Analysis of Transferring Air Traffic from Radar to Non-Radar Airspaces

Emre AYDOĞAN
Air Traffic Control Department
Anadolu University
Eskişehir, TURKEY
emreaydogan@anadolu.edu.tr

Cem CETEK, PhD
Air Traffic Control Department
Anadolu University
Eskişehir, TURKEY
ccetek@anadolu.edu.tr

***Abstract*—This paper presents analysis of transferring air traffic from Radar to Non-radar airspaces. Baghdad Flight Information Region (FIR) has Radar coverage problems which requires to perform Non-radar separation procedures. This situation affects Turkey FIR and compels it to use Non-radar separation minimums for en-route air traffic before their transfer to Baghdad FIR. In this paper, the delay analysis for this transferring problem models is carried out with fast time simulation. Also, according to the analysis a control methodology is developed as a solution to decrease the delays caused by this traffic hand off problem. The control methodology is similar with point merge procedure which is actually an approach sequencing procedure. The control methodology offers extending the routes until getting the required a separation between the aircraft prior to their hand off time. The total delay can be decreased among the Turkey FIR %88 as a result of this control methodology. The total delay for the actual condition 312.42 minutes is decreased to 35.7 minutes.**

Keywords- Radar control; procedural control; delay; longititional seperation

I. INTRODUCTION

Overflights are usually transferred several times from airspace to another along their en-route flight paths. Each Air navigation service provider (ANSP) has the responsibility to maintain pre-defined separation minima between aircraft to provide safe and efficient traffic flow within its airspace. Technical facilitation and ATS surveillance capabilities play a critical role to set up the required separation minima between aircraft. Airspaces with good radar coverage allows the use of decreased minima since they provide more accurate aircraft position data to air traffic controllers to predict aircraft trajectories. In an airspace with no or poor radar coverage, however, the controllers have to use the procedural control separation minima which are much greater than the radar equipped airspace separation minima. In such a case, the airspace capacity decreases and total delay increases within the airspace. Due to air traffic transfer requirements, the airspace with poor radar coverage has also adverse effects on the capacity and delays in well-equipped radar airspaces around it. According to ICAO [1], when control of an identified aircraft is to be transferred to a control sector that will provide the aircraft with procedural separation, such separation shall be established by the transferring controller before the aircraft reaches the limits of the transferring controller's area of responsibility, or before the aircraft leaves the relevant area of surveillance coverage. This brings an increase of total delay for the radar equipped airspace due to vectoring delays to satisfy the required separation for the procedural control before the transferring the traffic to a non-radar airspace. This problem has been experiencing especially in the southeast borders of pan-European Network and imposes capacity and delay problems in Area Control Centers (ACCs), such as Ankara (LTAA) in its periphery.

Air traffic demand is increasing day by day in the world due to many reasons. Especially in Turkey the total air traffic is rising considerably. According to January 2014 flight data, in Turkey the total flight is increased with a percentage of %15.1 and the over-flight that is occurred January 2014 is also increased with a percentage of % 5,4 with respect to January 2013 [2]. The Eurocontrol flight statistics also shows a remarkable increase the amount of air traffic demand for Turkey airspace. The overall air traffic increased %2,2 in European airspace. Turkey airspace has the biggest part of this increment with a %16 percentage excluding the over-flights [3]. This increase trend necessitates an efficient usage of airspace capacity with an optimum air traffic flow management. Separation minimums have a great role to define the airspace capacity. Ankara ACC uses the Radar separation minima as 10 NM. However neighbor Baghdad ACC uses the procedural control minima as 30 NM. Before transferring the air traffic from Ankara FIR to Baghdad FIR all longitudinal separations must be satisfy the minimum 30 NM. This issue brings vector and speed delays for Ankara FIR. The delay in Ankara ACC caused by Baghdad ACC procedural control NOTAMs is reported in Monthly Network Operation Reports by the Eurocontrol. The latest report states that the Ankara ACC's average daily delay is 555 minutes due to Baghdad NOTAM [3]. It also states that Ankara ACC is in top of 20 delay generating locations in Europe. These reports and statistics also point out the huge obstacle which is capacity problems in front of the steady growing of air traffic demand.

In this paper, the hand off problem for Ankara ACC is analyzed with an experimental simulation model to determine the delay caused by the requirements for transferring air traffic to a procedural controlled airspace. A control methodology is also developed to decrease the delays for this hand off problem. For these purposes the current air traffic flow condition is simulated and analyzed according to actual flight data by a fast time simulation program which is Simulation and Modelling Program (SIMMOD). After the analysis an alternative solution to meets the separation requirements for the baseline scenario is developed. An alternative simulation scenario is created and analyzed. Simulation results and delay analysis for baseline and alternative scenarios is compared to observe the effectiveness of the new control methodology. In this way pros and cons of solution for the procedural control requirements caused by Baghdad FIR can be analyzed statistically with simulation results.

