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ABSTRACT

High rates of attrition among students in Undergraduate Navigator Training (UNT) is a major concern for Air Training Command. The main objective of this research was to evaluate the Basic Navigator Battery (BNB), a multi-test experimental selection instrument, for its potential to increase the validity of the Air Force Officer Qualifying Test (AFOQT) in predicting attrition among students in UNT. Three selection models were evaluated against four UNT performance standards. The three models consisted of AFOQT Nav-Tech composite score only (Model I), AFOQT Nav-Tech composite score plus other AFOQT composite scores (Model II), and AFOQT Nav-Test composite score, other AFOQT composite scores and BNB subtest scores (Model III). The four measures of UNT performance were training outcome, average classroom lesson score, average simulator lesson score, and average flying lesson score. Model III was found to have the highest predictive accuracy for all four performance standards; it also identified more unqualified candidates. It was concluded that BNB is useful in reducing UNT attrition through improved selection. Further research is suggested for better estimates of the stability and the validity of the test. The specific findings are illustrated in eight tables. (JAZ)

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BASIC NAVIGATOR BATTERY: AN EXPERIMENTAL SELECTION COMPOSITE FOR UNDERGRADUATE NAVIGATOR TRAINING

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The Basic Navigator Battery (BNB), a multi-test experimental selection instrument, was evaluated for its potential to increase the validity of the Air Force Officer Qualifying Test (AFOQT) in predicting graduation/elimination from Undergraduate Navigator Training (UNT). Two BNB subtests, the Pre-Nav and the Obstacles and Remedies, were found to contribute significantly to the predictive validity of the AFOQT Nav-Tech and Quantitative composites for overall training outcome. The Pre-Nav also added significantly to the validity of the AFOQT for predicting classroom, simulator, and flying training performance. Results are discussed in terms of the elimination rates projected by using two models limited to AFOQT composite scores and a third model which uses scores from both the AFOQT and BNB.

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SUMMARY

High rates of attrition among students in Undergraduate Navigator Training (UNT) continue to be a major concern for Air Training Command. In an effort to address this problem, research was conducted by the Air Force Human Resources Laboratory to reduce attrition by improving the method by which candidates are selected. Currently, UNT students are chosen primarily on the basis of their scores on the Navigator-Technical (Nav-Tech) composite of the Air Force Officer Qualifying Test (AFOQT). The present effort sought to determine the extent to which scores on an experimental selection battery, known as the Basic Navigator Battery (BNB), added to the quality of selection screening provided solely by the Nav-Tech composite score.

Three selection models were evaluated against four UNT performance standards. The three models examined consisted of AFOQT Nav-Tech composite score only (Model I), AFOQT Nav-Tech composite score plus other AFOQT composite scores (Model II), and AFOQT Nav-Tech composite score, other AFOQT composite scores and BNB subtest scores (Model III). The four measures of UNT performance were training outcome (graduation/elimination), average classroom lesson score, average simulator lesson score, and average flying lesson score.

Model III was found to have the highest predictive accuracy for all four performance standards. Compared to Models I and II, Model III identified more unqualified candidates. This model was also particularly good in predicting classroom and simulator performance, suggesting it may be useful as a diagnostic aid to identify students who may need remedial help during training.

The results of this effort provided preliminary evidence of the usefulness of the BNB in reducing UNT attrition through improved selection. Further research is necessary, however, to obtain better estimates of the stability and validity of this test and to develop new forms of the BNB before it could be used operationally.

PREFACE

This work was performed under Project 7719, Air Force Personnel System Development of Selection, Assignment, Evaluation, Quality Control, Retention, Promotion, and Utilization; Task 771918, Selection and Classification Instruments for Officer Personnel Programs, and responds to Request for Personnel Research (RPR) No. 78-12, Selection for Undergraduate Navigator Training, issued by Air Training Command. The authors wish to express their appreciation to Ben Roach, Debbie Rogers, and Gary McDaniel for their efforts in the initial development of this project.

