

How to Build a Guideway or Highway Positioning System from Credentialed Markers

You need a vehicle to know where it is along a lane, aisle, taxiway, or track without leaning on a satellite fix or a central positioning service, and you want the position data to be trustworthy rather than spoofable. This guide teaches an architecture for exactly that: infrastructure markers that carry authority-signed positional data a vehicle reads and admits on its own. It describes an approach disclosed in U.S. Provisional Application No. 64/049,409, not a shipping library, and its home inventive step is the Marker Track Transport inventive step.

What You Are Building

You are building a positioning system in which the guideway tells the vehicle where it is, rather than the vehicle computing its own position from the sky or from a remote service. The unit of infrastructure is a marker installed on or embedded in the navigable surface, a lane stud, a curb element, a platform-edge strip, a taxiway element. Each marker stores a spatial reference for its own location plus the local geometry of the segment around it, and it emits that data to a reader carried by a passing vehicle.

A vehicle reading a sequence of these markers along its path accumulates their encoded data into a geometry track of where it has been and where the lane goes next. Crucially, every marker's data is signed by the authority that installed it, and the vehicle decides, on its own, how much to trust each reading. There is no central positioning service in the loop.

This suits anyone operating in a bounded, structured corridor where a satellite fix is unreliable or unavailable and where the geometry is fixed and worth encoding once: highways and interchanges, warehouse aisles, port berths, airfield taxiways, rail-like guideways, mining haul roads, and indoor or subterranean routes.

Why the Obvious Approaches Fall Short

The default is a satellite fix, optionally corrected. Global navigation satellite systems broadcast from centrally operated constellations; positioning requires acquiring those signals, and where they are blocked, jammed, or spoofed, you lose the fix. Differential and assisted variants improve accuracy but add a dependency on reference-station networks run by a positioning-service operator. Both are real and useful; both put your positioning on infrastructure you do not control, and both can be denied.

The second default is on-board perception: cameras, lidar, radar reconstructing the world per vehicle. This works, but each vehicle pays the full cost independently, sees only to its own sensor horizon, and reads lane markings and signs that were designed for human eyes and degrade when worn, wet, or occluded.

A third approach embeds identifier tags (for instance passive RFID) in the road. This removes the sky dependency, but the common designs treat each tag as a bare identifier that you look up against a remote database, and they treat every authenticated tag the same. So you inherit a database dependency, and an authenticated but low-authority or spoofed tag is weighed identically to a regulator-installed one.

The structural gap across all three: none carries, in the reading itself, both the position and a governance-checkable statement of who vouches for it, such that the vehicle can localize and decide trust locally without calling anyone.

The Architecture

The disclosed approach closes that gap with credentialed markers that a vehicle consumes through a governance chain running on the vehicle itself.

The marker as a self-contained spatial record. A passive environmental marker is installed on or in the infrastructure and emits or modulates its stored data in response to interrogation by a passing reader, drawing its emission energy from the interrogation rather than an internal battery. The spec is explicit that the signaling mechanism is interchangeable: radio-frequency backscatter, optical retroreflection with data modulation, surface-acoustic-wave, magnetic induction, and others are all enumerated. The invention is not any one of those; it is the credentialed, lineage-attached, authority-scoped nature of the stored data. Pick the modality that fits your environment.

Each marker stores, at minimum: a marker identifier; a spatial-reference field giving its position in a coordinate frame; a segment or zone identifier; a delineation-role classification (lane-center, lane-edge, shoulder-edge, gore, taxiway-boundary, platform-edge, and so on); a geometry field carrying local parameters such as curvature, grade, width, elevation change, or bank angle; an advisory field (for example a speed or class-restriction advisory); a distance field to neighboring markers; and a hazard-flag field. Further, it can carry an authority credential identifying who installed or maintains it, a temporal-scope field for validity, and a cryptographic attestation binding the data to that authority.

Note what this buys you: the marker encodes the geometry of its own segment, not just an identifier to resolve elsewhere. A vehicle gets usable lane geometry from the reading itself, with no database round-trip.

The coordinate frame is your choice. The spatial-reference field can be expressed in geographic coordinates, in a local frame, or in mesh-derived coordinates. The last is a cooperative coordinate frame that participating agents build among themselves through inter-agent ranging and admission of credentialed anchor positions, with positions solved by multilateration, so a corridor can carry a self-referencing frame that does not depend on an external positioning service. You do not have to use it; geographic or local-frame coordinates are equally in scope.

