EUROPEAN ORGANISATION

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AIRSPACE MODEL SIMULATION OF THE BERLIN FIR/UIR (Phase I)

EEC TASK AF39
EEC NOTE No. 21/93

Approved for publication by:
Head of Division B1

Issued: December 1993

REPORT DOCUMENTATION PAGE

Reference: EEC Note No. 21/93	**Security Classification:** Unclassified
Originator Code: EEC Division B1	**Originator (Corporate Author) Name/Location:** EUROCONTROL Experimental Centre BP15 91222 Brétigny-sur-Orge CEDEX FRANCE Telephone : (1) 69 88 75 00
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TITLE:

AIRSPACE MODEL SIMULATION OF THE BERLIN FIR/UIR
PHASE I

Authors	Date	Pages	Figs.	Refs.	Appendices
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Detailed Task Specification	Period	Task No. Sponsor	Task No. Originator
EEC Task AF39	1993		AF39

Distribution Statement:
(a) Controlled by: Head of Division B1
(b) Special Limitations: None
(c) Copy to NTIS: No

Descriptors (keywords):
AF39 - Airspace Model Simulation - Arrival Delays - ATC Tasks - ATC Workload - Berlin FIR/UIR - Controller Loadings - Controller Workload - Coordinator - Departure Delays - Forecast Traffic Samples - Radar Controller - Routeings - Sectorisation

Abstract:
This report describes the first phase of a simulation study conducted using the EUROCONTROL Airspace Model on behalf of the DFS Deutsche Flugsicherung GmbH.

The study evaluated the effects of proposed new sectorisations, routeings, procedures and equipment on the approach, TMA and en route sectors contained within the Berlin FIR/UIR consequent on the release of military airspace for civil use.

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EEC Task AF39
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AIRSPACE MODEL SIMULATION OF THE BERLIN FIR/UIR (Phase I)

by
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SUMMARY

This report describes the first phase of a two-phase simulation study conducted on the Berlin FIR/UIR using the EUROCONTROL Airspace Model (EAM) on behalf of the DFS Deutsche Flugsicherung GmbH.

The objective of the study was to investigate the effects of proposed new sectorisations, routeings, procedures and equipment on the approach, TMA and en route sectors contained within the Berlin FIR/UIR consequent on the release of military airspace for civil use. The study examined the effects of the proposed changes on traffic distribution, controller workloads, distribution of work between sectors and between working positions, and penalties to traffic.

In all, four organisations were simulated: a reference organisation comprising the sectorisation, routeings and equipment in use on 18th September 1992 and using a traffic sample from that day and three proposed future organisations with the traffic sample enhanced by 50% (to reflect year 2000 traffic levels) and with the proposed sectorisation, routeings and equipment of each of the future scenarios.

The study concluded that in two of the future organisations the proposed sectorisation, routeings, procedures and equipment permitted the handling of future traffic levels without severe loadings on controller working positions or excessive penalties to traffic.

In particular, one organisation was shown to be the most efficient organisation in terms of the distribution of traffic, workload and loadings amongst the sectors while, at the same time, having the lowest amount of work per aircraft.

Nevertheless, some radar controller positions experienced heavy loadings and some sectors had high levels of traffic, so further optimisation will be required to address these problems as well as those concerning the interface between the Dresden and Leipzig approach areas and the effects of military traffic upon the system.

FOREWORD

In June 1992, the then BFS Bundesanstalt für Flugsicherung, now DFS Deutsche Flugsicherung GmbH, requested a simulation study to be carried out on the Berlin FIR/UIR using the EUROCONTROL Airspace Model.

The study was planned to be executed in two phases over two years.

Phase I of the study was assigned the EEC task number AF39. Outline specifications were defined in October 1992. A number of meetings between representatives of the Berlin/DFS and the EEC study team took place during the execution of the simulation in order to define the organisations to be tested and to review the results of the various stages of the study.

The objective of the study was to investigate the effects of proposed new sectorisations, routeings, procedures and equipment on the approach, TMA and en route sectors contained within the Berlin FIR/UIR consequent on the release of military airspace for civil use. The study examined the effects of the proposed changes on traffic distribution, controller workload, distribution of work between sectors and between working positions, and penalties to traffic.

The results were presented in Berlin on the 24th June 1993.

This report is organised into the following chapters:

Chapter 1 Objective and description of the study plus the input data used.

Chapter 2 Analysis of the results of reference organisation A.

Chapter 3 Analysis of the results of proposed organisation B.

Chapter 4 Analysis of the results of proposed organisation C.

Chapter 5 Analysis of the results of proposed organisation D.

Chapter 6 Comparison between the organisations.

Chapter 7 Summary and conclusions.

Detailed tables of results for the four organisations simulated in this study are contained in appendix D on pages 70 to 85.

1. INTRODUCTION

This chapter contains:

- The objective and general description of the study.
- A brief description of the organisations simulated.
- An outline of the traffic samples used.
- An explanation of the ATC tasks and controller percentage loadings recorded.
- The format of this report.

1.1. Objective and General Description

Objective

The objective of the study was to investigate the effects of proposed new sectorisations, routeings, procedures and equipment on the approach, TMA and en route sectors contained within the Berlin FIR/UIR consequent on the release of military airspace for civil use. The study examined the effects of the proposed changes on traffic distribution, controller workloads, distribution of work between sectors and between working positions, and penalties to traffic.

General Description of the Study

The airspace currently controlled by the TMA and en route sectors of the Berlin FIR/UIR and the same airspace adapted to the three proposed design specifications were simulated.

The current Dresden and Leipzig TMAs were simulated but not evaluated as their results were not relevant to the objective of this phase of the study.

1.2. Brief Description of the Simulated Organisations

Four organisations were simulated, one reference and three proposed.

In all organisations, Tegel, Tempelhof and Schönefeld airfields had arrivals simulated down to their respective final approach fixes (approximately 10nm from touchdown). The proposed future organisations included full stack management. Leipzig and Dresden arrivals exited simulated airspace at FL130. Departures from these five airfields were simulated from the ground upwards to ensure correct profiles exiting lower airspace.

For all exercises simulated, a westerly runway configuration was assumed to be in operation for all inbound and outbound traffic at all airports.

1.2.1. Berlin Reference Organisation A

The terminal area and en route sectorisation, control procedures, routes and equipment for both the BARTCC and Schönefeld centres which were in operation on the 18th September 1992 (the date of the traffic sample used) were simulated. This organisation was used mainly to validate the performance of the model. As the proposed organisations differed radically from the present-day scenario, only a very limited comparison will be made between the present and future organisations.

1.2.1.1. Sectors

A sector configuration typical of that necessary to cope with peak traffic conditions was simulated, i.e. 11 radar sectors (five BARTCC and six Schönefeld).

1.2.1.2. Working Positions

Each radar sector was manned by an Radar Controller (EC) and a Coordinator (CC).

The Assistant/Flight Data positions were not evaluated during the study.

1.2.1.3. Holding Stacks

Holding stacks were not simulated for the reference organisation.

1.2.1.4. Separation Standards

Within the BARTCC TMA a radar separation standard of 4nm was used and above that 6nm was used. Between BARTCC and its adjacent centres the standard used was 10nm except for Schönefeld and Karlsruhe where 20nm was employed.

In the Schönefeld TMA the separation used was 6nm with 8nm being used above that. Between Schönefeld and its adjacent centres the standard was 30nm except for BARTCC and Prague where it was 20nm.

1.2.1.5. Coordination

BARTCC was simulated using automatic data transfer with other centres except Schönefeld and silent handovers between its sectors. All coordination with Schönefeld took place over the telephone and radar handovers were used with BARTCC.

1.2.2. Proposed Organisations B, C and D

The terminal area and en route sectorisation, control procedures, routes and equipment detailed in the specifications for each proposed organisation were simulated. Each of these organisations was simulated with a year 2000 traffic sample, i.e. the sample for 18th September 1992 with a compound 5% per annum increase, giving an overall increase of 50% over 1992.

1.2.2.1. Equipment

The proposed organisations were simulated with ASCAP, DEPCOS and ACT in operation.

1.2.2.2. Sectors

In general, each proposed organisation consisted of the following sectorisation:

- Three high-level sectors covering the northern, central and southern portions of the airspace with a base of FL285. The exceptions to this were in organisation B where the northern high-level sector had a base of FL245 and the southern high-level sector a base of FL245 where it was not above the medium-level sector OR3.

- Six to eight medium-level en route sectors, generally CTA to FL285 except where they overlay the TMA sectors and a lower limit of FL135 where they overlay Leipzig and Dresden TMAs. In organisation B the north, south and south-east sectors had an upper limit of FL245.

- In organisation B one departure sector and two pick-up sectors were simulated up to FL205; no feeder sector was contained in this proposal. Organisation C proposed two departure sectors, north and south, and two pick-up sectors, all with an upper limit of FL165. The proposals for organisation D contained a low departure sector up to FL85 underneath a high departure sector. This high departure sector together with the two pick-up sectors had upper limits of FL205. In both organisations C and D a feeder sector was simulated, but not evaluated in the results, up to FL75 and FL85, respectively.

Maps detailing the complete sectorisations are contained in their relevant chapters.

1.2.2.3. Working Positions

Each radar sector was manned by a Radar Controller (EC) and a Coordinator (CC), with the exception of the north/south and high/low departure sectors in organisations C and D, respectively, where one CC had responsibility for both sectors.

The Assistant/Flight Data positions were not evaluated.

1.2.2.4. Holding Stacks and Ground Delays

Full stack management was simulated in all the proposed organisations. This involved the calculation by the model of both air and ground delays to aircraft based on times defined for the minimum interval between successive movements at the three Berlin airports. The values used were 1.5 minutes for Tegel and 2 minutes for both Schönefeld and Tempelhof. Where the model calculated a time interval between two successive movements at these airports as being less than the minimum interval value, the delay was absorbed in the holding stacks or on the ground. If no delay was required for an arrival then the aircraft did not enter the arrival stack.

Table 1 details the holding stacks used for each organisation.

Organisation	AIRPORT		
	Tegel	Schönefeld	Tempelhof
Org B	IAF Nord ("TPN") (FL100-FL200). SOLVU (FL120-FL200).	IAF Sued ("RSF") (FL100-FL200). FWE (FL100-FL200).	As Schönefeld.
Org C	IAF Nord ("TPN") (FL140-FL200). IAF Sued ("RSF") (FL140-FL200). IAF West (FL140-FL200).	As Tegel.	As Tegel.
Org D	IAF Nord ("TPN") (FL100-FL200). IAF Sued ("RSF") (FL100-FL200).	As Tegel.	As Tegel.

Table 1

1.2.2.5. Separation Standards

The separation standards used for BARTCC in the reference organisation were used for each sector in the proposed organisations, i.e. 4nm in the TMA sectors and 6nm elsewhere. Between Berlin and adjacent centres the standard used was 10nm except for Karlsruhe/Prague (20nm) and Warsaw (30nm).

1.2.2.6. Coordination

All proposed organisations were simulated using silent handovers between the sectors and automatic data transfer with other centres except Prague and Warsaw.

1.3. Traffic Samples Tested and Aircraft Performance Data

The specifications of the study required the detailed simulation for the reference organisation of a busy three-hour period taken from Berlin weekday records for 1992, with the same sample enhanced to forecast 2000 traffic levels being simulated for the three proposed organisations.

1.3.1. Traffic Sample Reference Organisation

The original traffic sample received contained 785 aircraft:

- Morning period 0438-0956 309 aircraft.
- Afternoon period 1225-1957 476 aircraft.

After the busiest three-hour sample for each period was extracted, the results were:

- Morning period 0455-0754 192 aircraft.
- Afternoon period 1305-1604 239 aircraft.

After analysis, the afternoon sample was chosen for simulation. A full breakdown of the original sample received and the one selected for simulation is contained in appendices A and B, pages 54 and 57.

1.3.2. Comparative Analysis of 1992 and 2000 Traffic Samples

For the proposed organisations B, C and D the basic traffic sample tested with the reference organisation was enhanced to year 2000 levels. This resulted in a 50% increase in GAT for the afternoon period simulated. In each of the future samples the routes flown by the aircraft were altered from the base sample to conform with the routeings proposed by each organisation.

A full breakdown of the future sample received with each proposed organisation is contained in appendix B on pages 58 to 60.

With future traffic samples, it should be borne in mind that the traffic levels foreseen may arise earlier or later than the year to which the forecast applies, and that significant unforeseen variations in the composition of the future traffic flows may occur.

1.3.3. Operational Air Traffic (OAT) Samples

As the primary objective of the first phase was to evaluate the TMA and medium level en route sectorisation proposals, it was decided not to include a representative OAT sample. Instead, this would be covered in the second phase when the civil/military interface would be known.

1.3.4. Summary of Traffic Samples Used

Table 2 summarises the four traffic samples simulated together with the details of their associated organisations.

ORG	TRAFFIC SAMPLE	ROUTE NETWORK	SECTOR-ISATION	EQUIPMENT
A	18th Sept 1992 239 Flights	18th Sept 1992	3 Upper 8 Lower (11)	18th Sept 1992
B	Future 366 Flights (+53%)	Future	3 Upper 8 Lower 2 Pick-up 1 Departure (14)	Future: ACT ASCAP DEPCOS
C	Future 358 Flights (+50%)	Future	3 Upper 7 Lower 2 Pick-up 2 Departure (14)	Future
D	Future 366 Flights (+53%)	Future	3 Upper 6 Lower 2 Pick-up 2 Departure (13)	Future

Table 2

1.3.5. Aircraft Performance Data

The airspace model recognises more than 200 different aircraft types. These types have been grouped into 60 categories of aircraft performance.

Detailed data on the cruising speed, climb/descent speed, and rates of climb/descent is available for each category of aircraft. The model can also distinguish between long, medium, and short range flights.

The data used has been derived from studies of aircraft performance, previous simulations, airline operating practices, and particular characteristics observed by operational controllers in each simulated area.

This aircraft performance data is used to construct the requested and actual profile of each aircraft within the simulated airspace.

Detailed information on the performance tables used in this simulation study may be obtained from the EUROCONTROL Experimental Centre, Sub-Division B1.3.

1.4. ATC Tasks and Controller Percentage Loadings

1.4.1. ATC Tasks

The airspace model analyses the progress of each flight as it transits the simulated area in order to detect the ATC actions necessary to process the flight. In determining these ATC actions, the model is capable of identifying and recording up to 110 different ATC tasks contained within five broad categories: ***flight data management***, ***coordination***, ***conflict search***, ***routine R/T***, and ***radar***.

Detailed descriptions of these tasks are contained in appendix C on page 61.

1.4.1.1. Flight Data Management Tasks

Flight data management tasks consist of, inter alia, the placement, verification, updating and removal of flight progress strips on the display board. Each sector was simulated with an individual strip display board. The tasks also include computer inputs such as "activating" or "overing" a flight.

1.4.1.2. Coordination Tasks

These tasks consist of the coordinations carried out with adjacent ATC units and within the simulated ATC unit, itself.

1.4.1.3. Conflict Search Tasks

Conflict search tasks represent the functions of detecting and resolving conflicts at cruising flight levels and of assuring sector crossing clearances.

1.4.1.4. Routine R/T Tasks

These tasks consist of the routine R/T work involved in the passage of an aircraft through a sector. They include the first call from the aircraft, level reports, instructions to the aircraft to comply with a new planning clearance, and the transfer of the aircraft to the next frequency.

1.4.1.5. Radar Tasks

The radar tasks recorded are divided into two main categories: radar supervisions, and radar interventions. These tasks also include radar handovers where a radar supervision or intervention is carried over to the next sector.

A ***radar supervision*** is the close monitoring of a potential conflict situation between two aircraft but where a tactical intervention is deemed unnecessary. Safe clearances such as "maintain heading" may be issued.

A ***radar intervention*** is the tactical alteration of an aircraft's heading, level or speed in order to ensure minimum radar separation between aircraft at all times.

There are nine types of radar conflicts identified by the model for the evaluation of radar workload on radar controllers:

Type 1 Same track, same level, both aircraft in cruise.
Type 2 Same track, one in cruise, one in climb or descent.
Type 3 Same track, both in climb or descent.
Type 4 Crossing tracks, same level, both aircraft in cruise.
Type 5 Crossing tracks, one in cruise, one in climb or descent.
Type 6 Crossing tracks, both in climb or descent.
Type 7 Opposite tracks, same level, both aircraft in cruise.
Type 8 Opposite tracks, one in cruise, one in climb or descent.
Type 9 Opposite tracks, both in climb or descent.

1.4.2. Controller Percentage Loadings

The ATC tasks recorded by the airspace model during a simulation are allocated to different working positions in accordance with the sector manning and distribution of duties specified for each sector. The model is, thus, able to calculate the percentage loading on each working position, either over the entire simulation period or over certain peak periods. Two values are generally used: the ***peak hour percentage loading*** and the ***average percentage loading***.

The ***peak hour percentage loading*** represents the total time spent by a working position on the tasks recorded by the model during the busiest 60 minute period for that position, and is expressed as a percentage of the 60 minutes. The actual time of the peak hour will vary from one position to another.

The peak hour percentage loadings are used to assess workload problems on individual working positions.

The ***average percentage loading*** represents the total time spent by a working position on the tasks recorded by the model for the duration of a simulation exercise (three hours), and is expressed as a percentage of that time.

The average percentage loadings are used primarily to assess the balance of workload between the working positions.

To assist in the interpretation of these loadings, approximate criteria are used to describe the nature of each loading.

Heavy peak hour loading - a loading in excess of 55%.

Severe peak hour loading - a loading in excess of 70%.

Heavy average loading - a loading in excess of 40%.

Severe average loading - a loading in excess of 50%.

1.5. Format and Presentation of the Results

An airspace model simulation produces a large number of results which can be classified as follows:

- Distribution of traffic in simulated sectors.
- Workload on sectors and individual working positions.
- Traffic loadings at different route points.
- Penalties imposed on traffic.

The results of this simulation study are presented in the following manner:

Chapter 2 Results of Berlin reference organisation A.

Chapter 3 Results of proposed organisation B.

Chapter 4 Results of proposed organisation C.

Chapter 5 Results of proposed organisation D.

Chapter 6 Comparison between the organisations.

Chapter 7 Summary and conclusions.

Sets of charts and tables are contained in each chapter showing the distribution of flights per sector, composition of total workload, and the percentage loadings on working positions.

2. BERLIN REFERENCE ORGANISATION A

The main purpose of the reference organisation was to test the validity of the airspace model in the Berlin environment. This was simulated using a three-hour traffic sample for the 18th September 1992.

Normally, a reference organisation is also used as a yardstick for measuring proposed changes in the airspace structure, but, as the proposed changes differed so radically from the present-day scenario, only limited comparisons can be made.

The Berlin reference organisation simulated the sectorisation, sector manning and ATC procedures normally applied in BARTCC and Schönefeld ACC during peak traffic conditions in 1992.

2.1 Sectors and Working Positions Simulated

2.1.1. Sectors

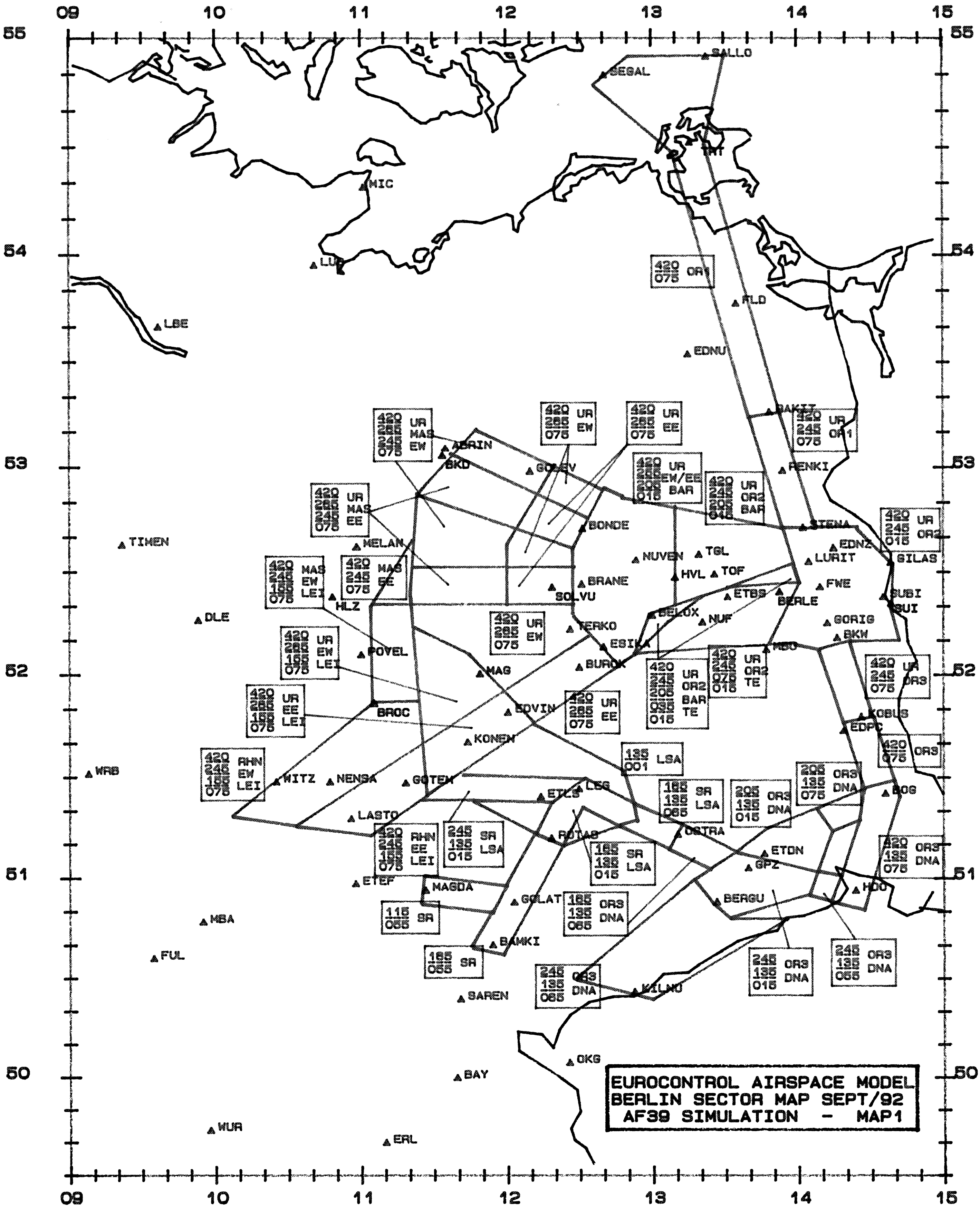
A sector configuration typical of that necessary to cope with peak traffic conditions was simulated as shown in **table 3**. Sector and route maps are shown on the following two pages.

CENTRE	SECTOR	ABBREVIATION
BARTCC 5 sectors	ARR DEP EW EE LEIPZIG	"BARA" "BARD" "LEIP"
Schönefeld ACC 6 sectors	OR1 OR2 OR3 SR TE UR	
Other sectors simulated but not measured	ETDN APP ETLS APP MAASTRICHT & KARLSRUHE (Delegated Airspace)	"DNA" "LSA" "MAS" "RHN"

Table 3

2.1.2. Working Positions

Each sector was simulated with a Radar Controller (EC) and a Coordinator (CC). The Assistant and Flight Data positions were not simulated.


EUROCONTROL AIRSPACE MODEL
BERLIN SECTOR MAP SEPT/92
AF39 SIMULATION - MAP1
SALLO
SEGAL
MIC
LBE
FLD
EDNU
TIMEN
DLE
WRB
MBA
FUL
WUR
ERL
BAY
OKG
SAREN
BAMKI
MAGDA
ETEF
LASTO
NENSA
KONEN
MAG
POVEL
HLZ
MELAN
BKD
BONDE
NUVEN
TGL
HVL
TOF
BRANE
SOLVU
ETBS
BERLE
NUF
TERKO
BURGK
BROC
EDVIN
GOTEN
ETCS
LEG
ROTAS
OSTRA
ETDN
GPZ
BERGU
HDO
BOG
KOBUS
EDPC
BKW
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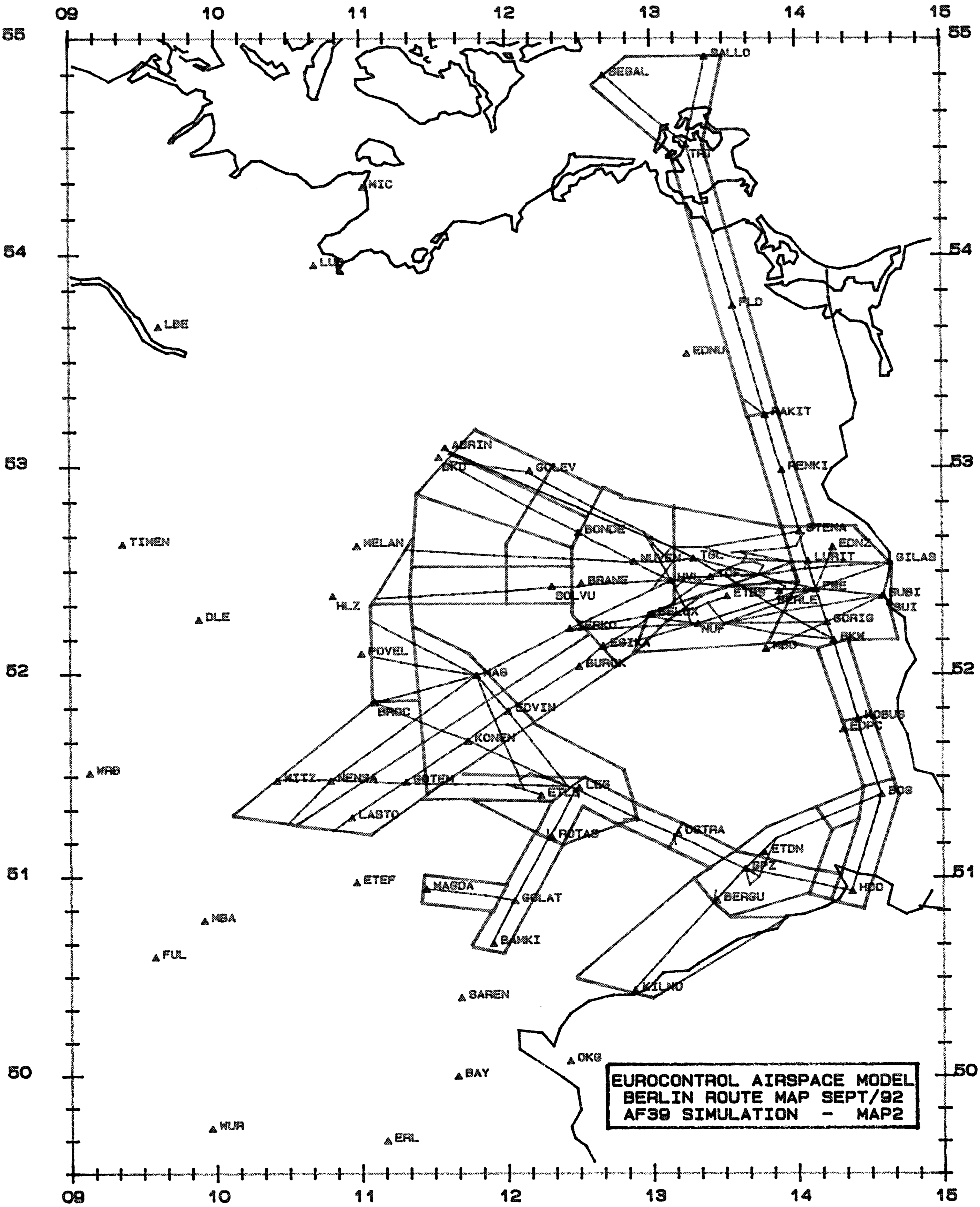
GILAS
RENKI
STENA


EUROCONTROL AIRSPACE MODEL
BERLIN ROUTE MAP SEPT/92
AF39 SIMULATION - MAP2
SALLO
SEGAL
MIC
LUB
LBE
PLD
EDNU
RAKIT
ABRIN
GOLEV
RENKI
BONDE
TIMEN
MELAN
TGL
GILAS
BRANE
SOLVU
HLZ
DLE
POVEL
BURUK
MAS
BRGC
EDVIN
KONEN
WRB
LASTO
ETEF
MAGDA
GOLAT
MBA
FUL
SAREN
OKG
BAY
WUR
ERL
BERGU
ETDN
HDO
BOG
DOBUS
EDPC
BKW
SUBI
SUI
ROTAS
MILNO
DOTRA
09 10 11 12 13 14 15
55 54 53 52 51 50

2.2. Distribution of Traffic - Berlin Reference Organisation A

Figure 1 shows the number of flights for each sector during the simulated period. A bar is shown for each sector designating the number of controlled flights entering this sector. In the case of three sectors, BARD, TE and UR, the upper part of the bar indicates the number of coordinated flights in these sectors, i.e. flights penetrating the sector whilst under the control of another.

