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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. ADA107 235	3. RECIPIENT'S CATALOG NUMBER Final rept.
4. TITLE (and Subtitle) Forecast of the Second Destination Transportation Tonnage for the Air Force		5. TYPE OF REPORT & PERIOD COVERED Final, February 1979
7. AUTHOR(s) Jack C. Hayya		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Jack C. Hayya & Associates 331 Toftrees Ave. State College, PA 16801		8. CONTRACT OR GRANT NUMBER(s) F33615-78-C-5214
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Business Research Management Center (AFBRMC/RDCB) Wright-Patterson AFB, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) <b>LEVEL II</b>		12. REPORT DATE February 1979
		13. NUMBER OF PAGES 49
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Distribution Unlimited--Approved for Public Release		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Distribution Unlimited--Approved for Public Release		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Second Destination Tonnage Time Series Models Tonnage Forecasts Exponential Smoothing Model		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study analyzed the time series of second destination tonnage and suggests models to forecast them. An assortment of models were attempted including: exponential smoothing, polynomial regression, and Box-Jenkins, and the author found that a range of models can be used to forecast tonnage.  The models were applied to eleven tonnage series, and two different types of forecasting models were recommended based on the principal of cost-effectiveness; single exponential smoothing for nine of the series, and decomposition		

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of the remaining two. There is no implementation cost in terms of computer programming or training in following these recommendations. Only two values are stored for exponential smoothing--the current tonnage and the forecast for current period. Time series decomposition requires the use of seasonal indices only. Seasonal indices are provided by the author.

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PMRC Contract No. F33615-78-C-5214

FORECAST OF THE SECOND DESTINATION  
TRANSPORTATION TONNAGE FOR THE AIR FORCE

FINAL REPORT

February, 1979

This research was conducted under Contract F33615-78-C-5214 for the Air Force Business Research Management Center, Wright-Patterson AFB, Ohio. The views expressed herein are solely the views of the authors and do not represent those of the United States Air Force.

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## SUMMARY AND RECOMMENDATIONS

The purpose of this study was to analyze the time series of the second destination tonnage and to suggest models to forecast them. The time series models to be attempted were: exponential smoothing, polynomial regression, and Box-Jenkins. A structural "regression" model using overseas flying hours as the independent variable was also to be attempted.

Table 1 gives the assortment of models we used. It can be ascertained that we examined more models than originally contemplated. The reason was some special problems with the sealift series: seasonality in some cases; and the confounding of the series by the change of the fiscal year in 1977.

An inspection of Table 1 reveals that a range of models can be used to forecast tonnage, the models themselves spanning the very simple to the extremely sophisticated. The simplest model used was that of the sample mean. This was then extended to provide high-low estimates. The most complicated model used was the Wiener-Kolmogorov method, an autoregressive spectral analysis technique.

In recommending one forecasting model for any one tonnage series, we have to adhere to the principle of cost-effectiveness. That is, if we recommend a forecasting technique to you, we wish it to be relatively accurate and at the same time we would like it to cost you as little as possible. This principle has led us to recommend the two types of models listed in Table 2: single exponential smoothing for nine of the eleven tonnage series; and time series decomposition for the remaining two. There is no implementation cost in terms of computer programming or training in following these recommendations. For exponential smoothing, one need only store two values: the current tonnage and the forecast for the current period. As for time series decomposition,

one need only use the seasonal indices that we have already calculated. These indices may be adjusted from time to time, according to the judgment of the manager.

TABLE 1  
MENU OF FORECASTING MODELS—SECOND DESTINATION TONNAGE

Series No.	Series	Sample Mean, $\bar{X}_t$	95% C.I. for $\bar{X}_t$	95% Prob. Int. for $X_t$	Broom's Exponential Smoothing			Regression				Box-Jenkins Models		Decomposition, Winters or BK	
					Single	Linear	Quadratic	Var. OSH (all dist)	Var. OSH (REGRESS-ORIG)	Linear Var. TIME	Quadratic Var. TIME	(1,0,0)	Other Models		
1	PAC/AIR	Yes (9.9%)	Yes	Yes	Yes (0.7%)	Yes (1.3%)	Yes (4.8%)	Yes: $R^2 = 0.94$ (-18.0%)	No: $R^2 = 0$	No: $R^2 = 0.03$ (6.2%)	No: $R^2 = 0$	No: $R^2 = 0.07$ (0.42)	Yes (6.7%)		Yes (***) (11.4%)
2	ALA/AIR	Yes (9.7%)	Yes	Yes	Yes (-1.4%)	Yes (0.7%)	Yes (3.9%)	No: $R^2 = 0$	No: $R^2 = 0.09$ (8.8%)	No: $R^2 = 0.03$ (-4.7%)	Yes: $R^2 = 0.23$ (13.5%)	Yes (-11.5%)		Yes (****) (-0.5%)	
3	NE/AIR	Yes (-20.1%)	Yes	Yes	Yes (-3.0%)	No	No	Yes: $R^2 = 0.50$ (-14.2%)	Yes: $R^2 = 0.40$ (6.6%)	No: $R^2 = 0.04$	No: $R^2 = 0.01$	Yes (-22.8%)		Yes (****) (1.4%)	
4	EUR/AIR	Yes (-9.1%)	Yes	Yes	Yes (6.0%)	Yes (13.5%)	Yes (-7.0%)	No: $R^2 = 0.03$ (2.0%)	Yes: $R^2 = 0.42$ (0.6%)	No: $R^2 = 0$	No: $R^2 = 0.13$	Yes (-3.7%)		Yes (****) (-17.8%)	
5	SEA/AIR	Yes (-9.7%)	Yes	Yes	Yes (-10.3%)	No	No	No: $R^2 = 0$	No: $R^2 = 0.01$ (-11.9%)	No: $R^2 = 0$ (-6.2%)	No: $R^2 = 0.02$ (30.9%)	Yes (-15.5%)			
6	PAC/SEA	No	No	No	Yes (4.9%)	No	No	Yes: $R^2 = 0.61$ (-91.6%)	Yes: $R^2 = 0.41$ (-27.5%)	Yes: $R^2 = 0.76$ (-3.8%)	Yes: $R^2 = 0.77$ (-9.6%)	Yes (-26.3%)	Yes (4,1,0); (4,1,1) (-19.5%) (-16.7%)		
7	ALA/SEA	No	No	No	Yes (16.5%)	Yes (11.2%)	Yes (6.7%)	Yes: $R^2 = 0.41$ (-18.0%)	No: $R^2 = 0.01$ (8.3%)	Yes: $R^2 = 0.55$ (27.8%)	Yes: $R^2 = 0.61$ (2.6%)	Yes (6.4%)			
8	NE/SEA	No	No	No	No	No	No	No: $R^2 = 0.04$	No: $R^2 = 0$	No: $R^2 = 0$	No: $R^2 = 0$	No		Yes (*) (-115.1%)	
9	EUR/SEA	No	No	No	Yes (-13.2%)	Yes (-22.2%)	Yes (-20.6%)	No: $R^2 = 0$	No: $R^2 = 0$ (-18.3%)	Yes: $R^2 = 0.60$ (-18.2%)	Yes: $R^2 = 0.70$ (-2.1%)	No	Yes (1,1,0) + (1,0,0) Yes: (12.3%)	Yes (**) (22.1%)	
10	SEA/SEA	No	No	No	No	No	No	Yes: $R^2 = 0.39$ (-47.8%)	Yes: $R^2 = 0.23$ (35.0%)	Yes: $R^2 = 0.39$ (63.0%)	Yes: $R^2 = 0.54$ (38.7%)	No	Yes (2,1,0) + (1,0,0) Yes: (37.4%)	Yes (*) (35.6%)	
11	CONUS	Yes (-28.7%)	Yes	Yes	Yes (-19.7%)	Yes (-10.4%)	Yes (-11.1%)	Yes: $R^2 = 0.05$ (-13.6%)	No: $R^2 = 0$	No: $R^2 = 0$ (-26.7%)	No: $R^2 = 0$ (-24.9%)	Yes (-31.6%)	Yes (2,1,0) + (1,0,0) Yes: (37.8%)	Yes (**) (17.6%)	

The percentage in parenthesis is the error for one-step-ahead forecast (July '78 or 3rd Qtr., '78)

C.I. = Confidence Interval; OSH = Overseas Flying Hours; WPH = Worldwide Flying Hours

WK = the Wiener-Mozzgorov Spectral Model

(\*) indicates the classical time series decomposition model

(\*\*) indicates the Winters exponential smoothing decomposition model

(\*\*\*) indicates the WK model

(\*\*\*\*) indicates the truncated WK model

TABLE 2  
FORECASTING MODELS RECOMMENDED

<u>Series</u>	<u>Name</u>	<u>Model</u>	<u>Forecasting Model</u>
#1	PAC/AIR	Single Exponential Smoothing	$S_{t+1} = 0.60X_t + 0.40S_t$
#2	ALA/AIR	"	$S_{t+1} = 0.24X_t + 0.76S_t$
#3	NE/AIR	"	$S_{t+1} = 0.65X_t + 0.35S_t$
#4	EUR/AIR	"	$S_{t+1} = 0.49X_t + 0.51S_t$
#5	SOUTH/AIR	"	$S_{t+1} = 0.10X_t + 0.90S_t$
#6	PAC/SEA	"	$S_{t+1} = 0.99X_t + 0.01S_t$
#7	ALA/SEA	"	$S_{t+1} = 0.42X_t + 0.58S_t$
#8	NE/SEA	Time Series Decomposition	See Annex F for the seasonal index
#9	EUR/SEA	Single Exponential Smoothing	$S_{t+1} = 0.42X_t + 0.58S_t$
#10	SOUTH/SEA	Time Series Decomposition	See Annex F for the seasonal index
#11	CONUS	Single Exponential Smoothing	$S_{t+1} = 0.60X_t = 0.40S_t$

Symbols:

$S_{t+1}$  is the forecast made in period t for period t + 1

$X_t$  is the actual value realized in period t

$S_t$  is the forecast made in period t - 1 for period t

ANNEX APLOT OF THE MODIFIED DATA AND THE DEVELOPMENT  
OF LOW-HIGH FORECASTS FOR THE STATIONARY SERIES

Exhibit A provides a plot of the tonnage data versus time. This is given for the eleven sets of tonnage series provided.

The plot of the data leads us to recommend forecasting models to use in each case. Series #1 (PAC/AIR) appears as a random walk; i.e., it is a stationary process. Hence, a ninety-five percent probability interval giving low-high forecasts would be appropriate. We shall also use other models for forecasting this series: single exponential smoothing; and some selected Box-Jenkins models. Similarly, Series #8 (NE/SEA) exhibits a seasonal component; witness the spikes during the July/August/September quarter. Consequently, we would recommend the use of a decomposition model. And so on!

The recommendations concerning the models to use are listed in Table A.1. Also listed are relevant information including the number of observations, N. We have censored the last three observations of each monthly series for purposes of comparing forecasts to actuals. These observations would be for July, August, and September of 1978. For the quarterly data, we censored the third and fourth quarters of 1978.

