ARD-140-5-82

Projected Traffic Loads and Computer Utilization for Sector Boundary Realignment in the Southwest Region

8/82

Jacques Press

FAA Technical Center
Atlantic City Airport, N.J. 08405

84-0432

August 1982

Final Report

FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER LIBRARY
ATLANTIC CITY INT'L ARPRT, NJ 08405

U.S. Department of Transportation
Federal Aviation Administration
Systems Research & Development Service
Washington, D.C. 20590

74P

Technical Report Documentation Page

1. Report No. ARD-140-5-82	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Projected Traffic Loads and Computer Utilization for Sector Boundary Realignment in the Southwest Region		5. Report Date August 1982
		6. Performing Organization Code ARD-142
7. Author(s) JACQUES PRESS		8. Performing Organization Report No. ARD-140-5-82
9. Performing Organization Name and Address FAA Technical Center ATC Automation Division Development Programming Branch, ARD-140 Atlantic City, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Southwest Regional Office Air Traffic Automation Branch, ASW-550		13. Type of Report and Period Covered Final
		14. Sponsoring Agency Code ASW-550

15. Supplementary Notes

Address of Item 12 above: P.O. Box 1689, Fort Worth, TX 76101

16. Abstract

Concerning air traffic loads and computer utilization, the study described in this document addresses the feasibility of boundary realignment between enroute air traffic control centers in the Southwest Region. According to data collected during actual operations, the analysis indicates that, with the proposed boundaries, ALBUQUERQUE will absorb about 9 percent of FORT WORTH's and 9 percent of KANSAS CITY's traffic load. Moreover, HOUSTON shall lose 30 percent of its traffic to FORT WORTH. As a result of these changes, ALBUQUERQUE's slow "9020A" computer will be significantly utilized. In contrast, FORT WORTH's faster "9020D" equipment will have ample computing capacity to sustain the loads created by the planned configuration. Consequently, ALBUQUERQUE's airspace change should be performed in steps over an extended period thus allowing the site enough time to monitor computer utilization with each gradual change.

17. Key Words		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 74	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

Background.

Requested by the Southwest Regional Office (SWRO), the study described in this report was conducted at the FAA Technical Center to determine the impact an airspace boundary realignment would have at the ALBUQUERQUE, FORT WORTH, HOUSTON and KANSAS CITY Air Route Traffic Control Centers (ARTCCs). In order to improve operations in that part of the country following the controllers' strike, the SWRO expects to establish new center boundaries by shifting sector airspace among the four ARTCCs. Before executing such plans however, the SWRO Automation Staff issued a memorandum (see Appendix A) stating the need to predict how these changes might affect the already highly utilized computers that process flight plans, radar tracks, and related information at each ARTCC. To this end, the following study provides estimates of the resultant traffic loads and the corresponding computer capacity essential to sustain these new loads once the proposed boundaries are in effect.

Methodology.

Based on sector workload data simultaneously recorded at the four ARTCCs during a busy time just preceding the 1982 Fourth of July Holiday, the analysis relied on observed radar track count (repre-

IOCE Offloading processing enhancement available in reserve since it is already functioning with it.

Because precautions were taken during the analysis, all stated projections remain unbiased by the current traffic reduction resulting from the controllers' strike. Consequently, these projections represent future values in effect when the National Airspace System returns to normal traffic handling after the strike. That event is not too far ahead. In fact, as noted during a recent speech *, in May 82, the FAA was already handling up to 83 percent of the pre-strike load, a value close to the 87 percent calculated in this study based on July 82 data. By May 83, the FAA expects to handle 100 percent of the pre-strike traffic using however flow control to smooth traffic peaks. But by July 84, the federal agency plans to manage full pre-strike loads with all supervisor and controller staff returned to their regular duties.

Aside from airspace impact, ground and terminal facilities to be shifted along with the sector airspace above them will cost about 5 to 10 percent beyond the utilization values stated above.

In summary, the proposed realignment will create a significant computer utilization of ALBUQUERQUE's slow 9020A equipment while moderately affecting FORT WORTH's faster 9020D.

---

* Remarks delivered by : J. Lynn Helms, Administrator, Federal Aviation Administration.
Society of Automotive Engineers, Commuter Aircraft and Airline Operations Meeting, Savannah, Georgia, May 25, 1982.

TABLE OF CONTENTS

PAGE

LIST OF FIGURES AND TABLES vi

INTRODUCTION 1

SITE MEASUREMENTS AND ANALYSIS 13

SECTOR LOADING RESULTS 16

PROJECTED TRAFFIC LOADS 32

PROJECTED COMPUTER UTILIZATION 41

RESIDUAL COMPUTER IMPACT DUE TO GROUND
AND TERMINAL FACILITIES 50

REFERENCES.....54

APPENDIX A: SOUTHWEST REGIONAL OFFICE MEMORANDUM 55

APPENDIX B: TRAFFIC LOADS OBSERVED DURING THE
MEASUREMENT.....58

APPENDIX C: DISTRIBUTION OF FLIGHT PLANS.....64

APPENDIX D : AIR TRAFFIC FLOW BETWEEN FACILITIES.....66

INTRODUCTION

Background

According to the National Airspace System Plan (see Reference 1), one of the FAA objectives to be accomplished in this decade calls for the consolidation of the twenty Air Route Traffic Control Centers (ARTCCs) that monitor enroute air traffic across the United States. Figure 1 depicts the present coverage boundaries between these facilities. Accomplished by reducing the number of control sectors and realigning boundaries between ARTCCs, the consolidation will create a more efficient use of airspace in the years ahead. Within a more immediate time frame, airspace changes are contemplated in order to streamline traffic handling following the 1981 controller strike. Furthermore, because the enroute computers at some ARTCCs are quickly approaching their maximum utilization, airspace changes could make it possible for those sites with sufficient computer capacity to accommodate sector traffic from adjacent facilities whose computers can no longer handle additional loads.

Purpose of the Study

At a more local level, the Southwest Regional Office (SWRO) is planning a sector realignment for the ALBUQUERQUE, KANSAS CITY, FORT WORTH, and HOUSTON ARTCCs in order to improve operations in that

centers have 9020D equipment and the remaining ten sites have the slower 9020A computer. As Figure 1 indicates, ALBUQUERQUE and HOUSTON have a 9020A, while FORT WORTH and KANSAS CITY have a 9020D.

ALBUQUERQUE, KANSAS CITY, FORT WORTH, DENVER AND HOUSTON CENTER BOUNDARIES ALTITUDES FROM 0 TO 23,900 FT

(PARTIAL MAP)

