AM 65-22

PROBLEMS IN AIR TRAFFIC MANAGEMENT

> David K. Trites, Ph. D. M. Clinton Miller, Ph. D. Bart B. Cobb, M.S.

Approved by

Stanl 10-1-6-14

STANLEY R. MOHLER, M.D. DIRECTOR, CARI

Released by

M. J. White

M. S. WHITE, M.D. FEDERAL AIR SURGEON

July 1965

FEDERAL AVIATION AGENCY

Office of Aviation Medicine Civil Aeromedical Research Institute Oklahoma City, Oklahoma

ACKNOWLEDGMENTS

Much of the statistical work described in this report was performed under Contract FA/AC-4-730 between the Civil Aeromedical Research Institute and the Biostatistical Unit, University of Oklahoma Medical Center, Oklahoma City. The authors wish to express their gratitude for the patience and perseverance of Mrs. Carolyne Wall during the preparation of this paper.

Opinions or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Federal Aviation Agency.

Qualified requestors may obtain Aviation Medical Reports from Defense Documentation Center. The general public may purchase from Clearinghouse for Federal Scientific and Technical Information, U.S. Dept. of Commerce, Springfield, Va. 22151.

PROBLEMS IN AIR TRAFFIC MANAGEMENT

VII. Job and Training Performance of Air Traffic Control Specialists—Measurement, Structure, and Prediction

I. Introduction.

In earlier reports in this series,^{1, 2, 5–8, 12} it has been shown that aptitude tests, previous experience directly relevant to the control of air traffic, and chronological age at entry into training are related to training and job performance of Air Traffic Control Specialists (ATCS) in the Federal Aviation Agency (FAA). Other studies have examined more specifically the characteristics of older ATCS trainess that may account for their poorer performance and have investigated the possibility that different aptitudes may be required of individuals in the three ATC subspecialties: Terminal (Tower) traffic control, Air Route (Enroute) traffic control, and Flight Service Station (FSS) activities.

This seventh, and perhaps final, report describes analyses of the training and job-criterion measures used to assess the performance of ATCS. The investigation was undertaken with the expectation that it would be possible to identify more precisely what course grades, training instructors, and job supervisors were actually evaluating when they rated ATCS personnel.

II. Method.

A. Samples.—Five different samples of ATCS trainees were used in the various phases of the research. These represented the three types of ATCS trainees and are described in Table 1. Because of known differences in demographic characteristics and training and job activities, the subspecialties have been investigated separately. The two samples within each of the Enroute and Terminal groups are accounted for by differences in the aptitude tests administered experimentally before the start of ATCS training and

Sample Identification	Description
Enroute Sample 1 (E–1)	Enroute course trainees entering training in September 1960 through July 1961.
Enroute Sample 2 (E-2)	Enroute course trainees entering training in August 1961 through September 1962.
Terminal Sample 1 (T–1)	Terminal course trainees entering training in September 1960 through July 1961.
Terminal Sample 2 (T-2)	Terminal course trainees entering training in August 1961 through March 1963. Includes three trainees selected for training by aptitude tests.
Flight Service Station Sample (FSS)	Flight Service Station course trainees entering training in September 1962 through March 1963. Includes 20 trainees selected for training by aptitude tests.

TABLE 1. Descriptions of Samples of ATCS Trainees.

by some minor differences in training criteria. To facilitate other analyses, they have been kept separate. With the exceptions described in Table 1, none of the individuals in these samples was selected for training by aptitude tests. Instead, they were selected because of previous jobrelevant experience. B. Training Criteria.—Descriptions of the training-performance measures that were studied and the samples for which they were available are contained in Table 2. The 24 criteria can be grouped into three types of measures: (1) those assessing academic performance in the training courses based upon formal written examinations; TABLE 2. Descriptions of Training Criteria.

Criteria and Sample	Description
± Personality Rating (Samples: E-1, E-2, T-1, T-2)	Normalized 9-point score based upon the number of negative statements made about a trainee by his instructors on the FAA Academy's Final Evaluation Form. Available only for <i>Pass</i> trainees.
Subjective Personality Rating (Samples: E-1, E-2, T-1, T-2)	Normalized 9-point score based upon the subjective evaluations by psychologists of the meaning of the statements made about a trainee by his instructors on the FAA Academy's Final Evaluation Form. Available only for <i>Pass</i> trainees.
Pass-Fail in Training (Samples: All)	Those trainees successfully completing the ATCS course were considered as Pass; those unsuccessful as Fail.
Supplementary Instructor Rating (Samples: E-2, T-2, FSS)	Based upon completion by instructors of a rating form similar to that used for job-performance ratings. Usually completed by only one instructor and not available for many classes. Available only for <i>Pass</i> trainees.
Reservation-No Reservation (Samples: E-2, T-2, FSS)	A dichotomous variable representing psychologists' opinion as to whether the in- structor had a definite reservation about a trainee's potential to succeed in ATCS work. Available only for <i>Pass</i> trainees.
Seven Intermediate Academic Grades (Samples: All)	At approximately the fourth week of the ATCS course students were given a set of seven academic examinations covering the areas of (1) Air Traffic Rules, (2) Airport Traffic Control Procedures, (3) Air Route Traffic Control Procedures, (4) Communications Procedures, (5) Flight Assistance Procedures, (6) Air Navi- gation Aids, and (7) Weather.
Seven Final Academic Grades (Samples: All)	At the end of the ATCS training course, students were given final examinations in the same seven areas covered by the Intermediate Grades. This set of final examinations constituted the Air Traffic Specialist Certification Examination.
Strip-Writing Lab Grade (Samples: E-1, E-2)	Final laboratory grade based upon strip-writing performance. For Enroute course only.
A-Position (Assistant ATCS) Lab Grade (Samples: E-1, E-2)	Final laboratory grade based upon performance in the assistant-controller position. For Enroute course only.
D-Position (ATCS) Lab Grade (Samples: E-1, E-2)	Final laboratory grade based upon performance in the controller position. For Enroute course only.
Final Lab Grade (Samples: T–1, T–2, FSS)	In the Terminal and FSS courses, only one final grade was given reflecting all aspects of laboratory performance.
Retakes (Samples: All)	Under certain circumstances, a trainee was permitted to "Retake" an academic examination he had failed previously. This variable is the number of such retakes listed for each trainee.

