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Investigating Human Error Within GoA-2 Metro Lines

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Abstract. The rail industry is progressing towards higher levels of automation and autonomy. Other industries, e.g. aviation, have discovered 'ironies of automation' where the reduction in workload actually contributes to unsafe events. The rail industry will not be immune from such issues as reductions in the complexity of workload often leads to work becoming mundane and routine. Further, without the need to be constantly reacting to their surroundings, drivers are ill-equipped to break the monotony to address anomalies which can lead to accidents. Such problems can arise in the transition from GoA-1 to GoA-2 and should lead to a rethink of system design, not to place blame on drivers. However, this redesign needs to consider both human workload and the system itself. The paper is a preliminary analysis of the challenges of increasing automation and identifies potential solutions such as reworking the transition by increasing the workload placed upon the driver within GoA-2 systems, increasing stress but decreasing monotony by making work non-routine and thus retaining driver attention. This is a positive trade-off and may be the cheapest and most effective solution, that isn't simply the transition to GoA-3.

Keywords: Automation · Human-error · Monotony

1 Introduction

Within Europe, rail is the safest mode of land transportation. Safety for rail has been improving for decades, with the annual rate of accidents resulting in a fatality falling by 5% every year. Further, a "major accident" which is defined as an accident where five or more fatalities occur have become very rare, with only two such accidents happening since 2018 (European Union Agency for Railways 2020). Not accounting for the 2019 pandemic which will have drastically affected travel for the past 2 years, rail has stayed relatively stable as a mode of transportation, with the general public using rail a similar amount each year for the previous five years (Gower 2021). This implies that all railway innovation within the past decade has either been for safety's sake, or has adequately considered safety, as the number of rail trips overall remains roughly constant as seen in Fig. 1, and the number of major accidents has fallen as seen in Fig. 2. Within the UK, the number of fatalities totals less than fifty per annum, excluding suicides (Rail Safety and Standards Board 2020).

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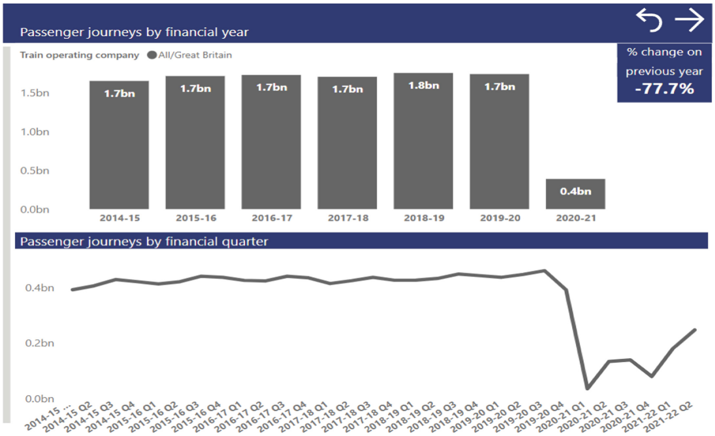

Fig. 1. Number of railway journeys within the UK per annum (Gower 2021)

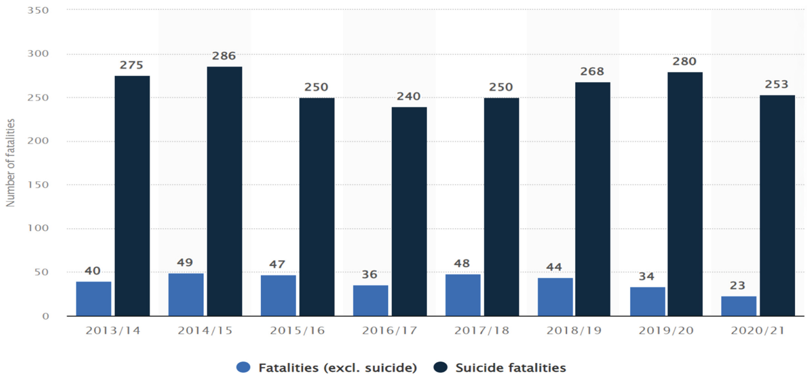

Fig. 2. Number of fatalities on rail within the UK per annum (Rail Safety and Standards Board 2021)

