

Advanced Network Geolocation in the Current Era.

Your network knows more than you think.
Making Location Intelligence work for your business.



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ADVANCED NETWORK GEOLOCATION IN THE CURRENT ERA

Executive Summary

For most mobile operators, the most commercially valuable data flowing through their network is also the least monetized. Every subscriber call, data session, and handover generates continuous location telemetry. At scale, across millions of subscribers, this telemetry offers a high-resolution, real-time picture of how people move, communicate, and use physical infrastructure. Converting it into measurable business value, reduced operational costs, new revenue streams, and a foundation for the next generation of AI, requires no new infrastructure. The capability already exists in the network.

VIAVI NITRO Location Intelligence transforms network telemetry into the industry's richest location data model. The output is not merely a coordinate but a structured record carrying movement vector, speed classification, indoor or outdoor status, confidence score, and spatial uncertainty metric, for every subscriber, continuously, without device modification or subscriber consent. This structural depth is what allows a single platform deployment to serve radio network optimization, VIP customer care, enterprise data licensing, and AI training pipelines simultaneously. NITRO Location Intelligence is deployed across more than 80 operators worldwide, generating location records for more than one billion subscribers, on a platform in continuous algorithmic development for over 20 years.

Two forces make 2026/2027 the critical window for operators to act. First, AI infrastructure decisions being made this year will determine which operators participate in the Physical AI data economy and which cede that position to third-party intermediaries. Network location data sits at the center of this shift: it is precisely the continuous, real-world, spatially diverse dataset that Physical AI foundation models require. Second, 5G Standalone networks, now reaching commercial density in key markets, are positioned to deliver a step-change in location accuracy that fundamentally changes the economics of every use case. Operators who establish their location data foundation now build a compounding advantage across every subsequent application wave. This paper sets out the business case, the technical foundation, and the emerging use cases that make network location intelligence one of the most immediate commercial returns available from 5G investment already made.

VIAVI NITRO LOCATION INTELLIGENCE

Proven at Global Scale



The most complete, continuously available, network-native location feed.

Per-cell ML models calibrated across every deployment.

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1. Why Now: The Case for Location Intelligence in 2026/2027

- Operators are under mounting pressure to reduce CapEx and OpEx while generating new revenue from their 5G network investments
- The data needed to do both already flows through every network continuously. Most operators have not yet converted it into commercial value
- Three vectors are immediately actionable: operational cost reduction through precision network management, external data revenue from enterprise and public sector customers, and participation in the Physical AI ecosystem as a real-world movement data provider
- Physical AI represents a fundamental shift in what AI models require: the ability to learn from the physical world, not just digital content. Network-derived location data sits at the center of this shift
- Architecture and data infrastructure decisions made in 2026/2027 will determine which operators capture this opportunity and which concede it to device-based or third-party data intermediaries

The telecommunications industry faces a structural challenge. Revenue per subscriber has remained flat or declined in most markets while 5G infrastructure investment continues. Operators need to generate returns from assets they have already built. Location intelligence is one of the clearest paths to doing so, because the underlying data is already being generated, at scale, on every network, every day.

