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How automation impacts worker ecosystems in organizations: A case study of autonomous bus operations at an international airport

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Abstract: Organizations are increasingly immersed in automation programs aimed at enhancing operational efficiency, yet these initiatives fundamentally impact and reshape traditional workplaces. Prior research has examined automation's effects on workers who directly interact with it, but less attention has been given to how broader worker ecosystems are impacted. To address this gap, we investigate an autonomous shuttle bus project at an international airport. We conduct an interview study with nine external experts holding prior experience in similar automation contexts. To engage participants in discussing the impacts of a future autonomous bus operation, we utilize systemic design as a lens and conduct co-design activities with them. Our findings surface key tasks, responsibilities, scenarios, and implementation considerations that affect workers within the broader ecosystem. Through this empirical case, we intend to move beyond techno-centric approaches to automation and illustrate the value of incorporating systemic perspectives in worker-centered automation efforts.

Keywords: automation; workers; systemic design; organizations

1. Introduction

In recent years, in line with the evolution of Artificial Intelligence (AI), a growing number of organizations are immersed in automation programs. These are framed and planned as long-term transformations aimed at ultimately integrating automation technologies¹ into routine organizational processes. Through automation, organizations expect to enhance their operational efficiency (Källbäcker et al., 2025), increase process reliability (Amaldi & Smoker, 2012; Chu et al., 2023), improve employees' working conditions (Baur & Iles, 2023) by eliminating “dirty, dull, and dangerous” tasks (Ivanov et al., 2023), or address labor shortages (Wang et al., 2019), among other benefits.

¹ In this paper, we use “automation” and “automated operations” as umbrella terms for AI-enabled systems that partially or fully transfer manual work from humans to machines within organizations.



Within these automation programs, organizations tend to focus primarily on the maturity and feasibility of available automation technologies and their gradual implementation in-context, an orientation that prior studies have characterized as overly technology-centered (Gamkrelidze et al., 2024; Gomez-Beldarrain et al., 2024). Prior works emphasize that automation also implies a major transformation for traditional workplaces (Hancock, 2025; Roto, 2024), since workers experience a shift in their roles, tasks, and overall value when required to work alongside autonomous technologies or see their jobs taken over by machines (Moradi & Levy, 2020). In that regard, design and HCI scholars warn about unexpected, new, and invisible work workers need to engage with (Delfanti & Frey, 2021; Fox et al., 2023; Montiel Valle & Shorey, 2024), and call for worker-centered research (Fox et al., 2020) to study the impacts, harms, and paradoxical effects of automation on workers in-the-loop (Bainbridge, 1983; Strauch, 2018).

Building on these worker-centered works and inspired by Kim et al. (2024), this paper is based on the premise that automation may impact not only the workers directly involved with it but also those within the broader ecosystem. While Kim et al. (2024) illustrate this in the context of municipal building departments, where the introduction of new technology (in their case, an online platform) impacted not only public sector employees but also diverse actors surrounding the department (e.g., local business owners), their approach is applicable to the context of automation in organizations, where these broader systemic impacts are often overlooked. We argue that this might further amplify automation's harm within organizations, and hence see a need to further explore this phenomenon and reflect on how these systemic impacts of automation could be considered during automation projects.

To do so, we specifically focus on a concrete, real-life case: the deployment of an automated shuttle bus in the airside of an international airport, Amsterdam Airport Schiphol, aimed at automating current boarding and deboarding procedures for transporting passengers between gates and parked aircrafts. Currently, this process not only involves bus drivers, but also actors such as bus coordinators, bus directors, and airline crews as part of the wider ecosystem. We draw on systemic design as a lens (Jones, 2014; van der Bijl-Brouwer & Malcolm, 2020), not only to map the multiple non-driver roles and tasks that currently ensure smooth bus operations, but also to guide our inquiry and support systemic sense-making. We aim to address the following research question:

What impacts arise in worker ecosystems from the implementation of autonomous shuttle bus operations in an airport's airside?

2. Background

2.1 *Worker-centered automation in organizational settings*

Prior research critiques the predominance of techno-centric approaches to automation in organizational settings, which primarily focus on the maturity, feasibility, and technical development of solutions (Baur & Iles, 2023; Gamkrelidze et al., 2024). Such approaches are often rooted in myths and full automation imaginaries (Bradshaw et al., 2013; Riek & Irani, 2025; Gomez-Beldarrain et al., 2025) and suffer from mismatches between developers' conception of workers' practices and the realities of work (Akridge et al., 2024; Riek & Irani, 2025; Joo et al., 2024). As a consequence, workers' jobs and working conditions are affected in various forms such as patchwork –additional work of calibration, troubleshooting, and repair required to support AI technologies over time (Fox et al., 2023) or extend machinery's reach (Delfanti & Frey, 2021)– skill degradation (Rinta-Kahila et al., 2023), or misplaced responsibilities (Shukla et al., 2025).

