

Navigating Tunnel Environments

Proven Solutions for Safe, Compliant
& Uninterrupted Operations



Tunnel Environments. Zero Margin for Error.

Monitoring a modern tunnel environment is a constant exercise in precision, where the margin for error is almost nonexistent. Operators and authorities face invisible threats that can escalate rapidly into catastrophic incidents and the tunnel environment itself is unforgiving.

The pressures no tunnel operator can ignore

Air quality & toxic gas build-up

- CO, NOx and particulate matter accumulate rapidly during peak hours.
- No early warning without continuous monitoring – thresholds breach silently.
- Direct risk to user safety, emergency responders and regulatory standing.

Ventilation control & energy efficiency

- Without real-time visibility, ventilation and lighting costs are difficult to track or control.
- Jet fans without real-time data under-perform in emergencies or waste energy needlessly.
- Every hour of inefficient operation carries a measurable financial and safety cost.

Visibility, lighting & driver safety

- Glare, haze, smoke and microclimate shifts degrade visibility without warning.
- Poor luminance adaptation at portals is a leading cause of tunnel entry incidents.
- Tunnel lighting that cannot adapt to changing conditions in real time can increase operational risks.

Reliability, maintenance & compliance

- Humidity, corrosive exhaust and vibration steadily degrade installed equipment.
- Unplanned maintenance requires traffic closures, specialist crews and significant cost.
- Regulatory standards are tightening – monitoring must be audit-ready at all times, not just during inspections.



63.7%

of tunnel accidents occur in the entrance zone – where luminance adaptation failure and inadequate lighting transition management are the primary contributing factors.

30–40%

of total tunnel operating costs are from ventilation and lighting.

€210 million

per year average cost of a tunnel operational shutdown.

67%

loss in a driver's visual field (MOR) occurs as tunnel traffic gridlocks, caused by exhaust, tyre dust, and water vapour particles.

Sources:

1. Norway Highway Bureau, cited in Safety Evaluation of Lighting at Very Long Tunnels, ScienceDirect 2019
2. PIARC Road Tunnels Manual – Energy Consumption
3. EU Directive 2004/54/EC Explanatory Memorandum, European Commission

Every challenge monitored. Every operation protected.

Acoem’s integrated tunnel monitoring solutions

Purpose-built to meet every challenge head-on, with proven technology that operators and EPC contractors trust through decades of operation. Designed to integrate seamlessly into existing infrastructure and deliver reliable, actionable data from day one.



Airflow monitoring
Real-time velocity and direction data drives intelligent, demand-responsive ventilation control.



Luminance & illuminance
Adaptive lighting control at portals and throughout the tunnel interior, eliminating dangerous light transition zones.



Gas monitoring
Continuous CO, NOx and particulate measurement with early-warning threshold alerting.



Control & integration
CTU, TSCU and TSCU-R units centralise all parameters into a single SCADA-ready integration point.



Visibility monitoring
Optical extinction measurement communicates directly with jet fan and traffic management systems.



Emissions monitoring
CAAQMS tracks background gases, particulate matter and recycled exhaust air, driving dynamic ventilation adjustments for optimal air dilution.

Proven globally

- Urban metro systems
- Highway and road tunnels
- Regional road tunnels
- Metro infrastructure
- Extreme-environment projects

35+
countries with active installations

10,000+
sensors installed globally

Proud partners of the Victorian Tunnelling Centre.

Acoem collaborates with Holmesglen TAFE at the Victorian Tunnelling Centre (VTC) in Australia, where our monitoring systems provide hands-on, real-world professional training. Our technology is actively shaping the next generation of tunnel professionals.



Your environment. Your challenge. The same proven system.

Whether you operate in the heart of a city, along a regional highway or in a remote extreme-environment corridor – Acoem’s monitoring solutions are engineered to perform. The same proven technology, configured for the specific demands of your infrastructure.



Urban tunnels
High-density traffic, continuous congestion and strict public health compliance demand immediate response.



Semi-urban & regional tunnels
High-speed transitions from open roads to confined environments create unique driver safety risks.



Extreme environments
Sub-sea passages, high-altitude mountain corridors and remote rail tunnels demand hardware that performs without compromise.



Retrofitting & upgrades
Ageing monitoring infrastructure is one of the most common – and most overlooked – tunnel risks.

Established expertise. Proven heritage.