(2) those assessing performance in the training laboratories based upon instructors' observations; and (3) those reflecting the instructors' more subjective opinions of a trainee's performance, potential, and adjustment.

C. Job Criteria.—Descriptions of the job-performance measures that were studied and the samples for which they were available are contained in Table 3. At the time this research was undertaken, job-performance evaluations were available for only former Enroute and Terminal trainees. For some of these individuals, ratings had been obtained upon several different occasions. Intensive analyses were made only of the evaluations collected from job supervisors approximately 10 to 12 months after the ATCS had completed training at the FAA Academy, Oklahoma City. The more recent evaluations of these individuals were included in the study in summary form and provided one basis for estimating the reliability of the ratings. In most instances, ratings of a former trainee were made by four of his supervisors, as requested. Very few ATCS were rated by only one supervisor.

D. Other Variables.—Table 4 contains descriptions of aptitude-test composite scores, demographic characteristics, and combinations of certain training criteria whose values as predictors of the job-performance measures were examined. The table also contains descriptions of the several job-performance summary measures previously mentioned. TABLE 3. Descriptions of Job-Performance Criteria.

	Criterion	Description
1. 2.	Steady attention to work and conduct. Ability to organize and make most effective use of time, equip- ment, and information currently available.	For Items 1 through 14 in this table, job supervisors were asked to rate the indi- vidual as Excellent, Very Good, Good, Fair, or Unsatisfactory For data processing.
3. 4. 5.	Demonstrated attitude and character. Rate of continued improvement. Ability to understand and apply controller procedures.	ratings given to each item were coded 4 through 0, respectively. Only ratings of ATCS still with the FAA were included in the analyses.
6. 7.	Ability to make decisions required by his position. Display of good judgment.	
8. 9.	Emotional stability under pressure. Demonstrated aptitude for air traffic control activities.	
10.	Potential for continued emotional stability in air traffic control activities.	
11.	Ability to get along well with others.	
12.	Ability to work cooperatively with others.	
13.	Present performance of OJT duties (complete only for trainees).	
14.	Potential ability to perform journeyman duties (complete only for trainees).	
15.	Do controller activities of this individual ever have undesirable effect on air traffic safety? Yes-No.	This item was coded as 1 if one or more of an individual's supervisors answered Yes; otherwise coded as 2.
16.	If you were a facility chief, would you want this individual on your staff as an active controller? Yes - No.	This item was coded as 1 if one or more of an individual's supervisors answered No;

III. Statistical Procedures.

A. Factor Analyses.—Using an IBM electronic computer, the intercorrelation matrices of the training- and job-criterion variables, separately, were subjected to a principal-component factor analysis⁴ for each sample, separately. Thus, five factor analyses were computed for the training criteria and four factor analyses for the job criteria. Communalities were estimated by using the highest correlation coefficient in each column of the correlation matrix. Factors were extracted until 100% of the communalities had been accounted for. The factoring of each correlation matrix was reiterated until the factor loadings and the percentage of the communalities accounted for by each factor had stabilized.

B. Factor Rotations.—Upon completion of factoring, the factor matrix was rotated using the varimax procedure.³ No attempt was made to adjust the rotated loadings graphically.

C. Factor Scoring.—Several methods of deriving

factor scores were compared empirically. The one finally selected involved the weighting of the criterion variables with the largest loadings on a factor by integer weights and summing the weighted values.¹³ Weights of 2, 3, or 4 were selected to approximate the inverse of the standard deviation of each variable entering into a factor score.

otherwise coded as 2.

IV. Results.

The results of the analyses are presented in three parts: (1) structure of the trainingcriterion measures; (2) structure of the jobcriterion measures; and (3) prediction of the job-criterion measures by training-criterion measures, aptitude tests, and demographic characteristics of the trainees. In Table 5, the means and standard deviations are given for the most important variables in the study. These statistics are based upon the maximum amount of data available for each of the three ATCS specialties, disregarding samples.

