

Gaming Engine Programming & Requirements Document for Immersive Virtual Driving Experience (IVDE)

Version: 1.0

Date: 2025-07-20

Author: Engineering & AI Team

1. Purpose & Scope

This document outlines the **programming, functional, non-functional (FURPS+), and interface requirements** for the IVDE gaming engine, integrating AI, GPS, and street view applications. It aligns with the **AI Requirements Specification, Technical Design Document (TDD), and Vision Concept**.

2. Functional Requirements (FURPS+)

2.1 Core Engine Functions

ID	Requirement	Description	Acceptance Criteria
FE-01	Real-Time Rendering	Photorealistic rendering (UE5 Nanite/Lumen) with HDR10, DLSS/FSR upscaling.	≤11ms/eye @90Hz VR, PSNR >40dB.
FE-02	Physics Simulation	Deterministic vehicle dynamics (Pacejka tire model, Chaos collisions).	120Hz tick rate, <1ms jitter.
FE-03	World Streaming	Dynamic tiled map loading with AI gap-filling (ALG-01).	≤300ms texture fill for 20m gaps.
FE-04	Multiplayer Sync	Lockstep state replication (10Hz authoritative server).	<120ms RTT, zero desyncs.
FE-05	AI Traffic (ALG-02)	Graph-RL agents for region-specific traffic.	≤40ms/tick, 85% realism score.

2.2 AI Integration

ID	Requirement	Description	Acceptance Criteria
AI-01	Generative World Synthesis	Latent Diffusion + ESRGAN for missing textures.	1024x1024 textures in ≤80ms (RTX 4070 Ti).

ID	Requirement	Description	Acceptance Criteria
AI-02	Emotion Adaptation (ALG-03)	Multimodal sentiment analysis (voice, HRV, gaze).	Valence/arousal output in <50ms.
AI-03	Predictive Streaming (ALG-04)	Transformer-based path prediction.	Pre-loads 60 poses in 10ms.

2.3 GPS & Street View Integration

ID	Requirement	Description	Acceptance Criteria
GPS-01	Real-World Route Import	GPX/KML parsing with POI tagging.	100% route accuracy, <1s load time.
GPS-02	Live Traffic Data	API integration (TomTom/Google Maps).	5s update latency, 95% accuracy.
SV-01	Street View Synthesis	AI-upscaled 8K panoramas (D-01).	≥85% visual similarity to source.

3. Non-Functional Requirements (FURPS+)

3.1 Performance

- **Latency:** ≤120ms end-to-end VR inference (AI-02).
- **Bandwidth:** ≤80KB/s avg (delta compression + FEC).
- **GPU Utilization:** ≤70% on RTX A6000 (48GB VRAM).

3.2 Security & Compliance

- **Data Encryption:** AES-256 for models, DTLS 1.3 for UDP.
- **Privacy:** GDPR/CCPA compliance; voice data deleted in 24h (D-04).

3.3 Scalability

- **Concurrent Users:** 8 players/convoy, 10K CCU per region.
- **Edge Deployment:** Qualcomm XR3 (8 TOPS NPU) support.

3.4 Usability

- **Accessibility:** WCAG 2.2 AA (subtitles, color-blind modes).
- **Localization:** 12 languages, ICU plural rules.

4. Interface Requirements

4.1 AI Microservices (gRPC/HTTP)

Endpoint	Protocol	Request/Response	Rate Limit
/ai/world-synth/fil l	gRPC	TileID, Pos → TexID (PNG)	20 req/s
/ai/mood/analyse	WebSocket	PCM Audio → Valence/Arousal	50 kB/s
/ai/npc/chat	HTTP/2	route_id, locale → NPC reply	5 req/10s

4.2 GPS/Street View APIs

Service	Integratio n	Data Format	Latency
TomTom Maps	REST	GeoJSON	<500ms
Google Street View	HTTP/2	Equirect JPEG	≤1s (cache)

4.3 Game Engine SDK

- **Languages:** C++, C#, TypeScript.
- **Telemetry:** model_version field for traceability.
- **Retry Policy:** Exponential backoff (max 3 attempts).

5. Data & MLOps Requirements

- **Training Data:** Licensed Street View (20TB), traffic CCTV.
- **Feature Store:** Feast on Snowflake.
- **Model Registry:** MLflow (signed artifacts).

6. Risk Mitigation

Risk	Mitigation
Model drift (traffic)	Live retraining + shadow testing.
GPU shortage	Edge-TPU fallback (ALG-06).
Toxic voice chat	Real-time NLP moderation (F1≥0.95).

7. Appendix

- **A1:** OpenAPI 3.1 specs for AI endpoints.
- **A2:** Sensor calibration procedures (S-01 to S-06).
- **A3:** Benchmark datasets (World Synth Bench v1).

Approval:
Engineering Lead: [Signature]
AI Architect: [Signature]
Date: 2025-07-20

Document Control:

- **Version 1.0:** Initial release.
- **Version 0.9:** Draft for review (2025-07-19).

Attachments:

- AI Requirements Specification.docx
- Technical Design Document.docx
- Vision Concept & Business Case.docx