Metaverse Standards Forum
Consistency of Experience

Last Update: November 03, 2025

Status: Approved for Public Distribution

Version: 1.0

Reviewer	Due Date	Status	Contact
3D Web Interoperability Group	May 01, 2025	Complete	3d_web_interop@lists.metaverse-standards.org
MSF Domains (Peer Review)	May 29, 2025	Complete	oversight@lists.metaverse-standards.org
Use Case Taskforce	November 03, 2025	Complete	use_case_task_force@lists.metaverse-standards.org

The purpose of this template is to provide a structured framework for collecting and documenting use cases within the Metaverse Standards Forum (MSF). Use cases are essential for understanding real-world scenarios where metaverse technologies are applied and where interoperability challenges may arise. This template guides MSF members in providing a concise yet comprehensive description of a use case, including its title, identifier, and summary. It also encourages contributors to list the benefits of the use case, identify actors or entities involved, and describe the use case scenario in detail, emphasizing interactions, challenges, and requirements. Additionally, it prompts the inclusion of relevant technical information, such as implementations, success metrics, and challenges faced. This template aims to facilitate the gathering of valuable use-case data to inform standards development and foster collaboration within the MSF community.

MSF members and MSF Domain Groups are invited to submit use cases.

NOTE: Organizations such SDOs who want to submit and add a use case would need a sponsor that is an MSF member. This process is established in order to have a contact person in MSF that can handle discussions and resolve open issues within regular meetings.

Eligible submitters:

- MSF Domain Groups
- MSF Members (Principal and Participant)
- External Organizations with Liaison Agreements (with the support of a MSF member that acts as sponsor)
- Standard Development Organizations (with the support of a MSF member that acts as sponsor)

Minimum Requirements for MSF Member Submissions not part of a Domain Group:

- Minimum required number of proposers: 3
- Minimum required number of supporters: 5

NOTE: Use cases submitted by SDOs and Liaison Organizations would also need to fulfill the same requirements (and would need a sponsor) unless they are submitted by a Domain Group.

MSF: *Metaverse Standards Forum*
POG: *Pre-qualified Organizations and Groups*
SPP: *Standards Related Publications and Projects*
DWG: *Domain Working Groups*
WG: *Working Group*
SDO: *Standards Development Organization*

Use Case Title

Consistency of Experience

Use Case Identifier

MSF2025-COE-001

- Version 1.0
- Year of Release: 2025

Summary of Use Case

Description: A visitor accessing the same virtual world via a web browser, from different devices (PC, phone, VR headset, VR/MR headset, MR headset, AR/MR glasses), will have a consistent experience, including environment, object, avatar scale, accessibility, and interactivity. The experience will be appropriate to the functionality of the device, and the intention of the virtual world creator (including full immersive experience in VR).

Benefits:

- Enables seamless scaling of virtual world environments, objects & embedded experiences
- Improves precision in physics application and collision detection techniques
- Enhances intuitive virtual world scene navigation and experience management
- Unlocks vast opportunities among virtual world objects interoperability
- Robustly displays player avatars and their features, including height, wearables & animations
- Elevates multiplayer synchronization, including voice-avatar lip sync and real-time avatar/object movement

- Ensures cross-device consistency in multiplayer experiences with identical avatars and interactions for players across varied devices
- Accommodates built-in security and safety protocols across all platforms and experiences
- Delivers uniform network performance for lag-free synchronization
- Streamlines consistent payment processing for frictionless transactions
- Amplifies immersive virtual experiences through universal, device-agnostic engagement

Contributors and Supporters

- 3D Web Interoperability Working Group
- MSF Domains (Peer Review)
- Use Case Taskforce

Keywords

3D Web, Cross platform compatibility, Cross platform consistency, User experience, Web XR, Web Browser, Immersive, Extended Reality (XR), Mixed Reality (MR), Augmented Reality (AR)

Actors/Entities

- **Player/Visitor:** User who loads the virtual experience via web browser (optionally selecting "Load in VR" or device-specific options for headsets) and interacts with the loaded environment.
- **Other Players/Visitors:** Additional users visible to the Player/Visitor in multiplayer sessions, enabling potential communication and interactions within the shared virtual experience.