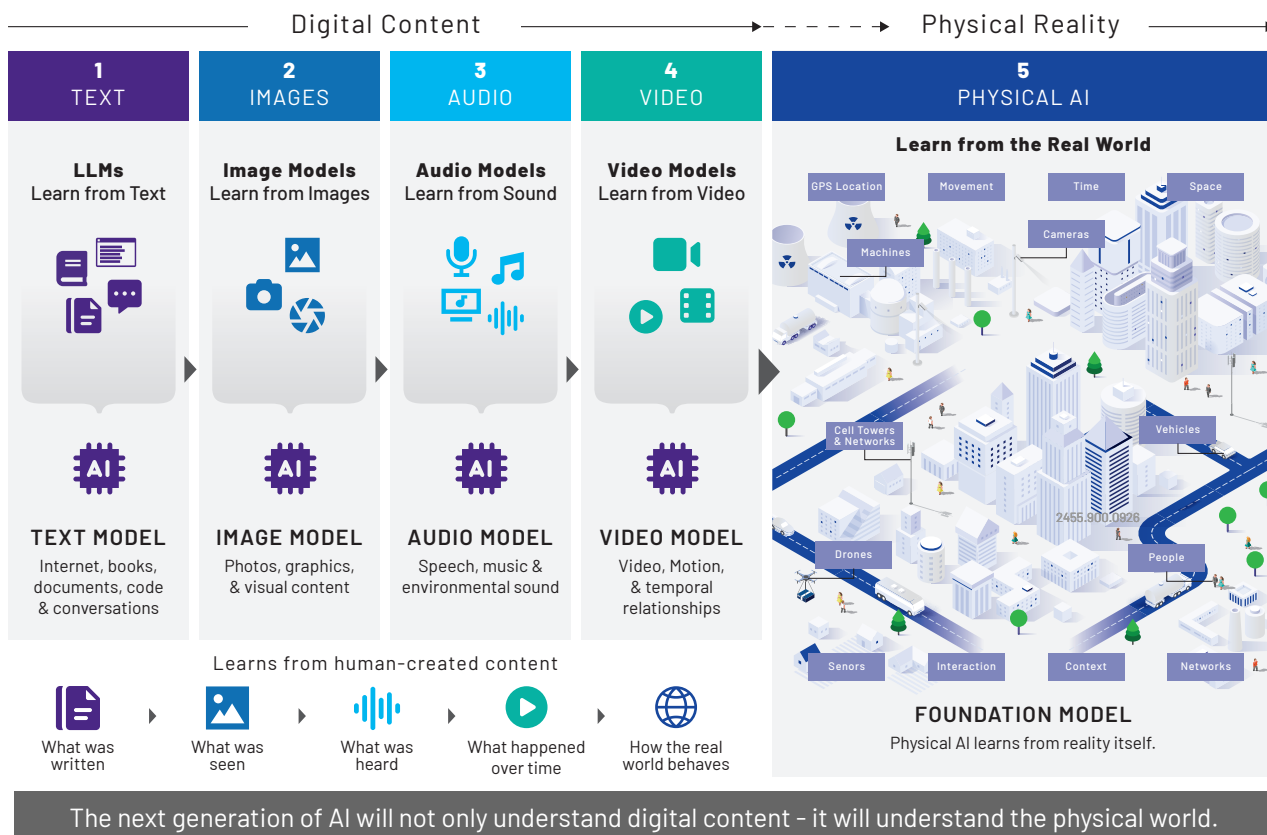
The CapEx and OpEx case. Network planning, optimization, and troubleshooting are among the highest recurring costs in an operator's operational model. Location intelligence directly reduces those costs. Continuous, geolocated subscriber data replaces periodic drive test campaigns with persistent network visibility. Automated QoE optimization driven by real location context reduces the manual engineering time required to maintain network performance. Fault resolution through virtual drive test and Layer 3 replay cuts the time from complaint to root cause. Operators who have deployed NITRO Location Intelligence consistently report measurable reductions in the cost of network operations.

The revenue case. Every operator network generates a continuous, anonymized record of how people move through cities, use transport infrastructure, and occupy commercial spaces. This is data that governments, transport authorities, retailers, and enterprises will pay to access. Location data monetization is already an established revenue line for operators in Europe and Asia Pacific. For operators who have not yet built a structured location data product, 2026/2027 represents the practical entry window before the market establishes preferred supplier relationships.

The Physical AI shift. Artificial intelligence is undergoing a fundamental transition from learning what humans create to learning how the physical world behaves. Text, images, audio, and video have defined the first generation of AI capability. The next generation requires real-world, real-time data: movement, location, environmental context, and physical interaction. Network operators are uniquely positioned in this landscape. Every base station is a physical world sensor. The continuous subscriber location record generated by a live network is precisely the kind of grounded, high-frequency, spatially diverse dataset that Physical AI foundation models require.

From Digital Data to Physical AI

AI models are evolving from learning what humans create to learning how the physical world behaves.



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From Digital Data to Physical AI: network location data at the center of the next AI wave

Operators who build structured, continuous, location-rich datasets today are creating an asset with commercial value that extends well beyond their existing customer relationships. Those who establish their data infrastructure now will be in a position to participate in a market that is currently being defined. Those who delay will find themselves dependent on external data providers for capabilities their own network already generates.

2. Why Network Geolocation? The Business Case

- Operators choose between four data collection approaches: drive testing, crowdsourced measurement, cell-based positioning, and network-based geolocation.
- Drive testing produces high-quality data but only a route-and-moment snapshot, with no continuous, network-wide, or roaming subscriber coverage.
- Crowdsourcing reflects real subscriber experience but depends entirely on application penetration, and sampling bias limits its value in low-penetration segments.
- Cell-based positioning covers all subscribers continuously, yet its resolution is bounded by the serving cell footprint and is insufficient for most analytical use cases in rural environments.
- Network geolocation combines continuous all-subscriber coverage with usable spatial accuracy, and its structured output record removes significant downstream pre-processing effort across every application built on it.

Network geolocation is the only method that is simultaneously continuous, network-wide, and spatially precise. The comparison below, drawn from operational experience across all four approaches, rates each method across the ten dimensions that matter most to operators evaluating location intelligence strategy.

Solution Comparison

Choose the right network intelligence approach for your operational needs.