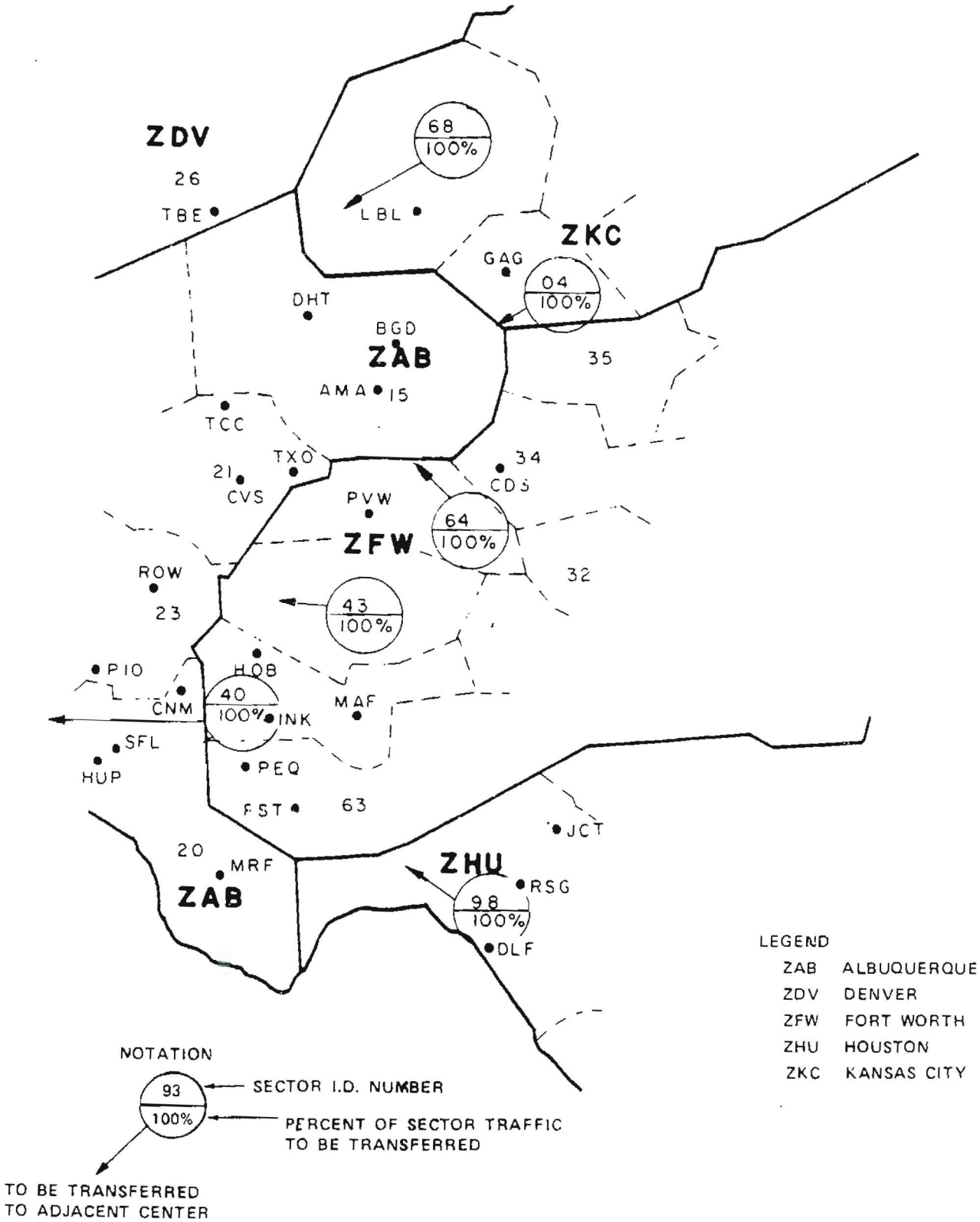


FIGURE 2

FORT WORTH CENTER BOUNDARIES
ALTITUDES FROM 0 TO 23,900 FT

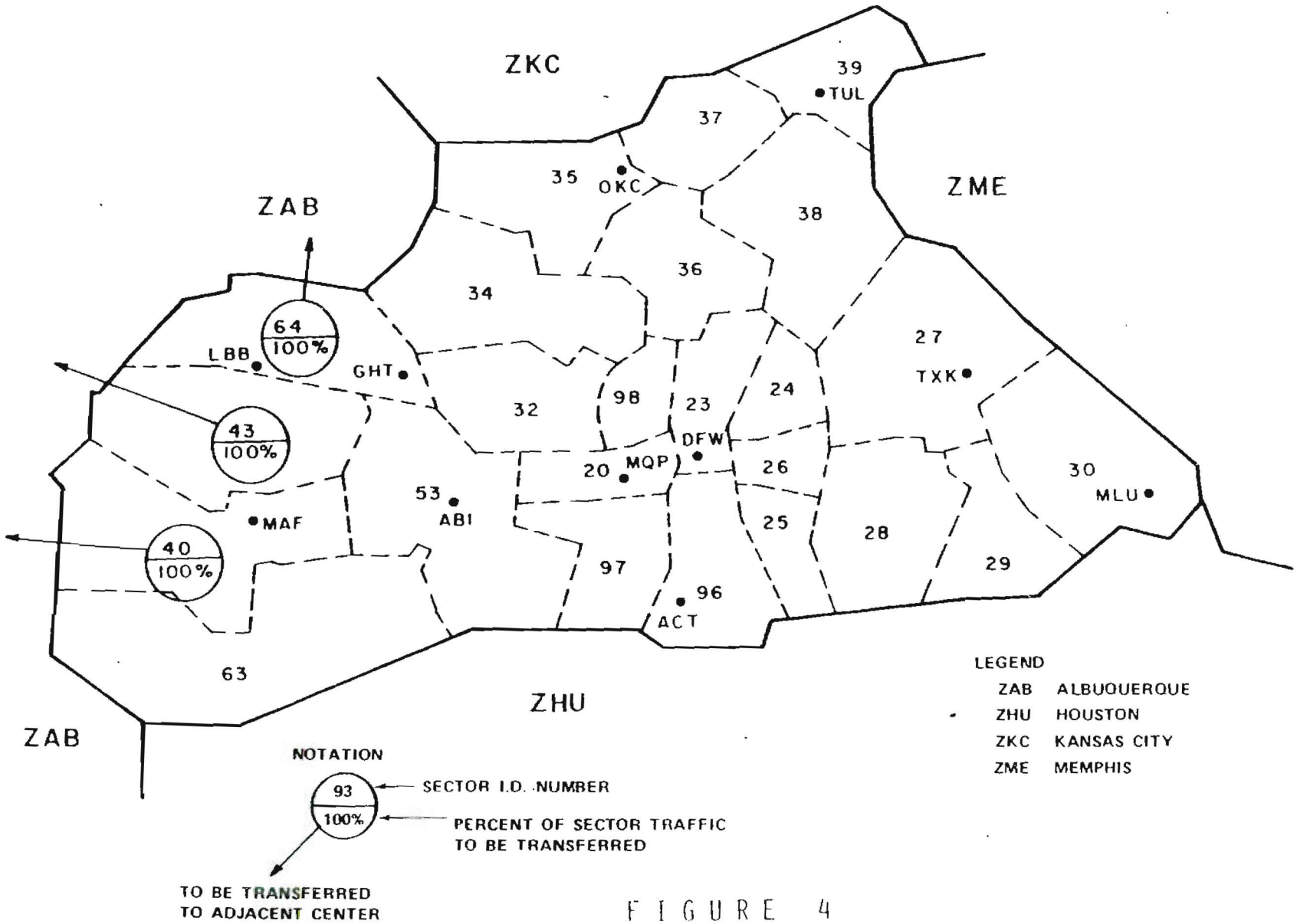
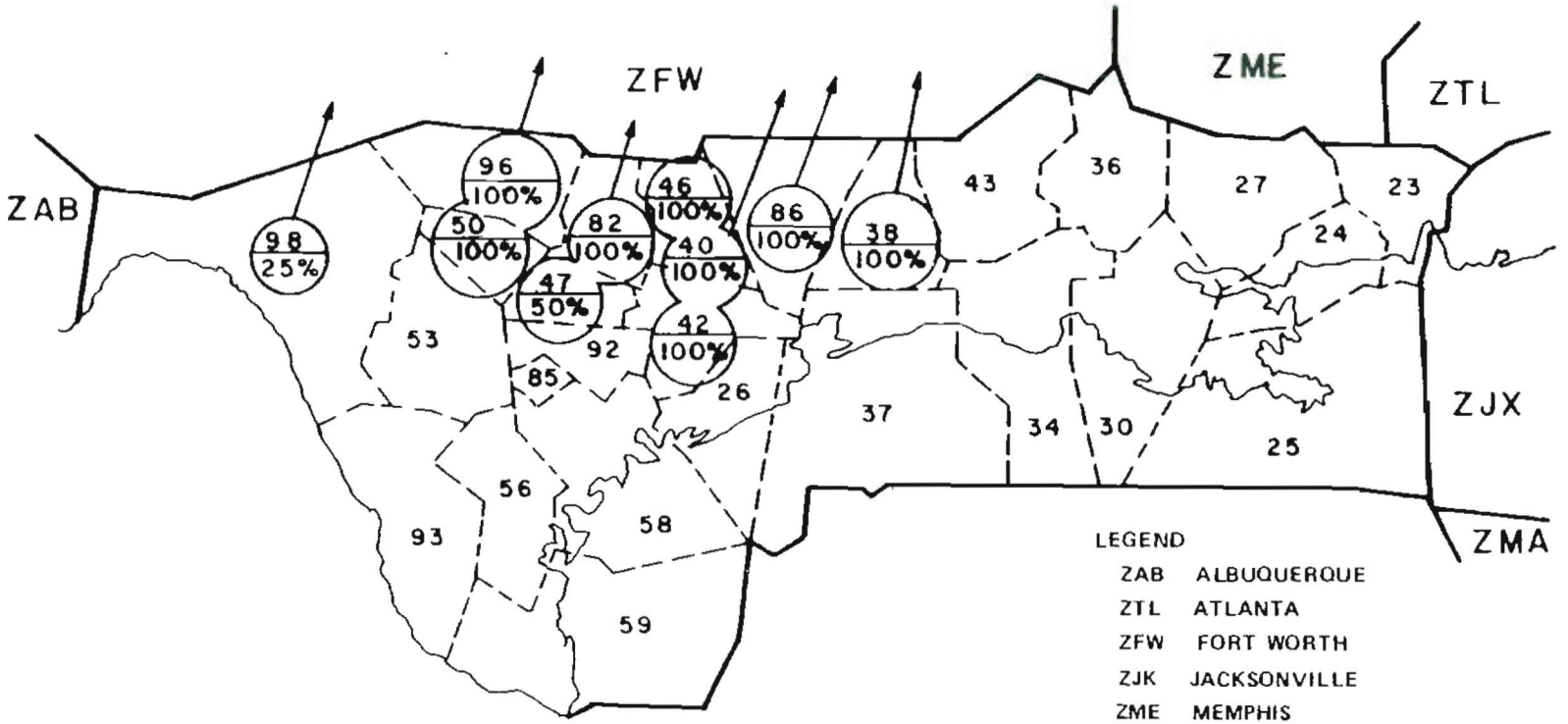


