Impact of RFID on Aircraft Turnaround Processes

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The air transport industry is a complex business where airports, airlines and handling operators have to work together to provide efficient services. The focus of this research is to look at how identification technologies such as RFID can improve aircraft turnaround processes and reduce the impact of operational disturbances.

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1. Introduction

This paper concerns the turnaround of aircraft at commercial airports and the role that RFID can play in improving turnaround processes. Such work is part of an on-going effort to improve the efficiency of existing airport facilities. The number of flights per year is increasing rapidly, and the need to minimise costs, improve reliability and deliver on-time departures is greater than ever. During the six months from June to November 2005 the number of scheduled departures from the 10 largest UK airports was 380,234[1]. The average departure delay was 17.4 minutes, equating to departure delays in the UK of over 605 hours (25 days) every day. The cost of departure delays is a complex issue, but the Met office stated that on average delays cost airlines £50 per minute in 2005[1]. Using this figure, the estimated cost of delays to flights leaving the 10 largest UK airports during 2005 was over £650m.

During the last eight years the Cambridge UK Auto-ID Lab has been one of seven global labs researching and supporting the adoption of networked Radio Frequency Identification (RFID) technology. The adoption of this technology is growing quickly and we have seen the biggest uptake within the fast moving consumer goods area, with organisations such as Wal*Mart mandating its use to enable greater efficiency within their supply chain. Recently, Boeing has indicated that they are adopting this technology to enhance through-life applications of components on the new 787 Dreamliner [3]. This paper discusses some of the initial work carried out to examine how RFID can be used improve aircraft turnaround processes.

2. Background

In this section we provide some background information relating to the nature of turnaround processes and some of the tools which are used to analyse these processes.

2.1. The Aircraft Turnaround Process

The turnaround of an aircraft comprises the sequence of ground operations required to service the aircraft from the time the chocks (rubber blocks to prevent aircraft from moving) are put in front of the wheels after it lands, to the time the chocks are removed and the aircraft is ready to leave. Many different organisations are involved in the turnaround process making it a complex and often inefficient operation. (Figure 2.1)

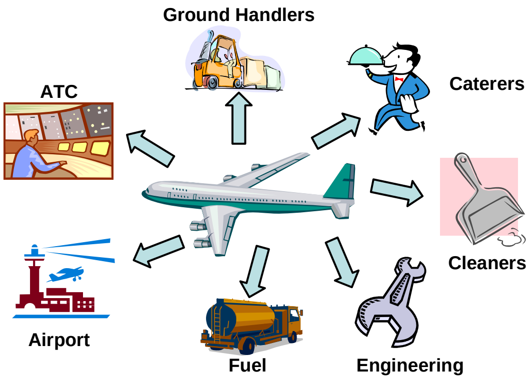


Figure 2.1 Organisations involved in an aircraft Turnaround

There are a number of key tasks carried out during an aircraft turnaround such as: loading and unloading passengers and baggage, safety and security checks, catering replenishment, cleaning, and the completion of essential post- and pre-flight administration. It should be noted that the servicing arrangements and turnaround tasks vary for different aircraft and different operators. The turnaround processes are typically shared between several organisations and it is essential that they work together effectively to deliver the optimal turnaround. This is further complicated when the aircraft is being handled at a remote airport by third party ground handling organisations.

2.2. Relevant Analysis Tools

The approach used for analysis in this research work draws heavily on existing tools from the manufacturing domain. The tools, which include single-minute exchange of dies, lean manufacturing processes, and production responsiveness and capability have been examined and applied to aircraft turnarounds.

2.2.1. Single Minute Exchange of Dies (SMED)

Single-minute exchange of dies (SMED) is a concept that focuses on improving machine setups. It was developed by Shingo [4] over a period of about 19 years during the mid to late twentieth century. Shingo's view is that it is necessary to understand why things are done, so that the way they are done may be changed for improvement. Shingo defines machine setup operations as being made up of two fundamentally different types:

- Internal setup – tasks that can only be performed when a machine has stopped. An example would be the removal or exchange of a die or drill bit.
- External setup – tasks that can be carried out while the machine is in operation. An example being the transportation of a new die or drill bit to the machine.