Detailed Description of Use Case/Scenario

Preconditions:

1. **Supported Devices & Browsers**
   - Devices capable of running a web browser are available as specified per scenario:
     - **Scenario 1:** PC, Smartphone, VR headset, VR/MR headset.
     - **Scenario 2:** Smartphone, MR headset, VR/MR headset, AR/MR glasses.
     - **Scenario 3:** Smartphone, MR headset, AR/MR glasses.
   - Browsers are standards-compliant (WebXR / WebGL / WebGPU support where required) and up to date.
2. **Identity, Avatar and Data Portability**
   - The Player/Visitor possesses an authenticated, portable profile (Universal Manifest or equivalent) stored in secure, accessible cloud or decentralized repositories.

- Avatar assets, wallet pointers, consent settings, preferences and relevant metadata are retrievable cross-device.

3. **Standards & Server Capabilities**
   - The platform implements Universal Manifest / DID / verifiable credentials and supports session-based and persistent state synchronization for single- and multi-player instances.
   - Real-time networking services (position + animation sync, voice, object state replication) and mixed/augmented rendering pipelines are available and can be negotiated with the client.
4. **Device Capability Discovery**
   - The system can detect device type and capability (immersive VR support, MR capability, presence of camera/microphone, input modalities, BCI presence) and map to an experience variant.
5. **Privacy, Permissions & Consent**
   - The Player's/Visitor's privacy settings and consent selections (voice, microphone, camera, location, sharing, wallet access) are present in their profile and can be overridden at session or device level.
   - Platform must be able to record, apply, and propagate consent changes in-session.
6. **Interaction Mechanisms**
   - Navigation and interaction mechanics available server-side and client-side are defined, implemented per device type (keyboard, touch, gamepad/controllers, hand-tracking, spatial gestures, BCI).
   - Helper UI / onboarding guidance is available for each device modality.
7. **Persistence and State Rules**
   - Rules for persistence (which object states, avatar changes, purchases, placements persist between sessions) are defined and accessible to the client.
   - The Platform supports conflict resolution rules for concurrent multi-user edits.
8. **Performance & Comfort Constraints**
   - Target frame rate and latency budgets per modality are defined to maintain comfort (especially for immersive VR).
   - Locomotion speed limits and sickness mitigation patterns are defined for each device class.

Main Flow:

- **Scenario 1**: Fully Virtual World (Virtual Retail Store Visit)
  - **Devices:** PC, Smartphone, VR headset, VR/MR headset
  - **Mode:** Single and Multi-player fully virtual experiences

1. **URL Load:** The Player/Visitor opens their browser and navigates to the virtual retail store URL.
2. **Device Capability Negotiation**
   - Client reports device, browser, hardware features (XR support, controllers, input types, camera/microphone) to the server.

- Server determines the appropriate experience variant (fully virtual desktop/mobile view, or immersive VR) and returns capability confirmation or rejection.

3. **Initial Welcome / Session Pre-Configuration**
   - The Player/Visitor can update personal and experience-specific configuration settings before entering the experience.
   - The initial welcome page loads with:
     - Authentication prompt (optional if SSO or session cookie exists).
     - Avatar selection / profile retrieval option.
     - Experience options (immersive vs browser, single vs join lobby, accessibility settings).
     - Permissions prompt summary (microphone, camera, motion sensors, location, wallet access) pulled from the Player's/Visitor's profile and overridable.
4. **Avatar & Profile Retrieval**
   - If the Player/Visitor elects to use a stored avatar, the platform fetches avatar assets, wearables/accessories, wallet pointers, and preferences from cloud or decentralized storage and resolves any device-specific variations (LOD, rig differences).
   - If the Player/Visitor elects to use a third-party avatar, the platform must support fetching, parsing, and transforming external avatar standards (e.g., VRM, Ready Player Me) into the appropriate target runtime rig specification with proper LOD and scale adjustments for in-world use.
   - If the Player/Visitor elects to upload or locally select an avatar, the asset is validated for compatibility with the selected experience variant; if incompatible, the system notifies the user and offers fallbacks.
5. **Enter Experience Selection**
   - The Player/Visitor selects "Enter Virtual World".
   - If VR/VR-MR headset is used, an additional toggle offers immersive VR mode. The client prompts for any runtime XR session permission.
6. **Session Join & Instance Assignment**
   - Server assigns the Player/Visitor to a session instance:
     - **Single-player:** isolated instance.
     - **Multi-player:** shared instance or private room as requested.
   - The Player's/Visitor's presence is instantiated; initial transform, avatar appearance, and initial state sync occur.
7. **Multi-User Presence & Cross-Device Consistency**
   - **For multi-player instances:**
     - Server replicates presence to other participants.
     - Movement, animation, and interaction state are transmitted with metadata to ensure consistent representation across device types.
     - The platform applies device-appropriate scaling and LOD so that each Player/Visitor perceives other participants correctly relative to their own device's spatial context.
8. **Navigation & Movement**

