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SIMMOD ANALYSIS FOR THE THESSALONIKI TMA STUDY PHASE I

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TITLE:

SIMMOD Analysis for the Thessaloniki TMA Study, Phase I.

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Abstract:

SIMMOD was used to perform a TMA study for Thessaloniki, Greece.

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1. INTRODUCTION

1.1 Background

The Hellenic Civil Aviation Authority (HCAA) requested the Eurocontrol Experimental Centre (EEC) for assistance in determining the most efficient spatial and procedural configuration for the four major Terminal Manoeuvring Areas (TMAs); Thessaloniki, Kerkika, Rhodos and Iraklion.

The HCAA wanted to begin the study by evaluating the effects of the use of radar in the Thessaloniki TMA, which meant using the MAKEDONIA Airport as the SIMMOD[1] Investigation starting point. Two radar control positions, which were described in terms of sector space within the simulation, were used:

- RAC - providing radar services to departures, overflights and arrivals until transferred to the RA control position; this control position is called sector TMA in the report,
- RA - providing radar service to arriving traffic and, in particular, vectoring aircraft so as to provide a sequence before the aircraft goes into final approach.

The study would be completed over various phases, this report deals with the initial stages of Phase 1 which consisted of eight simulation exercises using Scenario One (see 1.4.4).

1.2 Objectives

The SIMMOD Investigation aimed to evaluate each of the following objectives both individually and in conjunction with one another. The objectives of the simulation were:

- to evaluate the effect of new SID and STAR procedures,
- to examine the impact a ceiling level change of FL245 to FL155 within the TMA on workload, and
- to evaluate the effect of radar in the Thessaloniki TMA.

[1] SIMMOD is the FAA's airspace and airport simulation model. See Annex A for details

1.3 Simulation method - SIMMOD

EUROCONTROL uses SIMMOD software in conjunction with specialised pre- and post-processors to analyse airspace and airfield systems. SIMMOD models the aircraft flight, both in the air and on the ground, gathering statistics for each aircraft. These statistics are processed to return aircraft travel and delay times, estimates of sector workload indices, and a graphical animation of the simulation.

The simulation data were provided by the HCAA authorities and developed for the simulation. The data included airspace and airfield descriptions for the existing situation and the proposed modifications necessary to achieve the objectives. Further details regarding SIMMOD can be found in Annex A.

1.4 Simulation Environment

1.4.1 Traffic Samples

The initial traffic sample was provided by the HCAA, a 24 hour sample issued from a busy 1994 day. This traffic sample, comprising of some 250 aircraft (IFR, VFR and MILITARY) was expanded by Eurocontrol Headquarters to forecast traffic for 1997 and the year 2000.

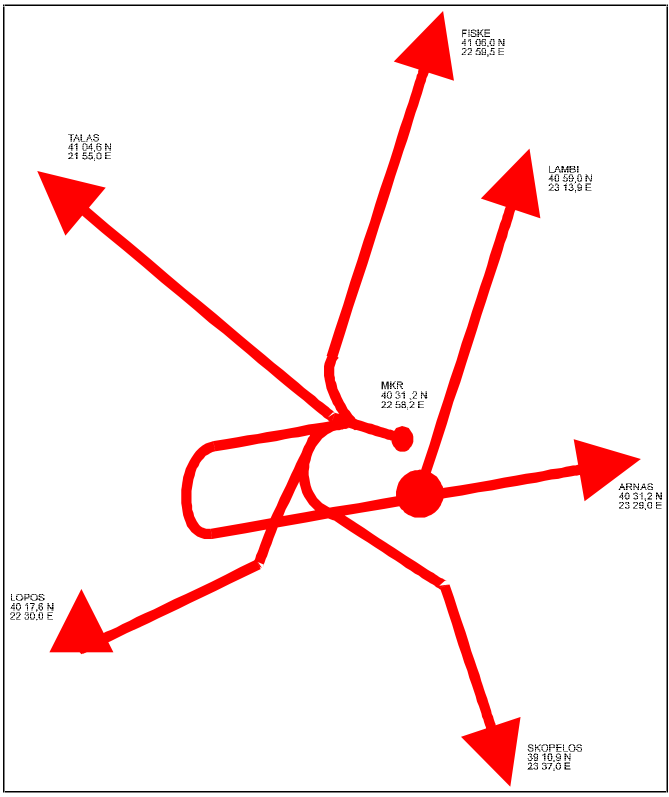
1.4.2 Separation Standards

The following separation minima were applied to the whole of the simulation area for all the scenarios:

- Vertical separation: 1000 feet
- Radar separation: 5nm
- Procedural separation: In order to achieve the required interval between successive landings on runway 16, whilst adhering to the applicable separation minima, the point 15DME from MIKRA-VOR/DME on R344 was specified as a check point for timing successive approaches every 5 minutes. This point will be referred to as MKR15 in this report. VFR traffic was integrated into the arrival and departure sequences with the applicable separation minima.

1.4.3 SID and STAR Procedures

New Standard DEPARTURE Procedures were introduced in conjunction with the new RADAR procedures. The Standard ARRIVAL Procedures remained the same as before.