II. Simulation and Analysis

A. *Modelling of Airspace with SIMMOD*

Turkish airspace consists of two FIRs which are Istanbul FIR and Ankara FIR. For this analysis Ankara FIR is taken into account because of its neighborliness to Baghdad FIR. Ankara FIR includes 6 different lateral sectors that are Ankara North, West, South, Central, North East and South East. Air traffic routes for transferring over flights to Baghdad FIR mainly passes through the North, West, Central, North East and South East sectors of Ankara FIR. Except of South sector all other 5 sectors have role for over flight to Baghdad FIR. The general view of Turkey airspace with its FIRs and Sectors can be seen in Figure 1.

Figure 1. Turkey Airspace

The experimental modelling of Turkey airspace is carried out by SIMMOD. According to the actual position and coordinate information in the Turkey AIP, all intersection and fixes integrated to the simulation model. The generated airspace can be seen in Figure 2.

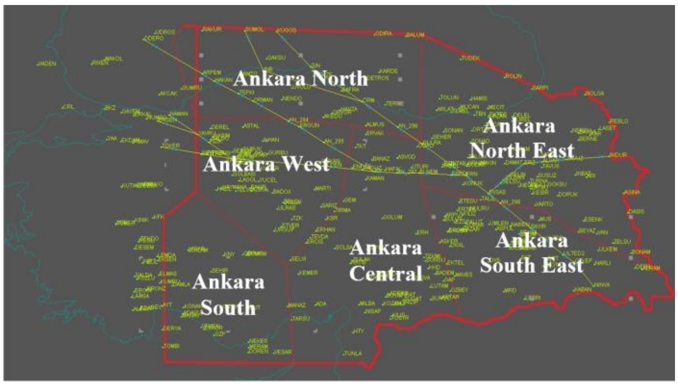

Figure 2. Modeled Turkey Airspace with SIMMOD

B. *Baseline Scenario*

Baseline scenario is created to represent the current air traffic control procedures. It includes real traffic data that belongs for 6th of January 2013. Totally 104 aircraft had a flight over Turkey airspace to Baghdad FIR at that date. However 5 flights data do not include the required flight route information for the simulation. Because of this reason only 99 flights are injected to simulation according to their flight plan routes. The real air traffics have multiple flight levels, however at this baseline scenario only one flight level is used for lateral separation analysis. This means that all 99 aircraft must fly the FL200. For this assumption, the first in first out procedure is applied to all aircraft. There is no overtake options for any aircraft. The lateral separation between aircraft is 10 NM at their first injection time into the simulation. The separation must be increased to 30 NM prior to traffic hand-off due to Non-Radar coverage airspace of Baghdad FIR. This separation increment is carried out stepwise manner by the Turkey air traffic controllers. This is simulated as nearer as the actual case in to baseline scenario. The separation between the preceding and the succeeding aircraft is increased 10NM-20NM-30NM gradually from their entrance sector to exit sector which is Ankara South East. The traffic hand-off intersection from Turkey FIR to Baghdad FIR is called NAMAN. At the NAMAN intersection all aircraft must be longitudinally separated with 30 NM distance between each other. The Ankara South East sector and the NAMAN intersection for the baseline scenario can be seen in Figure 3. In Figure 3, a screen capture can be seen as an example of the current separation method.

