INSIDE THIS ISSUE – WHAT IS SHAPING THE RAIL INDUSTRY TODAY AND INTO THE FUTURE

Drone Technology in Rail Asset Management

This article briefly explores the advantages drone technology can provide in the realm of rail asset management. The rail industry is constantly looking to look for efficiencies in managing assets using innovation and new technology in order to ultimately drive OPEX costs down and continue to deliver effective services for customers. Opportunities from using drones have markedly improved since first being introduced for military purposes. The figure below highlights some of the areas where drones can be used in rail asset management.

Some of the types of drones includes: unmanned aircraft (UA), unmanned air system (UAS), remotely piloted vehicles (RPV), unmanned aerial vehicles (UAV) and remotely piloted aircraft (RPA).

Opportunities drones can provide in asset management include:

- safety benefits for hard to reach areas or danger zones
- improved Maintenance inspections – quality of capturing corrosion or rust early on
- ability to undertake ultrasonic / x-ray surveys/thermal imaging
- overall assurance of the asset construction (progressive updates using live information)
- an increase in the frequency of assessment as well as the scope and depth of condition assessment, particularly visual (and thermal or infrared)
- efficiencies in live data input of configurable items to support asset baselines and management systems
- supports creation of new roles (pilots, maintenance, look outs etc.)

One key area where drone technology is currently being effectively utilised is for topographic surveys which supports the Building Information Modelling (BIM). Further, Laser scanning to create data which can be tagged with satellite (GPS) information to support Asset management systems along with 3D BIM models. This information combined with photogrammetric surveys provides in-depth information about the layouts to allow upgrades, installation of new equipment and continual update and management of maintenance activities to support the assets lifecycle.

Of course, no new technology comes with risks, however if controlled, the benefits would significantly outweigh the costs. Some of the risks are: Increased initial expenditure, Collisions, Cyber attacks, fire or explosion, Limited Operations during adverse weather etc.

Design Lessons from an Italian Microwave

It's easy to believe that if your design works for you, then your design will work for everyone else too. If you find yourself thinking like this, just remember the wise words of Admiral Ackbar: It's A Trap! This belief is a trap because our personal experiences, upbringing, education and personality shape how we interpret the world, so we are unconsciously inclined towards designing solutions that we understand - and then naturally assume our solutions will work for others too.

However, we humans are complicated creatures. If we could all predict the thoughts and behaviours of other people with ease, then fields such as human factors, psychology and cognitive science wouldn't exist. And yet they do exist, and every day these fields reveal new insights about human thoughts and behaviours that are contrary to common intuitions. So blindly trusting intuition alone that your design will work for everyone else is a significant risk to the usability of your solution.

My kitchen at work provides a regular reminder of the consequences of designing for oneself, rather than for end users. Our kitchen is stocked with a particular Italian microwave. No doubt this device is a feat of clever engineering with high quality construction, and the microwave's four-figure price tag is further justified by its sleek black aesthetic. Yet I often observe staff struggling to heat their meals (you might recognise this as, "The Primary Function Of A Microwave"), as they attempt to decipher the panel of glowing, minimalist hieroglyphic buttons. To the engineers of this microwave, an exclamation symbol inside a diamond obviously denotes 'Start' and of course the 'W' stands for 'Wattage', which is used to set the power level. How could the users of the microwave *not* understand this?

So, what can you do to avoid the Italian microwave problem for (significantly more complex) rail projects?

First, spend time collecting and understanding the project's requirements. Just like the slab of a house, the requirements are the foundation that everything else is subsequently built on. Speak with end users early and regularly to gain a deep understanding of the operational concepts and the actual problems the users need solved. Recognise that all of the requirements are unlikely to be elicited by sitting around a room and talking; unexpected insights are often had whilst drawing on a whiteboard or playing with a toy model.

Second, involve Human Factors specialists in your project: the earlier the better. I believe the best solutions arise from exposure to a diverse range of opinions and considerations. Technical considerations for calculating shear forces, operating temperatures and failure thresholds are absolutely necessary for an effective design. But human considerations are important too, because ultimately every product should improve the lives of its users in some way, and Human Factors specialists are trained to consider the implications of a design from the end users' perspective. Will this handrail be reachable by the majority of members of the public? Could a person with poor eyesight understand this sign from this distance? What is the risk that this alarm will be missed due to distraction by other elements on the screen?

