Improving the Efficiency of Passenger Boarding on Commercial Aircraft

A Systems approach to improving the current methods of passenger boarding on commercial aircraft for increased efficiency

ENGN2225 Individual Design Portfolio

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Abstract
This portfolio applies a systems engineering approach to help improve the efficiency of current passenger boarding methods on commercial aircraft. Through the use of techniques such as problem scoping, evaluation, requirements analysis, idea generation, testing and further evaluation, a solution was found that would benefit and suit the client based on their needs. The use of this process analyses the current methods and the suggested solution that could be implemented by the client, Qantas Airlines. The proposed solution is a combination and adjustment of the Steffen and Flying Carpet methods, which harnesses elements of both methods to produce the best possible outcome.

Table of Contents and Outcomes:

Introduction

With almost 80'000 scheduled passenger flights per day and 37.4 million flights in 2014 alone, carrying 2.97 billion passengers, the need for efficiency in commercial aircraft processes is evident. Increasing the efficiency of this process translates to an improved service for the passengers and increased revenue for the company (van den Briel, Villalobos et al. 2003, Air Transport Action Group 2014). A simple way to increase the efficiency is via the method of passenger boarding. Current boarding methods include back to front, zones and outside-in, see Figure 1 (Bachmat, Berend et al. 2009).

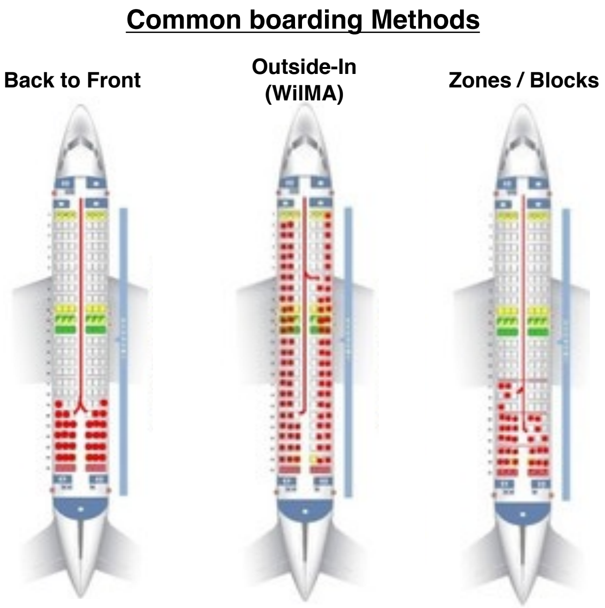

Figure 1: Commonly used current boarding methods for commercial aircraft

However, these current methods are inefficient, meaning more time is spent on the tarmac than necessary (van den Briel, Villalobos et al. 2003). For this reason, the proposed solution combines elements of two new boarding methods that fulfil the prescribed client requirements and perform the task with the greatest efficiency and cost trade-off. Figure 2 outlines the top-level proposed solution that will be elaborated on further in the report. Economy boarding is the key targeted area as maintaining the elitism of priority boarding is key to the client and passengers.