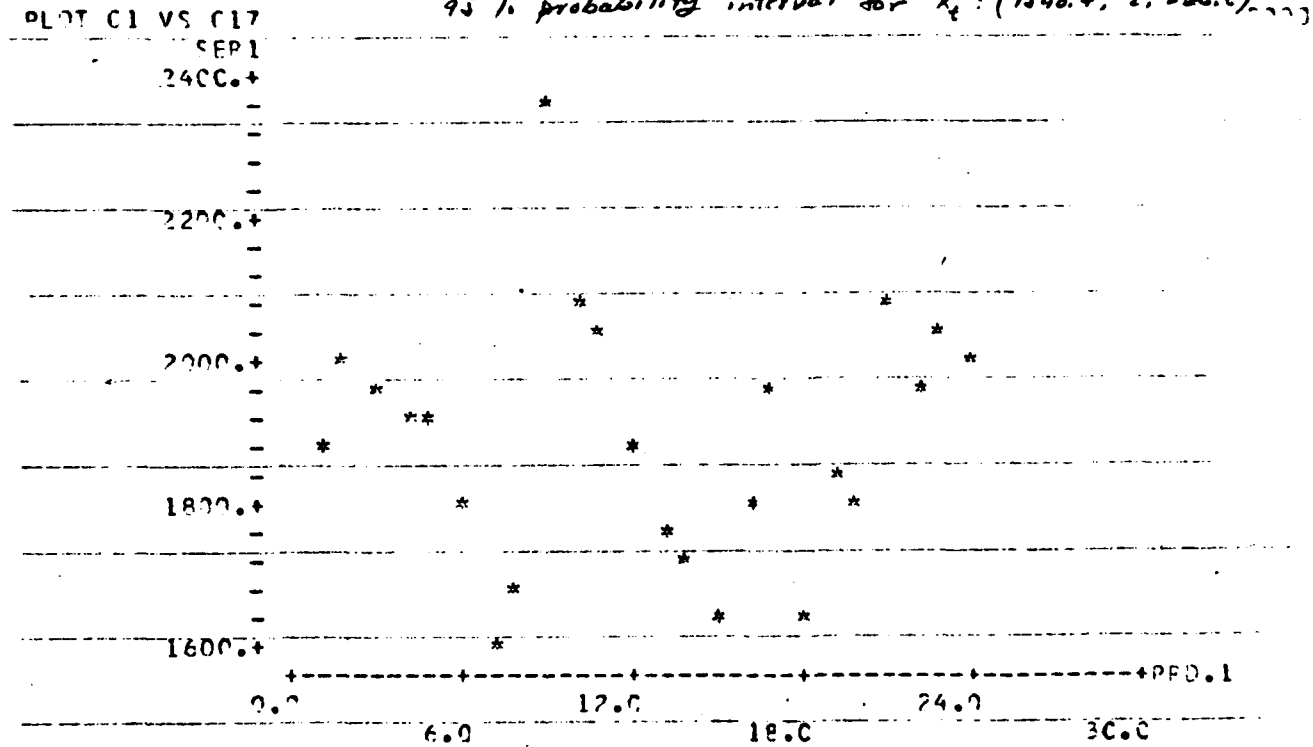
EXHIBIT A

PLOT OF THE DATA  
VERSUS TIME

PAC AIRLIFT (MONTHLY)  
Series #1  
July '76 - June '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR CI  
SEP1 N = 24 MEAN = 1888.5 ST.DEV. = 178.

95.00 PERCENT C.I. FOR MU IS ( 1813.5269, 1963.5559 )  
95 % probability interval for  $X_2$ : (1540.4, 2,226.6)



ALA AIRLIFT (MONTHLY)  
 Series #2  
 July '72 - June '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR C2  
 SER? N = 72 MEAN = 617.10 ST.DEV. = 98.5

A 95.00 PERCENT C.I. FOR MU IS ( 593.9548, 640.2302)

*95% probability interval for  $\chi^2$  (0.29, 0.810.2)*

PLT C2 VS C18

SER?

870.+

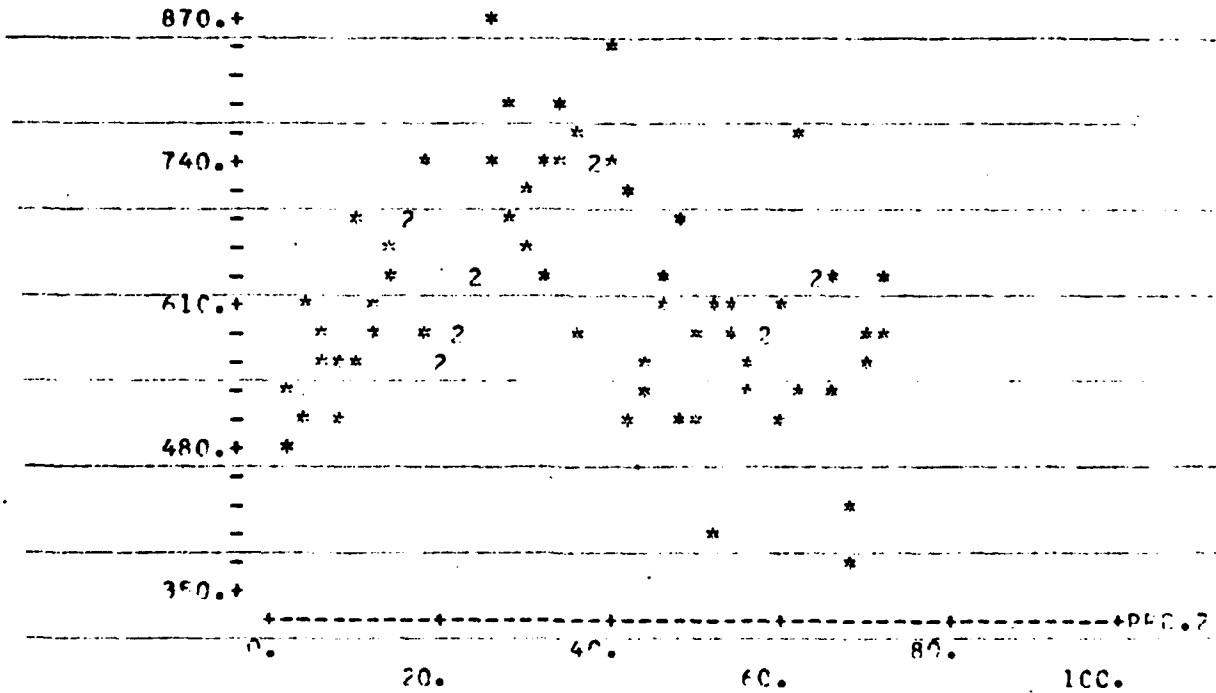
740.+

610.+

480.+

350.+

0. 20. 40. 60. 80. 100. P50.2

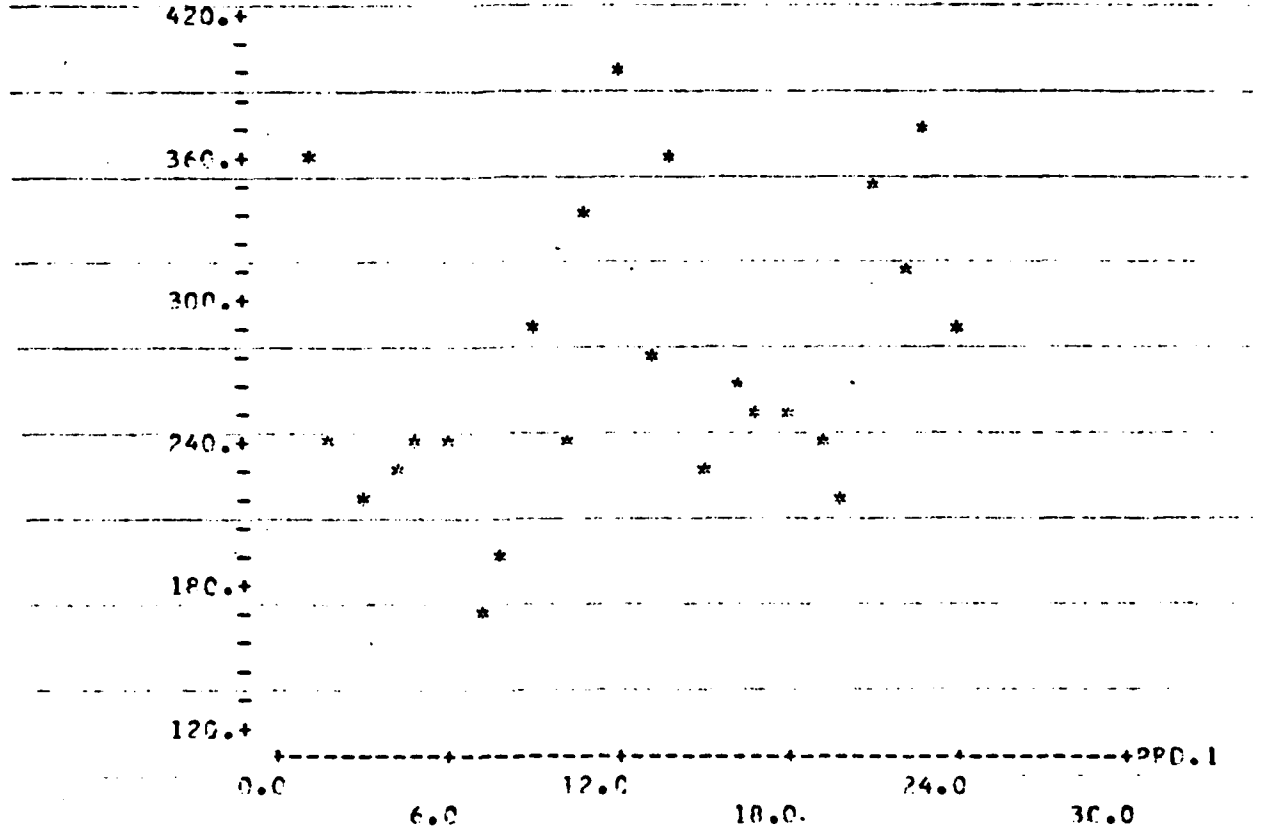


NE AIRLIFT (MONTHLY)  
Series #3  
July '76 - June '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR C3 0  
SER3 N = 24 MEAN = 273.75 ST.DEV. = 61.4

A 95.00 PERCENT C.I. FOR MU IS ( 247.8269, 299.6731)

PLOT C3 VS C17 95% probability interval for  $X_c$ : (143.4, 394.1) 0  
SER3

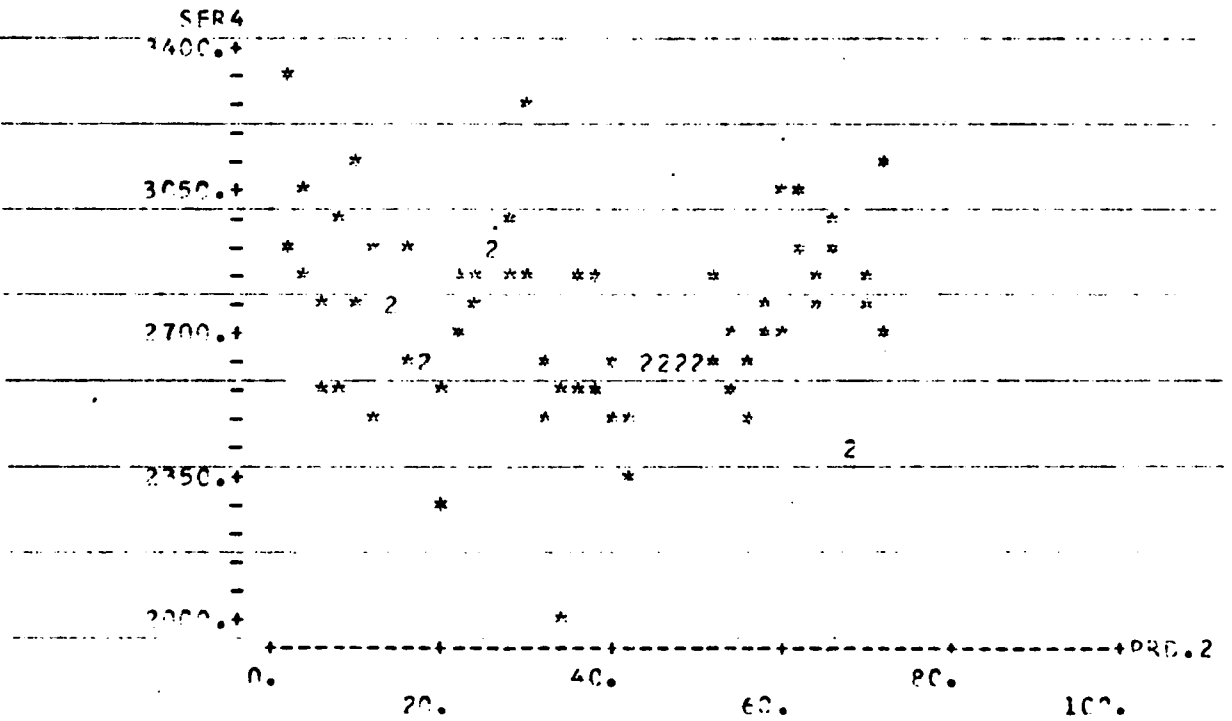


EUR AIRLIFT (MONTHLY)  
 Series #4  
 July '72 - June '78

T INTERVAL WITH 95 PERCENT CONFIDENCE FOR C4  
 SFR4 N = 72 "MEAN" = 2732.7 ST. DEV. = 223.

