Testing Quick Reference Handbooks in Simulators

Anthony Berg

23rd February 2024

1 Context

1.1 Introduction

Context

Designing aviation checklists is difficult and requires time to test them in simulators and the real world. [1] The simulators require trained pilots to test them to make sure that they work consistently [2], which tests that the procedures in the checklist are concise, achieves the goal of the critical procedure, and will not take too long to complete. These checklists are also carried out in high workload environments, and this workload is elevated if an emergency were to occur. [3]

Problem

Testing procedures in checklists is often neglected by designers. [1] This is shown as there are certain checklists that are not fit for certain scenarios. An example of this is the checklist for ditching (water landing) which would have been applicable to use on US Airways Flight 1549. This checklist assumed that at least one engine was running [4], but this flight lost both of their engines, and if this checklist was used, it could have ended in an incident that could have resulted in people losing their lives. If occurrences like happened more frequently, this could result in pilots losing their trust in checklists, which could result in pilots not using them, when they are designed to aid in situations where they missing a critical step could be detrimental to the safety of everyone onboard the aircraft. [2]

Rationale

Therefore, to aid designers in testing checklists, this project will create a tester for checklists to find flaws in checklists by using simulators without the need of trained crew. This will test that the procedures in the checklist can be done in a reasonable amount of time that will not endanger the aircraft and that the procedures will have reproducible results for the given goal of the checklist. With this, the results can be used to show areas of improvement in the checklist.

1.2 Key Background Sources

Resource	Info
US Airways 1549 NTSB Investigation [4]	**Description:** An investigation carried out by the NTSB on an aircraft that suffered from a dual engine failure from a bird strike forcing the pilots to land one the Hudson River. **Reason:** The investigation found that the Quick Reference Handbook (QRH) was too lengthy and the pilots' used their experience to prioritize essential actions outside the QRH to keep the aircraft in control.
	Continued...

Key Background Sources (continued)	
Resource	Info
Design Guidance for Emergency and Abnormal Checklists in Aviation [5]	**Description:** Provides the challenges researched requirements for designing aviation checklists. It also talks about the problems that occur in checklist design process. This work was funded by NASA as a part of Emergency and Abnormal Situations Study. **Reason:** This will guide looking out for certain aspects to test for in checklists, such as if certain actions require waiting, or if it could be completed in a different order.
Designing Flightdeck Procedures [1]	**Description:** Guidance provided by NASA on the process of developing checklists, which includes steps to focus on and how to make a well designed checklist. **Reason:** This report includes steps on testing checklists which is the focus of this project and will provide guidance on how the tests should be carried out, such as testing the feasibility of the checklist.
The Checklist Manifesto [2]	**Description:** Insight into the steps of implementing a checklist in medicine, by a public health researcher, whilst learning about how checklists are designed and used in industries such as aviation and construction. **Reason:** Checklist designer from Boeing is interviewed where they go through the vital design choices to make them effective and how they gain pilots' trust to use checklists.
Intraindividual Variability in Basic Reaction Time Predicts Middle-Aged and Older Pilots' Flight Simulator Performance [6]	**Description:** Tested 236 pilots aged between 40-69 years old, to measure their reaction times and how they are affected by age. The tests were conducted by Stanford University and MIRECC, and results have been peer reviewed. **Reason:** Gives insightful statistics into pilots reaction times and how they will affect the performance when carrying out procedures in checklists.

2 Aims and Objectives

Aims

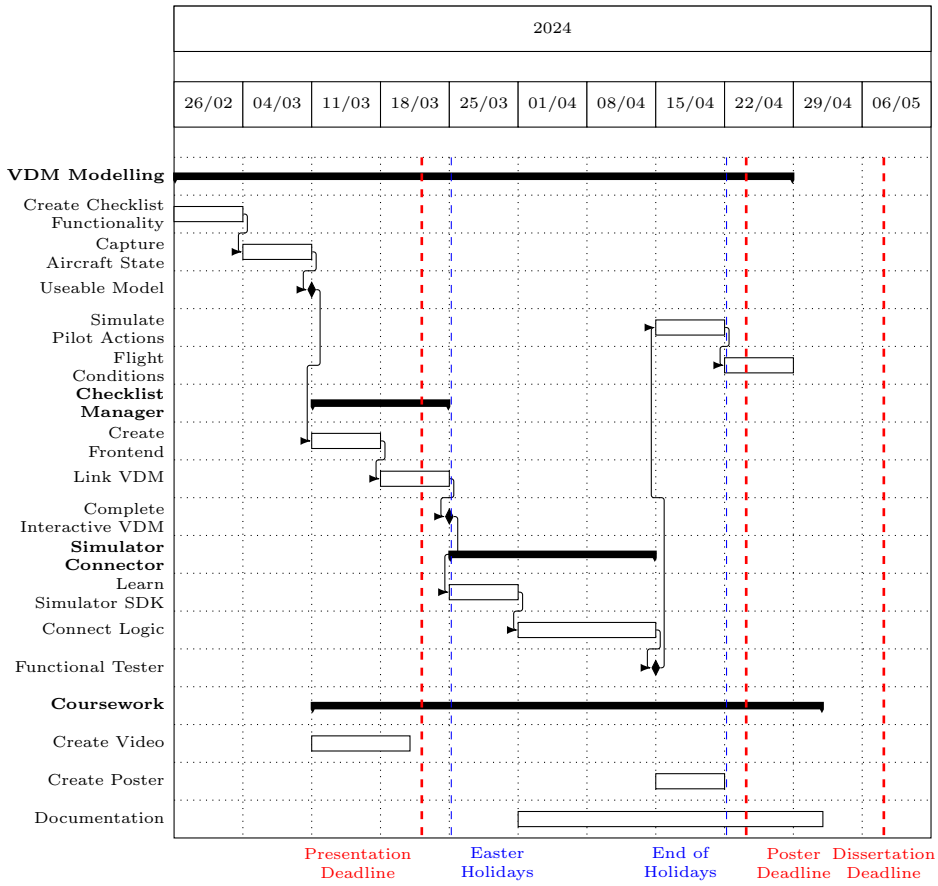
To test checklists for flaws that could compromise the aircraft and to make sure that the checklist can be completed in a reasonable amount of time for multiple different conditions (such as the weather or pilot's reaction times) that could affect the amount of time the pilots will have to complete the checklist. As a result, this will also test the reproducibility of the checklist's goal.