Feature	Drive Testing	Crowdsource	Cell-based	Geolocation
QoE Reporting	•	• • •	—	• •
Network Performance Reporting 24/7	— —	—	• •	• •
24/7 Coverage for All Subscribers	— —	—	—	• • •
Full network RF Performance Testing	•	•	—	• • •
Troubleshooting/L3 Drilldown	—	— —	— —	• • •
Troubleshooting/Replay Network Issues	•	— —	—	•
VIP Complaints	— —	— —	—	• • •
RF Environment Analysis	• •	• •	— —	• • •
Roaming In	— —	— —	•	• • •
Data Availability/Time to Install	—	—	• •	•

• • •	Excellent Best coverage, depth and speed	• •	Good Strong capability with minor limitations	•	Basic Limited coverage or depth	—	Limited Partial capability with significant gaps	— —	Not Suitable Does not meet the requirement
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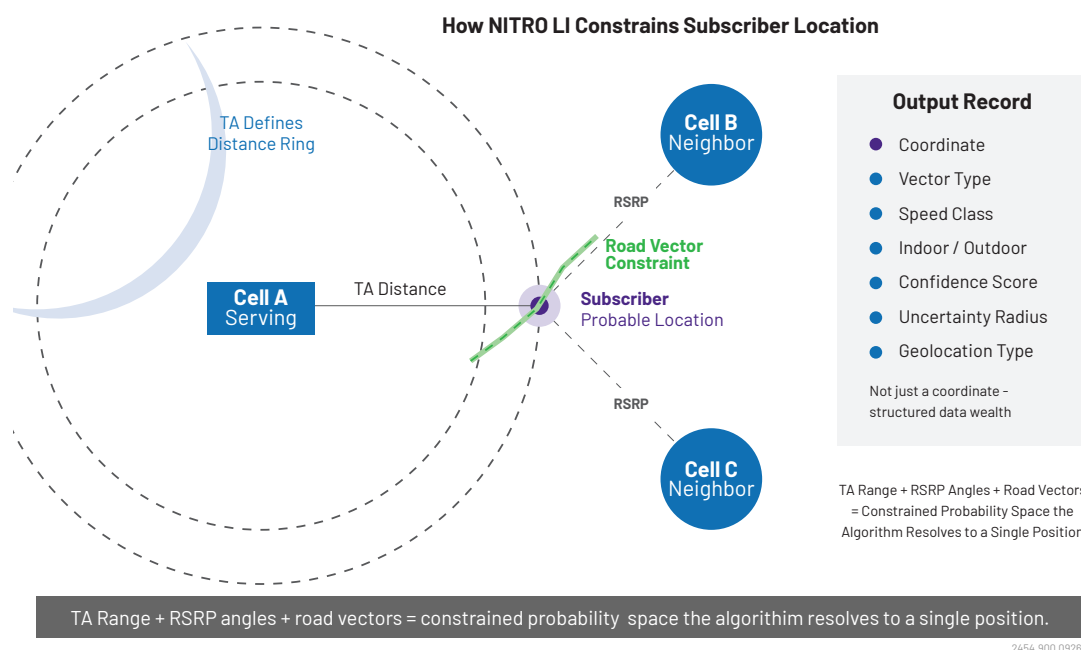
Solution comparison across four methods

The strategic case goes further than coverage and accuracy. A data feed that already classifies subscribers by movement type, speed, and indoor status eliminates a pre-processing burden that would otherwise sit inside every downstream system. For operators running multiple analytics platforms, customer care tools, and external data products from a single location feed, that structural richness is the difference between a viable data architecture and one that requires a separate enrichment layer for every application.

3. How VIAVI Geolocation Works

- Core inputs are timing advance, which gives a range estimate from the serving cell, and RSRP measurements from serving and neighboring cells, which add angular information
- Road and transport vectors, building footprints, and terrain models constrain the estimate to plausible geography
- A particle swarm optimization engine searches the resulting probability space, supported by per-cell machine learning models that calibrate local propagation and by non-line-of-sight detection from the rate of change of timing advance
- A genetic search selects the most probable trajectory across the batch window, 15 minutes by default, where longer windows raise accuracy and shorter windows lower latency
- Every record carries vector type, speed class, indoor or outdoor status, confidence score, uncertainty radius, and geolocation type, including whether the subscriber was located as stationary using historical priors or mobile using road and transport vectors

Network-based geolocation converts radio telemetry into structured location records without requiring any participation from the subscriber device. The accuracy of any network-based system is a direct function of the algorithm applied to that telemetry. NITRO Location Intelligence has been developed against that constraint continuously for over 20 years.



