RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

FASTTRACK

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Rail Temperature Sensors for Automating Headway Restrictions

The Goonyella System is a rail network in Central Queensland responsible for transporting over 100 million tonnes of commodities each year. The Black Mountain section is a key bottleneck in the system due to slower speeds required to traverse the steep gradients and winding topology of the area. This bottleneck is worsened during the summer months when headway restrictions are introduced to combat a higher rate of track misalignments due to high temperatures.

On a hot day when headways between loaded trains are short, the rail doesn't have enough time to cool between trains and the rail temperature will continue to rise well beyond temperatures experienced in the rest of the network. Trains traversing down the mountain with brakes applied cause heat from the wheels to transfer to the rail and the rail to overheat. Rail temperatures over 71 degrees cause track buckles to occur. This issue exists during warm weather for both roads when successive loaded services are sent down the mountain on the same track at headways less than 25 minutes.

Historically blanket headway restrictions were used to manually queue train routes based off ambient air temperature data from the closest public weather station. These restrictions were often over-restrictive and ineffective as they were enforced based off air temperature rather than rail temperature.

Rail temperature sensors have been installed in four critical locations on each rail and each road at Black Mountain. This data is then used to automatically alert the network controller and enforce three categories of headway restrictions via the network train control system when the temperature exceeds threshold values. This data is also logged and stored in the centralised remote monitoring system.

Category 3: Rail Temperature > 62°C

- Queues routes in down direction until temp reduces below 55°C or 25 minutes have passed.

Category 2: Rail Temperature > 66°C

- Stops trains.
- Queues routes in down direction until temp reduces below 55°C

Category 1: Rail Temperature > 71°C

- Stop trains
- Arrange for track to be inspected.
- Queues routes in all direction until temp reduces below 55°C.

The key benefits of this system are decreased rail buckling, increased throughput and accurate data to inform future decisions.

Utilisation of Image Recognition for Wayside Condition Monitoring of Ore Cars

Typical wayside condition monitoring includes the use of hot box detectors, wheel profile condition monitors, Wheel Impact and Dragging Equipment Detectors, among other devices, to capture the various types of faults & to mitigate operational risk. The drawback of such equipment is that these typical rollingstock condition monitoring tools is that they typically identify faults further down the PF-curve, and act as a line of 'last defense' - many unable to identify leading indicators prior to catastrophic failure or breach of allowable limits.

Furthermore, many railways across the nation, conduct physical Roll-By inspections as a means of identifying faulty rollingstock as a basic practice. This poses a risk in itself, due to the reliance on human interpretation & uninterrupted focus to identify such issues.

An answer to this risk is the introduction and utilisation of image recognition technology, as a form of wayside condition monitoring - aiding in the early identification of faults and as a means of alerting for faults of differing criticality.

Automated Roll-By Systems utilise the same approach to that of a human conducting a roll-by - however through systems design, can be programmed to capture desired fault modes which the typical human may not see. This also allows trains to continue traveling at increased speeds than what is required for an effective manual roll-by inspection.

Effort is put in placing such equipment in high traffic locations, in order to provide the greatest coverage possible for a given rollingstock fleet. Both empty and loaded condition can provide insight into different degrees of problems, and it is recommended to be situated at such a location.

Images can be tuned to identify & detect faults to the client's specific requirements, and the associated level of criticality can be assigned upon interpreted risk – for further action.

Automated Image recognition systems can be integrated into Train Control systems to automatically bring rolling stock to a halt if particular critical faults are identified (pending hardware/software capabilities of the client). Such image recognition systems can provide alerts to Reliability & Maintenance Engineering teams at differing levels of criticality for varying levels of response. This also allows maintenance tactics to be refined & tuned based on the evidence captured. Much of which is not typically captured by a standard piece of wayside equipment, or through a roll-by inspection.