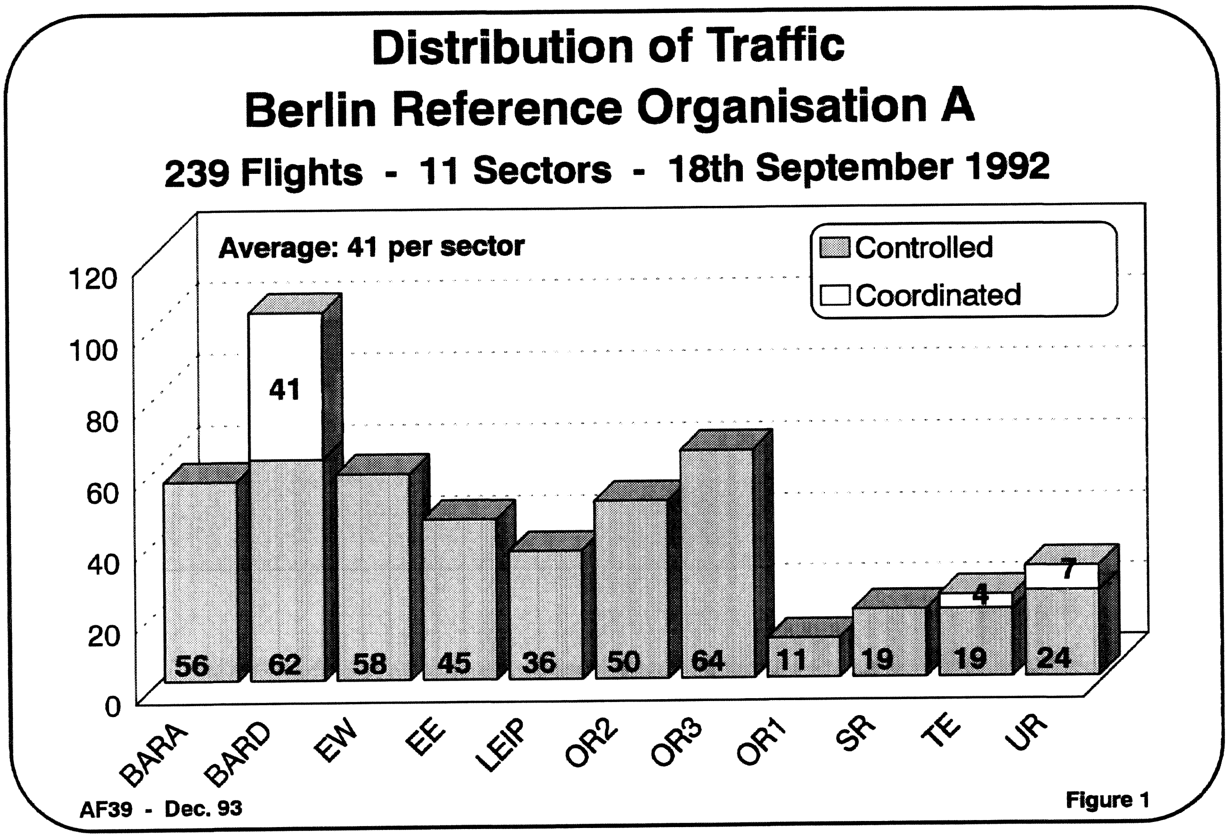


Figure 1

Firstly, the 41 coordinated flights shown for BARD are there for technical reasons to ensure that each arrival was coordinated by the arrival controller with the departure controller. This coordination was the only task generated in the departure sector with these flights. Discounting those flights for BARD and with the exception of the OR1, SR, TE and UR sectors, there was a reasonably good distribution of traffic amongst the sectors.

In the case of the UR and OR1 sectors, the traffic sample did not reflect the true situation here, e.g. no OAT traffic. The TE sector is virtually dependant on the Schönefeld arrival/departure traffic for its workload as is the SR sector in regard to Leipzig.

2.3. Workload Recorded - Berlin Reference Organisation A

Figure 2 gives the total workload in minutes recorded by each sector, i.e. by both the EC and CC combined.

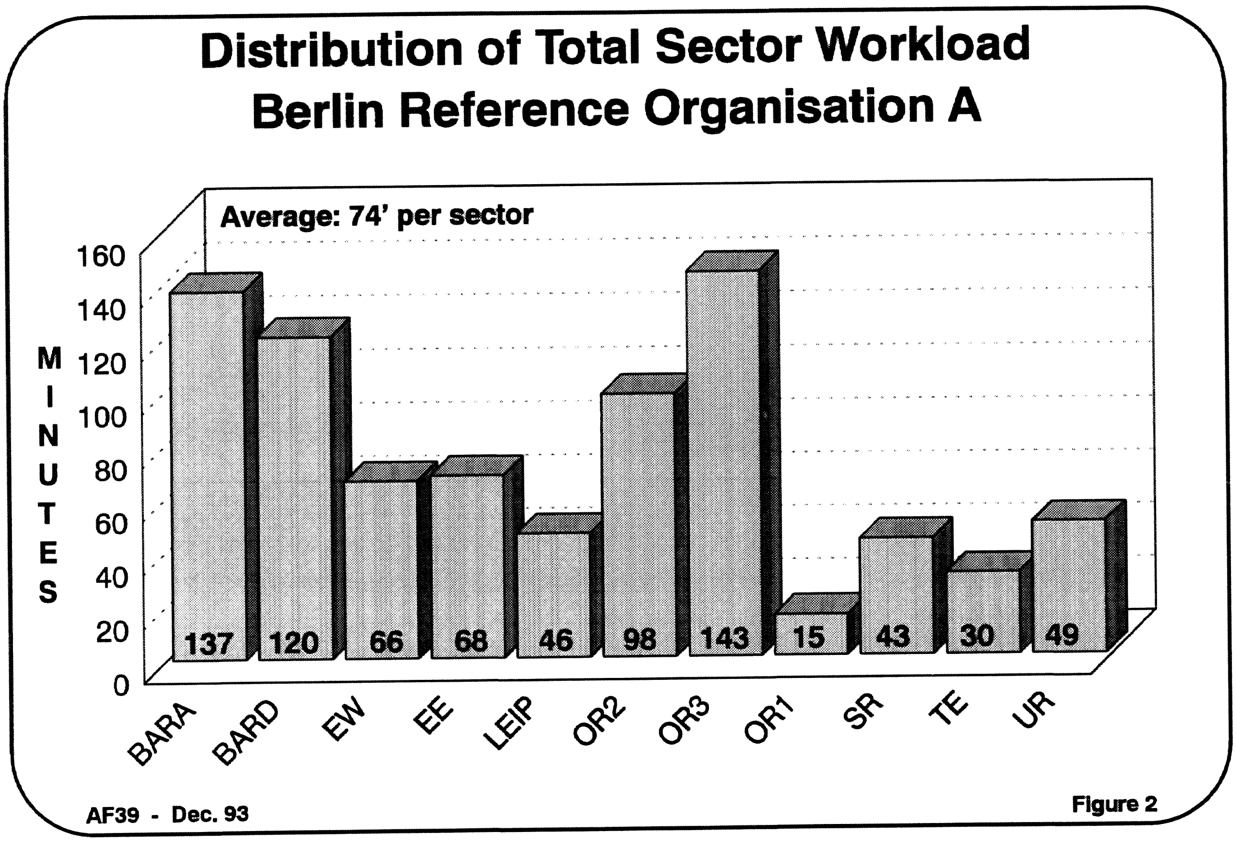


Figure 2

The results for the workload are in clear contrast to the distribution of traffic - a good example of the false indications the number of aircraft per sector can give where working methods differ.

Amongst the BARTCC sectors, the arrival sector had twice the workload of the en route east sector and three times the workload of the Leipzig sector. Similarly, the departure sector had virtually twice the workload of the en route west sector. The arrival and departure sectors had similar levels of workload, as had the en route east and west sectors.

With the Schönefeld sectors the contrast is even greater. Leaving aside the OR1 sector in making comparisons, OR3, with the highest total workload of all 11 sectors simulated, was approaching five times the workload of the TE sector and had more than three times that of the SR sector. Likewise, OR2 had more than three times the workload of the TE sector and more than twice that of SR.

An explanation for the differences in workload is given overleaf.

2.3.1. Composition of Workload - Berlin Reference Organisation A

Figure 3 shows the workload in minutes recorded for each of the five categories of ATC tasks (flight data management ["FDM"], coordination ["COORD"], conflict search ["CFS"], routine R/T and radar).

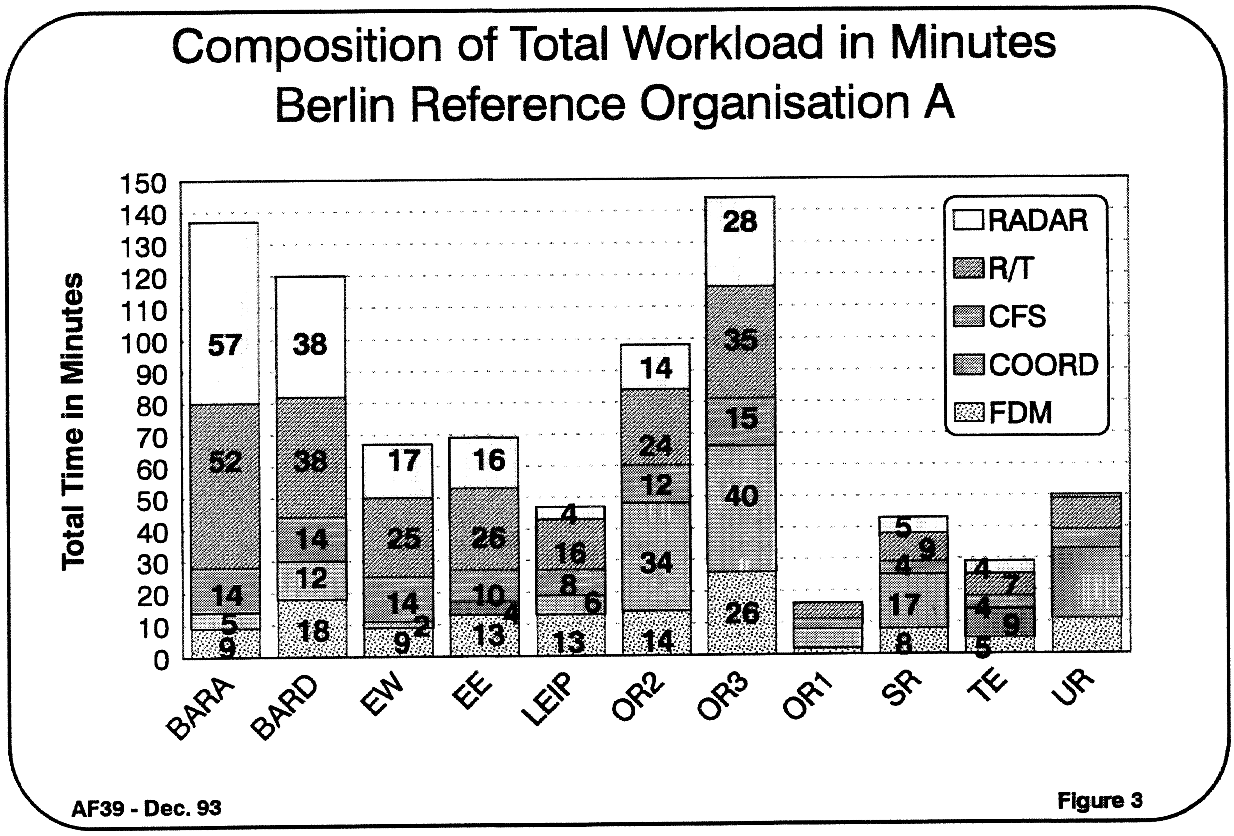


Figure 3

Although BARA had less aircraft than either BARD or EW both its radar and R/T workloads were higher than the other two sectors due to the nature of the traffic in the sector - all arriving traffic being vectored to three points coupled with a large number of level reclearances and aircraft level reports.

In the Schönefeld sectors, the coordination tasks accounted for the highest proportion of work in all sectors where all coordinations took place over the telephone.

2.4. Working Position Loadings - Berlin Reference Organisation A

From section 1.4.2., *"Controller Percentage Loadings"*, on page 8, it will be recalled that a ***peak hour percentage loading*** in excess of 55% is considered to be heavy, one in excess of 70% to be severe, and that an ***average percentage loading*** (measured over three hours) in excess of 40% is considered to be heavy, whereas one in excess of 50% is considered to be severe.

Peak Hour Percentage Loadings - EC and CC
Berlin Reference Organisation A
239 Flights - 11 Sectors - 18th September 1992

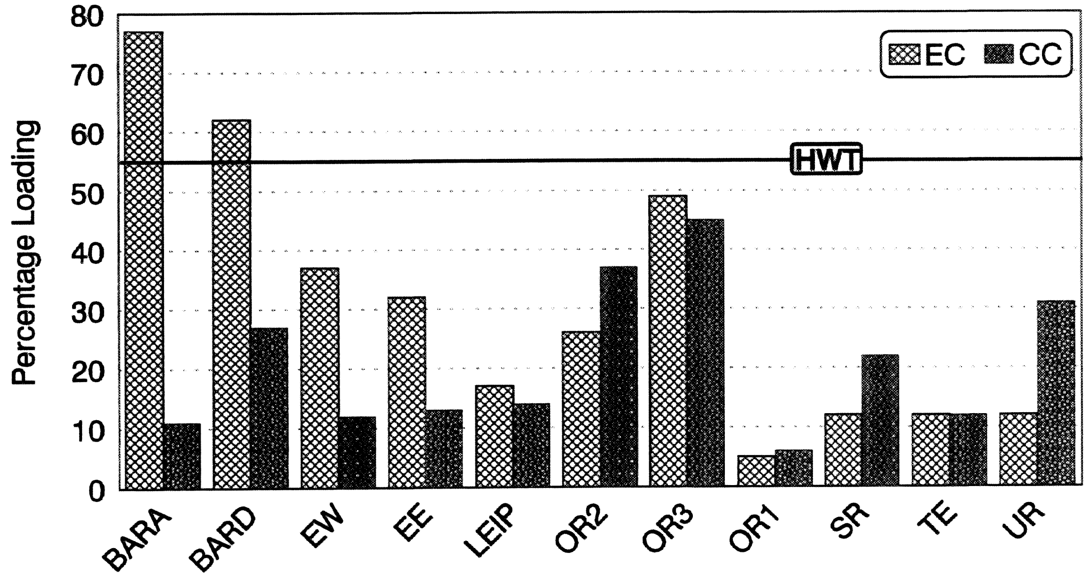


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Figure 4

Average Percentage Loadings - EC and CC
Berlin Reference Organisation A
239 Flights - 11 Sectors - 18th September 1992

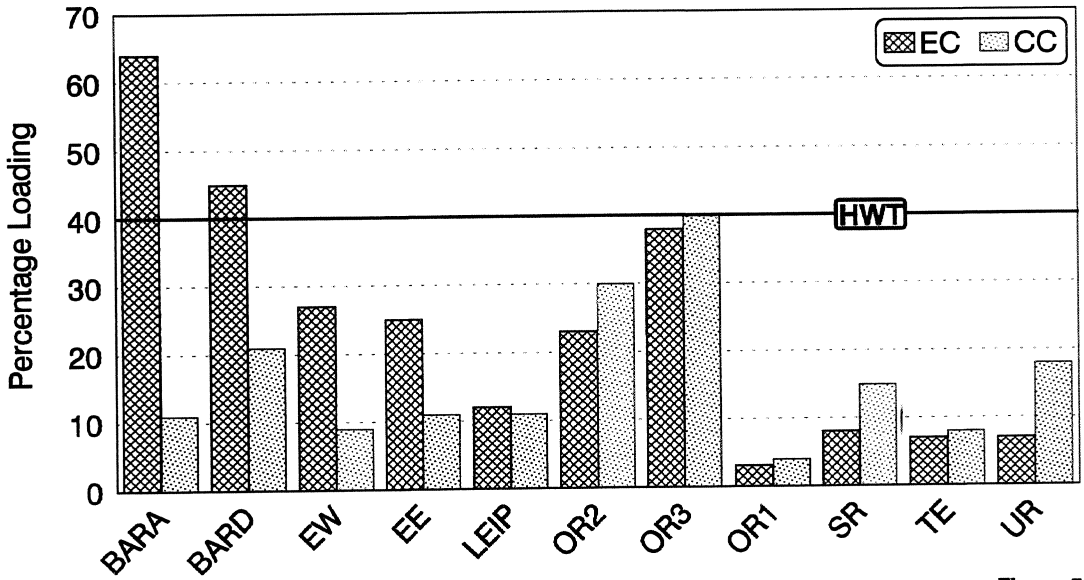

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Figure 5

2.4.1. EC and CC Peak and Average Percentage Loadings

Figure 4 shows the EC and CC peak hour loadings for each sector while **figure 5** gives the average percentage loadings for the same sectors. A line showing the heavy workload threshold (labelled "HWT") has been drawn at the 55% (peak hour) and 40% (average) values in figures 4 and 5, respectively.

The BARTCC arrival sector EC was severely loaded and the departure sector EC was heavily loaded during their respective peak hours. All other BARTCC positions recorded low to moderate loadings during their peak hours. In BARTCC there was a marked difference between the loading of the EC and his equivalent CC, except for the Leipzig sector.

None of the Schönefeld sectors was heavily loaded during their peak hours and in the busier OR3 sector there was a good division of work between the EC and CC. This, however, was not the case with the less busy SR and UR sectors where the CC had twice the loading, or more, of his equivalent EC.

Over three hours, the BARTCC arrival and departure ECs were again severely and heavily loaded, respectively. This result indicates that the workload problems in these sectors were of a sustained nature and not merely caused by short-term peaks. An overall imbalance in the loadings of the EC positions is quite evident from the chart. This was not the case with the BARTCC CCs where there was a reasonable spread of work amongst them, albeit with low loadings. Again, with the exception of the Leipzig sector, there was a marked difference in the workloads of the EC and his equivalent CC.

Over in Schönefeld, the OR3 CC was heavily loaded, while his equivalent EC was approaching the heavy workload threshold. Sector OR2 recorded moderate loadings for both controllers with the other sectors registering low results. Unlike BARTCC, each sector in Schönefeld had a heavier loaded CC than EC over the three hours, due primarily to the amount of coordination required.

2.5. Summary - Berlin Reference Organisation A

Table 4, overleaf, gives a summary of the results for the Berlin reference organisation A. For the busier sectors the table shows the number of controlled and coordinated aircraft in each sector, the nature of this traffic and some relevant comments, chiefly concerning the radar workload.

REFERENCE ORGANISATION A			
SECTOR	**No. of Aircraft Cont (Coord) EC Loadings**	**Traffic Handled**	**Comments**
BARA	56 (0) Peak 77% Average 64%	BB/BS/BT arrivals via NUVEN, SOLVU, BUROK. BB/BT arrivals from the East, South and North.	Most radar work recorded close to EDBB and EDBT.
BARD	62 (41) Peak 62% Average 45%	All BB/BT departures. BS departures to the South-West.	Radar conflicts spread throughout the sector. High number of coordinated aircraft for technical reasons.
EW	58 (0) Peak 37% Average 27%	All BB/BS/BT departures to the West, North-West and South-West.	All radar conflicts occur between TERKO and MAG.
EE	45 (0) Peak 32% Average 25%	BB/BS/BT arrivals via NUVEN, SOLVU, BUROK.	
OR2	50 (0) Peak 26% Average 23%	BB/BS/BT arrivals from the East, South and North. BB/BS/BT departures from the East, South and North.	CC Peak 37% CC Average 30%
OR3	64 (0) Peak 49% Average 38%	BB/BS/BT arrivals and departures from/to the South. ETDN arrivals and departures.	Most radar conflicts are opposite direction. CC Peak 45% CC Average 40%
LEIP **OR1** **SR** **TE** **UR**	Low results recorded.		

Table 4

The results for the Berlin reference organisation A showed:

- The validity of the airspace model in simulating the Berlin ACC/UAC environment with the results being as expected by the controllers on the working group.
- A reasonably good distribution of traffic amongst the sectors.
- An unequal distribution of workload between the sectors.
- High levels of R/T and radar workload in the BARTCC arrival sector.
- A high proportion of coordination tasks in the Schönefeld sectors, particularly OR2 and OR3.
- Severe peak hour and average percentage loadings on the BARTCC arrival EC.
- Heavy peak hour and average percentage loadings on the BARTCC departure EC.
- An inequality in both the peak hour and average percentage loadings between the EC and his equivalent CC in BARTCC.
- A heavy average percentage loading on the OR3 CC, with other Schönefeld sectors recording light to moderate loadings on all positions.
- The Schönefeld CC having a higher average percentage loading than his equivalent EC in all sectors.

3. BERLIN PROPOSED ORGANISATION B

In organisation B, as in all the proposed organisations, the traffic sample simulated contained an increase of 50% over the 1992 sample. This roughly equates to a year 2000 sample based on a compound increase of 5% per annum from 1992. The total sample was 366 flights for this organisation.

Organisation B tested the Terminal Area and en route sectorisation, control procedures, routes and equipment contained in the detailed specifications outlined. The equipment assumed to be in operation was ASCAP, DEPCOS and ACT. Silent handovers were used between the sectors as well as automatic data transfer with other centres except Prague and Warsaw.

Both the TRA Nord and the TRA Sued were assumed to be active from FL100 to FL350.

3.1 Sectors and Working Positions Simulated

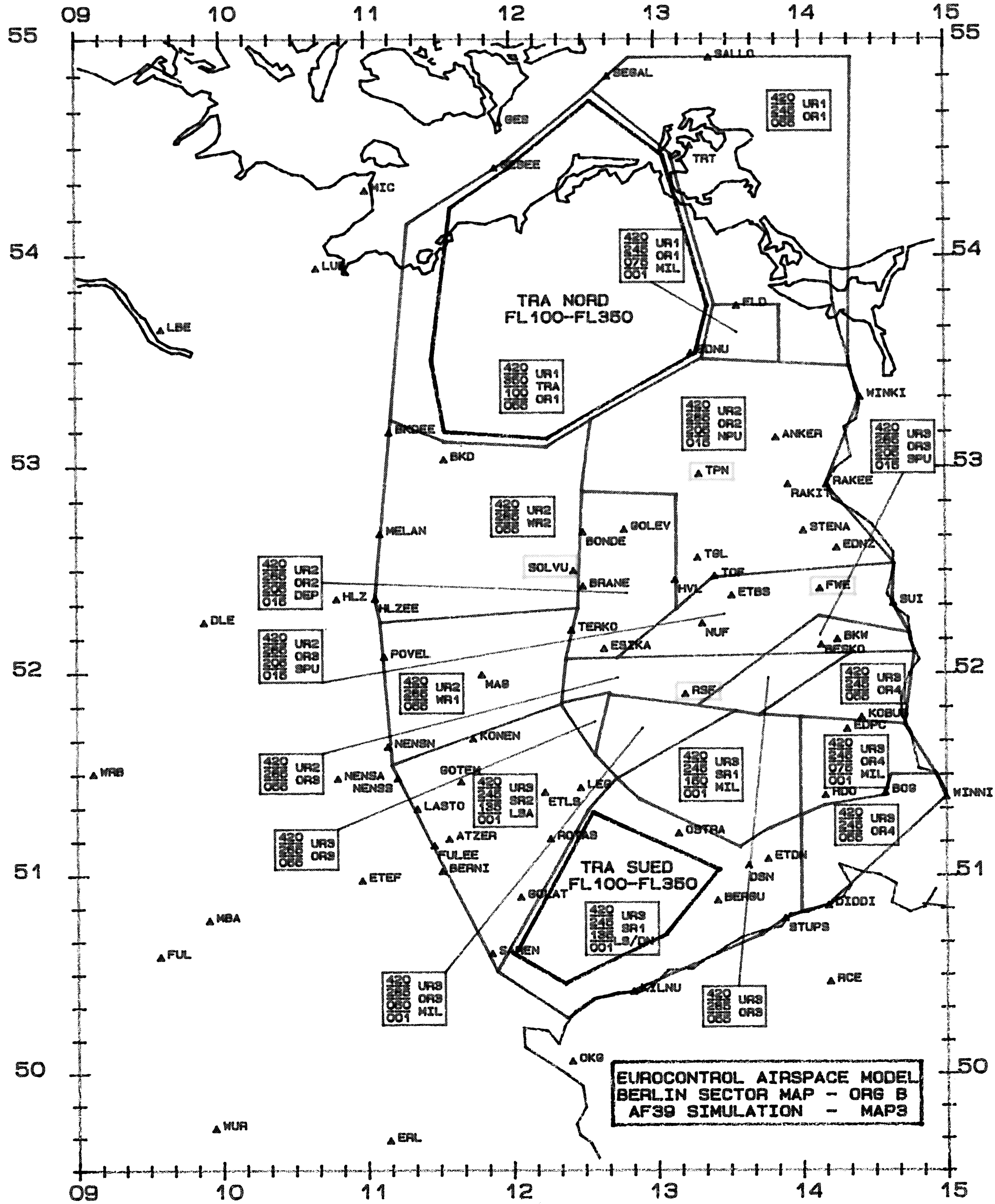
3.1.1. Sectors

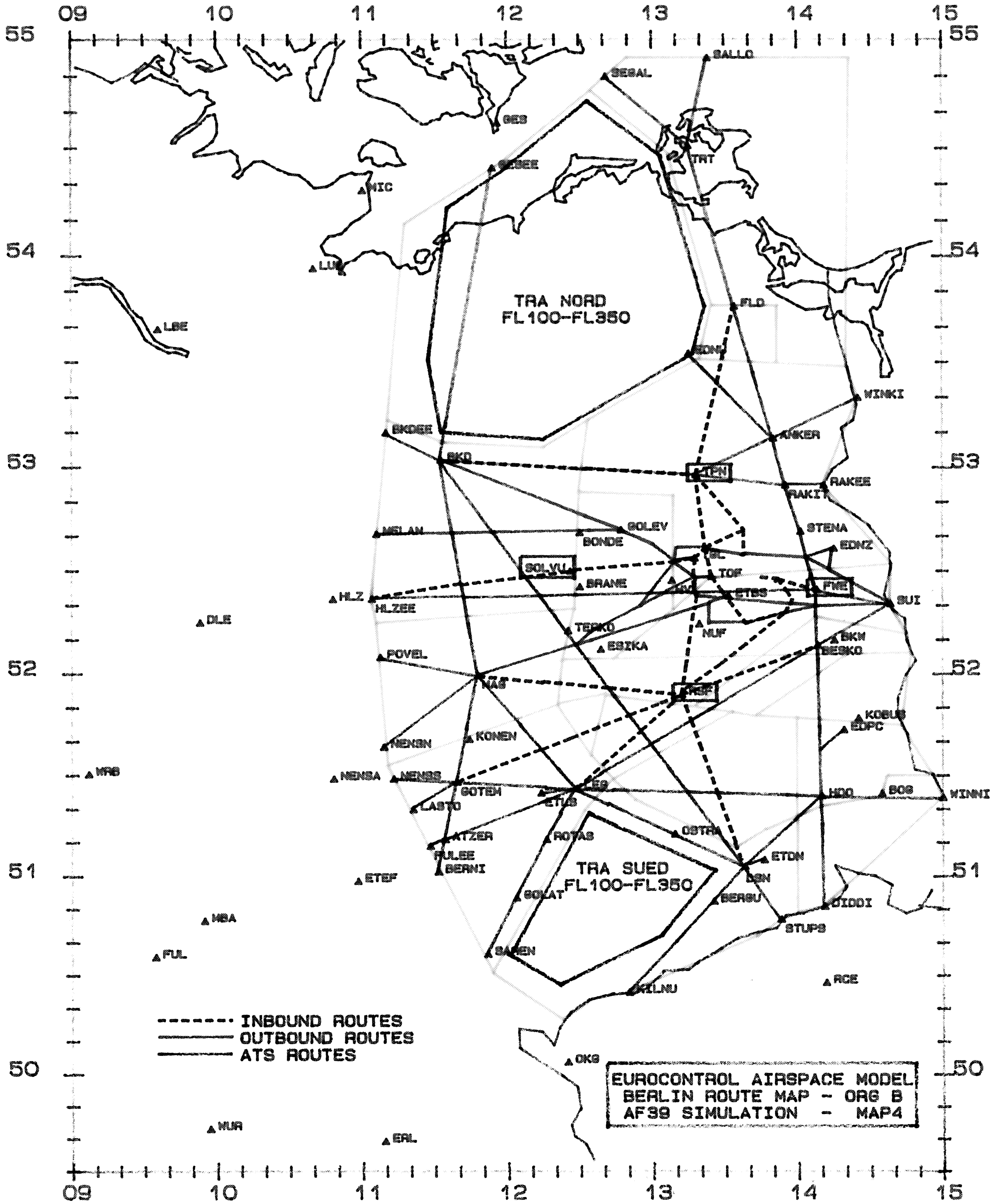
The 14 sector configuration outlined for organisation B is shown in **table 5**, below, and **map 3**, overleaf. The defined routes are shown in **map 4** on page 21.

