



STRUCTURAL GAPS IN PRODUCT INFORMATION SYSTEMS
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Traceability Without Disclosure

*Why movement data does not constitute
product intelligibility*

Food moves. Its meaning does not.

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HEALTH · WISDOM · VIRTUE



EXECUTIVE SUMMARY

Traceability systems preserve histories of movement through food supply chains. They underpin recall, fraud prevention, disease containment, and border admissibility across the major trading jurisdictions, and they are widely adopted for those tasks. Yet a product may pass through a fully compliant traceability regime and still yield no portable, producer-declared description of its characteristics, heritage, or practices. This paper examines that gap. It proposes a diagnostic pair – *admissibility* and *intelligibility* – to distinguish what traceability systems are organised to answer from what product description requires. Across six jurisdictions and two global standards, the public regulation text and system documentation examined do not enumerate producer-declared attributes describing the product itself; such attributes, where they exist, sit in adjacent instruments. The paper does not argue that traceability systems can never carry such attributes. It argues, more narrowly, that event history does not by itself yield portable product intelligibility.

SECTION 1

The Promise

The rise of food traceability over the past three decades responded to a sequence of crises in which institutions could not answer, quickly enough, the question *where has this product been*. The 1986–2001 bovine spongiform encephalopathy outbreak in the United Kingdom, the 2008 melamine adulteration of dairy ingredients in China, the 2008–09 *Salmonella* outbreak linked to peanut products in the United States, and the recurrent pesticide-residue crises that threatened Indian grape exports to the European Union in the early 2000s each made the case that food safety, public-health protection, and market access depended on the ability to follow the movement of food through specified stages of production, processing, and distribution.

The multilateral response was codified in the Codex Alimentarius guideline CAC/GL 60-2006, which defines traceability as “the ability to follow the movement of a food through specified stage(s) of production, processing and distribution” (Codex Alimentarius Commission 2006). Subsequent FAO guidance reaffirmed this scope and noted explicitly that traceability “does not in itself improve food safety outcomes unless combined with appropriate measures and requirements” (FAO 2017). National regulators built systems on this foundation: the United States Food and Drug Administration issued the Food Safety Modernization Act Section 204 final rule (21 CFR Part 1 Subpart S) in 2022; the European Union adopted Regulation (EU) 2023/1115 on deforestation-free products; India’s Agricultural and Processed Food Products Export Development Authority built GrapeNet and TraceNet; Australia’s Integrity Systems Company

operates the National Livestock Identification System; Chile's Servicio Agrícola y Ganadero administers livestock traceability under Ley Orgánica 18.755.

These systems have produced real gains across the tasks they were designed to address. Recalls are faster and more precise than before; fraud is harder to sustain; disease traceback is more reliable; market access across regulatory borders is preserved where traceability has become the condition of admissibility. The achievements are real and should be named.

SECTION 2

The Structural Problem

Traceability systems preserve histories of movement. Product intelligibility requires something different: organised representation of attributes, practices, and context that do not arise from event history alone. These are two different questions, answered by two different kinds of information structure.

What traceability is organised around

At the level of data, traceability systems compose three elements: identifiers (lot codes, establishment codes, animal devices), events (receiving, transformation, shipping, slaughter, export declaration), and the links between them (who held what, when, and where it moved). Every major reference standard describes the architecture in these terms. ISO 22005:2007 specifies that a traceability system's design shall include objectives, regulatory requirements, products and ingredients, position in the feed and food chain, flow of materials, information requirements, procedures, documentation, and chain coordination – that is, the structure around which events and identifiers are organised (International Organization for Standardization 2007). GS1 Digital Link standardises the URI syntax through which identifiers resolve to information sources, separating primary keys (identifiers) from key qualifiers (batch, serial) and attributes (GS1 2022). The academic literature converges on the same framing: Bosona and Gebresenbet (2013), in a widely cited review, position food traceability formally as a logistics-management function.

What intelligibility requires

Product intelligibility requires a different unit of information: attributes that describe the product itself – its varietal heritage, its agronomic practice, its soil and water regime, its health-relevant composition beyond compliance thresholds. These are properties that obtain at the point of production. They are declared, not observed through movement. They do not emerge from custody transfer.