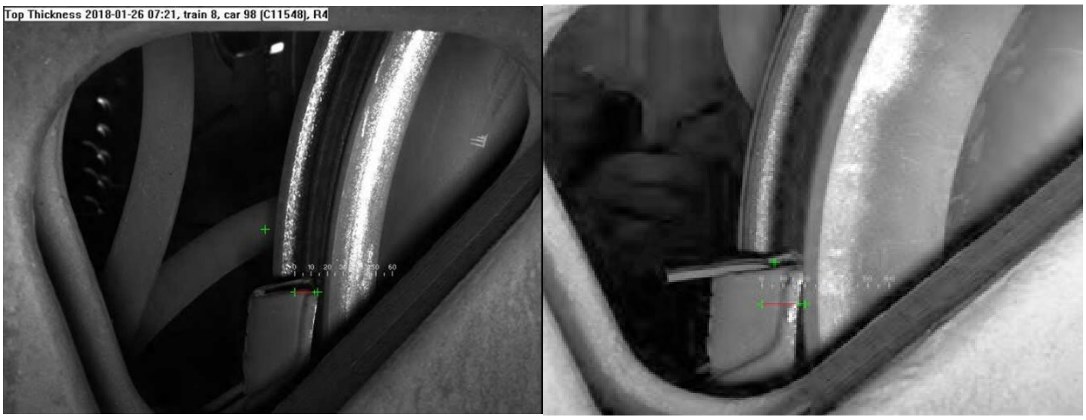


Figure 1: Missing brake shoe - if left unresolved will result in a burnt brake beam

Application of Machine Learning and Automation, with the layer of classification identifiers - can be used to tune the image recognition system over time to become increasingly accurate - eventually eliminating the need for human review.

Image recognition systems utilised in this manner provide a significantly increased understanding of fleet health, improved safety & reduced risk in operation, and ultimately an improvement to productivity through operations.

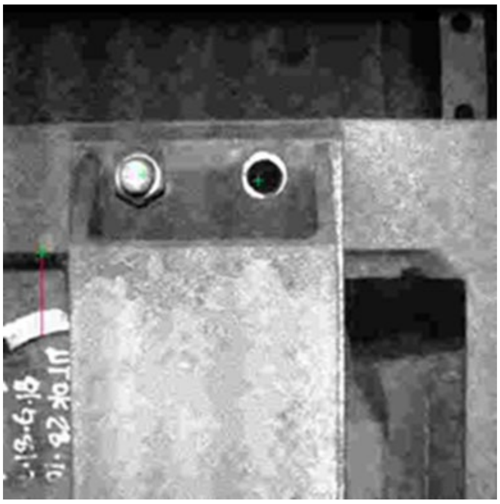


Figure 2: Missing drawgear retainer plate bolt - train separation in the making.

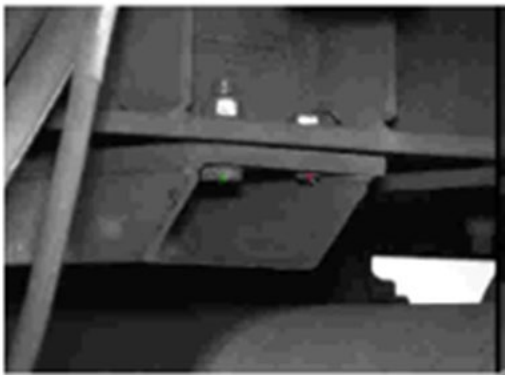


Figure 3: Snapped retainer plate bolt – without attention result in train separation.

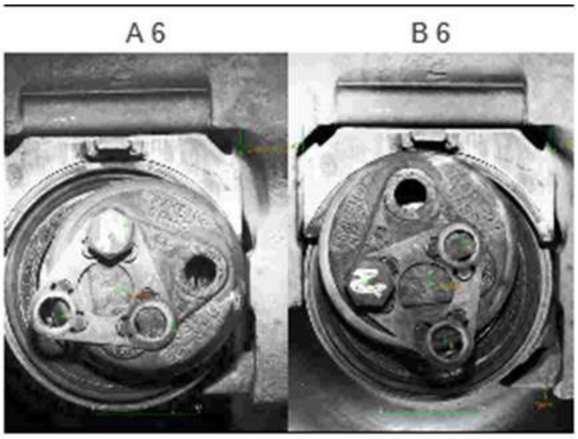


Figure 4: Missing end cap bolts – leading to bearing issues.

