TMSystems- *Regulatory Environment- ECE/EN R141 Mandate Alignment and Implementation in Australian On-Road Vehicles- Discussion + Analysis*

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Discussion: Roll- out Costs + Savings + ROI- TMSystems

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1. INTRODUCTION.

This paper has been prepared by the Engineering Manager and CEO of LSM Technologies, who brings over 20 years of specialist expertise in the design, testing, and deployment of Tyre Monitoring Systems (TMSystems) for heavy vehicles.

The author has actively contributed to national safety initiatives with regulators and industry bodies including NHVR, ARTSA-i, HVIA, NBTA and TfNSW, and was responsible for the first TMSystem in the world tested and certified for use in Dangerous Goods (DG) Transport in 2016.

Tyre Monitoring Systems (TMSystems) are increasingly recognised as a critical industry safety and productivity measure. By providing continuous monitoring of tyre pressures and temperatures, TMSystems prevent many of the most common and costly tyre-related incidents- including blowouts, rollovers, fires, and equipment damage.

The specific benefits and advantages of TMSystems include:

- **Extended Tyre Service Life & Fuel Savings:** Maintaining correct set-point pressures reduces rolling resistance, prolongs tyre life, and lowers fuel consumption.
- **Increased Safety:** Early detection avoids catastrophic tyre failures, blowouts, and wheel- end fires caused by under-inflation, bearing failures or dragging brakes.
- **Avoid Risk of DG Truck / Tanker Explosions**: By preventing tyre and wheel- end fires, pyrolysis, TMSystems significantly reduce the risk of catastrophic explosions in Dangerous Goods transport, protecting lives, cargo, and infrastructure.
- **Avoid Environmental Impacts:** Preventing tyre/ wheel- end fires and tanker incidents reduces the risk of dangerous goods spillages and secondary fires that damage ecosystems (grasslands) and other infrastructure (road / houses / bridges).
- **Reduced CO_2 Emissions:** Maintaining correct tyre pressures lowers rolling resistance, directly reducing fuel use and greenhouse gas emissions.
- **Less Road Damage & Wear:** Properly inflated tyres distribute loads more evenly, lowering road surface wear and reducing maintenance costs for road authorities.
- **Improved Braking, Traction & Control:** Correct tyre pressures enhance stability and handling in both dry and wet conditions.
- **Meeting Delivery Schedules & Productivity:** By reducing unplanned breakdowns, blowouts and fires, TMSystems improve on-time delivery performance, minimise penalties for late arrivals and boost fleet productivity.
- **Lower Labour & Productivity Costs:** Manual tyre checks are labour-intensive. TMSystems allow operators to identify / target only tyres that need attention (e.g. re- pressurisation), saving time and reducing downtime.
- **Reduced Equipment Damage:** Prevents collateral damage (other e.g. vehicles) from catastrophic failures such as rollovers, tyre fires, wheel- offs and tanker incidents.
- **Insurance & Liability Reductions:** Lower incident frequency and severity should translate into reduced insurance claims and premiums.
- **Emergency & Risk Mitigation:** TMSystems support compliance with OH&S standards, mitigate risks of fires and improve post-incident analysis.

This discussion paper should be read in conjunction with: TMSystems Roll-Out, Cost savings, ROI Benefits. Heavy Vehicles Australia- Discussion + Analysis

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2. EXECUTIVE SUMMARY.

Tyre Monitoring Systems (TMSystems) are increasingly recognised worldwide as essential engineering controls that improve safety, operational resilience, and environmental outcomes.

By continuously monitoring tyre pressures and temperatures, TMSystems can prevent many of the most common and catastrophic wheel- end failures, tyre blowouts, rollovers, wheel- end fires, and dangerous goods tanker explosions.

Australia's unique transport industry with road trains up to **60 metres long,** and **Low Loader Trailers** with more than **190 tyres / wheels per rig-** face risks far greater than those encountered in Europe or North America.

Failures in these fleets have proven to lead to fatalities, infrastructure loss, environmental damage, and significant disruption to national freight.

Globally, regulators have already mandated tyre monitoring for large segments of the on- road heavy vehicle fleet (e.g., ECE R141 in the EU).

Australia currently has no national mandate across heavy vehicles and so adoption remains voluntary.

However, the engineering case is clear- TMSystems should be treated as essential safety mitigation controls comparable to ABS or Stability systems and other aligned ADR specified safety technology.

Cost justification for TMSystems can also be validated with:

- Australian heavy vehicle fleet (all classes) fleet base includes **5.1 million heavy vehicles** and trailers for On- road usage.
- Rollout investment is **~$5B ($5,184,000,000).**
- Annual benefits are **$31- $37B**, delivering a payback of under one year and 10- year net benefits of **$310- 370B.**
- Reference is made to the LSM *2025- Aug 20- TMS Roll Out Costs + Sav- Australia- v1* White Paper that discusses the Roll- out andjapanbstantial potential ROI (operators, government, environmental and the tax payer) and with savings through increase in driver / workplace and public safety.
- The regulative landscape has / is changing with may Industries advocates, regulators and even operators in all sorts of industry (that use a pneumatic tyre) recommending, establishing guidelines and mandates for the implementation of TMSystems.

3. GLOBAL STANDARDS AND REGULATORY LANDSCAPE.

It is interesting to note that in 2000 the USA TREAD Act mandated that T(P)MSystem (Tyre Pressure and Temperature Monitoring Systems) were to be installed (at vehicle manufacture) an all passenger vehicles.

This mandating has today been implemented by many other countries including Japan, Korea, China and the EU with their ECE R141 Directive TMSystem now mandated also for On- road Heavy Vehicles and Trailers.

Some of these mandates (On- and Off Road) are below:

- **UNECE** Regulation R141 Mandates T(P)MS / CTIS / APRS for heavy vehicles and trailers in the EU (phased since 2022–2024). Defines under-inflation detection (≥20% below placard) and standardised in-cab indication.
- **EU General Safety Regulation** (EU) 2019 / 2144 Integrates T(P)MS with broader safety requirements in EU type approval.
- FMVSS 138 (USA) T(P)MS for passenger vehicles; no federal mandate for heavy trucks (adoption varies by sector / operator).
- China GB 26149: In Japan / South Korea, passenger- vehicle mandates with commercial adoption evolving.
- Australian ADR update under review (VSCC).
- Western Australia's mining guidance recommends TMSystems Tyre Safety (includes TMSystems).

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- **DG / Explosives guidance** DMP (Department of Mines and Petroleum) WA WorkSafe has introduced a new Code of Practice for AN/ANE Tankers.
- SAE J2848 (heavy vehicle communications / EMC) & ECE R10 (EMC).
- ISO 11992 Truck- trailer communication; relevant for T(P)MS / CTIS interoperability with EBS/ABS.
- Functional Safety (ISO 26262 principles) Good practice for software integrity in alarm logic.
- NfNSW (2017) develop their Bus TMSystem Standard- BC17/18562 on Buses.
- **QLD recommended** Standard 13 wheel and rim management (include TMSystems).
- CICA Pick and Carry Crane guidance recommends TMSystems for stability.
- And there are others…….

4. WHY TMSYSTEMS ARE NO LONGER OPTIONAL

Tyres are the only point of contact between a vehicle and the road. When they fail, consequences are immediate and often catastrophic (see this linked in https://go.lsm.com.au/TGuardLI of reposted incidents).

Traditional maintenance (tyre tapping, periodic manual checks) cannot detect fast leaks, invisible zipper failures, bearing overheat, or brake drag

that quickly elevate into rollovers, fires, wheel- offs.

TMSystems detect and escalate these hazards in real time- dynamically, as the vehicle is moving and informs the driver in cabin so as to be able to take immediate corrective action.

TMSystems align with ISO 45001 Standard for Occupational Health and Safety Management System and Australian NHVL COR (Chain of Responsibility), Australian WHS Act to eliminate risks at the source.

