Department of
Transport and Main Roads

PIARC Technical Committee 4.4 Tunnels
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Plenary Meeting 5, Annecy, 9 March to 12 March 2026

EXECUTIVE SUMMARY

The fifth in-person meeting of PIARC Technical Committee 4.4 (Tunnels) was held in Annecy, France, from 9 to 12 March 2026. The meeting marked a clear transition point in the 2024–2027 PIARC cycle where TC4.4 has moved from surveys, literature reviews and case study collection into delivery of technical reports, recommendations, Road Tunnel Manual updates, conference sessions and future World Road Congress contributions.

The meeting reviewed progress across all TC4.4 work areas: sustainability of tunnel operation, active modes of transport in road tunnels, digitalisation, new energy carrier vehicle risks, the Road Tunnel Manual, preparation for the 3rd PIARC International Conference on Road Tunnel Operation and Safety in Cracow, and updates to the international software tool for dangerous good risk assessment DG-QRAM. It also covered PIARC governance changes, communication, gender inclusion and diversity, international liaison, future work cycle topics, learnings from recent tunnel fire incidents and various technical site visit material.

The main implications for the Australia and New Zealand (ANZ) road tunnel industry are:

- **Operational assurance is becoming as important as design compliance.** TC4.4's work is increasingly focused on control centre capability, tunnel safety officers, minimum operating requirements, user behaviour, emergency response and post-incident recovery. This aligns closely with Austroads' current work on tunnel operations and safety officer guidance.
- **Digitalisation needs to support asset management and operations.** Working Group 3 (WG3) showcased that digital twins, BIM, artificial intelligence and monitoring systems only deliver value when they are connected to operational decisions, maintenance planning and asset information governance.
- **Active mobility in existing tunnels needs a formal decision framework.** Working Group 2 (WG2) works to date have highlighted that pedestrians, cyclists, wheelchair users and personal mobility devices introduce safety, operational and emergency response issues that are not fully addressed in traditional road tunnel guidance.
- **New energy carrier vehicle risks need evidence-based treatment.** Working Group 4 (WG4) has reinforced that electric vehicles should not be assumed to have a higher fire likelihood than conventional vehicles, but their incident characteristics can differ. Future guidance needs to address firefighting tactics, ventilation, re-ignition, toxic emissions, contaminated runoff and responder safety.
- **Post-fire recovery is a guidance gap.** Recent fire case studies from the Huguenot and Brentenberg tunnels show the importance of damaged structural supports, temporary works, electromechanical reinstatement, user communication, scanning, monitoring and staged reopening.

As attendance to the Annecy meeting was conducted remotely, this report is based on formal presentations, working group documents, technical visit material and shared PIARC updates. It does not include first-hand observations from the in-person technical visits, informal discussions, working group breakouts or networking sessions.

BACKGROUND:

PIARC Technical Committee 4.4 is working through the 2024–2027 cycle with a program focused on tunnel sustainability, active mobility, digitalisation, new energy carrier vehicles, dangerous goods risk assessment, updates to the PIARC Road Tunnel Manual, and preparation for the 3rd PIARC International Conference on

Road Tunnel Operation and Safety. The Annecy meeting was the fifth TC4.4 meeting of the cycle and occurred at a point where several working groups were moving from information gathering into publication, dissemination and implementation planning.

The meeting was held in Annecy, France, in conjunction with the Chambéry World Winter Service and Road Resilience Congress. This gave TC4.4 the opportunity to align its tunnel work with wider PIARC priorities on resilience, decarbonisation, winter service, asset management and knowledge transfer. The PIARC General Secretariat update also confirmed a stronger focus on intermediate milestones for written outputs, early review by Strategic Theme Coordinators, and preparation for the Vancouver 2027 World Road Congress.

Compared with earlier TC4.4 meetings in the cycle, Annecy was less about starting new work and more about consolidating deliverables. WG1 and WG2 had already published outputs on sustainability and active modes. WG3 had completed its digitalisation survey and assembled case studies. WG4 was progressing a literature review on new energy carrier vehicle risks. WG5 was moving into practical update processes for the Road Tunnel Manual. WG6 was preparing the Cracow 2026 tunnel conference as a major dissemination platform for TC4.4 outputs.

