From Fragmentation to Interoperability in the Citiverse

A perspective from VDC and StandICT

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Chair „*NA 043-01-24 AA Metaverse und Extended Reality*"

Chair „*Technical Working Group Virtual Worlds*"

Chair „*Metaverse Standards Register Working Group*"

The Challenge: Fragmentation at Every Level

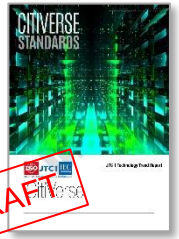
- **Too many SDOs:** 179 standards bodies active in Virtual Worlds alone — dozens relevant for Citiverse. Coordinated approach across SDOs is structurally absent.
- **Overlapping scopes:** Smart City, Metaverse & Digital Twin standards developed in parallel silos — no cross-domain view, no shared reference model.

Source: ETSI GR ARF 010/011 (2025, VDC) — 814 gaps · 549 structural issues identified across 8 Virtual Worlds domains

- **Low adoption:** Standards exist but major industry players often bypass them — proprietary solutions fill the gap. ETSI GR ARF 010 (2025): *„adoption remains low even where standards are mature“*.

Three Key Reference Source

StandICT / EUOS Citiverse Landscape Report (2023)
Rich taxonomy: verticals, enablers. first systematic mapping of Citiverse standards domains.
Primary finding: 'integration challenge‘. Many references to geospatial (85 refs) and Security (61)



ISO/IEC JTC 1 Technical Trend Report – CitiVerse (Draft 2026)
Defines CitiVerse as convergence of Smart City + Digital Twins + Metaverse.
Systematic gap analysis across all three domains: no unified reference model · no cross-domain interoperability · no shared data semantics · no governance framework · no integrated security model.

Global Digital Citiverse Framework (Draft 2026)
3-phase architecture: City Assets → Data Hubs → CitiVerse in Operation.
Broadest stakeholder consensus; vision-level.

The VDC Metaverse Standards Register

World's largest curated collection of XR & Metaverse standards

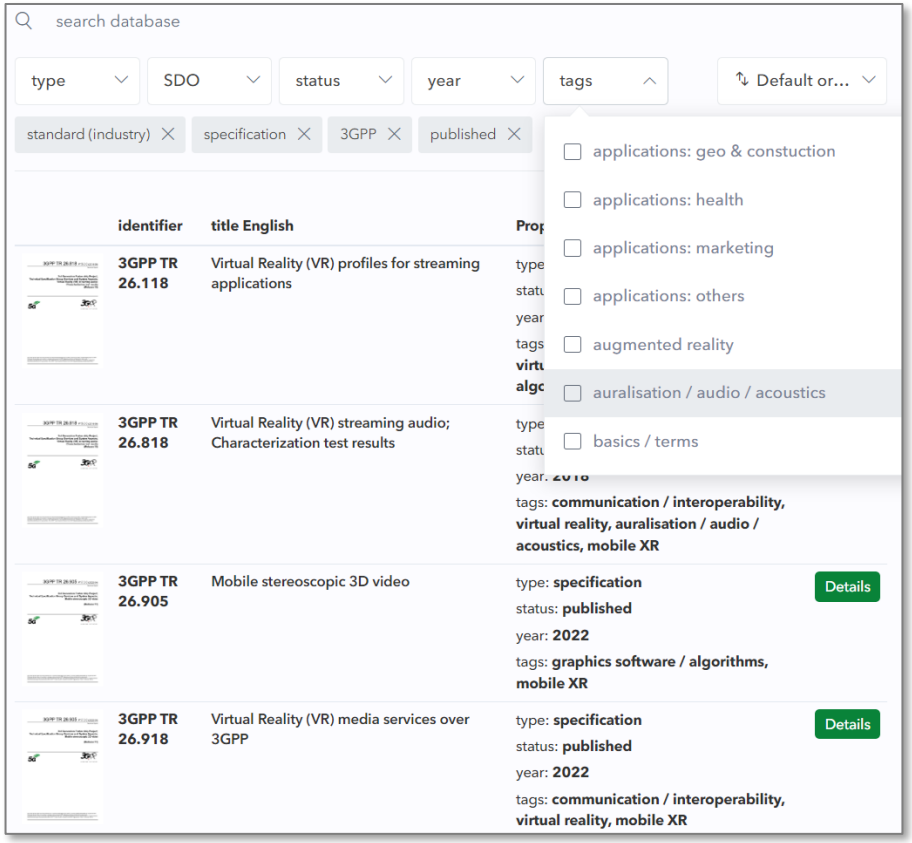
- 1.222 XR standards, specifications
- 432 guidelines and recommendations
- 416 standardization working groups
- 163 standards organization (SDOs)
- 150+ entries in preparation for upload