To address those issues, several scholars advocate for worker-centered approaches to the development of automation (Fox et al., 2020). Beyond the technical feasibility of systems, these approaches also consider improvements in job quality (Spektor et al., 2023a) and employee well-being (Roto et al., 2019), seek to counter imbalances caused by the introduction of technology (Elish & Watkins, 2020), and emphasize the need to define human roles with detail and care (Akridge et al., 2024; Gomez-Beldarrain et al., 2025). Several case studies document worker-centered design examples for AI and automation applications. For example, Spektor et al. (2023b) report the design of an algorithmic room assignment system based on ideas generated by guest room attendants, and Uhde et al. (2021) describe the design of a well-being-oriented automated self-scheduling system, which gives healthcare workers more control during shift planning. Overall, authors emphasize the need for participatory approaches that involve workers' opinions, needs, and experiences in the design of automation (Akridge et al., 2024; Chu et al., 2023), support transparent deployment procedures (Spektor et al., 2023a), and, once implemented, create methods and tools for on-going evaluation and iteration (Heikkila et al., 2024).

Nevertheless, fewer studies consider the wider ecosystem of workers affected by automation. In this regard, our work draws on Kim et al. (2024), who highlight that the adoption of new technologies affects not only a single, directly involved employee group, but also the wider ecosystem. In their case, they examined how the adoption of an online portal, aimed at digitalizing in-person communication and administrative tasks in municipal building departments, affected the work of a wider array of stakeholders, including local business owners, construction experts, community representatives, and department employees. Their findings revealed a multifaceted experience with the technology, as well as challenges in meeting the needs of public service actors. The authors advocate for technology design that enables the engagement of all constituents (i.e., actors in the wider ecosystem). Our study aims to bring this systemic perspective into the worker-centered automation domain, to anticipate effects on worker ecosystems and identify relevant considerations for organizations.

2.2 Utilizing systemic design as a lens to study impacts in worker ecosystems

To address the gap we present in this paper, where we aim to investigate how automation would impact worker ecosystems surrounding shuttle bus operations in an airport, we draw inspiration from systemic design approaches (Jones, 2014; van der Bijl-Brouwer & Malcolm, 2020), particularly from prior works using systemic design to address organizational transformations (Rosini and Barbero, 2022).

Systemic design originates from integrating systems theories and practices with design theories and practices, and it studies design's role in transformative change (van der Bijl-Brouwer et al., 2024). According to Rosini and Barbero (2022), the main characteristic of systemic design is a holistic approach to problems, as well as the capability of dealing with complex systems through identifying them, producing comprehensive mappings, defining boundaries, conducting analysis into their different problems, and recognizing opportunities for change. Two types of systemic design are distinguished by The UK Design Council (2021), namely, system-conscious design (i.e., analyzing the systemic side-effects of products and services) and system-shifting design (i.e., shifting systems into a desired direction through interventions).

Regarding systemic design practices, van der Bijl-Brouwer et al. (2024) distinguish three main categories, two of which are derived from existing literature, with the third introduced in their study for complementing them. We detail them below:

1. Making sense of complex contexts by *generating systemic visualizations*, which are later used as sense-making and inspiration sources for design processes;
2. '*Designing from within*', perceiving systems as being continuously and collectively redesigned from the inside out by system stakeholders;
3. '*Systemic design reasoning*', combining a pluralistic perspective on systems change with design reasoning practices to develop *systemic design rationales*, which support the design of systemic interventions.

In our work, we study a complex organizational operation (i.e., passenger transportation in an international airport), to examine how the workforce around it would be impacted when implementing automated shuttle buses. We therefore are taking a *system-conscious* approach to the design of the process (The UK Design Council, 2021). Regarding systemic design practices, we mostly engage with generating systemic visualizations for making sense of the complexity of the context and issue at hand; specifically, we a) conduct a field research to identify and understand relevant worker groups constituting the ecosystem, b) create sensitizing materials (i.e., a video and a stakeholder map) to convey this information to external experts, and c) co-design a future system with those experts, where they shared their knowledge about workforce implications we should take into account in our context. We discuss how future works could translate these initial efforts into system-shifting design objectives, which could make use of collective '*designing from within*' practices with workers and relevant airport stakeholders, supported by '*systemic design rationales*'.

