Track Worker Safety Options

Interactive Report

Introduction

The Office of the National Safety Regulator and Rail Industry Safety Standards Board have partnered with the Australian Centre for Rail Innovation with Arup as the delivery partner to explore track worker safety (TWS) options available for Australian railways to drive and inform future investment and implementation.

This research project has been undertaken to establish a shared understanding of TWS options and their use in the rail sector. The purpose of the project is to identify primarily current, and some emerging, TWS options for improving the safety of workers on Australian rail networks. It is anticipated that understanding the options available as well as their context for use in providing TWS will enable the rail sector to invest in these solutions and implement them successfully.

This report captures many aspects of this project, including a summary of the literature review, highlights from the survey findings, a snapshot of the stakeholder engagement workshop and an options table. Figure 1 shows the project stages from inception to this final report and options table. The project team has engaged with stakeholders and experts across every stage.

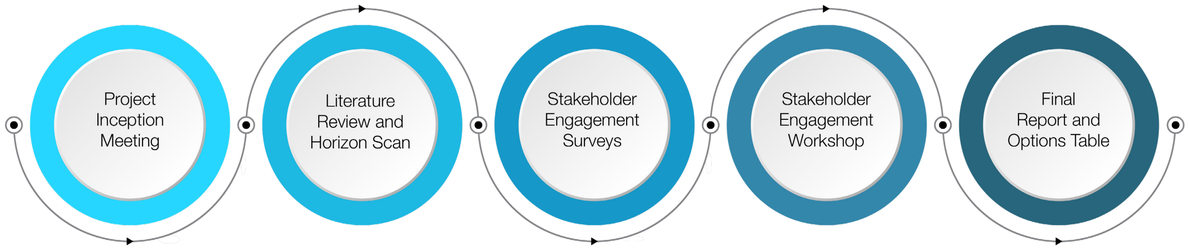

Figure 1: Project stages

This report is interactive.

Navigate the report sections using the buttons in the upper right.

Glossary

ACRI – Australian Centre for Rail Innovation
AI – Artificial Intelligence
ATWS – Automatic Track Warning Systems
AUD – Australian Dollars
EWDS – Early Warning Detection System
GPS – Global Positioning System
km – Kilometres
LED – Light Emitting Diode
LiDAR – Light Detection and Ranging
m – Meters
OLED – Organic Light Emitting Diode
ONRSR – Office of the National Rail Safety Regulator
PAD – Personal Alert Devices
PPE – Personal Protection Equipment
RISSB – Rail Industry Safety and Standards Board
TPWS – Train Protection Warning System
TWS – Track Worker Safety
UAV – Unmanned Aerial Vehicle
Wi-Fi – Wireless Fidelity
WPS – Worksite Protection System

Options Table

Introduction

This options table has been developed based on the findings from all stages of this research project. This includes a thorough scan of leading literature and stakeholder engagement through surveys and workshops. Additional in-depth research has been conducted to identify suppliers, indicative pricings, and implementation considerations for each option.

The options are split into five typologies, which are:

1. Vehicle installed sensors and devices that give warnings to train crew.

2. Worksite installed sensors and devices that give warnings to track workers.

3. Sensors and devices that give targeted alerts to both vehicle crew and track workers.

4. Infrastructure systems, methods and devices that remove the need for workers on tracks to undertake work.

5. Infrastructure systems and devices that automatically prevent vehicles from entering a worksite.

Each of these typologies has several options that have been explored in detail. For each option, we have conducted a maturity assessment, which is explained in the following section. Each option is summarised, given context for its use in track worker safety and includes some example providers. For each provider, we have included indicative costs as well as any implementation considerations. Links to provider websites and more information are also included for each option.

Option Maturity Assessment

A high-level maturity assessment has been conducted for each of the options. This assessment takes into consideration two factors:

1. How long the option has been commercially available/in use.

2. The amount/depth of available literature/research on the option and its use.

The assessment is represented as a comparative scale in the options table from one to ten. The higher the score, the more mature the option based on the above factors.

This assessment should not be used as a metric to judge or rank the options in their entirety, but rather be considered as part of any further assessment and approach for adopting TWS options. The assessment also does not represent the example providers, or their available products included in this report.

Railway Construction © QA Photos_LCR

This section is interactive.

The options table can be interacted with to navigate between categories and options. Click the arrows to see more content for each option.

Option Typologies

1. Vehicle installed devices that give warnings to train crew

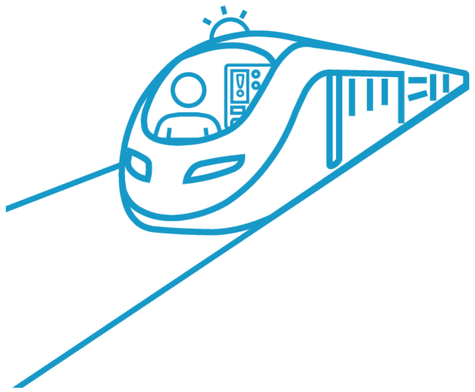

Figure 9 – Typology 1: Vehicle mounted sensor alerting operator to the presence of danger

This typology includes all types of sensors and devices mounted to trains and other rail construction/maintenance vehicles that alert the vehicle operators to the presence of potential dangers such as workers, other vehicles, and obstacles.

2. Worksite installed devices that give warnings to track workers

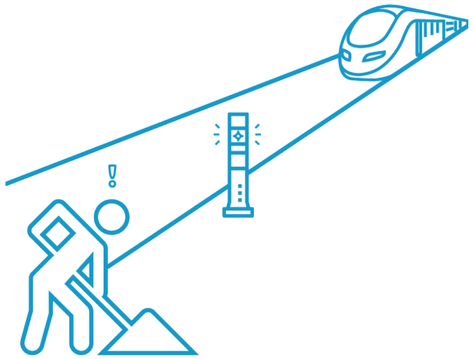

Figure 10 – Typology 2: Worksite sensor detecting potential danger and alerting worker

This typology includes all types of sensors and devices present on a work site or worn on a worker that alert workers to the presence of potential danger such as being close to a danger zone or warning of an approaching vehicle.

3. Sensors and devices that give targeted alerts to both vehicle crew and track workers

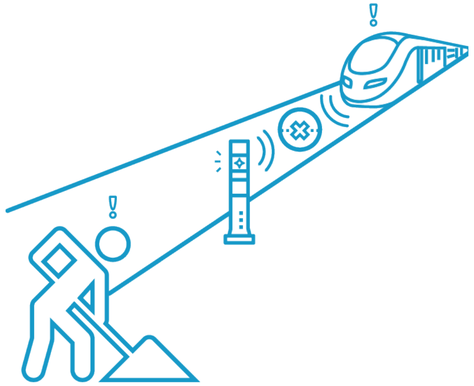

Figure 11 – Typology 3: A sensor detecting potential danger and generating alerts to both vehicle operators and workers

This typology includes all sensors and devices that generate alerts for both track workers and vehicle crew that alert to the presence of danger or potential danger. Warning vehicle crew of the presence of workers and warning workers of approaching vehicles.

4. Infrastructure systems, methods and devices that remove the need for workers on tracks to undertake work

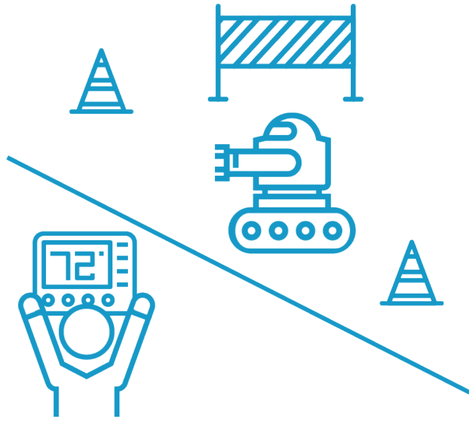

Figure 12 – Typology 4: Track work being undertaken with the worker physically segregated from the danger zone.

This typology includes all systems and methods that segregate human workers from tracks and other danger zones when work is being undertaken in these areas.

5. Infrastructure systems and devices that automatically prevent vehicles from entering a worksite

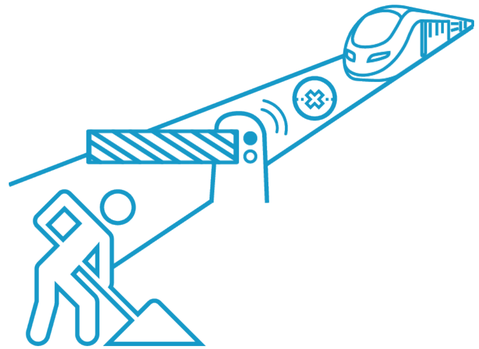

Figure 13 – Typology 5: Vehicle automatically prevented from entering site where track worker is present.

This typology includes all systems and devices that will automatically stop any trains or vehicles from entering a site where track workers may be present.

Options Table

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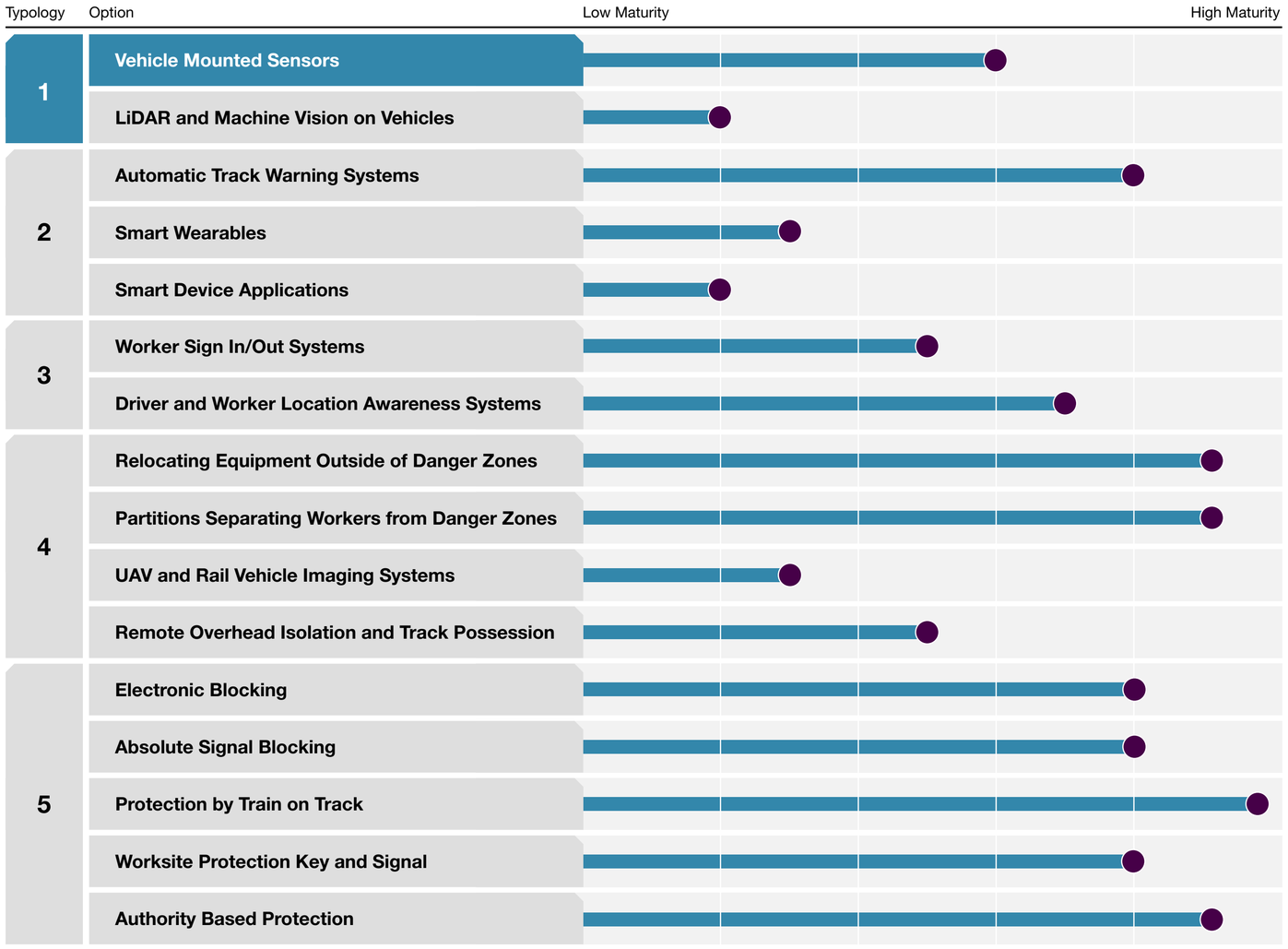

Vehicle Mounted Sensors

Summary

Maintenance vehicle mounted sensors involve a device mounted to the vehicle that will emit a signal when detecting and/or is in close proximity to a hazard or track worker. The alert given to a maintenance vehicle operator will often inform them of which direction, how far away and what hazard was detected such as a worker or other vehicle. In some cases, devices possessed by track workers may send a signal to the vehicle operator when they are in a safe location.

Supplier Options

- Early Warning Detection System (EWDS-01) – Blue Electronics
- Collision Avoidance System – Protran Technologies
- Blindsight – Presien

Option Details

The Early Warning Detection System (EWDS-01) is designed specifically for Rail Maintenance Machines. It provides the operators with speed, distance, and direction of travel of each machine and warns the operators if a potential collision is detected. The system can also be expanded to include GPS tracking, points of interest warnings and personal proximity detection for track workers. This system's price ranges from AUD$6000-$20,000 per machine and is dependent on the number of operator stations and size of the machine.

The Protran Collision Avoidance System is designed to keep a vehicle operators' attention when approaching other vehicles, workers, and work site boundaries. The system is equipped with a high-resolution OLED daylight display with visual and audible alarms. The system aims to prevents costly accidents and injuries to equipment and operators. It performs ranging for distances up to and over 750 m in the harshest conditions, including tunnels and curves.

