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AUTOMATIC CARRIER LANDING SYSTEM (ACLS) CATEGORY III CERTIFICATION MANUAL

July 1982

Prepared for
THE NAVAL ELECTRONIC SYSTEMS ENGINEERING ACTIVITY
ST. INIGOES, MARYLAND
AND
NAVAL AIR TEST CENTER
NAS PATUXENT RIVER, MARYLAND
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The purpose of this Automatic Carrier Landing System (ACLS) Certification Manual is to give information and guidance for the proper conduct of an ACLS certification. Information contained herein is a compilation of pertinent data, tests, and methods intended to guide the user through the complete planning, testing, and reporting required during a certification effort.

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SECTION ONE

INTRODUCTION

1.1 PURPOSE

The purpose of this Automatic Carrier Landing System (ACLS) Certification Manual is to give information and guidance for the proper conduct of an ACLS certification. Information contained herein is a compilation of pertinent data, tests, and methods intended to guide the user through the complete planning, testing, and reporting required during a certification effort.

NAVMATINST 5400.20 (Appendix A) provides direction on responsibilities of Navy Systems Commands for certification of AN/SPN-42A and AN/SPN-42-T4. NAVAIRINST 13800.11A (Appendix B) provides a further breakdown of responsibilities. Naval Electronic Systems Engineering Activity (NESEA) Document No. 022-102B presents the details for conducting Category I and IIA portions of the certification. This manual sets forth the details for conducting the Category IIB and III portions of the certification.

1.2 BACKGROUND

The Navy's ACLS began development in the late 1950s with the primary purpose being to reduce the carrier landing accident rate. The Navy's Specific Operational Requirement (SOR) No. 34-06R1 states, in part: "In support of the Navy's mission in general and limited warfare there is a requirement for development of an All-Weather Carrier Landing System. This system should be capable of providing for the safe and reliable final approach and landing of jet-powered carrier-based aircraft during daylight or darkness, with minimum interference from conditions of severe weather and sea state and no limitations due to low ceilings and visibility." While ACLS is currently capable of meeting most of this SOR, a continuing effort must be exerted to keep the entire shipboard/airborne system operating within defined electrical specifications. This effort is the ACLS certification process.

ACLS certification testing is divided into three categories, as follows:

- Category I tests are electrical checks of the various components of the ACLS suite. The Category I test for shipboard equipment requires seven to ten days in-port to accomplish and is normally conducted by a team from NESEA.
- Category II tests are flight tests conducted pier-side to determine system alignment and to verify system operation. Category IIA tests, normally conducted by NESEA with flight assistance by Naval Air Test Center (NAVAIRTESTCEN), assure that the alignment of the system (glidepath and center line) is within specified tolerances. Category IIB, normally conducted by NAVAIRTESTCEN in conjunction with NESEA, involves a data-link-equipped aircraft flying approaches to the ship to ensure proper closed-loop system operation.
- Category III tests are normally conducted by NAVAIRTESTCEN flying ACLS-qualified aircraft with support from NESEA while the ship is under way. Category IIIA testing verifies the alignment and proper operation of the stabilization equipment. Category IIIB testing assures suitable Mode I control performance from lock-on to touchdown of the aircraft types that are to be deployed on that ship.

1.3 SECURITY

This document is unclassified, and any or all portions of it may be reproduced by users.

1.4 AUTHORITY

This ACLS Certification Manual was prepared by ARINC Research Corporation under Contract N00421-81-C-0187 by the authority of the Naval Electronic Systems Engineering Activity.

SECTION TWO

ACLS CERTIFICATION

2.1 OBJECTIVES

There are two objectives of ACLS certification. The first is to define the expected performance of an ACLS ship or shore installation with quantitative metrics. The second is to determine the limits of ambient conditions for which the measured performance would permit the continued system usage for automatically controlling aircraft to a safe landing.

2.2 SCHEDULE

The certification effort requires approximately 18 weeks of activity, which may be divided into planning and preparation, pretrials, at-sea tests, and post-at-sea analysis. Typical milestones for an ACLS certification are listed in Table 2-1, together with the organization responsible for meeting the milestone.

The NAVAIRTESTCEN project team normally begins work on the certification approximately six weeks before the at-sea trials, with the first phase of the effort devoted to planning and preparation of the certification.

Table 2-1. ACLS CERTIFICATION MILESTONES	
Event	**Timing**
Certification scheduled (Type Commander [TYCOM] to Naval Air Systems Command [NAVAIR] Headquarters [HQ])	24 weeks BC*
Special schedule or support requirements request (NESEA/NAVAIRTESTCEN to ship)	6 weeks BC
Outline of test operations (NAVAIRTESTCEN)	4 weeks BC
Certification planning meeting (TYCOM, ship, NESEA, NAVAIRTESTCEN)	4 weeks BC
Precertification inspection (NESEA)	4 weeks BC
Modification installation (NESEA)	2 weeks BC
Ships Inertial Navigation System (SINS) and Fresnel Lens Optical Landing System (FLOLS) verified before Category I tests (TYCOM)	2 weeks BC
Category I tests (NESEA)	1 week BC
Category IIA tests (NESEA)	1 week BC
Mode III certification (NESEA)	1 week BC
Category IIB tests (NAVAIRTESTCEN/NESEA)	1 week BC**
Category III tests (NAVAIRTESTCEN/NESEA)	1 week of certification
Final certification Mode I situation report with interim certification (NAVAIRTESTCEN/NESEA from ship)	End of at-sea certification
Certification message report with outstanding discrepancies (NESEA)	2 weeks AC†
Certified computer program patch tapes forwarded (NESEA to ship)	4 weeks AC
Category I electrical test results forwarded (NESEA to ship)	4 weeks AC
Final certification results (NAVAIRTESTCEN TO NAVAIR HQ)	10 weeks AC
Final electrical test results (NESEA to Naval Electronic Systems Command [NAVELEX] HQ)	10 weeks AC
Final certification (NAVAIR HQ to TYCOM)	12 weeks AC

*Before at-sea certification testing.
**There should be a one-week interval between the completion of CAT II tests and the start of CAT III tests.
†After at-sea certification testing.

SECTION THREE

ACLS SYSTEM OPERATIONAL CHARACTERISTICS

3.1 INTRODUCTION

The purpose of the ground ACLS is to control aircraft assigned by the Air Traffic Control System and to bring the aircraft to safe landings. Landings may be accomplished in fully automatic, semiautomatic, or manual talk-down modes, with the mode of landing being selected by the pilot. The complete surface elements of the ACLS consist of the AN/SPN-42A Landing Control Central with the AN/SPN-41 Instrument Landing System and Fresnel Lens Optical Landing System (FLOLS) as independent monitors.

3.2 AN/SPN-42A LANDING CONTROL CENTRAL

The ACLS AN/SPN-42 is an all-weather landing system designed to provide safe and reliable final approaches and landings for carrier-based aircraft. Aircraft employing the AN/SPN-42 may be landed safely on a moving carrier during daylight or darkness with minimal interference from adverse weather, poor visibility, or sea-state conditions.

The major components of the AN/SPN-42 include a precision tracking radar, a stable platform, and a high-speed general-purpose computer. The radar is mounted on the aft end of the carrier island 30 to 60 feet above the flight deck. The stable platform is mounted adjacent to the radar pedestal. The AN/SPN-42 computer and associated peripherals are located in an equipment room near the Carrier Air Traffic Control Center (CATCC), where the control consoles are located. Auxiliary displays are provided at the Landing Signal Officer platform and in Primary Flight Control.

Operationally, the ACLS sequence is similar to a voice-controlled aircraft approach and landing. The shipboard radar tracks a point source on the aircraft, such as a beacon or corner reflector, to determine the aircraft's spatial position with respect to the radar antenna. These data for slant range and angular position are then converted by the ACLS computer into lateral, longitudinal, and vertical position coordinates relative to the desired touchdown point on the deck. The stabilization subsystem provides data to the computer in order to compensate for the ship's rotational motion (yaw, pitch, and roll) and heave. The computer evaluates the effects of the ship's motion and removes those effects from the data. The corrected data are entered into a flight computation routine in the computer for comparison with a stored flight path for the type of aircraft currently under ACLS control. Deviations from the desired flight path are converted by the computer into pitch and bank commands, taking into account the response characteristics of the controlled aircraft type. These commands are then transmitted to the aircraft through the data link or by ACLS operator verbal commands, depending on the mode of operation employed.

3.3 OPERATIONAL MODES

Four modes of operation are available to the pilot of an aircraft under control of the ACLS:

- Mode I provides totally automatic control through the aircraft's flight control system from ACLS entry to touchdown on the carrier deck.
- Mode II provides semiautomatic control, requiring manual navigation of the aircraft while supplying the pilot with cockpit displays of the error signals generated by the ACLS.
- Mode III is a manual carrier-controlled approach (CCA) with talk-down guidance by the ACLS operator.
- Mode IA is similar to Mode I but requires the pilot to take control and manually fly the last one-half mile to touchdown.

The mode of operation is selected by the pilot, who may take manual control of his aircraft at any time during the landing sequence. When the AN/SPN-42 first locks onto the aircraft, the computer is operating in Mode II. The pilot may continue to fly his aircraft in Mode II or engage the autopilot (Mode I) and request commands. Mode I approaches require an operational beacon on beacon-equipped aircraft.

In a Mode I approach, the computer-generated flight commands are transmitted through the data link to the aircraft, where they are coupled into the Automatic Flight Control System (AFCS). Flight-path-error data are also transmitted to the aircraft for cockpit displays to allow the pilot to monitor the system. The AFCS, controlled by the ACLS, keeps the aircraft on the designated flight path and glideslope while the autothrottle (APC) maintains the approach angle of attack by controlling the throttle setting. Approximately 12 seconds before touch down, the ACLS generates and transmits deck motion compensation (DMC) commands to the aircraft. These DMC commands are introduced over a 2-second span at the 12-second mark to control the vertical position of the aircraft so that the aircraft will be in phase with the ship's moving flight deck.

In the final seconds of the approach, normally 6 to 10 seconds from touchdown, additional ramp input pitch commands may be applied to assist the aircraft through the aircraft carrier air wake or burble. These ramp commands are tailored to each specific ship and aircraft type during a certification and are based on the aircraft's measured ACLS performance through the burble.

In a Mode II approach, the flight-error data are transmitted to the aircraft and displayed on appropriate aircraft heads-up and heads-down displays. The pilot flies the aircraft by observing the display until the carrier deck becomes visible. At this point in his approach, typically three-quarters of a mile from the ship, the pilot transitions to visual landing aids (normally FLOLS). With the aircraft already on the correct glideslope and center line as directed by the ACLS, the pilot should only need to make minor corrections to maintain his lineup to touchdown.

The AN/SPN-42 operator, a safety monitor in Mode I and II approaches, enters the control loop in Mode III approaches by observing the azimuth and elevation (AZ-EL) deviations on the control console radar scope and by issuing verbal commands to the pilot. The azimuth and glideslope deviations of the aircraft from the desired glidepath are transmitted to the aircraft through a standard voice communications link and the pilot is "talked down." Appendix C presents a detailed description of the landing modes and procedures.

ACLS design incorporates a number of safety factors, including redundant subsystems, computer checks, and independent monitors on-board ship, and independent position displays in aircraft. All phases of final approach and landing in Modes I and II can be monitored by both the pilot and shipboard controller. A provision for manual override at the discretion of the pilot is provided.

If the approaching aircraft exceeds preset control-volume limits, the ACLS will either switch the system from an automatic mode of operation to a manual mode of operation or initiate a wave-off command. A wave-off command is automatically initiated in Mode I if the control-volume limits are exceeded when the aircraft is between 12 and 5 seconds from touchdown. If warranted, the control-volume limits can be overridden by the ACLS operator. Equipment malfunctions will automatically switch the system from an automatic to a manual mode or initiate a wave-off, depending on the nature of the failure and the aircraft's position relative to touchdown.

SECTION FOUR

CERTIFICATION PLANNING AND PREPARATION

4.1 INTRODUCTION

The planning and preparation phase of the certification effort consists of developing the various plans, memoranda, requirements, and other efforts required to actually conduct the at-sea certification. This effort includes documenting the certification requirements to the various expected support activities, developing the logistic requirements, reviewing past test results, and preparing various test documentation as the anticipated back-up material that may be required during the certification effort.

4.2 CERTIFICATION CORRESPONDENCE

The certification begins with the preparation of various correspondence to coordinate the at-sea trials. The major correspondence expected is as follows:

- Detailed cost estimate to establish the expected certification cost
- NESEA memo to request that various AN/SPN-42 aircraft programs be provided together with expected ramp configurations (ramps are discussed in Section Seven)
- TSD memo to coordinate instrumentation requirements
- Test plan to define ACLS certification schedule, cost, and participants
- Requirements message to TYCOM to detail NAVAIRTESTCEN test support requirements
- Operations plan that details ACLS certification requirements and schedule to the ship or shore station that is being certified
- Airlift request for transportation from NAVAIRTESTCEN to test site (if required)
- Commercial transportation request (if airlift unavailable)

• Ship's briefing notes to explain the purpose, goals, and requirements of certifications to shipboard personnel

• Development of test notebook to document certification effort

4.2.1 Detailed Cost Estimate

The detailed cost estimate establishes the expected cost of the certification and provides a funding justification. The cost estimate includes the cost of NAVAIRTESTCEN aircraft, direct travel, material, data processing, and direct labor. The cost estimate should present alternative costs for back-up travel whenever an expected airlift may be canceled. Figure 4-1* presents a detailed cost estimate for the certification.

4.2.2 NESEA Memorandum

A memorandum is sent from NAVAIRTESTCEN to NESEA a minimum of three weeks before CAT III certification to detail the aircraft programs to be included in the AN/SPN-42 patch tape for the certification effort. This memorandum makes *NAVAIRTESTCEN responsible for defining* the shipboard programs and *NESEA responsible for implementing* the shipboard programs. This documentation also serves as a ready reference for checking the various aircraft configurations during the at-sea trials, if necessary, and documenting any changes such as ramp configurations. A representative memorandum for detailing the various aircraft programs is shown in Figure 4-2. The aircraft program parameters are defined in Appendix D.

4.2.3 Technical Support Directorate (TSD) Memorandum

The TSD memorandum from the Strike Aircraft Test Directorate (SATD) to TSD outlines the requirements of TSD for support of the certification effort. In addition to specifying the various instrumentation requirements, the TSD memorandum is also used to establish the TSD cost estimate for the certification, to obtain cargo and personnel requirements, and to obtain information for the operations plan. The memorandum formally establishes job order charge numbers for TSD and specifies the SATD point of contact (POC). The response to the memorandum designates the TSD POC as well as providing the information requested. A sample memorandum from SATD to TSD is shown in Figure 4-3.

4.2.4 Test Plan

The test plan required for a certification effort normally consists of a NAVAIRTESTCEN project test plan cover sheet (Form NDW-NATC-3930/2 [Rev. 10-75]), the shipboard operations plan, and a safety checklist (Form NDW-NATC-3930/13 [Rev. 1-78]) which is signed by all assigned project flight crews and the project engineer. A completed project test plan cover sheet is shown in Figure 4-4. Various additional examples of both project test plan cover sheets and shipboard operations plans are contained within the carrier system's branch files.

*All figures are presented at the end of this section.

4.2.5 Certification Requirements Message

The certification requirements message is sent from NAVAIRTESTCEN to all fleet activities that are required to provide direct support for the certification effort. These activities include fleet commands, the ship to be certified, and supporting Naval Air Stations. The requirements message notifies everyone involved of the fleet support required and sets up the pretrial conference.

Fleet commands such as AIRLANT, AIRPAC, or appropriate Marine Air Wings are requested to provide fleet test aircraft, air crews, and maintenance support. Requests may also be made to ensure that the designated fleet aircraft are ACLS-ready and in position for flight checks of pre-shipboard trials. The requirements message details the host squadron's responsibility as well as NAVAIRTESTCEN responsibility for "borrowed" test aircraft.

The portion of the requirements message directed toward the ship to be certified will request various equipments to be operational and available during at-sea certification tests. In addition, test periods will be defined together with logistic support requirements.

The requirements message is also directed toward any support that may be required at a Naval Air Station, such as running shore-based ACLS check-out flights, or any transient support. Figure 4-5 illustrates a typical ACLS requirements message.

4.2.6 Operations Plan

The shipboard operations plan (OPS Plan) outlines the planned NAVAIRTESTCEN operations while aboard ship. The OPS Plan specifies the test objectives, aircraft and air crews, test personnel, test responsibilities, communications, logistics requirements, and all other support required from the ship, such as desired test conditions. In addition, the OPS Plan will specify any operational support necessary from activities other than the ship, such as a particular carrier air wing, or any required Naval Air Station support.

The OPS Plan shall include, in appendix format, a narrative on the test methods and instrumentation requirements for conducting the ACLS certification tests.

Figure 4-6 presents a sample OPS Plan and ACLS certification test narrative. A complete shipboard OPS Plan can be found in NAVAIR document, NAVAIR 51-35-501, "Carrier Suitability Tests."

4.2.7 Airlift Requests

Airlift requests are written in accordance with OPNAV Instruction 4631.2A. Figure 4-7 illustrates the standard airlift request format as well as sample inputs.

4.2.8 Commercial Shipping

Occasionally, airlift requests cannot be fulfilled by AIRLANT or AIRPAC, or the deploying detachment is too small to warrant an airlift because of economic reasons. In these cases, personnel normally fly commercial air and the cargo is sent via a commercial method such as Quick Trans.

Sending material via commercial methods is an easy process that mainly involves a coordination effort. To send cargo commercially, the following procedure is required:

- Complete a DD-1149 Form or a 4610 Shipping Form specifying:
  - Weight and volume (cube) of cargo (include equipment from all support directorates and NESEA)
  - Priority of shipment (fleet operational support)
  - Required date of arrival and justification (fleet operational support)
  - Location of where the cargo is to be shipped
- Submit four copies of the 4610 Shipping Form to STRIKE Material Control for their completion and approval.
- Coordinate with points of contact throughout support divisions to ensure that all cargo arrives at NAS Supply (Shipping Branch) at approximately the same time. The proper time will be determined by the project engineer and the shipping supervisor.
- Present the completed 4610 Shipping Form to the shipping supervisor. Double-check all cargo as to number, size, weight, etc., against the project engineer's list and the lists that have been submitted by the support directorates.

It should be noted that the method of cargo transportation (commercial or military carrier) is at the discretion of NAS supply and will normally depend on time limits and priority.

4.2.9 Shipboard Briefing Notes

The shipboard briefing notes explain to ship and airwing personnel the influence of the operating environment during a certification. The notes explain the ACLS Quality Rating Scale (see Appendix L) and list the various factors affecting the burble. The burble factors are also shown in tabular form as to how the normal wind matrix of certification can affect the burble and therefore aircraft control. A graphic illustration of glidepath deviation with respect to wind condition is also shown to emphasize how aircraft control and touchdown can vary with wind conditions.

The shipboard briefing notes list the number of touchdowns desired in a particular block of the wind matrix, together with the number of passes required to achieve confidence levels in the data. An instrumentation set-up is included to assist in the explanation of the types of data being analyzed to determine the certification limits. Data may also be included of past certifications. A complete set of shipboard briefing notes is shown in Appendix E.

4.2.10 Test Notebook

The test notebook is a collection of all the notes and correspondence related to the certification. The test notebook serves as a ready reference for any question that may arise regarding the certification. It also serves as a record of the certification effort. In particular, the test notebook should contain situation report samples, appropriate aircraft data, and details of previous certification efforts on a specific ship.

4.2.11 Maintenance Requirements Memorandum

The maintenance memorandum from Carrier Systems Branch (CVS) to maintenance outlines the requirements of maintenance for support of the certification effort. It details the aircraft expected to be used and defines the maintenance support required. The memorandum will also list any fleet aircraft that may be used as well as which activity is provided the fleet aircraft maintenance. It should provide a tentative schedule and adequate information for preparing travel orders. A sample memorandum from CVS to maintenance is shown in Figure 4-8.

4.2.12 Other Correspondence

Although not formal certification requirements, there is other correspondence (informational-type documents) that the project personnel should be aware of and prepare.

4.2.12.1 Ship Information Sheet

A ship information sheet should be prepared for all personnel participating in the certification. This sheet will list the purpose of the trip, key personnel, schedules, space assignments, etc. Such information sheets can save answering the same question a number of times. The certification is supported by a number of people (maintenance, TSD) who are not as familiar with the total scope of the program as the actual project team may be. An example of a ship information sheet is shown in Figure 4-9.

4.2.12.2 Ship Key Personnel

An information sheet should be prepared listing the key personnel that the ACLS project team will be in contact with. Normally, such a sheet will include operations, CATTC, engineering, and CAG personnel who will assist during the certification. Host squadrons and their key personnel will also be listed. This information sheet is normally distributed only on a need-to-know basis. Figure 4-10 is an example of a key personnel sheet.

4.3 CERTIFICATION PREPARATION

The actual at-sea certification trials include the collection and analysis of large quantities of data in a short period of time. In addition, the continual demands on the project team for flight planning, pre- and post-flight briefings, and reporting requirements leave little time for planning how the certification will be conducted, what data will be gathered, and what will be the possible solutions to many common certification problems. In order for the certification to run smoothly, test logs and plans should be developed during the pre-deployment of the certification test team. Contingency plans should also be developed to cope with unexpected test or conditions (e.g., unusual weather, test aircraft maintenance problems).

Proper preparation of a certification requires that the project team familiarize themselves with a number of different documents related to the intended trip and to past certifications. Any certification effort, with the exception of a new ship, can draw heavily on previous certifications of the particular ship being certified as well as known aircraft performance characteristics. The more familiar the project team is with the various systems affecting the certification, the better prepared they will be to handle contingencies that may arise.

4.3.1 Previous Certification Effort

The first documentation that should be reviewed is the test notebook of the last shipboard certification. This notebook (or certification message) should give the data results, highlight peculiar ACLS problems, and provide a general indication of any problems that may be expected. This review should provide a general overview of what to look for and expect during the certification. Figure 4-11 illustrates the type of certification sheet that should be developed from the past certification. This information sheet should be available for discussion at the pretrials conference.

After reviewing the past certification effort, the review can be expanded to cover as many past certifications as there are data for that particular ship. The major intent is to gain an intuitive grasp for the problems that have been experienced in the past and the way in which those problems were solved. The review may include various ship certifications from the past 12 months to determine the types of problems, if any, that have occurred during certifications. These problems may be related to either shipboard control or aircraft-peculiar problems.

In addition to reviewing the past documented certification results, the project team should also review the AN/SPN-42 instrumentation as appropriate to determine the performance of the tracking and stabilization systems. Copies of these records may be taken on the certification trip so that a ready reference is available of an equipment's past performance. (Instrumentation is discussed in Section Five.)

4.3.2 Ship's Information

Ship's geometry and survey points are important when calculating FLOLS corrections and AN/SPN-42 alignment (discussed in Section Six). The project team should obtain the most recent ship's survey data from the Naval Air Engineering Center to determine the geometry of the expected touchdown point. NESEA also uses these data to check AN/SPN-42 touchdown coordinates.

The ship's geometry data will also be used to calculate landing predictions from the certification data.

Other ship's information that should be obtained before embarking is the location of the FLOLS control room, CATTC, equipment room, etc., since the project team will be working with all of these work centers. Since NESEA is normally on the ship before NAVAIRTESTCEN, they can supply this type of information.

4.3.3 Anemometer Calibration

One of the governing factors of a certification is the wind over deck (WOD). All WOD information is taken from the ship anemometer system. The project engineer should research when the last anemometer calibration was performed on the ship to be certified to determine how well the anemometer system may be working. This is done by the Naval Air Engineering Center. If the anemometers (Synchros) have not been calibrated within the specified time period of six months, the ACLS project personnel should request that the wind-measuring system be calibrated by CASU prior to ACLS tests. It is not the responsibility of the ACLS test team to calibrate or align the anemometer equipment.

4.3.4 Aircraft Configuration

The acceptable aircraft configuration for ACLS is defined in Appendix F. Occasionally, the test team will find that an aircraft does not have all of the modifications required for ACLS approaches. This is especially true for aircraft that have just been certified for Mode I operations or for aircraft that have undergone a major modification.

4.3.5 Aircraft Control Programs

Aircraft control programs will be defined when the memorandum to NESEA is prepared. Since the programs do not vary from ship to ship, with the exception of control ramps, they are easy to check out. The project team should be familiar with the closed-loop, frequency-response curves of the control programs that are being implemented aboard ship. Copies of these frequency response curves should be included in the test notebook for the pretrial check-out flights.

4.3.6 Aircraft Control

The project team should be familiar with the closed-loop control of each type of aircraft being used during the certification. This familiarity should extend to the basic approach characteristics of the aircraft with respect to airspeed, weight, and angle of attack. Appendix G lists some of the basic approach characteristics of ACLS aircraft.

NAVAIRTESTCEN personnel are responsible for the proper operation of the test aircraft and for ascertaining that the test aircraft are suitable test vehicles. This responsibility requires an understanding of the flight characteristics associated with different aircraft under dynamic test conditions.

The project team should also be familiar with the expected touchdown statistics of the aircraft being certified. The historical averages should be compared with the data obtained during the last certification trip to determine how well that data reflected the historical averages. Reasons for any large deviations should be analyzed to determine if these same deviations can be expected on the upcoming certifications. Reasons may be WOD, ship motion, aircraft problems, or other system-related problems.

Appendix H lists the historical averages of some certification parameters for Mode I certified aircraft. The results of past ship trips are also included. The certification parameters listed are those deemed the most important in certifying a ship.

4.3.7 Situation Reports

Situation reports (SITREPS) are sent from the ship after each day's operations. Since the format (with respect to addressees and information provided) is similar for all SITREPS, these forms may be made up ahead of time and placed in the test notebook. With the forms in hand, only the day's events need be filled in to satisfy the reporting requirements. Any problem areas or requests for assistance will also be included in the SITREP. A sample SITREP form is shown in Figure 4-12. A completed SITREP form is shown in Figure 4-13.

4.4 PRETRIALS CONFERENCE

The pretrials conference is held to discuss the overall certification requirements, with respect to both test requirements and logistics requirements. Major topics that the project team should discuss are as follows:

- Requirements message
- Ship's trim desired
- Last certification results
- WOD requirements
- Anemometer calibrations
- FLOLS calibration schedule

- Stabilization system comparisons (DSS/SINS and DSS/FWD and AFT MK 19 gyros)
- DSS to lens repeater with different stabilization systems
- Logistics requirements

A complete pretrials agenda is presented in Appendix I. The pretrials conference should be used to establish a working relationship with shipboard personnel. It should establish who the key personnel are and their names and telephone numbers.

USS CORAL SEA MODE I CERT (1976)
Detailed Cost Estimates

1. Cost estimates contained in NATC message 102146Z of 10 June 1976 were determined as follows:

Item	Cost
a. NATC A-7 flight hour cost:	
(1) Pre-carrier build up at NATC, three pilots, 4.5 hr total at current rate of $834 - (4.5)(834) -	$ 3,753
(2) Transit to West Coast and return to NATC - (10)(834) -	$ 8,340
(3) Ship trials, eight 2.0 hr exclusive periods during CAT III tests - (8)(2)(834) -	$13,344
Total -	$25,437
b. NATC F-4 pre-carrier build up flight hour cost at NATC:	
(1) Three pilots, 4.0 hrs total at current rate of $1,252 per hr - (4)(1252) -	$ 5,008
c. Direct travel and per diem (including check-out of Fleet Assist acft) based on past trials costs:	
(1) Strike (CVS and Maint) -	$ 3,500
(2) TSD Acft Inst -	$ 500
(3) TSD Tape Processing -	$ 1,000
(4) TSD Camera Coverage -	$ 2,000
(5) Fleet Acft Check out -	$ 800
Total -	$ 7,800
d. Material (tapes, film);	
(1) Eight acft tapes at $50 per tape - (8)(50) -	$ 400

Figure 4-1. DETAILED COST ESTIMATE OF CERTIFICATION

Item	Cost
(2) Fourteen rolls of 16mm film at $30 per roll - (14)(30) -	$ 420
(3) Fourteen rolls of 35mm film at $50 per roll - (14)(50) -	$ 700
Total -	$ 1,520
e. Instrumentation Data Processing:	
(1) Two technicians at $10.00 per hour, estimate 250 hr total - (10)(250) -	$ 2,500
f. Camera Coverage:	
(1) Four technicians at $10.00 per hour, estimate 400 hr total - (10)(400) -	$ 4,000
(2) Film data reduction after trials, estimate 200 hr total -	$ 2,000
Total -	$ 6,000
g. Airplane Instrumentation Servicing:	
(1) One technician at $10.00 per hour, estimate 100 hr total - (10)(100) -	$ 1,000
h. Engineering and Technical Support:	
(1) Pre-trials preparation, estimate 30 man-days at $92.96 per day - (30)(92.96) -	$ 2,789
(2) At-sea trials, estimate 40 man-days - (40)(92.96) -	$ 3,718
(3) Post-trials, estimate 33 man-days - (38)(92.96) -	$ 3,532
Total -	$10,039
2. Combined total as originally estimated -	$69,327

Detailed Travel Cost Estimate

1. Number of personnel:

a. CIV engineers and technicians - 13

Figure 4-1. (continued)

Detailed Travel Cost Estimate

b. Military enlisted - 15

c. Military officers - 5

2. Schedule, 3 days on beach and 10 days on ship, send two tech out 3 days early to check out fleet acft.

3. Per Diem Cost Breakdown:

a. 13 civ, 3 days (shore) - (13)(3)(39)	=	$1,521
b. 2 civ, 3 days (shore acft checks) - (2)(3)(39)	=	$ 234
c. 13 civ, 10 days (ship) - (13)(10)(6)	=	$ 780
d. 5 officers, 3 days (shore) - (5)(3)(33)	=	$ 495
e. 1 officer, 3 days (pre-sail) - (1)(3)(33)	=	$ 99
f. 15 enlisted, 3 days (shore) - (15)(3)(33)	=	$1,485
Total	=	$4,614

4. Commercial flight costs:

a. Pilot pre-sail conference	=	$ 386
b. R. Alphin Acft checks	=	$ 386
c. R. Kable Acft checks	=	$ 192
Total	=	$ 964

5. Rental car for all CIV and MIL - (5)(3)(20)	=	$ 300
Total	=	$5,878

Figure 4-1. (continued)

13900
Ser SA73A/497

From: Commander, Naval Air Test Center, Patuxent River, Maryland 20670
To: Officer in Charge, Naval Electronic Systems Engineering Activity, St. Inigoes, Maryland 20684

Subj: USS INDEPENDENCE ACLS Verification AN/SPN-42A Control Program Configuration

Ref: (a) COMNAVAIRTESTCEN ltr 13900 Ser SA72/190 of 2 Jun 1981
(b) NAVAIRTESTCEN PATUXENT RIVER MD 232127Z Mar 1979

1. The subject verification is scheduled to take place in January 1982. The aircraft AN/SPN-42A control program configurations required are unchanged from the previous certification and are detailed in references (a) and (b). The aircraft pitch command ramp and geometry offset configurations should be as follows:

Aircraft	Mode	Augmentor Height (ft)	Far Ramp	Close Ramp	Range Correction (ft)
A-7	I	10	3/8 deg, 11-8 sec	3/8 deg, 4.5-3.5 sec	0
A-6	I	13	3/16 deg, 18.5-15 sec	3/8 deg, 7-3 sec	20
F-4	I	14	3/8 deg, 16.5-15 sec	1/4 deg, 4-2.5 sec	0
EA-6B	IA	10	_____	_____	34
S-3	IA	12	_____	_____	0

2. Instrumentation requirements will be defined jointly by Naval Air Test Center (NAVAIRTESTCEN) and Naval Electronic Systems Engineering Activity personnel due to MK-16 Ring Laser Gyro feasibility testing being conducted concurrently with the subject verification.

3. A copy of the subject program listing is required by NAVAIRTESTCEN no later than 8 January 1982. NAVAIRTESTCEN point of contact is Mr. R. Kable, x4644.

J. D. JAHN
By direction

Figure 4-2. REPRESENTATIVE NESEA MEMORANDUM

13800
SA73B
10 Nov 1980

MEMORANDUM

From: Director, Strike Aircraft Test Directorate
To: Director, Technical Support Directorate

Subj: USS AMERICA Automatic Carrier Landing System (ACLS) Certification

1. In order to support the USS AMERICA (CV 66) AN/SPN-42 ACLS Certification we request you supply the following:

a. Two 35mm motion picture cameras to provide aircraft touchdown dispersion and hook to ramp data coverage. One camera is to be mounted on the starboard side parallel with the ramp to provide hook to ramp coverage. The second camera is to be mounted on the ship's island to provide coverage of the arresting gear.

b. Antenna tracking camera coverage for both of the AN/SPN-42 radar antennas.

c. The Fresnel lens calibration pole and three hand held radios be provided.

d. Instrumentation servicing and recording playback capability for A-7E BuNo 159296.

2. We also request the following:

a. A cost estimate be submitted for this effort.

b. Total weight and volume of the equipment to be transported.

c. A list of personnel supporting this effort specifying name, rate/CPE, SSN, and security clearance.

3. The certification is scheduled to be conducted 10 thru 16 December 1980.

4. Energies devoted to this effort are to be charged to J. O. number KS86066SA.

5. For additional necessary information, please contact J. Jones, X4644.

A. B. Smith
By direction

Figure 4-3. SAMPLE MEMORANDUM FROM SATD TO TSD

NDW-NATC-3930/2 (REV.10-75)

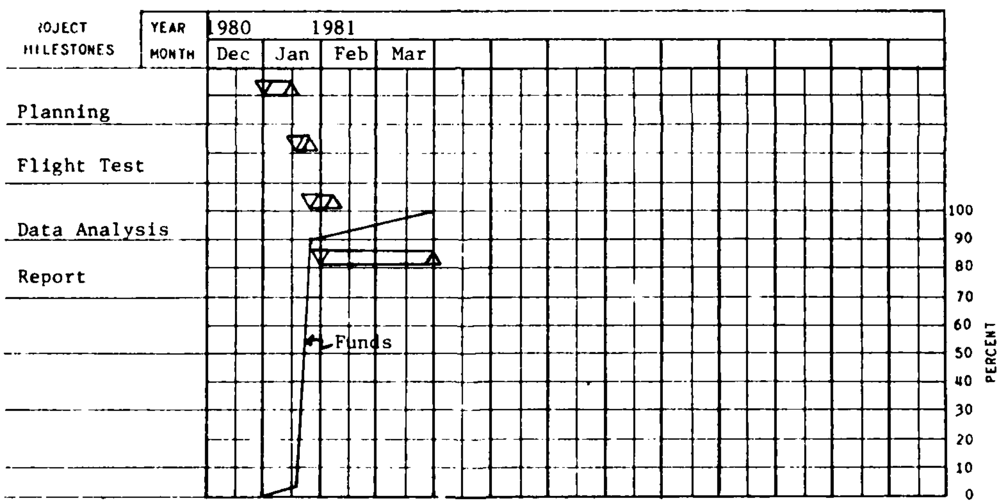
NAVAL AIR TEST CENTER
PROJECT TEST PLAN

16 January 1981
DATE SUBMITTED

DATE REVISED

PROJECT TITLE NAS Lemoore and NAS Whidbey Island TRN-18 Certification	
AIRTASK/WORK UNIT A5515511/0534/1551000018, W.U. NATC 0442	DATE 24 September 1980
COGNIZANT NAVAIR DIVISION AIR-5511G	COGNIZANT NAVAIR ENGINEER/CODE/TEL NO. Mr. L. Miles/5511G/692-3290
NATC DIRECTORATE/BRANCH/COST CENTER Strike Aircraft Test Directorate, Carrier Systems Branch, SADO	
NATC PROJECT ENGINEER/CODE/TEL NO Mr. R. Kable/SA73A/X4644	PROJECT OFFICER/CODE/TEL NO

AUTHORIZED FUNDS/EXPIRATION DATE	JOB ORDER NO	ESTIMATED COMPLETION DATE
$25,000 /30 September 1981	KC87863SA	



	PLANNED	ACTUAL
START	▽	▼
FINISH	△	▲

1 TOTAL FUNDS FOR 100% = $25,000

2 TOTAL FLIGHT HRS FOR 100% = 8

REVIEWED:

SA70A	D	SA01A	
SA70	D	SA04	
SA73A	KN	SA03	
SA31		SA02	

APPROVED: ______ DIRECTOR 19 Jan 81 DATE

Cover Sheet

Figure 4-4. SAMPLE OF COMPLETED PROJECT TEST PLAN COVER SHEET

```
RTTUZYUW RUEBRDA2276 3191800-UUUU--RULSSAA RUWDVAA RUWFAAA RUWFA AB
 RUWNMJA RUWNZFF.
 ZNR UUUUU
 R 142133Z NOV 80
FM NAVAIRTESTCEN PAXTUXENT RIVER  MD
TO RUWFAAB/COMNAVAIRPAC SAN DIEG O CA
RUWNZFF/USS KITTY HAWK
RUWDVAA/NAS MIRAMAR CA
RUWFAAA/NAS NORTH ISLAND CA
RUWDVAA/COMCARAIRWING FIFTEEN
INFO RULSSAA/COMNAVAIRSYSCOM WAS HINGTON DC
RULSSAA/COMNAVELEXSYSCOM WASHING TON DC
RUWNMJA/COMCARGRU THREE
ZEN/NAVELEXSYSENGACT ST INIGOES  MD
 BT
 UNCLAS //N13800//
SUBJ: USS KITTY HAWK ACLS CERTIFICATION REQUIREMENTS (U)
A.  COMNAVAIRPAC SAN DIEGO CA 06 1834Z OCT 80
B.  COMNAVAIRSYSCOM WASHINGTON D C 102130Z OCT 80
.   REF A PROPOSED DATES FOR SUBJ CERT AND REF B PROVIDED
   .CTION AND FUNDING.
2.  FOR COMNAVAIRPAC: IN ORDER TO INSURE SUCCESSFUL COMPLETION,
THE FOL SUPPORT IS REQUESTED:



PAGE 02 RUEBRDA2276 UNCLAS
    A.   ONE (1) A-7E MODE I CAPABLE FLEET ACFT BE MADE
 AVAIL AS FOL:
         (1) AFCS, APCS, ARABS, AND AN/ARA-63 SYSTEMS FULLY
OPERATIONAL  AND PERFORMANCE CHECKED PER THE LATEST MIMS.
         (2) SUCCESSFULLY DEMONSTRATE FIELD MODE I ACLS CAPABILI TY
PRIOR TO 6 JAN 81,  NAVAIRTESTCEN PILOT CHECKOUT 7 JAN 81.
    B.   ONE (1) A-6E MODE I CAPABLE FLEET ACFT BE MADE AVAIL
 AS FOL:
         (1) AFCS, APCE, ARABS, AND AN/ARA-63 SYSTEMS FULLY
OPERATIONAL AND PERFORMANCE CHEC KED PER LATEST MIMS.
         (2) SUCCESSFULLY DEMONSTRATE  FIELD MODE I ACLS CAPABIL ITY
PRIOR TO 6 JAN 81,  NAVAIRTESTCEN PILOT CHECKOUT 7 JAN81.
    C.   ONE (1) EA-6B MODE I CAPABLE FLEET ACFT BE MADE AVAIL
 AS FOL:
         (1) AFCS, APCS, ARABS, AND AN/ARA-63 SYSTEMS FULLY
OPERATIONAL AND PERFORMANCE CHEC KED PER LATEST MIMS.
         (2) SUCCESSFULLY DEMONSTRATE FIELD MODE I ACLS CAPABILI TY
  .OR TO 6 JAN 81,  NAVAIRTESTCEN PILOT CHECKOUT 7 JAN 81.
    D.   UPON SUCCESSFUL NAVAIRTESTCEN FLIGHTS, NAVAIRTESTCEN
PILOT WILL FLY A-7 ACFT TO NAS MIRAMAR FOR ADDITIONAL TESTS
```

O:SA

I: NESEA, SY, CNATC, RADM

NOV 17 1980

CVS FILE ACLS C-5

Note: Any message detailing ship movement is normally classified for a period of three to six months.

Figure 4-5. SAMPLE OF ACLS REQUIREMENTS MESSAGE

PAGE 03 RUEBRDA2276 UNCLAS
AND THEN FLY ABOARD USS KITTY HAWK, FLEET A-6E AND EA-6B TO
BE FLOWN BY A FLEET AIRCREW TO NAS MIRAMAR FOR ADDITIONAL TESTS
AND THEN ABOARD USS KITTY HAWK, THE AIRCRAFT WILL REMAIN ONBOAR D
USS KITTY HAWK FOR DURATION OF C ERTIFICATION TRIALS,
    E, DESIGNATE HOST SQUADRONS TO PROVIDE SHIPBOARD AND SHORE -
BASED MAINTENANCE SUPPORT FOR FLEET A-7E, A-6E, AND EA-6B ACFT
AND NAVAIRTESTCEN A-7E, A-6E, AN D EA-6B ACFT,
    F, HOST SQUADRONS PROVIDE SUFFICIENT PERSONNEL TO STAND
REQUIRED INTEGRITY WATCHES DUE TO MINIMAL NAVAIRTESTCEN PERSONNE L,
    G, NAVAIRTESTCEN WILL ASSUME MISHAP REPORTING/ACCOUNTABILI TY
FOR FLIGHTS BY NAVAIRTESTCEN PIL OTS,
    H, PROPOSE PRETRIALS CONFERENCE AT CNAP 10 DEC 80, REQUEST
COORDINATE,
    I, REQUEST DIRLAUTH ALCON,
3, FOR USS KITTY HAWK, FOL SUPP ORT REQUIRED:
    A, FOL EQUIPMENT UP AND OPERATING WITH SUPPORT PERS AVAIL
FOR CAT IIB/CAT III AT SEA TESTS :
        (1) AN/SPN-42A CCHAN A AND B)
        (2) AN/SPN-41
        (3) LINK 4A

PAGE 04 RUEBRDA2276 UNCLAS
        (4) CATTC/DAIR
        (5) NTDS
        (6) SINS (CERTIFIED)
        (7) MK-19 GYROS (CERTIF IED)
        (8) FLOLS (CERTIFIED)
        (9) TACAN
        (10) UHF (INCLUDING LSO PLATFORM)
    B, FREQ PLAN FOR AT SEA TESTS INCLUDING ACLS LINK FREQ,
SINS FREQ AND AN/SPN-41 AND TACA N CHANNELS,
    C, ACLS DECK REQUIREMENTS ARE AS FOL:
        (1) 5 EXCLUSIVE 2-HOUR FLIGHT PERIODS, ON DAYS WHEN
2 FLT PERIODS ARE REQUESTED, REQUIRE AT LEAST 4 HOUR SEPARATION
BETWEEN FLT PERIODS,
        (2) 3 NONEXCLUSIVE 2-HOUR FLT PERIODS WITH PRIORITY
IN PATTERN,
    D, LOGISTIC REQUIREMENTS F OL:
        (1) DOWN CHAINS FOR ALL ACLS ACFT,
        (2) STATUS OF AVCAL SUPP, MAIN PUB AVAIL AND AIMD BENCH
SUPPORT FOR A-7E, A-6E, AND EA-6 B ACFT,
        (3) FOR APPROX 25 OFF/OFF EQUIVALENTS AND 7 ENLISTED

PAGE 05 RUEBRDA2276 UNCLAS

Figure 4-5. (continued)

RS,
(4) ONLOAD SERVICE FOR APPROX 6,000 LB CARGO ON 10 JAN 81,
(5) FORKLIFT, DRIVER AND RAILED PLATFORM FOR FLT DECK ALIGNMENT CHECKS ON 11/12 JAN 81 ,
(6) READY ROOM SPACE FOR PILOT/ENGINEER BRIEFINGS WITH NEARBY MAINTENANCE SPACES AND OFFICE SPACE FOR DATA RUDUCTION/ ANALYSIS,
(7) ELECTRICAL AND WELDING ASSISTANCE FOR RAMP, CENTERL INE AND ISLAND CAMERA MOUNTS ON 11/1 2 JAN 81'
(8) INSTRUMENTATION WORK SPACE FOR DATA LINK, CAMERA AND INSTRUMENTATION PERS, SPACE SHOULD BE AIR CONDITIONED AND BE EQUIPPED WITH 28 VDC AND 115V 400 HZ THREE PHASE Y WOUND AC POWER,
(9) ONE 200 SQ FT AIR CONDITIONED SPACE WITH 115V 60 HZ POWER FOR INSTRUMENTATION TAP E PLAYBACK EQUIPMENT,
(10) NO INTENTIONAL POWER OR AIR CONDITIONING INTERRUPT IONS IN ANY ACLS DATA OR EQUIPMENT SPACE WHILE TESTS ARE IN PROGRESE, THIS ITEM HAS PREVIOUSLY CAUSED NUMEROUS ELECTRONIC FAILURES DUE TO POWER SURGES,

GE 06 RUEBRDA2276 UNCLAS
(11) COD/VOD OFF LOAD FOR NAVAIRTESTCEN PERSONNEL AND EQUIPMENT UPON COMPLETION OF CER TIFICATION,
FOR NAS MIRAMAR; REQUEST FOL SUPPORT:
A, TRANSIENT PARKING/SERVICING FOR TWO (2) A-7E, TWO (2) A-6E, AND TWO (2) EA-6B ACFT 7 JAN 81 THROUGH COMPLETION OF CERTIFICATION, ANTICIPATE AIRCRAFT REMAINING ABOARD SHIP DURING MAJORITY OF CERTIFICATION,
B, PROVIDE USE OF AN/SPN-42A, OPERATIONS/MAINTENANCE PERSO NNEL FOR NAVAIRTESTCEN CHECKOUT OF FLEET ACFT; ANTICIPATE CHECKOUTS ON 8/9 JAN 81,
5, FOR NAS NORIS; REQUEST FOL SUPPORT:
A, FLAT BED TRAILER TO TRANSFER 8,000 LB CARGO FROM AIRLI FT TO USS KITTY HAWK ON 9/10 JAN 8 1,
B, BUS TO TRANSPORT APPROX32 NAVAIRTESTCEN PERSONNEL FROM AIRLIFT ACFT TO USS KITTY HAWK ON 9/10 JAN 81,
6, FOR COMCARAWING FIFTEEN: RE QUEST FOL SUPPORT:
A, CAG LSO'S TO ASSIST ON LSO PLATFORM DURING ACLS FLT PERIODS,
7, REQ CONFIRMATION OF COMPLIANCE WITH ALL REQUIREMENTS ASAP; NAVAIRTESTCEN POC, LCDR D, ROPER, TRIP COORDINATOR; MR, R, KABLE, CERTIFICATION ENGINEER AT AV356-4646,
BT
#2276

Figure 4-5. (continued)

13900
Ser SA70/477

OUTLINE OF NAVAIRTESTCEN OPERATIONS
ABOARD
USS KITTY HAWK (CV 63)

1. Purposes of Trials. The purposes of the trials are:

a. To certify A-7B/C/E, A-6E, and EA-6B aircraft for Mode I operation utilizing the ship's AN/SPN-42A Automatic Carrier Landing System (ACLS). (See Appendix A)

b. To conduct a shipboard evaluation of the A-4M aircraft with increased landing/take-off weight modifications. (See Appendix B)

c. To conduct a shipboard evaluation of the F-4S aircraft with wing leading edge slats. (See Appendix C)

2. Base of Operations. Two A-7E, two A-6E, two EA-6B, one A-4M, and F-4S aircraft will be based aboard USS KITTY HAWK for the duration of the trials.

3. Airplane and Pilots. Airplanes, test pilots, and project officers assigned to these trials are listed in Appendix E.

4. Loading. The project personnel and equipment will be loaded aboard USS KITTY HAWK at Naval Air Station (NAS), North Island. Test airplanes will be flown aboard as directed by USS KITTY HAWK.

5. Off-Loading. The test airplanes will remain aboard at the conclusion of the trials with the exception of the NAVAIRTESTCEN aircraft which will be flown off and returned to NAVAIRTESTCEN. Personnel and equipment will be off-loaded upon the ship's return to NAS North Island or will be flown off at the conclusion of the trials.

6. Personnel Embarking. A list of NAVAIRTESTCEN/NAVELEXSYSNGACT personnel embarking is provided in Appendix F. Security clearances are provided and Civilian Personnel Equivalents (CPE) are noted in parenthesis.

7. Communications. Messages originated aboard ship by NAVAIRTESTCEN/NAVELEXSYSENGACT personnel will be cleared through the NAVAIRTESTCEN Detachment Officer in Charge and released by the USS KITTY HAWK. It is requested that copies of all messages relating to the trials be provided to the Trip Coordinator.

1 Enclosure (1)

Figure 4-6. SAMPLE OPERATIONS PLAN AND ACLS CERTIFICATION TEST NARRATIVE

8. Test Responsibilities. NAVAIRTESTCEN/NAVELEXSYSENGACT will assume the following responsibilities:

a. Plan, conduct, and supervise tests.

b. Provide one instrumented A-6E, one EA-6B, one A-4M, one F-4S, pilots, engineers, instrumentation technicians, and a Landing Signal Officer (LSO).

c. Provide USS KITTY HAWK with fueling requirements and BINGO fuel requirements for project airplanes.

d. Specify wind-over-deck (WOD) requirements for each test period.

e. Provide, maintain, and operate all special recording equipment.

f. Supervise the operation of certain key operator positions of the Navy Tactical Data System (NTDS)/SPN-42A system. These positions are:

(1) NTDS SYA 4 consoles

(2) SPN-42 consoles

g. Specify Fresnel Lens Optical Landing System (FLOLS) settings for NAVAIRTESTCEN recoveries, if nonstandard.

h. Provide photographic film. All test film coverage of NAVAIR-TESTCEN operations will be retained by NAVAIRTESTCEN.

9. Operational, Test, and Logistics Support. To minimize the impact of NAVAIRTESTCEN testing on USS KITTY HAWK and to maximize the efficiency of the trials, the following support is requested:

a. Provide the test conditions requested by NAVAIRTESTCEN personnel where feasible.

b. Provide working spaces as follows:

(1) Carrier Air Traffic Control Center (CATCC) SPN-42 consoles and NTDS facilities.

(2) A ready room space for pilot/engineer briefing and debriefing with nearby office spaces for data reduction/analysis.

Figure 4-6. (continued)

(3) Instrumentation work space in ASSC room or Avionics Shop for Data Link, camera, and instrumentation support personnel. Spaces should be air conditioned and equipped with 28 VDC and 115V/400-cycle 3 phase Y wound AC power.

(4) Space in or near the island for telemetry ground stations. Space should be 150 sq. ft., air conditioned, and equipped with 115V/60-cycle AC power. Hatch opening must be large enough to accommodate a box 2 × 2 × 4 ft.

(5) Space for NAVAIRTESTCEN engineers in CATCC, primary, flag plot, and on flag bridge for test control.

c. Provide sufficient tie-down chains for one EA-6B, one A-6E, one A-4M, and one F-4S aircraft on signature custody to the NAVAIRTESTCEN Maintenance Chief Petty Officer.

d. Provide experienced console operators for all CATCC stations and insure appropriate ACLS/NTDS equipment technicians are on station prior to and during the ACLS certification flight periods.

e. Provide fueling, electrical, air starter, hydraulic jenny, LOX, and high/low pressure air services for test airplanes.

f. Provide supply support of general stock items normally available on board to support the trials and test airplanes.

g. Provide electrical and welding assistance for placement of special test cameras on the port side abeam the ramp, on centerline at the ramp, and on the island, and for placement of anemometer boom for F-4/A-4 tests.

h. Provide copies of USS KITTY HAWK frequency plans, including UHF, data link, and navigation frequencies.

i. Provide sound-powered telephone circuits connecting primary flight control, CATCC, SPN-42 equipment room, and the LSO platform.

j. Establish the WOD requested by the senior NAVAIRTESTCEN engineers as feasible. Nonstandard requirements will be provided one day in advance.

k. Provide an airborne rescue helo during all flight operations.

Figure 4-6. (continued)

l. Provide integrity watches, wardroom, and mess deck personnel due to the minimum number of NAVAIRTESTCEN personnel available, the highly concentrated work load, and funding restrictions.

m. Request that test airplanes be moved to the hanger bay following the day's flight operations and as required to change instrumentation tapes and perform data link checks.

o. Provide Ship's Inertial Navigation System (SINS) cables for A-7E, and A-6E system alignment.

p. Ensure no intentional power interruptions are scheduled during drills or maintenance while CAT III testing is in progress.

q. Provide crane, conveyor belt, forklift, and elevator services as required for loading, positioning, and off-loading NAVAIRTESTCEN test equipment.

r. If surveillance radar generates interference during the SPN-42A testing with beacon equipped airplanes, request it be secured if conditions permit.

s. Request safety brief/tour on flight deck procedures by Air Department representative.

