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**Keywords:** AI Native Network; PoC;

**Abstract:** This document describes a submission towards Build-a-thon 4.0, 2026 conducted in New Delhi on February 17th, 2026.

## 1. Introduction

1.a) Background to the Topic: The Precise Positioning Imperative

Precise positioning is a foundational dependency for safety-critical and mission-critical mobility services such as autonomous driving, advanced driver assistance (ADAS), fleet automation, emergency response, and intelligent logistics. Under open-sky conditions, conventional GNSS can provide acceptable positioning, but its performance degrades sharply in tunnels, urban canyons, dense city blocks, and signal-blocked zones, where satellite visibility is reduced and multipath reflections dominate. In such conditions, positioning errors can escalate from centimetres to metres within seconds, forcing systems to fall back to dead-reckoning and other sensors, increasing cost and operational complexity.

High-precision techniques such as RTK (Real-Time Kinematic) can deliver centimetre-level accuracy by applying real-time corrections derived from reference stations. However, RTK depends on continuous availability of correction messages and stable radio delivery, which is often unreliable or economically inefficient in challenging coverage environments. Consequently, there is a practical need for a robust, scalable, and cost-efficient correction delivery and control mechanism that sustains high-precision positioning even when GNSS observability and connectivity fluctuate.

This PoC addresses that need by leveraging broadcast delivery (ATSC 3.0) for wide-area dissemination of correction and positioning assistance data, combined with an AI-native control loop that dynamically adapts the delivery strategy based on observed fleet positioning outcomes.

1.b) Need for AI-Native Positioning Automation (Non-Radio Focus)

Traditional positioning augmentation systems typically operate with static configurations: fixed correction message types, fixed update rates, fixed robustness settings, and limited feedback regarding whether field receivers actually achieve the intended RTK performance. This “configure once, operate forever” approach is misaligned with real environments where the optimal trade-off between accuracy, reliability, latency, and broadcast resource usag**e** varies by geography (tunnels vs open sky), time (traffic density, blockage patterns), and receiver conditions.

The proposed PoC adopts an AI-native, intent-driven paradigm, where the system exposes a service intent interface (e.g., *maximise accuracy*, *maximise reliability*, *minimise bandwidth*, *prioritise tunnel corridors*) and continuously translates that intent into real-time operational decisions for the positioning assistance pipeline. The key shift is the introduction of a closed-loop feedback controller that uses fleet telemetry to evaluate outcomes (e.g., RTK FIX availability, positioning degradation events) and then adjusts broadcast and edge delivery parameters accordingly.

This architecture is explicitly aligned with AI-native principles for non-radio functions: it embeds intelligence into the operational fabric via continuous observation → decision → actuation → validation, enabling the system to (i) adapt to real-time conditions, (ii) avoid wasteful over-provisioning during “good” conditions, and (iii) increase robustness when the environment deteriorates.

1. c) Proposed PoC Overview: Intent-Driven AI-Native Precise Positioning-as-a-Service

This PoC demonstrates an **Intent-Driven AI-Native Precise Positioning-as-a-Service** platform that sustains high-precision vehicle positioning in extreme GNSS environments (tunnels, urban canyons, blockage zones) by combining:

- **GNSS reference station corrections** (RTK-style error vectors; RTCM-like correction streams),
- **Broadcast delivery using ATSC 3.0** (one-to-many dissemination of corrections and positioning assistance),
- **Bitmap / grid-based positioning assistance** (coverage-aware augmentation, location-dependent robustness and assistance payloads),
- **AI-driven adaptive control** of correction delivery policies (e.g., update rate, redundancy, tile/bitmap resolution, robustness/FEC-style settings, and bandwidth allocation).

The core innovation is that a **real-time AI controller** adapts the positioning assistance strategy based on fleet-level observed performance. Instead of assuming that “more corrections” always help, the system continuously measures whether vehicles maintain high-precision states (e.g., RTK FIX) and dynamically adjusts the pipeline to maximise outcome metrics under resource constraints.