Third, follow the human-centered design (HCD) process as closely as possible. The exact steps in the HCD process may differ slightly depending on who you speak to and which direction the wind happens to be blowing on the day, but at its core the process advocates interacting with end users throughout every phase of the project, iterating through mock-ups and prototypes early to test out theories, and collecting objective data to make evidence-based design decisions. Discovering a design failure on a whiteboard, wireframe or virtual reality model is a thousand times cheaper and faster to fix compared to discovering the failure after you've built the solution.

Finally, and perhaps most importantly, allow for all of this in the project schedule. The logistics of sourcing, meeting with and training end users isn't always straightforward, and collecting and analysing data to arrive at justifiable design conclusions isn't instant either. Even the best Human Factors specialists are likely to produce suboptimal advice if they aren't given enough time (search YouTube for "Spiderman Speed Challenge" to see this principle in action). In the end, the users of your product will thank you for taking the time to understand, design, build and test something that enriches their lives. Good solutions meet the functional specifications, but great solutions meet the user's needs.

Systems Thinking in Rail: The Questions That We Need to Be Asking

When managing and designing for rail projects, do you feel confident that:

1. All components of your original project brief have been met, with no gaps or scope creep?
2. Your system is safe, and that all interfaces and hazards have been recognised?
3. You understand the system's users, stakeholders and what their needs are?
4. You and the client understand the operational concept?
5. Your project brief will meet the operational concept?

These are the questions that we need to be answering successfully to deliver rail projects within time, cost and scope. In Australia we are seeing rapid shifts in project demand, economic activity, urbanisation, availability of information, resource scarcity and human connectivity resulting in increasingly complex Public Transport projects. As this complexity increases, we cannot rely on traditional methods to deliver public transport projects. We must look toward a more structured approach and novel ways of working to meet stakeholder needs.

Using a simple Systems Thinking approach is one way we can work towards confidently answering "YES" to the above questions, improving project performance and smooth introduction into operational service and integration with minimal impact on ongoing infrastructure operations.

Systems Engineering is applied Systems Thinking. It is a perspective, process and discipline that is designed to manage and deliver projects in an uncertain and complex environment. Systems Engineering effort can be varied, and a simple, applied process can often support pragmatic delivery of our major rail projects. Our challenge is to optimise and tailor systems engineering to each infrastructure project, keeping it simple but thorough enough to add value to the design process.

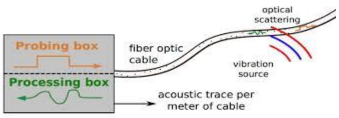
Systems Engineering can help you technically manage your project (scope) in addition to project management (traditionally managing time and cost). All engineers can incorporate a level of systems thinking and systems engineering in their work, to increase traceability of decisions and requirements, understand the interfaces and share the understanding of the larger project objectives and operational concept. The project lifecycle from a Systems Engineering perspective is defined in the *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*:

1. Concept: Develop a concept of operations (Characterize solution space, Identify stakeholders' needs)
2. Development / Design: Requirements Definition, Create solution description
3. Development / Delivery: Requirements Management, Verification and Validation
4. Production / Build: Validate and Test
5. Utilisation / Operation: Asset and risk management, provide sustained system capability
6. Retirement / Demolition: Store / archive, lessons learnt

All 'engineer' roles should and do have an element of 'systems engineer' in them. Ask the questions, and work out how you can feel confident that your infrastructure projects will be safely integrated into an operational system – does that require engaging systems engineers to technically manage your project scope and interfaces?

Application of Distributed Acoustic Sensing within the Railway Industry

Distributed Acoustic Sensing (DAS) is a new technology where objects are detected and measured through pulses of light, which are sent through a fiber optic cable. The fiber optic cable acts as a sensor which detects the signal produced or refracted off an object within a 10m radius of the cable. An algorithm can then be used to measure the strain produced by rolling stock on the railway infrastructure. This has the potential to significantly improve the asset management strategy of railway operators and maintainers by providing live monitoring of the railway line and train wheels. This would be a significant improvement on the current frequency of data as current inspections are either conducted through visual inspection on a weekly basis or through track machines that only run through a section every few months.



