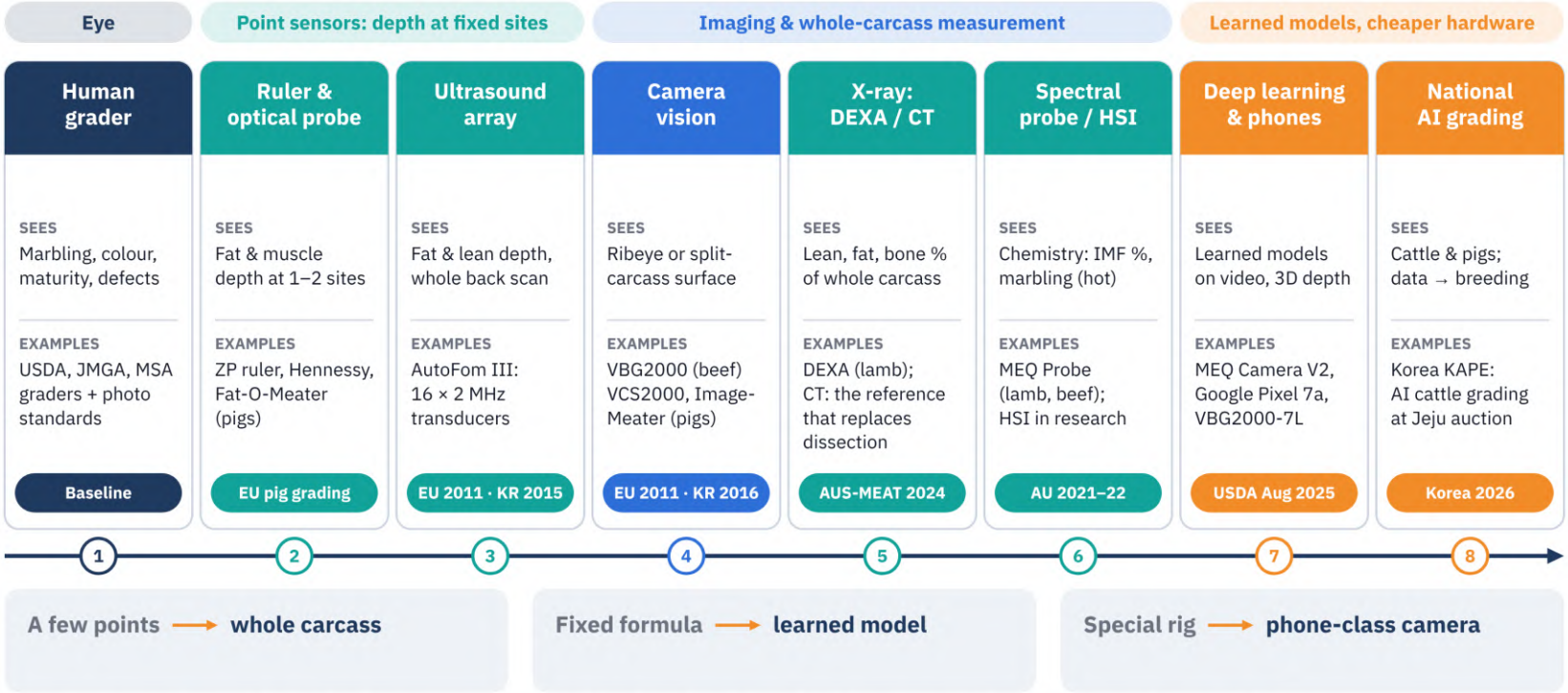
meatandlivestock · not verified

Link: verified — oEmbed 200 (embeddable); not played

- Two experts agreed on pork marbling scores at only R 0.58–0.72
- Fast and cheap, but depends on the person

Source: MLA (YouTube, meatandlivestock); PIC North America / Bery et al. (2025)

Evolution of Carcass Grading Technology



Pills = dated approvals or installs found in the sources, not invention dates. Ground truth throughout: dissection, expert or consumer panels, increasingly CT.

Source: EU Decision 2011/258/EU; Choi et al. (2018); Kim et al. (2021); USDA AMS (Aug 2025); Farm Weekly (Mar 2025); MLA P.PSH.1132; Beef Central (May 2023); Livesnews (2026)

USDA-Approved Camera Grading (MEQ, 2025)

Pixel 7a

Phone model used with the USDA-approved MEQ Camera system

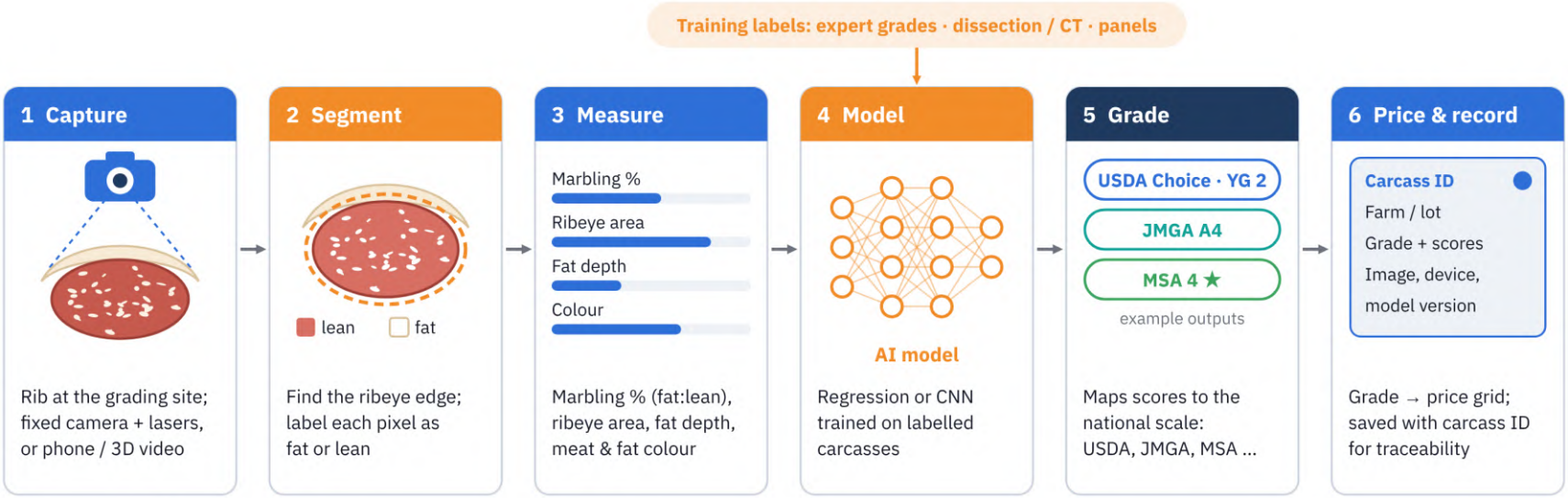
- Beef Marbling Score
- Ribeye Area
- Preliminary Yield Grade



- **MEQ Camera**: first new technology approved by USDA in more than 15 years (tested on more than 10,000 carcasses)
- **Approved by model** and serial-number range
- **Supports plant graders**; does not replace them

Source: USDA AMS (Aug 2025); Food & Drink Business (Aug 2025)
https://www.ams.usda.gov/sites/default/files/media/Beefgradingvisualaid_8.15.25_508.pdf

Computer Vision Grading Pipeline



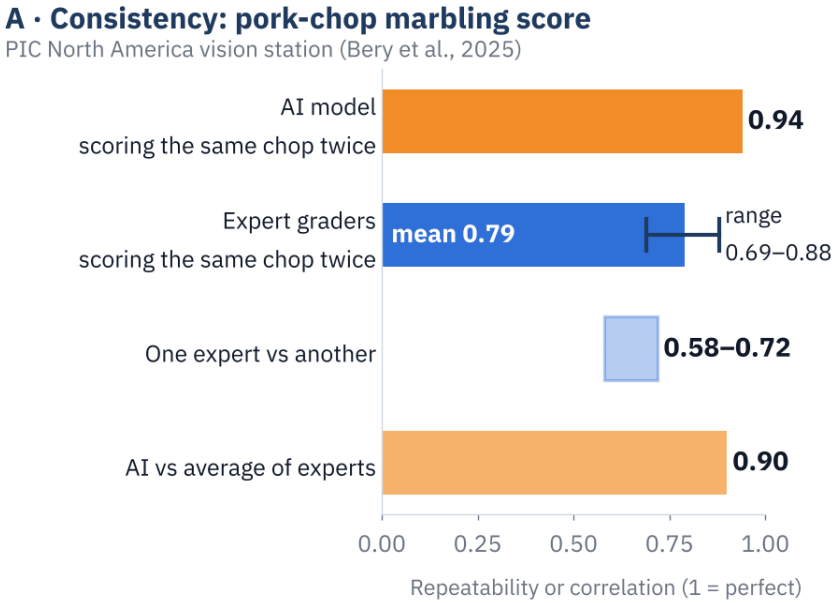
Where the grade goes

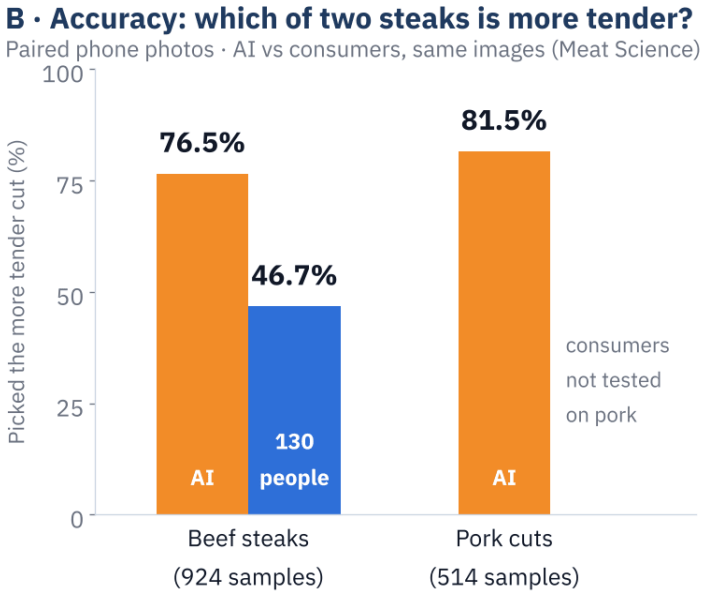
Value-based pay grid · Chiller sort & boning plan · Farmer feedback, breeding · **Traceability record** · Supplier benchmarking

It must keep line speed:
Korean pig lines allow 9–12 s per carcass (~300 pigs/h) · MEQ Camera ~450 carcasses/h · YOLOv8x marbling model < 0.5 s per image (research)

Source: USDA AMS (Aug 2025); Beef Central (May 2023); Liu et al., Foods (2025); TSRI RDG5220039; JBT Marel; MLA P.PSH.1367; Kim et al. (2021)

AI Grading Consistency





Thai proof point (poultry, research in a commercial plant):
A webcam + vision software graded broiler carcass scratches (A / B / C) at 120 birds/min with 95% accuracy, no significant difference from an experienced operator (70 birds). RMUTT & Chitralada Technology Institute at KVS Fresh Products, Nakhon Sawan, 2023.

Source: PIC North America / Bery et al. (2025); FGV EMAp on a Meat Science study; Chunluan et al., ANRES (Oct 2023)

Instrument Grading Approval

EU (pork)

Dissection or CT on at least 120 carcasses · error (RMSEP) < 2.5

USDA

Approval by model and serial-number range

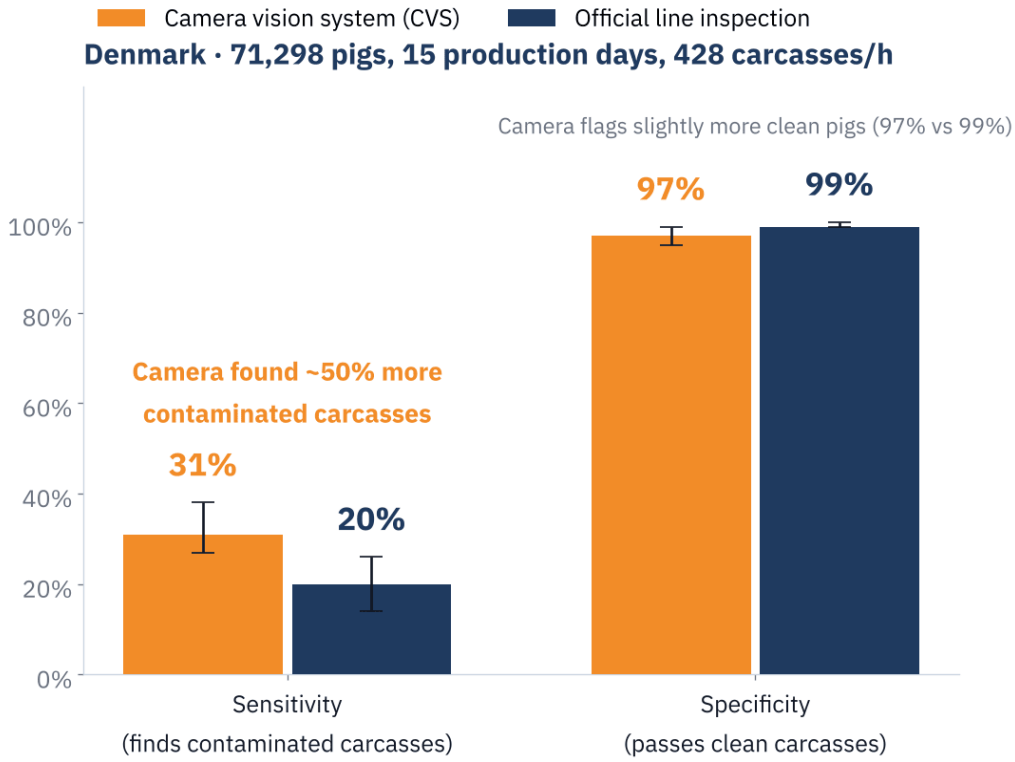
AUS-MEAT

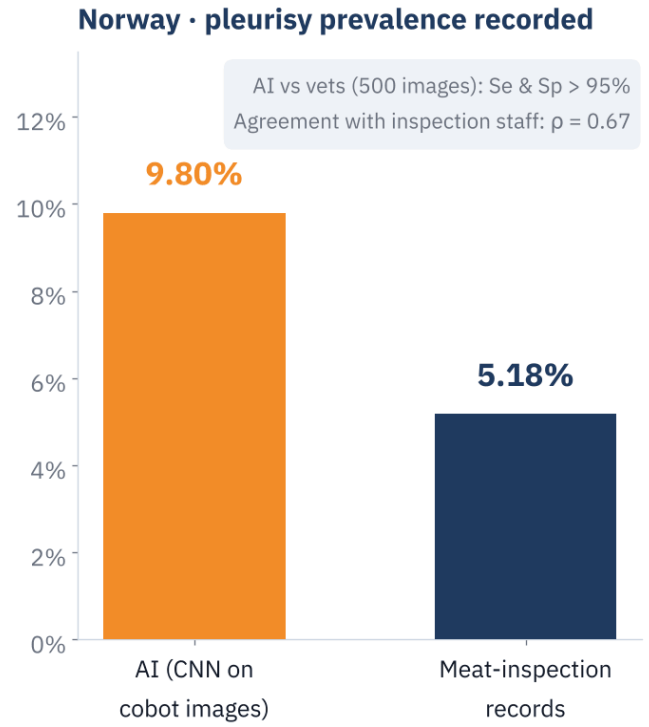
Approval trait by trait

Approval abroad is not approval in Thailand
· Thailand has no instrument approval route yet