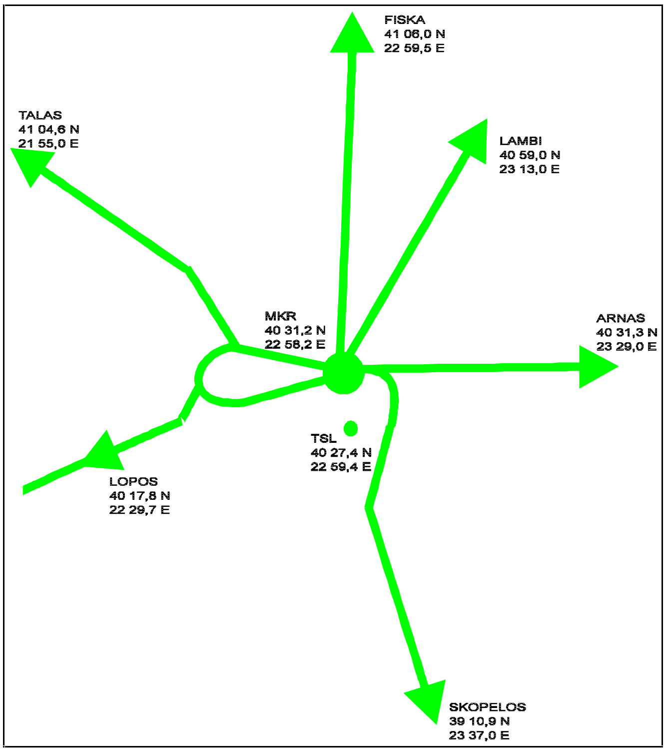
OLD STANDARD DEPARTURE CHART

The diagram on the left illustrates the original Standard Departure Chart.

The original SIDs had the indication, 1E, and had been in force since March 1993. These SIDs required more than one radio aid, namely, TSL/VORTAC, MKR/VOR-DME and TSL-NDB. As these radio aids were inter-dependant, problems arose if one radio aid was out of action.

The diagram on the right illustrates the New Standard Departure Procedures.

The new SIDs have either the indication 2E (except LOPOS with 1P) and are related to MKR/VOR-DME or the indication 1N related to TSL/VORTAC. Both the 2E SIDs and the 1N SIDs produce the same results, thus, for the purposes of this simulation, it was decided to use only the 2E SIDs



NEW STANDARD DEPARTURE CHART

1.4.4 Simulation Scenarios

Three scenarios were planned:

- Scenario One : Runway 16 arrivals
  Runway 28 departures
- Scenario Two : Runway 34 arrivals and departures (CIVIL)
  Runway 28 arrivals and departures (MILITARY)
- Scenario Three : Runway 16 arrivals and departures (CIVIL)
  Runway 10 arrivals and departures (MILITARY)

This report discusses only Phase 1, using Scenario One, which is the situation 65-70% of the time at MAKEDONIA Airport.

The table below gives a brief summary of the eight simulation exercises used in the simulation study

Scenario	Traffic Sample	SID/STAR case	TMA Ceiling	AC Separations
TSB (Basecase)	1994	Old	245	Procedural
TS1	1997	Old	245	Procedural
TS2	1997	New	245	Procedural
TS3	1997	New	245	RADAR
TS4	1997	New	155	Procedural
TS5	1997	New	155	RADAR
TS6	2000	New	245	RADAR
TS7	2000	New	155	RADAR

1.5 Measurements

The following measurements were made for each scenario:

Total : The total number of aircraft in the TMA during the measured time slot
Entries : The number of aircraft entering each sector.
Climbs : Of the total aircraft, those with an exit level higher than the entry level.
Level : Of the total aircraft, those with the entry level equal to the exit level.
Descents : Of the total aircraft, those with the entry level higher than the exit level.
Peaks : The greatest number of flights present in the sector during the measured time slot.
Conflicts : The number of control actions required due to lack of separation.
Workload : An estimation of sector workload induced by the traffic.
Aircraft Holding Time : The average flight time, during the entire simulation period, of an aircraft in the sector.
Total Held : The total number of aircraft held at a particular holding point during the measured simulation period.
Max Held : The maximum number of aircraft held at a holding point at one time.
Holding Times : The time an aircraft was held at a particular holding point (Total, Average and Maximum).

Remarks concerning the measurements

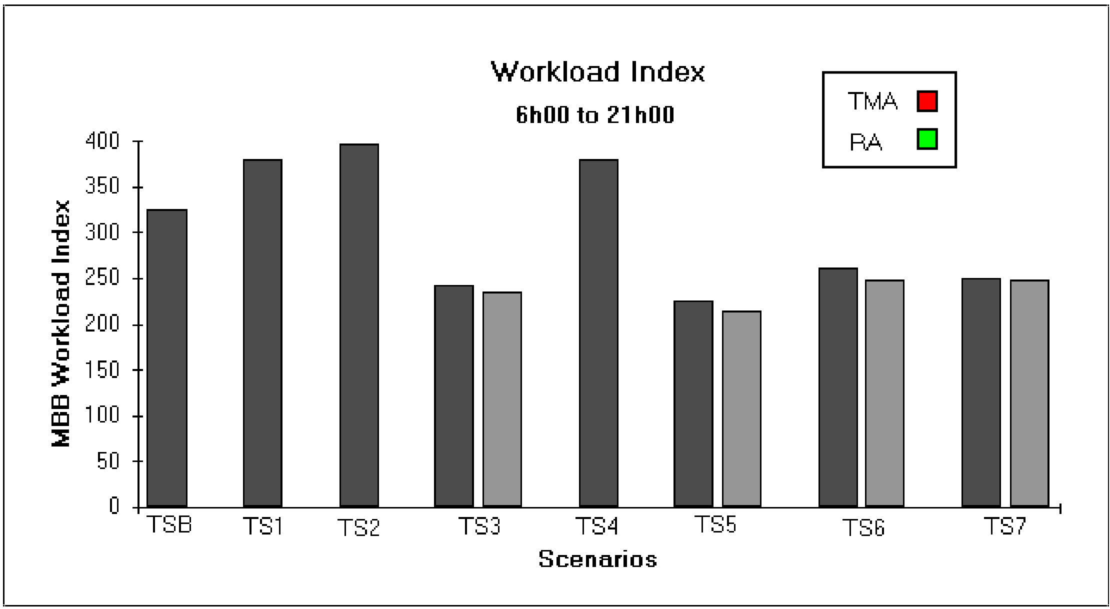
When SIMMOD detects a lack of defined separation it applies a delay to one or the other aircraft. The conflict results then indicate the separation problems which arose due to the traffic conditions but do not pretend to indicate that they were solved in the most efficient way in real world ATC terms. As such, they may not represent the actual number of conflicts which would have existed in a real situation but can be used to compare scenarios as they were all subjected to the same conflict resolution rules.