3. The case: autonomous bus operations in an international airport

As part of the Autonomous Airside Operations program, Amsterdam Airport Schiphol aims to automate the bus operation that currently facilitates distant boarding and deboarding procedures on the airside. The organization envisions the autonomous bus operation as one where autonomous, driverless vehicles would pick up travellers at a terminal gate and would transport them to their aircraft, or inversely, would bring passengers from an incoming aircraft to the terminal. Note that the airside is the external, security-restricted area of an airport terminal dedicated to aircraft operations and the supporting ground operations (including baggage, passenger, and resource flows) (Airport Consulting Partners, 2024). As such, it is a unique environment where safety restrictions and standardization make automation adoption particularly difficult. Currently, the project is at its initial stage; the airport is closely working with a supplier of autonomous shuttle vehicles to conduct various technology readiness and acceptance tests in-context.

Currently, several worker groups are involved in manual bus processes:

- **Bus drivers:** they drive, accompany, and assist passengers during rides;
- **Bus coordinators:** they support and manage bus drivers from the terminal, by requesting additional buses if needed or taking care of missing items that are left behind by passengers;
- **Bus directors:** they oversee the entire operation and schedule buses and drivers in advance;
- **Airline staff:** they wait for the buses, welcome passengers on board, and assist them with any needs.

The extent to which these roles will change or be affected by the implementation of autonomous shuttle buses is still unclear. As a pre-study, we conducted various shadowing sessions with these stakeholders not only to understand the airside context, but also to map their daily tasks, current relations and communication means, as well as to create support materials for the expert interviews.

4. Research approach: expert interviews

Following the aim of identifying the impacts of autonomous shuttle bus operations on worker ecosystems, we conducted interviews with nine experts holding prior experience in automation projects in contexts similar to the one studied here, namely the automation of transportation systems. We considered those experiences to be very suitable for our research aim, since automation projects have longer trajectories in other mobility sectors, such as the railway and port sectors, yet share with airports the characteristics of high regulation and complex stakeholder networks. Overall, our aim was to bring in knowledge from those domains to our own, inspired by the *'outside-in'* innovation concept (Bagherzadeh et al., 2020; Carlsson et al., 2011).

4.1 Participants

We recruited domain experts through purposive sampling (Patton, 2015), where we invited professionals from various mobility contexts with experience in either strategic or implementation roles within organizational automation transitions. The recruitment followed a combination of direct contact and snowball sampling (Patton, 2015). After nine interviews were conducted, the data failed to bring in new themes, and we stopped recruiting further participants. The final subset of participants is shown in Table 1.

Table 1 Overview of the participants of the interview study. We include their roles, organization type they belong to, and years of experience.

Participant ID	Role	Organisation type	Experience (years)
P1	Solution architect	Airport	21-30
P2	Advisor smart and green mobility	Municipality	11-20
P3	Founder	Public-private partnership organization	0-10
P4	Head of R&D	Autonomous bus manufacturer	0-10
P5	Program manager smart mobility	Harbour	+30
P6	Founder	Autonomous bus start-up	21-30
P7	Team lead sales engineer	Autonomous bus manufacturer	0-10
P8	Business developer	Autonomous bus manufacturer	11-20
P9	Advisor smart public mobility	Consultancy	+30

4.2 Procedure and support materials

The interview procedure and study set up were approved by the Human Research Ethics Committee of our university (ID: 3882). Informed by the pre-study, we created a semi-structured interview guide and prepared all necessary probing materials to introduce our context to the experts. Via email, we requested written consent from participants to record the interviews.

The interviews were conducted by the second author in either Dutch or in English, lasted 46 minutes on average (ranging between 30 and 60 minutes) and were audio-recorded. All interviews were held online, following the preference of each participant.

After an introduction of the research purpose by the interviewer, the participants were asked to introduce themselves as well as their experience in automation-related organizational transformations. The remaining of the interview was organized in three main blocks, where participants engaged with different probing materials (see below):

0. Introduction of the research and participants;

1. **Prior experience** – As an introduction to the topic, we asked the experts about their perspectives on the future operator role in autonomous bus systems and how this differs from the current role;
2. **Sensitization: airside context** – To sensitize the participants to the airside context and to inquire about their perceived opportunities and challenges of an autonomous bus system, two prompts were used. First, a video showed the main tasks of the human operators within the current manual bus system (i.e., bus driver, bus coordinator, and bus director). The video was created by the research team, through the compilation of clips from the airport's publications (see Figure 1). Second, we used a stakeholder map (Figure 2), illustrating current relationships between stakeholders in the provision of the bus service;
3. **Co-designing an autonomous bus system and discussing systemic considerations** – The third part of the interview was dedicated to the co-design of a future bus system within the airside, where autonomous shuttle buses would be operating. We inquired the experts about where in the system humans would be needed, as well as what their tasks, responsibilities, and interactions with the bus system would be. In this part, we used an empty template of a stakeholder map (Figure 3) to outline the roles and interactions in the future, co-designed system. The main researcher shared their screen and completed the template with participants' input. The template was later used to guide the discussion, where participants highlighted scenarios that need to be considered, as well as how automation transitions happen in organizational settings.

