UNIVERSITY OF SOUTHERN QUEENSLAND

POLICE OPERATION CENTRES: FROM A TRADITIONAL TO PREVENTIVE POLICING MODEL

A Thesis submitted by

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ABSTRACT

The rigid hierarchical paramilitary nature of policing has led to an inadequate and reactionary business and operating model. Especially affected is the police operation centre or communication centre when it comes to service delivery. Moreover, market competition provides industries with a drive to innovate and create lean solutions for service delivery. Currently, when policing is feeling the competitive pressure of funding measures from the government budget, a drive to do more with less is propelling change. The unpredictable nature of policing is closely mirrored by the unpredictable nature of disruptions faced by airlines. This parallel drew the researcher to explore the structures and operations of the airline industries operation centres and examine how they create and manage an efficient operation in a disruptive changing environment as compared to policing. Understanding what learnings have the two industries made in design and scope of their operation centres and appreciating how the onset of IoT data was assisting them with their daily operations and how it is being harnessed are important aims. To understand how an operation centre can affect the overall service delivery of an organisation, this study undertook a systemic review of academic literature of airline industry and policing operation centres. It also observed the functional operation centres and gained access to industries professionals to gain a set of recommendations for implementation into the enhancement of Policing Operation Centres.

CERTIFICATION OF THESIS

This Thesis is entirely the work of Simon TAYLER except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Associate Professor Marcus Harmes

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Student and supervisors' signatures of endorsement are held at the University.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

AOCC – Airline Operation Control Centre.

AOC – Airline Operation Centre

DTACC – District Tasking and Coordination Centre.

IOC – Integrated Operation Centre.

IoT – Internet of Things

MAS – Multi-Agent Systems.

NOC – Network Operation Centre.

OCC – Operations Control Centre.

POC – Police Operation Centre.

PCC – Police Communication Centre.

SPOC – State Police Operation Centre

QPS – Queensland Police Service

SA – Situational Awareness

Chapter 1: Introduction

In a world of habitual change, where agility and flexibility are the traits of successful people and organisations, the majority of skills and knowledge needed to not only survive but thrive are no longer stored in university textbooks (Fergusson, Allred, & Dux, 2018). Policing is constantly faced with the pressures of strategically and economically resourcing under an increasingly disruptive environment.

1.1 BACKGROUND

Policing is experiencing a demand for increased operational scope and calls for service, which are not directly aligned to funding models. This mismatch between demand and funding reflects the organisational need to make its current operating model more efficient, agile and economical.

The current Queensland Police Service (QPS) model is based on Regions running districts that contain patrol groups which house divisional police stations (Queensland Police Annual Report 2019-2020). The regions are supported by specialist central command functions and centralised business functions. In response, the QPS is exploring ways to decentralize its operational control and transfer authority at the district level to district-based operation centres in an attempt to gain this efficiency and meet demand.

Traditionally, Police Communication Centres (PCC) have focussed on managing calls for service directly from the community and dispatching them to first responding officers. Recently, Customer Relationship Management (CRM) centres such as Policelink have been introduced to relieve pressure on PCC's and frontline stations. These two areas have been the primary focus of operational demand management for the QPS. Police Operation Centres (POC) are another entity traditionally used to coordinate or manage policing resources during events or emerging incidents. These areas have little or no coordination with the demand or resource management of the broader QPS specialist policing areas or incorporate business as usual (BAU) demand.

It is essential to broaden our understanding of the functions and structures of operations centres which is why the researcher reviewed several industries, including

mining, road infrastructure, cyber security and the airline industry, in order to gain other perspectives on operation centre management. Of note was the conscious decision not to examine the working of other emergency service organisations such as Fire, Ambulance, State Emergency Services or Defence organisations. This is in major part due to the historical and current working relationship between these organisations where themes, ideas, processes and designs have already been shared. A working example of this is the Queensland State Disaster Management Centre which is a multi-agency operation centre currently under QPS management.

Of the commercial industries viewed at a macro level the airline industry provided the greatest synergy to the overall organisational structure and business model of policing based on the following characteristics:

1. The airline industry is a large people-based workforce whose operational practises directly impact service delivery in line with policing;

2. Airlines business practices and operations are driven by the needs of their consumers, as the needs of the community drive policing practices;

3. Airlines have multiple specialist areas (ground crew, cabin crew, engineering, sales, Information Communication & Technology (ICT) & Fleet) like policing (General Duties, Criminal Investigation Branch (CIB), Forensics, Police Communication Centre, ICT & Fleet) which require integration to provide a full-service organisation;

4. Airlines rely on daily operational plans to efficiently administer their resources to meet the needs of the consumer (community) comparable to policing.

There is considerable literature on Airline Operation Control Centre (AOCC) structures and their supporting multi-agent systems (MAS) technology (Bouarfa, Müller, & Blom, 2018). Of considerable interest in the AOCC is the holistic nature of

the structure where every element or entity of the organisation is accessed to deliver the operational outcome of the business. In contrast, traditional policing operation centres or police communication centres have siloed uniform reactionary assets in their control, greatly limiting their capabilities to meet the organisations strategic objectives.

The current QPS strategic plan outlines four major objectives of stopping crime, making the community safer, creating and strengthening community partnerships and equipping our workforce for the future. This is where AOCC's have significantly advanced by using disruption management and supporting MAS technology as a method of efficiently delivering daily operational services (Bouarfa, Blom, & Curran, 2016).

Disruption as a concept is still emerging and is mainly concerned with technological change, which is impacting on an industry strategy and changing the way in which businesses operates and compete. These changes are disruptive because of their impact on organizations and their need to improve services (Drejer, 2018). Rapid disruptive changes in Information and Communication Technology (ICT), such as digitisation, automation, and Internet of Things (IoT), have challenged organizations and industries to keep pace and explore new ways of conducting business and re-aligning their strategic thinking to these changes.

For the airline industry and policing, disruption takes a more literal meaning, "disturbance or problem which interrupts an event, activity or problem" p.813 (Clausen, Larsen, Larsen, & Rezanova, 2010). Airlines constantly face disturbances (weather, crew sickness and aircraft maintenance and most recently the Covid-19 pandemic) which disrupt their complex and carefully planned operations (Bouarfa et al., 2018). This comparison parallels operational policing where similar disturbances (staff sickness, disaster events and vehicular maintenance) disrupt preventative policing operations. Due to the unpredictable nature of the disruptions experienced such as the Covid-19 pandemic, it is acknowledged there will never be 100% automation within airline AOCCs, which is similar to policing (Baltazar, Rosa, & Silva, 2018).

The contrast between the industries comes through airlines recognising the economic impact disruptions have on their operations which in 2007 for US carriers reached over $8 billion (Barnhart, 2009) and when researched by Gershkoff (2016) the aviation estimating disruptions cost the industry over 8% of their revenue or $60

billion worldwide. For airlines this revenue loss is potential profits coming from their bottom line whereas policing this expenditure of money is the divergence of funding away from vital enhanced equipment, more operational officers and services back to the community.

1.2 CONTEXT

The success of an organisation to meet its strategic objectives can be directly linked to their operational efficiencies. Operation centres for both the airline and policing allow for the efficient and effective use of resources to provide a service. Policing Operation Centres which allocate and manage resources can vary in design, scope, purpose and location.

1.3 PURPOSE

The main purpose of this research was to explore a new and innovative way to operate using methodologies external from law enforcement to create an effective, efficient and economical service delivery mechanism. To achieve this purpose the study answered the following question:

- RQ 1: What is the optimal design and structure of a Police Operation Centre and supporting multi-agent systems (MAS) for resource allocation in an agile, economical and structured manner in a disruption-based operating environment for the QPS?

The sub-questions given below assisted in answering the overarching research question.

- Sub-RQ 1: How and to what extent can MAS improve organisational deliverables of an operation centre within a police operation centre?

- Sub-RQ 2: How and to what extent can IoT data assist in disruption management in the police operations centres?

1.4 SIGNIFICANCE, SCOPE AND DEFINITIONS

This research uses advanced learnings from the airline industry and implemented its holistic approach to operational management into POC's that were both economical and efficient. The power of integrated MAS technology could see the redeployment of human assets to frontline duties. The study focused on the system design of MAS which supports the Integrated Multi-Modal Operations Centre (IMMOC) and Integrated District Tasking Coordination Centre (IDTACC) along with the IoT data needed to ensure these centres were intuitive by nature

The use of systems theories as a methodology of description and analysis originates from the drive to simplify reality and comprehend natural events (Dekkers, 2017). Systems theory is the study of society as a complex arrangement of elements, including individuals and their beliefs, as they relate to a whole (Barry, 2019). In this research, systems theory assisted in highlighting a system from its surrounds and helped in understanding the relationship between the system and its environment (Dekkers, 2017).

1.5 THESIS OUTLINE

The aim of the research is to find areas of improvement in the design, structure and function of QPS POCs that increased the effectiveness of their service delivery by using a qualitative methodology in a pragmatist paradigm. Chapter 2 includes an extensive literature review to explore the benefits of the AOCC operating environment and systems related to disruption management and their applicability within a policing operation centre while working within a preventative policing model. Chapter 3 outlines the methodology for the research that underpins the theoretical aspect of the adopted paradigm. It includes the design, proposed data collection methods, analysis methods and finally ethical considerations for the research. Chapter 4 breaks down the research question into three major components, Physical Design, Structure and Operations and Supporting MAS Technology. Within each of the three areas the results of content analysis, observations and interviews are presented with the view of providing insight for the discussion and subsequent conclusion chapter. Chapter 5 is a discussion on the results and the insights on area of possible enhancements of current police operation centres. It also explores areas of possible future research based on

emerging trends. Finally, Chapter 6 concludes the research outlining limitations and addressing a set of recommendations based on the research findings.

Chapter 2: Literature Review

This chapter outlines the academic definitions and research on the key components analysed within this research. Section 2.1 summarises the history of and reviews academic literature on Multi-Agent Systems (MAS), a computing ecosystem implemented to bring efficiency and accuracy in decision making within a given industry. Section 2.3 defines Disruption management as a concept and its effect on AOCC and Police Operations Centre (POC).

In Section 2.4, the review expands on the history, structure, design, and use of the AOCC within the airline industry, finishing with disruption management in AOCC. It defines the overarching components (MAS and IoT) used in creating efficiencies within Airline Operational Control Centre (AOCC's). The AOCC is the operational hub used by airlines to control and manage their assets along with staff and customer interaction to complete their daily schedule. It highlights the evolution of the AOCC and the impact MAS and IoT has on efficiency management. Section 2.5 examines research around preventative policing model, highlighting the benefits of this model, which is a major aspect of this research. Finally, it identifies current research and models for POCs and their ability to effectively and efficiently operationalise a preventative policing model. The aim of this literature review is to explore the benefits of the AOCC operative systems related to disruption management and their applicability within a policing operation centre while working within a preventative policing model.

2.1 MULTI-AGENT SYSTEMS

The field of computer science refers to the "agent" as a metaphor, which has its origins in the field of artificial intelligence (AI). An agent is referred to as a single entity in a complex network of systems. Importantly, Russell (2003), outlined two fundamental characteristics of agents, autonomy and situatedness (the agents intertwined relationship within an environment). Wooldridge (2002) describes these two important capabilities of agents as the autonomous action or their ability to some extent to decide for themselves what they need to do in order to satisfy their design objectives. Secondly, an agent has the capability of interacting with other agents and

not in a simplistic exchange of data, but by engaging in activities analogous to social activities humans do in everyday lives such as cooperation, coordination and negotiation. These two characteristics of an agent have significant bearing on this research due to the current siloed systems within the Queensland Police Service.

A definition for the term multi-agent system (MAS) describes a system consisting of a number of agents, which interact (communicate) with one another, typically by exchanging messages through some computer network infrastructure (Wooldridge, 2002). The autonomy aspect of the MAS is a crucial element as it enables them to find the best solution for their problems without intervention, thus creating a flexible and intuitive system designed to reduce fault propagation and enhance self-recovery (Ranganathan, Nakai, & Schonbach, 2018). As opposed to automatic systems which are fully pre-programmed most often with rigid rules, autonomous MAS are self-steering or self-regulating and able to follow an externally given path while compensating for small deviations caused by disruptions (Ranganathan et al., 2018). The power of MAS technology described above is the aggregation of voluminous data from an organisations ecosystem to provide intelligible and actionable decision which can add to efficiencies.

The primary function of a MAS is to solve problems that are beyond the capabilities or knowledge of an individual agent or single system (Weiss, 2013). Expanding on this Weiss (2013), highlights four important factors;

1. Each agent has incomplete information or capabilities for solving the problem and, thus has a limited perspective;

2. There is no system global control;

3. Data and information is decentralised; and

4. Computation is asynchronous.

The cumulative impact of these factors is a system which can be seen as a distributed problem solver, used to navigate and answer issues or problems which are impossible or difficult to solve by an individual agent or monolithic system (Weiss, 2013). This also underscores another important factor of a MAS, which is coordination. The system or agent exists and performs its activity in an ecosystem in which other systems or agents operate (Ranganathan et al., 2018). Wooldridge (2002), discusses the economic encounters between self-interested entities (agents) which

occur among computing elements in a MAS environment. This concept where the systems or agents negotiate to create possible solutions to complex problems in the most efficient and economic manner is an important aspect to apply in AOCCs and POC's environments. This concept, which is automation through artificial intelligence, has the ability to create efficiencies of latent capacity in the operations centre staffing capacity. This research explores what agents need to be incorporated into policing MAS to create similar efficiencies as seen in the airline industry through the implementation of MAS technology.

2.2 INTERNET OF THINGS

The term "Internet of Things" or IoT can be traced back to 1989 when people began connecting "Things" via the internet. An example of this is the Trojan Room coffee pot when in 1990, John Romkey created a toaster (device) which could be turned on or off by the internet (Suresh, Daniel, Parthasarathy, & Aswathy, 2014). IoT technology is a platform where a wide variety of independent networks along with mass sensors function together and interoperate with a common set of protocols (Bhayani, Patel, & Bhatt, 2016). The IoT environments allow users to manage and optimise electronic and electrical equipment through the internet (Suresh et al., 2014). Goyal, Garg, Rastogi, and Singhal (2018) created a simplistic illustration of the relationship between people, computers (PC) and mobile devices as shown in Fig. 1.
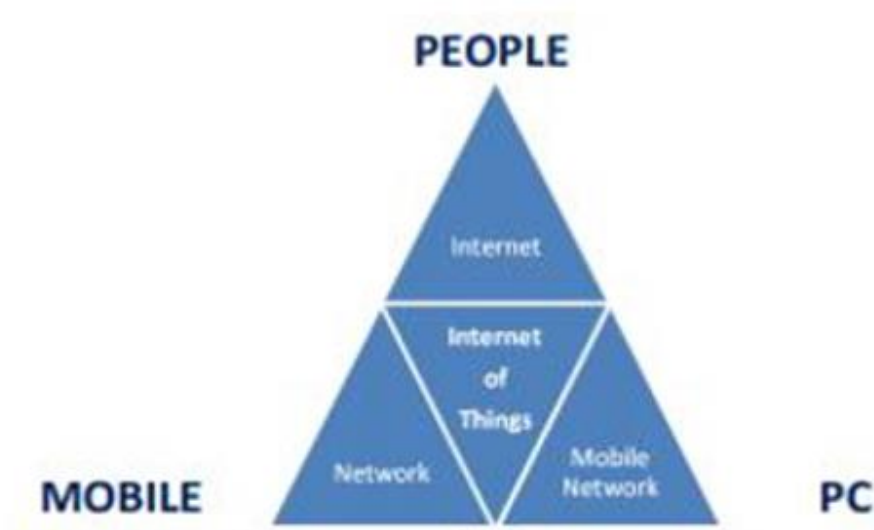
Figure 1 - Basics of Internet of Things Goyal et al. (2018)

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The overarching design of IoT architecture is linking diverse network/devices so that they can bring qualitative change in how society works and lives, increasingly simplifying life while increasing connectivity, analytics and task management (Bhayani et al., 2016). Miao, Ting-Jie, Fei-Yang, Jing, and Hui-Ying (2010) describe the evolution of IoT architecture from a three-layer model at its inception (Perception, Network and Application layers), to a five-layer model (Perception, Transport, Processing, Application and Business) as illustrated in Fig. 2.
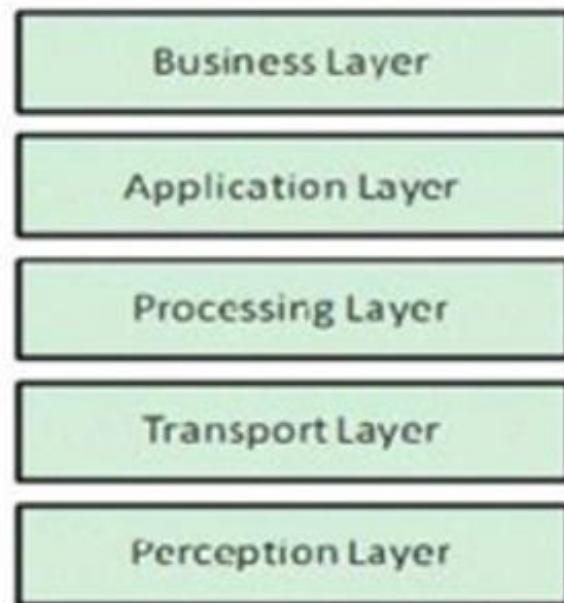
Figure 2 - IoT architecture Miao et al. (2010)

It is important to define the IoT architecture layers as seen in figure 2, as they are referred to throughout this project. The perception layer is where the sensors with the IoT ecosystem are located and have a unique job to collect data and convert this into digital signals to move through the layers. The transport layer is where communication technology such as Wi-Fi, Bluetooth, infrared and 4G transmit the digital signals from the perception layer through the system (Miao et al., 2010). The processing layer has to perform a major task of computing all the information gathered at the perception layer which causes a need for large scale data storage (Goyal et al., 2018). The function of the application layer is to provide varied platforms for the processed data to industry specific solutions (Miao et al., 2010). Finally, the Business layer handles the complex areas of research on business and profit models within the various applications. For continual improvement to occur with the IoT cycle the business layer performs an important role of ensuring both innovation and

reasonableness of the business model are considered (Miao et al., 2010). Goyal et al. (2018) also highlight the importance this layer plays in privacy and data security, a major apprehension of IoT technology for many in society and business community alike.

