PILOT PERFORMANCE MEASUREMENT SYSTEM FOR THE A-7 NIGHT CARRIER LANDING TRAINER (NCLT)

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ABSTRACT

Vought Corporation - Systems Division is under contract to NAVAIR (4131) to develop a pilot performance measurement system that will aid the Landing Signal Officer (LSO) during training in the A-7 Night Carrier Landing Trainer (NCLT). This paper discusses (a) how parametric performance data (lineup and glideslope error, sink rate, airspeed, etc.) are collected on categories I and II A-7 replacement pilots during NCLT and night carrier qualifications, (b) how the data will be statistically analyzed to determine those factors that indicate student progress, (c) how these factors will be combined into a single predictive index, and (d) how the program products can be applied as training aids. Finally, the results of preliminary analyses are presented.

INTRODUCTION

The Vought Corporation - Systems Division is conducting a Night Carrier Landing Trainer data collection program for the Naval Air Systems Command (AIR-4131) under Contract No. N00019-73A-0010. The objective of the program is to develop valid computer-scored measures of student pilot progress in the NCLT. These measures are also to be explored for their predictive value in the field carrier landing practice (FCLP) and the carrier qualification (CARQUAL) environments. The resultant measures are to be incorporated into a student pilot trend analysis summary printout as a training aid to the Landing Signal Officer (LSO) community.

Vought is currently contracted to, (a) develop and install an automatic data collection system in the NCLT, (b) collect quantitative NCLT and CARQUAL performance data on 60 A-7 replacement pilots, (c) collect questionnaire data and qualitative LSO student performance comments and records for the 60 replacement pilots, (d) perform preliminary analyses on these data, and (e) recommend NCLT training aids.

Preliminary performance measures, grading boundaries, and training aid formats have been developed for the data collection system. At this time, the data collection system has been implemented at NAS LeMoore, California, and is operational. The data collection effort is complete. The results of preliminary analyses indicate a predictive relationship between NCLT and CARQUAL performance exists and that a more in-depth analytical effort should be undertaken to validate the system and to develop the desired program products.

Figure 1 is a simplified overview of data collection, data analysis and program product relationship. Shown are the data from two samples (development and validation) of 30 replacement pilots (RP's) going through the NCLT-FCLP-CARQUAL cycle. These data are then shown to be analyzed for the ultimate development of the program products - a grading system and an instructional strategy (training aid). Data collection, analyses and validation, and training aid development are discussed in later paragraphs.

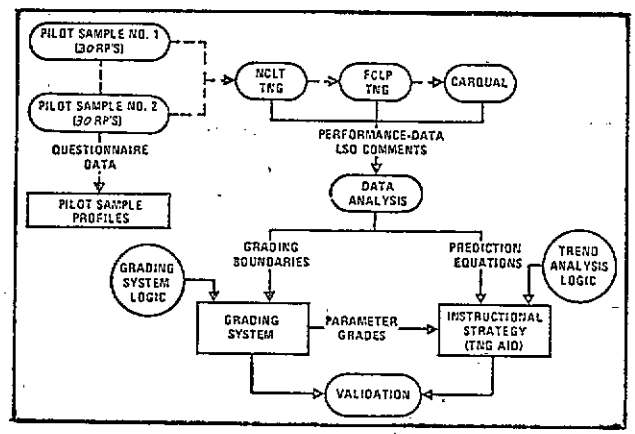

Figure 1. Overview of Program

Preliminary Performance Measures

The initial candidate performance measures selected included lateral and vertical error, sink rate, and airspeed at specified intervals (3/4, 1/2, 1/4, 1/8 NM and at the ramp). These measures were selected because they are the only measures that can be collected through the carrier ACLS SPN-42 radar system. However, additional performance measures were selected for collection in the NCLT. These include glideslope, lineup, fuel flow, angle of attack and pitch attitude as well as velocity vector and a work response index. The measurement system is designed to continuously sample these parameters from 1 1/4 NM to the ramp, and to print out means and variances for each of six selected segments. Both absolute error data, and error data weighted by range, are considered.

Weighting by range emphasizes the criticality of errors when "close in." Mean percent time in tolerance for the first five of these parameters are also collected across each of the six segments.

