Mind the Gap! Can achieving green and efficient rail travel, with a focus on passenger experience, be effectively delivered through service-based contracts?

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Abstract. Urban population growth means that 66% of the population is expected to live in cities by 2050. A green, efficient rail service that minimizes delays, increases capacity and reduces overcrowding on trains and platforms will be an essential contributor to nations' post-Covid, green recovery. Digitally Enhanced Advanced Services (DEAS) are one way to help improve performance, maximize productive capacity and open additional revenue streams. Therefore, investigations are needed into how digital technologies can enhance business model design, thus impacting how business capabilities, engineering functions and human factors can be combined to improve performance and user experience within rail transport systems. This paper explores how deploying green and energy efficient rail travel as a DEAS could be an ideal solution to bridge the gap between efficiency and capacity. We also consider how service-based contracts may enable user experience to be put at the forefront of post-Covid rail services.

Keywords: Servitization· Green rail services · Digitally Enhanced Advanced Services (DEAS) · Service-based contracts · Semi-structured interviews

1 Introduction

Urban population growth means that 66% of the population is expected to live in cities by 2050. The 2019 Williams Rail Review [1] proposes that rail will be key for the efficient movement of people living in urban areas. Recent advances in technology and investments in infrastructure has enabled the UK rail industry to increase volume, improve visibility and adjust to variation of demand. However, whilst improvements have been made, delays and lost customer hours still increased by over one-third (or 7.2m hours) between April and November 2019 (26.6m) compared to the corresponding period in 2018 (19.4m) on the London Underground alone [2]. Given demand is

[*] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames (first name then last name). This determines the structure of the names in the running heads and the author index.

(or was) projected to increase further and volume increases directly affecting train punctuality [3], work is needed to improve the system performance of the rail networks, above and below ground. A green, efficient rail service that minimizes delays, increases capacity and reduces overcrowding on trains and platforms will be an essential contributor to nations Post-Covid, green recovery.

Digitally Enhanced Advanced Services (DEAS) are one way to help improve performance, maximize productive capacity and open additional revenue streams. This can be achieved by shifting the focus from the sale of a product, to its capabilities in use – in this way, providing customers with their desired 'outcomes'. This signifies a major change in how firms earn money and is being enabled by transformative digital technologies. The impact of these changes is in firm productivity and using digital technologies to transform the value of the output – which also lies at the center of the sustainability argument. Reducing resource usage requires aligning incentivizes of producers and users in use-based contracts and is fast emerging as the only viable business model to achieve that goal [4]. An important consideration for this paper is how customer data can be used to design personalized products or services, as identified in [5] this is an important future research direction for the servitization domain.

There are limited examples of DEAS within the rail industry, Alstom's availability contract with Virgin's West Coast mainline is one, where Alstom is contracted to present 51 viable trains to Virgin every morning and ensure these are available for 18 hours per day. Trains have to be clean and have all customer-facing features (such as toilets and catering) in working order. Alstom is paid on the basis of pence per mile traveled by trains, and since they take on the risk of technical failures, it receives penalties if trains are delayed or canceled due to technical or maintenance problems [6].

Therefore, investigations are needed into how digital technologies can enhance business model design, impacting how business capabilities, engineering functions and human factors can be combined to improve performance and experience with rail transport systems. This paper explores how deploying green and energy efficient rail travel as a DEAS could be an ideal solution to bridge the gap between efficiency and capacity. We also consider how service-based contracts may enable user experience to be put at the forefront of post-Covid rail services.

GreenTechCo [a pseudonym for our case organization] have a product called 'Green CBTC' (Communications-Based Train Control), which is suggested to optimize the acceleration and deceleration (in order to maximize regenerative braking) of a train, resulting in up to 15% less energy consumption, reduced heat generation and offering the passenger a smoother ride. Similar results and reductions are observed in the automotive domain where a smooth speed profiles (facilitated through a lower standard deviation of speed) lead to significant energy savings [7]. Within the rail network this can be achieved by real-time monitoring, feedback and predictions on the way the trains use energy, both through Train Managements Systems (TMS) and in-cab driver feedback. A key difference is that Green CBTC monitors energy efficiency for all trains in its system (i.e. on a specific train line), rather than individual trains, and hence delivers greater system efficiency. According to the simulation results by [8], using Beijing as a real-world use case, compared to the traditional systems the Green CBTC system can reduce energy consumption significantly and improve the utilization rate of regenerative braking. Resulting in cost savings of 9.94% (or $280k USD) and saving 2.3m kWh.