Classified according to:

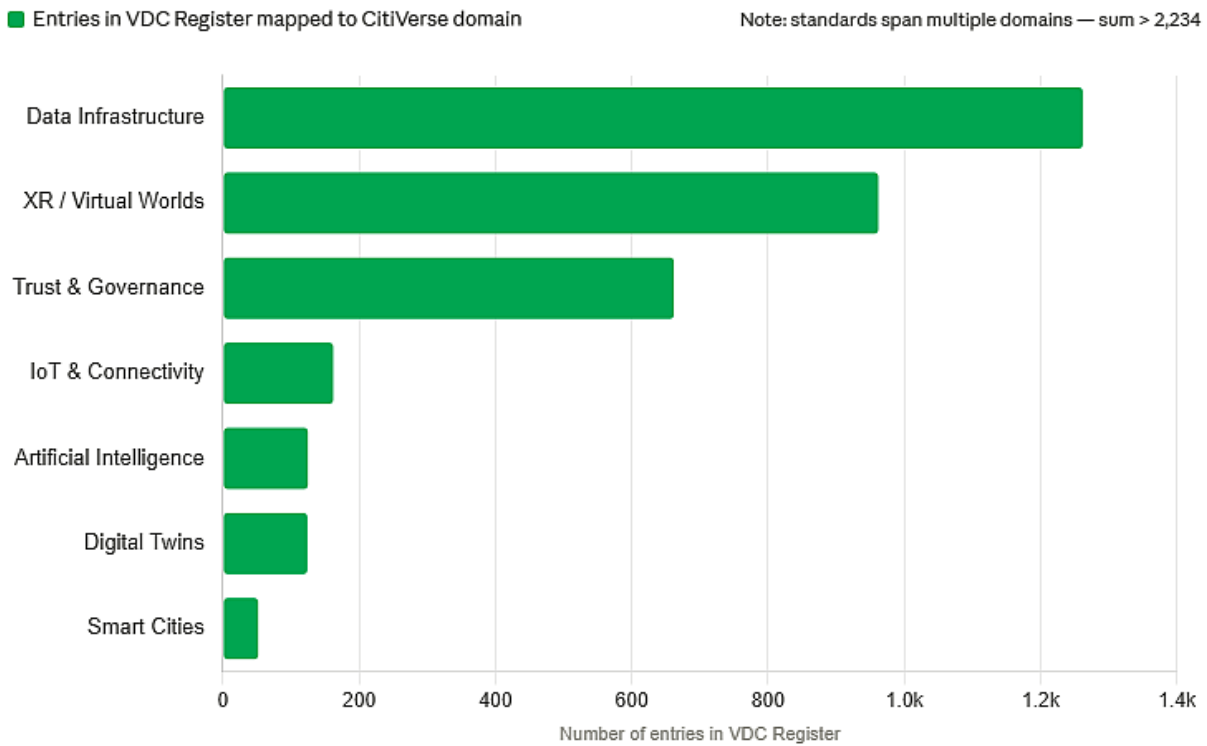
- Industries/verticals
- application areas
- EUOS scheme
- EC/ViWISSO scheme
- NATO scheme
- VDC domains scheme

and with a searchable text description.

Statuses: published - work in progress - withdrawn



CitiVerse in the Register: 7 Domain Clusters



Key Actors: Who Dominates Which Domain?