Options Table

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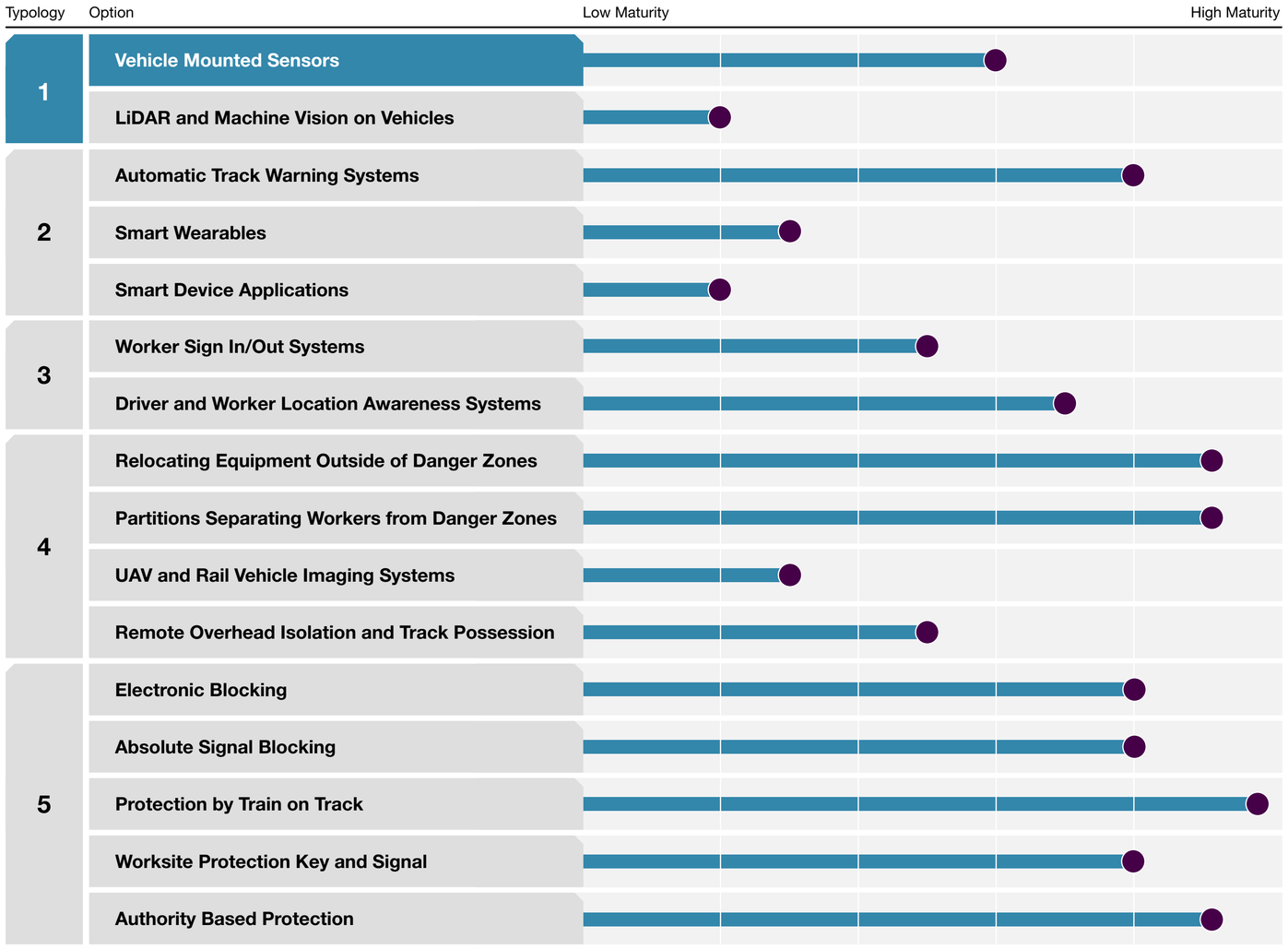

Vehicle Mounted Sensors

The Blindsight System from Presien uses vehicle mounted sensors and computer vision AI to prevent incidents and automate incident reporting. The system can be fixed to vehicles and infrastructure and does not require, tags, high-vis wear, or internet connectivity to function. When the system detects a potentially dangerous situation, it alerts operators in the area, calling their attention to the risk before it can become an incident. Once connected to the internet, the system will automatically upload recorded data to the cloud. The hardware and software subscription offering can cost from AUD$5000 for hardware and AUD$100-200 per month for software with discounts for longer contracts.

Links to Sources

- Blue Electronics, Early Warning Detection System (EWDS-01), Product Website, bit.ly/3d5dBS6
- Protran Technologies, Collision Avoidance System, Product Website, bit.ly/3tSrgTh
- Presien, Blindsight, Product Website, bit.ly/3stry2E

Options Table

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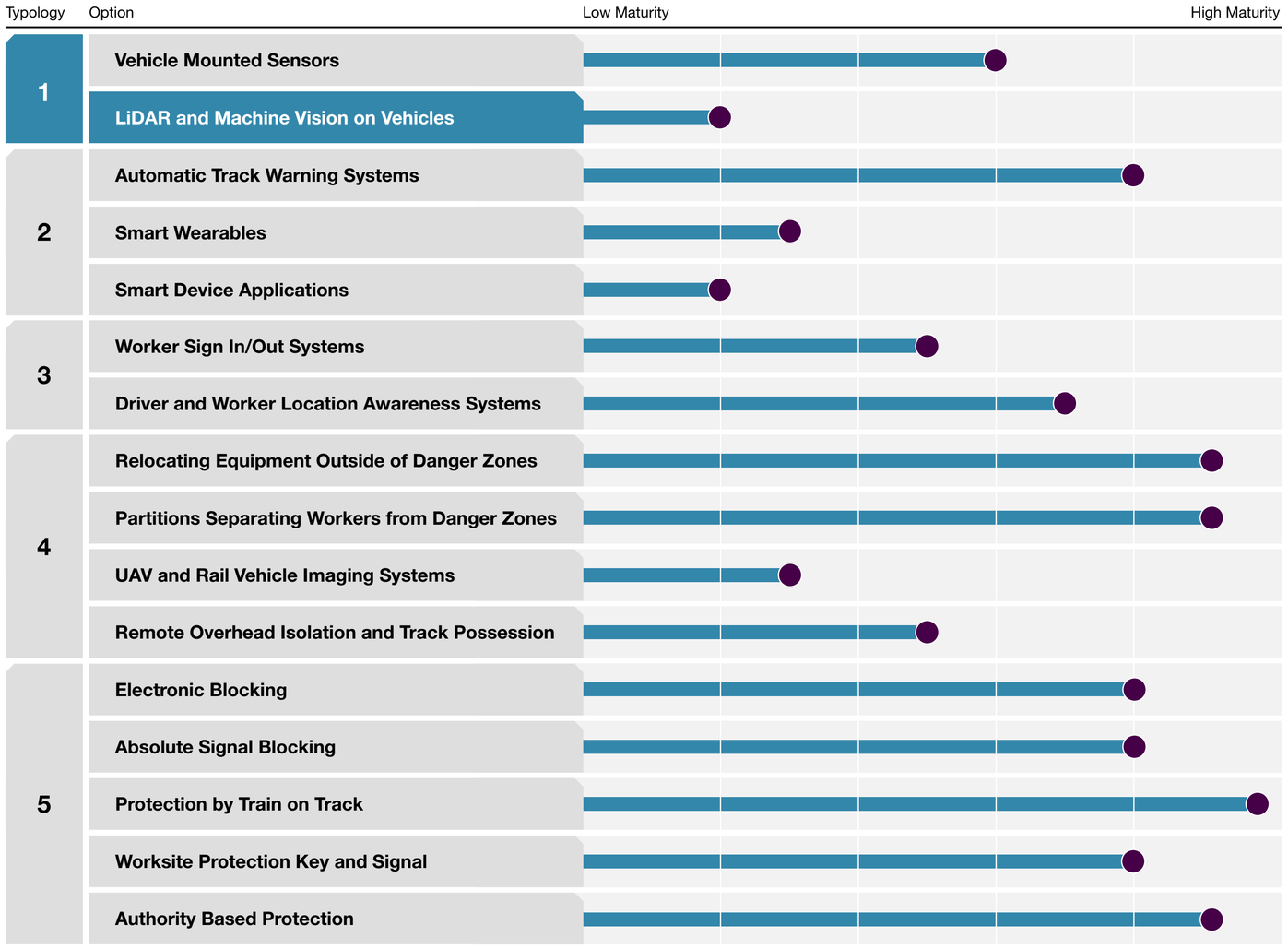

LiDAR and Machine Vision on Vehicles

Summary

The use of LiDAR and machine vision to identify potential collisions is an emerging option for providing track worker safety in the rail sector. These types of systems are more developed in the automotive industry, particularly with use in autonomous vehicles. Further details on these road vehicle systems are discussed in the section on worker safety options outside the rail sector. There are however international examples of solutions that have been developed for rail applications. These systems combine AI with visual data to identify hazards in real-time and act automatically, removing human error.

Supplier Options

- Main Line System - Rail Vision
- Rail Computer Vision – Vicomtech

Option Details

Rail Vision's Main Line System aims to prevent collisions through the use of train mounted sensors that leverage computer vision and AI to identify hazards and respond appropriately. Their sensor systems combine imaging, AI, and machine learning to detect hazards at a range of 2 km regardless of weather and light conditions. The system detects and classifies obstacles on or near the tracks and generates real-time visual and acoustic alerts for both the driver and the operator's control centre.

Vicomtech have explored the applications of machine vision in railways for improving safety. Trains fitted with video sensors are capable of detecting and identifying objects on the rail line. They have also explored the use of these systems for identifying areas on rail lines in need of maintenance.

Options Table

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Typology	Option	Low Maturity — High Maturity
1	Vehicle Mounted Sensors	
	LiDAR and Machine Vision on Vehicles	
2	Automatic Track Warning Systems	
	Smart Wearables	
	Smart Device Applications	
3	Worker Sign In/Out Systems	
	Driver and Worker Location Awareness Systems	
4	Relocating Equipment Outside of Danger Zones	
	Partitions Separating Workers from Danger Zones	
	UAV and Rail Vehicle Imaging Systems	
	Remote Overhead Isolation and Track Possession	
5	Electronic Blocking	
	Absolute Signal Blocking	
	Protection by Train on Track	
	Worksite Protection Key and Signal	
	Authority Based Protection	

LiDAR and Machine Vision on Vehicles

Links to Sources

- Rail Vision, Main Line System, Product Website, bit.ly/3lIB5QU
- Vicomtech, Rail Computer Vision, Product Website, bit.ly/3f8oOnD

Options Table

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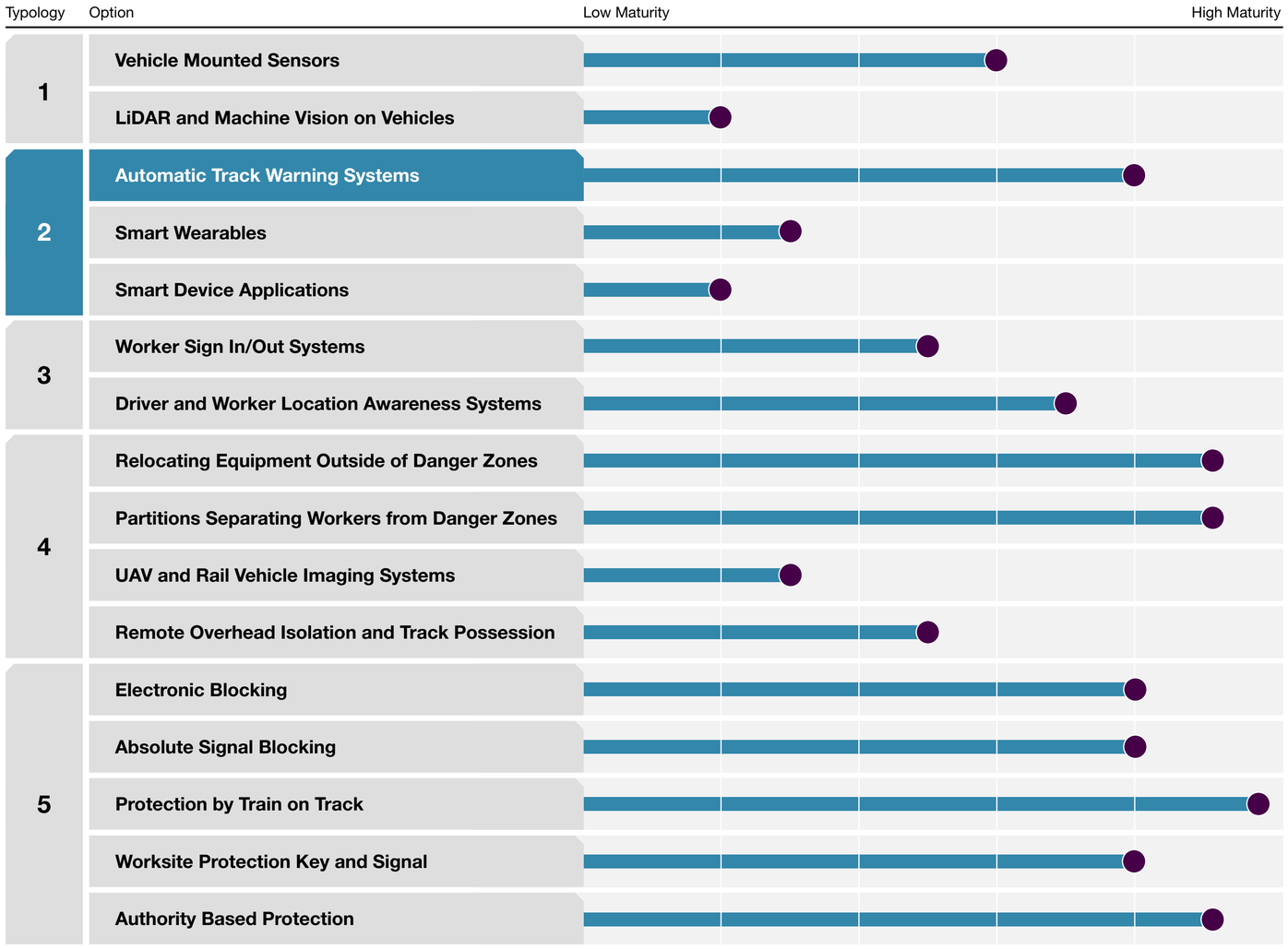

Automatic Track Warning Systems

Summary

Automatic track warning systems will often use train detection sensors positioned on or near the track. These sensors, when triggered, will signal to track workers through methods such as alarms, flashing lights and personally worn devices. These systems aim to provide prompt warnings to workers so they can safely leave the danger zone well before vehicles pass through. Advanced systems prioritise longer periods of time from warnings to the presence of the hazard, maintaining strong signals through tunnels and the capability for providing suitable protection for larger worksites.

Supplier Options

- Minimel 95 Series – Schweizer Electronic
- Autoprowa System – Zollner Technologies

Option Details

The Minimel 95 Series ATWS from Schweizer Electronics is a cable-based warning system that will warn track workers in the vicinity of the track of approaching trains. The movement of a train is detected by rail contact sensors that are connected to the Minimel 95 central unit. The central unit triggers a visual and audible warning in the vicinity of present workers. The departure of the train from the work site can be automatically recorded by additional rail contact sensors. This system is typically used on construction sites with spatial extensions of several hundred meters. Additional units allow the system to be used on much greater areas.

The Autoprowa ATWS from Zollner is designed to safely and reliably warn track workers of approaching trains. The system is capable of adjusting is volume level at each warning device automatically depending on detected surrounding noise levels. This ensures that the warning is optimally audible while creating minimal environmental noise pollution. There is the option for

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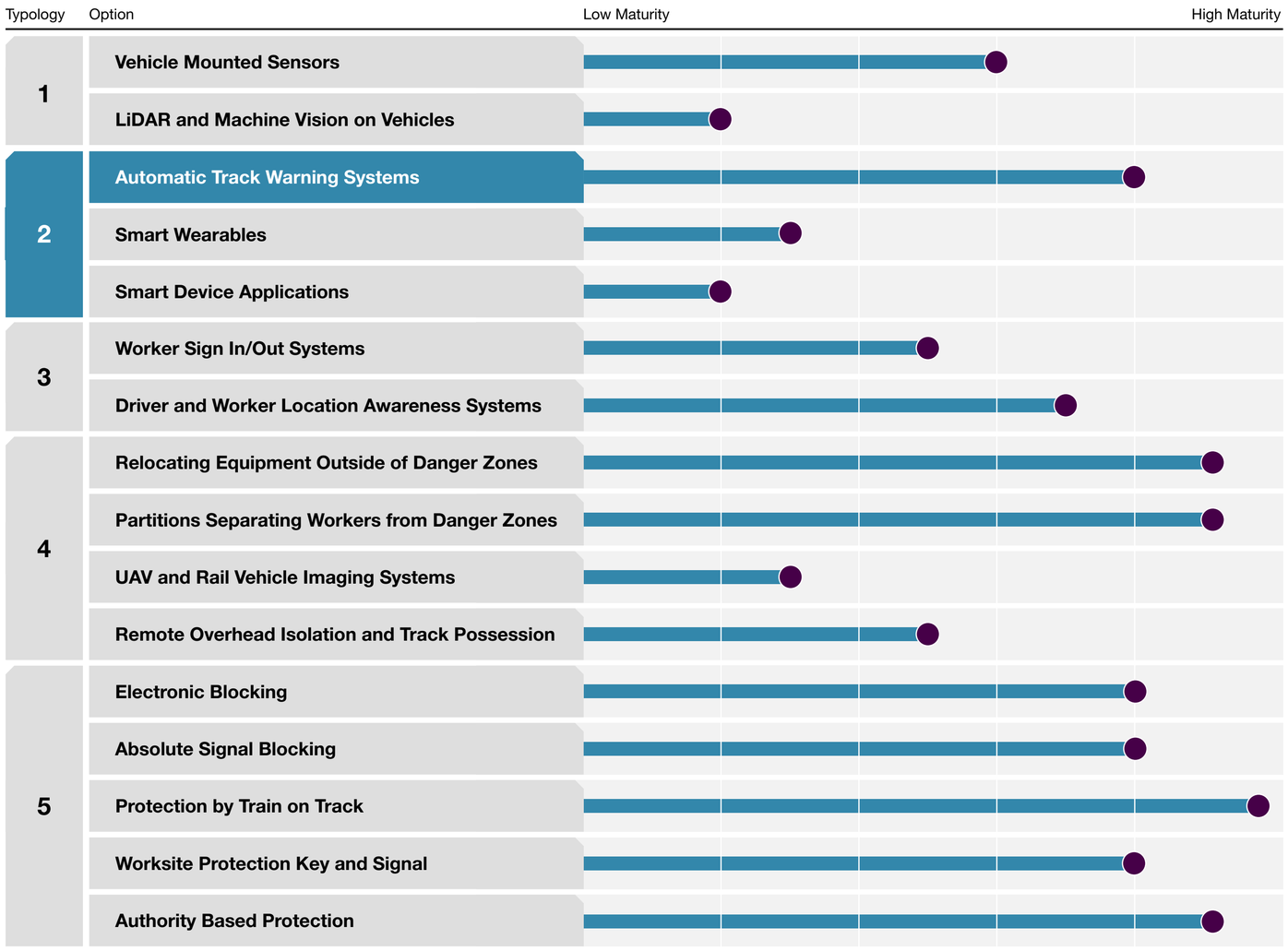

Automatic Track Warning Systems

the system to be hard wired (cable based) and / or radio signal based. Both of these options work the same way fundamentally. The system is controlled by a central unit which manages all warning devices. Depending on work site characteristics, the warning can be cancelled automatically, through strike out points, or manually by track workers.

