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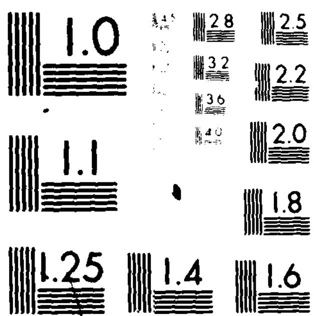

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Technical Report NAVTRAEQUIPCEN 78-C-0060-11

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VISUAL TECHNOLOGY RESEARCH SIMULATOR (VTRS) HUMAN PERFORMANCE RESEARCH: PHASE III

G. Lintern; B.E. Nelson;
D.J. Sheppard; D.P. Westra;
R.S. Kennedy

CANYON RESEARCH GROUP, INC.
741 Lakefield Road, Suite B
Westlake Village, California 91361

Final Report for Period

1 May 1980 - 30 November 1981

Prepared for:

NAVAL TRAINING EQUIPMENT CENTER
Orlando, Florida 32813

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This report summarizes the research projects for which Canyon Research Group, Inc. has a major responsibility under the Visual Technology Research Simulator (VTRS) Human Performance Research Contract. The basic research approach has been multifactor and much of the experimental preparations involved demonstration of the feasibility of efficient multifactor designs. Multifactor performance and transfer studies have been completed. Other work has involved the investigation of unconventional visual displays

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for flight training, automatic freeze techniques for carrier landing instruction, and descent rate cuing as an aid to glideslope tracking for carrier landings. Work has also continued on the development of performance measurement and statistical analysis capabilities.

Common emphases of the experimental program were that disparate and generally costly equipment features were studied experimentally in pilots making carrier landings. The general findings were that: 1) practice effects were small; 2) main effects of equipment features modest; 3) some display principles improve performance; and 4) individual differences were reliable and large. The following suggestions for simulator design can be made based on the experimental evidence in a large study of 12 costly simulation features: Simulation for carrier landing skill maintenance and transition training does not require the more costly levels of fidelity. The requirements for fidelity for undergraduate training on carrier landing is presently under study. The importance of fidelity for other purposes (e.g., pilot acceptance, realism) is problematic.

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SECTION I

INTRODUCTION

In May, 1978, Canyon Research Group, Inc. undertook a three-year effort in support of the Navy's Visual Technology Research Simulator (VTRS).

The present report describes progress on the VTRS during the period May, 1978 through November, 1981 under support Contract N61339-78-C-0060. Work completed during the three-year support contract includes ten separate technical reports, in addition to the current report. The titles and abstracts of the completed reports are contained in Section II of this report.

SECTION II

TECHNICAL REPORTS

NAVTRAEQUIPCEN 78-C-0060-1
(Unpublished Canyon Report)

Visual Technology Research Simulator (VTRS) Human Performance Research: Phase I

G. Lintern; D. Westra; H. Iavecchia; S.M. Roscoe

April, 1979; 40 pages

This report summarizes discussions between Canyon and NTEC personnel that focused on issues relating to VTRS experimental design, economical multifactor methodology, carrier-landing performance, and contents of the VTRS visual display. Carrier-landing performance measurement research is also reviewed, and data collected during simulated carrier-landing trials on the ASPT at Williams Air Force Base, Arizona, and on the VTRS at Orlando, Florida, are discussed.

NAVTRAEQUIPCEN 78-C-0060-2
(Unpublished Canyon Report)

Visual Technology Research Simulator (VTRS) Human Performance Research: Phase II

G. Lintern; D. Westra; H. Iavecchia; R. Hennessy

April, 1980; 145 pages

This report summarizes the research projects in progress for which Canyon Research Group, Inc. has a major responsibility under the VTRS Human Performance Research Contract. Work has continued on multifactor performance testing with carrier landings. A project is also planned to examine relationships between performance and transfer data. Other experiments to test a glideslope rate-cuing display to aid glideslope control, and to test alternative display concepts for teaching basic contact flying skills have been completed. Progress on analysis of data for both of these experiments is reported here.

NAVTRAEQUIPCEN 78-C-0060-3

Applications of Advanced Experimental Methods to Visual Technology Research Simulator Studies: Supplemental Techniques

Charles W. Simon

January, 1981; 127 pages

This report is made up of a series of individual papers on techniques to enhance the behavioral research methods being used in the VTRS, or Visual Technology Research Simulator (formerly referred to as AWAVS, or Aviation Wide-Angle Visual System). These methods are applicable to many other topical areas in addition to flight simulation. The techniques discussed, which relate to problems of design, analysis and interpretation, are important addenda to material discussed elsewhere by Simon.

In particular, this report supplements NAVTRAEQUIPCEN 77-C-0065-1 (Simon, 1979).

The following techniques are discussed:

a. What to do when the model for the experimental design inadequately represents the empirical data. I. Introduction; II. Lack of Fit Test; III. Transformation; IV. Augmentation.

b. Using Yates' algorithm with screening designs.

c. Analyzing residuals.

d. Identifying the experimental conditions in 2^{k-P} designs when given the defining generators.

e. An economical design for screening interaction effects.

f. Graphic method and internal comparison for multiple response data.

g. The place for replication in economical multifactor research.

h. The significance of tests of statistical significance.

i. Determining the probability of accepting the null hypothesis when in fact it is false.

j. Testing non-additivity in experimental data from a 'atin square design.

k. How to include factors with more than two levels in a screening design.

l. Analyzing extra-period change-over designs.

m. Analyzing serially-balanced sequence designs.

n. Design economy when experimental factors selectively affect bi-variate criteria.

NAVTRAEQUIPCEN 78-C-0060-4

Glideslope Descent-Rate Cuing to Aid Carrier Landings[1]

Lt. Charles E. Kaul; Stanley C. Collyer and Gavan Lintern

October, 1980; 56 pages

Two techniques for providing descent rate information to pilots making carrier landings were evaluated and shown to be effective in a flight simulator. Landing performance of experienced Naval aviators was tested in the Visual Technology Research Simulator, with a conventional Fresnel Lens Optical Landing System (FLOLS) and with a simple modification to the FLOLS to include variable length vertical light arrays, or arrows.

The FLOLS, which is used for glideslope guidance during carrier approaches, provides zero-order or displacement information for the pilot to judge whether he is above or below the glideslope. Aircraft system dynamics can create substantial lags between an incorrect control input and the resulting error indication from the FLOLS. The techniques that were evaluated compensated for that lag by providing first-order or rate information to the pilot.

The two techniques involved different first-order drive algorithms. One system, designated the RATE display, showed the difference between the aircraft's actual descent rate and the descent rate that would maintain its present glideslope angle with respect to the FLOLS. The other, designated the COMMAND display, showed the magnitude of descent rate correction needed, and indicated a no-error condition when the pilot was tracking the glideslope or returning to it at an appropriate rate of closure.

The first-order displays improved glideslope tracking performance significantly throughout the approach. Lineup performance was not adversely affected. Differences between the two first-order configurations favored the COMMAND display. The pilot subjects and Landing Signal Officers involved in the evaluation were unanimous in strongly endorsing the modified systems and indicated a preference for the COMMAND over the RATE display.

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[1]Published as NAVTRAEQUIPCEN IH-322. An abbreviated version appears in the Proceedings of the 7th Symposium on Psychology in the Department of Defense, Colorado Springs, Colorado, 1980.

Currently available equipment could be used to modify the existing FLOLS on aircraft carriers at a relatively low cost. If comparable improvements in glideslope performance as found in the simulator are found in carrier operations, boarding rates and glideslope-related accident rates can be expected to improve substantially.

NAVTRAEQUIPCEN 78-C-0060-5

Unconventional Visual Displays for Flight Training[2]

R.T. Hennessy; G. Lintern and S.C. Collyer

November 1981; 61 pages

Use of simulators for flight instruction has typically followed the pattern of using similar instructional approaches as have traditionally been used for in-flight instruction. However there is a growing awareness that a simulator permits radical departures from the traditional methods, and some of these may be less expensive and even more effective in terms of acquiring the skill. The general purpose of the research reported here was to examine training effectiveness for basic flight tasks of radically different methods of displaying the information that is necessary to support learning of the tasks.

Four different visual tasks were evaluated for their effectiveness in the acquisition of flight tasks in a simulator. The control condition had a wide field of view, a horizon, and a checkerboard ground plane that obeyed laws of motion and perspective. The experimental displays were 1) a narrow field of view with horizon and checkerboard ground plane; 2) an outside viewpoint of the aircraft; and 3) a display that consisted only of normal flight instruments. Flight-naive subjects were taught to fly straight and level for twenty trials with either the control or one of the experimental displays and then tested for twenty trials on the control display. Training, transfer, and differential transfer were examined.

Pretraining with the experimental displays resulted in substantial transfer savings to the control display. The differential transfer analyses did not show a clear advantage for any of the displays. The hypothesis that control skills can be learned using representations of the essential information that depart radically from the form found in natural scenes was supported by the results. The results also suggest that perceptual learning may occur quickly relative to control skill learning. Field of view did not importantly affect training or transfer performance of the Straight-and-Level task. In particular, there was no evident advantage of using a wide field of view for training of this task. Unconventional

[2]Also presented at the Annual Convention of the American Psychological Association, Montreal, Canada, September, 1980.

visual displays show promise as cost effective means for teaching some flight skills. Research on optimizing visual displays for flight training need not be restricted to conventional out-of-cockpit scenes. It is possible that unconventional displays might prove to be superior to conventional displays on a time-to-train as well as a cost basis.

NAVTRAEQUIPCEN 78-C-0060-6

Application of a Multifactor Approach to Transfer-of-Training Research

Charles W. Simon and Stanley N. Roscoe

July, 1981; 83 pages

Multifactor transfer-of-training experiments are expensive to perform because of the large number of subjects required, the extended training they receive, and their subsequent operational testing. More economical data collection techniques are needed to fulfill the mission of the Naval Training Equipment Center's Visual Technology Research Simulator.

