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SECTOR CAPACITY ASSESSMENT FOR DUBLIN ACC

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Abstract:
This report presents an assessment of sector capacity carried out for Dublin Area Control Centre using the EUROCONTROL capacity analyser. The Irish Aviation Authority requested this study to provide the CFMU with sector capacity figures.
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1. INTRODUCTION

This document presents an assessment of sector capacity carried out for the Dublin ACC using the EUROCONTROL ATC Capacity Analyser.

In 1997, the Irish Aviation Authority (IAA) requested the assistance of EUROCONTROL for a review and update of sector capacity figures for its airspace. This review was designed to provide the Central Flow Management Unit with new figures of sector capacity. The method selected to derive sector capacity figures was the ATC Capacity Analyser (CAPAN), a simulation tool developed by EUROCONTROL under its’ Studies Tests and Applied Research (STAR) programme.

The Dublin study was conducted during late 1997 and early 1998 at the EUROCONTROL Experimental Centre in Brétigny.

It should be noted that it is the sole responsibility of the IAA to issue declared capacity values for it’s sectors. The values presented and discussed in this report shall not, under any circumstances, be considered as declared capacity values.
2. GENERAL DESCRIPTION OF THE AIRSPACE

The Dublin ACC provides Air Traffic Services within the limits of the Dublin FIR. The airspace is normally divided into two en-route sectors and a single approach sector. As a result of the Airspace Model Simulation of Irish Airspace (EEC Task F01) carried out in 1997, it was agreed to simulate the best option for sectorisation recommended by this study.

The two en-route sectors, Dublin Area North and Dublin Area South which became operational in April 1996 were simulated and Dublin Approach Sector. A Dublin Departure Sector was also simulated with an upper limit of FL095.

The Dublin Area North and South sectors combined had a southern boundary which ran from the south-east corner of the Shannon FIR, just south of VATRY, through BEPAN, to 0730W and then northwards to the northern edge of the B1, turning north-eastwards along the eastern edge of the RINUS/DEGOS track to the Shannon/Scottish boundary. The area west of 0630W containing the B1, W14, W12 and W10 airways was delegated to Shannon LOW between FL195 and FL245. Elsewhere, the Dublin sectors controlled up to FL245.

The Dublin Departure sector which was small and box-shaped, extended from RSH and KLY in the east to 0630W. The Radar Controller (RC) and Flight Data Controller (FDC) manning the sector dealt only with departures from Dublin, handing them off separated and without coordination to Dublin Area North and South sectors.

Aircraft were modelled down to and up from runway 28 at Dublin.

2.1. Sectorisation plan

For this study, the airspace was configured into four sectors.

These were:

<table>
<thead>
<tr>
<th>Sector Name</th>
<th>Sector Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dublin Area North</td>
<td>DWN</td>
</tr>
<tr>
<td>Dublin Area South</td>
<td>DWS</td>
</tr>
<tr>
<td>Dublin Departure</td>
<td>DDP</td>
</tr>
<tr>
<td>Dublin Approach</td>
<td>DAP</td>
</tr>
</tbody>
</table>

Table 1

A map of the simulated airspace is displayed on the next page.
3. TRAFFIC SAMPLE

The basic traffic sample used for the study was the same traffic sample used for the Fast Time Simulation study (F01) conducted on Irish Airspace during 1996 and 1997. These traffic records were prepared by the IAA and covered the 24 hour period of Saturday 22nd July 1995 and the 24 hour period for Friday 4th August 1995. The Saturday sample contained 1,252 flights and the Friday sample 1,085 flights.

Two three hour samples were selected from these traffic samples, one for each day. The three hour traffic sample for Saturday 22nd July, from 1140 to 1440, was used for the Capacity Study of Dublin.

A full breakdown and analysis of the original traffic sample is available in EEC Note No. 20/97, Airspace Model Simulation of Irish Airspace.
4. DESCRIPTION OF THE METHODOLOGY USED FOR CAPACITY ASSESSMENT

4.1. Overview

The ATC Capacity Analyser used for this study was developed by EUROCONTROL. This method of capacity assessment uses the EUROCONTROL Airspace Model as a simulation tool to generate the workloads on the simulated controller positions for a given traffic sample. On completion of a simulation run, the ATC Capacity Analyser analyses the loading recorded on the simulated controller positions of the sector whose capacity is being determined. These results are compared with pre-defined thresholds for workload and based on this analysis, the traffic sample for the sector is either increased or decreased and the simulation is re-run. This process is continued until the loading on the simulated working positions has reached the value fixed for this capacity study (68-71%).