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I. INTRODUCTION

Unacceptably high rates of attrition among students in the Undergraduate Navigator Training (UNT) Program have been a continuing concern for the Air Training Command (ATC). Loss of students in UNT represents a substantial cost to the Air Force both in terms of the waste of training resources and the subsequent difficulty in meeting operational manpower needs. While retention of all entering trainees is virtually impossible due to a variety of factors beyond the control of the Air Force, lower rates of attrition may be achieved by improving the screening/selection of trainees, and designing curriculum and instructional methods to optimize student learning. This report focuses on the former of these two approaches to minimizing the loss of students in UNT.

The most obvious method for reducing attrition among UNT trainees is through the initial selection of highly qualified candidates. Since World War II, trainees have been selected primarily on the basis of their scores on the Navigator-Technical (Nav-Tech) composite of the Air Force Officer Qualifying Test (AFOQT). The validity of this paper-and-pencil test for predicting success (i.e., passing) in UNT has been supported by previous research (Miller, 1966; Valentine & Creager, 1961).

In spite of the significant predictive validity of the AFOQT, continuously high trainee attrition rates have provided the impetus for research to identify supplemental and/or alternative selection instruments. Based on their multi-faceted investigation of the causes of turnover in UNT, DeVries, Yakimo, Curtin, and McKenzie (1975) recommended the implementation of a selection system which utilized AFOQT scores, as well as personality, interest, and cognitive ability measures. Subsequently, Valentine (1977) conducted a study designed to reassess the predictive validity of the AFOQT following changes in the UNT curriculum, and also to examine the potential validity of an experimental selection battery consisting of personality, interest, biographical, attitude, and cognitive ability measures. Improvements in the predictive validity of the AFOQT were achieved with some of the cognitive ability measures, but not with any of the noncognitive measures. On the basis of this research, Valentine recommended a revision of the Nav-Tech composite of the AFOQT to incorporate those measures which were significantly related to success in UNT.

The purpose of the present effort was to examine the potential usefulness of an experimental navigator selection battery, the Basic Navigator Battery (BNB), in increasing the predictive validity of the current navigator selection system. Specifically, this effort attempted to determine which, if any, of the subtests of the BNB added significantly to the overall predictive validity of the Nav-Tech composite of the AFOQT. The present study represented a significant departure from previous investigations of navigator selection in that, in addition to the standard pass/fail criterion of success in training, lesson grades for each phase of UNT were also used as criterion measures. Use of these lesson grades provides a more detailed analysis of the relationships between the predictors of interest (i.e., AFOQT, BNB) and specific phases of UNT training.

II. APPROACH

Subjects

Air Force officers entering UNT (course N-V6A-F) at Mather AFB, California, during the 1980 calendar year (CY80) served as subjects. This sample was comprised of UNT classes 80-18 through

81-17. Of the 800 officers who went through the program during this period, relatively complete data were available for 544, who comprised the sample analyzed in this report.

Predictor Variables

Two sets of predictor variables were examined. The first consisted of the five composites (Pilot, Navigator-Technical, Academic Aptitude, Verbal, and Quantitative) of the AFOQT. Common metric percentile scores (Roach & Rogers, 1982) for these subtests were obtained from historical personnel records. The second set of predictors was the percentage scores from the five subtests of the BNB. The BNB was administered to all subjects 1 week prior to the beginning of their assigned training class. The BNB subtests were as follows:

Pre-Nav (PE7935) -- a 40-item, multiple-choice test measuring mathematical reasoning ability within the context of navigational problem solving. This test was originally designed as a diagnostic instrument for identifying students in need of remedial mathematics training.

Information Processing (PE7935) -- a 30-item test of perceptual reasoning, divided equally between hidden figures items and figure analogy items. Hidden figures is a template-matching task that requires the subject to locate a simple geometric figure embedded within a complex drawing. Figure analogies is a test of symbolic logic in which the subject must first discern the logic of a relationship (i.e., shape, size, axis rotation) between a pair of sample geometric figures, and then apply this logic in attempting to match a target stimulus figure with one of five alternatives.

Obstacles and Remedies (PE7933/7934) -- an 80-item speeded test that measures the subject's ability to follow a set of procedures. The subject's task is to apply a set of rules and priorities in removing sets of obstacles encountered along an imaginary path.

