The Impact of Automatic Train Protection on Ways of Working in Australian Rail: Preliminary Findings from the Driver Perspective

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Abstract. Automatic Train Protection (ATP) systems monitor and control train movements independently of the driver to provide increased safety. However, few studies have investigated the impact that ATP has on the driver. Given ATP uptake, there is a need to fill this research gap. Using interviews, this study investigated the impact of ATP on traditional train driving in the Australian context. Preliminary findings suggest that uses of ATP are multifarious from the driver perspective and raise further questions for study.

Keywords. Train driving; Rail Safety; Automatic Train Protection; Automation

1. Introduction

New systems and technologies have slowly improved the safety, security, and efficiencies by which rail systems operate today, changing the way that train driver's work. In spite of this, the train-driving task itself occupies a liminal space and draws on very traditional skills (Branton, 1979; Naweed, 2014). While the underlying skills remain principally the same, there is nevertheless a huge variance in train networks globally. Some are very traditional and use basic train state indication, closely coupled to traditional skills while others use next-generation driver-machine interfaces and automation to compensate for human limitations, especially when driving at very fast speeds. And then there are hybrid networks that require the driver to switch between these modes.

In the 1990's, the Automatic Train Protection (ATP) system was introduced to rail (Halliday, 1996), forever changing the technical landscape and provoking economic arguments (Evans, 1996). These technologies monitor and control train movements independently of the driver and can intervene to stop the train if it is unable to remain within its safety envelope (for whatever reason). Viewed by industry as a 'safety backup,' there are multiple interpretations of these technologies, but their relationship with the human draws on principles of *adaptive* automation (Parasuraman, Sheridan, & Wickens, 2000) – that is, they only intervene to take control under certain conditions, typically when the operator may be experiencing extremes in workload (high, low) or being compromised by human factors born from other system issues (e.g. distracted by other tasks, fatigued). These usually show in the form of deviancy from prescribed thresholds (e.g. driving at/over maximum line speeds, deviating from target speeds).

However, few studies have investigated how train drivers perceive these technologies relative to how the organisation views them, and more importantly, the impact that they have had on current ways of working. The literature on resistance to technology suggests that drivers may distrust the information these systems provide, or view them as intrusive, though much of it appears to point to negative attitudes associated with change management (Victoria, Steve, & Lawrence, 2001) rather than the technology itself. In one of the key studies in this area, Giesemann (2013) looked at the automation effects of train protection systems with seven drivers and found that there is little empirical basis for concern related to driver attitude to these systems. Giesemann did however posit that use of ATP-type systems might elevate trust in the technology, with corresponding impact to other human factors (e.g., reduced situation awareness, expectation bias). Incidentally, this was the same year as the tragic Santiago de Compostela high-speed train derailment, where an ATP-type system was believed to have been in a deactivated state (Puente, 2014).

Suffice it to say, investigating the impact of ATP systems on train driving is a critical concern in today's world, but outside the connection with other analogous industries, the topic is under researched. More and more rail networks are migrating to ATP-type systems without being fully aware of what effects it may have on existing skill, and how the task must adapt when traditional and modern driving principles collide. In the context of Australia, this is an ever-increasing trend, with two regions using ATP (Naweed, Rainbird, & Chapman, 2015) and others in the process of implementing it. With the growing uptake and procurement of these types of train control and protection systems, there is a pressing need to fill the substantive research gap.

1.1 Research Aims

This research sought to investigate how ATP is altering train driving in the Australian context by gaining first-hand insights into the issue. The study was carried out in the Northeastern region of Queensland, and the aim was to provide a qualitative, exploratory investigation in the themes characterising the relationship dynamics. This paper presents preliminary findings.