10. CVW-15 Operational Test and Logistic Support. Support from CVW-15 is requested as follows:

a. Designate host squadrons to provide primary A-7E test aircraft and backup A-6E, A-7E, and EA-6B test aircraft and associated maintenance support.

11. NAS North Island Logistics Support. NAS North Island is requested to provide the following:

a. One carryall/van type vehicle for personnel and logistics support.

12. NAS Miramar Logistics Support.

a. Prior permission required authorization for all detachment aircraft.

Figure 4-6. (continued)

b. Ramp space chocks tie downs and basic GSE for detachment aircraft. All test aircraft to arrive on approximately 5 January 1979.

c. BEQ accommodations for detachment maintenance crew as required.

d. Exclusive AN/SPN-42 and ACLS flight pattern availability during the early morning time frame of 6 January 1979.

e. Operable Brush strip chart recorders or offner recorders at the AN/SPN-42 computer site for recording AN/SPN-42 parameters.

Figure 4-6. (continued)

SPN-41/SPN-42 ACLS CERTIFICATION
USS KITTY HAWK (CV 63)

1. Purpose. The purpose of these tests is to certify A-7B/C/E, A-6E, and EA-6B aircraft for Mode I, IA, and II operations utilizing the AN/SPN-42 installation aboard USS KITTY HAWK.

2. Test Methods.

a. ACLS approaches will be flown from a 6-8 mile racetrack pattern astern of the ship with a pattern altitude of 1200 feet until glide slope interception. During VFR weather, the proper interval and pattern will be maintained by project pilots with radar monitoring. CCA control will be used during IFR weather. Special cameras will record aircraft touchdown point and hook-to-ramp/landing conditions for Mode I approaches.

b. The certification will consist of three flight test phases. The first phase will be conducted to determine satisfactory stabilization systems operation, complete SPN-42A, beacon and NTDS system checkout, and to determine the aircraft's glide slope control characteristics in the presence of ships burble. For these tests, the WOD should be held 21-23 kt, 350° degrees relative to ship's axial deck. Approximately 20 successful A-7C/E, 20 successful EA-6B, and 20 successful A-6E landings will be required.

c. Once the basic control characteristics have been determined for each type airplane, the second phase will be conducted wherein changes will be made to the SPN-42 control program, as required, to compensate for undesirable control characteristics. During this second phase, approaches will be flown to evaluate the effect of the program changes on glide slope control and touchdown point location. WOD should be held at the same setting as listed for phase one tests in order to minimize the effect from variations in ships burble due to changing WOD conditions. Approximately 20 successful landings per airplane type are anticipated for the second phase of the certification.

d. Once the optimum SPN-42 control program has been determined, the third and final phase of the certification will be conducted to collect touchdown dispersion data. Approximately 20 successful Mode I touch-and-go/arrested landings per channel will be required with each type aircraft to collect sufficient control and touchdown dispersion

Figure 4-6. (continued)

data. Another 20 Mode I landings are required with variations in the WOD conditions from 15-30 kt, 340 to 005 deg relative, to determine operational limitations and restrictions. Special NAVAIRTESTCEN cameras will record the aircraft touchdown point and approach/landing conditions.

e. Tests will be conducted on the flight deck to verify the static setting and stabilization of FLOLS basic angle. A pole mounted mirror will be used to visually locate the height of the FLOLS beam above the deck at several positions along the angle deck centerline. A forklift, driver, and chocks capable of elevating a personnel platform or pallet above the flight deck are required. Ensure that no aircraft or equipment are parked in line of sight between FLOLS and angled deck centerline positions to be checked.

3. Instrumentation Requirements

a. Centerline/hook-to-ramp cameras.

b. Three SPN-42 recorders (Offner and brush).

c. Airplane instrumentation.

d. SPN-42A antenna tracking cameras.

Figure 4-6. (continued)

STANDARD AIRLIFT REQUEST FORMAT

FROM: NATC
TO: COMTACSUPWINGONE NORFOLK VA
INFO: COMRESTACSUPPWINGLOG
(Support base) N S MAYPORT FL
(Ship) USS FORRESTAL MAYPORT FL
BT

UNCLAS //N04631//
CLASSIFICATION
AIRLIFT REQUEST

LIFT A **(USE ONLY IF MORE THAN 1 LIFT)**

1. **UNIT** SATD/NATC **(UIC/RUC/NA)** 00421 .

2. **DEPARTURE** NHK (AIRFIELD) ; 071500ZApr79 (DESIRED (DTGZ/MO/YR)) ; 061500ZApr79 (EARLIEST (DTGZ/MO/YR)) .

3. **DESTINATION** MAYPORT FL (AIRFIELD) ; 071630ZApr79 (DESIRED (DTGZ/MO/YR)) ; 061630ZApr79 (REQUIRED (DTGZ/MO/YR)) .

4. **PUJ** 2 / 2 / C . [Priority/Urgency/Justification (PUJ)]

5. **NO. PAX** 33 **BAG WT** 1320 **LBS.**

6. A. **CARGO** 7,275 **LBS CUBIC FEET** 255 **TYPE CODE(S)** B, C, G .

   B. **LARGEST SINGLE ITEM** 48 (LENGTH) **IN** 36 (HEIGHT) **IN** 24 (WIDTH) **IN** 240 **LBS.**

   C. **HEAVIEST SINGLE ITEM** 48 (LENGTH) **IN** 36 (HEIGHT) **IN** 24 (WIDTH) **IN** 240 **LBS.**

   D. **SPECIAL/HAZARDOUS CRGO WILL BE CERTIFIED/PACKED IAW APPLICABLE INSTRUCTIONS AND IS DESCRIBED IN REMARKS BELOW.**

7. A. **AIRLIFT REQUEST COORDINATOR** (As Appropriate) .
   NAME/RANK/DUTY PHONE/HOME PHONE/ LOCATION

   B. **ON SCENE DEPARTURE COORDINATOR** (As Appropriate) .
   NAME/RANK/DUTY PHONE/HOME PHONE/ LOCATION

   C. **DESTINATION COORDINATOR** (As Appropriate) .
   NAME/RANK/DUTY PHONE/HOME PHONE/ LOCATION

8. **VIP CODE** NA **NAME** NA .
9. **REMARKS:**

BT

ENCLOSURE (2)

Figure 4-7. EXAMPLE OF A STANDARD AIRLIFT REQUEST FORMAT

SA70
30 Oct 1980

MEMORANDUM

From: Head, Carrier Systems Branch, Strike Aircraft Test Directorate
To: Head, Maintenance Branch, Strike Aircraft Test Directorate

Subj: Maintenance Requirements for USS AMERICA (CV 66) Deployment

1. The Naval Air Test Center (NAVAIRTESTCEN) has been tasked to conduct an Automatic Carrier Landing System (ACLS) certification aboard the USS AMERICA (CV 66) from 10 - 16 December 1980. An ASW S-3A will accompany for FQIP testing but will not require any Strike assistance.

2. The following aircraft are anticipated to be utilized for the certification:

Acft	Source	BuNo	Maint Source	Packup Kit	Est Flt Hr	Est Arr Ldgs
A-6E	CAG 8	TBA	CAG 8/VA-42	No	15	5
A-6E	CAG 8	TBA	CAG 8/VA-42	No	15	5
EA-6B	Strike	158546	CAG 8/VA-42	Yes	15	10
A-7E	Strike	159296	Strike	Yes	15	10
A-7E	CAG 8	TBA	Strike	Yes	15	5
S-3A	ASW	TBA	ASW	NR	10	0

3. The following support is requested:

a. Maintenance Chief Petty Officer with A/C releasing authority.

b. Plane captains for EA-6B and A-7E.

c. Sufficient personnel to provide maintenance support for NAVAIRTESTCEN A-7E and fleet A-7E.

d. Assign personnel to stage gear for surface lift to Norfolk.

4. A tentative schedule is provided:

10-12 November	ACLS checkout of designated A-7E for CAT IIA testing.
10 November	List of maintenance personnel, SSN, clearance, special qualification rate to LCDR Hazelrigg, Trip Coordinator.
17 November	Estimated weight/cube/largest item (Include Data Link Shop gear).

Note: Any message detailing ship movement is normally classified for a period of three to six months.

Figure 4-8. MAINTENANCE MEMORANDUM

SA70

1-5 December	ACL checkout (A-6, EA-6, A-7). Bounce (A-6, EA-6, A-7).
8-9 December	CAT IIB testing A-7E NAS Norfolk.
8 December	Stage gear for surface lift Hangar 201.
9 December	Surface lift departs for NAS Norfolk.
10-16 December	At sea (NAVAIRTESTCEN acft fly aboard).
16-17 December	Surface lift to NAVAIRTESTCEN. NAVAIRTESTCEN acft return.

5. Travel orders should be prepared and issued by Strike Admin. Orders should read "to NAS Norfolk, Va./USS AMERICA (CV 66) and return" with authorization to omit, vary, revisit, visit additional places as necessary. Enlisted personnel should also have a remark authorizing travel in clean pressed dungarees as member of work party. The job order number to be used is Y99 6066SA.

CAPT USN

Copy to:
Chief Test Pilot
Strike Admin

Figure 4-8. (continued)

USS AMERICA INFORMATION SHEET

PURPOSE

ACLS certification for A-6, EA-6, A-7 and remote possibility of F-4S and S-3A

AIRCRAFT

1 NATC A-7	1 VA-82 A-7	we provide maint.
1 NATC EA-6		we provide P/C's VA-42 provide maint.
2 VA-35 A-6's		VA-42 provides maint.,one on board other spare at NTU
1 S-3A		not our concern T&G's only
1 NATC F-4S		we provide maint.

KEY PERSONNEL

OinC:CAPT Smith
Trip Coordinator: LCDR HAzelrigg
Test Coordinator: Mr Tom Zalesak
Maint. Chief: ADC McKanna

SPACE ASSIGNMENTS

Ready Room #9 Maint Spaces: 03-49-7-A,03-208-3, and 1-210-4-Q

Berthing spaces to be assigned by CWO2 KRETZSCHMAR X 929
Staterooms to be assigned by ship's mess

SCHEDULE

8 DEC 80	0900	Stage and load equipment for surface lift in Hgr 201 vicinity of mat'l
9 DEC 80	0800	Bus (Keller Bus Co.) and surface lift depart from Hgr 201 for NAS Norfolk
9 DEC 80	1300	Arrive NAS Norfolk on Load
9 DEC 80	TBA	After completion of on load liberty to expire on board TBA by USS AMERICA
10 DEC 80	0645	USS AMERICA underway
10 DEC 80	TBA	Test aircraft fly aboard
10-16 DEC 80		ACLS/FCQ
16 DEC 80	1645	USS AMERICA moored pier 12 off load
16 DEC 80	ASAP	Surface lift and bus departs for NATC

MOTHERHOOD

Learn your way around-KNOW ESCAPE ROUTES!
KNOW HOW TO USE OXYGEN BREATHING APARATUS
Have a flashlight
It's cold in VaCapes! have sufficient foul weather gear
Have flight deck gear and know how to use it
P/C required with planes anytime during flight ops
MAN OVERBOARD muster by sight with Maint Chief
Shower shoes

Note: Any message detailing ship movement is normally classified for a period of three to six months.

Figure 4-9. SAMPLE SHIP'S INFORMATION SHEET

CONSTELLATION CERTIFICATION KEY PERSONNEL		
CDR A	Air OPS	951-7281
CDR B	Strike OPS	
LCDR C	Asst AIR OPS	
LCDR D	Asst CATTC	
LT E	Asst CATTC	PRIMARY POC
LT F	EMO	
CDR G	CAG	949-3087, 3187
LCDR H	CAG OPS	
LCDR J	CAG LSO	
CDR X	CO	
CDR Y	XO VA-146	949-3143
LCDR Z	M.O.	
MAJ W	OPS	
CDR X	PO VA-147	949-3355
LCDR Y	M.O.	
LCDR Z	OPS	
CDR X	CO VA-165	820-2519
LCDR Y	OPS	
LCDR Z	MAINT	2018

Figure 4-10. EXAMPLE OF SHIP'S KEY PERSONNEL SHEET

AMERICA CERTIFICATION PROGRAM - 12-19 OCTOBER 1978

AIRCRAFT	GAINS	BEACON HEIGHT	RANGE CORRECTION	RAMPS
A-6E	V13/L8	13 FT	20 FT	NONE
A-7	F-5/L3	9 FT	10 FT	1/4° at 18 to 16 sec, 3/8° at 3 to 1.5 sec

WIND OVER DECK (WOD)

OPTIMUM	22-28 KNOTS	345-355°	(TRUE WOD)
CERTIFIED	20-30 KNOTS	345-005°	
EXPERIENCED	17-37 KNOTS	341-010°	

SHIP TRIM

PITCH (θ)	.3° - .6°	BOW UP
ROLL (ϕ)	.0° - .6°	STARBOARD UP

GLIDESLOPE = 3.5°

Figure 4-11. EXAMPLE OF PAST CERTIFICATION INFORMATION SHEET

FM: USS (Ship Being Certified)
TO: NAVAIRTESTCEN PATUXENT RIVER MD
INFO: COMNAVAIRLANT NORFOLK, VA OR COMNAVAIRPAC SAN DIEGO CA
COMNAVAIRSYSCOM WASHINGTON DC
COMNAVELEXSYSCOM WASHINGTON DC
COMCARGRU ______________
COMCARAIRWING ____________
CNO WASHINGTON DC
NAVELEXSYSENGACT ST INIGOES MD
FLTCOMBATDIRSSACT SAN DIEGO CA
BT
UNCLAS // N 13900 //
USS (Ship Being Certified) ACLS CERTIFICATION SITREP __________

1. NATC/NESEA SENDS

2. REPORT FLIGHT PERIODS, APPROACHES BY AIRCRAFT TYPE, TEST RESULTS IF RELEVANT

3. REPORT AIRCRAFT STATUS

4. REPORT SYSTEMS STATUS

5. ANY REMAINING PARAGRAPHS ARE FOR GENERAL COMMENTS OR REQUESTS. SITREPS SHOULD BE KEPT SHORT AND TO THE POINT.

Figure 4-12. SAMPLE OF SITREP FORM

Outgoing

PTTUZYUW RULYNQN0480 3160152-UUUU--RULYSUU.
ZNR UUUUU
P R 120141Z NOV 78
FM USS INDEPENDENCE
TO NAVAIRTESTCEN PATUXENT RIVER MD
INFO COMNAVAIRLANT NORFOLK VA
COMNAVAIRSYSCOM WASHINGTON DC
COMNAVELEXSYSCOM WASHINGTON DC
COMCARGRU FOUR
ZEN/COMCARAIRWING SIX
CNO WASHINGTON DC
NAVELEXSYSENGACT ST INIGOES MD
FLTCOMBATDIRSSACT SAN DIEGO CA
BT
UNCLAS //N13900//
USS INDEPENDENCE ACLS CERTIFICATION SITREP SIX
1. NATC/NESEA SENDS.
2. TWO FLT PERIODS CONDUCTED. CONTINUING WITH OPTIMIZATION OF A6 AND A7 PROGRAMS. F4 IN FINAL CONFIG

ACFT	ATT	COMPL	TOTAL TO DATE
A6	14	11	95/59
A7	14	11	48/32
F4	14	13	68/51

3. TWO F4 H-DOT PERIODS FLOWN RESULTING IN 25 MODE I COMPLETIONS OF 26 ATTEMPTS.
4. ALL ACFT OPRDY EXCEPT NATC A7 752 WHICH HAS DAMAGED RIGHT MAIN GEAR UPLOCK ASSEMBLY. INTEND TO FLY 752 TO NHIC GEAR DOWN 12 NOV. ETA 1800Z.
5. FOR LCDR DWYER, SATD: EXPECT TWO PERIODS 12 NOV BRING YOUR OWN GAS.
6. FOR BOB WIGGINTON/JOHN HERNDON:
AN/SPN-42 B CHANNEL BEACON TRACKING EXHIBITS CYCLIC OSCILLATION IN SLANT RANGE OF APPROX 40 FEET MAGN AND 2 SECOND PERIOD FOR LAST 5 SECONDS BEFORE TOUCHDOWN. THIS RESULTS IN UNACCEPTABLE PITCH AND BANK COMMAND PERTURBATIONS. REQUEST RECOMMEND TEST PROCEDURE TO ISOLATE PROBLEM.
BT
0480

NNNN

DFT LCDR BEATY
REL CDR KUHLKE

FLAG __	CAPT I	EXEC I	CVW C
OPS O/L	DECK __	AIMD I	DENT __
ADMIN __	SUPP __	SFTY __	WEPS __
ENG __	NAV __	AIR I	TRNG __
MED __	COMM __	CHAP __	CMSG __
CDO __	OOD __	SIGS __	SFOMS __

Figure 4-13. SAMPLE OF COMPLETED SITREP FORM

SECTION FIVE

INSTRUMENTATION

5.1 INTRODUCTION

The quantitative measurements for ACLS involve three different sets of instrumentation: aircraft instrumentation, camera instrumentation, and AN/SPN-42 instrumentation.

5.2 AIRCRAFT INSTRUMENTATION

Aircraft instrumentation has a minor role during ship certifications, because of the quantity of quantitative and qualitative data being generated from other sources. The assimilation and analysis of these other data are so time-consuming as to preclude analyzing aircraft instrumentation during the at-sea tests.

Proper interpretation of AN/SPN-42 instrumentation permits the project engineer to review aircraft performance through the shipboard instrumentation. This is particularly true for parameters such as speed control, altitude excursions, and proper beacon operation. The dependence on shipboard instrumentation was developed because of the high usage of fleet aircraft for certification tests.

The major benefit of aircraft instrumentation is the ability to evaluate turbulence levels from angle of attack (AOA) and acceleration excursions. AOA excursions can affect autothrottle speed control which in turn can affect ACLS control. (Altitude deviations are directly related to aircraft speed through aircraft open-loop response characteristics.) However, past certifications have not sought to quantify turbulence levels.

If aircraft instrumentation is going to be used, it should be thoroughly checked out before the certification trip. This includes current calibrations, a telemetry checkout, and up-to-date playback setups. Instrumentation formats and scale factors are presented in NAVAIRTESTCEN notebooks.

5.3 FILM INSTRUMENTATION

The major post-certification instrumentation analyzed is the film data. These data are taken from center-line, island, side-view, and hook-to-ramp cameras. The center-line, island, and side-view cameras provide various touchdown parameters whereas the hook-to-ramp camera provides the vertical distance between the aircraft hook and ship's ramp.

5.3.1 Center-Line Camera

The major data camera is the center-line camera. It is mounted on the ship's stern with a field of view forward of the landing area. It provides data for longitudinal and lateral touchdown distance; sink speed; engaging speed; pitch, roll and yaw attitudes; glidepath; and crosstrack angles.

The major disadvantages of the center-line camera are that its mount on the ship's ramp makes changing the film difficult and its lens becomes dirty easily with stack gas and spray from the flight deck. Even with these disadvantages, the center line is the best single data source for film data. Color film can aid in overcoming the effects of a dirty lens.

5.3.2 Side-View Cameras

Side-view cameras are mounted to the side of the landing area. Generally, two or more side-view cameras are required to obtain film coverage of the entire landing area.

The data obtained from these cameras are longitudinal touch-down distance, sink speed, engaging speed, and pitch altitude. The advantage of these cameras is their location. Since these cameras are side-looking rather than forward-looking, they do not suffer from the same grimy lens or film-loading problems that the center-line cameras do. A disadvantage is that more than one camera is required to give adequate coverage of the landing area. In addition, these cameras provide less data than the center-line cameras.

5.3.3 Island Camera

The use of an island camera looking back and down into the landing area is still an evolving process. The camera provides essentially the same data as the center-line camera but with less accuracy. Aircraft altitudes are difficult to obtain because of the camera angle. This, in turn, hampers the accurate determination of all touchdown parameters. The successful evolution of the island camera would solve the camera maintenance problems of the center-line camera (film-loading and lens-cleaning) and the field-of-view problems of the side-view cameras.

5.3.4 Hook-to-Ramp Camera

The hook-to-ramp camera provides film data on the vertical distance between the hook and the ramp. The camera is mounted on the deck edge at the ramp looking across the deck.

5.3.5 Camera Coverage

Certification data may be adequately recorded by using only a hook-to-ramp and center-line camera. Side-view cameras may be used as a back-up to the center-line camera; however, they require additional material and personnel costs for essentially no improvement in data quality or quantity. The island camera is still somewhat experimental, but it may eventually replace the center-line camera.

5.4 AN/SPN-42 INSTRUMENTATION

The AN/SPN-42 instrumentation analyzed by the certification team consists of analog strip charts and input/output console digital data. This subsection presents an overview of AN/SPN-42 instrumentation. Specific problems are discussed in Section Eleven.

5.4.1 Analog Strip Charts

The analog strip charts used during a certification are generated by four strip chart (brush) recorders. The normal set-ups for the recorders are shown in Table 5-1. To obtain the proper parameters on the brush, the instrumentation patch tape switch must be in the "on" position.

5.4.1.1 Brush 1

Brush 1 parameters are grouped to provide an analog of vertical control. As shown in Table 5-1, these parameters are range, vertical error, pitch command, altitude, elevation encoder, and DSS pitch angle or ship's pitch. In order to obtain an analog of the elevation encoder and DSS pitch angle, the instrumentation patch tape must be on. The following briefly describes each of the brush 1 parameters:

- Range (X). The range parameter is important because all gains in the AN/SPN-42 control programs are range-variable. Analysis of the range trace is useful to determine if control anomalies are always occurring at the same place. Range is normally ignored if there are no problems. Range should be a smooth trace with no perturbations.
- Altitude (Z). The altitude parameter gives an indication of height above touchdown point. It should be a smooth trace.
- Vertical Error (Z_e). The vertical error parameter gives an indication of how well the aircraft is controlling about glideslope. This parameter should be relatively smooth with no periodic oscillations. The large pertubation at range is due to tip over. Perturbations in-close are generally attributed to burble. There should be no large deviations (greater than 5 feet) from glideslope other than under these two conditions. At 12 seconds from touchdown a spike appears in the vertical error trace as an alert

Table 5-1. SET-UP FOR AN/SPN-42A BRUSH RECORDER

Pen No.	Parameter	Buffer Number	Potentiometer Setting	Scale Range		Comments
				Left	Right	
Brush 1						
1	Range (X)	12	X2	0	50,000	
2	Z error (Z_e)	16	X0.1	31.25 (low)	31.25 (high)	
3	Pitch Command (θ_c)	02	X0.2	13.18 (up)	13.18 (down)	
4	Altitude (Z)	15	X2	0	2,500	
5	EL Encoder	30	X0.2	0 (down)	1.0 (up)	Repeats
6	DSS Pitch Angle (θ_s)	22	X0.2	0.5 (stern up)	0.5 (stern down)	Repeats
Brush 2						
1	Range (X)	12	X2	0	50,000	
2	Y error (Y_e)	14	X0.2	50 (port)	50 (stbd)	
3	Roll Command (ϕ_c)	03	X0.2	29.3 (right)	29.3 (left)	
4	AZ Encoder	31	X0.2	0.5 (stbd)	0.5 (port)	Repeats
5	DSS Roll Angle (ϕ_s)	23	X0.2	0.5 (stbd down)	0.5 (stbd up)	Repeats
6	Ship's Yaw (Ψ_s)	25	X0.2	0.5 (stern port)	0.5 (stern stbd)	Repeats
Brush 3						
1	Range (X)	12	X2	0	50,000	
2	R_s Washout (R_s)	27	X0.2	0	100	Repeats
3	Accel Output (Z_{10})	45	X0.2	2 (up)	2 (down)	Repeats
4	Accel Heave (Z_{10})	24	X0.1	7.81 (down)	7.81 (up)	
5	Touch-Down Heave (Z_{11})	21	X0.1	7.81 (down)	7.81 (up)	
6	Z Error (Z_e)	16	X0.1	31.25 (low)	31.25 (up)	
Brush 4						
1	EL Encoder	30		0 (down)	1.0 (up)	Repeats
2	Spin Error			0.1 (down)	0.1 (up)	
3	EL Summation			0.0 (down)	1.0 (up)	Repeats
4	AZ Encoder	31		0.5 (stbd down)	0.5 (stbd up)	Repeats
5	Spin Error			0.1 (stbd left)	0.1 (right)	
6	AZ Summation			0.5 (stbd down)	0.5 (stbd up)	Repeats

that DMC has started. The last 20 seconds of the vertical error trace is quantized and printed out on the AN/SPN-42 I/O console.

- Pitch Command (θ_C). The pitch command trace is used to record ship's pitching motion. It provides a measure of the type of ship's motion seen during the certification. The DSS pitch is also used to determine ship's pitch trim. The bias exhibited by this trace may be equated to ship's pitch trim.

5.4.1.2 Brush 2

Brush 2 parameters are grouped to provide an analog of lateral control. These parameters are range, lateral error, roll command, azimuth encoder, DSS roll or ship's roll, and ship's yaw. The last three parameters are dependent on the instrumentation patch being on. The following briefly describes each of the brush 2 parameters:

- Range (X). This is the same parameter as for brush 1.
- Lateral Error (Y_e). The lateral error trace gives an indication of the center-line control of the aircraft. Lateral gains are relatively low at large distances from the ship (see Appendix D); therefore, some aircraft wandering about center-line is to be expected. In-close, the trace should be steady with no deviations. The last 20 seconds of this parameter are quantized and printed out at the AN/SPN-42 I/O console.
- Roll Command (ϕ_C). This parameter is a trace of the AN/SPN-42-generated roll command sent to the aircraft. Generally, the commands are small with no large pertubations. The exception could occur immediately following "couple," depending on the aircraft's trim condition.
- Azimuth Encoder. The azimuth encoder is a trace of the radar's azimuth position. The trace should be relatively smooth with no "steppiness."
- DSS Roll (ϕ_S). The DSS roll comes from the AN/SPN-42 stabilization subsystem and provides an indication of the ship's roll. Mistrim may be determined from this trace by observing the trace bias. One of the difficulties of obtaining ship's roll mistrim is in determining where the center of this trace should be, because it is a trace that repeats about a scale of ±0.5 degrees. Ship's roll mistrim could be of a magnitude of up to 5 degrees of mistrim.
- Ship's Yaw (ψ_S). The ship's yaw trace comes from whatever stabilization system the ship is using, i.e., SINS, FWD MK 19 or AFT MK 19 gyros. This trace is important in the early part of the certification to determine the proper phasing of the yaw input to the AN/SPN-42.

5.4.1.3 Brush 3

Brush 3 has a range trace and vertical error trace similar to brush 1. In addition, brush 3 has traces of the range washouts, AN/SPN-42 stabilization accelerometer output, the accelerometer heave, and the actual touchdown point heave. The instrumentation patch tape must be on to receive range washout, accelerometer output, and accelerometer heave. The following briefly describes each of the brush 3 parameters:

- Range (X). Range is similar to brushes 1 and 2.
- Range Washout (R_s). The range washout trace is essentially a high-frequency noise component obtained by subtracting the range filter from the range input. Any bias associated with this trace is relatively unimportant; what is important is any sudden changes or short-term effects in the trace, which may be indicative of tracking problems. An example of a tracking problem is shown in Section Eleven.
- Accelerometer Output (Z_{10}) and Accelerometer Input ($\ddot{Z}_{10}$). The accelerometer output trace, Z_{10}, is the vertical motion of the accelerometer. The accelerometer output undergoes a space transformation by adding in the accelerometer to touchdown point offsets (x, y, and z) to develop the actual touchdown point heave Z_{11}. The accelerometer input trace, $\ddot{Z}_{10}$, is double-integrated to give the accelerometer output Z_{10}. These two traces are not analyzed by NAVAIRTESTCEN personnel.
- Touchdown Heave (Z_{11}). This parameter is used to measure touchdown point vertical displacement.
- Vertical Error (Z_e). This parameter is the same as for brush 1.

5.4.1.4 Brush 4

Brush 4 is associated with AN/SPN-42 encoders and filters. It is designed to give an indication of how well the radar is tracking the aircraft. The six recorder parameters on Brush 4 are the elevation encoder, elevation spin error, elevation spin error summation, azimuth encoder, azimuth spin error, and azimuth spin error summation. The following briefly describes each of the brush 4 parameters.

- Elevation Encoder. The elevation encoder is identical to the trace on brush 1.
- Elevation Spin Error. The spin error trace is essentially a 15 Hz filter output that gives an indication of how well the elevation encoder is working. The amplitude of spin error is proportional to the angular tracking error. The important characteristic of elevation spin error is the peak-to-peak deviations. Bias is relatively unimportant. A more complete explanation of the ramifications of this trace will be found in Section Eleven, which deals with common problems.
- Elevation Spin Error Summation. This trace is the true target angle that results from summing the elevation encoder signal with the elevation spin error signal. If spin error is working adequately, there should be a smooth trace reflecting the elevation encoder movement without any of the "steppiness" that may be associated with the elevation encoder. The reason for this is that the

spin error is designed to reduce the effects of poor radar tracking by allowing the summation of an analog signal (which is proportional to the elevation component of spin error) with the elevation encoder signal. Since the amplitude of the spin error signal is proportional to the angular tracking error (target angular displacement from antenna boresight), the position anomalies caused by poor tracking are compensated or "smoothed." The overall effect of the spin error summation is less noise on the pitch and bank commands and therefore smoother aircraft control.

- Azimuth Encoder, Azimuth Spin Error, Azimuth Spin Error Summation. These three parameters are similar to the elevation parameters.

5.4.2 Input/Output (I/O) Console Digital Data

The second set of AN/SPN-42 instrumentation analyzed by the certification team is the AN/SPN-42 I/O console digital data. These data are a digital output of the vertical and lateral error analog traces of the last 20 seconds of each approach, as well as a third parameter that is a combination of the proportional and integral terms in the AN/SPN-42 pitch command. These data are used to generate statistical time histories of the approach to determine where pitch ramps may be necessary. The I/O console data, its reduction, and uses are discussed in Section Eight.

5.5 NICOLET ANALYZER

The Nicolet Analyzer uses the Fast Fourier Transform to calculate the open- or closed-loop frequency response of the AN/SPN-42 aircraft system of interest. Since the procedures and use of this instrument are still in the evaluation stage, they are not currently included in this document.

SECTION SIX

PRE-SAIL TESTS

6.1 INTRODUCTION

Pre-sail testing includes two major elements of the certification effort: evaluating the basic alignment between the AN/SPN-42, the AN/SPN-41, and the Fresnel Lens Optical Landing System (FLOLS) and functionally checking the test aircraft.

6.2 ALIGNMENT EVALUATIONS

ACLS is designed to land aircraft under zero-visibility conditions with no other landing aids. However, operating procedures require that independent monitoring systems be provided to the pilot to check the performance of the ACLS. These independent systems are the AN/SPN-41 and the FLOLS.

The AN/SPN-41 is an electronic scanning beam radar, independent of the AN/SPN-42, which generates glidepath guidance signals similar to the AN/SPN-42 needle display. A complete description of AN/SPN-41 is provided in Appendix J. The AN/SPN-41 is used to monitor the AN/SPN-42 until FLOLS is visually acquired by the pilot.

The FLOLS is the normal visual landing aid used for all manual approaches. A description of the FLOLS is contained in Appendix K.

All three systems are surveyed for their location on the ship and are then electronically or mechanically corrected geometrically to the same touchdown point. The use of three systems in conjunction with each other requires that they be in alignment. Misalignment between the systems can cause pilot nonacceptability of ACLS.

Alignment testing falls within the Category II pier-side/shore-station flight tests. Category IIA tests use helicopter or fixed-wing aircraft to determine AN/SPN-42 glidepath and azimuth accuracy; AN/SPN-42, AN/SPN-41, and FLOLS glidepath alignment; and Mode III performance. Category IIA tests are the responsibility of NESEA with flight assistance by NAVAIRTESTCEN. However, NAVAIRTESTCEN project personnel have historically played a major role in the alignment testing, because of the pilot requirements and the need for the FLOLS checkouts. Proper alignment of the AN/SPN-42, AN/SPN-41, and FLOLS is highly crucial to the certification results and may be affected by both the geometric survey of system locations or the stabilization systems that compensate for a ship's motion.

6.2.1 FLOLS Geometric Alignment

While the ACLS is inherently more accurate and better aligned than the FLOLS, the FLOLS is the primary landing aid. Therefore, the pilot must assume that it will be the standard of comparison. In general, the pilot can perceive FLOLS "meatball" displacements of about one-quarter cell at ranges of up to about 9,000 feet in daylight and good visibility.* This means that at about one mile the pilot can, through the FLOLS, perceive altitude errors of approximately six feet with correspondingly smaller altitude errors as the aircraft flies closer to the ship.

The ability of the pilot to see such fine altitude deviations is the reason for the criterion that the AN/SPN-42 be aligned to the FLOLS. Before any AN/SPN-42 adjustments are made, however, the entire FLOLS system should be checked by the NAVAIRTESTCEN project team.

6.2.1.1 Basic FLOLS Checks

The FLOLS is checked by taking height measurements corresponding to a centered meatball at various points along the flight deck. The centered ball is determined by using a mirror mounted on an extendable pole. Geometric calculations are made to ascertain the actual glideslope angle.

Performing the FLOLS check-out will require a tape measure, a pole and mirror, masking tape to mark distances, and a forklift to raise the pole and mirror high enough above the flight deck to check the centered ball. The FLOLS is checked both caged and with SINS stabilization. A caged ball checks the basic FLOLS alignment.

The project engineer will generally mark off distances along the angle deck center line 50 feet forward, 50 feet aft, and 100 feet aft of the expected touchdown point. Expected touchdown points are provided in Aircraft Recovery Bulletin (ARB) No. 61-12M and are repeated here for convenience in Table 6-1.

Measurements of the mirror height required to show the centered ball are taken at each of these marked distances and the touchdown point. The required mirror height decreases with distance from the end of the ramp. These changes in height with distance are used to determine the glideslope geometrically. An example of a check-out geometry is shown in Figure 6-1.

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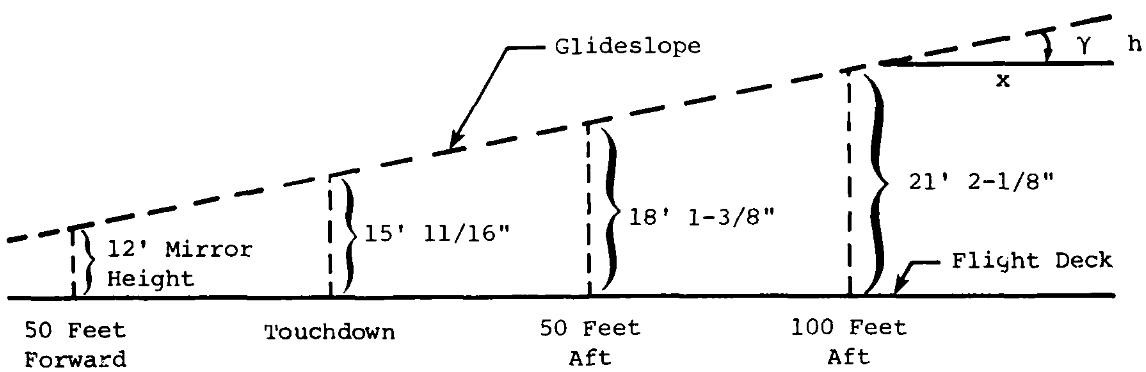
*Teper, G.L., Ashkenas, I, G., Campbell, A., and Durand, T.S., *Carrier Landing Performance; An Analysis of Flight Tests Under Simulated Pitching Deck Conditions*, Systems Technology, Inc., Report No. 137-4, October 1969.

Table 6-1. HOOK TOUCHDOWN DISTANCES FOR DIFFERENT AIRCRAFT CARRIERS	
Aircraft Carrier	Touchdown Point Distance from Ramp (Feet)*
CV-41	190
CV-43	185
CV-59	178
CV-60	178
CV-61	195
CV-62	185
CV-63	234
CV-64	234
CV-65	233
CV-66	234
CV-67	235
CV-68	230
CV-69	230
CV-70	230

*Actual deck surveys may show slight variances in these distances. For example, on CV-66, the touchdown point is surveyed to be 233.9 feet rather than 234 feet.



$$\tan \gamma = \frac{h}{x} = \frac{21'\ 2\text{-}1/8" - 12'}{100'\ \text{Aft} - 50'\ \text{Fwd}} = \frac{9'\ 2\text{-}1/8"}{150'} = \frac{9.1771}{150} = 0.0612$$

$$\gamma = \tan^{-1} 0.0612 = 3.501°$$

Figure 6-1. FLOLS CHECK-OUT GEOMETRY

While two points will determine the angle, three or more points will permit a more accurate determination, as well as to provide points for checking calculations.

The FLOLS check-out should be performed at a constant-roll setting on the FLOLS and with and without stabilization inputs. Radio communications will be required with the lens control room to coordinate measurements with stabilization inputs.

There may be differences in the vertical distance measurements with stabilization inputs because of ship's trim conditions that are sensed with the ship at the pier. While these differences may be small (on the order of inches), it must be remembered that the glidepath angle variances are small, and the pilot has adequate perception of the FLOLS to detect errors to a minimum of two inches movement on the cell. The project engineer must be prepared to ensure that mistrim conditions are compensated for in the FLOLS roll angle. A review of ARB No. 61-12M will illustrate vertical glideslope deviations with roll angle settings.

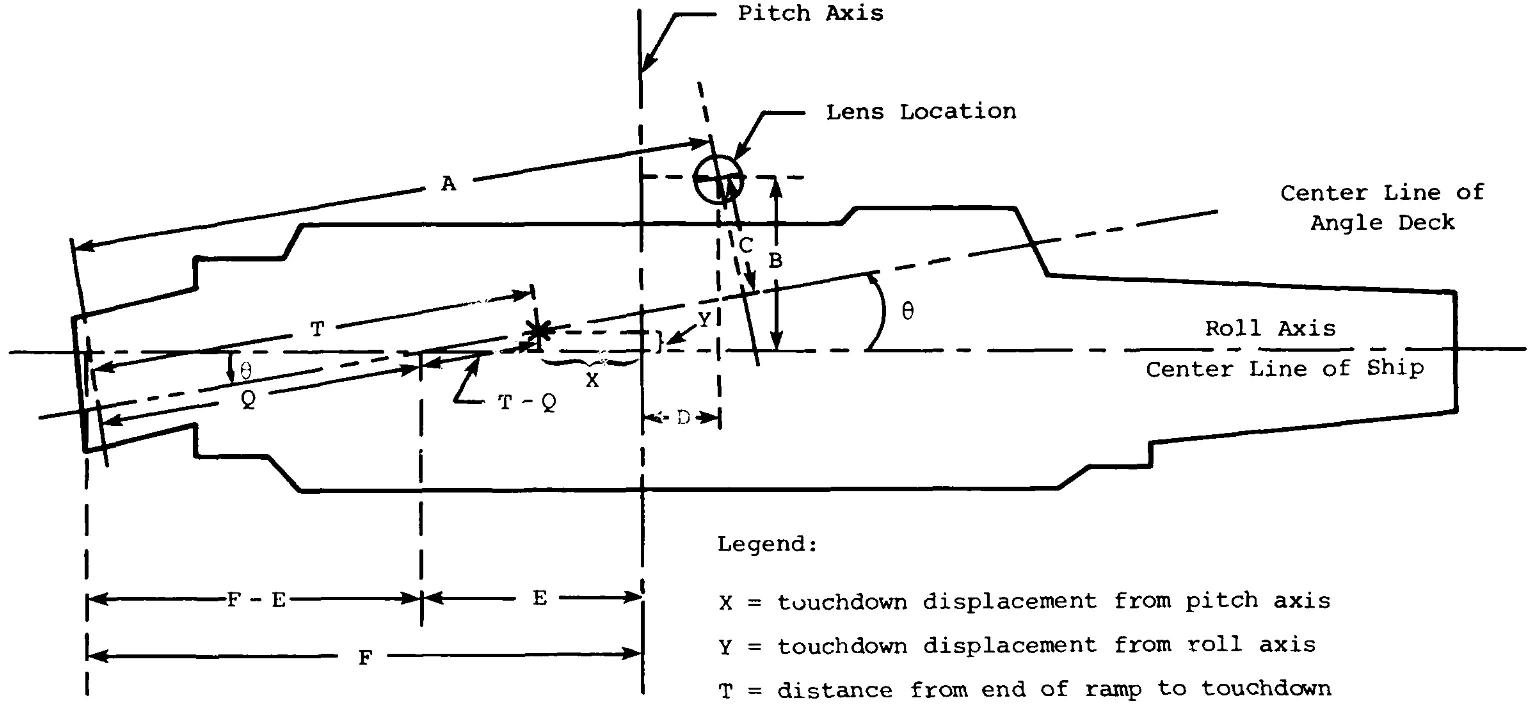
6.2.1.2 <u>FLOLS Corrections for Ship's Trim</u>

The desired ACLS and FLOLS touchdown point does not lie on the pitch or roll axis of the ship. Because of this, any ship mistrim will result in a geometric displacement of the touchdown point as projected by the FLOLS unless adjustments are made to the FLOLS roll angle. Variances in the roll angle cause a vertical translation of the glideslope, which, in turn, changes the location of the touchdown point. In general, a one-unit change in roll angle will cause a vertical translation of 1.25 to 1.50 feet. The exact translation distance as a function of roll angle may be found in ARB No. 61-12M. Present basic ship's stabilization systems will not compensate the FLOLS for the ship's trim condition. Trim harmonization equipment that rolls the FLOLS to compensate for ship's trim is being planned for all aircraft carriers. The equipment is currently installed aboard CV-59, CV-61, and CV-66. CV-63 has trim harmonization through FLOLS MK 6 Mod 3.

Figure 6-2 illustrates the ship's geometry required to begin calculations of trim corrections. The two dimensions that must be calculated are X and Y, the touchdown point displacements from the pitch and roll axis. The distance Q is used as a dummy variable for clarity. The dimensions A, B, C, D, E, F, and θ can be taken from Table 6-2, although A, B, and D are not used in these calculations. Dimension T comes from Table 6-1. The equations for X and Y are shown in Figure 6-1.

After determining the X and Y dimensions, it is possible to calculate the FLOLS roll-setting correction through the following method:

Let R = lens roll setting required with the in-board edge up being positive



Legend:

X = touchdown displacement from pitch axis

Y = touchdown displacement from roll axis

T = distance from end of ramp to touchdown

Q = distance from end of ramp to roll axis along center line

C = distance from lens to angle deck center line

$$Q = (F - E) \cos \theta$$

$$Y = (T - Q) \sin \theta = (T - [F - E] \cos \theta) \sin \theta$$

$$X = E - (T - Q) \cos \theta = E - (T - [F - E] \cos \theta) \cos \theta$$

Figure 6-2. SHIP'S GEOMETRY FOR FLOLS ROLL-ANGLE CORRECTIONS

Table 6-2. SHIP'S DIMENSIONAL DATA

Carriers	Dimensions						
	A	B	C	D*	E	F	θ
AVT-16	375' 7"	108' 2"	55' 6"	27' 8" Aft	311' 6"	391' 0"	9° 59'
CV-41	430' 0"	128' 6"	76' 0"	9' 3" Aft	229' 0"	420' 9"	13° 0'
CV-43	438' 2"	117' 8"	66' 3"	1' 0" Fwd	248' 0"	422' 9"	11° 20'
CV-59	413' 11"	134' 10"	85' 0"	28' 0" Aft	300' 0"	424' 0"	10° 22'
CV-60	412' 6"	134' 1"	85' 6"	29' 5" Aft	300' 0"	424' 0"	9° 59'
CV-61	450' 3"	133' 9"	80' 3"	2' 1" Fwd	298' 0"	431' 6"	9° 53' 19"
CV-62	421' 3"	133' 3"	85' 7"	26' 6" Aft	297' 6"	431' 0"	9° 53'
CV-63	501' 8"	133' 11"	71' 5"	52' 0" Fwd	252' 6"	433' 0"	11° 20' 21"
CV-64	500' 5"	133' 7"	71' 5"	51' 11" Fwd	252' 6"	433' 0"	11° 18'
CVN-65	491' 3"	133' 7"	80' 2"	20' 4" Fwd	278' 0"	455' 0"	10° 7'
CV-66	501' 6"	132' 11"	70' 5"	51' 0" Fwd	253' 0"	433' 0"	11° 20'
CV-67	500' 3"	133' 1"	72' 8"	55' 1" Fwd	260' 8"	437' 10"	11° 0"
CVN-68	485' 10"	135' 3"	86' 3"	10' 6" Fwd	286' 6"	460' 1"	9° 3'
CVN-69	486' 1"	134' 4"	85' 0"	10' 0" Fwd	287' 4"	460' 11"	9° 3'
CVN-70**							

*Distance forward or aft of pitch axis.
**Data not available at time of publication.

R_B = lens roll per bulletin ARB No. 61-12M

ΔR = lens roll correction for ship's mistrim

(Note: Lens roll in units = lens roll in degrees + 7.5 degrees)

Then

$$R = R_B + \Delta R \tag{1}$$

and

$$\Delta R = \Delta R_{pitch} + \Delta R_{roll} \tag{2}$$

where

ΔR_{pitch} = lens roll correction for ship's pitch mistrim (θ)

ΔR_{roll} = lens roll correction for ship's roll mistrim (ϕ)

The development of ΔR_{pitch} and ΔR_{roll} is shown in Figures 6-3 and 6-4.

By using Equation 2 with Equations 3 and 4 from Figures 6-3 and 6-4, it is derived that:

$$\Delta R = \Delta R_{pitch} + \Delta R_{roll}$$

$$= - \tan^{-1} \frac{X \tan \theta s}{C} - \tan^{-1} \frac{Y \tan \phi s}{C}$$

which denotes that from Equation 1

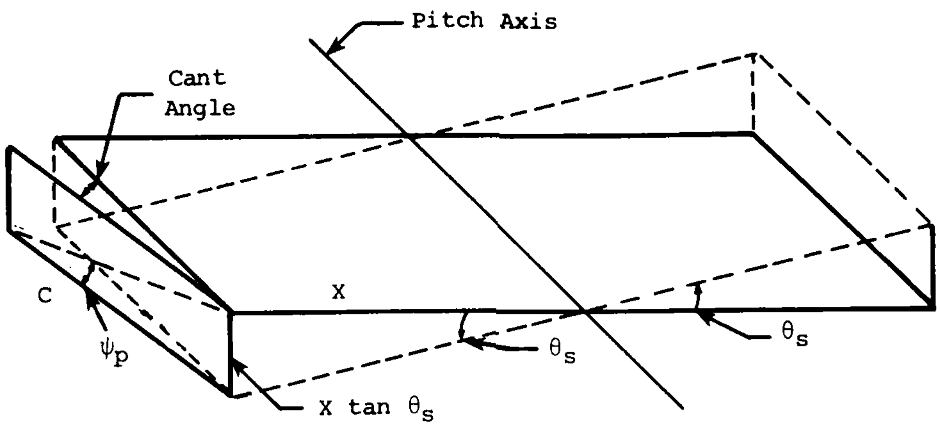
$$R = R_B - \tan^{-1} \frac{X \tan \theta s}{C} - \tan^{-1} \frac{Y \tan \phi s}{C}$$

A complete check-out of the FLOLS with respect to proper angle settings for the surveyed touchdown point and ship's trim is the first step in checking the AN/SPN-42/AN/SPN-41/FLOLS alignment. The second step is a comparison of system stabilization subsystems to check their alignment with each other.

6.2.2 Stabilization Subsystems

The ship's stabilization subsystems are intended to compensate for the effects of ship's motion on the geometric touchdown point projected by the AN/SPN-42, AN/SPN-41, and FLOLS. FLOLS is stabilized against ship's pitch and roll, and the AN/SPN-41 azimuth is stabilized for ship's yaw and roll

To correct for ship's pitch mistrim:



θ_s = pitch mistrim angle (bow up is positive)

ψ_p = lens roll correction for pitch mistrim

$$\tan \psi_p = \frac{X \tan \theta_s}{C}$$

$$\psi_p = \tan^{-1} \left[\frac{X \tan \theta_s}{C}\right]$$

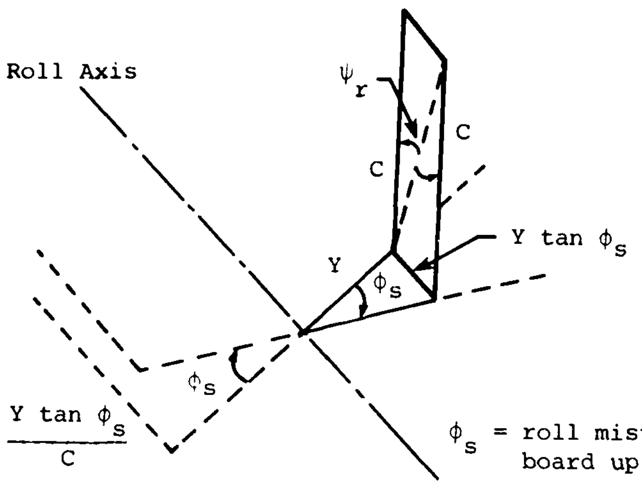
ψ_p is the angle through which the lens must be rolled about the pitch axis to compensate for ship's pitch mistrim. Because ψ_p is negative (by definition),

$$\Delta R_{pitch} = - \tan^{-1} \left[\frac{X \tan \theta_s}{C}\right] \qquad (3)$$

Figure 6-3. ΔR_{PITCH} EQUATIONS

with the AN/SPN-41 elevation being stabilized against ship's pitch and roll, while the AN/SPN-42 is stabilized against ship's pitch, roll, yaw, and heave. The AN/SPN-41 and FLOLS use the basic ship's stabilization system of MK 19 gyros or Ship's Inertial Navigation System (SINS), while the AN/SPN-42 has its own stabilization system except for the yaw input (obtained from the basic ship's stabilization system).

Similarly, to correct for ship's roll mistrim:



$$\tan \psi_r = \frac{Y \tan \phi_s}{C}$$

$$\psi_r = \tan^{-1}\left[\frac{Y \tan \phi_s}{C}\right]$$

ϕ_s = roll mistrim angle (starboard up is positive)

ψ_r = lens rolls correction for roll mistrim

ψ_r is the angle through which the lens must be rolled about the roll axis to compensate for ship's roll mistrim. Because ψ_r is negative by definition,

$$\Delta R_{roll} = -\tan^{-1}\left[\frac{Y \tan \phi_s}{C}\right] \quad (4)$$

Figure 6-4. ΔR_{ROLL} EQUATIONS

6.2.2.1 AN/SPN-42 Stabilization

AN/SPN-42 stabilization translates actual radar-derived position vector data of the landing aircraft to a stabilized deck-coordinate system referenced to the touchdown point on the flight deck. Actual ship motion (yaw, pitch, roll, and heave) is also averaged to provide a stabilized flight path for the landing aircraft. The stable platform generates stabilization signals for the ACLS radar antennas. Separate MK 4 gyros systems, which are mounted next to their respective radar antennas, supply pitch and roll information for each channel. Two accelerometer units, one for each operating ACLS channel, are mounted on the stable platforms to provide vertical translation (heave) information. Yaw information is provided to the ACLS system by the MK 19 gyro system or SINS stabilization system.

6.2.2.2 AN/SPN-41 and FLOLS Stabilization

Both the AN/SPN-41 and FLOLS landing systems use stabilization signals generated by the MK 19 gyro stabilization system or the SINS stabilization system. Because SINS is an inertial system, it is much more accurate than the MK 19. However, during the certification effort, the project engineer must evaluate both the SINS and the MK 19 stabilization systems.

6.2.2.3 Yaw Stabilization

Both the AN/SPN-42 and AN/SPN-4] use yaw stabilization inputs from the ship's MK 19 gyro system or SINS stabilization system. While the system inputs are the same, the modes of implementation for the two systems are different.

The AN/SPN-42 yaw stabilization is implemented as a function of range. Beyond four nmi from the touchdown point the yaw stabilization is loosely tied to the ship's center line. From four nmi to one-half nmi to touchdown the yaw stabilization is gradually shifted from the ship's center line to the angle deck center line. From one-half nmi to touchdown the AN/SPN-42 is stabilized in yaw about the angle deck center line.