In Australia's heavy- vehicle context (multi-combination road trains, DG tankers, high-temperature corridors, etc), continuous wheel- end / tyre monitoring is a necessary safety mitigation engineering control.

5. VALIDATION THROUGH INCIDENT DATA & INVESTIGATIONS.

A few reported incidents, as well as studies which validate the implementation of TMSystems:

5.1 General Statistics- Reported Events / Source Reports.

Some referenced reports and data are as follows:

- Queensland Coroner (2010–2014, Foxleigh Mine fatality) Fatal tyre zipper failure- recommended banning manual "tyre tapping" and recommended adopting TMSystems as industry standard for mining heavy haulage within 2 years.
- NSW Centre for Road Safety (2012) >22% of transport truck crashes involved tyres.
- NHTSA USA (2015): Motorcoach fires commonly linked to dragging brakes, failed bearings, underinflation.
- OTSI NSW (2016) ~43% of bus fires originated in wheel wells.
- NTI / NTARC 2024 non-impact fires ***doubled*** since 2021 (5.45- 10.8 per 10,000 heavy vehicles) and ***61.3%*** originate in **wheel- end / tyres**.

5.2 Tyre / Wheel Related Heavy Vehicle Incidents (2015–2025).

- Tyre and wheel- end system failures in heavy vehicles (trucks, trailers, buses, etc.) have been repeatedly highlighted as critical safety issues.
- Official crash and insurance **data** are limited, but industry sources (NTI/NTARC) and safety reports provide insight.
- For example, NTI reported **848 major heavy-vehicle crashes** in 2019 more than in 2017.
- These NTI "major crash" reports include all causes; within them, tyre / wheel faults are a significant subset.

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- The numbers are **derived** from NTI heavy- vehicle claims analysis and case investigations. For example, NTI's *Major Accident Investigation* reports provide counts of total incidents and the proportion due to tyre failures.
- Unfortunately, no single publicly available database tracks all tyre / wheel incidents, so these figures combine **insurance** data and official investigations.
- The below Table encapsulates the best- available data on tyre / wheel incidents by type.

Incident category	Example data (year)	Source
Total major incidents	2019: 848 (up from 756 in 2017)	NTI NTARC reports
Truck rollovers (tippers)	≈5% of major incidents (≈42 of 848 in 2019)	NTI (2017 data)
Wheel-end fires	Tyre-originated in 46–47% of cases (2019 data)	NTI (2020–22 reports)
Tyre blowouts / failures	Steer-tyre failures cause >50% of mechanical crashes	NTI (2020 report)

- See other reported, news articles on rollovers (https://go.lsm.com.au/TGuardLI).

5.3 Trends and Data Gaps.

- Data on tyre / wheel incidents are not routinely collected in isolation by any authority and are usually aggregated into crash statistics which rarely advise causes.
- The above table draws on insurer NTI's claim data and special investigations. NTI's heavy-vehicle accident reports **show steering- tyre failures** jumped in recent years with over half of all "mechanical failure" crashes were due to catastrophic steer- tyre blowouts.
- Similarly, NTI found that **truck fires** account for ~8% of its large-loss claims, but these almost always destroy the vehicle- "usually a six-figure payout as truck, trailer and cargo can all be destroyed".
- Official road-crash statistics (e.g. BITRE, State road agencies) report heavy-vehicle casualties but do not specify tyre / **wheel** causes- hence industry reports, case studies and reported news articles (https://go.lsm.com.au/TGuardLI) are key.

5.4 Truck Rollovers.

- Rollovers are a major **crash** type for heavy trucks, especially tippers / unloaders.
- NTI's investigations **show tipper rollovers** are consistently about **5%** of major heavy-truck incidents.
- An NTI analysis **covering** 2017, tipper-rollover crashes were ~5% of all large- loss claims.
- Many of these **rollovers** have no single human- error trigger (e.g. high- centre-of-gravity topple while tipping), and Western Australia accounts for a large share (~40%) of tipping rollovers.
- Rollover crashes **tend** to be severe, although exact Australian fatality rates from rollovers are unpublished, research suggests rollovers of heavy vehicles carry high risk of death or injury.
- One example of **rollovers** is with Pick and Carry cranes- see CICA Guidance. Due to the lack of outriggers and articulation and carry of a load, the tyre pressures are critical for stability.
- See other reported news articles (https://go.lsm.com.au/TGuardLI).

5.5 Wheel Detachment ("Wheel-offs").

- Instances of wheels breaking free from heavy vehicles on road are rare but have occurred**.**
- A detached truck wheel can strike other vehicles or pedestrians with lethal force.

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- No comprehensive Australian data exist for wheel- offs, however they are often reported as “one-off crashes or near-misses in media.
- Causes are usually failed wheel bearings or where the wheel has operated for a long time with a flat tyre and it actually over-heats and laterally rips the wheel off the hub.
- See other reported news articles (https://go.lsm.com.au/TGuardLI).

5.6 Wheel- End and Tyre Fires.

- Fires originating at the wheel / hub can rapidly destroy a truck or trailer.
- Typically, a dragging / locked brake or failed bearing overheats and ignites the tyre.
- NTI data show that tyres themselves were the initiating source in about 45- 47% of wheel- end (non-collision) fire incidents.
- 2019 NTI found tyre- related failures (e.g. blowouts or tread delamination causing overheating) contributed to 45% of wheel- end fires
- A follow- up report showed tyres were the source in 46.5% of wheel- end fires (bearing failure caused 25%). These fires often result in complete loss of the wheel and tyre and can spread to the axle or chassis.
- Causes are under-inflated or worn tyres that overheat under load, seized or damaged wheel bearings, locked / dragging brakes.
- NTI notes that increased tyre failures were driving up wheel- end fires possibly due to underinflation or overload.
- Fire authorities have warned that a tyre fire can lead to explosive fragmentation of up to 20 m away.
- Back in 2016 (nearly 10 years ago) **Dr. Peter Hart** (ARTSA), through his doctoral thesis from Monash University examined the leading causes of fires in heavy trucks, buses, and trailers based on nearly two decades of forensic investigation. It highlights common ignition sources, contributing factors such as environmental conditions and vehicle design, and underscores the importance of forensic fire examination for improving safety standard. Dr Hart rewrote and updated his technical white paper in **2021** and the causation of tyre / wheel- end fires has not changed ARTS-i- Dr Peter Hart- Truck and Trailer Fire Guidance Reports.
- See other reported news articles (https://go.lsm.com.au/TGuardLI).

5.7 Tyre Explosions and Blowouts.

- High-pressure blowouts can be catastrophic and result in vehicle roll- overs crashes.
- A fast- blowout of a **steer** tyre (often due to operating under- inflated- zipper failure) can cause immediate loss of vehicle control.
- NTI highlights **that** steering- tyre failures accounted for over 50% of its mechanical- failure crash losses.
- In other words, **most** sudden mechanical breakdowns leading to crashes were from steer-axle tyre bursts.
- Blowouts can **also** turn into **tyre explosions** under certain conditions (e.g. inflating a damaged tyre).
- On- road tyre **explosions** (e.g. on a moving truck due to pyrolysis) are less common but could happen after blowouts at high speed.
- Underinflation, **incorrect** inflation procedures, damaged tyre (operated under- inflated for long periods) can cause tyre bursts and vehicle roll- over.
- For road operations, **maintaining** correct pressure, avoiding overloading and replacing worn tyres are critical to prevent high-speed blowouts.
- See other reported news articles (https://go.lsm.com.au/TGuardLI).

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5.8 ANE Truck & Tanker Explosion Incidents in Australia.