Target outcomes for the PoC are:

- **3–10 cm positioning accuracy** under representative conditions,
- **high reliability** in rural and obstructed zones (including tunnel-like signal loss events),
- **efficient utilisation of ATSC 3.0 broadcast capacity**, prioritising robustness only where and when needed.

## 2. State of the Art in High-Precision Positioning Augmentation

### 2.a) Current High-Precision GNSS and Correction Delivery Approaches

Standard GNSS typically provides metre-level accuracy, which is insufficient for autonomy and safety-critical mobility. RTK-class positioning improves accuracy to centimetre-level by using carrier-phase measurements together with real-time corrections from a reference/base station; however, RTK performance depends on timely delivery of those corrections and degrades when conditions deteriorate (e.g., blockage, multipath). This PoC positions **ATSC 3.0** as a scalable one-to-many correction distribution channel, leveraging wide-area broadcast range and configurable robustness/capacity trade-offs (with practical broadcast latency on the order of seconds) to disseminate correction and assistance data to many receivers simultaneously.

### 2.b) Broadcast-Delivered Positioning Assistance and Adaptive Broadcasting

Academic work has investigated GNSS error modelling (ionospheric/tropospheric effects), multipath-aware positioning, map-assisted localisation, and learning-based techniques to predict or detect positioning degradation. Research has also explored adaptive communications and edge processing to optimise reliability and latency for distributed systems. Despite these advances, many solutions remain siloed: either optimising GNSS estimation without controlling delivery resources, or optimising delivery without closing the loop on positioning outcomes at the receiver.

### 2.c) Practical Standardisation and Interoperability Considerations

High-precision correction ecosystems often depend on established message formats and receiver interoperability constraints. Broadcast delivery introduces additional considerations around packaging, scheduling, and robustness configuration. A key practical requirement is therefore an architectural approach that preserves interoperability at the positioning layer while enabling policy-level adaptation at the orchestration layer.

## 3. Research Gaps and System Limitations Addressed by this PoC

Analysis of real-world deployment constraints reveals four core gaps that this PoC addresses:

- **GPS Signal Loss in Tunnels and Deep Blockage Zones:** Vehicles can lose centimetre-level positioning for extended intervals when satellite visibility collapses. A static correction delivery strategy does not provide sufficient robustness across such transitions.
- **Uncertainty in Urban Canyons (Multipath and NLOS):** GNSS performance degrades due to reflections and non-line-of-sight reception. Without environment awareness, systems cannot selectively increase robustness where multipath risk is highest.
- **Wasted Broadcast Resources Under Good Conditions:** Broadcasting at a uniformly high robustness level everywhere is inefficient. The system needs to scale broadcast robustness and payload composition according to real-time needs.
- **No Closed-Loop Feedback from Field Outcomes:** Traditional systems do not directly optimise for fleet-level outcome metrics (e.g., RTK FIX availability, degradation duration).

This PoC introduces a telemetry-driven feedback loop so that decisions are validated against observed positioning performance.

## 4. Technological Foundations and Proposed Architecture (AI-Positioning PoC)

### 4.a) A Closed-Loop Intent-Driven Control System

The PoC is designed as a closed-loop system that continuously translates service intent into operational control actions:

**Observe:** Vehicles/receivers provide positioning telemetry (e.g., accuracy indicators, FIX/float state, degradation events) and contextual signals (location corridor, blockage risk).
**Decide:** An AI decision engine selects policies that best satisfy the declared intent (accuracy/reliability/bandwidth objectives).
**Act:** The controller generates a broadcast assistance configuration (payload composition, update strategy, robustness level, bitmap/tile policies).
**Validate:** Outcomes are measured at the fleet level; the controller updates policies to improve performance over time.

This delivers AI-native behaviour by construction: the system is outcome-driven, adaptive, and continuously validated against real telemetry.

### 4.b) Broadcast-Assisted Positioning Delivery Using ATSC 3.0

ATSC 3.0 is utilized as the wide-area broadcast mechanism to disseminate positioning assistance data efficiently at scale. The PoC design uses broadcast delivery to reduce per-vehicle dependency on unicast connectivity while preserving the ability to adapt delivery robustness dynamically. Where required, the architecture supports fallback policies (e.g., selective unicast supplementation) without undermining the core broadcast-first design.