The distinction is foreshadowed in several existing literatures. The economic theory of credence attributes, formulated by Darby and Karni (1973) and developed in food-systems research by Cottrill, Gil and Tilley (2023), names a class of product properties that buyers cannot verify by inspection and that therefore require specific assurance mechanisms. The systematic review of supply-chain transparency by Budler, Quiroga and Trkman (2024) positions traceability as one dimension within a broader transparency construct, not coterminous with it. The FAO review *Traceability and Transparency in Supply Chains for Agricultural and Forest Commodities* (2019) draws the distinction explicitly at the multilateral level. Most directly, Golan et al. (2004), in a United States Department of Agriculture Economic Research Service report, observed that “traceability systems do not create credence attributes, they simply provide evidence of their existence.” That observation, now more than two decades old, has not been developed into a general architectural frame.

Non-accumulation

Event records do not aggregate into producer-level description. A grape shipment can pass through India’s GrapeNet with full chain of custody – farm registration, pre-harvest residue analysis, Agmark grading, phyto-sanitary certification, carton-level identification – and arrive at a European port with its admissibility fully documented. The public documentation examined yields no portable, producer-declared account of soil management, cultivar lineage, or agronomic method that travels with the product to a buyer in Berlin or Copenhagen as part of the export record. The events record where the shipment has been. They do not, on their own and as documented, describe what it is.

Admissibility and intelligibility

We propose a diagnostic pair to frame this distinction: *admissibility* for what a system is organised to establish within its regulatory scope, and *intelligibility* for what describes the product itself. The pair is not an established distinction in the peer-reviewed food-systems, traceability, or supply-chain literature. It is coined here. Its analytical content is foreshadowed by the credence-attribute frame, by the internal/external traceability distinction (Olsen and Borit 2013), by the logistics-management framing (Bosona and Gebresenbet 2013), and by the traceability/transparency distinction (FAO 2019; Budler et al. 2024). The coinage is offered as diagnostic vocabulary for an observation already present in the literature, not as inherited terminology.

On the objection that traceability systems can simply carry additional fields

One response to the distinction is that attribute information can be appended to existing traceability architectures: an additional field in a data schema, an attribute resolver attached to an identifier, a linked record at a URI endpoint. This response misreads what is at stake. GS1 Digital Link, for example, standardises how identifiers link to in-

formation via URI syntax; it does not define which attributes are recorded, who declares them, or how they are structured (GS1 2022). ISO 22005 specifies design elements a traceability system must address but leaves the content of information requirements to the implementer (International Organization for Standardization 2007). Where richer attributes have been layered on — European wine e-labels under Regulation (EU) 2021/2117, the legality-and-deforestation variables required by EUDR Article 9, the sustainability self-assessment that supports Chile’s *Chile Origen Consciente* sello — they have not by themselves produced portable, producer-anchored intelligibility that travels across contexts. Appending attribute fields to a movement-record system yields enriched records. It does not, by itself, yield coherent product description.

The narrower claim the paper advances is this: event history does not by itself yield portable product intelligibility. Traceability records movement. Intelligibility describes the product. One does not arise automatically from the other.

Traceability records movement. Intelligibility describes the product. One does not arise automatically from the other.

THE PIVOT OF THE PAPER

SECTION 2A

What Traceability Does Well

Before proceeding, the achievements of traceability should be named directly and without qualification.

Food safety recalls are faster and more precise than they were thirty years ago. The FDA’s FSMA Section 204 final rule, codified at 21 CFR Part 1 Subpart S, defines seven Critical Tracking Events and a corresponding set of Key Data Elements. The rule requires records to be producible to FDA within twenty-four hours of request and was designed, in FDA’s own framing, to “help FDA rapidly and effectively identify recipients” of contaminated food in outbreak and recall situations (Food and Drug Administration 2022; Federal Register 2022). For the task of rapid recall, event architecture is well suited to the problem.

Livestock disease containment in Australia rests on the National Livestock Identification System. NLIS is the mandatory identification and movement-tracking system for cattle, sheep, and goats, integrated into the country’s animal-health surveillance and used in biosecurity response (Integrity Systems Company 2024). For traceback in a disease event, movement data is the relevant data.