- **The Player/Visitor navigates using device-appropriate controls:**
  - **PC:** keyboard (WASD) / mouse for rotation and movement.
  - **Smartphone:** touch gestures, virtual joystick.
  - **VR headset:** controllers, thumbsticks, teleport or smooth locomotion depending on configured options.
  - **VR/MR headset:** hand-tracking and/or controllers.
  - **BCI:** treated as alternate input channel with mapped navigation actions.
- The client enforces locomotion speed caps and comfort options depending on device and user preferences.

9. **Environmental Scale & Perceptual Consistency**
   - Scene scale is normalized:
     - **Browser/mobile:** environment may be scaled with camera FOV or zoom to preserve readable UI and relative object proportions.
     - **Immersive VR:** physical scale of objects and avatar must be accurate to human scale to avoid perceptual mismatch.
   - Mirrors and reflective surfaces render the Player/Visitor at expected height and proportions for the chosen modality.
10. **Collision & Spatial Integrity**
    - Physics or navigation constraints prevent walking through walls, dropping through floors, or entering non-navigable volumes.
    - Staircases and sloped surfaces provide smooth transitions and maintain correct avatar height relative to the environment.
11. **Object Interaction**
    - The Player/Visitor can pick up and relocate items (drag in 2D, grab/hold in 3D).
    - Interactions update authoritative object state on the server.
    - The server propagates object state changes to other participants in multi-player sessions so they observe moved objects consistently.
12. **Vertical Transport**
    - Stairs and elevators animate the Player's/Visitor's transform smoothly.
    - Elevator transit is synchronized for multi-player participants sharing the elevator instance; height and relative position are maintained.
13. **Voice & Real-time Communication**
    - If allowed, voice channels are established between participants.
    - Voice is routed with minimal latency; avatars with lip-sync capability animate mouth movement when voice data is present.
    - If avatars do not support lip sync, a fallback is used (voice bubble or indicator).
14. **Interactive Displays & UI**
    - The Player/Visitor can interact with informational displays and buttons.
    - Text and media are auto-formatted for readability per device (responsive UI layout).

- Buttons trigger informational animations or UI overlays (detail view, purchase flow, product specifications).

15. **Session Exit:** The Player/Visitor selects exit or closes the browser:
    - Client signals session termination to server.
    - Server removes presence and propagates exit to other participants so the Player/Visitor disappears from their instances.
    - Object state and any allowed persistence (cart contents, picked-up items that are flagged to persist) are committed according to platform persistence rules.

- **Scenario 2**: Mixed Reality World (Collaborative Furniture Selection)
  - **Devices:** Smartphone, MR headset, VR/MR headset, AR/MR glasses
  - **Mode:** Multiplayer mixed reality, real-world anchored placements

16. **User Location & Real-World Context Initialization**
    - The Player/Visitor and Other Players/Visitors open the same experience URL at the physical site where furniture will be visualized.
    - Client requests and receives permission to access necessary sensors (camera, spatial mapping, location).
17. **Device Capability Negotiation for MR**
    - Clients report MR capabilities (spatial mapping, SLAM support, plane detection, occlusion support).
    - Server returns the MR experience variant optimized for the participant's device capability set.
18. **Private Instance & Participant Invitations**
    - The Player/Visitor creates or joins a private instance of the MR session.
    - Invitations are sent to Other Players/Visitors (link, QR, or manifest-based join).
    - The private instance coordinates a shared spatial origin (world anchor) so that placements are aligned across all participants.
19. **Shared Spatial Anchoring & Alignment**
    - Clients perform anchor calibration:
      - Detect common real-world reference points or scan the environment to establish consistent coordinate frames.
      - Exchange anchor data and confirm alignment across participants.
20. **Mixed Reality Content Load**
    - An interactive furniture catalogue loads with assets optimized for MR (accurate scale, colliders, physics, PBR materials).
    - Each participant receives the same catalogue and metadata (dimensions, weight, price, material spec, energy estimate data if applicable).
21. **Catalog Browsing & Collaborative Discussion**
    - Participants scroll the catalogue; audio/voice and in-app chat facilitate real-time discussion.

- Because all participants are physically in the same real-world space, they do not require full avatars to see each other – they visually see each other physically.