Timing advance (TA) from the serving cell constrains the subscriber to an annular region around that cell. Reference Signal Received Power (RSRP) measurements from multiple neighboring cells add angular constraints that reduce the search space further. A heuristic particle swarm optimization algorithm then searches that probability space, using per-cell machine learning models to correct for local propagation characteristics (urban clutter, building geometry, antenna configuration) that generic models cannot capture. Non-line-of-sight conditions are identified from anomalous rates of change in timing advance and handled through adjusted probability weighting.

A genetic search selects the most probable subscriber trajectory across the batch window. Subscribers classified as stationary are positioned from accumulated historical priors. Mobile subscribers are constrained to the transport network model, including motorway, rail, tram, and ferry routes. Every output record carries six attributes alongside the coordinate: vector type, speed classification, indoor or outdoor determination, confidence score, uncertainty radius, and geolocation type identifier.

4. Factors Enabling Accuracy

- Three capabilities beyond the core algorithm shape deployment accuracy: the Consolidated Segment Model, UE Fraction, and the Geolocation Accuracy Levels framework
- The Consolidated Segment Model (CSM) can combine multiple eRAB changes into a single segment, cutting record volume and outliers while leaving median accuracy unchanged
- Three CSM variants and a 15-minute wall-clock segment boundary let operators balance volume, latency, and accuracy for their specific deployment requirements
- UE Fraction applies geolocation to a randomly selected, statistically representative share of the subscriber population to manage total cost of ownership; testing confirmed less than four meters of median accuracy difference between a 100% and a 37% dataset, with a VIP list ensuring priority subscribers are always included
- An 11-level accuracy classification, from under 10 meters to over 1,000 meters, provides a consistent quality taxonomy for use case thresholds, performance reporting, and optimization targeting

Without the Consolidated Segment Model (CSM), the system creates a new location record each time an Evolved Radio Access Bearer (eRAB) changes, roughly every five seconds of measurement data. Each record draws on limited telemetry. With CSM enabled, the measurement data boundary extends to 20 seconds, giving the algorithm more measurements to work with. Outlier geolocations drop substantially. Median accuracy is unchanged. Operators receive a cleaner dataset at a lower cost of ownership.

The User Equipment (UE) Fraction feature applies geolocation to a configured share of the subscriber IMSI population. In controlled testing, the median accuracy difference between a 100% and a 37% dataset was less than four meters, confirming that processing cost can be reduced without degrading the quality of records produced. A VIP IMSI list ensures priority subscribers (enterprise accounts, regulatory requirements, escalated care cases) are always tracked regardless of the fraction setting.

