Collaboration and Awareness Amongst Flight Attendants

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ABSTRACT

Collaboration is a core component of work activities amongst flight attendants as they work to promote onboard safety and a high level of customer service. Yet we know little of how flight attendants collaborate and whether or not technology adequately supports their practices. Through an interview study with flight attendants, we explored their collaborative practices and processes and how technology aided such practices. While technologies like interphones and flight attendant call buttons acted as collaboration tools, we identified instances where the usability and functionality of these devices were the main barriers for maintaining efficient communication, situation awareness, and information exchange. Our findings inform the design of future technologies for enhancing communication and collaboration in an aircraft setting amongst flight attendants with an emphasis on real time information access and direct communication between flight attendants regardless of their location.

Author Keywords

Flight attendants; situation awareness; workspace awareness; collaboration; pursers; cabin crew; Crew Resource Management (CRM)

ACM Classification Keywords

H.5.3 [*Computer-supported cooperative work*]: Group and Organization Interfaces

INTRODUCTION

Collaboration amongst flight attendants is important as they are responsible for the delivery of both customer service and on-board safety. Miscommunication or error has the potential to be embarrassing and highly publicized [48,52]. It can also lead to critical accidents and incidents [48, 52]. Understanding that communication needs to be optimized, past research [38,48,52,62] has emphasized the improvement of communication processes between pilots in

the cockpit and cabin crew, but there has been little research that focuses solely on how flight attendants collaborate during flight operation [19]. Thus, there is a gap in understanding how new technologies can support the collaboration needs and practices of flight attendants.

We conducted in-depth interviews with ten flight attendants from domestic and international airlines with the goal of bridging this gap. Our study focuses around their collaborative practices involving flight attendant interaction, awareness, and the exchange of information. To foreshadow, our results show that the tools currently available to flight attendants to aid collaboration (e.g., interphones, call buttons, visual displays) do not easily fit within their needs and routines. Instead, in order to match their on-the-job needs, workarounds were required to communicate with one another and maintain a high level of awareness of the environment. In times of emergency, these tools provide an added cognitive load and were difficult to access. Without the proper integration of these tools with current work practices, flight attendants lacked the support necessary to easily communicate and collaborate when in-flight. These results suggest that in order to gain a high level of situation awareness and seamless collaboration, future technologies should be designed to make communications clearer, provide real time information access, be hands-free to assist work activities, and be ubiquitous enough to assist in emergency situations.

The paper is structured as follows. First, we provide background on the importance of collaboration in the airline industry and theoretical frameworks for collaborative practices. Second, we describe the interview methodology we used in our study. Third, we present the findings and insights derived from the study. We conclude with design suggestions for future technologies to foster a high level of situation awareness and workplace collaboration amongst flight attendants.

RELATED WORK

Aviation Training and Collaboration

In the 1950s, as flight operations expanded from single to multi-operator, the significance of synchronized teamwork in the aviation industry was initially overlooked and underestimated [31]. This posed a challenge to aviation safety [31]. Despite rigorous operator trainings and improvements in the cockpit interface, the number of accidents in US commercial and charter flights did not reduce. Such fatal discrepancies claimed an average of two

hundred and forty (240) lives per year [40]. However, in the early 1970s, insights from interviews with pilots led to an understanding that flight accidents may be due to a lack of crew coordination and communication rather than individual skills [32].

Thus, in 1981, United Airlines (an American air carrier) was the first airline to provide training for its cockpit crews [32]. By the 1990s, it had become a global standard and training was extended from the cockpit to the entire flight crew [32]. This was called the Crew Resource Management (CRM) training [32,42,48]. In 1999, the Federal Aviation Administration (FAA) of the United States made CRM a mandatory training component for airlines based in the country [32,40]. While some airlines gradually adopted similar policies, some faced challenges in integrating it into their organizational culture and operational settings.

The CRM training comprises of a set of training procedures which are tailored to the airline's needs [42,47]. It focuses on developing crewmembers' skills in team building, information sharing, problem solving, decision-making, situational awareness, and dealing with automated systems for the safety and efficiency of a flight [32,42,48]. This also includes training in Standard Operating Procedures (SOPs) and Line Oriented Flight Training (LOFT) [36,37]. The SOPs are detailed in the Flight Attendant Manual (FAM); it enlists procedures of who should do what and when [36,47]. The SOPs try to ensure that crewmembers who have never flown with each other before will be able to work together with the common knowledge provided in the Flight Attendant Manual [36]. Studies shows that while the training is beneficial, it focuses on critical situations and emergency evacuation and not on non-emergency communication on a daily basis [32,40,48], such as social support [30,57], feedback, supervision, and leadership [4]. The LOFT assesses how crewmembers can manage the operational environment and process information available during irregularities on a daily basis at an individual-level and at a team-level [37]. It is where crewmembers combine their technical skills and CRM theory into practical skills in simulator scenarios [37]. The scenarios are made up of typical daily operations with reasonable and realistic difficulties and emergencies to test crewmembers' ability to make a series of low-risk, safe operational decisions [37]. Airline operators require that flight attendants complete the CRM training before they are allowed to take a position in-flight [37,42,47].

The basic collaboration tools found in today's aircraft are the interphone, the flight attendant call button, visual indicators (no-smoking sign, seat belt sign), and audio alerts [10,13, 61]. Pilots on a simulated aircraft analyzed that the availability of these collaboration tools reflected a higher degree of awareness and coordination amongst crewmembers [40]. Crewmembers became more responsive because they were well-informed and they began to spend more time in communicating and making shared decisions

[40]. It is highly likely that, in the near future, flight decks will become increasingly automated and communication systems will become more advanced [3,22,34,46]. This will improve a flight attendant's adaptability to the crew in each flight, as well as reduce conflicts [8,45]. As part of these efforts, it is critical to understand the routines and needs of flight attendants in order to properly guide design and development of such collaborative systems.

