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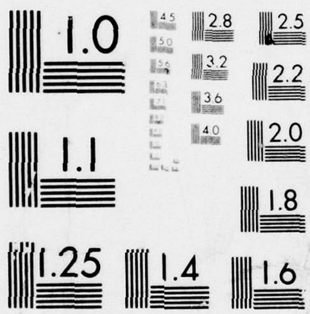

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AIR FORCE HUMAN RESOURCES LABORATORY

PREDICTING JOB DIFFICULTY IN HIGH APTITUDE CAREER LADDERS WITH STANDARD SCORE REGRESSION EQUATIONS

By

Kenneth G. Koym

OCCUPATION AND MANPOWER RESEARCH DIVISION
Lackland Air Force Base, Texas 78236

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AIR FORCE SYSTEMS COMMAND
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This technical report has been reviewed and is approved for publication.

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Occupation and Manpower Research Division

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized Occupational Data Analysis Program (CODAP)
hierarchical grouping
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was designed to validate a method for evaluating the difficulty levels of Air Force enlisted jobs. Multiple regression equations which captured the job difficulty evaluation policy of supervisors in two electronics and two general career ladders were produced. The equations yielded predicted difficulty values for 250 jobs from each career ladder. These values correlated above .81 with supervisory rankings of job difficulty validating the findings of previous job difficulty studies conducted in 12 Air Force career ladders. Various constant standard weight equations were developed and compared. Of these, an equation derived from all 16 career ladders offered valid predictions when it was applied in the electronics area. Although this 16-ladder equation showed no significant improvement over the 12-ladder equation, it has wider applicability than the 12-ladder equation currently in use.

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Item 20 Continued:

The 16-ladder equation is recommended as a replacement because it is based upon results from all four aptitude areas and because it has been successfully applied in career ladders with both high and low aptitude entrance requirements.

PREFACE

This research was initiated under project 7734, Occupational and Career Management, task 773407, Development and Appraisal of Methods for Job Evaluation. The analyses were completed under task 773407, Development and Assessment of Methods for Determining the Requirements of Air Force Jobs; work unit 77340701, Development of Methods for Specifying Education, Training Aptitude, and Experience Requirements for Air Force Jobs.

Technical assistance and suggestions have been made by Mr. William Titsworth and Drs. Llewellyn N. Wiley and Raymond E. Christal. Appreciation is expressed to Mr. William B. Lecznar for advice given during the development of job and task difficulty measures.

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I. INTRODUCTION

Determining the relative difficulty of jobs has long been a desired product in the area of job evaluation (Kelday, 1922). Recently a method for developing a comparative measure of job difficulty has been produced (Lecznar, 1971; Mead, 1970a, 1970b; Mead & Christal, 1970). The method predicts ranked difficulty of whole job descriptions with three job content variables. This capability has made it possible to undertake Air Force objectives which have affected enlisted force personnel, career planning, and personnel management research (Christal, 1972,1974; Wiley, 1972).

The methodological studies by Mead (1970a, 1970b) and Mead and Christal (1970) used equations involving task difficulty ratings as predictors to account for the rank order values assigned by noncommissioned officers (NCOs) to 250 job descriptions in three career ladders. These ladders were Medical Materiel, Accounting and Finance, and Vehicle Maintenance. The resulting multiple Rs were .95 for the first two ladders and .93 for the last. Similarities among the equations indicate that a single common equation would approximate the job difficulty rankings in all three career ladders. A standard weight equation was applied and found to retain the R value of .95 for the first two ladders and to drop to .92 for the last.

Subsequently, ladder-specific equations were developed in nine additional career ladders and used to study the difficulty of jobs performed by first-term airmen (Wiley, 1972, p. 4). Although these 12 career ladders involved jobs of differing composition and complexity, the same three predictors were found suitable. An alternate constant standard weight equation was developed (based on the 12 ladders) but remained to be tested in more technical occupational specialties (Christal, 1974, p. 15). Additional studies involving four career ladders were considered necessary before extending the applications of the constant standard weight equation.

The present study applies and expands the job difficulty research methodology in career ladders which require entering personnel to possess high aptitude in the general and the electronics areas. The critical question asked by this study was: Will a generalized equation for job difficulty determination apply to select career ladders with electronics or general aptitude entrance requirements of 80 or above? The specific objectives of the investigation were:

1. To provide equations for evaluating jobs which are based on three job content variables for the Aircraft Control and Warning (AC&W) Radar, Ground Radio Communications, Weather Observer, and Information Specialist career ladders.