It is via the connectivity and interactions of a wide variety of sensors or devices such as appliances, CCTV cameras, wearables, smart phones, vehicles and industrial sensors, that IoT can facilitate the development of many new services for an organisation, government department and society in general (Kankanhalli, Charalabidis, & Mellouli, 2019). Most importantly, IoT does not just connect sensing devices, it has the ability to generate insights and create knowledge from the data, directly leading to the ability to solve problems and or automate without human intervention (Chatterjee, Kar, & Gupta, 2018). The greatest challenge of IoT and its application within industry and especially government is the inherent risk around data privacy and security. All literature cited above touches upon and outlines this very concept of data security within IoT, as discussed during the business layer of the IoT architecture.

The importance of defining IoT is its linkages within MAS technology and the expansion of sensors within the working environment and the potential data they can provide. This research explored the concept of IoT data feeding into a MAS inside a POC and its effect on operational efficiencies and economic benefits. The efficiencies in areas of resource allocation have the potential to lead to extra officer hours which can be used in the allocation of policing resources to preventative tasking such as bail and curfew compliance. Currently the QPS is rapidly expanding the mobile capability of frontline officers which therefore creates more sensors or IoT data in real-time which can be harnessed by a MAS within an operations centre.

2.3 DISRUPTION MANAGEMENT

This research examined the linkages between the QPS's desire to operate in a preventative policing model and how disruptions to this model could be better managed. Defining exactly what is a disruption within this policing service delivery model and its possible causes, could feed the MAS technology implemented within a POC to manage and restore normal operations in the most efficient and economical manner. It is important to distinguish disruptive technology or competition from

disruption management in this research as the two concepts have different applications in the development of a service delivery model. Disruption management focuses on causal relationships that effect planned operations as opposed to disruptive technology or competition which focuses on organisational business models and their market competitiveness.

The literal meaning of disruption is a disturbance or problem which interrupts an event, activity, or process which has relevance to the daily operations of a 'network' or 'operating environment' (Drejer, 2018). For the global supply chain network, this concept of disturbance to planned operations can have serious economic impacts on organisational bottom line or survival. The 2011 example of the automotive and electronics supply chains industry which was effected by flooding in Thailand, created massive disruption to automakers and electronics manufacturers with significant financial loss across both sectors (Haraguchi & Lall, 2015). The responding disruption risk management frameworks which ensued saw the implementation of strategies such as greater on hand stock inventories, diversification in suppliers and even supporting the recovery process of their suppliers (Sawik, 2017).

However, conceptually 'disruption' is still an emerging and a misunderstood term within innovation or business (Drejer, 2018). Christensen, McDonald, Altman, and Palmer (2018) outline the concept of disruptive innovation as any technology or start-up that aims to shake up an industry and alter its competitive norms. Policing or law enforcement within Queensland is the responsibility of the State Government which is the equivalent of a monopolised industry. Despite its internalised structure, there are external factors such as emergency situations (health pandemics, natural disasters), financial limitations, community or customer expectations and the introduction of private security firms which create the disruptive pressure to innovate.

In this study 'disruption' within the police operating environment has been viewed holistically from a systems viewpoint and not from the perspective of handling one off incidents. Within this holistic view, the effects of disruption within the system led to the creation of an entirely new business model arising from the need to operate in new and more efficient ways (Drejer, 2018). Christensen et al. (2018) referred to this type of disruption as sustaining innovations, which are designed to improve products and services along dimensions of performance that the traditional customer values.

Moreover, from a policing context the term 'disruption' has also been associated with a tactical intent to unsettle, disturb, interrupt or dislocate a criminal enterprise or person through overt acts. Within this research, disruption will focus on the 'event' or 'incident' which causes a deviation from or the service delivery model in line with the disruption terminology referred to within the airline industry. Practically and for the purpose of this research, a disruption in the literal sense for both industries could be the absentee of staff for a specific function which renders it inoperable directly effecting the service delivery model of the respective organisation.

2.4   ORGANISATIONAL STRUCTURE

In understanding the need or "why" AOCCs and POCs are created Castro (2013) in his doctoral study highlighted the importance of an organisations structure. Fundamentally the structure of an organisation is at the core of its ability to succeed or fail. The AOCC or POC within their respective industries play an integral part in the commercial success of these industries. Customer satisfaction in airlines and community confidence in policing dictate their organisational structures to ensure they are conducive to achieving their respective strategic objectives. An organisational structure should allow for the best possible interaction and communication among several specialists while at the same time elicit the best possible benefit from available information systems or decision support systems (Castro, 2013).

An earlier study conducted by Castro and Oliveira (2007) adopted the organisational view to see the AOCC as a distributed system composed as several sub-systems, according to the expertise and/or skill levels required for: operations controllers, aircraft scheduling, crew scheduling and flight dispatchers among others. This description can relate to a policing context to mirror a distributed system with areas such as District Duty Officers, Tacticians, Roster clerks, Communication room operators among others are integrated through a POC which will be explored through the research.

Importantly the research conducted by Castro (2013) and the work of Fox (1988) on the limitation of the human's mind processing capacity, highlight this concept as a major factor. Research around humans limited process capacity led to a term of Bounded Rationality which implies a person has a limit regarding two things: the

information that they are able to deal with and the control by which they are able to handle it (March, 1993). Both the terms of structure and control are not the only considerations for an organisation when considering how a system could be distributed. Other considerations such as task complexity, uncertainty and resource restriction all need to feature in a distributed system (Castro, 2013).

2.5   AIRLINE OPERATION CONTROL CENTRES

As with policing, the daily operations of airlines revolve around both planned and unplanned events which require an organisational response (Jimenez Serrano & Kazda, 2017). Throughout the course of an airline's daily operations the staff are often faced with situations which may result in substantial variation from its planned operation (Bouarfa et al., 2018). The role of the AOCC is to effectively and efficiently deal with the irregularities in the organisations daily routine and produce an operational response which meets the needs of the airline and the customer (Jimenez Serrano & Kazda, 2017). Researchers describe the continued deregulation of the airline industry worldwide as a driving force for airlines to streamline operations with a view of achieving lower overall costs (Baltazar et al., 2018; Jimenez Serrano & Kazda, 2017). The disruption in the industry with the onset of low-cost carriers (LCC) and more recently ultra-low-cost carriers (UCC) was a significant efficiency driver within the AOCC design and operation (Baltazar et al., 2018).

This study focused on how "operational" efficiency of AOCC affected the airline performance. With the rapid expansion in capability for data transmission, airlines have moved to centralised control centres with the intention of controlling far-ranging operations towards more "optimal" decisions (Feigh & Pritchett, 2010). The primary function of the AOCC is to monitor the conformance of flight activity according to the pre-defined schedule (Machado, 2010). To understand the sequence of scheduling or planning and the involvement of different areas of the business at specific times during the process of operation and when it is finally controlled by the AOCC, the research examined the components and business drivers that were used to plan the airlines schedule. These were then compared to policing plans for preventative policing operations.

Eltoukhy Abdelrahman (2017) describes the competitive marketplace, high operational costs, variable passenger demand, heavy traffic and strong regulations as

drivers that force airline companies to efficiently manage their resources. Figure 3 is a simplistic illustration of the long-term and short-term flight operation sequence used in airline scheduling (Machado, 2010). Through the linear airline scheduling process, we can see the interaction between different aspects of the business such as, fleet, crew and revenue management needing to engage and then re-engage to ensure the airline is ready to operationally carry out its intended action.
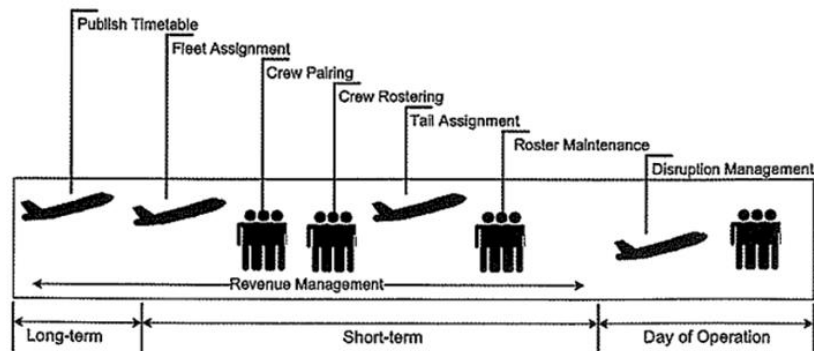
Figure 3 - Airline scheduling process Castro and Oliveira (2011)

Understanding the scheduling process and the areas of the business that complement each other to successfully undertake their daily operations is central to the success of the AOCC. The design and makeup of an AOCC is central in disruption management. Disruptions managed by an AOCC are focused on the literal meaning (Planned Daily Operations) and not the introduction of new competition into the market. The most common disruptions for airlines include weather events, geo-political events, aircraft malfunctions and mechanical incidents and staffing related issues such as absenteeism. With this concept at its core the AOCC's role is to manage planned operations along with solving disruptions in its daily schedule (Castro & Oliveira, 2011). Ascertaining the business drivers of the AOCC assisted the research in identifying similar drivers within policing and adding and applying these in the structure of the POC (Baltazar et al., 2018; Jimenez Serrano & Kazda, 2017).

The origin and composition of an AOCC was a human decision system composed by teams of experts specialised in solving the disruption events described above (Machado, 2010). According to Kohl, Larsen, Larsen, Ross, and Tiourine (2007) the most common support roles within an AOCC are flight dispatch, aircraft control, crew tracking, aircraft engineering, customer service and Air Traffic Control (ATC) coordination. What is important to note is that though each of these teams have

specific goals they all are integral contributors to the overarching objective of minimising the effects of disruptions to the airlines operational plan to ensure economical efficiencies and greater customer satisfaction (Baltazar et al., 2018; Bouarfa et al., 2016; Castro & Oliveira, 2011; Kohl et al., 2007). These corresponding roles in policing are seen through similar teams such as uniform first response, criminal investigators, forensic investigators and police communications officers all have specific "goals" or "missions" which need overarching coordination.

These daily operations of airlines revolve around both planned and unplanned events (described above) which require an organisational response (Jimenez Serrano & Kazda, 2017). Throughout the course of an airlines daily operations, the AOCC is often faced with situations which may result in substantial variation from its planned operation (Bouarfa et al., 2018). Figure 4 illustrates a typical modern integrated AOCC.
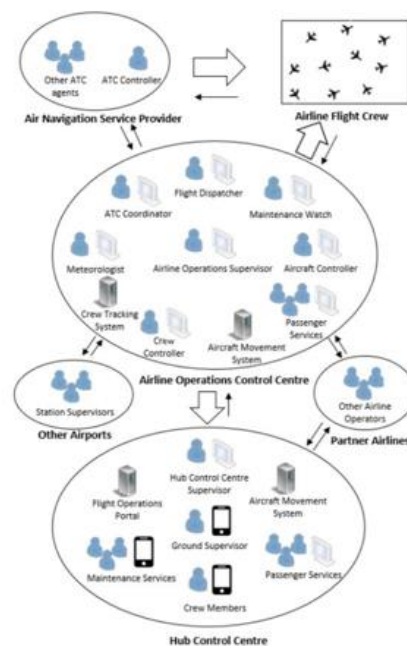
Figure 4 - Integrated AOCC (Bouarfa et al., 2018)

This figure displays the main AOCC (hub) which houses various business elements and coordinates these organisational resources to provide a service to the customer. As displayed in Figure 4, the AOCC is a centralised coordination point operating across both at strategic and tactical levels through interactions with Hub Control Centres (airports or spokes) which execute the planned services signalled from the AOCC. This hub and spoke methodology directly resonates with the QPS where

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the centralised specialist assets support the organizational operations at the interlinked regional (hub) and district (spokes) levels.

Within an AOCC, task based analysis is automated in complex decision support systems using algorithms to enhance the organisations ability to deal with disruption (Bouarfa et al., 2018). These systems are called Multi-Agent System or MAS, which is the technology explained in section 2.1. According to Russel et al. in Cruz et al. (2018) an agent is able to perceive its environment by means of sensors, and act upon this same environment through actuators. IoT data is another form of sensory information, which is becoming increasingly more important for organisations to integrate into their decision-making systems. Each agent can have individual purpose and, collectively, agents can cooperate and collaborate in improving the performance of the system (Cruz et al., 2018) as depicted in Figure 4. Understanding the concepts of agents is important as there is a large area of research which conducts agent based simulation in order to model new or existing practises (Bouarfa et al., 2016; Clausen et al., 2010; Feigh & Pritchett, 2010).

It became apparent in the United States of America (USA) a decade ago that disruption in the airline industry was an issue when in 2007 US carriers reported losses of over $8 billion dollars alone through operational disruptions such as weather, crew and aircraft cancellations (Bouarfa et al., 2018). Figure 5 highlights how all business processes meet at the conjunction of disruption management in airline planning and management. It underscores the need for the entire business to be involved or at the very least to be considered, when forming an operation centre to deal with disruptions in service delivery. This area of disruption management needs considerable improvement in policing, in order to ensure all aspects of the business are feeding into an operations centre designed to deal with disruptions from their planned operations.
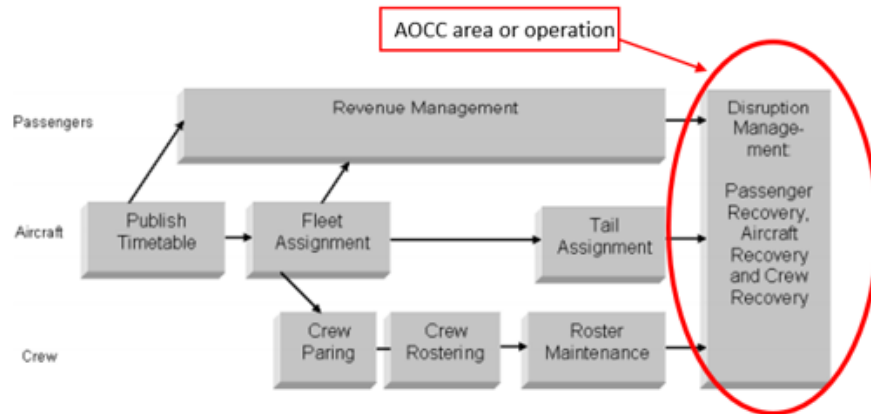
Figure 5 - Airline planning and disruption management Kohl et al. (2007)

The idea of using MAS technology in AOCCs is to assist with the emerging threat of disruption at the point of multiple business units' intersection. This optimal decision making from an airline perspective is to ensure control, reduce costs, minimise delays, stop reputational damage and enhance customer satisfaction (Richters, Schraagen, & Heerkens, 2016). The elements described are what policing seeks to address which is why the learnings from airlines industry are important and can be adopted for disruption management.

It is important to highlight at this point there is a human element to the AOCC which can directly influence the effectiveness of the centre. Research conducted by Richters et al. (2016) investigated the socio-technical aspect of the AOCC. The results showed that under non-routine circumstances decisions and outcomes varied considerably case by case. It is not the intention of this research to explore the human elements of decision making within the AOCC rather it explores the roles, function, design and information needed to process optimal decisions. Focusing on efficiencies, Figure 6 highlights the use of MAS technology to enhance and automate a number of business areas which are directly affected and needed in dealing with disruption. This concept of using MAS technology in disruptive environments has recently been explored and developed in the airline industry under the proposed acronym of MASDIMA (MAS for Disruption Management in AOC) (Bouarfa et al., 2018). Research work conducted by Castro (2013) proposed replacing several roles within an AOCC with software agents. These intelligent software agents negotiate with each other to manage airline disruptions, keeping the human supervisor in the loop (Bouarfa

et al., 2018) with a view of creating greater efficiencies, an area of potential enhancement within policing.
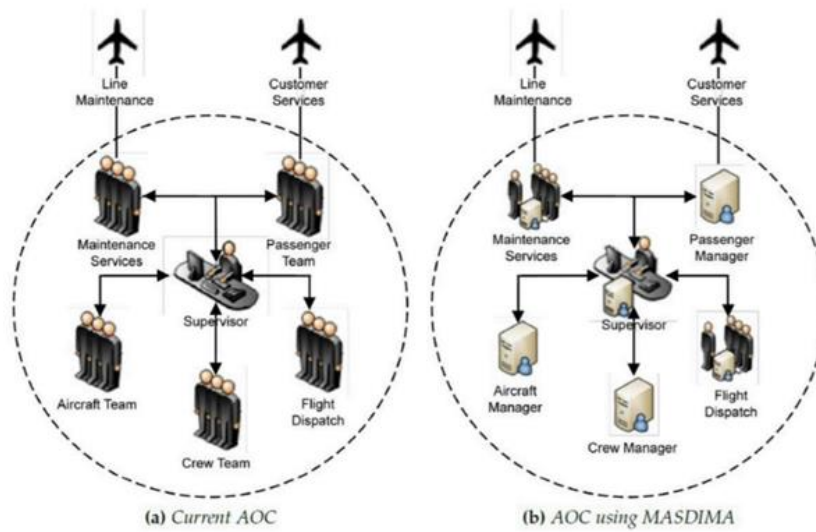
Figure 6 - Traditional AOCC v AOCC using MASDIMA (Castro, 2013)

2.6 PREVENTATIVE POLICING MODELS

A prevention based policing model is grounded in crime prevention. Welsh, Zimmerman, and Zane (2018) describe crime prevention as a unique social and environmental strategy for reducing crime, one that is distinct from crime control or punishment. Studies throughout the late 1990's on vehicle-based preventive patrols, rapid response and criminal investigation – The staples of law enforcement – showed that they had little to no effect on crime (Visher & Weisburd, 1997). It became increasingly apparent to the researchers that a criminal justice response on its own was insufficient in reducing crime (Welsh & Pfeffer, 2013). Interestingly studies conducted throughout the 1970's also concluded that directly increasing policing numbers did not equate to lower crime rates, these studies showed increasing policing numbers had little direct impact on crime (Visher & Weisburd, 1997).