In the UK the most popular mode of transportation is the car. While the rate of accidents has been gradually decreasing over the past decade, total annual fatalities within the United Kingdom are still in four figures (UK Department for Transport 2020). There has been long-standing research on the safety of road vehicles, however road vehicles are inherently less safe than other modes of transportation, they are involved in more scenarios where accidents can happen, they take non pre-planned routes, get involved with non-scheduled traffic, and encounter more anomalies in general. In comparison, things are more planned within rail, so it is easier to account for and manage potentially hazardous situations. Rolling stock operates on a set path, meaning that it is easier to account for its surroundings. This is helpful because, whilst there are currently active programs to introduce autonomy within both rail and road, rail's more constrained environment should lead to its developments being smoother. With a clear path for the future of automation being constructed, there are good guidelines for where we should be looking regarding innovation.

1.1 Context of the Problem

At present, the majority of autonomous systems are within their infancy. The rail industry is no different, with automation being split into four stages, or four Grades of Automation (GoA), as shown within Fig. 3, GoA-0 is simply an unautomated train where movements are fully under the control of the driver. GoA-1 is essentially limiters that take control away from the driver, stopping them from speeding, this is known as Automatic Train Protection (ATP) and has been criticized for the ability to ignore the commands of the driver (Dave Keevill 2017) could cause reluctance to adopt the systems by the drivers who are used to having full control. Despite this, GoA-1 is the most common form of automation seen today (Brandenburger and Naumann 2021).

Railway	Road	Aircraft	Resp.	
Grades of automation	SAE levels	Levels of automation	(person)	(train)
GoA-0 Sight train operator	**L0** No automation	**Level 1** Raw data, no automation at all	All time	Warn Protect
GoA-1 Manual train operation Automated train protection	**L1** Driver assistance Park assist/cruise control	**Level 2** Assistance Flight director Auto-throttle	Drivers	Guide Assist
GoA-2 Semi-automated train operation (STO). Autom. train op. (ATO)	**L2** Partial automation Traffic jam assist	**Level 3** Tactical use Autopilot	Monitors all time	Manage movements within limits
GoA-3 Driverless train operation (DTO) Automated control (ATC)	**L3** Conditional automation	**Level 4** Strategic Flight management system	Ready to take back control	Drives itself, may give back control
Some control by attendant (operating doors, emergencies)	**L4** High automation Highway traffic jam system	Uninterrupted autopilot project (Boing) Drones (unmanned)	May not take back control	Drives itself with graceful degradation
GoA-4 Unattended train op (UTO) Automated doors Platform screen doors	**L5** Full automation (all situations)		Not required	All time

Fig. 3. Grades of automation (Dave Keevill 2017)

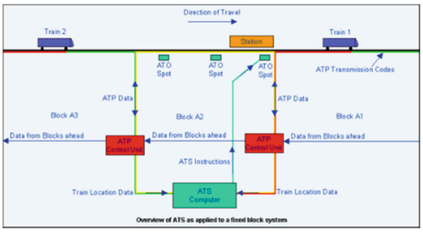

Fig. 4. ATS diagram (The Railway Technical 2021)

GoA-2 is defined as a locomotive with ATP and Automatic Train Operation (ATO), meaning the actual driving and braking of the train is automated with drivers taking over in case of disruption such as a tree falling on the rails or operating specific safety-related tasks such as door closure. It is worth noting that within GoA-2 and GoA-1 a driver is still required, and their average day doesn't change very much. GoA-2 has been set as a target for railway companies that are interested in automation (European Union Agency for Railways 2020). GoA-3 is the start of what could truly be considered self-sufficient automation, and GoA-4 is considered fully autonomous, and a goal of railway innovations as defined by the European Union (Shift2Rail EU 2019). In both GoA-3 and 4 ATO and ATP are utilized to ensure safety in basic driving operations. GoA-3 retains an attendant on-board to operate doors, assist passengers and operate the train in event of disruption but the bulk of the work is done either by automation or by remote operation from an off-site driver cabin. GoA-3 allows for Automatic Train Stopping (ATS/Fig. 4); if a train ahead is involved in an accident, ATS will "kick in" and stop the train from experiencing the same fate.