The NCLT data collection system printout is shown in Figure 2. The figure shows that the printout includes initial and terminal conditions, record-keeping data, and computed grades for lineup, glideslope, angle of attack, fuel flow and pitch attitude. These grades (0 to 4 scale) are based on preliminary performance boundaries established early in the program and are implemented in the current data collection system.

PILOT: SSN: SQDN: DATE: 4 MAR 74 PERIOD: 0 RUN: 8
LSO: LPS: WING: TOTAL RUNS: 10
LSO GRADE: COMMENTS:

TERMINAL PERFORMANCE VALUES

SINK RATE: 12.516 WOD TO RAMP: 13.188 LATERAL ERROR: -3.125 PITCH ATTITUDE: 8.0250 ROLL ATTITUDE: .49097

INITIAL CONDITIONS

SEA: 0 VISBTY: 42. CEILING: 11800. GUSTS: 0 WOD DIR: 0 WOD SPD: 30. WEIGHT: 21634
A-7E CLEAN CVA-61

MEAN OF ABSOLUTE ERRORS

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
LINE-UP	40.03125	6.	3.84375	2.75	1.90625	2.	17.59375
GLIDESLOPE	29.125	1.03125	1.1875	2.34375	1.03125	1.5625	12.375
ANGLE OF ATTACK	1.281437	1.538567	1.066238	.424522	.525829	.959038	1.138092
FUEL FLOW	610.503906	118.966797	44.408391	87.40625	59.607429	60.089844	248.4375
PITCH ATTITUDE	.960999	1.654286	1.414579	.499451	.545714	1.449868	1.120769

VARIANCE OF ABSOLUTE ERRORS

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
LINE-UP	186.	17.5	1.	0	0	0	355.25
GLIDESLOPE	524.609375	.90625	.5	.5	.53125	.15625	396.9375
ANGLE OF ATTACK	.436157	.096313	.047241	.017578	.281812	.037964	.347096
FUEL FLOW	249580	950	300	100	90	90	166000
PITCH ATTITUDE	.308594	.105469	.0625	.035156	.25	.007813	.332031

MEAN OF WEIGHTED ERRORS

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
LINE-UP	.005605	.001415	.001493	.002046	.009749	.00564	.003426
GLIDESLOPE	.00421	.000972	.000529	.001672	.001777	.004372	.002229
ANGLE OF ATTACK	.00021	.000361	.000425	.000322	.000941	.002635	.0004
FUEL FLOW	.079506	.028992	.020401	.042849	.080765	.140694	.06118
PITCH ATTITUDE	.002517	.006992	.009053	.005791	.014635	.064428	.007178
VELOCITY VECTOR	.038863	.034563	.025869	.027419	.026363	.039922	.033622

VARIANCE OF WEIGHTED ERRORS

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
LINE-UP	.0000019	.0000008	.	.0000001	.0000009	.0000008	.0000051
GLIDESLOPE	.0000088	.0000001	.0000001	.0000001	.0000024	.0000002	.0000066
ANGLE OF ATTACK	.00000001	.00000001	.	.00000002	.00000106	.00000008	.00000022
FUEL FLOW	.004639	.000051	.000061	.000107	.000795	.000961	.003149
PITCH ATTITUDE	.00000001	.000000009	.000000007	.000000014	.000001256	.000000019	.000000415
VELOCITY VECTOR	.000069	.000039	.000031	.000065	.00008	.000238	.000093

WORK RESPONSE

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
RMS LONG. STK.	1.	.566243	.439983	.25	.75	.395264	.75
RMS LAT. STK.	.985366	1.030762	.728821	1.75409	.395964	0	1.
RMS THROTTLE	1.060608	0	.353516	0	0	0	.68457
ALL	4.975972	1.617804	1.51552	2.00885	1.149964	.395264	2.43457

PERCENT TIME IN TOLERANCE

	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	TOTAL PASS
LINE-UP	3.915647	100.	100.	100.	100.	100.	61.750595
GLIDESLOPE	59.63845	100.	100.	100.	100.	100.	83.932846
ANGLE OF ATTACK	32.831314	0	1.183926	100.	68.181808	20.	29.376495
FUEL FLOW	40.192764	100.	100.	100.	100.	100.	79.376495
PITCH ATTITUDE	62.265045	15.060226	94.443787	100.	83.333328	0	51.438843
ALL	0	0	1.183926	100.	68.181808	0	15.947235