SECTOR	VERTICAL DIMENSIONS
Departure ("DEP")	Max FL205.
Pick-up North ("NPU")	Max FL205.
Pick-up South ("SPU")	Max FL205.
OR1	Max FL245, base FL75 above MIL area south of FLD, else FL55.
OR2	FL205 - FL285.
OR3	Max FL285, base FL205 above SPU, else FL55.
OR4	Max FL245, base FL75 above MIL area south of KOBUS, else FL55.
SR1	Max FL245, base FL135 above Leipzig/Dresden, FL150 above MIL area north of OSTRA.
SR2	Max FL245, base FL135 above Leipzig.
WR1 and WR2	FL55 - FL285.
UR1	FL245 - UNL.
UR2	FL285 - UNL.
UR3	Max UNL, base FL285 above OR3, else FL245.
ETDN and ETLS	Max FL135.

Table 5

The Dresden and Leipzig approach areas were simulated but not evaluated as their results were not relevant to the objectives of the study. A feeder sector for Berlin was not included in the specifications for this organisation.


EUROCONTROL AIRSPACE MODEL
BERLIN SECTOR MAP - ORG B
AF39 SIMULATION - MAP3
TRA NORD
FL100-FL350
TRA SUED
FL100-FL350
09
10
11
12
13
14
15
55
54
53
52
51
50
SALLO
SEGAL
GES
TRT
MIC
LUB
LBE
ELD
WINKI
ANKER
TPN
RAKEE
RAKIT
BKD
MELAN
BONDE
SOLEV
STENA
SOLVU
BRANE
TGL
HLZ
HLZEE
ETBS
FWE
SUI
DLE
TERKO
NUF
ESIKA
BKW
POVEL
MAS
RSE
KOBUS
EDPC
NENSN
KONEN
WRB
NENSA
GOTEM
LASTO
ETLS
ATZER
ETEF
BERNI
FULEE
ETDN
DSN
BERSU
MBA
FUL
DIDDI
STUPS
RCE
OKG
WUR
ERL
WINNI
BOS


TRA NORD
FL100-FL350
TRA SUED
FL100-FL350
INBOUND ROUTES
OUTBOUND ROUTES
ATS ROUTES
EUROCONTROL AIRSPACE MODEL
BERLIN ROUTE MAP - ORG B
AF39 SIMULATION - MAP4
SALLO
SEGAL
TRT
FLD
WINKI
ANKER
BKDEE
BKD
RAKEE
STENA
GOLEV
BONDE
EDNZ
SOLVU
TOF
BRANE
HLZ
HLZEE
FWE
SUI
DLE
NUF
ESIKA
POVEL
BKW
BESKO
KONEN
NENSA
GOTEM
LASTO
HDO
BOS
WINNI
OSTRA
ETDN
ROTAS
ATZER
BERNI
ETEF
DBN
BERGU
DIDDI
STUPS
MBA
FUL
RCE
OKG
WUR
ERL
LBE
WRB
NIC
GES
09
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11
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55
54
53
52
51
50

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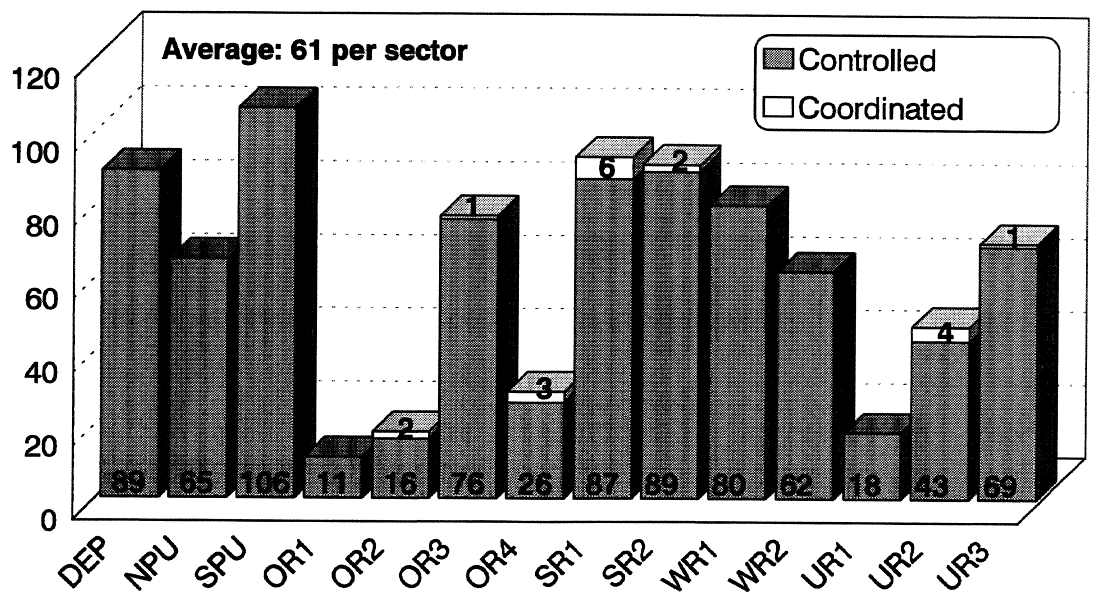
Distribution of Traffic - Berlin Organisation B

366 Flights - 14 Sectors - 3 Upper, 8 En Route, 3 TMA



AF39 - Dec. 93

Figure 6

3.1.2. Working Positions

Each sector was simulated with a Radar Controller (EC) and a Coordinator (CC). The Assistant and Flight Data positions were not simulated.

3.1.3. Holding Stacks

Full stack management was simulated in organisation B. As mentioned in section 1.2.2.4., ***"Holding Stacks and Ground Delays"***, on page 3, the time values used for the minimum interval between successive movements were 1.5 minutes at Tegel and 2 minutes at Schönefeld and Tempelhof. It is on these values that the need for, and duration of, air and ground delays are calculated by the model.

Four holding stacks were simulated:

- IAF Nord ("TPN") - FL100-FL200 - Tegel inbounds.
- SOLVU - FL120-FL200 - Tegel inbounds.
- IAF Sued ("RSF") - FL100-FL200 - Schönefeld and Tempelhof inbounds.
- FWE - FL100-FL200 - Schönefeld and Tempelhof inbounds.

3.2. Distribution of Traffic - Berlin Proposed Organisation B

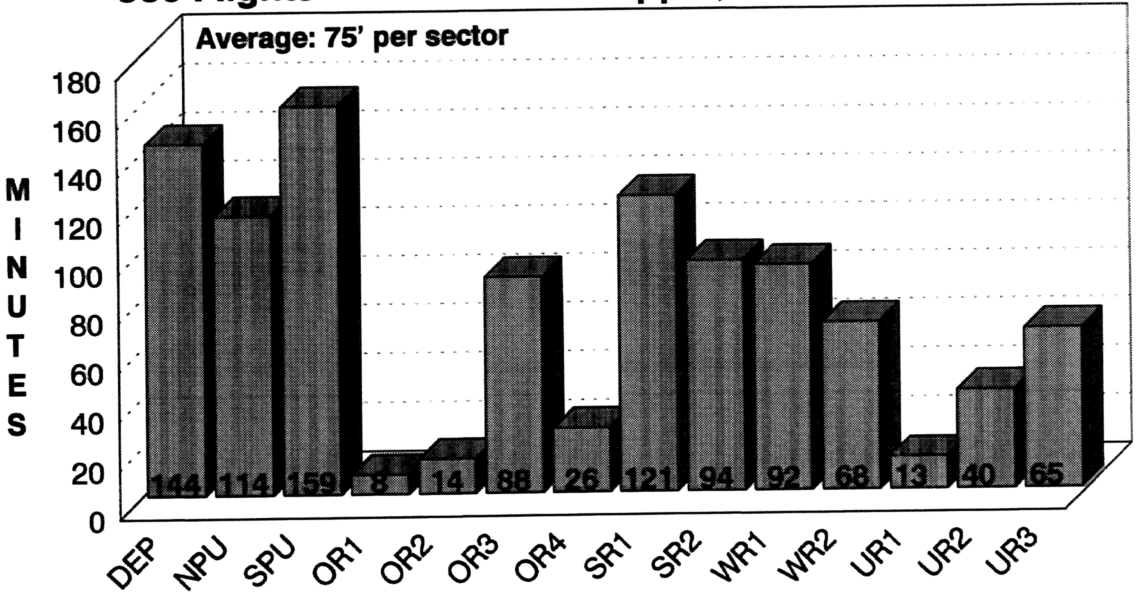
Figure 6 shows the number of flights for each sector during the simulated period. A bar is shown for each sector designating the number of controlled flights entering this sector. In the case of seven sectors, the upper part of the bar indicates the number of coordinated flights in these sectors, i.e. flights penetrating the sector whilst under the control of another.

An unequal distribution of traffic between the sectors can be seen from the chart with the SPU sector having almost ten times the traffic of OR1. The dispersion of traffic around the mean value was large - a standard deviation of 30 around a mean value of 61 aircraft.

In the case of the northern sectors, OR1 and UR1, the traffic sample did not reflect the true nature of the traffic in these sectors, having only SEGAL/SALLO traffic to deal with. Sector OR2 did not have the north holding stack within its airspace, whereas OR3, its "complementary" sector to the south of Berlin, had the south holding stack to manage.

Amongst the TMA sectors, 20% of SPU's traffic (21) was inbound traffic to Tegel from KILNU/LASTO routeing from overhead the south stack to the north stack, level at FL200. Similarly, 20% of DEP's traffic (18) were Tegel inbounds from HLZ leaving the SOLVU stack and routeing to the NPU sector.

Distribution of Total Sector Workload
Berlin Organisation B
366 Flights - 14 Sectors - 3 Upper, 8 En Route, 3 TMA



AF39 - Dec. 93

Figure 7

3.3. Workload Recorded - Berlin Proposed Organisation B

Figure 7 gives the total workload in minutes recorded by each sector (EC and CC combined) and **figure 8** shows the composition of this workload.

From figure 7 it can be seen that, as with the distribution of traffic, there was an unequal distribution of workload between the sectors. The SPU sector had more than twice the average sector workload and twenty times the workload of OR1. Other sectors with a workload at least 50% greater than the average were DEP, NPU and SR1.

Sectors with similar numbers of aircraft, e.g. DEP/SR1/SR2 (89/87+6/89+2) and NPU/WR2/UR3 (65/62/69+1) had varying amounts of workload due to the nature of the traffic controlled by each sector. For example, DEP and SR1 had at least twice the radar workload of SR2 (figure 8). The DEP sector had the difficulty of integrating high- and low-performance aircraft from Tegel and Tempelhof, and almost 50% of the sector's radar conflicts involved Tegel versus Tempelhof outbounds. The SR1 sector had similar difficulties with 66% of the radar conflicts occurring between OSTRA and LEG and half of these involving Leipzig and Dresden traffic. While SR2 also had to deal with Leipzig/Dresden traffic, the radar conflicts were spread around the sector rather than concentrated in a certain area.

The sectors NPU and SPU had high R/T workloads, which was to be expected with vectoring aircraft to final approach.

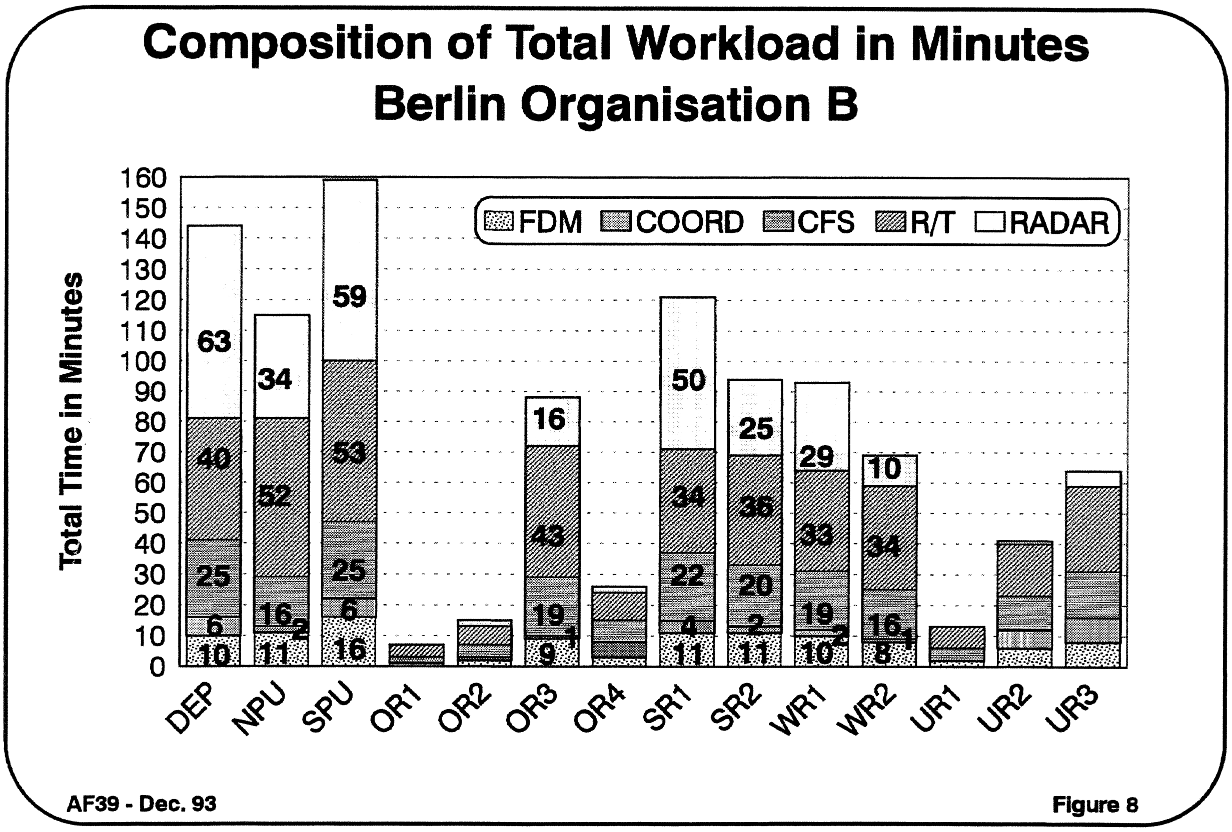
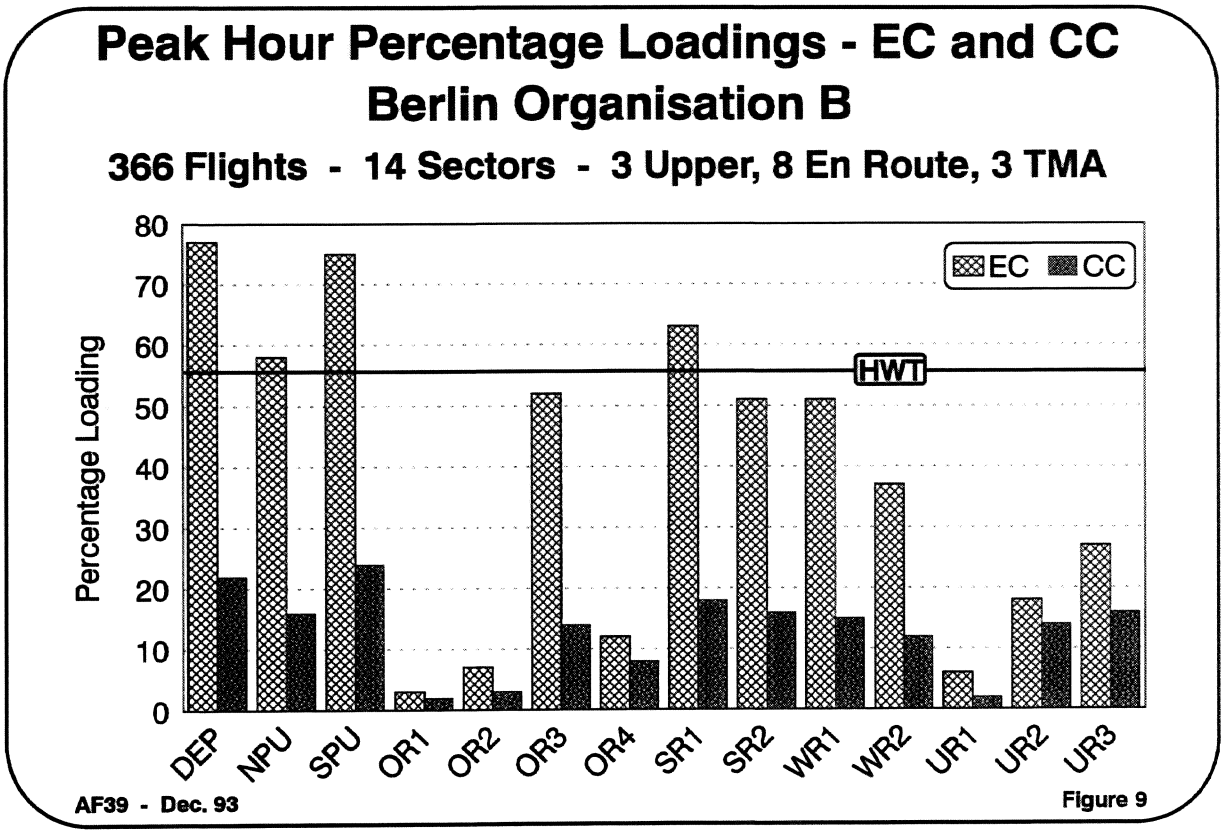
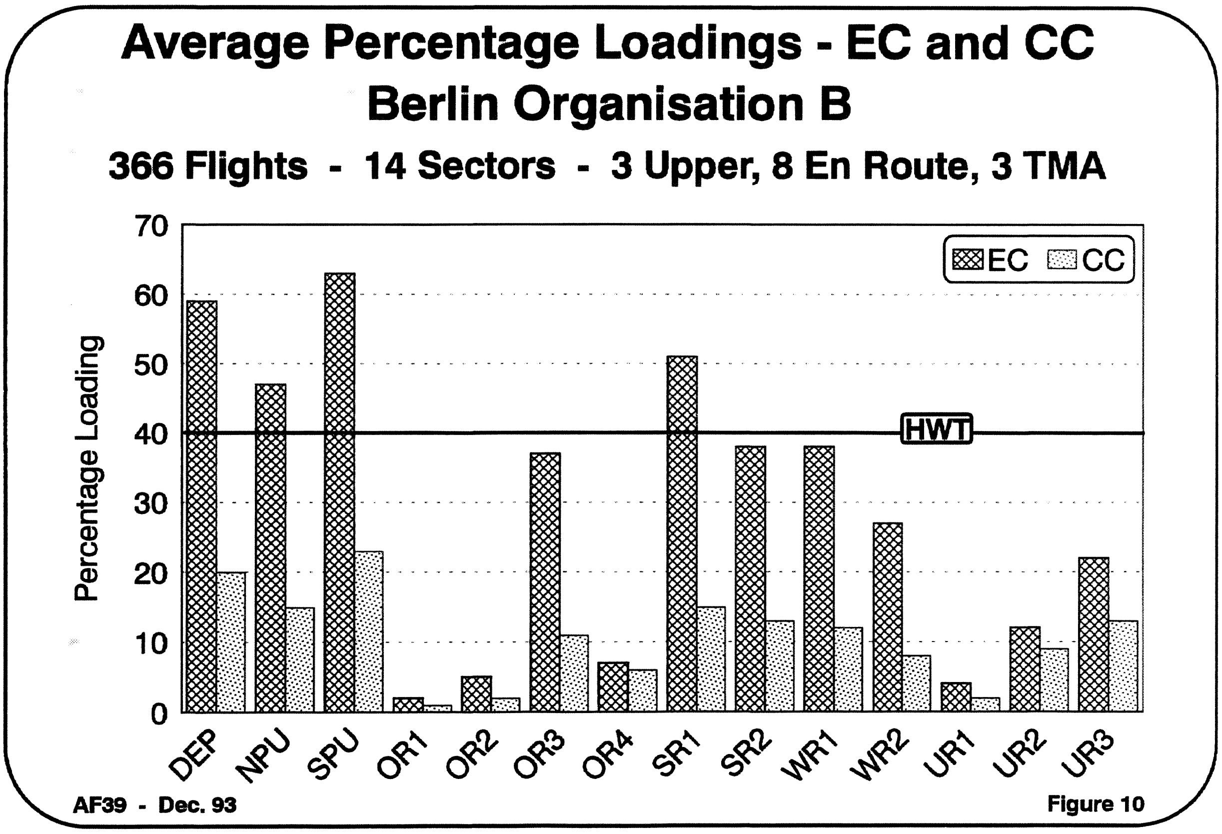


Figure 8


Peak Hour Percentage Loadings - EC and CC
Berlin Organisation B
366 Flights - 14 Sectors - 3 Upper, 8 En Route, 3 TMA
Percentage Loading
80
70
60
50
40
30
20
10
0
EC
CC
HWT
DEP
NPU
SPU
OR1
OR2
OR3
OR4
SR1
SR2
WR1
WR2
UR1
UR2
UR3
AF39 - Dec. 93
Figure 9


Average Percentage Loadings - EC and CC
Berlin Organisation B
366 Flights - 14 Sectors - 3 Upper, 8 En Route, 3 TMA
Percentage Loading
70
60
50
40
30
20
10
0
EC
CC
HWT
DEP
NPU
SPU
OR1
OR2
OR3
OR4
SR1
SR2
WR1
WR2
UR1
UR2
UR3
AF39 - Dec. 93
Figure 10

3.4. Working Position Loadings - Berlin Proposed Organisation B

From section 1.4.2., *"Controller Percentage Loadings"*, on page 8, it will be recalled that a ***peak hour percentage loading*** in excess of 55% is considered to be heavy, one in excess of 70% to be severe, and that an ***average percentage loading*** (measured over three hours) in excess of 40% is considered to be heavy, whereas one in excess of 50% is considered to be severe.

3.4.1. EC and CC Peak and Average Percentage Loadings

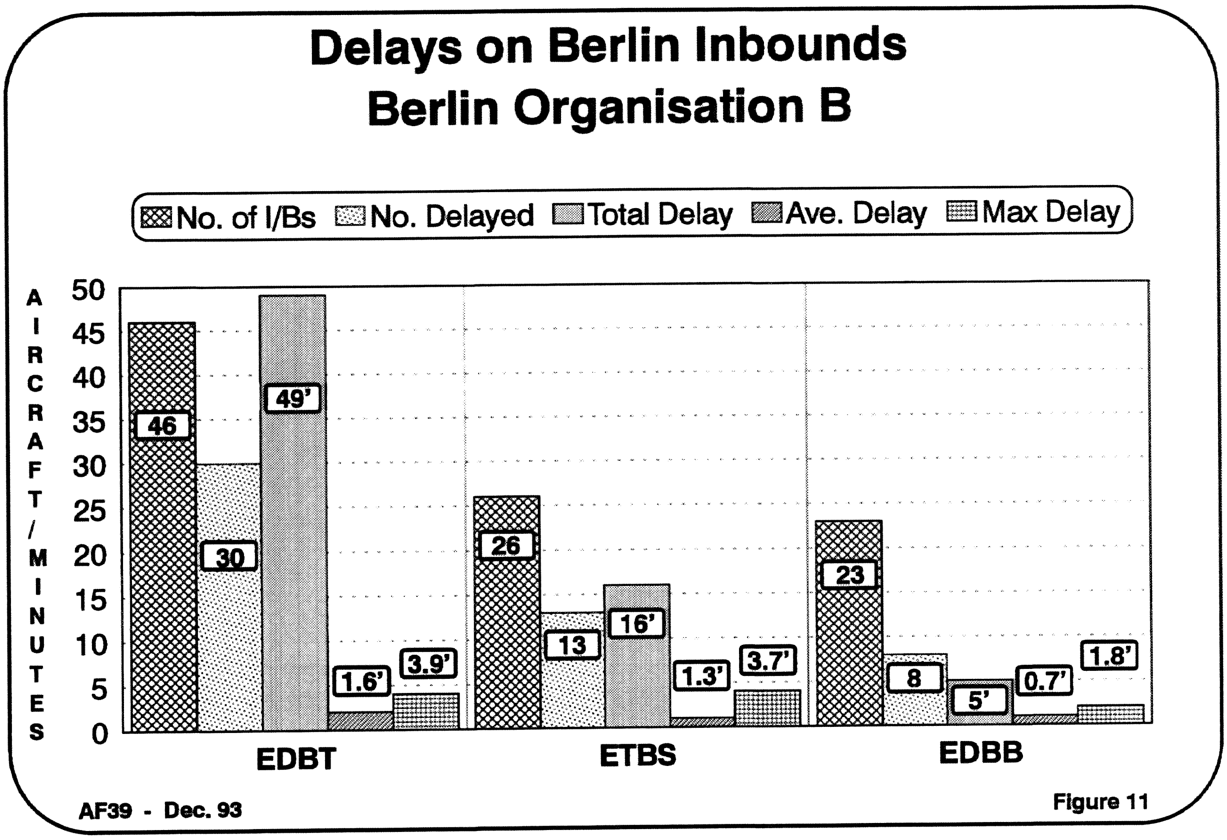
Figure 9 shows the EC and CC peak hour loadings for each sector while **figure 10** shows the average percentage loadings for the same sectors. A line showing the heavy workload threshold (labelled "HWT") has been drawn at the 55% (peak hour) and 40% (average) values in figures 9 and 10, respectively.

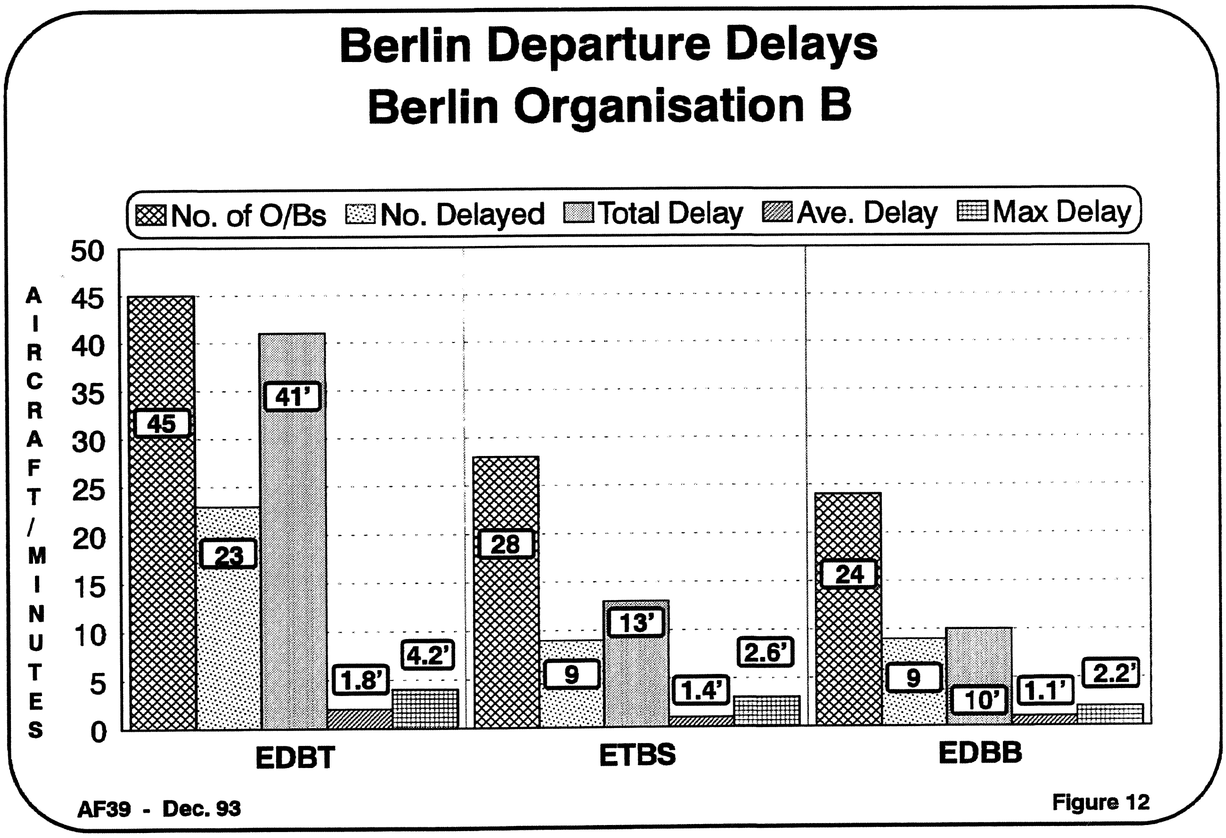
Referring to figure 9, two EC positions, DEP and SPU, were severely loaded during their peak hours. Another two sectors, NPU and SR1, had heavily loaded ECs. Of the other sectors, the OR3, SR2, WR1 and WR2 ECs recorded moderate loadings while OR1, 2, 4 and the upper sectors returned low loadings. All CC positions were lightly loaded during their respective peak hours.