For ANZ road tunnel stakeholders, the meeting was relevant because the topics being progressed by TC4.4 are closely aligned with current local challenges: operational assurance, tunnel control centres, tunnel safety officers, active mobility, digital asset management, post-fire recovery, tunnel renewal, sustainability in operation and new energy carrier risks. These issues affect local road authorities, tunnel operators, contractors, consultants, maintainers, emergency services, professional bodies and technical societies.

TC4.4 MEETING OVERVIEW

The Annecy meeting reviewed progress against the 2024–2027 TC4.4 work program and set direction for the final phase of the cycle. The committee also discussed future PIARC events, the Vancouver 2027 World Road Congress, possible topics for the 2028–2031 cycle, communication activities and gender inclusion and diversity.

TC4.4 membership was reported as 123 members across 38 countries. This included 56 full members expected to participate in TC meetings in person, 41 corresponding members and 26 associated members.

The meeting had a delivery-focused character compared to earlier meetings in the cycle which were more oriented toward team forming, scoping, information gathering and survey design. Annecy was more focused on reinforcing deadlines, deliverables and turning earlier works into outputs such as reports, recommendations, Road Tunnel Manual changes, conference sessions, technical workshops and future work cycle proposals.

WG1 – Sustainability of Tunnel Operations: New Approaches

WG1 confirmed that its briefing note and case study collection on sustainable tunnel operation had been published. The group is now preparing the full technical report, with the table of contents agreed and chapter responsibilities allocated.

The report intends to update PIARC's earlier tunnel sustainability work and expand the discussion to operating energy, renewable energy, equipment lifespan, thresholds, monitoring and whole-of-life performance. The draft structure includes background frameworks, safety and operational challenges, sustainable and energy-efficient design, contractual delivery of sustainability goals, operation and monitoring, and environmental protection measures.

This is relevant locally because sustainability in tunnels because has just completed a major boom in road tunnel activities across the east coast and has moved beyond design intent. The operational load from ventilation, lighting, pumps, controls, communications and maintenance activities needs to be measured and managed through the asset life. Austroads has already updated its tunnel guidance to include sustainability considerations, but WG1 points to the next step of operational sustainability metrics.

WG2 – Active Transport in Road Tunnels

WG2 has published its first report on the current situation and case studies for active transport modes in road tunnels. The working group is now preparing recommendations and safety measures for situations where pedestrians, cyclists, wheelchair users and other active mobility users are permitted in road tunnels.

The WG2 work is important because many tunnels around the world that are now being considered for active mobility were not originally designed for those users. The international survey received 60 responses from 13 countries and identified 45 tunnels. The case studies were grouped into four categories: safety galleries used by active modes, protected internal walkways, tunnels with specific roadway layouts and operating conditions, and tunnels dedicated entirely to active transport.

WG2's initial conclusions are directly applicable to the ANZ context. Experience with mixed traffic remains limited, standards are often absent or generic, and new risks include collisions between different users, falls and cargo bike fires. The presence of active users also changes the assumptions behind detection, lighting, ventilation, evacuation and emergency response.

This suggests a need for a formal active mobility in tunnels assessment framework. Such a framework should help owners decide whether active modes are appropriate, what minimum controls are needed, and when active modes should remain prohibited within a road tunnel environment. It should not be limited to geometric design and should aim to address detection, separation, speed management, lighting, ventilation, public address, emergency services, operating procedures and control centre action plans.

This topic also has clear value for the wider ANZ tunnelling industry. It sits across transport planning, tunnel systems, human factors, fire safety, operations and community expectations. Industry forums would help test how the WG2 recommendations apply to brownfield tunnels, new urban tunnels, emergency galleries, greenway proposals and constrained upgrade projects.

WG3 – Digitalisation for Operations and Maintenance

WG3 reported that its survey was complete and that 32 international case studies had been assembled. The case study report was in final draft for review.

The material shows that digitalisation is now much broader than BIM or digital twins during design and construction. Case studies include artificial intelligence for ITS integration, mobile surveying, Bluetooth Low Energy positioning, digital twins, dynamic lighting, LED marking, pacemaker lighting, ventilation system health monitoring, solar energy for tunnel lighting, tunnel inspection robots, incident alert systems and automatic recognition of new energy carrier vehicles.