FIGURE 4

HOUSTON CENTER BOUNDARIES
ALTITUDES FROM 0 TO 23,900 FT



NOTATION

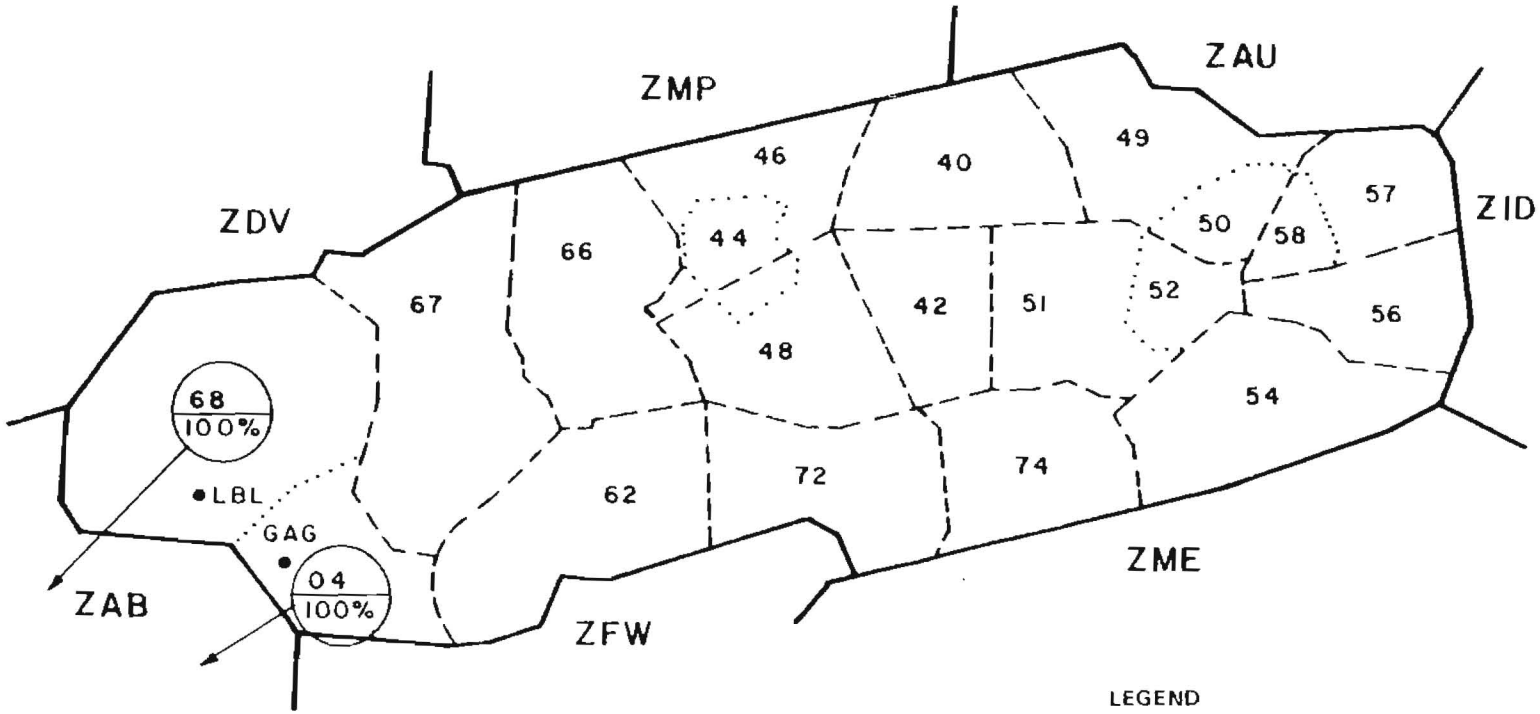
93 ← SECTOR I.D. NUMBER

100% ← PERCENT OF SECTOR TRAFFIC TO BE TRANSFERRED

TO BE TRANSFERRED TO ADJACENT CENTER

FIGURE 6

KANSAS CITY CENTER BOUNDARIES
ALTITUDES FROM 0 TO 23,900 FT



NOTATION

93 ← SECTOR I.D. NUMBER

100% ← PERCENT OF SECTOR TRAFFIC TO BE TRANSFERRED

TO BE TRANSFERRED TO ADJACENT CENTER

LEGEND

ZAU	CHICAGO
ZDV	DENVER
ZFW	FORT WORTH
ZID	INDIANAPOLIS
ZME	MEMPHIS
ZMP	MINNEAPOLIS

FIGURE 8

SITE MEASUREMENTS AND ANALYSIS

Site Measurements

Because airspace is to be reapportioned between sites on a sector basis, load estimates were derived for each individual sector relative to all active control positions at the four ARTCCs. To obtain these estimates, sector data based on System Analysis Recordings (SAR) was collected at the four facilities simultaneously during a busy time on a specified day selected by uniform agreement among sites and the SWRO. Chosen to be 19:00 to 20:00 (GMT) on Thursday July 1, 1982, that time reflects an intense traffic load preceding the Fourth of July Holiday period. By expressing this load in terms of flight plans and radar tracks, Tables B-1 through B-4 (see Appendix B) show traffic activity differences between the four sites at various times during the measurement. Furthermore, the last two columns in each table indicate load differences between the present and a previous measurement taken before the controllers' strike. According to Appendix B, ALBUQUERQUE's, FORT WORTH's, and HOUSTON's post-strike track load represents 84, 81, and 95 percent, respectively, of what it used to be before the strike. The three sites average 87 percent altogether. In contrast, KANSAS CITY's load is now higher than before because, during the interim, it acquired airspace that previously belonged to CHICAGO and INDIANAPOLIS Centers, thus increasing its traffic load accordingly. Although observed at the same time-of-day, these pre- and post-strike differences are only approximations because they do not correspond to the same calendar day.

b. the corresponding number of computer output messages, and

c. the number of aircraft handled by each sector.

It is assumed that these three items closely reflect the intensity of traffic handling at each position mainly because they indicate (1) the rate of controller input actions requesting computer processing of flight plans, radar tracks and related air traffic information; (2) automatically displayed computer responses; and (3) sector traffic count, respectively. (a), (b), and (c) were therefore extracted using the reduction tool and, for each sector, expressed as a percentage value relative to the center's total traffic handling activity.

SECTOR LOADING RESULTS

Tables 1 through 4 summarize the sector loading results for KANSAS CITY, FORT WORTH, HOUSTON and ALBUQUERQUE, respectively. Sectors are indicated by their I.D. numbers in the first column in each table. Columns B, D, and F contain percentages expressing the values in columns A, C, and E as ratios of the total load for all sectors. Column "G", representing the average of "B", "D", and "F", summarizes each sector's load. Because some sectors were combined with each other during the measurement, their I.D. numbers are shown in the tables on the same line with a "/" symbol separating them. One large group of sectors, shown with multiple "/" at the end of each table, are not combined but instead represent several convenience positions used for military interface, flow control information exchange, training, flight strip printing, etc. Although they do not actively handle traffic, the individuals acting at these miscellaneous positions request message processing and thereby impact computer utilization. Their actions were therefore accounted in the analysis. in the tables, each "subtotal" line corresponds to the sector group (appearing above it) which is to be transferred to the adjacent ARTCC, as stated in the SWRO Memorandum. Since ALBUQUERQUE is not expected to lose but instead receive airspace, its subtotal applies to sectors that are bordering the donating centers and indicates what portion of ALBUQUERQUE's present sector load will be immediately affected by additional loads once the realignment is in effect.

Summarizing the preceding tables, Table 5 shows in column "A" the observed traffic load, in column "B" the percentage factor imposed

- T A B L E 1 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: KANSAS CITY

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(14:00 TO 15:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
04/67/68	45	4.43	219	5.17	3240	4.84	4.81
22/91	34	3.35	134	3.16	2470	3.69	3.40
06	31	3.05	118	2.78	1769	2.64	2.82
SUBTOTAL	110	10.83	471	11.11	7479	11.17	11.04
02	62	6.10	218	5.14	3658	5.46	5.57
12	34	3.35	113	2.67	2129	3.18	3.07
14	52	5.12	239	5.64	3670	5.48	5.41
16	45	4.43	171	4.03	2119	3.16	3.87
18/86	46	4.53	171	4.03	3213	4.80	4.45
20	49	4.82	271	6.39	3347	5.00	5.40
24	35	3.44	130	3.07	1929	2.88	3.13
26	35	3.44	80	1.89	1621	2.42	2.58
28	41	4.04	163	3.84	2771	4.14	4.01
30	43	4.23	211	4.98	2545	3.80	4.34

- T A B L E 1 -

- C O N C L U D E D -

- P A G E 3 O F 3 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: KANSAS CITY

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(14:00 TO 15:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F
66	34	3.35	91	2.15	1782	2.66	2.72
72	19	1.87	51	1.20	996	1.49	1.52
74	39	3.84	103	2.43	2580	3.85	3.37
FC/01/15/25 35/45/55/64 65/87/93/95	--	----	244	5.75	2459	3.67	4.71
TOTAL	1016	100.02	4240	100.02	67003	100.04	------

- T A B L E 2 -

- P A G E 2 O F 3 -

- C O N T I N U E D -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: FORT WORTH

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(14:00 TO 15:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
29/30	40	3.22	96	1.83	1645	1.77	2.27
32	34	2.74	128	2.45	1573	1.70	2.30
34	33	2.66	175	3.34	1816	1.96	2.65
35/36	53	4.27	194	3.71	3107	3.35	3.78
37/39	53	4.27	175	3.34	3280	3.54	3.72
38	44	3.54	187	3.57	3640	3.93	3.68
46	33	2.66	107	2.04	2169	2.34	2.35
47/48	47	3.78	178	3.40	2905	3.13	3.44
49	31	2.50	148	2.83	1731	1.87	2.40
50	50	4.03	250	4.78	4427	4.77	4.53
53	35	2.82	138	2.64	2353	2.54	2.67
63	31	2.50	97	1.85	1727	1.86	2.07

- T A B L E 3 -

- P A G E 1 O F 3 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: HOUSTON

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(14:00 TO 15:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
97/98	42	3.89	116	3.26	1842	2.86	3.34
74/75	45	4.17	144	4.05	3169	4.93	4.38
49	40	3.71	134	3.77	2986	4.64	4.04
28	32	2.97	133	3.74	1911	2.97	3.23
38	26	2.41	95	2.67	1543	2.40	2.49
86	38	3.52	151	4.25	2516	3.91	3.89
40/46	37	3.43	139	3.91	2976	4.63	3.99
42	40	3.71	140	3.94	2585	4.02	3.89
47	30	2.78	83	2.34	1408	2.19	2.44
50/96	37	3.43	136	3.83	2932	4.56	3.94
82	23	2.13	69	1.94	1673	2.60	2.22
SUBTOTAL	390	36.14	1340	37.71	25541	39.70	37.8[illegible]

- T A B L E 3 -

- C O N C L U D E D -

- P A G E 3 O F 3 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: HOUSTON

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(14:00 TO 15:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
68	48	4.45	198	5.57	3214	5.00	5.01
70	45	4.17	168	4.73	4140	6.44	5.11
72/79	17	1.58	80	2.25	679	1.06	1.63
92	32	2.97	100	2.81	2247	3.49	3.09
93/95	30	2.78	133	3.74	1746	2.71	3.08
FC/15/55/ 61/77/80/ 87/89/91	---	----	16	0.45	130	0.20	0.33
TOTAL	1079	100.01	3553	99.98	64331	100.00	-------