4.3 Data analysis

We transcribed and anonymized all interviews, collected the filled-in templates that resulted from the third block of the interviews, and familiarized ourselves with the data.

We used a reflexive thematic analysis approach (Braun & Clarke, 2021) to analyse the data. The second author open-coded all data, by focusing on the parts where experts would point at impacts that resulted from such an automation transition, including new tasks, responsibilities, and roles that humans in the ecosystem would need to carry in autonomous bus operations, new scenarios that organizations need to be ready for, or explanations related to how such implementations unfold. Later, both the first and second author grouped the initial open codes, in various rounds, which resulted in the creation of themes and sub-themes. Afterwards, the first author went through the themes again to look for further patterns and relations among the themes. After discussing, iterating, and refining those themes, in the following section we present the resulting categories.

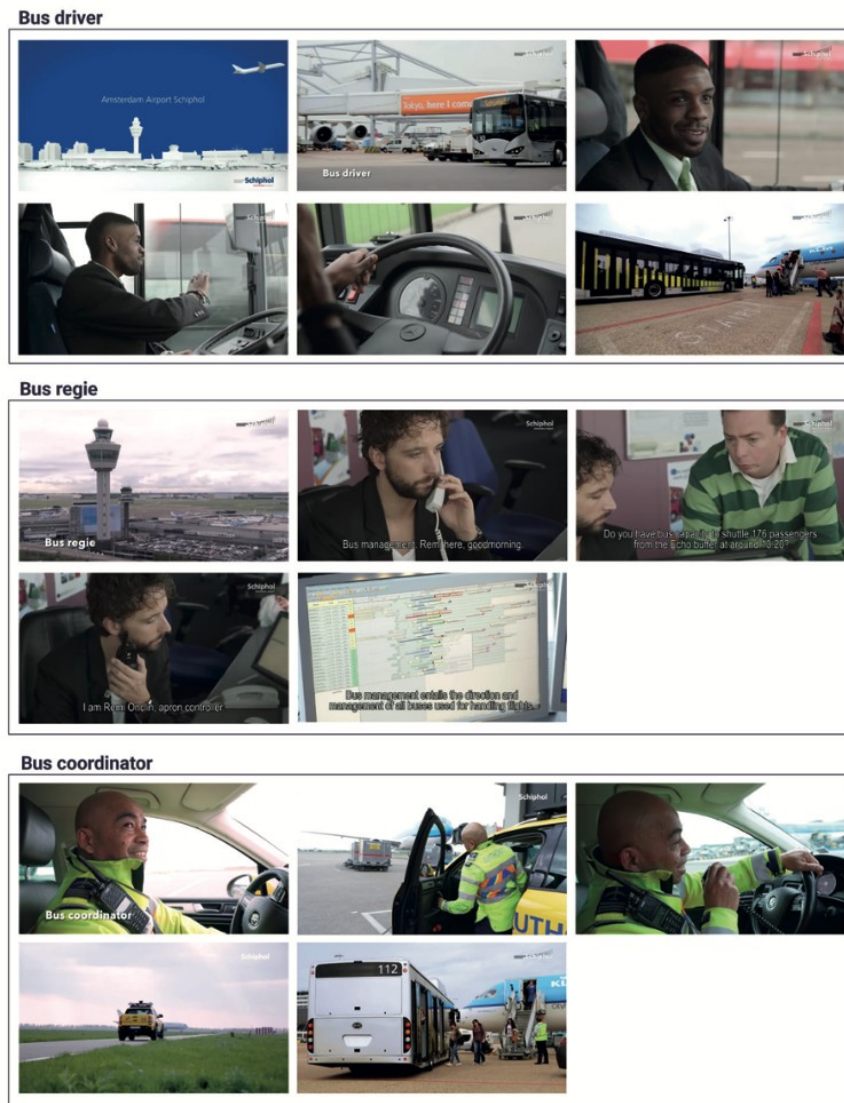


Figure 1 Frames of the video shown to the participants in the first block of the interviews. The video compiles clips from Amsterdam Airport Schiphol's publications and presents the current tasks of the main stakeholders involved in the manual bus service.