Our tunnel monitoring roots run deep – founded in 2005 as Tunnel Sensors Ltd (Banbury, UK) and acquired by Acoem in 2019, our heritage spans over 20 years of continuous innovation, field-proven across tunnel environments worldwide.

Trusted by leading tunnel operators, authorities and EPC contractors in 35+ countries.



As a service engineer who has spent years installing and maintaining tunnel monitoring products, I must say that Acoem’s Tunnel Sensors instruments are bulletproof.

Tunnel ventilation contractor (Australia)

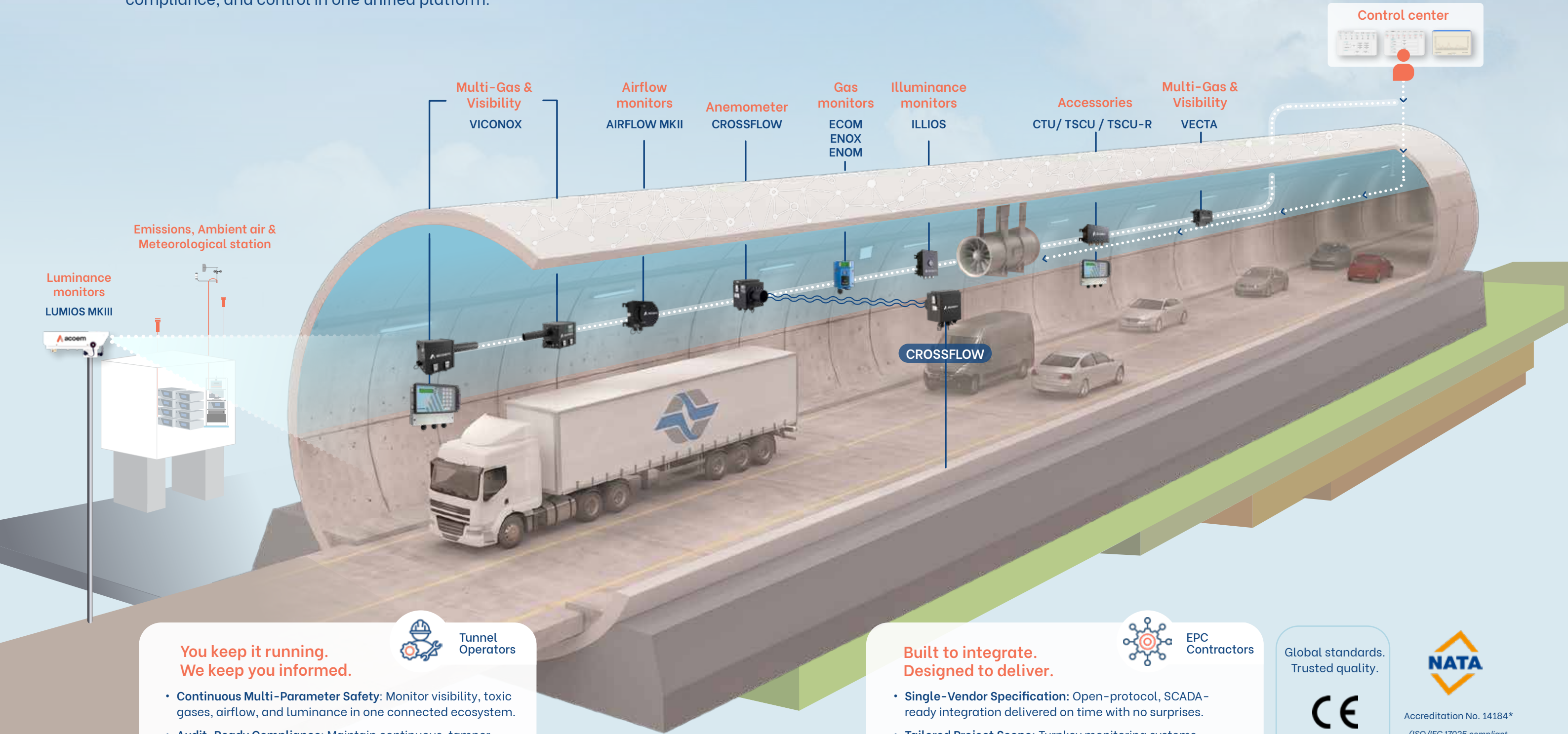
Acoem’s technical support has been invaluable. When we had questions about connectivity, they guided us through the process and gave us all the information we needed. Our Tunnel Sensors monitors and TSCU-R work perfectly.