The key message from WG3 is that the technical tools are advancing faster than governance and operational integration. Many operators use digital systems for traffic monitoring, lighting, ventilation and fire detection, but fewer have mature data standards, BIM-to-asset handover processes, digital twin governance or clear arrangements for ownership and maintenance of operational data.

For local tunnel owners and operators, the next step is not simply to encourage "digital twins". The next step is to define what information tunnel owners need to operate and maintain assets safely and efficiently. This includes data ownership, asset hierarchy, exchange standards, update frequency, maintenance system links and control centre use cases. This also affects contractors and consultants. Digital delivery requirements need to be written so that project information can be used in operations, not just handed over as a contractual deliverable. If asset information requirements are not defined early, owners may receive models and data that are technically impressive but operationally weak.

WG4 – New Energy Carriers

WG4 continued its review of tunnel safety issues relating to new energy carrier vehicles, including battery electric vehicles, hydrogen fuel cell vehicles and gaseous fuel vehicles. The work recognises that the number of real-world tunnel incidents involving these vehicles remains limited, which means statistically strong conclusions are not yet well established.

The WG4 current position is balanced. The evidence provided internationally currently does not support a simple claim that electric vehicles are more likely to catch fire than conventional vehicles. However, the consequences and response requirements may differ. Battery fires can involve thermal runaway, re-ignition, toxic emissions, difficult access to battery packs and contaminated firefighting water. Hydrogen and other gaseous fuels raise different issues around gas release, dilution, ignition and explosion scenarios.

The implication is that new energy carrier guidance should be evidence-based. Guidance should not overstate likelihood, but it should address consequence management. This includes ventilation response, firefighting tactics, water runoff, post-incident inspection, responder safety, detection and tunnel reopening.

This area is not only a tunnel design issue. It involves fire safety engineering, mechanical ventilation, electrical systems, toxicology, dangerous goods risk assessment, emergency service training, drainage treatment, control centre procedures and operator decision-making. It will require cross-disciplinary input from road authorities, operators, consultants, contractors and emergency services.

WG5 – Road Tunnel Manual

WG5 reported that the PIARC Road Tunnel Manual has been migrated to Drupal 10 in English, French and Spanish. Older language versions will be retained as archived PDFs.

The group raised the significant workload required to maintain the Road Tunnel Manual and as a result the PIARC General Secretariat has agreed to support web implementation and tool management, allowing TC4.4 to focus more on technical content. The agreed process is to work in Word with tracked changes and return revised pages to the General Secretariat for implementation.

The highest priority is to incorporate links and introductory material for relevant PIARC reports from previous and current cycles. This is important because the Road Tunnel Manual is intended to function as a knowledge gateway, not only as a static reference document.

For local practice, the Road Tunnel Manual should be treated as a strategic reference source. Local guidance does not need to duplicate all PIARC content, but it should maintain a process to review new PIARC material and identify what should be adopted, adapted or referenced locally.
A practical action could be for a short ANZ applicability note to be drafted and disseminated through Austroads whenever a major PIARC tunnel output is published. This would help translate international reports into local guidance decisions.

TECHNICAL SITE VISITS:

Due to travel restrictions and international time difference between Brisbane and Annecy, I could only attended parts of the TC meetings online so did not participate in any on-site activities or the technical site visits to the Tunnel du Chat and the PC CESAR tunnel management centre (TMC).

From what was described in the TC meeting:

- The Tunnel du Chat was commissioned in 1932 within the in the Savoie department. The tunnel is 1.486 km long and underwent significant modernisation to resolve lingering evacuation and ventilation issues. The chosen solution featured a parallel safety gallery, four cross passages, and 14 smoke extraction openings, ultimately restricting heavy goods vehicles while safely opening the gallery to pedestrians and cyclists
- The PC CESAR TMC manages approximately 426 km of network, including six tunnels. Its functions include real-time monitoring, traffic management, tunnel safety equipment control, roadside assistance coordination, technical intervention coordination, customer information, emergency service liaison and event tracking. The CESAR II system can automatically suggest actions based on event type and location, including variable message sign content, camera selection, stakeholder contacts and field equipment control.

More information could be sourced from PIARC TC4.4 contacts on request.

