



The "Driverless" LED: What Transit Agencies Need to Know Before Their Next Tunnel Lighting Procurement

How LED Power Supply
Architecture Affects Reliability,
Maintenance Cost, and Compliance
Over a 25-Year Lifecycle

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Table of Contents

Executive Summary	3
What Transit Leaders Need to Know	4
The Physics: Every LED Needs a Driver	5
How the Two Dominant Architectures Work	5
Why Modular Drivers Became the Industry Standard	7
The Thermal Trade-Off That Comes with Integration	7
What Temperature Does to Component Life	9
What This Means in a Real Tunnel	11
The Tunnel Stress Test: Why Architecture Matters More Underground	13
EMI Compliance: What It Proves and What It Does Not	15
Buy America Compliance: Follow the Components	16
What to Ask Before You Specify	17
What To Ask In An RFP	18
Conclusion: Architecture Over Terminology	19
A Note on Longevity	20
Learn More	21
References	22

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Executive Summary

A new term has entered the transit lighting vocabulary: "driverless."

An LED driver is the power supply unit inside every LED light fixture (known in the industry as a "luminaire"). The driver converts high-voltage alternating current from the building's electrical system (120-277V AC) into the precise, low-voltage direct current that LEDs need to operate safely and consistently [2]. Without a driver, an LED connected to standard power would burn out almost instantly.

Drivers also protect LEDs from voltage fluctuations, overheating, and flickering. They are essential to every LED lighting system, and they are also the component most likely to fail: industry data shows that approximately 90% of LED luminaire field failures originate in the driver circuit [8, 13].

The "driverless" premise is appealing on its face. If the driver is the primary source of failure, eliminating it should mean longer-lasting lights. But the physics of semiconductor operation do not work that way. Every LED luminaire connected to AC mains power requires current regulation, rectification, and surge suppression.

These are not optional features. They are dictated by the physics of how light-emitting diodes work [2]. So-called "driverless" or "Direct-AC" designs do not actually remove driver circuitry. They relocate it, moving regulation and rectification stages directly onto the LED board itself.

This distinction matters enormously for transit agencies. The question is not whether a driver exists inside a tunnel lighting fixture. It must. The question is how that driver is architected, how it is thermally managed, how it is protected from the electrical stress unique to transit environments, and how it is serviced over a 20-to-25-year lifecycle. The architecture difference can represent \$3M to \$7M in additional maintenance cost over 25 years for a 1,200-fixture tunnel installation.

This paper examines the engineering differences between integrated driver-on-board (DOB) architectures and modular isolated driver architectures, drawing on publicly available U.S. patent documentation, established principles of semiconductor physics, thermal modeling, and lifecycle economics. It is intended to give procurement executives, chief engineers, and transit board members a clear, evidence-based framework for evaluating tunnel lighting on architecture, not terminology.

[2] AGC Lighting, "Constant Current vs. Constant Voltage LED Driver"

[8] ZGSM Lighting, "Mean Time Between Failure of LED Driver and the Importance of MTBF," 2026.

[13] U.S. DOE, "LED Luminaire Lifetime: Recommendations for Testing and Reporting."

[2] AGC Lighting, "Constant Current vs. Constant Voltage LED Driver," 2025.

What Transit Leaders Need to Know

Tunnel lighting systems installed today will likely remain in service well into the 2040s. The architectural decisions made at procurement directly influence not only lighting performance, but decades of maintenance cost, operational risk, and fiscal predictability.

Here is what the evidence shows:

- ◆ "Driverless" does not mean the driver was eliminated. At least one manufacturer's own U.S. patent (No. 11,832,361) explicitly describes the device as containing "a light-emitting diode (LED) driver including a high-voltage linear constant current regulator." The term "LED driver" appears in every independent claim of the patent [1]. The driver was not removed. It was moved onto the LED board.
- ◆ The same manufacturer's published specification sheet references "drivers" as a distinct component category, noting that LED boards and drivers are sourced differently from the fixture housing and other components [3]. A product that had truly eliminated its driver would have no reason to reference one.
- ◆ The design trades one advantage for a significant liability. The linear regulator topology used in these designs achieves low electromagnetic interference, a genuine benefit for transit tunnels with RF-sensitive communication systems. But linear regulators dissipate excess voltage as heat rather than converting it efficiently. When that heat source is co-located on the LED board, it creates thermal coupling that degrades both the driver electronics and the LED emitters simultaneously [4, 5].
- ◆ When it fails, you replace everything. In a modular architecture, a driver failure requires replacing only the driver module, typically a 10-minute field swap. In an integrated design, a driver failure means replacing the entire light engine (the LED board and its electronics) or the complete fixture, a 30-to-45-minute procedure requiring more complex inventory and longer track occupancy [13].
- ◆ Buy America compliance warrants scrutiny. At least one manufacturer's documentation confirms that LED boards and drivers are manufactured outside the United States. For federally funded transit projects subject to the Build America, Buy America Act (BABAA), this raises material domestic content compliance questions that agencies should investigate before specification [3, 14].

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line

[4] RECOM Power, "The Advantages and Disadvantages of Switching Regulators versus Linear Regulators," 2026.

[5] WonderfulPCB, "Linear Voltage Regulators vs. Switching Regulators: Key Differences," 2025

[13] U.S. DOE, "LED Luminaire Lifetime: Recommendations for Testing and Reporting."