Workload measurements are derived from the application of a subset of the workload factors used in the method known as the MBB. The absolute values of the so-called ‘workload indices’ thus determined must be interpreted with care but comparisons between scenarios indicate whether or not overall workload was greater, equal or less.

Note: Complete tables of the above measurements can be found in Annex C.

2. RESULTS

Note: With the simulated traffic demand for the year 2000 it was found that the existing ground capacity was unable to cope with the predicted forecast. Therefore, in order to run the required simulation exercises it was necessary to increase the existing gate capacity. With the existing ground capacity it would have been impossible to accomplish the required number of operations and the resultant delay would have been high. The question of ground capacity will be further addressed in the Recommendation Section.



The diagram above illustrates the workload index figures for each scenario for the full simulation period (6h00 to 21h00).

The table on the right illustrates the actual workload indices for those scenarios where AC separations were procedural. Scenario TS1 represents the workload expected for the TMA given the existing sectorisation and procedures. When compared to the Basecase, TSB, we can see an increase (+54.76) in the workload as would be expected with the increase in traffic.

	Workload Indices **AC Separations Procedural**	
	TMA	Difference to TSB
TSB	324.78	0
TS1	379.54	+54.76
TS2	397.54	+72.86
TS4	379.16	+54.38

The implementation of the new Departure Procedures whilst maintaining a ceiling level of 245FL, as represented by scenario TS2, resulted in an even higher increase (+72.86) in workload when compared to the Basecase. This is due to the increase in Average Flight Time value which is slightly higher for TS2(11.48 minutes) than for either TS1 (10.72 minutes) or TSB (10.71 minutes). Scenario TS4 represents the implementation of both the new Departure Procedures and the lowering of the TMA ceiling to 155FL; this caused the workload index to increase (+54.38) when compared to the Basecase. This increase is not significantly lower than the workload index for TS1 (TS1 workload index = 379.54 and TS4 workload index = 379.16).

Significant changes in the workload indices can be seen in Scenarios TS3, TS5, TS6 and TS7. These Scenarios represent the implementation of RADAR procedures, which caused the airspace to be divided into two control regions, TMA and RA. Whilst the overall combined workload of the two control positions is higher than when one position is used; the resultant effect has been a balanced distribution of the workload between the two control regions; with each control position (TMA and

RA) having a much lower workload index than the single sector operational in scenarios TSB,TS1, TS2 and TS4. The diagram on page 9 illustrates quite clearly that there is a dramatic lowering of the sector workload indices in Scenarios TS3, TS5, TS6 and TS7.

Scenarios TS3 and TS5 show the effect of the use of RADAR in conjunction with the new Departure procedures using the traffic sample for 1997. TS5 differs from TS3 as the TMA ceiling has been lowered to 155FL, this added change causes the workload distribution for TS5 to be significantly lower than that of TS3, as shown by the table on the right.

	Workload Indices **AC Separation RADAR**		
	TS3	TS5	Difference (TS3-TS5)
TMA	242.04	224.66	-17.38
RA	235.50	214.20	-21.30

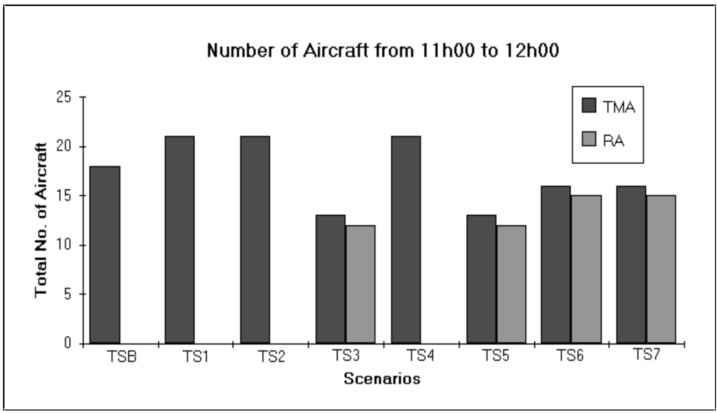
	Workload Indices **AC Separation RADAR**		
	TS6	TS7	Difference (TS6 - TS7)
TMA	261.14	249.32	-11.82
RA	248.00	248.00	0

Scenarios TS6 and TS7 show the effect of the new RADAR procedures in conjunction with the new Departure procedures using the traffic sample for the year 2000. TS7 differs from TS6 as the TMA ceiling has been lowered to 155FL, this added change causes the workload distribution for TS7, control region TMA, to be lower than that of TS6, as shown by the table above. The workload index for the RA control region remains the same. However, these values will change when these two scenarios are re-run using the HCAA approved traffic sample for the year 2000.