Composite Sleepers

The railway industry is always looking for new innovative ways to incorporate sustainability into the design and construction process. With type approvals requiring rigorous testing, researching backing and network trials Druatrak have recently been awarded type approval for their recycled plastic sleepers on the MTM and Vline Networks.

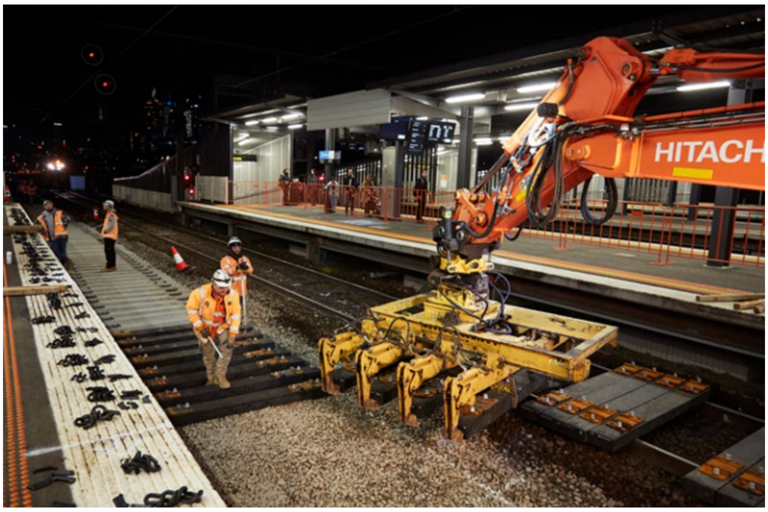
Manufactured in Mildura, northwest of the Victoria by parent company Integrated Recycling these sleepers are comprised of mixture of local agriculture waste such as cotton bale wrap, piping from the mining industry and polystyrene that are unable to be recycled and typically end up as landfill.

Recycled plastic makes up to 85% of each sleeper. Just one kilometre of these sleepers (translating to around 1500 units) uses approx. 64T of recycled plastic. These sleepers are also fully recyclable at end of service life – this is a major step forward in creating a more circular economy for Australian railway components

Most importantly, and crucial for successful type approval, the properties of these sleepers make them competitive with traditional sleepers used on the market in terms of loading performance, durability and maintainability. With a service life of 50 years, these sleepers boast a lifespan that is three time longer that traditional timber sleepers and perform with a similar characterises as concrete sleepers. With less maintenance required, due to low water absorption, fire, termite, UV light resistant these sleepers are far less likely to rot, decay and split.

The environmental benefits of using these sleepers is clear, reducing the need for timber resources, and reducing concrete production which is the second largest carbon emitter in the world and providing meaningful recycled plastic waster.

These innovative sleepers are the product of nearly four years of research and development by Integrated Recycling and Monash Institute if Railway Technology (Monash IRT). Given there are little to no design standards, guidelines or specifications surrounding recycled plastic sleepers in Australia these the undertaking of the type approval let alone inherent risks of developing and trialling a new sleeper composition on an Australian railway network was ambitious



This project and recent type approval is a great example of industry, universities, government and rail authorities can work together to help create a circular economy though innovation and rethinking the ways we use everyday items.

Simulated Response Training

At One Rail Australia (NSW), train drivers are required to be route qualified for an expansive rail network, which can see them drive upwards of 400km in a shift. To facilitate adequate training over the network, ORA introduced the use of a train driving simulator. The simulator is a replica of the XRN- C44 aci class locomotive, combined with realistic computer-generated imagery (CGI) of the ARTC Hunter Valley network. This allows simulation of real-life driving conditions, emergency scenarios and incident response training.

Train Driving simulators are not a new concept for Rail Transport Operators, they have been used extensively throughout the industry to develop and refine train driving techniques. Additional to the established training methodologies used in simulator training, ORA are working through a series of packages to develop assistant drivers' abilities to stop a train in a situation where the driver has become incapacitated or unresponsive.

