

PROBLEMS IN AIR TRAFFIC MANAGEMENT

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

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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 trainees 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

TABLE 1. Descriptions of Samples of ATCS Trainees.

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.

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 job-relevant 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 <i>Pass</i> ; those unsuccessful as <i>Fail</i> .
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 instructor 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 Navigation 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. Steady attention to work and conduct.	For Items 1 through 14 in this table, job supervisors were asked to rate the individual as Excellent, Very Good, Good, Fair, or Unsatisfactory. For data processing, ratings given to each item were coded 4 through 0, respectively. Only ratings of ATCS still with the FAA were included in the analyses.
2. Ability to organize and make most effective use of time, equipment, and information currently available.	
3. Demonstrated attitude and character.	
4. Rate of continued improvement.	
5. Ability to understand and apply controller procedures.	
6. Ability to make decisions required by his position.	
7. Display of good judgment.	
8. Emotional stability under pressure.	
9. 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; otherwise coded as 2.

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.⁵ 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.

IV. Results.

The results of the analyses are presented in three parts: (1) structure of the training-criterion measures; (2) structure of the job-criterion 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.

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 individual 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 individual 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 (Σ AT)	A coded variable with a range from 1 to 9, with 1 representing no experience 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 Control Center.
Sum of Communications Experience (Σ Com)	A coded variable with a range from 1 to 9, with 1 representing no experience 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,

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

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
ΣAT.....	10.86	4.72	986	12.91	4.72	576	9.77	5.20	139
ΣCom.....	4.70	3.30	986	4.11	2.60	576	5.86	4.45	139

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

Variables	Instructor Based						Grades					
	Obj Pers		Supp		Reser. ^a		Acad		Lab		Acad + Lab	
	r	N	r	N	r	N	r	N	r	N	r	N
1-Super.....	22 ^b	537	33 ^b	176	15 ^c	275	19 ^b	577	29 ^b	577	28 ^b	577
2, 3, 4-Super.....	12 ^c	370	34 ^b	121	16 ^c	204	08	371	20 ^b	371	17 ^b	371
Sep-Not Sep ^a	08 ^c	628	-02	188	*11 ^c	307	06	672	16 ^b	672	14 ^b	672
Halo.....	23 ^b	454	32 ^b	141	14 ^c	221	21 ^b	489	32 ^b	489	32 ^b	489
IPO.....	18 ^b	548	24 ^b	173	06	271	13 ^b	588	16 ^b	588	17 ^b	588
JO.....	23 ^b	548	24 ^b	173	08	271	22 ^b	588	28 ^b	588	30 ^b	588
J Pot.....	17 ^b	457	24 ^b	143	14 ^c	224	19 ^b	492	30 ^b	492	30 ^b	492
J Per.....	22 ^b	544	31 ^b	172	19 ^b	270	16 ^b	584	28 ^b	584	27 ^b	584
Emot.....	20 ^b	548	29 ^b	173	16 ^c	271	15 ^b	588	29 ^b	588	27 ^b	588
1-Item 15 ^a	09 ^c	534	21 ^b	174	*09	272	-03	574	10 ^c	574	04	574
1-Item 16 ^a	21 ^b	534	22 ^b	174	*15 ^c	272	15 ^b	574	18 ^b	574	19 ^b	574
2, 3, 4-Item 15 ^a	11 ^c	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

^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.

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

Variables	Instructor Based						Grades					
	Obj Pers		Supp		Reser. ^a		Acad		Lab		Acad + Lab	
	r	N	r	N	r	N	r	N	r	N	r	N
1-Super.....	32 ^b	320	24 ^b	157	11	217	31 ^b	403	07	403	23 ^b	403
2, 3, 4-Super.....	33 ^b	248	27 ^c	79	22 ^c	120	30 ^b	248	19 ^b	248	29 ^b	248
Sep-Not Sep ^a	05	374	04	172	14 ^c	245	02	466	00	466	01	466
Halo.....	31 ^b	287	31 ^b	121	23 ^b	169	29 ^b	349	07	349	21 ^b	349
IPO.....	30 ^b	338	13	157	02	217	22 ^b	421	03	421	14 ^b	421
JO.....	29 ^b	338	23 ^b	157	10	217	35 ^b	421	09 ^c	421	27 ^b	421
J Pot.....	25 ^b	281	26 ^b	121	23 ^b	169	28 ^b	343	08	343	22 ^b	343
J Per.....	25 ^b	332	18 ^c	154	14 ^c	213	23 ^b	414	07	414	18 ^b	414
Emot.....	25 ^b	338	26 ^b	157	16 ^c	217	25 ^b	421	07	421	19 ^b	421
1-Item 15 ^a	26 ^b	320	13	157	*07	217	17 ^b	403	07	403	15 ^b	403
1-Item 16 ^a	22 ^b	320	16	157	*16 ^c	217	20 ^b	403	07	403	16 ^b	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 ^c	248	10	79	*10	120	15 ^c	248	08	248	14 ^c	248

^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.

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

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

Variables	CSC Test		Comm Test		Age		Educ		Σ AT		Σ Com	
	r	N	r	N	r	N	r	N	r	N	r	N
1-Super-----	-.07	231	.08	499	-.15 ^b	577	-.06	569	.12 ^b	577	-.12 ^b	577
2, 3, 4-Super-----	.07	185	-.05	343	-.14 ^b	371	-.08	363	.12 ^c	371	-.07	371
Sep-Not Sep ^a -----	.08	259	.01	584	-.18 ^b	672	-.08 ^c	664	.07	672	-.02	672
Halo-----	-.12	185	.11 ^c	424	-.19 ^b	489	-.07	482	.12 ^b	489	-.14 ^b	489
IPO-----	-.19 ^b	228	.02	509	.03	588	-.04	580	.07	588	-.08 ^c	588
JO-----	-.07	228	.10 ^c	509	-.06	588	-.02	580	.10 ^c	588	-.11 ^b	588
J Pot-----	-.02	188	.11 ^c	427	-.24 ^b	492	-.07	485	.15 ^b	492	-.12 ^b	492
J Per-----	-.01	227	.08	505	-.23 ^b	584	-.03	576	.10 ^c	584	-.11 ^b	584
Emot-----	.00	228	.09 ^c	509	-.19	588	-.04	580	.11 ^c	588	-.09 ^c	588
1-Item 15 ^a -----	.00	229	-.03	497	-.11 ^b	574	-.02	566	.01	574	-.06	574
1-Item 16 ^a -----	-.02	229	.06	497	-.22 ^b	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

^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.

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

Variables	CSC Test		Comm Test		Age		Educ		Σ AT		Σ Com	
	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 ^c	248	-.05	247	07	248	-.05	248
Sep-Not Sep ^a -----	00	222	-.01	336	-.15	466	-.11 ^c	464	-.04	466	04	466
Halo-----	24 ^b	155	10	258	-.13 ^c	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 ^c	194	07	302	-.18 ^b	414	-.03	412	05	414	00	414
Emot-----	17 ^c	197	13 ^c	307	-.13 ^b	421	-.06	419	08	421	-.03	421
1-Item 15 ^a -----	10	197	06	291	-.11 ^c	403	-.05	401	00	403	05	403
1-Item 16 ^a -----	14 ^c	197	07	291	-.16 ^b	403	-.07	401	03	403	-.03	403
2, 3, 4-Item 15 ^a ---	-.07	114	-.14 ^c	228	-.14 ^c	248	-.18 ^a	247	02	248	06	248
2, 3, 4-Item 16 ^a ---	01	114	-.08	228	-.10	248	-.07	247	07	248	02	248

^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 CSC-test 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 job- and 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.

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