# Using Simulations to Investigate
# decision-making in Airline Operations

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## Abstract

This paper examines a range of methods to collect data for the investigation of decision-making in airline Operations Control Centres (OCCs). A study was conducted of 52 controllers in five OCCs of both domestic and international airlines in the Asia-Pacific region. A range of methods was used including: surveys, interviews, observations, simulations, and think-aloud protocol. The paper compares and evaluates the suitability of these techniques for gathering data and provides recommendations on the application of simulations.

In airline operations, decisions yielding optimal results may be the difference between company survival and bankruptcy. Stakes are high, timing is crucial, and the consequences of poor decisions could be critical. An airline's Operations Control Centre (OCC) operates in a complex, dynamic, and intense environment and serves as the airline's nerve centre. It is responsible for the control of aircraft to ensure economical, operational (Williams, 1967) and commercial efficiency. Although decision-making has been examined in the aviation industry, for example in Air Traffic Control (Corker, Pisanich and Bunzo, 1997), Pilot Crewing (Fischer and Orasanu, 1997), Schedule Disruption Management (Thengvall, Bard and Yu, 2000), and in Emergency Services (Flin, Stewart, and Slaven, 1996), empirical research on OCC decision-making is very limited. Understanding decision-making in OCCs requires the investigator to gain an appreciation of the demands presented by disruptions to operational schedules and the necessity to recover the situations, often under severe time constraints. A study of decision-making would require an investigator to be present 24 hours a day for many days, or even weeks in the international environment, to gain a full understanding of the work demands. Alternatively, an investigation would rely on the abilities of personnel to recall events and responses well after the disruption, exposing the investigation to inaccuracies. Consequently, studying decision-making in OCCs presents many challenges in terms of the study design. This paper examines and evaluates a range of methods for gathering data in airline operations.

*Review of Data Collection Methods*

Investigators face a difficult task in attempting to capture data accurately in a way that is methodologically sound so that generalisations can be made (Bordia and Rosnow, 1998). According to Zikmund (2000), the main primary data collection methods include surveys (including questionnaires and interviews), observation, and experiments. This paper examines the appropriateness of each of these methods for investigating decision-making in OCCs.

*Survey*

A common method of collecting data is the use of a survey (Sekaran, 1992) based on pre-determined questions. A survey can be widely distributed at reasonable cost and is an excellent basis for describing people's attitudes and behaviours (Shaughnessy and

2

Zechmeister, 1994). However gathering information which relies on the recall of past events and behaviour may be of dubious validity and reliability (Foddy, 1994). Further, the current study was predicated on self-reflection by controllers and accurate analysis of events often well after the events occurred. There could be a lack of accuracy in recalling events, and confusion of details particularly where simultaneous disruptions occurred. A major weakness of surveys is that they are ill-suited for in-depth examination of the thoughts and feelings of individual respondents (Shaughnessy and Zechmeister, 1994). In addition, surveys do not provide the means to explore uncertainty or to clarify responses (Sekaran, 1992).

*Interviews*

The use of interviews as a method of data collection provides a means for establishing rapport with respondents, and exploring and understanding complex issues (Sekaran, 1992). Interviews allow researchers to adapt the questions as necessary, clarify doubts, and ensure responses are understood properly (Sekaran, 1992). Interviews also assist in understanding how individuals perceive and give meaning to certain phenomena or events (Berg, 1995). For example Yorkston, Klasner and Swanson (2001) used in-depth interviews to gain insider perspectives of communication by individuals (N=7) with multiple sclerosis. Yorkston et al (2001) found that this process of interviewing respondents yielded rich information. Interviews, therefore, may be useful for studying decision-making by controllers in OCCs as they allow a great deal of interaction between researcher and respondent. However there are limitations with interviews. Yin (1994) warns that interviews are verbal reports only, and are thus subject to bias, poor recall, and poor or inaccurate articulation. To address this issue in the current study interviews could be conducted during disruptions to elicit accurate and timely information but such action could interfere with the work process and controllers could be unwilling to cooperate. Even if interviews are conducted at a later time, the problems of accurate recall of details would still be a problem.

*Observation*

Observation in the work setting is useful to further understanding of the context or phenomenon (Yin, 1994) and establishes the validity of the findings. Observation enables

3

researchers to distinguish between real and verbal behaviour (Bogdewic, 1999), and gather data at the time behaviour occurs (Atherton and Klemmack, 1982). In OCCs, observing disruptions as they occur permits the researcher to monitor the progress of the disruption and any actions being taken by controllers. Boote and Matthews (1999) found observation to be the most appropriate research methodology to observe customer traffic flows along main streets. Observational research requires no effort on the part of the respondent, and is a very effective way to enrich and supplement data gathered by other means (Boote and Matthews, 1999). However, attitudes and opinions cannot be recorded using observation (Zikmund, 2000). Systematic observation may be costly and very time consuming, and the lack of predictability of events may also create problems for researchers. For example in OCCs, observation may be conducted over several hours or even days without incident. Further, Zikmund (2000) noted several deficiencies with the collection of data using this technique such as observer subjectivity, memory limitations, inability to record all details, and inability to interpret observations such as body language, appropriately. Consequently in the current study observation alone would not capture the required information.