The geometry track and the missing-marker signal. A collection of markers along a corridor is a self-maintaining geometry store. An operating unit reading a sequence of markers along its path accumulates the encoded data into a geometry track of that path. And the absence of an expected marker, detected when a unit fails to read a marker it expected in the sequence, is itself a governed observation of marker absence that propagates for corrective action. No external survey process is required to keep the store current; it is maintained by installing and updating the markers.

Authority-credentialed consumption. Every reading carries an authority credential: an issuing-authority identifier, a scope specification, a temporal-validity window, a device-binding attestation, and a cryptographic attestation (the spec leaves the specific primitive open, from digital signatures through threshold signatures and post-quantum attestations). On the vehicle, a governance-configurable authority taxonomy maps each credential level to a behavioral response, an evidential weight, a mutation-admission rule, and a supersession rule. In a roadway example the taxonomy runs from a regulatory-infrastructure authority, through emergency-preemptive and operational levels, down to advisory and a no-authority level for uncredentialed devices. So a regulator-installed marker and an unsigned one are not weighed the same, and this decision happens on the vehicle.

Composite admissibility, not a binary check. Each reading passes through a composite admissibility evaluator on the consuming unit that integrates several factors (authority, staleness, modality, continuity, and others) and produces one of several outcomes: admit, gate (admit at reduced weight or under added constraints), defer (hold pending corroboration), solicit (actively query for corroborating observations), reject (with a reason such as insufficient authority or stale observation), or escalate. Every determination is written to a lineage field, so each position the vehicle acts on carries a reconstructable derivation chain.

Consensus calibration. Marker coordinates need not be perfect at install time. A consensus calibration mechanism refines a marker's spatial reference over time from the position readings of equipped units as they pass. A marker can start with approximate coordinates; accumulated pass-readings converge toward a statistical centroid under outlier filtering and authority-weighted accumulation; and once refinement confidence crosses a policy threshold, the refined coordinates are written back to the marker. The same mechanism flags drift: a marker whose coordinates diverge from the pass-reading consensus emits a calibration-anomaly observation for maintenance.

How to Approach the Build

You are implementing this yourself. The steps below are the order the architecture implies.

1. **Fix your deployment envelope.** Choose the domain (highway, aisle, taxiway, guideway), the delineation roles you need, and the target precision. Precision is bounded by your signaling modality and marker spacing, so decide spacing against the geometry you must resolve.
2. **Choose the signaling modality.** Match it to the environment: backscatter and retroreflection behave differently in weather, dirt, and metal-dense settings. The data contract below is modality-independent.

3. **Define the stored-data schema.** Populate the fields the spec calls out. An illustrative sketch, faithful to the disclosed fields and clearly not a shipping format:

Marker (illustrative)

marker_id	
spatial_reference	{ frame: geographic local mesh-derived, coords }
segment_id	
delineation_role	{ lane-center lane-edge gore platform-edge ... }
geometry	{ curvature, grade, width, elevation_change, bank_angle }
advisory	{ speed?, class_restriction?, ... }
neighbor_distances	[...]
hazard_flags	[...]
authority_credential	{ issuer, scope, valid_from, valid_to, device_binding }
attestation	(signature over the above, bound to authority)

4. **Choose your coordinate frame.** Geographic and local frames are simplest to start. Adopt mesh-derived coordinates only if you want a corridor-local frame independent of external positioning; that is a larger build (ranging, anchors, multilateration) and can come later.
5. **Stand up the credentialing authority and taxonomy.** Decide who signs markers and define the taxonomy your vehicles will evaluate against: for each level, its behavioral response, evidential weight, mutation-admission eligibility, and supersession rule. This is the policy that makes trust local and configurable; treat it as a first-class artifact.
6. **Build the vehicle-side reader and consumption pipeline.** The reader interrogates markers and recovers stored data. Then run each reading through: signature and credential verification, taxonomy lookup, and the composite admissibility evaluator producing admit/gate/defer/solicit/reject/escalate. Write every determination to a lineage record.

7. **Accumulate the geometry track and watch for gaps.** As readings are admitted, accumulate them into the vehicle's running geometry track. Track the expected next marker from the distance field; on a miss, emit a marker-absence observation.
8. **Add consensus calibration once units are on the corridor.** Have equipped units record their own position-determination at the moment of each read, accumulate pass-readings, refine toward the filtered centroid, and write refined coordinates back past a confidence threshold. Wire the drift check to raise a calibration-anomaly observation.
9. **Plan marker maintenance.** For read-only markers, updates are by physical replacement, with a replacement-lineage observation recording the swap; writable markers update in place. Either way the update is credentialed and lineage-recorded.