Tunnel operations manager (Qatar)



Connected tunnel intelligence

Continuous, multi-parameter monitoring for safety, compliance, and control in one unified platform.



**You keep it running.
We keep you informed.**



Tunnel
Operators

- **Continuous Multi-Parameter Safety:** Monitor visibility, toxic gases, airflow, and luminance in one connected ecosystem.
- **Audit-Ready Compliance:** Maintain continuous, tamper-evident data logging to ensure instant compliance during inspections.
- **Full-Lifecycle Support:** Long-term calibration services, smooth upgrades, and responsive technical support.

**Built to integrate.
Designed to deliver.**



EPC
Contractors

- **Single-Vendor Specification:** Open-protocol, SCADA-ready integration delivered on time with no surprises.
- **Tailored Project Scope:** Turnkey monitoring systems or individual specialized sensors for new builds and refurbishments.
- **Global Network, Local Support:** Certified local partners across 20+ countries for seamless on-site execution.

Global standards.
Trusted quality.



Accreditation No. 14184*
(ISO/IEC 17025 compliant
testing to AS/NZS 3580.18)

*for tunnel air quality and
emission stack pressure
monitoring.

Note: Diagram is for illustrative purposes only and not to scale.
Final equipment placement depends on site-specific standards and engineering specifications.

Atmospheric & airflow solutions

What's in the tunnel air, and how it's moving. Measured live, so ventilation responds before conditions turn dangerous.

VICONOX

Multi-parameter tunnel atmosphere monitor

Measures NO₂, NO (NO_x), CO, visibility and temperature at the same time, feeding ventilation control, traffic management and emergency response. Secondary smoke detection comes as standard.

Visibility threats it tracks:

- Weather conditions at tunnel portals.
- Internal microclimate, including fog formation.
- Road surface abrasion, tyre and brake particle wear.
- Pollution from stationary vehicles in congestion.
- Smoke and fire from accidents or faulty vehicles



VECTA

Electrochemical gas and visibility monitor

Toxic gas and visibility readings from one compact sensor. Its in-situ design removes the need for separate control units and multi-sensor setups. Pre-calibrated, plug-in smart modules sync data with the CPU on installation.

Best suited to:

- Localised gas build-up (CO, NO₂ or NO) in targeted tunnel sections.
- Sections prone to reduced visibility from dust, soot and haze

Dedicated tunnel gas monitors

Rugged, single-gas monitoring assemblies engineered for continuous tracking of harmful emissions inside enclosed spaces.

ECOM (CO) | ENOM (NO) | ENOX (NO₂):

Rapid-response, highly selective sensors built to withstand severe humidity and resist baseline drift during peak congestion.

Tunnel airflow monitors

Precision air velocity and direction data that drives automated ventilation loops and emergency smoke management.

- **AIRFLOW MkII:** ultrasonic fixed-point anemometer for continuous, point-specific tracking.
- **CROSSFLOW:** multi-lane bidirectional anemometer. Measures airflow across the full tunnel cross-section where single-point data isn't enough.

Core applications

- Ventilation on Demand (VoD) optimisation
- Fire and emergency smoke path control



Visibility & Portal lighting control

Drivers shouldn't have to adapt to the tunnel.
The lighting should adapt to them.

LUMIOS MkIII

Tunnel luminance monitor

The reference standard for portal and interior luminance measurement. It tracks the light levels that decide how safely drivers adapt between daylight and tunnel, and feeds lighting control that responds in real time, not on a fixed schedule.

What it prevents:

The "black hole" effect, the sudden perception of darkness as drivers enter a tunnel on a bright day, and a leading cause of tunnel entry incidents. LUMIOS MkIII keeps lighting matched to actual outside conditions, not a programmed timer.

Conditions it manages:

- Bright daylight portal entry and exit.
- Seasonal and time-of-day light variation.
- Overcast and low-light conditions.
- Rapid weather changes at the portal.
- Night-time lighting levels.



ILLIOS

Interior illuminance monitor

Measures light levels throughout the tunnel tube and balances driver visibility around the clock, while cutting off-peak energy use.

Core applications

- Adaptive portal lighting control
- Interior lighting management
- Energy optimisation



Beyond the portal

Ambient air, emissions & weather

Extending monitoring beyond the tunnel threshold to protect surrounding communities and meet environmental regulations.