Border admissibility in horticultural export has been preserved in cases where it was at genuine risk. India's GrapeNet, operated under APEDA, was built in response to a pesticide-residue crisis that threatened a European ban on Indian grape exports in the early 2000s. The system now tracks farm registration, residue analysis, phyto-sanitary certification, and carton-level custody for each consignment. European market access for Indian grapes has been sustained; consignment-level recall in the event of MRL non-compliance is possible (APEDA 2026).

Fraud prevention and legality assurance have advanced under the European Union's deforestation regulation. EUDR Article 9 requires operators to collect, before placement on the Union market, geolocation of all plots of land where the relevant commodity was produced, the country of production, the date range, supplier-chain identifiers, and adequately verifiable information on legality and deforestation status (European Parliament and Council 2023). For deforestation due diligence, the EUDR architecture is a serious regulatory instrument.

These are not small achievements. A disclosure layer, as this paper uses the term, would be complementary to traceability, not a replacement for it.

SECTION 3

Comparative Analysis

Across the six jurisdictions and two global standards examined, the public regulation text and system documentation define scope in terms of events, custody, identifiers, and – in specific cases – particular due-diligence variables. The documentation examined does not enumerate producer-declared attributes describing the product itself for the systems reviewed.

The European Union

Regulation (EU) 2023/1115 (EUDR) requires operators placing seven listed commodities – cattle, cocoa, coffee, oil palm, rubber, soya, and wood – on the Union market to file a due-diligence statement through the TRACES information system. Article 9 enumerates the information the operator must collect: product description and quantity, country of production, geolocation of all plots of land on which the commodity was produced (polygons for plots over four hectares; latitude and longitude to six decimals for smaller plots), production date or time-range, supplier and recipient identifiers, and “adequately conclusive and verifiable information” on legality and deforestation-free status (European Parliament and Council 2023). The listed variables are a due-diligence set; producer-declared agronomic practice, cultivar heritage, or composition are not enumerated. Regulation (EU) 2021/2117 introduced mandatory ingredient lists, nutritional declarations, and energy values for wines produced from the 2024 harvest onward, with digital provision permitted for most fields; the regulation does not mandate

producer-declared fields for viticultural practice, terroir description, or cultivar heritage.

The United States

FSMA Section 204, codified at 21 CFR Part 1 Subpart S, applies to foods on the FDA Food Traceability List — certain cheeses, eggs, nut butters, cucumbers, fresh herbs, leafy greens, melons, peppers, sprouts, tomatoes, tropical tree fruits, finfish, crustaceans, molluscan shellfish, and ready-to-eat deli salads. Seven Critical Tracking Events are defined: harvesting, cooling, initial packing of a raw agricultural commodity, first land-based receiving from a fishing vessel, shipping, receiving, and transformation. The Key Data Elements associated with each event comprise product descriptions, lot codes, quantities, dates, traceability lot codes, and location and reference-document information for the event (Food and Drug Administration 2022; Federal Register 2022). The original compliance date of January 20, 2026 has been overtaken by a delayed enforcement posture: FDA has stated that it will not enforce the Food Traceability Rule before July 20, 2028. The rule does not require producer records of agronomic practices, cultivar heritage, soil or water management, or health-relevant compositional attributes beyond the information necessary to identify a lot. These matters are not enumerated in the rule's CTE/KDE requirements, which are directed to rapid identification of contaminated food rather than farm-practice disclosure.

India

APEDA's GrapeNet was established under the Standard Operating Procedure for Export of Fresh Grapes from India and associated procedures for export to the European Union (APEDA 2026). The system records farm registration with State Horticulture Departments, packhouse registration, pre-harvest residue analysis performed by APEDA-authorized laboratories, Agmark grading, phyto-sanitary certification, and carton-level chain of custody. The APEDA portal positions the system as monitoring residue levels against the pesticides permitted by India's Central Insecticide Board and Registration Committee. The public documentation examined does not enumerate producer-declared fields for agronomic narrative, cultivar heritage beyond identification, soil-amendment regime, or irrigation profile as part of the system's core schema.