2. Methods

2.1 Study Design

This study viewed train drivers as specialists of their own experiences. In order to gain a rich first-hand account of a skill-based task performed in a naturalistic setting, a qualitative approach was deigned the best method to satisfy research aims. Semi-structured interviews were conducted with eleven active train drivers working under an ATP system; as a method suited to collecting data in naturalistic settings (Cooke, 1994), it allowed free flowing extraction of knowledge. Knowledge was collected through one-to-one interviews over ~30 minutes. Given that experienced-based knowledge is implicit and normally difficult to articulate, the interview protocol transitioned the participant through a number of question categories: (1) general background; (2) train driving and ATP; (3) influence and use of ATP; (4) ATP and signal infrastructure/train variations; and (5) ATP – experience and general questions.

2.2 Rail Context & ATP System Description

The study was undertaken in the context of train driving in two different organisations in Townsville, Queensland. Both organisations use continuous ATP systems on-board their locomotives. Figure 1 shows how the ATP interface is presented to the driver. This particular system continuously updated the current speed of the line, as well as a target speed that train drivers should be driving at. They also displayed the state of the upcoming signal. This type of ATP system is currently operated over 2500 route kilometres equipped, including 1000 kilometres in "dark territory" (e.g. a section of track not controlled by signals, in this case, the Townsville to Mt Isa line) (Nikandros, 2008).

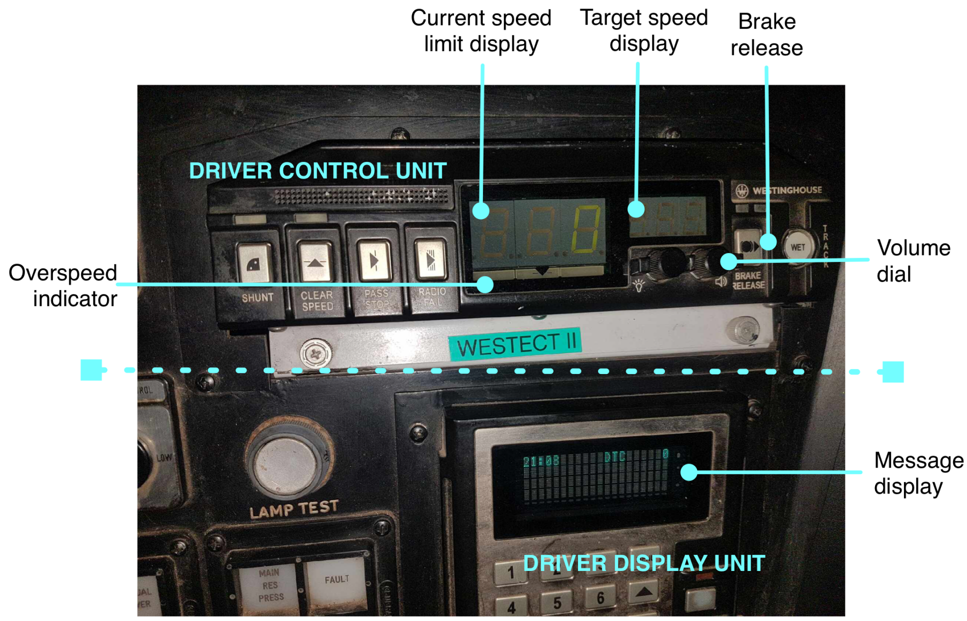

Figure 1. Photo of the Driver Control (top-half) and Display Units comprising the ATP system in the driver-cab interface

2.3 Participants

Eleven participants were interviewed. The age of the sample ranged from 30 to 62 years (*M* = 43.6; *SD* = 10.8). Ten drivers were male, one was female, and years of experience ranged from 1 to 41 years. Ten of the participants were qualified drivers; four of these were also driver trainers/tutors and one was a driver coordinator. The eleventh participant was an advanced trainee of the training process with 1 year of driving experience. Participants had experience in both freight and passenger operations and worked both in single and two driver operations. Participation was voluntarily, scheduled outside of work hours, and approved by Central Queensland University Ethics in Human Research Committee (Approval number: H14/08-178).

