EUROPEAN CENTRAL BANK

EUROSYSTEM

Introduction to the ECB Tokenisation Reference Model – a framework for standardisation discussion

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Executive Summary

Tokenisation represents a structural transformation of the European financial market ecosystem – i.e. the financial markets and the infrastructures that underpin them – rather than merely an infrastructure upgrade.

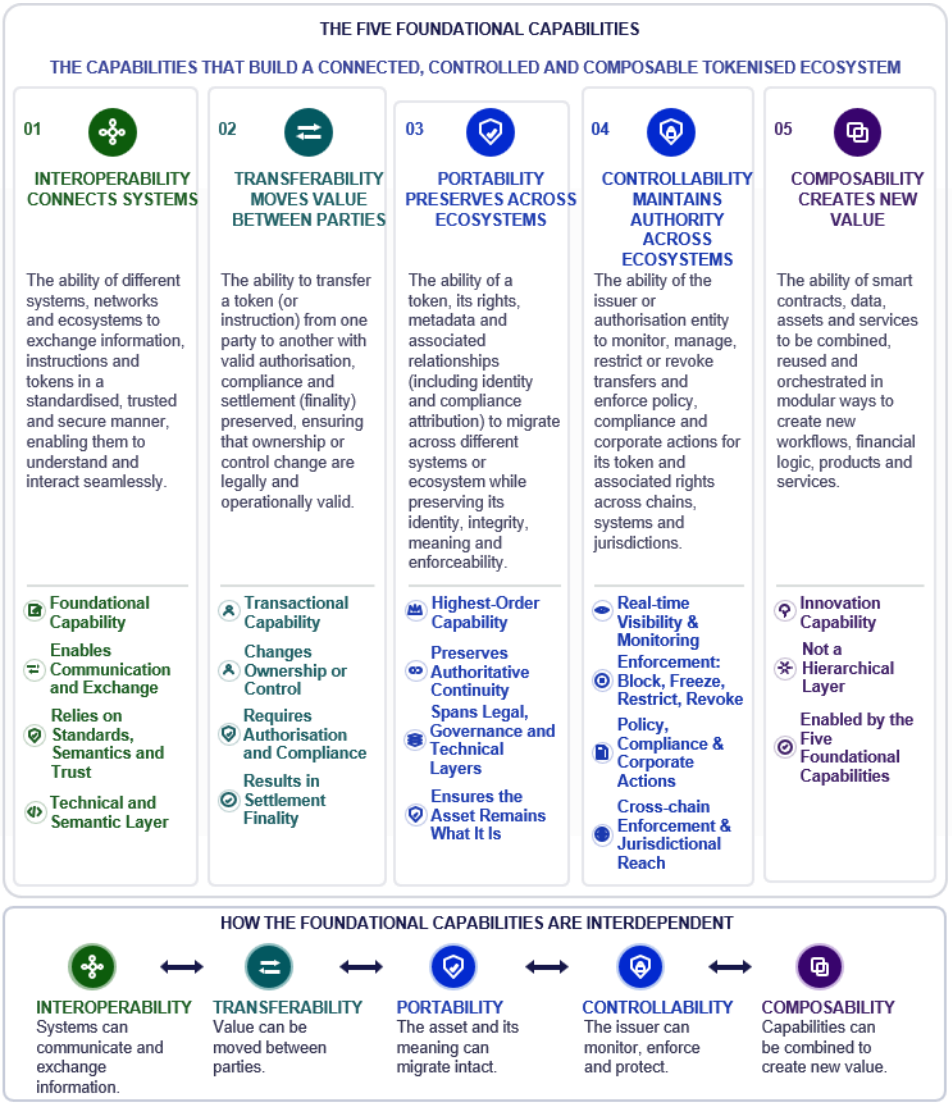
The use of distributed ledger technologies (DLT) for financial market token arrangements lowers the technological barrier to entry for platforms operating as infrastructures. While this may be positive from a competition perspective, offering a unique opportunity to overcome the inefficiencies that still affect traditional ecosystems, there is a risk that re-fragmentation could resurface if coordinated action is not taken to ensure the use of common standards. Competition on services must prevail over competition on technology and standards.

The aim must be to create an ecosystem with sufficient interoperability to ensure that a single end user of financial services or intermediary need only join one or a few DLT networks to access the vast majority of tokenised assets or services. Achieving a scalable, interoperable and trustworthy tokenised ecosystem therefore calls for effective coordination across legal, governance, semantic, operational and infrastructural domains. The ultimate goal is not simply to digitise the existing market structures, but rather to jointly assemble a common rulebook for tokenised European financial markets that will enable a connected, interoperable, portable and composable European tokenised financial ecosystem capable of operating safely and efficiently.

To refine the vision of full interoperability, this report identifies five foundational capabilities (see Figure 1).

Figure 1

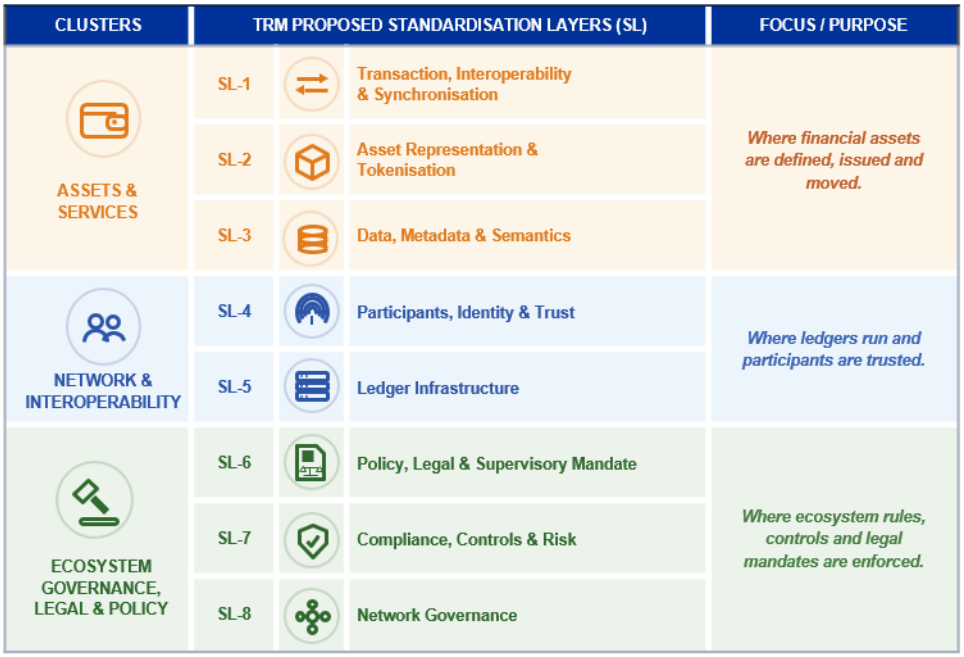
Key capabilities for the vision of a fully interoperable ecosystem



To facilitate a holistic discussion on how a common rulebook and standards can deliver these five foundational capabilities, a Tokenisation Reference Model (TRM) could be developed to provide a common framework for the transition. The TRM would take the work already done in the industry into account. However, it would go beyond purely technical standards to include governance, supervisory, semantic and interoperability-related aspects. The TRM would consist of eight domains, each represented as a layer in which coordination is needed – with rules to be followed – to ensure that the tokenised ecosystem exhibits all five key capabilities (see Figure 2).