3

 TABLE 4. Descriptions of Aptitude-Test Composite Scores, Demographic Variables, and Combinations of Training- and Job-Performance Criteria.

Variable and Abbreviation	Description
Civil Service Commission Aptitude-Test Composite Score (CSC Test)	A composite score obtained by weighting and adding the scores on indi- vidual tests of numerical ability, nonverbal abstract reasoning, letter sequence (a type of nonverbal abstract reasoning), spatial patterns, air traffic problems, and oral direction following. Other forms of these tests are currently being used to select all new ATCS trainees.
Commercial Aptitude-Test Composite Score (Comm Test)	A composite score obtained by weighting and adding the scores on indi- vidual tests of numerical ability, nonverbal abstract reasoning, space relations, nonverbal analogies, and air traffic problems.
Age	Chronological age to nearest birthday on date of entry into training.
Education (Educ)	A coded variable with a range from 1 to 9, with 1 representing less than a high-school graduate and 9 representing six or more years of college.
Sum of Air-Traffic Experience (∑AT)	A coded variable with a range from 1 to 9, with 1 representing no experi- ence and 9 representing 16 years or more experience of the following types: VFR Tower, Approach Control Tower, Radar Approach Control Tower, Center, Ground Controlled Approach, and Radar Approach Con- trol Center.
Sum of Communications Experience (∑Com)	A coded variable with a range from 1 to 9, with 1 representing no experi- ence and 9 representing 16 years or more experience of the following types: Station, Ground to Air Communications, and Point to Point Communications.
Academic Grade Average (Acad)	An average of the seven intermediate and seven final academic grades described in Table 2.
Laboratory Grade Average (Lab)	For Enroute trainees, the average of the three lab grades described in Table 2. For Terminal and FSS trainees, the Final Lab Grade described in Table 2.
Academic + Laboratory Grade (Acad + Lab)	An average of the Academic Grade Average plus the Laboratory Grade Average.
First Supervisory Rating Average (1-Super)	An average of the first available supervisory ratings of Items 1-14 described in Table 3.
Most Recent Supervisory Rating Average (2, 3, 4-Super)	An average of the most recent supervisory ratings of Items 1-14 described in Table 3. Depending upon the sample, ratings were made either 2, 3, or 4 years after completion of ATCS training.
First Answer to Item 15 (1–Item 15)	First available answers to Item 15 described in Table 3
Most Recent Answers to Item 15 (2, 3, 4–Item 15)	Most recent answers to Item 15 described in Table 3.
First Answer to Item 16 (1-Item 16)	First available answers to Item 16 described in Table 3.
Most Recent Answers to Item 16 (2, 3, 4–Item 16)	Most recent answers to Item 16 described in Table 3.
Separated—Not Separated from the FAA (Sep–Not Sep)	A classification of an individual as being with the FAA based upon the most recent information. Individuals for whom no information was available were not classified as either Separated or Not Separated.

A. Training-Criterion Structure.—From the five factor analyses, five interpretable factors were identified. Each of the five factors was clearly recognizable in at least three of the analyses. Table 6 contains the average of the rotated factor loadings from the analyses in which the factors occurred and specification of the variables that identify the factors.

1. Factor I. Laboratory Performance: This factor was heavily loaded on the criteria representing performance in the training laboratories.

The Pass-Fail status of the trainees also had its highest loading on this factor.

2. Factor II. Instructor Evaluation A: Although all four of the instructor evaluations had significant loadings on this factor, it was most clearly defined by the \pm and Subjective Personality Rating variables.

3. Factor III. Intermediate Academic Performance: The seven intermediate academic examinations tended to cluster on this factor. As the loadings on Factor IV indicate, however,

Variables		Enroute			Terminal	*	FSS			
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	
Age	28, 56	6,50	984	28.07	5.83	575	31.73	7.69	139	
1-Super	2.54	. 51	577	2.61	. 56	403				
2,3,4,-Super	2.74	. 51	371	2.77	. 52	248				
Sep-Not Sep	1.74	. 43	672	1.84	. 36	466				
Halo	101.22	21.84	489	101.98	25.68	349				
IPO	25.67	4,98	589	25.88	5.77	421				
JO	15.56	3.30	589	15.19	3.54	421				
J Pot	9.83	2.73	492	10.40	2.95	343				
J Per	7.38	3.47	585	7.57	4.07	414				
Emot.	14.71 •	3,54	589	15.07	4.02	421				
1-Item 15	1.84	. 36	575	1.81	. 39	403				
1-Item 16	1.20	. 40	575	1.19	. 39	403				
2,3,4-Item 15	1.84	.38	371	1.87	.34	248				
2,3,4-Item 16	1.19	. 39	371	1.18	. 39	248				
Obj Pers	5,02	1.90	629	5.01	1.74	374				
Supp	2.54	. 56	188	2,53	. 58	172	22,81	8.23	63	
Reser	1.71	.45	307	1.73	.44	245	1.78	.41	114	
Acad	83.30	7.24	983	85,86	6.73	575	84.41	6.88	139	
Lab	78.50	12.36	963	78.42	9.41	560	85.17	6.26	127	
Acad+Lab	80.81	8.94	980	81.99	7.64	575	84.22	6.74	139	
CSC Test	189.43	37.54	395	193.24	39.04	306	189,55	46.61	103	
Comm Test	1702.15	359.98	838	1723.61	36.17	395				
Educ	2.83	1.51	972	276	1.34	573	3.01	1.54	138	
ΣΑΤ	10.86	4.72	986	12.91	4.72	576	9.77	5.20	139	
$\Sigma Com_{}$	4.70	3.30	986	4.11	2.60	576	5.86	4.45	139	