OPERATIONAL COMPARISON DATA

	3/4 NM	1/2 NM	1/4 NM	1/8 NM	AT RAMP
SINK RATE	9.225586	11.546387	11.820801	10.095947	11.130615
AIRSPEED	134.585327	137.834961	134.530722	133.669434	132.518311
LATERAL ERROR	14.8125	-5.5	-2.375	-2.5	-1.8125
VERTICAL ERROR	-2.9375	1.34375	-2.625	-.90625	2.03125
AOA ERROR	-1.860912	-1.27013	-.706375	-.426460	-1.275082
FUEL FLOW ERROR	131.857422	73.072266	61.939947	42.601563	78.46875
PITCH ERROR	-1.654785	-1.499426	-1.114929	-.409668	-1.614175

GRADES:	LINE-UP	GLIDESLOPE	ANGLE OF ATTACK	FUEL FLOW	PITCH ATTITUDE
	3.96	4.	2.34	4.	0

MALFUNCTIONS: NONE

Figure 2. NCLT Data Printout Format

Preliminary Performance Boundaries

Preliminary boundaries/standards were identified from existing operational data and from handling qualities characteristics of the A-7E. These were refined through evaluation by LSO's and are currently used as the initial set of standards.

At this time, preliminary boundaries have been further refined for glideslope, lineup, angle of attack, fuel flow, and pitch attitude. This modification was based on the results of a group of seven LSO's flying 202 approaches in the NCLT. The approaches were grouped by LSO grade (0.0 to 4.0) and compared with the total sample of mixed grades. Figure 3 illustrates the rationale for boundaries that are being established for all performance measures. This example (based on glideslope performance data) shows how upper

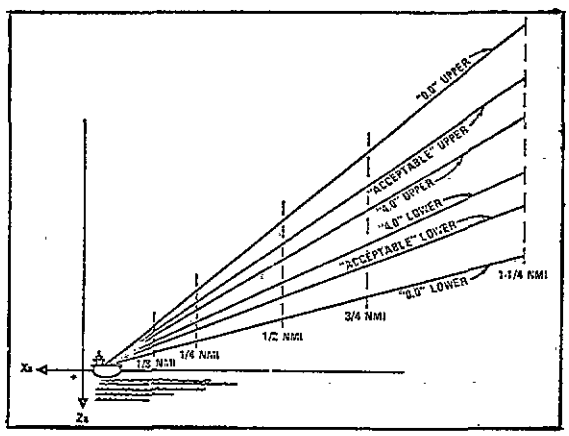

Figure 3. Sample Vertical Error Boundary Rationale

and lower limits for 0.0 through 4.0 grades are established at six points from 1 1/4 NM out to the Number 1 wire. "Acceptable" upper and lower limits are being established by examining three types of data: (a) one standard deviation from the mean error at the "windows" for all approaches (class average), (b) the mean values for a minimally acceptable approach (grade of 2.0) and (c) the region within which LSO comments do not occur.

The initial boundary sets will be updated and refined, subsequent to the completion of the data analysis phase.

DATA COLLECTION

Initial data collection activities involved testing a sample of 7 LSO's from NAS LeMoore (VA-122, VA-125) and NAS Cecil Field (VA-174) in the NCLT to refine the preliminary performance standards. This data collection effort was conducted at NAS LeMoore, California. NCLT predictor and criterion data were collected for the LSO sample during NCLT simulation as currently defined in the A-7 Replacement Pilot NCLT syllabus.

In addition to flying the NCLT, the LSO's have participated in the program in other ways: first, they were consulted to provide subjective information relevant to the rationale behind their descriptive comments and symbology when evaluating a student night carrier landing pass. This information aided in the formulation of a rationale for development of a computerized trend analysis system. Next, the LSO's again flew the NCLT to provide additional flight data for debugging the initial computerized procedures for assessing trends and assigning grades. Finally, the LSO's continue to monitor and assess both NCLT and CARQUAL performance to provide grades.

Data from two separate samples of 30 A-7 category I and category II replacement pilots (RP's) was collected in the NCLT and during CARQUAL to provide a basis for development of the pilot performance measurement system products. Syllabus variations have been minimized by utilizing, for analytical purposes, only those data applicable to the relatively standardized approaches flown during NCLT syllabus periods two through six.