Figure 2

Standardisation domains identified based on existing industry initiatives and discussions



This report maps the proposed TRM onto existing industry standardisation initiatives in order to i) provide an overview of the current DLT standardisation landscape, and ii) understand how the layers identified in the TRM relate to industry activities to date. This mapping exercise shows that most current industry standardisation initiatives only address specific subsets of the tokenisation ecosystem, rather than the ecosystem as a whole.

The proposed approach aligns with the feedback received from the respondents during the standards and interoperability-related section of the Appia roadmap public consultation (Appia Building Block 1).

The TRM is put forward as an initial framework for discussion and could be used, once vetted by key stakeholders, to structure the discussion in a pan-European standardisation governance forum. The TRM is not meant to be imposed on the industry, but rather is a framework to facilitate future discussions on standardisation with all stakeholders.

Since market initiatives are at different stages of maturity and given the finite resources of the industry and the public authorities, any discussions under the TRM would also require careful pacing and prioritisation. Based on the emerging landscape of siloed market DLT platforms – primarily covering securities issuance, settlement and processing – the most pressing areas for standardisation would appear to be cross-platform token transferability, technical token standards and a common reference data library for tokenised financial instruments. While existing

initiatives have also focused mainly on these areas, the work on standards (and, even more so, on their adoption) is still incomplete.

Section 1 of this report sets the scene and explains the underlying rationale for the TRM. Section 2 introduces the five foundational capabilities for a scalable tokenised financial ecosystem. Section 3 outlines the need for a European tokenisation rulebook. Section 4 describes the TRM in greater detail. Section 5 explains how the TRM layers contribute to the five foundational capabilities. Sections 6 and 7 assess and compare the TRM with selected interoperability-related industry initiatives. Finally, Section 8 sets out the priority areas. The key standards-related industry initiatives are described in greater depth in an annex.

1 Background

The emergence of tokenised financial assets and distributed ledger technologies is increasingly affecting the architecture of financial markets, market infrastructures and payment ecosystems. Across Europe and internationally, public authorities, financial market infrastructures, banks, issuers, asset managers and technology providers are all exploring (and to some extent already implementing) tokenisation to support new forms of securities issuance, settlement, collateral mobility and programmable financial services.

Tokenised bonds, deposits and funds, digital collateral mechanisms and synchronised settlement models are progressively moving from proof-of-concept environments toward institutional deployment scenarios. In parallel, a growing number of market coordination initiatives are emerging globally. These include the European Union DLT Pilot Regime; Eurosystem experimentation activities; work by the International Capital Market Association (ICMA) on the Bond Data Taxonomy (BDT) and by the Fintech Open Source Foundation (FINOS) on the Common Domain Model (CDM); the DTCC-Euroclear-Clearstream interoperability framework; the Digital Asset Securities Control Principles (DASCP) framework (an industry-led blueprint published by the Depository Trust & Clearing Corporation (DTCC), Clearstream, and Euroclear, in collaboration with Boston Consulting Group (BCG)) and public-private initiatives such as Global Layer One (GL/1).

While these initiatives confirm strong market momentum, they also reveal a growing structural challenge. Most tokenisation initiatives remain fragmented across technologies, infrastructures, governance models and operational approaches. Many initiatives focus predominantly on technical token standards or ledger implementations, without sufficiently addressing broader market structure, governance, supervisory and interoperability considerations. There is a growing risk that tokenisation could reproduce – or even amplify – the fragmentation already present in traditional financial markets and market infrastructures.

The Tokenisation Reference Model (TRM) could help address this challenge. The TRM proposes a structured, technology-neutral framework that aims to fully capture the dimensions of the ecosystem required for institutional-scale tokenised financial markets. Rather than focusing solely on technical infrastructure or token formats, the TRM seeks to introduce a broader reference architecture covering the legal, supervisory, governance, operational, semantic, transactional and infrastructural domains simultaneously, holistically and in close coordination with all of the relevant public and private sector stakeholders, in line with the Eurosystem's Appia objectives and key principles.

The aim of the TRM is not to replace existing initiatives, standards or frameworks. Its purpose is to provide a basis for discussing a common analytical and coordination model capable of positioning, comparing, embracing and aligning existing initiatives within a coherent end-to-end ecosystem architecture. Thus, the TRM would serve as a meta-framework with which to structure the discussion on interoperability and

convergence across the rapidly evolving tokenisation landscape, ultimately supporting the creation of a common European rulebook for tokenised financial markets.

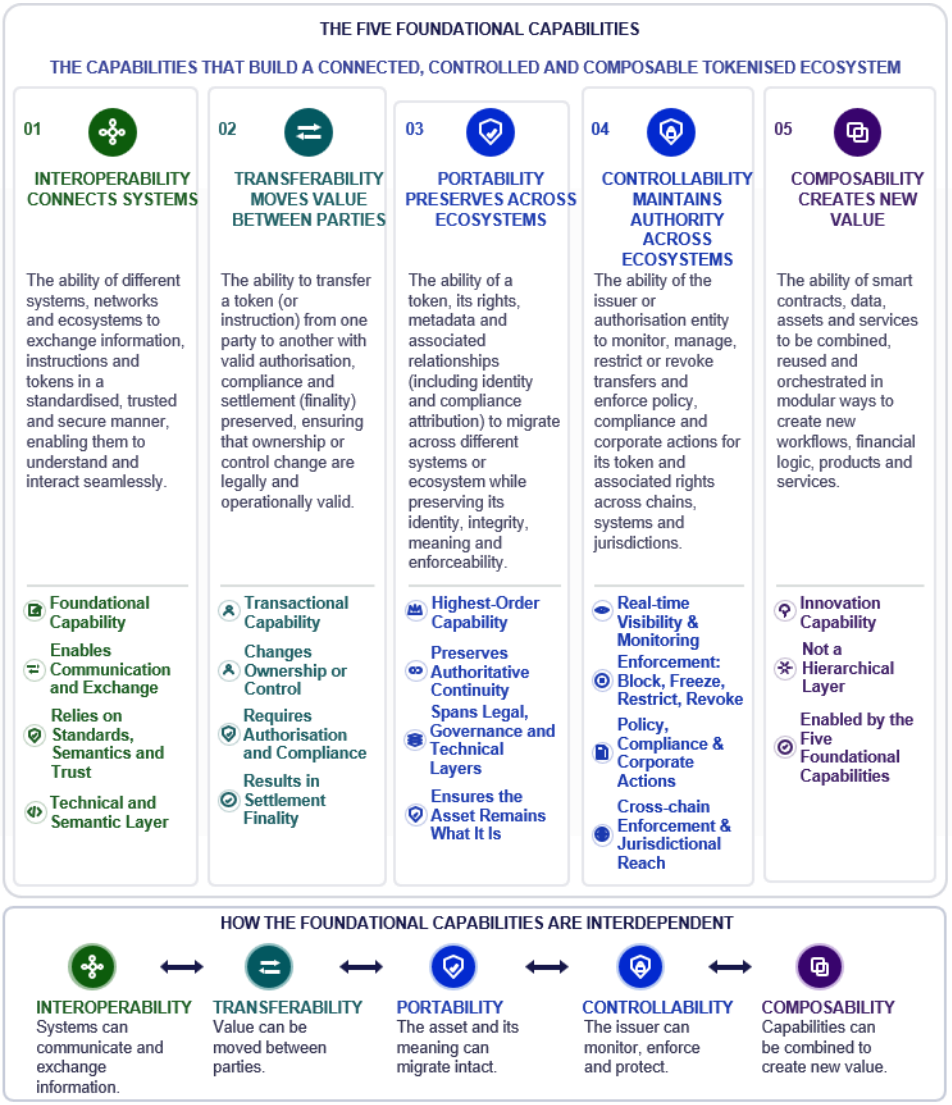
2 Five foundational capabilities for institutional tokenised financial markets