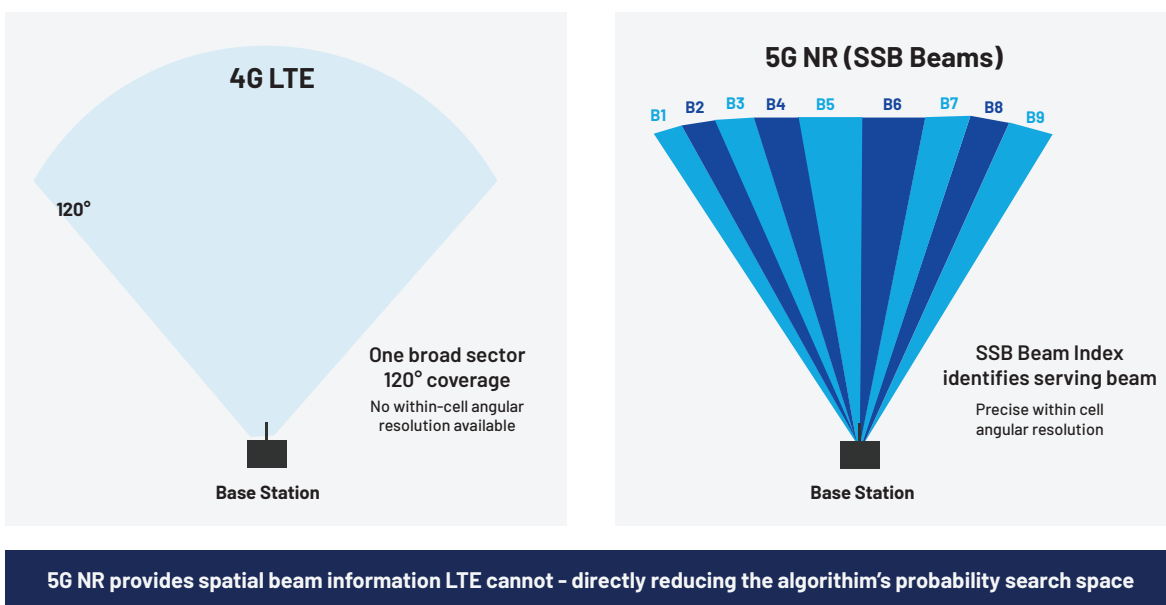
5. What Changes in 5G

- 5G NR introduces directional SSB coverage beams, providing within-cell angular information that LTE cannot deliver
- Higher-resolution timing advance and uplink angle-of-arrival measurements further increase the information available to the algorithm per subscriber event
- In Non-Standalone mode, the majority of current deployments, 5G events are processed as LTE plus supplementary NR measurements, so accuracy is at least equivalent to LTE
- In Standalone mode, the full NR measurement set becomes available, with a theoretical accuracy gain over LTE of approximately six times in FR1 and ten times in FR2; the algorithm is validated and formal benchmarking is underway
- Vertical angle-of-arrival combined with building height data enables 3D positioning with approximately 4.5 meters of height resolution at 500 meters, supporting floor-level localization and elevated infrastructure differentiation

5.1 5G New Radio Inputs

5G NR cells transmit Synchronization Signal Blocks (SSBs) that define spatially distinct coverage beams at far finer angular resolution than LTE's broad sector pattern. The SSB beam index identifies exactly which beam is serving the subscriber device, providing within-cell angular information that LTE cannot deliver. Combined with higher-resolution NR timing advance and uplink angle-of-arrival (AoA) measurements, the algorithm receives substantially more information per event in a 5G NR environment.

Angular Resolution: LET vs. 5G New Radio



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Angular resolution: LTE sector vs 5G NR SSB beams

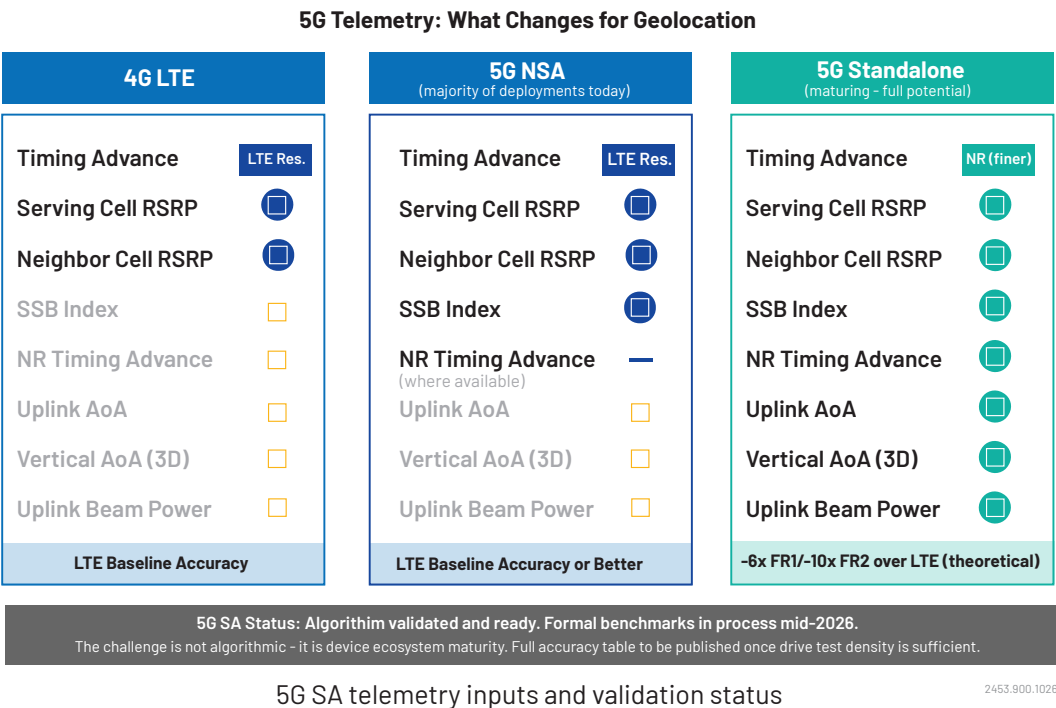
5.2 Non-Standalone Architecture

Most 5G deployments today operate in Non-Standalone (NSA) mode, where 5G NR provides additional data capacity alongside LTE control plane signalling. NITRO Location Intelligence processes NSA connections as LTE events supplemented by NR measurements: neighbor cell reports, SSB beam index where reported, and NR timing advance where available. The combined telemetry is richer than pure LTE, and NSA accuracy is expected to be at least equivalent to LTE as a result.

5.3 5G Standalone: Current Status

The NITRO Location Intelligence algorithm works on 5G SA telemetry. That is the outcome of isolated validation testing completed ahead of full statistical benchmarking. The algorithm processes 5G SA measurements without modification. The question is when live network density will be sufficient to quantify the theoretical accuracy gains in a statistically representative drive test campaign.