2.4 Data Analysis

All of the recorded interviews were transcribed and organised in order to allow for the identification of themes, patterns, and categories essential to the study aims. Data analysis was undertaken inductively (i.e. without determining categories in advance) by coding text from the transcripts. Thematic analysis was used to classify interview text into repeated concepts and phrases (Auerbach & Silverstein, 2003). The data was collected and analysed by a single individual. Data saturation was reached within the eleven participants in the study; that is, no new themes emerged during interviews and further coding was no feasible, indicating the sample was representative of the population.

3. Preliminary Results

Preliminary analysis of the data identified four key themes associated with the driver and their relationship dynamics with ATP. Each of these is presented in turn with example excerpts where necessary to show consensus in the data.

3.1 ATP as a Safety Feature

The first theme was associated with ATP safety and provided insight into how drivers understood this relationship. Most participants indicated that their ATP system had increased baseline safety in their operations and reduced certain accident types. However, some caution was expressed in terms of the potential to rely on the system to control the train even though the consensus was that it was not designed for this purpose:

> I think it's more of a safety feature, rather than drivers using it to control their train's speed.
>
> Over the years [ATP] has been relied upon more by the drivers as to assist or to control the train [sic], which it was never meant to do.

ATP was also considered to be a conservative device, that is, it intervened when participants did not think it necessary. However, most participants indicated that their ATP system made them feel more at ease and secure in their role, particularly under certain conditions:

> It's comforting to know that [ATP] is there to pull you up. You know, if you're fatigued or you misjudge or something like that.

The relationship between safety and ATP was also described in terms of its role as a "supervisory" system, and this relationship was personified in a number of ways:

> [ATP] is someone who's going to smack your fingers, if you're doing the wrong thing.
>
> [ATP] is a bit of a big brother thing keep an eye on what you are doing.

3.2 ATP Impacting Use of Route Knowledge

Preliminary analysis of the second theme provided insight into how participants understood the relationship between ATP and route knowledge. In spite of the generally positive view of ATP and safety, perspectives as to whether the system influenced driver route knowledge was decidedly mixed. One participants believed that ATP was useful for assisting with route knowledge, but more so in dark territory where there are no signals:

> Yeah I thought [the line speed] was 80 across the whole section. I thought you clear this 80 board, I was doing 80 and then all of a sudden I've got ATP working. I'm thinking [ATP] is telling me I can do a 100 here. I did not realise that. So it has given me a little bit more insight to the actual route.

However, other participants believed that ATP did not allow them to use their route knowledge in a way that enabled them to drive to the conditions:

> In [dark territory] in between stations when [the train is] in non-ATP status it allows you to drive more freely using knowledge and experience. Before you could use your route knowledge and experience to allow gradients to slow you down or just let the natural run of the train coming into the yards.
>
> [ATP] doesn't allow you to use, like, your route knowledge or to use the gradients to slow […] ATP will make you slow [the train] a lot quicker.

However, some participants viewed specific utility in how ATP impacted route knowledge, particularly when the latter was not fully established, or when temporary changes in the environment required them to update their route knowledge:

> If I have just been signed off on a road [and] I'm still a bit vague with [my] route knowledge, then the ATP will assist you a little bit there.

> [ATP] jogs your memory. That's right I remember, that's where the start of that TSR is, or I should be braking a lot earlier – that sort of stuff.

Despite this, there was concern that ATP would threaten what drivers do in the absence of ATP, that is, their ability to access and use their route knowledge appropriately This was connected with a perceived growing dependency:

> We now have three generations of drivers who know nothing else but ATP. Therein lies the problem. Ok if you keep ATP going, but if you turn it off you may have a whole heap of system problems.

3.3 ATP Affecting Driver Awareness and Alertness

The third theme focused on how ATP affected driver awareness and alertness. Participants identified that ATP had impacted on their awareness of signals, situation awareness and general alertness. The consensus across all interviews was that in areas where signals were controlled, ATP assisted drivers when driving around blind corners:

> We do have at least three blind signals that I can think of. That when you have ATP and you do feel more at ease because it is basically giving us an indication of the signal ahead is.