The development of tokenised financial markets requires more than the deployment of distributed ledger technology (DLT). It calls for sufficient levels of overall interoperability to enable tokenised assets to be issued, transferred, governed, supervised and reused across networks.

Five foundational capabilities are particularly important here, both in terms of design (in particular Appia Building Block 1) and as a common language for engaging with the industry tokenisation landscape, ultimately supporting the development of a common European rulebook for tokenised financial markets.

Figure 3

Key capabilities for the vision of a fully interoperable ecosystem



Tokens and the way they are used must be standardised. Only this can ensure safe and efficient interoperability, transferability, portability, controllability and composability across systems and networks.

These five capabilities are interdependent. Interoperability connects new and legacy systems and networks. Transferability allows for the movement of values. Portability preserves seamless continuity. Controllability preserves authority. Composability enables new financial logic.

The TRM could provide a structured way of identifying where common rules are needed to ensure that these capabilities can be realised across the full stack of a tokenised financial ecosystem.

2.1 Interoperability

Interoperability means the ability of different systems or networks to exchange information, instructions and states in a standardised, trusted and secure manner.

In the lifecycle of tokenised securities, interoperability means that issuance platforms, investor systems, custodians, CSDs, payment systems, trading venues, collateral platforms and supervisory systems can all understand each other. This includes not only technical messaging or interfaces, but also common semantics, identifiers, data models, rulebooks and operational procedures. It also encompasses backward compatibility requirements with existing systems and infrastructures, since end-to-end business processes will involve interactions between existing and new, token-based systems.

Interoperability is important because tokenised markets will not develop as a single network by themselves. They are likely to consist of multiple ledgers, platforms, legal domains and assurance zones. Without interoperability, tokenisation risks creating new silos rather than reducing existing fragmentation.

2.2 Transferability

Transferability means the ability to transfer a token, or an instruction relating to a token, from one party to another with valid authorisation, compliance and settlement finality.

For a tokenised bond, for instance, transferability means that ownership or entitlement can be transferred from one investor to another in a legal and operationally valid manner. This requires clear rights, eligible participants, valid instructions, settlement certainty, auditability and enforceability.

Transferability is narrower than portability. A token may be transferable within one ecosystem without being portable across ecosystems.

2.3 Portability

Portability means the ability to migrate a token, together with its rights, obligations, metadata, identity attributes and authoritative relationships, across systems or ecosystems while preserving its integrity, meaning and enforceability.

For a tokenised bond, for instance, portability means that the bond remains unchanged when it moves across platforms. Its ISIN, issuer, rights, restrictions, servicing history, corporate action obligations and ownership context all remain intact.

Portability is therefore a higher-order capability. It requires more than movement. It requires continuity of the legal, operational, data and governance context.

2.4 Controllability

Controllability means the ability of the issuer or another authoritative entity to maintain visibility, policy enforcement and operational control over a token and its associated rights across systems, chains and jurisdictions. Controllability also implies the ability to exercise legally and contractually defined rights and obligations in accordance with the applicable regulatory framework

For a bond issuer, for instance, controllability may include the ability to monitor holders, enforce investor eligibility, block unauthorised transfers, apply sanctions restrictions, execute corporate actions, trigger redemption and preserve legal and operational authority after the token has been transferred to another platform.

This concept is essential for regulated financial assets. A tokenised security cannot be treated simply as a bearer-style crypto-asset if the issuer continues to have legal, regulatory and operational obligations.

2.5 Composability

Composability means the ability to embed, execute and orchestrate business logic in relation to tokenised assets, transactions, data and services to link the execution of several transactions (e.g. by making them conditional on each other).

For instance, in the lifecycle of a tokenised bond, composability can support automated coupon payments, conditional settlement, automatic eligibility checks, collateral substitution, repo workflows, corporate action processing, redemption, reporting and compliance automation.

Composability can enable far more efficient processing of events and transactions. However, in regulated markets it needs to be implemented alongside interoperability, transferability, portability and controllability. Composability without control can create operational and legal risk.

3 The need for a European rulebook (including TRM)

Europe has historically achieved financial market integration through coordinated standards, rulebooks, schemes, harmonised infrastructures and common governance frameworks.

The development of SEPA, TARGET Services, ISO 20022 messaging standards, LEI frameworks, T2S harmonisation and the Single Collateral Management Rulebook for Europe all demonstrate that European market integration depends fundamentally on coordinated standardisation efforts.

Tokenisation requires similar coordination, but across a significantly broader and more complex ecosystem.

A tokenised market is not merely a different technical implementation of existing processes. It changes how assets are represented, transferred, synchronised, governed and supervised. In a tokenised environment, the distinction between data, processes, messaging, infrastructure and control mechanisms becomes increasingly blurred. Smart contracts can embed operational logic directly within assets. Settlement mechanisms can become synchronised across infrastructures. Data semantics become operationally critical. Governance frameworks can increasingly influence the foundational capabilities themselves.

As a consequence, tokenisation cannot be addressed solely through technical ledger standards. For example, a token may technically move between infrastructures while still failing operationally or legally because:

- ownership rights are not recognised;
- compliance obligations differ;
- governance frameworks are incompatible;
- settlement finality is uncertain.

Similarly, smart contracts may technically interoperate while remaining operationally or legally unusable because the semantic models, control frameworks or liability structures are not aligned.

Europe therefore requires a broader framework capable of structuring tokenisation at ecosystem level, rather than only at technology level.

The TRM could meet precisely this objective by creating a common language capable of linking:

- technology standards;

- legal frameworks;
- governance models;
- interoperability mechanisms;
- identity structures;
- semantic standards;
- supervisory requirements.

This is particularly important in the European context, where tokenised markets operate across multiple jurisdictions, infrastructures and regulatory environments.

Without coordinated standards, tokenised markets risk turning into fragmented ecosystems characterised by incompatible token models, isolated liquidity pools, proprietary interoperability mechanisms, duplicated control frameworks and reduced asset portability.

The TRM could help mitigate this fragmentation risk by introducing a layered, technology-neutral reference architecture.

4 Description of the three clusters and eight standardisation layers of the proposed TRM

The proposed TRM structures the tokenised ecosystem into eight distinct standardisation layers (SLs) grouped into three major clusters.[1]

The TRM takes account of previous work in the industry (including the IMF's ASAP model) in an attempt to incorporate and identify common ground in the industry's approach to standardisation across the different domains.