22. Item Selection & Placement

- The Player/Visitor selects a furniture item and places it in the real-world coordinates.
- The placed item uses accurate scale and preserves physical constraints (clearance, collision with real-world geometry).
  - The placement is mirrored to Other Players/Visitors with transform and anchor metadata so all devices render the furniture at the same real-world location.

23. Concurrent Edits & Rearrangement

- Any participant can move or rotate placed furniture; server manages authoritative state and resolves potential conflicts (last-writer-wins or explicit lock/claim).
- Rearrangement actions propagate in near real-time to all participants with smooth interpolation to avoid visual popping.

24. Energy Consumption Estimation

- For furniture requiring energy (lighting, powered desks, smart furniture), the platform calculates an energy consumption estimate:
  - Uses item metadata (power draw, usage patterns) and local context (expected hours, user-configured schedules) to present an estimate.
  - All participants can view and discuss the energy estimate.

25. Predictive Modeling

- The platform runs predictive models to surface contextual recommendations and expected outcomes:
  - **Example models:** spatial fit confidence, ergonomics scoring, estimated maintenance or energy cost over time, compatibility with existing room systems.
  - Models execute server-side (or locally where privacy/edge rules permit) and return explainable outputs to participants.

26. Decision & Checkout / Save

- Participants finalize selections; options:
  - Save placement as proposal (persist anchors, metadata for later review).
  - Proceed to purchase or request a quote (invokes commerce or procurement flow with required credentials and wallet pointers).
- The commerce flow must utilize standardized, interoperable commerce APIs (e.g., Inventory Management, Pricing, Order Placement) to ensure the virtual purchase of physical goods reflects real-time stock availability and triggers the real-world fulfillment pipeline reliably and consistently across platforms.
- If proceeding to commerce, the system uses verifiable credentials as needed to confirm identity and payment authorization.

27. Session Termination

- Participants exit; placements that are saved persist per platform rules.
- Anchors used for alignment may be retained in persistent storage or discarded.

- **Scenario 3:** Mixed Reality Tourist Town Visit (Single-Player)

- **Devices**: Smartphone, MR headset, AR/MR glasses
- **Mode:** Single-player mixed reality, location-aware experience

1. **Local Arrival & Context Trigger**
   - The Player/Visitor arrives at the tourist town and opens the tourist experience URL in their browser
2. **Device Capability & Location Confirmation**
   - Client confirms device supports MR features required (camera, SLAM).
   - Client obtains location (GPS) and optionally requests permission to use local sensors for spatial mapping.
3. **Town Detection & Experience Options**
   - Server detects the Player's/Visitor's precise location and serves a set of relevant experience options:
     - Suggested walking tours, themed tours, historical overlays, AR exhibitions, accessibility-aware tours.
4. **Onboarding and Safety Guidance**
   - The system displays an onboarding overlay with safety guidance (watch surroundings, do not walk while using certain interactions), and control hints appropriate to the device.
5. **Visual Anchors & Dynamic Content Loading**
   - As the Player/Visitor moves, the client queries for POI (Points of Interest) data for the current vicinity and dynamically loads AR content:
     - Historical building overlays, short-form videos, animation layers, mapped camera-based augmentations.
6. **Guided Tours & POI Presentation**
   - Suggested walking tours appear with route guidance and estimated time.
   - At each POI, layered content appears:
     - Text summaries, optional videos, interactive hotspots, and animated reconstructions (views of the town from the past).
7. **Chatbot Avatars & Interactions**
   - The Player/Visitor can invoke chatbot-driven historical characters rendered as spatial AR avatars.
   - Avatar interactions include text/voice Q&A and optional guided micro-narrative experiences.
8. **Scale & Spatial Consistency**
   - All AR overlays and virtual reconstructions are scaled to real-world context and remain consistent across devices using local mapping and anchor persistence.
9. **Offline Resilience & Caching**
   - Frequently used assets (tour routes, nearby POI data) are cached for offline continuity where network conditions degrade.
10. **Exit & Auto-Close**
    - When the Player/Visitor leaves the geofenced area or selects exit, the experience cleans up AR anchors and auto-closes according to configured rules.