We know major infrastructure projects are expensive, and rail is no exception to this, in fact the added complexities of conducting building work underground only increase these complexities. Transport for London (TfL) has allocated £5.4bn for the 'Four lines modernization programme', which is the largest single upgrade in the history of the London Underground network [9]. Whilst an infrastructure upgrade of this size would be outside of scope for delivering via service-based contracts, components of the upgrades *could* be within scope. For example, the £760m contract awarded to upgrade signaling on the four lines could have been awarded based on Key Performance Indicators (KPIs) such as increased capacity, reduced delays, or even increases in customer satisfaction.

This research is being conducted to better understand the Human Factors along with the facilitators and barriers to the implementation of such green services, and how new business models could help achieve the carbon reduction needed by offering digital service through new service-based contracts which are delivered against energy savings.

2 Methodology

In order to understand how the implementation of servitization-based contract may work within the use case of Green CBTC, semi-structured interviews were conducted with six individuals experienced with implementing, managing or maintaining innovation and digital services within both mainline and underground rail services. Two rounds of interviews were conducted with five out of six participants, totaling 11 separate interviews with an average duration of just over 51 minutes per interview.

Questions were piloted internally as part of the project, with the final set of interview questions, relevant to this paper, listed below.

- Describe your formal position, role, and how involved you are with signaling and traffic management services provided for the main line and/or the London Underground?
- What products or services related to signaling and traffic management do you currently offer on the mainline and what are the future aspirations toward service implementation in these areas?
    - How are these delivered?
- What products services related to signaling and traffic management do you currently offer on the London Underground and what are the future aspirations toward service implementation in these areas?
    - How are these delivered?
- Can you talk us through the Green CBTC for the London Underground?
- Could you describe what services you think could be provided with this CBTC system on the Underground?
- And for both mainline and the underground, can you describe to me what your customers' business goals are, and the nature and role of operations in relation to the business goals?

Within this paper, the focus of the analysis from the interviews was from the Human Factors perspective, focusing on the perceptions people within the system rather than the technology and business model innovations. Hence, only this relevant subset of the data were analyzed and discussed as per Table 1.

Table 1. Outline of the data collection process and theme definition.

Steps	Process description
Preparation for field-work	Review of the relevant literature Initial meeting with project champion to familiarise with the case organisation and discuss data collection Creation of interview protocol based on the literature
Familiarising our-selves with the data	Interviews transcribed verbatim by third-party transcription service Transcripts are read by the lead researcher to ensure accuracy of the transcripts Transcripts re-read several times to familiarise the re-searcher with the data Notes made on the transcript to capture initial thoughts.
Generating initial codes	Relevant data across the entire dataset were allocated codes
Defining and naming themes and sub-themes	Coded data within each theme and sub-theme were re-read and checked, helping to refine themes and sub-themes and the overall story told by the analysis Clear definitions and names for each theme and sub-theme were derived
Production of the output	Analysis was written up to allow for meaningful representations of the analysis to be presented Final checks and refinements to the analysis were applied follow-ing feedback

3 Results and Discussion

Data from the interviews were analyzed as per Table 1, with 56 sub-themes identified. These were grouped into seven main themes:

1. Unfamiliarity with service-based business models (11 sub-themes identified)
2. Familiarity with capital expenditure business models (6)
3. Benefits to the Customer of service-based business models (14)
4. Risks to the technology developer of service-based business models (3)
5. Upselling opportunities or secondary benefits (7)
6. System and operational benefits of Green CBTC (9)
7. End-User Expectations (6)

3.1 New and old business models collide

The first two sub-themes outline decision makers perceived reluctance to engage in unfamiliar business models and stick with the ‘tried and trusted’ capital expenditure models that the current rail network has been, literally, built on. There was also a

strong implication that the lack of maturity in the service-based business models and the 'fear-of-missing-out' on big savings at a later date were also holding back the uptake of service-based contracts. Participant 4 suggests '*They can see the benefit, but they are just scared that they sign up to something that they get ripped off and, and they give away huge amounts of savings to a third party*', and '*So we've got the technology and haven't got the right model or maturity to get a contract in place*'. This is further highlighted by P7 who states '*Are we necessarily ready for a service based solution to something that once upon a time, we would have sold as a box. Yeah, and I don't think I don't think we are ready and neither is the customer yet*'.

Interestingly there seems a willingness to work within the limitations of the old capital expenditure business models, despite as we know projects often run over time and budget. P1 suggests *'...you know people like doing things how they've always done*', and P2 '*So we put a system in … and it's very complex, and the operation requirements are extremely complex. So then you say well okay we've got a system then and it takes sometimes two or three years to bed the system in and get it working correctly to meet all their operational requirements*'.