*Think-aloud protocol*

Think-aloud protocol is a technique for verbalisation, where participants are instructed to think aloud as they work on a problem (Woods, 1993). This technique allows the researcher to access the underlying thought processes, reasoning, and behaviours involved in analysing and solving the problem (Ericsson and Simon, 1993). Respondents in numerous studies have been asked to think aloud and talk through their thoughts. For example de Groot (1978) presented chess players (N=22) with various combinations of chess pieces on a board, and asked the players to think aloud while selecting the best move. De Groot (1978) noted that most subjects found thinking aloud, slowed thinking down, and made the subject think more explicitly. Think-aloud protocol may be appropriate to gain an insight of controllers' thought processes in decision-making. However, controllers do not have time during actual disruptions to elucidate their reasons for taking particular actions.

*Methods for recording responses*

4

Various methods and devices can be used to record responses, such as tape recordings of dialogue, written responses, computer inputs, observations, or by some combination of these approaches. However the method used may influence the results. For example having participants respond in writing may be tedious and limiting. Adelman, Tolcott and Bresnick (1993) examined the effect of gathering data on quality judgement with trained Army Air Defence personnel (N=63), and concluded that the artificialities of the paper and pencil task may have influenced the results.

*Case study approach*

The case study method is well suited to exploratory or descriptive studies (Yin, 1994). The multiple case study approach has the benefits of deepening the understanding of the subject (Miles and Huberman, 1994), enabling more information to be gathered and increasing the generalisability of the research (Bryman, 1989). Using a case study method would allow the investigation of decision-making in several OCCs. The case study method may be limited due to the necessity to gain access to (Burgess, 1984), and cooperation of (Zikmund 2000) a number of suitable companies, and to the time taken to complete the study (Yin, 1984).

*Experiments and simulations*

In an experiment, variables may be manipulated in controlled conditions to test a hypothesis (Zikmund, 2000). Often comparisons are made between results from a control group and an experimental group (Burgess, 1993). A simulation is akin to an experiment; specially created in an artificial setting, but not very different from reality (Sekaran, 1992). One of the most important aspects of simulation is its ability to mimic reality so that researchers can study phenomena too difficult or impossible to study in real life (Bordt, 1999). The use of simulation is also recognised as one of the most widely used techniques in operational research and management science (Law and Kelton, 1991). The ability to control the simulation allows the replication of situations, and the manipulation of certain conditions (Blank, 1984). These aspects were important considerations in the current study.

5

Simulations have wide applications in research and practice. Simulation has been used as a decision support tool for management. For example, in a study of operational changes in an army hospital, simulation was used to assess alternative patient capacity and staffing capabilities (Ledlow and Bradshaw, 1999). Simulation may also be used in a teaching or training context. According to Salas and Burke (2002), simulation may be effective provided that it is instructional, meets task, performance, and feedback needs, and helps to guide learning. Bordt (1999) found simulation to be a very effective teaching aid to students studying criminology, because the students became fully engaged in the process, could readily test real life situations, and demonstrated critical evaluation skills. Fisher, Laurie, Glaser, Connerney, Pollatsek, Duffy, and Brock (2002) used simulation to test a PC-based driving skills program with young drivers (N=45). Simulation provided a safe environment to study the effects of experience and risk awareness on drivers.

In aviation, one of the most useful applications of simulation is the flight simulator which allows the representation of aircraft flight with safety, training, and financial efficiencies (Moroney and Moroney, 1999). Simulation is also used extensively in Air Traffic Control, particularly for selection and training (Ackerman and Kanfer, 1993). The conclusion from the use of simulation in these domains is that where appropriately designed and used, simulation can be a most effective tool for testing, teaching, and learning. The suitability of simulations as a data collection method relies on the degree to which the simulation replicates the work situation. Therefore it is important to pay attention to detail in the design of simulations.

In summary, all the methods of data collection considered have limitations. Therefore, collecting data through multi-methods, although costly and time-consuming, lends rigour to research (Sekaran, 1992). The current study combined a number of data-collection methods to counter the deficiencies of any single method. This paper focuses on data collection methods and therefore the substantive findings are not reported in the paper.