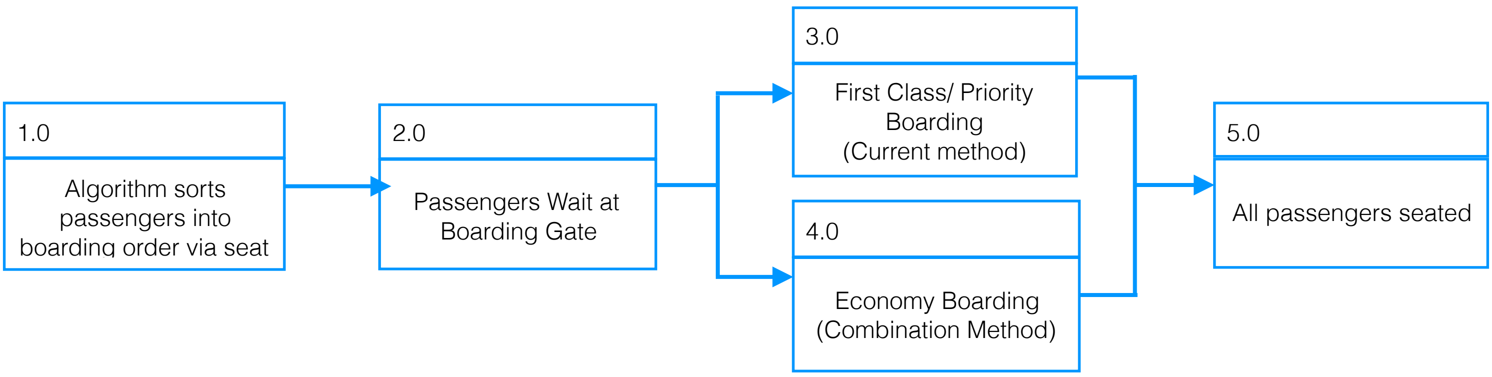

Figure 2: Flow diagram of proposed solution

Project Scope

Boarding time contributes to a significant amount of time between a plane landing and taking off again(Albert Steiner, Philipp et al.). Since time is money, any time wasted is revenue lost (van den Briel, Villalobos et al. 2003). It could also help in ensuring planes run consistently on-time, a key influence in airline brand perception (International Air Transport Association 2015). As boarding is a bottleneck for many companies in the turnaround process, increasing the efficiency has the potential to increase revenue, savings and customer satisfaction (Karp 2011). For example, in 2015, Qantas flew 461,344 flights domestically alone, so if 3 minutes could be saved on boarding time where each minute costs $81, it would save the airline 23% of its annual domestic profit (Airlines For America 2013, Qantas 2015).

Upon exploring boarding procedure, the main stakeholders were found to be the passengers, the airline and the airport itself as they have the largest interest in the process. Through exploring these relationships it became apparent that the greatest influence on passenger boarding time is the airline’s protocols. Through using an innovative protocol like the combination method it could set the airline apart and increase the ease of travel, just as Next Generation Check-in has done for Qantas (Flynn 2011).

After establishing the key problem area, the project scope was identified. In setting the project scope, it was important to understand what would be focused on and what would be not be taken into account in the proposed solution. Table 1 shows a system boundary chart, depicting what is internal to the system, external influencing factors and uncontrollable factors outside of the system scope. This set the boundaries of the problem and the scope of the solution. A key outside factor for this system is the exclusion of late passengers and variation in traffic density, as these may influence the system but are external to it. For simplistic sake of the initial model, this has been excluded, but may be incorporated later on as the process becomes more robust.

Table 1: System Boundary Chart

Internal	External	Outside
- Protocol - Safety - Seating passengers - Luggage stowage time - Waiting time	- Plane Design - Passengers - Airline Crew - Ticketing process	- Terminal design - Variation in traffic density - Late passengers - Incorrect use of protocol.

Evaluation of Boarding Methods and Proposed Solution

There are numerous boarding methods currently used, but some of the most commonly used and frequently used by the client are the random method and zone method in commercial flights (Briel 2010, Karp 2011). The methods will be evaluated against the proposed solution to reveal the best solution according to requirements inferred from the client and translated into design requirements.

Current Methods

The current methods being investigated are the zone and random methods, as these are the methods predominantly used by Qantas (Karp 2011, Qantas 2015). Figure 3 shows both methods, with the numbers and colours indicating the order of boarding. The issue with both methods is that they create lines and bottlenecks within the plane as people sitting further back must wait for others in front to settle into their seats (van den Briel, Villalobos et al. 2003, Bachmat, Berend et al. 2009). This is turn increases the time taken for all passengers to be seated. The zone method is more effective for larger aircraft, but creates confusion when preparing for boarding as there is no infrastructure currently in place that effectively manages when and how zones are called to board (Briel 2010).

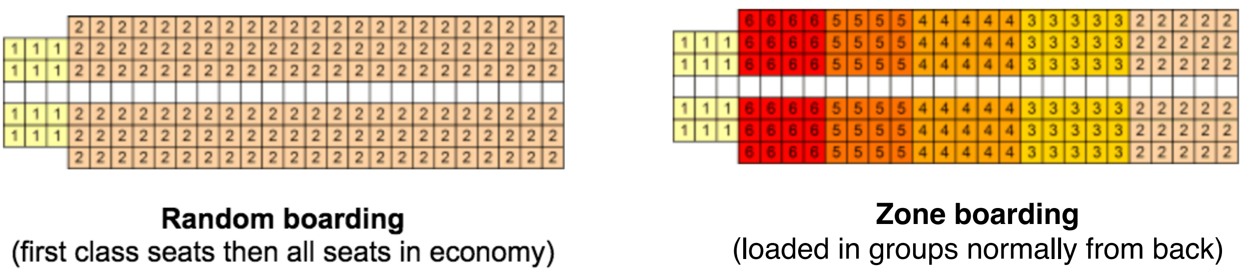

Figure 3: Random and Zone boarding Method diagrams

The flying carpet method works on the principle of a carpet replica of the plane being part of the pre-boarding process. As passengers line up for boarding pass scanning in any order, small groups of people are permitted through at a time instead of a progressing line. In these groups, people find and stand on their corresponding seat on the carpet, moving as a group onto the plane in order from the front (Wallace and Chiang), as can be seen in Figure 4. The issue with this method is that it assumes passengers line up in a random order with evenly distributed seating order, however this is not the case in the majority of circumstances as many families travel, board and sit together (Wallace and Chiang , International Air Transport Association 2015).