Figure 4
Standardisation domains identified based on existing industry initiatives and discussions

CLUSTERS		TRM PROPOSED STANDARDISATION LAYERS (SL)	FOCUS / PURPOSE
ASSETS & SERVICES	SL-1	Transaction, Interoperability & Synchronisation	*Where financial assets are defined, issued and moved.*
	SL-2	Asset Representation & Tokenisation	
	SL-3	Data, Metadata & Semantics	
NETWORK & INTEROPERABILITY	SL-4	Participants, Identity & Trust	*Where ledgers run and participants are trusted.*
	SL-5	Ledger Infrastructure	
ECOSYSTEM GOVERNANCE, LEGAL & POLICY	SL-6	Policy, Legal & Supervisory Mandate	*Where ecosystem rules, controls and legal mandates are enforced.*
	SL-7	Compliance, Controls & Risk	
	SL-8	Network Governance	

A key design principle of the proposed TRM is that tokenisation should not be viewed only or primarily as a ledger problem. The model deliberately positions Ledger Infrastructure (SL-5) as just one component within a broader institutional ecosystem. It operates on the assumption[2] that the standards for the upper layers may be agnostic to the choice of ledger. In practice, the most critical interoperability and scalability challenges often emerge not from infrastructure itself, but rather from governance (SL-8), legal (SL-6), semantic (SL3) and supervisory (SL-6) fragmentation. The bottom two layers (SL7 and SL8) are clearly the purview of the

1 Aligned with the Networks, Assets & Services visual presented in the Appia Roadmap document.

2 This assumption must still be thoroughly discussed and validated in collaboration with the industry.

public sector, since they focus largely on policy, supervision and compliance-related matters.

These layers are described in greater detail below.

4.1 Assets & Services Cluster

SL-1 — Transaction, Interoperability & Synchronisation

This layer captures transaction orchestration and interoperability mechanisms. It includes synchronisation models, settlement coordination, messaging semantics, DvP and PvP mechanisms, reconciliation logic and interoperability protocols.

This is one of the key operational interoperability layers within the TRM. It enables transactions to be coordinated and orchestrated consistently and reliably across systems and networks, including across different chains and with legacy infrastructures. This is important because tokenised and traditional infrastructures are expected to coexist for the foreseeable future.

This layer also increasingly supports programmable coordination between assets, cash and collateral across multiple infrastructures simultaneously.

SL-2 — Asset Representation & Tokenisation

This layer defines how financial assets are digitally represented.

It includes token standards, smart contract structures, lifecycle logic, rights and obligations, token metadata and behavioural models.

The objective of this layer is to ensure that tokenised assets remain consistently interpretable and operationally portable across infrastructures and ecosystems. To achieve this, a minimum set of information (e.g., account, balance) and functionalities (e.g., transfers, coupon payments) could be defined, into which each specific digital representation could be translated, e.g. to enable portability. In line with technological neutrality, no specific digital representation should be required or specified.

SL-3 — Data, Metadata & Semantics

This layer addresses semantic interoperability and reference data consistency.

It includes identifiers, metadata structures, taxonomies, semantic models and data portability frameworks.

In tokenised ecosystems, semantic alignment becomes operationally critical because smart contracts and interoperable systems increasingly depend on machine-readable interpretation of financial data and events.

Without semantic consistency, interoperability remains fragile and difficult to scale.

4.2 Network & Interoperability

SL-4 — Participants, Identity & Trust

This layer structures participant identity and trust frameworks.

It includes identity standards, credentials, participant entitlements, Legal Entity Identifiers (LEIs), Decentralised Identifiers (DIDs) and trust anchors.

Tokenised ecosystems require trusted identity because operational permissions, ownership rights and compliance obligations become increasingly embedded directly within digital workflows.

This layer therefore enables trusted participation across interoperable ecosystems.

SL-5 — Ledger Infrastructure

This layer represents the underlying infrastructure environment.

It includes distributed ledgers, consensus mechanisms, networking, runtime environments, node structures and infrastructure resilience and security.

The TRM deliberately treats this layer as infrastructure-neutral. The objective is not to standardise the full ecosystem on one specific technology stack, but rather to ensure that infrastructures remain interoperable and coordinated within a broader ecosystem architecture.

4.3 Ecosystem Governance, Legal & Policy Cluster

SL-6 — Policy, Legal & Supervisory Mandate

This layer captures the policy and legal foundations of tokenised financial markets.

It defines the legal recognition of tokenised assets, ownership rights, settlement finality, liability structures and supervisory mandates.

This layer is critical because tokenisation ultimately depends on legal enforceability rather than purely technical execution. Regardless of technological sophistication, a

tokenised ecosystem cannot scale institutionally without legal certainty over ownership, transferability and enforceability.

This layer also captures the broader policy objectives associated with tokenisation, including financial stability, market integrity, strategic autonomy and supervisory visibility.

SL-7 — Compliance, Controls & Risk

This layer addresses compliance, control and risk management mechanisms. This includes AML and KYC obligations, sanctions screening, operational resilience requirements, auditability, reporting obligations and prudential controls.

In institutional tokenised ecosystems, controls cannot remain external overlays disconnected from operational infrastructure. Increasingly, controls are being embedded directly into workflows, smart contracts and interoperability mechanisms.

This layer therefore plays a central role in ensuring that tokenised ecosystems remain trustworthy, controllable and supervisory-compatible at systemic scale.

SL-8 — Network Governance

This layer defines the governance structure of tokenised networks and ecosystems. It includes participation rules, onboarding requirements, federation models, governance mechanisms, dispute resolution approaches and liability allocation between actors.

The importance of this layer is often underestimated in technology-focused discussions. In practice, interoperability depends not only on technical connectivity, but also on governance compatibility. Two infrastructures may technically interoperate while remaining operationally incompatible because their governance obligations, risk frameworks or participant rights are not aligned.

This layer is therefore essential to support trusted ecosystem coordination.

5 How the layers included in the proposed TRM can contribute to the five foundational capabilities

The proposed TRM introduces a layered perspective where interoperability, portability, transferability, control and composability are understood as ecosystem-wide properties requiring coordination across all layers simultaneously. This section outlines how the standards and policies at each level of the TRM can contribute to the five foundational capabilities.

5.1 SL-1 — Transaction, Interoperability & Synchronisation

SL-1 defines how transactions are initiated, validated, synchronised and settled across systems. It includes DvP, PvP, atomic settlement, messaging, bridge mechanisms, synchronisation logic and cross-network workflows.

- For **interoperability,** SL-1 is the operational interoperability layer. It enables systems to exchange instructions and synchronise states.
- For **transferability,** SL-1 ensures that ownership changes are executed with settlement finality. It is the layer where transfer instructions become completed transactions.
- For **portability,** SL-1 preserves settlement status and lifecycle state when assets move across ecosystems, and potentially also continuity of transaction history.
- For **controllability,** SL-1 is where issuer or regulatory restrictions must be enforced during transfers. A transfer should not be completed if eligibility, sanctions, holding limits or other policy conditions are breached.
- For **composability,** SL-1 enables conditional settlement, automated DvP, collateral substitution, repo workflows, lifecycle automation and event-driven transaction logic.