### 4.c) System Specifications and Success Metrics

i. **Target accuracy:** Maintain **centimetre-class positioning (≈3–10 cm, where conditions permit)**, with controlled degradation behaviour under deep blockage and severe multipath (e.g., tunnel segments, dense urban canyon).
ii. **Reliability objective:** Increase **RTK FIX availability** and **valid correction availability** by ensuring broadcast-delivered corrections/assistance remain decodable and fresh across varying channel conditions, reducing time spent in degraded states (FLOAT / standalone).
iii. **Continuity objective:** Minimise service interruptions by reducing **dropout/degradation events per corridor/trip** and reducing outage-induced error spikes, with faster recovery back to FIX after GNSS loss or impaired reception.
iv. **Efficiency objective:** Optimise ATSC 3.0 broadcast resource usage by dynamically tuning the **positioning datacast policy**—including **correction update rate**, **redundancy/repetition**, **FEC/robustness settings**, and **bitmap/tile resolution/refresh strategy**—based on fleet telemetry, channel state, and geo-context, while staying within an intent-dependent broadcast budget.
v. **Closed-loop control specification:** The **Data Aggregator & AI Feedback Controller (AI Agent)** shall ingest fleet/receiver telemetry and environment features, run inference with a confidence check, and output actionable configuration updates for the ATSC 3.0 positioning service (PLP distribution/robustness, payload

strategy, and scheduling). The broadcast chain shall apply these updates and the resulting positioning outcomes shall be fed back to the controller to close the loop.

## 5. Current Status & Demo Proposal

Our project, **"Intent-Driven AI-Native Precise Positioning-as-a-Service over ATSC 3.0,"** will culminate in a demonstration of a complete, closed-loop **adaptive positioning datacast** workflow in a controlled simulation/testbed. The demo will show how fleet telemetry and operator intent drive **dynamic configuration of the ATSC 3.0 positioning service**—including correction delivery strategy and assistance/bitmap policy—so that **centimetre-class positioning performance is sustained where feasible** while **broadcast resources are kept within a configured budget**.

The demonstration will visualise the following sequence:

- **The system observes the fleet and channel state**, using aggregated positioning outcomes and broadcast/network indicators (e.g., FIX/FLOAT distribution, convergence time, correction availability/age, packet loss patterns, and geo-context such as open-sky vs tunnel/urban canyon via assistance maps).
- **The Data Aggregator & AI Feedback Controller executes the decision loop**:
  - gathers fleet telemetry and environment features,
  - runs **neural-network inference** to determine broadcast configuration,
  - performs a **confidence check** and falls back to conservative/rule-based logic when confidence is low,
  - generates a broadcast command that adjusts the positioning datacast policy (e.g., **redundancy**, **correction update frequency**, **bitmap/tile resolution**, **FEC overhead**, and **PLP distribution**).
- **The ATSC 3.0 Broadcast Encoder applies the AI command** by packaging RTCM correction frames and assistance/bitmap tiles according to the selected policy (priority, scheduling, redundancy insertion, and robustness settings), and transmits them over the ATSC 3.0 RF channel using the configured protection settings (e.g., FEC/PLP choices).
- **The receiver / client pipeline consumes the datacast** (corrections + assistance), updates the positioning solution (e.g., RTK engine / fusion parameters as applicable), and reports the resulting performance back to the controller to close the loop (telemetry → decision → broadcast update → improved outcome).
- **The results are presented as baseline vs AI-adaptive comparative runs**, showing time-series improvements in positioning stability and continuity under impairments (tunnel-like outages / urban-canyon multipath) alongside controlled broadcast overhead and spectrum use.