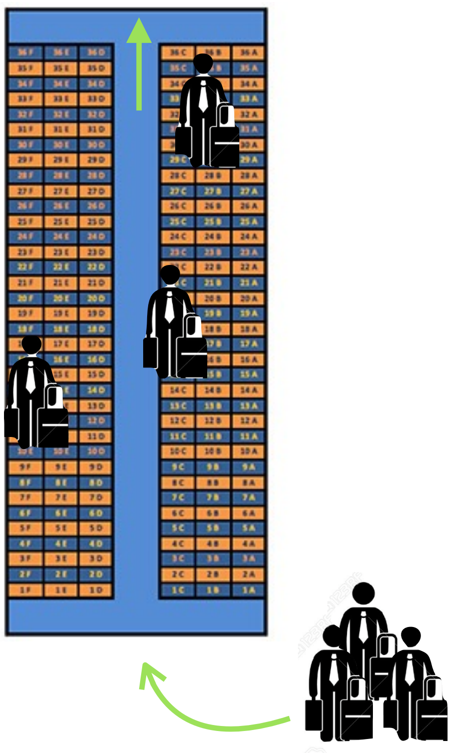

Figure 4: Flying Carpet Method of Boarding where a group of passengers steps onto the carpet to determine boarding order

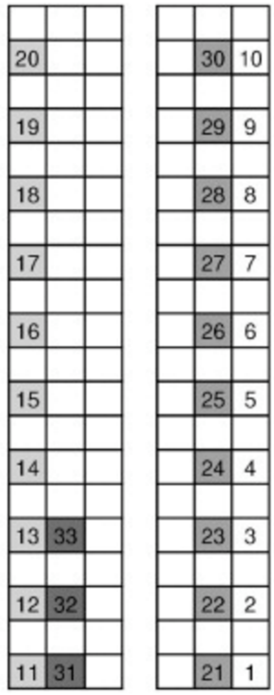

Figure 5: Steffen method of optimal boarding, the shading indicating which passengers are loading luggage at the same time

Alternately, the Steffen method, created by the physicist Jason Steffen, is a mathematical model that utilises the fact that loading luggage is the most time consuming element of boarding, and loads passengers so that 'as many people as possible can use the aisle to store their luggage, allowing many more people to simultaneously prepare to sit' (Steffen 2011). This is done by boarding passengers systematically by aisle and seat order to ensure enough aisle space is available to load luggage quickly and without disrupting other passengers. A representation of the order of boarding respective of seat is shown in Figure 5. The method has been proven to produce an almost five-fold reduction in boarding time and would only increase the time saved as the plane capacity increases(Steffen 2008). This method has been tested via simulated and experimentally but is not common practice (Steffen 2008, Steffen 2011).

This model does not however account for passengers who wish to board and sit together (e.g families) and relies on the fact that 10 people board at a time and in the specified order (Steffen 2008).

Solution

In combining and adjusting these two methods an optimal and feasible boarding method could be produced. To do this the Steffen algorithm would have to be changed to allow passengers who are seated together to board together and the flying carpet would have to be printed in reverse, so as the passengers at the back of the section board first. The groups created by the improved Steffen algorithm would be printed on boarding passes and each group called in turn at the gate. The flying carpet would then be used to act as as a troubleshooter for the algorithm and would ensure the groups were the correct size and boarding in the correct order, from back to front. Figure 6 illustrates the functional flow of the entire process. However, employing this new system could be costly and time intensive, with a long implementation timeframe when compared to the existing solutions.