EUROCONTROL Airspace Model

The EUROCONTROL Airspace Model is used by the Capacity Analyser to determine controller workloads for a given traffic sample. This is a critical event model which during the simulation treats a number of defined events in the life-cycle of a simulated flight, (for example, entry into the first simulated sector, exit from a sector, conflict search and resolution, etc). On completion of the simulation, an analysis package examines the resulting profiles of each aircraft and determines a defined number of tasks that were required of the controllers to process the flight. As each task has a defined execution time and working position(s), it is possible to determine the amount of work required to handle a given traffic sample.

The model has four main types of control and input data:

1) Airspace structure and route network,
2) Traffic samples,
3) ATC logic and procedures,
4) Controller task definitions.

When used for capacity assessment, all data and parameters are defined to the model, then simulated and the results analysed for conformity with the specifications. Thereafter, the only data changing between iterations of the model is the traffic sample.
4.2. Workload thresholds

As already discussed, the Airspace Model produces values representing the loading on the simulated working positions, and the Capacity Analyser compares these loadings to defined thresholds when determining if the capacity of the sector has been reached. The selection of these thresholds is of crucial importance in determination of capacity.

The determination in modelling of qualitative values (heavy load, light load, etc.) from quantitative values (numbers) is always one of empirical experimentation and is a function of the “realism” or “fidelity” of the model being used to the real world that is being simulated. The thresholds used by the ATC Capacity Analyser have been validated by several real time simulation studies.

The quantitative threshold values used and their corresponding qualitative interpretations are:

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Interpretation</th>
<th>Recorded working time during 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 % or above</td>
<td>Overload</td>
<td>42 minutes +</td>
</tr>
<tr>
<td>54 % - 69 %</td>
<td>Heavy Load</td>
<td>32 - 41 minutes</td>
</tr>
<tr>
<td>30 % - 53 %</td>
<td>Medium Load</td>
<td>18 - 31 minutes</td>
</tr>
<tr>
<td>18 % - 29%</td>
<td>Light Load</td>
<td>11 - 17 minutes</td>
</tr>
<tr>
<td>0 % - 17 %</td>
<td>Very Light Load</td>
<td>0 - 10 minutes</td>
</tr>
</tbody>
</table>

Table 2

It is important to note that the ATC Capacity Analyser records those workloads associated with identifiable control tasks defined to the model. It does not for example, record a specific task for general radar surveillance of traffic within a sector, nor are recuperation times recorded. The 70 % threshold, based on empirical experimentation, corresponds to 42 minutes measured working time in one hour, leaving 18 minutes time available for other tasks not defined within the model and also for general recuperation.

4.3. Variation in traffic position

In order to generate differing conflict situations within the sector being studied, several simulation runs are executed for a given traffic sample, generally between 5 and 30 simulation runs. The ATC Capacity Analyser applies random variations to entry times and aircraft performance, so that across several iterations, the conflicts detected within the sector are different and their resolution, and hence workloads, will vary between the different simulation runs. The workload value which is compared to the threshold is an average value from the different runs of the model.
4.4. Modification of traffic samples

After one iteration of several runs of the simulation, the Capacity Analyser determines the resulting workload on the control positions, and based on this analysis will proceed to increase or decrease the traffic flows by modifying the traffic sample being used. This modification of the traffic sample is carried out automatically and the choice of which individual flight is to be removed or added is of crucial importance to the process. It is well known that the same amount of traffic might generate significantly different workloads on the ATC system, and in order to modify traffic samples in a manner as objective as possible, the following technique is used:

4.4.1. Increasing the traffic sample

From analysis of the workload recorded during one iteration, a global percentage increase is specified to the traffic generation program. By analysis of the traffic flows within the sector, this global percentage is translated proportionally into number of flights per traffic flow. The flights to be added are selected from the real traffic found in the time period outside the simulated period. The entry times of these flights are modified to place them within the simulated period and to ensure that no artificial conflicts are created at the entry point. The construction of an augmented traffic sample is in this way designed to respect the relative importance of each traffic flow within the sector and also to respect the entry time distribution of the sector.

4.4.2. Reducing the traffic sample

When the workload analysis determines that the traffic is to be reduced, the reduction is carried out in a similar manner. The choice of flights to be eliminated is also done in a manner which is proportional to each traffic flow and which respects the hourly distribution of entry rates into the sector as observed in the basic traffic sample.
5. RESULTS OF THE STUDY

The ATC Capacity Analyser uses a precise examination of the controller workload recorded during the simulation run, to determine the sector capacity. When these workloads are at the overload threshold, the maximum theoretical capacity is deemed to have been achieved. The Capacity Analyser then examines the traffic of the capacity iteration containing the peak hour and produces three values:

The number of aircraft entering the sector during the peak 60 minutes.

The number of aircraft which have generated work for the sector during the peak hour. This is aimed at smoothing out the impact on a non-even traffic flow, in particular where bunching of traffic just before the peak hour will generate workloads but the volume of this traffic will not be correctly reflected in the capacity figures.