**Success metrics measured by:**

- **Positioning Quality:** ΔHPE_p95 (and where applicable ΔVPE_p95), RTK FIX availability (% time FIX), and **TTR** (time-to-recover after outage/degradation).
- **Reliability / Correction Availability:** valid correction availability at the receiver and correction age / freshness under stress scenarios (tunnel/urban canyon).
- **Correction Delivery Latency:** broadcast → receiver decode latency and end-to-end time to usable correction/assistance at the client.
- **ATSC 3.0 Spectrum Efficiency / Overhead:** relative broadcast resource usage versus baseline (e.g., effective bits/s/Hz for correction PLP and incremental overhead from redundancy/FEC/tiles).
- **Service Continuity:** dropout/degradation event rate per trip/corridor and reduction in outage-induced error spikes (especially in tunnel/urban canyon segments).

**Target:** Maintain **centimetre-class performance (≈3–10 cm where conditions permit)**, improve **RTK FIX availability** and reduce **TTR**, while keeping broadcast usage **within the configured budget** via adaptive redundancy/FEC/update-rate/tile policy decisions.

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| *Submission Id* | *FG-AINN-PoC-xxx*<br>*(Id number is to be assigned by the secretariat)* |
| *Title* | Intent-Driven AI-Native Precise Positioning-as-a-Service over ATSC 3.0 (RTK + Bitmap Assistance with Closed-Loop Orchestration) |
| *Created by* | Team: NoWiresAttached<br>Team lead: Ms. Tarunika D.<br>Team members:<br>1.Mr. Anirudh Nishtala<br>2.Mr. Rishiraj Rakesh Kumar<br>Internal guide: Asst. Prof. Dr. Shweta Singh |
| *Creation date* | 13 January 2026 |
| *Category* | Intent-Based AI Agents; AI-Native Orchestration; Distributed Decision-Making; Resilience-Centric AI Inference (Service Continuity under GNSS Impairments) |
| *PoC Objective* | To demonstrate an **intent-driven AI-native precise positioning system delivered through ATSC 3.0 broadcast**, where operator/service intents (e.g., **maximise accuracy**, **maximise reliability in challenging environments**, **optimise ATSC 3.0 spectrum usage**) are **automatically translated by an AI agent into real-time configurations** of the positioning pipeline (broadcast PLPs, correction strategy, and edge policies). |
| *Description* | This PoC implements a **closed-loop broadcast-assisted RTK positioning service**. A base/reference segment generates **RTCM/RTK corrections** and **bitmap/grid error maps**, which are delivered over **ATSC 3.0 datacast**. Vehicles/clients compute positions using an RTK engine (e.g., RTKLIB) and send **telemetry feedback** (e.g., fix availability/quality indicators) back to the AI decision function. The **AI agent adapts the broadcast strategy in real time** by tuning parameters such as **PLP robustness/FEC, redundancy, correction update rate, and tile resolution**, so that centimeter-level performance is sustained in **tunnels/urban canyons/signal blockage zones**, while controlling broadcast resource usage. |
| *Feedback to WG1* — *Gaps Addressed* | • Demonstrates **intent-driven orchestration** where high-level service intents are mapped to **concrete broadcast + positioning controls** (PLP configuration, RTK/SSR/bitmap policy, edge processing).<br>• Establishes a measurable **closed-loop control model** for AI-native positioning: fleet/receiver telemetry → AI decision → broadcast adaptation → improved positioning outcomes.<br>• Defines **PoC-level KPIs** spanning accuracy, reliability, latency, spectrum efficiency, and continuity for evaluation consistency. |
| *POCs Test Setup* | **Software-defined PoC stack (open-source-first):** |

