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SECTOR CAPACITY ASSESSMENT FOR DÜSSELDORF ACC

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SECTOR CAPACITY ASSESSMENT FOR DÜSSELDORF ACC

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Abstract:

This report presents an assessment of sector capacity carried out for Düsseldorf Area Control Centre using the EUROCONTROL capacity analyser. This study was requested by the DFS to assist her in providing to CFMU sector capacity figures.

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AN ASSESSMENT OF THE SECTOR CAPACITY OF THE DÜSSELDORF ACC USING THE EUROCONTROL ATC CAPACITY ANALYSER

1. INTRODUCTION

This report presents an assessment of sector capacity carried out for the Düsseldorf Area Control Centre using the EUROCONTROL ATC Capacity Analyser.

In 1994, the German Air Traffic Control Authority, DFS Deutche Flugsicherung, requested the assistance of EUROCONTROL with a review and update of sector capacity figures for its airspace. This review is designed to provide the Central Flow Management Unit with new figures of sector capacity and to assist the DFS in planning to better meet present and future demand. The method selected to derive sector capacity figures was the ATC Capacity Analyser, a simulation tool developed by EUROCONTROL under its' Studies Tests and Applied Research (STAR) programme.

The Düsseldorf study was conducted during 1996 at the EUROCONTROL Experimental Centre in Brétigny.

It should be noted that it is the sole responsibility of the DFS to issue declared capacity values for it's sectors. The values presented and discussed in this report shall not, under any circumstance be considered as declared capacity values.

2. GENERAL DESCRIPTION OF THE AIRSPACE

The DÜSSELDORF ACC provides Air Traffic Services below FL245 in the western part of Germany, within the limits of the Düsseldorf Flight Information Region. The airspace simulated was composed of 8 sectors.

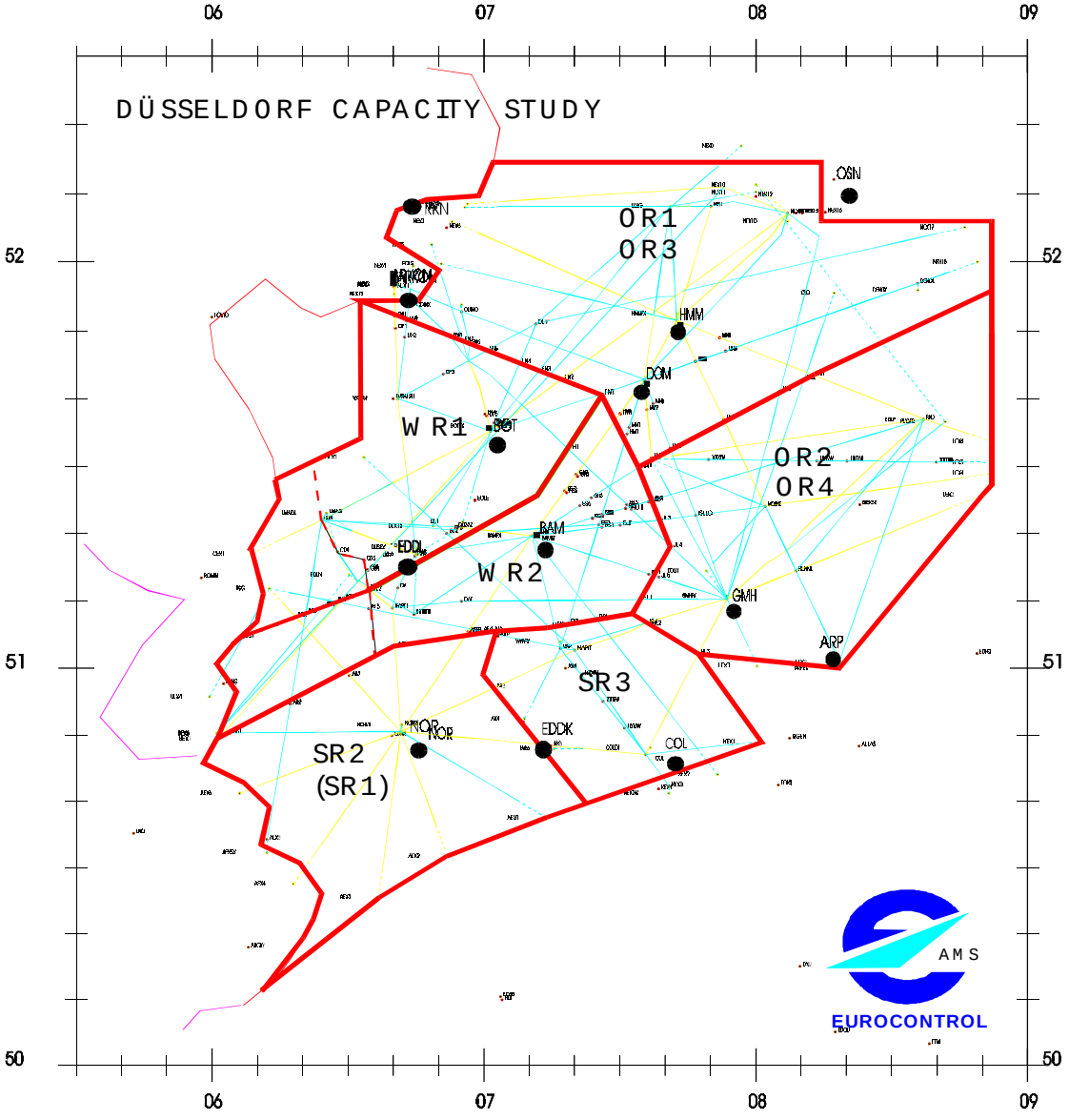
Many of the sectors are designed to cater the arriving and departing flows of Düsseldorf and Köln Airports.

