Evaluation of Controller Strategies in Air Traffic Management for KLFIR Oceanic Sector

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ABSTRACT

Air Traffic Control (ATC) is a service provided by ground to control movement of all aircraft within a controlled airspace. This is done by using either Radar Control or Procedural Control depending on the availability of radar system in the area. In Peninsular Malaysia, these controlled areas are known as Kuala Lumpur Flight Information Region (KLFIR). These areas are divided into 6 Sectors that was assigned to a different team of controllers. As this research is aimed at examining the strategies used by Air Traffic Controller (ATCO) during Procedural Control, Lumpur Oceanic Sector or Lumpur Sector 4 was chosen as the participating controlled airspace. To gather insights on controller strategies, participants from Kuala Lumpur Air Traffic Control Centre (KLATCC) have volunteered to participate in Static Conflict Detection Exercise (SCDE). Based on the results, the most prominent issue that can be highlighted was on delays, where it is seen as unavoidable in regulating air traffic. However, it is also gathered that some minimum differences between Requested Cruising Altitude (FPL) and Assigned Cruising Altitude (XFL) can be achieved by pre-planning the traffic prior to Estimated Time of Departure (ETD). Also, by doing so, the controller workload may be reduced by 45% in average, as reported by the participants. As there are several control strategies that can be used, regards to the airlines operation cost is important in selecting the best strategy that may benefit both controller and airlines. Additionally,

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managing traffic would be more manageable as available cruising altitude will be known at any given time as a result from the pre-planning exercise.

Keywords: *En-route, Workload, Procedural Control, Air Traffic Management*

Nomenclature

σ_x	Standard Deviation
μ	Mean Value
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ETD	Estimated Time of Departure filed on flight plan
FIR	Flight Information Region
FPL	Requested Cruising Altitude filed on flight plan
KLATCC	Kuala Lumpur Air Traffic Centre
KLFIR	Kuala Lumpur Flight Information Region
SCDE	Static Conflict Detection Exercise
W_{ACM}	Aircraft Manoeuvres Workload
W_{COR}	Coordination Workload
W_{CDR}	Conflict Detection and Resolution Workload
W_{MON}	Monitoring Workload
XPL	Final Cruising Altitude assigned by ATCO

Introduction

Rapid growth in air traffic movement has bring new challenges to Air Traffic Controller (ATCO). With wide array of aircraft performance, the task in managing traffic flow is getting bigger and more difficult. Several strategies available in regulating and managing traffic flow, such as ground delay technique, single point rate restrictions (e.g., Mach Number Technique (MIT), minute-in-trail) and also rerouting [1]. Real time planning, calculation, and executing are essential in determining cruising altitude for any two-aircraft based on their performance characteristics. However, ATCO has limited time in making these decisions as situation can change rapidly, and any delay in decision making can contribute to even worse situations. Even though the best solution is required immediately, but this may not be feasible in real practice [2].

The problem is the efficiency of air traffic flow management is deteriorating as aviation industry continue to growth with increased number of scheduled traffic, introduction of new routing and establishment of many new low-cost airlines. Flight approval is also granted without reconsidering the sector capacity and little research on the sector design and complexity. En-route airspace capacity is defined as the maximum number of flight passing through any given geometrical airspace for a period of time. Any two-aircraft flying must be within internationally agreed specified separation with respect to their performance characteristics [3]. Cruising altitude allocation is normally decided based on Flight Plan submitted or upon pilot request and its best fit based on procedural separation minima. As traffic volume increase, demands for same cruising altitude increases and vast differences in performance characteristics between aircraft will also increase the ATCO mental workload.

Kuala Lumpur Flight Information Region (KLFIR) is divided into 6 Sectors that was assigned to a different team of controllers. As this research is aimed at examining the strategies used by ATCO during Procedural Control, Lumpur Oceanic Sector or Lumpur Sector 4 was chosen as the respective controlled airspace. Lumpur Oceanic Sector also known as Lumpur Sector 4 is bounded by geometrical boundary from waypoint TASEK along the Flight Information Region (FIR) boundary [4]. It shares common entry or exit waypoints with other adjacent neighbouring FIR. With Chennai FIR, the entry or exit point are NOPEK, ANOKO, IGOGU, SAMAK and IGREX. With Jakarta FIR are POVOS, and ANSAX, and with Bangkok FIR are RUSET and SAPAM. The geometrical boundary of Lumpur Sector 4 is shown in Figure 1.