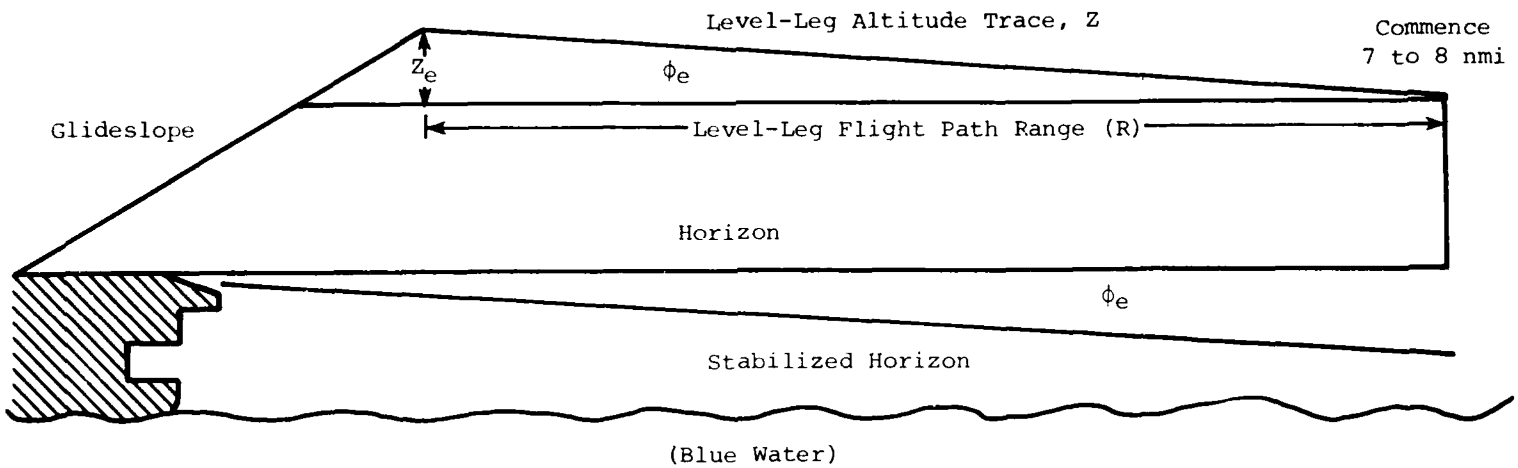
The AN/SPN-41 yaw stabilization is implemented about the angle deck center line out to 20 nmi, but it is only stabilized for up to 3 degrees of yaw. Beyond 3 degrees the yaw motion is washed out through the use of a long time constant.

Since the AN/SPN-42 yaw stabilization implementation is different from that of the AN/SPN-41, there may be needle disagreement when the pilot switches his airborne display between one system and the other. In addition, with the AN/SPN-42, AN/SPN-41, and FLOLS having different stabilization systems or stabilization system implementation, ship's motion may cause nonagreement between the three systems even though the geometric offsets are correct.

After NAVAIRTESTCEN has verified the correct FLOLS geometry and angle settings, NESEA will verify the stabilization system alignments. This is done by checking the data stabilization subsystems (DSSs) against themselves and against the basic ship's stabilization system.

6.2.2.3.1 Level-Leg Flights

Level-leg flights are performed to check system alignment and to determine ship's mistrim as seen through the DSSs. To perform a level-leg flight, the airplane flies at a constant altitude while being tracked with the AN/SPN-42 radars. By expanding the altitude error (Z_e) scale, it is possible to tell the altitude deviations due to mistrim or stabilization system misalignment. The AN/SPN-42 DSS gyros are "tweaked" until the level-leg flights produce a constant Z_e trace rather than one that has a constant slope. The Z_e slope, if any, may be equated to the ship's mistrim from a deck-level condition. After level-leg DSS adjustments, the SINS and DSS should be in close alignment (less than 0.1 degree). Figure 6-5 illustrates the procedures required for the level-leg flights.



Purpose -- Determine glideslope alignment deviation caused by either initial radar survey misalignment or DSS misalignment

Theory -- Glideslope deviation (ϕ_e) computed by using Z_e or altitude trace over maximum range level-leg

$$\text{Tan } \phi_e = \frac{Z_e}{R}$$

Pilot Procedures

- Commence 7 to 8 nmi, 1,200-foot AGL, AFCS altitude-hold engaged, dirty configuration
- Radar lock-on at maximum range with beacon on
- Maintain constant altitude to one-fourth nmi
- Radar end-of-run altitude deviation
- Mode II desired for line-up

Figure 6-5. AN/SPN-42 LEVEL-LEG FLIGHT TEST

During static pier-side tests, level legs are tracked with a deck-mounted theodolite as an added measure of instrumentation. Level legs are repeated during the initial at-sea flight tests to confirm pier-side readings.

6.2.2.3.2 Stabilization System Comparisons

Once the AN/SPN-42 DSSs have been checked out by the level-leg tests, they are compared with the basic shipboard stabilization system. This is accomplished by taking SINS or MK 19 gyros readings and comparing them with DSS readings taken at the same point in time.

The ship's stabilization outputs should be checked at their respective sources if possible. These inputs are compared with the DSS outputs that are being recorded on the AN/SPN-42 instrumentation recorders. The normal method of communicating data is over telephone lines with the ship stabilization data being manually written on the analog strip charts at the appropriate time. The data for SINS may be taken directly from the data link monitor and patched to the AN/SPN-42 instrumentation recorders. The stabilization inputs to the FLOLS are checked at the FLOLS repeaters.

A number of measurements averaged over a period of time should give an indication of any discrepancy between the stabilization systems. If there is a discrepancy, the AN/SPN-42 is aligned with the SINS to ensure alignment with the FLOLS. After stabilization checks and tweaks, the AN/SPN-42 glideslope is aligned with the FLOLS glideslope by adjusting the AN/SPN-42 glideslope parameter to the glideslope projected by the SINS-stabilized FLOLS.

Any discrepancy between SINS and MK 19 gyros or DSSs and MK 19 gyros are commented on but are not corrected. The SINS is considered the shipboard standard and is generally referred to in the certification message. The MK 19 gyro are less precise than the SINS, and a deterioration in yaw stabilization can be expected when the MK 19 gyros are used. A pilot's perception of ACLS controllability can also change if the MK 19 gyros have large ($\approx$0.25°) variances from the SINS.

6.2.2.3.3 Stabilization Source Switching

The check-out and comparison of stabilization sources require a knowledge of the switch positions that control the various stabilization systems. Figure 6-6 illustrates the stabilization switching for CV-64 (USS CONSTELLATION), although every aircraft carrier has its own particular switching logic. While NAVAIRTESTCEN personnel should be familiar with the various stabilization sources and their effects, NESEA is responsible for ensuring the alignment of the stabilization system.

6.3 AIRCRAFT CHECK-OUT TESTS

In certification efforts it is the ship's equipment that is being certified, since the aircraft are assumed to be operating properly. To

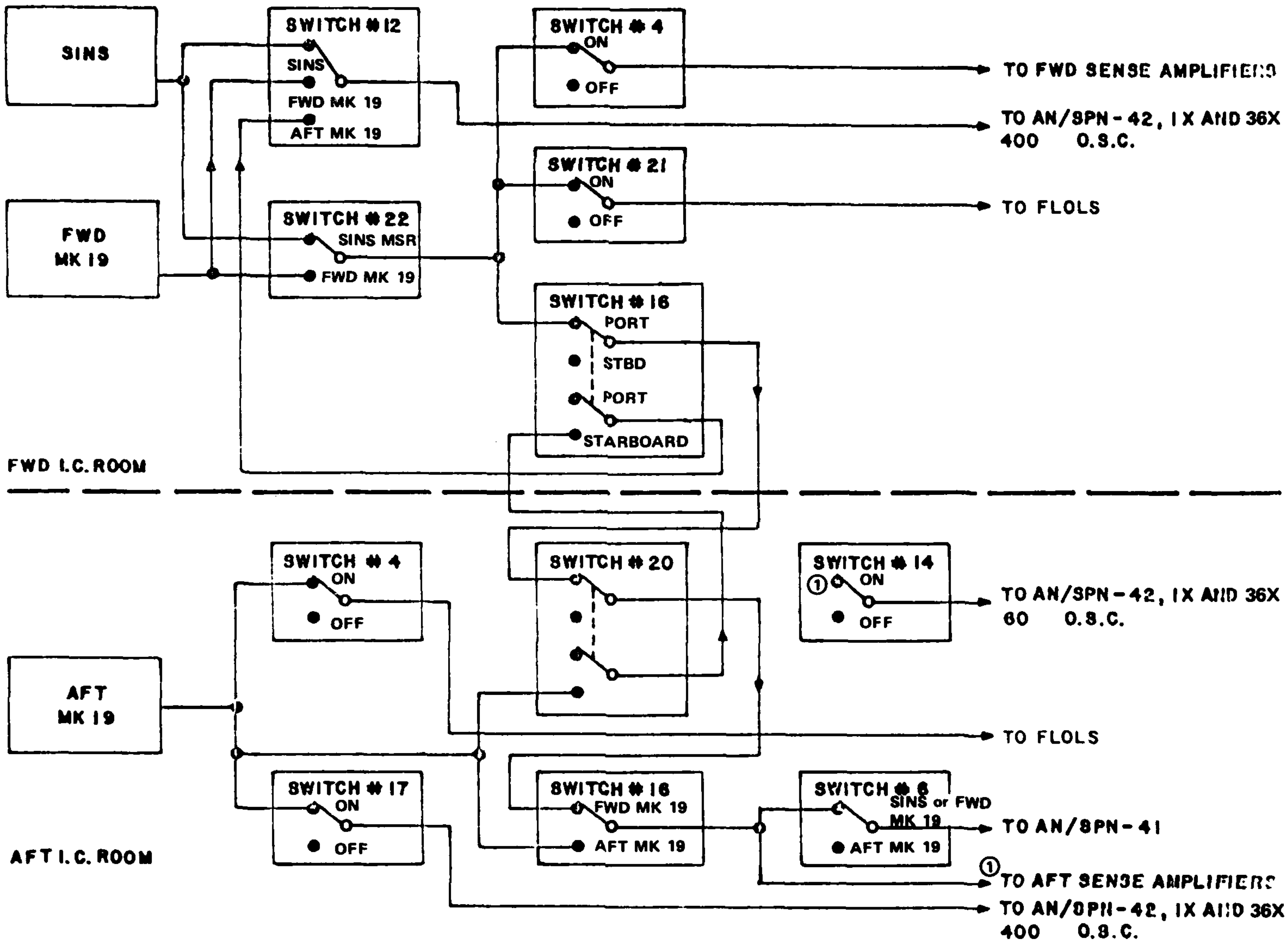


Figure 6-6. GYRO SWITCHBOARD SWITCH CONFIGURATION FOR ACLS EQUIPMENTS

validate this assumption, all ACLS aircraft used for the certification must be evaluated for proper ACLS operation before the certification tests begin.

6.3.1 Ground Checks

The aircraft ACLS ground check-out includes checking the automatic flight control system, autothrottle, beacon, data link, and AN/SPN-41 receiver (ARA-63) for proper operation. These checks are performed at NAVAIRTESTCEN by the data link shop for NAVAIRTESTCEN aircraft. All of these tests are discussed in the appropriate aircraft maintenance manuals.

Fleet aircraft should have these same checks performed by squadron personnel to familiarize squadron personnel with ACLS systems aboard their aircraft. These checks are especially important since it is these same squadron personnel who will be responsible for maintaining the aircraft ACLS once the squadron is deployed. NAVAIRTESTCEN data link personnel may give advice but should not do the work for the host squadrons. When NAVAIRTESTCEN personnel work with squadron personnel during ACLS tests, it should be in a training role rather than in a maintenance role.

Once all required ground checks and tests have been completed, flight checks should be conducted on the test aircraft.

6.3.2 Flight Checks

Flight checks consist of a basic flight check and a closed-loop system flight check.

6.3.2.1 Basic Flight Check

The basic flight check consists of the pilot manually flying the aircraft and evaluating the operation of the AFCS and autothrottle. The pilot also checks the AOA indicator against the airspeed indication to ensure that the AOA reference is set properly. A bit check is made on all aircraft ACLS systems.

The aircraft should be sent open-loop pitch and bank steps for a complete aircraft systems check.

6.3.2.2 Closed-Loop System Flight Check

Once the test aircraft have been determined to be ready for ACLS, they should be put through a closed-loop flight test before being taken to the ship. This is the final system check that ensures the airplane is ACLS operational and will fly similar to other aircraft of its type.

The closed-loop system flight check includes coupled Mode I approaches and vertical closed-loop frequency response. These two tests will give a reasonable indication of control and performance. The Nicolet analyzer should be used for frequency response tests whenever possible.

The Mode I approach is just a typical ACLS pass. The closed-loop frequency response presents no problem if performed at NAVAIRTESTCEN. It is conducted as a normal test ACLS flight, and a full range of closed-loop frequencies are evaluated (0.2, 0.4, 0.6, 0.8, and 1.0 rad/second). The closed-loop response data are reduced and compared with aircraft standard closed-loop response data. Table 6-3 shows the standard closed-loop frequency response at full gains for current Mode I certified aircraft. Data are also presented for the current S-3A Mode I programs.

Table 6-3. VERTICAL CLOSED-LOOP FREQUENCY RESPONSE OF ACLS AIRCRAFT

Aircraft (Program)	Parameter	Frequency (Radians/Second)									
		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2
F-4 (V1)	Gain - dB Phase - Degrees	1.2 -17	1.5 -29	1.5 -41	1.2 -53	0.9 -64	0.7 -75	0.5 -88	0.0 -105	-0.6 -119	-4.1 -159
A-7 (F5)	Gain - dB Phase - Degrees	1.2 -13	1.2 -21	2.0 -29	2.3 -36	2.3 -46	2.0 -58	2.0 -71	2.0 -85	1.9 -100	1.0 -133
A-6 (V13)	Gain - dB Phase - Degrees	0.2 -16	-0.1 -27	0.2 -36	0.4 -46	0.3 -58	0.7 -69	0.6 -82	0.8 -92	0.7 -106	2.3 -117
EA-6 (V10)	Gain - dB Phase - Degrees	0.6 -7	1.0 -16	1.1 -26	1.3 -32	1.6 -37	2.0 -42	2.4 -49	2.8 -60	2.9 -77	1.6 -126
S-3 (V9)	Gain - dB Phase - Degrees	0.4 -27	-0.3 -41	-0.9 -52	-1 1 -63	-1.1 -73	-0.8 -83	-0.7 -95	-- --	-1.2 -115	-3.7 -127

If the ACLS closed-loop frequency response is to be performed at another certified ACLS site (e.g., NAS Miramar, NAS Lemoore), various coordination efforts must be made. In addition, the scope of the frequency response tests should be reduced to minimize the impact on base operations and maximize the data quality.

Flight tests at an operational base require being listed on the daily flight schedule, scheduling use of the ACLS site, ensuring that the test aircraft are ready at the designated time, and obtaining NESEA support for programming and AN/SPN-42 instrumentation. In other words, these tests cannot be an afterthought.

Procedures at an operational base are similar to NAVAIRTESTCEN ACLS tests. The exception is that the project engineer should take only one or two frequencies and repeat them so that the data can be averaged. Engineering preferences must give way to what is operationally feasible. This is especially true if the project engineer is attempting to evaluate two or three fleet aircraft during the flight period.

The best procedure is to attempt to take frequencies of 0.4 and 0.8 radians/second and to repeat each frequency twice. For three aircraft, this should be accomplished in a one-hour flight period if everything proceeds according to plan. When performing these tests at an operational base, the touchdown point must be raised.

During these pre-certification frequency response tests, the data should be within ±1 dB of gain and ±5 degrees of phase to be acceptable. However, the project engineer should take into consideration the environmental conditions of the test and when the field site was last certified. The main intent of these tests is to ascertain that all aircraft are operationally ready for the certification tests.

Generally, all east coast aircraft should be brought to NAVAIRTESTCEN for pre-certification flight checks. West coast aircraft are generally taken to NAS Miramar, especially if the ship is leaving from San Diego. The most important consideration is ensuring that the tests are conducted where the test can most easily be supported by aircraft and required test personnel.

6.4 PILOT FAMILIARIZATION

While pilot familiarization is not a pre-sail test, it is a requirement for a successful certification effort. The pilot plays a major role in the certification effort. As such, he should be intimately familiar with ACLS and the performance of specific aircraft types while under ACLS control.

The pre-sail flight checks are an opportune time for certification project pilots to reacquaint themselves with ACLS and AQRs and to meet with project engineers to discuss recurring ACLS problems and expected ACLS controllability.

SECTION SEVEN

AT-SEA FLIGHT TESTS

7.1 INTRODUCTION

At-sea flight tests are conducted to quantify the performance of the ACLS under the dynamic conditions of ship motion and wind over deck (WOD). The actual test flights are a repetitive process designed to generate useful statistical data. This section is a discussion of the roles of the test team, the data to be gathered, test conditions, and program configurations. It also deals with ACLS problems normally encountered during a certification.

7.2 TEST TEAM

NAVMAT Instruction 5400.20 states, in part, that COMNAVAIRSYSCOM is responsible for "managing, funding and scheduling the flight portion of certification of ACLS ship and shore installations." COMNAVELEXSYSCOM is responsible for "assisting NAVAIR in the certification of ACLS shipboard and shore-based systems." This statement gives NAVAIRTESTCEN the authority to conduct ACLS certifications (as NAVAIR's designee) and the responsibility for conducting the certification. It also helps to define the role of each member of the test team. The two focal points of the at-sea certification are the test coordinator and project engineer.

7.2.1 Test Coordinator

The entire shipboard test operation, which is divided into two major tasks, is the responsibility of the test coordinator. One task is the operational problem of arranging aircraft availability, schedules, and sequencing operations and generally fitting the test program within the operational limitations of the aircraft carrier and the automatically controlled aircraft. The other task is to achieve the technical objectives of the certification by anticipating the operational opportunities and being prepared to utilize conditions as they exist to attain the test results. The test coordinator or project engineer will maintain liaison with the cognizant ship's personnel. Specifically, they will perform the following functions:

- Keep the ship's captain/air boss informed at all times during operations.

- Arrange the flight schedule with the Operations Officer.
- Make any additions or changes to ACLS test programs when necessary.
- Provide reports of airplane and pilot availability to appropriate shipboard personnel.
- Ensure that daily reporting requirements are met.

7.2.2 Project Engineer

The project engineer is responsible for conducting the certification effort. He uses the operational assets provided by the test coordinator to ensure that the data requirements of the certification are met. The project engineer plans the scope of the certification as well as each flight period. He is the focal point for all supporting engineering activities. As a minimum, and prior to each test period, the project engineer or his designee will perform the following functions:

- Plan each flight period for maximum utility of assets.
- Prepare all pilot flight cards.
- Determine the operational status of the camera and aircraft instrumentation from the senior TSD representative.
- Determine the operational status of the ACLS equipment for each flight period from the senior NESEA representative.
- Determine the appropriateness of the flight period on the basis of ship motion, ambient conditions, ACLS status, and aircraft availability.
- Define with the test coordinator the aircraft/ship system parameters that will determine go/no-go decisions; designate the personnel responsible for making those decisions in the air and on the ship.
- Conduct the test period flight briefing.
- Ensure that all test stations are manned, checked out, and operational 15 minutes before aircraft launching.

During each test period the project engineer or his designee will perform the following functions:

- Coordinate all test stations.
- Schedule aircraft into the pattern based on data needs.
- Coordinate required test conditions (WOD) through air operations.
- Inform pilots in all test aircraft of changes in system configuration or operation.
- Make all final engineering decisions required during the test period.

After each test period the project engineer or his designee will perform the following functions:

- Debrief the test period through discussions with test pilots, Landing Signal Officer, Primary Flight observers, NESEA personnel, and instrumentation personnel.
- Attempt to resolve any obvious technical problems or variance in subjective opinions through detailed discussions with pertinent personnel.
- Attempt to develop a timetable for when such decisions as next flight periods, AN/SPN-42 discrepancies, and instrumentation problems will be resolved.
- After the last test period of the day and on the basis of postflight debriefs and an initial explanation of problems and expected solutions, schedule a late evening meeting to discuss the day's operations and overall certification effort. As a minimum, this meeting will include the project engineer, test coordinator, and senior NESEA representative. It may include other personnel if their inputs are required.

Between test flights or after the day's test operations, the project engineer or his designee should perform the following:

- Review AN/SPN-42 instrumentation to assess the consistency of approaches.
- Look for any parameters that exceed normal expectations.
- Partition the data with respect to wind conditions.
- Develop master test logs for each aircraft type to correlate the data from all test stations.
- Plot AN/SPN-42 20-second data printouts.
- Review and plot observed touchdown data.
- Develop the daily situation report with the test coordinator.

7.2.3 Other Team Members

Although the test coordinator and project engineer are the focal points for test planning, operations, and conduct of the certification, there are many other test team personnel in addition to the instrumentation and maintenance support who have major roles in the certification effort. Each of these team members provide inputs to the overall certification decision-making process.

7.2.3.1 Project Pilots

Project pilots provide a qualitative and quantitative assessment of the system performance with respect to controllability at the AN/SPN-42 and the alignment with AN/SPN-41 and FLOLS. Pilot quantitative assessments are one of the major factors in ACLS certifications. Appendix L is a discussion of pilot ACLS quantitative measures.

7.2.3.2 Landing Signal Officer (LSO)

The certification LSO performs the normal functions of an LSO. He provides a qualitative assessment of ACLS performance from his perspective. The LSO grades ACLS approaches in the same manner as manual approaches, and he should accept or reject ACLS approaches with the same criteria as manual approaches. Acceptance of bad ACLS approaches for data purposes can bias the data with long or short landings. LSO rejection of ACLS passes for cause can reduce the statistical numbers for touchdown dispersion; however, the approaches are reflected in the overall boarding rate.

7.2.3.3 Primary Flight (PRI-FLY) Observer

The PRI-FLY observer works closely with the Air Boss to ensure that the required test conditions are obtained. The PRI-FLY observer is essentially an Air Boss in performing his duties. He is responsible for informing the Air Boss to launch airplanes, suspending a launch in the event a sudden change in test conditions occurs, confirming the wind, informing the Air Boss when to recover airplanes and what airplanes should be hot-refueled or struck below, monitoring fuel states to preclude a "BINGO" condition, and confirming that the arresting gear and FLOLS are set properly and recovery wind is adequate. The test coordinator or his representative is usually located in PRI-FLY during test operations, and he and the senior engineer work as a team in implementing the test program. The test coordinator should handle emergency situations and have contact with pilots or contractor representatives who can speedily get to PRI-FLY to advise a pilot on the emergency use of aircraft systems. The PRI-FLY observer also records observed touchdown points.

7.2.3.4 Island Observer

Generally, during test operations there are instrumentation personnel on the "island" with a view of the touchdown area. These personnel are a valuable source of observed touchdown position and can communicate their observations over the communications network for recording on instrumentation charts. In addition, TSD instrumentation personnel record observed touchdown position on their daily running film log. Between the LSO, PRI-FLY observer, island personnel, and film logs, there are four independent qualitative assessments of touchdown position for each ACLS approach. This assessment can be a valuable real-time data input to the certification effort.

7.2.3.5 NESEA Personnel

NESEA personnel provide direct support to the certification by ensuring the operational integrity of the AN/SPN-42 and AN/SPN-41 system. They provide programming support as required, are responsible for implementing any desired program change, and maintain and operate the AN/SPN-42 instrumentations that are passed to the NAVAIRTESTCEN engineering personnel for review and analysis.

In addition to monitoring equipment operation, NESEA personnel also serve in a liaison role in CATTC during test operations. They provide assistance to console operators as required.

7.3 TEST STATIONS

There are six major test stations that are manned during a flight test period. These are CATCC, equipment room, radar room, PRI-FLY, LSO platform, and the camera operator's station. PRI-FLY and the LSO platform are operational requirements as well as test requirements and are manned by designated personnel. The camera operator's stations are manned by TSD personnel who are responsible for collecting film data of the touchdowns. The engineering portions of the test period are conducted and controlled from CATTC, the equipment room, and the radar room. The test communications network permits a ready exchange of information between the latter three test stations.

7.3.1 Carrier Air Traffic Control Center (CATCC)

CATCC is the control center for ACLS operations. It contains the AN/SPN-42 landing control consoles used to monitor and control the various functions of the landing system. CATCC also provides immediate communications with test aircraft, PRI-FLY, LSO, and air operations. The AN/SPN-42 control console allows communications with the equipment room and radar room through the console intercom station.

During the test period, CATCC is manned by a minimum of one NAVAIRTESTCEN engineer and one NESEA engineer. These engineers keep duplicate test logs of the flight period to ensure that all pertinent data are recorded for each ACLS approach. These data include aircraft type, lock-on times, WOD information, touchdown condition, and pertinent pilot or LSO comments. This information is also passed over the communications network for recording on the AN/SPN-42 instrumentation. During a test period duplicate test logs are kept because either of the test team personnel may be involved in other test functions and not have adequate time to record test data.

NAVAIRTESTCEN personnel will also communicate with the aircraft, LSO, PRI-FLY, or air operations as necessary to ascertain the controllability of aircraft or change test conditions. NAVAIRTESTCEN personnel act as a liaison to provide information on the certification and aircraft controllability.

NESEA personnel provide assistance to console controllers as required, interpret the various console caution and warning indications as necessary, and exercise console control or test functions when requested. NESEA personnel act as a liaison to provide a knowledge of the AN/SPN-42 equipment and its operation.

7.3.2 Equipment Room

A majority of the engineering test team is located in the equipment room with the AN/SPN-42 major assemblies, which permits immediate access to the input-output control console (for program changes or interpretation of system malfunctions) and the AN/SPN-42 instrumentation recorders. The aircraft data link monitor is also set up in the equipment room to record proper data link operation.

The equipment room is manned by adequate personnel to ensure continued operation of instrumentation recorders and to respond to any equipment problems that may require detailed analysis. Generally, there are two chart recorder operators, a data link monitor operator, and an AN/SPN-42 programmer. NESEA personnel are responsible for the proper operation of all the ground AN/SPN-42 instrumentation. NAVAIRTESTCEN personnel are responsible for the data link monitor operation.

Generally, the data collected in the equipment room include the AN/SPN-42 instrumentation recorders with the proper annotations as to WOD, touchdown conditions, aircraft number, and type and time of event. Pilot comments passed from CATCC are also recorded on the strip charts. Aircraft lock-on times and ranges are recorded from the input-output control console.

7.3.3 Radar Room

The third major engineering station manned during the test period is the radar room. NESEA personnel in the radar room monitor both the radar video signals and the beacon video signals before system lock-on and during the coupled approach. Only one video signal will be coupled to the tracking circuit at any one time. Radar room personnel provide a qualitative assessment of the tracking quality during the approach and are able to provide real-time information with respect to tracking roughness. These personnel can also adjust the servo response if necessary.

7.4 TEST OPERATIONS

7.4.1 Ship Operations

At-sea flight tests deploy a large number of people specializing in maintenance, instrumentation, and the actual certification. Generally, the test coordinator will define key department points of contact such as air operations, ship's engineering, maintenance offices, and any host squadrons and will pass these contacts on to the appropriate support team personnel. The support team personnel will then work with the appropriate ship's company or designated squadron personnel to see that test requirements are satisfied. Any problems that the support people cannot handle will normally be passed to the test coordinator.

7.4.2 Flight Operations

Flight operations are dictated by the ship's schedule, fleet requirements, and ACLS test requirements. The desires of the test team, with respect to flight operations, are subordinate to fleet flight requirements. It is the project engineer's responsibility to plan the flight periods for maximum utility. ACLS operations during air-wing carrier qualification operations are adequate when gathering touchdown data, but these operations can be a problem during the initial phase of the certification when troubleshooting ACLS problems. Nonexclusive (i.e., tests in conjunction with other activities) periods also hamper observing off-nominal wind conditions.

7.5 TEST CONDITIONS

The ACLS sends command inputs to the aircraft by measuring deviations from the expected flight path. Any environmental perturbation that drives the aircraft from the intended flight path can increase the magnitude of commands sent by the AN/SPN-42. It is possible to achieve perfect ACLS approaches and touchdowns with perfect at-sea conditions. Experience dictates, however, that the test team should be prepared to accept less-than-perfect test conditions and approaches.

ACLS operations are influenced by the dynamic operating environment. The operating environment contains elements that are both natural and uncontrollable (WOD and sea state) and man-made and controllable (ship's loading and ship's trim). The certification test team must understand the limits of the controlled and uncontrolled environment as well as the total influence of the environment on ACLS operations. One of the major fallacies assumed of ACLS is that it can provide consistent aircraft control regardless of the operating environment. ACLS has its limitations.

7.5.1 Natural Environment

Aircraft operations at sea are dependent on the WOD. The WOD, in turn, directly influences the carrier air wake or burble directly aft of the landing area. With aircraft stability and control characteristics directly dependent on the dynamics of the air mass the aircraft is flying in, the burble and its causes have a major influence on ACLS controllability and are a major source of touchdown error.

7.5.1.1 Burble Factors

The burble has a direct influence on the flight path of the aircraft. The burble, in turn, is influenced by variations in wind speed and direction as well as ship's motion. The steady-state vertical and horizontal components of the burble vary nonlinearly with distance aft of the carrier and in direct proportion to WOD. Ship's motion adds additional turbulent components to the burble dependent on WOD, ship's pitch, and distance aft of the flight deck.

The burble may be compensated for by the addition of command ramps to the AN/SPN-42 control program. These ramps are tailored to the ship and the aircraft type. However, these ramps are also dependent on a repeatable burble pattern. A change in the burble pattern from the compensated burble will change the approach and touchdown characteristics of the aircraft under control.

Over the years various studies have been performed to define the burble and its effects. One of these studies* evaluated the burble with respect to varying wind conditions and reached the conclusions summarized in Table 7-1.

Table 7-1 presents the variations that may be expected in both the burble and aircraft approach and landing characteristics with WOD variations. All of the burble factors listed in the table are taken relative to the nominal conditions of the center box where the wind is down the angle at any nominal speed.

Figure 7-1 illustrates the variations in the ACLS-controlled approach flight path that may be expected because of the burble factors presented in Table 7-1. Figure 7-1 is a reasonable approximation for turbojet aircraft. Actual flight path control will depend on any command ramps that are implemented.

Table 7-1 and Figure 7-1 indicate the differences in flight path that may be expected under varying wind conditions. They also imply that consistent ACLS control should not be expected for every possible wind speed/direction that the ship is certified for (normally 345 to 005 degrees and from 22 to 32 knots). What may be inferred from Table 7-1 and Figure 7-1 is that an ACLS certification should be conducted through a wind matrix, and the certification data should be partitioned with respect to that matrix. The command ramps are implemented for the expected nominal condition, and the majority of the data are gathered for the nominal condition. Approaches other than nominal are discussed as deviations in relation to the nominal condition.

7.5.1.2 Wind Matrix

Figure 7-2 shows a sample wind matrix for certification purposes. It assumes an angle deck of 10 degrees and a recovery WOD of 27 knots as the nominal condition for the majority of the certification data. The block labeled "I" should be the next block of interest because of the possibilities of the ship making its own wind. The block labeled "II" should be the third area of interest because of steaming costs and low WOD recoveries. Figure 7-2 is meant to be a sample and the actual wind speed numbers may be changed. What is important is the realization that aircraft control will

*Lehman, A.F. and Kaplan P., *Experimental Model Studies of the Dynamic Velocity Fluctuations Existing in the Air Wake of an Aircraft Carrier*, Oceanics, Inc., Report 65-21, March 1965.

Table 7-1. BURBLE FACTORS IN RELATION TO THE WIND MATRIX

Burble Factors

1. Burble becomes stronger
2. Burble becomes weaker
3. Lower wind i landing area
4. Airflow conditions improved
5. Turbulence increases
6. Turbulence decreases
7. Burble moves closer to ship
8. Natural wind component increases
9. Effects of island are most severe
10. Burble moves farther out
11. Vertical wind component will decrease faster
12. Increase in head wind component
13. Decrease in head wind component
14. Below glideslope results in a decrease in headwind
15. Higher effective glideslope
16. Shallower glideslope, more "q" loss
17. Pitch transfer function increases
18. Pitch transfer function decreases
19. Increase in sink speed
20. Lateral control is more oscillatory
21. Lateral control is worst
22. Strong right rolling moments
23. Rolling moments dependent on centerline condition, i.e., right offset will cause right roll

Wind Direction (Degrees)	Wind Velocity (Knots): < Nominal -3	Nominal ±3	> Nominal +3
354 to 000	3, 4, 5, 11, 15, 18, 19, 22	2, 3, 4, 11, 12, 18, 22	3, 6, 7, 8, 11, 16, 18, 22
347 to 353	4, 5, 15, 19	14	1, 6, 7, 8, 16, 20
340 to 346	4, 5, 9, 10, 11, 17, 19, 21, 23	9, 10, 13, 17, 21, 23	1, 6, 8, 9, 10, 16, 17, 21, 23

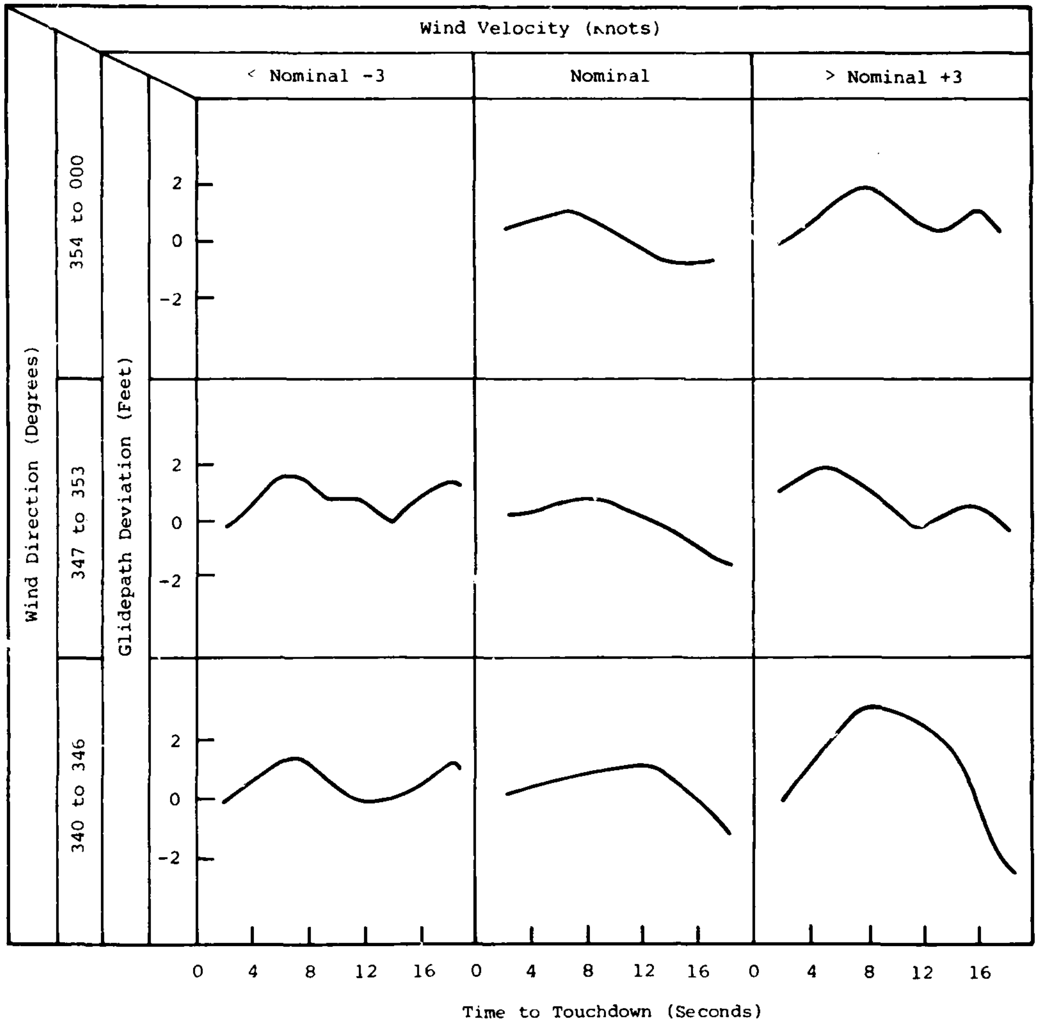


Figure 7-1. ACLS FLIGHT PATH VARIATIONS DUE TO BURBLE FACTORS

		Relative Wind Direction (Degrees)			
Wind Velocity (Knots)		< 347	347 to 353	354 to 000	> 000
	> 30				
	24 to 30		Nominal	I	
	< 24		II		

Figure 7-2. PROPOSED CERTIFICATION WIND MATRIX

vary with WOD variations. A wide wind envelope, while operationally enhancing, can be detrimental to the overall fleet acceptance of ACLS simply because the flight path characteristics will not be the same for all wind conditions.

7.5.1.3 Turbulence

Air turbulence, independent of aircraft-carrier-generated turbulence, is another major environmental factor affecting ACLS certifications. Its major influence is normally seen during shore-based tests in which the terrain variations generate higher turbulence levels. The nonsteady characteristics of turbulence or gusts can give an erroneous measure of AN/SPN-42 controllability unless turbulence is quantized.

Various simulation studies indicate that the major turbulence effect is vertical path deviation due to the vertical turbulence component. Simulation results* have shown, for an F-4J, that the vertical error due to longitudinal turbulence was 0.4 feet for each foot per second (fps) RMS gust and the vertical error due to the vertical gust component was 1.29 feet for each one fps RMS gust. Other aircraft will be similarly affected, although the lower the wing loading of an aircraft, the more severe the effect will be. For example, in a power-approach configuration an S-3 has a wing loading of approximately 53 pounds per square foot at a landing

*Urnes, J.M., *Guidance and Control Mechanics Note 226, NATC Automatic Carrier Landing System Analysis,* McDonnell Aircraft Company Report GCMN 226, 22 December 1972.

weight of 31,800 pounds; the F-4 has a wing loading of approximately 64 pounds per square foot at its landing weight of 34,000 pounds. These two aircraft, flying through the same turbulence, will experience different flight path errors while under ACLS control.

Currently, the only measure of turbulence used is subjective pilot opinion as to whether or not the turbulence is light, moderate, or heavy. However, the impression a pilot has of turbulence is directly related to his perceived aircraft motion and control activity as a result of the turbulence and, as stated previously, that perception will be dependent on aircraft type. Unfortunately, the gust response of an airplane can change with fuel load because of changes in wing loading. In addition, the same level of turbulence can create different perceptions among pilots in similar aircraft.

Table 7-2 presents turbulence measurement criteria.* Table 7-3 separates the various gust components into the three translational axes of flight and defines turbulence with respect to RMS values rather than peak values. Together, Tables 7-2 and 7-3 offer a quantized measure of turbulence through both velocity changes and acceleration changes. A pilot's subjective measure of turbulence can be quantized through aircraft records or excursions on the AN/SPN-42 instrumentation. This quantization allows another definitive parameter to be used for the certification process, since different levels of turbulence will affect the certification touchdown statistics and the aircraft approach path controllability.

7.5.1.4 Ship's Motion

Ship's motion has a double influence on ACLS certification. First, and most obvious, is the movement of the touchdown point, but this is compensated for to a degree by deck motion compensation (DMC). The secondary effect of ship's motion is its influence on the ship's burble.

7.5.1.4.1 Sea State

A ship's motion is directly related to sea state in magnitude and frequency. In general, the waves are the major contributor to ship's pitch and swells are the major cause of ship's heave. The motion is random in nature and generally nonperiodic. A ship's pitch will, on occasion, become periodic for short periods of time, although total ship's motion is a long-term event. Figure 7-3 presents a descriptive measure of sea state. At sea state six (SS6), the combined wave and swell motion causes a ship's pitch of approximately 1.0 degree RMS and a ship's heave of approximately 4.5 feet RMS.**

Journal of ATC, April-June 1981.

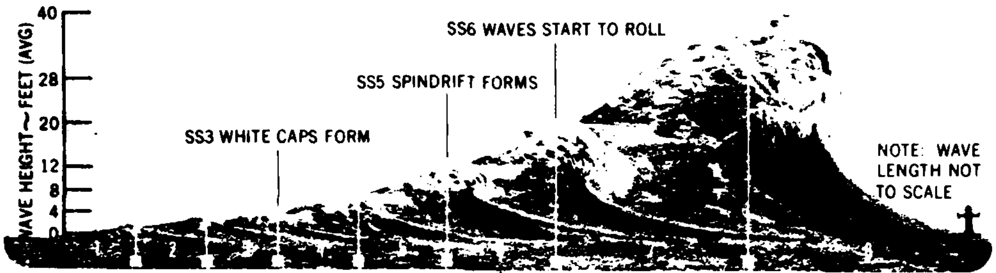
**Durand, T.S. and Teper, G.L., *An Analysis of Terminal Flight Path Control in Carrier Landing*, Systems Technology, Inc., Technical Report No. 137-1, August 1964.

Table 7-2. TURBULENCE MEASUREMENT CRITERIA		
Intensity	Aircraft Reaction	Reaction Inside Aircraft
5 to 20 ft/sec peak-gust increments with accelerations of ±0.2 to 0.5 g	Light turbulence: Momentarily causes slight, erratic changes in altitude or attitude. Light chop: Causes slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude.	Pilot may feel a slight strain against seat belts or shoulder straps.
20 to 35 ft/sec peak-gust increments with accelerations of ±0.5 to 1.0 g	Moderate turbulence: Causes changes in altitude or attitude, but with the aircraft remaining in positive control at all times. Usually causes variations in indicated airspeed. Moderate chop: Causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude.	Pilot feels definite strains against seat belts or shoulder straps.
35 to 50 ft/sec peak-gust increments with accelerations of ±1 to 2.g	Severe turbulence: Causes large, abrupt changes in altitude or attitude. Usually causes large variation in indicated airspeed. Aircraft may be momentarily out of control.	Pilot is forced violently against seat belts or shoulder straps.
> 50 ft/sec peak-gust increments with accelerations of 2 g	Extreme turbulence: Aircraft is violently tossed about and is practically impossible to control. May cause structural damage.	
Frequency: Occasional (less than 1/3 of the time), intermittent (1/3 to 2/3 of the time), continuous (more than 2/3 of the time).		

Table 7-3. RMS COMPONENT GUST VELOCITIES DUE TO ATMOSPHERIC TURBULENCE			
Turbulence Level	1 Sigma Standard Deviation (Feet per Second)		
	Vertical	Longitudinal	Lateral
Light	0	0	0
Moderate	1.5	2.5	1.7
Severe	2.0	3.5	2.4

a guide to

Sea State WITH A LISTING OF VISUAL AND TACTILE CLUES



SEA STATE DESCRIPTION

SS1 — **SMOOTH SEA**
Ripples, no foam. Wind*: light air, 1-4 kts. Beaufort 1. Not felt on face.

SS2 — **SLIGHT SEA**
Small wavelets, no foam. Wind*: light to gentle breeze, 4-10 kts. Beaufort 2-3. Felt on face, light flags wave.

SS3 — **MODERATE SEA**
Large wavelets, crests begin to break. Wind*: gentle to moderate breeze, 7-15 kts. Beaufort 3-4. Light flags extended.

SS4 — ***ROUGH SEA***
Moderate waves, many white caps, some spray. Wind*: moderate to strong breeze, 14-27 kts. Beaufort 4-6. Wind whistles in rigging.

SS5 — **VERY ROUGH**
Sea heaps up, with spindrift and foam streaks. Wind*: moderate to fresh gale, 27-40 kts. Beaufort 6-8. Walking resistance high.

SS6 — **HIGH SEA**
Sea begins to roll, dense streaks of foam and much spray. Wind*: strong gale, 40-48 kts. Beaufort 9. Loose gear and light canvas may part.

SS7 — **VERY HIGH SEA**
Very high waves with overhanging crests. Sea appears white as foam scuds in very dense streaks. Visibility reduced. Wind*: whole gale, 48-55 kts. Beaufort 10.

SS8 — **MOUNTAINOUS SEA**
Very, very high rolling breaking waves. Sea covered with foam. Very poor visibility. Wind*: storm, 55-65 kts. Beaufort 11.

* Correlation between sea state and wind description is highly variable and dependent on fetch and wind duration. For seas not fully arisen wind speeds may be much higher than indicated.

For either a copy of this guide on heavy stock, or a plasticized wallet sized version, please write: Director of Marketing, Ocean Surveillance Systems.

SEA STATE

SS2

SS3

SS4

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Figure 7-3. DESCRIPTIVE MEASURES OF SEA STATE

7.5.1.4.2 Deck Motion Compensation

To lessen the influence of a ship's motion on the touchdown point, the AN/SPN-42 controls the aircraft to follow the vertical motion of the flight deck during the last 12 seconds of the approach. The vertical translation of the touchdown point is calculated from a ship's pitch, roll, and vertical acceleration as measured by the data stabilization system (DSS) gyro package. DMC is designed for the most effective operation in the frequency band of 0.3 to 0.8 rad/sec, which bounds the expected critical deck-heave frequencies.

The specified deck motion limits for ACLS operations are as follows:

- Pitch - ±1.25 degrees RMS
- Roll - ±5.0 degrees RMS
- Heave - ±4.0 feet RMS
- Ramp - ±20.0 feet maximum

During a certification, the deck motion that is generally seen is up to the following magnitudes:

- 1 degree peak-to-peak (p-p) in pitch
- 2 degrees p-p in roll
- 5 feet p-p in heave

A certification trip with a good deal of ship's motion (San Francisco and Norfolk operations in the winter) may experience ship's motion up to and exceeding the following conditions:

- 2 degrees to 2.5 degrees p-p in pitch
- 5 degrees p-p in roll
- 8 feet to 9 feet p-p in heave

7.5.1.4.3 Ship's Motion and the Burble

Ship's pitch motion has a direct effect on the burble. Although this is not quantified, it may be expected that the continual pitching motion of the ship will lessen the steady-state components of the burble and aggravate the turbulence aspects of the burble. The overall result is less repeatability of approaches because of the turbulence effects and a less predictable burble because of the nonsteady wind influence. The nonpredictable burble will not permit the calculation or evaluation of any useful command ramp data.

7.5.2 Controlled Environment

Ship's loading and ship's trim are the two controllable major factors that affect the operating environment.

7.5.2.1 Ship's Loading

Ship's loading can affect the certification through the actual loading of the ship to how deep it rides in the water and through the flight-deck loading. An ACLS certification should be conducted when a ship is reaching its deployment state of provisioning. This timing would permit the certification to be conducted under near operational conditions for ship loading. Unfortunately, such scheduling is rarely practical.

It is important to remember that ACLS has operational bounds within its dynamic environment. Any change to that dynamic environment can affect ACLS controllability. A ship out of the yard, which rides high in the water, has the same susceptibility to wave motion that the light-wing-loaded aircraft has to turbulence. Certification of a lightly loaded ship can be difficult because of the burble variance caused by the ship's susceptibility to wave motion. In addition, an acceptable certification of a ship directly from the yard can be affected by a change in burble characteristics to perhaps a more steady burble once deployment provisioning has been accomplished. This is true if the steady burble assumes different characteristics from the burble pattern seen during the certification.

A ship coming from a one- or two-year yard period will be more susceptible to ship-loading problems than one coming from a three-month yard period.

Another consideration in ship loading is flight-deck loading. Obviously, any protrusion on the flight deck will contribute to the turbulence behind the flight deck. However, aircraft on the flight deck is the operational environment. Conducting ACLS certification with an empty flight deck is beneficial to data gathering but is nonrepresentative of the real-world situation. The most effective operational certification is that which is conducted under near operational conditions. Again, this is often impractical, but the more the certification is removed from the sterile test environment to the actual operating environment, the more beneficial the certification will be to the operating fleet. It may also be assumed that the closer the certification approaches actual operating environment conditions, the more difficult and time-consuming the certification effort will be.

7.5.2.2 Ship's Trim

Ship's trim is another parameter that bounds the certification, because of the effect that a ship's attitude has on the burble characteristics. The certification should be conducted with respect to the ship's normal operating trim condition; to do otherwise can negate the certification through the creation of unacceptable deployment landings. The change in landing condition may normally be traced to a change in ship's trim affecting burble characteristics and their attendant effects on any pitch command ramps. Normally, a ship's trim variation of one-quarter degree in the positive direction about the nominal certification trim condition is acceptable. Ship's trim variations in the negative direction appear to have greater degrading influence on the ACLS certification parameters.

7.6 PROGRAM CONFIGURATION

The control programs used for each aircraft type are developed during aircraft certification evaluations at NAVAIRTESTCEN. After testing, they are certified for use by the ACLS configuration control board. It is these aircraft control programs which are implemented throughout the fleet, and the basic parameters of the program cannot be altered during certifications. However, the project team is permitted to influence flight through the burble and the actual touchdown position by the addition of command ramps, change in aircraft tracking reference geometry, or glideslope changes.

7.6.1 Pitch Command Ramps

Ramp inputs of pitch command are often added to the basic program to assist the aircraft in flying through the burble. These ramps are tailored to each aircraft type for each ship. The pitch commands generated by the command ramps provide a slight increase in an aircraft's power to overcome the down-draft effects of the burble.

Implementation of pitch ramps is very subjective based on quantitative assessments of vertical error data for the last 20 seconds of the approach. Figure 7-4 shows a generalized ramp configuration, with the parameters to be specified. The times of the ramp input, TIMV(I), are determined from a plot of the average vertical error data and are based on where the aircraft deviates from glideslope. The time for a command to be ramped in varies from one to two seconds. The magnitude of the ramp is normally chosen as 1/8, 1/4, or 3/8 degrees, depending on magnitude of the error deviation. Aircraft simulations could be run to determine probable ramp magnitudes on the basis of altitude changes with pitch commands for a more definite measure of ramp command magnitude. Currently, the project engineer may nearly quantify the ramp magnitude by statistically averaging the third parameter on the input/output (I/O) console 20-second data. This parameter is a sum of the integral and proportional gain contributions to the pitch command. The parameter's average, plotted with the Z_e average, will give an indication of the amount of command required to keep the Z_e steady. It is this

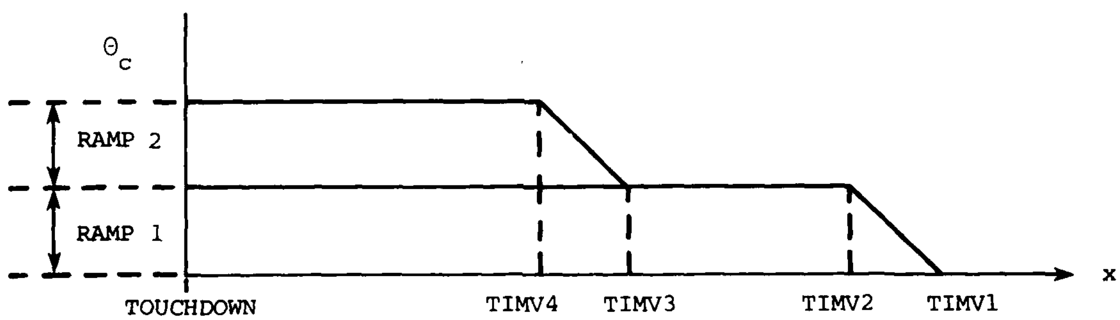


Figure 7-4. GENERALIZED RAMP CONFIGURATION

additional amount of command (ramp magnitude) that should be added to the aircraft on the glideslope to counteract the effects of the burble.

Because the approach is a dynamic situation, the timing of the command input is important. The plot of the Z_e data will give a reasonable indication of where the burble is encountered by the glideslope deviation. The command ramp should be implemented at least one or two seconds before the deviation to counteract the settling tendency.

The use of one or two ramps is dependent on the error traces or a desire for a slight attitude change in-close. In-close ramps (two to three seconds from touchdown) are highly subjective and normally inputted for slight attitude changes.

7.6.2 Vertical Reference Change of Tracking Source

Command ramps are designed to change the flight characteristics through the burble. A change in the vertical reference of the tracked point source to hook distance (corner reflector height or program parameter THOOKC) will move the touchdown point up or down the flight deck. As an example, if an airplane is continually landing long, a reduction in THOOKC by one foot will shorten the touchdown point by 15 to 20 feet, depending on the effective glideslope. The theoretical change in touchdown distance may easily be calculated by dividing the proposed change by the tangent of the effective glideslope, i.e.,

$$X_{TD} = \frac{1.0}{\tan 3.5°} = 16.34 \text{ feet}$$

7.6.3 Glideslope Variations

Occasionally, ACLS performance will be continually inconsistent with WOD, which prevents a useful pitch ramp from being determined. In these cases, a glideslope change from 3.5 to 4.0 degrees will offer improved performance through the burble. This is frequently the case on smaller ships (e.g., CV-41 and CV-43), and a 4.0 degree glideslope has also been used on the larger aircraft carriers.

