To the Graduate Council:

I am submitting herewith a thesis written by Matthew Lewis Klunder entitled "PROJECT OFFICER'S HANDBOOK FOR THE CERTIFICATION OF INCREASED GROSS WEIGHTS ON CARRIER BASED AIRPLANES." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Aviation Systems.

Prof. Robert Richards, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor
and Dean of the Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at the University of Tennessee, Knoxville, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowed without special permission, provided that accurate acknowledgement of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of Interlibrary Services when, in the opinion of either, the purposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Matthew J. Klumb

Date APRIL 17, 1992

PROJECT OFFICER'S HANDBOOK FOR THE CERTIFICATION OF INCREASED GROSS WEIGHTS ON CARRIER BASED AIRPLANES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Matthew Lewis Klunder

August 1992

DEDICATION

This thesis is dedicated to all test pilots who proudly wear the "Wings of Gold"

ACKNOWLEDGMENTS

The author would like to express his thanks to the Graduate School of the University of Tennessee for designing a higher education program that effectively matches the goals and career paths of motivated Naval Officers. Through the use of video taped instruction, this program provided great flexibility and understanding within the guidelines of today's hectic working environment. The author would like to thank the Force Warfare Aircraft Test Directorate for making the ultimate commitment to graduate education and for providing the necessary monetary support that was so beneficial. Finally, the author would like to thank his beautiful wife Marylee who is truly the inspiration in his life. Without her constant patience and devotion to the cause, this goal would never have been fulfilled.

ABSTRACT

This thesis was developed to provide project officers and project engineers with a useful and effective guide in the certification of Increased Gross Weights (IGW) on carrier based airplanes. The guidelines were presented in a new and informative project officer's handbook that was designed to provide the project officer with a detailed yet simple reference work to assist in proper planning, preparation, and coordination of a successful IGW test program. From the author's personal experiences as a successful IGW project officer, this handbook has answered all the critical questions that specifically arise from an IGW program. For the solutions, this handbook has taken the project officer and engineer all the way from the infant stages of an IGW test program to the structural demonstration and shipboard qualification of an airplane.

It was concluded that this project officer's handbook has excellent potential for use in today's Navy test environment. With discussion of the recently completed E-2C Hawkeye aircraft IGW program results, it is hoped that the practices and philosophies taught in this handbook will significantly improve a test teams capability at completing an IGW certification program. The utilization of this handbook should provide a greater understanding of how to properly execute an IGW test program for any carrier based airplane.

TABLE OF CONTENTS

CHAPTER PAGE

I. INTRODUCTION....1

General....1

Purpose....3

II. BACKGROUND....4

Birth of U.S. Carrier Aviation 4

E-2 Hawkeye Aircraft....7

III. LITERATURE REVIEW....10

Government Information....10

Contractor Information....12

IV. METHODOLOGY....15

Project Management....15

GENERAL....15

TEST PLANS....16

FLIGHT CLEARANCES....18

FUNDING....21

ASSET ALLOCATION....22

ENGINEERING SUPPORT....24

SAFETY....26

MISCELLANEOUS....28

Aircraft Structural Requirements....30

GENERAL....30

GROUND VIBRATION MODAL TESTS.....31
AIRPLANE DROP TESTS.....34
AIRPLANE STATIC TESTS.....36
AIRPLANE FATIGUE TESTS.....38
Aircraft Flying Qualities Evaluations.....40
GENERAL.....40
E-2C HAWKEYE AIRCRAFT.....42
Carrier Suitability Demonstrations.....43
LANDBASED TESTS.....43
SHIPBOARD TESTS.....48
Program Report Requirements.....53
INTERIM MESSAGE REPORTS.....53
FINAL REPORT.....55
Final Flight Clearance Approval.....56
V. RESULTS AND DISCUSSION.....58
General.....58
Project Planning and Management.....58
Aircraft Structural Tests.....60
Aircraft Flying Qualities and Performance.....62
Carrier Suitability Demonstrations.....64
VI. CONCLUSION.....67
General.....67
Specific.....67
LIST OF REFERENCES.....69

APPENDIXES.....73
APPENDIX A. TABLES.....73
APPENDIX B. FIGURES.....94
APPENDIX C. E-2C IGW SAMPLE CATEGORY "C" TEST TECHNIQUES.....131
APPENDIX D. LIST OF SYMBOLS AND ABBREVIATIONS.....137
VITA.....140

LIST OF TABLES

TABLE		PAGE
I.	Military Specifications and Standards for Increased Gross Weight Testing	74
II.	Airplane Drop Tests	75
III.	Catapulting and Arrestment Test	76
IV.	Wing Group Tests	77
V.	Tailgroup Tests	79
VI.	Fuselage Tests	80
VII.	Landing Gear Installation Test	81
VIII.	Control System Tests	82
IX.	Engine Installation Tests	83
X.	Supporting Structures for Fixed-Equipment and Useful Load Items	84
XI.	Miscellaneous Parts Tests	85
XII.	E-2C Increased Gross Weight Phase II- Flying Qualities Evaluation Tests and Test Conditions	86
XIII.	Arrested Landing Tests	92

LIST OF FIGURES

FIGURE PAGE

1. Sample IGW Test Plan.....95
2. Sample IGW Flight Clearance Request.....102
3. Sample IGW Project Support Checklist.....104
4. Sample IGW Safety Checklist.....111
5. Diagram of E-2C Free Flight Engagement Analysis.118
6. Diagram of Test Configuration for E-2C Free Flight Engagement.....119
7. E-2C Drop Test Article Side View Instrumentation120
8. E-2C Drop Test Article Top View Instrumentation.121
9. E-2C Drop Test Apparatus: Front View.....122
10. E-2C Drop Test Apparatus: Side View.....123
11. E-2C Catapult Tow Load Static Test Set-up.....124
12. Deflection Gage Locations: Tow Load Static Test.125
13. Cooper Harper Handling Qualities Rating Scale...126
14. E-2C Load Stroke Curve Comparison for Drop Test.127
15. E-2C Forward Fuselage Bending Moment Comparison for Drop Test.....128
16. Sample Time History of E-2C Approach Handling: Increased Landing Weight in Configuration PA(20).....129
17. E-2C Free Flight Engagements: Right Lower Fuselage Strain Station 268.....130

CHAPTER I

INTRODUCTION

General

The duties of a project officer and project engineer during an Increased Gross Weight (IGW) program are considerable. These individuals are required to act as leaders, organizers, and planners, and must also ensure that their responsibilities as test pilots and test conductors are met. Their high profile roles as project managers are characterized by tasks such as coordinating ground and flight tests, being a liason between the test team and Naval Air Systems Command (NASC), and ensuring that appropriate engineering support, data processing support, and manpower support are provided. Unfortunately, these types of concerns are presented to the project officer and project engineer on a daily basis and can become rather exhaustive. From the author's personal experience as a project officer involved in the completion of a successful IGW program, there is currently no published work that specifically addresses the problems of an IGW program. To relieve some of these concerns and help the project officer and engineer conduct a successful and safe IGW certification program, this handbook was developed. It is a handbook created from the author's

personal experiences as a project officer and it is filled with proven strategies and advice on how to complete an IGW certification program.

This project officer's handbook is designed to be a useful and effective guide in the certification of IGW on carrier based airplanes. Its innovative structure is intended to provide the project officer with a detailed yet simple reference work to assist in proper planning, coordination, and implementation. It provides the pure essentials of testing carrier based airplanes within the current U.S. Navy specification system, but at the same time addresses the flexibility that must be maintained when dealing with proven older airframes that are undergoing enhancement modifications. The handbook is being developed as a primary working tool for the project officer and project engineer during the conduct of an IGW certification program. Its new step by step approach with helpful insights and proven advice should ensure that adequate planning, preparation, and coordination are accomplished and that all critical phases of testing are fulfilled. The general text of the handbook presents basic methodology and a discussion of past test results for an IGW program. The all important methodology section is divided into six critical phases: project management, aircraft structural requirements, aircraft flying qualities evaluations, carrier suitability demonstrations,

final report requirements, and final flight clearance approval. The project management phase lays the groundwork for the planning of an IGW program and the remaining phases give the project officer a good understanding of how to execute the test evolution itself.

Purpose

The purpose of this project officer's handbook is to provide guidance to project officers and project engineers in a clear, concise, and simple format from which successful certification of carrier based airplanes at increased gross weights can be achieved.

CHAPTER II

BACKGROUND

Birth of U.S. Carrier Aviation

In November 1910, Eugene Ely, flying a plane built by Glenn Curtiss, made both U.S. aviation history and naval history by taking off from a crude platform rigged to the deck of the cruiser Birmingham, then lying off the mouth of the James River in Virginia. Later in January 1911, Eugene Ely again made naval aviation history, but this time it was because he landed an airplane safely on the deck of the battleship Pennsylvania (Miller, 1977). It was the first time that this concept of airplanes configured with arresting hooks and catching wires stretched across a flight deck had ever been attempted on a U.S. ship. In the case of Ely's successful landing, the wires had been stretched across the flight deck and held in place by sandbags thus providing the mechanism for the short stopping distance.

Further development of this idea came in 1919 with the conversion of the fleet collier Jupiter into the Navy's first aircraft carrier, the Langley. The Langley, combined with the aircraft carriers Lexington and Saratoga, commissioned in 1927 (Miller, 1977), soon gave the U.S. Navy an excellent training platform from which to experiment with

equipment, tactics, and procedures for operating aircraft at sea. Some of the tremendous achievements that were realized during this infant stage of development included the refinement of arresting gear wires and weights, the creation of landing signaling officers for assisting pilots in landing safely on the carrier, and the development of aircraft spotting procedures for tighter crowding of airplanes on the flight deck. Some of the airplanes that were utilized in this initial growing stage included the Boeing F4B Phantom II, the Curtiss F8C Helldiver, and the Curtiss F6C Hawk. Famous aircraft that were seen in later years were the Grumman F4F Wildcat, the F8F Bearcat, the TBF Avenger, the Dauntless SBD dive bomber, and the Devastator TBD torpedo plane.

All of these airplanes, developed prior to and during the World War II era, demonstrated incredible advances in technological design theory and as a result allowed their pilots to enjoy tremendous gains in handling qualities and performance. Fortunately, as the demands for greater airspeed, structural "g" loading, and payload capacity increased, the designers were able to quickly respond with airframe structures and propulsion systems that could meet the tougher requirements. In some cases, the airplane designers were forced to create new technologically advanced airframes, but in other instances, the manufac-

turers were able to simply modify and expand on existing designs which had proven reliable and successful. A perfect example of this upgrading and modifying process can be seen in the utilization of a later era carrier based aircraft, the light attack Douglas A-4 Skyhawk. The A4D was first flown on June 22, 1954 and it continued in production until February 1979. This ageless wonder of the U.S. Navy's inventory encompassed approximately 15 variants and included both single seat and dual seat versions. At final count, the total number of Skyhawks produced worldwide was 2096 units (Loftin, 1985).

The Skyhawk, built under the watchful eye of designer Edward H. Heinemann, was created with simplicity and light gross weights in mind. The first version of the A-4 came off the production line at a highly effective 15,000 pounds. However, because of the airplane's great success and sound basic design, the concepts of growth capability and increased gross weight immediately caught the interests of leading U.S. Navy decision makers. The decision among naval aviation experts was to increase the gross weight of the aircraft to 18,311 pounds and to continue utilizing it effectively onboard the carrier into the 1980's. Even though the airplane is no longer a functioning asset of today's carrier based airwings, it is still used extensively by elements of the Navy and Marine Corps for training and utility

purposes (Loftin, 1985).

E-2 Hawkeye Aircraft

A classic example of the most recent attempt to extend the life of a proven carrier based airplane, is the E-2 Hawkeye. The Hawkeye, the Navy's carrier based airborne early warning aircraft, was first introduced to the fleet in 1961 as the E-2A and used as a replacement for the E-1B Tracer. The subsequent upgrade airframe to the E-2A was the E-2B. It included several sophisticated weapon system improvements over the old platform and was instrumental for the Navy during the Vietnam conflict. Unfortunately, as the world's aviation threats increased in capability, so did the requirements for the Hawkeye to detect and prosecute them. As a result, the third variant, the E-2C was introduced in 1971 and employed a highly improved APS-120 radar. Over the years, as the demand for early warning detection has grown the airplane has seen numerous radar upgrades (APS-125, APS-138, APS-139) and associated weight increases (NAVAIR, 1991). As can be expected with the increase of aircraft gross weight, certain fuselage, wing, and tail structural enhancements and propulsion system upgrades were required.

Most of these upgrades, designed to combat the reality of reduced airframe life due to fatigue, were incorporated through Airframes Changes (AC) or Engineering Change

Proposals (ECP). Fuselage structural enhancements utilized upper and lower longeron splices that improved the load bearing capacity of the forward and aft fuselage sections. The wing structural enhancements were completed by reinforcing the wing center section supports and fasteners and strengthening the outer wing panel assemblies. Horizontal and vertical tail allowable loads were increased by improving the design and load capacity of the tail and rudder fin attachment fittings. Finally, the acquisition of an upgraded turboprop engine improved the regular climb performance and ensured a safe single engine rate of climb capability in the event of takeoff and landing emergencies. All of these modifications were designed to allow the reliable E-2C attain an extended and useful airframe life into the year 2000. Unfortunately, as in any design improvement program, these modifications needed appropriate verification. For the E-2C, airframe verification involved full-scale laboratory test articles for static strength tests, fatigue tests, drop tests, and a ground vibration survey. Additionally, flying qualities, carrier suitability, and performance tests were also conducted before the airplane could be approved for final fleet acceptance.

Citing these numerous requirements, the Naval Air Warfare Center, Aircraft Division (NAWC,AD) recently completed a thorough increase gross weight certification

program for the E-2C. As a result, this E-2C Hawkeye test program has produced some very valuable information from which to develop this project officer handbook. This handbook presents analysis generic in type for all carrier based airplanes and at the same time addresses many specific test results from this recent E-2C test. These test results will allow the project officer to review events of an actual Navy IGW program and efficiently apply them to his or her specific test airplane.

It must be stated, however, that this flight test data comes from a Naval Air Systems Command sponsored test program. As such, it must be understood that the analysis and conclusions presented in this handbook are those of the author and not of the government or the NAWC,AD.

CHAPTER III

LITERATURE REVIEW

Government Information

The United States Government and specifically the Department of Defense currently utilize official documents to define particular requirements for Navy aircraft. These documents are listed in the Department of Defense Index of Specifications and Standards (DODISS), and are available for use by all Departments and Agencies of the Department of Defense (DOD, 1992). The applicable specifications and standards for Navy airplanes are additionally subjected to approval by the Department of the Navy and the NASC. These specifications and standards are intended to provide appropriate requirements to contractors and test evaluators in the design, manufacture, and testing of Navy aircraft. In many cases, these documents are the acceptance criteria for a particular Navy acquisition program (Naval Air Engineering Center, 1987). The final acceptance, however, always comes under the specific procurement contract from which a more detailed or definitive requirement may have arisen.

The scope of this handbook pertains solely to the specifications and standards that apply to carrier based airplanes and the testing of increased gross weights. Cur-

rently, the Department of the Navy and NASC utilize a complex and often confusing number of different documents that overlap each other. A list of the specific documents that apply to an IGW certification program are included in table 1, Appendix A. Unfortunately, this huge amount of reading and requirements may seem a bit overwhelming to the project officer in charge of an IGW certification program. Not only are these documents long, as in the 49 page MIL-A-8867C(AS), "Military Specification for Airplane Strength and Rigidity During Ground Tests", but they can be extremely confusing (NAEC,1987). The verbiage and subdivision used within these documents makes it terribly difficult to read and understand with any fluidity. As a result, the project officer is faced with a very time consuming evolution in the interpretation of these documents.

The current military specifications and standards that have been mentioned certainly provide the technical and contractual requirements that must be attained to have a successful IGW program. What they do not provide, however, is the management perspective by which these goals will be reached. To meet these requirements within a reasonable time frame, the project officer and project engineer must be able to combine all the efforts of the surrounding team members into an effective working group. They must be able to identify those individuals with special abilities and then

motivate and direct them in their respective technical fields. They must also realize that on many occasions they will not have sufficient time to study large numbers of technical requirements like those encountered in the previously listed specifications. Instead, they must be able to derive the information critical to the program's success and react accordingly with intelligent and well thought out decisions. This handbook provides the answers and guidance to most of the problems that will face an IGW project officer. Currently, there is no other published work or government document that can provide this information. This handbook also enables the project officer and project engineer to avoid many of the pitfalls encountered during a program of this magnitude and complexity. The significant improvement that this handbook offers in the way of organizing an effective IGW certification program will surely help in alleviating some of the embarrassments and delays that always seem to surface during the execution phases of these tests.

Contractor Information

The research of contractor information reveals many of the same requirements and lack of guidelines that were presented in the government information section. Here again, contractors and designers are somewhat limited in their in-

terpretation of the government specifications and standards. The only area that reveals any flexibility is the actual written contract for the procurement of a test airplane or the requirements of a test program. Information in this format, is generally written to fulfill the obligations of the appropriate specifications and to list any modifications that may be more or less stringent than the requirements of the specification (NASC, 1991). The usual course of action is that a cognizant branch of the NASC will study the airplane issue at hand and then determine appropriate test requirements based on its analysis and inputs presented by the contractors, evaluators, and operators. These final requirements, as in an IGW program, will also depend heavily on the age and previous performance of the particular airplane and the government funding that is available for testing.

Historically, most Navy defense contractors involved in designing and producing carrier based airplanes have not had a project pilot or project engineer handbook from which to formulate an IGW certification program. Instead, they had to pass along critical information in the form of internal memorandums and historical test reports (Grumman, 1990). This can sometimes be helpful in successfully organizing an large test program, but in many cases, it can once again prove to be overwhelming to the project pilot or project en-

gineer who simply does not have ample time to sort through the massive backlogs of past data, memorandums, and reports. At corporations such as Grumman Aerospace Corporation (GAC), the project leaders and project teams get further direction in the scope of their test programs by studying previously documented deficiency sheets or test reports that might be outstanding against an airplane soon to be tested. For example, with the E-2C plus airplane, GAC explicitly analyzed earlier documented objectionable approach handling qualities before applying its criteria for a successful IGW certification program (Grumman, 1990). This gave the contracting project leaders essential test data that might have otherwise created a delay or duplication in the test program.

This review of contractor information has revealed that many important results from previous airplane testing can be successfully applied to an IGW certification program. It has also shown that a vast array of past data can still be sometimes overwhelming to the weary project officer or project engineer. It is with this information, both government and contractor, that the idea of an simple and efficient handbook for the certification of IGW becomes a more respectable and advantageous concept.

CHAPTER IV

METHODOLOGY

Project Management

GENERAL

The role of a project officer or project engineer in any certification program is one of a planner, coordinator, organizer, and most definitely a leader. He must be able to clearly reflect the goals of a successful test program to all team members and at the same time be cognizant of underlying concerns such as funding, asset allocation, support facilities, and safety. He should utilize efficient long term and short term planning to ensure that appropriate scheduling of required flight clearances, test plans, and test flights is achieved. Additionally, coordination between support activities such as aircraft instrumentation, real time telemetry processing, and normal maintenance must also be accomplished in an effective manner. These are areas in a generic program's development and execution that always seem to create the most concern and stress among project officers and engineers. There are certainly other issues that cause anxiety during the decision making process, however, these tend to group themselves in a rather miscellaneous category. In this category, issues related to project travel, coor-

dination meetings, and communication infastructure always seem to take inordinate amounts of time and effort to resolve and contribute heavily to a programs overall success or failure. Additionally, the infrequent but always time consuming areas of visit requests, security, and public relations also greatly increase the scope of a project officers duties during a certification program.

These topics of discussion under the project management section can apply to any general certification test program, including an IGW program. What this handbook attempts to present, however, is a more detailed and ambitious checklist from which the requirements of a particular IGW certification program can be realistically applied to the project management decisions facing a project officer or engineer. As such, the project management discussion for IGW will be divided into seven extensive sections: Test Plans, Flight Clearances, Funding, Asset Allocation, Engineering Support, Safety, and Miscellaneous.

TEST PLANS

Test plans can be a very effective tool for the project officer in the advance planning of his IGW program. As a rule, he must have an approved test plan signed out by the director of his test facility before any laboratory, ground, or flight tests can be initiated. Furthermore,

depending upon the scope of the IGW certification program, the number of test plans can reach a very high level. As a minimum, there will usually be at least one test plan for each phase of aircraft structural testing, flying qualities testing, land based carrier suitability testing, and shipboard carrier suitability testing. The list should probably encompass at least: one airplane ground vibrational modal test, one airplane ground drop test, one airplane ground static test, one airplane ground fatigue test, one airborne flying qualities test, one land based carrier suitability test to include catapults and arrestments, and one shipboard carrier suitability test to include at least nominal approaches. Now, the scope of these test plans can certainly increase if NASC determines that separate components or test conditions must be established before final fleet clearance is issued. For the project officer, however, the best method to prepare for this is to write an initial test plan as complete as possible and then simply modify it as necessary with appropriate amendments. These amendments will have to be routed and reviewed in the same manner as the original test plan, but at least the final signing authority will have an already working knowledge of the tasking at hand.

A sample IGW test plan, as seen in figure 1, Appendix B, reveals a rather standard format for describing the type of testing that will be completed. The specific sec-

tions that deal with the test conditions and configurations are very dependent upon the type of airplane being utilized and the type of IGW program being attempted. There are also other particular appendices that will be included in an IGW certification test plan, such as the flight clearance appendix, the project support checklist, and the safety checklist, but these will be discussed later in the text. The routing of an IGW test plan will follow much the same routing process as any test plan. As a minimum, the test plan must undergo a section review, a department review, a Chief projects review, an Operations and Safety review, and a Director or Technical Director review (NAVAIRTESTCENINST 3960.1D, 1990). The reviewing process will be done according to the particular directorate procedures, but may include either a serial chain of command review process or a review board. In all cases, the final approving authority will be either the Director or Technical Director.

FLIGHT CLEARANCES

The flight clearance is an essential element of any successful test program. Without it, no testing can begin; and with it, testing becomes very specific. The flight clearance allows the approving authority at NASC's Air Vehicle Division to have some form of regulation over the type and magnitude of testing being attempted. For the IGW

certification program, this creates a big advanced planning issue for the project officer and engineer. The written policy out of NASC currently states that a minimum of thirty days must be allowed between receipt of clearance message and approval of request. Certainly if the approving authority at NASC deems it possible to send out the approval early; then that is beneficial for the test schedule. However, for general planning purposes, it is advisable to plan your schedules based on a thirty day window. An area of concern that this thirty day window highlights, is that if the test program involves many different phases it is possible that some of the flight clearances will not be approved until data relating to earlier tests are received at NASC. This creates quite a burden among the test team to provide quick and accurate test results to NASC as soon as possible. Because an IGW certification program involves testing and flight operations outside the normal and published aircraft envelope, a flight clearance is required before any testing can be attempted. Furthermore, the test plan written for the evaluation will generally not be approved by the Director or Technical Director until a NASC flight clearance is in hand. There are instances when a portion of the test program can be approved because an initial flight clearance has been received. In this case, the Director will approve an incremental test plan and require that a

new test plan be routed when the additional flight clearances are received. This is very common in an IGW test program because so many of the separate flying tests rely critically on the results of the proceeding structural certification events.