5.2 SL-2 — Asset Representation & Tokenisation

SL-2 defines how a financial asset is represented as a token, how rights and obligations are embedded or referenced and how the token links to the underlying legal asset.

- For **interoperability,** SL-2 requires common or at least mappable token standards. A tokenised bond should be recognisable as a bond, not merely as a generic digital object.
- For **transferability,** SL-2 determines how ownership or entitlement is transferred. It defines whether a transfer of the token equals a transfer of legal title, beneficial ownership, entitlement or another form of control.
- For **portability,** SL-2 is one of the most important layers. The token must preserve its identity, rights, restrictions and legal meaning when represented on another platform.
- For **controllability,** SL-2 embeds or references issuer controls such as transfer restrictions, freeze rights, whitelist logic, redemption mechanics, voting rights and corporate action functionality.
- For **composability,** SL-2 turns the asset into a programmable object. Coupons, redemptions, collateral eligibility, repo use and corporate actions can be automated or orchestrated around the token model.

5.3 SL-3 — Data, Metadata & Semantics

SL-3 defines the data models, identifiers, reference data, metadata and semantic standards used to describe tokenised assets and events.

- For **interoperability,** SL-3 is central. Systems can only interoperate if they understand the same data in the same way. For a tokenised bond, this includes the ISIN, issuer, maturity, coupon, currency, governing law, restrictions, corporate action data and settlement attributes.
- For **transferability,** SL-3 ensures that all of the data required for a valid transfer accompanies the transaction. The receiving system must understand what asset is being transferred and under which conditions.
- For **portability,** SL-3 is critical because the asset's meaning is carried in its metadata. If metadata is lost, corrupted or reinterpreted, the asset may no longer remain the same across ecosystems.
- For **controllability,** SL-3 provides visibility over positions, lifecycle events, holder attributes and compliance status. Issuer control depends on reliable data.
- For **composability,** SL-3 allows smart contracts and automated workflows to consume standardised data. Composability becomes safer and more scalable when it operates on trusted data models rather than bespoke platform-specific fields.

5.4 SL-4 — Participants, Identity & Trust

SL-4 defines who the participants are, how they are identified, what credentials they hold and how trust is established between them.

- For **interoperability,** SL-4 ensures that participants recognised in one ecosystem can be understood in another. This may require LEIs, digital identity credentials, regulated participant roles, KYC/AML attributes and permissioning frameworks.
- For **transferability,** SL-4 is essential because transfers are only valid if the sender and receiver are eligible. A bond should not be transferable to any investor not permitted to hold it.
- For **portability,** SL-4 ensures that identity and eligibility information can accompany the token across ecosystems. A portable bond requires portable trust attributes.
- For **controllability,** SL-4 allows the issuer to enforce holder restrictions, whitelist eligible investors, block sanctioned entities and apply jurisdictional limits.
- For **composability,** SL-4 enables automated eligibility checks, rule-based access, identity-triggered workflows and participant-specific business logic.

5.5 SL-5 — Ledger Infrastructure

SL-5 provides the foundational platform or ledger infrastructure on which tokenised assets and transactions are recorded, executed and anchored.

- For **interoperability,** SL-5 determines whether ledgers can technically connect, expose trustable transactions states, exchange messages and support interfaces with other platforms. If the platform is closed, opaque or technically incompatible, transferability, portability and other foundational capabilities become difficult.
- For **transferability,** SL-5 provides the technical means by which asset movements are executed and recorded. Transfer instructions require reliable execution, deterministic or otherwise acceptable finality and robust infrastructure.
- For **portability,** SL-5 determines whether the state of a token can be migrated, mirrored, locked, burned, minted, wrapped or otherwise represented across infrastructures without loss of integrity.
- For **controllability,** SL-5 must support the technical consistency of issuer controls. If a token moves to another infrastructure, the relevant control logic must not disappear simply because the asset has changed chain or execution environment.

- For **composability**, SL-5 provides the execution environment for smart contracts, workflow automation and programmable settlement logic. However, composability at this layer remains purely technical unless supported by the higher TRM layers.

5.6 SL-6 — Policy, Legal & Supervisory Mandate

SL-6 defines the legal basis, public policy objectives, supervisory mandates and enforceability framework for the ecosystem.

- For **interoperability,** SL-6 ensures that cross-system activity has a recognised legal and supervisory basis. Technical interoperability without legal recognition remains fragile.
- For **transferability,** SL-6 determines whether ownership transfer is legally valid and enforceable.
- For **portability,** SL-6 is decisive. Rights and obligations can only survive migration across ecosystems if the legal frameworks recognise the continuity of the asset.
- For **controllability,** SL-6 anchors the authority of issuers, supervisors and public authorities. It defines which controls are legitimate, enforceable and binding.
- For **composability,** SL-6 sets the boundaries within which programmable finance can operate. It determines whether automated actions have legal effect and whether they are compatible with supervisory expectations.

5.7 SL-7 — Compliance, Controls & Risk

SL-7 defines the compliance, risk management, audit, resilience, reporting and control framework required for regulated financial activity.

- For **interoperability,** SL-7 ensures that systems can interoperate without creating unacceptable risk. Controls, monitoring, auditability and resilience expectations must be aligned.
- For **transferability,** SL-7 validates whether transfers comply with the applicable laws, risk controls and sanctions and market rules.
- For **portability,** SL-7 ensures that risk controls are transferred with the asset or re-established in the destination ecosystem.
- For **controllability,** SL-7 is central. It provides the control framework through which issuers, regulators and operators can monitor, restrict, audit and intervene where necessary.

- For **composability**, SL-7 ensures that programmable workflows remain compliant, auditable, resilient and risk-controlled. Composability must not bypass the control environment.

5.8 SL-8 — Network Governance

SL-8 defines the governance of the ecosystem: membership, node policies, operating rules, dispute resolution, rulebook adoption, governance rights and shared decision-making.

- For **interoperability,** SL-8 ensures that networks do not merely connect technically, but operate under compatible governance arrangements.
- For **transferability,** SL-8 determines whether transfers are permitted, under which rules, and with which responsibilities for participants and operators.
- For **portability,** SL-8 is essential because assets that move across ecosystems may also need governance continuity. The asset should not lose its rulebook context when it moves.
- For **controllability,** SL-8 defines how issuer rights, platform controls, participant obligations and enforcement powers are recognised across the network.
- For **composability,** SL-8 provides governance over programmable functions. It determines who can deploy code, approve changes, validate smart contracts and modify shared workflow logic.

5.9 The need for congruence between the layers

Interoperability begins with connectivity, but also requires common semantics, governance and trust.

Transferability begins with token movement, but also requires legal title, compliance and settlement finality. Portability begins with migration, but also requires the preservation of identity, rights, obligations and authoritative state. Controllability begins with issuer visibility, but also requires enforceable rights, controls and governance across ecosystems. Composability begins with code to implement a business logic, but also requires legal validity, risk controls and supervisory acceptance. The key feature of DLT ecosystems, programmability, is horizontal across the five capabilities and serves as a connective thread linking them all.