An experimental effort was undertaken: (a) to establish relationships among training, test, and transfer scores in the context of the manual control of a maneuvering vehicle, (b) to determine the relative complexities of response surfaces for training, test, and transfer, (c) to demonstrate a new transfer research paradigm that makes economically feasible the simultaneous investigation of the effects of a large number of equipment design variables found in pilot training simulators on transfer to multiple test configurations, and (d) to extract from the available data indications that will enable the transfer effectiveness of simulator characteristics to be estimated with minimum costs.

A horizontal tracking task was used in the study. Six factors were varied to form 49 simulator training configurations. These factors included five dynamic simulator design variables: vehicle control order, display lag, tracking mode (pursuit vs. compensatory), prediction time, and control gain. The sixth variable was the number of training trials given before transition to one of three transfer vehicle configurations, designated Hard, Central, and Easy.

Flight-naive adult males were used as participants. Each was trained on a different training-transfer simulator combination. The 49 points in the experimental design were selected to provide estimates of all main effects (including those of the transfer configurations) and all two-factor interactions and to test the adequacy of the second-order model. Additional data were collected from three control groups who received no prior training.

Relationships between training and transfer performance included: (a) transfer surfaces appeared less complex than training surfaces, (b) the relationship between training and transfer scores was positive but too weak for predictive purposes, (c) some factors had large effects in training and small effects in transfer, and vice versa, and (d) transfer was facilitated when the values of certain variables result in training conditions that were more difficult than the subsequent transfer criterion conditions.

The study demonstrated the efficiency and economy in collecting multifactor, multicriterion transfer-of-training data. This type of experiment is particularly useful in the early stages of a simulator design program when many alternatives should be considered and the individual contributions of component design parameters should be evaluated separately from overall simulator effectiveness.

NAVTRAEQUIPCEN 78-C-0060-7

Investigation of Simulator Design Features for Carrier Landing[3]

D. P. Westra; C. W. Simon; S. C. Collyer; W. S. Chambers and B. Nelson

In Press

The effects of twelve factors on carrier-landing performance were investigated in the Visual Technology Research Simulator (VTRS) with three experiments. Subjects for the experiments were eight experienced Naval aviators. In the first experiment with the task defined as straight-in approach and landing to an aircraft carrier, nine display and simulator factors were studied. Turbulence was also varied as a difficulty factor. These factors were Fresnel Lens Optical Landing System image, ship detail, field of view, visual lags, seascape, brightness, TV line rate, motion and engine lags. Six factors were studied in a second experiment which included the final turn, approach and landing in the task. The factors were ship detail, visual lags, seascape, brightness, motion and turbulence. In the third experiment involving straight-in approaches, ship type (model-board vs. CIG), G-seat and turbulence were studied. The purpose was to determine and rank order the sizes of effects, identify factors having no effect, and to obtain information for making decisions about future transfer-of-training studies. With the exception of ship detail (there was better compensation for the right-to-left drift that occurs because of ship movement with the high detail ship), no high cost, high fidelity versions of the factors resulted in a clear-cut task outcome performance advantage. As these factors were manipulated over a wide range of interest representing expensive vs. inexpensive simulation options, the implication is that simulation for carrier-landing skill maintenance and transition training does not require the more costly levels of fidelity for these features. Simulator requirements for training at the undergraduate level are currently being examined.

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[3]A shortened version appears in the Proceedings of the Image Generation/Display Conference II, Scottsdale, Arizona, June, 1981.

NAVTRAEQUIPCEN 78-C-0060-8
(Unpublished Canyon Report TR-81-015)

Descent-Rate Cuing for Carrier Landings:
Effects of Display Gain, Display Noise
and Aircraft Type

Gavan Lintern, LT. Charles E. Kaul and
Daniel J. Sheppard

October, 1981; 41 pages

Two studies are reported concerning the utility of modifying a conventional Fresnel Lens Optical Landing System (FLOLS) to include variable-length vertical light arrays, or arrows in order to provide descent-rate information to pilots making carrier landings.

In the first study, the Descent-Rate Cuing (DRC) algorithm incorporated an angular gain to provide glideslope displacement information. The DRC system did not significantly improve glideslope tracking performance. Lineup performance was not adversely affected. The effects of aircraft type and noise on the DRC were also examined.

In the second study, the DRC algorithm incorporated a linear gain to provide glideslope displacement information. The DRC system consistently reduced glideslope error throughout the approach.

Comparison of the data and previous research suggests that a DRC system incorporating a linear gain can produce a strong and consistent improvement in glideslope control in carrier landings.

NAVTRAEQUIPCEN 78-C-0060-9/AFHRL-TR-82-3

Applications of Freeze to Carrier
Glideslope Tracking Instruction[4]

Ronald G. Hughes, Gavan Lintern,
Dennis Wightman, Rebecca Brooks and J. Singleton

November, 1981; 50 pages

Twenty-five experienced F-4 and F-16 Air Force pilots were trained to perform carrier landings in the Visual Technology Research Simulator (VTRS). The training was conducted under one of two instructional strategies using the simulator freeze feature. Additionally, two methods of defining errors for carrier glideslope tracking were examined. These experimental training techniques were compared to a conventional training approach where no freezes were imposed during the training sequence.

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[4]To be published as a joint NAVTRAEQUIPCEN/AFHRL Technical Report. A shortened version appears in the Proceedings for the Interservice/Industry Conference, Orlando, Florida, November, 1981.

While pilots who were trained under the freeze condition developed control strategies that distinguished them from pilots trained by conventional measures, no differences were found between these groups on rate of learning or level of performance. In response to a post-experimental questionnaire, pilots who were trained under freeze conditions indicated that the simulator freeze was "frustrating" and added to the overall difficulty of the task. These pilots further reported being more motivated to avoid the freeze than to perform the task during training.

A probe technique was used to examine differential transfer in lieu of the more traditional transfer-of-training technique. Although this experimental use of the probe technique was a preliminary effort, it does appear to hold promise for transfer-of-training experiments of this type.

NAVTRAEQUIPCEN 78-C-0060-10
(Unpublished Canyon Report TR-81-025)

Reports by Systems Technology, Inc. in Support of Carrier-Landing Research in the Visual Technology Research Simulator

W.F. Jewell, H.R. Jex, R.E. Magdaleno, and R.F. Ringland

December, 1981; 59 pages

This report contains a series of papers prepared by Systems Technology, Inc. (STI) in support of the carrier-landing research in the Visual Technology Research Simulator (VTRS). The following work was undertaken:

1) development of a quasi-random turbulence model for the experiment reported in NAVTRAEQUIPCEN 78-C-0060-8. This model was preferred to the one provided initially with the VTRS system because it enabled better analysis of pilot responses to turbulence inputs. The STI model is expected to be appropriate for tasks other than carrier landings, and for simulations of other aircraft types.

2) modification of the T-2C simulation to more closely represent the A-7 and F-18 aircraft for the experiment reported in NAVTRAEQUIPCEN 78-C-0060-8.

3) application and evaluation of STI's Non-Intrusive Pilot Identification Program (NIPIP), which was developed to estimate the pilot's input-output describing function and combined pilot-vehicle performance parameters such as crossover frequency and phase margin by using a time-domain model of the pilot and a least-squares identification algorithm. NIPIP functions in real-time and uses a "sliding" time window to maintain freshness in the data; thus time-characteristics in the pilot's control strategy can be measured.

It was proposed to evaluate this technique for its application to VTRS research. STI could possible identify pilot behavioral variations as a function of task changes on dependent measures of:

1) pilot input bandwidth;
2) pilot stability margin; and
3) crossfeed control.

In particular, development of proper crossfeed control might be a good criterion of learning for glideslope control. The novice pilot is unlikely to be able to coordinate power and pitch adjustments in an optimum manner. The NIPIP may be able to identify development of crossfeed control, or any breakdown in the strategy, and thus could provide a valuable supplement to the existing VTRS performance measurement package.

The first set of data supplied to STI to test NIPIP was unsuitable for complete analysis because of errors in the turbulence model used during data collection. More data were collected and were used to analyze selected runs from an aircraft simulation of the T-2C on final approach to an aircraft carrier. The NIPIP results demonstrated changes in the pilot's describing functions with simulated glideslope disturbances (injected beam noise) and the "tight" versus "loose" tracking runs. For the "loose" tracking runs, there was a very low glideslope gain and virtually no crossfeed gain. For the "tight" tracking runs, the pilot exhibited high glideslope and crossfeed gains with relatively low variability in the data, especially for the runs with beam noise. The implication is that adequate glideslope disturbances must be present in order for the pilot to demonstrate his ability to control the aircraft properly.

SECTION III

SUPPORT ACTIVITIES[5]

A major portion of the support team's effort has been devoted to preparing the VTRS for human performance research. At the outset of these preparations, it was readily apparent that pilots could not land the VTRS with recommended control techniques. Both glideslope and lineup control were difficult. Problems with them have been successfully identified through the human performance testing. Modifications to hardware and software have corrected most of the problems that were identified. An apparent drift to the right during the approach, and the appearance of a sharp crab to the left near touchdown proved particularly difficult to correct. Simultaneous hardware and software modifications were needed to resolve the lineup problems. A substantial effort was also directed towards the model of the Fresnel Lens Optical Landing System. This model has been improved throughout the program and it is only in the last year that it has offered a good representation of the real FLOLS.

There was an initial primary effort, and then a continuing need for software support. This was provided throughout most of the contract by subcontract with Appli-Mation, Inc. Software was provided in the VTRS system to allow data collection trials to be controlled from the Experimenter/Operator Station. This software was developed with the intent that minor programming would be required to pre-program the start and end points of a trial, and to collect the desired data. The system, as delivered to the Navy, was only partially adequate in this regard.