Team Cognition and Awareness

The execution of coordinated behaviors amongst team members is called team cognition according to the distributed cognition perspective [21,33]. Achieving successful team cognition is not easy. Early theories promote the idea of team members producing a shared mental model or representation of a situation to aid team cognition [5,41,44]. Research shows that teams with a shared mental model are likely to work better together as they interpret cues and prioritize information in a similar manner [19,29,41]. They take coordinated actions and make compatible decisions to manage situations in their environment [19,29,41]. Sharing the same mental model improves the team's synchronization and team cognition and reduces the need to explicitly communicate, as noted by studies on firefighter training [59]. This also suggests that team members who are familiar with each other and have been trained together tend to develop faster team cognition [15,29,59] and can perform their tasks better in a group setting [54]. Cross training in multiple roles has shown to be an effective way to help team members create a shared mental model and be easily assigned to different roles as the situation warrants [59].

More recently, CSCW researchers have reflected on the concept of shared mental models to describe its limitations as a theory for understanding distributed cognition [11]. Shared mental models imply that all collaborators need to have the same shared knowledge, but this is not always the case [11]. If team members have distinct roles and do not change these roles, then not everyone will have nor need the same knowledge [11]. Alternative theories such as activity awareness [2, 11] broaden our understanding of how teams successfully collaborate. Activity awareness contains four main parts which are important for achieving team cognition and successful collaboration [11]: common ground [12] involving full or partially shared knowledge beliefs [43], communities of practice (tacit knowledge of expected behaviors) [60], social capital (creating social good) [14], and human development (reacting to changes in tasks). Thus, distributed cognition is shown to be about mental structures, such as shared mental models, as well as knowledge of the social, cultural, and physical contexts [11]. This includes knowledge sharing through the shared use of physical artifacts in the environment (e.g., boundary objects [55]), as well as expertise sharing that occurs through interactions and communication [2].

As can be seen, effective team cognition requires collaborators to be aware of the conditions around them and to communicate efficiently [7,15,29]. This involves situation awareness: "being aware of what is happening around you and understanding what that information means to you now and in the future" [1,19]. Situation awareness equips people with an understanding of what information is required to accomplish a particular task and the formation of knowledge through interactions with team members. [19,25,28]. Highly dynamic environments make the role of situation awareness pivotal; this has been shown in studies of commercial aviation [50], air traffic control [54], and anesthesiology [23].

Situation awareness can vary among team members; even when collaborators are able to see or hear the same information, they may understand it differently [18,19,28,49]. Situation awareness can be divided into three main levels: perception, comprehension, and the prediction of consequences [26]. Many teams face challenges in the comprehension of the situation, as their analysis may be directed by an incorrect understanding of a situation [19]. Such a failure to reason independently is likely to lead to inappropriate decision making and to negative consequences for the team [7].

Workspace awareness is part of situational awareness; it is the "up-to-the-moment understanding of another person's interaction in a shared workspace" [25]. Workspace awareness is a combination of verbal and visual communication [9,27]. Workspace awareness is gained by observing and monitoring each other's gestures, activities, whereabouts, conversations, and the presentation and manipulation of artefacts [26,27]. Collaborators use this knowledge to obtain a mutual understanding about the coordinated tasks and resources, to anticipate the actions of others, interpret deictic references to objects, and find opportunities to assist one another with individual and shared tasks [25,26,38,51]. The degree to which collaborators work together is called "coupling" [56,57]. When a collaborator needs to wait for a team member to finish their work before beginning his/her own task, it is called "tightly-coupled" work. When collaborators can continue with their own tasks without any interaction with other group members for long periods of time, the work is called "loosely-coupled" [43].

In our study, we explore how flight attendants move into and out of tightly and loosely coupled collaboration as they shift between performing their own tasks on flight and helping other flight attendants in normal routine tasks and emergency incidents. This involves explorations of situation awareness, workspace awareness, and distributed cognition to understand how flight attendants collaborate and what ways technology supports or hinders such processes.

STUDY METHODOLOGY
We conducted an interview-based study with flight attendants in order to understand their current work practices, the manner in which they collaborate with one another, the role of technology in supporting these collaborations, and the benefits and challenges faced when using technology to support collaboration and awareness.

Participants Demographics
We interviewed flight attendants from domestic as well as international airlines to get a broader understanding of the work practices. We recruited ten participants through snowball sampling (word-of-mouth) [24], social media (posts on Twitter and Facebook), and by requesting locally-based airlines to distribute our advertisement to their employees. Participants included three males and seven females who were employed by one domestic airline and five different international airlines. These airlines were based in Canada, the United States, Germany, China, and Dubai. The median age of participants was 41 years old with a range of 26 to 56 years old. The median numbers of years worked in the aviation industry was 8.25 years with a range of 2 to 25 years. Participants were familiar with the use of technologies like tablets, laptops and smartphones. Two participants owned wearables such as smart watches. Participants included three pursers and seven lead/cabin crewmembers. We describe these roles in our results. Pursers were from three different international airlines and leads/cabin crewmembers were from a mix of domestic and international airlines (some had worked in both).