Moving from a global picture to a more detailed analysis, we now look at the busiest hour in the simulation period. The hour 11h00 to 12h00 was found to have the heaviest traffic flow and was thus chosen as the busiest hour. On the following pages we look at three possible factors (Total Number of Aircraft per Sector, Peak Number of Aircraft per Sector and Control Actions per Sector) that contribute towards determining the sector workload indices for the scenario’s sectors during the busiest hour (11h00 to 12h00).

Total Number of Aircraft per Sector, 11h00 to 12h00

	Total Number of Aircraft in Sector	
Scenario	TMA	RA
TSB	18	0
TS1	21	0
TS2	21	0
TS3	13	12
TS4	21	0
TS5	13	12
TS6	16	15
TS7	16	15

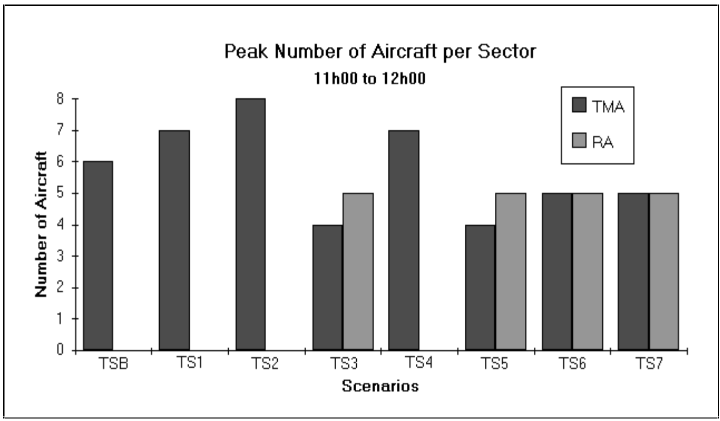


The table and the diagram above illustrate the number of aircraft in a sector for the busiest hour (11h00 to 12h00) of the simulation period.

Scenarios TS1, TS2 and TS4 all show the same result as the simulation area was represented by only one sector, namely, the TMA and all three scenarios used the same 1997 traffic sample. Scenarios TS3, TS5, TS6 and TS7 show the distribution for the two sectors, TMA and RA, used when Radar Procedures were implemented; the total numbers, for TS3 and TS5, are the same as both scenarios used the same 1997 traffic sample and, for TS6 and TS7 when the 2000 traffic sample was used. In Scenarios TS3, TS5, TS6 and TS7 the number of aircraft in sector TMA is greater than in sector RA.

Peak Number of Aircraft per Sector, 11h00 to 12h00

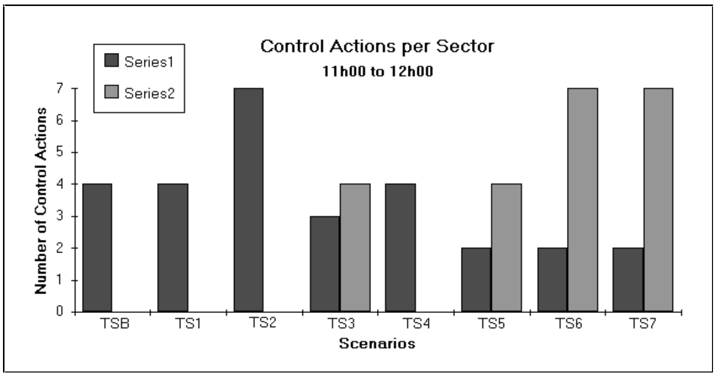
	Peak Number of Aircraft per Sector	
Scenario	TMA	RA
TSB	6	0
TS1	7	0
TS2	8	0
TS3	4	5
TS4	7	0
TS5	4	5
TS6	5	5
TS7	5	5



The table and Diagram above illustrate the Peak Number of Aircraft per Sector during 11h00 to 12h00. The Peak Number of Aircraft per Sector follow the same trend, seen later, as that of the Workload Indices for the busiest hour, 11h00 to 12h00.

Control Actions per Sector, 11h00 to 12h00

	Control Actions per Sector	
Scenario	TMA	RA
TSB	4	0
TS1	4	0
TS2	7	0
TS3	3	4
TS4	4	0
TS5	2	4
TS6	2	7
TS7	1	7



The table and diagram above illustrate the Control Actions per Sector during the busiest hour (11h00 to 12h00) of the simulation period.

Scenarios TSB, TS1, TS2 and TS4 show a fairly balanced set of results with TS2 as the exception. TS2 records the highest number of control actions (7). When Radar procedures are implemented (TS3, TS5, TS6 and TS7), sector RA has markedly more control actions recorded than sector TMA, particularly when the 2000 traffic sample (TS6 and TS7) was used. The number of Control Actions per Sector follow a similar trend, seen later, as that of the Workload Indices for the busiest hour, 11h00 to 12h00. This would indicate that the number of Control Actions per Sector plays a significant role in determining the resulting sector workload.