Scrutiny Within Automation

It is important to note that rail is such a safe mode of transportation with annual fatalities in the single or double digits in many countries, that we must treat each fatality with higher scrutiny than within road travel. When creating automation within cars and other road-based systems, there is leeway in the fact that accidents happen, the road is not an intrinsically safe place; accidents can be reduced but they are impossible to avoid altogether. In contrast, in railways, autonomous systems are expected to act as well as a human would, or even better, within a given scenario. Although that is hard to define on a philosophical level, on a quantitative level that would simply mean an autonomous railway system cannot be declared ready until it can run without incident and if an incident was to occur, accountability must be traceable within the system to find out why the incident happened.

Within rail travel we must discuss the possibility of even reducing minor incidents, while safety is the number one priority, it is also important to ensure that the public are getting the best possible experience while using an automated system. Thus, as well as having as few, or fewer, accidents as a human driver, an automated railway would be expected to achieve at least current levels of punctuality. Thus, automation within the railway industry requires scrutiny to ensure that the public are getting the best possible service.

Automation and Perceived Human Error

It is easy to look at the shortcomings of a system and blame it upon human error. However, when the human error is correlated with the introduction of a new system component, it is important to step back and consider whether or not there is an issue with the way that the new component is injected into the overall system and the assistance given to the individuals involved to help them to adapt.

Numerous reports have found that the exposure to extended periods of monotonous work within railways can cause drivers to experience "microsleep" which is defined as an individual experiencing a high Karolinska Sleepiness Score (KSS) (Åkerstedt and Gillberg 1989). In contrast, drivers who have the typical varied work schedule found within GoA-0 experience microsleep "substantially less" and often have lower KSS scores (Naumann 2016). The monotonous work typically linked with microsleep is attributed to the work commonly found within GoA-2 (Brandenburger and Naumann 2021). A potential critique of these trials is that they sometimes pushed the drivers to the limit for a short period of time in regard to monotony, not investigating the long term effects of minor daily monotony, the tests took place over two time variables, (PRE vs POST) the specifics of these variables were not published, however, they supported the overall point that there is an irony of automation, where during GoA-0, the gradient at which takeover time increases over the day is small, as seen in Fig. 5, but during GoA-2 the gradient gets much larger as seen in Fig. 6, but then decreases as Automation increases.

Being that the topic of monotony within the workplace is an incredibly wide area, it would be immature to suggest that GoA-2 is the only issue and the removal/reworking of GoA-2 systems would completely resolve any problems that may be linked, but there is sufficient evidence to suggest that it is a symptom of a wider problem.

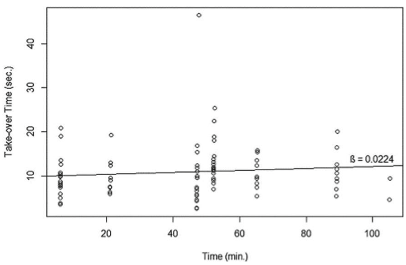

Fig. 5. Takeover time within GoA-0 systems (Brandenburger and Naumann 2021)

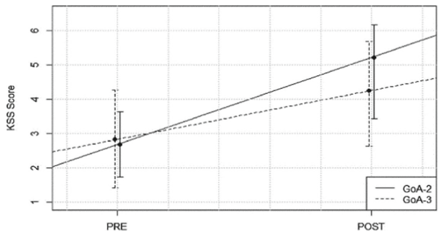

Fig. 6. KSS Score comparing GoA-2 and GoA-3 systems (Brandenburger and Naumann 2021)

2 Analysis

2.1 Real-World Examples of Problems

The world has slowly been adopting automated locomotives, which means that there are real-world examples of the potential issues within the different GoA. Several issues that have been declared as "human error" in that there are no specific issues with the software, with all computational components working as intended, meaning the drivers are fully to blame. However, while there are cases where this may be a fair attribution, there are several examples where extraneous circumstances have been identified:

Incidents Within the London Underground

Jubilee Incident (7 February 2018)

The majority of London Underground stations were converted to allow ATO between 2006 and 2008. When running in ATO, movement of the train is controlled automatically. At stations, the train operator is responsible for opening and closing the passenger doors, checking in-cab CCTV monitors for potential issues at the platform train interface (e.g. passengers or objects trapped in closed train doors) and initiating the start of the train. Between stations, the train operator is expected to monitor the ATO system, remain vigilant and look out for any obstruction on the track ahead of the train (United Kingdom Department for Transport 2018a, b). This can be considered as textbook GoA2.