2. To test the predictive effectiveness of the constant standard weight equations when applied in these four career ladders.

3. To compare the predictive effectiveness of the constant standard weight equations with that of each specific ladder equation.

II. METHOD

Job and task difficulty measures were developed using various features of other job evaluation procedures (Christal, 1967; Mead & Christal, 1970). Job descriptions were selected and arranged, then ranked in varying random order contexts by supervisory personnel to develop job difficulty criterion measures. Task difficulty ratings were obtained to develop predictor variables being examined by multiple regression analysis. An analysis design for testing the predictive effectiveness of various constant standard weight equations (including the Mead and Christal equation) was developed in keeping with objective 3 given previously.

Selection and Arrangement of Job Descriptions

Two-hundred fifty job descriptions were randomly selected from all jobs identified in each of the four career ladder occupational surveys as given in Table 1. To control for context effects, job descriptions were randomly placed in varying contexts. Sixteen different contexts were developed, each containing ten, 25-job-description

Table 1. **Population and Survey Characteristics**

Career Ladders	Number of Jobs Surveyed	Number Tasks in Inventory	Aptitude Entrance Requirement
AC&W Radar	1,375	456	Electronics 80
Ground Radio Communications	2,112	326	Electronics 80
Weather Observer	1,549	441	General 80
Information Specialist	616	388	General 80

subsets using the Individual Job Description (JOBIND) sample selection routine of the Comprehensive Occupational Data Analysis Programs (CODAP), developed by Stacey, Weissmuller, Barton, and Rogers (1974).

Each job description was printed for distribution in the above arrangement. The printed job descriptions each contained an identification number, a list of tasks, the percent of time job incumbents spent performing each, and the cumulative time spent, under respective columnar headings.

Development of Job Difficulty Criterion Measures

One-hundred sixty 7-skill level and 9-skill level noncommissioned officers (NCO) working in each career ladder were requested to evaluate the relative difficulty of the job descriptions of the respective career ladders. This request was made by mail through consolidated base personnel office (CBPO) personnel who were requested to select the desired number of NCOs.

Each of the 640 individuals was provided a packet of materials which included one subset of 25 job descriptions, and instruction sheet, a ranker background information sheet, and a job ranking sheet. The NCOs were requested to carefully review each of the 25 job descriptions and rank order them according to relative difficulty.

Development of Task Difficulty Measures

A job inventory containing all tasks (see Table 1) for each career ladder was constructed; each inventory contained a relative difficulty rating scale. The respective inventory booklets were printed with the 7-point relative difficulty scale at the top of each page for ready rater reference. Task difficulty was defined as time required to learn to do the task satisfactorily.

Personnel with 7- and 9-skill level Air Force specialty codes (AFSC) in these four career ladders provided ratings on relative difficulty of the task statements. These personnel completed the inventories under the direction of CBPOs.

Development of Predictor Variables

In keeping with the Mead and Christal (1970) methodological study, three predictors were developed in all four ladders based on the assumption that they would yield efficient prediction. Predictor 1 was the number of tasks in the job, and predictor 2 was the number of tasks squared. Inclusion of the squared term was necessary because Mead and Christal (1970) found a curvilinear relationship between the number of tasks in jobs and their perceived difficulty levels. Predictor 3 was a complex variable reflecting the average difficulty level of tasks performed per unit time spent. This variable was computed as simply the cross-products of time spent and task difficulty, summed across all tasks in the inventory for a particular job. Additional variables were developed in the electronics ladders using task difficulty measures.

Analysis of Supervisors' Judgment Policy

The predictor variables were analyzed by multiple regression to capture the supervisors' job difficulty evaluation policy. These problems were hypothesized as containing the most logical grouping of predictors for the current study on the basis of the earlier results. For each problem, R and R^2 values were derived.

In the electronics ladders, variables were considered and withdrawn from these groupings to observe their effects upon criterion variance (R^2) accounted for by such modifications. These computations provided the most feasible predictors and associated weights relative to the supervisors' judgment of job difficúlt.