- T A B L E 4 -

- C O N T I N U E D -

- P A G E 2 O F 4 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: ALBUQUERQUE

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(13:00 TO 14:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
16	24	2.64	121	3.72	2032	4.23	3.53
17	19	2.09	72	2.12	1047	2.18	2.13
19	21	2.31	80	2.46	1042	2.17	2.31
37	10	1.10	34	1.04	954	1.99	1.38
39	54	5.94	109	3.35	1272	2.65	3.98
40	23	2.53	64	1.97	1574	3.28	2.59
42	30	3.30	105	3.23	2087	4.35	3.62
41/43	34	3.74	106	3.26	1583	3.30	3.43
45	22	2.42	95	2.92	1670	3.48	2.94
46	24	2.64	96	2.95	1648	3.43	3.01

- T A B L E 4 -

- C O N C L U D E D -

- P A G E 4 O F 4 -

AIR ROUTE TRAFFIC CONTROL CENTER

BOUNDARY REALLIGNMENT STUDY FOR THE SOUTHWEST REGION

AIR TRAFFIC CONTROL SECTOR LOADINGS

SITE: ALBUQUERQUE

MEASUREMENT DATE: JULY 1ST, 1982
MEASUREMENT TIME : 19:00 TO 20:00 (GMT)
(13:00 TO 14:00 (LOCAL TIME))

SECTOR I.D. NUMBER	-A- NUMBER OF DIFF. AIRCRAFT HANDLED DURING MEASUREMENT	-B- AS A PERCENT OF ALL ACTIVE SECTORS	-C- TOTAL NUMBER OF INPUT MESSAGES PER HOUR DURING MEASUREMENT	-D- AS A PERCENT OF ALL ACTIVE SECTORS	-E- TOTAL NUMBER OUPUT MESSAGES PER HOUR DURING MEASUREMENT	-F- AS A PERCENT OF ALL ACTIVE SECTORS	-G- AVERAGE OF COLUMNS "B", "D" AND "F"
90	31	3.41	124	3.81	1598	3.33	3.52
91	41	4.51	151	4.64	2801	5.84	5.00
92	35	3.85	112	3.44	2242	4.67	3.99
93	36	3.96	132	4.06	1919	4.00	4.01
94	46	5.06	206	6.33	2104	4.38	5.26
95	35	3.85	109	3.35	1580	3.29	3.50
FC/11/14/16/ 20/38/55/64/ 65/66/69/78/ 88/98	--	----	43	1.32	798	1.66	1.49
TOTAL	909	99.99	3254	99.91	47999	100.01	-------

- T A B L E 5 -

AIR ROUTE TRAFFIC CONTROL CENTER
BOUNDARY REALLIGNMENT STUDY FOR THE SOUTWEST REGION

LOAD SUMMARY FOR SPECIFIED SECTORS

MEASUREMENT TIME = 1900-2000 (GMT)
MEASUREMENT DATE = JULY 1, 1982

SITE NAME	SECTOR I.D. NUMBER	-A- ESTIMATE OF THAT SECTOR TRAFFIC LOAD IN PERCENT OF TOTAL LOAD FOR CENTER (COLUMN "G" FROM TABLES 1, 2, AND 3)	-B- TRAFFIC LOAD FACTOR IMPOSED BY THE SOUTH-WEST REGIONAL OFFICE FOR THAT SECTOR (SEE MEMORANDUM IN APPENDIX A)	-C- FINAL COMPUTED SECTOR TRAFFIC LOAD IN PERCENT OF TOTAL CENTER LOAD (COLS. "A" TIMES "B")
KANSAS	04/67/68	4.78	100%	4.78
KANSAS	22/91	3.38	100%	3.38
KANSAS	06	2.80	25%	0.70
			GROUP TOTAL	8.86
FORT WORTH	64	3.15	100%	3.15
FORT WORTH	43/93	2.18	100%	2.18
FORT WORTH	40	1.41	100%	1.41
FORT WORTH	82	1.86	100%	1.86
			GROUP TOTAL	8.59
CASE 1 FOR HOUSTON				
HOUSTON	97/98	3.34	25%	0.84
HOUSTON	74/75	4.38	(100%+60%)/2	3.50
HOUSTON	49	4.04	75%	3.03
HOUSTON	28	3.23	100%	3.23
HOUSTON	38	2.49	100%	2.49
HOUSTON	86	3.89	100%	3.89
HOUSTON	40/46	3.99	100%	3.99
HOUSTON	42	3.89	50%	1.95
HOUSTON	47	2.44	50%	1.22
HOUSTON	50/96	3.94	100%	3.94
HOUSTON	82	2.22	100%	2.22
			GROUP TOTAL	30.30
CASE 2 FOR HOUSTON				
HOUSTON	97/98	3.34	50%	1.67
HOUSTON	74/75	4.38	(100%+60%)/2	3.50
HOUSTON	49	4.04	80%	3.23
HOUSTON	28	3.23	100%	3.23
HOUSTON	38	2.49	100%	2.49
HOUSTON	86	3.89	100%	3.89
HOUSTON	40/46	3.99	100%	3.99
HOUSTON	42	3.89	85%	3.31
HOUSTON	47	2.44	100%	2.44
HOUSTON	50/96	3.94	100%	3.94
HOUSTON	82	2.22	100%	2.22
			GROUP TOTAL	33.91

PROJECTED TRAFFIC LOADS

As part of a recent study of all ARTCCs, substantial air traffic data has been collected to characterize processing loads on the Centers' computers (see References 2 through 6). The data consists of flight plan and radar track counts recorded minute by minute for several days during live air traffic operations. In addition to traffic data, computer utilization was also recorded during that same time. Collected in the 1980-81 period preceding the controllers' strike, the track count data, representing traffic load information, is particularly useful in predicting future loads because it is not biased by the strike's current traffic reduction described in Appendix B. Consequently, the 1980-81 track count was increased or decreased by the relative percent load derived for each site in the preceding section (see the four lines labeled "GROUP TOTAL" in Table 5). That is, the final computed relative percent load corresponding to the transferable group of sectors was equated to a relative percent track load to reflect each Center's traffic loss to the adjacent facility. The "GROUP TOTAL" for HOUSTON's case number 2 is almost identical to case number 1 and is therefore dropped from further analysis. In the 1980-81 study, track count was assumed to be a consistent overall load indicator. This assumption holds true in this study as well. Figures 10 through 16 illustrate how the track load rises and decays as a function of time-of-day (the latter being expressed in minutes from midnight, local time) with and without the airspace changes. The KANSAS CITY-CHICAGO-INDIANAPOLIS airspace change (when KANSAS CITY acquired more