An example of an IGW message requesting clearance for E-2C increased gross weight shore based arrested landing tests can be seen in figure 2, Appendix B. In this sample message, the requester of the clearance is listed by the From (FM) and the receiver of the message is listed by the To (TO). The subject line is where the actual request statement is placed and the reference lines are used to provide any background publications for the approving authority's benefit. The remarks section is left for qualifying information and in the case of an IGW message will provide background data to support why the test is being attempted and specific information on how the tests will be attempted. The specific information should list, as a minimum; the location of the test, the aircraft being tested, the aircrew involved in the testing, the configurations of the airplane being tested, the actual test matrix being attempted, the structural flight envelope being utilized, and the safety exceedance limits being utilized. Additional remarks sentences will list the date requesting the approved clearance and the date to which the clearance will expire. The last formal

part of the message is the listing of points of contact for both the receiving side of the message and the sending side of the message. Generally, the message will be sent as an unclassified message, but it is always wise to check with the security officer before submitting the final copy.

FUNDING

When a branch of NASC decides to task a test pilot or engineer with the duties of project officer for a specific program they are immediately assuming the responsibilities as the project officer's sponsor. As a project officer in the initial planning phases of an IGW certification program, one will probably be required to provide the sponsor with a budget or cost estimate for the execution of the test program. This can be quite a monumental task, however, it is one that must be accomplished. For the project officer or engineer, the funding issues that must be determined will center around facility costs, ground and flight hour costs, labor costs, material costs, travel costs, and fuel costs. The expense of actually obtaining an airplane asset or special equipment will usually be calculated by the sponsor himself. After all these cost estimates have been determined, the sponsor will then decide if the program can be legitimately started with the current funds available. If the funds are available, the sponsor will

draft an AIRTASK which will definitively explain the tasking requirements that the project officer is expected to meet.

When funding is received from your sponsor, that money is placed in a command job order data bank and the pool of money is assigned an active Job Order Number (JON). In the data base, a nine digit JON is listed with; the specific program, the lead project officer or engineer, the job title, and the expiration date. This JON becomes the means of paying for services and material by simply listing the number when charging something to the program. It seems simple on the surface, but in reality it resembles something on the order of a gigantic computer checkbook. We all know how difficult it can be sometimes to balance one's own personal checkbook. This, however, is on a much larger program scale. In an attempt to regulate this massive check writing business, costs involved with each IGW test plan must be approved by the Director prior to any initiation of tests. This is accomplished through the project officer and engineer by listing in each separate test plan the funding requirements and manpower requirements germane to the successful execution of that plan.

ASSET ALLOCATION

The initiation of an IGW certification program immediately brings to mind the issues of airplane allocation.

According to MIL-A-8867C(AS) the contractor must furnish the test specimens for performance of the required certification evolutions unless it is specified differently in the supporting contractual document (NASC,1987). Depending on the scope of the IGW test program, the contractor will provide three full-scale laboratory test articles that shall be used: one for static tests; one for fatigue tests; and one for drop tests. The contractor should also provide an asset to evaluate any flying qualities tests or carrier suitability tests. In some cases with IGW testing, a flying qualities airplane may have already been designated through a previous test program. This allows the Navy test pilots to utilize an airplane asset that should have a majority of the required instrumentation already installed onboard. Additionally, if approved through NASC's flight clearance branch, it should allow flying qualities test events to be conducted while static or fatigue tests are also being conducted. Certainly, no expanded arrested landings tests can be initiated until the entire drop test is proved successful.

Any flight testing that will be done with the contractor as the pilot in command will require that the airplane asset be maintained in the contractor's custody. If the airplane is being flight tested with the Navy's test pilots as the pilot in command, the asset will then be

transferred to Navy custody and all incident and accident reporting will be done by the cognizant Navy activity.

ENGINEERING SUPPORT

Engineering support requirements for an IGW test program can be numerous and expensive. As the project officer, the scheduling and funding of these requirements involves extensive planning and coordination. Test instrumentation, data extraction, and data processing tend to be some of the more complicated issues. There are also, however, engineering support requirements that can include metal and machine shops, photo laboratories, special radar tracking facilities, and specially designated Navy test facilities. These support functions can be filled by either contractor work billets or currently established government and military billets. In all cases, some form of funding for manpower utilization or facilities services will be charged to the test programs overall budget.

Test instrumentation for the IGW airplane asset will include internal and external instrumentation. If there is only one asset being utilized for both flying qualities evaluations and structural arrested landing evaluations, the airplane must have appropriate internal data collection devices or real time telemetry devices installed to ensure accurate collection in both areas. For the external in-

strumentation, sufficient data collection stations will be required to properly retain all the ground and flight test data seen during the IGW test program. These stations can include radar and theodolite sites, camera and signal platforms, and portable and stationary real time processing systems. Once the test data has been obtained, the requirement to perform accurate data processing becomes paramount. This may involve regular support functions such as data playback stations and graphic reproduction facilities, but it may also involve more technical capabilities such as special computer processing or highly advanced video reproductions.

The support requirements forced upon a project officer during an IGW program are usually spelled out in the individual test plans and the project support checklist. The concept of test plans has already been discussed. The project support checklist, as shown in figure 3, Appendix B, is a working guide developed to provide maintenance and project personnel with an ample tool to assist them in performing maintenance actions. Generally, no project maintenance, hardware installations, or de-installations will be performed until this document is signed by a project liason officer. A good example of the type support functions included in this document is the manufacture and installation of ballast for preparation of an airplane involved in IGW testing. Here, a metal and machine shop may be employed to

construct the ballast and then special contractors hired to install the weights. In any case, this ballast example points out that many special support requirements can become evident through proper utilization of the project support checklist.

SAFETY

Safe ground and flight testing during any certification program is the number one goal for the test team. Not only is there a vested interest in the well being of all the test pilots and crew, but in many cases, the test program may revolve around a "one of a kind" airplane that cannot afford to be destroyed without damaging the entire test program. As project officers and engineers, an IGW test program must be formulated so that the minimum amount of risk is being taken within the particular test events. To formulate this plan, a very thorough assessment of all risks to both airplane, people and budget must be considered. Consulting past test programs with similiar goals and researching all former government and contractor test data will greatly enhance this risk reduction effort. Additionally, all IGW test plans will go through the standard formal test plan review process which should highlight any high risk evolution. As project officer, one should recognize these high risk areas and determine if a safer means of data col-

lection is available to the test team. If it is determined that the high risk test events must be attempted for the success of the program, it is also essential that one realizes that the Director or Commanding Officer still makes the final decision on all test events. He is ultimately accountable for all the directorate's testing and, as such, must feel comfortable with the potential hazards and risks being taken.

To help ensure this thorough method of risk assessment is maintained, a safety checklist is included in all Navy test plans. A sample IGW safety checklist is shown in figure 4, Appendix B. In these checklists, a minimum of at least the following is presented: aircrew qualifications, special flight restrictions imposed on the project, lessons learned from previous similar testing, special ground personnel procedures, hazard analysis and risk assessment of failure modes, build-up planning for high risk-pilot workload data points, and go-no-go criteria for flight test weather, chase requirements, and instrumentation requirements (NAVAIRTESTCENINST 3960.10D, 1990). For the IGW test program, areas such as IGW engine out testing, high sink arrested landings, free-flight arrested engagements, minimum endspeed catapult shots, and emergency flap shipboard arrested landings are all considered high risk type evolutions. For each specific airplane, these high risk areas may

be slightly different, but in each case there will be plenty with which to be concerned.

MISCELLANEOUS

The concept of miscellaneous can include many hidden categories in the IGW test program. Basically, if it is something that has caught one unaware it tends to be thrown into the miscellaneous section. For the purposes of the IGW testing, some problem areas are the issues of project related travel, communication infastructure, and coordination of team meetings. For project related travel, long lead times for items such as visit requests, security clearances, travel orders and travel arrangements are characteristic. The age of the fax machine has helped immensely in the concept of on-time security clearances and visit requests, but certainly good prior planning always makes this evolution easier. The headaches for travel arrangements and corresponding travel orders will never go away. The main area of discontent on this issue is that orders usually must be submitted long before the project officer or engineer even know that a test event or meeting has been finalized. To help remedy this situation, tend to write very general travel orders and include as many allowable deviations as possible. As a result, if the meeting or test evolution is delayed or changed there is still recourse to make it to the

event on time.

Concerning the problems associated with communication infastructure, here are a few tips. If at all possible, try and obtain a personal phone line that includes a built in answering machine and a toll free telephone number. The reality is that no one can ever depend totally on someone else to record his or her messages and that it always seems easier to get people to call you when it doesn't cost them anything. Granted it may cost a little more up front for your project, but it will save large funding dollars in terms of keeping a test schedule on time and on budget. As for the issue of team meeting coordination, the key here is to make meetings as small as possible without leaving out any important members. This way you can generally have more frequent meetings because not every team member's schedule has to agree. Furthermore, attempt to make the meetings short and efficient and certainly don't schedule one unless something important has to be decided upon or passed. Another helpful hint, is the utilization of weekly or biweekly reports submitted to your sponsor or lead contractor. The moral here being; "a consistently advised individual is one that seldom has to attend meetings." Now certainly, these regular reports should not be long or carry unnecessary verbiage, but they should address any issues concerning test asset availability, current project

priorities, or current program status. All of these previously mentioned issues can greatly enhance or degrade your overall IGW test program. Be sure and pay special attention to these type concerns for they are routinely left out of the normal project officers duties.

Aircraft Structural Requirements

GENERAL

The required structural tests of an IGW certification program play an essential role in the final qualification of a heavier airplane. Because of the critical nature of this phase of testing, the sequencing of particular structural tests becomes very important. In terms of contractual obligations, it is normal that all structural requirements be met at least 30 days prior to the scheduled flight demonstration test events. Furthermore, it is stated in the military specifications that all tests to design ultimate load and design sinking speeds shall be completed prior to performing failing load tests for any condition (MIL-A-8867C(AS), 1987). NASC additionally puts the following conditions on the structural testing of an IGW program: repeated load tests of integral fuel tank structures shall be completed prior to performing any other load tests that may result in permanent airframe deformation; design ultimate load tests for flight conditions shall be completed

prior to performing any other design ultimate load tests; and the Navy will make the final decision on any delays in the delivery of an airplane clearance based on the amount of critical testing completed. Actual strength tests for individual components on the airframe also undergo special testing criteria and these may be found in sections of the previously mentioned specification. The highlights of these conditions include the issues of: airframe support structure testing, substitute part utilization, powerplant and accessory substitution, paint and finish requirements, reference station identification on the test article, mechanical hardware and hydraulic actuator operations, and landing gear door or armament bay door actuation. In each case, the analysis of the specific airplane structural design will determine what critical areas shall be tested for verification. Following this analysis, test conditions will be built and then applied to the most strength critical failure modes and the environment within which they exist.

GROUND VIBRATION MODAL TESTS

An airplane ground vibration modal test is generally performed during any IGW certification program and definitely when there is a drop test to be completed. The test is utilized to determine modal frequencies, mode shapes and node lines, and modal damping coefficients for the as-

sembled airplane and main airplane components (MIL-A-8867C(AS), 1987). In an IGW test, the vibration survey is performed so that sufficient modal data can be obtained to update or validate the current airplane analytical load model. From the collected data, the dynamic model can then be tuned so that analytical modes correlate accurately in shape and frequency with the measured modes. Once this has been accomplished, dynamic landing conditions can be determined which will provide the highest loads for the required drop test. If it is deemed necessary by the NASC sponsor, separate component vibrational modal tests for control surfaces, tabs, flaps, actuating systems, and linkages for balance weights can also be performed.

The test equipment utilized in these surveys should consist of airplane exciters, force gauges, measuring accelerometers, and electronic monitoring equipment. The airplane should be equipped with all items that have appreciable mass and when practicable, the tests should include several weight configurations that simulate variable gross weight conditions. Items such as fuel tanks, bombs, rockets, ammunition, guns, and tip tanks should be utilized unless a possible safety hazard exists; in which case simulated ballast weight or inert stores can be used. The support structures utilized in an IGW vibration survey will depend heavily on the size and weight of the test article.

Some methods of support for tests of this nature include: supporting the airplane on its landing gear with the tires inflated to a minimum pressure; suspending the airplane on airsprings so that landing gear retraction can be accomplished; supporting the airplane on its landing gear resting on spring platforms; and supporting the airplane fuselage and wings with large air-filled flotation bags. As a comparison for project officers to consider, the recent E-2C ground vibration survey utilized airspring platforms that were attached to existing airplane jacking points.

The general procedures used for vibration surveys center around numerous vibration pickups located at suitable positions throughout the airplane. From these positions, amplitude-frequency response curves can be obtained and natural frequencies determined. It is important to use sufficiently small frequency increments so that no valuable resonant peaks are overlooked. Additionally, at each resonant frequency, amplitude and phase measurements should be collected so that vibration modes can be accurately defined (MIL-A-8867C(AS), 1987). The actual modes that are excited during an IGW vibrational survey depends on the types of configurations being tested. As a rule, the following predominant vibrational modes should be obtained regardless of the airplane configuration: the wing group including engine masses, control surfaces, accessories, and props; the

tail group including stabilizers, rudders, and fins; the canard group; the tab group; the spring tab group; the externally suspended stores group; the actuating systems group; and the landing gear group. Following all of these data acquisitions, it becomes time for analysis. This analysis will be explained partially in the next section along with the requirements for IGW drop tests.

AIRPLANE DROP TESTS

Historically, a full scale IGW certification program may include as many as nine different drop test conditions to meet the goals of the test program. Those nine conditions, taken from specification MIL-A-8867C(AS), are shown in table 2, Appendix A. Today, however, because of the severe budget constraints and availability of test articles, it is usually recommended by the NASC sponsor that only the most severe load conditions be tested on the airplane structure. As a result, the accuracy of the data obtained from the ground vibration surveys and the corresponding dynamic analysis becomes extremely important to the success of the drop test. An example of this type development can be seen in the recently completed September 1991 E-2C drop test. In this test, effective dynamic analysis allowed the test team to determine that the highest landing loads on the airplane were exhibited with the Forward Fuselage Bending Moment

(FFBM). This FFBM was further determined to have its highest values during a Free Flight Engagement (FFE) with the following conditions: aircraft attitude of 3.0 degrees nose down; aircraft sink speed of 8.6 fps; nose gear sink speed of 18.8 fps; aircraft pitch rate of 28.2 degrees per second nose down; aircraft horizontal speed of 73 knots; and aircraft lift of 1/3 of the aircraft weight (Grumman, 1991). A diagram of this specific FFE can be seen in figures 5 and 6, Appendix B.

The drop tests of any IGW certification program, will have certain restrictions upon which the program must operate. During the drop tests, the integral fuel tanks must be made fuel tight with sealing representative of production airplanes. Additionally, the nonflammable liquid utilized in the tanks must have similar viscosity and density values to that of representative jet fuel. The gross weight of the test article will be that of the carrier designed maximum gross weight for arrested landings. The tests shall include a survey of wheel touchdown speeds to investigate critical effects of spin-up and spring-back loads and the coefficients of friction developed shall be representative of that occurring on carrier decks (MIL-A-8867C(AS), 1987). The instrumentation required will be airplane specific, however, the type and location of all transducers, accelerometers, and strain gages shall be identical to those installed in

the carrier suitability demonstration airplane. The cockpit shall be instrumented so that acceleration levels experienced by the crewmembers will be recorded and deemed not excessive. Some diagrams of the particular E-2C drop test article instrumentation are shown in figures 7 and 8, Appendix B. The test apparatus required to execute the drop test will also be airplane specific. Regardless of the method of dropping the test article, sufficient drops must be completed that include various combinations of tire and shock pressures and various drops over known carrier deck obstructions. Some sample diagrams displaying the particular E-2C drop test apparatus are shown in figures 9 and 10, Appendix B.

AIRPLANE STATIC TESTS

The airplane static tests required during an IGW certification program can, as revealed in the earlier drop test section, become quite extensive and costly if the NASC sponsor wants all listed tests physically performed. The entire list of static test conditions, as presented in specification MIL-A-8867C(AS), is shown in tables 3-11, Appendix A. To help alleviate the burden and cost of performing all these test conditions, the IGW static tests generally try and follow the same test approach as previously discussed in the IGW drop test section. Here, the

concept of thorough and precise structural analysis, before any actual initiation of static tests, is again repeated. This approach does involve some updates to current aerodynamic, structural, and load models, but it does allow the safe determination of worst case airplane load conditions before physically having to test them.

The E-2C IGW certification program extensively utilized this approach to determine its highest static load conditions on the airplane. After effective analysis, it was concluded that the worst case static load condition would be found on the nose gear launch bar and supporting structure during new IGW maximum catapult launches (Grumman, 1991). As a result, an ultimate tow load static test was performed on the nose gear structure to see if a premature component failure would occur. The specific objectives of the test were to qualify the nose landing gear and fuselage support structure for increased horizontal tow loads and to determine what horizontal catapult tow load would cause a failure of either the nose landing gear or fuselage structure. Some diagrams portraying the type of set-up that may be encountered during a test of this magnitude can be seen in figures 11 and 12, Appendix B.

The specific static tests that are required for each particular IGW airplane will have to be individually determined by the test team, the program office, and the NASC

sponsor. To ensure that all conditions of possible static tests are discussed prior to initiation, please thoroughly review the military specifications on this subject.

AIRPLANE FATIGUE TESTS

The concept of fatigue tests on an IGW certification program can sometimes be misleading to the project officer and engineer. Seldom, in this day of shrinking military budgets is a fatigue test article built solely for the benefit of an IGW test program. Conversely, if the airplane has already been utilized in the operational Navy long enough to require an IGW program, then there is probably a fatigue test article already being run. What an IGW certification program does is create a modification of the currently used fatigue test article in order to simulate the worst case fatigue cycles anticipated with the higher gross weights. Once this modification has been established, the fatigue tests take on the normal requirements of any particular fatigue article. For these normal requirements, NASC states that fatigue tests will continue until the specific airframe life times a scatter factor of two is achieved. After that milestone is reached, the test is continued until either a major component failure is observed or until the fourth lifetime is achieved. During the entire evolution, inspections are to be made to detect cracks and to track

crack progression. General inspections shall be made at least every 250 hours with major inspections each 1000 hours. Any crack, delamination, or similar defect that occurs during the first two lifetimes shall be considered a failure and require redesign and retest (MIL-A-8867C(AS), 1987).

These guidelines stated above are exactly the ones that were utilized during the E-2C IGW program. As a result of these guidelines and a thorough analysis, it was determined that the worst case fatigue cycles due to the increased weight would be observed on the arresting hook truss. The heavier carrier landing weights would require that drag loads and side loads be measured on the arresting hook truss and that dashpot loads and hook bounce loads also be measured for the arresting truss tubes and the hook stinger. To accomplish the fatigue lifetime goals presented in the specification, it was established that 3,000 arrestment fatigue cycles, an inspection, and then 3,000 more arrestment fatigue cycles would have to be completed before the arresting truss assembly could be validated at the heavier carrier landing weight. Now, of course, this was the requirement of an E-2C airplane. It is very probable that another type airplane will require more arrestment fatigue cycles or actually that a different worst case fatigue situation will exist all together. Refer to your test teams

structural analysis group to determine the significant test conditions for your airplane.

Aircraft Flying Qualities Evaluations

GENERAL

The purpose of a flying qualities evaluation during an IGW program is to assess the flying and handling qualities of the test airplane and determine if there is any impact attributable to the increase in maximum takeoff or landing weights. Depending on the type test airplane, this evaluation can also be used to investigate any effects that the IGW may have on the mission capability of the platform. This larger scale certification program may include weapons delivery evaluations, air-to-air maneuvering evaluations, and weapons system load out evaluations. For the NASC sponsor of the test program, the scope of the testing will be determined greatly by the amount of research and development funding available to his office. Regardless of the funding questions, as a project officer all eventual flying qualities tests must be conducted as per the prescribed United States Naval Test Pilot School (USNTPS) Stability and Control Manual or the USNTPS Fixed Wing Airplane Performance Manual (USNTPS, 1981). There are occasions with newly developed or augmented airplanes where these tests can be modified, however, that should be approved by the cognizant

NASC flying qualities branch before attempting the test techniques.

The project officer and engineer should ensure that the scope of the IGW flying qualities evaluation concentrates on the areas most impacted by the increase in weight and inertia. To accomplish this goal effectively, it is a good idea to ensure that an in depth flying qualities analysis is completed before initiating any tests. This way test dollars can be best directed in the most critical flying areas. Additionally, any previously documented deficiency reports against the test airplane should also be re-tested in this IGW configuration to determine if any beneficial or degraded characteristics will surface. The actual contractual obligations that may arise from an IGW flying qualities evaluation generally will center around the specifications of the particular airplane. Some common specifications that apply to todays naval aircraft include: Military Specification Flying Qualities Of Piloted Airplanes, (MIL-F-8785C, NOV 1980); Military Standard Flying Qualities Of Piloted Vehicles, (MIL-STD-1797, JAN 1990); AND Military Specification Flying Qualities Of Piloted Airplanes, (MIL-F-8785(ASG)-4, APRIL 1959).

E-2C HAWKEYE AIRCRAFT

The E-2C Hawkeye recently underwent a thorough IGW flying qualities evaluation. The test evolution was accomplished within the test guidelines presented in the previous section. This test program should provide the project officer with a sample test matrix that can be applied to his or her specific airplane. To make the testing more realistic for your airplane simply modify the test matrix as necessary. A copy of an E-2C IGW flying qualities evaluation can be seen in table XII, Appendix A. It should be noted that the test methods for the specific test conditions are as per the USNTPS flying qualities manuals previously discussed. Furthermore, the test methods are also listed in the Remarks column of the test table. In reading the test matrix, one can observe that most emphasis tends to be on the takeoff, landing, and single engine test configurations. Granted, other areas were tested, however, these specific test configurations were the ones most identified with possible handling qualities problems because of the IGW.

An IGW flying qualities evaluation can involve many category "C" test flights. A category of this nature states that the ground or flight tests associated with the test program involves known hazardous operations (NAVAIRTESTCENINST 3960.10D, 1990). Based on that description, it is usually advisable for the project officer to in-

clude a separate appendix in his IGW test plan to address the more dangerous tests. An example of detailed category "C" test techniques can be found in Appendix C. Here, depending on the history or usefulness of the test technique, modifications can be presented. Again, if this is going to be a modification that needs NASC approval, do so before the test airplane is ready to fly.

Carrier Suitability Demonstrations

LANDBASED TESTS

The landbased carrier suitability tests of an IGW certification program are demonstrated as per the requirements of two major specifications: Military Specification, Airplane Strength and Rigidity, Ground Loads For Navy Acquired Airplanes, (MIL-A-8863B(AS), 1987); and Military Specification, Demonstration Requirements For Airplanes, (MIL-D-8708B(AS), 1987). These specifications, along with other less critical ones, provide the project officer with a multitude of exact data requirements. Even though it is advisable to read these documents, it can also be helpful to think of the IGW Landbased Carrier Suitability (LCS) tests in three simple phases: the roll-in arrestment phase; the arrested landing phase; and the catapult launch phase. In each of these separate phases, specific demonstration points will be required to meet the approval criteria of NASC and

the sponsor of the program. As project officer, it is essential that these demonstration points be agreed upon before the initiation of the carrier suitability testing. Furthermore, it will important for the project officer and the NASC-530 clearance branch to decide what blend of contractor-navy aircrew will be in the airplane during the test evolution. Since much of the testing is envelope expansion work, a participatory flight schedule should be agreed upon by all members. The experience of the contractor aircrew and the hazard level of the test project will play a major role in this decision process.