Links to Sources

- Schweizer Electronic, Minimel 95 Series, Product Website, bit.ly/3cg46jP
- Zoellner technologies, Autoprowa System, Product Website, bit.ly/3rbWumF

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	Protection by Train on Track		
	Worksite Protection Key and Signal		
	Authority Based Protection		

Smart Wearables

Summary

Smart wearables such as helmets, vests, boots, and watches, may detect and or respond to approaching hazards and received signals. These wearables may alert the worker through coloured lights, sounds and/or vibrations. These alerts may trigger to warn of approaching hazards such as vehicles as well as warn workers when they have entered a danger zone when used alongside geo-fencing. Workers can be alerted to different types of hazards and different levels of threats through different coloured light or different sound alerts.

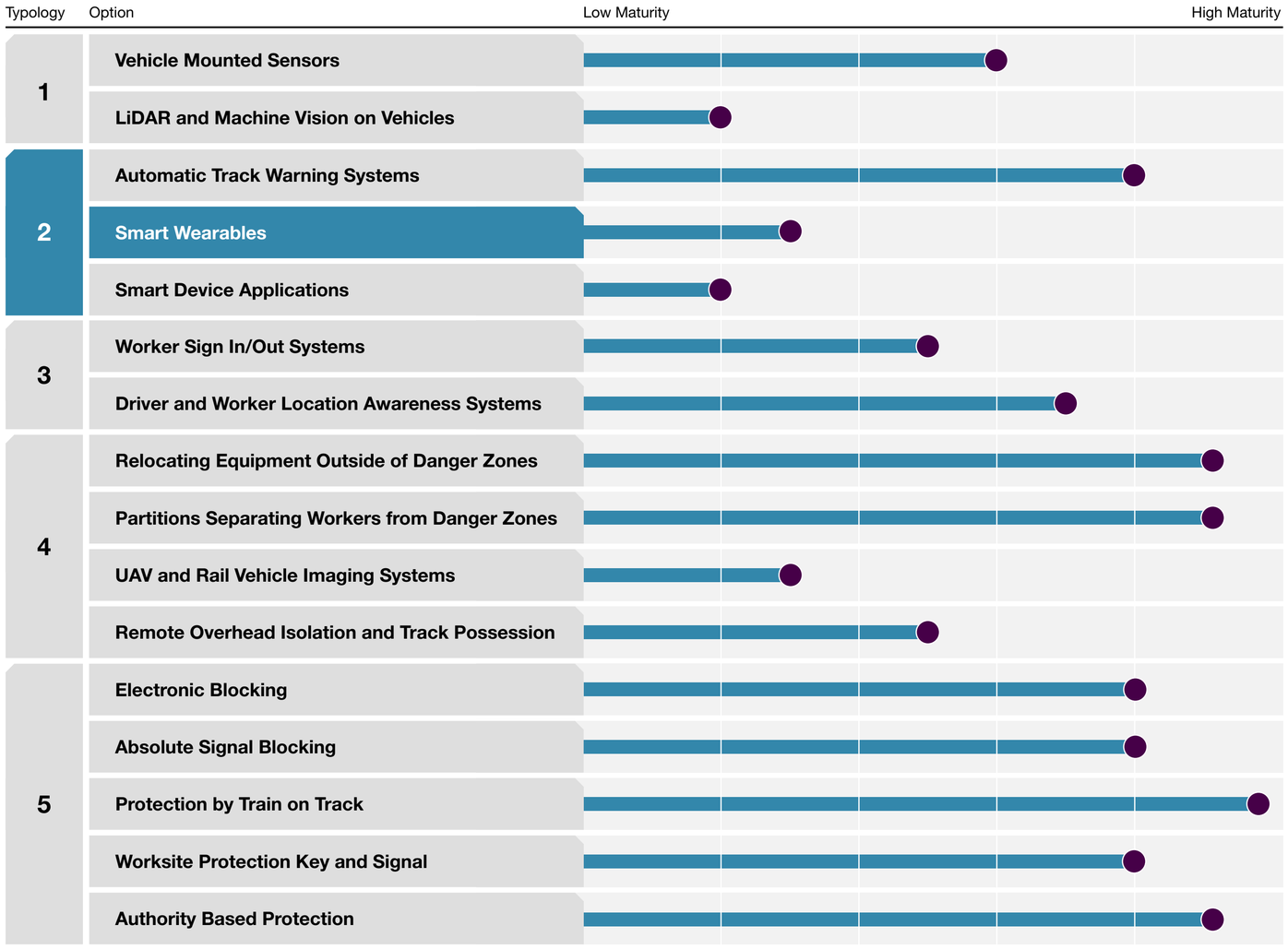
Supplier Options

- Embedded Active Visibility – Eleksen Technologies
- Smart Wearable - Siemens

Option Details

The Embedded Active Visibility system from Eleksen Technologies is the base line of three levels of wearable offerings designed to provide site worker safety. This system uses embedded garments such as industrial PPE vests and jackets. These wearables contain multi-colour LEDs that act as visual alerts. The smart features are powered by a rechargeable hub that can last for over 12 hours of use. The equipment can also be installed to existing PPE equipment. The more advanced versions of this system can deliver alerts from threats in close proximity as well as other environmental harms such as heat, noise, and vibration. The wearables include emergency SOS signals, audible and haptic alarms to communicate in high noise situations. Data can be collected from the wearables and analysed through a dashboard.

Options Table



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Smart Wearables

Siemens are developing a Smart Wearable device for use by track workers to warn of approaching trains. Train approaching a danger zone are detected by track mounted sensors. These sensors send a signal to the track worker's wearable device positioned on their wrist. This device warns workers through audio, LED visual and vibrations. Track workers can then safely leave the danger zone.

Links to Sources

- Eleksen Technologies, Embedded Active Visibility, Product Website, bit.ly/3rhUDNp
- Siemens, Smart Wearable, Product Article, sie.ag/39az0bA

Options Table

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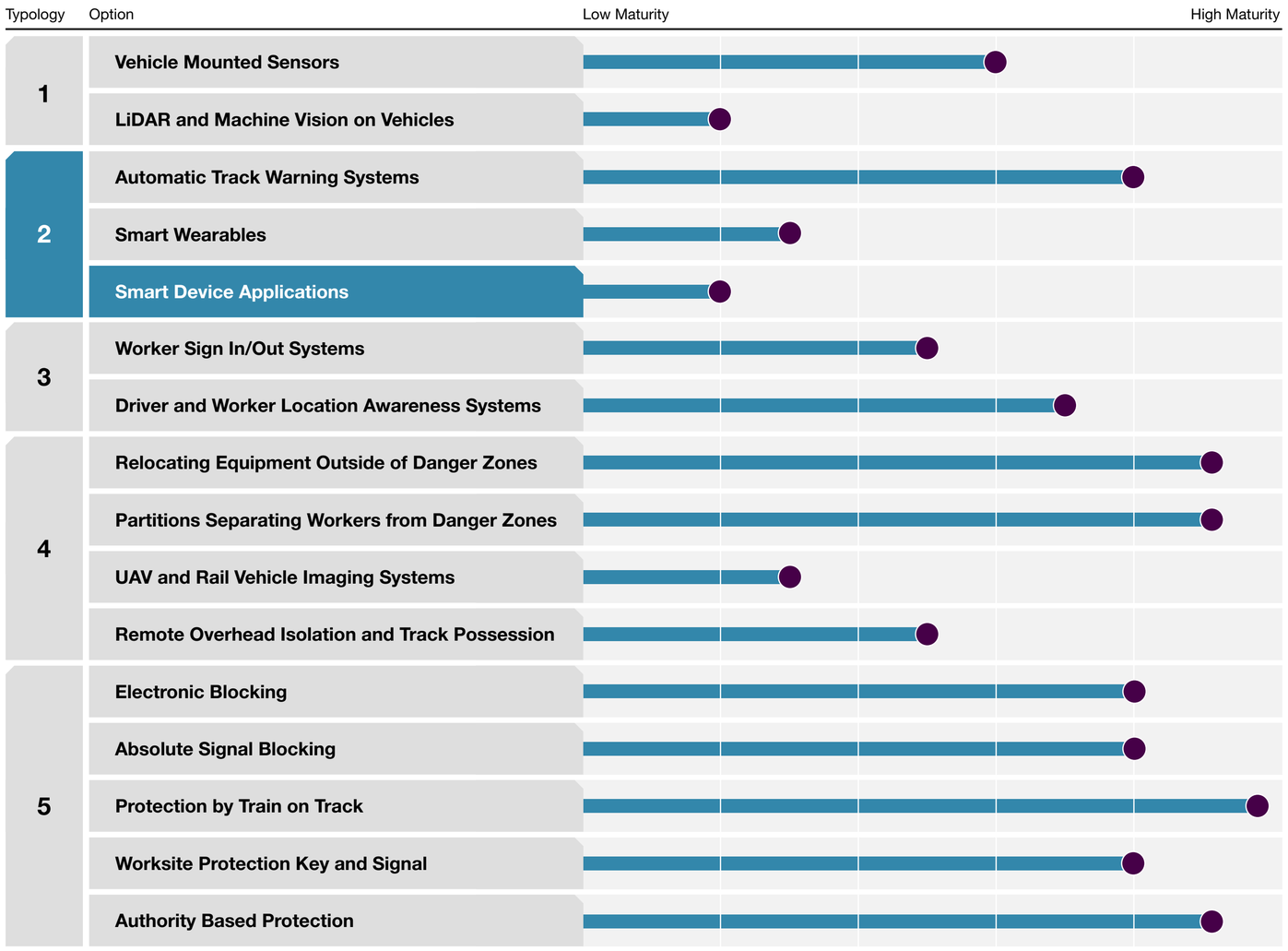


Smart Device Applications

Summary

Applications on smart devices carried by workers can be used to monitor their locations as well as send and receive alerts to the presence of danger. These applications are often linked to a dashboard or hub operated by a control centre. The control centre receives real-time information on the worker and can receive distress signals from the worker. Workers set parameters such as the site they are working in as well as they expected duration of their work at that site. These solutions are often cost effective as they can make use of existing smart phone systems.

Supplier Options

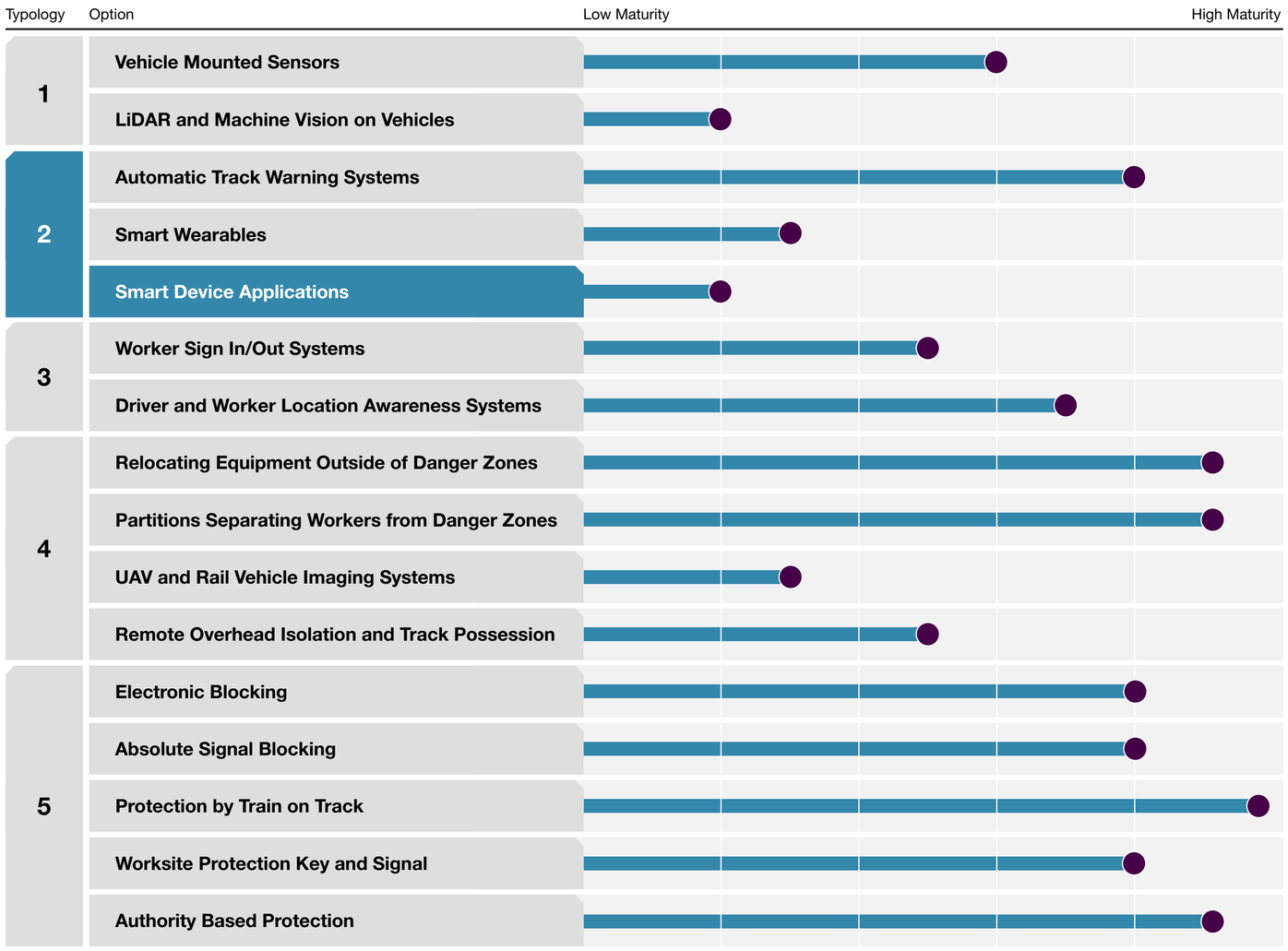
- StaySafe Lone Worker Application – StaySafe
- WorkSafe Guardian Application – WorkSafe Guardian

Option Details

The StaySafe Lone Worker Smart Device Application is targeted towards workers operating alone on work sites. The worker can set their location and duration for working on the site. Workers can end sessions they are currently running, extend the session or use the panic button to send a distress signal. This distress signal is received by the StaySafe hub where someone can contact the worker in distress and send assistance to their location.

