Design with intent on the flight deck

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ABSTRACT

New flight deck technologies must be carefully integrated to ensure that the demands of the system match the capabilities of the user. However, as technological advances make technologies more efficient, end users become the increasingly weak link within the chain. With this in mind, it is important that manufacturers take the time to acknowledge Human Factors within the design process and utilise opportunities to engage with actual end users, in this case line pilots. This article focuses on the design and development of a new pilot decision aid that can offer flight crews with relevant information regarding the status of the aircraft during abnormal operating procedures (e.g. following an indication of an engine oil leak). It utilises the Design with Intent method to generate novel design concepts for a new flight deck interface. This is a new method to apply to the domain but holds the potential to incorporate extensive feedback from pilots into the design of new technologies in the flight deck. Preliminary findings from workshops with pilots using this method are discussed with examples taken from the workshop on how the method can inform design concepts. Overall the method was found to generate important key areas of discussion that can be utilised in a user-centred design approach within future flight deck technology development.

KEYWORDS

Design with intent; persuasive technology; interface design

Introduction

Persuasive technology (Fogg, 2003) can be described as a technology that is designed to elicit a certain user behaviour. On the flight deck, an Engine-Indicating and Crew-Alerting System (EICAS) or Electronic Centralised Aircraft Monitor (ECAM) message is designed as a trigger for pilot action. In most cases, this results in flight crews actioning a checklist. However, with ever increasing technological capability, there is potential to offer flight crews with even more information that can help guide them through the decision-making process and point to the most appropriate action(s). This paper discusses the design and development of a new pilot decision aid targeting engine system parameters. Currently, flight crews are only alerted to an issue when minimum or maximum thresholds have been met. However, the development and implementation of additional sensor technology means that there is potential to offer better information to flight crews that could aid in their decision making process. For example, it is possible that a system may automatically trend oil system parameters meaning that subtle changes can be detected earlier. Trend data could be made available to flight crews via a new interface as well as indicating the options available to deal with such a scenario.

Designing an interface for a brand new system can however be extremely challenging. Designers must consider what users may need to do and therefore prioritise the information that is made available to them. This relies upon designers understanding “who” their end users are. Within the context of aviation, there is a tendency to rely upon the expertise of test pilots who may not behave like an average line pilot. Test pilots instead represent a highly specialised cohort of individuals who complete flight test techniques (e.g., focus on performing specific manoeuvres). Thus, in order to fully understand the interaction between the pilot and any new technology on the flight deck, it is important that research is conducted with a representative pilot cohort. In this case, line pilots represent the end user of new flight deck technologies rather than airlines, who represent the role of a customer. Relying solely on test pilots may bring a considerable risk that the expected benefits of a new technology may not come to fruition in reality (Damodaran, 1996).

Whilst there a number of Human Factors methods available to assist designers throughout the design lifecycle, this paper introduces the Design with Intent (DwI) method, which was originally developed by Lockton et al. (2009; 2010) following the recognition that designers lack guidance on choosing appropriate design techniques to influence end user interaction. The DwI toolkit is marketed as a 'suggestion tool' that can be used to promote directed brainstorming. Given that a new pilot decision aid is intended to assist in, and facilitate pilot action, the DwI method seems like an appropriate approach to adopt in the development of a new pilot decision tool interface. The DwI toolkit utilises 101 design cards covering eight different design lenses; Architectural, Error-proofing, Interaction, Ludic, Perceptual, Cognitive, Machiavellian and Security. These lenses provide different 'worldviews' on behaviour change and therefore challenge designers to "think outside the box". Each card can be used to allow for more detailed deliberations as they all incorporate their own provocative questions. The method was originally developed to help reduce the environmental impact of new technologies and products by influencing the types of behaviour exhibited by users (Lockton et al. 2010). It has been predominantly applied within sustainability contexts (e.g. Lockton et al. 2013). However, we wanted to explore its utility in a new area of application; a pilot's cockpit, especially given that Lockton (2017) advocates its use as a tool for interaction designers more widely. The requirements for the application of DwI, in terms of input, equipment, personnel and expected outputs, are presented in Table 1.

Table 1. DwI requirements

Input	Equipment	Personnel	Time	Expected Outputs
Scenario developed from Concept of Operations (CONOPs)	DwI cards Pen / paper	Human Factors Practitioners (facilitators) Commercial airline pilots (participants)	8 hours (for all 101 cards)	Novel design concepts Discussion on individual DwI cards

Method

A series of focus groups were conducted involving multiple airline pilots from a number of different operators using the DwI method to guide discussion. The design workshops were ethically approved by the Ethical Research Governance Office (reference ID: 41697).