The proposed eight-layer TRM shows that these capabilities only become real when all layers are congruent. SL-1 enables transactions and synchronisation. SL-2 and SL-3 define the asset, its data and its legal and technical representation. SL-4 and SL-5 provide the technical and trust foundation. SL-6 anchors the entire construct in law, policy and supervision. SL-7 ensures compliance and control, and SL-8

provides ecosystem governance. This layered approach ensures that each element reinforces the next, creating a robust and coherent framework.

6 How existing industry initiatives relate to the proposed TRM

One of the objectives of the proposed TRM is to position existing tokenisation initiatives within a coherent common framework.

Several major initiatives have been considered,[3] including:

- FINOS Common Domain Model (CDM);
- Global Layer One (GL/1);
- ISO20022;
- Ethereum Enterprise Alliance ERCs;
- IEEE Standards Association DLT Standards;
- The DTCC-Euroclear-Clearstream interoperability framework.[4]

Most current standardisation initiatives only address specific subsets of the tokenisation ecosystem, rather than the ecosystem as a whole. The FINOS CDM deals primarily with semantic, lifecycle and operational coordination dimensions. GL/1 focuses heavily on interoperability tooling, governance and infrastructure orchestration. The DTCC-Euroclear-Clearstream framework concentrates primarily on portability and interoperability mechanisms between infrastructures.

The TRM helps understand how these initiatives relate to one another, while also identifying overlaps, interoperability dependencies, governance gaps and future standardisation priorities. This is particularly important in the European and global contexts, where multiple public and private initiatives are likely to coexist simultaneously.

[3] This is a work in progress. Other initiatives (e.g. the GBBC's Global Standards Mapping Initiative, I-SODA and ISO TC307) are also being analysed.

[4] See Annex 1 for a high-level description of these standards and initiatives.

7 Preliminary high-level assessment of standardisation initiatives against the TRM

7.1 Key findings

An initial high-level assessment of major standardisation initiatives – including ISO 20022, GS1/GL1, ICMA BDT/FINOS CDM, the Euroclear-DTCC-Clearstream Interoperability Framework, EEA standards, and IEEE DLT standards – shows a high degree of alignment with the objectives of the Tokenisation Reference Model (TRM), but only partial coverage of its full scope.

No single initiative addresses all eight TRM layers. Instead, each one contributes valuable capabilities within specific domains, reflecting its original focus on payments, securities, digital assets, interoperability or technology infrastructure.

The existing standards landscape provides a solid foundation for technical and business interoperability, but remains fragmented and incomplete from a public policy and market structure perspective.

The TRM should therefore be viewed as an overarching integration framework that brings together complementary initiatives within a coherent European sovereign architecture. In this context, the objective of the TRM is not to replace existing standards or policies, but rather to provide the governance, assurance, supervisory and interoperability framework required to pave the way for the creation of a European tokenisation rulebook.

7.2 Preliminary coverage assessment

The analysis suggests that the existing initiatives provide extensive coverage of the lower and middle layers of the TRM, particularly:

- data and metadata standards;
- asset representation models;
- business semantics;
- messaging frameworks;
- transaction processing;
- technical interoperability.

Collectively, these initiatives establish a solid foundation for Layers SL-1 to SL-5 of the TRM.

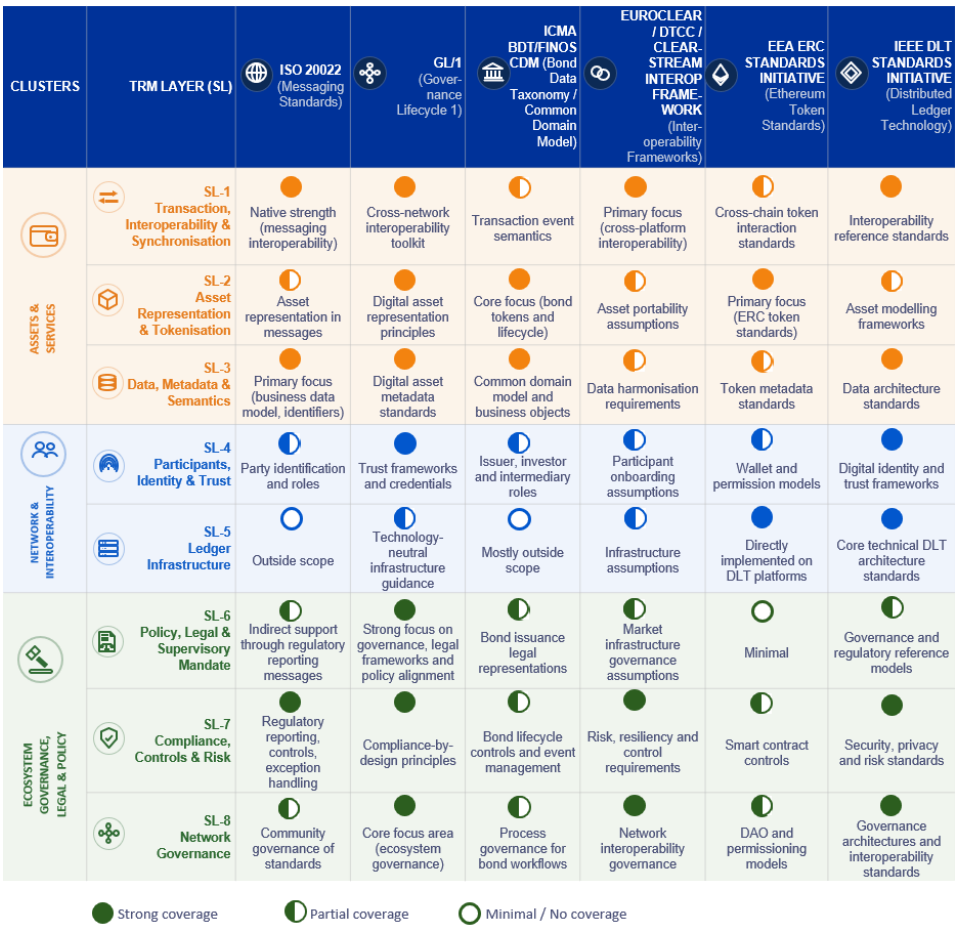
Coverage appears to be weaker in the bottom layers, namely:

- SL-5 Ledger Infrastructure
- SL-6 Policy, Legal & Supervisory Mandate
- SL-7 Compliance, Control & Risk
- SL-8 Network Governance

In particular, there is currently limited standardisation for governance models, supervisory oversight, assurance frameworks, monetary policy integration and public-sector coordination. These areas remain critical gaps for large-scale institutional adoption.

Figure 5

Coverage of major standardisation initiatives across TRM layers (SL)



7.3 Preliminary alignment assessment

While coverage varies, alignment with TRM objectives is generally strong.

