

Goldlane Technical Paper

System Architecture, Vehicle Design, and Distributed Control

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About This Document

This paper describes the engineering of the Goldlane automated guideway network: the guideway, the vehicles, the distributed control system, the structural basis, and the failure-handling model. It is written for engineers and transit professionals who want to understand how the system actually works.

It is a concept-level technical description, not a final specification. Many parameters are deliberately left open for the vehicle designer and the structural engineer to determine;

those are marked as open items. The companion policy document (the South Florida white paper) covers the regional deployment and public-benefit case and is written for a general and governmental audience.

A note on figures. The numbers in this paper are indicative concept-level estimates intended to convey scale and relationships, not validated engineering values. Cost-per-mile ranges, cargo tonnages, container weight distributions, headway targets, and similar figures require dedicated analysis and physical validation before they are relied upon. Where a value is a locked design decision rather than an estimate, the text says so.

1. System Overview

Goldlane is a connected guideway network that moves three kinds of traffic on one shared infrastructure: automated transit, cargo, and privately owned autonomous vehicles. The engineering rests on three layers:

A fixed, passive guideway. An elevated U-channel with no moving parts anywhere in the network, including at junctions. There are no track switches, no actuated components, and nothing in the guideway that can fail to move.

Autonomous vehicles. Small, self-directed vehicles that carry the network map (the atlas), plan their own routes, and execute them, selecting their path at each junction by a steering mechanism carried entirely on the vehicle.

A distributed control layer. Vehicles coordinate with each other directly, pacing themselves against a shared virtual-signal schedule, with a central Operations Control Center acting as a supervisory and verification layer rather than a real-time controller.

The defining engineering choice is that intelligence and motion live on the vehicle, while the guideway is dumb, fixed, and passive. This is the inverse of conventional rail, where the track switches and the central signaling system carry the complexity. It is what allows closely spaced junctions, eliminates switch failures, and removes any single central point of failure for real-time operation.

2. The Guideway

Cross-section

The guideway is a U-channel with a **98.5 in clear running surface** and **9.75 in walls** on each side, for a **118 in (9 ft 10 in) overall channel width**. These are locked, standardized dimensions, held constant across the entire network and every future deployment. The running-surface width was set by the requirement to accommodate the full range of U.S. passenger vehicles for the drive-on (AVEX) service; a narrower channel would exclude common vehicles, and a wider one would raise structure cost across thousands of miles.

The wall is a **uniform 9.75 in throughout, including at junctions**. There is no thickened section anywhere; the pivot-wheel engagement mechanism that steers the vehicle through junctions is carried on the vehicle, not built into the guideway (Section 4). This uniformity is what permits closely spaced junctions.

Structure

The guideway is elevated on a single-pier viaduct. Elevation is a deliberate engineering choice with several consequences: it provides grade separation (no at-grade crossings, no intersections, no interaction with surface traffic), it keeps the running surface above flood level in a region where surface flooding is routine, and it is engineered for hurricane-force winds well beyond the regional building-code baseline. At-grade configurations are possible where available right of way exists, but elevated is the default.

One-way guideway is estimated at roughly \$15–20M per mile, dual guideway at roughly \$25–30M per mile, and at-grade guideway at roughly \$3–5M per mile. These are concept-level estimates and do not include the inductive charging system; delivered cost per mile must still be validated (Section 12).

The atlas: network geometry as data

The physical network is represented to the vehicles as an **atlas**: a data model of nodes (points in the network, including junctions) and segments (the guideway between nodes). Each segment carries attributes including its geometry (tangent or arc, radius, length), its **maximum speed**, and its **load rating**. The vehicle plans and drives against this atlas.

Two attributes are worth highlighting because they are segment properties rather than vehicle behaviors:

- **Speed is a segment attribute, and it already incorporates the curve limit.** The posted maximum for a segment reflects its geometry, so the vehicle always obeys the segment maximum; it does not independently compute curve dynamics. A consequence is that the atlas speed data is safety-critical, because the vehicle trusts it with no independent curve-speed check.
- **Load rating is a segment attribute.** Most of the network is built to the standard vehicle load; a small fraction (heavy-freight segments, Section 9) is built to a heavier class. A vehicle too heavy for a segment simply cannot route onto it, enforced the same way a minimum-radius limit is.