Ambient air quality station (CAAQMS)

A complete station for tunnel portals, housed in one relocatable, weatherproof shelter. The Continuous Ambient Air Quality Monitoring Station (CAAQMS) combines multiple instruments:

- **Gas and particulate monitoring:** Serinus® gas analysers and BAM particulate monitors track PM2.5, PM10, NOx, SO₂ and CO at tunnel portals.
- **Audit-ready compliance:** Automated remote calibration and continuous logging demonstrate compliance with national and local air quality standards.
- **Ventilation feedback:** Real-time gas and inter-bore recirculation data goes straight to portal ventilation control, keeping air dilution optimal



Meteorological sensors

Local weather tracking at tunnel approaches, so operators can respond to portal microclimate shifts. Ultrasonic weather stations (Met One range) measure wind speed and direction, temperature, relative humidity, barometric pressure and precipitation.

- **Operational impact:** Feeds portal lighting control, alerts operators to crosswind risk on open approaches and flags conditions that favour portal fog.
- **Tailored configurations**
From a compact portal weather mast to a full CAAQMS shelter, every set-up is modular and tailored to your project, local regulations and site constraints.

Case studies

Lighting the way through Heathrow tunnels



Heathrow’s road tunnels required advanced portal luminance monitoring to ensure safe driver adaptation across constant passenger, cargo, and service traffic.

Problem

- Rapid lighting transitions posed compliance and safety risks.
- Sudden luminance changes risked temporary driver blindness.
- Instruments needed seamless integration with Heathrow’s existing lighting system.

Acoem’s solution

- Acoem delivered advanced luminance monitoring to ensure safe adaptation and compliance.
- LUMIOS MkIII deployed for continuous portal measurement and dynamic lighting control.

Outcomes

- Dynamic adjustments cut energy use while maintaining driver comfort.
- Enhanced safety, reliable compliance, and seamless integration – with zero operational disruption.



Maintaining air quality in Brazil’s mountain tunnels



A 360m single-tube, two-lane road tunnel in Rio de Janeiro required targeted gas detection to meet vehicular safety and compliance standards.

Problem

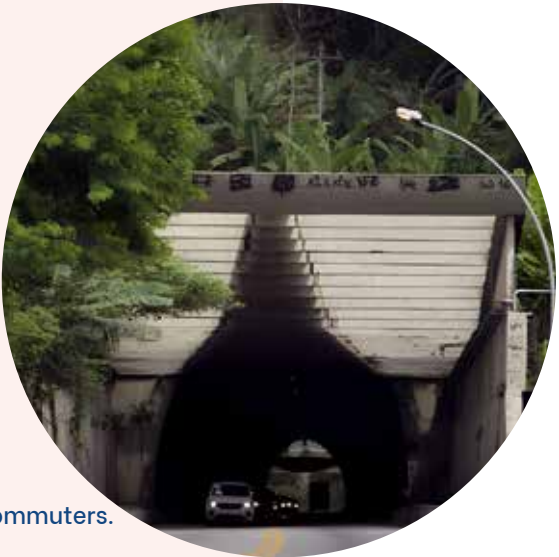
- Precise gas monitoring was essential – visibility monitoring was out of scope.
- CO, NO, and NO₂ detection required across a compact, defined environment.

Acoem’s solution

- Electrochemical gas sensors deployed to monitor CO, NO, and NO₂.
- Six complete sensor sets integrated into the tunnel’s safety system.

Outcomes

- Automated data integration optimised airflow and protected commuters.
- Precise toxic gas mitigation, strict regulatory compliance, and a cost-effective, targeted monitoring scope.



Acoem:
Your partner in environmental monitoring

At Acoem, we create environments of possibility—helping organisations find the right balance between progress and preservation. Our holistic environmental monitoring solutions empower industries, governments, and communities with accurate data to drive meaningful action for a cleaner, healthier planet.

As pioneers in designing, manufacturing, and maintaining integrated monitoring systems, we develop innovative technologies that simplify monitoring processes and enhance accessibility.

With a global presence in 50 countries and dedicated environmental hubs worldwide, Acoem provides localised expertise and cutting-edge solutions to help you make informed decisions that protect people, places, and the planet.



Environmental hubs

- **Australia**
- **Brazil**
- **France**
- **Germany**
- **India**
- **Thailand**
- **USA**
- **UK**



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