TABLE 5. Means and Standard Deviations Based upon Maximum Amount of Data Available for Each Variable.

intermediate academic performance was not clearly differentiated from final academic performance. The Pass-Fail variable had its next highest loading on the factor as did the Strip-Writing Lab Grade for the Enroute trainees. This is logical since many of the training failures were eliminated as a result of the intermediate examinations and the strip-writing grade was given at about this time.

4. Factor IV. Final Academic Performance: The seven final academic examinations tended to cluster on this factor, but it was clearly not independent of Factor III. The number of examination "Retakes" also had its highest loading on the factor and the Pass-Fail variable had its third highest loading on the factor.

5. Factor V. Instruction Evaluation B: This was best defined by the Supplementary Instructor Evaluation and the Reservation-No Reservation variable.

After thorough consideration of the factors and

their defining variables, it was decided that the Laboratory Performance Factor score would be estimated by averaging the three lab grades in the case of Enroute trainees, and by the Final Lab Grade in the case of Terminal and FSS trainees. Since the two personality ratings defining Factor II were based upon the same data, the more objective of the two, the \pm Personality Rating, was selected as the variable to estimate this factor. As pointed out, the two academicperformance factors were not clearly independent. Therefore, an average academic grade based upon all 14 examination scores was selected as a single estimate of both Factors III and IV. Finally, since the Supplementary Instructor Evaluation was a continuous variable and the Reservation-No Reservation variable was a dichotomy, each variable was retained as a separate estimate of Factor V.

B. Job-Criterion Structure.—The four-factor analyses of the 16 job-performance measures

TABLE 6. Average Varimax-Rotated Factor Loadings for Training Criteria.

Olitaria		Factor Loadings *							
Criteria		1	1	endere.	TR. W. S. S.				
	I	п	III	IV	V				
=Personality Rating	. 05	. 88	. 10	.08	et de la				
Subjective Personality Rating	.06	. 83	. 11	.11	- 16				
Pass-Fail	.78	09	. 38	. 27	.25				
Supplementary Instructor Rating ^b	. 27	.34	.12	.08	19				
Reservation-No Reservation ^b	.13	. 38	.04	.13	.07				
Air Traffic Rules: Intermediate	.08	. 08	. 55	.26	- 05				
Airport Control Procedures: Intermediate	. 24	.08	. 22	.37					
Air Route Control Procedures: Intermediate	. 22	. 08	. 26	.28	-11				
Communications Procedures: Intermediate	.11	.10	.63	.30	. 10				
Flight Assistance Procedures: Intermediate	.17	.12	. 28	.23	.05				
Air Navigation Aids: Intermediate	.08	.02	.66	.34	.15				
Weather: Intermediate	.18	.09	.62	.29	.15				
Air Traffic Rules: Final	.11	.04	. 22	.48	.04				
Airport Control Procedures: Final	.14	.09	.13	.43	.10				
Air Route Control Procedures: Final	.16	.08	.16	.44	.13				
Communications Procedures: Final	.12	.12	.18	.48	.07				
Flight Assistance Procedures: Final	.14	.07	. 22	.39	.09				
Air Navigation Aids: Final	.07	02	.19	. 47	.00				
Weather: Final	.16	.03	. 26	. 46	.13				
Strip-Writing Lab ^e	.38	.16	. 54	.13					
A-Position Lab	.66	.10	.18	.24	. 25				
D-Position Lab ^e	.83	. 30	.07	.34	.30				
Retakes	11	04	26	43	31				
Final Lab ^d	.76	. 20	.30	.14	. 38				
		2		1.1.1.1.1.1					

a Italicized loadings are those considered as best defining the factor.

^b Available for only Enroute sample 2, Terminal sample 2, and the FSS sample.

^c Available only for the two Enroute samples.

^d Available only for the two Terminal samples and the FSS sample.

yielded six clearly identifiable factors. These six factors appeared in at least three of the four analyses. Table 7 contains the average of the rotated factor loadings from the analyses in which the factors occurred.

1. Factor I. Halo: All 16 items had loadings greater than 0.20 on this factor. It was interpreted as reflecting the supervisor's overall opinion of an individual.

2. Factor II. Interpersonal Orientation (IPO): The two highest loadings on this factor were for the items representing the ability to work cooperatively and the ability to get along well with others. The next highest loading was for demonstrated attitude and character. A number of the other items had significant loadings but only attention to work and conduct approached the magnitude of the preceding three items. Apparently, the supervisors judge an in-

dividual to some extent by his interpersonal activities.

3. Factor III. Job Orientation (JO): This factor was best defined by the first three items in Table 7, representing ratings of attention to work and conduct, organizing time, equipment and information, and attitude and character. This is the first of three factors related to job performance and was interpreted as representing the orientation (motivation) to the job rather than job potential or actual job performance.