Design with Intent cards

There are numerous ways in which the DwI method and so DwI can be described as being a highly flexible approach (see www.designwithintent.co.uk for further information). Whilst there are 101 design cards within the DwI method, only 42 were selected for inclusion in our design workshops. This represents the 'prescriptive mode' of application that enables facilitators to choose the most appropriate cards to their problem (Lockhart et al. 2010). Down-selection was made by two Human Factors experts who assessed the cards for relevance to the scenario in question. For instance, cards relating to gamification were not included as these were not deemed relevant to the scenario under investigation. In addition, cards relating to the manipulation of human emotion were also removed as they were also deemed to be inappropriate in this context. At least one card from each lens was included. This is in contrast to the 'alternative inspiration mode' that utilises all 101 cards in the discussion.

Participants

To date, five commercial airline pilots have taken part in this study (3 female; 2 male) aged between 31-38 years. All participants were qualified fixed-wing ATPL or CPL pilots, having held their licences for an average 9.7 years, with an average 4140 hours flight experience. All were employed by a commercial airline company at the time of the study. Design workshops lasted for approximately 4 hours and pilots were reimbursed for their travel and time spent participating in the study.

Experimental design and procedure

Upon arrival, participants were invited to read the participant information sheet and sign a consent form. They were then provided with a brief introduction pertaining to the purpose of the design workshop and the activities that would be involved. Participants were presented with a hypothetical scenario relating to an engine oil leak that would be the focus of our discussion (see Figure 1).

During normal operational flight, you are alerted to a suspected oil leak following a warning signal on the flight deck. You are aware that this may be a spurious alarm so must check to see if…

1. *The warning signal is valid*
2. *Determine the criticality of the leak (i.e. trend oil system parameters)*
3. *Take appropriate action*

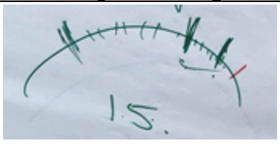
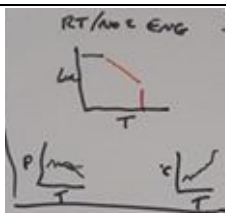
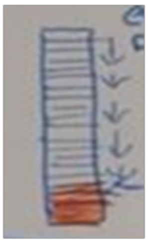
Figure 1. Hypothetical scenario under discussion

For the purposes of discussion, participants were told to assume that the initial warning was valid and were asked to think about what information they would require to respond appropriately to this event and how this may be presented to them. Participants were then invited to draw 'initial designs' for the interface of a new pilot decision aid, either independently or as a group. Once this first activity was complete, 42 DwI cards were then presented to participants in a singular manner to encourage further discussion. Discussions were captured via audio recording but key discussions relating to each design card was noted by the researchers throughout the workshops. This enabled the researchers to later identify which design cards were used to generate the final design. Participants were invited to modify their drawings and note down anything that came to mind as discussions progressed. Once all 42 DwI cards had been discussed, participants were invited to draw a 'final design' based upon the discussions that had taken place. Again, this could be completed independently or as a group.

Findings

Three unique design concepts were generated as part of this study as pilots chose to collaborate on their designs. They all have in common the requirement for pilots to be provided with an indication of time and trend (i.e., time left before absolute minimum/maximum levels reached) via some form of pictorial indication. Examples on how this may be achieved are shown in extracts taken from the individual workshops (see Table 2). Of course, further research is needed to ascertain which, if any, of the representations are appropriate for use on the flight deck.

Table 2. Examples taken from workshops (WS) 1, 2 and 3

Design concept	Notes
 WS1	Use of lines on gauge to show change in system parameter
 WS2	Pictorial representation incorporating a prediction of downward trend based on current system parameters in real time.
 WS3	A form of 'count down timer'

There were many other novel design ideas generated from the discussions. For instance, some participants stated that it would be helpful to be automatically presented with the most relevant checklists and/or pages within the Quick Reference Handbook. Three participants suggested that the interface should be aligned to current training processes, in particular surrounding decision-making tools such as DODAR (Diagnose, Options, Decide, Assign tasks, Review; Walters, 2002) or variations of such (one example of such is presented in Figure 2). In addition, despite the new pilot decision aid having the potential to offer suggestions relating to an appropriate course of action, all participants said it was important that multiple options were presented to them so that flight crews still had authority over the decision-making process (i.e. they didn't want to be told what to do). With this in mind, three participants recognised it may be useful to highlight 'company preferred' or 'maintenance preferred' actions, but this would be something they could opt-out of depending upon the situation. Further, participants recognised that having the capability to automatically send data to the airline and/or maintenance teams would be beneficial, as flight crews currently have to communicate via the Aircraft Communications Addressing and Reporting System (ACARS) which is intermittent and cumbersome to use. Table 3 provides a further summary of findings in relation to the different design lenses.