Objectives

1. Research current checklists that may be problematic that could be tested
2. Research how pilots act within certain situations for the checklists that will be tested
3. Implement a formal model that runs through checklists, with the research gathered, to produce an accurate test
   (a) Understand the relative states of the aircraft that need to be captured
   (b) Ensure the consistency of the checklist procedures are tested
4. Implement a manager for the checklist testing logic to provide information about how the test results
5. Connect the formal model to a flight simulator allowing for a more accurate representation of the aircraft systems and flight conditions

3 Planning

3.1 Diagrammatic Work Plan



3.2 Brief Explanation

The Diagrammatic Work Plan provides guidance for how long each objective should take whilst making them more specific tasks. These tasks in the gantt chart are have a pessimistic estimation for how long they should take to complete, as it should give a buffer for falling behind due to unforeseen circumstances, such as getting ill.

The Easter Holidays is an important time to take a break to prevent burnout, however, the decision to continue working on the dissertation during the holidays is to prevent the problem of getting up to speed again once the term starts, hence the tasks are simple which should allow for taking more breaks from work during the holidays.

The last tasks in the Vienna Development Method (VDM) [7] modelling is not essential to provide a proof of concept of the checklist tester, as they are features that would improve the test quality. This would allow for redundancy if time were to become a problem as these tasks could be taken out, in favour of writing the dissertation, and could be implemented at another time.

Coursework tasks will be done in parallel to programming to be as efficient as possible. This will also allow for features that complement the coursework to be implemented. As a result, the prototype will enhance the poster and presentation.

3.3 Risks

The main risk is time management, as falling too far behind could be detrimental. However, to prevent falling behind, certain days will be planned to include breaks, which is included in the plan, to prevent a burnout. Even if a burnout were to occur, there should be enough spare time built up from the pessimistic deadlines to prevent falling behind schedule.

There is also a small risk of the current home flight simulators not being suitable to test the formal model, as their SDKs may not have the tools necessary or the formal model may be too complex to connect to the simulator. If this were to be the case, there could be other another way to test, such as manually flying the plane in the simulator, but recording data in the model manually, to provide feedback on the checklist tests.

4 Ethics

4.1 Ethics Checklist

My project:

1. Will *not* involve working with **animals** or users/staff/premises of the **NHS**
2. Will be carried out **within the UK or European Economic Area**
3. Will *not* have any impact on the **environment**
4. Will *not* work with populations who do *not* have **capacity to consent**
5. Will *not* involve work with **human tissues**
6. Will *not* involve work with **vulnerable groups** (Children/Learning disabled/Mental health issues, etc.)
7. Will *not* involve any *potentially* **sensitive topics** (Examples include but are not exclusive to body image; relationships; protected characteristics; sexual behaviours; substance use; political views; distressing images, etc.)
8. Will *not* involve the collection of any identifiable personal data

4.2 Ethical Considerations

This project will involve referencing previous aviation accidents which had resulted in deaths. However, it should not be a problem by being respectful towards everyone involved in those accidents.

This project will also not involve the use of any users, so no data collection considerations will need to be taken into account for.

5 References

[1] Immanuel Barshi, Robert Mauro, Asaf Degani et al. *Designing Flightdeck Procedures*. eng. Ames Research Center, Nov. 2016. URL: https://ntrs.nasa.gov/citations/20160013263.

[2] Atul Gawande. *The Checklist Manifesto: How To Get Things Right*. Main Edition. Profile Books, July 2010. ISBN: 9781846683145.

[3] Civil Aviation Authority. *Aircraft Emergencies: Considerations for air traffic controllers*. CAP745. Mar. 2005. URL: https://www.caa.co.uk/cap745.

[4] National Tranportation Safety Board. *Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River*. Technical Report PB2010-910403. May 2010. URL: https://www.ntsb.gov/investigations/Pages/DCA09MA026.aspx.

[5] Barbara Burian. 'Design Guidance for Emergency and Abnormal Checklists in Aviation'. In: *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 50 (Oct. 2006). DOI: 10.1177/154193120605000123.

[6] Quinn Kennedy, Joy Taylor, Daniel Heraldez et al. 'Intraindividual Variability in Basic Reaction Time Predicts Middle-Aged and Older Pilots' Flight Simulator Performance'. In: *The Journals of Gerontology: Series B* 68.4 (Oct. 2012), pp. 487–494. ISSN: 1079-5014. DOI: 10.1093/geronb/gbs090. eprint: https://academic.oup.com/psychsocgerontology/article-pdf/68/4/487/1520662/gbs090.pdf.

[7] The Overture Project. *The Vienna Development Method*. URL: https://www.overturetool.org/method/ (visited on 23/02/2024).