FIGURE 10 - ALBUQUERQUE TRACK LOAD WITH KANSAS CITY SECTORS

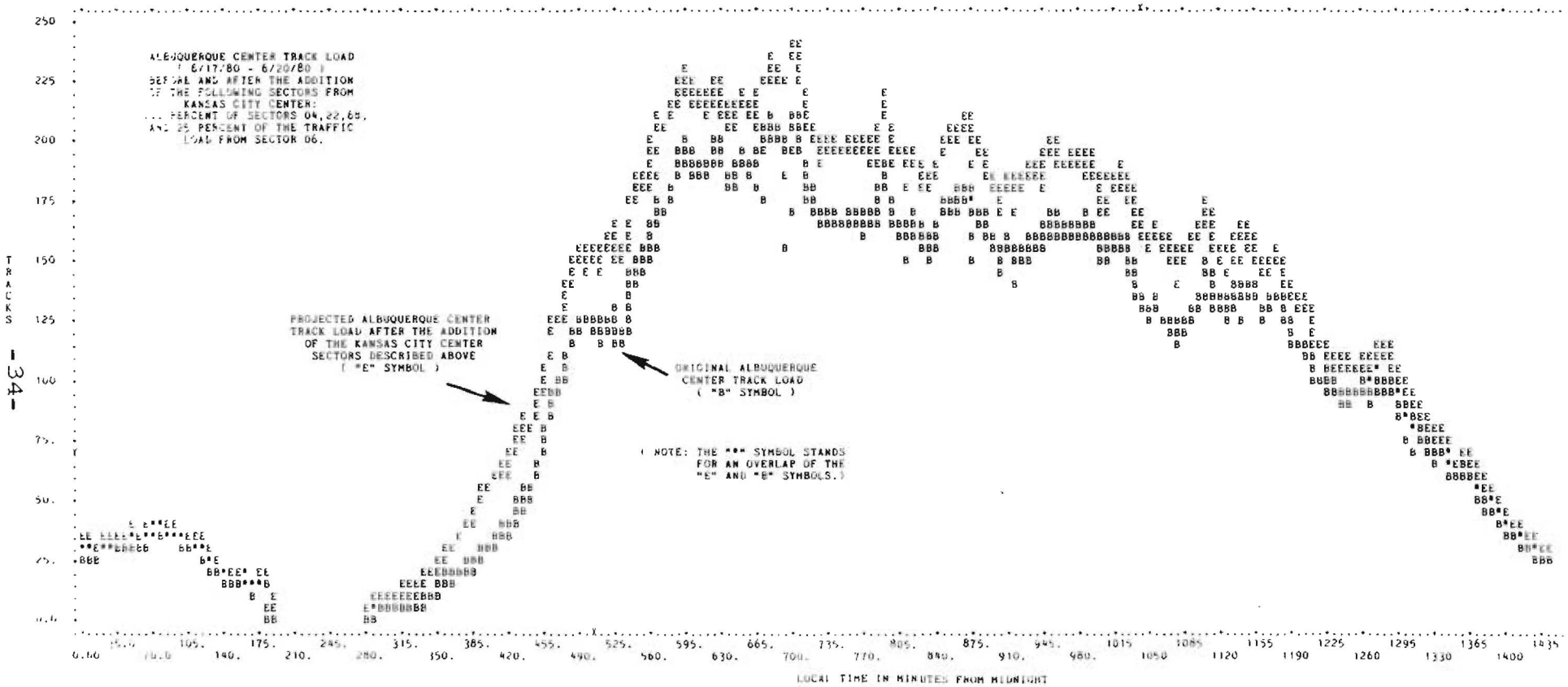


FIGURE 12 - ALBUQUERQUE TRACK LOAD WITH KANSAS CITY AND FORT WORTH SECTORS

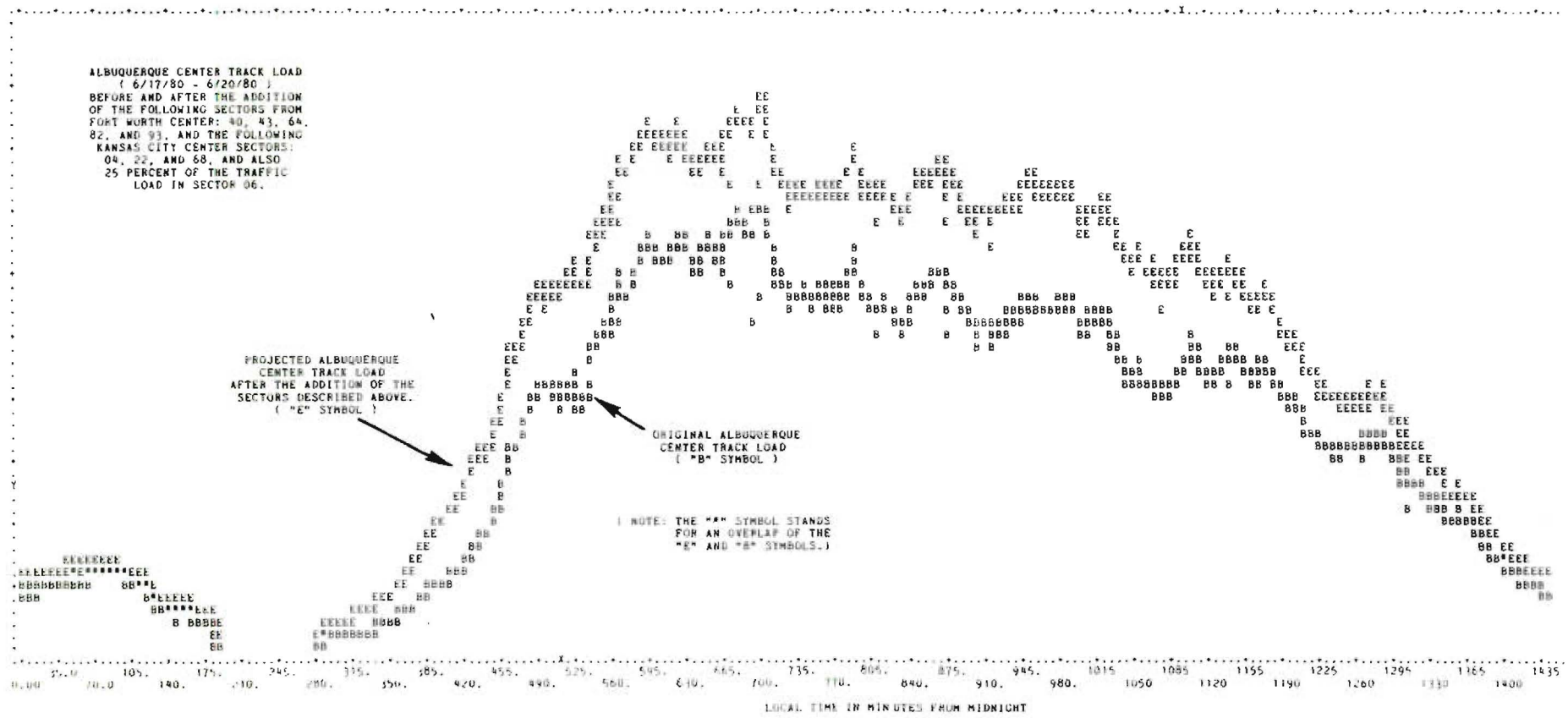


FIGURE 14 - FORT WORTH TRACK LOAD WITH HOUSTON SECTORS

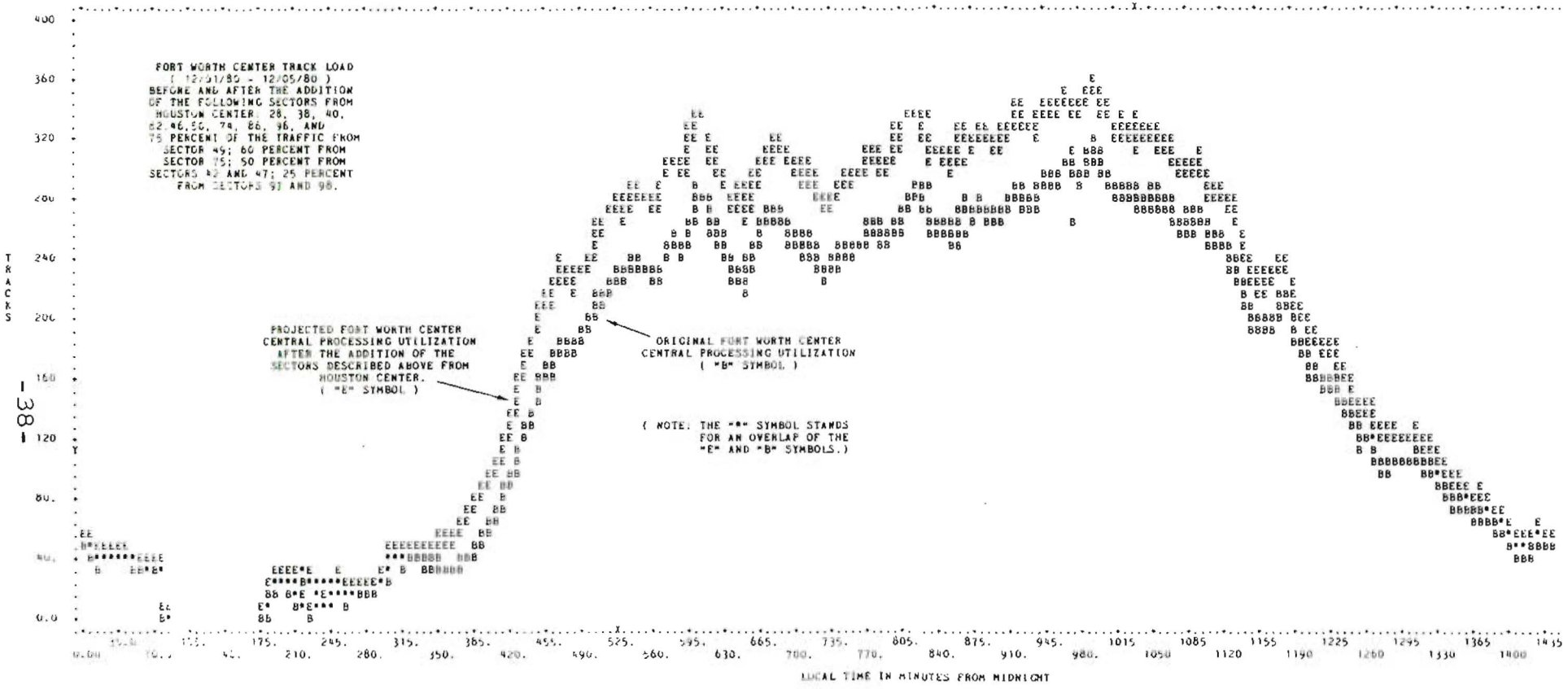
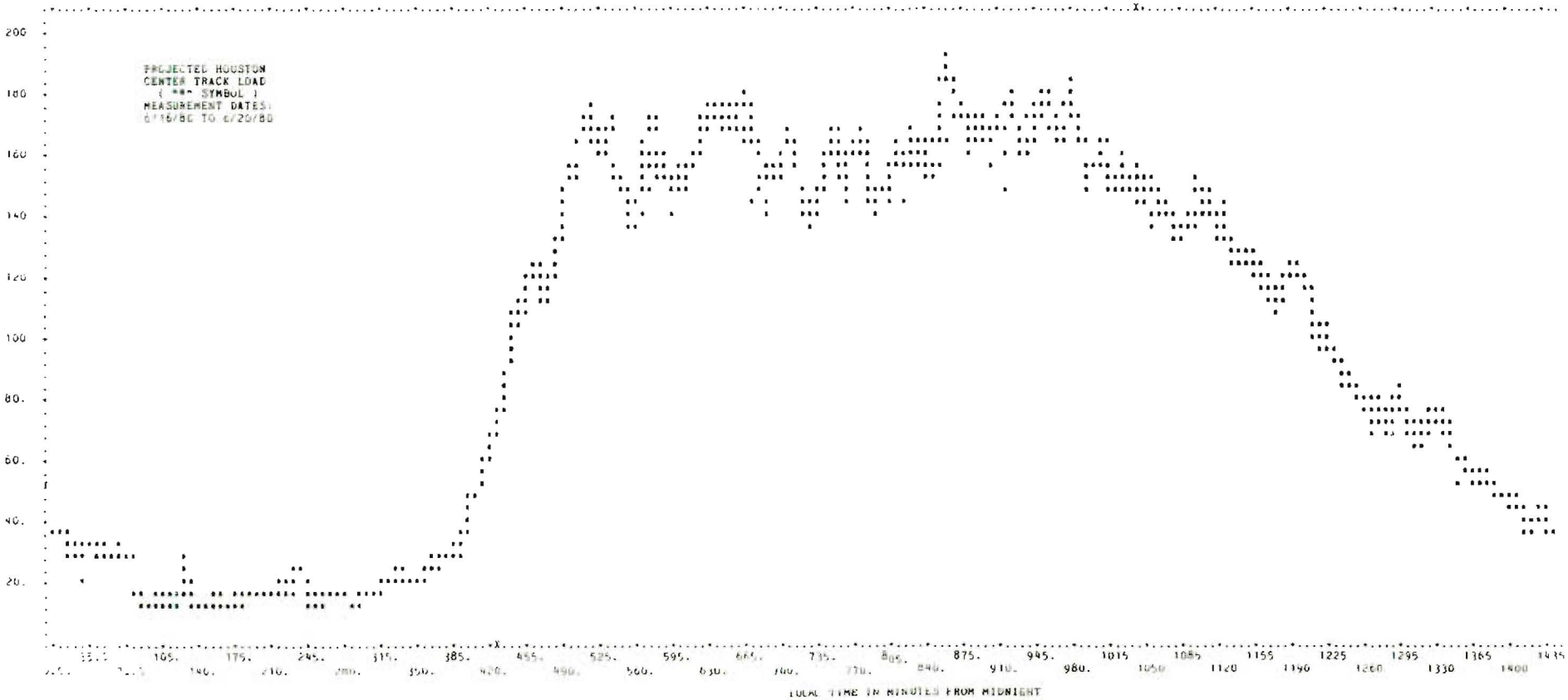