With an ageing workforce and an influx of trainee drivers to support an uptrend in demand, the combinations of experienced drivers and assistant or trainee drivers has increased. This increase heightens the risk of an incapacitated or unresponsive driver becoming more apparent. Due to the remote locations ORA drivers are required to traverse, it is essential that should an emergency arise, the assistant driver would be able to progress the train to a location that is easily accessible for emergency services.

One scenario ORA have developed, incorporates the Bylong number 3 tunnel. The tunnel is 1975m in length and due to its narrow diameter, all trains that travel through this tunnel are required to carry self-rescuing equipment in case of locomotive failure. Without adequate training for assistant or trainee drivers in dealing with an incapacitated or unresponsive driver in this scenario, the outcome is almost certainly catastrophic.

ORA assistant and trainee drivers develop their skills through a series or simulations and roleplays, they are coached on the correct powering and braking techniques to navigate the tunnel and bring the train to a safe stop in a location outside of the tunnel entrance so that emergency services can access.

ORA is constantly looking for innovative ways to adapt new technologies, the integration of these new technologies ensures a bright future for the Rail Safety Workers at ORA

Autonomous Trains

Now more than ever, the rail industry needs innovative solutions that help to combat the challenges of rapidly growing urbanisation, climate change and a pressured transport network. In recent years, we've seen how the emergence of automatic and autonomous vehicle technology has led to a cleaner and more efficient mode of transport. For most, this means cars and trucks, however, this technology also has the power to transform our railways – from greater flexibility in their timetables to more efficient use of energy, automatic and autonomous trains can unlock benefits in our railways to help meet passenger expectations, improve capacity, increase connectivity, and reduce our carbon footprint. Automatic technology in trains is nothing new and has actually been around since the 1960's, but to become more efficient, our railways need to start embracing autonomous mobility, and that means employing autonomous trains.

<u>Automatic trains or Autonomous trains - what's the difference?</u>

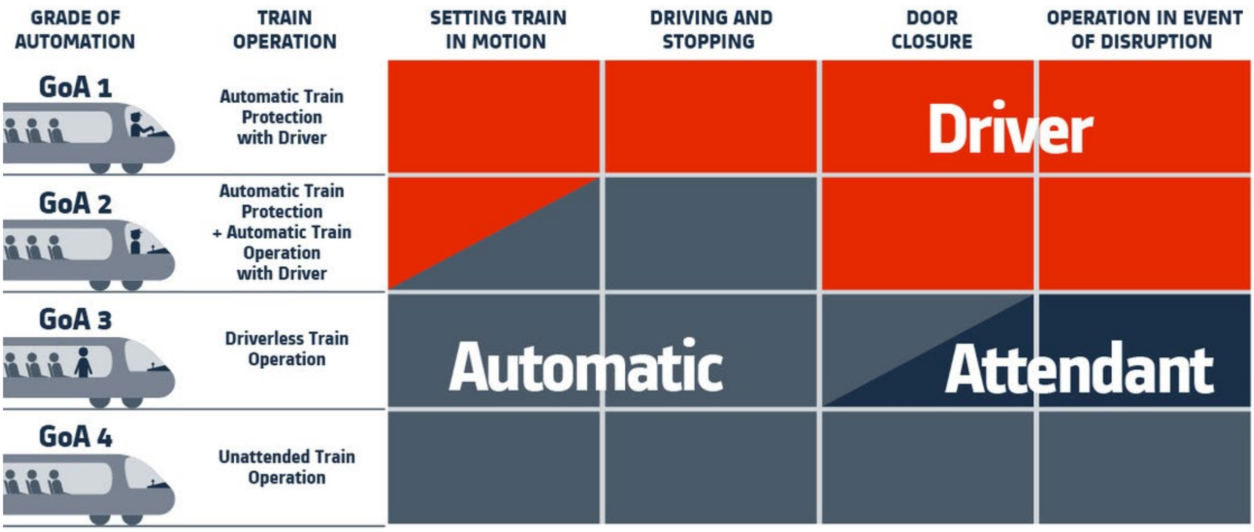
Automatic train

- Operates on segregated tracks
- Closed and secure system
- Software establishes a security bubble around the train to ensure proper distance
- Strong communication between vehicle and infrastructure

Autonomous train

- Operates on shared track
- Must share path with other trains, cars and pedestrians
- Trains need the ability to see ahead and around track
- Train needs to be able to communicate and make decisions

Train automation is based on five grades of automation (GoA), from GoA0 (no automation) to GoA4 (fully autonomous). Each step along the grade increases operators' control over their fleets while improving the fleet's efficiency and performance. The image below shows train operation across different levels of automation.