What This Does Not Give You

This is an architecture, not a drop-in library or an SDK. There is no package to install and nothing here "just works" on import; you implement the marker schema, the credentialing, the reader, and the consumption pipeline yourself. The pseudocode above is illustrative, not a wire format.

The approach is disclosed in a patent filing. It is not presented as a benchmarked or production-proven product, and this guide states no accuracy, latency, or coverage numbers, because the filing does not attach performance guarantees to these mechanisms and neither should you until you measure your own build.

The disclosure is explicit that precision is bounded by ranging or reading accuracy and by marker density; sparse markers or a noisy modality give you a coarse track. Positioning between markers is not something the marker layer provides on its own; the spec contemplates fusing mesh-derived positions with external sources such as inertial dead-reckoning or visual-inertial odometry through the same admissibility evaluator,

and you would need that fusion to fill gaps. The architecture fits bounded, instrumented corridors whose geometry is worth encoding; it is not a general answer for unstructured open terrain where there is no infrastructure to credential.

Disclosure Scope

The architecture described in this guide, credentialed infrastructure markers that store and emit authority-signed spatial references and local geometry, consumed by an operating unit through an on-board authority taxonomy and composite admissibility evaluator with lineage recording, and refined through consensus calibration, is disclosed in U.S. Provisional Application No. 64/049,409, whose home inventive step is the Marker Track Transport inventive step. This guide is educational. It is not a warranty, a specification, or an offer of software, and it describes an approach a reader can implement rather than a product being distributed.

Marker Track Transport ([/marker-track](#))

[All 40 steps → \(/inventive-steps\)](#)

Rail-analogous guidance on existing roads. Per-segment regulatory authorization.

Provisional application

PRIMARY TECHNICAL DISCLOSURE

- [Marker Track Transport: Credentialed Marker Sequences as Primary Routing \(/articles/marker-track-transport-credentialed-marker-sequences-as-primary-routing\)](#)

SECONDARY TECHNICAL

- [Credentialed Markers as Primary Routing Reference \(/articles/marker-track/credentialed-marker-primary\)](#)
- [Per-Segment Authority Attestation \(/articles/marker-track/per-segment-attestation\)](#)
- [Route Manifest Composition \(/articles/marker-track/route-manifest-composition\)](#)
- [Cross-Authority Route Composition \(/articles/marker-track/cross-authority-routes\)](#)

- [Progressive-Density Fallback \(/articles/marker-track/progressive-density-fallback\)](/articles/marker-track/progressive-density-fallback)
- [Byzantine-Robust Platooning Under Credentialed Sequences \(/articles/marker-track/byzantine-platooning\)](/articles/marker-track/byzantine-platooning)
- [Adversarial Marker Rejection \(/articles/marker-track/adversarial-marker-rejection\)](/articles/marker-track/adversarial-marker-rejection)
- [Regulatory Segment Approval \(/articles/marker-track/regulatory-segment-approval\)](/articles/marker-track/regulatory-segment-approval)
- [Multi-Class Operator Parameterization \(/articles/marker-track/multi-class-parameterization\)](/articles/marker-track/multi-class-parameterization)
- [Dual-Use Marker Article: Roadway Infrastructure as Credentialed Device \(/articles/marker-track/dual-use-marker-article\)](/articles/marker-track/dual-use-marker-article)