From figure 10 it can be seen that three EC positions, DEP, SPU and SR1, were severely loaded over three hours with the NPU EC being heavily loaded. With these same four EC positions being severely or heavily loaded during their peak hours as well, the result indicates that the workload problems in these sectors were of a sustained nature and not merely caused by short-term peaks.

The results for the other EC positions over three hours are similar to those for the peak hour loadings with OR3, SR2, WR1 and WR2 recording moderate loadings and the other EC positions returning low figures.

All CC positions were lightly loaded over the three hours. From both figures, it can be seen that, amongst the sectors that recorded a moderate loading or greater, the EC had a loading which was three times, or more, that of his equivalent CC. Such imbalances have been found in many Airspace Model studies where the tactical controller/planning controller concept has been simulated. In reality, a light loading on a CC position enables the CC to assist the EC in his executive functions but quantifying this assistance can only be done to a limited extent on a mathematical simulator.


Delays on Berlin Inbounds
Berlin Organisation B
No. of I/Bs
No. Delayed
Total Delay
Ave. Delay
Max Delay
AIRCRAFT / MINUTES
50
45
40
35
30
25
20
15
10
5
0
46
30
49'
1.6'
3.9'
26
13
16'
1.3'
3.7'
23
8
5'
0.7'
1.8'
EDBT
ETBS
EDBB
AF39 - Dec. 93
Figure 11


Berlin Departure Delays
Berlin Organisation B
No. of O/Bs
No. Delayed
Total Delay
Ave. Delay
Max Delay
AIRCRAFT / MINUTES
50
45
40
35
30
25
20
15
10
5
0
45
23
41'
1.8'
4.2'
28
9
13'
1.4'
2.6'
24
9
10'
1.1'
2.2'
EDBT
ETBS
EDBB
AF39 - Dec. 93
Figure 12

3.5. Arrival and Departure Delays - Berlin Proposed Organisation B

Table 6 gives the results found for the four holding stacks simulated with this organisation. **Figures 11 and 12** describe the arrival and departure delays as experienced by each of the three Berlin airports.

STACK (Base)	Highest Level Used	Number of Aircraft Holding	Average Delay in Minutes	Maximum Delay in Minutes
RSF (FL100)	FL120	17	1.1'	3.7'
TPN (FL100)	FL120	18	1.8'	3.9'
SOLVU (FL120)	FL130	12	1.3'	2.6'
FWE (FL100)	FL110	4	0.6'	1.7'

Table 6

The TPN and RSF stacks were the most commonly used with the TPN stack returning the highest holding time of almost four minutes and the highest average holding time of 1.8 minutes. However, it must be pointed out that, in reality, not all of these aircraft would have been held as small delays would have been absorbed by extended radar vectoring. As this facility is not available with the model, it is necessary to absorb all inbound delays, no matter how small, in the relevant holding stack.

To that end, **table 7** breaks down the figures for each stack showing the number of aircraft held for less than one minute, for more than one minute but less than two, and for two minutes or more.

STACK	DELAY			
	< 1'	1' <> 2'	> 2'	Total
RSF	9	6	2	17
TPN	3	7	8	18
SOLVU	5	4	3	12
FWE	3	1	0	4

Table 7

Figure 11 shows that 65% of the Tegel inbounds, 50% of the Schönefeld inbounds and 35% of the Tempelhof inbounds were delayed. **Figure 12**, for the departures, shows that 51% of the Tegel outbounds, 32% of the Schönefeld outbounds and 38% of the Tempelhof outbounds were delayed. In both figures the cumulative delay, average delay and maximum delay (all in minutes) are given.

3.6. Summary - Berlin Proposed Organisation B

Table 8, below, and **table 8A**, overleaf, give a summary of the results found.

PROPOSED ORGANISATION B			
SECTOR	**No. of A/C Cont(Coord) EC Loadings**	**Traffic Handled**	**Comments**
DEP	89 (0) Peak 77% Average 59%	All BB/BT departures except those via the A4 and SUI. All BS departures to NENSA and POVEL. All HLZ arrivals to BT from the SOLVU stack.	High radar workload - 50% involving BB/BT departures. HLZ arrivals amount to 17% of total workload.
NPU	65 (0) Peak 58% Average 47%	Manages the TPN stack. Mostly BT inbounds.	Most radar work involved with vectoring BT traffic inbound from the stack.
SPU	106 (0) Peak 75% Average 63%	Manages the FWE stack. All BB/BS inbounds. BS departures. BT inbounds FL200 from overhead RSF to TPN.	Highest total workload (159'). Mixture of radar conflicts - mostly BB/BS inbounds. 7 aircraft from SUI route SPU-OR3-SPU via RSF stack.
OR3	76 (1) Peak 52% Average 37%	Manages the RSF stack. Mostly BB/BS arrivals. Works BT inbounds from KILNU/LASTO to TPN stack.	
SR1	87 (6) Peak 63% Average 51%	DN arrivals and departures. LS arrivals and departures to the East and South. Berlin arrivals from the South.	High radar workload due to opposite direction conflicts. 50% of radar conflicts occur between OSTRA and LEG.
SR2	89 (2) Peak 51% Average 38%	LS arrivals and departures. DN arrivals and departures to the West. Berlin low arrivals from LASTO/SAREN.	Moderate radar work. Mostly opposite direction conflicts involving DN/LS traffic.

Table 8

PROPOSED ORGANISATION B			
SECTOR	No. of A/C Cont(Coord) EC Loadings	Traffic Handled	Comments
WR1	80 (0) Peak 51% Average 38%	Berlin departures to the West. DN/LS traffic to the North-West. BB/BS low arrivals from POVEL.	Most radar conflicts are same direction Berlin departures.
WR2	62 (0) Peak 37% Average 27%	Manages the SOLVU stack. Berlin arrivals from BKD. BT arrivals from HLZ. BB/BT departures to the North-West.	
UR3	69 (1) Peak 27% Average 22%	BB/BS/BT arrivals from KILNU/LASTO/RCE. BB/BT departures to ERL. BS departures to RCE.	
OR1,2 and 4 UR1 and 2	Low results recorded.		

Table 8A

The results for the Berlin proposed organisation B showed:

- An unequal distribution of traffic and workload between the sectors.
- High radar workloads in the DEP, SPU and SR1 sectors.
- High R/T workloads in the NPU and SPU sectors.
- With the EC positions, the DEP and SPU sectors were severely loaded over one and three hours, the SR1 sector heavily loaded over the peak hour and severely loaded over three hours, and the NPU sector heavily loaded over one and three hours.
- Light loadings on all CC positions over both one and three hours.
- All four stacks being lightly used with the maximum delay for the two main stacks, RSF and TPN, being just under four minutes.
- The maximum departure delay was 4.2 minutes at Tegel.

4. BERLIN PROPOSED ORGANISATION C

The traffic sample simulated contained an increase of 50% over the 1992 sample. This roughly equates to a year 2000 sample based on a compound increase of 5% per annum from 1992. The total sample was 358 flights for this organisation.

Organisation C tested the Terminal Area and en route sectorisation, control procedures, routes and equipment contained in the detailed specifications outlined. The equipment assumed to be in operation was ASCAP, DEPCOS and ACT. Silent handovers were used between the sectors as well as automatic data transfer with other centres except Prague and Warsaw.

Both the TRA Nord and the TRA Sued were assumed to be active from FL100 to FL350.

4.1 Sectors and Working Positions Simulated

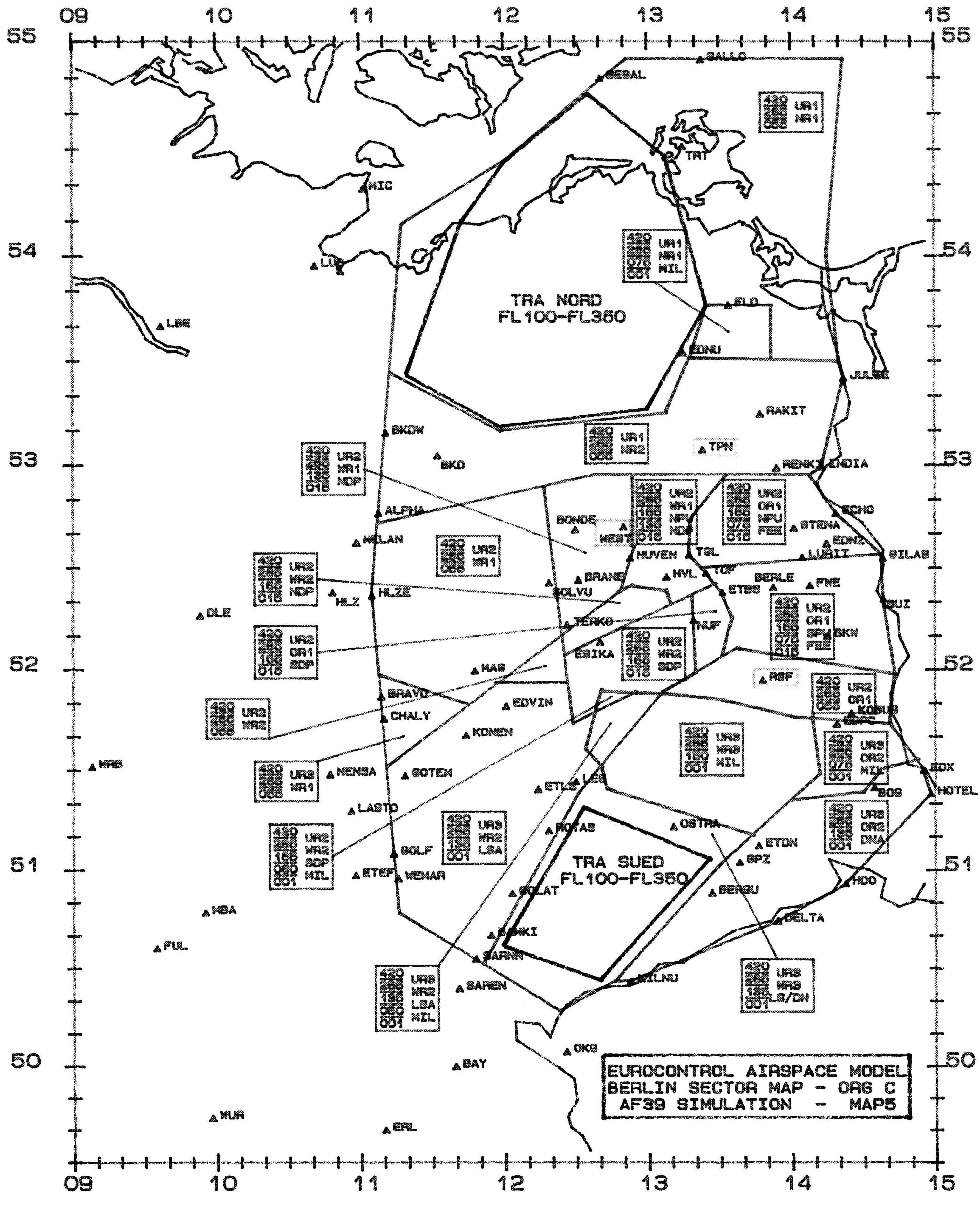
4.1.1. Sectors

The 14 sector configuration outlined for organisation C is shown in **table 9**, below, and **map 5**, overleaf. The defined routes are shown in **map 6** on page 30.

SECTOR	VERTICAL DIMENSIONS
Dep. North ("NDP")	Max FL165 below WR2, else FL135 below WR1/NPU.
Dep. South ("SDP")	Max FL165.
Pick-up North ("NPU")	Max FL165, base FL135 above NDP, FL75 above Feeder.
Pick-up South ("SPU")	Max FL165, base FL75 above Feeder.
NR1	Max FL285, base FL75 above MIL area south of FLD, else FL55.
NR2	FL55 - FL285.
OR1	Max FL285, base FL165 over NPU/SPU/SDP, else FL55.
OR2	Max FL285, base FL135 above Dresden, FL75 above MIL area south of KOBUS.
WR1	Max FL285, base FL165 above NPU, FL135 above NDP, else FL55.
WR2	Max FL285, base FL165 above NDP and SDP, FL135 above Leipzig, else FL55.
WR3	Max FL285, base FL150 above MIL area north of OSTRA, FL135 above Leipzig/Dresden.
UR1, UR2, UR3	FL285 - UNL.
Feeder ("FEE")	Max FL75.
ETDN and ETLS	Max FL135.

Table 9

The Dresden and Leipzig TMAs and the feeder sector for Berlin were simulated but not evaluated as their results were not relevant to the objectives of the study.


TRA NORD
FL100-FL350
TRA SUED
FL100-FL350
EUROCONTROL AIRSPACE MODEL
BERLIN SECTOR MAP - ORG C
AF39 SIMULATION - MAP5
SALLO
SEGAL
TRT
MIC
LUB
LBE
FLD
EDNU
JULIE
RAKIT
TPN
BKDW
BKD
RENKI
INDIA
ALPHA
ECHO
BONDE
WEST
STENA
EDNZ
MELAN
NUVEN
TGL
LUBIT
SILAS
BRANE
HVL
TOF
BERLE
FWE
DLE
HLZ
HLZE
SOLVU
ETBS
SUI
TERKO
NUF
SKW
ESIKA
MAG
RSF
BRAVO
EDVIN
CHALY
KONEN
KOBUS
EDPC
WRB
NENSA
SOTEN
ETLS
LEG
EDX
HOTEL
LASTO
BOG
ROTAS
OSTRA
ETDN
GOLF
GPZ
ETEF
WEMAR
BERGU
HDO
DELTA
MBA
FUL
SARNA
SAREN
MILNU
OKG
BAY
WUR
ERL
UR1
NR1
MIL
UR2
WR1
WR2
NDP
OR1
SDP
UR3
WR3
OR2
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DNA
LS/DN
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11
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14
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51
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54
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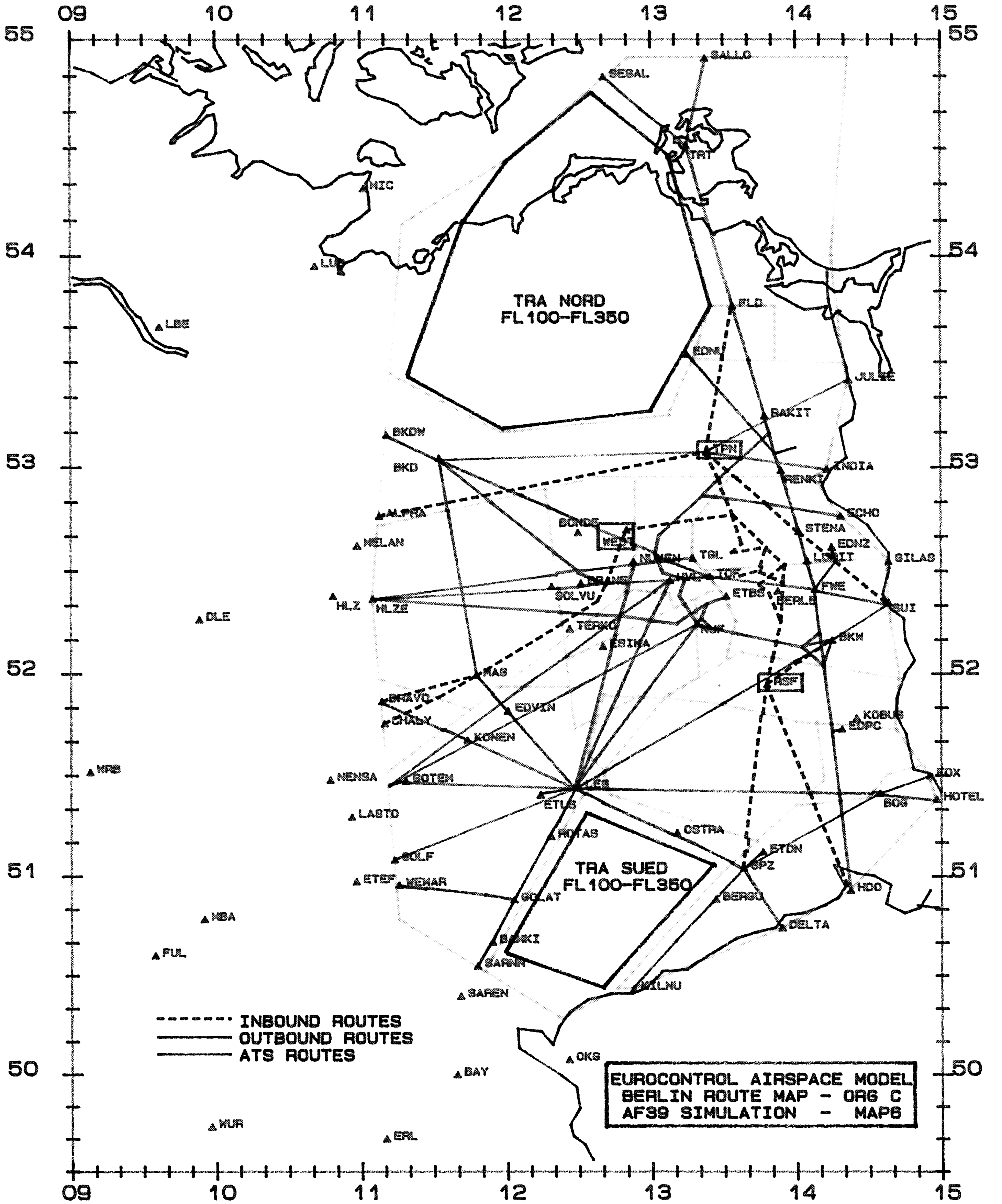
09
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52
51
50
SALLO
SEGAL
TRT
MIC
LUB
LBE
TRA NORD
FL100-FL350
FLD
EDNL
JULIE
BAKIT
BKDW
TPN
BKD
INDIA
RENKI
ALPHA
ECHO
BONDE
STENA
MELAN
WEST
EDNZ
NIMEN
TGL
GILAS
BRANE
TOF
HLZ
HLZE
SOLVU
ETBS
BERLE
FWE
SUI
DLE
TERKO
NUF
ESIKA
BKW
MAG
RSF
BRAVO
EDVIN
CHALY
KOBUS
EDPC
KONEN
WRB
NENSA
GOTEM
LEG
EDX
ETLS
BOG
HOTEL
LASTO
ROTAS
OSTRA
ETDN
GOLF
TRA SUED
FL100-FL350
SPZ
ETEF
WEMAR
GOLAT
BERGU
HDO
MBA
DELTA
FUL
BAMKI
SAREN
KILNU
INBOUND ROUTES
OUTBOUND ROUTES
ATS ROUTES
OKG
BAY
WUR
ERL
EUROCONTROL AIRSPACE MODEL
BERLIN ROUTE MAP - ORG C
AF39 SIMULATION - MAP6

Intentionally Blank

Distribution of Traffic - Berlin Organisation C

358 Flights - 14 Sectors - 3 Upper, 7 En Route, 4 TMA

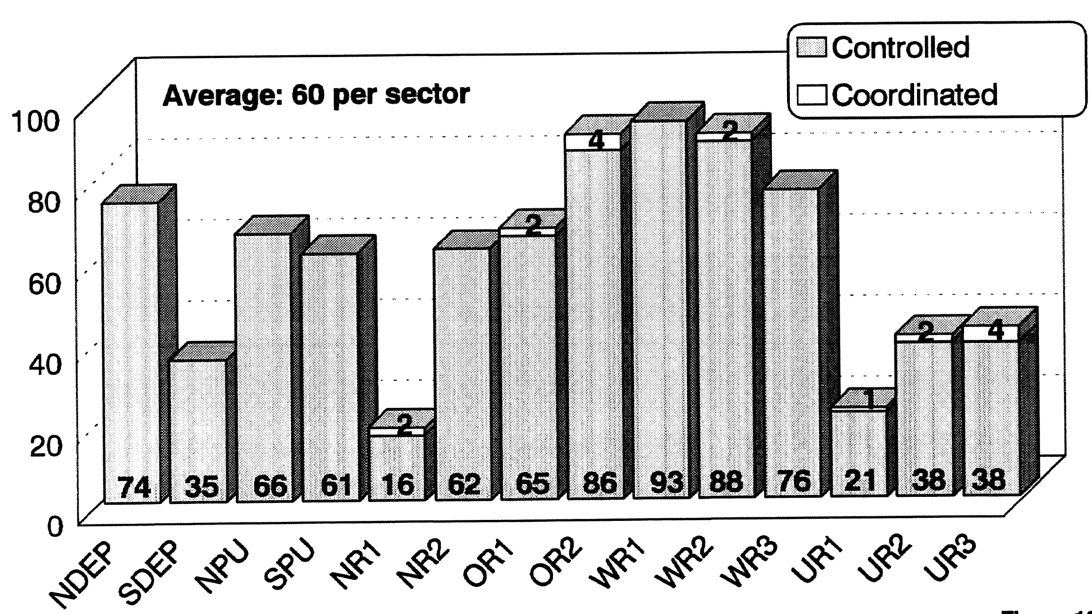

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Figure 13

4.1.2. Working Positions

Each sector was simulated with an EC and a CC except the NDP and SDP sectors which had the CC positions combined. The Assistant and Flight Data positions were not simulated.

4.1.3. Holding Stacks

Full stack management was simulated in organisation C. As mentioned in section 1.2.2.4., ***"Holding Stacks and Ground Delays"***, on page 3, the time values used for the minimum interval between successive movements were 1.5 minutes at Tegel and 2 minutes at Schönefeld and Tempelhof. It is on these values that the need for, and duration of, air and ground delays are calculated by the model.

Three holding stacks were simulated:

- IAF Nord ("TPN") - FL140-FL200 - All Berlin inbounds.
- IAF West ("WEST") - FL140-FL200 - All Berlin inbounds.
- IAF Sued ("RSF") - FL140-FL200 - All Berlin inbounds.

4.2. Distribution of Traffic - Berlin Proposed Organisation C

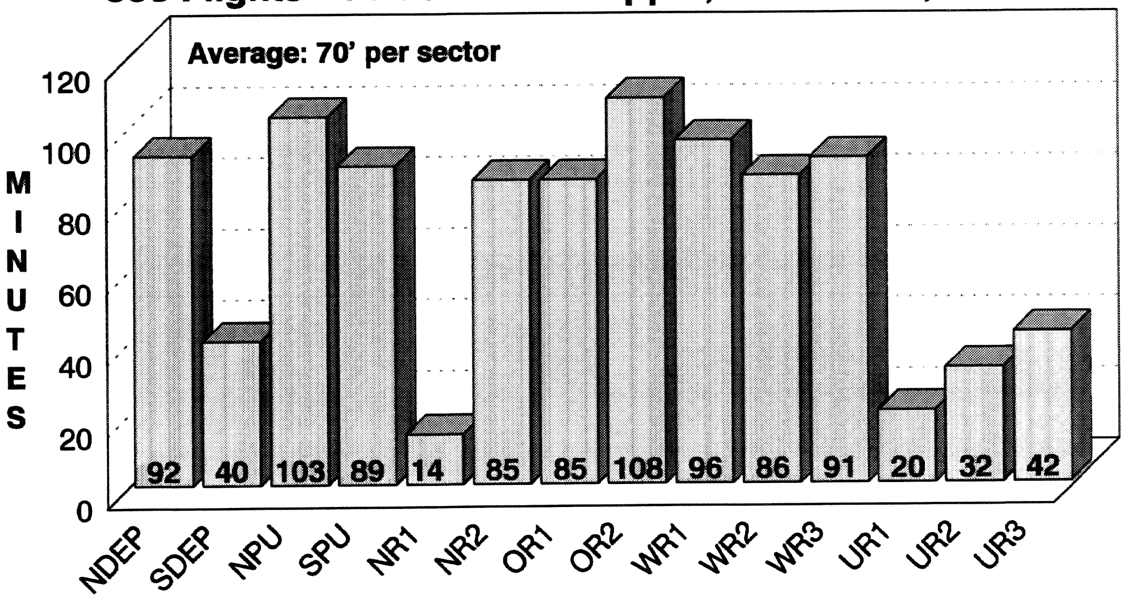
Figure 13 shows the number of flights for each sector during the simulated period. The format is the same as for the previous distribution of traffic charts.

An unequal distribution of traffic between the sectors can be seen from the chart with the WR1 sector having five times the traffic of NR1. The dispersion of traffic around the mean value was large - a standard deviation of 24 around a mean value of 60 aircraft.

The comments made with organisation B concerning the low traffic levels in the northern sectors also apply here to NR1 and UR1.

The three en route sectors, OR2, WR1 and WR2, had the highest amount of traffic with 50% more than average. Amongst the TMA sectors, NDP had twice the traffic of SDP but the two pick-up sectors were evenly matched. The upper sectors, UR2 and UR3 had low levels of traffic to deal with.

Distribution of Total Sector Workload
Berlin Organisation C
358 Flights - 14 Sectors - 3 Upper, 7 En Route, 4 TMA



AF39 - Dec. 93

Figure 14

4.3. Workload Recorded - Berlin Proposed Organisation C

Figure 14 gives the total workload in minutes recorded by each sector (EC and CC combined) and **figure 15** shows the composition of this workload.

From figure 14 it can be seen that there was an unequal distribution of workload between the sectors. However, closer inspection reveals that, among the sectors recording above-average workloads (i.e. more than 70 minutes), there is, in fact, a good distribution of work between them. That said, the NDP had more than twice the workload of the SDP, while the OR2 sector had more than three times the workload of UR2.

Almost 50% of the NPU workload was devoted to radar tasks (figure 15). All of the radar work consisted of integrating and vectoring the flow of traffic from two stacks, TPN and WEST, prior to their handoff to the feeder. Other sectors with a radar workload in excess of 33.3% of their total sector workload were SPU and WR3. In the case of WR3, 60% of the radar conflicts (17 out of 28) were opposite direction, mostly involving Dresden/Leipzig traffic.