- Overall top SDOs across all CitiVerse-relevant VDC Register entries:
  ISO/IEC (419) · ISO (182) · IEEE (124) · ITU-T (110) · IEC (101) · NATO NSO (67) · W3C (47) · XRSI (44) · OGC (40)
- Domain leaders:

Digital Twins — IDTA · ITU-T SG20 · DTC · ISO/IEC SC41 — Most active: IDTA (28), ITU-T (18), DTC (16)

Smart Cities — ISO/IEC JTC1 · ETSI · ITU-T · OGC — Smallest domain (52) — largest standardisation gap

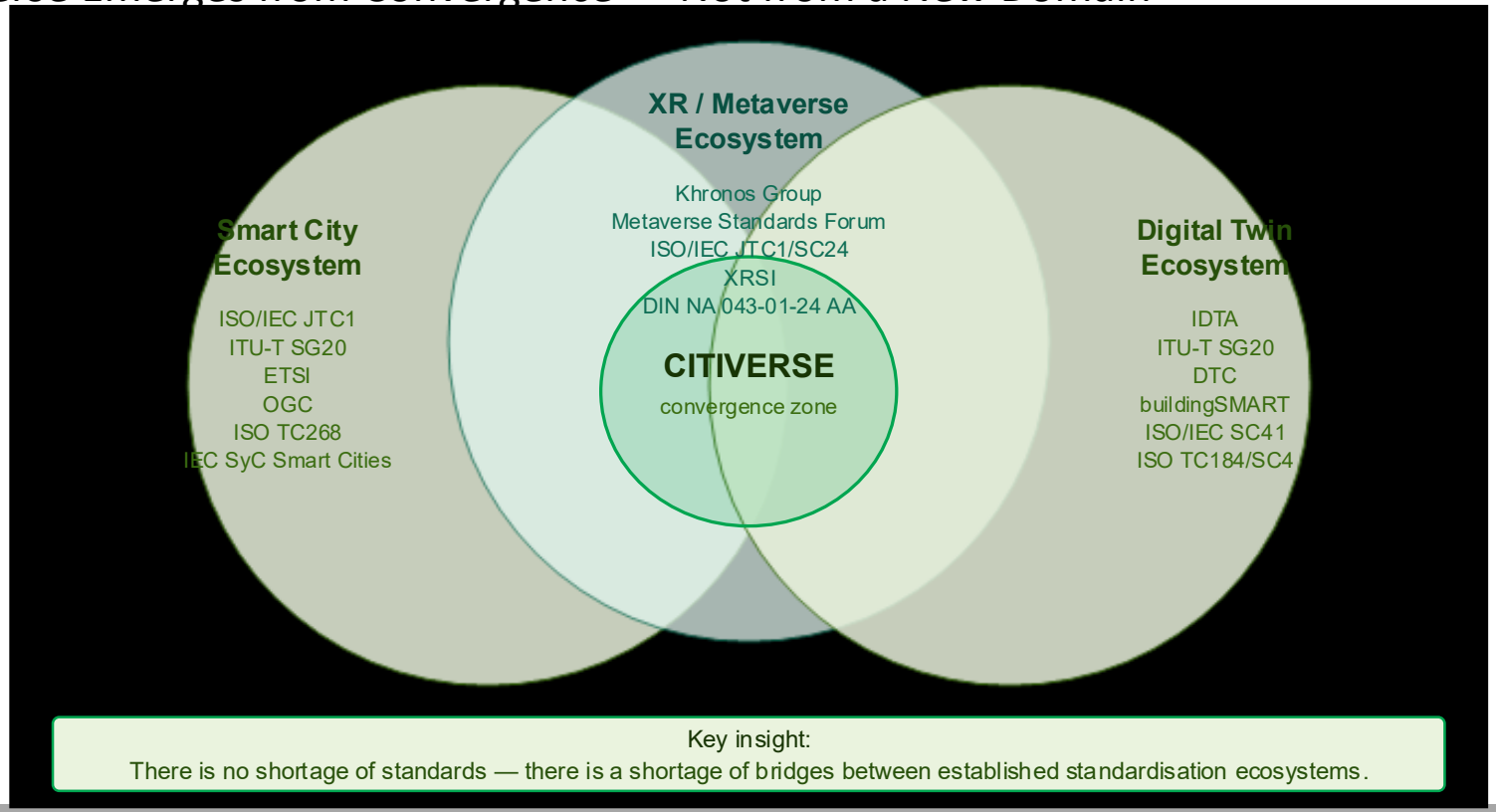
Artificial Intelligence — ISO/IEC JTC1/SC42 · IEEE · ITU-T · MPAI — ETSI 2025: 'critically underrepresented'