CARQUAL data collection efforts to date included cruises aboard the USS Enterprise, USS Saratoga, USS Nimitz, USS Coral Sea, and the USS Kitty Hawk. Data obtained aboard these carriers included LSO comments and analog traces from the carriers' SPN-42 equipment. These traces include ranges, ship heave and pitch, vertical error, lateral error, airspeed, sink rate and closure speed for each pass. Figure 4 is a partial sample of a SPN-42 strip chart recording for a carrier approach.

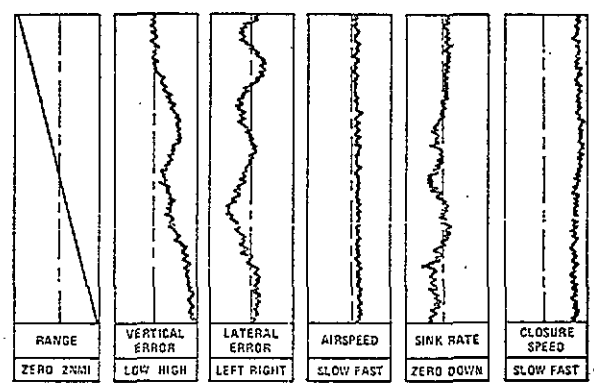

Figure 4. Sample SPN-42 Strip Chart Record

SPN-42 data will be converted to digital form for comparison with similar NCLT data. LSO comment data from both the NCLT and the CARQUAL environments will be used to develop a trend analysis summary as a training aid. This training aid is discussed in a later paragraph.

DATA ANALYSIS AND VALIDATION

The first analytical effort will involve development of normative performance (norms) for each independent variable using NCLT data only. Statistical studies will examine function distribution variances and means to determine those measures which are most descriptive of techniques resulting in good performance. It is anticipated that for some of the measures, mean values may be the most descriptive of normative performance. For others, such statistics as maximum deviation or percent time within tolerance may be more appropriate to predict the number of periods (passes) required by a pilot to reach the criterion performance level as set by the LSO's for NCLT training. The data for making these predictions will be based on pilot flight histories and from NCLT data.

Normative performance values will also be established for final performance measures. These normative performance values will be determined for each of the two RP samples of 30 students, and for the combined sample (60 students). These data (mean errors and standard deviations) will be plotted for the five parameters that comprise the NCLT grading system (e.g., lineup, glideslope, angle of attack, fuel flow and pitch attitude) at each LSO grade level. The plots will be used to establish criteria for grading the parameters. Figure 5 is an example of this type of plot.

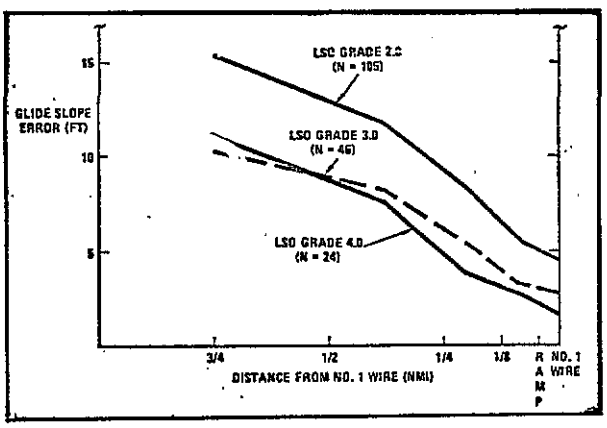

Figure 5. Parameter Grading Criteria

Data for the example was extracted from the LSO sample that was collected and analyzed early in the program. Grading boundaries will be adjusted such that the parameter grades "best fit" the overall LSO grade. The initial boundaries (those currently in the NCLT) will be adjusted during further data analysis efforts.

Subsequent to establishment of final performance norms for each of the performance measures, multiple correlation techniques employing a linear regression model will be used to account for the variance in LSO scores and Landing Performance Scores (LPS). The LPS assesses the quality of a landing on the basis of terminal conditions (wire no., etc.). The objective is to determine the equation which, according to a defined criterion, best describes the dependent variable (LSO grade or LPS) in terms of those independent (predictor) variables that the analysis shows are factors that influence the LSO's evaluation of the quality of a night carrier approach.