The support team has rewritten the data collection module, and has written routines for the real-time simulation that automatically perform several switching and keyboard functions that previously had to be performed manually between trials. Software has also been written to enable data to be stored on tape where it could previously be sent only to disk, line printer, or CRT. Several pre-programming modules have been developed to permit the on-line display of selected parameters so that, in addition to obtaining a comprehensive record of many variables on magnetic tape, a small number of values can be displayed on a screen at the Experimenter/Operator Station to enable the Experimenter to check on the progress of the trial, and as a backup in case of failure in transferring the comprehensive data to tape.

Each experiment has required further software development, and it is anticipated that this type of activity will be required in the future for the experimental work with the VTRS. Examples of software routines developed for specific studies are:

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[5]Performed by Canyon Research Group, Inc. personnel unless otherwise indicated.

- Simulation design features for carrier landings (Westra, Simon, Collyer, Chambers, Nelson): Experimental control functions for switching and monitoring factor levels

- Unconventional visual displays for flight training (Hennessy, Lintern, Collyer): Routines to control an outside view display

- Descent rate cuing for carrier landing (Lintern, Kaul, Sheppard): Development of the turbulence model

- Applications of freeze to carrier glideslope tracking instruction (Hughes, Lintern, Wightman, Brooks, Singleton): Routines to freeze and reset the simulator in response to specific types of errors.

A substantial effort was devoted to performance measurement issues throughout the term of the contract. This work has been reported in detail in the final reports for phases I and II, and in Technical Report No. NAVTRAEQUIPCEN 78-C-0060-7.

Members of the Vreuls Research Corporation assisted with performance measurement issues and multivariate data analysis procedures. In addition, they performed some ridge discriminant procedures for multivariate analyses which were designed to maximally differentiate between levels of experimental factors using many relevant measures of performance simultaneously. Ridge discriminant analysis is the one way multivariate analysis of variance (MANOVA) analogue of ordinary ridge regression.

Ridge procedures can provide more stable estimates of relationships between predictor and criterion variables than ordinary least-squares regression when the predictor variables are intercorrelated.

An extensive and flexible data collection and reduction system were developed specifically for the carrier landing task. Essentially, the system produces summary measures for each trial on up to seven user defined task segments. The measures currently computed are RMS, average, standard deviation, time on target and average control movement. The user can define the variables for which the summary scores are computed. The user can also define 'capture' points at which a number of variables can be collected. This would generally include, for example, the touchdown point at which such variables as distance from the ramp, centerline deviation and aircraft attitude would be collected.

The summary measures are computed from variables sampled at a 30 Hz rate and collected in "raw" data files. The files contain data from up to 40 variables which essentially provide a recording of an entire trial. Canyon maintains raw data files from all experiments and these can be used for additional or special purpose analysis or performance measurement work.

The Biomedical Computer Data Package (BMDP-79) was installed at the Naval Training Equipment Center's (NTEC) Computer Simulation Laboratory on the VAX-11/780 system. BMDP programs provide capabilities ranging from simple data description to advanced analytical techniques. The most frequently used programs and a brief description of each are listed below:

P1D - Simple Data Description
P9D - Multiway Description of Groups
P7M - Stepwise Discriminant Analysis
P1R - Multiple Linear Regression
P2R - Stepwise Linear Regression
P2V - Analysis of Variance and Covariance, Repeated Measures

The BMDP programs on the VAX-11/780 are used for most of the VTRS data analysis and provisions have been made for installation of BMDP revisions. Data analysis programs have also been prepared on the PDP-11 as a backup to the VAX system.

Canyon personnel have developed software to be used in conjunction with BMDP programs to further data management (i.e., insertion of missing data, header information verification and correction, data transformations and case selection) that extend beyond the capabilities of the BMDP programs. Special data analysis programs have also been prepared for use on the VAX-11/780. YAT1 was programmed to provide the capability for data analysis at fractionalized factorial designs (see Appendix A). Software was also developed to allow for data conversion from character to real-number format, thus increasing the flexibility of data formats for input to analytic software previously outlined.

One major experiment control effort was in the development of instructional resources for carrier-landing research. This was particularly important because instructional methods can introduce uncontrolled or spurious sources of variance. The carrier-landing task might be considered sufficiently complex that the use of qualified Navy instructors would seem essential. However the continued service of these personnel has been difficult to acquire. In addition, there is some potential difficulty in maintaining strict experimental control of student-instructor interactions, particularly where experimental treatments require the instructor to do less than his best for a student. Phenomena such as increased assistance for those who do poorly (which may correspond to specific experimental treatments) and changes in instructional techniques (generally as instructors adapt their techniques to better suit their new environment) are serious concerns. These effects can dilute the experimental effects of interest, and are to be avoided where, as in transfer-of-training studies, experimental sensitivity is at a premium.

For the most recent experiment, personnel with an experimental behavioral science background have been trained to teach the required skills. While this approach loses something in the quality of instruction, that loss may be offset by gains in experimental control and efficiency. The documentation for carrier-landing instruction is included as Appendix B to this report.

Data collection and preliminary data analysis for the second stage of the VTRS carrier-landing research program, a quasi-transfer study, has been completed. The first stage of this three-stage program was a performance study comparing simulator design options on performance in the simulator. The second stage involved the quasi-transfer experiment just completed. In this experiment, aviators unfamiliar with the carrier-landing task trained in the simulator under various conditions involving simulator design options. After training, these pilots transferred to the "optional" simulator configuration. The third stage of the program will entail an actual transfer-of-training experiment comprising novice naval aviators trained under various configurations within VTRS who will then transfer to FCLP and carrier qualification.

In addition to the work reported in NAVTRAEQUIPCEN 78-C-0060-10, STI delivered handwritten notes on a noise model for Descent Rate Cuing (DRC) indictors and optimum DRC gain schedules (as reported in NAVTRAEQUIPCEN 78-C-0060-8) were delivered as Working Papers 2122-3 and 2122-4. These papers were not prepared for final publication because the information contained was intended specifically for the experiment reported in NAVTRAEQUIPCEN 78-C-0060-8 and is of limited interest beyond the description contained in that report.

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APPENDIX A

PROGRAM DESCRIPTION: YAT1

YAT1.FDR is an interactive computer program designed for use in estimating effects of qualitative factors in a fractional factorial design experiment. The program is based on the algorithm described by Yates, (1937) for computing effects (mean differences). Output consists of a table of: original data points, relative effect size, mean effect under low condition, mean effect under high condition, original factor label, and the aliases to the original factor labels.

YAT1.FDR is logically divided into three phases: data input, analysis, and computation of residuals. The data input phase (Phase I) allows the following:

1) Data entry from file YATORDAT.DAT which is created from MAKEGE.FDR to reorder trials into Yates' standard order.

2) Logorithmic data transformation

2a) Program termination or entry of new variable to be analyzed

3) Entry of number of conditions

4) Entry of defining generators

5) Entry of factor names

6) Entry of index and name of variable to be analyzed

7) Printing of plot of original observations by order of execution

8) Resetting of data points, the primary use of which has been to remove outlines

9) Trend removal

YAT1.FDR is currently dimensioned for up to 256 conditions and 10 defining generators. Aliases may be computed for up to 32 factors.

After option nine of Phase I, the user enters the analysis phase (Phase II). Output of the table previously described includes cumulative percent variance of clean two-factor interactions, cumulative percent variance of trial terms, and total sum of squares for effects, after which factor names are output.

The option of construction of a full normal plot of effects ends Phase II (analysis phase).

In this factorial design analysis all effects can be estimated (Phase III). This implies that no provision is made for the calculation of an error term. However, some higher-order effects may be considered negligible in which case the effects of these terms may be set to zero by the user. For an effect to be negligible, the variability in performance would be no greater than is expected by chance. These higher-order interactions may be used to obtain an estimate of the error variance. Tests of statistical significance can now be made. The user should be aware, however, that identification of factors as critical should be based on the effect on performance and not merely statistical significance. Provision is also made for the study of specific effects via reconstruction of the full normal plot of effects (with specific effects under study set to zero).

If the user opts to reset any effects to zero, then additional options are provided along with the mandatory output of residuals and predicted scores. These options are in the form of: 1) a full normal plot of residuals, and 2) a plot of residuals versus the original data points. The user is then given the option of performing recomputation with different effects set to zero. If the user does not require recomputation, the program returns to option 2a in Phase I.

APPENDIX B

BRIEFING CARRIER LANDINGS IN THE VISUAL TECHNOLOGY RESEARCH SIMULATOR MULTIFACTOR Q-T

INTRODUCTION

Welcome to the Visual Technology Research Simulator (VTRS). This is a Naval Research Facility developed to study the use of simulators for teaching flight skills.

The VTRS simulates a T-2C aircraft and consists of a single seat cockpit, a ten foot radius spherical screen which surrounds the cockpit, and control computers which run the simulator. The cockpit controls and instruments operate just as they do in a real aircraft. A picture of an aircraft carrier is projected on the screen, and when the simulator is running, the scene will look just as it would if you were flying a real carrier approach.

We have been investigating instructional methods of carrier landings. This experiment is a continuation of that work.

Because this is a controlled experiment, we will be using a special sequence and schedule to instruct you in what you are to learn. This is to assure that each person in the experiment receives the same material in exactly the same manner. However be sure to ask for clarification on any points you do not understand.

We are teaching different people under different conditions. While we do not believe that knowledge about other conditions will affect your performance, we would like you to inhibit your curiosity about what others are doing until your experimental work is over. It is possible that viewing the displays at the control station could affect your performance, so we would like you to wait in the subject room if you arrive early for a session. Brief exposure to the control station displays or those found elsewhere in the VTRS building will not affect you, but please do not spend any substantial amount of time studying them. Also, please do not watch the video game or the visual acuity testing.

We will tell you when you have finished the experiment and will be prepared to describe other conditions at that time, or to let you view the control station operation if you wish.

We appreciate your participation in this experiment and we hope that it will be a meaningful experience for you.