[14] Build America, Buy America Act (BABAA), Infrastructure Investment and Jobs Act, Public Law 117-58, Section 70901 et seq., 2021

The Physics: Every LED Needs a Driver

Light-emitting diodes are current-driven semiconductor devices. They require a precise, regulated DC current to produce stable light output.

Operating LEDs from 120V or 277V AC mains power, the standard supply in North American transit infrastructure, requires a minimum of four functional stages regardless of fixture architecture [2]:

- ◆ DAC-to-DC Rectification: Converting alternating current to direct current
- ◆ Current Regulation: Controlling the precise current delivered to LED junctions
- ◆ Surge Suppression: Protecting sensitive semiconductor junctions from voltage transients
- ◆ Thermal Management: Dissipating waste heat from regulation electronics and LED junctions

These functions are governed by fundamental electrical engineering principles. No LED luminaire connected to AC mains can operate without them [2]. The question is never whether these functions exist, but how and where they are implemented.

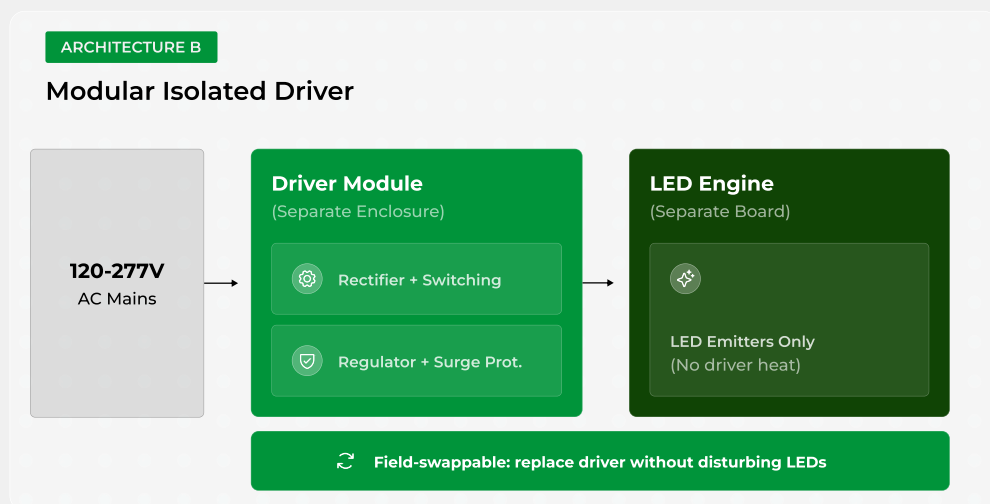
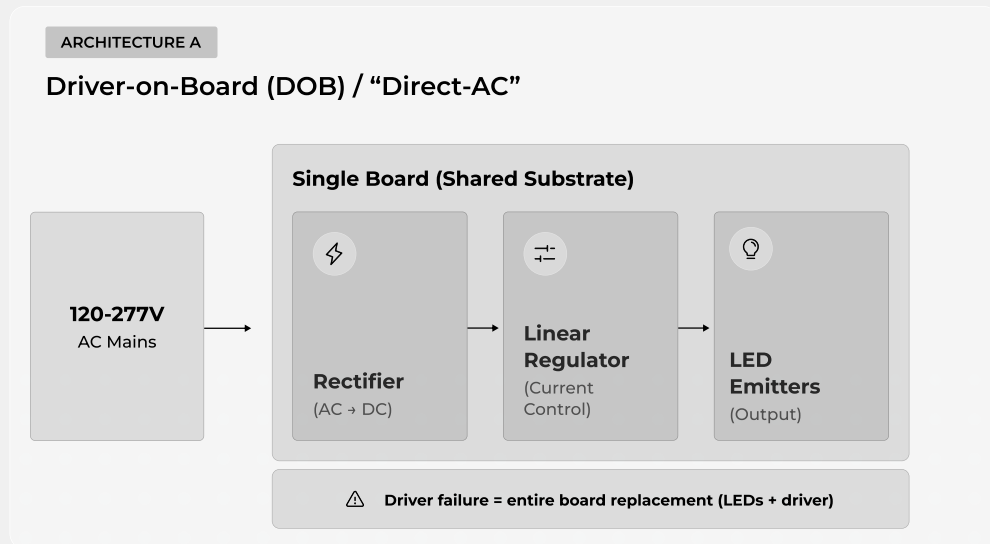
How the Two Dominant Architectures Work

There are two primary approaches to LED driver architecture in tunnel lighting, and understanding the structural difference between them is the key to understanding everything that follows.

- ◆ Discrete Driver Architecture: A physically separate driver module performs rectification and regulation. The driver is thermally and electrically isolated from the LED engine, and can be independently replaced, tested, and inventoried. This is the established architecture in infrastructure lighting.

[2] AGC Lighting, "Constant Current vs. Constant Voltage LED Driver"

- ◆ Driver-on-Board (DOB) / Direct-AC Architecture: Rectification and regulation circuitry is integrated directly onto the LED board. The external driver housing is removed, but the functional driver electronics remain. High-voltage linear constant-current regulators and rectification components share the LED substrate. Products using this approach are sometimes described as "driverless" or "Direct-AC" [3].



The term "driverless" therefore describes where the driver circuitry lives, not whether it exists. The power electronics are still present. They have been repackaged, not removed.

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line.

Why Modular Drivers Became the Industry Standard

For more than two decades, infrastructure-grade lighting, including roadway, aviation, and rail transit systems, has relied on discrete driver modules.