From the node-and-segment data, a complete and accurate 2-D layout of the guideway is fully determined. All guideway segments are forward-only in normal operation.

3. The Vehicle

Common chassis

All Goldlane vehicles (transit, cargo, flatbed, maintenance) share one common **chassis-guideway interface**: the same bogie geometry, running-gear envelope, wheel systems, and the way the vehicle sits in and engages the channel. The vehicles look alike from the guideway's point of view, but they are not identical underneath: because the loading differs by body type, the structural components are sized differently, and a longer body (a 40 ft container, for example) sits on a longer chassis. What is common is the interface to the guideway, not every part. This commonality gives the guideway a consistent loading and engagement pattern to design for, lets the inductive-charging pickup be placed for one geometry, creates parts commonality where loading allows, supports a single certification path, and supports an open manufacturing model in which any qualified company builds complete vehicles to a published specification.

The chassis rides on **two bogies**. The wheelbase is maximized based on the chassis length, which spreads the load over a longer span and improves passenger ride quality and high-speed stability. Swivel bogies follow curves while remaining within the running surface.

Running gear: three wheel systems

Each bogie carries three distinct wheel systems, each with a separate job:

- **Load wheels** (on top of the running surface) carry the vehicle's weight and provide traction and braking.
- **Guide wheels** bear horizontally against the **inner face** of both channel walls, holding the vehicle centered in normal running. This two-sided contact is what keeps the vehicle on line between junctions. Guide-wheel size and material are open design items.
- **Pivot wheels** select the vehicle's path at junctions. They do no steering work on normal track. One pivot assembly per bogie, carried on a **horizontal-travel suspension** that keeps them retracted just off the wall during normal running.

Monodirectional, with a constrained reverse mode

The vehicle has a fixed front and back in normal service and does not turn around; terminals use loops or network geometry to reorient. This eliminates a bidirectional control cab and a symmetric interior. The running gear must nonetheless be capable of reverse travel for the failure-evacuation protocol (Section 10), but reverse is a constrained special-case mode that can be limited to lower speed and larger following buffers; it does not imply full-speed bidirectional running.

Body types and envelope

The body rides above the channel walls and may cantilever beyond the 118 in channel. Maximum body width is governed by vehicle-to-vehicle clearance on **tangent parallel**

guideway (two vehicles passing on adjacent straight tracks); curve sweep is handled in guideway layout planning, not by constraining body dimensions.

- **Passenger body.** 102 in wide, 20 ft long, ~110 in high, aluminum. Up to 12 passengers in a 2×2 quadrant layout around a central door zone, with 42 in center doors on both sides (only the platform side opens at a given station). Level boarding; wheelchair accessible with automated securement and no operator. This is the most common vehicle.
- **Cargo bodies.** Built to carry the air-cargo unit load devices used at MIA, so freight transfers between aircraft and guideway without repacking. The reference case is four LD3/AKE containers (roughly 61.5 × 60.4 in base, 64 in high, 3,500 lb max gross each) in a 2×2 arrangement; a single P6P/PMC main-deck pallet (125 × 96 in, up to ~15,000 lb) is the heavy case. A single cargo body adapts to different loads through different floor systems or tie-down patterns (roller floor for containers, pallet locks for pallets, flat floor with tie-downs for parcel freight). Cargo vehicles normally back into loading bays, with rear dock doors so the vehicle loads at dock height like a truck.
- **Flatbed.** Carries a user's own conventional vehicle up to ~7,000 lb GVW (covering the large majority of the passenger fleet), ideally with an semi-automated tie-down system. The maximum GVW could change based on use, this is really only useful for longer trips.
- **Maintenance.** Sanitation, mechanical, and general-maintenance variants on the same chassis, operating as roving mobile work vehicles.

Future variants (for example a recovery vehicle) will be developed later and may use a separate chassis configuration.