Shortly after 09:00 h on Saturday 1 September 2018, a London Underground train travelled on the Jubilee line between Finchley Road and West Hampstead stations in north-west London with doors open at ten passenger doorways. The train travelled for 56 s and reached a maximum speed of 62 km/h between the two stations. There were approximately 30 passengers on the train, but no one fell out of it during the journey to West Hampstead, and there were no reported injuries or damage. After the incident, an investigation was undertaken and found a probable cause of this accident was the driver entering a microsleep, with them stating "*that he had 'zoned out' and made 'rushed decisions' when dealing with the door problems at Finchley Road. These are indicators that the sudden transition from a low workload to high workload situation, fatigue and/or low blood sugar levels were probably adversely affecting his capacity to deal with the stress caused by the unusual situation*" (Rail Accident Investigation Branch 2018).

Notting Hill Gate Incident (31 January 2018)
At about 16:00 h on Wednesday 31 January 2018, a passenger became trapped in the doors of a London Underground train as she attempted to board a west-bound Central Line service at Notting Hill Gate station while the doors were closing. The train departed and reached a maximum speed of 35 km/h before the emergency brakes were applied and the train stopped. The passenger was dragged for approximately 75 m along the platform, and about 15 m further into the tunnel. She suffered serious injuries and was taken to hospital, where she was treated for about a month (United Kingdom Department for Transport 2018a, b). An investigation following the event found similar results as Brandenburger stating "*Trains running with an active ATO system present a train operator with relatively low workload (compared to manual operation), and repetitive actions at stations. Research conducted by the Transport Research Laboratory for RSSB showed that, under such circumstances, it is possible for people to enter an automatic mode of responding, associated with faster reaction times but reduced attention and more errors. Witness evidence suggests that the ATO train operator's task can require effort to maintain attention, and that it can result in a reliance on the ATO system.*" (United Kingdom Department for Transport 2018a, b).

Although the outcomes were different, within both the Notting Hill and the Jubilee Line incidents, the circumstances leading up to the two incidents were identical; the driver had low blood sugar and found it difficult to focus in the first place, tied up with the repeated monotonous work leads to microsleeps causing the driver to miss an important detail and unfortunately, cause an accident.

Further Incidents Taking Place on the London Underground
Numerous similar events have happened on the London Underground throughout the years since GoA-2 has been introduced, the reasoning behind them have all been similar, three of the events are listed, however more events do exist:

- Passenger trapped in a closed train door, Tooting Broadway, Northern line, London Underground, 1 November 2007 (RAIB report 17/2008).
- l Passenger dragged a short distance by a train at Holborn station, 3 February 2014 (RAIB report 22/2014).
- Victoria line of London Underground departed from Warren Street station with all the passenger doors open (RAIB 2011).

Bucharest Metro Line 2019 Incident

The main city centre of Romania's capital, Bucharest has had full GoA-2 rail infrastructure since 1995 (Hinojal 2017), however, the transition to a 2015 upgrade of the software seems to have caused some issues highlighting some problems with GoA-2. The upgrade saw the rail control system updated from relay-based technology in which commands were coded on rails to a computer-based system which increased operational efficiency and capacity while maintaining safety. An objectively positive change, should it all have worked correctly; however, through a combination of an inexperienced driver, poor weather and the software not receiving the proper updates on the situation, the upgrade ultimately led to a train derailing and crashing into a wall.

As an investigation was launched into the issue, it was brought to light that the onboard software was known to not work within extended icy conditions, with a representative of Metrorex, the company that supplied the train involved in the incident stating:

> "*The train couldn't park because of the weather. It had to be parked outside, you couldn't park because of the ice. It may have been an incorrect maneuverer by the driver (…) I don't know (how experienced the locomotive driver is - ed.), But all the locomotive mechanics are experienced. I don't know (how long it will take them to get the train back in motion - ed.).*"
>
> (Șodolescu 2019) (Translated from Romanian)