The first phase of the IGW LCS test is the roll-in arrestment test evolution. The purpose of this test is to determine the optimum arresting gear weight setting and the maximum engaging speed for the test airplane at its new maximum arrested landing weight and at its new maximum arresting hook load. Using current carrier equipment, the tests should be performed on a Mk-7 Mod 3 arresting gear. The required tests are spelled out in the MIL-A-8863B(AS) specification, although, a few general test concepts do apply. For the project officer, four different roll-in engaging positions for the airplane should be anticipated. With a tricycle type landing gear, the airplane should engage the arresting gear at on-center positions, 5 feet right positions, 10 feet left positions, and 20 feet right

positions. These tests should all be accomplished at the optimum arresting gear weight setting determined at the beginning of the test evolution. The project officer should also anticipate utilizing varied airspeeds and airplane weight settings once this optimum arresting gear weight setting has been determined. This additional test data will further allow the project officer and engineer to formulate an accurate ground roll versus engaging speed chart for future use. The roll-in arrestment tests should take one to three days depending on weather conditions and may take as many as 30 test events to establish a good curve fit for the determination of the maximum arrested engaging speed and the optimum arresting gear weight setting.

The second phase of the IGW LCS tests is the arrested landing evaluation. The purpose of this flight test phase is to demonstrate that the test airplane is structurally capable of conducting carrier landings at the new maximum arrested landing weight. The number of test events required are a function of the standard carrier suitability demonstration table located in specification MIL-D-8708B(AS). The requirements, seen in table XIII, Appendix A, provide the project officer with a complete list of possible arrested landing test conditions. These test conditions are designed to subject the IGW test airplane to the highest load conditions that may ever be encountered onboard the

carrier. Additionally, the required number of test events may be increased if it is determined by the NASC structures branch and the test team that a particular type of arrested landing needs more attention than another. An example of this type situation occurred recently during the E-2C IGW certification program. With this program, analytical studies revealed that the worst case load predictions for the E-2C were to be encountered during the Free Flight Engagement (FFE) mode (Grumman, 1991). As a result, the largest number of demonstration points completed during the testing were in the FFE category. There were also high sink rate arrested landing test events established for the on centerline category, however, these load conditions were still found to be less significant than the FFE. The arrested landing phase of the IGW LCS tests are to be monitored by a qualified Landing Signal Officer (LSO) at all times. Through the agreement of the aircrew and the LSO, the test airplane can be flown in any configuration during the testing as long as it is listed in the test plan. The primary goal of the arrested landing phase is to ensure that the structural demonstration points required by NASC are performed correctly. The secondary goal, although a more critical one, is the safety and well being of the test team. Because this is an envelope expansion program all attempts must be made to reduce risk and ensure a safe test evolution.

The third phase of the IGW LCS tests is the catapult launch evaluation. The purpose of this evaluation is to demonstrate that the IGW test airplane is structurally capable of conducting catapult takeoffs at the new increased maximum gross weight and the new increased maximum horizontal tow force. It is stated in the previously discussed specification, Military Specification MIL-D-8708B(AS), that catapult launches shall be made to demonstrate that the IGW airplane can be suitably launched from the catapults of the aircraft carriers from which it is designed to operate (NAEC, 1987). The specification explains that catapult launches should be initiated at the target optimum airspeed and then repeated at higher and lower airspeed intervals from that optimum setting. These adjustments are usually accomplished in 5 knot intervals and can go as high as the maximum horizontal tow force or as low as the minimum allowable endspeed for single engine operation. The catapult launches are normally completed in all current airplane takeoff configurations with engines set to maximum rated thrust or maximum rated power. The launches are completed in a systematic fashion with catapult endspeeds being gradually built up until the limit horizontal tow force is attained. Certain test events will be repeated twice with the airplane aligned 6 degrees left or 6 degrees right of center. This actual off center spotting is measured as the

airplane centerline is adjusted relative to the catapult centerline as the nose gear enters the nose gear guide track. To alleviate any real difficulty in measuring this parameter, brightly painted lines are placed on the catapult track for the pilot and catapult officer to see. Despite these added technical requirements placed upon the test pilot and project officer the entire evolution of a landbased catapult test proceeds much like that of a normal shipboard one. The big difference here is that aspects such as trimmability, flyaway performance, pitch attitudes, and handling qualities are now also evaluated. With the successful completion of this third phase of the IGW LCS tests, the test airplane is now ready for its final shipboard certification. The next stop on the project officer agenda is the carrier flight deck.

SHIPBOARD TESTS

The shipboard portion of an IGW carrier suitability demonstration is the last test flight phase of a certification process. This phase of the testing allows the project officer to give final qualification to every phase that has been previously evaluated during the program. By direction, NASC will not allow shipboard evaluations of any IGW airplane until all previous landbased test phases have been completed and the results approved. This ensures that navy

test pilots fly a specific airplane, for the first time at the carrier, that meets all flying qualities and structural landbased requirements for IGW. The actual purpose of the IGW Shipboard Carrier Suitability (SCS) tests is to evaluate the heavier gross weight airplane around the carrier and determine if it is operationally acceptable to the fleet Navy. Specifically, the SCS test attempts to verify trim settings and optimum airspeeds for the IGW catapult launches and it provides an assessment of the pattern and approach handling qualities of the test airplane for the increased landing weights. Most of the configurations tested are those that airplanes in the fleet utilize on an every day basis. There are, however, emergency configurations that are evaluated for IGW and these center around single engine operation or reduced flap and slat settings.

The first portion of any large scale IGW SCS test is the carrier qualification of the test pilots. The NASC Landing Signal Officer Manual of september 1990 provides the requirements that the pilots must fulfill before any testing is conducted. If it occurs that the test pilots are already current from earlier testing, this requirement can be validated. The second portion of the test program is the catapult launch tests. During this phase, launches with the IGW will be conducted as per an Aircraft Launch Bulletin (ALB) developed from the earlier tests done on land. Trim

settings for the initial launch in each configuration will be as recommended in the current ALB. Pilots should qualitatively evaluate the airplane's tendencies to seek the proper flyaway pitch attitude and to maintain constant heading. If in the opinion of the project pilots the airplane appears mistrimmed, then the subsequent launches should be conducted with the recommended adjustments. Once proper trim settings have been established, launches can be conducted at non-optimum airspeeds. Depending on the scope of the test program, the airspeeds can range from minimum single engine endspeeds all the way to the maximum horizontal tow force established during the land based tests. Regardless of the range of airspeeds evaluated, it is still standard to raise and lower the catapult endspeeds in intervals of 5 knots only. During the catapult test events the project pilots will qualitatively evaluate the tasks shown in table I. To assign ratings to these tasks, the pilots will utilize the Cooper Harper Handling Qualities Rating Scale shown in figure 13, Appendix B.

Table I: Non-optimum airspeed catapult launch evaluation; tasks and tolerances

Task	Tolerance
Capture Pitch	2 Degree
Maintain Heading	3 Degree

The evaluation of approach and pattern handling qualities for the IGW test airplane will be conducted while flying normal patterns and approaches at the carrier. The test landings being evaluated may be either touch-and-go landings or arrested landings. To evaluate qualitatively the tasks of approach handling, the pilots should use the table shown in table II. The same handling qualities rating scale will apply.

Table II: Approach handling qualities evaluation with tasks and tolerances

Task	Tolerance
Control Angle-of-Attack	1/2 Degree (approx. 1 unit)
Control Lineup	1 Degree
Control Glideslope	1/2 Ball
Control Centerline Touchdown	5 Feet

The normal Navy Case I pattern with counterclockwise flow and weather of at least 1000 feet and 3 nautical miles will be utilized for the pattern handling qualities evaluation. At the ship commanding officer's discretion, this value may be lowered to 700 feet cloud ceilings and 2 nautical mile visibility. The pilots should evaluate qualitatively the tasks shown in table III.

Table III: Pattern handling qualities evaluation with tasks and tolerances

Phase	Task	Tolerance
Downwind Leg	Control Airspeed	2 Knot
	Control Heading	2 Degree
Approach Turn	Capture Angle-of-Attack	1/2 Degree
	Control Angle of Bank	1 Degree
	Control Heading	2 Degree

Following this extensive IGW testing at the carrier, the test team will formulate its data and opinions and provide a written technical report to NASC and the program's sponsor. The next section will provide details on how to efficiently promulgate the information that was collected at the ship.

Program Report Requirements

INTERIM MESSAGE REPORTS

The interim reports produced during an IGW test program are designed to provide the sponsor and NASC with a quick overview and status of the recently completed test events. Through these mediums, the project officer and engineer are able to deliver preliminary results of IGW tests and evaluations in an efficient manner. Additionally, if the test team deems it necessary, this type of report can also be used to transmit any urgent information that may have been encountered by the team and considered significant. There are a number of ways of transmitting this information to the approving authorities, however, the two most popular and respected formats are the message report and the quick response report.

The message report is an interim report that is sent out in a standard Navy message format. It is designed to be brief and factual and it should give a quick flavor of the test's results and conclusions and any recommendations that may have been reached by the test team. This report is usually issued within 72 hours of the completion of the test events, although this number may grow to as high as 10 days depending on the scope of the program (NAVAIRTESTCENINST 5213.3F, 1984). For the recently completed E-2C IGW certification program, this form of interim report was used ex-

tensively to provide specific progress reports on each of the separate test phases. By utilizing this concept of reporting, the programs schedule did not slow down and it enabled the clearance branch of NASC to have sufficient data from which to clear the test program for the next phase of testing.

The second popular format from which project officers issue interim reports is the Quick Response Report (QRR). The QRR provides limited scope data to the sponsors and NASC in a timely manner. It is presented to the reader in a standard Navy letter format and it is generally no more than six pages long (NAVAIRTESTCENINST 5213.3F, 1984). The outside cover looks exactly like that of a technical report, however, the inside text can be written in any style that the project officer feels will be beneficial. For an IGW test program, this form of interim report is generally saved for any developing issue that needs a good amount of supporting data. It is not quite as expeditious as the message report and therefore the sponsor expects a little more polished presentation. A good example of this concept was the static and dynamic engine out testing that was conducted during the E-2C IGW program. Because the test results were somewhat different from what previous test teams had encountered the appropriate data and analysis had to be presented in a detailed yet concise form that the sponsor could under-

stand. Once the sponsor was happy with the explanation of the test data, the test program was able to move on effectively. Through this type of example, it is clear that the QRR can be a useful tool to the project officer and engineer in keeping their IGW program on schedule.

FINAL REPORT

The final report of an IGW certification program is presented as a Technical Report (TR) to the sponsor and NASC. The TR encompasses the evaluated relevant facts drawn from an assigned technical investigation and stands as a permanent official record in a formal document (NAVAIRTESTCENINST 5213.3F, 1984). Just by the description, one must realize that this is a very orderly and structured report. This final report will be written in clear, concise and logical manner, and it must follow some very strict guidelines on text formatting. Because the TR is the final report of an IGW program, it must disseminate the technical results and conclusions of all the separate test phases completed during the program. Furthermore, because it is also the formal technical document of the IGW program, it will be used as the authoritative baseline from which most IGW program decisions will be made.

Unfortunately, because the TR is so formal and lengthy in size, it is sometimes not effectively understood

by the sponsor. As a warning to the project officer, ensure that your TR is as clear and easy to read as possible. As a result, the sponsor and NASC will be able to easily decipher the important facts of the test program and not become bogged down in heavy technical matter. For future use of this type report, be aware that there is a current plan to change the TR into a more user friendly and less structured document. For your specific IGW airplane, it would be advisable to research the reports required by your sponsor and determine if an updated TR is in order.

Final Flight Clearance Approval

The ultimate goal of any project officer and engineer is to see their program be successful and the results effectively implemented to the fleet Navy. The manner in which these steps are accomplished depends greatly on the items we have previously discussed. Assuming for any IGW certification program that the earlier requirements have been met, NASC then becomes the critical link in providing the final flight clearance approval to the fleet. As project officer, it is essential that all your report requirements and test data accurately be provided to the approving authority. As is natural in any decision making process, it may sometimes be important for you and the engineer to amplify on some previous data or re-explain some critical

technical issues. In any case, this will ensure at least a few personal trips to NASC to participate in the clearance process. There are instances were the final clearance approval may be made based on interim reports provided by the project officer, however, this will depend on each individual sponsor and clearance branch and how comfortable they feel with the results. Once all the necessary data has been evaluated by the clearance branch of NASC, the IGW flight clearance for the fleet will be promulgated through a standard Navy message.

CHAPTER V

RESULTS AND DISCUSSION

General

The results and discussion section of this project officers handbook will highlight some of the major issues that came about during the methodology section of the text. Because so much of the generic analysis of this handbook has been addressed throughout the course of the methodology discussion, the highlights of this section will pertain strictly to the recently completed E-2C Hawkeye IGW certification program. Any results or discussion items that can fit your specific airplane's test requirements should be applied.

Project Planning and Management

The concept of project planning and management throughout an E-2C IGW certification program brought forth some interesting and certainly surprising occurrences. The goals and team structure discussed earlier in the methodology section seemed to go quite as planned for the scope of the program. The philosophy behind test plans, flight clearances, engineering support, safety, and miscellaneous also seemed to track as anticipated. The areas that tended

to surprise test team members and the project officer were the regimes of asset allocation and funding. In these days of tight budgets and lost dollars, one could guess that funding issues may come to be a problem for a project officer. The hard part to anticipate, however, is that once the contract is written there still seems to be some room for confusion. As a project officer, reading a contract is usually not a hard task. Beware, because in these times of high priced lawyers, nothing is read simply. What all this means, is that what you expect the contractor to provide and pay for is not always what you get. Additionally, if there is something the project officer thinks can be accomplished in a cheaper and just as efficient way, don't be afraid to speak out.

The difficulties arising from asset allocation were probably interconnected to the funding concerns, although, the problems tended to run deeper than that. When dealing with a program such as an IGW program, there tends to be a lot of airplane custody transfers because of the nature of the testing. Anytime, an envelope expansion demonstration point has to be obtained the airplane has to be in contractor custody. This doesn't seem to create many problems until it is time for the contractor to transfer the airplane back to the Navy. For some reason, contractor transfer schedules and Navy delivery dates never seem to correspond. As a

result, remaining Navy IGW testing becomes delayed and continued funding must be supplied to the contractor to maintain the airplane. This is the exact scenario encountered during the E-2C IGW program. The only real avenue available to the project officer was the NASC connection. Because NASC was the government agency providing the funding to the contractor, it was sometimes possible for the project officer to deal directly with NASC and convince them to be tough with the contractor. If this was successful, the schedule situation usually worked itself out. If it was not, then it was time to be creative in talking to the contractor management. Regardless of the type situation facing the project officer and engineer, these two management concerns definitely required more leadership abilities than the other project management categories. The best strategy that can be recommended is try to plan the initial program schedules so that plenty of lead time is available for the transfer of any test assets.

Aircraft Structural Tests

The highlight of the E-2C IGW structural testing certainly had to be the drop test results of the test article. In the methodology section, it was explained how this certification program utilized a dynamic landing analysis to determine the most severe condition on the airplane's for-

ward fuselage. Through this analysis, the test team determined that the highest forward fuselage bending moment would occur as a result of a Free Flight Engagement (FFE). The exact parameters of the FFE were discussed earlier. After obtaining the accurate FFE condition, the test team formulated the appropriate drop test design point. This design point, as seen in figures 14 and 15, Appendix B matched the nose gear load stroke curve and the forward fuselage bending moment curve very closely. Because the drop test article did not have wing lift, engine thrust, or hook load, the design point could not match the FFE analysis exactly.

The actual IGW drop test encompassed 16 drops. The ninth drop was the qualification drop that simulated the energy loads and bending moments of the FFE. For drop number nine, the sink speeds at the nose landing gear and the center of gravity were 17.70 and 7.50 ft/sec respectively. Looking at figures 14 and 15, these values correlate very well to the data developed during the FFE analysis and the drop test design point. The best comparision between the analysis and the drop test, however, was seen in the nose gear stroke and the fuselage bending moment. With drop number 9, the nose gear stroke was 14.48 inches and fuselage bending moment at Fuselage Station 279 was 9.24e+6 in-lbs. The correlation here with the FFE analysis and the drop test design point showed little deviation. The real success of

the drop test from a project officer stand point, however, was the fact that no airplane structural defects were found during the drop. The airplane was found to be totally functional and therefore qualified at the heavier weight. There were an additional seven drops completed during this test program, but they were beyond the scope of the certification process and dealt with extra envelope expansion. These subsequent drops did indicate a possible growth capability for the future and added even more success to the already successful program.

Aircraft Flying Qualities and Performance

The flying qualities evaluations completed during the E-2C IGW certification program showed no significant changes in the airplane's flying qualities or performance characteristics. The test events completed were discussed previously in table XII, Appendix A. To ensure that the flight test program encountered no unusual or suprising characteristics, prior to the initiation of flying the project officer was provided with a Grumman IGW flying qualities analysis. This analysis encompassed most of the test events presented in the Navy test table and came to similar conclusions that the E-2C handling qualities and performance characteristics would not be significantly degraded by the increased weight.

The actual flying qualities evaluation was conducted during a eight month window. The initial phases centered around basic airplane handling and approach flying characteristics. An example of the extensive E-2C approach handling tests at increased landing weights can be seen in figure 16, Appendix B. During this test event, data shows a time history of airplane responses for a pilot correcting from a two balls high degree glideslope start to a full touch down. This maneuver is intended to determine the correction capability of the airplane to make a safe arrested landing after starting on final approach with an extremely high glideslope. One can see from the data strip that a compensation of approximately five degrees of power lever movement over a four second period is all that was required to establish the airplane back on glideslope. Considering that the entire approach lasted over 20 seconds that short amount of time is seen as favorable. There was a small deviation in airspeed during that correction to glideslope, however the value of approximately 2 to 3 knots is not significant. This result for the E-2C airplane was fairly consistent over the entire flying qualities evaluation. As project officer, it is essential that this be the case before attempting any of the more hazardous and difficult demonstration requirements.

Carrier Suitability Demonstrations

The landbased and shipboard portions of the E-2C IGW carrier suitability demonstration proved to be the most demanding flight test phases for the project officer and engineer to coordinate. Because, the demonstration requirements were specifically determined before testing began possible hardships were identified early in the program and limited to a few previously discussed items. As for the flying aspects, it was truly the most exciting portion of the test program. The highlight of the carrier suitability demonstrations was the FFE phase. By definition, the FFE is a maneuver that results from a pilot's incorrect flare or waveoff attempt that results in a low sink speed, high pitch attitude arrestment with wire pick up prior to main gear touchdown (Grumman, 1991). For the IGW testing with the E-2C, eighteen of these successful FFE were completed. Of those eighteen, six satisfied the minimum requirements of the demonstration specification and all loads were found to be well within the design values of the airplane. All nose gear load trends and all measured forward fuselage bending moments and strains were also found to compare favorably with the values encountered during the heavy weight E-2C drop tests. An example of this correlation can be seen in figure 17, Appendix B. In this figure, the values of one particular fuselage station strain are plotted versus the

nose gear axle vertical load in pounds. The values are highlighted by comparing them to the drop test data accumulated earlier in the certification program. From this data plot and other similar station strain plots, it is observed that the slope of the curves and the strain levels match very well between drop test and FFE. The reason for some minor deviations was the fact that variables were identified that did not exist during the drop test: the addition of wing lift and arresting hook loads; the initial main gear touchdown during flight test as opposed to the initial nose gear touchdown during the drop test; and the slight deviation of strain gage location.

The success of this exciting FFE carrier suitability testing also proved to be one of the keys to the entire E-2C IGW certification process. It was known through previous analysis and structural ground testing that the possible weak link in the E-2C IGW certification program could be the FFE phase. By demonstrating the airplane's structural capability during these FFE and the other landbased carrier suitability tests, the airplane proved itself ready for shipboard use. With this success and the satisfactory results from the carrier evaluation, the E-2C was quantitatively and qualitatively approved for operations at the increased weights and structural limits. The only remaining requirement was for NASC to issue a fleet flight clearance

allowing full operation aboard all Navy carriers. That clearance is forthcoming.

CHAPTER VI

CONCLUSION

General

This project officer's handbook was designed to be a useful and effective guide in the certification of Increased Gross Weights (IGW) on carrier based airplanes. It was developed as a primary working tool for the project officer and project engineer and it should hopefully improve a test teams capability at successfully completing an IGW certification program. Its informative step by step approach to project management and the accomplishment of critical specification testing makes this handbook a potentially valuable commodity. For the project officer involved in a large scale IGW certification process, the understanding and utilization of this handbook will be important. It is a clear, concise, and simple manual filled with proven insights and advice that can be applied to any carrier based airplane.

Specific

The use of this handbook during IGW testing on any carrier based airplane, should hopefully improve a project officer's chances at success. Specifically, the recently

completed E-2C Hawkeye IGW program results show us that the practices and philosophies implemented in this handbook have excellent potential in the Navy test environment. By taking the project officer and engineer all the way from the infant stages of this IGW test program to the structural demonstration and shipboard qualification of the airplane, it is hoped that valuable confidence can be instilled in the capabilities of the test team. With the utilization of this handbook from any particular airplane perspective, the project officer should be able to receive a better understanding of how to properly execute an IGW program.

LIST OF REFERENCES

LIST OF REFERENCES

1. Miller, Nathan, "The U.S. Navy, An Illustrated History", U.S. Naval Institute Press, Annapolis, MD.,1977.
2. Loftin, Laurence K. Jr., "Quest for Performance, The Evolution of Modern Aircraft", National Aeronautics and Space Administration, Washington, D.C., 1985.
3. Naval Air Systems Command, "NATOPS Flight Manual, Navy Model E-2C (PLUS) Aircraft", NASC, Washington, D.C., 1991.
4. Naval Air Engineering Center, "Military Specification, Airplane Strength and Rigidity, Ground Tests;MIL-A-8867 C(AS)", NAEC, Lakehurst, NJ., 1987
5. Department of Defense, "Department of Defense Index of Specifications and Standards", DOD, Washington, D.C., 1992.
6. Naval Air Systems Command, E-2C Increased Carrier Landing Weight Program Contract, 1991.
7. Grumman Aerospace Corporation, Memorandum on E-2C Heavyweight Carrier Suitability Test Plan Meeting, 1991.
8. Grumman Aerospace Corporation, "E-2C Increased Carrier Landing Weight Program Flying Qualities Analysis", GAC, Bethpage, NY., 1990.
9. Naval Air Test Center, Instruction 3960.10D, Preparation Review, and Implementation of Project Test Plans, 1990.

