Testing Quick Reference Handbooks in Simulators

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Preface

Abstract

This is an abstract.

Declaration

I declare that this dissertation represents my own work except where otherwise stated.

Acknowledgements

This is the acknowledgements.

Contents

Chapter 1

Introduction

1.1 Motivation

Context

- Designing Emergency Checklists is difficult

- Procedures in checklists must be tested in simulators [1], which usually means trained pilots test it, as the tests need to work consistently [2] (making sure it's not lengthy, concicse and gets critical procedures)

- Checklists are usually carried out in high workload environments, especially emergency ones

Problem

- Testing procedures in checklists are often neglected [1]

- There are some checklists that may not be fit for certain scenarios - e.g. ditching (water landing) checklist for US Airways Flight 1549 assumed at least one engine was running [3], but in this scenario, there were none

- Some checklists may make pilots 'stuck' - not widely implemented, could be fixed with 'opt out' points. e.g. US Airways 1549, plane below 3000ft, could have skip to later in the checklist to something like turn on APU, otherwise plane will have limited control [3].

- Checklists may take too long to carry out - Swissair 111

Rationale

- Test checklists in a simulated environment to find flaws in checklist for things like

    - Can be done in an amount of time that will not endanger aircraft
    - Provides reproducible results
    - Procedures will not endanger aircraft or crew further (Crew refering to Checklist Manifesto with the cargo door blowout)

- Results in being able to see where to improve checklists

1.2 Objectives

1. Research current checklists that may be problematic and are testable in the QRH tester being made

2. 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 that the results of the checklist procedures are consistent

3. Implement a QRH tester manager that

- Runs the formal model and reacts to the output of the formal model
- Connect to a flight simulator to run actions from the formal model
- Implement checklist procedures to be tested, run them, and get feedback on how well the procedure ran

Chapter 2

Background

2.1 Solution Stack

- There would be around 3 main components to this tester

    - Formal Model
    - Flight Simulator plugin
    - Checklist Tester (to connect the formal model and flight simulator)

- As VDM-SL is being used, it uses VDMJ to parse the model [4]. This was a starting point for the tech stack, as VDMJ is also open source.

- VDMJ is written in Java [4], therefore to simplify implementing VDMJ into the Checklist Tester, it would be logical to use a Java virtual machine (JVM) language.

2.1.1 Formal Model

- There were a few ways of implementing the formal model into another application

- Some of these methods were provided by Overture [5]

    - RemoteControl interface
    - VDMTools API [6]

- However, both of these methods did not suit what was required as most of the documentation for RemoteControl was designed for the Overture Tool IDE. VDMTools may have handled the formal model differently

- The choice was to create a VDMJ wrapper, as the modules are available on Maven

2.1.2 Checklist Tester

JVM Langauge

- There are multiple langauges that are made for or support JVMs [7]

- Requirements for language

    - Be able to interact with Java code because of VDMJ
    - Have Graphical User Interface (GUI) libraries
    - Have good support (the more popular, the more resources available)

- The main contenders were Java and Kotlin [8]

- Kotlin [8] was the choice in the end as Google has been putting Kotlin first instead of Java. Kotlin also requires less boilerplate code (e.g. getters and setters) [9]

Graphical User Interface

- As the tester is going to include a UI, the language choice was still important

- There are a variety of GUI libraries to consider using

  - JavaFX [10]
  - Swing [11]
  - Compose Multiplatform [12]

- The decision was to use Compose Multiplatform in the end, due to time limitations and having prior experience in using Flutter [13]

- Compose Multiplatform has the ability to create a desktop application and a server, which would allow for leeway if a server would be needed

2.1.3 Flight Simulator Plugin

- There are two main choices for flight simulators that can be used for professional simulation

  - X-Plane [14]
  - Prepar3D [15]

- X-Plane was the choice due to having better documentation for the SDK, and a variety of development libraries for the simulator itself

- For the plugin itself, there was already a solution developed by NASA, X-Plane Connect [16] that is more appropriate due to the time limitations and would be more likely to be reliable as it has been developed since 2015