Significant events have occurred specifically with ANE Transport Tankers:

Year	Location	Cause of Fire / Initiating Event	Outcome
2014	Angellala Creek, QLD	Road train rollover ignited 52 t ANE	Twin blasts destroyed bridge, 8 injured (driver, police, firefighters)
2014	Ti Tree, NT	Axle / tyre fire on triple road train trailer	Driver detached trailers; rear trailer exploded; no injuries; evacuation required
2022	Laverton (Cosmo Newbery), WA	Brake/tyre fire under ANE tanker (33.8 t)	Explosion after ~2 h, debris >600 m; no injuries; first known ANE tanker detonation
2024	Bororen, QLD	Collision + fire involving ANE tanker (42 t)	Explosion killed 1, injured truck driver, destroyed Bruce Hwy, damaged homes

- In each case, a wheel- end or **crash**- related fire preceded detonation.
- TMSystems provide earliest **warning** (under-pressure, fast leak, over-temp), enabling intervention before escalation.
- Substantial damage and injury occurred and highlights the ramifications of such an event should this occur closer to a popular area or traffic congestion.
- See other reported news articles (https://go.lsm.com.au/TGuardLI).

5.9 Severity and Consequences.

- Wheel and tyre related failures often have severe outcomes.
- Rollovers are frequently fatal **or** cause serious injury to drivers. Literature suggests heavy- truck rollovers are disproportionately deadly.
- Tyre- ignited fires typically **destroy** the entire vehicle, NTI notes that a fire claim almost always involves total loss of truck, trailer and cargo.
- For instance, one NTI study **found** trucks represent just 8% of large- loss claims by event type, *but* those few fire incidents “usually result in a six-figure payout” due to complete asset loss
- On-road, a detached wheel or tyre can kill other motorists or bystanders- documented in some dashcam videos (formal records / reports are scarce).

5.10 Contributing Factors.

Multiple factors contribute to tyre / wheel failures:

- **Underinflation and Overloading:** A heavy load on a poorly inflated tyre causes excess heat and structural strain. NHVR reports (NHVR PBS project) found many trucks run with tyres severely underinflated. Underinflated tyres are prone to blowouts and fires.
- **Brake / Bearing Neglect:** Worn brake shoes or seized bearings generate heat at the wheel hub. If unaddressed, this can ignite tyres. NTI data show many wheel- end fires trace back to brake / bearing issues.
- **Rocks / Debris Caught Between Duals**: Underinflation with stones, ballast, and other debris lodged between dual tyres generate friction and heat, causing sidewall abrasion and potential blowouts. This is common on mine sites, quarries, and unsealed roads.

- **Overheating from Excessive Braking**: Repeated heavy braking, especially on steep descents, transfers heat into the rim and bead area. Combined with low inflation, this accelerates tyre breakdown and can ignite fires.
- **Valve Stem**: Cracked or bent rims, corroded bead seats, or damaged valve stems allow gradual leaks. Slow leaks often go undetected until the tyre runs dangerously underinflated.
- **Pyrolysis and External Heat Sources**: In mining and dangerous goods transport, external heat (lightning strikes) can trigger tyre pyrolysis and catastrophic explosion.
- **Poor Maintenance Practices**: Skipped inspections, failure to torque wheel nuts, or neglecting to rotate tyres increases risk of wheel-offs and uneven wear. NTI accident reports cite wheel- offs as a significant cause of truck fires and rollovers.
- **Operational Abuse**: Curb strikes, potholes, and off-road impacts damage sidewalls and beads. Even minor cuts can evolve into catastrophic blowouts under high loads.

6. ECE R141 VS. MODERN TMSYSTEMS- WHERE THE STANDARD FALLS SHORT.

6.1 ECE R141- Applicability.

The **ECE R141** was **originally** established as a necessary minimum baseline for tyre safety in passenger cars.

As of recent, the R141 has been simply **adopted** for heavy vehicles and only considers primarily design around **urban / regional trucking in Europe**, not the **unique demands of Australian heavy haulage**.

Its detection thresholds, test cycles and tell- tale requirements leave large **safety** gaps:

- **No stationary or low-speed protection:** precisely when many wheel- end fires and blowouts start.
- **No mandatory temperature or over-pressure monitoring:** missing early fire prevention indicators.
- **No multi- trailer visibility:** ineffective for road- trains and drop- and- hook fleets does not identify individual trailer, axle of tyre issue.
- **Slow detection windows:** allowing drivers to remain unaware of dangerous leaks for up to an hour.
- **No data / analytics mandate:** offering no value for preventive maintenance or fleet risk reduction and ensuring safety compliance with integration to telematics.

By contrast, **modern TMSystems** go far beyond the minimum- the ECE R141 mandates:

- In cabin display monitor to inform the driver of alerts (R141 requires a simple yellow waring light).
- Real-time, wheel- by- wheel pressure and temperature monitoring- driver identification.
- FastLeak™- **loss** of 2.8 psi- 12 secs (driver aware offending / pending blowout).
- High **temperature** alarms.
- Multiple Over / Under-**pressure** staging.
- Full multi- trailer **support**- drop and hook.
- Ruggedisation (IP 69 Sensors).
- External Serviceable Sensors.
- Fleet integration **capability** into third party telematics systems.
- Fit- for- purpose **safety** systems across other industry sectors such as Mining, DG Transport, Bus, Ports, Agriculture, Forestry, etc.

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7. SCOPE & INTENT (WHAT R141 DOES AND DOES NOT COVER).

7.1 Applicability / Design.

- **Who it applies to:** R141 now covers M1≤3.5 t plus heavy vehicle and trailer classes (M2 / M3, N1 / N2 / N3, O3 / O4) when a T(P)MS is fitted- it defines performance, not a full feature set.
- **Design aim: Minimum** detection and tell- tale behaviour- it does not prescribe richer functions (analytics, mapping, telematics, etc).

7.2 Low- Speed & Stationary Coverage Only.

- **R141 requires operation only above a threshold speed:** 40 km/h for M1 / N1; 30 km / h for N2 /N3 /O3 / O4. Below those speeds and when stationary, no performance is required.
- **Modern TMSystems:** displays alerts whether the vehicle is moving or stationary- useful for depot checks, coupling, quarry / yard work, and slow manoeuvres.
- **Gap:** Safety- critical **visibility** at low speeds and at rest is not guaranteed by R141.

7.3 Detection Thresholds & Timing (Under inflation Only, & Slow).

- **Thresholds:** Trigger when a tyre falls **20%** below in-service pressure (with a 150 kPa minimum for C1 (passenger) or 220 **kPa** for C2 (light commercial) and C3 heavy commercial) where applicable.
- **Timing windows:** Up to **10 minutes** cumulative drive time for a rapid loss (“puncture”) and **60 minutes** for diffusion / slow leak before the driver must be warned.
- **Modern TMSystems:** provide **real-time** monitoring with immediate alarms when programmed thresholds are crossed.
- **Gap:** R141 permits long **latencies** (especially for slow leaks), and notifies essentially only once to driver via the illumination of a single yellow light.

7.4 Temperature & Over- Pressure (not required by R141).

- **Temperature:** R141’s **towing**- **towed** data model allows **optional** tyre temperature messaging. It is **not mandatory** to sense, transmit, or display temperature.
- **Over-pressure:** R141 **does not** require detection of over-pressure conditions.
- **Modern TMSystems: monitors pressure and temperature** and raises a dedicated “HOT wheel” alert (e.g., ≥80 °C)- a crucial early indicator of brake drag, bearing failure and wheel- end fire risk. It also supports **high-pressure** alerts (e.g., ≥25% above set point).
- **Gap:** Significant wheel- end hazards are outside R141’s minimum remit- note that the R141 does require the Sensors to be temperature “ready” .

7.5 Multi- Trailer (Road- train) Usability & Mapping.

- **What R141 mandates:** A towing vehicle must show whether a warning comes from the **towing unit or a towed unit** and must support a **communications interface** (wired via ISO 11992/ISO 7638 or an **open wireless** link). It does **not** require wheel- by- wheel maps or trailer- sequence visualisation to the driver.
- **Modern TMSystems: supports multi-trailer road-trains** with up to **8 trailers / 180 wheels**, plus drop-and- hook handshakes and per- wheel position mapping on the in- cab display.
- **Gap:** R141 ensures a minimum “warning exists” signal. It does not ensure the driver can **locate the exact tyre / trailer** quickly under real- world road- train conditions.