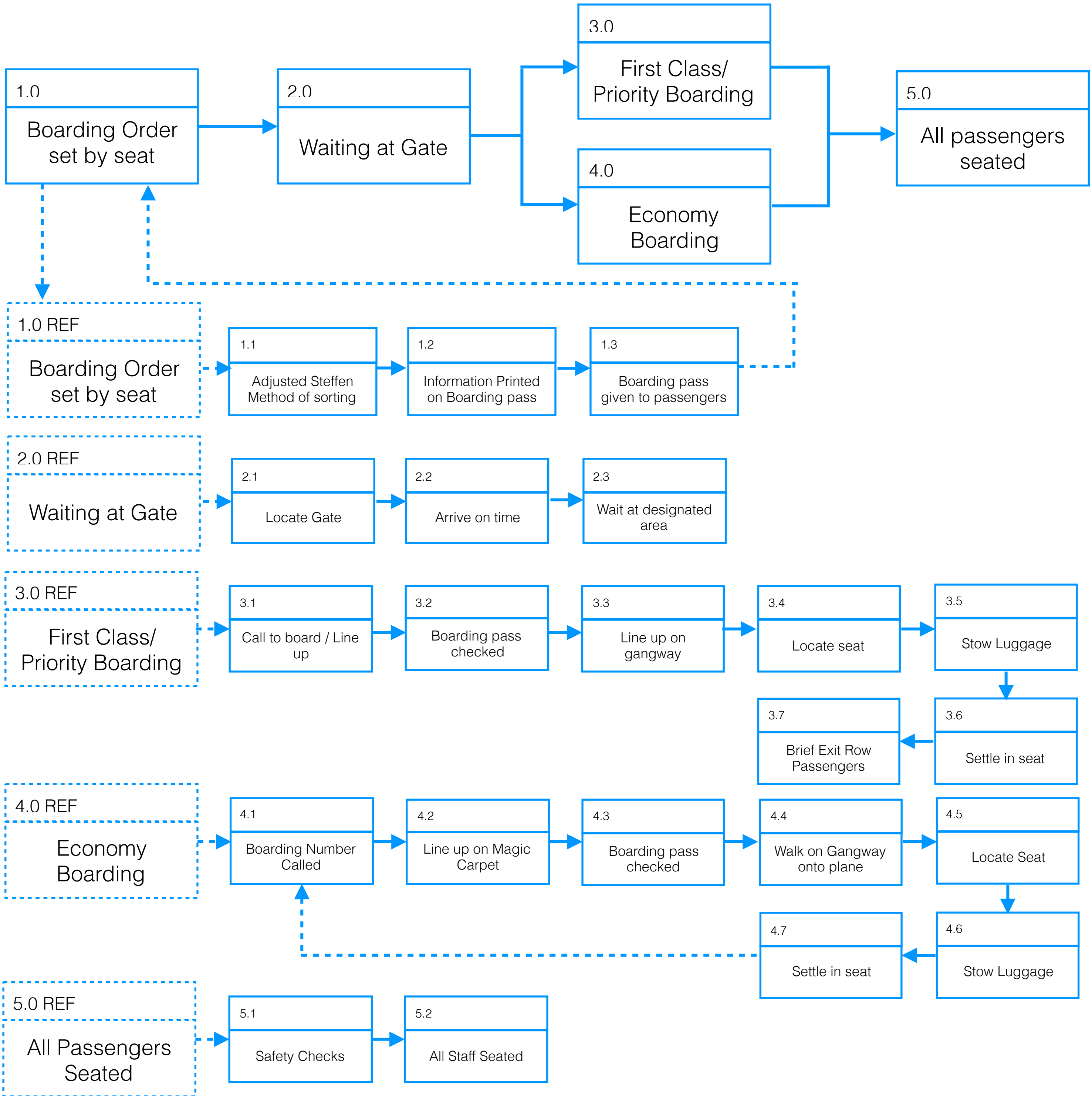

Figure 6: An in-depth functional flow analysis of the proposed solution

As can be seen in the evaluation matrix, Table 2, this solution is shown to be the best option when compared to the design criteria and two previously listed current methods. However, this is a preliminary evaluation and further testing would increase the precision and accuracy of the evaluation. The combination of methods increases the ease of understanding through the flying carpet and the adjusted the Steffen method increases efficiency and allows family seating, ultimately increasing the satisfaction of the customer and profits for the client.

Evaluation Matrix

The design requirements found from interpreted customer requirements set the specifications and limitations for the project and had great influence on selecting the best solution for the client. During the idea generation phase these dictated the direction of the project and possible solutions that arose. The requirements can be seen in Table 2, ranked in order from most important to least. Additionally the current methods and the proposed solution evaluated against these to form an evaluation matrix. The methods have been evaluated using a ranking score from 3 to 1 in each criteria, with the best given a 3 and the worst awarded a 1 and then weighted by the ranking of the design requirement.

NOTE: The rankings for these three options were found via simulations and assumptions from the current solutions.