AVEX Vehicles

The vehicles described above are built to the Goldlane standard and operated as part of the network. AVEX vehicles are different: they are privately owned autonomous vehicles that drive onto the guideway under their own power and travel it directly, rather than being carried on a flatbed. AVEX, the drive-on service, is what lets a personal vehicle use the network as a dedicated expressway.

An AVEX vehicle rides within the guideway walls, and the network's minimum horizontal radius becomes a significant constraint for it: a conventionally steered vehicle has to hold the channel through a curve at speed. This is why the running-surface width is set to accommodate the full range of U.S. passenger vehicles (Section 2).

The AVEX criteria are deliberately flexible, so that different manufacturers can reach their own design solutions. An AVEX vehicle does not have to engage the guideway walls the way a Goldlane standard vehicle does; it can use ordinary vehicle steering to stay within the channel rather than guide wheels and a pivot system. What it must do is follow the Goldlane control criteria, obeying the virtual signal timing and the posted segment speeds (Section 5) so that it moves in coordination with every other vehicle on the network. Beyond that, the vehicle's design is up to the manufacturer.

Every AVEX vehicle is tested and certified at the SunTrax facility before it is admitted to the network. AVEX vehicles enter and leave at dedicated drive-on and drive-off points, typically peripheral garages where the owner parks offsite, and are credentialed to those access points only (Section 6).

4. Junction Navigation and the Pivot System

This is the most safety-critical subsystem, and the one where the engineering is most distinctive.

The principle: dumb guideway, smart vehicle

A junction is a fixed, passive piece of guideway with no moving parts. The vehicle selects its path by setting its pivot wheels to one side before it arrives. There is nothing in the track to switch, so there is no switch to fail, and every junction is passive.

How a pivot wheel engages

In normal running the pivot wheels are retracted, hanging just off the wall, doing no work; the guide wheels do the centering against the inner wall faces. At a junction, the active pivot wheel **extends horizontally to engage the outer face of the wall** on the side the vehicle intends to follow. The wall is then captured between the guide wheel on its inner face and the pivot wheel on its outer face, holding the vehicle positively to that wall so it tracks the chosen branch through the junction. Because the wall is uniform everywhere, the engagement happens entirely through vehicle-side travel; an optional thin bearing strip may be applied to the outer wall face at junctions, but thin if any. Past the junction, the pivot wheel retracts and the guide wheels resume centering.

The pivot wheel is therefore an intermittent, junction-only load-bearing device, not a continuously loaded steering element. The horizontal-travel suspension (travel distance, actuation speed, hold force, failsafe) and the pivot-wheel material are open design items, sized for the full junction load since some junctions may be taken at high speed (see Junction speed below).

One up, one down: passive gore protection

There is one pivot wheel per bogie (one left and one right), and both are always set to the same side; the vehicle has a single logical pivot state. In the retracted condition the wheels sit only a slight distance off the wall. This yields a passive safety property: if the atlas or commanding system fails and a vehicle reaches a split with no commanded side, the disengaged wheel still catches the split gore and **prevents the vehicle from striking the gore head-on**. The failsafe emerges from the geometry itself, independent of any control computation.

Split and merge

- **At a split**, the vehicle travels to whichever side its pivot wheels are engaged. Left engagement takes the left branch; right engagement takes the right.

- **At a merge**, two channels converge into one. The vehicle must engage its pivot wheel on the **outer** wall, the wall that carries it smoothly through. Engaging on the inside instead drives the vehicle toward the cusp where the inner faces converge: **an inside pivot engagement at a merge is catastrophic**. This is an absolute safety invariant, enforced by multiple independent failsafe checks. A design in which the pivot could engage the inside wall at a merge is not acceptable under any circumstances.

Pivot-switch clearance and junction spacing

The pivot side can change only in open guideway past a junction: the wheel must retract, swap its engagement side, and be ready to extend again, all clear of the junction. Clearance is measured from the trailing bogie, and the governing distance is set by the junction geometry and stored in the atlas per junction (at a merge, once the trailing bogie is past the node; at a split, an atlas distance set by each path's speed and radius). Because the system provides for reverse travel, the clearance is established for both the merge and split senses of each junction.