Real-World Consequence

With the knowledge of past examples, it is reasonable to assume that this is an issue that we could blame on the "human factor" with drivers simply being unaccustomed to the software and its limitations. However, this would be premature as following further investigation it has been deemed a software issue by the Romanian Railway Investigation Agency (Leidig 2020) due to the ATP present within GoA-2 systems seizing control of the speed factor within the train due to a glitch caused by the poor weather conditions, an issue which is categorized as a structural one rather than an issue stemming from the driver. The lessons to be learned from this incident is both that drivers need more rigorous training before becoming acquainted with new software and that software must be ready for the scenarios in which it will be used and any extremes such as weather that it may encounter. Although GoA-2 serves to minimize the amount of work required by a driver, a manual override must be possible, and ATP must not have the final say (Leidig 2020).

Other similar events have taken place within GoA-2 metro systems throughout Europe's metro systems, however for the purposes of this paper it would be repeating points. The topic of modelling responsibility is not an easy one, it's impossible to say drivers are faultless, however there is sufficient evidence to suggest that the topic is not black and white.

2.2 Current Real-World Solutions

Since the failures of GoA-2 that have been presented, several specific solutions have been applied, often to ensure that the same problem doesn't happen twice. This is a desirable since it increases safety, is relatively cost effective and prevents recurrence of accidents with the same signature. However, it could be argued that this is not enough and that the fact these solutions were not implemented ahead of time shows a lack of critical understanding of the possible pitfalls within different grades of automation. It is still important to analyse the specific solutions and think of how they can help us to understand a more widespread and systematic one.

Passenger Report Buttons

In the event that any on-board protocol fails, drivers fail to note any anomalies such as in the Jubilee Line and Notting Hill Gate Incidents in 2018, passengers may take it upon themselves to cause a train to stop.

Year by year the number of alarm activations rises, despite the number of passenger journeys staying relatively stable. Indeed, 2019 actually had a 6% decline in railway usage compared to 2018 throughout all of Great Britain as shown in Fig. 7 (Gower 2021), meaning the 9% increase in emergency usage is implying either that passengers are getting more comfortable reporting issues or issues are becoming more commonplace. However, as discussed previously, the number of major incidents has been on a steady decline, but this has no real bearing on the usage of an emergency stop. There are reports of customers typically using the emergency stop button for smaller issues. There have been reports of passengers with bodily physical difficulties, such as the required use of a wheelchair using the emergency stop on a train to call for staff in order to assist them getting off the train, with one passenger telling the BBC "If I can't get off at my stop that's an emergency for me" and the Railways customer service representative declaring this a legitimate use of the emergency button, stating the company trusts passengers judgement in using the button (Rob-England 2020).

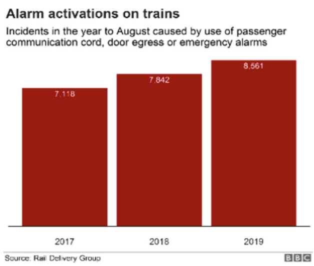

Fig. 7. (National Rail Delivery Group 2019)

As expected, 2020/21 saw a reduction in the total number of button presses compared to previous years, due to less people using the railway as shown in Fig. 8. However, the button presses per million passengers is up drastically. There could be several reasons behind this, but it is safe to assume that these results are anomalous and do not mean much for the purposes of reducing incident rates within GoA-2. It is not unreasonable to assume that, given a non-pandemic time, the alarm activation rate would have stayed steady (National Rail Delivery Group 2021). The purpose of the button is to help alleviate issues caused within GoA2 systems. At lower grades of automation there would always

	Period	Data / Results
Passenger Train Delay Incidents	2020/2021	6908
Passenger Train Delay Incidents	2021/2022	6952
Associated Passenger Train Delay minutes	2020/2021	129578
Associated Passenger Train Delay minutes	2021/2022	87563

Fig. 8. 2020/21 button usage (National Rail Delivery Group 2021)

be a staff member to help an individual with a wheelchair onto the station, for example, than within a higher grade of automation.

Aircraft Often Opting to Not Use Autoland Feature

Autoland as a feature has existed since 1937, being created by aircraft pioneers Captain Carl Crane, George Holloman and Raymond Stout (Larson 2012). However, the practise of using the feature is still not standard to this day for several reasons.