The evolution of prevention-based policing and strategies has seen the adoption of evidence-based policing. This complementary approach uses the most scientifically valid methods to evaluate crime prevention programs and their effectiveness (Welsh & Pfeffer, 2013). There are several examples, including a Minneapolis study which examined the effectiveness of preventative policing. The results showed a 19 percent

reduction in total crime calls in comparison to a 6 percent reduction in control locations (Sherman & Weisburd, 1995).

At the forefront of modern preventative policing models is the New Zealand Police Service 'Prevention First' model. At the centre of this model is its structure, process and policies which direct more resources to activities that prevent further harm. It is explicitly victim focused and aligns with the aspirational objectives of 'Be safe, Feel safe' (*Prevention First: National operating strategy 2011-2015*, 2011). Figure 8 shows the NZ Police 2017 operating model which is a visual representation of how it operationalises this type of policing.
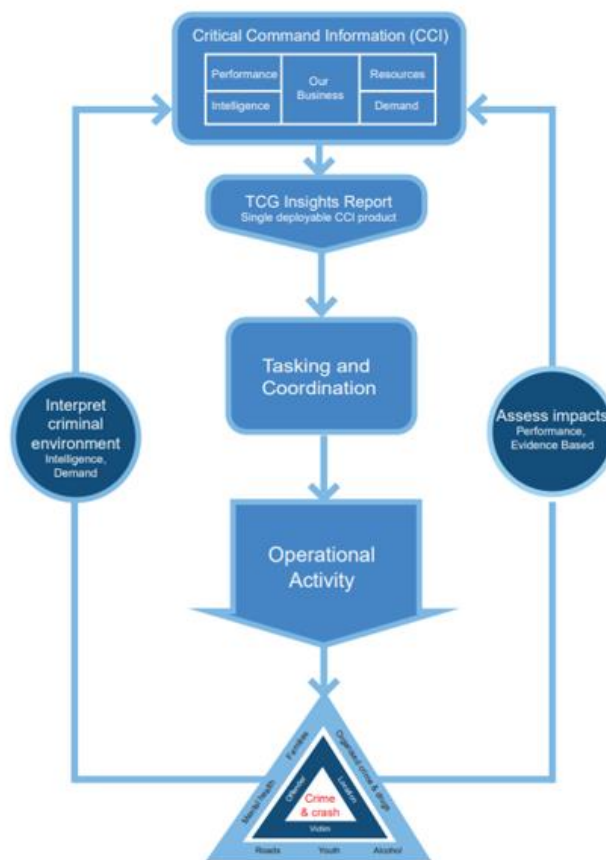
Figure 7 - NZ Police 'Prevention First' Deployment Model 2013

The framework was designed to gain greater understanding and to respond more proactively to the root causational issues of crime in order to avoid reactionism, stasis and solving cases in isolation (Smith, Frondigoun, Martin, Campbell, & Thomas, 2018). Keeping the issues of reactionism, stasis and silos in perspective and supporting MAS technology are fundamental in the design of any POC to ensure effective and efficient deployment of preventative resources (Baltazar et al., 2018; Jimenez Serrano

& Kazda, 2017). The crime prevention framework or a preventative policing model is based around strategically targeting the causes or drivers of crime in a particular area. MAS and IoT technology within the preventing policing model are designed to provide decision makers with greater analytics to inform and influence the allocation of resources within an operating environment.

2.7   POLICE OPERATION CENTRES

The Queensland Police Service (QPS) is currently undertaking transformational change to move from a traditional, reactive policing model to a preventative policing model. Currently POCs are either centred on traditional police communication centres (PCCs are like 'call centres' where jobs are received then detailed out via radio.) or event-based coordination centres (Police Coordination Centres). An event-based coordination centre provides functionality to a specific event with respect to public safety activities normally in conjunction with an event organiser. These centres differ from the traditional POC as they have a holistic approach to community safety incorporating other emergency services, event staff and local government response agencies. Figure 8 is a simplistic illustration of the current operating model used within the Queensland Police Service (QPS) for administering services to the community. This is reflective of a traditional reactive policing model applied within several Australian policing jurisdictions.
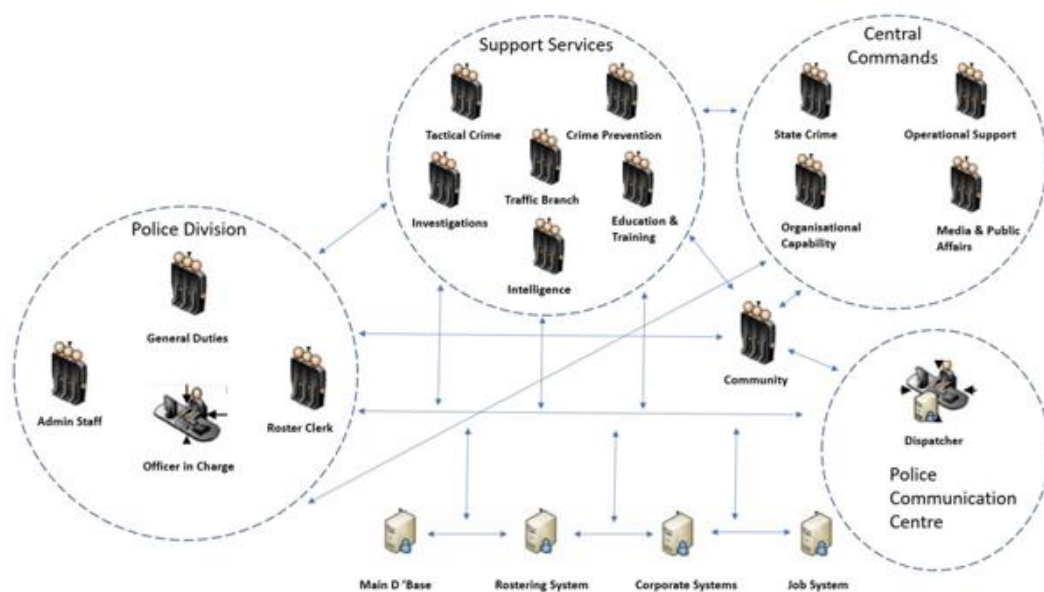
Figure 8 - Simplistic current service delivery model

As is evident from the model shown in Figure 8, the PCC supported by divisional resources is separated from central commands and support services. It highlights the lack of overarching coordination of multiple QPS business units leading to a reactionary policing model. The community has multiple touch points within the QPS providing valuable services, which are not currently interconnected and are not internally integrated within the POC model. To create a lean service model requires coordination of multiple business entities at the point of operations which minimizes waste in every procedure and maximizes value to the customer through an ongoing system of improvement (Poppendieck & Cusumano, 2012).

With many modern policing services emphasizing the need to become more customer (community) focused, police operation centre deliverables must match the desires and needs of the customer or the community (Burn, 2010). They must also address the increased demand for non-traditional policing services such as cybercrimes. Airline industries are progressing towards passenger-centric disruption management framework whereby their desired outcome will directly impact the decision making and resource allocation in the operation centres (Jimenez Serrano & Kazda, 2017).

The potential for law enforcement agencies using a model similar to the passenger-centric model could lead to greater satisfaction and trust along with direct reduction in resource allocation through negotiated responses. The introduction of hub and spoke model in POCs which integrates the entirety of the organisation's capability in line with the functionality of AOCC has the potential to create greater efficiencies in police operations. These efficiencies are enhanced by MAS technology to ensure fusion across the organisation's information and resource flows.

The use of MAS-based systems in policing has increased over the last decade with the introduction of systems designed to help with routine policing functions such as patrolling. There are four types of multi-agent patrolling strategies which have been studied and implemented in MAS-based systems internationally (Chen, Cheng, & Wise, 2017). The four strategies are: pioneer strategies, operations research strategies, alternative coordination strategies, and interactions strategies. Chen et al. (2017), suggest that these strategies for routine patrolling do not take into account the

complexities of modern policing as they omit the peculiarities and challenges faced in daily police operations which this researcher describes as 'disruptions'.

Similar to the airline industry daily schedules, a preventative policing model experiences disruption-based incidents, such as calls for service from the community. It requires organisational resources to respond to such calls to prevent, resolve and recover from the incident reported. It is the role of police operations centres to control the resources to attend to these calls for service to ensure community safety (Yang et al., 2018). This research built on the research undertaken within the airline industry around passenger-centric disruption management framework which created a framework of an Integrated Multimodal and Multi-airline Operations Centre (IMMOC) (Jimenez Serrano & Kazda, 2017). The adaptation of the Airlines Model for policing would involve the development of a community centric disruption management model which could be handled within an Integrated District Tasking and Coordination Centre (IDTACC) displayed in figure 22 (Jimenez Serrano & Kazda, 2017). The onset of artificial intelligence (AI) has given unique opportunities to harness some of the predictive nature of policing through historical crime data (Yang et al., 2018). This integration of AI and predictive policing technology will be a crucial aspect of a future MPOC MAS system. Therefore, this research advocates a system design of MAS which supports the IMMOC and IDTACC along with the IoT data to ensure the framework is intuitive by nature.

2.8 CONCLUSION

The review of literature discussed the findings of existing research on AOCC, POC, Crime Prevention, MAS technology, IoT and disruption management. The review underlined the significance of business drivers and technology implemented over time to design and operate successful AOCC's. The literature uncovered numerous important similarities between the airlines operating environments and policing, ascertaining the potential of transferable learnings between the two. What also become apparent from literature was the lack of implementation of MAS technology to assist with the operational efficiency within policing.

The review highlighted optimal decision making within AOCC through the advancements in structure and design leading to greater control, reduced costs, minimised delays, enhanced organisational reputation and customer satisfaction. The

results also showed the similarities in the functioning of POCs and AOCCs. If an Integrated Multimodal and Multi-airline Operations Centre (IMMOC) is replicated within a policing context, it can increase QPS efficiency in diverting resources towards a preventative policing model which could have enormous community and industry benefits.

Chapter 3: Research Design

The research identifies areas of improvement in the design, structure and function of Police Operations Centres (POC) that could increase the effectiveness of Queensland Police Service (QPS) service delivery due to learnings gathered from the airline industry. Theory and methods are interrelated in management and organisational research as theory guides the selection of research questions and research methods are used to answer those questions. Our quest for knowledge necessitates grounding theory and theoretical references in empirical data (Cornelissen, 2017). The study used qualitative method and applied a Pragmatist paradigm to answer the research questions.

3.1 METHODOLOGY AND RESEARCH DESIGN

3.1.1 METHODOLOGY

This chapter outlines the methodology for the research that underpins the theoretical aspect of the adopted paradigm. It includes the design, data collection methods, analysis methods and finally ethical considerations. The research paradigm is the lens through which the researcher's action are guided throughout the research (Creswell, 2009). Pragmatism is not affiliated with any system or philosophy which allows the researcher to freely use both quantitative and qualitative approaches (Rahi, 2017). Strict qualitative research is not traditionally associated with pragmatism. However, Cornelissen (2017) states that with a pragmatic explanation there is no immediate concern with semantic complexity or with arriving at ultimate explanations which often is the driver in qualitative research. The focus, instead within this research was purely pragmatic in offering targeted explanations towards possible interventions or actions (Cornelissen, 2017) which can be adopted by the QPS.

The intention of applying the Pragmatist paradigm was to collect, analyse and interpret qualitative data to explore how the Airline Operation Control Centre (AOCC)'s systems theory approach in their operational model could be transferred to enrich and enhance current POC operational models. I used content analysis, observations, and interviews to extract this qualitative data from both the airline and the policing industries.

3.1.2 RESEARCH DESIGN

The Pragmatist approach within this research through content analysis, observations and interviews progressively separated the effects of different potential interventions or causes from one another (Cornelissen, 2017). The qualitative research was designed around the research questions to guide the researcher (Kozleski, 2017). The research was conducted over three phases using documents content analysis followed by observations and interviews. Content analysis is a research method that is used to classify large amount of text data in an efficient number of categories that represent similar meanings to describe and quantify a phenomenon (Sengur & Kuyucak, 2016). There are several crucial values the researcher used through observation as outlined by Bryant 2018, including:

- Gained a greater understanding and captured the context within which participants interacted.

- Examined behaviours, process and interactions using observations and interviews.

- Gained knowledge from observations and document analysis which participants might have been unwilling to discuss in the interview.

For the content analysis the researcher used the premise posed by Demil and Lecocq (2010) comprising three main concepts. These were resources and competencies, organisational structures, and value propositions. The phased approach to this research was deigned to create a dynamic environment whereby analysed data was used to influence the tools and methods in the subsequent phases.

3.2   PARTICIPANTS AND STUDY POPULATION

The researcher applied purposive sampling (Sengur & Kuyucak, 2016) as the method of participant selection. Purposive sampling is also known as 'judgement sampling' which is a deliberate choice of an informant or participant due to the qualities they possess (Tongco, 2007). These informants or participants are observant and reflective members of their organisation who know much about the culture and practices and are able to impart this knowledge (Tongco, 2007).

The researcher requested the key Airline Industry officials to select the most suitable participants in their organisation with respect to participants' positions and

interactions with the AOCC. In order to correctly target the most appropriate persons within the respective organisation, a brief outlining the study which included the objectives was incorporated in the introduction letter to assist the key officials in the selection process. The methodology dictated the individuals selected had the knowledge and capacity to provide the necessary information appropriate to their relationship to the AOCC and POC. Proposed study participants included the following:

- Phase 1: Airline Industry personal from executive level through to operational staff within the AOCC - 5 staff.

- Phase 2: QPS ELT and supporting management within the trial regions - 10 staff.

3.3   INSTRUMENTS

The research used the following tools to collect the data;

1. Document analysis – Operational procedure manuals of both the AOCC and POC were examined to analyse the categories of structure, design, operations, MAS systems and Human resources.

2. Interviews – The purpose of the interviews was to allow the researcher to elicit as much information as possible from the participants. This technique allowed the researcher to achieve a knowledge saturation point by asking follow-up questions from the set questions which would not be achieved by a questionnaire style method. The researcher developed a proforma set of interview questions for the airline industry participants and labelled it as Appendix A. An interview proforma was also created for policing participants and was labelled Appendix B. The interview was conducted in person or through video link depending on health limitations caused by COVID19 pandemic.

3. Observations – This tool allowed the researcher to gain a greater understanding and capture the context within which the participants along with other persons interacted within their respective operating environments. The method examined behaviours, process and

interactions which routinely escapes the awareness of participants (Sengur & Kuyucak, 2016).

3.4 DATA ANALYSIS

The research was divided into three phases. Phase 1 consisted of document analysis of AOCC's operations, design and structure documentation. The operations, design and structure of AOCC's system was compared with resources and competencies, organisational structures, and value propositions. These three core components were the drivers for a successful business model (Demil & Lecocq, 2010). Phase 1 also consisted of thematic analysis of semi-structured interviews with airline industry staff directly involved with the function of the AOCC at the strategic, operational and tactical level to support the data collected from content analysis and observations. A disruption-based question was posed during the interview in phase 1 as disruption management was identified during the literature review as being an area of difference to explore.

During Phase 1, the researcher made site visits to AOCC operation centres and used overt observations of the implementation and running of the AOCC. These observations were noted down for future use. The information from these observations was compared with the thematic analysis of the data collected from the interviews and content analysis on the design, structure and operations of AOCC. The findings from the combined analysis of the three tools were used to examine the effects of disruption management in the AOCC directly relating to the core components listed in the initial analysis. The information collected in Phase 1 was used as a baseline for comparison with the data collected from POC in Phase 2.

The research methods applied in Phase 1 were repeated in Phase 2. This phase included content analysis of current QPS POC's (Both Communications and District based) design, structure and operation and its comparison with the three core business model components listed by Demil and Lecocq (2010). The researcher then conducted semi-structured interviews with the members of the QPS Executive Leadership Team (ELT) along with Regional and District management teams to collect qualitative data on strategic, organisational and tactical level business drivers for POCs. The researcher attended and overtly observed the Gold Coast DTACC operation and Brisbane Police Communication Centre (PCC) and created a data set to make comparisons with data

from Phase 1 interviews and observation. This data was complemented by a content review of national and international POCs that ensured a holistic understanding of current industry trends and capability.

In Phase 3 the researcher compared the two analyses of qualitative data sets collected during Phases 1 and 2 for further analysis and interpretation using thematic coding. The coding created recurring or similar categories which were clustered together to generate themes for further analysis or recommendations. The process of data collection, review, analysis, and additional data collection by means of follow-up questions, within this research featured the relationship between the questions, data collection and the emerging evidence (Kozleski, 2017). The intention was to create a relationship which was fluid and neither hierarchical nor unidirectional (Ritchie & Lewis, 2003). The premise was to assist the implementation of recommendations derived from the research to create positive change in the POC system. This fluidity in adapting the data collected in Phase 2 based on emerging issues discovered throughout the research directly impacted the comparison conducted in Phase 3. The data collected on POC's was compared with the data and business drivers collected from the airline industry.