Most initiatives support key Appia principles such as:

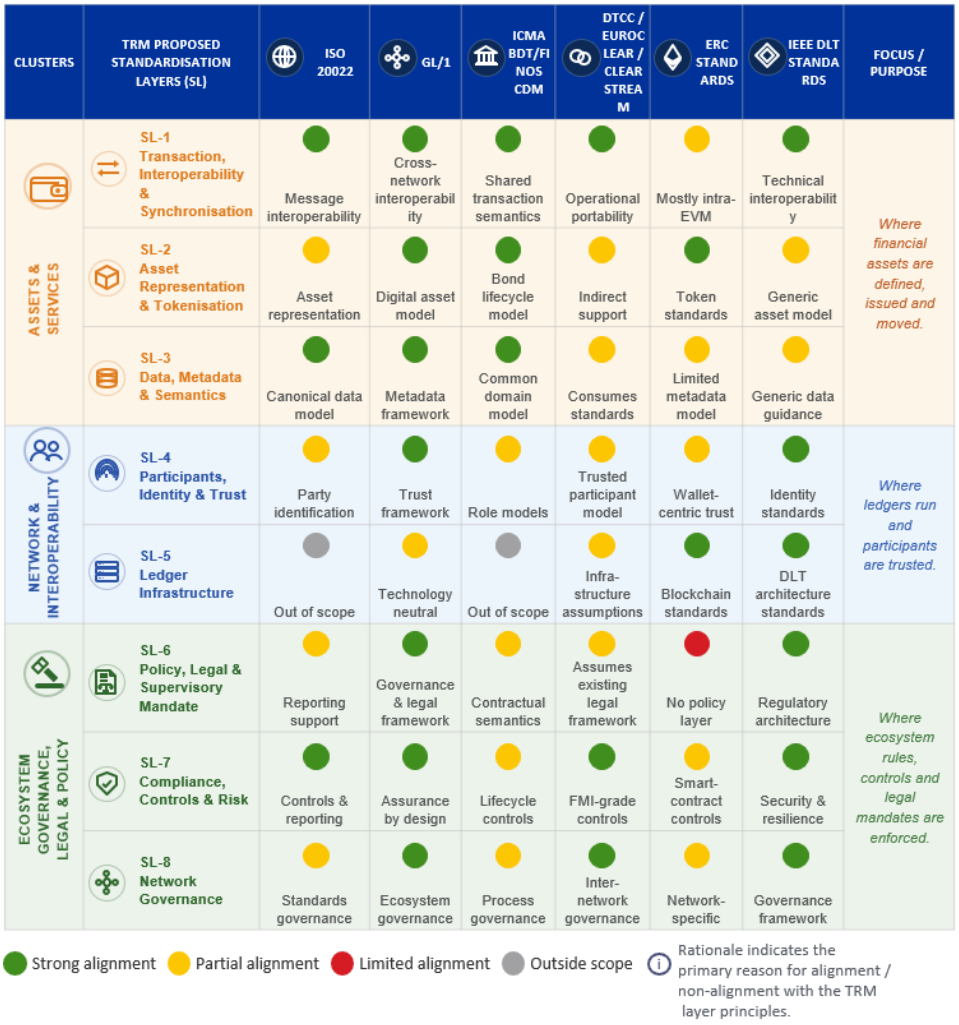
- interoperability across networks and infrastructures;
- portability of assets and data;
- transferability of ownership and rights;
- composability of services and applications;
- common semantic understanding across participants.

Alignment is strongest around interoperability, where a broad industry consensus is emerging around the need for common standards, identifiers, data models and connectivity mechanisms. However, even in these areas, no complete rulebooks are available and large-scale adoption is still pending.

Alignment is less mature in areas related to controllability, supervisory visibility and policy enforcement, where the requirements of central banks, regulators and market infrastructures are not yet consistently reflected in the existing standards.

Figure 6

TRM principles alignment matrix with embedded rationale



7.4 Implications for the Eurosystem's Appia

At this stage of the analysis, three conclusions emerge:

- **First,** the TRM provides a broader and more complete coverage of the tokenised ecosystem from a standards point of view than any individual standards initiative, each of which focuses on specific domains of standardisation.
- **Second,** Appia should focus on orchestrating and aligning existing standards rather than creating new standards where mature solutions already exist, with a focus on creating a European tokenisation rulebook, aligned with global market practices. A particular focus should be on whether the existing standards are fit

for use from a European perspective and whether European stakeholders adopt such standards.

- **Third,** Appia's greatest contribution is likely to be furthering the adoption of already created or agreed standards and catalysing the creation of standards in the upper layers of the TRM, where significant gaps remain around governance, legal certainty, supervision, risk management and monetary policy integration.

8 Prioritisation and focus areas

The TRM takes a comprehensive approach, covering all of the key aspects and layers for achieving ultimate interoperability in a DLT-based ecosystem. Nevertheless, it is clear that i) progress on standardisation may be uneven across the different TRM domains, owing to the different stages of maturity of market and innovation initiatives; and ii) the finite resources available at both industry and Eurosystem level mean that work will have to be carefully paced and prioritised.

With this in mind, any discussions with the industry under the TRM should initially focus on those layers and aspects where the lack of interoperability and adoption of the associated standards is actually most pressing in the current landscape, while still acknowledging and respecting the importance of the other layers.

Given the emergence of non-interoperable DLT platforms, particularly in the securities issuance, settlement and servicing space, the clearest priority areas for discussions appear to fall within the Assets & Services block of the TRM, namely:

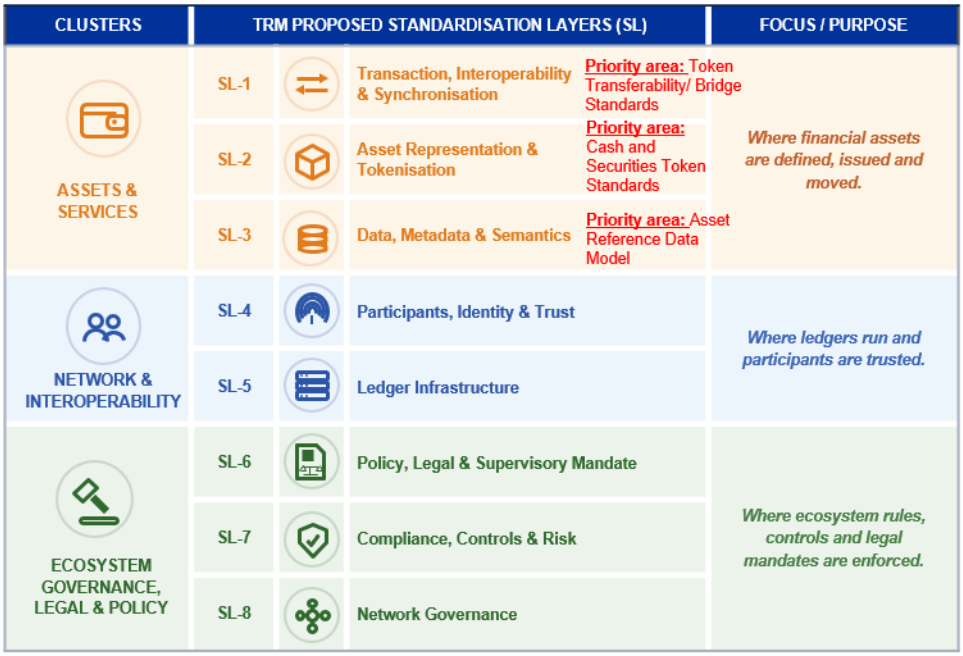
- **Transferability of cash and securities tokens** (within SL-1) – to address and agree on mechanisms that facilitate safe and efficient interoperability between DLT platforms and the transfer of tokens across DLT platforms (as a first step, at least, DLT platforms that use the same underlying technology, predominantly EVM).
- **Cash and securities token standard** (within SL-2) – to facilitate agreement on (technical) token standards so that tokens representing securities and cash observe the same technical standards across DLT platforms (or technology family), building on advanced work on token standards already developed or being developed by the industry (e.g. ERC standards within the Ethereum ecosystem[5]).
- **Common reference data library for asset (cash and securities) tokens** (within SL-3) – to be used by all issuers of assets across DLT platforms. This area also depends heavily on ongoing initiatives in the legacy ecosystem, in particular the AMI-SeCo's IMPACT Task Force on securities reference data standards, building on existing industry initiatives (ICMA Bond Data Taxonomy/FINOS Common Domain Model).