Formal 5G SA benchmarking commenced in mid-2026. The constraint is ecological rather than algorithmic. Even in networks where 5G SA services have launched, devices do not consistently connect via SA. Device software, carrier policies, and device hardware all determine actual SA connection rates, regardless of network capability. VIAVI is monitoring SA adoption across its operator base and will publish full Urban, Suburban, and Rural benchmarks when the statistical conditions are met.



5G SA telemetry inputs and validation status

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5.4 Height Estimation and 3D Geolocation

Vertical AoA from uplink signal processing provides height estimates refined by building footprint and terrain data. At 500 meters from a 20-meter antenna, 0.5-degree angular steps provide approximately 4.5 meters of height resolution. Applications include floor-level localization in multi-story buildings, differentiation between elevated transport infrastructure and ground-level roads, and height profiling for drone identification use cases addressed in Section 8.

6. Low-Latency Feeds

- Standard processing uses a 15-minute batch window to maximize accuracy, which is incompatible with near-real-time applications
- Two low-latency mechanisms are available: an event-based feed that bypasses batch accumulation, and a segment-based feed that applies the reduced window to Consolidated Segment Model records
- Both configurations deliver location records with end-to-end latency of under five minutes from the originating network event
- The accuracy cost is variable: no degradation where telemetry density is sufficient within the shorter window, up to twice the positional error where it is sparse
- The batch interval is configurable from a 30-second default to 180 seconds, balancing latency against accuracy for each specific application requirement

6.1 Use Cases

Emergency response. Emergency services applications require subscriber location within seconds of a call event, with no dependency on device-side GNSS, particularly critical indoors where satellites cannot penetrate. Low-latency feeds provide a network-native source that is independent of device capability and available for every subscriber on the network.

Real-time network event response. Developing congestion events, abnormal subscriber concentrations at a venue, density spikes in coverage gaps: all are detectable within the low-latency window. Operators can identify and respond to subscriber distribution changes before a standard 15-minute batch cycle completes.

Location-triggered communications. Geofence-conditional messaging requires location updates frequent enough to support reliable entry and exit detection across a large subscriber population. The low-latency feed provides that update rate without requiring additional network infrastructure.

Standard Feed

15-minute batch window



Low-latency Feed

Event-based, configurable 30-180s batch interval



No additional infrastructure required - low-latency mode runs within the standard NITRO LI deployment

Standard vs low-latency processing timeline

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6.2 Architecture and Trade-off

Two mechanisms are available. The event-based feed bypasses standard batch accumulation and passes telemetry directly to the geolocation processor as events arrive, generating position estimates as soon as sufficient data is available within the shorter window. The segment-based feed applies the same reduced-window approach to Consolidated Segment Model records, combining the outlier reduction benefits of CSM with low-latency output.

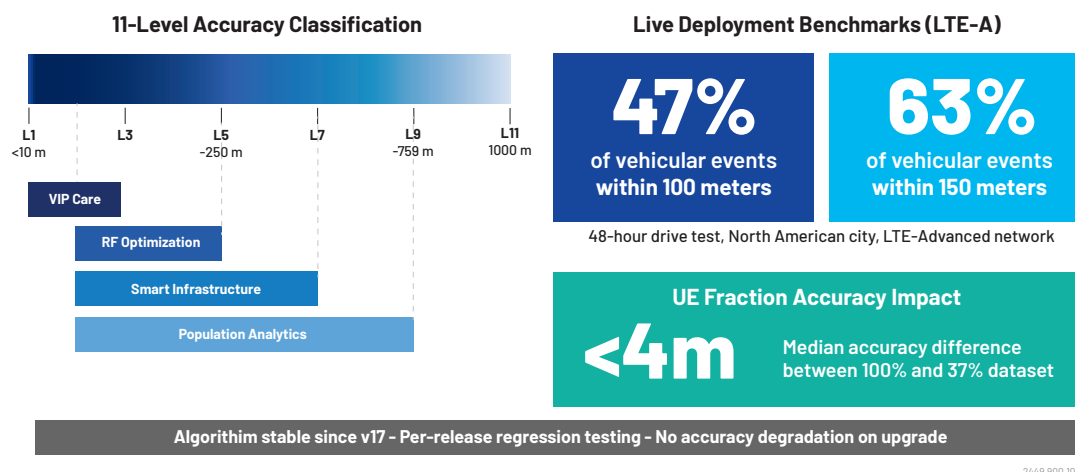
The accuracy trade-off is real and variable. Where telemetry density is high, low-latency output shows no degradation relative to standard processing. Where density is low, positional error can increase by up to a factor of two. The batch interval is configurable from 30 seconds to 180 seconds. Extending the interval adds processing latency but substantially reduces high-error estimates for subscribers with sparse telemetry. VIAVI configures the parameters in consultation with each operator based on the latency threshold and accuracy tolerance required by the target application.