Shingo came up with techniques for shortening setup times and called the concept single-minute exchange of die, or SMED [4]. It was hoped that SMED would enable any machine setup to be performed in under ten minutes (hence the name single-minute exchange of die). The concepts of SMED can be applied to aircraft turnaround time, where an aircraft turnaround is seen as a setup operation. Tasks carried out while the plane is on the ground are the internal setup, and external setup refers to activities which may be carried out before the plane lands (or after it takes off).

2.2.2. Lean Manufacturing

Lean manufacturing is 'a philosophy of production that emphasises the minimisation of the amount of resources (including time) used in the various activities of the enterprise'. Lean manufacturing involves identifying and eliminating non value adding activities and focuses on the start-to-end value streams rather than the idea of optimising individual departments in isolation. Waste is a term frequently associated with lean manufacturing, and John Bicheno [5] suggests that the focus should be on preventing waste rather than eliminating it.

The principles of lean manufacturing can be applied to aircraft turnaround, but it is important in this project to be able to distinguish between lean improvements (improvements identified by using the principles of lean manufacturing) and the additional improvements ID technologies can offer.

2.2.3. Production Responsiveness

Production responsiveness is ‘the ability of a production system to achieve its goals in the presence of disturbances’. A disturbance is ‘a change occurring internally or externally to a production system, which can affect its operational performance, and is either outside its control or has not been planned for by the system’.

Matson and McFarlane [6] suggest that a sensible assessment of the impact of disturbances can only be made with direct reference to an organisation’s production goals, and that the overall effect of a disturbance covers the immediate effects of the disturbance and the effects of any response. To achieve its goals in the presence of disturbances, a production system must respond after the disturbance has occurred and/or have responded in advance to the known possibility of the occurrence of the disturbance.

A Production Responsiveness auditing tool can be used to help a company evaluate its current ability to handle disturbances affecting its production performance, and decide appropriate actions for improving its responsiveness.

The 5 steps of this audit are outlined as follows:

Step 1: Understand the operation - Tools such as process mapping can be used to clarify processes.

Step 2: Goal identification - Understand how operational performance is measured.

Step 3: Disturbance responsiveness assessment - For each type or each class of disturbances a Disturbance Responsiveness Chart is plotted to capture the nature of the disturbance and its impact on the process.

Step 4: Disturbance response capability assessment - For each type of disturbance a Capability Chart is also produced. This chart provides an assessment of how well the capability can respond to the disturbance.

Step 5 – Impact/Response - capability summary chart - The final step involves producing a chart that can assist in comparing disturbances in terms of the current impact on production goals, and the extent to which capabilities exist for overcoming them. This chart can be used to help make decisions on actions for adding or improving capabilities.

The responsiveness auditing tool can be applied to examine how well processes and systems handle the different disturbances that occur during a turnaround operation, and highlight the level of their impact. These processes and systems can be examined more closely to see if improvements can be made through the use of ID technologies.

3. Analysis Approach

In this section we will outline the approach taken to examine the turnaround process and the likely impact from the adoption of ID technologies. It was important to select suitable airlines and airports to participate in the case studies. To get a clear understanding of which airports and airlines within the UK were most appropriate, punctuality statistics published by the Civil Aviation Authority (CAA) were examined [1].

Table 3.1 shows the ranking of 9 out of the 20 airlines we examined in the UK. They have been ranked by average departure delay time, with higher rankings denoting worst on-time departure performance.

Rank	Airline	Average delay (mins)
1	VIRGIN ATLANTIC AIRWAYS	24.8
2	GB AIRWAYS LTD	22.7
3	FLYBE.BRITISH EUROPEAN	22.3
4	BRITISH AIRWAYS PLC	19.3
5	ALITALIA	19.1
6	BMIBABY LTD	18.1
7	LOGANAIR	17.9
8	MONARCH AIRLINES	15.6
9	EASYJET AIRLINE COMPANY	15.4

Table 3.1 Average departure delay by airlines in the UK

From the list shown above three short haul airlines were selected on the basis of the distribution of their turnaround issues and their proximity. These airlines agreed to participate in the research activity, although due to sensitivity around some of the data, the names of the airlines are not given.

3.1. Structure Investigation

The research was carried out in two distinct phases:

- examine approaches for reducing the mean aircraft turnaround time
- how to reduce the variance in aircraft turnaround time.

Part 1: Mean Turnaround Time Reduction. The first part looks at how identification technologies (ID) can be used to improve mean aircraft turnaround time by streamlining different processes located on the turnaround path. This will make use of the SMED and Critical Path Analysis to streamline existing processes.