Table 2: Design Requirements and Evaluation Matrix

				Combination		Zone		Random	
Rank	**Design Requirement**	**Metric**	**Direction**	*Rank*	*Weighting*	*Rank*	*Weighting*	*Rank*	*Weighting*
6	Load Time: Time taken to load and seat all passengers	Minutes	↓	3	18	1	6	2	12
5	Cost of implementation: training, signage and personnel	$	↓	1	5	2	10	3	15
4	Safety: Injury claims	Integer	↓	2	8	2	8	1	4
3	Customer Satisfaction: Fly with company again	%	↑	3	9	2	4	2	4
2	Ease of Implementation: customer confusion resulting in delays	Minutes	↓	1	2	2	4	2	4
1	Maintenance	$	↓	1	1	2	2	3	3
	TOTAL			11	**43**	11	**34**	13	**42**

The weighted evaluation matrix reveals that the random method is almost as good as the proposed combination method, however this does not take into account the main purpose of the project, which is to increase the efficiency of boarding. Even though the solution does have higher cost and maintenance, the money it could save outweighs the initial cost.

Idea Generation

Several other ideas were considered prior to selecting the final solution for various reasons, these ideas can be seen in Figure 7 in a concept classification tree. Possible solutions were grouped by theme: Plane Design, Multi-tasking, Protocol/Method. Three possible ideas to be explored were existing methods, altering plane design and loading the plane while refuelling. However, two of these methods would not satisfy the design criteria (e.g cost of implementation of new planes), were inefficient (most of the suggested methods) or were not feasible at the time (new plane design with different number of aisles). Therefore, the idea of combining existing methods was founded as a result of this process.