4. Factor IV. Job Potential (J Pot): The two items dealing with performance of OJT (On the Job Training) duties and potential for journeyman duties clearly defined this factor.

5. Factor V. Job Performance (J Per): The two Yes-No type items had their highest loadings on this factor. These items reflected an individual's impact on air safety and his desirability The on t unde tion: Tl whice each was and

C. .

this

of

sam

data

form

Aca

1963

dure

man

III acco

Criteria	Factor Loadings*									
	I	II	III	IV	v	VI				
to work and conduct	98	64	59	00	19	03				
tention to work and conduct	.00	38	.00	13	.12	.03				
ganizing time, equipment and mormation	.70	.00	.04	. 15	14	.01				
titude and onaracter	.00	.14	.02	12	24	.00				
ntinued improvement	. 86	.00	.06	06	26	- 04				
derstanding and apprying proceduros	.86	.22	.00	.02	. 18	.01				
king decisions	.78	. 40	.17	.01	.17	.03				
tional stability	.73	. 33	. 06	02	.17	. 37				
tude for ATCS activities	. 86	. 26	. 08	.02	.28	.10				
tential for continued emotional stability	.78	.36	.06	.04	. 19	. 35				
ting along well with others	.24	. 92	03	.08	.14	. 05				
uting along work cooperatively	.25	. 90	. 05	.06	. 19	. 02				
mily to meremance of OJT duties	.74	.31	.13	. 44	.18	01				
tential to perform journeyman duties	.78	.30	. 08	.31	.24	. 02				
activities have an undesirable or desirable effect on air										
afety	. 38	.25	01	. 03	.46	.08				
uld you want this individual on your staff	. 30	. 20	.10	.02	.66	.01				

TABLE 7. Average Varimax-Rotated Factor Loadings for Job Criteria.

•Italicized loadings are for items used in estimating a factor score.

Or At CC UI M JU EI AFP OGA APP PO

in a facility. Considerably smaller but significant loadings were found for rate of continued improvement, understanding and applying procedures, aptitude for ATCS activities, and journeyman potential. The factor is related to Factors III and IV but seems to represent more actual accomplishment than the other two.

6. Factor VI. Emotional Stability (Emot): The only two items having significant loadings on this factor were those of emotional stability under pressure and potential for continued emotional stability.

The italicized loadings in Table 7 indicate which items were used to estimate a score for each factor. As indicated previously, each item was weighted inversely to its standard deviation and summed to obtain the score.

C. Prediction of Job-Performance Criteria.—For this part of the investigation, the two samples of Enroute ATCS were combined and the two samples of Terminal ATCS were combined. The data, then, are for the maximum amount of information available on trainees entering the FAA Academy between September 1960 and March 1963. 1. Reliability of Job-Performance Criteria. One feature of job-performance ratings that must be considered in the interpretation of their predictability is their reliability. To assess this, two kinds of reliability data were examined.

First, the supervisory-rating forms collected 10 to 12 months after Academy graduation were randomly divided into two groups for each individual rated and two average supervisory-ratings scores (based on Items I through 14 in Table 3) computed for 468 Enroute and 262 Terminal ATCS. For Enroute, the uncorrected correlation between the two averages was 0.58; for Terminal, it was 0.78.

Second, the average supervisory-rating score computed from the most recent ratings (2, 3, 4-Super) was correlated with the average score (1-Super) computed from the earliest ratings of the same individuals. For 367 Enroute ATCS, the correlation was 0.43; for 244 Terminal ATCS, the correlation was 0.47. These findings indicated that, contrary to a previously published hypothesis,⁸ the Terminal supervisors made more reliable, or consistent, ratings than did Enroute supervisors.

		Instructor Based							Grades						
Variables	Obj Pers		Supp		Res	Reser. ª		Acad		Lab		Acad + Lab			
	r	N	r	N	r	N	r	N	r	N	r	N			
1-Super	225	537	333	176	15¢	275	198	577	295	577	285	577			
2, 3, 4-Super	12°	370	340	121	16°	204	08	371	205	371	170	371			
Sep-Not Sep ^a	08°	628	-02	188	*11 °	307	06	672	165	672	146	672			
Halo	230	454	32 ^b	141	14°	221	210	489	320	489	326	489			
IPO	185	548	24 ^b	173	06	271	130	588	16 ^b	588	176	588			
JO	230	548	24 ^b	173	08	271	226	588	28 ^b	588	30%	588			
J Pot	17°	457	24 ^b	143	14°	224	198	492	30 ^b	492	30%	492			
J Per	22 ^b	544	316	172	198	270	16 ^b	584	285	584	27 b	584			
Emot	20 ^b	548	295	173	16°	271	15 ^b	588	29 ^b	588	276	588			
1-Item 15 ^a	09¢	534	216	174	*09	272	-03	574	10¢	574	04	574			
1-Item 16 ^a	21 ^b	534	226	174	*15°	272	155	574	183	574	195	574			
2, 3, 4-Item 15 ^a	110	370	11	121	*08	204	09	371	05	371	08	371			
2, 3, 4-Item 16 ^a	16 ^b	370	15	121	*12	204	-02	371	16 ^b	371	08	371			

TABLE 8. Correlations of Training-Performance Measures with Job-Performance Information for Former Enroute Trainees.

a Correlations in these rows and columns are point-biserial except for those marked,* which are phi-coefficients. All other correlations are product-moment. Decimal points omitted.