The advantage of a glideslope change is that it may offer more representative glideslope control over a wider WOD variation. Pitch command ramps are designed to be the most effective for a particular WOD cell.

The disadvantage of a glideslope change is that it may be an angle different from that used for normal fleet operations. Two glideslope angles create a problem of potential FLOLS angle changes between approaches or negate ACLS in a mixed pattern. Second, since most ships operate with a 3.5 degree glideslope, a 4.0 degree glideslope places the pilot in a slightly different attitude form that which he has trained with and is accustomed to.

7.7 QUANTITY OF APPROACHES

The number of approaches and touchdowns required during a certification is dependent on the touchdown dispersion, the confidence level desired, and to what accuracy the data are measured.

Appendix M illustrates that the data from past certification are basically normally distributed. Since these data are normally distributed, the sample size, accuracy, touchdown dispersion, and confidence levels are related by the equation:

$$\frac{\text{Accuracy (a)}\sqrt{\text{Sample Size (n)}}}{\text{Touchdown Dispersion }(\sigma x)} = \begin{array}{l}\text{Standard Deviations for}\\ \text{Confidence (Z)}\end{array}$$

The development of this equation is explained in Appendix M, which also presents a table of sample sizes as a function of accuracy, touchdown dispersion, and confidence levels. Table M-3 shows that an assumption of an accuracy of 10 feet for the mean touch point with a touchdown dispersion of 40 feet requires 62 touchdowns for a confidence level of 95 percent. The 95 percent confidence level has a Z of 1.96 standard deviations. A Z of 1.96 in the standard normal distribution tables equals 0.475 one-sided probability, or 2 × 0.475 for 95 percent total probability or total confidence.

The use of the above equation, Appendix M, and standard normal distribution tables will permit the project engineer to calculate the number of samples required for any aircraft type before the certification by using the historic data presented in Appendix H. It also allows the confidence level of the certification to be established after the data have been collected and analyzed. The desired accuracy of the data should be within 10 feet at a minimum confidence level of 90 percent. With these requirements being used, together with an A-7 aircraft historic average touchdown dispersion of 44.9 feet (from Appendix H), the calculation for sample size is

$$n = \left[\frac{\sigma x \text{ (90\% Confidence)}}{a}\right]^2 = \left[\frac{44.9\ (1.645)}{10}\right]^2 \approx 55 \text{ Touchdowns}$$

Lesser accuracies (>10 feet) or confidence levels (<90 percent) obviously permit less touchdown data to be collected.

SECTION EIGHT

TEST LOGS AND CHARTS

8.1 INTRODUCTION

Certification tests generate quantities of data during each test period. These data are maintained on a per-flight-period basis as well as a cumulative basis.

8.2 APPROACH LOG

The approach log is maintained in CATTC by the NAVAIRTESTCEN project engineer. The logs record the pass-by-pass approaches and results as well as various environmental data. Space is provided on the approach log for LSO or any other comments. The LSO comments are normally filled in during the debriefing and are taken from the LSO grade book. The other comments section of the approach log is normally filled in with comments that may occur from project personnel reviewing the AN/SPN-42 records during the approach, from project pilots, or comments from CATTC. This comments section is normally used as an aid in pointing out particular parameters to review on the AN/SPN-42 instrumentation (e.g., loose tracking, data anomalies, glideslope deviations).

The WOD is taken from the CATTC indicators and the touchdown, and estimated wire positions come from the camera operators.

NESEA personnel maintain a similar approach log in CATTC that serves as a back-up to the NAVAIRTESTCEN log. This double log-keeping assists in tracking the proper approach and aircraft, especially when attention may be diverted to telephone calls.

After the flight period, the approach log forms a permanent record of the certification. Pertinent data from other sources is recorded, if necessary (pilot card notes), and the two CATTC test logs are reconciled with each other. These approach logs are then used in reviewing the AN/SPN-42 instrumentation. A sample approach log is shown in Figure 8-1.

NDW-NATC-3960 10

APPROACH LOG

DATE	TIME	AMBIENT CONDITIONS			FLT NO	SHEET
		BARO	TEMP	SURFACE WIND		
12-17-81	0800-1000	29.92	59°	10 kts @ 340	A-3	1 OF

ACFT	A7E	A7E	A6E			SHIPS TRIM 0.1° Bow up, 0.5° PORT
BU NO	752	310	542			PROGRAM A7 Ramp 1/4° at 8-7 sec
PILOT	JONES	SMITH	WILSON			A6 No RAMP

EVENT NO	BU NO	LO TIME	LO RANGE	CH	WOD	T/G	ARR	WO	PTO	MODE	EST WIRE	LSO COMMENTS	COMMENTS
1	752	8 05	4.1	A	28 350	✓				I	2		Loose Tracking
2	310	8 07	3.8	B	27 352	✓				I	3		—
3	542	8 10	4.0	A	28 351			✓		—			Airplane cut in front
4	752	8 15	4.3	B	29 353	✓					2		good touchdown
5	3										B		AYED HIGH

Figure 8-1. SAMPLE APPROACH LOG

8.3 PILOT CARDS

The pilot card is used to record the pilot's impression of the flight. The pilot records ACLS Quality Ratings (AQRs) in the allotted spaces as well as other pertinent information as applicable. After the flight, the project engineer reviews the pilot card to determine the flight-period AQRs and also to debrief the pilot. Any major discrepancies between the pilct's and the engineer's impressions of the approach are discussed and resolved.

Fiqure 8-2 illustrates a typical pilot's card. Parameters such as TEMP, BARO, TURB, and APCS are to be filled in by the pilot.

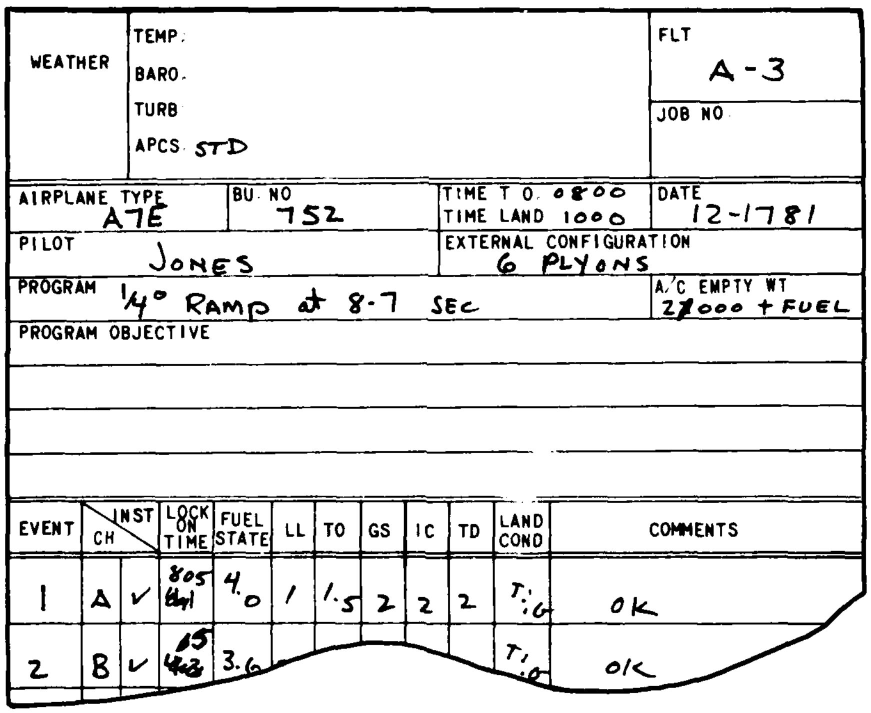


Figure 8-2. SAMPLE PILOT'S CARD

8.4 20-SECOND DATA GRAPHS

Printed numerical data of the vertical and lateral error at 2-second intervals for the last 20 seconds of the approach are provided at the I/O control console in the AN/SPN-42 equipment room. After each flight period, these data may be partitioned by approach and aircraft type. These cumulative data may then be inputted to the AN/SPN-42 for a statistical analysis of mean and variance of glidepath deviations. The statistical measures are graphed to provide a picture of in-close ACLS control. These data are also used to determine where a ramp input may be appropriate.

Graphs developed from the 20-second data also become part of the overall test log. They are used period-by-period and cumulatively. Data gathered from one test period may be combined with data from other test periods to form an overall picture of the certification. In addition, these data may be partitioned with respect to wind conditions.

Figure 8-3 illustrates what the raw 20-second data looks like coming from the I/O console. Figure 8-4 illustrates similar data that have been collected, partitioned, and statistically analyzed during the at-sea trials. Only the means have been plotted in this figure.

In addition, Figure 8-4 illustrates the differences in vertical glidepath deviations that may be expected as WOD shifts speed and direction. It also illustrates that all of the data averaged together are indicative of fairly constant glidepath controls. This is not the true case, however, as may be seen by referring to the graph for angle winds less than 22 knots.

8.5 WIND MATRIX CHARTS

The wind matrix chart is filled in at the end of each test period. This chart lists the number of touchdowns and expected wire positions for each approach. The charts provide an indication of the probable touchdown positions with respect to wind condition. The cumulative wind matrix chart is a tabulation of all flight periods and provides an immediate picture of where the majority of the approaches are taking place and whether or not more data should be gathered in different wind cells. Quantities of data gathered are discussed in Section Seven.

Figure 8-5 illustrates a sample of one type of summary wind matrix chart that may be used. Immediately obvious from the figure is the number of 4 wires and bolters. The figure shows that the less-than-22-knot wind cell results in 2 and 3 wires. Reviewing Figure 8-4 shows that for angle winds less than 22 knots, the airplane is in a descending condition on a steep downward slope. The angle wind condition of Figure 8-4 shows the airplane starting to descend. The difference in the steep descent and the start to descend is the difference between 2 and 3 wires and 4 wires and bolters.

```
A AC ADRES: 01101, X: 031239, Y: 004422 S, Z: + 001202, TIME: 1130 #19
B TRAI 1130
B AC ADRES: 01520, X: 234300, Y: 270239 P, Z : + 200357, TIME: 1130 #20
+02.72 +00.65 +02.00 -01.55 -23.15 -01.50 -22.22 +00.23 -02.44 -03.22
+07.36 +01.75 +02.51 +02.34 +01.77 +02.15 +01.00 -02.30 +01.37 -01.23
-02.05 +02.25 -00.17 -00.47 -72.41 -02.27 -72.31 +00.03 -00.31 -02.42   } #19
```

FOR PASS #19

A, B - CHANNEL

AC ADRES - AIRCRAFT ADDRESS - Ø11Ø1

X - LOCK-ON RANGE - 31,239 FT

Y - LATERAL OFFSET - 4,422 FT STARBOARD

Z - ALTITUDE -12Ø2 FT

TIME - LOCK-ON TIME -113Ø HOURS

FIRST LINE - VERTICAL ERROR IN FEET AT 2 SECOND INTERVALS

SECOND LINE - LATERAL ERROR IN FEET AT 2 SECOND INTERVALS

THIRD LINE - COMBINED INTEGRAL AND PROPORTIONAL GAIN

Figure 8-3. AIRCRAFT INFORMATION AND 20-SECOND DATA FROM AN/SPN-42 I/O CONSOLE

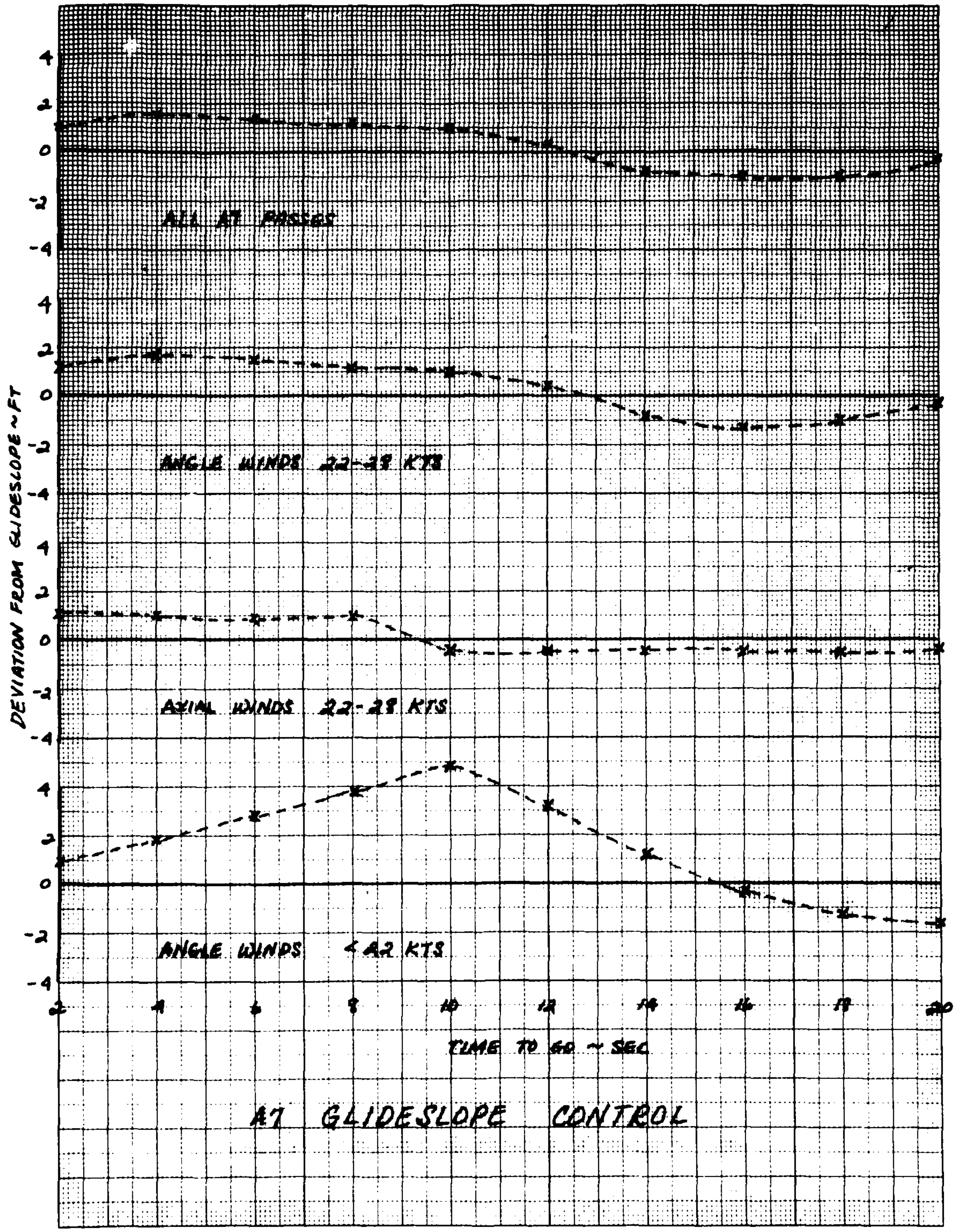


Figure 8-4. GRAPHIC PRESENTATION OF 20-SECOND DATA

WIND DIRECTION

< 347	347-353	354-000	> 000	WIND SPEED
	2 passes 2-3 wires	1 pass 4 wire		> 29 KTS
1 pass 3 wire	54 passes 3-1 wires 12-2 wires 18-3 wires 9-4 wires 11 - bolters	16 passes 4-3 wires 4-4 wires 7 - bolters	4 passes 2 wire 2-3 wires 4 wire	28-22 KTS
1 pass 3 WIRE	8 passes 4-2 wires 3-3 wires 1-bolter		1 pass 3 wire	< 22 KTS

A7 SUMMARY

Figure 8-5. SAMPLE OF A SUMMARY WIND MATRIX CHART

SECTION NINE

ACLS CERTIFICATION CRITERIA

9.1 INTRODUCTION

ACLS certification is both an objective and a subjective process. It is objective because substantial data are gathered to provide a quantitative evaluation of the certification, and it is subjective because of the manner in which the data may be evaluated. Assuming that a ship's equipment and test aircraft are operating within acceptable tolerances, the parameters actually used for a certification can be reduced to four major determinants. These are pilot acceptability, boarding rate, longitudinal touchdown point, and longitudinal touchdown point dispersion. The subjective view of these four parameters must be made with respect to aircraft type and test condition.

9.2 TEST CONDITIONS

As discussed in Section Seven, the test condition for WOD and ship's motion and their effect on the burble will have a major impact on the certification. The certification data must be evaluated with respect to the test conditions. Marginal test conditions will produce marginal test data.

A second point to consider regarding test conditions is that a ship may be certified, if necessary, with a restricted wind envelope. An evaluation based on all of the data gathered may quantitatively suggest no certification. Partitioning of the data into the various wind cells of the test matrix may allow certification for the nominal wind cell.

9.3 TEST AIRCRAFT

All aircraft do not fly the same, do not have the same design limits, and therefore, should not be evaluated in the same way. Continual good performance with an A-6 aircraft during a certification does not mean that an A-7 aircraft will also have good performance. Experience has shown that turbojet-powered aircraft are better ACLS performers than turbofan aircraft. Turbofan aircraft with low-wing loadings will show more glidepath deviations during the closed-loop approach.

Unacceptable statistics for an A-6 aircraft may not be unreasonable for an A-7 aircraft. Again, the certification provides data for an objective evaluation, but the evaluation is subjective.

9.4 CRITERIA DATA

Film data gathered during a certification consist of nine parameters: aircraft longitudinal and lateral touchdown point, glidepath angle, yaw angle, sink speed, cross-track angle, pitch attitude, roll attitude, and hook-to-ramp distance. While all of these parameters are recorded and their distribution tabulated and reported, experience has shown that the only relevant parameters are pilot acceptability, longitudinal touchdown point and its distribution, and boarding rate. The other six parameters, with the exception of lateral touchdown point, are reflected in these four evaluation criteria. Historically, lateral control either has been adequate or has had a beacon range error that caused large lateral deviations that were easily correctable. Because of this, lateral touchdowns are not considered to be an influential certification criterion.

9.4.1 Pilot Acceptability

A pilot's acceptability of ACLS control should be governed by what he sees and what he feels during the approach. Glideslope is evaluated on the basis of alignment with FLOLS. Satisfactory alignment indicates acceptable hook-to-ramp and sink speeds. The LSO provides a second opinion on hook-to-ramp and sink-speed acceptability in discussions of the graded approach with the pilot. Pilot acceptability also provides an indication of aircraft attitude at touchdown (pitch, roll, and yaw angle) and a commentary on longitudinal and lateral touchdown points.

The pilot rates his acceptability through the ACLS quality rating scale discussed in Appendix L. A review of the AQR scale will show that the standard is considered to have an AQR of 2, and an AQR of 4 or more requires some action to improve controllability. A good certification will have AQRs that average between 2 and 3. Generally, level legs and the approach will have an average AQR between 1 and 2, with the in-close and touch-down phases having AQRs of 2 to 3.

Table 9-1 shows the average AQR values from past certifications for different types of certified aircraft. Space has been provided for including future certified aircraft.

A final point to consider in pilot acceptability is AQRs in relation to pilot takeovers. Occasionally a pilot will take manual control of the aircraft to preclude an unsatisfactory touchdown condition. Pilot takeover results in a nonrated portion of the approach for AQR statistics but is reflected in the boarding-rate statistic.

Table 9-1. EXPECTED AQR VALUES			
Aircraft Type	Average AQR	1 Sigma Standard Deviation	Sample Size
F-4	2.7	0.4	11
A-7	2.5	0.5	19
A-6	2.1	0.2	9
EA-6	1.8	0.7	5
F-14			
S-3			
F-18			

9.4.2 Boarding Rate

The ACLS boarding rate may be defined as the successful Mode I touch downs divided by the Mode I attempts minus foul-deck wave-offs; ship turning; obvious aircraft problems such as AFCS, APCS, or beacon malfunctions; and AN/SPN-42 failures that are readily correctable. AN/SPN-42 downgrades, AN/SPN-42 wave-offs, pilot takeovers, and LSO wave-offs should all be included in Mode I attempts.

It is the intent of an ACLS certification to evaluate the ship ACLS equipment for use under operating conditions within nominal ACLS capability. NAVAIRTESTCEN test aircraft are considered to be a controlled part of the test, and any aircraft malfunction that affects test data should preclude that data sample from being included in the certification data.

A second consideration for boarding rate is the test condition. F[illegible]me operating conditions should not be counted in the boarding rate. ACLS performance deteriorates above 30 to 32 knots WOD, and it should be expected that boarding rate will go down under these WOD conditions.

Table 9-2 shows the average boarding rate from past certifications for different types of certified aircraft. Space has been provided for including future certified aircraft.

A satisfactory certification should have a boarding rate that exceeds 80 percent. A boarding rate of less than 65 percent should be considered unsatisfactory.

9.4.3 Longitudinal Touchdown Point

The two major criteria used for certification are longitudinal touchdown point and the dispersion about that touchdown point.

Aircraft Type	Average Boarding Rate (Percentage)	1 Sigma Standard Deviation	Sample Size
F-4	71	20	21
A-7	77	14	27
A-6	77	13	9
EA-6	78	21	4
F-14			
S-3			
F-18			

Table 9-2. EXPECTED BOARDING-RATE VALUES

The landing area on the flight deck may range from 40 feet aft of the Number 1 wire forward to the Number 4 wire, or approximately 160 feet, assuming 40 feet between arresting cables. The desired ACLS controlled-hook touchdown point is approximately midway between the Number 2 and Number 3 cable. It is this touchdown point that defines the zero mean longitudinal touchdown distance and allows for a safe landing approximately 60 feet forward and 100 feet aft of the touchdown point. Any large deviations forward of the programmed touchdown point will increase the probability for bolters; deviations aft will increase the probability of short landings with lower hook-to-ramp clearances.

Longitudinal mean touchdowns within 10 feet of the desired touchdown point are acceptable, those greater than 25 feet are unacceptable, and those between 10 and 25 feet are marginal. The marginal touchdown points depend on the touchdown dispersion and a calculation of landing probabilities to determine their acceptability for certification.

Table 9-3 tabulates the cumulative mean longitudinal touchdown point from past certifications for different types of certified aircraft. Additional space has been provided for future certified aircraft.

Table 9-3. EXPECTED TOUCHDOWN POINTS (3.5 DEGREE GLIDESLOPE) (REFERENCED TO PROGRAMMED TOUCHDOWN POINT)

Aircraft Type	Average Touchdown Point	1 Sigma Standard Deviation	Sample Size
F-4	-10.6	16.6	26
A-7	- 4.4	20.8	30
A-6	7.4	8.6	9
EA-6	-13.6	16.9	5
F-14			
S-3			
F-18			

Table 9-3 shows that the expected touchdown point should be within 25 feet of the desired touchdown point when the average of all certifications is considered. A review of the historical data presented in Appendix H shows that some certifications exceeded these values.

In order to generate touchdown statistics that have a touchdown mean in excess of ±25 feet of the desired touchdown point, the aircraft must have a number of bolters or short landings. Such landings should be noticeable in pilot acceptability ratings as well as wire calls and should be corrected during the certification. In addition, with mean longitudinal touchdown points in excess of 10 to 15 feet from the desired position, the data should be partitioned into wind cells to see the effect, if any, of the WOD on the touchdown point.

9.4.4 Longitudinal Touchdown Dispersion

Longitudinal touchdown dispersion is defined as one standard deviation of the touchdowns about the determined mean touchdown point. The specified criterion has always been ±40 feet; however, this value has never been adhered to for various philosophical and operational reasons. Any value of touchdown dispersion may be adequate depending on the mean touchdown point. Large values of touchdown dispersion signify loose overall control; however, that loose control may be caused by environmental factors such as turbulence, burble or ship motion, aircraft characteristics, or AN/SPN-42 command ramp inputs. Large dispersions because of environmental factors (WOD or turbulence) are to be expected and are therefore acceptable. Large excursions under nominal test conditions are not acceptable. The primary measure of acceptability is the combination of touchdown dispersion with mean touchdown point to predict landing probability. If these two statistics are predicting bolter probabilities greater than 10 percent, or Taxi 1 wire probabilities greater than 5 percent, then an overall acceptable condition does not exist. Again, this criterion must be caveated with "consider the test condition."

Table 9-4 presents the average touchdown dispersions from past certifications for different types of aircraft. Space has been provided for future aircraft.

Table 9-4. EXPECTED LONGITUDINAL DISPERSIONS (3.5 DEGREE GLIDESLOPE)

Aircraft Type	Average Touchdown Dispersion	1 Sigma Standard Deviation	Sample Size
F-4	36.4	9.5	26
A-7	44.9	10.7	30
A-6	45.3	5.9	9
EA-6	36.4	4.8	5
F-14			
S-3			
F-18			

Table 9-4 shows that on the average the A-7 and A-6 aircraft do not meet the specified criterion of 40 feet touchdown dispersion; however, the aircraft are within approximately 10 percent of the criterion.

9.5 LANDING-RATE PREDICTIONS

Once the mean touchdown and the dispersion of that touchdown data have been calculated, it is possible to predict the landing statistics of the certification through application of standard normal distribution statistics. (An example calculation is shown in Appendix N). The landing statistic predictions present an expectation of where the ACLS will land aircraft with respect to the arresting cables. This provides the system user a better idea of the operational acceptability of the ACLS. It also permits the system user to make a judgment of whether or not the system is operating satisfactorily (e.g., a greater number of bolters on a continuing basis would probably indicate a shift in mean touchdown point).

9.6 COMBINING CRITERIA DATA

The intent of ACLS is to land aircraft safely and reliably. Under nominal test conditions (e.g., the center wind cell, light-to-moderate turbulence, ship's motion within aircraft certified limits), ACLS should be able to land aircraft with (1) high boarding rates (80 percent or better), (2) pilot acceptability of less than 3.0 AQR average at touchdown, (3) within 10 feet of the desired touchdown point, and (4) with a touchdown dispersion of between 40 and 45 feet. A variance in these acceptable parameters should cause a more critical look at the other parameters.

An average AQR of 2 or less with a low boarding rate and large touchdown dispersion is probably a questionable measure of acceptability just as an average AQR of greater than 3 would be with a high boarding rate and small touchdown dispersion.

It is the project engineer's responsibility to determine why data anomalies occur and the significance of these anomalies. The unacceptability of any one parameter must be weighed against the acceptability of the other parameters before the acceptability or nonacceptability of the certification can be determined. Table 9-5 lists certification parameters and their limits with respect to aircraft type. These data have been developed from past certification data.

Table 9-5 is intended to det[illegible] acceptable data and marginal data. A definition of unacceptability must rest with the project engineer and that decision must be made with regard to the total certification effort as well as recourse to past certification data if appropriate.

A ship should not be certified if all aircraft types exceed the marginal limits of Table 9-5. A ship may be certified if one aircraft type exceeds the marginal limits and the other aircraft are within the marginal limits. Such a certification would depend highly on what past certification data

Table 9-5. CERTIFICATION CRITERIA

Aircraft Type	Boarding Rate (Percentage)	AQR	Mean Touchdown (Feet)	Touchdown Dispersion (Feet)	Taxi 1 Prediction (Percentage)	Bolter Prediction (Percentage)
Acceptable						
F-4	> 80	< 2.8	± 10	40	< 5	< 10
A-7	> 80	< 2.8	± 10	45	< 5	< 10
A-6	> 80	< 2.8	± 10	45	< 5	< 10
EA-6	> 80	< 2.8	± 10	40	< 5	< 10
F-14	> 80	< 2.8	± 10		< 5	< 10
S-3	> 80	< 2.8	± 10		< 5	< 10
F-18	> 80	< 2.8	± 10		< 5	< 10
Marginal						
F-4	65 to 80	2.8 to 3.0	± 11 to 25	41 to 45	5 to 7	10 to 15
A-7	65 to 80	2.8 to 3.0	± 11 to 25	46 to 50	5 to 7	10 to 15
A-6	65 to 80	2.8 to 3.0	± 11 to 25	46 to 50	5 to 7	10 to 15
EA-6	65 to 80	2.8 to 3.0	± 11 to 25	41 to 45	5 to 7	10 to 15
F-14	65 to 80	2.8 to 3.0	± 11 to 25		5 to 7	10 to 15
S-3	65 to 80	2.8 to 3.0	± 11 to 25		5 to 7	10 to 15
F-18	65 to 80	2.8 to 3.0	± 11 to 25		5 to 7	10 to 15

looked like and the test conditions of the present certification effort. A ship should be certified if one aircraft exceeds some of the marginal limits and the other certification aircraft are within the acceptable limits. In this latter case, past certification trips will be a major factor.

Figure 9-1 is an example of the narrative for certifying an aircraft with marginal to unacceptable certification criteria.

```
12. THE A7E TOUCHDOWN STATISTICS WOULD BE UNACCEPTABLE FOR MODE I
OPERATIONS IF THE TESTS HAD BEEN CONDUCTED UNDER CONDITIONS OF
LESS DECK MOTION, TURBULENCE, AND BURBLE. THE MEAN TOUCHDOWN
POINT EXCEEDS THE DESIRED MAXIMUM LIMIT OF 20 FT (6.1 M) BY 38
PERCENT AND THE TOUCHDOWN STD DEV EXCEEDS THE NOMINALLY EXPERIENCED
VALUE OF 43.4 FT (13.2 M) BY 36 PERCENT. THE TOUCHDOWN STATISTICS
FORWARD MEAN AND LARGE STD DEV WHEN COUPLED WITH THE ACLS BOARDING
RATE PREDICT THAT THE ACLS WILL ONLY LAND 60 PERCENT OF THE MODE I
ATTEMPTS FOR THE TEST CONDITION ENVIRONMENT. A REVIEW OF THE
CERTIFICATION REF N WHICH WAS CONDUCTED UNDER P-P SHIP MOTION
CONDITIONS OF 0.6 DEG PITCH, 1.7 DEG ROLL, AND 3.4 FT (1.0 M)
HEAVE AND SIMILAR WIND CONDITIONS SHOWS AN A7 COMPLETION RATE OF
OF 91 PERCENT, A MEAN TOUCHDOWN OF -4.1 FT (1.3 M) AND A TOUCHDOWN
STD DEV OF 43.3 FT (13.2 M). THESE NUMBERS EQUATE TO A PREDICTED
LANDING RATE OF 87 PERCENT. REF O, THE A7E ACLS QUALIFICATION
REPORT, RECOMMENDS THAT THE A7 BE RESTRICTED TO DECK MOTION LIMITS
OF 1.5 DEG P-P SHIP PITCH AND 6.0 FT (1.9 M) P-P OF SHIP'S HEAVE
BECAUSE OF DETERIORATED CLOSED LOOP CONTROL AT THE HIGHER DECK
MOTIONS. HOWEVER THE A7'S AUTOMATIC CONTROLLABILITY IS INFLUENCED
MORE BY THE BURBLE, THE AIRPLANE'S ATTITUDE AT BURBLE ENCOUNTER, AND
THE EFFECT OF SHIP'S MOTION ON THE BURBLE RATHER THAN BY THE ACTUAL
SHIP MOTION ITSELF. THE A7 AERODYNAMIC AND ENGINE CHARACTERISTICS
CAUSE THE AIRCRAFT ACLS CONTROL TO DETERIORATE UNDER OTHER THAN
LIGHT TURBULENT CONDITIONS. THIS IS NOT TRUE OF THE F-4, RA5C, A6E
OR EA6B AIRCRAFT. THE UNACCEPTABLE CERTIFICATION STD DEV TOUCHDOWN
STATISTICS OF THE A7 ARE ATTRIBUTED TO THE TEST CONDITIONS AND
KNOWN AIRCRAFT CHARACTERISTICS RATHER THAN TO CONTROLLABILITY BY
THE SHIPBOARD SYSTEM. IT IS RECOMMENDED THAT THE A7 BE CERTIFIED
FOR MODE I OPERATIONS ON USS KITTY HAWK BASED ON PREVIOUS CERTIFI-
CATION DATA, KNOWN ACLS CHARACTERISTICS OF THE A7 AIRCRAFT AND THE
DEMONSTRATED ACCEPTABLE PERFORMANCE OF THE KITTY HAWK SHIPBOARD
ACLS (A6 AND EA6B STATISTICS). IT IS ALSO RECOMMENDED THAT A7
SQUADRON AND SHIPBOARD PERSONNEL BE APPRISED OF THE EXPECTED
DETERIORATION IN LANDING PERFORMANCE DURING PERIODS OF MODERATE TO
HEAVY TURBULENCE. IF THE A7E ARRESTMENTS UNDER NOMINAL CONDITIONS
RESULT IN A LARGE NUMBER OF 4 WIRES OR BOLTERS IT IS RECOMMENDED
THAT THE A7E CORNER REFLECTOR HEIGHT BE REDUCED FROM 10 FT (3.1 M)
TO 9 FT (2.7 M). THIS CAN BE ACCOMPLISHED BY A MESSAGE FROM THE
USS KITTY HAWK TO NAVAIRTESTCEN VIA COMNAVAIRSYSCOM.
```

Figure 9-1. EXAMPLE OF NARRATIVE FOR CERTIFYING MARGINAL AIRCRAFT

SECTION TEN

POST-CERTIFICATION ANALYSIS AND REPORTING

10.1 INTRODUCTION

The post-certification effort is devoted to ensuring that (1) camera data are properly read and tabulated, (2) overall certification effort is analyzed, and (3) the final certification message is written.

10.2 FINAL DATA REDUCTION

Final data reduction consists of partitioning the various aircraft data into the appropriate wind cells for statistical analysis. The analysis is straightforward with respect to calculating means and standard deviations for all parameters. AN/SPN-42 and aircraft records may be reviewed to investigate any anomalies that occurred during the certification. However, in this phase of the certification it is too late to review the records for potential AN/SPN-42 problems or to calculate the tolerances on encoders or stabilization systems. The records may be reviewed for lessons-learned-type data or examples of satisfactory or unsatisfactory approaches that may be made part of the in-house ship's certification notebook.

10.3 DATA ANALYSIS

The data analysis phase of the post-certification effort includes quantifying the various qualitative impressions that were formed during the at-sea trials. Data are analyzed with respect to the acceptable and marginal criteria discussed in Section Nine.

The post-trip data analysis should correlate with any qualitative assessments made during the at-sea trials. There should be no surprises in the data review. An aircraft that was assessed to be certifiable from the at-sea data (SPN-42 records, pilot acceptability, wire calls) should not suddenly reveal itself to be uncertifiable through post-trip data analysis. An aircraft type that was assessed to be marginally certifiable during the at-sea period may be deemed uncertifiable because of the post-trip data analysis.

The difference in these two cases is that one aircraft was deemed certifiable before any film data were observed, and the second was dependent on the quantitative data before a certification decision could be made.

The project engineer should have an opinion of what the post-trip data analysis will reveal before the data are even observed. This means that the certification opinion is formed before the test team even leaves the ship. This opinion may be acceptable, marginal, or unacceptable, with the data influencing the marginal case more so than any other.

10.4 CERTIFICATION REPORT

The final certification report is generally sent out in a message format. The message should be definitive, but brief, and should consist of three parts: the summary and test conditions section, the data section, and the recommendations section.

10.4.1 Summary and Test Conditions

The summary is a brief narrative on the certification that details what was investigated when, the results of the investigation, and any appropriate recommendations.

The test conditions should immediately follow the summary section. These paragraphs define the entire test conditions observed with respect to WOD, ship's motion, and ship's trim. The nominal certification WOD envelope is also defined (350° ±3° to 5°, nominal wind velocity ±3 knots [27 knots is normally the target nominal wind velocity]). Included with the test conditions is a definition of the final ACLS control program.

Figure 10-1 is an example of a summary and test conditions section. Numerous other examples should be contained within the certification notebooks.

10.4.2 Data Section

The data section of the report should present touchdown statistics for mean-hook touchdown, sink speed, and hook-to-ramp, together with the dispersions and sample sizes of each of these parameters. Hook-to-ramp and sink speed are presented for informational purposes, because these parameters have a definite meaning to the operational pilots and LSOs.

Other data that should be presented are boarding rates, AQRs, and the landing prediction statistics. All of these parameters give an indication of how well the system may be expected to operate.

The AQRs and boarding rates are presented for all approaches regardless of WOD. The touchdown parameters are presented only for the nominal WOD condition. To include statistics from the total WOD investigated can present a false impression of expected ACLS performance, since off-nominal WOD

1, SUMMARY: IAW REFS A AND B, FLIGHT TESTS WERE CONDUCTED 16-24 MAY 77 WITH RA-5C, A-6E, AND A-7E AIRCRAFT TO CERTIFY THE USS KITTY HAWK AN/SPN-42A ACLS FOR MODE I, IA, II , AND III OPERATION, CONCURRENT TESTING WAS PERFORMED TO CERTIFY THE USS KITTY HAWK AN/SPN-41 INSTALLATION AS A MODE I MONITOR AND PRIMARY ILS. FINAL ANALYSIS OF QUANTATIVE AND QUALITATIVE DATA INDICATES PERFORMANCE OF THE AN/SPN-42A ACLS WITH N-III-2 CONTROL PROGRAM AND MODE IV OPS III NTDS PROGRAM INTERFACE WITH PATCH TAPE P-63-9 DATED 1 JUN 77 IS SATISFACTORY FOR MODE I OPERATIONS WITH RA-5C, A-6A/E, AND A-7B/C/E AIRCRAFT PROPERLY CONFIGURED AS LISTED IN REF C, RECOMMEND USS KITTY HAWK AN/SPN-42A ACLS WITH N-II-2 CONTROL PROGRAM AND MODE IV OPS III NTDS PROGRAM BE CERTIFIED FOR MODE I, IA, II, AND III OPERATIONS AND THAT CLEARANCE FOR USE OF THE AN/SPN-41 AS A MODE I MONITOR AND PRIMARY ILS BE WITHDRAWN IF THE ITEMS IN PARA 3.A, 3.B, 3.C AND 3.D OF THIS REPORT ARE NOT COMPLETED BY 11 OCT 77. THIS REPORT COMPLETES WORK UNDER SUBJECT AIRTASK, END SUMMARY.

2, TEST CONDITIONS WERE DAY VFR, WIND-OVER-DECK (WOD) AVERAGED 27 KT (14 M/S) AT 354 DEG AND VARIED FROM 19 TO 31 KT (1Ø TO 16 M/S) AND 338 TO Ø12 DEG RELATIVE, MAXIMUM PEAK-TO-PEAK DECK MOTION WAS Ø.6 DEG PITCH, 1.7 DEG ROLL, AND 3.4 FT (1.Ø M) HEAVE, SHIP'S MISTRIM AVERAGED Ø.4 DEG BOW UP AND Ø.7 DEG PORT UP. FINAL AN/SPN-42A AND AN/SPN-41 GLIDE SLOPE SETTINGS WERE 3.65 DEG AND 3.75 DEG, RESPECTIVELY. THE AN/SPN-42A SETTING WAS ADJUSTED FROM 3.5 DEG TO 3.65 DEG WITHIN THE BASIC PATCH TAPE, ALL APPROACHES WERE CONDUCTED WITH A 3.5 DEG SETTING ON THE FRESNEL LENS OPTICAL LANDING SYSTEM (FLOLS).

3, THE AN/SPN-42A CS-3-2 OPERATIONAL PROGRAM WITH P63-1NT DTD JAN 79 WAS UTILIZED WITH THE FINAL CONFIGURATION LISTED BELOW:

A/C	GAINS	RADAR AUGMENTATOR TO HOOK HEIGHT FT(M)	PITCH COMMAND RAMP
A6E	V-13/L-8	13(3,9)	NONE
A7E	F-5/L-3	1Ø (3,Ø)	1/4 DEG 16-14 SEC 3/16 DEG 2,5-1,5 SEC
EA6B	V1Ø/L-3	1Ø (3,Ø)	NONE

Figure 10-1. EXAMPLE OF CERTIFICATION MESSAGE SUMMARY AND TEST CONDITIONS SECTION

conditions normally result in more erratic touchdown statistics or have a marked influence on mean touchdown points. The landing prediction statistics are based on the nominal WOD conditions.

The report should contain narratives on expected changes in ACLS control and a touchdown performance with the wind variance from the nominal condition. Some examples of these narratives are shown in Figure 10-2.

These narratives give an idea of the deterioration in control and touchdown statistics that may be expected as the WOD shifts from nominal conditions. They also indicate that ACLS will not provide the same performance for all WOD conditions.

Figure 10-3 is an example of the data section of a report. Data should only be presented to one decimal place. Recording equipment is not that accurate, and the certification itself does not depend on data any more accurate than one decimal place.

IT SHOULD BE NOTED THAT VARIATION IN SHIPS WOD OR PITCH TRIM HAVE A SIGNIFICANT EFFECT ON ACFT LANDING CONDITIONS, LOW WINDS, WIND STBD OF ANGLE DECK CENTERLINE OR A PITCH TRIM OF LESS THAN 0.1 DEG BOW UP WILL TEND TO CAUSE THE ACFT TO LAND LONG; HIGH WINDS, WINDS PORT OF ANGLE DECK CENTERLINE OR PITCH TRIM GREATER THAN 0.3 DEGREES BOW UP WILL TEND TO CAUSE THE ACFT TO LAND SHORT, A WOD OF 345 TO 355 DEG AT 22 TO 28 KTS CONSIDERED OPTIMUM; SHIPS PITCH TRIM SHOULD BE MAINTAINED BETWEEN 0.1 AND 0.3 DEGREE BOW UP.

F. A6E - THE AIRCRAFT EXHIBITS A TENDENCY TO LAND LONG (FOUR WIRE OR BOLTER) WHEN WIND DIRECTION EXCEEDED 355 DEG. THE AIRCRAFT ALSO TENDED TO LAND SHORT (1 WIRE) WHEN WIND MAGNITUDE DROPPED BELOW 22 KTS (6.7 M/S). GLIDE SLOPE CONTROL WAS CONSISTENT FOR ALL CONDITIONS TESTED.

7. DURING INITIAL TEST PERIODS BOTH ACFT EXPERIENCED LONG TOUCHDOWNS (3 WIRE TO BOLTER) AND WITH LOW STBD WINDS (020 TO 022 DEG REL, AT 10 TO 15 KTS) OR IN THE PRESENCE OF MODERATE TURBULENCE THE LONGITUDINAL TOUCHDOWN POINT MOVED FURTHER FORWARD (4 WIRE TO LONG BOLTER). THIS TENDENCY TO LAND LONG WAS CORRECTED BY LOWERING THE VERTICAL OFFSET IN THE COMPUTER PROGRAM 1.5 FT (0.5 M);

Figure 10-2. EXAMPLES OF NARRATIVES

The other data collected during the certification (e.g., yaw angle, pitch angle, glideslope angle) are superfluous as to the certification and only clutter the final report message. These data should be documented and placed in the certification notebook merely to maintain a complete record of the certification.

10.4.3 Recommendations

The recommendations section contains the overall results of the certification and restrictions, if any. This section lists the wind envelope, aircraft control programs, conditions under which the approach should be downgraded, and other pertinent data as appropriate. Figure 10-4 illustrates a typical recommendation section.

10.4.4 Other Narratives

Other narrative paragraphs may be appropriate to the certification message, especially if special tests are being performed or the certification was conducted under unusual circumstances. These paragraphs would appear where appropriate. Frequently, these supplemental narratives confirm previous messages alluding to the certification. Figure 10-5 shows an example of a narrative that is not pertinent to the certification.

4, DURING THE 17-27 APR TEST PERIOD, A CORRECTED TOTAL OF 108 A-7E AND 84 A-6E APPROACHES WERE MADE, RESULTS AS FOLLOWS (READ IN THREE COLUMNS):

RESULT	NUMBER A-7E	NUMBER A-6E
MODE I COMPLETION	97	69
SYSTEM RELATED ABORTS	9	11
NON SYSTEM RELATED ABORTS	2	4
ATTEMPTS EXCLUDING NON SYSTEMS RELATED ABORTS	106	80
PERCENT MODE I COMPLETIONS	92	86

5, UNDER FINAL CONFIGURATION CONDITIONS, PILOT ACLS QUALITY RATINGS FOR ACFT MODE I CONTROL WERE AS FOLLOWS: (READ IN SEVEN COLUMNS)

		LEVEL LEG	TIPOVER	GLIDE SLOPE	INCLOSE	TOUCH-DOWN
A6E	NO EVENTS	63	65	72	7[illegible]	71
	MEAN RATINGS	1,71	1,67	1,73	1,[illegible]	1,85
	STD DEV	0,41	0,43	0,47	0,[illegible]	0,56
A7E	NO EVENTS	76	79	84	84	82
	MEAN RATINGS	1,44	1,45	1,60	2,10	2,24
	STD DEV	1,26	2,31	0,35	0,65	0,65
EA6B	NO EVENTS	49	55	56	56	55
	MEAN RATINGS	1,19	1,07	1,32	1,61	1,72
	STD DEV	2,32	0,19	0,40	0,50	0,57

MEAN RATINGS WERE DERIVED FROM A QUALITATIVE SCALE OF SYSTEM PERFORMANCE WHICH IS DEFINED AS FOLLOWS: 1,0 EXCELLENT; 2,0 GOOD, NEGLIGIBLE DEFICIENCIES; 3,0 FAIR, SOME UNPLEASANT DEFICIENCIES; 4,0 MODERATELY OBJECTIONABLE, PERFORMANCE INCONSISTENT; 5,0 OBJECTIONABLE, UNSATISFACTORY FOR MODE I; 6,0 MAJOR SYSTEM DEFICIENCIES,

6, FINAL CONFIGURATION TOUCHDOWN STATISTICS OF KEY ACLS PERFORMANCE PARAMETERS ARE AS FOLLOWS: (READ IN SEVEN COLUMNS):

PARAMETERS	TYPE	NUMBER SAMPLES	MEAN VALUE	STANDARD DEVIATION	MAXIMUM	MINIMUM
HOOK RELATIVE	A6E	54	-8,9	46,2	115,9	-85,1
LONGITUDINAL TOUCHDOWN-FT(M)			(-2,70)	(14,1)	(35,3)	(-25,9)
	A7E	65	27,5	59,1	132,5	-113,9
			(8,4)	(18,0)	(40,9)	(-34,7)
	EA6B	50	-1,7	35,1	103,5	076,1
			(-,51)	(10,7)	(31,5)	(-23,3)
SINK SPEED FPS (M/S)	A6E	54	11,3	1,8	14,7	7,2
			(3,4)	(,54)	(4,5)	(2,2)
	A7E	65	13,0	1,4	16,8	8,9
			(4,0)	(,43)	(5,1)	(2,7)
	EA6B	50	11,0	1,9	14,7	5,8
			(3,3)	(,56)	(4,5)	(1,8)
HOOK TO RAMP FT(M)	A6E	57	15,1	3,0	23,0	9,6
			(4,6)	(,9)	(7,0)	(2,9)
	A7E	66	15,8	3,3	22,5	7,2
			(4,82)	(,99)	(6,9)	(2,2)
	EA6B	45	14,5	2,4	20,1	10,4
			(4,4)	(,7)	(6,1)	(3,2)

NOTE: NEGATIVE VALUE INDICATES AFT OF DESIRED TOUCHDOWN POINT, THE TARGET TOUCHDOWN POINT WAS MIDWAY BETWEEN THE TWO AND THREE WIRE 234,0 FT (71,3 M) FWD OF THE RAMP,

7, Any appropriate commentary on statistical parameters in relation to certification limits or specifications.

8, BASED UPON FINAL CONFIGURATION QUANTITATIVE TEST STATISTPCS, PROBABILITIES OF HOOK TOUCHDOWN ARE AS FOLLOWS: (READ IN SEVEN COLUMNS):

TYPE AIRCRAFT	40 FT AFT NO, 1 WIRE	NO, 1 WIRE	NO, 2 WIRE	NO, 3 WIRE	NO, 4 WIRE	FWD NO, 4 WIRE(BOLTER)
A-6E	0,03	0,11	0,25	0,35	0,20	0,06
A7E	0,02	0,06	0,13	0,25	0,27	0,27
EA6B	0,01	0,05	0,24	0,44	0,23	0,03

Figure 10-3. EXAMPLE OF CERTIFICATION DATA SECTION

```
9.  RECOMMEND USS KITTY HAWK AN/SPN-42A ACLS BE CERTIFIED FOR THE
FOLLOWING OPS:
    A.  MODE I WITH A6E AND A7 ACFT WITH THE FOLLOWING RESTRICTIONS:
        (1) AN/SPN-42A DS-3-2 OPERATIONAL PROGRAM WITH PATCH TAPE
P63-1 DATED 2 FEB 79 ONLY AUTHORIZED SOFTWARE.
        (2) APPROACH WEATHER MINIMUMS OF 200 FT (61 M) CEILING ABOVE
THE FLIGHT DECK AND 1/2 NM (926 M) VISIBILITY.
        (3) CALIBRATED (TRUE) WOD CONDITIONS MUST BE 20 TO 30 KTS
(10.3 TO 14.4 M/S), 347 TO 000 DEG RELATIVE FOR ALL AIRCRAFT.
OPTIMUM WOD CONDITIONS ARE 22 TO 28 KTS (11.3 - 14.4 M/S), 346 TO
353 DEG RELATIVE.
        (4) P-P SHIPS MOTION MUST NOT EXCEED 1.5 DEG
PITCH, 2.0 DEG ROLL AND 10 FT (3.0 M) HEAVE.
        (5) APPROACH MUST BE DOWNGRADED TO MODE IA IF AOA EXCURSIONS
REPEATEDLY EXCEED PLUS OR MINUS 1.5 UNITS.
        (6) APPROACH MUST BE DOWNGRADED TO MODE II IF AOA EXCURSIONS
EXCEED PLUS OR MINUS 2.5 UNITS.
        (7) A-6/EA6B/A7/S3A/RA5C MUST UTILIZE BEACON TRACKING FOR
MODE I/IA APPROACHES AND ALL AIRCRAFT BEACONS MUST BE SECURED WHEN
AIRCRAFT ARE ON DECK.
        (8) SINS ARE PRIMARY OSC STABILIZATION REFERENCE SOURCE
WITH ONLY THE FWD MK-19 BACKUP.
        (9) ALL ACFT MUST BE CONFIGURED IAW REF E.
        (10) GLIDE SLOPE OF 3.5 DEG FOR AN/SPN-42A, AN/SPN-41 AND
FLOLS.
        (11) AN/SPN-42A MUST BE CALIBRATED USING THE THREE CORNER
REFLECTORS AND RTF DAILY. THE FINAL CALIBRATION PARAMETERS MUST
BE RECORDED IN A DAILY CALIBRATION LOG.
    B.  MODE IA OPS WITH S3A, A6A/E, F4B/J/N, A7B/C/E AND RA5C WITH
RESTRICTIONS LISTED IN PARA 15A, (1) (2) (6) (7) (8) (9) (10) (11).
    C.  MODE II OPS WITH S3A, EA6B, A6A/E, F-4B/N/J, A7B/C/E,
RA5C, F14A AND E-2B/C WITHIN THE RESTRICTIONS LISTED IN PARA 15A,
(2) (6) AND (9).
    D.  MODE III OPS WITH ALL AIRCRAFT WITHIN RESTRICTIONS LISTED IN
15A, (2) AND (8).
```

Figure 10-4. EXAMPLE OF CERTIFICATION MESSAGE RECOMMENDATIONS SECTION

```
8. THE SPIN ERROR SUMMATION MODIFICATION WAS IMPLEMENTED AS AUTH-
ORIZED BY REF F COMMAND NOISE LEVELS WERE REDUCED AS REPORTED BY REF
E. NO SIGNIFICANT EFFECT ON TOUCHDOWN PERFORMANCE WAS OBSERVED WITH THE
SPIN ERROR SUMMATION MODIFICATION IMPLEMENTED AND IT IS SATISFACTORY FOR
SHIPBOARD MODE I OPERATIONS.
```

Figure 10-5. EXAMPLE OF REPORT NARRATIVE OF TEST CONDUCTED IN CONJUNCTION WITH CERTIFICATION

SECTION ELEVEN

ACLS CERTIFICATION TROUBLESHOOTING

11.1 INTRODUCTION

ACLS approaches consist of a ground-based system and an airborne automatic system operating together to fly an aircraft to a moving flight deck. Both of these systems are designed to operate together in a defined electrical parameter tolerance band. One of the major purposes of a certification effort is to measure whether or not all of the system parameters are within their respective tolerance bands. In-port system electrical checks will generally ensure that the system is operating to specification. At-sea tests are designed to check how well the system is operating under dynamic conditions.