Chile

Chilean livestock traceability operates under the Servicio Agrícola y Ganadero's statutory authority (Ley Orgánica 18.755; SAG 1989, as amended) and a sequence of implementing resolutions on establishment-level identification, movement recording, and biosecurity compliance across cattle and poultry. *Chile Origen Consciente* — the sustainability sello operated by the Ministry of Agriculture's policy office Odepa and ProChile in cooperation with the International Trade Centre — is a separate instrument layered over production (ProChile 2025). Participating firms complete a sustainability self-assessment on the ITC Sustainability Map and undergo a compliance audit on achieving

full self-assessed compliance. ChOC is documented as an attestation sello, not a chain-of-custody database; SAG traceability is documented as an event-and-establishment schema. Producer-declared husbandry narrative, genetic lineage beyond identification, feed composition, and health-relevant compositional attributes are not enumerated as core fields of either instrument.

Australia

The National Livestock Identification System integrates three elements: the Property Identification Code (PIC), a visual or electronic device on each animal, and a national web-based database recording device status, PIC status, and livestock movements (Integrity Systems Company 2024). Events recorded include device-to-PIC attachment and detachment, livestock movement between establishments, saleyard and abattoir arrivals, and status changes. On-farm assurance attributes — welfare practice, feed regime, husbandry narrative, meat-quality grading criteria — sit in separate industry programmes, principally Livestock Production Assurance, the National Vendor Declaration, and Meat Standards Australia, which operate alongside NLIS rather than within it.

Global standards

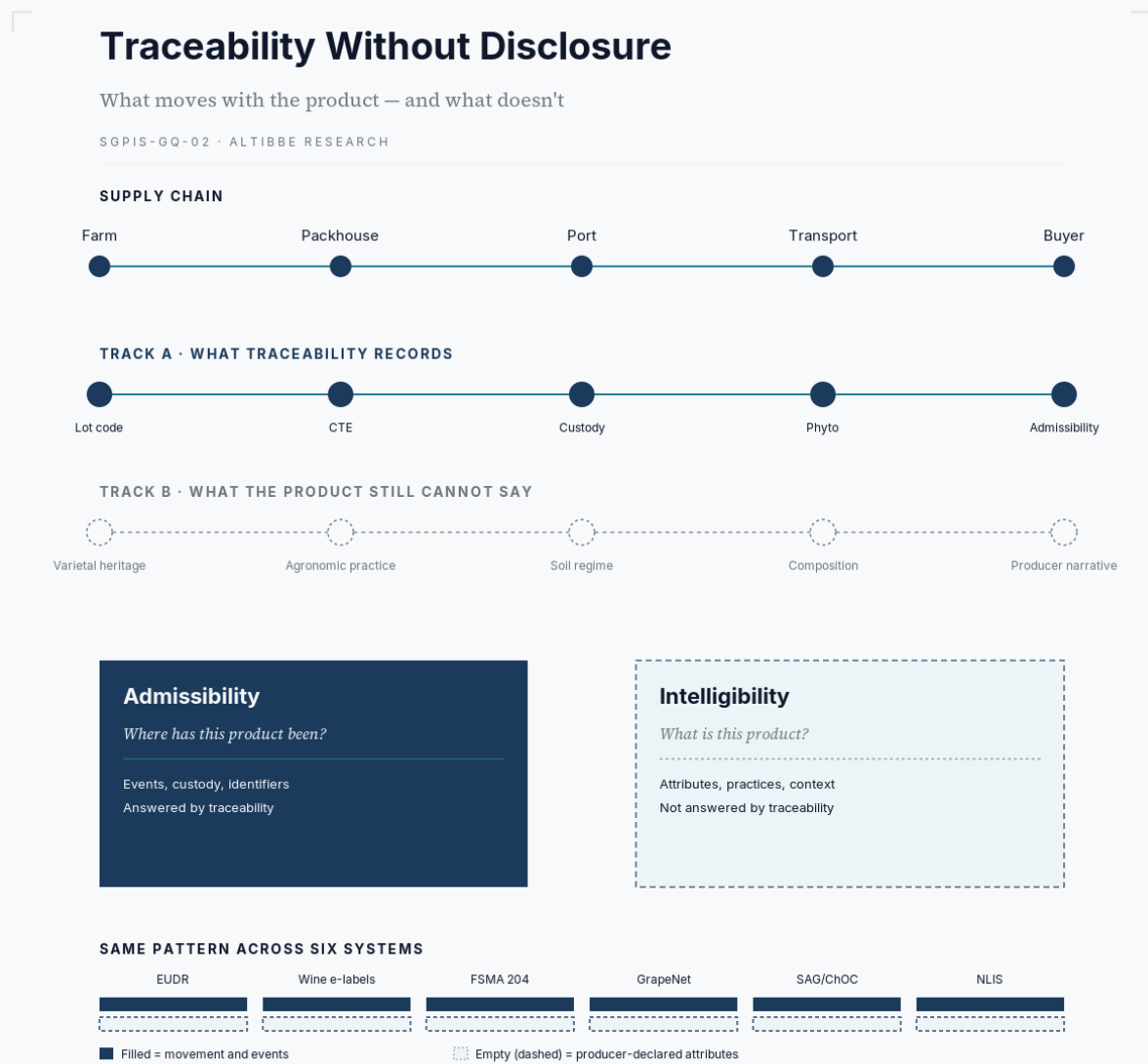
GS1 Digital Link (Release 1.2.1, 2022) is data-carrier-agnostic URI syntax. The standard specifies how GS1 identifiers and associated qualifiers resolve to information sources via the Web; it does not enumerate a canonical attribute set for producer-declared properties (GS1 2022). ISO 22005:2007 defines traceability as the ability to follow movement through specified stages and specifies design elements a traceability system must address, but leaves the content of information requirements to the implementer. The ANSI summary of ISO 22005 notes that the standard does not include attributes such as product quality, which it treats as “outside the scope of the traceability definition.” Both standards are voluntary and are referenced by regulators across jurisdictions.