ABOUT THE EXPERIMENT

This study has been designed to tell us something about how simulation can be used to teach carrier landings. We are examining the training efficiency of several different simulator configurations by teaching carrier landings under the different configurations and then testing landing ability in a simulator configuration that is as close to full fidelity as we can get. While the experiment will be conducted entirely in the simulator we intend to use the information gathered from it to help us design a study in which pilots will be taught first in the simulator and then tested in the aircraft.

Note that this experiment is aimed at testing the simulator, and is not a test of your ability. Nevertheless there will be differences between pilots and we need to account for these when we analyze the data. Differences will minimized if everyone does their best. We would like you to concentrate on learning the task in the correct manner and as quickly as possible. We would also like you to do your best on every trial.

For a normal day carrier landing the pilot circles the carrier to fly a downwind leg parallel to and in the opposite direction to the carrier heading, and about one mile to port (left looking towards the bow). This is where you will start your circling approaches. The simulator will be flying straight and level in the landing configuration (wheels down, flaps down, hook down and brakes out) with 15 units Angle of Attack (AOA), 600 feet of altitude, 85% power, and on a heading of 180°. Start a left turn with 15° to 18° of bank when the tip tank is abeam the carrier ramp. Throttle back to establish a descent rate of approximately 400 fpm but maintain 15 units AOA. At the 90° position (see Figure 1) you should be close to 400 feet of altitude. From that point continue the turn to roll out on the glideslope and on the extended centerline of the landing deck. You should be about 3000 feet from the carrier (20 to 25 seconds out to touchdown) at roll out. Continue the approach to touchdown.

You will not be making circling approaches in the first part of the experiment. Instead you will be making straight-in approaches.

The simulator will be initialized in the landing configuration two miles from the ramp, 15 units Angle of Attack, 400 feet altitude and left of the centerline. This is where you will start your straight-in approach.

Upon release you will fly the aircraft straight and level and maintain 400 feet altitude (approximately 86% power). Flying this configuration you will make a gradual cut into the extended centerline of the landing deck. In addition, by maintaining a 400 feet altitude you will intercept the glideslope and a centered meatball at approximately 4500 feet from the ramp. When the meatball approaches centerball you are to reduce power to 83-84% and continue the approach to touchdown.

THE CARRIER APPROACH

Precise aircraft control is essential in a carrier approach. Vertical displacement errors at the ramp (threshold of the landing deck) of a few feet can be disastrous, as can descent rate, airspeed or attitude

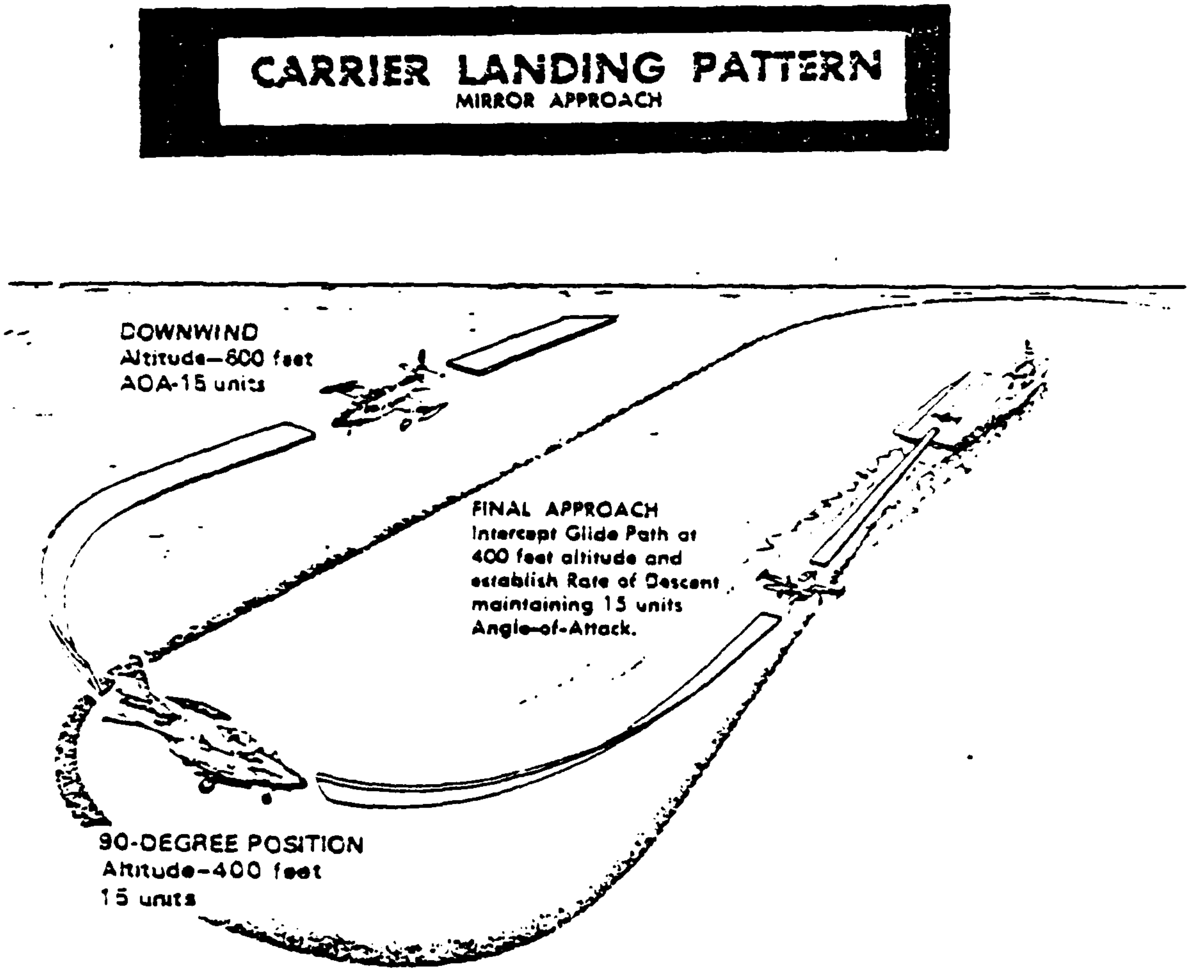


Figure 1. Carrier Landing Pattern from the Downwind Leg.

errors at touchdown. Thus, the pilot must maintain a precise glideslope (generally set at 3.5°) and maintain the correct descent rate, airspeed and attitude. Conventional landings permit some deviations in these parameters but Navy carrier pilots must establish them early in the approach and maintain them to touchdown. Neither is it acceptable for a Navy pilot to fly a loose early approach with the aim of establishing better control near the carrier. The potentially disastrous consequences of errors makes the uncertainty associated with this type of behavior quite unacceptable. In this experiment you will learn some of the skills needed for carrier landings.

PARAMETERS FOR APPROACH CONTROL

In making an approach from the roll out position the carrier pilot must be concerned with:

1) current position in relation to the glideslope

2) current descent rate--is it correct, if not, is it taking him away from the glideslope,

3) airspeed and pitch attitude--integrated into one instrument known as the Approach (Angle-of-Attack) Indexer, and

4) lineup.

GLIDESLOPE POSITION

Glideslope guidance is normally given by the Fresnel Lens Optical Landing System (FLOLS). We have simulated this system with two horizontal bars (to represent the datum bars) and a moving dot (referred to as the ball or the meatball). The system is illustrated in Figure 2 and Figure 3, a to e. A centerball indicates that the aircraft is on the glideslope (later discussion will note that correct aircraft attitude is necessary for that to be true). A high ball indicates that the aircraft is above glideslope, and a low ball that it is below glideslope. At two balls low the meatball starts to flash. Plus or minus two balls is the maximum effective range of the system. The ball will be lost off the top or the bottom at larger deviations from glideslope.

A real FLOLS projects cones of light from the ship as shown in Figure 4. Thus the system is angular. Larger errors are required far from the ship to see meatball movement than are required near the ship. At 3/4 mile a 12 foot glideslope displacement is needed to move the ball off center while at the ramp, a one foot displacement will move the ball off center. The range of the FLOLS is approximately ± 3/4° (precisely ± 47.5') or, if set for a 3.5° glideslope, from 2.75° to 4.25° (approximately).

CARRIER LANDINGS

In making a carrier landing, the pilot attempts to follow the FLOLS center beam to the deck of the carrier. If he can maintain a center ball,