A 95.00 PERCENT C.I. FOR MU IS ( 2679.8743, 2784.5658)

PLOT C4 VS C1R *95% probability interval for  $X_4$ : (2,295.1, 3169.3)*

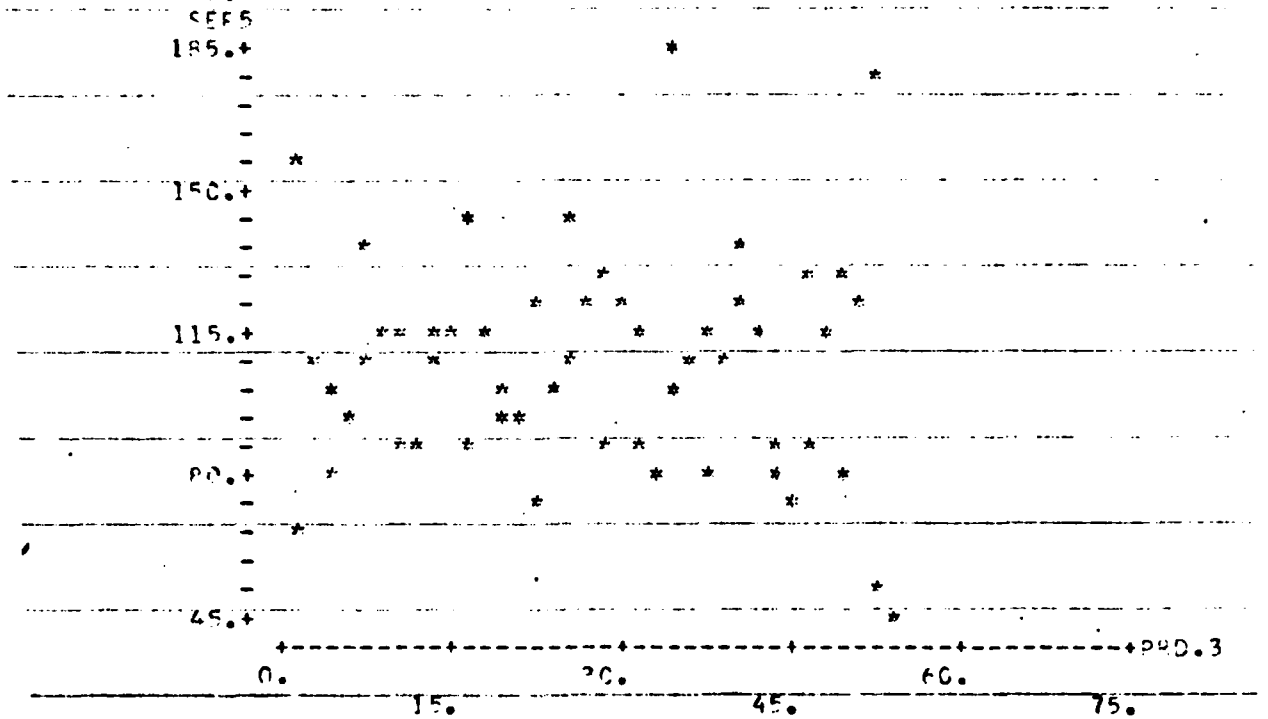


SOUTH AIRLIFT (MONTHLY)  
Series #5  
Jan. '74 - June '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR  $\mu$   
SER5 N = 54 MEAN = 106.43 ST.DEV. = 27.0

A 95.00 PERCENT C.I. FOR  $\mu$  IS ( 90.0547, 112.7972)

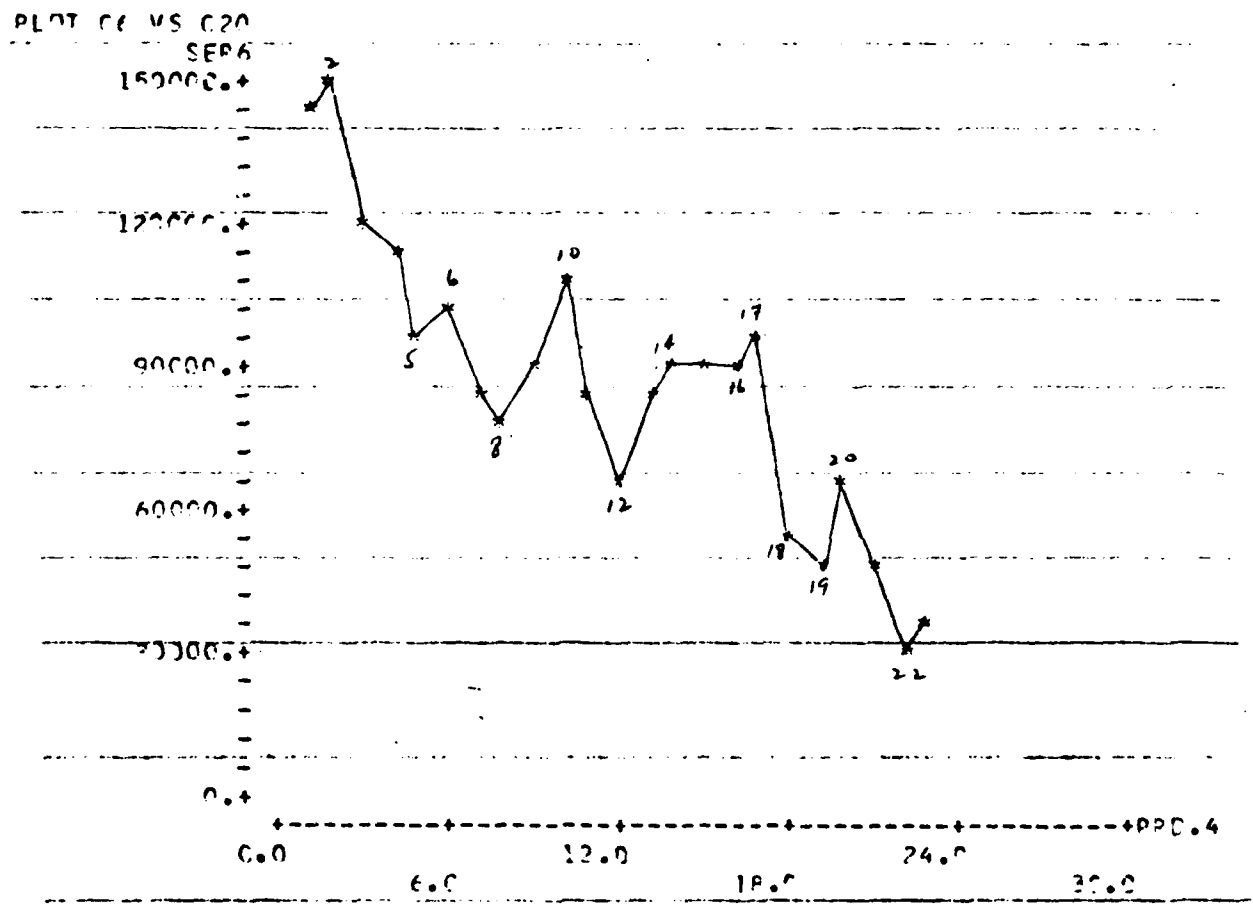
PLOT OF VS C19 95% probability interval for  $\mu$ : (53.5, 159.4)



PAC SEALIFT (QUARTERLY)  
 Series #6  
 1st Qtr. '73 - 2nd Qtr. '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR C6  
 SE6 N = 23 MEAN = 87113. ST.DEV. = 31236.

AT 95.00 PERCENT C.I. FOR MU IS ( 71602.6250, 98623.8125)



ALA SEALIFT (QUARTERLY)

Series #7

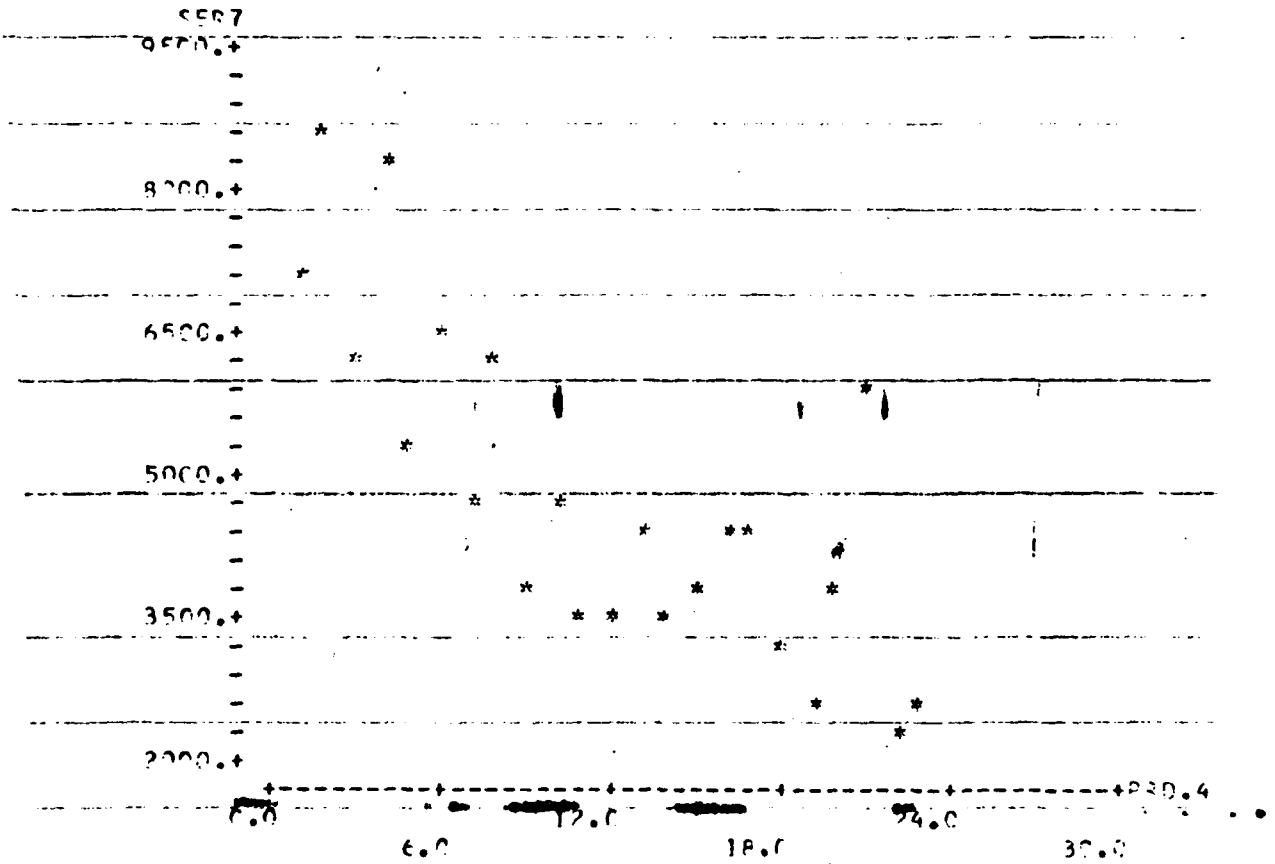
1st Qtr. '73 - 2nd Qtr. '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR C7

SER7 N = 23 MEAN = 4727.2 ST. DEV. = 1761.