Chapter 3

Design/Implementation

3.1 Abstraction

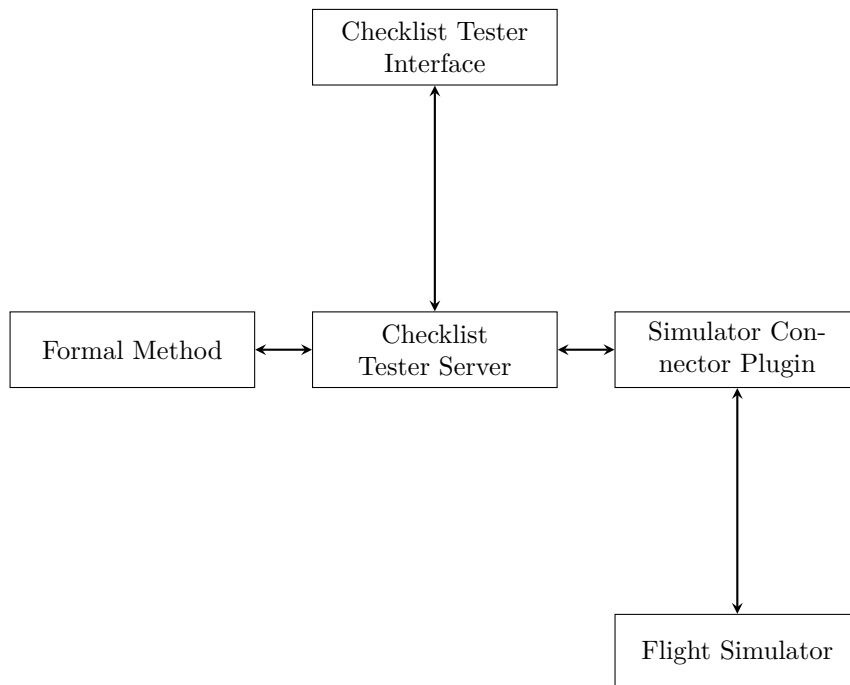

Figure 3.1: Abstract layout of components

3.2 Model

- Formal modelling is the heart of the logic for testing checklists

- Formal model created using VDM-SL

- It allows to test that the checklists have been completed in a proper manner - and that it is provable

- Model keeps track of

  – Aircraft state
  – Checklist state

- If an error were to occur in the model, this can be relayed that there was something wrong with running the test for the checklist, such as:

– Procedure compromises integrity of aircraft

– There is not enough time to complete the procedure

– There is a contradiction with the steps of the checklist

3.3 Scenarios

- Use a Quick Reference Handbook (QRH) to find potential list of checklists to test

- Look at previous accident reports that had an incident related to checklists and test it with my tool to see if it will pick it up

- These previous accident reports can be good metrics to know what statistics to look out for

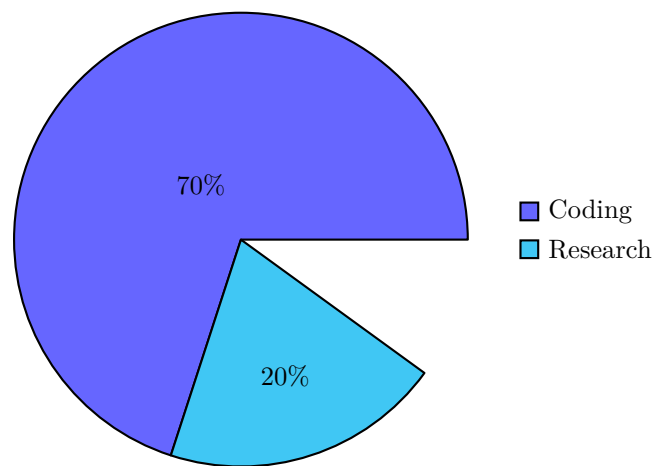## 3.4 Decisions

Chapter 4

Results

4.1   Time Spent

Figure 4.1: Time spent on ... **Improve wording**

Chapter 5

Conclusion

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