The best way to evaluate an ACLS approach is to check the AN/SPN-42 instrumentation to ensure that all traces are relatively smooth with no abrupt departures from a smooth trace, and there should not be any type of continual periodic motion (DSS and encoders excepted). There is no definition for a normal approach, because every approach is dependent on the test conditions. The project engineer can develop an intuitive understanding of what the ordinary approach is going to look like by reviewing a number of records. This intuitiveness for the approach will tend to highlight an approach when it is out of the ordinary.

A number of common problems are often experienced during the at-sea tests. Some are attributable to equipment malfunctions, others to electrical tolerances, and some are just random events. This section illustrates some of the recurring problems that could surface during any certification. It also highlights two unusual problems observed during past certifications.

11.2 COMMON ACLS PROBLEMS

11.2.1 Beacon Malfunction

Beacon baselining is a problem frequently experienced during certification trials. It is attributed to the beacon operating at the edge of the Intermediate Frequency (IF), which causes the beacon not to reply to every bit. This overall result as seen by the project team may be observed on an oscilloscope as "fruit" on the beacon video. It shows up on the AN/SPN-42 instrumentation as noisy tracking and a high spin error.

The most obvious indication of a beacon gain problem is in the slant-range (R_s) washout trace, spin error data, or AGC. A beacon problem will cause an abrupt change in the overall level of the R_s trace. Such a change is shown in Figure 11-1. The lateral-error and roll-command trace corresponding to the range-washout trace are also shown to illustrate the associated effects of variances in the R_s washout term.

The beacon problem shown in Figure 11-1 represents a shipboard problem in one channel. It occurred for three different beacon aircraft on the "B" channel. The "A" channel showed all aircraft with good beacons. If only one aircraft had a problem, it could be assumed that the aircraft had a beacon problem. If only one aircraft is being used during certification, a cross-check between A and B channels may isolate the problem to the aircraft or ground system.

Figure 11-2 illustrates the effects of a "bad" beacon showing up in the vertical-error trace.

11.2.2 Side-Lobe Lock-Ons

Side-lobe lock-ons (i.e., the airborne beacon receiver locks on to one of the side lobes of the Ka-band ground beacon rather than the main lobe) are an occasional problem seen during certifications. Since the side lobes are at a lower gain level than the main lobe, the tracking is very noisy with large abrupt tracking changes. A side-lobe lock-on is shown in Figure 11-3 in the slant-range-washout and vertical-error traces. These traces effectively illustrate the high noise levels associated with the tracking. Side-lobe lock-ons are random events; if one occurs, break lock and reacquire the aircraft.

11.2.3 Range Bias Error

Any system that is geometrically offset from a desired point must provide accurate range measurements for the correct calculation of angles and distances. With an island-mounted AN/SPN-42 using a coordinate system that has a flight deck touchdown point as the origin, any range bias error will translate to lateral, vertical, and longitudinal errors. With a given range bias error, the lateral and vertical errors increase as the range to the touchdown point decreases. This is caused by the rapidly increasing azimuth angle and the negative elevation angle to the aircraft from the offset antennas as the aircraft approaches touchdown.

Range bias errors are the most noticeable in the lateral channel and manifest themselves as off-center landings. A range bias error may be suspected if there is a trend in the lateral error trace to move one way while the aircraft is observed to move the other way, or if the aircraft is landing to one side of the center line more than 50 percent of the time. A range bias error will normally cause the aircraft to land with the same-direction lateral error more than 90 percent of the time, depending on the magnitude of the range bias error.

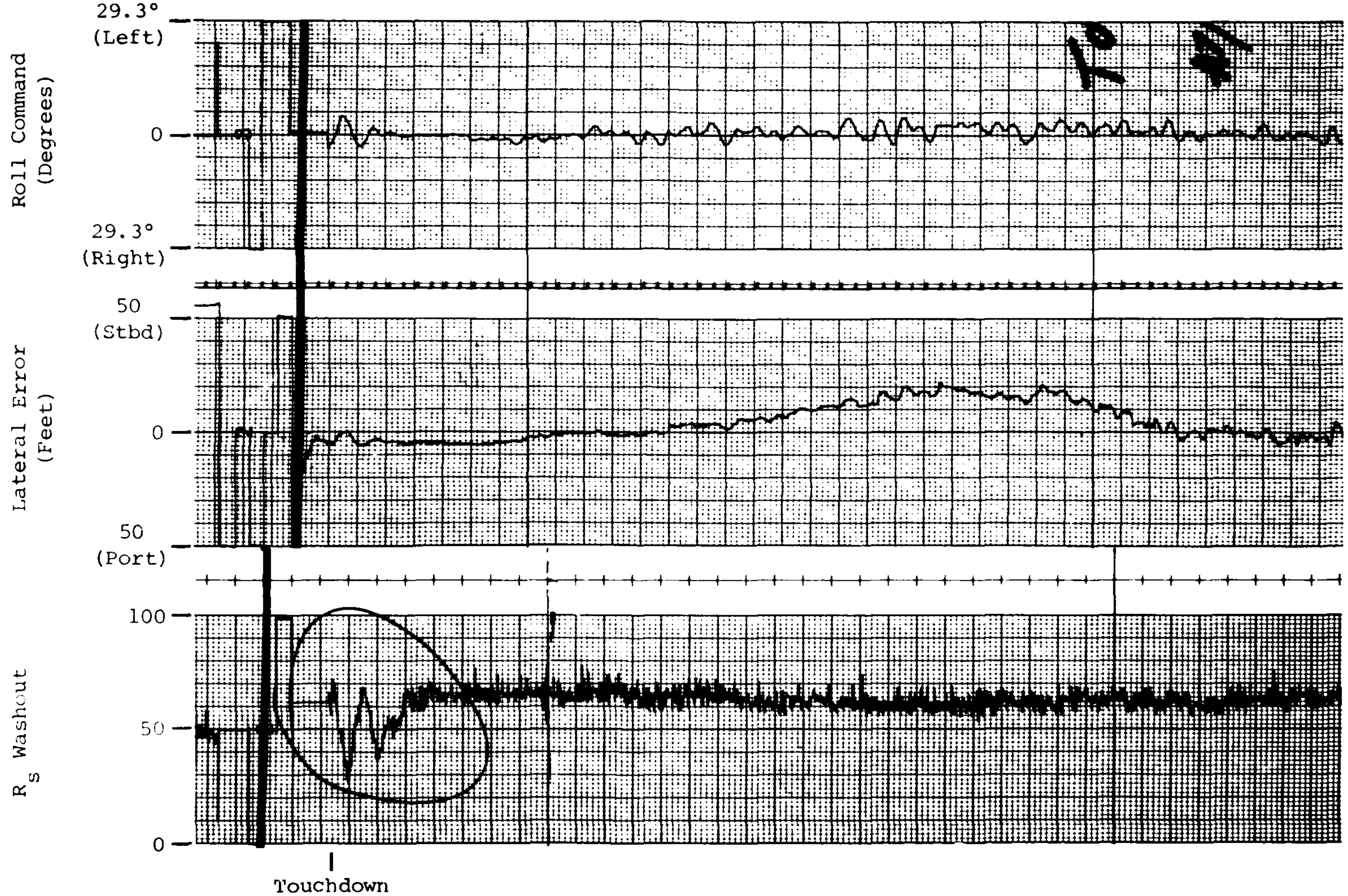


Figure 11-1. BEACON MALFUNCTION AS INDICATED ON THE AN/SPN-42 INSTRUMENTATION (USS INDEPENDENCE, NOVEMBER 1978)

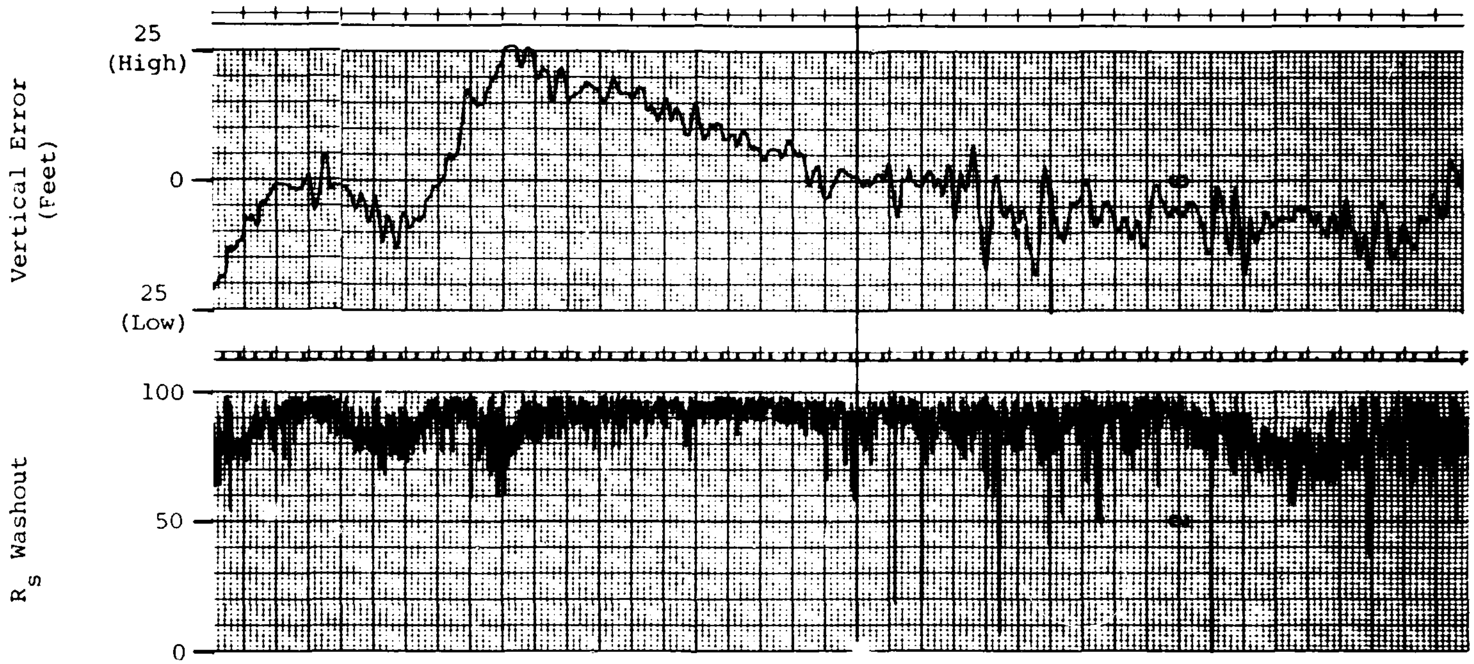


Figure 11-2. BEACON MALFUNCTION AS INDICATED ON THE AN/SPN-42 INSTRUMENTATION (USS RANGER, APRIL 1978)

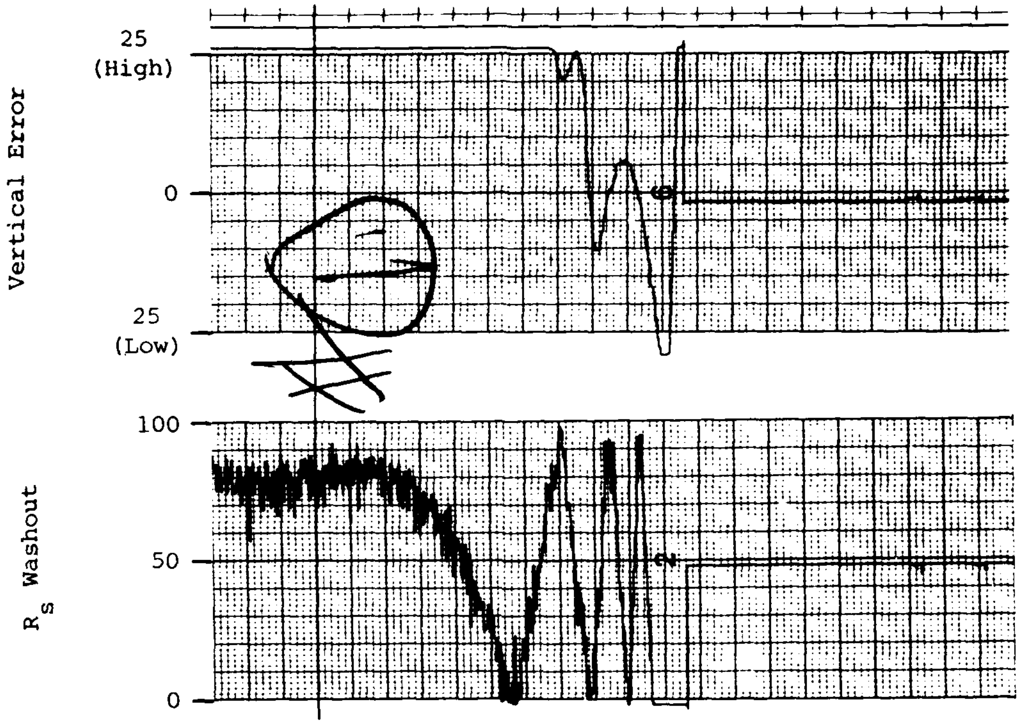


Figure 11-3. SIDE-LOBE LOCK-ON AS INDICATED ON THE AN/SPN-42 INSTRUMENTATION (USS RANGER, APRIL 1978)

The range bias error may be calculated geometrically, but the calculations are dependent on antenna offsets, aircraft geometry, and actual lateral and vertical error. The actual lateral and vertical errors will be influenced by the test conditions.

To illustrate the effects of range bias error it may be assumed that for a given ship's geometry at the command freeze point, with no deck motion, a range error of approximately 10 feet will cause a lateral error of approximately 4 feet and a vertical error of 0.8 foot. The longitudinal deck touchdown error corresponding to the vertical error due to range bias error will be approximately 15 feet.

It is possible to attempt to calculate range errors by evaluating the error traces while the pilot filies center-line MODE II approaches. Pilot confirmation should always be obtained as to the direction of the range error.

11.2.4 Radar Encoders and Data Stabilization Subsystem (DSS)

Aircraft pitch and bank commands are computed on the basis of an aircraft's measured vertical and lateral position errors. The position errors are computed with the angular data derived from the summation of the radar encoder signals and the spin-error signals from the AN/SPN-42 synchronizer. The vertical error is developed from the elevation encoder and elevation spin error. The lateral error comes from the azimuth encoder and azimuth spin error. The spin-error signals from the AN/SPN-42 synchronizer are rectified and filtered, then converted to a digital format scaled in degrees. The purpose of the spin-error summation is to compensate for poor tracking of the aircraft by the radar antenna. The overall effect of summing the encoder and spin-error signals to determine the position error should be a smoothing of the encoder perturbations and a rounder peak on the encoder data. How well the spin-error summation is working may be evaluated by analyzing the encoder, spin error, and spin-error summation traces on the AN/SPN-42 instrumentation.

Figures 11-4 and 11-5 illustrate composite vertical and lateral data. Both figures show encoder, spin-error, and spin-error summation traces. In Figure 11-4 the antenna drive backlash or stickiness are obvious from the flat peaks of the encoder trace and the "steppiness" of the encoder as it moves with the ship's motion. Comparatively speaking, the azimuth encoder trace of Figure 11-5 is much smoother, with very little sticking or backlash. Also obvious from Figures 11-4 and 11-5 is that a larger spin-error input is required to compensate for the poorer-quality encoder in the elevation channel. This may be seen from the magnitude of the spin-error trace in Figure 11-4 as compared with the spin-error trace in Figure 11-5. The magnitude of the sticking antenna drive shown in Figure 11-4 may be calculated as approximately 0.04 degrees in both the encoder and spin-error trace.

A quick analysis of the spin-error summation trace of Figure 11-4 illustrates that some of the antenna sticking is coming through to the position error, although the antenna backlash is being compensated for. This is seen by observing the slight steppiness in the spin-error summation trace that shares the antenna stickiness. The rounded peaks of the spin-error summation illustrate that the encoder backlash has been compensated for.

The spin-error trace of Figure 11-5 illustrates that less spin error is required to compensate for the azimuth encoder. In addition, the overall spin-error summation trace is smoother. This is a good indication of a more properly operating encoder.

In the overall evaluation of spin-error and encoder traces, the desire is to obtain relatively small spin-error perturbations. There is relatively little concern about the bias of the trace. Generally, the encoders should have less than ±0.02 degrees of stickiness; however, there are no set rules for the project engineer for the quality of the encoders, since responsibility for proper operation and tolerances of the encoders rests

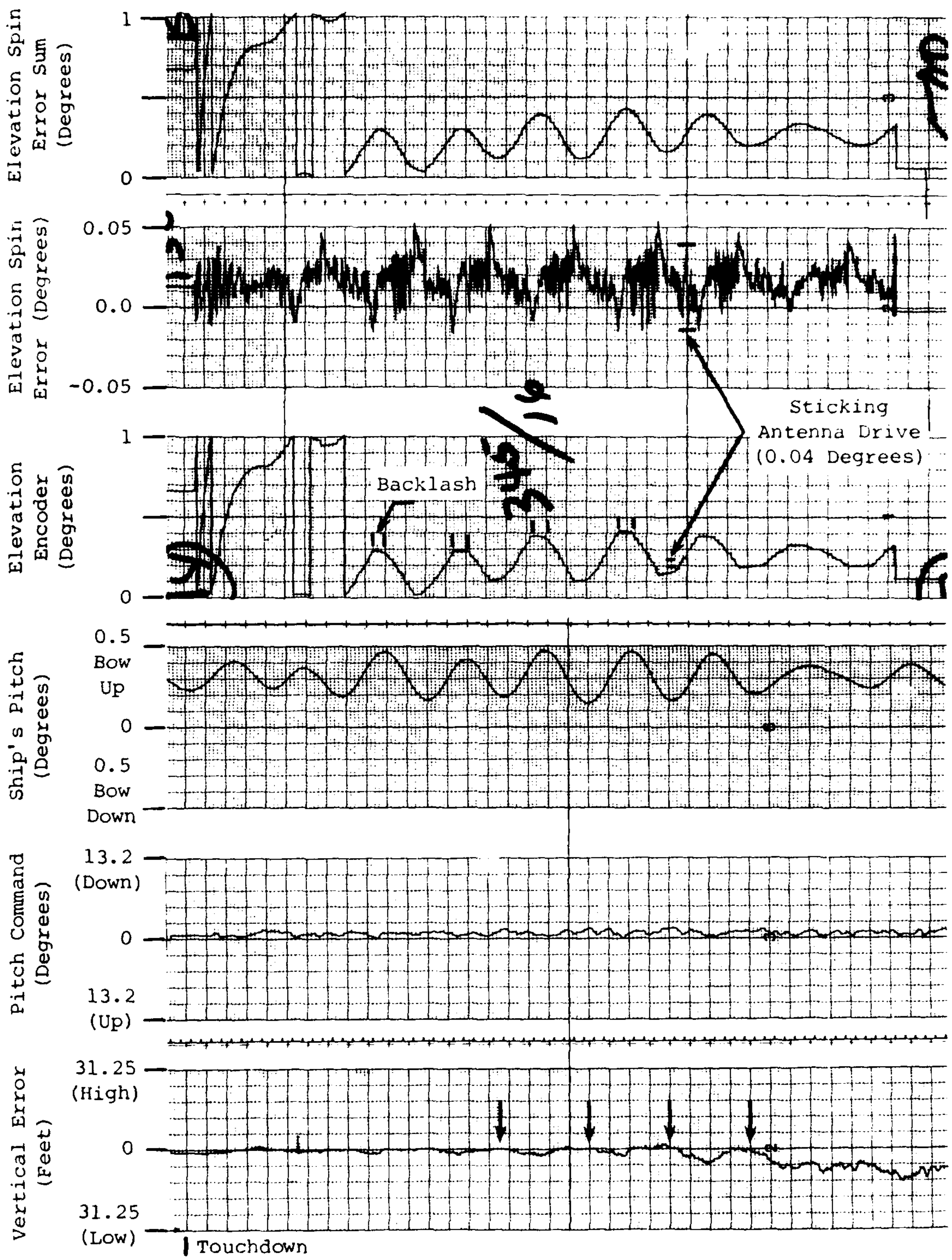


Figure 11-4. TIME HISTORY OF VERTICAL PARAMETERS ON AN/SPN-42 INSTRUMENTATION

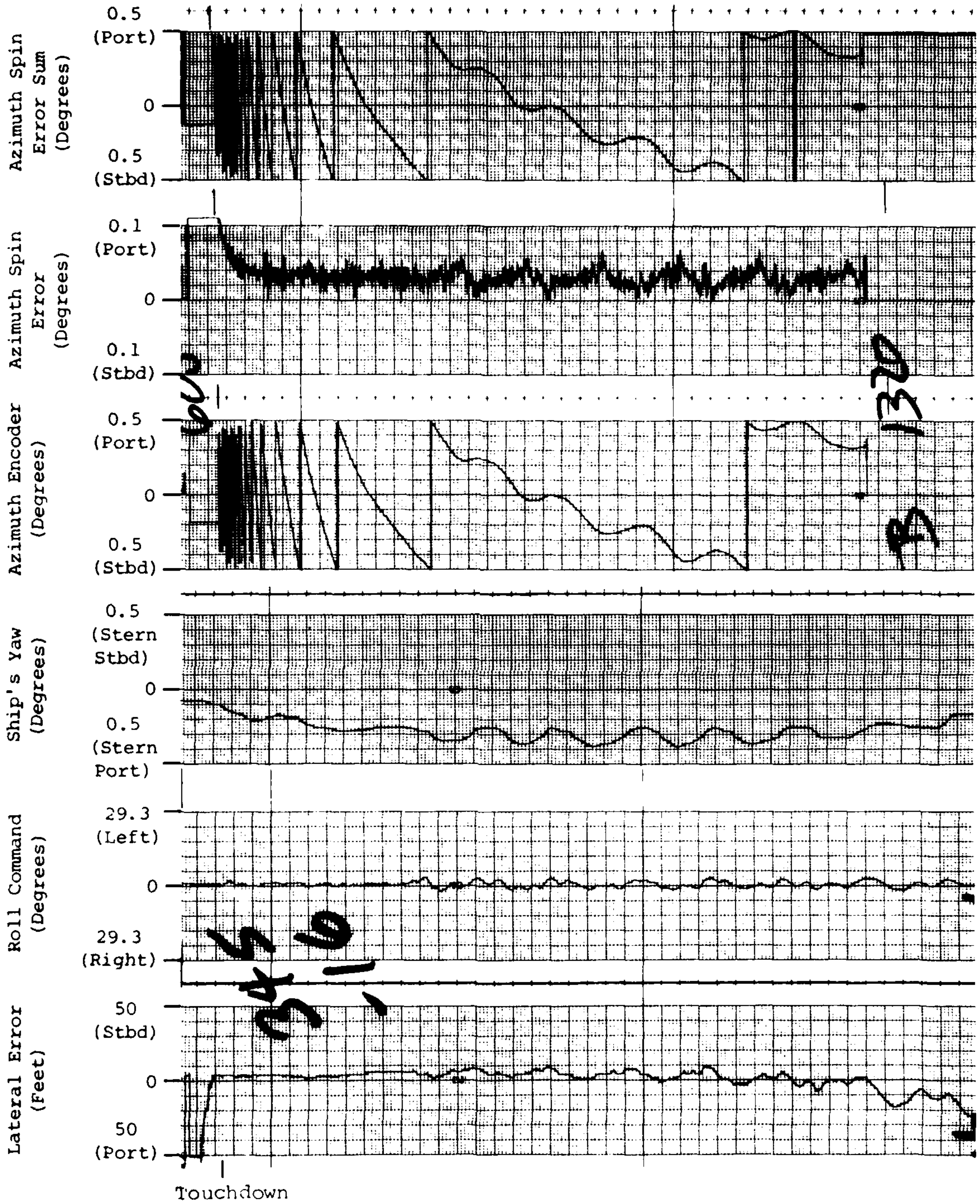


Figure 11-5. TIME HISTORY OF LATERAL PARAMETERS ON AN/SPN-42 INSTRUMENTATION

with NESEA personnel. The project engineer must be concerned with the encoder error getting through to the position errors.

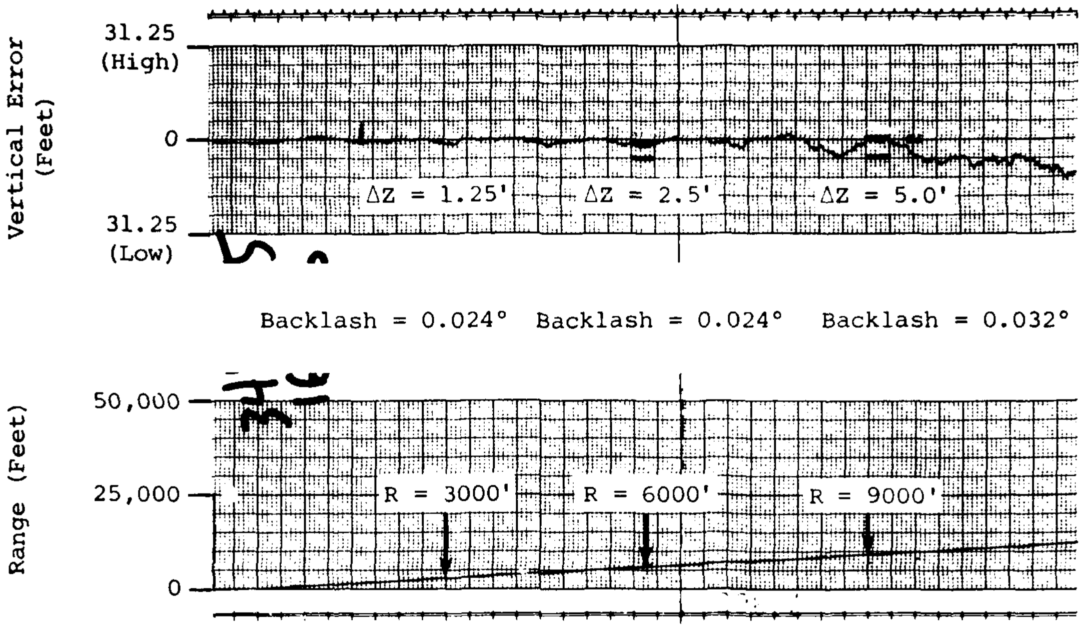
In the case of Figure 11-4, a quick look at the vertical-error trace will show that the slight periodic motion of the trace corresponds to the elevation encoder peaks. These peaks on the vertical-error trace are marked with arrows. It is interesting to note on this particular vertical-error trace that the overall vertical control is very good with respect to control about glideslope. The periodic motion is very easily ignored unless the elevation-encoder trace is being analyzed. This is a good example of data that can create a wrong impression of the total system. Apparent good control can often mask other problems in the overall ACLS system, especially when the pitch-command trace shows no apparent periodic commands.

The backlash or flat spots with spin-error summation in the elevation encoder may be calculated by looking at the peak-to-peak vertical error due to the elevation encoder and dividing that error by the range. The arctangent of the quotient is equal to the antenna backlash. Figure 11-6 shows the vertical-error trace of Figure 11-4 with the range trace and illustrates the calculation for the elevation encoder backlash.

The first step in analyzing the lateral-error trace is to observe the ship's yaw trace and then the azimuth encoder. The azimuth encoder should be following the ship's yaw motion, and it is this yaw motion that is being fed to the lateral error. If the azimuth encoder is not following the yaw motion, then there is a problem with the azimuth encoder or the yaw input. The lateral-error trace of Figure 11-5 also shows a periodic motion that may be traced to the azimuth encoder, although there is no backlash in the azimuth encoder. This illustrates one of the major differences between the lateral- and vertical-error traces. The vertical-error trace is a stabilized trace that has all ship's motion removed and should not be affected by the elevation encoders. In other words, the vertical-error trace is a smooth trace. The lateral-error trace, on the other hand, is supposed to have ship's motion in it. Lateral error is destabilized as a function of frequency.

The radar encoders and the DSSs should always exhibit the same motion with the encoders matched to the DSSs. Any difference in magnitudes or periods between the encoders and DSSs is indicative of a problem.

Any ship's yaw transitions that the azimuth encoder does not follow are generally indicative of a low servo gain in the lateral channel. The vertical servo gain may be evaluated by observing the ship's pitching motion data at a transition point. Any dead spots with a sudden jump are indicative of low servo gains not following the lower amplitudes of ship's motion. Frequently, this is because of the ship's low frequency gain being set too low to follow the lower ship's frequencies. The gain is set low so that the bandwidth of the antenna may be adjusted to follow the aircraft at higher frequencies.



$$\text{Backlash} = \tan^{-1} \frac{\Delta Z}{R}$$

Figure 11-6. VERTICAL ERROR AND RANGE PARAMETERS FROM AN/SPN-42 INSTRUMENTATION

While there are no illustrations of this type of DSS problem, it may be assumed that the pitch DSS trace would be similar in appearance to the elevation-encoder trace of Figure 11-4. Obviously, the elevation-encoder trace of Figure 11-4 is not caused by the pitch DSS, which is the smooth trace next to the elevation encoder.

11.3 UNCOMMON ACLS PROBLEMS

Common ACLS problems are worth mentioning because they are often seen during ACLS certifications; uncommon problems are also important because of their uniqueness and the possibility that they may occur again.

11.3.1 FLOLS Misalignment (USS MIDWAY, August 1977)

Two major problems with FLOLS alignment were encountered during the USS MIDWAY certification. The first was an error between the FLOLS survey data and the published FLOLS Bulletin data and the second was that the FLOLS was not being compensated for ship's mistrim.

The FLOLS survey data and Bulletin data were in error by the equivalent of 0.5 to 0.7 feet high at the touchdown point. This equates to a FLOLS roll-setting error of approximately 0.5 units. The error was determined by checking the Bulletin pole-check positions and comparing that data with data from pole-check positions on the angle deck center line. The problem resulted from the pilot's qualitative assessment of FLOLS, AN/SPN-41, and AN/SPN-42 alignment.

The second problem encountered on the USS MIDWAY with FLOLS was the determination that corrections for ship's trim was not being added to the FLOLS. This resulted in an error of approximately 0.6 feet high at touchdown for a typical ship's pitch trim of 0.2 degrees bow up. This again equates to approximately a 0.5-unit roll setting.

The total error from both sources was approximately 1.0 units of FLOLS roll setting, which resulted in a low boarding rate for manual approaches with a centered ball and an unacceptable misalignment with the AN/SPN-42 and AN/SPN-41.

11.3.2 Spikes on AN/SPN-42 Instrumentation Parameters (USS RANGER, April 1978)

Spikes on all parameters of any instrumentation system are not uncommon. What may be unusual is spikes on only particular parameters.

Two examples of representative spikes are shown in Figures 11-7 and 11-8. In Figure 11-7, there is a spike in the altitude (Z) trace and a corresponding perturbation in altitude error (Z_e) and pitch command (θ_c). Since the spike does not show up on any other trace, it indicates a probable computer or software problem affecting either the calculation of Z or the storage of Z. The perturbations in Z_e and θ_c result because Z_e is calculated from Z and the perturbation shapes result from the dynamics of the filters of Z_e and θ_c.

Figure 11-8 shows a similar spike problem occurring in range (X) and Z_e. There was no perturbation for θ_c because an immediate wave-off was generated. The dynamics of X are a result of the filtering on X. The reason for the spikes in Figures 11-7 and 11-8 was traced to a random software problem of storing data on top of the calculated X, Y, and Z data. During the USS RANGER certification, a software patch tape was developed to eliminate the effect of single spikes. If two consecutive spikes were encountered, a wave-off was generated.

11.3.3 Electromagnetic Interference (EMI)

An occasional problem observed on certifications is that of EMI. Unfortunately, EMI manifests itself in many different ways, which are not particularly consistent. EMI may be observed as problems in the UHF data link, random uncouplings, or even perturbations in position data attributable to the AN/SPN-42 radar jumping as it operates in the high EMI environment aboard ship.

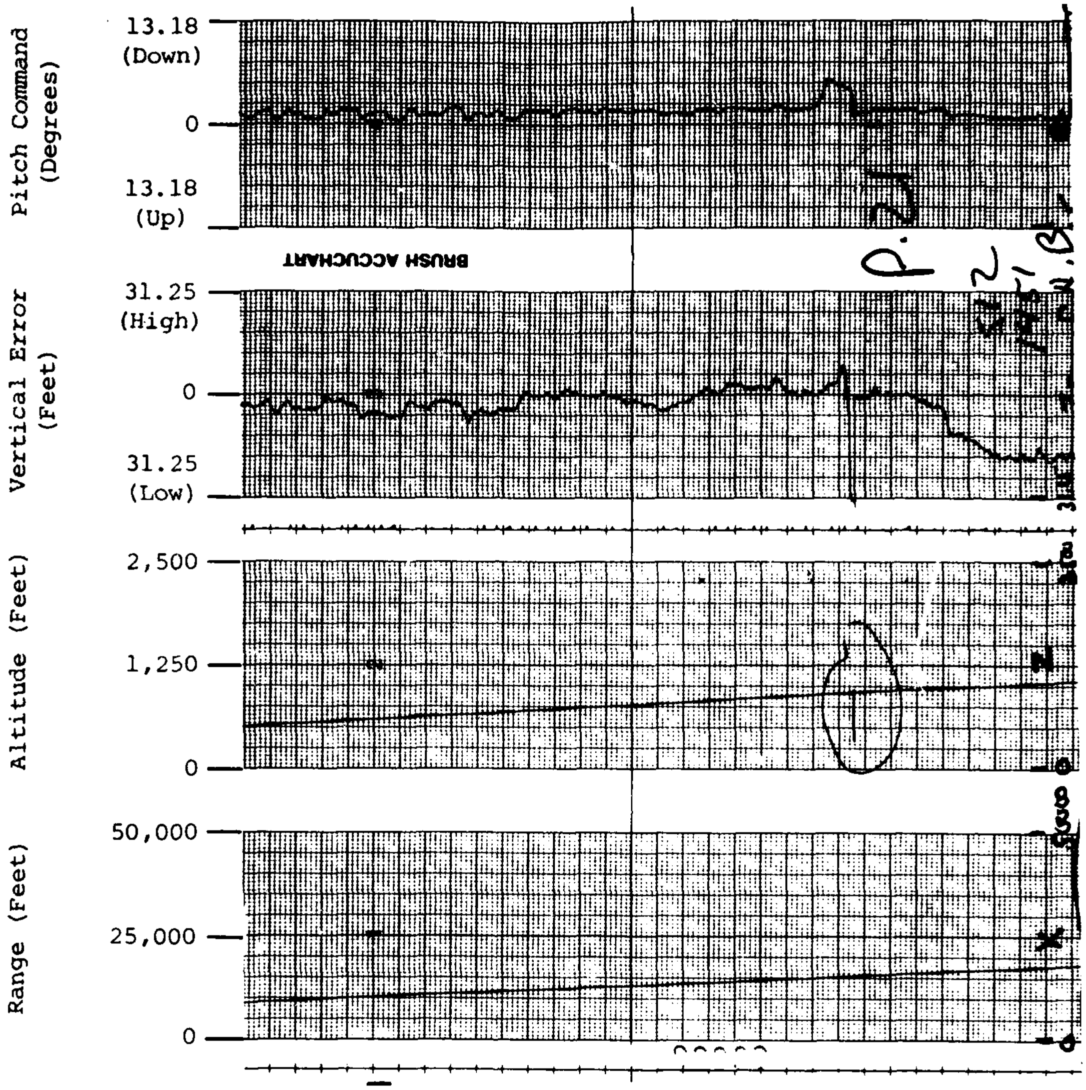


Figure 11-7. AN/SPN-42 INSTRUMENTATION SHOWING SPIKES IN ALTITUDE, VERTICAL ERROR, AND PITCH COMMAND

EMI as the source of problems is generally only detectable by NESEA personnel through the monitoring of system test equipment.

11.4 AIRCRAFT INSTRUMENTATION

Aircraft instrumentation may be used, when available, to evaluate proper system functioning. This is particularly true with respect to approach parameters such as airspeed, angle of attack, and aircraft

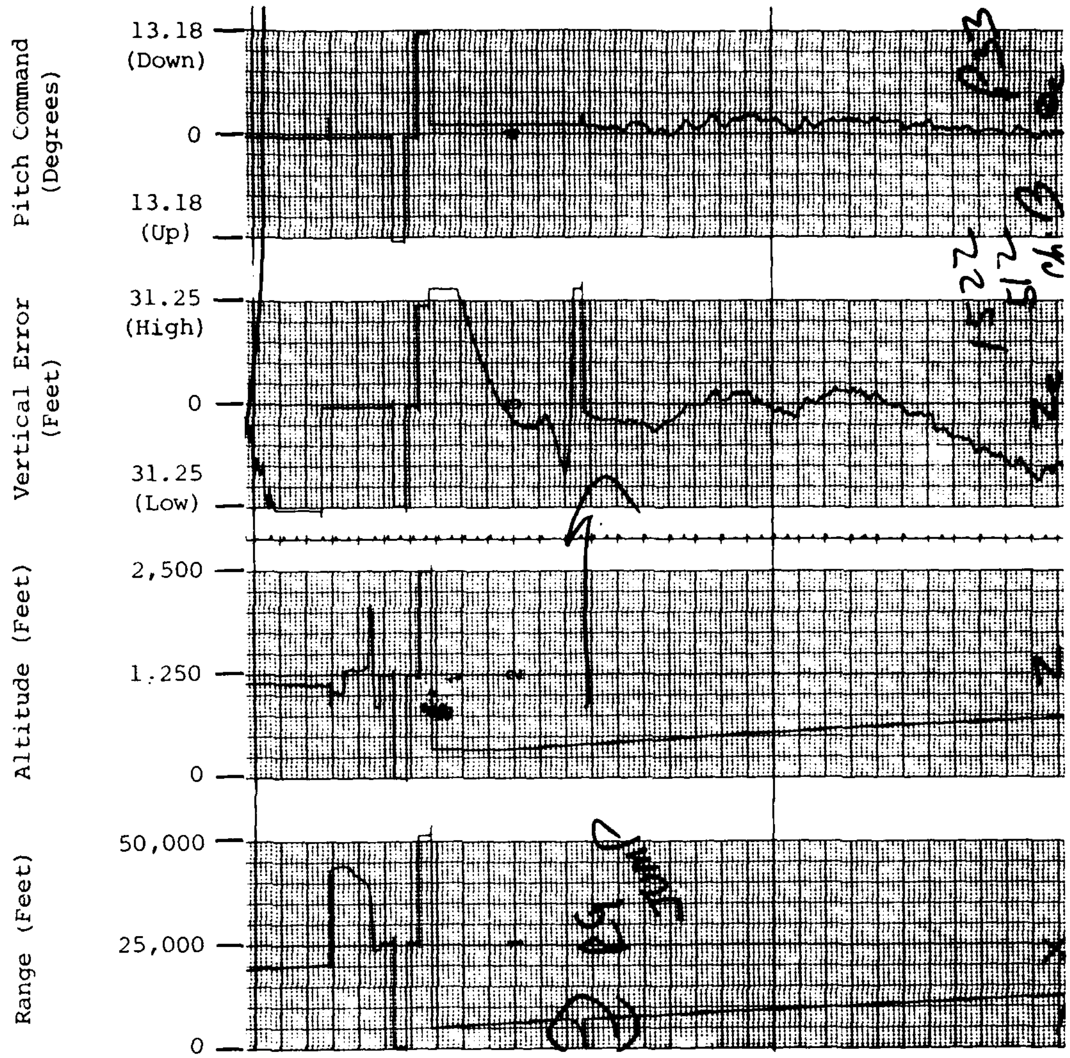


Figure 11-8. AN/SPN-42 INSTRUMENTATION SHOWING SPIKES IN RANGE AND VERTICAL ERROR

attitudes. In addition, the aircraft instrumentation is useful in the alignment evaluation to determine the proper reception of AN/SPN-42 and AN/SPN-41 guidance signals.

Aircraft approach parameters different from nominal can affect the closed-loop control. However, pilot observation can often serve as an adequate substitute for aircraft instrumentation.

SECTION TWELVE

AN/SPN-41 AND TRN-28 CERTIFICATION

12.1 INTRODUCTION

The AN/SPN-41 Instrument Landing System (ILS) (described in Appendix J) and its shore-based counterpart, the TRN-28, are certified as primary ILSs as well as AN/SPN-42 monitors. The certification tests for these two systems include alignment checks and coverage tests.

12.2 IN-PORT ALIGNMENT

Alignment checks of the AN/SPN-41 and TRN-28 are performed after all electrical tests have been completed and are performed by NESEA with NAVAIRTESTCEN flight support. Initial in-port alignment checks are made by NESEA using an optical theodolite on the flight deck to obtain aircraft position data during the approach. Agreement between the AN/SPN-42, AN/SPN-41, and FLOLS is checked by tracking an aircraft with the AN/SPN-42 and having the pilot compare AN/SPN-41 needles while verifying the ball location when on glideslope. Aircraft instrumentation can also be used to verify the comparison of AN/SPN-42/41 needle displays. If alignment corrections are required, the AN/SPN-41 is aligned with the AN/SPN-42.

12.3 AT-SEA ALIGNMENT

The in-port alignment tests are conducted in a static condition (no ship's motion). The at-sea alignment reevaluates the in-port alignment tests by using stabilization inputs from both the MK 19 gyros and SINS stabilization system. The at-sea alignment tests are performed in conjunction with the constant altitude approaches (level legs) used to confirm basic AN/SPN-42 alignment. These level-leg approaches entail the aircraft being tracked by the AN/SPN-42 until the radar breaks lock over the ship. All of the various stabilization systems are evaluated during these level-leg tests.

Once the basic alignment has been verified (and corrected if necessary), coupled ACLS approaches are flown with the pilot checking the alignment between AN/SPN-42, AN/SPN-41, and FLOLS with all three stabilization systems: MK 19 gyros, SINS, and AN/SPN-42 stabilization.

12.4 COVERAGE TESTS

The AN/SPN-41 or TRN-28 is also evaluated to ensure that they provide the expected coverage in azimuth, elevation, and range.

12.4.1 Azimuth Coverage

The AN/SPN-41 or TRN-28 is designed to provide coverage to ±20 degrees of center line. This may be checked through the use of two methods. The first is to fly a constant arc at some distance from the ship. Generally, a 12 nmi arc is used for this test. By using the TACAN to provide distance (for the constant arc) and bearing information, it is possible to determine the total angular coverage of the system by recording when the ARA-63 flags disappear (signifying signal acquisition) and when the flags reappear (signifying the signal loss). The difference in the two bearings is the total angular coverage. The aircraft should be flown in both directions to verify the initial coverage results.

The second method of determining azimuth coverage is by using the AN/SPN-42 to track the aircraft flying lateral offsets parallel to the AN/SPN-42 center line.

When the ARA-63 flags disappear, the range and lateral error measurements from the AN/SPN-42 allow the azimuth angular coverage to be calculated geometrically as shown in Figure 12-1.

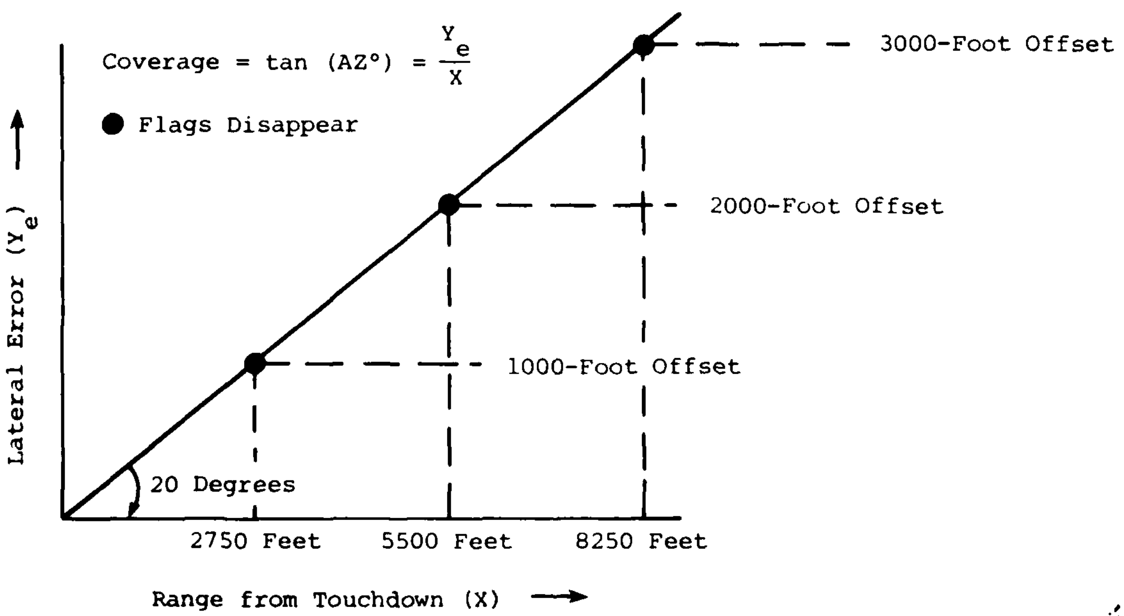


Figure 12-1. GEOMETRY OF ANGULAR-COVERAGE CALCULATIONS

The AN/SPN-42 may also be used to track the aircraft along constant arcs; however, the arcs must be within the range of the AN/SPN-42, which is limited to 8 nmi. The azimuth coverage of the AN/SPN-42 is ±55 degrees.

12.4.2 Elevation Coverage

The elevation coverage of the AN/SPN-41 may also be checked by the same two methods used for the azimuth coverage. Measurement of elevation coverage requires that the aircraft be flown at a constant altitude. The altitude is used with a range measurement to calculate the angle where the ARA-63 flags disappear. The geometry for the elevation-coverage calculation is similar to Figure 12-1, where the vertical error would replace the lateral error term in the equation.

The AN/SPN-42 will search through -15 to +30 degrees of elevation whereas the AN/SPN-41 currently only has 0 to 10 degrees of elevation-angular coverage. The AN/SPN-41 improvement program will raise the elevation-angular coverage from 0 to 20 degrees. The TRN-28 currently searches through 0 to 20 degrees of elevation angle.

Since TACAN distance measurements are displayed only to an accuracy of 600 feet, the AN/SPN-42 method will give the most accurate measurements for the angular-coverage measurements; however, the AN/SPN-42 is not always available for these tests.

12.4.3 Range Coverage

Range coverage of the AN/SPN-41 or TRN-28 is required to be up to 20 nmi from the touchdown point but generally exceeds 50 nmi in clear weather. The range coverage is determined by the aircraft flying to the limits of the AN/SPN-41 and recording the distance at which the ARA-63 flags disappear. This test is normally performed during the initial approaches of the aircraft from the host shore station to the ship.

12.4.4 Proportional Coverage

The proportional azimuth and elevation-angular coverage may be determined by the same methods used for the total angular coverage. The difference is that the pilot must watch for needle movement through small angles. The elevation-angle proportional coverage is only ±1.4 degrees about the selected glideslope while the azimuth proportional coverage is limited to ±6.0 degrees.

Aircraft instrumentation may be used to detect needle movement, but ACLS aircraft instrumentation does not generally include range measurements.

An alternative method of measuring proportional coverage is to use intentional glidepath deviations during ACLS Mode II approaches to measure the geometric errors associated with full-proportional coverage. These geometric errors are then converted to angular measurements.

12.5 CERTIFICATION REPORT

The certification report on the AN/SPN-41 or TRN-28 does not give any details of the tests, only that the systems were tested, aligned, and are satisfactory for operation as an AN/SPN-42 Mode I monitor or primary ILS.

12.6 TRN-28 CERTIFICATION

TRN-28 certifications are conducted in the same manner as AN/SPN-41 certifications. There are no particular differences, with the exception that some TRN-28 installations may not be sited with AN/SPN-42 shore-based systems (e.g., NALF San Clemente). This obviates any testing with the AN/SPN-42 tracking system and makes all evaluations dependent on pilot records and aircraft instrumentation (cockpit or test).

SECTION THIRTEEN

CERTIFICATION OF SHORE-BASED ACLS INSTALLATIONS

13.1 INTRODUCTION

Certification of shore-based ACLS installations is conducted in the same manner as certification of ship installations. The major difference is the magnitude of the effort required for certification.

Shore-based installations are normally certified with one type of aircraft. Since there are no pitch ramps involved, the other Mode I ACLS aircraft are not required to be flown during the certification effort. This certification effort requiring only one aircraft, one pilot, and one project engineer eliminates most of the logistics effort involved in a ship certification. The data required are minimal, since the data originates from the AN/SPN-42 or aircraft instrumentation. No camera data are collected nor are any landing parameters measured. The certification is not predicated on touchdown dispersion but rather on glidepath acceptability. Touchdown dispersion data are not used because runway length and width permit large touchdown dispersions without affecting landing safety.

13.2 RESPONSIBILITIES AND PROCEDURES

The responsibility for conducting a shore-based ACLS certification test is the same as for a shipboard certification. NAVAIRTESTCEN is responsible for the flight test portion of the certification as well as the required FLOLS check. NESEA is responsible for the electrical checks, alignment, and proper operation of the ground equipment.

The NAVAIRTESTCEN engineer follows the same precertification procedures required of a ship's certification except that the shore-based effort may allow a number of required memoranda to be disregarded. In general, all certification correspondence will be required (although it may be reduced in content). Maintenance, TSD, airlift, and shipboard briefing memoranda may be eliminated. The TSD memoranda will depend on whether or not aircraft instrumentation will be used.

Generally, if only one aircraft is being used for the certification, it will be requested that the air station with the ACLS installation being certified designate a host squadron to provide maintenance support for the NAVAIRTESTCEN aircraft.

13.3 CONDUCT OF CERTIFICATION

The certification is conducted in the same manner as a shipboard ACLS certification with respect to FLOLS, AN/SPN-42, and TRN-28 (the shore-based version of the AN/SPN-41) alignment ground and flight checks. Since there are no stabilization systems for ship's motion required with a shore-based installation, this should be a straightforward process.

Once the systems are aligned, Mode I approaches are flown to evaluate the controllability of the system. AN/SPN-42 instrumentation is used to evaluate system control, and pilot AQRs are used for pilot acceptability.

Many of the problems associated with shipboard test conditions are eliminated during the shore-based certification. It can be expected, however, to observe more turbulence because of changes in terrain or temperature during a shore-based certification. This turbulence must be considered when reviewing the AN/SPN-42 instrumentation.

Generally, two or three flight periods are used for each touchdown point in an attempt to observe different times of day and different wind conditions. Turbulence is less during the early morning and early evening hours.

13.4 CERTIFICATION CRITERIA

Glidepath data from the AN/SPN-42 I/O console and pilot ratings are used for the certification. The overall average of the glideslope data should be within +5 feet of the desired glideslope. The glideslope should be a smooth trace or plot with no sharp glideslope deviations in-close.

Pilot ratings should average 3.0 or less under nonturbulent conditions and 4.0 or less with turbulence. With these criteria, it is assumed that AN/SPN-42 tracking is satisfactory and that there is no excessive noise on the command parameters.

13.5 REPORTING REQUIREMENTS

The reporting requirements for a shore-based certification are the same as for a ship certification. The difference is that there are less data to report and no landing predictions to be made.

SECTION FOURTEEN

CERTIFICATION VERSUS VERIFICATION

14.1 INTRODUCTION

Certification is a complex process designed to thoroughly document the performance of ship or shore-based AN/SPN-42 installations. ACLS, as a closed-loop system, should provide constant controllability when operated within specified tolerances for equipment electronics and for the dynamic operating conditions of wind speed, wind direction, ship's motion, and ship's trim.

Once a certification is accomplished, the question may be asked: Is it necessary to repeat the process every 18 to 24 months? The answer depends on how operationally acceptable the certification has been. Ships that use ACLS with reasonable success probably should not be recertified but *should only have the ACLS performance* verified by *a* NAVAIRTESTCEN/ NESEA test team. Ships that have unsuccessful ACLS deployments because of aircraft controllability or touchdown dispersion should be recertified. In addition, NAVAIR Instruction 13800.11A specifies when an ACLS verification is required.

14.2 VERIFICATION

Verification tests are logistically less complex than certification tests. A verification requires the complete electrical and alignment checks by NESEA but only limited flight tests by NAVAIRTESTCEN. The limited flight tests are generally flown with one test aircraft type to verify the in-close control and touchdown performance data of that aircraft type obtained during the previous certification effort. Successful data repeatability for the one aircraft type during the verification allows the assumption of certification data validity to be extended to all previous certification data.