Interview Method
We conducted semi-structured interviews with each participant with the goal of understanding their work practices from the moment they boarded the plane to the point at which it landed and all passengers had disembarked. The interview questions were divided into two phases. The first phase explored the participants' demographics and work experience e.g., job positions, time in positions, and knowledge of technology. In the second phase, we investigated larger issues such as work practices, use of technology, exchange of information, work challenges, and areas of improvement. For example, questions included: "How do you communicate with your crewmembers and when?", "Where are you located?", "What works well about this activity?", "What does not work well?", "Do you use technology to support this activity?", "If so, how?", and "Are there any drawbacks or obstacles to using technology as part of this activity?" We ordered the interview questions from general to specific in order to give the participants more time to think about and reflect on their practices.

Since it was not easily possible to observe flight attendants during their actual work due to security and safety concerns from the airlines, we had flight attendants describe a range of specific stories of their experiences in-flight, e.g., "Tell me about a time when communication with other flight

attendants worked well" and "Tell me about a time when there were communication breakdowns."

Data Collection and Analysis

Interviews were conducted over the telephone or a video communication system (e.g., FaceTime, Skype) and lasted 45 to 90 minutes. Each participant was given a $30 gift card or cash. We collected data in the form of researcher's notes and audio-recorded all interviews. All interviews were transcribed. We analyzed our results first by iteratively reading through our data. Next, we analyzed our transcripts and field notes using inductive thematic coding [16]. This involved initial coding and then explorations for categories and central themes. Our coding revealed key themes around the cabin crews' collaborative practices. This includes their roles and activities, team cognition developed from face-to-face communication, ambient monitoring through the collaborative system, and information flow in their interactions. We detail these next in our findings.

ROLES AND RESPONSIBILITIES

Our participants explained that there are three main team member roles that are common in both domestic and international airlines: the pilots, the pursers/leads, and the cabin crewmembers. The reporting lines are defined in that order from highest ranked to lowest.

For a domestic flight, the aircraft is typically small, has a limited number of passengers and the duration of the flight is relatively short (e.g., a few hours at most); thus, a maximum of three flight attendants are typically assigned. Flight attendants in the domestic airlines follow a compulsory rotation in the three positions of the aircraft: Position 1, the fore (front); Position 2, the aft (back); and, Position 3, the middle. Positions 2 and 3 act in the role of cabin crewmembers. Position 1, also known as the lead, is responsible for supervising and managing the team of flight attendants and overseeing the flight attendants' workflows to ensure a comfortable and safe flight. He/she acts as a intermediary between the pilots and crewmembers; Pilots will share information with the lead who can then relay this information to the other flight attendants.

Domestic flight attendants rotate between the three positions in successive flights. Thus, while they are assigned to a single position for an entire flight, over several flights, they will likely work in a series of different positions. As P1 explains: "*It is part of the training to know what every position entails.*" This means that typically flight attendants on domestic airlines have knowledge of what the other crewmembers should be doing; there is shared knowledge around roles, responsibilities, and who has what information.

Our participants told us that international airlines work somewhat differently. The aircraft is larger, has a higher number of passengers on-board, and the duration of flights is longer (e.g., 6-12 hours). Depending on the size of the plane and the culture of the airlines, the hierarchy of the crew can differ. For instance, we found that airlines based in Asia and the Middle East have two to three pursers onboard each flight where each one is assigned to a particular cabin (first/business/economy class). They also have a cabin senior director to whom the pursers report. Pursers are in charge of the same responsibilities as the lead on domestic flights and when they require help, the cabin senior director oversees it. For European airlines, we were told that pursers are divided by two tiers: a short and long haul purser. Long haul pursers have higher seniority over short haul pursers and are responsible for greeting passengers when they come onboard. Short haul pursers are not dedicated to any particular cabin. They are expected to assist and manage the entire crew of the flight.

Pursers for international airlines are specifically selected for their roles based on the amount of experience and training they have, whereas the role of the domestic flight lead is assigned based on who would like to do a position and who has not done a certain position in an effort to ensure that each person has a chance to work in every position.

For both domestic and international flights, the careful assignment of roles and cabins to particular flight attendants means that there is a specific communication protocol where knowledge works its way from cabin crewmembers to leads/pursers to cabin senior directors (if that role exists), to pilots. The opposite also occurs where information from pilots makes its way to flight attendants first through a senior director (if that roles exists) to leads/pursers to cabin crewmembers. It also means that different levels of knowledge must be maintained by different people. For example, it is not the case that each flight attendant will know the same level of information about a situation. Leads/pursers and cabin senior directors need to maintain a broader understanding of what is happening across the entire aircraft, whereas other cabin crewmembers may only need to know information pertaining to their specific section of the plane. This only changes if emergency situations arise.

During emergency incidents, the hierarchy on planes is flatter: crewmembers are encouraged to directly communicate to the pilots to inform them of any danger to the safety and security of the flight. Thus, in times of emergency an understanding of who knows what changes and pilots attempt to maintain a larger degree of situational knowledge. The knowledge maintained by pursers/leads may be less than under normal circumstances. In situations where crewmembers need help from each other, they may directly communicate with each other depending on who may be best to help them.

Lead/pursers on both domestic and international airlines typically take special care to note if there are flight attendants with less experience on board. They do this by making use of subtle cues like crewmembers' pace of work or visually scanning the tag number of employees; higher tag numbers often indicate new crewmembers. In an effort

to ensure consistency of service, the leads/pursers will sometimes walk to the less experienced crewmembers and provide coaching tips in a discreet manner.