The reasons are practical: thermal separation between power electronics and optical components, independent replacement of the most failure-prone subsystem, surge protection design flexibility, and simplified field service procedures [8].

Field data consistently bears this out. The U.S. Department of Energy has noted that observed failures in LED luminaires typically occurred in the driver circuit [13]. Modular architectures allow those circuits to be replaced independently, preserving the optical assembly while minimizing service time and cost.

Driver-on-board designs emerged primarily in cost-optimized commercial lighting where fixture replacement is easy and service access is unconstrained. Tunnel lighting presents very different requirements: constrained access, elevated ambient temperatures, traction-induced electrical stress, and multi-decade service expectations.

Modular driver architecture is the established engineering practice for this class of installation. The question this paper examines is what happens when Direct-AC designs depart from that practice.

The Thermal Trade-Off That Comes with Integration

Temperature is the single most significant accelerator of electronic component aging. In integrated driver-on-board architectures, regulation electronics and LED junctions share the same physical substrate.

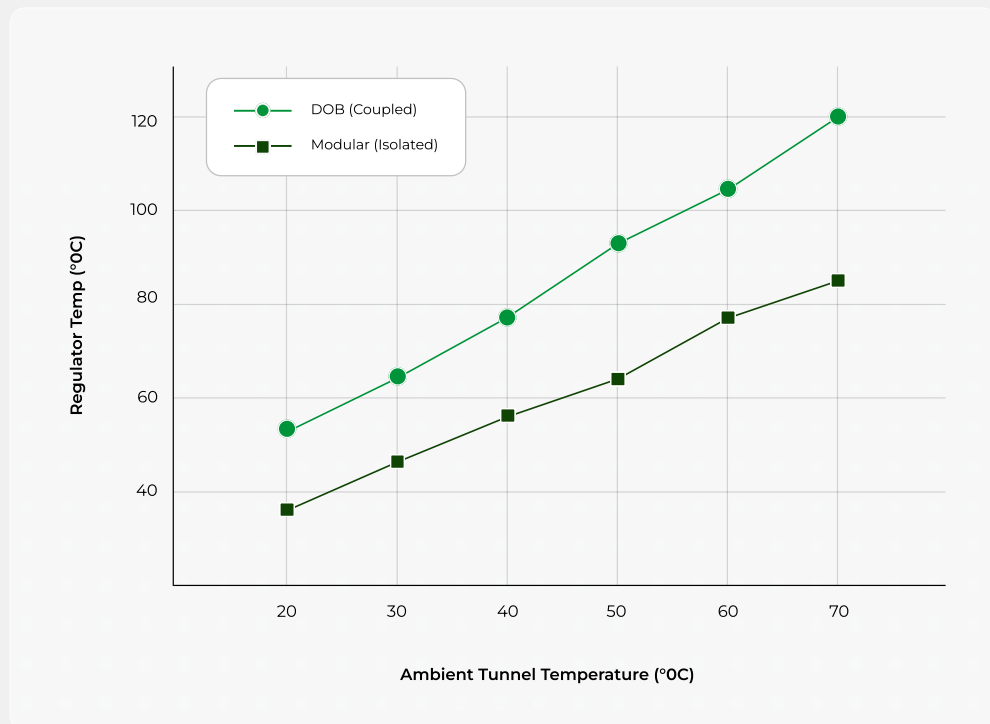
The heat generated by the linear regulator's inefficiency is conducted directly into the LED package, creating thermal coupling, a condition where the waste heat from power conversion degrades the very optical components it powers.

[8] ZGSM Lighting, "Mean Time Between Failure of LED Driver and the Importance of MTBF," 2026.

[13] U.S. DOE, "LED Luminaire Lifetime: Recommendations for Testing and Reporting."

Think of it this way: imagine running a space heater inside the same sealed box as your computer's processor. The heater (linear regulator) and the processor (LEDs) cannot cool independently. One makes the other hotter. In a modular design, the heater is in a separate box that can be vented, replaced, or upgraded without touching the processor.

The efficiency numbers tell the story. Switching regulators used in modular drivers achieve 85 to 94% efficiency. Linear regulators, the topology used in "driverless" designs, achieve 50 to 64% efficiency at equivalent power levels [4, 5]. That efficiency gap is not lost energy in the abstract. It is converted directly into heat on the LED board.



In transit tunnel environments where ambient temperatures can reach 40 to 55 degrees Celsius during peak operations, the coupled architecture drives regulator temperatures significantly higher than the isolated configuration.

At least one manufacturer rates its fixture for operation at negative 20 to 55 degrees Celsius but provides no published data on regulator junction temperatures at the upper bound of this range [3].

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line

[4] RECOM Power, "The Advantages and Disadvantages of Switching Regulators versus Linear Regulators," 2026.

[5] WonderfulPCB, "Linear Voltage Regulators vs. Switching Regulators: Key Differences," 2025

Why this matters for LED longevity: LED lumen depreciation accelerates with junction temperature. Higher sustained temperatures reduce the L70 lifetime, the point at which output degrades to 70% of initial lumens.

Solder joint integrity degrades under thermal cycling, and co-located power electronics amplify thermal excursions on the LED substrate. Phosphor degradation also accelerates at elevated temperatures, shifting color temperature and reducing color rendering quality over time [6].