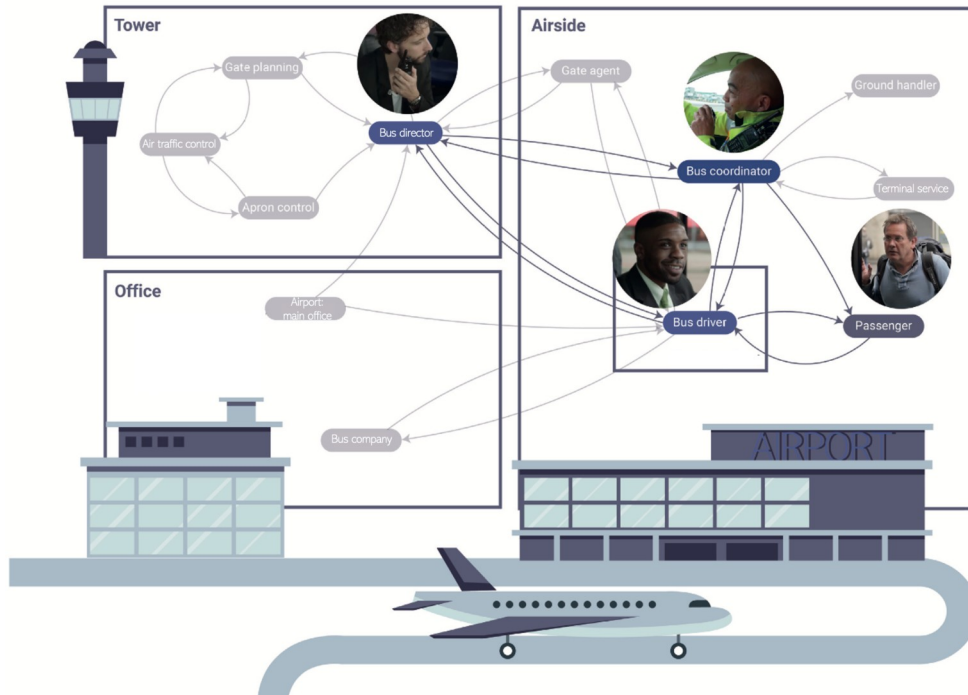


Figure 2 Stakeholder map illustrating the relationships between stakeholders in the provision of the current bus service. This map was used as part of the sensitization exercise conducted with participants (block 2).

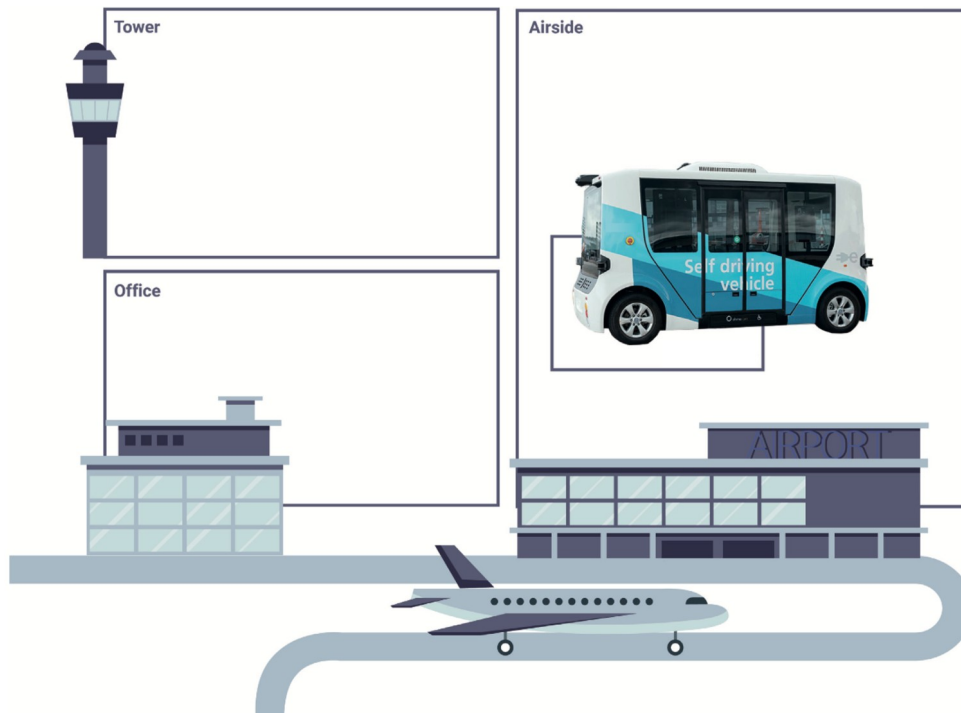


Figure 3 Empty template for a stakeholder map, used during the third block of the interview to co-design a future bus system, visualize the roles and interactions among stakeholders, and guide the discussion with the participants.