Pivot completion has a further rule: the wheels must be on the correct side no later than 1.25 times the stopping distance before a critical node (a node where the required side differs from the current side). If the vehicle cannot complete the switch in that distance, it slows until it can. Junction spacing is limited only by this clearance plus pivot actuation time, both vehicle parameters, so closely spaced junctions are permitted. Pivot actuation time therefore directly affects achievable speed and capacity through tight junction sequences: a faster, reliable actuator buys network performance.

Junction speed and tapers

Junction design speed is simply a segment-speed attribute in the atlas, and it is primarily a **guideway cost decision**. A full-speed (90 mph) diverging junction requires very long tapers to stay within lateral-acceleration limits, which costs structure; a lower-speed junction is shorter and cheaper, at the price of a few seconds of travel time as a through vehicle slows and re-accelerates. Where the budget favors it, a junction is built for reduced speed (on the order of 45 mph); where high throughput at speed justifies the taper length, a junction is built for full speed. Because some junctions may remain at 90 mph, the pivot assembly is designed for the full junction load rather than a reduced-speed case.

5. Distributed Control and Virtual Signal Timing

Autonomous agents

Every vehicle carries the complete atlas and computes its own shortest-time route under the segment speed limits and signal timing. There is no central controller issuing real-time movement commands; vehicles coordinate with each other directly. The control logic (routing, signal-timing computation, conflict resolution) is a distinct development scope from the physical vehicle: the vehicle executes speed and pivot commands and provides

sensing, while the planning that produces those commands is a separate software and systems workstream. “Distributed” means the control runs per vehicle rather than from a central point, and it is the reason there is no single real-time failure point.

Virtual signal timing: the conflict-free merge mechanism

Every merge operates as a **virtual signal** with a known, published cycle: major green, all-red, minor green, all-red. There is no physical signal hardware; the timing is a schedule the vehicles know. The whole cycle is expected to be short, under about 10 seconds, enough time for a few vehicles to pass through on each green. Because major and minor approaches never receive green simultaneously, two vehicles from different approaches physically cannot reach the merge point at the same time. The signal geometry guarantees separation with no negotiation between vehicles.

Because the schedule is known and each vehicle has exact position and speed data, a vehicle approaching a red does not stop and wait. It computes backward from the next green window and modulates its speed upstream to arrive at the merge exactly on green, at full speed, with enough green remaining for its entire length to clear the merge point. In normal operation vehicles do not stop at signals; they pace themselves through.

Two-layer conflict resolution

Conflict resolution has two independent, deterministic layers:

- **Cross-approach conflicts** (vehicles arriving at a merge from different directions) are eliminated by the virtual signal. The signal is the consensus mechanism; it converts a hard multi-agent coordination problem into an independent single-agent timing problem that each vehicle solves identically against a shared clock.
- **Same-approach spacing** (vehicles following one another) is handled by a follower-yields rule: each vehicle maintains a fixed minimum time gap behind the vehicle directly ahead, forming platoons that flow through a green phase in order. This following buffer would start at about 2 seconds and decrease as system performance is proven; the indicative full-buildout target is 0.09 seconds (roughly 12 ft at line speed), an aggressive figure representing the long-term goal rather than an initial operating value.

Neither layer requires central arbitration.

Time-of-day schemes and dissimilar-speed merges

A signal can change its timing between periods (for example, giving more green to a minor route during a peak). Each timing scheme has a begin count and runs until the next scheme’s begin count supersedes it; a scheme change must occur at an all-red boundary, so the phase pattern stays continuous and no green is cut short. When approaches have different design speeds (say a 45-mph major and a 20-mph minor), the all-red phase after the minor green is sized to let the slower vehicle fully clear and accelerate away before the faster direction goes green. All of this is captured in the signal timing itself, so a vehicle planning against the schedule is automatically correct, with no special-case logic.

Future-dated flight plans and latency immunity

Vehicles broadcast **flight plans**: not present-position reports, but full future trajectories (planned position as a function of time for the next 60 seconds), rebroadcast whenever the plan changes and tagged “no-change” otherwise. A vehicle identifies the vehicles directly ahead and adjusts to hold its gap.