Part 2: Turnaround Variation Reduction: The second part of the research examines how ID technologies can be used to reduce the impact of operational disturbances on aircraft turnarounds by identifying the different disturbances and the interdependence of processes.

In the following sections we describe the approach taken in each case.

3.2. Approach to Mean Turnaround Time Improvement

An outline of the process used to determine opportunities for reduction in mean turnaround times can be seen in Figure 3.1 below.

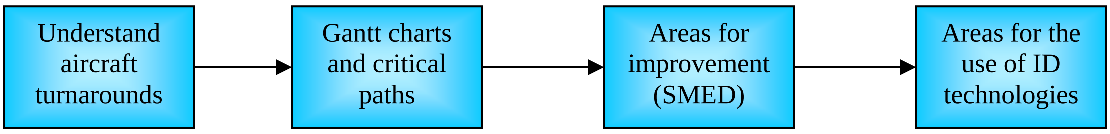


Figure 3.1 Mean Aircraft Turnaround time improvement

The analysis of mean turnaround time consists of three main steps:

Step 1: Turnaround operations, Gantt charts and critical paths; The objectives were to get an overview of the turnaround operations, the timings of these operations, who performs them (airline staff, ground handling staff or other external staff), and the technology and information currently used. This information was obtained during site visits to the airlines. Using the information collected, a Gantt chart and the critical path for the ideal/minimum turnaround was produced for each airline. The critical path is the series of consecutive activities representing the longest path through the turnaround operations.

Step 2: Critical path processes; On later site visits to each airline a more in-depth understanding of the processes was acquired in order to identify the critical path for each airline's turnaround. This was achieved by walking through the processes, watching them in real time, and speaking to cabin and flight deck crew, ground staff and the operations staff involved.

Step 3: Areas for the application of ID technologies; Areas where critical path processes could be improved (for example a reduction in the required resources) and/or areas where the time of these processes could be reduced by using ID technologies were identified. Distinguishing between areas where general or lean improvements could be made and areas where ID technologies could bring additional or unique benefits was important.

3.3. Approach to Reduce Turnaround Time Disruptions

In this section the techniques used to analyse the disturbances and capabilities of different processes within the aircraft turnaround procedure are discussed. The disruption analysis consists of 6 main steps and investigates how ID technologies can be used to reduce the impact of operational disturbances on aircraft turnarounds.

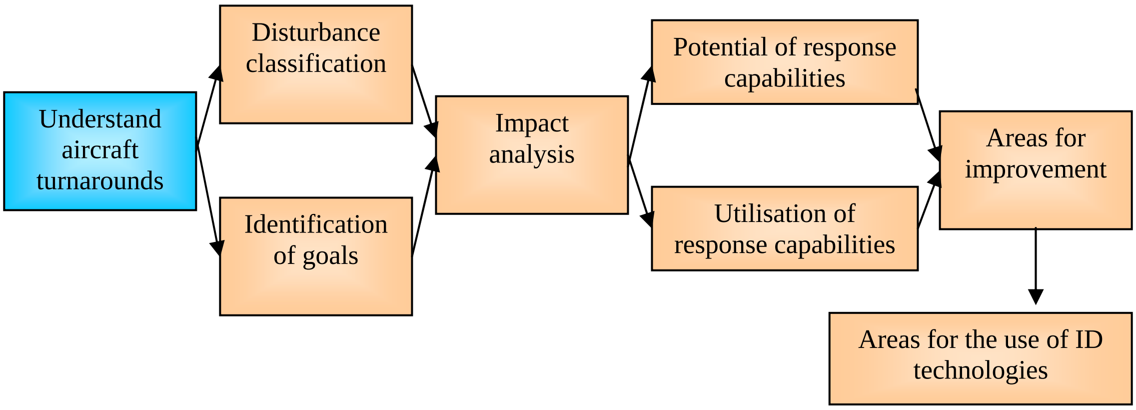


Figure 3.2 Reduction in Aircraft Turnaround Disturbances

This part of the research builds on tools used to analyse Production Responsiveness as discussed in Section 2.2. The cause of a disturbance to an airline can be a supplier, a customer, and can be external or internal. This is shown diagrammatically in Figure 3.3. External disturbances such as the weather and air traffic flow management restrictions are by definition out of the control of an airline and are not considered in the subsequent analysis.