10. Naval Air Systems Command, Message Requesting Flight Clearance for Increased Gross Weight Shore Based Arrested Landing Tests, 252001Z, NASC, 1991.
11. Klunder, Matthew L. and Dagenhart, Raymond, "E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)", Force Warfare Test Directorate, Patuxent River, MD., 1991.
12. Grumman Aerospace Corporation, "Results of E-2C Heavyweight Drop Test", GAC, Bethpage, NY., 1991.
13. Grumman Aerospace Corporation, "Plan for E-2C Catapult Ultimate Tow Load Static Test", GAC, Bethpage, NY., 1991
14. United States Naval Test Pilot School, "FTM No. 103, Fixed Wing Stability and Control, Theory and Flight Test Techniques", USNTPS, Patuxent River, MD., 1977.
15. United States Naval Test Pilot School, "FTM No. 104, Fixed Wing Performance, Theory and Flight Test Techniques", USNTPS, Patuxent River, MD., 1977.
16. Wright-Patterson AFB, ASD/ENESS, "Military Specification Flying Qualities of Piloted Airplanes;MIL-F-8785C", ASD/ENESS, Dayton, OH., 1980.
17. Wright-Patterson AFB, ASD/ENESS, "Military Standard, Flying Qualities of Piloted Vehicles;MIL-D-1797", ASD/ENESS, Dayton, OH., 1990.
18. Naval Air System Command, "Military Specification, Flying Qualities of Piloted Airplanes;MIL-F-8785(ASG)",

NASC, Washington, D.C., 1959.

19. Naval Air Engineering Center, "Military Specification, Airplane Strength and Rigidity, Ground Loads for Navy Procured Aircraft;MIL-A-8863B(AS), NAEC, Lakehurst, NJ., 1987.
20. Naval Air Engineering Center, "Military Standard, Demonstration Requirements for Airplanes;MIL-D-8708B(AS)", NAEC, Lakehurst, NJ., 1987.
21. Naval Air Systems Command, "CV, NATOPS MANUAL", NASC, Washington, D.C., 1988.
22. Naval Air Test Center, Instruction 5213.3F, Report Writing Handbook, Patuxent River, MD., 1984.

APPENDIX A

TABLES

Table I: Military specifications and standards for increased gross weight testing.

DESIGNATION	TITLE
MIL-A-8870	Airplane Strength and Rigidity - Vibration, Flutter, and Divergence
MIL-A-8868	Airplane Strength and Rigidity - Data and Reports
MIL-A-8867	Airplane Strength and Rigidity - Ground Test
MIL-A-8866	Airplane Strength and Rigidity - Reliability Requirements, Repeated Loads, Fatique and Damage Tolerance
MIL-A-8863	Airplane Strength and Rigidity - Ground Loads for Navy Procured Aircraft
MIL-A-8860	Airplane Strength and Rigidity - General Specification for
MIL-A-8708	Demonstration Requirements for Airplanes
MIL-L-8552	Landing Gear, Aircraft Shock Absorber (Air and Oil Type)
MIL-STD-2066	Catapulting and Arresting Gear Forcing Functions for Aircraft Structural Design
MIL-A-18717	Arresting Hook Installations, Aircraft
MIL-L-22589	Launching System, Nose Gear Type, Aircraft
MIL-F-8785C	Flying Qualities of Piloted Airplanes

TABLE II: Airplane drop tests

TEST	CONDITION	WEIGHT DISTRIBUTION	ATTITUDE	SINKING SPEED
a. b.	TAIL DOWN	CRITICAL FOR MAIN LANDING GEAR (MLG)	PITCH 0.9 CLIMAX ROLL 0° AND 2°	MAXIMUM DESIGN
c.	MULTIVARIATE	CRITICAL FOR MLG	ROLL AND PITCH SURVEY TO DETERMINE CRITICAL COMBINATION	MOST CRITICAL FOR THE MULTIVARIATE ENVELOPE
d.	MULTIVARIATE	CRITICAL FOR NOSE LANDING GEAR (NLG)	ROLL AND PITCH SURVEY TO DETERMINE CRITICAL COMBINATION	MOST CRITICAL FOR THE MULTIVARIATE ENVELOPE
e. f.	THREE POINT	CRITICAL FOR NLG	0° AND 2° ROLL	MAXIMUM DESIGN
g. h.	TAIL BUMPER	CRITICAL FOR TAIL BUMPER	MAXIMUN TAIL DOWN 0° AND 2° ROLL	MAXIMUM DESIGN
i. j.	FREE FLIGHT ENGAGEMENT	CRITICAL FOR NLG	PITCH CORRESPONDING TO 1.0W AND 1.3W AT WIRE PICKUP	MAXIMUM NLG RESULTING FROM DESIGN CONDITIONS
k.	FAILING TEST FOR MLG	CRITICAL FOR MLG	MOST CRITICAL RESULTING FROM TESTS a., b., c.	FAIL BY GRADUALLY INCREASING WEIGHT AND SINKING SPEED. INCREMENTS TO BE APPROVED BY NAVAIR
l.	FAILING TEST FOR NLG	CRITICAL FOR NLG	MOST CRITICAL RESULTING FROM TESTS d., e., f.	FAIL BY GRADUALLY INCREASING WEIGHT AND SINKING SPEED. INCREMENTS TO BE APPROVED BY NAVAIR
m.	FAILING TEST BUMPER	CRITICAL FOR TAIL BUMPER	MOST CRITICAL	FAIL BY GRADUALLY INCREASING WEIGHT AND SINKING SPEED. INCREMENTS TO BE APPROVED BY NAVAIR

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., 1987 pp. 16-26.

TABLE III: Catapulting and Arrestment Test

Test	Component	Loading Condition	Magnitude of Load	Special Requirements
a.	Airplane	Catapult release	Failing	Simulate Transient Loading and off-center effects
b.	Airplane	Catapult run	Failing	
c.	Catapult Launch Bar	Maximum tow load	Failing	Include side load and bending
d.	Airplane	Arresting with maximum drag load and maximum side load	Failing	
e.	Airplane	Arresting with 2.0w drag load and maximum side load	Design Ultimate	
f.	Arresting Hook	Maximum drag load	Failing	Include side load and bending. Fail each component
g.	Buffing	Maximum side load	Ultimate	

SOURCE: Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pp. 16-26.

Table IV: Wing Group Tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Wing	Most critical condition for wing bending	Failing	
b.	Wing	Second most critical condition	Design ultimate	
c.	Wing	Critical condition with stores	Design ultimate	
d.	Wing	Rolling pull-out-in more critical of basic and high-drag configuration	Design ultimate	
e.	Wing	Negative angle of attack	Design ultimate	
f.	Wing	Gust	Failing	Test to design ultimate if wing more critical for Table IIa above
g.	Center box (variable sweep)	Most generally critical combined bending and torsion condition	Failing	
h.	Outer panel (variable sweep)	Maximum bending moment at pivot	Failing	
i.	Flap and supporting structure	Critical	Failing	
j.	Aileron and supporting structure	Critical	Failing	
k.	Aileron tab and supporting structure	Critical	Failing	Test each type of tab

Source:

Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

Table IV: Wing Group Tests (Continued)

Test	Component	Loading Condition	Magnitude of load	Special requirements
l.	Wing folding or sweeping mechanism and supporting structure	Critical	Design ultimate	
m.	Slat, spoiler wing-mounted speed-reduction device, leading edge droop, and supporting structure	Critical	Failing	Test each type of slat, spoiler wing-mounted speed-reduction device, leading edge droop, and supporting structure
n.	Barricade engagement	Critical	Design ultimate	

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26."

Table V: Tailgroup tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Horizontal tail	Critical stabilizer bending	Stabilizer failing	Applicable also to unit, one piece, or all moveable horizontal tails
b.	Horizontal tail	Critical stabilizer torsion	Design ultimate	
c.	Horizontal tail	Critical loading	Elevator failing	
d.	Elevator tab and supporting structure	Critical	Failing	Test each type of tab
e.	Vertical tail	Critical fin bending	Fin failing	Applicable also to unit, one piece, or all movable vertical tails
f.	Vertical tail	Critical fin torsion	Design ultimate	
g.	Vertical tail	Critical rudder loading	Rudder failing	
h.	Rudder tab and supporting structure	Critical	Failing	Test each type of tab
i.	Canard	Critical	Failing	
j.	Canard	Second most critical	Design ultimate	
k.	Tail folding mechanism and supporting structure	Critical	Design ultimate	

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

APPENDIX A

Table VI: Fuselage tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Fuselage	Maximum vertical bending including torsion	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVb, c, or d herein are more critical
b.	Fuselage	Maximum lateral bending including torsion	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, c, and d herein are more critical
c.	Fuselage	Maximum torsiong	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, b, or c herein are more critical
d.	Fuselage	Maximum total tail load	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, b, or d herein are more critical
e.	Fuselage	Flight load - in condition that is critical for fuselage in way of and forward of the wing	Fuselage failing	
f.	Fuselage mounted speed reduction device and supporting structure	Critical	Failing	Test each type of fuselage-mounted speed reduction device
g.	Fuselage fuel tanks	Critical	Ultimate	

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

Table VII: Landing gear installation test

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Main landing gear and carry-through structure	Side drift loading, inboard and outboard	Max design side loads in combination with max design vertical load	Turning, steering, pivoting, drift
b.	Auxiliary landing gear and carry-through structure	Critical side load	Design	
c.	Main landing gear and carry-through structure	Critical ground towing	Design ultimate	
d.	Auxiliary landing gear and carry-through structure	Critical ground towing	Design ultimate	
e.	Main landing gear retracting mechanism	Critical, including braking	Design ultimate	Gear in most critical position of retracting and alternatively extension cycle
f.	Auxiliary gear retracting mechanism	Critical	Design ultimate	Gear in most critical position of retracting and alternatively extension cycle
g.	Main and nose landing gears	Sudden extension from most critical compressed position and the most critical servicing	Failing	Strut shall have maximum clearance between inner and outer cylinders based on maximum production tolerances

Source:

Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

APPENDIX A

Table VIII: Control system tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Longitudinal control system	Critical	Failing	Test each type of system. For each system that contains an irreversible mechanism, test the control system on each side of and including the irreversible mechanism
b.	Lateral control system	Critical	Failing	
c.	Directional control system	Critical	Failing	
d.	Control system for tab, slat, spoiler, and speed reduction device, arresting hook, wing fold, leading edge, droop, etc.	Critical	Failing	
e.	Flap control system	Critical	Failing	
f.	Operational		Ultimate	Demonstrate that each control and control system operate under ultimate load

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

Table IX: Engine installation tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Engine installation	Critical symmetrical positive flight condition	Mount failing	Demonstration that catastrophic failure cannot occur if each member, taken separately, fails
b.	Engine installation	More critical of spin or symmetrical flight conditions	Design ultimate	
c.	Engine installation	Critical nonflight condition	Design ultimate	
d.	Engine installation	Fail safe	Limit	
e.	Ducts, ramps, inlets	Critical	Failing	

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

TABLE X: Supporting structures for fixed-equipment and useful load items.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Armament and auxiliary fuel-tank supporting structure	Critical	Design ultimate for less critical condition, failing for more critical condition	Test with typical bomb, missile, rocket, and auxiliary fuel-tank supporting structure for its two most critical conditions including critical combinations
b.	Bomb displacing gear	Critical	Design ultimate	
c.	Seat supporting structure	Critical	Failing	Test each typical seat supporting structure
d.	In-flight fueling installation	Critical	Design ultimate	

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pp. 16-26

Table XI: Miscellaneous parts tests

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Cockpit enclosure	Critical symmetrical	Failing	Test only to design-ultimate load if test of Table IXb herein is more critical. Simulate temperature gradients.
b.	Cockpit enclosure	Critical unsymmetrical	Failing	Test only to design-ultimate load if test of Table IXa herein is more critical. Simulate temperature gradients.
c.	Hoisting sling	Critical	Failing	
d.	Doors and removable sections	Critical flight	Design ultimate	Test each external door and removable section, excluding small inspection-hole covers. Doors that are supported wholly or partially by retracting mechanisms shall be tested while so mounted. Test also with critical 10 percent of fasteners removed.
e.	Main ribs, bulkheads, and frames	Critical	Failing	Test each main rib, bulkhead, or frame of the wing, tail surface, and fuselage, the design ultimate strength of which is not demonstrated by other tests.
f.	Fittings	Critical	Failing	Test each principal fitting, the design ultimate strength of which is not demonstrated by other tests.
g.	Miscellaneous assemblies	Critical	Failing	Test those miscellaneous assemblies, the allowable loads of which are not known and cannot be calculated with reasonable accuracy
h.	Elements	Critical	Failing	Test each structural element, the allowable stresses of which are not known and cannot be calculated with reasonable accuracy.

Source:
Naval Air Engineering Center, Systems and Standardization Department, "Military Specification, Airplane Strength and Rigidity Ground Tests." Military Specification, Naval Air Systems Command, Washington D.C., June 1987 pg. 16-26.

Table XII: E-2C Increased Gross Weight Phase II - Flying Qualities Evaluation Tests and Test Conditions

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
APPROACH HANDLING QUALITIES CAT B	PA(20) PA(30) PA(10) PA(0)	FIELD-1000	AS REQUIRED	46,500	24.0-26.5	PGS	1.5	STANDARD AND NON-STANDARD APPROACHES (HIGH START, LOW START, OVERSHOOTING, ANGLING.) HQR: RUNWAY CENTERLINE ± 20FT AIRSPEED ± 2 KIAS (1) GLIDESLOPE ± 1 BALL
FIELD CARRIER LANDING PRACTICE CAT B	PA(20) PA(30) PA(10) PA(0)	FIELD-600	20 UNITS 22 UNITS 24 UNITS	46,500	24.0-26.5	PGS	1.5	STANDARD AND NON-STANDARD APPROACHES. ASSIGN HQR. (1)
WAVEOFF HANDLING QUALITIES AND PERFORMANCE CAT B	WO(20) WO(30)	FIELD-300	AS REQUIRED	46,500	24.0-26.5	5,100 4,600	1.5	WAVEOFFS FROM STANDARD AND NON-STANDARD APPROACHES. ASSIGN HQR. (1)
BOLTER PERFORMANCE CAT B	WO(20) WO(30)	FIELD-300	AS REQUIRED	46,500	24.0-26.5	5,100 4,600	1.5	BOLTERS FROM STANDARD AND NON-STANDARD APPROACHES. ASSIGN HQR. (1)
APPROACH AIRSPEED SURVEY CAT B	PA(20) PA(30) PA(10) PA(0)	FIELD-1000	20 UNITS 22 UNITS 24 UNITS	46,500 TO 42,500	24.0-26.5	PGS	2.0	
FIELD LANDING PERFORMANCE CAT B	L(20) L(30) L(10) L(0)	FIELD	20 UNITS 22 UNITS 24 UNITS	46,500	24.0-26.5	PGS	0.5	SEQUENCE: FLT IDLE TO GRD IDLE TO REVERSE. FLAPS UP AND FLAPS STILL DOWN.

NOTE: (1) These test events will utilize an Landing Signal Officer as per Carrier Suitability Department Standard Operating Procedure.

SOURCE: Matthew L. Klunder and Raymond Dagenhart, "E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)", Naval Air Test Center, Patuxent River, MD., 1991.

Table XII: (Continued)

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
STATIC LATERAL DIRECTIONAL STABILITY CAT B	PA(20) PA(30)	5,000	20 UNITS	46,500	24.0-26.5	PLF	1.0	STABILIZED POINT TECHNIQUE. STEADY HEADING SIDESLIP ± 15 DEG QUALITATIVELY DETERMINE LIMITING AXIS
DYNAMIC LATERAL DIRECTIONAL STABILITY CAT B	PA(20) PA(30) L(20) L(30)	5,000	20 UNITS	46,500	24.0-26.5	PLF FI	1.0	RUDDER PUMPING TO DETERMINE DAMPED NATURAL FREQUENCY. RUDDER DOUBLET AT NATURAL FREQUENCY. QUALITATIVELY EVALUATE EXCITABILITY
ROLL PERFORMANCE ROLL SENSITIVITY CAT B	PA(20) PA(30) L(20) L(30)	5,000	20 UNITS	46,500	24.0-26.5	PLF FI	1.0	RECORD TIME FOR 30 DEG ANGLE OF BANK CHANGE (SENSITIVITY) RECORD TIME FOR 120 DEG ANGLE OF BANK CHANGE (PERFORMANCE) EVALUATE ADVERSE/PROVERSE YAW

Source: Klunder and Dagenhart, January 1991.

Table XII: (Continued)

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
ASYMMETRIC POWER SINGLE ENGINE TRIMMABILITY CAT C	TO(10)SE PA(20)SE PA(30)SE	5,000	150 20 UNITS	55,000 46,500	24.0-26.5	PLF	1.0	CRITICAL ENGINE FEATHERED WITH PLF ON OPERATING ENGINE. WINGS LEVEL
CONFIGURATION CHANGE (OPEN AND CLOSED LOOP) CAT B	TO(20) TO(10) PA(20) PA(30)	5,000	120 UNITS 20 UNITS	55,000 46,500	24.0-26.5	5,100 PGS	2.0	RAISE GEAR AND MAINTAIN ATTITUDE. AT 125 KIAS, RAISE FLAPS TO 10 DEG AND MAINTAIN ATTITUDE. RAISE FLAPS TO UP AND MAINTAIN ATTITUDE. STABILIZE IN 500 FPM DESCENT. APPLY 5,100 ISHP AND MAINTAIN ATTITUDE. NOTE ANY OBJECTIONABLE PITCH-UP FORCES OR MOTIONS HQR: ALTITUDE $\pm$ 100 FT ANGLE OF BAND $\pm$ 2 DEG HEADING $\pm$ 2 DEG
SINGLE ENGINE CLIMB PERFORMANCE CAT C	TO(10)SE TO(20)SE WO(20)SE WO(30)SE	3,000 THRU 5,000	150 TO 24 UNITS	55,000 46,500	24.0-26.5	5,100	1.5	SAWTOOTH CLIMBS. CRITICAL ENGINE SECURED AND PROPELLER FEATHERED. TIME FOR 2,000 FT OR 2 MINUTES. COMMENT ON ASYMMETRIC FLYING QUALITIES

Source: Klunder and Dagenhart, January 1991.

Table XII: (Continued)

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
MINIMUM CONTROL AIRSPEED (Vmc) CAT C	P(0)SE TO(10)SE TO(20)SE WO(20)SE WO(30)SE	4,000	180 130 130	55,000 55,000 46,500	24.0-26.5	5,100	6.0	6-2 DEG MAXIMUM RUDDER 20 DEG MAXIMUM RUDDER DETERMINE SINGLE ENGINE MINIMUM TRIM SPEED, AND WINGS LEVEL AND 5 DEG BANK STATIC Vmc DETERMINE DYNAMIC Vmc
STATIC LONGITUDINAL STABILITY CAT B	TO(10) TO(20)	5,000	135	55,000	24.0-26.5	PLF	1.0	STABILIZED POINT TECHNIQUE (± 15% OR 24 UNITS)
FLIGHT PATH STABILITY CAT B	PA(20) PA(30)	5,000	20 UNITS	46,500	24.0-26.5	PLF	1.0	TIME FOR MINIMUM OF 15 SECONDS. -5, -10, +5, +10 KTS
DYNAMIC LONGITUDINAL STABILITY (1) SHORT PERIOD CAT B	TO(10) TO(20) PA(20) PA(30)	5,000	120 20 UNITS	55,000 46,500	24.0-26.5	PLF	1.0	SINUSOIDAL STICK PUMPING TO DETERMINE NATURAL FREQUENCY, ELEVATOR DOUBLET AT DAMPED NATURAL FREQUENCY QUALITATIVELY EVALUATE EXCITABILITY

Source: Klunder and Dagenhart, January 1991.

Table XII: (Continued)

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
SINGLE CONTROL TURNS CAT B	PA(20) PA(30) PA(10) PA(0)	5,000	20 UNITS 22 UNITS 24 UNITS	46,500	24.0-26.5	PLF	0.5	HQR HDG ± 2 DEG AOB ± 2 DEG EVALUATE ADVERSE/PROVERSE YAW
AIRSPEED CALIBRATION (TOWER FLY-BY) (2) CAT B	PA(20) PA(30) (PA10) PA(0) CR(0)	100 - 200	300 24 UNITS AOA	55,000 TO 44,000	24.0-26.5	PLF	3.0	DONE AT WEBSTER TOWER
STALL WARNING (2) CAT B	TO(10) PA(20) PA(30)	5,000	20-26 UNITS	55,000 TO 44,000	24.0-26.5	PLF	1.0	1KT/SEC DECEL TO STALL WARNING ACTIVATION

NOTE: (2) These tests will be proceeded by an angle of attack/stall warning system check with the wingboom installed and at a minimum of 15,0000 MSL, AOA will be up to 28 units.

Source: Klunder and Dagenhart, January 1991.

Table XII: (Continued)

TEST	CONFIG	ALTITUDE (FT)	AIRSPEED (KIAS)	GROSS WT (LB)	CG (% MAC)	HORSEPOWER (ISHP)	FLT HRS	REMARKS
FIELD TAKEOFF PERFOMANCE CAT B	TO(10) TO(20)	FIELD - 1,000	AS REQUIRED	55,000	24.0-26.5	5,100	0.5	HQR: PITCH ATTITUDE ±2 DEG HEADING ±2 DEG RECORD TIME/DISTANCE TO LIFTOFF AND 180 KIAS
SIMULATED SINGLE ENGINE APPROACHES CAT C	PA(20)SSE PA(30)SSE	FIELD - 1,000	20 UNITS	46,500	24.0-26.5	PGS	1.5	HQR: MAINTAIN RUNWAY CENTERLINE ±20 FT AIRSPEED ± 2 KTS LANDING DISTANCE ± 100 FT QUALITATIVELY EVALUATE TRIMMABILITY

Source: Klunder and Dagenhart, January 1991.

Table XIII: Arrested landing tests

Test No.	Type of Landing	Sinking Speed (FPS)	Pitch Angle (DEG)	Roll Angle (DEG)	Off-Center Distance	Remarks
1	On Center	Not Less than V_{VC}	Optional	Optional	0	Attain limit hook load
2	Off Center	Not less than V_{VC}	Optional	Optional	25 feet	Attain limit hook load
3	Rolled	Not less than V_{VC}	Mean ± 1	Not less than 6	Optional	Attain limit hook load
4	Rolled and Yawed	Not less than V_{VC}	Optional	Not less than 5	Optional	Perform twice, once with roll in same direction as yaw and once with roll in opposite direction to the yaw. The yaw angle shall not be less than 5 degrees.
5	Tail Down	See Note 1	Not less than mean +3	Optional	1/2 main gear wheel tread See Note 2	Perform once to the conditions specified or, alternatively three times but with sinking speed not less than 0.8 times the sinking speed of Note 1.
6	Nose Down	See Note 1	Not greater than mean -3	Optional	Optional	" " "
7	Mean Attitude	See Note 1	Mean $\pm$ 1.5	Optional	Optional	" " "
8	Free Flight	See Note 3	Not less than that angle corresponding to 1.3W lift at $1.1V_{PA_{min}}$ at wire engagement	Optional	See Note 2	Perform once to the conditions specified or, alternatively 3 times but with the specified sinking speed increased by 2 FPS and the specified pitch angle reduced by 2 degrees. The hook load for all free flight engagements shall not be less than 85 percent of limit.

Source: Naval Air Engineering Center, "Demonstration Requirements for Airplanes." Military Specification, Naval Air Systems Command, Washington D.C., June 1987

Table XIII: (continued)

Notes:

1. For test numbers 5, 6 and 7 the required sinking speeds shall be not less than the maximum design sinking speed corresponding to airplane pitch angles of mean =3, mean-3, and mean respectively.

