Metaverse Standards Forum
Carousel Social Dancing across the Metaverse

Last Update: September 17, 2025

Status: Approved for Public Distribution

Version: 1.0

Reviewer	Due Date	Status	Contact
End-User Technical Troubleshooting Working Group	March 27, 2025	Complete	end_asset_management@lists.metaverse-standards.org
MSF Domains (Peer Review)	Apil 17, 2025	Complete	oversight@lists.metaverse-standards.org
Use Case Taskforce	September 17, 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

Carousel Social Dancing across the Metaverse

Use Case Identifier

MSF2025-CSR-001

- Version 1.0
- Year of Release: 2025

Summary of Use Case

Description: This use case addresses the testing of both generic and specialized hardware designed to support immersive dance interactions in the metaverse. It involves evaluating the performance, accuracy, and interoperability of a variety of devices such as motion capture systems, haptic feedback equipment, and standard VR/AR peripherals. The primary goal is to ensure a seamless, high-fidelity, and low-latency dance experience that is compatible across different metaverse platforms. The use case builds on the CAROUSEL European Research Project's objective to enable real-time co-presence and synchronized movements for both freestyle and classical partner dancing, focusing on challenges like sensor fusion, desynchronization due to network latency, and the integration of new haptic interfaces using existing hardware.

Benefits:

- Enhanced user experience for dance and other physical activities in the metaverse.
- Improved performance and reliability of both generic and specialized hardware.
- Increased interoperability between different types of hardware and metaverse software platforms.
- Contribution to the development of standards that support a wide range of physical interactions in virtual environments.

Contributors and Supporters

- End-User Technical Troubleshooting Working Group
- MSF Domains (Peer Review)
- Use Case Taskforce

Keywords

Metaverse Platforms, Hardware, Dance Interactions, User Experience, Feedback, Interoperability, Low-latency, Network, Virtual Reality (VR) / Augmented Reality (AR) / Extended Reality (XR)

Actors/Entities

- **End Users:** Individuals who use the hardware to engage in dance activities within the metaverse. They test the user experience and provide feedback on motion tracking accuracy, haptic feedback, and overall immersion during dance interactions.
- **Hardware Manufacturers:** Entities that produce and optimize generic and specialized hardware, including motion capture systems, VR/AR headsets, and haptic feedback devices. They ensure compatibility with Metaverse Platforms and implement updates based on user feedback.
- **Metaverse Platform Developers:** Entities that develop and maintain the metaverse platforms where dance interactions occur. They're responsible for integrating hardware support, ensuring interoperability between different devices, and refining the platform for low-latency, high-fidelity dance experiences.
- **Metaverse Platforms:** Digital environments specifically designed to enable online social dancing in the context of this use case. They are intended to provide virtual worlds and co-presence through technologies like VR/AR/XR, backed by AI and improved network latency to ensure a high-fidelity, real-time social experience.
- **Standards Development Organizations (SDOs):** Entities that develop and maintain interoperability standards for the metaverse. Their responsibilities include facilitating the creation and adoption of standards to ensure seamless interactions between different hardware and metaverse platforms, especially for physical activities like dance.
- **Network Providers:** such as cellular networks and Internet Service Providers (ISPs), are entities that provide the network infrastructure connecting users to the metaverse. They're responsible for ensuring stable, low-latency connections to support real-time dance

interactions, optimizing bandwidth for high-fidelity experiences, and troubleshooting any connectivity issues that could disrupt the user experience.

- **Test Engineers:** Professionals who conduct rigorous testing of hardware in controlled environments. They are responsible for designing and executing test cases that evaluate hardware performance, interoperability, and user experience for dance-related interactions, including assessing the impact of different network conditions.

Detailed Description of Use Case/Scenario

Preconditions:

- **Setup Hardware:** Devices, including VR headsets, motion capture suits, and haptic feedback devices and connect them to the User's metaverse account.
- **Stable Connectivity:** Ensure User's network connection (e.g., via ISP or cellular network) is stable and meets the minimum requirements for latency and bandwidth.
- **Configure Platform:** Test Engineers configure the Metaverse Platform to recognize and integrate each device
- **Optimized Network:** Network providers must ensure that the network infrastructure is optimized for real-time interactions, minimizing latency and packet loss.