"If they are new - we take extra care to help them get their work done. I just go and offer if they need help physically completing the task or remembering the next task to do or all the tasks they need to get done." - P6, Female, Lead/Cabin Crewmember

Our participants explained that in both domestic and international airlines, crewmembers are frequently scheduled to work with new team members and switch into different roles [40]. This means that it can be difficult to get a sense of a particular person's experience at the beginning of a flight and flight attendants must trust the fact that a person will follow through with the appropriate actions for a given position based on their training. During international flights, flight attendants have more time and allowance from the airlines to interact with one another on a personal level. This occurs during breaks and 'downtime' when there is less work to do. The importance of these informal conversations is that they provide flight attendants with a better understanding of each other's personalities, experiences, and attitudes towards life and work, which can help the flight attendants understand each other's work practices and idiosyncrasies.

"We talk about everything under the sun. We call it 'jumpseat confessionals.' Our life is a bit strange. We are thrown into a situation with people you probably have not met before and probably will not again so lot of the people that I work with that I will never ever see again in my career. There is a certain kind of anonymity when we are talking to each other, so people tend to disclose lots of personal information." - P3, Female, Lead/Cabin Crewmember

WORK ACTIVITIES

A pre-flight briefing is held immediately before each flight. Depending on the availability of crewmembers and the culture of the airline, the briefing is carried out by the most senior crew member in the following order: captain, cabin senior director, and lead/purser. He/she uses this discussion platform to introduce crewmembers to the team, assign the positions, and answer questions about the flight time, possible turbulence enroute, and strategies for dealing with safety and security issues that might impact the flight. Crewmembers also get an understanding of who is in what role so they can structure their communication appropriately during the flight.

After the briefing, flight attendants perform safety and security checks where they walk around and ensure all passengers are seated with their seatbelts done up, bags are properly stowed, etc. During this time, flight attendants look up and down the aisles to the next visible flight attendant. Once they are done their own check, they give a "thumbs-up" gesture to signal that their area is clear and ready. Flight attendants who were in close proximity to each other verbally say, "Cabin is secure." This information is relied between flight attendants until all areas are secure.

"When it comes to reporting the safety and security checks; the right hand side will inform the left hand side and they will in return inform the purser for the Economy cabin." - P5, Male, Purser

During the in-flight stage of work, the lead/purser coordinates with crewmembers as to when each in-flight activity should occur. For example, crewmembers wait for the lead/purser to let them know which row to start serving through calls on an interphone (described more later). The lead/purser tries to coordinate serving amongst crewmembers (in a tightly-coupled style) to ensure the food is served at approximately the same time to all passengers in a particular cabin.

"I am responsible for coordinating with the other flight attendants and also doing the tasks of serving the guests in my area. I need to crosscheck to make sure that the meals are served hot when it is placed on a guest table." - P5, Male, Purser

During this time, the lead/purser periodically glances around the cabin to monitor the service's progress and see if anyone needs help.

"We are like Galitarians, who are always on the lookout for each other to make sure that things are working out as they are supposed to be in the environment." - P2, Male, Lead/Cabin Crew Member

Verbal communication is typically kept to a minimum since flight attendants are very busy and pressed for time. After takeoff, the plane's motors can be very loud making it hard to hear people. Instead of large portions of speech, our participants described relying heavily on gestures and jargon to simplify communication. P2 and P3 described using hand gestures for sitting down, picking up the phone, getting oxygen masks, and requests to "please bring more blankets."

Throughout the remainder of the flight, flight attendants perform routine checks to see if passengers need anything and ensure everything and everyone is safe. After the service, the lead/purser splits up crewmembers into two halves to either perform routine checks or to rest. For example, in the international airlines where P4 works, crewmembers can rest in the flight attendants' cabin, while other crewmembers make rounds every 15 to 30 minutes to check the toilets or serve beverages to the passengers. After half of the crewmembers have rested, the purser wakes the crew by calling them on an interphone and instructs the other half of the crew to take a rest.

"Just making sure that everyone gets to have their breaks and eat well. So some days that can be very challenging and I have to make sure that they are taken care of – as they in-turn will take care of my guests. Happy crew and happy plane!" - P6, Female, Lead/Cabin Crewmember

During this time, the lead/purser will also check with the pilots in the cockpit to see if they need anything. For example, in the case of P3, his airline's safety and security policy entails that two people have to be always present in the flight deck. This means that pilots sometimes ask the purser/lead to send a flight attendant to monitor the cockpit when they have to leave.

"If the captain needs to use the washroom, he has to call a flight attendant and she/he has to stay in there while he is out and then switch when he comes back in." - P3, Female, Lead/Cabin Crewmember

COLLABORATIVE TECHNOLOGIES
The airplanes that our participants worked on all contained three basic types of collaborative technologies: a series of interconnected interphones, flight attendant call buttons at each seat, and visual indicators in the form of lights and panels. We describe how each was used next.

Interphone
When flight attendants are unable to visually see each other to share information using body language and they are not in close proximity to talk, they make use of the interphone. This occurs most often during their in-flight work such as during service rounds and routine checks. Regardless of their role, flight attendants will use an interphone when they need to talk to a crewmember that is far away or when they need to make announcements to all passengers. Thus, interphones can be used for public announcements that are played on speakers throughout the aircraft, internal conference calls between all interphones, and cabin-to-cabin communication between pairs of interphones. An interphone is stationed at each key area: the cockpit, the galleys, and (most often) at each exit door. When calls come in, a panel indicates which other interphone initiated the call through a display panel [53]. The types of information that flight attendants share over the interphone include:
a. *Broadcasting of public announcements*, e.g., take off and fastening seat belts.
b. *Progress updates* on activities, e.g., readiness for lunch/water service.
c. Giving and acknowledgement of *orders/directions*, e.g., assisting pilots in their absence in flight deck
d. *Status updates* requiring immediate assistance, e.g., passengers being intoxicated and requiring assistance
e. *Transmission of emergency information* to other team members, e.g., notifying others about turbulence, bomb threats, etc.