What Temperature Does to Component Life

The relationship between temperature and electronic component reliability is well-established through the Arrhenius equation, which defines the acceleration factor for thermally-driven failure mechanisms [7].

For many electronic components, including the linear regulators and capacitors present in DOB architectures, the commonly cited rule of thumb holds: a 10-degree-Celsius increase in operating temperature approximately halves component life [7].

What this means in practice: for a driver circuit rated at 25 degrees Celsius, operating at 55 degrees Celsius (a realistic tunnel temperature) can reduce expected life by roughly an order of magnitude, depending on activation energy and specific failure mechanism.

When driver electronics run even hotter because they share a board with the LEDs, the reduction is more severe. Industry data consistently shows that approximately 90% of LED luminaire field failures originate in the driver circuit, not the LED emitters themselves [8]. This makes driver thermal management the single most critical determinant of luminaire reliability.

When the driver electronics are thermally coupled to the LED engine, as in DOB architectures, the compounding thermal burden reduces both driver and LED lifetimes simultaneously.

[6] Endrich Bauelemente, "LED Drivers: Reliability and Performance Factors," 2016.

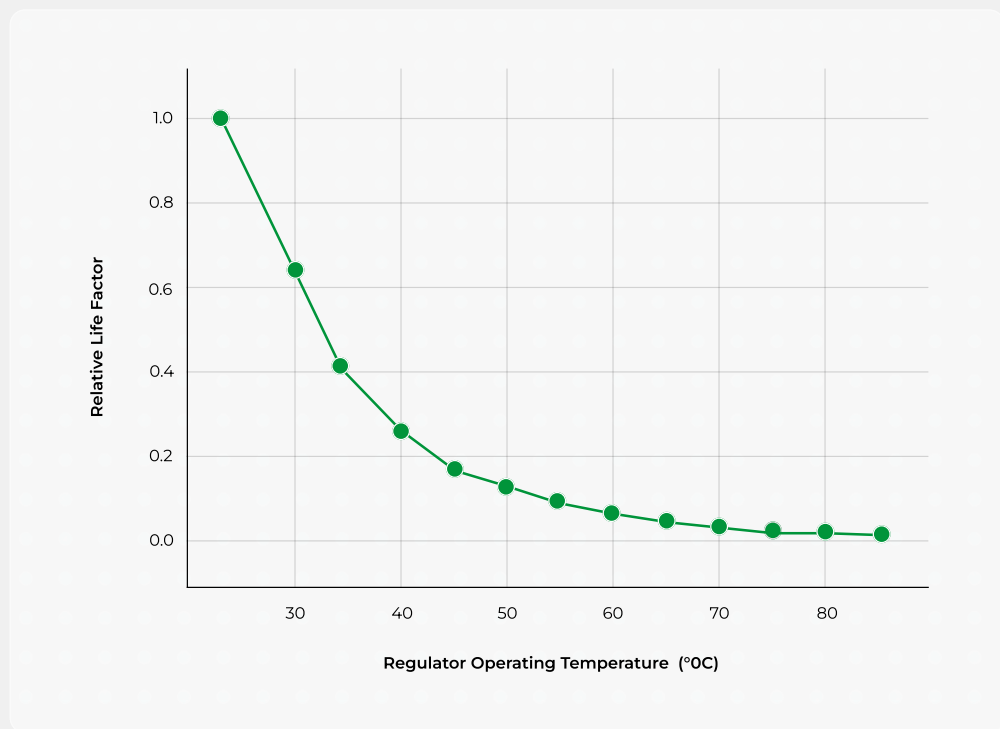
[7] Electronics Cooling, "Does a 10C Increase in Temperature Really Reduce the Life of Electronics by Half?" 2017

Illustrative Reliability Impact Under Arrhenius Acceleration ($E_a = 0.7 \text{ eV}$)

Condition	Regulator Temp Illustrative	Relative Life Factor	Effective MTBF Impact
Modular at 40C ambient	56C	1.0x (baseline)	Full rated life
DOB at 40C ambient	76C	~0.25x	~75% reduction
Modular at 55C ambient	66C	~0.50x	~50% reduction
DOB at 55C ambient	90C	~0.10x	~90% reduction

Table: Illustrative Reliability Impact Under Arrhenius Acceleration (based on thermal model, $E_a = 0.7 \text{ eV}$).

The thermal model presented here is illustrative and intended to demonstrate architectural differences rather than represent measured performance of any specific product.



What it Means in Real Tunnel

The following scenario translates the thermal and reliability data above into the operational terms transit agencies manage daily: crew hours, track occupancy, inventory, and maintenance budgets.

Scenario: 1,200 LED fixtures in a 2.4-mile commuter rail tunnel

Parameter	Value
Service life target	25 years
Average ambient temperature	45C (summer peak: 55C)
Maintenance access	Revenue service shutdown windows (nights/ weekends)
Crew cost per tunnel entry	Approx. \$2,500 to \$4,000 per event (crew + safety + track time)
Annual driver failure rate (modular)	~2 to 3% of fixtures (industry-typical at 45C)
Annual driver failure rate (DOB)	~5 to 8% of fixtures (elevated due to thermal coupling)