It is planned to employ the Efroymson method (Efroymson, 1960 and Rosenthal, 1966) which combines the forward selection (step-up) and the backward elimination (step-down) procedures with a check for co-linearity. The essential idea of the Efroymson method is, of those variables that were in the regression equation at the last step, delete that variable which gives the "minimum nonsignificant (at a specified F-value) increase to the residual sums of squares" and where the multiple correlation coefficient is not significantly large. If no variable is deleted in the first stage, those variables that were not in the regression at the last step are inspected. Among the variables, that variable which gives the maximum significant (judged by the F-test) decrease to the residual sums of squares is added. If no such variable exists, the procedure is finished and the "best" equation has been determined.

Data collected during the program will be employed in the development of the final performance measurement system for the NCLT, based on both CARQUAL and NCLT variables. An intercorrelation matrix will be computed on each of the sample groups of RP's to modify the preliminary NCLT performance standards and grading criteria such that they are consistent with their CARQUAL counterparts. NCLT predictor scores and correlations will be redetermined in these cases where acceptable performance envelopes have been modified. Intercorrelations between segments will also be presented.

Results of the regression equation developed for the first sample group of RP's will be evaluated for effectiveness by using predictor data in the regression equation and comparing predicted criterion data to NCLT and CARQUAL criterion data.

A double cross-validation design will be employed; that is, the data collected on the second RP sample will be used to validate the regression equations developed on the first RP sample, and the data collected for the first RP sample will be used to validate the regression equations developed for the second RP sample. The final regression equations, grading and prediction system, performance standards, and trend analysis forms will be based on all 60 pilot subjects utilizing both NCLT and CARQUAL data. The cross-correlation analysis will be tested for residual or second order effects.

Analysis of LSO Comment Data

An important feature of the NCLT training aid to be developed during this program will be automatic emulation of LSO qualitative comments whenever performance does not meet specified criteria. To establish these criteria, both NCLT and CARQUAL data will be analyzed. For example, if during CARQUAL, the LSO records the comment, "high in the middle" (HIM), the analog trace will be examined for a peak in glideslope error. Both the range of this peak and the corresponding magnitude of the glideslope error will be recorded. This data will be sorted and analyzed to determine how many feet above glideslope the LSO considers to be 'high', and at what range the LSO considers to be the 'middle' of the approach. Subsequently, range and glideslope error thresholds can be established which, if exceeded, will cause an automatic 'high in the middle' comment to be printed. Ranges for the CARQUAL data may be slightly different from those collected from the NCLT. This could occur because NCLT data is being collected at discrete 'windows', whereas CARQUAL data is being collected on a continuous analog trace.

For example, it will be possible to determine the range from touchdown the LSO considers the 'middle' of the pass. (See the vertical dashed line in Figure 6). This value will be determined from the average range of the flagged data. Glideslope error threshold values (shown by the horizontal dashed line) will also be determined. This will be accomplished by selecting a value for the glideslope error threshold that may include, for example, 75% of the flagged data.

It is anticipated that a combination of the glideslope error thresholds from 'high start', 'high in the middle', 'high in close', and 'high at the ramp' comments, will result in more objective glideslope scoring boundaries. These scoring boundaries will be compared to the results of the regression analyses. From these dual analyses, quantitative scoring boundaries will be identified.

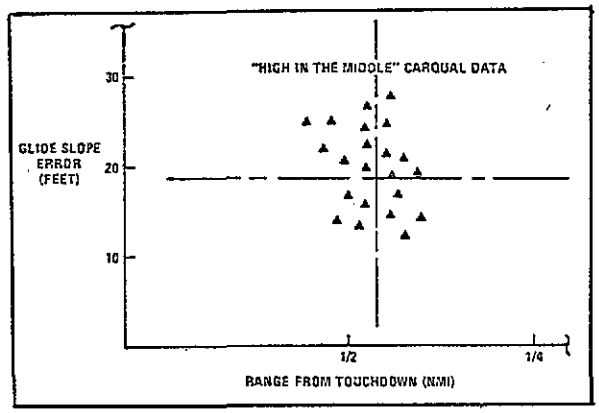

Figure 6. Range Versus LSO Comments

TRAINING AID DEVELOPMENT

One of the products of this program will be an automatic NCLT performance trend analysis printout to aid the LSO in the NCLT training environment. Development of this training aid will be accomplished through analysis of LSO suggestions and from NCLT and CARQUAL data collected during the program. LSO comment data will be examined and compared with digital and analog data to establish boundary values pertaining to specific comments. These data, along with extensive discussion with LSO's, will be used to develop a performance trend analysis printout addressing those elements which the LSO considers critical, dangerous, or unacceptable.