The limited flight tests must be conducted within the limits of the previous certification for wind speed, wind direction, ship's motion, and ship's trim. Conducting the verification under conditions other than those of the original certification can produce a new set of control and touchdown data that may disagree with the previous certification data. Any attempts to influence the verification data through new control ramps or any other AN/SPN-42 program change would invalidate all of the previous certification flight test data and require a new flight test certification effort.

14.3 TEST PROCEDURES

Test procedures for a verification are the same as for certification. The major difference is that only one aircraft will be used. All pre-sail tests such as FLOLS alignment and aircraft check-outs must be performed.

Perhaps the most important procedure during a verification is a thorough review of the previous certification records with respect to the control experience, 20-second data, and AN/SPN-42 problems, if any. The project team is testing only to verify the previous certification, not to generate data for a new certification. During a verification, the major emphasis should be placed on ensuring proper alignment and operation of the AN/SPN-42 rather than generating touchdown statistics.

APPENDIX A

NAVMATINST 5400.20

This appendix is a reproduction of NAVMATINST 5400.20, dated 24 July 1979.

DEPARTMENT OF THE NAVY
HEADQUARTERS NAVAL MATERIAL COMMAND
WASHINGTON D C 20360

IN REPLY REFER TO

NAVMATINST 5400.20
MAT 09H1/CSW
24 July 1979

NAVMAT INSTRUCTION 5400.20

From: Chief of Naval Material

Subj: Management of the Automatic Carrier Landing System (ACLS) and National Microwave Landing System (NMLS)

Ref: (a) NAVMATINST 5460.2A of 28 July 1975, NMC Organization Manual

1. Purpose. To assign responsibilities and prescribe procedures for management of ACLS and NMLS within the Naval Material Command, in amplification of reference (a).

2. Cancellation. NAVMATINST 13800.1 of 29 April 1975 is cancelled.

3. Background. The Chief of Naval Material assigned lead management/coordination responsibility for the ACLS and NMLS programs to the Naval Air Systems Command (NAVAIR) when the Naval Air Control and Identification Systems (NACIS) Project Management Office (PM-6/8) was dissolved. NAVAIR was also directed to provide material support (including management and funding) for ACLS/NMLS airborne subsystems. The Naval Electronic Systems Command (NAVELEX) was directed to provide material support (including management and funding) for ACLS/NMLS shipboard and shore subsystems. For purposes of this instruction, ACLS consists of: (1) shipboard equipment: AN/SPN-41, AN/SPN-42A, and AN/SPN-XX; (2) shore-based equipment: AN/SPN-42T1/2/3/4, AN/SPN-XX, and AN/TRN-28; and (3) aircraft equipment: AN/ARA-63, AN/APN-154 or AN/APN-202, AN/ASW-25 or AN/ASW-27, Automatic Flight Control System (AFSC) and Approach Power Compensator (APC).

4. Responsibilities. Specific responsibilities are assigned as follows:

a. COMNAVAIRSYSCOM is responsible for:

(1) Providing lead management, coordination and certification functions within the NMC, for the ACLS, NMLS and other landing systems programs, as assigned.

(2) Acting as primary NMC point-of-contact with OPNAV, higher authority, and other military/civil agencies regarding ACLS, NMLS and other landing systems programs, as assigned.

(3) Exercising management control (establishing priorities) of field activity support provided at ACLS and NMLS test sites.

(4) Providing, on an additional duty basis, a Navy project officer (0-5) as the representative to both the NMLS Project Office of the FAA and to the Joint Tactical Microwave Landing System (JTMLS) Lead Service Program Office (LSPO). The project officer will ensure that Navy/Marine Corps operational requirements are properly accommodated, and that Navy/Marine Corps development tasks are coordinated with those of other participating agencies.

(5) Providing lead management/coordination of the overall Navy/Marine Corps participation in the approved Joint National MLS Development Program. In performing this function, the NAVAIR NMLS Project Coordinator shall chair an intercommand Navy/Marine Corps NMLS Working Group of representatives designated by each participating command to provide coordination of Navy/Marine Corps supporting development tasks and assistance to the FAA.

(6) Planning for and, when specifically assigned by OSD, performing the DOD Lead Service Program Office duties for development of the Shipboard Microwave Landing System (SMLS) including any associated airborne subsystem.

(7) Providing RDT&E Advance Development planning, programming, and budget support of the Navy/Marine Corps participation in the joint NMLS development program.

(8) Based on NMLS Advanced Development, plan, manage and coordinate an intercommand RDT&E Engineering Development program to provide operational shore-based shipboard and airborne NMLS equipment.

(9) Planning and managing the Navy/Marine Corps flight test program of prototype NMLS equipment.

(10) Acting as NMC focal point for consideration of changes to the ACLS. In this capacity, the ACLS project coordinator shall periodically chair an intercommand ACLS Engineering Change Coordination (ECC) meeting to monitor and maintain the integrity and compatibility of all elements of the ACLS system. NAVAIR shall issue an instruction describing the ACLS ECC process.

(11) Overseeing ACLS aircraft installation activity, and issuing a list of ACLS aircraft and the modes for which these aircraft are qualified. Included are resolution of planning and budgeting problems

with appropriate aircraft project managers/coordinators, ensuring adequate procurement and timely installation of ACLS components, and coordination of ACLS qualification testing of existing and new aircraft types.

(12) Planning and managing/coordinating intercommand RDT&E efforts to overcome ACLS deficiencies and provide system improvements to satisfy approved operational requirements.

(13) Monitoring the training of ACLS maintenance and operation personnel and the updating of technical publications, NATOPS manuals, etc.

(14) Managing, funding, and scheduling the flight portion of certification of ACLS ship and shore installations. NAVAIR will issue an instruction describing the ACLS certification process. MMLS certification procedures will be published when appropriate.

(15) Assuring that all landing system program matters, for which NAVAIR is responsible, and which involve Marine Corps landing systems under NAVELEX PDA responsibilities, are coordinated with NAVELEX prior to implementation.

b. COMNAVELEXSYSCOM is responsible for:

(1) Cooperating with and supporting NAVAIR in its ACLS/MMLS lead management role. All contact with higher authority in ACLS/MMLS matters will be closely coordinated with NAVAIR.

(2) Providing representatives to the MMLS working group and participating in ACLS engineering change coordination meetings. These representatives will function as NAVELEX points-of-contact for interagency coordination of MMLS and ACLS matters.

(3) Providing material support (including management, funding and scheduling) for shipboard and shore-based subsystems. Costs of flight test support for such subsystems will be funded by NAVELEX (this does not include flight certification costs).

(4) Providing pre-certification support, including logistic support assistance teams (LOGSATS) to aid ships' personnel in identifying ACLS COSAL shortages (shortage lists will be provided to NAVSUP).

(5) Assisting NAVAIR in the certification of ACLS shipboard and shore-based subsystems.

(6) Monitoring field change status, and advising NAVAIR of conditions that could degrade ACLS/MMLS performance.

(7) Acting as Principal Development Activity (PDA) and Acquisition Manager (AM) for all surface systems and equipment of all Marine Corps landing systems not delegated to NAVAIR.

(8) Assuring that all landing system program matters, for which NAVELEX is responsible, and which involve airborne equipment under NAVAIR cognizance, are coordinated with NAVAIR prior to implementation.

c. COMNAVSEASYSCOM is responsible for:

(1) Assisting NAVAIR in the certification of ACLS shipboard subsystems.

(2) Monitoring SEIPALTS and field change status, and advising NAVAIR of conditions that could degrade ACLS/MMLS performance.

(3) Funding the certification of new construction.

d. NAVSUPSYSCOM is responsible for providing support to LOGSATS in expediting COSAL shortages, prior to the start of certifications.

5. Action. Addressees shall take action as required to carry out responsibilities assigned in paragraph 4.

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Special Assistant to the
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APPENDIX B

NAVAIRINST 13800.11A

This appendix is a reproduction of NAVAIRINST 13800.11A, dated 25 May 1982.

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
NAVAL AIR SYSTEMS COMMAND HEADQUARTERS
WASHINGTON DC 20361

IN REPLY REFER TO
NAVAIRINST 13800.11A
AIR-551
25 May 1982

NAVAIR INSTRUCTION 13800.11A

From: Commander, Naval Air Systems Command

Subj: Procedures and responsibilities for certification/verification of Automatic Carrier Landing System (ACLS)

Ref: (a) NAVMATINST 5400.20 of 24 Jul 1979
(b) NAVELEX-0967-LP-304-4300, "Operational Logistics Support Summary for the AN/SPN-42A and T-4," dtd Jun 1979
(c) NESTED No. 022-102B, "ACLS Certification Procedures, Category I and IIA", dtd 1 Jun 1979
(d) NAVELEX/NAVAIRTESTCEN Automatic Carrier Landing System (ACLS) Category III Certification Manual dtd Jan 1982 (NOTAL)
(e) NESTED No. 022-106A, "Certification Test Procedures for Aircraft Approach AN/SPN-41", dtd 1 May 1979

Encl: (1) ACLS Certification Events

1. Purpose. To establish procedures and assign responsibilities within the Naval Air Systems Command Headquarters (NAVAIR HQ) for certification/verification of ACLS and to promulgate responsibilities for the Naval Electronic Systems Command Headquarters (NAVELEX HQ), Naval Electronic Systems Engineering Activity (NAVELEXSYSENGACT) and the Naval Sea Systems Command Headquarters (NAVSEA HQ) as established by reference (a).

2. Cancellation. NAVAIR Instruction 13800.11 of 9 Nov 1978 is hereby superseded. Because this is a complete revision, changes have not been identified.

3. Background. Reference (a) assigned the Commander, Naval Air Systems Command the lead management/coordination responsibility for ACLS certification/verification efforts, to include acting as primary point of contact for the Naval Material Command. The procedures developed by the NAVAIR HQ and delineated in this instruction will be adhered to during certification/verification of the ACLS.

4. Definitions

a. Automatic Carrier Landing System (ACLS). A system for the all-weather recovery of carrier-based aircraft consisting of the following components:

(1) Landing Control Central (AN/SPN-42 series).

(2) Link 4A Data Link and Naval Tactical Data System (NTDS) or Carrier Traffic Control Center Direct Altitude Identity Readout (CATCC DAIR) aboard ship.

(3) Independent System Monitor (AN/SPN-41 or AN/TRN-28 series).

(4) Qualified ACLS Capable Aircraft.

b. ACLS Approach Modes

(1) ACLS Mode I Approach. An approach in which the aircraft is controlled automatically to touchdown.

(2) ACLS Mode IA Approach. An approach in which the aircraft is controlled automatically to 200 feet above and 1/2 mile from the touchdown point.

(3) ACLS Mode II Approach. A monitored approach in which precise and continuous position error information is displayed in the aircraft enabling a manually controlled precision approach to appropriate visual conditions (similar to conventional Instrument Landing System (ILS)).

(4) ACLS Mode III Approach. An approach in which the pilot is supplied position and guidance information by voice by a surface controller (similar to Ground Control Approach (GCA)/Carrier Control Approach (CCA)).

c. Qualified ACLS Aircraft. An ACLS-configured aircraft model that has been flight tested and found suitable for ACLS Mode I, IA or II approaches and the qualification promulgated in that aircraft Naval Air Training and Operating Procedures Standarization (NATOPS) manual.

d. Instrumented ACLS Aircraft. Qualified ACLS aircraft with special onboard instrumentation recording/telemetry system for monitoring aircraft flight and ACLS system parameters.

e. ACLS Installation Certification. A shipboard or shore-based installation that has been flight checked and certified for a designated mode of operational or qualified ACLS-configured aircraft. Appropriate restrictions such as ceiling/visibility, maximum/minimum wind conditions, specified glide slope, deck motion limitations, and aircraft model/series will be included in the certification. When an installation is certified for a particular mode of operation, all modes with a numerically greater designation are included (e.g., a Mode I certification includes Mode IA, II and III certification). No aircraft will make approaches in any mode until that shipboard/shorebased ACLS facility has been certified or verified as outlined in this instruction.

f. ACLS Installation Verification. A functional check on the operation of all or part of an ACLS system restricted to currently certified aircraft within the limits specified in the most recent Mode I certification clearance.

5. Determination of Certification/Verification Requirement. Reference (b) provides guidance for determining when a certification/verification is required. The following sections provide additional guidance. When ambiguities result, an engineering determination will be made by the Naval Air Test Center (NAVAIRTESTCEN)/NAVELEXSYSENGACT to determine the scope and timing of required tests.

a. Certification. A Certification of a shipboard/shorebased ACLS installation is required:

(1) after initial ACLS installation or installation of a new modification/update to major ACLS related systems;

(2) after relocation of system components which affect basic system alignment (radar pedestals and Data Stabilization System (DSS) platforms);

(3) after a significant change in the average operating conditions from those which had previously been certified (more than 0.2 degree ship's pitch trim, and more than 5 kts Wind Over Deck (WOD));

(4) after a major structural change to the flight deck/island structure which may change the burble or location of touch down point;

(5) for certification of a qualified aircraft model series not included in previous certifications;

(6) when electrical/flight verification tests confirm unsafe and/or improper operations of the installations;

(7) for control program modification to improve aircraft control during last mile of the approach;

(8) for certification of a basic glide slope setting not previously certified;

(9) after an installation has been downgraded from a Mode I to a Mode IA and reasons for downgrade are determined to require recertification.

(10) SPN-42 certification tests will be accomplished in accordance with references (c) and (d). As a part of the SPN-42 certification, SPN-41, which is monitored during Mode I approaches, will be tested in accordance with reference (e) and certified.

b. Verification. The verification of a shipboard/shorebased ACLS is of smaller scope and shorter duration than a complete certification. The functional operation of a ship or shorebased ACLS system may be verified by ship's force to the limits set in reference (c). When verification is beyond ship's force capabilities as stated in reference (c), a test team will be furnished by NAVAIR HQ and NAVELEX HQ to assist in the verification using the procedures of reference (d).

(1) The system certification will be downgraded appropriately until verification has been performed when:

(a) major system overhaul/repair or modification/update to ACLS related systems is made;

(b) modification/updates are made to Navy Tactical Data System (NTDS)/ACLS programs affecting system performance;

(c) repair/replacement of certain components which affect basic system alignment and/or operation as listed in reference (b) occurs. An engineering determination will be made in each case by NAVAIRTESTCEN/NAVELEXSYSENGACT to determine the scope of effort required.

(2) A verification is also required when more than 18 months has elapsed since the last certification or verification and when surface/airborne system performance trends raise doubt as to the safe and proper operation of the ACLS equipment.

c. The primary certification/verification activity will be NAVAIR HQ assisted by NAVELEX HQ and NAVSEA HQ. Requests for certification/verification will be made by the Type Commander to NAVAIR HQ (AIR-551) with copies to NAVAIRTESTCEN, NAVELEX HQ, NAVELEXSYSENGACT and NAVSEA HQ. Requests should be initiated at least six months prior to the Category I tests to facilitate planning.

d. Enclosure (1) outlines the sequence of the events which must be followed to accomplish an ACLS certification/verfication.

6. Procedures

a. Certification Tests. Three categories of certification tests are established:

(1) Category I - Diagnostic tests to ensure the correct installation, interconnection, interface, alignment and performance of ship/shore station ACLS components.

(2) Category II - Pier-side/shore station flight tests.

(a) Category IIA - Helicopter or fixed-wing aircraft flight checks to determine SPN-42 glidepath and azimuth accuracy, SPN-42/SPN-41/FLOLS glidepath alignment, and Mode III performance, within limits for Mode III certification.

(b) Category IIB - Fixed-wing ACLS equipped aircraft (instrumented when feasible) flight checks to ensure satisfactory automatic control of the aircraft in static (no ship's motion) condition.

(3) Category III - At sea or shore station tests using ACLS-qualified aircraft to ensure satisfactory automatic control of the aircraft in the operational environment. The ACLS qualified aircraft used in certification will normally include at least one instrumented aircraft. Measurement of Mode I aircraft touchdown parameters will normally be required. A sufficient number of passes will be required to establish statistical confidence in the data.

b. Documentation. Operations plan specifying personnel, procedures and schedule for the verification/certification team, certification situation reports (SITREPS) and interim/final certification reports.

c. Verification Tests. Data will be obtained to determine satisfactory ACLS derived aircraft position data alignment and noise characteristics. Normally, tests with one aircraft type will be sufficient to verify all aircraft types certified for the ACLS ship/shore installation. Measurement of Mode I ACFT touchdown parameters normally will not be required.

7. Clearance Authority

a. NAVAIR HQ (AIR-551) is designated the issuing authority for ACLS clearances. Authority to issue, by message, specific mode clearances is delegated to certification team members as follows:

(1) Mode III - will be issued by senior NAVELEXSYSENGACT team member upon successful completion of Category IIA tests. Category IIB and III tests can proceed only after completion of Category I and IIA tests.

(2) Mode II - will be issued by senior NAVAIRTESTCEN certification test coordinator after completion of Category IIB tests and satisfactory system performance during initial phases or Category III tests.

(3) Mode IA - will be issued by NAVAIRTESTCEN certification test coordinator after completion of the system optimization phase of Category III tests.

(4) Interim Mode I - will be issued by NAVAIRTESTCEN certification coordinator at completion of Category III tests based on preliminary data analysis provided that no Part I deficiencies are outstanding. A Part I deficiency must be corrected because it adversely affects airworthiness of the aircraft, the ability of the aircraft to accomplish its primary or secondary mission, effectiveness of the crew as an essential subsystem or the safety of the crew. Remote possibilities or unlikely sequences of events shall not be used as a basis for safety items.

(5) Final Mode I - will be issued by NAVAIR HQ (AIR-551). NAVAIRTESTCEN, following detailed data analysis, will forward certification recommendation by message to NAVAIR HQ (AIR-551).

b. When testing reveals system deficiencies, specific certification clearances shall be withheld until corrective action has been completed. NAVELEX HQ, NAVAIR HQ, NAVSEA HQ and the ship or shore station concerned will be informed of test results by the test activity (NAVAIRTESTCEN and/or NAVELEXSYSENGACT). After the certification is completed, a final status report will be transmitted to operational and Type Commanders.

8. Responsibilities

a. NAVAIR HQ

(1) Coordination of the schedule and conduct of the certification, with NAVELEX HQ, NAVSEA HQ and supporting test activities.

(2) Budgeting and funding of the flight portion of ACLS certification/verifications.

(3) Promulgation of an outline of certification test activities to all concerned specifying projected flight hours, personnel, and carrier deck time requirements.

(4) Upon completion of testing and analysis of test data, issuance of a final Mode I ACLS certification to the commanding officer of the specific ship or shore station involved, via the Type Commander, with information copy to the Fleet Commander and Carrier Airwing Commander.

(5) Promulgation of status of compatibility/capability of various ACLS-equipped aircraft model/series with specific ACLS installations.

(6) Designate or provide a qualified Certification Test Coordinator and team members to perform Category IIB and III tests. The Test Coordinator is the certification team leader and NAVAIR HQ representative for Category IIB and III tests. He/she is the interface among all members of the certification team (NAVAIRTESTCEN and NAVELEXSYSENGACT) and the ship or shore station being certified. All team members will keep the Test Coordinator informed of test progress in their respective areas.

b. NAVELEX HQ

(1) Update reference (c) as necessary and issue additional implementation instructions and technical publications as required for ACLS certification, with NAVAIR HQ (AIR-551) assistance and concurrence.

(2) Support NAVAIR HQ by providing certification team members qualified with respect to the system's ship/shore components to perform Category I and IIA certification tests. The senior team member will act as Test Coordinator during these tests.

(3) Support NAVAIR HQ by providing certification team members qualified with respect to the system's ship/shore components to assist in the Category IIB and III tests.

(4) Retain budgetary and funding responsibility for the above support (does not include flight test financial responsibility).

(5) Provide guidance relative to certification/verification criteria.

(6) Advise NAVAIR HQ that Category I and IIA tests are complete and system status permits commencement of Category IIB and III tests.

(7) Provide team members for verification.

c. NAVSEA HQ

(1) Assist NAVAIR HQ, as required, during certification of ACLS ship subsystems.

(2) Monitor the status of all shipalts and field changes, and advise NAVAIR HQ of conditions which would result in ACLS performance degradation.

9. Action. Addressees will take required action to carry out the responsibilities assigned in paragraph 8 above.

R. D. Johnson

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Assistant Commander for
Systems and Engineering

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ACLS CERTIFICATION/VERIFICATION EVENTS

1. Certification Requested (TYCOM to NAVAIR HQ).

2. Special schedule or support requirements request (NAVELEXSYSENGACT/ NAVAIRTESTCEN to ship/shore station).

3. Certification planning meeting (TYCOM, Ship, NAVELEXSYSENGACT, NAVAIRTESTCEN).

4. Precertification inspection (NAVELEXSYSENGACT).

5. Modification installations (NAVELEXSYSENGACT).

6. Category I tests (NAVELEXSYSENGACT).

7. Category IIA tests (NAVELEXSYSENGACT).

8. Mode III certification (NAVELEXSYSENGACT).

9. Ships Inertial Navigation System and Fresnel Lens certified prior to Category IIB tests (TYCOM).

10. Category IIB tests (NAVAIRTESTCEN/NAVELEXSYSENGACT).

11. Electrical Verification of ACLS for CAT III Tests (NAVELEXSYSENGACT).

12. Category III tests (NAVAIRTESTCEN/NAVELEXSYSENGACT).

13. Certification report and outstanding discrepancies (NAVELEXSYSENGACT).

14. Interim Mode I certification (NAVAIRTESTCEN).

15. Certified computer program patch tapes forwarded (NAVELEXSYSENGACT) to carrier/shore station).

16. Category I electrical tests results forwarded (NAVELEXSYSENGACT to carrier/shore station).

17. Final certification results (NAVAIRTESTCEN to NAVAIR HQ).

18. Final electrical tests results (NAVELEXSYSENGACT).

19. Final certification (NAVAIR HQ).

Enclosure (1)

APPENDIX C

LANDING PROCEDURES

1. INTRODUCTION

The ACLS landing sequence is composed of two distinct phases: approach and landing. The approach phase is defined as the flight from the marshalling point (the point at which the CATCC first acquires the aircraft from the ATCS) to the radar acquisition window. The landing phase is defined as the flight from the radar acquisition window to touchdown.

2. THE APPROACH PHASE

The purpose of the approach phase is to guide the aircraft to the radar acquisition window. Once the aircraft enters the marshalling area (approximately 20 miles astern of the carrier), it is sequenced for landing on the basis of fuel status and other parameters that determine landing priority. The ILS AN/ARA-63A system is activated upon entry into the marshalling area. The AN/ARA-63A is a receiver/decoder used to process AN/SPN-41 information.

During the letdown from marshalling, an ACLS AN/SPN-42 channel is assigned to the aircraft and the appropriate aircraft control parameters are selected on the AN/SPN-42 control console. Each aircraft type has its own set of control parameters that take into account the response characteristics of that particular type of aircraft. The LANDING CHECK discrete is then transmitted to the aircraft, illuminating the LANDING CHECK light on the cockpit display. The LANDING CHECK discrete indicates that CATCC has an ACLS channel available and verifies that positive data link contact with CATCC has been established. LANDING CHECK also alerts the pilot to prepare his aircraft for a carrier landing if he has not already done so. The aircraft is normally already in a landing configuration upon receipt of the LANDING CHECK discrete.

3. THE LANDING PHASE

When the aircraft passes through the radar acquisition window, it is acquired by the ACLS AN/SPN-42 radar. The radar tracks a point source on the aircraft, such as a radar beacon or a corner reflector, to determine its spatial position with respect to the radar antenna. The ACLS automatically transmits the ACL READY discrete to the aircraft, indicating that the aircraft has been acquired by CATCC and that glidepath data are being transmitted for heads-up or heads-down cockpit display. Control of the aircraft is then transferred from the approach controller to the final controller, and the desired landing mode (I, II, or III) is selected by the pilot.

3.1 Mode I Landing Sequence

In a Mode I descent, CATCC generates an AP CPLR or COUPLER AVAILABLE discrete to indicate that CATCC is ready to control the aircraft and the autopilot (AFCS) should be engaged. Once the pilot couples the AFCS to the data link, CATCC is automatically advised of the coupling by data link reply messages. The controller then transmits the CMD CONTROL discrete. Illumination of the CMD CONTROL light signifies that the aircraft is under data link control for landing. Pitch and bank commands are transmitted over the data link to the aircraft. The AFCS executes the data link commands while the autothrottle (APC) maintains the angle of attack through thrust control.

Whenever the aircraft exceeds the Mode I flight path control envelope defined by the ACLS, the AFCS is automatically uncoupled, a COUPLER OFF discrete is displayed, and control of the aircraft is reverted back to the pilot. The approach is continued as a Mode II or Mode III descent. If the aircraft has deviated too greatly from the ACLS flight path, a WAVE OFF discrete is transmitted by the controller. The WAVE OFF discrete informs the pilot that unsafe landing conditions exist. The AFCS, if engaged, automatically disengages and the aircraft reverts to manual control. The pilot may make a manual landing, if feasible, if he is waved off by the ACLS controller. The pilot then transfers the guidance of the aircraft to the bolter/wave-off controller, who directs the pilot back into the landing sequence.

If within any 2-second period during the Mode I descent the data link information is not updated, the TILT discrete is sent to the aircraft. Like the WAVE OFF discrete, the TILT discrete automatically uncouples the AFCS and reverts the aircraft to manual control. The descent may be continued in Mode II or Mode III.

When the aircraft is approximately 12.5 seconds from touchdown on the carrier deck, the 10 SECOND discrete is illuminated to tell the pilot that deck motion compensation (DMC) data are being added to the glidepath information and the data link commands. If any component of the carrier-based landing system equipment fails when the aircraft is between 12.5 and 1.5 seconds from touchdown, CATCC generates a WAVE OFF discrete. A WAVE OFF is also generated up to 5 seconds before touchdown if the aircraft exceeds the AN/SPN-42 flightpath control envelope. The final controller may initiate a WAVE OFF when the aircraft is within one mile from touchdown. In addition, if the pilot cannot see the Fresnel Lens "meatball" at weather minimums (200 foot ceiling, 1/2 mile visibility), the approach must be waved off.

At 1.5 seconds from touchdown, pitch and bank commands are frozen by the ACLS. The AFCS holds the aircraft at a constant attitude until touchdown. However, the pilot may override the AFCS by maneuvering the control stick with sufficient force or by disengaging the system manually and assuming control of the aircraft. If, for example, the aircraft receives a wave-off or if the pilot decides to go around, maneuvering the control stick automatically disconnects the AFCS so that the pilot can enter the bolter/wave-off pattern. An ACLS bolter will disengage the AFCS through the weight-on-wheels disconnect.

3.2 Mode II Landing Sequence

A Mode II approach is identical to a Mode I approach until the receipt of the ACL READY discrete. The pilot does not couple the AFCS to the data link, but continues to fly the aircraft manually in response to the flight-path data being displayed in the cockpit by the data link. The pilot may switch to a Mode I approach at any time prior to 12.5 seconds to touchdown, provided that the ACL CPLR discrete is being received and ACL interlock is true.

If any of the shipboard ACLS equipment fails during a Mode II approach, the pilot receives a VOICE discrete from the controller, denoting that CATCC SPN-42 is not available for ACL. The pilot then expects to receive voice commands over a standard voice communications link.

As long as the aircraft is flying within the AN/SPN-42 flightpath control envelope, the descent is continued until the meatball of the Fresnel Lens becomes visible. As with the Mode I landing sequence, the approach is terminated if the pilot cannot see the meatball at weather minimums. Wave-offs may only be generated by the final controller or the LSO; however, the ACLS cannot initiate a wave-off.

3.3 Mode III Landing Sequence

A Mode III landing is a talk-down landing. The Mode III landing sequence follows the same format as that of Modes I and II, but all flight path data and corrections are transmitted to the aircraft by voice. No data link discrete signals are sent. If the pilot cannot see the meatball to continue his landing, the approach is terminated by either the final controller or the LSO.

APPENDIX D

AN/SPN-42 CONTROL PROGRAM AND AIRCRAFT-DEPENDENT PARAMETERS

The AN/SPN-42 controls aircraft through the command transfer functions used to generate appropriate pitch (θ_C) and bank (ϕ_C) commands. These two transfer functions use the measured-position data with the pre-set aircraft-type constants to generate the appropriate commands. The aircraft-type constants are determined through aircraft Mode I certification tests.

In preparing the memorandum from NAVAIRTESTCEN to NESEA, the ACLS project engineer details the various aircraft parameters, gains, and range scheduling desired for the AN/SPN-42 control program for the particular aircraft being used for the ship's certification. This is accomplished by referencing "AN/SPN-42A Aircraft Dependent Parameter" forms, shown in Figure D-1 (for an A-7E aircraft).

1. AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM

The top of the form in Figure D-1 is self-explanatory. The remainder of the form is developed from the AN/SPN-42 control program for the particular aircraft parameters. The axis column refers to which control axis (vertical control or lateral control) the parameter belongs. The symbol column is the form the parameter takes in the control equation or contains an explanatory note of the actual program name. The program name defines the parameters in the AN/SPN-42 control program. The decimal value of the parameters is the value calculated and discussed. The octal value is the way in which the parameter is inputted to the AN/SPN-42 program. The scale factor is the bit values used in the program. The program location is the actual address in the AN/SPN-42 program of each parameter and may vary between ships. Figures D-1, D-2, D-3, D-4, and D-5 illustrate these forms filled out for the A-7, F-4, A-6, S-3, and EA-6 aircraft, which are currently the only active Mode I/IA certified aircraft.

It should be noted that the pitch command ramp values may change for different ship installations and that these values in Figures D-1 through D-5 have been excluded.

AN/SPN-42A Aircraft Dependent Parameters

A-7E **Airplane** F5/L3 **Control Program**

Program TYPE 6 **Installation** ______________

Patch Tape ______________ **Date** ______________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Loca- tion	Date of Last Change
	Glide Slope	TGLIDE					
	A/C Data	ACDATA	MI/B/O				
Vert	$1/T_I$	TIGAIN	15.0				
Vert	K_c	TVGAIN	0.13282				
Vert	T_R	TRGAIN	2.00				
Vert	T_A	TA	2.8				
Lat	T_R	RATEGN	6.5				
Vert	α_p	ALPHAP	0.08594				
Lat	α_p	ALPHAB	0.08594				
Lat	K_c	BCPGN	0.115				
Lat	T_A	ACCGN	5.5				
Lat	$1/T_I$	BINTGN	30				
		VRXMAX	22,600				
		VRXMIN	7,600				
Vert	R_x	VRGMIN	0.2				
		VRGMAX	1.0				
		T1MV1					
		T1MV2					
Vert	Pitch	T1MV3					
	Command	T1MV4					
	Ramp	RAMP1					
		RAMP2					
Lat	K_x	LX1	5,000				
		LG1	5,000				
		VX1	30,000				
		VX2	6,000				
Vert	K_x	VX3	3,000				
		VX4	2,400				
		VG1	0.25				
		VG2	1.00				
		VG3	1.25				
Vert	α_A	KAP	0.08008				
	α_A	KAB	0.1250				
		LRX1	30,000				
Lat	D_x	LRX2	5,000				
		LR1	2.125				
		LR2	1.0				
	Hook-to-Beacon	THOOKC					
	α	ALFAX1	15,000				
	Range	ALFAX2	5,000				
Lat	Schedule	ALFA1	0.095169				
	for α-β	ALFA2	0.3				
	Filter						

Figure D-1. SAMPLE OF AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM (A-7E)

AN/SPN-42A Aircraft Dependent Parameters

A-7E **Airplane** F5/13 **Control Program**

Program TYPE 6 **Installation** ________

Patch Tape ________ **Date** ________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/Unit)	Octal Value	Prog Location	Date of Last Change
DMC Filter Difference Equation Gains	KXØ	TUSTA0, L TUSTA0, U	2.177504021				
	KX1	TUSTA1, L TUSTA1, U	-2.096597093				
	KX2	TUSTA2, L TUSTA2, U	-2.172688133				
	KX3	TUSTA3, L TUSTA3, U	2.101412982				
	KY1	TUSTB1, L TUSTB1, U	2.361702128				
	KY2	TUSTB2, L TUSTB2, U	-1.859212313				
	KY3	TUSTB3, L TUSTB3, U	0.487878408				
	KXX0	TUSTCØ, L TUSTCØ, U	2.904761905				
	KXX1	TUSTC1, L TUSTC1, U	-2.809523810				
	KYY1	TUSTD1, L TUSTD1, U	0.904761905				
DMC Filter LaPlace Equation Gains	K	TUSKØ	0.8300				
	K_1		1.11				
	K_2		1.79				
	K_3		1.50				
	t_1		0.21				
	t_2		0.50				
Lat	K_R		.174				

Figure D-1. (continued)

AN/SPN-42A Aircraft Dependent Parameters

F-4 Airplane V-1/L-2 Control Program

Program TYPE 3 **Installation** ______

Patch Tape ______ **Date** ______

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Loca- tion	Date of Last Change
	Glide Slope	TGLIDE					
	A/C Data	ACDATA	MI/R/O				
Vert	$1/T_I$	TIGAIN	15				
Vert	K_c	TVGAIN	0.13333				
Vert	T_R	TRGAIN	1.18				
Vert	T_A	TA	1.00				
Lat	T_R	RATEGN	7.5				
Vert	α_P	ALPHAP	0.125				
Lat	α_P	ALPHAB	0.0625				
Lat	K_c	BCPGN	0.10				
Lat	T_A	ACCGN	7.5				
Lat	$1/T_I$	BINTGN	30				
Vert	R_x	VRXMAX	18,000				
		VRXMIN	6,000				
		VRGMIN	0				
		VRGMAX	1.0				
Vert	Pitch Command Ramp	T1MV1					
		T1MV2					
		T1MV3					
		T1MV4					
		RAMP1					
		RAMP2					
Lac	K_x	LX1	5,000				
		LG1	5,000				
Vert	K_x	VX1	30,000				
		VX2	6,000				
		VX3	0				
		VX4	0				
		VG1	0.25				
		VG2	1.0				
		VG3	1.0				
Vert	α_A	KAP	0.125				
	α_A	KAB	0.125				
Lat	D_x	LRX1	30,000				
		LRX2	5,000				
		LR1	2.125				
		LR2	1.000				
	Hook-to-Beacon	THOOKC					
Lat	α Range Schedule for α-β Filter	ALFAX1	15,000				
		ALFAX2	5,000				
		ALFA1	.095169				
		ALFA2	0.300000				

Figure D-2. SAMPLE OF AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM (F-4)

AN/SPN-42A Aircraft Dependent Parameters
F-4 **Airplane** V-1/L-2 **Control Program**

Program TYPE 3 **Installation** ______

Patch Tape ______ **Date** ______

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Location	Date of Last Change
DMC Filter Difference Equation Gains	KXØ	TUSTAO, L	0.976376				
		TUSTAO, U	3.000000				
	KX1	TUSTA1, L	-0.824569				
		TUSTA1, U	-3.000000				
	KX2	TUSTA2, L	-0.970889				
		TUSTA2, U	-3.000000				
	KX3	TUSTA3, L	0.830056				
		TUSTA3, U	3.000000				
	KY1	TUSTB1, L	0.333333				
		TUSTB1, U	2.000000				
	KY2	TUSTB2, L	-0.814815				
		TUSTB2, U	-1.000000				
	KY3	TUSTB3, L	0.470508				
		TUSTB3, U	0.000000				
	KXX0	TUSTCØ, L	0.877778				
		TUSTCØ, U	3.000000				
	KXX1	TUSTC1, L	-0.655556				
		TUSTC1, U	-3.000000				
	KYY1	TUSTD1, L	0.777778				
		TUSTD1, [illegible]	0.000000				
DMC Filter LaPlace Equation Gains	K	TUSKØ	.80				
	K_1		1.77				
	K_2		1.3				
	K_3		.847				
	t_1		.2				
	t_2		.2				
Lat	K_R		.174				

Figure D-2. (continued)

AN/SPN-42A Aircraft Dependent Parameters
KA-6D/A-6E **Airplane** V13/L8 **Control Program**

Program Type 1 **Installation** ________

Patch Tape ________ **Date** ________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Loca-tion	Date of Last Change
	Glide Slope	TGLIDE					
	A/C Data	ACDATA	MI/B/20				
Vert	$1/T_I$	TIGAIN	15.0				
Vert	K_c	TVGAIN	0.1504				
Vert	T_R	TRGAIN	1.703				
Vert	T_A	TA	1.2031				
Lat	T_R	RATEGN	7.5				
Vert	α_p	ALPHAP	0.1504				
Lat	α_p	ALPHAB	0.0625				
Lat	K_c	BCPGN	0.0996				
Lat	T_A	ACCGN	7.5				
Lat	$1/T_I$	BINTGN	30.0				
Vert	P_x	VRXMAX	22,600				
		VRXMIN	7,600				
		VRGMIN	0.2031				
		VRGMAX	1.0				
Vert	Pitch Command Ramp	T1MV1					
		T1MV2					
		T1MV3					
		T1MV4					
		RAMP1					
		RAMP2					
Lat	K_x	LX1	5,000				
		LG1	5,000				
Vert	K_x	VX1	30,000				
		VX2	6,000				
		VX3	4,000				
		VX4	3,000				
		VG1	0.25				
		VG2	0.90625				
		VG3	1.0				
Vert	α_A	KAP	0.125				
	α_A	KAB	0.125				
Lat	D_x	LRX1	30,000				
		LRX2	5,000				
		LR1	2.125				
		LR2	1.0				
	Hook-to-Beacon	THOOKC					
Lat	α Range Schedule for α-β Filter	ALFAX1	15,000				
		ALFAX2	5,000				
		ALFA1	0.095169				
		ALFA2	0.3				

Figure D-3. SAMPLE OF AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM (A-6)

AN/SPN-42A Aircraft Dependent Parameters

KA-6D/A-6E **Airplane** V13/L8 **Control Program**

Program Type 1 **Installation** ____________

Patch Tape ____________ **Date** ____________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Location	Date of Last Change
DMC Filter Difference Equation Gains	KXØ	TUSTAO, L	3.584362140				
		TUSTAO, U					
	KX1	TUSTA1, L	-3.436213992				
		TUSTA1, U					
	KX2	TUSTA2, L	-3.578875172				
		TUSTA2, U					
	KX3	TUSTA3, L	3.441700960				
		TUSTA3, U					
	KY1	TUSTB1, L	2.333333333				
		TUSTB1, U					
	KY2	TUSTB2, L	-1.814814815				
		TUSTB2, U					
	KY3	TUSTB3, L	0.470507545				
		TUSTB3, U					
	KXX0	TUSTCØ, L	3.000000000				
		TUSTCØ, U					
	KXX1	TUSTC1, L	-2.777777778				
		TUSTC1, U					
	KYY1	TUSTD1, L	0.777777778				
		TUSTD1, U					
DMC Filter LaPlace Equation Gains	K	TUSKØ	0.86				
	K_1		1.6				
	K_2		1.3				
	K_3		0.65				
	t_1		0.2				
	t_2		0.2				
Lat	K_R		.174				

Figure D-3. (continued)

AN/SPN-42A Aircraft Dependent Parameters
S-3A Airplane Mode 1A Control Program

Program Type 9 **Installation** ____

Patch Tape ____ **Date** ____

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/Unit)	Octal Value	Prog Location	Date of Last Change
	Glide Slope	TGLIDE					
	A/C Data	ACDATA	MIA/B/O				
Vert	$1/T_I$	TIGAIN	15				
Vert	K_c	TVGAIN	0.13282				
Vert	T_R	TRGAIN	1.703				
Vert	T_A	TA	0.906				
Lat	T_R	RATEGN	7.5				
Vert	α_P	ALPHAP	0.093750				
Lat	α_P	ALPHAB	0.093750				
Lat	K_c	BCPGN	0.083984				
Lat	T_A	ACCGN	7.5				
Lat	$1/T_I$	BINTGN	33.33				
Vert	R_x	VRXMAX	22,600				
		VRXMIN	7,600				
		VRGMIN	0.203				
		VRGMAX	1.000				
Vert	Pitch Command Ramp	T1MV1					
		T1MV2					
		T1MV3					
		T1MV4					
		RAMP1					
		RAMP2					
Lat	K_x	LX1	5,000				
		LG1	5,000				
Vert	K_x	VX1	30,000				
		VX2	6,000				
		VX3	4,000				
		VX4	3,000				
		VG1	0.2500				
		VG2	1.0000				
		VG3	1.15625				
Vert	α_A	KAP	0.1250				
	α_A	KAB	0.1250				
Lat	D_x	LRX1	30,000				
		LRX2	5,000				
		LR1	2.125				
		LR2	1.000				
	Hook-to-Beacon	THOOKC					
Lat	α Range Schedule for α-β Filter	ALFAX1	15,000				
		ALFAX2	5,000				
		ALFA1	0.095169				
		ALFA2	0.3000				

Figure D-4. SAMPLE OF AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM (S-3A)

AN/SPN-42A Aircraft Dependent Parameters

EA-6B **Airplane** V10/L3 **Control Program**

Program Type 10 **Installation** ____________

Patch Tape ____________ **Date** ____________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/ Unit)	Octal Value	Prog Loca- tion	Date of Last Change
	Glide Slope	TGLIDE					
	A/C Data	ACDATA	MI/B/34				
Vert	$1/T_I$	TIGAIN	9.00				
Vert	K_c	TVGAIN	0.13793				
Vert	T_R	TRGAIN	1.75				
Vert	T_A	TA	0.7875				
Lat	T_R	RATEGN	8.0				
Vert	α_p	ALPHAP	0.17188				
Lat	α_p	ALPHAB	0.07812				
Lat	K_c	BCPGN	0.111111				
Lat	T_A	ACCGN	7.5				
Lat	$1/T_I$	BINTGN	30				
Vert	R_x	VRXMAX	24,000				
		VRXMIN	5,000				
		VRGMIN	0.2				
		VRGMAX	1.0				
Vert	Pitch Command Ramp	T1MV1					
		T1MV2					
		T1MV3					
		T1MV4					
		RAMP1					
		RAMP2					
Lat	K_x	LX1	5,000				
		LG1	5,000				
Vert	K_x	VX1	30,000				
		VX2	4,000				
		VX3	4,000				
		VX4	2,000				
		VG1	0.25				
		VG2	1.00				
		VG3	1.60				
Vert	α_A	KAP	0.1250				
	α_A	KAB	0.1250				
Lat	D_x	LRX1	20,000				
		LRX2	5,000				
		LR1	1.50				
		LR2	1.00				
	Hook-to-Beacon	THOOKC					
Lat	α Range Schedule for α-β Filter	ALFAX1	15,000				
		ALFAX2	3,000				
		ALFA1	0.095169				
		ALFA2	0.3				

Figure D-5. SAMPLE OF AN/SPN-42 AIRCRAFT-DEPENDENT PARAMETERS FORM (EA-6B)

AN/SPN-42A Aircraft Dependent Parameters
EA-6B **Airplane** V10/L3 **Control Program**

Program Type 10 **Installation** ______________

Patch Tape ______________ **Date** ______________

Axis	Symbol	Prog Name	Dec Value	Scale Factor (BIT/Unit)	Octal Value	Prog Location	Date of Last Change
	KXØ	TUSTAO, L	6.770470294				
		TUSTAO, U					
	KX1	TUSTA1, L					
		TUSTA1, U	-6.339948338				
	KX2	TUSTA2, L	-6.749969249				
		TUSTA2, U					
	KX3	TUSTA3, L					
DMC Filter Difference Equation Gains		TUSTA3, U	6.360449383				
	KY1	TUSTB1, L	1.965517241				
		TUSTB1, U					
	KY2	TUSTB2, L					
		TUSTB2, U	-1.287752675				
	KY3	TUSTB3, L	0.281233343				
		TUSTB3, U					
	KXX0	TUSTCØ, L					
		TUSTCØ, U	2.017647059				
	KXX1	TUSTC1, L	-1.900000000				
		TUSTC1, U					
	KYY1	TUSTD1, L	0.882352941				
		TUSTD1, U					
	K	TUSKØ	0.8500				
DMC Filter LaPlace Equation Gains	K_1		0.8000				
	K_2		1.0000				
	K_3		0.83250				
	t_1		0.12000				
	t_2		0.40000				
Lat	K_R		.174				

Figure D-5. (continued)

2. AN/SPN-42 CONTROL PROGRAM

The AN/SPN-42 Aircraft-Dependent Parameter forms illustrated in Figures D-1 through D-5 are developed from the pitch and bank command transfer functions for each aircraft type. Parameter values are also included for the deck motion compensation (DMC) parameters, pitch ramps, and other aircraft parameters. The parameters shown in Figures D-1 through D-5 are discussed in the following sections.

2.1 Pitch Command to Vertical Error Transfer Function

The pitch command to vertical error transfer function is the vertical control equation, which has the following form:

$$\frac{\theta_c}{Z_e} = \frac{K_c\, K(x)}{K_p\, S + 1}\left[\left(\frac{1 + \frac{S}{3.9}}{1 + \frac{S}{3.5} + \frac{S^2}{25}}\right)\left(1 + \frac{\tau_i\, K(x)}{S}\right) + \left(\frac{S\, R(x)}{1 + \frac{S}{3.5} + \frac{S^2}{25}}\right)\left(\tau_R + \frac{\tau_A\, S}{(K_A\, S + 1)^2}\right)\right]$$

Terms such as K(x) and R(x) denote range-variable terms. The other terms are as follows:

Gain	Type	Program Name	Value in Program
K_c	Forward Loop	TVGAIN	K_c
K_p	Alpha Filler Constant	ALPHAP	$\alpha_p = 1 - \exp\left(\frac{-.05}{K_p}\right)$
τ_i	Integral	TIGAIN	$1/\tau_i$
τ_R	Rate	TRGAIN	τ_R
τ_A	Acceleration	TA	τ_A
K_A	Alpha Filler Constant	KAP	$\alpha_A = 1 - \exp\left(\frac{-.05}{K_A}\right)$

The K_p and K_A terms are implemented as alpha (α) filters utilizing the equations for α_p and α_A. The range variable gains are defined with respect to the value of the gain and range at which those gain values change. The transitional paths or curves that the gains follow between one gain level and the next are preprogrammed. The certification engineer defines only the gain levels and the ranges where the gains begin to change. Figures D-6 and D-7 graphically illustrate the parameters associated with the range variable gains for the vertical control equation.

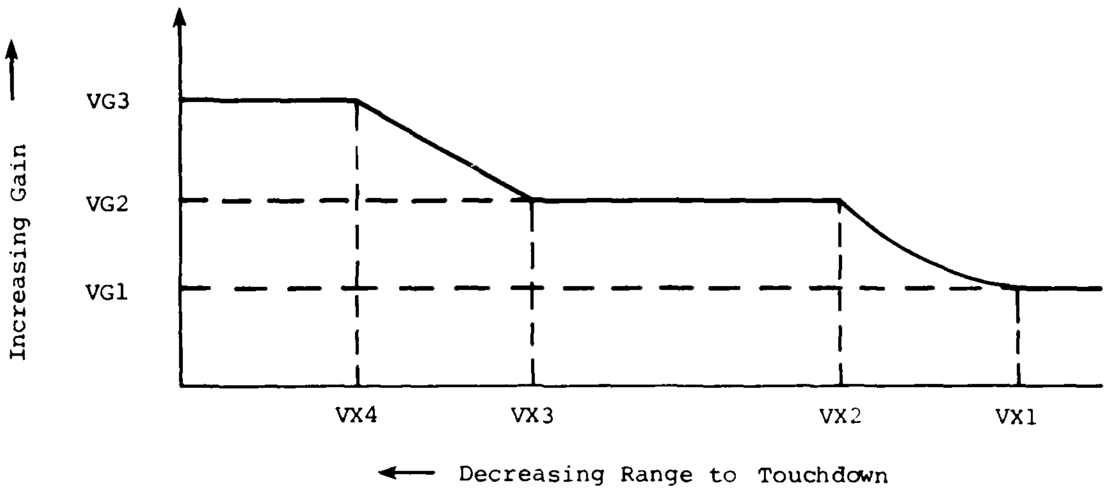


Figure D-6. K(x) GAIN VARIANCE WITH RANGE TO TOUCHDOWN

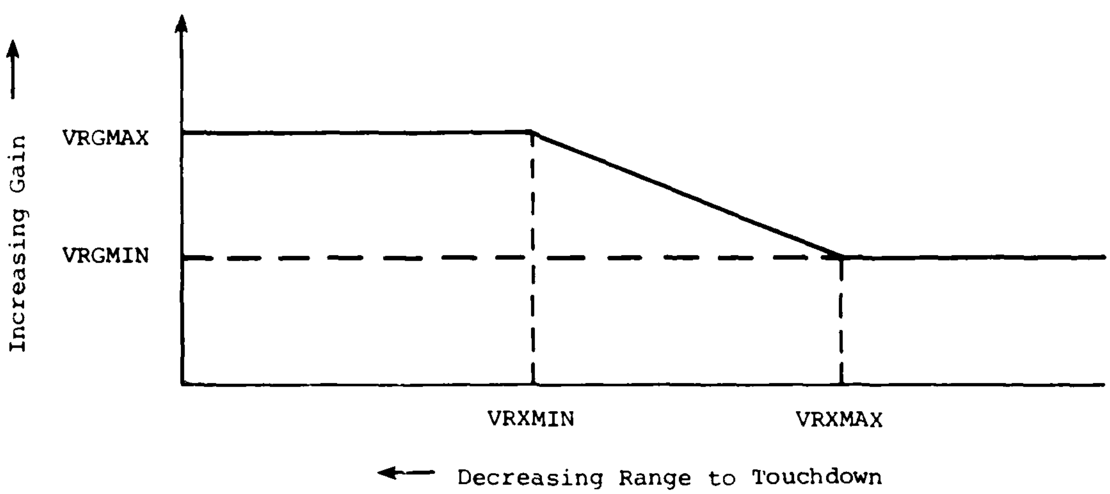


Figure D-7. R(x) GAIN VARIANCE WITH RANGE TO TOUCHDOWN

2.2 Bank Command to Lateral Error Transfer Function

The bank command to lateral error transfer function is the lateral control equation, which has the following form:

$$\frac{\phi_c}{Y_e} = \frac{K_{\ell c}\,M(x)}{K_{\ell p}\,S + 1}\left[\left(\frac{1 + \frac{S}{3.9}}{1 + \frac{S}{3.5} + \frac{S^2}{25}}\right)\left(1 + \frac{\tau_{\ell i}}{S}\right) + \left(\frac{S}{1 + \frac{S}{3.5} + \frac{S^2}{25}}\right)\left(\frac{\tau_{\ell R}\,D(x)}{K_{\ell R}\,S + 1} + \frac{\tau_{\ell A}\,S}{(K_{\ell A}\,S + 1)^2}\right)\right]$$

Terms such as M(x) and D(x) denote range-variable terms. The other terms are as follows:

Gain	Type	Program Name	Value in Program
$K_{\ell c}$	Forward Loop	BCPGN	$K_{\ell c}$
$K_{\ell p}$	Alpha Filter Constant	ALPHAB	$\alpha_{\ell p} = 1 - \exp\left(\frac{-.05}{K_{\ell p}}\right)$
$\tau_{\ell i}$	Integral	BINTGN	$1/\tau_{\ell i}$
$\tau_{\ell R}$	Rate	RATEGN	$\tau_{\ell R}$
$\tau_{\ell A}$	Acceleration	ACCGN	$\tau_{\ell A}$
$K_{\ell R}$	Alpha Filter Constant	KR	In main program
$K_{\ell A}$	Alpha Filter Constant	KAB	$\alpha_{\ell A} = 1 - \exp\left(\frac{-.05}{K_{\ell A}}\right)$

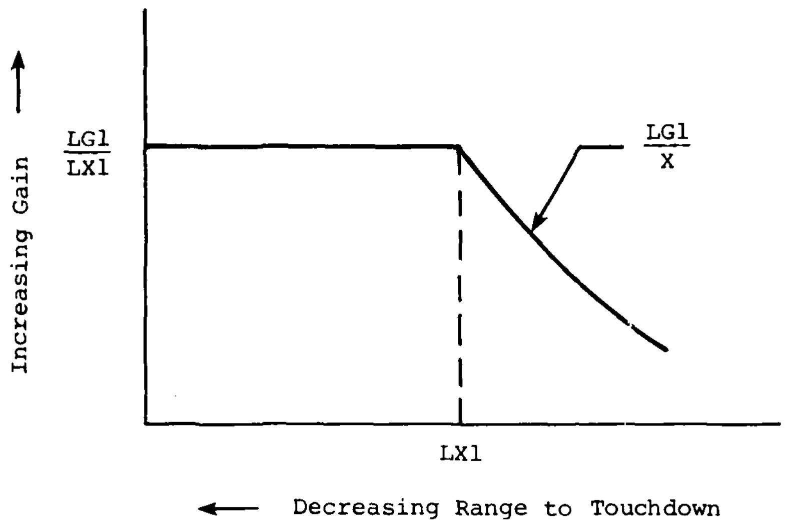
The lateral range variable gains are similar to the vertical range variable gains and are graphically illustrated in Figures D-8 and D-9.