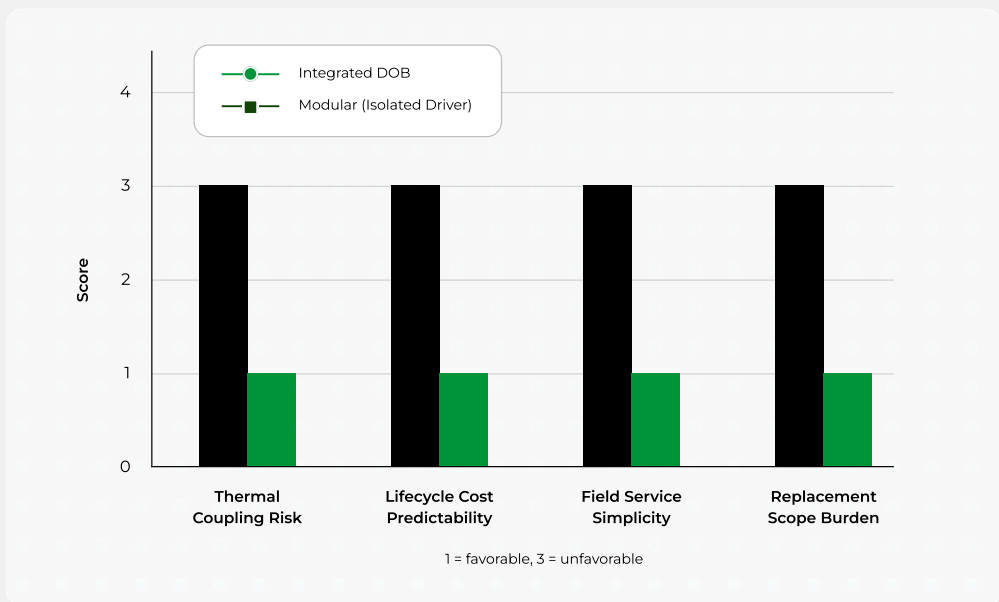
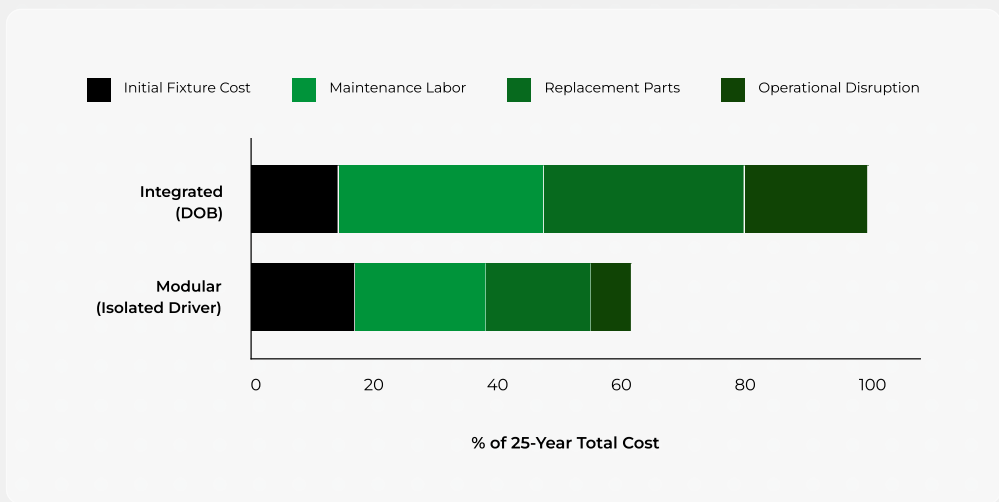
25-Year Maintenance Comparison (Illustrative)

Metrics	Modular Isolated Driver	Integrated DOB
Annual failures (1,200 fixtures)	24 to 36 driver modules	60 to 96 fixture/board units
Replacement scope per event	Driver module only (~10 min field swap)	Full board or fixture (~30 to 45 min per unit)
Annual track occupancy	~4 to ~6 crew-nights	~12 to 20 crew-nights
Annual maintenance cost (est)	\$60K to \$100K	\$180K to \$380K
25-year maintenance cost (est.)	\$1.5M to \$2.5 M	\$4.5M to \$9.5M

Inventory stocking	Small driver modules (low, per-unit cost)	Full assemblies (high per-unit cost)
Operational disruption	Minimal, fewer windows	Significant, more windows with longer duration

These estimates are illustrative and intended to demonstrate the magnitude of the cost differential, not to predict exact outcomes for any specific installation.

Agencies should request vendor-specific lifecycle cost models using their own labor rates, access constraints, and failure rate assumptions as part of the RFP evaluation process.



The initial purchase price of a tunnel lighting fixture is typically 10 to 15% of its 25-year total cost of ownership.

Maintenance labor, track occupancy, inventory, and operational disruption dominate. Architecture choices made at procurement directly determine which cost trajectory an agency locks in for the next quarter century.

The Tunnel Stress Test: Why Architecture Matters More Underground

Transit tunnels represent one of the most demanding operating environments for electronic systems. Lighting fixtures installed in these environments must withstand multiple simultaneous stress vectors that compound over a 20-to-25-year lifecycle [9]:

Stress Vector	Source	Integrated DOB
Voltage transients	DC traction power systems (600 to 800 Vdc)	Transients couple directly into regulator on LED substrate
Continuous vibration	Rail operations, ventilation systems	Solder joints under combined thermal + mechanical fatigue
Elevated ambient temperature	Train braking, HVAC, enclosed geometry	Amplified by thermal coupling
Corrosive atmosphere	Rail dust, brake dust, moisture ingress	Accelerated degradation of exposed regulation components
Constrained maintenance access	Active rail operations, safety protocols	Full fixture replacement increases track occupancy time

[9] NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems, 2023 Edition

Scenario: 1,200 LED fixtures in a 2.4-mile commuter rail tunnel

Traction electrification systems introduce electrical conditions not typically encountered in commercial lighting installations. Switching substations, regenerative braking events, and long feeder cables can produce voltage transients that propagate through the tunnel electrical infrastructure.