Simulated Navigation Mission (PE7936/7938) -- a test that requires the subject to plot the location of an aircraft at 10 points during a "mission." Radio signals generated at two locations, flying time, wind speed, wind direction, and altitude are provided to the subject for use in calculating aircraft locations. At each location, the subject must compute both the distance travelled since the last reading and the aircraft speed, as well as answer questions about fuel consumption.

Rotated Letters (PE7932) -- a speeded test in which the subject must judge whether each of 288 pairs of rotated letters is in the same orientation or whether they are mirror images.

Descriptive statistics for all of the predictor variables are presented in Table 1.

Criterion Variables

Two types of variables were used as indicators of UNT performance. The first was a single dichotomous measure of overall training outcome, scored 0 for elimination, 1 for graduation. The second type of indicator consisted of summary variables for each of the three phases of training (i.e., classroom, simulator, and flying lessons). These summary variables were formed by averaging the individual lesson grades for each phase of training. Descriptive statistics for these summary scores and the individual lesson grades are provided in Table 2.

Table 1. Descriptive Statistics for Predictor Variables

	Mean	SD	N
AFOQT Composites			
1. Pilot	61.33	22.75	544
2. Navigator-Technical	56.07	22.55	544
3. Academic Aptitude	64.17	22.71	544
4. Verbal	63.00	23.84	544
5. Quantitative	62.45	22.52	543
Basic Navigator Battery Composites			
1. Pre-Nav	69.34	15.03	544
2. Information Processing	54.72	17.29	544
3. Obstacles and Remedies	58.38	18.51	543
4. Simulated Navigation Mission	50.86	22.10	544
5. Rotated Letters	68.93	15.67	542

Table 2. Descriptive Statistics for Criterion Variables
(Individual Lesson Grades and Composite Lesson Grades)

	Mean	SD	N
UNT Lessons			
1. Aerospace Physiology	92.57	5.58	544
2. Airmanship	93.34	6.18	544
3. Advanced Airmanship	89.31	7.50	541
4. Weather	93.16	7.09	540
5. Navigation Procedures	88.70	11.07	538
6. Basic Navigation	93.03	6.27	509
7. Day Celestial	85.08	11.64	487
8. Night Celestial	92.18	6.80	469
UNT Simulator Lessons			
9. Navigation Procedures T-45	86.81	13.95	527
10. Basic Navigation T-45	81.05	12.68	505
11. Tactical Navigation T-45	88.31	9.41	456
UNT Flying Lessons			
12. Radar T-43	85.42	10.52	493
13. Day Celestial T-43	84.59	10.75	475
14. Night Celestial T-43	86.39	10.39	467
15. Tactical Navigation T-37	89.43	8.65	460
UNT Graduation/Elimination[a]	.84	.37	544
UNT Composite Scores			
1. Classroom Lessons	90.77	5.14	538
2. Simulator Lessons	85.29	8.52	505
3. Flying Lessons	86.62	5.67	467

[a]Coded 1 if graduate; 0 if eliminee.

Data Analysis

The data were analyzed with hierarchical multiple regression procedures. A separate analysis was conducted for each of the four measures of UNT performance (i.e., overall training outcome, classroom grades, simulator grades, flying grades). Entry order of the predictor variables in each regression was determined as follows. The Nav-Tech composite of the AFOQT was entered on the first step of each regression, since it was used to select candidates for UNT. The four remaining AFOQT composites were then analyzed to determine if they individually added to the predictive validity of the Nav-Tech composite. The significance of the contribution of each of the four AFOQT composites to the Nav-Tech-based prediction equation was assessed with F-tests. Those composites which added significantly to the amount of criterion variance accounted for were subsequently entered into an AFOQT-based prediction equation in descending order of the magnitude of their contribution.

After delineating the final AFOQT-based prediction equation, the five subtests of the BNB were assessed for their potential contributions toward increasing the amount of variance accounted for in each of the UNT performance measures. As in the preceding analysis, F-tests were used to determine the significance of the increase in predictive validity resulting from the addition of each BNB subtest to the AFOQT equation. Those subtests which produced a significant increase were entered into a final prediction equation, again in descending order of the increase produced.