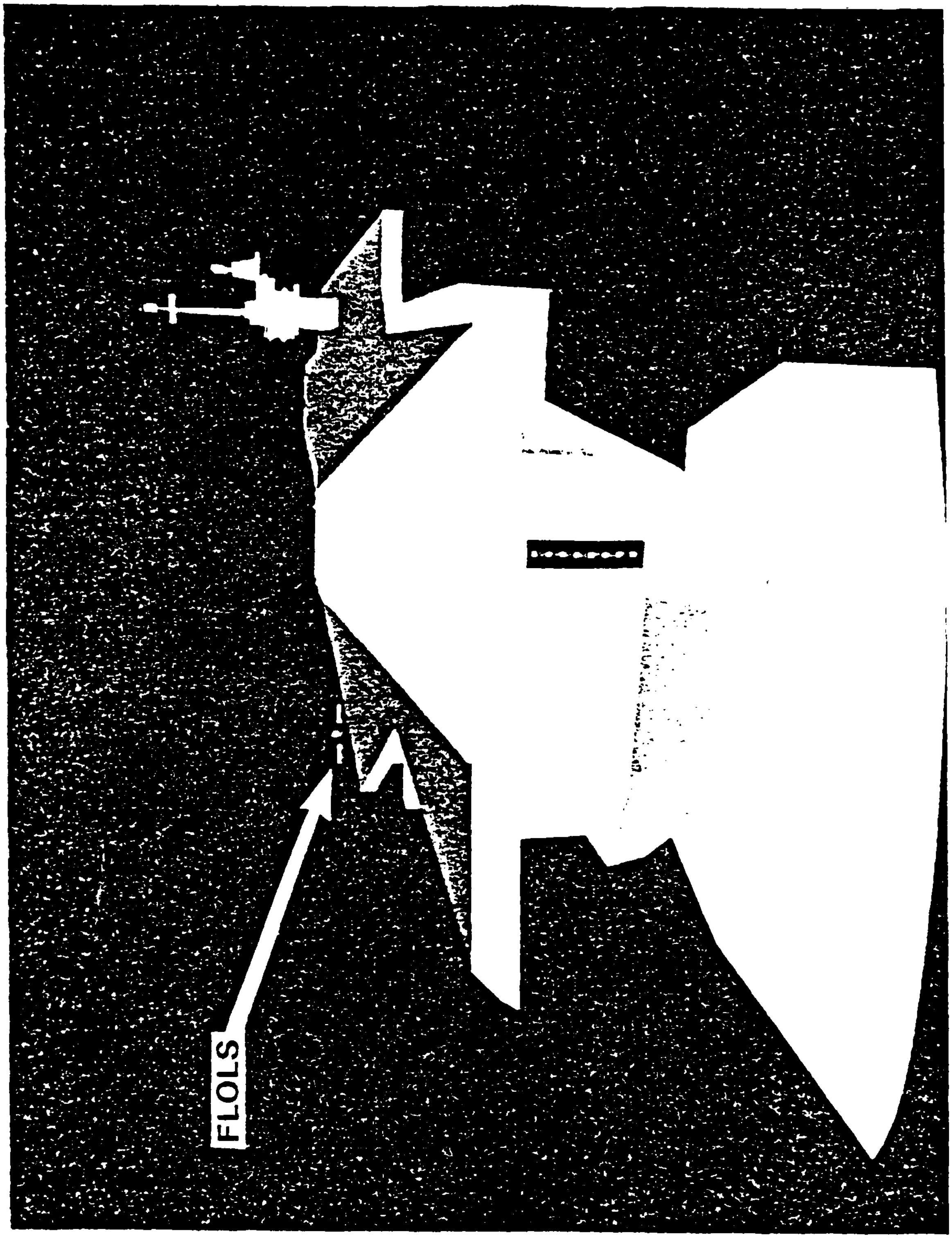


Figure 2. Aircraft Carrier from the Glideslope.
(Note: The Fresnel Lens Optical Landing Systems (FLOLS))

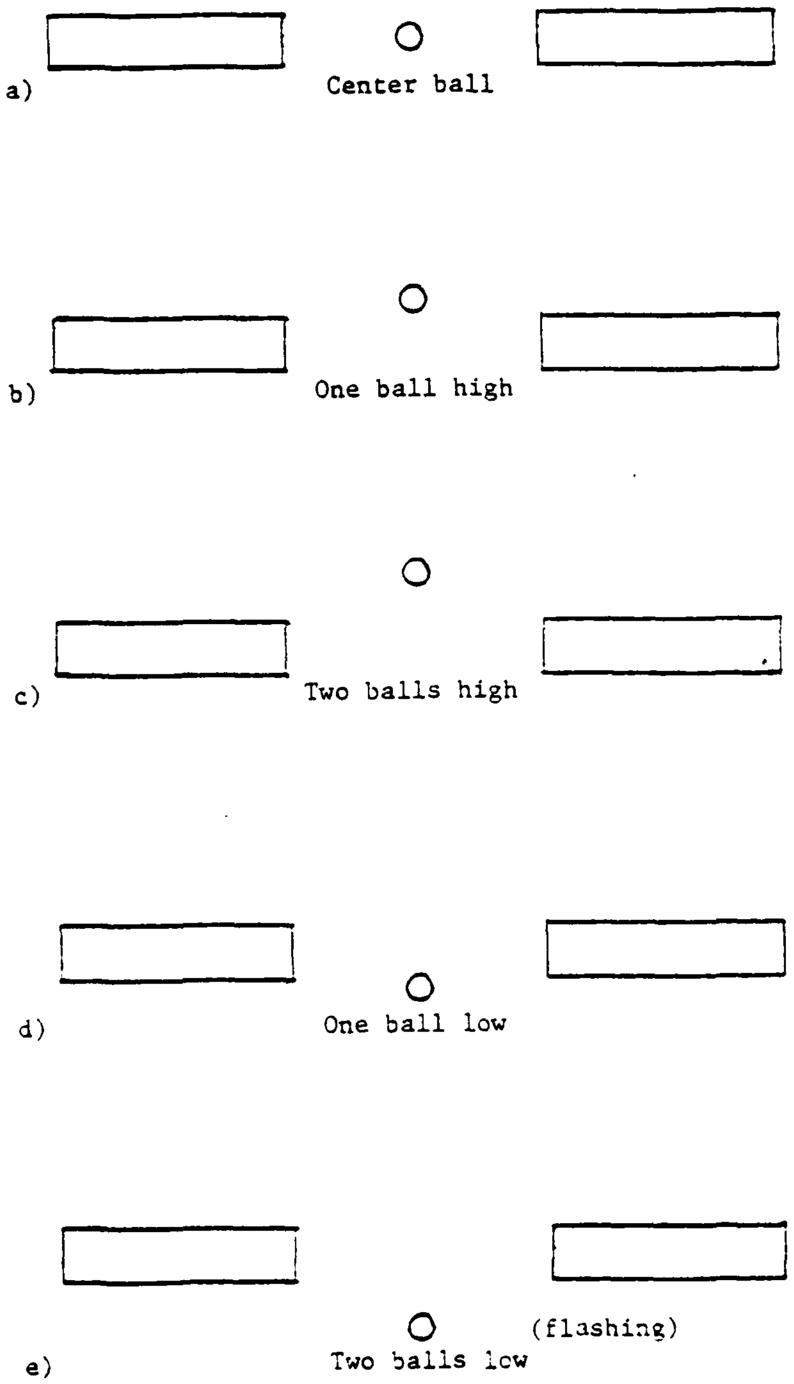


Figure 3. The Fresnel Lens Optical Landing System.

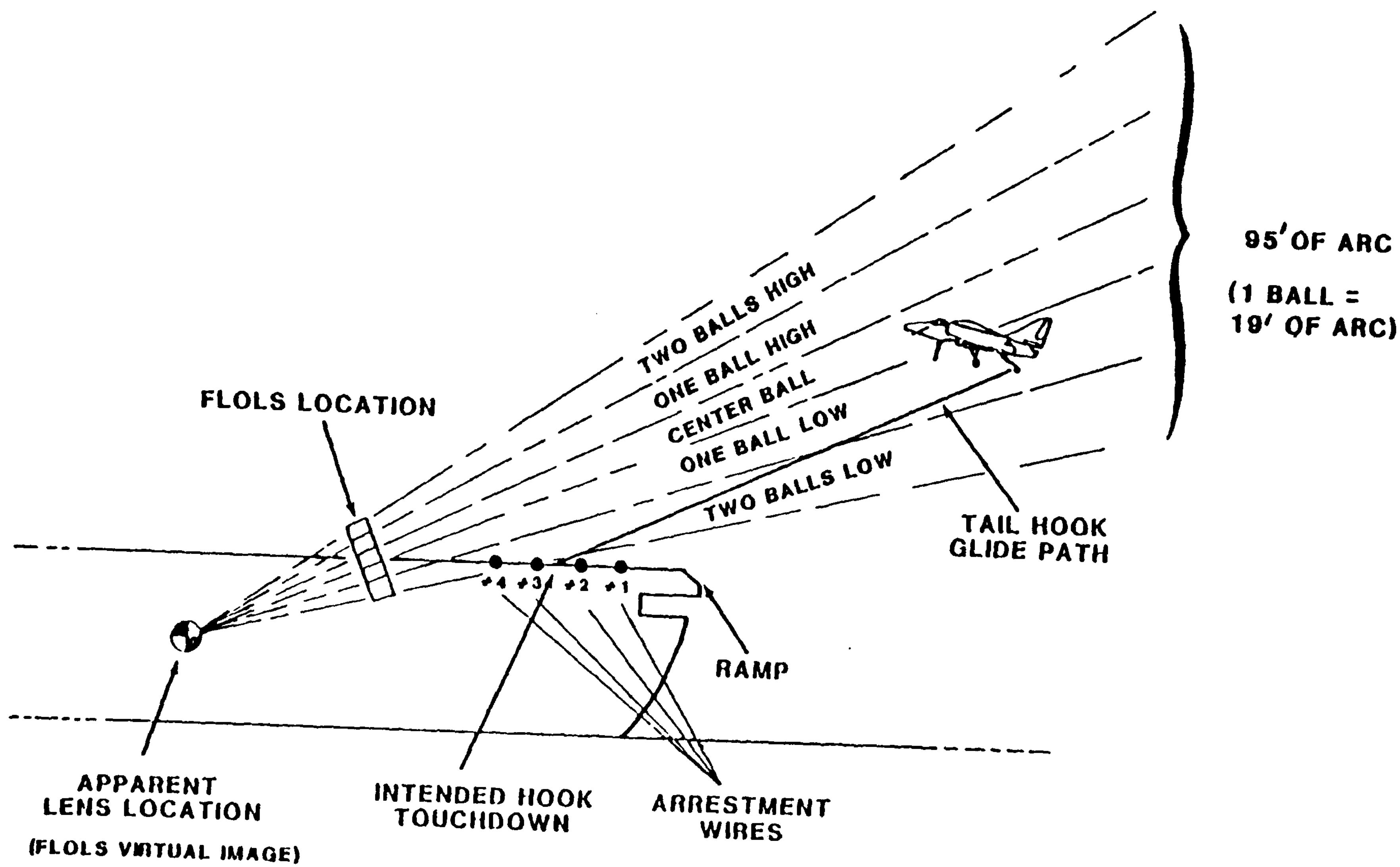


Figure 4. Carrier Approach Schematic Depicting FLOLS Envelope, Tail Hook Glide Path, and Arrestment Wire Locations.

and keep the aircraft in the correct pitch attitude, a hook fixed to the tail of the aircraft (Figure 4) will follow a glide path that is parallel to, but lower than the center FLOLS beam. It is intended that the hook contact the deck midway between the second and third of four cables stretched across the deck (these cables are known as arrestment wires). The hook travels forward from this point to snag the third wire, and so the aircraft is halted.