RECENT TUNNEL FIRE INCIDENTS

Huguenot Tunnel Bus Fire

The Huguenot Tunnel incident occurred at approximately 23:30 on 3 October 2025. A bus carrying 55 passengers caught fire inside the tunnel. No casualties were reported, passengers were escorted out, response was on scene in approximately six minutes, and extraction fans activated.

The fire damaged lighting, communications, fire detection, CCTV, side panels and ceiling elements over approximately 50 m to 100 m. The most severe damage was concentrated around the location where the bus stopped and ignited. Temporary propping was installed beneath damaged precast ceiling panels, and permanent repairs included M12 stainless steel hangers to introduce a new load path, as well as concrete spalling repairs.

The incident also highlighted user behaviour issues. People were slow to react or exit, escape routes were not fully used, and some users filmed the incident. The presentation identified the need for stronger public safety education, improved public announcements, immediate tunnel closure after accidents, better exit lighting and clearer direction to safe areas.

Brentenberg Tunnel Truck Fire

The Brentenberg Tunnel incident occurred on 9 January 2026 on the A10 Tauern Highway in Austria. A fully loaded truck crashed near the south portal, became trapped at the transition between gallery and tunnel tube, and burned out completely. The fire load was very high for 30 to 40 minutes.

The fire caused severe structural impacts, including major concrete spalling and exposed reinforcement in one gallery block and one tunnel tube block. Safety equipment near the fire was destroyed, including lighting, fire alarm cables, radio cables and escape route signage. The tunnel was also contaminated throughout.

The Austrian recovery process is particularly useful. It included close-range inspection from an aerial platform, material testing, high-pressure cleaning, temporary lighting, monitoring cross-sections, tunnel scanning, protective scaffolding and vault netting. Two-lane interim operation was restored after seven days, with monitoring and frequent inspection under a safety management plan.

Local ANZ Relevance

These two incidents show that local guidance should address post-fire recovery more explicitly. The issue is not just whether a tunnel survives a design fire. It is whether the owner can make a defensible decision about temporary stabilisation, system reinstatement, interim operation and permanent repair.

A post-fire reopening framework should cover:

- immediate stabilisation
- structural assessment
- electromechanical assessment
- tunnel scanning and evidence preservation
- temporary lighting and communications
- minimum operating requirements
- temporary supports and falling debris controls
- monitoring frequency
- interim operating restrictions
- permanent repair planning
- post-event lessons learned

This would be useful for road authorities, tunnel operators, structural engineers, mechanical and electrical designers, fire safety engineers, maintenance providers and emergency services.

GENDER INCLUSION, DIVERTIY AND COMMUNICATION

TC4.4 continued to treat Promotion of Gender Inclusion and Diversity as a standing committee issue. The PGID subgroup, represented by Corinne Chiodini, Kate Hunt and myself, provided an update on training, survey participation and practical actions to support inclusive participation. The Annecy material also confirmed that TC4.4 had prepared a formal submission for the PIARC Promotion of Gender Inclusion and Diversity Awards 2026, recognising the committee’s work to improve representation, inclusive participation and diversity of contributors across the current cycle

The later PGID award application recorded 26 responses from 16 countries. The survey showed generally positive comfort in sharing ideas and equal treatment of contributions, but also highlighted language barriers, quieter members and psychological safety as issues requiring attention. The PGID Award application described several practical examples of inclusive leadership within TC4.4. It recognised the contributions of Corinne Chiodini, Kate Hunt, Evan Lo and Hélène Mongeot, as well as other female contributors across the working groups and the DG-QRAM task force. The application also noted that while overall female representation in TC4.4 remains low, female participation is stronger in some working groups, including WG2 where active female authorship was reported as up to 50%.

TC4.4's submission was subsequently recognised by PIARC with a Silver Medal and Honourable Mention for the Promotion of Gender Inclusion and Diversity Awards 2026. Although the committee did not receive the main award, the Honourable Mention was presented during the Chambéry Gala Dinner and represents formal recognition of TC4.4's PGID activities, including the survey, standing agenda focus, inclusive leadership examples and the submission prepared by the PGID team in a short timeframe. This recognition is important because it demonstrates that TC4.4's work on inclusion was visible within PIARC and was treated as part of the committee's professional and technical culture, not as a separate administrative exercise.

At, Annecy the PGID subgroup highlighted that diversity is beyond gender alone. It recognised cultural, religious, language and regional differences, which is important in an international committee where English is often the working language but not the first language of many contributors.