The Current Training Aid Format

The training aid format as currently printed out in the NCLT is shown in Figure 7.

PILOT: SSN:			SQDN:	DATE:		PERIOD:	RUN:
LSO: LPS:			WIRE:	TOTAL RUNS:			
PASS	PERFORMANCE MEASURE	STD	GRADE	CALL BALL 0.75 NMI	MIDDLE 0.50 NMI	IN CLOSE 0.25 NMI	AT RAMP
	LINE UP	XXXX	2.86	LEFT	LEFT	***	***
	GLIDE SLOPE	XXXX	3.50	***	***	***	***
	ANGLE OF ATTACK	XXXX	1.21	***	FAST	FAST	FAST
	FUEL FLOW	XXXX	3.60	***	***	***	***
	PITCH ATTITUDE	XXXX	1.0	***	***	NOSE LOW	NOSE LOW
	LSO GRADE		2.0				
	WORK INDEX	XXXX	15.1				
	ACCURACY INDEX	XXXX	41.0				
	CALCULATED GRADE		2.1				

Figure 7. CARQUAL Trend Analysis Format

The specific features of this printout are:

1. Records of such data as pilot's name, SSN, squadron, date, LSO's name, Landing Performance Score (LPS), wire caught, NCLT lesson or period, number of runs for the period, and

the total number of runs to date.

2. Qualitative comments when a parameter boundary is exceeded at one of four windows (3/4, 1/2, 1/4 NM from touchdown, and the Ramp) are printed ('left', 'right', 'high', 'low', 'slow', 'fast', etc.). In addition, the performance score or grade for each parameter is printed under the heading "GRADE." After data collection and analysis are completed, standards for each parameter grade will be determined for evaluating an individual pass, i.e., how an individual's performance in lineup, for instance, compares to the population or standard lineup performance.

3. The LSO grade, LPS, work index, accuracy index, wire caught and an overall calculated grade.

4. Appropriate LSO comments that are entered at the teletype. Four additional discrete performance items or comments will be automatically flagged for use in the printout. These are: "WING ROCK IN CLOSE," "DROPPED NOSE IN CLOSE," "LANDED ON WAVEOFF," and "APC IN USE."

A Refined Version of the Training Format

The initial NCLT data collection software system included a preliminary version of a performance analysis printout. An improved training aid will be developed during the analysis phase. The LSO's input is the key element in this development. The goal of this printout is to assist the LSO in his training task. There are several potential output formats; one possibility is shown in Figure 8.

PILOT:		DATE:	NCLT PERIOD NO.		LSO:
	AVE GRADE	CALL BALL	MIDDLE	IN CLOSE	RAMP
GLIDE SLOPE	3.21	H-L--L--	--HH-L--	H--H--H-	--H---H-
LINE UP	3.32	LR--R--R	-R--R---	-R-------	-------L
AOA	2.91	HH--L----	-H--L----	-L-L--LL	H-----L--
FUEL FLOW	3.16	L--H--LL	-L----LL	H L-L H--L	H--H---H
PITCH	2.80	HH-LL----	-H LLL----	-L----LL	-H----L--
PASSES 1 THRU 8					

PASS	12345678
WIRE	33433341
LSO GRADE	33234332
MEAN LSO GRADE	2.80
MEAN CALC GRADE	2.85

SUMMARY COMMENTS BY LSO

Figure 8. Period Trend Analysis Summary

This printout summarizes an entire NCLT period. Each column under each segment of the approach corresponds to a separate pass. In the example, the first pass was high on the glideslope, the second pass was on the glideslope, the third pass was low, etc. The wire number and LSO grade are summarized in the block at the lower right. It can be seen that significant trends would readily show up in this summary. Coordination with the LSO will further define the most desirable summary format.