The analysis assisted in achieving the ultimate goal of answering RQ1 and producing a new intuitive, intelligent, and economical, structure and operating model for POC capable of disruption management in preventative policing. A set of recommendations was also developed based on the research findings.

3.5   ANALYSIS

There are two common approaches to content analysis, inductive or deductive. The inductive approach is used when there is limited knowledge about the phenomenon and categories come from the data (Kondracki, Wellman, & Amundson, 2002). This is most relevant in policing as opposed to the airline industry which contains substantial research. In this study, an inductive content analysis was conducted on the collected data because the business model components of both the airline and policing industry were acquired through this analysis of data (Sengur & Kuyucak, 2016). Thematic coding was applied for the detailed analysis of data derived from content analysis, interviews and observations from the airline industry and

policing. The coding was analysed to identify categories (Creswell, 2009). Recurring or similar categories were clustered together to generate themes for further analysis.

As stated in Section 5.2, the data collected using content analysis, observations and interviews from AOCCs and POCs focused on structure, design and operation of the two industries. This data was then compared with the three major components of the Demil and Lecocq (2010) business model including resources and competencies, organisational structures, and value propositions. Figure 9 illustrates the interdependency of the data collected on AOCCs and POCs in a continual improvement business model. For the purpose of this research, the resources and competencies were benchmarked against human (employees and their competencies) and MAS technology.
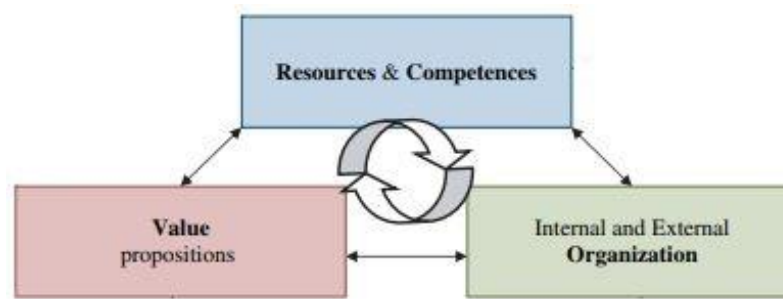
Figure 9 - Business model framework for data analysis Demil and Lecocq (2010)

The observations and interviews during both Phase 1 and 2 focused on gathering data on the three major questions of design, structure and operation of the respective POC and AOCC operation centres. The comparison of the two data sets assisted in answering the main research question around the optimal design of a Police Operations Centre and generating a set of recommendations supporting multi-agent systems in a preventative policing model.

Specific questions were posed to the interview participants directly addressing the areas of structure, design and operation relating to their organisational position. The data obtained from the observations of the researcher focused on the transferability of business process and technology from the aviation industry to policing. The analysis of the collected data in the phase two interviews mirrored that of phase one to ensure the integrity of the comparison between the two data sets that was carried out in phase three. Interview questions in phase two within the QPS however focused more on the business drivers as opposed to the structure, design and operation of a POC. This was

due to the fact the researcher used the data of the airline industry to influence a change in the structure, design and operation within a POC. The researcher examined how the QPS ELT defined a disruption event within its operating model. This was to ensure if any proposed changes to the current operating model had the capability to cope with disruption.

Observations during the first phase had two primary objectives: i) to examine the implementation of AOCC business model operationally and ii) the use of MAS technology to create operational efficiencies. The data from these observations answered the sub research questions posed around MAS technology and the use of IoT data within disruption management. Observations in phase two examined the applicability of AOCC structures, design and operations within the constraints of the QPS operating environment. This observational data was combined with an analysis of the use of technology within these operating environments.

The qualitative analysis of the initial data sets from both the airline and policing industry were examined, coded and compared in phase three for the existence of any latent or inferred relationships between the three dependant variables of structure, design and operation of AOCCs and POCs (Kondracki et al., 2002). The interpreted data guided the researcher to provide recommendations and develop an overarching strategic design, structure and operational system for a preventive policing model in district based POCs.

3.6   ETHICS AND LIMITATIONS

The QPS Research Committee (QPSRC) is internal to the organisation and ensures the appropriate level of governance is placed around both the organisation and individuals within the service conducting research. This includes the necessity to address ethical research practices prior to any research being endorsed by the QPS adhering to the standards outlined in the National Statement on Ethical Conduct in Haman Research 2018. This included pre-approval of the researcher's data collection instruments, such as interview questions, observation. The participants were informed about the research and its purpose through information sheets and they signed the consent forms before any data was collected. The ethical approval also addressed issues of confidentiality, risk management and mitigation and any permission to use third party Intellectual Property.

The research similarly observed the key principles outlined by USQ Human Research Ethics Committee and include:

- Obtained informed consent from each participant;

- Ensured all participants were doing so voluntarily and understood their right of withdrawal at any time:

- Ensured the confidentiality of participants and records;

- Safe and secure storage of relevant data for a minimum period of five years post completion of research.

- Clarified the overt style of observation

- Regularly monitored the research outcomes of the project.

Data obtained from interviews and observations was transcribed prior to analysis. Any electronic data files were stored securely, and were password protected. Analysed qualitative data which was printed was de-identified prior to publication. The research received USQ ethics approval prior to data collection of the QPS to ensure the academic rigour of the research was met along with the appropriate ethical considerations. Finally, due to the researcher's dual role of worker and researcher, consideration was given to both conscious and unconscious bias. These considerations included the use of the QPS research committee and airline industry personal to select the study participants. The researcher ensured not to conduct the interviews or observations in uniform.

Chapter 4: Analysis and Results

The following chapter analyses the results of the research to answer the proposed research question, "What is the optimal design and structure of a Police Operation Centre and supporting multi-agent systems (MAS) for resource allocation in an agile, economical and structured manner in a disruption-based operating environment for the QPS?" The chapter breaks down the question and the answers from the interviews and observational data into three major components, Physical Design, Structure and Operations and Supporting MAS Technology. Within each of the three areas the results of content analysis, observations and interviews are presented with the view of providing insight for the discussion and subsequent conclusion chapter. As discussed in Chapter 3 participants were selected on their knowledge of and relationship to their respective operation centres. The participants, their roles and organisations are displayed in table 1. Due to ethical consideration, they have been de-identified, numbered and listed purely by the "*p*" prefix.

Participant ID	Industry
P1	Policing
P2	Policing
P3	Policing
P4	Policing
P5	Policing
P6	Policing
P7	Policing
P8	Policing
P9	Policing
P10	Policing
P11	Airline
P12	Airline
P13	Airline
P14	Airline
P15	Airline

Table 1 Research Participants

4.1 PHYSICAL DESIGN

In this section the physical form, including the layout design and associated physical infrastructure of an airline operation centre (AOC), QPS State Police Operation Centre (SPOC) and Gold Coast District Tasking and Coordination Centre

(DTACC) are discussed. When analysing this aspect of the AOC, POC and DTACC several methods were used including content analysis, observation of the physical space and direct questioning during the interviews with participants. The age and location of the respective centres is included in Table 2 as this is crucial to the analysis of design elements in each. To ensure consistent approach participants from both industries were asked the same two questions around design and physical environment to compare the design elements of AOC, POC and DTACC. These were, "Were there physical design considerations in the make-up of the current operation centre? If Yes what were they?" and "Upon reflection would you change the current physical design or your operation centre?"

Name	Location	Constructed
Virgin Australia OCC	Brisbane	2017
Brisbane PCC & State Police Operation Centre (QPS)	Brisbane	2013
District Tasking & Coordination Centre (QPS)	Gold Coast	2018

Table 2 Operation Centres visited

The observational data was collected through a guided interaction in the physical environment with the Head of Integrated Operations Virgin Australia (Airline), SPOC Manager and DTACC Manager (Policing). This allowed the researcher to apply clarification and context on the observations recorded for the research. During the observational tours of the respective centres listed in table 2, a set of key design elements were detected that are listed in Table 3. A word query was applied to participants' interviews (n = 5 for airline and n = 10 for policing). Key words were coded according to the commonalty in participant responses, both airline and policing, and percentages of recurring key words were calculated for each of the key design elements.

Table 3 lists the percentages that show the level of perceptions of the police and airline industry participants about the key design elements. These design elements were visible in all three of the operation centres visited. The low recognition of some design elements seen during the observations could be related to the fact that all the centres were established prior to the participants taking up their respective roles so had no input in influencing design. The Gold Coast DTACC, was a legacy item from the 2018 Gold Coast Commonwealth Games, funded by the organising authority and

gifted back to the QPS. In fact, the existing infrastructure was one of the business driver for the establishment of the DTACC.

Design Element	Airline	Policing
Audio Visual	80%	30%
Ergonomic Furniture	80%	90%
Workgroup Clusters	100%	90%
Business Systems	40%	30%
Command and Control area	60%	50%
Breakout and Collaboration space	40%	30%

Table 3 Operation Centre Design Elements

The interview results indicated that the availability for visual information was at the forefront of the physical design. The participants perceived that operation centres played a key role in operational decision making. These centres provided situational information that was critical prior to making operational decisions. The term, 'being situationally aware' was mentioned on several occasions during the interviews of both the airline and policing staff. Therefore, physical design was considered crucial in creating an integrated environment that was viewed complementary to creating a situationally aware staff member:

> *Yeah, a lot of the centres are designed for better integration and situational awareness. I have worked in the Qantas IOC and it's like Mission Control in Houston (P13).*

In one interview the participant made a point around the need to create situational awareness among both operators and decision makers within the centre. The participants' perceptions of Situational awareness (SA) were consistent with how it is defined in the aviation sector as , 'appropriate awareness of a given situation (Stanton, Chambers, and Piggott (2001). The participants felt that to ensure optimal decisions are made by the staff, the enabling environment of a fully functioning 24-hour seven day a week centre was considered a priority. P13 stating:

> *A lot of centres are designed for better integration and situational awareness (P13).*

4.1.1 AUDIO VISUAL EQUIPMENT

Access to real-time information and vision was evident during observational data collection in the design of all operation centres (airline and policing). During

observations within the airline operation centre both P11 and P14 highlighted the large number of TV screens which provided situational awareness to staff within the centre. During the interviews with airline participants 80% directly mentioned the placement of AV within the centres. The AV provided staff with visual cues around information such as flight tracking and weather. In their view, having the ability to visualise an impending weather event assisted flight operations when preparing for a possible disruption event.

The QPS SPOC and DTACC were also observed to contain large video walls. Participants who managed the respective policing centres discussed the importance of the AV equipment for situational awareness. In the policing centres situational awareness was created using the AV through Close Circuit Television (CCTV) feeds. The observation data in Figure 1 from the SPOC and DTACC shows the video walls with CCTV feeds from the local City Council along with Television and news station that created situational awareness during specific operations.
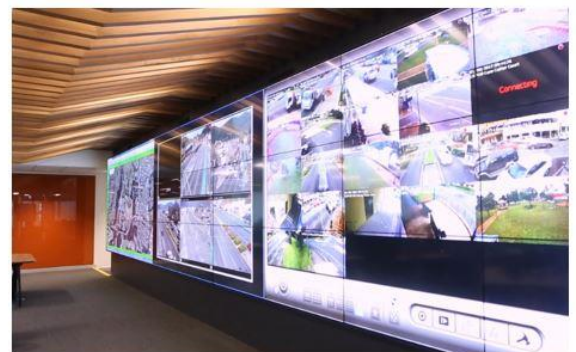
State Police Operation Centre   DTACC Video Wall

Figure 10 Video Walls at police operation centres.

It was evident in the physical similarities witnessed during this research that video walls and AV are synonymous to operational control centres and transcend all industries. A higher percentage of airline respondents mentioned the importance of this design element and their desire to create a heightened level of situational awareness for decision makers in the centre as compared to the QPS participants. During the interviews only 30% of police participants directly mentioned the need for AV equipment. This result when compared to the direct observation where AV was prominent in each of the police operation centres reflects an element of complacency or expectation that AV was a standard element for an operation centre and could account for a small percentage of interviewees not mentioning this element when

questioned on design. It was notable in both centres that some devices were not solely displaying business information for staff in creating situational awareness, but displayed commercial television stations that were not news related or of use to the operation of the centre. One participant specifically commented that more AV did not necessarily create greater SA and in fact the introduction of the AV had been manipulated by staff for non-work-related activities. The participant said:

In fairness most of the screens are on Foxtel when I get into work (P5).

When analysing this comment, it was mirrored by conversations with P11 (airline) and P4, P6 (policing) and when conducting the observational tour of the operational AOC, POC and DTACC respectively. The overarching sentiment by these participants and observations made by the researcher indicated the potential for the misuse of AV by staff within the respective centres.

The interviewees perceived the design and introduction of AV into the centre was crucial to the overall operational success of the organisation as it aided in operational decision making for staff at all levels within the centre. During one observation session within the QPS SPOC, participants were using the CCTV vision displayed on the video wall to assist with an operational job being coordinated from the centre, that showed the importance of this element. The use of AV for non-work-related purposes indicated that the staff was missing out on the information and vision availability in real-time and could run the risk of executing crucial business decision based on partial information. This conundrum was reinforced by P11 from the airline industry who stated;

I would move in with less AV and go with minimum viable product the first day and let people settle in and let people see and then we should go what else do people need. Follow up needed. You have quoted, now analyse (P11).

4.1.2 ERGONOMIC FURNISHINGS

The findings from the interview data indicated that 80% of the airline and 90% police staff perceived that advancements in design and functionality of furnishings such as desks, computer monitors, seats and phones needed to be integrated into standard designs and refits of operation centres. The observational data indicated that the operation centres had ergonomic furnishings that allowed the staff to stand rather

than just sit for long periods at a desk or workstation. This benefit added to the overall effectiveness of an operational decision-making centre and is supported by academic research by Jancey et al. (2016), outlining the compelling evidence around the detrimental physical effects of prolonged sitting. Research shows that employees who sit less and stand more demonstrate increased higher energy and higher potential for group collaboration (John, Lyden, and Bassett (2015).

The 60% increase in responses around ergonomic furnishing compared to AV from police participants clearly indicated their desire to create a more productive and comfortable work environment.

The SPOC displayed in figure 10 has a primary function to stand up (operate) during crisis or major events and not year-round 24hr operation centre. During observations of the SPOC, designed and implemented in 2013 for the 2014 G20 Summit, the furnishings were traditional linear desks with no sit stand capability. Similarly, the DTACC centre that is used 24/7 a week and that looks after the resource and demand management for the Gold Coast Policing district was built for the Commonwealth Games in 2018, had a different modular design in pods for desks and seating, along with dual screen monitors. The participants perceived that the modern electronic ergonomic sit / stand desks were not installed in this centre due to cost and the uncertainty of the legacy use for the space.

The researcher observed that in contrast, Brisbane Police Communication Centre (PCC) which operates the demand and tasking for the Brisbane policing region was retrofitted in 2016. It featured fully ergonomically designed workstations. During the interviews it was indicated that, in the design phase of this retrofit the project team partnered with an ergonomic design specialist to customise the workstation areas for staff in the centre. The participants explained the design of Brisbane PCC adjacent to the SPOC was created on a floating floor and furnished with modern ergonomic fully powered sit / stand workstations due to the demanding environment faced by workers in this 24/7 a week operation centre.

> *We have full sit / stand desks with multiple monitors for all staff, so they have everything they need at their fingertips. The floating floor is so that we can move workstations if needed (P4).*

SPOC & DTACC with traditional furniture

Brisbane PCC with modern ergonomic sit stand furnishings

Figure 11 Contrasting ergonomic furnishings

The modular ergonomic workstations at PCC were similar to those observed within the Virgin Australia AOC. Both centres, the Virgin AOC and Brisbane PCC were designed, constructed and furnished with the understanding the space would be used and staffed in a year-round, 24/7 a week capacity. Contrastingly the SPOC and DTACC were both originally designed and furnished for singular use events or unplanned crises. The linear design along with the furnishings was considered state of the art when the SPOC was commissioned in 2013 and has not been revisited since, explaining the lack of modern ergonomic furnishings within the space. These findings show the importance of ergonomic design as it relates to the health and wellbeing of staff. These findings are consistent with the emerging research being undertaken in studies (John et al. (2015).

4.1.3   WORKGROUP CLUSTERS

Operation centres house a variety of roles from different departments with diverse reporting lines. The observational data indicated that within the airline AOC, departments such as crew rostering, engineering, aircraft allocation coordinator, social media, weather and meteorology and customer experience were all represented. Their physical location was dictated by their need to interact with other departments within the centre and proximity to decision makers depending on the role importance. The need for work units to be located together from a design perspective was reinforced by 100% response rate during the interviews with airline participants. One airline participant commented

> *(staff) predominately sitting in functional groups…with integration and situational awareness (P5).*

The QPS participants also felt the design and layout of the space must be conducive to allowing workgroup clustering with a 90% response rate. The QPS used a designated command and control model which included areas such as planning, operations, intelligence and administration and logics which were separated into 'cells' or work units. When observing the functional SPOC, staff within the allocated cells were assigned an area according to their roles and responsibilities and seated side by side facing the video wall. Figure 3 is an illustration of what a setup during an event could look like in the SPOC, highlighting the cells and their possible locations. The commander at the time stated they preferred the operations cell to be seated close to command or decision-making area to allow greater access to real-time information.
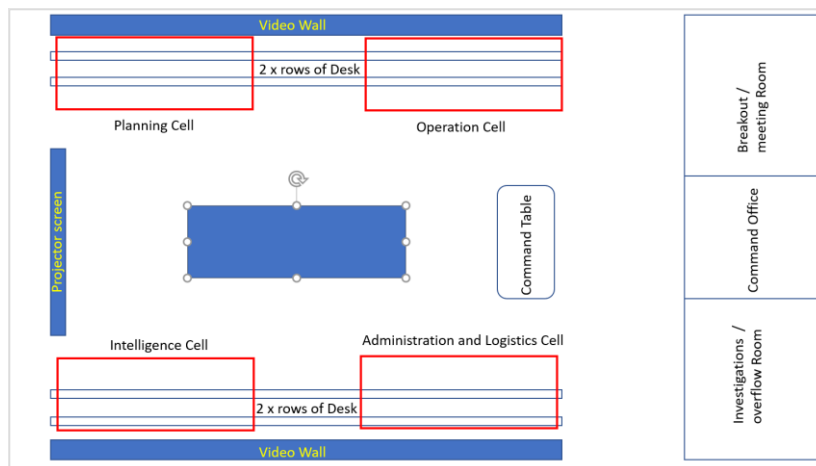
Figure 12 – QPS SPOC with functional cells

This was in contrast to the DTACC which was more modular or in pods with the ability of all staff to access the vision of the video wall. The pod setup in the DTACC was similar to the Virgin AOC with the exception of the command or Duty Ops area within the Virgin AOC located in front of the video wall. Compared to the QPS seating arrangements, the pod formation allowed for greater collaboration between functional areas with the ability for several different touch points to a different workgroup within the centre. Figure 5 illustrates this collaborative ability of the modular clustered work group. The clustering in a modular formation increases the situational awareness of staff due to their ability to interact with more areas as opposed to the linear setup witnessed in the SPOC.