Source: Del. Reg. (EU) 2017/1182 Annex V; USDA AMS visual aid (Aug 2025); Beef Central (May 2023); MLA P.PSH.1132

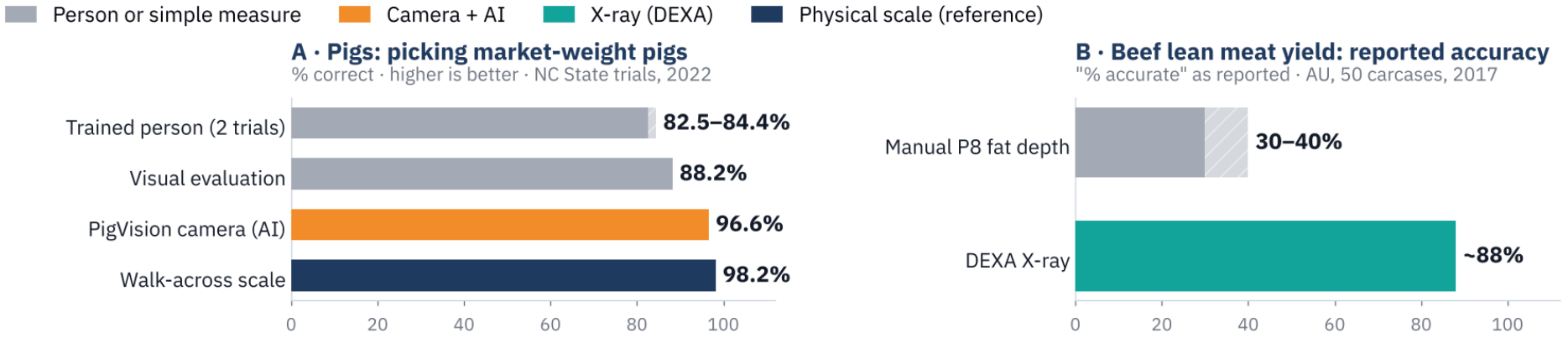
Camera Inspection vs Line Inspectors





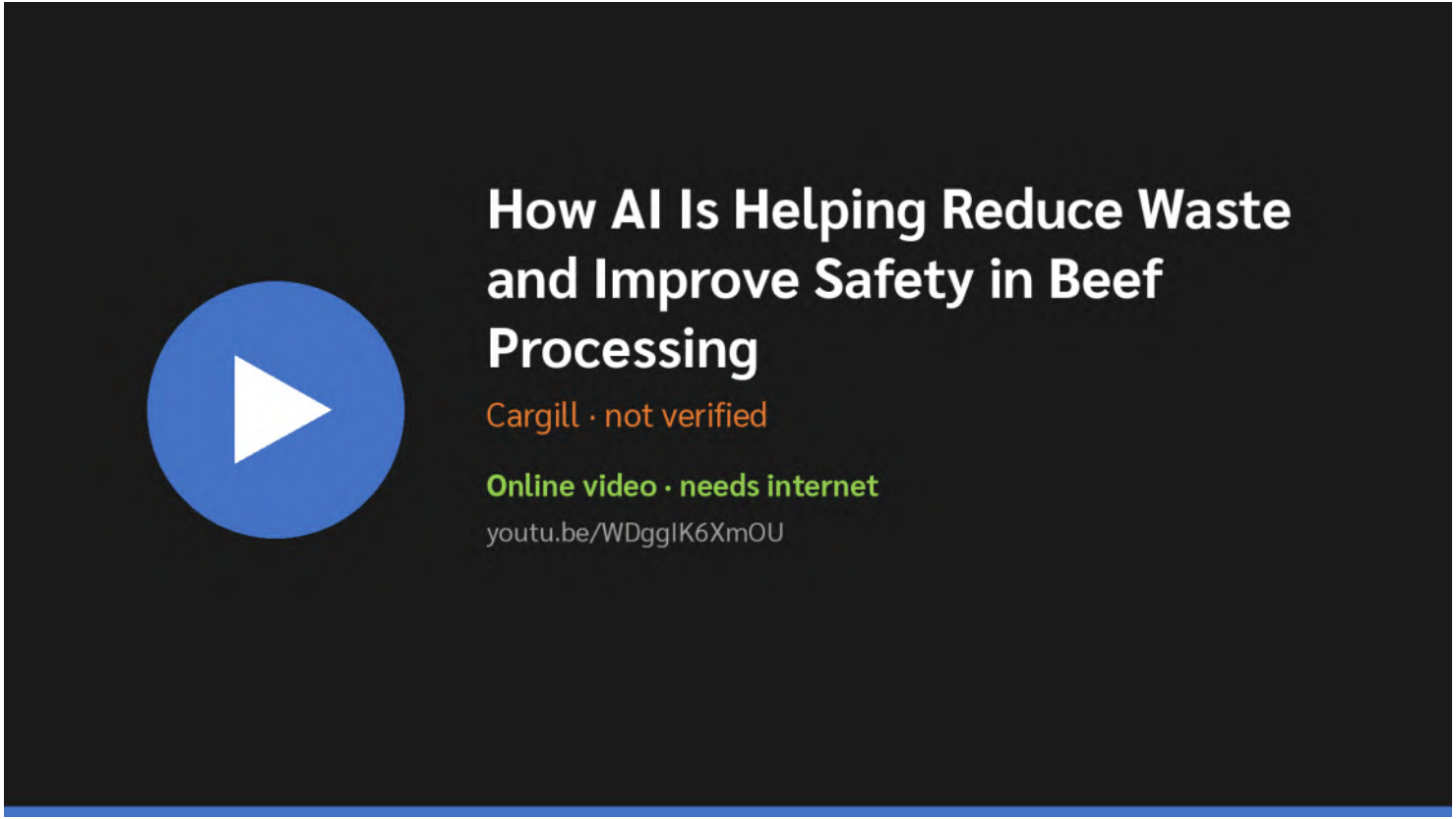
Source: Lund et al., DTI/DMRI ICoMST 2024 poster; Teknologisk Institut VTK report (Dec 2024); Romano et al., Food Control (2025, via 3tres3)

Weight and Yield Prediction Accuracy



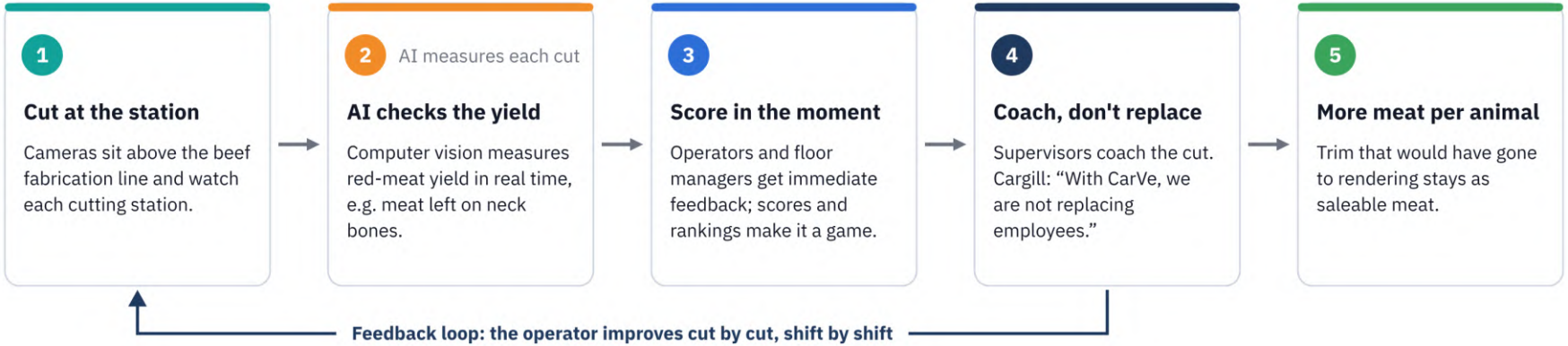
Source: National Hog Farmer (Feb 2022, historical); Beef Central (Jul 2017, historical; 50 carcases)

Global Case Study: Cargill CarVe



Source: The Spoon (May 2026); Drovers (Mar 2026); Food Dive (Jun 2025) — company-reported

Global Case Study: Cargill CarVe



3–5%
yield gain per cut
typical, as operators improve (Apr 2026)

~US$2M
value per site targeted
from ~0.25 lb more meat per carcass

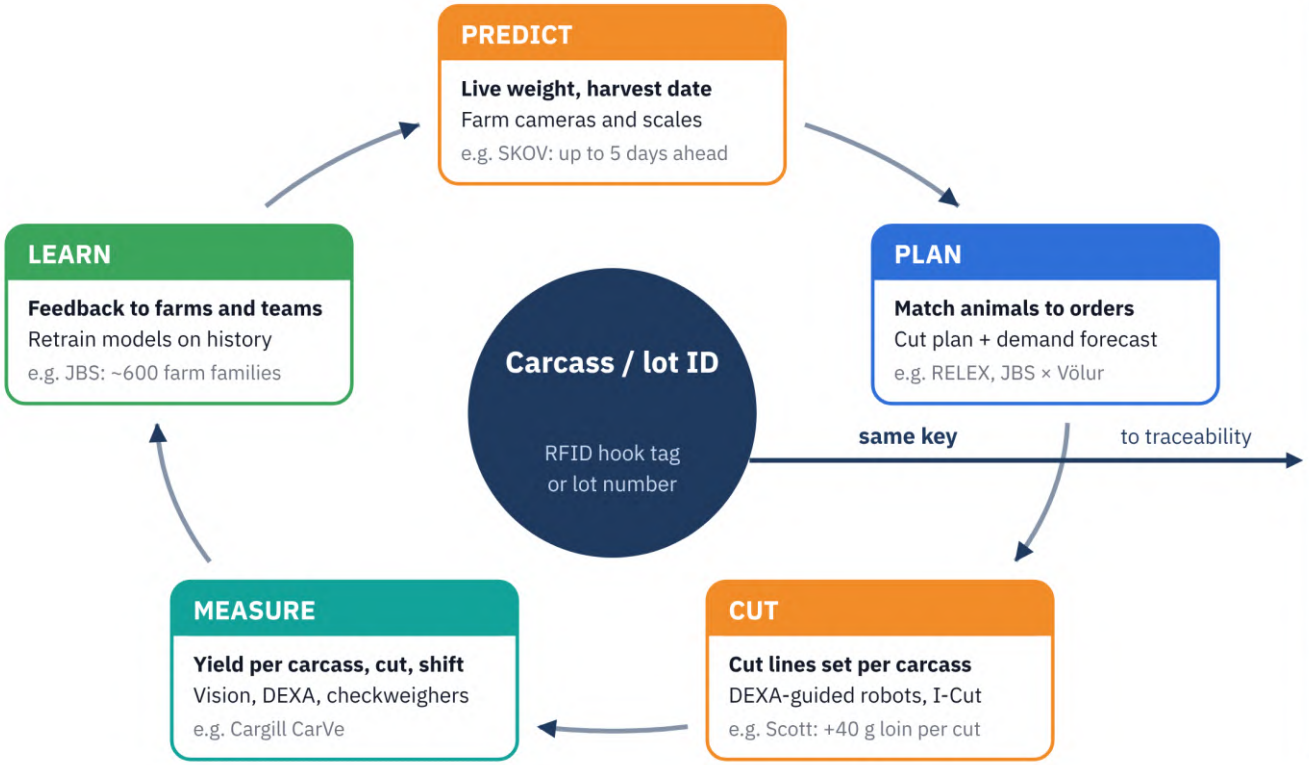
3 + 4
beef plants live + planned
Friona TX, Fort Morgan CO, High River (Canada)

3,500
cattle per shift supported
at plants with ~2,500 team members

- **3–5%** more meat per cut (company-reported)
- **~US$2M** per plant (target)
- "With CarVe, we are not replacing employees."

Source: The Spoon (May 2026); Drovers (Mar 2026); Food Dive (Jun 2025) — company-reported

Closed-Loop Yield Optimisation



One ID, two jobs

- **JBS Dinmore, beef (2016)**
  RFID tag on each hook tells the robot which cut spec to use
- **JBS lamb DEXA (2016–22)**
  RFID-linked scans send lean yield feedback to ~600 farms
- **Danish Crown (2023)**
  Building camera tracking of cuts through its plants

Without the ID, a yield result cannot be traced back to a farm, a flock or an order.