These transient events can exceed standard industrial surge thresholds, placing additional stress on lighting electronics connected to the same power distribution network [10].

At least one manufacturer specifies built-in 4kV surge protection [3]. While this meets baseline requirements, transit tunnel environments with DC traction power systems operating at 600 to 800 Vdc can produce transient events significantly exceeding this threshold.

The Transportation Research Board has documented voltage transients in traction power systems that can stress lighting electronics beyond typical industrial thresholds [10].

In a DOB architecture, surge energy that exceeds the protection threshold enters the same substrate that hosts both the LED emitters and the current regulators. The propagation path runs directly through the components responsible for light output and current control, meaning a single transient event can damage the entire light engine.

In a modular architecture, the isolated driver module acts as a sacrificial buffer: surge protection components absorb the transient event independently, preventing surge energy from reaching the LED engine. Even if the driver module fails, it can be replaced without disturbing the optical assembly [10].

Applicable Standards

- ◆ NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems, defines fire protection and life safety requirements including emergency lighting provisions [9]
- ◆ IES RP-22-11: Recommended Practice for Tunnel Lighting, provides design criteria for threshold, transition, and interior zone illumination [11]
- ◆ MIL-STD-461E/F: Requirements for the Control of Electromagnetic Interference, ensures compatibility with transit communication systems [12]
- ◆ UL 8750: Standard for Safety of LED Equipment for Use in Lighting Products
- ◆ ANSI C136.31: Vibration resistance standard for roadway and area lighting

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line.

[9] NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems, 2023 Edition

[10] Transportation Research Board, "Operational and Safety Considerations for Light Rail DC Traction Electrification System Design."

[11] IES RP-22-11, "Tunnel Lighting," Illuminating Engineering Society, 2011.

[12] MIL-STD-461E/F, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," U.S. Department of Defense.

EMI Compliance: What It Proves and What It Does Not

Some Direct-AC fixtures have achieved compliance with MIL-STD-461E RE102 testing and are described as "EMI silent" [3]. This is a legitimate and valuable engineering achievement.

Transit tunnels house radiating cable systems, radio communication infrastructure, and wireless networks that are sensitive to electromagnetic interference. Low EMI is a genuine functional requirement.

Some Direct-AC fixtures have also demonstrated strong certification portfolios that reflect genuine engineering work, including high system efficacy ratings, IK10 impact resistance, NFPA 130/502 compliance, and 3G vibration resistance [3]. These credentials are not disputed.

However, none of them address the architectural questions central to this analysis: how the driver circuitry is thermally managed, how it is serviced in the field, and what the minimum replaceable unit is when driver electronics fail. A product can pass every certification and still present significant lifecycle cost and serviceability disadvantages due to its internal architecture.

It is critical to understand what EMI compliance demonstrates and what it does not.

EMI Compliance Demonstrates	EMI Compliance Does Not Demonstrate
Low radiated emissions at tested output levels	Absence of driver circuitry
Compatibility with nearby RF-sensitive equipment	Immunity from surge or voltage transients
Effective regulation topology for EMI suppression	Thermal management adequacy over 25 years
Regulatory conformance (FCC Part 15B)	Mechanical reliability under continuous vibration

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line.

The low EMI performance is a direct consequence of the linear regulator topology. Linear regulators avoid the high-frequency switching that generates RF noise, which explains the strong MIL-STD-461E performance. But that same topology is also the source of the thermal penalty described throughout this paper [4].

Modern switching-regulator-based LED drivers with proper EMI filtering (common-mode chokes, X/Y capacitors, shielding) routinely achieve FCC Part 15B Class A compliance, sufficient for the vast majority of transit installations.

MIL-STD-461E compliance, while more stringent, is achievable with switching topologies and does not inherently require linear regulation.

Buy America Compliance: Follow the Components

The Build America, Buy America Act (BABAA), enacted as part of the Infrastructure Investment and Jobs Act (IIJA) of 2021, requires that manufactured products used in federally funded infrastructure projects be produced in the United States, with domestic components meeting specified cost thresholds [14].

Transit lighting installed in projects funded by the Federal Transit Administration (FTA) is subject to these requirements.

The Domestic Content Requirement

For manufactured products such as LED luminaires, BABAA requires that the product must be manufactured in the United States (final assembly and all significant manufacturing processes), and the cost of domestic components must meet or exceed the applicable threshold: 55% (2022), rising to 65% (2024 to 2028) and 75% (2028 onward) [14]. Iron and steel products must be produced entirely in the United States from melting through coating.

Agencies reading this in 2026 are already operating under the 65% domestic content threshold, and projects delivering in 2028 or later face the 75% requirement, making today's component sourcing decisions even more consequential.

[4] RECOM Power, "The Advantages and Disadvantages of Switching Regulators versus Linear Regulators," 2026.

[14] Build America, Buy America Act (BABAA), Infrastructure Investment and Jobs Act, Public Law 117-58, Section 70901 et seq., 2021.