7.6 CTIS /TPRS Equivalence (may omit T(P)MS entirely).

- **Regulatory equivalence:** Vehicles can comply **without T(P)MS** if a Tyre Pressure Refill System (TPRS) or Central Tyre **Inflation** System (CTIS) passes Annex 4 criteria.
- **Implication:** CTIS maintains pressure but typically does **not** monitor **temperature** or provide granular wheel -by- wheel diagnostics and history.

- **Gap:** A vehicle **can** be compliant yet lack temperature based fire mitigation and detailed diagnostics provided by modern TMSystems technology.

7.7 Test Envelopes vs. Harsh Reality.

- **R141 test conditions:** Dry **road**, ambient **0- 40 °C**, defined speed bands (≥30- 40 km/h), structured warm- up phases (up to **120 minutes** for heavy vehicles).
- **Modern TMSystems:** Designed for **on / off-road**, low-speed, heat-affected and stop-start operations (e.g., mining, quarries, roadworks).
- **Gap:** The standard's lab / track envelope excludes many severe duty scenarios where advanced monitoring adds most value.

7.8 Fault Handling & Data Loss.

- **R141 requires:** A malfunction tell- tale within **10 minutes** and a warning if required towed-vehicle T(P)MS data is **missing**.
- **Modern TMSystems:** Provide **explicit lost sensor / lost signal** alerts and guidance for rapid troubleshooting.
- **Gap:** R141 ensures a lamp- **modern** system guides the operator / maintainer to **which** tyre on what axle on what trailer needs attention.

7.9 Data, Telematics & Analytics.

- **R141:** No requirements for **logging**, trending, remote notifications or fleet analytics.
- **Modern TMSystems: integrates** with FSM® telematics for **live monitoring, alarms, reporting and trend analysis** across the fleet (including road- trains).
- **Gap:** Compliance does not equal **fleet- level risk management** or ensuring **safety compliance** or **continuous improvement**.

7.10 Pressure Ranges & Fit- For- Purpose Heavy Duty Hardware.

- **R141:** Silent on practical **measurement** ranges and ruggedisation- it focuses on performance outcomes and tell-tales.
- **Modern TMSystems:** covers ~**69- 1,300 kPa (10–188 psi)**, suited to high-pressure heavy tyres, and uses robust, potted Sensors **for** harsh environments.
- **Gap:** Heavy- duty **suitability** and serviceability are implementation **choices**, **not regulated** minima.

8. DEFICIENCIES OF ECE R141 VS. CAPABILITIES OF MODERN TMSYSTEMS.

UN ECE R141 establishes a **minimum** bar (basic under-inflation detection, a tell-tale, and a towing / towed interface).

It **does not require** low-speed / stationary visibility, wheel-end temperature alerts, over-pressure detection, per-wheel/trailer mapping, analytics / telematics, or the rich fault diagnostics that road-train fleets rely on.

Modern TMSystems deliver these capabilities today- closing the practical safety and productivity gaps left outside the regulation.

Area	ECE R141 Requirement	Modern TMSystems	Gap / Deficiency
Speed Thresholds	Only requires monitoring above 30–40 km/h. No requirement when stationary or at very low speeds.	Provides live data when stationary, coupling trailers, or operating at slow speeds (quarries, depots, mining).	Safety blind-spot below regulatory speed thresholds.

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Area	ECE R141 Requirement	Modern TMSystems	Gap / Deficiency
Detection Thresholds	Alerts only when pressure drops 20% or more. Up to 10 mins (rapid loss) and 60 mins (slow leak) allowed before warning.	Real-time alerts: FastLeak™ (≥31 kPa drop in 16 sec), staged under-pressure alarms (12.5% and 25%), immediate driver notification.	R141 latency allows significant hazard exposure.
Temperature Monitoring	Optional, not mandated.	Mandatory in ®: “Hot wheel” alerts ≥80 °C to warn of brake drag, bearing failure, wheel-end fires.	Wheel-end fire risk unaddressed by R141.
Over-Pressure	Not required.	® provides ≥25% over-pressure alarms.	Missed hazard in over-inflation conditions.
Trailer & Multi-Combination Support	Requires only “towed unit warning” and an interface. No mandate for wheel maps or trailer sequencing.	Supports up to 8 trailers / 180 wheels, RF drop-and-hook, sequential trailer mapping, wheel-by-wheel visibility.	R141 insufficient for Australian road-train operations.
Alternative Systems	Allows CTIS / TPRS as equivalent compliance (no T(P)MS required).	® integrates CTI but still provides wheel-level pressure + temperature diagnostics.	A compliant vehicle may have no monitoring at all.
Environmental & Duty Cycle Testing	Validated in narrow lab / track conditions (0- 40 °C, dry surfaces, defined speed profiles).	Proven in heavy industrial, mining, on / off-road, extreme heat, and continuous duty.	R141 test envelope excludes real-world extremes.
Fault Detection	Requires only a generic malfunction lamp within 10 minutes.	Lost-signal alarms, depleted battery detection, per-wheel sensor status.	R141 gives limited diagnostic granularity.
Data & Analytics	No requirement for recording, telematics, trend analysis, or compliance reporting.	Telemetry, fleet management portal, RS232 / J1939 integration, reporting, remote SMS/email alerts.	Compliance does not equal proactive risk management.
Hardware Robustness	Silent on sensor design, mounting, or IP rating.	IP69K potted external sensors; field replaceable in minutes; large-bore/standard-bore compatibility.	Regulation does not ensure heavy-duty fit-for-purpose design.

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9. CTIS / TPRS "REGULATORY EQUIVALENCE" UNDER ECE R141- WHAT IT MEANS.

It is worthwhile at this juncture to discuss and expand on section **7.6 CTIS /TPRS Equivalence (may omit T(P)MS entirely)**. which is a little daunting.

9.1 What the Rule Say's.

- R141 explicitly allows a Tyre Pressure Refill System (TPRS) or Central Tyre Inflation System (CTIS) to be deemed **equivalent** to a T(P)MS for type approval if it meets the Annex 4 test criteria and the general requirements in 5.1.2, 5.1.3 and 5.4- 5.6.
- In that case, a T(P)MS is not required to be installed.

9.2 What Annex 4 Actually Tests.

- Annex 4 focuses on the refill / maintain function and driver warnings- not rich diagnostics.
- The core checks include- deflate one tyre to ~20% below the manufacturer's recommended cold pressure, verify the system begins refilling within ≤2 minutes, and that the refill completes within ≤8 minutes
- The low- pressure tell- tale must behave as specified. It also verifies the malfunction tell- tale behaviour and the towing- towed communication interface (wired ISO 11992/ISO 7638 or compatible wireless).
- There is no temperature- monitoring requirement in Annex 4.
- **Practical upshot:** Compliance can be achieved with a pressure- maintenance system alone (CTIS/TPRS) that passes refill timing and warning logic- without any obligation to sense or display temperature, or to provide wheel- by- wheel diagnostics / history.

9.3 Why the "Equivalence" Creates a Safety / Operations Gap.

- **Temperature is outside Annex 4's scope:** CTIS / TPRS approval does not require detecting hot wheel- ends (brake drag / bearing faults)- a key early indicator of wheel- end fires.
- **Granularity is limited:** Annex 4 validates refill function and a generic tell- tale. It does not require per- wheel ID mapping, trend history, or analytics.
- **Therefore:** a vehicle can be fully compliant with R141 yet lack temperature- based fire mitigation and detailed wheel- level diagnostics and no back to base remote data that modern TMSystems provide.