If the pilot is slightly low on the approach he may snag the first or second wires. If he is very low (actually an error of 10 feet may be enough) he may hit the ramp, thereby bring disgrace, and physical harm to himself, and severely damaging a multi-million dollar aircraft. If a pilot is slightly high on the approach he may snag the fourth wire. If higher (possibly only two feet higher than optimum he may miss the wires altogether and fly off the end of the carrier. A missed approach of this type is called a bolter. Fortunately, bolters do no lasting damage (about 5% of approaches result in bolters), but they do detract from shipboard efficiency. Thus the ability to follow the glideslope contributes to a Navy pilot's health, happiness and self-esteem.

DESCENT RATE

The aircraft has a Vertical Speed Indicator (VSI) (Figure 5), with hash marks shown at 200 fpm intervals (Figure 6). The reference descent rate for the T-2 in the configuration that you will be flying is 480 fpm. That is, if the aircraft is on the glideslope and with the correct attitude and airspeed, it will stay on the glideslope if the reference descent rate is maintained.

If you are above glideslope you will need to establish a descent rate of up to 800 fpm, while if you are below glideslope you will need to establish a descent rate of as low as 200 fpm. These corrections will return you to the glideslope at an appropriate rate. Maximum, minimum, and optimum vertical speeds are indicated in Figure 6.

Note that if you perceive an incorrect vertical speed, it will probably not be sufficient merely to correct back to the reference rate (480 fpm) even if you are on glideslope. By the time your correction has taken effect you will probably be off glideslope and will need to correct in a direction opposite to that which caused the error. The techniques for correcting glideslope errors are central to good carrier landings, and will be discussed in detail in a later section.

Descent rate information can also be obtained from the meatball. If you have a center ball, but see it moving, you can judge that your descent rate is incorrect. In addition, if you are high, you need to start the ball moving down, and if low, start it moving up. You can use the rate of ball movement to establish an appropriate corrective descent rate. This can be useful because it means that you do not have to look inside the cockpit at the VSI. Unfortunately, it is possible to discern movement of the meatball only when the aircraft is approximately 1500 feet from the ship. At greater distances the rate of movement is so low that it is below the threshold for the psychological process that

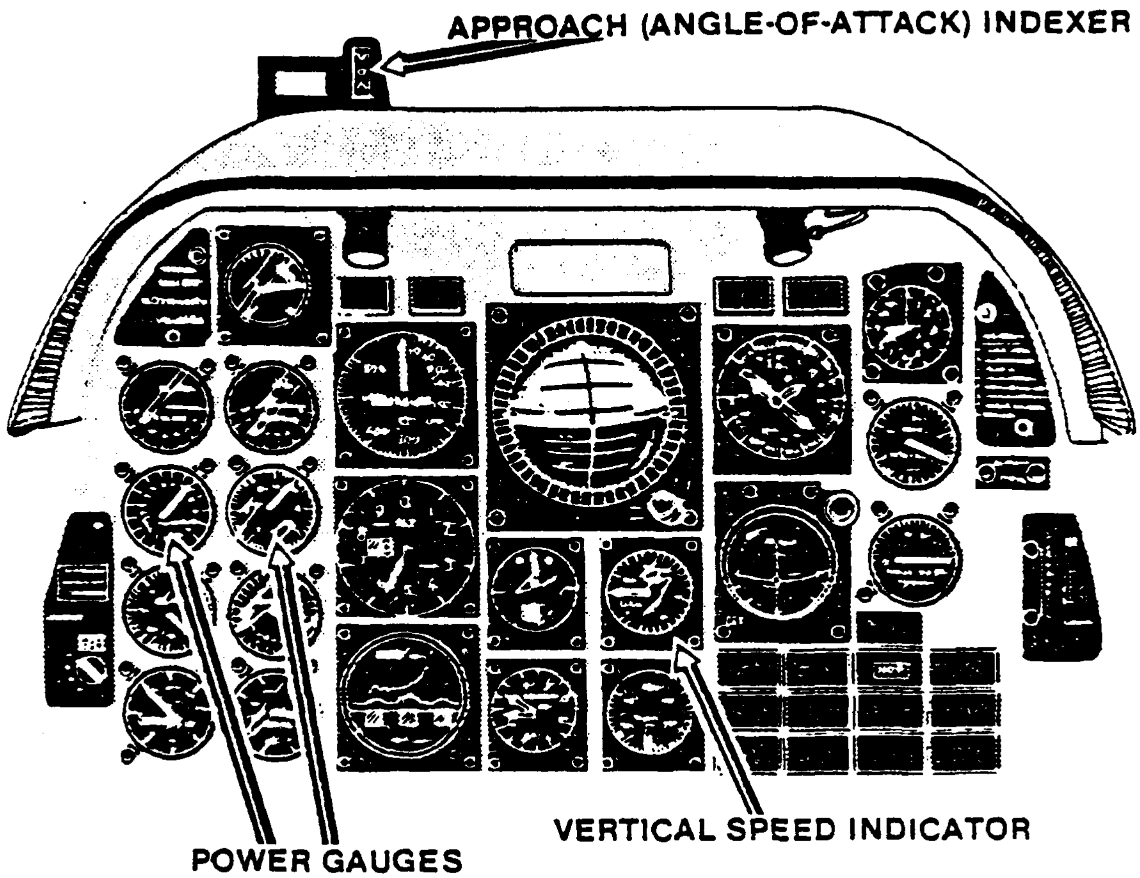


Figure 5. T-2C Instrument Panel.

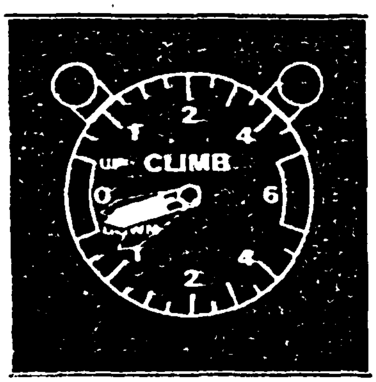


Diagram of T-2C VSI showing 200 fpm hash marks (needle at -480 fpm, and dotted needles at -200 and -800 fpm.)

Figure 6. Vertical Speed Indicator.

interprets changes in position as rates of movement. Thus, you will have to rely on the VSI until you close on the carrier.

COMMAND ONLY

To assist your rate judgements we have added some vertical arrows to the FLOLS as shown in Figure 7. They are calibrated to indicate whether you should modify your vertical speed. A null indication while you have a center ball indicates that you are on glideslope and staying there. Arrows up or down indicate that, although you may now have a center ball, you will soon be high or low. If you are above or below glideslope, a null indication shows that you are returning to the glideslope at an appropriate rate. Down arrows mean you are descending too quickly. Up arrows indicate you are not descending quickly enough.

If you are high, up arrows indicate that you are not returning to the glideslope quickly enough, and could even be going further from it. You should descend more quickly. Down arrows indicate that you are returning to the glideslope too quickly and will probably overshoot. Reduce your descent rate.

For a low meatball the interpretations are just the opposite, down arrows indicate that you are not returning to the glideslope quickly enough and may even be flying further from it, while up arrows indicate you are approaching it too quickly and will overshoot.

The basic rule is to null the arrows wherever you are. Up arrows indicate you are not descending quickly enough. Down arrows mean you are descending too quickly.

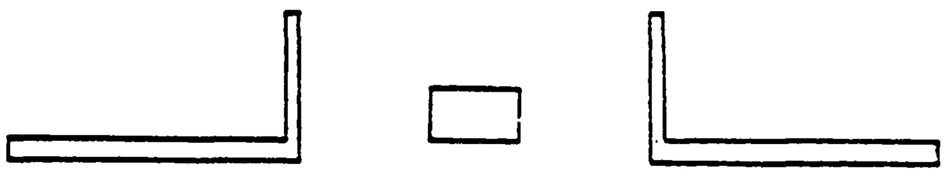
The arrows will be available during your initial training, but they will not be available in a later session. Use them for guidance, but do not rely on them at the expense of the other rate information. Use the arrows to help you learn to use the other rate indications.

ANGLE OF ATTACK

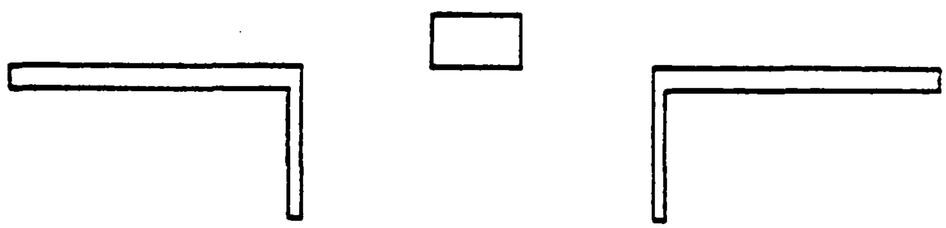
The FLOLS is a passive optical system, and the pilot sees a center ball when his eye is in the center beam. The center beam is set so that at the correct aircraft attitude, the tail hook of the aircraft is proceeding on a glide path of its own, towards a point on the carrier deck midway between the second and third arrestment cable (Figure 4). However, the hook is at the other end of the aircraft from the pilot's eye, and simple geometry would suggest that an incorrect pitch attitude will move the hook above or below its glide path even when the pilot's eye is on the correct FLOLS glideslope. In fact, the hook is the critical point of the aircraft for touchdown accuracy, not the eye of the pilot. The only means the pilot has of ensuring that the hook is in the correct position is by following the FLOLS beam with his eye, and flying the correct AOA (which will ensure correct pitch attitude).