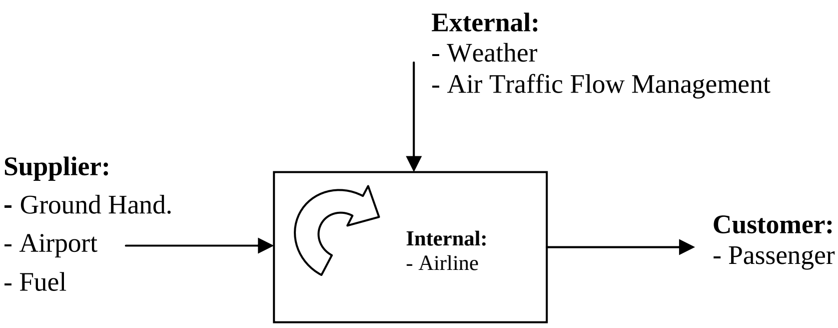


Figure 3.3 Disturbance Sources

Step 1: Understand the operation;

Step 2: Goal identification; Discussions were held with operations staff at the 3 airlines who confirmed that the main goal relevant to turnaround was on-time performance. Other factors mentioned by the airlines were the knock on effects (reactionary delays), the cost of the delay, and the negative impact on customer satisfaction and loyalty. These 3 factors are linked to the initial delay and hence are linked to on-time departures, and can be reduced by decreasing the frequency of occurrence and duration of delays

Step 3: Disturbance responsiveness assessment; This assessment was concerned with determining the nature of disturbances and their impact on the goals of an organisation. To assess the nature of the disturbances, data on departure delays was obtained from two of the airlines involved and was grouped by IATA Aircraft Movement and Diversion Message Codes. IATA code is assigned to a delay by the Ground handling or operations staff. Listed below in Table 3.2.are some of the pertinent delay codes used in the analysis.

41	Technical defects - including items in the Minimum Equipment List
43	Non-scheduled Maintenance - Special and/or additional checks beyond normal maintenance
46	Aircraft Change - For technical reasons e.g. long technical delay
32	Loading/unloading - Bulky, special load; lack of loading staff
36	Fuelling/defuelling - late delivery of fuel - excludes late request
16	Commercial or passenger convenience
31	Late documents - Weight/balance, manifests etc
37	Catering

Table 3.2 IATA Aircraft Movement and Diversion Message Codes

Because the measures of frequency of occurrence and average duration of a delay cover both the nature and impact of a disturbance, it is felt that a single disturbance impact measure would enable the comparison of disturbances. The disturbance impact measure (per unit time) that will be used to compare disturbances is given in the following equation.

Average Disturbance Impact = Average delay (min) x Frequency of disturbance (min)

Step 4: Disturbance response capability assessment; For each disturbance or class of disturbances identified in Step 3 a corresponding Disturbance Response Capability Chart will be produced. The available response capabilities will be categorised as recognition capabilities, response and decision making capabilities. To determine the existing response capabilities, their potential to solve disturbances and their current utilisation, visits and interviews with staff from the airlines and the other companies involved in a turnaround were carried out.

Each capability was assigned a value of 0, 1, 2 or 3 depending on the potential of that capability to solve the disturbance. (3 High, 0 Low capability, filled dot)

Each capability was assigned a value of 0, 1, 2 or 3 depending on the utilisation of that capability. (3 High, 0 no utilisation, hollow dot)

Step 5: Impact/Response summary; To make decisions on potential improvements it is necessary to be able to simultaneously consider the impact of a disturbance, the potential of capabilities to solve disturbances and the current utilisation of these capabilities to solve disturbances. To determine the potential and current utilisation of capabilities, interviews and site visits were conducted with relevant ground handling and with operational staff involved in the turnaround process.

Condition 1: The impact of a disturbance is high and the potential of current capabilities to solve the disturbance is low. This indicates an area where the additional improvement to existing capabilities should be strongly considered.

Condition 2: The impact of a disturbance is high, the potential of current capabilities to solve the disturbance is high, but the current utilisation of these capabilities is low. This indicates that staff may need further training or systems may need to be adapted to make better use of information available.

To aid in determining the presence of these two conditions, three measures are proposed [6]:

Average Disturbance Impact: Average delay x Frequency of disturbance

Disturbance Response Capability Index: Average of non-zero values for the capability.