Main Flow:

- **Initial Testing**
  - The user, equipped with the hardware, enters a virtual dance space within the metaverse.
  - The platform automatically calibrates the devices to ensure accurate motion tracking and haptic feedback corresponding to the user's movements.
  - Initial data on latency, motion accuracy, and haptic response is recorded for baseline analysis.
- **Dance Interaction Testing**
  - The user performs a series of dance routines, ranging from simple movements to complex choreography, to test the responsiveness and accuracy of the hardware.
  - During the interaction, the metaverse platform processes the user's movements in real-time, providing visual, auditory, and haptic feedback.
  - Test engineers monitor the hardware performance, focusing on aspects such as motion capture fidelity, the synchronicity of audio-visual feedback, and the impact of network conditions (e.g., varying levels of latency).
- **Interoperability Testing**
  - The user switches between different hardware setups (e.g., using different brands of VR headsets or motion capture suits) to assess interoperability across platforms.
  - The metaverse platform is tested for its ability to seamlessly integrate different devices without requiring extensive reconfiguration.
  - Data on the user experience, device compatibility, and any challenges faced during

switching is recorded.

Alternative Flow

- **Network Impact Assessment:**
  - The impact of different network conditions (e.g., high latency, low bandwidth, intermittent connectivity) on the dance experience is evaluated.
  - Engineers simulate network disruptions to observe how well the hardware and platform handle these issues.
  - The responsiveness of the platform and hardware under varying network conditions is measured, focusing on maintaining a consistent user experience.

Postconditions

- **Post-Test Analysis:**
  - After completing the tests, data is compiled and analyzed to identify any performance issues, interoperability challenges, or network-related disruptions.
  - The results are used to refine hardware designs, improve network configurations, and develop interoperability standards for future metaverse applications.

Implementations and Demonstrations or Technical Feasibility

Existing Implementations

- **CAROUSEL+ Project:** A European Innovation Council (EIC) funded research initiative. The project uses social dancing to explore how a combination of AI and immersive technologies can enable individuals to feel each other's presence, touch, and movement in a virtual space, thereby creating a more embodied and emotional online experience. .
- **Dance Graph:** A lab prototype showcased at the SIGGRAPH 2023 "Frontiers Workshop: Expressive Avatar Interactions in Online Co-Experiences" in Los Angeles. The prototype demonstrates a novel system for low-latency synchronous dancing and real-time avatar interactions in virtual environments .
- **Medica 2023:** The project had a presence at this medical trade fair. The focus was on demonstrating how online social dancing can combat loneliness and improve well-being. They showcased their AI-controlled dancing avatars, haptic feedback solutions for feeling connected, and methods to diminish latency.
- **Gamescom 2024: CAROUSEL+** had a booth and a presentation at the devcom Developer Conference, which is part of Gamescom. The presentation covered the concepts and technologies behind the project, including the "DanceGraph Engine" for synchronous dancing, the use of AI for autonomous dancing avatars, and a hands-on physical dance experience for the audience.

Demonstrations

- **Live Demonstration***:* A live demonstration at a metaverse event where users from different locations participate in a synchronized dance performance using a mix of generic and specialized hardware. The event showcases real-time performance, highlighting the seamless interaction between the devices and the platform.

- **Recorded Demonstration***:* A recorded demonstration featuring users with varying network conditions (e.g., high latency, low bandwidth) to show how different setups perform under less-than-ideal circumstances.

Technical Feasibility

- **Prototype Testing Environment:**
  - A controlled virtual dance studio in the metaverse is set up as the primary environment for testing. This studio is equipped with features like variable lighting, customizable soundscapes, and real-time audience simulation to mimic different dance performance scenarios.
  - Various prototypes of VR headsets, motion capture suits, and haptic feedback devices from multiple manufacturers are integrated into the studio. These prototypes are connected via a common metaverse platform to ensure interoperability.

Challenges:

- **Interoperability:** While current metaverse platforms support basic VR hardware and some specialized devices, achieving full cross-brand and cross-model compatibility depends on further standardization and testing.
- **Scalability:** Preliminary tests indicate that while most generic VR hardware is well-integrated, the incorporation of advanced motion capture and haptic devices presents scalability challenges, particularly concerning real-time synchronization and feedback.
- **Network and Latency:** The use case is heavily dependent on stable, high-speed internet connections (recommended latency of <50ms and bandwidth of 25 Mbps per user). Suboptimal network conditions can lead to significant degradation in user experience, particularly in the timing and accuracy of motion capture and feedback loops. Adaptive technologies, such as edge computing, may mitigate some of these issues.
- **Data Privacy:** The use case may involve the collection of highly sensitive biometric and behavioral data, including unique body movements, social interactions, and haptic feedback responses. Ensuring the secure handling, user consent, and anonymization of this data is a must.
- **Security:** A high degree of real-time interaction and immersion makes the platform vulnerable to new forms of attack. The main challenge is securing the high-fidelity data streams (e.g., motion capture, haptic feedback) and protecting digital identities and assets from unique threats such as avatar hijacking, social engineering, and data tampering.
- **Regulatory Compliance:** Operating a cross-border metaverse platform presents significant legal and jurisdictional complexities. A key challenge is navigating the diverse and evolving international laws related to data privacy (e.g., GDPR), digital asset ownership, and content moderation to ensure the platform remains compliant across all regions.