Source: MLA P.PIP.0466; Beef Central (Nov 2016); Just Food (Oct 2023); SKOV; RELEX; Scott DEXA Primal (2025); Drovers (Mar 2026)

AI Adoption Path for Thai Plants

0

Decide what grade or yield data is for

1

Capture image and weight, linked to the carcass / lot ID

2

AI works alongside people (shadow mode)

3

Calibrate, then use for pricing

Fresh/frozen chicken exports 2026 forecast −13% · labour shortage

Source: Aviagen BBN Asia (Jul 2026); FTI via The Thaiger (Aug 2025)

Summary: AI, IoT, Digital Label

1. **Measure**
2. **Link to the carcass / lot ID**
3. **Calibrate, then price on it**

5. Cybersecurity protects the data
4. AI, IoT and digital labels add value
3. Records linked at every hand-over
2. Data captured where the event happens
1. An ID on every lot and carcass

Source: SupplementaryDocs 04–06

Sub-topic 2

Cold-Chain Transparency with IoT, and Traceability with Blockchain

Food Loss from Cold-Chain Gaps

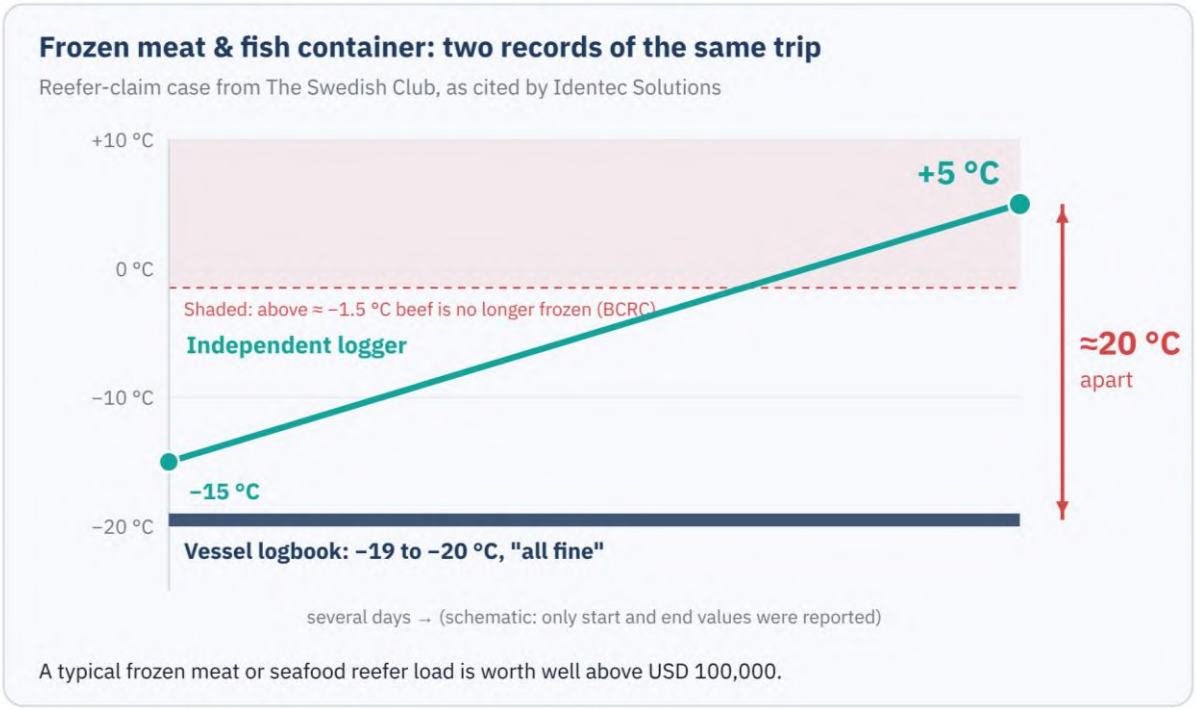
526 Mt · 12%

About 526 million tonnes of food, 12% of the world total, lost for lack of adequate refrigeration

About 1 Gt CO_2e of greenhouse gas (~2% of the global total) in 2017

Source: UNEP/FAO, Sustainable Food Cold Chains — UNEP press release (Nov 2022)

Independent Temperature Monitoring



56%

of a US poultry supplier's monitored restaurant deliveries had temperature excursions, found only after real-time loggers were added

Controlant case study (vendor-reported)

48%

of its retail loads saw reefer air below −3.9 °C, so fresh chicken risked freezing: alarms need a lower limit as well as an upper one

Same Controlant case (vendor-reported)

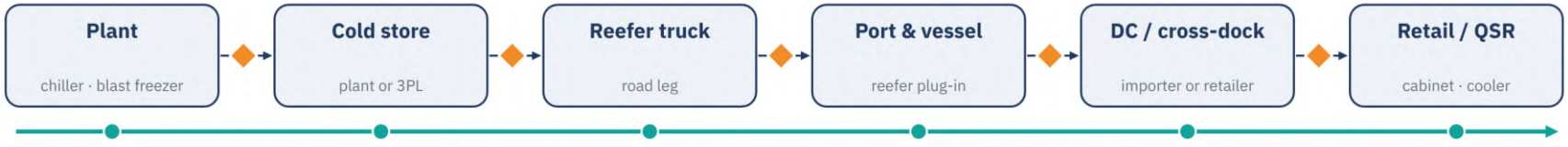
65%

of reefer cargo claims in 2021 came from temperature variation; the average reefer claim cost about USD 38,000

The Swedish Club 2022, cited by Identec Solutions

Source: Identec Solutions citing The Swedish Club (2022); Controlant poultry case study (vendor-reported)

IoT Cold-Chain Architecture

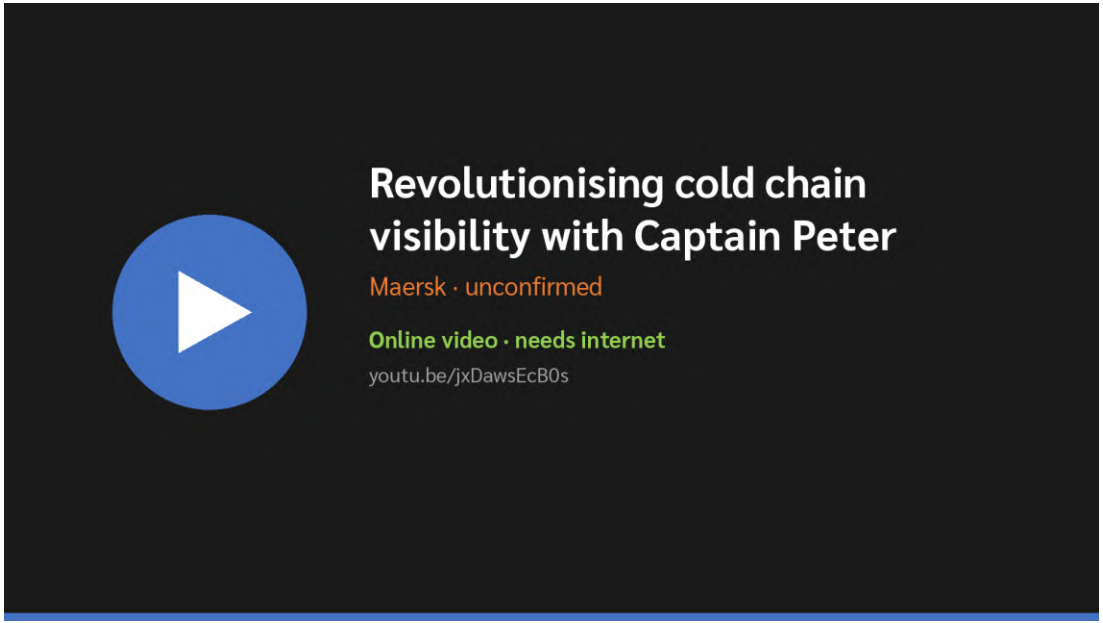


Data stack (bottom → top)

L7 Share	Customer & regulator portal · audit records · consumer QR / digital label
L6 Record	GS1 EPCIS 2.0 event: lot + location + time + temperature series — optional: hash anchor
L5 Analyse & act	Dynamic shelf life · FEFO · anomaly detection · maintenance · **remote set-point**
L4 Platform	Device management · time-series data · alert rules (upper AND lower limits) · API
L3 Connect	Cellular 2G–5G, LTE-M / NB-IoT · Wi-Fi · vessel connectivity / satellite
L2 Edge	Gateway · BLE bridge · RFID reader · buffers data offline · local siren / SMS
L1 Sense	Room & core probes · reefer sensors · shipment tracker · BLE / RFID tag · TTI label

Source: Maersk (Jul 2026); Thermo King TracKing; Wiliot; Walmart (2021); GS1 EPCIS 2.0; Goedhals-Gerber & Stander (2017); CERT-FR (Oct 2026) — author's synthesis, not a published reference design

Remote Container Monitoring: Maersk Captain Peter



► Watch on YouTube youtube.com/watch?v=jxDawsEcB0s

VIDEO · ONLINE (needs internet)

Revolutionising cold chain visibility with Captain Peter

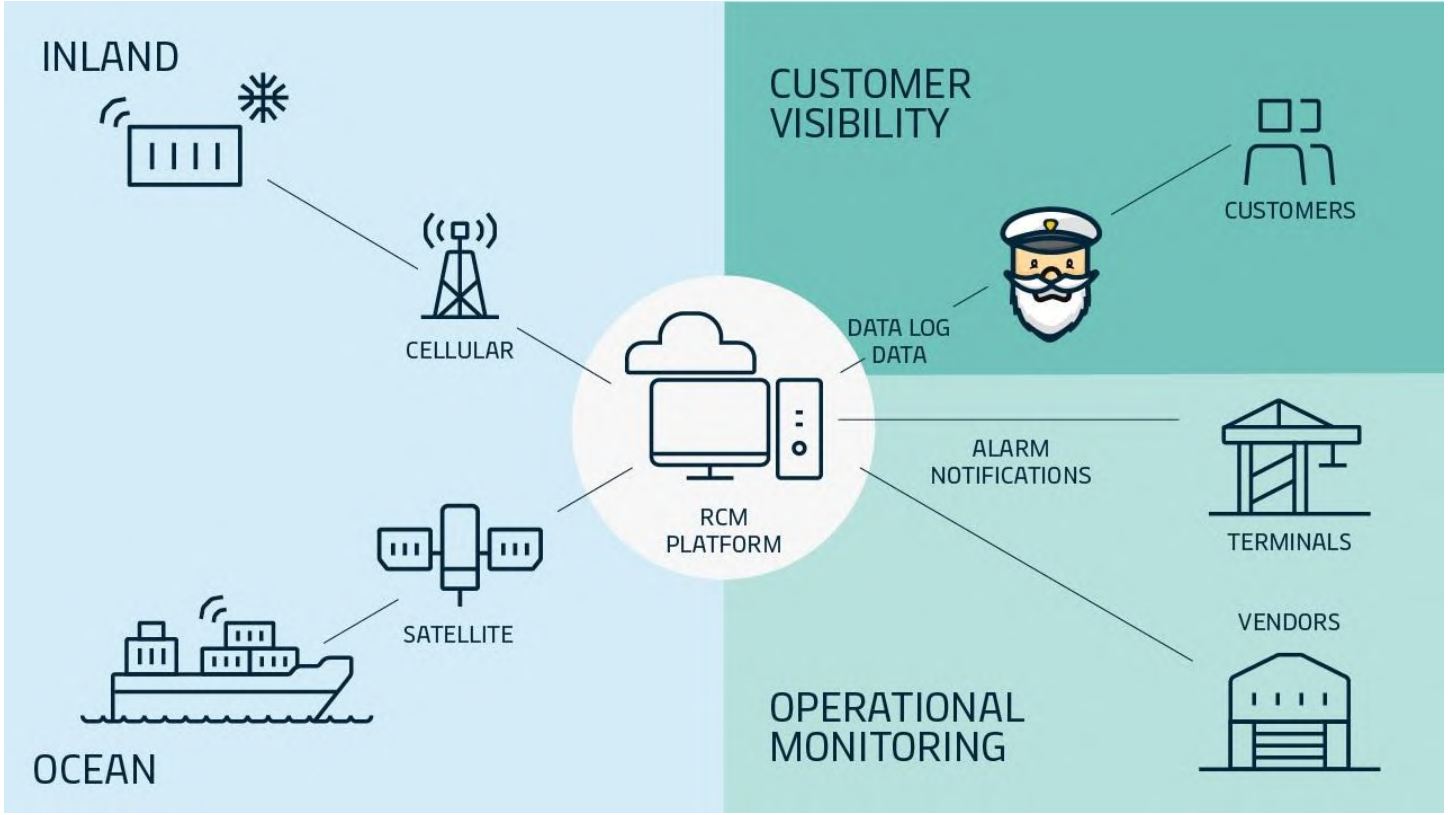
Maersk · unconfirmed

Link: verified — oEmbed 200 (embeddable); not played

- ~30% of Maersk containers fitted with the new device (Jun 2026)
- Captain Peter: 0 / 50 / 75 USD per container

Source: Maersk news (2 Jul 2026); Maersk Captain Peter product page

Remote Container Monitoring: Maersk Captain Peter



Source: Maersk news (2 Jul 2026); Maersk Captain Peter product page

GS1 EPCIS 2.0 Event with Temperature Data

GS1 EPCIS 2.0 event

Lot	**X**
Event	**Shipped from plant Y**
Time	**Z**
Temperature	**min −1.2 / max 3.4 °C**

hash anchor = optional

illustrative

- **One query** returns ID, location, time and product condition
- **Works on an ordinary event database**; no blockchain needed
- **A hash** shows later edits but cannot catch a sensor that reports wrong values from the start

Source: GS1 EPCIS / CBV 2.0 (ratified Jun 2022; SensorElement); GS1 EPCIS 2.0 standard (ref.gs1.org)

กฎระเบียบในห่วงโซ่ระบบ Cold Chain ของไทย

รถขนส่ง

Q Cold Chain (กรมการขนส่งทางบก): ครอบคลุมเฉพาะการขนส่ง B2B

ห้องเย็น

ยังไม่มีข้อกำหนดเรื่องห้องเย็น (การประเมินปี 2022)