Workload Index per Sector, 11h00 to 12h00

	Workload Index per Sector	
Scenario	TMA	RA
TSB	46.2	n/a
TS1	53.3	n/a
TS2	62.6	n/a
TS3	34.4	36.0
TS4	53.3	n/a
TS5	34.1	36.0
TS6	38.6	41.4
TS7	38.6	41.4

The table and diagram above illustrate the Workload Indices per Sector during the busiest hour (11h00 to 12h00) of the simulation period.

The highest workload index is for TS2 (62.6); TS1 and TS4 both record the same result (53.3) implying that the implementation of the new Departure procedure and lowering the TMA ceiling to 155FL would not increase the controller workload, using the 1997 traffic sample. Scenarios TS3, TS5, TS6 and TS7, as expected, show lower workload indices as the simulation area is now divided into two control sectors. The TMA sector workload indices are slightly lower than the RA sector readings. When the 1997 traffic sample is used the workload indices are the same for both TS3 and TS5. The same exists for TS6 and TS7, however, the readings are slightly higher as the traffic sample used is for the year 2000.

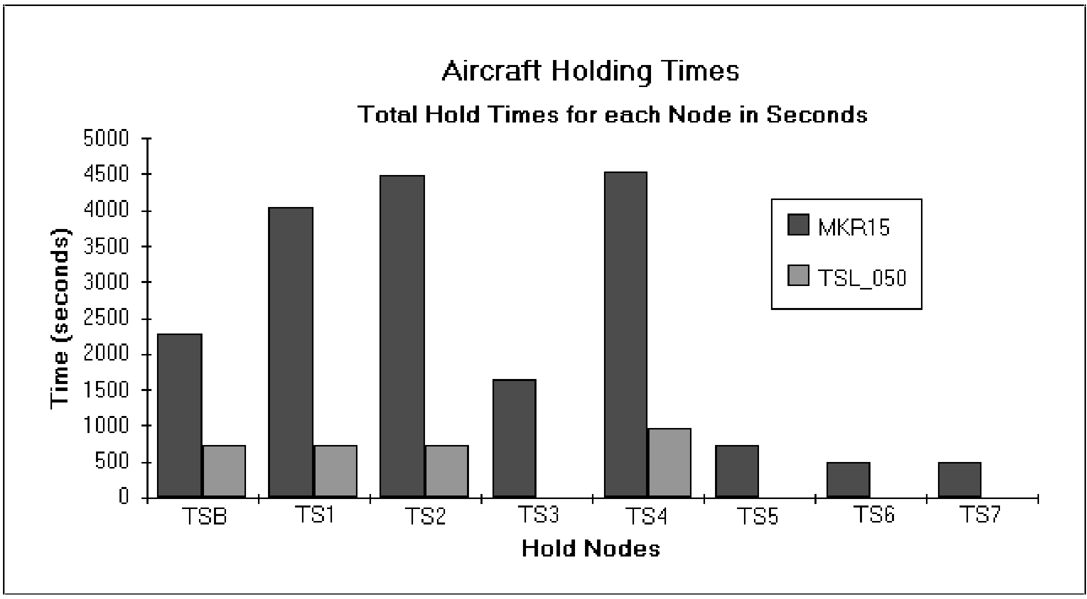
HOLDS

HOLD TIME (SECONDS)		
SCENARIO	HOLD NODE	TOTAL HOLD TIME
TSB	MKR15	2277.6
	TSL_050	720.0
TS1	MKR15	4048.8
	TSL_050	720.0
TS2	MKR15	4499.1
	TSL_050	720.0
TS3	MKR15	1635.6
TS4	MKR15	4537.5
	TSL_050	959.1
TS5	MKR15	719.9
TS6	MKR15	480.0
TS7	MKR15	480.0

The diagram below and the table on the left illustrate the Total Holding Times for the Holding Nodes used, primarily, for arrivals landing on Runway 16. When Radar Procedures are implemented (TS3, TS5, TS6 and TS7 scenarios) only one hold is used, namely, MKR15.