Earlier this month, a fully autonomous GoA4 freight train led by Finnish technology company Proxion, took a major step in the autonomous train development space by carrying out field tests successfully in Finland. The autonomous freight train was electric and aims to revolutionise short-distance transportation from industrial sites by 2023.

Applications of PCDS for condition monitoring of OHW infrastructure

At present, there is no centralised or automated system for monitoring the condition of the 1500V DC Over Head Wire (OHW) infrastructure in Sydney Trains. Condition monitoring of the OHW infrastructure is performed by a combination of manual visual inspections and examinations with hand-held measurement equipment, which are carried out by local territory electrical technicians in accordance with the Technical Maintenance Plans (TMPs).

The Pantograph Collision Detection System (PCDS) provides new capabilities to be utilized as an automated pantograph mounted inspection tool to reduce manual visual inspections and assist predictive maintenance with the consideration of dynamic behaviour of OHW condition when combined with varying train speeds, ambient conditions and different rolling stock and pantographs.

The PCDS system is installed on the pantograph structure (see Figure 1) on selected electric passenger trains.

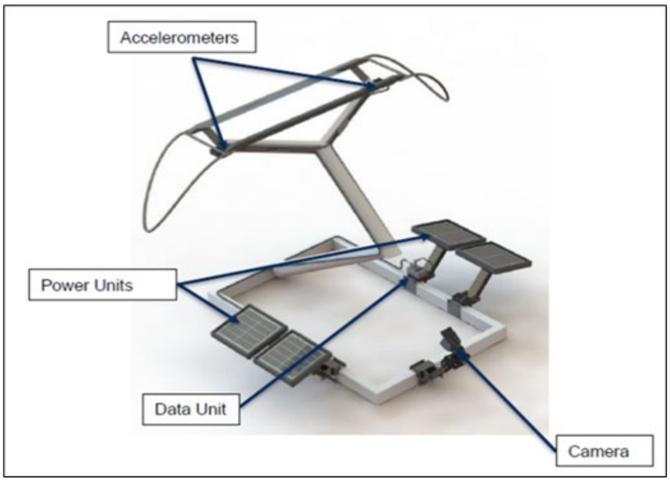


Figure 1 - Overview of PCDS System

The PCDS system components include:

- Accelerometers: a pair of tri-axial accelerometers mounted on the pantograph head provides dynamic strike or impact detection.
- Camera: a high-resolution video camera is connected to the system to capture video of impact location (with the pantograph in view).
- Data Unit: a data unit for storing and transferring the impact information, the GPS location data and the video footage of the impact to the PCDS server, which can be accessed from a web client platform by using authorised login and password credentials.
- Power Units: four power units that consist of batteries and solar panels are provided to power the PCDS without having to draw power from the train supply.

The PCDS system monitors the interface between the overhead centenary and the pantograph of EMU passenger trains and provides near real time warnings for abnormal strikes. In regular use, a pantograph may be struck by an overhead support component that is loose or defective and misaligned. Identification of the loose or defective part can be time consuming and difficult, causing unnecessary network downtime. The PCDS records the strikes or impact details along with the GPS location, heading, speed, and data and time for each.

The advantages for this new condition monitoring capability that PCDS is providing are:

- Rail operations reliability and sustainability
    - Increase in the accuracy of the asset’s technical integrity information collection, and hence increasing the quality of the technical assurance delivery for the OHW infrastructure.
- OHW infrastructure maintenance
    - Increase in capabilities for maintenance with visibility into conditions of assets using automated tools.