Capability Utilisation Index: Average of non-zero values for the utilisation.

Step 6: Areas for the use of ID technologies; By examining the Impact / Response table and the 2D Impact / Response chart, it is possible to highlight processes that may benefit from the use of RFID or ID technologies.

The next two sections present the results of the analysis of the three airlines involved in the turnaround research.

4. Mean Turnaround Time Improvement Study

The analysis presented here for examining approaches to reducing mean turnaround time follow the approach presented in Section 3.2

4.1. Critical Path Analysis for Turnaround

From the information collected and the observations made during site visits to the three airlines, Gantt charts and the corresponding critical paths were produced for each airline. On the Gantt charts each operation is numbered and the prerequisite steps for each operation are shown in brackets. In the Gantt charts the operations are divided into:

Operations on the aircraft – carried out by cabin crew, the flight deck and cleaners

Operations on the ramp – carried out by ground handlers

Tasks completed by a Dispatcher – Airline staff. Not all airlines used these

Passenger (PAX) services – carried out by ground handlers

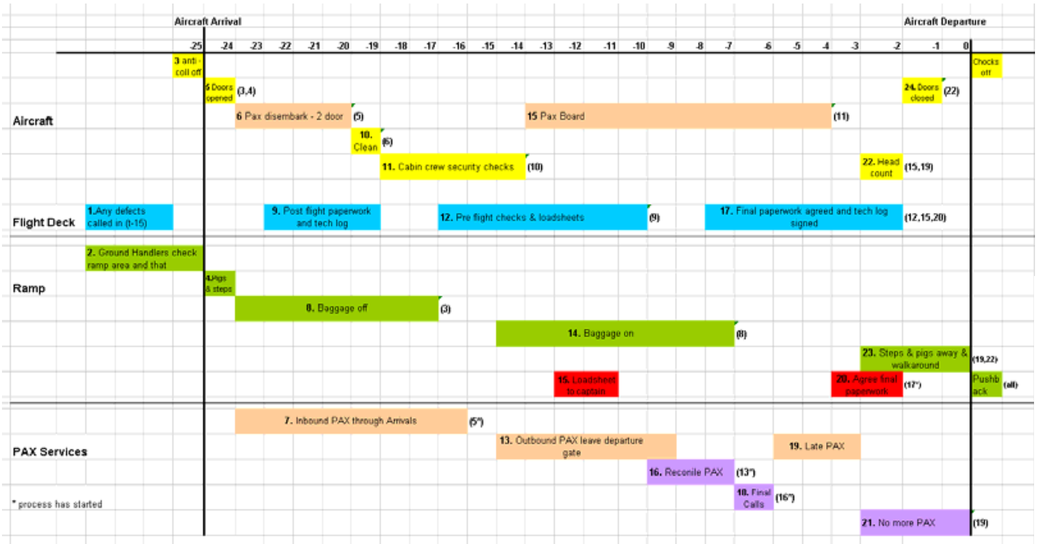


Figure 4.1   Gantt chart for Airline A's 25 minute turnaround

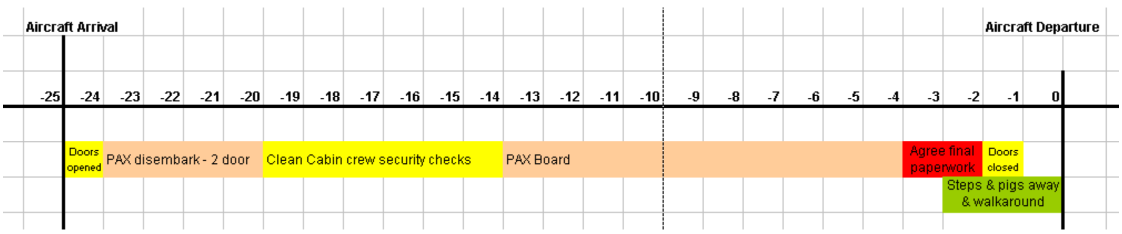


Figure 4.2   Critical Path for Airline A's 25 minute turnaround

Figure 4.2 shows that passenger boarding accounts for 10 minutes (40% of the total turnaround time), cleaning and security checks account for 6 minutes (24%) and passenger disembarking accounts for 4 minutes (16%).