*Data collection in the current study*
A survey was distributed as a preliminary test to controllers (n=6) from one Australian domestic OCC. Respondents were asked to complete a questionnaire at the conclusion of

each disruption or at the end of each shift. Questions asked respondents to record the nature, cause and duration of each disruption. Respondents were asked to answer questions such as 'where did they obtain information for decision-making', and 'what amount of information did they need to make decisions'? Qualitative data were also collected by observing controllers during disruptions and asking unstructured and semi-structured questions.

However the use of surveys and observations to collect data about decision-making during disruptions was inappropriate. The frequency, regularity, and duration of disruptions were unpredictable, making data collection inefficient. Some disruptions continued across a number of shifts or even days. Therefore, decision-making processes of any one respondent were difficult to capture. Second, respondents were generally unable or unwilling to answer questions during a disruption as they needed to focus intensely on solving operational problems. Third, there was no way to compare the decision-making outcomes of respondents. Some disruptions were resolved quickly and with minimal decision-making from controllers, while others were longer and required extensive decision-making. Fourth, if a number of disruptions occurred simultaneously, decision-making relevant to any particular disruption could not necessarily be determined. Fifth, there was no means by which the researcher could be confident that respondents completed the questionnaire with any degree of accuracy or timeliness. The conclusion reached was that the method using surveys and observation to study decision-making in an OCC was inappropriate.

*Simulation study*

The study was re-designed using a multiple case study approach to examine decision outcomes of controllers (N=52) in five Operations Control Centres. The study was broadened to include OCCs in other Australian domestic airlines, as well as OCCs of international airlines in the Asia-Pacific region. One airline operated solely domestic services, two operated solely international services and two operated both domestic and international services. In domestic operations, flight stages are short, aircraft are scheduled to operate a high number of flight stages in a day, and are on the ground for short durations between flights. Controllers handling domestic disruptions, therefore, make numerous

7

decisions within very short timeframes. In contrast, international flight stages may be very long, aircraft may only operate a small number of flights per day, and are on the ground between flights for longer durations. Decision-making therefore is generally less intense.

A simulation to replicate each of the operational environments was designed in collaboration with a panel of experts. The experts were current or retired senior operations managers (N=10). For each simulation, hypothetical flight schedules were constructed to replicate typical airline schedules. Each simulation consisted of a visual display showing a coloured utilisation of a fleet of aircraft, and was laminated to allow respondents to write or draw on the surface. The display was a close representation of the computerised display normally used by operations controllers. Information on the display included aircraft flight stages with flight numbers, city pairs (routes), flight loadings, maintenance unserviceabilities and requirements, and other relevant information. The flight stages were positioned on the display according to a continuous time scale. A time-line could be positioned along the time-scale to indicate the specific time of day, or a passage of elapsed time.

*Domestic Simulation*
The domestic simulation was designed for OCCs in the Australasian region. Hence the flight schedule was constructed for a hypothetical airline operating within Australia. The base location of the airline was irrelevant for the study.

*International Simulation*
The international simulation was designed for OCCs in the Asia-Pacific region. Hence the hypothetical airline was based at a fictitious location, but within the Pacific region. Information for respondents included the approximate location depicted on a map, and the local time zone of the location. Respondents could determine the flying time and therefore distance to any destination of the airline from the flight schedules.

A series of simulation scenarios was designed in collaboration with the panel of experts. The scenarios consisted of three typical operational problems for each of the domestic and international operations, and each successive scenario was more complex than the previous

8

one, in terms of the nature of the disruption, the consequences of any decision, and timeframes for decision-making. The three scenarios were completely independent of each other. A short audio briefing tape was made for each of the domestic and international simulations. The tape served to ensure a consistent briefing for each respondent, and contained important information for the simulation. The preamble outlined the reason for the study and emphasised to the respondent that the study was concerned with decision-making processes rather than solutions to the scenarios. Respondents were asked to think aloud as the simulation proceeded.

The simulation was conducted between the researcher and one respondent at a time at the respondent's workplace, but in a separate room. Respondents were invited by their managers to participate voluntarily in the study. As only three OCC controllers from three different airlines declined the study, the sample was highly representative of the population of controllers in the airlines studied. While large sample sizes are more reliable, they are also more costly (Blank, 1984). The study was limited to the Asia-Pacific region for this reason. In the OCCs of the two airlines in the study that operated both domestic and international operations, respondents worked either as domestic or international controllers. These respondents were permitted to select either the domestic or international simulation.

Prior to running the simulation, each respondent listened to the five minute audio briefing tape. Respondents were asked if any information required clarification or whether they felt they needed additional information. When respondents indicated their readiness to commence the simulation, the tape recorder was set to record all subsequent communications. Taping is more accurate than any other method of recording interview data, providing the respondent agrees to being taped, and the taped data are transcribed (Yin, 1994). The current study satisfied both these criteria. The taping process did not appear to present any difficulties and the respondents did not react adversely to the tape recorder, even to the extent of waiting while tapes were changed. According to Ericsson and Simon, (1993) respondents become so involved in the task that they soon become accustomed to the presence of the taping device.