INTERNATIONAL LIAISON AND FUTURE EVENTS

The meeting included updates from ITA, ITACOSUF and AASHTO. These updates show that the same issues are being discussed internationally across multiple organisations: digital tools for safe operation, tunnel safety officers, lithium-ion battery fires, refurbishment, commissioning, post-fire assessment, scanning technologies and ventilation performance.

ITA and ITACOSUF are planning events relevant to TC4.4, including the 8th Tunnel Safety Officers Forum in Tromsø on 13-15th April 2026, an ITACOSUF workshop in Asturias on fire safety in road tunnels, and potential collaboration with PIARC on digital tools for safe tunnel operation.

AASHTO reported work on research road maps, operating guidelines, smoke removal capability, post-fire structural component assessment, scanning technology and recent US tunnel rehabilitation experience.

Upcoming tunnel events also reinforce the same direction. Forum Tunnels 2027 in Lyon will focus on "Tunnel operation: new challenges, new solutions", while a Madrid 2027 road tunnel symposium theme is "Tunnels in new mobility: digital, connected and sustainable".

EMERGING ISSUES FOR AUSTRALIA AND NEW ZEALAND

Guidance needs to move from design to operation

The strongest theme from Annecy is the shift from design guidance to operational assurance. Design remains essential, but TC4.4 is increasingly dealing with the systems and people that keep tunnels safe after opening: control centres, operators, safety officers, emergency services, dashboards, action plans, training, exercises and post-incident recovery.

This aligns with current local work on road tunnel operations and tunnel safety officers. The opportunity is to use PIARC material to strengthen local practice before it becomes fragmented across jurisdictions, operators and project-specific requirements.

Active mobility requires a safety case approach

Active mobility in tunnels has shown to be a multi-disciplinary consideration international and is by no means a simple access decision. It requires a safety case approach that accounts for user type, geometry, separation, lighting, ventilation, detection, behaviour, emergency response and control centre action plans.

This has been particularly relevant to urban areas where active transport policy have pressured owners to open existing spaces to cyclists, pedestrians or personal mobility devices. WG2 is working to provide a starting point for a more consistent framework that can be applied before local decisions become inconsistent.

Digitalisation needs governance

Digital systems are now common in road tunnels, but many jurisdictions still lack data standards, ownership rules, model update processes and PIM-to-AIM handover arrangements. Without governance, digital twins can become expensive visualisations rather than operational tools.

Australian and New Zealand tunnel projects already produce significant digital information. The challenge is to make that information usable for operators, maintainers and emergency response teams over the asset life.

Post -fire reopening is a gap

The Huguenot and Brentenberg cases show that practical reopening decisions require more than fire engineering. They require structural assessment, system assessment, cleaning, temporary works, lighting, communication, monitoring, public safety, traffic management and clear risk acceptance.

This should be considered in future guidance and professional development for tunnel asset owners, operators, consultants, contractors and emergency services.

INPUT REQUESTED ON POSSIBLE PIARC 2028–2031 WORK CYCLE TOPICS

The Annecy meeting included an early discussion on possible topics for the next PIARC work cycle, 2028–2031. Proposed topics included digital twins for tunnel operation, cybersecurity, operator training and simulators, equipment renewal planning, predictive maintenance, safety performance indicators, RAMS-based analysis, ageing infrastructure, refurbishment under operating constraints, incident management with new communication technologies, tunnel safety management systems and safety exercises.

These topics are highly relevant to ANZ. Feedback is requested from local tunnel owners, operators, designers, contractors, maintainers, emergency services and technical specialists on which topics should be prioritised, where local guidance gaps exist, and whether Australia or New Zealand can contribute case studies or technical input.

Responses should focus on:

- priority topics for the 2028–2031 PIARC cycle
- local gaps in current tunnel guidance or practice
- potential Australian or New Zealand case studies
- topics that would support future guidance updates
- areas where industry capability needs to improve

This feedback will help inform Australia and New Zealand’s contribution to future TC4.4 discussions and ensure that the next PIARC work cycle remains relevant to local road tunnel practice.