^b Significant at less than 0.01 level. ^c Significant at less than the 0.05 level.

		Instructor Based							Grades						
Variables -	Obj Pers		Su	Supp		Reser. ^a		Acad		Lab		Acad + Lab			
	r	N	r	N	r	N	r	N	r	N	r	N			
1-Super	325	320	24 ^b	157	11	217	316	403	07	403	235	403			
2, 3, 4-Super	33 ^b	248	270	79	220	120	30%	248	195	248	295	248			
Sep-Not Sep ^a	05	374	04	172	14°	245	02	466	00	466	01	466			
Halo	310	287	315	121	235	169	295	349	07	349	215	349			
IPO	30 ^b	338	13	157	02	217	223	421	03	421	140	42			
JO	29 ^b	338	23*	157	10	217	35%	421	090	421	276	42			
J Pot	250	281	26 ^b	121	23 *	169	28 ^b	343	08	343	226	343			
J Per	25 %	332	18¢	154	14°	213	238	414	07	414	180	414			
Emot	25^{b}	338	26 ^b	157	16°	217	25 ^b	421	07	421	195	42			
1-Item 15 ^a	26^{b}	320	13	157	*07	217	170	403	07	403	150	403			
1-Item 16 ^a	22^{b}	320	16	157	*16°	217	20 ^b	403	07	403	165	403			
2, 3, 4-Item 15 ^a	06	248	00	79	*06	120	02	248	10	248	08	248			
2, 3, 4-Item 16 ^a	15°	248	10	79	*10	120	15°	248	08	248	14°	248			

TABLE 9. Correlations of Training-Performance Measures with Job-Performance Information for Former Terminal Trainees.

a Correlations in these rows and columns are point-biserial except for those marked,* which are phi-coefficients. All other corre-lations are product-moment. Decimal points omitted. ^b Significant at less than 0.01 level. ^c Significant at less than the 0.05 level.

2. Prediction of Job Performance by Training Performance: Correlations of the Job Factor Scores and the summary job-performance measures with the training-criterion measures are presented in Table 8 for former Enroute ATCS trainees and in Table 9 for former Terminal ATCS trainees. Generally, the relationships between job and training performance were higher for Terminal than for Enroute ATCS.

More specifically, training-performance measures based upon instructor evaluations were usually better predictors of job performance than either academic or laboratory grades. Among Terminal ATCS, academic grades were superior to laboratory grades in predicting early job performance. For Enroute ATCS, the opposite was true: laboratory grades were superior to academic grades as predictors of job performance. For both types of ATCS, the relative importance of laboratory grades as an index of future job performance increased with the length of time an ATCS was on the job. This finding illustrates well the relevance of ATCS training to later job performance, but also emphasizes the differences in skills required for good job performance in towers and centers. It suggests that there may be less in common between the work requirements of towers and centers than previously thought.

Among the job-factor scores, the Halo Factor tended to correlate most highly with the training criteria. In every instance but one, either Job Orientation, Job Potential, or Job Performance had the next highest correlations.

Surprisingly, in every instance, the correlations between the training criteria and the average of the supervisory ratings either stayed essentially the same or increased as a function of the length of time a Terminal ATCS had been in the field; i.e., the correlations with the earliest supervisory ratings usually were lower than the correlations with the most recent supervisory ratings. For Enroute ATCS, this was true only for the Supplementary Instructor Rating and the Reservation-No Reservation criterion.

It is also interesting to note that relative to opinions regarding the effect an ATCS had on air safety (Item 15), the supervisors' opinions of the desirability (Item 16) of an ATCS were more predictable by almost every training-performance measure. This was true of both the earliest and the most recent ratings.

3. Prediction of Job Performance by Demographic Information: Tables 10 and 11 contain the correlation of the job criteria with Age, Education, Sum of Air Traffic Experience, and the Sum of Communications Experience for former Enroute and Terminal trainees. As reported in

Variables	CSC Test		Comm Test		Age		Educ		ΣΑΤ		ΣCom	
	r	N	r	N	r	N	r	N	r	N	r	N
										-		
1-Super	-07	231	08	499	-15b	577	-06	569	125	577	-12b	577
2, 3, 4-Super	07	185	-05	343	-140	371	- 08	363	12°	371	-07	371
Sep-Not Sep ^a	08	259	01	584	-180	672	-08°	664	07	672	-02	672
Halo	-12	185	110	424	-19 ^b	489	-07	482	120	489	-14 ^b	489
IPO	-19^{b}	228	02	509	03	588	-04	580	07	588	-08°	588
JO	-07	228	10°	509	-06	588	-02	580	100	588	-11^{b}	588
J Pot	-02	188	110	427	-24	492	-07	485	155	492	-12^{b}	492
J Per	-01	227	08	505	-23	584	-03	576	100	584	-110	584
Emot	00	228	090	509	-19	588	-04	580	110	588	- 090	588
1-Item 15 ^a	00	229	-03	497	-11	574	-02	566	01	574	-06	574
1-Item 16 ^a	-02	229	06	497	-22b	574	-05	566	08	574	-07	574
2, 3, 4-Item 15 ^a	-06	185	-05	343	-04	371	- 02	363	-02	371	-03	371
2, 3, 4-Item 16 ^a	09	185	-07	343	-09	371	-07	363	07	371	-08	371