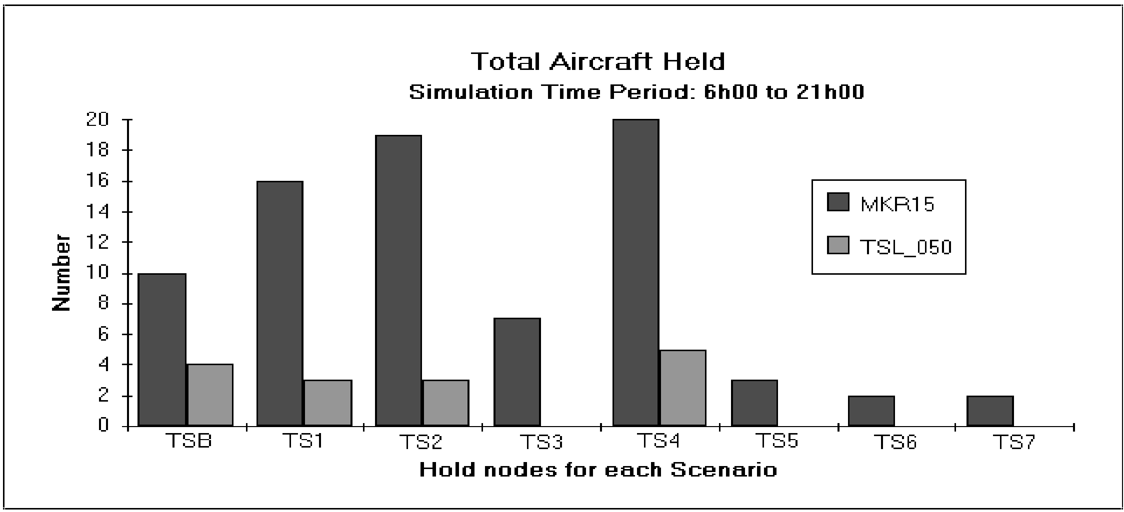
The Total Holding Time for MKR15 increases dramatically with the increase in traffic expected for 1997 (Scenarios TS1, TS2 and TS4) when compared to the Basecase (TSB). The implementation of the New Departure Procedure (Scenarios TS2 and TS4) results in an increase in Total Holding time and the lowering of the TMA ceiling to 155FL (Scenario TS4) results in the highest Total Holding Time (4537.5 seconds). The implementation of the Radar procedures (Scenarios TS3, TS5, TS6, TS7) causes the Total Holding Time for MKR15 to decrease when compared to the Basecase. This is due directly to the smaller number of aircraft that are forced to hold when the Radar procedures are in operation.

The Total Holding Time for TSL_050 remains fairly consistent for Scenarios TSB, TS1 and TS2; however, with the lowering of the TMA ceiling to 155FL (Scenario TS4) the Total Holding Time increases. TSL_050 is not used by the aircraft when Radar procedures are in use and the results are thus zero for these scenarios.

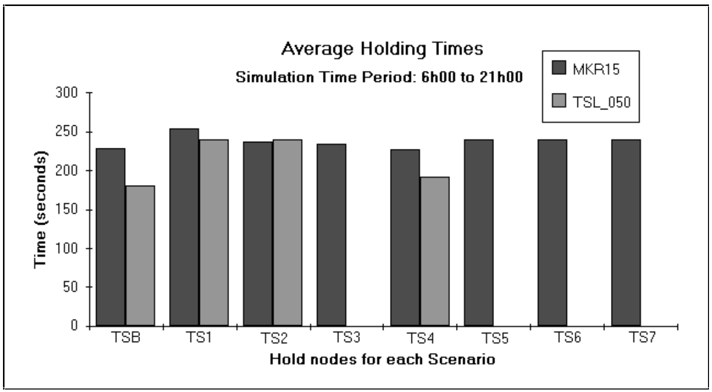


NUMBER OF AIRCRAFT HELD (from 6h00 to 21h00)		
SCENARIO	HOLD NODE	TOTAL
TSB	MKR15	10
	TSL_050	4
TS1	MKR15	16
	TSL_050	3
TS2	MKR15	19
	TSL_050	3
TS3	MKR15	7
	TSL_050	0
TS4	MKR15	20
	TSL_050	5
TS5	MKR15	3
	TSL_050	0
TS6	MKR15	2
	TSL_050	0
TS7	MKR15	2
	TSL_050	0

The diagram below and the table on the left illustrate the number of aircraft held during each scenario for the total simulation time period (6h00 to 21h00). The trend is exactly the same as the trend seen for the Total Holding Times. Indicating that the number of aircraft held directly effects the Total Holding Time for each node.



The diagram on the right illustrates the average holding time for each Scenario. Here, the results show only a slight variation between the scenarios. This is a positive result as it indicates that aircraft are not spending a long time in the hold.



3. CONCLUSIONS

- **The effect of the new Standard Departure Procedures**
  Under present procedural conditions, the benefits of the new Standard Departure Procedures were not obvious (scenario TS2) as the new procedures saw an increase in control actions, average flight time and in the overal workload index when compared to scenario TS1.

- **The effect of the new Standard Departure Procedures with the TMA ceiling lowered to 155FL**
  The implementation of the new Standard Departure Procedures with the TMA ceiling lowered to 155FL showed a small decrease in the workload index (scenario TS4 compared with TS1). Small reductions were recorded in the number of control actions and average flight time for scenario TS4.

- **The effect of the new Standard Departure Procedures with the TMA ceiling lowered to 155FL and implementation of radar in the Thessaloniki TMA**
  With the implementation of radar the TMA was divided into two radar working positions (called sectors TMA and RA in this simulation). This resulted in a distributed workload over the two sectors that was considerably lower than with the one sector under procedural control. The lowering of the TMA ceiling under radar was beneficial and resulted in the best distribution of workload indices (scenario TS5, traffic sample 1997, and scenario TS7, traffic sample 2000).

- **Ground Capacity**
  It was found that the present ground environment was unable to sustain the forecast traffic for the year 2000. It was necessary to increase the gate capacity with the simulation environment, in order to try and fulfil the objectives of the simulation.

4. THE NEXT PHASE

Phase Two of the Thessaliniki TMA Study will have the same objectives as Phase One, namely,

- to evaluate the effect of new SID and STAR procedures,
- to examine the impact a ceiling level change of FL245 to FL155 within the TMA on workload, and
- to evaluate the effect of radar in the Thessaloniki TMA.

The scenario, however, will have the following characteristic:

- scenario 2: RWY 34 arrivals and departures (CIVIL).
  RWY 28 arrivals and departures (MILITARY).