It should be noted that the correlations used in the regression analyses were not corrected for the restriction in test score variance which is likely to result from the use of a sample that is pre-selected on one of the predictors of interest (i.e., AFOQT Nav-Tech scores in the present study). Since this study used a design in which all subjects had been pre-selected for UNT prior to testing on the BNB, it was to be expected that the magnitude of the validity coefficients would be attenuated to a certain degree. Thus, it is reasonable to assume that in a sample unrestricted by pre-selection effects, the strength of the resulting validity coefficients would be larger than those evidenced in the present study. However, the procedures used in this study do address the primary concern; i.e., whether or not the BNB has the potential to improve the selection of UNT candidates over and above that which can be expected with the AFOQT already in use.

III. RESULTS AND DISCUSSION

The zero-order correlations among all predictor and criterion variables are presented in Table 3. All of the AFOQT and BNB subtests, with the exception of the BNB Rotated Letters subtest, were found to correlate significantly ($p < .05$) with the graduation/elimination (grad/elim) performance measure. Similar results were obtained for the classroom lesson grades criterion. All AFOQT composites and BNB subtests correlated significantly ($p < .05$) with simulator lesson grades, and all but the AFOQT Verbal composite correlated significantly with the flying grades criterion.

The results of the hierarchical regression analyses are presented in Tables 4 through 7. Overall, these tables provide evidence that the validity of the AFOQT Nav-Tech composite can be improved significantly by including scores from selected AFOQT composites and BNB subtests in the selection decision.

Table 4 summarizes the results for the prediction of the overall training outcome. This table shows that adding three predictors (AFOQT Quantitative, BNB Pre-Nav, BNB Obstacles and

Table 3. Zero-Order Correlations Among Predictor and Criterion Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
AFOQT														
1. Pilot	-													
2. Nav-Tech	73	-												
3. Academic	37	51	-											
4. Verbal	22	34	83	-										
5. Quantitative	38	58	76	38	-									
BNB														
6. Pre-Nav	47	53	53	36	56	-								
7. Information Processing	37	46	31	27	31	43	-							
8. Obstacles and Remedies	24	35	18	10	26	30	19	-						
9. Simulated Navigation Mission	39	51	44	29	50	53	33	34	-					
10. Rotated Letters	23	32	10	08	13	23	26	31	20	-				
11. Grad/Elim	16	17	16	10	19	25	14	17	21	02x	-			
12. UNT Classroom Lessons Grade	30	37	36	22	40	49	25	23	37	01x	48	-		
13. UNT Simulator Lessons Grade	26	29	24	11	32	42	21	26	33	14	[illegible]	51	-	
14. UNT Flying Lessons Grade	21	24	09*	01[a]	14	27	18	17	22	09*	20	33	42	-

Note. Decimal points omitted. For each correlation, n varied from 536-547. All correlations significant for $p \leq .01$ unless otherwise noted.

[a]Nonsignificant correlation.

$*p \leq .05$.

Table 4. Prediction of Graduation/Elimination from UNT

Predictors	R	R^2	R^2 Change
AFOQT Nav-Tech	.15	.023	
AFOQT Nav-Tech + AFOQT Quantitative	.20	.039	.016**
AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav	.25	.063	.024**
AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav + BNB Obstacles and Remedies	.27	.071	.007*

Note. N = 542.

$*p < .05$.

$**p < .01$.

Remedies) to the AFOQT Nav-Tech-based prediction equation significantly raised the coefficient of multiple correlation (R) from .15 to .27, thus increasing the amount of variance accounted for (R^2) in the graduation/elimination outcome measure.

Table 5 summarizes the results of the analysis for the prediction of the UNT classroom lesson grades performance. As in the analysis of the grad/elim outcome, using the AFOQT Quantitative composite and both the Pre-Nav and Obstacles and Remedies subtests of the BNB significantly increased the predictive validity provided solely by the Nav-Tech composite. The BNB Rotated Letters subtest also provided a significant increase in overall predictive validity. The Nav-Tech composite alone had a correlation of .36 with classroom performance, whereas a prediction equation incorporating the Nav-Tech composite plus the other four predictors identified by this analysis had a multiple correlation of .54.