A 95.00 PERCENT C.I. FOR MU IS ( 3965.5164, 5488.8504)

PLOT C7 VS C20



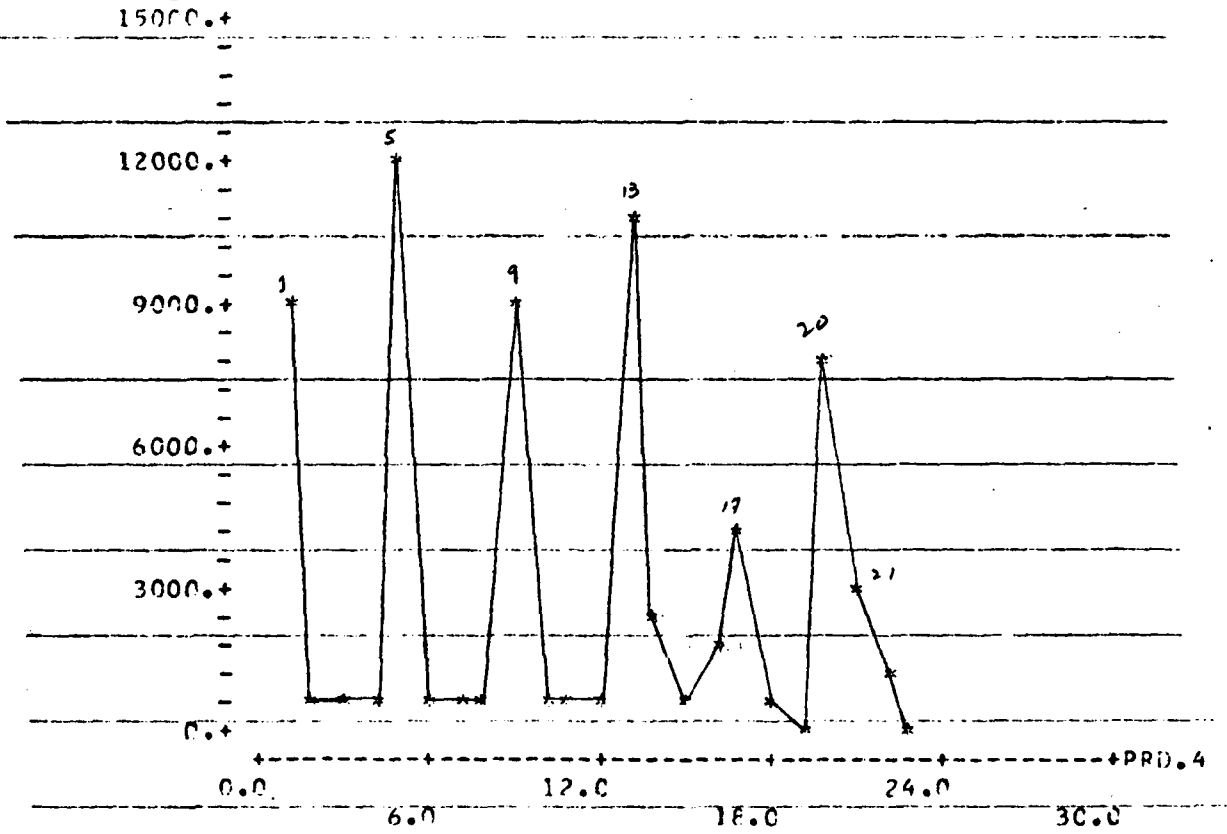
NE SEALIFT (QUARTERLY)  
Series #8  
1st Qtr. '73 - 2nd Qtr. '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR CP  
SERP N = 23 MEAN = 2946.9 ST.DEV. = 3833.

A 95.00 PERCENT C.I. FOR MU IS ( 1288.8675, 4604.8672)

PLOT CP VS C20

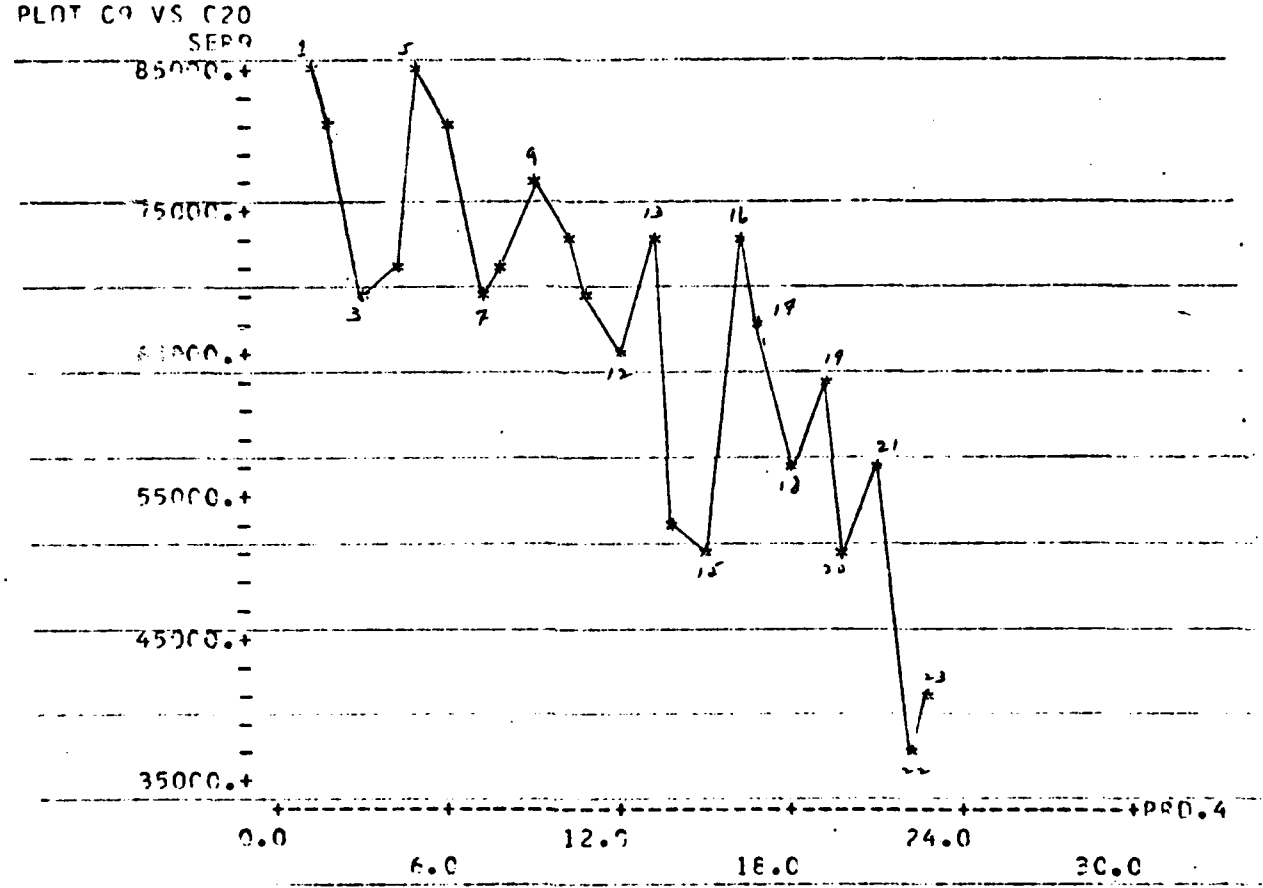
SER8



EUR SEALIFT (QUARTERLY)  
Series #9  
1st Qtr. '73 - 2nd Qtr. '78

INTERVAL WITH 95 PERCENT CONFIDENCE FOR C9  
SER9 N = 23 MEAN = 66118. ST.DEV. = 13060.

A 95.00 PERCENT C.I. FOR MU IS ( 60466.7344, 71766.3750)



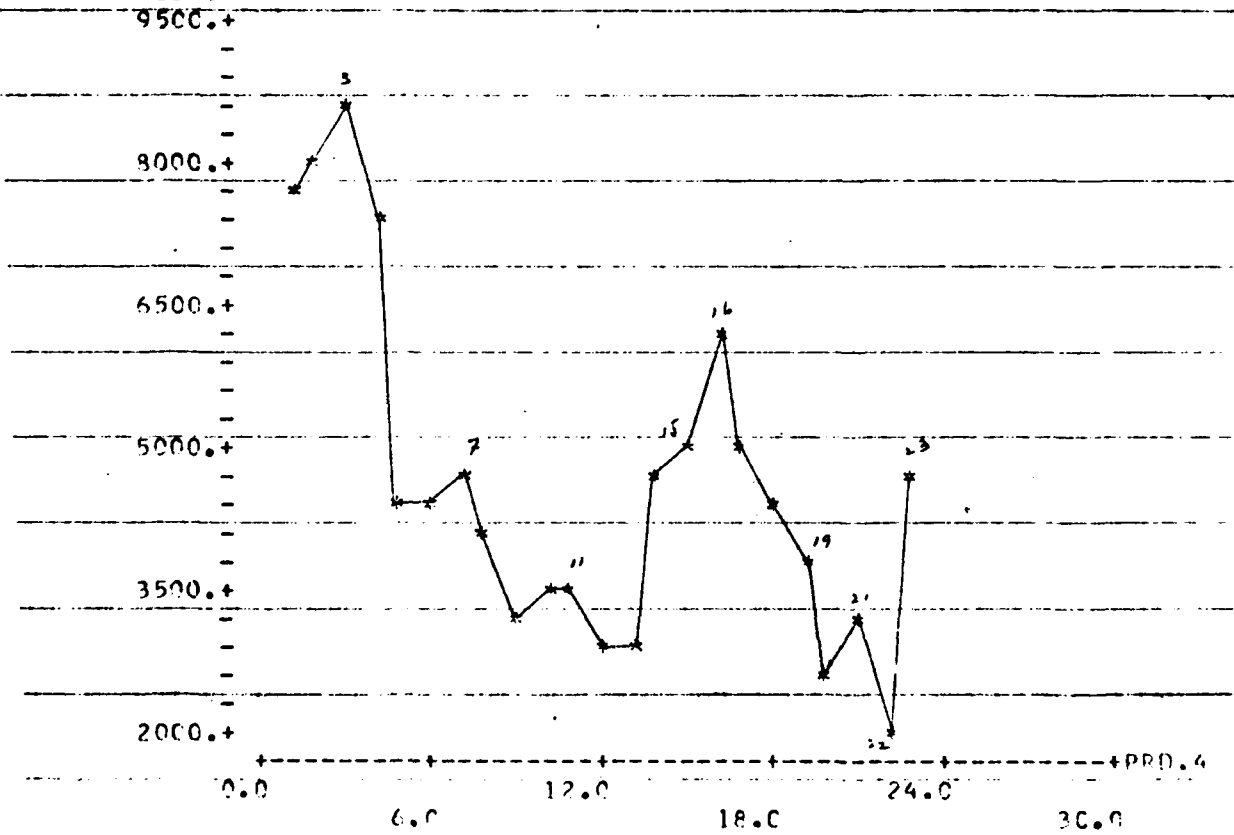
SOUTH SEALIFT (QUARTERLY)  
 Series #10  
 1st Qtr. '73 - 2nd Qtr. '78

13C

T INTERVAL WITH 95 PERCENT CONFIDENCE FOR C10  
 SER10 N = 23 MEAN = 4674.5 ST.DEV. = 1806.