2.1. Sectorisation Plan

For this study, the airspace was composed of the 8 following sectors:

Sector Name	Sector Code
West Radar 1	WR1
West Radar 2	WR2
Sud Radar 2	SR2
Sud Radar 3	SR 3
Ost Radar 1	OR 1
Ost Radar 2	OR 2
Ost Radar 3	OR 3
Ost Radar 4	OR4

The Düsseldorf and Köln feeder positions were not simulated.



3. TRAFFIC SAMPLE

The basic traffic sample used for the study was taken from traffic records prepared by DFS and covered the 24 hour period of Friday 10th September 1993. The basic 24 hour traffic sample contained 1443 flights.

3.1. Analysis by Aircraft Type

They were 115 different types of aircraft in the traffic sample. The 10 most frequent types of aircraft were

Aircraft Type	Number of Flights	Percentage of total traffic
B737S	284	20%
B737	122	9%
AT42	84	6%
FK50	63	4%
EA32	52	4%
MD80	49	3%
B757	46	3%
L101	34	2%
BA46	32	2%
DH8	32	2%

3.2. Analysis of Traffic Sample by Aerodrome

The following table contains a list of the 10 aerodromes that occurred most frequently in the traffic sample as aerodrome of departure or arrival:

Code	Departures	Arrivals	Airport Total	Percentage of Sample
EDDL	298	281	579	40%
EDDK	214	203	417	29%
EDDF	118	38	156	11%
EDBT	44	45	89	6%
EDDM	40	41	81	5%
LEPA	30	33	63	4%
EDLG	30	32	62	4%
EDLW	25	31	56	4%
EHAM	28	22	50	3%
EDDS	25	23	48	3%

4. DESCRIPTION OF THE METHODOLOGY USED FOR CAPACITY ASSESSMENT

4.1. Overview

The ATC Capacity Analyser used for this study was developed by EUROCONTROL under Task ORA1 of it's Studies Tests and Applied Research (STAR) programme. 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 heavy load threshold.