2. For each of tests 5 and 8, one third of the total number of landings performed to satisfy the requirements of this Table, or three landings, whichever is less, shall result in the landing gear rolling over a deck obstruction. For test 5 the main gear shall roll over a centerline light and for test 8 the nose gear shall roll over a PLAT head. For each of these landings the vertical load on the landing gear, just prior to contact with obstruction, shall not abe less than 75 per cent of the peak load attained without the superposition of the incremental deck obstruction load.

3. For test number 8, the sinking speed shall not be greater than the minimum specified in MIL-A-8863.

APPENDIX B

FIGURES

NDW-NATC-3930/2 (REV.10-78)

NAVAL AIR TEST CENTER

CATEGORY C
PROJECT CATEGORY

PROJECT TEST PLAN

UNCLASSIFIED
TEST PLAN CLASSIFICATION

UNCLASSIFIED
PROJECT CLASSIFICATION

CATEGORY C

28 January 1991
DATE SUBMITTED

DATE REVISED

PROJECT TITLE
E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)

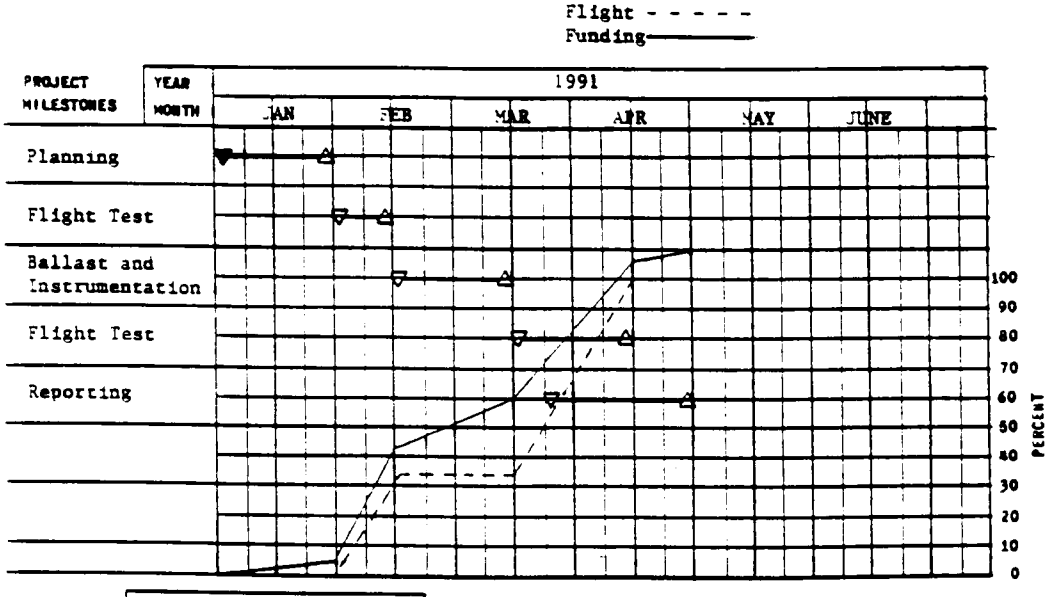
AIRTASK/WORK UNIT — **DATE**
AIRTASK A5115116C/053-F-1W0463-0000, Work Unit A5116C-03 — 27 September 1990

COGNIZANT NAVAIR DIVISION	COGNIZANT NAVAIR ENGINEER/CODE/TEL.NO.
AIR-530	Mr. Jim Katrivanos/AIR-53022C/A/V 222-3592

NATC DIRECTORATE/BRANCH/COST CENTER
FW/FT/ATLT

NATC PROJECT ENGINEER/CODE/TEL.NO.	PROJECT OFFICER/CODE/TEL.NO.
Mr. Ray Dagenhart/FW314/x3553	LT Matt Klunder/FW70K/737-3714

AUTHORIZED FUNDS/EXPIRATION DATE	JOB ORDER NO.	ESTIMATED COMPLETION DATE
$282,650/30 September 1991	PY6671 CAT	30 April 1991



	PLANNED	ACTUAL
START	▽	▼
FINISH	△	▲

1. TOTAL FUNDS FOR 100% = $282,650
2. TOTAL FLIGHT HRS FOR 100% = 28.5 (E-2C) / 8.5 (T-34C)

REVIEWED:
FW30 JH. — FW01A 1/30
FW70 — FW05 1/30/91
FW05S — FW03 30 Jan
FWOPS 1/31 — FW02

APPROVED: WJ Broadhurst — DIRECTOR — 30JAN91 — DATE

THIS TEST PLAN IS SIGNED WITH THE UNDERSTANDING THAT FLIGHT ABOVE 53,000 LB REQUIRING BALLAST INSTALLATION. AND FIELD TOUCH/GO, BOLTER, WAVEOFF AND FCLP LANDINGS ABOVE 45,000 LB WILL NOT BE DONE WITHOUT NAVAIRSYSCO FLIGHT CLEARANCE AND NAVAIRSYSCOM LOCAL CLEARA

Cover Sheet

Figure 1. Sample IGW Test Plan

Source: Matthew L. Klunder and Raymond Dagenhart, "E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)" E-2C Test Plan, Naval Air Test Center, Patuxent River, MD., January 1991.

APPENDIX B

INTRODUCTION

BACKGROUND

1. The E-2C Increased Gross Weight (IGW) program has arisen because the new E-2C Group II aircraft are predicted to have a maximum takeoff gross weight of approximately 54,400 lb. Inclusive in this heavier weight will be a scheduled zero fuel gross weight increase of approximately 1,500 lb. With the increased zero fuel gross weight, and the accompanying current maximum trap weight of 45,000 lb, and bingo fuel of 3,900 lb, a dangerous decrease in available fuel load at landing will be identified. Furthermore, E-2C Group II aircraft will encounter below bingo fuel reserves on the first pass during night carrier operations. For safety considerations, it has therefore been proposed that the E-2C carrier landing weight be increased to at least 46,500 lb. Ground testing, including drop testing of the fuselage, which has been conducted in the past has thus far served to clear the aircraft for steadily increasing weights. Recently, a dynamic landing analysis for the free flight engagement event was considered by NAVAIRSYSCOM Structures Branch to be an insufficient basis for the heavier production weight aircraft clearance. The IGW test program was proposed as a ground and flight test program devised to clear the E-2C for carrier landings up to 46,500 lb and flight at gross weights up to 55,000 lb. The IGW program consists of a Ground Vibration Survey (GVS), heavyweight flying qualities demonstration, drop test, and carrier suitability demonstration. The first phase of the program, the GVS, was completed in October 1990. This test plan addresses the second phase of the evaluation, the heavyweight flying qualities demonstration. NAVAIRTESTCEN TASKING IS PER NAVAIRSYSCOM AIRTASK AS115116C/053-F-IW0463-0000

PURPOSE

2. The purpose of this evaluation is to assess the flying and handling qualities of the E-2C at gross weights of 55,000 lb and 46,500 lb, indicative of the proposed increased takeoff and landing weights.

DESCRIPTION OF TEST AIRPLANE

3. The E-2C PLUS airplane is a high-wing, twin-engine turboprop, all-weather, carrier- and shore-based AEW airplane manufactured by the Grumman Aircraft Systems Division (GASD). Distinguishing features of the airplane are its horizontal 24-ft diameter rotodome and four vertical tails. The E-2C PLUS is powered by T56-A-427 engines with limited maximum ratings of 5,100 indicated shaft horsepower manufactured by Allsion Gas Turbine Division. The engines are fitted with Hamilton Standard Division 54460-1 constant speed propellers.

4. Two test airplanes are proposed, BuNo 160012 and BuNo 163535. BuNo 160012 will be utilized as practicable until its delivery at the end of January 1991 to GASD for preparation for use as the drop test article. BuNo 163535 will be the test airplane for the remainder of the heavyweight flying qualities demonstration. The external configuration of both test airplanes is representative of current production E-2C aircraft, except for an instrumented

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

wingboom installed on the right wing of BuNo 160012. The wingboom will be removed prior to the airplane's delivery to GASD and will be installed on BuNo 163535. The internal configuration of both test airplanes differs from production E-2C aircraft in two ways. The test airplanes are fitted with onboard instrumentation which includes a tape recorder and a telemetry package. Also, the weapons systems avionics have been removed and replaced with appropriate ballast. Furthermore, BuNo 163535 will be ballasted to the projected weight distribution for a 55,000 lb takeoff gross weight airplane. A detailed description of the basic airplane is contained in the E-2C PLUS NATOPS Manual, reference (a).

SCOPE OF TEST

TESTS AND TEST CONDITIONS

5. The test program will be conducted at NAVAIRTESTCEN. NAVAIRTESTCEN may conduct selected tests jointly with Grumman test pilots if required due to a temporary shortage of NAVAIRTESTCEN aircrew, or if the NAVAIRTESTCEN project officer/engineer deem joint participation to greatly benefit both the Navy and Grumman. If joint participation is required, NAVAIRTESTCEN shall sign for the aircraft and act as pilot in command. The test program will consist of 20 flights totaling 28.5 flight hours. A detailed table of tests and test conditions is presented in appendix II.

TEST ENVELOPE

6. All tests will be conducted within the E-2C PLUS NATOPS normal operating envelope, reference (a), as modified by flight clearances from NAVAIRSYSCOM. Flight clearances are presented in appendix III. The following clearances will be obtained prior to flight testing:

a) Field takeoff maximum gross weight limit of 55,000 lb. (* AND FCLP)
b) Field touch/go, bolter, and waveoff*landings with arresting hook retracted and a maximum gross weight limit of 46,500 lb.

TEST LOADINGS

7. The E-2C does not carry external stores. Airplane center of gravity will vary from 24.0% to 26.5% Mean Aerodynamic Chord (MAC) and will be within the NATOPS Flight Manual, reference (a), limits of 22.5% to 26.5% MAC. The airplane will be tested to a maximum arrested landing gross weight of 46,500 lb vice the present limit of 45,000 lb, and to a maximum takeoff gross weight of 55,000 lb vice the present limit of 53,000 lb. AIRCRAFT BALLAST WILL BE INSTALLED TO ACHIEVE THE 55,000 lb TAKEOFF GROSS WEIGHT AND WILL BE CLEARED THROUGH A LOCAL NAVAIRTESTCEN CLEARANCE.

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

TEST CONFIGURATIONS

8. Test configurations are defined in table I.

Table I
TEST CONFIGURATIONS

CONFIGURATION	TRAILING EDGE FLAP POSITION (DEG)	LANDING GEAR POSITION	POWER
PA(20)	20	DOWN	PGS(1)
PA(20)SSE(2)	20	DOWN	PGS/FX ISHP(3)
PA(30)	30	DOWN	PGS
PA(30)SSE	30	DOWN	PGS/FX ISHP
PA(0)	0	DOWN	PGS
PA(10)	10	DOWN	PGS
L(20)	20	DOWN	FLT IDLE
L(30)	30	DOWN	FLT IDLE
L(0)	0	DOWN	FLT IDLE
L(10)	10	DOWN	FLT IDLE
WO(20)	20	DOWN	MRP(4)
WO(20)SE(5)	20	DOWN	MRP
WO(20)SSE	20	DOWN	MRP
WO(30)	30	DOWN	MRP
WO(30)SE	30	DOWN	MRP
WO(30)SSE	30	DOWN	MRP
TO(10)	10	DOWN	MRP
TO(10)SE	10	DOWN	MRP
TO(20)	20	DOWN	MRP
TO(20)SE	20	DOWN	MRP
P(0)SE	0	UP	MRP

NOTES: (1) PGS - Power for glideslope
(2) SSE - Simulated single engine
(3) FX ISHP - Horsepower to simulate a power off, propeller feathered engine
(4) MRP - Maximum Rated Power (5,100 ISHP below 180 KIAS or 865°C TMT)
(5) SE - Actual single engine, feaathered propeller on inoperative engine.

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

TEST STANDARDS

9. The airplanes will be tested for specificacion compliance with applicable paragraphs of the Military Specification MIL-F-8785 (ASG), reference (b) and Supplement No. 1 to the Detailed Specification, reference (c).

METHOD OF TEST

TEST METHOD AND PROCEDURES

10. Testing will be conducted using buildup/builddown techniques, with progress reviews to ensure that a structured approach to critical test areas is maintained. Prior to each flight, previously obtained data and planned flight conditions will be reviewed with the project team members. The method of test for this evaluation is contained in appendix IV.

INSTRUMENTATION AND DATA EXTRACTION/PROCESSING

11. Instrumentation parameters will be recorded on tape by the onboard pulse code modulation tape recorder and real-time by the Real-time Telemetry Processing System (RTPS). All flight tests will be monitored real-time at RTPS by the test team. A detailed instrumentation list is presented in appendix V. Grumman instrumentation and support will be used for BuNo 160012 and Range Directorate instrumentation and support will be used for BuNo 163535.

SUPPORT REQUIREMENTS

12. A list of directorate support requirements are presented in table II. A project support checklist is contained in appendix VI.

Table II
SUPPORT REQUIREMENTS

FORCE WARFARE AIRCRAFT TEST DIRECTORATE	E-2C qualified pilots (category C)
	Test airplanes (BuNo's 160012 and 163535)
	Engineering support
	Maintenance support (military and Grumman)
STRIKE AIRCRAFT TEST DIRECTORATE	Carrier Suitability engineering support
RANGE DIRECTORATE	Instrumentation engineers and engineering technicians

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

	RTPS
COMPUTER SCIENCES DIRECTORATE	Data extraction and software support
GRUMMAN AIRCRAFT SYSTEMS DIVISION	Instrumentation engineers and engineering technicians

SPECIAL PRECAUTIONS

13. All testing will be conducted using buildups/builddowns. Test progress and results will be monitored continuously. A safety checklist is presented in appendix VII. Specific points that have been addressed are:

a. Real-time telemetry for all flight tests.

b. Actual single engine flights will be accompanied by a chase airplane.

c. Approaches in PA(30) will be flown at airspeeds below dynamic minimum control airspeed. Aircrew will be briefed not to apply max power during waveoffs and bolters.

d. GAC was contracted by NAVAIRSYSCOM to perform an analytical study of the flying qualities of the E-2C at a landing gross weight of 46,500 lb. The general conclusion of the GAC study was that the E-2C handling qualities characteristics do not change significantly as a result of the increase in landing weight from 44,500 lb to 46,500 lb.

e. The airframe and landing gear will be subjected to higher than normal loads due to the increased landing weight during touch and go and landing tests. The airframe and landing gear have been subjected to drop tests at gross weights greater than 46,500 lb. The only condition not cleared at the heavier weights is the free flight engagement. All tests addressed in this test plan will be conducted with the arresting hook up to avoid the free flight engagement condition.

f. For Vmc tests including high angle of attack data points, a buildup sequence working toward the slowest airspeeds will be utilized.

MANAGEMENT

FUNDING AND MANPOWER REQUIREMENTS

14. A detailed cost estimate and manpower requirements summary are provided in appendix VIII.

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

SCHEDULE/MILESTONES

15. A general project milestone summary is presented on the cover of this test plan.

PERSONNEL ASSIGNMENT

16. The NAVAIRTESTCEN personnel assigned to assist this program are listed below.

	Name	Phone
Project Officer/Pilot	LT Matt Klunder	737-3714
Project Pilot	LT Eric Hinger	737-3787
Project Lead Engineer	Mr. Ray Dagenhart	x3553
CVS Engineer	Mr. Eric Ryberg	x4644
RD Instrumentation	Mr. Gary Guiles	x1583

REPORTS

17. A Quick Response Report will be issued following the completion of the Heavyweight Flying Qualities Demonstration phase of the E-2C Increased Gross Weight Program.

Figure 1. (continued)

Source: Klunder and Dagenhart, January 1991.

```
                UUUUUUUUU  UUUUUUUUUUUUUUUUUUUUUUUUU
                U      U N C L A S S I F I E D      U
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU

R   ZYUW RUEBRDA0855 2611600-UUUU--RUCOSUU.
    UUUUU
R 1619162 SEP 91 ZYB
FM NAVAIRTESTCEN PATUXENT RIVER MD//SA71D//
TO COMNAVAIRSYSCOM WASHINGTON DC//5308/5116C//
INFO SUPPO GRUMMAN BETHPAGE NY//RGEPE2/GASD//
NAVAIRENGCEN LAKEHURST NJ//54//
ET
UNCLAS //N13034//
SUBJ:  REQUEST FOR FLIGHT CLEARANCE FOR E-2C INCREASED GROSS
WEIGHT SHORE BASED ARRESTED LANDING TESTS
REF/A/DOC/NAVAIRSYSCOM/CONTRACT NO. N00019-90-C-0218/9AUG91//
REF B/DOC/GRUMMAN/REPORT NO. TED-123-3.80/30AUG91//
REF C/RMG/COMNAVAIRSYSCOM/261920ZMAY89/NOTAL//
NARR/REF A CONTRACTS GRUMMAN TO CONDUCT ARRESTED LANDING TESTS
TO INCREASE MAX E-2C CARRIER LANDING WEIGHT TO 46,500 LB.  REF
B IS GRUMMAN TEST PLAN WHICH DESCRIBES IN DETAIL TEST POINTS,
PROCEDURES, AND LIMITS.  REF C IS PREVIOUS FLIGHT CLEARANCE FOR
E-2C SHORE BASED CARRIER SUITABILITY TESTS.//
RMKS/1.  GROUP II E-2C ACFT ARE SKED TO BE DELIVERED IN EARLY
92.  WITH INSTALLATION OF GROUP II SYSTEMS, E-2C ZFGW HAS
INCREASED TO APPROX 41,500 LB.  FUTURE PRODUCTION LOTS WILL
CONTINUE THIS GROWTH TREND.  TO MAINTAIN CURRENT BINGO FUEL
RESERVES (3900 LB) AND TO ALLOW FOR AN ADDITIONAL 1000 LB
GROWTH IN GW, MAX CARRIER LANDING WEIGHT MUST BE INCREASED FROM
 000 LB TO 46,500 LB.  REF A CONTRACTED GRUMMAN TO CONDUCT
   ESTED LANDING TESTS WITH NAVAIRTESTCEN SUPPORT AND
  HESSING.  PURPOSE OF THESE TESTS IS TO DEMONSTRATE E-2C IS
STRUCTURALLY CAPABLE OF CONDUCTING CARRIER LANDINGS AT GW OF
46,500 LB.
2.  REQUEST AUTH TO CONDUCT SUBJ TETS IAW FOLI
   A.  LOCATION.  TESTING WILL BE CONDUCTED USING MK-7 MOD 3
ARRESTING GEAR LOCATED AT NAVAIRENGCEN OR NAVAIRTESTCEN.
    B.  ACFT.  TEST ACFT WILL BE E-2C BUNYR000 KA143).  ACFT
IS STRUCTURALLY REPRESENTATIVE OF A PRODUCTION E-2C.  IT HAS
BEEN BALLASTED TO ATTAIN A ZFGW OF 42,500 LB.  BALLAST HAS BEEN
DISTRIBUTED SUCH THAT ACFT CG APPROXIMATES THAT OF ANFT IN
GROUP II CONFIG.  ACFT IS INSTRUMENTED TO OBTAIN CRITICAL
STRUCTURAL DATA SUCH AS FUSELAGE STRAINS AND LANDING GEAR
LOADS.
    C.  AIRCREW.  ARRESTED LANDING TESTS WILL UTILIZE A GRUMMAN
TEST PILOT AS PILOT IN COMMAND WITH A NAVAIRTESTCEN OR GRUMMAN
COPILOT.
    D.  CONFIGS.  APPROACHES WILL BE FLOWN WITH FLAPS SET AT 20
OR 30 DEG.  APPROACHES IN 30 DEG FLAPS WILL BE AT AIRSPEEDS
BELOW DYNAMIC MINIMUM CONTROL SPEED (VMC).  AIRCREW WILL BE
BRIEFED TO LIMIT HORSEPOWER TO 4600 ISHP.  REF C AUTH USE OF 30
DEG FLAPS FOR SHORE BASED CARRIER SUITABILITY TESTING OF
T56-A-427 ENGINE.
    E.  TEST MATRIX.  ARRESTED LANDING TESTS WILL BEGIN WITH
FCLP TOUCH AND GO LANDINGS TO FAMILIARIZE PILOTS WITH HEAVY WT


          5070/261     1           MI 1020    261/16:00Z
* * COURTESY COPY
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
                U      U N C L A S S I F I E D      U
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
```

Figure 2. Sample IGW Flight Clearance Request

Source: Matthew L. Klunder and Raymond Dagenhart,"E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)", E-2c Test Plan, Naval Air Test Center, Patuxent River, MD,1991.

```
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
                U     U N C L A S S I F I E D      U
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU

F     G QUALITIES AND NAVAIRENGCEN FACILITY.  THIS WILL BE
FOLLOWED BY A SERIES OF ARRESTED LANDINGS BASED ON
MIL-STD-8708B STRUCTURAL DEMONSTRATION RQMTS, WITH ADDITIONAL
EMPHASIS ON FREE-FLIGHT ENGAGEMENTS.  REF 8 LISTS DETAILED
SCOPE OF ARRESTED LANDING TESTS.  APPROX 25 TOUCH AND GO AND 30
ARRESTED LANDINGS WILL BE CONDUCTED.
    F.  STRUCTURAL FLIGHT ENVELOPE.
        (1) MAX ARRESTED LANDING GW:  46,750 LB.
        (2) MAX ARRESTING HOOK LOAD:  108,000 LB.
        (3) MAX ARRESTED LANDING DECEL:  AS LIMITED BY HOOK
LOAD.
        (4) DESIGN SINK SPEED:  20.4 FT/SEC.
        (5) FUSELAGE STRAINS:  FLIGHT ALLOWABLE STRAIN LEVELS
 AS LISTED IN REF 8.
        (6) LANDING GEAR LOADS:  STRENGTH ENVELOPES AS LISTED
IN REF 8.
    G.  OVERSHOOT PROCEDURES:  TESTS WILL BE DISCONTINUED AND
APPROPRIATE INSPECTIONS WILL BE COMPLETED IN EVENT OF ONE OF
FOL:
        (1) EXCEEDANCE OF LIMIT ARRESTING HOOK LOAD GREATER
THAN 15 PERCENT.
        (2) ATTAINMENT OF DESIGN SINK SPEED.
        (3) ATTAINMENT OF DESIGN ENVELOPE LOADS.
        (4) ATTAINMENT OF FLIGHT ALLOWABLE STRAIN LEVELS.
4   REQUEST FLIGHT CLEARANCE BE RECD BY 23 SEP 91 AND EXTEND
T    31 DEC 91.
5.  NAVAIR-5302 POC'S ARE MR. RANDY LEFLER, AIR-53021C4 AND MR.
JIM KATRIVANOS, AIR-53022C, DSN 222-3591 OR COMMERCIAL (703)
692-3591.  NAVAIRTESTCEN CARRIER SUITABILITY POINT OF CONTACT
IS MR. ERIC RYBERG, SA71D, DSN 326-4441, OR COMMERCIAL (301)
863-4441.//
BT
#0855
NNNN

          5070/261     2          MI 1020    261/16:002
* * COURTESY COPY
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
                U     U C L A S S I F I E D      U
                UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
```

Figure 2. (continued)

Source: Klunder and Dagenhart, January 1991.