Software Not Fully Adaptable to All Forms of Weather

Much like the Bucharest 2019 metro incident, there have been cases in the past of aviation accidents caused partially by poor weather in which overcast clouds caused an auto-landing plane to crash onto grasslands near the landing zone (German Federal Bureau of Aircraft Accident Investigation 2011).

Causing Pilot Enjoyment to Dwindle

As shown within the open doorway incident within the London Underground, if a job becomes routine and unenjoyable there is a risk that the worker will enter a micro-sleep state while working. This is no different within air transport, with landing being one of the more difficult parts of the job, it is also the most engaging. Although the process can be automated, it seems counterintuitive to do so as, much like within rail, removing the more difficult parts of a pilot's job while still needing them in case of emergency can cause brainfog (Brandenburger and Naumann 2021).

Occasionally the Software Fails

Although piloting can theoretically be automated there are scenarios where the automation fails. Within these scenarios it is important that pilots can undertake the full extent of their jobs, else disaster may strike as it did within Asiana Airlines Flight 214, a flight in which crew had become dependent on autopilot to land and had gradually overtime forgotten their training and how to land at all, leading to several casualties (US National Transportation Safety Board 2013).

Complacency Within Aviation

Another irony within the working world is one of experience making workers less attentive, 'the better you get at work the less effort you put in to any given day' also known as complacency, a state of 'self-satisfaction with one's own performance coupled with an unawareness of danger, trouble' (Moray and Inagaki 2000). What all of this means is that overall as skill increases, less focus is needed to operate at average capacity. There has been some research into the overlap of complacency and over reliance on automation (Automation Bias) within aviation in which a link between the two was suggested stating that once experts (pilots) found an automated system to be reliable, they became complacent and allowed for their automation bias to take over (Parasuraman and Manzey 2010).

3 Synthesis

Using the knowledge of previous incidents, we now know the typical causes of most anomalies within GoA-2, so we are able to suggest methodologies to reduce the number of errors present and, hopefully, a methodology to better facilitate safe innovation within the rail industry. The key underlying factor with all examples of error in GoA-2 is the repetitiveness of a driver's task list combined with any negatives on the day (low blood sugar, lack of sleep etc.) which can lead to a driver easily getting distracted and switching to "auto-pilot" mode in which they enact their actions without sufficient thought. There are numerous ways to avoid this problem.

3.1 Solutions Within the Expansion of GoA-2

If the goal is to eventually get all rail to GoA-4, it is important to consider each step that will need to be taken in order to get there. If it is decided that GoA-2 is a necessary step towards total automation, it is important to consider its role. There is discussion to be had on expanding the definition of GoA-2 to reflect this transitionary period between the control being mostly in the drivers' hands in the case of GoA-1 and the system gaining more autonomy within GoA-3. This transitionary period could be used to identify potential issues within further automation, this process of identifying issues and applying solutions is sometimes called a "band-aid solution" the process of treating the symptoms of a problem instead of treating the cause. However, this is not necessarily bad if we think of GoA-2 as a transitionary period, it is important to learn from experience and ensure that accidents with a similar signature can be avoided within further automation.

The London Underground Jubilee incident, although unfortunate, serves as a perfect template for an expansion of automation. Currently GoA-2 systems use ATP in order to ensure trains operate at a safe speed and do not exceed the limits (Dave Keevill 2017). There is room for discussion whether ATP should include safety precautions related to doors, just as there is no reason why a locomotive should be allowed to speed, there is no reason the train should move with open doors. Within GoA-2 the job of opening and closing doors is a responsibility of the driver. GoA-2 technology is not reactive, meaning it cannot act autonomously regarding the irregular amount of time it will take for individuals to board from a platform, it cannot be suggested that GoA-2 should handle the opening and closing of doors, a driver will always be required to operate the doors within a GoA-2 system. However, in the cases where a driver makes a mistake and sets the train in motion with the doors still open, ATP should act as a backup and close the doors (or prevent movement) to ensure that incidents similar to that taken place on the London Underground Jubilee line cannot happen again.

3.2 Upgrading to GoA-3

GoA-3 typically operates with a Rail Operating Centre (ROC), an off-site location in which a single driver is responsible for the operation of numerous vehicles. This leads to both a higher intensity of work per individual and a lower overall number of staff needed than GoA-2, as each worker can be more specialized and each worker is more engaged in their job. A less repetitive environment leads to less worker fatigue, which leads to better work and less accidents, even if it causes a higher amount of stress for workers (Brandenburger and Naumann 2021).