Alternative Flow

- **Scenario 1 Alternatives:** Fully Virtual World (Virtual Retail Store Visit)

1. **Unsupported Device**
   - If device capability check fails (device cannot render fully virtual experience), the system:
     - Presents a fallback “lite” 2D catalogue or product detail page, or
     - Instructs on which device/setting is needed to access full experience.
2. **Avatar Not Available on Device**
   - If the requested avatar asset is not accessible from cloud/local storage:
     - Offer a default portable avatar or a quick-create avatar with limited customization.
     - Provide instructions to upload or sync the desired avatar from another device.
3. **Partial Permission Denial**
   - If user denies microphone/camera mid-session:
     - Voice chat or certain MR features are disabled.
     - The system notifies other participants and replaces missing cues with text indicators or visual presence proxies.
4. **Network or Sync Failure**
   - On transient network loss:
     - Client caches local interactions and queues authoritative updates.
     - On reconnection, the client reconciles with the server authoritative state; conflicts resolved per rules.
   - On prolonged failure, the client may switch to single-player local mode with limited functionality.
5. **Motion Sickness / Comfort Request**
   - If the Player/Visitor experiences discomfort:
     - Offer an immediate comfort mode (teleportation, reduce motion, limit vertical acceleration).
     - Persist comfort preference for this device and user profile.
6. **Object State Conflict**
   - If two participants attempt to move the same object simultaneously:
     - Apply locking/claim mechanism or last-writer-wins based on configured conflict policy.
     - Notify affected participants of resolution.

- **Scenario 2:** Mixed Reality World (Collaborative Furniture Selection)

1. **Anchor Calibration Failure**
   - If spatial alignment cannot be established:
     - Offer manual alignment tools (manual marker placement, pin-and-align workflows).
     - If manual alignment fails, fall back to independent device-only local preview mode with note that placements will not be shared accurately.

2. **Catalog Asset Incompatibility**
   - If an item's asset is too high-fidelity for a participant's device:
     - Server provides a lower LOD or simplified proxy version.
     - Notify participants when proxies are used and allow one-click requests for higher fidelity when the device supports it.
3. **Predictive Modeling Failure**
   - If predictive models cannot run due to server or permission limitations:
     - Notify participants that energy/predictive analytics are temporarily unavailable.
     - Provide cached last-known estimates or a basic heuristic fallback.
4. **Commerce / Checkout Failure**
   - If commerce flow fails (payment, credential validation):
     - Offer save-and-continue flow to preserve placement and order details.
     - Provide clear error messages and guidance to resolve transactions.
5. **Privacy or Consent Withdrawal Mid-Collab**
   - If a participant withdraws consent to share location/anchor data:
     - Their device ceases to transmit anchor updates.
     - The server maintains previously shared anchor data per policy; others are notified of reduced visibility.

- **Scenario 3:** Mixed Reality Tourist Town Visit (Single-Player)

1. **Geolocation Mismatch**
   - If GPS or location data is inaccurate:
     - Offer manual point selection or scan-based local mapping to reposition experience elements.
2. **Sensor / SLAM Failure**
   - If SLAM cannot initialize:
     - Fall back to 2D route maps and audio-guided tours until mapping resumes.
3. **Content Overload / Performance Degradation**
   - If device shows rendering overload:
     - Auto-degrade visuals (reduce animation density, lower particle effects) and prioritize essential POI content.
4. **User Safety Override**
   - If the Player/Visitor fails safety checks (e.g., walking into a hazard while interacting):
     - System triggers an urgent overlay to stop certain interactions and provides audible warning; optionally pauses location-based interactions.

Postconditions

1. **Session Synchronization & Persistence**
   - If persistence is enabled, authoritative final state (saved placements, purchased items, cart contents, saved anchors) is committed to persistent storage and linked to the Player's/Visitor's profile.

- All ephemeral session states (temporary animations, unsaved object positions) are discarded according to retention rules.

2. **Privacy & Consent Enforcement**
   - Any in-session changes to privacy or consent are recorded and enforced across active participants and retained in the user's profile for future sessions where applicable.
3. **Presence & Verification**
   - Exited participants are removed from active presence lists; verification tokens used during the session are invalidated or refreshed according to session security policy.
4. **State Reconciliation**
   - After every session, server-side reconciliation verifies consistency for persisted objects and resolves any residual conflicts logged during the session.
5. **Accessibility & Comfort Persistence**
   - Device- and user-level comfort and accessibility settings (locomotion preferences, text scaling, audio captions) persist or are logged per retention policy.
6. **Audit & Logging**
   - Event logs capture critical operations: device capability negotiation, consent changes, commerce authorizations, anchor creation, object persistence events, predictive model outcomes, and conflict resolutions. Logs respect privacy and retention rules.
7. **Recovery & Recovery Points**
   - Where sessions are long-running or commerce-critical, checkpoints are stored so that in the event of client or network failure the Player/Visitor can resume with minimal disruption.
8. **Reporting & Analytics**
   - Platform analytics aggregate anonymized telemetry for performance, UX, predictive model accuracy, and energy estimation correctness; such analytics are used for continuous improvement while preserving user privacy.