The results of the regression analysis for the prediction of the simulator lesson grades are presented in Table 6. Two AFOQT composites (Quantitative and Pilot) and three BNB subtests (Pre-Nav, Obstacles and Remedies, Simulated Navigation Mission) produced significant increases to the level of prediction provided solely by the Nav-Tech composite. Addition of the two other AFOQT composites significantly raised the correlation from .29 to .35. Adding the three BNB subtest scores to the prediction equation further significantly raised the correlation to .46.

Table 7 presents the results of the regression analysis for the prediction of flying lesson grades. The Nav-Tech composite had a correlation of .24 with these grades. The addition of the AFOQT Verbal composite and the BNB Pre-Nav subtest significantly raised the correlation to .33.

Table 5. Prediction of Average UNT Classroom Lesson Grades

Predictors	R	R^2	R^2 Change
AFOQT Nav-Tech	.36	.127	
AFOQT Nav-Tech + AFOQT Quantitative	.43	.182	.055**
AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav	.51	.265	.083**
AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav + BNB Rotated Letters	.53	.283	.018**
AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav + BNB Rotated Letters + BNB Obstacles and Remedies	.54	.289	.006*

Note. $N = 534$.
*$p \leq .05$.
**$p \leq .01$.

Table 6. Prediction of Average UNT Simulator Lesson Grades

Predictors	R	R^2	R^2 Change
AFOQT Nav-Tech	.29	.082	
AFOQT Nav-Tech + AFOQT Quantitative	.34	.116	.034**
AFOQT Nav-Tech + AFOQT Quantitative + AFOQT Pilot	.35	.126	.009*
AFOQT Nav-Tech + AFOQT Quantitative + AFOQT Pilot + BNB Pre-Nav	.43	.187	.061**
AFOQT Nav-Tech + AFOQT Quantitative + AFOQT Pilot + BNB Pre-Nav + BNB Obstacles and Remedies	.45	.205	.018*
AFOQT Nav-Tech + AFOQT Quantitative + AFOQT Pilot + BNB Pre-Nav + BNB Obstacles and Remedies + BNB Simulated Navigation Mission	.46	.214	.009*

Note. *N* = 505.
*$p \leq .05$.
**$p \leq .01$.

Table 7. Prediction of Average UNT Flying Lesson Grades

Predictors	R	R^2	R^2 Change
AFOQT Nav-Tech	.24	.058	
AFOQT Nav-Tech + AFOQT Verbal	.26	.068	.01*
AFOQT Nav-Tech + AFOQT Verbal + BNB Pre-Nav	.33	.108	.04**

Note. *N* = 467.
*$p \leq .05$.
**$p \leq .01$.

IV. CONCLUSIONS AND RECOMMENDATIONS

The major findings of this effort can be summarized as follows:

1. The Nav-Tech composite of the AFOQT was a significant predictor for all four UNT performance criteria examined.

2. The predictive validity of the Nav-Tech composite was significantly increased for each criterion measure by the addition of at least one other AFOQT composite. The Quantitative composite provided a significant increase in the predictive validity for three of four criteria (i.e., grad/elim, classroom grades, simulator grades).

3. The predictive validity of the Nav-Tech and the other selected AFOQT composites was significantly increased for all criteria by the addition of certain BNB subtests to the prediction equation. The Pre-Nav subtest produced a significant increase in predictive validity for all four criteria, while the Obstacles and Remedies subtest significantly incremented the predictive validity for three of four criteria (i.e., grad/elim, classroom grades, simulator grades).

These results provide preliminary evidence that the predictive validity of the current selection system for UNT trainees can be improved by adding information from the AFOQT Quantitative composite and at least two BNB subtests to the selection decision process. The practical implications of the potential increase in predictive validity are illustrated in Table 8. This table shows the percentage of trainees in the present sample which would have been correctly or incorrectly rejected using the three prediction models identified in the analysis of UNT graduation/elimination. The upper portion of the table summarizes the percentage of eliminees in the sample who would have been correctly rejected (i.e., true negatives) by rank-ordering the candidates by their final prediction equation scores and then using one of three different percentile scores as a cutoff point. These percentages, therefore, are indicative of the relative efficiency of each model at correctly screening out unqualified UNT candidates. Model I, containing only the AFOQT Nav-Tech composite, screened the lowest percentage of eliminees at all percentile score levels. Model III, containing the AFOQT Nav-Tech and Quantitative composites, and BNB Pre-Nav and Obstacles and Remedies scores, correctly screened the largest percentage of unqualified candidates at all the percentile scores.