Figure 13 – AOC modular setup with greater touch points

Virgin during the redesign of their AOC split their centre into two campuses based on noise issues. A participant explained:

> *We have teams which when they are busy go silent because they are very focused on data and we have other teams when they become busy become collaborative and start to talk to each other (P11).*

The splitting of some business areas from the AOC was perceived by one participant as loss in communication and situational awareness. The participants discussed the prospect of amalgamating the areas back into one space if given the opportunity. The results of the observation matching the high response rate during interviews indicate that clustering of workgroups was an important aspect of design. It reinforced the need for including this element in any operation centre design.

4.1.4   BUSINESS SYSTEMS

Access to information and data is crucial to making informed decisions. While conducting observations within the AOC it was evident the use of an areas specific business system was crucial to their success. Most systems were contained on their desktop or docked laptop computing device with multiple screens to assist with displaying the information. Some systems would also display this information on the AV walls contained within the centre. This observation was consistent across both the airline and police operation centres and PCC. When comparing this observation to the interview data specifically around design it did not register as highly with only 40%

of airline participants and even lower 30% of policing participants directly discussed the need to consider business systems during design.

This result could be in part due to the language used in the question around "physical" design instead of the technological setup of the internal information technology (IT) architecture. One police participant during the interview perceived that too much technology had the potential to create "white noise" and distract staff from the task at hand. It was, however, evident during observations that the physical design was an important aspect of how staff within the centre access these systems. To create a situationally aware environment, access to business systems must be included which was not very evident from the interview results.

4.1.5   COMMAND AND CONTROL AREA

The aim of the AOC is to make operational decisions during disruption events which have the potential to save or cost substantial time and money for the business and customer alike. Similarly, within a policing operations centre, tactical decisions are made based on the input of information which leads to the deployment of resources to a given area or problem. The placement of the command and control area varied between the two industries and even between the two QPS centres, SPOC and DTACC. As displayed in figure 4 the command area within the SPOC had multiple areas for the commander to work from.

In the SPOC there was a desk located in the middle between both lines of desks along with an adjoining office. In contrast, the command desk at the AOC was located at the front of the room facing outwards towards the staff. The DTACC was different in comparison to the SPOC with the more traditional video wall at the front modular workgroups in between a command desk located at the rear of the room. Both the SPOC and DTACC are legacy centres from major event-based operation centres, therefore, the traditional layout including the command table could be attributed to the initial intended use which was a major planned event, in comparison to an AOC or PCC which are 24hr a day 365 day of the year centres.

The command desk or what was described by an aviation participant as the "wedding table" (in reference to the table where all the important decision makers sit), was the focal point within all operation centres. This is the point where information must flow into so that decisions can be made. About 60% of aviation participants

directly referenced this during their interviews indicating its importance. The design element of workgroup clustering received a 100% response from aviation participants. The participants specifically mentioned the term "touch points" between the areas which included "command" workgroup. The importance was reinforced by airline participant who reflected:

> *So, what you still have is your operational decision making in the hub (centre of the area) which is your final escalation point and if you have your right teams side by side that way conversation can go on (P11).*

Although the AOC had a different layout the concept was similar to the SPOC and DTACC placing their command area in a position which oversaw the entire operation centre. The placement of the command area would reflect why only half of the police participants directly mentioned the design or placement of the command area within the centre. The intent of the command area whether it is in an AOC or POC is to be aware of the entire operation in order to make informed decisions. The centres observed for this research highlighted the similarities in design of the command areas.

4.1.6   BREAKOUT AND COLLABORATION SPACE

The operational tempo of the respective AOC and POC can fluctuate depending on the demand for services, the particular event or disruption they are managing. When observing the daily grind of the AOC there was a steady "hum" or noise level of people going about their business along with the supporting AV in the room. Similar situation was observed in the SPOC and DTACC within the QPS during their routine operation. During the observational data collection, both airline and policing participants noted when a deviation from routine operations occurred the requirement for an area to bring people from different areas into a single space became an operational necessity.

The Gold Coast DTACC used one of their collaboration spaces equipped with video conferencing capability, to conduct their daily synchronisation briefings for the entire District. Having this area off to the side of the operation centre allowed staff in leadership positions from the centre to attend all while being close enough to respond in a crisis and maintain SA of the centre. The AOC had similar spaces lined with whiteboards where staff could overflow to collaborate during unplanned major disruptions to commence contingency planning.

The unpredictable nature of airline disruptions and policing calls for service demands more physical space to achieve collaborative outcomes. It is this reason the inclusion of collaboration, breakout or meeting spaces is an imperative design element and one observed in both industries. However, the low responses (40% from airline and 30% from policing participants) did not reflect their understanding of the need and use of these spaces during times of disruption within the centres.

4.1.7   PARTICIPANT POTENTIAL DESIGN ENHANCEMENTS

When both sets of participants were questioned around potential changes to their current centre's physical environment an overwhelming consideration in both industries was the financial implication of modification. They perceived that the infrastructure such as AV, furnishings and ICT was a substantial investment and therefore any changes required a proven business case whereby the new facility would provide a return on investment. Design similarities across operation centres were observed during the content analysis of imagery of aviation operation centres and QPS operation centres. The similarities were visually noticeable and were consistent with the observations during this research (Figure 6).

Dubai Airport Integrated Operation Centre — Brisbane City Major Event Coordination Centre — American Airlines Integrated Operation Centre

QPS State Police Operation Centre — Delta Airlines Operational Control Centre — QPS Gold Coast DTACC
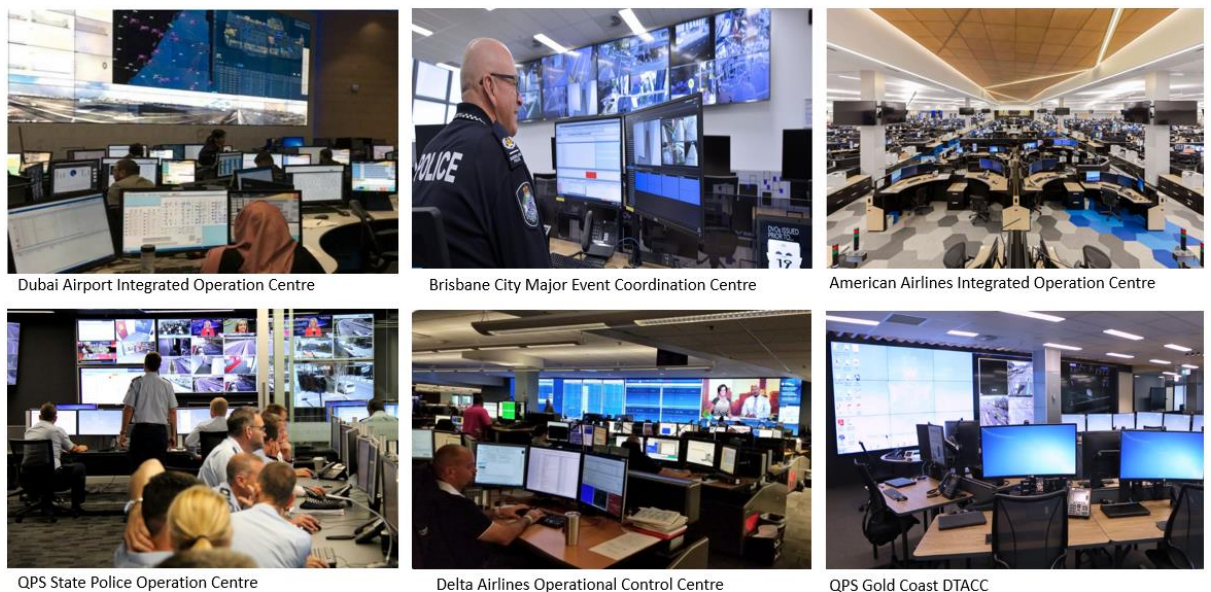
Figure 14 – Example of design similarities between aviation and policing operation centres

During the interview around possible changes to the DTACC a participant stated:

Ergonomically (furnishings) there are probably a couple of things we could improve on and maybe a couple of extra screens (computer

monitors). But other than that, we are grateful to have a $3.8 million facility (P6).

This comment reflects the financial consideration of building or upgrading an operation centre when considering change. Taking the financial consideration out of the equation the AOC participants believed a redesign of the Virgin AOC and the amalgamation of all areas of the OCC into one space would be a major operational benefit which would create efficiencies and economic savings. About this proposed redesign a participant stated:

> *More ideal now, I would go a central pod for the duty manager. The person that owns the end result of that floor, the achievements of that floor, and go in like a sunray type situation. .....So, you can have the people who want (or need) to be really quiet at one end of the room and the noisy people at the other end of the room where you don't lose your situational awareness because all your leaders are located together (P11).*

This concept is substantially different from the current trend of linear or modular pod style setups found across both industries. During document analysis, the new Qatar Airways Operation Centre was a near replica of the sunray concept. Figure 15 shows the sunray style setup with the duty ops manager in the centre and the capabilities areas fanned out across the room. This setup allows for the more boisterous workers and those who need a quieter space to be located at opposite ends of the space while allowing the respective supervisors to be located close to the decision-making hub of the centre. All design elements, including AV, workgroup clustering, ergonomic furnishings, command and control area, business systems and collaboration / breakout space merge into the overarching design. This conceptual design change is reflective of the data sort to influence an optimal design of a future police operation centre

Figure 15 – Qatar Airways Operation centre outlining enhanced design.

4.2   STRUCTURE AND OPERATION

In this section the day to day operations of the AOC, QPS Police Communication Centre (PCC) and Gold Coast District Tasking and Coordination Centre (DTACC) are discussed. The methods used for this analysis of the AOC, PCC and DTACC included content analysis, observation of the centres operating in business as usual (BAU) mode and interviews with the participants. Table 1 lists the participants industries. Interview questions were structured to uncover the business drivers and the subsequent structure or composition of the respective centres for both aviation and policing.

The aviation sector is in the business of moving people from different destinations at particular times and dates in a manner, which is enjoyable to the customer while economical and commercially viable to airline. When analysing the AOC research data, it was important to consider their business model as it provided the strategic direction the operation centre was desirous of attaining. Within the policing environment there are different policing models. The QPS under their new Commissioner are moving to a "prevention" based policing model. The research assessed the data around this model.

4.2.1   BUSINESS DRIVERS

In the AOC interviewees' perception, the successful movement of passengers on time was the primary business driver, three terms used for this driver were effective, efficient and economical. To achieve this driver, the AOC looked at the previous day's

operation, the day of operation and then projected 13 days into their future schedule. When asked how the AOC contributes to the overall service delivery and efficiency of their organisation a participant responded:

It is the fulfilment of what we do (P11).

The AOC operationalised the organisations strategic drivers whereby the centre executed the long-term plans and direction of the organisation on a day-to-day real-time basis. A participant elaborating:

The main concept of the Operation Centre is to work on integrating the daily operations with unpredictable disruptions which occur on a daily basis within the airline (P15).

When addressing the business drivers for PCC and DTACC the response of the participants highlighted a conflict within the QPS. The conflict was articulated by participants during the interviews primarily around demand management. For instance, the participants from PCC felt that the allocation of resources to calls for service were the primary business driver and the function within PCC. One PCC participant stated:

We have the ability to allocate resources (attending police) to a job (P6).

This was opposed to the DTACC participant who felt the need to "skirt" or avoid calls for services with competing demands for limited policing resources within the Gold Coast policing district, a participant stated:

At the moment it (DTACC) is skirting around the edges or our volume (demand), our calls for service (P2).

This conflict reflected a level of inefficiency within the policing business model whereby PCC's drive to allocate resources to calls for service clashed with the DTACC's holistic understanding of "demand" for their specific geographical location. The competing business driver was best described by a participant:

This intervention (DTACC) adds latent capacity back where ideally you can get enough latent capacity back to get into the preventative space (P2).

With the QPS having a strategic policing model of "prevention" based policing it is imperative the business drivers behind the respective operations centre solely focus on moving all available policing resources into the prevention space. Figure 16 outlines the business drivers including desired outputs and outcomes derived from the interview data and content analysis of the Gold Coast DTACC. These drivers reflected a more holistic approach to community safety as opposed to PCC who was desirous of resource allocation to a call for service.
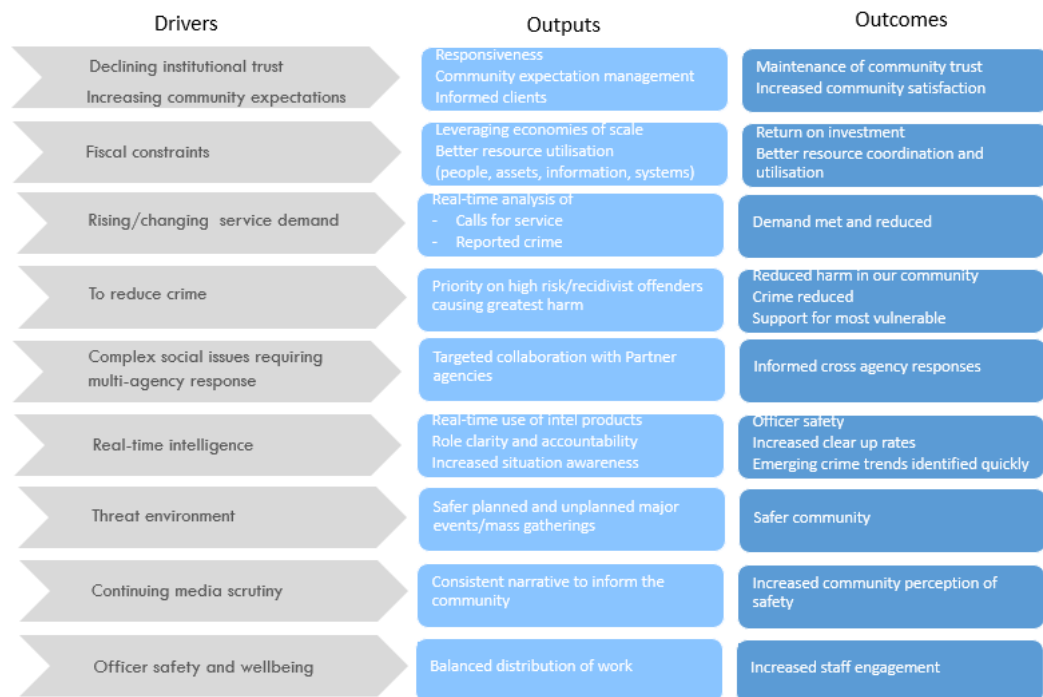

Figure 16 – Gold Coast DTACC business drivers

4.2.1 PCC VERSES DRACC – DAILY OPERATIONS

When observing and interviewing the operations of a PCC and the Gold Coast DTACC the differences were outlined in Table 4. Importantly table 4 summarises the inputs, capabilities and outputs of the respective centres from observational and interview participant data.

	Police Communication Centre (PCC)		District Tasking and Coordination Centre (DTACC)	
Inputs	• PoliceLink online and call diversion. • 000 Telephone Network • Radio Dispatch Network. • Frontline on-road inquiries.		• PCC Job system. • District crime trends (Intelligence products) • Planned and Unplanned events. • Divisional priority taskings. • Inter-agency requests. • Local council CCTV network. • Frontline on-road inquiries.	
Capabilities	• Entering and allocation of calls for service. • Resource allocation and Triage of calls from PoliceLink. • Client management. • Emergency incident coordination.		• Tactical intelligence – identify crime trends. • Resource allocation and Triage of calls from PCC. • Demand management to District priorities on a real-time basis. • Event coordination. • Governance. • Planning	
Outputs	• Calls for Service. • Resource coordination. • Emergency incident coordination.		• District demand coordination. • Triage management on calls for service. • Major event and incident coordination. • Crime trend analysis.	

Table 4 PCC v DTACC Operations

The QPS had several PCC distributed across the state which could operate across divisional and district boundaries. It was noted that PCC's were centrally administered from a state-based command structure. During an interview the PCC was described by one police participant:

> *We are the first point of call for members of the public and the Police service whether they are stakeholders or just members of the community (P5).*

In contrast the DTACC was owned by a geographic policing district and for this research paper the Gold Coast DTACC was used as it is one of the few fully functioning centres in the QPS. This centre did not take calls directly from the public and had a greater overarching responsibility for the entirety of policing services within the Gold Coast policing district. As described in table 4 one of the inputs to the DTACC included "calls for service" and only one aspect of demand and not its entirety. A participant said:

> *The intent is to overview calls for service and prioritise them based on District needs and also have the capacity to manage District resourcing in a borderless model (P6).*

When analysing both operations (DTACC and PCC) the PCC operating model was purely reactionary and only focused on the singular business driver within the QPS demand model, which was "calls for service" by phone or online reporting. PCC operations did not include any proactive police tasking for the policing area of which they were responsible and dispatched for. They also did not manage operations or unplanned events beyond the initial call. The importance of this finding was the contrast in operations highlighting the DTACC model has a greater opportunity to provide business efficiencies through a more holistic understanding of demand.