Test of Constant Standard Weight Equations

To reflect an estimate of the predictive effectiveness of various constant standard weight equations (see Section IV), indices of job difficulty were derived for each equation respectively and correlated with the criterion job rankings provided by supervisors. This revealed an estimate of the difference in effectiveness between the R derived from the standard score weights for the specific equation for each ladder and the R obtained by use of standard score weights from each constant standard weight equation. The constant standard weight equations being tested were developed by taking the arithmetic average of the standard score weights of selected ladder-specific multiple regression equations.

III. RESULTS

Job Difficulty Criterion Measures

Criterion measures were derived by computing a mean of the rank order values assigned to each job by supervisors in the respective career ladders. As shown in Table 2, of the 160 ranking packets mailed to evaluators in each career ladder, 100 (63%) to 130 (81%) of the packets were returned for analysis. The number of rankings per job description varied from 8 to 16, with most jobs receiving 10 or more evaluations. The estimated reliability of these ranking judgments was computed using the components of variance technique as it appears in the Computerized Occupational Data Analysis Program (CODAP) Interrater Reliability (REXALL) program (Stacey, Weissmuller, Barton, & Rogers, 1974). The Spearman-Brown formula was applied to the derived (R_{11}) values to obtain reliability estimates. The reliability estimates for all four ladders are presented in Table 2. The total sample and a reduced sample size are reported for the AC&W Radar and Ground Radio Communications ladders. The reduced sized samples were created to observe the effect of removing deviant raters.

Table 2. **Estimated Reliability Coefficients for Mean Job Difficulty Rankings by Differing N Judges**

Ladder	Total Group				Reduced Size Group[a]			
	N rankers	R_{11}[b]	k	R_{kk}[c]	N rankers	R_{11}	k	R_{kk}
AC&W Radar	126	.168	12.60	.718	101	.302	10.10	.814
Ground Radio Communications	130	.403	13.00	.898	123	.478	12.30	.919
Weather Observer	102	.722	10.20	.964				
Information Specialist	100	.765	10.00	.970				

[a]Examined in electronics ladders only.
[b]Intraclass correlation coefficient.
[c]Spearman0Brown correlation coefficient.

Supervisor agreement concerning the relative difficulty of jobs ranked varied in the four ladders. However, the reliability estimates approximate those obtained in the 12 other ladders (Mead, 1970a, 1970b; Mead & Christal, 1970; Wiley, 1972). These findings appear to warrant the use of multiple regression analysis to capture the supervisor ranking policies.

Thereafter a refining process was applied in the two electronics ladders to the criterion measures. In this process each rank value for each of the 25 jobs evaluated by a supervisor was correlated with the mean rank value obtained from all supervisors. In turn, a *t* test of significance was applied to determine if any supervisor judgment deviated significantly from the mean rank values. Cases with nonsignificant t values (N = 7 in the Ground Radio Communications ladder and N = 25 in the AC&W Radar ladder) were removed; then the criterion measures and reliability estimates were recomputed. With the rank values for those cases removed, additional interrater reliability estimates were computed. Table 2 reports these much improved R_{11} and R_{kk} values. As indicated, a refined form of the criterion measure was developed for the AC&W Radar and Ground Radio Communications ladders. These criteria are considered in the following problems.

Task Difficulty Ratings

A difficulty value was computed for each task from rating booklets returned by supervisors in the four career ladders. The intraclass correlation technique in the CODAP REXALL program (Stacey et al., 1974) was used to compute the estimates of reliability. These estimates are presented in Table 3. The reliability estimates obtained for each ladder were quite similar. In the Electronics ladders, a noticeable improvement in the R_{11} value was obtained for the total group by removing a number of disparate cases which did not correlate appreciably with the mean task values for all raters. Using the definition of task difficulty and the 7-point scale employed in these studies, results indicate that NCOs provide stable measures.

Table 3. **Estimated Reliability of Task Difficulty Measures**

Career Ladder	K	R_{11}	R_{kk}
AC&W Radar	82	.28	.97
AC&W Radar (reduced N)	78	.33	.98
Ground Radio Communications	94	.25	.97
Ground Radio Communication (reduced N)	89	.30	.97
Weather Observer	78	.26	.96
Information Specialist	54	.24	.94

Development of Job Difficulty Prediction Equations

Three predictor variables were analyzed concerning their potential for use in a regression equation to provide job difficulty values similar to the supervisors' ranking policies. The three predictors obtained by Mead (1970a, 1970b) were found to be efficient in these regression equations. The correlation between the derived and criterion job difficulty values yielded: R^2 = .86 for AC&W Radar; R^2 = .93 for Ground Radio Communications; R^2 = .79 for Weather Observer; and R^2 = .86 for the Information Specialist career ladder.