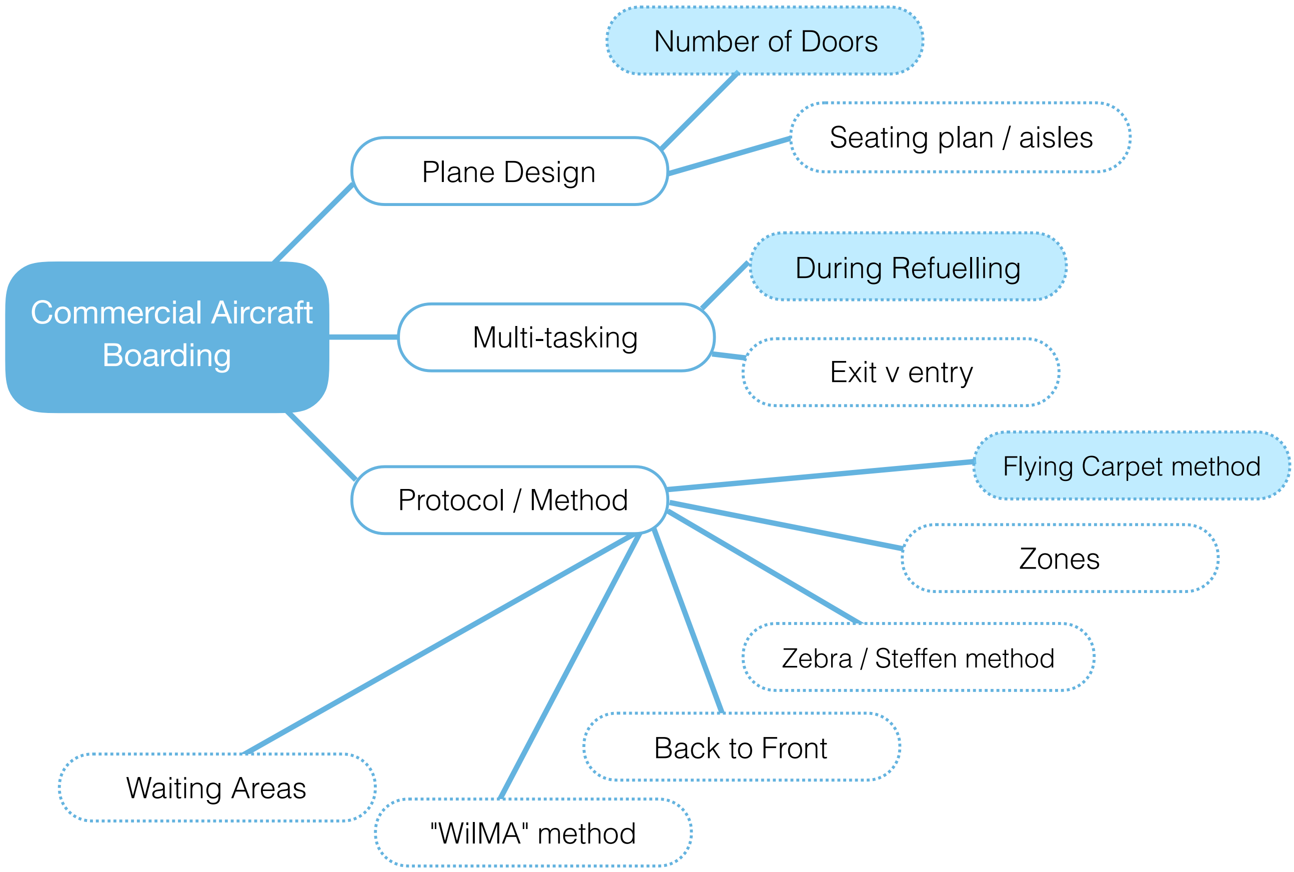

Figure 7: Idea generation for increasing efficiency of passenger aircraft

System Architecture

In understanding how the systems within the solution interact, the system was mapped and the sub-system interactions revealed. Figure 8 shows this mapping and describes the relationships between various sub-systems within the overall solution.

From this mapping, it was revealed that the system is heavily reliant on the software component as it is what dictates the boarding order. The current solutions are not as reliant on this type of software, making it more flexible but less efficient, a major component of the customer requirements. This is because without a strict boarding order it is easier to fix errors and solve issues with boarding. Additionally, in segregating the boarding sections, there is more room for human error and miscommunication, possibly increasing cost. However, as the software portion is detached, if there is an issue with the software, the system could be altered, and instead the current method could be used as a last resort. Staff are also heavily relied upon in the system, but as staff are relied upon heavily in the current solution's system, there will not be an increase in their tasks.