4.2.2   AIRLINE AOC DAILY OPERATIONS

The results of the observations and interview responses from airline participants exposed the crucial function the AOC plays in the execution of the airlines service delivery. An airline participant best described what the operations centre was in relation to the business and service delivery:

> *We are a microcosm of the airline to be able to run the airline on a daily basis (P15).*

The microcosm comment was reference to the participants understanding that all capabilities of the business are represented in the operation centre.

During observation the size and scale of the organisation affected the number of people represented within the respective centres. With the responsibility of fulfilling the airlines schedule each day and the effects of any disruptions the AOC was resourced with a variety of departments in two key areas of aircraft operations and Engineering. Participants described the AOC as managing everything with respect to the execution of the daily schedule and any disruption which might affect the effective, efficient and economic running of the daily operations. One participant best described it as:

> *Things will go late out of Sydney and we will have to manage the Tetris puzzle. So, by the end of the day we have either fly all the flights or if we haven't fly all the flights as much as we can on time or if we have had to cancel how are we going to recover all of our guests (P14).*

The airline participants described the daily output of the AOC as an entity responsible for coordinating multiple business arms and ensuring they seamlessly combined to produce a product to the consumer. Day of operations within the centre monitored the schedule in conjunction with their ground assets located distally in airports all while managing the unique challenges of a disruption event. This was best described by the participants as input management, taking a piece of information whether it be a sick crew member, broken down plane or weather event and making an operational decision to ensure there was minimal effect to the daily or future schedule of the airline.

When asked about pricing their daily operations it was discovered the airline industry understood what a specific day of operation costed. Although it was not reported daily within the AOC, airline participants in their interviews reflected the ability to understand leakage as a major benefit which was not understood within the QPS during their interviews. Figure 5, from the literature review was reinforced in the airline participant interviews and observational data that the operation centre predominately worked at the point of disruption within the organisation. Of note was how the airline participants highlighted the importance of amalgamation of revenue management with operational decision-making within the AOC. Although policing is not a revenue generating business, there still was a distinct lack of understanding among those interviewed for the research around the cost (expenditure) of policing throughout their daily operations.
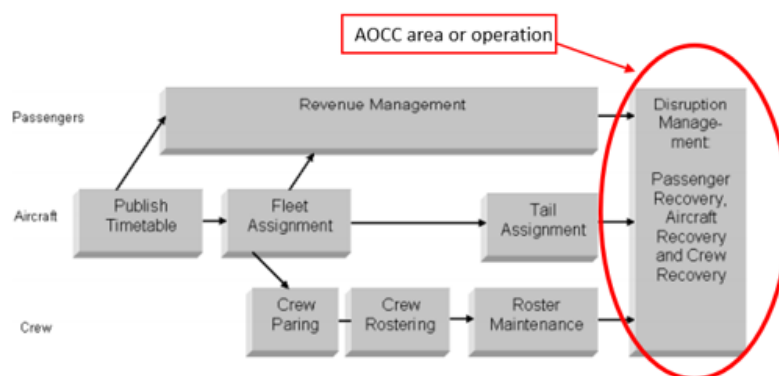

Figure 5 - Airline planning and disruption management Kohl et al. (2007)

4.2.3   DISRUPTION MANAGEMENT

The data collected during the observations and interviews with airline participants was overwhelmingly focused on the theme of disruption management within the AOC. The operation centre generally got the airline schedule 14 days out from what they termed "day of operation", along with crew rosters posted for a 28-day period. There was a large focus on the daily disruptions i.e. crew absenteeism, aircraft engineering faults and how that affected the day and managing onward disruptions for the next 13 days. The participants felt that disruption was norm for an airline, therefore, a strong planning capability was extremely important to the operations ability to recover from a disruption with minimal impact. One participant stated:

> *We are very fickle to these events, dollar goes up dollar goes down. A country sneezes and the airline industry catches a cold (P11).*

During the interviews a comment was made about the level of acceptance by the customers when a major disruption occurs similar to the disruptive event, such as Covid-19 global pandemic. It was discovered through interviews this kind of disruption caused inconvenience to the customers and change in the product offered by the airline. What was considered as less palatable to the consumer was how the airline handled an incident such as a routine weather event in an area which was always susceptible to weather events. It was accepted by several airline participants during their interviews that role of the operation centre was to pre-empt these potential "typical" disruption events and have the capability to create alternate solutions which allowed fulfilment of their advertised schedule or as close to it. The role of the operation centre in this was emphasised:

> *When we sell a ticket to a customer we are selling a promise. For you to fly at a particular time from that port to that port and hopefully arrive at that time. If we brake that promise once its normally ok but don't brake it a third time. So, it's better to try and remove some of those things like systemic issues through the schedule so remove them at that point so people aren't buying tickets on them (P11).*

This comment underlines the importance of the operation centre not only enacting the daily schedule but feeding back into a continual improvement model

whereby their lessons learned through disruptions are considered during the planning of their schedule. One airline participant stated:

> *Disruptions doesn't come in the form you think it's going to come in the form of and if you don't plan to the best of your ability you are going to fail on the day of ops. Failing in the day of Ops is when you fail the customer you don't fail them in the planning you fail them in the day (P11).*

This statement highlights the symbiotic relationship between planning and operations to successfully execute the daily business. The AOC participants' responses indicated that the planning elements were imbedded within airline operation centres to assist with disruption decision making to ensure a more effective outcome which contrasted with DTACC responses and observations. The observational data indicated that the DTACC capability setup was in contrast to the traditional setup utilised in the SPOC operation centre which when stood up for an event or operation had a planning cell among other capability cells. The airline industry interviewees reflected that disruption management was the steady norm for an airline. One participant used the analogy:

> *Disruption is the norm in aviation and the more we can get our customers to trust that we will do our absolute best to support you though it then they will probably come back to us (P12).*

Airline participants spoke of the susceptibility to external uncontrolled and unplanned disruptions as a major driver of daily operations within the AOC. One airline participant declared the customers' perception of the airline's ability to navigate through unpredictable events directly related to repeat business and repeat business equalling more revenue. A relatable finding during interviews with senior policing participants was a comment made around the need to create community confidence as a commodity. It was evident through observation and interviewing that a form of disruption management was occurring within policing, however had not yet matured to become a standalone strategic business driver. One police participant during an interview when posed the question about formal disruption management responded:

> *Although we don't refer to it as "disruption management" the DTAC looks at disrupting in the calls for service space as every time they can*

intervene at the DTACC and a vehicle or a crew doesn't have to go to
a job that is a positive thing (P6).

When examining the results of disruption management within the airline industry what was evident was that no one disruption event was similar, and a template solution or pure automation was not prevalent in operation centre management. While discussing potential enhancements in disruption management within an AOC participants spoke of the time it took functional areas within the operation centre to analyse information and come up with an alternate course of action to manage the disruption. The current reactive disruption management process was described by one participant as being inefficient and un-economical. Extended periods of inaction during disruptions in the airline industry increased the delays and flow on effect to other services according to airline participants. The movement for airline industry operations centre was to preventative disruption management with one participant stating:

30min additional delay for preventative maintenance so that you are
not staring down the barrel of a full-blown turn around and cancelation
in your network (P15).

It was found during interviews with airline participants that one operation centre had realigned the role of some staff in day of operations to what was described as an "opportunity" based planning role. The participant articulated that title of the role stayed the same with a transition in their key accountabilities for the role to have a more forward and preventative focus for that specific day and time. The transition to forward focusing, opportunity-based positions along with decisions made in the disruption space were driven around efficiencies to assist the organisation economically and operationally.

As discussed in the previous section the airlines ability to cost their operation also extended to costing a disruptive event. One enhancement in the airline industry disruption management was discussed around the addition of real-time access to this financial data for supervisors and duty operations managers. The airline participant stated:

That is one thing that I really want to give them is real quick access to
cost and revenue data or yield not revenue (P11).

The significance of this comment emphasised the desire for the airline industry to understand the impact of operational decision making in real time. By creating a more informed decision maker the intent is to create greater efficiencies and limit the economic impact to the organisation. Observational data incorporated with the interview responses exposed the important role the AOC played in disruption management. It also highlighted the investment and movement towards preventative disruption management as an efficiency tactic to streamline and enhance services offered by airlines. This data underscores the importance of policing incorporating disruption management into their operation centres as an efficiency mechanism.

4.2.4   OPERATIONAL STRUCTURES

The findings of the observational data combined with the interviews of the airline participants were consistent with the academic research around capabilities represented within the AOC and displayed in figure 18 that shows the airline as a microcosm.
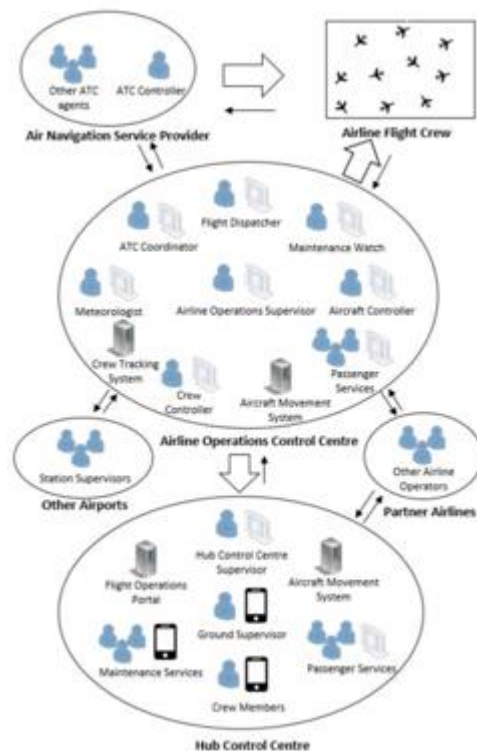

Figure 17 - Integrated AOCC (Bouarfa et al., 2018)

Contrastingly the capabilities and staffing of the DTACC model did not reflect the same ethos of the airline industry of being a microcosm. Importantly it was found the operational structure of the DTACC was not permanent and the positions within

the centre were repurposed from areas within the district. At the time of data collection, the DTACC was essentially an ongoing "trial" which had been running for three years. This lack of permanency according to several police participants was a contributing factor to an ongoing negative perception of the role of the centre which in turn affected the operational performance.

Both airline and policing participants were questioned around possible enhancement from the perspective of adding different roles or capabilities in their respective centres. For the airline participants it was the addition of financial analysts to assist with operational decision makers. This was perceived to be of greater importance in the low-cost airline industry where cost minimisation was a major business driver. Another potential finding was the centralisation of disruption coordinators from the airports back to the AOC.

The policing participants overwhelmingly advocated for multiagency representation within the centre, such as liaison or coordination with fellow emergency services such as fire and ambulance and with mental health coordinators and specialist practitioners such as the domestic violence officers. This underlined the complexity of jobs being attended by the police which crossover to multiple government services that are delivered by the policing operation centres.

4.3 SUPPORTING MAS TECHNOLOGY

A consistent finding across design, operations and structure was the creating of situational awareness for decision makers in their respective operation centres. The business systems or technology which supports the individual capabilities within the respective industries operation centres was also observed to be an integral part of a functioning operation centre. The multi-agent system (MAS) theory discussed earlier in this paper was examined by an airline industry participant who highlighted the system integration within the Virgin Australia OCC:

> *Yep running multiple systems. They're not siloed as they are all integrated, you know all times (flights) are moving throughout the systems. So, if we delay an aircraft here then the flight planning team know about it (P11).*

Considering the variety of roles observed in the AOC, from engineering to crew rostering the need for specific individualised systems was evident. All participants

interviewed in both airlines and policing consistently spoke of the importance of departmental systems sharing data to ensure an integrated operating environment. A notable difference was witnessed within the policing operating environment where several systems are siloed and not integrated, an example observed was their rostering system and the job or resource allocation system. The lack of integration between those systems in a MAS environment hinders the QPS using the power of AI. This point was reinforced by a shared frustration of several police participants during interviews around the lack of perceived system integration:

> *We really need a whole of service client management system. There is no single system which allows you to understand the customer and how we have interacted with them (P1).*

The airline industry has embraced the need for systems integration especially in the operation centre environment. MAS technology was an area of the business which had the ability to create a competitive advantage within the marketplace through operational efficiencies. The policing participants openly acknowledged the potential benefits of moving towards greater systems integration and the use of MAS technology. What was clearly understood was the financial impact of not integrating versus the cost of systems implementation needed to be balanced.

4.3.1   IoT DATA INTEGRATION

When discussing internet of things (IoT) and the use of this technology it is important to understand the data set originates from sensors in the organisational environment. During the questioning around technology within the airline industry operation centre the volume of data available was extremely evident. The modern aircraft produced a large volume of data which could be aggregated and monitored as trend data to assist centres in the preventative disruption management space discussed earlier. One participant stated:

> *Aircraft is data rich and actually has that much data the airline doesn't know what to do with it. We are becoming smarter (P15).*

This ability to make use of data was observed as advancements in efficiencies within the centre and was reinforced during interviews with airline participants. Participants gave the example of the use of trend data from the maintenance system which logged a trend of failures in a specific part triggering an automated alarm for

the next time the aircraft was scheduled for maintenance. The system would allow for the replacement of the part to avoid a catastrophic failure resulting in a flight cancellation and schedule disruption. The airline participants perceived the use IoT technology from the operation centre to give the customer more opportunity to interact during a disruption event. The senior airline operation staff perceived IoT to be advantageous with the ability to push information to customers around the specific disruption and allowed the staff to advocate a preferred solution. This particular enhancement in AOC operations was seen by airline participants as an area of exploration for their industry into the future.

The mobile technology observed throughout the QPS was described as world leading by several police participants through the introduction of the Qlite device. Qlite is a tablet based handheld unit deployed with frontline officers to enable remote and mobile working. Police participants described the operation centre providing operational decision making and resource allocation in a preventative and reactive mode. The ability for the Qlite and officers to feedback data such as video to the centre (situational awareness) was an area discussed by one police participant:

The potential for real-time vision to be streamed into the DTACC (P6).

One senior police participant spoke of the need to harness the vast volume of IoT data and create analytics to add to the effective, efficient and economical running of the operation centre through more informed decisions. Multiple airline participants spoke of the importance for airlines to use this sensory data feeds directly into their preventative disruption management framework. For policing participants the use of this data could lead to greater latent capacity in their demand model and could assist in shifting resources to the prevention and disruption space which was considered the strategic direction of their organisation. The integration of IoT data into MAS technology architecture provides an organisation with additional sensors across their environment, which improve decision making.

4.3.2   TECHNOLOGICAL AUTOMATION IN OPERATION

There have been academic studies such as Castro (2013), which discussed the ability of replacing a number of human roles within the AOC by automated software. This concept was discussed with participants during their interviews. The illustration in figure 6 shows possibilities of role automation within the centre which were not

overtly observed within the AOC. Under the premise of creating effective, efficient and economical operation centres participants within the airline industry were asked about the levels of automation experienced within the operation centre. One participant who had worked in a low-cost airline spoke of a "mandraulic" environment whereby automation had not been implemented. Another airline participant spoke of the use of automation to enhance roles as opposed to replace. The enhancement discussed was particularly focused on tasks which were repetitive and administrative in nature. During the interview one airline participant said that the crew manager within the observed centre was still staffed and not fully automated. However, the systems they were using had employed artificial intelligence (AI) to assist with the number of staff required to perform the role.
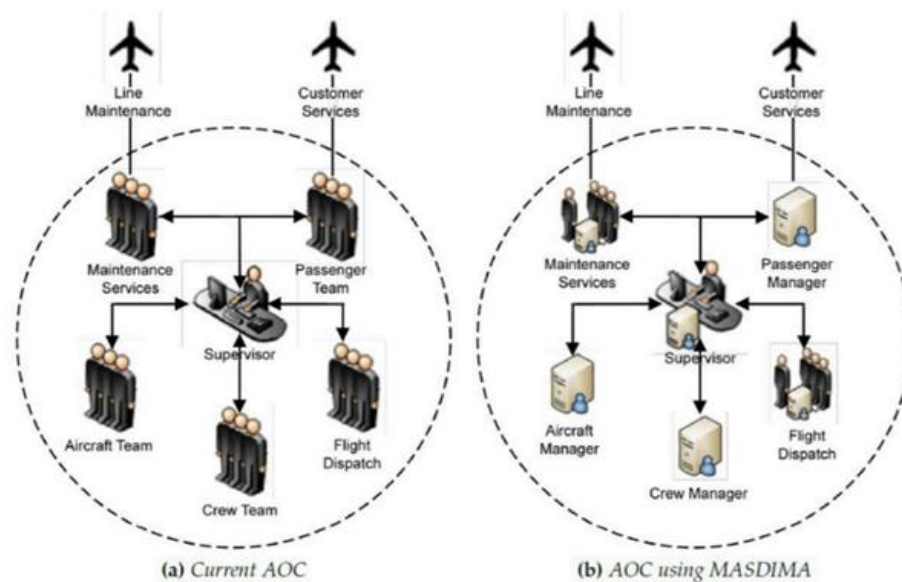
Figure 18 - Traditional AOCC v AOCC using MASDIMA (Castro, 2013)

This response was similar to that experienced during the interviews with policing participants when asked about technological automation. The major area of automation was around the introduction of online reporting and the impact of that on call takers. One police participant made the following comment:

> *(People) are more important than the technology that goes in. If the relationships, the communication the interactions are not right, it doesn't matter how good your technology is. The technology is an enabler (P2).*

The human element of the operation centre was extremely obvious during the observation and was reinforced during the interviews highlighting that automation was used to free up capacity for staff to work in the preventative space whether that be disruptions for airlines or proactive policing for the QPS.