While it would be simple to state that the most effective solution is simply to increase automation, that does not necessarily take into consideration the cost and scientific research required into so doing. Currently the usage of GoA 3 and 4 are very limited (UITP Observatory of Automated Metros 2018) so there is still much room for innovation, which leads to the question of whether or not we are even ready for increased automation; if we are to assume that the end goal is complete automation of railways then it would be reasonable to suggest that we should implement GoA-3 as soon as possible, something which is being discussed around the world already (Miller and Collet 2020). Costs of GoA-3 are higher initially than within other rail solutions (Zhou 2016) but the staff reductions could result in a much lower management and training cost, meaning lower costs in the long run, especially with the ever-increasing cost for labour. This, however, raises several questions about labour ethics and the discussion to be had with unions, topics which are out of scope for this discussion.

3.3 Decrease of Automation

If upgrading to GoA-3 is not an option, the reasonable suggestion is to rethink automation and how it is handled. Within GoA-2 the driver is acting as an assistant to the overall system, when naturally it seems safer if the roles were to be reversed. A GoA-2 system cannot detect anomalies, yet it is the one in control of acceleration and braking. There is an important question to be asked, are we giving control to a system that is not yet ready, if the driver needs to be within the cabin anyway, why not simply have them provide train operation? It is possible to put the driver back in control and give them the more stimulating job of acceleration and braking and simply have the GoA-2 system as a backup in case of emergency, in order to avoid events such as the Jubilee Incident, as well as taking advantage of the speed regulation and other features of ATP. Communication with other rolling stock is also a feature of GoA-2 which provides ATS given an incident that the driver could not have known about. Drivers within GoA-2 systems have less responsibility than drivers in GoA-1/unautomated systems, they do not have to maintain acceleration or pull into stations, it seems only natural to assume that economically this will mean that the drivers are cheaper. However, this is not the case, costs for a driver who operates the London Underground, using a GoA-2 system are no lower than drivers in an unautomated rail (Glassdoor 2021), the drivers still need to be trained for all scenarios in case the ATO fails.

If there are issues with GoA-2 from both an engineering and an economic standpoint there is discussion to be had about the definition of GoA-2. Currently a goal of railway innovation is the normalization of GoA-4 within passenger rails (Shift2Rail EU 2019) so it is important to ask if the current iteration of GoA-2 is an inevitable part of that journey or, if until automation gets to the point where it can run autonomously, it should take a back-seat and run in a limited capacity.

4 Conclusion

This paper presents a preliminary discussion on the topic of making work easier, with respect to introduction of automation on the railways. It poses the question of that being a good thing in the first place and more specifically it discusses the failure rate of work that is boring against work that is more challenging hence more engaging. Common beliefs would suggest that easier work will yield better results with less errors, however evidence suggests that is not the case. Although more research is required into just how much monotonous tasks within GoA-2 can lead to brainfog/microsleeping and it would be immature to suggest that the entire scope has been covered, it is safe to say that there is a link and to simply call each example "Human Error" is incorrect. Current safety precautions such as placing some responsibility on the consumer through an emergency button are effective in harm reduction however are more fixing the symptoms rather than fixing the cause. The most effective overall solution would be to simply increase the amount of automation and attempt to get to GoA-3 as soon as possible. However, until that time arrives, it would be useful to re-examine GoA-2's role in the future of railway automation. There is an irony of innovation, it is possible that a scientific breakthrough can happen but cannot be applied yet because the surrounding systems are not yet ready for it. Within piloting, although automated landing exists it is not commonplace because if you have a pilot in the cockpit, there is little-to-no reason for them not be the ones to land. Is this not the same within GoA-2, the driver is in the cab, what purpose is there to not have them drive? GoA-2 is in a sort of 'uncanny valley', meaning the automation is developed enough that it has surpassed being a novelty and somewhat demands respect; the train can move autonomously but also it has not developed to the point where it can be considered autonomous. Just because GoA-2 systems can be implemented doesn't necessarily mean they should. Thus, there is a discussion to be had on the overall need for, and definition of, GoA-2 within rail.

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