The WorkSafe Guardian Smart Device Application allows workers to be monitored 24/7 from a control centre. Workers set a location and duration for working at a site, if the worker does not check-in before the timer expires or manually sends a distress signal, the control centre can quickly contact the worker and organise for assistance to be sent to their location. Emergency triggers can be done through on-screen buttons, voice or shaking the device.

Options Table



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Smart Device Applications

Links to Sources

- StaySafe, StaySafe Lone Worker Application, Product Website, bit.ly/2NMhaUR
- WorkSafe Guardian, WorkSafe Guardian Application, Product Website, bit.ly/3rhcq76

Options Table

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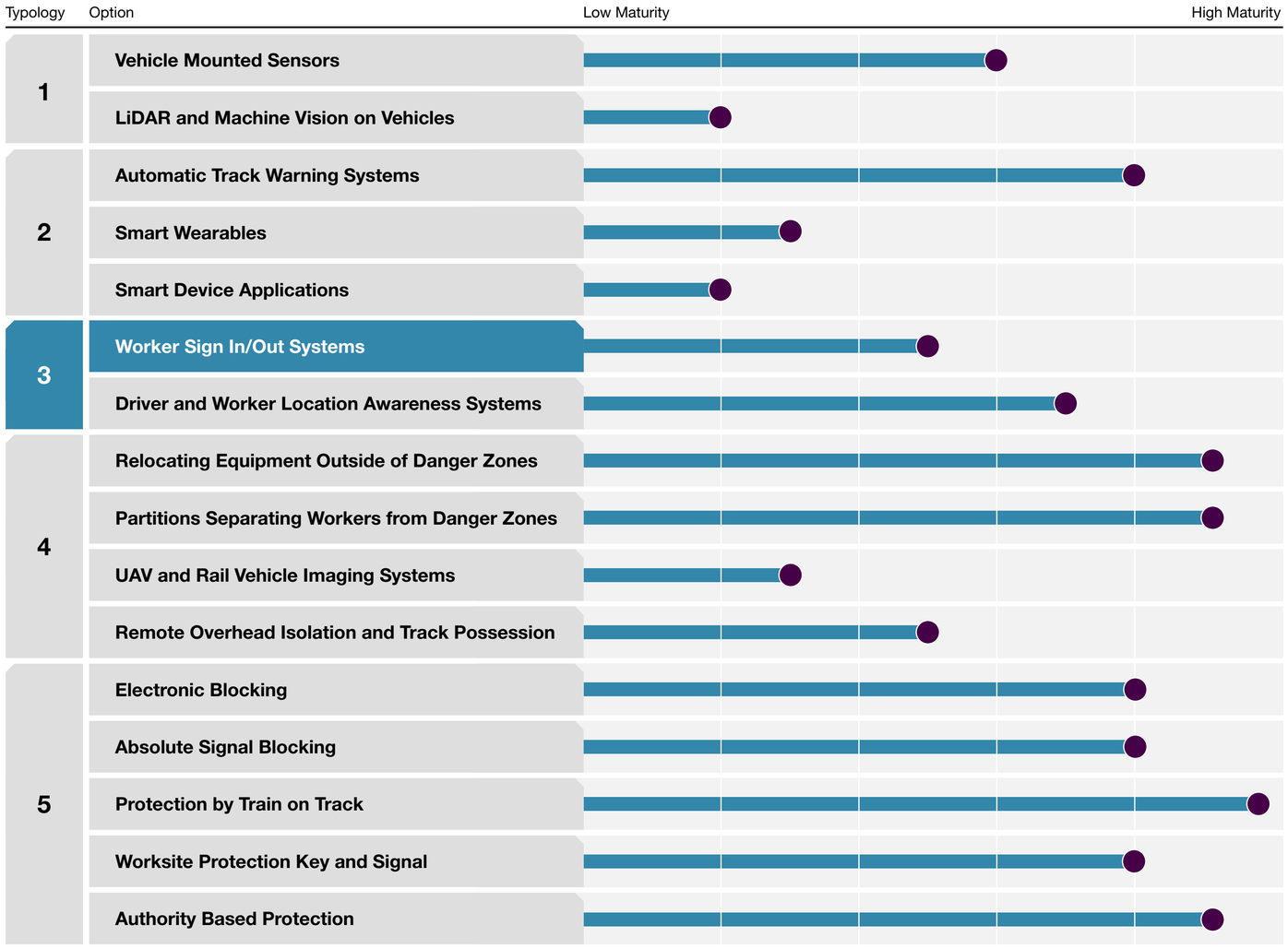

Worker Sign In/Out Systems

Summary

Worker sign in/out systems involve a check-in point for track workers to use when entering a danger zone. These systems (when registering that a worker has signed into a particular area) will signal to vehicle operators that they must adhere to speed restrictions or stop when approaching the site where a worker is present. These systems may additionally signal to workers when a vehicle is approaching, so they are prepared to be out of the way and are not caught by surprise. These systems can be permanent or temporary installed devices. Systems designed for use in temporary worksites may use trackside horns and lights as well as pre-installed devices on trains to warn both track workers and train crew to each other's presence.

Supplier options

- Track Safe – Bombardier

Option Details

The TrackSafe system from Bombardier has three functions. It provides warnings for track workers as the train approaches, it provides control over access to the right-of-way and keeps the real-time position of track workers. The system uses a wayside access unit, which workers use to sign in and out of areas on the rail line. That information goes back to the rail control. The tag in unit used by workers is also part of the protection system and records the equipment being used by the track worker. Warning lights are used to warn operators that they are approaching a track worker on the system.

Links to Sources

- Bombardier, TrackSafe, Product Article, bit.ly/3lLhG23

Options Table

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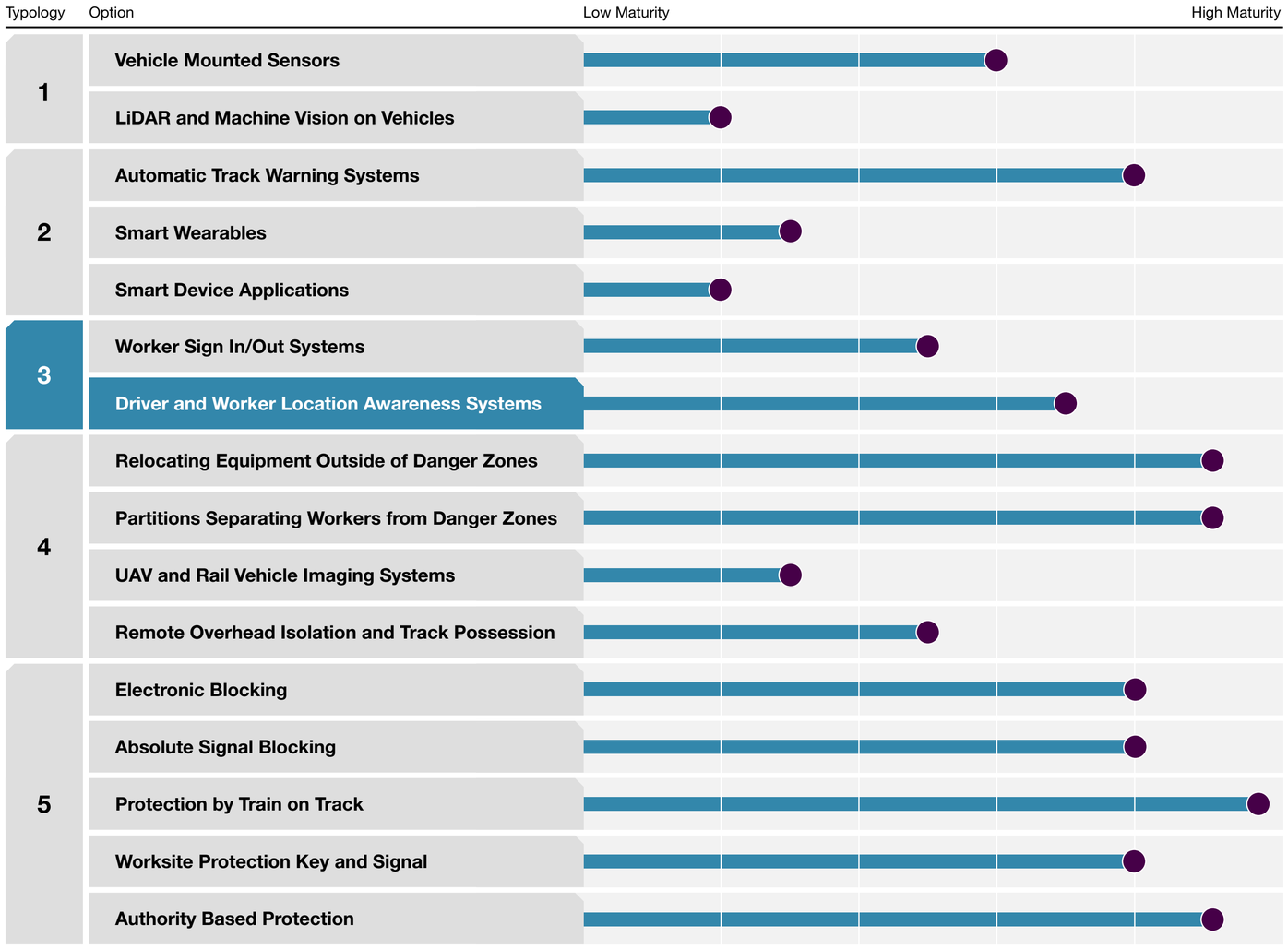


Driver and Worker Location Awareness Systems

Summary

Location awareness systems will often use permanently installed devices that will inform both track workers and vehicle operators to each other's locations in real-time. These systems may also incorporate the use of PADs or smart wearables to communicate information to track workers and monitor their positions more accurately. Location awareness systems will provide two-way communication to keep both parties informed of each other's location so appropriate actions can be taken to ensure worker safety.

Supplier Options

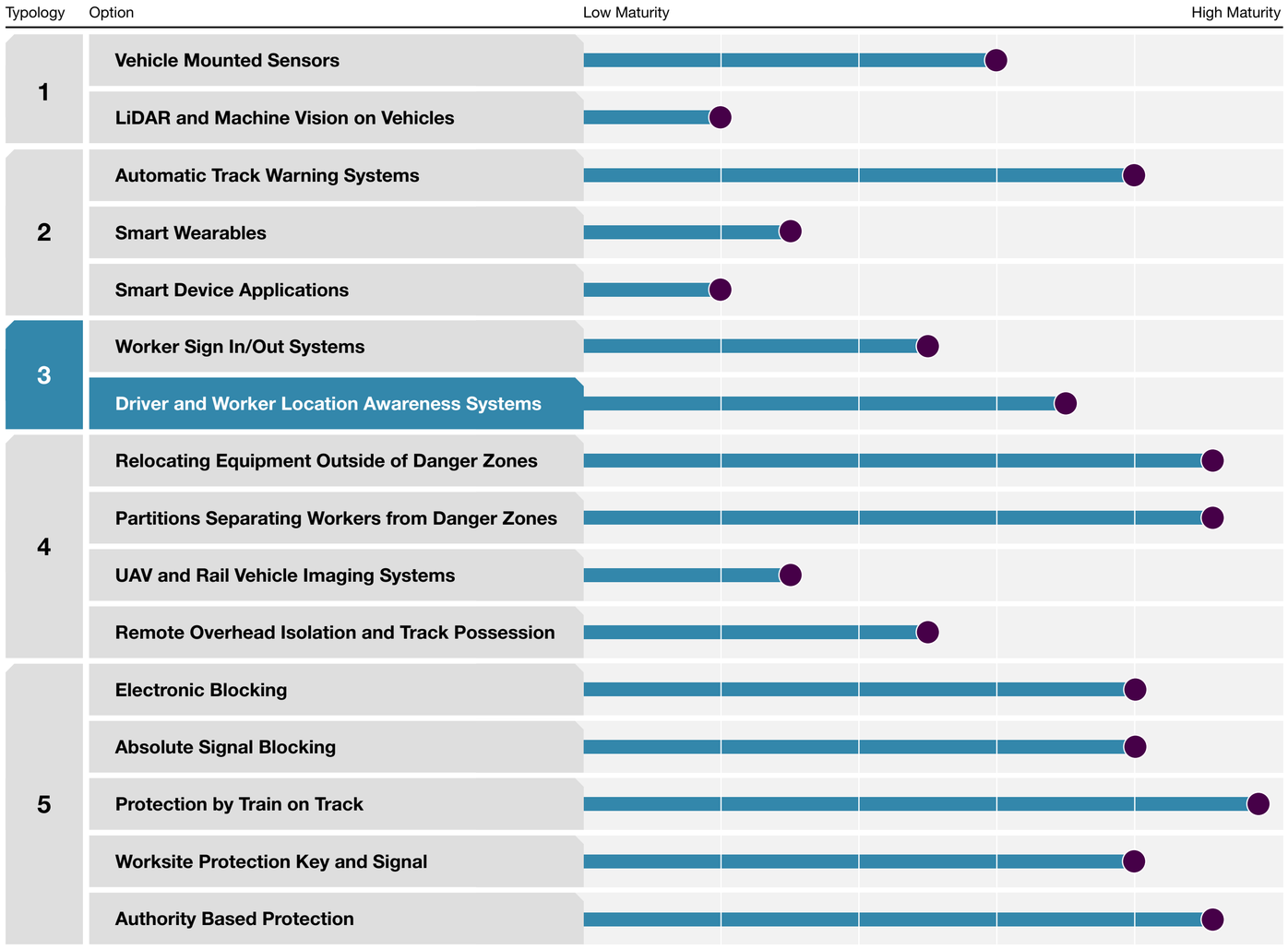
- Ranging Protracker System – Protran Technologies
- ProAccess System – Protran Technologies

Option Details

Protran Technology's Ranging Protracker worker protection system uses a vehicle-mounted device that transmits an alert to the personal alert device worn by the worker. This system provides a visual and audible advanced warning alert to the train operator of track workers ahead. A visual and audible advanced warning is also sent to the track workers warning of a train approaching the work zone. The system allows worker to acknowledge the alert back to the train operator confirming they are in a place of safety. The Ranging Protracker system warning alerts are configurable based on time or distance.

The ProAccess Advanced Warning System from Protran is designed to provide a secondary warning to mitigate all vehicle and track worker incidents. Visual alerts are provided to rail vehicles via the wayside ProAccess system. Visual and audible alerts are also sent to the track workers via a PAD. This PAD is activated when a train passes a wayside train detector sensor, warning the PAD wearer of an approaching vehicle to their location. The ProAccess system

Options Table



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Driver and Worker Location Awareness Systems

can also track worker entry/exit time, location, and worker movement along the rail line. This information is transmitted to the control centre in real time.

Links to Sources

- Protran Technologies, Ranging Protracker System, Product Website, bit.ly/2QpXQ0q
- Protran technologies, ProAccess System, Product Website, bit.ly/3tMDM6W

Options Table

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Relocating Equipment Outside of Danger Zones

Summary

Relocating equipment outside of the danger zone is not always possible, but where it is, some of the considerations are; alternate spatial provisions, feasibility of relocation, relocating of associated services such as power. Negative ramifications of relocation may include; less than ideal work processes, introduced hazards, risk to workers implementing the relocation, and costs.
An alternative to relocating equipment is introducing or retrofitting of remote control or monitoring which eliminates or reduces time in the danger zone.

Examples of this include:

- Moving overhead wiring switches to safe zone adjacent to tracks and preferring safe locations for new installations.
- Providing remote monitoring of signalling systems to detect faults, reducing the onsite workload.
- Providing remote monitoring of points systems to detect faults, reducing the onsite workload.

Supplier Options

This option has no specific suppliers for equipment. It is facilitated by the design and installation of track equipment.

Options Table

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Partitions Separating Workers from Danger Zones

Summary

Partitions and fall arrest systems act as barriers between track workers and danger zones reducing the risk of accidents and injuries significantly. This option is comparatively simple to other solutions and is easily adapted and installed into existing track work areas. These systems can be temporarily installed systems or fixed. This system also can provide visual barriers with the use of bright and reflective materials that are highly visible to workers and vehicle operators. These systems are often developed with the rigidity to withstand the lateral force of several people falling directly onto the barrier.