AT FORM 13010

PROJECT OFFICER: LT M. Klunder

PROJECT ENGINEER: Mr. R. Dagenhart

DEPARTMENT/PHONE NO: FT/3553

NATC PRIORITY:

ANTICIPATED PRIORITY:

JOB ORDER: PY6671CAT

DATE: 7 January 1991

PROJECT SUPPORT CHECKLIST

E-2C HEAVYWEIGHT FLYING QUALITIES DEMONSTRATION
(TITLE)

1. Is the project classified? YES ____, LEVEL _____, NO __X__

2. Is the project associated maintenance data classified? YES ____,

LEVEL _____, CUSTODIAN _____, NO __X__

3. What is the purpose of the test? The purpose of this evaluation is to assess the flying and handling qualities of the E-2C at gross weights of 55,000 lb and 46,500 lb, indicative of the proposed increased takeoff and landing weights.

4. Are there any peculiar hazardous procedures/installations which are not identified as standard maintenance/operational procedures? YES ____,

INFORMATION TO BE PROVIDED BY _____/_____
(DATE)

NO __X__

5. List the flight restrictions officially placed on the project and those restrictions/special pilot procedure(s) that have been/will be added to the Aircraft Discrepancy Book (ADB).

NATOPS limits as modified by flight clearance and Safety Checklist. Flight clearances will be added to the ADB.

Appendix VI

Figure 3. Sample IGW Project Support Checklist

Source: Matthew L. Klunder and Raymond Dagenhart, "E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)", E-2C Test Plan, Naval Air Test Center, Patuxent River, MD., 1991.

6. When will the Project Pre-Maintenance brief occur? (Give best estimate)

Date 28 January 1991.

7. Is the test schedule, including ground and flight times, available at the brief? YES __X__ NO _____ TO BE PROVIDED BY: Ray Dagenhart

_____, 28 January 1991
(DATE)

8. What is the BuNo of the required aircraft? 160012 and 163535.

9. Will the aircraft/component require on-site installation? YES _____,

COORDINATOR _____, A/C LOCATION _____

SCHEDULE _____, NO __X__

10. Will the aircraft/component require off-site installation? YES _____,

LOCATION/DURATION _____, NO __X__

11. Does the effect of instrumentation/component installation necessitate EMC/Safety of Flight Testing (SOFT) IAW NATCINST 13050.3 Series? YES __X__,

SCHEDULED FOR Already accomplished by SETD on each test airplane, NO _____

12. Aircrew Station:

(a) Does the instrumentation/component installation make a modification to an aircrew station? (NATCINST 13050.3 Series). YES __X__ NO _____

(b) Aircrew systems branch check scheduled for Already accomplished

13. Will "Pink Sheet(s)" be initiated? YES __X__ NO _____

If yes, for what function (installation, deinstallation, photo, weight and balance, etc.):

* Ballast installation in BuNo 163535 ~~TO~~ TO BE CLEARED LOCALLY WITH FLIGHT CLEARANCE.
* Weight and Balance
* Instrumentation calibrations

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

14. Will the effect of instrumentation require a Functional Check Flight (FCF), engine trim, etc? YES _____, SPECIFY _____

_____ NO __X__

15. Is the component under test currently installed on the aircraft?

YES __X__ NO _____ BUT WILL BE PROVIDED BY _____

_____, _____
(DATE)

16. All modified components will be marked with an orange stripe and tagged with instructions for disposition should a failure occur. The modified units are not to be inducted into the normal supply channels.

(a) Will the installed components require special identification?

YES _____ NO __X__

(b) Problems incurred with modified units should be brought to the immediate attention of: __N/A__

17. Are there any specific instructions/restrictions which would prohibit cannibalization actions? YES _____ SPECIFY

NO __X__

18. Are spare test components available? YES _____ TO BE PROVIDED _____

_____, NO _____ N/A __X__

19. If project components require installation/removal, are consumables (seals, O-rings, special lubricants, etc.) available: YES _____, NO _____

TO BE PROVIDED BY _____, N/A __X__

_____
DATE)

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

20. Will ground checks/diagnostics be required to assess system operation?

YES __X__, PERFORMED BY MAINTENANCE _____

PERFORMED BY PROJECT PERSONNEL __X__, NAMES/EXTENSION RD and Grumman instrumentation (Instrumentation checkouts and preflights)

_____ NO _____

21. When will ground checks/diagnostics be required? PREFLT __X__,

POSTFLT __X__, OTHER (specify) _____

N/A _____

22. Will ground test impair other testing, maintenance, or aircraft utilization? YES _____, SPECIFY _____, NO __X__

23. Is a specific aircraft spotting location required? YES _____,

_____, NO __X__

24. Will Support Equipment/Project Support Equipment (SE/PSE) be required?

YES __X__, OPERATED BY MAINTENANCE __X__, OPERATED BY PROJECT

PERSONNEL/CONTRACTORS _____

_____, NO _____

25. List required SE/PSE: AIR CONDITIONER _____, ELECTRICAL POWER __X__,

HYDRAULIC POWER _____, OTHER Air start cart, stands as required to perform ground checks, NO _____

26. Do project personnel/contractors possess valid NAS Patuxent River SE licenses for the equipment specified above? YES _____ NO __X__ N/A _____

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

27. Being as specific as possible, list the required "fully" operable systems (other than safety of flight) necessary for the performance of these tests:

None, other than essential instrumentation.

28. Will Force Warfare Aircraft Test Directorate maintenance support be required to perform the test?

YES __X__ NO _____

29. Are specific maintenance rates/individuals desired to assist in the test?

YES _____ RATE/NAMES/EXTENSION _____

_____, NO __X__

30. Will specific training be required for the maintenance personnel?

YES _____, SPECIFY _____, NO __X__

31. Will contractor maintenance support be provided to perform the test?

YES __X__, CONTRACTOR POINT OF CONTACT John Carroll / 737-3749,
(NAME) (PHONE NO)

SPECIFY _____, NO _____

32. If contractor maintenance support is utilized, will QA inspections/functions be performed by Navy personnel? YES __X__ NO _____

TO BE PROVIDED BY _____

33. Will instrumentation PODS, camera mounts, suspension equipment, weapons loading configurations or ordnance not specifically cleared in applicable tactical manuals be used during these tests. YES _____ NO __X__

If yes, has NATCINST 3710.18 (Series) regarding local flight clearance authorization been complied with? YES _____ NO _____

When will local flight clearance be issued? _____

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

If the requested clearance is beyond the authority of the NAVAIRTESTCEN Flight Clearance Authorization Board, has a request for clearance been submitted to NAVAIRSYSCOM for approval? YES _____ (Date _____) NO _____

If no, what is plan of action?

If yes, has the clearance been received from NAVAIRSYSCOM? (Or if not what is anticipated receipt date)

34. Will ordnance be requisitioned? YES _____ NO __X__. If yes, specify MK and MOD numbers _____;

Quantity _____; Live or Inert _____; Name of person responsible for initiating requisition: _____, extension _____.

35. Is support equipment required: YES _____ NO __X__. If yes, specify nomenclature _____;

Model/Part Number _____;

Adapters (Identify) _____;

Interface cables (Identify) _____.

36. If support equipment is required, specify custodian __N/A__ _____. extension _____

Name of person responsible for obtaining equipment _____ _____ extension _____, N/A __X__

37. Will aircraft functional ground tests be required? YES _____ NO __X__

If yes, specify the type of test, i.e., System, Release, and Control, etc.:

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

(SIGNATURE OF PROJECT OFFICER)	(DATE)
Ray Dagenhart (SIGNATURE OF PROJECT ENGINEER)	28 January 1991 (DATE)
(SIGNATURE OF DEPARTMENT HEAD)	(DATE)
(SIGNATURE OF PROJECT LIAISON)	(DATE)

Appendix VI

Figure 3. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

SAFETY CHECKLIST

The purpose of this checklist is to stimulate thought in the area of safety. Most of these questions have been written from lessons learned from past accidents in the RDT&E community.

Notes:

(1) This checklist will be completed and signed by the project officer, all project pilots, and the project engineer(s).

(2) Simple yes-no answers are <u>not satisfactory</u>. If an item is not applicable, so state.

(3) Any changes to the Test Plan or Safety Checklist will be formally submitted as an addendum.

1. In accordance with NATCINST 3960.10 series and current directorate instructions, list the category testing to be conducted. If category varies with different phases of testing, so state. Ensure that pilot's workload during critical flight maneuvers is taken into consideration. (Refer to test plan if appropriate).

Category C.

2. Flight crew qualifications as of 20 JAN 91 :

PILOT/ NFO	TOTAL FLIGHT HOURS	TOTAL FLIGHT HOURS IN TYPE	FLIGHT HOURS LAST 90 DAYS	CATEGORY QUALIFIED	REMARKS
LT Klunder	380.4	350.4	31.0	C	
LT Hinger	443.0	530.7	112.2	C	
CAPT Broadhurst	2414.5	1237.1	24.9	C	
Mr. Sanders	3873.3	3873.3	2.2	C	

NDW-NATC-3930/13 (REV.11-81) Appendix VII

Figure 4. Sample IGW Safety Checklist

Source: Matthew L. Klunder and Raymond Dagenhart, "E-2C Increased Gross Weight (Phase II-Heavyweight Flying Qualities Demonstration)", E-2C Test Plan, Naval Air Test Center, Patuxent River, MD., 1991.

3. List the flight restrictions officially placed on the project and those restrictions/special pilot procedures that have been/will be added to the aircraft information sheet.

Flight tests will be in accordance with E-2C PLUS NATOPS as modified by Flight Clearance. Flight clearances are presented in Appendix III of the test plan.

4. List aircraft downing discrepancies which are applicable to the aircraft system(s) to be tested.

a. Normal NATOPS downing criteria will apply.
b. Inoperative instrumented critical parameters.

5. What background material (contractor reports, previous NAVAIRTESTCEN reports on similar aircraft or equipment, discussion with contractor's pilots, Naval Safety Center data) and known problem areas have been studied so that "surprises" will be minimized?

Similar flying qualities and approach handling qualities tests have been performed at NAVAIRTESTCEN during the DT-IIC and DT-IID evaluations of the E-2C/T56-A-427 test program. Grumman was contracted by NAVAIRSYSCOM to perform an analytical study of the flying qualities of the E-2C at a landing gross weight of 46,500 lb. Contractor pilots and engineers have been consulted, resulting in considerable interface regarding test methods and procedures.

6. What ground checks will be conducted to assess proper operation of project equipment and emergency equipment unique to the test airplane? (Refer to test plan paragraph if desired).

Normal maintenance and NATOPS preflight checks will be performed prior to and after each flight.

7. In order to ensure that no undue hazard to ground personnel or possible damage to equipment exists, what changes or special precautions to normal aircraft maintenance and/or ground handling procedures are required? Is crew change with engines running required? If so, describe procedures. Does removal/installation of project equipment constitute PMCF criteria?

No changes to normal aircraft maintenance and/or ground handling procedures are required for the conduct of this test. Crew change with engines running is not required. Removal/installation of project equipment does not constitute PMCF criteria.

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

8. If locally manufactured components are necessary for the completion of the project, what steps have been taken to ensure that adequate detailed drawings/schematics and operating instructions are prepared, components are inspected and tested prior to installation in accordance with current quality assurance /configuration control instructions?

No locally manufactured components are required.

9. Have aircraft discrepancy review procedures been established to avoid adverse impact on evaluation flights? The project officer and engineer will review and include as part of the preflight brief all up discrepancies prior to each flight to ensure that no potential exists for interference with scheduled test maneuvers.

The aircraft discrepancy review will be conducted prior to each flight by the project pilot and engineer. Airplane status will be reviewed to ensure that all test maneuvers can be conducted safely. Discrepancies will be discussed with maintenance personnel prior to each flight.

10. Do test instrumentation systems under any conditions prevent the normal operation of aircraft systems? Describe fully. Has the system been checked for EMC safety-of-flight in accordance with NATCINST 13050.3 series? Are instrumentation controls easily identified and conveniently placed? Have they been checked by SY Aircrew Systems Branch? What is the established envelope for externally carried instrumentation?

The wingboom prevents FCLP landings. All landings performed with the wingboom installed will be flared. The instrumentation systems have been subjected to a SOFT by SETD. All instrumentation controls located on the pilot and/or copilot's flight controls have been evaluated to ensure that flight control travel is not restricted. There is no provision for externally carried instrumentation.

11. Engineering design deficiencies are not uncommon in project equipment; therefore, a hazard analysis and risk assessment is required so that we can systematically determine possible hazards and minimize surprises.

a. Asking the questions "what if?" and "how?", what aircraft system and subsystem failure modes can be identified?

The airframe and landing gear will be subjected to higher than normal loads due to the increased landing weight during touch and go and landing tests.

b. If the failure mode cannot be eliminated, what special precautions, emergencies, and emergency procedures are anticipated?

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

The airframe and landing gear have been subjected to drop tests at gross weights greater than 46,500 lb. The only condition not cleared at the heavier weights is the free flight engagement. All tests addressed in this test plan will be conducted with the arresting hook up to avoid the free flight engagement condition.

c. If any safety device or interlock will be bypassed or overridden in these tests, what additional hazards are involved and what steps will be taken to reduce these risks?

No safety device or interlock will be bypassed or overridden.

12. Discuss the desirability for project flight crewmembers to preview high risk/workload data points and compound emergency procedures in a flight simulator.

The E-2C Operational Flight Trainer will be utilized, if time and schedules permit, to review minimum control airspeed tests to ensure flight crew coordination.

13. What are the real time and/or post flight critical parameters to be monitored during the test? Specify who will monitor the real time critical parameters. Describe data management techniques to detect adverse trends in these parameters.
Real-time critical parameters include: shaft horsepower, turbine measured temperature, engine speed, airspeed, altitude, angle of attack, aileron and rudder positions, and sideslip. Project engineers will monitor flight tests real-time at the Real-time Telemetry Processing System. All intentional single engine flights will be chased.

14. What logical buildup is planned for high risk/pilot workload data points? (Reference to test plan is sufficient).

Flight tests will be conducted in a buildup fashion working toward the slowest airspeeds. See the Method of Test appendix (appendix IV) for detailed test procedures.

15. For high angle of attack test, provide a premaneuver checklist. (Reference to test plan is sufficient).

* STAB AUG off
* Max rudder 20 deg
* Loose gear stowed
* Recovery procedures briefed
* Harness locked
* Radio check with ground station
* Area clear

NDW-NATC-3930/13 (REV.11-81) Appendix VII

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

* Cross-check airspeed and AOA

Stall approaches prior to airspeed calibration

a. No high angle of attack tests are planned except for Vmc tests and stall approaches to 26 units AOA.

b. Maintenance Instruction Manual AOA check will be performed prior to high AOA tests.

c. Ensure stall warning (rudder shaker) is operative (during prestart checklist.

16. Specify who will be required to attend pre/post flight briefings. Preflight briefings shall include a review of:

Aircraft Limitations/Restrictions
High Risk/Pilot Workload Data Point Techniques
Possible Project Related Emergency Procedures
Any Options or Deviations from Test Card
Special Precautions
Chase Pilot, Support Personnel Requirements

The flight crew, project engineers and contractor representatives will attend all pre/post flight briefings.

17. List the following Go-No-Go criteria:

a. Weather criteria (specific ceiling/visibility criteria is required).

(1) Terminal. VFR.

(2) Area. VFR. Clearly defined horizon available for stall approaches and Vmc tests.

b. Chase requirements. During all intentional single engine flights.

c. Instrumentation requirements. Instrumentation requirements are listed in appendix V. Acceptability of degraded instrumentation will be determined on a flight by flight basis.

d. Other. None.

18. For flight operations away from Patuxent River, face-to-face briefings with resident operations officers and support personnel will be conducted prior to first project flight, to include: local traffic pattern, radio communication procedures, hazardous area, available crash/rescue equipment,

NDW-NATC-3930/13 (REV.11-81) Appendix VII

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

emergency procedures, local warning or civil avoidance areas, emergency ejection, fuel dump or ordnance jettison areas, GSE availability, and details of test to be conducted?

No flight operations are required away from Patuxent River.

19. Have other agencies, both military and civilian, who have conducted similar tests been consulted so that benefit can be realized from consideration of their standard procedures and lessons learned?

Test procedures and results of similar tests conducted at NAVAIRTESTCEN have been reviewed prior to flight tests. NAVAIRTESTCEN personnel have witnessed previous ground and flight tests conducted by the contractors in order to understand their test methods and standard procedures.

20. PROJECT SECURITY

a. What is the overall security classification of the project?

Unclassified.

b. Have classification guides (OPNAVINST C5513.2 for most Naval Aviation Equipment) for all project aircraft and support equipment been reviewed for appropriate classification?

Classification guides have been reviewed.

c. Are any components of equipment classified? If so, are procedures established for storage and shipment in accordance with OPNAVINST 5510.1G?

No components of equipment are classified.

d. Will project data be classified? If so, how will it be protected?

Project data is unclassified.

e. Will any classified equipment or ordnance be delivered to or received from NAVAIRTESTCEN during the project? If so, have proper arrangements been made and accepted procedures followed to ensure its safeguard?

No classified equipment or ordnance will be delivered to or shipped from NAVAIRTESTCEN during the project.

NDW-NATC-3930/13 (REV.11-81) Appendix VII

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

Reviewed by:

Project Officer

Project Pilot

Lead Project Engineer

Project Engineer

Project Pilot

Project Pilot

Project Pilot

Additional project personnel will sign prior to project involvement.

Project Engineer

NDW-NATC-3930/13 (REV.11-81)

Appendix VII

Figure 4. (continued)

Source: Klunder and Dagenhart, January 1991.

APPENDIX B

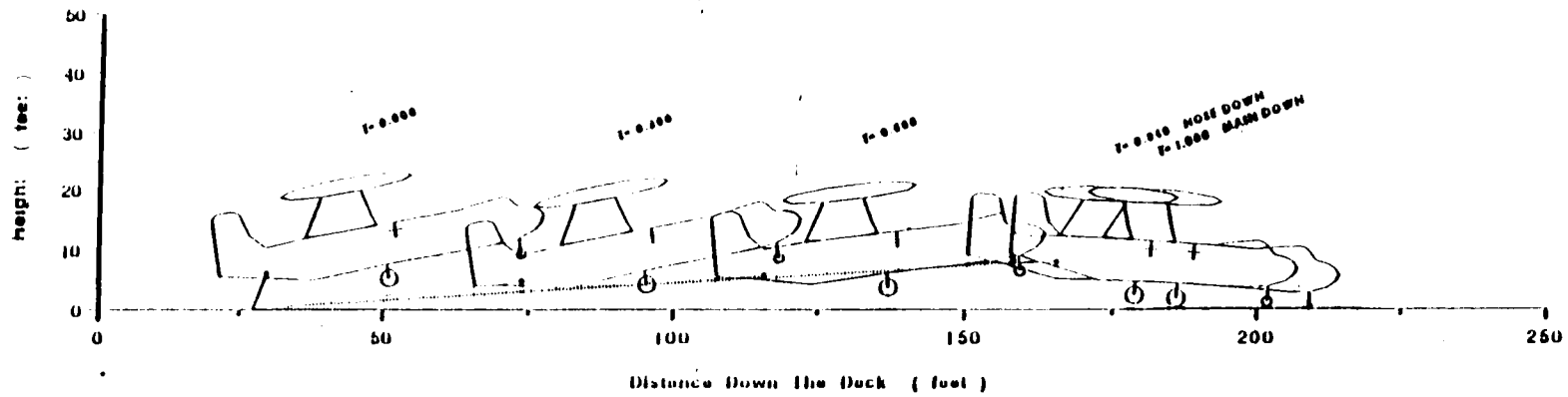


Figure 5. Diagram of E-2C Free Flight Engagement Analysis

Source: Grumman Engineering, "E-2C Increased Carrier Landing Weight Program; Drop Test." Test Readiness Review Meeting, Grumman Bethpage, NY. August 1991.

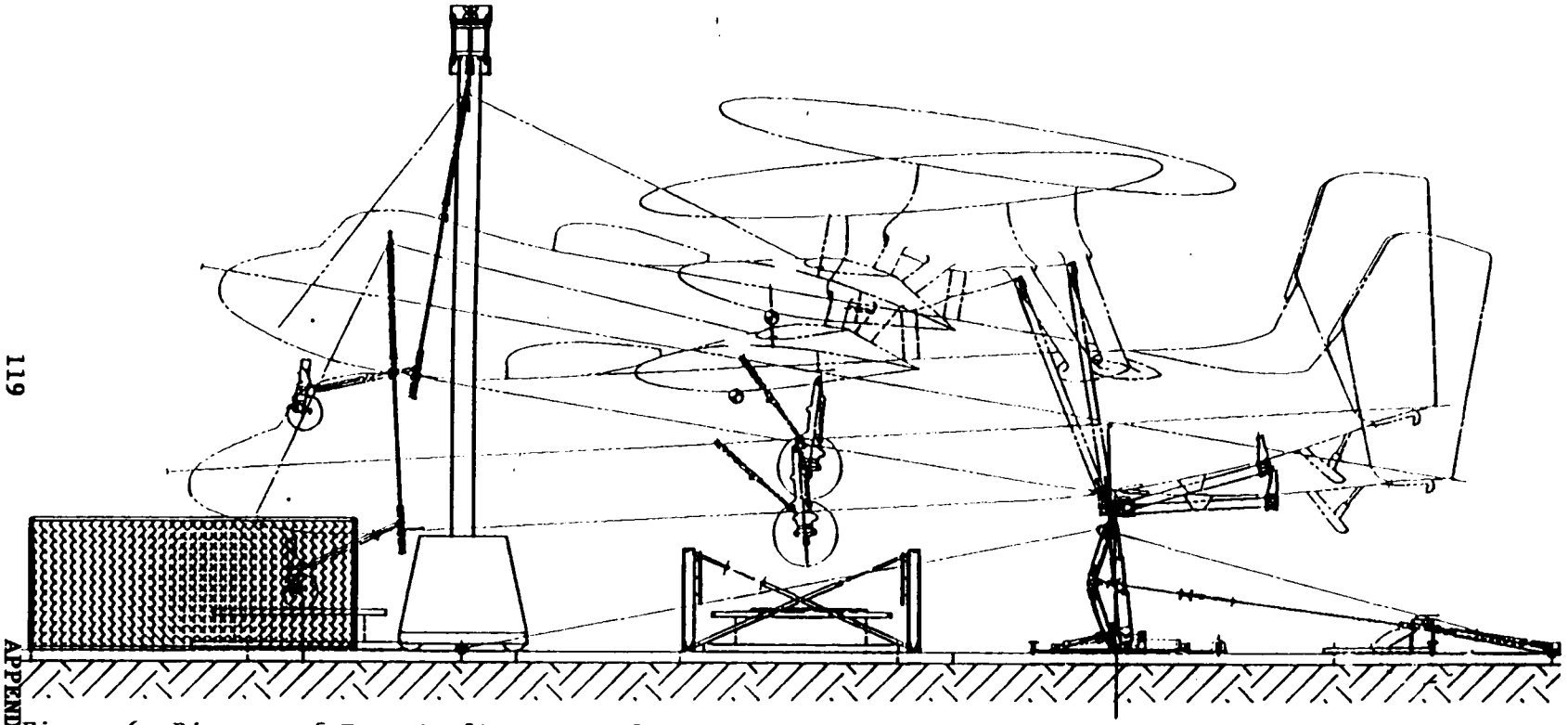


Figure 6. Diagram of Test Configuration for E-2C Free Flight Engagement

Source: Grumman Engineering, " E-2C Increased Carrier Landing Weight Program; Drop Test." Test Readiness Review Meeting, Grumman Bethpage, NY., August 1991.