Comparative summary

System	What it tracks	What its public documentation does not structure	Primary use case	Regulatory basis
EUDR (EU)	Geolocation of production plots, commodity flow to EU market, legality and deforestation-free status	Producer-declared practice, cultivar heritage, composition	Deforestation due diligence	Regulation (EU) 2023/1115
Wine e-labels (EU)	Ingredient list, nutrition declaration, energy values	Viticultural practice, terroir description, cultivar heritage	Consumer nutrition information	Regulation (EU) 2021/2117
FSMA 204 (US)	Critical Tracking Events and Key Data Elements for listed foods	Agronomic practice, cultivar heritage, soil/water management, compositional attributes	Rapid recall and outbreak response	21 CFR Part 1 Subpart S
GrapeNet (India)	Farm registration, residue analysis, phyto-sanitary certification, carton custody	Agronomic narrative, cultivar heritage beyond identification, soil-amendment regime	Export admissibility (EU grapes)	APEDA Act 1985; EU Regulation 396/2005 interface
SAG (Chile)	Establishment and animal identification, movement, biosecurity compliance	Husbandry narrative, feed composition, compositional attributes	Disease control; export admissibility	Ley Orgánica 18.755
NLIS (Australia)	PIC and device identification, livestock movement, device/PIC status	Welfare practice, feed regime, meat-quality grading (in separate adjacent programmes)	Disease traceback and market access	State biosecurity legislation; industry-government co-regulation
GS1 Digital Link	URI syntax for identifier resolution	Which attributes are recorded, who declares them, how they are structured	Identifier infrastructure	Voluntary standard (GS1 Global Office)
ISO 22005	Design elements for movement-based traceability systems	Product-quality and descriptive attributes (explicitly outside scope per ANSI summary)	General principles for system design	Voluntary international standard

FIGURE 1

The two-track architecture – traceability and intelligibility along the same supply chain.



Food moves. Its meaning does not.

Author's analysis from the systems documentation reviewed in §3. The Track A row records what each system documents; the Track B row records what its public schema does not enumerate.

On adjacent systems

Several instruments in the broader information ecosystem carry producer-declared or producer-attributable information alongside traceability systems. In Australia, Live-stock Production Assurance and Meat Standards Australia capture on-farm practice and meat-quality attributes adjacent to NLIS. In Chile, *Chile Origen Consciente* carries sustainability attestations alongside SAG livestock traceability. In India, the National Programme for Organic Production attests organic practice alongside the GrapeNet export traceability pipeline. In the European Union, the organic-farming regulation and the geographical-indication framework sit alongside EUDR and the wine e-label regime. GS1 Digital Link and the emerging class of Digital Product Passport deployments provide resolver infrastructure to which attribute information can be linked.