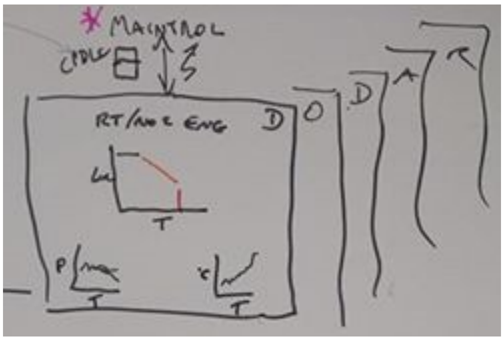


Figure 2. Example menu structure aligned to pilot decision-making tools. Design concept is formed of a five page menu, each page offering relevant information to each stage of DODAR.

Table 3. Summary of design recommendations yielded from different design lenses

DwI Lens	Summary of design recommendations
Architecture	1. Standardised menu navigation is important to anchor in critical situations 2. Include automatic communication with the maintenance teams 3. Automatic pop up of relevant Quick Reference Handbook information 4. Enable movement of display (e.g., via touchscreen) to show others 5. Only present additional information when required
Error Proofing	1. Maintain guarded switches for irreversible actions 2. Touch screens should be used for confirmation actions rather than manual action buttons 3. Maintain aviate, navigate, communicate tasks 4. System should automatically consider variables (e.g., weather, runway length) when presenting alternative routes
Interaction	1. Only present oil information when it becomes critical to the continuity of the flight 2. Give estimated time until oil starvation to change expectations and evoke action 3. Enable users to amend actions based on new information (e.g., action suggestions from the maintenance teams via improved communication tools) 4. Provide a simulation/prediction of what will happen if certain actions are taken
Ludic	1. Utilise DODAR to structure the menu rather than current checklist representations 2. Group relevant information to facilitate next action
Perceptual	1. Remain consistent and comply with traditional colour conventions 2. Enable a comparison to be made between both engines 3. Provide options and make the preferred one larger, although pilot should still have freedom to choose

	4. Addition of a camera or a diagram representation of the oil system may assist in the 'diagnose' phase of DODAR
Cognitive	1. The system should not commit pilots to an action, only guide them 2. Use of charts to represent oil chart
Machiavellian	1. Automatically place relevant screens in the right place and allow these to be moved freely by the pilot (i.e., dark cockpit scenario) 2. Match design to training 3. Telling the pilot they have less oil then they do could change decisions and prevent oil starvation
Security	1. Provide different information/options based on where you are in the flight, or the terrain you are flying over – recognise that different decisions will need to be depending on context 2. Provide a map display with information about the locations and order options for alternatives based on your current position and requirements

Discussion

To date, three workshops have been conducted showing great potential for the DwI method for manufacturers to use in the design and development of interface concepts for new flight deck technology. Specifically, we have been able to demonstrate that by engaging end users during the early phases of the design lifecycle, it is possible to generate and capture accurate user requirements. Further, using the process of participatory design (Damodaran, 1996), we have been able to deliver insight into the types of information that flight crews may want to be presented with during abnormal operating scenarios and the ways in which a new pilot decision aid may be used. DwI essentially provides a method that can be used by Human Factors practitioners to bridge the gap between engineers and designers and actual end users (i.e., line pilots) much earlier on in the design lifecycle.

Of course, further research is needed to ensure that an appropriate interface is developed. More design workshops need to be conducted, utilising a broader range of the commercial pilot cohort (i.e., it is important to consider aircraft type, culture, gender, experience level etc.) to assess whether their design requirements differ. However, the purpose of this paper was to explore the utility of the DwI method within the aviation domain hence why only preliminary data and discussion is presented here. We are however confident that its utility goes far beyond its roots within sustainability and seems to offer a useful approach in generating novel ideas for new flight deck technologies.

Acknowledgement

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