<table>
<tr><td colspan="2"></td><td><ul><li>GNSS/RTK: RTKLIB-based baseline and assisted positioning runs producing .pos outputs.</li><li>Broadcast pipeline (ATSC 3.0 data): ALP encapsulation + ROUTE/DASH packaging + service signalling; positioning data carried as datacast objects/streams.</li><li>AI control loop: intent parser + decision engine/optimiser + controller that updates broadcast/positioning parameters (e.g., PLP robustness, correction rate, tile resolution).</li><li>Receiver/client pipeline: ATSC 3.0 client (ALP/ROUTE/DASH) feeds correction/bitmap inputs into positioning client (RTK/SSR + bitmap consumer).</li><li>Orchestration/analytics interface: REST/gRPC style intent input plus real-time analytics outputs for demo visualization.</li></ul></td></tr>
<tr><td colspan="2">Data Sets</td><td>• GNSS observation logs for baseline and assisted runs (sample logs sufficient for PoC).<br><br>• RTK correction frames (RTCM/MSM): from RTKLIB sample RTCM or synthesised generator.<br><br>• Bitmap tiles / grid maps: small synthetic tiles (e.g., 100×100) representing correction coverage / environmental error masks.<br><br>• Telemetry features: correction age, position residuals, integrity indicators, PLP loss, and environmental state indicators used as AI inputs.</td></tr>
<tr><td>Feedback to WG2</td><td>Simulated Use cases</td><td>The PoC evaluates intent-driven adaptation under representative scenarios:<ol><li>High-Accuracy Rural Drone: intent “guarantee sub-10 cm accuracy” → increase correction rate, high-resolution tiles, stronger PLP robustness.</li><li>Low-Bandwidth Rural Coverage: intent “optimize ATSC spectrum use” → reduce correction bitrate, switch to lower-rate policy, reduce PLP bandwidth.</li><li>Urban Canyon Reliability: intent “maximize reliability” → strengthen grids/tiles + integrity updates, adjust multipath mitigation/fusion weighting.</li></ol></td></tr>
<tr><td>Feedback to WG3</td><td>Architectural concepts</td><td>Reference architecture comprising:<ul><li>GNSS reference/base station segment producing RTCM corrections and grid/bitmap error models with timing/latency awareness.</li><li>Broadcast core hosting intent-driven control and selecting PLP strategy, RTK vs SSR ratio, bitmap resolution/update rate, redundancy and FEC.</li><li>ATSC 3.0 broadcast RAN with dedicated positioning PLPs (e.g., RTK correction stream; bitmap/error maps/integrity).</li><li>Receiver/vehicle stack consuming broadcast corrections and producing RTK solution + telemetry feedback loop.</li></ul></td></tr>
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| *Demo and Evaluation* | **Demo flow:** Baseline static broadcast/assistance policy versus **AI-intent-driven adaptive policy**, shown through time-series plots and comparative runs demonstrating (a) improved positioning performance/continuity and (b) controlled broadcast resource usage.<br><br>**Evaluation KPIs (reported per scenario and overall):**<br><br>• **Positioning Accuracy:** horizontal/vertical error.<br>• **Reliability:** valid correction availability.<br>• **Correction Delivery Latency:** broadcast → UE decode.<br>• **ATSC 3.0 Spectrum Efficiency:** bits/s/Hz for correction PLP.<br>• **Service Continuity:** dropout rate (rural/urban canyon). |
| *PoC Observation and discussions* | During implementation, the team will document: (i) which intents produced the most measurable gains, (ii) observed trade-offs between robustness and broadcast overhead, (iii) stability of the feedback loop under changing channel conditions, and (iv) limitations encountered due to synthetic vs real field datasets and transmitter control constraints. |
| *Conclusion* | The PoC demonstrates that **intent-driven AI control** can dynamically adapt **ATSC 3.0 broadcast assistance** (PLP robustness, redundancy, correction strategy and tile policy) using fleet telemetry, enabling **centimetre-class RTK positioning** to be sustained more reliably in degraded GNSS environments while maintaining **efficient use of broadcast resources**. |
| *Open Problems and Future Work* | • Validate with **real field GNSS + mobility datasets** and real urban canyon/tunnel traces (beyond synthetic tiles).<br><br>• Integrate with **actual transmitter control interfaces** to vary PLP/FEC parameters in real time at broadcast side.<br><br>• Extend integrity/assurance: explicit integrity messaging, fail-safe policies, and robustness to telemetry loss.<br><br>• Standardization alignment: specify data models for bitmap tiles and intent→control mappings for interoperability. |
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