A 95.00 PERCENT C.I. FOR MU IS ( 2893.2290, 5455.9086)

PLOT C10 VS C20  
 SER10



CONUS (MONTHLY)  
 Series #11  
 July '74 - March '78

T INTERVAL WITH 95 PERCENT CONFIDENCE FOR C11  
 SFR11 N = 45 MEAN = 1897.8 ST.DEV. = 304.

A 95.00 PERCENT C.I. FOR MU IS ( 1806.5466, 1989.0063)

PLOT C11 VS C21 95% probability interval for  $\chi^2$  (1,302.0, 2,493.6)

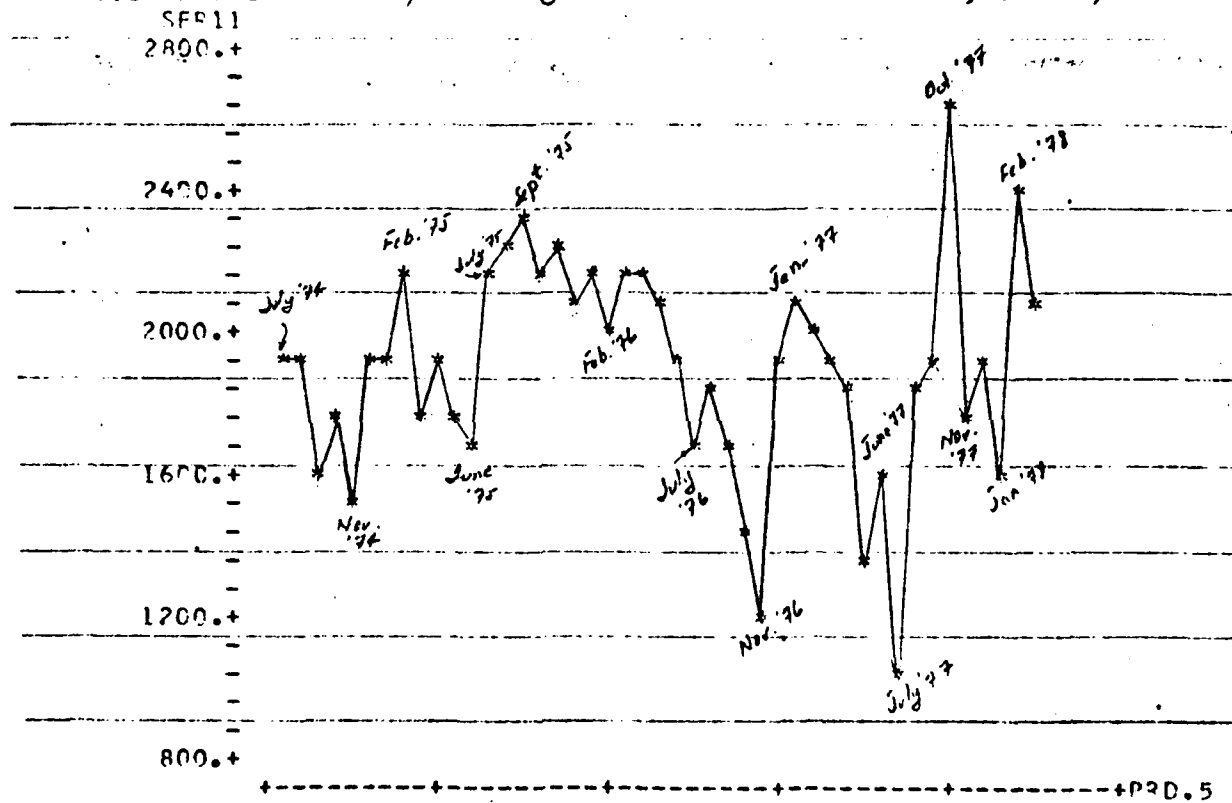


TABLE A.1  
MONTHLY DATA: TIME SERIES MODELS

<u>Series</u>	<u>Series No.</u>	<u>Start Date</u>	<u>End Date</u>	<u>N</u>	<u>Visual Identification</u>	<u>Models to Use</u>
PAC/AIR	1	July 1976	June 1978	24	Random Walk	a. Probability Interval b. Single and Double Exp. Smoothing c. Selected Box-Jenkins Models
ALA/AIR	2	July 1972	June 1978	72	Random Walk or Quadratic	a. Probability Interval b. Single, Double, and Triple Exp. Smoothing c. Optimal Box-Jenkins Model
NE/AIR	3	July 1976	June 1978	24	Random Walk	a. Probability Interval b. Single Exponential Smoothing c. Selected Box-Jenkins Models
EUR/AIR	4	July 1972 (Modified Data)	June 1978	72	Random Walk	a. Probability Interval b. Single and Double Smoothing c. Optimal Box-Jenkins Model
SOUTH/AIR	5	Jan. 1974	June 1978	54	Random Walk	a. Probability Interval b. Single Exponential Smoothing c. Optimal Box-Jenkins Model
PAC/SEA	6	1st Qtr., 1973 (Corrected Data)	2nd Qtr., 1978	23	Curvilinear	a. Single & Double Exp. Smoothing b. Selected Box-Jenkins Models
ALA/SEA	7	" (Corrected Data)	"	23	Curvilinear	a. Single, Double, and Triple Exp. Smoothing b. Selected Box-Jenkins Models
NE/SEA	8	" (Corrected Data)	"	23	Seasonal	a. Time Series De- composition Without Trend

TABLE A.1 (Continued)  
MONTHLY DATA: TIME SERIES MODELS

<u>Series</u>	<u>Series No.</u>	<u>Start Date</u>	<u>End Date</u>	<u>N</u>	<u>Visual Identification</u>	<u>Models to Use</u>
EUR/SEA	9	1st Qtr., 1973 (Corrected Data)	2nd Qtr., 1978	23	Straight Line	a. 1st Order Polynomial b. Single, Double, and Triple Exp. Smoothing c. Selected Box-Jenkins Models
SOUTH/SEA	10	" (Corrected Data)	"	23	Complex with Some Seasonality	a. Decomposition Model b. Sinusoidal Model
CONUS	11	July 1974	March 1978	45	Random Walk or Quadratic	a. Probability Interval b. Single, Double and Triple Exp. Smoothing c. Optimal Box-Jenkins

ANNEX B

## HIGH-LOW FORECASTS FOR THE RANDOM WALK MODEL

We can make the assumption that some of the tonnage series conform to the random walk model. These are: Series #1 - #5 and Series #11. The rest of the Series, #6 - #10, do not exhibit stationarity.

If we assume that the data for the stationary series are normally distributed, we can construct ninety-five percent probability intervals for the population values of the series. The lower limit of the interval would be considered as a low forecast; the higher limit of the interval would be a high forecast. Table B.1 gives these limits, calculated using the expression  $\bar{X} \pm 1.96s$ . (Note that this is different from constructing a ninety-five percent confidence interval for the population mean, in which case we would use the expression  $\bar{X} \pm 1.96 s/\sqrt{n}$ .)

If we wished one value, rather than a high-low range of values, the best forecast would be the mean of the series,  $\bar{X}$ . We compare the mean of the series with the actuals for July 1978 in Table B.2. We see that the percentage error is relatively small. What is more important is that all the actuals for July 1978 are within the low-high limits given in Table B.1.

TABLE B.1  
HIGH-LOW FORECASTS FOR SELECTED TONNAGE SERIES:  
RANDOM WALK

<u>Series No.</u>	<u>Series</u>	<u>Arithmetic Mean, <math>\bar{X}</math> (tons)</u>	<u>Standard Deviation, s (tons)</u>	<u>Forecast (tons)</u>	
				<u>Low</u>	<u>High</u>
1	PAC/AIR	1,888.5	178	1,540.4	2,236.6
2	ALA/AIR	617.1	98.5	424.0	810.2
3	NE/AIR	273.8	61.4	143.4	394.1
4	EUR/AIR	2,732.8	223.0	2,295.1	3,169.3
5	SOUTH/AIR	106.4	27.0	53.5	159.4
6	PAC/SEA	85,113.0	31,236.0	Not Applicable	
7	ALA/SEA	4,727.2	1,761.0	Not Applicable	
8	NE/SEA	2,946.9	3,833.0	Not Applicable	
9	EUR/SEA	66,118.0	13,060.0	Not Applicable	
10	SOUTH/SEA	4,674.5	1,806.0	Not Applicable	
11	CONUS	1,897.8	304.0	1,302.0	2,493.6

TABLE B.2  
PERCENTAGE ERROR IN ONE-STEP AHEAD FORECASTS USING  
THE RANDOM WALK MODEL.

<u>Series No.</u>	<u>Series</u>	<u>Arithmetic Mean, X (tons)</u>	<u>Actual for July '78</u>	<u>Percentage Error</u>
1	PAC/AIR	1888.5	2,011	6.9
2	ACA/AIR	617.1	565	- 9.2
3	NE/AIR	273.8	228	-20.1
4	EUR/AIR	2732.8	2,506	- 9.1
5	SOUTH/AIR	106.4	97	- 9.7
11	CONUS	1897.8	1,475	-28.7

ANNEX C

## EXPONENTIAL SMOOTHING MODELS

This annex presents the exponential smoothing forecasting models that performed best in making one-step-ahead forecasts. Table C.1 lists the eleven tonnage time series in question, the Brown exponential smoothing model used, the corresponding smoothing constant, the one-step-ahead forecast, and the percentage forecast error. Because some series such as NE/SEA (Series #8) did not fare well using Brown's model, another exponential smoothing procedure which incorporates trend and seasonality was used: this is the Winters model. Some results are shown in Table C.1A.

Table C.2 is developed from Tables C.1 and C.1A. It lists the feasible exponential smoothing models, based on one-step-ahead forecast errors. Table C.2 should serve as only a guide.

It may be of interest to note that the smoothing constants were found by means of a computer search. In effect, the smoothing constant was chosen so as to minimize the mean absolute deviation (MAD) of the historical data.

It may also be of interest to remark that for most of the tonnage series, the exponential smoothing models are robust to "data updates." For example, the percentage forecasting error has not changed considerably (except for CONSU--Series #17) when the actuals for July or 3rd Qtr. 1978 were updated.