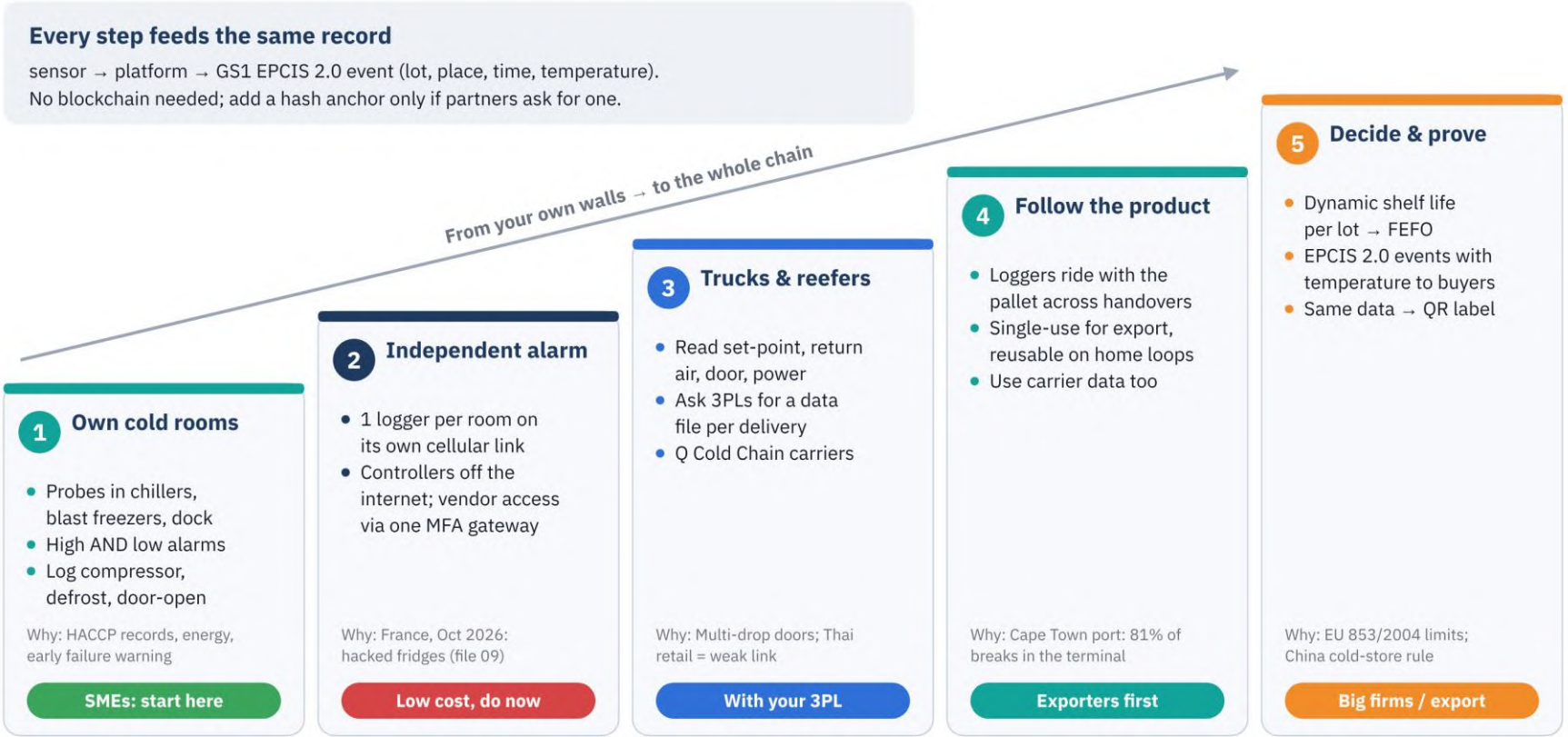
จุดส่งต่อสินค้า

ยังไม่มีข้อกำหนด ・ข้อมูลต่อเนื่องข้ามจุดส่งต่อคือหลักฐานของผู้แปรรูป

จีนให้ห้องเย็นต่างประเทศขึ้นทะเบียนแล้ว (Decree 280)

ที่มา: TPSO (2023); WFLO/GCCA for USDA FAS (Jul 2022, historical); SFA trade circular (Jul 2026)

Cold-Chain IoT Adoption Path



Source: Author's synthesis from Maersk (2026); Goedhals-Gerber & Stander (2017); CERT-FR (2026); TPSO (2023); GS1 EPCIS 2.0; GACC Decree 280; EU 853/2004

Technology Convergence: The Power of Three

Memory: IDs + linked events

Central database · SaaS · or blockchain

blockchain = one option



AI (the brain)

Analyse, predict, support decisions

IoT (the senses)

Measure temperature, location and product condition

Adapted from Asst. Prof. Dr. Suvaluk Asavasanti (base-deck slide 28, labels corrected)

+ Cybersecurity protects all three

Source: NIST IR 8202 (2018); GS1 blockchain page; Demestichas et al., Applied Sciences (2020) · Adapted from Asst. Prof. Dr. Suvaluk Asavasanti

Global Case Study: Walmart

7 days

Tracing sliced mangoes with paper records

2.2 seconds*

Query on the platform (pilot 2016–18)

**IBM/Walmart-reported*



Rasting (Germany) 1999: 36-hour product recall → after adopting GS1 standards, answers in minutes, without blockchain

Source: LF Decentralized Trust, Walmart case; F. Yiannas, US House testimony (14 Feb 2018); Demestichas et al. (2020); GS1 Rasting/Westfleisch case (2006, historical)

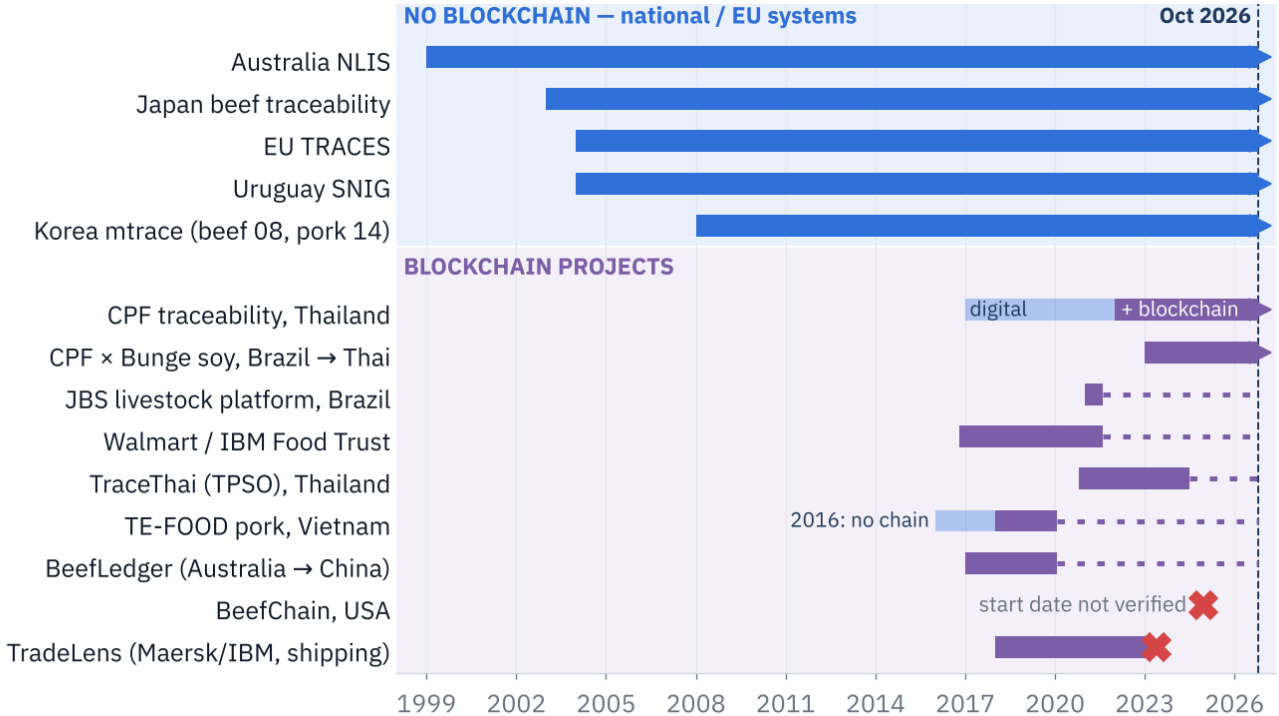
What Blockchain Guarantees

Guarantees	Does not guarantee
✓ No silent after-the-fact edits	✗ That the entered data is correct *garbage in, immutable garbage out*
✓ Shared writing by several parties without a central owner	✗ A link between the data and the real animal or carcass

NIST IR 8202: "It is not magical; it will not solve all problems."

Source: NIST IR 8202 (Oct 2018); Demestichas et al., Applied Sciences (2020); McKinsey (Jun 2018)

Traceability Systems: Status in 2026



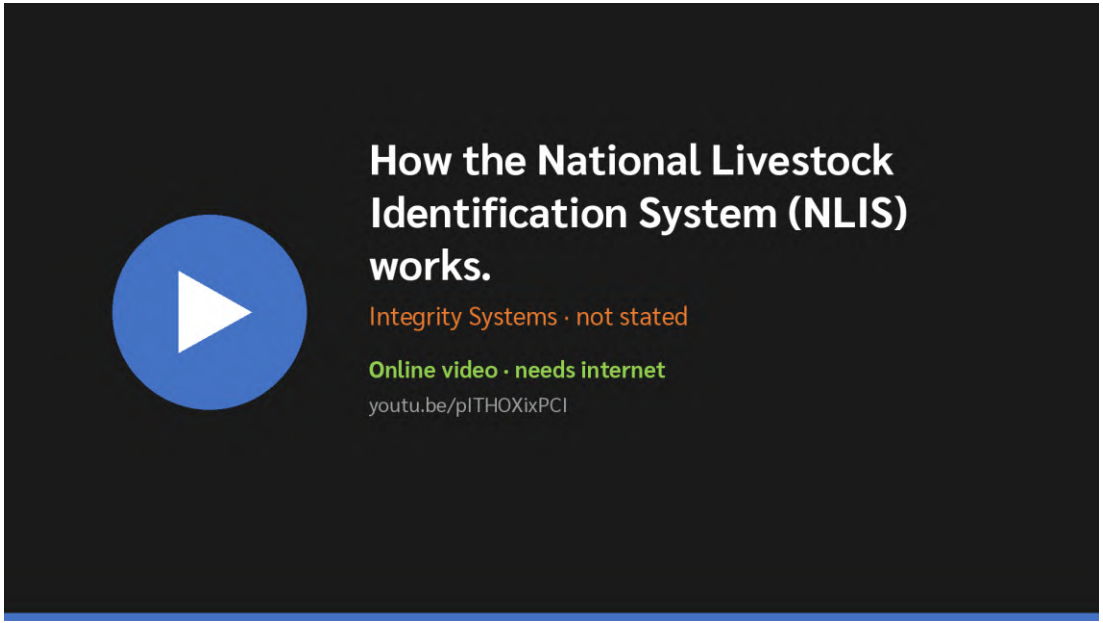
STATUS (Oct 2026 check)

- **Running · 180M+ records (Jun 2026)**
- **Running · law amended 2023**
- **Running · 5.4M documents (2024)**
- **Running · digital dispatch May 2026**
- **Running · 2026 service notices**
- **Running · single integrated firm**
- **~360–375 kt traced (blockchain + satellite)**
- End-2025 target: outcome not verified
- Quiet: no deployment news since ~2021
- Still a prototype (seminars Jun 2024)
- Website static, no dated news after 2020
- No status found after 2020
- **Domain reused for crypto news by Dec 2024**
- **Closed Q1 2023: "not commercially viable"**

Solid bar = verifiable public activity found · dotted line = no public evidence found · ▶ still running · ✖ closed or domain lost · pale blue = earlier non-blockchain digital system

Source: ISC/ICAR (Jun 2026); MAFF; EC DG SANTE; World Bank (2015); SNIG; mtrace.go.kr; CPF (Feb 2024; SR 2024); CPF × Bunge; The Cattle Site (2021); LF Decentralized Trust; Ledger Insights; TraceThai.com; te-food.com; Supply Chain Dive (Nov 2022)

National Livestock Identification Systems



► **Watch on YouTube** youtube.com/watch?v=pITHOXixPCI

VIDEO · ONLINE (needs internet)

How the National Livestock Identification System (NLIS) works.

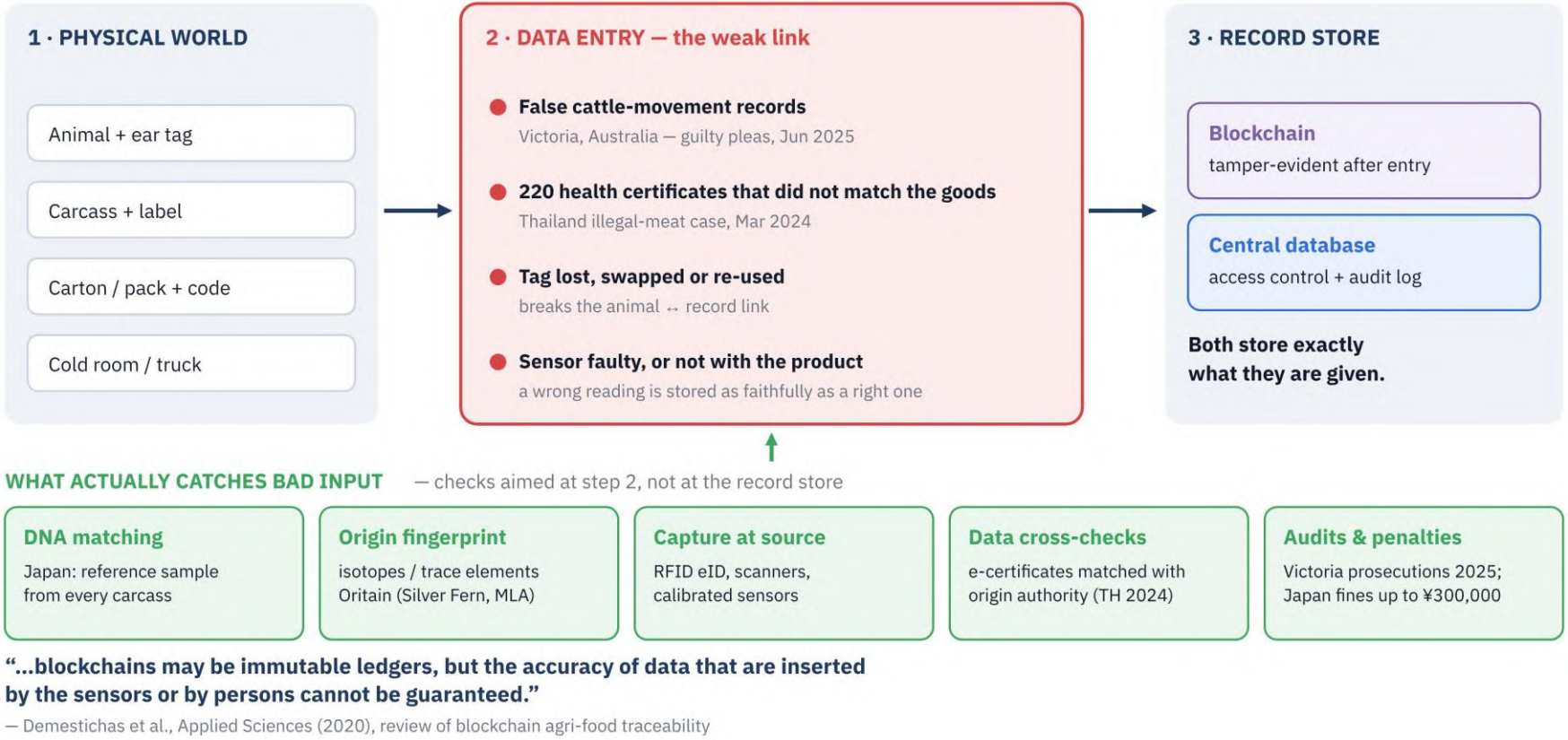
Integrity Systems · not stated

Link: verified — oEmbed 200 (embeddable); not played

- NLIS **>180 million** records (since 1999)
- Japan keeps DNA from **every beef carcass**
- Uruguay traces **100%** of cattle (World Bank, 2015)

Source: ICAR 2026 (Jun 2026); MAFF Law No. 72 of 2003; World Bank Blogs (Oct 2015); Integrity Systems Company

Data Integrity at Entry



"...blockchains may be immutable ledgers, but the accuracy of data that are inserted by the sensors or by persons cannot be guaranteed."