2.3 Alpha-Beta Filters (α-β)

The terms in both control equations of

$$\frac{1 + S/3.9}{1 + \frac{S}{3.5} + \frac{S^2}{25}}$$

are Laplace Transform terms for the alpha-beta filters being used in the AN/SPN-42 program. The numerical values in the Laplace Transform correspond



$$M(X) = \frac{LG1}{X}, \; X \geq LX1$$
$$= \frac{LG1}{LX1}, \; X < LX1$$

Figure D-8. M(X) GAIN VARIANCE WITH RANGE TO TOUCHDOWN

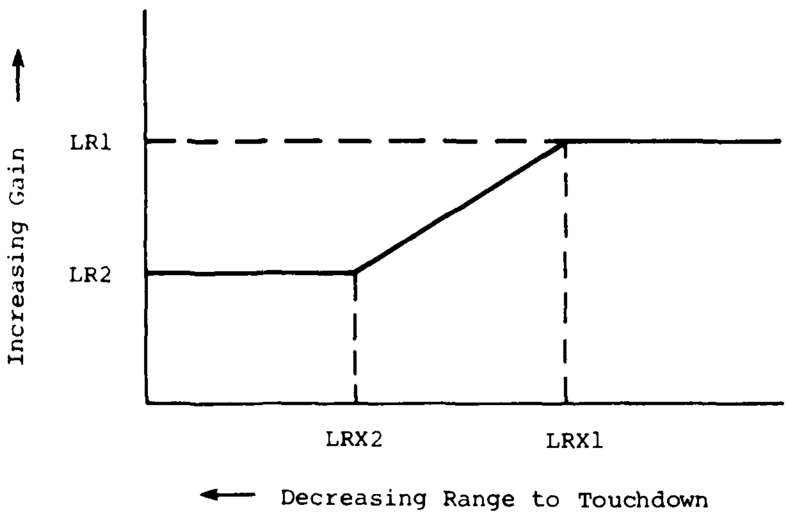


Figure D-9. D(X) GAIN VARIANCE WITH RANGE TO TOUCHDOWN to the in-close values of $\alpha = 0.3$ and $\beta = 0.05294$. The α value in the lateral control equation is range-scheduled, and β is calculated using the equation:

$$\beta = \frac{\alpha^2}{2 - \alpha}$$

The range scheduling of α for the lateral control equation is shown in Figure D-10.

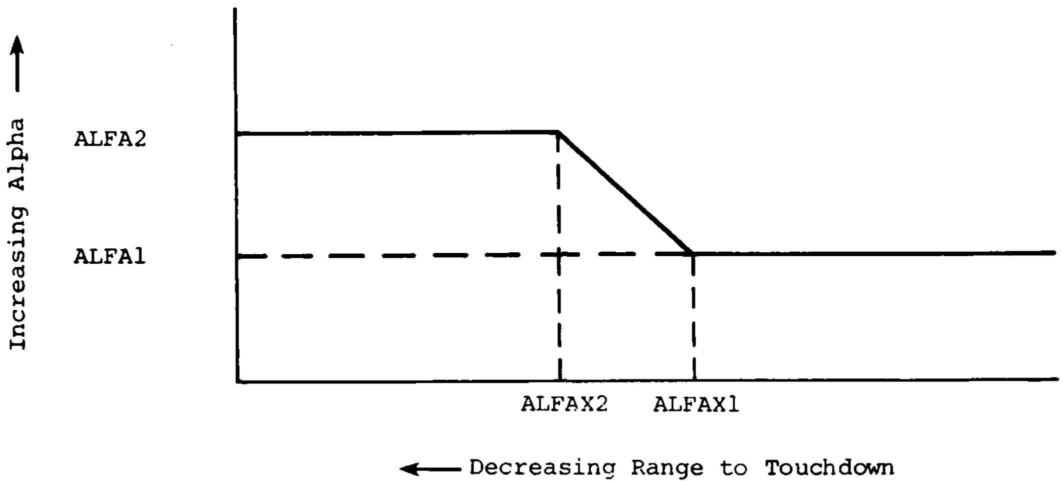


Figure D-10. ALPHA VARIANCE WITH RANGE TO TOUCHDOWN

The variables shown in Figure D-10 are included on the AN/SPN-42 Aircraft-Dependent Parameters form as the range schedule for the α-β filter.

2.4 Deck Motion Compensation (DMC) Equation

The DMC equation is added to the vertical control equation inside 12.5 seconds to touchdown to synchronize the controlled glideslope with ship's motion. The DMC is nominally designed to match the inverse of the aircraft's closed-loop response to result in a flat response up to a frequency of approximately 1.0 radians/second.

The basic DMC transfer function of vertical command to touchdown point heave has the form:

$$\frac{Z_{DMC}}{Z_{11}} = K \left[\frac{(K_1 S^2 + K_2 S + 1)}{(t_1 S + 1)^2} \right] \left[\frac{(K_3 S + 1)}{(t_2 S + 1)} \right]$$

The DMC equation that is different for each aircraft is implemented by using the Tustin Transformation and the following difference equations:

- For the first filter:

$$Y = (KX0)X + (KX1)(Z^{-1})X + (KX2)(Z^{-2})X + KX3\ (Z^{-3})X + (KY1)(Z^{-1})Y$$
$$+ (KY2)(Z^{-2})Y + (KY3)(Z^{-3})Y$$

- For the second filter:

$$Y = (KXX0)X + (KXX1)(Z^{-1})X + KYY1\ (Z^{-1})Y$$

The AN/SPN-42 Aircraft-Dependent Parameters form includes the gains for both the DMC filter Laplace equation and the DMC filter difference equation.

2.5 Pitch Command Ramps

Pitch command ramps may be implemented in addition to both the vertical control equation and the DMC equation. The project engineer is concerned with the timing and the magnitude of the command ramps. These two parameters are graphically illustrated in Figure D-11.

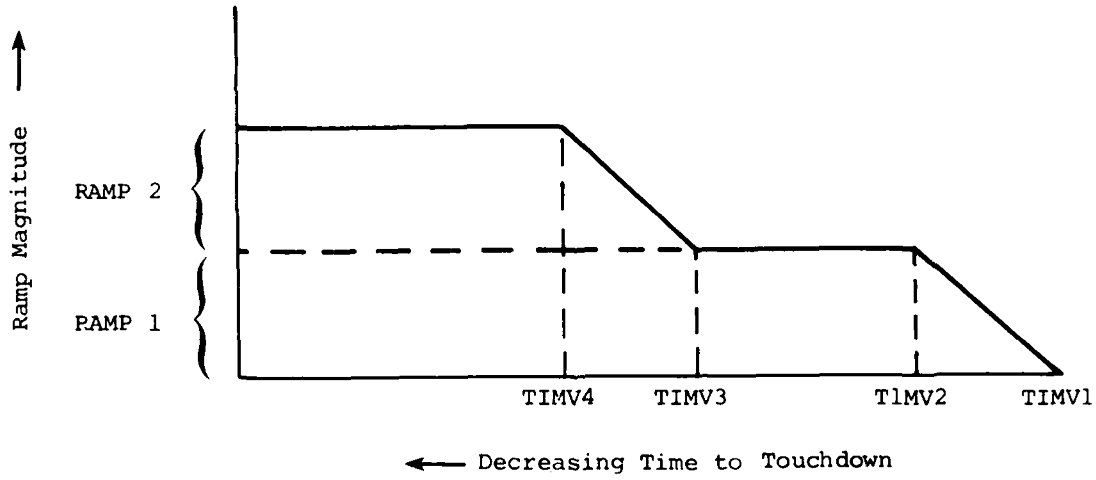


Figure D-11. PITCH COMMAND RAMP IMPLEMENTATION

2.6 Other Aircraft Data

The AN/SPN-42 Aircraft-Dependent Parameter forms include other aircraft data in addition to the various gains associated with the control equations. These other parameters are as follows:

- TGLIDE. The glideslope angle being used on the ship; normally 3.5 degrees.

- THOOKC. The hook-to-beacon height of the aircraft being certified.
- ACDATA. The 17 bits of miscellaneous aircraft data:
  - Bit 0-8 is slant range correction scaled 1/2 bit/ft
  - Bit 14 is data link (0 = 1 way; 1 = 1 or 2 way)
  - Bit 15 and i6 is maximum ACLS mode (00 = IA, 01 = 1, 10 = II, 11 = III)
  - Bit 17 is tracking source (0 = radar, 1 = beacon)

APPENDIX E

SHIPBOARD BRIEFING CHARTS

This appendix presents a sample package of shipboard briefing charts, which are used to explain to pertinent shipboard personnel how and why the certification is conducted.

Figure E-1, the AQR rating scale explained in Appendix L, is used to illustrate the effect of pilot acceptability.

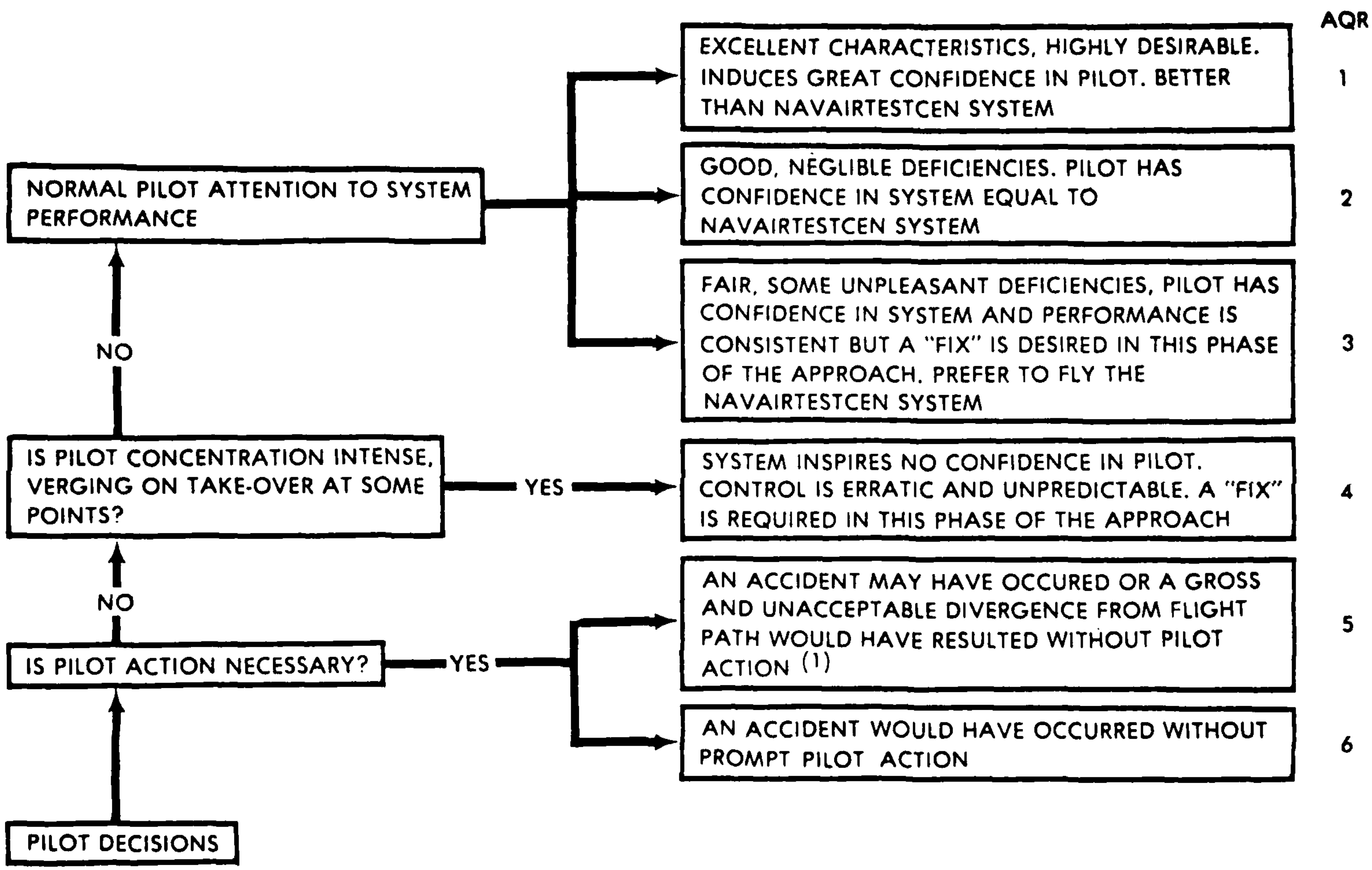
Table E-1, explained in Section Seven, is used to illustrate the influence of wind over deck (WOD) on the burble. Figure E-2 is a graphic illustration of the burble and how it may change as the WOD moves through the wind matrix.

Figure E-3, explained in Section Seven, is a graphic illustration of how ACLS glidepath control changes as the WOD moves through the wind matrix. It is Figure E-3 glidepath variations that illustrate the changes in touchdown point that may be expected with varying wind conditions. This was developed from both theoretical and actual certification data.

Figure E-4 is an illustration of the number of touchdowns needed to certify the ship with a reasonable level of confidence. Figure E-4 sample sizes are based on a 20-foot accuracy and a 40-foot standard deviation.

Table E-2, explained in Section Five, is used to illustrate the various parameters analyzed during the certification.

The total intent of these six charts used in conjunction with each other is to quantify why a certain number of touchdowns is needed. In addition, they quickly explain why ACLS control will vary with WOD.



(1) INCLUDES SYSTEM WAVE-OFFS RESULTING FROM FLIGHT PATH ERRORS

Figure E-1. PILOT'S ACLS QUALITY RATING SCALE

Table E-1. BURBLE FACTORS IN RELATION TO THE WIND MATRIX

Burble Factors

1. Burble becomes stronger
2. Burble becomes weaker
3. Lower wind in landing area
4. Airflow conditions improved
5. Turbulence increases
6. Turbulence decreases
7. Burble moves closer to ship
8. Natural wind component increases
9. Effects of island are most severe
10. Burble moves farther out
11. Vertical wind component will decrease faster
12. Increase in head wind component
13. Decrease in head wind component
14. Below glideslope results in a decrease in headwind
15. Higher effective glideslope
16. Shallower glideslope, more "q" loss
17. Pitch transfer function increases
18. Pitch transfer function decreases
19. Increase in sink speed
20. Lateral control is more oscillatory
21. Lateral control is worst
22. Strong right rolling moments
23. Rolling moments dependent on centerline condition, i.e., right offset will cause right roll

Wind Direction (Degrees)	Wind Velocity (Knots): < Nominal -3	Nominal ±3	> Nominal +3
354 to 000	3, 4, 5, 11, 15, 18, 19, 22	2, 3, 4, 11, 12, 18, 22	3, 6, 7, 8, 11, 16, 18, 22
347 to 353	4, 5, 15, 19	14	1, 6, 7, 8, 16, 20
340 to 346	4, 5, 9, 10, 11, 17, 19, 21, 23	9, 10, 13, 17, 21, 23	1, 6, 8, 9, 10, 16, 17, 21, 23

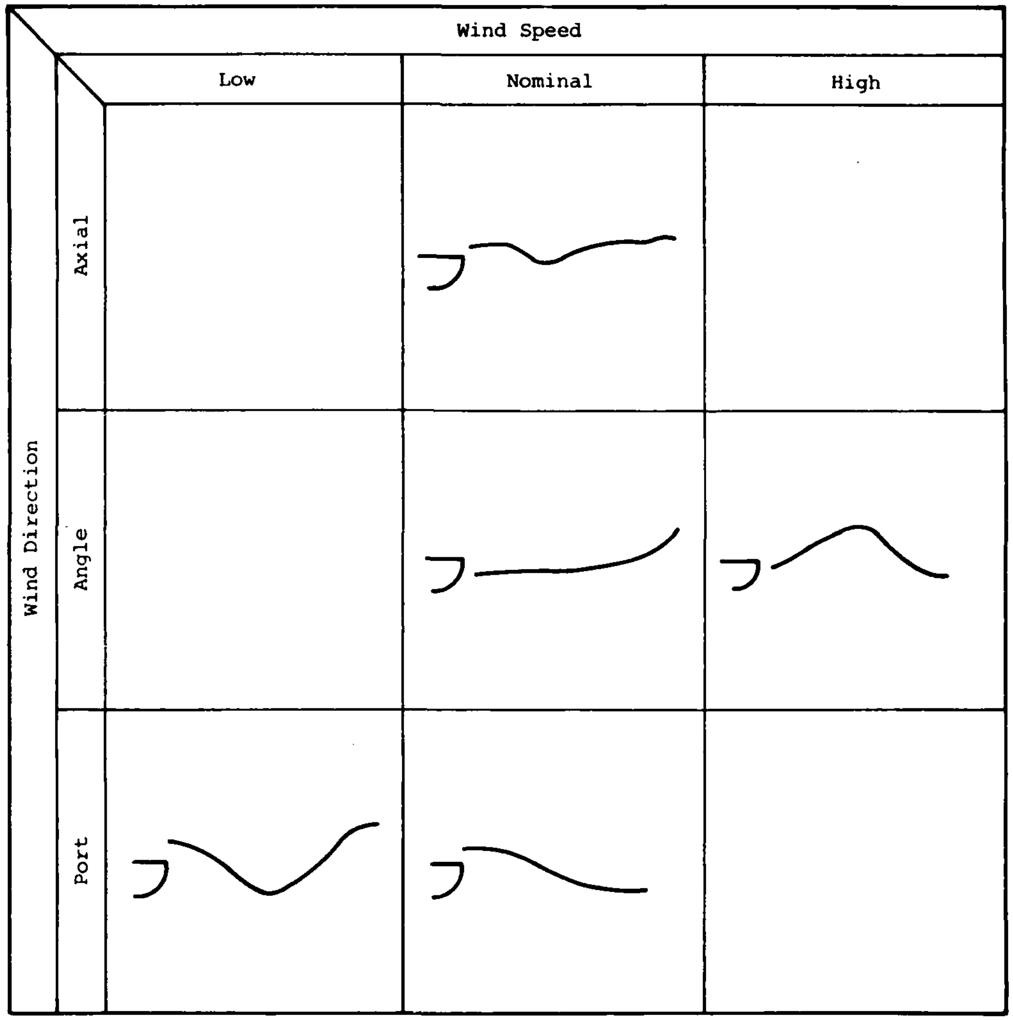


Figure E-2. BURBLE VARIATIONS WITH VARYING WIND CONDITIONS

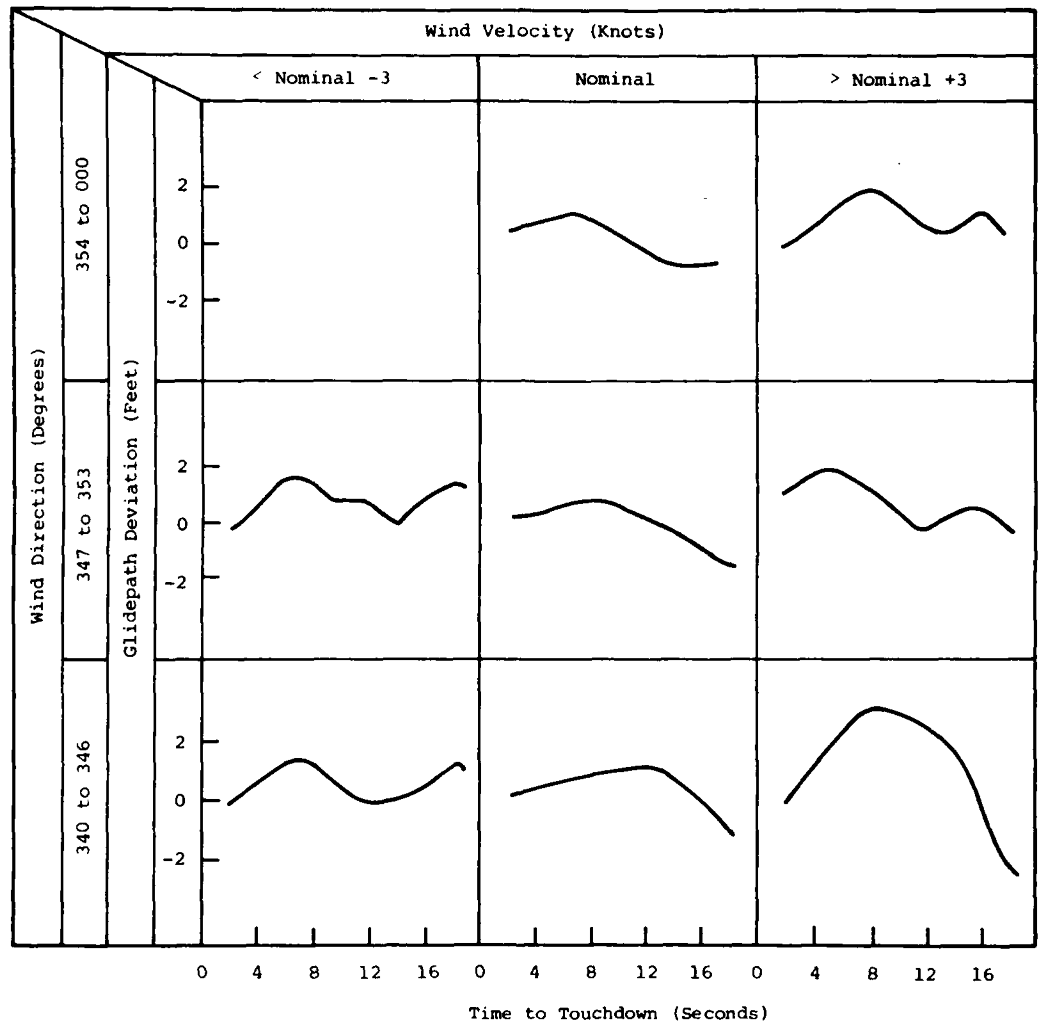


Figure E-3. ACLS GLIDEPATH CONTROL WITH VARYING WIND CONDITIONS

Wind Direction (Degrees)	Wind Velocity (Knots): < Nominal -3	Nominal	> Nominal +3
354 to 000	2	3	2
347 to 353	5	25	5
340 to 346	2	3	2

Mean Touchdown = ±20 Feet

Standard Deviation = 40 Feet

Confidence	Passes
99%	27
95%	16
90%	11
80%	7
70%	4
60%	3

Figure E-4. NUMBER OF TOUCHDOWNS REQUIRED FOR EACH WIND MATRIX CELL

Table E-2. SET-UP FOR AN/SPN-42A BRUSH RECORDER

Pen No.	Parameter	Buffer Number	Potentiometer Setting	Scale Range		Comments
				Left	Right	
Brush 1						
1	Range (X)	12	X2	0	50,000	
2	Z error (Z_e)	16	X0.1	31.25 (low)	31.25 (high)	
3	Pitch Command (θ_c)	02	X0.2	13.18 (up)	13.18 (down)	
4	Altitude (Z)	15	X2	0	2,500	
5	EL Encoder	30	X0.2	0 (down)	1.0 (up)	Repeats
6	DSS Pitch Angle (θ_s)	22	X0.2	0.5 (stern up)	0.5 (stern down)	Repeats
Brush 2						
1	Range (X)	12	X2	0	50,000	
2	Y error (Y_e)	14	X0.2	50 (port)	50 (stbd)	
3	Roll Command (ϕ_c)	03	X0.2	29.3 (right)	29.3 (left)	
4	AZ Encoder	31	X0.2	0.5 (stbd)	0.5 (port)	Repeats
5	DSS Roll Angle (ϕ_s)	23	X0.2	0.5 (stbd down)	0.5 (stbd up)	Repeats
6	Ship's Yaw (Ψ_s)	25	X0.2	0.5 (stern port)	0.5 (stern stbd)	Repeats
Brush 3						
1	Range (X)	12	X2	0	50,000	
2	R_s Washout (R_s)	27	X0.2	0	100	Repeats
3	Accel Output (Z_{10})	45	X0.2	2 (up)	2 (down)	Repeats
4	Accel Heave (Z_{10})	24	X0.1	7.81 (down)	7.81 (up)	
5	Touch-Down Heave (Z_{11})	21	X0.1	7.81 (down)	7.81 (up)	
6	Z Error (Z_e)	16	X0.1	31.25 (low)	31.25 (up)	
Brush 4						
1	EL Encoder	30		0 (down)	1.0 (up)	Repeats
2	Spin Error			0.1 (down)	0.1 (up)	
3	EL Summation			0.0 (down)	1.0 (up)	Repeats
4	AZ Encoder	31		0.5 (stbd down)	0.5 (stbd up)	Repeats
5	Spin Error			0.1 (stbd left)	0.1 (right)	
6	AZ Summation			0.5 (stbd down)	0.5 (stbd up)	Repeats

APPENDIX F

AIRCRAFT ACLS CONFIGURATIONS

This appendix lists the proper aircraft configurations for qualified ACLS aircraft. It provides a ready-reference of the aircraft configuration required for a particular aircraft to operate at a certified ACLS site. This appendix is current as of the date of this manual.

1. Mode I

a. EA-6B (ICAP) with CP-1404/ASN-54(V) APCS (AVC-2268), AFC-369, AFC-437, and AFC-449.

b. KA-6D with AFC-136, AFC-161, AFC-230, AFC-240, AFC-462, CP-1133/ASN-54(V) APCS (AVC-1376), ID-1791A/A VGI with electrical erection, and AS-3017/APN Horizontally Polarized Radar Beacon Antenna (AFC-431).

c. A-6E (NSN 159895 and subsequent)/A-6E Mod (Numbers M121 and subsequent) with CP-1133/ASN-54(V) APCS (AVC-1376), ID-1791A/A VGI with electrical erection, and AS-3017/APN Horizontally Polarized Radar Beacon Antenna (AFC-431).

d. A-7B/C with CP-1116/ASN-54 APCS; AFC-181 with AVC-1122 and AVC-1430; and AFC-213 Parts I and II with AVC-1210 Parts I, II, and III incorporated.

e. A-7E with CP-990A/ASN-54 APCS; AFC-181 with AVC-1122 and AVC-1430; and AFC-213 Parts I and II with AVC-1210 Parts I, II, and III incorporated.

f. F-4B/N with AFC-288, AVC-1222, AFC-364, and CU-1803/ASA-32L with AVC-947.

g. F-4J with AFC-388, AVC-743, AFC-364, and CU-1803/ASA-32L with AVC-947.

h. RF-4B with AFC-583, AFC-584, and AFC-589.

2. Mode IA. All aircraft listed in paragraph 1, with the following additions/modifications:

a. A-6E with AFC-161 and AFC-230. CP-1133/ASN-54(V) or CP-878/ASN-54(V) APCS required. ID-1791A/A VGI with electrical erection is not required.

b. KA-6D with AFC-136, AFC-161, and AFC-230. CP-1133/ASN-54(V) or CP-878/ASN-54(V) APCS required. ID-1791A/A VGI with electrical erection is not required.

c. A-7A/B with CP-829/ASN-54(V) APCS.

d. A-7B/C/E. Part II of AFC-213 and Part III of AVC-1210 are not required.

e. TA-7C (Ashore Only) in normal fleet configuration.

f. F-4S in normal fleet configuration.

g. S-3A in normal fleet configuration.

3. Mode II. All aircraft listed in paragraphs 1 and 2, with the following additions/modifications:

a. A-6A/B/C/E and KA-6D with AFC-230. AS-3017/APN Horizontally Polarized Radar Beacon Antenna is not required.

b. EA-6A with AFC-230.

c. EA-6B with AFC-230 or AFC-369.

d. TA-7C in normal fleet configuration.

e. E-2B/C with ECP-E-2C-060E.

f. F-14A utilizing AN/SPN-42 skin tracking only.

4. Mode III. All aircraft listed in paragraphs 1, 2, and 3 and all aircraft that are otherwise qualified for instrument approaches.

5. AN/SPN-41/TRN-28 ILS. Aircraft equipped with AN/ARA-63 receiver/decoder equipment as follows:

a. A-4E/F with AFC-463

b. A-4M with AFC-538

c. A-6E 159895 and subsequent, A-6E Mod M121 and subsequent, and A-6/KA-6 airplanes with AFC-161 incorporated

d. EA-6B with AFC-437

e. A-7A/B/C/E with AFC-241

f. TA-7C

g. C-2A with AFC-86

h. KC-130R in normal configuration

i. F-4B with AFC-470 Part II

j. F-4J with AFC-470 Part I

k. F-4N/S (all)

l. RF-4B with AFC-470 Part III

m. RF-8G with AFC-572

n. F-14A (all)

o. S-3A (all)

APPENDIX G

AIRCRAFT APPROACH CHARACTERISTICS

1. INTRODUCTION

The closed-loop performance of the aircraft/ACLS is dependent not only on how well the ACLS ground system is functioning but also on various open-loop aircraft parameters, such as aircraft speed, weight, and glideslope. The closed-loop performance is also affected by pseudochanges in aircraft autopilot or autothrottle variables brought about by environmental factors.

2. AIRCRAFT HEIGHT RESPONSE

Aircraft vertical closed-loop control is dependent on the aircraft altitude open-loop height response of the aircraft, that is, the magnitude of altitude change with respect to aircraft pitch attitude change. The open-loop height response is dependent on the aircraft flight path response, which is governed by the autopilot and autothrottle gains. The height response is also dependent on the aircraft airspeed. These two open-loop height response characteristics of pitch attitude and airspeed and their relationship to the height response are defined through the equation:

$$H/\theta_c = \frac{V_o}{\omega} \frac{\gamma}{\theta_c} \frac{1}{57.3}$$

The flight path term, γ, is determined from the vectorial relationship expressed by the equation:

$$\gamma = \theta - \alpha$$

where pitch attitude, θ, is controlled by the pitch autopilot, and the angle of attack, α, is controlled by the autothrottle. During ACLS approaches, the AN/SPN-42 sends pitch commands to the aircraft pitch autopilot. The pitch autopilot then controls the angle of attack about its reference value. Any change in autopilot or autothrottle gains or reference angle of attack can affect the flight path, γ, and subsequently the height response of the aircraft. Variances in the expected aircraft airspeed can also affect the open-loop height response of the aircraft.

Any effects on the open-loop height response will affect the closed-loop control performance since AN/SPN-42 aircraft programs are developed around expected open-loop height response transfer functions. Normally, the autopilot gains are electrically fixed within certain tolerances and therefore do not present a problem. On the other hand, the autothrottle controls the engine, which is directly affected by ambient conditions and aircraft parameters such as weight and flight attitude. The variances in ambient conditions and aircraft parameters can affect the autothrottle, its control of angle of attack, and subsequently the flight path response.

3. AUTOTHROTTLE CHARACTERISTICS

The autothrottle (APC) has three pilot-selectable temperature settings (HOT, STD, COLD), which compensate for ambient temperature effects on engine performance. Flying with HOT gains on a standard or cold day increases the overall APC gains, and flying with COLD gains on a hot or standard day reduces the overall gains. These variations in gains affect the flight path response of the aircraft.

Other parameters that affect the autothrottle gains are the aircraft weight, closing speed, and glideslope. A heavy-weight aircraft gives a pseudo-higher APC gain because of the increase in thrust required to propel the aircraft. A high wind over deck (WOD) and the resultant lower effective glideslope can also cause an increase in APC gains. As aircraft weight is reduced, the autothrottle becomes more lightly damped. Overall, a heavy-weight aircraft on a shallow glideslope with a large WOD has a high overall gain. The APC gain may be increased further by using a HOT APC temperature-select on a cold or standard day. The overall APC gain may be reduced with a low aircraft weight, high glideslope, low WOD, and with a COLD APC setting on a hot day.

Autothrottle effectiveness may also be compromised by an erroneous reference setting. The autothrottle is set to control the aircraft speed to a reference angle of attack. An incorrectly set reference angle of attack will cause the aircraft to fly faster or slower, depending on the direction of the error. This change in controlled airspeed will have a direct effect on the aircraft open-loop height response.

4. AIRCRAFT POWER-APPROACH CHARACTERISTICS

ACLS control characteristics are dependent on aircraft power-approach characteristics. These power-approach characteristics will vary with ambient conditions and the amount of fuel used. Table G-1 presents geometrical and inertial data for ACLS aircraft power-approach configurations under standard conditions.

Table G-1. GEOMETRICAL AND INERTIAL DATA FOR AIRCRAFT POWER APPROACH

Aircraft Characteristic	Characteristic Value by Aircraft Type				
	F-4	A-7	A-6	S-3	F-14
Mach Number	0.197	0.195	0.172	0.147	0.195
True Airspeed (V_o)	220.8 ft/sec	218 ft/sec	192 ft/sec	164 ft/sec	218 ft/sec
Wing Span (b)	38.666 ft	38.73 ft	53.0 ft	68 ft	64.13 ft
Wing Area (S)	530 ft^2	375 ft^2	528.9 ft^2	598 ft^2	565 ft^2
Mean Aerodynamic Chord ($\bar{c}$)	16.04 ft	10.84 ft	10.9 ft	9.85 ft	9.8 ft
Weight (W)	34,000 lbs	24,000 lbs	33,768 lbs	31,790 lbs	47,049 lbs
Center of Gravity (% MAC)	29.1	28.6	24.0	25.0	16.2
Angle of Attack (α)	12.8 degrees	12.0 degrees	9.8 degrees	12.0 degrees	10.6 degrees
Pitch Attitude (θ)	9.3 degrees	8.0 degrees	6.3 degrees	8.5 degrees	7.1 degrees
Flight Path Angle (γ)	3.5 degrees	3.5 degrees	3.5 degrees	3.5 degrees	3.5 degrees
Trim Thrust	4700 lbs	2613 lbs	4500 lbs	2800 lbs	4500 lbs
Engine Gain	220 lb/degree*	190.0 lb/degree*	139 lb/degree*	138 lb/degree*	200 lb/degree*

*Degree of power-lever-angle change.

APPENDIX H

HISTORIC CERTIFICATION DATA

This appendix presents a tabulation of past certification test results for the selected parameters of boarding rate, touchdown AQRs, mean touchdown, and touchdown dispersion. This appendix of certification data is intended to provide a ready reference for comparing data between aircraft types and ship trips. Expected values of these statistics are presented for each certified aircraft type in Table H-1.

Tables H-2, H-3, H-4, and H-5 present the boarding rate, touchdown AQRs, mean touchdown point, and touchdown dispersion, respectively, for each ship trip for which data are available. These tables present the data by ship, year, and aircraft type.

Tables H-6, H-7, H-8, H-9, and H-10 present the selected parameters for F-4, RA-5C, A-7, A-6E, and EA-6B aircraft, respectively. These tables present the data by ship and year and include touchdown sample sizes, glideslopes, and WOD.

Table H-1. STATISTICAL AVERAGES OF HISTORIC CERTIFICATION DATA BY AIRCRAFT TYPE

Category	Number of Samples	Expected Value
F-4 Aircraft (3.5 Degree Glideslope)		
Boarding Rate	21	71 ±20 %
AQR	11	2.7 ±0.4
Mean Touchdown Point	26	-10.6 ±16.6 Ft.
Touchdown Dispersion	26	36.4 ±9.5 Ft.
F-4 Aircraft (4.5 Degree Glideslope)		
Boarding Rate	5	75 ±8 %
AQR	1	3 ±N/A
Mean Touchdown Point	6	-4.3 ±14.6 Ft.
Touchdown Dispersion	6	36.6 ±6.2 Ft.
A-7 Aircraft (3.5 Degree Glideslope)		
Boarding Rate	27	77 ±14 %
AQR	19	2.5 ±0.5
Mean Touchdown Point	30	-4.4 ±20.8 Ft.
Touchdown Dispersion	30	44.9 ±10.7 Ft.
A-7 Aircraft (4.0 Degree Glideslope)		
Boarding Rate	6	66 ±32 %
AQR	2	2.6 ±1.1
Mean Touchdown Point	10	-2.6 ±21.8 Ft.
Touchdown Dispersion	10	39.5 ±9.4 Ft.
A-6E Aircraft (3.5 Degree Glideslope)		
Boarding Rate	9	77 ±13 %
AQR	9	2.1 ±0.2
Mean Touchdown Point	9	7.4 ±8.6 Ft.
Touchdown Dispersion	9	45.3 ±5.9 Ft.
EA-6B Aircraft (3.5 Degree Glideslope)		
Boarding Rate	4	78 ±21 %
AQR	5	1.8 ±0.7
Mean Touchdown Point	5	-13.6 ±16.9 Ft.
Touchdown Dispersion	5	36.4 ±4.8 Ft.
A-5 Aircraft (3.5 Degree Glideslope)		
Boarding Rate	12	64 ±19 %
AQR	5	2.6 ±0.7
Mean Touchdown Point	8	-5.6 ±30.0 Ft.
Touchdown Dispersion	9	31.7 ±10.9 Ft.

Table H-2. PERCENTAGE OF CERTIFICATION BOARDING RATES BY AIRCRAFT TYPE

Ship	Year	Aircraft Type				
		F-4	A-7	RA-5C	A-6E	EA-6B
CONSTELLATION	71	84	-	-	-	-
FORRESTAL	72	67	52	-	-	-
RANGER	72	74	72	-	-	-
INDEPENDENCE	73	71	73	40	-	-
KITTY HAWK (3.5)	73				-	-
KITTY HAWK (4.0)	73				-	-
KENNEDY	73	46	64	59	-	-
SARATOGA	74	86	84	79	-	-
RANGER	74	87	74	83	-	-
ENTERPRISE	74	71	94	83	-	-
CONSTELLATION	74	55	48	51	-	-
CORAL SEA	74	50	47	-	-	-
RANGER	75	72	93	80	-	-
INDEPENDENCE (3.5)	75	73	68	-	-	-
INDEPENDENCE (4.0)	75	80	86	47	-	-
KITTY HAWK	75	-	65	-	-	-
KENNEDY	75	59	60	47	-	-
INDEPENDENCE	76	52	48	28	-	-
ENTERPRISE	76	-	83	-	-	-
CONSTELLATION	76	-	71	-	-	-
NIMITZ	76	79	64	-	-	-
CORAL SEA	76	87	89	-	-	-
SARATOGA	77	89	78	-	-	-
KITTY HAWK	77	-	91	84	-	-
MIDWAY	77	90	76	-	-	-
FORRESTAL	77	92	87	-	-	-
EISENHOWER	77	93	89	-	86	-
ENTERPRISE	77	-	94	70	85	-
KENNEDY	78	-	83	-	47	-
EISENHOWER	78	-	86	-	66	-
RANGER (3.5)	78	66	92	61	80	-
RANGER (4.0)	78	-	96	-	-	-
CONSTELLATION	78	-	92	-	86	-
AMERICA	78	-	59	-	73	-
INDEPENDENCE	78	82	78	-	88	-
CORAL SEA	79	92	84	-	88	-
KITTY HAWK	79	-	93	-	-	-
NIMITZ	79	-	84	-	89	69
FORRESTAL	79	-	93	-	-	-
AMERICA	80	-	69	-	84	90
MIDWAY	80	89	80	-	-	53
KITTY HAWK	81	-	74	-	82	100

Table H-3. CERTIFICATION TOUCHDOWN ACLS QUALITY RATINGS (AQRs) BY AIRCRAFT TYPE

Ship	Year	Aircraft Type				
		F-4	A-7	RA-5C	A-6E	EA-6B
FORRESTAL	72		3.0			
CONSTELLATION	74	2.8	3.4	2.8	-	-
INDEPENDENCE (3.5)	75	3.2	3.1	3.8	-	-
INDEPENDENCE (4.0)	75	3.0	3.4	-	-	-
INDEPENDENCE	76	2.8	3.1	-	-	-
CONSTELLATION	76	-	2.9	-	-	-
AMERICA	76	3.2	2.9	-	-	-
NIMITZ	76	3.0	3.2	-	-	-
SARATOGA	77	2.6	2.8	-	-	-
KITTY HAWK	77	-	2.1	2.1	-	-
MIDWAY	77	2.6	2.8	-	-	-
FORRESTAL	77	2.4	2.2	-	-	-
EISENHOWER	77	2.3	2.2	-	-	-
ENTERPRISE	77	-	2.1	2.1	2.1	-
EISENHOWER	78	-	2.5	-	1.9	-
KENNEDY	78	-	2.1	-	2.2	-
RANGER (3.5)	78	2.4	2.0	2.2	2.4	-
RANGER (4.0)	78	-	1.8	-	-	-
CONSTELLATION	78	-	2.1	-	1.8	-
AMERICA	78	-	1.8	-	2.1	-
INDEPENDENCE	78	2.2	2.1	-	2.1	-
CORAL SEA	79	3.0	2.6	-	1.9	-
KITTY HAWK	79	-	2.0	-	1.9	1.7
NIMITZ	79	-	2.6	-	2.5	1.8
FORRESTAL	79	-	2.4	-	-	-
AMERICA	80	-	3.2	-	2.5	1.8
MIDWAY	80	2.3	2.8	-	-	2.8
KITTY HAWK	81	-	2.9	-	2.0	2.1

Table H-4. CERTIFICATION ACTUAL MEAN TOUCHDOWN POINT (IN FEET) RELATIVE TO DESIRED TOUCHDOWN POINT BY AIRCRAFT TYPE

Ship	Year	Aircraft Type				
		F-4	A-7	RA-5C	A-6E	EA-6B
KENNEDY	70	-20	-	-	-	-
CONSTALLATION	71	9	-	-	-	-
CONSTALLATION	72	-7	-12	-	-	-
FORRESTAL	72	1	31	-	-	-
SARATOGA	72	-16	-2	-	-	-
RANGER	72	-2	-8	-	-	-
CORAL SEA	72	-	1	-	-	-
INDEPENDENCE	73	-4	-14	-16	-	-
KITTY HAWK (3.5)	73		13			
KITTY HAWK (4.0)	73		-38			
KENNEDY	73	-17	-13	-17	-	-
SARATOGA	74	10	-1	33	-	-
RANGER	74	-26	-37	-	-	-
CONSTELLATION	74	-36	-42	-51	-	-
CORAL SEA	74	-17	-	-	-	-
RANGER	75	-12	-19	-29	-	-
INDEPENDENCE	75	-40	-19	-14	-	-
KENNEDY	75	-17	-13	7	-	-
INDEPENDENCE	76	-9	+19	-	-	-
CONSTELLATION	76	-	-	-	-	-
AMERICA	76	-21	-11	-	-	-
NIMITZ	76	-16	12	-	-	-
CORAL SEA	76	22	-17	-	-	-
SARATOGA	77	7	1	-	-	-
MIDWAY	77	-25	-15	-	-	-
FORRESTAL	77	-16	-22	-	-	-
EISENHOWER	77	-19	-28	-	2	-
ENTERPRISE	77	-	0	-9	9	-
EISENHOWER	78	-	-19	-	-4	-
KENNEDY	78	-	-	-	20	-
RANGER (3.5)	78	-13	-8	37	12	-
RANGER (4.0)	78	-	-10	-	-	-
CONSTELLATION	78	-	2	-	18	-
AMERICA	78	-	-2	-	9	-
INDEPENDENCE	78	-9	-24	-	5	-
CORAL SEA	79	-2	3	-	-13	-
KITTY HAWK	79	-	28	-	-9	-2
NIMITZ	79	-	-10	-	-7	-37
FORRESTAL	79	-	-10	-	-	-
AMERICA	80	-	-15	-	8	-26
MIDWAY	80	10	9	-	-	0
KITTY HAWK	81	-	-34	-	-28	-3

Table H-5. CERTIFICATION LONGITUDINAL TOUCHDOWN POINT DISPERSION (IN FEET) BY AIRCRAFT TYPE

Ship	Year	Aircraft Type				
		F-4	A-7	RA-5C	A-6E	EA-6B
KENNEDY	70	19.0	-	-	-	-
CONSTELLATION	71	39.7	-	-	-	
CONSTALLATION	72	47.8	56.4	-	-	-
FORRESTAL	72	35.7	31.6	-	-	-
SARATOGA	72	35.0	40.0	-	-	-
RANGER	72	30.0	56.2	-	-	-
CORAL SEA	72	-	61.0	-	-	-
INDEPENDENCE	73	37.9	34.5	17.8	-	-
KITTY HAWK (3.5)	73	-	63.6	40.7	-	-
KITTY HAWK (4.0)	73	46.1	34.3	-	-	-
KENNEDY	73	44.0	44.0	20.0	-	-
SARATOGA	74	30.0	30.0	27.0	-	-
RANGER	74	37.0	32.0	32.0	-	-
CONSTELLATION	74	33.6	27.2	21.1	-	-
CORAL SEA	74	29.9	-	-	-	-
RANGER	75	19.9	41.1	40.0	-	-
INDEPENDENCE	75	36.8	44.7	35.5	-	-
KENNEDY	75	37.0	40.0	37.0	-	-
INDEPENDENCE	76	43.6	38.6	-	-	-
CONSTELLATION	76	-	53.6	-	-	-
AMERICA	76	40.0	48.6	-	-	-
NIMITZ	76	41.4	34.3	-	-	-
CORAL SEA	76	26.8	33.9	-	-	-
SARATOGA	77	26.0	36.8	-	-	-
MIDWAY	77	28.3	37.9	-	-	-
FORESSTAL	77	36.1	28.1	-	-	-
EISENHOWER	77	29.1	41.7	-	44.0	-
ENTERPRISE	77	-	50.4	49.6	48.2	-
EISENHOWER	78	-	44.1	-	36.2	-
KENNEDY	78	-	-	-	45.8	-
RANGER (3.5)	78	34.3	42.1	-	42.3	-
RANGER (4.0)	78	-	35.6	-	-	-
CONSTELLATION	78	-	36.7	-	43.1	-
AMERICA	78	-	66.0	-	58.5	-
INDEPENDENCE	78	31.8	29.3	-	43.6	-
CORAL SEA	79	30.1	45.7	-	43.5	-
KITTY HAWK	79	-	59.1	-	46.2	35.1
NIMITZ	79	-	40.4	-	34.0	30.5
FORRESTAL	79	-	47.8	-	-	-
AMERICA	80	-	44.1	-	44.7	43.3
MIDWAY	80	32.4	49.3	-	-	38.5
KITTY HAWK	81	-	54.1	-	27.9	34.4

Table H-6. SELECTED CERTIFICATION PARAMETERS OF F-4 AIRCRAFT

Ship	Yr	Board Rate (%)	AQR	Mean TD (Ft.)	Std Dev TD (Ft.)	Sample	G.S. (Deg.)	Wind Dir (Deg.)	Wind Vel (Kts.)
KENNEDY	70			-20	19.0	80	3.5	345-005	28-39
ENTERPRISE	71			-30	32.5	42	3.5	340-000	25-40
CONSTELLATION	72	RAMP		-3	53.3	27	3.5	345-000	23-33
CONSTELLATION	72	NO RAMP		-5	42.2	21	3.5	345-000	23-33
FORRESTAL	72	67		1	35.7	20	4.0	345-000	27-36
SARATOGA	72			-16	35.0	37	4.0	345-355	29-36
RANGER	72	74		-2	30.0	34	3.5	340-000	25-35
INDEPENDENCE	73	71		-4	37.9	49	4.0	335-010	15-40
KITTY HAWK	73	71		-14	46.1	26	4.0	345-010	25-40
KENNEDY	73	46		-17	44.0	10	3.5	330-010	12-31
ENTERPRISE	74	71		8	62.2	28	3.5	340-015	21-36
SARATOGA	74	86		10	30.0	19	3.5	343-357	23-37
SARATOGA	74	86		24	41.0	4	3.5	358-015	23-37
RANGER	74	87		-26	37.0	25	3.75	340-357	26-35
CONSTELLATION	74	55	2.8	-36	33.6	40	3.5	345-005	19-33
CORAL SEA	74	54		-17	29.9	22	3.5	340-000	22-31
RANGER	75	72		-12	19.9	13	3.5	345-000	24-33
INDEPENDENCE	75	73	3.2	-40	36.8	8	3.5	330-003	22-39
INDEPENDENCE	75	80	3.0	-15	37.8	16	4.0	330-003	22-39
KENNEDY	75	59		-17	37.0	27	3.5	341-015	17-35
INDEPENDENCE	76	52	2.8	-8	43.6	39	3.5	340-020	20-35
AMERICA	76		3.2	-21	40.0	25	3.5	340-015	18-33
NIMITZ	76	79	3.0	-16	41.4	31	3.5	340-000	10-42
CORAL SEA	76	87		22	26.8	10	4.0	350-010	20-38
SARATOGA	77	89	2.6	7	26.0	44	3.65	340-012	15-29
MIDWAY	77	90	2.6	-25	28.3		3.5	340-005	20-35
FORRESTAL	77	92	2.4	-16	36.1	10	3.5	345-355	19-29
EISENHOWER	77	93	2.3	-19	29.1	41	3.5	340-355	18-30
RANGER	78	66	2.4	-13	34.3	30	3.5	340-005	20-32
CONSTELLATION	71	84		9	39.7	69	3.5	340-010	25-45
RANGER	74	87		25	47.0	18	3.75	358-005	26-35
INDEPENDENCE	78	82	2.2	-9	31.8	39	3.5	345-005	21-31
CORAL SEA	79	92	3.0	-2	30.1	11			
MIDWAY	80	89	2.3	10	32.4	47			

Table H-7. SELECTED CERTIFICATION PARAMETERS OF RA-5C AIRCRAFT

Ship	Yr	Board Rate (%)	AQR	Mean TD (Ft.)	Std Dev TD (Ft.)	Sample	G.S. (Deg.)	Wind Dir (Deg.)	Wind Vel (Kts.)
KITTY HAWK	73				40.7				
INDEPENDENCE	73	40		-16	17.8				
KENNEDY	73	59		-17	20.0				
SARATOGA	74	79		33	27.0				
RANGER	74	83			32.0				
ENTERPRISE	74	83							
CONSTELLATION	74	51	2.8	-51	21.1				
RANGER	75	80		-29	40.0				
INDEPENDENCE3.5	75		3.8						
INDEPENDENCE4.0	75	47		-14	35.5				
KENNEDY	75	47		7	37.0				
INDEPENDENCE	76	28							
KITTY HAWK	77	84	2.1						
ENTERPRISE	77	70	2.1	-9	49.6				
RANGER	78	61	2.2	37					

Table H-8. SELECTED CERTIFICATION PARAMETERS OF A-7 AIRCRAFT

Ship	Yr	Board Rate (%)	AQR	Mean TD (Ft.)	Std Dev TD (Ft.)	Sample	G.S. (Deg.)	Wind Dir (Deg.)	Wind Vel (Kts.)
CONSTELLATION	72			2	59.9	60	3.5	345-000	23-33
CONSTELLATION	72			9	49.7	19	4.0	345-000	23-33
FORRESTAL	72	52		31	31.6	9	4.0	345-000	27-36
RANGER	72	72		-8	56.0	63	3.5	340-000	25-35
SARATOGA	72			-2	40.0	14	4.0	350-	27
SARATOGA	72			-16	37.0	11	4.0	350-	34
CORAL SEA	72			1	61.0	50	4.0	340-015	6-37
INDEPENDENCE	73	73		-14	34.5	15	4.0	335-010	15-40
KITTY HAWK	73	79		13	63.6	12	3.5	342-358	25-40
KITTY HAWK	73	79		-39	30.3	13	4.0	358-010	25-40
KENNEDY	73	64		-31	44.0	66	3.5	330-010	12-31
SARATOGA	74	84		-1	29.8	31	3.5	343-357	23-37
SARATOGA	74	84		16	54.0	16	3.5	358-015	23-37
RANGER	74			-37	32.0	12	3.75	348-357	26-35
RANGER	74			49	46.0	14	3.75	358-008	26-35
CONSTELLATION	74	48	3.42	-42	27.2	8	3.5	345-005	19-33
CORAL SEA	74	55		NO DATA TAKEN					
ENTERPRISE	74	94		-13	60.6	53	3.5	340-015	21-36
RANGER	75	93		-19	41.1	61	3.625	345-000	24-33
INDEPENDENCE	75	68	3.10	-19	44.7	38	3.5	330-003	22-39
INDEPENDENCE	75	86	3.40	31	41.5	11	4.0	330-003	22-39
KENNEDY	75	60		-13	40.0	16	3.5	341-015	17-35
KITTY HAWK	75	65		NO DATA TAKEN					
INDEPENDENCE	76	48	3.12	19	38.6	42	3.5	340-020	20-35
ENTERPRISE	76	83		16	52.0	31	3.5	345-015	17-37
CONSTELLATION	76	76	2.89	17	53.6	101	3.5	345-005	20-30
NIMITZ	76	64	3.20	12	41.4	37	3.5	340-000	10-42
CORAL SEA	76	89		-17	33.9	38	4.0	350-010	20-32
AMERICA	76		2.91	-13	48.6	45	3.5	340-012	18-24
SARATOGA	77	78	2.76		36.8	38	3.65	340-012	15-29
KITTY HAWK	77	91	2.10		43.3	61	3.5		
MIDWAY	77	76	2.80	-15	37.9		3.5	340-005	20-30
FORRESTAL	77	87	2.20	-22	28.1	22	3.5	345-355	19-29
EISENHOWER	77	89	2.20	-28	41.7	30	3.5	340-355	18-30
ENTERPRISE	77	94	2.10	0	50.4	109	3.5	340-355	20-30
EISENHOWER	78	86	2.50	-19	44.1	17	3.5	340-005	18-30
KENNEDY	78	83	2.10	NO DATA TAKEN					
RANGER-1	78	68	2.30	37	57.6	33	3.5	340-005	17-28
RANGER-2	78	92	2.0	-8	42.1	56	3.5	340-005	20-32
RANGER-3	78	96	1.8	-10	35.6	53	4.0	340-005	20-32
CONSTELLATION	78	92	2.10	2	36.7	24	3.5	345-005	17-30
INDEPENDENCE	78	78	2.1	-24	29.3	15	3.5	345-355	22-29
AMERICA	78	59	1.8	-2	66.0	26	3.5	345-005	20-30
KITTY HAWK	79		2.0	28	59.1	65			
NIMITZ	79	84	2.6	-10	40.4	49			
FORRESTAL	79	93	2.4	-10	47.8	48			
CORAL SEA	79	84	2.6	3	45.7	63			
MIDWAY	80	80	2.8	9	49.3	44			
AMERICA	80	69	3.2	-15	44.1	18			
KITTY HAWK	81	74	2.9	-34	54.1	40			

Ship	Yr	Board Rate (%)	AQR	Mean TD (Ft.)	Std Dev TD (Ft.)	Sample	G.S. (Deg.)	Wind Dir (Deg.)	Wind Vel (Kts.)
KITTY HAWK	77	80	2.3	-4	45.7	32	3.5		
EISENHOWER	77	86	2.2	2	44.0	18	3.5	340-355	18-30
ENTERPRISE	77	85	2.1	9	48.2		3.5	340-355	20-30
EISENHOWER	78	66	1.9	-4	36.2	20	3.5	340-005	18-30
KENNEDY	78	47	2.2	20	45.8	64	3.5	345-005	17-28
RANGER	78	80	2.4	12	42.3	44	3.5	340-005	20-32
CONSTELLATION	78	86	1.8	18	43.1	23	3.5	345-355	22-28
AMERICA	78	73	2.1	9	58.5	19	3.5	345-005	20-30
INDEPENDENCE	78	88	2.1	5	43.6	22	3.5	345-005	20-29
KITTY HAWK	79		1.9	-9	46.2	54			
NIMITZ	79	89	2.5	-7	34.0	32			
CORAL SEA	79	88	1.9	-13	43.5	30			
AMERICA	80	84	2.5	8	44.7	35			
KITTY HAWK	81	82	2.0	-28	27.9	20			

Table H-9. SELECTED CERTIFICATION PARAMETERS OF A-6E AIRCRAFT

Table H-10. SELECTED CERTIFICATION PARAMETERS OF EA-6 AIRCRAFT

Ship	Yr	Board Rate (%)	AQR	Mean TD (Ft.)	Std Dev TD (Ft.)	Sample	G.S. (Deg.)	Wind Dir (Deg.)	Wind Vel (Kts.)
KITTY HAWK	79		1.7	-2	35.1	50			
NIMITZ	79	69	1.8	-37	30.5	15			
MIDWAY	80	53	2.8	0.2	38.5	12			
AMERICA	80	90	1.8	-26.0	43.3	21			
KITTY HAWK	81	100	2.1	-3	34.4	24			

APPENDIX I

CARRIER SUITABILITY SHIPBOARD ACLS TRIALS CONFERENCE

This appendix presents the agenda for the Carrier Suitability Shipboard Trials Conference.