 TABLE 10.
 Correlations of Composite Aptitude-Test Scores and Biographical Data With Job-Performance Information for Former Enroute Trainees.

a Correlations in these rows are point-biserial. All other correlations are product-moment. Decimal points omitted. b Significant at less than the 0.01 level.

c Significant at less than the 0.05 level.

Variables	CSC Test		Comm Test		Age		Educ		ΣΑΤ		ΣCom	
	r	N	r	N	r	N	r	N	r	N	r	N
1-Super	13	197	10	291	-07	403	- 02	401	07	403	00	403
2, 3, 4-Super	15	114	07	228	-14°	248	-05	247	07	248	-05	248
Sep-Not Sep ^a	00	222	-01	336	-15	466	-110	464	-04	466	04	466
Halo	24 ^b	155	10	258	-13°	349	-02	347	02	349	-01	349
IPO	05	197	01	307	08	421	01	419	-02	421	06	421
JO	07	197	06	307	05	421	01	419	06	421	00	421
J Pot	26 ^b	155	10	252	-18 ^b	343	- 02	341	11	343	-03	343
J Per	15°	194	07	302	-185	414	-03	412	05	414	00	414
Emot	17¢	197	130	307	-13b	421	-06	419	08	421	-03	421
1-Item 15 ^a	10	197	06	291	-11°	403	- 05	401	00	403	05	403
1-Item 16 ^a	14°	197	07	291	-16b	403	-07	401	03	403	-03	403
2, 3, 4-Item 15 ^a	-07	114	-140	228	-14°	248	- 18ª	247	02	248	06	248
2, 3, 4-Item 16 ^a	01	114	-08	228	-10	248	-07	247	07	248	02	248

 TABLE 11. Correlations of Composite Aptitude-Test Scores and Biographical Data With Job-Performance Information for Former Terminal Trainees.

a Correlations in these rows are point-biserial. All other correlations are product-moment. Decimal points omitted.

b Significant at less than 0.01 level.

c Significant at less than the 0.05 level.

previous studies, ^{6, 10, 12} the older the individual at entry into training, the less well he was rated by his job supervisors. For both types of ATCS, age is the most significant predictor of separation from the FAA. This being so, it would be expected that the relationship between the supervisory ratings and age would decrease as time passed because of the restriction in range of the age variable resulting from the separation of the older individuals. The fact that this relationship did not significantly diminish with the length of time an ATCS was on the job indicates the importance of age in the perceived functioning of Terminal and Enroute controllers.

Education tended to have negative relationships with most of the job-performance measures; i.e., the more education, the less well an ATCS was rated. Since the older individuals tended to have more education, however, these negative relationships primarily reflected age. Consequently, it may be concluded that education had essentially no relationship to job performance.

Air traffic and communications-experience variables had significant relationships only among the Enroute ATCS. The more air traffic experience reported by a former Enroute trainee, the higher he was rated by his supervisors. In contrast, the more communications experience reported, the lower the supervisory ratings.

4. Prediction of Job Performance by Aptitude Tests: Tables 10 and 11 contain the correlations of the job criteria with the CSC and Commercial aptitude-test composite scores. Once again there were differences between the Enroute and Terminal ATCS. The CSC-test composite score was significantly correlated with four of the six Job Factor Scores in the Terminal ATCS group, but the Commercial aptitude-test composite was significantly correlated with only one of the Factor Scores. Among the Enroute ATCS, the Commercial aptitude-test composite was significantly correlated with four of the Job Factor Scores, and the CSC composite score was significantly related to only one of the Job Factor Scores and this in a negative direction.

Although none of the correlations of the CSCtest composite score with either the earliest or the most recent average supervisory ratings was statistically significant, the size of the correlations did increase as the amount of time in a field facility increased. It may be that aptitudes assessed by the tests increase in importance as a man progresses in his career.

V. Discussion.

The duplication of the structure of the joband training-performance measures in all of the samples studied does not necessarily mean that the instructors and supervisors in the three ATCS specialties were evaluating the same personal characteristics and achievements. It does mean that the interrelationships of the variables are the same in each specialty, regardless of the basis of the evaluations.

Some evidence for a differential behavioral basis of the Enroute and Terminal supervisory evaluations is provided by the differences in their correlations with the training-performance measures, aptitude tests, and biographical data. In particular, the differences in the prediction of early job performance by Academic and Laboratory grades and the increase in the relative importance of the Laboratory grades as a predictor of later job performance suggest a difference in the job requirements. The previously reported finding² that performance in Terminal ATCS work seems to involve a verbal aptitude not required for Enroute performance also lends support to the hypothesis that there may be differences in required aptitudes and behavior.