9.4 TMSystems vs CTI / APR (ATIS/TPRS): Functions, Strengths & Blind Spots.

Capability	TMSystem (T(P)MS)	CTI / APR (ATIS/TPRS)	Why it matters
Primary function	**Monitor** tyre condition and **alert** (pressure drop, imbalance; modern systems often add **temperature**, over-pressure, fast- leak).	**Maintain / regulate** pressure: automatically refill to a set point (ATIS / TPRS) or allow driver to **select different set points** for terrain (CTIS).	Monitoring vs active regulation are complementary, not substitutes.
Regulatory path under R141	Tested under **Annex 3** (detection thresholds & timing).	Tested under **Annex 4** (refill start ≤2 min; completion ≤8 min; tell-tales & interface). If Annex 4 is met, **T(P)MS not required**.	"Equivalence" can remove T(P)MS from the bill of materials.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

Temperature & wheel-end risk	Modern systems frequently **monitor temperature** and warn of hot wheel-ends.	**Not required** for Annex 4 approval (focus is refill/tell-tale).	Temperature alarms are crucial for early fire mitigation.
Per-wheel visibility & mapping	Wheel -specific IDs, locations, often with **history / trends** and telematics.	Typically **axle / circuit-level** control; **per-wheel telemetry** is not inherent nor required by R141 Annex 4.	Fast fault-finding (which wheel?) saves time and reduces risk.
Telemetry & analytics	Often integrated: remote alerts, reports, trend analysis.	Not part of Annex 4; some vendor add-ons exist but are not required for compliance.	Fleets need data to prevent repeat events and optimise maintenance.
Hardware footprint	Valve-mounted/internal sensors; no rotating seals; low air plumbing.	Manifolds, valves, lines through rotating seals/hubs; higher installation complexity / maintenance. (General CTIS/ATIS architecture.)	More points of failure vs fast field-replaceable sensors.
Use cases	**All duty cycles**, including low-speed yards, depots, quarries, mining; driver awareness.	**On-road trailers** (ATIS / TPRS) keep tyres at target; **off-road/military** (CTIS) for terrain mobility (sand/mud/haul roads).	Pick the tool that matches the mission.

9.5 Practical Recommendations to Close the Gap.

Because of the “regulatory equivalence” pathway, a vehicle can be legally compliant (EU) but without a true TMSystem- relying solely on CTIS / APR to maintain pressure.

This leaves **critical blind** spots:

- **No hot- wheel temperature alerts**, missing early fire detection for brake drag, bearing failure.
- **No wheel- level diagnostics or history,** slowing fault isolation and preventing proactive maintenance.
- **No real-time leak detection**, since refill systems only restore pressure but do not log the leak event.
- **Modern TMSystems close these gaps** by combining pressure maintenance with intelligent monitoring, ensuring both regulatory compliance and operational safety.

The recommended total approach for safety- critical or heavy- haul operations is **CTI / APR** for pressure maintenance + **TMSystem** for detection, localisation and analytics:

- **Pair CTI / APR with a modern TMSystem:** Use CTIS / TPRS to maintain pressure (fuel, tyre life) and a TMSystem to detect hazardous conditions (fast leaks, hot wheels, over-pressure) and to localise faults by wheel / trailer with remote history / analytics. This combination gives safety + efficiency while remaining fully compliant. (Annex 4 alone will not provide temperature or wheel-by- wheel insight.)

- **For trailers where "equivalence" is being used to omit T(P)MS**: document the residual risk, no temperature alarms, no wheel- level diagnostics, and longer time- to- find the offending tyre in multi- combination rigs. Then specify a TMSystem if risk tolerance is low (DG transport, road-trains, hot / brake duty routes).
- **Specify interfaces up-front**: Whether utilising CTIS, TPRS and / or T(P)MS, ensure compatibility with telematics (J1939 / RS232 / other) so the driver gets a clear, non-contradictory warning and your back- office gets usable (remote) data.

10. COMPARE EUROPEAN ON ROAD NETWORKS AND LIMITS TO AUSTRALIA.

The EU (and USA) have the **technology** to operate long multi- trailer rigs, but lack the **regulatory**, **political**, and **physical** environment to support them at scale.

Australia's unique geography, freight demands and infrastructure design makes it one of the only country in the world to routinely and successfully operate 3- 7 Trailer (tow assets) road trains and other PBS vehicles on public highways.

Let's now look at the difference:

10.1 Infrastructure Design & Constraints.

Europe:

- Road networks are centuries old, often narrow, winding, and passing directly through towns.
- Features such as roundabouts, tight corners, tunnels, and short merging lanes make manoeuvring long combinations impractical.
- Bridges, overpasses, and docks are not engineered for extreme axle weights or 30 + metre combinations.

Australia:

- Remote regions (NT, WA, QLD) feature long, straight highways designed with road trains in mind.
- Infrastructure includes extended turning bays, overtaking lanes, and dedicated road train assembly areas.

10.2 Regulatory Philosophy and Safety.

Europe:

- Policy prioritises safety, road wear mitigation, and environmental outcomes.
- Intermodal freight and rail are actively encouraged over long- haul trucking.
- Exceptions (Scandinavia, Netherlands) allow EMS (European Modular System) combinations up to 25.25 m.

Australia:

- Performance- Based Standards (PBS) framework enables innovation in multi-combinations, balancing productivity with safety compliance.

10.3 Urban Density and Mixed Traffic.

Europe:

- Highly **dense** cities with limited space for turning, loading, or parking large rigs.

Australia:

- Road trains rarely enter urban areas- cargo is transferred at exchange / break- bulk / assembly location to smaller trucks for "last- mile" delivery.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

10.4 Environmental and Public Perception.

Europe:

- Larger rigs face public opposition on safety and “road sharing” grounds. Policies favour limiting size to reduce emissions, congestion, and noise.
- **Standardisation** is the priority (40- 44t max GVW, 16.5- 18.75m length).

Australia:

- Road trains are seen as essential for economic efficiency in remote freight tasks.

10.5 Legal, Licensing & Insurance Complexity.

Europe:

- Longer **combinations** increase liability risk in collisions and rollovers.
- Insurance **costs** and driver training / licensing requirements are higher.
- Licensing is restrictive (C+E, CDL) and adds regulatory burden.

Australia:

- Special multi- combination licenses exist, with training geared specifically for road train operations.

10.6 Operating Contexts.

Europe:

- Dense corridors, shorter combinations (18- 25 m),
- Lower wheel counts (18- 22), stringent urban safety constraints.
- Mosly single- “married” Trailers (no need for drop- hook functionality) and sequencing.

Australia:

- PBS road trains up to 60 m+; 22–190 (low loaders)+ wheels
- Remote corridors.
- Frequent Drop- and- hook.
- DG mining / energy freight.
- High ambient temperatures.
- Heavy loads.

10.7 Summary Table.

Factor	Australia	Europe
Infrastructure	Long, remote, straight roads	Narrow, urban, historic roads
Road design	Built for road trains	Built for single trailers
Regulation	PBS allows innovation	Restrictive, shift-to-rail policy
Safety stance	Managed with PBS & licensing	Strong safety-first limits
Urban compatibility	Limited to depots outside towns	Very poor
Policy goal	Maximise remote freight efficiency	Rail-first, reduce emissions

Discussion: Roll- out Costs + Savings + ROI- TMSystems

11. AUSTRALIAN MULTI- COMBINATION FREIGHT CONTEXT.

11.1 Operating Realities.

- **Road trains (A-double, B-triple, A-quad) with dollies:** frequent drop- and- hook at depots.
- **Remote coverage:** Cellular blackspots- require satellite or store- and- forward gateways.
- **DG Tankers:** Wheel- end fires have high-consequence pathways (ANE / AN detonation under prolonged heat).

11.2 TMSystem Design Needs.

- **Auto-sequencing:** Detect and maintain trailer order at power-up / coupling, survive mid-train reconfiguration.
- **Asset identity:** Persist trailer IDs and display alerts tied to labelling that matches fleet rosters.
- **RF robustness:** Repeaters mid-train; antenna placement away from metal shadows; validate with RF surveys.
- **Hardwired Sequencing:** A hardwired TMSystem eliminates potential RF “daisy-chain” interference, ensures reliable data transfer between tow assets and the truck, and guarantees correct sequencing for drop-and-hook operations- without relying on driver intervention or risking errors from forgotten manual setup).
- **Serviceability:** Field sensor swap without re- commissioning entire rigs- simple provisioning workflows.