High R/T workloads were recorded in WR1 (50% of total workload), NR2 (47%) and WR2 (43%)

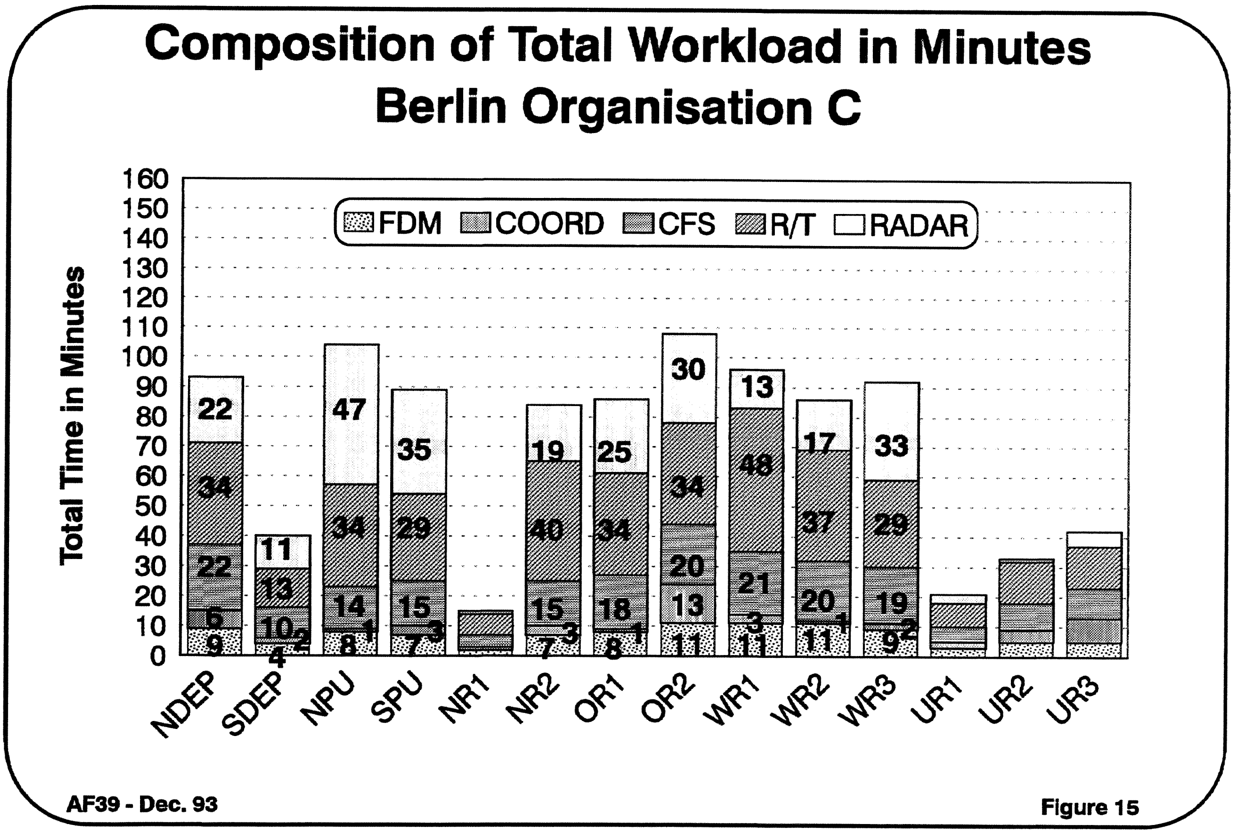


Figure 15

Peak Hour Percentage Loadings - EC and CC
Berlin Organisation C
358 Flights - 14 Sectors - 3 Upper, 7 En Route, 4 TMA

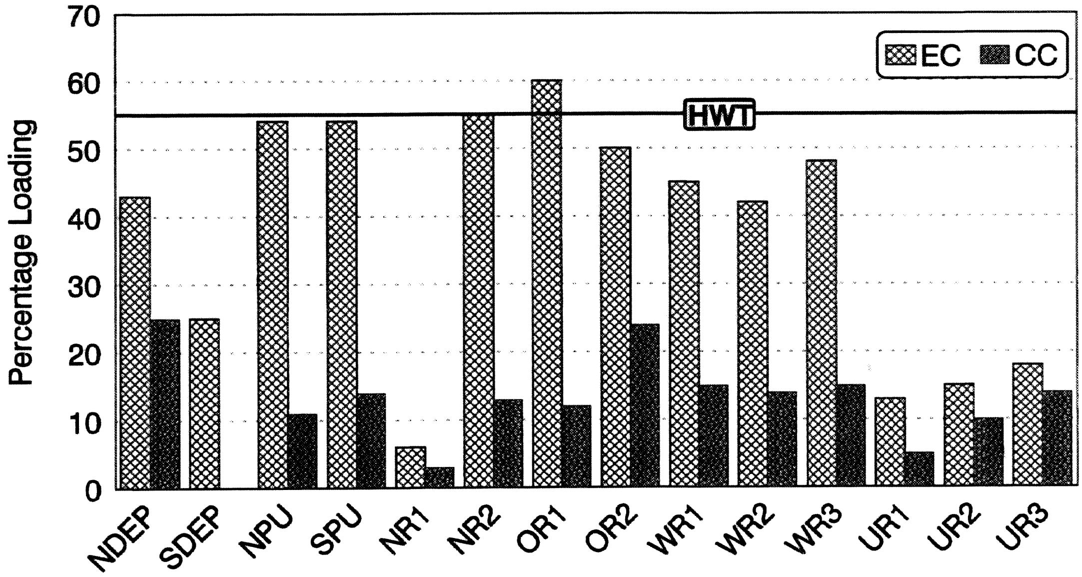


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Figure 16

Average Percentage Loadings - EC and CC
Berlin Organisation C
358 Flights - 14 Sectors - 3 Upper, 7 En Route, 4 TMA

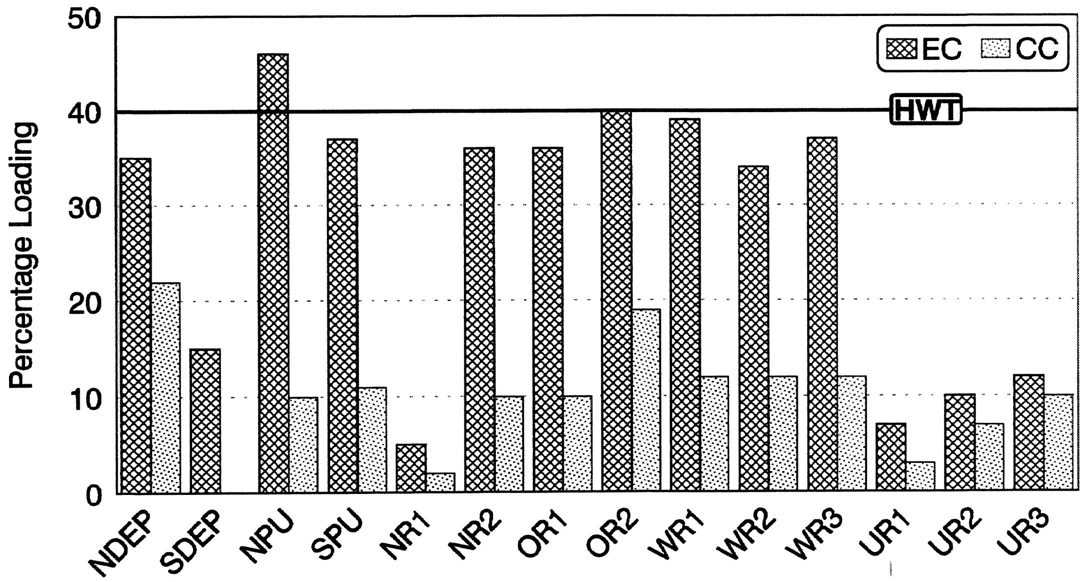

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Figure 17

4.4. Working Position Loadings - Berlin Proposed Organisation C

From section 1.4.2., ***"Controller Percentage Loadings"***, on page 8, it will be recalled that a ***peak hour percentage loading*** in excess of 55% is considered to be heavy, one in excess of 70% to be severe, and that an ***average percentage loading*** (measured over three hours) in excess of 40% is considered to be heavy, whereas one in excess of 50% is considered to be severe.

4.4.1. EC and CC Peak and Average Percentage Loadings

Figure 16 shows the EC and CC peak hour loadings for each sector while **figure 17** shows the average percentage loadings for the same sectors. A line showing the heavy workload threshold (labelled "HWT") has been drawn at the 55% (peak hour) and 40% (average) values in figures 16 and 17, respectively.

Referring to figure 16, two EC positions, OR1 and NR2, were heavily loaded during their peak hours. Another two sectors, NPU and SPU, were approaching the heavy workload threshold. Of the other sectors, the NDP, OR2, WR1, WR2 and WR3 ECs recorded moderate loadings while SDP, NR1 and the upper sectors returned low loadings. All CC positions were lightly loaded during their respective peak hours.

From figure 17 it can be seen that two EC positions, NPU and OR2, were heavily loaded over three hours with the WR1 EC approaching the heavy workload threshold. With the exception of the SDP, NR1 and the upper sectors, there is quite a good balance between the sectors over the three hours.

All CC positions were lightly loaded over the three hours. The comments made in regard to the EC/CC loadings in organisation B apply here also.

Delays on Berlin Inbounds
Berlin Organisation C

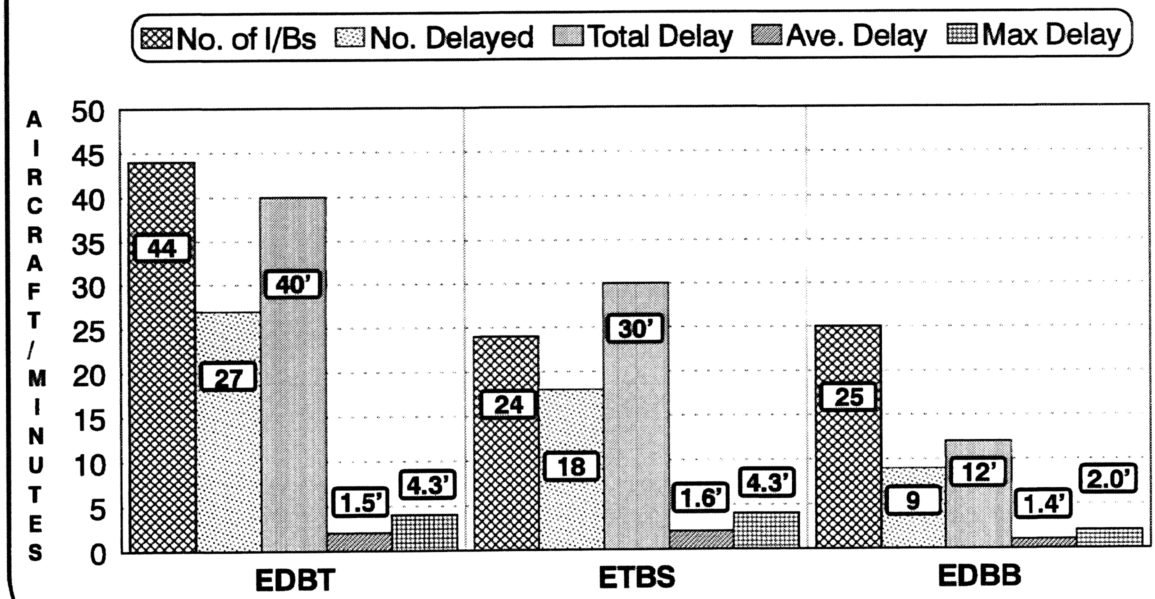

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Figure 18

Berlin Departure Delays
Berlin Organisation C

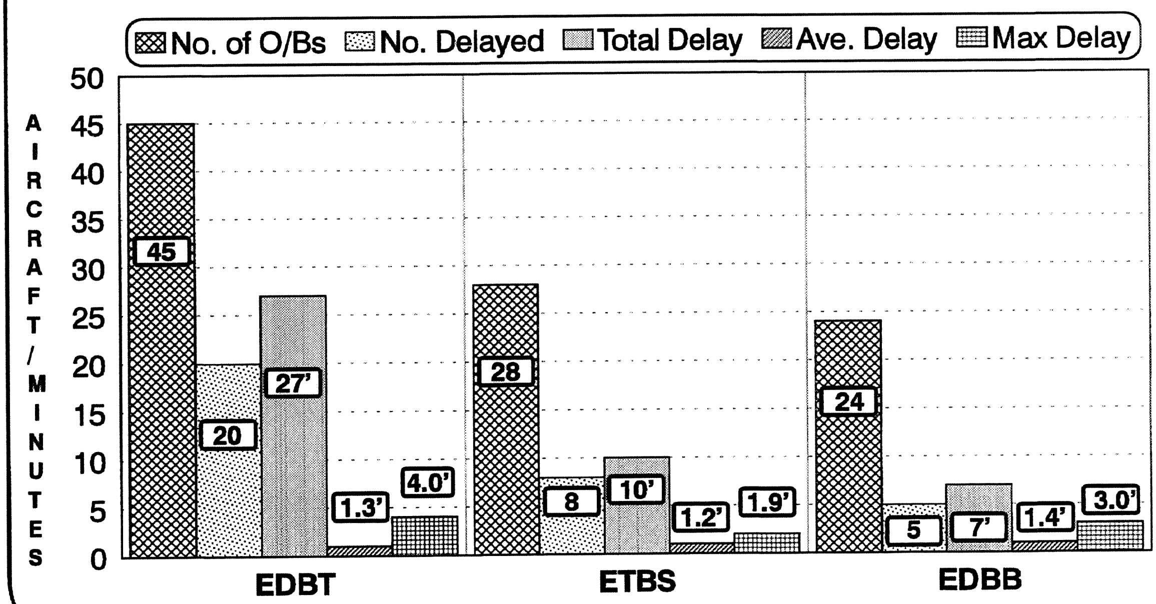

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Figure 19

4.5. Arrival and Departure Delays - Berlin Proposed Organisation C

Table 10 gives the results found for the three holding stacks simulated with this organisation. **Figures 18 and 19** describe the arrival and departure delays as experienced by each of the three Berlin airports.

STACK (Base)	Highest Level Used	Number of Aircraft Holding	Average Delay in Minutes	Maximum Delay in Minutes
RSF (FL140)	FL170	19	1.7'	4.3'
TPN (FL140)	FL160	18	1.5'	3.7'
WEST (FL140)	FL160	17	1.4'	3.3'

Table 10

All three stacks had similar usage with the RSF stack returning the highest holding time of 4.3 minutes and the highest average holding time of 1.7 minutes. The comments made for organisation B about absorbing small delays by extended radar vectoring also apply here.

Table 11 breaks down the figures for each stack showing the number of aircraft held for less than one minute, for more than one minute but less than two, and for two minutes or more.

STACK	DELAY			
	< 1'	1' <> 2'	> 2'	Total
RSF	7	7	5	19
TPN	7	5	6	18
WEST	5	9	3	17

Table 11

Figure 18 shows that 61% of the Tegel inbounds, 75% of the Schönefeld inbounds and 36% of the Tempelhof inbounds were delayed. **Figure 19**, for the departures, shows that 44% of the Tegel outbounds, 29% of the Schönefeld outbounds and 21% of the Tempelhof outbounds were delayed. In both figures the cumulative delay, average delay and maximum delay (all in minutes) are given.

4.6. Summary - Berlin Proposed Organisation C

Table 12, below, and **table 12A**, overleaf, give a summary of the results found.

PROPOSED ORGANISATION C			
SECTOR	**No. of A/C Cont(Coord) EC Loadings**	**Traffic Handled**	**Comments**
NDP	74 (0) Peak 43% Average 35%	All BB/BT departures. All BS departures to HLZ.	Almost 50% of radar conflicts involve BB/BT departures on crossing tracks, e.g. BT southbound versus BB westbound.
SDP	35 (0) Peak 25% Average 15%	All BB departures to the South. All BS departures.	Combined CC position with NDP. CC Peak 25% CC Average 22%
NPU	66 (0) Peak 54% Average 46%	All Berlin arrivals from the North and North-West via the TPN stack. BT arrivals from SUI via the TPN stack. All Berlin arrivals from the South-West via the WEST stack. BT departures to the East and South.	Almost all radar work involved with vectoring traffic inbound from the TPN and WEST stacks prior to handoff to the Feeder.
SPU	61 (0) Peak 54% Average 37%	Berlin arrivals from the South via the RSF stack. BB/BS inbounds from SUI, either direct or via the RSF stack. BS departures to the South, North and East.	
NR2	62 (0) Peak 55% Average 36%	Manages the TPN stack. All Berlin arrivals using the TPN stack from the North, North-West and East. Departures to BKD including those from Dresden/Leipzig.	High R/T workload. Most radar work concerned with the TPN stack.

Table 12

PROPOSED ORGANISATION C			
SECTOR	**No. of A/C Cont(Coord) EC Loadings**	**Traffic Handled**	**Comments**
OR1	65 (2) Peak 60% Average 36%	Manages the RSF stack. All BB/BT departures to the South. BS departures to the South and North.	
OR2	86 (4) Peak 50% Average 40%	Dresden traffic. Berlin arrivals to the RSF stack from KILNU/HDO. BS departures to the South.	
WR1	93 (0) Peak 45% Average 39%	Manages the WEST stack. Berlin arrivals from the South-West via the WEST stack. Departures to BKD/HLZ/"B".	
WR2	88 (2) Peak 42% Average 34%	Berlin departures to the South-West. Dresden/Leipzig arrivals and departures.	Most radar work on the BAMKI-ROTAS segment.
WR3	76 (0) Peak 48% Average 37%	Dresden/Leipzig arrivals and departures. All Berlin arrivals using the RSF stack from HDO/KILNU.	25 out of 28 radar conflicts between AMAKO/LOMAP. 17 of these were opposite direction conflicts, mostly Dresden/Leipzig traffic.
NR1 and UR1/2/3	Low to moderate results recorded.		

Table 12A

The results for the Berlin proposed organisation C showed:

- An unequal distribution of traffic between the sectors.
- A good distribution of workload between the busier sectors.
- High radar workloads in the NPU, SPU and WR3 sectors.
- High R/T workloads in the NR2, WR1 and WR2 sectors.
- With the EC positions, the NR2 and OR1 sectors were heavily loaded during their peak hours. The NPU and OR2 sectors were heavily loaded over three hours.
- Light loadings on all CC positions over one and three hours.
- Similar usage of all three stacks with the RSF stack returning the highest maximum delay of 4.3 minutes.
- The maximum departure delay was 4.0 minutes at Tegel.

5. BERLIN PROPOSED ORGANISATION D

The traffic sample simulated contained an increase of 50% over the 1992 sample. This roughly equates to a year 2000 sample based on a compound increase of 5% per annum from 1992. The total sample was 366 flights for this organisation.

Organisation D tested the Terminal Area and en route sectorisation, control procedures, routes and equipment contained in the detailed specifications outlined. The equipment assumed to be in operation was ASCAP, DEPCOS and ACT. Silent handovers were used between the sectors as well as automatic data transfer with other centres except Prague and Warsaw.

Both the TRA Nord and the TRA Sued were assumed to be active from FL100 to FL350.

5.1 Sectors and Working Positions Simulated

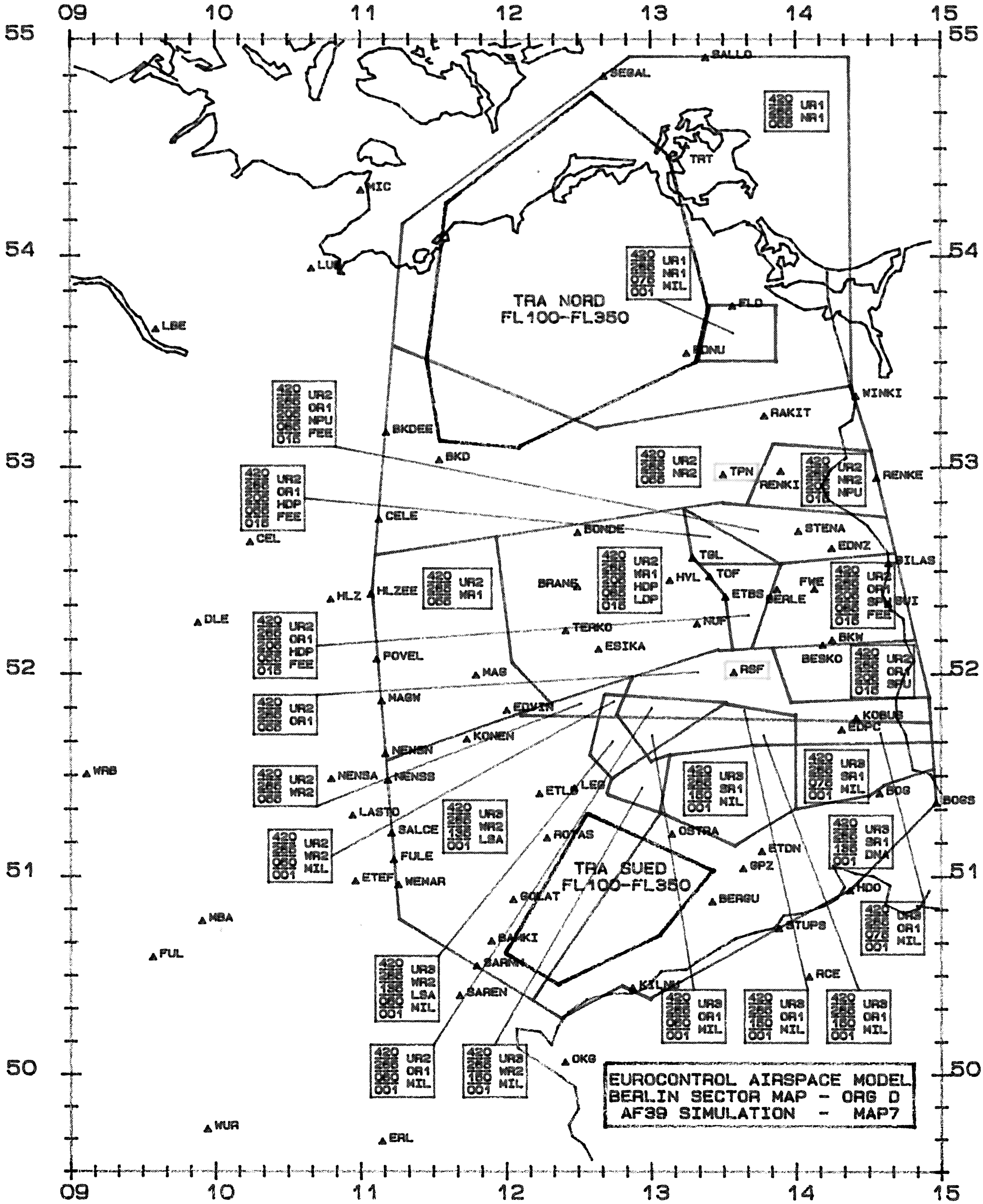
5.1.1. Sectors

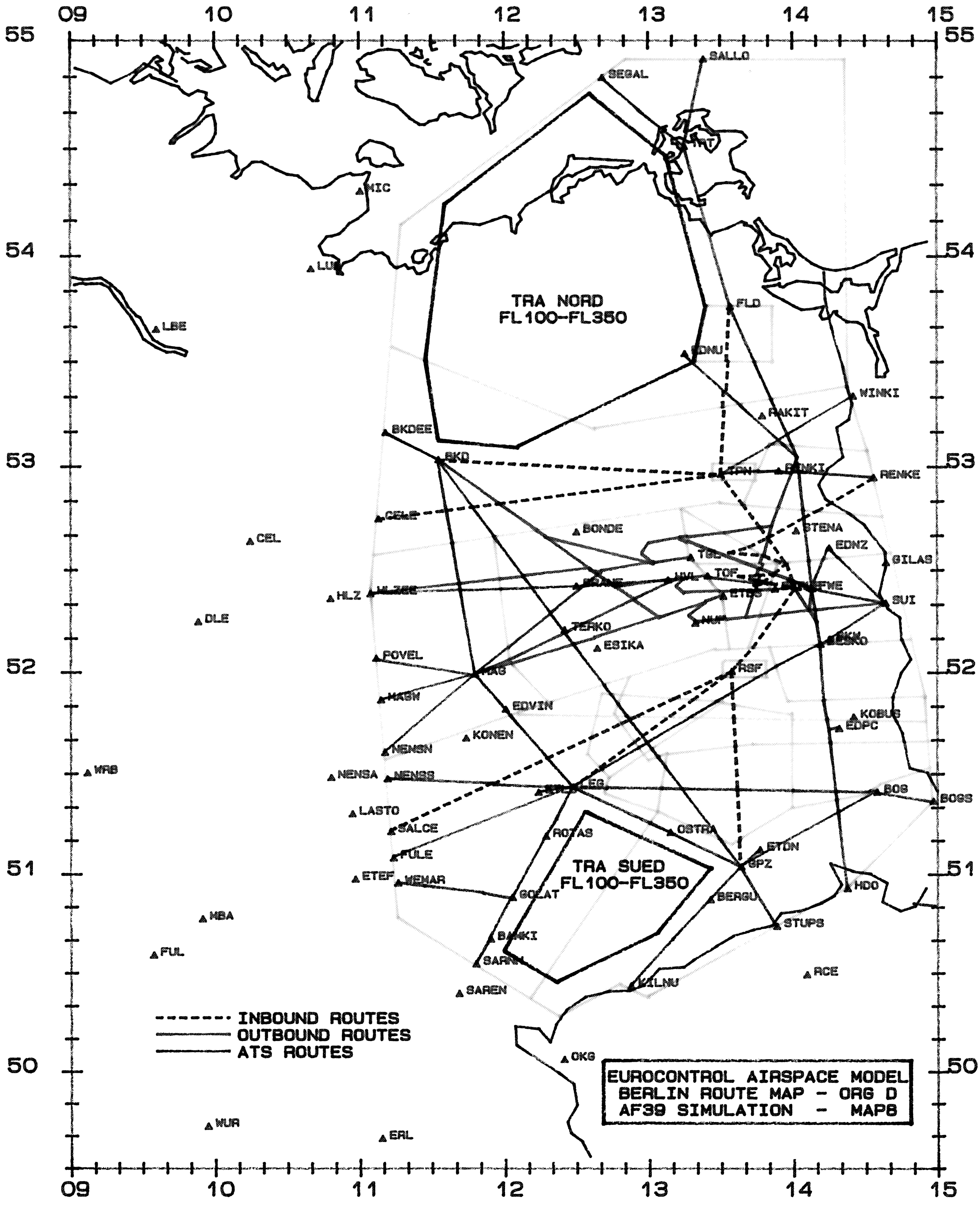
The 13 sector configuration outlined for organisation D is shown in **table 13**, below, and **map 7**, overleaf. The defined routes are shown in **map 8** on page 40.

SECTOR	VERTICAL DIMENSIONS
Dep. High ("HDP")	Max FL205, base FL85 over LDP else FL55 over Feeder.
Dep. Low ("LDP")	Max FL85.
Pick-up North ("NPU")	Max FL205, base FL85 above Feeder else GND.
Pick-up South ("SPU")	Max FL205, base FL85 above Feeder else GND.
NR1	Max FL285, base FL75 above MIL area south of FLD, else FL55.
NR2	Max FL285, base FL205 above NPU else FL55.
OR1	Max FL285, base FL205 above HDP, NPU, SPU, FL150 above MIL area south of RSF, FL75 above MIL area south of KOBUS, else FL55.
SR1	Max FL285, base FL150 above MIL area north of OSTRA, FL135 above Dresden, FL75 above MIL area south of KOBUS.
WR1	Max FL285, base FL205 above HDP else FL55.
WR2	Max FL285, base FL150 above MIL area north-east of LEG, FL135 above Leipzig, else FL55.
UR1, UR2, UR3	FL285 - UNL.
Feeder ("FEE")	Max FL85 under NPU and SPU, FL 55 under HDP.
ETDN and ETLS	Max FL135.

Table 13

The Dresden and Leipzig TMAs and the feeder sector for Berlin were simulated but not evaluated as their results were not relevant to the objectives of the study.


TRA NORD
FL100-FL350
TRA SUED
FL100-FL350
EUROCONTROL AIRSPACE MODEL
BERLIN SECTOR MAP - ORG D
AF39 SIMULATION - MAP7


TRA NORD
FL100-FL350
TRA SUED
FL100-FL350
INBOUND ROUTES
OUTBOUND ROUTES
ATS ROUTES
EUROCONTROL AIRSPACE MODEL
BERLIN ROUTE MAP - ORG D
AF39 SIMULATION - MAP8
SALLO
SEGAL
NIC
LBE
FLD
WINKI
RAKIT
BKDEE
BKD
RENKE
CEL
BONDE
STENA
EDNZ
GILAS
SUI
HLZ
DLE
TERKO
ESIKA
POVEL
MAG
RSF
EDVIN
KONEN
KOBUS
EDPC
WRB
NENSA
LASTO
SALCE
OSTRA
STDN
GPZ
ETEF
GOLAT
BERGU
STUPS
HDO
FUL
MBA
SAREN
RCE
OKG
WUR
ERL
BOGS

Intentionally Blank

Distribution of Traffic - Berlin Organisation D

366 Flights - 13 Sectors - 3 Upper, 6 En Route, 4 TMA

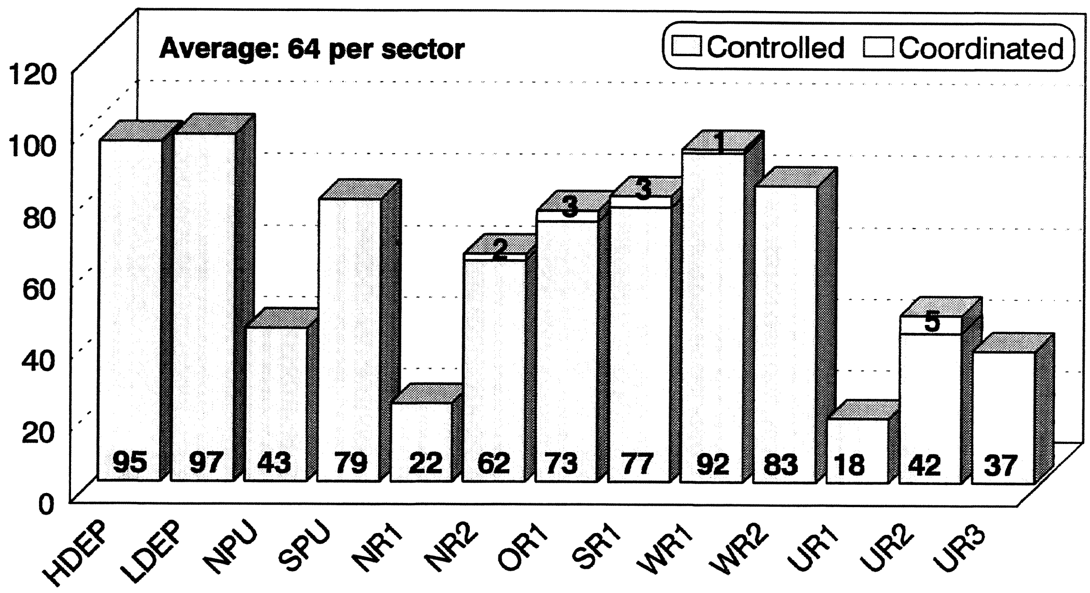


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Figure 20

5.1.2. Working Positions

Each sector was simulated with an EC and a CC except the HDP and LDP sectors which had the CC positions combined. The Assistant and Flight Data positions were not simulated.

5.1.3. Holding Stacks

Full stack management was simulated in organisation D. As mentioned in section 1.2.2.4., ***"Holding Stacks and Ground Delays"***, on page 3, the time values used for the minimum interval between successive movements were 1.5 minutes at Tegel and 2 minutes at Schönefeld and Tempelhof. It is on these values that the need for, and duration of, air and ground delays are calculated by the model.

Two holding stacks were simulated:

- IAF Nord ("TPN") - FL100-FL200 - All Berlin inbounds.

- IAF Sued ("RSF") - FL100-FL200 - All Berlin inbounds.