Resulting equations are given in Table 4 with those equations obtained in the 12 other ladders. The standard score weights for the predictor variables are reasonably uniform over all 16 ladders.

IV. DEVELOPMENT AND ANALYSIS OF CONSTANT STANDARD WEIGHT EQUATION

Various constant standard weight equations were developed and tested for predictive effectiveness in the AC&W Radar and Ground Radio Communications career ladders. In this process predicted job difficulty values were computed using each constant standard weight equation. The predicted values obtained for each equation were then correlated with the criterion measure and tested for significant differences using the F statistic. A constant standard weight equation was selected based on the results.

The standard score weights for the three variables were drawn from each ladder-specific equation (as required to create a particular constant standard weight equation) and mean standard score weights were successively computed. The mean standard score weights (for four constant standard weight equations) were applied to the predictor data from each of the two career ladders to derive job difficulty indices (JDI) using the formula,

Table 4. **Predictors and Associated Standard Score (SS) Weights**

Career Ladder	Number of Tasks Performed	Squared Number of Tasks Performed	Average Task Difficulty per Unit Time Spent
1. Vehicle Maintenance	1.2913	−0.6153	0.5161
2. Medical Materiel	1.1258	−0.5867	0.4526
3. Accounting and Finance	1.5851	−0.9584	0.3923
Mead and Christal SS Equation	1.3341	−0.7201	0.4537
4. Security Police	1.2152	−0.6925	0.4901
5. Administration	1.5143	−0.7825	0.2427
6. Materiel Facilities	1.4724	−0.8707	0.3310
7. Inventory Management	1.8287	−1.1442	0.2236
8. Fuel Services	1.3686	−0.8188	0.4967
9. Transportation	1.6957	−1.0797	0.3039
10. Fire Protection	0.9389	−0.5065	0.6659
11. CE Structural/Pavements	1.3874	−0.7706	0.2806
12. Electrical Power Production	1.6607	−0.9411	0.2059
SS Equation for 12 Career Ladders	1.4237	−0.8139	0.3834
13. AC&W Radar	1.8139	−1.0511	0.4814
14. Ground Radio Communications	1.4824	−0.7789	0.2479
15. Weather Observer	0.9525	−0.3484	0.7020
16. Information Specialist	1.7444	−0.9732	0.1750
SS Equation for 16 Career Ladders	1.4431	−0.8236	0.4010

$$Y = \frac{\beta_1 \sigma_c X_1 - \overline{X}_1}{\sigma_1} + \frac{\beta_2 \sigma_c X_2 - \overline{X}_2}{\sigma_2} + \frac{\beta_3 \sigma_c X_3 - \overline{X}_3}{\sigma_3} + C,$$

where

Y = job difficulty index (JDI)

σ_c = standard deviation of criterion job difficulty

X_1 = number of tasks performed (NTSK)

$\overline{X}_1$ = mean number of tasks performed

β_1 = constant standard score weight for X_1

σ_1 = standard deviation of X_1

X_2 = squared number of tasks performed (SNTSK)

$\overline{X}_2$ = mean squared number of tasks performed

β_2 = constant standard score weight for X_2

σ_2 = standard deviation of X_2

X_3 = average task difficulty per unit time spent (ATDPUT)

$\overline{X}_3$ = mean average task difficulty per unit time spent

β_3 = constant standard score weight for X_3

σ_3 = standard deviation of X_3

C = mean criterion job difficulty value obtained by combining the ranked scores for each ladder involved. These values were obtained with a McNemar technique (1962, p. 18).

Each set of the JDIs computed with the constant standard weight equations permitted a comparison and a possible maximization of the correlations between the predicted values and supervisors' evaluations. These correlations and associated F tests are reported in Table 5. They indicate that each constant standard weight equation approximated the predictive efficiency of the ladder-specific equations. As far as the variances are concerned, any one of the equations

Table 5. **Multiple Correlations and F Ratios[a] Comparing Specific Versus Generalized Equations**

Equations	AC&W Radar			Ground Radio Communications		
	R^2	R	F ratio	R^2	R	F ratio
Ladder-Specific Equations	.698	.836		.825	.909	
Three-Ladder Equation	.688	.829	1.03	.788	.888	1.21
Twelve-Ladder Equation	.689	.830	1.03	.803	.896	1.12
Two-Ladder Electronics Equation	.689	.829	1.03	.819	.904	1.04
Sixteen-Ladder Equation	.698	.835	1.00	.807	.898	1.10

[a]Nonsignificant at the .02 level for df = 249. F ratios were obtained using Guilford's (1956) formula 10.11, larger variance/smaller variance $(1 - R^2_G/1 - R^2_L)$.

could have represented the populations almost as well as the ladder-specific equations.