IoT / Connectivity — ITU-T SG20 · 3GPP · ISO/IEC · ETSI — Protocol diversity: MQTT, CoAP, OPC UA

XR / Virtual Worlds — ISO/IEC JTC1/SC24 · ITU-T · Khronos · IEEE — Largest entry count (962) — most mature

Trust & Governance — ISO/IEC 27xxx · IEEE · XRSI · ITU-T — XRSI unique: XR-specific ethics & privacy body

CitiVerse Emerges from Convergence — Not from a New Domain



Structural Gaps: Where Coordination Fails

From EUOS Register analysis

Smart Cities — only 52 entries
Smallest CitiVerse domain. Under-represented relative to its strategic importance.

AI — 125 entries, critically fragmented
ETSI 2025: AI 'critically underrepresented despite its central role' in immersive systems.

Cross-domain gap: Data Infra vs. XR
1,262 data infrastructure vs. 962 XR entries — separate ecosystems, minimal shared interfaces.

EUOS 2023: 6G (3) · Openness (1) · Inclusivity (2) — near-empty

From ETSI GR ARF 011 + ISO/IEC JTC1 TTR

No unified reference model
No framework integrates Smart City + Digital Twin + Metaverse for the CitiVerse. (ISO/IEC TTR 2026)

Process vs. pace mismatch
Technology evolves faster than standardisation cycles. Proprietary solutions fill the vacuum.

Power imbalances
Large corporations dominate SDOs. SMEs, cities, and civil society structurally excluded.

Geopolitical fragmentation
EU, US, China, Korea: competing frameworks with limited cross-recognition.

Implications for International CitiVerse Coordination

1 Fragmentation is structural

Cannot be solved domain by domain. A cross-SDO architecture layer is needed — the CitiVerse is the proof of concept.

2 Register before you standardise

Empirical mapping must precede new standardisation. Duplication and contradiction are avoidable.

3 Cities need a seat at the table

Municipal governments are primary CitiVerse stakeholders but nearly absent from SDO governance structures.

4 Governance before technology

Roles, data sovereignty, liability — most urgent CitiVerse gap. Not another rendering standard.

5 Europe has a strategic role

Open standards, human-centric, sovereignty-focused approach is a geopolitical opportunity.

6 Standards alone won't work

ETSI Top-10 Rec #4: approve only after multiple independent implementations. Testbeds essential.

Pathways Forward: Concrete Next Steps

01

Map before you build

Deploy empirical landscape tools — like the EUOS Register — as a shared CitiVerse resource. Identify gaps and overlaps before launching new WGs.

→ Establish a joint CitiVerse Standards Observatory

02

Bridge the ecosystems

Formal liaison mechanisms between CitiVerse SDO clusters:

Smart City (ITU-T SG20, ETSI, OGC)
↔ Digital Twin (IDTA, SC41)
↔ XR (Khronos, MSF, DIN)

→ ITU + ISO/IEC JTC1 joint coordination mandate

03

Pilot before standardising

Anchor every new CitiVerse standard in real city deployments. Standards proven in Rotterdam, Tampere, or Valencia set the baseline — not vice versa.

→ EDIC LDT/CitiVERSE as testbed for standard validation

The CitiVerse will be built on standards —
but only if those standards are built on coordination.

Thank you for your attention!

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„Without standards, there can be no improvement.“
Ōno Taiichi

(* 29 February 1912 in Manchuria; † 28 May 1990) was the inventor of the Toyota production system. He developed today's basic logistics methods, the Kanban system and just-in-time production, between 1950 and 1982. The Japanese management concept Kaizen is also based on his ideas.