Table 4.1 summarises the critical path analysis for three airlines. In each case we provide the % of time devoted to each of the three categories (Boarding, Cleaning / Security and Disembarking). To enable closer comparison the data is normalised as % in each case. The fourth column reflects a mean or typical turnaround distribution which is used as a bases for the following analysis.

ATA Process	Airline A	Airline B	Airline C	Mean
Boarding	40%	35%	40%	38%
Cleaning / Security	24%	25%	30%	26%
Disembarking	16%	25%	20%	20%

Table 4.1 Turn around critical path analysis for Airline A , B and C

4.2. Impact of RFID on Reducing Mean Aircraft Turnaround Times

In this section of the report we provide some estimates on the impact that RFID will have on the Aircraft turnaround performance. Through observing the turnaround process from the gate, ramp, the aircraft and by discussions with cabin crew and ground handling organisations, we confirmed the premise that there are areas within the boarding process, cleaning / security and other ancillary tasks that could be made more efficient through the use of non-line of site and simultaneous read ID technologies. Figure 4.3 and the bullet points below shows the estimated savings and the different tasks where we believe these savings can be made. Future research will provide more analytical data in this area.

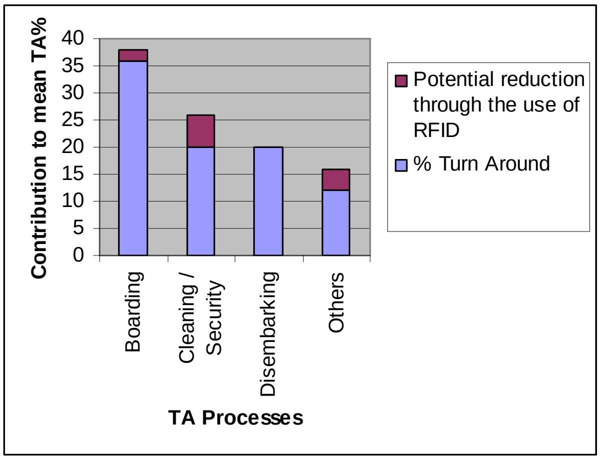


Figure 4.3 Estimates on the Potential Reduction in Mean Time using RFID

Boarding

- Handling staff check the person, ticket and passport match at the gate.
- Cabin crew check the details on each boarding pass at the aircraft door.
- Oversize or unusual luggage (prams) are left at the door of the aircraft for loading into the hold.

Cleaning / Security

- Checking configuration of safety equipment onboard the aircraft (oxygen bottles, fire extinguishers and portable breathing equipment)
- Ensuring that life jackets and safety placards are present before each flight)

Others

- Location information on baggage in an aircraft's hold (enabling fast and accurate baggage retrieval for no show passengers)
- Tracking of catering / merchandising trolleys
- Automated ticket passenger count.

5. Turnaround Disturbance Impact Reduction Study

In this section we examine issues leading to variations in turnaround time. Two of the airlines involved in the research provided data with disturbances that caused departure delays between January 06 to March 06, and January 06 and February 06 at two UK Airports.

5.1. Disturbance Analysis

The frequency of occurrence, the average isolated delay time, the average reactionary delay time and the average delay time (isolated delay time + reactionary delay time) were calculated from the data. Note that any delay time due to a late incoming aircraft was removed before calculating the averages. For each delay the Average Disturbance Impact was calculated as discussed in Section 3.3. The Average Disturbance Impact was calculated using both the average isolated delay and the average total delay for each IATA code.