In Table 5, it is apparent that there would be no advantage to develop separate constant standard weight equations for each aptitude entrance requirement area. The R^2s and F ratios for the two-ladder electronics equations were no better than the 12- or the 16-ladder equations.

To further insure that some other combination of career ladders would not produce a better constant standard weight equation, the 16 ladder-specific equations (given in Table 4) were hierarchically grouped using the Bottenberg and Christal (1961) technique. The results indicated that five groups of career ladders (equations) would be required to increase the overall R^2 by .03 from .84. This small increase in predictive efficiency made it impractical to consider pursuing a separate equation for each aptitude area.

Therefore, it was of interest to closely compare the predictive effectiveness of the 12- and the 16-ladder constant standard weight equations with the ladder-specific (or least squares) equation for each ladder. The multiple correlations (Table 6) for the 12- and the 16-ladder equations are in close agreement. They also compare favorably with the multiple correlations for the ladder-specific (least squares) equations.

It is interesting that the original 12-ladder equation held up when it was applied to each of the 16 ladders. Only practical considerations would suggest that the 16-ladder equation should be used over the 12-ladder equation.

Table 6. **Ladder by Ladder Comparisons of Least Squares Equations with Two Standard Weight Equations**

Career Ladders		Least Squares R	16 AFSC Mn SS Weights R	12 AFSC Mn SS Weights R
811X0	Security Police	.9215	.9132	.9138
702X0	Administrative	.9772	.9714	.9705
647X0	Supply Materiel Facilities	.9417	.9402	.9404
645X0	Inventory Management	.9358	.9173	.9170
631X0	Fuel Services	.9420	.9349	.9359
605X0	Transportation	.9305	.9229	.9235
571X0	Fire Portection	.9390	.8867	.8879
551X0	CE Structural/Pavements	.9285	.9264	.9260
543X0	Electrical Power Production	.9374	.9235	.9226
473X0	Vehicle Maintenance	.9269	.9158	.9153
915X0	Medical Materiel	.9487	.9450	.9450
671X0	Accounting & Finance	.9511	.9499	.9503
252X0	Weather Observer	.8870	.7966	.7972
791X0	Information Specialist	.9296	.8983	.8964
303X0	AC&W Radar	.8356	.8353	.8355
304X4	Ground Radio Communications	.9086	.8984	.8970

V. CONCLUSIONS AND IMPLICATIONS

Job and task difficulty measures were developed in the four career ladders studied. The supervisor job evaluation policies were captured in each ladder in a three-variable multiple regression equation. The results from the four career ladders added by this study were considered sufficiently efficient when grouped with results obtained in 12 other career ladders to develop a comprehensive constant standard weight equation. This comprehensive equation was based upon standard score weights developed in 16 career ladders representative of the four aptitude areas (General, Administrative, Mechanical, and Electronics) required for entry into Air Force occupational specialties. From this standpoint, the 16-ladder equation is more comprehensive (inclusive) than the 12-ladder equation. Other results indicated that equations produced by grouping ladders from like aptitude areas were no more efficient than the generalized equations.

The variance which has been captured relative to the job difficulty criterion measures may be attributed to the observability of a distinction in performance. The task difficulty measures permit a primary technique for observing this distinction.

The results show little (if any) improvement was gained by using the 16-ladder equation instead of the 12-ladder equation to predict the job difficulty policy rankings. However, from a practical standpoint, it would appear that the comprehensive constant weight equation developed for 16 career ladders representing all four aptitude areas would be more generalizable to all Air Force career ladders than the equation based upon 12 career ladders representing two aptitude areas.

The 12-ladder constant standard weight equation has been used to operationally derive difficulty indices for jobs surveyed in all the Air Force career ladders which have been studied. In the future, it would appear advantageous to use the 16-ladder equation instead of the 12-ladder equation.

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