5. Results

Through the analysis of the interviews, we identified impacts on the wider worker ecosystem emerging from the automation of bus operations in the airside, in the form of new scenarios, tasks, and responsibilities, and considerations related to the gradual implementation of automation.

5.1 Emerging scenarios, tasks, and responsibilities for ecosystem workers

We present four main categories of tasks and responsibilities that, according to the experts, workers in the ecosystem would need to assume following the elimination of driver roles in autonomous shuttle bus operations (see an overview in Table 2). To support their reasoning, the experts often associated these tasks and responsibilities with potential scenarios.

Table 2 Overview of the emerging tasks and responsibilities that workers in the wider ecosystem would need to assume in autonomous shuttle bus operations

Themes	Examples of tasks and responsibilities
Supporting smooth boarding and deboarding operations	<i>Resolving malfunctions, ensuring that buses are emptied, clean, and well-maintained; conducting rutinary engineering inspections; supervising the bus operation</i>
Intervening in case of an emergency	<i>Assessing emergency situations; making key decisions; being familiar with different emergency protocols</i>
Enhancing passenger experience	<i>Supporting passengers; assisting their specific needs; answering their questions</i>
Controlling passenger behavior	<i>Monitoring passenger behavior</i>

Supporting smooth boarding and deboarding operations

Participants noted that on-site human support will remain essential for smooth boarding and deboarding, as some current driver responsibilities will still require human handling. First, experts emphasized that human workers would *resolve malfunctions* that might arise to the bus; they cited examples such as bus resets (P2, P5) and the removal of road barriers (P8). Those malfunctions result both from the limitations of the technology and the airside environment itself, as it is one where different actors coexist and has intensive traffic (P6) and debris (P3, P8). Second, human operators would *ensure that buses are emptied, clean, and well-maintained*. In the envisioned scenarios, autonomous systems were unable to solve recurring issues such as cleaning when the bus became dirty, thus needing manual back-up processes to handle occasional passenger-caused dirt. Besides, forgotten luggage must also be retrieved (P9), which is a task that should fall on humans. Finally, participants emphasized the relevance of *on-site engineering*. Engineers should be responsible for rutinary, “daily”, inspections of autonomous shuttles, including minor maintenance tasks and software updates. Some participants questioned whether these responsibilities could eventually be delegated to cameras and sensors.

Beyond on-site support, all experts stressed the need for human *supervision of the bus operation*. This would preferably be located in a control room; participants mentioned that it is not possible to simultaneously monitor all aspects of the system, but suggested alert-based notifications to enable timely intervention during emergencies (see next section), as explained by P8:

“In tram systems, they have someone behind the screen making decisions and checking that everything is OK. That will be the same for us [autonomous shuttle manufacturer]. No one on board, but someone behind the screen taking care of several shuttles and maybe making a go-no-go decision.” (P8)

Participants mentioned that while supervision could occur remotely, *remote operation* was instead seen as risky because of solely relying on cameras for driving tasks. However, limited remote functions (e.g., braking, acceleration, or parking) could remain an option.

Intervening in case of an emergency

In an emergency, unexpected incidents around autonomous shuttles would require immediate, predefined airport response, underscoring the critical role of human intervention.

First, a human operator must *assess the situation*, understanding both the context of the problem as well as its underlying causes. The experts agreed that human operators should remain in charge of *making key decisions*, such as opening bus doors, selecting protocols, dispatching operators to physically attend the incident, or initiating system resets. Related to that, they stressed the importance of *being familiar with protocols* for unusual or complex scenarios. Additional human responsibilities would include *rescuing passengers* and *evacuating them* to safe airside zones.

Besides, the experts agreed that operators would *communicate directly with the passengers*, providing immediate reassurance through *“a video call or someone who can come on the intercom and say that everything will be alright. That there is reassurance that someone is monitoring it so that passengers always know that they are in good hands and that it is safe”* (P1). They mentioned that current communication protocols are very organic, which should be reconsidered when integrating autonomous systems.

Enhancing passenger experience

Experts highlighted the need for service-oriented staff to *support passengers, answer their questions, and assist their needs*, emphasizing the importance of staff in *supporting passengers with special needs*.