These instruments matter. They carry relevant information, and their existence is a legitimate element of any honest account of the ecosystem. They do so, however, unevenly – with differing scopes, governance logics, portability rules, and audience assumptions. LPA addresses Australian primary producers and their meat-chain partners; ChOC addresses participating Chilean exporters in specific commodity subsets; NPOP addresses Indian organic-certified producers. The instruments are adjacent to, rather than integrated with, the traceability architectures of their jurisdictions. Taken together, the public-facing instruments examined do not yet amount to coherent product intelligibility across contexts. Whether this fragmentation is consequential is a question §4 addresses directly. That it is the current state of affairs is a documentation-derived observation.

Pattern

Across the public-facing regulation text and system documentation examined, traceability systems do not enumerate producer-declared attributes describing the product itself. Where such attributes are structured at all within national ecosystems, they reside in adjacent, separately governed instruments. This is an observation about current documented architecture, not a claim about what is technically achievable within existing data models.

SECTION 4

Implications

After a consignment has moved through a fully compliant traceability regime, questions may remain at the product level about how the commodity was grown, what varietal and heritage it carries, what soil-and-water practices obtained on the production

plot, what health-relevant properties extend beyond the compliance thresholds enforced by safety regulation, and what practices the producer observed beyond the minimum required by the applicable legal regime. These questions are raised, among others, by sovereign-wealth procurement programmes, institutional buyers, and structured export markets.

They are not, in general, questions that traceability systems were designed to answer. The documented architectures examined in this paper concentrate on events, custody, identifiers, and regulatory scope variables. The questions listed above concern attributes that obtain at the point of production and do not emerge through movement. When such attributes are captured at all in the national ecosystems examined, they are captured in adjacent instruments with their own scope, governance, and audience assumptions.

The implication is not that traceability systems fail. They succeed at their documented tasks. The implication is that a different information structure is required for a different kind of question – one organised around the product as a described object rather than around events of custody and movement. Whether such a structure should be built, where it should sit, and how it should relate to existing traceability architectures are questions this paper does not attempt to resolve.

The trade-related measures catalogued by the OECD (OECD 2024) – some 130 instruments across member countries linking trade to environmental sustainability since 1997 – record a broad proliferation of production-attribute requirements at the interface of trade and regulation. In a related comparative scan, Charlebois et al. (2024) observe that many national digital traceability systems do not fully address transparency or provide end-to-end visibility. Taken together, these observations suggest the concern is structural rather than merely academic, though the question of how to respond to it lies beyond the scope of this paper.

SECTION 5

Structural Requirements

What would a disclosure layer – distinct from traceability, complementary to it – require at the level of design?

The answer must be stated in properties, not in workflow, actors, or implementation. The following properties are necessary conditions.

Attributable. Attribute data would need to be declared by an identified producer, carrying the provenance of its declaration with it. This is a descriptive-architecture requirement, not a governance mechanism; the question of how producer declarations are verified, audited, or assured belongs to separate instruments and is outside the scope of this paper.

Structured. Attributes would need to be organised according to a schema, not narrated in free text. Unstructured description does not compose into comparable product information across producers or across contexts.

Portable. The attribute structure would need to travel with the product – or with its identifier – across jurisdictions and trading partners. Attribute data locked to a single national system, a single buyer’s requirements, or a single certification scheme does not yield intelligibility across contexts.

Comparable. Attributes from different producers of the same commodity would need to be expressed in ways that permit comparison. The data model must impose enough discipline to make producer declarations diagnostically useful.

Jurisdiction-compatible. The structure would need to operate without requiring regulatory harmonisation it does not have. Disclosure should be capable of functioning across existing regulatory regimes rather than waiting for a harmonised regime to be constructed.

Complementary to traceability. The disclosure architecture would need to co-exist with traceability systems without displacing or duplicating them. Each architecture answers a different question; the design of one should not obscure the other.

These are design properties. They describe what a disclosure layer would need to be. They do not describe what any specific deployment should look like, who should build it, how it should be adopted, or how it should scale. Their resolution lies outside the scope of this paper.

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SOURCES, STANDARDS, REGULATION

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