> I have [used ATP] in situations where I haven't had a clear view of the signals and I've used approaching signals that are unable to be seen, I've used the ATP prompts there to let me know whether I have a red signal approaching.

The utility of early signal indication on situation awareness was, however, discussed with the same caution displayed in earlier themes, that is, it could build a dependency on the system:

> When you don't have [ATP], you have to be relying on yourself looking at the signals, confirming it with yourself. [ATP] can be dangerous because you get so use to it.

However, participant's considered ATP systems very useful in situations where limitations born of their own human factor limitations could decrease their efficiency in the role, particularly in high-risk spots such as when they were approaching the limits of their track authority:

> There have been times when you've had a bad night, you're buggered, and you come into RCS territory. You're sort of getting a bit tired and you come in and out of a bit of – you're not actually going to sleep or anything but you sort of just in a daze and have the brakes come on because there's a red light up in front.

A benefit to driving performance and awareness of the task itself was also perceived in situations where there was high distraction potential or the capacity for slips in attention.

> [ATP] is good in areas where there are a lot of high distractions, I think.
>
> I try to be ahead of the ATP. So thinking of what I need to be doing but there are situations and times where I've been caught out and have the ATP alarm go off. [ATP] makes you aware of what you are doing.

3.4 The Effects of ATP on Train Speed

The final theme provided insights into the effects that ATP had on speed vis-à-vis the speed choices that were made when driving a train. Participants felt that they tended to drive faster when ATP was not installed, so by comparison the ATP system was considered to reduce speed-errors. Participants indicated that in the absence of ATP, they approached signals quicker and apply brakes later. This was said in the context of less conservative driving and also interpreted as a restriction:

> …you can approach [the] end of authorities a bit more aggressively. I'll delay my braking before my point I'd normally brake. I'll leave that off for another 30 seconds so that I get closer.
>
> Well [ATP] restricts you in one way. Where coming into yards and things like that where you've gotta apply the brakes to meet the braking curve, where before you could use the grade or the weight of the train etcetera knowing that it would slow you down [sic].

In view of this, participants felt that their ATP system played a role in reducing speed-errors amongst drivers. This was conveyed through clear accounts of what the ATP system did, however, participants also indicated that the way their ATP system worked was useful when they forgot speeds, or alternatively failed to see "certain speeds." However, conflicting perspectives drew on the importance of route knowledge:

> It all comes down to route knowledge. You should be aware of what speeds [are ahead] and where they're at.

4. Discussion

The preliminary findings in this study provide some insight into the relationship between ATP systems and the train driver, specifically in terms of their attitudes, perspectives, and behaviours engendered by this type of safety system, and the impacts on the task. Figure 2 consolidates the results from this analysis, showing the main themes and where the data points intersect. The overarching theme of ATP as a safety feature, and the capacity to maintain alertness and awareness was linked with the shift-working nature of the job, and in this regard, it was perceived a risk management and mitigation aid for biological human factors (e.g. fatigue, sleepiness). The main property here was the specific ATP system warning emitted when the train was not driving within an ATP-determined safety envelope. While there are clear safety implications for appropriating ATP type systems to manage fatigue and sleepiness (e.g., in terms of fitness for duty), this finding indicates that the system subscribes to the basic parameters of adaptive automation in this context. Environmental constraints (e.g. blind corners, fog) overlapped safety with route knowledge as a way of compensating for this limitation. However another counterpoint and contradiction in perspectives was highlighted, which is that the system was considered to restrict driving choices, or rather the ability to exercise control parameters routinely used in the absence of the system. Many participants chose to differentiate the utility of their ATP system according to different environments, for example dark territory and areas that are signaled and remotely controlled, suggesting that the specific driving context is an important construct in the relationship.