Their views differed regarding where these human tasks should take place. While some experts mentioned that having an operator inside the bus is essential to assist passengers with tasks such as luggage handling and to earn their trust, *“you really need to have enough people to guide passengers because it is all new for those passengers”* (P9), others mentioned that having someone stand next to the bus would suffice, as an operator could then oversee a larger number of buses. It was also mentioned that passenger service could be provided via remote voice communication.

Controlling passenger behaviour

Passengers are “*an uncertain factor*” in autonomous shuttle systems, as they can cause a variety of unexpected scenarios (P1, P7). As illustrated by P1: “*I think that a lot of situations will arise that you have never anticipated in advance, [regarding] what passengers will do with such a bus*” (P1).

Based on their experiences, some of the experts foresaw that passengers might want to test the boundaries of the technology (P7), especially when no operators are physically present. For example, P2 recalled an instance where passengers positioned themselves in front of the exterior cameras of a shuttle bus, preventing it from departing. Still, they noted this might be unlikely in a highly regulated environment like the airport.

A solution could be educating passengers on boarding and deboarding protocols, clarifying how an autonomous bus works and the associated rules. Participants mentioned different formats for providing such instructions, including videos in the terminal boarding or inside the bus.

However, *monitoring tasks* would still be needed *to control passenger behavior*, similar to other contexts where passenger shuttles are operating. In the airside context, the importance of having human control laid in different reasons, such as preventing unauthorized passenger movement on the apron, checking if every passenger boards and deboards the bus, or avoiding incidents like passengers getting trapped in the doors.

5.2 Impacts arising from gradual automation implementation

In their explanations, participants also noted that gradual, lengthy, “*step by step*” processes are needed for implementing automation. They reckoned that a fully autonomous system would not be possible soon and they highlighted several considerations that affect the broader ecosystem of workers during this process (see Table 3 for an overview).

Integrating automation into traffic with multiple co-existing actors

Participants recommended to initially use autonomous buses as an addition to current manual operations, and phasing out manual buses as the system matures. There will exist a “*mixed traffic transition*”, “*with initially very few autonomous vehicles, and many manual vehicles. That ratio may change in the future and may ultimately exclude one species. But it is precisely that transition phase that is actually the most complex*” (P5).

Unlike public roads, airport road users are trained employees, who need to follow defined conduct. “*Here, you have a closed area where you actually have all kinds of predictable behavior*” (P2). However, the current operational environment is traffic-intensive, as it involves many different actors, roles, and vehicles, which P8 described as “*quite complex*”. A common concern was the non-human driving behavior of autonomous buses, which can frustrate human operators and lead to “*reckless*” reactions. P6 noted that current manual operations at the airport rely on highly organic, person-to-person interactions and procedures that would be disrupted in mixed traffic, as autonomous vehicles cannot replicate these behaviors. Drawing on experience from other mixed traffic contexts, participants proposed giving autonomous systems priority and minimizing unnecessary

movements by human operators, emphasizing the need for external communication from the autonomous bus to human drivers.

Table 3 Overview of key considerations during gradual automation implementation and related impacts on surrounding worker ecosystems

Themes	Examples of impacts on surrounding workers
Integrating automation into traffic with multiple co-existing actors	<i>The non-human driving behaviour of autonomous buses can frustrate human operators and lead to reckless reactions; person-to-person interactions would be disrupted</i>
Managing passengers' reactions to new technology	<i>Workers need to be prepared to introduce the technology, explain the particularities of autonomous boarding or deboarding procedures, and reassure passengers when needed</i>
Training workers	<i>Workers must feel comfortable working with new technologies and may initially feel anxious due to the complexity and novelty of automated systems</i>

Managing passengers' reactions to new technology

The experts emphasized that autonomous shuttle buses would be new to many passengers. Since autonomous vehicles vary in their level of development and maturity, for instance being currently more feasible in smaller sizes than regular buses, passengers might experience them differently. Workers would therefore need to be prepared to introduce the technology, explain the particularities of autonomous boarding or deboarding procedures, and reassure passengers when needed, especially during the early stages of implementation.

Training workers

Experts noted a transition in human operator tasks and responsibilities (Section 5.1), highlighting the need for training as roles are redefined.