Despite the range of uses for the interphone and its critical role in flight attendant communication and collaboration, participants told us that their use of the interphone faced several challenges. First, the sharing of information was static. For example, in cases of turbulence, the pilot will typically notify the purser/lead by calling him/her on the nearest interphone and explain the situation once. The lead/purser will then disseminate the information to the other crewmembers by calling them on an interphone, this time with a one-to-many call. However, information on situations such as turbulence can change rapidly and pilots typically do not repeatedly call to relay new information because they are busy dealing with the situation themselves. Thus, up-to-date knowledge of the situation is unknown and difficult to share.

"The hardest part is that we don't have a face-to-face communication with the pilots and that is hard as sometimes we cannot relay a complete message on the interphone." - P2, Male, Lead/Cabin Crewmember

Many of our participants desired to have more frequent information in such situations as it was related to the safety of all passengers and the time to begin their service.

"The reason why the flight is delayed is because this information comes from the captain and no one is allowed to go in the cockpit, when it is 'secure cabin' during take-off. We are then supposed to wait. We waited for an hour last time and we didn't know what was happening." - P1, Female, Lead/Cabin Crewmember

Second, flight attendants need to be in close proximity to the interphone in order to hear it ring and answer it, as interphones are permanently fixed in particular locations on the plane. However, our participants described many incidents, particularly during lunch/water service, when they were highly mobile and not close to an interphone within their own cabin area.

"Once, I was standing at the back and a gentleman fainted after using the washroom. Although, I got hold of him and landed him down on the ground, but the other crewmembers especially in the front, could not see this happen as both of us were on the ground and the bathroom door was left open." - P3, Female, Lead/Cabin Crewmember

In the above situation, P3 was pulled into the washroom and could not release herself as the passenger was on top of her. The only way she was able to get out of the situation was to ask the closest passengers for help. Thus, she was unable to call the other crewmembers on an interphone and they could also not see her since they were too far away.

Another instance comes from P5, who was caught in the middle of two kitchens when a passenger had first-degree burns. Other cabin crewmembers could not see them and so P5 was unable to visually notify them that there was a problem.

"The passenger had not only split coffee on his hand but also on the metal watch he was wearing, which exasperated his pain. I needed help to wash off the coffee and at the same time I wanted to ask for medical assistance and inform the captain about the incident." - P5, Male, Purser

Luckily P5 could reach a nearby interphone to call for immediate assistance. Yet there were no flight attendants close enough to another interphone to hear it ring. P5

decided that the only way to communicate with the other crewmembers was to make a public announcement over the interphone to indicate to the cabin senior director that he needed help. This unfortunately made the incident public and gave the cabin senior director the wrong impression that his cabin crewmembers were not efficient enough in assisting one another.

Lastly, several participants said that it was difficult to know whether sounds were coming from the interphone or the flight attendant call button and whether or not it was a normal or emergency call. All audio alerts coming from a particular destination had the same sound. For instance, if a flight attendant called another flight attendant using either the interphone or the flight attendant call button, it would play double twin chimes, but there would be no difference in the ringtones. Participants felt that distinguishing calls was important as it could indicate the urgency of a situation.

Flight Attendant Call Button
Unlike the interphone, flight attendant calls buttons are installed in each passenger seat or adjacent to them. Thus, they are fairly ubiquitous throughout the plane. While they are meant for mainly passenger use, they have been appropriated by flight attendants as a part of their own communication practices. Here they are routinely used as a means for notifying other flight attendants for assistance regardless of the flight attendants' role or position in the plane. For example, during service rounds and routine checks, a flight attendant in the aft may require help from someone in the back of the plane. To alert this person, she might push a passenger call button near her. This creates an audio alert that is heard in the present and adjacent cabins. Flight attendants can then look at the flight attendant panel next to an interphone to see which passenger's seat light is illuminated.

While certainly beneficial, the call button raises several challenges for flight attendants. First, a press of the call button is sometimes not heard since the alert is only played in the present and adjacent cabins and the noise from the aircraft is generally loud. If it is an urgent situation, participants said they will push multiple call buttons to notify a team member.

"If six call buttons go out at the same time, you know that it is a serious situation and that way you will get their attention." - P3, Female, Lead/Cabin Crewmember

Second, it can be difficult for a flight attendant to push a call button rendering it an ineffective tool for notifying others. On domestic flights, our participants said that the call button is usually easy to reach and always in the same position: above the passengers' heads on a ceiling control panel. Yet international airlines often have the call button in varied locations depending on the aircraft and not all locations are easy to find or natural for flight attendants to reach. For example, sometimes the call button is located on the armrest of a passenger's seat. Pushing these call buttons may require asking a passenger to do it, which is less desired, or, awkwardly reaching in front of a passenger or under their arm. As such, our participants felt hesitant to make use of such call buttons.