APPLICATIONS · GENERAL

- [Automated Guideway Transit Without Rails: A Virtual Fixed Guideway From Credentialed Track Markers \(/articles/marker-track/automated-guideway-transit\)](/articles/marker-track/automated-guideway-transit)
- [Credentialed Highway Marker Network for GNSS-Denied Autonomous Vehicle Positioning \(/articles/marker-track/highway-infrastructure-marker-network\)](/articles/marker-track/highway-infrastructure-marker-network)
- [Indoor Positioning Without Vendor Lock-In: Credentialed Marker Infrastructure for Hospitals, Airports, and Multi-Tenant Buildings \(/articles/marker-track/indoor-positioning-credentialed-infrastructure\)](/articles/marker-track/indoor-positioning-credentialed-infrastructure)
- [Audit-Grade Warehouse RFID Positioning: A Credentialed Marker Mesh for DSCSA, FSMA 204, and FTZ Compliance \(/articles/marker-track/warehouse-credentialed-rfid-mesh\)](/articles/marker-track/warehouse-credentialed-rfid-mesh)
- [Credentialed Field Markers for Precision Agriculture and GPS-Resilient Autonomy \(/articles/marker-track/agricultural-marker-network\)](/articles/marker-track/agricultural-marker-network)
- [Credentialed Markers for Construction Site Safety and Autonomous Equipment Authorization \(/articles/marker-track/construction-site-credentialed-markers\)](/articles/marker-track/construction-site-credentialed-markers)
- [Credentialed Marker Positioning for Underground and Open-Pit Mining \(/articles/marker-track/mining-credentialed-positioning\)](/articles/marker-track/mining-credentialed-positioning)
- [Credentialed Trail Markers for National Parks: Multi-Authority Positioning for Hikers, SAR, and Park Shuttles \(/articles/marker-track/national-park-trail-markers\)](/articles/marker-track/national-park-trail-markers)
- [Smart Stadium Positioning: Credentialed Marker Networks for Event Venues \(/articles/marker-track/smart-stadium-event-positioning\)](/articles/marker-track/smart-stadium-event-positioning)

APPLICATIONS · SPECIFIC

- [3M Connected Roads vs Credentialed Marker Architecture \(/articles/marker-track/3m-connected-roads\)](/articles/marker-track/3m-connected-roads)
- [Avery Dennison RFID vs Credentialed Marker Observations \(/articles/marker-track/avery-dennison-rfid\)](/articles/marker-track/avery-dennison-rfid)

- [Trimble RTK Alternative for GNSS-Denied Positioning: Credentialed Markers \(/articles/marker-track/trimble-rtk-corrections\)](/articles/marker-track/trimble-rtk-corrections)
- [Impinj RFID Alternative: Credentialed Marker Substrate Beyond Item Identity \(/articles/marker-track/impinj-rfid\)](/articles/marker-track/impinj-rfid)
- [NXP RFID IC Alternative: Credentialed Marker Specification Beyond UCODE and NTAG \(/articles/marker-track/nxp-rfid-ic\)](/articles/marker-track/nxp-rfid-ic)
- [Does a RoadVista retroreflectometer read a credentialed road marker? \(/articles/marker-track/roadvista-tape\)](/articles/marker-track/roadvista-tape)
- [Trimble Survey Markers vs Credentialed Machine-Readable Monuments \(/articles/marker-track/trimble-survey-marker\)](/articles/marker-track/trimble-survey-marker)
- [Zebra RFID Alternative: Credentialed Marker and Track Beyond EPC Identification \(/articles/marker-track/zebra-rfid\)](/articles/marker-track/zebra-rfid)
- [6 River Systems \(Shopify/Ocado\) Chuck vs Credentialed Marker and Track \(/articles/marker-track/6-river-systems-shopify\)](/articles/marker-track/6-river-systems-shopify)
- [AutoStore Alternative: Credentialed Marker and Track Positioning for Warehouse Robots \(/articles/marker-track/autostore-warehouse\)](/articles/marker-track/autostore-warehouse)
- [Berkshire Grey Alternative: Credentialed Marker and Track for Mixed-Vendor Fulfillment \(/articles/marker-track/berkshire-grey\)](/articles/marker-track/berkshire-grey)
- [Brain Corp Alternative: Credentialed Lane Authority for Mixed-Fleet Floor Care \(/articles/marker-track/brain-corp-floor-care\)](/articles/marker-track/brain-corp-floor-care)
- [Fetch Robotics \(Zebra\) FetchCore Alternative: Credentialed Marker and Track for Mixed Fleets \(/articles/marker-track/fetch-zebra-fulfillment\)](/articles/marker-track/fetch-zebra-fulfillment)
- [Geek+ Alternative for Multi-Vendor Warehouses: Credentialed Marker and Track \(/articles/marker-track/geek-plus-warehouse\)](/articles/marker-track/geek-plus-warehouse)
- [inVia Robotics Alternative: Credentialed Marker-Track Routing for Multi-Vendor Warehouses \(/articles/marker-track/invia-robotics\)](/articles/marker-track/invia-robotics)
- [Locus Robotics vs Credentialed Marker and Track Warehouse Positioning \(/articles/marker-track/locus-robotics\)](/articles/marker-track/locus-robotics)
- [Ocado Smart Platform Alternative: Credentialed Marker-Track Routing Beyond the Grid \(/articles/marker-track/ocado-smart-platform\)](/articles/marker-track/ocado-smart-platform)

[Marker Track Transport overview → \(/marker-track\)](/marker-track)