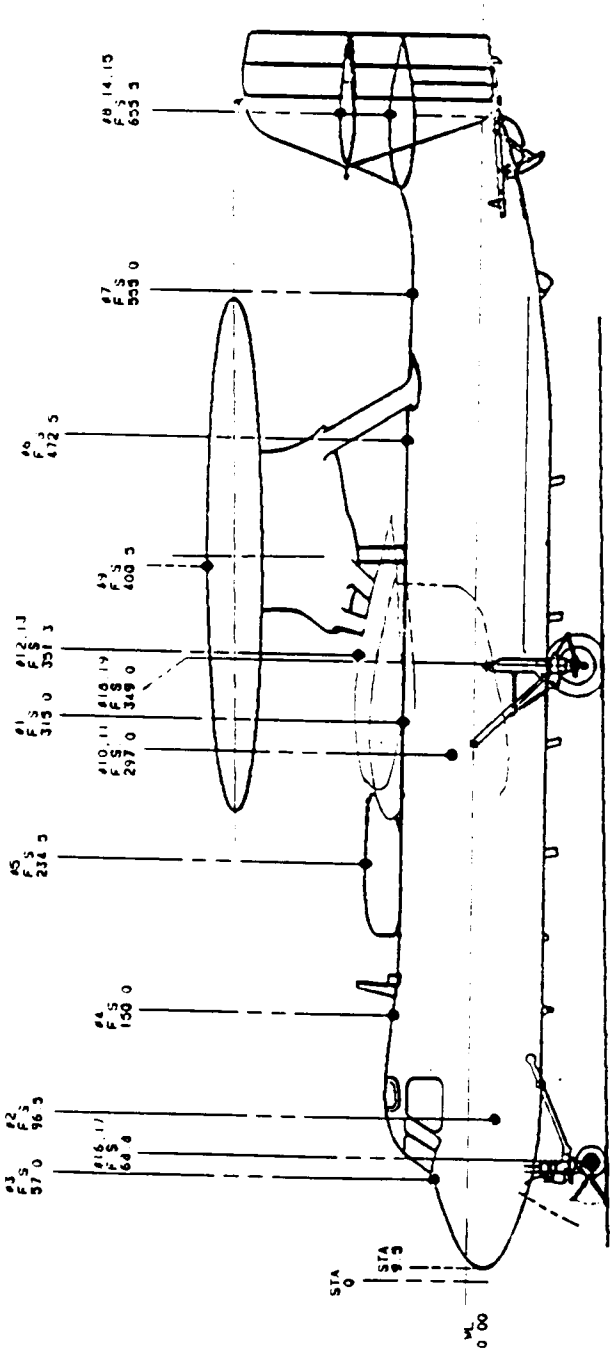


Figure 7. E-2C Drop Test Article Side View Instrumentation

Source: Grumman Engineering, "E-2C Heavyweight Drop Test Plan." Drop Test Plan, Grumman Bethpage, NY., July 1991.

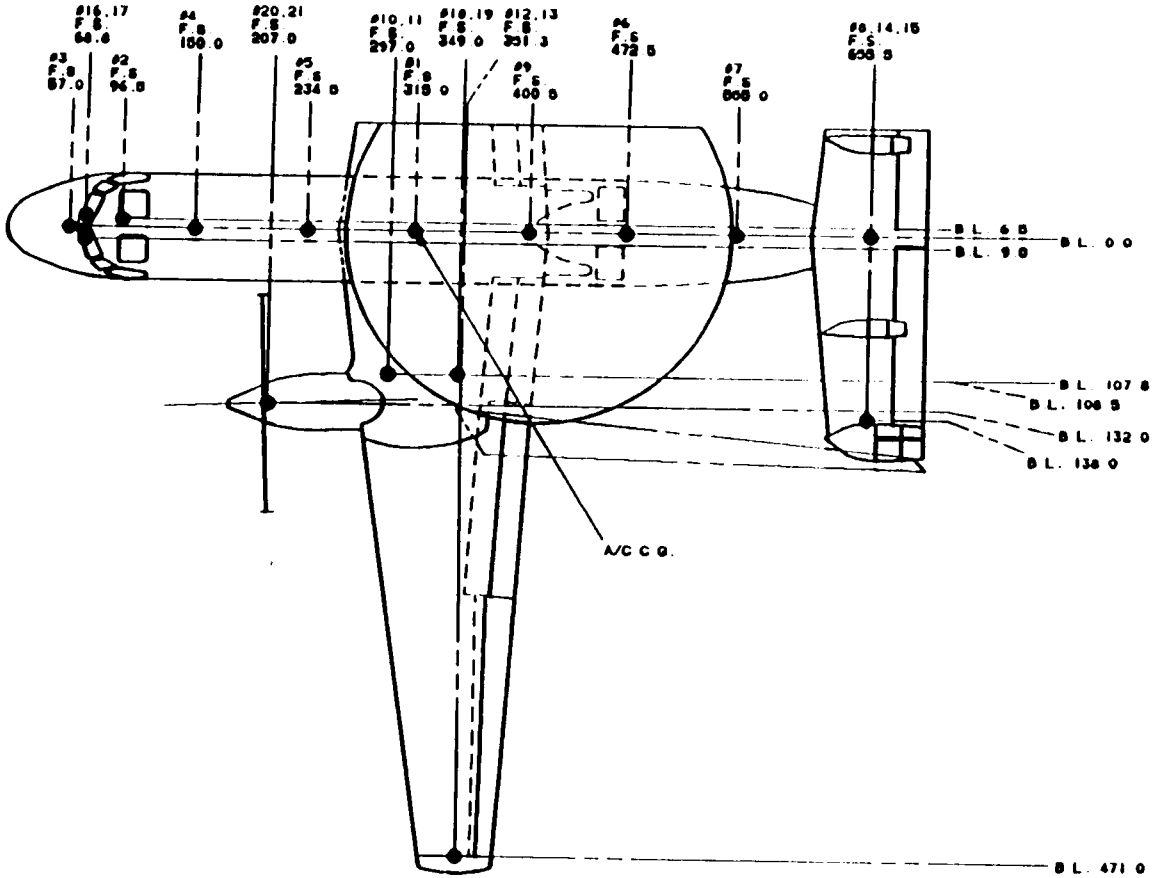


Figure 8. E-2C Drop Test Article Top View Instrumentation

Source: Grumman Engineering, "E-2C Heavyweight Drop Test Plan." Drop Test Plan, Grumman Bethpage, NY., July 1991.

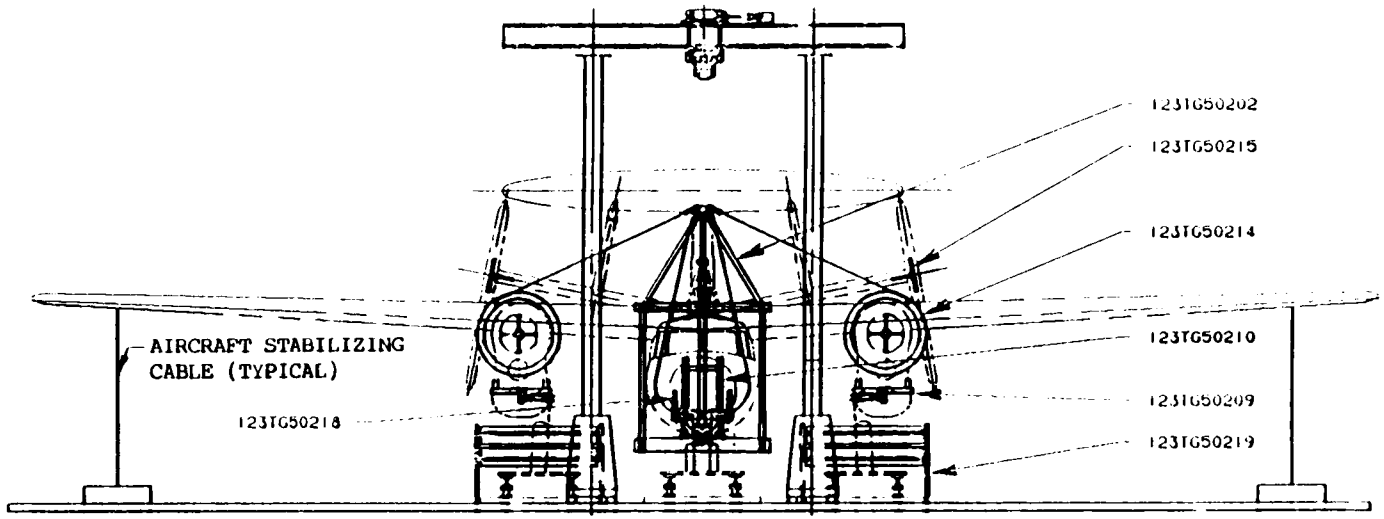


Figure 9. E-2C Drop Test Apparatus: Front View

Source: Grumman Engineering, "Results of E-2C Heavyweight Drop Test." Grumman E-2C Publication, Grumman Bethpage, NY., November 1991.

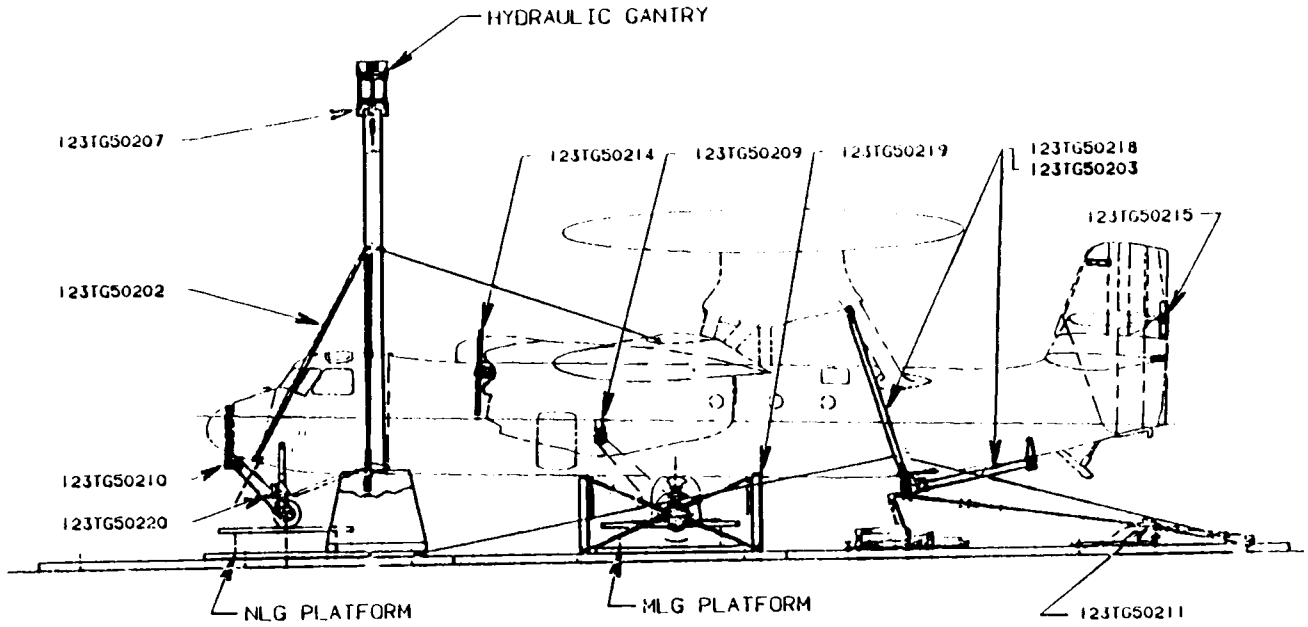


Figure 10. E-2C Drop Test Apparatus: Side View

Source: Grumman Engineering, "Results of E-2C Heavyweight Drop Test." Grumman E-2C Publication, Grumman Bethpage, NY., November 1991.

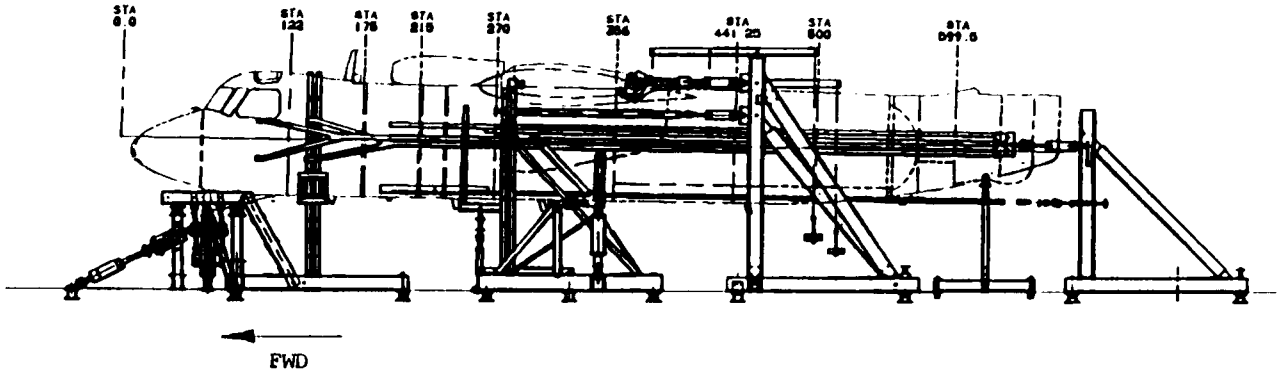


Figure 11. E-2C Catapult Tow Load Static Test Set-up

Source: Grumman Engineering, "Plan for E-2C Catapult Ultimate Tow Load Static Test." E-2C Ground Test Plan, Grumman Bethpage, NY., August 1991.

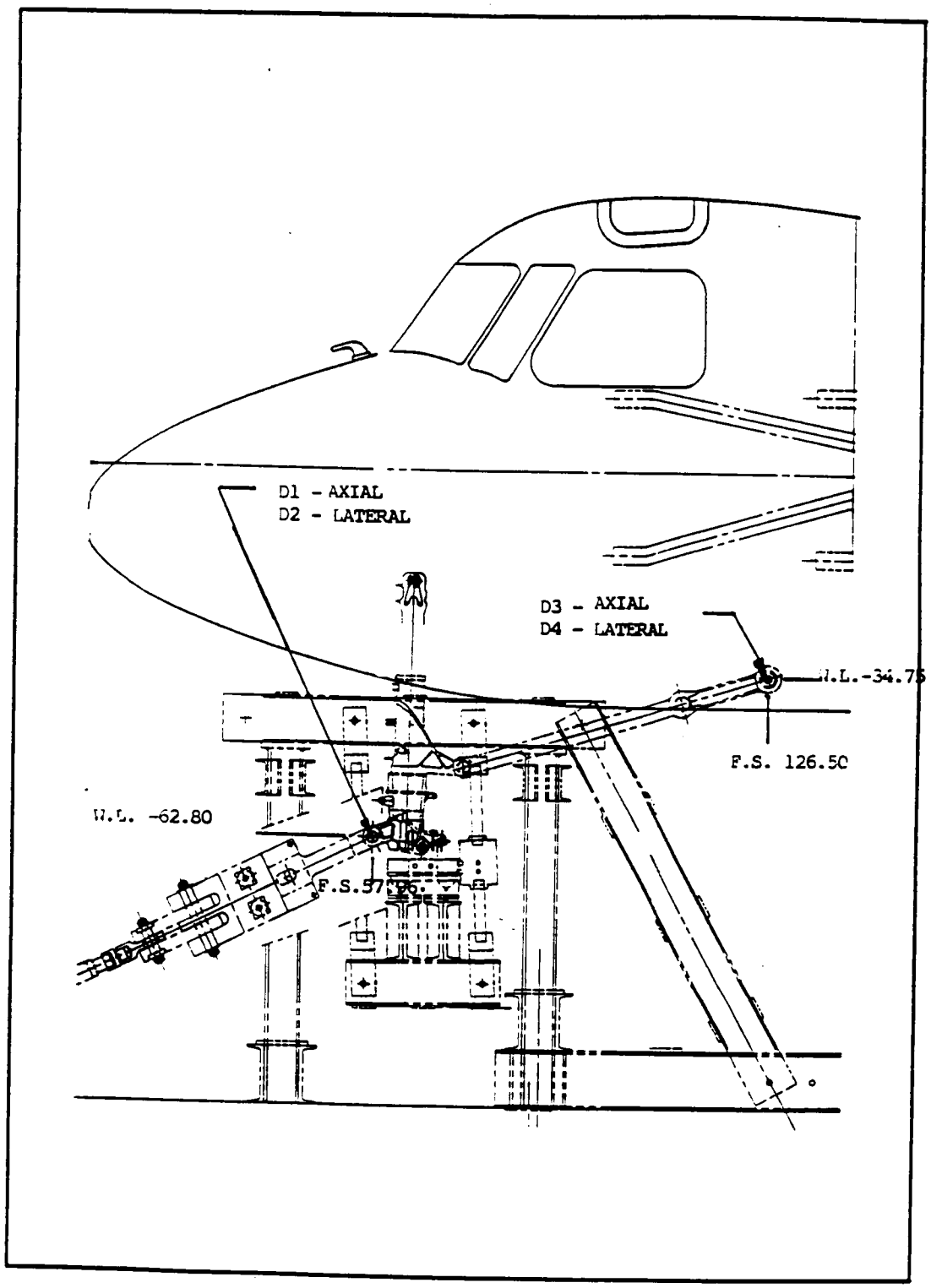


Figure 12. Deflection Gage Locations: Tow Load Static Test

Source: Grumman Engineering, "Plan for E-2C Catapult Ultimate Tow Load Static Test." E-2C Ground Test Plan, Grumman Bethpage, NY., August 1991.

COOPER-HARPER HANDLING QUALITIES
RATING SCALE

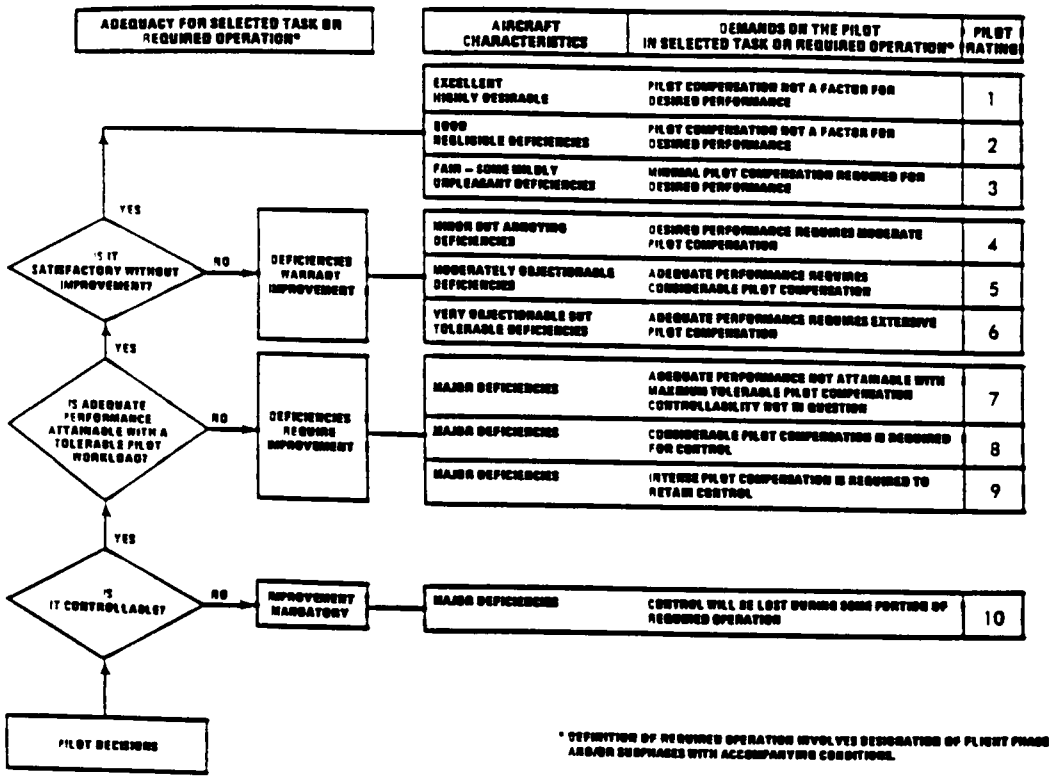


Figure 13. Cooper Harper Handling Qualities Rating Scale

Source: Unites States Naval Test Pilot School, Classroom Notes Patuxent River, MD., July 1989.

APPENDIX B

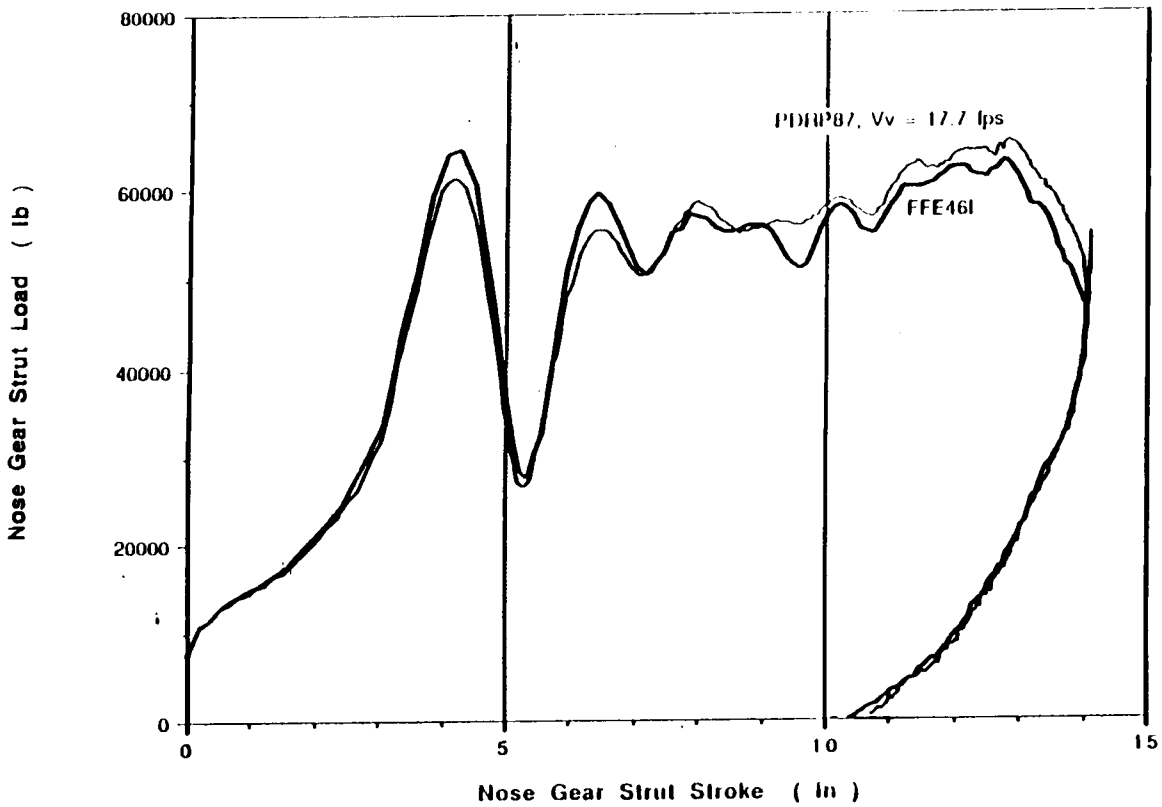


Figure 14. E-2C Load Stroke Curve Comparison for Drop Test
FFE461; -- Free Flight Engagement Analysis Curve
PDRP87; -- Pre Drop Test Curve Adjusted for Non-flight

Source: Grumman Engineering, "E-2C Increased Carrier Landing Weight Program; Drop Test." Test Readiness Review Meeting, Grumman Bethpage, NY., August 1991.