"It is placed either at a weird location that is near the guest's lap or in the middle of their entertainment screen - it is not normally found at the top and is not easy to find." - P5, Male, Purser

Third, it can be difficult to know if a flight attendant *or* a passenger pushed the call button. Flight attendants are able to push the call button in a certain configuration to create a different alert sound, yet, in times of emergency, it may be difficult to remember to do so. The configuration for using the call button is: one push creates a single chime meaning a passenger is calling, while two pushes creates double twin chimes which flight attendants sometimes use to signal that they are calling. However, P5 said that in an emergency situation their *"presence of mind is completely gone,"* so knowing the button's location or the configuration is an extra cognitive step.

In these situations, flight attendants will opt to try to call out loud (yell) to others in order to get their attention. However, this practice is contrary to what is taught in CRM training about passengers' in-flight experience. Flight attendants are not supposed to create panic amongst the passengers.

Visual Indicators
The planes that our participants flew on also contained various visual indicators that were used as a part of their work routine. Again, this was regardless of the flight attendant's position, be it cabin senior director lead/purser, or crewmember. For example, visual indicators included the 'no smoking' and seat belt signs, which had audio alerts associated with them. When the seat belt sign is turned on, a single chime is heard and it means flight attendants have to stay seated. In times of service and heavy passenger load, this visual cue and sound can be easily missed as flight attendants are not paying attention to them. Each interphone also had a display panel next to it that showed which seat call button was pushed or which interphone was calling. Participants said this panel saved them from unnecessary search and directed them to the specific location that required their attention when call button notifications came in. Such calls occurred throughout their in-flight work, including during service rounds and checks. All cabin crewmembers had to respond to such calls, including leads and pursers.

"The aircraft is huge, so when a passenger call is heard, we do not start looking everywhere, but simply look at the display of the flight attendant panel. It will tell me exactly which row and seat the passenger is calling from." - P2, Male, Lead/Cabin Crewmember

A corresponding visual cue to the flight attendant panel is the seat light above the passenger's seat, which is turned on when the passenger presses the flight attendant call button. Participants said that seeing the light was generally easy if they knew which general area to look in. But those that served on international flights faced challenges because the amount of space to look in was larger. Flight attendants would look at the flight attendant panel to see which area they needed to go to and memorize the seat number. However, on their way, they might be distracted by another passenger's request. This sometimes made them forget the seat number. While they could look for the seat light, if they did not remember the approximate location, this task was very difficult.

"I kept repeating the passenger seat number so that I would not forget and was looking for the seat light too, suddenly this lady who did not press the flight attendant call button asks me to get her a glass of water and some other items. I was upset as I had to attend to the one who pressed the button first; I told her politely that I will attend to her as soon as possible. However, I realized I forgot the passenger seat number and had to go back to check again." - P5, Male, Purser

Another problem came from not remembering to reset the flight attendant button to neutral after they attended to the passenger. Most flight attendants focus on attending to the needs of the passenger and it is easy to forget to reset the button so that the passenger's seat light and the light on the flight attendant panel are turned off. This can create miscommunication for the other crewmembers and, at times, can cause multiple crewmembers to attend to the same passenger.

SHARED KNOWLEDGE AND RESOURCES
Flight attendants share resources related to their training while they are in-flight. The Flight Attendant Manual (called the FAM by flight attendants) and the guest experience manual (GEM) are on hand when in-flight so that flight attendants can reference them as needed. In contrast to people's typical views on manuals as being underused artifacts, flight attendants refer to manuals frequently because they contain instructions for each city that they might fly into, along with detailed information on all passengers.

"I reference it fairly often almost every day. As I am pretty familiar with it and I can recall a lot of information without having to look it, so I am usually showing people where they can find that info or if they doubt what it says because maybe it was different before- thence I use it for the team. – P6, Female, Lead/Cabin Crewmember

Depending on the airline's policies, some provide flight attendants with manuals in a paper-based format. Others have started allowing flight attendants to use their own mobile devices to check manuals, while others provide pursers with a tablet for the whole team to share. Flight

attendants also actively discuss their work procedures at various points with each other while in-flight and they routinely ask one another if something is unclear. In this way, flight attendants can continue to train and mentor each other throughout their work time in addition to the training that flight attendants receive prior to their first flights. Sometimes discussions involve flight attendants referring to the manuals and other times they discuss knowledge that might augment them.

Paper-Based Manuals
Participants who used the paper-based manuals explained that it was difficult to find information in them and they were large, heavy and cumbersome to carry around and prone to pages going missing.

"I don't like carrying the manual around. It weighs about 2 or 3 pounds. I would like to see a PDF copy." - P2, Male, Lead/Cabin Crew Member

"Sometimes the Guest Experience Manual is missing a whole bunch of pages or sections – we need to reference it and we don't have that information on our finger tips." - P3, Female, Lead/Cabin Crewmember.

The paper format also did not carry the updated version of unfamiliar places or when the policies and rules of a country suddenly changed.

"It is better to better memorize the information, so you do not have to reference the paper, but if you are flying to Cancun and you don't fly there very often, so it is harder to keep Cancun specific information fresh in mind so it is definitely handy to have that sheet for reference." - P3, Female, Lead/Cabin Crewmember

Information about a crew's flight can also change at the last minute. If this happens for a domestic flight, our participants told us that the leads typically do not find it difficult as they have to only reconfigure the seating arrangements. However, for the international airlines, the pursers in our study said that such changes had a large impact on their work. Last minute changes meant they did not have a chance to learn information for the new location.

"Every aircraft is designed differently so we need to study before boarding. I studied the aircraft the whole night and when I came the next morning it was all changed and my team was asking me for their tasks." - P5, Male, Purser

Digital Manuals and Information
Some of the airlines that our participants worked for had introduced policies that allowed them to bring their personal devices to work such as laptop, tablets, and mobile phones. One of the international airlines had even started allocating iPads to the pursers so they would have access to flight attendant manuals, the pre-briefing flights details, and reporting forms.