COMMAND ONLY

(a) One-ball high; returning to the reference glideslo[illegible] t an appropriate rate.



(b) One-ball high; not returning to the glideslope quickly enough (may even be going higher).



(c) One-ball high; returning to the glideslope too quickly and will probably fly through it.

Figure 7. Three Types of Indications from the Rate Arrows.

To monitor AOA the Navy pilot is provided an instrument called the Approach Indexer. You will find it above and to the left of the instrument panel (Figure 5). It consists of an upper and lower chevron and a center circle (donut). It is possible for one chevron, or the donut, or a chevron-donut pair to be illuminated. The readings and their interpretations are shown in Figure 8.

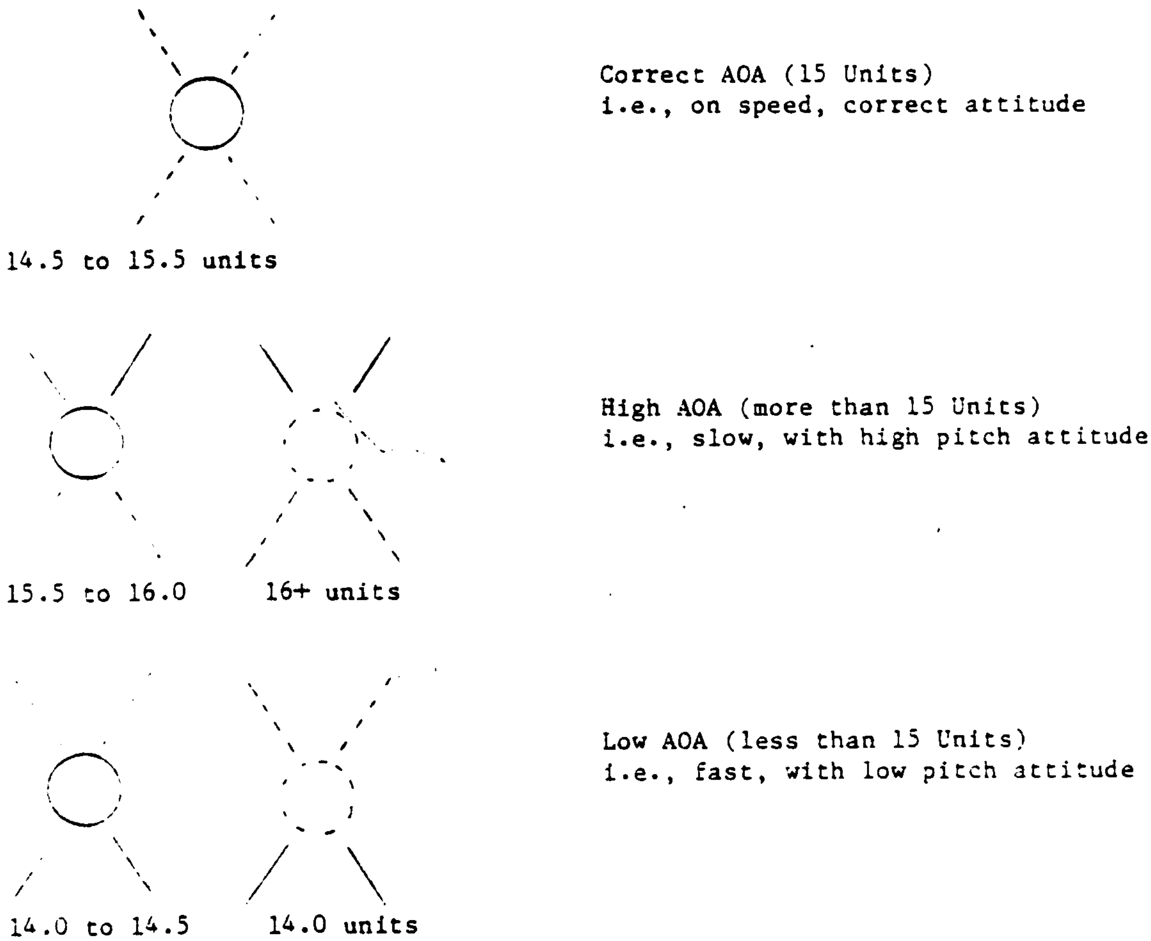


Figure 8. Indications from the Approach (Angle of Attack) Indexer.

A chevron-donut pair can generally be regarded as acceptable. This would allow a range of 15±1 units. More extreme AOA errors should be corrected as is described in a later section of this reading.

LINEUP

In carrier landings the pilot lines up with the extended center line of the landing deck. Note that the landing deck is canted at 10.5° to the longitudinal axis of the ship. It is not, therefore, appropriate to use the carrier wake or the main deck for lineup. Lineup errors are corrected with small banking turns to the left or right. You will need to use fine control pressures in moving the stick to the left or right, and on the rudder pedals, to start these turns. In turning onto the center line, you should anticipate closing on it, that is, start your lineup turn before you reach it. If you start your lineup turn when you reach the center line, you will find yourself a long way past it by the time you are heading the simulator in the right direction.

At night you will need to use the drop lights at the stern of the carrier to assist you with lineup. If you are lined up it will appear as a straight extension of the center line of the landing deck. If you are off center it will appear angled to the center line. It will, in fact, form a V with the center line, with the apex of the V pointing in the direction you must go to line up (Figure 9).

ERROR CORRECTION: GLIDESLOPE AND AOA

Upon reaching the 90 degree position (about halfway through the turn) and acquiring the ball, the aircraft is on the glideslope. Due to ever-increasing closure rate on the touchdown point, the rate of descent required to maintain a centered ball from the 90 to wings level on final is an ever-increasing amount. Therefore, less power may be required from the 90 to the start of the final so as to maintain a centered ball, while the nose attitude is adjusted to maintain 15 units angle of attack. In addition, you will need to reduce power when you roll your wings level to compensate for the increased lift.

Always keep in mind your glideslope position (i.e., meatball position), your vertical speed (noted from the VSI and the rate of movement of the meatball), and your AOA. Try to determine a reference power level that will maintain you on the glideslope. The location of the left and right power gauges is shown in Figure 5, while Figure 10 shows approximate optimum, maximum, and minimum values. Also, note in Figure 10 that each minor hash mark represents 1% of power and major hash marks represent 10% of power. A reference power of about 83% should work well. Lead corrections with power (except as noted in 2)c) below); changes of 2% to 4% should be sufficient. Certainly do not go above 90% or below 75%. Follow with small pitch changes to correct or maintain AOA. An 8.5° pitch up is correct; and corrections for AOA should not require pitch movements to below 7° or above 10° (the dot on the attitude indicator corresponds to 1°). Greater changes than that will indicate that you are overcontrolling in pitch.

Remember that corrections are almost always started with a power adjustment and AOA errors should generally be corrected before glideslope errors (except as noted in 2)c) below). The power adjustments for a correction will be made in three (and sometimes four) steps. First

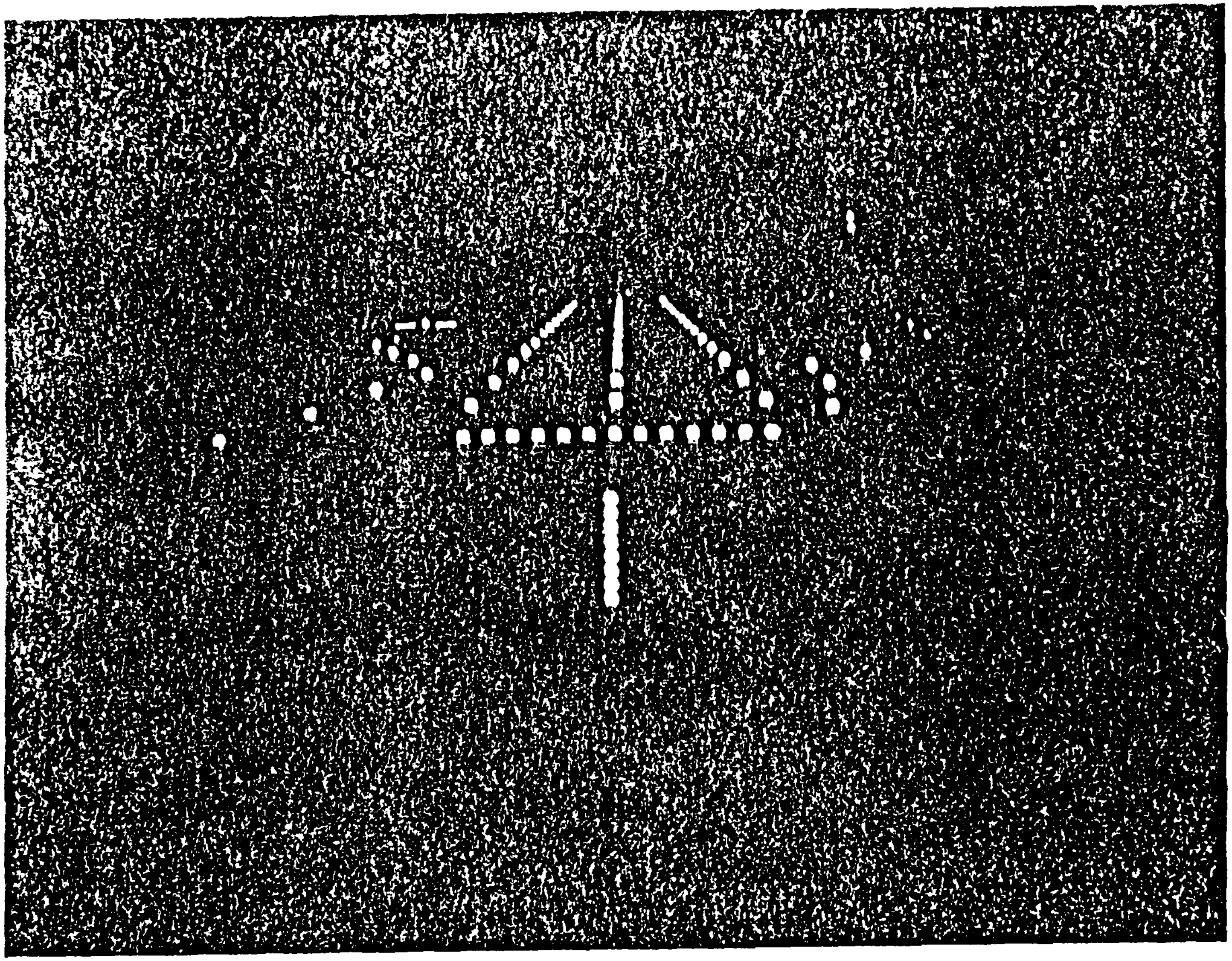


Figure 9. Computer-Generated Image of the Night Carrier, with FLOLS, Showing an On centerline view. A Centerline-dropline Configuration Such as Indicates the Need to Fly to the Right While One Such as Indicates the Need to Fly to the Left.