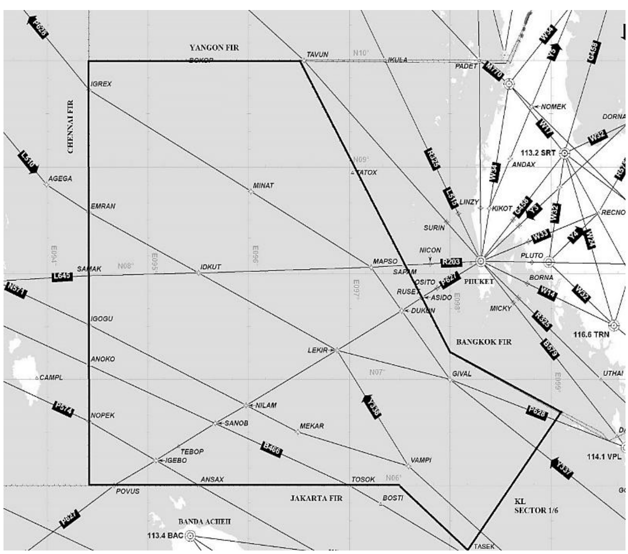

Figure 1: KLFIR oceanic sector

Static Conflict Detection Exercise (SCDE)

The exercise is intended to investigate participants' strategy selection, mental workload comparison, and task completion time in static conflict detection [5, 6]. Participants, on their best discretion are required to arrange slot time for departing aircraft based on their Requested Cruising Altitude (FPL), Estimated Time of Departure (ETD) and aircraft performance. Twenty (20) ATCO (μ= 30 year, σ_x = 5 year) from Kuala Lumpur Air Traffic Control Centre (KLATCC) volunteered for the exercise. All participants are area procedural rated controller and is currently actively involved with Lumpur Sector 4.

The exercise was designed based on actual Flight Plan submitted for the month of September 2015. The Flight Plan was filtered to only westbound traffic and those who were corresponding to Lumpur Sector 4. All aircraft in the exercise are westbound traffic and are exiting KLFIR from either IGOGU or SAMAK. Due to converging route, those two waypoints are considered not separated and normal separation minima need to be applied.

The exercise is a true reflection of actual traffic for Lumpur Sector 4 between 1130 to 1400 UTC. During the selected time, volume of pending departure is high and based on previous interview with controller, the workload occupied by controller during the time are among the highest. The Flight Plan consists of 20 pending departures and two overflying traffic. Among the pending departure, 11 are from Changi International Airport (CIA), 7 are from Kuala Lumpur International Airport (KLIA), and 2 from Phuket International Airport (PIA). Figure 2 shows the Flight Plan given to participants during the Static Conflict Detection Exercise (SCDE).

CallSign	A/C Type	Departure	Destination	Speed (Mach)	Exit WayPoint	Position	ETO/ETD	FPL	ATD	Delay (Min)	ATO (GUNIP)	ATO (IGOGU/ SAMAK)	XFL
SIA424	B77W/H	WSSS	VABB	0.83	IGOGU	WSSS	1105	F340					
AIC343	B788/H	WSSS	VABB	0.85	IGOGU	WSSS	1115	F380					
UAE347	B77W/H	WMKK	OMDB	0.83	IGOGU	WMKK	1145	F340					
QTR841	B788/H	VTSP	OTHH	0.85	SAMAK	VTSP	1145	F400					
SLK474	B738/M	WSSS	VOHS	0.78	IGOGU	WSSS	1200	F360					
JAI11	B738/M	WSSS	VABB	0.78	IGOGU	WSSS	1205	F340					
ETD411	A333/H	WMKK	OMAA	0.82	IGOGU	WMKK	1205	F380					
SIA502	B772/H	WSSS	VOBL	0.83	IGOGU	WSSS	1205	F360					
TGW2638	A320/M	WSSS	VOMM	0.78	IGOGU	WSSS	1210	F340					
ETD473	B789/H	WSSS	OMAA	0.85	IGOGU	WSSS	1210	F380					

Figure 2: SCDE Sheet

To study the ATCO strategies in managing traffic during Procedural Control, changes are only allowed to yet to depart aircraft. Participants are prohibited from making changes to overflying traffic in order to capture different strategies of separating converging traffic. Any strategies used for achieving separation minima are allowed and exercise completion time was logged. At the end of exercise, participants ware asked on percentage of workload reduced if departure slot time are calculated and arranged prior to ETD.