7. Accuracy in Live Deployments

- All published figures derive from drive test campaigns in live operator networks across multiple countries and network generations
- LTE and 5G NSA deliver 25 to 150 meters in urban and suburban environments and 25 to 300 meters in rural areas; UMTS and GSM are progressively coarser
- A 48-hour LTE-Advanced campaign in a North American city geolocated 47% of vehicular events to within 100 meters and 63% to within 150 meters
- Accuracy improves with cell density; in high-density urban subsets of the same networks, performance consistently exceeds the published averages
- The algorithm has been stable since version 17, with per-release regression testing ensuring no software update degrades the median accuracy operators depend on

VIAVI uses two complementary approaches to assess accuracy. Controlled drive test campaigns use GPS-confirmed positions as ground truth, matched to geolocation output for the same events, to produce absolute error distributions. Statistical analysis of live deployment data uses the confidence score, uncertainty radius, and accuracy level in every output record to provide continuous quality visibility across the full subscriber base without requiring a GPS reference.

Environment	GSM	UMTS	LTE / 5G NSA	5G SA
Urban	50 to 200 m	25 to 75 m	25 to 150 m	25 to 150 m
Suburban	100 to 250 m	50 to 150 m	25 to 150 m	25 to 150 m
Rural	200 to 700 m	100 to 300 m	25 to 300 m	25 to 250 m



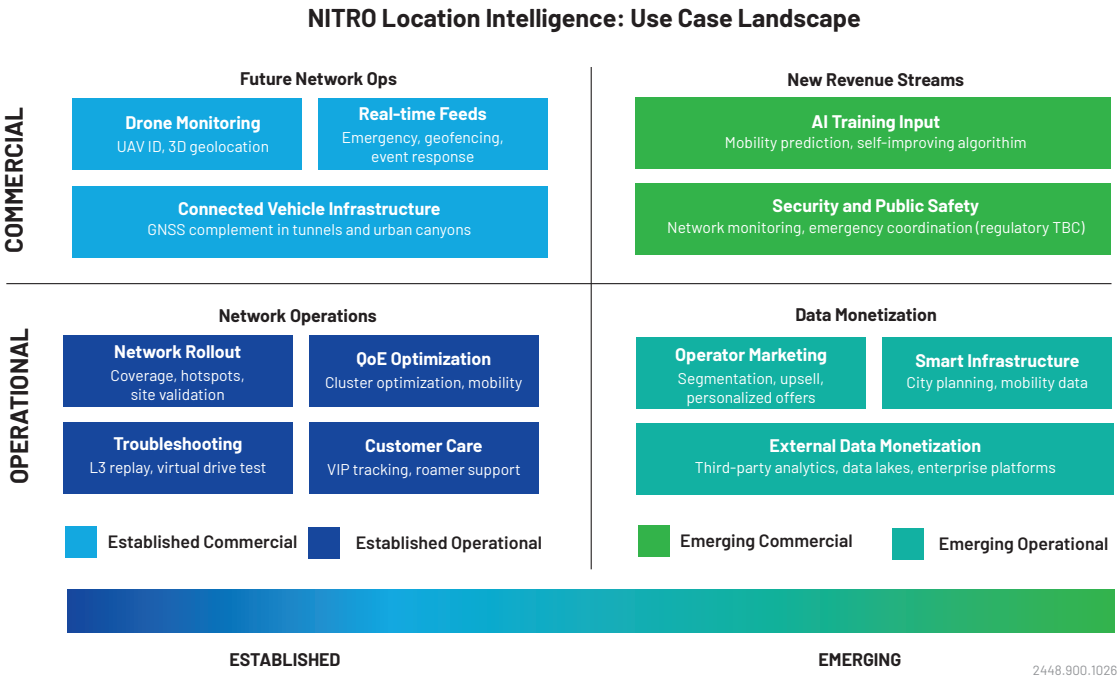
Accuracy levels, live benchmarks, and UE Fraction impact

VIAMI continuously improves geolocation accuracy across software releases. Per-release regression testing ensures no release that degrades median accuracy against reference networks reaches deployment. Operators can adopt algorithm improvements with confidence that performance continuity is guaranteed.

8. Emerging Use Cases

- Established uses span network rollout and planning, QoE optimization with spatial context, and troubleshooting via Layer 3 replay and virtual drive test
- Also proven in production: customer care with VIP and roamer tracking, operator marketing segmentation, and anonymized mobility data for external and smart infrastructure applications
- Emerging: drone identification and monitoring using 3D geolocation, height estimation, and movement vector analysis, in direct response to evolving UAV regulation over licensed spectrum
- Emerging: geolocation as a Physical AI training input for mobility prediction, network resource pre-positioning, and a longer-term self-improving algorithm architecture
- Forward-looking: security and public safety applications subject to regulatory alignment, and connected vehicle positioning where GNSS fails in tunnels and urban canyons

The established use case landscape below reflects what is in production across the NITRO Location Intelligence operator base today.