Shipboard Trials

I. Introductions

a. CVS Branch Head/Trip Coordinator/Test Coordinator

b. ACLS Program Manager

c. NESTED

II. Schedule

a. Confirm trial dates and ship schedule.

b. Find out other aviation activities which will be aboard during trials. Discuss priorities (Airwing, carquals, etc.).

c. NATC airlift information.

d. On-load NATC personnel/equipment (when, where, cranes, trucks, busses, ship's loading coordinator, etc.).

e. Fly-aboard/hoist aboard.

f. Fly-off.

g. Off-load NATC personnel/equipment (when, where, trucks, busses, ship's/NATC off-loading coordinator, etc.).

h. NATC return airlift information

III. NATC Carrier Trials Operation Outline

a. Deliver advance copies.

b. Review Op outline, in particular, items NATC will provide, and support requested from ship such as working spaces.

c. Test instrumentation - time required for installation and removal, centerline camera; instrumentation personnel in catwalk, on deck, etc.

IV. Flight Operations and Procedures

a. ACLS

(1) Number/type planes/approaches, T&G, traps, cycle time, hot refuel, tank, NATC acft D/L address, Mode I squawk.

(2) Pattern

(a) VFR-Pilot controlled, CATCC monitor, up to four acft.

(b) IFR-CATCC controlled, two acft, weather minimums variable.

(c) Exclusive deck time if required, priority over acft in VFR landing pattern.

(3) Standard Voice calls will be used. Ship's UHF frequency, D/L frequency, Call sign, TACAN, UHF HOMER.

(4) Acft based ashore, Intended scheduling. Communications with pilots ashore.

b. General

(1) Acft based ashore. Support/logistic acft (C-1, KA-6).

(2) PRI-FLY observer.

(a) BINGO info.

(b) Emergency procedures.

(c) Acft basic weight, lens, arresting gear settings.

(3) NATC LSO on platform.

(4) Daily sitrep to COMNATC.

V. ACLS Program

a. Initial

b. Revisions:

(1) Communications - LSO, PRI-FLY, SPN-42.

(2) Program adjustments.

c. Final program

d. Approximately 40 T&G/arrest per channel after final program established.

e. NATC and NAVAIR recommend ACLS certification. CNO certifies. Interim clearance given as soon as possible. Final clearance given after data reduction. Clearance limits (deck, pitch, WOD) determined by conditions tested.

VI. Maintenance

a. NATC Maintenance Officer - Contact In Flight Deck Control.

b. Supply support (tires).

c. Ship's starters, LOX plant, etc.

d. AIMD shops, test benches.

e. Flight deck clothing.

f. Special requirements (air for F-4's).

VII. Miscellaneous

a. Uniforms

(1) Officer mess bill

(2) Enlisted mess bill

b. Liberty, liberty cards

c. Mess hall hours, cards.

d. Room assignments - request advance assignments using roster or OP plan.

e. Enlisted berthing spaces.

f. BINGO procedures, ADIZ penetration.

g. Raspberry communication facilities/procedures.

APPENDIX J

AN/SPN-41 INSTRUMENT LANDING SYSTEM

The AN/SPN-41 Aircraft Carrier Instrument Landing System (ILS) employs microwave scanning techniques to give guidance information to aircraft within a 20-mile operating range.

The AN/SPN-41 makes safe landings possible under any condition of visibility that permits the use of visual guidance systems, such as the FLOLS, during the final 200 to 300 feet of descent. The AN/SPN-41 can also be used to guide a pilot to the acquisition window of an AN/SPN-42 radar for an ACLS Mode I approach and as an independent monitor glideslope display during a Mode I approach. Should the AN/SPN-42 landing system fail, the AN/SPN-41 can be used for a Mode II approach.

The major components of the AN/SPN-41 ILS include an azimuth antenna and an elevation antenna, both located aboard ship, and an airborne receiver/decoder (ARA-63). The azimuth antenna is mounted on a torsion bar located on the fantail of the carrier. The elevation antenna, also mounted on a torsion bar, is located near the FLOLS on the flight deck. The eleva' antenna is stabilized against the pitch and roll of the carrier deck.

The azimuth and elevation antennas send coded microwave signals into the aircraft approach area astern of the carrier. The receiver/decoder in the aircraft receives the signals, decodes the data, and presents the data for heads-up or heads-down cockpit display. This display shows the position of the aircraft with respect to the optimum flight path to the carrier deck.

The scanning action of the transmitted microwave signal is produced by the rapid oscillation, caused by an electric actuator, of the azimuth and elevation antennas. The azimuth signal produces a 2-degree beam, which scans back and forth through an angle of 10 degrees on either side of the runway center line. The elevation signal produces a 1.3-degree beam that scans up and down through an angle of 10 degrees to the horizon. Each beam consists of a succession of paired microwave pulses coded to relay the pointing angle of the antenna at each instant in time.

The azimuth and elevation scanning beams define an AN/SPN-41 acquisition window approximately 7 miles wide and 3-1/2 miles high at a distance of 20 miles astern of the carrier. Once the approaching aircraft passes through this window, it acquires landing guidance along a path aligned with the FLOLS and the flight deck. Each time the scanning beam sweeps past the approaching aircraft, the equipment in the aircraft receives and processes the coded signals and provides a cockpit display of the data. The cockpit display shows the pilot the flight path he must follow to line up his aircraft accurately with the deck of the carrier. Because each beam completes 3.3 scanning sweeps per second, the aircraft receives this flight path information continuously.

The elevation antenna, while it transmits only between 0° and 10° above the horizon, actually sweeps through a 20° arc (15° above the horizon to 5° below). Similarly, the azimuth antenna transmits only during the middle 20° of a 30° scan (±15° to either side of the center line). This "dead time" at the end of each scan permits the antenna to reverse its direction of travel for the return scan. However, each antenna radiates for only one direction of scan. Thus, by driving the antennas 180° out of phase, one antenna will radiate while the other is in its back-swing and all of the signals can be transmitted over a single radio channel. An angle decoder in the airborne equipment is then time-shared between the azimuth and elevation signals, and separate memories for the azimuth and elevation are updated each time the appropriate beam is received and decoded.

AN/SPN-41 guidance is available to all properly equipped aircraft in the approach zone. Aircraft employing the AN/SPN-41 landing system can maintain the correct orientation to the approach path while awaiting their turn to land. Because the guidance information is transmitted directly to and used directly in the aircraft, no data link or voice communication with the carrier is required, thus relieving the workload of the pilot, CATCC, and the already-busy communications channel.

APPENDIX K

FRESNEL LENS OPTICAL LANDING SYSTEM

The Fresnel Lens Optical Landing System (FLOLS) provides the pilot of an aircraft with a visual indication relating the position of his approaching aircraft to a prescribed glideslope. The glideslope is determined by the FLOLS setting and is designed to bring the aircraft down to the deck with a safe arresting-hook clearance above the ramp of the carrier. The FLOLS setting is itself determined by the type of aircraft landing on the carrier.

The lens unit consists of an independent assembly, green datum lights, red wave-off lights, and blue "cut" lights. A bar of yellow light, known as the "meatball," is displayed over the full width of the independent assembly to indicate the aircraft's position with respect to the designated FLOLS glideslope. If the aircraft is flying on the appointed glideslope, the meatball will be in line with the green datum lights. If the aircraft is too high, the meatball appears above the datum lights. Conversely, if the aircraft is too low, the meatball turns from yellow to red and appears below the datum lights. The red wave-off lights are manually activated by the LSO or PRI-FLY when dangerous landing conditions exist; the blue "cut" lights are used to tell the pilot of a propeller-driven aircraft when to cut his engines.

The independent assembly of the lens unit can be rotated about two horizontal and perpendicular axes. These axes correspond roughly to the pitch and roll axes of the carrier. The FLOLS glideslope angle is determined by the basic angle setting of the lens unit, or the tilt of the independent assembly about the pitch axis. The roll angle indicator setting of the lens unit, i.e., the tilt of the assembly about the roll axis, causes the glideslope at the runway center line to be raised or lowered to accommodate the hook-to-eye (H/E) of the various types of aircraft.

The lens unit provides optical glideslope information within approximately 3/4 degrees above and below the prescribed glideslope. The meatball may be seen within approximately a 20-degree azimuth to either side of the independent assembly. The roll angle indicator setting causes the optical window to be tilted in space. The degree of tilt in roll, which is a function of the aircraft's H/E, and the glideslope angle chosen determine where the pilot will penetrate the window and pick up the meatball. Thus the window penetration point varies for each aircraft type as well as for a given aircraft type flying different glideslope angles.

The prescribed glideslope is the glideslope dictated by the lens when viewed from the vertical plane of the landing area center line. The pilot is therefore required to line up with the runway center line while maintaining the meatball in line with the green datum lights. No ship's pitch or roll is assumed. However, ship's normal pitch and roll cause the vertical plane of the center line and hence the glideslope to move and therefore cannot be ignored. Shipboard computers take signals from the ship's stable element and calculate and transmit correction signals to the lens, thus stabilizing both the lens and the glideslope.

There are two basic lens systems: the Mark 6 Mod 0 Lens System and the Mark 6 Mod 1 and Mod 2 Lens System. These systems are differentiated by the modes of stabilization employed. The Mark 6 Mod 0 Lens System is point-stabilized, i.e., the lens is aimed to keep the prescribed glideslope at a point 2500 feet aft of the ship relatively motionless even though the carrier is pitching. The lens is thus stabilized against only the ship's pitch. As the aircraft approaches the carrier, the meatball begins to move above and below the datum lights with increased frequency because of the pitch of the ship. The pilot must average out the motion of the meatball rather than follow it. With the exception of AVT-16, all currently commissioned aircraft carriers (CVs) have Mod 1 or 2 FLOLS.

The Mark 6 Mod 1 and Mod 2 Lens System employs two stabilization modes -- point and line. The point mode is the same as that described above; the line mode controls both pitch and roll so that the glideslope is stabilized as a line in space. The meatball then appears stationary on the face of the lens unit when viewed from any point on the prescribed glideslope, even though the carrier is pitching and rolling. No averaging of the meatball's position is necessary; the pilot must correct for any displacement of the meatball on the face of the lens unit.

A ship's heave causes the glideslope to translate vertically. Neither of the lens systems discussed above provide lens correction for a ship's heave. There are also no automatic corrections for a ship's mistrim. Because a ship's mistrim affects the orientation of the FLOLS, and thus the FLOLS glideslope, the lens unit must be adjusted to compensate for mistrim.

When incorporated, trim harmonization, or CLASS (Carrier Landing Aid Stabilization System), will maintain the FLOLS basic angle with respect to the average (trim) pitch and roll attitude of the deck. This will prevent the static-commanded hook-to-ramp clearance, touchdown position, and sinking speed from varying with ship's mistrim. CV-63 currently has a CLASS, whereas CV-59, CV-61, and CV-66 all have trim harmonization.

APPENDIX L

PILOT ACLS RATINGS

1. INTRODUCTION

The assignment of a useful rating to an ACL system is not an easy task, since several subsystems (e.g., AFCS, AN/SPN-42) constitute the whole system and the whole system is influenced by the operating environment. In addition, greater degrees of deviation from optimum are permitted during different phases of the approach. Because pilot acceptability is a subjective measure, the ACLS Quality Rating Scale (AQR) was devised to standardize ratings and to allow a quantitative evaluation of a qualitative assessment.

For an ACLS rating system, a basis of comparison is required. Since the only basis that is readily available to NAVAIRTESTCEN pilots is the AN/SPN-42 located at NAVAIRTESTCEN, this system is the normal standard of comparison. The system control experienced at NAVAIRTESTCEN (under headwind conditions) should be classified as AQR-2. Since different aircraft have different control characteristics both ashore and at sea, the AQR-2 rating should be established for the type of aircraft being flown rather than standardizing the performance of all aircraft types to the performance of one aircraft type. For example, an A-7 aircraft AQR should be based on its performance at NAVAIRTESTCEN, not on the performance of an F-4 or A-6 aircraft at NAVAIRTESTCEN.

Another factor the pilot must consider in rating aircraft/ACLS control performance is ACLS control compared with pilot control. This question must be evaluated in the context that a pilot manually flies the aircraft differently from the ACLS in the automatic mode. A pilot will have smoother control motion, be more tolerant of relatively large-scale glidepath deviations, and lead the aircraft control as he anticipates the need for attitude corrections. On the other hand, ACLS will continually work the controls to maintain negligible glidepath deviations and will only respond to errors rather than anticipate errors.

With the understanding that ACLS does not fly an aircraft the way a pilot would fly an aircraft, the pilot is still asked to rate ACLS controllability by using pilot acceptance as a dominant factor. In determining AQRs, the pilot should use the criterion whether or not control is safe and reasonable, not whether or not ACLS can do the job better than a pilot. Just like a pilot, ACLS will not provide zero glidepath deviations throughout the approach. ACLS does provide constant control motion to zero out all glidepath errors.

2. AQR EVALUATION CRITERIA

In determining AQRs, there are many different factors to consider; some of the major factors are as follows:

- Attitude Changes. Are attitude commands and airplane response smooth? Do they approximate the inputs of a pilot or are they jerky and too tight?
- Altitude Excursions. Does the airplane maintain level flight to small excursions or does it oscillate about "couple" altitude?
- Needle Movement. Is movement steady and flyable or jerky and annoying?
- AOA Excursions. This is a function of control and turbulence; therefore, the pilot has to distinguish between the two. Are AOA excursions (which are caused by control) minimal or are AOA excursions of such magnitude that they are driving the APC excessively? Does rudder shaker/pre-stall buffet activate at any time during the approach?
- Deviation from Glideslope. Are deviations from glideslope minimal or large? Does this system initiate a correction immediately? Do the magnitude of glideslope deviations tend to instill confidence in the pilot or do they cause the pilot to question the performance of the system?
- Consistency. This factor deals particularly to the in-close or burble position. Does the airplane arrive at the burble consistently in the same position so that a ramp function or other input to the computer program will improve touchdown or position over the ramp?
- Burble. How does the airplane handle the effects of the burble? Does it settle excessively? Does it react in a proper manner (e.g., add power)?
- Touchdown. Includes touchdown position, sink rate, and attitude. Are they optimal or otherwise?

3. EVALUATION OF APPROACH PHASES

The standard pilot card shown in Figure L-1 allows space for evaluating five phases of the approach. These phases and the factors that the pilot is considering are as follows:

- Level Leg (LL). (Prior to commencement of tip over) Attitude changes, altitude excursions, needle movement, AOA excursions, line-up corrections.

WEATHER	TEMP. BARO. TURB APCS STD	FLT A-3 JOB NO.

AIRPLANE TYPE A7E	BU NO 752	TIME T O. 0800 TIME LAND 1000	DATE 12-17 81
PILOT JONES		EXTERNAL CONFIGURATION 6 PLYONS	
PROGRAM 1/4° RAMP at 8.7 SEC			A/C EMPTY WT 27000 + FUEL
PROGRAM OBJECTIVE			

EVENT	CH	INST	LOCK ON TIME	FUEL STATE	LL	TO	GS	IC	TD	LAND COND	COMMENTS
1	A	✓	805 841	4.0	1	1.5	2	2	2	T .6	MODE 1 OK
2	B	✓	15 43	3.6						T .6	MODE 1 OK

Figure L-1. SAMPLE PILOT'S CARD

- Tip Over (TO). Attitude change, rate of descent, over/undershoot AOA excursion needle.
- Glideslope (GS). (After tip over until in-close or proximity of burble) Attitude changes, AOA excursions, deviation from glide-slope consistency needle movement.
- In-Close (IC). (Burble onset to command freeze) The effects of the burble and how the system handles it.
- Touchdown (TD). (Over the ramp to actual touchdown) Touchdown deviation from optimum position at ramp, sink rate, actual touch-down point.

The ACLS Quality Rating Scale is shown in Figure L-2, together with a description of the quantitative metric.

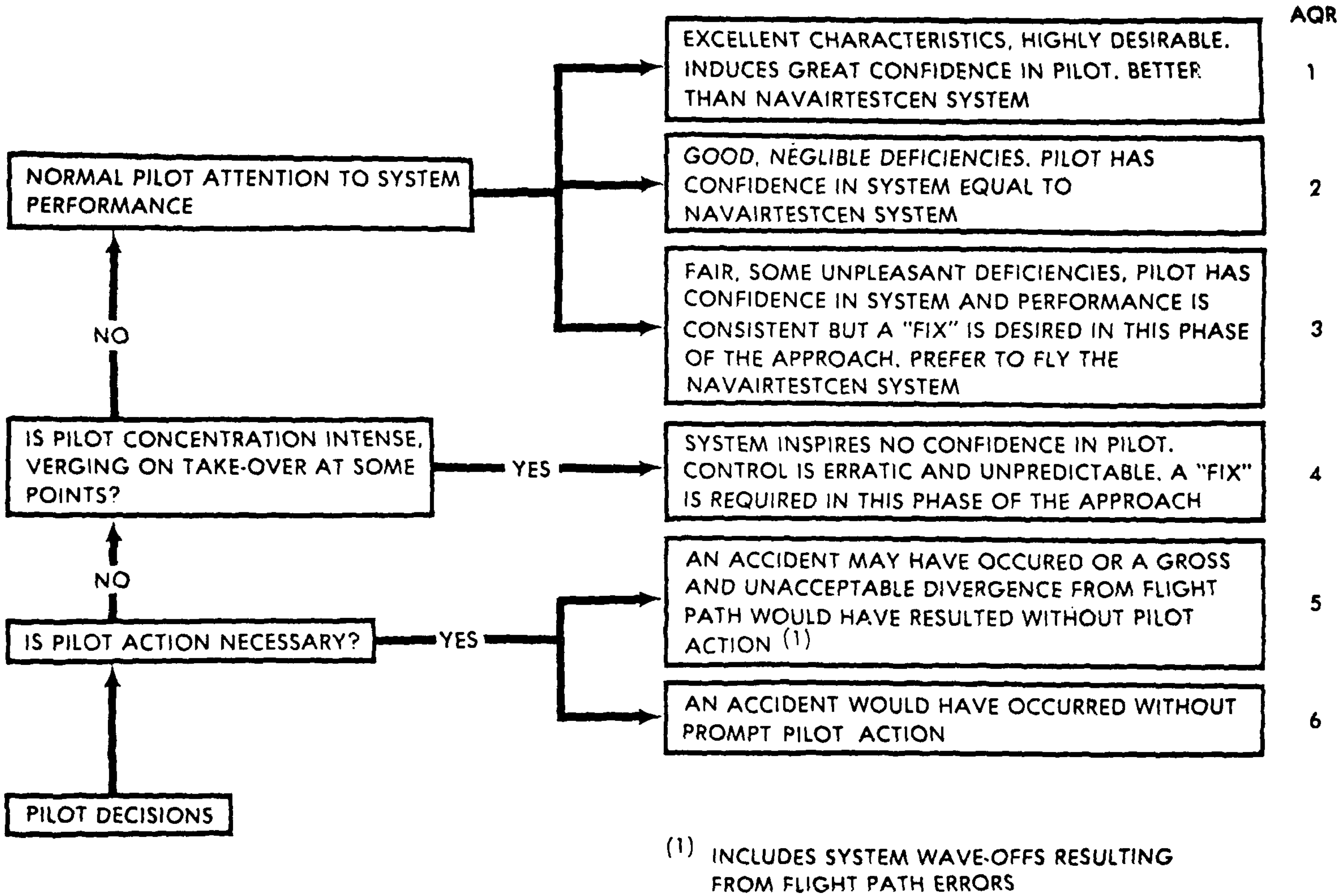


Figure L-2. ACLS QUALITY RATING SCALE

APPENDIX M

STATISTICAL MEASURES OF TEST RESULTS

1. INTRODUCTION

Data from six ACLS Mode I certification tests were analyzed to determine the form of the statistical distribution. The data were extracted from the certifications shown in Table M-1.

Table M-1. ACLS CERTIFICATION DATA EXAMINED

Certification	Ship	Date of Certification	Aircraft Data
1	USS KITTY HAWK	May 1977	A-6E
2	USS INDEPENDENCE	November 1978	A-6E
3	USS CORAL SEA	March 1979	A-6E, A-7E
4	USS AMERICA	December 1980	A-6E, EA-6B, A-7E
5	USS KITTY HAWK	January 1981	A-6E
6	USS EISENHOWER	May 1981	A-6E, EA-6B

Hook touchdown point (longitudinal) and off-center-line point (lateral) data were examined for distributional form and values of means and standard deviations. A total of 26 data sets were examined both singly and in combination. After adjusting for values of the mean, the data for aircraft type were combined over the available certification data. In each instance, the mean, mode, and median were found to be within 3 to 4 percent of each other; when plotted on probability scale paper, the deviation of the cumulative probability from that presented by a normal distribution is insignificant.

This allows the assumption of a normal distribution. Figure M-1 shows the frequency distribution data for the A-6E touchdown point combined over the six ACLS certification trials and is fairly typical of the data examined. Figure M-2 shows the associated probability plot. This high correlation with the normal distribution was apparent in both the longitudinal and

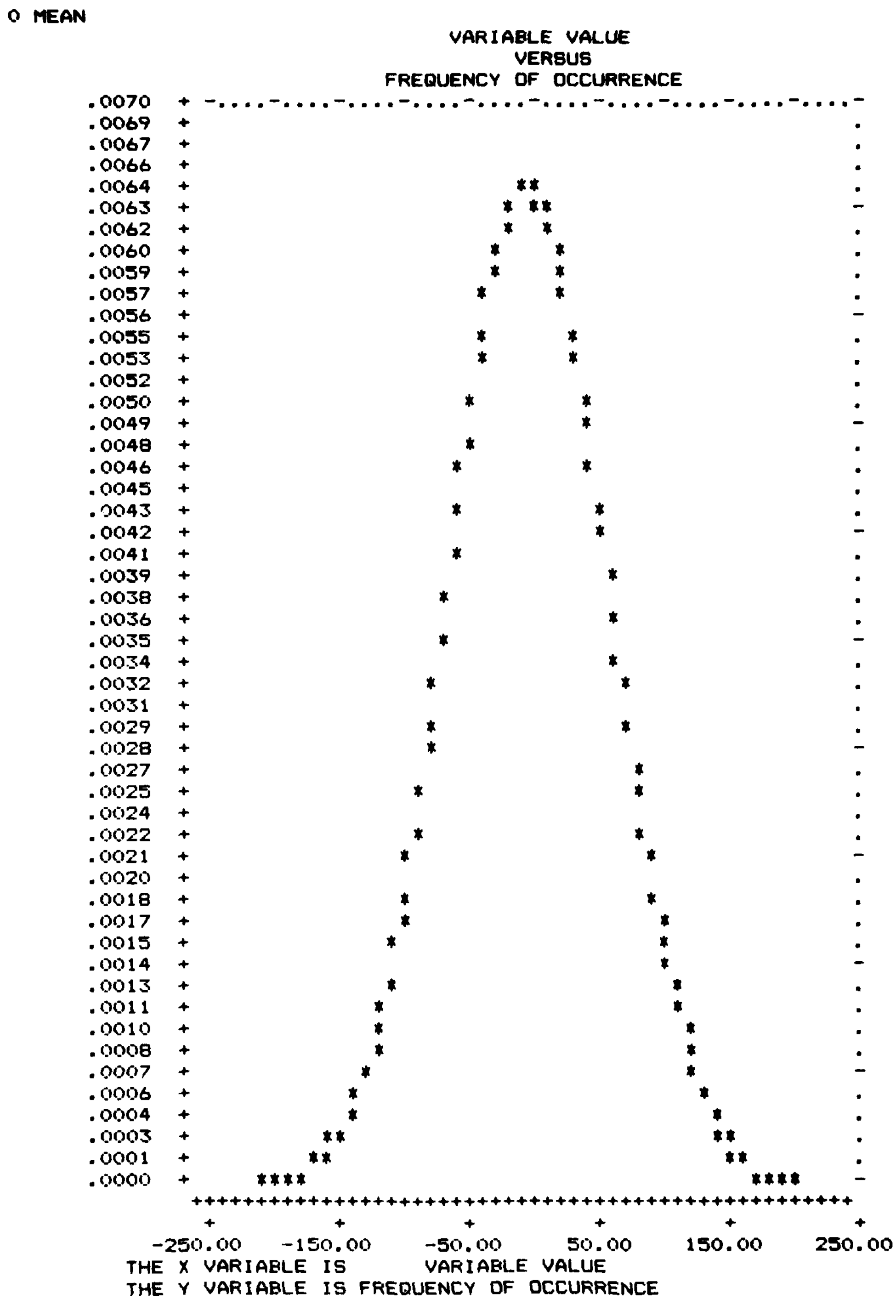


Figure M-1. COMBINED FREQUENCY DISTRIBUTION FOR A-6E LONGITUDINAL TOUCHDOWN DATA

0 MEAN

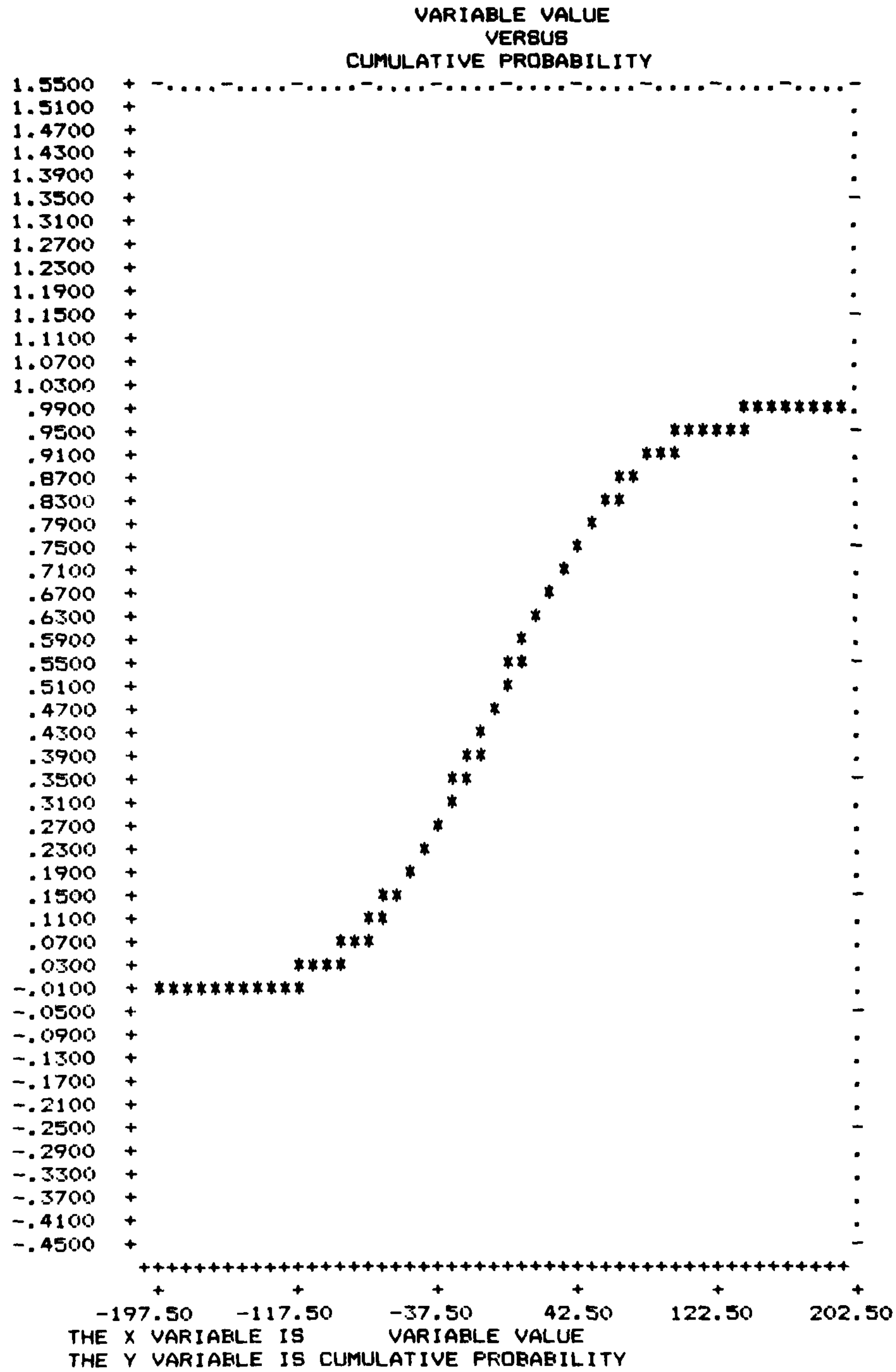


Figure M-2. PROBABILITY PLOT OF COMBINED A-6E LONGITUDINAL TOUCHDOWN DATA lateral data, although the lateral data were found to be more peaked (i.e., the lateral data exhibited a relatively lower variance), as shown in Figures M-3 and M-4. On the basis of these data, the assumption of normal distribution will introduce little error when conducting ACLS Mode I certifications. Major values of the surveyed data are given in Table M-2.

2. TOUCHDOWN POINT AND BOARDING RATE AS RELATED TO NORMAL DISTRIBUTION

The properties of a normal distribution can be used to quantify the probability required for a certification. Figure M-5 shows the basic touchdown geometry to be considered.

The shaded region in Figure M-5 shows the desired touchdown area. For the perfect system, all automatic touchdowns would occur in this area. In actuality, however, only a percentage of touchdowns will occur in this area. The pilot, LSO, or ACLS will initiate takeover or wave-off procedures if the parameters defining the landing area (x, y, and δ) are exceeded.

The parameters x, y, and δ are a function of the individual ship. The percentage of touchdowns occurring within the prescribed area can be defined as the area under the frequency distribution between the extremes (x and $x + \delta$ for the longitudinal case). Given the symmetry of the normal distribution, this area can be maximized by adjusting the touchdown point so that the mean value occurs halfway between the extremes.

The value placed on the probability of landing within the defined touchdown area shown in Figure M-5 is determined by the project engineer. Under conditions of high turbulence and rough seas the probability of landing within the specified boundaries would be expected to be less than the touchdown probability for calm conditions. The test conditions of any given certification must always govern the touchdown probabilities. With the touchdown point adjusted in this way, the probability of touchdown will be given by:*

$$\int_{-t}^{t} N(\tau)d\tau,$$

which can be approximated by:

$$P_i = 2\left(1 - \frac{1}{2}\left[1 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4\right]^{-4}\right) - 1$$

where

$c_1 = 0.196854$ $c_3 = 0.000344$

$c_2 = 0.115194$ $c_4 = 0.019527$

*Abramowitz and Stegun, *Handbook of Mathematical Functions*, Dover, 1970.

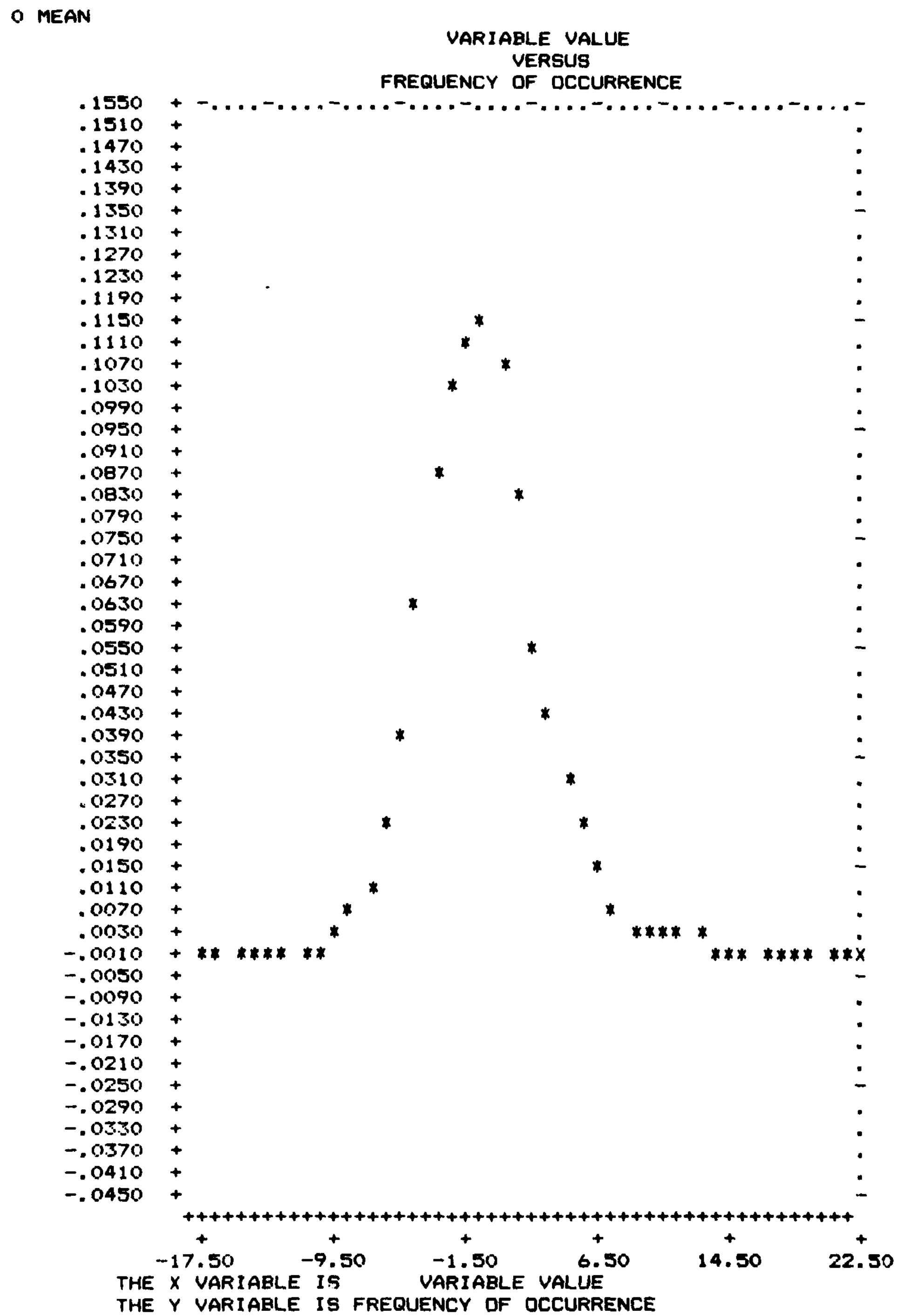


Figure M-3. COMBINED FREQUENCY DISTRIBUTION FOR A-7E LATERAL TOUCHDOWN DATA

0 MEAN

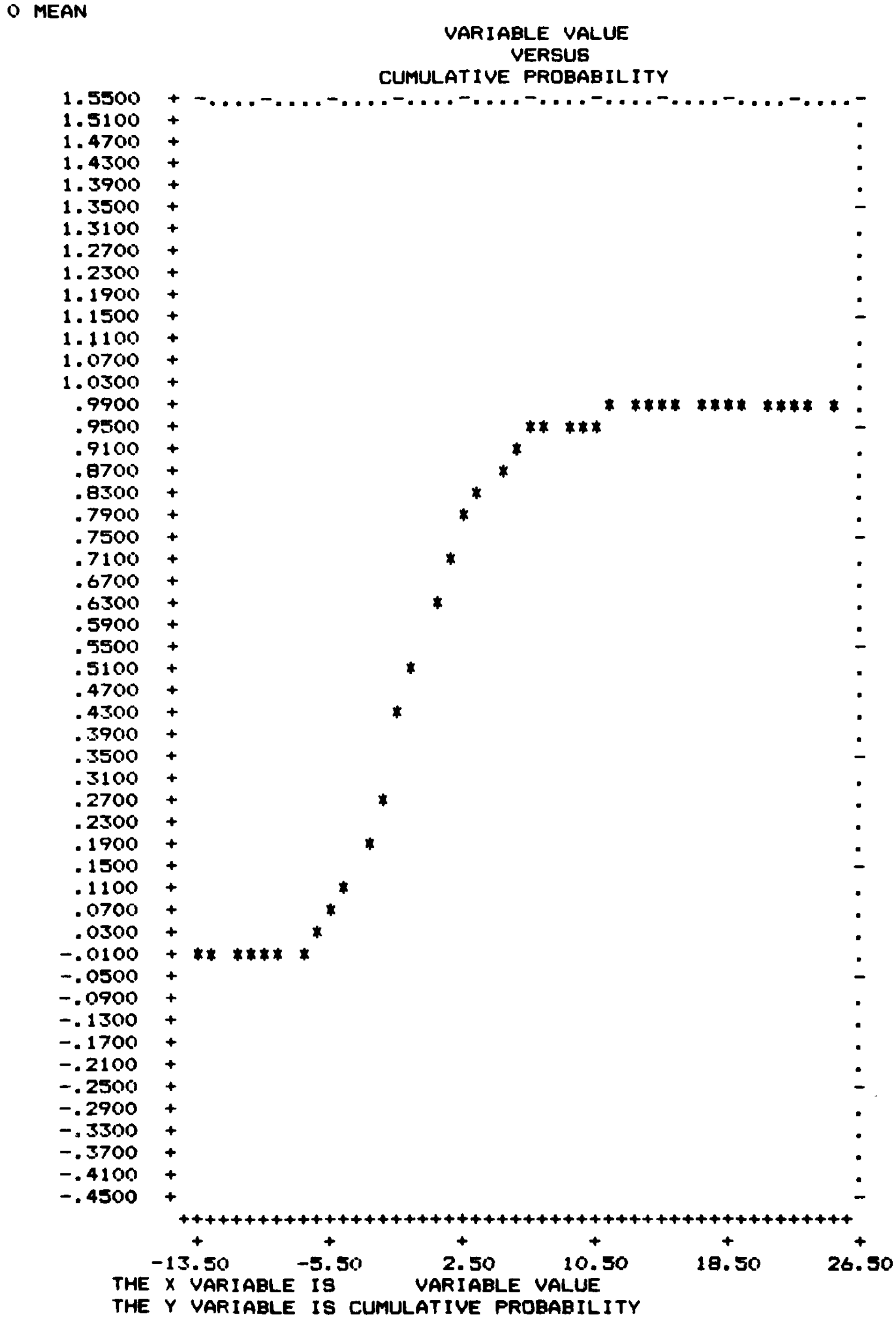


Figure M-4. PROBABILITY PLOT OF COMBINED A-7E LATERAL TOUCHDOWN DATA

Table M-2. STATISTICAL CHARACTERISTICS OF SURVEYED DATA				
Aircraft	Off-Center Line*		Hook Touchdown*	
	Mean ($\bar{x}$)	Variance (σ^2)	Mean ($\bar{x}$)	Variance (σ^2)
A-7E	-2.4 to 2.3	12.9 to 15.3	-14.6 to 11.8	4502 to 5037
A-6E	-4.5 to 3.1	7.5 to 30.2	-35.5 to 4.6	1153 to 5345
EA-6B	3.5 to 4.9	8.4 to 9.0	-2.8 to -25.8	4112 to 5745

*Data adjusted relative to desired touchdown point.

Note: Negative values indicate landing aft or to the left of the desired touchdown point.

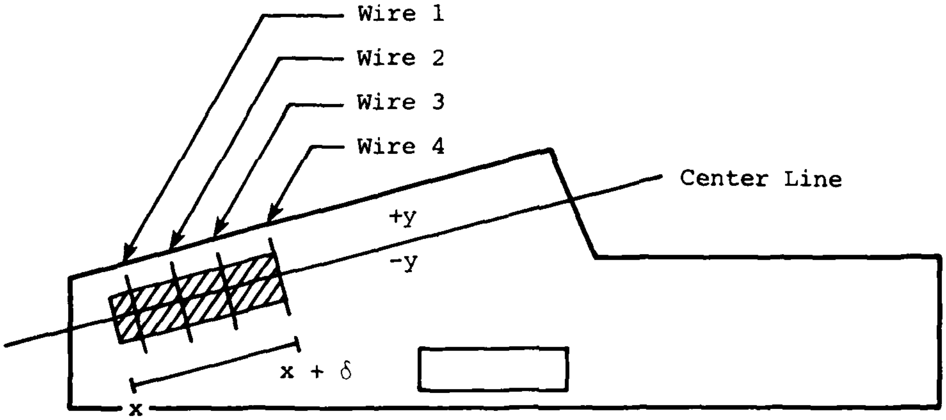


Figure M-5. LANDING AREA GEOMETRY

For the longitudinal case,

$$t = \frac{\delta}{2\sigma_x}$$

where δ is taken from Figure M-5, and σ_x is the test data variance.

For the lateral case,

$$t = \frac{y}{\sigma_y}$$

where y is taken from Figure M-5, and σ_y is the test data variance.

For the data sets examined, the lateral line-up was never a problem with the lateral touchdown probability approaching unity for y larger than 10 feet.

The total probability of touching down within the shaded landing area may be determined by assuming independent lateral and longitudinal axes (which is valid for aircraft that are not short-coupled) and by taking the product of the longitudinal and lateral probabilities:

$$P_T = P_{LONG} \times P_{LAT}$$

The total probability of an arrested landing will be related to the boarding rate but may not be equal to the boarding rate for several reasons; for example:

- Hook slaps can cause bolters, which this calculation does not consider.
- Automatic landings at the extremes of the landing area will often be taken away from the system by the pilot.
- The touchdown probability will be related to test conditions and will be valid only for the operational envelope defined for the certification.

3. SAMPLE SIZES FOR CERTIFICATION SETS

The properties of the normally distributed data set can be used to ascertain the sample size required to yield certification to any desired accuracy. The accuracy, a, may be defined as the deviation or tolerance that one is willing to accept in the mean of the touchdown data. For instance, is the statistical mean accurate to within 5 feet, 10 feet, or 20 feet?

It may be shown mathematically that the accuracy, a, of a normal distribution is given by the equation

$$a = \frac{Z_c \sigma}{\sqrt{n}} \qquad (1)$$

where

Z_c = the standardized normal variate for confidence level c

σ = the variance of the data from the mean

n = the sample size

Solving for Z_c to allow use of the standard normal distribution table shown in Appendix N, we obtain

$$Z_c = \frac{a\sqrt{n}}{\sigma} \qquad (2)$$

Z_c is a function of the confidence level desired in the sample data. To obtain 95 percent confidence, for example, $Z_c = 1.96$; to attain 90 percent confidence, $Z_c = 1.645$. Solving Equation 1 for n, we obtain

$$n = \frac{Z_c^2 \sigma^2}{a^2} \qquad (3)$$

Table M-3 gives the appropriate sample sizes required to obtain 95 percent confidence and 90 percent confidence in the sampled data, given a desired accuracy and an expected standard deviation.

Table M-3. DATA SAMPLES (N) REQUIRED AS A FUNCTION OF DESIRED ACCURACY, VARIANCE, AND CONFIDENCE LEVEL

Accuracy in Feet (a)	Measured Standard Deviation in Feet (σ)	95 Percent Confidence Samples Required (n)	90 Percent Confidence Samples Required (n)
0	Any	∞	∞
5	20	62	43
10	20	16	11
10	30	35	25
10	40	62	44
10	50	97	68
20	40	16	11
20	50	24	17
20	60	35	25
25	50	16	11
25	60	22	16
25	70	30	22
25	80	40	28

APPENDIX N

LANDING PREDICTIONS

Landing predictions for the probable wire engagements are based on an assumption that the certification data are normally distributed. The standard normal variate is defined by the equation

$$z = \frac{x - \mu}{\sigma} \tag{1}$$

where it is assumed that x is normally distributed with mean μ and standard deviation σ for this analysis

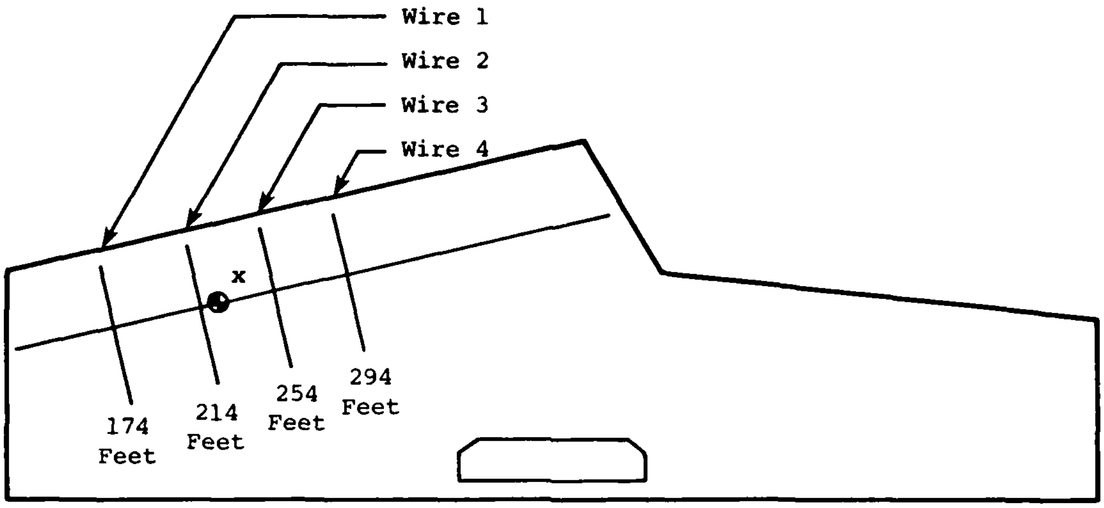
x = random distance from end of ramp

μ = touchdown distance from end of ramp = 236 feet

σ = touchdown dispersion (standard deviation) = 36.7 feet

It is desirable to determine the probability of hook touch down for each wire. This is accomplished by using Equation 1 to calculate z and Table N-1 (presented at the end of this appendix), which presents the desired probability for a given z. The calculations for landing predictions are presented in the following paragraphs.

From the certification film data analysis, the mean touchdown point was calculated to be 2 feet forward of the desired touchdown point with a touchdown dispersion of 36.7 feet. The desired touchdown point was given as 234 feet from the end of the ramp; the actual touchdown point (μ) is therefore 236 feet from the end of the ramp. Assuming 40 feet between cables and applying standard normal distribution statistics, the probability of hook touchdown for each wire can be determined. The wire distances from the ramp are shown in Figure N-1.



⊕ Aim Point ($TD_{desired}$) = 234 Feet

x Actual Touchdown Point (TD_{actual}) = 236 Feet

Figure N-1. WIRE DISTANCES FROM RAMP

The calculations for wire 3 are as follows:

$$z = \frac{x-\mu}{\sigma}$$

where

$x = 214$

$\mu = 236$

$\sigma = 36.7$

$$z_{3,1} = \frac{214 - 236}{36.7} = \frac{-22}{36.7} = -0.5995$$

The normal distribution is symmetrical about its mean (μ); therefore, in Table N-1 look under $z = 0.5995$ or ≈ 0.60, to obtain a probability of 0.2257 or ≈ 0.23 for the probability corresponding to $P_{3,1}$. However, this is only the probability of landing aft of the touchdown point between wires 2 and 3. The probability of landing forward of the touchdown point between wires 2 and 3 must also be calculated, and the two probabilities summed to determine the probability of a hook touchdown for wire 3:

$$z_{3,2} = \frac{254 - 236}{36.7} = 0.4905 \approx 0.49$$

$P_{3,2} = 0.1879 \approx 0.19$

$P_3 = P_{3,1} + P_{3,2} \approx 0.42$

The calculations for wire 4 are as follows:

$$z_4 = \frac{294 - 236}{36.7} = 1.5804 \approx 1.58$$

$$P_4 = P(1.58) - P_3 = 0.44 - 0.19 = 0.25$$

The probability of a wire 3 (P_3) must be subtracted out because the aircraft landing between the touchdown point and wire 3 must be excluded from the aircraft landing between wires 3 and 4.

For a bolter (forward of wire 4), the probability is simply $0.5 - P_4 - P_3$, because of the symmetry of the normal distribution about its mean. Therefore, P_{bolter} equals $0.5 - 0.25 - 0.19 = 0.06$.

The calculations for taxi wire 1 (40 feet aft of wire 1), wire 1, and wire 2 are similar. The total landing predictions are summarized as follows:

Taxi	Wire 1	Wire 2	Wire 3	Wire 4	Bolter
0.01	0.04	0.22	0.42	0.25	0.06

Table N-1. THE STANDARD NORMAL DISTRIBUTION										
±z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2281	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

*Values in this table give the probability corresponding to the interval from the mean to the mean $+z\sigma$.