The evaluation of the usefulness of aptitude tests for prediction of job performance is left in a puzzling state by the results of this study. In the case of Terminal job performance, the experimentally administered Civil Service Commission aptitude tests significantly predicted the supervisory ratings, whereas for Enroute job performance, the experimentally administered Commercial aptitude tests significantly predicted the supervisory ratings, although less effectively than prediction of Terminal job performance by the CSC tests. The lower level of prediction among Enroute ATCS can be partially accounted for by the lower reliability of the Enroute supervisory ratings, but this still would not account for the differences in prediction by the two groups of tests. It may be that differences in test content (even though the tests in the two batteries were supposedly measuring essentially the same things) reflect differences in job requirements. In any event, the results do not contraindicate the

use of aptitude tests for trainee selection and, when considered in conjunction with previous studies, ^{2, 5, 8, 12} modestly support their usefulness for predicting job performance. Further investigation is obviously required to resolve this puzzle once and for all.

The appropriateness of the nonstatistically derived measures of training performance that have been used to evaluate the usefulness of aptitude tests in earlier research is supported by the statistical analyses of the training measures. The three areas of training performance that are relatively independent reflect academic performance, laboratory performance, and evaluations by instructors. These have been the major performance indexes used in developing the Civil Service Commission test battery now in use for selection of all new ATCS trainees.

VI. Conclusions.

In summary, from this study it was concluded that: (1) job supervisors can make evaluations of ATCS job performance that are reliable and predictable; (2) the evaluations of the job performance of Terminal ATCS are more reliable and usually more predictable than the evaluations of Enroute ATCS; (3) job supervisors can evaluate different aspects of ATCS job performance, suggesting that improved rating procedures might be developed by orienting the procedures to the behavioral areas identified in this study; (4) the evaluations of trainees made by the ATCS training-course instructors at the FAA Academy provide the best single method for predicting ATCS job performance; (5) the clusters of training-performance measures resulting from their statistical analyses are in essential agreement with the nonstatistically derived clusters used in earlier research; and (6) aptitude tests and demographic characteristics of former ATCS trainees are related to job performance but not at very high levels, and, perhaps, in a manner reflecting differences in the requirements for Enroute and Terminal ATCS job performance.

- COBB, B. B. Problems in Air Traffic Management: II. Prediction of Success in Air Traffic Controller School. *Aerospace Med.* 33:702, 1962. Also published as Civil Aeromedical Research Institute Report 62–2. FAA, Oklahoma City, Oklahoma, 1962.
- COBB, B. B. Problems in Air Traffic Management:
 V. Identification and Potential of Aptitude Test Measures for Selection of Tower Air Traffic Controller Trainees. *Aerospace Med.* 35:1019, 1964.
- 3. HARMON, H. H. Modern Factor Analysis. Chicago, University of Chicago Press, 1962.
- 4. KENDALL, M. G. A. Course In Multivariate Analysis. London, Charles Griffin Co., Ltd., 1961.
- TRITES, D. K. Problems in Air Traffic Management: I. Longitudinal Prediction of Effectiveness of Air Traffic Controllers. *Aerospace Med.* 32:1112, 1961. Also published as Civil Aeromedical Research Institute Report 61–1, FAA, Oklahoma City, Oklahoma, 1961.
- 6. TRITES, D. K., and COBB, B. B. Problems in Air Traffic Management: III. Implications of Age for Training and Job Performance of Air Traffic Controllers. Civil Aeromedical Research Institute Report 62–3, FAA, Oklahoma City, Okla., 1962.
- 7. TRITES, D. K., and COBB, B. B. Problems in Air Traffc Management: III. Implications of Training-Entry Age for Training and Job Performance of Air Traffic Control Specialists. *Aerospace Med.* 35:336, 1964.

- 8. TRITES, D. K., and COBB, B. B. Problems in Air Traffic Management: IV. Comparison of Pre-employment, Job-Related Experience With Aptitude Tests as Predictors of Training and Job Performance of Air Traffic Control Specialists. *Aerospace Med.* 35:428, 1964.
- 9. TRITES, D. K. Ground Support Personnel. Aerospace Med. 34:539, 1963.
- TRITES, D. K., and COBB, B. B. CARI Research on Air Traffic Control Specialists: Age, Aptitude, and Experience as Predictors of Performance. Civil Aeromedical Research Institute, Unnumbered Report, FAA, Oklahoma City, Okla., 1964.
- TRITES, D. K. Age, Aptitude, and Experience as Predictors of Performance of Air Traffic Controllers. *In:* Aviation Psychological Research, Reports of the 5th Conference for Aviation Psychology, Seifert, R., ed. (Mimeo.) Bad Godesberg, Kolner Strasse 70, Germany, 1964, 157–176.
- TRITES, D. K. Problems in Air Traffic Management: VI. Interaction of Training-Entry Age With Intellectual and Personality Characteristics of Air Traffic Control Specialists. *Aerospace Med.* 35:1184, 1964.
- TRITES, D. K., and SELLS, S. B. A Note on Alternative Methods for Estimating Factor Scores. J. Appl. Psychol. 39:455, 1955.