Implementations and Demonstrations or Technical Feasibility

Implementations and Demonstrations

- Hubs (WebXR) by Hubs Foundation: The open-source successor to Mozilla Hubs—whose official support ended May 31, 2024–enables private, virtual 3D worlds directly in web browsers, empowering users to create and share consistent environments across devices (desktop, mobile, Web + WebXR) with immersive VR support on compatible headsets via standards like A-Frame and Three.js. This community-driven platform maintains low-friction collaboration, asset portability (e.g., glTF imports), and cross-platform fidelity without proprietary hosting, fostering accessible metaverse prototyping.
- eXtensible 3D Graphics Version 4 (X3Dv4): A major upgrade to the Extensible 3D (X3D) Graphics Standard that provides close support for the HTML5 Recommendation. X3Dv4 architecture and base components are designed to enable publishing and displaying interactive 3D content anywhere on the Web without requiring browser plugins, supporting new capabilities for immersive and interoperable applications via ISO/IEC 19775-1:2023.

Technical Feasibility:

- **Hubs Community Edition (Mozilla Legacy)**: Building on Mozilla's original framework—now independently maintained since the 2024 sunset—this enables default 3D templates or fully custom-coded environments (built on A-Frame and Three.js; Unity WebGL exports embeddable as static glTF assets, without native API pipelines). It delivers consistent experiences across devices (desktop, mobile, Web + WebXR, immersive VR) via open standards, with self-hosting on any infrastructure using Kubernetes for complete independence from Mozilla servers.
- **X3Dv4:** Using X3Dv4 Standard (ISO/IEC 19775-1:2023) makes core virtual world mechanics technically feasible. It offers built-in, standardized components for Physics (preventing walking through walls) and Navigation (managing movement speed and device-specific controls). This adherence to an open ISO standard ensures interoperability and simplifies implementing realistic user interaction across platforms.
- **Unity Technologies:** Supports WebXR experiences via its WebGL build target in combination with community-supported WebXR plugins and tooling (rather than full native built-in WebXR). Unity's current roadmap reflects emerging consideration of deeper WebXR alignment, but not full formal native commitment as of now. This workflow enables developers to deploy similar codebases across desktop, mobile, and VR headsets via web browsers–fostering consistency of experience and low-friction access.
- **Unreal Engine (Epic Games):** Emphasizes high-fidelity cross-platform consistency through its Pixel Streaming technology, which streams AAA-quality experiences to web browsers with low-latency support for XR inputs. For XR consistency, Unreal is a founding member of the OpenXR standard and provides full, active OpenXR runtime support, enabling standardized input/output handling across diverse VR/AR hardware.

Challenges:

- **Experience Consistency Challenge:** Determining the appropriate "consistency of experience" for the device. The challenge lies in harmonizing the user's perception and functionality across radically different hardware, from a small smartphone screen to a fully immersive VR headset.
- **Object Scale Consistency:** Ensuring the scale for all objects across all platforms/devices is appropriate for the platform/device. Inconsistent scaling breaks immersion and can cause motion sickness, particularly in VR.
- **Avatar Consistency:** Avatar (plus wearables) scale, movement, interactions are **consistent**. A user's digital representation must retain its identity, proportions, and animation fidelity regardless of the viewing device.
- **Complex Purchasing Scenario:** Purchasing goods is complex, especially in VR, and it's unclear whether we assume traditional FIAT payments or CRYPTO/Blockchain, along with the concept of "Bring your digital identity with you." Standardizing commerce requires resolving payment method integration and portable wallet/identity security.
- **Cross-Platform Security:** The challenge of security is paramount. A holistic, reliable, and non-intrusive security framework is needed to protect user identity, digital assets, and transactions across all environments.