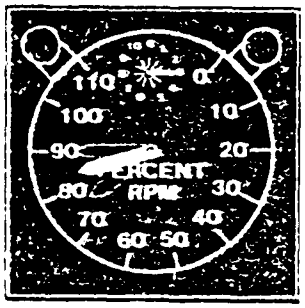


Diagram of T-2C power gauge, showing hash marks - note: the needle at 83%, and dotted needles at 90% and 75%.

Figure 10. Power Gauge (Both Left and Right Gauges are Identical).

increase or decrease power to initiate the correction. Secondly, take out the correction as you approach the correct AOA or glideslope position. In taking out the correction go past your reference power to null any acceleration or unwanted velocity component that you have introduced in the first step. The third step; to return the power to its reference level, follows the second step almost immediately.

If you need to make a large power correction for a glideslope error, you may find it necessary to insert another power adjustment between the first and second steps. After the initial correction you should look for a target descent rate that will return you to the glideslope quickly enough, but not so quickly that you will not be able to stop on the glideslope. You may achieve the target descent rate before you near the glideslope. If so, you should take out some of your power correction (probably about half) so that you do not go past your target descent rate. Specific types of errors are discussed below.

1) AOA errors

If on glideslope and correct vertical speed,

a) high AOA (slow): add power, smoothly push the stick forward (slightly) to correct AOA; as aircraft accelerates, reduce power to slightly less than reference level, and then almost immediately adjust back to reference level.

b) low AOA (fast): decrease power, smoothly pull stick (slightly) to correct AOA; as aircraft decelerates, increase power to slightly higher than reference level and then almost immediately decrease ower to reference level.

2) Glideslope errors

Note that if your AOA is correct and you add power to make a glideslope correction, you will need to pull the stick back slightly to maintain the correct AOA (because with the same stick pressure the extra surge of power will push the aircraft a little faster and tend to lower its attitude). If you decrease power you will need to push the stick forward slightly to maintain AOA.

a) Going high: decrease power (if AOA is low the decrease in power will tend to correct the AOA error before it corrects the glideslope error; otherwise you need to push the stick forward). When you see that you have started back to the glideslope add about half the power you have taken out. As you near the glideslope add more power so that the power level is now slightly above the reference level. Almost immediately reduce power to the reference level.

b) Going low: increase power to start the ball moving up (if AOA is high, the increase in power will tend to correct the AOA error, but let the ball start moving before you ensure that AOA is closing on the correct value. When you see that you have started back to the glideslope, take out about half the power you have added. As you near the glideslope take out more power so that the power level is now slightly below the reference level. Almost immediately increase power to the reference level.

c) Correcting for a low or a high in close (less than 1000 ft from touchdown): for a low add power to start the ball moving up. Stop the ball moving up by adjusting the pitch (this is the only time that pitch should lead power in making an adjustment). Use power to get back on speed.

   If the ball is moving up in close or has stopped with a high indication in close (either as a result of an overcorrection from a low, a slightly low descent rate from farther out, or for some other reason), do not recenter.

   A correction at this point can lead to an excessive descent rate at touchdown (correction for a high ball in close can produce a 5° glideslope). If the ball develops a rapid motion towards the bottom of the lens, apply enough power to stop the movement.

LANDING SIGNAL OFFICER

In real carrier approaches a Landing Signal Officer (LSO) is stationed to the side of the landing deck and advises the approaching pilot by radio on the suitability of his approach. He may, for example, advise the pilot that he is high or low, or to the left or right. He may give instructions, such as "POWER" to indicate that the pilot should add power. He may instruct the pilot to discontinue his approach, and go around to set up for another approach by flashing two vertical light arrays on the FLOLS and calling "WAVEOFF".

The role of the LSO is also instructional, in that he will make a record of the pilot's performance, and use this in a debrief to point out errors, and to advise him on how to improve his approaches.

In this experiment we have a computerized LSO to give selected calls during the approach. The calls are listed in Table 1, together with the type of error that will evoke the call and the corrective action required.

The instructional role of the LSO will be filled by an experimenter who has been trained by an LSO for this task. He will comment on the significant features of your approach at the end of each trial, and will suggest ways to improve. These suggestions will not cover new material. Anything that should be explained to you already has been explained. The LSO - experimenter's comments will be taken from this briefing, and will serve to remind you of the material covered, and to orient you towards the errors that you are making and the appropriate corrective action. Common terminology that might be used during these instructions is shown in Table 2.

TABLE 1. LSO TRANSMISSIONS, THEIR MEANING AND REQUIRED CORRECTIVE ACTION

TRANSMISSION	MEANING	REQUIRED RESPONSE
"YOU'RE A LITTLE HIGH"	A/C is between .5 and 1.5 meatballs above glideslope.	Adjust altitude to a centered meatball immediately.
"YOU'RE HIGH"	A/C is 1.5 meatballs or more above glideslope.	Reduce power and adjust altitude to a centered meatball immediately.
"YOU'RE GOING HIGH"	A/C is less than .5 meatballs above glideslope and sink rate is less than 60 ft/min.	Reduce power and re-establish rate of descent.
"YOU'RE A LITTLE LOW"	A/C is between .5 and 1 meatball below glideslope.	Maintain current altitude until glideslope is intercepted.
"YOU'RE LOW"	A/C is more than 1 meatball below glideslope.	Add power and adjust altitude to a centered meatball immediately.
"YOU'RE GOING LOW"	A/C is less than .5 meathall below glideslope and sink rate is greater than 660 ft/min.	Add power and re-establish rate of descent.

TABLE 1. LSO TRANSMISSIONS, THEIR MEANING AND REQUIRED CORRECTIVE ACTION (Cont'd)

TRANSMISSION	MEANING	REQUIRED RESPONSE
"A LITTLE POWER"	A/C is between .5 and 1 meatball below glideslope.	Add 1 to 2% power to adjust altitude to a centered meatball immediately.
"POWER"	A/C is more than 1 meatball below glideslope, or A/C is in-close, more than .5 meatballs below glideslope and sink rate is greater than 480 ft/min.	Add power to adjust altitude to a centered meatball.
"MORE POWER"	Response to an initial "power command" was inappropriate.	Add more power.
"YOU'RE FAST"	Angle of Attack is less than 13 units and sink rate is between 210 and 390 ft/min.	Correct Airspeed/Angle of Attack Indication.
"YOU'RE SLOW"	Angle of Attack is greater than 16 units and sink rate is between 480 and 660 ft/min.	Correct Airspeed/Angle of Indication with power addition.
"FLY THE BALL"	A/C is "in-close" and more than 1 ball above glideslope, or A/C is "in-close" and sink rate is less than 210 ft/min.	Fly and use the meatball for rate/altitude information.

TABLE 2. COMMON TERMINOLOGY

1) The 180° position - A position on the downwind leg where the initial turn onto the base leg is commenced.

2) The 90° position - A position reached halfway along the 180° arc from the "180" to the landing line.

3) Final approach - That portion of the pattern flown from the sighting of the meatball to touchdown.

4) Groove - That portion of the final approach which coincides with the landing line. It commences upon rolling the wings level with the aircraft on the line and allows for approximately a 18-25 second straightway.

5) Cocked up - Flying too slowly or at too high an angle of attack, causing the use of excessive power to maintain altitude or rate of descent. This is a condition that exists when operating on the back side of the power curve.

6) Dive for the deck - Pushing the nose over and establishing an excessive rate of descent. This causes either a three-point landing (all gear hitting the deck at the same time) or possible nose wheel first.

7) Ramp - The after end of the flight deck or the downwind end of the platform of the runway.

8) Bolter - A touchdown on board the carrier in which the arresting hook does not engage an arresting wire, usually caused by landing past the wire area or by the hook's skipping over the arresting wires.

9) Meatball - Terminology used to describe the mirror presentation of the source lights as seen by the pilot.

10) Clara - A term used to signify that the meatball has not been sighted.

SUMMARY

It requires care and effort to learn the control techniques for carrier landings. Navy pilots complete more than 100 approaches in a simulator or to a shore-based landing strip before they attempt a carrier landing. Our research indicates that even after hundreds of carrier landings pilots continue to improve their glideslope control. We will be measuring your performance throughout the trial, not just at the deck of the carrier. Follow the recommended procedures, and in particular try to set yourself on the glideslope, and with the correct AOA early in the approach. Your errors along the glideslope will be assessed. Avoid the temptation to correct by leading with pitch adjustments. Also avoid the temptation to trap a wire at all costs. If you are high as you approach the wires, accept it. A sudden dive for the deck at this point will down-grade your overall rating for that approach more than a bolter. You should approach the task with care and perseverance. Review this lesson, and note the feedback during the trials. There is something to learn from even a bad performance.