This future-dated design gives the system an important property: **communication latency does not degrade coordination accuracy**. A delayed message is still perfectly accurate about the future; it simply arrives with less lead time. As long as the planning horizon exceeds the worst-case latency plus reaction time, coordination is exact regardless of latency. Latency becomes a margin-budgeting problem rather than an accuracy problem.

Deterministic travel time

Because a vehicle knows its full route, every segment speed, and every signal schedule in advance, it computes the exact free-flow journey time before departing. The only uncertainty is small, bounded platoon delay from yielding to maintain gaps, which can be presented separately: a theoretical time plus a short traffic allowance (for example, “5 minutes 28 seconds, plus 4 seconds for traffic”).

A worked intuition for those two numbers: a vehicle continuing on the major approach hits each successive green in stride, so its run is at or near free-flow; a vehicle merging from the minor approach always slows a little to drop into the green progression, and that slowing is already accounted for in the theoretical time (the “5:28”). The added allowance (the “4 seconds”) appears only when another vehicle is already in the same green cycle, so the subject vehicle slows by about the time for one vehicle to pass even though it still makes the same green. In the worst case it slows to catch the next green cycle, a few seconds of delay. This determinism, impossible for a road or a conventional bus, is the operational payoff of the whole control architecture.

Capacity assumption

When a vehicle slows, it republishes its updated plan; the small delay ripples backward and dampens out within a few vehicles as long as the network operates below capacity. As the safety time buffers are decreased with proven performance, capacity increases. Near 100% utilization, delays could stop dampening and cascade, so normal operation is assumed well below that regime. This is a design assumption to be validated by simulation before high-density operation.

6. Credentialed Access and Vehicle Groups

Not every vehicle should be able to reach every station. A freight vehicle has no business pulling into a passenger transit platform, and a vehicle carrying screened airline passengers must not be able to stop at an unsecured location. The network handles this with credentialed access: a set of rules, carried in the atlas, that governs which vehicles may travel where.

Access as an atlas attribute

Access permission is treated exactly like the load rating and minimum radius of Section 2: it is an attribute of the network, enforced by self-routing. Each station and each segment carries an allowed-group list, and each vehicle belongs to one or more credential groups. When a vehicle plans its path, the router only produces routes whose every node the vehicle is credentialed for. A vehicle simply cannot generate a route to a station it is not cleared for, the same way a heavy vehicle cannot route onto a standard-rated segment. There is no gate to defeat and no barrier to fail; the permission lives in the routing logic itself.

The vehicles themselves are not special. A transit vehicle, a cargo vehicle, and a secure-zone vehicle can be identical hardware built to the same standard. What separates them is the credential group they are assigned to, which the atlas rules then act on.

Worked examples

- **Cargo and passenger separation.** Transit stations are credentialed for passenger groups only; freight terminals are credentialed for cargo groups. A cargo vehicle routing through the network can pass over or past a transit station on a shared segment, but it can never select that station as a destination, so freight and passengers never share a platform.
- **Secure airport access.** A distinct group of vehicles serves the screened (TSA) side of an airport. These are the same vehicles as elsewhere on the network, assigned to a secure-zone credential group whose only permitted stations are those inside the screened perimeter. A secure vehicle cannot route to any station outside the perimeter, and a general vehicle cannot route to a station inside it, which keeps the sterile boundary intact without fences or manual control at the platform.

The same mechanism extends naturally to any access distinction the network needs: privately owned AVEX vehicles cleared only for drive-on and drive-off points, maintenance vehicles cleared for pull-offs and yards, or priority groups for emergency use. Each is just another credential group mapped against the atlas.

Enforcement and verification

Because enforcement is in the routing, it holds even though control is distributed and no central computer dispatches vehicles. The Operations Control Center (Section 11) provides the supervisory check: it holds the authoritative group-to-station credential map, verifies that vehicles are operating within their permitted set, and is the control point for issuing, changing, or revoking a vehicle's group assignment. Routine routing never consults the OCC, but the OCC is where the access policy is defined and audited.