- Effective and efficient support for implementation of network maintenance improvement initiatives
- Asset management assurance tool
    - Increase in capabilities for infrastructure asset management information
    - Increase in efficiency by implementation of technologies, hence alignment of the maintenance process with the enterprise-wide business efficiency improvement
    - Increase in capabilities for asset planning
- Network maintenance safety
    - Reduction in exposure time of maintenance personnel to rail corridor with live traffic, and hence increase in safety of network maintenance
    - Reduction in the need for unplanned access of the maintenance personnel to rail corridor with live traffic by targeting proactive maintenance that eliminates assets failures.

Applications for Artificial Intelligent Camera systems within the rail sector

The Camera Artificial Intelligence (AI) ecosystem is rapidly maturing, with many transport operators either investigating or deploying systems across their network. As AI solutions significantly reduce the resourcing requirement compared to traditional CCTV and demonstrate novel applications it is no wonder that these technologies are seeing a massive uptake, within and outside the Transport sector.

Key learnings from transport operators already in this space show that CCTV AI solutions will only be effective when deployed and designed as an ecosystem. Integral to this is the control centre where an individual is required to monitor alerts and take actions such as engaging emergency services, voicing warnings to on-platform incidents and alerting drivers.

The latest key market trend is the extensive division between hardware manufacturers and application providers within the industry. A noticeable example is Azena – a management system & marketplace for AI cameras. Alternatively, Lidar is an emerging solution that is seeing increased adoption in districts with heightened privacy legislation, as it doesn't record images. Lidar solutions use a use a series of 3D laser trackers and an AI interface to conduct activities such as passenger counting, incident detection, asset condition monitoring.

Incident Detection (Camera)

Detect abnormal behaviours at a location, including abandoned objects, track intrusion, attacks, thefts etc.

Incident Detection (Microphone)

A sound algorithm is used to monitor noises and detect disturbances. Allowing for situations to be identified before they become violent or cause damage. Additionally off-camera incidents can be identified

Passenger Counting

Crowd density is measured in real-time and can be on-board or at stop. Unlike traditional Automatic Passenger Counting (APC) systems a camera-based solution can create passenger heat maps, identifying congestion zones at stops or on-board trains and accounts for passengers moving between sections

Abandoned Items Detection

Abandoned items can be identified both on vehicles and at network locations. The owner of these items can then be automatically identified and dependent on the breadth of cameras, their current location can be identified

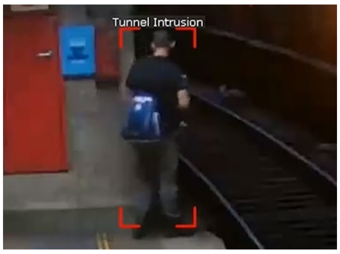
Intrusion detection

Spatial mapping facilitates the marking of areas as non-access. Monitoring of intrusions to these areas can then trigger alerts or automated actions i.e. warning to step off track or locking of sensitive equipment rooms

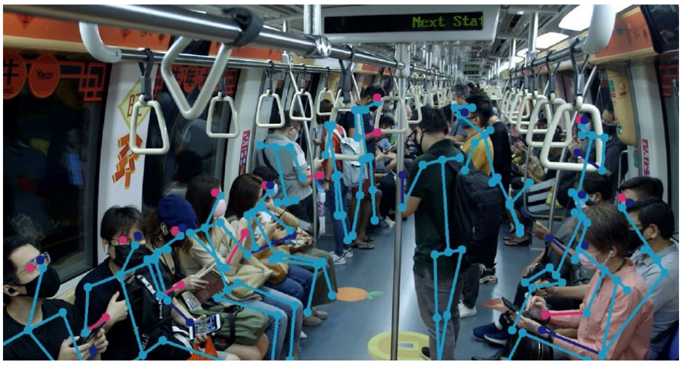
Remaining Passenger Detection

On-board systems can be employed to notify drivers of passengers remaining on trains beyond the last scheduled stop

Berlin U-Bahn Alert Area



Sydney Trains Tunnel Intrusion Detection



Thales on-board Passenger counting Solution

Human Factors Integration for Technology in Rail

Over the last two decades there has been a huge increase in demand for Human Factors (HF) specialists in rail. This in part is due to the increasing recognition of the value of HF integration and positive influence it can have as organisations strive to balance competing needs for improved safety, capacity and resilience combined (Gibson, 2021). Also, this is due to the increase in digital technologies and the impact this has across systems, with humans at the centre.