5.2. Distribution of Traffic - Berlin Proposed Organisation D

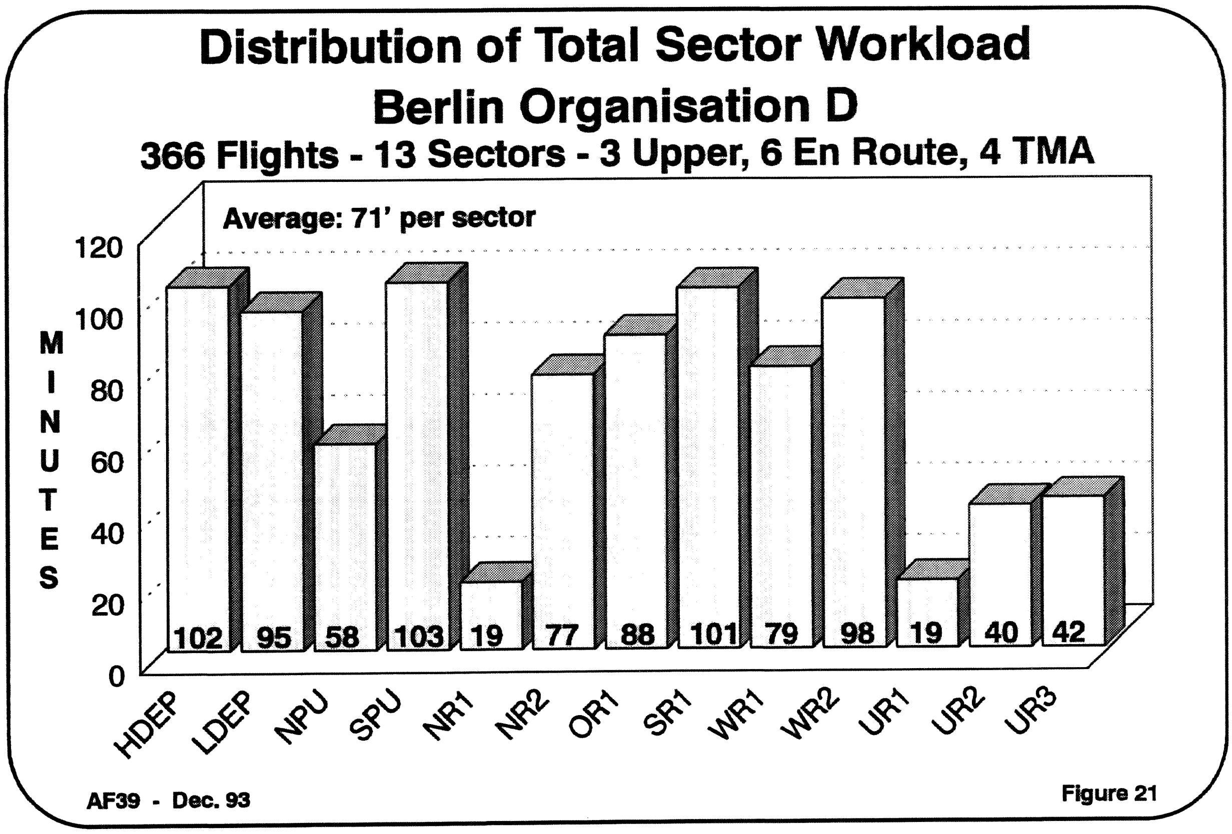
Figure 20 shows the number of flights for each sector during the simulated period. The format is the same as for the previous distribution of traffic charts.

An unequal distribution of traffic between the sectors can be seen from the chart with the LDP sector having more than five times the traffic of UR1. The dispersion of traffic around the mean value was large - a standard deviation of 27 around a mean value of 64 aircraft.

The comments made with organisations B and C concerning the low traffic levels in the northern sectors also apply here to NR1 and UR1.

Amongst the TMA sectors, HDP and LDP had the highest amount of traffic of all the sectors. Each sector worked virtually the same number of aircraft, which they were designed to do - each Berlin departure working both sectors. The SPU sector had almost twice the traffic of NPU but 29% (23 aircraft) of SPU's traffic were departures whereas only 7% (3) of NPU's traffic were departures.

The en route sectors had varying amounts of traffic - WR1 having almost 50% more than the average which was on a par with the HDP and LDP sectors - and the upper sectors had low traffic levels.


Distribution of Total Sector Workload
Berlin Organisation D
366 Flights - 13 Sectors - 3 Upper, 6 En Route, 4 TMA
Average: 71' per sector
MINUTES
120
100
80
60
40
20
0
102
95
58
103
19
77
88
101
79
98
19
40
42
HDEP
LDEP
NPU
SPU
NR1
NR2
OR1
SR1
WR1
WR2
UR1
UR2
UR3
AF39 - Dec. 93
Figure 21

5.3. Workload Recorded - Berlin Proposed Organisation D

Figure 21 gives the total workload in minutes recorded by each sector (EC and CC combined) and **figure 22** shows the composition of this workload.

From figure 21 it can be seen that there was an unequal distribution of workload between the sectors. However, as with organisation C, the sectors recording above-average workloads (i.e. more than 71 minutes) have a reasonably good distribution of work between them. The NPU sector had just 56% of the workload of the SPU sector, which recorded the highest total workload.

From figure 22, the sectors with a radar workload in excess of 33.3% of their total sector workload were NPU (47%), SPU (40%) and WR2 (38%). In the case of NPU this was not of major significance as the sector did not have a high workload; however, a comparison with SPU is interesting. Both sectors dealt with traffic coming out of their respective stacks and, in fact, both recorded the same number of radar conflicts with inbound traffic (20). However, that was the only radar work recorded for NPU. SPU, on the other hand, had 13 other conflicts to deal with involving inbounds versus departures, departures versus departures and others involving EDNZ departures. All of this led to SPU recording the highest radar work of all the sectors. In the case of WR2, 74% of the radar conflicts (20 out of 27) were recorded between LEG and the boundary with SR1. Of these, 50% were opposite direction conflicts involving Dresden arrivals and departures.

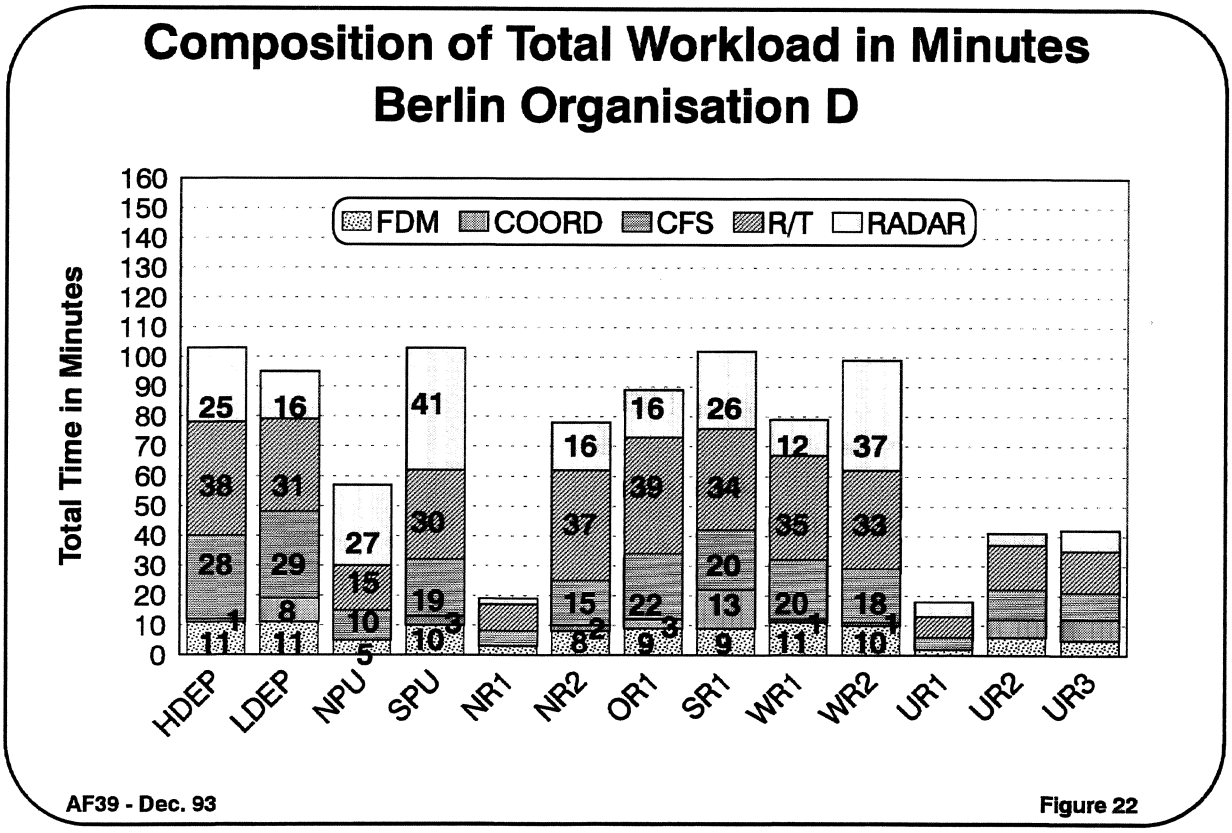


Figure 22

Peak Hour Percentage Loadings - EC and CC
Berlin Organisation D

366 Flights - 13 Sectors - 3 Upper, 6 En Route, 4 TMA

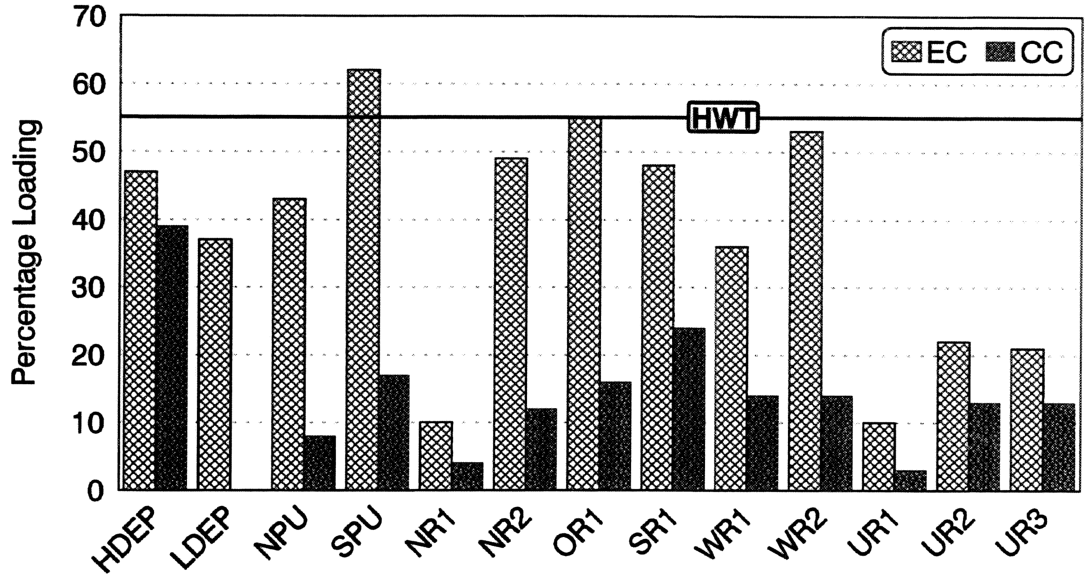


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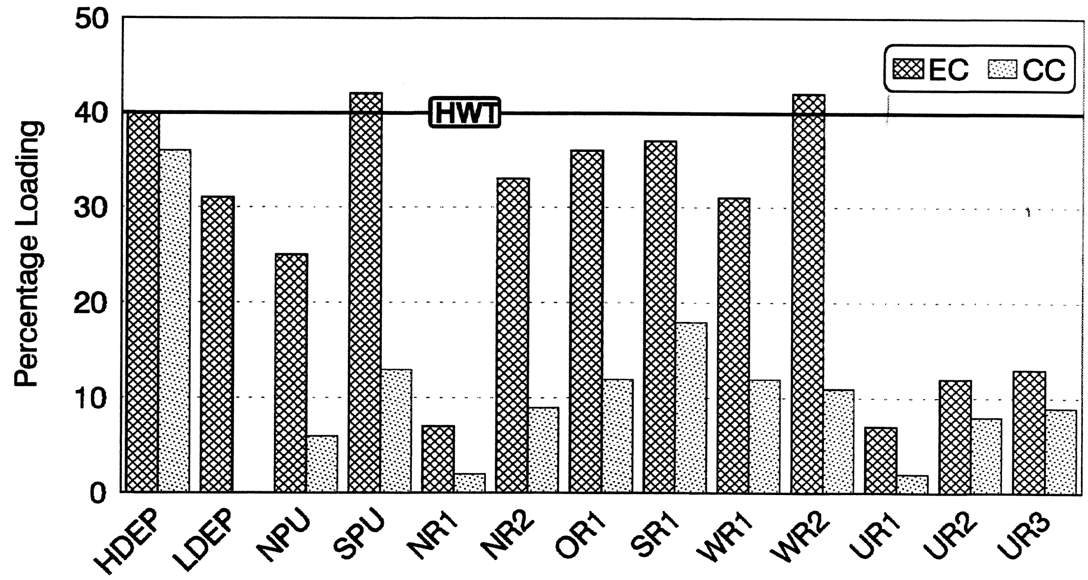
Figure 23

Average Percentage Loadings - EC and CC
Berlin Organisation D

366 Flights - 13 Sectors - 3 Upper, 6 En Route, 4 TMA



AF39 - Dec. 93

Figure 24

5.4. Working Position Loadings - Berlin Proposed Organisation D

From section 1.4.2., *"Controller Percentage Loadings"*, on page 8, it will be recalled that a ***peak hour percentage loading*** in excess of 55% is considered to be heavy, one in excess of 70% to be severe, and that an ***average percentage loading*** (measured over three hours) in excess of 40% is considered to be heavy, whereas one in excess of 50% is considered to be severe.

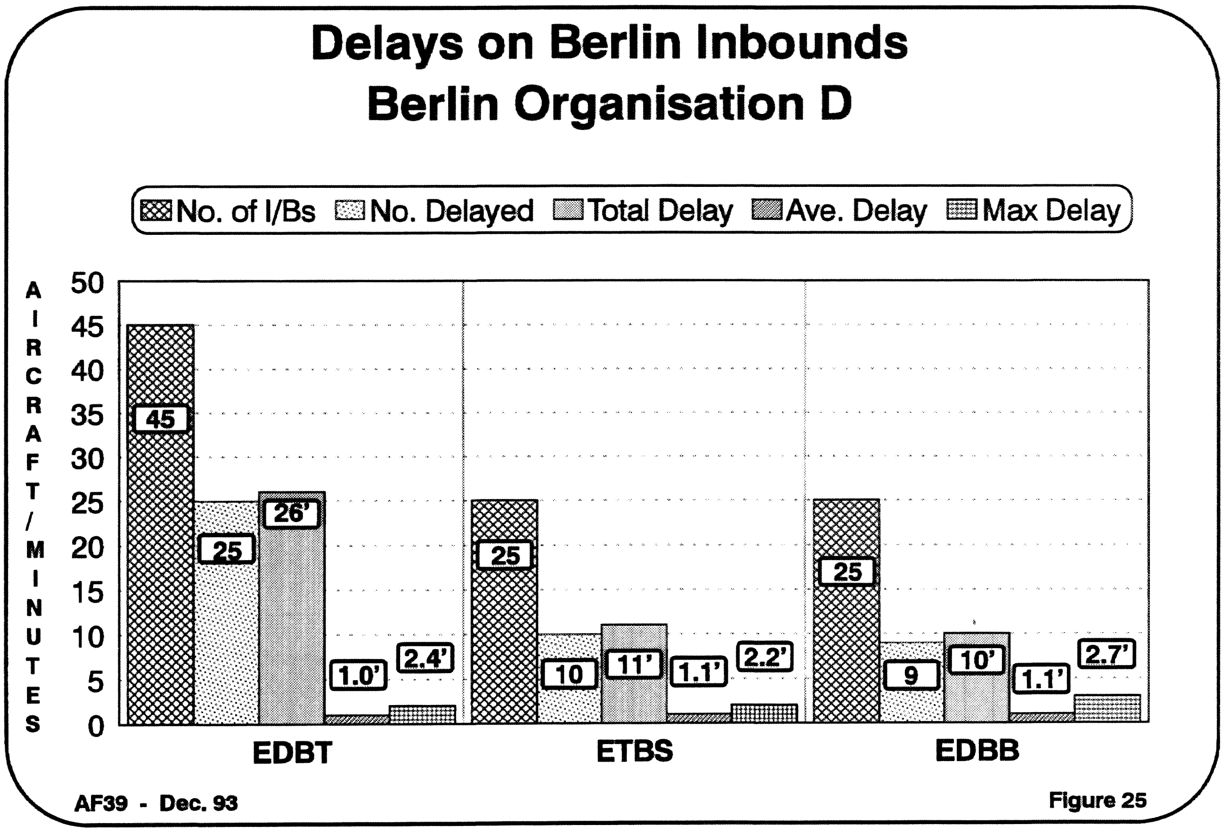
5.4.1. EC and CC Peak and Average Percentage Loadings

Figure 23 shows the EC and CC peak hour loadings for each sector while **figure 24** shows the average percentage loadings for the same sectors. A line showing the heavy workload threshold (labelled "HWT") has been drawn at the 55% (peak hour) and 40% (average) values in figures 23 and 24, respectively.

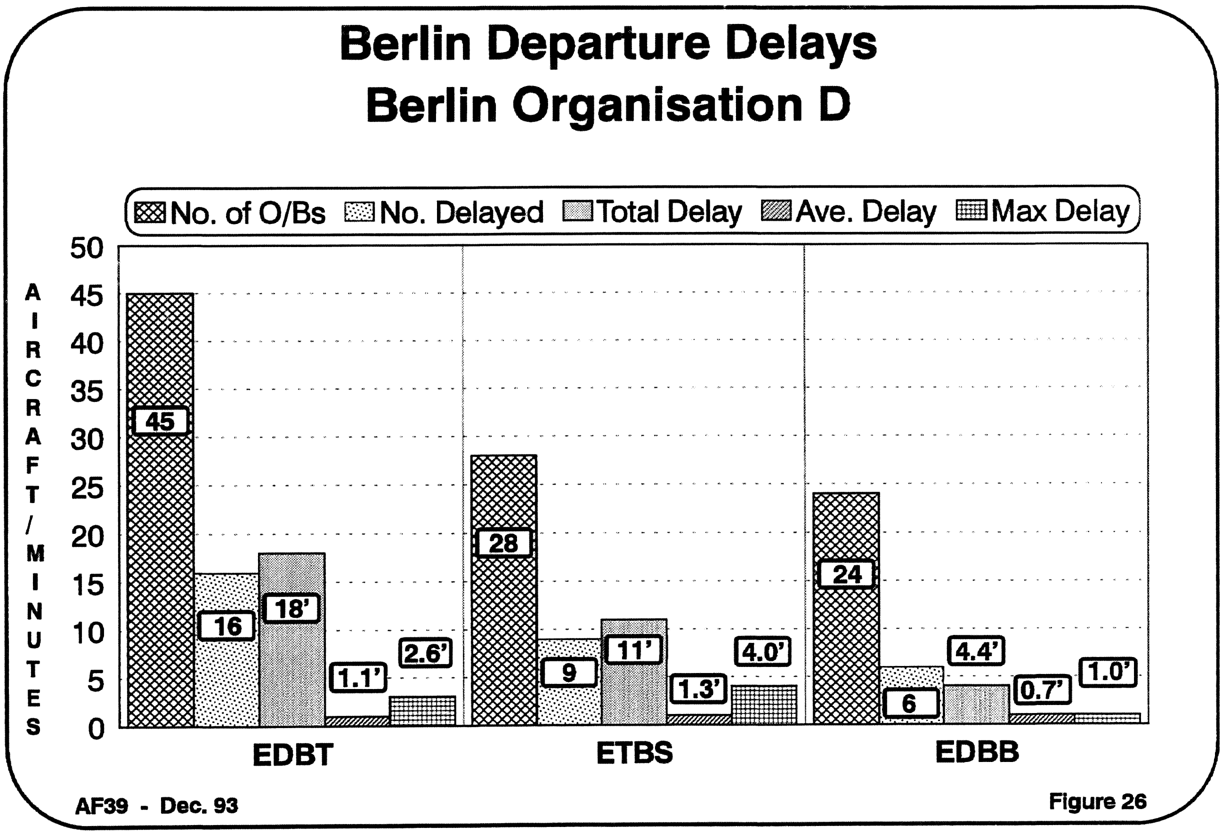
Referring to figure 23, two EC positions, SPU and OR1, were heavily loaded during their peak hours. Of the other sectors, the WR2 EC was approaching the heavy workload threshold with 53%, HDP, LDP, NPU, NR2, SR1 and WR1 ECs recorded moderate loadings while NR1 and the upper sectors returned low loadings. With one exception, the departure CC, all CC positions were lightly loaded during their respective peak hours.

From figure 24 it can be seen that three EC positions, HDP, SPU, WR2, were heavily loaded over three hours. With the exception of the NPU, NR1 and the upper sectors, there is a reasonably good balance between the sectors over the three hours.

Again, with the exception of the departure CC, all CC positions were lightly loaded over the three hours. The comments made in regard to the EC/CC loadings in organisations B and C apply here also.



Delays on Berlin Inbounds
Berlin Organisation D
No. of I/Bs
No. Delayed
Total Delay
Ave. Delay
Max Delay
AIRCRAFT / MINUTES
0
5
10
15
20
25
30
35
40
45
50
45
25
26'
1.0'
2.4'
25
10
11'
1.1'
2.2'
25
9
10'
1.1'
2.7'
EDBT
ETBS
EDBB
AF39 - Dec. 93
Figure 25



Berlin Departure Delays
Berlin Organisation D
No. of O/Bs
No. Delayed
Total Delay
Ave. Delay
Max Delay
AIRCRAFT / MINUTES
0
5
10
15
20
25
30
35
40
45
50
45
16
18'
1.1'
2.6'
28
9
11'
1.3'
4.0'
24
6
4.4'
0.7'
1.0'
EDBT
ETBS
EDBB
AF39 - Dec. 93
Figure 26

5.5. Arrival and Departure Delays - Berlin Proposed Organisation D

Table 14 gives the results found for the two holding stacks simulated with this organisation. **Figures 25 and 26** describe the arrival and departure delays as experienced by each of the three Berlin airports.

STACK (Base)	Highest Level Used	Number of Aircraft Holding	Average Delay in Minutes	Maximum Delay in Minutes
RSF (FL100)	FL120	24	0.9'	2.7'
TPN (FL100)	FL130	19	1.2'	2.2'

Table 14

The RSF stack had the highest usage returning the highest holding time of 2.7 minutes but the highest average holding time was with the TPN stack which was 1.2 minutes. The comments made for organisations B and C about absorbing small delays by extended radar vectoring also apply here.

Table 15 breaks down the figures for each stack showing the number of aircraft held for less than one minute, for more than one minute but less than two, and for two minutes or more.

STACK	DELAY			
	< 1'	1' <> 2'	> 2'	Total
RSF	15	7	2	24
TPN	6	8	5	19

Table 15

Figure 25 shows that 56% of the Tegel inbounds, 40% of the Schönefeld inbounds and 36% of the Tempelhof inbounds were delayed. **Figure 26**, for the departures, shows that 36% of the Tegel outbounds, 32% of the Schönefeld outbounds and 25% of the Tempelhof outbounds were delayed. In both figures the cumulative delay, average delay and maximum delay (all in minutes) are given.

5.6. **Summary - Berlin Proposed Organisation D**

Table 16, below, and **table 16A**, overleaf, give a summary of the results found.

PROPOSED ORGANISATION D			
SECTOR	**No. of A/C Cont(Coord) EC Loadings**	**Traffic Handled**	**Comments**
HDP	95 (0) Peak 47% Average 40%	All Berlin departures FL90+.	50% of radar conflicts involve BT and BB/BS departures on crossing tracks, e.g. BT westbound versus BB/BS to BKD.
LDP	97 (0) Peak 37% Average 31%	All Berlin departures.	Combined CC position with HDP. CC peak 39% CC average 36%
NPU	43 (0) Peak 43% Average 25%	All Berlin arrivals from the North and North-West via the TPN stack.	All radar work involved with vectoring traffic inbound from the TPN stack prior to handoff to the Feeder.
SPU	79 (0) Peak 62% Average 42%	Berlin arrivals from the South and South-West via the RSF stack. BB/BS inbounds direct from SUI. BS departures to the South and East.	As well as the radar work with aircraft coming off the RSF stack, the sector also has to deal with radar conflicts concerning arrival and departure traffic and EDNZ traffic.
NR2	62 (2) Peak 49% Average 33%	Manages the TPN stack. All Berlin arrivals using the TPN stack from the North and North-West. Departures to BKD/the North.	Radar work spread throughout the sector.
OR1	73 (3) Peak 55% Average 36%	Manages the RSF stack. Berlin arrivals using the RSF stack from the South and South-West. Berlin departures to the South. BS departures to the North.	

Table 16

PROPOSED ORGANISATION D			
SECTOR	**No. of A/C Cont(Coord) EC Loadings**	**Traffic Handled**	**Comments**
SR1	77 (3) Peak 48% Average 37%	Dresden/Leipzig traffic. Berlin arrivals to the RSF stack from KILNU/RCE.	Most radar conflicts are opposite direction involving Dresden arrivals versus departures.
WR1	92 (1) Peak 36% Average 31%	Berlin departures to BKD/HLZ/NENSA. Dresden/Leipzig traffic to/from BKD and POVEL.	Radar work well spread throughout the sector.
WR2	83 (0) Peak 53% Average 42%	Berlin arrivals from LASTO. Dresden/Leipzig arrivals and departures.	74% of radar conflicts (20 out of 27) occurred between LEG and the boundary with SR1. 50% of these concern Dresden arrivals versus departures.
NR1 and UR1/2/3	Low to moderate results recorded.		

Table 16A

The results for the Berlin proposed organisation D showed:

- An unequal distribution of traffic between the sectors.
- A good distribution of workload between the busier sectors.
- High radar workloads in the SPU and WR2 sectors.
- With the EC positions, the SPU and OR1 sectors were heavily loaded during their peak hours. The HDP, SPU and WR2 sectors were heavily loaded over three hours.
- Light loadings on all CC positions over one and three hours except the departure CC where moderate loadings were recorded.
- Similar usage of both stacks with the RSF stack returning the highest maximum delay of 2.7 minutes.
- The maximum departure delay was 4.0 minutes at Schönefeld.

Distribution of ATC Tasks
Berlin - All Organisations

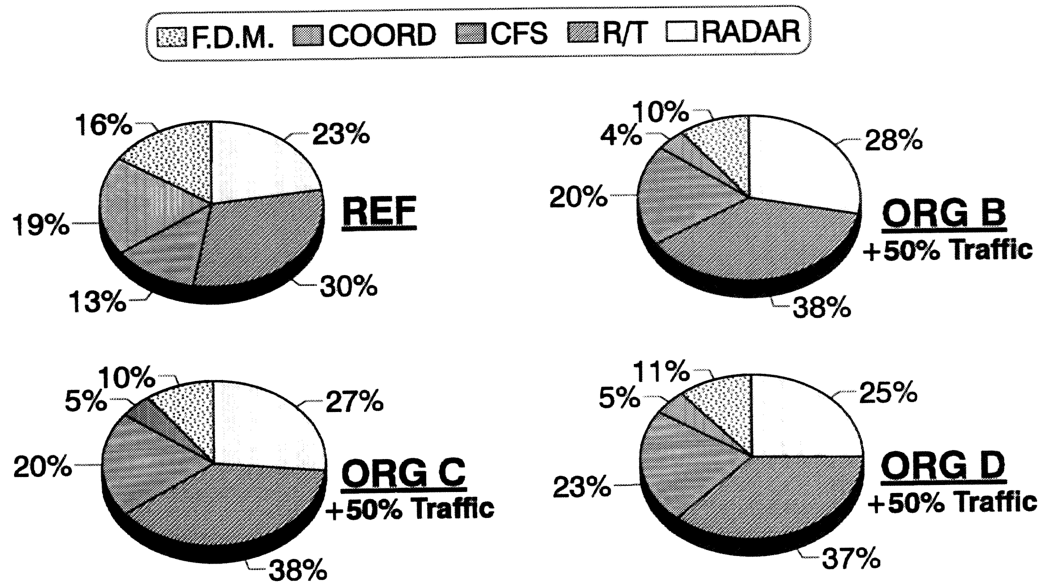


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Figure 27

6. COMPARISON BETWEEN THE ORGANISATIONS

6.1. Comparison between the Reference and Proposed Organisations

As stated earlier, a comparison between the reference organisation and the proposed organisations is difficult to make as the proposed changes differed so radically from the present-day scenario; however, some limited comparisons can be made. **Figure 27** shows the distribution of ATC tasks for each of the four organisations. Each pie slice represents the percentage of the total time spent on the five categories of tasks for each organisation.