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:

- Airspace Structure and Route Network,
- Traffic Samples,
- ATC Logic and Procedures,
- 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:

Threshold	Interpretation	Recorded Working Time during 1 hour
70 % or above	Overload	42 minutes +
54 % - 69 %	Heavy Load	32 - 41 minutes
30 % - 53 %	Medium Load	18 - 31 minutes
18 % - 29%	Light Load	11 - 17 minutes
0 % - 17 %	Very Light Load	0 - 10 minutes

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 or 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 samples. 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 can generate significantly different workloads on the ATC system, and in order to modify traffic samples in an objective a manner 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 into specific number of flights per traffic flow, proportional to that 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 model simulation 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.

Sector	Acft entering during the peak hour	Acft generating workload of the peak hour	Acft entering during peak hour - 3 minutes
WR 1	42	43	41
WR 2	39	40	40
SR 2	41	42	41
SR 3	43	42	44
OR 1	48	51	46
OR 2	40	41	41
OR 3	39	40	41
OR 4	37	37	38

The results show a very small variation for the three measures, no more than one or two aircraft for most sectors. The differences for the OR1 sector indicate a small peak of traffic entering the sector at the start of the peak hour.

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.

Sector	Acft generating workload of the peak hour	Average 60 minute loading on the Radar Controller	Average 60 minute loading on the Co-ordinator
WR 1	43	71 %	64 %
WR 2	40	71 %	46 %
SR 2	42	70 %	61 %
SR 3	42	69 %	43 %
OR 1	51	72 %	49 %
OR 2	41	67 %	35 %
OR 3	40	71 %	54 %
OR 4	37	70 %	55 %

From this table it can be seen that for all simulated sectors, the loadings on the Radar Controller position determined the capacity of the sector. Most Coordinator positions were moderately loaded with the sector at capacity. However, the WR1 and SR2 Coordinator positions were heavily 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.

5.2. Modification of Traffic Sample for the study

The next table compares the number of aircraft per hour entering the sector when at capacity, as assessed by the Capacity Analyser, with the peak hour traffic volume found in the Basic Traffic Sample.

Sector	Acft entering during the peak hour	Basic Peak Hour Traffic	Change on Basic Traffic
WR 1	42	33	+ 27 %
WR 2	39	36	+ 8 %
SR 2	41	29	+ 41 %
SR 3	43	35	+ 23 %
OR 1	48	33	+ 45 %
OR 2	40	33	+ 21 %
OR 3	39	11	+ 255 %
OR 4	37	21	+ 76 %

It can be seen that for all sectors, the traffic levels at capacity was increased from the basic sample. While most increases in traffic are below 50 % and are thus considered within the bounds of model accuracy, the OR3 sector had very low traffic levels in the basic sample and required a 255 % increase in traffic to attain capacity workload threshold. This value should be considered with caution although the capacity value obtained is very close to those obtained with other sectors.

6. CONCLUSION

This study is the fifth in a series conducted for the DFS. In three of the previous studies, the traffic of sectors assessed at capacity were the subject of real-time simulation at the DESIM facilities at the ACC's. The participating controllers assessed the traffic conditions as being realistic and close to or at capacity levels.

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.

Sector	**Assessed Sector Capacity (Number of aircraft per hour)**	**Peak Hour Time (UTC)**
WR 1	43	0832-0931
WR 2	40	0739-0838
SR 2	42	0839-0938
SR 3	42	1217-1316
OR 1	51	0833-0932
OR 2	41	1416-1515
OR 3	40	0925-1024
OR 4	37	1502-1601

As can be seen, the peak traffic period for each sector occurred at widely differing times during the 24 hour period simulated. This also shows how unlikely it is to have all sectors experiencing peak traffic at similar times. It should be noted that the WR1 and WR2 sectors were not considered to be constrained by landing capacity at Dusseldorf airport.

An important element not considered in these simulations is what we may 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. Many of these effects can have a significant impact of the work, and hence the capacity of the sector. Both of these areas have a big impact on the flow control aspects of sector capacity. These factors must be considered when declaring sector capacity figures for flow control purposes. However their impact on the figures calculated using the ATC Capacity Analyser and modification for flow control is a matter of local judgement.