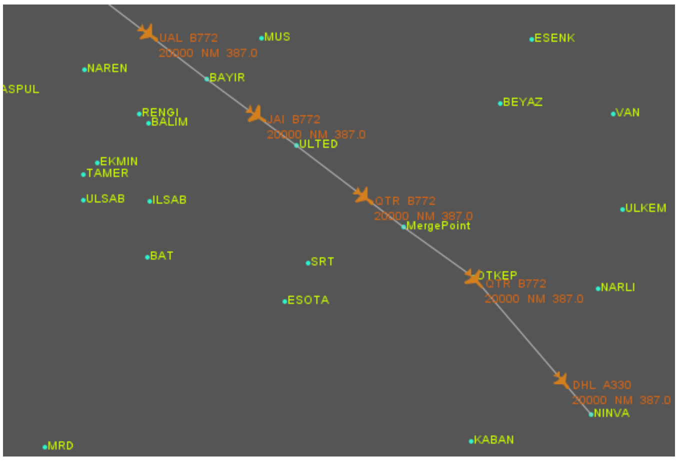

Figure 3. Aircraft Separations at Baseline Scenario

C. *Alternative Scenario*

There is no way to decrease the separation minimum which is 30 NM for procedural control for Baghdad FIR unless Baghdad radar coverage is enhanced. Because of this reason an air traffic flow management is required to optimize the current air space and airways for Ankara FIR. In this alternate scenario a solution procedure is developed adopted for this problem. This solution procedure is similar with Point-Merge which is actually an approach sequencing procedure. In this alternative scenario all of the inputs such as aircraft numbers and their injection times are the same with the baseline scenario. The only difference at this scenario is separation methodology. Instead of increasing the separation distance between the aircraft gradually, all aircraft are separated 10 NM until OTKEP intersection point. After the OTKEP intersection, the required separation distance which is 30 NM is achieved by point merge procedure prior to the NAMAN exit intersection. 20 NM additional separation is added to all aircraft in by the point merge procedure. The alternative scenario separation methodology can be seen in Figure 4.

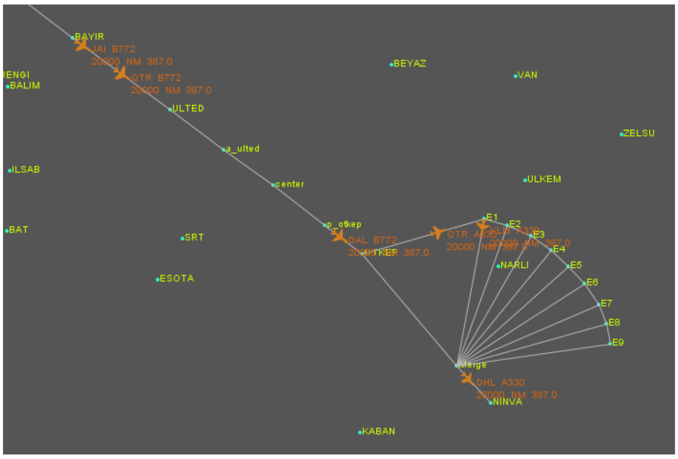

Figure 4. Aircraft Separations at Alternative Scenario

At this separation methodology, succeeding aircraft must fly until it has a 30 separation distance between the preceding aircraft. This brings an additional 20 NM travelling distance for the succeeding aircraft. The first in first out procedure is again a main rule for point-merge separation. During the simulation all aircraft must obey the separation and first in first out rules. E1 to E9 points are check points for the simulation. At this points each aircraft check the separation distance whether it is satisfied or not. If the separation is satisfied the aircraft flies direct to merge point, if it is not satisfied aircraft continues to fly another check point. If the aircraft cannot be separated until the final check point which is E9, the last solution which is vertical separation is carried out. During the all simulation only 5 of the 99 aircraft have such a situation. These aircraft fly directly from OTKEP to NINVA at an upper flight level which is FL210. The flight levels are not determined according the flight direction east or west, they are assumed to be FL200 and FL210 among the simulation.

III. RESULTS

The baseline and alternative scenarios are built and run separately by SIMMOD. Then the statistical information about each scenario is taken out. The aircraft types and their categories for both scenario can be seen in Table I. As it stated previously for both scenario the aircraft number and types are the same. Totally 69 heavy, 29 large and 1 small aircraft are flight input for each scenarios.

TABLE I. AIRCRAFT DISTRIBUTION FOR SIMULATION SCENARIOS

Aircraft		
Category	**Type**	**Number**
HVY	A300	1
HVY	747200	1
HVY	A330	23
HVY	A340	6
HVY	B772	23
HVY	767300	2
HVY	747400	13
LRG	A319	4
LRG	B737800	8
LRG	A321	6
LRG	A320	7
LRG	737500	2
LRG	737	2
SML	LEAR35	1
Total:		99

TABLE II. NUMBER OF DELAYED AIRCRAFT FOR THE SCENARIOS

Number of Delayed Aircraft			
Category	**Type**	**Baseline Scenario**	**Alternate Scenario**
HVY	747200	1	1
HVY	A330	15	11
HVY	A340	5	3
HVY	B772	10	5
HVY	767300	1	1
HVY	747400	7	3
LRG	A319	2	2
LRG	B737800	3	2
LRG	A321	1	0
LRG	A320	6	1
LRG	737500	2	1
LRG	737	1	0
Total:		54	30

Number of delayed aircraft for baseline scenario and alternate scenario can be seen in Table II. Delayed aircraft are the aircraft which have any kind of delay such as speed delay vectoring delay caused by the separation requirements due to non-radar traffic hand of problem. As it can be seen the delayed aircraft number is decreasing from 54 to 30 with the alternative scenario. The delay amount is decreased with a % 44 percentage. This delay decrease shows that the new separation methodology which is developed in the alternative scenario is useful for the problem. This result can be seem a little bit surprising. Decreasing the delay with satisfying the 30 NM separation requirements brings the question ‘how is it possible’. To find an answer for this question, the travelling time of aircraft should be analyzed. The total travelling times for each aircraft in the simulation can be seen in Table III.