FIGURE 1: - HOUSTON TRACK LOAD WITH NO SECTOR CHANGES



PROJECTED COMPUTER UTILIZATION

During the 1980-81 study, statistical equations based on the data for each site were derived in order to express computer utilization as a function of traffic loads. One set of equations (see pages 3-6 and 2-9 in References 2 and 3, respectively) relate central processing utilization, a key measure of computer usage, to track count. Consequently, these equations were also used in the present study in an effort to project computer use once the airspace changes take effect. Furthermore, the original equations were updated to include a utilization reduction created by two major enhancements inserted in the enroute software since 1980-81, namely, "IOCE Offloading" and "Direct Route Processing Improvement". The 1980-81 original equations are stated below:

ALBUQUERQUE :	% central processing utilization	= 10.17 + 0.338 tracks
FORT WORTH :	"	= 4.610 + 0.145 tracks
HOUSTON :	"	= 7.502 + 0.415 tracks
KANSAS CITY :	"	= 5.229 + 0.134 tracks

While the updated equations used in this study are :

ALBUQUERQUE :	% central processing utilization	= 3.147 + 0.267 tracks
FORT WORTH :	"	= 4.092 + 0.139 tracks
HOUSTON :	"	= 5.795 + 0.332 tracks
KANSAS CITY :	"	= 4.641 + 0.128 tracks

The above equations pertain to computer utilization estimated at minimum recording levels, namely, SARC=1, TARS=OFF, REMON=OFF, with