P5 said it *"makes us look very professional, well informed and knowledgeable about customer's profile."* P5 felt that the iPad allowed him to build customer relationships more

easily because it contained details about each passenger. He would use it to greet important and frequent passengers and also to confirm their preference of meals, seats and connecting flights in a short time. P5 described how his team also benefitted from the tablet as they were able to cross-reference each other on updated information in the manuals, ideas about changes in the procedures, and also about suggested policy changes that they noted in their shared reports.

Conversely, despite the iPads being of great convenience, the pursers in our study found them to be overwhelming to manage. Participants said that sharing them was not easy.

"There are some difficulties using this technology as it crashes from time to time and because it is just one iPad it runs out of battery fairly quickly when carried to the other crewmember." - P5, Male, Purser

At times they would be completing a report on the iPad and another crewmember wanted to access the flight attendant manual. They would then need to negotiate its use and also ensure there would be enough battery power to complete their work later. Naturally, they could plug the iPad in to charge, but this was awkward and confined them to a single location.

"We can not really do many things on the iPad and use it some times as there are only three in total for three pursers. In case of emergencies, we would reference it for the manuals, but otherwise we can see only some information about the flight, the aircraft layout and the seat number and connecting flight of the passengers. - P8, Female, Cabin Crewmember

The pursers in our study felt that the iPads did little to improve their work practices and, instead, added more responsibilities for them. For instance, P5 explained the iPad contained personal details of each passenger and it was his responsibility to ensure its privacy, so he had to keep it near him all of the time. Given the size of the iPad, it did not easily fit into his pockets and so he was forced to hold it in his hands as a result. This made the iPad prone to accidental damage.

"I am always carrying the iPad, when I am serving the food to the guest I place it on the cart. There are times and chances of coffee spilling over the iPad or the screen becoming crack - in that case I find this gadget might not be useful." - P5, Male, Purser

Reporting
Our participants described needing to complete mandatory reports at the end of each flight. This was necessary in case situations arose that might cause passengers to complain to the airline. Thus, having a flight attendant's record of the event was valuable. We found that retaining and compiling this information was challenging for our participants. The leads and pursers in our study wrote this information out on paper or their mobile phones during the flight so they would remember. Those who collected it on paper worried that

their hands would be occupied and the information could be lost. Other participants struggled to compile the reporting information because of a lack of time and energy. It was mandatory for pursers/leads to complete reports, but an optional task for other crewmembers. Thus, sometimes pursers/leads needed to collect information from other crewmembers who might know more about a situation.

"The problem with the current way of reporting is that there is the time lapse, that you lose the information when you leave the aircraft and some time you don't even get to it, because you only have to report it within 24 hours and people won't do it in their own time, as they are not paid for that." - P1, Female, Lead/Cabin Crewmember

Several participants felt that if they had in-flight access to WiFi (which not all planes had), they would be able to complete their report immediately before leaving the plane.

"I would like to report incidences from the aircraft so that it is done before I leave, so that the information is even fresher in my brains. With WiFi, the management could have the report before we even reach the ground. That is one piece of the job that I would like to complete on the aircraft, rather than at home." - P6, Female, Lead/Cabin Crewmember

DISCUSSION
We now discuss our findings in relation to the related literature by performing comparisons to other team-based work, including firefighting [35,39,59], emergency call operation [6], and medical trauma centers [20]. Certainly the work of flight attendants is not the same as that of these occupations and centers where work may nearly always be dealing with emergency situations. We are not meaning to be insensitive with such a comparison. Instead, we aim to provide a broader understanding of the ways in which collaboration occurs amongst flight attendants by providing a comparison to other professions that deal with safety and emergency situations some or all of the time. Following this comparison, we present implications for the design of collaborative technologies for flight attendants.

In many ways, the collaborative practices that flight attendants face are similar to that of other team-based occupations dealing with emergency situations. Like firefighters [39,59], flight attendants work in various roles and have knowledge of the work practices of those in other positions. Similar to firefighters [35,59], emergency call responders [6], and medical trauma centers [20], flight attendants' tasks change on-the-fly as new situations arise. They also have a fairly structured communication line where information flows between particular people in certain roles unless unexpected situations arise [6,20,35,59]. Yet flight attendants face unique challenges in using collaborative technologies, which creates issues for maintaining an awareness of what is happening during flights. Firefighters have a radio that stays with them and allows them to communicate with each other [35,39,59]; flight attendants do not have personalized communication

devices. Overhearing phone/radio conversations is pivotal for emergency call operators and firefighters as it allows them to develop a shared mental model [6,59]; flight attendants do not have this benefit. Medical trauma centers rely heavily on face-to-face communication for information exchange [20]; flight attendants gather some information in face-to-face exchanges or by visually looking around the plane, but this does not provide all of the situational information they need since some planes are quite large and crewmembers are dispersed.

In contrast, flight attendants need to rely on situated displays (interphones, visual indicators) and notification buttons that are only in particular places (passenger call buttons) as a core part of their collaborative routines. Yet crewmembers are highly mobile and it is not possible to always be in close-proximity to such tools. This leads to delays in waiting times or interference with flight attendants' current tasks. For emergency situations, these collaboration tools become even more inaccessible or are burdensome to use due to issues with cognitive load, lack of immediate assistance, and a lack of feedback of how others are responding to a situation. When it comes to training information and manuals, breakdowns similarly occur because of a lack of available information in an easy-to-use format.