9

The researcher commenced the simulation by showing respondents the utilisation of flight schedules and describing the display. The respondents were asked to familiarise themselves with the utilisation, and communicate observations and any questions to the researcher. As each scenario was introduced, respondents were asked to think aloud as they attempted to solve the operational problems. The researcher played two critical roles throughout the simulation. The main role of the researcher during the simulation was to control and direct each scenario according to a script. As the scenario progressed, further information was given to respondents at appropriate times. Typical developments included sudden maintenance failures, deteriorating weather conditions, or particular commercial requirements. Second, the researcher acted as a resource base for the scenario, providing any information required by respondents as the scenario progressed. On request from respondents, the researcher provided information or answered questions relating, for example, to crew availability or roster commitments, passenger connections, airport or air traffic control related information, maintenance requirements, and weather advice.

As each scenario progressed, respondents were required to make decisions and attempt to construct solutions to the operational problems. By observing respondents' actions, and listening to their verbalised thought processes, the researcher could explore the decision-making process. For example if a respondent noted several flights with low loadings (proportion of booked passengers, to available seats), the researcher could probe the reason for the respondent's comment. The researcher also asked questions such as 'why do you doubt the information provided by Engineering?' or 'how do you know when you have enough information to help you make a decision?' The scenario was continued until respondents considered a problem was solved satisfactorily or the researcher considered little would be gained by extending the scenario.

*Discussion*

Most respondents were familiar with details contained within the simulated displays. However, respondents working in OCCs outside Australia, but participating in the domestic simulation, required clarification of information such as Australian airport abbreviations. Respondents were asked to treat the initial familiarisation of schedules as akin to

commencing a normal shift. The researcher provided a briefing (handover) to facilitate this process.

Respondents described their thought processes throughout the simulation and readily offered comments or answered questions as the scenarios progressed. Periods of silence did not suggest disinterest or loss of awareness of the scenario. During these periods, the researcher prompted respondents to verbalise their thoughts by asking questions such as 'what are you looking at'? or 'why are you indicating this flight'? Respondents became totally absorbed in the scenarios. At times the researcher had to clarify flight numbers or aircraft identifications to ensure the tapes could be transcribed accurately.

*Preliminary findings*

The influence of respondents' experience in other areas of the airline became apparent in their approach to tackling the task. For example, respondents who had a crew rostering background tended to give priority to crew-related problems during the scenarios. Similarly respondents who had experience in airline ground-handling roles, attended initially to issues such as airport congestion or potential aircraft handling problems. These preliminary findings suggest that a controller's previous experience, particularly in areas outside OCCs may influence the decision-making process. The findings should not be seen necessarily as negative but may imply that OCCs need to be aware of the influence of controller background.

*Participant response*

Respondents reported that they enjoyed participating in the simulation. One respondent (Male, 41-50 yrs old, 2 years experience in OCC) who participated in the domestic simulation commented that he felt he should be reaching an immediate solution, but in the absence of co-workers, was unable to solve the scenario.

*Management response*

Management in the five OCCs participating in the study commented very favourably on the use of the simulations. None of the OCCs conducted simulations that investigated decision-making outcomes of controllers prior to the study. Managers suggested that the

11

simulation method may provide OCCs with a valuable tool for selecting suitable staff, and as a means of identifying staff development and training opportunities.

*Data collection methods in the current study*

The use of simulation in the current study provided a suitable means of investigating decision-making of controllers in OCCs. However simulation alone would not have yielded the degree of richness of information that was collected. The necessity to interact with participants and observe their behaviour as they made decisions was a critical aspect which contributed to the success of the data gathering method necessary for the study. The simulation also provided a suitable context in which respondents could verbalise their thoughts. In contrast, other individual methods of data collection fail to capture the degree of data necessary for an in-depth investigation of decision-making. The study emphasised that the use of simulation in conjunction with observation, interviews and think-aloud verbal protocol was the most appropriate combination of methods to study decision-making in OCCs.

*Conclusion*

The study represents a preliminary investigation of the application of several methods of data collection in OCCs. A conclusion drawn was that no one method was sufficient to investigate controller decision-making. However a multi-method approach using simulation together with observation, interviews and think-aloud protocol provided a most appropriate means. The full results of the study should make a substantial contribution to the research to gain further understanding of thought processes behind OCC decision-making. The simulation method has wide application and should lead to the development of an appropriate management tool to identify selection and training opportunities, and measure performance of controllers in OCCs. The current study strongly lends itself to the development of a computer-based simulation.

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13

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