— Demestichas et al., Applied Sciences (2020), review of blockchain agri-food traceability

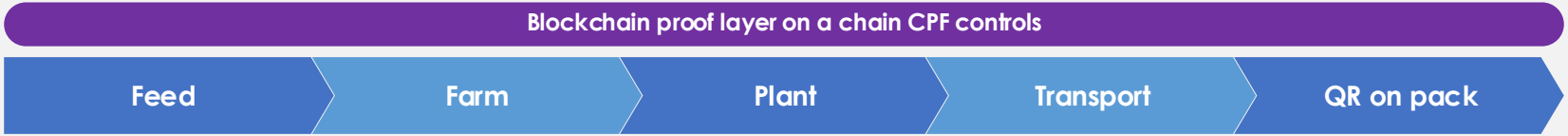
Source: Agriculture Victoria (5 Jun 2025); Prachachat (25 Mar 2024); Demestichas et al. (2020); MAFF; Silver Fern Farms; MLA (2021)

Thai Case Study: CPF

CPF (Charoen Pokphand Foods)

Blockchain: Y

Thailand · chicken, pork, eggs, shrimp, duck, feed



What	CPF iTrace (SR 2022) → now AXONS Trace (SR 2024): QR on chicken, pork, egg, shrimp and duck packs · digital since 2017 · blockchain layer since 2022, covering 100% of fresh chicken and pork in 2022
Core work	Data capture: Smart Eye cameras, farm software, truck temperature tracking
Cross-company	CPF × Bunge: ~360,000–375,000 t of Brazilian soybean meal traced to plot (blockchain + satellite)
Status 2026	In use · zero product recalls in 2024 (company-reported, not credited to any one technology) · multi-country scope (Thailand, Vietnam, Laos, Malaysia) not verified

Source: CPF Sustainability Reports 2022 (p.25) and 2024; CPF press release (14 Feb 2024); CPF soybean-meal project page

When Blockchain Fits

Good candidates:

1 Cattle / deforestation-free soy

EUDR starts 30 Dec 2026

2 Cross-border halal

No verified example found yet

3 Premium meat / anti-counterfeit

When verifiable proof is part of what is sold

Hybrid: EPCIS kept by each company, only the hash goes on chain

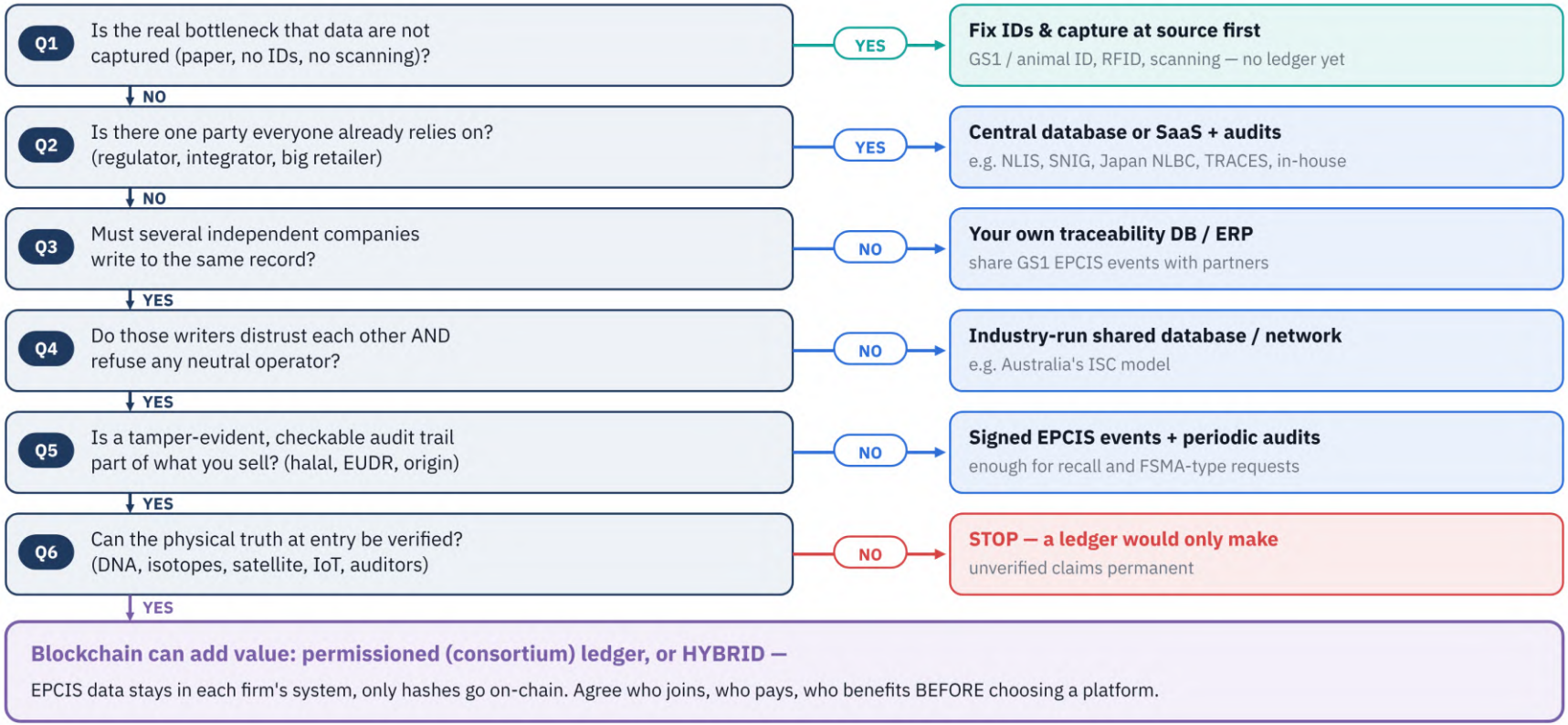
Source: Wüst & Gervais (2018); NIST IR 8202; McKinsey (2018); Arendt (2026); The Cattle Site (2021); CPF soybean project; Ledger Insights (Thai Union pilot, ~2022); GS1

Traceability Success Factors

LAYER (build from the bottom up)	PROVEN EXAMPLES
7 Consumer / buyer value QR lookup, label claims, premium, faster recall	Japan: ID lookup on every beef pack CPF QR (AXONS Trace) · Silver Fern QR
6 Independent verification DNA, isotopes, audits, tag standards, penalties	Japan: DNA sample from every carcass Oritain origin test · Victoria prosecutions 2025
5 Database / trust layer pick one — any of these can work: Central DB · Industry / SaaS · Blockchain / hybrid	Central: NLIS, SNIG, Japan, TRACES Blockchain: CPF (2022), JBS (2021)
4 Data capture at source RFID eID, scanning, in-plant readers, sensors	NLIS & SNIG: RFID ear tags Uruguay: in-plant "black boxes", 38 plants (2009)
3 Unique IDs & standards Animal ID, premises ID, GS1 GTIN/GLN/SSCC, EPCIS	Japan 10-digit · Korea 12-digit · Uruguay 12-digit NLIS PIC · Walmart EPCIS 2.0 spec
2 Governance & who pays Who operates, who pays, who benefits	SNIG: free to farmers, US$1/head fee TradeLens closed 2023: no industry buy-in
1 Pull: regulation / market access A law, a buyer or an export market that demands it	Japan BSE law 2003 · EU Hilton Quota 2010 EUDR Dec 2026 · Indonesia halal Oct 2026

Source: ISC/ICAR (2026); MAFF; INAC/World Bank; FAOLEX; EC TRACES; CPF (2024); The Cattle Site (2021); Supply Chain Dive (2022); GS1

Do You Need a Blockchain?



Source: Adapted by the author from Wüst & Gervais, "Do you need a blockchain?" (IACR ePrint 2017/375) and NIST IR 8202 — a screening guide, not a rule

Data Trust and Cyber Risk

5. Cybersecurity protects the data
4. AI, IoT and digital labels add value
3. Records linked at every hand-over
2. Data captured where the event happens
1. An ID on every lot and carcass

Every layer added today (cameras, sensors, QR, cloud records) is also a new entry point

Next: France, 11–12 Oct 2026

Cybersecurity in the Cold Chain

News Report: France 2026



► **Watch on YouTube** youtube.com/watch?v=bgc3bAvmn1Y

VIDEO · ONLINE (needs internet)

Des hackers piratent les réfrigérateurs de supermarchés, des millions d'euros de nourriture jetés

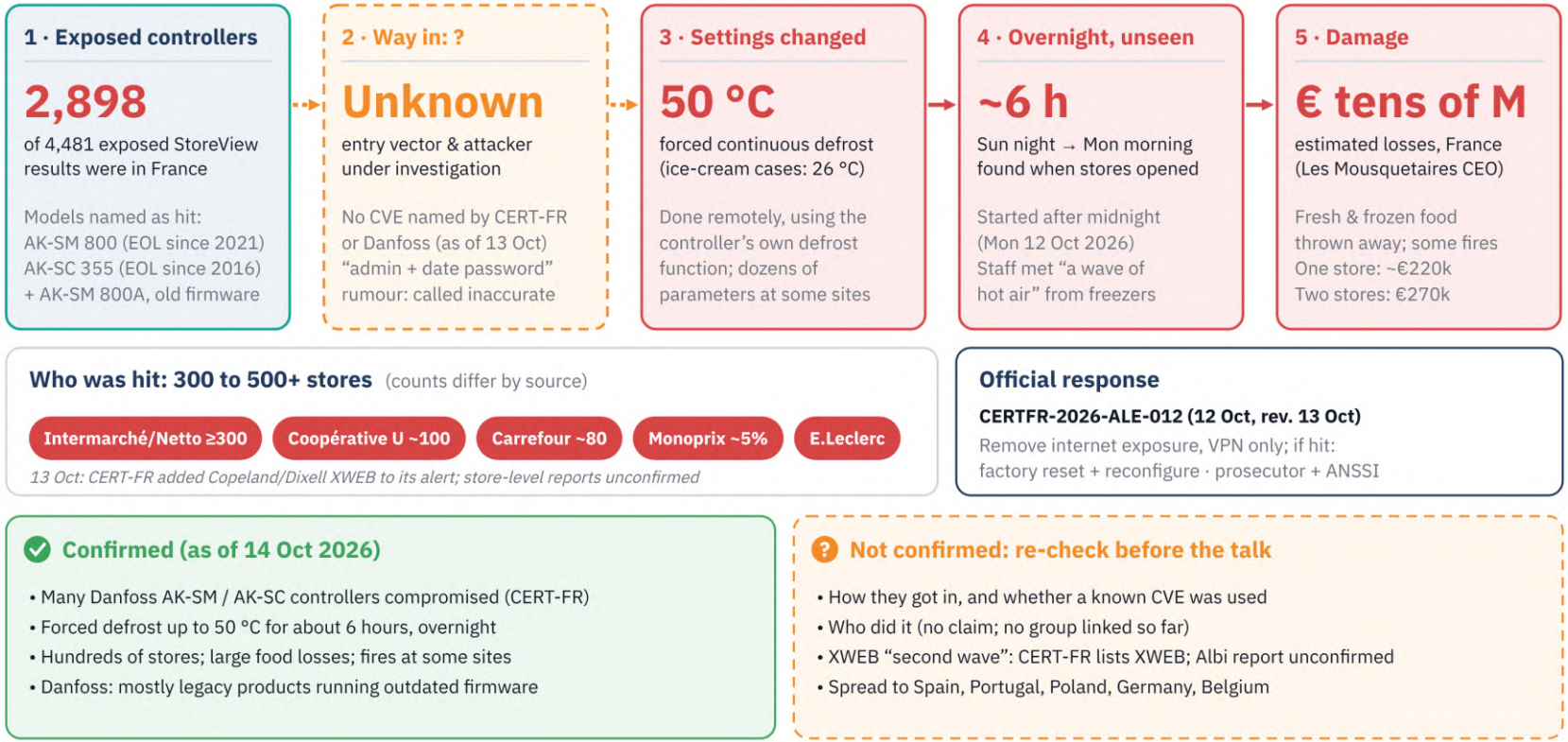
franceinfo · 2026

Link: verified — oEmbed 200 (embeddable); not played

- Staff opening on Monday morning found hot air coming from the cabinets (as reported)
- Investigation still open (14 Oct 2026)

Source: franceinfo (YouTube, Oct 2026)

France Refrigeration Attack, 11–12 Oct 2026



Source: CERT-FR CERTFR-2026-ALE-012 (12 Oct 2026, revised 13 Oct 2026); SOCRadar, Al Jazeera, Journal du Geek, Cybernews, NordiskPost (13 Oct 2026) — breaking news

Exposed Refrigeration Controllers

2,898

Danfoss StoreView screens exposed on the internet in France (65% of the world total, the next day)

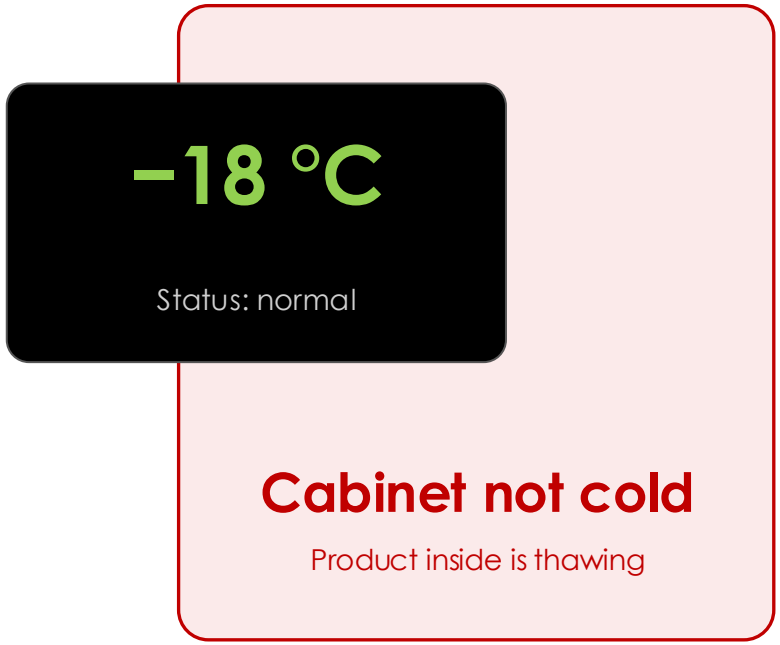
- **Happened before**: 2022, 16 stores in Russia and 40 in Israel
- **Exposed** does not mean breached
- **Entry point** still under investigation