Use case landscape: established and emerging

Drone identification and monitoring. UAVs generate telemetry with characteristics distinct from ground-based subscribers: altitude, movement profile, and propagation geometry that NITRO Location Intelligence’s 3D capability can identify. Vertical AoA, height estimation, and movement vector classification detect devices operating at heights inconsistent with ground-based infrastructure. Operators in multiple markets are facing regulatory requirements for UAV monitoring over licensed spectrum. VIAVI is actively developing this capability in direct response to operator demand.

Geolocation as a Physical AI training input. The continuous, network-wide location record is a large-scale, real-world movement dataset at high temporal resolution. It is a natural training input for Physical AI foundation models that require grounded, spatially diverse, real-world data. For network operators, this represents a commercial opportunity: the data they already generate has value to AI developers and platform builders who need to understand how the physical world behaves. VIAVI is also exploring a feedback architecture in which geolocation output trains models that learn residual error patterns specific to each deployment, applying those corrections as a calibration layer within the positioning pipeline.

Security and public safety. Subscriber location data has direct applicability to network security monitoring, emergency coordination, and public safety event management. These applications require data protection regulatory alignment and, in many markets, specific authorization. VIAVI is working with operators and regulators to define appropriate implementation frameworks. Specific configurations and applicable conditions will vary by market.

Connected and autonomous vehicle infrastructure. Network-based geolocation provides a positioning input unaffected by satellite visibility constraints: continuously available, with no additional vehicle hardware required. The role of network geolocation in connected vehicle architectures is subject to ongoing 3GPP and automotive industry standardization, and VIAVI is monitoring these developments to ensure NITRO Location Intelligence participates effectively as the standards mature.

9. Why VIAVI

- VIAVI delivers the industry's richest location data model: not just a position, but a structured record with six attributes that removes pre-processing burden across every downstream application
- NITRO Location Intelligence is multi-vendor by design, working across all major network equipment manufacturers, making it deployable across the mixed-vendor infrastructure that characterizes every major operator network
- More than 20 years in the network location intelligence market, with deployments across 80+ operators and location records for more than one billion subscribers: a depth of calibration and operational experience that cannot be replicated
- VIAVI's own business units are building Digital Twin applications using NITRO Location Intelligence geolocated data, demonstrating the platform's value as a foundational data layer beyond traditional geolocation use cases
- As 5G Standalone matures, the algorithm is already validated and positioned to deliver the theoretical six times FR1 and ten times FR2 accuracy improvement, extending applicability into drone monitoring, 3D positioning, and connected infrastructure

The richest data model in the market. Most location systems deliver a coordinate. NITRO Location Intelligence delivers a structured record: coordinate, vector type, speed classification, indoor or outdoor determination, confidence score, uncertainty radius, and geolocation type. That structural depth is not a feature; it is what makes the same platform serve radio engineering, customer care, enterprise data products, and AI training pipelines simultaneously, from a single deployment. Operators who have initially deployed NITRO Location Intelligence for one use case consistently find they can activate additional applications without additional infrastructure investment.

Multi-vendor, across your entire network. NITRO Location Intelligence is designed to operate across all major network equipment manufacturers. Whether a network runs on Ericsson, Nokia, Huawei, Samsung, or a combination of vendors, NITRO Location Intelligence processes the available telemetry consistently. This is not incidental: multi-vendor compatibility is a prerequisite for any platform intended to provide network-wide visibility in real operator environments, where mixed-vendor infrastructure is the rule rather than the exception.

20 years of operational depth. Over 20 years and 80+ operator deployments, VIAVI has accumulated per-cell propagation calibration data, algorithm optimization benchmarks, and deployment knowledge across every network topology and geographic environment. That accumulated depth benefits every new deployment from day one and cannot be acquired quickly by newer entrants to the market. It is the compounding advantage behind the accuracy numbers published in Section 7.

Foundational to the VIAVI platform. VIAVI's other business units are already building Digital Twin applications using geolocated subscriber data from NITRO Location Intelligence. This is not a future roadmap item: it is evidence that geolocated network data has value as a foundational layer for next-generation network applications beyond traditional geolocation use cases. Operators who establish NITRO Location Intelligence as their location data foundation are positioning themselves to benefit from this expanding application ecosystem.

Operators ready to treat location intelligence as a strategic data layer, monetizing the data they already generate, reducing the cost of the network they already operate, and positioning themselves for the Physical AI data market emerging now, have a clear starting point. The platform is deployed, proven, and ready to scale.



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