Together this illustrates that flight attendants face communication breakdowns and team cognition can be limited because of the tools available to them. It is not the case that flight attendants need to have a shared mental model of everything that is happening on the plane; but they do need to be able to know when it is necessary to help out others, especially in times of emergency or immediate need. Flight attendants are also forced to appropriate technologies such as passenger call buttons in ways that were not likely intended by the designers. The idea of technology appropriation is fairly common for new technology and sometimes seen as an important part of technology adoption as it helps increase users' acceptance towards a technology [17]. However, the appropriation we see by flight attendants does not involve new technologies per se, as one could easily argue that phones and call buttons have been around for decades. Instead, appropriation is about changing the use of an existing design solution (that is arguably somewhat dated) to fit the actual needs of flight attendants.

These findings point to important implications for the design of collaborative technologies for flight attendants. At a high level, flight attendants need collaborative tools that provide a better understanding of what is happening in their workspace, including knowledge of situation awareness and communication channels from a much larger set of locations than is currently present. Collaborative technologies for flight attendants should provide immediate access to communicate and exchange real time information with other crewmembers, regardless of where they are on the plane. The idea of going to a centralized location in order to communicate with others (e.g., using an interphone in a small number of locations) does not reflect work practices. Flight attendants also need to be able to identify between information about normal and emergency situations, and information from passengers vs. other crewmembers. There are also pragmatic challenges when working as a flight attendant that technology designs need to consider. This includes the ability to hear information such as audio alerts over the loud noise of the aircraft, be able to use technology while performing other tasks (e.g., pushing a service cart), not have to carry or hold on to technology designs (e.g., iPads), and not have to remember information before acting on it (e.g., remembering a seat number to approach).

Of course, there are likely many ways that technology can be designed to support these needs and work practices. One might imagine, for example, the use of wearable technologies like smart watches that allow flight attendants to exchange messages instantly or view updates on flight status without the need to hold a device such as a tablet or smartphone. Smart watches could allow crewmembers to remotely receive calls from any part of the aircraft and efficiently respond. If they were worn by all crewmembers, person-to-person messaging would be simplified and not require the use of a situated display in a small number of airplane locations. Haptic feedback could be used to alert flight attendants to particular information such as notifications about upcoming turbulence. On the other hand, the downside of smart watches would be that flight attendants may need to continually glance at their wrist if incoming information was frequent. It may also be hard to send or reply to messages between flight attendants if voice input was needed. Not all flight attendants need to know the same information (e.g., pursers/leads require a higher level of awareness than crewmembers); thus, it would be pivotal for designers to consider various levels of information access. On the other hand, while increased information sharing amongst flight attendants (e.g., all flight attendants knowing the same information) would change their existing work practices, it could lead to different types of collaborative work that may turn out to be more beneficial. This raises interesting design questions that would need to be asked and addressed with such designs.

Alternatively, other design solutions may include an increased use of embedded devices and displays throughout the plane. For example, one could imagine situated displays placed in the doors of overhead storage bins in more locations than is presently done with interphones. These would be at a height conducive to flight attendant viewing and interaction rather than that of passengers, yet it still may be difficult to ensure that private information was only seen by flight attendants. There is also the downside that a likely large amount of displays would need to be installed, e.g., one at every few rows of the plane. One could similarly consider embedding interactive displays in the artifacts that flight attendants routinely use, such as service

carts. This would allow flight attendants to be able to communicate with other flight attendants more easily during service rounds. It could, however, mean that flight attendants are increasingly distracted by such displays and less focused on the customer needs at-hand.

Overall, we see several promising design directions for collaborative flight attendant tools. These suggestions are certainly speculative, however, and future work would need to explore such design options to assess their viability.

LIMITATIONS

Our study is limited in that we were not able to directly observe flight attendant practices due to security and safety concerns on-board flights. Our interview results could have been validated or extended with such observations of actual practices. After all, people's recollections of what they do are not always reflective of what they actually do. That said, our study should act as a basis for understanding what types of observations would be valuable to make as a part of future studies, if one is able to observe flight attendants' practices during flights.

Our study did not contain interviews or data collected from crewmembers that were not flight attendants, such as pilots and cabin senior directors. This would have provided further details on the communication practices occurring within airplanes and a different perspective from the flight attendants that we studied. We chose to study flight attendants as an initial step, however, future work should consider including pilots and other crewmembers. Nonetheless, our results should be interpreted with this limitation in mind.

Our last limitation is in the disclosure of the name of the airlines with whom our flight attendants worked for and the specific types of aircrafts that they flew on. This information may have helped the reader understand if there are particular differences across airlines and how various cultures are represented in the study. In order to ensure that participants' privacy is protected and respected as a part of ethical procedures, and for safety reasons, we had to exclude the name of participants' organizations.

CONCLUSION

Our paper contributes to the growing research and demand for incorporating new technologies in the aviation industry. We conducted a series of in-depth interviews with flight attendants that highlight the challenges and limitations they face in maintaining situation and workspace awareness that persist in both the domestic and international airlines that we studied. We discovered a diverse set of challenges and communication breakdowns that were focused around situation awareness, physical space, and technology that lead to incidents and mishaps. Therefore, our suggestion is to focus on the design of future technologies that can enhance the communication practices of flight attendants and foster a high level of situation awareness to help them collaborate more easily. Future work should continue the study of flight attendants and their work practices, along with design explorations of new technologies, while incorporating a broader set of stakeholders such as pilots, cabin senior director and ground crewmembers.

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