The number of aircraft entering the sector in the 60 minutes displaced by 3 minutes. This is to examine the effect of traffic anticipation on workload, as the work required to handle traffic starts before the actual entry into the sector.

The following table gives an overview of the results obtained for this study:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Acft entering during the peak hour</th>
<th>Acft generating workload of the peak hour</th>
<th>Acft entering during peak hour displaced by - 3 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWN</td>
<td>35</td>
<td>38</td>
<td>35</td>
</tr>
<tr>
<td>DWS</td>
<td>33</td>
<td>35</td>
<td>34</td>
</tr>
<tr>
<td>DDP</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>DAP</td>
<td>42</td>
<td>32</td>
<td>43</td>
</tr>
</tbody>
</table>

Table 3
5.1. Loadings recorded on the sector controller positions at capacity

The next table presents, for each of the simulated sectors, the actual loadings recorded on the simulated working positions during the final iterations of the ATC Capacity Analyser.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Acft generating workload of the peak hour</th>
<th>Average 60 minutes loading on the Executive controller</th>
<th>Average 60 minutes loading on the Planning controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWN</td>
<td>38</td>
<td>71%</td>
<td>31%</td>
</tr>
<tr>
<td>DWS</td>
<td>35</td>
<td>71%</td>
<td>30%</td>
</tr>
<tr>
<td>DDP</td>
<td>31</td>
<td>59%</td>
<td>-</td>
</tr>
<tr>
<td>DAP</td>
<td>32</td>
<td>68%</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4

From this table it can be seen that for all simulated sectors, the loadings on the executive controller position determined the capacity of the sector. All planning controller positions were lightly loaded with the sector at capacity.

The number of aircraft generating the workload of the peak hour, being based on workload generated rather than traffic flow rates, provides an appropriate measure of the sector capacity.

Note: A capacity figure for the Dublin departure sector was not achieved with the number of iterations available. This was due to the fact that the busy hour for the departure sector during the simulation run occurred during the last hour of the traffic sample. As the capacity analyser clones flights from the previous hour and/or the following hour the number of flights required to achieve the threshold for capacity could not be found.
6. CONCLUSION

The Dublin Departure sector, operating up to FL095, which is not yet operational, had a significant impact on the reduction in radar work for the radar controllers of the Dublin North (particularly) and South sectors by taking responsibility for any radar conflicts occurring shortly after take-off.

Dublin North sector had falls of 16% in total workload and 30% in radar workload, mainly due to the presence of the Departure sector. The Dublin South sector also benefited from the presence of a Departure sector but to a more modest degree. (See EEC Note No. 20/97 - Airspace Model Simulation of Irish Airspace). This should be taken into consideration when deciding capacity figures for the current (1998) sectorisation at Dublin, which does not include a Departure sector.

The levels of traffic calculated by the Capacity Analyser are intended to represent the maximum sustainable traffic capacity of the sector. At this point, additional traffic would be expected to overload the sector, and measures to restrict additional traffic would have to be introduced. With these considerations in mind, the following table recapitulates the assessed capacity, using the number of aircraft generating the workload of the peak hour as the measure of sector capacity. The table includes the actual time of the peak hour for each sector.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Assessed sector capacity (number of aircraft per hour)</th>
<th>Peak hour time (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWN</td>
<td>38</td>
<td>1338 - 1448</td>
</tr>
<tr>
<td>DWS</td>
<td>35</td>
<td>1344 - 1444</td>
</tr>
<tr>
<td>DDP</td>
<td>31</td>
<td>1340 - 1440</td>
</tr>
<tr>
<td>DAP</td>
<td>32</td>
<td>1411 - 1511</td>
</tr>
</tbody>
</table>

Table 5

In general, the peak traffic period for each sector occurred at the same time during the 3 hour period simulated, except in the case of the DAP sector where the peak hour was slightly later. This is as a result of the approach sector’s traffic being a follow on from the two enroute sectors busy times.

It is important to remember that the measurement of workload is derived from the mathematical calculation of the total working times recorded for each ATC task category (Flight data management; Coordinations; Conflict search; Routine R/T; Radar). The standard execution times for these tasks can not be dynamically altered during the course of a simulation exercise.
In reality however, at times of severe workload for the executive controller, the execution times of many of these tasks are accelerated. In fact some tasks relating to flight data management and R/T communications are often not executed. In addition, the coordinating controller may assist the executive controller by handling the internal and external coordination tasks normally attributed to the executive controller.

Another important element not considered in these simulations is what we call random system effects, that is the effect of system failures and non-standard operations covering aircraft alerts and emergencies, and also the effect of weather on operations. These effects can have a significant impact on the work, and hence the capacity of the sector.

However, please remember that sector capacity figures declared to the CFMU must always be based on normal operating conditions. When random effect situations exist the correct operating procedure is to call on the CFMU for an adjustment to the protection required.