Results and Discussion

Workload in ATC is complicated as it is related to many factors which are quantitative and qualitative. Conventionally researcher estimate workload by three different categories namely subjective ratings, traffic characteristics and behavioural/physiological recordings. For en-route sector, ATCO workload can be divided into four variable which are; Monitoring Workload (W_{MON}), Coordination Workload (W_{COR}), Aircraft Manoeuvres Workload (W_{ACM}) and Conflict Detection and Resolution Workload (W_{CDR}) [9]. In this exercise, direct subjective ratings approach is used, where at the end of exercise, respondents were asked on the percentage of workload reduction if the XPL and ETD are assigned and rearrange respectively prior to aircraft departure. In the exercise, the cruising altitude and departure time for pending traffic are calculated and assigned prior to departure. Based on the comments from the participants, they agreed that the workload can be reduce by 45% in average by pre-planning the traffic prior to ETD (Figure 3). One of the sources of workload in ATC is mental demand related. It is something that cannot be measure directly, but must be inferred from what can be measured [3]. Indirectly, the link between ATC task load and workload is connective [7].

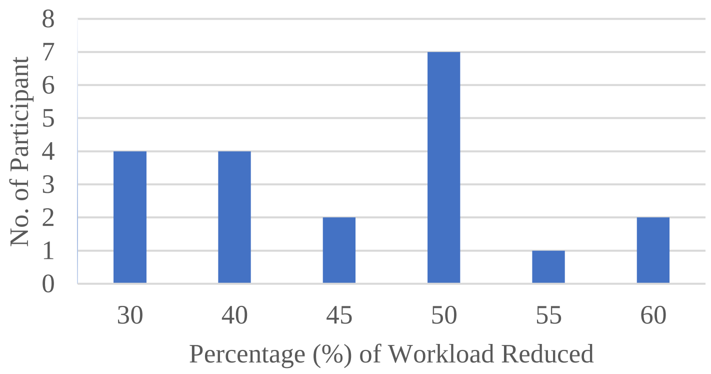

Figure 3: Percentage of Workload Reduce

Thus, in this case, by reducing the task demand load it is hypothesized that it will eventually reduce the mental workload. It is expected by determining cruising altitude prior to ETD, ATCO can reduce their task load on live coordination for clearance hence coordination workload (W_{COR}), conflict detection and resolution workload (W_{CDR}) as all conflicting traffic are resolved prior to departure and also on time spent for mental calculation on requirement or restriction if necessary for flow management. Albeit this strategy will add additional workload on monitoring (W_{MON}) and making sure pending departure comply with restriction or requirement given, all participants still agree that their total workload shall reduce significantly.

Based on the SCDE outcome, majority of the participants were able to finish the exercise within 60 minutes time, with only two participants having a completion time of 80 minutes (Table 1). Based on their performance, it is safe to conclude that, for determining and rearrange ETD of 20 pending departure, a maximum of 80 minutes time is required. For a busy period, such as between 1130 to 1400 UTC, it is suggested that Flight Plan should be submitted before 0930 UTC. This is to allow ATCO to calculate and rearrange aircraft ETD with an additional 30 to 40 minutes to inform and receive feedback from airlines regarding any changes.