- **Network Performance:** Specifically outside the home/office environment. Maintaining the low latency and high bandwidth required for real-time interaction is difficult on variable mobile connections.
- **Interaction Metaphors Standard:** Establishing consistent metaphors for user interaction, navigation, and physics. Users should intuitively know how to move and interact regardless of their device.
  - **Walk and Terrain:** Walk: terrain-following (avatar sizing: e.g. `stepHeight`, collision distance). This detail is vital for maintaining grounded, natural movement within the world's geometry.
  - **Collision Detection:** Ensuring effective User collision-detection to prevent avatars from passing through virtual objects or falling through floors.
  - **Interaction Modes:** Standardizing `Examine`, `lookat`, and other interaction modes that enable users to engage with objects and information effectively.
  - **Controller Mappings:** Controllers and button mappings which are application-specific (i.e. consider handedness). Customization must be flexible but intuitive for the user's input hardware.
  - **Object Physics Behavior:** Metaverse object physics (e.g. velocity, gravity). The virtual world must maintain uniform, believable physical laws for object behavior across all hosting platforms.

Requirements:

Technical and Functional Requirements

- **Standardized Experience Adjustment:** A technical mechanism is required to automatically adjust scale, physics handling, and navigation parameters to maintain a consistent user experience when transitioning between immersive VR and non-immersive web browser environments (PC or phone). This ensures the feeling of interaction and movement is stable across devices, even if the underlying mechanics differ.
- **Object Scale Integrity:** Implementation must ensure the scale of all objects in a scene remains proportionate to the player and to each other across all devices. This is critical in immersive VR where scale inaccuracies (objects appearing too large or too small) are immediately noticeable and can break presence, unless specifically intended by the experience design.
- **Avatar Scale and Asset Portability:** The system must ensure that avatar scale is appropriate to the platform/device, as badly scaled avatars severely degrade immersion in immersive VR. This must integrate with the concept of "take your avatar/accessories with you" to ensure seamless transfer and correct rendering of digital assets.
- **360 Media Scaling Correction:** The system must incorporate automatic scaling adjustments for content like 360 images and video, which typically appear twice the scale in immersive VR environments, to maintain visual accuracy and prevent distortion.
- **Adaptive Asset Streaming:** The system must implement an adaptive streaming mechanism for the delivery of large, high-fidelity digital assets (e.g., avatar meshes, high-resolution textures, furniture models) to the client. This mechanism must dynamically adjust the quality and compression of the asset payload in real-time based on the client's

instantaneous network bandwidth and device resource limits (VRAM, GPU load) to minimize load times and prevent download failure or mid-session stalls

Interoperability Requirements

- **Standardized Payment Methods:** A standard method (or methods) for purchasing goods must be available and function consistently across all platforms/devices. This is mandatory for supporting the concept of "take your digital wallet/identity/consent/preferences with you," which includes payment types.
- **Hybrid Payment Protocol:** The standardized payment protocols must, at least initially, include the option to use FIAT currency, as well as CRYPTO currency, ensuring broad user adoption and accessibility while managing the complexities of both traditional and blockchain-based transactions.
- **Consistent Security Standard:** Security must be consistent across all platforms/devices for the experience. The underlying security protocols protecting user identity, assets, and transactions must be uniform, regardless of the device or environment.
- **Dynamic Control Adaptation:** The system requires standardized APIs to dynamically map controls—including keyboard, hand swipe, hand gestures, VR controllers, and BCI-based navigation—to the appropriate in-world actions, ensuring that navigation remains consistent across diverse input methods (PC browser, Smartphone browser, AR/MR glasses, and immersive VR).

Other Key Considerations:

- **Privacy:** Privacy controls must specifically address the collection and use of behavioral data generated by the listed requirements (e.g., avatar movement patterns for walking/terrain, control preferences, and purchasing habits). This must also include the collection, storage, and persistence rules for real-world spatial data (e.g., shared spatial anchors and environmental maps) generated in Mixed Reality scenarios. This ensures compliance with regulations and user expectations regarding both non-visual behavior and highly sensitive environmental data.
- **Cybersecurity:** Cybersecurity measures must be robust and device agnostic to secure user data and experience consistency across all supported platforms (PC, phone, VR/MR headsets), mitigating risks from unauthorized access regardless of the user's hardware.
- **Identity Verification:** Identity verification must be integrated with the wallet component to authenticate user interaction during purchasing, specifically verifying the link between the user's "digital wallet/identity" and the selected payment method (FIAT or CRYPTO).
- **Networking and Latency:** Network and infrastructure optimization must achieve performance consistency both within the home/office environment and outside, with specific considerations for latency mitigation in rural environments to ensure equitable access to real-time experiences.
- **Ownership:** Ownership controls must allow users granular limits on the disclosure of their preferences, payment type defaults, and control settings as they move across platforms, supporting data sovereignty expectations linked to the "take your digital wallet/identity/consent/preferences with you" concept.
- **Digital Ethics:** Ethical standards must guide the implementation of scaling and consistency features to prevent manipulation or bias (e.g., ensuring avatar scale adjustments don't unintentionally promote body image issues or that control mappings don't exclude specific user groups).