Why This Matters for "Driverless" Fixtures

At least one manufacturer's own specification sheet states that LED boards and drivers are manufactured outside the United States [3].

In an LED luminaire, the LED boards and driver electronics typically represent the highest-cost components, often 40 to 60% of total component cost. If these core electrical subsystems are sourced internationally, meeting BABAA's domestic content thresholds becomes difficult.

The procurement risk is real. A transit agency that specifies "driverless" fixtures for a federally funded project may face BABAA compliance challenges during FTA audit. Non-compliance can jeopardize federal grant funding and require costly product substitutions after contract award [15].

Recommended Due Diligence

Agencies should request a full Bill of Materials with country of origin, a domestic content cost calculation, and written BABAA certification from any tunnel lighting manufacturer. The "Questions for Your Next RFP" section of this paper provides specific language for this purpose.

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line

[15] Federal Transit Administration, "Oversight Procedure 36: Buy America Compliance Review," November 2024.

What to Ask Before You Specify

Transit agencies frequently rely on specification sheets that summarize performance metrics but do not reveal architectural design choices that influence long-term reliability. The following evaluation framework is intended to ensure that procurement decisions consider both performance specifications and underlying system architecture.

Specification	What to Evaluate	Key Question
Efficacy (LPW)	System-level efficiency including driver losses	Does efficacy include regulator thermal losses?
L70 Lifetime	Stated at what ambient temperature?	Is L70 tested at 25C or at rated max ambient?
Surge Protection	kV rating, waveform type, energy rating (Joules)	Is 4kV adequate for traction power environments?
THD	Total Harmonic Distortion at rated load	What is THD at elevated temperatures?
Power Factor	At what load percentage?	Is 0.9 nominal or worst-case?
MTBF / MTF	Testing standard used, test temperature	Is MTBF stated for driver or complete luminaire?
Warranty	What is covered? What voids coverage?	Does warranty require specific operating conditions?
Serviceability	Field-replaceable components?	What is the minimum replaceable unit?
BABAA Compliance	Domestic content percentage?	Are LED boards and drivers manufactured in the USA?

Transit agencies should avoid specifying terminology such as "driverless fixtures" in RFP language.

Specifications should instead define architectural, thermal, and serviceability requirements that allow objective evaluation of competing designs regardless of branding. Performance-based specifications ensure that procurement decisions are driven by engineering merit, not product terminology.

What To Ask In An RFP

The following questions can be inserted directly into request for proposal (RFP) evaluation criteria. They are written in plain language so that procurement officers, engineering committees, and transit board members can evaluate responses without a power electronics background.

1. Provide a complete circuit block diagram showing every power conversion stage from AC mains input to LED output. Label the location and type of all rectification, regulation, surge protection, and thermal management components. If the product is described as "driverless," explain what performs the driver function.
2. What is the operating temperature of the current regulator at the maximum rated ambient temperature (e.g., 55C) under full load? Provide thermal modeling data or third-party test results.
3. What is the minimum replaceable unit (MRU) in the event of a driver circuit failure? Can the driver be replaced independently of the LED engine? Provide a documented field replacement procedure with estimated labor time.
4. Provide MTBF calculations with the testing standard cited (e.g., MIL-HDBK-217F, Telcordia SR-332). State the ambient temperature at which MTBF was calculated. Is the MTBF for the driver circuit, the LED engine, or the complete luminaire?
5. Provide surge test reports including waveform type (combination wave per IEEE C62.41), kV rating, energy rating in Joules, and number of test impulses applied. Explain how the fixture is protected against traction-induced voltage transients.
6. Provide a 25-year lifecycle cost model under at least three failure rate scenarios (optimistic, expected, pessimistic). Include labor costs at the agency's track occupancy rate, replacement component costs, inventory requirements, and operational disruption costs.
7. Certify BABAA compliance. Provide the bill of materials with country of origin for each component category, the domestic content cost percentage, and written certification that the product meets the applicable BABAA threshold. Identify where LED boards and driver electronics are manufactured.
8. Detail warranty terms including what is covered, what voids coverage, the replacement scope (module vs. fixture), and how warranty claims are processed for fixtures installed in active transit tunnels with limited access.

Conclusion: Architecture Over Terminology

The term "driverless," as applied to AC-powered LED tunnel lighting, describes a packaging configuration, not a fundamental engineering breakthrough.

Every AC-powered LED luminaire contains driver functionality, as confirmed by publicly available patent documentation and manufacturer specification sheets.

The engineering question is not whether a driver exists, but how it is architected, thermally managed, protected from surge events, serviced in the field, and verified for BABAA compliance.

Five points deserve emphasis:

- 1. "Driverless" does not mean the driver was eliminated.** The driver was relocated onto the LED board, not removed. Patent documentation and specification sheets confirm this.
- 2. The architecture creates a thermal trade-off.** Linear regulators achieve low EMI but dissipate excess energy as heat on the LED substrate, accelerating component aging in tunnel environments.
- 3. Maintenance cost is the dominant lifecycle expense.** A driver failure in a DOB fixture requires replacing the entire light engine or fixture. In a modular design, only the driver module is swapped.
- 4. BABAA compliance warrants scrutiny.** At least one manufacturer acknowledges that LED boards and drivers are produced outside the USA. Agencies should request documented domestic content percentages before specifying these products in federally funded projects.
- 5. Procurement language matters.** Specifying "driverless" fixtures in an RFP may inadvertently exclude architecturally superior alternatives. Specifications should define performance and serviceability requirements rather than product branding terms.