Table 1: Simplified result for static exercise

No.	Year of Experience in KLFIR Sector 4	No. of a/c With Different FPL and XFL	Max differences between FPL n XFL (ft)	No. of A/C Delayed	Minimum delay time (minutes)	maximum delay time (minutes)	average delay time (minutes)	Exercise Completion Time (minutes)	Total WorkLoad Reduce (%)
1	2	10	6000	5	5	10	8	60	50
2	2	1	8000	12	5	40	22	30	50
3	2	1	2000	10	5	22	14	55	60
4	2	2	2000	6	5	25	19	50	55
5	6	4	6000	5	10	30	18	45	30
6	2	6	2000	11	5	40	21	60	30
7	2	1	8000	12	5	40	21	30	50
8	6	5	8000	3	10	15	14	80	60
9	2	6	8000	3	5	15	10	80	45
10	2	1	4000	11	5	35	23	45	30
11	2	5	10000	13	5	20	10	65	50
12	6	2	4000	8	5	25	16	45	50
13	2	5	8000	3	5	15	10	45	40
14	6	9	6000	5	5	10	7	60	40
15	2	4	6000	6	10	30	17	45	40
16	15	1	2000	10	5	22	14	57	50
17	6	9	6000	5	5	10	8	60	40
18	6	4	6000	6	10	30	17	55	45
19	2	4	6000	6	10	30	16	50	50
20	2	4	6000	5	10	30	18	45	30

There are several criteria that should be taken into consideration in determining ETD and Cruising Altitude of an aircraft. Other than based on the Flight Plan submitted by airlines, ATCO must also consider the allocated aircraft's speed based on aircraft performance. Based on the Flight Plan, it is gathered that aircraft's speed flying through Lumpur Sector 4 vary from 0.78 MACH to 0.85 MACH. In using MACH Number Technique, by allowing slower aircraft to fly in front of faster aircraft will result in greater requirement of time separation.

As a result, sometimes it is impossible to fulfil a certain FPL or departure time as submitted in the Flight Plan. Consequently, if the working procedure is maintained using current practice, whereby ATC clearance is only given once the aircraft is ready, and most of the time, cruising altitude will be decided on "first come first serve" basis, the level of task demand imposed on the controller will be higher.

By having the time to pre-plan the traffic, the constraint of having to make these decision within limited time frame can be avoided and in the end alleviating the demand imposed on ATCO.In completing the exercise, technique selected by participants have yield varying outcome. This can be observed in Table 1 and Figure 4 and 5.

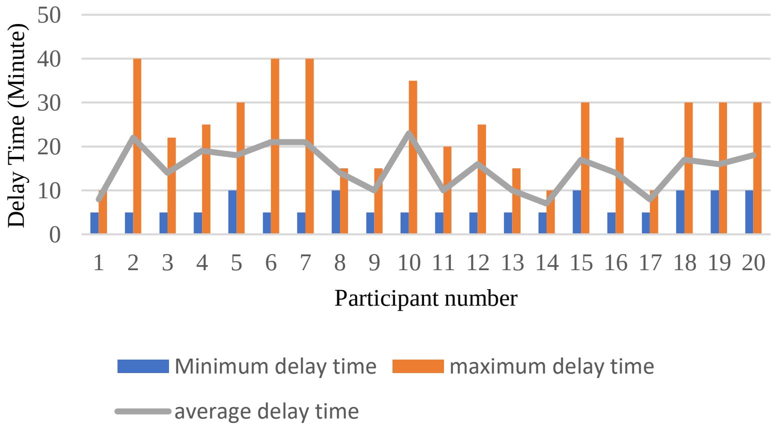

Figure 4: Delay Time based on Participant

Based on the results, Participant number 2 has chosen to strictly follow the FPL as the main reference. By using that strategy, only one aircraft will have to fly with different altitude than requested. However, the difference in cruising altitude is very large with the Assigned Cruising Altitude (XFL) having a difference of 8000ft from the original FPL. It also resulted in huge number of aircraft being delayed and with greater delay time.

Participants 8 and 9 on the other hand used original ETD as their main reference. This has resulted in less aircraft being delayed and the delay time itself are minimum. In contrast, the number of aircraft with different XFL to

FPL increased. It is observed that, when the participants were assigning the altitude, priority was given to aircraft with an earlier ETD. The following aircraft with same FPL was given the next available altitude. This strategy is almost similar to current day to day practice done by oceanic sector controller.