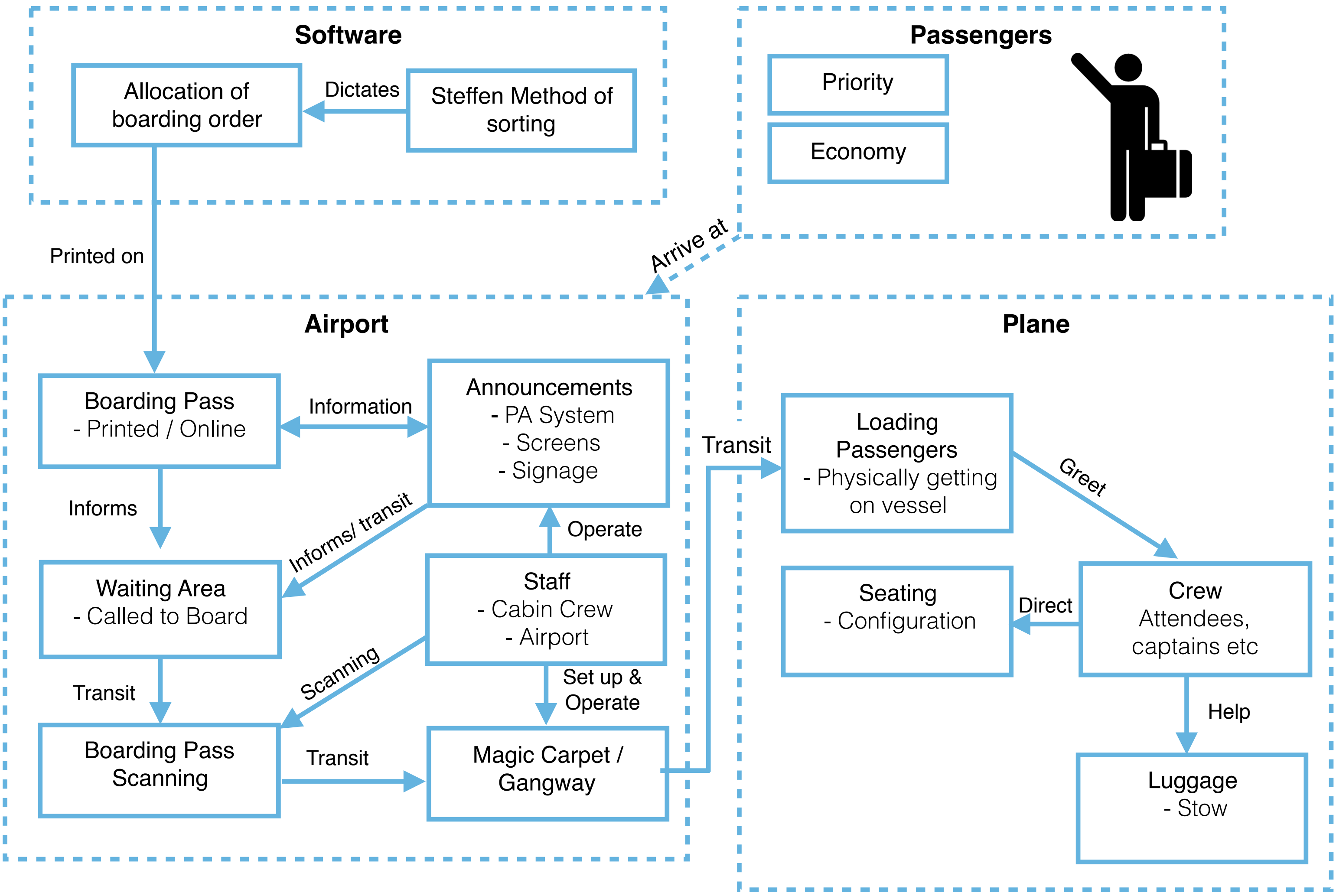

Figure 8: System Architecture of Combination Method

Future Testing and Evaluation

The next stage of the design process is to test and evaluate the proposed solution, the Combination Method. Through this checking stage, the solution can be adjusted where necessary and troubleshooted. The first level of testing would be simulation, as this is a new solution in its design phase. Simulation would entail writing code to mimic the method of boarding and altering parameters such as the number of people in a boarding group, the type of plane and any issues that may arise. These tests can help in troubleshooting the proposed solution prior to experimental testing.

The second level of testing would be experimental. Experimental testing would entail using a human crew and passengers to trial the method. These experiments would most likely be compared to a base test in another current method, so as to prove which is the more efficient in real life. This might resemble a run through of boarding using numerous planes, crew and test passengers. The first stage of experimental testing would most likely be entered around a single airport, crew and passenger group that would form the initial testing. If any issues arise from these first tests the method would be adapted and altered for the second round of testing, which could then involve numerous airports under controlled conditions. This would assess how universally the method could be used and if it needs to be customised depending on the location or airport terminal configuration. In these tests, there would need to be a new crew and passengers for every testing site, who would need to be briefed in the method so as it is as realistic as possible. Additionally, testing could be performed using variations of the model so as to find the best solution by evaluating the responses. If this occurred, the same crew would be used for the group of tests but be replaced if another stage commenced. Initially, it would be desirable to start testing on one plane model and then expand to various models in the fleet.

Testing could also be performed into the best way to communicate the changes and process of boarding to passengers. This could be done via consultation or independent testing prior to experiments, based on data from surveys of travellers, such as the Global Passenger Survey the International Air Transport Association conducted last year .

From these tests, the solution would continuously be evaluated and refined until it is the best possible solution for the client and able to be implemented. This is supported by the aim to increase efficiency of plane boarding and save Qantas money for every minute saved. Much like online check-in, it might start out as bothersome or time-consuming but could become second nature to travellers.

Future of the Project, Recommendations and Communication

The future of the project is reliant on the testing and evaluation process but does require funds and looking into modes of delivery. The estimated cost of the project is $70'000 for testing, experiments and implementation via training courses, signage and advertisements (Medak).

A key flaw of the design is not factoring in passengers who are not ready to board at the correct time (e.g are delayed in transit) or the high traffic times of the year (i.e holidays). Since these circumstances are hard to simulate in controlled situations during the testing and evaluation process currently, a pilot test may need to be performed with these conditions factored in. This may mean purposefully delaying certain passengers or performing a test in a busy environment such as before Christmas, to test the limitations of the system and make necessary adjustments. This could be performed as a later part of the testing and evaluation process.

This project could also be extended into finding a more efficient method of disembarking, perhaps through mathematical models and social change. It may also lead to consulting with designers and manufacturers such as Boeing and Airbus, alongside airports to revise plane design and increasing the number of loading doors. This would be a large-scale and time intensive project that would involve leasing long-term with industry, research and airlines. Research has indicated that interior plane design is a key factor in boarding times during simulation, which is another area that could be explored. (Bachmat, Berend et al. 2009)

Recommendations to the Client:

- Further Testing, Evaluation and Modification of Design
- Design of software
- Understanding and researching best method of communication delivery
- Planning out steps of implementation incl. incorporating the software
- Customising and expanding solution for various planes' make and model

In regards to communicating the design, there is much scope for the method of delivery. A possible solution is to have a step by step pictorial of the method for passengers, similar to the safety cards in the pockets of airplanes. This would most likely be an image portrayal of Figure 9, a step by step process of the method. This would be effective as it relates to the established resource of safety communication and is not limited by language.