In infrastructure engineering, serviceability acts as a reliability multiplier. Systems designed so that their most failure-prone components can be replaced independently typically outperform architectures that integrate those components with long-life optical assemblies.

By adopting architectural transparency as a procurement benchmark, agencies strengthen safety, fiscal stewardship, regulatory compliance, and operational continuity across multi-decade infrastructure commitments.

A Note on Longevity

Transit agencies think in decades. When specifying emergency lighting systems that must perform reliably for 15+ years in harsh underground environments, the supplier's stability and product longevity matters as much as the product specifications.

Clear-Vu Lighting was founded in 2008, with third-generation manufacturing heritage through parent company Autronic Plastics (est. 1953).

The company operates from a 100,000 square foot U.S. facility with approximately 130 employees. Certifications include ISO 9001, UL Certified Assembler and Fabricator, and full Buy America compliance.

Learn More

Clear-Vu has supplied tunnel lighting systems to transit agencies across North America.

For technical specifications on industrial-grade NiMH tunnel lighting systems, pilot program information, or to schedule a facility tour, visit clearvulighting.com or contact Clear-Vu Lighting CEO Daniel Lax at dlax@clearvulighting.com.

Daniel is the Founder and Chief Executive Officer of Clear-Vu Lighting.

References

[1] U.S. Patent No. 11,832,361 B2, "Low electromagnetic interference lighting device with variable output levels," Filed Oct. 8, 2021, Granted Nov. 28, 2023.
<https://patents.justia.com/patent/11832361>

[2] AGC Lighting, "Constant Current vs. Constant Voltage LED Driver," 2025.
<https://www.agcled.com/blog/constant-current-vs-constant-voltage-led-driver-need.html>

[3] Publicly available manufacturer specification sheets for a Direct-AC tunnel lighting fixture product line, including fixture spec sheet (Rev. 22 0126) and product spec sheet (Rev. 0225), as referenced in product documentation available through the manufacturer's rail tunnel lighting product page. Specification sheet quotes and data points cited in this paper are drawn directly from these published documents. Copies available upon request from the author.

[4] RECOM Power, "The Advantages and Disadvantages of Switching Regulators versus Linear Regulators," 2026.
<https://recom-power.com/en/rec-n-the-advantages-and-disadvantages-of-switching-regulators-versus-linear-regulators-for-dc!sdc-conversion-398.html>

[5] WonderfulPCB, "Linear Voltage Regulators vs. Switching Regulators: Key Differences," 2025. Comparison data: Linear regulator 50-64% efficiency vs. switching 85-94% at equivalent power levels.
<https://www.wonderfulpcb.com/blog/linear-voltage-regulators-vs-switching-regulators/>

[6] Endrich Bauelemente, "LED Drivers: Reliability and Performance Factors," 2016. Reports that LED driver failure rate increases 25-40% per 10C case temperature increase.
<https://electronics-articles.com/LED040/en-led-drivers-reliability-and-performance-factors.html>

[7] Electronics Cooling, "Does a 10C Increase in Temperature Really Reduce the Life of Electronics by Half?" 2017. Based on Arrhenius equation with activation energy 0.7-0.8 eV.
<https://www.electronics-cooling.com/2017/08/10c-increase-temperature-really-reduce-life-electronics-half/>

[8] ZGSM Lighting, "Mean Time Between Failure of LED Driver and the Importance of MTBF," 2026. Reports ~90% of LED luminaire failures originate from driver circuits.
<https://www.zgsm-china.com/blog/mean-time-between-failure-of-led-driver-and-the-importance-of-mtbf.html>

[9] NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems, 2023 Edition. National Fire Protection Association.
<https://www.nfpa.org/codes-and-standards/nfpa-130-standard-development/130>

[10] Transportation Research Board, "Operational and Safety Considerations for Light Rail DC Traction Electrification System Design," TRB Circular EC-058.

https://onlinepubs.trb.org/onlinepubs/circulars/ec058/14_02_pham.pdf

[11] IES RP-22-11, "Tunnel Lighting," Illuminating Engineering Society, 2011. ANSI-approved recommended practice for vehicular tunnel lighting design.

<https://www.ecmweb.com/construction/article/20885398/new-recommended-practice-published-by-ies-rp-22-11-tunnel-lighting>

[12] MIL-STD-461E/F, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," U.S. Department of Defense.

[13] U.S. DOE, "LED Luminaire Lifetime: Recommendations for Testing and Reporting." Reports that observed failures typically occurred in the driver circuit.

<https://www.energy.gov/eere/ssl/articles/led-luminaire-lifetime-recommendations-testing-and-reporting-0>

[14] Build America, Buy America Act (BABAA), Infrastructure Investment and Jobs Act, Public Law 117-58, Section 70901 et seq., 2021. Domestic content thresholds for manufactured products: 55% (2022), 65% (2024-2028), 75% (2028+).

<https://www.accessfixtures.com/understanding-the-build-america-buy-america-act-baba-and-its-compliance-requirements-for-baba-lights/>

[15] Federal Transit Administration, "Oversight Procedure 36: Buy America Compliance Review," November 2024. Details FTA audit procedures for domestic content verification.

<https://www.transit.dot.gov/sites/fta.dot.gov/files/2024-11/Oversight-Procedure-36-Buy-America-Compliance-Review.pdf>

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