While the reduction in the time spent on flight data management and coordination can be clearly seen, what is not immediately apparent from figure 27 are the other changes that took place. **Table 17** quantifies these changes in terms of the amount of time spent per aircraft (multiplied by 100 for easier reading) on each category of task for the reference organisation and the average time for the three proposed organisations. The percentages in brackets indicate the changes from the reference organisation.

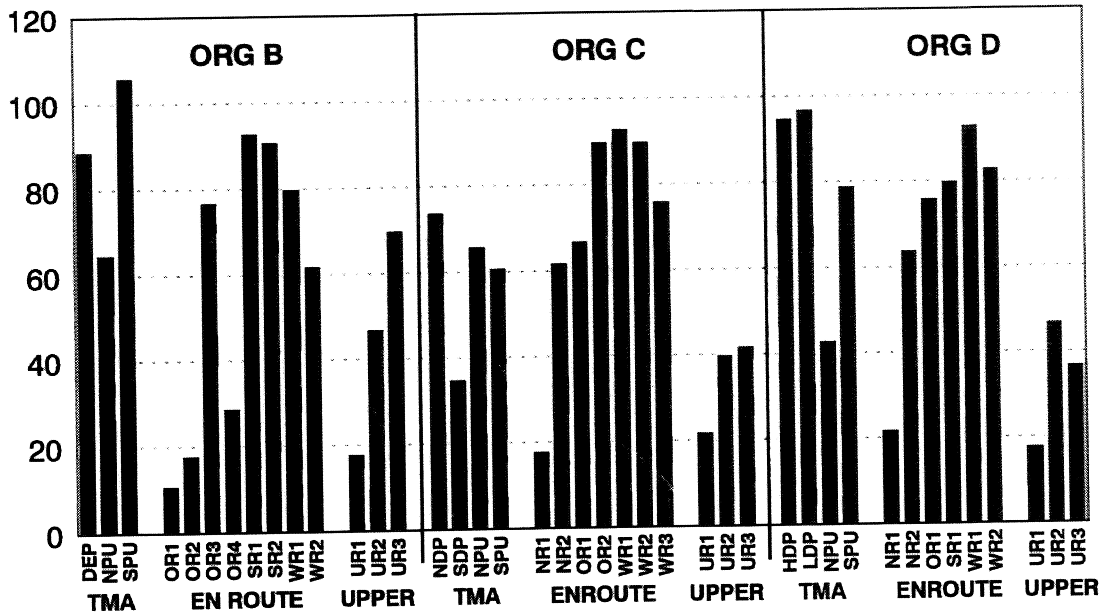
WORK PER AIRCRAFT IN MINUTES (x 100)						
ORG	**FDM**	**Coord**	**CFS**	**R/T**	**Radar**	**Total**
Ref	26'	31'	21'	49'	37'	164'
Proposed Average	12' (-54%)	5' (-84%)	24' (+14%)	44' (-10%)	31' (-16%)	117' (-29%)

Table 17

As can be seen from table 17, the amount of time spent per aircraft on each task category fell in all areas except for conflict search. The reasons for the conflict search increase are twofold: firstly, there were more sectors in the proposed organisations with each aircraft crossing 2.3 sectors, on average, as opposed to 2.0 sectors per aircraft in the reference organisation; this resulted in less conflict search tasks being carried out. Secondly, no holding stacks were simulated in the reference organisation and, therefore, no associated conflict search tasks were recorded.

The reductions in the flight data management and coordination tasks are significant, and are the result of the new equipment and the reallocation of the CC tasks in Schönefeld to the flight data assistant in the proposed organisations, e.g. estimates to/from Prague or Warsaw. The R/T tasks fell due to less level reclearances being given and, consequently, less level reports being received. With the radar tasks, there was a significant reduction in the number of same direction conflicts, the most common type, but this was partly offset by increases in crossing and opposite direction conflicts.

Distribution of Traffic
Berlin Organisations B, C, D



AF39 - Dec. 93 Figure 28

6.2. Comparison between Organisations B, C and D

6.2.1. Distribution of Traffic and Total Workload

Figure 28 shows the distribution of traffic divided into TMA, en route and upper for the three organisations and **figure 29** gives the distribution of total workload in the same manner.

Organisation B returned clear imbalances between the sectors in both numbers of aircraft and total workload. The only benefit in having the upper sectors UR1 and UR3 with a base of FL245 instead of FL285 was to keep 14 aircraft with UR3 and out of SR2, a sector with no major workload problems. The DEP and SPU sectors had high levels of traffic and workload while NPU had a high level of workload for moderate traffic levels. Amongst the en route sectors, SR1 recorded high levels of traffic and workload with the other sectors yielding low to moderate results.

Organisation C had imbalances in the number of aircraft per sector but a fairly good balance of total workload amongst the busier sectors. The SDP sector had half the aircraft and workload of NDP but, apart from that, the results were good.

While there was only a reasonable distribution of aircraft amongst the busier sectors in organisation D, it resulted in a fairly good distribution of total workload between the same sectors. As in organisation C with the TMA sectors, NPU had significantly lower levels of traffic and workload than SPU.

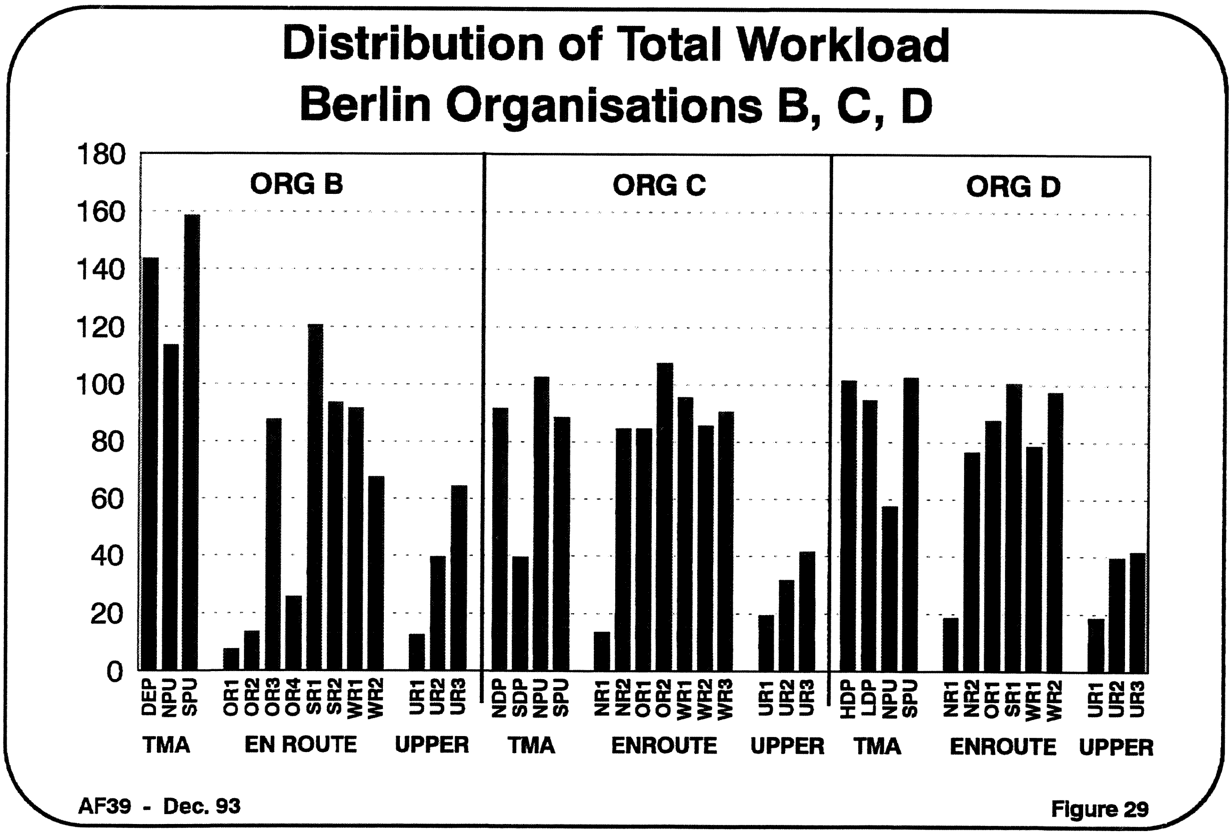


Figure 29

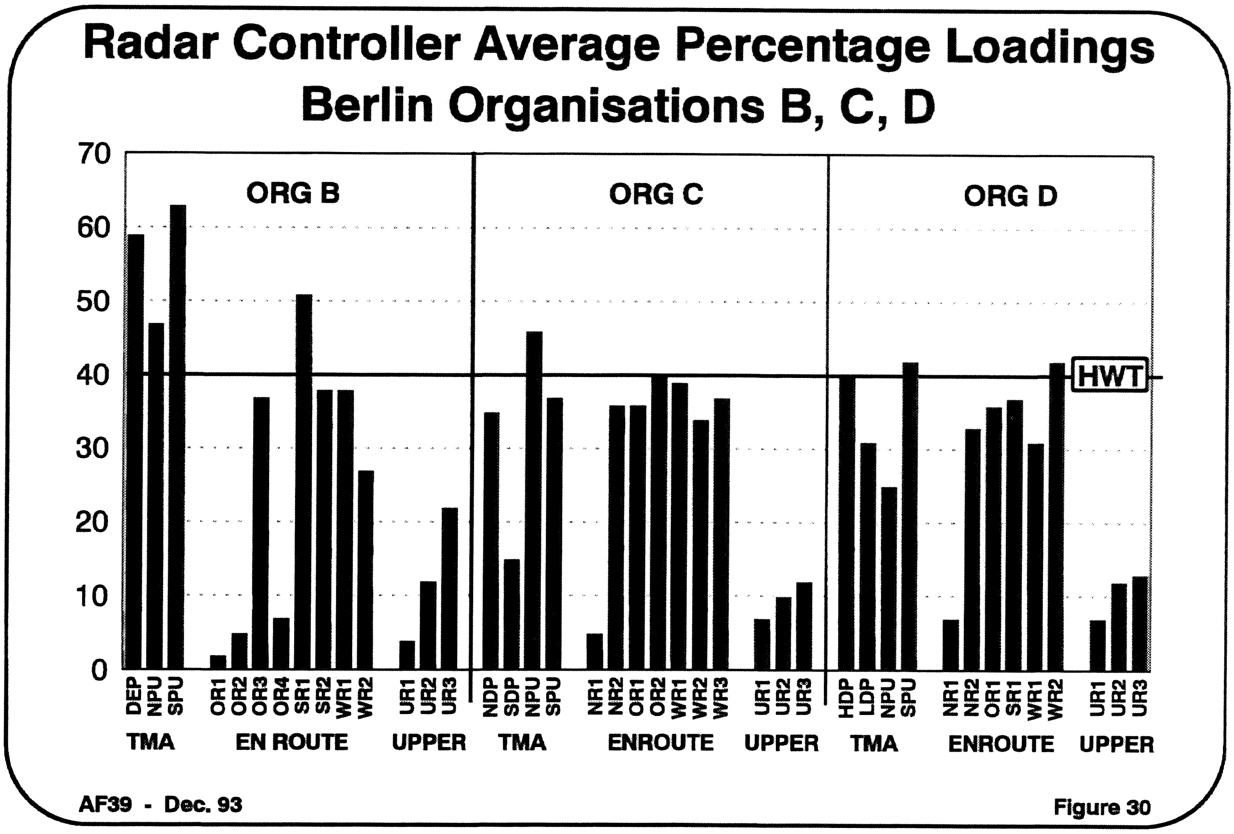


Figure 30

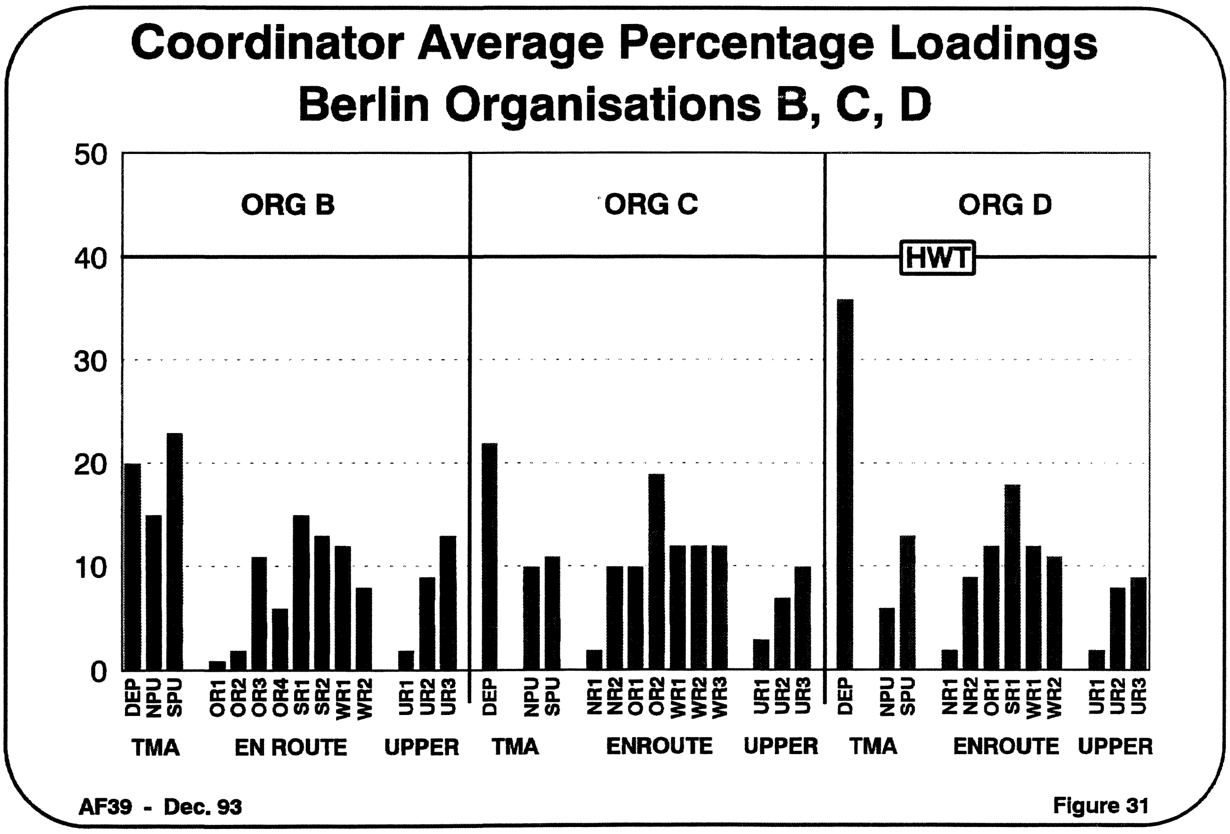


Figure 31

6.2.2. Average Percentage Loadings

Figures 30 and **31** show the three-hour average percentage loadings for the radar controller and the coordinator positions, respectively. A line indicating the heavy workload threshold has been drawn at the 40% value.

In organisation B three EC positions, DEP, SPU and SR1, were severely loaded and one EC position, NPU, was heavily loaded. In organisation C two EC positions, NPU and OR2, were heavily loaded while organisation D had three EC positions heavily loaded, HDP, SPU and WR2. In both organisations C and D there was a reasonably good balance between the busier sectors, especially the en route sectors in organisation C.

With the exception of the DEP coordinator in organisation D, all three organisations returned low coordinator loadings in all sectors. Combining the coordinator between the two departure sectors in organisations C and D produced no workload problems.

6.2.3. Task Category Comparison

Table 18 shows the amount of time spent per aircraft (multiplied by 100 for easier reading) on each of the five categories of tasks in the three organisations.

WORK PER AIRCRAFT IN MINUTES (x 100)						
ORG	**FDM**	**Coord**	**CFS**	**R/T**	**Radar**	**Total**
Org B	13'	5'	24'	46'	34'	122'
Org C	12'	5'	24'	45'	31'	117'
Org D	12'	5'	25'	40'	28'	110'

Table 18

While the areas of traffic distribution, total sector workload distribution and average percentage loadings would indicate that there is little difference between organisations C and D, it is clear from table 18 that, especially in the key areas of R/T and radar workload, organisation D produced better results, overall.

6.3. Summary

- An average reduction of 29% in the total workload recorded for the proposed organisations as compared to the reference organisation, with significant reductions in the areas of flight data management and coordination.

- Little to choose between organisations C and D in terms of traffic and total workload distribution and average percentage loadings.

- Organisation D produced the lowest amount of work per aircraft in total workload and in the key areas of R/T and radar work.

7. SUMMARY OF RESULTS AND CONCLUSIONS

7.1. Berlin Reference Organisation A

The results for the Berlin reference organisation A showed:

- The validity of the airspace model in simulating the Berlin ACC/UAC environment with the results being as expected by the controllers on the working group.
- A reasonably good distribution of traffic amongst the sectors.
- An unequal distribution of workload between the sectors.
- High levels of R/T and radar workload in the BARTCC arrival sector.
- A high proportion of coordination tasks in the Schönefeld sectors, particularly OR2 and OR3.
- Severe peak hour and average percentage loadings on the BARTCC arrival EC.
- Heavy peak hour and average percentage loadings on the BARTCC departure EC.
- An inequality in both the peak hour and average percentage loadings between the EC and his equivalent CC in BARTCC.
- A heavy average percentage loading on the OR3 CC, with other Schönefeld sectors recording light to moderate loadings on all positions.
- The Schönefeld CC having a higher average percentage loading than his equivalent EC in all sectors.

7.2. Berlin Proposed Organisation B

The results for the Berlin proposed organisation B showed:

- An unequal distribution of traffic and workload between the sectors.
- High radar workloads in the DEP, SPU and SR1 sectors.
- High R/T workloads in the NPU and SPU sectors.
- With the EC positions, the DEP and SPU sectors were severely loaded over one and three hours, the SR1 sector heavily loaded over the peak hour and severely loaded over three hours, and the NPU sector heavily loaded over one and three hours.
- Light loadings on all CC positions over both one and three hours.

- All four stacks being lightly used with the maximum delay for the two main stacks, RSF and TPN, being just under four minutes.

- The maximum departure delay was 4.2 minutes at Tegel.

7.3. Berlin Proposed Organisation C

The results for the Berlin proposed organisation C showed:

- An unequal distribution of traffic between the sectors.

- A good distribution of workload between the busier sectors.

- High radar workloads in the NPU, SPU and WR3 sectors.

- High R/T workloads in the NR2, WR1 and WR2 sectors.

- With the EC positions, the NR2 and OR1 sectors were heavily loaded during their peak hours. The NPU and OR2 sectors were heavily loaded over three hours.

- Light loadings on all CC positions over one and three hours.

- Similar usage of all three stacks with the RSF stack returning the highest maximum delay of 4.3 minutes.

- The maximum departure delay was 4.0 minutes at Tegel.

7.4. Berlin Proposed Organisation D

The results for the Berlin proposed organisation D showed:

- An unequal distribution of traffic between the sectors.

- A good distribution of workload between the busier sectors.

- High radar workloads in the SPU and WR2 sectors.

- With the EC positions, the SPU and OR1 sectors were heavily loaded during their peak hours. The HDP, SPU and WR2 sectors were heavily loaded over three hours.

- Light loadings on all CC positions over one and three hours except the departure CC where a moderate loading was recorded.

- Similar usage of both stacks with the RSF stack returning the highest maximum delay of 2.7 minutes.

- The maximum departure delay was 4.0 minutes at Schönefeld.

7.5. Comparison between the Organisations

- There was an average reduction of 29% in the total workload recorded for the proposed organisations as compared to the reference organisation, with significant reductions in the areas of flight data management and coordination.

- Little difference was indicated between organisations C and D in terms of traffic and total workload distribution and average percentage loadings.

- Organisation D produced the lowest amount of work per aircraft in total workload and in the key areas of R/T and radar work.

7.6. Conclusions

The study concluded that in two of the future organisations (C and D) the proposed sectorisation, routeings, procedures and equipment permitted the handling of future traffic levels (+50%) without severe loadings on controller working positions or excessive penalties to traffic.

In particular, organisation D was shown to be the most efficient organisation in terms of the distribution of traffic, workload and loadings amongst the sectors while, at the same time, having the lowest amount of work per aircraft.

Nevertheless, some radar controller positions experienced heavy loadings and some sectors had high levels of traffic, so further optimisation will be required to address these problems as well as those concerning the interface between the Dresden and Leipzig approach areas and the effects of military traffic upon the system.

APPENDICES

Traffic Samples Tested

The specifications of the study required the detailed simulation for the reference organisation of a busy three-hour period taken from Berlin weekday records for 1992, with the same sample enhanced to forecast 2000 traffic levels being simulated for the three proposed organisations.

Traffic Sample Reference Organisation

The original traffic sample received contained 785 aircraft:

- Morning period 0438-0956 309 aircraft.
- Afternoon period 1225-1957 476 aircraft.

After the busiest three-hour sample for each period was extracted, the results were:

- Morning period 0455-0754 192 aircraft.
- Afternoon period 1305-1604 239 aircraft.

Table A gives the breakdown of the two traffic samples for the Berlin FIR/UIR as a whole.

REGION	DEPS TO		ARRS FROM		TOTAL	
	A/noon	Morn	A/noon	Morn	A/noon	Morn
NORTH-WEST	8	4	8	12	16	16
WEST	46	28	28	34	74	62
SOUTH-WEST	28	30	27	30	55	60
SOUTH	39	22	39	26	78	48
EAST	16	14	15	7	31	21
NORTH	6	1	4	1	10	2

Table A

Compared to the morning sample, the afternoon sample gave a smaller arrival flow from the north-west and west, but a larger departure flow to the same regions.

The south-west figures showed little difference between the two samples.

To and from the south, east and north there was a higher flow of traffic in the afternoon.

The comparative figures for the three Berlin airports are given in **table B**.

AIRPORT	DEPARTURES		ARRIVALS	
	A/noon	Morn	A/noon	Morn
EDBB	25	20	22	21
EDBT	31	34	32	32
ETBS	12	4	7	4
TOTAL	68	58	61	57

Table B

From the table it can be seen that the total number of departures and arrivals is greater in the afternoon (except for Tegel), although the difference in the number of arrivals is small.

How the two samples compare with regard to the intermediate departure and arrival points for the Berlin TMA is shown in **table C**. (Note: "PM" denotes the afternoon traffic sample and "AM" the morning traffic sample.)

DEPARTURES			ARRIVALS			
Dep.Pt.	PM	AM	From	Arr.Pt.	PM	AM
GOLEV	6	2		SOLVU	13	14
PODUS	10	9	**N-WEST/WEST**	HVL	8	13
				NUVEN	1	4
				NUF	6	3
TERKO	34	32		BUROK	17	14
BKW	10	9	**S-WEST/SOUTH/**	BKW	10	9
FWE	6	4	**EAST/NORTH**	LURIT	2	0
STENA	2	2		FWE	1	0
				STENA	3	0

Table C

Table D gives the breakdown for Dresden and Leipzig.

AIRPORT	DEPARTURES		ARRIVALS	
	A/noon	Morn	A/noon	Morn
ETDN	20	9	17	17
ETLS	23	13	15	18
TOTAL	43	22	32	35

Table D

Table E gives the figures for the overflights.

OVERFLIGHTS		
DIRECTION	**A/noon**	**Morn**
Eastbound	10	11
Westbound	13	7
Northbound	4	0
Southbound	2	1
TOTAL	29	19

Table E

Finally, **table F** shows the number of items for the other Berlin FIR airports.

AIRPORT	DEPARTURES		ARRIVALS	
	A/noon	Morn	A/noon	Morn
ETEF	0	3	4	1
EDNZ	4	0	0	1
ETSP	2	1	0	1
EDPC	1	0	1	0
EDNU	1	0	0	0
TOTAL	8	4	5	3

Table F

Based on the figures given above, the afternoon sample was chosen. A full breakdown of this sample and those for the proposed organisations is given in appendix B on page 57.

REFERENCE ORGANISATION			
Airport/Point	DEP/EXIT	ARR/ENTRY	Total
EDBB	25	22	47
EDBT	31	32	63
ETBS	12	7	19
ETDN	20	15	35
ETLS	22	15	37
Other	8	5	13
ABRIN	1	3	4
BKD	7	5	12
GILAS	6	10	16
HDO	16	21	37
HLZ	16	24	40
KILNU	15	11	26
LARET	-	4	4
LASTO	-	20	20
MELAN	10	-	10
NENSA	20	-	20
POVEL	11	-	11
RISOK	9	-	9
SALLO	2	3	5
SAREN	8	6	14
SEGAL	4	1	5
SUI	10	5	15
WITZ	8	7	15

PROPOSED ORGANISATION B			
Airport/Point	DEP/EXIT	ARR/ENTRY	Total
EDBB	24	23	47
EDBT	45	46	91
ETBS	28	26	54
ETDN	31	31	62
ETLS	29	30	59
Other	6	5	11
ATZER	6	5	11
BKD	16	13	29
DENKO	2	3	5
ERL	9	1	10
FUL	-	2	2
GES	1	1	2
HLZ	8	21	29
KILNU	14	22	36
LASTO	-	23	23
MELAN	21	-	21
NENSA	42	12	54
POVEL	20	19	39
RAKIT	-	3	3
RCE	24	27	51
SALLO	6	8	14
SAREN	7	9	16
SEGAL	6	6	12
SUI	14	21	35
WINKI	2	1	3
WINNI	7	5	12

PROPOSED ORGANISATION C			
Airport/Point	DEP/EXIT	ARR/ENTRY	Total
EDBB	24	25	49
EDBT	45	44	89
ETBS	28	24	52
ETDN	31	31	62
ETLS	27	30	57
Other	6	5	11
ALPHA	-	17	17
BKD	17	14	31
BRAVO	11	20	31
CHALY	-	17	17
DELTA	6	11	17
ECHO	2	-	2
FOX	5	3	8
GOLF	8	2	10
GOTEM	23	11	34
HDO	23	21	44
HLZ	40	3	43
HOTEL	1	-	1
INDIA	2	3	5
JULIE	1	1	2
KILNU	14	24	38
SALLO	6	11	17
SAREN	20	11	31
SEGAL	6	2	8
SUI	13	26	39

PROPOSED ORGANISATION D			
Airport/Point	DEP/EXIT	ARR/ENTRY	Total
EDBB	24	25	49
EDBT	45	45	90
ETBS	28	25	53
ETDN	31	32	63
ETLS	30	30	60
Other	6	5	11
BKD	17	13	30
CEL	-	24	24
DRE	2	7	9
FUL	7	6	13
HLZ	37	3	40
KILNU	14	22	36
LASTO	-	23	23
NENSA	45	14	59
POVEL	13	11	24
RISOK	1	-	1
RCE	25	28	53
SALLO	6	13	19
SAREN	8	10	18
SEGAL	7	2	9
SUI	15	21	36
TRZ	7	5	12
WINKI	1	-	1

ATC TASKS SPECIFICATION

Introduction

The Airspace Model analyses the progress of each flight as it transits the simulated area in order to detect the ATC actions necessary to process the flight. In determining these ATC actions, the model is capable of identifying and recording up to 110 different ATC tasks.

The tasks are grouped into five categories.

- Flight data management tasks.
- Coordination tasks with other ATC units and within the simulated unit, itself.
- Planning conflict search tasks to determine ATC clearances.
- Routine R/T communications.
- Radar tasks which include radar handovers, radar supervisions, and radar interventions.

The "standard execution time" for each task is allocated in seconds. The time specified is the average duration of time spent on the task by a fully trained controller, ignoring extreme situations which, in real life, could favourably or unfavourably affect the execution time specified.

The "standard execution time" is not intended to represent the actual duration of the task but the amount of time for which the controller is considered to be totally committed to the task to the exclusion of all other functions.

In some cases a task may involve more than one control position where different execution times may be allocated to each position.

Different execution times may be allocated for the same task occurring in different sectors. Some tasks described correspond to specific duties in certain ATCCs and may not necessarily be applicable to the Berlin simulation. In this case, a time of zero seconds is allocated to the task concerned.

Tasks normally allocated to the assistant positions are not included in the tables as these positions were not measured in the study.

In the Berlin scenario, "CC" refers to the Coordinator and "EC" to the Radar Controller, "B" to BARTCC and "S" to Schönefeld, "REF" to the reference organisation and "PROP" to the proposed organisations. Where a listed task is either unused or is an assistant task it is marked by a "-".