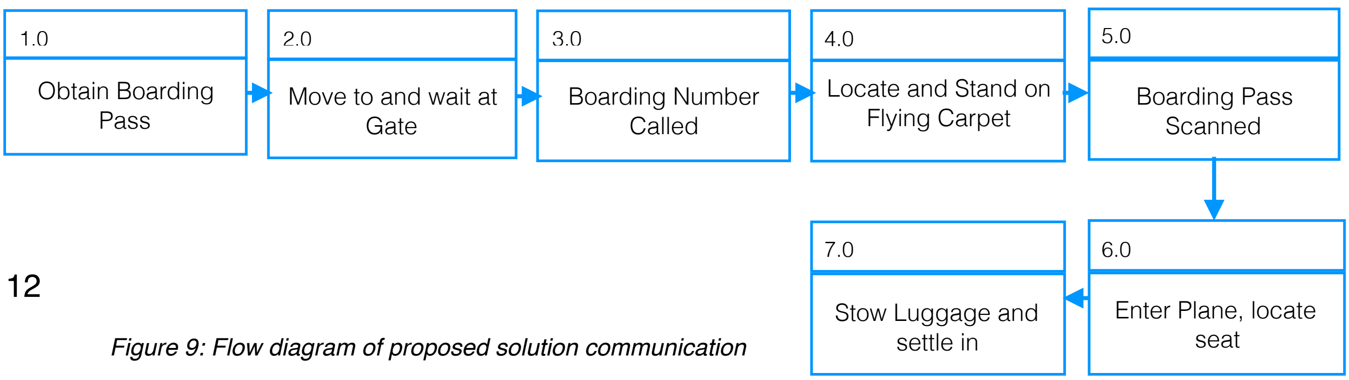

Figure 9: Flow diagram of proposed solution communication

Conclusion

By increasing the efficiency of passengers boarding, the efficiency of airplane travel can be increased. This increase in efficiency has the potential to save airlines and airports' revenue as well as increasing customer satisfaction. After the project scope was established and boarding identified as an inefficient area of the flying process, ideas were proposed and compared to the design requirements. Through assessing current boarding methods and the feasibility of several idea, the Combination Method was proposed. This method uses and adapts two current innovative methods, the Steffen and Flying Carpet, to produce the ultimate solution. This solution is currently in the design stage, but with testing, evaluation and modification in the future, it has the potential to be an innovative and efficient boarding method that satisfies the client requirements and sets Qantas apart from competitors.

Reflection

So far in this course and in compiling this portfolio I have learnt how much I love using a systems approach, how much I practice it already in my daily life and how versatile it is. The approach we have used is very logical but also creative, two thing that come quite easily to me. I appreciated the opportunity to be independent and tailor the course to my own interests. A phrase that comes to mind is 'you do you', something I adhere to in my own life. I have been shown that the systems approach can be applied to almost any situation, no matter the discipline or the problem. It is a way of thinking I would like to employ moving forward not only in my studies but also in my personal life. Certain skills I have learnt along the way such as design communication and problem scoping are transferable skills that I can use in many aspects of my life and career.

Though TC's were good practice for certain techniques, I found the seminar's the most helpful resource throughout the course. I responded to the interactive method of teaching and in completing examples with others. Overall I did not use the course resources heavily but used them to clarify and extend knowledge where necessary.

In the future, I would like to choose a group for the poster who were more active in their roles within the group. While effort was made to incorporate all members, several did not respond and it made the entire process quite difficult and incoherent. Although these aspects were challenging for the success of our group, personally I was able to perform my duties and help others with theirs. In the future, I would place a greater importance on assigning team roles and on group meetings. Team roles means there is less confusion and you are held more accountable, additionally it allows for better delegation.

My experience with the peer review process on the whole was quite positive. My reviewers gave lots of constructive feedback (e.g increasing explanation of certain areas and including system architecture) that was employed. Some advice however was disregarded or the suggestion made addressed in a different way. The process of writing my peer reviews for others gave me many ideas and pointed out flaws in my portfolio such as flow, formatting and justification. In the future, I would suggest making the draft process compulsory for all students and allowing greater flexibility of response questions, such as decreasing the rigid questions. However, I acknowledge that these are a guideline to many students in the process. Overall, I was satisfied with my peer-review and have been satisfied with ENGN2225 experience so far.

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