TABLE C.1

RESULTS OF EXPONENTIAL SMOOTHING--BROWN'S MODEL

No.	Series	Type	N	Smoothing Model	Optimal Smoothing Constant, $\alpha$	Forecast for July '78 or 3rd Qtr. '78	Actual for July '78 or 3rd Qtr. '78	Percentage Error
1	PAC/AIR (Chopped)	Monthly	24	Single Linear Quadratic	0.60 0.30 0.06	1996 2037 1914	2011 " "	0.7 1.3 4.8
2	ALA/AIR	"	72	Single Linear Quadratic	0.24 0.12 0.06	573 561 543	565 " "	- 1.4 0.7 3.9
3	NE/AIR (Chopped)	"	24	Single	0.65	235	228	- 3.0
4	EUR/AIR		72	Single Linear Quadratic	0.49 0.26 0.10	2356 2168 2681	2506 " "	6.0 13.5 - 7.0
5	SOUTH/AIR (Chopped)	"	52 (March '74 - June '78)	Single	0.10	107	97	-10.3
6	PAC/SEA	Quarterly	23	Single Linear Quadratic	0.99 0.38 0.72	33341 27156 34959	35054	4.9 0.3
7	ALA/SEA	"	23	Single Linear Quadratic	0.42 0.36 0.25	3194 3395 3567	3823	16.5 11.2 6.7
8	NE/SEA	"	23	Single Linear Quadratic	0.28 0.18 0.12	1899 1454 1313	318	Inadmissible Model
9	EUR/SEA	"	23	Single Linear Quadratic	0.42 0.15 0.09	45316 48956 48297	40047	-13.2 -22.2 -20.6

TABLE C.1  
(Continued)

RESULTS OF EXPONENTIAL SMOOTHING--BROWN'S MODEL

<u>No.</u>	<u>Series</u>	<u>Type</u>	<u>N</u>	<u>Smoothing Model</u>	<u>Optimal Smoothing Constant, <math>\alpha</math></u>	<u>Forecast for July '78 or 3rd Qtr. '78</u>	<u>Actual for July '78 or 3rd Qtr. '78</u>	<u>Percentage Error</u>
10	SOUTH/SEA	"	23	Single Linear Quadratic	0.94 0.60 0.72	4425 4599 5069	7231	Inadmissible Model
11	CONUS (Chopped)	Monthly	45	Single Linear Quadratic	0.60 0.30 0.02	1766 1628 1638	1475 " "	-19.7 -10.4 -11.1

TABLE C.1A

RESULTS OF EXPONENTIAL SMOOTHING (WINTERS' MODEL)

No.	Series	Type	N	Optimal Smoothing Constants			Forecast for July '78 or 3rd Qtr. '78	Actual for July '78 or 3rd Qtr. '78	Percentage Error
				$\alpha$	$\beta$	$\gamma$			
1	PAC/AIR	Monthly	24				2011		
2	ALA/AIR	"	72				565		
3	NE/AIR	"	24				228		
4	EUR/AIR	"	72				2506		
5	SOUTH/AIR	"	52				97		
6	PAC/SEA	Quarterly	23				35054		
7	ALA/SEA	"	23				3823		
8	NE/SEA	"	23	0.05	0.05	0.30	3205	318	--
9	EUR/SEA	"	23	0.05	0.30	0.30	48915	40047	22.1
10	SOUTH/SEA	"	23				7231		
11	CONUS	Monthly	45	0.10	0.10	0.30	1738	1475	17.8

TABLE C.2  
FEASIBLE EXPONENTIAL SMOOTHING  
MODELS

<u>Series</u>	<u>Model</u>	<u>Smoothing Constant</u>	<u>Brown's One-Step-Ahead Forecast Error</u>	<u>Winter's One-Step-Ahead Forecast Error</u>
PAC/AIR (Chopped)	Single	0.60	0.7%	
	Linear	0.30	1.3	
	Quadratic	0.06	4.8	
ALA/AIR	Single	0.24	- 1.4	
	Linear	0.12	0.7	
	Quadratic	0.06	3.9	
NE/AIR (Chopped)	Single	0.65	- 3.0	
EUR/AIR	Single	0.49	6.0	
	Linear	0.26	13.5	
	Quadratic	0.10	- 7.0	
SOUTH/AIR	Single	0.10	-10.3	
PAC/SEA	Single	0.99	4.9	
ALA/SEA	Single	0.42	16.5	
	Linear	0.36	11.2	
	Quadratic	0.25	6.7	
EUR/SEA	Single	0.42	-13.2	22.1
	Linear	0.15	-22.2	
	Quadratic	0.09	-20.6	
CONUS (Chopped)	Single	0.60	-19.7	17.8
	Linear	0.30	-10.4	
	Quadratic	0.02	-11.1	

Source: Table C.1 & C.2

ANNEX D

## REGRESSION ON FLYING HOURS

In Interim Report No. 2, we used all the data that were available and regressed tonnage on flying hours. The results in terms of percentage error were disappointing, as seen in Table D.4. Consequently, we followed the suggestion that we regress only the most recent eight to ten observations. This we did in Interim Report No. 3. Table D.3A is a summary of this regression and Table D.4A presents the percentage errors. For purposes of comparison these tables are appended to Tables D.3 and D.4. It is seen that recent observations give better results in terms of percentage error, but that in many of these cases the  $R^2$  is zero or near-zero. A small  $R^2$  says that there is no relationship between tonnage and flying hours.

What does it mean when the  $R^2$  is very small but when the regression equation developed gives good forecasts? It means that an average value for recent tonnages would by itself be a good forecast; that in these circumstances the knowledge of flying hours does not help.

TABLE D.1

CODE USED IN REGRESSION ON FLYING HOURS

MILITARY AIRLIFT COMMAND TONNAGE		MONTHLY DATA
PAC	C1	
ALA	C2	
NE	C3	
EUR	C4	
SOUTH	C5	
MILITARY AIRLIFT COMMAND TONNAGE		AGGREGATED QUARTERLY DATA
PAC/AIR	C17	
ALA/AIR	C18	
NE/AIR	C19	
EUR/AIR	C20	
SOUTH/AIR	C21	
MILITARY SEALIFT COMMAND TONNAGE		QUARTERLY DATA
PAC/SEA	C6	
ALA/SEA	C7	
NE/SEA	C8	
EUR/SEA	C9	
SOUTH/SEA	C10	
CONTINENTAL US (CONUS) TONS		MONTHLY DATA
CONUS	C11	
OVERSEAS FLYING HOURS (OSFH)		QUARTERLY DATA
PAC	C12	
ALA	C13	
NE	C14	
EUR	C15	
SOUTH	C16	
SEA PLUS AIRLIFT COMMANDS TONNAGE		AGGREGATED QUARTERLY DATA
PAC-AGG	C30	
ALA-AGG	C31	
NE-AGG	C32	
EUR-AGG	C33	
SOUTH-AGG	C34	

TABLE D.2

QUARTERLY DATA: REGRESSING TONNAGE ON OVERSEAS FLYING HOURS (OSFH) --  
ALL DATA

<u>Tonnage Series</u>	<u>Overseas Flying Hrs. Series</u>	<u>Start Date</u>	<u>End Date</u>	<u>N</u>	<u>Visual Identification</u>	<u>Regression Models to Use</u>
PAC/AIR C17 vs. C12	PAC/OSFH	1st Qtr. '73	3rd Qtr. '78	24	Linear Trend	Straight Line
ALA/AIR C18 vs. C13	ALA/OSFH	"	"	"	No Discernible Relationship	--
NE/AIR C19 vs. C14	NE/OSFH	"	"	23	Linear Trend (Delete first quarter outlier)	Straight Line
EUR/AIR C20 vs. C15	EUR/OSFH	"	"	24	Linear Trend (?)	Straight Line
SOUTH/AIR C21 vs. C16	SOUTH/OSFH	"	"	"	No Discernible Relationship	--
PAC/SEA C6 vs. C12	PAC/OSFH	"	"	"	Quadratic	a. Straight Line b. Parabola
ALA/SEA C7 vs. C13	ALA/OSFH	"	"	"	Linear Trend	Straight Line
NE/SEA C8 vs. C14	NE/OSFH	"	"	"	Linear Trend (?)	Straight Line
EUR/SEA C9 vs. C15	EUR/OSFH	"	"	"	No Discernible Relationship	--
SOUTH/SEA C10 vs. C16	SOUTH/OSFH	"	"	"	Linear Trend	Straight Line
PAC-AGG C30 vs. C12	PAC/OSFH	"	"	"	Quadratic	a. Straight Line b. Parabola
ALA-AGG C31 vs. C13	ALA/OSFH	"	"	"	Linear Trend	Straight Line
NE-AGG C32 vs. C14	NE/OSFH	"	"	23	Linear Trend (Delete first quarter outlier)	Straight Line
EUR-AGG C33 vs. C15	EUR/OSFH	"	"	24	No Discernible Relationship	--
SOUTH-AGG C34 vs. C16	SOUTH/OSFH	"	"	"	Linear Trend	Straight Line
CONUS-AGG	Worldwide Flying Hours (WFH)	"	"	"	No Discernible Relationship	--

TABLE D.3

QUARTERLY DATA: REGRESSION EQUATIONS, TONNAGE VS. OVERSEAS FLYING HRS.--  
ALL DATA

<u>Tonnage,</u> <u>Y</u>	<u>Overseas</u> <u>Flying Hrs.,</u> <u>X</u>	<u>Adjusted</u> <u>R<sup>2</sup></u>	<u>Regression Equation</u>	<u>S<sub>y·x</sub></u>
PAC/AIR C17 vs. C12	PAC/OSFH	94.3%	Y = 4055 + 0.0905X (Recommended)	1,882
ALA/AIR C18 vs. C13	ALA/OSFH		No discernible relationship	
NE/AIR C19 vs. C14	NE/OSFH	50.2	Y = 96.3 + 0.704X (Recommended)	263
EUR/AIR C20 vs. C15	EUR/OSFH	3.2	Y = 6415 + 0.0323X (Not recommended)	815
SOUTH/AIR C21 vs. C16	SOUTH/OSFH		No discernible relationship	
PAC/SEA C6 vs. C12	PAC/OSFH	61.4	Y = 56718 + 0.300X (Recommended; second order polynomial not statistically significant)	19,917
ALA/SEA C7 vs. C13	ALA/OSFH	40.9	Y = -2420 + 0.740X (Recommended)	1,343
NE/SEA C8 vs. C14	NE/OSFH	3.6	Y = -905 + 2.28X (Not recommended)	3,719
EUR/SEA C9 vs. C16	EUR/OSFH		No discernible relationship	
SOUTH/SEA C10 vs. C16	SOUTH/OSFH	39.0	Y = 2427 + -.873X (Recommended)	1,426
PAC/AGG C30 vs. C12	PAC/OSFH	71.1	Y = 60773 + 0.391X (Recommended; second order polynomial not statistically significant)	20,949
ALA/AGG C31 vs. C12	ALA/OSFH	39.1	Y = -460 + 0.729X (Recommended)	1,370
NE-AGG C32 vs. C14	NE/OSFH		(No statistically significant linear relationship found)	

TABLE D.3 (Continued)  
QUARTERLY DATA: REGRESSION EQUATIONS, TONNAGE VS. OVERSEAS FLYING HRS.--  
ALL DATA

<u>Tonnage,</u> <u>Y</u>	<u>Overseas</u> <u>Flying Hrs.,</u> <u>X</u>	<u>Adjusted</u> <u>R<sup>2</sup></u>	<u>Regression Equation</u>	<u>S</u> <u>y·x</u>
EUR-AGG C33 vs. C15	EUR/OSFH		No discernible relationship	
SOUTH-AGG C34 vs. C16	SOUTH/OSFH	43.8%	$Y = 2579 + 0.987X$	1,466
CONUS-AGG	Worldwide Flying Hrs. (WFH)		No discernible relationship	