7. Motion, Positioning, and Sensing

Acceleration and speed

Normal acceleration and deceleration are expressed as a fraction of gravity: $\text{rate} = g / \text{NormalAccelDivisor}$, using the same rate for both. The working value for passenger comfort is a divisor of **8** ($g/8 \approx 1.23 \text{ m/s}^2$), revisable. A separate, higher emergency-stop rate is defined for emergency stops. Maximum operating speed is up to ~90 mph on regional and express segments, with urban segments slower; the vehicle always obeys the posted segment maximum.

Ninety mph on rubber tires is well within the limits of cost-effective tires, and bogie arrangements are well tested and understood.

Positioning

Positioning combines two sensors against a shared clock:

- An **optical sensor** detects a high-reflectivity target in the guideway (a thermoplastic pavement-marking stripe or a raised pavement marker). Passing over the target produces a signal spike that fixes the vehicle's location to within a few inches at a precise clock time. This is the accurate position reference.
- An **RFID detector** reads guideway tags to provide an approximate location that corroborates and disambiguates the optical fixes.

Everything is referenced to clock time. At the start of each trip the vehicle synchronizes its clock to a master clock, to the thousandth of a second, so that positioning, signal timing, and flight-plan coordination all share a common time base. This shared clock is what makes the virtual-signal pacing and the deterministic travel-time calculation possible.

Spacing and feedback sensing

Front and rear LiDAR maintain vehicle-to-vehicle spacing (rear LiDAR also serves the reverse-evacuation case). The motors report actual RPM, which is cycled back against the optical and RFID position fixes to infer tread wear and keep the speed calibration accurate over time. Rear-facing sensing is a requirement, not an option, because of the reverse-evacuation protocol.

8. Energy and Charging

The vehicle carries a modest onboard battery sized as a **buffer**, not a range source (indicatively 30–40 kWh for the passenger vehicle). The guideway supplies power through inductive charging; the battery smooths the gaps between charging zones, handles short unpowered stretches, and supplies the peak power surges for acceleration while absorbing regenerative energy during deceleration. Sizing it as a buffer rather than a range battery cuts vehicle weight and cost. Exact capacity depends on the final charging-coverage plan and peak surge demand.

High-speed dynamic inductive charging, delivering full propulsion energy at line speed, is the least-proven core technology in the system (Section 12). The physics is sound and the trajectory favorable, but it is not yet deployed at scale, and it is the highest-priority item for physical validation. The fallback, if high-speed dynamic charging disappoints, is larger onboard batteries, which adds weight and undermines the buffer-only design but is not fundamentally infeasible. The long-term intent is a much larger network extending up the East Coast, so that a vehicle drawing power continuously as it runs would have essentially unlimited range.

For the heavy-freight guideway (Section 9), a conductive **third rail** is likely preferable to induction: it is the highest-power application, which is the worst case for induction, and the heavy line is a closed, access-restricted, passenger-free environment in which a live conductive rail is acceptable, unlike the mixed-use passenger network.

9. Loading and Structural Basis

Live loads by vehicle type

Live load is the payload the structure carries, separate from the vehicle's own dead weight. Indicative design live loads:

Body type	Per unit	Count	Total live load
Passenger / transit	250 lb/passenger	12	3,000 lb
Cargo, 4×LD3	3,500 lb each	4	14,000 lb
Cargo, P6P pallet	15,000 lb	1	15,000 lb
Flatbed	carried vehicle at 7,000 lb GVW	1	7,000 lb
Maintenance	crew + equipment	n/a	open
20 ft container, empty	5,000 lb	1	5,000 lb
20 ft container, light load	15,000 lb	1	15,000 lb
40 ft container, empty	8,300 lb	1	8,300 lb
40 ft container, light load	22,000 lb	1	22,000 lb
20 ft container, heavy	52,900 lb	1	52,900 lb
40 ft container, heavy	67,200 lb	1	67,200 lb

Container weights are indicative ISO figures. The two heavy container rows (shaded) belong to the heavy-freight class and run only on heavy-rated guideway segments (see below); the empty and light-load containers travel intact on the standard network.