Current NCLT trend analysis comments flag positional and range parameters that stray from nominal values. LSO's have mentioned that the decelerating pass never gets identified, nor is a good correction ever recognized in the data output. Pilot responsiveness (acting upon or ignoring) to a LSO command is also not considered. Several LSO's and pilots have mentioned the desirability of giving the pilot credit for exceptional performance. The LSO will do this occasionally with comments such as 'good correction' or 'rails pass'. An attempt will be made to explore the possibility of making similar note of outstanding performance in the NCLT. It is felt that the collection of both LSO comment data and objective performance data offers a unique opportunity with which to explore this relatively untouched region of performance evaluation.

For example, if beyond a certain minimum range, a pilot can correct an excessive (but not dangerous) positional error and maintain the optimum flight path for the remainder of the pass, such a complimentary comment could be made. If implemented, the feature could prove to be a strong motivator for the pilot in the simulator.

In addition to the automatic comments featured in the current training aid printout, dangerous performance tendencies or 'NO-NCs' will be investigated. In conjunction with this, several LSO's have mentioned that it may be desirable to call greater attention to the existance of such unacceptable performance. This could be done by printing a large 'X' through the output. In order to better distinguish performance that is just outside acceptable boundaries, LSO's indicate 'slightly high', 'slightly low', 'slightly fast', etc. The LSO currently notes this with parentheses, i.e. (HIGH) means slightly high. The same scheme will be considered for the automatic trend analysis printout.

Preliminary Analysis of a Sample of Replacement Pilots

This is a quick analysis of NCLT data for twenty-three replacement pilots. The sample is a mix of RP's who subsequently reported for CARQUAL aboard either the USS Saratoga during the period 10-11 May 1975, or the USS Kitty Hawk during the period 2-6 February 1976.

Of the total sample of twenty-three RP's, three failed to qualify during night CARQUALS. This situation offered an opportunity to test for the predictive capability

of NCLT performance and system credibility. Two other pilots failed to qualify during these CARQUALS. However, sufficient NCLT data for these two pilots were not available for inclusion in this analysis.

Figure 9 compares mean NCLT lineup error data for the three RP's who failed during CARQUAL with the samples of 20 RP's who did qualify. For reference, values for the total sample are shown as a dashed line. Percentage

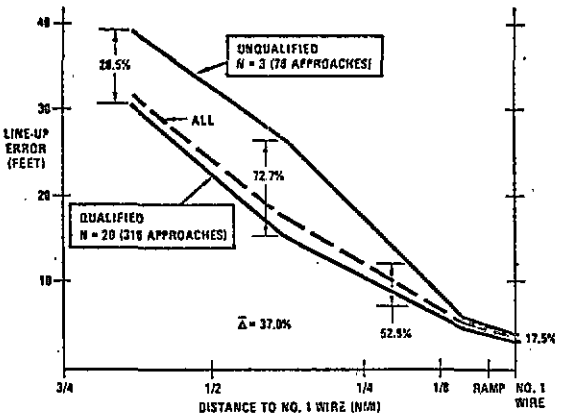

Figure 9. Mean Lineup Error - Qualified Versus Unqualified Groups

differences between those who qualified and those who did not are shown at the midpoint of each segment. The differences are rather startling.

Figure 10 is a similar comparison for mean glideslope error.

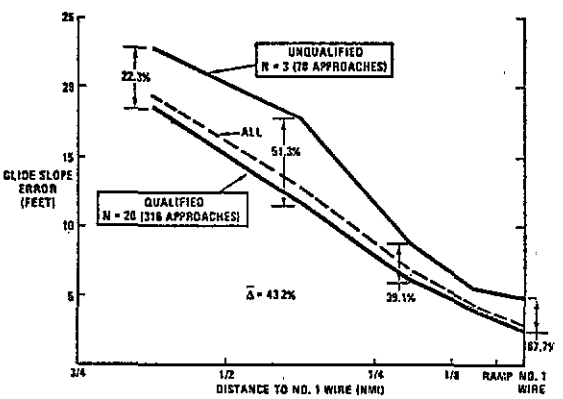

Figure 10. Mean Glideslope Error - Qualified Versus Unqualified Groups

These figures show that the three unqualified individuals performed far worse than the class average in both lineup and glideslope control. The percent differences (Δ) values between the two groups are shown at five points. The overall $\bar{\Delta}$ is shown in the box in the lower center of the figures. It should be noted that the data plotted reflects arrested landings only. Waveoff and bolter rates for the three unqualified individuals were also significantly higher than the class average.