Requirements:

Technical and Functional Requirements

- **Scalable Infrastructure:** The underlying infrastructure, including the metaverse environment and cloud services, must support widespread adoption without performance degradation. It must process high volumes of real-time data from multiple VR goggles, stereo cameras, and audio devices simultaneously to maintain the illusion of a shared, synchronized space—particularly for AI-human dance pairings. The infrastructure should handle a wide range of devices, from mobile phones to high-end consoles, scale efficiently across operating systems, and dynamically orchestrate AI character instances with cost-effective GPU resource allocation.
- **Robust Security Measures:** Advanced security mechanisms, including encryption and secure credential verification, are essential to protect the high-fidelity data streams of the dance environment. The system must secure connections between all components, from in-house networks to carrier links, preventing tampering or unauthorized access. Sensitive biometric data (e.g., body movement tracking) and personal identity information from avatar repositories must be safeguarded against unique threats like avatar hijacking, especially in AI-driven scenarios where characters could mimic user behaviors.
- **Reliability:** The system must ensure real-time synchronization between all components to maintain the illusion of co-presence and fluid movement, extending to seamless AI-human interactions where AI characters autonomously respond to user cues. Conflict resolution protocols must resolve concurrent updates reliably (e.g., pose discrepancies in group dances) and maintain a seamless performance, with failover processes for AI inference or device connection delays.
- **User Interface:** The user interface must deliver an intuitive experience that supports embodied dance learning and performance flow. It should:
  - Simplify device setup (VR goggles, cameras, audio, and network).
  - Provide avatar customization, including AI dance partner style and skill adaptation.
  - Offer choreography tools or guided improvisation.
  - Include accessibility features (gesture assistance, haptic cues, voice-guided tutorials).
  - Provide clear controls for privacy, consent, and data sharing.
- **Notifications:** The system must send clear, contextual notifications about connection status, device performance, or AI desynchronization.
- **Uniform Interactions & Troubleshooting:** The system must enable uniform interactions and provide easy-to-use troubleshooting tools. This includes automated diagnostics that suggest quick fixes (e.g., switching audio input to reduce lag) and integrated logs for tracing AI-human interaction issues in real-time. Basic users should see simple recommendations, while advanced users can access detailed logs. The system should include network-specific diagnostics to identify and resolve issues related to in-house networks (e.g., Wi-Fi congestion), carrier networks (e.g., cellular signal drops), or long-haul networks (e.g., packet loss across countries), providing users with actionable steps to optimize connectivity for dance performances.
- **Data Submission and Verification:** The system must provide a secure and user-friendly process for submitting and verifying data generated during dance interactions, such as biometric movement data or user-customized choreography. Users should have clear, consent-driven options to submit data for AI training or community sharing (e.g., dance replays), with automated verification to ensure data integrity and authenticity. The system must log submission metadata (e.g., timestamp, device, user consent status) and align with applicable regulatory frameworks and requirements (e.g., EU AI Act and GDPR) for

transparency and auditability, enabling users to review or revoke submitted data at any time to maintain trust and support ethical AI-driven dance experiences.

Interoperability Requirements

- **Cross-Platform Compatibility:** The system must support diverse hardware and platforms, including legacy devices, by providing multiple integration options. Synchronization mechanisms must ensure consistent experiences across VR and non-VR setups (e.g., mobile previews for audiences watching Carousel's social outreach).
- **Standardized Protocols:** To ensure consistent interoperability, the system must adopt standardized protocols such as WebXR for VR, OpenPose-like frameworks for motion data, and MPEG-I (ISO/IEC 23090) for immersive streaming. These standards enable effective communication between VR goggles, stereo cameras, third-party avatar tools, and AI animation frameworks regardless of brand.
- **Endpoint Interoperability:** Users may operate multiple endpoints simultaneously (VR headset, stereo camera, phone). The system must fuse these into a coherent experience (e.g., blending VR visuals with phone audio and AI choreography). Troubleshooting tools must help users identify and resolve issues across endpoints without disrupting the performance.