Supplier Options

- Trackside Safety Barriers – Safetrax
- Tracksafe Barrier – Goldschmidt

Option Details

The Trackside Safety Barriers from Safetrax is a temporary handrail system that is designed to be quickly assembled for a worksite where workers are near live tracks. This system does not require any excavation or ballast disturbance for its installation. The frame of the barrier is made from fibre glass which is safer than steel in an electrified rail environment. The vertical post height can also be adjusted to suit its area of installation.

The Tracksafe Barrier from Goldschmidt is a temporary solution that attached to the tracks with magnets. This magnet system for attachment makes this solution fast to install and remove. The system is easy to operate and store. This system also has no impact on the ballast and requires no excavation.

Options Table

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Partitions Separating Workers from Danger Zones

Links to Sources

- Safetrax, Trackside Safety Barriers, Product Website, bit.ly/3f7m1v5
- Goldschmidt, Tracksafe Barrier, Product Website, bit.ly/3faIck6

Options Table

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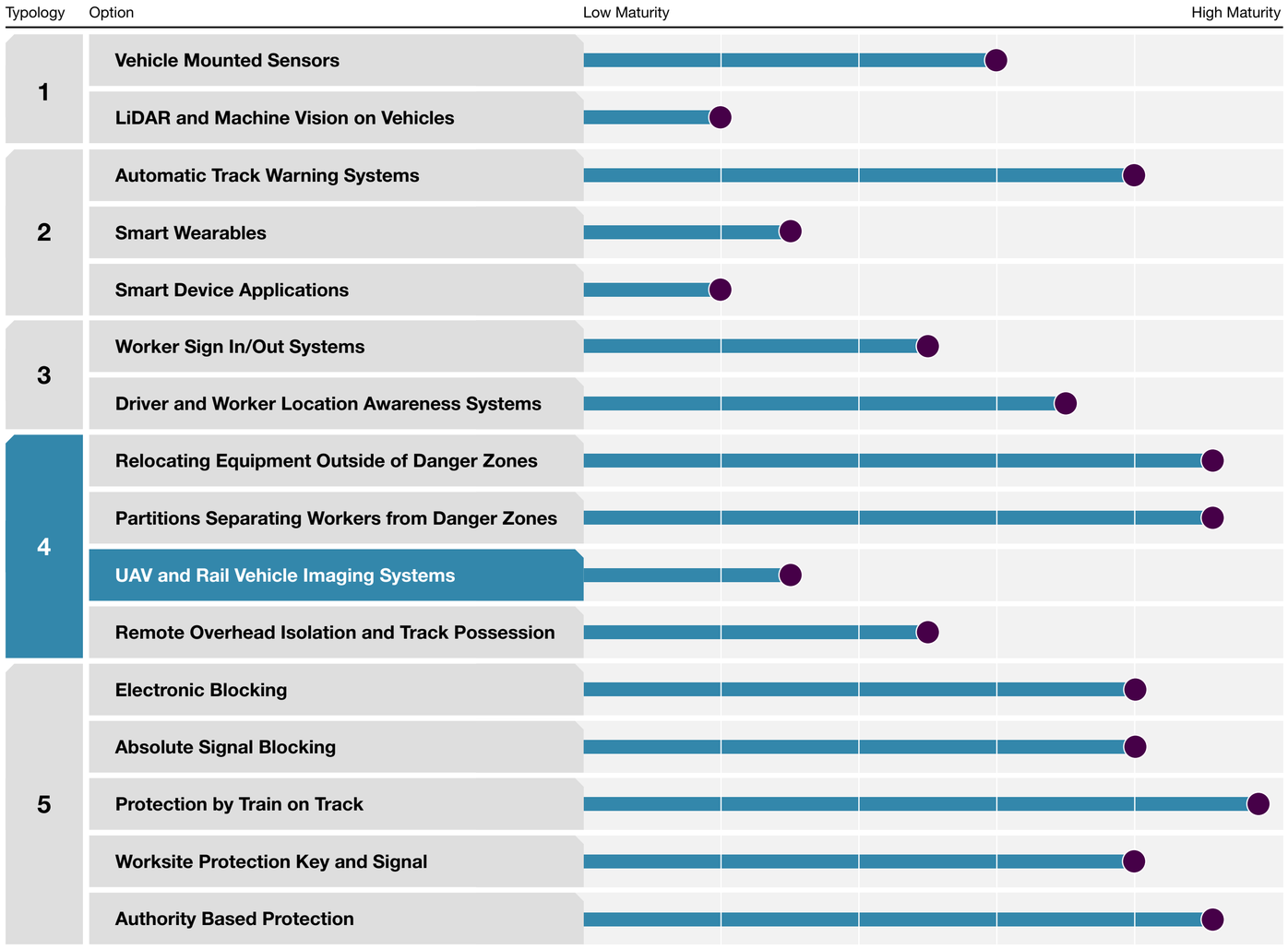
Click or tap the < > arrows to read more about each option.



UAV and Rail Vehicle Imaging Systems

Summary

Rail imaging systems provide an automated solution for monitoring track conditions as well as the condition of workers, vehicles, and equipment on tracks. Conducting this imaging using drones can provide early warning, situation assessment and decision support applications. Drone capabilities are being evaluated in railway monitoring frameworks including structural faults and security threat detection as well as investigation on the consequences of natural hazards and terror attacks. Conducting this imaging using rail vehicle imaging system allows railways to automatically collect continuous images of the roadbed from a moving platform. The ability to store these geo-referenced images allows for any area in question to be evaluated from outside the danger zone. Automated algorithms and processing software can accompany this technology for comprehensive analysis.

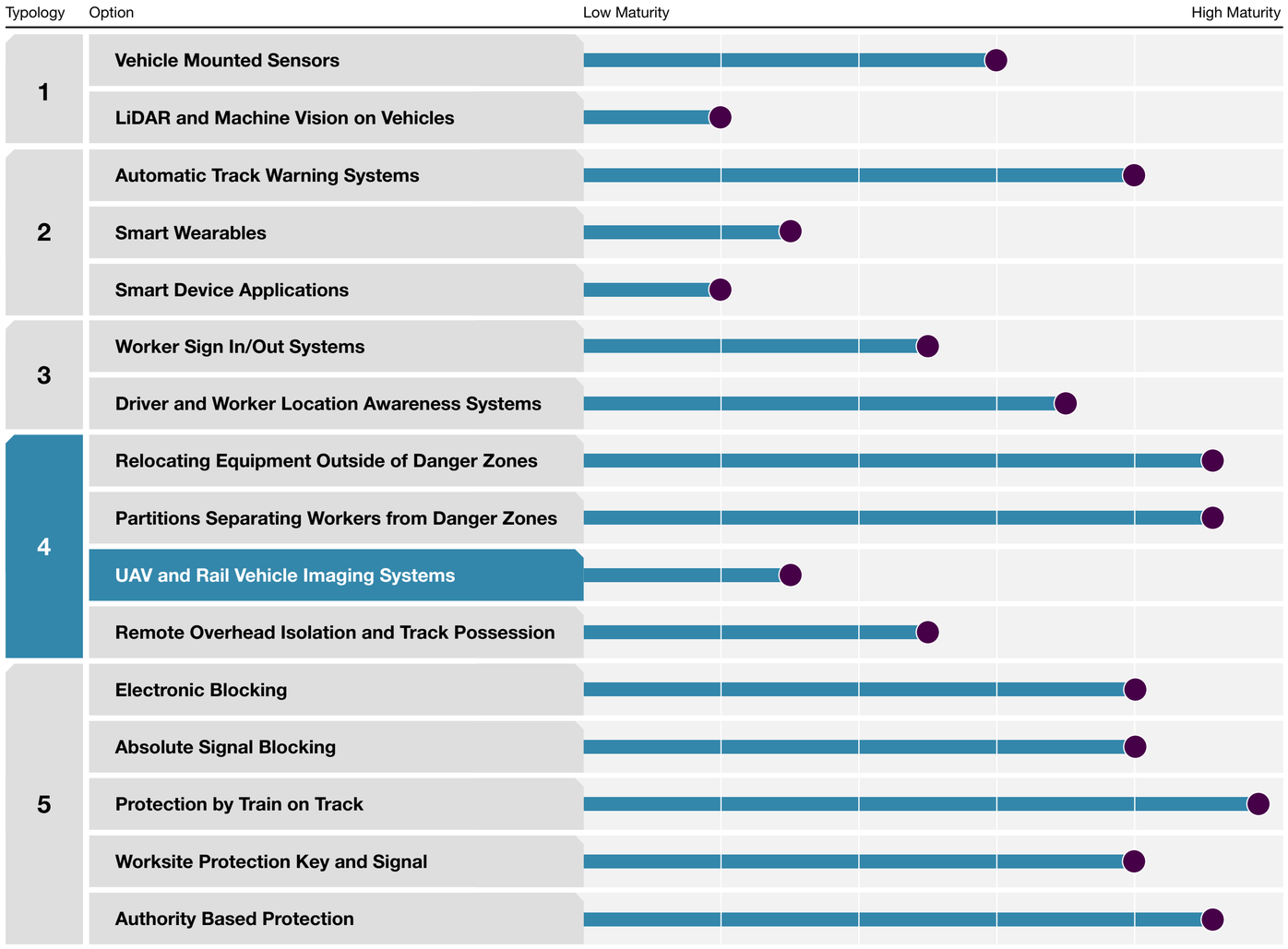
Supplier Options

- Rail Inspector – Ardenna
- Rail Surface Imaging System – Ensco
- Trackside Robot – ACRI

Option Details

The Rail Inspector solution from Ardenna is designed to use machine learning algorithms to automatically process and analyse visual data captured from aerial surveys of tracks. This includes the identification and measurement of railway features, classifying anomalies and assessing the health of track and rail bed infrastructure. Ardenna provides details on their website for which drone providers are supported by their software. This includes their own Ardenna M600 drone as well as some drones from other providers. This solution is priced based on the length of track to be analysed, the number of sub-segments to process and the frequency of processing required.

Options Table



This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

UAV and Rail Vehicle Imaging Systems

The Rail Surface Imaging System from Ensco uses line scan imaging methods to collect and record continuous images of rail surface from a vehicle moving along the track. The system allows for the surveying of rail conditions in high resolution. The system can identify rolling contact fatigue, shelling, spalling, squat surface cracking, engine burns and broken rails. Other systems from this provider cover imaging from the perspective of the driver and overhead wires. Imaging solutions can also assess tunnel walls and capture thermal imagery.

ACRI is conducting a project to explore a proof-of-concept of a remotely deployed track isolation and protection system. This device would be deployed from a safe space within the rail corridor, navigate through the danger zone and isolate or protect an area of rail without human intervention. Additionally, this pilot study will develop transferable technology, enabling future technologies such as autonomous inspection. This development has the prospect of improving the long-term efficiency of Australian rail operations.

Links to Sources

- Ardenna, Rail Inspector, Product Website, bit.ly/3lIE5Na
- Ensco, Rail Surface Imaging System, Product Website, bit.ly/2PjWa8g
- ACRI, Trackside Robot, Project Website, bit.ly/3mdj51l

Options Table

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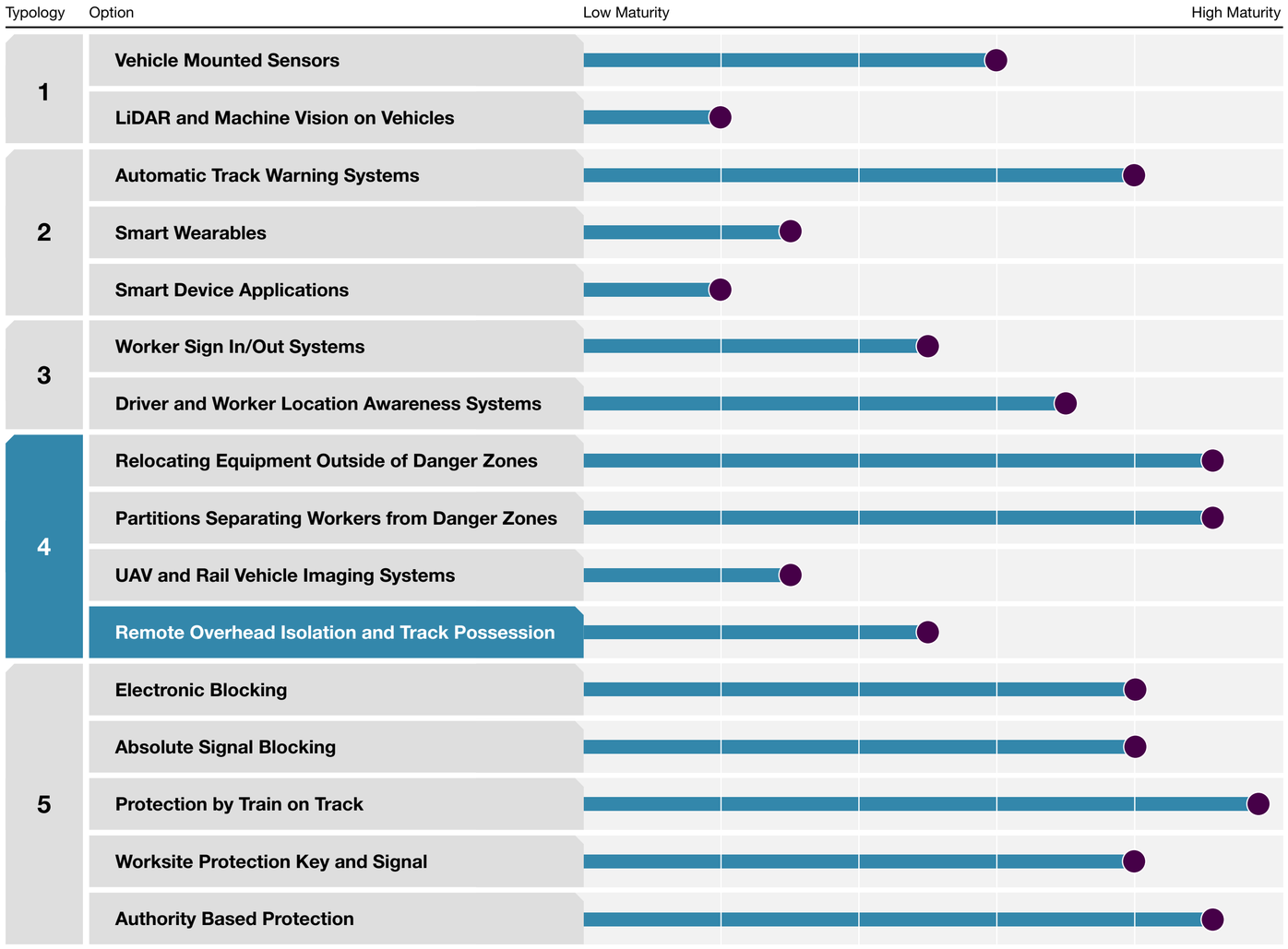


Remote Overhead Isolation and Track Possession

Summary

The equipment for the isolation of traction power is often located trackside, in or near to the danger zone. Traditionally, authorised operators have attended site to perform and secure switching and rail connections at both the beginning and end of outages. Some equipment may be able to be modified for remote operation but removing the need entirely for staff attendance requires a complete solution including confirmation of rail connection, and application of danger tags.

Remotely activated solutions for track posession aim to minimise the amount of time track workers need to be on track for the purpose of taking or giving possession. These systems involved an installed device on tracks that can be remotely activaed to remove the need for manual posession or line blocks.