Furthermore, as a priority, the standardisation workstream should also explore and investigate whether commercial incentives by market DLT platforms in Europe may prevent interoperability, despite the availability of technical standards to support it.

[5] See the Annex for a high-level description of this Ethereum-based initiative.

Figure 7

Priority areas for standards discussions under the TRM



Annex – High-level description of key standardisation-related initiatives

IEEE

The IEEE Standards Association (IEEE SA), a globally recognised standards-setting body within the IEEE, has been actively pursuing blockchain standardisation efforts through various activities across multiple industry sectors. The IEEE SA seeks to serve as a global hub for advancing innovation and practical applications in this transformative field. The association's mission is described as fostering interdisciplinary collaboration, driving cutting-edge research and supporting the education and commercialisation of blockchain technologies across various industries and geographies. By creating a platform for knowledge exchange and partnerships, the association also aims to address the challenges and opportunities presented by blockchain and DLT.

Based on the latest available information, nearly 55 blockchain and DLT-related standards have been published by IEEE SA. These standards cover a range of topics, including token taxonomy, decentralised identity, governance and framework definitions. There are around 140 standards currently under development, reflecting the IEEE's active engagement in addressing emerging blockchain and DLT needs

GL1

The Monetary Authority of Singapore (MAS) has led the Global Layer One (GL1) and Project Guardian initiatives, which are among the most substantive international attempts to move tokenisation from the pilot stage to a more operational, interoperable market infrastructure model.

GL1 is described as a collaborative public-private initiative intended to foster open, interoperable, shared-ledger infrastructures for tokenised assets, with a particular emphasis on seamless cross-border financial transactions under regulatory expectations. Its stated objectives are to support open infrastructures for tokenised assets, enable applications such as payments, capital raising and secondary trading, and encourage internationally accepted common principles, policies and standards across networks. GL1 also aims to build on other existing standardisation initiatives, such as ICMA Bond Data Taxonomy/FINOS Common Domain Model and the DASCP framework put forward by the EU ICSDs and DTCC.

The GL1 website also notes that participating industry members include institutions such as J.P. Morgan, MUFG, HSBC, Standard Chartered and Forge, with policymakers including MAS, the Banque de France and the City of London Corporation.

Interoperability building blocks (Euroclear, Clearstream and DTCC)

The February 2026 interoperability paper published jointly by Euroclear, Clearstream and DTCC is a timely contribution to the emerging debate on how digital asset ecosystems can interconnect safely and at scale.

The paper identifies five capital market foundations and twenty-nine interoperability building blocks intended to support the movement of assets across distributed ledgers, as well as between distributed ledger environments and traditional infrastructures.

Its central proposition is that interoperability cannot be reduced to a purely technical bridging problem. Rather, it depends equally on common data standards, aligned processes, consistent role definitions, legal certainty and regulatory compliance.

By contrast, the Euroclear-Clearstream-DTCC framework is primarily an operational interoperability model. It translates broad architectural requirements into specific implementation building blocks such as contract versioning, beneficial ownership traceability, cross-DLT protocols, asset location control, segregation of duties and dispute-resolution responsibilities.

ICMA BDT/FINOS CDM

The FINOS Common Domain Model (CDM) and the International Capital Market Association's Bond Data Taxonomy (BDT) are transformative initiatives aimed at addressing operational inefficiencies and semantic fragmentation in financial markets. The CDM standardises the representation of financial products, transactions and lifecycle events in a machine-readable format, enabling consistent processing across systems and reducing reconciliation overhead, operational risks and inefficiencies in workflow automation. Meanwhile, the BDT focuses on bond issuance terms and metadata, with its latest version (BDT 2.0) supporting complex issuance structures like multi-class and tranche-based bonds, facilitating automation throughout the issuance and lifecycle management process. Both frameworks are designed with technology neutrality, allowing them to function across traditional, hybrid and tokenised infrastructures without being tied to specific settlement systems or governance models. This adaptability ensures their relevance across diverse ecosystems, though questions of settlement authority and supervisory structures remain outside their scope. Together, these initiatives advance semantic interoperability and operational efficiency in financial markets.

Ethereum Enterprise Alliance

The Ethereum Enterprise Alliance (EEA) and its Enterprise Ethereum Standards, including Ethereum Request for Comments (ERCs), play a vital role in promoting interoperability and standardisation within blockchain-based ecosystems. ERCs

establish technical standards for Ethereum-based applications, enabling consistent functionality and communication across decentralised platforms and enterprise environments. These standards address key challenges such as fragmentation and inefficiencies in smart contract execution, ensuring that applications can operate seamlessly within the Ethereum ecosystem. Additionally, the EEA's focus on enterprise use cases fosters collaboration between businesses and blockchain developers, facilitating the adoption of Ethereum for complex processes like supply chain management, tokenisation and decentralised finance (DeFi). Like other industry initiatives, the ERC framework is designed with technology neutrality in mind, allowing it to integrate with diverse infrastructures and architectures beyond Ethereum itself. This adaptability ensures its relevance across industries, while questions of governance, regulatory compliance and settlement mechanisms are left to external frameworks and entities. Together, the EEA and ERC standards advance operational efficiency, scalability and innovation in blockchain-enabled systems.

ISO20022

The ISO 20022 standard is a critical global initiative aimed at enhancing interoperability, efficiency and standardisation in financial messaging and data exchange across institutions and systems. Designed to provide a common language for financial communications, ISO 20022 enables the consistent representation of payment instructions, securities transactions, trade services and other financial processes. By facilitating the structured, machine-readable exchange of data, the standard helps reduce operational risks, reconciliation overhead and inefficiencies stemming from fragmented messaging formats. It supports automation, improves straight-through processing (STP) and strengthens interoperability between financial institutions and market infrastructures. Importantly, ISO 20022 is technology-neutral, meaning it can integrate seamlessly into diverse systems, whether traditional or blockchain-based, and adapt to evolving technological landscapes. This flexibility ensures its longevity and relevance across global financial ecosystems. However, while ISO 20022 addresses semantic standardisation, it does not directly define governance structures, settlement mechanisms or compliance frameworks, leaving those elements to individual institutions and regulatory bodies. As adoption accelerates worldwide, ISO 20022 serves as a foundational pillar for modernising financial communication and fostering global alignment.

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