Technology is ever increasing in the amount we use and rely on it day to day, as well as its function and capability. With this we also expect it to be easier to use as it modernises. Making it easier to use, and safer is something that HF specialises in. This is leading to more emphasis on HF research and practice because of the need to reduce the likelihood of human error through design, as well as improve user experiences with technology.

What is HF and why integrate HF in technology development and implementation?

HF is not about eliminating human error. As humans we are fallible, we will make mistakes. What HF specialists can do is provide expert guidance about how and where there is potential for human error based on understanding of human capabilities and limitations, and where a design may be more or less likely to cause users to make errors. Effectively doing this and integrating this in the design and implementation process leads to technology and systems that are more resilient to the potential for errors to result in adverse consequences.

HF advocates for the end user, however, HF isn't about solely focusing only on the human, but rather the interactions within the wider system between people, process, environment, and subsystems – such as technology. HF professionals specialise in applying both science from psychological and physiological areas, and professional practice through HF process and methodology.

Process for HF integration with technology

1. **Confirm the type of change and engage human factors early**

Typically getting HF involved earlier is better. This doesn't mean more resource is required for the duration of the project as early integration of HF can almost always improve efficiency and reduce effort later.

Determine the impact and scale of change that is likely or intended to be introduced by the technology. Considering how the technology will impact users' such as their information environment, physical environment, workload, and other factors, will help define the best way to integrate HF.

2. **Determine the extent of HF integration required and when**

HF integration can and should be scaled appropriately to the context.

Define the concept, use, and stage of implementation for the technology, and then determine to what extent HF integration is required (if at all).

Whether the technology is off the shelf with limited alteration available or is an entirely new technology being created will impact the level of HF effort required.

3. **Conduct early analysis on the technology's impact to users' system-wide**

Early analysis of the technology based on the type of change and anticipated impacts will provide early findings that can be used to both plan the HF integration methods, and inform design requirements early, avoiding issues later such as design-based user-interface issues.

4. **Human factors method selection**

Based on the information gathered, the HF specialist will select the most appropriate methods for HF integration.

Where the integration is scaled low, a short and simple technical review of the design could be completed to assess the technology against standards, good practice, and HF principles. This would be quick and easy to do and still provide useful input to design.

Where the integration is scaled high, the information already gathered will help the HF specialist to identify where to focus effort, prioritise, and best influence the design and/or implementation of the technology.

5. Applying human factors integration

HF specialists engage with many stakeholders and integrate into different teams to work collaboratively and understand the context across the whole system from both a micro and macro perspective.

A large range of core and specialist HF methods can be applied. These should be selected based on the specific context of work and completed by a competent HF specialist.

A competent HF specialist can determine the best approach based on the context, business needs, and scaling of work, to ensure that the assessment is sufficient and appropriate for context and scale, to get the best from the technology.

6. Present findings and propose recommendations, solutions and/or inform design iterations

Whether the technology is off the shelf or an entirely new technology, HF specialists can identify issues and propose solutions and/or recommendations through design to implementation to improve outcomes for safety, human error consequence, and user experience.

Findings, recommendations, and solutions by HF specialists consider cost-benefit, and short-, medium- and long-term solutions.

Benefits of HF integration for new technology

HF specialists don't look at technology as standalone, but consider both the micro; digital interface, accessibility, task, environment, etc., and the macro; the system, interaction points with other people, processes and systems, and end to end journey for the user, etc.

Integrating HF for technology in rail adds value at any stage and can avoid undesirable outcomes that may not be realised by other specialists.

References

Gibson, H. (2021). A platform for rail HF. *The Ergonomist*, 14-15.

Thanks for reading

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