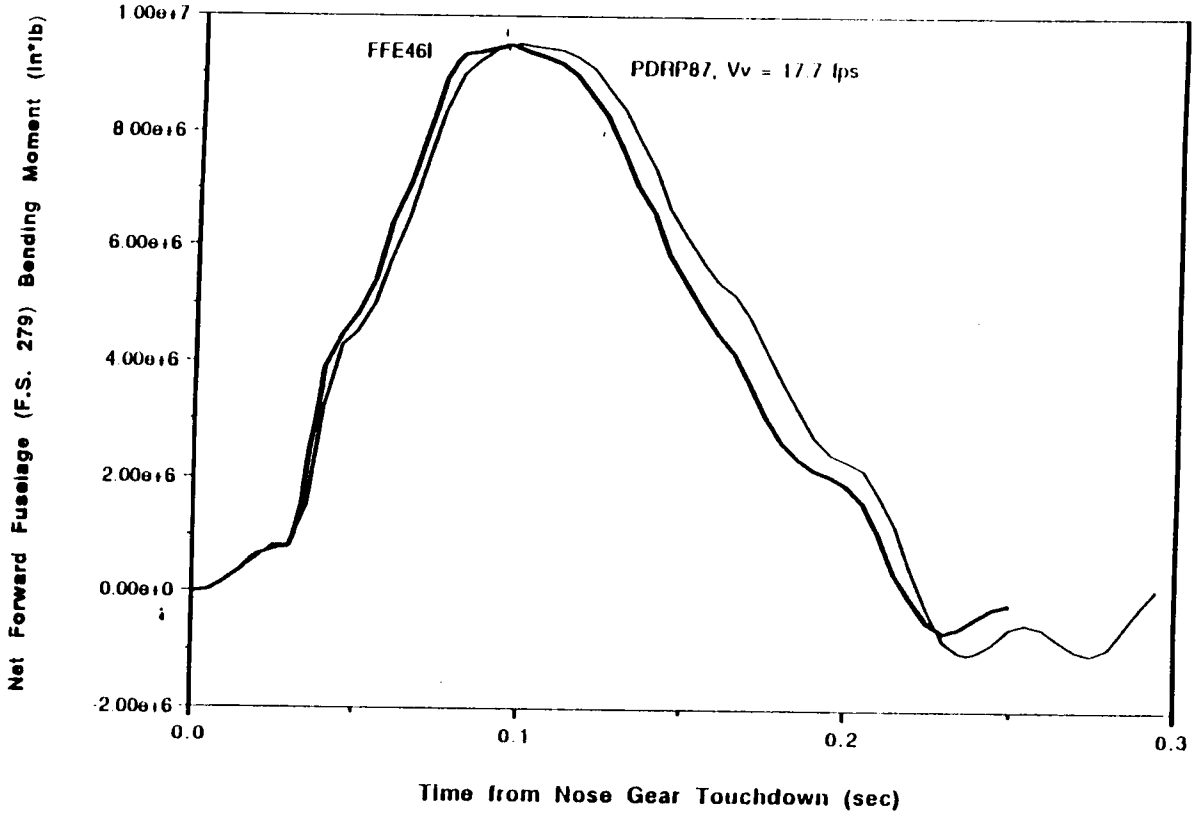


Figure 15. E-2C Forward Fuselage Bending Moment Comparison for Drop Test: FFE461; -- Free Flight Engagement Analysis Curve, PDRP87; -- Pre Drop Test Curve Adjusted for Non-flight

Source: Grumman Engineering, "E-2C Increased Carrier Landing Weight Program; Drop Test." Test Readiness Review Mtg Grumman Bethpage, NY., August 1991.

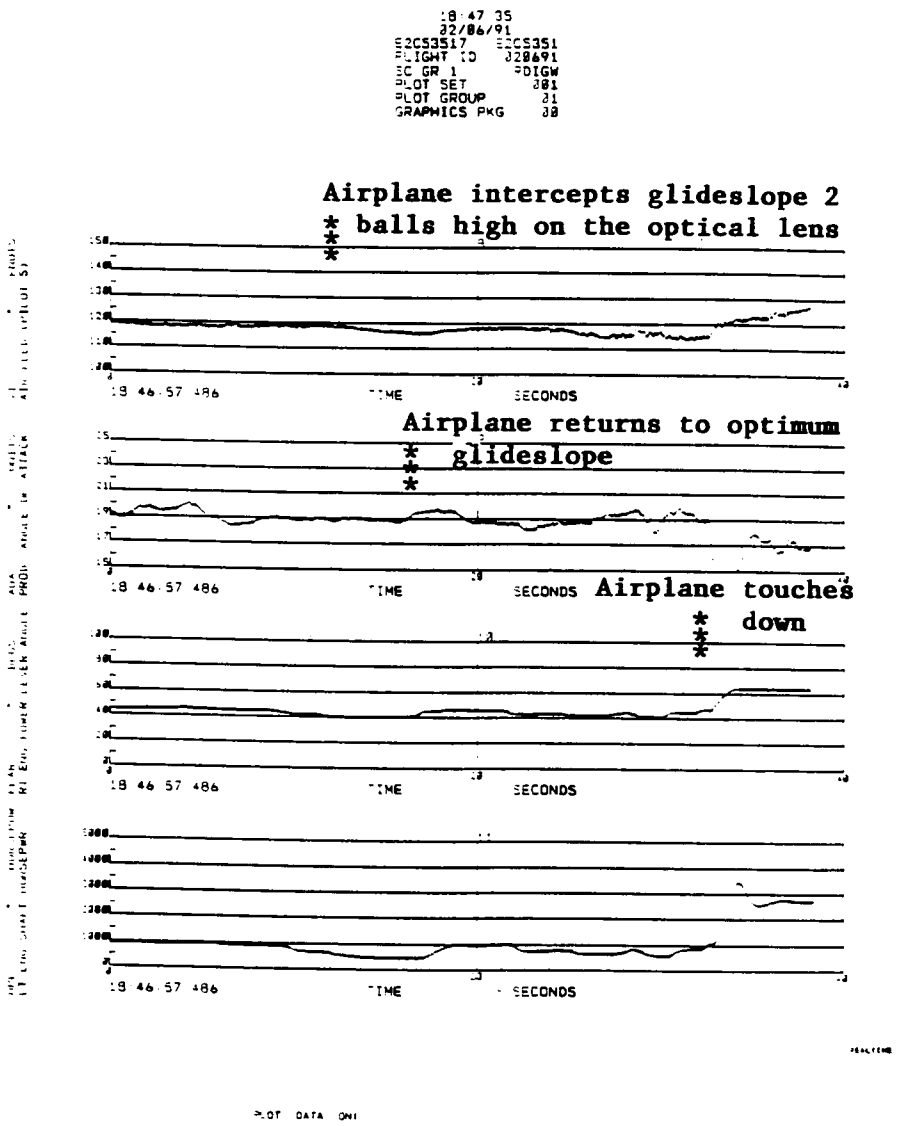


Figure 16. Sample Time History of E-2C Approach Handling Increased Landing Weight in Configuration PA(20)

Source: Raymond Dagenhart and Eric Ryberg, "Results of E-2C Heavyweight Flying Qualities Evaluation." Strip Chart Data, Naval Air Test Center, Patuxent River, MD., February 1991.

APPENDIX B

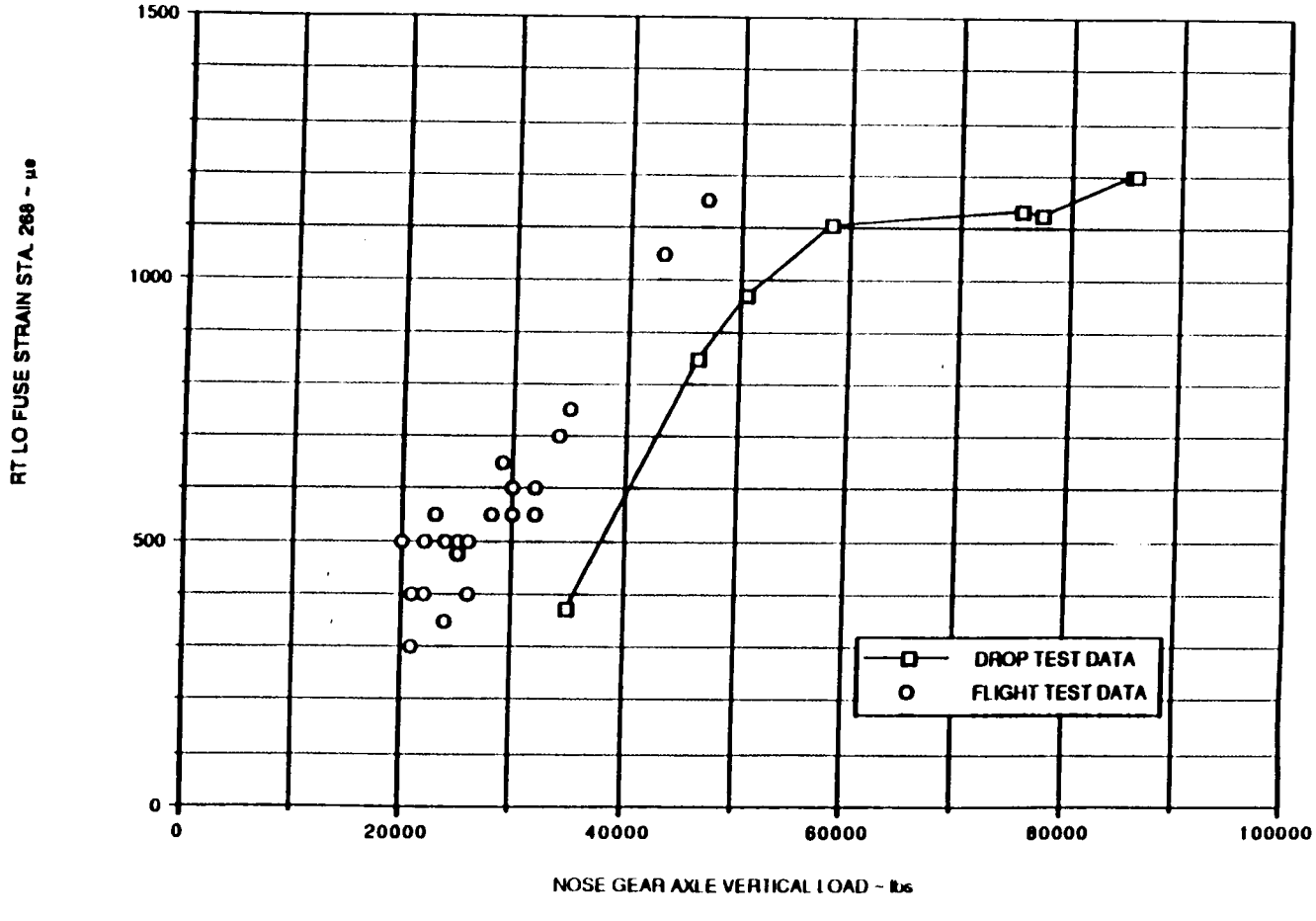


Figure 17. E-2C Free Flight Engagements: Right Lower Fuselage Strain Station 268

Source: Grumman Engineering, "E-2C Increased Carrier Landing Weight Program, Test Report: Part IV Arrested Landing Structural Flight Tests." E-2C Flight Test Report, Grumman Bethpage, NY., January 1992.

APPENDIX C

E-2C IGW SAMPLE CATEGORY "C" TEST TECHNIQUES

METHOD OF TEST

TEST METHODS AND PROCEDURES

1. In general, the tests will be conducted in accordance with the USNTPS Stability and Control Manual, reference (d), and the USNTPS Fixed Wing Airplane Performance Manual, reference (e). Test methods for specific tests are discussed in the REMARKS column of appendix II. Category C tests are discussed in detail in the following paragraphs.

SINGLE ENGINE MINIMUM CONTROL AIRSPEED (Vmc)

General

2. Care must be exercised to obtain data only when the airplane is stabilized in unaccelerated flight conditions. Primarily, outside visual references should be used to maintain bank angle as desired and zero yaw rate. Cockpit instruments should be cross-checked frequently. The ball of the turn-and-slip indicator will be monitored because it is an excellent indicator of lateral accelerations resulting from unbalanced lateral forces. All static and dynamic Vmc testing will be terminated at 26 units AOA (stall warning) in order to avoid any possibility of a single engine stall. Static and dynamic Vmc at gross weights up to 51,000 lb were determined during the E-2C/T56-A-427 DT-IIC Flying Qualities Evaluation. Static and dynamic Vmc should not vary greatly at 55,000 lb gross weight.

Static Minimum Control Airspeed

3. Static Vmc will be determined for both right and left engine failures. Static Vmc shall be considered reached when any one of the following limiting criteria are met:

a. Full rudder deflection is required to maintain a steady heading

b. 75% of the lateral control deflection is required

c. 26 units AOA

d. 15 deg of sideslip.

4. The following procedures shall be utilized for determining static Vmc:

a. Conduct flight test per FTM 103, reference (b), to determine the horsepower (FX ISHP) required to simulate a secured engine with propeller feathered vice the FLT IDLE setting often used. The engine under investigation will then be chopped to FX ISHP to simulate a feathered engine during static and dynamic Vmc tests.

b. Stabilize at 4,000 ft MSL at 140 KIAS with the right engine set at FX ISHP and the left engine at 5,100 ISHP. Record altitude, airspeed, fuel state, and trim settings.

c. Smoothly and slowly reduce airspeed (1 kt/sec or less) by use of longitudinal control only. As airspeed is reduced, trim out all control forces in steady heading flight. When an airspeed is reached where one of the trim systems is at its' limit, stabilize the airplane and mark as Single Engine Static Minimum Trim Airspeed. Record airspeed, trim settings, and limiting trim axis.

d. Continue to smoothly and slowly reduce airspeed using longitudinal control in wings level, steady heading flight. The airspeed at which one of the limiting criteria is met will be defined as Wings Level Static Vmc. Record airspeed, altitude, and limiting factor.

e. If rudder limited, establish a 5 deg bank into the operating engine. Continue to slowly reduce airspeed while maintaining steady heading flight until a limiting criteria is met. This will define Static Vmc with 5 deg bank. Record airspeed, bank angle, and limiting factor.

f. Repeat steps b-e with the left engine set at FX ISHP and the right engine set at 5,100 ISHP.

g. Repeat steps b-f with the propeller feathered and engine secured vice the FX ISHP setting.

5. The critical engine will be determined as that engine which, when secured, results in the highest static Vmc.

Dynamic Minimum Control Airspeed

6. In past E-2C dynamic Vmc testing, power lever chops to FLT IDLE have been used successfully to simulate an engine failure. However, during E-2C/T56-A-427 DT-IIC testing, it was discovered that the airplane's response to a power lever chop was less dynamic than that of an actual engine shutdown. Therefore, dynamic Vmc will have to be determined using actual engine shutdowns instead of power lever chops. Additionally, past experience has shown that it is possible for the dynamic critical engine for a given critical configuration to be different from the critical engine determined from static Vmc tests. For this reason, dynamic Vmc tests will be conducted first with the left engine critical, followed by similar tests with the right engine critical.

7. During the E-2C/T56-A-427 DT-IIC Evaluation, dynamic Vmc tests were conducted using the classical technique of FTM 103, reference (b). The use of this technique resulted in a very high nose-up, climbing pitch attitude prior to engine failure which is not representative of the takeoff and waveoff

scenarios. Upon NAVAIRSYSCOM direction, NAVAIRTESTCEN developed an alternate technique which more closely replicates the waveoff condition, termed the waveoff technique. However, NAVAIRTESTCEN could not formulate a technique that simulated the takeoff condition to a greater degree than the classical technique. For these reasons, the waveoff technique will be used for dynamic Vmc determination in the 20 and 30 deg flap configurations, and the classical technique will be used in the 0 and 10 deg flap configurations.

8. Dynamic Vmc will be determined for a critical engine failure to a feathered condition. Dynamic Vmc shall be considered reached when any one of the following limiting criteria are met:

a. Maximum rudder deflection is required for greater than 1 sec.

b. A heading change in excess of 20 deg.

c. 75% of the lateral control deflection is required.

d. A bank angle change in excess of 30 deg.

e. AOA exceeds 26 units.

f. Sideslip exceeds 15 deg.

g. Target airspeed cannot be maintained without altitude loss.

h. In the judgment of the test pilot, the recovery maneuver is unsafe or requires excessive workload for the average pilot.

9. The following procedures (classical technique) shall be utilized for determining dynamic Vmc in the 10 and 0 flap configurations:

a. Stabilize in a climb at 130 KIAS with 5,100 ISHP set on both engines. Trim out all control forces. Record airspeed, fuel state (in level flight prior to maneuver), and trim setting.

b. At 4,000 ft MSL, the copilot will smartly reduce power on the engine under investigation to FX ISHP, simulating engine failure with propeller feathered.

c. Recovery control inputs will be applied at the earlier of 1 sec lapsed, a 20 deg angle of bank change, or the sideslip angle exceeding 10 deg. The pilot will attempt to regain steady heading flight at the original target airspeed. Longitudinal, lateral, and directional control inputs shall be used as required for recovery to controlled flight.

APPENDIX C

d. Steps a-c will be repeated with the target airspeed reduced in 5 KIAS or less decrements. The airspeed at which one of the above limiting criteria is met using a simulated engine failure will be defined as simulated dynamic Vmc.

e. Beginning at a target airspeed of simulated dynamic Vmc plus 10 KIAS, repeat steps a-c performing actual engine shutdowns. The airspeed at which one of the above limiting criteria is met will be defined as actual dynamic Vmc.

10. The following procedures (waveoff technique) shall be utilized for determining dynamic Vmc in the 20 and 30 flap configurations:

a. Establish 500 fpm rate of descent at target airspeed.

b. At target airspeed and altitude, pilot will advance power levers to maximum power.

c. As power levers are advanced, the copilot will rapidly retard the left power lever to flight idle while pilot maintains airspeed.

d. Apply control inputs to maintain target airspeed without altitude loss. Return to and maintain wings level flight.

e. Reduce target airspeed in 5 KIAS decrements and repeat technique until Vmc is reached.

f. Repeat steps a-e with actual engine shutdowns using condition lever to feather.

11. Performing actual engine shutdowns to determine dynamic Vmc requires more time (waiting for the engine to cool down before an airstart can be done) but will not be unsafe for the following reasons:

a. Dynamic Vmc has been determined at gross weights up to 51,000 lb and should not change appreciably at weights up to 55,000 lb.

b. Builddown in airspeed would be performed cautiously with decreases of no more than 5 kts from the previous point.

c. If an engine is secured slightly below Vmc, the pilot will be able to trade altitude for airspeed and reduce power on the operating engine to reduce the asymmetric thrust and assist in recovery.

d. Steps a-c will be repeated with the target airspeed reduced in 5 KIAS or less decrements. The airspeed at which one of the above limiting criteria is met using a simulated engine failure will be defined as simulated dynamic Vmc.

e. Beginning at a target airspeed of simulated dynamic Vmc plus 10 KIAS, repeat steps a-c performing actual engine shutdowns. The airspeed at which one of the above limiting criteria is met will be defined as actual dynamic Vmc.

10. The following procedures (waveoff technique) shall be utilized for determining dynamic Vmc in the 20 and 30 flap configurations:

a. Establish 500 fpm rate of descent at target airspeed.

b. At target airspeed and altitude, pilot will advance power levers to maximum power.

c. As power levers are advanced, the copilot will rapidly retard the left power lever to flight idle while pilot maintains airspeed.

d. Apply control inputs to maintain target airspeed without altitude loss. Return to and maintain wings level flight.

e. Reduce target airspeed in 5 KIAS decrements and repeat technique until Vmc is reached.

f. Repeat steps a-e with actual engine shutdowns using condition lever to feather.

11. Performing actual engine shutdowns to determine dynamic Vmc requires more time (waiting for the engine to cool down before an airstart can be done) but will not be unsafe for the following reasons:

a. Dynamic Vmc has been determined at gross weights up to 51,000 lb and should not change appreciably at weights up to 55,000 lb.

b. Builddown in airspeed would be performed cautiously with decreases of no more than 5 kts from the previous point.

c. If an engine is secured slightly below Vmc, the pilot will be able to trade altitude for airspeed and reduce power on the operating engine to reduce the asymmetric thrust and assist in recovery.

APPENDIX D

LIST OF SYMBOLS AND ABBREVIATIONS

LIST OF SYMBOLS AND ABBREVIATIONS

A-4.....Douglas Light Attack Airplane

AC.....Airframes Change

ALB.....Aircraft Launch Bulletin

AOA.....Angle of Attack

APS-120.....Grumman Radar Weapon System

C.G.....Center of Gravity

DODISS.....Department of Defense Index of Specifications and Standards

E-2.....Grumman E-2 Airplane

ECP.....Engineering Change Proposals

FFE.....Free Flight Engagement

GAC.....Grumman Aerospace Corporation

HPL.....Left Engine Shaft Horsepower

IGW.....Increased Gross Weight

in.....inches

JON.....Job Order Number

LSO.....Landing Signal Officer

lb.....pound(s)

LCS.....Landbased Carrier Suitability

NAWC,AD.....Naval Air Warfare Center,
Aircraft Division

NASC.....Naval Air Systems Command

NAEC.....Naval Air Engineering Center

NLG.....Nose Landing Gear

PLAR.....Right Power Lever Angle

QRR.....Quick Response Report

SCS.....Shipboard Carrier Suitability

sec.....second(s)

TR.....Technical Report

uo.....micro strains

vi.....airspeed

APPENDIX D

VITA

Matthew Lewis Klunder was born in Fort Eustis, Virginia on June 24, 1960. He attended elementary and intermediate schools in the Fairfax County area of Northern Virginia and graduated from Groveton High School in June, 1978. That summer he entered the United States Naval Academy and in May, 1982 he received the degree of Bachelor of Science in Oceanography and Ocean Physics and was commissioned as an Ensign in the United States Navy. He entered flight training in October, 1982 and was awarded Navy pilot wings in September 1984. From October 1984 to May 1989 he completed numerous tours as an airborne early warning pilot and instructor. During his assignment as an instructor pilot, he was awarded the "1988 Hawkeye of the Year". Following his tours as an airborne early warning pilot, he attended the United States Naval Test Pilot School and graduated in June, 1990. In January, 1991 he entered the University of Tennessee, Knoxville and in May, 1991 received a Master of Science degree in Aviation Systems.

He is presently completing an assignment as a test pilot for the Force Warfare Test Directorate at the Naval Air Warfare Center, Aircraft Division, Patuxent River, Maryland.