TABLE D.3A

QUARTERLY DATA: REGRESSION EQUATIONS, TONNAGE VS. OVERSEAS  
FLYING HOURS--RECENT OBSERVATIONS

Tonnage Y	No. of Observations N	r	$R^2$	Regression Equation	$s_{y.x}$
PAC/AIR C17 vs. C12	8	-0.184	0.03	$Y = 6,672 - 0.0293X$	323
ALA/AIR C18 vs. C13	8	-0.295	0.09	$Y = 2,310 - 0.0707X$	181
NE/AIR C19 vs. C14	8	0.631	0.40	$Y = 207 + 0.489X$	93
EUR/AIR C20 vs. C15	10	0.649	0.42	$Y = 3,963 + 0.0723X$	695
SOUTH/AIR C21 vs. C16	8	0.117	0.01	$Y = 294 + 0.0123X$	53
PAC/SEA C6 vs. C12	7	-0.645	0.41	$Y = 259,131 - 6.15X$	1,288
ALA/SEA C7 vs. C13	10	-0.102	0.01	$Y = 4,852 - 0.144X$	1,092
NE/SEA C8 vs. C14	8	0	0	$Y = -65 + 1.76X$	2,911
EUR/SEA C9 vs. C15	8	-0.504	0.25	$Y = 98,730 - 0.798X$	10,063
SOUTH/SEA C10 vs. C16	8	-0.476	0.23	$Y = 6,814 - 1.55X$	1,457
PAC/AGG C30 vs. C12	7	-0.641	0.41	$Y = 265,000 - 6.15X$	10,392
ALA/AGG C31 vs. C13	8	-0.001	0	$Y = 5,217 - 0.0022X$	1,378
NE/AGG C32 vs. C14	8	0.116	0.01	$Y = 142 + 2.25X$	2,970
EUR/AGG C33 vs. C15	8	-0.455	0.21	$Y = 100,000 - 0.688X$	9,912
SOUTH/AGG C34 vs. C16	8	-0.476	0.23	$Y = 7,108 - 1.54X$	1,444
CONUS/AGG vs. WFH	8	0.226	0.05	$Y = 4,031 + 0.0021X$	700

Note

The  $R^2$  is not corrected for degrees of freedom

TABLE D.4

PREDICTION OF 1978 3RD QTR TONNAGE USING OVERSEAS FLYING HOURS (OSFH)--ALL DATA

<u>Quarterly Series</u>	<u>Regression Equation</u>	<u>3rd Qtr '78 OSFH (X)</u>	<u>Predicted 3rd Qtr '78 Tonnage (Y)</u>	<u>R<sup>2</sup></u>	<u>Actual 3rd Qtr '78 Tonnage</u>	<u>% Error</u>
PAC/AIR	$Y = 4055 + 0.0905X$	34,865	7120	0.943	6033	-18.0
SE/AIR	$Y = 96.3 + 0.704X$	1,476	1135	0.502	994	-14.2
EUR/AIR	$Y = 6415 + 0.0323X$	64,399	8495	0.032	8664	2.0
PAC/SEA	$Y = 56,718 + 0.300X$	34,865	67178(?)	0.614	35054	-91.6
ALA/SEA	$Y = -2420 + 0.740X$	9,365	4510	0.409	3823	-18.0
SE/SEA	$Y = -905 + 2.28X$	1,476	2460	0.036	318	--
SOUTH/SEA	$Y = 2427 + 0.873X$	1,363	3617(?)	0.390	6927	47.8
PAC/AGG	$Y = 60773 + 0.391X$	34,865	74405	0.711	41087	--
SOUTH/AGG	$Y = 2579 + 0.985X$	1,363	3921	0.438	2934	-33.6

TABLE D.4A

PREDICTION OF 1978 3RD QUARTER TONNAGE USING OVERSEAS  
FLYING HOURS (OSFH)--RECENT OBSERVATIONS

<u>Quarterly Series</u>	<u>Regression Equation</u>	<u>3rd Qtr. '78 OSFH (X)</u>	<u>Predicted 3rd Qtr. '78 Tonnage (Y)</u>	<u>R<sup>2</sup></u>	<u>Actual 3rd Qtr. '78 Tonnage</u>	<u>% Error</u>
PAC/AIR	Y = 6,672 - 0.0293X	34,865	5,650	0.03	6,033	6.3
ALA/AIR	Y = 2,310 - 0.0707X	9,365	1,648	0.09	1,807	8.8
NE/AIR	Y = 207 + 0.489X	1,476	928	0.40	994	6.6
EUR/AIR	Y = 3,963 + 0.0723X	64,339	8,614	0.42	8,664	0.6
SOUTH/AIR	Y = 294 + 0.0123X	1,363	311	0.01	278	-11.9
PAC/SEA	Y = 259,131 - 6.15X	34,865	44,693	0.41	35,054	-27.5
ALA/SEA	Y = 4,852 - 0.144X	9,365	3,505	0.01	3,823	8.3
NE/SEA	Y = -65 + 1.76X	1,476	2,533	0	318	--
EUR/SEA	Y = 98,730 - 0.798X	64,339	47,387	0	40,047	-18.3
SOUTH/SEA	Y = 6,814 - 1.55X	1,363	4,701	0.23	7,231	35.0
PAC/AGG	Y = 265,000 - 6.15X	34,865	50,580	0.41	41,087	-23.1
ALA/AGG	Y = 5,217 - 0.0022X	9,365	5,196	0	5,630	7.7
NE/AGG	Y = 142 + 2.25X	1,476	3,463	0.01	1,303	-165.8
EUR/AGG	Y = 100,000 - 0.688X	64,399	55,693	0.21	48,863	-14.0
SOUTH/AGG	Y = 7,108 - 1.54X	1,363	5,009	0.23	2,934	-70.7
CONUS/AGG Vs. WFH	Y = 4,031 + 0.0021X	709,030 (WFH)	5,519	0.05	4,857	-13.6

NotesWFH  $\approx$  Worldwide Flying HoursThe R<sup>2</sup> is not corrected for degrees of freedom

ANNEX E

## BOX-JENKINS MODELS

Of the Box-Jenkins models attempted the most powerful group was the first-order autoregressive model (1,0,0). The results for this model are given in Table E.1. The one-step-ahead percentage error for this model appears reasonable, in most cases. The Box-Jenkins (1,0,0) model was not applicable to series #8, #9, and #10 (NE/SEA, EUR/SEA, SOUTH/SEA) because of some obvious seasonal patterns in these. See Annex F for an explication on the seasonal patterns in some of the Sealift series.

We also attempted some other Box-Jenkins models in the hope that we would improve upon the (1,0,0) model. In some cases we could. In series #6 (PAC/SEA), for example, we reduced the one-step-ahead error from -26.3 percent for the (1,0,0) model to -16.7 percent for the (4,1,1) model.

TABLE E.1  
 FIRST ORDER AUTOREGRESSIVE MODEL: BOX-JENKINS (1,0,0)

No.	Series	Equation	Forecast for July '78 or 3rd Qtr. '78	Actual for July '78 or 3rd Qtr. '78	Percentage Error
1.	PAC/AIR	$X_t = 1334.1 + 0.2938X_{t-1}$	1,916	2,011	4.7
2.	ALA/AIR	$X_t = 305.7 + 0.5040X_{t-1}$	630	565	-11.5
3.	NE/AIR	$X_t = 197.5 + 0.2828X_{t-1}$	280	228	-22.8
4.	EUR/AIR	$X_t = 2028.8 + 0.2575X_{t-1}$	2,725	2,506	- 8.7
5.	SOUTH/AIR	$X_t = 116.1 - 0.0915X_{t-1}$	112	97	-15.5
6.	PAC/SEA	$X_t = 14872.8 + 0.8803X_{t-1}$ (Regression analysis)	44,267	35,054	-26.3
7.	ALA/SEA	$X_t = 2159.4 + 0.5440X_{t-1}$	3,578	3,823	6.4
8.	NE/SEA	Inadmissible Model because of Seasonality			
9.	EUR/SEA	"			
10.	SOUTH/SEA	"			
11.	CONUS	$X_t = 1214.59 + 0.3604X_{t-1}$	1,971	1,475	-33.6

TABLE E.2

OTHER BOX-JENKINS MODELS

<u>Series No.</u>	<u>Series</u>	<u>Model (p.d.q.)</u>	<u>Forecast for July '78 or 3rd Qtr. '78</u>	<u>Actual for July '78 or 3rd Qtr. '78</u>	<u>Percent Error</u>
1.	PAC/AIR				
2.	ALA/AIR				
3.	NE/AIR				
4.	EUR/AIR				
5.	SOUTH/AIR				
6.	PAC/SEA	(4,1,0)	41,899	35,054	-19.5
	"	(4,1,1)	40,907	"	-16.7
7.	ALA/SEA				
8.	NE/SEA				
9.	EUR/SEA	(1,1,0)	35,114	40,047	12.3
	"	(1,0,0) - for seasonality	60,970	40,047	-52.2
	"	(3,1,1)			
	"	(1,1,1) - for seasonality			
10.	SOUTH/SEA	(2,1,0)	4,530	7,231	37.4
	"	(1,0,0) - seasonality	4,501	7,231	37.8
	"	(2,1,0)*			
	"	(1,0,0) - seasonality			

\* Constant term included

ANNEX FTIME SERIES DECOMPOSITION FOR  
NE/SEALIFT (Series #8) and SOUTH/SEALIFT (Series #10)

The quarterly data of the Sealift series exhibits special problems:

1) Some of these series appear to be seasonal--witness the spikes every first quarter for series #8 (NE/Sealift); and 2) The change of the fiscal year in FY77 has confounded the recent data.

We wish to use a time series decomposition model on some of these series, particularly series #8 (NE/Sealift) and series #10 (SOUTH/Sealift). A decomposition model easily yields a seasonal index. But since there are two first quarters in FY77, we have decided to combine these into data for just one quarter. Thus, the number of the period would be consistent with its quarterly position in the fiscal year.

We now concentrate on NE/Sealift and SOUTH/Sealift. The two series, NE/Sealift and SOUTH/Sealift have posed special problems: most of the conventional time series models failed to forecast them accurately. An inspection of their plots exhibits seasonality; but the periodicity of the peaks and troughs becomes erratic toward the end of the series. Both series appear to lack a trend. (This is true for SOUTH/Sealift if we delete the data for the fiscal year 1973). A tentative way to handle these two series is to calculate for them seasonal indices by means of moving averages. These calculations are given in Tables F.1 - F.3 for NE/Sealift (series #8) and in Tables F.4 - F.6 for SOUTH/Sealift (series #10).

Tables F.7 and F.8 give the forecasts and forecast error for the third quarter of 1978. The forecast errors are high, and the seasonal indices may have to be adjusted if these errors persist.

TABLE F.1

TIME SERIES DECOMPOSITION: NEA/SEALIFT (Series #8)

<u>Qtr., Yr.</u>	<u>Period</u>	<u>X<sub>t</sub></u>	<u>Four-quarter Moving Average</u>	<u>4×4 Centered Moving Average</u>	<u>Percentage of Centered Moving Average</u>
1, '73	1	8.715	-	-	-
2, '73	2	508	2,590.75	-	-
3, '73	3	736	3,486.50	-	-
4, '73	4	404	3,538.75	3,288.69	12.28
1, '74	5	12,298	3,538.75	3,554.94	345.94
2, '74	6	717	3,655.75	3,391.69	21.14
3, '74	7	736	2,833.50	3,209.38	22.93
4, '74	8	872	2,809.50	3,020.69	28.87
1, '75	9	9,009	2,784.00	2,767.25	325.56
2, '75	10	621	2,642.00	2,822.13	22.00
3, '75	11	634	3,052.50	2,986.63	21.23
4, '75	12	304	3,468.00	3,142.06	9.68
1, '76	13	10,651	3,405.75	3,444.13	309.25
2, '76	14	2,283	3,850.25	3,236.25	70.54
3, '76	15	385	2,310.75	2,165.67	17.78
4, '76	16	2,082	1,798.25	2,898.81	71.82
1, '77	17*	4,493	3,636.00	2,908.60	154.47
2, '77	18	233	3,889.25	3,087.75	7.55
3, '77	19	7,736	3,027.50	3,394.25	227.91
4, '77	20	3,095	3,024.25	-	-
5, '77	21	1,046	-	-	-
6, '77	22	220	-	-	-

\* Change in the fiscal year (1st Qtr. '75); combined tonnage

Source: Croxton, Cowden, and Klein, Applied General Statistics, Third edition, Englewood Cliffs, N.J.: Prentice-Hall, pp. 293-302.