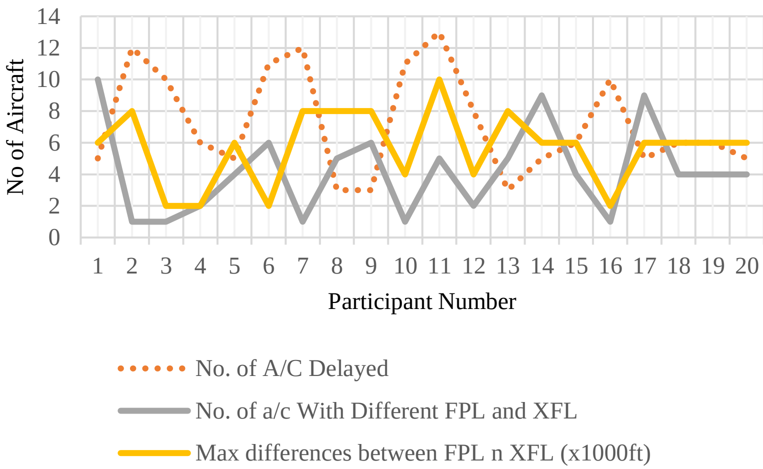

Figure 5: Relationship between Cruising Altitude and Number of Delayed Aircraft

In contrast to Participants 8 and 9, Participant number 10 did try to rearrange the ETD in order to meet the FPL. However, Participant 10 fails to consider aircraft speed performance in making this decision. As a result, to complete the exercise, slower aircraft was allowed to depart earlier than faster aircraft resulting in longer a delay time.

Participants number 3 and 4 have provided the almost ideal solution. By taking all criteria into consideration, they were able to minimise the number of aircraft with different in FPL to XFL. The differences itself are considered small with 2000ft between FPL and XFL. Maximum delay time encountered by these participants were almost similar. However, this strategy can only be applied if the assigned ATCO have a complete knowledge of the daily traffic volume and flight plan beforehand.

Air traffic movement is not a repetitive task and the pattern changes every day. From the exercise, it can be observed that the years of experience have minor effect in the time needed to complete the exercise (Figure 6). This shows that each participant have equal knowledge in Procedural Control irrespective of years of experience. Any methods or strategies that were used are deem correct but resulted in different level of efficiency (number of aircraft delay, maximum time delay or difference between FPL and XFL). However, there are no correlation found between years of experience and the level of efficiency achieved. Exercise completion time also not depend solely on strategy used as every respondent have their own analytical and calculation skills limit/capability. However, it was noticeable that, completion time is increase with the number of criteria being considered.

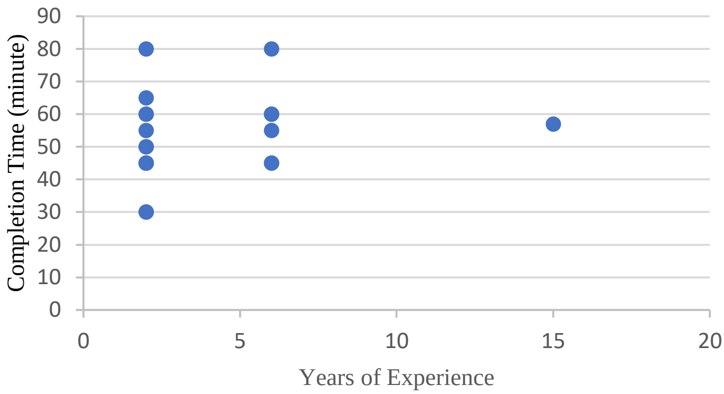

Figure 6: Years of Experience vs Exercise Completion Time

Conclusion

With increasing number of air traffic, better management is essential in utilising airspace capacity and reducing controller workload especially in non-radar surveillance area. By using information available in the Flight Plan, the controller feels that pre-planning the traffic will reduced their workload by half and will also manage to increase traffic flow efficiency. By working blindly, ATCO are facing difficulty in utilising the airspace capacity. If the information was made available prior to start-up, airline can arrange their fuel endurance accordingly. For example, for long-haul flight, different flight profile or altitude resulted in different fuel consumption with respect to wind and weight of the aircraft [8]. Less aircraft with delay or minimum delay time is favourable, but this is impossible to be achieve together with minimum differences in FPL and XFL. Thus, airline has to collaborate with ATC to achieve an optimal condition, which will benefit both parties.

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