Despite the initial reluctance, there is a way to demonstrate the potential benefits to the rail operator, and this is by taking a data driven approach and demonstrating the saving that can be made in both cost but also energy savings. P1 states *'… they're saying, well, you need to demonstrate the benefit*', and '*I'm used to purchasing from a capex perspective, now you want to sell me a really long term service … what value are you adding to me over the longer term*'.

3.2 Buy now, don't pay later

There is the potential with new business models that no money has to change hands for a service to be provided on the proviso of a proportion of the costs savings are paid once the service is up and running. This has great potential as P1 states '*So that fits perfectly for [end customer] at the moment, given budget constraints. You know, it's a service that they don't have to find the money for basically*', and P3 '*And then we actually implement the system … Right up to that point, the customer hasn't paid any money*'. This does however shift the risk from the train operation to the technology supplier as P1 indicates '*So obviously this is where it's a challenge (as for capital expenditure projects) we don't have negative cash flow, but (for service based contracts) we will have a negative cash flow development phase*'. Another risk is that a really good baseline performance needs to be established as KPIs are calculated from this current performance, this presents a challenge as P4 suggests '*So one of the issues that we're having, is the fact that they can't meter the energy, so it can't simply demonstrate the saving'*.

It was highlighted by the interviewees that there also exists the opportunity to 'upsell' to the customer, once existing services are delivered. Even if there is a resistance in moving completely to service based contracts for aspects like signaling infrastructure (for example), the opportunity to offer additional services as an add on was highlighted. P4 states '*Coasting that's your biggest bang for the buck, you're going to get 70% of your benefit out of coasting. Now regen might give you another 10 or 20% on top of that*', following up with '*And there could be an additional fee to*

bring regen into it but I'm saying, if I can demonstrate to you that regen will even push it to the next level then you must be incentivized to take regen as well'.

3.3 Managing end-user expectations

An important issue that was highlighted by our interviewees was how the implementation of Green CBTC would be received by the end-user, which on this occasion are rail passengers. Previous implementations of coasting had been perceived negatively by passengers with P4 experience suggesting '*So I've worked on a system that does this in a previous life and in another city, in [city] and customers got quite unhappy because we were afraid to slow the trains down a lot*', following up later with '*And the customer, we got customer feedback to see what on earth is going on, why are the trains creeping along here*'. However the actual impact on journey times is negligible.

There are also other benefits to the end-user, as the system minimizes trains stopping in tunnels or underground, with P1 suggesting '*I think even as a passenger, if you're stopped on the road in your car it's frustrating but if you're moving at 10 or 20 miles an hour you feel better don't you so it's better for the passengers, at least if the trains are still moving, and from a user perspective*'. Another secondary benefit of Green CBTC to the end-user is improved thermal comfort, as coasting can reduce heat generating by unnecessary braking. P1 highlights this issue by saying '*So, the trains through the braking, and just the heat generated by the train etc. and the people on the train is continually adding heat into the tunnels*'.

3.4 Changing KPIs to focus on improving user experience

Traditional infrastructure build (or capital expenditure) projects typically have just two Key Performance Indicators, or KPIs, these are was it on time and to budget. Much of the discussion about the introduction of service-based contracts, including the exemplar agreement between Virgin and Alstom, is around guaranteeing train availability or capacity, or energy reduction. However, of even more importance in a post-Covid pandemic world could be around user experience and satisfaction. Research conducted has shown a 50% increase (from 8 to 12%) among 1200 questionnaire respondents who said they would never consider using public transport post pandemic [10]. Hence the previous need to continually increase capacity may, in the short term at least, make way for increased personalization by using adaptive, on-demand timetabling, or improving passenger experience by having user-focused KPIs such as improving passenger thermal comfort or providing a smoother train ride.

4 Conclusion

Service based contracts, enabled through Digitally Enhanced Advanced Services (DEAS), have great potential to deliver green and efficient rail travel as energy (and hence cost) savings could be used to offset the initial high infrastructure costs. However, challenges exist which are both technical (e.g. setting an accurate benchmark to compare performance against) and human (e.g. skepticism in new business models).

Conversely, in order to encourage people back onto public transport post Covid-pandemic increasing capacity is not needed, but improving passenger experience may entice people out of their cars (which least we forget by 2025 will be zero emission capable) back onto trains. Service based contracts with a focus on delivering customer experience have huge potential, and may well be the best way in achieving this transition back to public transport in the future.

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