4.3.3   EMERGING AREAS OF TECHNOLOGICAL IMPROVEMENT

Participants from both the airline and policing were asked if there was once piece of technology, they would like to see introduced to the operations centre what would that be and why? A common theme across both industries was the importance of relevance from the perspective of just because the technology is emerging, is it needed, or would it create additional unwanted layers within the centre. Having systems for the sake of systems was described excessive as in the case of AV. It created an element of "white noise" within the operation centre which is best described as anything which districts staff from their primary task. P11 (airline) and P4, P6 (policing) from both industries specifically commented on the effect "white noise" can have on the centre's operational effectiveness. Another similarity between industries during interviews was that the theme of technology was considered an "enabler". The importance of decision makers within the respective operation centres being able to access meaningful data at their time or need or choosing was stressed by the participants.

Exception based alerts within the operation centre, was considered an area of potential enhancement during the interviews showing relevance across both industries. The ability of an integrated MAS technology architecture to provide decision makers with data about possible disruptions or trends whereby an overt intervention can be made by the operation centre to work in the preventative space. The participants felt that this exception-based alter system enabled controllers or decision makers to minimise their response time which had a direct effect on the centres operational effectiveness. This type of system was described by one airline participant as a "lessons learned" or knowledge hub.

An airline participant perceived that to enable an effective preventative system to function, further exploration of Artificial Intelligence (AI) such as solider robots which work in the background of organisational system constantly looking and interpreting data could be explored. The airline participants perceived the introduction of a dashboard interface for controllers or decision makers, whereby the described AI

could detect and alert when a set of circumstances which mimicked or replicated a previous disruption event as the next frontier. The interface described by the airline participants would list the actions taken and outcome from the previous decision in combination with live data from the operation centre to enhance possible outcomes. This could then be used by the controller or decision maker to pre-emptively implement strategies earlier which could avoid or minimise the effects of the disruption. The economic benefits of early intervention or minimised response time were outlined by one airline participant saying:

> *There is a cost of not making a decision early and not waiting til it brakes (P11).*

Overwhelmingly, police participants described the need for greater system integration within the operation centre IT environment. When discussing this question the participants felt that the complex system architecture currently used within the QPS was prohibitive to efficiencies. They perceived financial considerations of a major new IT system as cost prohibitive. The participants felt that the introduction of dashboard technology or interfaces which read data from the established organisational system needed to be explored. In their view, these dashboards or interfaces would present the information in a logical and efficient manner within operation centres to aid in the situational awareness and decision-making process.

4.4 CONCLUSION

When answering the original research question, "What is the optimal design and structure of a Police Operation Centre and supporting multi-agent systems (MAS) for resource allocation in an agile, economical and structured manner in a disruption-based operating environment for the QPS?" The following comment by an airline participant highlights the complexity of this proposition:

> *No one disruption is the same which is why you can't overlay a templated solution (P12)*

This stance or understanding was the driver for the airline industry to have robust operation centres with the ability to manipulate organisational leavers in real-time to affect operational outcomes. Although policing did not formally define disruption management within their business model the concept of unpredictability described above is consistent with the challenges facing policing and the structure of their

operation or tasking coordination centres as they referred to them. Whether it is a design enhancement, organisational structural improvement or supporting MAS technology enhancement the overwhelming evidence from the participant interviews in both industries is that it must be complementary and not prohibitive. The results indicated that an informed and aware operation centre is at the heart of creating an agile and economical environment for decision makers to execute the strategic intent of the respective organisations.

Chapter 5: Discussion

These data sets highlight several discussion points and areas for consideration when addressing the original research question: "What is the optimal design and structure of a Police Operation Centre and supporting multi-agent systems (MAS) for resource allocation in a disruption-based operating environment for the QPS?" Contrasting a law enforcement operation centre to a commercial industry such as aviation and not military or emergency services offered unique perspectives at a micro or process level and valuable learnings from a business optimisation perspective. In this chapter, the findings from the three data sets collected, Physical Design, Structure and Operations and Supporting MAS technology are discussed with a set of recommendation including a framework for a police operation centre. Finally, further areas of research are provided in the conclusion.

5.1 OPERATION CENTRE DESIGN

Evident from the findings was the commonality in physical design elements and in the motives for their inclusion in both aviation and policing. The theme of design elements as an "enabler of situational awareness" was overarching. It was cohesively aligned with the creation of situational awareness as the driver of operation centre design for staff who work within the centre. More importantly, the design element created situational awareness for those in decision-making roles who directly influence the organisations ability to meet its operational and strategic objectives. The research highlighted six key physical design elements common across both industries, which were considered when designing a Police Operation Centre;

1. Audio Visual Equipment;

2. Ergonomic Furnishings;

3. Workgroup Clustering;

4. Business Systems (ICT) accessibility;

5. Command and Control; and

6. Breakout and Collaboration area

5.1.1   DESIGN ELEMENT CONSIDERATIONS

The project teams responsible for the respective industries introduced design elements to minimise the time it takes for the individual to attain crucial operational information by placing them in easy to acquire areas. For aviation, lost time and extended delays in the daily schedule were viewed as loss of customer satisfaction and ultimately loss of revenue. Within policing additional time delays in operational decision making were viewed as a loss in community confidence along with potentially more fatal consequence through a delayed response. These perceptions show that understanding the operating environment of the centre is a major consideration when constructing a Police operation centre. The SPOC and Gold Coast DTACC were originally designed for an individual event or unplanned disasters. The original use, along with the age of the centre impacted their designs in areas such as technology, ergonomic furnishings, clustered workstation and technology directly affecting decisions around investment into those design areas. The detrimental effects of poor furnishings has been researched outlining the enormous benefits of state of the art ergonomic furnishings (Jancey et al., 2016); John et al. (2015). The airline AOC, along with the policing PCC, are centres which operate on a 24-hour year-round capacity. The data collected during this research indicates consideration must be given to the existing design elements in the centres, ergonomic furnishings, breakout spaces, audio-visual (AV) technology placements and business systems integration. The data showed each element performs a role in creating the optimal environment for operational decision making which is crucial for a high performing operation centre.

The findings revealed that a situationally aware working force within the centre is created by accessing the information from design elements such as audio-visual (AV) equipment and business systems. Although the design elements enable users' access to real-time information, individuals were still reliant on their personal ability to interpret and contextualise the information in relation to their specific role within the centre. This finding shows that the creation of situational awareness through design elements such as AV must be balanced so as not to overload and distract staff within the centre. This issue was evident during both observational and interview data collected whereby numerous AV monitors had non-work-related content displayed and this was consistent across both industries.

Continuing the theme of situational awareness within the centres was the ability to create a collaborative environment for decision makers. Participants saw the ability to collaborate as essential for the successful operation of the centre. Advances in collaboration and groupware software have enabled greater connectivity and communications through specific ICT platforms. These platforms allow users to communicate their work, in coordinating their actions to optimise group performance, while producing the results expected of a team or work unit (Moran, Favela, Enriquez, & Decouchant, 2004). The unpredictable nature of disruptions in airlines and policing demand a more physical space to achieve the collaborative outcomes. It is this reason breakout or meeting spaces were observed as a design element in both industries.

5.2   GREATER EFFIECENCY AND STRATEGIC INTENT

Conversations during observational tours of the operation centre and interviews with airline participants highlighted the need to be adaptive and innovative when constructing strategies to drive their operation centres. This approach is consistent with research for organisations operating in complex and challenging market environments which require flexible and innovative strategies in order to maintain their competitiveness (Gaspary, Moura, & Wegner, 2020). The comparative structural differences between aviation and police operations underscored aviation having greater departmental representation within their centres is an area of immediate improvement at minimal cost. Research also shows that organisational structure has the ability to boost or hinder a company's capacity to operate and innovate (Dekoulou & Trivellas, 2017). In the airline industry the research findings indicated that greater profitability was linked to customer satisfaction. For policing lowering the crime rate in conjunction with professionalism and integrity was seen as directly affecting community confidence. These results showed that regardless of industry, strategic intent of the organisation drives the daily operational process of an operation centre.

The airline's organisational goal of moving passengers from point to point in the most efficient and economical means that relies on airline scheduling process was perceived as a key element in the success of the AOC. For this to occur the AOC structurally required significant access via imbedded positions in areas such as crew rostering and engineering assignments to ensure capability existed to drive the schedule and mange disruption. The findings indicated that business driver for an airline operation centre was the ability to seamlessly perform disruption management

on "Day of Operation". This was critically different to the business driver of the police operation centres within the QPS which was perceived to be reactive demand management.

5.2.1 PREVENTING DEMAND THROUGH OPERATIONAL EFFICIENCIES

The QPS has set the strategic direction or business model to be a "prevention" based policing organisation. The findings of this research indicated that it was perceived important that QPS operation centre which is presently structured on demand resourcing needed to be structured towards prevention-based policing. Furthermore, the airline industry operation centre working and operating at the point of disruption was much more efficient as compared to the QPS traditional operation centre working on a reactionary transaction-based demand model which, indicated a high level of inefficiency.

The inefficiencies discovered in POCs and DTACC's through this research included: a resource allocation model which was heavily siloed, decentralised control of the resources, a lack of demand-based rostering and a lack of agility due to dated command and control issues. Therefore, QPS needs to refocus and reframe its operation centres to work in the disruption management space. To fully understand the conceptual change around what constitutes a disruption within the policing service delivery model, this research defined the communities' unplanned call for service as a disruption in the context of policing. The airline definition "disturbance or problem which interrupt an event, activity or problem" (Clausen et al., 2010) whereby the event or activity is the airlines published and pre-planned schedule. The same definition was applied to the QPS in a preventative policing model whereby the schedule, event or activity was considered as a prevention based policing task or deployment.

The research findings uncovered conflicting business drivers behind PCC (calls for service in demand) and DTACC (demand as a whole) is an area of potential improvement within the structure of police operation centres. The findings revealed that the PCC is a reactionary operation centre which completes transactions between community and policing resource. This centre is not responsible for any proactive resource allocation based on demand indicators other than calls from the community. Observations of the PCC showed a call for service is received. Subsequently a "job" is created for a geographic location and without greater understanding of the

overarching demand pressure points for that area a resource is tasked and allocated from that area. The integrated DTACC model has the additional policing capabilities such as intelligence to gain a greater understanding of that call for service. In contrast, DTACC is responsible for not only receiving those "jobs" and attempting to triage by way of non-attendance, negotiated response or diversion of an additional district resource, it is also responsible for the preventative policing resourcing designated to their area based on numerous other demand inputs.

The conflict observed between the PCC and DTACC where PCC has a reactive demand driver and the DTACC combines both proactive reactive demand drivers is counterintuitive to the overall success of the QPS. With the Commissioner's (CEO) overarching strategic objective of creating "The safest state" the organisations service delivery model must be streamlined to take advantage of the benefits of a prevention based policing model. The structure of the integrated DTACC model proposed in section (Figure 22) can assist the ability for police to adhere to their business model of allocating resources to prevention-based policing.

The strategic concept of DTACC was perceived as creating latent capacity with the policing demand model to divert reactionary resources into proactive prevention-based policing which was evident in the findings. This strategic concept is incorporated in the new framework of QPS that can greatly benefit from the integrated disruption management model recommended in this research (Figure 22).

5.2.2 AN INTEGRATED APPROACH TO SERVICE DELIVERY

The results from the observations of the Virgin AOC and subsequent interviews with airline participants showed that AOC was considered a microcosm of the organisation with representation from all areas critical to the operation of the airline including, crew rostering, engineering, flight dispatchers and passenger services. This was a major point of difference from both police operations centres (PCC & DTACC) which were not representative of the capabilities involved in policing districts such as investigators, intelligence analysts, crime prevention officers, planning officers and crime managers. It highlighted the importance of the AOC in executing operational decision leading to what is known in the industry as Integrated Operations Centre (IOC). The theory of transitioning to an IOC is the movement from department-focused decision-making to company-focused decision making (Jimenez Serrano & Kazda, 2017) a finding consistent with the perceptions of airline participants.

The integrated IOC witnessed in the research included the traditional departments with additional areas such as catering, ground handling, social media, data analysis and importantly revenue management all included within the AOC structure. It represented a more holistic representation of an IOC which had the ability and authority to implement operational decisions, expediting the implementation of solutions (Jimenez Serrano & Kazda, 2017). DTACC and PCC in contrast did not possess the same level of organisational capability embedded in their centres. This siloed approach inhibited the centres ability to make efficient operational decisions on resource allocation. An integrated operation centre approach similar to the airline industry would add to the overall effectiveness of the police operation centres when dealing with demand, which is outlined in the recommendations.

The findings showed that the presentation and access to information through design elements such as AV and business systems created situational awareness. The representation of departments directly within the decision-making environment (AOC) also created situational awareness.
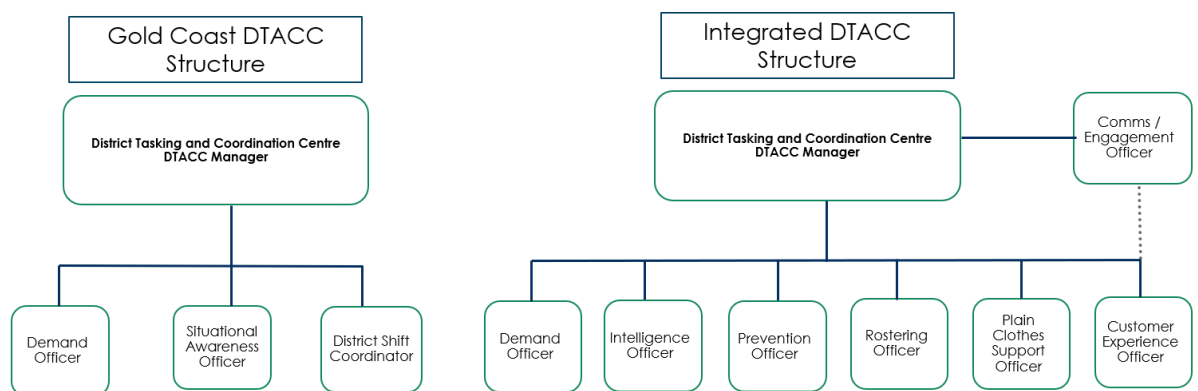

Figure 19 Traditional DTACC v Integrated DTACC structure

Figure 19 is a comparison of the current Gold Coast DTACC structure against a recommended integrated DTACC using existing QPS capabilities which currently operate outside the operation centre environment. The POC is established for a specific operation or event. It has a singular intent or focus as opposed to DTACC that works in a business as usual (BAU) mode. The research has focused on the DTACC concept, as it closely resembles the QPS transitioning its daily business of service delivery. A PCC will also continue to operate as a conduit or call centre to community to triage

the reactionary demand from the community similar to a call centre within the airline industry.

The visual expansion of capabilities which include the addition of Intel, investigative, prevention, rostering and communication support within the structure can create a decision-making environment which is missing in the current policing capabilities to address demand. These additional elements add a more holistic view of policing capabilities to deliver services within a policing district, which will reflect the DTACC as a microcosm of the organisation. These additional capabilities in the centre can focus on "day of operation" and allow QPS to move from their current siloed approach (departmental or capability-based decision-making) to the district (organisation) based decision-making and can lead to more efficient, effective and economical service delivery.

Another area of consideration was the planning element which dictates the schedule in airline operation centres and the preventative policing tasking within the police operation centre. There is considerable research about the crucial part scheduling (planning) plays in the success of overall service delivery within the airline industry (Yimga and Gorjidooz (2019); Zhou, Liang, Chou, and Chaovalitwongse (2020) Eltoukhy Abdelrahman (2017); Nenem, Graham, and Dennis (2020)). The findings of this research indicated the interwoven nature of the operation centre and the scheduling area of the business were considered vital in ensuring day of operations was delivered in an efficient, effective and economical manner.