Source: SOCRadar (13 Oct 2026; Shodan count, vendor-reported; 2022 precedent second-hand via a Danfoss newsletter); CERT-FR (12 Oct 2026, revised 13 Oct)

Falsified Sensor Readings

The display shows normal while the cabinet is warm

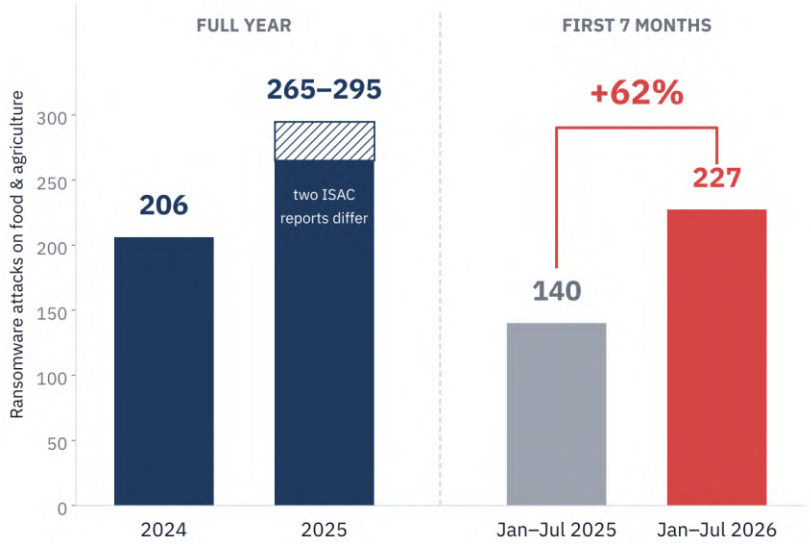
In research, a hacked display showed false values from −50 °C to 110 °C while the researchers controlled the refrigeration



illustration

Source: Refindustry (13 Aug 2026), on Claroty Team82 research into Copeland XWEB Pro (vendor research); Food & Drink Business (20 Aug 2026)

Ransomware in Food and Agriculture



~1 in 20

ransomware victims is a food or agriculture firm (~5%; 8th most targeted sector, Jan–Jul 2026)

Qilin 47

top group vs. the sector, Jan–Jul 2026; then The Gentlemen 31, Akira 14

~3,300

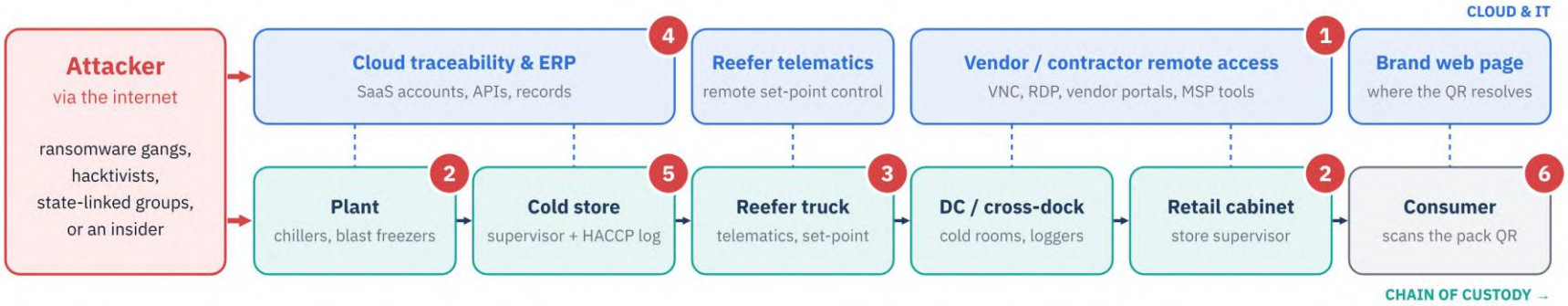
industrial organisations hit by ransomware in 2025 (Dragos, all sectors)

JBS 2021

- Ransom paid: **US$11M**
- 7,000 employees in Australia stood down

Source: Food and Ag-ISAC (Feb and Aug 2026); Bloomberg (9 Jun 2021) and ABC Australia (1 Jun 2021), historical (the JBS attack began 30 May 2021)

Attack Paths in a Connected Cold Chain



1 Vendor / contractor remote access

- **How** A supplier's remote tool is hijacked, then used on many sites
- **Seen** Kaseya → Coop Sweden 2021; France 2026 "supplier-side" (unconfirmed)
- **Fix** **MFA gateway, time-boxed, logged, off by default**

2 Internet-exposed controller / HMI

- **How** Weak, default or date-based login on a supervisor reachable online
- **Seen** France 2026 (Danfoss); Unitronics PLCs 2023–24
- **Fix** **No OT online; patch; replace end-of-life units**

3 Reefer telematics remote control

- **How** Abuse of normal two-way control: set-point, on/off
- **Seen** Feature exists (e.g., Thermo King TracKing); no attack case verified
- **Fix** **MFA and roles; alert on any set-point change**

4 Cloud traceability / ERP takeover

- **How** Phishing, help-desk social engineering, AI voice clones
- **Seen** M&S 2025 (~£300M); JBS 2021 ransomware
- **Fix** **Strong MFA; help-desk ID checks; offline backups**

5 Falsified temperature display / log

- **How** Hacked screen shows "normal" while cooling is altered
- **Seen** Claroty demo on Copeland XWEB Pro, Aug 2026
- **Fix** **Independent logger on its own network; hash-chained logs**

6 Fake QR sticker ("quishing")

- **How** Sticker over the pack QR leads to a phishing site
- **Seen** FTC warning 2023 (parking meters); no meat-pack case verified
- **Fix** **Print QR into the label; link only to your domain**

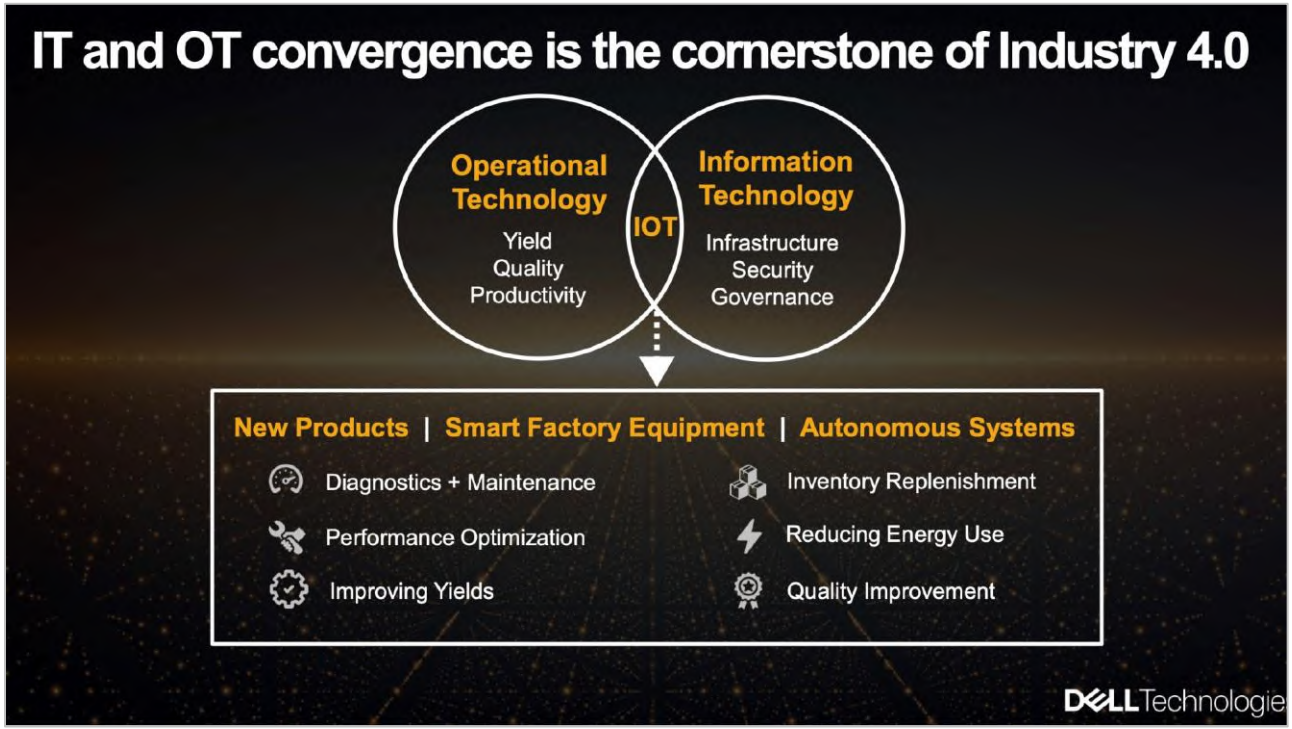
Source: CERT-FR; SOCRadar; Refindustry/Claroty; CISA AA23-335A; FBI PIN (2021); Food and Ag-ISAC; FTC (2023); Thermo King; Al Jazeera

Hashing and Blockchain Against Cyber Threats

Threat	Hash / blockchain	What helps
Editing records after the fact	✓ Helps	Detects later edits (hash-chained log)
Hacked sensor sends wrong values from the start	✗ Does not help	Independent sensor on a separate network
Fake QR sticker	✗ Does not help	QR printed into the label, on the company's own domain

Source: Demestichas et al. (2020); SOCRadar (Oct 2026); FTC (Dec 2023

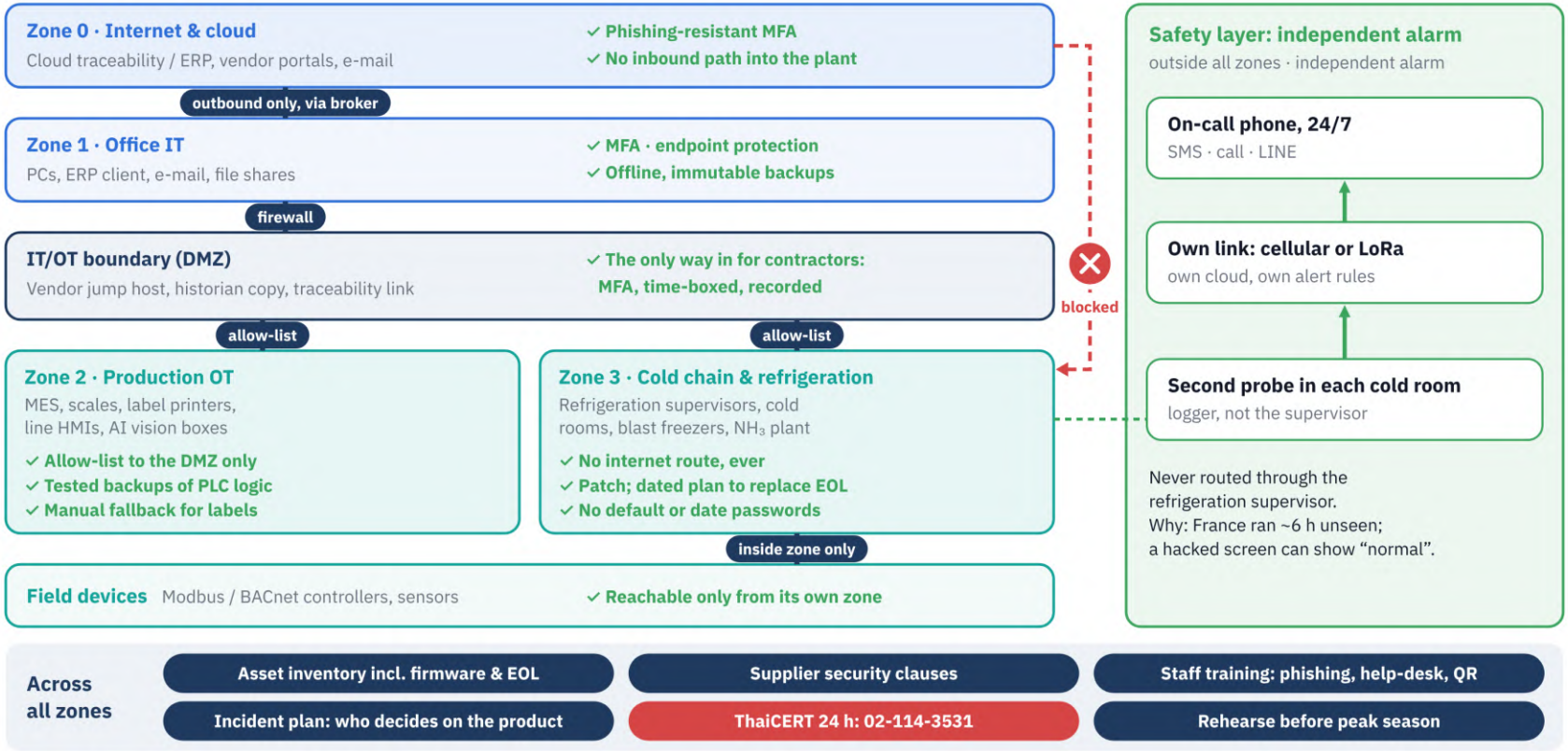
Defence in Depth for OT



IT/OT convergence needs segmentation

Source: NIST SP 800-82r3 (2023); CISA AA23-335A; CERT-FR (2026); SOCRadar (2026); FBI PINs; NCSA — IEC 62443 terms used as concepts only

Defence in Depth for OT



Source: NIST SP 800-82r3 (2023); CISA AA23-335A; CERT-FR (2026); SOCRadar (2026); FBI PINs; NCSA — IEC 62443 terms used as concepts only

Four Basic Cyber Controls

1

Take controllers off the internet

Start by searching your own IPs on Shodan / Censys

2

One vendor access path, via VPN with MFA

Opened when needed, time-limited, logged

3

Temperature alarm on a separate network

Second sensor, 24-hour on-call alert

4

Offline backups

With real restore tests

Full 12-point list in the appendix (B08) · ThaiCERT 24 h 02-114-3531 (confirm the number before printing)