Supplier Options

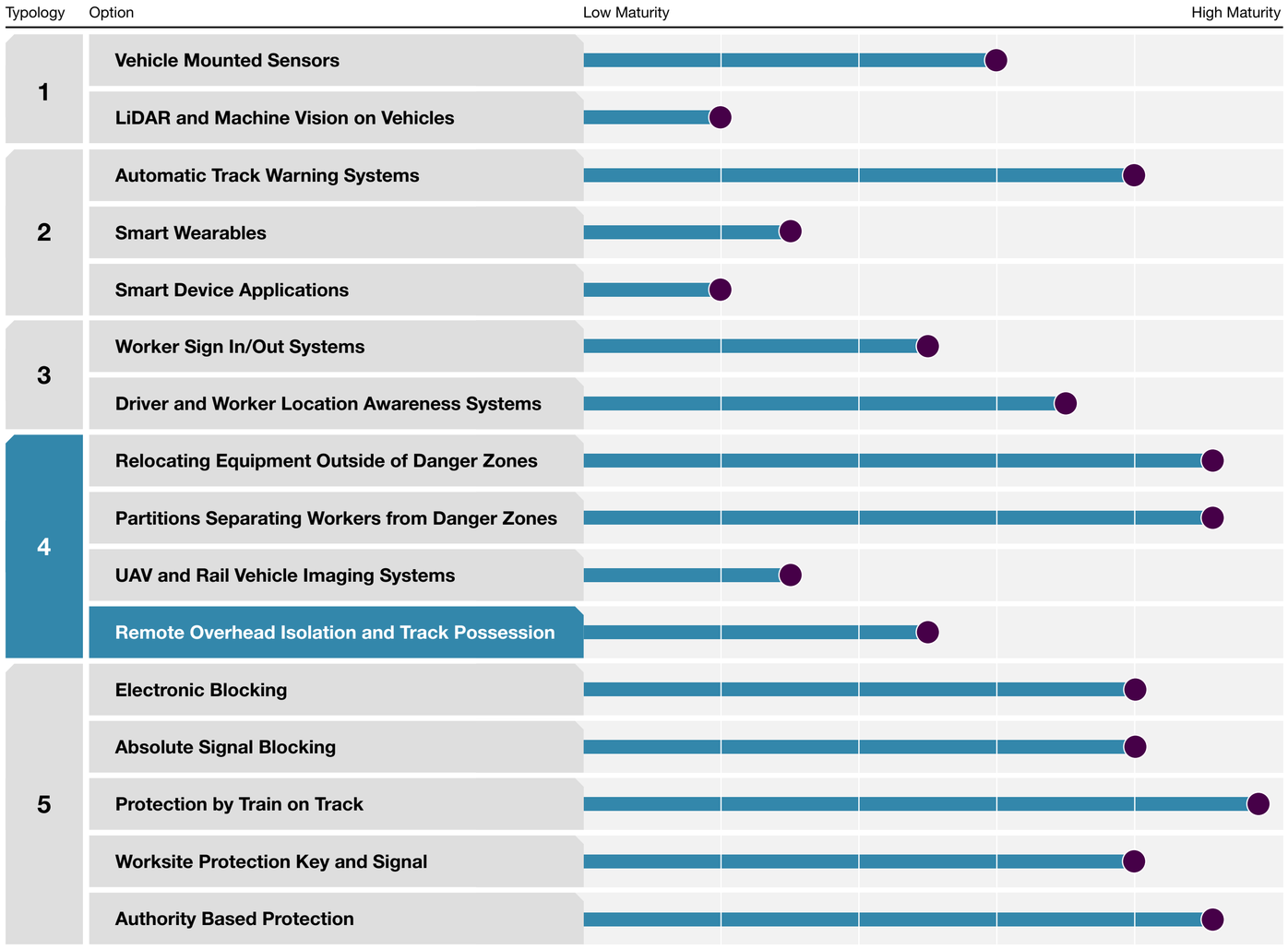
- Infraco
- Australian Rail Technology
- ZKL 3000 RC - Structon

Option Details

The traction power isolation solution from Infraco is currently under development. The system involves four components: Switch, motor drive unit, electronic danger tag and feeder circuit status evaluator.

Australian Rail Technology does not currently have an option available, but has the capability to develop one.

Options Table



This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

Remote Overhead Isolation and Track Possession

The ZKL 3000 RC system from Strukton is designed to re-move the need for workers to manually acquire track pos-session after initial installation. Once installed, sections of track separated by each unit can be switched on and off within sectors with a single button. This solution is also de-signed to be more efficient than other methods, by removing the need to travel and manually set up possession blocks, emissions generated travelling to points on the track will be negated as well as saved time spent by the workers.

Links to Sources

- Infraco, Company Website, bit.ly/3lMkoE9
- Australian Rail Technology, Company Website, bit.ly/3siJxc3
- Structon, ZKL 3000 RC, Product Website, bit.ly/3rBLkrL

Options Table

This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

Electronic Blocking

Summary

Automatic Train Protection (ATP) and Train Protection Warning Systems (TPWS) are electronic blocking methods that can automatically prevent rail vehicles entering a work site. When these systems are enabled, they apply the train brakes if the signal/transmitter is passed at stop or if the speed is greater than permitted. This can be utilised to prevent a train passing a signal prior to entry to a worksite. While this is usually associated with a signal, it could be deployed for a worksite, although this would require installation of equipment between the tracks. This option requires every train (or every train that it is to act upon) to be fitted with the technology.

Supplier Options

- TPWS and ATP – Thales Group
- TPWS and Advanced Warning System – Mors Smitt

Option Details

The TPWS and ATP systems from Thales Group are designed to reduce the likelihood and minimise the consequences of a signal being passed at danger or a train exceeding a permissible speed. This could be at a permanent speed restriction area or on approach to a buffer stop. These systems provide the train protection capability of a train stop and uses over speed sensors in combination with automatic warning systems. The system requires various equipment including; a control unit, receivers, acknowledgement button and alarm indicator unit.

The TPWS from Mors Smitt combines an automatic warning system to improve safety for track workers. The system is comprised of an overspeed sensor and train stop system. The overspeed sensor automatically applies the vehicles emergency brakes when exceeding the posted speed over a transmitter. The train stop system automatically applies the vehicles emergency brakes when passing an active transmitter installed at stop signal. The automatic warning system gives

Options Table

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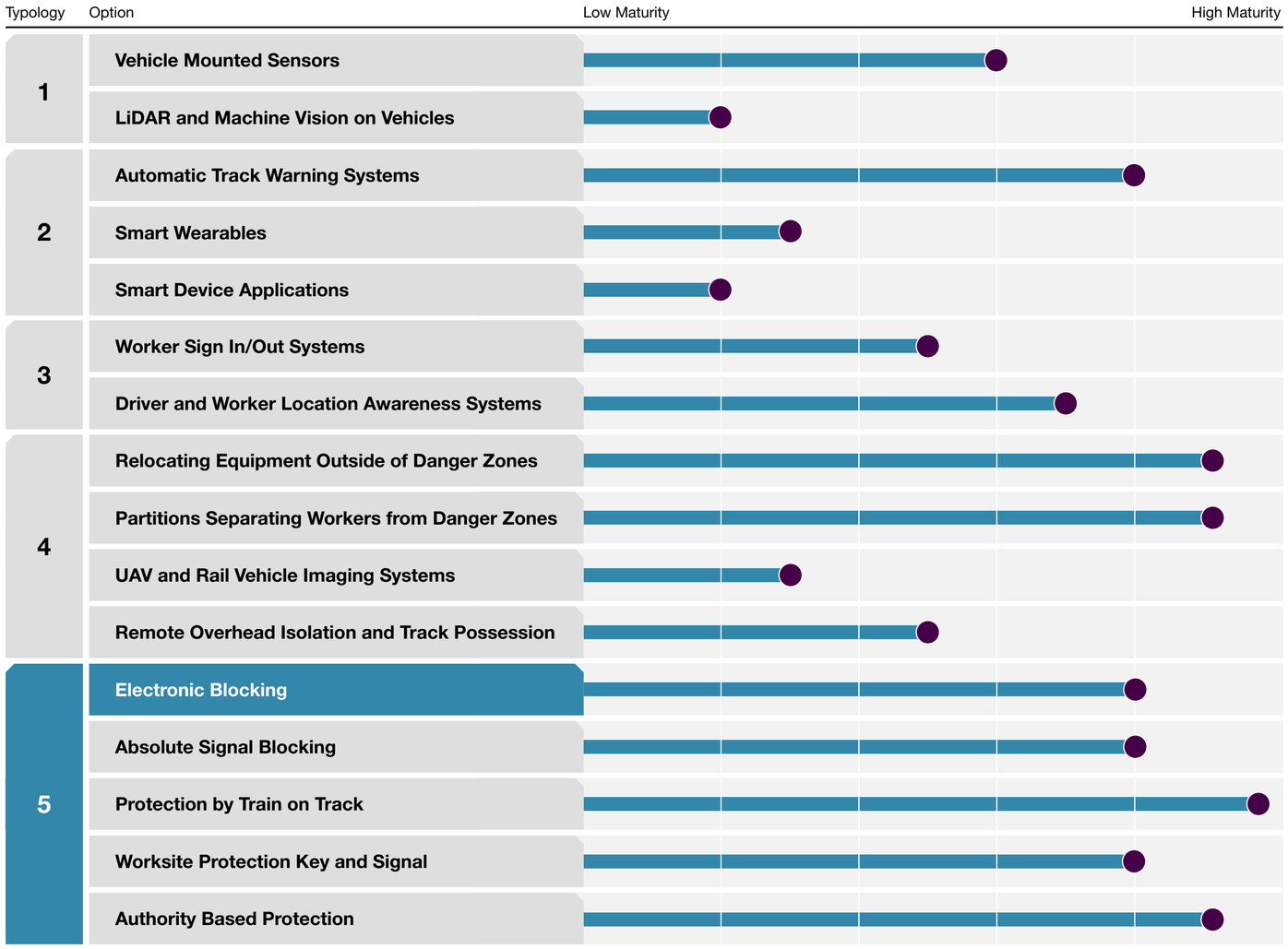

Electronic Blocking

train drivers an audible and visual indication of the status of the signal ahead. If the driver does not acknowledge the signal the automatic warning system automatically applies the vehicles emergency brakes.

Links to Sources

- Thales Group, TPWS and ATP, Product Website, bit.ly/39772gY
- Mors Smitt, TPWS and Advanced Warning System, Product Website, bit.ly/3fcJY42

Options Table

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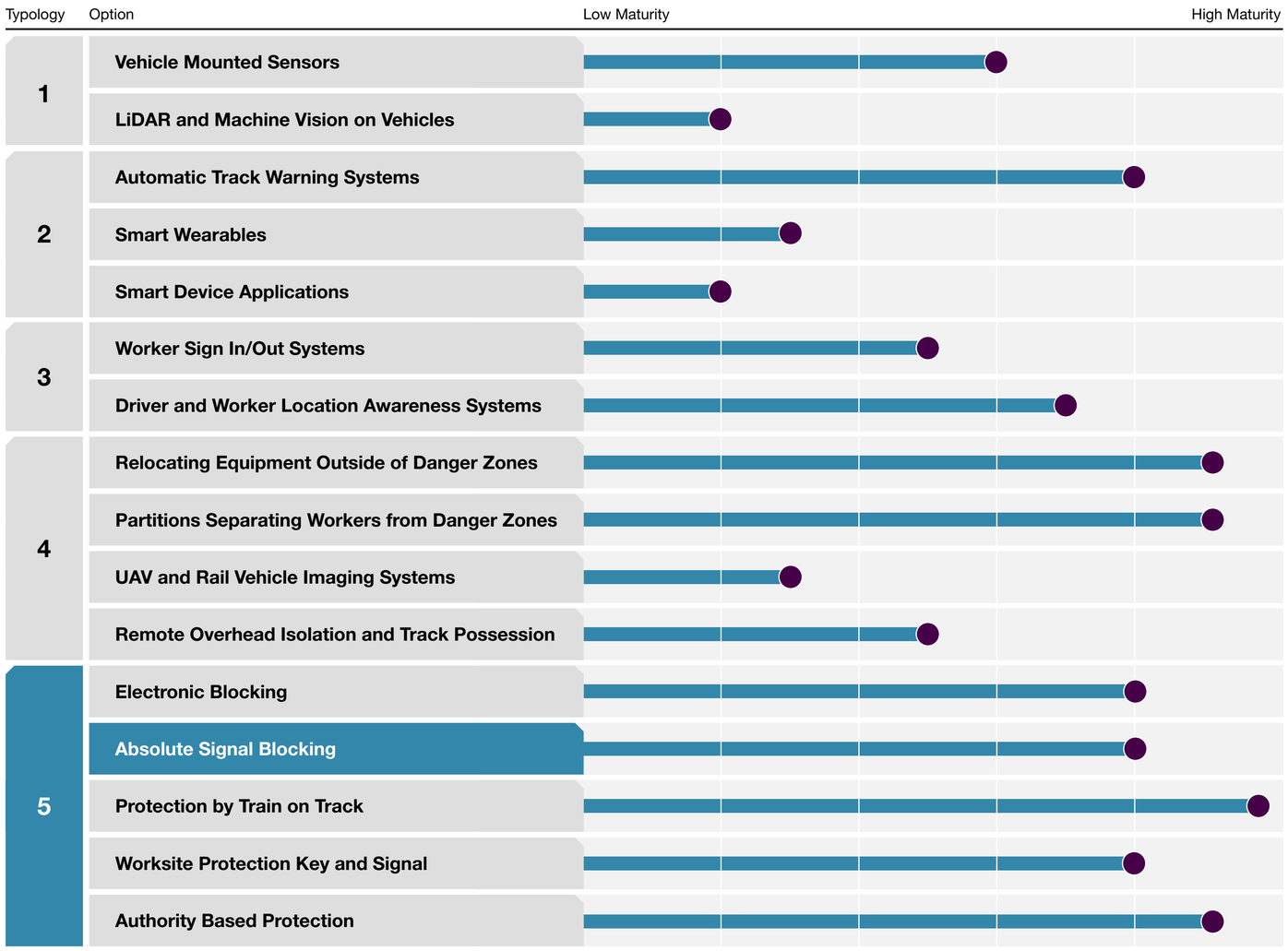


Absolute Signal Blocking

Summary

Absolute Signal Blocking systems controls trains using trackside signals, limiting one train per track ‘block’. To restrict train movement into a worksite, the system changes the signal aspect (to stop), and in some cases inserts a clip to secure the rail in the desired position.

In some railway systems, the system of signals is physically supported by the use of trip valves on trains, and train stop arms on signals. While a signal is at Stop, the arm is raised, tripping the trip valve on any train that passes. This applies the train brakes. An alternative to setting an approach signal to red would be to install a ‘trip cock’ on the approach to the worksite, which would apply brakes if passed. This protection requires all trains to be fitted with the trip valve, and the distance must take into account stopping distance.

On high speed lines, it is unreasonable or impractical to expect the driver to read the trackside signal at speed. On these lines, cab signalling can be used as an alternative, where signalling information is transmitted through the rails and displayed to the driver in the cab.

Supplier Options

This option does not require the implementation of a specific system or technology from a provider. The option involves procedural implementation, with the use of existing components such as signals, points, rail clips. A signaller or signal electrician can implement in accordance with appropriate procedures.

With signalling systems that are controlled electronically, it is feasible for a signal block to be placed by the worksite controller to directly manipulate the signals and provide confirmation of the block.