FIGURE 17 - ALBUQUERQUE COMPUTER UTILIZATION WITH KANSAS CITY SECTORS

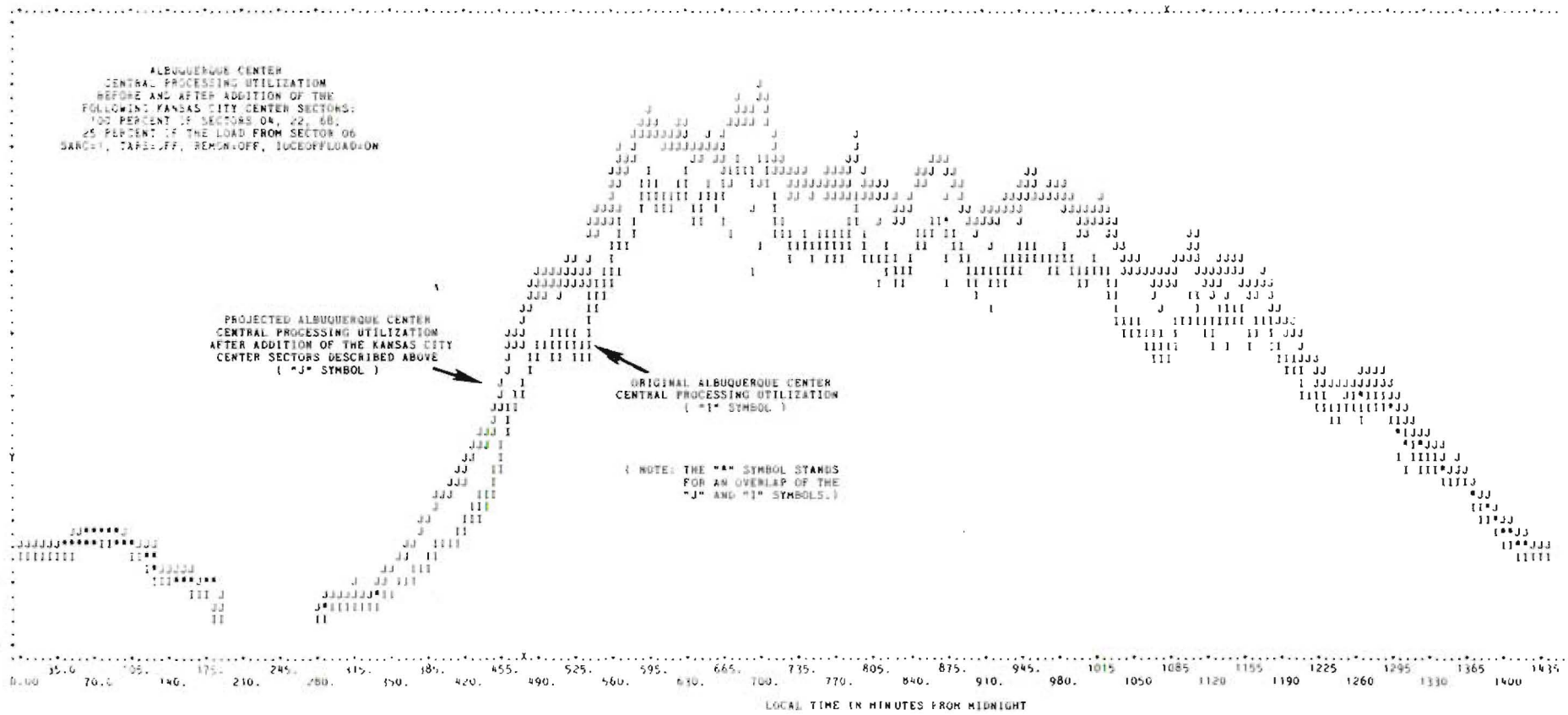


FIGURE 19 - ALBUQUERQUE COMPUTER UTILIZATION WITH KANSAS CITY AND FORT WORTH SECTORS

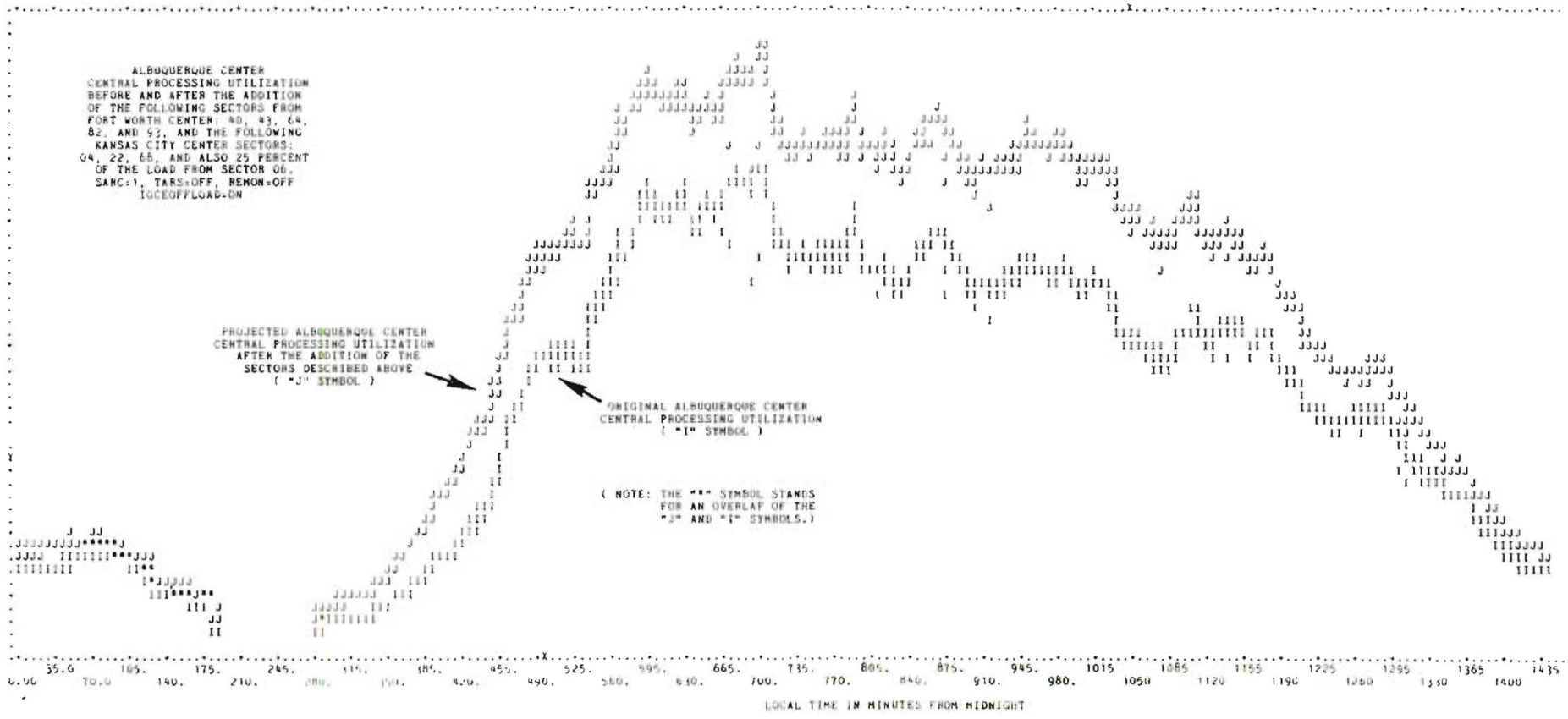


FIGURE 27 - FORT WORTH COMPUTER UTILIZATION WITH HOUSTON SECTORS

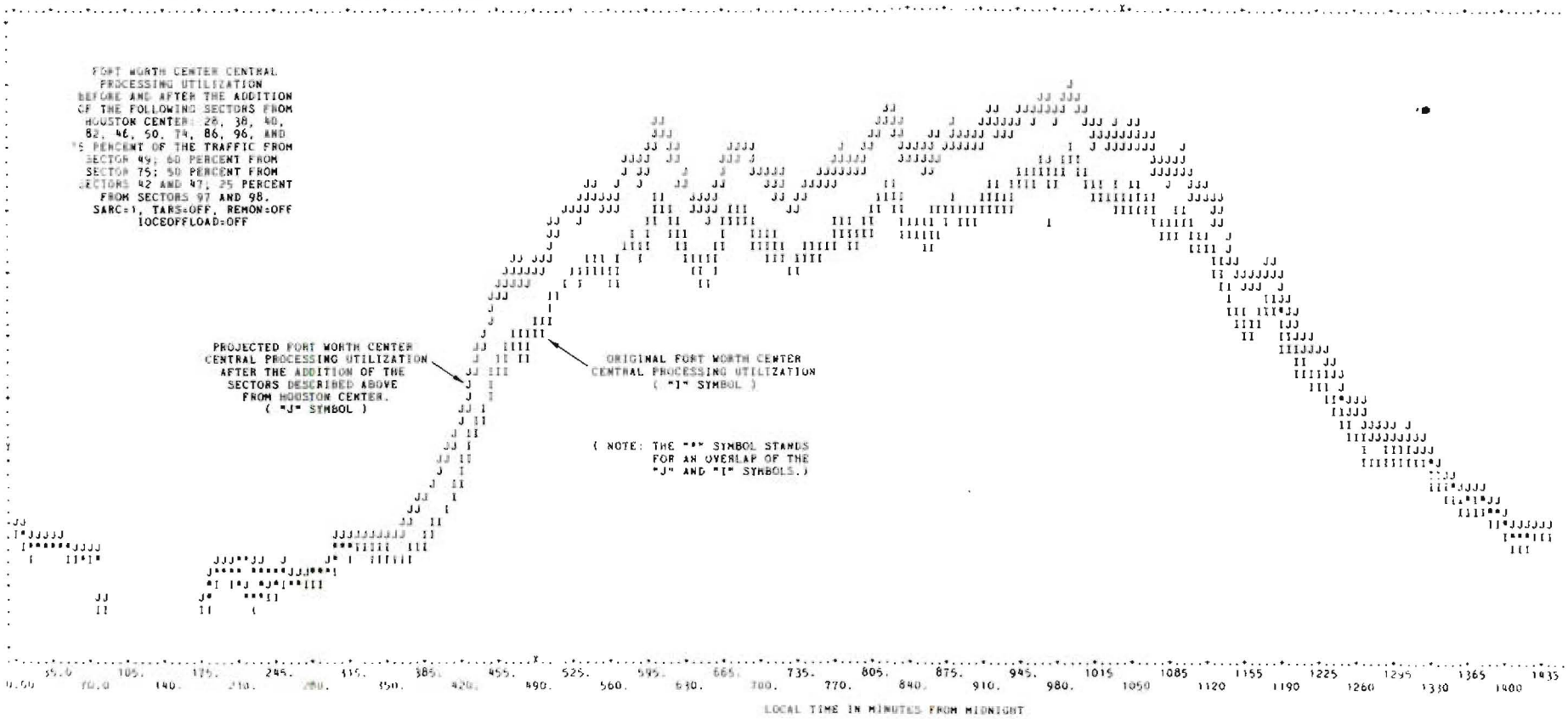
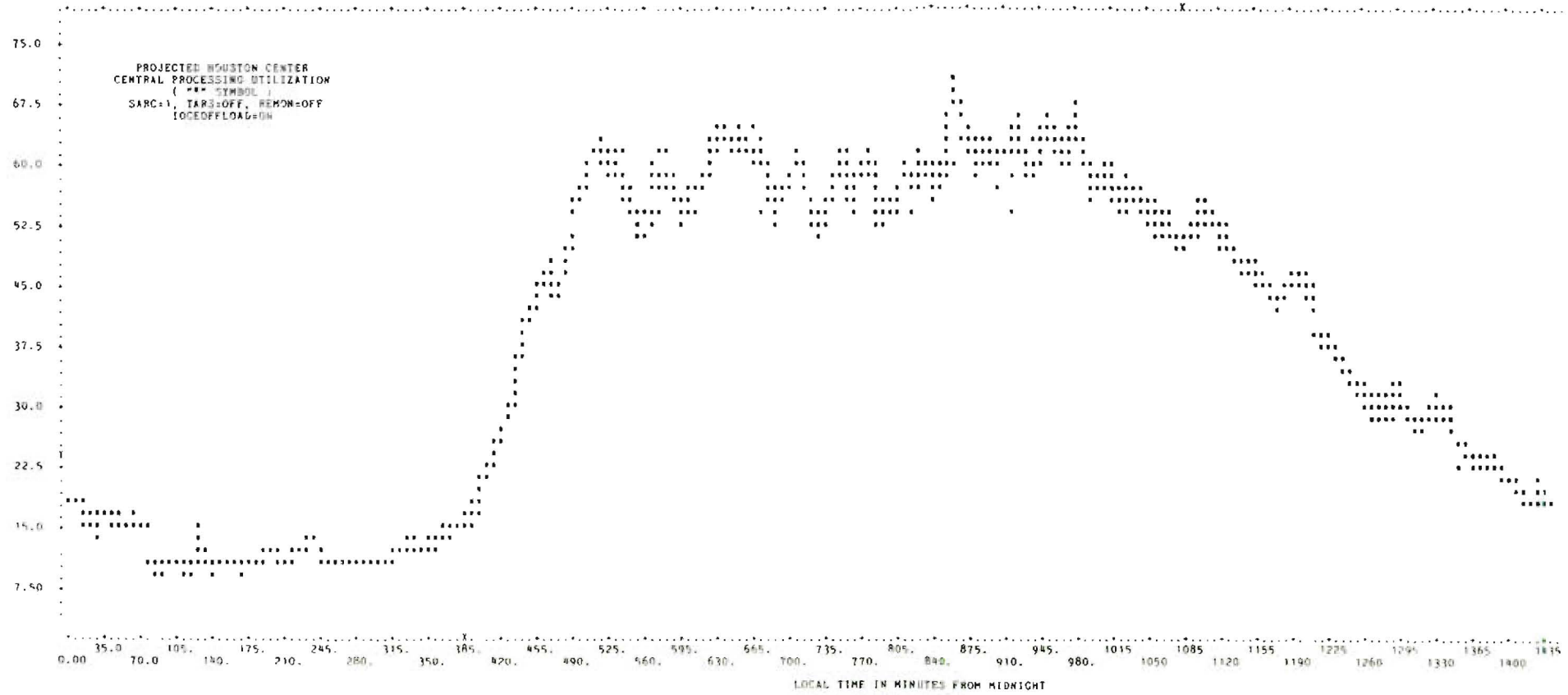


FIGURE 23 - HOUSTON COMPUTER UTILIZATION WITH NO SECTOR CHANGES



RESIDUAL COMPUTER IMPACT DUE TO ASSOCIATED GROUND AND TERMINAL FACILITIES

As a result of boundary realignment, ground and terminal facilities situated immediately below the sectors to be shifted will now fall under the jurisdiction of the ARTCC receiving the enroute airspace. Consequently, the accepting ARTCC's computer will have to process air traffic data for these additional facilities. Such data is exchanged between facilities and ARTCC via messages issued and received at flight service station and airline office teletypewriters (TTYs), tower flight data entry and printout devices (FDEPs), as well as Automated Radar Tracking System (ARTS) computers located at airports. Because message input and output rates directly affect computer utilization, the TTY, FDEP, and ARTS message rates were considered as indicators of computer impact during a ground facilities analysis also conducted in this study. Summarizing the results of this analysis, Table 6 indicates that the TTY and FDEP message rates are relatively low (see percentage values in parentheses in the table) when compared to the rates for all sources. Of the three device types, only the ARTS rates appear significant. Furthermore, in the FORT WORTH case, only one out of six ARTS (Lubbock), three out of about two dozens FDEPs (Lubbock, Reese and Midland), and five out of nearly three dozens TTYs are to be processed by ALBUQUERQUE's computer. At HOUSTON, messages for only one out of six ARTS (Austin), two out of about two dozens FDEPs, and three out of approximately three dozens TTYs will become part of FORT WORTH's processing tasks. Unlike FORT WORTH and HOUSTON, KANSAS CITY will lose no ARTS in the realignment process.