Source: CERT-FR (revised 13 Oct 2026); CISA AA23-335A; SOCRadar (13 Oct 2026); FBI PIN (2021); 12-point checklist in SupplementaryDocs 09 §6.4

! verify

Sub-topic 3

Smart Packaging and Digital Labels as Value-Adding Tools

Consumer Interest in QR Codes



79%

say they would buy more if a QR code gave information (stated intention, not observed behaviour)

No QR scan-rate data found for meat packs, and no Thai consumer data yet

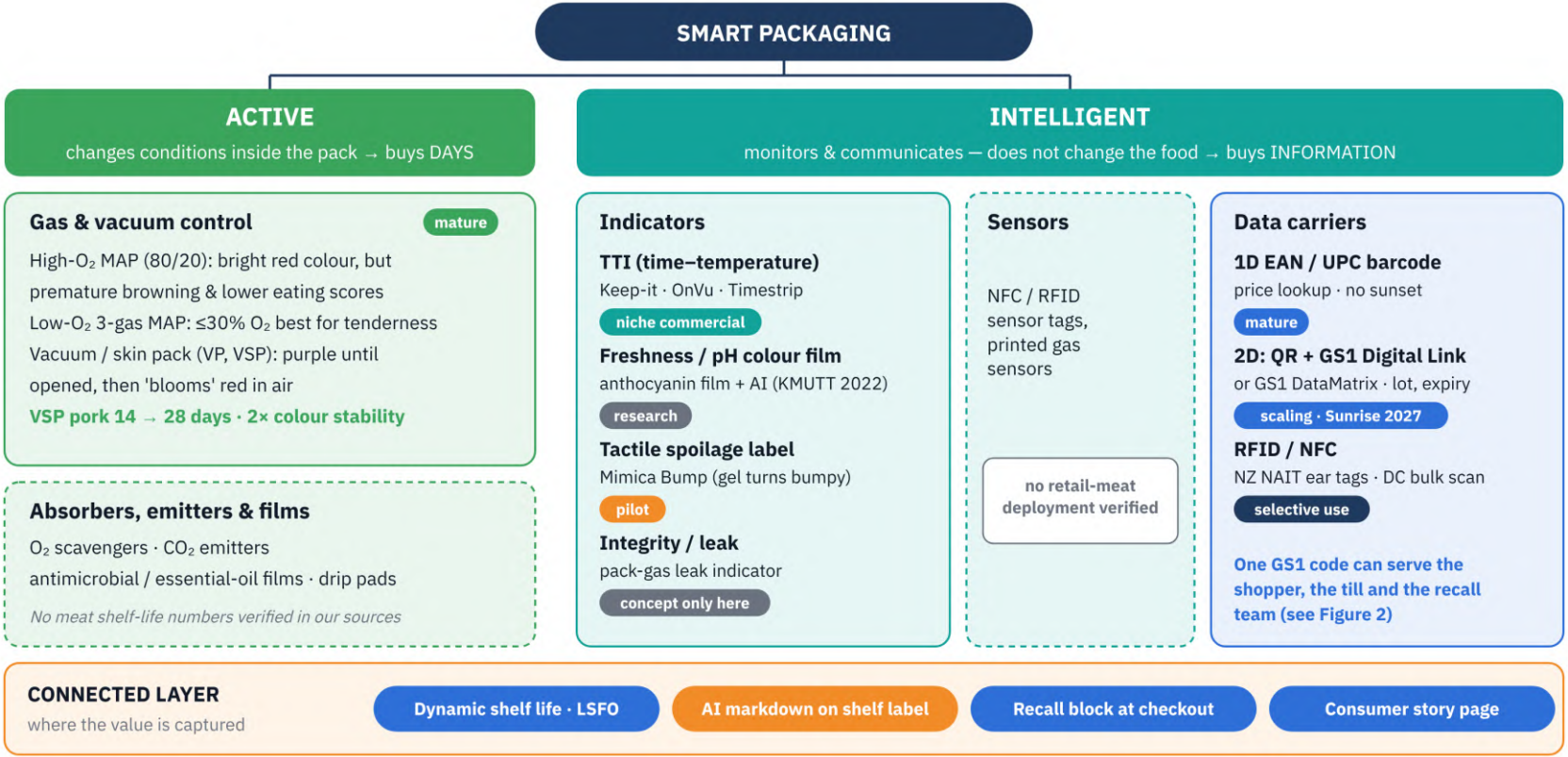
Source: GS1 US Sunrise 2027 page (2025 survey, stated intent

Freshness Indicators



Source: Wikipedia, Keep-it Technologies (secondary); keep-it.com (Oct 2026); Albrecht et al. (2019, PMC); KMUTT CRIS (2022)

Smart Packaging Technologies



Source: Conte-Junior et al. (2020); DTI; Food Processing AU (2017); Albrecht et al. (2019); KMUTT CRIS (2022); Mimica; GS1; IFPA; Packaging World (2026)

Freshness Indicators

Keep-it × REMA 1000 (Norway) historical

More than 70 million units sold up to 2018; now preparing a relaunch

OnVu TTI on chicken breast packs (Germany) field trial

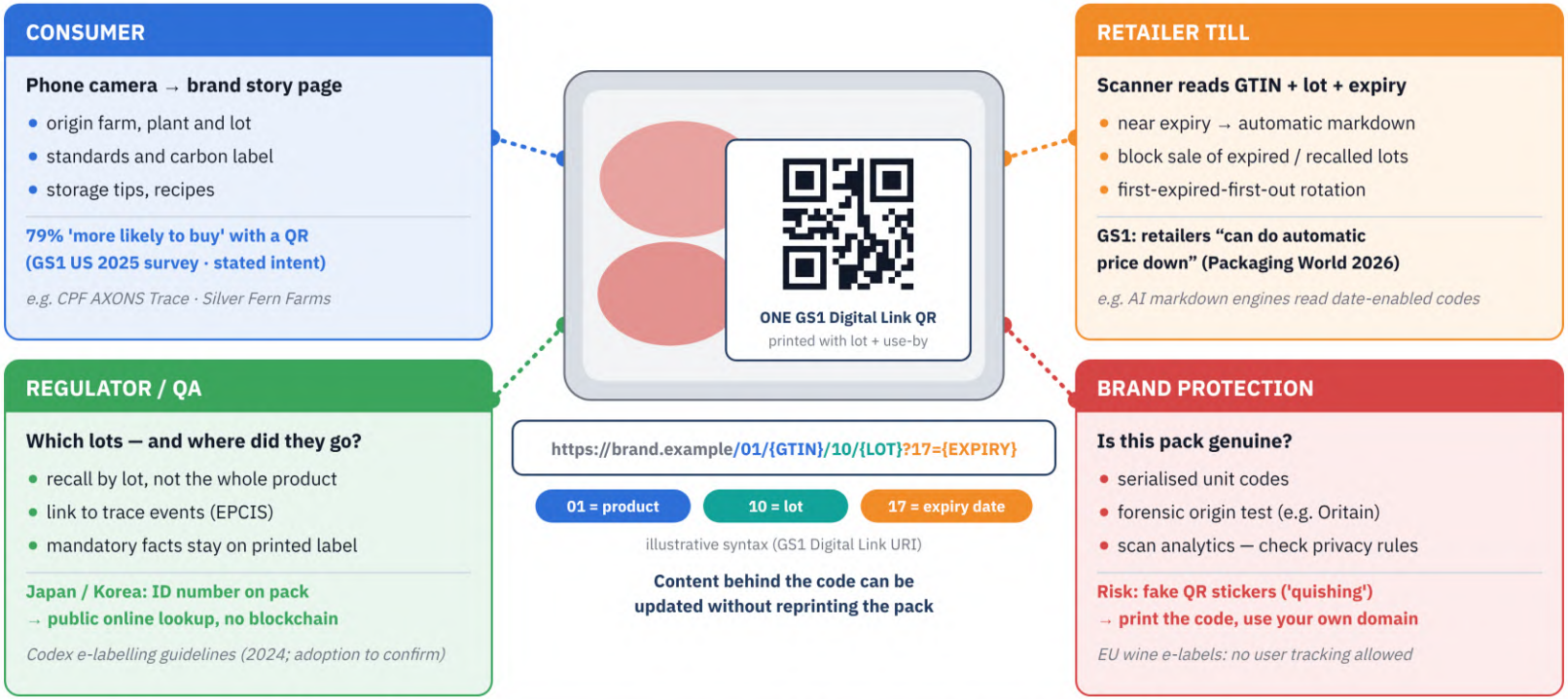
Trial of 480 packs: predicted slightly longer life than actual; researchers judged an error within 24 h acceptable

Colour-changing film + AI colour reading research

Joint research with KMUTT: R^2 0.94–0.98 against freshness values

Source: Wikipedia, Keep-it Technologies (secondary); keep-it.com (Oct 2026); Albrecht et al. (2019, PMC); KMUTT CRIS (2022)

GS1 Digital Link QR



Source: GS1 Digital Link; IFPA 2D guidance; Packaging World (19 Feb 2026); GS1 US Sunrise 2027 page; USDA CCFL48 report; MAFF; mtrace.go.kr; Silver Fern Farms; FTC (Dec 2023)

GS1 Sunrise 2027



Source: IFPA 2D guidance; Advanced Automation (Apr 2026); NACS (Oct 2026); RFID Journal (Mar 2026); GS1 US

Dynamic Markdown Pricing

35–80%

Waste reduction (vendor-reported)

2.2 million lb

Meat not thrown away in 1 year (150 stores, vendor-reported)

Mechanism



Source: Waste360 (Oct 2024; Wasteless, vendor-reported); NoCamels (Sep 2022); FAO AgriTech Observatory

QR Traceability in Thailand: CPF and CP Axtra

CPF

Blockchain: Y

Thailand · fresh chicken and pork

QR

CPF iTrace (SR 2022) → now AXONS Trace (SR 2024) · digital since 2017 · blockchain layer and QR on fresh chicken and pork packs since 2022, 100% coverage in 2022

Carbon label

1,016 products (Apr 2026)

Note

Carbon or "antibiotic-free" claims must trace back to an LCA or farm records

CP Axtra × DLD

Blockchain: not stated

Thailand · retail beef

i-Trace

Retail system, separate from CPF · beef QR shows farm, cutting plant and packing plant (MoU Aug 2025)

Scale

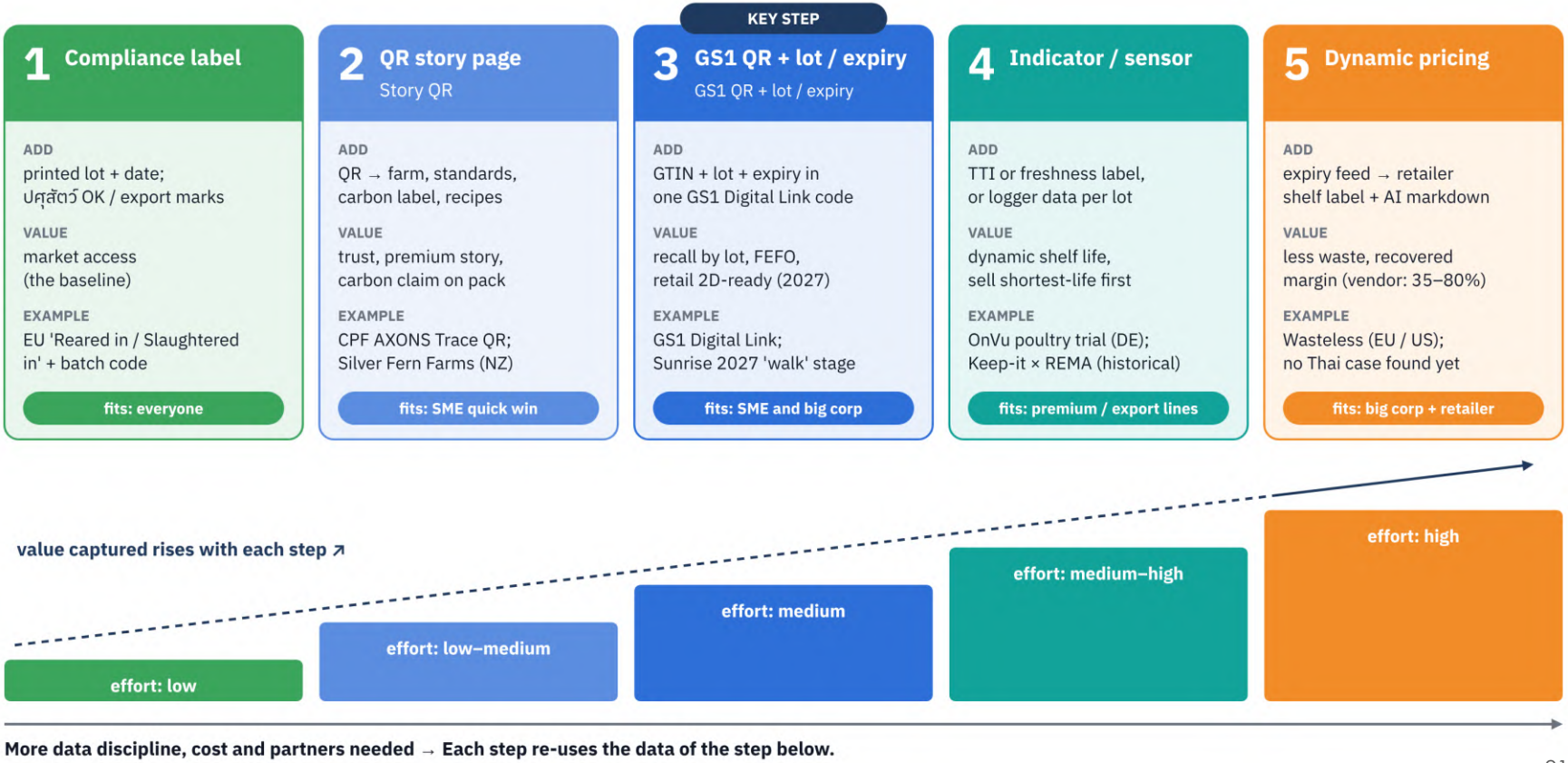
Makro i-Trace QR on more than 19,000 items (Jul 2023)

Not found

National rules for meat QR / digital labels · automatic markdowns in Thai retail

Source: CPF (14 Feb 2024); CPF Sustainability Reports 2022 and 2024; CPF (1 Apr 2026); Naewna (Aug 2025); The Nation (Sep 2025); WealthyThai (Jul 2023)