The lower portion of Table 8 provides data on the percentage of UNT graduates who would have been incorrectly rejected (i.e., false positives) by each model for three percentile cutoff scores. Because these percentages represent each model's efficiency in minimizing the incorrect rejection of qualified candidates, smaller percentages indicate greater efficiency. These comparisons revealed very little difference among the three models at any of the percentile cutoff scores. Essentially, all three models were equivalent in their rates of incorrectly rejecting candidates who would successfully complete UNT. Overall, considering the correct and incorrect rejection characteristics of all three models, Model III appears to be the best available selection system at the present time.

Although these results are encouraging, incorporation of the changes suggested by this study into the present system for selecting navigator trainees would be premature at this time. Additional research on the BNB is needed in two areas. First, the psychometric characteristics of the BNB subtests, such as internal consistency, should be assessed at a more in-depth level than was possible in the present study since only total test scores, not individual item data, were available for each subtest. Second, the unique predictive validity of the BNB subtests should be assessed when they are given at the same time as the AFOQT. In the present study, because of testing limitations, the BNB was given to UNT candidates 1 week prior to their training whereas the AFOQT was administered, for operational selection purposes, several months

Table 8. Comparative Rejection Rates for Three UNT Selection Models

	Percentile		
	10th	20th	30th
I. Percentage of Actual Eliminees Rejected			
Model I. AFOQT Nav-Tech	11.5%	28.7%	41.4%
Model II. AFOQT Nav-Tech + AFOQT Quantitative	16.3%	39.5%	44.2%
Model III. AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav + BNB Obstacles and Remedies	27.1%	43.5%	55.3%
II. Percentage of Actual Graduates Rejected			
Model I. AFOQT Nav-Tech	7.4%	16.4%	25.6%
Model II. AFOQT Nav-Tech + AFOQT Quantitative	7.7%	16.8%	25.6%
Model III. AFOQT Nav-Tech + AFOQT Quantitative + BNB Pre-Nav + BNB Obstacles and Remedies	7.7%	16.8%	24.1%

prior to training. The effects of this time difference could not be accounted for in the present effort. A follow-on study with concurrent administration of the AFOQT and BNB could provide the data necessary to address both areas of concern.

Three recommendations for future navigator selection research are offered. First, a study should be conducted in which simultaneous data collection on all predictor measures is possible. Optimally, all tests would be given to UNT applicants prior to their operational selection. This type of design would allow for an assessment of the unique predictive validity of the BNB and also provide an estimate of the distribution of BNB test scores within the applicant pool. However, because of applicant testing time constraints, this approach might not be feasible. A fall-back approach would be to re-test UNT selectees on the AFOQT and administer the BNB just prior to training. Although this design would not provide a good estimate of the applicant pool BNB score distribution, it would answer the major question about the unique predictive validity of the BNB when administered with the AFOQT.

The second recommendation is to begin the development of new forms of the BNB. The current version could not be used operationally because it has been available for several years as an uncontrolled test. Therefore, it is likely that an unacceptable level of test compromise (i.e., applicants having access to test questions) would prevent its operational use. For operational use, new versions would have to be developed and protected from compromise such that applicants' scores would reflect their true abilities rather than their familiarity with the test.

The third recommendation is more general. Future efforts in navigator selection research might benefit from ongoing research in the field of computerized selection testing. As part of a program to improve pilot selection, a computerized test system has been developed to measure information processing capabilities, psychomotor abilities, and certain personality characteristics. A similar computerized system, adapted specifically for navigator selection, might further increase the accuracy of prediction over that obtainable from conventional paper-and-pencil tests such as the AFOQT and BNB.

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