- T A B L E 6 -

MEASUREMENT DATE = JULY 1, 1982
MEASUREMENT TIME = 1900-2000 (GMT)

MESSAGE INPUT/OUTPUT RATES FOR
GROUND AND TERMINAL FACILITIES

SITE	TTY RATE (MESSAGES/HR)		FDEP RATE (MESSAGES/HR)		ARTS RATE (MESSAGES/HR)		ALL SOURCES RATE (MESSAGES/HR)	
	INPUTS	OUTPUTS	INPUTS	OUTPUTS	INPUTS	OUTPUTS	INPUTS	OUTPUTS
MKC	201 (2.5%)	84 (0.1%)	32 (0.4%)	324 (0.3%)	1347 (17.1%)	1596 (1.9%)	7899 (100%)	81335 (100%)
ABQ	172 (2.7%)	97 (0.2%)	44 (0.6%)	499 (0.8%)	1573 (24.6%)	1498 (2.5%)	6389 (100%)	59448 (100%)
HOU	255 (3.5%)	172 (0.2%)	108 (1.5%)	737 (0.9%)	1993 (27.4%)	2125 (2.8%)	7269 (100%)	75382 (100%)
FTW	227 (2.3%)	123 (0.1%)	96 (0.9%)	640 (0.5%)	2363 (23.5%)	2481 (2.0%)	10076 (100%)	121068 (100%)

NOTE:

VALUES IN PARENTHESES ARE PERCENT OF THE "ALL SOURCES" COLUMNS
FOR THAT SITE (SEE LAST TWO COLUMNS)

FDEP : FLIGHT DATA ENTRY PRINTOUT DEVICE
TTY : TELETYPEWRITER
ARTS : AUTOMATED RADAR TRACKING SYSTEM

ABBREVIATIONS

ABQ ALBUQUERQUE
FTW FORT WORTH
HOU HOUSTON
MKC KANSAS CITY

REFERENCES

1. National Airspace System Plan, Facilities, Equipment, and Associated Development, Federal Aviation Administration, Department of Transportation, December 1981.

2. Computer Utilization at Several Air Route Air Traffic Control Centers (A3D2.9 System), J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, ARD-140-1-81, December 1980.

3. Computer Utilization at Several Air Route Air Traffic Control Centers (A3D2.10 System), J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, ARD-140-8-81, June 1981.

4. Traffic Loads and Computer Utilization Patterns at the Twenty Enroute Air Traffic Control Centers, J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, ARD-140-11-81, April 1981.

5. Computer Utilization at the HOUSTON Air Route Air Traffic Control Center (A3D2.10 System), J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, ARD-140-14-81, July 1981.

6. Performance Analysis of Enroute Air Traffic Control Computers in the National Airspace System, J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, Proceedings, American Institute of Aeronautics and Astronautics Computers in Aerospace III Conference, San Diego, California, October 26-28, 1981.

7. Computer Utilization at the Fort Worth Air Route Traffic Control Center (A3d2.12 System), J. Press, Federal Aviation Administration Technical Center, Systems Research and Development Service, ARD-140-3-82, April 1982.

A P P E N D I X A

SOUTHWEST REGIONAL OFFICE MEMORANDUM

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: CPU Projections

Date JUN 10 1982

From: Roy J. Browning
Chief, Automation Staff, ASW-550

Reply to Attn of ASW-554

To ARD-140
Attn: ARD-142 (Jacques Press)

You previously indicated that CPU projections for Southwest Region Centers could be based on anticipated airspace changes if the sector numbers were known. It would be appreciated if you could simulate the following situations:

1. Albuquerque Center with present airspace plus the following Kansas City Center Sectors:

04	All Traffic
68	" "
22	" "
06	25% Traffic

2. Albuquerque Center with the sectors in above plus the following Fort Worth Center Sectors:

64	All Traffic
43	" "
40	" "
93	" "
82	" "

3. Fort Worth Center with current sectors plus the following Houston Center Sectors:

97	25% Traffic	40	All Traffic
74	All Traffic	46	All Traffic
75	60% Traffic	42	50% Traffic
49	75% Traffic	47	50% Traffic
28	All Traffic	50	All Traffic
38	" "	96	All Traffic
86	" "	98	25% Traffic
		82	All Traffic

A P P E N D I X B

TRAFFIC LOADS OBSERVED DURING THE MEASUREMENT

T A B L E B - 1

TRAFFIC LOAD
DURING THE MEASUREMENT PERIOD 19:00 TO 20:00 GMT

SITE: ALBUQUERQUE
DATE: JULY 1, 1982

SELECTED TIMES (GMT) (HOURS:MINUTES)	PROPOSED FLIGHT PLANS	ACTIVE FLIGHT PLANS	TRACKS	PRE-STRIKE TRACKS (SEE BOTTOM NOTE)
19:04	210	221	148	177
19:09	216	215	142	187
19:14	214	214	142	180
19:19	216	215	145	169
19:24	212	207	143	164
19:29	216	226	141	163
19:35	224	233	146	161
19:40	228	228	143	165
19:45	235	216	129	153
19:50	236	217	130	151
19:56	245	219	125	158
AVERAGE	223	219	139	166

NOTE: PRE-STRIKE TRACKS CORRESPOND TO OBSERVATIONS MADE AT THAT SAME TIME DURING A PREVIOUS MEASUREMENT TAKEN BETWEEN 6/17 AND 6/20 1980.

T A B L E B - 2 (CONCLUDED)

- P A G E 2 O F 2 -

TRAFFIC LOAD
DURING THE MEASUREMENT PERIOD 19:00 TO 20:00 GMT

SITE: FORT WORTH (CONTINUED)
DATE: JULY 1, 1982

SELECTED TIMES (GMT) (HOURS:MINUTES)	PROPOSED FLIGHT PLANS	ACTIVE FLIGHT PLANS	TRACKS	PRE-STRIKE TRACKS (SEE BOTTOM NOTE)
19:31	424	329	231	277
19:32	420	335	231	276
19:34	420	331	229	281
19:36	421	332	229	283
19:37	420	330	227	282
19:39	419	330	220	285
19:40	413	328	217	287
19:44	410	334	222	285
19:46	425	334	218	278
19:49	420	331	211	271
19:54	416	324	204	255
19:56	419	327	201	259
19:57	413	322	192	260
19:58	414	324	196	261
AVERAGE	412	324	214	265

NOTE: PRE-STRIKE TRACKS CORRESPOND TO OBSERVATIONS MADE AT THAT SAME TIME DURING A PREVIOUS MEASUREMENT TAKEN BETWEEN 12/1 AND 12/4 1980.

T A B L E B - 4

TRAFFIC LOAD
DURING THE MEASUREMENT PERIOD 19:00 TO 20:00 GMT

SITE: KANSAS CITY
DATE: JULY 1, 1982

SELECTED TIMES (GMT) (HOURS:MINUTES)	PROPOSED FLIGHT PLANS	ACTIVE FLIGHT PLANS	TRACKS	PRE-STRIKE TRACKS (SEE BOTTOM NOTE)
19:04	278	270	203	145
19:14	270	259	202	149
19:19	288	247	195	155
19:24	279	237	190	167
19:29	294	253	193	172
19:34	297	251	198	166
19:39	294	250	194	170
19:44	286	260	196	160
19:49	280	262	199	158
19:54	273	265	197	161
19:59	262	265	200	166
AVERAGE	282	256	197	161

NOTE: PRE-STRIKE TRACKS CORRESPOND TO OBSERVATIONS MADE AT THAT SAME TIME DURING A PREVIOUS MEASUREMENT TAKEN BETWEEN 7/4 AND 7/7 1980.

A P P E N D I X C

DISTRIBUTION OF FLIGHT PLANS

- A P P E N D I X C -

D I S T R I B U T I O N O F F L I G H T P L A N S

MEASUREMENT DATE = JULY 1, 1982
MEASUREMENT TIME = 1900-2000 (GMT)

SITE	SAMPLE SIZE	DEPARTURES OUTBOUND		DEPARTURES WITHIN		DEPARTURES AIRFILE		ARRIVALS		OVERFLIGHTS		UNCLASSIFIABLE	
		COUNT	PERCENT OF TOTAL	COUNT	PERCENT OF TOTAL	COUNT	PERCENT OF TOTAL	COUNT	PERCENT OF TOTAL	COUNT	PERCENT OF TOTAL	COUNT	PERCENT OF TOTAL
ABQ	298	41	13.75	132	44.29	20	6.71	56	18.79	46	15.43	3	1.00
FTW	423	90	21.27	98	23.16	31	7.32	131	30.96	57	13.47	16	3.78
HOU	348	*	*	*	*	*	*	*	*	*	*	*	*
MKC	274	66	24.08	42	15.32	16	5.83	81	29.56	62	22.62	7	2.55

SITE ABBREVIATIONS USED ABOVE:

ABQ ALBUQUERQUE
FTW FORT WORTH
HOU HOUSTON
MKC KANSAS CITY

* BECAUSE OF HIGH COMPUTER UTILIZATION HOUSTON CENTER DOES NOT NORMALLY RECORD SAR DATA FOR THIS TABLE.

A P P E N D I X D

AIR TRAFFIC FLOW BETWEEN FACILITIES

- A P P E N D I X D -

TABLE OF AIR TRAFFIC FLOW BETWEEN ARTCCS

MEASUREMENT DATE : JULY 1, 1982
MEASUREMENT TIMES: 1900-2000 (GMT)

	- A -	- B -	- C -			
SITE NAME	NUMBER OF ACTUAL FLIGHTS ACCEPTED OR HANDED OFF TO THE OTHER THREE CENTERS INVOLVED IN THIS STUDY	COLUMN "A" AS A PERCENT OF TOTAL ACTUAL FLIGHTS HANDLED BY THIS SITE (EXCLUDING DYSIM FLIGHTS*)	BREAKDOWN OF FLIGHTS FROM COLUMN "A"			
			ALBUQUERQUE	FORT WORTH	HOUSTON	KANSAS CITY
ABQ	25	9.8 %	--	15	3	7
FTW	76	22.2 %	15	--	35	26
HOU	38	11.8 %	3	35	--	0
MKC	33	13.8 %	7	26	0	--

* DYSIM FLIGHTS ARE ARTIFICIAL FLIGHT PLANS USED FOR AIR TRAFFIC CONTROL TRAINING PURPOSES.

ABBREVIATIONS:

ABQ - ALBUQUERQUE
FTW - FORT WORTH
HOU - HOUSTON
MKC - KANSAS CITY