12. ADVANCED FEATURES REQUIRED FOR AUSTRALIA.

- **Drop-and-Hook Sequencing:** Automatic trailer discovery and ordering with no interaction.
- **Per- Asset Profiles:** Baselines (CIP), temp thresholds stored per trailer / dolly.
- **High- Temperature Alarms:** Hard threshold (e.g., >80 °C) and rate-of-rise to catch brake drag / bearing failures.
- **Fast-Leak Detection:** Short-window dP algorithms (e.g., ≥30 kPa/16 s) for punctures / valve failures.
- **CTI / APR Awareness:** Accept mode signals or quick profile switching to avoid nuisance alarms- pressure change management (On- Off Road).
- **Telematics Integration:** Real-time exception streaming and remote access / storage of data / events.
- **Analytics & Compliance:** Exception heatmaps, wheel- end trend lines, audit records for regulators / insurers and compliance.

13. RISKS OF R141 ONLY TMSYSTEMS.

13.1 Technical Gaps.

- **Single lamp ambiguity:** No tyre / trailer localisation, inadequate for multi- trailer road trains / large low loaders trailers.
- **Late thresholding:** ≥20% under-pressure can miss incipient leaks and thermal run-up periods.
- **No temperature sensing:** Blind to brake drag / bearing / tyre pre-ignition states.
- **No Sequencing / ID:** Not designed for dynamic trailer / dolly “daisy chains”.
- **No telematics:** Fleet managers receive no live exceptions (compliance recording), dependent solely on driver notice / response and physical reporting.

13.2 Escalation Scenario (DG Tanker).

- **Scenario:** A sticking brake heats rim and tyre- pressure / temperature rise- pyrolysis risk increases. R141 lamp may not trigger until late (pressure loss)- driver unaware of thermal runaway- tank shell heat soak- potential ANE detonation.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

- **Mitigation:** High-temp alarms + per- tyre localisation + fast- leak logic + telematics escalation to operations.

13.3 Super-Single Tyre Adoption.

Wider tyres can reduce rolling resistance and simplify maintenance, improving payload efficiency.

13.4 Risk Profile.

- **Single- Point failure:** Loss of a super- single can immediately compromises axle support.
- **Thermal behaviour:** Larger carcass can accumulate heat under brake drag- careful monitoring required.
- **Baselines:** Different CIP than duals- profiles must match axle / tyre specifications.

13.5 TMSystem Guidance.

- Stricter thresholds on super-single positions (earlier Level I alert).
- Prioritise temperature on converted axles.
- **HMI accuracy**: Clearly mark single vs dual positions, ensure the per- wheel map matches fitment.

14. DEPLOYMENT CHALLENGES.

14.1 RF & Physical.

- **Long rigs and metal bodies shadow RF:** mitigate with repeaters and validated antenna placement.
- **Tank shells / containers cause multipath:** conduct site-specific RF tests.

14.2 Integration & Legacy Fleets.

- **Mixed vintages and protocols:** provide dual J1939 / RS-232 outputs (telematics) and adapter harnesses.
- **EMC diligence:** to coexist with EBS / ABS and other technology electrical and RF such as cameras, telematics, refrigeration units, etc.

14.3 People & Process.

- **Driver training:** Interpreting alerts, safe responses, DG protocols.
- **Driver intervention:** System must self-check and operate automatically, without driver input or manual connection.
- **Workshop upskilling:** Provisioning, diagnostics, baseline management- formal SOPs.
- **Change management:** Shift to exception- based maintenance- align KPIs and job cards.

14.4 Environmental & Serviceability.

- **Dust, mud, and hot-wash:** Specify IP69K for Sensors / Transceivers, etc, guarded locations, corrosion-resistant fasteners.
- **Spares logistics and field-swap SOPs:** for remote depots to protect uptime.

14.5 Governance & Data.

- **Event retention for audits / incident review:** clarify data ownership / retention and privacy.
- **Supplier SLAs:** parts availability, firmware cadence, security maintenance.

14.6 Regulatory Alignment.

- Ensure ADR pathway captures multi- trailer specifics, over- temperature alarms for DG tankers, and roadworthiness inspection checks for TMSystem functionality.

14.7 Summary.

TMSystems are **essential engineering mitigation controls** for heavy vehicles.

Reports from coronial inquiries, insurer data, and catastrophic AN / ANE events evidences that unmonitored (dynamic) wheel- ends pose unacceptable risk.

Australia's operating environment- multi-trailer road trains, DG movements, remote corridors- demands **industrial-grade TMSystems**- with per- tyre localisation, high- temperature alarms, fast- leak detection, trailer sequencing, and telematics and driver in- cabin warning monitor.

15. SHORTCOMINGS OF UNECE R141 IN THE AUSTRALIAN CONTEXT.

While R141 sets a baseline, it is insufficient for Australian fleets because:

- Permits up to 60 minutes to warn of leaks.
- Applies only above 30- 40 km / h- no coverage at low-speed or stationery.
- Does not require temperature monitoring, the key precursor to fires.
- Provides only a "towed unit" lamp, no wheel- by- wheel mapping or trailer sequencing.
- Allows Central Tyre Inflation Systems (CTIS) to substitute without true monitoring.
- No requirements for telematics, analytics, or data retention.
- Australia's unique fleet mix demands standards far beyond these minimums.

16. ADR- TMSYSTEM MANDATORY REQUIREMENTS.

16.1 Interoperability and OEM Neutrality.

- **Imported Vehicles:** Many trucks, buses, and cranes imported from the EU will soon arrive with OEM-fitted TMSystems, each tied to the manufacturer's preferred technology.
- **Compatibility Challenges:** OEM systems are often incompatible with locally built trailers and typically do not support Australia's multi-trailer "drop-and-hook" operations.
- **Servicing Burden:** Factory systems usually require dealer- only servicing, adding cost, downtime, and reducing operator flexibility.
- **Fleet Fragmentation:** A mix of OEM- preferred systems from different countries creates difficulties in standardisation, spare parts, and technical support.
- **Local Advantage:** A locally supported, fit- for- purpose TMSystem ensures fleet-wide compatibility, serviceability and safety compliance.
- **Open Standards:** TMSystems must operate on open communication standards (ISO 11992, SAE J1939, RS232) to allow seamless telematics integration.
- **Regulatory Compliance:** Factory- fitted systems are not ADR- compliant unless they meet interoperability and open-interface requirements. Proprietary OEM systems that block trailer or telematics integration are unacceptable.
- **Trailer Integration:** Australian- made trailers must integrate seamlessly with imported prime movers. Compliance demands mixed- vendor interoperability testing to guarantee full fleet compatibility
- **Special / Other Vehicles:** Many operators run mixed fleets with a wide range of vehicle and machine types- such as container handlers, forklifts, agricultural equipment, EWPs, earthmoving machinery, as well as large vehicles including PBS combinations and low-loader trailers. In addition, there are special-purpose vehicles such as fire engines, ambulances, 4 x 4s, and garbage trucks. Selecting a local TMSystem supplier that can support this **full spectrum of configurations** and provide **standardised components / full support** is essential to simplify maintenance, reduce downtime, and maintain productivity.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

16.2 Technical Performance.

ADR-compliant TMSystems must deliver:

- **Fast-leak detection**: ≥30 kPa drop in ≤15 s.
- **Staged under-pressure alerts**: 12.5% and 25% drops.
- **Over-pressure alarm**: ≥25% above setpoint.
- **High-temperature alarm**: ≥80 °C or rapid rate-of-rise detection.
- **Per-tyre, per-axle, per-trailer identification**: The in-cab display must show the exact tyre, wheel, axle, and trailer with fault.
- **Drop-and-hook trailer sequencing**: Automatic trailer recognition and ordering at power-up, ensuring drivers see accurate trailer order on the display.
- **Lost-signal:** and sensor- battery alerts.
- **Ruggedisation**: IP69K sensors, serviceable externally without tyre removal.
- **Hardwired Data:** Preference for **hardwired** TMSystem eliminates potential RF “daisy-chain” interference or relying on driver intervention or risking errors from forgotten manual setup).