Options Table

This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

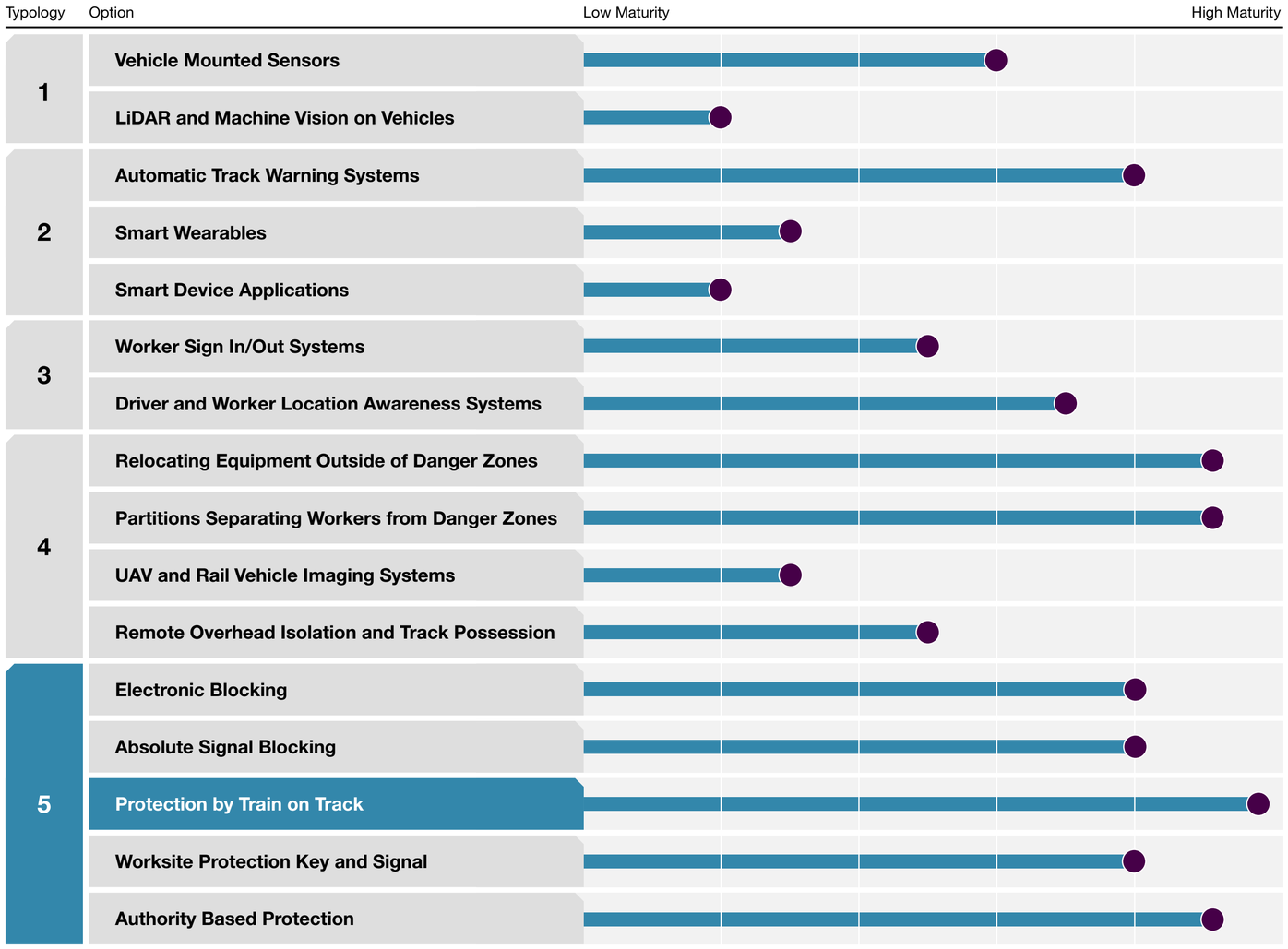
Typology	Option	Low Maturity — High Maturity
1	Vehicle Mounted Sensors	
	LiDAR and Machine Vision on Vehicles	
2	Automatic Track Warning Systems	
	Smart Wearables	
	Smart Device Applications	
3	Worker Sign In/Out Systems	
	Driver and Worker Location Awareness Systems	
4	Relocating Equipment Outside of Danger Zones	
	Partitions Separating Workers from Danger Zones	
	UAV and Rail Vehicle Imaging Systems	
	Remote Overhead Isolation and Track Possession	
5	Electronic Blocking	
	Absolute Signal Blocking	
	Protection by Train on Track	
	Worksite Protection Key and Signal	
	Authority Based Protection	

Absolute Signal Blocking

Option Details

There is no specific equipment required. The barriers and cost for implementation are the existing signalling system or upgrades required for the signalling system.

Options Table



This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

Protection by Train on Track

Summary

A train can be stopped before a worksite, and if it remains in this position, it will prevent other trains entering the worksite. This must be implemented on each track and both ends of each track if bi-directional running. This method only works in track circuited areas, not in axle counting implementations of signalling.

Supplier Options

- Procedural implementation, with the use of existing trains.

Options Table

This section is interactive.

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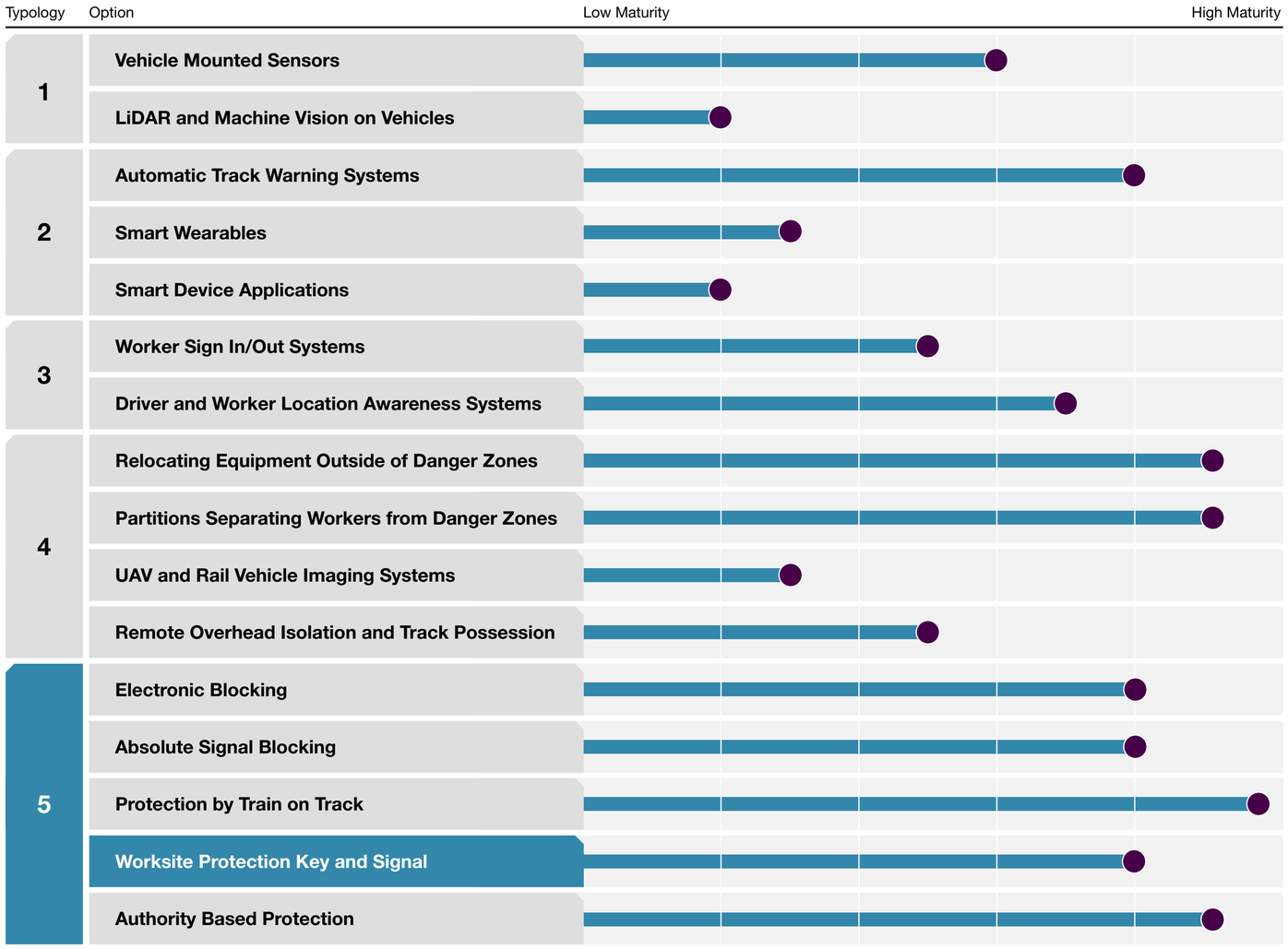


Worksite Protection Key and Signal

Summary

Fixed Wayside signals may include a key, which when removed sets and maintains the signal at stop, and may also impact preceding signals. An authorised worksite supervisor may, when permitted, remove the key from the approach signal(s), therefore ensuring no trains enter the worksite. This option relies on the manipulation of a signal to keep it at Stop. This functionality may be provided at time of acquisition of signalling equipment or may be retrofitted at a later time.

Supplier Options

- Signalling Equipment – Hitachi

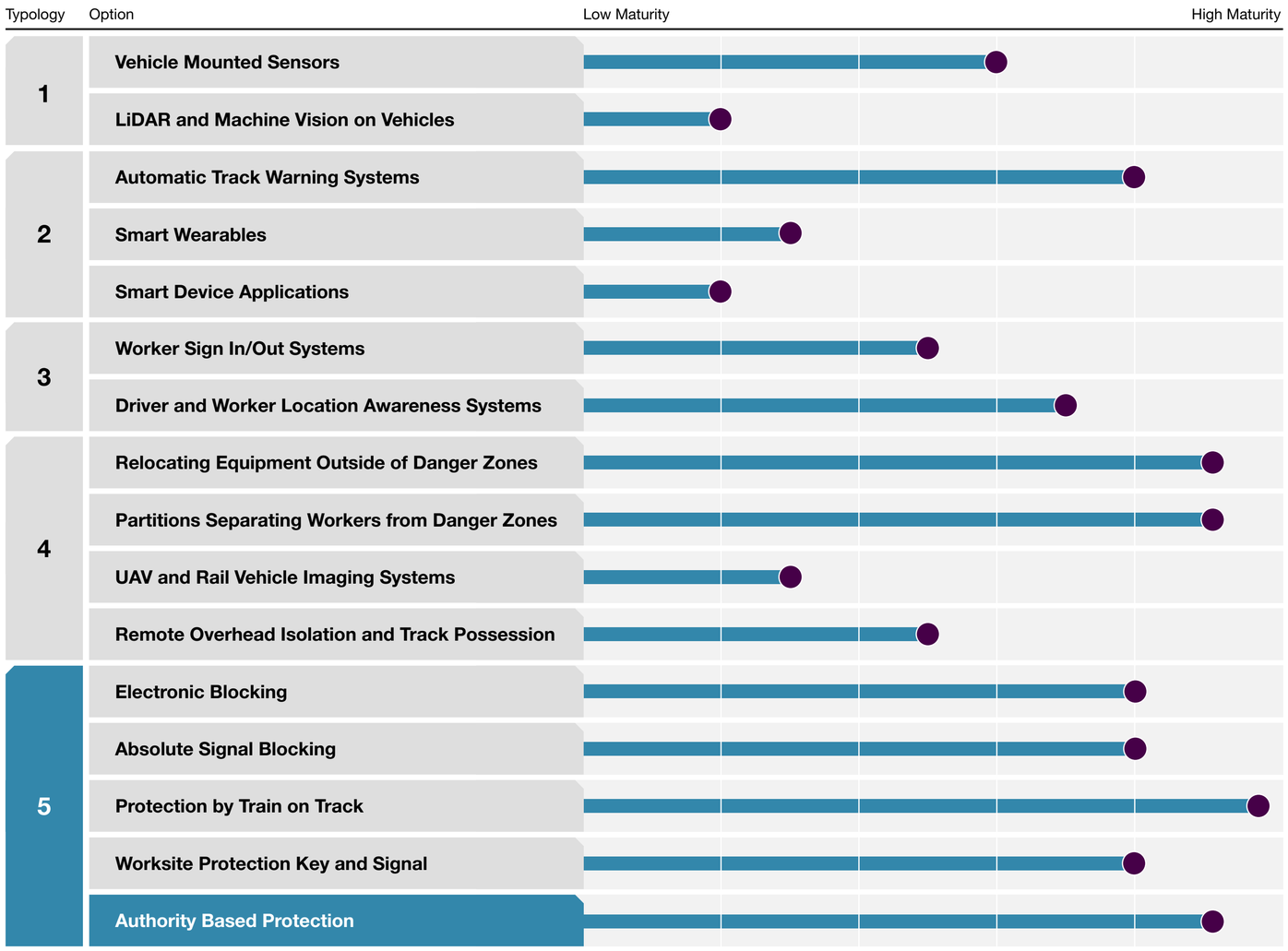
Option Details

This signalling equipment from Hitachi contains common wayside and trackside signalling components and products for a typical rail system. These may be sold as individual components to an existing rail operation, or comprehensively for a new system.

Supplier Options

- Hitachi, Signalling Equipment, Product Website, bit.ly/3rh81RU

Options Table



This section is interactive.

Click or tap the optins or categories on the left to jump to that option or category.

Click or tap the < > arrows to read more about each option.

Authority Based Protection

Summary

Procedural activities designate an area from which (running) trains are excluded for the purposes of work activities in the area. They are implemented differently in each jurisdiction, but have commonality in terms of planned/unplanned or emergency triggers, and extent of area. They are controlled by an authorised officer. Work vehicles are often permitted in these areas, and the separation of these work vehicles and workers is necessary by other methods.

Supplier Options

Existing procedural system(s). Trains are restricted by an authority from entering certain tracks during specified times. This is implemented through timetabling, and train movement control.

Literature Scan

Following the establishment of our research direction in the project inception meeting, the Arup team conducted a thorough literature review with the support of its library team. This section is a summary of the key findings from what was explored in this review. A full copy of the literature review can be accessed on the ACRI website.

The review established a baseline of knowledge on safety in the rail sector broadly as well as TWS options and their use on rail networks. By sector, transport is one of the highest in the proportion of fatalities of workers. In 2018, transport, postal and warehousing accounted for over 25% of worker fatalities. Industry is concerned about any serious injury or fatality occuring on a railway. The implementation of additional measures to improve safety will be of great benefit to the rail sector in Australia.

The review aimed to broadly define the different types of TWS options that could be used to differentiate the ways that these options provided protection to workers. Five typologies were defined which capture the options explored in this study. These typologies are:

1. Vehicle installed sensors and devices that give warnings to train crew.

2. Worksite installed sensors and devices that give warnings to track workers.

3. Sensors and devices that give targeted alerts to both vehicle crew and track workers.

4. Infrastructure systems, methods and devices that remove the need for workers on tracks to undertake work.

5. Infrastructure systems and devices that automatically prevent vehicles from entering a worksite.

A more detailed explanation of these typologies and how they are differentiated can be found in the options table section.

Within these typologies, the literature review covered a range of TWS options that would be explored further in the study.

In the first typology, we identified the following options:

- Train mounted sensors and devices
- Maintenance vehicle mounted sensors and devices

In the second typology, we identified the following options:

- Automatic Track Warning Systems (ATWS)
- Smart Wearables

In the third typology, we identified the following options:

- Worker sign in/out systems
- Personal Alert Devices (PAD)

In the fourth typology, we identified the following options:

- Relocation of equipment outside of the danger zone
- Partitions separating workers from the danger zone
- UAV and rail vehicle imaging systems
- Removal of requirement for workers on track

In the fifth typology, we identified the following options:

- Authority based protection systems
- Absolute Signal Blocking
- Worksite Protection Key

These identified options, as well as others identified at later stages of the project have been incorporated into the options table. The literature review identified some potential product suppliers that have also been included in the options table.

Several worker safety systems being used outside the rail sector were explored that were seen as relevant and have the potential for application within the rail sector. These included; Automated vision-based detection systems used in the construction sector and entity tracking systems being used in the mining sector. These as well as other worker safety options from outside the rail sector identified in the surveys are explored in the other opportunities section.

The findings from this literature review were used to inform the engagement stages of the project that followed. This included a survey and workshop that gathered input from stakeholders in the rail industry. Respondents to the survey and workshop participants familiarised themselves this review to inform their contributions to the project.

Track worker in tunnel © Ricardo Gomez Angel

Engagement Survey

The Arup team developed a survey to gather insights into various aspects of track worker safety and available options. There were over forty respondents to the survey from across the rail sector. This section summarises the key findings from the responses. These findings were used to inform the stages of the project that followed including the workshop and this options report.

Survey participants were asked about what types of work are being done by workers on tracks. Across all responses, there were over twenty different types of work being done by workers. The top five responses can be seen in figure 2.