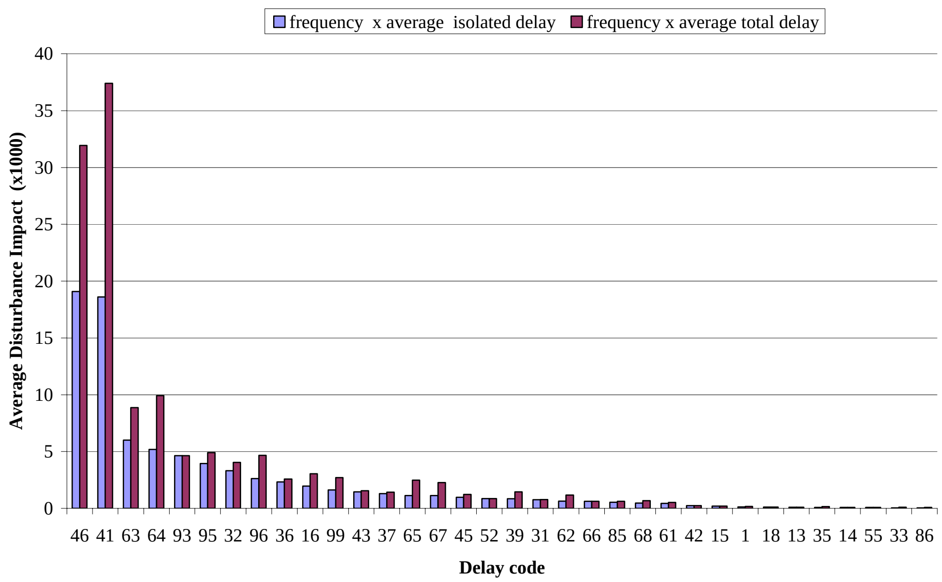


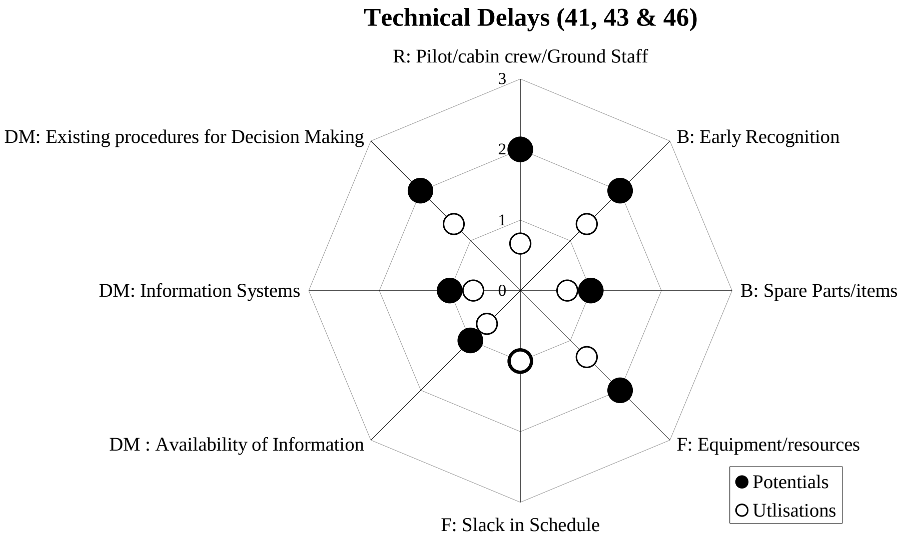
Figure 5.1 Average Disturbance Impact by IATA code for Airline A at Airport 1

By comparing data from the two airlines involved it was seen that the ranking of the delay (IATA) codes is very similar, with 8 out of the top 10 codes being identical. Because of the agreement between the two rankings, and the limited time scale of the research, it was decided to carry out the next stage of the study with Airline A only.

5.2. Disturbance Response Capability Assessment

The top 20 delay codes in Figure 5.1 account for over 95% of the Average Disturbance impact caused by all delays. Out of these 20 delays it was decided to produce Disturbance Response Capability Charts for the delay codes listed in Table 3.2 as these codes related closely to the turnaround process. Analysis was not performed on any of the reactionary delays (90's) because they are the knock on effect from other delays. Flight Operations, Crewing (60') and Ground damage (52) were not examined because it was determined that ID technologies could offer no benefits to these areas, and the time available for this research was limited.

To determine the potential and current utilisation of capabilities to solve the 8 causes of disturbances, interviews and site visits were conducted with relevant staff at Airport 1. From these interviews and site visits 8 generic response capabilities were identified, as shown in Figure 5.2. Capabilities related to providing turnaround operations were chosen to allow all 8 causes of disturbances to be analysed and compared using the same Disturbance Impact Response chart. One of the Disturbance Response Capability charts can be seen below in Figure 5.2.



DM (Decision Making), B (Buffer), F (Flexibility), R (Recognition)

Figure 5.2 Disturbance Response Capability Chart

5.3. Impact/Response Summary Chart

Step 5 in Section 6.3 explained the importance of being able to identify the existence of 2 conditions:

Condition 1: The impact of a disturbance is high and the potential of current capabilities to solve the disturbance is low. This indicates area where the addition or improvement of existing capabilities should be strongly considered.