TABLE F.2

PERCENTAGES OF CENTERED FOUR-QUARTER MOVING AVERAGES  
FOR SECOND DESTINATION TONNAGE, NE/SEALIFT (Series #8)

Fiscal Year	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
73	--	--	--	12.28
74	345.94	21.14	22.93	28.87
75	325.56	22.00	21	9.68
76	309.25	70.54	17.78	71.82
77	154.47	7.55	227.91	--

Source: Table F.1

TABLE F.3

ARRAY OF PERCENTAGES

Rank	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Mean
1	345.94	70.54	227.91	71.82	--
2	325.56	22.10	22.93	28.87	--
3	309.25	21.14	21.23	12.28	--
4	154.47	7.55	17.78	9.68	--
Mean of ranks 2 & 3	317.4	21.6	22.1	20.6	95.4
Seasonal index	332.6	22.6	23.2	21.6	100.0

Source: Table F.2

TABLE F.4  
TIME SERIES DECOMPOSITION: SOUTH SEALIFT (Series #8)

<u>Qtr., Yr.</u>	<u>Period</u>	<u>X<sub>t</sub></u>	<u>Five-Quarter Moving Average</u>	<u>Percentage of Centered Moving Average</u>
1 '73	1	7,726	--	--
2 '73	2	8,109	--	--
3 '73	3	8,610	7,239.0	118.94
4 '73	4	7,481	6,588.8	113.45
1 '74	5	4,269	5,917.4	72.14
2 '74	6	4,475	5,023.4	89.08
3 '74	7	4,752	4,162.4	114.16
4 '74	8	4,140	4,008.2	103.29
1 '75	9	3,181	3,832.4	83.00
2 '75	10	3,493	3,485.0	100.23
3 '75	11	3,596	3,251.0	110.61
4 '75	12	3,015	3,549.8	84.93
1 '76	13	2,970	3,849.2	77.16
2 '76	14	4,675	4,363.6	107.14
3 '76	15	4,990	5,677.2	87.90
4 '76	16	6,168	5,817.8	106.02
1 '77	17*	9,583	5,421.8	176.75
2 '77	18	3,673	5,093.6	72.11
3 '77	19	2,695	4,258.8	63.28
4 '77	20	3,349	3,267.2	102.82
5 '77	21	1,994	--	--
6 '77	22	4,575	--	--

\*Combined tonnage--change of Federal fiscal year

Source: Croxton, Cowdren, and Klein, loc. cit.

TABLE F.5  
PERCENTAGE OF CENTERED FIVE-QUARTER MOVING AVERAGES  
FOR SECOND DESTINATION TONNAGE, SOUTH/SEALIFT (Series #10)

Fiscal Year	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
73	--	--	118.94	113.54
74	72.14	89.08	114.16	103.29
75	83.00	100.23	110.61	84.93
76	77.16	107.14	87.90	106.02
77	176.75	72.11	63.28	102.82

Source: Table F.4

TABLE F.6  
ARRAY OF PERCENTAGES

Rank	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Mean
1	176.75	107.14	118.94	113.54	
2	83.10	100.23	114.16	106.02	
3	77.16	89.08	110.61	103.29	
4	72.14	72.11	87.90	102.82	
5	--	--	63.28	84.93	
Mean of ranks 2 & 3	80.1	94.7	112.4	104.7	97.975
Seasonal index	81.8	96.6	114.7	106.9	100.0

Source: Table F.6

TABLE F.7

ACTUAL ERROR IN TONS AND PERCENTAGE ERROR  
FOR NE/SEALIFT (Series #8)

<u>Quarter</u>	<u>Seasonal Index</u>	<u>Forecast (<math>\bar{x}</math> Multiplied by Index)</u>	<u>Actual 3rd Qtr. 1978</u>	<u>Percentage Error</u>	<u>Actual Error (Tons)</u>
First	332.6	9,801	--	--	--
Second	33.6	666	--	--	--
Third	23.2	684	318	-115.1%	-366
Fourth	21.6	637	--	--	--

Note: The mean of the series used was  $\bar{x} = 2,946.9$

TABLE F.8

ACTUAL ERROR IN TONS AND PERCENTAGE ERROR  
FOR SOUTH/SEALIFT (Series #10)

<u>Quarter</u>	<u>Seasonal Index</u>	<u>Forecast (<math>\bar{x}</math> Multiplied by Index)</u>	<u>Actual 3rd Qtr. 1978</u>	<u>Percentage Error</u>	<u>Actual Error (Tons)</u>
First	81.8	3,825	--	--	--
Second	96.6	4,516	--	--	--
Third	114.7	5,363	7,231	25.8%	1,868
Fourth	106.9	4,998	--	--	--

Note: The mean of the series used was  $\bar{x} = 4,674.5$

ANNEX G

## POLYNOMIAL REGRESSION VERSUS TIME

Tables G.1 and G.2 give the results obtained from regressing the tonnage series versus time. Table G.1 gives the results for a first-order polynomial (i.e., a straight line). Table G.2 gives the results for a second-order polynomial (i.e., a quadratic). It is not recommended to go beyond a quadratic in developing forecasting models using time as an independent variable. In terms of goodness of fit as measured by  $R^2$ , PAC/SEA (Series #6), ALA/SEA (Series #7), EUR/SEA (Series #9), and SOUTH/SEA (Series #10) perform remarkably well.

TABLE G.1  
STRAIGHT LINE REGRESSION VERSUS TIME (t)

<u>No.</u>	<u>Series</u>	<u>N</u>	<u>R<sup>2</sup></u>	<u>Regression Equation</u>	<u>Predicted Tonnage</u>	<u>Actual Tonnage</u>	<u>% Error</u>
1	PAC/AIR	24	0	$Y = 1891 - 0.2t$	1,886	2,011	6.2
2	ALA/AIR	72	0.03	$Y = 645 - 0.768t$	589	565	- 4.2
3	NE/AIR	24	0.04			228	
4	EUR/AIR	72	0			2,506	
5	SOUTH/AIR	54	0	$Y = 109 - 0.105t$	103	97	- 6.2
6	PAC/SEA	23	0.76	$Y = 133,000 - 4026t$	36,376	35,054	- 3.8
7	ALA/SEA	23	0.55	$Y = 7080 - 196t$	2,376	3,823	37.8
8	NE/SEA	23	0	$Y = 3960 - 84.5t$	1,932	318	--
9	EUR/SEA	23	0.66	$Y = 84904 - 1566t$	47,320	40,047	-18.2
10	SOUTH/SEA	23	0.39	$Y = 6672 - 166.5t$	2,676	7,231	63.0
11	CONUS	45	0.03	$Y = 1926 - 1.24t$	1,869	1,475	-26.7

TABLE G.2  
QUADRATIC REGRESSION VERSUS TIME (t)

<u>No.</u>	<u>Series</u>	<u>N</u>	<u>R<sup>2</sup></u>	<u>Regression Equation</u>	<u>Predicted Tonnage</u>	<u>Actual Tonnage</u>	<u>% Error</u>
1	PAC/AIR	24	0.07	$Y = 2010 - 27.8t + 1.1t^2$	2,003	2,011	0.4
2	ALA/AIR	72	0.23	$Y = 542 + 759t - 0.114t^2$	489	565	13.5
3	NE/AIR	24	0.01			228	
4	EUR/AIR	72	0.13			2,506	
5	SOUTH/AIR	54	0.02	$Y = 101 + 0.732t - 0.0152t^2$	67	97	30.9
6	PAC/SEA	23	0.77	$Y = 135000 - 4512t + 20.3t^2$	38,405	35,054	- 9.6
7	ALA/SEA	23	0.63	$Y = 8414 - 517t + 13.4t^2$	3,724	3,823	2.6
8	NE/SEA	23	0.02	$Y = 4002 - 94.5t + 0.417t^2$	1,974	318	--
9	EUR/SEA	23	0.70	$Y = 78486 - 25.1t - 64.2t^2$	40,904	40,047	- 2.1
10	SOUTH/SEA	23	0.54	$Y = 8434 - 589t + 17.62t^2$	4,436	7,231	38.7
11	CONUS	45	0	$Y = 1900 - 2.18t - 0.0743t^2$	1,843	1,475	-24.9

ANNEX H

## THE WIENER-KOLMOGOROV METHOD

The Wiener-Kolmogorov (WK) method is a spectral autoregressive method.\* It is used here because in theory it is superior to other methods such as autoregressive regression. One of its disadvantages, however, is that it requires a long series for parameter estimation. (The same is true of the Box-Jenkins model; but one can always choose the latter by guessing or by trial and error).

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\* See Chan, K. H. and J. C. Hayya, "Spectral Analysis in Business Forecasting: The Wiener-Kolmogorov Method," Decision Sciences, Vol. 9, No. 4 (October 1978), pp. 700-711.

TABLE B.1

RESULTS OBTAINED USING THE WIENER-KOLMOGOROV

METHOD

Series	Name	N	Model Fitted (t = 1 for July '72)	Prediction for July '78 (t = 73)	Actual for July '78	Forecast Error
#1	PAC/AIR	69	$X_t = 8028 - 112.66t$ $+ 0.9196X_{t-1} + 0.0289X_{t-2}$ $+ 0.0771X_{t-3} - 0.3234X_{t-4}$ $+ 0.3456X_{t-5}$	1781	2011	11.4%
#2	ALA/AIR	69	$X_t = 654 - 1.17t$ $+ 0.4720X_{t-1} - 0.0120X_{t-2}$ $+ 0.2828X_{t-3}$	956 (568)	565 "	-69.3 (- 0.5)
#3	NE/AIR	69	$X_t = 575.54 - 48092t$ $+ 0.00846X_{t-1} + 0.2550X_{t-2}$ $- 0.1302X_{t-3} + 0.1252X_{t-4}$ $+ 0.1501X_{t-5} - 0.1592X_{t-6}$	319 (224)	228 "	-39.9 ( 1.8)
#4	NE/EUR	69	$X_t = 2932 - 7.3431t$ $+ 0.3892X_{t-1} + 0.1853X_{t-2}$ $- 0.0274X_{t-3} + 0.0011X_{t-4}$ $+ 0.0685X_{t-5}$	4121 (2954)	2506	-64.4 (-17.8)
#5	SOUTH/AIR	69	Experimentation not successful			
#11	CONUS	67	$X_t = 1945.7 - 2.3031t$ $+ 0.4602X_{t-1} - 0.0317X_{t-2}$ $- 0.1203X_{t-3} - 0.1380X_{t-4}$ $+ 0.1085X_{t-5}$	2437 (1778)	1475	-65.2 (-20.5)
#17	WFH	69	$X_t = 342610 - 2464.2t$ $+ 0.5082X_{t-1} + 0.2501X_{t-2}$ $- 0.1614X_{t-3} - 0.0060X_{t-4}$	303916 (162723)	222754	-36.4 ( 26.9)

Note: The numbers in parentheses refer, respectively, to forecasts and forecast errors using only the mean and trend components (i.e., the first two terms of the formula). This we shall call the "truncated WK model."

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