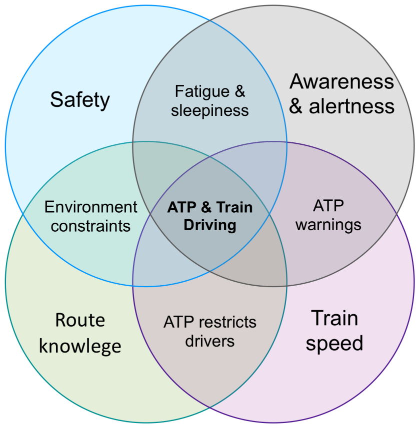

Figure 2. Venn diagram summarizing relationships between key themes and subcategories

The results, whilst preliminary, also seem to suggest that train drivers have established schemas for driving under ATP vs. non-ATP. This was shown in the participants' self-awareness of how they operated in each mode, though more thorough analysis and follow-up work is needed to determine if this is indeed the case. There was also some indication that the handover in task dynamic and supervision facilitated by the ATP system was perceived to be more active, suggesting a need to review the language around how ATP is described as a "background safety" system. Lastly, the results show strong views on the impact of ATP on route knowledge – this relationship has been seen in other studies but more empirical work is needed, particularly on distinguishing it as an objection to changes in ways of working from legitimate safety concerns when switching modes (i.e. working in ATP vs. non-ATP conditions and vice versa).

5. Conclusions

The preliminary findings identified in the study provide some indication of how Australian train drivers perceive ATP, and some rich insights into how they have adapted their ways of working. Some important themes emerged; ATP was harnessed as way of maintaining alertness and perceived as a risk management and mitigation aid, however it was also used to compensate for the environmental factors that constrain ease of driving. The data also indicated that ATP is perceived and treated as an active system, and suggested it is having a large impact on how route knowledge is applied in comparison to non-ATP driving. More analysis is needed to unpack these data and understand the implications of these systems on route knowledge to determine whether that is a serious issue or an effect of transition, and on mode switching, which is becoming increasingly relevant. Given the findings of this study, follow-up research could extend beyond the driver-ATP relationship to investigate how drivers adjust to driving without ATP.

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References

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative data: An introduction to coding and*

analysis. New York: New York University Press.
Branton, P. (1979). Investigations into the skills of train-driving. *Ergonomics, 22*(2), 155-164.
Cooke, N. J. (1994). Varieties of knowledge elicitation techniques. *International Journal of Human-Computer Studies, 41*(6), 801-849.
Evans, A. W. (1996). The economics of automatic train protection in Britain. *Transport Policy, 3*(3), 105-110. doi: http://dx.doi.org/10.1016/0967-070X(96)00015-7
Giesemann, S. (2013). Automation effects in train driving with train protection systems-assessing person-and task-related factors. *Rail Human Factors 2013 Proceedings*, 139-149.
Halliday, M. (1996). Automatic train protection. *Vision in vehicles, 5*, 245-252.
Naweed, A. (2014). Investigations into the skills of modern and traditional train driving. *Applied Ergonomics, 45*(3), 462-470. doi: http://dx.doi.org/10.1016/j.apergo.2013.06.006
Naweed, A., Rainbird, S., & Chapman, J. (2015). Investigating the formal countermeasures and informal strategies used to mitigate SPAD risk in train driving. *Ergonomics, 58*(6), 883-896. doi: 10.1080/00140139.2014.1001448
Nikandros, G. (2008). *ATP - 20 years on*. Paper presented at IRSE Tech Convention, Sydney.
Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans, 30*(3), 286-297.
Puente, F. (2014). Driver error "only cause" of Santiago accident, says report. *Inernational Railway Journal*.
Victoria, J. M., Steve, F., & Lawrence, G. (2001). Harnessing resistance: using the theory of constraints to assist change management. *Journal of European Industrial Training, 25*(2/3/4), 168-191. doi: 10.1108/eum0000000005446