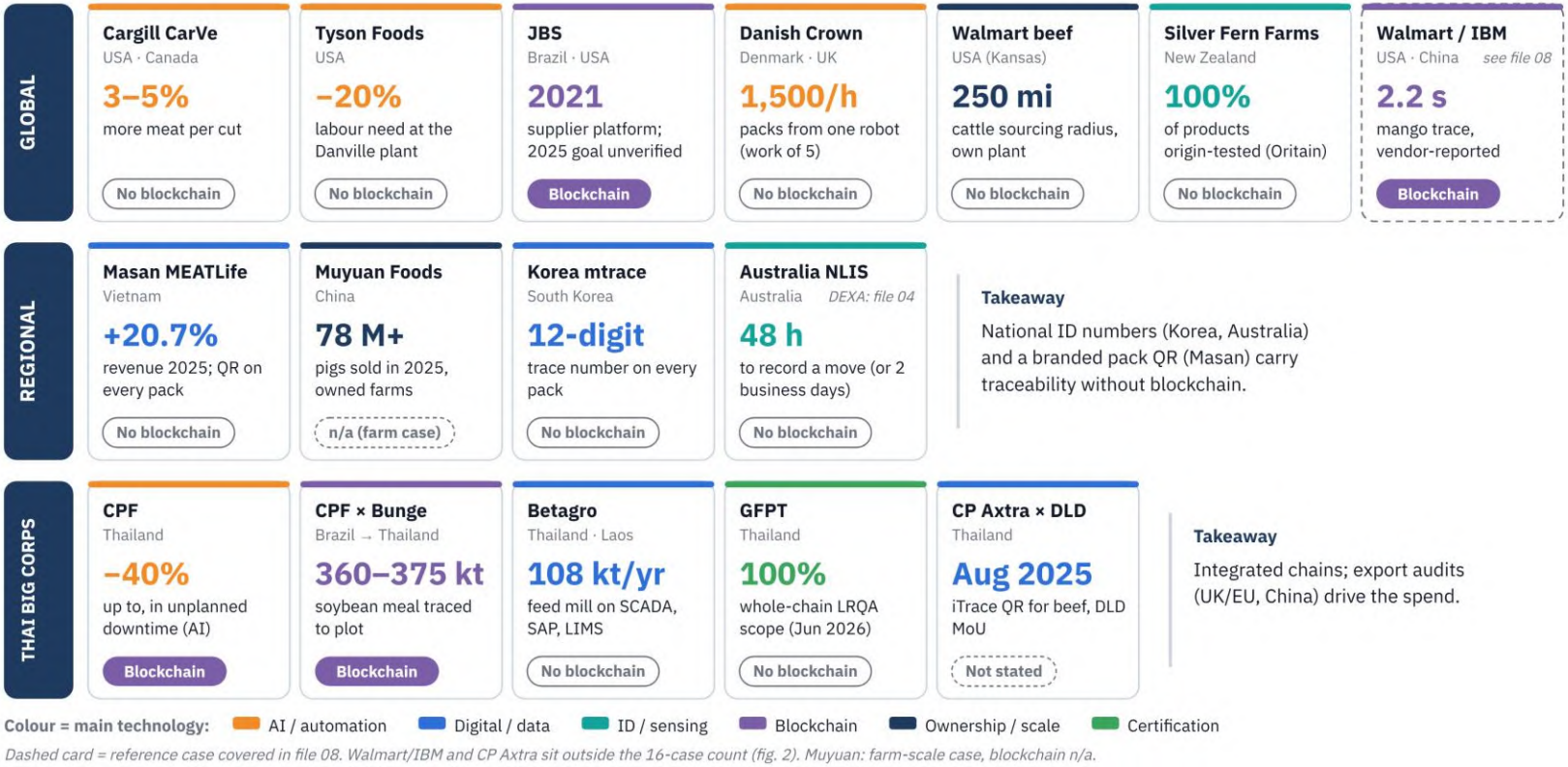
Digital Label Value Ladder



Source: Author's synthesis from GS1/IFPA/Packaging World (2026); CPF; Silver Fern Farms; Albrecht et al. (2019); Keep-it; Waste360 (2024)

Case Studies: Global, Regional, Thai

Case Map: Global, Regional, Thai



Source: Company releases and reports (Cargill, Tyson, JBS, Walmart, Silver Fern Farms, Masan AR 2025, CPF SR 2024 and 2026 news, Betagro, GFPT) and trade press

Thai Big Corporations: Published Digital Initiatives

Company	Traceability / QR	AI grading	AI / vision QA	Yield / automation	Cold-chain IoT	Cyber / OT security
CPF chicken · pork · feed	iTrace (SR 2022) → now AXONS Trace (SR 2024): blockchain + QR; 100% of fresh chicken and pork (2022)	AI cameras check lean-to-fat ratio in pork; no accuracy given	AI 'Smart Eye' cameras count products and check quality	Robotic sausage line and RFID robot store; no yield data	Real-time tracking of truck location, temperature and speed	ISO 27001, NIST CSF 2.0, cyber committee; OT not mentioned
Betagro chicken · pork · feed	S-Pure eggs traceable from breeder flock; no meat QR found	*Not found in public sources checked*	*No vision or X-ray QA; 'Smart Quality' named only*	Smart-factory feed mill, Nong Bun Mak (2023); real-time monitoring at Lampang chicken plant (2025)	Digital transport management (2025); no temperature IoT disclosed	*No cyber disclosure found; One Report site blocks automated reading*
GFPT integrated chicken	LRQA Platinum certificate, 100% farm-to-slaughter scope; no QR	*Not found in public sources checked*	*Not found in public sources checked*	*New Chonburi plants announced; no automation detail published*	*Not found in public sources checked*	IT security policy only; no OT, ISO 27001 or NIST
Thai Foods Group TFG	*Not found; reports not accessible, news silent (all six areas)*					
CP Axtra × DLD retail · beef	Makro i-Trace QR, 19,000+ items (2023); DLD beef MoU (2025); separate from CPF	*Not found in public sources checked*	*Not found in public sources checked*	*Retailer; no plant automation disclosed*	*No store or truck temperature IoT disclosed*	0 data breaches in 2025; SEC NIST score 4.22 vs 1.91

Source: Company reports and releases (checked 14 Oct 2026): CPF SR 2022/2024 and news (2023–26); Betagro, GFPT and CP Axtra releases; Thai business press

Common Success Factors

	ID standard or lot ID	Captured at source	Integrated chain	Published result (KPI)	Market or legal pull	Independent check	Blockchain used?
Cargill CarVe	—	●	—	●	—	—	No
Tyson Danville plant	—	●	●	●	—	—	No
JBS supplier platform	●	◐	◐	—	●	●	Yes
Danish Crown	◐	●	—	●	—	—	No
Walmart beef plant	—	—	●	—	—	—	No
Silver Fern Farms	●	●	●	◐	●	●	No
Australia NLIS	●	●	●	—	●	◐	No
Korea mtrace	●	◐	●	—	●	●	No
Masan MEATLife	●	—	●	◐	—	●	No
CPF (incl. × Bunge)	●	●	●	●	—	●	Yes
Betagro	—	●	●	◐	—	—	No
GFPT	—	—	●	◐	●	●	No
Documented (full + partly)	**7 of 12**	**9 of 12**	**10 of 12**	**8 of 12**	**5 of 12**	**7 of 12**	

● documented in sources ◐ partly / implied — not found in sources (not the same as absent)

3 of 16

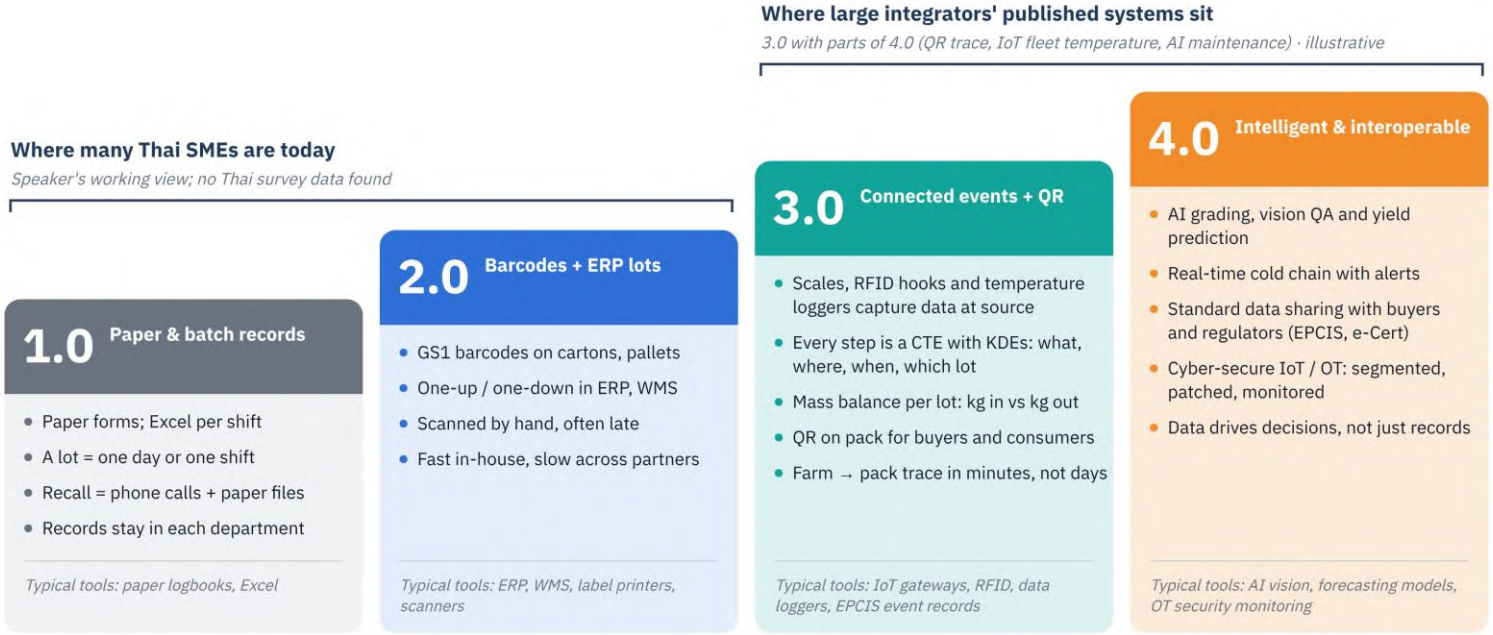
Cases using blockchain

Illustrates the point; not a market share

Source: Author's assessment of company releases, annual reports and regulator pages (SupplementaryDocs 11); count from the 16-case table

Roadmap for Thai Meat Processors

Traceability Self-Assessment: 1.0 to 4.0



2.0
Lot code on every carton and pallet? · Can ERP show which customers received a lot within 1 day?

3.0
Weight and temperature recorded by machine? · Mass balance for every lot?

4.0
AI used for decisions? · Alerts before product spoils? · Controllers isolated from the internet?

Source: company examples: CPF SR 2024, CPF (Sep 2026), GFPT (Jun 2026), Prachachat (Nov 2024)

Singapore Food Manufacturing Industry Digital Plan



VIDEO · EMBEDDED MP4 (from base deck)

Digital plan for Singapore's food manufacturers

CNA · about 2021 (inference from the news ticker)

Link: available in base deck (embedded mp4, 4.8 MB); source URL not recorded; check it still plays

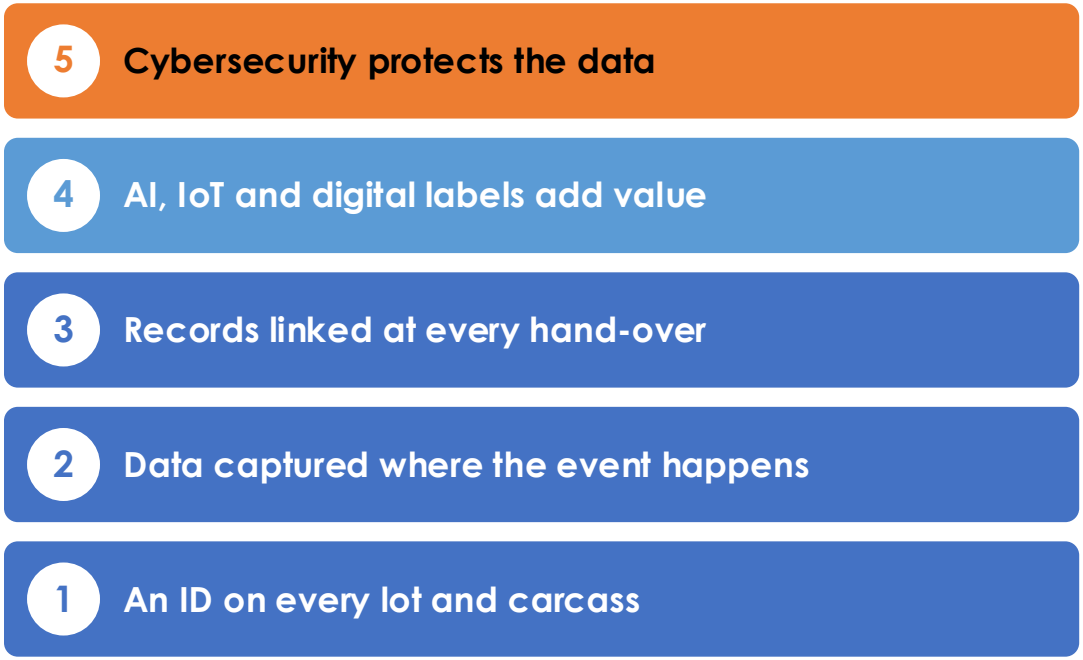


Adapted from Asst. Prof. Dr. Suvaluk Asavasanti (slide 55, IMDA roadmap)

IMDA plan launched 1 Apr 2021 · refreshed 9 Feb 2026 (more than 1,500 firms):
adds AI/GenAI, a Logistics Control Tower and a cybersecurity and data-protection roadmap

Source: CNA (about 2021, historical; upload year not read); IMDA Food Manufacturing Industry Digital Plan (launched 1 Apr 2021; refreshed 9 Feb 2026)

Key Takeaways



1 Traceability = data you can prove: ID + capture at source + linked records

2 AI, IoT and digital labels add value when results are linked to the lot or carcass ID

3 Blockchain is one tool, suited to several parties writing shared records

4 Cybersecurity in the budget from day one

5 Start tomorrow with a one-pack mock recall

Questions and discussion

Thank you for your kind attention

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Flow adapted, with thanks, from Asst. Prof. Dr. Suvaluk Asavasanti