COORDINATION TASKS

Task No./Description	REF	PROP
1. Receipt of flight plan information by telephone from a neighbouring ATC unit for an unknown flight. This task was applied to 10% of flights from neighbouring ATC units and the time averaged out.	B CC 1" S CC 5"	CC 1"
2. Receipt of a request for an airways clearance from a non-simulated unit. In BARTCC this occurs only in the LEIP sector.	B CC 10" S CC 14"	CC 4"
3. Receipt of a request for permission to take-off from a specified airport.	B CC 4"	4"
4. Receipt of an airborne time from a specified airport.	B CC 3" S CC 3"	CC 3"
5. Receipt of a "time and level" estimate from an adjacent ATC unit.	S CC 14"	CC 14"
6. Receipt of a "time and level" estimate from an adjacent ATC unit with a request for coordination.	S CC 14"	CC 14"
7. Receipt of a request for a special coordination from a non-simulated unit for a sector entry clearance.	-	-
8. Assignment of SSR code by the first sector of the ATC unit being entered.	B CC 4" S CC 20"	-
9. Receipt of a revision from an adjacent ATC unit. Applied to 10% of flights from neighbouring ATC units. Combined with task 1.	-	-
10. Receipt of a request from the next ATC unit for the reclearance of an aircraft before transfer of control.	B CC 15" S CC 15"	CC 15"
11. Spare.	-	-
12. Receipt of a request for a flight level release from a non-simulated unit.	S CC 5" S EC 10"	CC 5" EC 10"
13. Spare.	-	-
14. Spare.	-	-
15. Transmission of a "time and level" estimate to an adjacent ATC unit.	B CC 20" S CC 20" S CC 40" in sectors OR2, SR, UR.	CC 20"

Task No./Description	REF	PROP
16. Transmission of a "time and level" estimate to an adjacent ATC unit with a request for climb or descent.	B CC 20" S CC 20" S CC 35" in sectors SR and UR.	CC 20"
17. Transmission of a special coordination to an adjacent ATC unit.	-	-
18. Input of an ACT amendment message where the exit level is not equal to the requested level.	-	-
19. Transmission of a revision to the next ATC unit.	B CC 15" S CC 17"	CC 15"
20. Transmission of a request to the previous ATC unit for a reclearance of an aircraft before transfer of control.	B CC 20" S CC 20"	CC 20"
21. Transmission of an "inbound release" to a specified airport.	-	-
22. Transmission of flight information to a non-simulated unit or an inbound release to an adjacent ATCC. This task was used in BARTCC for "overing". The task was counted under the flight data management tasks.	B EC 2"	-
23. Receipt of an airborne time for a specified airport from another sector of the same ATC unit.	B CC 3" S CC 5"	CC 5"
24. Receipt of a request for an airways clearance from another sector of the same ATC unit.	-	-
25. Receipt of a request for coordination from another sector of the same ATC unit - aircraft in level flight.	B EC 2" S CC 10"	CC 2"
26. Receipt of a request for coordination from another sector of the same ATC unit - flight in climb or descent.	B EC 2" S CC 11"	CC 12" LDP CC 5"
27. Receipt of a special coordination request from another sector of the same ATC unit.	-	-
28. Receipt of a request for a flight level release from another sector of the same ATC unit.	B CC 4" S CC 4"	CC 8"
29. Receipt of a revision from another sector of the same ATC unit.	B CC 10" S CC 10"	CC 10"
30. Receipt of a request from the next sector of the same ATC unit for reclearance of an aircraft before transfer of control to that sector.	B CC 10" S CC 10"	CC 10"

Task No./Description	REF	PROP
31. Spare.	-	-
32. Spare.	-	-
33. Transmission of an airborne time to the next sector of the same ATC unit.	-	-
34. Transmission of details to the Flight Data position.	S CC 3"	-
35. Transmission of a coordination to the next sector of the same ATC unit - aircraft in level flight.	B EC 2" S CC 15"	CC 15"
36. Transmission of a coordination to the next sector of the same ATC unit - aircraft in climb or descent.	B EC 2" S CC 16"	CC 17"
37. Transmission of a special coordination to another sector of the same ATC unit.	-	-
38. Transmission of a request for a flight level release to another sector of the same ATC unit.	B CC 10"	CC 10"
39. Transmission of a revision to another sector of the same ATC unit.	B CC 15" S CC 15"	CC 15"
40. Transmission of a request to another sector of the same ATC unit for the reclearance of an aircraft before transfer of control.	B CC 15" S CC 15"	CC 15"
41. Transmission of an "inbound release" to another sector of the same ATC unit.	-	-
42. Spare.	-	-

FLIGHT DATA MANAGEMENT TASKS

Task No./Description	REF	PROP
43. Loading and distribution of warning strips.	-	-
44. Loading and distribution of flight progress strips.	B CC 15" if first sector. B CC 5" S CC 5" S EC 2"	CC 5"
45. Removal of the flight progress strips from the sector console and associated tasks.	B EC 2" S EC 2"	EC 2"
46. Receipt of a strip update message and amendment of the flight progress strip.	-	-
47. Discovery of an error in the time estimates and amendment of the flight progress strips.	B EC 5" S EC 5"	CC 5"

CONFLICT SEARCH TASKS

Task No./Description	REF	PROP
48. Conflict search to establish an initial clearance for a flight departing from a specified airport.	S CC 10"	CC 8" EC 4"
49. Conflict search by a radar controller to establish an initial clearance for a flight entering a sector in climb or descent.	B CC 4" B EC 2" S CC 4" S EC 2"	CC 4" EC 2"
50. Conflict search to establish a sector planning clearance.	B CC 8" B EC 4" S CC 8" S EC 4"	CC 8" EC 4"
51. Conflict search to establish a sector planning clearance for a coordinated flight.	-	CC 8" EC 4"
52. Conflict search to establish a sector planning clearance for a flight not contacting the sector frequency.	B CC 8" S CC 8"	CC 8" EC 4"
53. Conflict search to establish a sector exit clearance.	B EC 5" S CC 5"	CC 5" EC 3"
54. Spare.	-	-
55. Conflict search to establish a new sector planning clearance for conflict resolution.	B CC 4" B EC 8" S CC 8" S EC 4"	CC 8" EC 4"
56. Conflict search to establish a new sector planning clearance for a flight contacting the sector.	-	-
57. Conflict search to establish a new sector planning clearance for a flight not contacting the sector frequency.	B CC 8" S CC 8"	CC 8"
58. Resolution of a potential conflict at sector exit point by selection of a new transfer level.	B CC 8" B EC 5" S CC 8" S EC 5"	CC 8" EC 5"
59. Conflict search to establish a initial level clearance for a flight approaching a holding stack.	-	EC 5"
60. Updating of flight information and notification of planning reclearance to the EC.	B CC 8" S CC 8"	CC 8"
61. Updating of flight information and notification to the EC of a planning reclearance for a flight that will not contact the sector frequency.	S CC 5" in sectors OR2 and UR only.	CC 5"

Task No./Description	REF	PROP
62. Receipt and acknowledgement by the EC of a planning reclearance.	B EC 5" S EC 5"	EC 5"
63. Input of a level reclearance into computer for transmission to other sectors.	B CC 8" in sectors BARD, EW, LEIP.	CC 8"

ROUTINE R/T COMMUNICATIONS

Task No./Description	REF	PROP
64. Receipt of flight plan information on the sector frequency from an unforeseen flight.	-	-
65. First call from an aircraft departing from a specified airport.	B EC 15" S EC 15"	EC 15"
66. First call from an aircraft entering the first sector from another ATCC.	B EC 15" B EC 20" EE sector S EC 15"	EC 15"
67. First call from an aircraft entering another sector of the same ACC.	B EC 12" S EC 12"	EC 12"
68. Position report from an aircraft.	-	-
69. Level report from an aircraft on reaching a cleared flight level.	B EC 6" S EC 6"	EC 6"
70. Instruction to an aircraft to comply with a new route clearance	B EC 13" S EC 13"	EC 13"
71. Instruction to an aircraft to comply with a new planning clearance, e.g. level change.	B EC 13" S EC 13"	EC 13"
72. Transfer of an aircraft to the next frequency.	B EC 7" S EC 7"	EC 7"
73. Spare.	-	-
74. Spare.	-	-
75. Spare.	-	-

RADAR TASKS (HANDOVERS AND CONFLICT SEARCHES)

Task No./Description	REF	PROP
76. Radar handover of an aircraft subject to an executive intervention between sectors of the same ATC unit.	BARA CC 2" BARA EC 7" BARD CC 3" BARD EC 10" B CC 5" B EC 15" S CC 5" S EC 15"	EC 15"
77. Radar handover of an aircraft subject to an executive supervision between sectors of the same ATC unit.	BARA CC 1" BARA EC 3" BARD CC 3" BARD EC 10" B CC 5" B EC 15" S CC 5" S EC 15"	EC 15"
78. Radar handover of an aircraft in climb or descent between sectors of the same ATC unit where there are no standard transfer procedures.	B CC 5" B EC 10" S CC 5" S EC 10"	EC 10"
79. Radar handover of an aircraft subject to an executive supervision or intervention between two ATCCs.	BARA CC 8" BARA EC 2" B CC 20" B EC 5" S CC 20" S EC 5"	CC 20" EC 5"
80. Radar handover of an aircraft in climb or descent between vertically superimposed sectors of two ATCCs where there are no standard transfer procedures.	B CC 15" B EC 5" S CC 15" S EC 5"	EC 5"
81. Late radar handover of an aircraft not complying with standard transfer procedures between sectors of the same ATC unit.	B CC 15" S CC 15"	CC 15"
82. Radar coordination in the event of a potential conflict between aircraft flying on proximate tracks when they are controlled by different sectors.	BARA/BARD EC 8" EW/LEIP CC 10" EW/LEIP EC 8"	CC 10" EC 8"
83. Radar handover with a non-simulated unit of an aircraft in climb/descent at specific entry/exit points.	-	-
84. Radar coordination between two sectors for an aircraft flying through one of these sectors whilst under the control of the other sector.	B EC 15" in sectors BARA/BARD only.	

Task No./Description	REF	PROP
85. Receipt of a request from military control to cross an air route with an "off-route" flight.	-	-
86. Spare.	-	-
87. Radar conflict search in a TMA sector for inbound and outbound traffic.	B CC 8" B EC 4" S EC 5"	EC 5"
88. Radar conflict search before issuing a clearance for climb or descent.	B EC 5" S EC 5"	EC 5"
89. Radar monitoring of track keeping accuracy in an area where there is a potential risk, e.g. in the event of proximate routes with insufficient lateral separation.	-	-
90. Radar monitoring of an OAT flight controlled by an "off-route" military controller and in potential conflict with a GAT flight.	-	-

RADAR CONFLICT RESOLUTION TASKS.

List of Radar Conflict Types Identified by the Airspace Model

Type 1 : Two aircraft on the same track, at the same flight level and in cruise.
Type 2 : Two aircraft on the same track, one in cruise and the other in climb or descent.
Type 3 : Two aircraft on the same track, both in climb or descent.

Type 4 : Two aircraft on crossing tracks, at the same flight level and in cruise.
Type 5 : Two aircraft on crossing tracks, one in cruise and the other in climb or descent.
Type 6 : Two aircraft on crossing tracks, both in climb or descent.

Type 7 : Two aircraft on opposite tracks, at the same flight level and in cruise.
Type 8 : Two aircraft on opposite tracks, one in cruise and the other in climb or descent.
Type 9 : Two aircraft on opposite tracks, both in climb or descent.

A ***radar supervision*** is the close monitoring of a potential conflict situation between two aircraft but where a tactical intervention is deemed unnecessary. Safe clearances such as "maintain heading" may be issued.

A ***radar intervention*** is the tactical alteration of an aircraft's heading, level or speed in order to ensure minimum radar separation between aircraft at all times.

Task No./Description	REF	PROP
91. Radar supervision for conflict type 1.	B/S CC 5" B/S EC 15"	CC 5" EC 15"
92. Radar supervision for conflict type 2.	B/S CC 5" B/S EC 23"	CC 5" EC 23"
93. Radar supervision for conflict type 3.	B/S CC 5" B/S EC 25"	CC 5" EC 25"
94. Radar supervision for conflict type 4.	B/S CC 5" B/S EC 30"	CC 5" EC 30"
95. Radar supervision for conflict type 5.	B/S CC 5" B/S EC 35"	CC 5" EC 35"
96. Radar supervision for conflict type 6.	B/S CC 5" B/S EC 35"	CC 5" EC 35"
97. Radar supervision for conflict type 7.	-	-
98. Radar supervision for conflict type 8.	B/S CC 5" B/S EC 35"	CC 5" EC 35"
99. Radar supervision for conflict type 9.	B/S CC 5" B/S EC 35"	CC 5" EC 35"
100. Radar vectoring in a TMA sector to solve a conflict between aircraft departing on the same SID.	-	-
101. Radar intervention for conflict type 1.	B/S EC 46"	EC 46"
102. Radar intervention for conflict type 2.	B/S EC 48"	EC 48"
103. Radar intervention for conflict type 3.	B/S EC 52"	EC 52"
104. Radar intervention for conflict type 4.	B/S EC 46"	EC 46"
105. Radar intervention for conflict type 5.	B/S EC 48"	EC 48"
106. Radar intervention for conflict type 6.	B/S EC 52"	EC 52"
107. Radar intervention for conflict type 7.	-	-
108. Radar intervention for conflict type 8.	B/S EC 48"	EC 48"
109. Radar intervention for conflict type 9.	B/S EC 88"	EC 88"
110. System task.	-	-

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39 - REFERENCE EXERCISE

SIMULATED TRAFFIC : ACTUAL 18/09/92 (1305-1604) 239 FLIGHTS

TABLE A1 : DISTRIBUTION OF TRAFFIC

TOTAL NUMBER OF SIMULATED FLIGHTS : 239

SECTOR	CONTROLLED FLIGHTS	COORDINATED FLIGHTS	TOTAL NBR	TOTAL FLT TIME	AVERAGE FLT TIME
BARA	56	0	56	555.0	9.9
BARD	62	41	103	642.7	6.2
EW	58	0	58	662.1	11.4
EE	45	0	45	403.2	9.0
LEIP	36	0	36	430.8	12.0
OR2	50	0	50	430.3	8.6
OR3	64	0	64	716.9	11.2
OR1	11	0	11	222.5	20.2
SR	19	0	19	227.7	12.0
TE	19	4	23	75.6	3.3
UR	24	7	31	388.7	12.5
11 TOTAL	444	52	496	4755.5	9.6
MIN	11	0	11		
MAX	64	41	103		
AVERAGE	40	5	45		
SD	18	12	25		

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39 - REFERENCE EXERCISE

SIMULATED TRAFFIC : ACTUAL 18/09/92 (1305-1604) 239 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	----- SECTORS -----							
	BARA	BARD	EW	EE	LEIP	OR2	OR3	ALL
FDM	9.4	18.2	8.9	12.8	12.6	14.1	25.6	127.4
COORD	4.6	11.7	2.4	3.5	5.6	33.8	39.7	155.7
CONFLICT SRCH	13.5	14.4	13.6	10.0	7.5	12.3	15.4	103.7
ROUTINE R/T	52.4	37.5	24.8	25.8	15.7	23.7	34.5	245.8
RADAR	56.6	38.2	16.7	15.8	4.1	14.1	27.6	182.8
TOTALS:	136.5	120.1	66.6	68.0	45.6	98.2	142.9	815.5

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39 - REFERENCE EXERCISE

SIMULATED TRAFFIC : ACTUAL 18/09/92 (1305-1604) 239 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	----- SECTORS -----				
	OR1	SR	TE	UR	ALL
FDM	1.6	8.1	5.1	10.6	127.4
COORD	5.9	17.1	9.3	21.7	155.7
CONFLICT SRCH	2.5	3.8	4.3	6.1	103.7
ROUTINE R/T	5.1	9.2	7.1	9.6	245.8
RADAR	0.2	4.6	4.1	0.5	182.8
TOTALS:	15.5	43.1	30.1	48.5	815.5

SIMULATED ORGANISATION : AF39 - REFERENCE EXERCISE

SIMULATED TRAFFIC : ACTUAL 18/09/92 (1305-1604) 239 FLIGHTS

TABLE D1 : TABLE D1 - RADAR CONTROLLER LOADINGS

	60'	90'	180'
BARA-EC	77%	66%	64%
BARD-EC	62%	50%	45%
EW-EC	37%	36%	27%
EE-EC	32%	29%	25%
LEIP-EC	17%	14%	12%
OR2-EC	26%	26%	23%
OR3-EC	49%	46%	38%
OR1-EC	5%	3%	3%
SR-EC	12%	9%	8%
TE-EC	12%	9%	7%
UR-EC	12%	9%	7%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39 - REFERENCE EXERCISE

SIMULATED TRAFFIC : ACTUAL 18/09/92 (1305-1604) 239 FLIGHTS

TABLE D2 : TABLE D2 - COORDINATOR LOADINGS

	60'	90'	180'
BARA-CC	11%	10%	11%
BARD-CC	27%	24%	21%
EW-CC	12%	12%	9%
EE-CC	13%	12%	11%
LEIP-CC	14%	13%	11%
OR2-CC	37%	34%	30%
OR3-CC	45%	42%	40%
OR1-CC	6%	5%	4%
SR-CC	22%	19%	15%
TE-CC	12%	10%	8%
UR-CC	31%	25%	18%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39B - ORGANISATION B

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A1 : DISTRIBUTION OF TRAFFIC

TOTAL NUMBER OF SIMULATED FLIGHTS : 366

SECTOR	CONTROLLED FLIGHTS	COORDINATED FLIGHTS	TOTAL NBR	TOTAL FLT TIME	AVERAGE FLT TIME
DEP	89	0	89	625.4	7.0
NPU	65	0	65	672.1	10.3
SPU	106	0	106	893.0	8.4
OR1	11	0	11	185.7	16.9
OR2	16	2	18	177.2	9.8
OR3	76	1	77	583.2	7.6
OR4	26	3	29	242.8	8.4
SR1	87	6	93	635.2	6.8
SR2	89	2	91	851.6	9.4
WR1	80	0	80	890.2	11.1
WR2	62	0	62	638.9	10.3
UR1	18	0	18	214.2	11.9
UR2	43	4	47	577.5	12.3
UR3	69	1	70	499.6	7.1
14 TOTAL	837	19	856	7686.6	9.0
MIN	11	0	11		
MAX	106	6	106		
AVERAGE	60	1	61		
SD	30	2	30		

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39B - ORGANISATION B

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	----- SECTORS -----							
	DEP	NPU	SPU	OR1	OR2	OR3	OR4	ALL
FDM	10.3	10.6	16.4	1.2	2.1	8.9	3.3	107.8
COORD	6.4	1.8	5.6	0.2	0.7	1.4	4.6	45.3
CONFLICT SRCH	24.6	16.4	25.4	2.4	4.0	19.1	6.7	204.0
ROUTINE R/T	39.7	51.6	52.8	3.7	5.6	42.9	9.4	395.1
RADAR	62.6	33.9	58.6	0.3	1.9	15.8	2.3	296.0
TOTALS:	143.8	114.5	158.9	7.9	14.4	88.3	26.4	1048.3

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39B - ORGANISATION B

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	----- SECTORS -----							
	SR1	SR2	WR1	WR2	UR1	UR2	UR3	ALL
FDM	10.8	10.7	9.6	7.5	2.1	5.6	8.1	107.8
COORD	3.9	2.1	2.2	1.3	0.1	6.1	8.3	45.3
CONFLICT SRCH	21.8	19.9	18.5	15.6	3.6	10.9	15.0	204.0
ROUTINE R/T	34.4	36.3	32.8	33.6	6.9	16.7	28.2	395.1
RADAR	50.3	25.2	29.1	9.5	0.2	0.6	5.1	296.0
TOTALS:	121.3	94.4	92.4	67.7	13.0	40.0	64.8	1048.3

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39B - ORGANISATION B

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE D1 : TABLE D1 - RADAR CONTROLLER LOADINGS

	60'	90'	180'
DEP-EC	77%	66%	59%
NPU-EC	58%	52%	47%
SPU-EC	75%	70%	63%
OR1-EC	3%	2%	2%
OR2-EC	7%	6%	5%
OR3-EC	52%	44%	37%
OR4-EC	12%	11%	7%
SR1-EC	63%	54%	51%
SR2-EC	51%	45%	38%
WR1-EC	51%	43%	38%
WR2-EC	37%	34%	27%
UR1-EC	6%	5%	4%
UR2-EC	18%	16%	12%
UR3-EC	27%	27%	22%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39B - ORGANISATION B

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE D2 : TABLE D2 - COORDINATOR LOADINGS

	60'	90'	180'
DEP-CC	22%	20%	20%
NPU-CC	16%	15%	15%
SPU-CC	24%	24%	23%
OR1-CC	2%	1%	1%
OR2-CC	3%	3%	2%
OR3-CC	14%	12%	11%
OR4-CC	8%	8%	6%
SR1-CC	18%	16%	15%
SR2-CC	16%	15%	13%
WR1-CC	15%	13%	12%
WR2-CC	12%	11%	8%
UR1-CC	2%	2%	2%
UR2-CC	14%	12%	9%
UR3-CC	16%	16%	13%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39C - ORGANISATION C

SIMULATED TRAFFIC : FORECAST TRAFFIC (1300-1559) 358 FLIGHTS

TABLE A1 : DISTRIBUTION OF TRAFFIC

TOTAL NUMBER OF SIMULATED FLIGHTS : 358

SECTOR	CONTROLLED FLIGHTS	COORDINATED FLIGHTS	TOTAL NBR	TOTAL FLT TIME	AVERAGE FLT TIME
NDP	74	0	74	603.4	8.2
SDP	35	0	35	188.8	5.4
NPU	66	0	66	385.8	5.8
SPU	61	0	61	353.2	5.8
NR1	16	2	18	222.2	12.3
NR2	62	0	62	768.0	12.4
OR1	65	2	67	431.4	6.4
OR2	86	4	90	567.4	6.3
WR1	93	0	93	937.9	10.1
WR2	88	2	90	961.1	10.7
WR3	76	0	76	471.1	6.2
UR1	21	1	22	266.0	12.1
UR2	38	2	40	427.7	10.7
UR3	38	4	42	285.3	6.8
14 TOTAL	819	17	836	6869.3	8.2
MIN	16	0	18		
MAX	93	4	93		
AVERAGE	59	1	60		
SD	24	1	24		

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39C - ORGANISATION C

SIMULATED TRAFFIC : FORECAST TRAFFIC (1300-1559) 358 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	-----	SECTORS	-----					
	NDP	SDP	NPU	SPU	NR1	NR2	OR1	ALL
FDM	8.6	4.0	7.7	7.4	2.1	7.3	7.9	98.6
COORD	5.7	2.3	0.6	2.7	0.5	2.5	1.1	46.7
CONFLICT SRCH	21.5	10.1	13.9	14.7	3.9	15.4	17.5	201.3
ROUTINE R/T	34.0	12.8	33.6	29.1	6.7	40.4	33.5	375.3
RADAR	22.0	11.2	46.9	35.1	0.6	19.3	24.9	261.4
TOTALS:	92.0	40.6	102.8	89.1	13.9	85.0	85.1	983.5

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39C - ORGANISATION C

SIMULATED TRAFFIC : FORECAST TRAFFIC (1300-1559) 358 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	-----	SECTORS	-----					
	OR2	WR1	WR2	WR3	UR1	UR2	UR3	ALL
FDM	10.5	10.9	10.5	9.1	2.5	4.6	5.0	98.6
COORD	12.6	2.6	1.0	1.7	1.5	3.7	7.8	46.7
CONFLICT SRCH	20.2	21.1	20.3	18.9	4.9	9.0	9.8	201.3
ROUTINE R/T	34.0	48.2	36.8	28.8	8.3	14.1	14.4	375.3
RADAR	30.3	12.8	17.0	32.5	2.6	0.8	4.9	261.4
TOTALS:	107.7	95.8	85.6	91.0	20.0	32.4	42.0	983.5

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39C - ORGANISATION C

SIMULATED TRAFFIC : FORECAST TRAFFIC (1300-1559) 358 FLIGHTS

TABLE D1 : TABLE D1 - RADAR CONTROLLER LOADINGS

	60'	90'	180'
NDP-EC	43%	40%	35%
SDP-EC	25%	20%	15%
NPU-EC	54%	47%	46%
SPU-EC	54%	47%	37%
NR1-EC	6%	5%	5%
NR2-EC	55%	47%	36%
OR1-EC	60%	49%	36%
OR2-EC	50%	49%	40%
WR1-EC	45%	43%	39%
WR2-EC	42%	35%	34%
WR3-EC	48%	41%	37%
UR1-EC	13%	10%	7%
UR2-EC	15%	14%	10%
UR3-EC	18%	17%	12%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39C - ORGANISATION C

SIMULATED TRAFFIC : FORECAST TRAFFIC (1300-1559) 358 FLIGHTS

TABLE D2 : TABLE D2 - COORDINATOR LOADINGS

	60'	90'	180'
DEP-CC	25%	23%	22%
NPU-CC	11%	10%	10%
SPU-CC	14%	13%	11%
NR1-CC	3%	3%	2%
NR2-CC	13%	11%	10%
OR1-CC	12%	11%	10%
OR2-CC	24%	22%	19%
WR1-CC	15%	13%	12%
WR2-CC	14%	12%	12%
WR3-CC	15%	14%	12%
UR1-CC	5%	4%	3%
UR2-CC	10%	9%	7%
UR3-CC	14%	14%	10%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39D - ORGANISATION D

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A1 : DISTRIBUTION OF TRAFFIC

TOTAL NUMBER OF SIMULATED FLIGHTS : 366

SECTOR	CONTROLLED FLIGHTS	COORDINATED FLIGHTS	TOTAL NBR	TOTAL FLT TIME	AVERAGE FLT TIME
HDP	95	0	95	647.6	6.8
LDP	97	0	97	323.4	3.3
NPU	43	0	43	154.5	3.6
SPU	79	0	79	401.4	5.1
NR1	22	0	22	267.3	12.2
NR2	62	2	64	866.7	13.5
OR1	73	3	76	538.8	7.1
SR1	77	3	80	620.5	7.8
WR1	92	1	93	886.9	9.5
WR2	83	0	83	874.9	10.5
UR1	18	0	18	204.5	11.4
UR2	42	5	47	531.2	11.3
UR3	37	0	37	348.1	9.4
13 TOTAL	820	14	834	6665.8	8.0
MIN	18	0	18		
MAX	97	5	97		
AVERAGE	63	1	64		
SD	27	2	27		

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39D - ORGANISATION D

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	SECTORS							
	HDP	LDP	NPU	SPU	NR1	NR2	OR1	ALL
FDM	11.0	11.3	5.1	9.6	2.5	7.5	9.3	99.7
COORD	0.6	8.0	0.0	3.4	0.3	2.0	2.6	45.4
CONFLICT SRCH	27.9	28.8	10.4	19.1	5.3	14.8	22.0	208.4
ROUTINE R/T	37.9	30.8	15.3	30.3	9.0	37.1	38.9	337.8
RADAR	24.6	16.1	27.3	40.8	2.1	16.0	15.6	232.4
TOTALS:	102.3	95.1	58.2	103.4	19.3	77.6	88.4	923.9

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39D - ORGANISATION D

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE A4 : DISTRIBUTION OF ATC WORKLOAD IN MINUTES

ATC FUNCTIONS	SECTORS						
	SR1	WR1	WR2	UR1	UR2	UR3	ALL
FDM	9.4	11.1	9.6	2.1	6.0	4.5	99.7
COORD	12.8	1.2	0.8	0.3	5.6	7.4	45.4
CONFLICT SRCH	19.5	20.0	17.7	3.9	9.7	9.2	208.4
ROUTINE R/T	33.5	35.2	33.1	7.3	15.2	13.7	337.8
RADAR	25.7	11.7	36.6	5.2	3.5	6.9	232.4
TOTALS:	101.0	79.4	97.9	18.9	40.1	41.8	923.9

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39D - ORGANISATION D

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE D1 : TABLE D1 - RADAR CONTROLLER LOADINGS

	60'	90'	180'
HDP-EC	47%	45%	40%
LDP-EC	37%	34%	31%
NPU-EC	43%	32%	25%
SPU-EC	62%	50%	42%
NR1-EC	10%	8%	7%
NR2-EC	49%	42%	33%
OR1-EC	55%	47%	36%
SR1-EC	48%	47%	37%
WR1-EC	36%	33%	31%
WR2-EC	53%	48%	42%
UR1-EC	10%	8%	7%
UR2-EC	22%	19%	12%
UR3-EC	21%	19%	13%

E U R O C O N T R O L   A I R S P A C E   M O D E L

SIMULATED ORGANISATION : AF39D - ORGANISATION D

SIMULATED TRAFFIC : FORECAST TRAFFIC (1305-1604) 366 FLIGHTS

TABLE D2 : TABLE D2 - COORDINATOR LOADINGS

	60'	90'	180'
DEP-CC	39%	37%	36%
NPU-CC	8%	7%	6%
SPU-CC	17%	16%	13%
NR1-CC	4%	3%	2%
NR2-CC	12%	10%	9%
OR1-CC	16%	15%	12%
SR1-CC	24%	22%	18%
WR1-CC	14%	13%	12%
WR2-CC	14%	12%	11%
UR1-CC	3%	2%	2%
UR2-CC	13%	12%	8%
UR3-CC	13%	12%	9%