TABLE III. TRAVELLING TIMES OF AIRCRAFT

Aircraft Travelling Times			
Category	**Type**	**Baseline Scenario (Hour)**	**Alternate Scenario (Hour)**
HVY	A300	1,778	1,771
HVY	747200	1,547	1,459
HVY	A330	37,818	37,549
HVY	A340	11,513	11,277
HVY	B772	35,611	35,957
HVY	767300	3,294	3,31
HVY	747400	19,114	19,188
LRG	A319	6,539	6,467
LRG	B737800	14,388	14,375
LRG	A321	11,08	11,251
LRG	A320	12,928	13,012
LRG	737500	3,422	3,447
LRG	737	3,364	3,351
SML	LEAR35	1,58	1,573
Total:		163,976	163,987

TABLE IV. AIR DELAY TIMES OF AIRCRAFT

Aircraft Air Delay Times			
Category	**Type**	**Baseline Scenario (Minute)**	**Alternate Scenario (Minute)**
HVY	747200	10,5	2,1
HVY	A330	93,78	9,96
HVY	A340	58,56	4,14
HVY	B772	47,64	5,04
HVY	767300	8,7	1,92
HVY	747400	27,84	2,04
LRG	A319	19,08	7,14
LRG	B737800	10,2	0,54
LRG	A321	9	0
LRG	A320	16,14	1,56
LRG	737500	6,42	1,26
LRG	737	4,56	0
Total:		312,42	35,7

As it can be seen in Table III, the travelling times of aircraft for baseline scenario and alternate scenario are almost the same. Even though the delayed aircraft number is decreased in alternative scenario, the total travelling time of aircraft is not changed in proportion to baseline case. This result shows that, the delay times for aircraft in the baseline case turn into travelling time in the alternative scenario. The 20 NM additional separation distance can be added in this way by travelling among the E1, E2, …., E9 routes. This means that alternative scenario uses extra travelling routes for separation in North East Ankara FIR sector instead of delay caused by the previous sectors. In this way, separation between the aircraft can be achieved at the final North East sector without any effect on the previous sectors. This issue brings some remarkable results. Firstly, the other sector capacities are increases since the delay amount decreases. Second, point merge procedure for the separation helps the controllers about decision making to separate aircraft 30 NM distance between the each other. This issue can be seen directly with the air delay times of aircraft. At the baseline scenario the total air delay time is 312,42 minutes. This total delay time decreases to 35,7 minutes in alternative scenario. The decision making procedure to satisfy the 312,42 minutes delay without any separation algorithm is too hard. The alternative scenario the point merge methodology makes the decision making progress much more clear than the base line case.

Another remarkable point between the baseline scenario and the alternative scenario is that fuel consumption amount. Any kind of flight maneuver caused by controller command to satisfy the vectoring or speed delay in the baseline scenario increases the fuel consumption. Instead of such maneuvers, the alternative scenario offer a new separation methodology with much more smooth maneuvers. This smooth maneuvers would decrease the fuel consumption amount. The fuel consumption analysis of this simulation will be carried out in further study of this master thesis.

The developed control methodology in the baseline scenario can be used for any similar condition. The developed control methodology can be used to satisfy any increased separation minimums due to any reason such as bad radar coverage, radar loss condition or defined separation minimums by NOTAMs. When the procedural control is required for over flight because of any reason, airspace capacity can be managed much more efficiently with this control methodology.

REFERENCES

[1] Air Traffic Management, DOC 4444, ICAO 15th Edition 2007.

[2] Turkey General Directorate of State Airports Authority, January 2014 Flight Statistics

[3] Eurocontrol Monthly Network Operations Report, January 2014 Analysis

[4] Aeronautical Information Publication, Enroute, Turkey, 7 March 2013

[5] Simulation and Modelling Pro Version 8.1 ATAC

[6] International Civil Aviation Organization, Middele East Air Navigation Planning and Implemantation Regional Group (MIDANPIRG) 14th Meeting, 15-19 December, Update on the normalization of Baghdad FIR