Figure 11 compares qualified and unqualified group performance grades for lineup, glideslope, fuel flow, angle of attack and pitch attitude. This comparison shows that the unqualified group was graded lower in lineup, glideslope, and fuel flow, but higher

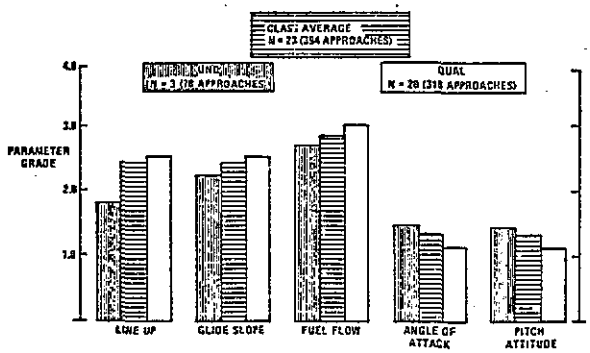

Figure 11. Parameter Grades - Qualified Versus Unqualified Groups

in angle of attack and pitch attitude. This could be an indication that the unqualified group tended to emphasize control of these parameters at the cost of control in the others (i.e., cockpit instrument scan versus position cues). The lineup and fuel flow deltas appear to be about right, but the glideslope grades are closer than the preliminary data warrants. This indicates that the glideslope grading equation may need to be more reflective of "close in" error.

Figure 12 compares a student who was disqualified during NCLT and FCLP with another student who was killed as a result of a ramp strike and with the two samples of students who either qualified or were disqualified at the ship. It should be noted that in all cases of disqualification, the students were graded lower in lineup, glideslope, and fuel flow but higher in angle of attack and pitch attitude. This indicates more emphasis by the student on certain parameters.

The foregoing data indicated a strong predictive relationship between NCLT performance and night CARQUAL performance, even though the preliminary analyses to date represent only rudimentary efforts.

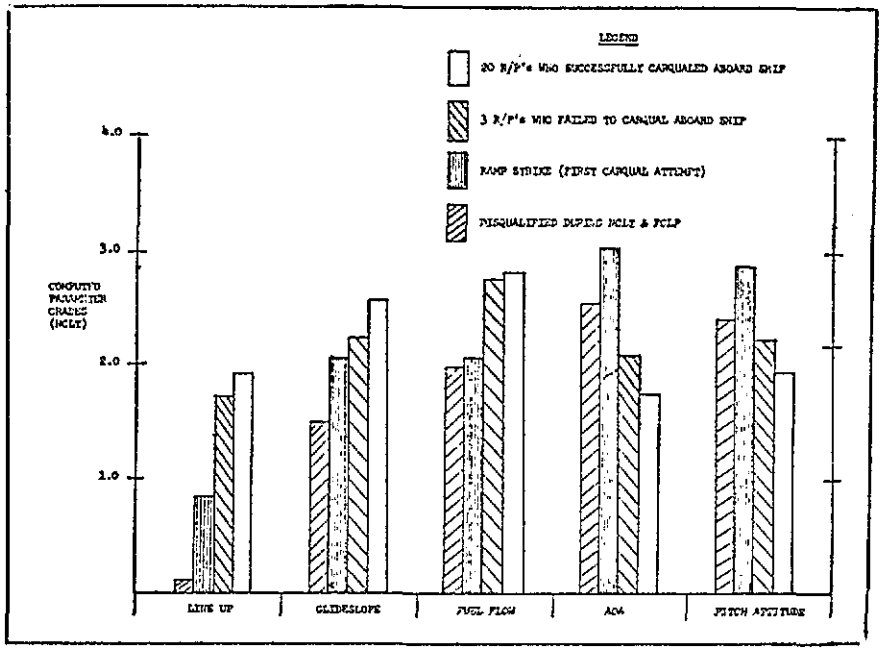

Figure 12. Comparison of Computed Parameter Grades

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