- **Provenance:** Provenance tracking is necessary to maintain an immutable history of avatar accessories and assets, verifying their integrity and ownership when they are transferred via the "take your avatar/accessories with you" concept.
- **Accessibility:** The system must adhere to accessibility standards by ensuring that variations in control methods (gestures, BCI, etc.) and the scaling of objects and avatars are inclusive and configurable for users with different abilities.

Relevant Domain Working Group (WGs):

- 3D Asset Interoperability using USD and glTF
- Interoperable Characters/Avatars
- Digital Fashion Wearables for Avatars
- Digital Asset Management
- Real/Virtual World Integration
- Privacy, Cybersecurity and Identity
- Network Requirements and Capabilities

Relevant Pre-qualified Organizations and Groups (POGs):

- **W3C (World Wide Web Consortium):** Plays a key role in developing foundational web standards (such as HTML, CSS, and WebGL) and emerging specifications, like WebXR, that are essential for supporting and enabling the cross-platform consistency of experience across diverse devices in the metaverse.
- **Web3D Consortium:** An independent, member-driven organization that develops and promotes royalty-free, open ISO standards for 3D graphics and communication on the web. Its core standard, X3D (Extensible 3D), is critical for ensuring the functional and visual consistency of experience and long-term interoperability across diverse virtual environments.
- **Khronos Group:** An open, royalty-free consortium that develops standards for 3D graphics and XR. Its standards — including WebGL and OpenXR — enable consistency of experience by providing unified APIs for cross-platform 3D rendering directly in browsers (WebGL) and standardized input/output/spatial handling across diverse VR/AR hardware (OpenXR).

Relevant Specifications, Publications and Projects (SPPs):

- **OMA3 IWPS:** A protocol standard by the Open Metaverse Alliance for Web3 (OMA3), released in late 2024, that serves as the "3D hyperlink" for the open metaverse. The Inter-World Portaling System (IWPS) standardizes decentralized teleportation of user avatars and assets (as NFTs) across diverse virtual worlds via a two-phase negotiation-execution process. At its core, IWPS ensures frictionless, consistent experiences by coordinating identity verification, asset transfer, messaging (e.g.,

portal-embedded links), and permissions between platforms—unlocking true Web3 interoperability through open, blockchain-native standards.

- **WebXR Device API**: A W3C Candidate Recommendation Draft released on October 1, 2025, this royalty-free API provides a unified interface for accessing VR and AR hardware directly from web browsers, enabling seamless integration of sensors, head-mounted displays, and spatial tracking to deliver consistent, immersive experiences across devices without plugins or downloads. It abstracts hardware variances—such as input controllers, output displays, and real-time rendering—allowing developers to build once and deploy everywhere, from desktops to mobile XR headsets, thereby promoting low-friction, vendor-agnostic XR ecosystems with high-fidelity spatial interactions and cross-platform portability.
- **WebX3D**: Built on the ISO/IEC-certified X3D standard from the Web3D Consortium—with file encoding updates on track for completion in 2025—this royalty-free, open-source format and runtime architecture enables real-time 3D graphics through declarative XML or JavaScript APIs, supporting the authoring, streaming, and interactive manipulation of dynamic scenes in web environments. It ensures frictionless consistency by providing extensible tools for geometry, animation, lighting, and physics across browsers and devices, fostering interoperable 3D content exchange (e.g., via glTF integration) and empowering metaverse applications with scalable, high-performance rendering without proprietary lock-in.

Related Use Cases

- NFT Metadata for the Metaverse (General, MSF2025-NFTG-001)
- NFT Metadata for the Metaverse (Avatar, MSF2025-NFTA-001)
- NFT Wearables Metadata for the Metaverse (MSF2024-NFTMW-001)
- Metaverse Universal Manifest (MUM, MSF2025-MUM-001)

Additional Comments

- This document is a living artifact and may be subject to revisions on a periodic basis to reflect the future state of Consistency of Experience, and or based on feedback received from MSF stakeholders that warrants an update in the future.