Condition 2: The impact of a disturbance is high, the potential of current capabilities to solve the disturbance is high, but the current utilisation of these capabilities is low. To determine the presence of condition 1 a 2D Impact/Response chart was used, and is shown in Figure 5.3. The dotted circle shows the disturbances that indicate the existence of condition 1. Although technical disturbances have the largest average disturbance impact by a factor of about 3, it may not be the area where the biggest benefits can be achieved.

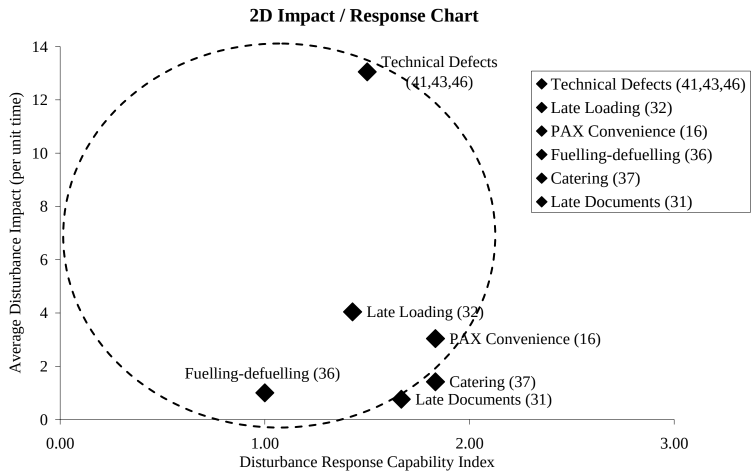


Figure 5.3 2D Impact/Response chart for the 8 causes of disturbance

Figure 5.3 indicates that the addition or improvement of existing capabilities should be strongly considered in the response to Technical (41, 43, 46) and Late loading (32) disturbances.

Figure 5.3 looks at whether or not ID technologies could improve existing capabilities for dealing with Technical (41, 43, 46) and Late loading (32) disturbances. As mentioned earlier in this section the Impact / Response chart in Figure 5.3 does not indicate which improvement actions are likely to be the most cost effective. The Impact / Response in Table 5.1 individually highlights high Average Disturbance Impact values, high Disturbance Response Capability Indexes, and low Capability Utilisation Indexes. If a cause of disturbance has all 3 of its values highlighted this indicates areas where the improvement of under utilised capabilities should be strongly considered (Condition 2). From Table 5.1 it can be seen that for Airline A, there are no occasions where the impact of a disturbance is high, the potential of current capabilities to solve the disturbance is high, but the current utilisation of these capabilities is low.

	Average disturbance impact	Disturbance Response Capability index	Capability Utilisation index
Technical (41,43,46)	13.05	1.50	2.00
Late loading (32)	4.04	1.43	1.86
Pax convenience (16)	3.04	1.83	2.17
Fuelling (36)	2.57	1.57	1.71
Catering (37)	1.42	1.83	1.67
Late documents (31)	0.76	1.67	2.33

Table 5.1 Impact/Response table for Turnaround Time

6. Conclusions

The objective of this research work was to investigate where the use of ID technologies could reduce mean turnaround time and the impact of operational disturbances on aircraft turnarounds. A number of areas within the critical path of the turnaround were identified and were discussed previously (Boarding, Cleaning / Security, Technical Delays). During the research it became apparent how interdependent the tasks are within the turnaround process, both at a physical level, and also in the information flows required. Examining the disturbance impact response in Table 5.1, it can be seen that technical delays and late loading cause a significant disturbance to the turnaround. These tasks are typically carried out by partner organisations and require timely, accurate information to be effective. ID technologies provide a mechanism for obtaining automated visibility of physical processes, but the information systems and business processes for sharing this information between partners are essential.

The results of the research were shared with the organizations involved to obtain feedback on the findings. This feedback shows that the tailored responsiveness tool has identified key aspects of turnaround that need closer investigation for the adoption of networked ID solutions.

The next step of this research will examine more closely the axes used in responsiveness analysis of turnaround processes and provide a more rigorous and quantitative approach to calculating impacts and improvements possible via RFID. It will also investigate the effect that airport configurations and the capability of different information systems have on the turnaround process.

7. References

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