E Martin, Sandford University: http://large.stanford.edu/courses/2015/ph240/martin1/

DAS technology has the potential to be rolled out across all railway networks through track side cables which would allow for real time monitoring throughout the network. This could be used to pick up new defects such as flat wheel, rail breaks, geometry issues or even track the improvements of railway maintenance on assets over time. It also reduces the risk of human error associated with visual inspections. Given that DAS is able to pick up objects within 10m of the railway line it presents an opportunity to be utilized for other applications within the railway industry as well.

The potential applications of DAS technology are:

- Monitoring of train wheels for defects
- Tracking train location and speed
- Live assets condition monitoring of track assets
- Potential to reduce the frequency of visual inspection
- Detection of trespassers
- Identification of obstructions within the danger zone (3m from the track)
- Infringements of road traffic at level crossing
- Provide a warning alarm of buried signal cables

Frauscher sensor technology
https://www.frauscher.com/en/tracking/

The main challenges DAS faces, within the railway environment, is that it is difficult to separate and analyze the relevant data in noisy environments and that there is significant cost in running fiber optic cable in locations where this is not already installed. This is still an emerging technology and has not been fully developed and tested, however it shows potential to improve the reliability and monitoring capabilities of railway operators.

Onboard Energy Storage: One Form of a Predominantly Catenary Free DC Traction Power System

With increasing population density in cities there is motivation to invest in rail rapid transit systems. This is to both ease road congestion and transit time for commuters through efficient public transport. Electrification systems are the key energy source for modern urban railway systems. However, the associated overhead catenary to supply traction power to rollingstock can have unwanted visual impacts on a city environment and be a source of energy usage inefficiencies through power losses in associated cabling. One possible solution is to provide rollingstock with enough onboard energy storage to allow for a predominantly catenary free rail system.

Typical DC Traction Systems

Traditional DC traction electrification systems consist of the following key infrastructure:

- Multiple points of supply from the local electricity utilities at typically 11 kV or 33 kV AC.
- Transformer rectifier substations outputting DC voltages at typically 750 VDC to 1500 VDC.
- The distance between substation is around 3km at 750 VDC.
- Substations output to a catenary arrangement supplying electrical energy to rollingstock through the overhead line (OHL).
- The rollingstock contact the OHL through a pantograph typically with a carbon strip.
- Traction power current is returned to the negative of the rectifier through the track.
- Underground ground feeder cables run in parallel to the OHL to mitigate IR drop.
- DC feeders from adjacent substations provide redundancy to OHL sections and are typically designed to provide N-1 operation.

To date this is normally the most cost-effective solution however it does have some key disadvantages:

- The track, if not well insulated can be a source of DC stray current and electrolytic corrosion to metal assets in the soil such as gas pipelines, Multiple-Earthed Neutrals and Public Switch Telephone Networks.
- The overhead catenary can negatively impact on the aesthetics of an urban environment.
- Load sharing between substation rectifiers must be optimised in order to minimise voltage drop in the rail as this can act as a source for excessive stray current.
- Energy from regenerative braking is not fully utilised.

Rolling Stock with Onboard Energy Storage

Two feasible technologies for onboard energy storage are batteries and super capacitors. Nickel-metal hydride and lithium ion batteries provide high energy density and low power density, however are unsuitable for rapid charge/discharge cycles meaning this solution has minimal capability to utilise regenerative braking energy. Conversely modern super capacitors are capable of a charge/discharge cycles of around 20 seconds meaning regenerative energy can be fully utilised. Both solutions require additional onboard energy management control systems and a dedicated DC-DC converter.

Integration of Rolling Stock to a Catenary Free System

By utilising onboard energy storage on rolling stock such as super capacitors, overhead catenary sections are limited to charging points at stations. During dwell times at stations the rollingstock will automatically raise the pantograph and charge the super capacitors to provide enough traction energy to travel to the next station. Due to limited onboard storage the typical distance between station (i.e. charging points) is around 500m. This solution has the following key advantages of traditional traction systems:

- Outside of charging points, there is no current flow in the rail as the electrical traction circuit is contained within the rolling stock. The track is only used as the return circuit to the substation at charging points. Using insulated rail joints (IRJs) either side of a station, the track is electrically discontinuous. This means in the general alignment (outside of charging points) no current will follow in the rail. This removes sources of DC stray current for areas that are not charging points.
- Less visual pollution in cities.
- Regenerative braking energy is more efficiently utilised as energy is stored on board, not distributed through the OHL.

Thanks for reading

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