IMPLICATION FOR LOCAL GUIDANCE AND INDUSTRY PRACTICE

The Annecy meeting outcomes are highly topical and relevant to current and future road tunnel practice in ANZ. The issues discussed by TC4.4 align closely with matters already being considered across local tunnel authorities, operators, designers, contractors, maintainers and emergency services, particularly in relation to tunnel operations, safety assurance, sustainability, digitalisation, active mobility and incident recovery.

The key value of the Annecy material is that it provides international examples and emerging guidance on issues that are becoming more prominent locally. These include operational sustainability, control centre capability, active mobility in existing tunnels, digital asset management, new energy carrier vehicles, post-fire assessment and ageing tunnel refurbishment.

A practical local outcome would be for each tunnel authority to develop a short technical note on tunnel operational sustainability metrics for use by road tunnel authorities, operators, designers and maintainers. The note could define measurable indicators such as ventilation energy intensity, peak demand, ventilation control thresholds, lighting control performance, asset intervention frequency and operational carbon. This would help shift sustainability from a design-stage objective to an operational performance measure over the full asset life. It would also support contractors and consultants by making efficiency expectations clearer during design, commissioning, handover and maintenance planning.

The Annecy material also supports the need for more consistent local approaches to operational assurance. This includes defining minimum tunnel control centre capability, improving tunnel safety officer and operator support arrangements, and strengthening operating procedures for degraded mode, emergency response and recovery. These areas are important because tunnel safety depends on the performance of people, procedures and systems after opening, not only on the design accepted at commissioning.

For active mobility, the work of WG2 highlights the need for a structured assessment framework before pedestrians, cyclists, wheelchair users or personal mobility devices are permitted in existing road tunnels. These decisions should consider user type, separation, detection, signage, lighting, ventilation, speed management, evacuation, emergency services and control centre action plans. This is particularly relevant where active transport objectives intersect with existing tunnel geometry and operational constraints.

For digitalisation, the key implication is that digital twins, BIM, AI and monitoring systems should be treated as operational and asset management tools, not just project deliverables. Local tunnel projects should have clear definitions on what asset information is required, who owns it, how it is updated, how it transfers from delivery into operation, and how it supports maintenance, incident response and renewal planning.

The recent Huguenot and Brentenberg tunnel fire case studies also show that post-fire recovery should be addressed more explicitly in local guidance. A post-fire reopening framework should cover structural assessment, electromechanical assessment, tunnel scanning, temporary lighting and communications, temporary supports, minimum operating requirements, monitoring frequency, interim restrictions and permanent repair planning.

Overall, the Annecy outputs are encouraged to be used as a reference point when reviewing future guidance, developing project requirements, preparing tunnel safety documentation, planning refurbishment works and shaping industry training or technical knowledge-sharing activities. Before any specific action is adopted locally, the relevant PIARC material should be validated against ANZ operating conditions, regulatory expectations, tunnel types and emergency response arrangements.

CONCLUSIONS

The Annecy TC4.4 meeting confirmed that the committee has moved into the delivery phase of the 2024–2027 PIARC cycle. Earlier work on surveys, case studies and literature reviews is now being converted into technical reports, recommendations, Road Tunnel Manual updates, conference sessions and future World Road Congress contributions. This delivery focus is important because the value of TC4.4's work will depend on whether the outputs are completed, published, communicated and then translated into practice by road tunnel owners and operators.

For Australia and New Zealand, the strongest message is that future road tunnel guidance and practice should give greater attention to:

- operational assurance
- control centre capability
- tunnel safety officers
- active mobility
- digital asset information models
- new energy carrier vehicles
- post-fire recovery
- ageing tunnel refurbishment
- sustainability in operation
- human behaviour during incidents

These topics are relevant to road authorities, tunnel operators, contractors, consultants, maintainers, emergency services and professional bodies. They also provide a practical opportunity to connect PIARC outputs with local guidance updates, project requirements, tunnel safety documentation, industry forums and professional development.

The Annecy meeting also highlighted the need for ANZ to provide input into the next PIARC work cycle, 2028–2031. Possible future topics such as digital twins for tunnel operation, cybersecurity, tunnel operator training, predictive maintenance, ageing infrastructure, safety management systems, incident management technologies and refurbishment under operating constraints are highly relevant locally. Input from local stakeholders are encouraged through the Austroads Tunnel Task Force before the next TC meeting in September 2027 so that future PIARC outputs remain useful to local ANZ tunnel practice.

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