Additionally, the need to constantly provide feedback on scheduling performance was perceived as a form of preventative disruption management (lessons learned from the decisions made within the AOC). A flight schedule which goes late on a given route and destination, and could be modified upon feedback from the AOC using a continual improvement methodology such as the Jeppesen System (figure 21) was incorporated into AOC business systems. This model was consistent with the data collected from airline participants which ensured the integrity of the schedule and provided greater customer satisfaction into the future.
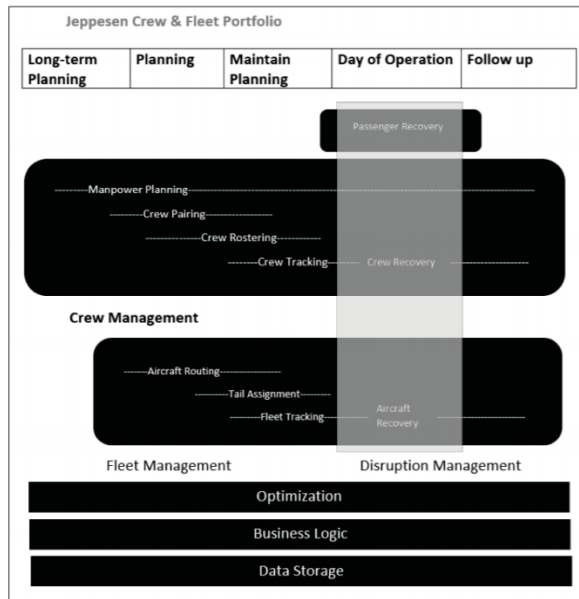
Figure 20 Jeppesen System planning process Manchala (2020)

5.2.3 PLANNING FOR OPERATIONAL SUCCESS

This integration of scheduling or planning in the policing context with day of operations was not evident during this research. There is not the same level of academic research available on the integration of pre-planning of daily operations and its execution into police operation centres as compared to the airline industry. The proposed integrated model within the QPS as the outcome of this research integrates planning (scheduling) with operations centres that are geared for "day of operation" and for managing the unpredictable nature of disruptions which occur.
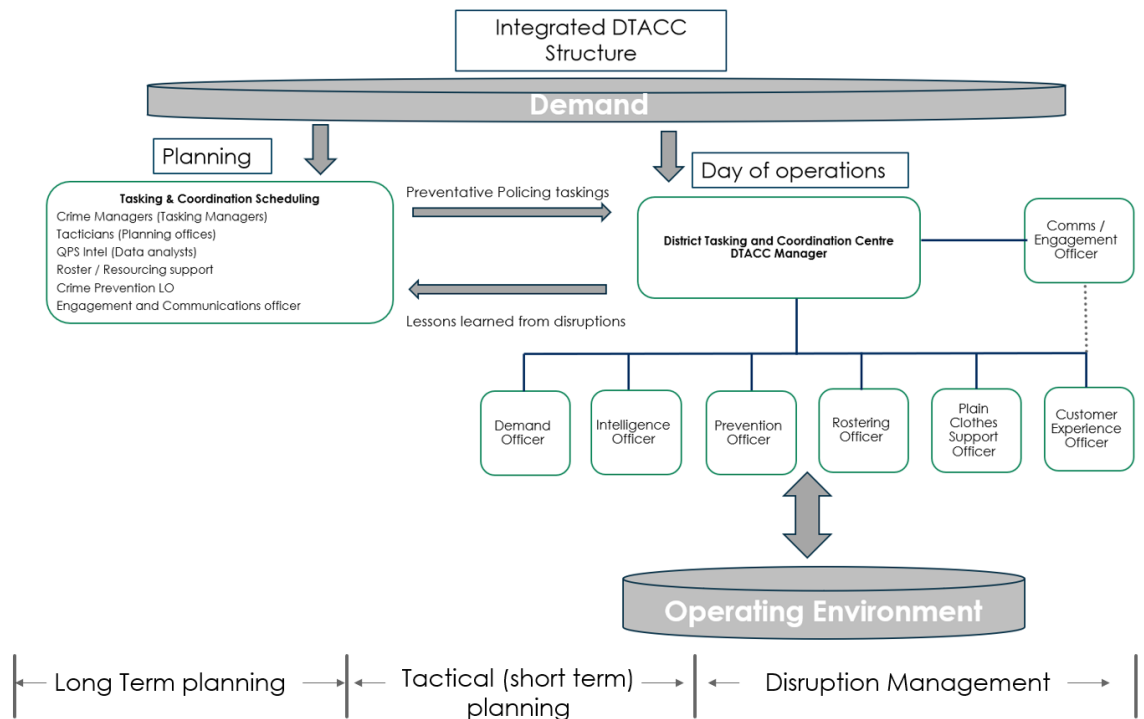
Figure 21 Integrated DTACC Operating Model

The integration of the planning element into the operation centre environment is adopted as a result of its significance which was evident from the comparison of the airline AOC with the current policing operation centre environment. The model (Figure 22) shows the current QPS planning capabilities such as Tacticians, Crime Managers, Roster Clerks, Intelligence officers and Crime prevention operating in an integrated system, which includes their current charter of the longer-term planning. This model shows a transition from current procedures. It adopts integrated tactical planning elements to produce a set of daily operational tasking based on real-time demand drivers. Some of the real-time demand drivers included in the model are the previous 24hr crime analysis, un-planned events (protests) and request for assistance both internally and externally. Importantly, the two-way communication line between planning and operation allows for agile and dynamic modifications to planning schedules based on disruptions and unplanned events.

The inclusion of an integrated planning element attached to the DTACC is the major difference between the model outlined in figure 20 and that which is seen in figure 22. The evolution of this integrated model with planning from the current DTACC operating environment is derived from the findings resulting from the comparison of DTACC with the AOC. The current operating model is reactionary to

demand and does not possess the full array of policing capabilities to better address service delivery in real-time. The advent of social media and greater connectivity in society must drive policing operation centres to have the ability to react in real-time to incidents or trends, which can be better achieved through an integrated DTACC model.

These systemic inclusions into a DTACC would turn it into a genuine disruption management system whereby the centre would have a schedule (tasking created by planning area) and be responsible for the execution of that schedule while managing unplanned disruptions. This new model diverges from the current DTACC model in its integration of the planning capabilities along with the addition of greater policing capabilities that will enable the centre to manage disruptions more holistically through the inclusion of more policing capabilities. The integrated DTACC model operates using the disruption management philosophy of any disturbance or problem which interrupts the pre-planned schedule (events or tasking created by the planning cell), which in policing terms is a "job" (call for service) or unplanned / planned incident (pop-up protest or major weather event) must be treated as a "disruption". The DTACC can use the coordinated capabilities such as intelligence and investigation, which have been expanded in the integrated DTACC structure to manage the disruption.

This study indicated that currently QPS operational centres are transactional in nature and concentrate purely on responding to demand in a siloed approach. In this model, the structure and function of the integrated DTACC is designed and operated through the coordinated execution of a targeted plan that invests policing resources to prevention-based tasking. To achieve this in an agile, efficient and economical manner the new model operation centre provides access through liaison officers (LO) to the full array of policing capabilities to resolve the disruption and return to the scheduled prevention tasking. This fundamental change in philosophy around calls for service (jobs) considered as disruptions in the model will allow operation centres to be geared towards the QPS main strategic goal and business driver of prevention-based policing.

5.3 SYSTEM INTEGRATION AND AUTOMATION

The importance of access to the right information at the right time was driven by the need to make the most informed decision possible to ensure optimal service delivery within the operation centre. From the research, the major difference observed between the two industries with respect to supporting Information Communication
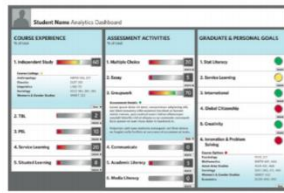
Technology (ICT) was the level of system integration. System integration and automation in the operation centre within the airline industry was geared towards automated disruption management systems. The introduction of these systems has led to only minor redundancy of human roles within the airline operation centres and created greater capacity for staff to be redirected into proactive roles within the centre. This result is consistent with the continuing research in the airline industry that is looking at AI and machine learning of operators behaviours within operation centres with a view to enhance disruption management systems (Manchala (2020). The findings of this study show that system integration and automation was of prime importance in the airline industry. This result has a strong bearing on policing operation centres observed which could re-divert potential latent capacity (police officer hours created) to frontline preventative policing tasks.

5.3.1 DASHBOARD TECHNOLOGY

The results show that QPS conceded the Information Communication Technology (ICT) system as problematic due to the large number of legacy systems. Findings of this research show that the emerging technology which could rapidly assist with ICT system integration was the dashboard technology. The emerging nature of this dashboard technology within the airline or policing operation centres can directly benefit the operational effectiveness through the creation of greater situational awareness for decision makers. The primary functions of these dashboards include Decision Support (Strategic, Tactical, and Operational) and Communication and Learning (Social). Both airline and policing operation centres can benefit from a combination of different dashboards listed in figure 23 (Sarikaya, Correll, Bartram, Tory, and Fisher (2019).

(a) Strategic Dashboard (DB001)　　　　　(b) Tactical Dashboard (DB106)

(c) Operational Dashboard (DB102)　　　　(d) Social Dashboard (DB028)

Figure 22 Visual example of Dashboard technology Sarikaya et al. (2019)

The ability for dashboards to create greater situational awareness for all users within the centre corroborates with the need identified for the centres to work towards a preventative framework. The QPS has recently created a set of dashboards which could be used within the recommended integrated model. The planning cell could use a strategic level dashboard illustrated in figure 24 to understand pressure points for resource allocation.
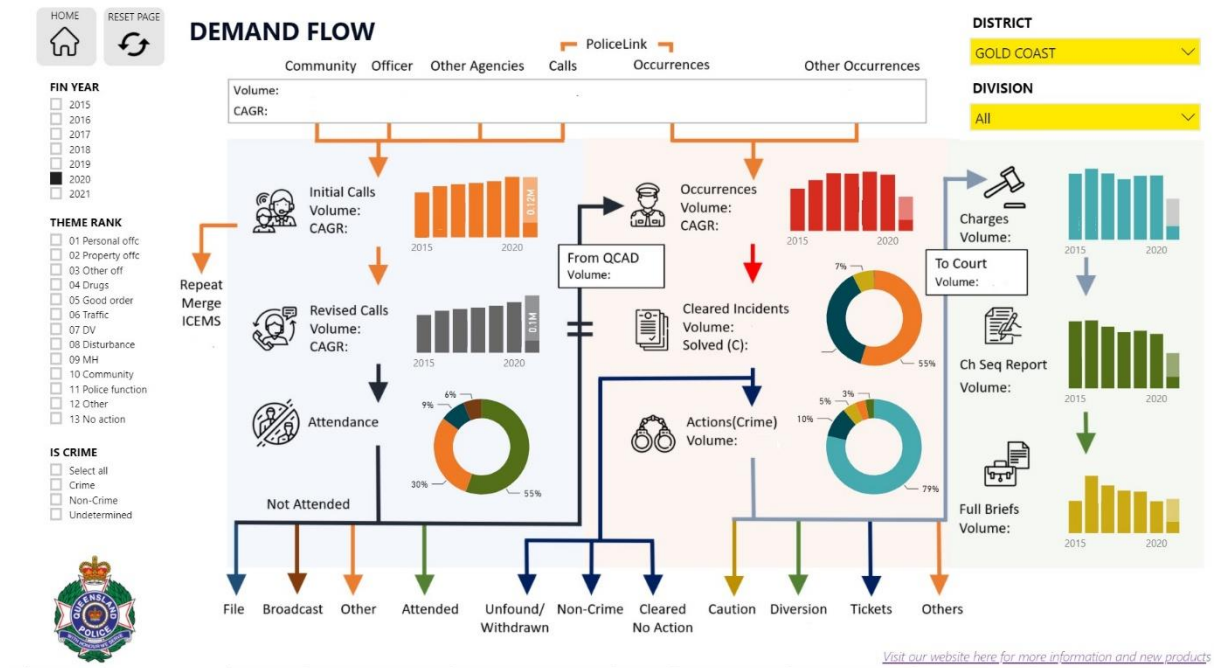

Figure 23 Example of Strategic level dashboard for DTACC

The dashboard displayed in figure 24 is a representation of a newly created dashboard which can be used in combination with tactical dashboards and operational

dashboards in the DTACC operation centre to add to decision making. Dashboard technology was found to be in its infancy with respect to its implementation but highlighted as an area of operational efficiency. There is need for further research on introducing a Client Relationship Management (CRM) system in the QPS to gain a greater understanding of touch points to community member throughout the policing environment. This CRM would produce data, which could be displayed on the dashboard technology discussed above.

5.3.2 RECOVERY FROM THE DISRUPTION THROUGH SENSORY DATA

The results show that the centres of both industries possess a large volume of IoT data in the handheld mobile devices and sensors within their respective operating environments. The findings uncovered an interesting use of IoT data from mobile devices by airline customers within the disruption management framework where push notifications assisted AOC's with customers preferred recovery option creating greater customer satisfaction and a more informed recovery plan

The results of this research show that the concept of power shift to the customer was the preferred recovery option from the disruption and was a major evolution in the airlines service delivery model. Research into automated disruption management systems also demonstrates the ability to assist the AOCs in recovering the schedule as quickly as possible (Baltazar et al. 2018, Bouarfa et al. 2018; Yimga & Gorjidooz, 2019). What was missing in the decision-making models referenced in the literature was the inclusion of the customers' preference which was derived from the possible recovery options issued from the AOC and found in this research to be a crucial aspect of customer led disruption management.

Results show that airline industry is exploring the use of push technology (data or information transmitted from device to device) with customers during disruption (preferred recovery options for the customer) to receive feedback on their preferred outcome. The feedback received from the customer could assist with the recovery options available to the decision makers in the AOC. The option of enhanced customer involvement directly increases the consumers experience in a positive manner during a disruption to their planned experience.

The results show that the access to and use of the vast volume of data from customers within the airline industry and policing has considerable potential. A finding

during comparison of capabilities within the respective operation centres was the use of a social media officer in the day of ops environment. Research in the airline industry by Tian et al. (2019) looks at social media data to predict service quality of the organisation and subsequently use information with a view to create competitive advantage. The ability to gain a greater understanding of consumer needs versus the organisation's service delivery model in real-time is an exciting area of development. The alternate and current use of social media discovered during this research was its use as another situational awareness tool for decision makers in operation centres.

Literature on the concept of social media data analytics was a driver for the inclusion of the communication and engagement position within the recommended integrated DTACC model in figure 22. This inclusion has potential to not only provide analytics on service delivery but a rich source of intelligence of community activity and sentiment which can be used in real-time in prevention-based tasking.

Chapter 6: Conclusions

The aim of this research was to answer the question "What is the optimal design and structure of a Police Operation Centre and supporting multi-agent systems (MAS) for resource allocation in a disruption-based operating environment for QPS?" It compared the current QPS operation centres with the airline industry operation centres within the three major areas of design, structure and supporting MAS technology. There were some limitations which must be acknowledged.

6.1.1 DESIGN ELEMENT LIMITATIONS

Both industries acknowledged the considerable financial burden in the setup of an operation centre highlighting the need to implement flexible and adaptable spaces at the frontend. Within policing, the cost prohibitive nature of creating new centres uncovered the idea of repurposing legacy centres such as the Gold Coast Commonwealth Games Joint Emergency Services Centre into 24-hour year-round tasking and coordination centre (DTACC). Repurposing is financially more achievable for QPS in contrast to developing a new facility. This research recommended the key design elements prior to the repurposing of the legacy centre. Research (Gershkoff, 2016) in the aviation estimates disruptions costing the industry over 8% of their revenue or $60 billion worldwide. Initial increase in setup budget can be offset by the efficiencies which will be created by repurposing the POCs into high functioning DTACC's.

A second and important limitation was the human aspect of the all operation centre and understanding and accounting for it. Although each design element was implemented with the core understanding of aiding staff in the execution of their role, the design elements alone do not dictate an automatic increase in the efficient, effective and economical operation of the centre. The findings of the research reinforced the importance of the symbiotic relationship between design and people within a centre whereby the design elements "enable" or create greater opportunity for success. What was not researched was the capability of the individuals or skill set needed to aid in the successful function of the operation centre. This area of research would be of benefit to complement the physical design of a Police operation centre.

6.1.2 OPERATIONAL STRUCTURE LIMITATIONS

The ability to create new roles within the existing police structure is seen as a potential limitation. The creation of additional positions within the QPS requires a submission to government for an overall increase in organisation numbers. A possible solution to this issue could be the reclassification of existing positions to undertake the proposed roles given in the integrated framework (Figure 22) which are designed to create latent capacity within the service delivery model of the QPS.

An emerging area of interest highlighted in this research was of preventative disruption management. The inclusion of data analytics and intelligence officers within the police operation centre, suggested in the integrated model (Figure 22), is an area of further study to understand and evaluate the impact and effectiveness of such a model.

6.1.3 MAS TECHNOLOGY LIMITATIONS

It is acknowledged that significant financial investment has implications for the implementation of major ICT projects in an organisation. The significant financial expenditure is the reason the research suggests that the policing and the airline industry should explore the more cost effective dashboard technology as an interface between legacy systems to provide real-time information to decision makers within their respective operation centres. Finally, and importantly consideration must but given to the human-centric decision-making environments which airline and policing operation centres are. All technology must focus on the ability to aid the human decision maker and not hinder or override this process.

6.2   RECOMMENDATIONS

Through comparative analysis of the competitive airline industries use of operation centres, the research has uncovered a set of recommendations for the QPS which include areas of further research. A summary of the major recommendations are as follows;

1. The physical design of an operation centre should take into consideration the six design elements (AV Equipment, Ergonomic Furnishings, Workgroup Clustering, Business system accessibility, Command and Control placement and Breakout Collaboration space) ensuring the overarching theme is to create a situational aware environment for users.

2. The organisational structure of the operation centre should be a microcosm of the organisation to allow for holistic decision-making through exposure to all organisational capabilities (Figure19).

3. Planning and task scheduling should be incorporated into the organisational structure of the operation centre (Figure 21)

4. Any event, incident, disturbance or resource demand which diverts the organisation from their business model of prevention-based policing should be treated as a disruption.

5. Police Operation Centres should be focused and structured to operate at the point of disruption.

6. Technology should be a decision-making enabler within the operation centre and the use of interface or dashboard technology is an economical solution for integrating legacy systems.

7. Consideration should be given to the approach of "less is more" initially when installing AV equipment. After a period of operation has been completed a review can then be conducted to assess the AV capability requirements.

8. The ability for the QPS to use a customer focused disruption management system be further researched with this methodology assisting in enhancing community confidence and demand management for the QPS.

9. Further consideration given to research into the aggregation of IoT data from both police officers in the field and community to create greater situational awareness within the operation centres.

10. Prioritising research into the psychological profile and skill set of the staff employed within the operation centre to assist with optimal decision-making similar to that which has been conducted in the airline industry.

The research has highlighted potential learnings and solutions for altering current operating practices which can create greater capacity within QPS demand management model. The function of a police operation centre must be re-engineered

to work in the disruption management space with the focus to restore the organisation to its business of prevention in real-time on day of operation, being every day.

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