5. FINAL REPORT

The Final Report will be published upon the completion of the three phases scheduled for the Thessaloniki TMA Study. The Final Report will included detailed conclusions for each phase with a relevant recommendation section.

ANNEX A: SIMMOD DETAILS

How are the end results achieved ?

The complete air and ground system is represented by a network of points and connecting segments along which the aircraft 'navigate'. Along with other point qualities, an altitude is associated to each point. This altitude is usually derived from free profiles but can be modified to represent, for example, height restrictions, SIDs, STARs, etc.

The simulation module is the core of the SIMMOD system. The module traces the "steps" through time and space of each aircraft defined in the traffic sample from one point to the next along its route. Potential violations of any of the modelled separation requirements between two or more aircraft moving towards a given point are detected and then resolved by adjusting their arrival times at the point. Depending on the importance of this adjustment, the controller action deemed to be causing it is interpreted as either track adjustment, speed control, holding or re-routeing of aircraft. Such specific occurrences as overtaking in the air, shuffling aircraft in the departure queue, as well as many other ATC procedures and actions either on the aerodrome, in the approach/departure environment or in en-route airspace can be simulated by careful selection of the input parameters.

Input requirements

The SIMMOD input is constructed in a number of files. The validity and correctness of the input data is crucial for the accuracy and realism of the simulation. The SIMMOD files constructed will contain detailed information regarding:

- Geographical boundaries of airspace and restrictions,
- Geographical boundaries of sectors and restrictions (capacities),
- Points data and restrictions (separation standards),
- Route data and restrictions (separation standards),
- Airfield data and restrictions (aircraft size limitations),
- Aircraft data and restrictions (wake turbulence),
- Scheduling of events (list of flights), and
- Weather considerations (reduced visibility operations).

Output

Output data is produced in a report format which may also be converted into charts and graphs. The data available from SIMMOD includes:

Airfields, which includes:

- Runway utilisation,
- Ground delays at gates, holding points or during taxiing,
- Average times for completing ground movements.

Sectors, which includes:

- Total number of aircraft that crossed the sectors within a specified time period,

- Maximum number of aircraft in each sector's area of responsibility at any one time within a specified time period,
- Average flight times for the sectors,
- A workload index for the sectors, and
- Number of aircraft in level flight, climbing or descending for each sector within a specified time period.

Points, which includes:

- Rate of traffic flow over points,
- Number of aircraft climbing, descending or in level flight at a point,
- Number of potential conflicts that will require ATC intervention.

Routes, which includes:

- Average flight times on each route, and
- Number of aircraft on each route.

Simulation Animation

In addition to the output data, the SIMMOD post-processor module produces an animated high resolution colour display of the simulation. All aircraft can be displayed during all stages of flight, or ground movement, following procedures defined in the input data.

During the animation run various items can be analysed:

- Evolution of a traffic situation and traffic flow,
- A visual check of the simulation's realism,
- Verification that procedures defined for the model do not violate the defined separation specifications, and
- Areas of scheduling congestion can be located.

Disadvantages - Limitations

SIMMOD is designed as a "quick look" simulation tool and has the following limitations:

- No resolution of conflicts during a simulation by changing an aircraft's level, and
- A global view only, no detail regarding an individual controller or operating position

ANNEX B: WORKLOAD INDEX CALCULATIONS

The Workload Index is an attempt to assess the workload in a sector by attributing different weightings to various characteristics of the traffic in the sector. The workload index values produced for this report come from a partial implementation of the MBB[1] system which was based on the radio telecommunication load observed in ATC sectors. From these observations, a series of parameters were developed to indicate the relative importance of the characteristics of the traffic giving rise to this load.

In a SIMMOD simulation it is not possible to determine all the conditions necessary to apply **all** of the 13 parameters defined by the classic MBB method for estimating sector workloads. However it is possible to determine 7 of them:

- A scheduled flight transiting the sector,
- A climbing or descending flight,
- A flight transiting the UIR/FIR,
- A flight entering or leaving a TMA,
- A radar vectoring action on a flight,
- A flight being held at a designated hold point, and
- A potential conflict detected and resolved.

For the purposes of this study, these have been implemented as follows:

- For each aircraft which at any moment during the specified time period is within the sector's sectors of responsibility: Add 1 unit of work,
- If the altitude at the sector entry point is not equal to the altitude at the sector exit point: Add 0.24 units,
- If the flight occurs solely in the UIR/FIR: Add 0.26 units else add 0.38 units,
- For each SIMMOD control action (speed up, slow down or radar vectoring): Add 0.3 units,
- For each SIMMOD hold at a specified holding point: Add 0.6 units, and
- For each potential conflict detected and resolved by a control action (speed up, slow down, vectoring or hold - whether at a specified holding point or not): Add 1.4 units.

Whilst the system must necessarily be viewed as an approximation, it does give an indication of the density of the traffic in a sector and the complexity of the controllers' tasks. As such, the values quoted in this report can reasonably be used for comparing the workload between sectors.

[1] MBB as defined in the report "Methods for the Determination of the Control Capacity of ATC Services" by Klaus Brauser, Messerschmitt-Bolkov-Blohm, Gmbh, 14/11/75.