First, participants foresaw a transition from in-vehicle drivers to different external specialists, handling tasks such as maintenance, software development, and updates. Second, participants discussed employees need a technical background, since they must feel comfortable working with new technologies and may initially feel anxious due to the complexity and novelty of automated systems. They agreed on the relevance of organizational and social skills, as well as the willingness to learn new skills. Finally, participants emphasized the importance of training employees not only in system use but also in new codes of conduct and emergency procedures, ensuring they can navigate real scenarios, solve problems, and respond appropriately in emergencies.

6. Discussion

6.1 *Impacts of an autonomous shuttle bus in worker ecosystems*

Through our interviews, we identified new scenarios that might occur in autonomous airside operations (e.g., emergencies, vandalism by passengers), as well as tasks, responsibilities, and considerations that will affect surrounding workers following the automation of driving tasks. These not only illustrate that automation transformations extend beyond mere technological implementations, but also emphasize the need to build on and extend current worker-centric automation approaches (Fox et al., 2020) toward *workforce-centric* approaches that would account for a wider array of affected workers. Additionally, the implications related to the gradual implementation of autonomous shuttles in the airside context suggest that more nuance is needed in organizations when configuring automation strategies. These strategies are framed as a ‘manual or full automation’ dichotomy, which our work tries to provide a more nuanced perspective on.

The tasks and responsibilities we identified often concerned *invisible work* bus drivers currently deal with to support both travellers and smooth bus operations, such as contacting controllers in cases of malfunction or making sure that all passengers board a flight, as already noted by Akridge et al. (2024). As such, our work aligns with prior research suggesting that understanding automation as a simple, one-on-one, substitution of human capability may be overly reductive (Bradshaw et al., 2014).

In this regard, automation projects require additional efforts to design human roles in advance, for which the tasks we identified could offer a useful starting point. Yet, we want to remind that 1) these roles should be co-created with workers and, 2) the roles would not be a mere compilation of such tasks, but would also need to specify additional arrangements, contingencies, and hierarchies in relation to the autonomous system and how to respond to the various potential scenarios described. Similarly, we hope the roles can also be used to shape the features of autonomous technology.

6.2 *Reflection on the systemic approach and tools used*

Drawing on systemic design approaches, we generated *systemic visualizations* of the airside context to support communication and sense-making, and to facilitate discussions with experts during the co-designing of a future autonomous shuttle system. During the interviews, these resources were very helpful to enlarge the scope of the problem we were presenting to the experts. While most of them referred to the automation of driving tasks and pointed at safety operators in the first exercise (i.e., role of future operator), they considered ecosystem-wide implications after engaging with the sensitizing materials. Additionally, the materials allowed us to communicate the intricacies of the airside context in a simple yet engaging manner, as well as to show intangible elements, such as means of communication among the different actors or their dependencies.

Reflecting on the limitations of our tools, we recognize our non-neutral role as designers in producing and introducing the systemic visualizations. While working with external experts necessitated this approach, in cases involving internal stakeholders, we would first allow them to design and visualize their own systems. At the same time, we acknowledge that our systemic visualizations may have occasionally compromised depth in favour of ease of use

and communication. While the visualizations effectively convey the overall tasks and relations among the different stakeholders of an autonomous bus operation, greater depth and nuance may be needed to discuss specific tasks, interactions among workers and automation, and how these dynamically evolve across different scenarios and over time.

We acknowledge that ours is just a first step toward addressing the issue at hand: countering technology-centered approaches that overlook the impacts of automation on human workers. We primarily adopted the *system-conscious* systemic design type, as classified by The UK Council (2021). As a follow-up to our research, future works should focus on *system-shifting* design (The UK Council, 2021), to shift automation and organizations towards desired directions, potentially engaging with ‘*designing from within*’ practices (van der Bijl-Bower et. al, 2024) that engage different stakeholders in the design of the desired system. Particularly, we emphasize a need to engage affected airport workers through participatory design methods.

6.3 Limitations and future work

The insights we present in this paper are illustrative of a single case study, and hence are not representative of the full breadth of automation’s ecosystem-wide impacts that could emerge in organizations. Still, an in-depth picture of a single airport is beneficial since it allows for the understanding of the intricacies of the context, as well as to illustrate how an organization navigates automation transitions. We argue that, although context-specific variations may shape automation strategies, the implications of our findings could still be relevant considerations to other airports. The main aim of the paper is to reflect on 1) the systemic approach used, 2) the chosen ecosystem-wide scope, and 3) the categories discussed (i.e., new tasks, responsibilities, scenarios, and considerations due to gradual automation implementation), which are relevant to other organizational contexts embarked in automated transitions.

For future work, we encourage works that support responsible automation transformations in organizations. Specifically, we see a need towards the creation of tools to support practitioners in considering the impact of automation in workers early in automation projects.

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