16.3 Driver In-Cabin Display Requirement.

The ADR **must** require a dedicated in- cab display that:

- Provides immediate visual and audible warnings.
- Shows which tyre, on which axle, on which trailer has triggered the alarm.
- Uses clear severity coding (e.g., colour / red-amber-green).
- Supports multiple trailers with correct sequencing for drop-and-hook fleets.
- Gives the driver enough clarity to take safe, corrective action quickly.

16.4 Local Support and Serviceability.

Suppliers must maintain:

- Onshore spare parts.
- National field service capacity.
- Driver / technician training and compliance documentation.
- Detailed manuals, RF survey guidance, and SOPs for installation / service.

16.5 Telematics and Compliance Evidence.

- Data model must include wheel position, pressure, temperature, alarms, ID, timestamps, and comms quality.
- APIs must support real-time streaming and daily batch export.
- Store- and- forward capability of ≥120 days.
- Data retention of ≥12 months (≥24 months for DG fleets).
- Exportable evidence packs for insurers and regulators.
- Data ownership remains with operators- suppliers must provide secure, non-proprietary access.

16.6 Retrofit Compatibility.

- Retrofit kits must support truck and trailers of all vintages.
- Must work with standalone in- cab monitors and / or integrate with existing telematics.
- Sensors must be transferrable across assets (standard and large bore valves).

- Must support duals, super-singles, dollies, buses, and DG tankers as well as many other vehicles in mixed fleets.

16.7 High-Risk Fleet Overlays.

- **DG transport**: Automatic escalation to fleet operations for high-temp or fast-leak alarms; logs must retain ≥24 months. Provide ATEX / Intrinsic safe systems.
- **Buses / coaches**: Prioritise wheel- well fire detection.
- **Mining / off-road**: Prioritise wheel (pyrolysis)- well fire detection and EMC compliance.

16.8 Certification & Enforcement.

- Independent “plug fest” testing for mixed- vendor truck + trailer interoperability.
- Roadworthiness inspections to verify TMS function and logs.
- Persistent TMS faults treated as compliance defects.
- Drivers and technicians must complete certified training, documented by operators.

16.9 National Rollout Roadmap.

- **Phase 1 (Year X+1)**: ADR applies to new type approvals.
- **Phase 2 (Year X+2)**: All new registrations.
- **Phase 3 (Year X+3)**: Retrofit deadlines: DG / buses first, line- haul next, then general freight.
- **Incentives**: Insurance premium discounts, NHVR credits, early- adopter grants.

16.10 Economic and Safety ROI.

- Investment: **~$5.1B** across **5.1M** heavy vehicles/trailers.
- **Annual benefits: $31–37B**.
- **Payback:** <1 year; 10-year net **>$310- 370B**.
- **Safety:** Prevents catastrophic rollovers, wheel-offs, wheel-end fires, and DG explosions.

17. IMPORTED VS LOCAL REALITIES OF TMSYSTEMS IN AUSTRALIA.

Australia no longer manufactures passenger vehicles and has not mandated TMSystems.

Since all new passenger cars are imported, they already arrive with TMSystems installed and importantly / Interestingly to not is that these factory systems **cannot** monitor tyres on **tow assets** such as trailers, caravans, or boats.

Similarly, many heavy vehicles (articulated trucks, rigids, buses, coaches, and cranes) are imported from the EU / USA and so will soon (EU) offer OEM- fitted TMSystems (R141).

This creates several additional challenges to section 16.1 Interoperability and OEM Neutrality. for Australian operators:

- **Trailer Compatibility:** Australian trailers are built locally, but OEM TMSystems may not integrate with them- especially for multi- trailer “drop-and-hook” operations.
- **Servicing & Spare Parts:** OEM systems are normally dealer- locked, requiring workshop visits for sensor replacement or maintenance. This increases costs, downtime, and productivity loss.
- **Local Support:** TMSystems are imported and so without strong local technical support and spare parts supply, operators risk extended delay and / or safety risks.
- **Fit- for- Purpose Concerns:** Not all TMSystems are designed for Australian heavy-haul and off-road conditions. Many may require high levels of maintenance and component replacement.
- **Fleet Fragmentation:** Operators could end up with a mix of incompatible TMSystems from different OEMs (EU, USA, China, Japan, Korea), making standardisation, common spares, and technical support difficult.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

- **Safety Implications:** A vehicle should not operate without a fully functional TMSystem. If only a dealer can service the OEM system, operators risk downtime until repairs are completed.
- **Body Builders & Local Fitment:** Australian heavy / commercial vehicle body builders may struggle to source a single standardised TMSystem that works seamlessly across different imported vehicle makes and models
- **Buyer Beware:** Operators should carefully consider sourcing TMSystem technology locally to ensure compatibility, serviceability, and fleet-wide standardisation in Australia.

18. NATIONAL ROLLOUT ROADMAP FOR TMSYSTEMS- AUSTRALIA.

So as to ensure:

- **Technical Standards & Specifications:** Adopt R141 as a floor and requires high-temp, fast-leak, sequencing, IP69K, −40…+85 °C.
- **Multi- Combination Fleet Complexity:** Standardise trailer ID / Auto-sequencing support >120+ Wheels / Tyres or even more in the case of Low Loader Trailers.
- **Telematics Integration:** Mandate J1939- RS232 outputs- require fleet-level exception reporting.
- **Industry Transition & Retrofits:** Phased deadlines (DG & buses- line-haul- general freight)- external sensor kits, local service capacity.
- **Training & Workforce:** Driver modules; technician certification, manuals and SOPs.
- **Regulatory & Enforcement:** Embed in ADR- include TMSystem checks in roadworthiness, define processes for alerts.
- **Insurance & Incentives:** Risk-based discounts, safety grants to accelerate early adopters.
- **Sector Priorities:** DG fleets (mandatory temperature alarms), buses / coaches (wheel- well fire risk), mining (explosion- safe hardware).
- **Roll- out Costs / ROI Analysis:** is provided in LSM Technologies white paper- LSM 2025- Aug 20- TMS Roll Out Costs + Sav- Australia- v1 White Paper.

19. FINAL POSITION STATEMENT: ADR MANDATE FOR TMSYSTEMS IN AUSTRALIA.

19.1 Context and Imperative

Tyre and wheel- end failures remain one of the most frequent and costly causes of catastrophic heavy-vehicle incidents in Australia. Underinflation, blowouts, and wheel- end fires have led to rollovers, loss of control, and even DG tanker explosions (e.g., Angellala Creek).

Globally, tyre monitoring is now recognised as essential:

- EU Regulation R141 mandates T(P)MS on heavy vehicles and trailers.
- The US TREAD Act mandates T(P)MS for passenger and light vehicles.
- DMP (Department of Mines and Petroleum) WA WorkSafe- Code of Practice for AN / ANE Tankers.
- 2010 Queensland Coroner's recommendation- TMSystems Mining / Heavy Haulage- within 2 x years
- QLD recommended Standard 13 wheel and rim management.
- Tyre safety for earth- moving machinery- WA mining operations.
- NfNSW (2017) develop their TMSystems Standard- BC17/18562 on Buses.
- Japan, Korea, and China have introduced similar mandates- passenger vehicles.
- And many more regulator and advocacy reference documents, recommendations and guidance are established in all heavy industries where vehicles utilise pneumatic tyres.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

Australia currently has no Australian Design Rule (**ADR**) mandate requiring the fitment of TMSystems on heavy on road transport vehicles.

This regulatory gap is particularly inconsistent with the elevated risk profile of our transport sector, which includes multi- trailer road trains, dangerous goods tankers, buses, and mining fleets operating in extreme heat and remote regions.

The Federal Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCSA) has acknowledged that it is considering the compulsory adoption of TMSystems, consistent with comparable international mandates.