Dual load-class network

Rather than build the entire network to carry the heaviest freight, load rating is treated as a **segment attribute**, with two classes:

- The **standard class** is rated to carry up to 22,000 lb, enough for the common vehicle and a 40-ft intact container. This is the vast majority of network miles.
- A **heavy-freight class** carries full ISO containers (a 4–5× jump, up toward 45,000–67,000 lb, which pushes live load into structural significance and raises cost per mile by roughly 30–60%). Because heavy-container corridors are geographically concentrated (seaport-to-warehouse runs), the heavy class is confined to a small fraction of network miles, avoiding the system-wide cost premium.

The heavy guideway uses the **same cross-section, running surface, and junction geometry** as the standard guideway, built on a heavier substructure (deeper beams, more piers). Standard vehicles can therefore traverse heavy segments freely, while heavy vehicles are atlas-restricted to rated segments, exactly as the minimum-radius limit works. The heavy-freight line is envisioned as a two-way, low-speed, advance-scheduled corridor with passing points: low speed, limited traffic, advance scheduling, and no passengers make the queuing delay of two-way single-track operation acceptable, and roughly halve the structure cost versus a dual guideway. This is an outer-phase concept whose load ceiling (39,000 / 45,000 / 55,000 lb) depends on real port data.

Container movement by weight

Indicatively, roughly 15% of arriving containers are light enough to use the standard guideway intact, and about half of outbound containers are empty. Because trucks rarely drop off and pick up on the same trip, every container moved on the guideway can eliminate two truck trips. These figures are indicative and require real port data.

10. Failure Scenarios and Graceful Degradation

Preventive maintenance reduces most issues, but some failures are inevitable, most likely a tire blowout or a mechanical fault. A defined, tiered response is what makes the system credible to a safety regulator; the existence of the protocol matters more than the exact automation level.

Tier 1: degraded but moving

A vehicle that can still move but cannot hold speed (for example after a tire blowout) broadcasts its speed reduction as a flight-plan update, functionally a large platoon delay. Surrounding vehicles absorb it through the normal follower-yields logic, with LiDAR providing an independent spacing backstop. A degraded vehicle is just a very slow vehicle, which the system already knows how to flow around. It limps to the next station or maintenance pull-off and exits service. Minimal disruption; handled entirely within the normal control model.

Tier 2: stopped and blocking

A vehicle dead on the line blocks everything behind it back to the previous split junction, because the guideway is forward-only single-path between junctions. Three responses run in parallel:

- **Upstream rerouting.** At the prior split junction, the control system reroutes so no new vehicles enter the blocked section, preventing the trapped count from growing.
- **Reverse evacuation.** The trapped vehicles reverse to the prior split junction and re-route onto the alternate branch from there. This requires temporarily holding normal flow through that split, backing the trapped vehicles out one at a time (maintaining reverse spacing), and releasing them onto the alternate route before restoring normal flow. The choreography scales to the number of trapped vehicles.
- **Casualty removal.** A recovery vehicle removes the dead vehicle, which cannot move under its own power.

Reverse evacuation imposes two engineering requirements worth flagging. First, **reverse junction traversal** is a genuinely new geometric case: running backward, a merge becomes a split and vice versa, and the pivot-wheel safety invariant (outer-side engagement) must be verified to hold in the reversed sense of travel, not assumed. Second, **rear sensing** is required so reversing vehicles maintain spacing.

Automation level

How much of this to automate is an open design decision, tiered by consequence:

- **Fully automated from day one:** detection, the speed-reduction broadcast, the LiDAR-backed spacing response, and upstream rerouting. These are time-critical, purely protective, and have no downside if triggered on a minor fault.
- **Automated but supervised, initially:** the reverse evacuation. The system computes the choreography; an operator confirms and monitors execution, with oversight relaxing toward full automation as the protocol proves out, the same conservative-to-tight trajectory as the platoon gaps.
- **Human-decided, for the foreseeable future:** evacuate-or-wait (if the failure might clear quickly, reversing a dozen vehicles may be worse than waiting), passenger welfare during reverse movement, and compound emergencies (medical or fire alongside mechanical).