We asked what TWS technologies and systems were currently being used to ensure worker safety. Over thirty unique technologies and systems were being used for TWS. The top five of these can be seen in figure 3.

20+

types of work being done on tracks

Most common types were:

1. Inspections to assess asset condition
2. Maintenance on rail lines
3. Driver operations
4. Upgrades and installation
5. Surveying for construction/design

Figure 2 – Top five responses to "What types of work are being done with workers on tracks?"

30+

technologies and systems currently being used

Most common types were:

1. Designated places of safety
2. Lockout working and track blocks
3. Permit controls
4. Lookouts
5. Automatic train warning systems (ATWS)

Figure 3 – Top five responses to "What types of TWS technologies and systems are being used now?"

4

technologies and systems not adopted yet

Responders predominantly had **not** experienced failed trials

Detonators
Not suitable for our network

Laser sensor systems and alarms
Cost factor

4WPS from 4Tel
Paused to test the system with smart devices

Zoellner ATWS
Option had not yet been widely adopted

Figure 4 – Four examples provided by respondents to "What TWS technologies and systems that had failed trials and why?"

12+

technologies and systems under trial or being implemented in the near future

Most common types were:

1. Evolutions/updates to existing systems
2. Worker smart device applications
3. Digital and LiDAR systems
4. ATWS and ATMS
5. Drone and UAV utilisation

Figure 5 – Top five responses to "What TWS technologies and systems are planned for future trials?"

We asked what TWS technologies and systems had failed trials, and why. Four respondents gave examples of TWS systems they had discontinued during trails. These four examples can be seen in figure 4.

We asked what TWS technologies and systems were being planned for future trials. There were over twelve unique technologies that were planned for trials. The five most common responses can be seen in figure 5.

Engagement Survey

RANK	OPTIONS
1	Infrastructure systems and devices that prevent trains from entering worksites automatically
2	Systems and methods that remove the need for workers on tracks to undertake work
3	Sensor system integration with targeted alerts to workers and operators
4	Sensors and worksite installed devices that give warnings to track workers
5	Sensors and train installed devices which give warnings to train crew

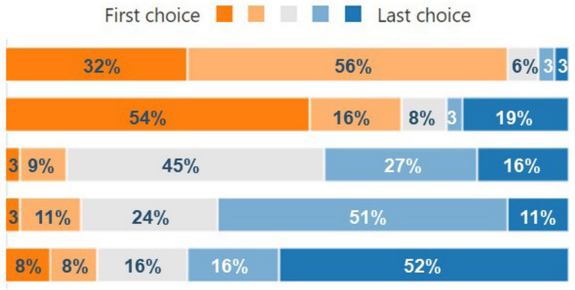


Figure 6 - Ranks of the five typologies

We asked the respondents to rank the five typologies of TWS solutions that we had established in our literature review. The typology that was most respondents first choice (54%) was “Systems and methods that remove the need for workers on tracks to undertake work”. The second most favoured option was “Infrastructure systems and devices that prevent trains from entering worksites automatically” followed by “Sensor system integration with targeted alerts to workers and operators”. A complete breakdown of the five typology rankings can be seen in figure 6.

The survey respondents were asked to provide reasoning for their ranking. Some highlights from these responses can be seen in figure 7.

Survey participants were asked what additional TWS options were not captured in the literature review. These suggested options were captured and have informed the final options table in this report. The survey lastly collected any additional comments on TWS technologies and systems. The highlights from these responses can be found in figure 8.

Figure 7 – Highlights of responses for reasoning of typology rankings.

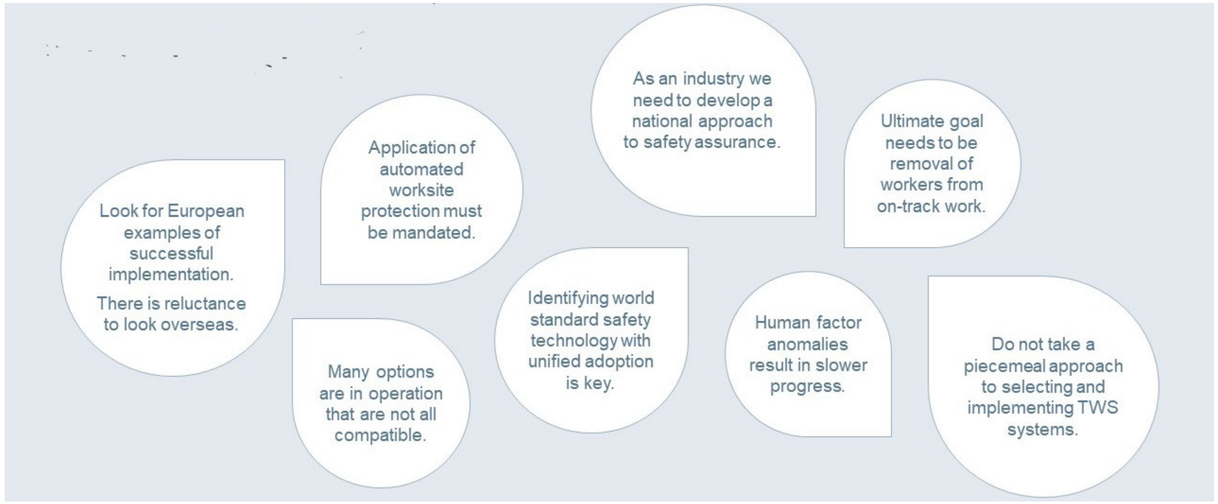


Figure 8 – Highlights of responses from general comments on TWS technologies and systems.

Engagement Workshop

An online stakeholder engagement workshop was held for ACRI, RISSB, ONRSR and rail industry stakeholders to further discuss track worker safety issues and options. The workshop was facilitated by the Arup Foresight team with support of two Arup rail experts.

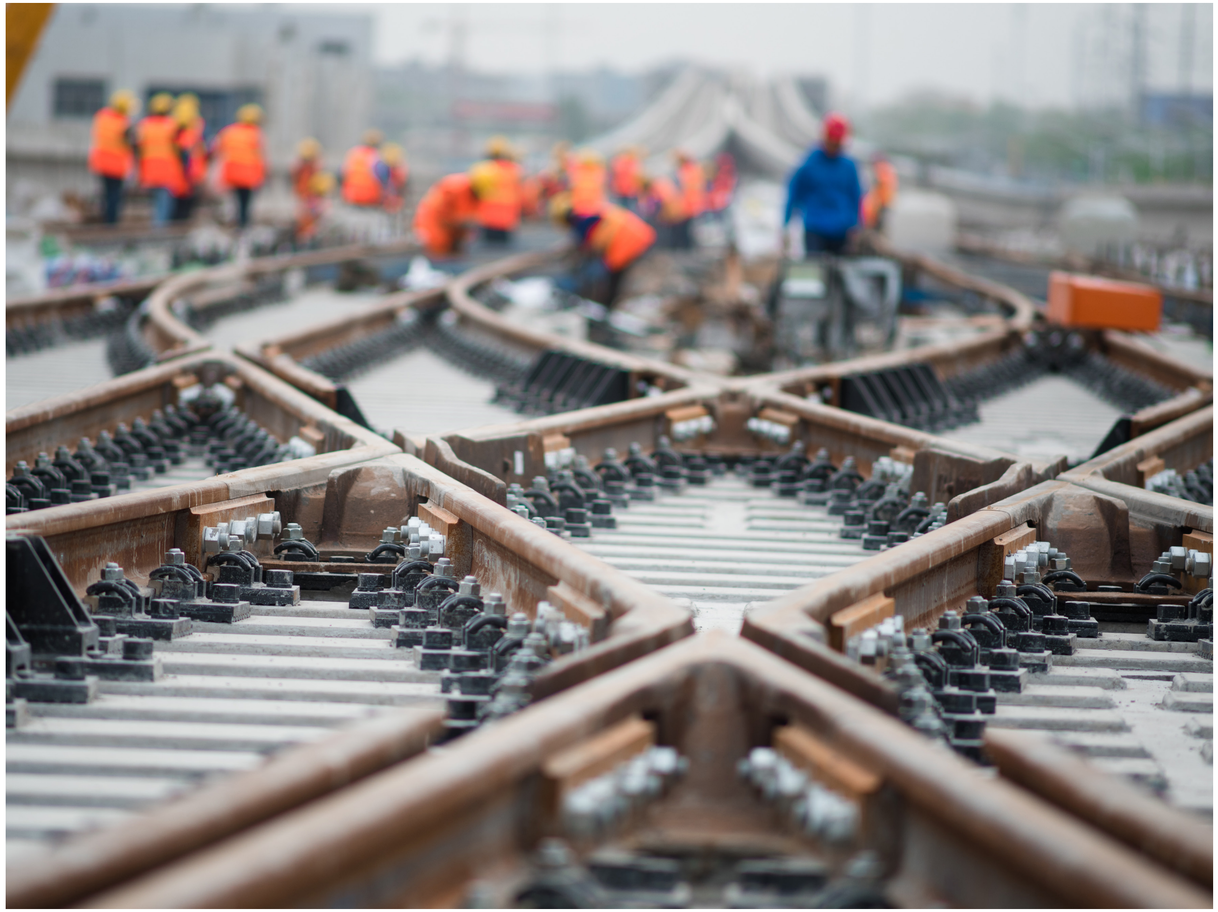
This section summarises the key findings from the workshop. A detailed report that covers the outcomes of the workshop was developed by the Arup team. A copy of this report can be accessed on the ACRI website. The workshop involved forty-seven attendees from across the rail sector in Australasia as well as some attendees participating from other regions.

The first activity explored what qualities and features make track worker safety options suitable. The participants brainstormed in groups and then voted on what qualities and features they believed were most important. Fail to safety was identified as the most important feature followed by being simple to implement, noting that this simplicity should be from a user's perspective. The third highest was options having the right functionality, usability and overall being fit for purpose.

The second activity had participants familiarise themselves with the TWS options previously identified through the literature review and surveys. Any additional options not captured were added by the participants. They then worked in groups to rank the TWS options and consider their strengths and weaknesses. Options under each of the five typologies were ranked separately. The additional options suggested by participants as well as the rankings for the options were considered in producing this reports options table.

The third activity aimed to identify the key challenges for adopting TWS options. The participants brainstormed nearly forty unique challenges. They then voted on which of the challenges they believed was the most difficult to overcome. From this voting, the top five challenges were discussed together. The top three challenges were resistance to change, integration with old signalling systems and knowledge on what is currently available.

The recorded outcomes and discussions from this workshop have been used to inform the development of this report's options table.



Railway Construction © iStock

Worker Safety Options Outside the Rail Sector

From the literature review and engagement survey, we identified additional worker safety technology options that were being used outside of the rail sector. These options were seen as having potential application or relevance to providing track worker safety. This section summarises each of the identified options and provides context for their relevance to track worker safety.

Computer Vision Detection Systems for Construction Worker Safety

Computer vision technology has been used in the construction sector to improve worker safety in worksites. This technology, researched by the American University of Beirut, was used to create a surveillance system designed to identify if workers are or are not wearing safety PPE such as a hard-hat. The system would flag on-site managers in real time when a worker without appropriate PPE was detected, so further action could be taken before further risk was taken.

This technology, if applied for TWS, could be used to automatically identify if track workers are present on tracks or a work site. Rail, construction, or maintenance vehicles could then be made aware of the worker's presence and be able to respond accordingly by stopping before entering that area or moving through slowly with added caution.

LiDAR and Wi-Fi in Road Safety

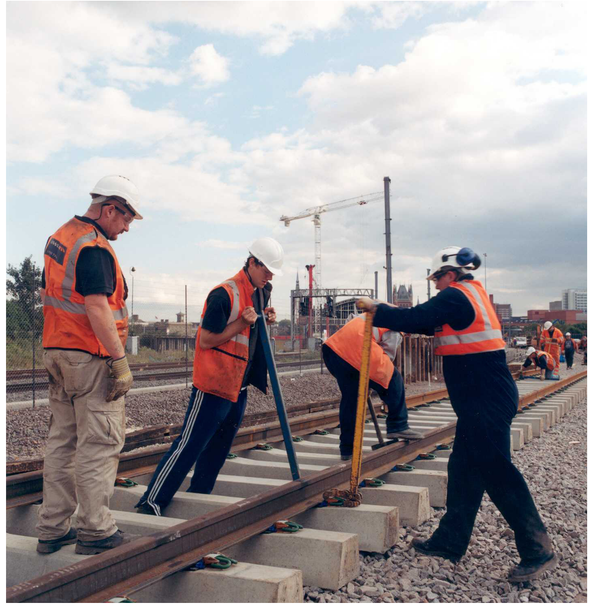
LiDAR and Wi-Fi technologies have been used in road applications to prevent crashes and save the lives of road workers, pedestrians, and drivers. The technology is capable of detecting hazards in real-time using camera sensors, AI, and machine learning. These systems may send warnings to vehicle operators or in some cases, these systems will trigger automated responses such as breaking, removing the need for operator action.

Some TWS systems that use this technology have been explored in the options table of this report. While the applications of these technologies are not very mature in the rail sector, there is a growing trend for their use in road vehicles, particularly in autonomous and semi-autonomous vehicles. It is anticipated that this technology will rapidly mature for rail applications into the future as its use becomes more widespread in the broader transport sector.

Entity Tracking Systems for Mining Workers

Some entity tracking technologies have been designed to provide collision avoidance when heavy machinery and vehicles are involved at a mining site. These systems will often monitor the position of workers, equipment, and other vehicles to ensure they do not come in contact with each other by sending warning signals and anticipating safety issues. This may involve the use of tags worn by workers and any equipment that feeds information to a control centre. The vehicle operators on-site should at all times be able to see the relative position of all tracked entities relative to themselves through a display. Alarms, both visual and audible, are often incorporated into these systems. The proximity range to trigger these alarms are often customisable to suit different operations, environments, and equipment in use.

This technology, if applied to TWS, could be used to inform vehicle operators of the presence of track workers and other potential hazards. The primary use case for these types of systems would be for use on slow moving rail maintenance or construction vehicles. One challenge for this type of system in rail applications is its use with vehicles moving at higher speeds such as trains.



Track Work © Urban Exposure_LCR

Options Table Reference List

1. Blue Electronics, Early Warning Detection System (EWDS-01), Product Website, bit.ly/3d5dBS6
2. Protran Technologies, Collision Avoidance System, Product Website, bit.ly/3tSrgTh
3. Presien, Blindsight, Product Website, bit.ly/3stry2E
4. Rail Vision, Main Line System, Product Website, bit.ly/3lIB5QU
5. Vicomtech, Rail Computer Vision, Product Website, bit.ly/3f8oOnD
6. Schweizer Electronic, Minimel 95 Series, Product Website, bit.ly/3cg46jP
7. Zoellner technologies, Autoprowa System, Product Website, bit.ly/3rbWumF
8. Eleksen Technologies, Embedded Active Visibility, Product Website, bit.ly/3rhUDNp
9. Siemens, Smart Wearable, Product Article, sie.ag/39az0bA
10. StaySafe, StaySafe Lone Worker Application, Product Website, bit.ly/2NMhaUR
11. WorkSafe Guardian, WorkSafe Guardian Application, Product Website, bit.ly/3rhcq76
12. Bombardier, TrackSafe, Product Article, bit.ly/3lLhG23
13. Protran Technologies, Ranging Protracker System, Product Website, bit.ly/2QpXQ0q
14. Protran technologies, ProAccess System, Product Website, bit.ly/3tMDM6W
15. Safetrax, Trackside Safety Barriers, Product Website, bit.ly/3f7m1v5
16. Goldschmidt, Tracksafe Barrier, Product Website, bit.ly/3faIck6
17. Ardenna, Rail Inspector, Product Website, bit.ly/3lIE5Na
18. Ensco, Rail Surface Imaging System, Product Website, bit.ly/2PjWa8g
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25. Hitachi, Signalling Equipment, Product Website, bit.ly/3rh81RU

Railway construction © QA Photos_LCR

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