As a signatory to both the UN 1958 Agreement and the 1998 Agreement, the Australian Government- through its Department of Infrastructure and Transport- seeks to harmonise national vehicle safety standards with European and broader international regulations.

Failure to address this regulatory gap carries significant implications- not only in terms of heightened safety risks, but also in increased economic costs, greater liability exposure for operators, and missed opportunities to align Australia's fleet safety with global best practice.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

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ARTS-i- Dr Peter Hart- Truck and Trailer Fire Guidance Reports
Insurance Business- Truck fire loss payouts Teletrac and NTI claims data
NTI 2022 Major Crash report
Refer to this LinkedIn link for reported: Blow- outs, Vehicle Fires, Wheel- end / Tyre Fires, Roll- overs
LSM 2025- Aug 20- TMS Roll Out Costs + Sav- Australia- v1 White Paper
ISO 45001 Occupational Health and Safety Management System
Australian NHVL COR
Australian National WHS Act 2011
UN ECE Regulation No. R141 for mandatory fitment of TMSystems / CTI and APR Systems
USA Transportation Recall Enhancement, Accountability and Documentation or Tread Act of 2000 mandating TMSystems on all passenger vehicle
2010 Queensland Coroner's recommendation that the Mining / heavy Haulage Industry adopt Wireless Tyre Monitoring Sensing Equipment- within 2 x years
QLD recommended Standard 13 wheel and rim management (include TMSystems)
Tyre safety for earth- moving machinery- WA mining operations- (includes TMSystems)
NfNSW (2017) develop their TMSystems Standard- BC17/18562 on Buses
DG / Explosives guidance: DMP (Department of Mines and Petroleum) WA WorkSafe has introduced a new Code of Practice for AN/ANE Tankers.
A few significant incidents (over past 15 years) can be found on LSM web site at this link.
CICA Pick and Carry Crane
HVIA Tyre Inflation Group
TMSystems Roll-Out, Cost savings, ROI Benefits. Heavy Vehicles Australia- Discussion + Analysis

Discussion: Roll- out Costs + Savings + ROI- TMSystems

UNECE Regulation No. 141 (R141) Mandates T(P)MS / CTIS / APRS for heavy vehicles and trailers
EU General Safety Regulation (EU) 2019 / 2144
FMVSS 138 (USA) T(P)MS for passenger vehicles
China GB 26149; Japan / South Korea Passenger-vehicle mandates commercial adoption evolving.
Australian ADR update under review (VSCC).
Western Australia's mining guidance Tyre Safety (includes TMSystems).
DG / Explosives guidance DMP WA WorkSafe Code of Practice for AN/ANE Tankers.
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ISO 11992 Truck- trailer communication; relevant for T(P)MS / CTIS interoperability with EBS/ABS.
Functional Safety (ISO 26262 principles) Good practice for software integrity in alarm logic.
NfNSW (2017) develop their Bus TMSystem Standard- BC17/18562 on Buses.
QLD recommended Standard 13 wheel and rim management (include TMSystems).
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ISO 45001 Standard for Occupational Health and Safety management
Australian NHVL COR (Chain of Responsibility)

21. ABOUT LSM TECHNOLOGIES & THE AUTHOR.

21.1 Evidence-Based Safety Advocacy in Tyre Monitoring Systems.

The Author, Engineering Manager and CEO of **LSM Technologies**, has dedicated nearly two decades to advancing **Tyre Monitoring Systems (TMSystems)** tailored for the unique demands of the Australian heavy vehicle industry.

With over 20 years of specialist knowledge, field research, and regulatory engagement, the Author is widely recognised as a subject matter expert in vehicle safety technologies.

Under their leadership, LSM Technologies has pioneered the design, testing, and deployment of innovative TMSystems that not only exceed Australian and international OH&S standards, but also deliver tangible safety and productivity benefits to operators across mining, dangerous goods, commercial freight, buses, cranes, and off-road fleets.

21.2 Contributions to Regulators and Industry Bodies.

The Author and LSM Technologies have played a central role in shaping the national dialogue on tyre and wheel safety.

Their active involvement includes:

- **Participation in Tyre Safety Working Groups**, including ARTSA-i, HVIA, and other technical committees.
- **Sponsorship of** ARTSA-i's Truck Fire Guidance Document, contributing technical expertise on mitigating wheel-end fire risks.
- **Technical presentations** at National Bulk Tanker Association (NBTA) workshops, stakeholder forums, and safety conferences.

- **Supporting regulatory funding initiatives**, including providing letters of support that helped NBTA secure NHVSI grant funding from the NHVR.
- **Contributed** to the NHVR Truck / Trailer Fire round table 2019.
- HVIA Tyre Inflation Working Group 2023.
- **Collaborative** live-fire testing, such as:
  - Bus and trailer fire trials with Transport for NSW (2017)
  - Truck and tanker fire simulations with Rocky's Own Transport and QLD Department of Mines- DG Transport (2015)
  - Other operator- led validation programs that examined wheel- end and tyre fire causation and mitigation.
  - First **TMSystem in the world** to be tested and certified for DG Transport 2016.

These activities highlight LSM's commitment to **evidence-based advocacy- t**ranslating empirical testing and field data into actionable safety standards and regulatory reforms.

21.3 Operational Data and Evidence.

LSM's influence is backed by an unmatched depth of **real-world operational data**:

- Over **20 years of deployments** of LSM TyreGuard® TMSystems across diverse fleets: mining, DG tankers, freight, cranes, buses, and multi-combination road trains.
- Continuous monitoring via the Fleet Safety Manager® Telematics platform, which has logged tyre pressure and temperature data every six minutes, 24/7, for more than 12 years on 1,000 tyres.
- With the use of their telematics coverage, spanning **thousands of sensors** installed on hundreds of vehicles, generating a comprehensive dataset correlating tyre **pressures and temperatures** with variables such as **speed, load, and terrain**.
- This data has never been recorded and is a **world first** to date.

This evidence base provides:

- Clear validation of TMSystem performance in Australian conditions.
- Quantifiable safety impacts and **ROI** from reduced blowouts, fewer wheel-end fires, longer tyre life, and lower maintenance costs.
- Empirical insights that can directly inform policy development, regulatory submissions, and fit-for-purpose mandates for Australian fleets.

21.4 Leadership in Safety and Innovation.

At its core, LSM Technologies embodies a culture of **life-saving mitigation**: delivering engineering solutions that enhance workplace safety, prevent equipment damage, and improve fleet productivity.

The Author's advocacy has helped regulators, industry bodies, and operators alike understand that **TMSystems are not just compliance tools, but proactive safety controls**.

Through continuous collaboration with NHVR, ARTSA-i, HVIA, NBTA, TfNSW, CICA, and BIC, the Author has ensured that the technical standards and safety codes being developed reflect both **global best practice and the unique realities of Australian operations**.

In 2016, LSM Technologies achieved a global first by becoming the only provider to have a Tyre Monitoring System formally tested and certified for Dangerous Goods (DG) Transport.

This milestone validated the system's capability to meet stringent regulatory and safety requirements, reinforcing its role as a proven engineering control for high-risk heavy vehicle operations.

Discussion: Roll- out Costs + Savings + ROI- TMSystems

21.5 Closing Statement.

With unmatched technical expertise, a vast operational evidence base, and two decades of collaboration with regulators and industry, **the Author and LSM Technologies stand ready to continue supporting the heavy transport sector**.

Their mission remains clear: to deliver safer, smarter, and more compliant transport solutions that protect people, equipment, and the broader community.

More details of their extensive contributions can be found via the following resources:

- LSM Technologies News Articles.
- LinkedIn.

Disclaimer: The information and estimates contained in the attached report are based on publicly available data, industry trials, and internal modelling as of the date of publication. While all efforts have been made to ensure accuracy, LSM Technologies makes no warranties or guarantees regarding the completeness, currency, or accuracy of this information. All figures are indicative only and subject to change.