11. The Operations Control Center

The OCC is a **supervisory and verification layer, not a real-time controller**. Vehicles handle all safety-critical, second-to-second control themselves; the OCC provides the global view above them. If the OCC went offline, vehicles would keep running safely on their onboard atlas and peer broadcasts; there is no central point of failure for real-time control. This mirrors modern air and rail traffic management, where vehicles have autonomy for

immediate operation and the central system handles flow management and verification over minutes and across the network.

OCC functions include receiving and verifying every vehicle's routing broadcasts (independent per-vehicle planning plus central verification catches errors that either alone would miss), global jam detection (seeing traffic converge on a junction from multiple directions, which no single vehicle can perceive), credential verification and tolling, predictive maintenance dispatch, emergency coordination, and storm protocols. Access metering (regulating how many vehicles are routed toward a congested station) is a future capability the architecture supports but which only matters near capacity, a long way off for early operations.

12. Development Risks

Nothing here requires unproven science or is physically infeasible; the risks are about cost convergence, one moderately unproven technology, and a long certification path. Notably, nearly every major risk ultimately expresses itself as pressure on guideway cost per mile, or on travel speed and capacity.

Low-risk, for the record. Ninety mph on a bogie is proven and unremarkable. The general vehicle architecture, the routing software, the credential system, elevated guideway construction, and the nonprofit financing structure are all established practice. The concept integrates known technologies rather than betting on a single breakthrough.

Risk 1, guideway cost per mile. The whole value proposition depends on guideway staying affordable enough to build a network. A precise running surface (it carries charging coils and optical positioning targets, and must hold alignment for guide-wheel contact), dimensionally stable walls, and the stiffness to control ride quality at 90 mph can all push delivered cost above concept estimates. Mitigations: keep vehicles light, make charging and positioning robust to looser tolerances, and run slower on cheaper guideway where high speed is not essential.

Risk 2, high-speed dynamic inductive charging (least-proven). Full-power dynamic charging at 90 mph is not yet deployed at scale. The fallback is larger onboard batteries.

Risk 3, distributed control and tight-platoon certification. The control concept is sound and the future-dated-planning property is robust to latency, but certifying tight-platoon operation for revenue passenger service is a long, expensive verification burden that simulation alone may not satisfy regulators on. Expect the initial headway gap to be relaxed and tightened only as a safety record accumulates, so early capacity may be lower than the tight-gap projections assume.

Risk 4, the pivot mechanism (safety-critical). With the pivot wheel engaging only at junctions, on a horizontal-travel suspension, the duty cycle is intermittent rather than continuous. The central risk is less "can the mechanism survive the loads" than "can we guarantee it is always on the correct side." That is a controls and interlock reliability problem, which is more tractable and more verifiable than mechanical fatigue.

Risk 5, vehicle-guideway wear and maintenance at scale. Surface wear and resurfacing is an ongoing cost easy to underestimate, and because the surface carries charging coils and optical targets, wear interacts with those systems. Underlying wear rates need validation by real operation.

13. Open Items and Validation

The following are the principal open engineering items, to be resolved by design work, simulation, and physical testing:

- **Vehicle design detail:** bogie load ratings, suspension, guide- and pivot-wheel size and material, exact wheelbase and running-gear width, body envelope, pivot actuator design and actuation time, battery capacity and chemistry, inductive pickup power and thermal design, all interior detailing, and the sensor/compute/actuator hardware to meet the specified sensing.
- **Structural:** delivered guideway cost per mile.
- **Control and operations:** simulation validation of the sub-capacity delay-dampening assumption before high-density operation; the failure-protocol automation policy; reverse junction traversal verification.
- **Core technology validation at SunTrax:** high-speed dynamic inductive charging; the pivot mechanism's correctness and interlock reliability; the junction-surface treatment and wear; speed certification.

The validation sequence is deliberately simulation-and-test-first: the control logic and vehicles are proven at SunTrax, through an at-grade proof-of-concept, then freight and low-speed testing, then high-speed certification, before any public segment carries a passenger.

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This paper describes the system at a concept level; figures are indicative and require validation. A companion vehicle design brief covers the vehicle in specification detail, and the South Florida white paper covers the regional deployment and public-benefit case.