ANNEX C : DATA MEASUREMENTS

Time: 6h00 to 21h00

Scenario	Sector	No. of Aircraft	Peak	Average Flight Time	Control Actions	MBB Workload
TSB	TMA	155	7	10.71	18	324.78
TS1	TMA	174	9	10.72	21	379.54
TS2	TMA	174	8	11.48	26	397.64
TS3	TMA	136	6	9.55	8	242.04
	RA	103	5	5.86	14	235.50
TS4	TMA	166	8	10.64	20	379.16
TS5	TMA	128	5	8.30	7	224.66
	RA	103	5	5.69	11	214.20
TS6	TMA	154	6	9.63	5	261.14
	RA	117	5	6.07	23	248.00
TS7	TMA	145	6	8.36	5	249.32
	RA	117	5	6.08	23	248.00

Time: 7h00 to 8h00

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	15	6	2	34.66
TS1	TMA	17	6	2	38.46
TS2	TMA	17	6	3	41.36
TS3	TMA	15	4	1	28.16
	RA	9	4	2	25.3
TS4	TMA	16	6	2	40.4
TS5	TMA	14	4	1	26.9
	RA	9	4	2	25.3
TS6	TMA	15	4	0	27.86
	RA	9	4	2	23.9
TS7	TMA	14	4	0	26.6
	RA	9	4	2	23.9

Time: 8h00 to 9h00

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	15	7	2	29.06
TS1	TMA	17	9	3	43.76
TS2	TMA	17	8	1	38.96
TS3	TMA	12	6	0	17.76
	RA	12	3	3	36.7
TS4	TMA	16	8	3	43.3
TS5	TMA	11	5	0	16.5
	RA	12	3	0	19.4
TS6	TMA	12	6	0	17.76
	RA	12	3	4	30.4
TS7	TMA	11	6	0	16.5
	RA	12	3	4	30.4

Time: 9h00 to 10h00

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	10	7	0	15
TS1	TMA	11	6	0	16.5
TS2	TMA	12	5	0	18
TS3	TMA	7	2	0	10.5
	RA	7	3	0	10.5
TS4	TMA	11	6	0	16.5
TS5	TMA	7	2	0	10.5
	RA	7	3	0	10.5
TS6	TMA	6	2	0	9
	RA	9	4	0	13.5
TS7	TMA	6	2	0	9
	RA	9	4	0	13.5

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	11	6	0	24.5
TS1	TMA	15	7	0	30.5
TS2	TMA	15	7	0	32.5
TS3	TMA	15	6	0	22.5
	RA	7	2	0	10.5
TS4	TMA	15	6	0	32.5
TS5	TMA	15	5	0	22.5
	RA	7	2	0	10.5
TS6	TMA	17	6	0	25.5
	RA	7	2	0	10.5
TS7	TMA	17	5	0	25.5
	RA	7	2	0	10.5

Time: 11h00 12h00

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	18	6	4	46.2
TS1	TMA	21	7	4	53.3
TS2	TMA	21	8	7	62.6
TS3	TMA	13	4	3	34.4
	RA	12	5	4	36
TS4	TMA	21	7	4	53.3
TS5	TMA	13	4	2	34.1
	RA	12	5	4	36
TS6	TMA	16	5	2	38.6
	RA	15	5	7	41.4
TS7	TMA	16	5	2	38.6
	RA	15	5	7	41.4

Time: 12h00 to 13h00

Scenario	Sector	No.of Aircraft	Peak	Control Actions	MBB Workload
TSB	TMA	13	4	0	23.26
TS1	TMA	17	6	3	46.32
TS2	TMA	15	6	4	43.62
TS3	TMA	13	4	4	39.82
	RA	10	3	0	22.4
TS4	TMA	15	6	3	43.8
TS5	TMA	12	4	3	31.5
	RA	10	3	0	18.4
TS6	TMA	18	5	3	40.26
	RA	13	4	4	31.1
TS7	TMA	15	5	3	36
	RA	13	4	4	31.1

Sector Loads Table

Scenario	Sector	Number of Aircraft				Control Actions	MBB Workload
		Total	Level	Climb	Descent		
TSB	TMA	155	8	55	92	18	325
TS1	TMA	174	9	62	103	21	380
TS2	TMA	174	9	62	103	26	398
TS3	TMA	136	9	62	65	8	242
	RA	103	0	0	103	14	235
TS4	TMA	166	1	62	103	20	379
TS5	TMA	128	1	62	65	7	225
	RA	103	0	0	103	11	214
TS6	TMA	154	9	71	74	5	261
	RA	117	0	0	117	23	248
TS7	TMA	145	2	70	73	5	249
	RA	117	0	0	117	23	248

Aircraft Holding Time.

Scenario	Node Name	Simmod No.	Total Held	Max Held	Total Flights	Holds Times (seconds)		
						Total	Ave	Max
TSB	MKR15	1291	10	1	58	2277.6	227.8	240
	TSL_050	1003	4	1	28	720	180	240
TS1	MKR15	1291	16	1	65	4048.8	253.1	480
	TSL_050	1003	3	1	31	720	240	240
TS2	MKR15	1291	19	1	65	4499.1	236.8	480
	TSL_050	1003	3	1	31	720	240	240
TS3	MKR15	1291	7	1	65	1635.6	233.7	240
TS4	MKR15	1291	20	1	65	4537.5	226.9	360
	TSL_050	1003	5	1	31	959.1	191.8	240
TS5	MKR15	1291	3	1	65	719.9	240	240
TS6	MKR15	1291	2	1	73	480	240	240
TS7	MKR15	1291	2	1	73	480	240	240