Other Key Considerations:

- **Privacy:** The system must implement strict privacy policies for the collection, storage, and anonymization of sensitive biometric and behavioral data. AI training data must be opt-in by default, ensuring user trust. All permissions must be transparent, granular, and revocable at any time.
- **Networking and Latency:** The system must maintain end-to-end latency under 50ms for fluid AI-human dances. It should leverage edge computing and adaptive streaming for low-bandwidth environments, ensuring consistent synchronization across in-house, carrier, and long-haul networks.
- **Ownership:** Users must retain oversight and control over avatars and the data generated by their movements. Export tools must allow movement datasets to be saved in interoperable formats (e.g., BVH, glTF animation clips). Where third-party repositories are used, terms must not override user ownership.
- **Digital Ethics:** An ethics framework must oversee body movement capture, AI use, and avatar behaviors. It should align with EU guidelines and IEEE P7000 AI ethics standards, addressing risks such as bias in dance representation, manipulation in loneliness-combating sessions, and emotional exploitation.
- **Provenance:** The system must track the origin of all data to ensure trustworthiness. Metadata should identify which device or network produced the data and clearly tag AI-generated elements (e.g., poses, movements) to distinguish them from human inputs.
- **Accessibility:** The system must support users across technical expertise levels and hardware tiers. Accessibility features should include voice-guided onboarding, adaptive AI difficulty for dance partners, haptic feedback for rhythm, and simplified mobile interfaces. Inclusivity in design ensures the widest adoption.
- **Well-being Safeguards:** Since dance can be used for mental and physical well-being, AI must not reinforce harmful behaviors (e.g., body shaming, unhealthy comparisons). Safeguards must guide AI partners to encourage positive reinforcement and safe physical movement.

Metaverse STANDARDS FORUM™

Relevant Domain Working Group (WGs):

- NA

Relevant Pre-qualified Organizations and Groups (POGs):

- **ITU/TM Forum:** Focus on network monitoring and developing standards for low-latency, real-time metaverse interactions, which is key to addressing the network challenges of this use case.
- **IEEE VR/AR Working Group:** This group develops standards for VR/AR technologies, including hardware such as VR headsets and motion capture systems. Their work directly impacts the implementation of this use case.
- **3GPP (3rd Generation Partnership Project):** Develops protocols for mobile telecommunications that support the low-latency communication required for real-time metaverse interactions, addressing the network challenges outlined in this use case.
- **W3C Immersive Web Working Group / WebXR:** This group is involved in creating web standards for immersive experiences, including the WebXR API. Their work directly impacts the interoperability and performance of hardware in the metaverse.

Relevant Specifications, Publications and Projects (SPPs):

- **Carousel Dance Project** (https://www.carouseldancing.org)
- **IEEE P2048 Standard for Virtual Reality and Augmented Reality:** This standard provides guidelines for the development and integration of VR/AR hardware, which are directly applicable to the devices used in this use case.
- **ITU-T Y.3101 - Framework of the IMT-2020 Network:** This ITU standard outlines the network performance requirements for 5G networks, which are critical for supporting the low-latency needs of metaverse interactions.
- **W3C WebXR Device API:** This specification allows for the integration of XR devices with web applications, ensuring that hardware used in the metaverse can operate effectively in a web-based environment.

Related Use Cases

- **Potential and Related Use Cases:**
  - **Motion Capture for Fitness Applications in the Metaverse:** This use case explores the application of motion capture hardware for fitness activities, sharing similar challenges with dance in terms of ensuring accurate motion tracking and a positive user experience.
  - **Haptic Feedback in Virtual Training Environments:** This use case explores the application of haptic feedback devices in virtual training, which directly relates to the need for consistent and realistic feedback during dance interactions.
  - **Cross-Platform Avatar Movement Synchronization:** This use case addresses

the challenge of synchronizing avatar movements across different metaverse platforms. This is critical for ensuring that dance interactions remain consistent and accurate, regardless of the user's hardware.

Additional Comments

- This use case highlights the importance of collaborative efforts between hardware manufacturers, network providers, and metaverse platform developers to create a truly immersive and accessible dance experience.
- Future developments in AI-driven motion prediction and adaptive network technologies will be key to enhancing the feasibility and effectiveness of this use case.
- This document is a living artifact and may be subject to revisions on a periodic basis to reflect the future state of Carousel Social Dancing across the Metaverse, and or based on feedback received from MSF stakeholders that warrants an update in the future.